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Review of particle properties

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ERRATA FOR THE 1984 EDITION OF THE "REVIEW OF PARTICLE PROPERTIES" (CONT'D)

On page S181, the Data Card Listings for the $\eta_c(2980)$ contain several errors pertaining to MARK-III data. The corrected Listings are given below.

$\eta_c(2980)$

```
26  ETA/C(2980,JPG=0-+) I=0

OBSERVED IN THE INCLUSIVE GAMMA SPECTRUM GENERATED FROM
PSI(3685) DECAY, THEREFORE C=+. FROM THE 4 PI DECAY
G=+, THEREFORE I=0.
FROM ANGULAR DISTRIBUTION IN J/PSI TO ETA/C, ETA/C TO
PHI PHI, JP=0- (HITLIN 83).

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                26  ETA/C(2980) MASS (MEV)

M  M    18 2982.      8.          HIMEL     80 SMK2     E+ E-          9/81
M  M       2980.      9.          PARTRIDGE 80 CBAL     E+ E-          9/81
M  A     (2980.)     (5.)         EINSWEILE 83 SMK3     PSI3100,ETAC GAM  6/84*
M  B     (2978.)     (6.)         EINSWEILE 83 SMK3     PSI3100,ETAC GAM  6/84*
M
M   AVG    2981.1      6.0     AVERAGE

M  M    MASS ADJUSTED BY US TO CORRESPOND TO J/PSI(3100) MASS = 3097.
M  A    ETA/C TO P PBAR
M  B    ETA/C TO PHI PHI

------ --------- --------- --------- --------- --------- --------- --------

                26  ETA/C(2980) WIDTH (MEV)

W       18  (40.)   OR LESS  CL=.90   HIMEL     80 SMK2     E+ E-          9/81
W           (20.)   OR LESS  CL=.90   PARTRIDGE 80 CBAL     E+ E-          9/81
W  A        (33.)   OR LESS  CL=.90   EINSWEILE 83 SMK3     PSI3100,ETAC GAM  6/84*
W  B        (36.)   OR LESS  CL=.90   EINSWEILE 83 SMK3     PSI3100,ETAC GAM  6/84*

W  A    ETA/C TO P PBAR
W  B    ETA/C TO PHI PHI

------ --------- --------- --------- --------- --------- --------- --------

                26  ETA/C(2980) PARTIAL DECAY MODES

P       HADRONIC DECAYS
P       ---------------
P11     ETA/C(2980) INTO 2(PI+PI-)                          140+ 140+ 140+ 140
P12     ETA/C(2980) INTO P PBAR                             938+ 938
P13     ETA/C(2980) INTO PI+ PI- P PBAR                     140+ 140+ 938+ 938
P14     ETA/C(2980) INTO K KBAR PI                          498+ 498+ 140
P15     ETA/C(2980) INTO PI+ PI- K+ K-                      140+ 140+ 494+ 494
P16     ETA/C(2980) INTO ETA PI+ PI-                        549+ 140+ 140
P17     ETA/C(2980) INTO PHI PHI                            1020+1020

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                26  ETA/C(2980) BRANCHING RATIOS

R1      ETA/C(2980) INTO (2(PI+PI-))/TOTAL                  (P11)
R1 A          0.013     0.009     0.006 HIMEL     80 SMK2     PSI3685,ETAC GAM  9/81

R2      ETA/C(2980) INTO (PBAR P)/TOTAL                     (P12)
R2 A          0.002     0.002     0.001 HIMEL     80 SMK2     PSI3685,ETAC GAM  9/81
R2  C        (0.0018) (0.0009)           EINSWEILE 83 SMK3     PSI3100,ETAC GAM  6/84*

R3      ETA/C(2980) INTO (2PI PBAR P)/TOTAL                 (P13)
R3           (0.012)OR LESS  CL=.90   HIMEL     80 SMK2     PSI3685,ETAC GAM  9/81

R4      ETA/C(2980) INTO (K KBAR PI)/TOTAL                  (P14)
R4 A B        0.14      0.07      0.06  HIMEL     80 SMK2     PSI3685,ETAC GAM  9/81

R5      ETA/C(2980) INTO (2PI 2K)/TOTAL                     (P15)
R5 A          0.009     0.014     0.006 HIMEL     80 SMK2     PSI3685,ETAC GAM  9/81

R7      ETA/C(2980) INTO PHI PHI/TOTAL                      (P17)
R7  C        (0.01)    (0.004)          EINSWEILE 83 SMK3     PSI3100,ETAC GAM  6/84*

R  A    ESTIMATED USING BR ( PSI(3685) INTO ETA/C(2980) GAMMA) = .0043
R  A    THE ERRORS DO NOT CONTAIN THE UNCERTAINTY IN THE PSI(3685) DECAY.
R    B  NOT SEEN BY PARTRIDGE IN K+ K- PIO.
R  C    EINSWEILER 83 USES BR(J/PSI INTO ETA/C GAMMA) = 0.0127+-0.0036
R    D  SYSTEMATIC ERROR ADDED LINEARLY BY US.

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                REFERENCES FOR ETA/C(2980)

BLOOM     79 FERMILAB SYMP.92  E.D.BLOOM          (CIT+HARV+PRIN+SLAC+STAN)

HIMEL     80 PRL 45 1146       +TRILLING,ABRAMS,ALAM+        (SLAC+LBL+UCB)
PARTRIDG  80 PRL 45 1150       PARTRIDGE,PECK+    (CIT+HARV+PRIN+STAN+SLAC)

EINSWEIL  83 BRIGHTON CONF.    K.F.EINSWEILER+MARKIII COLLABORATION (SLAC)
HITLIN    83 CORNELL CONF.     D. HITLIN                            (CIT)
****** ********* ********* ********* ********* ********* ********* ********
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On page S203, in the Data Card Listings for the D*(2010), there are several omissions of MARK-II data. The corrected Listings are given below.

$D^{*\pm}(2010)$

```
62  CHARGED D*(2010,JP=1-) I=1/2
------ --------- --------- --------- --------- --------- --------- --------

                62  CHARGED D*(2010) MASS (MEV)

M   G     (2008.)     (3.)          GOLDHABE  77 SMAG +- E+E-          12/77
M   P     (2008.6)    (1.0)         PERUZZI   77 SMAG +- E+E-          12/77
M
M   MASS   2010.1      0.7   FROM DO MASS (TRILLING 81 RVUE) AND
M                            MASS DIFFERENCE BELOW

M   G   FROM SIMULTANEUS FIT TO D*+,D*0,D+,AND DO,NOT INDEPENDENT OF
M   G   FELDMAN 77 MASS DIFFERENCE BELOW.
M   P   PERUZZI 77 MASS NOT INDEPENDENT OF FELDMAN 77 MASS DIFFERENCE
M   P   BELOW AND PERUZZI 77 DO MASS VALUE.

------ --------- --------- --------- --------- --------- --------- --------

                62  (D*+) - (D0) MASS DIFFERENCE (MEV)

DM      30  145.3      0.5           FELDMAN   77 SMAG   D*+ TO DO PI+    12/77
DM       2  145.2      0.6           BLIETSCHA 79 BEBC   NEUTRINO P       12/79
DM        (145.5)  APPROX.           AVERY     80 SPEC   GAMMA A           1/82
DM      60  145.5      0.3           FITCH     81 SPEC   PI- A             1/82
DM      14  145.5      0.5           YELTON    82 SMK2   29 E+E-,K-PI+     8/83*
DM      16  145.8      1.5           AHLEN     83 HRS    D*+ TO DO PI+    12/83*
DM      12  145.1      1.8           BAILEY    83 SPEC   D*+- TO DO PI+-   9/83*
DM      28  145.5      0.3           BAILEY    83 SPEC   D*+- TO DO PI+-  12/83*
DM      14  145.1      0.5           BAILEY    83 SPEC   D*+- TO DO PI+-  12/83*
DM
DM  AVG     145.41     0.16    AVERAGE

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                62  (D*+) - (D*0) MASS DIFFERENCE (MEV)

EM  P        2.6       1.8           PERUZZI   77 SMAG +- E+E-          12/77
EM  P  NOT INDEPENDENT OF FELDMAN 77 MASS DIFFERENCE ABOVE, PERUZZI 77
EM  P  DO MASS, AND GOLDHABER 77 D*0 MASS.
EM
EM  DMASS    2.9       1.3   FROM (D*+)-(D0) AND (D*0)-(D0)
EM                            MASS DIFFERENCES

------ --------- --------- --------- --------- --------- --------- --------

                62  CHARGED D*(2010) WIDTH (MEV)

W       30  (2.0)  OR LESS  CL=.90   FELDMAN   77 SMAG   D*+ TO DO PI+    12/77
W           (2.2)  OR LESS           YELTON    82 SMK2   29 E+E-,K-PI+PI-  8/83*

------ --------- --------- --------- --------- --------- --------- --------

                62  CHARGED D*(2010) PARTIAL DECAY MODES

                                                        DECAY MASSES
P1      D*+(2010) INTO DO PI+                          1865+ 140
P2      D*+(2010) INTO D+ GAMMA                        1869+   0
P3      D*+(2010) INTO D+ PIO                          1869+ 135

P       D*-(2010) MODES ARE CHARGE CONJUGATES OF ABOVE MODES

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FITTED PARTIAL DECAY MODE BRANCHING FRACTIONS

The matrix below is derived from the error matrix for the fitted partial decay mode
branching fractions, P_i, as follows: The diagonal elements are P_i ± δP_i, where
δP_i = √(δP_i δP_j), while the off-diagonal elements are the normalized correlation coeffi-
cients (δP_i δP_j)/(δP_i · δP_j). For the definitions of the individual P_i, see the listings
above; only those P_i appearing in the matrix are assumed in the fit to be nonzero and
are thus constrained to add to 1.

        P 1       P 2       P 3
P 1 .4892+-.0832
P 2   -.7652   .1708+-.1087
P 3   -.0000   -.6438  .3400+-.0700

------ --------- --------- --------- --------- --------- --------- --------

                62  CHARGED D*(2010) BRANCHING RATIOS

R1      D*+(2010) INTO (DO PI+)/TOTAL                      (P1)
R1 G          0.6       0.15          GOLDHABE  77 SMAG +  E+E-          12/77
R1            0.44      0.10          COLES     82 SMK2   E+ E-          6/84*
R1 G    ASSUMING THAT ISOSPIN IS CONSERVED IN THE DECAY
R1
R1  AVG       0.489     0.083   AVERAGE
R1  FIT       0.489     0.083   FROM FIT

R2      D*+(2010) INTO (D+ GAMMA)/TOTAL                    (P2)
R2  C        (0.22)    (0.12)         COLES     82 SMK2   E+ E-          6/84*
R2  C  NOT INDEPENDENT OF R1 AND R3 MEASUREMENT.
R2
R2  FIT       0.17      0.11    FROM FIT

R3      D*+(2010) INTO (D+ PIO)/TOTAL                      (P3)
R3            0.34      0.07          COLES     82 SMK2   E+ E-          6/84*
R3
R3  FIT       0.340     0.070   FROM FIT

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                REFERENCES FOR CHARGED D*(2010)

PERUZZI  76 PRL 37 569       +PICCOLO,FELDMAN,NGUYEN,WISS,+   (SLAC+LBL)

FELDMAN  77 PRL 38 1313      +PERUZZI,PICCOLO,ABRAMS,ALAM+    (SLAC+LBL)
PERUZZI  77 PRL 39 1301      +PICCOLO,FELDMAN,PERL,+(SLAC,LBL,NWES+HAWA)
GOLDHABE 77 PL 69 B 503      +WISS,ABRAMS,ALAM,BOYARSKI,+     (LBL+SLAC)

BLIETSCH 79 PL 86 B 108      BLIETSCHAU,+      (AACH+BONN+CERN+MPIM+OXF)

AVERY    80 PRL 44 1309      +WISS,BINKLEY,ATIYA,+       (ILL+FNAL+COLU)

FITCH    81 PRL 46 761       +DEVAUX,CAVAGLIA,MAY,+ (PRIN+SACL+TORI+BNL)
TRILLING 81 PRPL 75 57       G.H.TRILLING                     (LBL+UCB)

BEBEK    82 PRL 49 610       +(HARV+OSU+ROCH+RUTG+SYRA+VAND+CORN+ITHACA)
COLES    82 PR D26 2190      +ABRAMS,BLOCKER,BLONDEL+         (LBL+SLAC)
YELTON   82 PRL 49 430       +FELDMAN,GOLDHABER,+    (SLAC+LBL+UCB+HARV)

AHLEN    83 PRL 51 1147      +AKERLOF+      (ANL+IND+LBL+MICH+PURD+SLAC)
ALTHOFF  83 PL 126 B 493     +FISCHER,BURKHARDT+   (TASSO COLLABORATION)
BAILEY   83 PL 132 B 230     +BARDSLEY+  (AMST+BRIS+CERN+CRAC+MPIM+RHEL)

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$D^{*0}(2010)$

```
61  NEUTRAL D*(2010,JP=1-) I=1/2
J CONSISTENT WITH 1, VALUE 0 RULED OUT (NGUYEN 77).

------ --------- --------- --------- --------- --------- --------- --------

                61  NEUTRAL D*(2010) MASS (MEV)

M   G     (2006.)     (1.5)         GOLDHABE  77 SMAG    E+E-          12/77
M   G   FROM SIMULTANEUS FIT TO D*+, D*0, D+, AND DO.
M
M   MASS   2007.2      2.1   FROM DO MASS (TRILLING 81 RVUE) AND
M                            MASS DIFFERENCE BELOW

------ --------- --------- --------- --------- --------- --------- --------

                61  (D*0) - (D0) MASS DIFFERENCE (MEV)

DM G        142.7      1.7           GOLDHABE  77 SMAG  0 E+E-          3/82
DM          142.2      2.0           SADROZIN  80 CBAL  0 D*0 TO DO PIO  3/82
DM G    FROM SIMULTANEOUS FIT TO D*+, D*0, D+, AND DO.
DM
DM  AVG     142.5      1.3     AVERAGE

------ --------- --------- --------- --------- --------- --------- --------

                61  NEUTRAL D*(2010) WIDTH (MEV)

W           (5.)   OR LESS           GOLDHAB2  76 SMAG    E+E- TO D*D*    3/77

------ --------- --------- --------- --------- --------- --------- --------

                61  NEUTRAL D*(2010) PARTIAL DECAY MODES

                                                        DECAY MASSES
P1      D*0(2010) INTO DO PIO                          1865+ 135
P2      D*0(2010) INTO DO GAMMA                        1865+   0

P       D*0(2010)BAR MODES ARE CHARGE CONJUGATES OF ABOVE MODES

------ --------- --------- --------- --------- --------- --------- --------

                61  NEUTRAL D*(2010) BRANCHING RATIOS

R1      D*0(2010) INTO (DO GAMMA)/(DO PIO + DO GAMMA)      (P2)/(P1+P2)
R1  G         0.45      0.15          GOLDHABE  77 SMAG    E+E-          12/77
R1            0.47      0.12          COLES     82 SMK2    E+ E-         6/84*
R1  G  WE QUOTE THE NORMAL FIT VALUE FROM TABLE 1. THE ISO-SPIN
R1  G  CONSTRAINED FIT IS NOW KNOWN TO GIVE A DO GAMMA FRACTION WHICH IS
R1  G  TOO LARGE. SEE DETAILS IN FOOTNOTE 21 OF FELDMAN 77 REVIEW.
R1
R1  AVG       0.462     0.094   AVERAGE
R1  FIT       0.462     0.094   FROM FIT

R2      D*0(2010) INTO (DO PIO)/TOTAL                      (P1)
R2  C        (0.53)    (0.12)         COLES     82 SMK2    E+ E-         6/84*
R2  C  NOT INDEPENDENT OF R1 MEASUREMENT.
R2
R2  FIT       0.538     0.094   FROM FIT

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                REFERENCES FOR NEUTRAL D*(2010)

GOLDHAB1 76 PRL 37 255       GOLDHABER,PIERRE,ABRAMS,ALAM,+   (LBL+SLAC)
GOLDHAB2 76 SLAC CONF. 379   G.GOLDHABER (AVAIL. AS LBL-5534) (LBL+SLAC)

GOLDHABE 77 PL 69 B 503      GOLDHABER,ABRAMS,ALAM,+          (LBL+SLAC)
    ALSO 77 BANFF SUM.INST 75 G.J.FELDMAN                         (SLAC)
NGUYEN   77 PRL 39 262       +WISS,ABRAMS,ALAM,BOYARSKI,+     (LBL+SLAC)

SADROZIN 80 MADISON CONF. 681 SADROZINSKI,+     (PRIN+CIT+HARV+SLAC+STAN)

TRILLING 81 PRPL 75 57       G.H.TRILLING                     (LBL+UCB)
COLES    82 PR D26 2190      +ABRAMS,BLOCKER,BLONDEL+         (LBL+SLAC)

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1984 "REVIEW OF PARTICLE PROPERTIES"

Enclosed you will find the various items you requested relating to the 1984 edition of the "Review of Particle Properties." Please note that the Review and the companion "Particle Properties Data Booklet" have undergone a major revision and reorganization this year. Those of you receiving the complete Review can read about this reorganization on page S4. Also, the Review now contains an index at the end, which we hope will be useful in finding desired information.

Several errata for this edition are given below and on the reverse.

Also enclosed are two new sheets to be added to the March 1983 edition of "Major Detectors in Elementary Particle Physics," LBL-91 Supplement, which most of you received. These pages are for the European Hybrid Spectrometer and PEP-9 2γ detectors.

Please note that the Pocket Diary for Physicists will not be sent out until the end of the summer.

As always, we would appreciate any comments or suggestions you may have regarding our reports.

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ERRATA FOR THE 1984 EDITION OF THE "REVIEW OF PARTICLE PROPERTIES" (AND FOR THE COMPANION "PARTICLE PROPERTIES DATA BOOKLET")

On page S22 (page 35 in the Data Booklet), in the $\Upsilon(10025)$ section of the Meson Table, the decay mode specified as $\Upsilon(9460)\pi\pi$ should be $\Upsilon(9460)\pi^+\pi^-$ instead. This correction also applies to the R3 branching ratio for $\Upsilon(10025)$ on page S191 of the Meson Data Card Listings.

On page S23 (page 38 in the Data Booklet), in the Meson Table, the branching fractions given for the D*(2010) are incorrect due to some omissions in the Data Card Listings (see over for these). The correct values (in per cent) are as follows:

$D^{*+}(2010) \to D^0\pi^+$	49 ± 8		$D^{*0}(2010) \to D^0\pi^0$	54 ± 9
$\to D^+\pi^0$	34 ± 7		$\to D^0\gamma$	46 ± 9
$\to D^+\gamma$	17 ± 11			

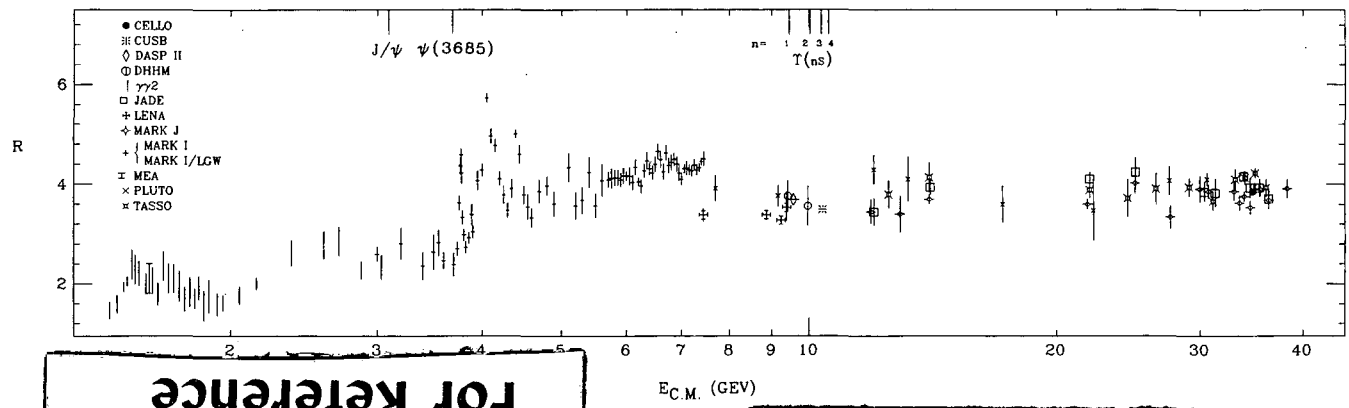
On page S31, in the Physical Constants Table, the first expression for the Bohr radius should read $\hbar^2/m_e e^2$. This error was fixed in the Data Booklet.

On page S43, in the section on Cabibbo and Kobayashi-Maskawa Mixing, the two references to Appendix II should be to Appendix III instead. This was also fixed in the Data Booklet.

On page S57 (page 125 in the Data Booklet), in the caption for the figure on Fractional Energy Loss for Electrons and Positrons in Lead, the Table of Atomic and Nuclear Properties of Materials should be indicated as preceding this figure, instead of following.

On page S59 (page 130 in the Data Booklet), in the section on Electromagnetic Relations, the $K_{5/3}(x)$ function referred to in the discussion of synchrotron radiation is a modified cylindrical (not spherical) Bessel function.

On page S64 (page 142 in the Data Booklet), in the figure for R, data points from the LENA experiment were inadvertently omitted. The corrected figure is given below. The reference for the LENA data is B. Niczyporuk et al., Zeit. fur Physik **C15**, 299 (1982).



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Review of particle properties

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This review of the properties of leptons, mesons, and baryons is an updating of the Review of Particle Properties, Particle Data Group [Phys. Lett. **111B** (1982)]. Data are evaluated, listed, averaged, and summarized in tables. Numerous tables, figures, and formulae of interest to particle physicists are also included. A data booklet is available.

†The Berkeley Particle Data Group is supported by the Director, Office of Energy Research, Office of High Energy and Nuclear Physics, Division of High Energy Physics of the U.S. Department of Energy under Contract No. DE-AC03-76SF00098, and by the U.S. National Science Foundation under Agreement No. PHY83-18358.

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I. OVERVIEW

This review is an updating through December 1983 of the Review of Particle Properties [Particle Data Group (1982)], a compilation of experimental results on the properties of particles studied in elementary particle physics. These properties include masses, widths or lifetimes, branching ratios, and other experimentally determined properties. Where feasible, we provide a suggested "best" value of each parameter based on our own judgment, using the best available data. A discussion of some of the procedures that we apply, and a brief review of the historical performance of averages of measurements, may be found below (Section V Part D).

The results of this compilation are presented in two sections, the "Tables of Particle Properties" and the "Data Card Listings." The Tables give our estimates of the properties of those states whose existence we consider well established. Our opinion of whether or not a particle's existence is well established can change as new data become available. We attempt to be conservative, so particles whose existence awaits confirmation are not included, even if they may be theoretically well understood. Reported states which have been omitted from the Tables are indicated there by a short arrow (→).

The Listings contain a complete record of our compiled data on all states whose existence is either well established or unconfirmed, but do not include reported states of historical interest only. All data used for the numerical estimates in the Tables are listed here, with references and our comments, if any. Those measurements considered recent enough or important enough to mention, but which for some reason were not used in the averaging, appear in parentheses.

The Listings also contain short reviews, which we call "mini-reviews," about subjects of particular interest or data which have particular problems. These are usually written by the same experts who have assisted with the data compilation itself.

In the past, we have attempted to use the Listings as an archive of all reported data on particles of interest. This is no longer possible because the growth of information would require a 5 to 10% per year expansion in this Review. Therefore we refer interested readers to previous editions [for example, Particle Data Group (1982)] for references to data considered obsolete.

We categorize the particles into types, intended to correspond roughly to the different types of data and problems encountered:

STABLE PARTICLES — All particles stable under the strong interaction. This includes the truly stable particles as well as those which decay weakly or electromagnetically, including the η, D(1865), F, Λ_c, W, Z^0, and so on.

MESONS — All meson resonances, including the ψ, χ, and Υ families.

BARYONS — All baryon resonances, including the resonant N and Δ families, dibaryon candidates, and so on.

This classification scheme is used to organize the Tables and the Listings.

We include a section of "Miscellaneous Tables, Figures, and Formulae." These are designed as a quick reference for the practicing elementary particle physicist. They normally presuppose some understanding of the subject matter, and do not attempt to serve as a textbook. We welcome all suggestions and comments regarding topics for inclusion or deletion, any errors or confusing passages, etc.

A pocket-sized Particle Properties Data Booklet is available. This contains the complete Tables of Particle Properties and the Miscellaneous Section, but not the Listings. For North and South America, Australia, and the Far East, write to Technical Information Department, Lawrence Berkeley Laboratory, Berkeley, CA 94720, USA. For all other areas, write to CERN Scientific Information Service, CH-1211 Geneva 23, Switzerland.

This year we are beginning a multiyear effort aimed at modernization and reorganization. The first fruits are visible immediately in the form of improved readability. We also include, for the first time, an Index at the back. The Miscellaneous Section has been almost completely reorganized. Some new material has been added, and some of the old material is now in different sections. A detailed description of the changes is given in Section III below.

II. AUTHORS AND CONSULTANTS

The primary responsibilities of the authors are as follows:

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(4) *General, including Introduction*: All authors.

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In addition, the Berkeley Particle Data Group has benefited from the advice of the PDG Advisory Committee, which meets annually to discuss matters of importance to the group, including the structure and content of this Review. The members of the 1983 committee are G. Feldman (SLAC) (chair), C.M. Lederer (University of California, Berkeley), J. Rosner (University of Chicago), R. Thun (University of Michigan), and L. Wolfenstein (Carnegie-Mellon University). In addition, G. Gidal (LBL) served in 1982.

The usefulness of this compilation depends in large part on the interaction between the users and the authors and

consultants. We appreciate comments, criticisms, and suggestions for improvements of all stages of data retrieval, evaluation, and presentation.

III. REORGANIZATION

This year we have reorganized the Introduction and Miscellaneous Sections, added an Index (at the back), changed the Appendices to reflect modern interest, and improved the readability of most of the Review. This is the first stage of our modernization of the Review of Particle Properties system. The input of our readership into this process is welcome and encouraged. Many of the planned future changes will be internal, e.g., in the data-handling programs, but we do plan some additional improvements in the appearance and layout of the Review.

The changes in the Introduction Section have been to move the portions with physics discussion to other places. The discussion on the quantum numbers of mesons is now found (condensed) in the new Nonrelativistic Quark Model discussion in the Miscellaneous Section. The discussion of partial-wave amplitudes is partly in the Kinematics, Decays, and Scattering portion of the Miscellaneous Section and partly in some of the baryon mini-reviews, along with the discussion of sign conventions for resonance couplings. The conventions and parameters for weak and electromagnetic decays are now in various mini-reviews in the Stable Particle Section, preceding the appropriate particles.

The changes to the Miscellaneous Section and the Appendices are as follows. Sections which have been substantially revised or which are new appear in italics.

Physical Constants:
General reorganization and updating. Most of the numerical constants have been removed to improve readability.

Clebsch-Gordan Coefficients, Spherical Harmonics, and d Functions:
No change.

SU(3) Isoscalar Factors:
No change.

SU(n) Multiplicities:
Removed; see new SU(n) Multiplets and Young Diagrams Section.

SU(n) Multiplets and Young Diagrams:
New.

Properties of Quarks:
Replaced by Nonrelativistic Quark Model Section.

Tests of Conservation Laws:
New.

Weak Interactions of Quarks and Leptons; Relativistic Kinematics; Lorentz Invariant Phase Space Formulae:
Incorporated into the following five new sections:

Kinematics, Decays, and Scattering
Standard Model of Electroweak Interactions
Cabibbo and Kobayashi-Maskawa Mixing
Quark Parton Model for Deep Inelastic Scattering
Nonrelativistic Quark Model

C.M. Energy and Momentum vs. Beam Momentum:
No change.

Probability and Statistics:
Minor revisions.

Particle Detectors, Absorbers, and Ranges:
Revised. Silicon detectors added. Mean Range in Pb, Cu, Al, C figure revised. Photon Mass Attenuation figures slightly revised. Atomic and Nuclear Properties of Materials revised.

Electromagnetic Relations:
Revised to include motion of charged particles in magnetic and electric fields, conversion of units.

Radioactivity and Radiation Protection:
Revised to include SI units, lethal dose, other changes.

Periodic Table:
No change.

Plots of Cross Sections and Related Quantities:
Revised. New νN figure. Structure Functions expanded. New e^+e^- figures. K_L^0 Regeneration figure deleted. π^+n ($=\pi^-p$) deleted.

Appendices:
Old Appendices [$\Delta I = 1/2$ Rule, SU(3) Classification of Baryon Resonances, Growth of Information] deleted. Portions of the Growth of Information Appendix moved to Introduction, Section V Part D.

Appendix I: *Status of the Standard Model of Electroweak Interactions*:
New.

Appendix II: *The Perturbative QCD Coupling Constant*:
New.

Appendix III: *Kobayashi-Maskawa Mixing Matrix*:
New.

IV. NOMENCLATURE

Our particle name conventions are summarized in Table I.

Stable particles tend to have a well-accepted colloquial name, e.g., e, τ, η, π, K, D, B, Λ, Σ, etc., and we use that name. If a *meson resonance* has such a well-accepted name, we use that. If not, or if there is conflict in the literature, we follow the naming conventions of Table I. For *baryon resonances*, the naming conventions of Table I are regularly followed in the literature. All of the resonances incorporate the mass value in the name, e.g., $\rho(770)$, $\omega(783)$, N(1440), $\Lambda(1520)$, $\Sigma(1385)$, etc. This allows one to distinguish, e.g., the charmed and bottomed mesons, D and B (stable under strong decay), from the meson resonances D(1285) and B(1235). It also distinguishes all of the N, Δ, Λ, etc., baryon resonances from one another.

The meson resonance naming convention of Table I incorporates some information as to the spin-parity J^P into the name. For a few such states believed to have identical quantum numbers, the colloquial names in the literature may incorporate primes into the name, e.g., $\rho(770)$, $\rho'(1600)$, f(1270), f′(1525), etc. However, we discourage this practice except for isosinglets within one SU(3) nonet. Thus $\eta'(958)$ and f′(1525) keep their primes, whereas $\rho'(1600)$ becomes $\rho(1600)$ in analogy with the radial excitations of the $\psi(3100)$ and the $\Upsilon(9460)$. We have taken the liberty of changing some colloquial meson names in accordance with Table I, having been urged for years to standardize the jungle of letters. The old names will still appear next to the new ones, to facilitate this conversion. We have restricted ourselves to relatively minor changes in this edition, but are considering more radical possibilities for the future. For example, it may be argued that, since the D(1285) and the

E(1420) have the same quantum numbers, they should get the same letter in spite of historical considerations. For a second example, there are several possible states whose interpretation is unclear [e.g., $\iota(1440)$, $\theta(1690)$, $\xi(2220)$, $g_S(1240)$, and $g_T(2240)$]. To the extent that some of these may be ordinary $q\bar{q}$ mesons, their exotic names should presumably be changed to more conventional ones. To the extent that some may not be ordinary mesons, it is less clear what naming convention, if any, should be adopted. We hope the reader will understand the rationale for the changes we have made and, in particular, not take any name change as an offense.

Table I. Particle name conventions. These names are used in the absence of a different generally accepted name in the literature.

Name	Isospin	G-Parity	Strangeness	Charm	Bottom
Mesons, $P=(-1)^J$ ("normal" J^P)					
ω, ϕ, ψ, $\Upsilon^\dagger$	0	−	0	0	0
ϵ, f	0	+	0	0	0
δ	1	−	0	0	0
ρ	1	+	0	0	0
K^*, κ	1/2		±1	0	0
D^*	1/2		0	±1	0
F^*	0		±1	±1	0
B^*	1/2		0	0	±1
Mesons, $P=(-1)^{J+1}$ ("abnormal" J^P)					
η, D	0	+	0	0	0
π, A	1	−	0	0	0
H	0	−	0	0	0
B	1	+	0	0	0
K, Q	1/2		±1	0	0
D	1/2		0	±1	0
F	0		±1	±1	0
B	1/2		0	0	±1
Baryons					
$N^\S$	1/2		0	0	0
$\Delta^\S$	3/2		0	0	0
Z_0, Z_1	0, 1		+1	0	0
$\Lambda^\S$	0		−1	0	0
$\Sigma^\S$	1		−1	0	0
Ξ	1/2		−2	0	0
Ω	0		−3	0	0
Λ_c	0		0	+1	0
Σ_c	1		0	+1	0
A	1/2		−1	+1	0
Λ_b	0		0	0	−1

† We use the symbol ω for $I^G = 0^-$ mesons which are mainly $u\bar{u}$ and $d\bar{d}$ quark states, ϕ for those which are mainly $s\bar{s}$ quark states, ψ for mainly $c\bar{c}$ states, and Υ for mainly $b\bar{b}$ states.

§ We occasionally use the symbol N^* to refer to the N and Δ resonances together, and Y^* to refer to the Λ and Σ resonances together.

For baryon resonances, the strangeness, charm, "bottomness," and isospin are incorporated into the name. The J^P is listed separately along with the spectroscopic notation for the partial-wave amplitude in which the particle is produced or decays. Our convention for spectroscopic notation is as follows:

$$L_{2I\cdot 2J}$$

for N, Δ, and Ξ resonances, and

$$L_{I\cdot 2J}$$

for Λ and Σ resonances. Here the orbital angular momentum L is represented by S, P, D, F, $\cdots$ as L = 0, 1, 2, 3, $\cdots$. For example, the $J^P = 7/2^-$ $\Lambda(2100)$ is G_{07} and the $J^P = 5/2^+$ $\Delta(1905)$ is F_{35}. Where more than one resonance with the same quantum numbers exists, we add a prime to the lowest mass state, two primes to the second lowest, etc. Thus, for example, the $J^P = 5/2^+$ states $\Lambda(1820)$ and $\Lambda(2100)$ are listed as F'_{05} and F''_{05}, respectively.

Some discussion about quantum numbers is found under the Nonrelativistic Quark Model in the Miscellaneous Section.

V. PROCEDURES

A. Selection and treatment of data

The Listings contain a complete record of all relevant data known to us from the journals listed in the Illustrative Key at the start of the Listings. As a general rule, we do not include results from preprints or conference reports. It is our experience that preprinted results may change before publication. In some cases, such results may be cited but not used in computing the estimates given in the Tables. There are a few exceptions to this exclusion, which we decide on a case-by-case basis after consultation with the experimenters.

As mentioned earlier, we no longer attempt to maintain an archival record of data of historical importance only. Thus, in this edition, results from many early papers on the baryon resonances have been omitted.

If data are included in the Listings but not used in the final average given in the Tables, they are set off by parentheses. We give explanatory comments in some such cases. If no comment is given, the reason the data were excluded is one or more of the following:

- No error was given.
- The data were contained in a preprint or conference report.
- The result involves some assumptions we do not wish to incorporate.
- The measurement has poor signal-to-noise ratio, low statistical significance, or is otherwise of much poorer quality than other data which are available.
- The measurement is clearly inconsistent with other results which appear to be highly reliable (see discussion in Section V Part D below).
- The measurement is not independent of other results, e.g., it is from one of several partial-wave analyses, all of which use the same data, rendering averaging meaningless.

In some cases, none of the measurements pass all these criteria and no statistically meaningful average is quoted. For example, the masses of many of the baryon resonances, obtained from partial-wave analyses, are quoted as a range thought to probably include the true value rather than as an average with error. This is discussed in more detail in some of the Listings mini-reviews in the Baryon Section.

Our treatment of upper limits is normally to quote in the Tables the strongest limit available from a single experiment. We do not average or combine upper limits except in a very few cases where they may be re-expressed as measured numbers with Gaussian errors.

Our treatment of quantum number assignments is to indicate in the Tables those which are either well established or probable. For the Meson Table, we underline those which we consider well established; the others are inferred from whatever experimental evidence is available. In the Stable Particles Section, nearly all quantum numbers are well established and we do not underline; those which are not well established are indicated by a footnote.

As is customary, we assume that antiparticles are the result of operating with CPT on particles, so both share the same spins, masses, and mean lives. There is a new entry in the Miscellaneous Section, Tests of Conservation Laws, which contains tests of CPT and other conservation laws.

B. Criteria for new states

An experimentalist who sees indications of a new state will of course want to know what has been seen in that region in the past. Hence, we include in the Listings all reported states which have not been, in our opinion, disproved by better (e.g., more reliable) data.

For the Tables we are much more conservative in our judgment. We include only those reported states which we feel have a large chance of survival. An arrow (→) at the left of the Tables of Particle Properties indicates that a questionable candidate has been omitted from the Table in that mass region, but that it can be found in the corresponding part of the Data Card Listings. One's betting odds for survival are of course subjective; therefore no precise criteria can be defined. For more detailed discussions, see the mini-reviews in the Listings. In what follows we shall attempt to specify some guidelines.

(a) When energy-independent partial-wave analyses are available (mostly for πN resonances), approximate Breit-Wigner behavior of the amplitude appears to us to be the most satisfactory test for a resonance. We can check that the Argand plot follows roughly a left-hand circle, and that the "speed" of the amplitude also shows a maximum near the resonance energy; further, there should be data well above the resonance, showing that the speed again decreases. Indeed proper behavior of the partial-wave amplitude could accredit a resonance even if its elasticity is too small to make a noticeable peak in the cross section.

Of course even if Argand plots are available, it may still be a matter of opinion as to what behavior constitutes a resonance. Such an example is the $Z_0(1780)$ state seen in KN total cross-section experiments and in partial-wave analyses. The partial-wave analyses of Giacomelli (1974) and Martin (1975) find preferred solutions which exhibit a resonance-like loop in the P_{01} wave near 1740 MeV. However, Giacomelli et al. and Martin point out that, despite the resonant-like *appearance* of the loop, the evidence for resonant *energy dependence* is inconclusive. Thus we omit the $Z_0(1780)$ from the Baryon Table. A similar quandary has existed for some time concerning the $Z_1(1900)$, and it too has been omitted from the Tables.

(b) When there are insufficient data to perform energy-independent analyses, one often resorts to energy-dependent partial-wave analyses. In this case Breit-Wigner behavior is an input. We therefore require that resonance solutions be found by several different analyses, preferably in different channels ($\bar{K}N \to \bar{K}N$, $\pi\Sigma$, etc.), before putting the claim in the Tables.

(c) Stable particles, most meson resonances, Ξ resonances, and high-mass N* and Y* resonances fall into a category for which no partial-wave analyses exist. In general, we accept such states if they are experimentally reliable, of high statistical significance, or observed in several different production processes.

(d) Partial-wave analyses of three-body final states ($\pi N \to \pi\pi N$) are also available. While these analyses are based on the isobar model ($\pi N \to \rho N$, $\pi\Delta$, etc.) and are subject to theoretical objections of varying importance, they provide increasingly reliable information on inelastic decay modes of otherwise-established resonances.

Thus, we enter into the Tables of Particle Properties only states for which there is experimentally convincing evidence, and we expect that nearly all of them will survive.

C. Statistical Procedures

We divide this discussion on obtaining averages and errors into two sections:

1. The unconstrained case, or "simple averaging;" and
2. The constrained case.

In what follows, the term "error" means one standard deviation (1σ); that is, for central value $\bar{x}$ and error $\delta\bar{x}$, the range $\bar{x} \pm \delta\bar{x}$ constitutes a 68.3% confidence interval.

1. Unconstrained averaging

We use a standard Gaussian procedure with a "scale factor" applied to the errors as our method of averaging the data. The Student's t-distribution, the basis of an earlier experiment of ours in data averaging, would give more conservative (and perhaps more realistic) errors at the two-standard-deviation (2σ) and higher level, but we do not choose to quote such errors. It is worth bearing in mind, however, that a 2σ error might more realistically be somewhat larger than twice a 1σ error, owing to the non-Gaussian character of some sets of real measurements. This is a persistent problem in data averaging arising from the existence of mildly discrepant measurements.

We begin by assuming that measurements of a given quantity obey a Gaussian distribution, and thus we calculate a weighted average and error

$$\bar{x} \pm \delta\bar{x} = \left(\sum_i w_i x_i / \sum_i w_i\right) \pm \left(\sum_i w_i\right)^{-1/2},$$

$$w_i = [1/(\delta x_i)^2], \tag{1}$$

where x_i and δx_i are the value and error, respectively, reported by the ith experiment, and the sums run over N experiments. We also calculate χ^2 and compare it with its expectation value of $N - 1$.

If $\chi^2/(N-1)$ is less than or equal to 1, and there are no known problems with the data, we accept the above results.

If $\chi^2/(N-1)$ is very large, or if there is prior knowledge of extremely large inconsistencies among experiments, we may choose not to average the data at all. Alternatively, we may quote the calculated average, but then give an educated guess as to the error; such a guess is generally a quite conservative estimate designed to take into account known problems with the data.

Finally, if $\chi^2/(N-1)$ is greater than 1, but not greatly so, we still average the data, but then also do the following:

(a) We plot an ideogram to display the pattern of the data. Sometimes only one or two data points lie apart from the main body; other times the data split into two or more roughly equal-sized groups. The reader may use this information in deciding upon an alternative average, but caution is urged, as "outlying" data points are sometimes the "correct" ones. An example of such an ideogram is given in Fig. 1 below. Each experiment appearing in the plot is represented by a Gaussian with central value x_i, error δx_i, and area proportional to $1/\delta x_i$. The choice of area is somewhat arbitrary; it assumes that an experimenter will work to reduce the systematic errors until they are slightly smaller (but seldom much smaller) than the statistical errors. Thus, as a physicist collects more events, he or she will use them both to reduce the statistical errors and to study the biases. Our confidence that a significant systematic error has not been made in a given experiment, as compared with other contradictory experiments, then tends to go up as $1/\delta x_i$.

But why not assign a weight $1/(\delta x_i)^2$, as is done when computing a weighted average? We feel that this assignment is equivalent to assuming that large systematic errors are as infrequent as large statistical fluctuations, and that this assumption is unrealistic.

We emphasize the difference between least-squares averaging (where the weighting factor is the inverse square of the error) and the ideograms prepared for visual display. The former arithmetic is of course best if one has unbiased data whose errors are well understood. In particular, the error analysis assumes that the true error on each datum is sampled from a Gaussian whose width is correctly reported. Then we obtain a narrow Gaussian distribution centered at the weighted mean for the answer. The ideogram (often multipeaked and certainly not Gaussian) is based on the opposite hypothesis that some of the input is systematically in error. The idea behind least-squares averaging is that experiments 1, 2, 3, etc., are *all* valid (so we should multiply their probabilities). Our *ideograms* are based on the assumption that 1 *or* 2 *or* 3, etc., is valid, "hedged" with $1/\delta x_i$ betting odds; we then add their probabilities. Both approaches cannot simultaneously be right; we allow the reader to choose. However, we quote the least-squares result in the Tables. This is the most precise value if the data satisfy the appropriate assumptions. A glance at the ideogram will show that the difference between the two approaches is usually not severe.

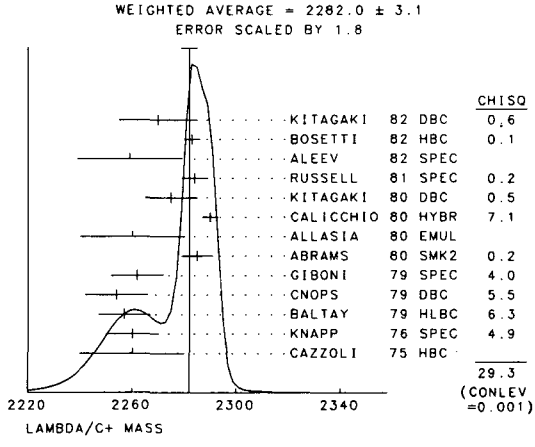

Fig. 1. Ideogram of measurements of the Λ_c^+ mass. The vertical line indicates the position of the weighted average, while the horizontal bar atop the line gives the error in the average after scaling by the SCALE factor. Only those experiments indicated by + error flags were precise enough to be accepted in the calculation of the SCALE factor; the column on the far right gives the χ^2 contribution of each of these experiments. The less precise experiments were included in the calculation of the weighted average, but not SCALE; they have ⊥ error flags.

(b) The second way in which we try to take account of $\chi^2/(N-1)$ being greater than 1 is to scale up our quoted error $\delta\bar{x}$ in Eq. (1) by a factor

$$\text{SCALE} = [\chi^2/(N-1)]^{1/2}. \tag{2}$$

Our reasoning is as follows. Since we do not know which of the experiments are wrong, we assume that all experimentalists underestimated their errors by the same scale factor (2). If we scale up all input errors by this factor, χ^2 becomes $N-1$, and of course the output error scales up by the same factor.

If we are to combine experiments with widely varying errors, we modify this procedure slightly. This is because it is the more precise experiments that most influence not only the average value $\bar{x}$, but also the error $\delta\bar{x}$. Now, on the average, the low-precision experiments each contribute about unity to both the numerator and the denominator of SCALE, hence the χ^2 contribution of the sensitive experiments is diluted, i.e., reduced. Therefore, we evaluate SCALE by using *only* experiments for which the errors are not much greater than those of the more precise experiments, i.e., only those experiments with errors less than δ_0, where the ceiling δ_0 is (arbitrarily) chosen to be

$$\delta_0 = 3N^{1/2}\delta\bar{x}.$$

Here $\delta\bar{x}$ is the unscaled error of the mean of all the experiments. Note that if each experiment had the same error δx_i, then $\delta\bar{x}$ would be $\delta x_i/N^{1/2}$, so each individual experiment would be well under the ceiling on SCALE.

This scaling approach has the property that if there are two values with comparable errors separated by much more than their stated errors (with or without a number of other experiments of lower accuracy), the error on the mean value $\delta\bar{x}$ is increased so that it is approximately half the interval between the two discrepant values.

We wish to emphasize the fact that our scaling procedures for *errors* in no way affect central values. In addition, if one wishes to recover the unscaled error $\delta\bar{x}$, one need only divide the given error by the SCALE factor for that error.

2. Constrained fits

Except for trivial cases, all branching ratios and rate measurements are analyzed by making a simultaneous

least-squares fit to all the data and extracting the partial decay fractions P_i, the width Γ, the partial widths Γ_i, and the associated error matrix.

Assume, for a simple example, that a state has only three partial decay fractions, P_1, P_2, and P_3 ($\sum P_i = 1$), which have been measured in four different ratios, $R_1, \cdots, R_4$, where, e.g., $R_1 = P_1/P_2$, $R_2 = P_1/P_3$, etc.‡ Further assume that *each* ratio r has been measured by N_r experiments (we designate each experiment with a subscript x, e.g., R_{1x}). We then find the best values of P_1, P_2, and P_3 by minimizing χ^2:

$$\chi^2 = \sum_{r=1}^{4} \left[\sum_{x=1}^{N_r} \left(\frac{R_{rx} - R_r(P_1,P_2,P_3)}{\delta R_{rx}} \right)^2 \right]. \quad (3)$$

In addition to the fitted values $\overline{P}_i$, we calculate an error matrix $\langle \delta\overline{P}_i \delta\overline{P}_j \rangle$. We tabulate the diagonal elements of $\delta\overline{P}_i = \langle \delta\overline{P}_i \delta\overline{P}_i \rangle^{1/2}$ (except that some errors are scaled as discussed below). In the Listings we give the complete error matrix; we also calculate the fitted value of each ratio, for comparison with the input data, and list it below the relevant input, along with a simple unconstrained average of the same input.

Two further comments on the example above:

(1) There was no connection between measurements of the width and the branching ratios. But often we also have information on partial widths Γ_i as well as total width Γ. In this case we must introduce Γ as a parameter into the fit, along with the relations $\Gamma_i = \Gamma P_i$, $\sum \Gamma_i = \Gamma$. When appropriate, we tabulate the Γ_i along with the P_i, and give error matrices in the Listings.

(2) We do *not* allow for correlations between input data. We *do* try to pick those ratios and widths which are as independent and as close to the original data as possible.

For *asymmetric* errors, we use a continuous function of $\delta(P)^+$ and $\delta(P)^-$ in the fitting. When no errors are reported, we merely list the data for inspection.

Inconsistent constrained data. According to Eq. (3), the double sum for χ^2 is first summed over experiments $x = 1$ to N_r, leaving a single sum over ratios

$$\chi^2 = \sum_r \chi_r^2 .$$

We test for SCALE factors after the fit. Knowing the fitted χ_r^2 and its expectation value $\langle \chi_r^2 \rangle$, we form SCALE factors (just as before), i.e.,

$$(\text{SCALE})_r^2 = \chi_r^2 / \langle \chi_r^2 \rangle ,$$

and if any $(\text{SCALE})_r$ is greater than 1, all N_r of the measurements of that particular ratio are equally penalized by having their errors increased by $(\text{SCALE})_r$. We then recycle the full fit, yielding new values $\delta\overline{P}_i'$ for the errors in the partial decay modes, as well as new central values $\overline{P}_i'$.

Because of the constraint ($\sum P_i = 1$), some of the new SCALE factors may still be greater than 1. If this is so, the whole procedure (i.e., increasing errors by the new SCALE factors and recycling through the fit) is repeated until the process converges.

At the end, we have final estimated errors $\delta\overline{P}_i'$ for the $\overline{P}_i'$. If SCALE factors have been used, they normally will have caused a shift in the central fitted values $\overline{P}_i'$, as well as having given larger errors $\delta\overline{P}_i'$. Often we find that the shift $|\overline{P}_i - \overline{P}_i'|$ due to the SCALE factors is the same size as (or greater than) the $\delta\overline{P}_i'$. We have decided to incorporate this shift into our errors as a reflection of the uncertainty due to the introduction of the SCALE factor; we tabulate an error

$$(\delta\overline{P}_i)_{\text{tab}} = [(\delta\overline{P}_i')^2 + (\overline{P}_i - \overline{P}_i')^2]^{1/2} ,$$

where $\overline{P}_i$ is the fitted value of the ith partial decay mode before scaling, $\overline{P}_i'$ is its value after all scaling, and $\delta\overline{P}_i'$ is the error in $\overline{P}_i'$. The SCALE factors we finally list in such cases are defined by

$$(\text{SCALE})_i = (\delta\overline{P}_i)_{\text{tab}} / \delta\overline{P}_i .$$

However, in line with our policy of not letting SCALE affect the central values, we quote the values of $\overline{P}_i$ obtained from the original (unscaled) fit [which are always less than or equal to one standard deviation from $\overline{P}_i'$, by construction of $(\delta\overline{P}_i)_{\text{tab}}$].

D. Discussion

The entire question of averaging data containing discrepant values is nicely discussed by Taylor (1982). He considers a number of algorithms which attempt to incorporate data which are not completely consistent into a meaningful average. Problems occur because it is very difficult to develop a procedure which handles simultaneously in a reasonable way two basic types of situations: (a) data which seem to lie apart from the main body of the data are incorrect (contain unreported errors); and (b) the opposite (the main body of the data is systematically wrong). Unfortunately, as Taylor shows, case (b) is not infrequent. His conclusion is that the choice of procedure is less significant than the initial choice of data to include or exclude.

We place a great emphasis on the choice of data to include or exclude. Unfortunately, the volume of data precludes spending as much time on the problem as we would like. We address this problem by soliciting the help of as many outside experts (consultants) as possible. In the final analysis, however, it is often impossible to determine which (if either) of two discrepant measurements is correct. Our SCALE factor technique is an attempt to address this ignorance by increasing the error above that suggested by least-squares analysis. In effect, we are saying that present experiments do not allow a precise determination of this constant because of unresolvable discrepancies, and one must await further measurements. The reader is warned of this situation by the size of the SCALE factor; he or she is then able to go back to the literature (via the Listings) and redo the average as desired.

Our situation with regard to discrepant data is easier to handle than most of the cases Taylor considers, such as estimates of the fundamental constants like $\hbar$, etc. Most of the errors in his case are dominated by systematic effects. In

‡ We can handle any R of the form $R = \sum \alpha_i P_i / \sum \beta_i P_i$, where α_i and β_i are constants, usually 1 or 0. The forms $R = P_i \cdot P_j$ and $R = (P_i \cdot P_j)^{1/2}$ are also allowed.

particle properties data, statistical effects are often at least as large as systematic effects, and statistical errors are usually easier to estimate. A notable exception occurs in partial-wave analyses, where different techniques applied to the same data yield different results. In this case, as stated earlier, we often do not attempt an average, but just quote a range of values.

A brief history of Particle Data Group averages is given in Rosenfeld (1975). Updated versions of some of Rosenfeld's figures are shown in Fig. 2. The least-squares error is shown by the thick portion of the error bars; the full error bar exhibits the SCALE factor extension.

Some cases of rather wild fluctuation are shown; this usually represents the introduction of significant new data or the discarding of some older data. Older data are sometimes discarded in favor of more modern data if it is felt that the newer data had fewer systematic errors, had more checks on their systematic errors, made some corrections unknown at the time of the older experiments, or some such reason. Near the time at which a large jump takes place, the SCALE factor sometimes becomes large, reflecting the uncertainty introduced by the new existence of partly inconsistent data.

By and large, a full scan of our history plots shows a rather dull progression toward greater precision at a central value completely consistent with the first data point shown. These plots are available on request from the Berkeley Particle Data Group.

We conclude that the reliability of the combination of experimental data and Particle Data Group averaging procedures is usually good, but it is important to realize that fluctuations outside of the quoted errors can and do occur, perhaps with more frequency than expected for truly Gaussian errors.

ACKNOWLEDGMENTS

The Particle Data Group wishes to acknowledge with appreciation the efforts made over many years by Robert Kelly. Kelly was in charge of the Baryon Section for a number of years and served a term as Berkeley group leader. His contributions will be missed, and we wish him well in his new endeavors.

We thank all those who have assisted in the many phases of preparing this Review. In particular, we acknowledge the usefulness of feedback from the physics community, especially those who have made suggestions or pointed out errors.

The European members of the Particle Data Group wish to acknowledge the generous support of CERN, in particular Division EP and Dr. A. Günther and his services.

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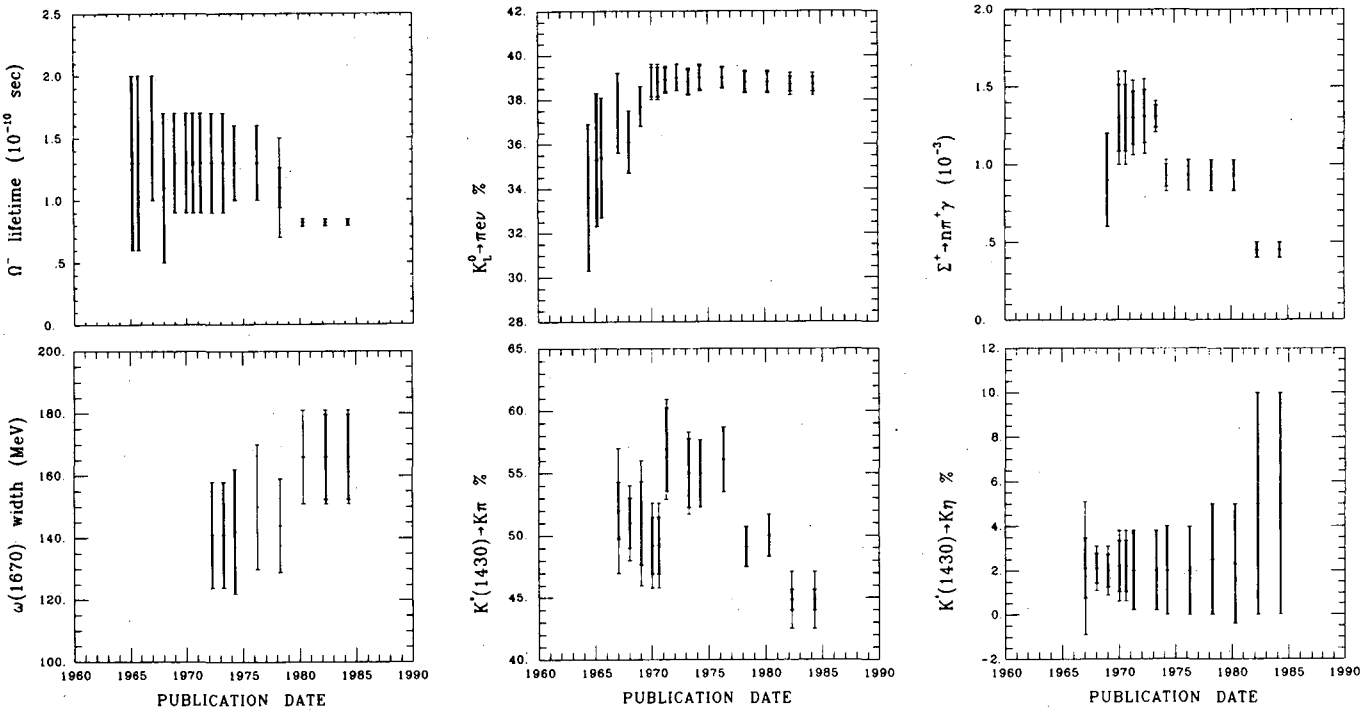

Fig. 2. Historical perspective of a few quantities tabulated in the Review of Particle Properties; abcissa specifies date of publication of the Review. Data measured by a variety of different techniques are included. The general reliability of the averages is good; very few are presently more than two standard deviations from their first tabulated values. Full error bar indicates quoted error; thick-lined portion indicates quoted error with "scale factor" removed (see Section V Part C above).

TABLES OF PARTICLE PROPERTIES

April 1984

M. Aguilar-Benitez, R.N. Cahn, R.L. Crawford, R. Frosch, G.P. Gopal, R.E. Hendrick, J.J. Hernandez, G. Höhler, M.J. Losty, L. Montanet, F.C. Porter, A. Rittenberg, M. Roos, L.D. Roper, T. Shimada, R.E. Shrock, N.A. Törnqvist, T.G. Trippe, W.P. Trower, Ch. Walck, C.G. Wohl, G.P. Yost, and B. Armstrong (Technical Associate)

(Closing date for data: Jan. 1, 1984)

Stable Particle Table

For additional parameters, see Addendum to this table.

Quantities in italics are new or have changed by more than one (old) standard deviation since April 1982.

Particle	$I^G(J^P)C$ [a]	Mass [b] (MeV)	Mean life [b] (sec) $c\tau$ (cm)	Partial decay mode: Mode	Fraction [b]	p or p_{max} [c] (MeV/c)
GAUGE BOSONS						
γ	$0,1(1^-)-$	$(<3\times10^{-33})$	——	stable		
W		*80800* ±*2700*	$\Gamma<7$ GeV	$e\nu$	(*seen*)	40400
Z		*92900* ±*1600*	$\Gamma<8.5$ GeV	e^+e^-	(*seen*)	46450
				$\mu^+\mu^-$	(*seen*)	46450
→ weak gauge boson searches						
LEPTONS						
ν_e	$J=\frac{1}{2}$	(<0.000046) [d]	stable ($>3\times10^8 m_{\nu_e}$ (MeV))	stable		
e	$J=\frac{1}{2}$	0.5110034 ±0.0000014	stable ($>2\times10^{22}$y)	stable		
ν_μ	$J=\frac{1}{2}$	$0(<0.50)$	stable ($>1.1\times10^5 m_{\nu_\mu}$ (MeV))	stable		
				μ^- → (or μ^+ → chg. conj.)		
μ	$J=\frac{1}{2}$	105.65932 ±0.00029	2.19709×10^{-6} ±0.00005 $c\tau=6.5867\times10^4$	$e^-\bar{\nu}\nu$	(100)%	53
				†[$e^-\bar{\nu}\nu\gamma$	[e] (1.4 ± 0.4)%	53
				$e^-\nu_e\bar{\nu}_\mu$	(<5)%]	53
				$e^-\bar{\nu}\nu e^+e^-$	[e] (2.2 ± 1.5)$\times10^{-5}$	53
				$e^-\gamma$	(<1.7)$\times10^{-10}$	53
				$e^-e^+e^-$	(<1.9)$\times10^{-9}$	53
				$e^-\gamma\gamma$	(<8.4)$\times10^{-9}$	53
ν_τ	$J=\frac{1}{2}$	<164				
				τ^- → (or τ^+ → chg. conj.)		
τ	$J=\frac{1}{2}$	1784.2 ±3.2	$(3.4\pm0.5)\times10^{-13}$ $c\tau=0.010$	$\mu^-\bar{\nu}\nu$	(18.5 ± 1.1)%	889
				$e^-\bar{\nu}\nu$	(16.5 ± 0.9)%	892
				hadron$^-$ neutrals	(*48.1* ± *2.0*)% S=1.1*	
				3(hadron$^\pm$) neutrals	(*17.0* ± *1.3*)% S=1.2*	
				5(hadron$^\pm$) neutrals	(<1.4)%	
				†[3(hadron$^\pm$)ν	(5 ± 4)%	
				3(hadron$^\pm$)$\nu(\geq1\gamma)$	(12 ± 4)%]	
				†[$\pi^-\nu$	(10.3 ± 1.2)%	887
				$\rho^-\nu$	(22.1 ± 2.4)%	726
				$K^-\nu$	(*1.3* ± *0.5*)%	824
				K^- neutrals	(*small*)%]	

(continued next page)

Stable Particle Table *(cont'd)*

Particle	$I^G(J^P)C$ [a]	Mass [b] (MeV)	Mean life [b] (sec) $c\tau$ (cm)	Partial decay mode: Mode	Fraction [b]		p or p_{max} [c] (MeV/c)
				$\tau^- \rightarrow$ (or $\tau^+ \rightarrow$chg. conj.)			
τ (continued)				†[$K^{*-}(892)\nu$	(1.7 ± 0.7)%		669
				$K^{*-}(1430)\nu$	(<0.9)%		323
				$\pi^-\rho^0\nu$	(5.4 ± 1.7)%]		718
				e^- chgd.parts. + μ^- chgd.parts.	(<4)%		
				$\mu^-\gamma$	(<5.5)$\times10^{-4}$		889
				$e^-\gamma$	(<6.4)$\times10^{-4}$		892
				$\mu^-\mu^+\mu^-$	(<4.9)$\times10^{-4}$		876
				$e^-\mu^+\mu^-$	(<3.3)$\times10^{-4}$		886
				$\mu^-e^+e^-$	(<4.4)$\times10^{-4}$		889
				$e^-e^+e^-$	(<4.0)$\times10^{-4}$		892
				$\mu^-\pi^0$	(<8.2)$\times10^{-4}$		884
				$e^-\pi^0$	(<2.1)$\times10^{-3}$		887
				μ^-K^0	(<1.0)$\times10^{-3}$		819
				e^-K^0	(<1.3)$\times10^{-3}$		823
				$\mu^-\rho^0$	(<4.4)$\times10^{-4}$		722
				$e^-\rho^0$	(<3.7)$\times10^{-4}$		726

→ searches for massive neutrinos and lepton mixing
→ ν bounds from astrophysics and cosmology
→ heavy lepton searches

NONSTRANGE MESONS [a]

Particle	$I^G(J^P)C$ [a]	Mass [b] (MeV)	Mean life [b] (sec) $c\tau$ (cm)	Partial decay mode: Mode	Fraction [b]		p or p_{max} [c] (MeV/c)
				$\pi^+ \rightarrow$ (or $\pi^- \rightarrow$chg. conj.)			
$\pi^\pm$	$1^-(0^-)$	139.5673 ±0.0007	2.6030×10^{-8} ±0.0023	$\mu^+\nu$	100%		30
			$c\tau$=780.4	$e^+\nu$	(*1.232±0.024*)$\times10^{-4}$	S=2.0*	70
				†[$\mu^+\nu\gamma$	[e] (1.24± 0.25)$\times10^{-4}$		30
	$m_{\pi^\pm}-m_{\mu^\pm}$ =33.9080 ±0.0008			$e^+\nu\gamma$	[e] (5.6 ± 0.7)$\times10^{-8}$]		70
				$e^+\nu\pi^0$	(1.033±0.034)$\times10^{-8}$		5
				$e^+\nu e^+e^-$	(<5)$\times10^{-9}$		70
				$\mu^+\bar{\nu}_e$	(*<1.5*)$\times10^{-3}$		30
				$\mu^+\nu_e$	(*<8*)$\times10^{-3}$		30
π^0	$1^-(0^-)+$	134.9630 ±0.0038	0.83×10^{-16} ±0.06 S=1.8*	$\gamma\gamma$	(98.802±0.030)%		67
			$c\tau=2.5\times10^{-6}$	γe^+e^-	(1.198)%		67
				$\gamma\gamma\gamma$	(<3.8)$\times10^{-7}$		67
	$m_{\pi^\pm}-m_{\pi^0}$ =4.6043 ±0.0037			$e^+e^-e^+e^-$	[f] (3.24)$\times10^{-5}$		67
				$\gamma\gamma\gamma\gamma$	(<4)$\times10^{-6}$		67
				e^+e^-	(1.8 ± 0.7)$\times10^{-7}$		67
				$\nu\nu$	(<2.4)$\times10^{-5}$		67
				$\mu^+e^-+\mu^-e^+$	(<7)$\times10^{-8}$		26
η	$0^+(0^-)+$	548.8 ±0.6 S=1.4*	Γ=(0.88±0.12)keV	$\gamma\gamma$	(39.0 ± 0.8)%		274
			Neutral decays (70.9±0.7)%	$3\pi^0$	(31.8 ± 0.8)%	S=1.1*	180
				$\pi^0\gamma\gamma$	(0.10 ± 0.02)%		258
				$\pi^+\pi^-\pi^0$	(23.7 ± 0.5)%		175
				$\pi^+\pi^-\gamma$	(4.91± 0.13)%		236
				$e^+e^-\gamma$	(0.50± 0.12)%		274
				$\mu^+\mu^-\gamma$	(3.1 ± 0.4)$\times10^{-4}$		253
				e^+e^-	(<3)$\times10^{-4}$		274
				$\mu^+\mu^-$	(6.5 ± 2.1)$\times10^{-6}$		253
			Charged decays (29.1±0.7)%	$\pi^+\pi^-e^+e^-$	(0.13± 0.13)%		236
				$\pi^+\pi^-\gamma\gamma$	(<0.21)%		236
				$\pi^+\pi^-\pi^0\gamma$	(<6)$\times10^{-4}$		175
				$\pi^+\pi^-$	(<0.15)%		236
				$\pi^0e^+e^-$	(<5)$\times10^{-5}$		258
				$\pi^0\mu^+\mu^-$	(<5)$\times10^{-6}$		211
				$\pi^0\mu^+\mu^-\gamma$	(<3)$\times10^{-6}$		211

Stable Particle Table *(cont'd)*

Particle	$I^G(J^P)$ [a]	Mass [b] (MeV)	Mean life [b] (sec) $c\tau$ (cm)	Partial decay mode: Mode	Fraction [b]	p or p_{max} [c] (MeV/c)
			STRANGE MESONS [a]			
				K^+ (or K^- → chg. conj.)		
$K^\pm$	$\frac{1}{2}(0^-)$	493.667 ±0.015	1.2371×10^{-8} ±0.0026 S=1.9* $c\tau$=370.9	$\mu^+\nu$	(63.51 ± 0.16)%	236
				$\pi^+\pi^0$	(21.17 ± 0.15)%	205
				$\pi^+\pi^+\pi^-$	(5.59 ± 0.03)% S=1.1*	125
				$\pi^+\pi^0\pi^0$	(1.73 ± 0.05)% S=1.4*	133
				$\pi^0\mu^+\nu$	(3.18 ± 0.10)% S=1.9*	215
		$m_{K^\pm}-m_{K^0}$ = −4.01 ±0.13 S=1.1*		$\pi^0e^+\nu$	(4.82 ± 0.05)% S=1.1*	228
				†[$\mu^+\nu\gamma$	[e] (5.8 ± 3.5)$\times10^{-3}$	236
				$\pi^+\pi^0\gamma$	[g] (2.75 ± 0.16)$\times10^{-4}$	205
				$\pi^+\pi^+\pi^-\gamma$	[e] (1.0 ± 0.4)$\times10^{-4}$	125
				$\pi^0\mu^+\nu\gamma$	[e] (<6)$\times10^{-5}$	215
				$\pi^0e^+\nu\gamma$	[e] (3.7 ± 1.4)$\times10^{-4}$]	228
				$\pi^0\pi^0e^+\nu$	($1.8^{+2.4}_{-0.6}$)$\times10^{-5}$	207
				$\pi^+\pi^-e^+\nu$	(3.90 ± 0.15)$\times10^{-5}$	203
				$\pi^+\pi^+e^-\bar{\nu}$	(<1.2)$\times10^{-8}$	203
				$\pi^+\pi^-\mu^+\nu$	(1.4 ± 0.9)$\times10^{-5}$	151
				$\pi^+\pi^+\mu^-\bar{\nu}$	(<3.0)$\times10^{-6}$	151
				$e^+\nu$	(1.54 ± 0.07)$\times10^{-5}$	247
				$e^+\nu\gamma$ (SD+) [h]	(1.52 ± 0.23)$\times10^{-5}$	247
				$e^+\nu\gamma$ (SD−) [h]	(<1.6)$\times10^{-4}$	247
				$\pi^+e^+e^-$	(2.7 ± 0.5)$\times10^{-7}$	227
				$\pi^-e^+e^+$	(<1)$\times10^{-8}$	227
				$\pi^+\mu^+\mu^-$	(<2.4)$\times10^{-6}$	172
				$\pi^+\gamma\gamma$	[e] (<8)$\times10^{-6}$	227
				$\pi^+\gamma\gamma\gamma$	[e] (<1.0)$\times10^{-4}$	227
				$\pi^+\nu\bar{\nu}$	(<1.4)$\times10^{-7}$	227
				$\pi^\mp e^+\mu^\pm$	(<7)$\times10^{-9}$	214
				$\pi^+e^-\mu^+$	(<5)$\times10^{-9}$	214
				$e^+\nu\nu\bar{\nu}$	(<6)$\times10^{-5}$	247
				$\mu^+\nu\nu\bar{\nu}$	(<6)$\times10^{-6}$	236
				$\mu^+\nu e^+e^-$	(11 ± 3)$\times10^{-7}$	236
				$\mu^-\nu e^+e^+$	(<2.0)$\times10^{-8}$	236
				$e^+\nu e^+e^-$	(2^{+2}_{-1})$\times10^{-7}$	247
				$\mu^+\nu_e$	(<4)$\times10^{-3}$	236
				$\mu^+\bar{\nu}_e$	(<3.3)$\times10^{-3}$	236
				$\pi^0e^+\bar{\nu}_e$	(<3)$\times10^{-3}$	228
K^0 / $\bar{K}^0$	$\frac{1}{2}(0^-)$	497.67 ±0.13 S=1.1*		50 % K_{Short}, 50% K_{Long}		
K^0_S	$\frac{1}{2}(0^-)$		0.8923×10^{-10} ±0.0022 $c\tau$=2.675	$\pi^+\pi^-$	(68.61 ± 0.24)%	206
				$\pi^0\pi^0$	(31.39)% S=1.1*	209
				†[$\pi^+\pi^-\gamma$	[e] (1.85 ± 0.10)$\times10^{-3}$]	206
				$\mu^+\mu^-$	(<3.2)$\times10^{-7}$	225
				e^+e^-	(<3.4)$\times10^{-4}$	249
				$\gamma\gamma$	(<4)$\times10^{-4}$	249
				$\pi^+\pi^-\pi^0$	(<8.5)$\times10^{-5}$	133
				$\pi^0\pi^0\pi^0$	(<3.7)$\times10^{-5}$	139
K^0_L	$\frac{1}{2}(0^-)$		5.183×10^{-8} ±0.040 $c\tau$=1554	$\pi^0\pi^0\pi^0$	(21.5 ± 1.0)% S=1.7*	139
				$\pi^+\pi^-\pi^0$	(12.39 ± 0.20)% S=1.3*	133
				$\pi^\pm\mu^\mp\nu$	(27.1 ± 0.4)% S=1.4*	216
				$\pi^\pm e^\mp\nu$	(38.7 ± 0.5)% S=1.5*	229
		$m_{K_L}-m_{K_S}$ = $0.5349\times10^{10}\ \hbar\ \mathrm{sec}^{-1}$ ±0.0022 = 3.521×10^{-12} MeV ±0.014		$\pi^+\pi^-$	[i] (0.203 ± 0.005)% S=1.1*	206
				$\pi^0\pi^0$	[i] (0.094 ± 0.018)% S=1.5*	209
				†[$\pi e\nu\gamma$	[e] (1.3 ± 0.8)%	229
				$\pi^+\pi^-\gamma$	[e] (4.41 ± 0.32)$\times10^{-5}$]	206
				$\pi^0\gamma\gamma$	(<2.4)$\times10^{-4}$	231
				$\gamma\gamma$	(4.9 ± 0.4)$\times10^{-4}$	249
				$e\mu$	[j] (<6)$\times10^{-6}$	238
				$\mu^+\mu^-$	(9.1 ± 1.9)$\times10^{-9}$	225
				$\mu^+\mu^-\gamma$	(2.8 ± 2.8)$\times10^{-7}$	225
				$\pi^0\mu^+\mu^-$	(<1.2)$\times10^{-6}$	177

(continued next page)

Stable Particle Table *(cont'd)*

Particle	$I^G(J^P)$ [a]	Mass [b] (MeV)	Mean life [b] (sec) $c\tau$ (cm)	Partial decay mode: Mode	Fraction [b]		p or p_{max} [c] (MeV/c)
K^0_L (continued)				e^+e^-	[j] (<2.0)$\times10^{-7}$		249
				$e^+e^-\gamma$	(1.7 ± 0.9)$\times10^{-5}$		249
				$\pi^0e^+e^-$	(<2.3)$\times10^{-6}$		231
				$\pi^+\pi^-e^+e^-$	(<9)$\times10^{-6}$		206
				$\pi^0\pi^\pm e^\mp\nu$	(6.2 ± 2.0)$\times10^{-5}$		207
				($\pi\mu$ atom) ν	(*1.05* ± *0.11*)$\times10^{-7}$		
CHARMED NONSTRANGE MESONS [a]							
$D^\pm$	$\frac{1}{2}(0^-)$	1869.4 ±0.6	$(9.2^{+1.7}_{-1.2})\times10^{-13}$ $c\tau$=0.028	D^+ → (or D^- → chg. conj.)			
				e^+ anything	(19 $^{+4}_{-3}$)%		
				K^- anything	(16 ± 4)%		
				$\bar{K}^0$ any + K^0 any	(48 ± 15)%		
				K^+ anything	(6.0 ± 3.3)%		
		$m_{D^\pm}-m_{D^0}$= 4.7 ±0.3		η anything	[k] (< 13)%		
				$\mu^+\nu$	(*<2*)%		932
				†[$K^-\pi^+\pi^+$	(4.6 ± 1.1)%	S=1.3*	845
				$K^-\pi^+\pi^+\pi^0$	(*2.6* $^{+3.1}_{-1.0}$)%		816
				$K^-\pi^+\pi^+\pi^+\pi^-$	(<4)%		772
				$\bar{K}^0\pi^+$	(1.8 ± 0.5)%		862
				$\bar{K}^0\pi^+\pi^0$	(13 ± 8)%		845
				$\bar{K}^0\pi^+\pi^+\pi^-$	(8.4 ± 3.5)%		814
				$\bar{K}^0K^+$	(0.45 ± 0.30)%		792
				$K^+K^-\pi^+$	(<0.6)%		744
				$K^+\pi^+\pi^-$	(<0.23)%		845
				$\pi^+\pi^0$	(<0.5)%		925
				$\pi^+\pi^+\pi^-$	(<0.4)%]		908
				†[$\bar{K}^{*0}\pi^+$	(<3.7)%]		714
D^0 / $\bar{D}^0$	$\frac{1}{2}(0^-)$	1864.7 ±0.6	$(4.4\ ^{+0.8}_{-0.6})\times10^{-13}$ $c\tau$=0.013	D^0 → (or $\bar{D}^0$ → chg. conj.)			
				e^+ anything	(5.3 $^{+2.9}_{-1.3}$)%		
				K^- anything	(44 ± 10)%	S=1.3*	
				$\bar{K}^0$ any+ K^0 any	(33 ± 10)%		
		$\lvert m_{D^0_1}-m_{D^0_2}\rvert$ < 6.5×10^{-10} MeV [ℓ]		K^+ anything	(8 ± 3)%		
				η anything	[k] (< 13)%		
				†[$K^-\pi^+$	(2.4 ± 0.4)%		861
				$K^-\pi^+\pi^0$	(9.3 ± 2.8)%		844
		$\frac{\lvert\tau_{D^0_1}-\tau_{D^0_2}\rvert}{\text{average}}$ < *0.55* [ℓ]		$K^-\pi^+\pi^+\pi^-$	(4.6 ± 1.4)%	S=1.2*	812
				$K^-\pi^+\pi^0\pi^0$	(seen)		815
				$\bar{K}^0\pi^0$	(2.2 ± 1.1)%		860
				$\bar{K}^0\pi^+\pi^-$	(4.2 ± 0.8)%		842
		$\frac{\Gamma(D^0\to\bar{D}^0\to K^+\pi^-)}{\Gamma(D^0\to K\pi)}$ < 0.16		$\pi^+\pi^-$	(7.9 ± 3.8)$\times10^{-4}$		922
				$\pi^+\pi^+\pi^-\pi^-$	(<1.0)%		880
				K^+K^-	(2.7 ± 0.8)$\times10^{-3}$]		791
				†[$K^{*-}\pi^+$	(3.4 ± 1.4)%		711
		$\frac{\Gamma(D^0\to\bar{D}^0\to\mu^-\text{ anything})}{\Gamma(D^0\to\mu^\pm\text{ anything})}$ < *0.044*		$\bar{K}^{*0}\pi^0$	(1.4 $^{+2.3}_{-1.4}$)%		711
				$K^-\rho^+$	(7.2 $^{+3.0}_{-3.1}$)%		679
				$\bar{K}^0\rho^0$	(0.1 $^{+0.6}_{-0.1}$)%		677
				$\bar{K}^{*0}\rho^0$	(0.7 $^{+0.8}_{-0.7}$)%		423
				$K^-\pi^+\rho^0$	(3.9 $^{+1.3}_{-1.6}$)%		613
				$\bar{K}^{*0}\pi^+\pi^-$	(<2.3)%		685
				$K^-A_2^+$	(<0.8)%]		198
CHARMED STRANGE MESON [a]							
$F^\pm$	$0(0^-)$ [m]	1971 [m] ±6	$(1.9^{+1.3}_{-0.7})\times10^{-13}$ $c\tau$=0.006	F^+ → (or F^- → chg. conj.)			
				$\phi\pi^+$	(*seen*)		713
				$\eta\pi^+$	(*possibly seen*)		903
				$\eta\pi^+\pi^+\pi^-$	(*possibly seen*)		857
				$\eta'\pi^+\pi^+\pi^-$	(*possibly seen*)		679
				$\phi\rho^+$	(*possibly seen*)		411

Stable Particle Table *(cont'd)*

Particle	$I^G(J^P)$ [a]	Mass [b] (MeV)	Mean life [b] (sec) $c\tau$ (cm)	Partial decay mode: Mode	Fraction [b]	p or p_{max} [c] (MeV/c)
BOTTOM MESONS [a]						
				B^+ → (or B^- → chg. conj.)		
$B^\pm$	$\frac{1}{2}(0^-)$ [n]	5270.8 ±3.0		$\bar{D}^0\pi^+$	(4.2 ± 4.2)%	2303
				$D^{*-}\pi^+\pi^+$	(4.8 ± 3.0)%	2243
				B^0 → (or $\bar{B}^0$ → chg. conj.)		
B^0, $\bar{B}^0$	$\frac{1}{2}(0^-)$ [n]	5274.2 ±2.8		$\bar{D}^0\pi^+\pi^-$	(13 ± 9)%	2298
				$D^{*-}\pi^+$	(2.6 ± 1.9)%	2253
$B^\pm$, B^0, $\bar{B}^0$ (not separated) [p]			$(14\pm4)\times10^{-13}$ $c\tau$=0.042	$e^\pm\nu$ hadrons	(13.0 ± 1.3)%	
				$\mu^\pm\nu$ hadrons	(12.4 ± 3.5)%	
				D^0 anything	(80 ± 28)%	
				K anything	(seen)	
				p anything	(>3.6)%	
				Λ anything	(>2.2)%	
				e^+e^- anything	(<0.8)%	
				$\mu^+\mu^-$ anything	(<0.7)%	
NONSTRANGE BARYONS [a]						
p	$\frac{1}{2}(\frac{1}{2}^+)$	938.2796 ±0.0027	stable ($>10^{32}$y) [q]	stable		
				$\lvert q_p\rvert-\lvert q_e\rvert < 10^{-21}\lvert q_e\rvert$ [r]		
n	$\frac{1}{2}(\frac{1}{2}^+)$	939.5731 ±0.0027	898±16 $c\tau=2.7\times10^{13}$	$pe^-\bar{\nu}$	100%	1.2
				$p\nu\bar{\nu}$ (chg.noncons.)	(<9)$\times10^{-24}$	1.3
	$m_p-m_n=-1.293323$ ±0.000016			$\lvert q_n\rvert < 10^{-21}\lvert q_e\rvert$ [r]		
STRANGENESS −1 BARYONS [a]						
Λ	$0(\frac{1}{2}^+)$	1115.60 ±0.05 S=1.2*	2.632×10^{-10} ±0.020 S=1.6* $c\tau$ =7.89	$p\pi^-$	(64.2 ± 0.5)%	100
				$n\pi^0$	(35.8 ± 0.5)%	104
				$pe^-\nu$	(8.37± 0.14)$\times10^{-4}$	163
				$p\mu^-\nu$	(1.57± 0.35)$\times10^{-4}$	131
	$m_\Lambda-m_{\Sigma^0}=-76.86$ ±0.08			†[$p\pi^-\gamma$	[e](8.5 ± 1.4)$\times10^{-4}$]	100
Σ^+	$1(\frac{1}{2}^+)$	1189.36 ±0.06 S=1.8*	0.800×10^{-10} ±0.004 $c\tau$=2.40	$p\pi^0$	(51.64 ± 0.30)%	189
				$n\pi^+$	(48.36 ± 0.30)%	185
				$p\gamma$	(1.20± 0.13)$\times10^{-3}$ S=1.2*	225
				†[$n\pi^+\gamma$	[e](4.5 ± 0.5)$\times10^{-4}$]	185
				$\Lambda e^+\nu$	(2.0 ± 0.5)$\times10^{-5}$	71
	$m_{\Sigma^+}-m_{\Sigma^-}=-7.97$ ±0.07 S=1.3*		$\frac{\Gamma(\Sigma^+\to\ell^+n\nu)}{\Gamma(\Sigma^-\to\ell^-n\nu)}<.04$	$n\mu^+\nu$	(<3.0)$\times10^{-5}$	202
				$ne^+\nu$	(<5)$\times10^{-6}$	224
				pe^+e^-	(<7)$\times10^{-6}$	225
Σ^0	$1(\frac{1}{2}^+)$ [s]	1192.46 ±0.08	5.8×10^{-20} ±1.3 $c\tau=1.7\times10^{-9}$	$\Lambda\gamma$	100%	74
				Λe^+e^-	[f](5.45)$\times10^{-3}$	74
				$\Lambda\gamma\gamma$	(<3)%	74
Σ^-	$1(\frac{1}{2}^+)$	1197.34 ±0.05	1.482×10^{-10} ±0.011 S=1.3* $c\tau$=4.44	$n\pi^-$	100%	193
				$ne^-\nu$	(*1.022±0.034*)$\times10^{-3}$	230
				$n\mu^-\nu$	(4.5 ± 0.4)$\times10^{-4}$	210
				$\Lambda e^-\nu$	(5.74± 0.27)$\times10^{-5}$	79
	$m_{\Sigma^0}-m_{\Sigma^-}=-4.88$ ±0.06			†[$n\pi^-\gamma$	[e](4.6 ± 0.6)$\times10^{-4}$]	193

Stable Particle Table *(cont'd)*

Particle	$I^G(J^P)$ [a]	Mass [b] (MeV)	Mean life [b] (sec) $c\tau$ (cm)	Partial decay mode: Mode	Fraction [b]	p or p_{max} [c] (MeV/c)
				STRANGENESS −2 BARYONS [a]		
Ξ^0	$\frac{1}{2}(\frac{1}{2}^+)$ [s]	1314.9 ±0.6	2.90×10^{-10} ±0.10 $c\tau$=8.69	$\Lambda\pi^0$	100%	135
				$\Lambda\gamma$	(0.5 ± 0.5)%	184
				$\Sigma^0\gamma$	(<7)%	117
				$p\pi^-$	(<3.6)$\times10^{-5}$	299
				$pe^-\nu$	(<1.3)$\times10^{-3}$	323
	$m_{\Xi^0}-m_{\Xi^-}$=−6.4 ±0.6			$\Sigma^+e^-\nu$	(<1.1)$\times10^{-3}$	120
				$\Sigma^-e^+\nu$	(<0.9)$\times10^{-3}$	112
				$\Sigma^+\mu^-\nu$	(<1.1)$\times10^{-3}$	65
				$\Sigma^-\mu^+\nu$	(<0.9)$\times10^{-3}$	49
				$p\mu^-\nu$	(<1.3)$\times10^{-3}$	309
Ξ^-	$\frac{1}{2}(\frac{1}{2}^+)$ [s]	1321.32 ±0.13	1.641×10^{-10} ±0.016 $c\tau$=4.92	$\Lambda\pi^-$	100%	139
				$\Lambda e^-\nu$	(5.5 ± 0.6)$\times10^{-4}$ S=2.0*	190
				$\Sigma^0e^-\nu$	(8.7 ± 1.7)$\times10^{-5}$	123
				$\Lambda\mu^-\nu$	(3.5 ± 3.5)$\times10^{-4}$	163
				$\Sigma^0\mu^-\nu$	(<8)$\times10^{-4}$	70
				$n\pi^-$	(<1.9)$\times10^{-5}$	303
				$ne^-\nu$	(<3.2)$\times10^{-3}$	327
				$n\mu^-\nu$	(<1.5)%	313
				$\Sigma^-\gamma$	(<1.2)$\times10^{-3}$	118
				$p\pi^-\pi^-$	(<4)$\times10^{-4}$	223
				$p\pi^-e^-\nu$	(<4)$\times10^{-4}$	304
				$p\pi^-\mu^-\nu$	(<4)$\times10^{-4}$	250
				$\Xi^0e^-\nu$	(<2.3)$\times10^{-3}$	6
				STRANGENESS −3 BARYON [a]		
Ω^-	$0(\frac{3}{2}^+)$ [s]	1672.45 ±0.32	0.819×10^{-10} ±0.027 $c\tau$=2.46	ΛK^-	(68.6 ± 1.3)%	211
				$\Xi^0\pi^-$	(23.4 ± 1.3)%	294
				$\Xi^-\pi^0$	(8.0 ± 0.8)%	290
				$\Xi^0e^-\nu$	(~1)%	319
				$\Xi^0(1530)\pi^-$	(~2)$\times10^{-3}$	
				$\Lambda\pi^-$	(<1.3)$\times10^{-3}$	449
				$\Xi^-\gamma$	(<3.1)$\times10^{-3}$	314
				NONSTRANGE CHARMED BARYON [a]		
Λ_c^+	$0(\frac{1}{2}^+)$ [s]	2282.0 ±3.1 S=1.8*	$(2.3^{+1.0}_{-0.6})\times10^{-13}$ $c\tau$=0.007	$pK^-\pi^+$	(2.2 ± 1.0)%	820
				$p\bar{K}^0$	(1.1 ± 0.7)%	870
				$p\bar{K}^0\pi^+\pi^-$	(<4, seen)%	751
				Λ anything	(33 ±29)%	
				†[$\Lambda\pi^+$	(0.6 ± 0.5)%	861
				$\Lambda\pi^+\pi^+\pi^-$	(< 3.1, seen)%	804
				$\Sigma^0\pi^+$	(seen)]	822
				†[pK^{*0}	(0.48± 0.30)%	681
				$\Delta^{++}K^-$	(0.45± 0.27)%	706
				$pK^{*-}\pi^+$	(seen)]	575
				e^+ anything	(4.5 ± 1.7)%	
				†[pe^+ anything	(1.8 ± 0.9)%	
				Λe^+ anything	(1.1 ± 0.8)%]	

→ A^+

→ Λ_b^0

→ top hadron searches
→ free quark searches
→ magnetic monopole searches
→ axion searches
→ other stable particle searches

ADDENDUM TO

Stable Particle Table

e^t	**Magnetic Moment** 1.001 159 652 209 ±.000 000 000 031 $\frac{e\hbar}{2m_e c}$	
μ^t	1.001 165 924 ±.000 000 009 $\frac{e\hbar}{2m_\mu c}$	**μ Decay parameters** [u] $\rho = 0.752 \pm 0.003$ $\eta = -0.06 \pm 0.15$ S=1.1* $\xi \cdot P_\mu > 0.9959$ [v] $\delta = 0.755 \pm 0.009$ $h = 1.01 \pm 0.06$ $\alpha' = -0.12 \pm 0.10$ $\beta' = 0.029 \pm 0.037$ $\bar{\eta} = 0.006 \pm 0.080$
τ	**Michel parameter** $\rho = 0.72 \pm 0.15$	$\lvert g_A/g_V \rvert = 0.91^{+0.24}_{-0.06}$ $\phi_{AV} = 180° \pm 9°$ $\lvert g_S/g_V \rvert < 0.29$ $\lvert g_T/g_V \rvert < 0.14$ $\lvert g_P/g_V \rvert < 0.25$

	Mode	Left-right asymmetry	Sextant asymmetry	Quadrant asymmetry	
η	$\pi^+\pi^-\pi^0$	(0.12±.17)%	(0.19±0.16)%	(−0.17±0.17)%	
	$\pi^+\pi^-\gamma$	(0.88±.40)%			$\beta = 0.047 \pm 0.062$ S=1.5*

K

Slope parameters for $K \to 3\pi$ [w]

$K^+ \to \pi^+\pi^+\pi^-$ g=−0.215±.004 S=1.4*
$K^- \to \pi^-\pi^-\pi^+$ g=−0.217±.007 S=2.5*
$K^\pm \to \pi^0\pi^0\pi^\pm$ g= 0.607±.030 S=1.3*
$K^0_L \to \pi^+\pi^-\pi^0$ g= 0.670±.014 S=1.6*

See Data Card Listings for quadratic coefficients.

$\Delta S = -\Delta Q$ in $K^0_{\ell 3}$ decay

Re x = 0.009±.020 S=1.4*
Im x = −0.004±.026 S=1.1*

Form factors for $K_{\ell 3}$ decays [x]

K^+_{e3}: $\lambda_+ = 0.029 \pm 0.004$; $\lvert f_S/f_+ \rvert = 0.125 \pm 0.044$; $\lvert f_T/f_+ \rvert = 0.22 \pm 0.14$

K^0_{e3}: $\lambda_+ = 0.0300 \pm 0.0016$ S=1.2*; $\lvert f_S/f_+ \rvert < 0.04$; $\lvert f_T/f_+ \rvert < 0.23$

$K^+_{\mu 3}$: $\lambda_+ = 0.032 \pm 0.008$ S=2.3*; $\lambda_0 = 0.004 \pm 0.007$ S=2.3*; $\lvert f_T/f_+ \rvert = 0.02 \pm 0.12$

$K^0_{\mu 3}$: $\lambda_+ = 0.034 \pm 0.005$ S=2.3*; $\lambda_0 = 0.025 \pm 0.006$ S=2.3*; $\lvert f_T/f_+ \rvert = 0.12 \pm 0.12$

CP-violation parameters [y,i]

$\lvert \eta_{+-} \rvert = (2.274 \pm .022) \times 10^{-3}$ $\lvert \eta_{00} \rvert = (2.33 \pm .08) \times 10^{-3}$ S=1.1*
$\phi_{+-} = (44.6 \pm 1.2)°$ $\phi_{00} = (54 \pm 5)°$ Re $\epsilon = (1.621 \pm 0.088) \times 10^{-3}$
$\lvert \eta_{+-0} \rvert^2 < 0.12$ $\lvert \eta_{000} \rvert^2 < 0.1$ $\delta = (0.330 \pm .012)$%

	Magnetic moment ($e\hbar/2m_pc$)	Decay parameters [z] Measured: α	Measured: ϕ(degree)	Derived: γ	Derived: Δ(degree)	Coupling Constant Ratios
p^t	2.7928456 ±.0000011					
n^t	−1.91304184 ±.00000088	$pe^-\nu$				$g_A/g_V = -1.254 \pm 0.006$ $\phi_{AV} = (180.11 \pm 0.17)°$
Λ^t	−0.613 ±.004	$p\pi^-$ 0.642±0.013 $n\pi^0$ 0.646±0.044 $pe\nu$	(−6.5±3.5)°	0.76	(7.7±4.1)°	$g_A/g_V = -0.694 \pm 0.025$ S=1.3*
Σ^+	2.379 ±.020	$p\pi^0$ −0.979±0.016 $n\pi^+$ +0.068±0.013 $p\gamma$ −0.72±0.29	(36±34)° (167±20)° S=1.1*	0.17 −0.97	(187±6)° $(-73^{+134}_{-10})°$	
Σ^-	*−1.10* *±.05* S=1.5*	$n\pi^-$ −0.068±0.008 $ne^-\nu$ $\Lambda e^-\nu$	(10±15)°	0.98	$(249^{+12}_{-116})°$	$\lvert g_A/g_V \rvert = 0.372 \pm 0.050$ S=1.9* $g_V/g_A = 0.01 \pm 0.10$ S=1.5* $g_{WM}/g_A = 2.4 \pm 1.7$
Ξ^0	−1.250 ±.014	$\Lambda\pi^0$ −0.413±0.022 S=2.0*	(21±12)°	0.85	$(218^{+12}_{-18})°$	
Ξ^-	−1.85 ±.75	$\Lambda\pi^-$ −0.434±0.015 S=1.4* $\Lambda e^-\nu$	(2±6)° S=1.1*	0.90	(184±12)°	$g_A/g_V = -0.25 \pm 0.05$
Ω^-		ΛK^- −0.10±0.38 S=1.2*				

Stable Particle Table *(cont'd)*

→ Indicates an entry in the Stable Particle Data Card Listings not entered in the Stable Particle Table.

* S = Scale factor = $\sqrt{\chi^2/(N-1)}$, where N ≈ number of experiments. S should be ≈1. If S > 1, we have enlarged the error of the mean, $\delta\bar{x}$; i.e., $\delta\bar{x} \rightarrow S\delta\bar{x}$. This convention is still inadequate, since if S >> 1 the experiments are probably inconsistent, and therefore the real uncertainty is probably even greater than Sδx. See the Introduction, and ideograms in Stable Particle Data Card Listings.

† Square brackets indicate subreactions of some previous unbracketed decay mode(s). Reactions in one set of brackets may overlap with reactions in another set of brackets. A radiative mode such as $\pi \rightarrow \mu\nu\gamma$ is a subreaction of its parent mode $\pi \rightarrow \mu\nu$.

a. The strangeness *S*, charm *C*, and bottomness (beauty) *B* of the hadrons which appear in the Table are as follows:

Mesons	*S*	*C*	*B*	Mesons	*S*	*C*	*B*	Baryons	*S*	*C*	*B*
π,η	0	0	0	F^+	+1	+1	0	p,n	0	0	0
K^+,K^0	+1	0	0	F^-	−1	−1	0	Λ,Σ	−1	0	0
$K^-,\bar{K}^0$	−1	0	0	B^+, B^0	0	0	+1	Ξ	−2	0	0
D^+,D^0	0	+1	0	$B^-, \bar{B}^0$	0	0	−1	Ω^-	−3	0	0
$D^-,\bar{D}^0$	0	−1	0					Λ_c^+	0	+1	0

b. Quoted upper limits correspond to a 90% confidence level. Masses, mean lives, and partial rates evaluated assuming equality for particles and antiparticles. See Conservation Laws Section for further details.

c. In decays with more than two bodies, p_{max} is the maximum momentum that any particle can have.

d. 99% confidence level. See footnote in Stable Particle Data Card Listings.

e. See Stable Particle Data Card Listings for energy limits used in this measurement.

f. Theoretical value; see also Stable Particle Data Card Listings.

g. The direct emission branching fraction is $(1.56\pm.35)\times10^{-5}$.

h. Structure-dependent part with positive (SD+) and negative (SD−) photon helicity.

i. The $K_S^0 \rightarrow \pi\pi$ and $K_L^0 \rightarrow \pi\pi$ branching fractions are from our branching fraction and rate fits and do not include results of K_L^0–K_S^0 interference experiments. The $\pi\pi$ rate results are combined with the interference results to obtain the $|\eta_{+-}|$ and $|\eta_{00}|$ values given in the addendum.

j. The stronger limit $<2\times10^{-9}$ of Clark et al., Phys. Rev. Lett. **26**, 1667 (1971) is not listed because of possible (but unknown) systematic errors. See Stable Particle Data Card Listings.

k. This is a weighted average of $D^\pm$ (44%) and D^0 (56%) branching fractions.

ℓ. $D_1^0 - D_2^0$ limits inferred from limit on $D^0 \rightarrow \bar{D}^0 \rightarrow \mu^-$ anything.

m. F mass determined from $\phi\pi$ mode. See note on conflicting F meson results in Stable Particle Data Card Listings. Quantum numbers shown are favored but not yet established.

n. Quantum numbers not measured. Values shown are quark model predictions.

p. Except for the neutral-current decay modes ($\ell^+\ell^-$ anything), only data from $\Upsilon(10575)$ decays are used. Behrends et al. [Phys. Rev. Lett. **50**, 881 (1983)] estimate the $\Upsilon(10575) \rightarrow B^+B^-$ and $\Upsilon(10575) \rightarrow B^0\bar{B}^0$ branching fractions to be 60±2 and 40±2%.

q. Partial mean life for $p \rightarrow e^+\pi^0$ mode. For antiprotons the best mean life limit, inferred from observation of cosmic ray $\bar{p}$'s, is $\tau_{\bar{p}} > 10^7$ yrs, the cosmic ray storage time.

r. Limit from neutrality-of-matter experiments. Assumes $|q_n| = |q_p| - |q_e|$.

s. P for Ξ, J^P for Ω^- and Σ^0, and J for Λ_c^+ not yet measured. Values shown are quark model predictions.

t. For limits on electric dipole moment, see Conservation Laws Section. Forbidden by P and T invariance.

u. $|g_A/g_V|$ defined by $g_A^2 = |C_A|^2 + |C_A'|^2$, $g_V^2 = |C_V|^2 + |C_V'|^2$, and $\Sigma[\bar{e}\Gamma_i\mu][\bar{\nu}\Gamma_i(C_i+C_i'\gamma_5)\nu]$; ϕ defined by $\cos\phi = -\mathrm{Re}(C_A^*C_V'+C_A'C_V^*)/g_Ag_V$. For more details, see Data Card Listings.

v. Value assumes $\rho = \delta$. P_μ is muon longitudinal polarization from π decay. In standard V-A theory, $P_\mu = 1$ and $\rho = \delta = 3/4$.

w. The definition of the slope parameter of the Dalitz plot is as follows [see also note in Data Card Listings]:

$$|M|^2 = 1 + g\left(\frac{s_3-s_0}{m_{\pi^+}^2}\right)$$

x. For definitions of form factors f_+, f_S, and f_T, and linear t dependences λ_+ and λ_0 of $f_+(t)$ and $f_0(t)$, see note in K^+ section of Data Card Listings.

y. The definition for the CP violation parameters is as follows [see also note in Data Card Listings]:

$$\eta_{+-} = |\eta_{+-}|e^{i\phi_{+-}} = \frac{A(K_L^0\rightarrow\pi^+\pi^-)}{A(K_S^0\rightarrow\pi^+\pi^-)} \qquad \eta_{00} = |\eta_{00}|e^{i\phi_{00}} = \frac{A(K_L^0\rightarrow\pi^0\pi^0)}{A(K_S^0\rightarrow\pi^0\pi^0)}$$

$$\delta = \frac{\Gamma(K_L^0\rightarrow\ell^+)-\Gamma(K_L^0\rightarrow\ell^-)}{\Gamma(K_L^0\rightarrow\ell^+)+\Gamma(K_L^0\rightarrow\ell^-)}, \quad |\eta_{+-0}|^2 = \frac{\Gamma(K_S^0\rightarrow\pi^+\pi^-\pi^0)^{\mathrm{CP\ viol.}}}{\Gamma(K_L^0\rightarrow\pi^+\pi^-\pi^0)}, \quad |\eta_{000}|^2 = \frac{\Gamma(K_S^0\rightarrow\pi^0\pi^0\pi^0)^{\mathrm{CP\ viol.}}}{\Gamma(K_L^0\rightarrow\pi^0\pi^0\pi^0)}.$$

z. The definition of these quantities is as follows [for more details and sign convention, see note in Data Card Listings]:

$$\alpha = \frac{2|s||p|\cos\Delta}{|s|^2+|p|^2} \qquad \beta = \sqrt{1-\alpha^2}\sin\phi \qquad g_A, g_V, g_{WM} \text{ defined by } \langle B_f|\gamma_\lambda(g_V-g_A\gamma_5)+(g_{WM}/m_{B_i})\sigma^{\lambda\nu}q_\nu|B_i\rangle$$

$$\beta = \frac{-2|s||p|\sin\Delta}{|s|^2+|p|^2} \qquad \gamma = \sqrt{1-\alpha^2}\cos\phi \qquad \phi_{AV} \text{ defined by } g_A/g_V = |g_A/g_V|e^{i\phi_{AV}}$$

Meson Table

April 1984

In addition to the entries in the Meson Table, the Meson Data Card Listings contain all substantial claims for meson resonances. See Contents of Meson Data Card Listings at end of this Table.

Quantities in italics are new or have changed by more than one (old) standard deviation since April 1982.

J^P	G \ I	0	1	$\frac{1}{2}$
N	+	ϵ/f	ρ	K^*,κ
	−	ω/ϕ	δ	
A	+	η/D	B	K,Q
	−	H	π/A	

	$I^G(J^P)C_n$ *estab.*	Mass M (MeV)	Full Width Γ (MeV)	Partial decay mode: Mode	Fraction(%) [Upper limits (%) are 90% CL]	p or p_{max} [b] (MeV/c)
NONSTRANGE MESONS						
$\pi^\pm$	$1^-(0^-)+$	139.57	0.0	See Stable Particle Table		
π^0		134.96	7.95 eV ±0.55 eV			
η	$0^+(0^-)+$	548.8 ±0.6	0.83 keV ±0.12 keV	Neutral	70.9	See Stable
				Charged	29.1	Particle Table
$\rho(770)$	$1^+(1^-)-$	769‡ ±3§	154‡ ±5§	$\pi\pi$	≈ 100	358
				$\pi\gamma$	0.046 ± 0.005	372
				$\mu^+\mu^-$	0.0067 ± 0.0012[d]	370
				e^+e^-	0.0046 ± 0.0002[d]	384
				$\eta\gamma$	seen‡	189
M and Γ from neutral mode.				For upper limits, see footnote *e*		
$\omega(783)$	$0^-(1^-)-$	782.6 ±0.2 S=1.1*	9.9 ±0.3	$\pi^+\pi^-\pi^0$	89.9 ± 0.5	327
				$\pi^0\gamma$	8.7 ± 0.5	380
				$\pi^+\pi^-$	1.4 ± 0.2	366
				$\pi^0\mu^+\mu^-$	0.010 ± 0.002	349
				e^+e^-	0.0067 ± 0.0004 S=1.2*	391
				$\eta\gamma$	seen‡	199
				For upper limits, see footnote *f*		
$\eta'(958)$	$0^+(0^-)+$‡	957.57 ±0.25	0.29 ±0.05	$\eta\pi\pi$	65.3 ± 1.6	231
				$\rho^0\gamma$	30.0 ± 1.6	170
				$\omega\gamma$	2.8 ± 0.5	159
				$\gamma\gamma$	1.9 ± 0.2	479
				$\mu^+\mu^-\gamma$	0.009 ± 0.002	467
				For upper limits, see footnote *g*		
S(975) or S*	$0^+(0^+)+$	975[c] ±4 S=1.4*	33[c] ±6	$\pi\pi$	78 ± 3	467
				$K\bar{K}$	22 ± 3	
See note on $\pi\pi$ and $K\bar{K}$ S wave.‡						
$\delta(980)$‡	$1^-(0^+)+$	983[h] ±2	54[h] ±7	$\eta\pi$	seen	320
				$K\bar{K}$	seen	
$\phi(1020)$	$0^-(1^-)-$	*1019.5* ±*0.1* S=1.2*	4.22 ±0.13	K^+K^-	49.3 ± 1.0 S=1.3*	127
				K_LK_S	34.7 ± 1.0 S=1.3*	110
				$\pi^+\pi^-\pi^0$ (incl. $\rho\pi$)	14.8 ± 0.7 S=1.2*	462
				$\eta\gamma$	*1.2 ± 0.2* S=1.4*	362
				$\pi^0\gamma$	0.14 ± 0.05	501
				e^+e^-	0.031 ± 0.001	510
				$\mu^+\mu^-$	0.025 ± 0.003	499
				$\pi^+\pi^-$	0.02 ± 0.01	490
				For upper limits, see footnote *i*		
H(1190)	$0^-(1^+)-$	1190 ±60	320 ±50	$\rho\pi$	seen	327
Seen in one experiment only.						
B(1235)	$1^+(1^+)-$	1234 ±10§	*150* ±*10*§	$\omega\pi$	only mode seen	350
				[D/S amplitude ratio = 0.29 ± 0.05]		
				For upper limits, see footnote *j*		

Meson Table *(cont'd)*

J^P \ G \ I	0	1	$\frac{1}{2}$
N +	ϵ/f	ρ	K^*,κ
N −	ω/ϕ	δ	
A +	η/D	B	K,Q
A −	H	π/A	

	$I^G(J^P)C_n$ *— estab.*	Mass M (MeV)	Full Width Γ (MeV)	Partial decay mode: Mode	Fraction(%) [Upper limits (%) are 90% CL]	p or p_{max} [b] (MeV/c)
f(1270)	$0^+(2^+)+$	1274 ± 5§	178 ± 20§	$\pi\pi$	84.3 ± 1.2	622
				$2\pi^+2\pi^-$	2.9 ± 0.4 S=1.2*	559
				$K\bar{K}$	2.9 ± 0.2	398
				$\gamma\gamma$	0.0015 ± 0.0002	637
				$\pi^+\pi^-2\pi^0$	seen	562
				For upper limits, see footnote *k*		
A(1270) or A_1	$1^-(1^+)+$	1275‡ ± 30	315‡ ± 45	$\rho\pi$	dominant	389
				$\pi(\pi\pi)_{S-wave}$	*< 0.7*§	599
→ D(1285)	$0^+(1^+)+$	1283 ± 5§	26 ± 5§	$K\bar{K}\pi$	11 ± 3	302
				$\eta\pi\pi$	49 ± 6	482
				†[$\delta\pi$	36 ± 7]	236
				4π (prob. $\rho\pi\pi$)‡	40 ± 7	564
ϵ(1300)	$0^+(0^+)+$	~1300	200−600	$\pi\pi$	~90	635
				$K\bar{K}$	~10	418
				$\eta\eta$	*possibly seen*	348
See note on $\pi\pi$ and $K\bar{K}$ S wave.‡						
π(1300)	$1^-(0^-)+$	1300§ ± 100§	200−600	$\rho\pi$	seen	407
				$\pi(\pi\pi)_{S-wave}$	seen	612
Not a well-established resonance.						
A_2(1320)	$1^-(2^+)+$	1318 ± 5§	110 ± 5§	$\rho\pi$	70.1 ± 2.2	419
				$\eta\pi$	14.5 ± 1.2	534
				$\omega\pi\pi$	10.6 ± 2.5	361
				$K\bar{K}$	4.9 ± 0.8	434
				$\eta'\pi$	< 2 (CL=97%)	286
				$\pi\gamma$	*0.27 ± 0.06*	652
				$\gamma\gamma$	0.0007 ± 0.0002	659
E(1420)‡	$0^+(1^+)+$	1418 ± 10§	52 ± 10§	$K\bar{K}\pi$ (incl. $K^*\bar{K}+K\bar{K}^*$)	seen	423
				$\eta\pi\pi$	possibly seen	565
				†[$\delta\pi$	possibly seen]	348
ι(1440)‡	$0^+(0^-)+$	*1440*§ *± 10*§	*76* *± 10*§	$K\bar{K}\pi$ (incl. $K^*\bar{K}+K\bar{K}^*$)	*seen*	441
				$\eta\pi\pi$	*seen*	579
				†[$\delta\pi$	*seen*]	366
f′(1525)	$0^+(2^+)+$	1525 ± 5§	70 ± 10§	$K\bar{K}$	dominant	578
				$\pi\pi$	possibly seen	750
				$\gamma\gamma$	*0.0011 ± 0.0002*	763
→ ρ(1600) or ρ'	$1^+(1^-)-$	1590‡§ ± 20§	260‡§ ± 100§	4π (incl. $\rho\pi^+\pi^-$,A(1270)π)	*60 ± 7*§	733
				$\pi\pi$	*23 ± 7*§	783
				$K^*\bar{K}$ + $\bar{K}^*K$	*9 ± 2*	377
				$\eta\pi\pi$	*7 ± 2*	669
				$\bar{K}K$	*1 ± 0.5*	623
				e^+e^-	*0.003 ± 0.001*	795
ω(1670)	$0^-(3^-)-$	1668 ± 5	166 ± 15§ S=1.1*	3π	seen	806
				†[$\rho\pi$	seen]	648
				5π	seen	740
				†[$\omega\pi\pi$ (prob. Bπ)	seen]	616
A(1680)‡ or A_3	$1^-(2^-)+$	1680§ ± 30§	250§ ± 50§	$f\pi$	53 ± 5	336
				$\rho\pi$	34 ± 6	656
				$\pi(\pi\pi)_{S-wave}$	9 ± 5	813
				$K^*\bar{K}$ + $\bar{K}^*K$	*4 ± 1.4*	459
				For upper limits, see footnote *ℓ*		
ϕ(1680) or ϕ'	$0^-(1^-)-$	1685 ± 10§	*150*§ *± 30*§	$K^*\bar{K}$ + $\bar{K}^*K$	dominant	466
				$\omega\pi\pi$	seen	624
				$K\bar{K}$	seen	683
				e^+e^-	*seen*	842
				$\pi^+\pi^-\pi^0$	*possibly seen*	814

Meson Table *(cont'd)*

J^P	$G \backslash I$	0	1	$\frac{1}{2}$
N	+	ϵ/f	ρ	K^*,κ
	−	ω/ϕ	δ	
A	+	η/D	B	K,Q
	−	H	π/A	

$I^G(J^P)C_n$ — *estab.*	Mass M (MeV)	Full Width Γ (MeV)	Partial decay mode: Mode	Fraction(%) [Upper limits (%) are 90% CL]		p or p_{max} [b] (MeV/c)
g(1690) $1^+(3^-)-$	1691 ±5§	200§ ±20§	2π	23.8 ± 1.3		834
			4π (incl. $\pi\pi\rho,\rho\rho,A_2\pi,\omega\pi$)	70.9 ± 1.9		787
			$K\bar{K}\pi$ (incl. $K^*\bar{K}+\bar{K}K^*$)	*3.8 ± 1.2*		625
			$K\bar{K}$	1.5 ± 0.3	S=1.3*	684
J^P, M, and Γ from the 2π and $K\bar{K}$ modes.						
θ(1690) $0^+(2^+)+$	*1690* ±*30*	*180* ±*50*	$\eta\eta$	*seen*		643
			$K\bar{K}$	*seen*		683
φ(1850) $0^-(3^-)-$	*1853* ±*10*	*96* ±*32*	$K\bar{K}$	*seen*		784
			$K^*\bar{K} + \bar{K}^*K$	*seen*		601
h(2030) $0^+(4^+)+$	2027 ±12	*220* ±*30*	$\pi\pi$	*17 ± 2*		1004
			$K\bar{K}$	$0.7^{+0.4}_{-0.2}$		883
$\eta_c(2980)$ $0^+(0^-)+$	2981 ±6	< 20	$\eta\pi^+\pi^-$	seen		1426
			$2(\pi^+\pi^-)$	seen		1458
			$K^+K^-\pi^+\pi^-$	seen		1343
			$p\bar{p}$	seen		1158
$J/\psi(3100)$ $0^-(1^-)-$	3096.9 ±0.1	0.063 ±0.009	e^+e^-	7.4 ± 1.2		1548
			$\mu^+\mu^-$	7.4 ± 1.2		1545
			hadrons + radiative	85 ± 2		

Decay modes into stable hadrons

†[$2(\pi^+\pi^-)\pi^0$	3.7 ± 0.5	1496
$3(\pi^+\pi^-)\pi^0$	2.9 ± 0.7	1433
$\pi^+\pi^-\pi^0K^+K^-$	1.2 ± 0.3	1368
$4(\pi^+\pi^-)\pi^0$	0.9 ± 0.3	1345
$\pi^+\pi^-K^+K^-$	0.72 ± 0.23	1407
$p\bar{p}\pi^+\pi^-$	0.53 ± 0.06	1107
$2(\pi^+\pi^-)$	0.4 ± 0.1	1517
$3(\pi^+\pi^-)$	0.4 ± 0.2	1466
$n\bar{n}\pi^+\pi^-$	0.38 ± 0.36	1106
$\Xi\bar{\Xi}$	0.32 ± 0.08	818
$2(\pi^+\pi^-)K^+K^-$	0.31 ± 0.13	1320
$K^0_SK^\pm\pi^\mp$	0.26 ± 0.07	1440
$\Sigma^+\bar{\Sigma}^-$	0.24 ± 0.26	988
$p\bar{p}\eta$	0.23 ± 0.04	948
$p\bar{p}$	0.22 ± 0.02	1232
$p\bar{n}\pi^-$ or $\bar{p}n\pi^+$	0.21 ± 0.02	1174
$n\bar{n}$	0.18 ± 0.09	1231
$p\bar{p}\pi^+\pi^-\pi^0$	0.16 ± 0.06[m]	1033
$\Sigma^0\bar{\Sigma}^0$	0.13 ± 0.04	988
$\Lambda\bar{\Lambda}$	0.11 ± 0.02	1074
$p\bar{p}\pi^0$	0.11 ± 0.01	1176
$2(K^+K^-)$	0.07 ± 0.03	1131
K^+K^-	0.022 ± 0.008	1468
$\pi^+\pi^-$	0.011 ± 0.005	1542
$\Lambda\bar{\Sigma}$	< 0.015	1032
$K^0_SK^0_L$]	< 0.009	1466

Decay modes into hadronic resonances

†[$\rho\pi$	1.22 ± 0.12		1449
$\omega 2\pi^+2\pi^-$	0.85 ± 0.34		1392
ρA_2	0.84 ± 0.45		1126
$\omega\pi\pi$	0.68 ± 0.19		1435
$K^{*0}(892)\bar{K}^{*0}(1430)$+c.c.	0.67 ± 0.26		1009
$K^\pm K^{*\mp}(892)$	0.34 ± 0.05		1373
$B^\pm(1235)\pi^\mp$	0.29 ± 0.07		1298
$K^0\bar{K}^{*0}(892)$+c.c.	0.27 ± 0.06		1370
ωf	0.23 ± 0.08	S=1.2*	1143
$\phi\pi^+\pi^-$	0.21 ± 0.09		1365
$\eta' p\bar{p}$	0.18 ± 0.06		596
$\phi K\bar{K}$	0.18 ± 0.08		1176
$\omega p\bar{p}$	0.16 ± 0.03		768
$\omega K\bar{K}$	0.16 ± 0.10		1265
$\phi\eta$	0.10 ± 0.06		1320
$\phi f'(1525)$	0.037 ± 0.013		871
$\phi S(975)$	*0.026 ± 0.006*		1184
$\pi^\pm A_2^\mp$	< 0.43		1263
$K^{*0}(1430)\bar{K}^{*0}(1430)$	< 0.29		606
$K^0\bar{K}^{*0}(1430)$+c.c.	< 0.2		1158
$K^\pm K^{*\mp}(1430)$	< 0.2		1159
$\phi 2\pi^+2\pi^-$	< 0.15		1318
$\phi\eta'$	< 0.13		1192
$K^{*0}(892)\bar{K}^{*0}(892)$	< 0.05		1261
ϕf	< 0.037		1037
$\omega f'(1525)$	< 0.016]		1003

Radiative decay modes

†[$\gamma 2(\pi^+\pi^-)$	*0.49 ± 0.17*	1517
$\gamma\rho\rho$	*seen*	1344
$\gamma\iota(1440)\to\gamma K\bar{K}\pi$	0.42 ± 0.12[n]	1214
$\gamma\eta'$	0.36 ± 0.05	1400
γf	0.15 ± 0.04	1286
$\gamma\eta$	0.086 ± 0.009	1500
$\gamma\pi^0$	0.007 ± 0.005	1546

Radiative decay modes (cont'd)

$\gamma\eta_c(2980)$	*seen*	114
$\gamma\theta(1690)$	*seen*	1087
$\gamma\eta\pi\pi$	*seen*	1487
$\gamma D(1285)$	< 0.6	1283
2γ	< 0.05	1548
$\gamma f'(1525)$	< 0.03	1173
$\gamma p\bar{p}$	< 0.01	1232
3γ]	< 0.006	1548

Meson Table *(cont'd)*

J^P \ G \ I	0	1	$\frac{1}{2}$
N +	ϵ/f	ρ	K^*,κ
N −	ω/ϕ	δ	
A +	η/D	B	K,Q
A −	H	π/A	

	$I^G(J^P)C_n$ *estab.*	Mass M (MeV)	Full Width Γ (MeV)	Partial decay mode: Mode	Fraction(%) [Upper limits (%) are 90% CL]	p or p_{max} [b] (MeV/c)
χ(3415)	$0^+(0^+)+$	3415.0 ±1.0		$2(\pi^+\pi^-)$ (incl. $\pi\pi\rho$)	4.3 ± 0.9	1679
				$\pi^+\pi^-K^+K^-$ (incl. $\pi K\bar{K}^*$)	3.4 ± 0.9	1580
				$3(\pi^+\pi^-)$	1.7 ± 0.6	1633
				$\pi^+\pi^-$	0.9 ± 0.2	1702
				$\gamma J/\psi(3100)$	0.8 ± 0.3	303
				K^+K^-	0.8 ± 0.2	1635
				$p\bar{p}\pi^+\pi^-$	0.6 ± 0.2	1320
				For upper limits, see footnote *o*		
χ(3510)	$0^+(1^+)+$	3510.0 ±0.6		$\gamma J/\psi(3100)$	28 ± 3	389
				$3(\pi^+\pi^-)$	2.4 ± 0.9	1683
				$2(\pi^+\pi^-)$ (incl. $\pi\pi\rho$)	1.8 ± 0.5	1727
				$\pi^+\pi^-K^+K^-$ (incl. $\pi K\bar{K}^*$)	1.0 ± 0.4	1632
				$\pi^+\pi^-p\bar{p}$	0.15 ± 0.10	1381
				For upper limits, see footnote *p*		
χ(3555)	$0^+(2^+)+$	3555.8 ±0.6		$\gamma J/\psi(3100)$	15.5 ± 1.8	429
				$2(\pi^+\pi^-)$ (incl. $\pi\pi\rho$)	2.3 ± 0.5	1750
				$\pi^+\pi^-K^+K^-$ (incl. $\pi K\bar{K}^*$)	2.0 ± 0.5	1656
				$3(\pi^+\pi^-)$	1.2 ± 0.8	1706
				$\pi^+\pi^-p\bar{p}$	0.35 ± 0.14	1410
				$\pi^+\pi^-$	0.20 ± 0.11	1772
				K^+K^-	0.16 ± 0.12	1708
				For upper limits, see footnote *q*		
→ ψ(3685)	$0^-(1^-)-$	3686.0 ±0.1	0.215 ±0.040	e^+e^-	0.9 ± 0.1	1843
				$\mu^+\mu^-$	0.8 ± 0.2	1840
				hadrons + radiative	98.1 ± 0.3	
	$m_{\psi(3685)} - m_{\psi(3100)} = 589.06 \pm 0.13$					
	Radiative decay modes			Decay modes into hadrons		
	†[$\gamma\chi(3415)$	8.2 ± 1.4	261	†[$J/\psi\pi^+\pi^-$	33 ± 2	477
	$\gamma\chi(3510)$	8.0 ± 1.3	172	$J/\psi\pi^0\pi^0$	17 ± 2	481
	$\gamma\chi(3555)$	7.4 ± 1.3	128	$J/\psi\eta$	2.8 ± 0.6[§]	196
	$\gamma\eta_c(2980)$	0.43 ± 0.26	638	$2(\pi^+\pi^-)\pi^0$	0.35 ± 0.15	1799
	$\gamma\eta'(3590)$	0.2 to 1.3	91	$\pi^+\pi^-K^+K^-$	0.16 ± 0.04	1726
	$\gamma\pi^0$	< 0.5 (CL=95%)	1841	$J/\psi\pi^0$	0.10 ± 0.03	528
	$\gamma\eta$	< 0.02	1802	$p\bar{p}\pi^+\pi^-$	0.08 ± 0.02	1491
	$\gamma\eta'$	< 0.02	1719	$K^{*0}(892)K^-\pi^+$ + cc.	0.067 ± 0.025	1674
	$\gamma\iota(1440)\to\gamma K\bar{K}\pi$	< 0.012[n]]	1562	$2(\pi^+\pi^-)$	0.05 ± 0.01	1817
				$\rho^0\pi^+\pi^-$	0.042 ± 0.015	1751
				$p\bar{p}$	0.019 ± 0.005	1586
				$3(\pi^+\pi^-)$	0.015 ± 0.010	1774
				K^+K^-	0.010 ± 0.007	1776
				$\pi^+\pi^-$	0.008 ± 0.005	1838
				$\rho\pi$	< 0.1	1760
				$\Lambda\bar{\Lambda}$	< 0.04]	1467
ψ(3770)	$(1^-)-$	3770 ±3	25 ±3	e^+e^-	0.0011 ± 0.0002	1885
				$D\bar{D}$	dominant	242
	$m_{\psi(3770)} - m_{\psi(3685)} = 83.9 \pm 2.4$ S=1.8*					
ψ(4030)	$(1^-)-$	4030[§] ±5[§]	52 ±10	e^+e^-	0.0014 ± 0.0004	2015
				hadrons	dominant	
				†[$D\bar{D}$	*seen*	752
				$D\bar{D}^* + D^*\bar{D}$	*seen*	559
				$D^*\bar{D}^*$	*seen*]	177
ψ(4160)	$(1^-)-$	4159 ±20	78 ±20	e^+e^-	0.0010 ± 0.0004	2079
				hadrons	dominant	
ψ(4415)	$(1^-)-$	4415 ±6	43 ±20[§]	e^+e^-	0.0010 ± 0.0003 S=1.4*	2207
				hadrons	dominant	

Meson Table *(cont'd)*

J^P \ G \ I	0	1	$\frac{1}{2}$
N +	ϵ/f	ρ	K^*,κ
N −	ω/ϕ	δ	
A +	η/D	B	K,Q
A −	H	π/A	

	$I^G(J^P)C_n$ ___ *estab.*	Mass M (MeV)	Full Width Γ (MeV)	Partial decay mode: Mode	Fraction(%) [Upper limits (%) are 90% CL]	p or p_{max} [b] (MeV/c)
Υ(9460) or Υ(1S)	(1⁻)−	9460.0 ±0.3 S=1.6*	0.0443 ±0.0066	$\mu^+\mu^-$	2.9±0.5	4729
				e^+e^-	2.5±0.5	4730
				$\tau^+\tau^-$	*3.4±0.8*	4381
$\chi_b(9875)$ or $\chi_b(1\,^3P_0)^r$	( )+	*9872.9 ±5.8*		γΥ(9460)	*seen*	404
$\chi_b(9895)$ or $\chi_b(1\,^3P_1)^r$	( )+	*9894.5 ±3.5*		γΥ(9460)	*43±11*	425
$\chi_b(9915)$ or $\chi_b(1\,^3P_2)^r$	( )+	*9914.6 ±2.4*		γΥ(9460)	*20.0±4.4*	444
Υ(10025) or Υ(2S)	(1⁻)−	10023.4 ±0.3	0.0296 ±0.0047	$\mu^+\mu^-$	*1.9±1.8*	5011
				e^+e^-	1.6±0.3	5012
				Υ(9460)ππ	*19.5±1.7*	476
	$m_{\Upsilon(10025)} - m_{\Upsilon(9460)}$ = *563.3±0.4*			$\gamma\chi_b(9875)$	*3.5±1.4*	149
				$\gamma\chi_b(9895)$	*5.9±1.4*	128
				$\gamma\chi_b(9915)$	*6.1±1.4*	108
→ $\chi_b(10255)$ or $\chi_b(2\,^3P_1)^r$	( )+	*10253.7 ±3.4*		γΥ(9460)	*seen*	763
				γΥ(10025)	*seen*	228
$\chi_b(10270)$ or $\chi_b(2\,^3P_2)^r$	( )+	*10271.0 ±2.4*		γΥ(9460)	*seen*	779
				γΥ(10025)	*seen*	245
Υ(10355) or Υ(3S)	(1⁻)−	10355.5 ±0.5	*0.0177 ±0.0051*	e^+e^-	*2.0±0.7*	5178
				$\mu^+\mu^-$	*3.3±2.0*	5177
				Υ(9460)$\pi^+\pi^-$	*5.1±1.1*	814
	$m_{\Upsilon(10355)} - m_{\Upsilon(9460)}$ = *895.5±.6*			Υ(10025)$\pi^+\pi^-$	*3±3*	177
				$\gamma\chi_b(10235)$	*7.6±3.5*	122
				$\gamma\chi_b(10255)$	*15.6±4.2*	101
				$\gamma\chi_b(10270)$	*12.7±4.1*	84
Υ(10575) or Υ(4S)	(1⁻)−	10573 ±4	14 ±5	e^+e^-	0.0017±0.0007	5286
	$m_{\Upsilon(10575)} - m_{\Upsilon(9460)}$ = 1113±4					

STRANGE MESONS

K^+	1/2(0⁻)	493.67	See Stable Particle Table			
K^0		497.67				
K*(892)	1/2(1⁻)	892.1 ±0.4 S=1.4*	51.3 ±1.0 S=1.1*	Kπ	≈ 100	288
				Kγ	0.10±0.01	309
				Kππ	< 0.05	216
M and Γ from charged mode; $m^0 - m^\pm$ = 6.7±1.2 MeV.						
Q(1280) or Q_1	1/2(1⁺)	1270§ ±10§	90§ ±20§	Kρ	42±6	45
				κ(1350)π	28±4	
				K*(892)π	16±5	298
				Kω	11±2	
				Kε	3±2	
κ(1350) See note on Kπ S wave.‡	1/2(0⁺)	~1350	~250	Kπ	seen	574
Q(1400) or Q_2	1/2(1⁺)	1406 ±10	184 ±9	K*(892)π	94±6	403
				Kρ	3±3	299
				Kε	2±2	
				Kω	1±1	285

Meson Table *(cont'd)*

J^P	G \ I	0	1	$\frac{1}{2}$
N	+	ϵ/f	ρ	K^*,κ
	−	ω/ϕ	δ	
A	+	η/D	B	K,Q
	−	H	π/A	

	$I^G(J^P)$ *estab.*	Mass M (MeV)	Full Width Γ (MeV)	Partial decay mode: Mode	Fraction(%) [Upper limits (%) are 90% CL]		p or p_{max} [b] (MeV/c)
$K^*(1430)$	$1/2(2^+)$	1425§ ±5§	100§ ±10§	$K\pi$	44.8±2.3	S=2.7*	618
				$K^*(892)\pi$	24.5±2.0	S=1.1*	417
				$K^*(892)\pi\pi$	13.0±2.6	S=1.1*	366
				$K\rho$	8.8±1.0	S=1.2*	324
				$K\omega$	4.2±1.5		310
				$K\eta$	5±5§		485
				$K\gamma$	*0.24±0.05*		627
→ L(1770)‡	$1/2(2^-)$	~1770§	~200§	$K^*(1430)\pi$	dominant		286
				$K^*(892)\pi$	seen		651
				Kf	seen		
				$K\phi$	*seen*		816
See note on L(1770).‡							
$K^*(1780)$‡ or K^*	$1/2(3^-)$	1780 ±10§	160 ±20§	$K\pi\pi$	large		796
				†[$K\rho$	large]		620
				†[$K^*(892)\pi$	large]		657
				$K\pi$	17±5§		815
See note on $K^*(1780)$.‡							
→ $K^*(2060)$	$1/2(4^+)$	*2060*§ *±30*§	*210*§ *±40*§	$K\pi$	*7±1*		966
				$K^*(892)\pi\pi$	*seen*		809
				$\rho K\pi$	*seen*		751
				$\omega K\pi$	*seen*		744
Not a well-established resonance.				$K^*(892)\pi\pi\pi$	*seen*		775

CHARMED, NONSTRANGE MESONS

D^+	$1/2(0^-)$	1869.4	See Stable Particle Table			
D^0		1864.7				
$D^{*+}(2010)$	$1/2(1^-)$	2010.1 ±0.7	< 2.0	$D^0\pi^+$	64±11	39
				$D^+\pi^0$	28±9	38
				$D^+\gamma$	8±7	136
	$m_{D^{*+}} - m_{D^0} = 145.4 \pm 0.2$ MeV					
$D^{*0}(2010)$	$1/2(1^-)$	2007.2 ±2.1	< 5	$D^0\pi^0$	55±15	44
				$D^0\gamma$	45±15	137

CHARMED, STRANGE MESON

F^+	$0(0^-)$	1971	See Stable Particle Table

BOTTOM, NONSTRANGE MESON

B^+	$1/2(0^-)$	5271	See Stable Particle Table
B^0		5274	

→ Indicates an entry in the Meson Data Card Listings not entered in the Meson Table. We do not regard these as established resonances. All the entries in the Listings can be found in the Table of Contents of the Meson Data Card Listings immediately following these footnotes.

‡ See Meson Data Card Listings.

* Quoted error includes scale factor $S = \sqrt{\chi^2/(N-1)}$. See footnote to Stable Particle Table.

† Square brackets indicate a subreaction of the previous (unbracketed) decay mode(s).

§ This is only an educated guess; the error given is larger than the error on the average of the published values. (See the Meson Data Card Listings for the latter.)

a. ΓM is approximately the half-width of the resonance when plotted against M^2.

b. For decay modes into ≥ 3 particles, p_{max} is the maximum momentum that any of the particles in the final state can have. The momenta have been calculated by using the averaged central mass values, without taking into account the widths of the resonances.

c. From pole position (M − iΓ/2).

Meson Table *(cont'd)*

d. The e^+e^- branching fraction is from $e^+e^- \to \pi^+\pi^-$ experiments only. The $\omega\rho$ interference is then due to $\omega\rho$ mixing only, and is expected to be small. See note in the Meson Data Card Listings. The $\mu^+\mu^-$ branching fraction is compiled from 3 experiments, each possibly with substantial $\omega\rho$ interference. The error reflects this uncertainty; see notes in the Meson Data Card Listings. If $e\mu$ universality holds, $\Gamma(\rho^0 \to \mu^+\mu^-) = \Gamma(\rho^0 \to e^+e^-) \times 0.99785$.

e. Empirical limits on fractions for other decay modes of $\rho(770)$ are $\pi^\pm\eta < 0.8\%$ (CL=84%), $\pi^+\pi^+\pi^-\pi^- < 0.15\%$, $\pi^\pm\pi^+\pi^-\pi^0 < 0.2\%$ (CL=84%).

f. Empirical limits on fractions for other decay modes of $\omega(783)$ are $\pi^+\pi^-\gamma < 5\%$, $\pi^0\pi^0\gamma < 1\%$, η + neutral(s) $< 1.5\%$, $\mu^+\mu^- < 0.02\%$.

g. Empirical limits on fractions for other decay modes of $\eta'(958)$ are $\pi^+\pi^- < 2\%$ (CL=84%), $\pi^+\pi^-\pi^0 < 5\%$ (CL=84%), $\pi^+\pi^+\pi^-\pi^- < 1\%$ (CL=95%), $\pi^+\pi^+\pi^-\pi^-\pi^0 < 1\%$ (CL=84%), $6\pi < 1\%$, $\pi^+\pi^-e^+e^- < 0.6\%$, $\pi^0e^+e^- < 1.3\%$ (CL=84%), $\eta e^+e^- < 1.1\%$, $\pi^0\rho^0 < 4\%$, $\eta\mu^+\mu^- < 1.5 \times 10^{-5}$, $\pi^0\mu^+\mu^- < 6 \times 10^{-5}$.

h. The mass and width are from the $\eta\pi$ mode only. If the $K\bar{K}$ channel is strongly coupled, the width may be larger.

i. Empirical limits on fractions for other decay modes of $\phi(1020)$ are $\pi^+\pi^-\gamma < 0.7\%$, $\omega\gamma < 5\%$ (CL=84%), $\rho\gamma < 2\%$ (CL=84%), $2\pi^+2\pi^-\pi^0 < 1\%$ (CL=95%), $2\pi^+2\pi^- < 0.1\%$.

j. Empirical limits on fractions for other decay modes of B(1235) are $\pi\pi < 15\%$, $K\bar{K} < 2\%$ (CL=84%), $4\pi < 50\%$ (CL=84%), $\phi\pi < 1.5\%$ (CL=84%), $\eta\pi < 25\%$, $(\bar{K}K)^\pm\pi^0 < 8\%$, $K_SK_S\pi^\pm < 2\%$, $K_SK_L\pi^\pm < 6\%$.

k. Empirical limits (CL=95%) on fractions for other decay modes of f(1270) are $\eta\pi\pi < 1\%$, $K^0K^-\pi^+$ + c.c. $< 0.4\%$, $\eta\eta < 2\%$.

ℓ. Empirical limits on fractions for other decay modes of A(1680) are $\eta\pi < 10\%$, $5\pi < 10\%$.

m. Includes $p\bar{p}\pi^+\pi^-\gamma$ and excludes $p\bar{p}\eta$, $p\bar{p}\omega$, $p\bar{p}\eta'$.

n. See E(1420) mini-review.

o. Empirical limits on fractions for other decay modes of $\chi(3415)$ are $2\gamma < 0.17\%$, $p\bar{p} < 0.11\%$.

p. Empirical limits on fractions for other decay modes of $\chi(3510)$ are ($\pi^+\pi^-$ and K^+K^-) $< 0.2\%$, $\gamma\gamma < 0.16\%$, $p\bar{p} < 0.13\%$.

q. Empirical limits on fractions for other decay modes of $\chi(3555)$ are $2\gamma < 0.06\%$, $p\bar{p} < 0.10\%$, $J/\psi\pi^+\pi^-\pi^0 < 1.5\%$.

r. Spectroscopic labeling for these states is theoretical, pending experimental information.

Contents of Meson Data Card Listings

Non-strange (S = 0; C,B = 0)									Strange (|S| = 1; C,B = 0)	
entry		$I^G(J^P)C_n$	entry		$I^G(J^P)C_n$	entry		$I^G(J^P)C_n$	entry	$I(J^P)$
π		$1^-(0^-)+$	ω	(1670)	$0^-(3^-)-$	→ e^+e^-	(1100—2200)	(1^-)	K	$1/2(0^-)$
η		$0^+(0^-)+$	A	(1680)	$1^-(2^-)+$	→ $\bar{N}N$	(1200—3600)		K*	(892) $1/2(1^-)$
ρ	(770)	$1^+(1^-)-$	ϕ	(1680)	$0^-(1^-)-$	→ X	(1900—3600)		Q	(1280) $1/2(1^+)$
ω	(783)	$0^-(1^-)-$	g	(1690)	$1^+(3^-)-$	η_c	(2980)	0^+ +	κ	(1350) $1/2(0^+)$
η'	(958)	$0^+(0^-)+$	θ	(1690)	$0^+(\ ^+)+$	J/ψ	(3100)	$0^-(1^-)-$	Q	(1400) $1/2(1^+)$
S	(975)	$0^+(0^+)+$	→ η	(1700)	+	χ	(3415)	$0^+(0^+)+$	→ K	(1400) $1/2(0^-)$
δ	(980)	$1^-(0^+)+$	→ S	(1730)	$0^+(0^+)+$	χ	(3510)	$0^+(1^+)+$	K*	(1430) $1/2(2^+)$
ϕ	(1020)	$0^-(1^-)-$	→ π	(1770)	$1^-(0^-)+$	χ	(3555)	$0^+(2^+)+$	→ L	(1580) $1/2(2^-)$
H	(1190)	$0^-(1^+)-$	→ f	(1810)	$0^+(2^+)+$	→ η_c	(3590)	+	→ K*	(1650) $1/2(1^-)$
B	(1235)	$1^+(1^+)-$	ϕ	(1850)	0	ψ	(3685)	$0^-(1^-)-$	L	(1770) $1/2(2^-)$
→ g_S	(1240)	$0^+(0^+)+$	→ S	(1935)		ψ	(3770)	$(1^-)-$	K*	(1780) $1/2(3^-)$
→ ρ	(1250)	$1^+(1^-)-$	h	(2030)	$0^+(4^+)+$	ψ	(4030)	$(1^-)-$	→ K	(1830) $1/2(0^-)$
f	(1270)	$0^+(2^+)+$	→ δ	(2040)	$1^-(4^+)+$	ψ	(4160)	$(1^-)-$	K*	(2060) $1/2(4^+)$
A	(1270)	$1^-(1^+)+$	→ A	(2050)	$1^-(3^+)+$	ψ	(4415)	$(1^-)-$	→ K	(2250) $1/2(2^-)$
→ η	(1275)	$0^+(0^-)+$	→ A	(2100)	$1^-(2^-)+$	Υ	(9460)	$(1^-)-$	→ K	(2320) $1/2(3^+)$
D	(1285)	$0^+(1^+)+$	→ ρ	(2150)	$1^+(1^-)-$	χ_b	(9875)	$(\ )+$	→ K	(2500) $1/2(4^-)$
ϵ	(1300)	$0^+(0^+)+$	→ ϵ	(2150)	$0^+(2^+)+$	χ_b	(9895)	$(\ )+$	**Charmed (|C| = 1)**	
π	(1300)	$1^-(0^-)+$	→ ξ	(2220)	$0\ (\ ^+)$	χ_b	(9915)	$(\ )+$	D	$1/2(0^-)$
A_2	(1320)	$1^-(2^+)+$	→ g_T	(2240)	$0^+(2^+)+$	Υ	(10025)	$(1^-)-$	D*	(2010) $1/2(1^-)$
E	(1420)	$0^+(1^+)+$	→ ρ	(2250)	$1^+(3^-)-$	→ χ_b	(10235)	$(\ )+$	F	$0\ (0^-)$
ι	(1440)	$0^+(0^-)+$	→ ϵ	(2300)	$0^+(4^+)+$	χ_b	(10255)	$(\ )+$	→ F*	(2140)
f'	(1525)	$0^+(2^+)+$	→ ρ	(2350)	$1^+(5^-)-$	χ_b	(10270)	$(\ )+$	**Bottom (Beauty) (|B| = 1)**	
→ D	(1530)	$0^+(1^+)+$	→ δ	(2450)	$1^-(6^+)$	Υ	(10355)	$(1^-)-$	B	
ρ	(1600)	$1^+(1^-)-$	→ τ	(2510)	$0^+(6^+)$	Υ	(10575)	$(1^-)-$	→ Exotics	

Baryon Table

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The following short list gives the name, the nominal mass, the quantum numbers (where known), and the status of each of the Baryon States in the Data Card Listings. States with 3- or 4-star status are included in the Baryon Table below; the others are omitted because the evidence for the existence of the effect and/or for its interpretation as a resonance is open to question.

N(939) P11	****	Δ(1232) P33	****	Z0(1780) P01	*	Σ(1193) P11	****	Ξ(1318) P11	****
N(1440) P11	****	Δ(1550) P31	*	Z0(1865) D03	*	Σ(1385) P13	****	Ξ(1530) P13	****
N(1520) D13	****	Δ(1600) P33	**	Z1(1900) P13	*	Σ(1480)	*	Ξ(1630)	*
N(1535) S11	****	Δ(1620) S31	****	Z1(2150)	*	Σ(1560)	**	Ξ(1680)	**
N(1540) P13	*	Δ(1700) D33	****	Z1(2500)	*	Σ(1580) D13	**	Ξ(1820) 13	***
N(1650) S11	****	Δ(1900) S31	***			Σ(1620) S11	**	Ξ(1940)	**
N(1675) D15	****	Δ(1905) F35	****	Λ(1116) P01	****	Σ(1660) P11	***	Ξ(2030) 1	***
N(1680) F15	****	Δ(1910) P31	****	Λ(1405) S01	****	Σ(1670) D13	****	Ξ(2120)	*
N(1700) D13	***	Δ(1920) P33	***	Λ(1520) D03	****	Σ(1690)	**	Ξ(2250)	**
N(1710) P11	***	Δ(1930) D35	***	Λ(1600) P01	***	Σ(1750) S11	***	Ξ(2370) 1	**
N(1720) P13	****	Δ(1940) D33	*	Λ(1670) S01	****	Σ(1770) P11	*	Ξ(2500)	*
N(1990) F17	**	Δ(1950) F37	****	Λ(1690) D03	****	Σ(1775) D15	****		
N(2000) F15	**	Δ(2150) S31	*	Λ(1800) S01	***	Σ(1840) P13	*	Ω(1672) P03	****
N(2080) D13	**	Δ(2200) G37	*	Λ(1800) P01	***	Σ(1880) P11	**	Λ_c(2282)	****
N(2090) S11	*	Δ(2300) H39	**	Λ(1820) F05	****	Σ(1915) F15	****		
N(2100) P11	*	Δ(2350) D35	*	Λ(1830) D05	****	Σ(1940) D13	***	Σ_c(2450)	**
N(2190) G17	****	Δ(2390) F37	*	Λ(1890) P03	****	Σ(2000) S11	*		
N(2200) D15	**	Δ(2400) G39	**	Λ(2000)	*	Σ(2030) F17	****	A(2460)	*
N(2220) H19	****	Δ(2420) H311	****	Λ(2020) F07	*	Σ(2070) F15	*	Λ_b(5500)	*
N(2250) G19	****	Δ(2750) I313	**	Λ(2100) G07	****	Σ(2080) P13	**		
N(2600) I111	***	Δ(2950) K315	**	Λ(2110) F05	***	Σ(2100) G17	*	Dibaryons	
N(2700) K113	**	Δ(~3000)		Λ(2325) D03	*	Σ(2250)	***	NN(2170) 1D2	**
N(~3000)				Λ(2350)	***	Σ(2455)	**	NN(2250) 3F3	**
				Λ(2585)	**	Σ(2620)	**	NN(?)	*
						Σ(3000)	*	ΛN(2130) 3S1	**
						Σ(3170)	*	ΞN(?)	*

**** Good, clear, and unmistakable.
*** Good, but in need of clarification or not absolutely certain.
** Not established; needs confirmation.
* Evidence weak; could disappear.

Particle[a]	$I(J^P)L^b_{2I\cdot 2J}$	P^c_{beam} (GeV/c) $\sigma = 4\pi\lambda\!\!\!^{-2}$ (mb)	Mass[d] M (MeV)	Full[e] width Γ (MeV)	Partial decay modes: Mode[f]	Fraction[g] (%)	p[h] (MeV/c)
S=0 I=1/2 NUCLEON RESONANCES (N)							
p	1/2(1/2+)		938.3		See Stable Particle Table		
n			939.6				
N(1440)	$1/2(1/2^+)P'_{11}$	p = 0.61	1400 to	120 to	Nπ	50-70	397
		σ = 31.0	1480	350	Nη	8-18	†
				(200)	Nππ	~30	342
					[Δπ	12-28]*	143
					Nρ	~ 7]	†
					Nε	~ 5]	†
N(1520)	$1/2(3/2^-)D'_{13}$	p = 0.74	1510 to	100 to	Nπ	50-60	456
		σ = 23.5	1530	140	Nη	~0.1	149
				(125)	Nππ	35-50	410
					[Δπ	15-25]*	228
					Nρ	15-25]	†
					Nε	< 5]	†

Baryon Table *(cont'd)*

Particle[a]	$I(J^P)L^b_{2I\cdot 2J}$	P^c_{beam} (GeV/c) $\sigma = 4\pi\lambda\!\!\!^{-2}$ (mb)	Mass[d] M (MeV)	Full[e] width Γ (MeV)	Partial decay modes: Mode[f]	Fraction[g] (%)	p[h] (MeV/c)
N(1535)	$1/2(1/2^-)S'_{11}$	p = 0.76	1520 to	100 to	$N\pi$	35-50	467
		σ = 22.5	1560	250	$N\eta$	~35	182
				(150)	$N\pi\pi$	~ 5	422
					$\Delta\pi$	~ 1 *	242
					$N\rho$	~ 3	†
					$N\epsilon$	~ 2	†
N(1650)	$1/2(1/2^-)S''_{11}$	p = 0.96	1620 to	100 to	$N\pi$	55-65	547
		σ = 16.4	1680	200	$N\eta$	~1.5	346
				(150)	ΛK	~ 8	161
					ΣK	3-10	†
					$N\pi\pi$	~30	511
					$\Delta\pi$	4-15 *	344
					$N\rho$	~20	†
					$N\epsilon$	< 5	†
N(1675)	$1/2(5/2^-)D'_{15}$	p = 1.01	1660 to	120 to	$N\pi$	30-40	563
		σ = 15.4	1690	180	$N\eta$	~ 1	374
				(155)	ΛK	~0.1	209
					$N\pi\pi$	55-70	529
					$\Delta\pi$	50-65 *	364
					$N\rho$	~ 5	†
N(1680)	$1/2(5/2^+)F'_{15}$	p = 1.01	1670 to	110 to	$N\pi$	55-65	567
		σ = 15.2	1690	140	$N\eta$	< 1	379
				(125)	ΛK	not seen	218
					$N\pi\pi$	~40	532
					$\Delta\pi$	~12 *	369
					$N\rho$	~10	†
					$N\epsilon$	~20	†
N(1700)	$1/2(3/2^-)D''_{13}$	p = 1.05	1670 to	70 to	$N\pi$	8-12	580
		σ = 14.5	1730	120	$N\eta$	~ 4	400
				(100)	ΛK	~0.2	250
					$N\pi\pi$	~85	547
					$\Delta\pi$	15-40 *	385
					$N\rho$	~ 5	†
					$N\epsilon$	<40	†
N(1710)	$1/2(1/2^+)P''_{11}$	p = 1.07	1680 to	90 to	$N\pi$	10-20	587
		σ = 14.2	1740	130	$N\eta$	~25	410
				(110)	ΛK	~15	264
					ΣK	2-10	138
					$N\pi\pi$	>50	554
					$\Delta\pi$	10-25 *	393
					$N\rho$	25-65	48
					$N\epsilon$	15-40	†
N(1720)	$1/2(3/2^+)P''_{13}$	p = 1.09	1690 to	125 to	$N\pi$	10-20	594
		σ = 13.9	1800	250	$N\eta$	~3.5	420
				(200)	ΛK	~ 5	278
					ΣK	2-5	162
					$N\pi\pi$	~70	561
					$\Delta\pi$	~20 *	401
					$N\rho$	45-70	104
					$N\epsilon$	~20	†
N(2190)	$1/2(7/2^-)G_{17}$	p = 2.07	2120 to	200 to	$N\pi$	~14	888
		σ = 6.21	2230	500	$N\eta$	~ 3	790
				(350)	ΛK	~0.3	712

Baryon Table *(cont'd)*

Particle[a]	$I(J^P)L^b_{2I\cdot 2J}$	P^c_{beam} (GeV/c) $\sigma = 4\pi\lambda\!\!\!^{-2}$ (mb)	Mass[d] M (MeV)	Full[e] width Γ (MeV)	Partial decay modes: Mode[f]	Fraction[g] (%)	p[h] (MeV/c)
N(2220)	$1/2(9/2^+)H_{19}$	p = 2.14 σ = 5.97	2150 to 2300	300 to 500 (400)	Nπ Nη ΛK	~18 ~0.5 ~0.2	905 811 732
N(2250)	$1/2(9/2^-)G'_{19}$	p = 2.21 σ = 5.74	2130 to 2270	200 to 500 (300)	Nπ Nη ΛK	~10 ~ 2 ~0.3	923 831 754
N(2600)	$1/2(11/2^-)I_{111}$	p = 3.12 σ = 3.86	2580 to 2700	>300 (400)	Nπ	~ 5	1126
S=0 I=3/2 DELTA RESONANCES (Δ)							
Δ(1232)	$3/2(3/2^+)P'_{33}$	p = 0.30 σ = 94.8	1230 to 1234	110 to 120 (115)	Nπ Nγ	99.4 0.6	227 259
Δ(1620)	$3/2(1/2^-)S'_{31}$	p = 0.91 σ = 17.7	1600 to 1650	120 to 160 (140)	Nπ Nππ [Δπ Nρ]	25-35 ~70 35-50]* <40	526 488 318 †
Δ(1700)	$3/2(3/2^-)D'_{33}$	p = 1.05 σ = 14.5	1630 to 1740	190 to 300 (250)	Nπ Nππ [Δπ Nρ]	10-20 ~85 <50]* ~40	580 547 385 †
Δ(1900)	$3/2(1/2^-)S''_{31}$	p = 1.44 σ = 9.71	1850 to 2000	130 to 300 (150)	Nπ ΣK	6-12 ~10	710 410
Δ(1905)	$3/2(5/2^+)F_{35}$	p = 1.45 σ = 9.62	1890 to 1920	250 to 400 (300)	Nπ ΣK Nππ [Δπ Nρ]	8-15 < 3 ~80 10-30]* ~60	713 415 687 542 421
Δ(1910)	$3/2(1/2^+)P''_{31}$	p = 1.46 σ = 9.54	1850 to 1950	200 to 330 (220)	Nπ ΣK Nππ [Δπ Nρ]	20-25 2-20 >40 small]* <40	716 421 691 545 426
Δ(1920)	$3/2(3/2^+)P'''_{33}$	p = 1.48 σ = 9.38	1860 to 2160	190 to 300 (250)	Nπ ΣK	14-20 ~ 5	722 431
Δ(1930)	$3/2(5/2^-)D'_{35}$	p = 1.50 σ = 9.21	1890 to 1960	150 to 350 (250)	Nπ ΣK	4-14 <10	729 441
Δ(1950)	$3/2(7/2^+)F'_{37}$	p = 1.54 σ = 8.91	1910 to 1960	200 to 340 (240)	Nπ ΣK Nππ [Δπ Nρ]	35-45 < 1 ~60 ~40]* ~20	741 460 716 574 469
Δ(2420)	$3/2(11/2^+)H_{311}$	p = 2.64 σ = 4.68	2380 to 2450	300 to 500 (300)	Nπ	5-15	1023

Baryon Table *(cont'd)*

Particle[a]	$I(J^P)L^b_{I\cdot 2J}$	P^c_{beam} (GeV/c) $\sigma = 4\pi\lambda\!\!\!^{-2}$ (mb)	Mass[d] M (MeV)	Full[e] width Γ (MeV)	Partial decay modes Mode	Fraction[g] (%)	p[h] (MeV/c)
		S=−1 I=0 LAMBDA RESONANCES (Λ)					
Λ	$0(1/2^+)$		1115.6		See Stable Particle Table		
Λ(1405)	$0(1/2^-)S'_{01}$	Below K^-p threshold	1405 ±5[i]	40±10[i]	Σπ	100	152
Λ(1520)	$0(3/2^-)D'_{03}$	p = 0.395 σ = 82.3	1519.5 ±1.0[i]	15.6±1.0[i]	$N\bar{K}$ Σπ Λππ Σππ Λγ	45±1 42±1 10±1 0.9±0.1 0.8±0.2	244 267 252 152 351
Λ(1600)	$0(1/2^+)P'_{01}$	p = 0.58 σ = 41.6	1560 to 1700	50 to 250 (150)	$N\bar{K}$ Σπ	15-30 10-60	343 336
Λ(1670)	$0(1/2^-)S''_{01}$	p = 0.74 σ = 28.5	1660 to 1680	25 to 50 (35)	$N\bar{K}$ Σπ Λη	15-25 20-60 15-35	414 393 64
Λ(1690)	$0(3/2^-)D''_{03}$	p = 0.78 σ = 26.1	1685 to 1695	50 to 70 (60)	$N\bar{K}$ Σπ Λππ Σππ	20-30 20-40 ~25 ~20	433 409 415 350
Λ(1800)	$0(1/2^-)S'''_{01}$	p = 1.01 σ = 17.5	1720 to 1850	200 to 400 (300)	$N\bar{K}$ Σπ Σ(1385)π $N\bar{K}^*(892)$	25-40 seen seen seen	528 493 345 †
Λ(1800)	$0(1/2^+)P''_{01}$	p = 1.01 σ = 17.5	1750 to 1850	50 to 250 (150)	$N\bar{K}$ Σπ Σ(1385)π $N\bar{K}^*(892)$	20-50 10-40 seen 30-60	528 493 345 †
Λ(1820)	$0(5/2^+)F'_{05}$	p = 1.06 σ = 16.5	1815 to 1825	70 to 90 (80)	$N\bar{K}$ Σπ Σ(1385)π	55-65 8-14 5-10	545 508 362
Λ(1830)	$0(5/2^-)D_{05}$	p = 1.08 σ = 16.0	1810 to 1830	60 to 110 (95)	$N\bar{K}$ Σπ Σ(1385)π	3-10 35-75 >15	553 515 371
Λ(1890)	$0(3/2^+)P'_{03}$	p = 1.21 σ = 13.6	1850 to 1910	60 to 200 (100)	$N\bar{K}$ Σπ Σ(1385)π $N\bar{K}^*(892)$	20-35 3-10 seen seen	599 559 420 233
Λ(2100)	$0(7/2^-)G_{07}$	p = 1.68 σ = 8.68	2090 to 2110	100 to 250 (200)	$N\bar{K}$ Σπ Λη ΞK Λω $N\bar{K}^*(892)$	25-35 ~ 5 < 3 < 3 < 8 10-20	751 704 617 483 443 514
Λ(2110)	$0(5/2^+)F''_{05}$	p = 1.70 σ = 8.53	2090 to 2140	150 to 250 (200)	$N\bar{K}$ Σπ Λω Σ(1385)π $N\bar{K}^*(892)$	5-25 10-40 seen seen 10-60	757 711 455 589 524
Λ(2350)	$0(9/2^+)$	p = 2.29 σ = 5.85	2340 to 2370	100 to 250 (150)	$N\bar{K}$ Σπ	~12 ~10	915 867

Baryon Table *(cont'd)*

Particle[a]	$I(J^P)L^b_{I\cdot 2J}$	P^c_{beam} (GeV/c) $\sigma = 4\pi\lambda\!\!\!^{-2}$ (mb)	Mass[d] M (MeV)	Full[e] width Γ (MeV)	Partial decay modes: Mode	Fraction[g] (%)	p[h] (MeV/c)
			S=−1 I=1 SIGMA RESONANCES (Σ)				
Σ	$1(1/2^+)$		(+)1189.4 (0)1192.5 (−)1197.3		See Stable Particle Table		
Σ(1385)	$1(3/2^+)P'_{13}$	Below K^-p threshold	(+)1382.3±0.4 S=1.6[j] (0)1382.0±2.5 S=1.6[j] (−)1387.4±0.6 S=2.2[j]	35±1 S=1.0[j] ~35 40±2 S=1.9[j]	Λπ Σπ	88±2 12±2	208 127
Σ(1660)	$1(1/2^+)P'_{11}$	p = 0.72 σ = 29.9	1630 to 1690	40 to 200 (100)	$N\bar{K}$ Λπ Σπ	10-30 seen seen	405 439 385
Σ(1670)	$1(3/2^-)D''_{13}$	p = 0.74 σ = 28.5	1665 to 1685	40 to 80 (60)	$N\bar{K}$ Λπ Σπ	7-13 5-15 30-60	414 447 393
Σ(1750)	$1(1/2^-)S''_{11}$	p = 0.91 σ = 20.7	1730 to 1800	60 to 160 (90)	$N\bar{K}$ Λπ Σπ Ση	10-40 seen < 8 15-55	486 507 455 81
Σ(1775)	$1(5/2^-)D_{15}$	p = 0.96 σ = 19.0	1770 to 1780	105 to 135 (120)	$N\bar{K}$ Λπ Σπ Σ(1385)π Λ(1520)π	37-43 14-20 2-5 8-12 17-23	508 525 474 324 198
Σ(1915)	$1(5/2^+)F'_{15}$	p = 1.26 σ = 12.8	1900 to 1935	80 to 160 (120)	$N\bar{K}$ Λπ Σπ Σ(1385)π	5-15 seen seen < 5	618 622 577 440
Σ(1940)	$1(3/2^-)D'''_{13}$	p = 1.32 σ = 12.1	1900 to 1950	150 to 300 (220)	$N\bar{K}$ Λπ Σπ Σ(1385)π Λ(1520)π Δ(1232)$\bar{K}$ $N\bar{K}^*(892)$	<20 seen seen seen seen seen seen	637 639 594 460 354 410 320
Σ(2030)	$1(7/2^+)F_{17}$	p = 1.52 σ = 9.93	2025 to 2040	150 to 200 (180)	$N\bar{K}$ Λπ Σπ ΞK Σ(1385)π Λ(1520)π Δ(1232)$\bar{K}$ $N\bar{K}^*(892)$	17-23 17-23 5-10 < 2 5-15 10-20 10-20 < 5	702 700 657 412 529 430 498 438
Σ(2250)	1(?)	p = 2.04 σ = 6.76	2210 to 2280	60 to 150 (100)	$N\bar{K}$ Λπ Σπ	<10 seen seen	851 842 803

Baryon Table *(cont'd)*

Particle[a]	$I(J^P)L^b_{2I\cdot 2J}$	Mass[d] M (MeV)	Full[e] width Γ (MeV)	Partial decay modes: Mode	Fraction (%)	p[h] (MeV/c)
		S=−2 I=1/2 CASCADE RESONANCES (Ξ)				
Ξ	$1/2(1/2^+)$	(0)1314.9 (−)1321.3		See Stable Particle Table		
Ξ(1530)	$1/2(3/2^+)P_{13}$	(0)1531.8 ± 0.3 S = 1.3[j] (−)1535.0 ± 0.6	9.1 ± 0.5 10.1 ± 1.9	Ξπ	100	148
Ξ(1820)	1/2(3/2)	1823 ± 6[i]	20^{+15}_{-10}[i]	ΛK̄ ΣK̄ Ξπ Ξ(1530)π	~45 ~10 small ~45	396 306 413 231
Ξ(2030)	1/(?)	2024 ± 6[i]	16^{+15}_{-5}[i]	ΛK̄ ΣK̄ Ξπ Ξ(1530)π	~20 ~80 small small	587 524 573 418
		OTHER BARYONS				
Ω^-	$0(3/2^+)$	1672.4		See Stable Particle Table		
Λ_c^+	$0(1/2^+)$	2282		See Stable Particle Table		

→ Each arrow in the left-hand margin indicates there is an entry in the Data Card Listings for a baryon that is not well enough established (status less than 3 stars) to be included here. There is a short list of *all* the baryons in the Listings, whatever their status, at the front of this Table.

†. This mode is energetically forbidden when the nominal mass of the decaying resonance (and of any resonance in the final state) is used, but is in fact allowed due to the nonzero widths of the resonance(s).

***. The modes in brackets are subreactions of the Nππ mode.

a. The nominal mass here (in MeV) is used for identification. See column 4 for the actual mass.

b. When there is more than one baryon with the same quantum numbers, one prime is attached to the spectroscopic symbol for the first of them (e.g., S'_{11}), two primes to the second, etc.

c. The quantities here are calculated using the nominal mass of column 1.

d. Usually a conservatively large range of masses rather than a statistical average of the various determinations of the mass is given. In these cases, the mass determinations are nearly entirely from various phase-shift analyses of more or less the same data. It is thus not appropriate to treat the determinations as independent measurements or to average them together. The masses, widths, and branching fractions in this Table are Breit-Wigner parameters. The Data Card Listings also include pole parameters where they are available.

e. Usually a conservatively large range of widths rather than a statistical average of the various determinations of the width is given (see note *d* for the reason). The nominal value in parentheses is then simply a best guess.

f. For information on the Nγ decay modes, see the Note on N and Δ Resonances in the Listings.

g. Most of the inelastic branching fractions come from partial-wave analyses, and these determine $\sqrt{xx'}$, where x and x′ are the elastic and inelastic branching fractions, not x′ directly. Thus any uncertainty (and it is often considerable) in x carries over into x′. When x′ so determined is really poorly known, we here simply note that the mode is seen. The values of $\sqrt{xx'}$ are given in the Data Card Listings.

h. For a 2-body decay mode, this is the momentum of the decay products in the rest frame of the decaying particle. For a mode with more than two decay products, this is the maximum momentum any of the products can have in this frame. The nominal mass of column 1 is used, as is the nominal mass of any resonance in the final state.

i. The error given here is only an educated guess. It is larger than the error on the weighted average of the published values (the error on this average is given in the Listings).

j. The error given here has been scaled up by the "S factor" (see the * footnote to the Stable Particle Table for how S is defined) because the various measurements disagree more seriously than one would expect from statistics.

PHYSICAL CONSTANTS*

Quantity	Symbol, equation	Value	Uncert. (ppm)
speed of light	c	$2.997\,924\,58(1.2)\times10^{10}$ cm s^{-1} (see note**)	0.004
Planck constant	h	$6.626\,176(36)\times10^{-27}$ erg s	5.4
Planck constant, reduced	$\hbar = h/2\pi$	$1.054\,588\,7(57)\times10^{-27}$ erg s	5.4
		$= 6.582\,173(17)\times10^{-22}$ MeV s	2.6
electron charge magnitude	e	$4.803\,242(14)\times10^{-10}$ esu	2.9
		$= 1.602\,189\,2(46)\times10^{-19}$ coulomb	2.9
conversion constant	$\hbar c$	197.328 58(51) MeV fm	2.6
conversion constant	$(\hbar c)^2$	0.389 385 7(20) GeV^2 mbarn	5.2
electron mass	m_e	0.511 003 4(14) MeV/c^2 = $9.109\,534(47)\times10^{-28}$ g	2.8, 5.1
proton mass	m_p	938.279 6(27) MeV/c^2 = $1.672\,648\,5(86)\times10^{-24}$ g	2.8, 5.1
		= 1.007 276 470(11) amu = 1836.151 52(70) m_e	0.011, 0.38
deuteron mass	m_d	1875.628 0(53) MeV/c^2	2.8
atomic mass unit (amu)	(mass C^{12} atom)/12 = (1 g)/N_A	931.501 6(26) MeV/c^2 = $1.660\,565\,5(86)\times10^{-24}$ g	2.8, 5.1
fine structure constant	$\alpha = e^2/\hbar c$	1/137.036 04(11)	0.82
classical electron radius	$r_e = e^2/m_e c^2$	2.817 938 0(70) fm	2.5
electron Compton wavelength	$\lambda_e = \hbar/m_e c = r_e\alpha^{-1}$	$3.861\,590\,5(64)\times10^{-11}$ cm	1.6
Bohr radius ($m_{nucleus} = \infty$)	$a_\infty = \hbar^2/cm_e e^2 = r_e\alpha^{-2}$	$0.529\,177\,06(44)\times10^{-8}$ cm	0.82
Rydberg energy	$hcR_\infty = m_e e^4/2\hbar^2 = m_e c^2\alpha^2/2$	13.605 804(36) eV	2.6
Thomson cross section	$\sigma_T = 8\pi r_e^2/3$	0.665 244 8(33) barn	4.9
Bohr magneton	$\mu_B = e\hbar/2m_e c$	$5.788\,378\,5(95)\times10^{-15}$ MeV gauss^{-1}	1.6
nuclear magneton	$\mu_N = e\hbar/2m_p c$	$3.152\,451\,5(53)\times10^{-18}$ MeV gauss^{-1}	1.7
electron cyclotron frequency/field	$\omega^e_{cycl}/B = e/m_e c$	$1.758\,804\,7(49)\times10^{7}$ rad s^{-1} gauss^{-1}	2.8
proton cyclotron frequency/field	$\omega^p_{cycl}/B = e/m_p c$	$9.578\,756(28)\times10^{3}$ rad s^{-1} gauss^{-1}	2.8
gravitational constant	G_N	$6.672\,0(41)\times10^{-8}$ cm^3 g^{-1} s^{-2}	615
grav. acceleration, sea level, 45° lat.	g	980.62 cm s^{-2}	—
Fermi coupling constant	$G_F/(\hbar c)^3$	$1.166\,37(2)\times10^{-5}$ GeV^{-2}	17
Avogadro number	N_A	$6.022\,045(31)\times10^{23}$ mol^{-1}	5.1
Boltzmann constant	k	$1.380\,662(44)\times10^{-16}$ erg K^{-1}	32
		$= 8.617\,35(28)\times10^{-5}$ eV K^{-1}	32
molar volume, ideal gas at STP	$N_A k(273.15\text{ K})/(1\text{ atmosphere})$	22 413.83(70) cm^3 mol^{-1}	31
Stefan-Boltzmann constant	$\sigma = \pi^2 k^4/60\hbar^3 c^2$	$5.670\,32(71)\times10^{-5}$ erg s^{-1} cm^{-2} K^{-4}	125

π = 3.141 592 653 589 793 238 e = 2.718 281 828 459 045 235 γ = 0.577 215 664 901 532 861

1 in = 2.54 cm	1 newton = 10^5 dyne	1 coulomb = $2.997\,924\,58\times10^9$ esu	1 tropical year ≃ $3.155\,69\times10^7$ s
1 Å = 10^{-8} cm	1 joule = 10^7 erg	1 tesla = 10^4 gauss	1 light year = $9.460\,528\times10^{17}$ cm
1 fm = 10^{-13} cm	1 eV = $1.602\,189\,2\times10^{-12}$ erg	1 atm. = $1.013\,25\times10^6$ dyne/cm^2	1 parsec = 3.261 633 light year
1 barn = 10^{-24} cm^2	1 eV/c^2 = $1.782\,676\times10^{-33}$ g	0°C = 273.15 K	1 astro. unit = $1.495\,979\times10^{13}$ cm

* Revised 1984 by Barry N. Taylor, based mainly on the "1973 Least-Squares Adjustment of the Fundamental Constants," by E.R. Cohen and B.N. Taylor, J. Phys. Chem. Ref. Data 2, 663 (1973). The figures in parentheses give the 1-standard-deviation uncertainties in the last digits of the main numbers; the uncertainties in parts per million (ppm) are given in the last column. The uncertainties of the output values of a least-squares adjustment are in general correlated, and the laws of error propagation must be used in calculating additional quantities.

The set of constants resulting from the 1973 adjustment of Cohen and Taylor has been recommended for international use by CODATA (Committee on Data for Science and Technology), and is the most up-to-date, generally accepted set currently available. Since the publication of the 1973 adjustment, new experiments have yielded better values for some of the constants: $N_A = 6.022\,097\,8(63)\times10^{23}$ mol^{-1} (1.04 ppm); $\alpha^{-1} = 137.035\,963(15)$ (0.11 ppm); and $m_p/m_e = 1836.152\,470(79)$ (0.043 ppm). However, since a change in the measured value of one constant usually leads to changes in the adjusted values of others, one must be cautious in using together the values from the 1973 adjustment and the results of more recent experiments.

A new adjustment of the fundamental constants is planned for completion in 1984.

** In October 1983, the Conférence Générale des Poids et Mesures adopted a new definition of the meter. The meter is the length of the path traveled by light in vacuum during a time interval of 1/299 792 458 s. Thus the speed of light is *defined* to be 299 792 458 m/s. For a discussion of this change, see B.W. Petley, Nature **303**, 373 (1983).

CLEBSCH-GORDAN COEFFICIENTS, SPHERICAL HARMONICS, AND D FUNCTIONS

Note: A $\sqrt{\ }$ is to be understood over every coefficient; e.g., for -8/15 read $-\sqrt{8/15}$.

Notation:

J J ...	
M M ...	
m_1 m_2	Coefficients
m_1 m_2	
. .	
. .	

$Y_1^0 = \sqrt{\frac{3}{4\pi}}\cos\theta$

$Y_1^1 = -\sqrt{\frac{3}{8\pi}}\sin\theta\, e^{i\phi}$

$Y_2^0 = \sqrt{\frac{5}{4\pi}}\left(\frac{3}{2}\cos^2\theta - \frac{1}{2}\right)$

$Y_2^1 = -\sqrt{\frac{15}{8\pi}}\sin\theta\cos\theta\, e^{i\phi}$

$Y_2^2 = \frac{1}{4}\sqrt{\frac{15}{2\pi}}\sin^2\theta\, e^{2i\phi}$

$Y_\ell^{-m} = (-1)^m Y_\ell^{m*}$

$d^\ell_{m,0} = \sqrt{\frac{4\pi}{2\ell+1}}\, Y_\ell^m e^{-im\phi}$

$\langle j_1 j_2 m_1 m_2 | j_1 j_2 J M\rangle = (-1)^{J - j_1 - j_2}\langle j_2 j_1 m_2 m_1 | j_2 j_1 J M\rangle$

$d^j_{m',m} = (-1)^{m-m'} d^j_{m,m'} = d^j_{-m,-m'}$

$d^{1/2}_{1/2,1/2} = \cos\frac{\theta}{2}$ $\quad d^{1/2}_{1/2,-1/2} = -\sin\frac{\theta}{2}$

$d^1_{1,1} = \frac{1+\cos\theta}{2}$ $\quad d^1_{1,0} = -\frac{\sin\theta}{\sqrt{2}}$ $\quad d^1_{1,-1} = \frac{1-\cos\theta}{2}$ $\quad d^1_{0,0} = \cos\theta$

$d^{3/2}_{3/2,3/2} = \frac{1+\cos\theta}{2}\cos\frac{\theta}{2}$

$d^{3/2}_{3/2,1/2} = -\sqrt{3}\,\frac{1+\cos\theta}{2}\sin\frac{\theta}{2}$ $\quad d^2_{2,2} = \left(\frac{1+\cos\theta}{2}\right)^2$

$d^{3/2}_{3/2,-1/2} = \sqrt{3}\,\frac{1-\cos\theta}{2}\cos\frac{\theta}{2}$ $\quad d^2_{2,1} = -\frac{1+\cos\theta}{2}\sin\theta$

$d^{3/2}_{3/2,-3/2} = -\frac{1-\cos\theta}{2}\sin\frac{\theta}{2}$ $\quad d^2_{2,0} = \frac{\sqrt{6}}{4}\sin^2\theta$ $\quad d^2_{1,1} = \frac{1+\cos\theta}{2}(2\cos\theta-1)$

$d^{3/2}_{1/2,1/2} = \frac{3\cos\theta-1}{2}\cos\frac{\theta}{2}$ $\quad d^2_{2,-1} = -\frac{1-\cos\theta}{2}\sin\theta$ $\quad d^2_{1,0} = -\sqrt{\frac{3}{2}}\sin\theta\cos\theta$

$d^{3/2}_{1/2,-1/2} = -\frac{3\cos\theta+1}{2}\sin\frac{\theta}{2}$ $\quad d^2_{2,-2} = \left(\frac{1-\cos\theta}{2}\right)^2$ $\quad d^2_{1,-1} = \frac{1-\cos\theta}{2}(2\cos\theta+1)$ $\quad d^2_{0,0} = \left(\frac{3}{2}\cos^2\theta - \frac{1}{2}\right)$

Sign convention is that of Wigner (*Group Theory*, Academic Press, New York, 1959), also used by Condon and Shortley (*The Theory of Atomic Spectra*, Cambridge Univ. Press, New York, 1953), Rose (*Elementary Theory of Angular Momentum*, Wiley, New York, 1957), and Cohen (*Tables of the Clebsch-Gordan Coefficients*, North American Rockwell Science Center, Thousand Oaks, Calif., 1974). The signs and numbers in the current tables have been calculated by computer programs written independently by Cohen and at LBL. (Table extended April 1974.)

SU(3) ISOSCALAR FACTORS

The most commonly used isoscalar factors, corresponding to the singlet, octet, and decuplet content of $8 \otimes 8$ and $10 \otimes 8$, are displayed at the right. The notation uses particle names to identify the coefficients, so that the pattern of relative couplings can be seen at a glance. We illustrate the use of the coefficients by example; see J.J de Swart, Rev. Mod Phys. 35, 916 (1963) for detailed explanation and phase conventions.

A $\sqrt{\ }$ *is understood over every integer in the matrices;* the exponent ½ is a reminder of this. For example, in de Swart's notation the $\Xi \to \Omega K$ element of our $10 \to 10 \otimes 8$ matrix reads

$$\left[\begin{array}{cc|c} 10 & 8 & 10 \\ 0 & -2 & \tfrac{1}{2}\ 1 \quad \tfrac{1}{2}\ -1 \end{array}\right] = \frac{-\sqrt{6}}{\sqrt{24}}\,.$$

Intramultiplet relative decay strengths can be read directly from our matrices. Thus, the partial widths for $\Delta \to (N\pi)_{I=3/2}$ and $\Omega^* \to (\Xi\bar{K})_{I=0}$ are in the ratio

$$\frac{\Gamma(\Omega^* \to (\Xi\bar{K})_{I=0})}{\Gamma(\Delta \to (N\pi)_{I=3/2})} = \frac{12}{6} \times \text{(phase space factors)}\,.$$

Supplying isospin Clebsch-Gordan coefficients, one obtains, e.g.,

$$\frac{\Gamma(\Omega^{*-} \to \Xi^0 K^-)}{\Gamma(\Delta^+ \to p\pi^0)} = \frac{1/2}{2/3} \times \frac{12}{6} \times \text{p.s.f.} = \frac{3}{2} \times \text{p.s.f.}$$

Partial widths for $8 \to 8 \otimes 8$ involve a linear superposition of 8_1 (symmetric) and 8_2 (antisymmetric) couplings. For example,

$$\Gamma(\Xi^* \to \Xi\pi) \sim \left(-\sqrt{\frac{9}{20}}g_1 + \sqrt{\frac{3}{12}}g_2\right)^2.$$

The relation between g_1, g_2 (with de Swart's normalization) and the standard D,F couplings appearing in the interaction Lagrangian,

$$\mathscr{L} = -\sqrt{2}D\,\mathrm{Tr}([\bar{B},B]_+M) + \sqrt{2}F\,\mathrm{Tr}([\bar{B},B]_-M)\,,$$

is

$$D = \frac{\sqrt{30}}{40}g_1\,,\quad F = \frac{\sqrt{6}}{24}g_2\,.$$

Thus,

$$\Gamma(\Xi^* \to \Xi\pi) \sim (1-2\alpha)^2$$

where $\alpha \equiv D/(D+F)$.

$1 \to 8 \otimes 8$

$$(\Lambda)_1 \to \begin{pmatrix} N\bar{K} & \Sigma\pi & \Lambda\eta & \Xi K \end{pmatrix}_{8\otimes 8} = \frac{1}{\sqrt{8}} \begin{pmatrix} 2 & 3 & -1 & -2 \end{pmatrix}^{\frac{1}{2}}$$

$8_1 \to 8 \otimes 8$

$$\begin{pmatrix} N \\ \Sigma \\ \Lambda \\ \Xi \end{pmatrix}_{8_1} \to \begin{pmatrix} N\pi & N\eta & \Sigma K & \Lambda K \\ N\bar{K} & \Sigma\pi & \Lambda\pi & \Sigma\eta & \Xi K \\ N\bar{K} & \Sigma\pi & \Lambda\eta & \Xi K \\ \Sigma\bar{K} & \Lambda\bar{K} & \Xi\pi & \Xi\eta \end{pmatrix}_{8\otimes 8} = \frac{1}{\sqrt{20}} \begin{pmatrix} 9 & -1 & -9 & -1 \\ -6 & 0 & 4 & 4 & -6 \\ 2 & -12 & -4 & -2 \\ 9 & -1 & -9 & -1 \end{pmatrix}^{\frac{1}{2}}$$

$8_2 \to 8 \otimes 8$

$$\begin{pmatrix} N \\ \Sigma \\ \Lambda \\ \Xi \end{pmatrix}_{8_2} \to \begin{pmatrix} N\pi & N\eta & \Sigma K & \Lambda K \\ N\bar{K} & \Sigma\pi & \Lambda\pi & \Sigma\eta & \Xi K \\ N\bar{K} & \Sigma\pi & \Lambda\eta & \Xi K \\ \Sigma\bar{K} & \Lambda\bar{K} & \Xi\pi & \Xi\eta \end{pmatrix}_{8\otimes 8} = \frac{1}{\sqrt{12}} \begin{pmatrix} 3 & 3 & 3 & -3 \\ 2 & 8 & 0 & 0 & -2 \\ 6 & 0 & 0 & 6 \\ 3 & 3 & 3 & -3 \end{pmatrix}^{\frac{1}{2}}$$

$10 \to 8 \otimes 8$

$$\begin{pmatrix} \Delta \\ \Sigma \\ \Xi \\ \Omega \end{pmatrix}_{10} \to \begin{pmatrix} & N\pi & & \Sigma K & \\ N\bar{K} & \Sigma\pi & \Lambda\pi & \Sigma\eta & \Xi K \\ \Sigma\bar{K} & \Lambda\bar{K} & \Xi\pi & \Xi\eta & \\ & & \Xi\bar{K} & & \end{pmatrix}_{8\otimes 8} = \frac{1}{\sqrt{12}} \begin{pmatrix} & -6 & & 6 & \\ -2 & 2 & -3 & 3 & 2 \\ & 3 & -3 & 3 & 3 \\ & & 12 & & \end{pmatrix}^{\frac{1}{2}}$$

$8 \to 10 \otimes 8$

$$\begin{pmatrix} N \\ \Sigma \\ \Lambda \\ \Xi \end{pmatrix}_{8} \to \begin{pmatrix} & \Delta\pi & \Sigma K & \\ \Delta\bar{K} & \Sigma\pi & \Sigma\eta & \Xi K \\ & \Sigma\pi & \Xi K & \\ \Sigma\bar{K} & \Xi\pi & \Xi\eta & \Omega K \end{pmatrix}_{10\otimes 8} = \frac{1}{\sqrt{15}} \begin{pmatrix} & -12 & 3 & \\ 8 & -2 & -3 & 2 \\ & -9 & 6 & \\ 3 & -3 & -3 & 6 \end{pmatrix}^{\frac{1}{2}}$$

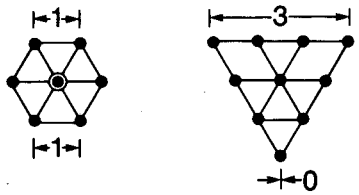
$10 \to 10 \otimes 8$

$$\begin{pmatrix} \Delta \\ \Sigma \\ \Xi \\ \Omega \end{pmatrix}_{10} \to \begin{pmatrix} \Delta\pi & \Delta\eta & \Sigma K \\ \Delta\bar{K} & \Sigma\pi & \Sigma\eta & \Xi K \\ \Sigma\bar{K} & \Xi\pi & \Xi\eta & \Omega K \\ & \Xi\bar{K} & \Omega\eta & \end{pmatrix}_{10\otimes 8} = \frac{1}{\sqrt{24}} \begin{pmatrix} 15 & 3 & -6 \\ 8 & 8 & 0 & -8 \\ 12 & 3 & -3 & -6 \\ & 12 & -12 & \end{pmatrix}^{\frac{1}{2}}$$

SU(N) MULTIPLETS AND YOUNG DIAGRAMS

This note tells how SU(n) particle multiplets are identified or labeled, how to find the number of particles in a multiplet from its label, how to draw the Young diagram for a multiplet, and how to use Young diagrams to determine the overall multiplet structure of a composite system, such as a 3-quark or a meson-baryon system.

(1) **Multiplet labels** — An SU(n) multiplet is uniquely identified by a string of (n−1) nonnegative integers: $(\alpha,\beta,\gamma,\cdots)$. Any such set of integers specifies a multiplet. For an SU(2) multiplet such as an isospin multiplet, the single integer α is the number of *steps* from one end of the multiplet to the other (i.e., it is one fewer than the number of particles in the multiplet). In SU(3), the two integers α and β are the numbers of steps across the top and bottom levels of the multiplet diagram. Thus the labels for the SU(3) octet and decuplet



are (1,1) and (3,0). For larger n, the interpretation of the integers in terms of the geometry of the multiplets, which exist in an (n−1)-dimensional space, is not so readily apparent.

The label for the SU(n) singlet is (0,0,...,0). In a flavor SU(n), the n quarks together form a (1,0,...,0) multiplet, and the n antiquarks belong to a (0,...,0,1) multiplet. These two multiplets are *conjugate* to one another, which means their labels are related by $(\alpha,\beta,\ldots) \longleftrightarrow (\ldots,\beta,\alpha)$.

(2) **Number of particles** — The number of particles in a multiplet, $N = N(\alpha,\beta,\ldots)$, is given as follows (note the pattern of the equations). In SU(2), $N = N(\alpha)$ is

$$N = \frac{(\alpha+1)}{1}\,.$$

In SU(3), $N = N(\alpha,\beta)$ is

$$N = \frac{(\alpha+1)}{1}\cdot\frac{(\beta+1)}{1}\cdot\frac{(\alpha+\beta+2)}{2}\,.$$

In SU(4), $N = N(\alpha,\beta,\gamma)$ is

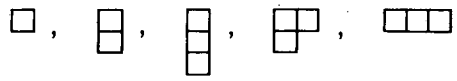
$$N = \frac{(\alpha+1)}{1}\cdot\frac{(\beta+1)}{1}\cdot\frac{(\gamma+1)}{1}\cdot\frac{(\alpha+\beta+2)}{2}\cdot\frac{(\beta+\gamma+2)}{2}\cdot\frac{(\alpha+\beta+\gamma+3)}{3}\,.$$

Note that there is no factor with $(\alpha+\gamma+2)$: only a *consecutive* sequence of the label integers appears in any factor. One more example should make the pattern clear for any SU(n). In SU(5), $N = N(\alpha,\beta,\gamma,\delta)$ is

$$N = \frac{(\alpha+1)}{1}\cdot\frac{(\beta+1)}{1}\cdot\frac{(\gamma+1)}{1}\cdot\frac{(\delta+1)}{1}\cdot\frac{(\alpha+\beta+2)}{2}\cdot\frac{(\beta+\gamma+2)}{2}\times$$
$$\frac{(\gamma+\delta+2)}{2}\cdot\frac{(\alpha+\beta+\gamma+3)}{3}\cdot\frac{(\beta+\gamma+\delta+3)}{3}\cdot\frac{(\alpha+\beta+\gamma+\delta+4)}{4}\,.$$

Multiplets that are conjugate to one another obviously have the same number of particles, but so can other multiplets. For example, the SU(4) multiplets (3,0,0) and (1,1,0) each have 20 particles.

(3) **Young diagrams** — A Young diagram consists of an array of boxes (or some other symbol) arranged in one or more *left-justified* rows, with each row being *at least as long* as the row beneath. The correspondence between a diagram and a multiplet label is: The top row juts out α boxes to the right past the end of the second row, the second row juts out β boxes to the right past the end of the third row, etc. A diagram in SU(n) has at most n rows. There can be any number of "completed" columns of n boxes buttressing the left of a diagram; these don't affect the label. Thus in SU(3) the diagrams



represent the multiplets (1,0), (0,1), (0,0), (1,1), and (3,0). In any SU(n), the quark multiplet is represented by a single box, the antiquark multiplet by a column of (n−1) boxes, and a singlet by a completed column of n boxes.

(4) **Coupling multiplets together** — The following recipe tells how to find the multiplets that occur in coupling two multiplets together. To couple together more than two multiplets, first couple two, then couple the third with each of the multiplets obtained from the first two, etc.

First a definition: A sequence of the letters *a,b,c,...* is *admissible* if at any point in the sequence at least as many *a*'s have been reached as *b*'s, at least as many *b*'s have been reached as *c*'s, etc. Thus *abcd* and *aabcb* are admissible sequences and *abb* and *acb* are not. Now the recipe:

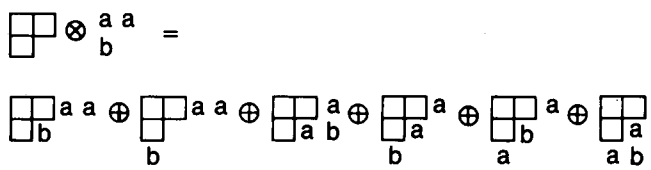
(a) Draw the Young diagrams for the two multiplets, but in one of the diagrams replace the boxes in the first row with *a*'s, the boxes in the second row with *b*'s, etc. The unlettered diagram forms the *upper left-hand corner* of all the enlarged diagrams constructed below.

(b) Add the *a*'s from the lettered diagram to the unlettered diagram to form all possible legitimate Young diagrams that have no more than one *a* per column. (All the *a*'s appear in each new diagram.)

(c) Use the *b*'s to further enlarge the diagrams already obtained, subject to the same rules. Throw away any diagram in which the sequence of letters formed by reading *right to left* in the first row, then the second row, etc., is not admissible.

(d) Proceed as in (c) with the *c*'s, etc.

Thus, for example, the calculation to find the multiplets that can occur in a system made up of two SU(3) octets (one might be the π-meson octet, the other the N-baryon octet) is as follows:



where only the diagrams with admissible sequences and with fewer than four rows (since n = 3) have been kept. In terms of multiplet labels, the above may be written

$$(1,1)\otimes(1,1) = (2,2)\oplus(3,0)\oplus(0,3)\oplus(1,1)\oplus(1,1)\oplus(0,0)\,,$$

or in terms of numbers of particles,

$$\mathbf{8}\otimes\mathbf{8} = \mathbf{27}\oplus\mathbf{10}\oplus\overline{\mathbf{10}}\oplus\mathbf{8}\oplus\mathbf{8}\oplus\mathbf{1}\,.$$

The product of the numbers of the left is equal to the sum on the right. (See the section on the Nonrelativistic Quark Model for results for 3-quark systems.)

TESTS OF CONSERVATION LAWS*

INTRODUCTION

In response to the current interest in tests of conservation laws, we have made a list of experimental limits on all weak and electromagnetic decays, mass differences, and moments, whose observation would violate conservation laws. The list is in two parts, "Number Conservation Laws," i.e., lepton, baryon, hadronic flavor, and charge conservation, and "Discrete Space Time Symmetries," i.e. C, P, T, CP, and CPT. The references for these data can be found in the Stable Particle Section of the Data Card Listings in this Review. A discussion of these tests follows.

CONSERVATION OF LEPTON NUMBERS

Present experimental evidence and the standard electroweak theory are consistent with the absolute conservation of three separate lepton numbers: electron number L_e, muon number L_μ, and τ-number L_τ. Searches for violations are of the following types:

a) $\Delta L = 2$ for one type of lepton. The best limit comes from the search for neutrinoless double beta decay $(Z,A) \to (Z+2,A) + e^- + e^-$. The best laboratory limit is $t_{1/2} > 2\times10^{22}$ yr for ^{76}Ge [E. Bellotti et al., Phys. Lett. **121B**, 72 (1983)].

b) Conversion of one lepton type to another. For purely leptonic processes, the best limit is on $\mu \to e\gamma$. For semileptonic processes, the best limit comes from the coherent conversion process in a muonic atom $\mu^- + (Z,A) \to e^- + (Z,A)$. Of special interest is the case in which the hadronic flavor also changes, as in $K_L \to \mu^\pm e^\mp$. Limits on the conversion of τ into e or μ are found in τ decay and are much less stringent that those for $\mu \to e$ conversion.

c) Conversion of one type of lepton into another type of antilepton. The case most studied is $\mu^- + (Z,A) \to e^+ + (Z-2,A)$.

d) Relation to neutrino mass. If neutrinos have masses then it is expected even in the standard electroweak theory that separate lepton numbers are not conserved. With small neutrino masses this would be observed first in neutrino oscillations which have been the subject of extensive experimental searches. If the $\Delta L = 2$ type of violation occurs, it is expected that neutrinos will have a nonzero mass of the Majorana type.

CONSERVATION OF HADRONIC FLAVORS

The conversion of quarks of a given charge, (d,s,b) or (u,c,t), into one another is forbidden in strong and electromagnetic interactions by the conservation of hadron flavors: S (strangeness), C (charm), B (bottomness), and T (topness). The weak interactions violate these conservation laws as a result of the Cabibbo or Kobayashi-Maskawa mixing (see Appendix III in the complete Review of Particle Properties). The way in which these conservation laws are violated is tested as follows:

a) $\Delta S = \Delta Q$ rule. In the semileptonic decay of strange particles, the strangeness change equals the change in charge of the hadrons. Tests come from limits on decay rates such as $\Sigma^+ \to ne^+\nu$ and from a detailed analysis of $K_L \to \pi e\nu$, which yields the parameter x. A corresponding rule for charm decays is $\Delta C = \Delta Q$.

b) Change of flavor by 2 units. In the standard model this occurs only in second-order weak interactions. The one example for which this has been measured is the $\Delta S = 2$ $K^0 - \overline{K}^0$ mixing, which is directly measured by $m(K_S) - m(K_L)$. A limit on the $\Delta C = 2$ $D^0 - \overline{D}^0$ mixing provides a limit on $|m(D_1^0) - m(D_2^0)|$.

c) Flavor-changing neutral-currents. In the standard model the neutral-current interactions do not change flavor. The low rate of $K_L \to \mu^+\mu^-$ puts limits on such interactions; the nonzero value for this rate is attributed to a combination of the weak and electromagnetic interactions. The best test should come from a limit on $K^+ \to \pi^+\nu\overline{\nu}$, which occurs in the standard model only as a second-order weak process with a branching fraction of 10^{-10} to 10^{-11}. Limits for charm-changing or bottom-changing neutral currents are much less stringent.

CPT INVARIANCE

General principles of relativistic field theory require invariance under the combined transformation CPT. The simplest tests of CPT invariance are the equality of the masses and lifetimes of a particle and its antiparticle. The best test comes from a limit on the mass difference between K^0 and $\overline{K}^0$. Any such mass difference contributes to the CP-violating parameter ϵ. In fact ϵ can be explained by a CPT-conserving but CP-violating mixing of K^0 and $\overline{K}^0$, which yields a prediction that $\phi_{+-} \approx 44°$, while a $K^0 - \overline{K}^0$ mass difference would yield $\phi_{+-} \approx 44° + 90°$. It is thus possible to deduce that $|m(K^0) - m(\overline{K}^0)| < 10^{-4}|m(K_S) - m(K_L)| < 3\times10^{-10}$ eV. Also, an upper limit on $|m(D^0)-m(\overline{D}^0)|$ can be derived from the bound $|m(D_1^0)-m(D_2^0)| < 0.65\times10^{-9}$ MeV (inferred from bound on $D^0 \to \overline{D}^0 \to \mu^-$ anything), given an input value of, or bound on, the CP-violation parameter ϵ for $D^0-\overline{D}^0$ mixing.

CP AND T INVARIANCE

Given CPT invariance, CP violation and T violation are equivalent. So far the only evidence for CP or T violation comes from the measurements of η_{+-}, η_{00}, and the semileptonic decay charge asymmetry for K_L. Other searches for CP or T violation should be divided into (a) those that involve weak interactions or parity violation, and (b) those that involve processes allowed by the strong or electromagnetic interactions. In class (a) the most sensitive is probably the search for an electric dipole moment of the neutron, which requires both P and T violation to be nonzero. Class (b) searches involve looking for C or T violation in strong or electromagnetic processes. Examples are the search for C violation in η decay, believed to be an electromagnetic process, and the search for T violation in a number of nuclear and electromagnetic reactions.

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* Prepared April 1984 by R.E. Shrock, T.G. Trippe, and L. Wolfenstein.

TESTS OF CONSERVATION LAWS (Cont'd)

Number Conservation Laws

Quantity[a]	Value[b]	Conservation Law Tested
$\mu^+ \to e^+\bar{\nu}_e\nu_\mu$ / all	$< 5 \times 10^{-2}$	Lepton family number[c,d]
$\to e^+\gamma$ / all	$< 1.7 \times 10^{-10}$	Lepton family number[d]
$\to e^+e^+e^-$ / all	$< 1.9 \times 10^{-9}$	" " "
$\to e^+\gamma\gamma$ / all	$< 8.4 \times 10^{-9}$	" " "
$\mu^- S_{32} \to e^- S_{32}$ / all	$< 7 \times 10^{-11}$	" " "
coupling for $(\mu^+e^- \to \mu^-e^+)_{bound}$	$< 42\ G_F$	" " "
$\tau^+ \to \mu^+\gamma$ / all	$< 5.5 \times 10^{-4}$	" " "
$\to e^+\gamma$ / all	$< 6.4 \times 10^{-4}$	" " "
$\to \mu^+\mu^+\mu^-$ / all	$< 4.9 \times 10^{-4}$	" " "
$\to e^+\mu^+\mu^-$ / all	$< 3.3 \times 10^{-4}$	" " "
$\to \mu^+e^+e^-$ / all	$< 4.4 \times 10^{-4}$	" " "
$\to e^+e^+e^-$ / all	$< 4.0 \times 10^{-4}$	" " "
$\to \mu^+\pi^0$ / all	$< 8.2 \times 10^{-4}$	" " "
$\to e^+\pi^0$ / all	$< 2.1 \times 10^{-3}$	" " "
$\to \mu^+K^0$ / all	$< 1.0 \times 10^{-3}$	" " "
$\to e^+K^0$ / all	$< 1.3 \times 10^{-3}$	" " "
$\to \mu^+\rho^0$ / all	$< 4.4 \times 10^{-4}$	" " "
$\to e^+\rho^0$ / all	$< 3.7 \times 10^{-4}$	" " "
$\pi^+ \to \mu^+\nu_e$ / all	$< 8.0 \times 10^{-3}$[e]	" " "
$K^+ \to \pi^+e^+\mu^-$ / all	$< 7 \times 10^{-9}$	" " "
$\to \pi^+e^-\mu^+$ / all	$< 5 \times 10^{-9}$	" " "
$\to \mu^+\nu_e$ / all	$< 4 \times 10^{-3}$[e]	" " "
$\to \mu^-\nu e^+e^+$ / all	$< 2 \times 10^{-8}$	" " "
$K_L^0 \to e\mu$ / charged	$< 8 \times 10^{-6}$	" " "
ν oscillations and lepton mixing effects in particle decays	See Data Card Listings	" " "
$\mu^- S_{32} \to e^+ Si^*_{32}$ / all	$< 9 \times 10^{-10}$	Total lepton number[f]
$\mu^- I_{127} \to e^+ Sb^{stable}_{127}$ / all	$< 3 \times 10^{-10}$	" " "
$\pi^+ \to \mu^+\bar{\nu}_e$ / all	$< 1.5 \times 10^{-3}$[e]	" " "
$K^+ \to \pi^-e^+e^+$ / all	$< 1 \times 10^{-8}$	" " "
$\to \pi^-e^+\mu^+$ / all	$< 7 \times 10^{-9}$	" " "
$\to \mu^+\bar{\nu}_e$ / all	$< 3.3 \times 10^{-3}$[e]	" " "
$\to e^+\pi^0\bar{\nu}_e$ / all	$< 3 \times 10^{-3}$[e]	" " "
neutrinoless double beta decay	See Data Card Listings	" " "
τ_p / BR$(p \to e^+\pi^0)$	$< 1 \times 10^{32}$ years	Baryon number
mean time for $n \to \bar{n}$ trans.	> 1.0 year	" "
e mean life	$> 2 \times 10^{22}$ years	Charge
$n \to p\nu\bar{\nu}$ / $pe^-\bar{\nu}$	$< 9 \times 10^{-24}$	"
Re x from $K^0 \to \pi e\nu$	0.009 ± 0.020	$\Delta S = \Delta Q$[g]
Im x from $K^0 \to \pi e\nu$	-0.004 ± 0.026	"
$K^+ \to \pi^+\pi^+e^-\nu$ / all	$< 1.2 \times 10^{-8}$	"
$\to \pi^+\pi^+\mu^-\nu$ / all	$< 3 \times 10^{-6}$	"
$\Sigma^+ \to ne^+\nu$ / all	$< 5 \times 10^{-6}$	"
$\to n\mu^+\nu$ / all	$< 3 \times 10^{-5}$	"
$(\Sigma^+ \to n\ell^+\nu)/(\Sigma^- \to n\ell^-\bar{\nu})$	< 0.04	"
$\Xi^0 \to \Sigma^-e^+\nu$ / all	$< 9 \times 10^{-4}$	"
$\to \Sigma^-\mu^+\nu$ / all	$< 9 \times 10^{-4}$	"
$\to pe^-\nu$ / all	$< 1.3 \times 10^{-3}$	$\Delta S = 2$ forbidden[g]
$\to p\mu^-\nu$ / all	$< 1.3 \times 10^{-3}$	" "
$\Xi^- \to ne^-\nu$ / all	$< 3.2 \times 10^{-3}$	" "
$\to n\mu^-\nu$ / all	$< 1.5 \times 10^{-2}$	" "
$\to p\pi^-e^-\nu$ / all	$< 4 \times 10^{-4}$	" "
$\to p\pi^-\mu^-\nu$ / all	$< 4 \times 10^{-4}$	" "
$\Xi^0 \to p\pi^-$ / all	$< 3.6 \times 10^{-5}$	" "
$\Xi^- \to n\pi^-$ / all	$< 1.9 \times 10^{-5}$	" "
$\to p\pi^-\pi^-$ / all	$< 4 \times 10^{-4}$	" "
$\Omega^- \to \Lambda\pi^-$ / all	$< 3.1 \times 10^{-3}$	" "
$m_{K_L} - m_{K_S}$	$(3.521 \pm 0.014) \times 10^{-12}$ MeV	" "
$(D^0 \to \bar{D}^0 \to K^+\pi^-)/(D^0 \to K\pi)$	< 0.16	$\Delta C = 2$ forbidden[g]
$(D^0 \to \bar{D}^0 \to \mu^-$ anything$)/(D^0 \to \mu^+$ anything$)$	< 0.044	" "
$\lvert m_{D_1^0} - m_{D_2^0} \rvert$ (from previous limit)	$< 6.5 \times 10^{-10}$ MeV	" "
$K_L^0 \to \mu^+\mu^-$ / all	$(9.1 \pm 1.9) \times 10^{-9}$	no flav. chng. neut. curr.
$\to e^+e^-$ / all	$< 2.0 \times 10^{-7}$	" " " " "
$\to \mu^+\mu^-\gamma$ / all	$(2.8 \pm 2.8) \times 10^{-7}$	" " " " "
$\to e^+e^-\gamma$ / all	$(1.7 \pm 0.9) \times 10^{-5}$	" " " " "
$\to \pi^0\mu^+\mu^-$ / all	$< 1.2 \times 10^{-6}$	" " " " "
$\to \pi^0e^+e^-$ / all	$< 2.3 \times 10^{-6}$	" " " " "
$\to \pi^+\pi^-e^+e^-$ / all	$< 9 \times 10^{-6}$	" " " " "
$K_S^0 \to \mu^+\mu^-$ / all	$< 3.2 \times 10^{-7}$	" " " " "
$\to e^+e^-$ / all	$< 3.4 \times 10^{-4}$	" " " " "
$K^+ \to \pi^+e^+e^-$ / all	$(2.7 \pm 0.5) \times 10^{-7}$	" " " " "
$\to \pi^+\mu^+\mu^-$ / all	$< 2.4 \times 10^{-6}$	" " " " "
$\to \pi^+\nu\bar{\nu}$ / all	$< 1.4 \times 10^{-7}$	" " " " "
$B \to e^+e^-$ anything / all	$< 8 \times 10^{-3}$	" " " " "
$\to \mu^+\mu^-$ anything / all	$< 7 \times 10^{-3}$	" " " " "

TESTS OF CONSERVATION LAWS (Cont'd)

Discrete Space Time Symmetries

Quantity[a]	Value[b]	Symmetry Tested or Violated
$\pi^0 \to \gamma\gamma\gamma$ / all	$< 3.8 \times 10^{-7}$	C
$(e^+e^-)_{J=1} \to \gamma\gamma\gamma$ / all	$(5 \pm 3) \times 10^{-4}$ [h]	C
$\eta \to e^+e^-\pi^0$ / all	$< 5 \times 10^{-5}$	C (single photon process)
$\eta \to \mu^+\mu^-\pi^0$ / all	$< 5 \times 10^{-6}$	C (single photon process)
$\eta \to \pi^+\pi^-\pi^0$ parameters:		
left-right asymmetry	$(1.2 \pm 1.7) \times 10^{-3}$	C
sextant asymmetry	$(1.9 \pm 1.6) \times 10^{-3}$	C
quadrant asymmetry	$(-1.7 \pm 1.7) \times 10^{-3}$	C
$\eta \to \pi^+\pi^-\gamma$ parameters:		
left-right asymmetry	$(8.8 \pm 4.0) \times 10^{-3}$	C
beta (D-wave)	0.047 ± 0.062	C
$\eta \to \pi^+\pi^-$ / all	$< 1.5 \times 10^{-3}$	P and CP
e electric dipole moment	$< 3 \times 10^{-24}$ e cm	T and P
μ electric dipole moment	$(3.7 \pm 3.4) \times 10^{-19}$ e cm	T and P
p electric dipole moment	$< 4 \times 10^{-21}$ e cm	T and P
n electric dipole moment	$(2.3 \pm 2.3) \times 10^{-25}$ e cm	T and P
Λ electric dipole moment	$< 1.5 \times 10^{-16}$ e cm	T and P
α' / a from $\mu \to e\bar{\nu}\nu$	-0.12 ± 0.10	T
β' / a from $\mu \to e\bar{\nu}\nu$	-0.029 ± 0.037	T
Im ξ in $K^{\pm}_{\mu 3}$ decay (from transverse μ pol.)	-0.017 ± 0.025	T
Im ξ in $K^0_{\mu 3}$ decay (from transverse μ pol.)	-0.020 ± 0.022	T
$\phi(g_A) - \phi(g_V)$ for n	$(180.11 \pm 0.17)°$	T (0° or 180°)
n 3-vector corr. coeff.	-0.0007 ± 0.0014	T
$K^{\pm} \to \pi^{\pm}\pi^+\pi^-$ rate difference / average	$(0.07 \pm 0.12)\%$	CP
$K^{\pm} \to \pi^{\pm}2\pi^0$ rate difference / average	$(-0.03 \pm 0.55)\%$	CP
$K^{\pm} \to \pi^{\pm}\pi^0\gamma$ rate difference / average	$(0.9 \pm 3.3)\%$	CP
$K \to 3\pi^{\pm}$ slope $(g^+ - g^-)$ / sum	$(-0.7 \pm 0.5)\%$	CP
$\lvert\eta_{+-0}\rvert^2 = \Gamma(K^0_S \to \pi^+\pi^-\pi^0)/\Gamma(K^0_L \to \pi^+\pi^-\pi^0)$	< 0.12	CP
$\lvert\eta_{000}\rvert^2 = \Gamma(K^0_S \to 3\pi^0)/\Gamma(K^0_L \to 3\pi^0)$	< 0.1	CP
Charge asymm. j in $K^0_L \to \pi^+\pi^-\pi^0$	0.0011 ± 0.0008	CP
$K^0_L \to (\mu^+\pi^-\nu - \mu^-\pi^+\nu)$ / sum	$(0.319 \pm 0.038)\%$	CP (violated)
$K^0_L \to (e^+\pi^-\nu - e^-\pi^+\nu)$ / sum	$(0.333 \pm 0.014)\%$	CP (violated)
$\lvert\eta_{00}\rvert = \lvert A(K^0_L \to \pi^0\pi^0)/A(K^0_S \to \pi^0\pi^0)\rvert$	$(2.33 \pm 0.08) \times 10^{-3}$	CP (violated)
$\lvert\eta_{+-}\rvert = \lvert A(K^0_L \to \pi^+\pi^-)/A(K^0_S \to \pi^+\pi^-)\rvert$	$(2.274 \pm 0.022) \times 10^{-3}$	CP (violated)
ϕ_{+-}: phase of η_{+-}	$(44.6 \pm 1.2)°$	CP (violated)
ϕ_{00}: phase of η_{00}	$(54 \pm 5)°$	CP (violated)
Re ϵ	$(1.621 \pm 0.088) \times 10^{-3}$	CP (violated)
$(g_{e^+} - g_{e^-})$ / average	$(2.2 \pm 6.4) \times 10^{-11}$	CPT
$(g_{\mu^+} - g_{\mu^-})$ / average	$(-2.6 \pm 1.6) \times 10^{-8}$	CPT
$(\mu_p - \mu_{\bar{p}})$ / average	$(-1 \pm 7) \times 10^{-3}$	CPT
$\pi^+ - \pi^-$ mass difference / average	$(2 \pm 5) \times 10^{-4}$	CPT
$K^+ - K^-$ mass difference / average	$(-0.6 \pm 1.8) \times 10^{-4}$	CPT
$\lvert K^0 - \bar{K}^0\rvert$ mass difference / average	$< 6 \times 10^{-19}$	CPT
$p - \bar{p}$ mass difference / average	$(7 \pm 4) \times 10^{-5}$	CPT
$\Lambda - \bar{\Lambda}$ mass difference / average	$(7 \pm 7) \times 10^{-6}$	CPT
$\Xi^- - \bar{\Xi}^+$ mass difference / average	$(1.1 \pm 2.7) \times 10^{-4}$	CPT
$\Omega^- - \bar{\Omega}^+$ mass difference / average	$(-4 \pm 6) \times 10^{-4}$	CPT
$\mu^+ - \mu^-$ mean life difference / average	$(3 \pm 8) \times 10^{-5}$	CPT
$\pi^+ - \pi^-$ mean life difference / average	$(5 \pm 7) \times 10^{-4}$	CPT
$K^+ - K^-$ mean life difference / average	$(1.1 \pm 0.9) \times 10^{-3}$	CPT
$\Lambda - \bar{\Lambda}$ mean life difference / average	$(4.4 \pm 8.5) \times 10^{-2}$	CPT
$\Xi^- - \bar{\Xi}^+$ mean life difference / average	(0.02 ± 0.18)	CPT
$K^{\pm} \to \mu^{\pm}\nu$ rate difference / average	$(-0.54 \pm 0.41)\%$	CPT
$K^{\pm} \to \pi^{\pm}\pi^0$ rate difference / average	$(0.8 \pm 1.2)\%$	CPT[i]

a. Branching fractions are described by a shorthand notation, e.g., "$\mu^+ \to e^+\gamma$/all" means $\Gamma(\mu^+ \to e^+\gamma)/\Gamma(\mu^+ \to \text{all})$.
b. Limits are given at 90% confidence level while errors are given as ±1 standard deviation.
c. Test of additive vs. multiplicative lepton family number conservation.
d. Lepton family number conservation means separate conservation of e-number, μ-number, and τ-number.
e. These limits are derived from the analysis of neutrino oscillation experiments.
f. Violation of total lepton number conservation also implies violation of lepton family number conservation.
g. Can be violated in second-order weak interactions.
h. Orthopositronium data are from Liu and Roberts, Phys. Rev. Lett. **16**, 67 (1966).
i. Neglecting photon channels. See, e.g., A. Pais and S.B. Treiman, Phys. Rev. **D12**, 2744 (1975).

KINEMATICS, DECAYS, AND SCATTERING

A. LORENTZ TRANSFORMATIONS

The energy E and three-momentum $\vec{p}$ of a particle form a four-vector $p = (E, \vec{p})$. Viewed from a second frame with velocity $\vec{v} = \beta c\hat{z}$ relative to the original frame, the components of p are $(E', \vec{p}')$, where

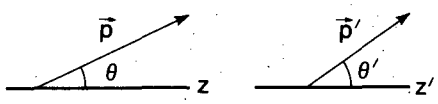
$$E' = \gamma E - \beta\gamma p_z ,$$

$$p_z' = \gamma p_z - \beta\gamma E ,$$

$$p_x' = p_x ; \; p_y' = p_y ,$$

and where $\gamma = (1-\beta^2)^{-1/2}$. It follows that the scalar product of two momenta, $p_1 \cdot p_2 = E_1E_2 - \vec{p}_1 \cdot \vec{p}_2$, is invariant, that is, frame independent.

If $\vec{p}$ makes an angle θ with the z-axis, then $\vec{p}'$ makes an angle θ' with the z-axis,



where

$$\tan\theta' = \frac{|\vec{p}|\sin\theta}{\gamma|\vec{p}|\cos\theta - \beta\gamma E} .$$

In particular, if the unprimed frame is the center of mass and the primed frame is the lab, and if the velocity of the center of mass in the lab frame is $\beta^*\hat{z}$, we use $\beta = -\beta^*$ above to find (denoting $p_{cm} = |\vec{p}_{cm}|$)

$$\tan\theta_{lab} = \frac{p_{cm}\sin\theta_{cm}}{\gamma^* p_{cm}\cos\theta_{cm} + \beta^*\gamma^* E_{cm}} .$$

If $\beta^* > p_{cm}/E_{cm}$, the particle is necessarily moving forward in the lab and

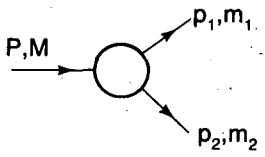
$$(\tan\theta_{lab})_{max} = \frac{p_{cm}}{\gamma^* E_{cm}} \frac{1}{\sqrt{\beta^{*2} - p_{cm}^2/E_{cm}^2}} .$$

We denote $p_\perp = p_\perp' = |\vec{p}|\sin\theta_{cm}$. Then given a fixed p_{cm} and E_{cm}, as, for example, in a two-to-two scattering process, as θ_{cm} varies from 0 to 2π the lab momentum describes an ellipse:

$$\frac{(p_z' - \beta^*\gamma^* E_{cm})^2}{\gamma^{*2} p_{cm}^2} + \frac{p_\perp'^2}{p_{cm}^2} = 1 .$$

B. DECAYS

B.1.a Two-body kinematics:



In the rest frame of the decaying particle,

$$E_1 = \frac{M^2 + m_1^2 - m_2^2}{2M} ,$$

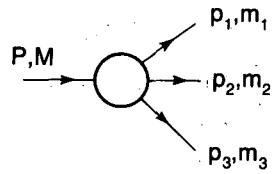
$$|\vec{p}_1| = \left[\frac{[M^2 - (m_1+m_2)^2][M^2 - (m_1-m_2)^2]}{4M^2}\right]^{1/2} .$$

B.1.b Two-body partial decay rate: If $\mathscr{M}$ is the Lorentz invariant matrix element (see Section D below), the partial decay rate in the rest frame of the decaying particle is

$$d\Gamma = \frac{1}{32\pi^2} |\mathscr{M}|^2 \frac{|\vec{p}_1|\, d\Omega}{M^2} ,$$

where $d\Omega$ is the differential solid angle in the rest frame of the decaying particle.

B.2.a Three-body kinematics:



We denote

$$p_{12} = p_1 + p_2 , \; m_{12}^2 = p_{12}^2 , \text{ etc.}$$

Then

$$m_{12}^2 + m_{23}^2 + m_{13}^2 = M^2 + m_1^2 + m_2^2 + m_3^2 .$$

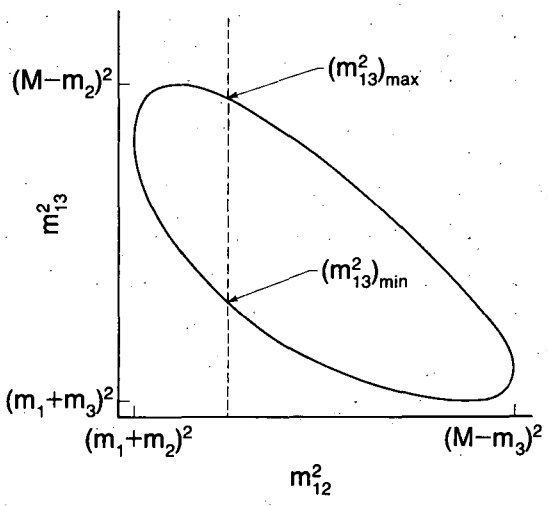
The invariant mass of the pair 1-2 is related to the energy of particle 3 in the rest frame of M,

$$m_{12}^2 = (P - p_3)^2 = M^2 + m_3^2 - 2ME_3 .$$

B.2.b Dalitz plot: If the orientation of the decaying particle is ignored, there are two kinematic variables, which may be chosen to be m_{12}^2 and m_{13}^2. For fixed m_{12}^2, the range of m_{13}^2 is determined by letting $\vec{p}_1$ be parallel or antiparallel to $\vec{p}_3$. In the rest frame of $(p_1 + p_2)$, the energy of particle 3 is $E_3^* = (M^2 - m_{12}^2 - m_3^2)/(2m_{12})$, and that of particle 1 is $E_1^* = (m_{12}^2 + m_1^2 - m_2^2)/(2m_{12})$. Thus for a given m_{12}^2,

$$(m_{13}^2)_{max} = (E_1^* + E_3^*)^2 - \left(\sqrt{E_1^{*2} - m_1^2} - \sqrt{E_3^{*2} - m_3^2}\right)^2$$

$$(m_{13}^2)_{min} = (E_1^* + E_3^*)^2 - \left(\sqrt{E_1^{*2} - m_1^2} + \sqrt{E_3^{*2} - m_3^2}\right)^2 .$$



The scatter plot in m_{12}^2 and m_{13}^2 is called a Dalitz plot. Phase space density is uniform across the plot. See below.

KINEMATICS, DECAYS, AND SCATTERING (Cont'd)

B.2.c Three-body phase space: Fixing the energies E_1 and E_2 of two of the final state particles in the M rest frame determines the relative orientation of the three outgoing particles. Their momenta may then be regarded as a rigid body whose orientation with respect to the initial particle is specified by the Euler angles α, β, and γ. The partial decay rate in the M rest frame is

$$d\Gamma = \frac{(2\pi)^{-5}}{16M} |\mathcal{M}|^2 \, dE_1 \, dE_2 \, d\alpha \, d\cos\beta \, d\gamma \, .$$

If the angles are integrated out, we have the Dalitz plot form,

$$d\Gamma = \frac{(2\pi)^{-3}}{8M} |\mathcal{M}|^2 \, dE_1 \, dE_2 = \frac{(2\pi)^{-3}}{32M^3} |\mathcal{M}|^2 \, dm_{12}^2 \, dm_{23}^2 \, .$$

An alternative expression is

$$d\Gamma = \frac{(2\pi)^{-5}}{16M^2} |\mathcal{M}|^2 \, |\vec{p}_1^{\,*}| \, |\vec{p}_3| \, dm_{12} \, d\Omega_1^* \, d\Omega_3 \, ,$$

where

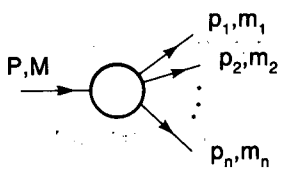
$$|\vec{p}_1^{\,*}| = \left[\frac{[m_{12}^2 - (m_1 + m_2)^2][m_{12}^2 - (m_1 - m_2)^2]}{4m_{12}^2} \right]^{1/2}$$

is the momentum of particle 1 in the rest frame of m_{12},

$$|\vec{p}_3| = \left[\frac{[M^2 - (m_{12} + m_3)^2][M^2 - (m_{12} - m_3)^2]}{4M^2} \right]^{1/2}$$

is the momentum of particle 3 in the M rest frame, $d\Omega_1^*$ is the solid angle element for particle 1 in the 1-2 rest frame, and $d\Omega_3$ is the solid angle element for particle 3 in the M rest frame.

B.3 n-body phase space:



The partial decay rate in the M rest frame is

$$d\Gamma = \frac{(2\pi)^4}{2M} |\mathcal{M}|^2 \, d\Phi_n(P; p_1, \cdots, p_n) \, ,$$

where

$$d\Phi_n(P; p_1, \cdots, p_n) = \delta^4(P - \sum_{i=1}^{n} p_i) \prod_{i=1}^{n} \frac{d^3 p_i}{(2\pi)^3 2E_i} \, .$$

In particular,

$$d\Phi_2(P; p_1, p_2) = (2\pi)^{-6} \frac{|\vec{p}_1^{\,*}|}{4M} d\Omega_1^* \, ,$$

where $|\vec{p}_1^{\,*}|$ is the momentum of particle 1 in the M rest frame and $d\Omega_1^*$ is the solid angle element in the same frame.

Phase space for n particles can be related to that for n−1 by treating particles 1 and 2 as a single system of momentum $p_{12} = p_1 + p_2$ and mass squared $m_{12}^2 = p_{12}^2$. Thus

$$d\Phi_n(P; p_1, p_2, \cdots, p_n) = d\Phi_{n-1}(P; p_{12}, p_3, \cdots, p_n)$$

$$\times d\Phi_2(p_{12}; p_1, p_2) \, (2\pi)^3 \, dm_{12}^2 \, .$$

C. SCATTERING

Throughout Section C, we set $\hbar = 1$, $c = 1$. Use $\hbar c = 197.3$ MeV fermi, and $(\hbar c)^2 = 0.3894$ GeV^2 mb for conversions.

C.1 Partial waves: The amplitude in the center of mass for elastic scattering of spinless particles may be written in a partial wave expansion

$$f(k,\theta) = \frac{1}{k} \sum_{\ell} (2\ell+1) \, a_\ell \, P_\ell(\cos\theta) \, ,$$

where k is the c.m. momentum, θ is the c.m. scattering angle, $a_\ell = (\eta_\ell e^{2i\delta_\ell} - 1)/2i$, $0 \leq \eta_\ell \leq 1$, and δ_ℓ is the phase shift of the ℓth partial wave. For purely elastic scattering, $\eta_\ell = 1$. The differential cross section is

$$\frac{d\sigma}{d\Omega} = |f(k,\theta)|^2 \, .$$

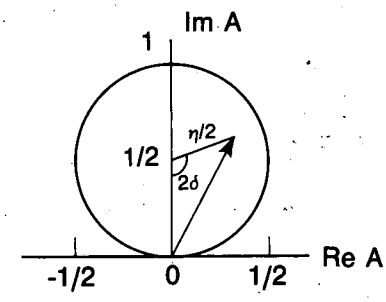
The optical theorem is

$$\sigma_{tot} = \frac{4\pi}{k} \, \mathrm{Im} \, f(k,0) \, ,$$

and the cross section in the ℓth partial wave is

$$\sigma_\ell = \frac{4\pi}{k^2} (2\ell + 1) \, |a_\ell|^2 \leq \frac{4\pi \, (2\ell + 1)}{k^2}$$

The partial-wave amplitude a_ℓ can be displayed in an Argand plot.



The usual Lorentz invariant matrix element $\mathcal{M}$ (see Section D below) for the elastic process is related to $f(k,\theta)$ by

$$\mathcal{M} = -8\pi\sqrt{s} \, f(k,\theta) \, ,$$

so

$$\sigma_{tot} = -\frac{1}{2k\sqrt{s}} \, \mathrm{Im}\mathcal{M}(t=0) \, ,$$

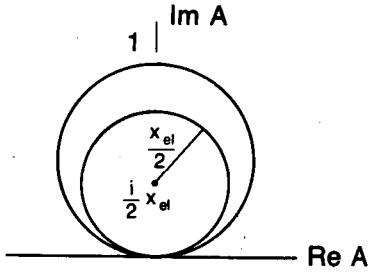
where s and t are the center-of-mass energy squared and momentum transfer squared, respectively (see Section C.3.a).

C.2 Resonances: The Breit-Wigner form for a_ℓ with a resonance at c.m. energy E_R, elastic width Γ_{el}, and total width Γ_{tot} is

$$a_\ell = \frac{\frac{1}{2}\Gamma_{el}}{E_R - E - \frac{i}{2}\Gamma_{tot}} \, ,$$

where E is the c.m. energy. This gives a circle in the Argand plot with center $ix_{el}/2$ and radius $x_{el}/2$, where $x_{el} = \Gamma_{el}/\Gamma_{tot}$. The quantity x_{el} is called the elasticity. The amplitude has a pole at $E = E_R - i\Gamma_{tot}/2$.

KINEMATICS, DECAYS, AND SCATTERING (Cont'd)

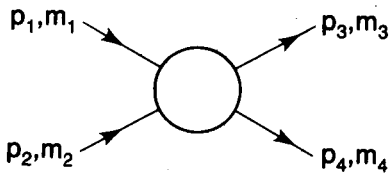


The Breit-Wigner cross section for a spin-J resonance produced in the collision of particles of spin S_1 and S_2 is

$$\sigma_{BW}(E) = \frac{(2J+1)}{(2S_1+1)(2S_2+1)}\,\frac{\pi}{k^2}\,\frac{B_{in}B_{out}\Gamma_{tot}^2}{(E-E_R)^2+\Gamma_{tot}^2/4},$$

where k is the c.m. momentum, E is the c.m. energy, and B_{in} and B_{out} are the branching fractions of the resonance into the entrance and exit channels. The 2S + 1 factors are the multiplicities of the incident spin states, so they are replaced by 2 for photons, etc.

C.3.a Two-body scattering kinematics:



In the center of mass,

$$E_{1cm} = \frac{s+m_1^2-m_2^2}{2\sqrt{s}},$$

$$p_{1cm} = \left[\frac{[s-(m_1+m_2)^2][s-(m_1-m_2)^2]}{4s}\right]^{1/2}$$

$$= \frac{p_{1lab}m_2}{\sqrt{s}},$$

where $\sqrt{s}$ is the total c.m. energy. The Lorentz invariant Mandelstam variables are

$$s = (p_1+p_2)^2 = (p_3+p_4)^2$$

$$= m_1^2 + 2E_1E_2 - 2\vec{p}_1\cdot\vec{p}_2 + m_2^2,$$

$$t = (p_1-p_3)^2 = (p_2-p_4)^2$$

$$= m_1^2 - 2E_1E_3 + 2\vec{p}_1\cdot\vec{p}_3 + m_3^2,$$

$$u = (p_1-p_4)^2 = (p_2-p_3)^2$$

$$= m_1^2 - 2E_1E_4 + 2\vec{p}_1\cdot\vec{p}_4 + m_4^2,$$

and they satisfy

$$s+t+u = m_1^2+m_2^2+m_3^2+m_4^2.$$

If θ_{cm} is the c.m. scattering angle between particles 1 and 3, then (denoting $p_{1cm} = |\vec{p}_{1cm}|$, $p_{3cm} = |\vec{p}_{3cm}|$)

$$t = (E_{1cm}-E_{3cm})^2 - (p_{1cm}-p_{3cm})^2 - 4p_{1cm}p_{3cm}\sin^2(\theta_{cm}/2).$$

For $\theta_{cm} = 0$, $-t$ is a minimum.

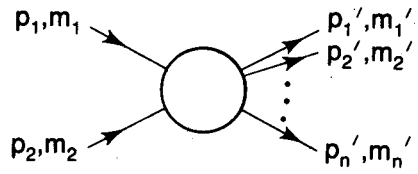
C.3.b Two-body differential cross sections: In the center of mass or lab,

$$\frac{d\sigma}{dt} = \frac{1}{64\pi s}\,\frac{1}{p_{1cm}^2}\,|\mathscr{M}|^2.$$

In the center of mass,

$$\frac{d\sigma}{d\Omega_{cm}} = \frac{p_{1cm}p_{3cm}}{\pi}\,\frac{d\sigma}{dt}.$$

C.4 n-body differential cross sections:

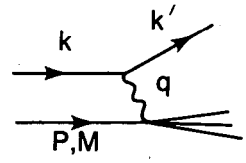


In the c.m. or lab

$$d\sigma = \frac{(2\pi)^4|\mathscr{M}|^2}{4\sqrt{(p_1\cdot p_2)^2 - m_1^2m_2^2}}\,d\Phi_n(p_1+p_2;p_1',p_2',\cdots,p_n'),$$

where n-body phase space, $d\Phi_n$, is described in Section B.3 above. Note that $\sqrt{(p_1\cdot p_2)^2 - m_1^2m_2^2} = p_{1lab}m_2 = p_{1cm}\sqrt{s}$.

C.5.a Leptoproduction kinematics:



$q = k - k'$ is the four-momentum transferred to the target.

Invariant quantities:

$\nu = \frac{q\cdot P}{M} = E - E'$ is the lepton's energy loss in the lab (in earlier literature sometimes $\nu = q\cdot P$). Here, E and E′ are the initial and final lepton energies in the lab.

$Q^2 = -q^2 = 2(EE' - \vec{k}\cdot\vec{k}') - m_\ell^2 - m_{\ell'}^2$ where $m_\ell(m_{\ell'})$ is the initial (final) lepton mass. If $EE'\sin^2(\theta/2) \gg m_\ell^2$, $m_{\ell'}^2$, then

$\simeq 4EE'\sin^2(\theta/2)$, where θ is the lepton's scattering angle in the lab.

$x = \frac{Q^2}{2M\nu}$ In the parton model, x is the fraction of the target nucleon's momentum carried by the struck quark. See section on Quark Parton Model.

$y = \frac{q\cdot P}{k\cdot P} = \frac{\nu}{E}$ is the fraction of the lepton's energy lost in the lab.

$W^2 = (P+q)^2 = M^2 + 2M\nu - Q^2$ is the mass squared of the system recoiling against the lepton.

C.5.b Leptoproduction cross sections:

$$\frac{d^2\sigma}{dx\,dy} = 2M\nu E\frac{d^2\sigma}{d\nu\,dQ^2} = \frac{2\pi M\nu}{E'}\,\frac{d^2\sigma}{d\Omega_{lab}\,dE'} = 2xME\frac{d^2\sigma}{dx\,dQ^2}.$$

KINEMATICS, DECAYS, AND SCATTERING (Cont'd)

C.5.b.i Electroproduction structure functions:

$$\frac{d^2\sigma}{dx\,dy} = \frac{8\pi\alpha^2 ME}{Q^4}\left[\frac{1+(1-y)^2}{2}\,2xF_1^{em} + (1-y)(F_2^{em} - 2xF_1^{em}) - \frac{M}{2E}xyF_2^{em}\right].$$

$F_1^{em}(x, Q^2)$ and $F_2^{em}(x, Q^2)$ are the (unpolarized) structure functions, which are, in the naive parton model, independent of Q^2.

C.5.b.ii Neutrino production structure functions:

$$\frac{d^2\sigma^{\nu}}{dx\,dy} = \frac{G_F^2 ME}{\pi}\left[(1-y-\frac{M}{2E}xy)\,F_2^{\nu} + \frac{y^2}{2}2xF_1^{\nu} + (y-\frac{y^2}{2})xF_3^{\nu}\right],$$

$$\frac{d^2\sigma^{\bar{\nu}}}{dx\,dy} = \frac{G_F^2 ME}{\pi}\left[(1-y-\frac{M}{2E}xy)\,F_2^{\bar{\nu}} + \frac{y^2}{2}2xF_1^{\bar{\nu}} - (y-\frac{y^2}{2})xF_3^{\bar{\nu}}\right].$$

The structure functions $F_i^{\nu,\bar{\nu}}$ are related to quark distributions in the parton model (see section on Quark Parton Model). There are separate F_i's for neutral- and charged-current processes.

C.6.a e^+e^- annihilation: For pointlike spin-1/2 fermions in the c.m., the differential cross section for $e^+e^- \to f\bar{f}$ via single photon annihilation is

$$\frac{d\sigma}{d\Omega} = \frac{\alpha^2}{4s}\beta\left[1+\cos^2\theta + (1-\beta^2)\sin^2\theta\right]e_Q^2,$$

where β is the velocity of the final state fermion in the center of mass, and where e_Q is the charge of the fermion in units of the proton charge. For $\beta \to 1$,

$$\sigma = \frac{4\pi\alpha^2}{3s}e_Q^2 = \frac{86.8\,e_Q^2\,\text{nb}}{s(\text{GeV}^2)}.$$

C.6.b e^+e^- two-photon process: In the equivalent photon approximation, the cross section for $e^+e^- \to e^+e^-X$ is related to the cross section for $\gamma\gamma \to X$ by

$$d\sigma_{e^+e^-\to e^+e^-X}(s) = \eta^2\int d\omega\, f(\omega)\, d\sigma_{\gamma\gamma\to X}(\omega s),$$

where

$$\eta \simeq \frac{\alpha}{2\pi}\ln\left[\frac{s}{4m_e^2}\right]$$

and

$$f(\omega) = \frac{1}{\omega}\left[(2+\omega)^2\ln\frac{1}{\omega} - 2(1-\omega)(3+\omega)\right].$$

For the production of a resonance of mass m_R and spin J,

$$\sigma(e^+e^-\to e^+e^-R) = \eta^2\frac{(2J+1)\,8\pi^2\Gamma(R\to\gamma\gamma)}{m_R s}\,f(\frac{m_R^2}{s}).$$

C.7 Inclusive hadronic reactions: A particle's momentum can be parametrized by selecting a particular direction for the z-axis and writing

$$(E = m_\perp\cosh y,\ p_z = m_\perp\sinh y,\ p_x,\ p_y),$$

where

$$m_\perp^2 = m^2 + p_x^2 + p_y^2,$$

$$y = \frac{1}{2}\ln\left(\frac{E+p_z}{E-p_z}\right) = \ln\left(\frac{E+p_z}{m_\perp}\right) = \tanh^{-1}\left(\frac{p_z}{E}\right).$$

The variable y is called the rapidity. A boost in the z-direction then modifies y by $y \to y + \Delta$, where $\gamma = \cosh\Delta$, $\beta = \tanh\Delta$. Thus the shape of the distribution dN/dy is invariant under such a boost, and

$$E\frac{d^3\sigma}{d^3p} = \frac{d^3\sigma}{dy\,d^2p_\perp}.$$

Feynman's x variable is defined to be

$$x = \left(\frac{p_z}{p_{z\,max}}\right)_{cm} \approx \frac{2p_{z\,cm}}{\sqrt{s}} \approx \frac{2m_\perp\sinh y_{cm}}{\sqrt{s}}.$$

For y_{cm} not small ($e^{-2y_{cm}} \ll 1$)

$$x \approx \frac{m_\perp}{\sqrt{s}}e^{y_{cm}}$$

and

$$(y_{cm})_{max} = \ln\frac{\sqrt{s}}{m}.$$

D. LORENTZ INVARIANT AMPLITUDES

The quantity $-i\mathcal{M}$ is determined in perturbation theory by the Feynman rules. Our convention above is consistent with the Appendices of Bjorken and Drell except that fermion spinors are normalized so that $\bar{u}u = 2m$, etc. In particular, the S-matrix for two-body scattering is

$$\langle p_1'p_2'|S|p_1p_2\rangle = I - i(2\pi)^4\delta^4(p_1+p_2-p_1'-p_2') \times \frac{\mathcal{M}(p_1,p_2;p_1',p_2')}{(2E_1)^{1/2}(2E_2)^{1/2}(2E_1')^{1/2}(2E_2')^{1/2}},$$

where the states are normalized so

$$\langle p'|p\rangle = (2\pi)^3\delta^3(\vec{p}-\vec{p}').$$

C.M. ENERGY AND MOMENTUM VS. BEAM MOMENTUM

(for scattering on a proton target)

$$E_{cm}dE_{cm} = m_p dT_{beam} = m_p v_{beam} dP_{beam} \approx m_p dP_{beam}$$

PBEAM (GEV/C)	C. M. ENERGY (GEV) γp,νp ~ep	πp	Kp	pp	MOMENTUM IN C. M. (GEV/C) γp,νp ~ep	πp	Kp	pp
0.00	.938	1.078	1.432	1.877	.000	.000	.000	.000
0.02	.958	1.079	1.432	1.877	.020	.017	.013	.010
0.04	.977	1.083	1.433	1.877	.038	.035	.026	.020
0.06	.996	1.089	1.434	1.878	.056	.052	.039	.030
0.08	1.015	1.096	1.436	1.878	.074	.068	.052	.040
0.10	1.033	1.105	1.439	1.879	.091	.085	.065	.050
0.12	1.051	1.116	1.441	1.880	.107	.101	.078	.060
0.14	1.069	1.127	1.445	1.882	.123	.117	.091	.070
0.16	1.087	1.139	1.448	1.883	.138	.132	.104	.080
0.18	1.104	1.152	1.453	1.885	.153	.147	.116	.090
0.20	1.121	1.165	1.457	1.887	.167	.161	.129	.099
0.22	1.137	1.178	1.462	1.889	.182	.175	.141	.109
0.24	1.154	1.192	1.468	1.892	.195	.189	.153	.119
0.26	1.170	1.206	1.473	1.894	.209	.202	.166	.129
0.28	1.186	1.219	1.480	1.897	.222	.215	.178	.138
0.30	1.201	1.233	1.486	1.900	.234	.228	.189	.148
0.32	1.217	1.247	1.493	1.903	.247	.241	.201	.158
0.34	1.232	1.261	1.500	1.906	.259	.253	.213	.167
0.36	1.247	1.275	1.507	1.910	.271	.265	.224	.177
0.38	1.262	1.288	1.514	1.913	.282	.277	.235	.186
0.40	1.277	1.302	1.522	1.917	.294	.288	.247	.196
0.42	1.292	1.315	1.530	1.921	.305	.300	.258	.205
0.44	1.306	1.329	1.538	1.925	.316	.311	.268	.214
0.46	1.320	1.342	1.546	1.929	.327	.322	.279	.224
0.48	1.335	1.356	1.554	1.934	.337	.332	.290	.233
0.50	1.349	1.369	1.563	1.938	.348	.343	.300	.242
0.52	1.362	1.382	1.571	1.943	.358	.353	.310	.251
0.54	1.376	1.395	1.580	1.947	.368	.363	.321	.260
0.56	1.390	1.408	1.589	1.952	.378	.373	.331	.269
0.58	1.403	1.421	1.598	1.957	.388	.383	.341	.278
0.60	1.416	1.434	1.607	1.962	.397	.393	.350	.287
0.62	1.430	1.447	1.616	1.968	.407	.402	.360	.296
0.64	1.443	1.459	1.625	1.973	.416	.412	.370	.304
0.66	1.456	1.472	1.634	1.978	.425	.421	.379	.313
0.68	1.468	1.484	1.643	1.984	.434	.430	.388	.322
0.70	1.481	1.496	1.653	1.989	.443	.439	.397	.330
0.72	1.494	1.509	1.662	1.995	.452	.448	.406	.339
0.74	1.506	1.521	1.671	2.001	.461	.457	.415	.347
0.76	1.519	1.533	1.681	2.007	.470	.465	.424	.355
0.78	1.531	1.545	1.690	2.013	.478	.474	.433	.364
0.80	1.543	1.557	1.699	2.019	.486	.482	.442	.372
0.82	1.555	1.569	1.709	2.025	.495	.490	.450	.380
0.84	1.567	1.580	1.718	2.031	.503	.499	.459	.388
0.86	1.579	1.592	1.728	2.037	.511	.507	.467	.396
0.88	1.591	1.604	1.737	2.043	.519	.515	.475	.404
0.90	1.603	1.615	1.747	2.050	.527	.523	.484	.412
0.92	1.615	1.627	1.756	2.056	.535	.531	.492	.420
0.94	1.626	1.638	1.765	2.062	.542	.538	.500	.428
0.96	1.638	1.649	1.775	2.069	.550	.546	.508	.435
0.98	1.649	1.661	1.784	2.075	.558	.554	.515	.443
1.00	1.660	1.672	1.794	2.082	.565	.561	.523	.451
1.02	1.672	1.683	1.803	2.088	.573	.569	.531	.458
1.04	1.683	1.694	1.812	2.095	.580	.576	.538	.466
1.06	1.694	1.705	1.822	2.102	.587	.583	.546	.473
1.08	1.705	1.716	1.831	2.108	.594	.591	.553	.481
1.10	1.716	1.726	1.840	2.115	.601	.598	.561	.488
1.12	1.727	1.737	1.850	2.122	.609	.605	.568	.495
1.14	1.738	1.748	1.859	2.129	.616	.612	.575	.502
1.16	1.748	1.759	1.868	2.136	.622	.619	.583	.510
1.18	1.759	1.769	1.877	2.142	.629	.626	.590	.517
1.20	1.770	1.780	1.887	2.149	.636	.633	.597	.524
1.22	1.780	1.790	1.896	2.156	.643	.639	.604	.531
1.24	1.791	1.800	1.905	2.163	.650	.646	.611	.538
1.26	1.801	1.811	1.914	2.170	.656	.653	.618	.545
1.28	1.812	1.821	1.923	2.177	.663	.660	.624	.552
1.30	1.822	1.831	1.932	2.184	.669	.666	.631	.559
1.32	1.832	1.841	1.941	2.191	.676	.673	.638	.565
1.34	1.843	1.851	1.950	2.198	.682	.679	.645	.572
1.36	1.853	1.862	1.959	2.205	.689	.685	.651	.579
1.38	1.863	1.872	1.968	2.212	.695	.692	.658	.585
1.40	1.873	1.882	1.977	2.219	.701	.698	.664	.592
1.42	1.883	1.891	1.986	2.226	.708	.704	.671	.599
1.44	1.893	1.901	1.995	2.233	.714	.711	.677	.605
1.46	1.903	1.911	2.004	2.240	.720	.717	.684	.612
1.48	1.913	1.921	2.013	2.247	.726	.723	.690	.618
1.50	1.922	1.931	2.022	2.254	.732	.729	.696	.624
1.52	1.932	1.940	2.031	2.261	.738	.735	.702	.631
1.54	1.942	1.950	2.039	2.268	.744	.741	.709	.637
1.56	1.951	1.959	2.048	2.275	.750	.747	.715	.643
1.58	1.961	1.969	2.057	2.282	.756	.753	.721	.650
1.60	1.970	1.978	2.065	2.289	.762	.759	.727	.656
1.62	1.980	1.988	2.074	2.296	.768	.765	.733	.662
1.64	1.989	1.997	2.083	2.304	.773	.770	.739	.668
1.66	1.999	2.006	2.091	2.311	.779	.776	.745	.674
1.68	2.008	2.016	2.100	2.318	.785	.782	.751	.680

PBEAM (GEV/C)	C. M. ENERGY (GEV) γp,νp ~ep	πp	Kp	pp	MOMENTUM IN C. M. (GEV/C) γp,νp ~ep	πp	Kp	pp
1.70	2.018	2.025	2.109	2.325	.791	.788	.756	.686
1.72	2.027	2.034	2.117	2.332	.796	.793	.762	.692
1.74	2.036	2.043	2.126	2.339	.802	.799	.768	.698
1.76	2.045	2.053	2.134	2.346	.807	.805	.774	.704
1.78	2.054	2.062	2.143	2.353	.813	.810	.780	.710
1.80	2.064	2.071	2.151	2.360	.818	.816	.785	.716
1.82	2.073	2.080	2.159	2.367	.824	.821	.791	.721
1.84	2.082	2.089	2.168	2.374	.829	.827	.796	.727
1.86	2.091	2.098	2.176	2.381	.835	.832	.802	.733
1.88	2.100	2.107	2.184	2.388	.840	.837	.808	.739
1.90	2.109	2.115	2.193	2.395	.845	.843	.813	.744
1.92	2.117	2.124	2.201	2.402	.851	.848	.819	.750
1.94	2.126	2.133	2.209	2.409	.856	.853	.824	.756
1.96	2.135	2.142	2.217	2.416	.861	.859	.829	.761
1.98	2.144	2.151	2.226	2.423	.867	.864	.835	.767
2.0	2.153	2.159	2.234	2.430	.872	.869	.840	.772
2.1	2.196	2.202	2.274	2.465	.897	.895	.866	.799
2.2	2.238	2.244	2.314	2.500	.922	.920	.892	.826
2.3	2.280	2.286	2.353	2.534	.947	.944	.917	.852
2.4	2.320	2.326	2.392	2.568	.970	.968	.941	.877
2.5	2.360	2.366	2.430	2.602	.994	.991	.965	.901
2.6	2.400	2.405	2.468	2.636	1.02	1.01	.989	.926
2.7	2.439	2.444	2.505	2.669	1.04	1.04	1.01	.949
2.8	2.477	2.482	2.542	2.702	1.06	1.06	1.03	.972
2.9	2.514	2.520	2.578	2.735	1.08	1.08	1.06	.995
3.0	2.551	2.556	2.613	2.768	1.10	1.10	1.08	1.02
3.1	2.588	2.593	2.649	2.800	1.12	1.12	1.10	1.04
3.2	2.624	2.629	2.683	2.832	1.14	1.14	1.12	1.06
3.3	2.660	2.664	2.718	2.863	1.16	1.16	1.14	1.08
3.4	2.695	2.699	2.752	2.895	1.18	1.18	1.16	1.10
3.5	2.729	2.734	2.785	2.926	1.20	1.20	1.18	1.12
3.6	2.763	2.768	2.818	2.957	1.22	1.22	1.20	1.14
3.7	2.797	2.801	2.851	2.987	1.24	1.24	1.22	1.16
3.8	2.830	2.835	2.884	3.018	1.26	1.26	1.24	1.18
3.9	2.863	2.868	2.916	3.048	1.28	1.28	1.26	1.20
4.0	2.896	2.900	2.947	3.077	1.30	1.29	1.27	1.22
4.1	2.928	2.932	2.979	3.107	1.31	1.31	1.29	1.24
4.2	2.960	2.964	3.010	3.136	1.33	1.33	1.31	1.26
4.3	2.992	2.996	3.041	3.165	1.35	1.35	1.33	1.27
4.4	3.023	3.027	3.071	3.194	1.37	1.36	1.34	1.29
4.5	3.054	3.058	3.101	3.223	1.38	1.38	1.36	1.31
4.6	3.084	3.088	3.131	3.251	1.40	1.40	1.38	1.33
4.7	3.115	3.118	3.161	3.279	1.42	1.41	1.40	1.34
4.8	3.144	3.148	3.190	3.307	1.43	1.43	1.41	1.36
4.9	3.174	3.178	3.220	3.335	1.45	1.45	1.43	1.38
5.0	3.204	3.207	3.248	3.363	1.46	1.46	1.44	1.40
5.2	3.262	3.265	3.305	3.417	1.50	1.49	1.48	1.43
5.4	3.319	3.322	3.362	3.471	1.53	1.53	1.51	1.46
5.6	3.375	3.378	3.417	3.524	1.56	1.56	1.54	1.49
5.8	3.430	3.433	3.471	3.576	1.59	1.59	1.57	1.52
6.0	3.484	3.487	3.524	3.627	1.62	1.61	1.60	1.55
6.2	3.538	3.541	3.577	3.678	1.64	1.64	1.63	1.58
6.4	3.590	3.593	3.629	3.728	1.67	1.67	1.65	1.61
6.6	3.642	3.645	3.680	3.778	1.70	1.70	1.68	1.64
6.8	3.693	3.696	3.731	3.827	1.73	1.73	1.71	1.67
7.0	3.744	3.747	3.781	3.875	1.75	1.75	1.74	1.70
7.2	3.794	3.797	3.830	3.923	1.78	1.78	1.76	1.72
7.4	3.843	3.846	3.878	3.970	1.81	1.81	1.79	1.75
7.6	3.891	3.894	3.926	4.016	1.83	1.83	1.82	1.78
7.8	3.939	3.942	3.974	4.062	1.86	1.86	1.84	1.80
8.0	3.987	3.989	4.021	4.108	1.88	1.88	1.87	1.83
8.2	4.033	4.036	4.067	4.153	1.91	1.91	1.89	1.85
8.4	4.080	4.082	4.113	4.198	1.93	1.93	1.92	1.88
8.6	4.125	4.128	4.158	4.242	1.96	1.95	1.94	1.90
8.8	4.171	4.173	4.203	4.286	1.98	1.98	1.96	1.93
9.0	4.215	4.218	4.247	4.329	2.00	2.00	1.99	1.95
9.2	4.260	4.262	4.291	4.372	2.03	2.03	2.01	1.97
9.4	4.303	4.306	4.335	4.415	2.05	2.05	2.03	2.00
9.6	4.347	4.349	4.378	4.457	2.07	2.07	2.06	2.02
9.8	4.390	4.392	4.420	4.498	2.09	2.09	2.08	2.04
10.0	4.432	4.435	4.462	4.540	2.12	2.12	2.10	2.07
10.5	4.537	4.539	4.566	4.641	2.17	2.17	2.16	2.12
11.0	4.639	4.642	4.668	4.741	2.22	2.22	2.21	2.18
11.5	4.739	4.742	4.767	4.839	2.28	2.28	2.26	2.23
12.0	4.837	4.839	4.864	4.934	2.33	2.33	2.31	2.28
12.5	4.933	4.935	4.960	5.028	2.38	2.38	2.36	2.33
13.0	5.027	5.030	5.053	5.120	2.43	2.43	2.41	2.38
13.5	5.120	5.122	5.145	5.211	2.47	2.47	2.46	2.43
14.0	5.211	5.213	5.236	5.300	2.52	2.52	2.51	2.48
14.5	5.300	5.302	5.324	5.388	2.57	2.57	2.56	2.53
15.0	5.388	5.390	5.412	5.474	2.61	2.61	2.60	2.57
15.5	5.474	5.476	5.498	5.559	2.66	2.66	2.65	2.62
16.0	5.559	5.561	5.582	5.642	2.70	2.70	2.69	2.66
16.5	5.643	5.645	5.666	5.725	2.74	2.74	2.73	2.70
17.0	5.726	5.727	5.748	5.806	2.79	2.79	2.78	2.75

PBEAM (GEV/C)	C. M. ENERGY (GEV) γp,νp ~ep	πp	Kp	pp	MOMENTUM IN C. M. (GEV/C) γp,νp ~ep	πp	Kp	pp
17.5	5.807	5.809	5.829	5.886	2.83	2.83	2.82	2.79
18.0	5.887	5.889	5.909	5.965	2.87	2.87	2.86	2.83
18.5	5.966	5.968	5.988	6.043	2.91	2.91	2.90	2.87
19.0	6.044	6.046	6.066	6.120	2.95	2.95	2.94	2.91
19.5	6.122	6.123	6.142	6.196	2.99	2.99	2.98	2.95
20	6.198	6.199	6.218	6.272	3.03	3.03	3.02	2.99
21	6.347	6.349	6.367	6.419	3.10	3.10	3.09	3.07
22	6.493	6.495	6.513	6.564	3.18	3.18	3.17	3.14
23	6.636	6.638	6.655	6.705	3.25	3.25	3.24	3.22
24	6.776	6.778	6.795	6.843	3.32	3.32	3.31	3.29
25	6.913	6.915	6.932	6.979	3.39	3.39	3.38	3.36
26	7.048	7.049	7.066	7.112	3.46	3.46	3.45	3.43
27	7.180	7.181	7.197	7.243	3.53	3.53	3.52	3.50
28	7.309	7.311	7.326	7.371	3.59	3.59	3.59	3.56
29	7.436	7.438	7.453	7.497	3.66	3.66	3.65	3.63
30	7.562	7.563	7.578	7.621	3.72	3.72	3.71	3.69
31	7.685	7.686	7.701	7.743	3.79	3.78	3.78	3.76
32	7.806	7.807	7.822	7.864	3.85	3.85	3.84	3.82
33	7.925	7.926	7.941	7.982	3.91	3.91	3.90	3.88
34	8.043	8.044	8.058	8.099	3.97	3.97	3.96	3.94
35	8.158	8.160	8.174	8.214	4.03	4.02	4.02	4.00
36	8.273	8.274	8.288	8.327	4.08	4.08	4.08	4.06
37	8.385	8.386	8.400	8.439	4.14	4.14	4.13	4.11
38	8.496	8.498	8.511	8.549	4.20	4.20	4.19	4.17
39	8.606	8.607	8.621	8.658	4.25	4.25	4.24	4.23
40	8.715	8.716	8.729	8.766	4.31	4.31	4.30	4.28
41	8.822	8.823	8.836	8.872	4.36	4.36	4.35	4.34
42	8.927	8.928	8.941	8.978	4.41	4.41	4.41	4.39
43	9.032	9.033	9.046	9.081	4.47	4.47	4.46	4.44
44	9.135	9.136	9.149	9.184	4.52	4.52	4.51	4.50
45	9.237	9.238	9.251	9.286	4.57	4.57	4.56	4.55
46	9.338	9.339	9.352	9.386	4.62	4.62	4.62	4.60
47	9.438	9.439	9.451	9.486	4.67	4.67	4.67	4.65
48	9.537	9.538	9.550	9.584	4.72	4.72	4.72	4.70
49	9.635	9.636	9.648	9.681	4.77	4.77	4.77	4.75
50	9.732	9.733	9.745	9.778	4.82	4.82	4.81	4.80
52	9.923	9.924	9.935	9.968	4.92	4.92	4.91	4.89
54	10.11	10.11	10.12	10.15	5.01	5.01	5.01	4.99
56	10.29	10.30	10.31	10.34	5.10	5.10	5.10	5.08
58	10.47	10.48	10.49	10.52	5.20	5.19	5.19	5.17
60	10.65	10.65	10.66	10.69	5.28	5.28	5.28	5.26
62	10.83	10.83	10.84	10.87	5.37	5.37	5.37	5.35
64	11.00	11.00	11.01	11.04	5.46	5.46	5.45	5.44
66	11.17	11.17	11.18	11.21	5.54	5.54	5.54	5.53
68	11.34	11.34	11.35	11.37	5.63	5.63	5.62	5.61
70	11.50	11.50	11.51	11.54	5.71	5.71	5.71	5.69
72	11.66	11.66	11.67	11.70	5.79	5.79	5.79	5.77
74	11.82	11.82	11.83	11.86	5.87	5.87	5.87	5.85
76	11.98	11.98	11.99	12.02	5.95	5.95	5.95	5.93
78	12.13	12.14	12.14	12.17	6.03	6.03	6.03	6.01
80	12.29	12.29	12.30	12.32	6.11	6.11	6.10	6.09
82	12.44	12.44	12.45	12.48	6.18	6.18	6.18	6.17
84	12.59	12.59	12.60	12.63	6.26	6.26	6.26	6.24
86	12.74	12.74	12.75	12.77	6.33	6.33	6.33	6.32
88	12.88	12.89	12.89	12.92	6.41	6.41	6.40	6.39
90	13.03	13.03	13.04	13.06	6.48	6.48	6.48	6.46
92	13.17	13.17	13.18	13.21	6.55	6.55	6.55	6.54
94	13.31	13.32	13.32	13.35	6.62	6.62	6.62	6.61
96	13.45	13.46	13.46	13.49	6.69	6.69	6.69	6.68
98	13.59	13.59	13.60	13.63	6.76	6.76	6.76	6.75
100	13.73	13.73	13.74	13.76	6.83	6.83	6.83	6.82
150	16.80	16.80	16.81	16.83	8.38	8.38	8.37	8.36
200	19.40	19.40	19.40	19.42	9.68	9.67	9.67	9.66
250	21.68	21.68	21.69	21.70	10.8	10.8	10.8	10.8
300	23.75	23.75	23.75	23.76	11.9	11.9	11.9	11.8
350	25.65	25.65	25.65	25.66	12.8	12.8	12.8	12.8
400	27.41	27.41	27.42	27.43	13.7	13.7	13.7	13.7
450	29.07	29.07	29.08	29.09	14.5	14.5	14.5	14.5
500	30.65	30.65	30.65	30.66	15.3	15.3	15.3	15.3
550	32.14	32.14	32.14	32.15	16.1	16.1	16.1	16.0
600	33.57	33.57	33.57	33.58	16.8	16.8	16.8	16.8
650	34.94	34.94	34.94	34.95	17.5	17.5	17.5	17.4
700	36.26	36.26	36.26	36.27	18.1	18.1	18.1	18.1
750	37.53	37.53	37.53	37.54	18.8	18.8	18.8	18.7
800	38.76	38.76	38.76	38.77	19.4	19.4	19.4	19.4
850	39.95	39.95	39.95	39.96	20.0	20.0	20.0	20.0
900	41.11	41.11	41.11	41.12	20.5	20.5	20.5	20.5
950	42.23	42.23	42.24	42.24	21.1	21.1	21.1	21.1
1000	43.33	43.33	43.33	43.34	21.7	21.7	21.7	21.6
2000	61.27	61.27	61.27	61.28	30.6	30.6	30.6	30.6
5000	96.87	96.87	96.87	96.87	48.4	48.4	48.4	48.4
10000	137.0	137.0	137.0	137.0	68.5	68.5	68.5	68.5
20000	193.7	193.7	193.7	193.7	96.9	96.9	96.9	96.9
50000	306.3	306.3	306.3	306.3	153	153	153	153
100000	433.2	433.2	433.2	433.2	217	217	217	217
200000	612.6	612.6	612.6	612.6	306	306	306	306
500000	968.6	968.6	968.6	968.6	484	484	484	484
1000000	1370	1370	1370	1370	685	685	685	685

STANDARD MODEL OF ELECTROWEAK INTERACTIONS

The couplings of the photon, $W^{\pm}$, and Z to fundamental fermions are

$$\bar{\psi}\gamma^{\mu}\left[eQA_{\mu} + \frac{e}{\sqrt{2}\sin\theta_W}\left(T^{+}W_{\mu}^{+} + T^{-}W_{\mu}^{-}\right) + \frac{e}{\sin\theta_W\cos\theta_W}\left(T_3 - \sin^2\theta_W Q\right)Z_{\mu}\right]\psi ,$$

where

$$\psi = \begin{pmatrix} u \\ d' \end{pmatrix}, \begin{pmatrix} c \\ s' \end{pmatrix}, \begin{pmatrix} t \\ b' \end{pmatrix}, \begin{pmatrix} \nu_e \\ e^- \end{pmatrix}, \begin{pmatrix} \nu_\mu \\ \mu^- \end{pmatrix}, \begin{pmatrix} \nu_\tau \\ \tau^- \end{pmatrix};$$

for mixing effects defining d′, s′, and b′ see the section on Cabibbo and Kobayashi-Maskawa Mixing;

T^{+} = $\frac{1}{2}(1-\gamma_5)\times$ weak isospin raising operator ($T^{\pm}$ act on left-handed fermions);

T_3 = $\frac{1}{2}(1-\gamma_5)\times$ third component of weak isospin, (i.e., 1/2 for ν_e, ν_μ, ν_τ, u, c, t; −1/2 for e^-, μ^-, τ^-, d, s, b);

Q = electric charge operator, in units of proton charge;

θ_W = weak mixing angle;

A = electromagnetic vector potential.

Thus, for example, the Weν coupling is

$$\left(\frac{e}{\sqrt{2}\sin\theta_W}\right)\left[W_{\mu}^{-}\bar{e}\gamma^{\mu}\tfrac{1}{2}(1-\gamma_5)\nu + W_{\mu}^{+}\bar{\nu}\gamma^{\mu}\tfrac{1}{2}(1-\gamma_5)e\right]$$

and the Zu$\bar{u}$ coupling is

$$\left(\frac{e}{\sin\theta_W\cos\theta_W}\right)Z_{\mu}\bar{u}\gamma^{\mu}\left[\tfrac{1}{4}(1-\gamma_5) - \tfrac{2}{3}\sin^2\theta_W\right]u .$$

The physical neutral fields A and Z are mixtures of W_3, the partner of $W^{\pm}$, and another field B:

$$A = W_3\sin\theta_W + B\cos\theta_W , \quad Z = W_3\cos\theta_W - B\sin\theta_W .$$

The SU(2) × U(1) gauge couplings g and g′ appear as

$$gW_{\mu}\cdot T + g'B_{\mu}\frac{Y}{2} ,$$

where electric charge Q, T_3, and Y/2 are connected by $Q = T_3 + Y/2$. The couplings and mixing angle are related by $\tan\theta_W = g'/g$, $\sin\theta_W = e/g$.

In lowest order

$$M_W^2 = \frac{\pi\alpha}{\sqrt{2}\sin^2\theta_W G_F} \simeq \left(\frac{37.3\text{ GeV}}{\sin\theta_W}\right)^2 ,$$

$$M_Z^2 = M_W^2/\cos^2\theta_W .$$

See Appendix I of this Review (found only in complete version, not in booklet) for more details.

Branching fractions of the $W^{\pm}$ and Z are predicted to be roughly

$BR(W^+ \to e^+\nu_e)$	= 0.08 ,	$BR(W^+ \to u\bar{d})$	= 0.24 ,
$BR(Z \to \nu_e\bar{\nu}_e)$	= 0.06 ,	$BR(Z \to e^+e^-)$	= 0.03 ,
$BR(Z \to u\bar{u})$	= 0.10 ,	$BR(Z \to d\bar{d})$	= 0.13 , etc.

and similarly for the other generations, assuming there is no suppression for phase space even for the t quark. The total widths are expected to be (with $\sin^2\theta_W \simeq 0.21$): $\Gamma(W) \simeq 2.8$ GeV and $\Gamma(Z) \simeq 2.8$ GeV.

CABIBBO AND KOBAYASHI-MASKAWA MIXING

The quark mass eigenstates are not the weak eigenstates. The unitary matrix connecting them is known as the Kobayashi-Maskawa matrix. It generalizes to three generations the Cabibbo mixing which includes only the first two generations. The K-M matrix can be parametrized by three angles θ_1, θ_2, and θ_3 and a phase $e^{i\delta}$, as described in Appendix II (found in the full Review of Particle Properties, not in the data booklet). Independent of such a parametrization we can write

$$\begin{pmatrix} d' \\ s' \\ b' \end{pmatrix} = \begin{pmatrix} V_{ud} & V_{us} & V_{ub} \\ V_{cd} & V_{cs} & V_{cb} \\ V_{td} & V_{ts} & V_{tb} \end{pmatrix}\begin{pmatrix} d \\ s \\ b \end{pmatrix} .$$

The primed quarks are the weak eigenstates, while the unprimed ones are the mass eigenstates. The analysis in Appendix II leads to an estimate of the K-M matrix:

$$\begin{pmatrix} 0.9705 \text{ to } 0.9770 & 0.21 \text{ to } 0.24 & 0. \text{ to } 0.014 \\ 0.21 \text{ to } 0.24 & 0.971 \text{ to } 0.973 & 0.036 \text{ to } 0.070 \\ 0. \text{ to } 0.024 & 0.036 \text{ to } 0.069 & 0.997 \text{ to } 0.999 \end{pmatrix} .$$

QUARK PARTON MODEL FOR DEEP INELASTIC SCATTERING

In the naive parton model, the number of quarks, q(x)dx, of type q carrying a fraction between x and x+dx of the proton's momentum (in a frame in which it is large) is independent of the Q^2 of the scattering. (In more complete QCD models there is a logarithmic dependence on Q^2.) Thus deep inelastic leptoproduction probes u(x), d(x), $\bar{u}$(x), etc. In particular, the structure functions for scattering from a proton (see section on Kinematics, Decays, and Scattering) are determined by these:

$$F_2^{\nu CC} = 2x\left[d(x) + s(x) + \bar{u}(x) + \bar{c}(x)\right]$$

$$xF_3^{\nu CC} = 2x\left[d(x) + s(x) - \bar{u}(x) - \bar{c}(x)\right]$$

$$F_2^{\bar{\nu} CC} = 2x\left[u(x) + c(x) + \bar{d}(x) + \bar{s}(x)\right]$$

$$xF_3^{\bar{\nu} CC} = 2x\left[u(x) + c(x) - \bar{d}(x) - \bar{s}(x)\right]$$

$$F_2^{em} = x\left[\tfrac{4}{9}\left(u(x) + \bar{u}(x)\right) + \tfrac{1}{9}\left(d(x) + \bar{d}(x)\right) + \cdots\right]$$

$$F_2^{\nu NC} = 2\rho^2 x\left\{\left[\tfrac{1}{4} - \tfrac{2}{3}\sin^2\theta_W + \tfrac{8}{9}\sin^4\theta_W\right]\left[u(x) + \bar{u}(x)\right] + \left[\tfrac{1}{4} - \tfrac{1}{3}\sin^2\theta_W + \tfrac{2}{9}\sin^4\theta_W\right]\left[d(x) + \bar{d}(x)\right]\right\}$$

$$xF_3^{\nu NC} = 2\rho^2 x\left\{\left[\tfrac{1}{4} - \tfrac{2}{3}\sin^2\theta_W\right]\left[u(x) - \bar{u}(x)\right] + \left[\tfrac{1}{4} - \tfrac{1}{3}\sin^2\theta_W\right]\left[d(x) - \bar{d}(x)\right]\right\}$$

$F_2 = 2xF_1$ (in all cases. This is the Callan-Gross relation, and ignores parton transverse momentum.)

$$F_i^{\bar{\nu} NC} = F_i^{\nu NC} .$$

Here $\rho = M_W^2/(M_Z^2\cos^2\theta_W)$. See section on the Standard Model of Electroweak Interactions and Appendix I of this Review (found only in complete version, not in booklet).

NONRELATIVISTIC QUARK MODEL

A. QUANTUM NUMBERS

Each quark has spin 1/2. The additive quantum numbers (other than baryon number = 1/3) of the known (and presumed) quarks are shown in the table.

Quantum number	Quark type (flavor) d	u	s	c	b	t
$\mathscr{Q}$— electric charge	$-\frac{1}{3}$	$+\frac{2}{3}$	$-\frac{1}{3}$	$+\frac{2}{3}$	$-\frac{1}{3}$	$+\frac{2}{3}$
$\mathscr{I}_z$ — z-component of isospin	$-\frac{1}{2}$	$+\frac{1}{2}$	0	0	0	0
$\mathscr{S}$— strangeness	0	0	−1	0	0	0
$\mathscr{C}$— charm	0	0	0	+1	0	0
$\mathscr{B}$— bottomness	0	0	0	0	−1	0
$\mathscr{T}$— topness	0	0	0	0	0	+1

With these conventions the strangeness $\mathscr{S}$ of the K^+ is +1 and the bottomness $\mathscr{B}$ of the B^+ is +1.

The G-parity operator is defined to be $G = Ce^{-i\pi I_y}$, where C is the charge conjugation operator. The mesons with $\mathscr{S} = \mathscr{C} = \mathscr{B} = \mathscr{T} = 0$ are eigenstates of G. If a meson is also an eigenstate of the charge conjugation operator with charge conjugation C, then $G = C(-1)^I$, where I is its isospin; all the other particles in the same isomultiplet have the same value of G: $G(\pi^\pm) = G(\pi^0) = -1$, $G(\rho^\pm) = G(\rho^0) = +1$, etc.

B. MESONS

Nearly all known mesons can be understood as bound states of a quark q and an antiquark $\bar{q}'$ (the flavors of q and q′ may be different). If the orbital angular momentum of the $q\bar{q}'$ state is L, then the parity $P = (-1)^{L+1}$. A state $q\bar{q}$ of a quark and its own antiquark is also an eigenstate of charge conjugation with $C = (-1)^{L+S}$, where the spin S = 0 or 1. The L = 0 states are the pseudoscalars, $J^P = 0^-$, and the vectors, $J^P = 1^-$. See table below.

States in the "normal" spin-parity series, $P = (-1)^J$, must, according to the above, have S = 1 and hence CP = +1. Thus mesons with normal spin-parity and CP = −1 are forbidden in the $q\bar{q}'$ quark model. The $J^{PC} = 0^{--}$ state is forbidden as well. Mesons with such J^{PC} could exist, but would lie outside the $q\bar{q}'$ model.

States with the same J^P and additive quantum numbers can mix (if they are eigenstates of charge conjugation, they must also have the same value of C). Thus the physical $J^P = 1^+$, strangeness $\mathscr{S} = 1$ states, Q(1280) and Q(1400), are mixtures of Q_A and Q_B. The $\psi(3770)$ is a mixture of $^3S_1$ and $^3D_1$. The η and η' are mixtures of the SU(3) octet and singlet states.

For the pseudoscalar mesons, the Gell-Mann-Okubo formula is

$$m_\eta^2 = \frac{1}{3}(4m_K^2 - m_\pi^2),$$

assuming no octet-singlet mixing. However, the octet η_8 and singlet η_1 mix because of SU(3) breaking. The physical states η and η' are given by

$$\eta = \eta_8 \cos\theta_P - \eta_1 \sin\theta_P$$

$$\eta' = \eta_8 \sin\theta_P + \eta_1 \cos\theta_P .$$

These combinations diagonalize the mass-squared matrix

$$M^2 = \begin{pmatrix} M_{11}^2 & M_{18}^2 \\ M_{18}^2 & M_{88}^2 \end{pmatrix},$$

where $M_{88}^2 = \frac{1}{3}(4m_K^2 - m_\pi^2)$. It follows that

$$\tan^2\theta_P = \frac{M_{88}^2 - m_\eta^2}{m_{\eta'}^2 - M_{88}^2} .$$

The sign of θ_P is meaningful in the quark model. If

$$\eta_1 = (u\bar{u} + d\bar{d} + s\bar{s})/\sqrt{3}$$

$$\eta_8 = (u\bar{u} + d\bar{d} - 2s\bar{s})/\sqrt{6},$$

then the matrix element M_{18}^2, which is due mostly to the strange

Standard quark model assignments for some of the known mesons. Some assignments, especially for 0^{++}, are controversial. Note that only the states in the $u\bar{u}$, $d\bar{d}$, $s\bar{s}$, $c\bar{c}$, and $b\bar{b}$ columns and the neutral states in the I = 1 column are eigenstates of charge conjugation C.

$^{2S+1}L_J$	J^{PC}	$u\bar{u}$, $d\bar{d}$, $s\bar{s}$ I = 0	$u\bar{d}$, $u\bar{u}$, $d\bar{d}$ I = 1	$\bar{s}u$, $\bar{s}d$ I = 1/2	$c\bar{u}$, $c\bar{d}$ I = 1/2	$c\bar{s}$ I = 0	$c\bar{c}$ I = 0	$\bar{b}u$, $\bar{b}d$ I = 1/2	$b\bar{b}$ I = 0
$^1S_0$	0^{-+}	η, η'	π	K	D	F	η_c	B	
$^3S_1$	1^{--}	ϕ, ω	ρ	K*(892)	D*(2010)		J/ψ		Υ
$^1P_1$	1^{+-}	H	B(1235)	Q_B					
$^3P_0$	0^{++}	S(975), ϵ	δ	κ			χ(3415)		χ_b(9875)
$^3P_1$	1^{++}	D(1285), E	A(1270)	Q_A			χ(3510)		χ_b(9895)
$^3P_2$	2^{++}	f′, f	A_2	K*(1430)			χ(3555)		χ_b(9915)
$^1D_2$	2^{-+}		A(1680)						
$^3D_1$	1^{--}						ψ(3770)		
$^3D_2$	2^{--}			L(1770)					
$^3D_3$	3^{--}	ω(1670)	g	K*(1780)					

NONRELATIVISTIC QUARK MODEL (Cont'd)

quark mass, is negative. From the relation

$$\tan\theta_P = \frac{M_{88}^2 - m_\eta^2}{M_{18}^2},$$

we find $\theta_P < 0$.

For the vector mesons we replace $\pi \to \rho$, $K \to K^*$, $\eta \to \phi$, and $\eta' \to \omega$, so

$$\phi = \omega_8 \cos\theta_V - \omega_1 \sin\theta_V$$

$$\omega = \omega_8 \sin\theta_V + \omega_1 \cos\theta_V .$$

For "ideal mixing," $\phi = s\bar{s}$, $\tan\theta_V = 1/\sqrt{2}$, so $\theta_V \approx 35.3°$. Experimentally, θ_V is near 35°, the sign being determined by a formula analogous to that for $\tan\theta_P$. Following this procedure we find the mixing angles below. There are uncertainties of a few degrees arising from electromagnetic mass splittings and uncertainties in resonance masses.

Singlet-octet mixing for the pseudoscalar, vector, and tensor mesons. The sign conventions are as above. The value of θ_{quad} is obtained from the equations above, and θ_{lin} is obtained by replacing $m^2 \to m$ throughout. Of the two isosinglets, the mostly octet one is listed first.

J^{PC}	Nonet Members	θ_{quad}	θ_{lin}
0^{-+}	π, K, η, η'	−10°	−23°
1^{--}	ρ, K*(892), ϕ, ω	39°	36°
2^{++}	A_2, K*(1430), f′, f	28°	26°
3^{--}	g(1690), K*(1780), ϕ(1850), ω(1670)	29°	28°

C. BARYONS

All the established baryons are apparently 3-quark (qqq) states, and each such state is an SU(3) color singlet, a completely antisymmetric state of the three possible colors. Since the quarks are fermions, the state function for any baryon must be antisymmetric under interchange of any two of its quarks. Thus the state is *symmetric* under interchange of the quantum labels other than color:

$$|qqq\rangle_A = |\text{color}\rangle_A \times |\text{space, spin, flavor}\rangle_S ,$$

where the subscripts S and A indicate symmetry or antisymmetry under interchange of any two of the quarks. Note the contrast with the state function for the three nucleons in ^{3}H or ^{3}He:

$$|NNN\rangle_A = |\text{space, spin, isospin}\rangle_A .$$

This difference has major implications for internal structure, magnetic moments, etc. (For a nice discussion, see Ref. 1.)

Few of the baryons containing c or heavier quarks have yet been discovered, so we restrict further attention to baryons made up of just d, u, and s quarks. The three flavors imply a flavor SU(3), which requires that baryons made of these quarks belong to the multiplets on the right side of

$$\mathbf{3} \otimes \mathbf{3} \otimes \mathbf{3} = \mathbf{10}_S \oplus \mathbf{8}_M \oplus \mathbf{8}_M \oplus \mathbf{1}_A$$

(see the section on SU(n) Multiplets and Young Diagrams). Here the subscripts indicate symmetric, mixed-symmetric, or antisymmetric states under interchange of any two quarks. The figure shows particle assignments in these multiplets. States Λ_8 and Λ_1 that have the same spin and parity can mix; an example is the mainly octet D_{03} $\Lambda(1690)$ and mainly singlet D_{03} $\Lambda(1520)$. The formalism is the same as for $\eta-\eta'$ or $\phi-\omega$ mixing (see above), except that for baryons the mass M instead of M^2 is used. The section SU(3) Isoscalar Factors shows how relative decay rates in, say, $\mathbf{10} \to \mathbf{8} \otimes \mathbf{8}$ decays may be calculated. A summary of results of fits to the observed baryon masses and decay rates for the best-known SU(3) multiplets is given in Appendix II of our 1982 edition.[2]

Flavor and spin may be combined in a flavor-spin SU(6) in which the six basic states are d↑, d↓, ···, s↓ (↑, ↓ = spin up, down). Then the baryons belong to the multiplets on the right side of

$$\mathbf{6} \otimes \mathbf{6} \otimes \mathbf{6} = \mathbf{56}_S \oplus \mathbf{70}_M \oplus \mathbf{70}_M \oplus \mathbf{20}_A .$$

These SU(6) multiplets decompose into flavor SU(3) multiplets as follows:

$$\mathbf{56} = {}^4\mathbf{10} \oplus {}^2\mathbf{8}$$

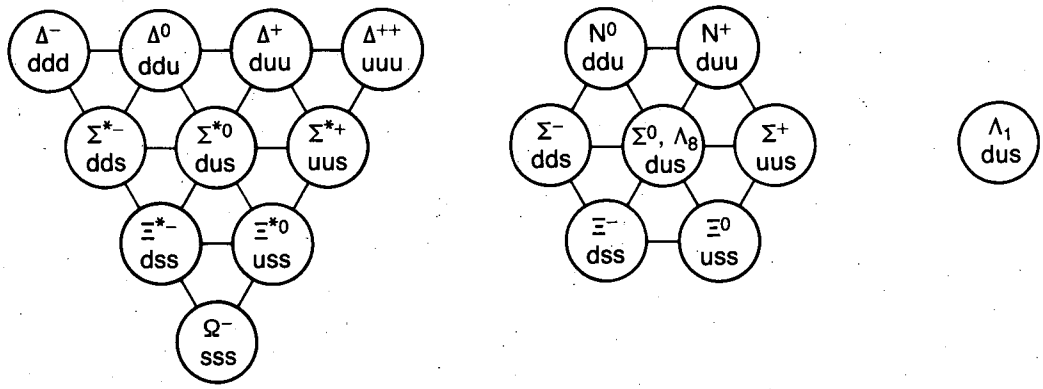
$$\mathbf{70} = {}^2\mathbf{10} \oplus {}^4\mathbf{8} \oplus {}^2\mathbf{8} \oplus {}^2\mathbf{1}$$

$$\mathbf{20} = {}^2\mathbf{8} \oplus {}^4\mathbf{1} ,$$

where the superscript (2S+1) gives the net spin S of the quarks for each particle in the SU(3) multiplet. The $J^P = 1/2^+$ octet containing the nucleon and the $J^P = 3/2^+$ decuplet containing the $\Delta(1232)$ together make up the "ground-state" 56-plet in which the orbital angular momenta between the quarks are zero (so that the spatial part of the state function is trivially symmetric). The **70** and **20** require some excitation of the spatial part of the state function in order to make the overall state function symmetric.

The quark model for baryons is extensively reviewed in Ref. 3.

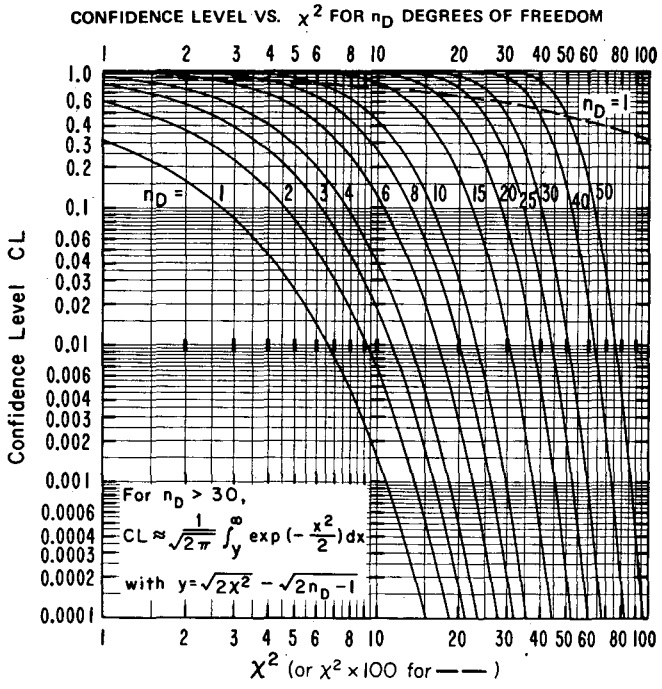
1. F.E. Close, in *Quarks and Nuclear Forces* (Springer-Verlag, 1982), p. 56.
2. Particle Data Group, Phys. Lett. **111B** (1982).
3. A.J.G. Hey and R.L. Kelly, Phys. Reports **96**, 71 (1983).



PROBABILITY AND STATISTICS

A. PROBABILITY DISTRIBUTIONS AND CONFIDENCE LEVELS

We give here properties of the three probability distributions most commonly used in high energy physics: normal (or Gaussian), chi-squared (χ^2), and Poisson. We *warn* the reader that there is no universal convention for the term "confidence level"; thus, explicit definitions that correspond to common usage are given for each distribution. It is explained below how confidence levels for all three distributions may be extracted from the following figure.



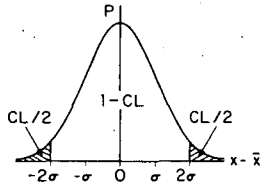
A.1 Normal distribution

The normal distribution with mean $\bar{x}$ and standard deviation σ (variance σ^2) is:

$$P(x)dx = \frac{1}{\sigma\sqrt{2\pi}} e^{-(x-\bar{x})^2/2\sigma^2} dx . \tag{1}$$

The *confidence level* associated with an observed deviation δ from the mean is the probability that $|x-\bar{x}| > \delta$, i.e.,

$$CL = 2\int_{\bar{x}+\delta}^{\infty} dx\, P(x) , \tag{2}$$



since the distribution is symmetric about $\bar{x}$. The small figure in Eq. (2) is drawn with $\delta = 2\sigma$. CL is given by the ordinate of the $n_D = 1$ curve in the large figure at $\chi^2 = (\delta/\sigma)^2$. The confidence level for $\delta = 1\sigma$ is 31.7%; 2σ, 4.6%; 3σ, 0.3%. The *odds* against exceeding δ, (1−CL)/CL, for $\delta = 1\sigma$ are 2.15:1; 2σ, 21:1; 3σ, 370:1; 4σ, 16,000:1; 5σ, 1,700,000:1. Relations between σ and other measures of the *width*: probable error (CL = 0.5) = 0.67σ; mean absolute deviation = 0.80σ; RMS deviation = σ; half width at half maximum = 1.18σ.

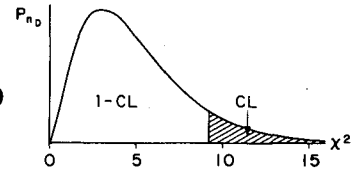
A.2 χ^2 distribution

The χ^2 distribution for n_D degrees of freedom is:

$$P_{n_D}(\chi^2)d\chi^2 = \frac{1}{2^h\Gamma(h)} (\chi^2)^{h-1} e^{-\chi^2/2} d\chi^2 \quad (\chi^2 \geq 0), \tag{3}$$

where h (for "half") = $n_D/2$. The mean and variance are n_D and $2n_D$ respectively. In evaluating Eq. (3) one may use *Stirling's approximation*: $\Gamma(h) \simeq 2.507\, e^{-h}\, h^{(h-1/2)}(1 + 0.0833/h)$, which is accurate to ± 0.1% for all $h \geq 1/2$. The *confidence level* associated with a given value of n_D and an observed value of χ_0^2 is the probability of the χ^2 exceeding the observed value, i.e.,

$$CL = \int_{\chi_0^2}^{\infty} d\chi^2\, P_{n_D}(\chi^2) \tag{4}$$



The small figure in Eq. (4) is drawn with $n_D = 5$ and CL = 10%. CL is plotted as a function of χ^2 for several values of n_D in the large figure. For *large* n_D, χ^2 becomes normally distributed about n_D. Thus,

$$y_1 = (\chi^2 - n_D)/\sqrt{2n_D} \tag{5}$$

becomes normally distributed with unit standard deviation and mean zero. A *better* approximation is that χ, not χ^2, becomes normally distributed; specifically

$$y_2 = \sqrt{2\chi^2} - \sqrt{2n_D - 1} \tag{6}$$

approaches normality with unit standard deviation and mean zero. For small CL's in particular, y_2 is much more accurate than y_1. Thus, for $n_D = 50$ and $\chi^2 = 80$, the true CL = 0.45%, but y_1 is 3.0 corresponding to a CL of 0.13%, while y_2 is 2.7 corresponding to a CL of 0.35%.

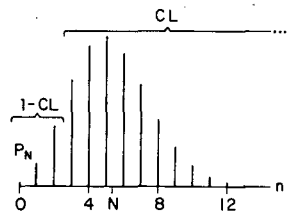
A.3 Poisson distribution

The Poisson distribution with mean $\bar{n}$ is:

$$P_{\bar{n}}(n) = \frac{e^{-\bar{n}}\bar{n}^n}{n!} \quad (n = 0, 1, 2, \cdots). \tag{7}$$

The variance is equal to the mean. *Confidence levels* for Poisson distributions are usually defined in terms of quantities called "*upper limits*" as follows: The confidence level associated with a given upper limit N and an observed value n_0 of n is the probability that $n > n_0$ if $\bar{n} = N$, i.e.,

$$CL = \sum_{n=n_0+1}^{\infty} P_N(n) = 1 - \sum_{n=0}^{n_0} P_N(n) \tag{8}$$



The small figure in Eq. (8) is drawn with $n_0 = 2$ and CL = 90%. A useful relation between Poisson and χ^2 confidence levels allows one to look up this quantity on the large figure. Specifically, the quantity 1−CL is given by the ordinate of the $n_D = 2(n_0+1)$ curve at $\chi^2 = 2N$. Thus, 90% confidence level upper limits for $n_0 = 0$, 1, and 2 are given by half the χ^2 value corresponding to an ordinate of 0.1 on the $n_D = 2$, 4, and 6 curves, respectively; the values are N = 2.3, 3.9, and 5.3.

Tables of confidence levels for all three of these distributions, the relation between Poisson and χ^2 confidence levels, and numerous other useful tables and relations may be found in Ref. 1.

PROBABILITY AND STATISTICS (Cont'd)

B. STATISTICS

Suppose one is presented with N independent data, $y_n \pm \sigma_n$, and it is desired to make some *inference* about the "true" value of the quantity represented by these data. For this purpose we interpret each datum y_n as a single sample point drawn randomly (and independently of the other data) from a distribution having true mean $\overline{y}_n$ (which we wish to estimate) and variance σ_n^2. We do not require that they be normally distributed. (Identification of the true σ_n with the σ_n datum is often an *approximation* which may become seriously inaccurate when σ_n is an appreciable fraction of y_n.) Some methods of estimation commonly used in high energy physics are given below; see Ref. 2 for numerous applications. Section B.1 deals with the case in which all $\overline{y}_n$ are the same, e.g., several different measurements of the same quantity; Sec. B.2 deals with the case in which $\overline{y}_n = \overline{y}(x_n)$, where x_n represents some set of independent variables, e.g., cross-section measurements at various values of energy and angle, $x_n = \{E_n, \theta_n\}$.

B.1 Single mean and variance estimates

(1) If the y_n represent a set of values all supposedly drawn from a single distribution with mean $\overline{y}$ and variance σ^2 (i.e., the σ_n are all the same, but their common value is unknown), then

$$\hat{y} = \frac{1}{N}\sum_{n=1}^{N} y_n \text{ and} \tag{9}$$

$$\hat{\sigma}^2 = \frac{1}{N-1}\sum_{n=1}^{N}(y_n-\hat{y})^2 = \frac{N}{N-1}\left[\langle(y^2)\rangle - (\hat{y})^2\right] \tag{10}$$

are unbiased estimates of $\overline{y}$ and σ^2; the angular brackets denote an average over the data. The variance of $\hat{y}$ is σ^2/N. If the parent distribution is normal and N is large, the variance of $\hat{\sigma}^2$ is $2\sigma^4/N$.

(2) If the y_n are independent estimates of the same $\overline{y}$, and the σ_n are known, then the weighted average

$$\hat{y} = \frac{1}{w}\sum_n w_n y_n, \tag{11}$$

where $w_n = 1/\sigma_n^2$ and $w = \Sigma\, w_n$, is an appropriate unbiased estimate of $\overline{y}$. This choice of weighting factors in Eq. (11) minimizes the variance of the estimate; the variance is $1/w$.

B.2 Linear least-squares fit

We wish to determine the best fit of independent unbiased data $y_n \pm \sigma_n$, measured at points x_n, to the form $y(x) = \Sigma a_i f_i(x)$, where the f_i are known, linearly independent functions (e.g., Legendre polynomials) one-to-one over the allowed range of x. The estimates for the linear coefficients a_i which minimize the sum of the squared deviations are

$$\hat{a}_i = \sum_{j,n} V_{ij}\, f_j(x_n) y_n/\sigma_n^2 . \tag{12}$$

Here V is the covariance matrix of the fitted parameters

$$V_{ij} = \overline{(\hat{a}_i - \overline{a}_i)(\hat{a}_j - \overline{a}_j)}, \tag{13}$$

where the overbar denotes the unknown true value; V is estimated by

$$(V^{-1})_{ij} = \sum_n f_i(x_n) f_j(x_n)/\sigma_n^2 . \tag{14}$$

The estimated variance of an interpolated or extrapolated value of y at point x, $\hat{y} = \Sigma\, \hat{a}_i f_i(x)$, is:

$$(\hat{y}-\overline{y})^2|_{est} = \sum_{ij} V_{ij} f_i(x) f_j(x) . \tag{15}$$

For the case of a *straight line fit*, $y(x) = a + bx$, one obtains the following estimates of a and b,

$$\hat{a} = (S_y S_{xx} - S_x S_{xy})/D, \tag{16}$$

$$\hat{b} = (S_1 S_{xy} - S_x S_y)/D,$$

where

$$S_1, S_x, S_y, S_{xx}, S_{xy} = \sum (1, x_n, y_n, x_n^2, x_n y_n)/\sigma_n^2 , \tag{17}$$

respectively, and

$$D = S_1 S_{xx} - S_x^2 .$$

The covariance matrix of the fitted parameters is:

$$\begin{pmatrix} V_{aa} & V_{ab} \\ V_{ab} & V_{bb} \end{pmatrix} = \frac{1}{D}\begin{pmatrix} S_{xx} & -S_x \\ -S_x & S_1 \end{pmatrix} . \tag{18}$$

The estimated variance of an interpolated or extrapolated value of y at point x is:

$$(\hat{y}-\overline{y})^2|_{est} = \frac{1}{S_1} + \frac{S_1}{D}\left(x - \frac{S_x}{S_1}\right)^2 . \tag{19}$$

A least-squares fit gives estimates for the a_i [Eq.(12)] with the smallest variance, under the conditions that the expansion of y in terms of $a_i f_i$ is the correct model and that the y_n are independent, unbiased measurements whose variances σ_n^2 are known.

C. ERROR PROPAGATION

Suppose one wishes to calculate the value and error of a function of some other quantities with errors, e.g., in a Monte Carlo program. Let $\{y\}$ be a set of random variables with means $\{\overline{y}\}$ and covariance matrix V. Then the mean and variance of a function of these variables are approximately (to second order in $\{y-\overline{y}\}$):

$$\overline{f} \simeq f(\{\overline{y}\}) + \frac{1}{2}\sum_{mn} V_{mn}\left(\frac{\partial^2 f}{\partial y_m \partial y_n}\right)_{\{y\}=\{\overline{y}\}}, \tag{20}$$

$$\overline{(f-\overline{f})^2} \simeq \sum_{mn} V_{mn}\left(\frac{\partial f}{\partial y_m}\right)_{\{y\}=\{\overline{y}\}}\left(\frac{\partial f}{\partial y_n}\right)_{\{y\}=\{\overline{y}\}} . \tag{21}$$

E.g., the mean and variance of a function of a *single variable* with mean $\overline{y}$ and variance σ^2 are

$$\overline{f} \simeq f(\overline{y}) + \frac{1}{2}\sigma^2 f''(\overline{y}) , \tag{22}$$

$$\overline{(f-\overline{f})^2} \simeq \sigma^2 f'(\overline{y})^2 . \tag{23}$$

Note that these equations will usually be applied by substituting measured quantities, $\{\tilde{y}\}$ say, for the true means, $\{\overline{y}\}$. If, as is often the case, $\tilde{y}_n - \overline{y}_n$ is of order $\sqrt{V_{nn}}$, then the second-order terms in Eqs. (20) and (22) may be small compared with the first-order errors introduced by the substitution.

1. M. Abramowitz and I. Stegun, eds., *Handbook of Mathematical Functions* (Dover, New York, 1972).
2. W.T. Eadie, D. Drijard, F.E. James, M. Roos, and B. Sadoulet, *Statistical Methods in Experimental Physics* (North Holland, Amsterdam and London, 1971); S.L. Meyer, *Data Analysis for Scientists and Engineers* (John Wiley and Sons, Inc., New York, 1975); A.G. Frodesen, O. Skjeggestad, and H. Tøfte, *Probability and Statistics in Particle Physics* (Universitetsforlaget, Oslo, Norway, 1979).

PARTICLE DETECTORS, ABSORBERS, AND RANGES*

A. DETECTOR PARAMETERS

In this section we give various parameters for common detectors. The quoted numbers are usually based on some typical apparatus, and obviously should be regarded as rough approximations, valid only for preliminary design when applied to other cases. A more detailed introduction to detectors can be found in "A Consumer's Guide to Particle Detectors," by D.J. Miller, Rutherford Lab Report RL-76-072, July 1976.

A.1 Scintillators: The photon yield in the frequency range of practical photomultiplier tubes is $\simeq 1\gamma$ per 100 eV of charged particle ionization energy loss in plastic scintillator[1] and $\simeq 1\gamma/25$ eV in NaI.[1,2]

A.2 Cerenkov:[3] The half-angle θ_c of the Cerenkov cone aperture in terms of the velocity β and the index of refraction n is:

$$\theta_c = \arccos\left(\frac{1}{\beta n}\right) \simeq \left[2\left(1-\frac{1}{\beta n}\right)\right]^{1/2}.$$

The threshold velocity is: $\beta_t = 1/n$; $\gamma_t = 1/\sqrt{1-\beta_t^2}$. Therefore, $\beta_t\gamma_t = 1/\sqrt{2\delta+\delta^2}$, where $\delta = n-1$. Values of δ for various commonly used gases are given as a function of pressure and wavelength in Ref. 4; for values at atmospheric pressure, see the Table of Atomic and Nuclear Properties, following.

The number of photons N per cm of path length is given by:

$$N = \frac{\alpha}{c}\int\left(1-\frac{1}{\beta^2 n^2}\right)2\pi d\nu = \frac{\alpha}{c}\beta_t^2\int\left(\frac{1}{\beta_t^2\gamma_t^2}-\frac{1}{\beta^2\gamma^2}\right)2\pi d\nu$$

$$\simeq 500\sin^2\theta_c/\text{cm (visible spectrum)}.$$

A.3 Photon collection: In addition to the photon yield, one should take into account the light collection efficiency ($\lesssim 10\%$ for typical 1-cm-thick scintillator), the attenuation length ($\simeq 1$ to 4 m for typical scintillators[5]), and the quantum efficiency of the photomultiplier cathode ($\lesssim 25\%$).

A.4 Typical detector characteristics:

Detector Type	Accuracy (rms)	Resolution Time	Dead Time
Bubble chamber	$\simeq \pm 10$ to $\simeq \pm 150\mu$	$\simeq$ 1 ms	$\simeq$1/20 s[a]
Streamer chamber	$\pm 300\mu$	$\simeq$ 2 μs	$\simeq$100 ms
Proportional chamber	$\gtrsim \pm 300\mu$[b,c]	$\simeq$ 50 ns	$\simeq$200 ns
Drift chamber	± 50 to 300μ	$\simeq$ 2 ns[d]	$\simeq$100 ns
Scintillator	—	$\simeq$150 ps	$\simeq$ 10 ns
Emulsion	$\pm 1\mu$	—	—
Silicon strip	$\pm 5\mu$	[e]	[e]

[a] Multiple pulsing time.
[b] 300μ is for 1 mm pitch.
[c] Delay line cathode readout can give $\pm 150\mu$ parallel to anode wire.
[d] For two chambers.
[e] Limited at present by noise and readout time of attached electronics.

A.5 Shower detectors: We give below typical energy resolutions (FWHM) for an incident electron in the 1 GeV range; E is in GeV. For a fixed number of radiation lengths, FWHM in the last three detectors would be expected to be proportional to $\sqrt{t}$ for t (= plate thickness) $\gtrsim$ 0.2 radiation lengths.[6] For all detectors, operational resolution may be up to 50% worse due to dead areas, non-normally incident tracks, and other effects.

NaI (20 rad. lengths):[7] $\frac{2\%}{E^{1/4}}$

Lead glass (14 rad. lengths):[8] $\frac{10-12\%}{\sqrt{E}}$

Lead-liquid argon (15.75 rad. lengths):[6] $\frac{16\%}{\sqrt{E}}$
(42 cells: 1.1 mm lead, 2 mm liquid argon, 2.3 mm lead-G10, 2 mm liquid argon)

Lead-scintillator sandwich (12.5 rad. lengths):[9] $\frac{17\%}{\sqrt{E}}$
(66 cells: 1 mm lead, 5 mm scintillator)

Proportional wire shower chamber (17 rad. lengths):[10] $\frac{40\%}{\sqrt{E}}$
(36 cells: 0.474 rad. length type-metal + Al, 9.5 mm 80% Ar - 20% CH_4 gas)

A.6 dE/dx resolution in Argon: Particle identification (relativistic, Q = 1 incident particles) by dE/dx is dependent on the width of the distribution:

Multiple-sample Ar gas counters (no lead):[11]

$$\frac{\text{FWHM}\left(\left.\frac{dE}{dx}\right|_{\text{most probable}}\right)}{\left.\frac{dE}{dx}\right|_{\text{most probable}}} = 0.96N^{-0.46}(tp)^{-0.32};$$

N = no. samples, t = thickness per sample (cm), p = pressure (atm.); most commonly used chamber gases (except Xe) give approximately the same resolution.

A.7. Proportional chamber wire instability: The limit on the voltage V for a wire tension T, due to mechanical effects when the electrostatic repulsion of adjacent wires exceeds the restoring force of wire tension, is given by (MSKA)[12]

$$V < \frac{S}{\ell C}\sqrt{4\pi\epsilon_0 T},$$

where s, ℓ, and C are the wire spacing, length, and capacitance per unit length. An approximation to C for chamber half-gap t and wire diameter d (good for s $\lesssim$ t) gives[13]

$$V \lesssim 59T^{1/2}\left[\frac{t}{\ell}+\frac{s}{\pi\ell}\ln\left(\frac{s}{\pi d}\right)\right],$$

where V is in kV, and T is in grams-weight equivalent.

A.8 Proportional and drift chamber potentials: The potential distributions and fields in a proportional or drift chamber can usually be calculated with good accuracy from the exact formula for the potential around an array of parallel line charges q (coul/m) along z and located at y = 0, x = 0, ±s, ±2s,...,

$$V(x,y) = -\frac{q}{4\pi\epsilon_0}\ln\left\{4\left[\sin^2\left(\frac{\pi x}{s}\right)+\sinh^2\left(\frac{\pi y}{s}\right)\right]\right\}.$$

Errors from the presence of cathodes, mechanical defects, TPC-type edge effects, etc., are usually small and are beyond the scope of this review.

A.9 Silicon strip detectors: These are silicon diodes operated with a reverse bias voltage V (typically 30-300 volts) sufficient to deplete the sensitive volume of most mobile charge carriers (electrons and holes). The active (depletion layer) thickness t is given in a simple model by (MKSA)

PARTICLE DETECTORS, ABSORBERS, AND RANGES (Cont'd)

$$t = \sqrt{\frac{2\epsilon V}{ne}} = \sqrt{2\rho\mu\epsilon V},$$

where

n = number of impurity centers/m^3
e = electron charge
ϵ = dielectric constant $\simeq$ 105 pF/m $\simeq 11.9\,\epsilon_0$
ρ = resistivity $\simeq$ 10-200 Ω-m
μ = majority charge carrier mobility
$\simeq$ 0.13-0.15 m^2/volt-sec (electrons)
$\simeq$ 0.045-0.06 m^2/volt-sec (holes).

A minimum-ionizing particle has a Landau energy-loss distribution with average energy loss 39 keV/100 μm and full width at half-maximum of $0.071t/\beta^2$ keV, where t is the detector thickness in microns and $\beta = v_{inc}/c$. The width is usually increased further by electronic noise ($\sigma \sim$1-10 keV) and for thin layers by a Gaussian contribution due to atomic effects [$\sigma \sim (0.3\text{-}0.4)\sqrt{t}$ keV]. The average energy required to produce an electron-hole pair is 3.62 eV, from which one can estimate total charge of either sign released. Silicon detectors can tolerate integrated charged-particle fluxes of up to $\sim 10^{14}$-10^{18}/m^2 and still operate as efficient detectors.

B. COSMIC RAY FLUXES

The fluxes of particles of different types depend on the latitude, their energy, and the conditions of measurement. Some typical sea-level values[14] for charged particles are given below:

I_v flux per unit solid angle about vertical direction crossing unit horizontal area
J_1 perpendicular component of total flux crossing unit horizontal area from above
J_2 total flux crossing unit horizontal area

	Total Intensity	Hard Component	Soft Component	
I_v	1.1×10^2	0.8×10^2	0.3×10^2	m^{-2} sec^{-1} sterad^{-1}
J_1	1.8×10^2	1.3×10^2	0.5×10^2	m^{-2} sec^{-1}
J_2	2.4×10^2	1.7×10^2	0.7×10^2	m^{-2} sec^{-1}

Very approximately, about 75% of all particles at sea level are penetrating, and are muons. The sea-level vertical flux ratio for protons to muons (both charges together) is about 3½% at 1 GeV/c, decreasing to about ½% at 10 GeV/c.

The muon flux at sea level has a mean energy of 2 GeV and a differential spectrum falling as E^{-2}, steepening smoothly to $E^{-3.6}$ above a few TeV. The angular distribution is $\cos^2\theta$, changing to $\sec\theta$ at energies above a TeV, where θ is the zenith angle at production. The +− charge ratio is 1.25-1.30. The mean energy of muons originating in the atmosphere is roughly 300 GeV at slant depths $\gtrsim$ a few hundred meters. Beyond slant depths of ~10 km water-equivalent, the muons are due primarily to in-the-earth neutrino interactions (roughly 1/8 interaction ton^{-1} year^{-1} for $E_\nu >$ 300 MeV, ~ constant throughout the earth).[15] Muons from this source arrive with a mean energy of 20 GeV, and have a flux of 2×10^{-9} m^{-2} sec^{-1} sterad^{-1} in the vertical direction and about twice that in the horizontal,[16] down at least as far as the deepest mines.

C. PASSAGE OF PARTICLES THROUGH MATTER

C.1 Energy loss rates for heavy charged projectiles: A heavy projectile (much more massive than an electron) of charge $Z_{inc}e$, incident at speed βc ($\beta \gg 1/137$) through a slowing medium, dissipates energy principally via interactions with the electrons of the medium. The mean rate of such energy loss per unit path length x, called the stopping power, is given by the Bethe-Bloch equation:[17]

$$\left(\frac{dE}{dx}\right)_{inc} = \frac{D\,Z_{med}\,\rho_{med}}{A_{med}}\left(\frac{Z_{inc}}{\beta}\right)^2$$

$$\times\left[\ln\left(\frac{2m_e\gamma^2\beta^2c^2}{I}\right) - \beta^2 - \frac{\delta}{2} - \frac{C}{Z_{med}}\right]\left\{1+\nu\right\},$$

where $D = 4\pi N_A r_e^2 m_e c^2 = 0.3070$ MeV cm^2/g (see Physical Constants Table). Mean range and energy loss figures appear at the end of this section.

Here, Z_{med} and A_{med} are the charge and mass numbers of the medium and ρ_{med} is the mass density of the medium; I, δ, C, and ν are phenomenological functions. Frequently, the values of δ, C, and ν are negligibly small; the parameter I characterizes the binding of the electrons of the medium. As a rule of thumb, we may estimate I for an idealized medium as $I \simeq 16\ (Z_{med})^{0.9}$ eV when $Z_{med} > 1$. For realistic media the value of I will vary at the 10% level from this estimate. Variations of this order occur due to atomic effects such as completion of a shell, also due to chemical binding, and even due to the phase of the substance. Hydrogen, perhaps the most sensitive, has I of about 15 eV in the atomic mode, rising to about 19.2 eV as H_2 gas and to 21.8 eV as H_2 liquid.[18] For many substances, the transition from gas to solid is accompanied by a 20-30% increase in I.[18] We may *approximately* treat media which are chemical mixtures or compounds by computing

$$\frac{dE}{dx} \simeq \sum_{n=1}^{N}\left(\frac{dE}{dx}\right)_n,$$

with $(dE/dx)_n$ appropriate to the nth chemical constituent (using $\rho_{med}^{(n)}$ as the partial density in the formula for dE/dx).[19] For many chemical compounds, small corrections to this additivity rule may be found in Ref. 18.

The function δ represents the density effect upon the energy loss rate; it is non-negligible only for highly relativistic projectiles in denser media.[20] For ultra-relativistic projectiles, δ approaches $2\ln\gamma$ + constant, where the value of the constant depends upon the density of the medium as well as its chemical composition.

The function C represents shell corrections to the energy loss rate.[17] These effects are non-negligible only for projectiles with speeds not much faster than the speeds of the fastest electrons bound in the medium.

The function ν represents corrections due to higher order electrodynamics.[21] These effects become important when $|Z_{inc}/\beta|$ is comparable to 137. For relativistic unit-charge projectiles, $|\nu|$ is of the order of 1%; positively charged projectiles lose energy more rapidly than do their charge conjugates.[21,22]

For nonrelativistic projectiles, our formulae above are inapplicable. At the very slowest speeds, total energy loss rates are believed to be proportional to β, rising through a peak at projectile speeds comparable to atomic speeds (β on the order of αc), after having passed through a smaller peak (due to elastic Coulomb collisions with the *nuclei* of the slowing medium[23]) at intermediate speeds. For example, for protons in Si, dE/dx = 61.23 β GeV/(gm cm^{-2}) for β <0.005; the peak occurs at β = 0.0126 where dE/dx = 522 MeV/(gm cm^{-2}). In some cases, energy loss rates depend significantly upon the relation of the projectile trajectory to the crystalline structure of the slowing medium.[24]

For relativistic projectiles, $(dE/dx)_{inc}$ falls rapidly with increasing β until reaching a minimum around β = 0.96 (almost independent of medium), followed by a slow rise. Because of the density

PARTICLE DETECTORS, ABSORBERS, AND RANGES (Cont'd)

effect, the quantity in square brackets approaches $\ell n\gamma$ + constant for large γ.

The quantity $(dE/dx)_{inc}\delta x$ is the *mean* total energy loss via interactions with electrons of the medium in a layer of thickness δx. For any finite δx, Poisson fluctuations can cause the actual energy loss to deviate from the mean. For thin layers, the distribution is broad and skewed, being peaked below $(dE/dx)\delta x$, and having a long tail toward large energy losses.[25] Only for a very thick layer $[(dE/dx)\delta x \gg 2m_e\beta^2\gamma^2c^2]$ will the distribution of energy losses become nearly Gaussian. The large fluctuations of the total energy loss rate from the mean are due to a small number of collisions involving large energy transfers. The fluctuations are greatly reduced for the so-called restricted energy loss rate, described in Section C.4.

C.2 Ionization yields: Physicists frequently relate total energy loss to the number of ion pairs produced near the projectile's track. This relation becomes complicated for relativistic projectiles due to the wandering of energetic knock-on electrons whose ranges exceed the dimensions of the fiducial volume. For a qualitative appraisal of the nonlocality of energy deposition by such modestly energetic knock-on electrons in various media, see Ref. 26. Furthermore, the mean local energy dissipation per local ion pair produced, W, while essentially constant for relativistic projectiles, increases at slow projectile speeds.[27] The numerical value of W for gases can be surprisingly sensitive to trace amounts of various contaminants.[27] Of course, in addition to the preceding effects, practical ionization yields may be greatly influenced by subsequent recombinations and other factors.[28]

C.3 Energetic knock-on electrons: For a relativistic point-charge projectile, the production of high energy (kinetic energy $T \gg I$) electrons is given by:[29]

$$\frac{d^2N}{dTdx} = \frac{1}{2}D\left(\frac{Z_{med}}{A_{med}}\right)\left(\frac{Z_{inc}}{\beta}\right)^2 \rho_{med}\frac{1}{T^2}F,$$

for $I \ll T \leq T_{max}$, where

$$T_{max} = \frac{2m_e\beta^2\gamma^2c^2}{1 + 2\gamma\frac{m_e}{M_{inc}} + \left(\frac{m_e}{M_{inc}}\right)^2},$$

M_{inc} is the mass of the incident projectile, and all other quantities except F are as in Sec. C.1. F ($\simeq 1$ for $T \ll T_{max}$) is a factor dependent upon the spin of the projectile.
For spin-0 projectiles,

$$F = 1 - \beta^2\frac{T}{T_{max}};$$

for spin-1/2 projectiles,

$$F = 1 - \beta^2\frac{T}{T_{max}} + \frac{1}{2}\left(\frac{T}{T_{inc} + M_{inc}c^2}\right)^2,$$

where T_{inc} is the kinetic energy of the projectile;
for electrons incident,

$$F = \beta^2T^2\left[\frac{T_{inc}}{T(T_{inc} - T)} - \frac{1}{T_{inc}}\right]^2;$$

and for positrons incident,

$$F = \beta^2\left[1 - \frac{T}{T_{inc}} + \left(\frac{T}{T_{inc}}\right)^2\right]^2.$$

For incident electrons, the indistinguishability of projectile and target means that the range of T is only up to $T_{inc}/2$. For additional formulas see Ref. 30. Our formula is inaccurate for T close to I; for $2I \lesssim T \lesssim 10I$, the $1/T^2$ dependence above becomes $\simeq T^{-\eta}$ with $3 \lesssim \eta \lesssim 5$.[31]

C.4 Rates of restricted energy loss for relativistic charged projectiles: The variability of energy loss for heavy projectiles is due primarily to the variability in the production of energetic knock-on electrons. Bremsstrahlung and pair-production processes make this variability even greater for electrons than for heavy particles as projectiles (see, e.g., the figure "Fractional Energy Loss for Electrons and Positrons in Lead," following). If an instrument, such as a bubble chamber, is capable of isolating these high-energy-loss interactions, then it is appropriate to consider the rate of energy loss excluding them, i.e., a restricted energy loss rate. The mean energy loss rate via all collisions which have energy transfer T such that $T \leq E_{max} \ll T_{max}$ is:[17]

$$\left(\frac{dE}{dx}\right)_{\leq E_{max}} = \frac{1}{2}D\frac{Z_{med}\rho_{med}}{A_{med}}\left(\frac{Z_{inc}}{\beta}\right)^2 \times\left[\ell n\left(\frac{E_{max}T_{max}}{I^2}\right) - \beta^2 - \delta - \frac{2C}{Z_{med}}\right].$$

Notice the overall factor of 1/2. See Sec. C.1 above for definitions of the quantities in this equation.

The density effect causes the restricted energy loss rate to approach a constant, the Fermi plateau value, for the fastest projectiles.

C.5 Multiple scattering through small angles: As a charged particle traverses a medium it is deflected by many small-angle elastic scatterings. The bulk of this deflection is due to elastic Coulomb scattering from the nuclei within the medium, hence the usual identification as multiple Coulomb scattering (note, however, that strong interactions do contribute to the total multiple scattering for hadronic projectiles). For both Coulomb and strong interactions, the Central Limit Theorem provides little useful guidance in establishing the precise nature of the distribution of the total deflections resulting from multiple scattering. The true distribution is roughly Gaussian only for small deflection angles, while it shows much greater probability for large-angle scatterings ($\gtrsim$ a few θ_0, see below, depending on absorber) than the Gaussian would suggest. These tails on the distribution (a few per cent of peak height in the region where the Gaussian part becomes negligible) are more pronounced for hadrons than for muons as projectiles. The large-angle behavior of these distributions is best estimated by computing the exact distribution for the vectorial sum of the largest deflections based upon the true elastic scattering cross section of the projectile against the medium,[32] or, when applicable, by interpolation from tabular data.[33] An easier alternative which may suffice for noncritical applications would be to use a Gaussian approximation with the following width:[34]

$$\theta_0 = \frac{14.1\ \text{MeV/c}}{p\beta}Z_{inc}\sqrt{L/L_R}\left[1 + \frac{1}{9}\log_{10}\left(L/L_R\right)\right]\ \text{(radians)},$$

where p, β, and Z_{inc} are the momentum (in MeV/c), velocity, and charge number of the incident particle, and L/L_R is the thickness, in radiation lengths, of the scattering medium. L_R for certain

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materials is given in the Table of Atomic and Nuclear Properties of Materials, following. See also Sec. C.7 below. The angle, θ_0, is a fit to Moliere[32] theory, accurate to about 5% for $10^{-3} < L/L_R < 10$ except for very light elements or low velocity where the error is about 10 to 20%. In this Gaussian approximation, θ_0 has the meaning

$$\theta_0 = \theta^{\rm rms}_{\rm plane} = \frac{1}{\sqrt{2}}\,\theta^{\rm rms}_{\rm space}\,.$$

The nonprojected (space) and projected (plane) angular distributions are given approximately[32] by the Gaussian forms:

$$\frac{1}{2\pi\theta_0^2}\exp\left[-\frac{\theta^2_{\rm space}}{2\theta_0^2}\right]d\Omega,$$

$$\frac{1}{\sqrt{2\pi}\,\theta_0}\exp\left[-\frac{\theta^2_{\rm plane}}{2\theta_0^2}\right]d\theta_{\rm plane},$$

where θ is the deflection angle.

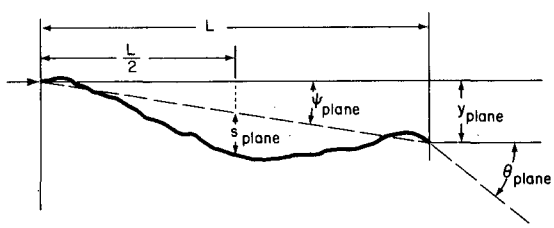
Other quantities are sometimes used to describe the amount of multiple Coulomb scattering: the auxiliary quantities $\psi_{\rm plane}$, $y_{\rm plane}$, and $s_{\rm plane}$ (see the figure) obey:

$$\psi^{\rm rms}_{\rm plane} = \frac{1}{\sqrt{3}}\,\theta^{\rm rms}_{\rm plane} = \frac{1}{\sqrt{3}}\theta_0\,,$$

$$y^{\rm rms}_{\rm plane} = \frac{1}{\sqrt{3}}\,L\,\theta^{\rm rms}_{\rm plane} = \frac{1}{\sqrt{3}}L\theta_0\,,$$

and

$$s^{\rm rms}_{\rm plane} = \frac{1}{4\sqrt{3}}\,L\,\theta^{\rm rms}_{\rm plane} = \frac{1}{4\sqrt{3}}L\theta_0\,.$$



All the quantitative estimates in this section apply only in the limit of small $\theta^{\rm rms}_{\rm plane}$ and in the absence of large-angle scatters.

C.6 Longitudinal distribution of electromagnetic showers: A photon of energy $E > 0.1$ GeV converting in a semi-infinite medium produces an electromagnetic cascade whose intensity initially increases with depth and then falls off. The average number of $e^\pm$ with kinetic energy above 1.5 MeV, crossing a plane at a depth of L radiation lengths from the beginning of the medium, in a material of atomic number Z, calculated using the Monte Carlo program EGS,[35] can be fit by the empirical formula[36]

$$N = N_0 L^a e^{-bL}\,,$$

where $N_0 = 5.51\,E(\text{GeV})\sqrt{Z}\,b^{a+1}/\Gamma(a+1)$ and $b = 0.634 - 0.0021\,Z$. For $Z > 26$, $a = 2.0 - Z/340 + (0.664 - Z/340)\ln E$. For $Z = 13$, $a = 1.77 - 0.52\ln E$. The maximum intensity, $N_{\rm max}$, occurs at the depth $L = a/b$. The maximum error of the fit occurs in the vicinity of this depth and is less than $0.15\,N_{\rm max}$. The integral of the tail, $\int_{1.5a/b}^{\infty} N\,dL$ is fit to better than 2.5%. The total longitudinally projected $e^\pm$ path length, $\int_0^\infty N\,dL = 5.51\,E\sqrt{Z}$, is less than the total $e^\pm$ path length due primarily to multiple Coulomb scattering.

C.7 Radiation length: For the passage of electromagnetically interacting particles through a medium it is convenient to measure thickness in terms of radiation length.[37] For most electromagnetic processes (Bremsstrahlung, Coulomb scattering, showering, pair production, etc.), over large energy intervals, some or all of the dependence upon the medium is contained in the radiation length.

The radiation length may be defined as the distance L_R over which a high energy electron ($\gtrsim$ 1 GeV for most materials) loses all but a fraction 1/e of its energy to Bremsstrahlung, on average. For a homogeneous monoatomic medium, $Z \geq 5$,

$$\frac{1}{L_R} = \frac{4\alpha r_e^2 N_A Z^2}{A}\left\{\ln\left(\frac{184.15}{Z^{1/3}}\right) + \frac{1}{Z}\ln\left(\frac{1194}{Z^{2/3}}\right) - 1.202\alpha^2Z^2 + 1.0369\alpha^4Z^4 - \frac{1.008\alpha^6Z^6}{1+\alpha^2Z^2}\right\} = \frac{Z^2\{\;\}}{716.405A}\,,$$

where α, r_e, and N_A are found in the Physical Constants Table, and Z and A are the atomic number and weight of the medium. For $Z < 5$, a more complex numerical calculation is required. Radiation lengths for many substances are tabulated in the Table of Atomic and Nuclear Properties of Materials, following. For media which are chemical mixtures or compounds,

$$\frac{1}{L_R} \simeq \sum_i \frac{f_i}{L_R^i}\,,$$

where f_i is the fraction by mass of atoms of type i, radiation length L_R^i. Chemical binding can lower L_R from this, typically by a few per cent.

For electrons of energy below about one GeV, the average fractional energy loss per unit length decreases as the energy decreases (see Fractional Energy Loss for Electrons and Positrons in Lead figure, following). With distances measured in units of L_R, dependence of the Bremsstrahlung fractional energy loss upon Z of the medium in the low energy region ($\gtrsim$ 10 MeV) is of order a few percent or less.

For photons of infinite energy, the total pair-production cross section is

$$\sigma = \tfrac{7}{9}(A/L_R N_A)\,.$$

This is accurate to within a few per cent down to ~1 GeV for most materials. For energies below about 1 GeV, the cross section varies in a manner which may be determined from the Photon Mass Attenuation figures, following. See also Contributions to Photon Cross Section in Carbon and Lead figure, following.

C.8 Electron practical range: The electron "practical range" — a common measure of straight-line penetration distance — is shorter than the total path length because of multiple Coulomb scattering, which becomes increasingly important as the electron slows down. E.g., for a fast electron the rms projected angle due to multiple Coulomb scattering reaches 1 radian by the time the electron has slowed to 0.4 MeV in hydrogen, 1.5 MeV in carbon, 9 MeV in copper, and 24 MeV in lead. Electrons which have energy less than

PARTICLE DETECTORS, ABSORBERS, AND RANGES (Cont'd)

0.2 MeV in Ar, 1.5 MeV in Cu, 3.5 MeV in Sn, and 5 MeV in Pb are likely to deposit 10% of their energy *behind* their starting plane. The practical range, R_p, is defined as that absorber thickness obtained by extrapolating to zero the linearly decreasing part of the curve of penetration probability vs. absorber thickness. Data for Al in the T range up to about 10 MeV are available, and fit (to $\sim\pm 10\%$) $R_p = AT[1-B/(1+CT)]$ mg cm^{-2}, a form suggested in Ref. 38, with A=0.55 mg cm^{-2} keV^{-1}, B = 0.9841, and C = 0.0030 keV^{-1}. At this penetration depth, 90 - 95% of the incident electrons have stopped. Data for other elements are sketchy, but suggest that higher-Z ($\lesssim 50$) elements have $1 \lesssim R_p/R_p(\mathrm{Al}) \lesssim 1.4$ below $\sim$10 keV, and $0.6 \lesssim R_p/R_p(\mathrm{Al}) \lesssim 1$ above $\sim$ 100 keV. The "critical energy" (above which the energy loss due to bremsstrahlung exceeds that due to ionization, and showering becomes important) is 400 MeV for hydrogen, 100 MeV for carbon, 25 MeV for copper, and 10 MeV for lead. The mean positron range may differ from the mean electron range by several percent. See Refs. 39 and 40. Electron energy deposition and penetration probability vs. range are discussed in Refs. 26, 41, and 42.

C.9 Atomic and nuclear properties of matter: See table following.

C.10 Range and energy loss for heavy projectiles in lead, copper, aluminum, and carbon: See figure following.

C.11 Range and energy loss for heavy projectiles in liquid hydrogen: See figure following.

C.12 Photon mass attenuation coefficients, energy deposition: See figures following.

C.13 Fractional energy loss for electrons and positrons in lead: See figure following.

C.14 Contributions to photon cross section in lead and carbon: See figures following.

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* Revised April 1984 by Sherwood Parker, Ray Hagstrom, and Geoff Hall.

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Atomic and Nuclear Properties of Materials*

Material	Z	A	Nuclear[a] total cross section σ_T [barn]	Nuclear[b] inelastic cross section σ_I [barn]	Nuclear[c] collision length λ_T [g/cm^2]	Nuclear[c] interaction length λ_I [g/cm^2]	dE/dx min[d] $\overline{\Delta E}$ $\left[\frac{\text{MeV}}{\text{g/cm}^2}\right]$	E_{mp}, 1 cm [MeV] () is for gas [keV]	Radiation length[e] L_{rad} [g/cm^2]	[cm] () is for gas	Density[f] [g/cm^3] () is for gas [g/ℓ]	Refractive index n[f] () is (n−1)×10^6 for gas
H_2	1	1.01	0.0387	0.033	43.3	50.8	4.12	(0.19)	61.28	865	0.0708(0.090)	1.112(140)
D_2	1	2.01	0.073	0.061	45.7	53.7	2.07	(0.17)	122.6	757	0.162(0.177)	1.128
He	2	4.00	0.133	0.102	49.9	65.1	1.94	(0.16)	94.32	755	0.125(0.178)	1.024(35)
Li	3	6.94	0.211	0.157	54.6	73.4	1.58	0.70	82.76	155	0.534	—
Be	4	9.01	0.268	0.199	55.8	75.2	1.61	2.61	65.19	35.3	1.848	—
C	6	12.01	0.331	0.231	60.2	86.3	1.78	3.57	42.70	18.8	2.265[g]	—
N_2	7	14.01	0.379	0.265	61.4	87.8	1.82	(0.93)	37.99	44.5	0.808(1.25)	1.205(300)
O_2	8	16.00	0.420	0.292	63.2	91.0	1.82	(1.31)	34.24	28.7	1.14(1.43)	1.22(266)
Ne	10	20.18	0.507	0.347	66.1	96.6	1.73	(0.75)	28.94	24.0	1.207(0.90)	1.092(67)
Al	13	26.98	0.634	0.421	70.6	106.4	1.62	3.81	24.01	8.9	2.70	—
Si	14	28.09	0.660	0.440	70.6	106.0	1.66	3.36	21.82	9.36	2.33	—
Ar	18	39.95	0.868	0.566	76.4	117.2	1.51	(1.30)	19.55	14.0	1.40(1.78)	1.233(283)
Fe	26	55.85	1.120	0.703	82.8	131.9	1.48	10.7	13.84	1.76	7.87	—
Cu	29	63.54	1.232	0.782	85.6	134.9	1.44	11.85	12.86	1.43	8.96	—
Sn	50	118.69	1.967	1.21	100.2	163	1.26	8.3	8.82	1.21	7.31	—
Xe	54	131.30	2.120	1.29	102.8	169	1.24	(3.57)	8.48	2.77	3.057(5.89)	(705)
W	74	183.85	2.767	1.65	110.3	185	1.16	21.1	6.76	0.35	19.3	—
Pb	82	207.19	2.960	1.77	116.2	194	1.13	11.7	6.37	0.56	11.35	—
U	92	238.03	3.378	1.98	117.0	199	1.09	19.3	6.00	≈0.32	≈18.95	—
Air, 20°C, 1 atm. (STP in paren.)					62.0	90.0	1.82	(1.12)	36.66	(30420)	0.001205(1.29)	1.000273(293)
H_2O					60.1	84.9	2.03	1.72	36.08	36.1	1.00	1.33
Shielding concrete[h]					67.4	99.9	1.70	3.68	26.7	10.7	2.5	—
SiO_2 (quartz)					67.0	99.2	1.72	3.28	27.05	12.3	2.2	1.458
H_2 (bubble chamber 26°K)					43.3	50.8	4.12	0.20	61.28	≈1000	≈0.063[i]	1.100
D_2 (bubble chamber 31°K)					45.7	53.7	2.07	0.22	122.6	≈900	≈0.140[i]	1.110
H-Ne mixture (50 mole percent)[j]					65.0	94.5	1.84	0.59	29.70	73.0	0.407	1.092
Ilford emulsion G5					82.0	134	1.44	4.79	11.0	2.89	3.815	—
NaI					94.8	152	1.32	4.13	9.49	2.59	3.67	1.775
BaF_2					92.1	146	1.35	3.78	9.91	2.05	4.83	1.56
BGO ($Bi_4Ge_3O_{12}$)					97.4	156	1.27	8.07	7.98	1.12	7.1	2.15
Polystyrene, scintillator (CH)[k]					58.4	82.0	1.95	1.72	43.8	42.4	1.032	1.581
Lucite, Plexiglas ($C_5H_8O_2$)					59.2	83.6	1.95	1.98	40.55	≈34.4	1.16-1.20	≈1.49
Polyethylene (CH_2)					56.9	78.8	2.09	1.68	44.8	≈47.9	0.92-0.95	—
Mylar ($C_5H_4O_2$)					60.2	85.7	1.86	2.24	39.95	28.7	1.39	—
Borosilicate glass (Pyrex)[ℓ]					66.2	97.6	1.72	3.32	28.3	12.7	2.23	1.474
CO_2					62.4	90.5	1.82	(1.92)	36.2	(18310)	(1.977)	(410)
Methane CH_4					54.7	74.0	2.41	(0.91)	46.5	(64850)	0.423(0.717)	(444)
Isobutane C_4H_{10}					56.3	77.4	2.22	(3.43)	45.2	(16930)	(2.67)	(1270)
Freon 12 (CCl_2F_2) gas, 26°C, 1 atm.[m]					70.6	106	1.62	4.49	23.7	4810	4.93	1.001080
Silica Aerogel[n]					65.5	95.7	1.83	0.28	29.85	≈150	0.1-0.3	1.0+0.25ρ
G10 plate[o]					62.6	90.2	1.87	2.7	33.0	19.4	1.7	—

* Table revised April 1984 by Joachim Engler. For details, see Report KfK 3386B, Kernforschungzentrum, D 7500 Karlsruhe, P.O. Box 3640, FRG.

a. σ_{total} at 80-240 GeV for neutrons (≈ σ for protons) from Murthy et al., Nucl. Phys. **B92**, 269 (1975).

b. $\sigma_{inelastic}=\sigma_{total}-\sigma_{elastic}-\sigma_{quasielastic}$; for neutrons at 60-375 GeV from Roberts et al., Nucl. Phys., **B159**, 56 (1979). For protons and other particles, see Carroll et al., Phys. Lett. **80B**, 319 (1979); note that $\sigma_I(p) \approx \sigma_I(n)$.

c. Mean free path between collisions (λ_T) or inelastic interactions (λ_I), calculated from $\lambda = A/(N\times\sigma)$.

d. For minimum-ionizing protons and pions. $\overline{\Delta E}$ is energy loss per g/cm^2 from Barkas and Berger, *Tables of Energy Losses and Ranges of Heavy Charged Particles*, NASA-SP-3013 (1964). For electrons and positrons see: M.J. Berger and S.M. Seltzer, *Stopping Powers and Ranges of Electrons and Positrons* (2nd Ed.), U.S. National Bureau of Standards report NBSIR 82-2550-A (1982). E_{mp} is the most probable deposited energy in one cm, in MeV for solids and liquids, in keV for gases. E_{mp} varies with depth in a nonproportional manner. (See Sec. C.1 preceding.) Parentheses refer to gaseous form at STP (0°C, 1 atm.).

e. From Y.S. Tsai, Rev. Mod. Phys. **46**, 815 (1974). Corrections for molecular binding applied for H_2, and D_2. Parentheses refer to gaseous form at STP (0°C, 1 atm.).

f. Values for solids, or the liquid phase at boiling point, except as noted. Values in parentheses for gaseous phase at STP (0°C, 1 atm.). Refractive index given for sodium D line.

g. For pure graphite; industrial graphite density may vary 2.1 - 2.3 g/cm^3.

h. Standard shielding blocks, typical composition O_2 52%, Si 32.5%, Ca 6%, Na 1.5%, Fe 2%, Al 4%, plus reinforcing iron bars. The attenuation length, ℓ = 115 ± 5 g/cm^2, is also valid for earth (typical ρ = 2.15), from CERN-LRL-RHEL Shielding exp., UCRL-17841 (1968).

i. Density may vary about ± 3%, depending on operating conditions.

j. Values for typical working conditions with H_2 target: 50 mole percent, 29°K, 7 atm.

k. Typical scintillator; e.g., PILOT B and NE 102A have an atomic ratio H/C = 1.10.

ℓ. Main components: 80% SiO_2 + 12% B_2O_3 + 5% Na_2O.

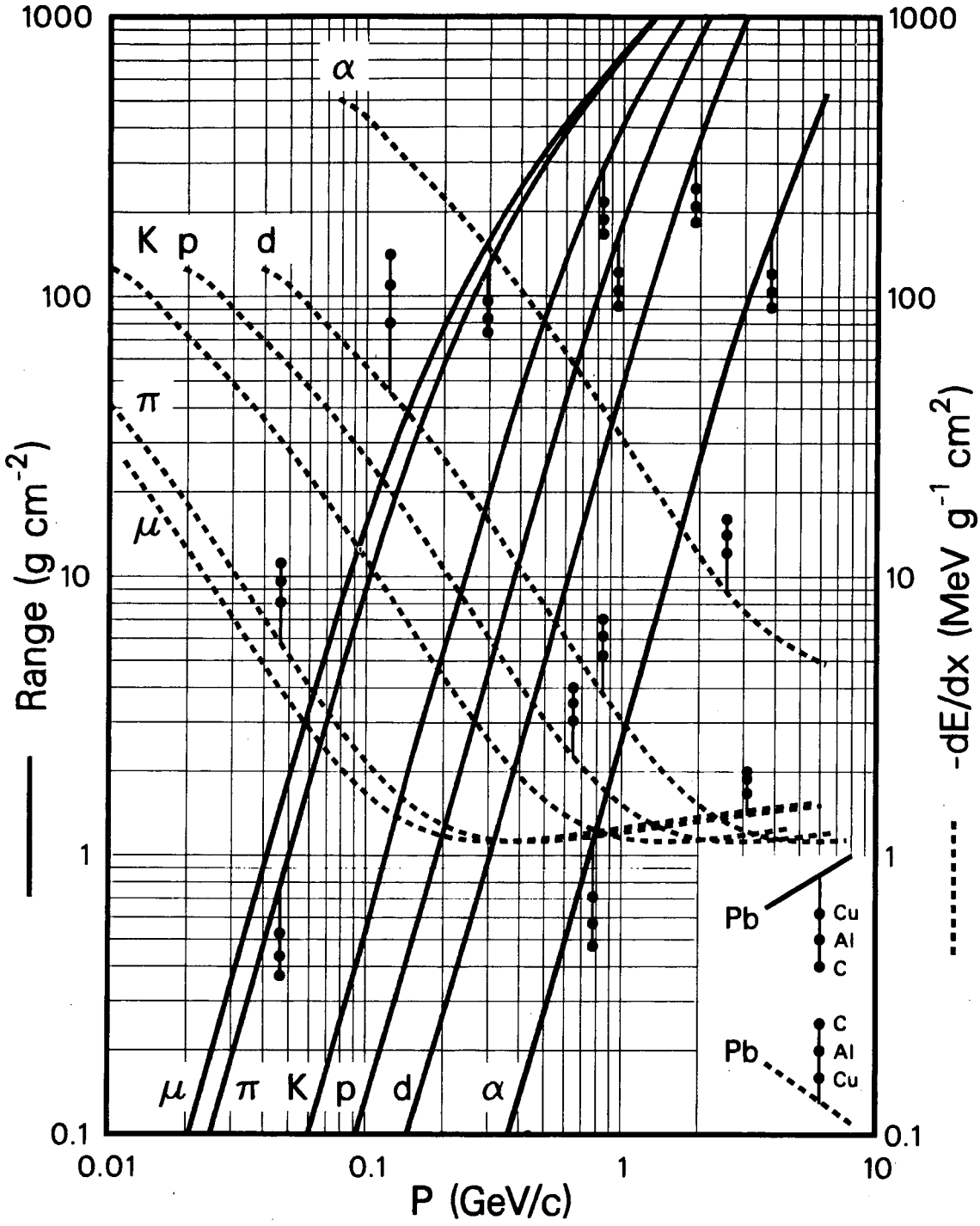
m. Used in Cerenkov counters. Values at 26°C and 1 atm. Indices of refraction from E.R. Hayes, R.A. Schluter, and A. Tamosaitis, ANL-6916 (1964).

n. n(SiO_2) + 2n(H_2O) used in Cerenkov counters, ρ = density in g/cm^3. From M. Cantin et al., Nucl. Instr. Meth. **118**, 177 (1974).

o. G10-plate, typical 60% SiO_2 and 40% Epoxy.

PARTICLE DETECTORS, ABSORBERS, AND RANGES (Cont'd)

Mean Range and Energy Loss in Lead, Copper, Aluminum, and Carbon



Mean range and energy loss due to ionization for the indicated particles in Pb, with scaling to Cu, Al, and C indicated, using Bethe-Bloch equation (Section C.1 above) with corrections. Calculated by M.J. Berger, using ionization potentials and density effect corrections as discussed in M.J. Berger and S.M. Seltzer, "Stopping Powers and Ranges of Electrons and Positrons," (2nd ed.), U.S. National Bureau of Standards Report NBSIR 82-2550-A (1982). The average ionization potentials (I) assumed were: Pb (823 eV), Cu (322 eV), Al (166 eV), and C (78.0 eV). Figure indicates total path length; observed range may be smaller (by ~ 1 % - 2% in heavy elements) due to multiple scattering, primarily from small energy-loss collisions with nuclei. The functional forms have not been experimentally verified to better than roughly ±1%. For higher energies refer to discussion by Cobb ["A Study of Some Electromagnetic Interactions of High Velocity Particles with Matter," University of Oxford Report HEP/T/55 (1973)] and by Turner ["Penetration of Charged Particles in Matter: A Symposium," National Academy of Sciences, Washington D.C. (1970), p. 48]. Scaling to other beam particles is, to a good approximation, described by the expression on the next page.

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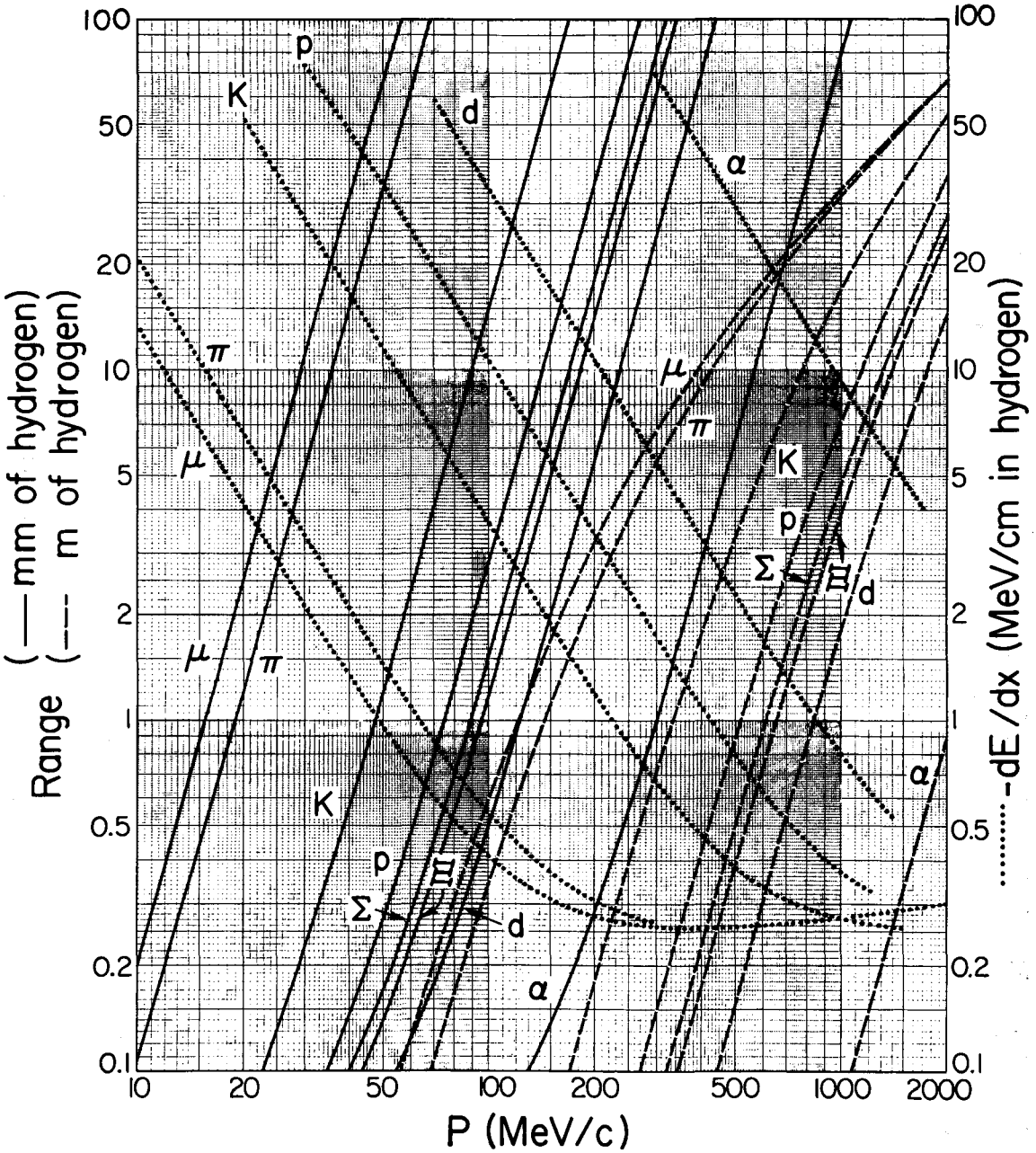
Mean Range and Energy Loss in Liquid Hydrogen

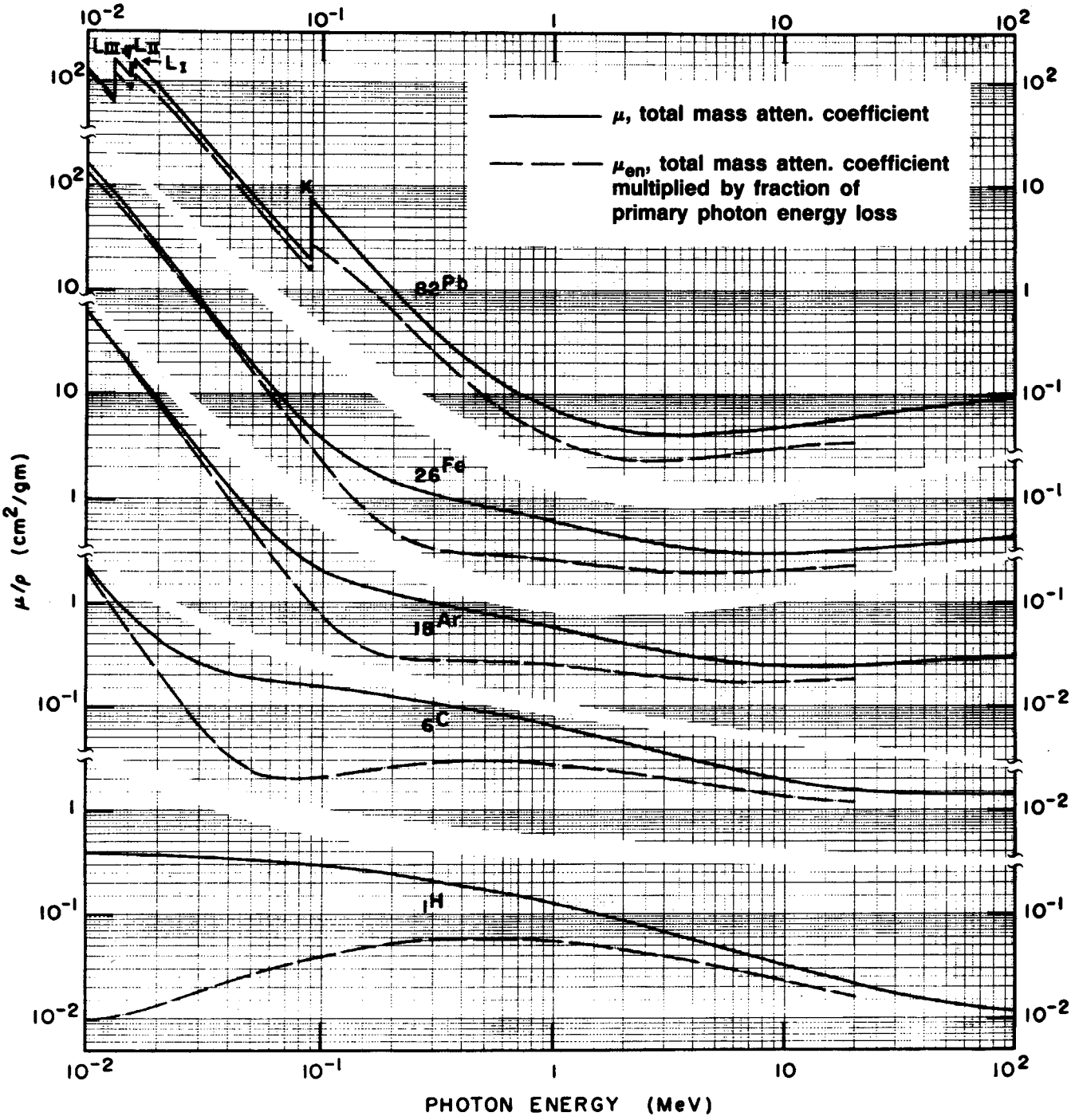


Range and energy loss in liquid hydrogen bubble chamber, based on Bethe-Bloch equation (Section C.1 above), using an average ionization potential for H_2 of I = 20.0 eV, which is an approximate average of the experimental result of Garbincius and Hyman [Phys. Rev. A2, 1834 (1970)] and the theoretical result of Ford and Browne [Phys. Rev. A7, 418 (1973)]. Bubble chamber conditions are chosen to be those of Garbincius and Hyman: parahydrogen of density = 0.0625 g/cm^3 (note: range $\propto$ 1/density), with vapor-pressure 60.8 lb/in^2 (absolute) and temperature 26.2°K. The functional dependence of the Bethe-Bloch equation is not experimentally verified to better than about ± 1% over large momentum ranges. It should be noted that the number of bubbles per cm of a track in a bubble chamber is nearly proportional to $1/\beta^2$, not dE/dx. For the linear portions of the range curves, $R \propto p^{3.6}$. ***Scaling law for particles of other mass or charge*** *(except electrons):* for a given medium, the range R_b of any beam particle with mass M_b, charge z_b, and momentum p_b is given in terms of the range R_a of any other particle with mass M_a, charge z_a, and momentum $p_a = p_b M_a/M_b$ (i.e., having the same velocity) by the expression:

$$R_b(M_b,z_b,p_b) = \left[\frac{M_b/M_a}{z_b^2/z_a^2}\right] R_a(M_a,z_a,p_a=p_b M_a/M_b) .$$

PARTICLE DETECTORS, ABSORBERS, AND RANGES (Cont'd)

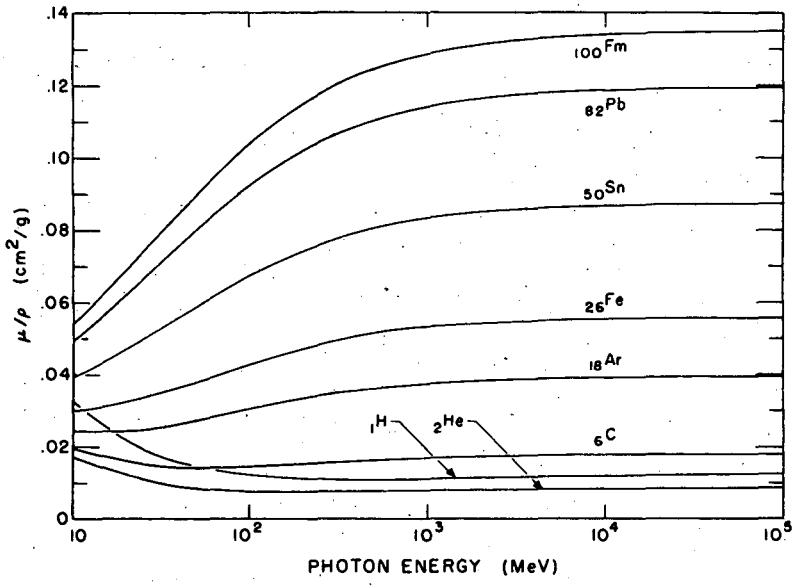
Photon Mass Attenuation Coefficients, Energy Deposition



The photon mass attenuation coefficient μ for various absorbers as a function of photon energy (***solid curves***). For a homogeneous medium of density ρ, the intensity I remaining after traversal of thickness t is given by $I = I_0 \exp(-\mu t)$. The accuracy is a few percent. Interpolation to other Z should be done in the cross section $\sigma = (\mu/\rho)\, A/N_A$ cm^2/atom, where A is the atomic weight of the absorber material and N_A is Avogadro's number. For a chemical compound or mixture, use $(\mu/\rho)_{eff} \simeq \sum w_i(\mu/\rho)_i$, accurate to a few percent, where w_i is the proportion by weight of the ith constituent. See next page for high energy range. The ***dashed curves*** give the mass energy-absorption coefficient μ_{en}, which is μ multiplied by the fraction of photon energy deposited in a small volume (assumed large enough to contain the ranges of most secondary electrons) about the interaction. This fraction is smaller than 1.0 because such processes as Compton scattering and electron bremsstrahlung imply radiation of some of the energy away from the immediate area. The absorption coefficient is an approximation to the energy available for chemical, biological, and other effects associated with exposure to ionizing radiation. At high energies, the range of secondary electrons tends to become comparable to the photon mean free path, and μ_{en} is not a useful approximation. From Hubbell, Gimm, and Øverbø, J. Phys. Chem. Ref. Data 9, 1023 (1980). See also J.H. Hubbell, Int. J. of Applied Rad. and Isotopes 33, 1269 (1982). Figures courtesy J.H. Hubbell.

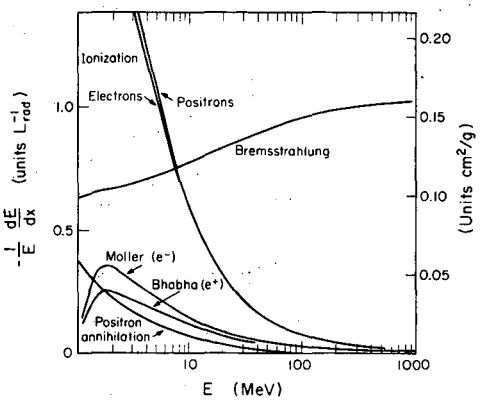
PARTICLE DETECTORS, ABSORBERS, AND RANGES (Cont'd)

Photon Mass Attenuation Coefficients (High Energy)



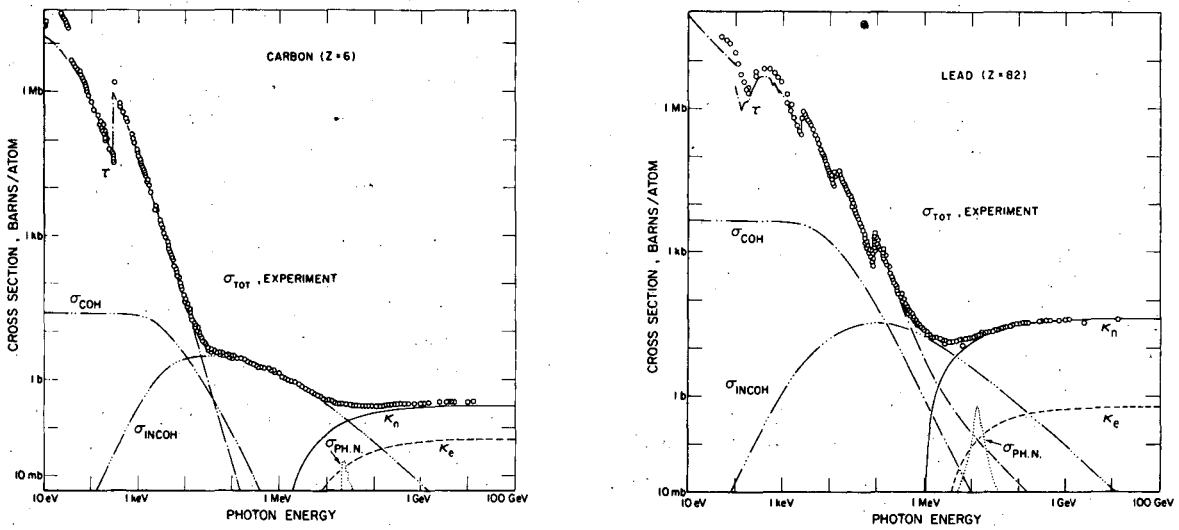
The photon mass attenuation coefficient, high energy range (note that ordinate is linear scale). See caption on previous page for details.

Fractional Energy Loss for Electrons and Positrons in Lead



Fractional energy loss per radiation length in lead as a function of electron or positron energy. Electron (positron) scattering is considered as ionization when the energy loss per collision is below 0.255 MeV, and as Moller (Bhabha) scattering when it is above. Adapted from Fig. 3.2 from Messel and Crawford, *Electron-Photon Shower Distribution Function Tables for Lead, Copper, and Air Absorbers*, Pergamon Press, 1970. Messel and Crawford use $L_r(\text{Pb}) = 5.82$ g/cm^2, but we have modified the figures to reflect the value given in the Table of Atomic and Nuclear Properties of Materials (following), namely $L_r(\text{Pb}) = 6.4$ g/cm^2. The development of electron-photon cascades is approximately independent of absorber when the results are expressed in terms of inverse radiation lengths (i.e., scale on left of plot).

Contributions to Photon Cross Section in Carbon and Lead



Photon total cross sections as a function of energy in carbon and lead, showing the contributions of different processes.

τ	=	Atomic photo-effect (electron ejection, photon absorption)
σ_{COH}	=	Coherent scattering (Rayleigh scattering — atom neither ionized nor excited)
σ_{INCOH}	=	Incoherent scattering (Compton scattering off an electron)
κ_n	=	Pair production, nuclear field
κ_e	=	Pair production, electron field
$\sigma_{PH.N.}$	=	Photonuclear absorption (nuclear absorption, usually followed by emission of a neutron or other particle)

From Hubbell, Gimm, and Øverbø, J. Phys. Chem. Ref. Data 9, 1023 (1980). Figures courtesy J.H. Hubbell.

ELECTROMAGNETIC RELATIONS

Quantity	Gaussian CGS	MKSA
Units and conversions:		
Charge:	2.99792×10^9 esu	= 1 coul = 1 amp-sec
Potential:	(1/299.792) statvolt = (1/299.792) erg/esu	= 1 volt = 1 joule/coul
Magnetic field:	10^4 gauss = 10^4 dyne/esu	= 1 tesla = 1 nt/amp-m
Electron charge:	$e = 4.803\,242\times10^{-10}$ esu	$= 1.602\,189\,2\times10^{-19}$ coul
Lorentz force:	$\mathbf{F} = q(\mathbf{E} + \frac{\mathbf{v}}{c}\times\mathbf{B})$	$\mathbf{F} = q(\mathbf{E} + \mathbf{v}\times\mathbf{B})$
Maxwell equations:	$\nabla\cdot\mathbf{D} = 4\pi\rho$ $\nabla\times\mathbf{E} = -\frac{1}{c}\frac{\partial\mathbf{B}}{\partial t}$ $\nabla\cdot\mathbf{B} = 0$ $\nabla\times\mathbf{H} = \frac{4\pi\mathbf{j}}{c} + \frac{1}{c}\frac{\partial\mathbf{D}}{\partial t}$	$\nabla\cdot\mathbf{D} = \rho$ $\nabla\times\mathbf{E} = -\frac{\partial\mathbf{B}}{\partial t}$ $\nabla\cdot\mathbf{B} = 0$ $\nabla\times\mathbf{H} = \mathbf{j} + \frac{\partial\mathbf{D}}{\partial t}$
Materials:	$\mathbf{D} = \epsilon\mathbf{E}$, $\mathbf{B} = \mu\mathbf{H}$	$\mathbf{D} = \epsilon\mathbf{E}$, $\mathbf{B} = \mu\mathbf{H}$
Dielectric constant:	$\epsilon_{vac} = 1$	$\epsilon_{vac} = \epsilon_0$
Magnetic susceptibility:	$\mu_{vac} = 1$	$\mu_{vac} = \mu_0$
Fields:	$\mathbf{E} = -\nabla V - \frac{1}{c}\frac{\partial\mathbf{A}}{\partial t}$ $\mathbf{B} = \nabla\times\mathbf{A}$	$\mathbf{E} = -\nabla V - \frac{\partial\mathbf{A}}{\partial t}$ $\mathbf{B} = \nabla\times\mathbf{A}$
Static potentials: (coulomb gauge)	$V = \sum_{\text{charges}} \frac{q}{r}$ $\mathbf{A} = \frac{1}{c}\sum_{\text{currents}} \frac{\mathbf{I}}{r}$	$V = \frac{1}{4\pi\epsilon_0}\sum_{\text{charges}} \frac{q}{r}$ $\mathbf{A} = \frac{\mu_0}{4\pi}\sum_{\text{currents}} \frac{\mathbf{I}}{r}$
Relativistic transformations: (v is the velocity of primed system as seen in unprimed system)	$\mathbf{E}'_\parallel = \mathbf{E}_\parallel$ $\mathbf{E}'_\perp = \gamma(\mathbf{E}_\perp + \frac{1}{c}\mathbf{v}\times\mathbf{B})$ $\mathbf{B}'_\parallel = \mathbf{B}_\parallel$ $\mathbf{B}'_\perp = \gamma(\mathbf{B}_\perp - \frac{1}{c}\mathbf{v}\times\mathbf{E})$	$\mathbf{E}'_\parallel = \mathbf{E}_\parallel$ $\mathbf{E}'_\perp = \gamma(\mathbf{E}_\perp + \mathbf{v}\times\mathbf{B})$ $\mathbf{B}'_\parallel = \mathbf{B}_\parallel$ $\mathbf{B}'_\perp = \gamma(\mathbf{B}_\perp - \frac{1}{c^2}\mathbf{v}\times\mathbf{E})$

$$4\pi\epsilon_0 = \frac{1}{c^2}10^7\frac{\text{coul}^2}{\text{nt sec}^2} = \frac{1}{8.987}55\times10^{-9}\frac{\text{coul}^2}{\text{nt m}^2}$$

$$\frac{\mu_0}{4\pi} = 10^{-7}\frac{\text{nt sec}^2}{\text{coul}^2}\ ;\quad c = 2.997\,924\,58\times10^8\ \text{m sec}^{-1}$$

Impedances (MKSA)

ρ = resistivity in 10^{-8} Ωm:

~ 1.7 for Cu	~ 5.5 for W
~ 2.4 for Au	~ 73 for SS 304
~ 2.8 for Al	~ 100 for Nichrome

(Al alloys may have double this value.)

For alternating currents, instantaneous current I, voltage V, angular frequency ω:

$$V = V_0 e^{i\omega t} = ZI\,.$$

Impedance of self-inductance L: $Z = i\omega L$.

Impedance of capacitance C: $Z = 1/i\omega C$.

Impedance of free space: $Z = \sqrt{\mu_0/\epsilon_0} = 376.7\ \Omega$.

Impedance per unit length of a flat conductor of width w (high frequency, ν):

$$Z = \frac{(1+i)\rho}{w\delta}\ ,\ \text{where } \delta = \text{effective skin depth}\ ;$$

$$\delta = \sqrt{\frac{\rho}{\pi\nu\mu}} \simeq \frac{6.6\ \text{cm}}{\sqrt{\nu(\text{sec}^{-1})}}\ \text{for Cu}\,.$$

Capacitance $\hat{C}$ and inductance $\hat{L}$ per unit length (MKSA)

Flat rectangular plates of width w, separated by d << w:

$$\hat{C} = \epsilon\frac{w}{d}\ ;\quad \hat{L} = \mu\frac{d}{w}\ ;$$

$$\frac{\epsilon}{\epsilon_0} = 2 \text{ to } 6 \text{ for plastics; } 4 \text{ to } 8 \text{ for porcelain, glasses.}$$

Coaxial cable of inner radius r_1, outer radius r_2:

$$\hat{C} = \frac{2\pi\epsilon}{\ell n(r_2/r_1)}\ ;\quad \hat{L} = \frac{\mu}{2\pi}\ell n(r_2/r_1)\,.$$

Transmission lines (no loss):

Impedance: $Z = \sqrt{\hat{L}/\hat{C}}$.

Velocity: $v = 1/\sqrt{\hat{L}\hat{C}} = 1/\sqrt{\mu\epsilon}$.

Motion of charged particles in a uniform, static, magnetic field

The path of motion of a charged particle of momentum p is a helix of constant radius R and constant pitch angle λ, with the axis of the helix along **B**:

$$p(\text{GeV}/c)\cos\lambda = 0.29979\ q\ B(\text{tesla})\ R(\text{m})\,,$$

where the charge q is in units of the electronic charge. The angular velocity about the axis of the helix is

$$\omega(\text{rad sec}^{-1}) = 8.98755\times10^7\ q\ B(\text{tesla})/E(\text{GeV})\,,$$

where E is the energy of the particle.

ELECTROMAGNETIC RELATIONS (Cont'd)

Synchrotron radiation (CGS)

For a relativistic particle of charge e, velocity β, γ, energy E, traveling in a circular orbit of radius R:

$$\text{Energy loss/revolution (MeV)} = \frac{4\pi}{3}\frac{e^2}{R}\beta^3\gamma^4$$

$$\simeq 0.0885\,[E(\text{GeV})]^4/R(\text{m}) \text{ for } e^\pm \text{ if } \beta \simeq 1.$$

Energy spectrum: The energy radiated into the photon energy interval $d(\hbar\omega)$ is

$$dI = \alpha\gamma F(\omega/\omega_c)d(\hbar\omega),$$

where $\alpha = e^2/(\hbar c)$ is the fine-structure constant,

$F(y) = 2\sqrt{3}y\int_{2y}^{\infty} dx\, K_{5/3}(x)$, with $K_{5/3}(x)$ a modified spherical Bessel function of the third kind, and $\omega_c = 3\gamma^3 c/R$ is a critical frequency;

$$\hbar\omega_c\,(\text{keV}) \simeq 4.44\,[E(\text{GeV})]^3/R(\text{m}) \text{ for } e^\pm \text{ if } \beta \simeq 1.$$

In the limit $\gamma \gg 1$,

for $\omega \ll \omega_c$:

$$\frac{dI}{d(\hbar\omega)} \simeq 3.3\alpha\left(\frac{\omega R}{c}\right)^{1/3};$$

for $\frac{\omega}{\omega_c} = (0.01, 0.1, 0.2, 1.0, 2.0)$:

$$\frac{dI}{d(\hbar\omega)} \simeq (1.0, 1.6, 1.6, 0.5, 0.08)\alpha\gamma\text{, respectively;}$$

for $\omega \gtrsim 2\omega_c$:

$$\frac{dI}{d(\hbar\omega)} \simeq \sqrt{3\pi}\alpha\gamma\left(\frac{\omega}{\omega_c}\right)^{1/2} e^{-2\omega/\omega_c}.$$

The radiation is confined to angles $\lesssim 1/\gamma$ relative to the instantaneous direction of motion.

See J.D. Jackson, *Classical Electrodynamics*, 2nd edition (John Wiley & Sons, New York, 1975) for more formulae and details. (Prepared April 1974; revised April 1984.)

RADIOACTIVITY AND RADIATION PROTECTION

The International Commission on Radiation Units and Measurements (ICRU) recommends the use of SI units. Therefore we list SI units first, followed by cgs (or other common) units in parentheses, where they differ.

Unit of activity = becquerel (curie):
1 Bq = 1 disintegration/sec [$= 1/(3.7\times10^{10})$ Ci].

Unit of exposure, the quantity of X- or γ- radiation at a point in space integrated over time, in terms of charge of either sign produced by showering electrons in a small volume of air about the point:
= 1 coul/kg of air (roentgen; 1 R = 2.58×10^{-4} coul/kg
= 1 esu/cm^3 = 87.8 erg released energy per g of air); implicit in the definition is the assumption that the small test volume is embedded in a sufficiently large uniformly irradiated volume that the number of secondary electrons entering the volume equals the number leaving.

Unit of absorbed dose = gray (rad):
1 Gy = 1 joule/kg (= 10^4 erg/g = 10^2 rad)
= 6.24×10^{12} MeV/kg deposited energy.

Unit of dose equivalent (for biological damage) = sievert [$= 10^2$ rem (roentgen equivalent for man)]:
Dose equivalent in Sv = grays × Q, where Q (quality factor) expresses long-term risk (primarily cancer and leukemia) from low-level chronic exposure; it depends upon the type of radiation and other factors. For γ rays and β particles, Q $\simeq$ 1; for protons, Q $\simeq$ 1 at ~10 MeV, rising gradually to $\simeq$ 2 at ~1 GeV; for thermal neutrons, Q $\simeq$ 3; for fast neutrons, Q ranges up to 10; and for α particles and heavy ions (assuming internal deposition — skin and clothing are usually sufficient protection against external sources), Q $\simeq$ 20.

Natural annual background, all sources: Most world areas, whole-body dose equivalent rate $\simeq$ (0.4-4) mSv (40-400 millirems). Can range up to 50 mSv (5 rems) in certain areas. U.S. average $\simeq$ 0.8 mSv. The lungs receive an additional $\simeq$ 0.1 mSv ($\simeq$ 10 mrem) from inhaled natural radioactivity, mostly radon and radon daughters (good to $\simeq$ factor of 2 in open areas; can range an order of magnitude higher in buildings and up to 1000× in poorly ventilated mines).

Cosmic ray background in counters (Earth's surface):
~10^4/min/m^2/ster. For more accurate estimates and more details, see Sec. B of Particle Detectors, Absorbers, and Ranges.

Fluxes (per m^2) to deposit one Gy in one kg of matter, assuming uniform irradiation:
$\simeq$ **(charged particles)** 6.24×10^{12}/(dE/dx), where dE/dx (MeV m^2/kg), the energy loss per unit length, may be obtained (after conversion of units) from the Mean Range and Energy Loss figures.
$\simeq 3.5\times10^{13}$ minimum-ionizing singly charged particles in carbon.
$\simeq$ **(photons)** $6.24\times10^{12}/[E(\text{MeV})(\mu_{en}/\rho)(\text{m}^2/\text{kg})]$, for photons of energy E, mass energy absorption coefficient μ_{en}, and density ρ (see Photon Mass Attenuation Coefficients, Energy Deposition figure), for samples of thickness enough to contain the secondary electrons but $\ll 1/\mu_{en}$.
$\simeq 2\times10^{15}$ photons of 1 MeV energy on carbon.
(Quoted fluxes good to about a factor of 2 for all materials.)

U.S. maximum permissible occupational dose for the whole body: 50 mSv/year (5 rem/year).

Lethal dose: Whole-body dose from penetrating ionizing radiation resulting in 50% mortality in 30 days (assuming no medical treatment), 2.5-3.0 Gy (250-300 rads) as measured internally on body longitudinal center line; surface dose varies due to variable body attenuation and may be a strong function of energy.

For a recent review, see E. Pochin, *Nuclear Radiation: Risks and Benefits* (Clarendon Press, Oxford, 1983).

PERIODIC TABLE OF THE ELEMENTS

IA	IIA											IIIA	IVA	VA	VIA	VIIA	2 He 4.00260
							1 H 1.0079										
3 Li 6.94	4 Be 9.01218											5 B 10.81	6 C 12.011	7 N 14.0067	8 O 15.9994	9 F 18.998403	10 Ne 20.17
11 Na 22.98977	12 Mg 24.305	IIIB	IVB	VB	VIB	VIIB	VIII			IB	IIB	13 Al 26.98154	14 Si 28.0855	15 P 30.97376	16 S 32.06	17 Cl 35.453	18 Ar 39.948
19 K 39.0983	20 Ca 40.08	21 Sc 44.9559	22 Ti 47.90	23 V 50.9415	24 Cr 51.996	25 Mn 54.9380	26 Fe 55.847	27 Co 58.9332	28 Ni 58.71	29 Cu 63.546	30 Zn 65.38	31 Ga 69.735	32 Ge 72.59	33 As 74.9216	34 Se 78.96	35 Br 79.904	36 Kr 83.80
37 Rb 85.467	38 Sr 87.62	39 Y 88.9059	40 Zr 91.22	41 Nb 92.9064	42 Mo 95.94	43 Tc 98.9062	44 Ru 101.07	45 Rh 102.9055	46 Pd 106.4	47 Ag 107.868	48 Cd 112.41	49 In 114.82	50 Sn 118.69	51 Sb 121.75	52 Te 127.60	53 I 126.9045	54 Xe 131.30
55 Cs 132.9054	56 Ba 137.33	57–71 Rare Earths	72 Hf 178.49	73 Ta 180.947	74 W 183.85	75 Re 186.207	76 Os 190.2	77 Ir 192.22	78 Pt 195.09	79 Au 196.9665	80 Hg 200.59	81 Tl 204.37	82 Pb 207.2	83 Bi 208.9804	84 Po (209)	85 At (210)	86 Rn (222)
87 Fr (223)	88 Ra 226.0254	89– Acti-nides	104 (260)	105 (260)	106 (263)												

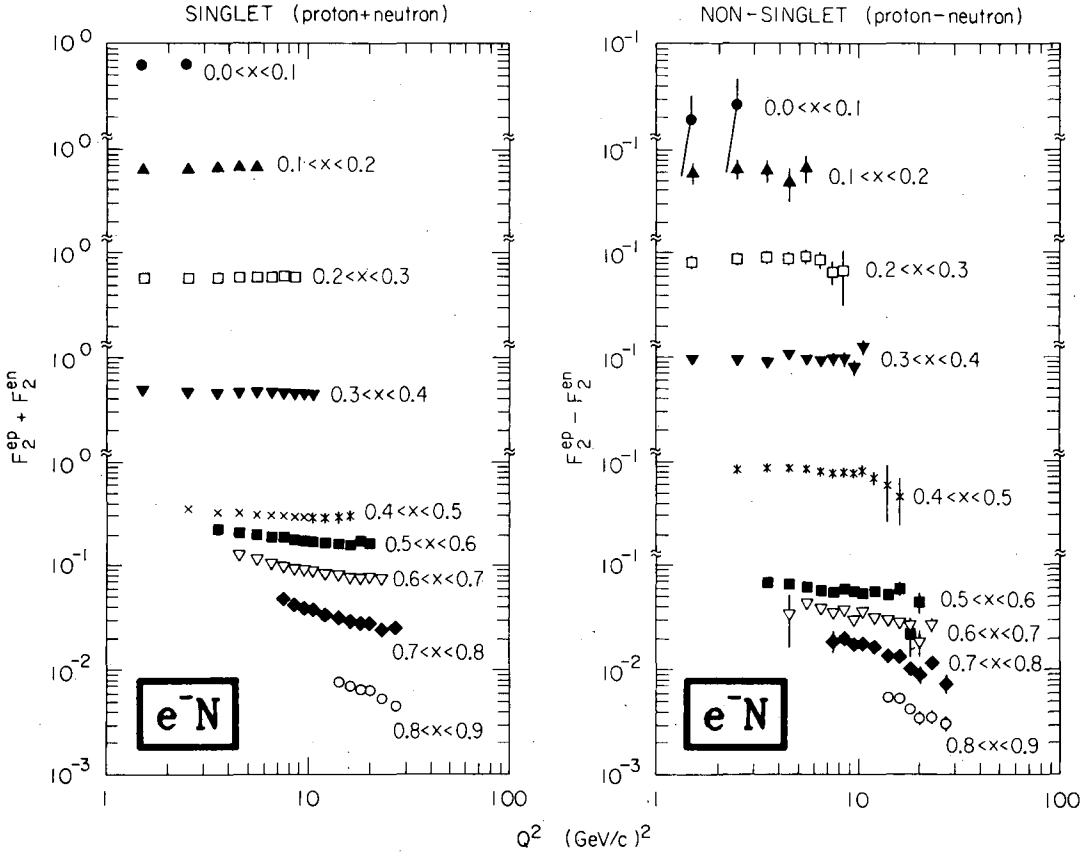
57 La 138.9055	58 Ce 140.12	59 Pr 140.9077	60 Nd 144.24	61 Pm (145)	62 Sm 150.4	63 Eu 151.96	64 Gd 157.25	65 Tb 158.9254	66 Dy 162.50	67 Ho 164.9304	68 Er 167.26	69 Tm 168.9342	70 Yb 173.04	71 Lu 174.967	Rare earths (Lanthanide series)
89 Ac (227)	90 Th 232.0381	91 Pa 231.0359	92 U 238.029	93 Np 237.0482	94 Pu (244)	95 Am (243)	96 Cm (247)	97 Bk (247)	98 Cf (251)	99 Es (254)	100 Fm (257)	101 Md (258)	102 No (259)	103 Lr (260)	Actinide series

Upper number is atomic number, expressing the positive charge of the nucleus in multiples of the electronic charge e. Lower number is atomic mass weighted by isotopic abundance in earth's surface, relative to the mass of the carbon 12 isotope, which has been arbitrarily assigned a mass of 12.00000 atomic mass units (amu). Numbers in parentheses are mass numbers (the whole number nearest the value of the atomic mass, in amu) of most stable isotope of that element. Adapted from the *Handbook of Chemistry and Physics, 64th Ed., 1983-1984.* (Particle Data Group update, April 1984.)

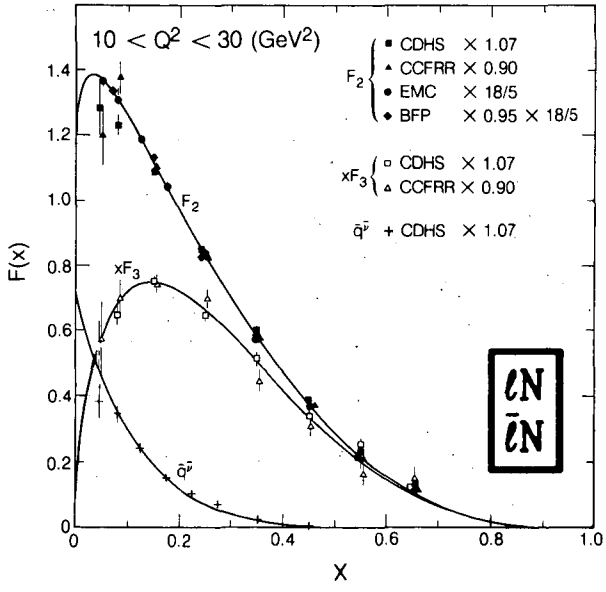
PLOTS OF CROSS SECTIONS AND RELATED QUANTITIES

NOTE: THE FIGURES IN THIS SECTION ARE INTENDED TO SHOW THE "BEST" OR "MOST REPRESENTATIVE" DATA IN THE OPINION OF THE COMPILER. THEY ARE NOT NECESSARILY COMPLETE COMPILATIONS OF ALL THE WORLD'S RELIABLE DATA.

Structure Functions



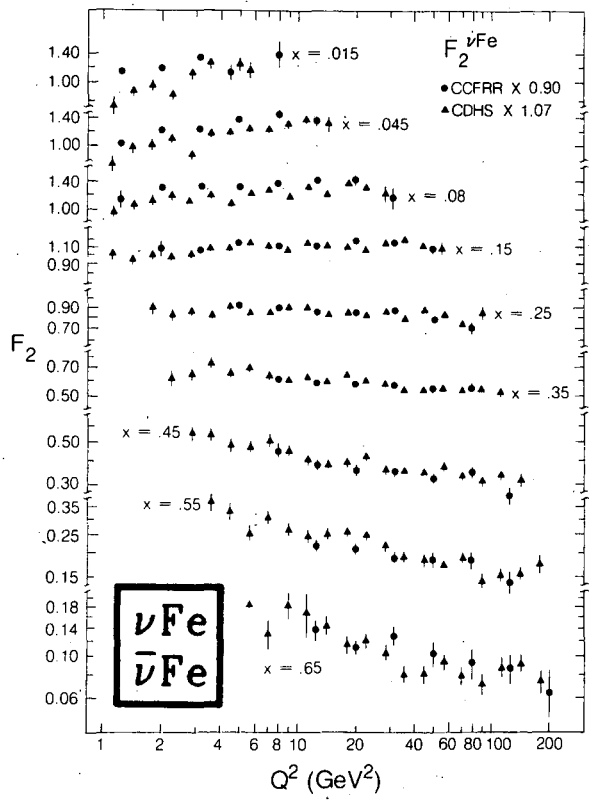
F_2 structure functions derived from inelastic electron-nucleon data taken at SLAC[1-4] with recoil mass > 2 GeV and four-momentum transfer squared $Q^2 > 1$ (GeV/c)^2 are shown. For definitions of F_2, x, and Q^2, see the Kinematics, Decays, and Scattering Section. $R = \sigma_L/\sigma_T = 0.21$ [3] was assumed. Systematic errors are comparable in size to the data point symbols. Corrections for nucleon motion in deuterium have been made. These corrections are small except for x > 0.7. No error was included to account for uncertainties in this correction. References: 1) A. Bodek et al., Phys. Rev. **D20**, 1471 (1979); 2) W.B. Atwood et al., SLAC Report No. 185 (1975); 3) M.D. Mestayer, SLAC Report No. 214 (1978); 4) S. Stein et al., Phys. Rev. **D12**, 1884 (1975). Courtesy W.B. Atwood, SLAC.

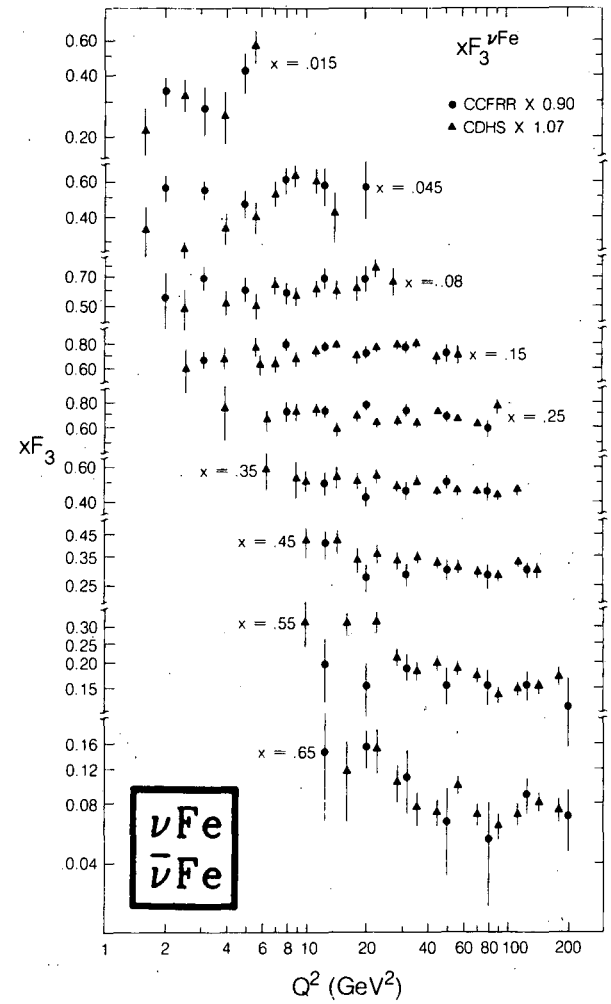


Structure functions F_2, xF_3, and $\bar{q}^{\bar{\nu}}$, measured in different experiments, for fixed Q^2 versus x, plotted assuming $R = \sigma_L/\sigma_T = 0$. The electromagnetic structure function $F_2^{\mu N}$ measured by EMC and BFP is compared with the charged-current structure function $F_2^{\nu N}$ using the 18/5 factor from the average charge squared of the quarks. No correction has been applied for the difference between the strange and charm sea quarks so the interpretation is $F_2 = x[q + \bar{q} - \frac{3}{5}(s + \bar{s} - c - \bar{c})]$. (In this Q^2 range, $F_2^{\nu N}$ is depleted by a similar amount due to charm threshold effects in the transition $s \rightarrow c$.) The antiquark distribution measured from antineutrino scattering is $\bar{q}^{\bar{\nu}} = x(\bar{u} + \bar{d} + 2\bar{s})$. The solid lines have the forms: $F_2 = 3.9x^{0.55}(1-x)^{3.2} + 1.1(1-x)^8$, $xF_3 = 3.6x^{0.55}(1-x)^{3.2}$, $\bar{q}^{\bar{\nu}} = 0.7(1-x)^8$. Relative normalization factors have been fitted to optimize agreement between the different data sets, and absolute changes have been arbitrarily chosen as indicated. References: **CDHS** — H. Abramowicz et al., Zeit. Phys. **C17**, 283 (1983); **CCFRR** — F. Sciulli, private communication; **EMC** — J.J. Aubert et al., Phys. Lett. **105B**, 322 (1981); and A. Edwards, private communication; **BFP** — A.R. Clark et al., Phys. Rev. Lett. **51**, 1826 (1983); and P. Meyers, Ph.D. Thesis, LBL-17108 (1983), Univ. of Calif., Berkeley. Courtesy J. Carr, LBL.

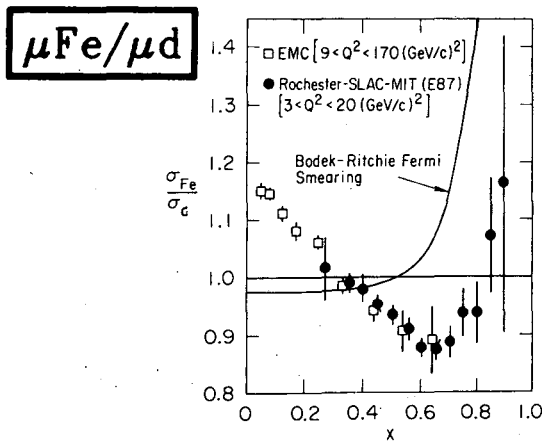
PLOTS OF CROSS SECTIONS AND RELATED QUANTITIES (Cont'd)

Structure Functions





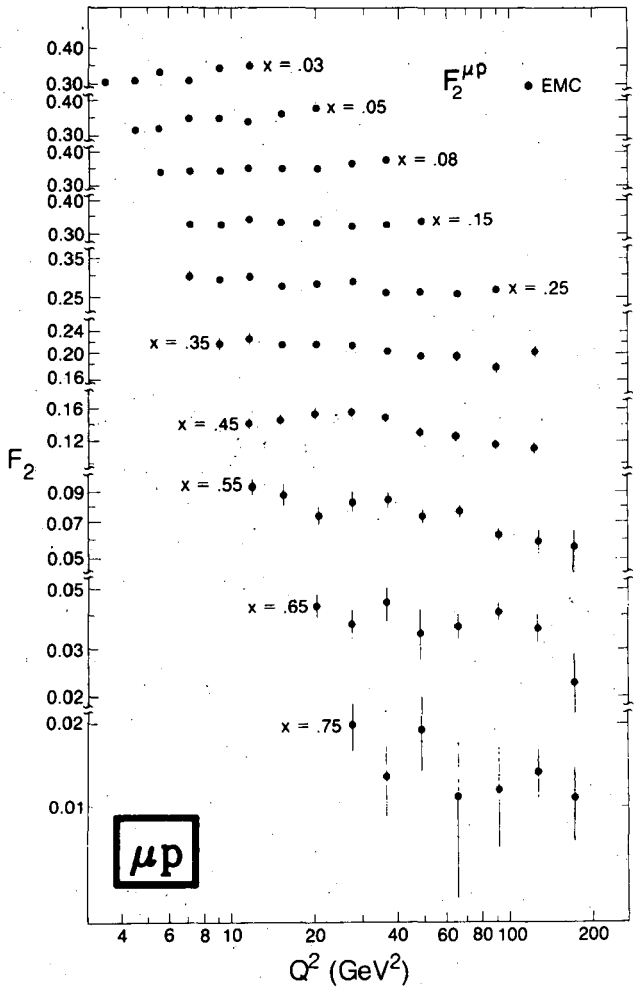
Structure functions F_2 and xF_3 for nucleons, measured in charged-current neutrino and antineutrino scattering from iron targets with $20 < E_\nu < 300$ GeV, versus Q^2 for fixed bins of x, plotted assuming $R = \sigma_L/\sigma_T = 0.1$. A relative normalization factor has been fitted to optimize the agreement between the different data sets, and absolute changes to the published data have been arbitrarily chosen as indicated. The point-to-point systematic errors for both experiments are generally smaller or of the same order as the statistical errors. In addition, CDHS quote an overall scale error of ±6% for F_2 and ±8% for xF_3, while for the CCFRR data the scale error is estimated to be ±4%. References: **CDHS** — H. Abramowicz et al., Zeit. Phys. **C17**, 283 (1983); **CCFRR** — F. Sciulli, private communication. Courtesy J. Carr, LBL.



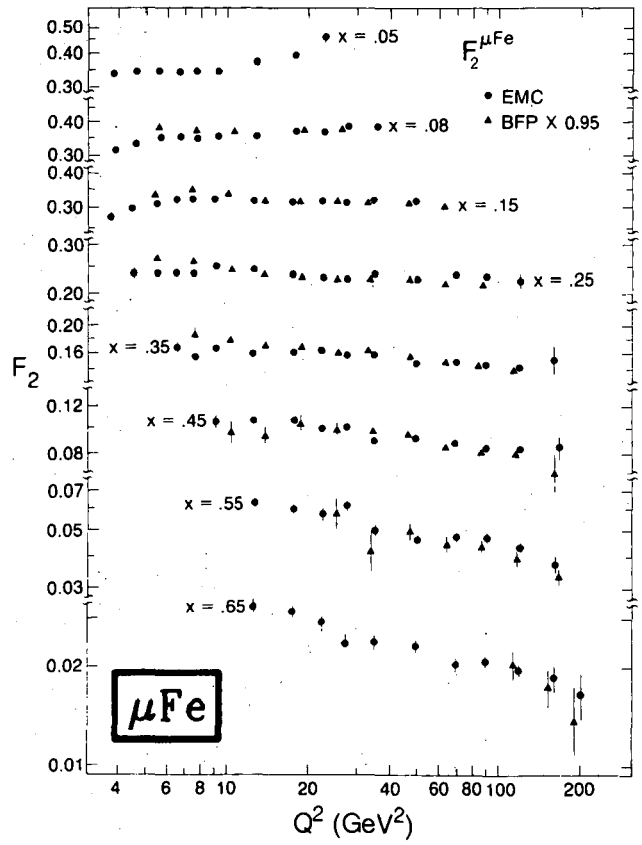
The "EMC" effect: the ratio of the differential cross section per nucleon, σ_{Fe}/σ_d, measured in electromagnetic deep inelastic scattering on iron and deuterium targets. (For equal values of $R = \sigma_L/\sigma_T$ on each target, $\sigma_{Fe}/\sigma_d = F_2^{Fe}/F_2^d$). The curve indicates the contribution to the ratio from Fermi motion in the nucleus [Phys. Rev. **D23**, 1070 (1981) and **D24**, 1400 (1981)]. The errors plotted are statistical only. The systematic errors are estimated as ±0.011 for the Rochester-SLAC-MIT data, and ±0.015 at x = 0.35 and ±0.06 at x = 0.05 and x = 0.65 for the EMC data. References: **Rochester-SLAC-MIT** (electrons) — Phys. Rev. Lett. **50**, 1431 (1983); and **EMC** (muons) — Phys. Lett. **123B**, 275 (1983). Courtesy D. Coward, SLAC.

PLOTS OF CROSS SECTIONS AND RELATED QUANTITIES (Cont'd)

Structure Functions

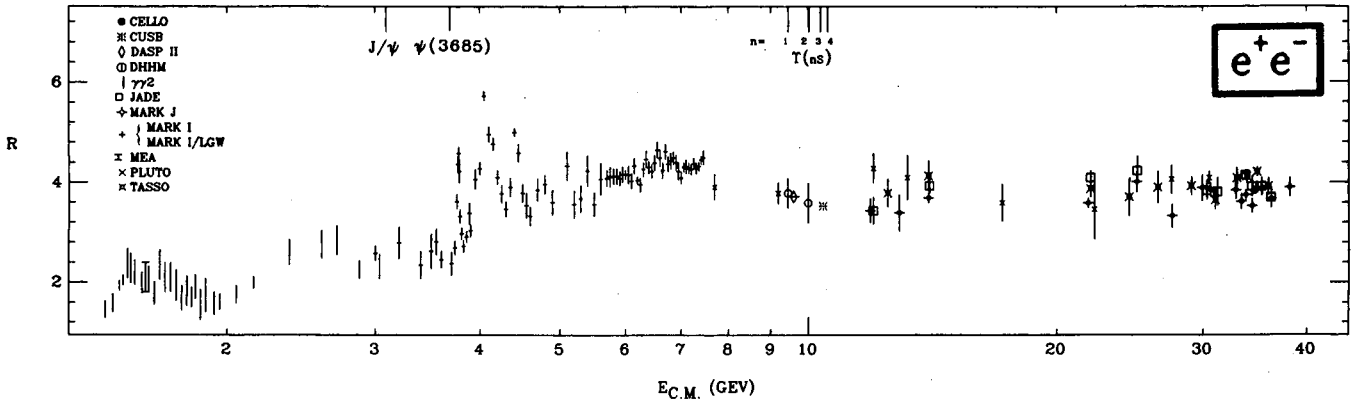


Structure function F_2^p, measured in electromagnetic muon scattering from a hydrogen target with beam energies 120, 200, 240, 280 GeV, versus Q^2 for fixed bins of x, plotted assuming $R = \sigma_L/\sigma_T = 0$. References: J.J. Aubert et al., Phys. Lett. **105B**, 315 (1981); and A. Edwards, private communication. Courtesy J. Carr, LBL.

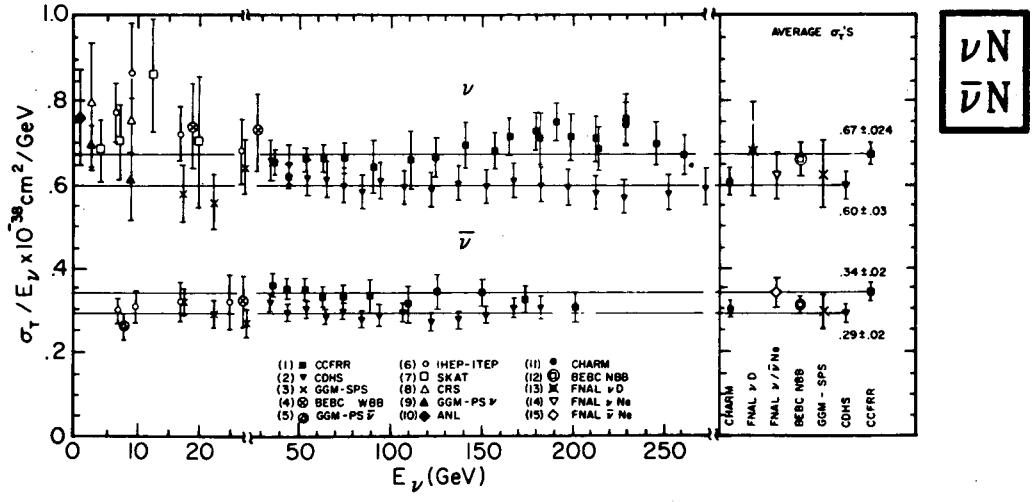


Structure function F_2 per nucleon, measured in electromagnetic muon scattering from iron targets with beam energies 120, 200, 250, 280 GeV (EMC) and 93, 215 GeV (BFP), versus Q^2 for fixed bins of x, plotted assuming $R = \sigma_L/\sigma_T = 0$. A relative normalization factor has been fitted to optimize agreement between the different data sets and has been arbitrarily applied to one data set as indicated. References: EMC — J.J. Aubert et al., Phys. Lett. **105B**, 322 (1981); and A. Edwards, private communication; BFP — A.R. Clark et al., Phys. Rev. Lett. **51**, 1826 (1983); and P. Meyers, Ph.D. Thesis, LBL-17108 (1983), Univ. of Calif., Berkeley. Courtesy J. Carr, LBL.

PLOTS OF CROSS SECTIONS AND RELATED QUANTITIES (Cont'd)

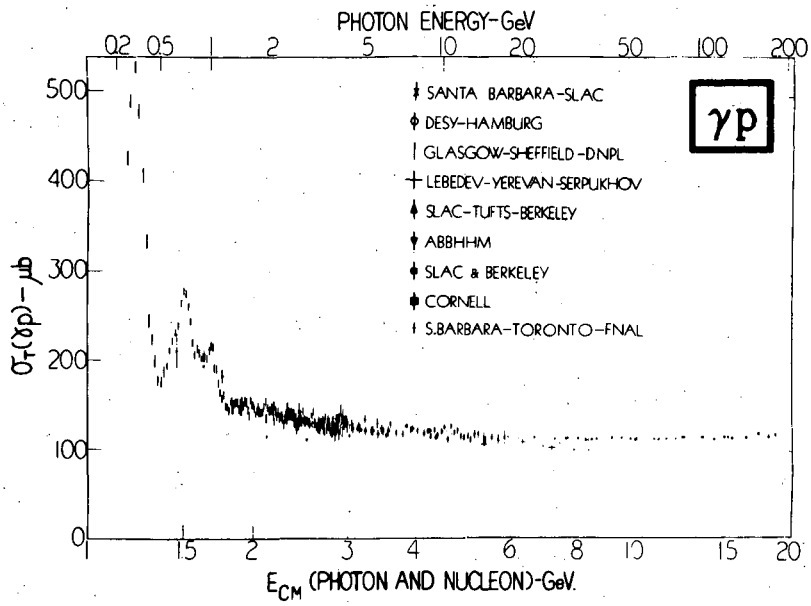


Measurements of $R \equiv \sigma(e^+e^- \to \text{hadrons})/\sigma(e^+e^- \to \mu^+\mu^-)$, where the annihilation proceeds via one photon. The denominator is a calculated quantity; see the section on Kinematics, Decays, and Scattering. Radiative corrections and, where important, corrections for two-photon processes and τ production have been made. Note that the ADONE data ($\gamma\gamma 2$ and MEA) is for $\geqslant 3$ hadrons. The points in the $\psi(3770)$ region are from the MARK I - Lead Glass Wall experiment. The DASP [R. Brandelik et al., Phys. Lett. **76B**, 361 (1978)] and PLUTO (see references below) measurements have been omitted in the charm threshold region for clarity. Also for clarity, some points have been combined or shifted slightly (<4%) in $E_{c.m.}$, and some points with low statistical significance have been omitted. Systematic normalization errors are not included; they range from ~5 - 20%, depending on experiment. Note the suppressed zero. The horizontal extent of the plot symbols has no significance. The positions of the $J/\psi(3100)$, $\psi(3685)$, and the four known Υ vector-meson resonances are indicated at the top of the figure. References: **CELLO** — H.-J. Behrend et al., Phys. Lett. **B**, to be published (preprint DESY 81-029); **CUSB** — E. Rice et al., Phys. Rev. Lett. **48**, 906 (1982); **DASP II** — Phys. Lett. **116B**, 383 (1982); **DHHM** — P. Bock et al. (DESY-Hamburg-Heidelberg-MPI München Collab.), Zeit. fur Physik **C6**, 125 (1980); **$\gamma\gamma 2$** — C. Bacci et al., Phys. Lett. **86B**, 234 (1979); **JADE** — W. Bartel et al., Phys. Lett. **129B**, 145 (1983); **MARK J** — B. Adeva et al., Phys. Rev. Lett. **50**, 799 (1983); and H. Newman, private communication; **MARK I** — J.L. Siegrist et al., Phys. Rev. **D26**, 969 (1982); **MARK I + Lead Glass Wall** — P.A. Rapidis et al., Phys. Rev. Lett. **39**, 526 (1977); and P.A. Rapidis, thesis, SLAC-Report-220 (1979); **MEA** — B. Esposito et al., Lett. Nuovo Cimento **19**, 21 (1977); **PLUTO** — A. Bäcker, thesis Gesamthochschule Siegen, DESY F33-77/03 (1977); C. Gerke, thesis, Hamburg Univ. (1979); Ch. Berger et al., Phys. Lett. **81B**, 410 (1979); and W. Lackas, thesis, RWTH Aachen, DESY PLUTO-81/11 (1981); **TASSO** — R. Brandelik et al., Phys. Lett. **113B**, 499 (1982).

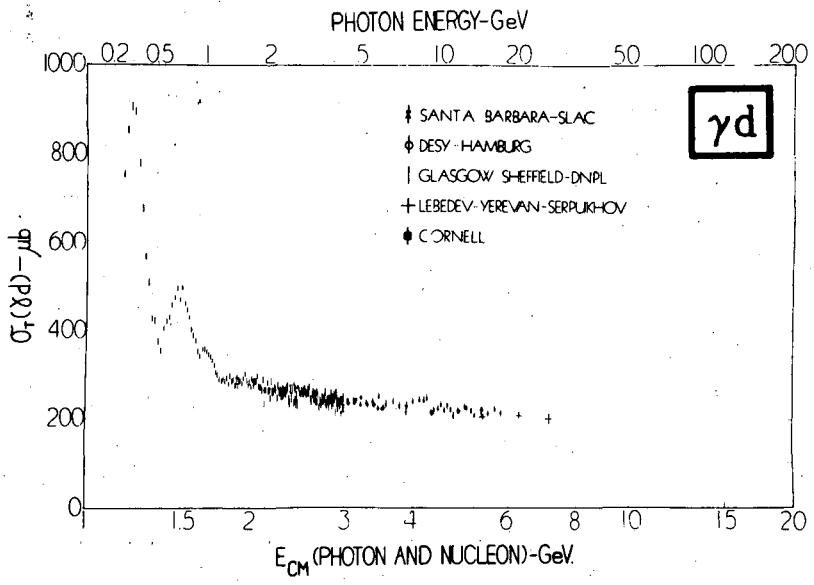


σ_T/E_ν for the muon neutrino and antineutrino charged-current total cross section as a function of neutrino energy. The error bars include both statistical and systematic errors. The straight lines are averages for the CCFRR and CDHS measurements. Note the change in the energy scale between 20 and 50 GeV. The data points on the right give averages for other high energy measurements. References: (1) R. Blair et al., Phys. Rev. Lett. **51**, 343 (1983), and J.R. Lee, Ph.D. Thesis, Caltech (1981), "Measurements of νN Charged Current Cross Sections from E_ν = 25 GeV to E_ν = 260 GeV;" (2) H. Abramowicz et al., Zeit. fur Physik **C17**, 283 (1983); (3) J. Morfin et al., Phys. Lett. **104B**, 235 (1981); (4) D.C. Colley et al., Zeit. fur Physik **C2**, 187 (1979); (5) O. Erriquez et al., Phys. Lett. **80B**, 309 (1979); (6) A.S. Vovenko et al., Sov. J. Nucl. Phys. **30**, 527 (1979); (7) D.S. Baranov et al., Phys. Lett. **81B**, 255 (1979); (8) C. Baltay et al., Phys. Rev. Lett. **44**, 916 (1980); (9) S. Ciampolillo et al., Phys. Lett. **84B**, 281 (1979); (10) S.J. Barish et al., Phys. Rev. **D19**, 2521 (1979); (11) M. Jonker et al., Phys. Lett. **99B**, 265 (1981), E_ν = 20-200 GeV; (12) P. Bosetti et al., Phys. Lett. **110B**, 167 (1982), E_ν = 20-200 GeV; (13) T. Kitagaki et al., Phys. Rev. Lett. **49**, 98 (1982), E_ν = 10-200 GeV; (14) N.J. Baker et al., Phys. Rev. Lett. **51**, 735 (1983), E_ν = 10-240 GeV; (15) G.N. Taylor et al., Phys. Rev. Lett. **51**, 739 (1983), E_ν = 5-250 GeV. Courtesy M.H. Shaevitz, Columbia University (Nevis Laboratory).

PLOTS OF CROSS SECTIONS AND RELATED QUANTITIES (Cont'd)

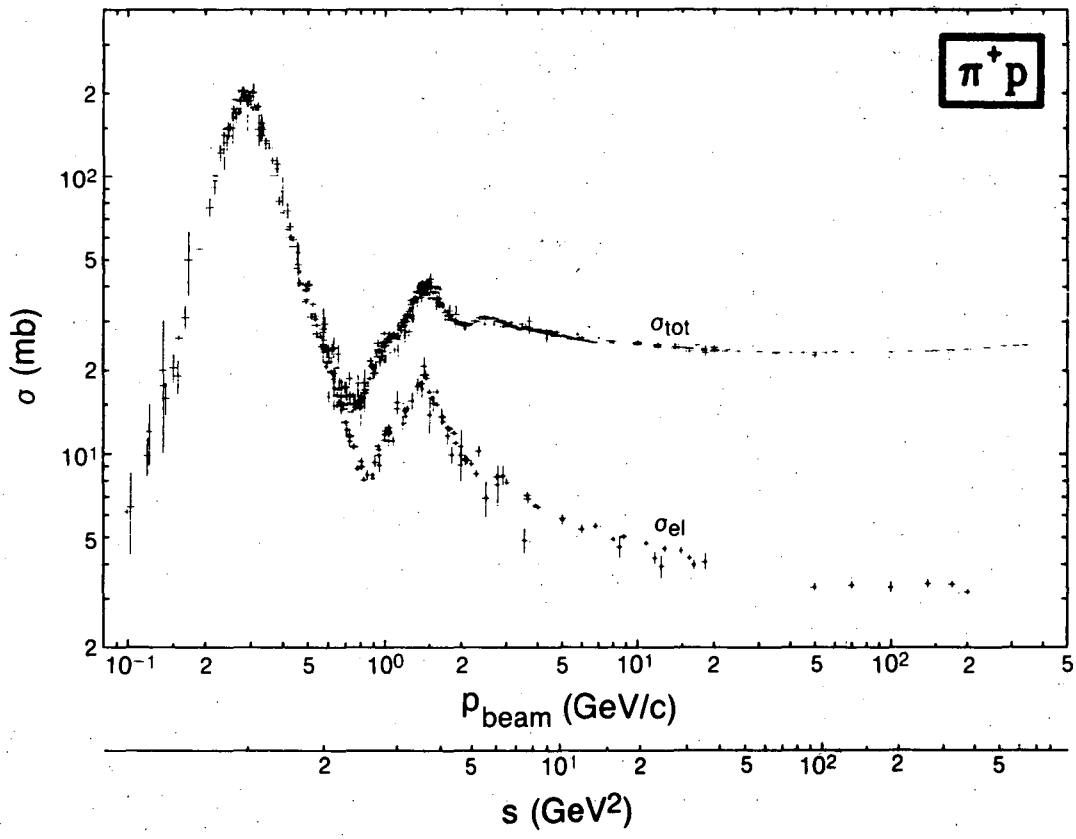


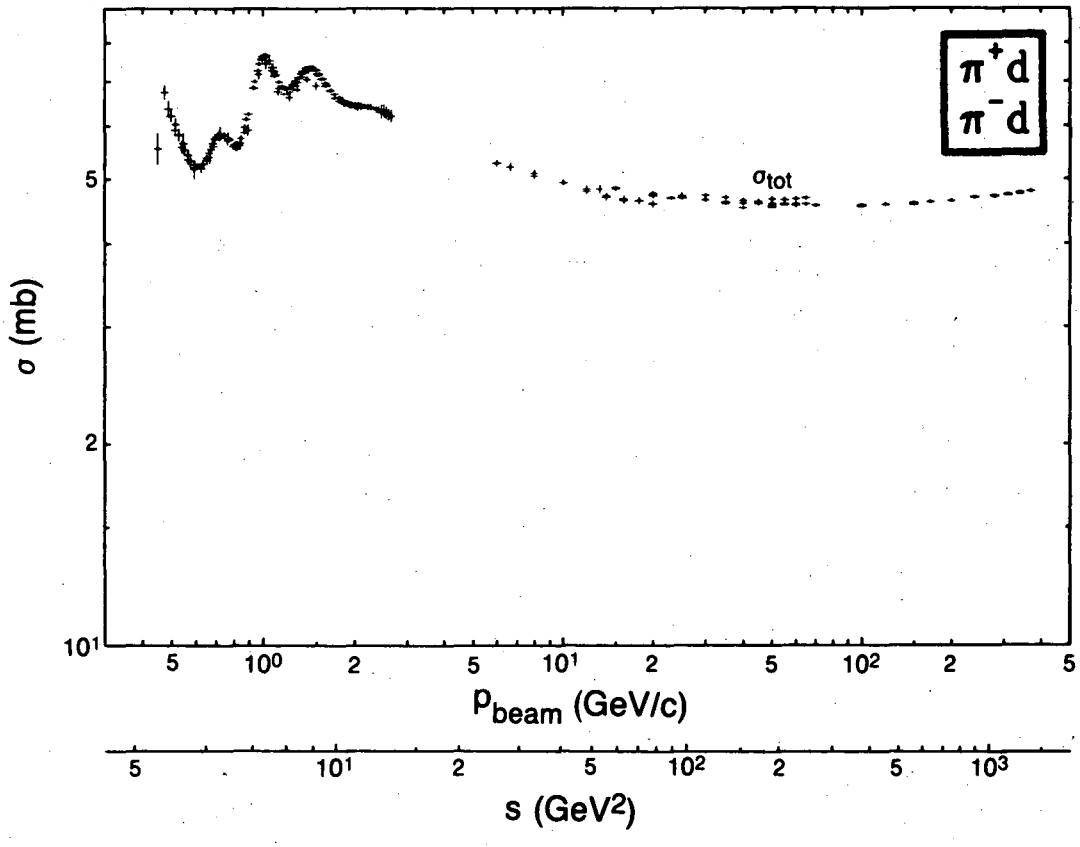
γp total cross section versus photon energy (top scale) and photon-plus-nucleon total center-of-mass energy (lower scale). References: **SANTA BARBARA-SLAC** — D.O. Caldwell et al., Phys. Rev. **D7**, 1362 (1973); **DESY-HAMBURG** — H. Meyer et al., Phys. Lett. **33B**, 189 (1970); **GLASGOW-SHEFFIELD-DNPL** — T.A. Armstrong et al., Phys. Rev. **D5**, 1640 (1972); **LEBEDEV-YEREVAN-SERPUKHOV** — A.S. Belousov et al., Preprint 19, Moscow, (1970); A. S. Belousov et al., Sov. Phys. Doklady **19**, 123 (1974); and A. S. Belousov et al., Sov. J. Nucl. Phys. **21**(3), 289 (1975); **SLAC-BERKELEY-TUFTS** — J. Ballam et al., Phys. Rev. **D5**, 545 (1972); **ABBHHM** — H.G. Hilpert et al., Phys. Lett. **27B**, 474 (1968); **SLAC** and **BERKELEY** — J. Ballam et al., Phys. Rev. Lett. **21**, 1544 (1968), and H.H. Bingham et al., Phys. Rev. **D8**, 1277 (1973); **CORNELL** — S. Michalowski et al., Phys. Rev. Lett. **39**, 737 (1977); **SANTA BARBARA-TORONTO-FNAL** — D.O. Caldwell et al., Phys. Rev. Lett. **40**, 1222 (1978). See, also, the ep data of E.D. Bloom et al., SLAC-PUB-653 (1969). Courtesy Gething M. Lewis, Glasgow.



γd total cross section versus photon energy (top scale) and photon-plus-single-nucleon total center-of-mass energy (lower scale). References: **SANTA BARBARA-SLAC** — D.O. Caldwell et al., Phys. Rev. **D7**, 1362 (1973); **DESY-HAMBURG** — H. Meyer et al., Phys. Lett. **33B**, 189 (1970); **GLASGOW-SHEFFIELD-DNPL** — T.A. Armstrong et al., Nucl. Phys. **B41**, 445 (1972); **LEBEDEV-YEREVAN-SERPUKHOV** — A.S. Belousov et al., Sov. J. Nucl. Phys. **21**(3), 289 (1975); **CORNELL** — S. Michalowski et al., Phys. Rev. Lett. **39**, 737 (1977). Courtesy Gething M. Lewis, Glasgow.

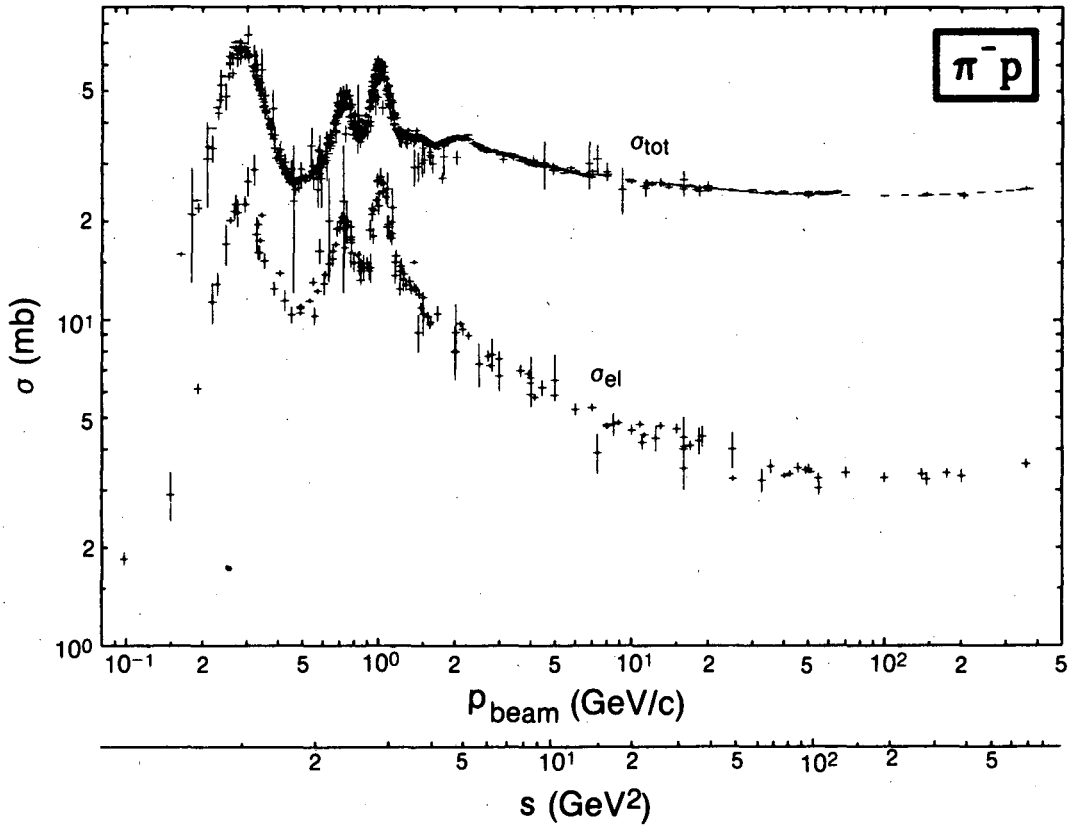
PLOTS OF CROSS SECTIONS AND RELATED QUANTITIES (Cont'd)

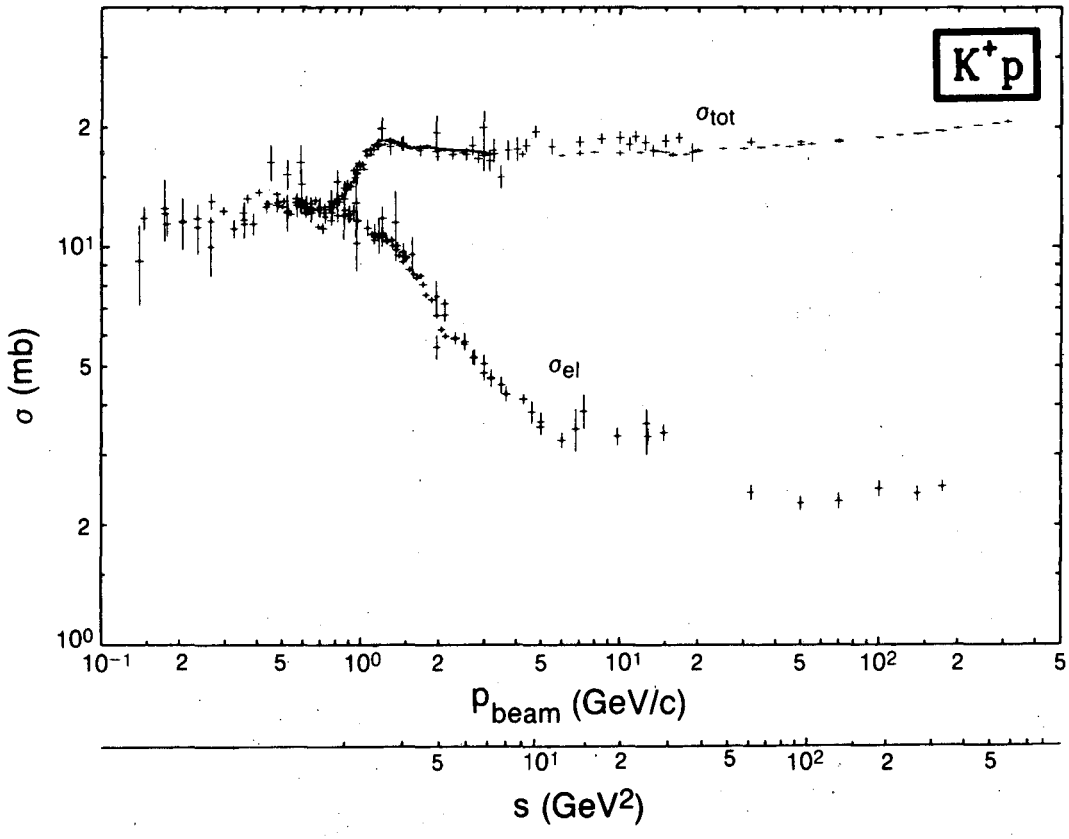




Hadronic total and elastic cross sections vs. laboratory beam momentum p_{beam} and center-of-mass energy squared s. Figures courtesy V. Flaminio, W.G. Moorhead, D.R.O. Morrison, and N. Rivoire, CERN.

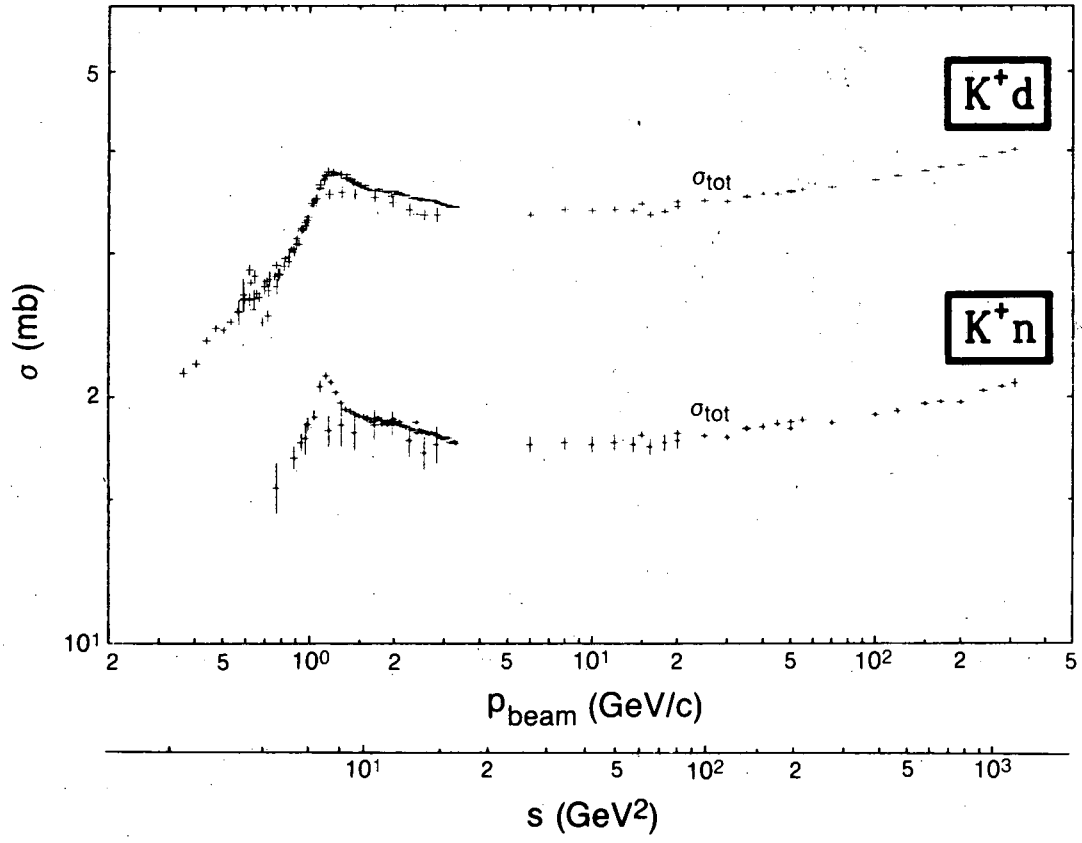
PLOTS OF CROSS SECTIONS AND RELATED QUANTITIES (Cont'd)

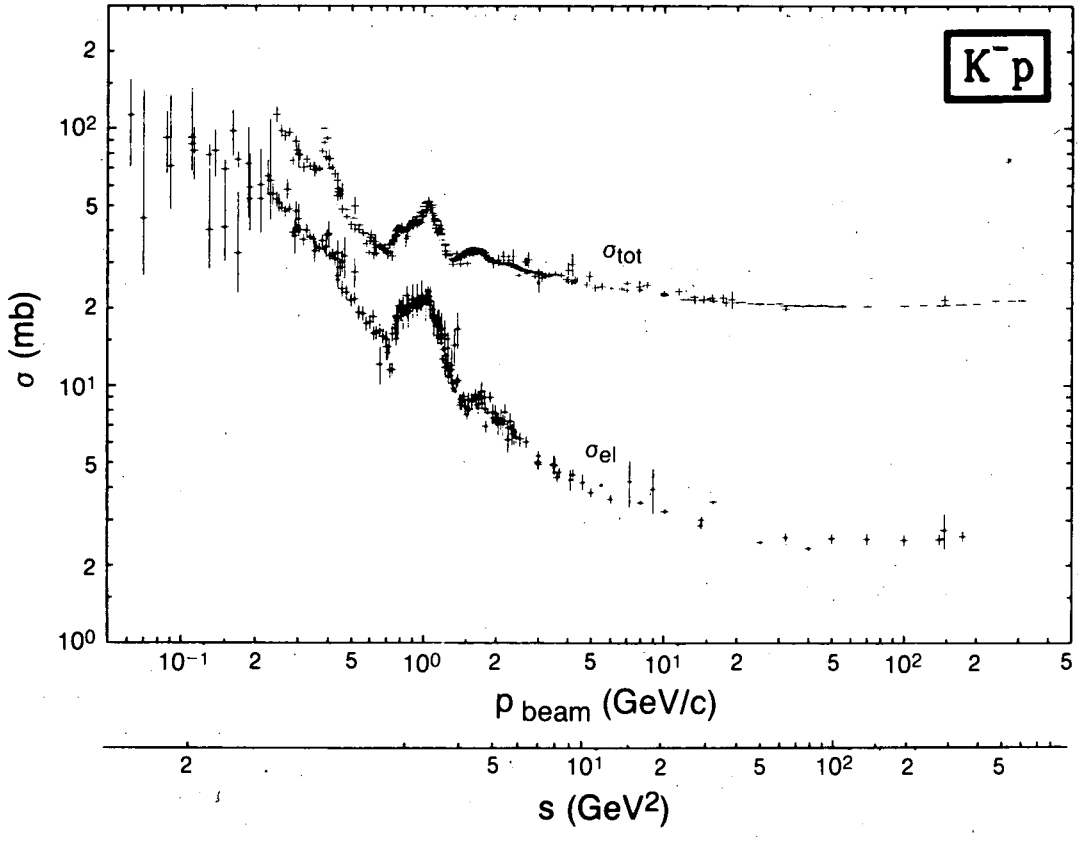




Hadronic total and elastic cross sections vs. laboratory beam momentum p_{beam} and center-of-mass energy squared s. Figures courtesy V. Flaminio, W.G. Moorhead, D.R.O. Morrison, and N. Rivoire, CERN.

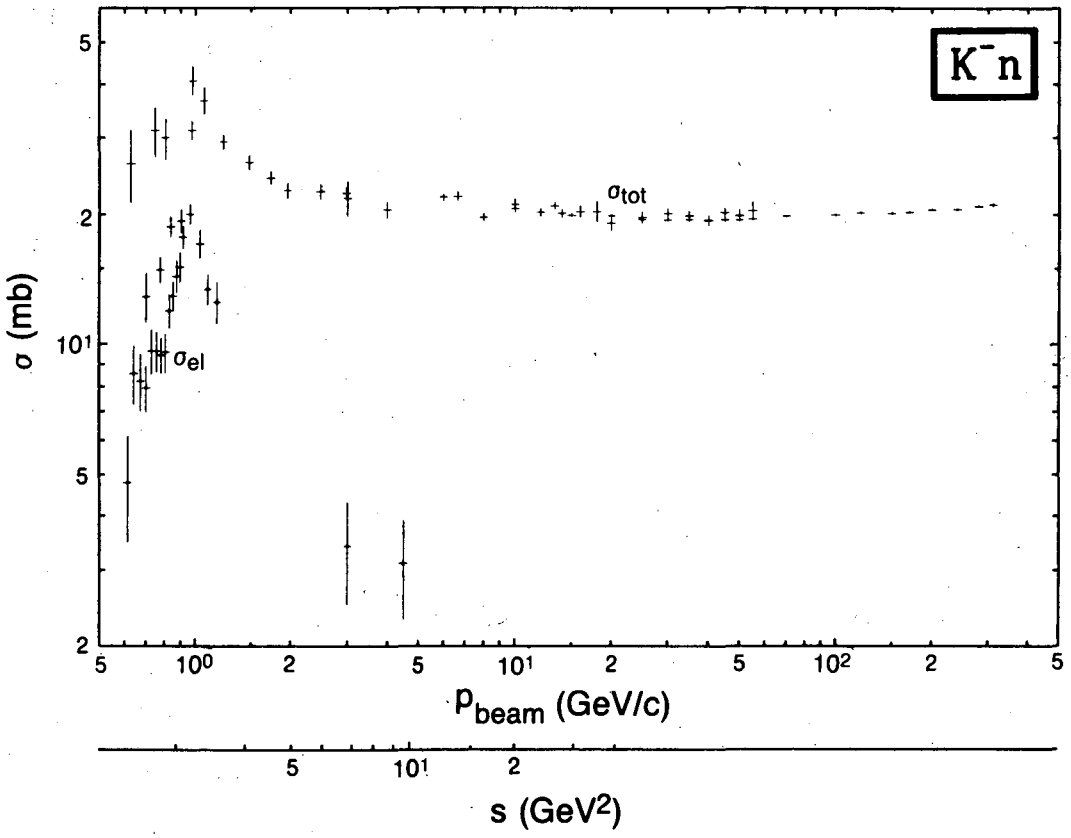
PLOTS OF CROSS SECTIONS AND RELATED QUANTITIES (Cont'd)

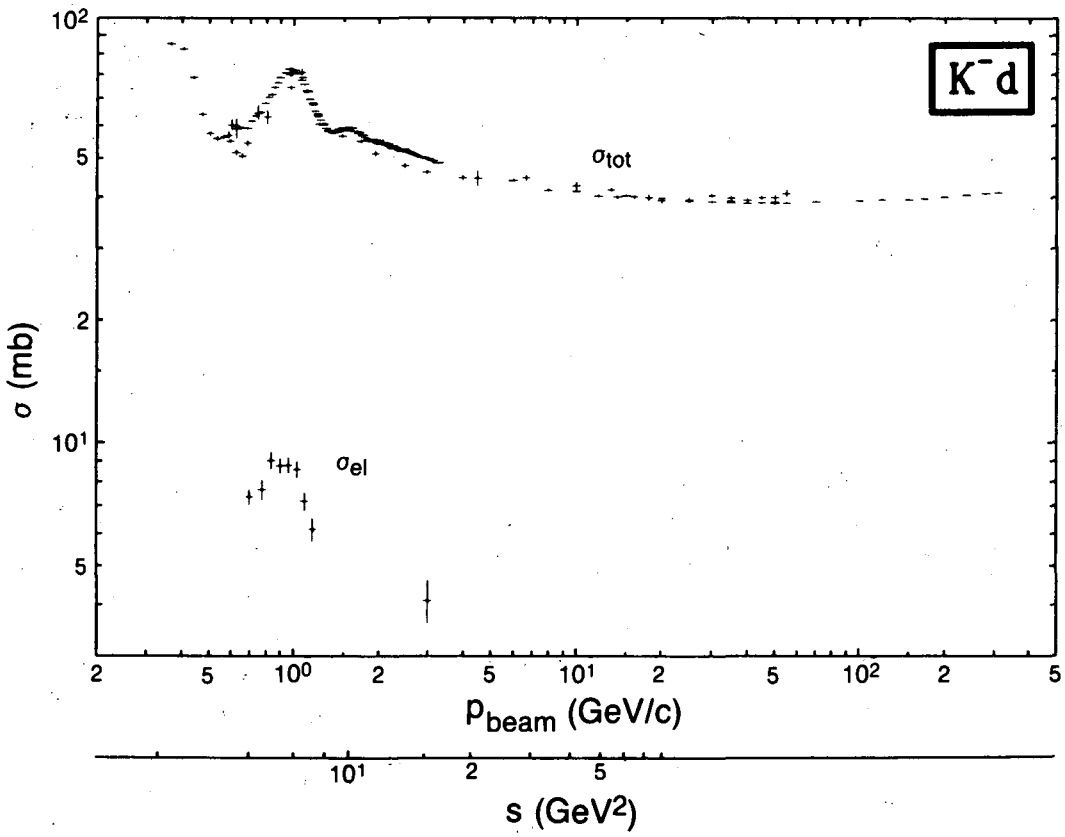




Hadronic total and elastic cross sections vs. laboratory beam momentum p_{beam} and center-of-mass energy squared s. Figures courtesy V. Flaminio, W.G. Moorhead, D.R.O. Morrison, and N. Rivoire, CERN.

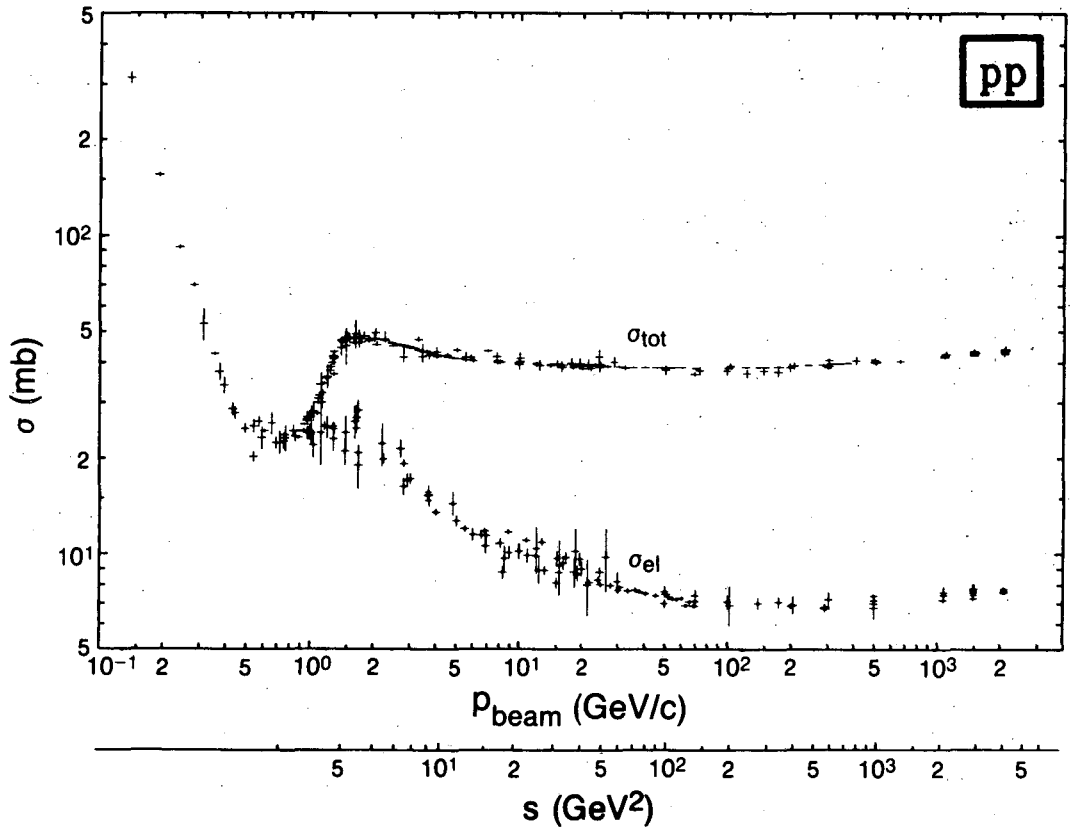
PLOTS OF CROSS SECTIONS AND RELATED QUANTITIES (Cont'd)

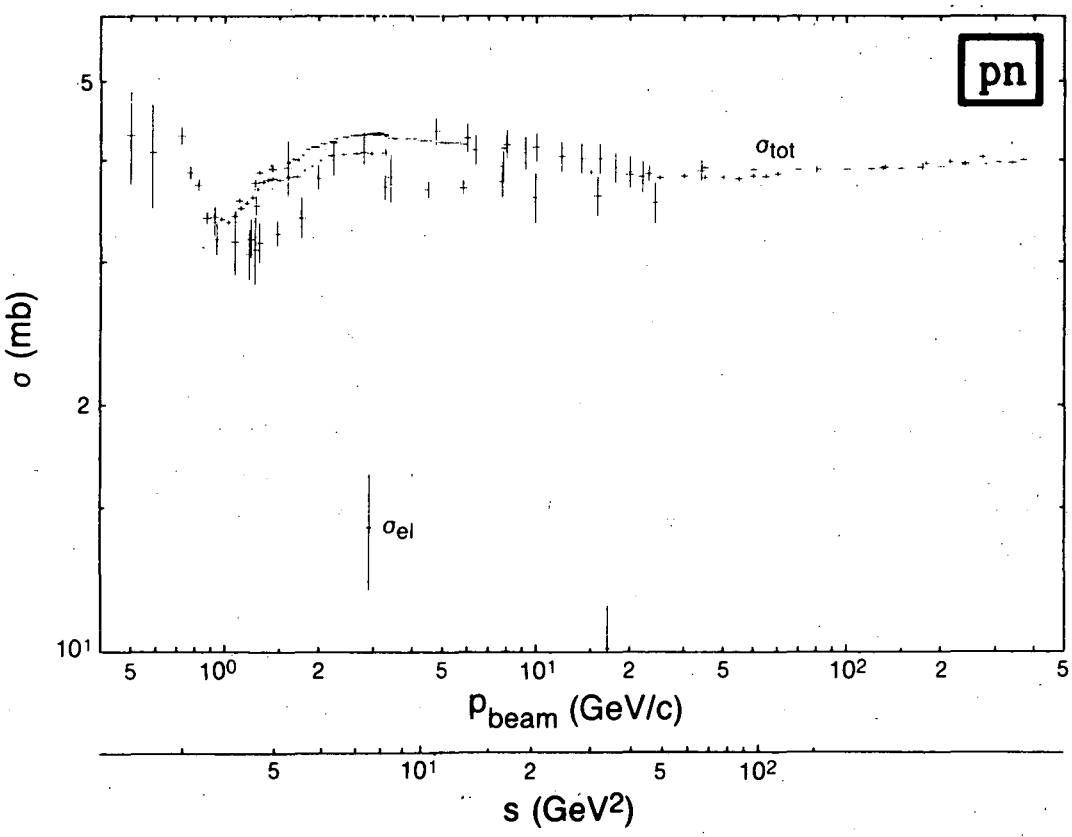




Hadronic total and elastic cross sections vs. laboratory beam momentum p_{beam} and center-of-mass energy squared s. Figures courtesy V. Flaminio, W.G. Moorhead, D.R.O. Morrison, and N. Rivoire, CERN.

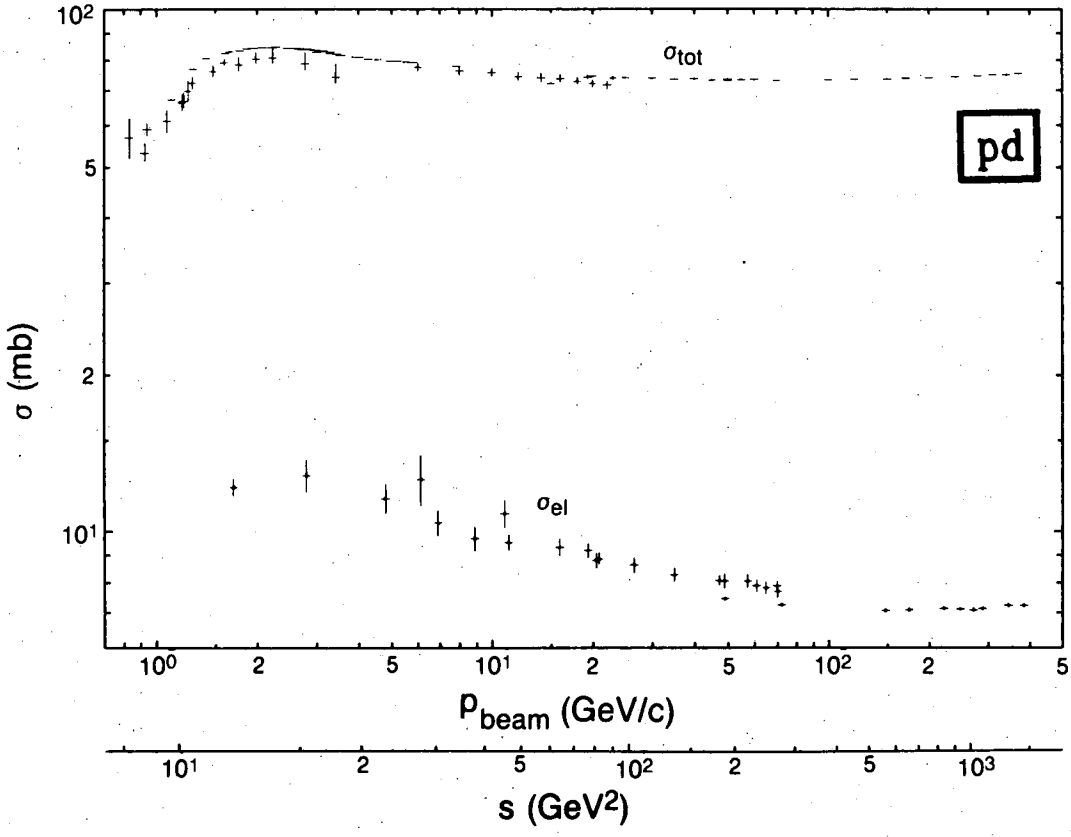
PLOTS OF CROSS SECTIONS AND RELATED QUANTITIES (Cont'd)

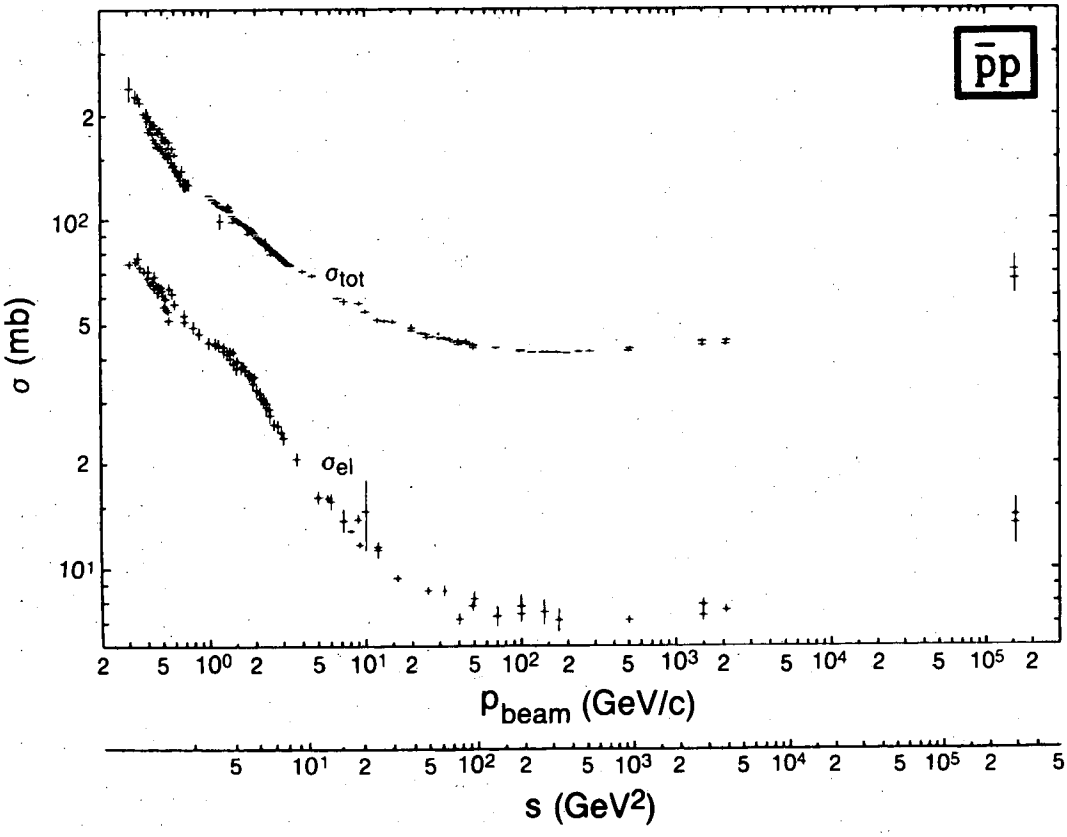




Hadronic total and elastic cross sections vs. laboratory beam momentum p_{beam} and center-of-mass energy squared s. Figures courtesy V. Flaminio, W.G. Moorhead, D.R.O. Morrison, and N. Rivoire, CERN.

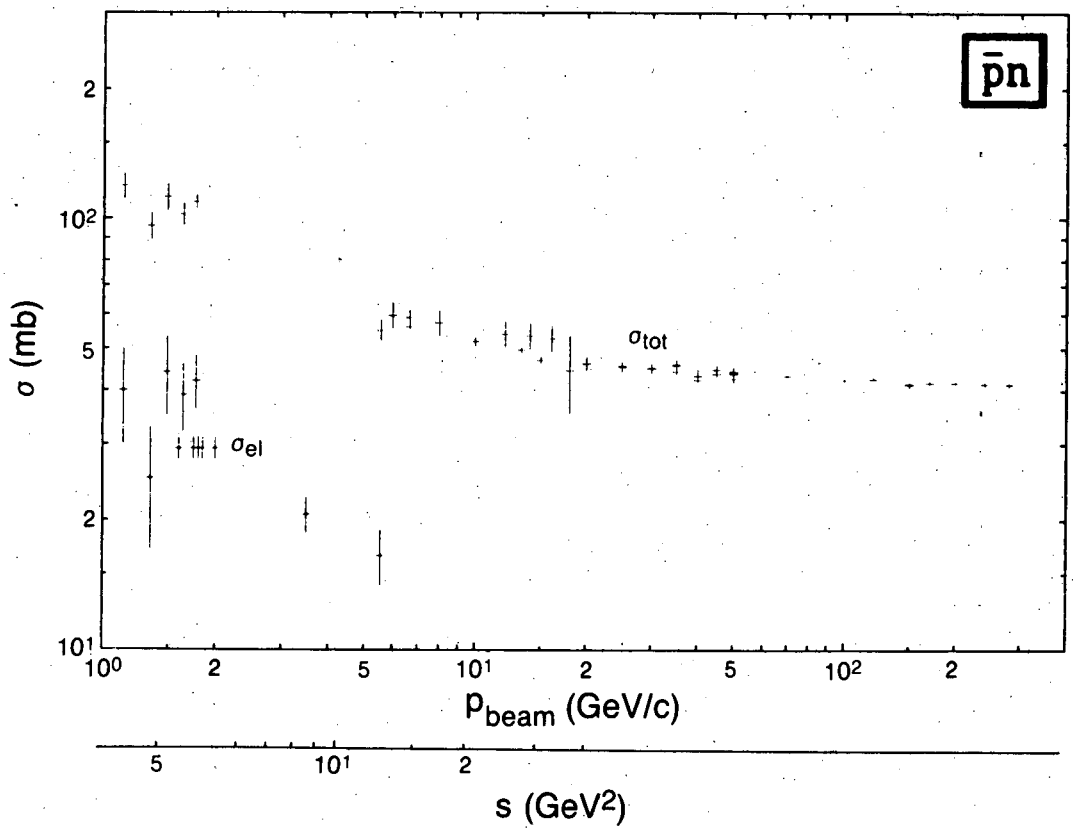
PLOTS OF CROSS SECTIONS AND RELATED QUANTITIES (Cont'd)

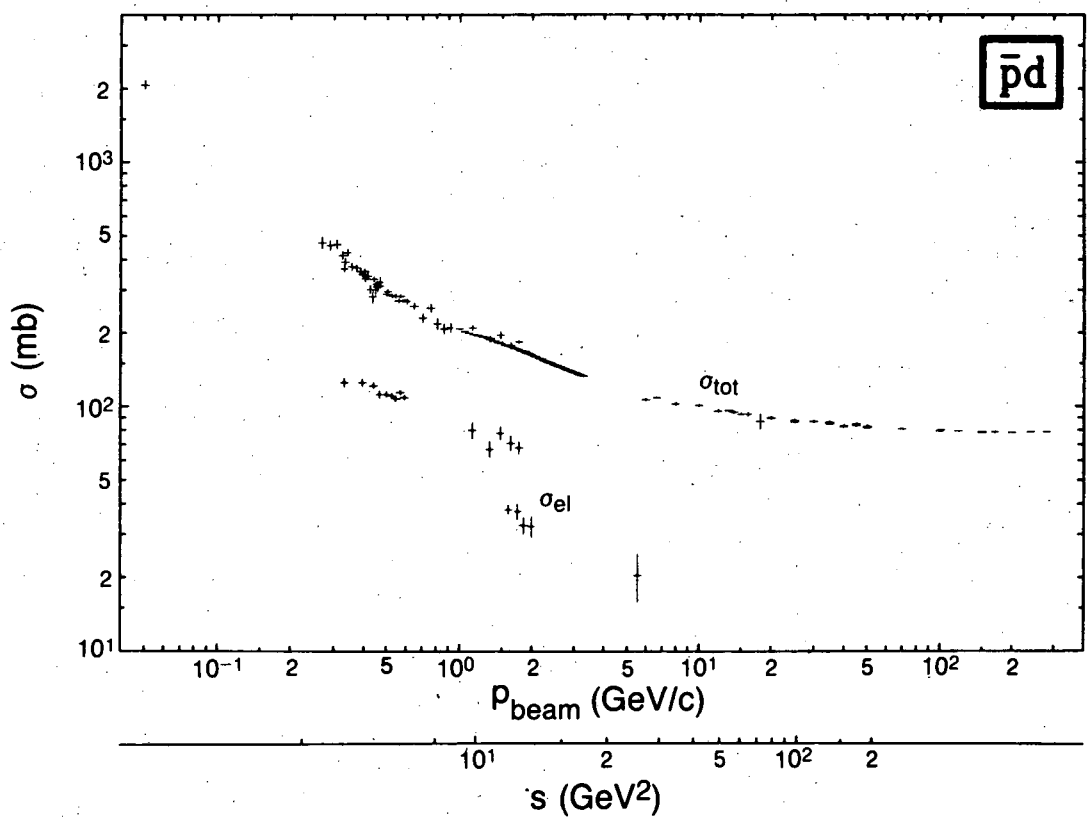




Hadronic total and elastic cross sections vs. laboratory beam momentum p_{beam} and center-of-mass energy squared s. Figures courtesy V. Flaminio, W.G. Moorhead, D.R.O. Morrison, and N. Rivoire, CERN.

PLOTS OF CROSS SECTIONS AND RELATED QUANTITIES (Cont'd)





Hadronic total and elastic cross sections vs. laboratory beam momentum p_{beam} and center-of-mass energy squared s. Figures courtesy V. Flaminio, W.G. Moorhead, D.R.O. Morrison, and N. Rivoire, CERN.

DATA CARD LISTINGS

Illustrative Key

Name of particle as it appears in table.

Arrow indicates this particle omitted from table.

Quantity tabulated below.

Code for quantity tabulated (M=mass, W=width, etc.).

Symbol used to key together data card and related comments.

Number of events above background.

Measured value (parentheses indicate value not used in average).

± error in measured value (- field blank if error symmetric; parentheses on error only indicate data not used in average due to problems with error estimation).

Average value (and error) of quantity tabulated.

Vertical bar indicates average; width of horizontal bar on top is (scaled) error on average.

Value and error for each experiment.

Partial decay mode (labeled by P_i).

Branching ratio (labeled by R_j).

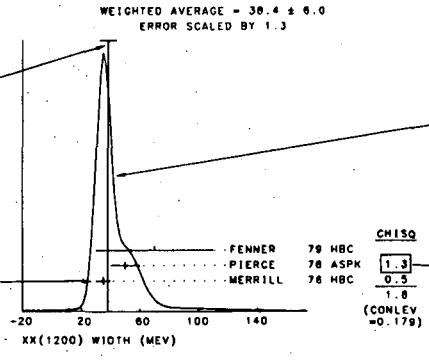
Value (and error) of quantity tabulated, as determined from constrained fit (using all measured branching ratios for this particle).

References, listed by year, then author.

Abbreviated reference form used on data cards above.

Journal, report, preprint, etc. (see abbreviations on next page).

```
XX(1200)                74  XX MESON (1200,JPG= -)  I=1
                            ORIGINALLY CALLED XXX
                            OMITTED FROM TABLE
------ --------- --------- --------- --------- --------- --------- --------
                        74  XX(1200) MASS (MEV)
M          1216.      11.          MERRILL   76 HBC    0 3.2 K-P        7/76
M   L  150(1192.)     (16.)        LYNCH     77 HBC   +- 2.7 PI-P       6/77
M   L  LYNCH DATA HAS QUESTIONABLE BACKGROUND SUBTRACTION
M          1198.      10.      7.  PIERCE    78 ASPK +    2.1 K-P        9/78
M         (1208.)                  FENNER    79 HBC    0 4.2 PI+P       9/79
M   S  80 1210.       8.           SMITH     83 MMS   - 3.5 PI-P        1/84*
M   S  SUPERSEDES EARLIER RESULT
M          . . . . . . . . .
M   AVG   1206.9      5.1     AVERAGE
------ --------- --------- --------- --------- --------- --------- --------
                        74  XX(1200) WIDTH (MEV)
W           35.       5.           MERRILL   76 HBC    0 3.2 K-P        7/76
W           50.      10.           PIERCE    78 ASPK +    2.1 K-P        9/78
W           70.      40.           FENNER    79 HBC    0 4.2 PI+P       9/79
W          (60.)  OR LESS          SMITH     83 MMS   - 3.5 PI-P        1/84*
W          . . . . . . . . .
W   AVG    38.4      6.0     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.3)
                             (SEE IDEOGRAM BELOW)
```

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------ --------- --------- --------- --------- --------- --------- --------
                        74  XX(1200) PARTIAL DECAY MODES
                                                        DECAY MASSES
P1      XX(1200) INTO 3PI                               139+ 139+ 139
P2      XX(1200) INTO K KBAR                            493+ 493
------ --------- --------- --------- --------- --------- --------- --------
                        74  XX(1200) BRANCHING RATIOS
R1      XX(1200) INTO 3PI/TOTAL                         (P1)
R1          .66       .02          MERRILL   76 HBC    0 3.2 K-P        7/76
R1  L      (.68)     (.03)         LYNCH     77 HBC   +- 2.7 PI-P       6/77
R1  L   LYNCH DATA HAS QUESTIONABLE BACKGROUND SUBTRACTION
R1          . . . . . . . . .
R1  FIT    0.675     0.012   FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.3)

R2      XX(1200) INTO KKBAR/TOTAL                       (P2)
R2          .35       .05          PIERCE    78 ASPK +    2.1 K-P        9/78
R2          . . . . . . . . .
R2  FIT    0.325     0.012   FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.3)

R3      XX(1200) INTO KKBAR/3PI                         (P2)/(P1)
R3          .50       .03          FENNER    79 HBC    0 4.2 PI+P       9/79
R3          .41       .04          SMITH     83 MMS   - 3.5 PI-P        1/84*
R3          . . . . . . . . .
R3  AVG    0.468     0.043   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.8)
R3  FIT    0.480     0.027   FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.3)

****** ********* ********* ********* ********* ********* ********* ********
                        REFERENCES FOR XX(1200)
MERRILL   76 PRL 16 143     A. MERRILL                  (SACLAY+CERN) IJP
LYNCH     77 PR 155 610     B. LYNCH                          (BNL)
PIERCE    78 PL 27B 230     N. PIERCE                         (LRL)
FENNER    79 NC 61B 372     D. FENNER,B. BEANE            (NYSE+AMEX)
SMITH     83 PRL 46 14      J. SMITH                         (SLAC)
****** ********* ********* ********* ********* ********* ********* ********
****** ********* ********* ********* ********* ********* ********* ********
```

Particle name, and quantum numbers (if known).

Particle code (for internal use only).

General comments on particle.

Abbreviated reference for this result; full reference given below.

Measurement technique (see abbreviations on next page).

Charge(s) of particle(s) detected.

Reaction producing particle, or comments.

Date this result entered (asterisk indicates result added or changed since previous edition).

Scale factor > 1 indicates inconsistent data.

Ideogram to display inconsistent data; curve is sum of Gaussians, one for each experiment (area of Gaussian = 1/error; width of Gaussian = ± error).

Contribution of experiment to χ^2 (if no entry present, experiment not used in calculating χ^2 or scale factor because of very large error).

Representative masses of decay products (used for calculating last column of Particle Property Tables).

Branching ratio R_j in terms of partial decay mode fractions P_i above.

Author(s).

Quantum number determinations in this reference.

Institution(s) of author(s) (see abbreviations on next page).

Illustrative Key *(cont'd)*

Abbreviations

Journals

APAH	Acta Phys. Acad. Hungarica
ADVP	Advances in Physics
ANP	Annals of Physics
APJ	Astrophysical Journal
APP	Acta Physica Polonica
ARNS	Annual Review of Nuclear Science
BAPS	Bulletin of the Amer. Phys. Soc.
CJP	Canadian Journal of Physics
JAP	Journal of Applied Physics
JETP	English Transl. of Soviet Physics JETP
JETPL	Letters of Soviet Physics JETP
JPA	Journal of Physics A
JPG	Journal of Physics G
JPSJ	Journal of the Phys. Soc. of Japan
LNC	Letters to Nuovo Cimento
NAT	Nature
NC	Nuovo Cimento
NIM	Nuclear Instruments and Methods
NP	Nuclear Physics
PL	Physics Letters
PN	Particles and Nuclei
PPSL	Proc. of the Phys. Soc. of London
PR	Physical Review
PRAM	Pramana
PRL	Physical Review Letters
PRPL	Physics Reports (Physics Letters C)
PRSE	Proc. of the Royal Soc. of Edinburgh
PRSL	Proc. of the Royal Soc. of London
PS	Physica Scripta
PTP	Progress of Theoretical Physics
RA	Radiochimica Acta
RMP	Reviews of Modern Physics
RRP	Revue Romaine de Physique
SCI	Science
SJNP	Soviet Journal of Nuclear Physics
SPU	Soviet Physics - Uspekhi
ZNAT	Zeitschrift fur Naturforschung
ZPHY	Zeitschrift fur Physik

Conferences

Conferences are referred to by the location in which they were held (e.g., DUBNA, BOULDER, LUND, etc.).

Measurement Techniques (i.e., Detectors and Methods of Analysis)

AEMS	Argonne effective mass spectrometer
ARG	ARGUS detector at DORIS
ASPK	Automatic spark chambers
BEBC	Big European bubble chamber at CERN
BONA	Bonanza nonmagnetic detector at DORIS
BPWA	Barrelet-zero partial-wave analysis
CALO	Calorimeter
CBAL	SLAC-SPEAR Crystal Ball detector
CC	Cloud chamber
CELL	CELLO detector at DESY
CHRM	CHARM neutrino detector at CERN
CIBS	CERN-IHEP boson spectrometer
CLEO	Cornell magnetic detector at CESR
CNTR	Counters
COSM	Cosmology and astrophysics
CUSB	Columbia U. - Stony Brook segmented NAI detector at CESR
DASP	DESY double-arm spectrometer
DBC	Deuterium bubble chamber
DLCO	SLAC-SPEAR DELCO detector
DM1	Detector at Orsay DMI collider
DPWA	Energy-dependent partial-wave analysis
ELEC	Electronic combination
EMUL	Emulsions
FBC	Freon bubble chamber
FIT	Fit to previously existing data
FRAB	ADONE $\beta\bar{\beta}$ Group detector
FRAG	ADONE $\gamma\bar{\gamma}$ Group detector
FRAM	ADONE MEA Group detector
FRBC	Freon bubble chamber
GOLI	CERN Goliath spectrometer
HBC	Hydrogen bubble chamber
HEBC	Helium bubble chamber
HDBC	Hydrogen and deuterium bubble chambers
HLBC	Heavy-liquid bubble chamber
HRS	SLAC high-resolution spectrometer
HYBR	Hybrid: bubble chamber + electronics
INDU	Magnetic induction
IPWA	Energy-independent partial-wave analysis
JADE	JADE detector at DESY
LASS	Large-angle superconducting solenoid spectrometer at SLAC
LENA	Non-magnetic lead-glass NaI detector at DORIS
MAC	MAC detector at PEP/SLAC
MBR	Molecular beam resonance technique
MMS	Missing mass spectrometer
MPS	Multiparticle spectrometer at BNL
MPWA	Model-dependent partial-wave analysis
MRKJ	Mark-J detector at DESY
MRS	Magnetic resonance spectrometer
NEUL	Neuland large-angle neutrino spectrometer
OLYA	Detector at VEPP-4, Novosibirsk
OMEG	CERN OMEGA spectrometer
OSPK	Optical spark chamber
PBC	Propane bubble chamber
PLAS	Plastic detector
PLUT	DESY PLUTO detector
PWA	Partial-wave analysis
REDE	Resonance depolarization
RVUE	Review of previous data
SFM	CERN split-field magnet
SILI	Silicon detector
SMAG	SPEAR magnetic detector
SMK2	SLAC Mark-II detector
SMK3	SLAC Mark-III detector
SPEC	Spectrometer
SPRK	Spark chamber
STRC	Streamer chamber
TASS	DESY TASSO detector
THEO	Theoretical or heavily model-dependent result
TPC	TPC detector at PEP/SLAC
UA1	UA1 detector at CERN
UA2	UA2 detector at CERN
UA5	UA5 detector at CERN
WIRE	Wire chamber
XEBC	Xenon bubble chamber

Institutions

AACH	Technische Univ. Aachen	Aachen, West Germany
AARH	Univ. of Aarhus	Aarhus, Denmark
ABO	Abo Akademi	Abo, Finland
ADEL	Adelphi Univ.	Garden City, NY, USA
AERE	Atomic Energy Res. Estab.	Harwell, Berks., England
AGDR	Acad. of Sci. of the German Demo. Rep.	Berlin-Zeuthen, East Germany
AICH	Aichi Univ. of Education	Kariya, Aichi Pref., Japan
AIKO	Inst. Kernphys. Onderzoek	Amsterdam, Netherlands
ALAH	Univ. of Alabama at Huntsville	Huntsville, AL, USA
ALBA	State Univ. of New York at Albany	Albany, NY, USA
ALBE	Alberta Univ., NRC	Edmonton, Alta., Canada
AMST	Univ. of Amsterdam	Amsterdam, Netherlands
ANIK	Amsterdam NIKHEF	Amsterdam, Netherlands
ANKA	Middle East Technical Univ.	Ankara, Turkey
ANL	Argonne National Lab.	Argonne, IL, USA
ARIZ	Univ. of Arizona	Tucson, AZ, USA
ARZS	Arizona State Univ.	Tempe, AZ, USA
ATEN	Nuclear Res. Centre Demokritos	Athens, Greece
ATHU	Univ. of Athens	Athens, Greece
AUCK	Univ. of Auckland	Auckland, New Zealand
BARC	Univ. de Barcelona	Barcelona, Spain
BARI	Univ. di Bari	Bari, Italy
BART	Bartol Research Foundation	Swarthmore, PA, USA
BASL	Univ. of Basel	Basel, Switzerland
BAYR	Univ. Bayreuth	Bayreuth, West Germany
BEDF	Bedford College	London, England
BELG	Inst. Interuniv. des Sci. Nuc.	Bruxelles, Belgium
BELL	Bell Labs.	Murray Hill, NJ, USA
BERG	Univ. of Bergen	Bergen, Norway
BERL	Inst. Hochenergiephys. DAW	Berlin-Zeuthen, East Germany
BERN	Univ. Bern	Bern, Switzerland
BGNA	Univ. di Bologna	Bologna, Italy
BHAB	Bhabha Atomic Research Center	Bombay, India
BHEP	Inst. of High Energy Physics	Beijing, China
BIEL	Univ. Bielefeld	Bielefeld, West Germany
BING	State Univ. of New York at Binghamton	Binghamton, NY, USA
BIRM	Birmingham Univ.	Birmingham, England
BNL	Brookhaven National Lab.	Upton, L.I., NY, USA
BOHR	Niels Bohr Inst.	Copenhagen, Denmark
BOIS	Boise State Univ.	Boise, ID, USA
BOMB	Univ. of Bombay	Bombay, India
BONN	Univ. Bonn	Bonn, West Germany
BORD	Univ. de Bordeaux	Bordeaux, France
BOST	Boston Univ.	Boston, MA, USA
BRAN	Brandeis Univ.	Waltham, MA, USA
BRCO	Univ. of British Columbia	Vancouver, B.C., Canada
BRIS	H. H. Wills Phys. Lab., U. of Bristol	Bristol, England
BROW	Brown Univ.	Providence, RI, USA
BRUX	Univ. Libre de Bruxelles	Bruxelles, Belgium
BUCH	Bucharest State Univ.	Bucharest, Romania
BUDA	Central Research Inst. of Physics	Budapest, Hungary
BUFF	State Univ. of New York at Buffalo	Buffalo, NY, USA
BURE	Inst. des Hautes Etutes Sci.	Bures-sur-Yvette, France
CAEN	Lab. de Phys. Corpusculaire	Caen, France
CAIW	Carnegie Inst. of Washington	Washington, DC, USA
CAMB	Cambridge Univ.	Cambridge, England
CANB	Australian National Univ.	Canberra, Australia
CARL	Carleton Univ.	Ottawa, Ont., Canada
CARN	Carnegie-Mellon Univ.	Pittsburgh, PA, USA
CASE	Case Western Reserve Univ.	Cleveland, OH, USA
CATH	Catholic Univ. of America	Washington, DC, USA
CAVE	Cavendish Lab., Cambridge Univ.	Cambridge, England
CCAC	Community College of Allegheny County	Pittsburgh, PA, USA
CDEF	College de France	Paris, France
CEA	Cambridge Electron Accel.	Cambridge, MA, USA
CENG	CEN, Grenoble	Grenoble, France
CERN	European Org. for Nuclear Research	Geneva, Switzerland
CHIC	Univ. of Chicago	Chicago, IL, USA
CINC	Univ. of Cincinnati	Cincinnati, OH, USA
CIT	Calif. Inst. of Technology	Pasadena, CA, USA
CLEV	Cleveland State Univ.	Cleveland, OH, USA
CNRC	Canadian National Research Council	Ottawa, Ont., Canada
COLO	Univ. of Colorado	Boulder, CO, USA
COLU	Columbia Univ.	New York, NY, USA
CORN	Cornell Univ.	Ithaca, NY, USA
COSU	Colorado State Univ.	Fort Collins, CO, USA
CRAC	Inst. for Nuclear Research	Cracow, Poland
CUNY	City Univ. of New York	New York, NY, USA
CURI	Laboratoire Joliot-Curie	Paris, France
DARE	Daresbury Nuclear Physics Lab.	Daresbury, England
DART	Dartmouth College	Hanover, NH, USA
DELF	Univ. of Technology	Delft, Netherlands
DELH	Univ. of Delhi	Delhi, India
DESY	Deutsches Elektronen-Synchrotron	Hamburg, West Germany
DOE	U.S. Department of Energy	Washington, DC, USA
DORT	Univ. Dortmund	Dortmund, West Germany
DUKE	Duke Univ.	Durham, NC, USA
DURH	Univ. of Durham	Durham, England
DUUC	University College	Dublin, Ireland
EDIN	Univ. of Edinburgh	Edinburgh, Scotland
EFI	Enrico Fermi Inst. for Nucl. Studies	Chicago, IL, USA
ELMT	Elmhurst College	Elmhurst, IL, USA
EPOL	Ecole Polytechnique	Palaiseau, France
ERLA	Univ. Erlangen-Nurnberg	Erlangen, West Germany
ETH	Swiss Federal Inst. of Technology	Zurich, Switzerland
FIRZ	Univ. di Firenze	Firenze, Italy
FISK	Fisk Univ.	Nashville, TN, USA
FLOR	Univ. of Florida	Gainsville, FL, USA
FNAL	Fermi National Accelerator Lab.	Batavia, IL, USA
FOM	Found. for Fundamental Res. on Matter	Utrecht, Netherlands
FRAS	Lab. Nazionali del C.N.E.N.	Frascati, Italy
FREI	Univ. of Freiburg	Freiburg, West Germany
FSU	Florida State Univ.	Tallahassee, FL, USA
GENO	Univ. di Genova	Genova, Italy
GESC	General Electric Res. and Dev. Center	Schenectady, NY, USA
GEVA	Univ. de Geneve	Geneva, Switzerland
GLAS	Univ. of Glasgow	Glasgow, Scotland
GMAS	George Mason Univ.	Fairfax, VA, USA
GRAZ	Univ. Graz	Graz, Austria
GREN	Inst. des Sci. Nuc., Univ. de Grenoble	Grenoble, France
GSCO	Geological Survey of Canada	Ottawa, Ont., Canada
GUEL	Guelph Univ.	Guelph, Ont., Canada
HAIF	Technion - Israel Inst. of Technology	Haifa, Israel
HAMB	Univ. Hamburg	Hamburg, West Germany
HARV	Harvard Univ.	Cambridge, MA, USA
HAWA	Univ. of Hawaii	Honolulu, HI, USA
HEBR	Hebrew Univ.	Jerusalem, Israel
HEID	Univ. Heidelberg	Heidelberg, West Germany
HELS	Helsingin Yliopisto	Helsinki, Finland
HIRO	Hiroshima Univ.	Hiroshima, Japan
HOUS	Univ. of Houston	Houston, TX, USA
HPC	Hewlett-Packard Corp.	Cupertino, CA, USA
IAS	Inst. for Advanced Study	Princeton, NJ, USA
IBM	International Business Machines	Palo Alto, CA, USA

Illustrative Key *(cont'd)*

Institutions (cont'd)

IFRJ	Inst. de Fisica, Rio de Janeiro	Rio de Janeiro, Brazil
IIT	Illinois Inst. of Tech.	Chicago, IL, USA
ILL	Univ. of Illinois	Urbana, IL, USA
ILLC	Univ. of Illinois at Chicago	Chicago, IL, USA
ILLG	Inst. Laue-Langevin	Grenoble, France
IND	Univ. of Indiana	Bloomington, IN, USA
INEL	Idaho National Engineering Lab.	Idaho Falls, ID, USA
INFN	Ist. Nazionale di Fisica Nuclear	Roma, Italy
INNS	Phys. Inst., Univ. Innsbruck	Innsbruck, Austria
INRM	Inst. for Nuclear Research	Moscow, USSR
INUS	Inst. for Nuclear Study at Tokyo Univ.	Tokyo, Japan
IOFF	Ioffe Inst. of Physics and Tech.	Leningrad, USSR
IOWA	Univ. of Iowa	Iowa City, IA, USA
IPCR	Inst. of Physical and Chemical Research	Saitama-ken, Japan
IPN	Inst. de Phys. Nucleaire	Orsay, France
IPNP	Inst. de Physique Nucleaire	Paris, France
IPPC	Inst. for Particle Physics of Canada	Montreal, Que., Canada
IRAD	Inst. du Radium	Paris, France
ISU	Iowa State Univ.	Ames, IA, USA
ITEP	Inst. for Theor. and Exp. Phys.	Moscow, USSR
ITHA	Ithaca College	Ithaca, NY, USA
ITPU	Inst. for Theoretical Physics	Utrecht, Netherlands
IUPU	Indiana U. - Purdue U. at Indianapolis	Indianapolis, IN, USA
JAGL	Jagellonian Univ.	Cracow, Poland
JHU	Johns Hopkins Univ.	Baltimore, MD, USA
JINR	Joint Inst. for Nucl. Research	Dubna, USSR
KAGO	Kagoshima Univ.	Kagoshima, Japan
KANS	Univ. of Kansas	Lawrence, KS, USA
KARL	Univ. Karlsruhe	Karlsruhe, West Germany
KAZA	Kazakh Academy of Science	Alma-Ata, USSR
KEK	Nat. Lab for High Energy Phys., Japan	Tsukuba-gun, Japan
KENT	Kent Univ. at Cantebury, Kent	Cantebury, England
KEYN	Open Univ.	Milton Keynes, England
KHAR	Phys.-Tech. Inst., Acad. Sci., Ukr.SSR	Kharkov, USSR
KIAE	Kurchatov Inst. of Atomic Energy	Moscow, USSR
KIEL	Kiel Univ.	Kiel, West Germany
KIEV	Physical-Technical Inst.	Kiev, USSR
KINK	Kinki Univ.	Osaka, Japan
KNTY	Univ. of Kentucky	Lexington, KY, USA
KOBE	Kobe Univ.	Kobé, Japan
KONA	Konan Univ.	Kobe, Japan
KONS	B. P. Konstantinov Inst. of Nucl. Phys.	USSR
KYOT	Kyoto Univ.	Kyoto, Japan
LALO	Linear Accelerator Lab, Orsay	Orsay, France
LANC	Lancaster Univ.	Lancaster, England
LANL	U.C. Los Alamos National Lab.	Los Alamos, NM, USA
LAPP	Lab. d'Annecy de Phys. des Particules	Annecy, France
LASL	U.C. Los Alamos Scientific Lab.	Los Alamos, NM, USA
LAUS	Univ. of Lausanne	Lausanne, Switzerland
LBL	U.C. Lawrence Berkeley Lab.	Berkeley, CA, USA
LCGT	Lab. di Cosmo-Geofisica del CNR	Torino, Italy
LEBD	Lebedev Physics Inst.	Moscow, USSR
LEED	Univ. of Leeds	Leeds, England
LEHI	Lehigh Univ.	Bethlehem, PA, USA
LEHM	Herbert H. Lehman College	Bronx, NY, USA
LEID	Inst. Lorentz	Leiden, Netherlands
LEMO	Le Moyne College	Syracuse, NY, USA
LENI	Inst. of Nucl. Phys., USSR Acad. Sci.	Leningrad, USSR
LIBH	Lab. Interuniv. Belge High Eng.	Bruxelles, Belgium
LINZ	Linz Inst. fur Physik, Kepler Hoch.	Linz, Austria
LISB	Univ. de Lisboa	Lisboa, Codex, Portugal
LIVP	Liverpool Univ.	Liverpool, England
LLL	Lawrence Livermore Lab.	Livermore, CA. USA
LOIC	Imperial Col. of Sci. and Tech.	London, England
LOQM	Queen Mary College	London, England
LOUC	University College	London, England
LOWC	Westfield College	London, England
LPNP	Lab. de Phys. Nucl. et Hautes Energies	Paris, France
LPTP	Lab. de Phys. Theor. et Hautes Energies	Paris, France
LRL	U.C. Lawrence Berkeley Lab.	Berkeley, CA, USA
LSU	Louisiana State Univ.	Baton Rouge, LA, USA
LUND	Univ. I Lund	Lund, Sweden
LVLN	Univ. Catholique de Louvain	Louvain-La-Neuve, Belgium
LYON	Univ. de Lyon	Villeurbanne, France
MADR	Junta de Energia Nuclear	Madrid, Spain
MADU	Univ. Autonome de Madrid	Madrid, Spain
MANH	Manhattan College	New York, NY, USA
MANI	Univ. of Manitoba	Winnipeg, Man., Canada
MANZ	Univ. Mainz	Mainz, West Germany
MARS	Center National de la Recherche Sci.	Marseille, France
MASA	Univ. of Massachusetts	Amherst, MA, USA
MASB	Univ. of Massachusetts	Boston, MA, USA
MCGI	McGill Univ.	Montreal, Que., Canada
MCHS	Univ. Manchester	Manchester, England
MEIS	Meisei Univ.	Hino, Tokyo, Japan
MELB	Univ. of Melbourne	Parkville, Australia
MHCO	Mount Holyoke College	South Hadley, MA, USA
MICH	Univ. of Michigan	Ann Arbor, MI, USA
MILA	Univ. di Milano	Milano, Italy
MINN	Univ. of Minnesota	Minneapolis, MN, USA
MINR	Inst. for Nuclear Research	Moscow, USSR
MIOH	Miami Univ.	Oxford, OH, USA
MIT	Massachusetts Inst. of Technology	Cambridge, MA, USA
MODE	Ist. di Fisica dell Univ.	Modena, Italy
MONP	Univ. de Montpellier	Montpellier, France
MONS	Univ. de l'Etat, Mons	Mons, Belgium
MONT	Univ. de Montreal	Montreal, Que., Canada
MOSU	Moscow State Univ.	Moscow, USSR
MPEI	Moscow Phys. Eng. Inst.	Moscow, USSR
MPIH	Max Planck Inst. fur Kernphysik	Heidelberg, West Germany
MPIM	Max Planck Inst. fur Phys.-Astrophys.	Munich, West Germany
MSNA	Ist. di Fisica dell Univ.	Messina, Italy
MSU	Michigan State Univ.	East Lansing, MI, USA
MTHO	Mt. Holyoke College	South Hadley, MA, USA
MULH	Centre Univ. du Haut-Rhin	Mulhouse, France
MUNI	Univ. of Munich	Munich, West Germany
MURA	Midwestern Univ. Research Assoc.	Stroughton, WI, USA
NAGO	Nagoya Univ.	Nagoya, Japan
NAPL	Univ. di Napoli	Napoli, Italy
NARA	Nara Women's Univ.	Nara, Japan
NASA	NASA, Goddard Space Flight Center	Greenbelt, MD, USA
NBS	U.S. National Bureau of Standards	Washington, DC, USA
NDAM	Univ. of Notre Dame	Notre Dame, IN, USA
NEAS	Northeastern Univ.	Boston, MA, USA
NEUC	Univ. de Neuchatel	Neuchatel, Switzerland
NEVI	Nevis Lab.	Irvington-on-Hudson, NY, USA
NIJM	R. K. Univ. Nijmegen	Nijmegen, Netherlands
NIU	Northern Illinois Univ.	De Kalb, IL, USA
NORD	Nordisk Inst. for Teor. Atomfys.	Copenhagen, Denmark
NOVO	Inst. of Nucl. Phys.	Novosibirsk, USSR
NPOL	Northern Polytechnic	London, England
NRL	Naval Research Laboratory	Washington, DC, USA
NSF	U.S. National Science Foundation	Washington, DC, USA
NTUA	National Technical Univ.	Athens, Greece
NWES	Northwestern Univ.	Evanston, IL, USA
NYU	New York Univ.	New York, NY, USA
OHIO	Ohio Univ.	Athens, OH, USA
OKAY	Okayama Univ.	Okayama, Japan
OREG	Univ. of Oregon	Eugene, OR, USA
ORNL	Oak Ridge National Lab.	Oak Ridge, TN, USA
ORSA	Univ. de Paris, Fac. des Sci.	Orsay, France
OSAK	Osaka Univ.	Osaka, Japan
OSKC	Osaka City Univ.	Osaka, Japan

Institutions (cont'd)

OSLO	Oslo Univ.	Oslo, Norway
OSU	Ohio State Univ.	Columbus, OH, USA
OTTA	Univ. of Ottawa	Ottawa, Ont., Canada
OXF	Oxford Univ.	Oxford, England
PADO	Univ. di Padova	Padova, Italy
PATR	Univ. of Patras	Patras, Greece
PAVI	Univ. di Pavia	Pavia, Italy
PENN	Univ. of Pennsylvania	Philadelphia, PA, USA
PGIA	Univ. di Perugia	Perugia, Italy
PHIL	Philipps Univ.	Marburg, West Germany
PISA	Univ. di Pisa	Pisa, Italy
PITT	Univ. of Pittsburgh	Pittsburgh, PA, USA
PNL	Pacific Northwest Lab.	Richland, WA, USA
PPA	Princeton-Penn. Proton Accel.	Princeton, NJ, USA
PRAG	Inst. of Physics, CSAV	Prague, Czechoslovakia
PRIN	Princeton Univ.	Princeton, NJ, USA
PSLL	Physical Science Lab.	Las Cruces, NM, USA
PURD	Purdue Univ.	Lafayette, IN, USA
QUKI	Queens Univ.	Kingston, Ont., Canada
RAL	Rutherford Appleton Lab. (formerly RL)	Chilton, Did., Berks., England
REGE	Univ. Regensburg	Regensburg, West Germany
REHO	Weizmann Inst. of Sci.	Rehovoth, Israel
RHEL	Rutherford High Energy Lab.	Chilton, Did., Berks., England
RICE	William Marsh Rice Univ.	Houston, TX, USA
RISO	Research Estab. Riso	Roskilde, Denmark
RL	Rutherford Lab. (formerly RHEL)	Chilton, Did., Berks., England
RMCS	Royal Military College of Science	Shrivenham, England
ROCH	Univ. of Rochester	Rochester, NY, USA
ROCK	Rockefeller Univ.	New York, NY, USA
ROMA	Univ. di Roma	Roma, Italy
ROSE	Rose Polytechnic Inst.	Terre Haute, IN, USA
RUTG	Rutgers Univ.	New Brunswick, NJ, USA
SACL	Cntr. d'Etudes Nucl. Saclay	Gif-sur-Yvette, France
SAGA	Saga Univ.	Saga, Japan
SANI	Ist. Superiore di Sanita	Roma, Italy
SBER	San Bernardino State College	San Bernardino, CA, USA
SCUC	Univ. of South Carolina	Columbia, SC, USA
SEAT	Seattle Pacific College	Seattle, WA, USA
SEIB	Research Center Seibersdorf	Vienna, Austria
SEOU	Korea Univ.	Seoul, Korea
SERP	Inst. of High Energy Physics	Serpukov, USSR
SETO	Seton Hall Univ.	South Orange, NJ, USA
SFLA	Univ. of South Florida	Tampa, FL, USA
SFSU	San Francisco State Univ.	San Francisco, CA, USA
SHEF	Univ. of Sheffield	Sheffield, England
SHMP	Univ. of Southampton	Southampton, England
SIBE	Inst. of Nucl. Phys., USSR Acad. Sci.	Siberia, USSR
SIEG	Gesamthochschule Siegen	Huttental, West Germany
SIN	Swiss Inst. of Nuclear Research	Villigen, Switzerland
SLAC	Stanford Linear Accel. Center	Stanford, CA, USA
SMAS	Southeastern Massachusetts Univ.	North Dartmouth, MA, USA
SOFI	Bulgarian Acad. of Sci.	Sofia, Bulgaria
STAN	Stanford Univ.	Stanford, CA, USA
STEV	Stevens Inst. of Tech.	Hoboken, NJ, USA
STLO	St. Louis Univ.	St. Louis, MO, USA
STOH	Stockholm Univ.	Stockholm, Sweden
STON	State Univ. of New York at Stonybrook	Stonybrook, L.I., NY, USA
STRB	Centre des Res. Nucleaires	Strasbourg, France
SURR	Univ. of Surrey	Surrey, England
SUSS	Univ. of Sussex	Falmer, Brighton, England
SYDN	Univ. of Sydney	Sydney, Australia
SYRA	Syracuse Univ.	Syracuse, NY, USA
TAMU	Texas A and M Univ.	College Station, TX, USA
TBLI	Tbilisi State Univ.	Tbilisi, USSR
TELA	Univ. of Tel-Aviv	Tel-Aviv, Israel
TEMP	Temple Univ.	Philadelphia, PA, USA
TENN	Univ. of Tennessee	Knoxville, TN, USA
TEXA	Univ. of Texas	Austin, TX, USA
THES	Univ. of Thessaloniki	Thessaloniki, Greece
TIFR	Tata Inst. of Fundamental Research	Bombay, India
TIT	Tokyo Inst. of Technology	Tokyo, Japan
TMSK	Nucl. Phys. Inst., Tomsk Polytech Inst.	Tomsk, USSR
TMU	Tokyo Metropolitan Univ.	Tokyo, Japan
TNTO	Univ. of Toronto	Toronto, Ont., Canada
TOHO	Tohoku Univ.	Sendai, Japan
TOIN	Tokyo Inst. of Technology	Tokyo, Japan
TOKY	Univ. of Tokyo	Tokyo, Japan
TORI	Univ. di Torino	Torino, Italy
TRIK	Rikkyo Univ.	Tokyo, Japan
TRIN	Trinity College	Dublin, Ireland
TRIU	TRIUMF, Univ. of British Columbia	Vancouver, B.C., Canada
TRST	Univ. di Trieste	Trieste, Italy
TSUK	Univ. of Tsukuba	Tsukuba, Japan
TTAM	Tamagawa Univ.	Tokyo, Japan
TUFT	Tufts Univ.	Medford, MA, USA
TWAS	Waseda Univ.	Tokyo, Japan
UBEL	Univ. of Belgrade	Belgrade, Yugoslavia
UCB	Univ. of Calif. at Berkeley	Berkeley, CA, USA
UCD	Univ. of Calif. at Davis	Davis, CA, USA
UCI	Univ. of Calif. at Irvine	Irvine, CA, USA
UCLA	Univ. of Calif. at Los Angeles	Los Angeles, CA, USA
UCND	Union Carbide Nuclear Division	Oak Ridge, TN, USA
UCR	Univ. of Calif. at Riverside	Riverside, CA, USA
UCSB	Univ. of Calif. at Santa Barbara	Santa Barbara, CA, USA
UCSC	Univ. of Calif. at Santa Cruz	Santa Cruz, CA, USA
UCSD	Univ. of Calif. at San Diego	La Jolla, CA, USA
UMD	Univ. of Maryland	College Park, MD, USA
UNCS	Union College	Schenectady, NY, USA
UNH	Univ. of New Hampshire	Durham, NH, USA
UNM	Univ. of New Mexico	Albuquerque, NM, USA
UOEH	Univ. of Occup. and Environ. Health	Kitakyushu, Japan
UPNJ	Upsala College	East Orange, NJ, USA
UPPS	Gustaf Werner Inst.	Uppsala, Sweden
USC	Univ. of Southern California	Los Angeles, CA, USA
USTL	Univ. Sci. et Tech. du Languedoc	Montpellier, France
UTAH	Univ. of Utah	Salt Lake City, UT, USA
UTRE	Univ. of Utrecht	Utrecht, Netherlands
VAND	Vanderbilt Univ.	Nashville, TN, USA
VICT	Univ. of Victoria	Victoria, B.C., Canada
VIEN	Inst. for High Energy Physics, A. A. S.	Vienna, Austria
VIRG	Univ. of Virginia	Charlottesville, VA, USA
VPI	Virginia Polytechnic Inst.	Blacksburg, VA, USA
WARS	Univ. of Warsaw	Warsaw, Poland
WASH	Univ. of Washington	Seattle, WA, USA
WIEN	Univ. Wien	Wien, Austria
WILL	College of William and Mary	Williamsburg, VA, USA
WINR	Warsaw Inst. of Nuclear Research	Warsaw, Poland
WISC	Univ. of Wisconsin	Madison, WI, USA
WITW	Univ. of the Witwatersrand	Johannesburg, S. Africa
WMIU	Western Michigan Univ.	Kalamazoo, MI, USA
WOOD	Woodstock College	Woodstock, MD, USA
WUPG	Gesamthochschule Wuppertal	Wuppertal, West Germany
WUPP	Univ. Wuppertal	Wuppertal, West Germany
WURZ	Univ. Wurzburg	Wurzburg, West Germany
WUSL	Washington Univ.	St. Louis, MO, USA
WYOM	Univ. of Wyoming	Laramie, WY, USA
YALE	Yale Univ.	New Haven, CT, USA
YERE	Yerevan Physics Inst.	Yerevan, Armenia, USSR
YOKO	Yokohama Univ.	Yokohama, Japan
YORK	York Univ.	Toronto, Ont., Canada
ZAGR	Inst. Rudjer Boskovic	Zagreb, Yugoslavia
ZEEM	Zeeman Lab., Univ. of Amsterdam	Amsterdam, Netherlands
ZURI	Univ. Zurich	Zurich, Switzerland

Stable Particles

γ, W, Z, WEAK GAUGE BOSON SEARCHES

Data Card Listings

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γ

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                    0  GAMMA(0,J=1)

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                    0  GAMMA MASS (MEV)

M   F      (6. E-21)OR LESS          PATEL     65        SATELLITE DATA   10/69
M          (6. E-21)OR LESS          GINTSBURG 64        SATELLITE DATA   10/69
M          (2.3E-21)OR LESS          GOLDHABER 68        SATELLITE DATA   10/69
M   F      (6. E-23)OR LESS          FRANKEN   71        LOW FREQ RES CIR  3/72
M          (1. E-20)OR LESS          WILLIAMS  71 CNTR   TESTS GAUSS LAW   3/71
M          (4. E-13)OR LESS          LOWENTHAL 73        GENL RELATIVITY   8/77
M          (7.3E-22)OR LESS          HOLLWEG   74        ALFVEN WAVES      7/74
M          (6. E-22)OR LESS  CL=.997 DAVIS     75        JUPITER MAGFIELD  1/78
M           3. E-33 OR LESS          CHIBISOV  76        GALACTIC MAG FLD  2/84*
M   F   VALIDITY QUESTIONABLE. SEE CRITICISM IN KROLL 71 AND GOLDHABER 71.  3/78

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REFERENCES FOR GAMMA


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GINTSBUR 64 SOV. ASTR.AJ7 536 M. A. GINTSBURG              (ACAD SCI,USSR)
PATEL    65 PL    14  105     V. L. PATEL                          (DURHAM)
GOLDHABE 68 PRL   21  567     A. GOLDHABER,M. NIETO          (STONY BROOK)
FRANKEN  71 PRL 26 115        P A FRANKEN, G W AMPULSKI            (MICH)
WILLIAMS 71 PRL 26 721        +FALLER,HILL                       (WESLEYAN)

LOWENTHA 73 PR D8 2349        D.D.LOWENTHAL                         (UCI)
HOLLWEG  74 PRL 32 961        J V HOLLWEG  (NATL CENTER FOR ATMOS RESRCH)
DAVIS    75 PRL 35 1402       +GOLDHABER,NIETO              (CIT+STON+LASL)
CHIBISOV 76 SPU 19 624        G.B.CHIBISOV                          (LEBD)

                              PAPERS NOT REFERRED TO IN DATA CARDS

GOLDHABE 71 RMP 43 277        A S GOLDHABER, M M NIETO   (STON+BOHR+UCSB)
KROLL    71 PRL 26 1395       N M KROLL                             (SLAC)
BYRNE    77 AST.SP.SCI.46 115 J.C.BYRNE                             (LOIC)
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W

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                    43  W(80000,JP=  )

      MEASUREMENTS OF CHARGED WEAK GAUGE BOSON PARAMETERS
      ARE LISTED HERE.  SEE ALSO WEAK GAUGE BOSON SEARCHES SECTION BELOW.

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                    43  W MASS (GEV)

M        6  (81.)     (5.)          ARNISON   83 UA1  REPL.BY ARNISON2 83  3/83*
M       27   80.9      2.9          ARNISON2  83 UA1  P AP, ECM=540 GEV.  11/83*
M   B       (81.0)    (2.8)         BAGNAIA   83 UA2  P AP, ECM=550 GEV.  11/83*
M        4   80.      10.      6.   BANNER    83 UA2  P AP, ECM=550 GEV.   3/83*
M   B   BAGNAIA 83 MASS IS PRELIMINARY VALUE OBTAINED IN Z0 EXPERIMENT .  11/83*
M            . . . . . . . . .
M   AVG      80.8      2.7     AVERAGE

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                    43  W WIDTH  (GEV)

W       27    7.    OR LESS  CL=.90   ARNISON2  83 UA1  P AP, ECM=540 GEV.  11/83*

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                    43  W PARTIAL DECAY MODES                              10/83*

                                                        DECAY MASSES
P1      W+- INTO E+- NEU                                .511+   0

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                    43  W BRANCHING RATIOS                                 10/83*

R1      W+- INTO (E+- NEU)/TOTAL                        (P1)                10/83*
R1       6    SEEN                    ARNISON   83 UA1  REPL.BY ARNISON2 83 10/83*
R1      52    SEEN                    ARNISON2  83 UA1  P AP ECM=540 GEV    11/83*
R1   B   4    SEEN                    BANNER    83 UA2  P AP ECM=540 GEV    10/83*

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REFERENCES FOR W


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ARNISON  83 PL 122B 103       UA1 COLLAB.(AACH+LAPP+BIRM+CERN+HELS+LOQM+)
ARNISON2 83 PL 129B 273       UA1 COLLAB.(AACH+LAPP+BIRM+CERN+HELS+LOQM+)
BAGNAIA  83 PL 129B 130       UA2 COLLAB. (BERN+CERN+BOHR+LALO+PAVI+SACL)
BANNER   83 PL 122B 476       UA2 COLLAB. (BERN+CERN+BOHR+LALO+PAVI+SACL)
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Z

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                    44  Z(95000,JP=  )

      MEASUREMENTS OF NEUTRAL WEAK GAUGE BOSON PARAMETERS
      ARE LISTED HERE.  SEE ALSO WEAK GAUGE BOSON SEARCHES SECTION BELOW.

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                    44  Z MASS (GEV)

M        5  (95.2)    (2.5)          ARNISON   83 UA1  REPL.BY ARNISON2 83 11/83*
M        5   95.6      3.2          ARNISON2  83 UA1  P AP, ECM=540 GEV.  11/83*
M        4   91.9      1.9          BAGNAIA   83 UA2  P AP, ECM=550 GEV.  11/83*
M            . . . . . . . . .
M   AVG      92.9      1.6     AVERAGE

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                    44  Z WIDTH  (GEV)

W    A   4  (10.2)  OR LESS  CL=.90   ARNISON   83 UA1  REPL.BY ARNISON2 83 11/83*
W        4    8.5   OR LESS  CL=.90   ARNISON2  83 UA1  P AP, ECM=550 GEV.  11/83*
W        4  (11.)   OR LESS  CL=.90   BAGNAIA   83 UA2  P AP, ECM=550 GEV.  11/83*
W    A  ARNISON 83 GIVE A MOST PROBABLE VALUE OF 6.2 GEV AND AN UPPER LIMIT 11/83*
W    A  OF 10.2 GEV FOR THE WIDTH.  THIS IS CONSISTENT WITH THEIR           11/83*
W    A  EXPERIMENTAL RESOLUTION AND A NATURAL Z WIDTH OF 3.0 GEV.           11/83*

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                    44  Z PARTIAL DECAY MODES

                                                        DECAY MASSES
P1      Z INTO E+ E-                                    .511+.511
P2      Z INTO MU+ MU-                                  106+ 106

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                    44  Z BRANCHING RATIOS

R1      Z INTO (E+ E-)/TOTAL                            (P1)                11/83*
R1       4    SEEN                    ARNISON   83 UA1  P AP, ECM=540 GEV.  11/83*
R1   B   8    SEEN                    BAGNAIA   83 UA2  P AP, ECM=550 GEV.  11/83*
R1   B  BAGNAIA 83 INTERPRET THEIR EVENTS AS EITHER (Z-->E+ E-) OR          11/83*
R1   B  (Z-->E+ E- GAMMA) .                                                 11/83*

R2      Z INTO (MU+ MU-)/TOTAL                          (P2)
R2       1    SEEN                    ARNISON   83 UA1  P AP, ECM=540 GEV.  11/83*

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REFERENCES FOR Z(95000)


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ARNISON  83 PL 126B 398       UA1 COLLAB.(AACH+LAPP+BIRM+CERN+HELS+LOQM+)
ARNISON2 83 PL 129B 273       UA1 COLLAB.(AACH+LAPP+BIRM+CERN+HELS+LOQM+)
BAGNAIA  83 PL 129B 130       UA2 COLLAB. (BERN+CERN+BOHR+LALO+PAVI+SACL)
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WEAK GAUGE BOSON SEARCHES

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      MEASUREMENTS OF PARAMETERS OF THE W AND Z ARE LISTED IN
      SEPARATE SECTIONS ABOVE.

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M       W BOSON MASS LIMITS (GEV)
M    A  0    1.7   OR MORE  CL=.99   BERNARDIN 65 HYBR +  NEU N, CERN       2/74
M    A  0    2.0   OR MORE  CL=.90   BURNS     65 OSPK +  NEU N, BNL       2/74
M    B  0    3.8   OR MORE  CL=.90   BARISH    73 ASPK +  W+ TO LEP+NEU=.2  2/74
M    B  0    4.5   OR MORE  CL=.90   BARISH    73 ASPK +  W+ TO LEP+NEU=.5  2/74
M    B  0    4.7   OR MORE  CL=.90   BARISH    73 ASPK +  W+ TO LEP+NEU=.8  2/74
M    C  0    5.0   OR MORE  CL=.95   BERGESON  73 ELEC                      1/76
M    D  0 NONE WITH MASS 10-20 GEV   BUSSER    74 WIRE +-0 P-P,52.7 GEV CM  8/76
M    E  0 NONE WITH MASS 5.5-8.5 GEV ABRAMOV   77 CNTR +-                  12/77
M
M    A  LOOKED FOR (NEU N) TO (W+ MU- N), W+ TO (MU+ NEU, E+ NEU, OR HDRNS)  2/74
M
M    B  BARISH 73 LOOKED FOR (NEU N) TO (W+ MU- N), W+ TO (MU+ NEU) AT NAL.  2/74
M    B  RESULT GIVEN FOR THREE ASSUMED BR.FRACS. W+ TO (LEPTON NEU)/ALL.     2/74
M
M    C  BERGESON 73 LOOKED AT ENERGY DISTR OF NEU-INDUCED MUON FLUX UNDER-   1/76
M    C  GROUND. SCALE INVARIANCE OF THE INELASTIC STRUCT FN ASSUMED.         1/76
M
M    D  BUSSER 74 IS CERN ISR EXPT. LOOKED FOR ELECTRONS OF LARGE            8/76
M    D  TRANSVERSE MOMENTUM. RESULT QUOTED ABOVE IS MODEL DEPENDENT.         8/76
M
M    E  ABRAMOV 77 IS 70 GEV P-CU EXPT AT SERP LOOKING AT DIRECT MUONS OF   12/77
M    E  HIGH TRANSVERSE MOM. RESULT IS MODEL DEPENDENT.                     12/77

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MR      RIGHT-HANDED W BOSON MASS LIMITS (GEV)                              11/83*
MR   A                                BERGSMA   83 CHRM +  NUMU E -->MU NUE  1/84*
MR   B      380.    OR MORE  CL=.90   CARR      83 ELEC +  MU+ DECAY        11/83*
MR
MR   A  BERGSMA 83 SET LIMIT M(W2)/M(W1) > 1.9 AT CL=.90.                    1/84*
MR
MR   B  CARR 83 IS TRIUMF EXPERIMENT WITH A HIGHLY POLARIZED MU+ BEAM.      11/83*
MR   B  LOOKED FOR DEVIATION FROM V-A AT THE HIGH MOMENTUM END OF THE DECAY 11/83*
MR   B  E+ ENERGY SPECTRUM. LIMIT FROM PREVIOUS WORLD-AV.MUON POLALIZATION  11/83*
MR   B  PARAMETER IS M(WR)> 240 GEV.                                        11/83*

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C       W BOSON PRODUCTION CROSS SECTION (10**-36 CM**2)
C    A  0    6.0   OR LESS            ANKENBRAN 71 CNTR +- W TO(MU NEU)=1.0  2/74
C
C    A  ANKENBRANDT 71 LOOKED FOR (P N)TO(W HADRONS), W TO (MU NEU) AT BNL.  2/74
C    A  THIS ASSUMES BR OF W TO MU NEU IS 1.  IN GENERAL THIS VALUE IS       2/74
C    A  6.0/BR, WHERE BR=(W TO MU NEU)/(W TO ALL).                           2/74

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Z0A     CHARGE ASYMMETRY IN E+ E- --> MU+ MU-                               1/83*
Z0A  A                                BARTEL    82 JADE WCM=25.-36.8GEV     1/83*
Z0A  B                                FERNANDEZ 83 MAC  WCM=29 GEV         11/83*
Z0A  C                                ALTHOFF   84 TASS WCM=34.4 GEV       11/83*
Z0A
Z0A  A  BARTEL 82 OBTAINED A=-0.118+-.038 AFTER RAD. COR. AND FOR            1/83*
Z0A  A  COS(THETA) WITHIN (+-0.8).  CONSISTENT WITH STANDARD MODEL           1/83*
Z0A  A  PREDICTION A=-0.078).                                                1/83*
Z0A
Z0A  B  FERNANDEZ 83 GOT A=-.076+.018-.003.ST.MODEL(INCL.RC) GIVES A=-.060. 11/83*
Z0A
Z0A  C  ALTHOFF 84 OBTAINED A=-.098+-.023+-.005, SIN(THETA/W)**2=.27+-.07.  11/83*

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Z0M     Z0 BOSON MASS LIMITS IN E+ E- ANNIHILATION (GEV)                     2/82
Z0M  A  0   51.    OR MORE  CL=.95   BARTEL    81 JADE                     2/82
Z0M  B  0   40.    OR MORE  CL=.95   BERGER    81 PLUT                     2/82
Z0M  C      45.0   OR MORE  CL=.95   BRANDELIK 82 TASS                    10/83*
Z0M  D     BETWEEN 43.1-81.8 CL=.95   BRANDEL2  82 TASS                    11/83*
Z0M  E      50.    OR MORE  CL=.95   FERNANDEZ 83 MAC                      11/83*
Z0M
Z0M     ABOVE LIMITS ARE IN STANDARD SU(2)XU(1) MODEL. FOR BOUND-PLOTS IN    2/82
Z0M     EXTENDED MODELS WITH TWO OR MORE Z0'S, SEE INDIVIDUAL PAPERS.        2/82
Z0M
Z0M  A  BARTEL 81 AT DESY-PETRA STUDIED E+E- -->E+E-,MU+MU- UP TO WCM=36GEV 2/82
Z0M  A  IN STANDARD MODEL WITH FREE Z0 MASS AND WITH COUPLINGS FIXED AT LOW  2/82
Z0M  A  Q2 VALUES(SIN(THETA/W)**2=.23).                                      2/82
Z0M
Z0M  B  BERGER 81 AT DESY-PETRA ANALYZED E+E- -->E+E-,MU+MU-,TAU+TAU- DATA   2/82
Z0M  B  AT WCM=27.5-31.6 GEV IN STANDARD MODEL. CL=.95 CONTOUR IN GV**2 AND  2/82
Z0M  B  GA**2 PLANE IS INCONSISTENT W. NU E RESULT IF MZ BELOW ABOVE LIMIT.  2/82
Z0M
Z0M  C  BRANDELIK 82 AT DESY-PETRA FITTED TO TOTAL E+E- CROSS SECTION WITH   1/83*
Z0M  C  WCM=14-36.7 GEV INCLUDING QCD CORRECTION WITH ALPHAS=0.17. ABOVE     1/83*
Z0M  C  LIMIT ASSUMES SIN(THETA/W)**2=.228.                                  1/83*
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For notation, see key at front of Listings.


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ZOM  D  BRANDELIK2 82 STUDIED E+E- -->E+E-,MU+MU- AT WCM=34.4 GEV. LIMIT     11/83*
ZOM  D  ASSUMES LOW-ENERGY NU E SCATTERING RESULT GV**2=.0016,GA**2=.25 .    11/83*
ZOM
ZOM  E  FERNANDEZ 83 ANALYZED E+E- -->MU+MU- AT WCM=29 GEV WITH PEP-MAC.     11/83*
ZOM  E  ABOVE LIMIT IS FROM FIT TO THE ENERGY-DEPENDENCE OF ASYMMETRY DATA   11/83*
ZOM  E  INCLUDING THIS DATA AND ASSUMES GA(E)*GA(MU)=0.25.                   11/83*

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S       SCALAR BOSON MASS LIMITS (GEV)
S    A   0   10.0   OR MORE  CL=.90   CONVERSI  73 ASPK  0 E+E- FRASCATI      3/74
S
S    A  CONVERSI 73 LOOKED FOR QED VIOLATION IN E+E- SCATTERING AT 2.8 GEV   3/74
S    A  AND ASSUMED W BOSON MASS=10 GEV.  FOR MW=15 GEV, MS LIMIT= 6.5 GEV   3/74

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REFERENCES FOR WEAK GAUGE BOSON SEARCHES


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BERNARDI 65 NC 38 608          BERNARDINI,BIENLEIN,BOHM,DARDEL,+     (CERN)
BURNS    65 PRL 15 42          +GOULIANOS,HYMAN,LEDERMAN,LEE +  (COLU+BNL)
ANKENBRA 71 PR D3 2582         ANKENBRANDT,LARSEN,LEIPUNER+     (BNL+YALE)

BARISH   73 PRL 31 180         +BARTLETT,BUCHHOLZ,HUMPHREY+     (CIT+FNAL)
BERGESON 73 PRL 31 66          +CASSIDAY,HENDRICKS                  (UTAH)
CONVERSI 73 PL 46B 269         +D'ANGELO,GATTO,PAOLUZI              (ROMA)
BUSSER   74 PL 48B 371         +CAMILLERI,DI LELLA +      (CERN+COLU+ROCK)
ABRAMOV  77 SJNP 25 41         +ANISIMOVA,BONDARENKO,GRIDASOV +     (SERP)

BARTEL   81 PL 99B 281         JADE C.  (DESY+HAMB+HEID+LANC+MCHS+RL+TOKY)
BERGER   81 ZPHY C7 289        PLUTO C.(AACH+BERG+DESY+HAMB+UMD+SIEG+WUPP)
BARTEL   82 PL 108B 140        JADE C.  (DESY+HAMB+HEID+LANC+MCHS+RL+TOKY)
BRANDELI 82 PL 113B 499        TASSO C.  (AACH+BONN+DESY+HAMB+LOIC+OXF+RL)
BRANDEL2 82 PL 117B 365        BRANDELIK+ TASSO C.  (AACH+BONN+DESY+HAMB+)

BERGSMA  83 PL 122B 465        CHARM C.          (ANIK+CERN+HAMB+ITEP+ROMA)
CARR     83 PRL 51 627         +GIDAL,GOBBI,JODIDIO,ORAM+  (LBL+NWES+TRIU)
FERNANDE 83 PRL 50 1238        + (COLO+FRAS+HOUS+NEAS+STAN+SLAC+UTAH+WISC)
ALTHOFF  84 ZPHY (TO BE PUBL.)TASSO C. (AACH+BONN+DESY+HAMB+LOIC+OXF+RL+)
    ALSO 82 BRANDELIK2
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NOTE ON NEUTRINOS

(by R.E. Shrock, State Univ. of New York, Stony Brook)

With the 1982 edition of this Review, the section on neutrino properties was expanded and reorganized. As before, there are listings which deal specifically with ν_e, ν_μ, and ν_τ. In addition, in the category of searches near the end of the Stable Particle Listings, we include sections which deal with correlated bounds on neutrino masses and lepton mixing but which do not pertain to any one weak eigenstate individually. Furthermore, we include constraints from cosmological and astrophysical data. (Since this Review is a compendium of data traditionally derived more or less directly from particle and nuclear physics, we have been somewhat less comprehensive in our coverage of astrophysical data.)

In contrast to the other particles in this Review, the neutrinos ν_e, ν_μ, and ν_τ are defined as weak eigenstates (that is, states which couple weakly with unit strength to e, ν, and τ) and are not, in general, states of definite mass. In the conventional case, where all neutrinos were assumed to be massless and hence degenerate, it was possible to define the weak eigenstates to be simultaneously mass eigenstates. However, in the general case of massive (nondegenerate) neutrinos, the weak eigenstates have no well-defined masses, but instead are linear combinations of mass eigenstates. Let us denote the charged leptons as the set $\{\ell_a\}$, a = 1, $\cdots$,n, where n $\geq$ 3 is the number of generations, with $\ell_1 \equiv$ e, $\ell_2 \equiv \mu$, $\ell_3 \equiv \tau$. In the standard $SU(2)_L \times U(1)$ electroweak theory[1] the mixing of the left-handed components of the mass eigenstates $(\nu_j)_L$ to form the weak gauge-group eigenstates $(\nu_{\ell_a})_L$ is specified by the transformation

$$(\nu_{\ell_a})_L = \sum_{j=1}^{n} U_{aj}(\nu_j)_L ,$$

where $U^\dagger = U^{-1}$. (In the case of Dirac neutrinos there are right-handed components of the ν_j, but they are singlets under the gauge group; in the case of Majorana neutrinos in the standard theory there are no right-handed components.) The ordering of the mass eigenbasis is defined such that U is as nearly diagonal as possible, i.e., $|U_{jj}|$ (no sum on j) $\geq |U_{jk}|$, $k \neq j$. This does not imply that $m(\nu_j) > m(\nu_k)$ if $j > k$, although this ordering might be regarded as natural in view of the similar one that obtains in the quark sector. The virtue of this convention is that a mass limit on "$m(\nu_{\ell_a})$" can be used as a definite limit on ν_j, j = a, the dominantly coupled mass eigenstate in ν_{ℓ_a}.

Thus, in this general case of n massive (Dirac or Majorana) neutrinos, decays such as $H^3 \to He^3 + e^- + \bar{\nu}_e$ and $\pi^+ \to \mu^+ + \nu_\mu$, which have been used to set the best bounds on the respective neutrino masses, really consist of incoherent sums of the separate decay modes $H^3 \to He^3 + e^- + \bar{\nu}_j$ and $\pi^+ \to \mu^+ + \nu_k$, where the ν_j, ν_k are mass eigenstates, and the indices j and k range over the subset $\{1, \cdots, n\}$ allowed by phase space in these two respective decays.[2] The coupling strengths for the jth modes are given for the two decays by the factors $|U_{1j}|^2$ and $|U_{2j}|^2$, respectively. There are, in addition, certain kinematic factors depending on the $m(\nu_j)$ which enter in determining the branching ratio for the jth decay mode. Assuming that the off-diagonal elements of the lepton mixing matrix U are small relative to the diagonal elements, the dominantly coupled decays are the ones with coupling strength $|U_{aj}|^2$, a = j, i.e., $H^3 \to He^3 + e^- + \bar{\nu}_1$ and $\pi^+ \to \mu^+ + \nu_2$.

It follows that the old neutrino mass limits quoted in the literature for "$m(\nu_e)$", "$m(\nu_\mu)$" and "$m(\nu_\tau)$" are meaningful only insofar as they are reinterpreted as limits on the corresponding mass eigenstates. Specifically, a bound such as the Bergkvist limit,[3] "$m(\nu_e)$" < 60 eV (90% CL), really constitutes a weighted limit on each of the mass eigenstates ν_j in the weak eigenstate ν_e which are kinematically allowed to occur in tritium decay and which are coupled with strength $|U_{1j}|^2$ sufficiently

Stable Particles

Neutrinos

Data Card Listings

large to make a significant contribution to the observed spectrum. It is thus certainly a limit on ν_1. If leptonic mixing is hierarchical as quark mixing is known to be (at least for the first three generations), i.e., $|U_{jj}|^2 >> |U_{jk}|^2$, $j \neq k$, then ν_1 is the only mass eigenstate significantly constrained by a bound on "$m(\nu_e)$." Furthermore, a neutrino mass limit cannot be stated in isolation; it always contains some implicit dependence on the relevant lepton mixing angles. Fortunately, this dependence is relatively unimportant for the dominantly coupled decay modes, i.e., $e\bar{\nu}_1$, $\mu\bar{\nu}_2$, and $\tau\bar{\nu}_3$. Since these modes were the ones responsible for the mass limits given previously, the latter can be reinterpreted without significant complication as proper limits on $m(\nu_j)$, j = 1, 2, and 3, respectively.

In addition to mass and lifetime limits, we have added data on neutrino magnetic dipole moments. These are of interest because a massless, purely chiral (empirically, left-handed) Dirac neutrino cannot have a magnetic (or electric) dipole moment. The same is true for a Majorana neutrino, whether massless or massive, because of its defining property of being self-conjugate.

If one considers the possibility of nonzero masses for neutrinos, for consistency one must also consider the leptonic mixing which would in general occur concomitantly. Accordingly we have devoted one category in the searches section to correlated bounds on neutrino masses and lepton mixing angles. These can be divided into two types. First, there are those due to decays involving neutrinos in the final state, which must be recognized to have the general multimode structure pointed out above. In the two most sensitive cases suggested as tests for neutrino masses and mixing,[2] one obtains a limit on $m(\nu_j)$ and $|U_{aj}|^2$ individually for each j. Second, there are those due to processes involving the propagation and subsequent interaction of neutrinos. The latter are often called neutrino "oscillation"[3] limits, although this term is correct only if the differences in neutrino masses are sufficiently small relative to their momenta that the propagation is effectively coherent in a quantum mechanical sense; otherwise, the individual ν_j from a given decay such as $\pi_{\mu 2}$ or $k_{\mu 2}$ propagate in a measurably incoherent manner and there is no "oscillation." Experimentalists usually present their results in terms of a simplifying model in which mixing is assumed to occur only between two neutrino species. Then the transformation equation becomes

$$\begin{pmatrix} \nu_{\ell_a} \\ \nu_{\ell_b} \end{pmatrix} = \begin{pmatrix} \cos\theta & \sin\theta \\ -\sin\theta & \cos\theta \end{pmatrix} \begin{pmatrix} \nu_i \\ \nu_j \end{pmatrix} .$$

Let the distance between the source of the neutrinos and their point of interaction be labeled as x, and their energy as E. Assume furthermore that the $m(\nu_j)$ are such that the coherence assumption is valid. Then, the probability of an initial ν_{ℓ_a} being equal to ν_{ℓ_b} at time t, or equivalently (given the above assumption) at distance x = t, is

$$|\langle \nu_{\ell_b}(0) | \nu_{\ell_a}(t) \rangle|^2 = \sin^2 2\theta \sin^2 \left(\frac{\Delta m^2 x}{4E} \right) ,$$

where

$$\Delta m^2 = m(\nu_i)^2 - m(\nu_j)^2 .$$

Thus, neutrino oscillation experiments cannot measure individual neutrino masses, but only differences of masses squared, and indeed these are generally weighted in a more complicated way by mixing-matrix coefficients than in the two-species model. Experimental results are presented as allowed regions on a plot, the axes of which are $|\Delta m^2|$ and $\sin^2 2\theta$. These are often summarized in terms of the asymptotic limits $|\Delta m^2|_{max}$ for $\sin^2 2\theta = 1$, and $\sin^2 2\theta$ for "large" $|\Delta m^2|$, i.e., sufficiently large $|\Delta m^2|$ that the detector averages over many cycles of oscillation (or there ceases to be any coherence). We refer the reader to the original papers for the two-dimensional plots; for the purpose of these Listings, we shall give only the asymptotic limits.

An important question has to do with whether neutrinos are Dirac or Majorana (self-conjugate) particles. In the former case neutrinoless double beta decay, (Z,A) $\rightarrow$ (Z+2,A) + e^- + e^-, is forbidden from occurring.[4] In the Majorana case it may occur if (a) neutrinos are massive and/or (b) there are right-handed leptonic currents. In the light-neutrino case an upper limit on neutrinoless double beta decay yields a correlated upper bound on the quantity

$$\bar{m} \equiv \left| \sum_{j=1}^{n} U_{1j}^2 \, m(\nu_j) \right|$$

and η, the fractional admixture of right-handed leptonic current.

The correlated limits given in the section on Massive Neutrinos and Lepton Mixing are in digital form. For

For notation, see key at front of Listings.

Stable Particles

Neutrinos, ν_e

recent compendia of limits in convenient graphical form, see Refs. 5 and 6, and Figs. 1 and 2 (pp. 332-333) of Ref. 7.

Further explanatory notes are included in the Listings.

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ν_e

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                    1  NU-E(J=1/2)

      NOT IN GENERAL A MASS EIGENSTATE

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                    1  NU-E ''MASS'' (EV)

      APPLIES TO NU-1, THE PRIMARY MASS EIGENSTATE IN NU-E.  WOULD ALSO
      APPLY TO ANY OTHER NU-J WHICH MIXES STRONGLY IN NU-E AND HAS
      SUFFICIENTLY SMALL MASS THAT IT CAN OCCUR IN THE RESPECTIVE DECAYS.
      THE NEUTRINO MASS MAY BE OF DIRAC OR MAJORANA TYPE; THE FORMER
      CONSERVES TOTAL LEPTON NUMBER WHILE THE LATTER VIOLATES IT.
      IN GENERAL, EITHER WOULD VIOLATE LEPTON FAMILY NUMBER, SINCE
      NOTHING FORCES THE NEUTRINO MASS EIGENSTATES TO COINCIDE WITH THE
      NEUTRINO INTERACTION EIGENSTATES.  FOR LIMITS ON MAJORANA NU-E
      MASS, SEE THE SECTION ON MASSIVE NEUTRINOS AND LEPTON MIXING,
      PART 5(C), ENTITLED SEARCHES FOR NEUTRINOLESS DOUBLE BETA DECAY.

      NOTE -- THE ABBREVIATION ANU IS USED BELOW FOR ANTINU

M          (250.)   OR LESS            LANGER    52 CNTR    ANU-E, TRITIUM
M          (500.)   OR LESS            HAMILTON  53 CNTR    ANU-E, TRITIUM   11/73
M          (550.)   (280.)             FRIEDMAN  58 CNTR    ANU-E, TRITIUM
M         (4100.)   OR LESS  CL=.67    BECK      68 CNTR    NU, SODIUM 22    11/73
M  D       (500.)   OR LESS  CL=.90    DARIS     69 CNTR    ANU-E, TRITIUM   11/73
M          (320.)   OR LESS  CL=.90    SALGO     69 CNTR    ANU-E, TRITIUM   11/73
M           (60.)   OR LESS  CL=.90    BERGKVIS  72 CNTR    ANU-E, TRITIUM   11/73
M           (86.)   OR LESS  CL=.90    RODE      72 CNTR    ANU-E, TRITIUM   11/73
M          (100.)   OR LESS            PIEL      73 CNTR    ANU-E, TRITIUM    1/81
M            (4.5E5)OR LESS  CL=.90    CLARK     74 ASPK    KE3 DECAY        11/75
M    L      (35.)   OR LESS  CL=.90    TRETYAKOV 76 SPEC    ANU-E, TRITIUM    4/82
M    L      (14.)  TO 46.   CL=.99     LUBIMOV   80 SPEC    ANU-E, TRITIUM    9/81
M           (65.)   OR LESS  CL=.95    SIMPSON   81 CNTR    ANU-E, TRITIUM    1/82
M         (1300.)   OR LESS            ANDERSEN  82 CNTR    NU, HOLMIUM 163  11/82*
M          (500.)   OR LESS  CL=.90    JONSON    83 CNTR    NU, PLATINUM 193  2/84*
M   P       (20.)   OR MORE  CL=.95    LUBIMOV   83 CNTR    ANU-E, TRITIUM    3/84*
M   Y     (1250.)   OR LESS            YASUMI    83 CNTR    NU, HOLMIUM 163  11/83*
M  D    DARIS 69 VALUE 75EV(CL=.67) DISAGREES WITH THEIR FIG.6. WE USE       11/73
M  D    FIG.6.                                                               11/73
M    L  TRETYAKOV 76 DATA INCLUDED, AT LEAST IN PART, IN LUBIMOV 80.          4/82
M    L  NOTE THAT LUBIMOV 83 REMARKS THAT THE 14 EV LOWER LIMIT GOES TO       3/84*
M    L  ZERO IF THE INTRINSIC RESOLUTION OF THE CONVERSION LINES USED FOR     3/84*
M    L  CALIBRATION ARE TAKEN INTO ACCOUNT.  A DETAILED DISCUSSION IS GIVEN   3/84*
M    L  BY SIMPSON 84.  SEE ALSO THE DISCUSSION OF THE LUBIMOV 80 RESULT      3/84*
M    L  BY BERGKVIST 80.  WE CONTINUE TO USE UPPER LIMIT FROM LUBIMOV 80      3/84*
M    L  IN THE STABLE PARTICLE TABLE.                                         3/84*
M   Y   LIMIT OBTAINED BY YASUMI 83 ASSUMES UPPER LIMIT ON Q-VALUE           11/83*
M   Y   REPORTED BY ANDERSEN 82.                                             11/83*
M   P  PRELIMINARY RESULT FROM BRIGHTON CONF.                                 3/84*

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                    1  (NU-1) - (ANU-1) MASS DIFF. (EV)

      TEST OF CPT FOR A DIRAC NEUTRINO

DM         (4100.)   OR LESS  CL=.67   BECK      68 CNTR    NU, SODIUM 22    11/73
DM           (4.5E5)OR LESS  CL=.90    CLARK     74 ASPK    KE3 DECAY        11/75
DM         (1300.)   OR LESS           ANDERSEN  82 CNTR    NU, HOLMIUM 163  11/82*
DM   Y      1250.    OR LESS           YASUMI    83 CNTR    NU, HOLMIUM 163  11/83*
DM   Y   ASSUMES UPPER LIMIT ON Q-VALUE REPORTED BY ANDERSEN 82.             11/83*

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                    1  NU-1 MEAN LIFE/MASS  (UNITS SEC/EV)

T    R       3. E 2  OR MORE           REINES    74 CNTR    ANTI-NEUTRINO     3/78
T    R  REINES 74 LOOKED FOR NU-E OF NON-ZERO MASS DECAYING TO A NEUTRAL      3/78
T    R  OF LESSER MASS + GAMMA.  USED LIQUID SCINT. DETECTOR NEAR FISSION     3/78
T    R  REACTOR.  FINDS LAB LIFETIME 6.E7 SEC OR MORE.  ABOVE VALUE OF        3/78
T    R  MEAN LIFE/MASS ASSUMES AVG. EFFECTIVE NEUTRINO ENERGY OF 0.2MEV.      3/78
T    R  TO OBTAIN THE LIMIT 6.E7 SEC REINES 74 ASSUMED THAT THE FULL          2/84*
T    R  ANTI-NUE REACTOR FLUX COULD BE RESPONSIBLE FOR YIELDING DECAYS        2/84*
T    R  WITH PHOTON ENERGIES IN THE INTERVAL 0.1 MEV TO 0.5 MEV.  THIS        2/84*
T    R  REPRESENTS SOME OVERESTIMATE SO THEIR LOWER LIMIT IS AN OVER-         2/84*
T    R  ESTIMATE OF THE LAB LIFETIME (P. VOGEL, PRIV. COMM., 1984).           2/84*

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                    1  NU-1 MAGNETIC MOMENT  (UNITS EV/GAUSS)

      MUST VANISH FOR MAJORANA NEUTRINO OR PURELY CHIRAL MASSLESS
      DIRAC NEUTRINO

MM  B      (1.1E-17)OR LESS           BERNSTEIN 63                           1/82
MM  B   BERNSTEIN 63 IS A THEORETICAL ANALYSIS OF REACTOR ANTINU-E            1/82
MM  B   SCATTERING DATA.                                                      1/82
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                          REFERENCES FOR NU-E

LANGER    52 PR  88  689      L M LANGER,R J D MOFFAT            (INDIANA)
HAMILTON 53 PR  92  1521      D HAMILTON,W P ALFORD,L GROSS   (PRINCETON)
FRIEDMAN 58 PR 109  2214      LEWIS FRIEDMAN,LINCOLN G SMITH        (BNL)
BERNSTEI 63 PR 132 1227       BERNSTEIN,RUDERMAN,FEINBERG       (NYU+COLU)
BECK      68 ZPHY 216 229     E BECK,H DANIEL                       (MPIH)
DARIS     69 NP A138 545      R DARIS,C ST-PIERRE            (LAVAL-QUEBEC)
SALGO     69 NP A138 417      R C SALGO,H H STAUB                 (ZURICH)

BERGKVIS 72 NP B39 317        KARL-ERIK BERGKVIST          (UNIV STOCKHOLM)
RODE      72 LNC 5 139        B RODE,H DANIEL                (MUNICH+MPIH)
PIEL      73 NP A203 369      WILLIAM F. PIEL, JR.                   (IND)
CLARK     74 PR D9 533        +ELIOFF,FRISCH,JOHNSON,KERTH,SHEN+     (LBL)
REINES    74 PRL 32 180       +SOBEL,GURR                            (UCI)
    ALSO 78  PRIVATE COMM.    V. BARNES                             (PURD)

TRETYAKO 76 BASUP 40 10-1     TRETYAKOV+ (BULL.ACAD.SCI.USSR,PHY.) (ITEP)
    ALSO 76 NU CONF. AACHEN   TRETYAKOV,MYASOEDOV,APALIKOV,KONYAEV+(ITEP)
BERGKVIS 80 NEUTRINO 80,ERICE K.E.BERGKVIST                         (STOH)
LUBIMOV   80 PL 94B 266       +NOVIKOV,NOZIK,TRETYAKOV,KOSIK        (ITEP)
    ALSO 80 SJNP 32 154       (YF 32 301) KOZIK,LUBIMOV,NOVIKOV,+   (ITEP)
    ALSO 81 JETP 54 616       (ZETF 81 1158) LUBIMOV,NOVIKOV,NOZIK+(ITEP)
SIMPSON   81 PR D23 649       J.J.SIMPSON                           (GUEL)

ANDERSEN 82 PL 113B 72        +BEYER,CHARPAK,DERUJULA +  (AARH+CERN+RISO)
JONSON    83 NP A396 479C     +ANDERSEN,BEYER+       (CERN+AARH+BOHR+LUND)
LUBIMOV   83 BRIGHTON CONF.   PROC. OF HEP 83, P. 386               (ITEP)
YASUMI    83 PL 122B 461      +RAJASEKARAN,ANDO+ (KEK+OSAK+TIT+TOHO+TSUK)
SIMPSON   84 PREPRNT SUB.TO PL  J.J. SIMPSON                        (GUEL)

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Stable Particles

Data Card Listings

e, ν_μ

e

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                    3  ELECTRON(0.5,J=1/2)
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                    3  ELECTRON MASS (MEV)

M          (0.511006 0.00002)          COHEN     65 RVUE
M          (0.5110041 .0000016)        TAYLOR    69 RVUE    USING NEW E/H      7/70
M           0.5110034 .0000014         COHEN     73 RVUE                       3/74
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                    3  ELECTRON MEAN LIFE / BRANCHING FRACTION (UNITS YRS)

                    TEST OF CHARGE CONSERVATION

T   MS      (2. E21) OR MORE            MOE       65 CNTR    SEE NOTE S BELOW  6/66
T          (4. E22) OR MORE             MOE       65 CNTR    E- --> NEU GAMMA  6/66
T    S     (5.3E21) OR MORE             STEINBERG 75 CNTR    SEE NOTE S BELOW  2/76
T    S      2. E22  OR MORE  CL=.68     KOVALCHUK 79 CNTR    SEE NOTE S BELOW  1/81
T          (3.5E23) OR MORE  CL=.68     KOVALCHUK 79 CNTR    E- --> NEU GAMMA  1/81
T          (3. E23) OR MORE  CL=.68     BELLOTTI  83 CNTR    E- --> NEU GAMMA 11/83*
T    B      2. E22  OR MORE  CL=.68     BELLOTTI  83 CNTR    SEE NOTE B BELOW 11/83*
T   M   SEE MOE 65 FOR DISCUSSION OF EARLIER EXPERIMENTS.                       1/81
T   M   MOE 65 LIMIT REESTIMATED BY STEINBERG 75 TO BE (1. E20).                1/81
T    S  THESE LIMITS ARE FOR ALL MODES IN WHICH DECAY PARTICLES ESCAPE           1/81
T    S  FROM THE DETECTOR WITHOUT DEPOSITING ENERGY.                             1/81
T    B  SECOND LIMIT OF BELLOTTI 83 IS FOR DISAPPEARANCE OF K-ELECTRONS IN      11/83*
T    B  GE-ATOMS. THIS WOULD PRODUCE A PEAK IN THE GE(LI) COUNTER SPECTRUM.     11/83*
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                    3  ELECTRON MAGNETIC MOMENT(E/2ME)

MM     ELECTRON OR POSITRON G/2-VALUE
MM      THIS IS MAGNETIC MOMENT IN UNITS (E/2ME-) FOR E-, (E/2ME+) FOR E+.
MM      FOR REVIEWS OF THEORY AND EXPERIMENTS, SEE KINOSHIA 78, LAUTRUP 72,
MM      AND RICH 72.
MM      FOR MOST ACCURATE THEORETICAL CALCULATION, SEE KINOSHITA 81.
MM        (1.0011609)   +-(24)E-7     SCHUPP    61 CNTR  -
MM        (1.001159622) +-(27)E-9     WILKINSON 63 CNTR  -                     8/66
MM        (1.001168)    +-(22)E-6     RICH      66 CNTR +  POSITRON            8/66
MM R      (1.001159557) +-(30)E-9     RICH      68 CNTR -                      6/68
MM        (1.0011596389)+-(31)E-10    TAYLOR    69 RVUE                        2/71
MM        (1.001159644) +-(7)E-9      WESLEY    70 CNTR                        6/70
MM        (1.0011596577)+-(35)E-10    WESLEY    71 CNTR -                      2/72
MM        (1.0011603)   +-(12)E-7     GILLELAND 72 CNTR +                      2/72
MM        (1.0011596567)+-(35)E-10    COHEN     73 RVUE                        3/74
MM        (1.001159667) +-(24)E-9     WALLS     73 CNTR -  BOLOMETRIC TECHN   11/77
MM        (1.00115965241)+-(20)E-11   VANDYCK   77 CNTR -  RPL.BY VANDYCK79   12/77
MM V       1.001159652200+-(40)E-12   VANDYCK   79 CNTR -  PENNING TRAP        1/82
MM         1.001159652222+-(50)E-12   SCHWINBER 81 CNTR +  PENNING TRAP        1/82
MM R    RICH 68 IS REEVALUATION OF WILKINSON 63.
MM V    VANDYCK 79 CONFIRMED FINAL BY H. DEHMELT, PRIV. COMM.                   1/82
MM
MM  AVG    1.001159652209+-(31)E-12 AVERAGE (ERROR INCL. SCALE FACTOR 1.0)      1/82
MM     AVERAGE ASSUMING EQUAL G/2-VALUES FOR E+ AND E- BY CPT.

MMR    POSITRON TO ELECTRON G-FACTOR RATIO MINUS ONE, (G+/G-)-1
MMR    TEST OF CPT
MMR       (1.6E-8) OR LESS  CL=.95    SEREDNYAK 77 CNTR ME+=ME- ASSUMED        4/82
MMR        2.2E-11  6.4E-11           SCHWINBER 81 ELEC    PENNING TRAP        4/82
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                    3  ELECTRON ELECTRIC DIPOLE MOMENT(UNITS 10**-23 E-CM)

                    FORBIDDEN BY BOTH T INVARIANCE AND P INVARIANCE

EDM          0.3    OR LESS  CL=.90    WEISSKOPF 68 MRS     CESIUM            12/79
EDM         (0.07)   (0.22) CL=.90     PLAYER    70 MRS     XENON              4/82
EDM         (0.19)   (0.34) CL=.90     SANDARS   75 MRS     THALLIUM           4/82
EDM         (8.1)    (11.6)            VASILEV   78                           12/79
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                    REFERENCES FOR ELECTRON

SCHUPP    61 PR  121   1        A A SCHUPP,R W PIDD,H R CRANE          (MICH)
WILKINSO 63 PR 130 852          D T WILKINSON,H R CRANE                (MICH)
COHEN     65 RMP 37 537         COHEN,DUMOND  (N.A.AVIATION SCI.CENTER+CIT)
MOE       65 PR 140 B 992       M K MOE,F REINES      (CASE INST TECHNOLOGY)

RICH      66 PRL  17  271       A RICH, H R CRANE                      (MICH)
RICH      68 PRL 20 967         A RICH                                 (MICH)
WEISSKOP 68 PRL 21 1645         WEISSKOPF,CARRICO,GOULD,LIPWORTH+      (BRAN)
TAYLOR    69 RMP 41 375         +PARKER,LANGENBERG          (PRIN+UCI+PENN)

PLAYER    70 JP B3 1620         M.A.PLAYER,P.G.H.SANDARS                (OXF)
WESLEY    70 PRL 24 1320        J C WESLEY,A.RICH                      (MICH)
WESLEY    71 PR A4 1341         J C WESLEY,A RICH                      (MICH)
GILLELAN 72 PR A5 38            J GILLELAND,A RICH                     (MICH)
LAUTRUP   72 PRPL 3 193         B.LAUTRUP,A.PETERMAN,E.DE RAFAEL(CERN+BURE)
RICH      72 RMP 44 250         A RICH,J C WESLEY                      (MICH)
COHEN     73 J.PHYS.CHEM.REF.DATA 2, P.663, E.R.COHEN,B.N.TAYLOR
WALLS     73 PRL 31 975         F.L.WALLS,T.S.STEIN                    (WASH)
SANDARS   75 PR A11 473         P.G.H.SANDARS,R.M.STERNHEIMER      (OXF+BNL)
STEINBER 75 PR D12 2582         R.I.STEINBERG,KWIATKOWSKI,MAENHAUT+    (UMD)
SEREDNYA 77 PL 66B 102          SEREDNYAKOV,SIDOROV,SKRINSKY+          (NOVO)
VANDYCK   77 PRL 38 310         +SCHWINBERG,DEHMELT                    (WASH)
KINOSHIT 78  TOKYO HEP P.571    T. KINOSHITA                           (CORN)

VASILEV   78 JETP 47 243        +KOLYCHEVA                             (JINR)
KOVALCHU 79 JETPL 29 145        KOVALCHUK,POMANSKY,SMOLNIKOV           (INRM)
VANDYCK   79 BULL. APS 24 758   +SCHWINBERG,DEHMELT                    (WASH)
    ALSO 81 AT.PHYS. 7, P.337   H.DEHMELT(EDS.KLEPPNER+,PLENUM,NY,81)(WASH)
KINOSHIT 81 PRL 47 1573         T.KINOSHITA, W.B.LINDQUIST             (CORN)
SCHWINBE 81 PRL 47 1679         SCHWINBERG,VAN DYCK,DEHMELT            (WASH)
BELLOTTI 83 PL 124B 435         +CORTI,FIORINI,LIGUORI,PULLIA+         (MILA)
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ν_μ

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                    2  NU-MU(J=1/2)
      NOT IN GENERAL A MASS EIGENSTATE.  SEE NOTE ON NEUTRINOS
      IN THE ELECTRON NEUTRINO SECTION ABOVE.
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                    2  NU-MU ''MASS'' (MEV)

      APPLIES TO NU-2, THE PRIMARY MASS EIGENSTATE IN NU-MU.  WOULD ALSO
      APPLY TO ANY OTHER NU-J WHICH MIXES STRONGLY IN NU-MU AND HAS
      SUFFICIENTLY SMALL MASS THAT IT CAN OCCUR IN THE RESPECTIVE DECAYS.
      (THIS WOULD BE NONTRIVIAL ONLY FOR J .GE. 3, GIVEN THE NU-E ''MASS''
      LIMIT ABOVE.)

M           (3.5)  OR LESS            BARKAS    56 EMUL
M           (4.0)  OR LESS            DUDZIAK   59 CNTR
M           (3.6)  OR LESS            FEINBERG  63 RVUE                       7/66
M           (3.0)  OR LESS            ALLCOCK   65 RVUE                       7/66
M           (2.5)  OR LESS            BARDON    65 ASPK
M           (2.8)  OR LESS  CL=.90    SHAFER    65 CNTR                       5/71
M           (1.6)  OR LESS  CL=.90    BOOTH     67 CNTR                       3/68
M           (2.2)  OR LESS  CL=.90    HYMAN     67 HEBC    0. K- HE          11/67
M  B M      (1.2)  OR LESS  CL=.90    BACKENSTO 71 CNTR    M**2=-1.28+-1.24  10/71
M  S        (1.15) OR LESS  CL=.90    SHRUM     71 CNTR    M**2=-1.55+-1.14  12/71
M  B M      (1.15) OR LESS  CL=.90    BACKENSTO 73 CNTR    M**2=-0.29+-0.90   1/73
M           (0.65) OR LESS  CL=.90    CLARK     74 ASPK    KMU3 DECAY         7/74
M           (0.57) OR LESS  CL=.90    DAUM      79 SPEC    M**2= 0.13+-0.14  10/81
M    L      (0.52) OR LESS  CL=.90    LU        80 CNTR    M**2=0.102+-.119   1/81
M            0.50  OR LESS  CL=.90    ANDERHUB  82 SPEC    M**2=-0.14+-0.20  11/82*
M    M  WE CALCULATE UPPER LIMIT AT CL=.90 FROM M**2.                          1/76
M  B    BACKENSTOSS 73 REPLACES BACKENSTOSS 71 AND USES THEIR NEW PI- MASS.    1/73
M  S    SHRUM 71 USES SHAFER 67 PI- MASS VALUE AND CRANE 71 MU MASS VALUE.     1/73
M    L  LU 80 COMBINES DAUM 79 PI+ --> MU+ NUMU MEASUREMENT WITH NEW LU 80     1/82
M    L  PI- MASS AND REPLACES DAUM 79.                                         1/82
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                    2  (NU-2) - (ANU-2) MASS DIFF. (MEV)

      TEST OF CPT FOR A DIRAC NEUTRINO

DM          (0.45) OR LESS  CL=.90    CLARK     74 ASPK KMU3 DECAY            11/75
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                    2  NU-2 MEAN LIFE/MASS  (UNITS SEC/EV)

T    B   0 (3. E-3) OR MORE  CL=.90   BELLOTTI  76 HLBC NU, CERN GGM           1/78
T    B   1 (1.3E-2) OR MORE  CL=.90   BELLOTTI  76 HLBC ANTINU, CERN GGM       1/78
T    B   0 (2.2E-3) OR MORE  CL=.90   BARNES    77 DBC  NU, ANL 12FT.          1/78
T    B   0 (1.0E-2) OR MORE  CL=.90   BLIETSCHA 78 HLBC NU-MU CERN GGM         1/82
T    B   0 (1.7E-2) OR MORE  CL=.90   BLIETSCHA 78 HLBC ANU-MU CERN GGM        1/82
T    B   0    0.11  OR MORE  CL=.90   FRANK     81 CNTR NU, ANU LAMPF          1/82
T    B  THESE EXPERIMENTS LOOK FOR NU(MU) --> NU(E)+GAMMA OR ANU(MU) -->       1/78
T    B  ANU(E)+GAMMA.                                                          1/78
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                    2  C - (NU-2 VELOCITY) -- ABS((V-C)/C) (UNITS 10**-4)
                         EXPECTED TO BE ZERO FOR MASSLESS NEUTRINO

V       77   (2.0)  OR LESS  CL=.99   ALSPECTOR 76 SPEC >50GEV NU              1/78
V       26   (4.0)  OR LESS  CL=.99   ALSPECTOR 76 SPEC <50GEV NU              1/78
V     9800   (0.4)  OR LESS  CL=.95   KALBFLEIS 79 SPEC                       12/79
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                    2  NU-2 MAGNETIC MOMENT  (UNITS EV/GAUSS)

      MUST VANISH FOR MAJORANA NEUTRINO OR PURELY CHIRAL MASSLESS
      DIRAC NEUTRINO

MM  K    (4.7 E-17)OR LESS            KIM       74                             1/82
MM  K   KIM 74 IS A THEORETICAL ANALYSIS OF ANTINU-MU REACTION DATA.            1/82
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                    REFERENCES FOR NU-MU

BARKAS    56 PR 101  778        W H BARKAS,W BIRNBAUM,F M SMITH        (LRL)
DUDZIAK   59 PR 114  336        W F DUDZIAK,R SAGANE,J VEDDER          (LRL)
FEINBERG 63 ARNS 13 431         G FEINBERG, L M LEDERMAN          (COLUMBIA)
ALLCOCK   65 PPSL  85  875      G R ALLCOCK                      (LIVERPOOL)
BARDON    65 PRL  14 449        BARDON,NORTON,PEOPLES +  (COLU+STONY BROOK)

SHAFER    65 PRL  14 923        R E SHAFER,CROWE,JENKINS               (LRL)
BOOTH     67 PL 26B  39         BOOTH,JOHNSON,WILLIAMS,WORMALD  (LIVERPOOL)
HYMAN     67 PL 25B 376         +LOKEN,PEWITT,MCKENZIE+     (ANL+CARN+NWES)
BACKENST 71 PL 36B 403          BACKENSTOSS,DANIEL,KOCH+   (CERN,KARL,HEID)
SHRUM     71 PL 37B 114         E V SHRUM,K O H ZIOCK    (UNIV OF VIRGINIA)
BACKENST 73 PL 43B 539          BACKENSTOSS,DANIEL,KOCH+ (CERN+KARL+MUNICH)

CLARK     74 PR D9 533          +ELIOFF,FRISCH,JOHNSON,KERTH,SHEN +   (LBL)
KIM       74 PR D9 3050         J.E.KIM,V.S.MATHER,S.OKUBO            (ROCH)
ALSPECTO 76 PRL 36 837          ALSPECTOR +          (BNL+PURD+CIT+FNAL+ROCK)
BELLOTTI 76 LNC 17 553          +CAVALLI,FIORINI,ROLLIER              (MILA)
BARNES    77 PRL 38 1049        +CARMONY,DAUWE,FERNANDEZ +       (PURD+ANL)
BLIETSCH 78 NP B133 205         BLIETSCHAU+(AACH+LIBH+CERN+EPOL+MILA+ORSA+)

KALBFLEI 79 PRL 43 1361         KALBFLEISCH,BAGGETT,FOWLER+(FNAL+PURD+BELL)
DAUM      79 PR D20 2692        +EATON,FROSCH,HIRSCHMANN,MCCULLOCH+   (SIN)
    ALSO 76 PL 60B 380          DAUM,DUBAL,EATON,FROSCH,MCCULLOCH+(SIN+ETH)
    ALSO 78 PL 74B 126          DAUM,EATON,FROSCH,HIRSCHMANN,+        (SIN)
LU        80 PRL 45 1066        +DELKER,DUGAN,WU,CAFFREY+   (YALE+COLU+JHU)
FRANK     81 PRD 24 2001        +BURMAN+ (LASL+YALE+MIT+SACL+SIN+CNRC+BERN)
ANDERHUB 82 PL 114B 76          +BOECKLIN,HOFER,KOTTMANN+          (ETH+SIN)
****** ********* ********* ********* ********* ********* ********* ********
****** ********* ********* ********* ********* ********* ********* ********
```

For notation, see key at front of Listings.

Stable Particles

μ

μ

4 MUON(106,J=1/2)

4 MUON MASS (MEV)

```
M          (105.659)  (0.002)           FEINBERG  63 RVUE
M          (105.6599) (0.0014)          TAYLOR    69 RVUE    USING NEW E/H    7/70
M    C     (105.6597) (0.0005)          CRANE     71 CNTR INCLUDED IN COHEN73  1/73
M    D     (105.6594) (0.0004)          CROWE     72 CNTR INCLUDED IN COHEN73  2/72
M          (105.65948)(0.00035)         COHEN     73 RVUE                      3/74
M    A     (105.65945)(0.00033)         CASPERSON 77 CNTR +                   12/77
M    K     (105.65933)(0.00029)         KLEMPT    82 CNTR + INCL IN MARIAM 82  2/82
M    M      105.65928  0.00029          MARIAM    82 CNTR +                    1/83*
M    C   CRANE 71 GIVES MU/ME=206.76878(85).  WE USE ME=.5110041(16)MEV.       1/73
M    D   CROWE 72 GIVES MU/ME=206.7682(5) AND USES ME=.5110041(16)MEV.         1/73
M    A   CASPERSON 77 GIVES MU/ME=206.76859(29).  WE USE ME=.5110034(14)MEV. 12/77
M    K   KLEMPT 82 GIVES MU/ME=206.76835(11).  WE USE ME=.5110034(14)MEV.      2/82
M    M   MARIAM 82 GIVES MMU/ME=206.768259(62). WE USE ME=.5110034(14)MEV.     1/83*
M           . . . . . . . . . .
M   FIT     105.65932  0.00029 FROM FIT                                       3/84*
```

4 MUON MEAN LIFE (UNITS 10-6 SEC)**

```
T            2.198     0.001     0.001    FARLEY    62 CNTR
T            2.203     0.004              LUNDY     62 CNTR    CONLEV=.98     11/67
T            2.202     0.003     0.003    ECKHAUSE  63 CNTR
T            2.197     0.005     0.002    MEYER     63 CNTR +
T            2.198     0.002     0.002    MEYER     63 CNTR -                  7/66
T    W     (2.20026)(0.00081)             WILLIAMS  72 CNTR +                  2/76
T            2.1973    0.0003             DUCLOS    73 CNTR +                  1/76
T            2.19711   0.00008            BALANDIN  74 CNTR +                  1/76
T            2.1948    0.0010             BAILEY2   77 CNTR -  STORAGE RINGS   2/79
T            2.1966    0.0020             BAILEY2   77 CNTR +  STORAGE RINGS   2/79
T          (2.197182 0.000121)            BARDIN    81 CNTR REPL. BY BARDIN 84  1/82
T            2.197078 0.000073            BARDIN    84 CNTR +                  2/84*
T            2.197025 0.000155            BARDIN    84 CNTR -                  2/84*
T    W   WILLIAMS 72 MEAN LIFE MEASUREMENT WAS NOT THE PRIMARY PURPOSE OF      1/76
T    W   THEIR EXPERIMENT AND DISAGREES STRONGLY WITH LATER EXPTS. NOT AVGD.   1/76
T           . . . . . . . . . .
T   AVG      2.197090 0.000050 0.000050 AVERAGE
```

4 MU+/MU- MEAN LIFE RATIO

```
DT       TEST OF CPT
DT           1.000     0.001              MEYER     63 CNTR  MEAN LIFE MU+/MU-   7/66
DT           1.0008    0.0010             BAILEY    79 CNTR    STORAGE RING      7/79
DT           1.000024 0.000078            BARDIN    84 CNTR                      2/84*
DT          . . . . . . . . . .
DT  AVG      1.000029 0.000078  AVERAGE
```

4 MUON ANOMALOUS MAGN. MOMENT (10-6*E/(2*MU MASS))**

```
MM       FOR REVIEWS OF THEORY AND EXPERIMENTS, SEE COMBLEY 81, FARLEY 79,
MM       KINOSHITA 78, CALMET 77, COMBLEY 74, LAUTRUP 72, AND RICH 72.
MM         (1162.0)    (5.0)              CHARPAK   62 CNTR +
MM   B     (1165.75)   (0.71)             BAILEY    68 CNTR +  STOR. RINGS      5/69
MM   B     (1166.25)   (0.24)             BAILEY    68 CNTR  - STOR. RINGS      5/69
MM   B      ERRORS STATISTICAL. VALUES COMBINED TO GIVE MU+- VALUE BELOW        5/69
MM          1166.16     0.31              BAILEY    68 CNTR +- STOR. RINGS      5/69
MM          1060.      67.                HENRY     69 CNTR +                   1/77
MM   IA    (1165.895)  (0.027)            BAILEY    75 CNTR +  STORAGE RING    11/75
MM   IA    (1165.922)  (0.009)            BAILEY    77 CNTR +- STORAGE RING    11/77
MM   I     (1165.911)  (0.011)            BAILEY    79 CNTR +  STORAGE RING     7/79
MM   I     (1165.937)  (0.012)            BAILEY    79 CNTR -  STORAGE RING     7/79
MM    I     1165.924    0.0085            BAILEY    79 CNTR +- STORAGE RING     7/79
MM    A  BAILEY 77 INCLUDES RESULTS OF BAILEY 75.                              11/77
MM    I  BAILEY 79 IS FINAL RESULT. INCLUDES BAILEY 75 AND 77 DATA.             7/79
MM    I  THIRD BAILEY 79 RESULT IS FIRST TWO COMBINED.                          7/79
MM          . . . . . . . . . .
MM  AVG     1165.9242   0.0085  AVERAGE

MMR    MU+ TO MU- G-FACTOR RATIO MINUS ONE, (G+/G-)-1
MMR      TEST OF CPT
MMR         -2.6E-8   1.6E-8              BAILEY    79                          2/84*
```

4 MUON ELECTRIC DIPOLE MOMENT (UNITS 10-19 E-CM)**

FORBIDDEN BY BOTH T INVARIANCE AND P INVARIANCE

```
EDM B         (8.6)     (4.5)             BAILEY    78 CNTR +  STORAGE RINGS    2/79
EDM B         (0.8)     (4.3)             BAILEY    78 CNTR -  STORAGE RINGS    2/79
EDM  B         3.7       3.4              BAILEY    78 CNTR +- STORAGE RING     2/79
EDM  B   BAILEY 78 YIELDS EDM < 1.05*10**-18 WITH CL=.95.  THIRD RESULT IS     2/79
EDM  B   FIRST TWO COMBINED ASSUMING CPT.                                      2/79
```

4 MUON TO PROTON MAGNETIC MOMENT RATIO

```
MPR      THIS RATIO IS USED TO OBTAIN A PRECISE VALUE OF THE MUON MASS.
MPR        (3.1865) (0.0022)              COFFIN    58 CNTR +  SPIN RESONANCE    2/72
MPR        (3.1830) (0.0011)              LUNDY     58 CNTR +  PRECESSION STROB  2/72
MPR        (3.176)  (0.013)               LUNDY     58 CNTR -  PRECESSION STROB  2/72
MPR        (3.1834) (0.0002)              GARWIN    60 CNTR +  PRECESSION PHASE  2/72
MPR        (3.18336)(0.00007)             BINGHAM   63 CNTR +  PRECESSION STROB  2/72
MPR        (3.1808) (0.0004)              BINGHAM   63 CNTR -  PRECESSION STROB  2/72
MPR        (3.18338)(0.00004)             HUTCHINS  63 CNTR +  PRECESSION PHASE  2/72
MPR D      (3.183351 0.000016)            EHRLICH   69 CNTR    HFS SPLITTING     2/72
MPR C      (3.183314 0.000034)            THOMPSON  69 CNTR    HFS SPLITTING     2/72
MPR        (3.183330 0.000044)            HUTCHINS  70 CNTR +  PRECESSION PHASE  2/72
MPR H      (3.183347 0.000009)            HAGUE     70 CNTR +  PRECESSION PHASE  2/72
MPR  C     (3.183336 0.000013)            CRANE     71 CNTR    HFS SPLITTING     2/72
MPR  D     (3.183349 0.000015)            DEVOE     71 CNTR    HFS SPLITTING     1/73
MPR F      (3.183326 0.000013)            FAVART    71 CNTR    HFS SPLITTING     2/72
MPR  H     (3.1833467 .0000082)           CROWE     72 CNTR +  PRECESSION PHASE  2/72
MPR  R   THE RESULTS THROUGH 1972 ARE INCLUDED IN COHEN 73.                      3/74
MPR  R      3.1833402 .0000072            COHEN     73 RVUE                      3/74
MPR E      (3.1833299 .0000025)           CASPERSON 75 CNTR                      2/76
MPR         3.1833403 .0000044            CASPERSON 77 CNTR +  HFS SPLITTING    12/77
MPR        (3.1833448 .0000029)           CAMANI    78 CNTR +  REPL.BY KLEMPT82  7/79
MPR         3.1833441 .0000017            KLEMPT    82 CNTR +  PRECESSION STROB  2/82
MPR         3.1833461 .0000011            MARIAM    82 CNTR +  HFS SPLITTING     1/83*
MPR  D   DEVOE 71 SUPERCEDES EHRLICH 69.  THIS IS NOT A DIRECT MEASUREMENT.      1/73
MPR  D   WE GIVE A NEW VALUE WHICH CONTAINS A THEORETICAL CORRECTION OF          1/73
MPR  D   -7.8+-2.3 PPM, AS DISCUSSED IN FOOTNOTE 35A OF CROWE 72.                1/73
MPR C    CRANE 71 SUPERSEDES THOMPSON 69. THIS IS NOT A DIRECT MEASUREMENT.      1/73
MPR H    CROWE 72 SUPERSEDES HAGUE 70.
MPR F    FAVART 71 ASSUMES A ZERO VALUE FOR THE PROTON POLARIZABILITY.           1/73
MPR  E   USES INCORRECT THEO. EXPRESSION FOR NU(HFS). SEE KLEMPT 82, TBL.XI.     2/82
MPR          . . . . . . . . . .
MPR AVG     3.1833452 .0000010  AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.1)
```

4 MUON PARTIAL DECAY MODES

```
                                                            DECAY MASSES
P1      MUON INTO E ANUE NUMU                               .511+   0+   0
P2      MUON INTO E ANUE NUMU GAMMA                         .511+   0+   0+   0
P3      MUON INTO E NUE ANUMU                               .511+   0+   0
P4      MUON INTO E GAMMA                                   .511+   0
P5      MUON INTO 3ELECTRONS                                .511+.511+.511
P6      MUON INTO E 2GAMMA                                  .511+   0+   0
P7      MUON INTO E- E+ E- ANUE NUMU                        .511+.511+.511+   0+
```

4 MUON BRANCHING RATIOS

```
R1      MUON INTO (E ANUE NUMU GAMMA)/TOTAL                    (P2)
R1       27 EVENTS SEEN                   ASHKIN    59 CNTR                         1/78
R1           1.4E-2   0.4E-2              CRITTENDE 61 CNTR T(GAM) GT 10 MEV        1/78
R1          (3.3E-3) (1.3E-3)             CRITTENDE 61 CNTR T(GAM) GT 20 MEV        1/78
R1       862 EVENTS SEEN                  BOGART    67 CNTR T(GAM) GT 14.5 MEV      1/78

R2      MUON+ INTO (E+ ANUE NUMU)/TOTAL                        (P3)
R2       FORBIDDEN BY ADDITIVE CONSERVATION LAW FOR LEPTON FAMILY NUMBER.
R2       MULTIPLICATIVE LAW PREDICTS THIS BRANCHING RATIO TO BE 1/2.
R2       FOR A RECENT REVIEW SEE NEMETHY 81.
R2           (0.25) OR LESS  CL=.90   EICHTEN   73 HLBC +                      11/75
R2           (0.13)    (0.15)         BLIETSCHA 78 HLBC +- AVG. OF 4 VALUES     1/82
R2           (0.09) OR LESS  CL=.90   JONKER    80 CALO REPL. BY BERGSMA 83     2/82
R2          (-0.001)  (0.061)         WILLIS    80 CNTR +                       8/81
R2    A       0.05  OR LESS  CL=.90   BERGSMA   83 CALO ANUMU E -->MU- ANUE 11/83*
R2    A  BERGSMA 83 GIVES LIMIT ON INVERSE MUON DECAY CROSS SECTION RATIO       2/82
R2    A  SIGMA(ANUMU E- --> MU- ANUE) / SIGMA(NUMU E- --> MU- NUE), WHICH       2/82
R2    A  IS ESSENTIALLY EQUIVALENT TO R2 FOR SMALL VALUES LIKE THAT QUOTED.     2/82

R3      MUON INTO (E GAMMA)/TOTAL (UNITS 10**-8)               (P4)
R3       FORBIDDEN BY LEPTON FAMILY NUMBER CONSERVATION
R3           (4.3)  OR LESS  CL=.90   FRANKEL1  63 OSPK
R3           (2.2)  OR LESS  CL=.90   PARKER    64 OSPK
R3           (2.9)  OR LESS  CL=.90   KORENCH1  71 OSPK +  DUBNA               10/71
R3           (0.36) OR LESS  CL=.90   DEPOMMIER 77 CNTR REPL. BY AZUELOS 83 12/77
R3           (0.11) OR LESS  CL=.90   POVEL     77 ELEC REPL. BY SCHAAF 80      1/79
R3           (0.019)OR LESS  CL=.90   BOWMAN    79 SPEC REPL.BY KINNISON 82     7/79
R3           (0.10) OR LESS  CL=.90   SCHAAF    80 ELEC +  SIN                  3/82
R3            0.017 OR LESS  CL=.90   KINNISON  82 SPEC +  LAMPF               11/82*
R3           (0.10) OR LESS  CL=.90   AZUELOS   83 CNTR +                      10/83*

R4      MUON INTO (3ELECTRONS)/TOTAL (UNITS 10**-7)            (P5)
R4       FORBIDDEN BY LEPTON FAMILY NUMBER CONSERVATION
R4 F         (5.0)  OR LESS  CL=.90   PARKER    62 CNTR
R4 F         (1.3)  OR LESS  CL=.90   ALIKHANOV 62 OSPK
R4 F         (1.5)  OR LESS  CL=.90   FRANKEL2  63 CNTR
R4 F         (1.2)  OR LESS  CL=.90   BABAEV    63 OSPK
R4 K         (0.062)OR LESS  CL=.90   KORENCH2  71 OSPK    DUBNA                2/72
R4 K          0.019 OR LESS  CL=.90   KORENCHEN 76 SPEC +  DUBNA                6/77
R4 F     FOUR ABOVE EXPERIMENTS EVALUATED UPPER LIMITS ASSUMING A SECOND
R4 F     ORDER V-A NEUTRINO LOOP DIAGRAM. LIMITS NOT SIGNIFICANTLY CHANGED
R4 F     BY ASSUMING A CONSTANT MATRIX ELEMENT.
R4 K     THESE EXPERIMENTS ASSUME A CONSTANT MATRIX ELEMENT.                   10/77

R5      MUON INTO (E 2GAMMA)/TOTAL (UNITS 10**-7)              (P6)
R5       FORBIDDEN BY LEPTON FAMILY NUMBER CONSERVATION
R5          (160.)  OR LESS  CL=.90   FRANKEL1  63 OSPK +
R5 P         (40.)  OR LESS  CL=.90   POUTISSOU 74 CNTR +  LBL                 12/75
R5    A      (0.5)  OR LESS  CL=.90   BOWMAN    78 CNTR DEPOMMIER 77 DATA       4/82
R5    B       0.084 OR LESS  CL=.90   AZUELOS   83 CNTR +                      10/83*
R5 P     POUTISSOU 74 LIMIT APPLIES TO SUM OF ALL NEUTRINOLESS MU+ DECAYS.      1/76
R5    A  BOWMAN 78 ASSUMES INT. LAGRANG. LOCAL ON SCALE OF INVERSE MU MASS.     4/82
R5    B  AZUELOS 83 USES PHASE SPACE DISTRIBUTION OF BOWMAN 78. SEE ABOVE.    10/83*
R6      MUON INTO (E- E+ E- ANUE NUMU)/TOT.(UNITS 10**-5)(P7)
R6   L    3   (1.5)      (1.0)        LEE       59 HBC  +                      11/83*
R6   G    1   (2.)                    GUREVICH  60 EMUL +                      11/83*
R6    C   7    2.2        1.5         CRITTENDE 61 HLBC +     E(E+E-)>10MEV 11/83*
R6   L   IN THE THREE LEE 59 EVENTS, THE SUM OF ENERGIES S=E(E+)+E(E-)+E(E+) 11/83*
R6   L   WAS S=51 MEV, 55 MEV, AND 33 MEV .                                    11/83*
R6   G   GUREVICH 60 INTERPRET THEIR EVENT AS EITHER VIRTUAL OR REAL PHOTON    11/83*
R6   G   CONVERSION.  E+ AND E- ENERGIES NOT MEASURED .                        11/83*
R6    C  CRITTENDEN 61 COUNT ONLY THOSE DECAYS WHERE TOTAL ENERGY OF EITHER    11/83*
R6    C  (E+,E-) COMBINATION IS >10 MEV )                                      11/83*
```

4 LIMIT ON MUON --> ELECTRON CONVERSION

FORBIDDEN BY LEPTON FAMILY NUMBER CONSERVATION

```
RE      (MU- SULFUR32 --> E- SULFUR32)/(MU-SULFUR32 --> NUMU PHOSPHORUS32*)
RE      CROSS SECTION RATIO
RE          (4. E-10)OR LESS  CL=.90   BADERTSCH 77 STRC     SIN                1/82
RE           0.7E-10 OR LESS  CL=.90   BADERTSCH 80 STRC     SIN                1/82
```

4 LIMIT ON MUON --> POSITRON CONVERSION

FORBIDDEN BY TOTAL LEPTON NUMBER CONSERVATION

```
RP1     (MU- SULFUR32 --> E+ SILICON32*)/(MU-SULF32 --> NUMU PHOSPHORUS32*)
RP1         (1.5E-9) OR LESS  CL=.90   BADERTSCH 78 STRC     SIN                1/82
RP1          0.9E-9  OR LESS  CL=.90   BADERTSCH 80 STRC     SIN                1/82

RP2     (MU- IODINE127 --> E+ ANTIMONY127*)/(MU- IODINE127 --> ANYTHING)        4/82
RP2  A       0.3E-9  OR LESS  CL=.90   ABELA      80 CNTR RADIOCHEMICAL TECH.   4/82
RP2  A  ABELA 80 IS UPPER LIMIT FOR MU- E+ CONVERSION LEADING TO PARTICLE-      4/82
RP2  A  STABLE STATES OF SB127. LIMIT FOR TOTAL CONVERSION RATE IS HIGHER       4/82
RP2  A  BY A FACTOR LESS THAN 4 (G. BACKENSTOSS, PRIVATE COMM.)                 4/82
```

4 LIMIT ON (MU+,E-) BND. STATE CONVERSION TO (MU-,E+)

FORBIDDEN BY LEPTON FAMILY NUMBER CONSERVATION

```
MC         RG = GC/GF
MC         WHERE GF = 1.16637E-5 GEV**(-2) IS THE FERMI CONSTANT AND
MC         GC IS AN EFFECTIVE COUPLING (DIMENSIONS GEV**(-2)) FOR A
MC         FOUR-FERMION INTERACTION ASSUMED TO BE RESPONSIBLE FOR THE
MC         CONVERSION OF THE (MU+,E-) BOUND STATE TO (MU-,E+).
MC
MC              42    OR LESS  CL=.95   MARSHALL  82 CNTR                      12/83*
```

Stable Particles

μ

Data Card Listings

NOTE ON MUON DECAY PARAMETERS

The μ decay parameters describe the momentum spectrum (ρ and η), the asymmetry (ξ and δ), and the helicity (h) of the electron in the process $\mu^- \to e^- + \nu_\mu + \overline{\nu}_e$. Assuming a local and lepton-conserving interaction, the matrix element in the charge-retention form may be written as

$$\sum_i [\overline{e}\Gamma_i\mu]\,[\overline{\nu}_\mu\Gamma_i(C_i + C_i'\gamma_5)\nu_e]\,,$$

where the summation is taken over i = S, V, T, A, P. Using the definitions and sign conventions of Sachs and Sirlin[1] and Scheck[2] for the Lorentz-covariant operators, we have for the momentum parameters:

$$\rho = (3g_A^2 + 3g_V^2 + 6g_T^2)/D\,,$$

$$\eta = (g_S^2 - g_P^2 + 2g_A^2 - 2g_V^2)/D\,;$$

for the asymmetry parameters:

$$\xi = \frac{-6g_Sg_P\cos\phi_{SP} - 8g_Ag_V\cos\phi_{AV} + 14g_T^2\cos\phi_{TT}}{D}\,,$$

$$\delta = (-6g_Ag_V\cos\phi_{AV} + 6g_T^2\cos\phi_{TT})/D\xi\,;$$

and for the parameter describing the helicity of the electron:

$$h = \frac{2g_Sg_P\cos\phi_{SP} + 8g_Ag_V\cos\phi_{AV} + 6g_T^2\cos\phi_{TT}}{D}\,.$$

Here

$$D = g_S^2 + g_P^2 + 4g_V^2 + 6g_T^2 + 4g_A^2\,,$$

$$g_i^2 = |C_i|^2 + |C_i'|^2\,,$$

and

$$\cos\phi_{ij} = \mathrm{Re}(C_i^*C_j' + C_i'C_j^*)/g_ig_j\,.$$

The quantities g_i are defined to be real non-negative numbers, and the ϕ_{ij} are phase angles between the i-type and j-type interactions. Under the assumption of two-component neutrinos, $C_V' = -C_V$ and $C_A' = -C_A$, the S, P, and T terms vanish, and ϕ_{AV} is the phase angle between C_A and C_V in the complex plane.

By using the above equations and the experimental determinations of ρ, η, ξ, δ, and h, limits can be placed on $|g_S/g_V|$, $|g_A/g_V|$, $|g_T/g_V|$, $|g_P/g_V|$, and ϕ_{AV}. The results, given in the Data Card Listings, assume neither two-component neutrinos nor time-reversal invariance. If, however, two-component neutrinos are assumed, then $\sin\phi_{AV}$ is the amplitude of time-reversal violation. Note that most experiments study only the upper end of the spectrum where ρ and η are highly correlated, so they can only report ρ for $\eta = 0$ and η for $\rho = 3/4$. The values for ρ and η we use here were obtained by combining measurements of both upper and lower ends of the spectrum and turn out to be nearly uncorrelated.

Note also that the radiative corrections are unambiguous only when $g_S = g_T = g_P = 0$. The same limits on g_A/g_V and ϕ_{AV} are obtained, however, as when g_S, g_T, and g_P are left free.

References

1. A.M. Sachs and A. Sirlin, in *Muon Physics II*, eds. C.S. Wu and V. Hughes (Academic Press, New York, 1975), p. 49.
2. F. Scheck, Phys. Rep. **44**, 187 (1978).


```
                    4  MUON DECAY PARAMETERS

RHO    RHO PARAMETER                    (V-A THEORY PREDICTS RHO=0.75)
RHO C          (0.741)  (0.027)          DUDZIAK   59 CNTR +  20-53 MEV E+     10/69
RHO  P9213     0.745    0.025           PLANO     60 HBC  +  WHOLE SPECTRUM   10/69
RHO  P  TWO PARAMETER FIT TO RHO AND ETA.
RHO C 2276     (0.751)  (0.034)          BLOCK     62 HEBC  - WHOLE SPECTRUM   10/69
RHO D          (0.64)   (0.04)           BARLOW    64 CNTR  - WHOLE SPECTRUM   10/69
RHO D          (0.661)  (0.016)          BARLOW    64 CNTR +  WHOLE SPECTRUM   10/69
RHO D          (0.867)  (0.035)          PONTECORV 64 CC    -                  10/69
RHO D   RESULTS IN DOUBT.                                                      10/69
RHO C 800K     (0.7503) (0.0026)         PEOPLES   66 ASPK +  20-53 MEV E+     10/69
RHO C 280K     (0.760)  (0.009)          SHERWOOD  67 ASPK +  25-53 MEV E+     10/69
RHO C 170K     (0.762)  (0.008)          FRYBERGER 68 ASPK +  25-53 MEV E+     10/69
RHO C   ETA CONSTRAINED =0. THESE VALUES INCORPORATED INTO A TWO PARAMETER
RHO C   FIT TO RHO AND ETA BY DERENZO 69.
RHO            0.7518   0.0026          DERENZO   69 RVUE                     10/69
RHO          . . . . . . . . . .
RHO AVG        0.7517   0.0026  AVERAGE

ETA    ETA PARAMETER                    (V-A THEORY PREDICTS ETA=0)
ETA P 9213  (-2.0)      (0.9)            PLANO     60 HBC  +  WHOLE SPECTRUM   10/69
ETA P    TWO PARAMETER FIT TO RHO AND ETA- PLANO 60 DISCOUNTS VALUE FOR ETA   10/69
ETA C 800K   (0.05)     (0.5)            PEOPLES   66 ASPK +  20-53 MEV E+     10/69
ETA C 280K  (-0.7)      (0.6)            SHERWOOD  67 ASPK +  25-53 MEV E+     10/69
ETA C 170K  (-0.7)      (0.5)            FRYBERGER 68 ASPK +  25-53 MEV E+     10/69
ETA C   RHO CONSTRAINED =0.75.
ETA   6346   -0.12      0.21             DERENZO   69 HBC  +  1.6-6.8 MEV E+   10/69
ETA  A1.2M    0.19      0.18             CORRIVEAU 83 CNTR +  10-53 MEV E+     11/83*
ETA  A  CORRIVEAU 83 MEASURE TRANSVERSE POLARIZATION OF E+ VERSUS ENERGY OF  11/83*
ETA  A  E+. THEY DERIVE (ALPHA/A)=0.11+-0.11 , (BETA/A)=-0.038+-0.037 , AND 11/83*
ETA  A  ETA=(ALPHA-2*BETA)/A. ALPHA,BETA AND A ARE DEFINED IN SECTION 3 OF  11/83*
ETA  A  SCHECK 78 . RESULTS ON T-VIOLATION SEE SECTIONS ALP, BTP BELOW .    11/83*
ETA          . . . . . . . . . .
ETA AVG        0.06      0.15    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.1)

XSI    (XSI PARAMETER)*(MUON LONGITUDINAL POLARIZATION)
XSI                                     (V-A THEORY PREDICTS XSI=1, LONG.POL.=1)
XSI      9K  (0.97)      (0.05)           BARDON    59 CNTR    BROMOFORM TARGET 10/69
XSI   8354   (0.93)      (0.06)           PLANO     60 HBC  +  8.8 KGAUSS       10/69
XSI A        (0.903)     (0.027)          ALI-ZADE  61 EMUL +  27 KGAUSS        10/69
XSI A   DEPOLARIZATION BY MEDIUM NOT KNOWN SUFFICIENTLY WELL.
XSI    66K   (0.975)     (0.030)          GUREVICH  64 EMUL REPL.BY AKHMANOV 68 10/69
XSI          (0.975)     (0.015)          AKHMANOV  68 EMUL    140 KGAUSS       9/81
XSI  C       0.9959 OR MORE  CL=.90       CARR      83 SPEC +  11 KGAUSS        10/83*
XSI  C  CARR 83 FIND (XSI*PMU*DELTA/RHO) > 0.9959. WE USE (DELTA/RHO) = 1.0 10/83*
XSI  C  FROM V-A THEORY TO DERIVE ABOVE LIMIT FOR (XSI*PMU) .                10/83*

DEL    DELTA PARAMETER                  (V-A THEORY PREDICTS DELTA=0.75)
DEL  8354      0.78      0.05             PLANO     60 HBC  +  WHOLE SPECTRUM   10/69
DEL            0.782     0.031            KRUGER    61                          10/69
DEL   490K     0.752     0.009            FRYBERGER 68 ASPK +  25-53 MEV E+     10/69
DEL     VOSSLER 69 HAS MEASURED THE ASYMMETRY BELOW 10 MEV                     11/69
DEL          . . . . . . . . . .
DEL AVG        0.7551    0.0085  AVERAGE
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For notation, see key at front of Listings.

Stable Particles

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HEL     HELICITY OF DECAY ELECTRON.
HEL      (V-A THEORY PREDICTS HELICITY=+-1 FOR E+-, RESPECTIVELY)
HEL      WE HAVE FLIPPED THE SIGN FOR E- SO OUR PROGRAMS CAN AVERAGE
HEL D        (0.28)   (0.16)          DICK     63 CNTR +  ANNIHILATION     10/69
HEL D    IN DOUBT- POSITRONS POSSIBLY DEPOLARIZED IN BE MODERATOR.
HEL            1.05     0.30          BUHLER   63 CNTR +  ANNIHILATION     10/69
HEL            0.94     0.38          BLOOM    64 CNTR +  BREMS TRANSMISS  10/69
HEL            1.04     0.18          DUCLOS   64 CNTR +  BHABHA SCATT    10/69
HEL     29K    0.89     0.28          SCHWARTZ 67 OSPK  - MOLLER SCATT    10/69
HEL     500K   1.010    0.064         CORRIVEAU 81 CNTR +  BHABHA + ANNIHIL  1/82
HEL            . . . . . . . . .
HEL AVG        1.008    0.057   AVERAGE

ALP     (ALPHA-PRIME)/A
ALP      ALPHA-PRIME AND BETA-PRIME (SEE BELOW) AFFECT DEPENDENCE OF DIFFER- 11/83*
ALP      ENTIAL DECAY PROBABILITY ON ELECTRON SPIN DIRECTION , AND ARE ZERO  11/83*
ALP      IF TIME-REVERSAL INVARIANCE HOLDS. ALPHA-PRIME, BETA-PRIME AND A    11/83*
ALP      ARE DEFINED IN SECTION 3 OF SCHECK 78 .                             11/83*
ALP  C1.2M   -0.12     0.10          CORRIVEAU 83 CNTR +  10-53 MEV E+      11/83*
ALP  C  CORRIVEAU 83 MEASURE TRANSVERSE E+ POLARIZATION VERSUS E+ ENERGY .  11/83*

BTP     (BETA-PRIME)/A                                                      11/83*
BTP      SEE COMMENT IN SECTION ALP ABOVE .                                 11/83*
BTP  C1.2M   0.029    0.037          CORRIVEAU 83 CNTR +  10-53 MEV E+      11/83*
BTP  C  CORRIVEAU 83 MEASURE TRANSVERSE E+ POLARIZATION VERSUS E+ ENERGY .  11/83*

ETB     ETA-BAR PARAMETER             (V-A THEORY PREDICTS ETA-BAR=0)
ETB      ETA-BAR AFFECTS SPECTRUM OF RADIATIVE MUON DECAY.                   2/84*
ETB          +0.09     0.14          BOGART   67 CNTR +                      2/84*
ETB         (-0.014)  (0.090)         EICHENBER 84 ELEC +  RHO FREE          2/84*
ETB          -0.035    0.098         EICHENBER 84 ELEC +  RHO=0.75 ASSUMED  2/84*
ETB          . . . . . . . . .
ETB AVG       0.006    0.080   AVERAGE

GS      SCALAR BOSON COUPLING CONSTANT IN MUON DECAY (IN UNITS OF GV)
GS            0.29  OR LESS           MURSULA   83 RVUE                    3/83*
GS  A        (0.16) OR LESS           MURSULA   83 RVUE                    3/83*
GS  A    ASSUMING EQUAL S AND PS COUPLINGS, AND NO TENSOR COUPLING.         3/83*

GA      AXIAL BOSON COUPLING CONSTANT IN MUON DECAY (IN UNITS OF GV)
GA            0.91     0.24     0.06 MURSULA   83 RVUE                    3/83*
GA  A        (0.94)   (0.19)   (0.07) MURSULA   83 RVUE                   3/83*
GA  B        (0.97)   (0.16)   (0.10) MURSULA   83 RVUE                   3/83*
GA  B    ASSUMING NO SCALAR OR PSEUDOSCALAR COUPLINGS.                      3/83*
GA  A    ASSUMING EQUAL S AND PS COUPLINGS, AND NO TENSOR COUPLING.         3/83*

FAV     PHASE BETWEEN VECTOR AND AXIAL VECTOR COUPLINGS  (DEGREES)
FAV           180.      9.           MURSULA   83 RVUE                    3/83*
FAV A       (182.)     (5.)     (9.)  MURSULA   83 RVUE                    3/83*
FAV B       (184.)     (4.)    (10.)  MURSULA   83 RVUE                    3/83*
FAV B    ASSUMING NO SCALAR OR PSEUDOSCALAR COUPLINGS.                      3/83*
FAV A    ASSUMING EQUAL S AND PS COUPLINGS, AND NO TENSOR COUPLING.         3/83*

GT      TENSOR BOSON COUPLING CONSTANT IN MUON DECAY (IN UNITS OF GV)
GT            0.14  OR LESS           MURSULA   83 RVUE                    3/83*

GP      PS.SCALAR BOSON COUPLING CONSTANT IN MUON DECAY (IN UNITS OF GV)
GP            0.25  OR LESS           MURSULA   83 RVUE                    3/83*

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REFERENCES FOR MUON


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COFFIN    58 PR 109 973        +GARWIN,PENMAN,LEDERMAN,SACHS    (COLUMBIA)
LUNDY     58 PRL 1 38          +SENS,SWANSON,TELEGDI,YOVANOVITCH (CHICAGO)
ASHKIN    59 NC 14 1266        +FAZZINI,FIDECARO,LIPMAN,MERRISON +  (CERN)
BARDON    59 PRL  2   56       M BARDON, D BERLEY, L LEDERMAN   (COLUMBIA)
DUDZIAK   59 PR  114  336      W DUDZIAK,R SAGANE, J VEDDER          (LRL)
LEE       59 PRL 3 55          JULIET LEE, N. P. SAMIOS             (COLU)
GARWIN    60 PR 118 271        GARWIN,HUTCHINSON,PENMAN,SHAPIRO (COLUMBIA)
GUREVICH  60 JETP 10 225       GUREVICH,NIKOLSKII,SURKOVA           (ITEP)
PLANO     60 PR  119 1400      R J PLANO                         (COLUMBIA)

ALI-ZADE  61 JETP  13  313     ALI-ZADE,GUREVICH,NIKOLSKI           (USSR)
CRITTEND  61 PR 121 1823       CRITTENDEN,WALKER,BALLAM          (WISC+MSU)
KRUGER    61 UCRL-9322 (UNPUB) H KRUGER                             (LRL)
ALIKHANO  62 CERN CONF 423     A I ALIKHANOV,A BABAEV +       (ITEP MOSCOW)
BLOCK     62 NC   23  1114     BLOCK,FIORINI,KIKUCHI+(DUKE,BOLOGNA,MILANO)
CHARPAK   62 PL    1  16       G CHARPAK,F J M FARLEY,R L GARWIN +  (CERN)
FARLEY    62 CERN CONF 415     FARLEY,MASSAM,MULLER,ZICHICHI        (CERN)

LUNDY     62 PR 125 1686       RICHARD A LUNDY                       (EFI)
PARKER    62 NC  23  485       S PARKER,S PENMAN                     (EFI)
BABAEV    63 JETP 16 1397      BABAEV,BALATS,KAFTANOV,LANDSBERG +   (ITEP)
BINGHAM   63 NC 27 1352        G.MCD.BINGHAM                         (LRL)
BUHLER    63 PL   7  368       +CABIBBO,FIDECARO,MASSAM,MULLER+     (CERN)
DICK      63 PL   7  150       DICK,FEUVRAIS,SPIGHEL                (CERN)

ECKHAUSE  63 PR 132  422       M ECKHAUSE,T A FILIPPAS +         (CARNEGIE)
FEINBERG  63 ARNS 13 431       GERALD FEINBERG, L M LEDERMAN    (COLUMBIA)
FRANKEL1  63 NC  27  894       S FRANKEL,W FRATI,J HALPERN +        (PENN)
FRANKEL2  63 PR 130  351       S FRANKEL,W FRATI,J HALPERN +        (PENN)
HUTCHINS  63 PR 131 1351       HUTCHINSON,MENES,PATLACH,SHAPIRO (COLUMBIA)
MEYER     63 PR  132  2693     S L MEYER,ANDERSON,BLESER,LEDERMAN+  (COLU)

BARLOW    64 PPS   84  239     +BOOTH,CARROL,COURT,DAVIES,EDWARDS+  (LIVP)
BLOOM     64 PL    8   87      +DICK,FEUVRAIS,HENRY,MACQ,SPIGHEL    (CERN)
DUCLOS    64 PL    9   62      +HEINTZE,DE RUJULA,SOERGEL           (CERN)
GUREVICH  64 PL   11  185      GUREVICH,MAKARIYNA+                  (KIAE)
PONTECOR  64 DUBNA CONF        PONTECORVO,SULYAEV                 (MOSCOW)
PARKER    64 PR 133B 768       S PARKER,H L ANDERSON,C REY           (EFI)

PEOPLES   66 NEVIS-147 (UNPUB) J PEOPLES                          (COLUMBIA)
BOGART    67 PR 156 1405       +DICAPUA,NEMETHY,STRELZOFF           (COLU)
SCHWARTZ  67 PR  162 1306      D M SCHWARTZ                          (EFI)
SHERWOOD  67 PR  156 1475      B A SHERWOOD                          (EFI)
AKHMANOV  68 SJNP 6 230        +GUREVICH,DOBRETSOV,MAKARINA+        (KIAE)
BAILEY    68 PL   28B  287     +BARTL,VON BOCHMANN,BROWN,FARLEY+    (CERN)
    ALSO  72 NC 9A 369         +BARTL,VON BOCHMANN,BROWN,FARLEY+    (CERN)
FRYBERGE  68 PR  166 1379      D FRYBERGER                           (EFI)

DERENZO   69 PR  181 1854      S DERENZO                             (EFI)
EHRLICH   69 PRL 23 513        +HOFER,MAGNON,STOWELL,SWANSON+    (CHICAGO)
HENRY     69 NC 63A 995        +SCHRANK,SWANSON            (STAN+UCSB+UCSD)
TAYLOR    69 RMP 41 375        +PARKER,LANGENBERG          (PRIN+UCI+PENN)
THOMPSON  69 PRL 22 163        +AMATO,CRANE,HUGHES,MOBLEY+          (YALE)
HAGUE     70 PRL 25 628        +ROTHBERG,SCHENCK,WILLIAMS+      (WASH+LRL)
HUTCHINS  70 PRL 24 1254       HUTCHINSON,LARSON,SCHOEN,SOBER,+      (PPA)

CRANE     71 PRL 27 474        +CASPERSON,CRANE,EGAN,HUGHES+        (YALE)
DEVOE     71 PRL 25 1779(ER)   +MCINTGRE,MAGNON,STOWELL,SWANSON+ (CHICAGO)
    ALSO  71 PRL 26 213        DEVOE,MCINTGRE,MAGNON,STOWELL+    (CHICAGO)
FAVART    71 PRL 27 1336       +MCINTYRE,STOWELL,TELEGDI,DEVOE+  (CHICAGO)
KORENCH1  71 SJNP 13 190       KORENCHENKO,KOSTIN,MICELMACHER+      (JINR)
KORENCH2  71 SJNP 13 728       KORENCHENKO,KOSTIN,MICELMACHER+      (JINR)

CROWE     72 PR D5 2145        +HAGUE,ROTHBERG,SCHENCK+          (LBL+WASH)
WILLIAMS  72 PR D6 737         R W WILLIAMS,D L WILLIAMS       (WASHINGTON)
COHEN     73 J.PHYS.CHEM.REF.DATA 2, P.663, E.R.COHEN,B.N.TAYLOR
DUCLOS    73 PL 47B 491        +MAGNON,PICARD                        (SACL)
EICHTEN   73 PL 46B 281        +DEDEN+(AACH+BELG+CERN+EPOL+MILA+LALO+LOUC)

BALANDIN  74 JETP 40 811       +GREBENYUK,ZINOV,KONIN,PONOMAREV     (JINR)
POUTISSO  74 NP B80 221        POUTISSOU,FELAWKA,INGRAM +      (MONT+BRCO)
BAILEY    75 PL 55B 420        +BORER+(CERN+DARE+BERN+SHEF+MANZ+RMCS+BIRM)
CASPERSO  75 PL 59B 397        CASPERSON,CRANE+ (YALE+LASL+HEID+BERN+WYOM)
KORENCHE  76 JETP 43 1         KORENCHENKO,KOSTIN,MITSELMAKHER+     (JINR)
BADERTSC  77 PRL 39 1385       BADERTSCHER,BORER,CZAPEK,FLUECKIGER+ (BERN)

BAILEY    77 PL 67B 225        +BORER+(CERN+DARE+BERN+SHEF+MANZ+RMCS+BIRM)
     OR   77 PL 68B 191        +BORER+/CERN+DARE+BERN+SHEF+MANZ+RMCS+BIRM
BAILEY2   77 NATURE 268 301          (DARE+BERN+SHEF+CERN+MANZ+RMCS+BIRM)
    ALSO  79 BAILEY
CASPERSO  77 PRL 38 956        CASPERSON,CRANE+ (BERN+HEID+LASL+WYOM+YALE)
DEPOMMIE  77 PRL 39 1113       DEPOMMIER,MARTIN+(MONT+BRCO+TRIU+VICT+MELB)
POVEL     77 PL 72B 183        +DEY,WALTER,PFEIFFER +       (ZURI+ETH+SIN)

BADERTSC  78 PL 79B 371        BADERTSCHER,BORER,CZAPEK,FLUECKIGER+ (BERN)
BAILEY    78 JPG 4 345                 (DARE+BERN+SHEF+MANZ+RMCS+CERN+BIRM)
    ALSO  79 BAILEY
BLIETSCH  78 NP B133 205       BLIETSCHAU+(AACH+LIBH+CERN+EPOL+MILA+ORSA+)
BOWMAN    78 PRL 41 442        +CHENG,LI,MATIS             (LASL+IAS+CARN+EFI)
CAMANI    78 PL 77B 326        +GYGAX,KLEMPT,SCHENCK,SCHULZE+   (ETH+MANZ)
BAILEY    79 NP B150 1           (DARE+BERN+SHEF+MANZ+RMCS+CERN+BIRM+LBL+)
BOWMAN    79 PRL 42 556        +COOPER,HAMM,HOFFMAN +      (LASL+EFI+STAN)

ABELA     80 PL 95B 318        +BACKENSTOSS,SIMONS,WUEST +      (BASL+KARL)
BADERTSC  80 LNC 28 401        BADERTSCHER,BORER,CZAPEK,FLUECKIGER+ (BERN)
JONKER    80 PL 93B 203        CHARM COLLAB.    (ANIK+CERN+HAMB+ITEP+ROMA)
SCHAAF    80 NP A340 249       +ENGFER,POVEL,DEY+              (ZURI+ETH+SIN)
WILLIS    80 PRL 44 522        +HUGHES+ (YALE+LBL+LASL+SACL+SIN+CNRC+BERN)
    ALSO  80 PRL 45 1370       WILLIS+  (YALE+LBL+LASL+SACL+SIN+CNRC+BERN)

BARDIN    81 NP A352 365       +DUCLOS,MAGNON+        (SACL+CERN+BGNA+TRIU)
CORRIVEA  81 PR D24 2004       CORRIVEAU,EGGER,FETSCHER +   (ETH+SIN+MANZ)
NEMETHY   81 CNPP 10 147       P.NEMETHY,V.W.HUGHES                (LBL+YALE)
KINNISON  82 PR D25 2846       +ANDERSON,MATIS,WRIGHT +     (EFI+STAN+LANL)
KLEMPT    82 PR D25 652        +SCHULZE,WOLF,CAMANI,GYGAX+       (MANZ+ETH)
MARIAM    82 PRL 49 993        +BEER,BOLTON,EGAN,GARDNER+ (YALE+HEID+BERN)
MARSHALL  82 PR D25 1174       +WARREN,ORAM,KIEFL                   (BRCO)

AZUELOS   83 PRL 51 164        +DEPOMMIER,LEROY,MARTIN+   (MONT+TRIU+BRCO)
BERGSMA   83 PL 122B 465       CHARM COLLAB.    (ANIK+CERN+HAMB+ITEP+ROMA)
CARR      83 PRL 51 627        +GIDAL,GOBBI,JODIDIO,ORAM+  (LBL+NWES+TRIU)
CORRIVEA  83 PL 129B 260       CORRIVEAU,EGGER,FETSCHER+    (ETH+SIN+MANZ)
MURSULA   83 NP B219 321       K.MURSULA,M.ROOS,F.SCHECK        (HELS+MANZ)
BARDIN    84 SACLAY PREPRINT   +DUCLOS,MAGNON+        (SACL+CERN+BGNA+FIRZ)
    ALSO  82 THESIS 2567       J. MARTINO                           (ORSA)
EICHENBE  84 NP A412 523       EICHENBERGER,ENGFER,VAN DER SCHAFF   (ZURI)

                               PAPERS NOT REFERRED TO IN DATA CARDS

FISHER    59 PRL  3  349       FISHER,LEONTIC,LUNDBY,MEUNIER,STROOT (CERN)
ASTBURY   60 ROCH CONF 60 542  ASTBURY,HATTERSLEY,HUSSAIN +    (LIVERPOOL)
DEVONS    60 PRL  5  330       DEVONS,GIDAL,LEDERMAN,SHAPIRO    (COLUMBIA)
LATHROP   60 NC   17 109       J LATHROP,R A LUNDY,V L TELEGDI +     (EFI)
LATHROP   60 NC   17 114       J LATHROP,R A LUNDY,S PENMAN +        (EFI)
REITER    60 PRL  5  22        REITER,ROMANOWSKI,SUTTON +       (CARNEGIE)
TELEGDI   60 ROCH CONF 60 713  V L TELEGDI                          (CERN)

CHARPAK   61 PRL   6 128       CHARPAK,FARLEY,GARWIN,MULLER,SENS +  (CERN)
HUTCHINS  61 PRL   7 129       D P HUTCHINSON,J MENES +         (COLUMBIA)
SHAPIRO   62 PR 125 1022       G SHAPIRO,L M LEDERMAN           (COLUMBIA)
FAIRLEY   66 NC 45A 281        FAIRLEY,BAILEY,BROWN,GIESCH +        (CERN)
VOSSLER   69 NC 63A 423        C VOSSLER                             (EFI)

LAUTRUP   72 PRPL 3 193        B.LAUTRUP,A.PETERMAN,E.DE RAFAEL(CERN+BURE)
RICH      72 RMP 44 250        A RICH,J C WESLEY                    (MICH)
COMBLEY   74 PRPL 14 1         F.COMBLEY,E.PICASSO                  (CERN)
CALMET    77 RMP 49 21         J.CALMET,S.NARISON,M.PERROTTET+      (MARS)
KINOSHIT  78  TOKYO HEP P.571  T. KINOSHITA                         (CORN)
SCHECK    78 PRPL 44C 187      F. SCHECK                           (MANZ)
FARLEY    79 ARNPS 29 243      F.J.M.FARLEY,E.PICASSO           (RMCS+CERN)
DEPOMMIE  80 NP A335 97        P.DEPOMMIER                          (MONT)
COMBLEY   81 PRPL 68 93        COMBELY,FARLEY,PICASSO      (SHEF+RMCS+CERN)
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36 NU-TAU(J=1/2)

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EXISTENCE INDIRECTLY ESTABLISHED FROM TAU DECAY DATA
COMBINED WITH NU REACTION DATA.  SEE FOR EXAMPLE
FELDMAN 81.  KIRKBY 79 RULES OUT J=3/2 USING
TAU --> PI NUTAU BRANCHING RATIO.

     NOT IN GENERAL A MASS EIGENSTATE.  SEE NOTE ON NEUTRINOS
     IN THE ELECTRON NEUTRINO SECTION ABOVE.
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36 NU-TAU ''MASS'' (MEV)

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     APPLIES TO NU-3, THE PRIMARY MASS EIGENSTATE IN NU-TAU.  WOULD ALSO
     APPLY TO ANY OTHER NU-J WHICH MIXES STRONGLY IN NU-TAU AND HAS
     SUFFICIENTLY SMALL MASS THAT IT CAN OCCUR IN THE RESPECTIVE DECAYS.
     (THIS WOULD BE NONTRIVIAL ONLY FOR A HYPOTHETICAL J .GE. 4, GIVEN
     THE NU-E AND NU-MU ''MASS'' LIMITS ABOVE.)

M    P 144 (600.)   OR LESS  CL=.95   PERL      77 SMAG E+E-3.8-7.8GEV ECM  12/77
M          (740.)   OR LESS  CL=.90   BRANDELIK 78 DASP ASSUMES V-A DECAY   3/78
M    B 594 (250.)   OR LESS  CL=.95   BACINO    79 DLCO E+E- ECM=3.5-7.4GEV  7/79
M          (250.)   OR LESS  CL=.95   BLOCKER   82 SMK2 E+E- ECM=5.2 GEV    2/82
M           164.    OR LESS  CL=.95   MATTEUZZI 84 SMK2 E+E- ECM=29 GEV     2/84*
M    P  PERL 77 IS E+E- TO TAU+ TAU- EXPT. VALUE QUOTED ASSUMES V-A DECAY  12/77
M    P  AND TAU MASS=1900 MEV.                                             12/77
M    B  BACINO 79 EXPT RULES OUT V+A DECAY, DISFAVORS PURE V OR A, AND IS   7/79
M    B  IN GOOD AGREEMENT WITH V-A.                                         1/82

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REFERENCES FOR NU-TAU


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PERL      77 PL 70B 487        +FELDMAN,ABRAMS,ALAM,BOYARSKI+   (SLAC+LBL)
BRANDELI  78 PL 73B 109        BRANDELIK +      (AACH+DESY+HAMB+MPIM+TOKY)
ALLES     79 NCL 25 404        W.ALLES                              (BGNA)J
BACINO    79 PRL 42 749        +FERGUSON,NODULMAN+    (UCLA+SLAC+UCI+STON)
KIRKBY    79  SLAC-PUB-2419    J.KIRKBY(LEPTON PHOTON SYMP. BATAVIA)(SLAC)J
FELDMAN   81  SLAC-PUB-2839    G.J.FELDMAN(SANTA CRUZ APS 1981)(SLAC+STAN)
BLOCKER   82 PL 109B 119       +DORFAN,ABRAMS,ALAM,BLONDEL+     (LBL+SLAC)
MATTEUZZ  84  SLAC-PUB-3291    MATTEUZZI,ABRAMS+            (SLAC+LBL+HARV)
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Stable Particles — Data Card Listings

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35  TAU+-(1785,J=1/2) HEAVY LEPTON

E+E- --> TAU+TAU- CROSS SECTION THRESHOLD BEHAVIOR
AND MAGNITUDE CONSISTENT WITH POINTLIKE SPIN 1/2
DIRAC PARTICLE.  BRANDELIK 78 RULES OUT POINTLIKE
SPIN 0 OR SPIN 1 PARTICLE.  FELDMAN 78 RULES OUT
J=3/2.  KIRKBY 79 ALSO RULES OUT J=INTEGER, J=3/2.

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                 35  TAU MASS (MEV)

M    P  64(1800.)  (200.)              PERL      75 SMAG   INCL. IN PERL 77  2/78
M   B 220(1910.)    (30.)              BURMEST1  77 PLUT ASSUMES V-A DECAY  12/77
M   P 144(1900.)   (100.)              PERL      77 SMAG E+E- 3.8-7.8GEV ECM 12/77
M   A 692 1783.      3.       4.       BACINO    78 DLCO E+E- 3.1-7.4GEV ECM  2/82
M   R 299 1787.     10.      18.       BARTEL    78 SPEC E+E- 3.6-4.4GEV ECM  7/79
M         1807.     20.                BRANDELIK 78 DASP E+E- 3.1-5.2GEV ECM  3/78
M         1787.     10.                BLOCKER   80 SMK2 E+E- 3.5-6.7GEV ECM  2/82
M    1138(1803.)   (16.)               BLOCKER1  82 SMK2 INCL. IN BLOCKER 80  2/82
M
M   B  BURMESTER 77 MASS VALUE ARE FROM EVENTS CONTAINING MU+- PLUS ONE     12/77
M   B  OTHER PRONG, ORIGINATING FROM E+ E- --> TAU+ TAU-. THE MASS          12/77
M   B  VALUES COME FROM A FIT TO THE SHAPE AND ECM DEPENDENCE OF THE        12/77
M   B  MU+- SPECTRA, ASSUMING THAT THE TAU SPIN IS 1/2 AND ITS ASSOC        12/77
M   B  NEUTRINO HAS M=0.                                                    12/77
M
M   P  PERL 77 VALUE COMES FROM E+ E- TO E+- MU-+ AND NO OTHER DETECTED     12/77
M   P  PARTICLES. ASSUMES V-A COUPLING AND ZERO MASS FOR ASSOC NEUTRINO.    12/77
M
M   A  BACINO 78 VALUE COMES FROM E+- X-+ THRESHOLD. PUBLISHED MASS 1782     2/82
M   A  MEV INCREASED BY 1 MEV USING THE HIGH PRECISION PSI-PRIME MASS        2/82
M   A  MEASUREMENT OF ZHOLENTZ 80 TO ELIMINATE THE ABSOLUTE SPEAR ENERGY     2/82
M   A  CALIBRATION UNCERTAINTY.                                              2/82
M
M   R  BARTEL 78 FITS ENERGY DEPENDENCE OF CS FOR E+- AND MU+- EVENTS.       7/79
M   R  MASS VALUE NOT DEPENDENT ON WHETHER V-A OR V+A DECAY ASSUMED.         7/79
M          . . . . . . . . . .
M   AVG    1784.2     3.2     AVERAGE

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                 35  TAU MEAN LIFE  (UNITS 10**-13 SEC)

T      77  (90.)   OR LESS  CL=.95   ALEXANDER 79 PLUT E+E- 3.9-5 GEV ECM    7/79
T     594  (23.)   OR LESS  CL=.95   BACINO2   79 DLCO E+E- ECM=3.5-7.4GEV   7/79
T      38  (14.)   OR LESS  CL=.95   BRANDELIK 80 TASS E+E- ECM=30GEV        8/81
T     102    4.6      1.9            FELDMAN   82 SMK2 E+E- ECM=29 GEV       1/82
T     131    4.9      2.0            FORD      82 MAC  E+E- ECM=28,29 GEV   11/82*
T     143    4.7      3.9      2.9   BEHREND2  83 CELL E+E- ECM=22,34 GEV   11/83*
T     156    3.20     0.54           JAROS     83 SMK2 E+E- ECM=29 GEV      10/83*
T          . . . . . . . . . .
T   AVG      3.43     0.50    AVERAGE                                        3/84*

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                 35  TAU PARTIAL DECAY MODES

                                                             DECAY MASSES
P1      TAU+- INTO MU+- NUMU NUTAU                          106+   0+   0
P2      TAU+- INTO E+- NUE NUTAU                            .511+   0+   0
P7      TAU+- INTO HADRON+- NEUTRAL(S)
P8      TAU+- INTO 3 HADRONS+- NEUTRAL(S)
P9      TAU+- INTO NUTAU RHO0 PI+-                            0+ 769+ 140
P10     TAU+- INTO NUTAU A1(1100)+-                           0+1275
P11     TAU+- INTO K+- NEUTRAL(S)
P12     TAU+- INTO NUTAU PI+-                                 0+ 140
P13     TAU+- INTO NUTAU 2PI+- PI-+ (INCL. P9, P10)           0+ 140+ 140+ 140
P14     TAU+- INTO NUTAU 2PI+- PI-+ (PI0S) (INCL. P13)        0+ 140+ 140+ 140
P15     TAU+- INTO NUTAU .GE.3HADRONS+- NEUTRAL(S)
P16     TAU+- INTO NUTAU RHO+-                                0+ 769
P17     TAU+- INTO 3 HADRONS+- NUTAU
P18     TAU+- INTO 3 HADRONS+- NUTAU GAMMA(S)
P19     TAU+- INTO HADRON+- (NOT RHO+-, PI+-) NEUTRAL(S)
P20     TAU+- INTO 5 HADRONS+- NEUTRAL(S)
P21     TAU+- INTO NUTAU K*(892)                              0+ 892
P22     TAU+- INTO NUTAU K*(1430)                             0+1425
P23     TAU+- INTO NUTAU K+-                                  0+ 494

        LEPTON FAMILY NUMBER VIOLATING MODES.
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P31     TAU+- INTO MU+- GAMMA                               106+   0
P32     TAU+- INTO E+- GAMMA                                .511+   0
P33     TAU+- INTO MU+- CHARGED PARTICLES
P34     TAU+- INTO E+- CHARGED PARTICLES
P35     TAU+- INTO MU+- MU+ MU-                             106+ 106+ 106
P36     TAU+- INTO E+- MU+ MU-                              .511+ 106+ 106
P37     TAU+- INTO MU+- E+ E-                               106+.511+.511
P38     TAU+- INTO E+- E+ E-                                .511+.511+.511
P39     TAU+- INTO MU+- PI0                                 106+ 135
P40     TAU+- INTO E+- PI0                                  .511+ 135
P41     TAU+- INTO MU+- K0                                  106+ 498
P42     TAU+- INTO E+- K0                                   .511+ 498
P43     TAU+- INTO MU+- RHO0                                106+ 769
P44     TAU+- INTO E+- RHO0                                 .511+ 769
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FITTED PARTIAL DECAY MODE BRANCHING FRACTIONS

The matrix below is derived from the error matrix for the fitted partial decay mode branching fractions, P_i, as follows: The diagonal elements are $P_i \pm \delta P_i$, where $\delta P_i = \sqrt{\langle \delta P_i \delta P_i \rangle}$, while the off-diagonal elements are the normalized correlation coefficients $\langle \delta P_i \delta P_j \rangle / (\delta P_i \cdot \delta P_j)$. For the definitions of the individual P_i, see the listings above; only those P_i appearing in the matrix are assumed in the fit to be nonzero and are thus constrained to add to 1.

```
        P 1         P 2         P12         P16         P17         P18         P19
P 1  .1845+-.0114
P 2   -.1141    .1646+-.0094
P12    .0145     -.1273    .1034+-.0125
P16   -.1190     -.1179      .0150    .2215+-.0242
P17    .0029      .0023     -.0003      -.0007   .0532+-.0409
P18    .0056      .0044     -.0006      -.0013     -.9476   .1171+-.0416
P19   -.2544     -.1233     -.3746      -.6963     -.0481     -.0927  .1557+-.0314

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                    35  TAU BRANCHING RATIOS

R1      TAU+- INTO (MU+- NUMU NUTAU)/TOTAL                  (P1)
R1      220    0.15     0.03            BURMEST1  77 PLUT ASSUMES V-A DECAY    12/77
R1             0.175    0.040           PERL      77 SMAG   E+E- TO MU+- X-+  12/77
R1             0.22     0.10      0.07  CAVALLISF 77 SPEC   E+E- TO MU+- X-+   1/78
R1       11    0.22     0.07      0.08  SMITH     78 SPEC   E+E- TO MU+MU-X0   7/79
R1             0.35     0.14            BRANDELIK 80 TASS   E+E- ECM=30GEV     8/81
R1             0.178    0.027           BERGER    81 PLUT   E+E- 9-32GEV ECM   1/82
R1    E  47    0.176    0.033           BEHREND   83 CELL   E+E- ECM=34 GEV. 11/83*
R1    E  STATISTICAL AND SYSTEMATIC ERRORS COMBINED IN QUADRATURE.             11/83*
R1          . . . . . . . . . .
R1   AVG       0.175    0.015   AVERAGE
R1   FIT       0.185    0.011   FROM FIT

R2      TAU+- INTO (E+- NUE NUTAU)/TOTAL                    (P2)
R2    B 459    0.160    0.013           BACINO    78 DLCO E+E- ECM=3.1-7.4GEV  1/79
R2             0.19     0.09            BRANDELIK 80 TASS E+E- ECM=30GEV       8/81
R2    E  60    0.183    0.031           BEHREND   83 CELL E+E- ECM=34 GEV.    11/83*
R2    B  BACINO 78 VALUE COMES FROM FIT TO EVENTS WITH E+- AND 1 OTHER          1/79
R2    B  NONELECTRON CHARGED PRONG.                                            1/79
R2    E  STATISTICAL AND SYSTEMATIC ERRORS COMBINED IN QUADRATURE.             11/83*
R2          . . . . . . . . . .
R2   AVG       0.164    0.012   AVERAGE
R2   FIT       0.1646   0.0094 FROM FIT

R3      TAU+- INTO (L+- NUL NUTAU)/TOTAL                    SQRT(P1*P2)
R3       WHERE L MEANS E OR MU.  EQUALITY OF E AND MU MODES IS ASSUMED.
R3    P 105    0.17     0.06      0.03  PERL      76 SMAG                      3/77
R3    B 144    0.186    0.030           PERL      77 SMAG                     12/77
R3    B  21    0.224    0.055           BARBARO-G 77 SMAG                     11/77
R3    B  13    0.182    0.031           BRANDELIK 78 DASP ASSUMES V-A DECAY    3/78
R3    B  WE HAVE COMBINED STATISTICAL AND SYSTEMATIC ERRORS QUADRATICALLY.     3/78
R3    P  ASSUMES V-A COUPLING, TAU MASS=1.8 GEV, TAU NEUTRINO MASS=0.
R3    B  ASSUMES V-A COUPLING, TAU MASS=1.9 GEV, TAU NEUTRINO MASS=0.
R3          . . . . . . . . . .
R3   AVG       0.186    0.018   AVERAGE
R3   FIT       0.1743   0.0069 FROM FIT

R4      TAU+- INTO E+- NUE NUTAU/MU+- NUMU NUTAU            (P2)/(P1)
R4       PREDICTED TO BE 1 FOR SEQUENTIAL LEPTON, 2 FOR PARAELECTRON,
R4       AND 1/2 FOR PARAMUON. PARAELECTRON ALSO RULED OUT BY HEILE 78.
R4       21    0.92     0.37            BURMEST2  77 PLUT ASSUMES V-A DECAY   12/77
R4    B  18    1.09     0.38            BRANDELIK 78 DASP E+E- 3.1-5.2GEV ECM 12/78
R4    L 154    0.75     0.23            BLOCKER1  82 SMK2 E+E- ECM=3.5-6.7GEV  2/82
R4    B  BRANDELIK 78 QUOTES THE INVERSE OF THIS RATIO AS .92+-.32 .          12/78
R4    L  BLOCKER 82 GIVES THE INVERSE OF THIS RATIO AS 1.33+-.18+-.36 .        2/82
R4          . . . . . . . . . .
R4   AVG       0.86     0.17    AVERAGE
R4   FIT       0.892    0.079   FROM FIT

R5      TAU+- INTO (MU+- NUMU NUTAU)*(E+- NUE NUTAU)        (P1)*(P2)
R5            (0.034)  (0.006)          ABRAMS    79 SMK2 REPL BY BLOCKER 82  12/79
R5    B  20    0.034    0.009           BACINO1   79 DLCO E+E- ECM=3.6-7.4GEV  1/79
R5      257    0.030    0.005           BLOCKER1  82 SMK2 E+E- ECM=3.5-6.7GEV  2/82
R5    B  BACINO1 79 QUOTES BR(MU)=0.21+-0.058(STAT.+SYST. ERRORS COMBINED IN   1/79
R5    B  QUADRATURE) ASSUMING BR(E)=0.16.  WE MPY. BY 0.16 TO GET ABOVE VAL.   1/79
R5          . . . . . . . . . .
R5   AVG       0.0309   0.0044  AVERAGE
R5   FIT       0.0304   0.0024 FROM FIT

R8      TAU+- INTO (HADRON+- NEUTRAL(S))/(TOTAL)            (P12+P16+P19)     11/77
R8       19    0.45     0.19            BARBARO-G 77 SMAG                     11/77
R8             0.29     0.11            BRANDELIK 78 DASP ASSUMES V-A DECAY    3/78
R8   B        (0.22)   (0.14)           BRANDELIK 80 TASS E+E- ECM=30GEV       8/81
R8   B  NOT INDEPENDENT OF BRANDELIK 80 R1, R2 AND R21 VALUES.                 8/81
R8          . . . . . . . . . .
R8   AVG       0.330    0.095   AVERAGE
R8   FIT       0.481    0.020   FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.1)

R9      TAU+- INTO (K+- NEUTRAL(S))/TOTAL                   (P11)
R9    B     SMALL                       BRANDELIK 77 DASP    3.6-5.2ECM E+E-   1/78
R9    B  BRANDELIK 77 FINDS 0.07+-0.06 K+- PER EVT IN E+E- --> E+- PRONG-+.    1/78

R10     TAU+- INTO (3 HADRONS+- NEUTRAL(S))/TOTAL           (P17+P18)
R10            0.35     0.11            BRANDELIK 78 DASP ASSUMES V-A DECAY    3/78
R10      35    0.24     0.06            BRANDELIK 80 TASS E+E- ECM=30 GEV      8/81
R10     186    0.150    0.020           BEHREND   82 CELL E+E- 32-36.8GEV ECM 10/83*
R10 B   152   (0.14)   (0.02)           BLOCKER3  82 SMK2 E+ E- ECM = 29 GEV  10/83*
R10 B   NOT INDEPENDENT OF BLOCKER3 82 ONE-PRONG VALUE (R21).                  10/83*
R10         . . . . . . . . . .
R10 AVG        0.165    0.027   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.5)
R10 FIT        0.170    0.013   FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.2)
                        (SEE IDEOGRAM BELOW)
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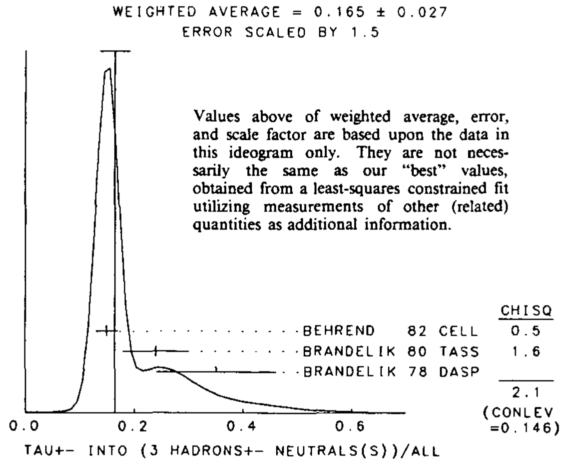

For notation, see key at front of Listings.

Stable Particles

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R11    TAU+- INTO (NUTAU RHO0 PI+-)/TOTAL                (P9)
R11     21   (0.0045) (0.0013)        ALEXAND1  78 PLUT REPL. BY WAGNER 80   3/78
R11     27    0.0054   0.0017         WAGNER    80 PLUT E+E- 4-5 GEV ECM    2/82

R12    TAU+- INTO (NUTAU A1(1100)+-)/TOTAL               (P10)
R12     21   (0.10)   (0.03)          ALEXAND1  78 PLUT REPL. BY WAGNER 80  12/78
R12 W   27   (0.108)  (0.034)          WAGNER    80 PLUT E+E- 4-5 GEV ECM    2/82
R12 W   NOT INDEPENDENT OF WAGNER 80 R11 VALUE ABOVE.  ASSUMES THAT ALL      2/82
R12 W   (NU RHO0 PI+-) EVENTS ARE (NU A1+-) AND BR(L+- NU NU)=               2/82
R12 W   .173+-.013 .                                                         2/82

R13    TAU+- INTO (NUTAU 2PI+- PI-+ (PI0S))/TOTAL        (P17+P18)
R13     ASSUMED EQUAL TO (3 HADRONS+- NEUTRAL(S)) FOR FIT SINCE DECAY
R13     MODES CONTAINING KAONS ARE EXPECTED TO BE CABIBBO SUPPRESSED.
R13     33    0.18     0.065          JAROS     78 SMAG E+E- ECM > 6 GEV    1/79
R13          . . . . . . . . .
R13 FIT       0.170    0.013  FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.2)

R14    TAU+- INTO (NUTAU 2PI+- PI-+)/TOTAL               (P17)
R14    ASSUMED EQUAL TO (3 HADRONS+- NUTAU) FOR FIT SINCE DECAY MODES
R14    CONTAINING KAONS ARE EXPECTED TO BE CABIBBO SUPPRESSED.
R14  J  13    0.07     0.05           JAROS     78 SMAG E+E- ECM > 6 GEV    1/79
R14  J  JAROS 78 EVENTS CONSISTENT WITH BEING RHO PI OR A1.                  1/79
R14          . . . . . . . . .
R14 FIT       0.053    0.041  FROM FIT

R15    TAU+- INTO (NUTAU .GE.3HADRONS+- NEUTRAL(S))      (P17+P18)
R15    692    0.32     0.05           BACINO    78 DLCO E+E- ECM=3.1-7.4GEV  1/79
R15     FOR THE FIT WE ASSUME THAT THIS EQUALS THE BRANCHING FRACTION FOR
R15     (3HADRONS+- NEUTRALS), I.E. THAT THE BRANCHING FRACTION FOR 5 OR
R15     MORE CHARGED HADRONS IS ZERO.
R15          . . . . . . . . .
R15 FIT       0.170    0.013  FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.2)

R16    TAU+- INTO (NUTAU PI+-)*(E+- NUE NUTAU)           (P12)*(P2)
R16  A  23    0.015    0.006          ALEXAND2  78 PLUT E+E- ECM=3.6-5 GEV   2/79
R16  B  10    0.013    0.006          BACINO1   79 DLCO E+E- ECM=3.6-7.4GEV  1/79
R16  A  ALEXANDER2 78 QUOTE BR(PI)=.090+-.038(STAT.+SYST.ERRORS COMBINED IN   2/79
R16  A  QUADRATURE) USING BR(E)=.167+-.010. WE MPY. BY .167 TO GET ABV.VAL.   2/79
R16  B  BACINO1 79 QUOTES BR(PI)=0.080+-0.035(STAT.+SYST.ERRORS COMBINED IN   1/79
R16  B  QUADRATURE) ASSUMING BR(E)=0.16.  WE MPY. BY 0.16 TO GET ABOVE VAL.   1/79
R16          . . . . . . . . .
R16 AVG       0.0140   0.0042  AVERAGE
R16 FIT       0.0170   0.0022 FROM FIT

R17    TAU+- INTO (NUTAU RHO+-)*(E+- NUTAU NUE)          (P16)*(P2)          12/79
R17           (0.0421) (0.0090)        ABRAMS    79 SMK2 REPL. BY BLOCKER 80 12/79
R17    139    0.034    0.008          BLOCKER   80 SMK2 E+E- ECM=3.5-6.7GEV  2/82
R17          . . . . . . . . .
R17 FIT       0.0365   0.0043 FROM FIT

R18    TAU+- INTO (NUTAU RHO+-)*(MU+- NUTAU NUMU)        (P16)*(P1)          12/79
R18           (0.0329) (0.0100)        ABRAMS    79 SMK2 REPL. BY BLOCKER 80 12/79
R18    103    0.041    0.009          BLOCKER   80 SMK2 E+E- ECM=3.5-6.7GEV  2/82
R18          . . . . . . . . .
R18 FIT       0.0409   0.0049 FROM FIT

R19    TAU+- INTO (3 HADRONS+- NUTAU)/TOTAL              (P17)                8/81
R19 B         (0.09)   (0.06)          BRANDELIK 80 TASS E+E- ECM=30GEV      8/81
R19 B  NOT INDEPENDENT OF BRANDELIK 80 R10 AND R20 VALUES.                    8/81
R19          . . . . . . . . .
R19 FIT       0.053    0.041  FROM FIT

R20    TAU+- INTO (3 HADRONS+- NUTAU GAMMA(S))/TOTAL     (P18)
R20           0.15     0.07           BRANDELIK 80 TASS E+E- ECM=30GEV      8/81
R20          . . . . . . . . .
R20 FIT       0.117    0.042  FROM FIT

R21    TAU+- INTO (1 CHARGED NEUTRAL(S))/TOTAL           (P1+P2+P12+P16+P19)  8/81
R21     37    0.76     0.06           BRANDELIK 80 TASS E+E- ECM=30GEV      8/81
R21    672    0.840    0.020          BEHREND   82 CELL E+E- 32-36.8GEV ECM 10/83*
R21  B 764    0.86     0.022          BLOCKER3  82 SMK2 E+ E- ECM = 29 GEV  10/83*
R21  B  SYSTEMATIC AND STATISTICAL ERRORS COMBINED IN QUADRATURE.            10/83*
R21          . . . . . . . . .
R21 AVG       0.844    0.016   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.1)
R21 FIT       0.830    0.013  FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.2)

R22    TAU+- INTO (5 HADRONS+- NEUTRAL(S))/TOTAL         (P20)                8/81
R22           (0.06) OR LESS  CL=.95   BRANDELIK 80 TASS E+E- ECM=30GEV      8/81
R22  B  10    0.010    0.004          BEHREND   82 CELL E+E- 32-36.8GEV ECM 10/83*
R22  B   2    0.005 OR LESS  CL=.95    BLOCKER3  82 SMK2 E+ E- ECM = 29 GEV  10/83*
R22  B  IN THE STABLE PARTICLE TABLES WE QUOTE AN UPPER LIMIT 0.014 OR LESS   3/84*

R23    TAU+- INTO (NUTAU K*(892)+-)/TOTAL                (P21)               12/81
R23     11    0.017    0.007          DORFAN    81 SMK2 E+E- 4.2-6.7GEV ECM 12/81

R24    TAU+- INTO (NUTAU K*(1430)+-)/TOTAL               (P22)               12/81
R24      0    0.009 OR LESS  CL=.95   DORFAN    81 SMK2 E+E- 4.2-6.7GEV ECM 12/81

R25    TAU+- INTO (NUTAU PI+-)/TOTAL                     (P12)
R25   1138    0.117    0.019          BLOCKER1  82 SMK2 E+E- ECM=3.5-6.7GEV  2/82
R25  E  34    0.099    0.021          BEHREND   83 CELL E+E- ECM=34 GEV.    11/83*
R25  E  STATISTICAL AND SYSTEMATIC ERRORS COMBINED IN QUADRATURE.            11/83*
R25          . . . . . . . . .
R25 AVG       0.109    0.014   AVERAGE
R25 FIT       0.103    0.012  FROM FIT

R26    TAU+- INTO (NUTAU 2PI+- PI-+ NON-RES.)/TOTAL      (P13-P9)
R26           (0.014)OR LESS  CL=.95   WAGNER    80 PLUT E+E- 4-5 GEV ECM     2/82

R27    TAU+- INTO (NUTAU K+-)/TOTAL                      (P23)               11/82*
R27     15    0.013    0.005          BLOCKER2  82 SMK2 E+E- ECM=3.9-6.7GEV 11/82*

R28    TAU+- INTO (NUTAU RHO+-)/TOTAL                    (P16)
R28  E 101    0.228    0.033          BEHREND   83 CELL E+E- ECM=34 GEV.    11/83*
R28  E  STATISTICAL AND SYSTEMATIC ERRORS COMBINED IN QUADRATURE.            11/83*
R28          . . . . . . . . .
R28 FIT       0.221    0.024  FROM FIT

R51    TAU+- INTO(MU+- GAMMA(S) + E+- GAMMA(S))/TOTAL    (P31+P32)
R51     TEST OF LEPTON FAMILY NUMBER CONSERVATION
R51  B        (0.12) OR LESS  CL=.90   BURMEST2  77 PLUT E+E- 4-5 GEV ECM    12/77
R51  B  ASSUMES SAME MU,E MOM. SPEC. AS (MU E + NOTHING DETECTED).            12/77

R52    TAU+- INTO(MU+- CHGD. PARTS. + E+- CHGD. PARTS.)/TOTAL (P33+P34)
R52     TEST OF LEPTON FAMILY NUMBER CONSERVATION
R52  B         0.04  OR LESS  CL=.90   BURMEST2  77 PLUT E+E- 4-5 GEV ECM    12/77
R52  B  ASSUMES SAME MU,E MOM. SPEC. AS (MU E + NOTHING DETECTED).            12/77

R53    TAU+- INTO (MU+- GAMMA)/TOTAL                     (P31)
R53     TEST OF LEPTON FAMILY NUMBER CONSERVATION
R53         5.5E-4  OR LESS  CL=.90   HAYES     82 SMK2 E+E- 3.8-6.8GEV ECM  4/82

R54    TAU+- INTO (E+- GAMMA)/TOTAL                      (P32)
R54     TEST OF LEPTON FAMILY NUMBER CONSERVATION
R54         6.4E-4  OR LESS  CL=.90   HAYES     82 SMK2 E+E- 3.8-6.8GEV ECM  4/82

R55    TAU+- INTO (MU+- MU+ MU-)/TOTAL                   (P35)
R55     TEST OF LEPTON FAMILY NUMBER CONSERVATION
R55         4.9E-4  OR LESS  CL=.90   HAYES     82 SMK2 E+E- 3.8-6.8GEV ECM  4/82

R56    TAU+- INTO (E+- MU+ MU-)/TOTAL                    (P36)
R56     TEST OF LEPTON FAMILY NUMBER CONSERVATION
R56         3.3E-4  OR LESS  CL=.90   HAYES     82 SMK2 E+E- 3.8-6.8GEV ECM  4/82

R57    TAU+- INTO (MU+- E+ E-)/TOTAL                     (P37)
R57     TEST OF LEPTON FAMILY NUMBER CONSERVATION
R57         4.4E-4  OR LESS  CL=.90   HAYES     82 SMK2 E+E- 3.8-6.8GEV ECM  4/82

R58    TAU+- INTO (E+- E+ E-)/TOTAL                      (P38)
R58     TEST OF LEPTON FAMILY NUMBER CONSERVATION
R58         4.0E-4  OR LESS  CL=.90   HAYES     82 SMK2 E+E- 3.8-6.8GEV ECM  4/82

R59    TAU+- INTO (MU+- PI0)/TOTAL                       (P39)
R59     TEST OF LEPTON FAMILY NUMBER CONSERVATION
R59         8.2E-4  OR LESS  CL=.90   HAYES     82 SMK2 E+E- 3.8-6.8GEV ECM  4/82

R60    TAU+- INTO (E+- PI0)/TOTAL                        (P40)
R60     TEST OF LEPTON FAMILY NUMBER CONSERVATION
R60         2.1E-3  OR LESS  CL=.90   HAYES     82 SMK2 E+E- 3.8-6.8GEV ECM  4/82

R61    TAU+- INTO (MU+- K0)/TOTAL                        (P41)
R61     TEST OF LEPTON FAMILY NUMBER CONSERVATION
R61         1.0E-3  OR LESS  CL=.90   HAYES     82 SMK2 E+E- 3.8-6.8GEV ECM  4/82

R62    TAU+- INTO (E+- K0)/TOTAL                         (P42)
R62     TEST OF LEPTON FAMILY NUMBER CONSERVATION
R62         1.3E-3  OR LESS  CL=.90   HAYES     82 SMK2 E+E- 3.8-6.8GEV ECM  4/82

R63    TAU+- INTO (MU+- RHO0)/TOTAL                      (P43)
R63     TEST OF LEPTON FAMILY NUMBER CONSERVATION
R63         4.4E-4  OR LESS  CL=.90   HAYES     82 SMK2 E+E- 3.8-6.8GEV ECM  4/82

R64    TAU+- INTO (E+- RHO0)/TOTAL                       (P44)
R64     TEST OF LEPTON FAMILY NUMBER CONSERVATION
R64         3.7E-4  OR LESS  CL=.90   HAYES     82 SMK2 E+E- 3.8-6.8GEV ECM  4/82

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                    35  TAU DECAY PARAMETERS

RHO    RHO (MICHEL) PARAMETER        (V-A THEORY PREDICTS RHO=0.75)
RHO    594    0.72     0.15           BACINO2   79 DLCO E+E- ECM=3.5-7.4GEV  3/83*

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                              REFERENCES FOR TAU(1785) HEAVY LEPTON

PERL      75 PRL 35 1489      +ABRAMS,BOYARSKI,BREIDENBACH +   (LBL+SLAC)
PERL      76 PL 63B 466       +FELDMAN,ABRAMS,ALAM,BOYARSKI +  (SLAC+LBL)

BARBARO-  77 PRL 39 1058      BARBARO-GALTIERI+       (LBL+NWES+SLAC+HAWA)
BRANDELI  77 PL 70B 125       BRANDELIK +       (AACH+DESY+HAMB+MPIM+TOKY)
BURMEST1  77 PL 68B 297       BURMESTER,CRIEGEE +   (DESY+HAMB+SIEG+WUPG)
BURMEST2  77 PL 68B 301       BURMESTER,CRIEGEE +   (DESY+HAMB+SIEG+WUPG)
CAVALLIS  77 LNC 20 337       CAVALLI-SFORZA,GOGGI +       (PAVI+PRIN+UMD)
PERL      77 PL 70B 487       +FELDMAN,ABRAMS,ALAM,BOYARSKI+   (SLAC+LBL)

ALEXAND1  78 PL 73B 99        ALEXANDER,CRIEGEE+    (DESY+AACH+SIEG+WUPG)
ALEXAND2  78 PL 78B 162       ALEXANDER+        (DESY+AACH+HAMB+SIEG+WUPG)
BACINO    78 PRL 41 13        +FERGUSON,NODULMAN +   (UCLA+SLAC+UCI+STON)J
    ALSO  78 TOKYO CONF. P.249 J.KIRZ(19TH INTL.CONF. ON HEP)       (STON)
    ALSO  80 PL 96B 214       ZHOLENTZ,KURDADZE,LELCHUK,MISHNEV+   (NOVO)
BARTEL    78 PL 77B 331       +DITTMANN,DUINKER,OLSSON,ONEILL+(DESY+HEID)

BRANDELI  78 PL 73B 109       BRANDELIK +     (AACH+DESY+HAMB+ MPIM+TOKY)J
HEILE     78 NP B138 189      +PERL,ABRAMS,ALAM,BOYARSKI+      (SLAC+LBL)
JAROS     78 PRL 40 1120      +ABRAMS,ALAM+          (SLAC+LBL+NWES+HAWA)
SMITH     78 PR D18 1         +FORD,MORSE,MANN,RESVANIS+ (COLO+PENN+WISC)

ABRAMS    79 PRL 43 1555      +ALAM,BLOCKER,BOYARSKI+          (SLAC+LBL)
ALEXANDE  79 PL 81B 84        ALEXANDER +       (DESY+AACH+HAMB+SIEG+WUPP)
ALLES     79 NCL 25 404       W.ALLES                                (BGNA)J
BACINO1   79 PRL 42 6         +FERGUSON,NODULMAN +   (UCLA+SLAC+UCI+STON)
BACINO2   79 PRL 42 749       +FERGUSON,NODULMAN+    (UCLA+SLAC+UCI+STON)

BLOCKER   80  LBL-10801,THESIS C.A.BLOCKER                            (LBL)
BRANDELI  80 PL 92B 199       BRANDELIK + (AACH+BONN+DESY+HAMB+LOIC+OXF+)
WAGNER    80 ZPHY C3 193      +ALEXANDER+       (AACH+DESY+HAMB+SIEG+WUPG)
ZHOLENTZ  80 PL 96B 214       +KURDADZE,LELCHUK,MISHNEV,NIKITIN+   (NOVO)
    ALSO  81 YAD.PHYS.34 1471 ZHOLENTZ +                            (NOVO)
BERGER    81 PL 99B 489       +GENZEL+(AACH+BERG+DESY+HAMB+UMD+SIEG+WUPG)
DORFAN    81 PRL 46 215       +BLOCKER,ABRAMS,ALAM +           (SLAC+LBL)

BEHREND   82 PL 114B 282      +CHEN+       (DESY+KARL+MPIM+LALO+LPNP+SACL)
BLOCKER1  82 PL 109B 119      +DORFAN,ABRAMS,ALAM,BLONDEL+     (LBL+SLAC)J
BLOCKER2  82 PRL 48 1586      +ABRAMS,ALAM,BLONDEL,BOYARSKI +  (SLAC+LBL)
BLOCKER3  82 PRL 49 1369      +LEVI,ABRAMS,AMIDEI,BACKER+ (HARV+LBL+SLAC)
FELDMAN   82 PRL 48 66        +TRILLING,ABRAMS,AMIDEI+    (SLAC+LBL+HARV)
FORD      82 PRL 49 106       +SMITH+(COLO+FRAS+NEAS+STAN+SLAC+UTAH+WISC)
HAYES     82 PR D25 2869      +PERL,ALAM,BOYARSKI,BREIDENBACH+ (SLAC+LBL)

BEHREND   83 PL 127B 270      +CHEN+       (DESY+KARL+MPIM+LALO+LPNP+SACL)
BEHREND2  83 NP B211 369      +CHEN+       (DESY+KARL+MPIM+LALO+LPNP+SACL)
JAROS     83 PRL 51 955       +AMIDEI,TRILLING+            (SLAC+LBL+HARV)

                              REVIEWS

PERL2     77 HAMBURG SYMP.    ALSO ISSUED AS SLAC-PUB-2022, M.PERL (SLAC)
FLUGGE    77 MESON CONF.BOSTON ALSO ISSUED AS DESY 77-35, G.FLUGGE  (DESY)

AZIMOV    78 SPU 21 225       +FRANKFURT,KHOZE                        (LENI)
FELDMAN   78 TOKYO CONF.,P.777 G.J.FELDMAN (19TH INTL. CONF. ON HEP)(SLAC)J
PERL      78 SLAC-PUB-2219    M.L.PERL (KARLSRUHE SUMMER INST.1978)(SLAC)

FLUGGE    79 ZPHY C1 121      G.FLUGGE                                (DESY)
KIRKBY    79  SLAC-PUB-2419   J.KIRKBY(LEPTON PHOTON SYMP. BATAVIA)(SLAC)J
PERL      80 ARNPS 30 299     M.L.PERL                                (SLAC)

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Stable Particles

SEARCHES FOR MASSIVE ν'S & LEPTON MIXING

Data Card Listings

SEARCHES FOR MASSIVE NEUTRINOS AND LEPTON MIXING

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        SEE THE NOTE ON NEUTRINOS BY R.E. SHROCK IN THE ELECTRON NEUTRINO
        SECTION NEAR THE BEGINNING OF THESE DATA CARD LISTINGS.

        SEARCHES FOR INDIRECT EFFECTS OF NEUTRINO MASSES AND LEPTON MIXING
        ARE LISTED HERE.  DIRECT SEARCHES FOR MASSES OF DOMINANTLY COUPLED
        NEUTRINOS ARE LISTED IN THE APPROPRIATE SECTION ON NU-MU, NU-E,
        OR NU-TAU.  RESULTS OF THESE INDIRECT SEARCHES ARE CORRELATED
        UPPER BOUNDS ON MIXING MATRIX COEFFICIENTS U(A,J) VERSUS
        NEUTRINO MASS.  THESE RESULTS ARE DIVIDED INTO THREE SECTIONS--
              (A) BOUNDS FROM PARTICLE AND NUCLEAR DECAYS
              (B) BOUNDS FROM NEUTRINO REACTIONS
              (C) SEARCHES FOR NEUTRINOLESS DOUBLE BETA DECAY

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                    5  (A).  BOUNDS FROM PARTICLE AND NUCLEAR DECAYS

U1J    LIMITS ON CABS(U(1,J))**2 AS FUNCTION OF MASS(NU-J)
U1J
U1J    APPLICATION OF PEAK SEARCH TEST TO EXISTING DATA.
U1J  D       1.      OR LESS  CL=.95   SIMPSON   81       M(NU-J)=0.1 KEV      1/82
U1J  D       4. E-3  OR LESS  CL=.95   SIMPSON   81             =10 KEV        1/82
U1J  A       0.1     OR LESS  CL=.68   SHROCK    80       M(NU-J)=0.1-3 MEV    1/82
U1J  B       1. E-4  OR LESS  CL=.68   SHROCK1   81       M(NU-J)=10 MEV       1/82
U1J  B       5. E-6  OR LESS  CL=.68   SHROCK1   81             =60 MEV        1/82
U1J  C       1. E-5  OR LESS  CL=.68   SHROCK    80       M(NU-J)=80 MEV       1/82
U1J  C       3. E-6  OR LESS  CL=.68   SHROCK    80             =160 MEV       1/82
U1J  D  APPLICATION OF KINK SEARCH TEST TO TRITIUM BETA DECAY KURIE PLOT.      1/82
U1J  A  APPLICATION OF TEST TO SEARCH FOR KINKS IN BETA DECAY KURIE PLOTS.     1/82
U1J  B  ANALYSIS OF (PI+ --> E+ NU-E)/(PI+ --> MU+ NUMU) AND                   1/82
U1J  B  (K+ --> E+ NUE)/(K+ --> MU+ NUMU) DECAY RATIOS.                        1/82
U1J  C  ANALYSIS OF (K+ --> E+ NUE) SPECTRUM.                                  1/82
U1J
U1J    NEW EXPERIMENTS TO APPLY PEAK AND KINK SEARCH TESTS.
U1J          1. E-4  OR LESS  CL=.90   BRYMAN    83 CNTR M(NU-J)=5 MEV        12/83*
U1J          1.5E-6  OR LESS  CL=.90   BRYMAN    83 CNTR        =53 MEV       12/83*
U1J          1. E-5  OR LESS  CL=.90   BRYMAN    83 CNTR        =70 MEV       12/83*
U1J          1. E-4  OR LESS  CL=.90   BRYMAN    83 CNTR        =130 MEV      12/83*
U1J
U1J    SEARCHES FOR DECAYS OF MASSIVE NEUTRINOS
U1J  B       1. E-2  OR LESS  CL=.90   BERGSMA   83 CNTR M(NU-J)=10 MEV        12/83*
U1J  B       1. E-5  OR LESS  CL=.90   BERGSMA   83 CNTR        =110 MEV      12/83*
U1J  B       6. E-7  OR LESS  CL=.90   BERGSMA   83 CNTR        =410 MEV      12/83*
U1J          1. E-5  OR LESS  CL=.90   GRONAU    83       M(NU-J)=160 MEV      2/84*
U1J          1. E-6  OR LESS  CL=.90   GRONAU    83       M(NU-J)=480 MEV      2/84*
U1J  B  BERGSMA 83 ALSO QUOTE LIMITS ON CABS(U(1,3))**2 WHERE THE INDEX 3      2/84*
U1J  B  REFERS TO THE MASS EIGENSTATE DOMINANTLY COUPLED TO THE TAU.  THOSE    2/84*
U1J  B  LIMITS ARE SENSITIVE TO ASSUMPTIONS ABOUT F PRODUCTION AND F MASS.     2/84*
U1J  B  A 1970 MEV F MASS WOULD WEAKEN THESE LIMITS AND WOULD GIVE NO          2/84*
U1J  B  LIMIT FOR NU-TAU MASS ABOVE 190 MEV.                                   2/84*
U1J
U1J    KINK SEARCH IN NUCLEAR BETA DECAY
U1J          2.5E-2  OR LESS  CL=.90   SCHRECKEN 83 CNTR M(NU-J)=30 KEV       2/84*
U1J          0.4E-2  OR LESS  CL=.90   SCHRECKEN 83 CNTR        =140 KEV      2/84*
U1J          0.8E-2  OR LESS  CL=.90   SCHRECKEN 83 CNTR        =440 KEV      2/84*

U2J    LIMITS ON CABS(U(2,J))**2 AS FUNCTION OF MASS(NU-J)
U2J
U2J    APPLICATION OF PEAK SEARCH TEST TO EXISTING DATA.
U2J  A       5. E-2  OR LESS  CL=.95   SHROCK    80       M(NU-J)=4-6 MEV      1/82
U2J  A       3. E-2  OR LESS  CL=.95   SHROCK1   81       M(NU-J)=7 MEV        1/82
U2J  A       1. E-2  OR LESS  CL=.95   SHROCK1   81             =13 MEV        1/82
U2J  A       1. E-4  OR LESS  CL=.68   SHROCK1   81       M(NU-J)=13 MEV       1/82
U2J  A       3. E-5  OR LESS  CL=.68   SHROCK1   81             =33 MEV        1/82
U2J  B       6. E-3  OR LESS  CL=.68   SHROCK1   81       M(NU-J)=80 MEV       1/82
U2J  B       5. E-3  OR LESS  CL=.68   SHROCK1   81             =120 MEV       1/82
U2J  C       6. E-6  OR LESS  CL=.95   ASANO     81       M(NU-J)=240 MEV      1/82
U2J  C       5. E-7  OR LESS  CL=.95   ASANO     81             =280 MEV       1/82
U2J  C       6. E-6  OR LESS  CL=.95   ASANO     81             =300 MEV       1/82
U2J
U2J    NEW EXPERIMENTS TO APPLY PEAK SEARCH TEST.
U2J  D       1. E-1  OR LESS  CL=.90   ABELA     81       M(NU-J)=4 MEV        1/82
U2J  D       7. E-5  OR LESS  CL=.90   ABELA     81             =11 MEV        1/82
U2J  D       2. E-4  OR LESS  CL=.90   ABELA     81       M(NU-J)=11 MEV       1/82
U2J  D       2. E-5  OR LESS  CL=.90   ABELA     81             =16 MEV        1/82
U2J  D       2. E-5  OR LESS  CL=.90   ABELA     81       M(NU-J)=16-30 MEV    1/82
U2J  D       1. E-2  OR LESS  CL=.95   CALAPRICE 81       M(NU-J)=7 MEV        1/82
U2J  D       3. E-3  OR LESS  CL=.95   CALAPRICE 81             =33 MEV        1/82
U2J  E       2. E-5  OR LESS  CL=.95   ASANO     81       M(NU-J)=170 MEV      1/82
U2J  E       3. E-6  OR LESS  CL=.95   ASANO     81             =210 MEV       1/82
U2J  E       3. E-6  OR LESS  CL=.95   ASANO     81             =230 MEV       1/82
U2J  E       1. E-4  OR LESS  CL=.90   HAYANO    82       M(NU-J)=70 MEV       11/82*
U2J  E       9. E-7  OR LESS  CL=.90   HAYANO    82             =250 MEV       11/82*
U2J  E       5. E-6  OR LESS  CL=.90   HAYANO    82             =330 MEV       11/82*
U2J  A  ANALYSIS OF MAG. SPEC. EXP., BC EXP. AND EMUL. EXP. ON PI+ --> MU+     1/82
U2J  A  NU-MU DECAY.                                                           1/82
U2J  B  ANALYSIS OF MAG. SPEC. EXP. ON K-->MU,NUMU DECAY.                      1/82
U2J  C  ANALYSIS OF EXP. ON K+ --> MU+ NU-MU NU-X ANU-X DECAY.                 1/82
U2J  D  PI+ --> MU+ NU-MU  PEAK SEARCH EXP.                                    1/82
U2J  E  K+ --> MU+ NU-MU  PEAK SEARCH EXP.                                     1/82
U2J
U2J    PEAK SEARCH IN MUON-CAPTURE
U2J    LIMIT ON CABS(U(2,J))**2 AS FUNCTION OF MASS(NU-J)
U2J        (1.E-1)  OR LESS            DEUTSCH   83       M(NU-J)=45 MEV       12/83*
U2J        (7.E-3)  OR LESS            DEUTSCH   83             =70 MEV        12/83*
U2J        (1.E-1)  OR LESS            DEUTSCH   83             =85 MEV        12/83*

UAJ    LIMITS ON CABS(U(A,J))**2, WHERE A=1,2, FROM RHO PARAM. IN MU DECAY.
UAJ          1. E-2  OR LESS  CL=.68   SHROCK2   81       M(NU-J)=10 MEV       1/82
UAJ          2. E-3  OR LESS  CL=.68   SHROCK2   81             =40 MEV        1/82
UAJ          4. E-2  OR LESS  CL=.68   SHROCK2   81             =70 MEV        1/82

PRO    LIMITS ON CABS(U(1,J)*U(2,J)) AS FUNCTION OF MASS(NU-J)
PRO
PRO          1. E-2  OR LESS  CL=.90   BERGSMA   83 CNTR M(NU-J)=10 MEV        12/83*
PRO          1. E-5  OR LESS  CL=.90   BERGSMA   83 CNTR        =140 MEV      12/83*
PRO          7. E-7  OR LESS  CL=.90   BERGSMA   83 CNTR        =370 MEV      12/83*

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                    5  (B).  BOUNDS FROM NEUTRINO REACTIONS

------ --------- -- 5  SOLAR NEUTRINO EXPERIMENTS  ---- --------- --------

S      SOLAR NU FLUX (UNITS, SNU)
S      (1 SOLAR NEUTRINO UNIT, SNU, =1.E-36 CAPTURES/SEC/TARGET ATOM)
S            (7.3)    (1.5)          BAHCALL   80          THEOR.CALC.FLUX    1/82
S             2.1      0.3           DAVIS     81          MEAS. FLUX         1/82
S            (7.0)    (3.0)          FILIPPONE 82          THEOR.CALC.FLUX    1/82
S       SEE ALSO THE REVIEW BY BAHCALL 82 AND THE ANALYSIS BY EHRLICH 82.     12/83*

------ --------- -- 5  DEEP MINE EXPERIMENTS  --------- --------- --------

DM     R= (MEASURED FLUX OF NU-MU)/(EXPECTED FLUX OF NU-MU)
DM            0.62     0.17          CROUCH    78          CASE WEST/UCI      1/82
DM   B        0.95     0.22          BOLIEV    81          BAKSAN             12/83*
DM   B  FROM THIS DATA BOLIEV 81 OBTAIN THE LIMIT DELTA(M**2) .LE. 6.E-3      12/83*
DM   B  EV**2 FOR MAXIMAL MIXING, NU(MU) -/-> NU(MU) TYPE OSCILLATION.        12/83*
DM
DM  AVERAGE MEANINGLESS (SCALE FACTOR = 1.2)

------ --------- -- 5  REACTOR ANTINEUTRINO EXPERIMENTS  -------- --------

RD     (EVENTS OBSERVED)/(EVENTS EXPECTED) FROM REACTOR ANU-E EXPTS.
RD  B        (0.89)   (0.15)          BOEHM     80          ANU-E P --> E+ N   1/82
RD A R        0.38     0.21           REINES    80          SEE NOTE A         1/82
RD A R        0.40     0.22           REINES    80          SEE NOTE A         1/82
RD   B        0.955    0.12           KWON      81          ANU-E P --> E+ N   1/82
RD   V        1.05     0.054          VUILLEUMI 82          ANU-E P --> E+ N   11/82*
RD   B  KWON 81 REPRESENTS AN ANALYSIS OF A LARGER SET OF DATA FROM THE        1/82
RD   B  SAME EXPERIMENT AS BOEHM 80. SYST.+STAT. ERRORS COMBINED IN            1/82
RD   B  QUADRATURE.                                                            1/82
RD   A  REINES 80 INVOLVES COMPARISON OF NEUTRAL- AND CHARGED-CURRENT          1/82
RD   A  REACTIONS ANU-E D --> N P ANU-E AND ANU-E D --> N N E+ RSPECTIVELY.    1/82
RD   A  COMBINED ANALYSIS OF REACTOR ANU-E EXPTS. WAS PERFORMED BY             1/82
RD   A  SILVERMAN 81.                                                          1/82
RD   R  THE TWO REINES 80 VALUES CORRESPOND TO THE CALCULATED ANU-E FLUXES     1/82
RD   R  OF AVIGNONE-GREENWOOD AND DAVIS ET AL RESPECTIVELY.                    1/82
RD   V  STATISTICAL AND SYSTEMATIC ERRORS COMBINED IN QUADRATURE.              11/82*

------ --------- -- 5  ACCELERATOR EXPERIMENTS  ------- --------- --------

       BOUNDS ON DELTA(M**2) VS. SIN(2*THETA)**2
       WHERE DELTA(M**2) IS MAGNITUDE OF ( MASS(NU-I)**2 - MASS(NU-J)**2)
       AND THETA IS THE MIXING ANGLE FOR THE SIMPLIFYING ASSUMPTION OF
       MIXING BETWEEN TWO NEUTRINO FAMILIES ONLY.

       EACH EXPERIMENTAL RESULT IS A PLOT GIVING ALLOWED AND EXCLUDED
       REGIONS AS FUNCTIONS OF DELTA(M**2) AND SIN(2*THETA)**2.  WE QUOTE
       TWO REPRESENTATIVE LIMITS FROM EACH PLOT --
          1)  DELTA(M**2) FOR SIN(2*THETA)**2=1.
          2)  SIN(2*THETA)**2 FOR ''LARGE'' DELTA(M**2), I.E. SUFFICIENTLY
              LARGE DELTA(M**2) THAT THE DETECTOR WOULD MEASURE ONLY AN
              EFFECT AVERAGED OVER MANY OSCILLATIONS.
       EXPERIMENTS ARE OF TWO GENERAL TYPES --
          (A) THOSE WHICH SEARCH FOR NU(A)-->NU(B) (B NOT EQUAL A), I.E.
              THE APPEARANCE OF L(B) FROM CHARGED CURRENT REACTION OF A
              NU(A) BEAM.
          (B) THOSE WHICH SEARCH FOR THE 'DISAPPEARANCE' OF PART OF THE
              INITITAL NU(A) BEAM BY COMPARING THE NUMBER OF OBSERVED L(A)
              EVENTS WITH THE NUMBER EXPECTED FROM FLUX CALCULATIONS.
              THESE EXPERIMENTS DO NOT TRY TO OBSERVE THE ANOMALOUS
              L(B)'S.  WE LABEL SUCH EXPERIMENTS AS NU-A -/-> NU-A


NU-MU --> NU-E
D1     DELTA(M**2) FOR SIN(2*THETA)**2=1   (UNITS EV**2)   NU-MU --> NU-E
D1           1.2      OR LESS  CL=.95   BELLOTTI  76 HLBC GGM CERN PS          1/82
D1           1.2      OR LESS  CL=.95   BLIETSCHA 78 HLBC GGM CERN PS          1/82
D1           1.7      OR LESS  CL=.90   ARMENISE  81 HLBC GGM CERN SPS         1/82
D1           0.6      OR LESS  CL=.90   BAKER     81 HLBC 15FT FNAL            1/82
D1           1.7      OR LESS  CL=.90   ERRIQUEZ  81 HLBC BEBC CERN SPS        1/82

S1     SIN(2*THETA)**2 FOR ''LARGE'' DELTA(M**2)           NU-MU --> NU-E
S1           1. E-2  OR LESS  CL=.95   BELLOTTI  76 HLBC GGM CERN PS          1/82
S1           6. E-2  OR LESS  CL=.95   BLIETSCHA 78 HLBC GGM CERN PS          1/82
S1           1. E-2  OR LESS  CL=.90   ARMENISE  81 HLBC GGM CERN SPS         1/82
S1           6. E-3  OR LESS  CL=.90   BAKER     81 HLBC 15FT FNAL            1/82
S1           1. E-2  OR LESS  CL=.90   ERRIQUEZ  81 HLBC BEBC CERN SPS        1/82

ANU-MU --> ANU-E
D2     DELTA(M**2) FOR SIN(2*THETA)**2=1   (UNITS EV**2)   ANU-MU --> ANU-E
D2           1.       OR LESS  CL=.95   BLIETSCHA 78 HLBC GGM CERN PS          1/82
D2           0.91     OR LESS  CL=.90   NEMETHY   81 CNTR LAMPF                1/82
D2           2.4      OR LESS  CL=.90   TAYLOR    83 HLBC    15 FT FNAL        2/84*

S2     SIN(2*THETA)**2 FOR ''LARGE'' DELTA(M**2)           ANU-MU --> ANU-E
S2           6. E-2  OR LESS  CL=.95   BLIETSCHA 78 HLBC GGM CERN PS          1/82
S2           0.2      OR LESS  CL=.90   NEMETHY   81 CNTR LAMPF                1/82
S2           1.3E-2  OR LESS  CL=.90   TAYLOR    83 HLBC    15 FT FNAL        2/84*

NU-MU --> NU-TAU
D3     DELTA(M**2) FOR SIN(2*THETA)**2=1   (UNITS EV**2)   NU-MU --> NU-TAU
D3           4.6      OR LESS  CL=.90   ARMENISE  81 HLBC GGM CERN SPS         1/82
D3           3.       OR LESS  CL=.90   BAKER     81 HLBC 15FT FNAL            1/82
D3           6.       OR LESS  CL=.90   ERRIQUEZ  81 HLBC BEBC CERN SPS        1/82
D3           3.       OR LESS  CL=.90   USHIDA    81 EMUL FNAL                 1/82

S3     SIN(2*THETA)**2 FOR ''LARGE'' DELTA(M**2)           NU-MU --> NU-TAU
S3           1.7E-2  OR LESS  CL=.90   ARMENISE  81 HLBC GGM CERN SPS         1/82
S3           6. E-2  OR LESS  CL=.90   BAKER     81 HLBC 15FT FNAL            1/82
S3           5. E-2  OR LESS  CL=.90   ERRIQUEZ  81 HLBC BEBC CERN SPS        1/82
S3           1.3E-2  OR LESS  CL=.90   USHIDA    81 EMUL FNAL                 1/82

ANU-MU --> ANU-TAU
D4     DELTA(M**2) FOR SIN(2*THETA)**2=1  (UNITS EV**2)  ANU-MU --> ANU-TAU
D4           2.2      OR LESS  CL=.90   ASRATYAN  81 HLBC FNAL                1/82
D4           7.4      OR LESS  CL=.90   TAYLOR    83 HLBC    15 FT FNAL        2/84*

S4     SIN(2*THETA)**2 FOR ''LARGE'' DELTA(M**2)          ANU-MU --> ANU-TAU
S4           4.4E-2  OR LESS  CL=.90   ASRATYAN  81 HLBC FNAL                1/82
S4           8.8E-2  OR LESS  CL=.90   TAYLOR    83 HLBC    15 FT FNAL        2/84*
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NU-E -/-> NU-E

D6      DELTA(M**2) FOR SIN(2*THETA)**2=1    (UNITS EV**2)    NU-E -/-> NU-E
D6           8.         OR LESS  CL=.90   BAKER      81 HLBC 15FT FNAL          1/82
D6          56.         OR LESS  CL=.90   DEDEN      81 HLBC BEBC CERN SPS      1/82
D6          10.         OR LESS  CL=.90   ERRIQUEZ   81 HLBC BEBC CERN SPS      1/82
D6          2.3 TO 8 EXCLUDED CL=.90      NEMETHY    81 CNTR LAMPF              1/82

S6      SIN(2*THETA)**2 FOR ''LARGE'' DELTA(M**2)           NU-E -/-> NU-E
S6           0.6        OR LESS  CL=.90   BAKER      81 HLBC 15FT FNAL          1/82
S6           0.3        OR LESS  CL=.90   DEDEN      81 HLBC BEBC CERN SPS      1/82
S6           7.E-2      OR LESS  CL=.90   ERRIQUEZ   81 HLBC BEBC CERN SPS      1/82

ANU-E --> ANU-TAU

S7      SIN(2*THETA)**2 FOR ''LARGE'' DELTA(M**2)           ANU-E --> ANU-TAU
S7   F       0.7        OR LESS  CL=.90   FRITZE     80 HYBR BEBC CERN SPS      1/82
S7   F   AUTHORS GIVE P(NUE-->NUTAU)< .35, EQUIVALENT TO ABOVE LIMIT.           1/82

NU-MU --> (ANU-E)-L

         THIS IS A LIMIT ON LEPTON FAMILY-NUMBER VIOLATION AND TOTAL LETPON-  12/83*
         NUMBER VIOLATION.  (ANU-E)-L DENOTES A HYPOTHETICAL LEFT-HANDED      12/83*
         ANTI-ELECTRON NEUTRINO.  THE BOUND IS QUOTED IN TERMS OF DELTA       12/83*
         (M**2), SIN(2*THETA), AND ALPHA, WHERE ALPHA DENOTES THE FRACTIONAL  12/83*
         ADMIXTURE OF (V+A) CHARGED CURRENT.                                  12/83*

AD1      ALPHA*DELTA(M**2) FOR SIN(2*THETA)**2=1 (UNITS EV**2)                12/83*
AD1  C        7.E-1  OR LESS  CL=.90   COOPER     82 HLBC                     12/83*
AD1  C   EXISTING BOUNDS ON V+A CURRENTS REQUIRE ALPHA SMALL - SEE COOPER82.  12/83*

AS1      ALPHA**2*SIN(2*THETA)**2 FOR ''LARGE'' DELTA(M**2)                   12/83*
AS1  C        1.E-3  OR LESS  CL=.90   COOPER     82 HLBC                     12/83*
AS1  C   EXISTING BOUNDS ON V+A CURRENTS REQUIRE ALPHA SMALL - SEE COOPER82.  12/83*

NU-E --> (ANU-E)-L                                                            12/83*

        SEE NOTE FOR NU-MU --> (ANU-E)-L LIMIT                                12/83*
AD2      ALPHA*DELTA(M**2) FOR SIN(2*THETA)=1 (UNITS EV**2)                   12/83*
AD2  C        7.        OR LESS  CL=.90   COOPER     82 HLBC                  12/83*
AD2  C   EXISTING BOUNDS ON V+A CURRENTS REQUIRE ALPHA SMALL - SEE COOPER82.  12/83*

AS2      ALPHA**2*SIN(2*THETA)**2 FOR ''LARGE'' DELTA(M**2)                   12/83*
AS2  C        5.E-2  OR LESS  CL=.90   COOPER     82 HLBC                     12/83*
AS2  C   EXISTING BOUNDS ON V+A CURRENTS REQUIRE ALPHA SMALL - SEE COOPER82.  12/83*

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5 (C). SEARCHES FOR NEUTRINOLESS DOUBLE BETA DECAY

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        THE DECAY (Z,A) --> (Z+2,A) + E- + E-, I.E. NEUTRINOLESS DOUBLE
        BETA DECAY, VIOLATES TOTAL LEPTON NUMBER BY TWO UNITS.  IT IS
        FORBIDDEN IF NEUTRINOS ARE DIRAC PARTICLES BUT CAN OCCUR IF
        NEUTRINOS ARE MAJORANA PARTICLES AND (A) THEY ARE MASSIVE OR
        (B) THEY HAVE NON (V-A) COUPLINGS.  PRIMAKOFF 81, ROSEN 81, AND
        HAXTON 83 DISCUSS CORRELATED BOUNDS ON MNUW AND RIGHT-HANDED
        COUPLINGS.  FURTHER THEORETICAL DISCUSSIONS INCLUDE DOI 81,
        HAXTON 82, AND GROTZ 83.

MW      MNUW, THE EFFECTIVE WEIGHTED SUM OF NEUTRINO MASSES CONTRIBUTING TO
MW      NEUTRINOLESS DOUBLE BETA DECAY    (UNITS EV)
MW        MNUW= CABS(SUM FROM 1 TO N OF U(1,J)**2*M(NU-J)), WHERE N= NUMBER
MW        OF NEUTRINO GENERATIONS, AND NU-J IS A MAJORANA NEUTRINO.  NOTE
MW        THAT U(1,J)**2, NOT CABS(U(1,J))**2, OCCURS IN THE SUM; THE
MW        POSSIBILITY OF CANCELLATIONS HAS BEEN STRESSED IN WOLFENSTEIN 81.
MW
MW   D       (30.)    APPROX.            DOI       81
MW   H        12.     OR LESS            HAXTON    81                          1/82
MW   M        (.8)    OR MORE            MINKOWSKI 82         CAUTION-SEE NOTE 12/83*
MW            40      OR LESS            VERGADOS  82         CA-48            12/83*
MW            10      OR LESS   CL=.90   AVIGNONE  83 CNTR+THY GE-76           12/83*
MW   B        22      OR LESS   CL=.68   BELLOTTI  83 CNTR+THY1  GE-76         12/83*
MW   B         8.3    OR LESS   CL=.68   BELLOTTI  83 CNTR+THY2  GE-76         12/83*
MW             5.6    OR LESS   CL=.95   KIRSTEN   83 SPEC+THY TE-128/TE-130   12/83*
MW   D  DOI 80 IS THEORETICAL ANALYSIS OF LIFETIME RATIO FOR                   1/82
MW   D  TELLURIUM-128/TELLURIUM-130 AND USES NUCLEAR MATRIX ELEMENTS           1/82
MW   D  CALCULATED BY VERGADOS.                                                1/82
MW   H  HAXTON 81 IS THEORETICAL ANALYSIS OF LIFETIMES OF GERMANIUM-76 AND     1/82
MW   H  SELENIUM-82, THE FORMER OF WHICH YIELDS MNUW.LT.12 EV AND THE          1/82
MW   H  LATER OF WHICH YIELDS MNUW.LT.15 EV.  WE LIST THE MORE RESTRICTIVE     1/82
MW   H  UPPER LIMIT ABOVE. THE DOI 81 VALUE OF MNUW AND THE HAXTON 81 LIMIT    1/82
MW   H  ON MNUW BOTH ASSUME V-A COUPLINGS.                                     1/82
MW   M  THE DEFINITION OF WEIGHTED NEUTRINO MASS GIVEN IN MINKOWSKI 82         12/83*
MW   M  IS WRONG; IT SHOULD INVOLVE U(1,J)**2, NOT CABS(U(1,J))**2. THE        12/83*
MW   M  CONCLUSION OF THIS PAPER, THAT 'EXPERIMENTAL RATES DO IMPLY A          12/83*
MW   M  VIOLATION OF LEPTON NUMBER', IS IN DISAGREEMENT WITH THE               12/83*
MW   M  CONCLUSIONS OF HAXTON 81, ROSEN 81, HAXTON 83, AVIGNONE 83,            12/83*
MW   M  KIRSTEN 83, AND BELLOTTI 83.                                           12/83*
MW   B  LIMITS ARE OBTAINED FROM ANALYSIS OF DATA USING THEORETICAL            12/83*
MW   B  CALCULATIONS BY DOI-83 (=THY1) AND ROSEN 81 (=THY2).                   12/83*

ETA     LIMITS ON LEPTON-NUMBER VIOLATING (V+A) CURRENT ADMIXTURE
ETA       ETA IS DEFINED AS THE FRACTIONAL ADMIXTURE OF (V+A)
ETA       CHARGED CURRENT, RELATIVE TO (V-A) IN ELECTRON-TYPE
ETA       LEPTON SECTOR.
ETA
ETA          2.4E-5  OR LESS            AVIGNONE  83 CNTR+THY GE-76            12/83*
ETA  B       4. E-5  OR LESS  CL=.68    BELLOTTI  83 CNTR+THY1  GE-76          12/83*
ETA  B       1.5E-5  OR LESS  CL=.68    BELLOTTI  83 CNTR+THY2  GE-76          12/83*
ETA          2.4E-5  OR LESS  CL=.95    KIRSTEN   83 SPEC+THY TE-128/TE-130    12/83*
ETA  B  LIMITS ARE OBTAINED FROM ANALYSIS OF DATA USING THEORETICAL            12/83*
ETA  B  CALCULATIONS BY DOI-83 (=THY1) AND ROSEN 81 (=THY2).                   12/83*

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REFERENCES FOR COR. BOUNDS ON NU MASS, MIXING.


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BELLOTTI 76 LNC 17 553          +CAVALLI,FIORINI,ROLLIER                (MILA)
BLIETSCH 78 NP B133 205         BLIETSCHAU+(AACH+LIBH+CERN+EPOL+MILA+ORSA+)
CROUCH   78 PR D18 2239         +LANDECKER,LATHROP,REINES+  (CASE+UCI+WITW)

BAHCALL  80 PRL 45 945          +LUBOW,HUEBNER+     (IAS+LASL+YALE+LLL+UCLA)
    ALSO 76 SCIENCE 191 264     J.N.BAHCALL,R.DAVIS                (IAS+BNL)
BOEHM    80 PL 97B 310          +CAVAIGNAC,FEILITZSCH+ (ILLG+CIT+GREN+MUNI)
FRITZE   80 PL 96B 427          +GRASSLER+    (AACH+BONN+CERN+LOIC+OXF+SACL)

REINES   80 PRL 45 1307         F.REINES,H.W.SOBEL,E.PASIERB             (UCI)
    ALSO 59 PR 113 273          F.REINES,C.L.COWAN                      (LASL)
    ALSO 66 PR 142 852          F.A.NEZRICK,F.REINES                    (CASE)
    ALSO 76 PRL 37 315          F.REINES,H.S.GURR,H.W.SOBEL              (UCI)
SHROCK   80 PL 96B 159          R.E.SHROCK                              (STON)

ABELA    81 PL 105B 263         +DAUM,EATON,FROSCH,JOST,KETTLE,STEINER(SIN)
ARMENISE 81 PL 100B 182         +FOGLI-MUCIACCIA+       (BARI+CERN+MILA+LALO)
ASANO    81 PL 104B 84          +HAYANO,KIKUTANI,KUROKAWA+  (KEK+TOKY+OSAK)
    ALSO 81 SHROCK1
ASRATYAN 81 PL 105B 301         +EFREMENKO,FEDOTOV +  (ITEP+FNAL+SERP+MICH)
BAKER    81 PRL 47 1576         +CONNOLLY,KAHN,KIRK,MURTAGH+      (BNL+COLU)
    ALSO 78 PRL 40 144          CNOPS,CONNOLLY,KAHN,KIRK+         (BNL+COLU)

BALTAY   81 NU 81 CONF HAWAII C.BALTAY                                 (COLU)
BOLIEV   81 SJNP 34 787         +BUTKEVICH,ZAKIDYSHEV,MAKOEV,MIKHEEV+(INRM)
CALAPRIC 81 PL 106B 175         CALAPRICE,SCHREIBER,SCHNEIDER +  (PRIN+IND)
DAVIS    81  BNL NU WKSHP       B.T.CLEVELAND,R.DAVIS JR., J.K.ROWLEY (BNL)
DEDEN    81 PL 98B 310          +       (AACH+BONN+CERN+ATEN+LOIC+OXF+SACL)
DOI      81 PL 103B 219         +KOTANI,NISHIURA,OKUDA,TAKASUGI        (OSAK)
    ALSO 81 PTP 66 1739         DOI,KOTANI,NISHIURA,OKUDA,TAKASUGI     (OSAK)
    ALSO 81 PTP 66 1765         DOI,KOTANI,NISHIURA,OKUDA,TAKASUGI     (OSAK)

ERRIQUEZ 81 PL 102B 73          +NATALI+    (BARI+BIRM+LIBH+EPOL+RHEL+SACL+)
HAXTON   81 PRL 47 153          +G.J.STEPHENSON,D.STROTTMAN      (PURD,LASL)
KWON     81 PR D24 1097         +BOEHM,HAHN,HENRIKSON+      (CIT+GREN+MUNI)
NEMETHY  81 PR D23 262          +     (YALE+LBL+LASL+MIT+SACL+SIN+CNRC+BERN)

PRIMAKOF 81 ARNS 31 145         H.PRIMAKOFF,S.P.ROSEN                  (PURD)
ROSEN    81 NU 81 CONF HAWAII S.P.ROSEN                                (PURD)
    ALSO 78 RMP 50 11           D.BRYMAN,C.PICCIOTTO              (TRIU,VICT)
SHROCK1  81 PR D24 1232         R.E.SHROCK                             (STON)
SHROCK2  81 PR D24 1275         R.E.SHROCK                             (STON)

SILVERMA 81 PRL 46 467          D.SILVERMAN,A.SONI                (UCI+UCLA)
SIMPSON  81 PR D24 2971         J.SIMPSON                              (GUEL)
USHIDA   81 PRL 47 1694           (AICH+FNAL+KOBE+SEOU+MCGI+NAGO+OSU+OKAY+)
WOLFENST 81 PL 107B 77          L.WOLFENSTEIN                          (CARN)

BAHCALL  82 RMP (TO BE PUBL.) +HUEBNER,LUBOW+     (IAS+LANL+HPC+YALE+UCLA)
COOPER   82 PL 112B 97          +GUY,MICHETTE,TYNDEL,VENUS               (RL)
EHRLICH  82 PR D25 2282         R.EHRLICH                              (GMAS)
FILIPPON 82 APJ 253 393         B.W.FILIPPONE,D.N.SCHRAMM           (ANL+EFI)
HAXTON   82 PR D25 2360         +STEPHENSON,STROTTMAN              (LANL+PURD)
HAYANO   82 PRL 49 1305         +TANIGUCHI,YAMANAKA +        (TOKY+KEK+TSUK)
MINKOWSK 82 NP B201 269         P.MINKOWSKI                            (BERN)
VERGADOS 82 PL 109B 96          J.D.VERGADOS                           (CERN)
    ALSO 82 PL 113B 513         J.D.VERGADOS                           (CERN)
    ALSO 83 NP 218B 109         J.D.VERGADOS                           (CERN)
VUILLEUM 82 PL 114B 298         VUILLEUMIER,BOEHM,EGGER +     (CIT+SIN+MUNI)

AVIGNONE 83 PRL 50 721          +BRODZINSKI,BROWN,EVANS,HENSLEY+ (SCUC+PNL)
BELLOTTI 83 PL 121B 72          +FIORINI,LIGURORI,PULLIA,SARRACINO+  (MILA)
BERGSMA  83 PL 128B 361         CHARM COLLAB.     (ANIK+CERN+HAMB+ITEP+INFN)
BRYMAN   83 PRL 50 1546         +DUBOIS,NUMAO,OLANIYI,OLIN+      (TRIU+CNRC)
    ALSO 83 PRL 50 7            BRYMAN,DUBOIS,NUMAO,OLANIYA+     (TRIU+CNRC)
DEUTSCH  83 PR D27 1644         J.P.DEUTSCH,M.LEBRUN,R.PRIEELS         (LVLN)
DOI      83 PTP 69 602          +KOTANI,NISHIURA,TAKASUGI         (OSAK+KYOT)
GRONAU   83 PR D28 2762         GRONAU                                 (HAIF)
GROTZ    83 JPG 9 L169          K.GROTZ,H.V.KLAPDOR,J.METZINGER        (MPIH)
HAXTON   83 CNPP 11 41          W.C.HAXTON                        (LASL+PURD)
KIRSTEN  83 PRL 50 474          T.KIRSTEN,H.RICHTER,E.JESSBERGER       (MPIH)
    ALSO 83 ZPHY 16 189         T.KIRSTEN,H.RICHTER,E.JESSBERGER       (MPIH)
SCHRECKE 83 PL 129B 265         SCHRECKENBACH,COLVIN+             (GREN+ILLG)
TAYLOR   83 PR D28 2705         +CENCE,HARRIS,JONES+         (HAWA+LBL+FNAL)
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NEUTRINO BOUNDS FROM ASTROPHYSICS AND COSMOLOGY

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     SEE THE NOTE ON NEUTRINOS BY R.E. SHROCK IN THE ELECTRON NEUTRINO
     SECTION NEAR THE BEGINNING OF THESE DATA CARD LISTINGS.  FOR
     INFORMATION ON NEUTRINOS DERIVED FROM MORE CONVENTIONAL
     (TERRESTRIAL) EXPERIMENTS, SEE THE NUE, NUMU, NUTAU, AND
     HEAVY-NU SECTIONS ABOVE.

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NOTE ON ν MASS LIMITS

These limits apply to m_{tot} given by

$$m_{tot} = \sum_{j=1,n} \left(\frac{g_{\nu_j}}{2} \right) m_{\nu_j} ,$$

where n is the number of neutrino species and g_{ν_j} is the number of independent components in the neutrino field: $g_{\nu_j} = 4$ for Dirac neutrinos; $g_{\nu_j} = 2$ for chiral Majorana neutrinos.

6 NU MASS (EV)

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M        LIMIT ON TOTAL NEUTRINO MASS, SUMMED OVER ALL SPIN COMPONENTS,
M        OF EFFECTIVELY STABLE NEUTRINOS (I.E. THOSE WITH MEAN LIVES ROUGHLY
M        EQUAL TO OR GREATER THAN THE AGE OF THE UNIVERSE)  (UNITS EV)
M    A      (132.)   OR LESS            COWSIK    72 COSM
M    A       (80.)   OR LESS            LEE       77 COSM                     9/81
M           (100.)   OR LESS            OLIVE     81 COSM                     1/82
M    A   COWSIK 72 AND LEE 77 HAVE BEEN GENERALIZED TO APPLY TO M(TOT) AS     4/82
M    A   DEFINED ABOVE, WHERE ONE ALLOWS EITHER DIRAC OR MAJORANA NEUTRINOS.  4/82
M    A   THESE PAPERS ASSUMED DIRAC NEUTRINOS.                                4/82
M        FOR OTHER LIMITS, SEE SATO 77, VYSOTSKY 77, DICUS 78, HUT 79,        2/82
M        AND ZELDOVICH 80.                                                    2/82
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Stable Particles — Data Card Listings

ν BOUNDS FROM ASTROPHYSICS & COSMOLOGY, HEAVY LEPTON SEARCHES

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ML      ASTROPHYSICAL AND COSMOLOGICAL LIMITS ON NEUTRINO MASSES. (UNITS EV)
ML      ANALYSES OF MASS/LIGHT RATIOS AND DYNAMICS OF GALAXIES AND
ML      CLUSTERS ARE CONSISTENT WITH PRESENCE OF DARK MATTER.  TREMAINE 79
ML      STATED THAT THE DARK MATTER COULD NOT BE MUON OR ELECTRON NEUTRINOS
ML      OF NONZERO REST MASS OR ANY NEUTRAL LEPTON LESS MASSIVE THAN 1 MEV.
ML      AUTHORS BOND 81, DAVIS 81, AND SCHRAMM 81 CLAIMED THAT THIS DARK
ML      MATTER COULD CONSISTENTLY BE ASCRIBED TO MASSIVE NEUTRINOS
ML      WITH SUFFICIENTLY LONG LIFETIMES.  SUBSEQUENT ANALYSES HAVE
ML      CHALLENGED THIS CLAIM; SEE PRIMACK 83.  FOR DEGENERATE NEUTRINOS,
ML      SEE FREESE 83.
ML
ML                                  TREMAINE  79 COSM  ISOTHERMAL          1/82
ML       ORDER 30                   BOND      81 COSM  ADIABATIC           2/82
ML         50-100                   DAVIS     81 COSM  ADIA.+DECAYING NUS  1/82
ML          4-20                    SCHRAMM   81 COSM  ISOTHERMAL          1/82
ML          NO CONSISTENT VALUE     PRIMACK   83 COSM                     12/83*

MSW     LIMITS ON MASSES OF STABLE RIGHT-HANDED NEUTRINOS
MSW     (WITH NECESSARILY SUPPRESSED INTERACTION STRENGTHS)
MSW  O                              OLIVE     82                         12/83*
MSW  O  ALLOWED VALUES OF MASS ARE STRONGLY CORRELATED WITH INTERACTION    12/83*
MSW  O  STRENGTH.  SEE FIG. 1 OF OLIVE 82.                                 12/83*

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                    6  NU RADIATIVE MEAN LIFE VERSUS MASS

T                                   COWSIK    77 COSM                      1/82
T                                   DICUS     77 COSM                      1/82
T                                   GOLDMAN   77 COSM                      4/82
T                                   FALK      78 COSM                      1/82
T            STRONGLY CORRELATED    COWSIK    79 COSM                      1/82
T            LIMITS. SEE REFERENCES GOLDMAN   79 COSM                      1/82
T                                   DERUJULA  80 COSM                      1/82
T                                   STECKER   80 COSM                      1/82
T                                   HENRY     81 COSM                      1/82
T                                   KIMBLE    81 COSM                      1/82
T                                   REPHAELI  81 COSM                     12/83*
T                                   TURNER    81 COSM                      1/82
T                                   KRAUSS    83 COSM                     12/83*

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                    6  POSSIBLE LIMITS ON NUMBER OF LIGHT (< ABOUT 1 MEV)
                       TWO-COMPONENT NU TYPES

N       NUMBER COUPLING WITH FULL WEAK STRENGTH
N                                   SHVARTSMA 69 COSM                      1/82
N            (7)   OR LESS          STEIGMAN  77 COSM                      1/82
N            (4)   OR LESS          YANG      79 COSM                      1/82
N     S     CRITICISM OF BOUND      STECKER2  80 COSM                      1/82
N          MAYBE NO FIRM BOUND      OLIVE     81 COSM                      1/82
N            (4)   OR LESS          TURNER    81 COSM                      1/82
N          CRITICISM OF BOUND       RANA      82 COSM                      1/82
N            (4)   OR LESS          SCHRAMM   82 COSM                      1/84*
N           (FROM 10 TO 1000) OR LESS ELLIS   83        ASTROPHYS MODEL-DEP 12/83*
N            (4)   OR LESS          YANG      84 COSM                      1/84*
N     S  SEE, HOWEVER OLIVE2 81 CRITIQUE AND STECKER 81 REPLY.             1/82
N        UNCERTAINTIES AND CRITICISMS COME FROM DIFFERING ESTIMATES OF LOWER 4/82
N        LIMIT ON BARYON DENSITY OF THE UNIVERSE AND UPPER LIMIT ON THE     4/82
N        PRIMORDIAL HELIUM-4 ABUNDANCE.  SEE ALSO BERNSTEIN 82.             4/82

NSW     NUMBER COUPLING WITH LESS THAN FULL WEAK STRENGTH
NSW  A       (20)   OR LESS         STEIGMAN  79 COSM                      1/82
NSW  A  LIMIT VARIES WITH STRENGTH OF COUPLING.                             4/82

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                    6  MAGNETIC MOMENT OF SUFFICIENTLY LIGHT NU
                                                      (UNITS EV/GAUSS)

MM   S     (4.9E-19)OR LESS         SUTHERLAN 76 COSM FOR M(NU)<10 KEV.    1/82
MM   S  USES SUTHERLAND 76 EQ.3 WITH F<1/3 FROM THEIR TABLE AS MODIFIED TO 1/82
MM   S  APPLY AS A LIMIT ON ANY ONE NEUTRINO SPECIES INDIVIDUALLY.         1/82

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REFERENCES FOR NU BOUNDS FROM ASTRO. AND COSM.


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SHVARTSM 69 JETPL 9 184        V. F. SHVARTSMAN                        (MOSU)
COWSIK   72 PRL 29 669         R.COWSIK,J.MC CLELLAND                  (UCB)
SUTHERLA 76 PR D13 2700        SUTHERLAND,NG,FLOWERS,+       (PENN+COLU+NYU)

COWSIK   77 PRL 39 784         R. COWSIK                     (MPIM+TIFR)
    ALSO 79 COWSIK
DICUS    77 PRL 39 168         D.A.DICUS,E.W.KOLB,V.L.TEPLITZ   (TEXA+VPI)
GOLDMAN  77 PR D16 2256        T.GOLDMAN, G.J.STEPHENSON               (LASL)
LEE      77 PRL 39 165         B. W. LEE, S. WEINBERG          (FNAL+STAN)
SATO     77 PTP 58 1775        K.SATO,M.KOBAYASHI                      (KYOT)
STEIGMAN 77 PL 66B 202         G.STEIGMAN,D.SCHRAMM,J.GUNN (YALE,CHIC,CIT)
VYSOTSKY 77 JETPL 26 188       VYSOTSKY,DOLGOV,ZELDOVICH               (ITEP)

DICUS    78 PR D17 1529        +KOLB,TEPLITZ,WAGONER         (TEXA+VPI+STAN)
FALK     78 PL 79B 511         S. FALK, D. SCHRAMM                     (CHIC)
    ALSO 78 APJ 223 1015       GUNN,LEE+            (CIT+CAMB+FNAL+CHIC+YALE)

COWSIK   79 PR D19 2219        R. COWSIK                               (TIFR)
GOLDMAN  79 PR D19 2215        T.GOLDMAN,G.J.STEPHENSON                (LASL)
HUT      79 PL 87B 144         P.HUT,K.A.OLIVE                (AMSTERDAM+EFI)
STEIGMAN 79 PRL 43 239         G.STEIGMAN,K.OLIVE,D.SCHRAMM      (BART+EFI)
TREMAINE 79 PRL 42 407         S. TREMAINE, J. E. GUNN      (CIT+CAMB+CAIW)
YANG     79 APJ 227 697        YANG,SCHRAMM,STEIGMAN,ROOD (CHIC+YALE+VIRG)
    ALSO 79 STEIGMAN           FOOTNOTE 4

DERUJULA 80 PRL 45 942         A.DE RUJULA,S.L.GLASHOW          (MIT+HARV)
STECKER  80 PRL 45 1460        F.W.STECKER                             (NASA)
    ALSO 81 NU 81 CONF HAWAII  F.W.STECKER (PROC. V.1, P. 124)         (NASA)
STECKER2 80 PRL 44 1237        F.W.STECKER                             (NASA)
ZELDOVIC 80 SJNP 31 664        ZELDOVICH,KLYPIN,KHLOPOV,CHECHETKIN

BOND     81 NU 81 CONF HAWAII  J.R.BOND, A.S.SZALAY             (UCB+CHIC)
DAVIS    81 APJ 250 423        M.DAVIS,M.LECAR,C.PRYOR,E.WITTEN(HARV+PRIN)
HENRY    81 PRL 47 618         R.C.HENRY, P.D.FELDMAN                  (JHU)
KIMBLE   81 PRL 46 80          R.KIMBLE,S.BOWYER,P.JAKOBSEN            (UCB)

OLIVE    81 APJ 246 557        +SCHRAMM,STEIGMAN,TURNER,YANG+  (CHIC+BART)
OLIVE2   81 PRL 46 516         K.A.OLIVE,M.S.TURNER                    (EFI)
REPHAELI 81 PL 106B 73         Y.REPHAELI,A.S.SZALAY           (UCSB+CHIC)
SCHRAMM  81 APJ 243 1          D. N. SCHRAMM, G. STEIGMAN      (CHIC+BART)
STECKER  81 PRL 46 517         F.W.STECKER                             (NASA)
TURNER   81 NU 81 CONF HAWAII  M.S.TURNER                      (UCSB+CHIC)

BERNSTEI 82 PRL 48 774         J.BERNSTEIN                             (STEV)
OLIVE    82 PR D25 213         K.A.OLIVE,M.S.TURNER            (CHIC+UCSB)
RANA     82 PRL 48 209         N.C.RANA                                (TIFR)
SCHRAMM  82 PRSL A307 43       D.N. SCHRAMM                            (CHIC)

ELLIS    83 NP B223 256        J.ELLIS,K.A.OLIVE                       (CERN)
FREESE   83 PR D27 1689        K.FREESE,E.W.KOLB,M.S.TURNER     (CHIC+LANL)
KRAUSS   83 PL 128B 37         L.M.KRAUSS                              (HARV)
PRIMACK  83 PHILADELPHIA       J.PRIMACK (4TH WKSHP. ON GRAND.UNIF.)(UCSC)
    ALSO 82 NAT 299 37         BLUMENTHAL,PAGELS,PRIMACK        (UCSC+ROCK)
YANG     84  APJ (TO BE PUBL)  +TURNER,STEIGMAN,SCHRAMM,OLIVE   (CHIC+BART)
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HEAVY LEPTON SEARCHES

Data on the $\tau^{\pm}$ are listed in a separate section above, following the e and μ listings.

The following section contains information on searches for heavy leptons of other types and searches for the $\tau^{\pm}$ in collisions other than e^+e^-.

Several types of heavy leptons (that is, non-strongly-interacting fermions other than e and μ) have been proposed. In the Data Card Listings we distinguish four types.[1,2] Each has a corresponding antiparticle with opposite charge and lepton number. For convenience we omit writing the antiparticles in the following descriptions. The four types are:

Sequential leptons (L^-, ν_L). Such a pair is assumed to have its own separately strictly conserved lepton number $n_L = +1$. This means that the radiative decays

$$\left.\begin{array}{l} L^- \to e^-\gamma \\ L^- \to \mu^-\gamma \end{array}\right\} \text{ are forbidden ,}$$

while the weak decays (assuming m_{L^-} sufficiently large)

$$\left.\begin{array}{l} L^- \to \nu_L\, e^-\bar{\nu}_e \\ L^- \to \nu_L\, \mu^-\bar{\nu}_\mu \\ L^- \to \nu_L \text{ hadrons} \end{array}\right\} \text{ are allowed .}$$

There could be an increasing mass sequence of such pairs. It is frequently assumed that the neutrinos are massless.

Decay rates are assumed calculable from conventional weak interaction theory. For an L^- mass between 1 and 3 GeV, the branching fraction to each of the two leptonic modes above should be roughly 10 to 20%. For an L^- mass above 1 GeV, the mean life should be $\lesssim 10^{-12}$ seconds.

Paraleptons (E^+, E^0) *and* (M^+, M^0). These pairs have the same lepton numbers as the opposite-charge ordinary leptons, i.e., e^- and μ^-, respectively. Radiative decays are again forbidden and decays similar to those allowed for L^- are allowed here, e.g.,

$$M^+ \to \nu_\mu\, e^+\nu_e$$

or

For notation, see key at front of Listings.

Stable Particles

HEAVY LEPTON SEARCHES

$$M^+ \to \nu_\mu \mu^+ \nu_\mu .$$

However, the lightest member is not stable as is the case for sequential leptons, so that bizarre decay schemes such as (assuming $m_{E^0} < m_{E^+}$)

$$E^+ \to E^0 \mu^+ \nu_\mu$$
$$\quad\quad \hookrightarrow e^- e^+ \nu_e$$

are allowed.

Heavy leptons of this type (and/or a neutral intermediate boson Z^0) are desired in unified gauge theories of weak and electromagnetic interactions to cancel unphysical high energy behavior in such processes as $e^+e^- \to W^+W^-$.[3]

Ortholeptons (F^- and N^-). These have the same lepton numbers as e^- and μ^-, respectively. They may or may not have associated neutral leptons. Radiative decays are allowed in addition to weak modes similar to those of sequential leptons. The radiative mode can dominate or can be relatively unimportant depending on the model.[4] Decays such as

$$F^- \to e^- + \text{hadrons}$$

are also allowed.

Long-lived penetrating particles. Heavy leptons could have long mean lives under certain circumstances. For example, if $m_{\nu_L} > m_{L^-}$, then L^-, the sequential lepton, is completely stable since its lepton number is conserved.

Experimental results. The results are summarized in the Data Card Listings below. Mass limits for sequential leptons are listed in subsection MS, while all other types are listed together in subsection M.

The Listings also contain cross-section upper limits reported as results of unsuccessful searches. We no longer list cross sections for anomalous $e\mu$ events in e^+e^- collisions. These cross sections are consistent with coming from $e^+e^- \to \tau^+\tau^-$ where the $\tau^\pm$ is assumed to be a spin-1/2 Dirac point particle with a mass about 1785 MeV.

References

1. M.L. Perl and P. Rapidis, SLAC-PUB-1496 (October 1974).
2. C.H. Llewellyn Smith, Invited paper presented at the Royal Society Meeting on New Particles and New Quantum Numbers, 11 March 1976, Oxford Ref. 33/76.
3. J.D. Bjorken and C.H. Llewellyn Smith, Phys. Rev. **D7**, 887 (1973).
4. F. Wilczek and A. Zee, Nucl. Phys. **B106**, 461 (1976).


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      SEE PERL 81 FOR A REVIEW

      PROPERTIES OF THE TAU+-(1785) HEAVY LEPTON AND ITS ASSOCIATED
      NEUTRINO ARE LISTED SEPARATELY ABOVE FOLLOWING THE E AND MU
      LISTINGS.  THE FOLLOWING SECTION CONTAINS INFORMATION ON SEARCHES
      FOR HEAVY LEPTONS OF OTHER TYPES AND SEARCHES FOR TAU+- IN
      COLLISIONS OTHER THAN E+E-.  WE LIST MASS LIMITS AND CROSS SECTION
      UPPER LIMITS REPORTED AS NEGATIVE SEARCH RESULTS.  WE NO LONGER
      LIST CROSS SECTIONS FOR THE ESTABLISHED PROCESS E+ E- --> TAU+ TAU-
      AS WAS DONE IN OUR 1977 SUPPLEMENT.

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                    25  HEAVY LEPTON MASS LIMITS

      LIMITS APPLY ONLY TO HEAVY LEPTON TYPE GIVEN IN COMMENT AT RIGHT ON  3/77
      DATA CARD.  SEE REVIEW ABOVE FOR DESCRIPTION OF TYPES.               3/77
      IN COMMENTS BELOW, ALL BEAMS ARE MU TYPE NEUTRINO OR ANTINEUTRINO.   3/77
      L,E,M,F,N STAND FOR SEQUENTIAL LEPTON,PARA-ELECTRON,PARA-MUON,       3/77
      ORTHO-ELECTRON,ORTHO-MUON RESPECTIVELY.                              3/77

MS      SEQUENTIAL HEAVY LEPTON MASS LIMITS (GEV)
MS   A      (13.)   OR MORE          AZIMOV    80       +- SEQUENTIAL (L)    2/82
MS   B       16.    OR MORE  CL=.95  BARBER    80 CNTR +- SEQUENTIAL (L)    9/81
MS   C  NONE 4GEV TO 14.5GEV CL=.95   BERGER    81 PLUT +- SEQUENTIAL (L)    1/82
MS   D  NONE BELOW 15.5 GEV  CL=.95   BRANDELIK 81 TASS +- SEQUENTIAL (L)    1/82
MS      NONE BELOW 14 GEV    CL=.95   ADEVA     82 MRKJ +- SEQUENTIAL (L)    1/84*
MS   E  NONE BELOW 18 GEV             ADEVA     83 MRKJ +- SEQUENTIAL (L)   11/83*
MS   F  NONE BELOW 18.0 GEV  CL=.95   BARTEL    83 JADE +- SEQUENTIAL (L)   11/83*
MS
MS   A  AZIMOV 80 ESTIMATED PROBABILITIES FOR M+N TYPE EVENTS IN E+ E- -->   2/82
MS   A  L+ L- DEDUCING SEMI-HADRONIC DECAY MULTIPLICITIES OF L FROM E+ E-    2/82
MS   A  ANNIHILATION DATA AT WCM=(2/3)*ML. OBTAINED ABOVE LIMIT COMPARING    2/82
MS   A  THESE WITH E+E- DATA (BRANDELIK 80,PL 92B 199).                      2/82
MS
MS   B  BARBER 80 LOOKED FOR E+ E- --> L+ L-, L-->NEU(L)+X WITH MARK-J AT    9/81
MS   B  DESY-PETRA.                                                          9/81
MS
MS   C  BERGER 81 IS DESY DORIS AND PETRA EXPT. LOOKING FOR E+E- --> L+L-.   1/82
MS
MS   D  BRANDELIK 81 IS DESY PETRA EXPT. LOOKING FOR E+E- --> L+L-.          1/82
MS
MS   E  ADEVA 83 LOOKED FOR MUON OPPOSITE AGAINST A HADRON JET.             11/83*
MS
MS   F  BARTEL 83 LIMIT IS FROM PETRA E+E- EXP WITH AVERAGE WCM=34.2 GEV.   11/83*

M      HEAVY LEPTON MASS LIMITS (GEV)
M    A   0     1.0    OR MORE          BEHREND   65 SPEC -  ORTHOELECTRON(F)  6/77
M    B  NONE BETWEEN 0.12 AND 0.57     BETOURNE  65 SPEC -  ORTHOELECTRON(F)  6/77
M    C  NONE BETWEEN 0.3  AND 0.7      BUDNITZ   66 SPEC -  ORTHOELECTRON(F)  6/77
M    D  NONE BETWEEN 0.2  AND 0.92     BARNA     68 CNTR -  LONG-LIVED        6/77
M    D  NONE BETWEEN 0.97 AND 1.03     BARNA     68 CNTR -  LONG-LIVED        6/77
M    E  NONE BETWEEN 0.1  AND 1.3      BOLEY     68 SPEC -  ORTHOELECTRON(F)  6/77
M    F  NONE BETWEEN 0.2  AND 0.6      LIBERMAN  69 OSPK -  ORTHOMUON(N)      6/77
M    G        0.490 OR MORE            ROTHE     69 RVUE                      6/77
M    H  NONE BETWEEN 0.26 AND 1.32     LICHTENST 70 SPEC -  ORTHOELECTRON(F)  6/77
M    I  20   (0.424)  (0.013)  (0.002)RAMM      70 HLBC 0                    6/77
M    I  22   (0.431)  (0.004)          RAMM      71 HLBC -  ORTHOMUON(N)      6/77
M    J   0    0.1    OR MORE           ANSORGE   73 HBC  -  LONG-LIVED        6/77
M    K   0    0.6    OR MORE           BACCI     73 ELEC +- ORTHOELECTRON(F)  1/76
M    K   0    2.2    OR MORE           BACCI     73 ELEC +- ORTHOELECTRON(F)  1/76
M    L   0    2.0    OR MORE  CL=.90   BARISH    73 ASPK +  PARAMUON (M)      2/74
M    M   0    1.4    OR MORE  CL=.95   BERNARDIN 73 ASPK +- ANY NON-RAD TYPE  2/74
M    M   0    1.0    OR MORE  CL=.95   BERNARDIN 73 ASPK +- ANY NON-RAD TYPE  2/74
M    N  NONE BETWEEN 0.55 AND 4.5      BUSHNIN   73 CNTR -  LONG-LIVED        2/74
M    O   0    2.4    OR MORE  CL=.90   EICHTEN   73 HLBC +  PARAMUON (M)      3/74
M    P        7.8    OR MORE  CL=.95   HANSON    73 WIRE    ORTHOELECTRON(F)  6/77
M    Q        1.8    OR MORE  CL=.90   ASRATYAN  74 HLBC +- ORTHOMUON (N)    11/75
M    R        8.4    OR MORE  CL=.90   BARISH    74 SPEC +  PARAMUON (M)      7/74
M    S   NONE BETWEEN 0 AND 2.0        GITTLESON 74 SPEC    ORTHOMUON (N)   12/77
M    T   0    1.15   OR MORE  CL=.95   ORITO     74 ASPK +- ANY NON-RAD TYPE 11/75
M    U   NONE BETWEEN 0.25 AND 2.3     BACCI     77 SPEC +- ORTHOELECTRON(F) 12/77
M    V        1.2    OR MORE           MEYER     77 SMAG 0  NEUTRAL          12/77
M    W       10.3    OR MORE  CL=.98   ASRATYAN  78      -  ORTHOMUON (N)     1/79
M    X   0    7.5    OR MORE           CNOPS     78 HLBC -  ORTHOMUON (N)     8/78
M    X   0    9.0    OR MORE           CNOPS     78 HLBC +  PARAMUON (M)      8/78
M    Y       10.0    OR MORE           ERRIQUEZ  78 BEBC                      1/79
M    Z       12.     OR MORE  CL=.90   HOLDER    78 CNTR +  PARAMUON (M)      6/78
M    1  NONE 1 GEV TO 9 GEV  CL=.90    CLARK     81 SPEC 0  PARAMUON(MOBAR)   1/82
M    1  NONE 1 GEV TO 9 GEV  CL=.90    CLARK     81 SPEC ++                   1/82
M    2  NONE BETWEEN 0.6 AND 3.3       HAYES     82 SMK2 +- ORTHOMUON (N)     4/82
M    2  NONE BETWEEN 0.5 AND 3.3       HAYES     82 SMK2 +- ORTHOELECTRON(F)  4/82
M    3       24.5    OR MORE  CL=.95   BARTEL    83 JADE 0  PARAELECTRON(E0) 11/83*
M    3       22.5    OR MORE  CL=.95   BARTEL    83 JADE 0  PARAELECTRON(E0) 11/83*
M
M    A  BEHREND 65 IS DESY EXPT. LOOKS FOR E P-->F P, F--> E GAMMA.           6/77
M    A  THIS MASS LIMIT CORRESPONDS TO A LIMIT ON LAMBDA**2 OF 6.25*10**-4.   6/77
M
M    B  BETOURNE 65 IS ORSAY EXPT. LOOKS FOR E P -->F P. MASS OF .12          6/77
M    B  CORRESPONDS TO COUPLING CONSTANT LAMBDA**2 GT .0016, MASS OF .57      6/77
M    B  TO LAMBDA**2 GT .22.                                                  6/77
M
M    C  BUDNITZ 66 IS CEA EXPT. LOOKS FOR E P-->F P.                          6/77
M
M    D  BARNA 68 IS SLAC PHOTOPRODUCTION EXPT.                                6/77
M
M    E  BOLEY 68 IS CEA EXPT. LOOKS FOR E P-->F P. MASS OF .1 CORRESPONDS     6/77
M    E  TO COUPLING CONSTANT LAMBDA**2 GT 3*10**-4, MASS LIMIT OF 1.3 TO      6/77
M    E  LAMBDA**2 GT .01.                                                     6/77
M
M    F  LIBERMAN 69 IS A BNL EXPT MEASURING MUON BREMSSTRAHLUNG.              6/77
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Stable Particles

Data Card Listings

HEAVY LEPTON SEARCHES

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M     G  ROTHE 69 EXAMINES PREVIOUS DATA ON MU PAIR PROD AND PI AND K DECAYS  6/77
M
M     H  LICHTENSTEIN 70 IS CORNELL EXPT MEASURING E BREMSSTRAHLUNG.          6/77
M     H  MASS LIMIT DEPENDS ON COUPLING CONSTANT. FIRST VALUE ABOVE IS FOR    6/77
M     H  LAMBDA**2 GT .17, SECOND IS FOR LAMBDA**2 GT .42.                    6/77
M
M     I  RAMM 70 FINDS PEAK IN MU PI COMBINED MASS PRODUCED BY NEUTRINO       6/77
M     I  INTERACTIONS. HE ALSO CLAIMS EVIDENCE FOR THIS IN KOMU3 DECAYS IN    6/77
M     I  HBC WHERE PI MU COMBINED MASS PEAKS IN SAME REGION. CLARK 72 FINDS   6/77
M     I  NO EVIDENCE FOR PI MU PEAK IN HIGH STATISTICS KL3 EXPT.              6/77
M     I  RAMM 71 SEES PEAK IN MU GAMMA COMBINED MASS PRODUCED BY NEUTRINOS.   6/77
M
M     J  ANSORGE 73 LOOKS FOR ELECTRON PAIR PROD AND ELECTRON-LIKE BREMSS.    6/77
M
M     K  BACCI 73 IS FRASCATI E+E- EXPT. LOOKS FOR F --> E GAMMA.             1/76
M     K  MASS LIMIT DEPENDS ON COUPLING CONSTANT LAMBDA FOR THIS DECAY.       1/76
M     K  FIRST VALUE ABOVE IS FOR LAMBDA**2 GT 9*10**-5, 2ND IS FOR           1/76
M     K  LAMBDA**2 GT 10**-3.                                                 1/76
M
M     L  BARISH 73 IS FNAL 50,145 GEV NEU EXPT.  LOOKS FOR (NEU NUCLEON -->   3/77
M     L  M+ ANYTHING). ASSUMES (M+ --> MU+ NEU NEU) WITH BR=.3.               3/77
M
M     M  BERNARDINI 73 IS FRASCATI E+E- EXPT. FIRST VALUE ASSUMES UNIVERSAL   2/74
M     M  COUPLING TO ORDINARY LEPTONS.  SECOND VALUE ALSO ASSUMES COUPLING    2/74
M     M  TO HADRONS.                                                          2/74
M
M     N  BUSHNIN 73 IS SERPUKOV 70 GEV P EXPT. MASSES ASSUME MEAN LIFE ABOVE  2/74
M     N  7E-10 AND 3E-8 RESPECTIVELY. CALCULATED FROM CROSS SEC(DC BELOW)     2/74
M     N  AND 30 GEV MUON PAIR PRODUCTION DATA.                                2/74
M
M     O  EICHTEN 73 IS CERN 1-10GEV NEU EXPT. LOOKS FOR M+ PRODUCED IN        2/76
M     O  NEU NUCL --> M+ HADRONS ASSUMING 15 PERCENT DECAY TO E+ NEU NEU.     2/76
M
M     P  HANSON 73 LOOK FOR DEVIATIONS FROM QED IN E+ E- -->2 GAMMA. THEY     6/77
M     P  MEASURE THE PRODUCT OF THE F MASS * THE COUPLING CONSTANT LAMBDA,    6/77
M     P  WHICH IS THE VALUE QUOTED ABOVE.                                     6/77
M
M     Q  ASRATYAN 74 USES EICHTEN 73 DATA ON NEU NUCL --> E- HADRONS AND      2/76
M     Q  ANTINEU NUCL --> E+ HADRONS TO SET LIMITS ON ORTHOMUON PRODUCTION.   2/76
M
M     R  BARISH 74 IS FNAL 50,135 GEV NEU EXPT.  LOOKS FOR (NEU NUCLEON -->   7/74
M     R  M+ ANYTHING).  ASSUMES (M+ -->MU+ NEU NEU) WITH BR=.3.               7/74
M
M     S  GITTLESON 74 IS MU P --> P ORTHOMUON SEARCH. COUPLING CONSTANT      12/77
M     S  LAMBDA**2 IS <.01 FOR MASS UP TO .7 GEV, LIMIT ON LAMBDA**2 RISES   12/77
M     S  TO <.1 FOR MASS OF 2.0 GEV.                                         12/77
M
M     T  ORITO 74 LOOKED FOR H+H- PAIRS GIVING MU-E PAIRS. MASS LIMIT REFERS  3/74
M     T  TO ANY NON-RADIATIVE TYPE HEAVY LEPTON -- L, E, M, F, N.             3/74
M     T  COUPLING TO HADRON ASSUMED FROM THEORETICAL MODELS.                  3/74
M
M     U  BACCI 77 IS SAME TYPE AS BACCI 73. LOWER MASS LIMIT CORRESPONDS TO  12/77
M     U  LAMBDA**2 LIMIT OF 4*10**-5, UPPER VALUE IS FOR LAMBDA**2 LIMIT OF  12/77
M     U  1.5*10**-3.                                                         12/77
M
M     V  MEYER 77 LOOKS FOR NARROW NEUTRAL RESONANCE IN(E PI)AND(MU PI)      12/77
M     V  CHANNELS PRODUCED BY E+E- AT 6.8 GEV (ECM). ASSUMED TO BE DECAY     12/77
M     V  PRODUCT OF THE TAU. SEE SECTION NE BELOW.
M
M     W  ASRATYAN 78 ANALYZES DEPENDENCE OF N.C./C.C. ON ENERGY OF ASSOC.     1/79
M     W  HADRONS. USES DATA OF HOLDER 77 (PL 72B, 254)--NUMU INTERACTIONS     1/79
M     W  AT CERN-SPS.                                                         1/79
M
M     X  CNOPS 78 IS FNAL EXPT LOOKING FOR NEUMU NE --> L+(-), FOLLOWD BY     8/78
M     X  L+(-) --> E+(-) NEU NEU.                                             8/78
M
M     Y  ERRIQUEZ 78 IS CERN SPS EXPT. LOOKS FOR NUMU NUCLEON-->MU- E+ X.     1/79
M     Y  FINDS CS FOR PRODUCING HVY LEPT--> E+ <.7*10**-3 *C.C. CS.           1/79
M
M     Z  HOLDER 78 IS A CERN NEU EXPT LOOKING FOR NEUMU NUCLEON --> MU+ ANY   6/78
M     Z  THING. ASSUMES M+ --> MU+ 2NEUMU WITH BR=0.2 .                       6/78
M
M     1  CLARK 81 IS FNAL EXP WITH 209 GEV MUONS. BOUNDS APPLY TO MO WHICH    1/82
M     1  COUPLES WITH FULL WEAK STRENGTH TO MUON. SEE ALSO SECTION MU.        1/82
M
M     2  HAYES 82 IS SLAC SPEAR EXPT.  THEIR TBL.5,6 GIVES CROSS SEC. LIMITS  4/82
M     2  FOR ORTHOMUON AND ORTHOELECTRON FOR MASSES IN ABOVE RANGE.           4/82
M
M     3  BARTEL 83 IS PETRA E+E- EXP WITH AVERAGE WCM=34.2 GEV.FIRST(SECOND) 11/83*
M     3  LIMIT IS FOR V+A(V-A) TYPE W-EO-E COUPLING.                         11/83*

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NEU      HEAVY LEPTON LIMITS (NEUTRINO NUCLEON)
NEU      SEE ALSO SECTION 'T' IN 'OTHER NEW PARTICLE SEARCHES'.
NEU  A    6 TRIMUON EVENTS            BENVENU1  77 NEUL    5/6NEU,1/6NEUBAR  1/78
NEU  A   10 MU+ MU-, 3 MU- MU- EVENTS BENVENU2  77 NEUL                      1/78
NEU  B                                BOSETTI   78 HYBR                      6/78
NEU
NEU  A   BENVENUT1 77 IS FNAL EXPT.AND CLAIMS TRIMUON EVTS. INDICATE BY PROD  7/77
NEU  A   OF A NEW HEAVY LEPTON -->MU- NEUBAR NEW LIGHTER LEPTON --> MU+ MU-   7/77
NEU  A   NEUTRINO. SEE ALSO BENVENUT2 77, ALBRIGHT 77 AND BARGER 77 FOR       7/77
NEU  A   FURTHER ANALYSIS.  THIS CLAIM WAS REFUTED BY LATER EXPS. AT CERN     7/77
NEU  A   (HOLDER 78)  AND FNAL (CNOPS 78), AND BY THEORETICAL ANALYSIS OF     7/77
NEU  A   OF COMBINED DATA - SEE SMITH 78.                                     7/77
NEU
NEU  B   BOSETTI 78 ANALYSES MOMENTA OF MUONS FROM DIMUON EVENTS USING        6/78
NEU  B   200 GEV NARROW BAND NEU BEAM AT CERN. FINDS (NEUMU P --> HVY-LEPT)/  6/78
NEU  B   (NEUMU P --> MU) < 0.06 (90 PCNT CL) WHERE HVY-LEPT --> E- NU(E)     6/78
NEU  B   NU(HVY-LEPT) 15 PCNT OF THE TIME.                                    6/78

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MU       HEAVY LEPTON PRODUCTION CROSS SECTION (MU NUCLEON) (CM**2)          10/81
MU       SEE ALSO SECT 'MU' IN CHARM SEARCHES AND OTHER NEW PARTICLE SEARCHES 10/81
MU   A      1.22E-34 OR LESS          LEBRITTON 80 SPEC    MO-->MU+ MU- NU   12/81
MU   B    0  4. E-38 OR LESS          CLARK     81 SPEC O  PARAMUON(MOBAR)    1/82
MU   B    0  6. E-38 OR LESS          CLARK     81 SPEC ++                    1/82
MU
MU   A   LEBRITTON 80 IS BNL EXP WITH 10.5GEV MUONS. TRIMUONS ARE CONSISTENT 12/81
MU   A   WITH QED TRIDENT AND DIFFRACTIVELY PRODUCED RHO DECAY.              12/81
MU
MU   B   CLARK 81 IS FNAL EXP WITH 209 GEV MUON. LOOKED FOR MU+ N-->MOBAR X,  1/82
MU   B   MOBAR-->MU+ MU- ANTINEU(MU) AND MU+ N-->M++ X,M++-->2MU+ NEU(MU).    1/82
MU   B   ABOVE LIMITS ARE FOR CS*BR TAKEN FROM THEIR MASS-DEP PLOT FIG.2.     1/82

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DC       HEAVY LEPTON PRODUCTION DIFF. CROSS SEC. (P NUCLEON) (CM**2/SR-GEV)
DC   A    0  1.6E-37 OR LESS  CL=.90   GOLOVKIN  72 CNTR- 70GEV P, SERPUKHOV  1/76
DC   B    0  4. E-38 OR LESS  CL=.90   BUSHNIN   73 CNTR- 70GEV P, SERPUKHOV  2/74
DC
DC   A   MASS RANGE 1 TO 4.5 GEV,THETA=0,P=25 GEV/C.                          1/76
DC
DC   B   BUSHNIN 73 HEAVY LEPTON PATH TRAVERSES 6800 GM/CM**2 ABSORBER.       2/74
DC   B   DIFFERENTIAL CROSS-SECTION MEASURED AT P=30 GEV/C THETA= 2 MRAD.     3/74

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TBD      TAU LEPTON PRODUCTION CROSS SECTIONS IN HADRONIC COLLISIONS (CM**2)  2/82
TBD  A       1.8E-30 OR LESS  CL=.90   AGAKISHIE 80 SPRK 70GEV P FE BM DUMP   2/82
TBD
TBD  A   AGAKISHIEV 80 REANALYZED BEAM DUMP DATA (ASRATYAN 78 PL 79B 497).    2/82
TBD  A   FOUND NO EXCESS OF MUONLESS EVENT IN NEUTRINO DETECTOR. ABOVE LIMIT  2/82
TBD  A   IS FOR CS(P NUC-->F X)*BR(F-->TAU NUTAU X) ASSUMING LINEAR A DEP     2/82
TBD  A   AND THAT SOLE SOURCE OF TAU LEPTON IS DECAY OF F-MESON.              2/82

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BD       PRODUCTION OF HEAVY LEPTON IN BEAM DUMP                              1/83*
BD   A                                LOSECCO   81 CALO    28 GEV PROTONS    1/83*
BD   A   LOSECCO 81 AT BNL AGS SET LIMIT FOR CS(PROD)*CS(INT) RATIO OF        1/83*
BD   A   SLOW (BETA<0.89) HEAVY LEPTONS TO PROMPT NEUS AS 2.2E-2(CL=.90).     1/83*

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IC       INVARIANT HEAVY LEPTON PROD. CROSS SEC. (P NUCLEON) (CM**2/GEV**2)
IC   A    0  5.4E-39 OR LESS  CL=.90   CRONIN    74 SPEC -  M=1-6.8 GEV       1/76
IC   B    0  6.4E-35 OR LESS  CL=.90   BINTINGER 75 SPEC +- M=1-5 GEV         2/76
IC   C    0  1.8E-33 OR LESS  CL=.90   ARMITAGE  79 SPEC    M=1.87 GEV        7/79
IC
IC   A   CRONIN 74 IS AN FNAL 300 GEV P CU EXPT.  LOOKED FOR LONG LIVED       2/76
IC   A   PENETRATING PARTICLES.  ABOVE LIMIT ASSUMES STABLE.  MULTIPLY IT BY  2/76
IC   A   EXP(1.22E-8*M/TAU) FOR MASS M(GEV) AND LIFETIME TAU(SEC). LIMIT      2/76
IC   A   OBTAINED AT THETA(LAB) = 77 MRAD, PT = 2.38 GEV/C.                   4/77
IC
IC   B   BINTINGER 75 IS A 30-300 GEV P C EXPT.  LOOKED FOR LONG LIVED        2/76
IC   B   PENETRATING PARTICLES.  ABOVE LIMIT ASSUMES STABLE.  MULTIPLY IT BY  2/76
IC   B   EXP(3.5E-8*M/TAU/P) FOR MASS M(GEV), LIFETIME TAU(SEC), MOM.P(GEV).  2/76
IC   B   OBTAINED AT THETA(LAB) = 91 MRAD, PT = 1-2.25 GEV/C..                4/77
IC
IC   C   ARMITAGE 79 IS CERN-ISR EXPT AT ECM=53 GEV.  VALUE IS FOR X=0.1 AND  7/79
IC   C   PT=.15.                                                              7/79

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RPI      HEAVY LEPTON PROD. CROSS SECTION ( CS(HVY LEP) / CS(PION) )         12/81
RPI  A    0  7. E-12 OR LESS  CL=.95   BUSSIERE  80 CNTR Q= -1   M=4-4.5 GEV 12/81
RPI  A    0  2.5E-12 OR LESS  CL=.95   BUSSIERE  80 CNTR Q= -2   M=5-7.5 GEV 12/81
RPI
RPI  A   BUSSIERE 80 IS CERN-SPS EXPT WITH 200-240 GEV PROTONS ON BE AND AL  12/81
RPI  A   TARGET SEARCHING FOR LONG-LIVED PARTICLES.  FOR LIMITS AT OTHER     12/81
RPI  A   MASS RANGES SEE THEIR FIG. 7.                                       12/81

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CN       NEUTRAL HEAVY LEPTON PRODUCTION CROSS SECTION  (CM**2)
CN   A    5 (1. E-37 OR MORE)         KRISHNASW 75 CNTR +0-  M=2-5 GEV        2/76
CN   B    0                           BENVENUTI 75 SPEC  0                    2/76
CN
CN   A   KRISHNASWAMY 75 IS KOLAR GOLD MINE COSMIC RAY EXPT.  TYPICAL EVENT   2/76
CN   A   HAS VERTEX IN AIR 70 CM FROM WALL WITH THREE OBSERVED CHARGED        2/76
CN   A   TRACKS.  AUTHORS SUGGEST NEU+ROCK GIVES NEW PARTICLE WITH MEAN LIFE  2/76
CN   A   10E-9 SEC OR LONGER.  DE RUJULA 75 GIVES ANOTHER INTERPRETATION.     2/76
CN   A   SEE ALSO RAJASEKARAN 75.                                             8/76
CN
CN   B   BENVENUTI 75 IS AN FNAL EXPERIMENT WHICH ROUGHLY SIMULATES THE       2/76
CN   B   KRISHNASWAMY 75 EXPT. BUT APPARENTLY CONTRADICTS IT, FINDING NO      2/76
CN   B   EVENTS. SENSITIVE TO DECAYS OF NEUTRAL PENETRATING PARTICLES         3/77
CN   B   PRODUCED BY THE PRIMARY PROTONS OR BY SECONDARY NEUTRINO             3/77
CN   B   INTERACTIONS IN THE 1 KM. NEUTRINO BEAM EARTH SHIELD.                3/77

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N        NEUTRAL HEAVY LEPTON PRODUCED IN NEUTRINO INTERACTIONS
N    A    1      POSSIBLY SEEN        BARANOV   77 HLBC  0 SERPUKHOV         12/77
N    A    2      POSSIBLY SEEN        BARANOV   79 HLBC  0 SERPUKHOV          1/82
N
N    A   BARANOV HEAVY LEPTON CLAIM REFUTED BY BALTAY 78.                      1/82

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MM       UNEXPLAINED MISSING NEUTRAL (HEAVY LEPTON?) MOMENTUM /TOTAL MOMENTUM
MM   A       0.05     0.03            ELLIOT    77 CALO                       1/78
MM
MM   A   ELLIOT 77 IS SLAC 10.5 GEV PI+ P --> P NPI+- NEUTRALS.  FINDS THAT   1/78
MM   A   NEUTRAL SPECTRUM CAN BE EXPLAINED BY GAMMA, KO, LAMBDA, NEUTRON.     1/78

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CP       NEUTRAL HEAVY LEPTON PROD. CROSS SEC. (PROTON NUCLEON) (CM**2)
CP   A    0  1. E-29 OR LESS          FAISSNER  76 HLBC 0                     1/77
CP   B    0  2.8E-35 OR LESS  CL=.90   BECHIS    78 SPEC  0                    8/78
CP   C    0  8.2E-40 OR LESS  CL=.90   AGAKISHIE 80 SPRK 0 M=4GEV,TAU=E-7 S   2/82
CP
CP   A   FAISSNER 76 LIMIT ASSUMES STABLE NEUTRAL WEAKLY INTERACTING LEPTON.  1/77
CP   A   ALSO RULES OUT DE RUJULA 75 INTERP. OF 5 KRISHNASWAMY 75 EVENTS AS   1/77
CP   A   (P NUCLEON --> L+ X, L+ --> L0 X) UNLESS L+ MASS IS ABOVE 3 GEV.     1/77
CP
CP   B   BECHIS 78 IS 400 GEV FNAL EXPT. LOOKS FOR P NUCLEON --> L+,          8/78
CP   B   L+ --> L0 X, L0 --> MU PI OR E PI. RESULT IS CL=.90 FOR MASS OF L0   8/78
CP   B   < 1 GEV, LIFETIME BETW 10**-10 AND 10**-8 SEC.(VALID ONLY FOR CASES  8/78
CP   B   WHEN L0 UNACCOMPANIED BY MUON OF P>10 GEV.)                          8/78
CP
CP   C   AGAKISHIEV 80 REANALYZED BEAM DUMP DATA FROM 70 GEV PROTON ON IRON   2/82
CP   C   (ASRATYAN 78 PL 79B,497). ASSUMED DRELL-YAN PROD OF CHGD HVY LEPTON  2/82
CP   C   PAIR FOLLOWED BY DECAY INTO NEUTRAL HVY LEPTON. ABOVE VALUE IS WHEN  2/82
CP   C   LIMIT IS MOST STRINGENT. FOR OTHER MASS AND LIFE,SEE THEIR TABLE 1,  2/82
CP   C   AND FOR LIMIT DEDUCED FOR PI NUCLEON INTERACTION,SEE THEIR TABLE 2.  2/82

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NE       NEUTRAL HEAVY LEPTON PROD. CROSS SECTION (E+ E-)  (CM**2)           12/77
NE   A       4.5E-36 OR LESS  CL=.90   MEYER     77 SMAG E+E- 6.8 GEV (ECM)  12/77
NE
NE   A   MEYER 77 EXPT LOOKS FOR NARROW NEUTRAL RESONANCE IN E-PI AND MU-PI  12/77
NE   A   CHANNELS. VALUE GIVEN IS FOR MASS OF .5 GEV, AND IS PRODUCT OF CS*  12/77
NE   A   BR(TAU--> NEW NEUTRAL LEPTON)*BR(NEUTRAL LEPTON--> E OR MU PI). IF  12/77
NE   A   MASS OF NEUTRAL LEPTON IS 1.5 GEV, LIMIT BECOMES 2.5E-36. SEE S25M. 12/77

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TNU      LIMIT ON NU(TAU) PRODUCTION IN BEAM DUMP EXPERIMENT                   1/82
TNU  A                                FRITZE    80 HYBR                       1/82
TNU
TNU  A   FRITZE 80 IS CERN SPS EXP WITH BEBC. NC/CC RATIO CORRESPONDS TO      1/82
TNU  A   R=(PROMPT-NU(TAU)-INDUCED EVENTS)/(ALL PROMPT-NU EVENTS) <0.1.       1/82
TNU  A   MIXING PROBABILITY P(NU(E)-->NU(TAU)) < 0.35 AT CL=.90.              1/82

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EXC      LIMITS ON EXCITED ELECTRONS(E*) AND MUONS(MU*)
EXC  A   NONE BELOW 58 GEV    CL=.95   ADEVA     82 MRKJ    E* PROD IN E+E-   1/84*
EXC  A   NONE BELOW 10 GEV    CL=.95   ADEVA     82 MRKJ    MU* PROD IN E+E-  1/84*
EXC  B                                 BUKIN     82         E* PROD IN E+E-   1/84*
EXC  C                                 RENARD    82         G-2 OF E*,MU*    11/83*
EXC  D                                 FORD      83 MAC     MU* PROD IN E+E- 11/83*
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For notation, see key at front of Listings.

Stable Particles

HEAVY LEPTON SEARCHES, $\pi^{\pm}$

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EXC  A  BERGSMA 83 M(E*) LIMIT ASSUMES E* COUPLING EQUALS TO THAT OF E.      1/84*
EXC  A  SEE THEIR FIG.2 FOR DEPENDENCE ON THE COUPLING.                      1/84*
EXC
EXC  B  BUKIN 82 IS VEPP-2M RING EXP FOR E+E- -->E+ E- GAMMA WITH WCM=0.64-  1/84*
EXC  B  1.4 GEV. OBSERVED NO PEAK IN M(E GAM) SPECTRUM. SET CL=.95 LIMIT     1/84*
EXC  B  CS(E*+E-)/CS(E+E-) < (0.2-6)*10**-4 FOR M(E*)=0.2-1.0 GEV.           1/84*
EXC
EXC  C  RENARD 82 DERIVED FROM G-2 DATA LIMITS ON MASS AND COUPLINGS OF E*  11/83*
EXC  C  AND MU*.  SEE FIGS.2 AND 3 OF THE PAPER.                            11/83*
EXC
EXC  D  FORD 83 AT PEP-MAC (WCM=29 GEV) SET CL=.90 LIMITS                   11/83*
EXC  D  CS(MU*MU*)/CS(MU+MU-) < (1-2)*10**-3 FOR M(MU*)=2-14 GEV, AND        11/83*
EXC  D  CS(MU* MU)/CS(MU+MU-) < (1-2)*10**-3 FOR M(MU*)=2.5-27 GEV.          11/83*

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                                REFERENCES FOR HEAVY LEPTON SEARCHES

BEHREND  65 PRL 15 900          +BRASSE,ENGLER,GANSSAUGE+        (DESY+KARL)
BETOURNE 65 PL 17 70            +NGUYEN NGOC,PEREZ Y JORBA+          (ORSA)
BUDNITZ  66 PR 141 1313         +DUNNING,GOITEIN,RAMSEY,WALKER,WILSON(HARV)
BARNA    68 PR 173 1391         +COX,MARTIN,PERL,TAN,TONER,ZIPF+(SLAC+STAN)
BOLEY    68 PR 167 1275         +ELIAS,FRIEDMAN,HARTMANN,KENDALL+ (MIT+CEA)

LIBERMAN 69 PRL 22 663          +HOFFMAN,ENGELS,IMRIE+(HARV+CASE+MCGI+SLAC)
ROTHE    69 NP B10 241          K.W.ROTHE,A.M.WOLSKY                 (PENN)
LICHTENS 70 PR D1 825           LICHTENSTEIN,ASH,BERKELMAN,HARTILL+  (CORN)
RAMM     70 NATURE 227 1323     C.A.RAMM                             (CERN)
    ALSO 72 NATURE 237 388      CLARK,ELIOFF,FIELD,FRISCH,JOHNSON+    (LBL)

RAMM     71 NAT.PH.SC.230 145 C.A.RAMM                             (CERN)
GOLOVKIN 72 PL 42B 136          +GRACHEV,KHODYREV,KUBAROVSKY+        (SERP)
ANSORGE  73 PR D7 26            +BAKER,KRZESINSKI,NEALE,RUSHBROOKE+  (CAVE)
BACCI    73 PL 44B 530          +PARISI,PENSO,SALVINI,STELLA+   (ROMA+FRAS)
BARISH   73 PRL 31 410          +BARTLETT,BUCHHOLZ,HUMPHREY+     (CIT+FNAL)

BERNARDI 73 NC 17A 383          BERNARDINI,BOLLINI,BRUNINI+(CERN+BGNA+FRAS)
    ALSO 70 LNC 4 1156          ALLES-BORELLI,BERNARDINI,BOLLINI+    (CERN)
BUSHNIN  73 NP B58 476          +DUNAYTZEV,GOLOVKIN,KUBAROVSKY +     (SERP)
    ALSO 72 PL 42B 136          GOLOVKIN,GRACHEV,SHODYREV +          (SERP)
EICHTEN  73 PL 46B 281          +DEDEN+(AACH+BELG+CERN+EPOL+MILA+LALO+LOUC)
HANSON   73 NCL 7 587           +LEONG,NEWMAN,LAW,LITKE+(MIT+HARV+CEA+HAIF)

ASRATYAN 74 PL 49B 488          +GERSHTEIN,KAFTANOV,KUBANTZEV,LAPIN+ (SERP)
BARISH   74 PRL 32 1387         +BARTLETT,BUCHHOLZ,MERRITT +     (CIT+FNAL)
CRONIN   74 PR D10 3093         +FRISCH,SHOCHET,BOYMOND,MERMOD + (EFI+PRIN)
GITTLESO 74 PR D10 1379         GITTLESON,KIRK+        (HARV+ROCH+COLU+FNAL)
ORITO    74 PL 48B 165          +VISENTIN,CERADINI,CONVERSI +   (FRAS+ROMA)

BENVENUT 75 PRL 35 1486         BENVENUTI,CLINE,FORD+ (HARV+PENN+WISC+FNAL)
BINTINGE 75 PRL 34 982          BINTINGER,CURRY+       (EFI+HARV+PENN+WISC)
BACCI    77 PL 71B 227          +DEZORZI,PENSO,STELLA+          (ROMA+FRAS)
KRISHNAS 75 PL 57B 105          KRISHNASWAMY,MENON+          (BOMBAY+OSAKA)
    ALSO 75 PRL 35 628          DE RUJULA,GEORGI,GLASHOW              (HARV)
    ALSO 75 PRAMANA 5 78        RAJASEKARAN,SARMA                     (TIFR)

FAISSNER 76 PL 60B 401          +HASERT+(AACH+BELG+CERN+EPOL+MILA+OXF+LOUC)
BARANOV  77 PL 70B 269          +VOLKOV,GERSHTEIN,IVANILOV +         (SERP)
    ALSO 77 SJNP 26 57          BARANOV,VOLKOV,GERSHTEIN,IVANILOV   +(SERP)
BENVENU1 77 PRL 38 1110         BENVENUTI,CLINE+ (FNAL+HARV+PENN+RUTG+WISC)
    ALSO 77 PRL 38 1187         ALBRIGHT,SMITH,VERMASEREN        (FNAL+STON)
    ALSO 77 PRL 38 1190         BARGER,GOTTSCHALK+      (WISC+ZARAGOZA+RHEL)
BENVENU2 77 PRL 38 1183         BENVENUTI,CLINE+ (FNAL+HARV+PENN+RUTG+WISC)

ELLIOT   77 PR D15 1851         +FORTNEY,GOSHAW,LAMSA,LOOS+      (DUKE+ALBA)
MEYER    77 PL 70B 469          +NGUYEN,ABRAMS,ALAM+   (SLAC+LBL+NWES+HAWA)
ASRATYAN 78 PL 76B 237          ASRATYAN,KUBANTSEV                   (ITEP)
BALTAY   78  TOKYO CONF.        C.BALTAY (19TH INTL. CONF. ON HEP)   (COLU)

BECHIS   78 PRL 40 602          +CHANG,DOMBECK,ELLSWORTH,GLASSER,LAU+ (UMD)
BOSETTI  78 PL 73B 380          +DEDEN +      (AACH+BONN+CERN+LOIC+OXF+SACL)
CNOPS    78 PRL 40 144          +CONNOLLY,KAHN,KIRK,MURTAGH +     (BNL+COLU)
ERRIQUEZ 78 PL 77B 227                  BARI+BIRM+BRUX+EPOL+RHEL+SACL+LOUC
HOLDER   78 PL 74B 277          +KNOBLOCH,MAY +  (CERN+DORT+HEID+SACL+BGNA)
SMITH    78  NU 78 CONF         J.SMITH                              (COLU)

ARMITAGE 79 NP B150 87          +BENZ,BOBBINK+ (CERN+DARE+FOM+MCHS+UTRECHT)
BARANOV  79 PL 81B 261          +IVANILOV,KONYUSHKO,KORABLEV+        (SERP)
    ALSO 79 SJNP 29 622         BARANOV,+VOLKOV,IVANILOV,KONYUSHKO,+ (SERP)

AGAKISHI 80 SJNP 32 345         AGAKISHIEV,VOVENKO,GORYACHEV,MUKHIN  (SERP)
AZIMOV   80 JETPL 32 665        YA.I.AZIMOV,V.A.KHOZE                (KONS)
BARBER   80 PRL 45 1904         +BECKER,BEI+        (AACH+DESY+MIT+AIKO+BHEP)
BUSSIERE 80 NP B174 1           +GIACOMELLI,LESQUOY+       (BGNA+SACL+LAPP)
FRITZE   80 PL 96B 427          AACH+BONN+CERN+LOIC+OXF+SACL COLLABORATION
LEBRITTO 80 PL 89B 271          LEBRITTON,MCCAL,MELISSINOS+  (ROCH+BNL+NSF)

BERGER   81 PL 99B 489          +GENZEL+(AACH+BERG+DESY+HAMB+UMD+SIEG+WUPP)
BRANDELI 81 PL 99B 163          BRANDELIK+  (AACH+BONN+DESY+HAMB+LOIC+OXF+)
CLARK    81 PRL 46 299          +JOHNSON,KERTH,LOKEN+   (UCB+LBL+FNAL+PRIN)
    ALSO 82 PR D25 2762         SMITH,CLARK,JOHNSON+    (UCB+LBL+FNAL+PRIN)
LOSECCO  81 PL 102B 209         +SULAK,GALIK,HORSTKOTTE+    (MICH+PENN+BNL)

ADEVA    82 PRL 15 967          MARK-J C (AACH+DESY+MIT+MADR+ANIK+CIT+BHEP)
BUKIN    82 SJNP 35 844         +KURDADZE,LELCHUK,PANIN,SIDOROV+     (SIBE)
HAYES    82 PR D25 2869         +PERL,ALAM,BOYARSKI,BREIDENBACH+ (SLAC+LBL)
RENARD   82 PL 116B 264         F.M.RENARD                           (CERN)

ADEVA    83 PRL 51 443          MARKJ C. (AACH+DESY+MIT+MADR+AIKO+BHEP+CIT)
BARTEL   83 PL 123B 353         +CORDS+(DESY+HAMB+HEID+LANC+MCHS+RHEL+TOKY)
FORD     83 PRL 51 257          +READ,SMITH+(COLO+FRAS+NEAS+SLAC+UTAH+WISC)

                                REVIEWS

PERL     81  SLAC-PUB-2752      M.L.PERL, PHYS. IN COLL. CONF, V.P.I.(SLAC)
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                    8  CHARGED PION(140,JPG=0--) I=1

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                    8  CHARGED PION MASS (MEV)

M          139.37     0.20          CROWE     54 CNTR  -
M          139.68     0.15          BARKAS    56 EMUL +
M   S     (139.577)  (0.013)        SHAFER    67 CNTR  - MESONIC ATOMS     6/68
M   B     (139.549)  (0.008)        BACKENSTO 71 CNTR  - MESONIC ATOMS    10/71
M    S     139.566    0.013         SHAFER    72 CNTR  - MESONIC ATOMS     1/73
M    B     139.569    0.008         BACKENSTO 73 CNTR  - MESONIC ATOMS     1/73
M          139.571    0.010         BRANDAODO 76 CNTR  - MESONIC ATOMS     1/78
M          139.5686   0.0020        CARTER    76 CNTR  - MESONIC ATOMS     6/77
M    M     139.5667   0.0024        MARUSHENK 76 CNTR  - MESONIC ATOMS    12/77
M   D     (139.5658) (0.0018)       DAUM      79 SPEC +  PI+ --> MU+ NEU  10/81
M          139.5675   0.0009        LU        80 CNTR  - MESONIC ATOMS     1/81
M    S  SHAFER 72 UPDATES SHAFER67 WITH NEW ALPHA AND NEW CALIB. LINE ENER.  1/73
M    B  BACKENSTOSS 73 CORRECTS BACKENSTOSS 71 WITH NEW VACUUM POL. CALC.    1/73
M    M  THIS MARUSHENKO 76 VALUE USED AT AUTHORS REQUEST BECAUSE IT USES     3/78
M    M  ACCEPTED SET OF CALIBRATION GAMMA ENERGIES.  ERROR INCREASED FROM    3/78
M    M  .0017 TO INCLUDE QED CALC. ERROR OF .0017 (12 PPM).                  3/78
M   D   DAUM 79 VALUE DEPENDS ON ASSUMED MU+ MASS M(MU)=105.65948+-.00035 .  2/78
M   D   ENTERS OUR FIT VIA PI-MU MASS DIFF. BELOW WHICH IS INDEP. OF M(MU).  2/78
M          . . . . . . . . . .
M   AVG    139.56761  0.00077  AVERAGE
M   FIT    139.5673   0.0007  FROM FIT                                      3/84*

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                    8  (PI+) - (MU+) MASS DIFFERENCE (MEV)

D          34.00      0.076         BARKAS    56 EMUL
D          33.89      0.076         BARKAS    56 EMUL
D     145  33.881      0.035         HYMAN     67 HEBC  + K-HE              2/71
D          33.925     0.025         BOOTH     70 CNTR  + MAGNETIC SPECT.    2/71
D          33.9063    0.0018        DAUM      79 SPEC +  SEE NOTE D ABOVE 10/81
D          . . . . . . . . . .
D   AVG    33.9064    0.0018  AVERAGE
D   FIT    33.9080    0.0008 FROM FIT                                       3/82

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                    8  ((PI+) - (PI-))/AVG., MASS DIFFERENCE (PERCENT)

DM      TEST OF CPT
DM          0.02      0.05          AYRES     71 CNTR                       3/71

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                    8  CHARGED PION MEAN LIFE (UNITS 10**-9 SEC)

T          25.6       0.5     0.5   CROWE     57 RVUE
T          25.6       0.8     0.8   ANDERSON  60 CNTR
T     8000 25.46      0.32    0.32  ASHKIN    60 CNTR +
T          26.02      0.04          ECKHAUSE  65 CNTR +                     9/66
T          25.6       0.3           BARDON    66 CNTR                       6/66
T          25.9       0.3           DUNAITSEV 66 CNTR                       6/68
T   N     (26.40)   (0.08)           KINSEY    66 CNTR +                     6/66
T   N   SYSTEMATIC ERRORS IN CALIBR.IN THIS EXP.DISCUSSED BY NORDBERG 67     8/67
T          26.67      0.24          LOBKOWICZ 66 CNTR                       9/66
T          26.04      0.05          NORDBERG  67 CNTR +                     8/67
T          26.02      0.04          AYRES     71 CNTR +-                    3/71
T          26.09      0.08          DUNAITSEV 73 CNTR +                     3/74
T          . . . . . . . . . .
T   AVG    26.030     0.023    0.023  AVERAGE

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                    8  ((PI+) - (PI-))/AVG., MEAN LIFE DIFF. (PERCENT)

DT  N   THIS QUANTITY IS A MEASURE OF CPT INVARIANCE IN W.I.

DT          0.23      0.40          LOBKOWICZ 66 CNTR     SEE NOTE L        9/66
DT  L   ABOVE IS THE MOST CONSERVATIVE VALUE QUOTED BY AUTHORS               9/66
DT          0.4       0.7           BARDON    66 CNTR                       7/66
DT         -0.14      0.29          PETRUKHIN 68 CNTR                       8/68
DT          0.055     0.071         AYRES     71 CNTR                       3/71
DT         . . . . . . . . . .
DT  AVG     0.053     0.068   AVERAGE

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                    8  CHARGED PION PARTIAL DECAY MODES

                                                        DECAY MASSES
P1      CHAR. PION INTO MU (MU-NEU)                    106+   0
P2      CHAR. PION INTO E ( E-NEU)                    .511+   0
P3      CHAR. PION INTO MU (MU-NEU) GAMMA              106+   0+   0
P4      CHAR. PION INTO PI0 E (E-NEU)                  135+.511+   0
P5      CHAR. PION INTO E NEU GAMMA                   .511+   0+   0
P6      CHAR. PION INTO E NEU E+ E-                   .511+   0+.511+.511
P7      PI+ INTO MU+ NEUBAR(E)                         106+   0
P8      PI+ INTO MU+ NEU(E)                            106+   0

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                    8  CHARGED PION BRANCHING RATIOS

R1      CHAR. PION INTO MU NEU GAMMA (UNITS 10**-4)       (P3)/(P1)
R1       26    1.24      0.25          CASTAGNOL 58 EMUL    E(MU).LT.3.38 MV

R2      CHAR. PION INTO E NEU (UNITS 10**-4)              (P2)/(P1)
R2          1.21      0.07          ANDERSON  60 CNTR
R2  D   11K   (1.247)  (0.028)        DI CAPUA  64 CNTR                    11/75
R2  D   11K   1.274     0.024         BRYMAN    75 RVUE                     9/75
R2      32K   1.218     0.014         BRYMAN    83 CNTR +                  10/83*
R2  D    BRYMAN 75 IS A RECALC. OF DICAPUA 64 EXPT USING LATEST PI LIFETIME.  9/75
R2         . . . . . . . . . .
R2  AVG     1.232     0.024   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 2.0)
                              (SEE IDEOGRAM BELOW)
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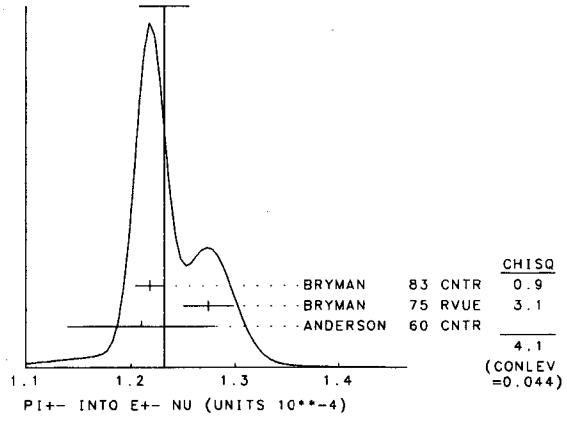
WEIGHTED AVERAGE = 1.232 ± 0.024

ERROR SCALED BY 2.0



Stable Particles

Data Card Listings

$\pi^{\pm}$, π^{0}

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R3      CHAR. PION INTO PIO E NEU (UNITS 10**-8)           (P4)/(P1)
R3  D   52   (1.15)   (0.22)          DEPOMMI1  63 CNTR +                     2/72
R3   D  36    0.97     0.20           BARTLETT  64 OSPK +
R3   D  38    1.07     0.21           BACASTOW  65 OSPK +
R3   D        1.10     0.26           BERTRAM   65 OSPK +                     6/66
R3   D  43    1.1      0.2            DUNAITSEV 65 CNTR +                     7/66
R3     332    1.00     0.08     0.10  DEPOMMIER 68 CNTR +                     3/68
R3 M  1235    1.036    0.039          MCFARLANE 83 CNTR +  DECAY IN FLIGHT   10/83*
R3  D   DEPOMMIER 68 STATES THAT THE RESULT OF DEPOMMIER 63 IS AT LEAST       2/72
R3  D   10 PERCENT TOO LARGE BECAUSE OF A SYSTEMATIC ERROR IN THE PIO         2/72
R3  D   DETECTION EFFICIENCY.  THIS MAY BE TRUE OF ALL THE PREVIOUS           2/72
R3  D   MEASUREMENTS ACCORDING TO DEPOMMIER 68 AND V.SOERGEL, PRIVATE         2/72
R3  D   COMMUNICATION, 1972.
R3 M    COMBINES MEASURED RATE(.398+-.015)/SEC WITH 1982 PDG MEAN LIFE.      10/83*
R3            . . . . . . . . . .
R3  AVG       1.033    0.034    AVERAGE

R4      CHAR. PION INTO E NEU GAMMA (UNITS 10**-8)         (P5)/(P1)
R4      143   (3.0)                   DEPOMMI2  63 CNTR + E+, GAM KE >48MEV   3/82
R4    S 226    5.6      0.7           STETZ     78 SPEC + E MOM >56 MEV/C.   12/79
R4    S  STETZ 78 IS FOR E-GAMMA OPENING ANGLE >132DEG.  OBTAINS 3.7 WHEN    12/79
R4    S  USING SAME CUTOFFS AS DEPOMMIER.                                    12/79

R5      CHAR. PION INTO E NEU E+ E- (UNITS 10**-8)         (P6)/(P1)
R5            (3.4)  OR LESS  CL=.90  KORENCHEN 71 OSPK +                    10/71
R5             0.48  OR LESS  CL=.90  KORENCHEN 76 SPEC +                     1/78

R6      PI+ INTO MU+ NEUBAR(E) (UNITS 10**-3)              (P7)/(P1)
R6       FORBIDDEN BY TOTAL LEPTON NUMBER CONSERVATION.
R6             1.5   OR LESS  CL=.90  COOPER    82 HLBC WIDEBAND NEU BEAM    1/83*

R7      PI+ INTO MU+ NEU(E) (UNITS 10**-3)                 (P8)/(P1)
R7       FORBIDDEN BY LEPTON FAMILY NUMBER CONSERVATION.
R7             8.0   OR LESS  CL=.90  COOPER    82 HLBC WIDEBAND NEU BEAM    1/83*

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REFERENCES FOR CHARGED PION


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CROWE    54 PR  96  470       K M CROWE,R H PHILLIPS                    (LRL)
BARKAS   56 PR 101  778       W H BARKAS,W BIRNBAUM,F M SMITH           (LRL)
CROWE    57 NC   5  541       K M CROWE                      (STANFORD HEPL)
CASTAGNO 58 PR 112 1779       C CASTAGNOLI,M MUCHNIK                   (ROMA)

ANDERSON 60 PR 119 2050       H L ANDERSON,T FUJII,R H MILLER +         (EFI)
ASHKIN   60 NC  16  490       ASHKIN,FAZZINI,FIDECARO,LIPMAN +         (CERN)
DEPOMMI1 63 PL 5 61           DEPOMMIER,HEINTZE,RUBBIA,SOERGEL         (CERN)
DEPOMMI2 63 PL 7 285          P DEPOMMIER,HEINTZE,RUBBIA,SOERGEL       (CERN)
BARTLETT 64 PR 136B 1452      BARTLETT,DEVONS,MEYER,ROSEN          (COLUMBIA)
DI CAPUA 64 PR 133B 1333      DI CAPUA,GARLAND,PONDROM,STRELZOFF       (COLU)

BACASTOW 65 PR 139 B407       +GHESQUIERE,WIEGAND,LARSEN           (LRL+SLAC)
BERTRAM  65 PR 139 B 617      BERTRAM,MEYER,CARRIGAN+        (MICH+CARNEGIE)
DUNAITSE 65 JETP 20 58        DUNAITSEV,PETRUKHIN,PROKOSHKIN +        (DUBNA)
ECKHAUSE 65 PL 19 348         ECKHAUSE,HARRIS,SHULER+  (WILLIAM AND MARY)

BARDON   66 PRL 16 775        BARDON,DORE,DORFAN,KRIEGER +         (COLUMBIA)
DUNAITSE 66 PL 23 283         +KUTYIN,PROKOSHKIN,RASUVAEV,SIMONOV (DUBNA)
KINSEY   66 PR 144    1132    KINSEY,LOBKOWICZ,NORDBERG  (ROCHESTER UNIV)
LOBKOWIC 66 PRL  17  548      LOBKOWICZ,MELISSINOS,NAGASHIMA+  (ROCH+BNL)

HYMAN    67 PL 25B 376        +LOKEN,PEWITT,DERRICK +       (ANL+CARN+NWES)
NORDBERG 67 PL 24B  594       NORDBERG,LOBKOWICZ,BURMAN  (ROCHESTER UNIV)
SHAFER   67 PR 163 1451       ROBERT E. SHAFER                          (LRL)
    ALSO 65 PRL 14 923        SHAFER,CROWE,JENKINS                      (LRL)

DEPOMMIE 68 NP B4 189         DEPOMMIER,DUCLOS,HEINTZE,KLEINKNECHT+(CERN)
PETRUKHI 68 JINR-P1-3862      PETRUKHIN,RYKALIN,KHAZINS,CISEK         (DUBNA)
BOOTH    70 PL 32B 723        +JOHNSON,WILLIAMS,WORMALD                (LIVP)
AYRES    71 PR 3D 1051        +CORMACK,GREENBERG,KENNEY +         (LRL,UCSB)
    ALSO 67 PR   157  1288    AYRES,CALDWELL,GREENBERG,KENNEY,KURZ+ (LRL)
    ALSO 68 PRL 21 261        AYRES,CORMACK,GREENBERG,KENNEY+   (LRL,UCSB)
    ALSO 69 UCRL-18369        DAVID S AYRES (THESIS)                    (LRL)
    ALSO 69 PRL 23 1267       GREENBERG,AYRES,CORMACK,KENNEY+   (LRL,UCSB)

BACKENST 71 PL 36B 403        BACKENSTOSS,DANIEL,KOCH+    (CERN,KARL,HEID)
    ALSO 70 THESIS            C. VON DER MALSBURG              (HEIDELBERG)
KORENCHE 71 SJNP 13 189       KORENCHENKO,KOSTIN,MICELMACHER+          (JINR)
SHAFER   72 PRIVATE COMM.     R. SHAFER, 1972                          (FNAL)
BACKENST 73 PL 43B 539        BACKENSTOSS,DANIEL,KOCH+ (CERN+KARL+MUNICH)
    ALSO 73 SUBMITTED TO NP   L. TAUSCHER
DUNAITSE 73 SJNP 16 292       DUNAITSEV,PROKOSHKIN,RAZUVAEV+           (SERP)

BRYMAN   75 PR D11 1337       +PICCIOTTO                 (UNIV OF VICTORIA)
BRANDAOD 76 ZNAT 31A 1150     BRANDAO D'OLIVERA,DANIEL,VON EGIDY+  (MUNI)
CARTER   76 PRL 37 1380       +DIXIT,SUNDARESAN+       (CARL+CNRC+CHIC+CIT)
KORENCHE 76 JETP 44 35        KORENCHENKO,KOSTIN,MICELMACHER+          (JINR)
MARUSHEN 76 JETPL 23 72       MARUSHENKO,MEZENTSEV,PETRUNIN+           (LENI)
    ALSO 76  PRIVATE COMM.    R. SHAFER                                (FNAL)
    ALSO 78  PRIVATE COMM.    A. I. SMIRNOV                            (LENI)

STETZ    78 NP B138 285       +CARROLL,ORTENDAHL,PEREZ-MENDEZ+ (LBL+UCLA)
DAUM     79 PR D20 2692       +EATON,FROSCH,HIRSCHMANN,MCCULLOCH+      (SIN)
    ALSO 78 PL 74B 126        DAUM,EATON,FROSCH,HIRSCHMANN,+            (SIN)
LU       80 PRL 45 1066       +DELKER,DUGAN,WU,CAFFREY+     (YALE+COLU+JHU)
COOPER   82 PL 112B 97        +GUY,MICHETTE,TYNDEL,VENUS                 (RL)
BRYMAN   83 PRL 50 7          +DUBOIS,NUMAO+    (TRIU+VICT+CNRC+BRCO+QUKI)
MCFARLAN 83 PRL 51 249        MCFARLANE,AUERBACH,GAILLE+        (TEMP+LANL)

                              PAPERS NOT REFERRED TO IN DATA CARDS

CARTWRIG 53 PR 91 677         CARTWRIGHT,RICHMAN,WHITEHEAD,WILCOX   (LRL)J
MERRISON 62 ADVP 11 1         A W MERRISON                        (LIVERPOOL)
SHAPIRO  62 PR 125 1022       G SHAPIRO,L M LEDERMAN               (COLUMBIA)
CZIRR    63 PR 130 341        JOHN B CZIRR                              (LRL)
CARRIGAN 68 NP B6 662         R.A.CARRIGAN JR.                        (CARN)J
DEPOMMIE 80 NP A335 97        P.DEPOMMIER                              (MONT)
WILKIN   80 JPG 6 L5          C. WILKIN                               (LOUC)P
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π^0 — 9 NEUTRAL PION(135,JPG=0--) I=1

9 (PI+-) - (PIO) MASS DIFFERENCE (MEV)

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D           (5.37)   (1.0)          PANOFSKY  51 CNTR  -
D            4.50     0.31          CHINOWSKY 54 CNTR  -
D            4.62     0.05          HADDOCK   59 CNTR  -
D            4.60     0.04          HILLMAN   59 CNTR
D            4.55     0.07          CASSELS   59 CNTR
D            4.69     0.07          SAMIOS    60 HBC                          2/72
D            4.6056   0.0055        CZIRR     63 CNTR
D            4.59     0.03          PETRUKHIN 63 CNTR  -
D            4.6034   0.0052        VASILEVSK 66 CNTR  -                        9/66
D          . . . . . . . . . .
D    AVG     4.6043   0.0037  AVERAGE
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9 NEUTRAL PION MEAN LIFE (UNITS 10-16 SEC)**

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T   N   76   (1.9)    (0.5)    (0.5)  GLASSER   61 EMUL
T   N   45   (2.3)    (1.1)    (1.0)  TIETGE    62 EMUL
T   N   88   (2.8)    (0.9)    (0.9)  KOLLER    63 EMUL    SEE STAMER 66
T             1.05     0.18     0.18  VON DARDE 63 CNTR
T   N   75   (1.7)    (0.5)           SHWE      64 EMUL
T             0.730    0.105          BELLETTIN 65 CNTR                      6/66
T   N   67   (1.6)    (0.6)    (0.5)  EVANS     65 EMUL                      6/66
T  K   232    1.0      0.5            STAMER    66 EMUL                      8/67
T             0.56     0.06           BELLETTIN 70 CNTR    PRIM.EFF. ON NUC  7/70
T             0.9      0.068          KRYSHKIN  70 CNTR    PRIMAKOFF EFFECT 12/70
T  B          0.82     0.04           BROWMAN   74 CNTR    PRIMAKOFF EFFECT  7/75
T   N   OLD EMULSION MEASUREMENTS NOT USED BECAUSE OF POSSIBLE SYSTEMATIC
T   N   SHIFT TO LARGER MEAN LIFE VALUES.
T  K    INCLUDES EVENTS OF KOLLER 63.                                         8/67
T  B    BROWMAN GIVES PIO WIDTH=8.02+-.42EV.  MEAN LIFE IS HBAR/WIDTH.       11/75
T          . . . . . . . . . .
T   AVG       0.828    0.057    0.053  AVERAGE (ERROR INCL. SCALE FACTOR OF 1.8)
                       (SEE IDEOGRAM BELOW)
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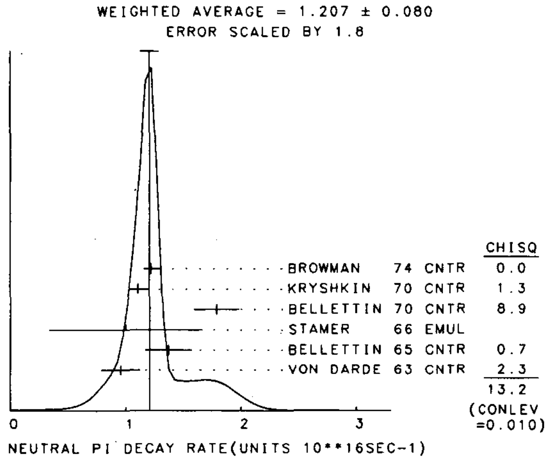

9 NEUTRAL PION PARTIAL DECAY MODES

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                                                   DECAY MASSES
P1      PIO INTO 2GAMMA                              0+    0
P2      PIO INTO E+ E- GAMMA                       .511+.511+   0
P3      PIO INTO 4ELECTRONS                        .511+.511+.511+.511
P4      PIO INTO 3 GAMMA                             0+    0+    0
P5      PIO INTO 4 GAMMA                             0+    0+    0+    0
P6      PIO INTO E+ E-                             .511+.511
P7      PIO INTO 2 NEUTRINOS                         0+    0
P8      PIO INTO MU+ E- + MU- E+                    106+.511
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9 NEUTRAL PION BRANCHING RATIOS

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R1      PIO INTO (GAMMA E+ E-)/(2GAMMA) (PERCENT)          (P2)/(P1)
R1           (1.196)  THEORET. CALC.  JOSEPH    60        QUANTUM ELECT.    9/66
R1      27    1.17     0.15           BUDAGOV   60 HBC
R1    3071    1.166    0.047          SAMIOS    61 HBC    PI- P --> PIO N
R1            1.25     0.04           SCHARDT   81 SPEC   PI- P --> PIO N   1/82
R1  S   SAMIOS VALUE USES PANOFSKY RATIO = 1.62
R1          . . . . . . . . . .
R1  AVG       1.213    0.030    AVERAGE

R2      PIO INTO (3 GAMMA)/TOTAL     (UNITS 10**-6)        (P4)
R2       FORBIDDEN BY C INVARIANCE.
R2   D   0   (4.9)  OR LESS  CL=.90   DUCLOS    65 CNTR                     6/66
R2   D       (4.9)  OR LESS  CL=.90   KUTIN     65 CNTR                     3/68
R2   D  THESE EXPTS. GIVE BR(3GAMMA/2GAMMA)<5.0*10**-6.
R2       0   (1.5)  OR LESS  CL=.90   AUERBAC1  78 CNTR                     1/79
R2       0    0.38  OR LESS  CL=.90   HIGHLAND  80 CNTR                     1/81

R3      PIO INTO (E+E+E-E-)/(2 GAMMA) (UNITS 10**-5)       (P3)/(P1)
R3  N  146   (3.18)   (0.30)          SAMIOS    62 HBC     SEE NOTE N BELOW  6/66
R3            3.28    THEORET. CALC.  MIYAZAKI  73         QUANTUM ELECT.    2/76
R3  N   ABOVE VALUE USES PANOFSKY RATIO = 1.62

R4      PIO INTO (4 GAMMA)/TOTAL      (UNITS 10**-5)   (P5)                 8/73
R4   A   0   (6.0)  OR LESS  CL=.90   ABRAMS     73 ASPK                    8/73
R4   A  ABRAMS 73 GIVES BR(4GAMMA/2GAMMA)<6.1*10**-5.
R4       0   (3.8)  OR LESS  CL=.90   AUERBAC2  78 CNTR                     2/79
R4       0    0.44  OR LESS  CL=.90   AUERBACH  80 CNTR                     8/81

R5      PIO INTO (E+ E-)/TOTAL  (UNITS 10**-6)             (P6)/(P1)       12/75
R5   D       (2.0)  OR LESS  CL=.90   DAVIES    74 RVUE                    12/75
R5           (4.0)  OR LESS  CL=.90   SCHACHER  77 STRC    PI- P --> PIO N 11/82*
R5       8    0.223    0.240    0.110 FISCHER2  78 SPRK    K+ EXPT. CL=.90  6/78
R5      58   (0.18)   (0.06)          MISCHKE   82 SPEC    REPL.BY FRANK 83 11/82*
R5      59    0.17     0.07           FRANK     83 SPEC    PI- P --> PIO N 11/83*
R5   D  DAVIES 74 EXTRACTS THIS INFORMATION FROM BLOCH 75 K+ EXPERIMENT.   12/75
R5          . . . . . . . . . .
R5  AVG       0.177    0.065    AVERAGE

R6      PIO INTO (2 NEU)/TOTAL   (UNITS 10**-5)           (P7)              2/82
R6       0    2.4   OR LESS  CL=.90   HERCZEG   81 RVUE                     2/82
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For notation, see key at front of Listings.

Stable Particles
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R7	PIO INTO (MU+ E- + MU- E+)/TOTAL			(P8)		
R7	FORBIDDEN BY LEPTON FAMILY NUMBER CONSERVATION					
R7	7E-8 OR LESS	BRYMAN	82 RVUE		K+ --> PI+ MU E	11/83*
R7	(14E-8) OR LESS	HERCZEG	84 RVUE		K+ --> PI+ MU E	2/84*
R7	(2E-15)OR LESS	HERCZEG	84 THEO		MU- --> E- CONV	2/84*

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9 NEUTRAL PION ELECTROMAGNETIC FORM FACTOR

THE AMPLITUDE FOR THE PROCESS PIO --> E+ E- GAMMA CONTAINS A FORM FACTOR GAMMA(X**2) AT THE (PIO GAMMA GAMMA) VERTEX WHERE X=MASS(E+E-)/MASS(PIO). THE PARAMETER A IN THE LINEAR EXPANSION GAMMA(X**2)=1+A*(X**2) IS LISTED BELOW.

A		LINEAR COEFFICIENT OF PIO ELECTROMAGNETIC FORM FACTOR						
A			(-0.15)	(0.10)	KOBRAK	61 HBC	NO RAD. CORR.	2/80
A		3071	(-0.24)	(0.16)	SAMIOS	61 HBC	NO RAD. CORR.	2/80
A		2200	(+0.01)	(0.11)	DEVONS	69 OSPK	NO RAD. CORR.	2/80
A	F	30K	+0.10	0.03	FISCHER1	78 SPEC	RAD. CORR.	2/80
A	F	ERROR STATISTICAL ONLY. RESULT WITHOUT RAD. CORR.=+0.05+-0.03.						2/80

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REFERENCES FOR NEUTRAL PION

PANOFSKY 51 PR 81 565	W K H PANOFSKY,R L AAMODT,J HADLEY	(LRL)
CHINOWSK 54 PR 93 586	W CHINOWSKY,J STEINBERGER	(COLUMBIA)
CASSELS 59 PPS 74 92	CASSELS,JONES,MURPHY,O.NEILL	(LIVERPOOL)
HADDOCK 59 PRL 3 478	HADDOCK,ABASHIAN,CROWE,CZIRR	(LRL)
HILLMAN 59 NC 14 887	HILLMAN,MIDDELKOOP,YAMAGATA,ZAVATTINI	(CERN)
BUDAGOV 60 JETP 11 755	BUDAGOV,VIKTOR,DZHELEPOV,ERMOLOV +	(JINR)
JOSEPH 60 NC 16 997	D W JOSEPH	(EFI)
SAMIOS 60 NC 18 154	N P SAMIOS	(COLUMBIA)
GLASSER 61 PR 123 1014	R G GLASSER,N SEEMAN,B STILLER	(NRL)
KOBRAK 61 NC 20 1115	H.KOBRAK	(EFI)
SAMIOS 61 PR 121 275	N P SAMIOS	(COLUMBIA+BNL)
SAMIOS 62 PR 126 1844	SAMIOS,PLANO,PRODELL +	(COLUMBIA+BNL)
TIETGE 62 PR 127 1324	J TIETGE,W PUESCHEL	(MAX PLANCK INST)
CZIRR 63 PR 130 341	JOHN B CZIRR	(LRL)
KOLLER 63 NC 27 1405	E L KOLLER,S TAYLOR,T HUETTER	(STEVENS)
ALSO 66 STAMER		
PETRUKHI 63 SIENA CONF 208	V I PETRUKHIN,YU D PROKOSHKIN	(JINR)
VON DARD 63 PL 4 51	VON DARDEL,DEKKERS,MERMOD,VAN PUTTEN+	(CERN)
SHWE 64 PR 136B 1839	H SHWE,F M SMITH,W H BARKAS	(LRL)
BELLETTI 65 NC 40 A 1139	BELLETTINI,BEMPORAD,BRACCINI+	(PISA+FIRENZE)
DUCLOS 65 PL 19 253	DUCLOS,FREYTAG,HEINTZE +	(CERN+HEIDELBERG)
EVANS 65 PR 139 B 982	D A EVANS	(OXFORD)
KUTIN 65 JETP LETT 2 243	KUTIN,PETRUKHIN,PROKOSHKIN	(JINR)
STAMER 66 PR 151 1108	STAMER,TAYLOR,KOLLER,HUETTER+	(STEVENS)
VASILEVS 66 PL 23 281	VASILEVSKY,VISHNYAKOV,DUNAITSEV +	(DUBNA)
DEVONS 69 PR 184 1356	+NEMENTHY,NISSIM-SABAT,DI CAPUA+	(COLU+ROMA)
BELLETTI 70 NC 66A 243	BELLETTINI,BEMPORAD,LUBELSMEY+	(PISA+BONN)
KRYSHKIN 70 JETP 30 1037	+STERLIGOV,USOV	(TOMSK POLYTECH.INST.)
ABRAMS 73 PL 45B 66	+CARROLL,KYCIA,LI,MICHAEL,MOCKETT +	(BNL)
MIYAZAKI 73 PR D8 2051	T.MIYAZAKI,E.TAKASUGI	(TOKY)
BROWMAN 74 PRL 33 1400	+DEWIRE,GITTELMAN,HANSON+	(CORN+BING)
DAVIES 74 NC 24A 324	+GUY,ZIA	(BIRM+RHEL+SHMP)
SCHACHER 77 LNC 20 177	+CZAPEK,HAHN,MARTI	(BERN)
AUERBAC1 78 PRL 41 275	AUERBACH,HIGHLAND,JOHNSON, +	(TEMP+LASL)
AUERBAC2 78 PL 78B 353	AUERBACH,HIGHLAND,JOHNSON, +	(TEMP+LASL)
FISCHER1 78 PL 73B 359	+EXTERMANN,GUISAN,MERMOD,+	(GEVA+SACL)
FISCHER2 78 PL 73B 364	+EXTERMANN,GUISAN,MERMOD,MOREL+	(GEVA+SACL)
AUERBACH 80 PL 90B 317	+HAIK,HIGHLAND,MCFARLANE,MACEK+	(TEMP+LASL)
HIGHLAND 80 PRL 44 628	+AUERBACH,HAIK,MCFARLANE,MACEK+	(TEMP+LASL)
HERCZEG 81 PL 100B 347	P. HERCZEG, C. M. HOFFMAN	(LANL)
SCHARDT 81 PRD 23 639	+FRANK,HOFFMANN,MISCHKE,MOIR +	(ARZS+LANL)
BRYMAN 82 PR D26 2538	D. BRYMAN	(TRIU)
MISCHKE 82 PRL 48 1153	+FRANK,HOFFMAN,MOIR,SARRACINO +	(LANL+ARZS)
FRANK 83 PR D28 423	+HOFFMAN,MISCHKE,MOIR+	(LANL+ARZS)
HERCZEG 84 PR D TO BE PUBL.	P.HERCZEG,C.M.HOFFMAN	(LANL)

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14 ETA(549,JPG=0-+) I=0

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14 ETA MASS (MEV)

M	53	549.0	1.2	BASTIEN	62 HBC	
M	35	546.0	4.0	PICKUP	62 HBC	
M	91	548.0	1.0	ALFF	62 HBC	
M		549.3	2.9	DELCOURT	63 CNTR	
M	148	549.0	0.7	FOELSCHE	64 HBC	
M	325	552.0	3.0	KRAEMER	64 DBC	
M		548.2	0.65	FOSTER3	65 HBC	7/66
M	250	555.0	2.0	JAMES	66 HBC	6/66
M		. . . . .	. . . .			
M	AVG	548.82	0.56	AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.4) (SEE IDEOGRAM BELOW)		

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14 ETA WIDTH

W	ETA WIDTH DETERMINED FROM MASS SPECTRUM (UNITS MEV)					
W	91	(10.0) OR LESS		ALFF	62 HBC	
W	148	(10.0) OR LESS		FOELSCHE	64 HBC	
W	31	(12.0) OR LESS		JAMES	66 HBC	6/66
W		(4.0) OR LESS		BALTAY	66 DBC	7/66
W		(0.9) OR LESS	CL=.95	JONES	66 CNTR	8/67

W ETA WIDTH DETERMINED FROM DECAY RATE (UNITS KEV)
W THIS IS THE PARTIAL DECAY RATE (W1) FOR THE MODE (ETA INTO 2GAMMA)
W DIVIDED BY THE FITTED BRANCHING FRACTION (P1) FOR THAT MODE.
W . . . .
W FIT 0.88 0.12 FROM FIT

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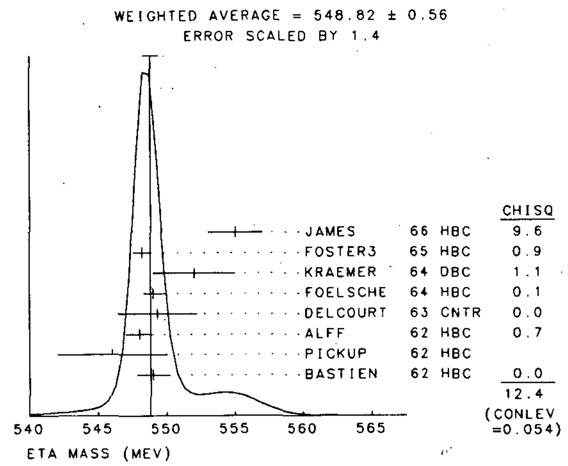

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14 ETA PARTIAL DECAY MODES

		DECAY MASSES
P1	ETA INTO 2GAMMA	0+ 0
P2	ETA INTO 3PIO	135+ 135+ 135
P3	ETA INTO PI+ PI- PIO	140+ 140+ 135
P4	ETA INTO PI+ PI- GAMMA	140+ 140+ 0
P5	ETA INTO E+ E- PIO	135+.511+.511
P6	ETA INTO E+ E- PI+ PI-	140+ 140+.511+.511
P7	ETA INTO PIO 2GAMMA	135+ 0+ 0
P8	ETA INTO E+ E- GAMMA	.511+.511+ 0
P10	ETA INTO PI+ PI- PIO GAMMA	140+ 140+ 135+ 0
P11	ETA INTO PI+ PI- 2GAMMA	140+ 140+ 0+ 0
P12	ETA INTO MU+ MU-	106+ 106
P13	ETA INTO MU+ MU- GAMMA	106+ 106+ 0
P14	ETA INTO MU+ MU- PIO	106+ 106+ 135
P15	ETA INTO PI+ PI-	140+ 140
P16	ETA INTO E+ E-	.511+.511
P17	ETA INTO MU+ MU- PIO GAMMA	106+ 106+ 135+ 0

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FITTED PARTIAL DECAY MODE BRANCHING FRACTIONS

The matrix below is derived from the error matrix for the fitted partial decay mode branching fractions, P_i, as follows: The diagonal elements are $P_i \pm \delta P_i$, where $\delta P_i = \sqrt{\langle \delta P_i \delta P_i \rangle}$, while the off-diagonal elements are the normalized correlation coefficients $\langle \delta P_i \delta P_j \rangle / (\delta P_i \cdot \delta P_j)$. For the definitions of the individual P_i, see the listings above; only those P_i appearing in the matrix are assumed in the fit to be nonzero and are thus constrained to add to 1.

	P 1	P 2	P 3	P 4	P 7	P 8
P 1	.3902+-.0084					
P 2	-.6885	.3179+-.0080				
P 3	-.4327	-.3366	.2368+-.0054			
P 4	-.3764	-.2950	.8016	.0491+-.0013		
P 7	-.0107	-.0162	-.0016	-.0013	.0010+-.0002	
P 8	-.0521	-.0462	-.0546	-.0540	-.0000	.0050+-.0012

FITTED PARTIAL DECAY MODE RATES

The matrix below is the branching fraction matrix above, transformed into rate space; i.e., $G_i \equiv \Gamma_i = \Gamma_{total} P_i$, in appropriate units. In analogy to the matrix above, the diagonal elements are $G_i \pm \delta G_i$, where $\delta G_i = \sqrt{\langle \delta G_i \delta G_i \rangle}$, while the off-diagonal elements are the normalized correlation coefficients $\langle \delta G_i \delta G_j \rangle / (\delta G_i \cdot \delta G_j)$. Note that, because of the error in Γ_{total}, the errors and correlations here are not directly derivable from those above.

	G 1	G 2	G 3	G 4	G 7	G 8
G 1	.3420+-.0443					
G 2	.9475	.2787+-.0381				
G 3	.9634	.9584	.2076+-.0279			
G 4	.9584	.9535	.9974	.0431+-.0058		
G 7	.4709	.4669	.4727	.4704	.0008+-.0002	
G 8	.4809	.4777	.4808	.4772	.2368	.0044+-.0012

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14 ETA DECAY RATES

W1		ETA INTO 2GAMMA (UNITS KEV)					(G1)	
W1	B		(1.00)	(0.22)	BEMPORAD	67 CNTR	PRIMAKOFF EFFECT	11/75
W1			0.324	0.046	BROWMAN	74 CNTR	PRIMAKOFF EFFECT	7/74
W1		56	0.56	0.16	WEINSTEIN	83 CNTR	E+E- -> E+E- ETA	2/84*
W1	B	BEMPORAD 67 GIVES W1=1.21+-.26 KEV ASSUMING THAT W1/TOTAL=0.314.						11/75
W1	B	BEMPORAD PRIVATE COMMUNICATION GIVES MORE GENERAL RESULT AS						11/75
W1	B	W1*W1/TOTAL=.380+-.083. WE EVALUATE THIS USING W1/TOTAL=.38+-.01.						11/75
W1	B	NOT INCLUDED IN AVERAGE BECAUSE THE UNCERTIANTY RESULTING FROM THE						2/76
W1	B	SEPARATION OF THE COULOMB AND NUCLEAR AMPLITUDES HAS APPARENTLY						2/76
W1	B	BEEN UNDERESTIMATED.						2/76
W1		. . . .						
W1	AVG		0.342	0.063	AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.4)			
W1	FIT		0.342	0.044	FROM FIT			

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Stable Particles

Data Card Listings

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                    14  ETA BRANCHING RATIOS

R1      ETA INTO NEUTRALS/CHARGED                                  (P1+P2+P7)/(P3+P4+P8)
R1
R1  N   10   (2.5)    (1.0)            PICKUP    62 HBC
R1  N   53   (3.20)   (1.26)           BASTIEN   62 HBC
R1  N  280   (4.5)    (1.0)            JAMES     66 HBC                                  6/66
R1  N    THESE EXPERIMENTS HAVE NOT BEEN USED IN COMPUTING THE AVERAGES
R1  N    AS THEY WERE UNABLE TO SEPARATE CLEARLY PARTIAL MODES (3) AND (4)
R1  N    FROM EACH OTHER.  THE REPORTED VALUES THUS PROBABLY CONTAIN
R1  N    SOME (UNKNOWN) FRACTION OF MODE (4).
R1            2.64     0.23             BALTAY2   67 DBC                                 11/67
R1          . . . . . . . . .
R1  FIT       2.437    0.076   FROM FIT

R2      ETA INTO 2GAMMA/CHARGED                                    (P1)/(P3+P4+P8)
R2            0.99     0.48             CRAWFORD  63 HBC
R2      75    1.51     0.93             KENDALL   74 OSPK                                12/75
R2          . . . . . . . . .
R2  AVG       1.10     0.43    AVERAGE
R2  FIT       1.341    0.050   FROM FIT
```

NOTE ON $\eta \to \pi^0\gamma\gamma$

It appears that earlier problems with the $\eta \to \pi^0\gamma\gamma$ branching fraction have been resolved by the excellent new measurement of BINON 82. Interested readers are referred to their paper and to the note in our 1982 edition.[1]

Reference

1. Particle Data Group, Phys. Lett. **111B** (1982).


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R3      ETA INTO (PIO 2GAMMA)/NEUTRALS                             (P7)/(P1+P2+P7)
R3       OTHER RESULTS ARE IN SECTIONS R14, R22(DAVYDOV 81), AND R26.
R3            (0.375)  (0.072)         DIGIUGNO  66 CNTR    ERROR DOUBLED                 6/66
R3            (0.27)   (0.10)          GRUNHAUS  66 OSPK                                   8/67
R3            (0.028)  (0.044)         BUNIATOV  67 OSPK REPL. BY SCHMITT 70              11/67
R3            (0.244)  (0.05)          FELDMAN   67 OSPK                                   8/67
R3            (0.026)  (0.019)         BUTTRAM   70 OSPK                                  12/70
R3            (0.122)  (0.052)  (0.044)COX       70 HBC                                    6/70
R3            (0.07) OR LESS  CL=.90   DEVONS    70 OSPK                                  12/70
R3      16    (0.016)  (0.047)         SCHMITT   70 OSPK REANAL. BUNIATOV 67               12/70
R3            (0.11)   (0.03)          STRUGALSK 71 HLBC                                   5/71
R3            (0.04) OR LESS  CL=.90   ABROSIMOV 80 HLBC                                  10/81
R3          . . . . . . . . .
R3  FIT       0.00134  0.00032 FROM FIT

R4      ETA INTO (PI+ PI- GAMMA)/(PI+ PI- PIO)                     (P4)/(P3)
R4            0.14     0.08             FOELSCHE  64 HBC
R4      24    (0.73)   (0.25)           PAULI     64 DBC
R4            0.30     0.06             CRAWFORD  66 HBC                                  6/66
R4            0.10     0.10             KRAEMER   64 DBC                                  7/66
R4            0.196    0.041            FOSTER3   65 HBC                                  7/66
R4            0.25     0.035            LITCHFIEL 67 DBC                                  8/67
R4            0.28     0.04             BALTAY2   67 DBC                                 11/67
R4    7250    0.201    0.006            GORMLEY   70 ASPK                                 6/70
R4     18K    0.209    0.004            THALER    73 ASPK                                 6/73
R4          . . . . . . . . .
R4  AVG       0.2074   0.0037  AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.1)
R4  FIT       0.2074   0.0033 FROM FIT

R6      ETA INTO 3PIO/2GAMMA                                       (P2)/(P1)
R6            (0.90) OR MORE           CHRETIEN  62 PBC
R6            (1.25)   (0.39)          BACCI     63 CNTR INVERSE BR REPORTED              7/66
R6            0.88     0.16             BALTAY1   67 DBC                                 11/67
R6            1.1      0.2              CENCE     67 OSPK                                 1/68
R6            0.91     0.14             COX       70 HBC                                  6/70
R6            0.75     0.09             DEVONS    70 OSPK                                12/70
R6          . . . . . . . . .
R6  AVG       0.842    0.065   AVERAGE
R6  FIT       0.815    0.035   FROM FIT

R7      ETA INTO 2GAMMA/(PI+ PI- PO)                               (P1)/(P3)
R7            1.61     0.39             FOSTER1   65 HBC
R7     401    1.72     0.25             BAGLIN    69 HLBC                                 7/69
R7          . . . . . . . . .
R7  AVG       1.69     0.21    AVERAGE
R7  FIT       1.647    0.061   FROM FIT

R8      ETA INTO NEUTRAL/(PI+ PI- PIO)                             (P1+P2+P7)/(P3)
R8      50    3.6      0.8              KRAEMER   64 DBC
R8            3.8      1.1              PAULI     64 DBC                                  7/66
R8            2.89     0.56             ALFF-STEI 66 HBC                                  9/66
R8     244    3.6      0.6              FLATTE2   67 HBC                                  1/68
R8      29    3.4      1.1              AGUILAR-B 72 HBC                                 11/72
R8 B    70    2.83     0.80             BLOODWORT 72 HBC                                 11/72
R8      74    2.54     1.89             KENDALL   74 OSPK                                12/75
R8 B    ERROR INCREASED FROM PUBLISHED VALUE 0.5 BY BLOODWORTH, PRIV. COMM.               1/73
R8          . . . . . . . . .
R8  AVG       3.26     0.30    AVERAGE
R8  FIT       2.994    0.095   FROM FIT

R9      ETA INTO (E+E-PIO)/(PI+PI-PIO) (UNITS 10**-4)              (P5)/(P3)
R9       SINGLE PHOTON PROCESS FORBIDDEN BY C-PARITY
R9          (110.)   OR LESS          PRICE     65 HBC
R9       0  (77.)    OR LESS          FOSTER2   65 HBC
R9          (42.)    OR LESS  CL=.90  BAGLIN1   67 HLBC                                  8/67
R9       0  (16.)    OR LESS  CL=.90  BILLING   67 HLBC                                 11/67
R9            1.9    OR LESS  CL=.90  JANE1     75 OSPK                                 12/75

R10     ETA INTO (E+E-PI+PI-)/TOTAL (UNITS 10**-2)                 (P6)
R10          (0.7)  OR LESS            RITTENBER 65 HBC                                   6/66

R11     ETA INTO (E+E-PI+PI-)/(PI+PI-GAMMA)                        (P6)/(P4)
R11      1    0.026    0.026           GROSSMAN  66 HBC                                   6/66

R12     ETA INTO 2 GAMMA/NEUTRALS                                  (P1)/(P1+P2+P7)
R12          (0.416)  (0.044)          DIGIUGNO  66 CNTR    ERROR DOUBLED                 6/66
R12          (0.44)   (0.07)           GRUNHAUS  66 OSPK                                   8/67
R12          (0.579)  (0.052)          FELDMAN   67 OSPK                                   8/67
R12 T        (0.39)   (0.06)           JONES     66 CNTR                                   8/67
R12 T   THIS RESULT FROM COMBINING CROSS SECTIONS FROM TWO DIFFERENT EXPTS.
R12           0.59     0.033            BUNIATOV  67 OSPK                                 11/67
R12           0.535    0.018            BUTTRAM   70 OSPK                                 12/70
R12          (0.57)   (0.09)            STRUGALSK 71 HLBC                                   5/71
R12     113   0.60     0.14             KENDALL   74 OSPK                                 12/75
R12      88   0.52     0.09             ABROSIMOV 80 HLBC                                 10/81
R12         . . . . . . . . .
R12 AVG       0.547    0.016   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.1)
R12 FIT       0.550    0.011   FROM FIT

R13     ETA INTO 3PIO/NEUTRALS                                     (P2)/(P1+P2+P7)
R13          (0.209)  (0.054)          DIGIUGNO  66 CNTR    ERROR DOUBLED                 6/66
R13          (0.29)   (0.10)           GRUNHAUS  66 OSPK                                   8/67
R13          (0.177)  (0.035)          FELDMAN   67 OSPK                                   8/67
R13          (0.41)   (0.033)          BUNIATOV  67 OSPK NOT INDEP. OF R12                11/67
R13           0.439    0.024            BUTTRAM   70 OSPK                                 12/70
R13          (0.32)   (0.09)           STRUGALSK 71 HLBC                                   5/71
R13      75   0.44     0.08             ABROSIMOV 80 HLBC                                 10/81
R13         . . . . . . . . .
R13 AVG       0.439    0.023   AVERAGE
R13 FIT       0.448    0.011   FROM FIT

R14     ETA INTO (PIO 2GAMMA)/2GAMMA                               (P7)/(P1)
R14          (0.5)  OR LESS  CL=.90    WAHLIG    66 SPRK                                   7/66
R14          (0.28) OR LESS  CL=.95    BALTAY1   67 DBC                                   11/67
R14         . . . . . . . . .
R14 FIT       0.00244  0.00059 FROM FIT

R15     ETA INTO (E+E-PIO)/TOTAL (UNITS 10**-2)                    (P5)
R15      SINGLE PHOTON PROCESS FORBIDDEN BY C-PARITY
R15          (0.7)  OR LESS            RITTENBER 65 HBC                                   6/66
R15          (0.084)OR LESS  CL=.90    BAZIN     68 DBC                                   6/68
R15      0   (0.016)OR LESS  CL=.90    MARTYNOV  76 HLBC                                  6/77

R17     ETA INTO (PI+PI-PIO GAMMA)/(PI+PI-PIO) (UNITS 10**-2)
R17                                                          (P10)/(P3)
R17          (7.0)  OR LESS            FLATTE    67 HBC                                   8/67
R17          (0.9)  OR LESS            PRICE     67 HBC                                   8/67
R17          (1.6)  OR LESS  CL=.95    BALTAY2   67 DBC                                  11/67
R17          (1.7)  OR LESS  CL=.90    ARNOLD    68 HLBC                                  9/68
R17      0    0.24  OR LESS  CL=.90    THALER    73 ASPK                                  6/73

R18     ETA INTO (PI+PI- 2GAMMA)/(PI+PI-PIO)                       (P11)/(P3)
R18          0.009 OR LESS             PRICE     67 HBC                                   8/67
R18          (0.016)OR LESS  CL=.95    BALTAY2   67 DBC                                  11/67

R19     ETA INTO 3PIO/(PI+ PI- PIO)                                (P2)/(P3)
R19           0.83     0.32             CRAWFORD  63 HBC                                   7/66
R19           2.0      1.0              FOELSCHE  64 HBC                                   7/66
R19           0.90     0.24             FOSTER1   65 HBC                                   7/66
R19           1.3      0.4              BAGLIN2   67 HLBC                                  8/67
R19           1.47     0.20     0.17    BULLOCK   68 HLBC                                  9/68
R19     199   1.50     0.15     0.29    BAGLIN    69 HLBC                                  7/69
R19         . . . . . . . . .
R19 AVG       1.28     0.14    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.3)
R19 FIT       1.342    0.052   FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.1)
                       (SEE IDEOGRAM BELOW)
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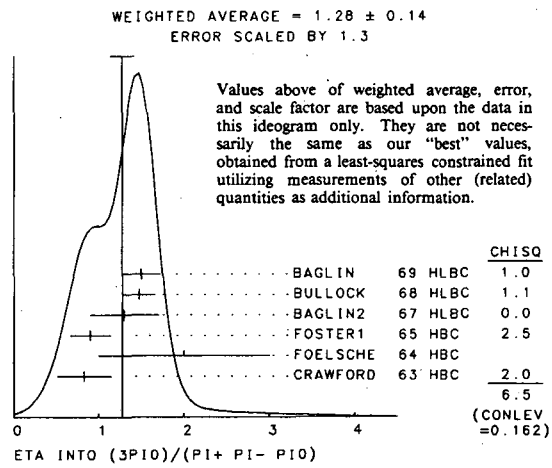


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R21     ETA INTO NEUTRALS/TOTAL                                    (P1+P2+P7)
R21           0.79     0.08             BUNIATOV  67 OSPK                                 11/67
R21     16K   0.705    0.008            BASILE    71 CNTR MM SPECTROMETER                 8/71
R21         . . . . . . . . .
R21 AVG       0.7058   0.0080  AVERAGE
R21 FIT       0.7091   0.0065 FROM FIT

R22     ETA INTO (PIO 2GAMMA)/TOTAL                                (P7)
R22          (0.12) OR LESS  CL=.95    JACQUET   69 HLBC                                   6/70
R22      0   (0.003)OR LESS  CL=.90    DAVYDOV   81 CNTR PI- P-->ETA N                    1/82
R22     70   0.00095  0.00023           BINON     82 CNTR PI- P-->ETA N                  11/83*
R22         . . . . . . . . .
R22 FIT       0.00095  0.00023 FROM FIT

R23     ETA INTO MU+MU-/TOTAL (UNITS 10**-5)                       (P12)
R23      0    (2.)    OR LESS  CL=.95  WEHMANN   68 OSPK                                   4/68
R23     27    0.65     0.21             DZHELYA2  80 SPEC PI- P-->ETA N                    9/81
```

For notation, see key at front of Listings.


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R24     ETA INTO MU+MU-PIO/TOTAL (UNITS 10**-4)          (P14)
R24      SINGLE PHOTON PROCESS FORBIDDEN BY C-PARITY
R24          (5.)   OR LESS          WEHMANN   68 OSPK                          4/68
R24           0.05  OR LESS  CL=.90   DZHELYADI 81 SPEC PI- P-->ETA N            1/82

R25     ETA INTO MU+MU-/2GAMMA (UNITS 10**-5)            (P12)/(P1)
R25          (5.9)    (2.2)           HYAMS     69 OSPK                          7/69

R26     ETA INTO (PIO 2GAMMA)/(3PIO + PIO 2GAMMA)        (P7)/(P2+P7)
R26          (0.1)    (0.3)           KANOFSKY  70 OSPK                          2/71
R26          . . . . . . . . .
R26 FIT       0.00298  0.00072 FROM FIT

R27     ETA INTO (PI+ PI-)/TOTAL (UNITS 10**-2)          (P15)                   6/73
R27      VIOLATES P AND T INVARIANCE
R27       0    0.15  OR LESS          THALER    73 ASPK CON. LEV. NOT GIVEN     6/73

R28     ETA INTO (E+E-GAMMA)/(PI+PI-PIO) (UNITS 10**-2)  (P8)/(P3)
R28  J  80     2.1      0.5            JANE2     75 OSPK                          2/76
R28  J  VALUE CHANGED BY ERRATUM.                                                 2/76
R28          . . . . . . . . .
R28 FIT       2.11     0.50   FROM FIT

R29     ETA INTO (E+ E-)/TOTAL  (UNITS 10**-4)           (P16)
R29  D         3.     OR LESS  CL=.90   DAVIES    74 RVUE                        2/78
R29  D  DAVIES 74 EXTRACTS THIS INFORMATION FROM ESTEN 67.                        2/78

R30     ETA INTO (MU+ MU- GAMMA)/TOTAL   (UNITS 10**-4)  (P13)                    2/79
R30     100   (1.5)    (0.75)          BUSHNIN   78 SPEC REPL.BY DZHELYA1 80     2/79
R30     600    3.1      0.4            DZHELYA1  80 SPEC PI- P-->ETA N            9/81

R31     ETA INTO (MU+ MU- PIO GAMMA)/TOT (UNITS 10**-6)  (P17)                    1/82
R31            3.     OR LESS  CL=.90   DZHELYADI 81 SPEC PI- P-->ETA N            1/82

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NOTE ON η DECAY PARAMETERS

C violation in η decays

As a test of possible C violation in electromagnetic interactions, a number of experiments have looked for possible charge asymmetries in the decays $\eta \to \pi^+\pi^-\pi^0$ and $\eta \to \pi^+\pi^-\gamma$. We list the following parameters:

(a) The left-right asymmetry

$$A = (N^+ - N^-)/(N^+ + N^-)\,,$$

where $N^\pm$ means the number of events with the $\pi^\pm$ energy greater than the $\pi^\mp$ energy in the η rest frame.

(b) The sextant asymmetry

$$A_s = \frac{N_1 + N_3 + N_5 - N_2 - N_4 - N_6}{N_1 + N_2 + N_3 + N_4 + N_5 + N_6}$$

for the decay $\eta \to \pi^+\pi^-\pi^0$. The numbers refer to sextants of the Dalitz plot (see, for example, Layter et al.[1]). A_s is sensitive to an I = 0 C-violating asymmetry.

(c) The quadrant asymmetry A_q, defined in a similar way as A_s, but with each sector of the Dalitz plot now containing $\pi/2$ rather than $\pi/3$ radians. A_q is sensitive to an I = 2 C-violating final state.

(d) The D-wave contribution to the C-violating amplitude in the decay $\eta \to \pi^+\pi^-\gamma$. The upper limit for this contribution is measured by the parameter β, defined by

$$dN/d|\cos\theta| \propto \sin^2\theta(1 + \beta\cos^2\theta)\,,$$

where θ is the angle between the π^+ and the γ in the dipion center of mass. A term proportional to $\cos^2\theta$ could also be due to P- and F-wave interference.

We list A for the decay modes $\eta \to \pi^+\pi^-\pi^0$ and $\eta \to \pi^+\pi^-\gamma$, A_s and A_q for the decay $\eta \to \pi^+\pi^-\pi^0$, and β for the decay $\eta \to \pi^+\pi^-\gamma$ in the Data Card Listings below.

Dalitz plot for $\eta \to \pi^+\pi^-\pi^0$

The Dalitz plot for the decay $\eta \to \pi^+\pi^-\pi^0$ may be fit by the distribution

$$|M(x,y)|^2 \propto 1 + ay + by^2 + cx + dx^2 + exy\,.$$

Here,

$$x = \sqrt{3}(T_+ - T_-)/Q, \quad y = (3T_0/Q) - 1\,,$$

T_+, T_-, and T_0 are the kinetic energies of the π^+, π^-, and π^0 in the η rest system, and $Q = m_\eta - m_{\pi^+} - m_{\pi^-} - m_{\pi^0}$. The coefficient of the term linear in x is sensitive to C-violation due to an I = 0 or I = 2 final state. We list papers presenting determinations of the parameters a, b, c, and d in the section DP below. However, we do not tabulate values of these parameters because the assumptions made by different authors are not compatible and do not allow comparison of the numerical values.

Dalitz plot for $\eta \to \pi^0\pi^0\pi^0$

The Dalitz plot for the decay $\eta \to \pi^0\pi^0\pi^0$ may be fit to the expression

$$|M|^2 \propto 1 + 2\alpha z\,,$$

where

$$z = \frac{2}{3}\sum_{i=1}^{3}\left[3(m_\eta - 3m_\pi)^{-1}(E_i - \tfrac{1}{3}m_\eta)\right]^2 = \rho^2/\rho^2_{max}\,.$$

Here E_i is the energy of the ith pion in the η rest frame, and ρ is the distance to the center of the Dalitz plot. We list the parameter α in section A0 below.

Reference

1. J.G. Layter et al., Phys. Rev. Lett. **29**, 316 (1972).

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                    14  ETA C-NONCONSERVING DECAY PARAMETERS

A1      LEFT-RIGHT ASYMMETRY PARAMETER FOR PI+ PI- PIO  (UNITS 10**-2)
A1     1351    7.2      2.8            BALTAY    66 DBC                        8/66
A1     1300    5.8      3.4            CLPWY     66 HBC                        8/66
A1    10665   (0.3)    (1.0)           CNOPS     66 OSPK REPL BY MULLER 69     8/67
A1      705   -6.1      4.0            LARRIBE   66 HBC                        8/67
A1   G36800   (1.5)    (0.5)           GORMLEY3  68 ASPK                       6/68
A1    10709    0.3      1.1            MULLER    69 OSPK                       9/69
A1     1138   -1.4      3.             CARPENTR  70 HBC                        6/70
A1      349    3.2      5.4            DANBURG   70 DBC                        2/71
A1     220K   -0.05     0.22           LAYTER    72 ASPK                       8/72
A1     165K    0.28     0.26           JANE1     74 OSPK                       3/74
A1  G   GORMLEY3 68 ASYMMETRY PROBABLY DUE TO UNMEASURED (E X B) SPK. CH.      3/74
A1  G   EFFECTS.  NEW EXPTS. WITH (E X B) CONTROLS DONT OBSERVE ASYMMETRY.     3/74
A1          . . . . . . . . .
A1  AVG       0.12     0.17    AVERAGE

A2      LEFT-RIGHT ASYMMETRY PARAMETER FOR PI+ PI- GAMMA (UNITS 10**-2)
A2       33   -2.      17.            CRAWFORD  66 HBC                       11/66
A2           -4.       8.             LITCHFIEL 67 DBC                        8/67
A2 N   1620    1.5      2.5            MULLER    69 OSPK                       9/69
A2     7257    1.22     1.56           GORMLEY   70 ASPK                       6/70
A2      36K    0.5      0.6            THALER    72 ASPK                       8/72
A2      35K    1.2      0.6            JANE2     74 OSPK                       3/74
A2 N  MULLER 69 IS SENSITIVE ONLY TO UPPER .4 OF GAMMA-RAY SPECTRUM.
A2          . . . . . . . . .
A2  AVG       0.88     0.40    AVERAGE
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Stable Particles

η, $K^{\pm}$

Data Card Listings

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AS       SEXTANT ASYMMETRY PARAMETER FOR PI+ PI- PIO  (UNITS 10**-2)
AS     1300     6.8       3.3            CLPWY      66 HBC                      12/75
AS      705    -2.4       4.0            LARRIBE    66 HBC                      12/75
AS      37K     0.5       0.5            GORMLEY3   68 WIRE                     12/75
AS     220K     0.10      0.22           LAYTER     72 ASPK                     12/75
AS     165K     0.20      0.25           JANE1      74 OSPK                     12/75
AS
AS   AVG        0.19      0.16     AVERAGE

AQ       QUADRANT ASYMMETRY PARAMETER FOR PI+ PI- PIO (UNITS 10**-2)
AQ     220K    -0.07      0.22           LAYTER     72 ASPK                     12/75
AQ     165K    -0.30      0.25           JANE1      74 OSPK                     12/75
AQ
AQ   AVG       -0.17      0.17     AVERAGE

BET      BETA FOR ETA TO PI+ PI- GAMMA. SENSITIVE TO D-WAVE CONTRIBUTION.
BET      DN/DCOS THETA = SIN**2 THETA * (1 + BETA * COS**2 THETA)               12/75
BET    7250    -0.060     0.065          GORMLEY    70 WIRE                     12/75
BET  L          0.12      0.06           THALER     72 ASPK                     12/75
BET     35K     0.11      0.11           JANE2      74 OSPK                     12/75
BET  L  AUTHORS DONT BELIEVE THIS TO INDICATE D-WAVE BECAUSE DEPENDENCE OF      12/75
BET  L  BETA ON GAMMA ENERGY INCONSISTENT WITH THEOR. PREDICTION.               12/75
BET  L  COS**2 DEPENDENCE MAY ALSO COME FROM P AND F-WAVE INTERFERENCE.        12/75
BET
BET AVG         0.047     0.062    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.5)
                          (SEE IDEOGRAM BELOW)
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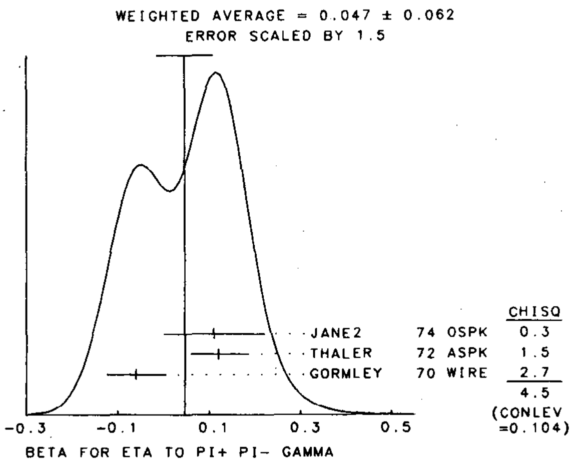


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                  14 ENERGY DEPENDENCE OF ETA DALITZ PLOT

DP       SEE NOTE ON ETA DECAY PARAMETERS ABOVE.
DP       THE FOLLOWING EXPTS FIT TO ONE OR MORE OF THE COEFFICIENTS
DP       A,B,C,D, OR E FOR ETA TO PI+ PI- PIO
DP       MATRIX ELEMENT**2=1 + A*Y + B*(Y**2) + C*X + D*(X**2) + E*X*Y
DP     1300 SEE NOTE ABOVE               CLPWY      66 HBC                      12/75
DP      705 SEE NOTE ABOVE               LARRIBE    66 HBC                      12/75
DP     7170 SEE NOTE ABOVE               CNOPS      68 OSPK                     12/75
DP      37K SEE NOTE ABOVE               GORMLEY3   68 WIRE                     12/75
DP      526 SEE NOTE ABOVE               BAGLIN     69 HLBC                     12/75
DP     1138 SEE NOTE ABOVE               CARPENTR   70 HBC                      12/75
DP      349 SEE NOTE ABOVE               DANBURG    70 DBC                      12/75
DP     7250 SEE NOTE ABOVE               GORMLEY    70 WIRE                     12/75
DP     220K SEE NOTE ABOVE               LAYTER     72 ASPK                     12/75
DP      81K SEE NOTE ABOVE               LAYTER     73 ASPK                     12/75

AO       ALPHA PARAMETER FOR ETA TO 3 PIO
AO       MATRIX ELEMENT **2 = 1 + 2*ALPHA*Z (SEE NOTE ABOVE)                    12/75
AO      192    -0.32      0.37           BAGLIN     70 HLBC                     12/75

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REFERENCES FOR ETA


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PEVSNER  61 PRL 7 421          PEVSNER,KRAEMER,NUSSBAUM,RICHARDSON + (JHU)

ALFF     62 PRL 9 322          ALFF,BERLEY,COLLEY,BRUGGER + (COLU+RUTGERS)
BASTIEN  62 PRL 8 114          BASTIEN,BERGE,DAHL,FERRO-LUZZI +       (LRL)
CHRETIEN 62 PRL  9  127        CHRETIEN+   (BRAN+BROWN+HARVARD+MIT+PADOVA)
PICKUP   62 PRL 8 329          E PICKUP,ROBINSON,SALANT          (CNRC+BNL)

BACCI    63 PRL 11 37          BACCI,PENSO,SALVINI +             (ROMA+FRAS)
CRAWFORD 63 PRL 10 546         F S CRAWFORD,LLOYD,FOWLER         (LRL+DUKE)
    ALSO 66 PRL 16 907         F S CRAWFORD,L LLOYD,E FOWLER     (LRL+DUKE)
DELCOURT 63 PL 7 215           DELCOURT,LEFRANCOIS,PEREZ Y JORBA+  (ORSAY)

FOELSCHE 64 PR 134 B 1138      H W FOELSCHE,H L KRAYBILL             (YALE)
KRAEMER  64 PR 136 B 496       KRAEMER,MADANSKY,FIELDS +   (JHU+NWES+WOOD)
PAULI    64 PL 13 351          E PAULI,A MULLER                    (SACLAY)

FOSTER1  65 PR 138 B 652       FOSTER,PETERS,MEER,LOEFFLER + (WISC+PURDUE)
FOSTER2  65 ATHENS             FOSTER,GOOD,MEER                 (WISCONSIN)
FOSTER3  65 THESIS             M.C.FOSTER                       (WISCONSIN)
PRICE    65 PRL  15  123       L.R.PRICE,F.S.CRAWFORD                 (LRL)
RITTENBE 65 PRL 15 556         RITTENBERG,KALBFLEISCH             (LRL+BNL)

ALFF-STE 66 PR 145 1072        ALFF-STEINBERGER,BERLEY+ (COLUMBIA+RUTGERS)
BALTAY   66 PRL 16 1224        +FRANZINI,KIM,KIRSCH+(COLUMBIA+STONY BROOK)
CLPWY    66 PR 149  1044       COLUMBIA,LRL,PURDUE,WISCONSIN,YALE
CNOPS    66 PL 22 546          CNOPS,FINOCCHIARS,LASSALLE,+(CERN,ETH,SACL)
CRAWFORD 66 PRL  16  333       F.S.CRAWFORD,L.R.PRICE                 (LRL)

DIGIUGNO 66 PRL 16 767         DIGIUGNO,GIORGI,SILVESTRI+ (NAPL,TRST,FRAS)
GROSSMAN 66 PR 146  993        R GROSSMAN,L PRICE,F CRAWFORD          (LRL)
GRUNHAUS 66 THESIS             J.GRUNHAUS                        (COLUMBIA)

JAMES    66 PR 142   896       F E JAMES,H L KRAYBILL            (YALE+BNL)
JONES    66 PL 23  597         JONES,BINNIE,DUANE,MORSEY,MASON,(LOIC,RHEL)
LARRIBE  66 PL 23 600          LARRIBE,LEVEQUE,MULLER,PAULI,+  (SACL+RHEL)
WAHLIG   66 PRL  17  221       WAHLIG,SHIBATA,MANNELLI           (MIT+PISA)

BAGLIN1  67 PL 24B 637         BAGLIN,BEZAGUET,DEGRANGE,+        (EPOL+UCB)
BAGLIN2  67 BAPS 12 567        BAGLIN,BEZAGUET,DEGRANGE,+        (EPOL+UCB)
BALTAY1  67 PRL 19 1495        BALTAY,FRANZINI,KIM,NEWMAN+     (COLU+BRAN)
BALTAY2  67 PRL 19 1498        BALTAY,FRANZINI,KIM,NEWMAN+     (COLU+STON)
BEMPORAD 67 PL 25B 380         BEMPORAD,BRACCINI,FOA,LUBELSMEY+(PISA,BONN)
    ALSO    PRIVATE COMMUNICATION

BILLING  67 PL 25B 435         BILLING,BULLOCK,ESTEN,GOVAN,+     (LOUC,OXF)
BOWEN    67 PL 24B 206         BOWEN,CNOPS ,FINOCCHIARO,+  (CERN+ETH+SACL)
BUNIATOV 67 PL 25B 560         BUNIATOV,ZAVATTINI,DEINET,+     (CERN+KARL)
CENCE    67 PRL 19 1393        CENCE,PETERSON,STENGER,CHIU+   (HAWAII+LRL)
ESTEN    67 PL 24B 115         +GOVAN,KNIGHT,MILLER,TOVEY+       (LOUC+OXF)

FELDMAN  67 PRL 18 868         FELDMAN,FRATI,GLEESON,HALPERN,+      (PENN)
FLATTE   67 PRL 18 976         S.M.FLATTE                            (LRL)
FLATTE2  67 PR 163 1441        S.M.FLATTE AND C.G.WOHL               (LRL)
LITCHFIE 67 PL 24B 486         LITCHFIELD,RANGAN,SEGAR,SMITH+(RHEL+SACLAY)
PRICE    67 PRL 18 1207        L.R.PRICE,F.S.CRAWFORD                (LRL)

ARNOLD   68 PL 27B 466         +PATY,BAGLIN,BINGHAM+  (STRB+MADR+EPOL+UCB)
BAZIN    68 PRL 20 895         BAZIN,GOSHAW,ZACHER,+    (PRINCETON,QUEENS)
BULLOCK  68 PL 27B 402         +ESTEN,FLEMING,GOVAN,HENDERSON,OWEN+ (LOUC)
GORMLEY3 68 PRL 21 402         GORMLEY,HYMAN,LEE,NASH,PEOPLES+  (COLU+BNL)
WEHMANN  68 PRL 20 748         WEHMANN,ENGELS,+ (HARV+CASE+SLAC+CORN+MCGI)

BAGLIN   69 PL 29B 445         BAGLIN,BEZAGUET,+       (EPOL,UCB,MADR,STRB)
    ALSO 70 NP B22 66          +BEZAGUET,DEGRANGE,MUSSET +(EPOL,MADR,STRB)
HYAMS    69 PL 29B 128         HYAMS,KOCH,POTTER,VON LINDERN,+ (CERN,MPIM)
JACQUET  69 NC 58 743          JACQUET,NGUYEN-KHAC,HAATUFT+    (EPOL,BERG)
MULLER   69 THESIS             ARMAND MULLER                        (STRB)

BAGLIN   70 NP B22 66          +BEZAGUET,DEGRANGE,MUSSET+ (EPOL+MADR+STRB)
BUTTRAM  70 PRL 25 1358        +KREISLER,MISCHKE                    (PRIN)
CARPENTR 70 PR D1 1303         CARPENTER,BINKLEY,CHAPMAN,COX,DAGAN+ (DUKE)
COX      70 PRL 24 534         COX,FORTNEY,GOLSON                   (DUKE)

DANBURG  70 PR D2 2564         +ABOLINS,DAHL,DAVIES,HOCH,KIRZ,+      (LRL)
DEVONS   70 PR D1 1936         +GRUNHAUS,KOZLOWSKI,NEMETHY +   (COLU,SYRA)
GORMLEY  70 PR D2 501          GORMLEY,HYMAN,LEE,NASH,PEOPLES+  (COLU+BNL)
    ALSO 70 NEVIS 181(THESIS) MICHAEL GORMLEY                       (COLU)
KANOFSKY 70 NC 68 413          A. KANOFSKY                          (LEHI)
SCHMITT  70 PL 32B 638         +BUNIATOV,ZAVATTINI,DEINET+     (CERN,KARL)

BASILE   71 NC 3A 796          +BOLLINI,DALPIAZ,FRABETTI+ (CERN,BGNA,STRB)
STRUGALS 71 NP B27 429         +CHUVILO,GEMESY,IVANOVSKAYA+         (JINR)
AGUILAR- 72 PR D6 29           AGUILAR-BENITEZ,CHUNG,EISNER,SAMIOS   (BNL)
BLOODWOR 72 NP B39 525         BLOODWORTH,JACKSON,PRENTICE,YOON  (TORONTO)
LAYTER   72 PRL 29 316         +APPEL,KOTLEWSKI,LEE,STEIN,THALER    (COLU)
THALER   72 PRL 29 313         +APPEL,KOTLEWSKI,LAYTER,LEE,STEIN    (COLU)

LAYTER   73 PR D7 2565         +APPEL,KOTLEWSKI,LEE,STEIN,THALER    (COLU)
THALER   73 PR D7 2569         +APPEL,KOTLEWSKI,LAYTER,LEE,STEIN    (COLU)
BROWMAN  74 PRL 32 1067        +DEWIRE,GITTELMAN,HANSON,LOH +  (CORN+BING)
DAVIES   74 NC 24A 324         +GUY,ZIA                   (BIRM+RHEL+SHMP)
JANE1    74 PL 48B 260         +JONES,LIPMAN,OWEN,PENNEY+ (RHEL+LOWC+SUSS)
JANE2    74 PL 48B 265         +JONES,LIPMAN,OWEN,PENNEY+ (RHEL+LOWC+SUSS)
KENDALL  74 NC 21A 387         +LANOU,MASSINO,SHAPIRO +     (BROW+BARI+MIT)

JANE1    75 PL 59B 99          +GRANNIS,JONES,LIPMAN,OWEN +    (RHEL+LOWC)
JANE2    75 PL 59B 103         +GRANNIS,JONES,LIPMAN,OWEN +    (RHEL+LOWC)
    ALSO 76 PL (TO BE PUBL.)   ERRATUM, M.R.JANE, PRIVATE COMMUNICATION.
MARTYNOV 76 SJNP 23 48         +SALTYKOV,TARASOV,UZHINSKII          (JINR)
BUSHNIN  78 PL 79B 147         +DZHELYADIN,GOLOVKIN,GRITSUCK +      (SERP)
    ALSO 78 SJNP 28 775        BUSHNIN,GOLOVKIN,GRITSUK,DZHELYADIN+ (SERP)

ABROSIMO 80 SJNP 31 195        ABROSIMOV,ILINA,NISZCZ,OKHRIMENKO+   (JINR)
DZHELYA1 80 PL 94B 548         DZHELYADIN,GOLOVKIN,KACHANOV +       (SERP)
    ALSO 80 SJNP 32 516 (YF 32 998) VIKTOROV, GOLOVKIN +           (SERP)
DZHELYA2 80 PL 97B 471         DZHELYADIN,GOLOVKIN,KACHANOF +       (SERP)
    ALSO 80 SJNP 32 518 (YF 32 1002) VIKTOROV, GOLOVKIN +          (SERP)

DAVYDOV  81 LNC 32 45          +DONSKOV,INYAKIN +    (SERP+BELG+LAPP+CERN)
    ALSO 81 SJNP 33 825 (YF 33 1534) BINON,BRICMAN+ (SERP+BELG+LAPP+CERN)
DZHELYAD 81 PL 105B 239        DZHELYADIN,GOLOVKIN,KONSTANTINOV +   (SERP)
    ALSO 81 SJNP 33 822 (YF 33 1529) VIKTOROV,GOLOVKIN+            (SERP)
BINON    82 SJNP 36 391        +BRICMAN,GOUANERE+    (SERP+BELG+LAPP+CERN)
    ALSO 82 NC 71A 497         BINON,BRICMAN,DAVYDOV+(SERP+BELG+LAPP+CERN)
WEINSTEI 83 PR D28 2896        WEINSTEIN+         (HARV+CIT+PRIN+STAN+SLAC)

      QUANTUM NUMBER DETERMINATIONS NOT REFERRED TO IN THE DATA CARDS

BASTIEN  62 PRL 8 114          BASTIEN,BERGE,DAHL,FERRO-LUZZI,MILLER+(LRL)
CARMONY  62 PRL 8 117          D CARMONY,A ROSENFELD,VAN DE WALLE    (LRL)
ROSENFEL 62 PRL 8 293          A ROSENFELD,D CARMONY,VAN DE WALLE    (LRL)
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$K^{\pm}$

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                 10  CHARGED K(494,JP=0-) I=1/2

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                 10  CHARGED K MASS (MEV)

M            493.9       0.2            COHEN      57 RVUE +
M            493.7       0.3            BARKAS     63 EMUL  -
M            493.78      0.17           GREINER    65 EMUL +   VIA TAU DECAY    7/66
M           (493.87)    (0.19)          KUNSELMAN  71 CNTR REPL.BY KUNSELMAN74 10/71
M            493.691     0.040          BACKENSTO  73 CNTR  - KAONIC ATOMS      1/73
M            493.662     0.19           KUNSELMAN  74 CNTR  - KAONIC ATOMS      3/74
M            493.657     0.020          CHENG      75 CNTR -  KAONIC ATOMS      6/77
M            493.670     0.029          BARKOV     79 EMUL +- E+E- --> K+ K-    7/79
M            493.640     0.054          LUM        81 CNTR -  KAONIC ATOMS      1/82
M
M   AVG      493.666     0.015    AVERAGE
M   FIT      493.667     0.015   FROM FIT                                       3/84*

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                 10  (K+) - (K-) MASS DIFFERENCE (MEV)

DM      TEST OF CPT
DM F  1.5M    -0.032     0.090          FORD       72 ASPK +-                   4/72
DM F    FORD 72 USES M(PI+)-M(PI-) = +28+-70 KEV.                               1/73

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For notation, see key at front of Listings.

Stable Particles

$K^{\pm}$

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                    10  CHARGED K MEAN LIFE (UNITS 10**-8 SEC)

T          CHAR. K MEAN LIFE
T   0          (0.95)   (0.36)   (0.25) ILOFF      56 EMUL
T   0   52     (1.60)   (0.3)    (0.3)  EISENBERG  58 EMUL
T               1.21     0.06     0.06  BURROWES   59 CNTR
T   0   33     (1.38)   (0.24)   (0.24) FREDEN     60 EMUL
T   0          (1.25)   (0.22)   (0.17) BARKAS     61 EMUL
T   0   51     (1.27)   (0.36)   (0.23) BHOWMIK     61 EMUL
T      293      1.31     0.08     0.08  NORDIN     61 HBC   -
T              (1.24)   (0.07)          NORDIN     61 RVUE  -
T               1.231    0.011    0.011 BOYARSKI   62 CNTR +
T               1.2443   0.0038         FITCH      65 CNTR +  K AT REST          6/66
T               1.221    0.011          FORD       67 CNTR +-                    8/67
T               1.2272   0.0036         LOBKOWICZ  69 CNTR +  K IN FLIGHT        9/66
T       3M      1.2380   0.0016         OTT        71 CNTR  +  STOPPING  K       2/71
T   0   OLD EXPERIMENTS WITH LARGE ERRORS EXCLUDED FROM AVERAGING                2/71
T
T   AVG         1.2370   0.0032   0.0032 AVERAGE (ERROR INCL. SCALE FACTOR OF 2.4)
T   FIT         1.2371   0.0026 FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.9)
                         (SEE IDEOGRAM BELOW)
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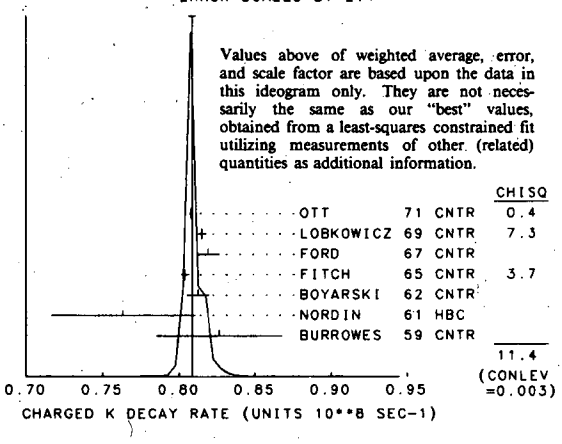
WEIGHTED AVERAGE = 0.8084 ± 0.0021
ERROR SCALED BY 2.4



Values above of weighted average, error, and scale factor are based upon the data in this ideogram only. They are not necessarily the same as our "best" values, obtained from a least-squares constrained fit utilizing measurements of other (related) quantities as additional information.

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                    10  ((K+) - (K-))/AVG., MEAN LIFE DIFFERENCE (PERCENT)

DT  N   THIS QUANTITY IS A MEASURE OF CPT INVARIANCE IN W.I.

DT              0.47     0.30          FORD       67 CNTR                        8/67
DT              0.090    0.078         LOBKOWICZ  69 CNTR                       12/70
DT
DT  AVG         0.114    0.093   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.2)

                    10  CHARGED K PARTIAL DECAY MODES

                                                          DECAY MASSES
P1      CHAR. K INTO MU NEU                K MU2          106+   0
P2      CHAR. K INTO PI PI0                K PI2          140+ 135
P3      CHAR. K INTO PI PI+ PI-            TAU            140+ 140+ 140
P4      CHAR. K INTO PI 2PI0               TAU PRIME      140+ 135+ 135
P5      CHAR. K INTO MU PI0 NEU            K MU3          106+ 135+   0
P6      CHAR. K INTO E PI0 NEU             K E3          .511+ 135+   0
P7      K+ INTO PI+ PI- E+ NEU             K E+ 4         140+ 140+.511+   0
P8      K+ INTO PI+ PI+ E- NEU             K E- 4         140+ 140+.511+   0
P9      K+ INTO PI+ PI- MU+ NEU            K+MU+ 4        140+ 140+ 106+   0
P10     K+ INTO PI+ PI+ MU- NEU            K+MU- 4        140+ 140+ 106+   0
P11     CHAR. K INTO E NEU                 K E2          .511+   0
P12     CHAR. K INTO MU NEU GAMMA          K MU RAD       106+   0+   0
P13     CHAR. K INTO PI PI0 GAMMA          K PI RAD       140+ 135+   0
P14     CHAR. K INTO PI PI+ PI- GAMMA      TAU RAD        140+ 140+ 140+   0
P15     CHAR. K INTO PI E+ E-              PI E E         140+.511+.511
P16     CHAR. K INTO PI MU+ MU-            PI MU MU       140+ 106+ 106
P17     CHAR. K INTO PI GAMMA GAMMA        PI GAM GAM     140+   0+   0
P18     CHAR. K INTO PI0 E NEU GAMMA       PI E NEU GAM   135+.511+   0+   0
P19     K+- INTO PI-+ E+- E+-              PI-+E+-E+-     140+.511+.511
P20     CHAR. K INTO PI NEU NEU            PI NEU NEU     140+   0+   0
P21     CHAR. K INTO E NEU GAMMA           K E2 RAD      .511+   0+   0
P22     CHAR. K INTO PI GAMMA              K PI GAM       140+   0
P23     CHAR. K INTO PI 3GAMMA             PI 3GAM        140+   0+   0+   0
P24     CHAR. K INTO PI0 PI0 E NEU         K E4 2PI0      135+ 135+.511+   0
P25     K+ INTO PI- E+ MU+                 PI-E+MU+       140+.511+ 106
P26     K+ INTO PI+ E+ MU-                 PI+E+MU-       140+.511+ 106
P27     CHAR. K INTO MU NEU NEU NEUBAR     MU 3NEU        106+   0+   0+   0
P28     CHAR. K INTO PI0 MU NEU GAMMA      PI MU NEU GAM  135+ 106+   0+   0
P29     K+ INTO PI+ MU+ E-                 PI+MU+E+       140+ 106+.511
P30     CHAR. K INTO MU NEU E+ E-          MU NEU E+E-    106+   0+.511+.511
P31     K+- INTO MU-+ NEU E+- E+-          MU-+ NEU 2E+-  106+   0+.511+.511
P32     CHAR. K INTO NEU E E E             NEU 3E           0+.511+.511+.511
P33     CHAR. K INTO E NEU NEU NEUBAR      E 3NEU        .511+   0+   0+   0
P34     K+ INTO MU+ NEU(E)                                106+   0
P35     K+ INTO MU+ NEUBAR(E)                             106+   0
P36     K+ INTO PI0 E+ NEUBAR(E)                          135+.511+   0

                    CHARGED K CONSTRAINED FIT
                OVERALL FIT OF MEAN LIFE, WIDTHS AND BRANCHING
                RATIOS USES 59 DATA POINTS TO DETERMINE SIX                      4/82
                QUANTITIES.  OVERALL FIT HAS CHISQ=78.0.  MAIN                   4/82
                CONTRIBUTION (13.2) COMES FROM R19 OF HAIDT                      4/82
                71 (WE SEE NO REASON TO REJECT THIS EXPERIMENT
                AT THIS TIME)
```

FITTED PARTIAL DECAY MODE BRANCHING FRACTIONS

The matrix below is derived from the error matrix for the fitted partial decay mode branching fractions, P_i, as follows: The diagonal elements are $P_i \pm \delta P_i$, where $\delta P_i = \sqrt{\langle \delta P_i \delta P_i \rangle}$, while the off-diagonal elements are the normalized correlation coefficients $\langle \delta P_i \delta P_j \rangle / (\delta P_i \cdot \delta P_j)$. For the definitions of the individual P_i, see the listings above; only those P_i appearing in the matrix are assumed in the fit to be nonzero and are thus constrained to add to 1.

	P 1	P 2	P 3	P 4	P 5	P 6
P 1	.6351+-.0016					
P 2	-.7202	.2117+-.0015				
P 3	-.1749	-.0208	.0559+-.0003			
P 4	-.1578	.0502	.2232	.0173+-.0005		
P 5	-.2912	-.2519	-.1649	-.3566	.0318+-.0010	
P 6	-.3397	-.1448	.1407	.0043	.2208	.0482+-.0005

FITTED PARTIAL DECAY MODE RATES

The matrix below is the branching fraction matrix above, transformed into rate space; i.e., $G_i \equiv \Gamma_i = \Gamma_{total} P_i$, in appropriate units. In analogy to the matrix above, the diagonal elements are $G_i \pm \delta G_i$, where $\delta G_i = \sqrt{\langle \delta G_i \delta G_i \rangle}$, while the off-diagonal elements are the normalized correlation coefficients $\langle \delta G_i \delta G_j \rangle / (\delta G_i \cdot \delta G_j)$. Note that, because of the error in Γ_{total}, the errors and correlations here are not directly derivable from those above.

	G 1	G 2	G 3	G 4	G 5	G 6
G 1	.5134+-.0017					
G 2	-.3170	.1711+-.0013				
G 3	-.0862	.0116	.0452+-.0002			
G 4	-.0904	.0629	.2263	.0140+-.0004		
G 5	-.1815	-.2190	-.1725	-.3534	.0257+-.0008	
G 6	-.1566	-.0868	.1432	.0095	.2270	.0390+-.0004

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                    10  CHARGED K DECAY RATES

W1      CHAR. K INTO MU NEU (UNITS 10**6 SEC-1)          (G1)
W1              51.2     0.8           FORD       67 CNTR +-                    8/67
W1
W1  FIT         51.34    0.17    FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.2)

W2      CHAR. K INTO PI PI+ PI- (UNITS 10**6 SEC-1)      (G3)
W2  F           (4.496)  (0.030)       FORD       67 CNTR +- SEE NOTE F         8/67
W2  F 3.2M      (4.529)  (0.032)       FORD       70 ASPK    SEE NOTE F        11/70
W2               4.511    0.024         FORD       70 ASPK    SEE NOTE F        11/70
W2  F   THE LAST IS THE COMBINED RESULT OF FORD 67 AND FORD 70
W2
W2  FIT          4.518    0.023   FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.1)

                    10  ((K+) - (K-))/AVG., DECAY RATE DIFFERENCE (PERCENT)

D1      DIFFERENCE IN K MU2 RATES      ((G1+)-(G1-))/G1          (PERCENT)
D1              -0.54    0.41          FORD       67 CNTR                       8/67

D2      DIFFERENCE IN TAU RATES        ((G3+)-(G3-))/G3          (PERCENT)
D2              -0.50    0.90          FLETCHER   67 OSPK                       8/67
D2  F           (-0.04)  (0.21)        FORD       67 CNTR    SEE NOTE F         8/67
D2  F 3.2M      (0.10)   (0.14)        FORD       70 ASPK    SEE NOTE F        11/70
D2  F            0.08    0.12          FORD       70 ASPK    SEE NOTE F        11/70
D2  S           (-0.02)  (0.16)        SMITH      73 ASPK +-                   11/73
D2  F   SECOND FORD 70 VALUE IS FIRST FORD 70 COMBINED WITH FORD 67.
D2  S   SMITH 73 VALUE OF D2 IS DERIVED FROM SMITH 73 VALUE OF D3.              11/73
D2
D2  AVG          0.07    0.12    AVERAGE

D3      DIFFERENCE IN TAU PRIME RATES ((G4+)-(G4-))/AVERAGE   (PERCENT)
D3   1802       -1.1     1.8           HERZO      69 OSPK                       5/70
D3               0.08    0.58          SMITH      73 ASPK +-                   11/73
D3
D3  AVG         -0.03    0.55    AVERAGE

D4      DIFFERENCE IN K PI2 RATES      ((G2+)-(G2-))/AVERAGE   (PERCENT)
D4               0.8     1.2           HERZO      69 OSPK                       5/70

D5      DIFFERENCE IN K PI RAD RATES   ((G13+)-(G13-))/AVERAGE (PERCENT)
D5      24       0.0    24.0           EDWARDS    72 OSPK    PI KE 58-90 MEV    8/72
D5    4000       1.0     4.0           ABRAMS     73 ASPK +- PI KE 51-100 MEV   3/74
D5    2461       0.8     5.8           SMITH      76 WIRE +- PI+-KE 55-90 MEV  11/76
D5
D5  AVG          0.9     3.3    AVERAGE

                    10  CHARGED K BRANCHING RATIOS

R   O       OLD DATA EXCLUDED

R1      CHAR. K INTO (MU NEU)/TOTAL (UNITS 10**-2)       (P1)
R1  O           (58.5)   (3.0)         BIRGE      56 EMUL +
R1  O           (56.9)   (2.6)         ALEXANDER  57 EMUL +
R1  O   OLD EXPERIMENTS NOT INCLUDED IN AVERAGING                                1/71
R1      62K      63.24   0.44          CHIANG     72 OSPK +  1.84 GEV/C K+      9/72
R1
R1  FIT          63.51   0.16    FROM FIT

R2      CHAR. K INTO (PI PI0)/TOTAL (UNITS 10**-2)       (P2)
R2  O           (27.7)   (2.7)         BIRGE      56 EMUL +
R2  O           (23.2)   (2.2)         ALEXANDER  57 EMUL +
R2  O   EARLIER EXPERIMENTS NOT AVERAGED
R2              (21.0)   (0.6)         CALLAHAN   65 HLBC    SEE R17
R2              (21.6)   (0.6)         TRILLING   65 RVUE                      6/66
R2      16K      21.18   0.28          CHIANG     72 OSPK +  1.84 GEV/C K+      9/72
R2
R2  FIT          21.17   0.15    FROM FIT
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Stable Particles

Data Card Listings

$K^{\pm}$

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R3      CHAR. K INTO (PI PI+ PI-)/TOTAL (UNITS 10**-2)    (P3)
R3  O        (5.6)     (0.4)            BIRGE      56 EMUL +
R3  O        (6.8)     (0.4)            ALEXANDER  57 EMUL +
R3  O        (5.2)     (0.3)            TAYLOR     59 EMUL +
R3  O   EARLIER EXPERIMENTS NOT AVERAGED
R3           5.7       0.3              ROE        61 HLBC +                    9/66
R3    2332   5.54      0.12             CALLAHAN   64 HLBC +
R3     540   5.1       0.2              SHAKLEE    64 HLBC +                    9/66
R3           5.71      0.15             DE MARCO   65 HBC                      6/66
R3      44   6.0       0.4              YOUNG      65 EMUL +                    6/66
R3 P   693   5.34      0.21             PANDOULAS  70 EMUL +                   10/70
R3  C 2330   (5.56)    (0.20)           CHIANG     72 OSPK +  1.84 GEV/C K+     9/72
R3  C   THIS VALUE IS NOT INDEPENDENT OF CHIANG 72 R1,R2,R4,R5, AND R6          9/72
R3 P    INCLUDES EVENTS OF TAYLOR 59.
R3          . . . . . . . . . .
R3  AVG      5.521     0.098    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.3)
R3  FIT      5.589     0.030  FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.1)
                       (SEE IDEOGRAM BELOW)
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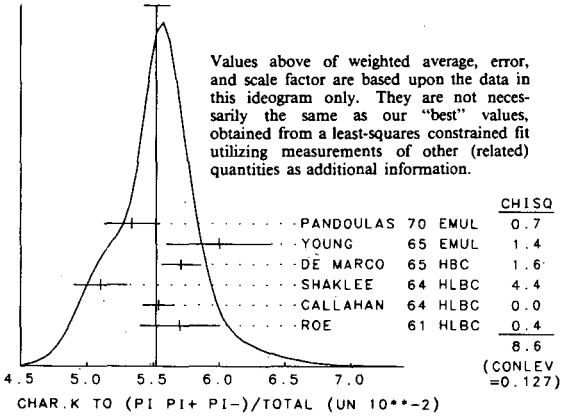
WEIGHTED AVERAGE = 5.521 ± 0.098
ERROR SCALED BY 1.3

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R4      CHAR. K INTO (PI 2PIO)/TOTAL (UNITS 10**-2)       (P4)
R4  O        (2.1)     (0.5)            BIRGE      56 EMUL +
R4  O        (2.2)     (0.4)            ALEXANDER  57 EMUL +
R4  O        (1.5)     (0.2)            TAYLOR     59 EMUL +
R4  O   EARLIER EXPERIMENTS NOT AVERAGED
R4           1.7       0.2              ROE        61 HLBC +                   11/67
R4     108   1.8       0.2              SHAKLEE    64 HLBC +                   11/67
R4 P   198   1.53      0.11             PANDOULAS  70 EMUL +                   10/70
R4    1307   1.84      0.06             CHIANG     72 OSPK +  1.84 GEV/C K+     9/72
R4 P    INCLUDES EVENTS OF TAYLOR 59.
R4          . . . . . . . . . .
R4  AVG      1.767     0.071    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.4)
R4  FIT      1.733     0.046  FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.4)
                       (SEE IDEOGRAM BELOW)
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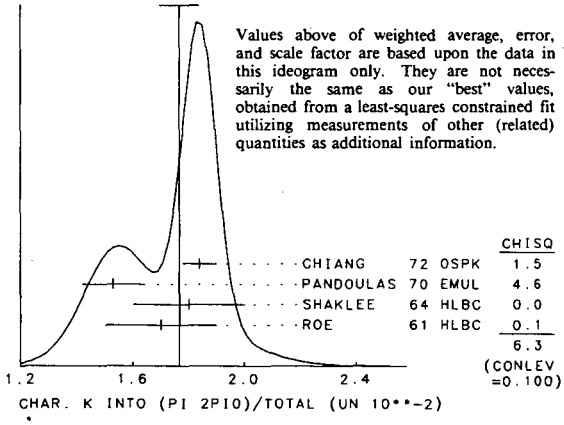
WEIGHTED AVERAGE = 1.767 ± 0.071
ERROR SCALED BY 1.4

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R5      CHAR. K INTO (MU PIO NEU)/TOTAL (UNITS 10**-2)    (P5)
R5  O        (2.8)     (1.0)            BIRGE      56 EMUL +
R5  O        (5.9)     (1.3)            ALEXANDER  57 EMUL +
R5  O        (2.8)     (0.4)            TAYLOR     59 EMUL +
R5  O   EARLIER EXPERIMENTS NOT AVERAGED
R5    2345   3.33      0.16             CHIANG     72 OSPK +  1.84 GEV/C K+     9/72
R5          . . . . . . . . . .
R5  FIT      3.180     0.095  FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.9)

R6      CHAR. K INTO (E PIO NEU)/TOTAL (UNITS 10**-2)     (P6)
R6  O        (3.2)     (1.3)            BIRGE      56 EMUL +
R6  O        (5.1)     (1.3)            ALEXANDER  57 EMUL +
R6  O   EARLIER EXPERIMENTS NOT AVERAGED
R6           5.0       0.5              ROE        61 HLBC +                   11/67
R6     429   4.7       0.3              SHAKLEE    64 HLBC +                   11/67
R6    3516   4.86      0.10             CHIANG     72 OSPK +  1.84 GEV/C K+     9/72
R6          . . . . . . . . . .
R6  AVG      4.849     0.093    AVERAGE
R6  FIT      4.819     0.052  FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.1)

R7      CHAR. K INTO (PI2 + MU3)/TOTAL (UNITS 10**-2)     (P2+P5)                11/67
R7       WE COMBINE THESE TWO MODES FOR EXPTS MEASURING THEM IN XENON BC
R7       BECAUSE OF DIFFICULTIES OF SEPARATING THEM THERE
R7          23.4      1.1              ROE        61 HLBC +                   11/67
R7     886  25.4      0.9              SHAKLEE    64 HLBC +                   11/67
R7          . . . . . . . . . .
R7  AVG     24.60     0.98     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.4)
R7  FIT     24.35     0.15   FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.1)

R8      K+ INTO (PI+ PI+ E- NEU)/TOTAL (UNITS 10**-7)     (P8)
R8       TEST OF DELTA-S = DELTA-Q RULE
R8          (20.)   OR LESS  CL=.95   BIRGE      65 FBC  +                    8/66
R8       0  (6.9)   OR LESS  CL=.95   ELY        69 HLBC +                   10/69
R8       0  (9.0)   OR LESS  CL=.95   SCHWEINBE  71 HLBC +                    9/71

R9      K+ INTO (PI+ PI- MU+ NEU)/TOTAL (UNITS 10**-5)    (P9)
R9       1  (0.77)  (0.54)  (0.50) CLINE      65 FBC  +                    8/66

R10     K+ INTO (PI+ PI+ MU- NEU)/TOTAL (UNITS 10**-6)    (P10)
R10      TEST OF DELTA-S = DELTA-Q RULE
R10      0   3.0   OR LESS  CL=.95   BIRGE      65 FBC  +                    8/66

R11     CHAR. K INTO (E NEU)/TOTAL (UNITS 10**-5)         (P11)
R11         (160.0) OR LESS  CL=.95   BORREANI  64 HBC  +                   11/67
R11      4  (2.1)   (1.8)   (1.3)  BOWEN      67 OSPK +                    8/67

R12     CHAR. K INTO (PI GAMMA GAMMA)/TOTAL (UNITS 10**-4)
R12                                                   (P17)
R12      ALL VALUES GIVEN HERE ASSUME A PHASE SPACE PION ENERGY SPECTRUM      2/72
R12         (-0.1)   (0.6)            CHEN       68 OSPK +  T(PI) 60-90 MEV   9/73
R12      0  (0.5)   OR LESS  CL=.90   KLEMS      71 OSPK +  T(PI)GT 117 MEV   8/71
R12      0  (0.35) OR LESS  CL=.90    LJUNG      73 HLBC +  6-102,114-127MEV  9/73
R12      0  (-0.42)  (0.52)           ABRAMS     77 SPEC +  T(PI)LT 92 MEV   12/77
R12      0   0.084 OR LESS  CL=.90    ASANO      82 CNTR +  TPI=117-127 MEV  11/82*

R13     CHAR. K INTO (PI PIO GAMMA)/TOTAL (UNITS 10**-4) (P13)
R13 O   18  (2.2)   (0.7)             CLINE      64 FBC  +  PI+ KE 55-80 MEV  8/66
R13      0  (1.9)   OR LESS  CL=.90   EMMERSON   69 OSPK    PI+ KE 55-80 MEV 10/69
R13  M   0  (1.0)   OR LESS           MALTSEV    70 HLBC +  PI+ KE LT 55 MEV 12/75
R13  A2100   2.71      0.19           ABRAMS     72 ASPK +- PI+ KE 55-90 MEV  1/73
R13 O   24  (2.4)   (0.8)             EDWARDS    72 OSPK    PI+ KE 58-90 MEV  8/72
R13 L       (1.5)   (1.1)    (0.6)    LJUNG      73 HLBC +  PI+ KE 55-80 MEV  9/73
R13 L       (2.6)   (1.5)    (1.1)    LJUNG      73 HLBC +  PI+ KE 55-90 MEV  9/73
R13 OL  17  (6.8)   (3.7)    (2.1)    LJUNG      73 HLBC +  PI+ KE 55-102MEV  9/73
R13   2461  2.87      0.32           SMITH      76 WIRE +- PI+-KE 55-90 MEV 11/76
R13 O   ONLY HIGH STATISTICS EXPERIMENTS ARE AVERAGED.                        3/78
R13  M  MALTSEV 70 SELECTS LOW PI+ ENERGY TO ENHANCE DIRECT EMISSION CONTR.   1/76
R13  L  THE LJUNG 73 VALUES ARE NOT INDEPENDENT.                              9/73
R13  A  ABRAMS 72 OBSERVES DIRECT EMISSION BR. RATIO OF (1.56+-0.35)*10**-5   1/73
R13  A  +-0.5*10**-5 ADDNL. SYST. ERROR  AND INNER BREMSSTRAHLUNG BR. RATIO   1/73
R13  A  OF (2.55+-0.18)*10**-4.  WE QUOTE THE SUM OF THESE BR. RATIOS.        1/73
R13         . . . . . . . . . .
R13 AVG      2.75      0.16     AVERAGE

R14     CHAR. K INTO (PI PI+ PI- GAMMA)/TOTAL (UNITS 10**-4)
R14                                                   (P14)
R14          1.0       0.4              STAMER     65 EMUL +  EGAM GT 11MEV     8/66

R15     CHAR. K INTO (PI E+ E-)/TOTAL (UNITS 10**-6)      (P15)
R15      1  (2.45) OR LESS  CL=.90   CAMERINI  64 FBC  +                    8/66
R15         (4.4)  OR LESS  CL=.90   BISI     67 DBC  +                   11/67
R15  C      (0.4)  OR LESS           CLINE1   67 FBC  +                   11/67
R15  C      (0.88) OR LESS  CL=.90   CLINE2   67 FBC  +                    2/74
R15        (32.0)  OR LESS  CL=.90   BEIER    72 OSPK +-                   9/72
R15         (1.7)  OR LESS  CL=.90   CENCE    74 ASPK +  THREE TRACK EVTS 10/74
R15         (0.27) OR LESS  CL=.90   CENCE    74 ASPK +  TWO TRACK EVENTS 10/74
R15  C  CLINE2 REPLACES CLINE1.  CLINE1 IS NOT FOR CL=.90 .                   2/74

R16     CHAR. K INTO (PI MU+ MU-)/TOTAL (UNITS 10**-6)    (P16)
R16         (3.0)  OR LESS  CL=.90   CAMERINI  65 FBC  +                    8/66
R16          2.4   OR LESS  CL=.90   BISI      67 DBC  +                   11/67

R17     CHAR. K INTO (PI PIO)/TAU                         (P2)/(P3)
R17    134  3.24      0.34             YOUNG      65 EMUL +                    8/66
R17   1045  3.96      0.15             CALLAHAN   66 FBC  +                    9/66
R17         . . . . . . . . . .
R17 AVG      3.84      0.27     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.9)
R17 FIT      3.787     0.034  FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.1)

R18     CHAR. K INTO (PI 2PIO)/TAU                        (P4)/(P3)
R18   2027   0.303     0.009            BISI       65 H+HL +                    8/66
R18     17   0.393     0.099            YOUNG      65 EMUL +                    8/66
R18         . . . . . . . . . .
R18 AVG      0.3037    0.0090   AVERAGE
R18 FIT      0.3100    0.0079 FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.3)

R19     CHAR. K INTO (MU PIO NEU)/TAU                     (P5)/(P3)
R19  B2845   0.63      0.07             BISI 1     65 H+HL +                    8/66
R19     38   0.90      0.16             YOUNG      65 EMUL +                    8/66
R19 H 1505  (0.510)  (0.017)            EICHTEN    68 HLBC +                   11/68
R19  H1505   0.503     0.019            HAIDT      71 HLBC +                   12/70
R19  B  ERROR ENLARGED FOR BACKGROUND PROBLEMS.  SEE GAILLARD 70.             11/83*
R19  H  HAIDT 71 IS A REANALYSIS OF EICHTEN 68.
R19         . . . . . . . . . .
R19 AVG      0.517     0.032    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.8)
R19 FIT      0.569     0.018  FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.9)
                       (SEE IDEOGRAM BELOW)

R20     CHAR. K INTO (E PIO NEU)/TAU                      (P6)/(P3)
R20    230   0.90      0.06             BORREANI   64 HBC  +                    8/66
R20     37   0.90      0.16             YOUNG      65 EMUL +                    8/66
R20    854   0.94      0.09             BELLOTT2   67 HLBC                     11/67
R20 H 4385  (0.846)  (0.021)            EICHTEN    68 HLBC +                   11/68
R20  H4385   0.850     0.019            HAIDT      71 HLBC +                   12/70
R20   2827   0.856     0.040            BRAUN      75 HLBC +                   12/75
R20  H  HAIDT 71 IS A REANALYSIS OF EICHTEN 68.
R20         . . . . . . . . . .
R20 AVG      0.858     0.016    AVERAGE
R20 FIT      0.8622    0.0098 FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.1)

R21     K+ INTO (PI+ PI- E+ NEU)/TAU (UNITS 10**-4)       (P7)/(P3)
R21     69   6.7       1.5              BIRGE      65 FBC  +                    8/66
R21    269   5.83      0.63             ELY        69 HLBC +                   11/68
R21    500   7.36      0.68             BOURQUIN   71 ASPK                     12/71
R21    106   7.0       0.9              SCHWEINBE  71 HLBC +                    9/71
R21    30K   7.21      0.32             ROSSELET   77 SPEC +                   11/77
R21         . . . . . . . . . .
R21 AVG      6.98      0.26     AVERAGE

R22     K+ INTO (PI+ PI- MU+ NEU)/TAU (UNITS 10**-4)      (P9)/(P3)
R22      1  (2.5)  APPROX            GREINER    64 EMUL +                    8/66
R22      7   2.57      1.55           BISI       67 DBC  +                   11/67
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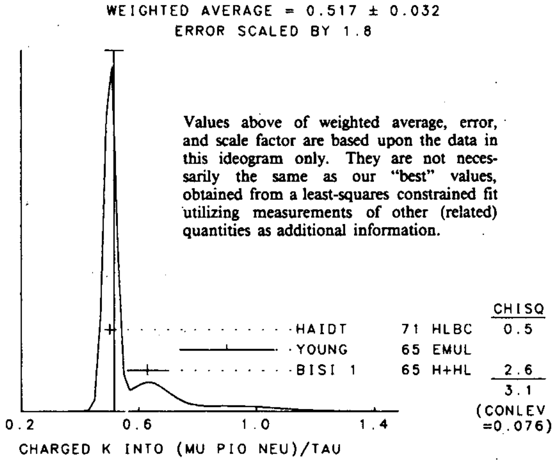
For notation, see key at front of Listings.

Stable Particles
$K^{\pm}$

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R23     CHAR. K INTO (E PIO NEU)/(MU2+PI2) (UNITS 10**-2)(P6)/(P1+P2)
R23    1679    5.89      0.21            CESTER    66 OSPK +                      8/67
R23    5110    6.16      0.22            ESCHSTRUT 68 OSPK +                      3/68
R23  W         5.92      0.65            WEISSENBE 76 SPEC +                      1/78
R23  W  VALUE CALCULATED FROM WEISSENBERG 76 KE3, KMU2, KPI2 VALUES               1/78
R23  W  TO ELIMINATE DEPENDENCE ON OUR 1974 TAU AND TAU-PRIME FRACTIONS.          1/78
R23           . . . . . . . . . .
R23 AVG        6.01      0.15    AVERAGE
R23 FIT        5.691     0.067  FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.1)
R24     CHAR. K INTO (PI PIO)/(MU NEU)                          (P2)/(P1)
R24  A4517     0.3277    0.0065          AUERBACH  67 OSPK +                      1/74
R24   1600     0.305     0.018           ZELLER    69 ASPK +                     10/69
R24 W  25K    (0.328)   (0.005)          WEISSENBE 74 STRC +                      7/74
R24  W         0.3355    0.0057          WEISSENBE 76 SPEC +                      1/78
R24  A  AUERBACH 67 CHANGED FROM .3253+-.0065.  SEE COMMENT WITH RATIO R26.       1/74
R24  W  WEISSENBERG 76 REVISES WEISSENBERG 74.                                     1/78
R24           . . . . . . . . . .
R24 AVG        0.3307    0.0051  AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.2)
R24 FIT        0.3333    0.0030 FROM FIT
                         (SEE IDEOGRAM BELOW)
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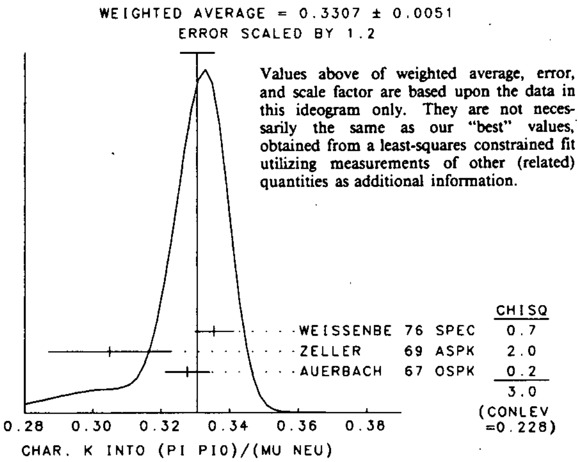


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R25     CHAR. K INTO (E PIO NEU)/(MU NEU)                       (P6)/(P1)
R25   A 295     0.0791    0.0054         AUERBACH  67 OSPK +                      1/74
R25     960     0.0775    0.0033         BOTTERI1  68 ASPK +                      5/68
R25     561     0.069     0.006          GARLAND   68 OSPK +                      4/68
R25     350     0.069     0.006          ZELLER    69 ASPK +                     10/69
R25   A  AUERBACH 67 CHANGED FROM .0797+-.0054.  SEE COMMENT WITH RATIO R26.      1/74
R25   A  THE VALUE .0785+-.0025 GIVEN IN AUERBACH 67 IS AN AVERAGE OF             3/74
R25   A  AUERBACH 67 R25 AND CESTER 66 R23.                                       3/74
R25            . . . . . . . . . .
R25 AVG         0.0752    0.0024  AVERAGE
R25 FIT        0.07588   0.00091 FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.1)

R26     CHAR. K INTO (MU PIO NEU)/(MU NEU)                      (P5)/(P1)
R26   A 307     0.0486    0.0040         AUERBACH  67 OSPK +                      1/74
R26   G 424     0.0480    0.0037         GARLAND   68 OSPK +                      1/74
R26     240     0.054     0.009          ZELLER    69 ASPK +                     10/69
R26   A  AUERBACH 67 CHANGED FROM .0602+-.0046 BY ERRATUM WHICH BRINGS THE        1/76
R26   A  MU-SPECTRUM CALCULATION INTO AGREEMENT WITH GAILLARD 70 APPENDIX B.      1/74
R26   G  GARLAND 68 CHANGED FROM .055+-.004 IN AGREEMENT WITH MU-SPECTRUM         1/74
R26   G  CALCULATION OF GAILLARD 70 APPENDIX B.  L.G.PONDROM, PRIV.COMM.(73)      1/74
R26            . . . . . . . . . .
R26 AVG         0.0488    0.0026  AVERAGE
R26 FIT         0.0501    0.0015 FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.8)

R27     CHAR. K INTO (MU NEU)/TAU                               (P1)/(P3)
R27 R   427  (10.38)    (0.82)           YOUNG     65 EMUL +                      9/66
R27 R    DELETED FROM OVERALL FIT BECAUSE YOUNG 65 CONSTRAINS HIS RESULTS.
R27 R    TO ADD UP TO 1.  ONLY YOUNG MEASURED MU2 DIRECTLY.
R27            . . . . . . . . . .
R27 FIT        11.363     0.072  FROM FIT
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R28     CHAR. K INTO (E NEU)/(MU NEU) (UNITS 10**-5)      (P11)/(P1)
R28      10     1.9       0.7      0.5    BOTTERILL 67 ASPK +                    11/67
R28       8     1.8       0.8      0.6    MACEK     69 ASPK +                     4/69
R28     112     2.42      0.42            CLARK     72 OSPK +                     1/73
R28     534     2.37      0.17            HEARD2    75 SPEC +                    11/75
R28     404     2.51      0.15            HEINTZE   76 SPEC +                     2/76
R28           . . . . . . . . . .
R28 AVG         2.42      0.11    AVERAGE

R29     CHAR. K INTO (MU PIO NEU)/(E PIO NEU)             (P5)/(P6)
R29  C1509      0.703     0.056           CALLAHA1  66 HLBC                       6/68
R29   5601      0.667     0.017           BOTTERI2  68 ASPK +                     6/68
R29 H 1398     (0.604)   (0.022)          EICHTEN   68 HLBC                      10/68
R29 H          (0.596)   (0.025)          HAIDT     71 HLBC +                    12/70
R29  D3480      0.698     0.025           CHIANG    72 OSPK +  1.84 GEV/C K+      9/72
R29  L 554      0.705     0.063           LUCAS2    73 HBC  -  DALITZ PRS ONLY   11/73
R29 B 1585     (0.608)   (0.014)          BRAUN     75 HLBC +                     1/76
R29             0.67      0.12            WEISSENBE 76 SPEC +                     1/78
R29 E          (0.670)   (0.014)          HEINTZE   77 SPEC +                    12/77
R29                  COMMENTS
R29  C  FROM CALLAHAN1 66 WE USE ONLY THE MU3/E3 RATIO AND DO NOT
R29  C  INCLUDE IN THE FIT THE RATIOS MU3/TAU AND E3/TAU, SINCE THEY SHOW
R29  C  LARGE DISAGREEMENTS WITH THE REST OF THE DATA.
R29 H   HAIDT 71 IS A REANALYSIS OF EICHTEN 68.
R29 H   ONLY INDIVIDUAL RATIOS INCLUDED IN FIT (SEE R19 AND R20).                11/68
R29  D  CHIANG 72 R29 IS STATISTICALLY INDEPENDENT OF CHIANG 72 R5 AND R6.        9/72
R29  L  LUCAS 73 GIVES N(MU3)=554+-7.6PCT, N(E3)=786+-3.1PCT.  WE DIVIDE.        11/73
R29 B   BRAUN 75 VALUE IS FROM FORM FACTOR FIT.  ASSUMES MU-E UNIVERSALITY.       1/76
R29 E   HEINTZE 77 VALUE FROM FIT TO LAMBDA0. ASSUMES MU-E UNIVERSALITY.         12/77
R29           . . . . . . . . . .
R29 AVG         0.679     0.013   AVERAGE
R29 FIT         0.660     0.019  FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.8)

R30     CHAR. K INTO (PIO E NEU GAMMA)/(PIO E NEU) (UNITS 10**-2)
R30                                                       (P18)/(P6)
R30            (1.2)     (0.8)            BELLOTT1  67 HLBC +  EGAM GT 30MEV     11/67
R30  R  13      0.76      0.28            ROMANO    71 HLBC    EGAM GT 10MEV     10/71
R30 R          (0.53)    (0.22)           ROMANO    71 HLBC +  EGAM GT 30 MEV     9/73
R30 L   16     (0.48)    (0.20)           LJUNG     73 HLBC +  EGAM GT 30 MEV     9/73
R30 L          (0.22)    (0.15)   (0.10)  LJUNG     73 HLBC +  EGAM GT 30 MEV     9/73
R30 L   FIRST LJUNG VALUE IS FOR COS(ELECT-GAMMA)L.T. 0.9, SECOND VALUE IS        9/73
R30 L   FOR COS(ELECT-GAMMA) BETW 0.6 AND 0.9 FOR COMPARISON WITH ROMANO.         9/73
R30 R   BOTH ROMANO VALUES ARE FOR COS(ELECT-GAMMA) BETW 0.6 AND 0.9.             9/73
R30 R   SECOND VALUE IS FOR COMPARISON WITH SECOND LJUNG VALUE.                   9/73
R30 R   WE USE LOWEST EGAM CUT FOR TABLE VALUE. SEE ROMANO FOR EGAM DEPEND.       9/73

R31     K- INTO (PI+ E- E-)/TOTAL (UNITS 10**-5)          (P19)
R31      TEST OF TOTAL LEPTON NUMBER CONSERVATION.
R31            (1.5)  OR LESS             CHANG     68 HBC  -                     3/68

R32     CHAR. K INTO (PI NEU NEU)/TOTAL (UNITS 10**-6)    (P20)
R32 C          (1.4)  OR LESS  CL=.90   KLEMS      71 OSPK +  T(PI) 117-127MEV    3/74
R32 C          (0.94) OR LESS  CL=.90   CABLE      73 CNTR +  T(PI) 60-105 MEV    2/74
R32  C         (0.56) OR LESS  CL=.90   CABLE      73 CNTR +  T(PI) 60-127 MEV    2/74
R32  L    0   (57.0)  OR LESS  CL=.90   LJUNG      73 HLBC +                      9/73
R32             0.14  OR LESS  CL=.90   ASANO      81 CNTR +  T(PI) 116-127MEV    1/82
R32  C  KLEMS 71 AND CABLE 73 ASSUME PI SPECTRUM SAME AS KE3 DECAY.               3/74
R32  C  SECOND CABLE LIMIT COMBINES CABLE AND KLEMS DATA FOR VECTOR INT.          2/74
R32  L  LJUNG 73 ASSUMES VECTOR INTERACTION.                                      9/73

R33     CHAR. K INTO (E NEU GAMMA)/TOTAL  (UNITS 10**-5) (P21)
R33  M         (7.1)  OR LESS           MACEK      70 OSPK +  P(E) 234 TO 247    12/70
R33  M  ABOVE IS MEASUREMENT OF STRUCTURE-DEPENDENT DECAY ONLY.

R34     CHAR. K INTO (PI GAMMA)/TOTAL (UNITS 10**-6)      (P22)
R34      VIOLATES ANGULAR MOMENTUM CONSERVATION.  NOT LISTED IN TABLES.
R34  K         (4.0)  OR LESS  CL=.90   KLEMS      71 OSPK +                      8/71
R34            (1.4)  OR LESS  CL=.90   ASANO      82 CNTR +                     11/82*
R34  K  TEST OF MODEL OF SELLERI, NC 60A, 291(1969).

R36     CHAR. K INTO (PI 3GAMMA)/TOTAL (UNITS 10**-4)     (P23)
R36      VALUES GIVEN HERE ASSUME A PHASE SPACE PION ENERGY SPECTRUM.
R36            (3.0)  OR LESS  CL=.90   KLEMS      71 OSPK +  T(PI) GT 117MEV     8/71
R36             1.0   OR LESS  CL=.90   ASANO      82 CNTR +  TPI=117-127 MEV    11/82*

R37     K+ INTO (PI+ PI+ E- NEU)/(PI+ PI- E+ NEU) (UNITS 10**-4)
R37                                                       (P8)/(P7)
R37      TEST OF DELTA-S = DELTA-Q RULE
R37       0 (130.)    OR LESS  CL=.95   BOURQUIN   71 ASPK                        8/76
R37  B    3    3.6    OR LESS  CL=.95   BLOCH      76 SPEC                        8/76
R37  B  CORRESPONDS TO 3E10-4 AT CL=.90.                                          2/80

R38     CHAR. K INTO (PIO PIO E NEU)/KE3 (UNITS 10**-4)  (P24)/(P6)
R38       0  (37.0)   OR LESS  CL=.90   ROMANO     71 HLBC +                     12/71
R38       2    3.8      5.0       1.2   LJUNG      73 HLBC +                      9/73

R39     K+ INTO (PI- E+ MU+)/TOTAL (UNITS 10**-8)         (P25)
R39     K- INTO (PI+ E- MU-)/TOTAL IS ALSO INCLUDED HERE
R39            (2.8)  OR LESS  CL=.90   BEIER      72 OSPK +-                     9/72

R40     K+ INTO (PI+ E+ MU-)/TOTAL (UNITS 10**-8)         (P26)
R40     K- INTO (PI- E- MU+)/TOTAL IS ALSO INCLUDED HERE
R40            (1.4)  OR LESS  CL=.90   BEIER      72 OSPK +-                     9/72

R41     CHAR. K INTO (MU 3NEU)/TOTAL (UNITS 10**-6)       (P27)
R41  P    0    6.0    OR LESS  CL=.90   PANG       73 CNTR +                     11/73
R41  P  PANG 73 ASSUMES MU SPECTRUM FROM NEU-NEU INTERACTION OF BARDIN 70.        3/74

R42     CHAR. K INTO (PIO MU NEU GAM)/TOTAL(UNITS 10**-5)(P28)                    9/73
R42       0    6.1    OR LESS  CL=.90   LJUNG      73 HLBC +  EGAM GT 30 MEV      9/73

R43     CHAR. K INTO (E PIO NEU)/(PI PIO)                 (P6)/(P2)
R43  L 786      0.221     0.012          LUCAS2    73 HBC  -  DALITZ PRS ONLY    11/73
R43  L  LUCAS 73 GIVES N(E3)=786+-3.1PCT, N(PI2)=3564+-3.1PCT.  WE DIVIDE.       11/73
R43           . . . . . . . . . .
R43 FIT         0.2277    0.0031 FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.1)

R44     CHAR. K INTO (PI 2PIO)/(PI PIO)                   (P4)/(P2)
R44  L 574      0.081     0.005          LUCAS2    73 HBC  -  DALITZ PRS ONLY    11/73
R44  L  LUCAS 73 GIVES N(PI 2PIO)=574+-5.9 PCT, N(PI2)=3564+-3.1 PCT.            11/73
R44  L  WE QUOTE 0.5*N(PI 2PIO)/N(PI2) WHERE 0.5 IS BECAUSE ONLY DALITZ          11/73
R44  L  PAIR PIO'S WERE USED.                                                    11/73
R44           . . . . . . . . . .
R44 FIT         0.0819    0.0022 FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.3)

R45     CHAR. K INTO(MU NEU GAMMA)/TOTAL  (UNITS 10**-3) (P12)                    7/74
R45      12     5.8       3.5             WEISSENBE 74 STRC +  E-GAMMA GT 9 MEV   7/74

R46     CHAR. K INTO (PI E+ E-)/(PI+ PI- E NEU) (UNITS 10**-3)  (P15)/(P7)
R46      TEST FOR DELTA-S = 1 WEAK NEUTRAL CURRENT.  ALLOWED BY COMBINED
R46      FIRST ORDER WEAK AND E.M. INTERACTIONS.
R46  B  41      7.0       1.3             BLOCH     75 SPEC +                    11/75
R46  B  BLOCH 75 QUOTES THIS RESULT MULTIPLIED BY OUR 1974 KE4 BR.FRAC.          11/75

R47     CHAR. K INTO (E NEU GAM)/(E NEU)                        (P21)/(P11)
R47      STRUCTURE DEPENDENT PART WITH + GAMMA HELICITY.
R47 H   56    (1.05)    (0.25)    (0.30) HEARD1     75 SPEC +  P(E) 236 TO 247   11/75
R47 H   THIS VALUE IS INCLUDED IN THE SECOND HEINTZE 79 VALUE IN SEC.R54         11/75
R47 H   BELOW.                                                                   11/75
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Stable Particles

$K^{\pm}$

Data Card Listings

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R48     K+ INTO (PI+-MU-+E+)/(PI+PI-E NEU) (UNITS 10**-4) (P25+P26)/(P7)      11/76
R48      TEST OF LEPTON FAMILY NUMBER OR TOTAL LEPTON NUMBER CONSERVATION.
R48  D    0    1.9    OR LESS  CL=.90   DIAMANTBE 76 SPEC +                   11/76
R48  D  DIAMANTBE 76 QUOTES THIS RESULT TIMES OUR 1975 KE4 BR. RATIO.         11/76

R49     K+ INTO (PI+ MU+ E-)/(PI+PI- E NEU) (UNITS 10**-4)  (P29)/(P7)        11/76
R48      TEST OF LEPTON FAMILY NUMBER CONSERVATION.
R49  D    0    1.3    OR LESS  CL=.90   DIAMANTBE 76 SPEC +                   11/76
R49  D  DIAMANTBE 76 QUOTES THIS RESULT TIMES OUR 1975 KE4 BR RATIO.          11/76

R50     CHAR. K INTO (MU NEU E+E-)/(PI+PI-ENEU) (UNITS 10**-3) (P30)/(P7)     11/76
R50 D   14   (3.3)    (0.9)            DIAMANTBE 76 SPEC +  M(EE) GT 140      11/76
R50  D  14    27.      8.              DIAMANTBE 76 SPEC +  EXTRAPOLATED BR   11/76
R50  D  DIAMANTBE 76 QUOTES THESE RESULTS TIMES OUR 1975 KE4 BR RATIO.        11/76
R50  D  THE SECOND DIAMANTBE 76 VALUE IS THE FIRST VALUE EXTRAPOLATED TO 0    11/76
R50  D  TO INCLUDE LOW MASS E PAIRS.                                          11/76

R51     K+ INTO(PI- E+ E+ )/(PI+ PI- E NEU) UNITS(10**-4) (P19)/(P7)          11/76
R51      TEST OF TOTAL LEPTON NUMBER CONSERVATION
R51  D    0    2.5    OR LESS  CL=.90   DIAMANTBE 76 SPEC +                   11/76
R51  D  DIAMANTBE 76 QUOTES THIS RESULT TIMES OUR 1975 BR RATIO.              11/76

R52     K+ INTO(MU- NEU E+ E+)/(PI+ PI- E NEU)  (UNITS 10**-3) (P31)/(P7)     11/76
R52      TEST OF LEPTON FAMILY NUMBER CONSERVATION.
R52  D    0    0.5    OR LESS  CL=.90   DIAMANTBE 76 SPEC +                   11/76
R52  D  DIAMANTBE 76 QUOTES THIS RESULT TIMES OUR 1975 KE4 BR RATIO.          11/76

R53     K+ INTO (NEU E+ E+ E-)/(PI+PI- E NEU) (UNITS 10**-2) (P32)/(P7)       11/76
R53      4    0.54     0.54     0.27  DIAMANTBE 76 SPEC +                     11/76
R53  D  DIAMANTBE 76 QUOTES THIS RESULT TIMES OUR 1975 KE4 BR RATIO.          11/76

R54     CHAR. K INTO (E NEU GAM)/(MU NEU)  (UNITS 10**-5)(P21)/(P1)
R54      STRUCTURE DEPENDENT PART WITH + GAMMA HELICITY
R54 H   51   (2.33)   (0.42)            HEINTZE   79 SPEC +                    7/79
R54  H 107    2.40     0.36             HEINTZE   79 SPEC +                    7/79
R54  H  SECOND HEINTZE 79 RESULT IS FIRST COMBINED WITH HEARD1 75 RESULT      7/79
R54  H  FROM SECTION R47 ABOVE.                                               7/79

R55     CHAR. K INTO (E NEU GAM)/TOTAL (UNITS 10**-4)    (P21)
R55      STRUCTURE DEPENDENT PART WITH - GAMMA HELICITY
R55  H        1.6    OR LESS  CL=.90   HEINTZE   79 SPEC +                    2/82
R55  H  IMPLIES (AXIAL VEC./VECTOR) AMPL. RATIO OUTSIDE RANGE -1.8 TO -.54.   2/82

R56     CHAR. K INTO (E NEU NEU NEUBAR)/(E NEU)          (P33)/(P11)          7/79
R56      0    3.8    OR LESS  CL=.90   HEINTZE   79 SPEC +                    7/79

R57     K+ INTO (MU+ NEU(E))/TOTAL                       (P34)
R57      FORBIDDEN BY LEPTON FAMILY NUMBER CONSERVATION.
R57      0    0.004 OR LESS  CL=.90   LYONS     81 HLBC 200GEV K+ N.B. BEAM  2/82
R57          (0.012)OR LESS  CL=.90   COOPER    82 HLBC WIDEBAND NEU BEAM    1/83*

R58     K+ INTO MU+ NEUBAR(E)/TOTAL (UNITS 10**-3)       (P35)
R58      FORBIDDEN BY TOTAL LEPTON NUMBER CONSERVATION.
R58           3.3    OR LESS  CL=.90   COOPER    82 HLBC WIDEBAND NEU BEAM    1/83*

R59     K+ INTO PIO E+ NEUBAR(E)/TOTAL                   (P36)
R59      FORBIDDEN BY TOTAL LEPTON NUMBER CONSERVATION.
R59           0.003 OR LESS  CL=.90   COOPER    82 HLBC WIDEBAND NEU BEAM    1/83*
------ --------- --------- --------- --------- --------- --------- --------
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NOTE ON DALITZ PLOT PARAMETERS FOR $K \to 3\pi$ DECAYS

The Dalitz plot distribution for $K^{\pm} \to \pi^{\pm}\pi^{\pm}\pi^{\mp}$, $K^{\pm} \to \pi^0\pi^0\pi^{\pm}$, and $K_L^0 \to \pi^+\pi^-\pi^0$ can be parametrized by a series expansion such as that introduced by Weinberg.[1] We use the form

$$|M|^2 \propto 1 + g\frac{(s_3 - s_0)}{m_{\pi^+}^2} + h\left(\frac{s_3 - s_0}{m_{\pi^+}^2}\right)^2 + j\frac{(s_2 - s_1)}{m_{\pi^+}^2} + k\left(\frac{s_2 - s_1}{m_{\pi^+}^2}\right)^2 + \cdots , \qquad (1)$$

where $m_{\pi^+}^2$ has been introduced to make the coefficients g, h, j, and k dimensionless, and

$$s_i = (P_K - P_i)^2 = (m_K - m_i)^2 - 2m_K T_i, \quad i = 1,2,3,$$

$$s_0 = \frac{1}{3}\sum_i s_i = \frac{1}{3}(m_K^2 + m_1^2 + m_2^2 + m_3^2) .$$

Here the P_i are four-vectors, m_i and T_i are the mass and kinetic energy of the ith pion, and the index 3 is used for the odd pion.

The coefficient g is a measure of the slope in the variable s_3 (or T_3) of the Dalitz plot, while h and k measure the quadratic dependence on s_3 and $(s_2 - s_1)$, respectively. The coefficient j is related to the asymmetry of the plot and must be zero if CP invariance holds. Note also that if CP is good, g, h, and k must be the same for $K^+ \to \pi^+\pi^+\pi^-$ as for $K^- \to \pi^-\pi^-\pi^+$.

Since different experiments use different forms for $|M|^2$, in order to compare the experiments we have converted to g, h, j, and k whatever coefficients have been measured. For details of this conversion and discussion of the data, see the April 1982 version of this note.[2]

See also the review of Devlin and Dickey,[3] which contains an analysis of $K \to 2\pi$ and $K \to 3\pi$ data in terms of transition amplitudes with appropriate energy dependence.

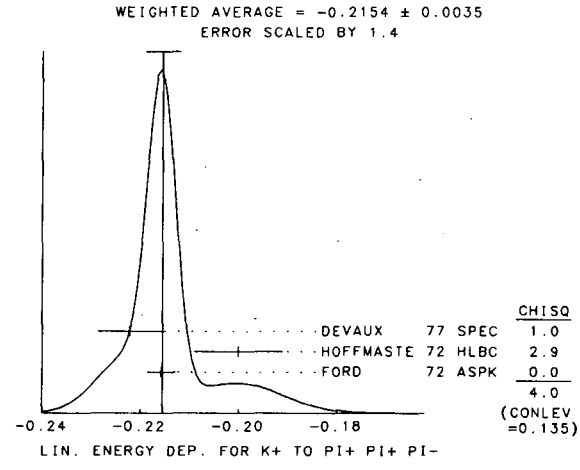
References

1. S. Weinberg, Phys. Rev. Lett. **4**, 87 (1960).
2. Particle Data Group, Phys. Lett. **111B**, 69 (1982).
3. T.J. Devlin and J.O. Dickey, Rev. Mod. Phys. **51**, 237 (1979).


```
                    10  CHARGED K ENERGY DEPENDENCE OF DALITZ PLOT

      MATRIX ELEMENT SQUARED = 1 + G*U + H*U**2 + K*V**2                      1/79
      WHERE U=(S3-S0)/(MPI**2) AND V=(S1-S2)/(MPI**2)                         1/79

GT+     LINEAR COEFFICIENT G FOR TAU DECAYS K+ --> PI+ PI+ PI-                1/79
GT+        SOME  EXPTS USE DALITZ VARIABLES X AND Y. WE GIVE AY=COEFF OF Y    1/79
GT+        TERM AT RIGHT. SEE MINI-REVIEW ABOVE.                              1/79
GT+ZL 5428  (-0.22)   (0.024)        ZINCHENKO 67 HBC  +  AY=0.28+-.03      10/69
GT+ L 9994  (-0.218)  (0.016)        BUTLER    68 HBC  +  AY=0.277+-.020    10/69
GT+ G17898  (-0.196)  (0.012)        GRAUMAN   70 HLBC +  AY=0.228+-.030     8/70
GT+   750K  -0.2157   0.0028         FORD      72 ASPK +  AY=0.2734+-.0035   1/79
GT+H 39819  -0.200    0.009          HOFFMASTE 72 HLBC +                     1/79
GT+   225K  -0.2221   0.0065         DEVAUX    77 SPEC +  AY=0.2814+-.0082   1/79
GT+ L   EXPERIMENTS WITH LARGE ERRORS NOT INCLUDED IN AVERAGE.                3/78
GT+ Z   ALSO INCLUDES DBC EVENTS
GT+ G   EMULS. DATA ADDED - ALL EVENTS INCLUDED BY HOFFMASTER 72              1/71
GT+H    HOFFMASTER 72 INCLUDES GRAUMAN 70 DATA.                               1/79
GT+        . . . . . . . . . .
GT+ AVG     -0.2154   0.0035  AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.4)
                      (SEE IDEOGRAM BELOW)
```

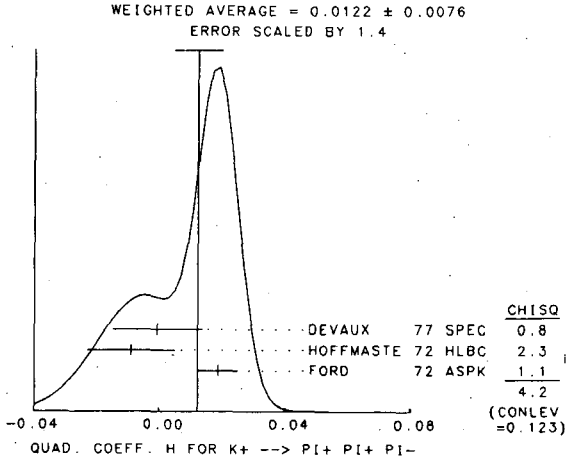


For notation, see key at front of Listings.

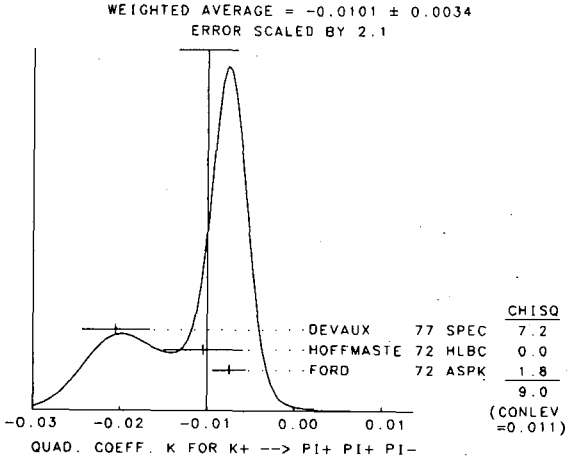
Stable Particles

$K^{\pm}$

```
HT+    QUADRATIC COEFF. H FOR K+ --> PI+ PI+ PI-                          1/79
HT+   750K    0.0187   0.0062          FORD       72 ASPK +                1/79
HT+  39819   -0.009    0.014           HOFFMASTE  72 HLBC +                1/79
HT+   225K   -0.0006   0.0143          DEVAUX     77 SPEC +                1/79
HT+
HT+ AVG       0.0122   0.0076  AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.4)
                               (SEE IDEOGRAM BELOW)
```




```
KT+    QUADRATIC COEFF. K FOR K+ --> PI+ PI+ PI-                          1/79
KT+   750K   -0.0075   0.0019          FORD       72 ASPK +                1/79
KT+  39819   -0.0105   0.0045          HOFFMASTE  72 HLBC +                1/79
KT+   225K   -0.0205   0.0039          DEVAUX     77 SPEC +                1/79
KT+
KT+ AVG      -0.0101   0.0034  AVERAGE (ERROR INCLUDES SCALE FACTOR OF 2.1)
                               (SEE IDEOGRAM BELOW)
```



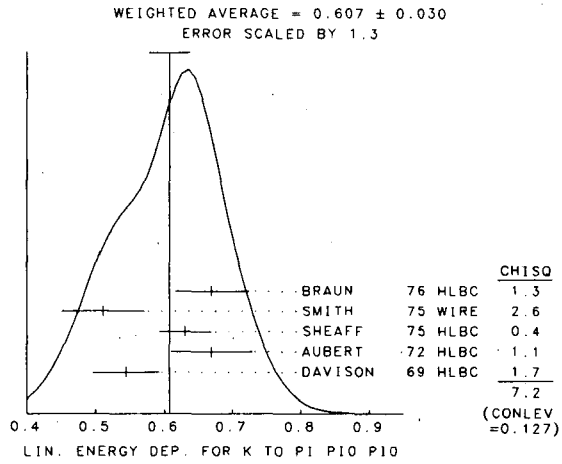

```
GT-    LINEAR COEFFICIENT G FOR TAU DECAYS K- --> PI- PI- PI+
GT-       FOR DEFINITION OF AY SEE NOTE IN SECTION GT+ ABOVE.
GT- F 1347  (-0.220)  (0.035)          FERRO-LUZ 61 HBC   - AY=0.28+-.045    10/69
GT-ML 5778  (-0.190)  (0.023)          MOSCOSO   68 HBC   - AY=0.242+-.029   10/69
GT-  50919   -0.193    0.010           MAST      69 HBC   - AY=0.244 +-.013   1/79
GT-   750K   -0.2186   0.0028          FORD      72 ASPK  - AY=0.2770+-.0035  1/79
GT- Q  81K  (-0.199)  (0.008)          LUCAS1    73 HBC   - AY=0.252+-.011   10/72
GT- F   NO RADIATIVE CORRECTIONS INCLUDED.
GT- L   EXPERIMENTS WITH LARGE ERRORS NOT INCLUDED IN AVERAGE.               3/78
GT- M   ALSO INCLUDES DBC EVENTS.
GT- Q  QUADRATIC DEPENDENCE IS REQUIRED BY KL EXPTS.  FOR COMPARISON WE      1/79
GT- Q  AVERAGE ONLY THOSE K+- EXPERIMENTS WHICH QUOTE QUADRATIC FIT VALUES.  1/79
GT-
GT- AVG      -0.2167   0.0066  AVERAGE (ERROR INCLUDES SCALE FACTOR OF 2.5)

HT-    QUADRATIC COEFF H FOR K- --> PI- PI- PI+                           1/79
HT-  50919   -0.001    0.012           MAST      69 HBC   -                1/79
HT-   750K    0.0125   0.0062          FORD      72 ASPK  -                1/79
HT-
HT- AVG       0.0097   0.0055  AVERAGE

KT-    QUADRATIC COEFF K FOR K- --> PI- PI- PI+                           1/79
KT-  50919   -0.014    0.012           MAST      69 HBC   -                1/79
KT-   750K   -0.0083   0.0019          FORD      72 ASPK  -                1/79
KT-
KT- AVG      -0.0084   0.0019  AVERAGE

DG  ((GT+)-(GT-))/((GT+)+(GT-)) IN PERCENT
DG     A NON-ZERO VALUE FOR THIS QUANTITY INDICATES CP VIOLATION
DG   3.2M   -0.70     0.53            FORD      70 ASPK                    11/70
```

```
GTP    LINEAR COEFFICIENT G FOR TAU PRIME DECAYS CHAR. K --> PI PIO PIO.
GTP    UNLESS OTHERWISE STATED, ALL EXPTS INCLUDE TERMS QUADRATIC IN
GTP    (S3-S0)/(MPI**2). SEE MINI-REVIEW ABOVE.
GTP K 1792   (0.48)   (0.04)           KALMUS    64 HLBC +                  1/79
GTP K 1874   (0.586)  (0.098)          BISI      65 HLBC +  ALSO HBC        1/79
GTP   4048    0.544    0.048           DAVISON   69 HLBC +  ALSO EMUL       1/79
GTP L  198   (0.527)  (0.102)          PANDOULAS 70 EMUL +                  1/79
GTP   1365    0.67     0.06            AUBERT    72 HLBC +                  1/79
GTP K  574   (0.484)  (0.084)          LUCAS2    73 HBC  -  DALITZ PRS ONLY 1/79
GTP   5635    0.630    0.038           SHEAFF    75 HLBC +                  1/79
GTP    27K    0.510    0.060           SMITH     75 WIRE +                  1/79
GTP L 4639   (0.806)  (0.220)          BERTRAND  76 EMUL +                  1/79
GTP   3263    0.670    0.054           BRAUN     76 HLBC +                  1/79
GTP K   AUTHORS GIVE LINEAR FIT ONLY.
GTP L   EXPERIMENTS WITH LARGE ERRORS NOT INCLUDED IN AVERAGE.
GTP
GTP AVG       0.607    0.030   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.3)
                               (SEE IDEOGRAM BELOW)
```




```
HTP    QUADRATIC COEFF H FOR CHAR K --> PI PIO PIO. SEE MINI-REVIEW ABOVE.
HTP   4048    0.026    0.050           DAVISON   69 HLBC +  ALSO EMUL       1/79
HTP L  198   (0.018)  (0.124)          PANDOULAS 70 EMUL +                  1/79
HTP   1365   -0.01     0.08            AUBERT    72 HLBC +                  1/79
HTP   5635    0.041    0.030           SHEAFF    75 HLBC +                  1/79
HTP    27K    0.009    0.040           SMITH     75 WIRE +                  1/79
HTP L 4639   (0.164)  (0.121)          BERTRAND  76 EMUL +                  1/79
HTP   3263    0.152    0.082           BRAUN     76 HLBC +                  1/79
HTP L   EXPERIMENTS WITH LARGE ERRORS NOT INCLUDED IN AVERAGE.               1/79
HTP
HTP AVG       0.034    0.020   AVERAGE
```

NOTE ON $K^{\pm}_{\ell 3}$ AND $K^{0}_{\ell 3}$ FORM FACTORS

Assuming that only the vector current contributes to $K \to \pi \ell \nu$ decays, we write the matrix element as

$$M \propto f_+(t)[(P_K + P_\pi)_\mu \bar{\ell}\gamma_\mu(1+\gamma_5)\nu]$$

$$+ f_-(t)[m_\ell \bar{\ell}(1+\gamma_5)\nu] , \qquad (1)$$

where P_K and P_π are the four-momenta of the K and π mesons, m_ℓ is the lepton mass, and f_+ and f_- are dimensionless form factors which can depend only on $t = (P_K - P_\pi)^2$, the square of the four-momentum transfer to the leptons. If time-reversal invariance holds, f_+ and f_- are relatively real. $K_{\mu 3}$ experiments measure f_+ and f_-, while K_{e3} experiments are sensitive only to f_+ because the small electron mass makes the f_- term negligible.

(a) $K_{\mu 3}$ experiments. Analyses of $K_{\mu 3}$ data frequently assume a linear dependence of f_+ and f_- on t, i.e.,

$$f_{\pm}(t) = f_{\pm}(0)[1 + \lambda_{\pm}(t/m_{\pi}^2)] . \quad (2)$$

Most $K_{\mu 3}$ data are adequately described by Eq. (2) for f_+ and a constant f_- (i.e., $\lambda_- = 0$). There are two equivalent parametrizations commonly used in these analyses:

(1) λ_+, $\xi(0)$ parametrization. Analyses of $K_{\mu 3}$ data often introduce the ratio of the two form factors

$$\xi(t) = f_-(t)/f_+(t) .$$

The $K_{\mu 3}$ decay distribution is then described by the two parameters λ_+ and $\xi(0)$ (assuming time reversal invariance and $\lambda_- = 0$). These parameters can be determined by three different methods:

Method A. By studying the Dalitz plot or the pion spectrum of $K_{\mu 3}$ decay. The Dalitz plot density is (see, e.g., Chounet et al.[4]):

$$\rho(E_{\pi}, E_{\mu}) \propto f_+^2(t)[A + B\xi(t) + C\xi(t)^2] ,$$

where

$$A = m_K(2E_{\mu}E_{\nu} - m_K E_{\pi}') + m_{\mu}^2(\tfrac{1}{4}E_{\pi}' - E_{\nu}) ,$$

$$B = m_{\mu}^2(E_{\nu} - \tfrac{1}{2}E_{\pi}') ,$$

$$C = \tfrac{1}{4}m_{\mu}^2 E_{\pi}' ,$$

$$E_{\pi}' = E_{\pi}^{max} - E_{\pi} = (m_K^2 + m_{\pi}^2 - m_{\mu}^2)/2m_K - E_{\pi} .$$

Here E_{π}, E_{μ}, and E_{ν} are, respectively, the pion, muon, and neutrino energies in the kaon center of mass. The density ρ is fit to the data to determine the values of λ_+, $\xi(0)$, and their correlation.

Method B. By measuring the $K_{\mu 3}/K_{e3}$ branching ratio and comparing it with the theoretical ratio (see, e.g., Fearing et al.[5]) as given in terms of λ_+ and $\xi(0)$, assuming μ-e universality:

$$\Gamma(K_{\mu 3}^{\pm})/\Gamma(K_{e3}^{\pm}) = 0.6457 + 1.4115\lambda_+ + 0.1264\xi(0) + 0.0192\xi(0)^2 + 0.0080\lambda_+\xi(0) ,$$

$$\Gamma(K_{\mu 3}^{0})/\Gamma(K_{e3}^{0}) = 0.6452 + 1.3162\lambda_+ + 0.1264\xi(0) + 0.0186\xi(0)^2 + 0.0064\lambda_+\xi(0) .$$

This cannot determine λ_+ and $\xi(0)$ simultaneously but simply fixes a relationship between them.

Method C. By measuring the muon polarization in $K_{\mu 3}$ decay. In the rest frame of the K, the μ is expected to be polarized in the direction **A** with $\mathbf{P} = \mathbf{A}/|\mathbf{A}|$, where **A** is given (Cabibbo and Maksymowicz[6]) by

$$\mathbf{A} = a_1(\xi)\mathbf{p}_{\mu} - a_2(\xi)\left[\frac{\mathbf{p}_{\mu}}{m_{\mu}}\left(m_K - E_{\pi} + \frac{\mathbf{p}_{\pi}\cdot\mathbf{p}_{\mu}}{|\mathbf{p}_{\mu}|^2}(E_{\mu} - m_{\mu})\right) + \mathbf{p}_{\pi}\right] + m_K \,\mathrm{Im}\xi(t)(\mathbf{p}_{\pi}\times\mathbf{p}_{\mu}) .$$

If time-reversal invariance holds, ξ is real, and thus there is no polarization perpendicular to the K-decay plane. Polarization experiments measure the weighted average of $\xi(t)$ over the t range of the experiment, where the weighting accounts for the variation with t of the sensitivity to $\xi(t)$.

(2) λ_+, λ_0 parametrization. Most of the more recent $K_{\mu 3}$ analyses have parametrized in terms of the form factors f_+ and f_0 which are associated with vector and scalar exchange, respectively, to the lepton pair. f_0 is related to f_+ and f_- by

$$f_0(t) = f_+(t) + [t/(m_K^2 - m_{\pi}^2)]f_-(t) .$$

Here $f_0(0)$ must equal $f_+(0)$ unless $f_-(t)$ diverges at t = 0. The earlier assumption that f_+ is linear in t and f_- is constant leads to f_0 linear in t:

$$f_0(t) = f_0(0)[1 + \lambda_0(t/m_{\pi}^2)] .$$

With the assumption that $f_0(0) = f_+(0)$, the two parametrizations, $(\lambda_+, \xi(0))$ and (λ_+, λ_0) are equivalent as long as correlation information is retained. (λ_+, λ_0) correlations tend to be less strong than $(\lambda_+, \xi(0))$ correlations.

The experimental results for $\xi(0)$ and its correlation with λ_+ are listed in the $K^{\pm}$ and K_L^0 sections of the Stable Particle Data Card Listings in section XIA, XIB, or XIC depending on whether method A, B, or C discussed above was used. The corresponding values of λ_+ are listed in subsection L+M.

Because recent experiments tend to use the (λ_+, λ_0) parametrization, we include a subsection L0 for λ_0 results. Wherever possible we have converted $\xi(0)$ results into λ_0 results and vice versa.

See the 1982 version of this note[4] for additional discussion of the $K^0_{\mu 3}$ parameters, correlations, and conversion between parametrizations, and also for a comparison of the experimental results.

(b) K_{e3} experiments. Analysis of K_{e3} data is simpler than that of $K_{\mu 3}$ because the second term of the matrix element assuming a pure vector current [Eq. (1) above] can be neglected. Here f_+ is usually assumed to be linear in t, and the linear coefficient λ_+ of Eq. (2) is determined.

If we remove the assumption of a pure vector current, then the matrix element for the decay, in addition to the terms in Eq. (2), would contain

$$+ 2m_K f_S \bar{\ell}(1 + \gamma_5)\nu$$

$$+ (2f_T/m_K)(P_K)_\lambda (P_\pi)_\mu \bar{\ell}\sigma_{\lambda\mu}(1 + \gamma_5)\nu ,$$

where f_S is the scalar form factor, and f_T is the tensor form factor. In the case of the K_{e3} decays where the f_- term can be neglected, experiments have yielded limits on $|f_S/f_+|$ and $|f_T/f_+|$.

The K_{e3} results for λ_+, $|f_S/f_+|$, and $|f_T/f_+|$ are listed in the subsections L+M, FS, and FT, respectively, of the $K^{\pm}$ and K^0_L sections of the Stable Particle Data Card Listings.

References

1. L.M. Chounet, J.M. Gaillard, and M.K. Gaillard, Phys. Rep. **4C**, 199 (1972).
2. H.W. Fearing, E. Fischbach, and J. Smith, Phys. Rev. **D2**, 542 (1970).
3. N. Cabibbo and A. Maksymowicz, Phys. Lett. **9**, 352 (1964).
4. Particle Data Group, Phys. Lett. **111B**, 73 (1982).

10 CHARGED K FORM FACTORS

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IN THE FORM FACTOR COMMENTS, THE FOLLOWING ABBREVIATIONS ARE USED.
F+ AND F- ARE FORM FACTORS FOR THE VECTOR MATRIX ELEMENT.
FS AND FT REFER TO THE SCALAR AND TENSOR TERM.
F0 = (F+) + (F-)*T/(MK**2-MPI**2)
L+, L- AND L0 ARE THE LINEAR EXPANSION COEFFS. OF F+, F- AND F0.
L+ REFERS TO THE KMU3 VALUE EXCEPT IN THE KE3 SECTIONS.
DXI/DL IS THE CORRELATION BETWEEN XI(0) AND L+ IN KMU3.
DL0/DL+ IS THE CORRELATION BETWEEN L0 AND L+ IN KMU3.
T  = MOMENTUM TRANSFER TO THE PI IN UNITS OF MPI**2.
DP = DALITZ PLOT ANALYSIS
PI = PI SPECTRUM ANALYSIS
MU = MU SPECTRUM ANALYSIS
POL= MU POLARIZATION ANALYSIS
BR = KMU3/KE3 BRANCHING RATIO ANALYSIS
E  = POSITRON OR ELECTRON SPECTRUM ANALYSIS
RC = RADIATIVE CORRECTIONS
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```
XIA     XIA = F-/F+ (DETERMINED FROM SPECTRA)   ---------------------------
XIA      76  (+1.8)     (0.6)               BROWN     62 XEBC +  DP+BR, L+=0        1/74
XIA      87  (+0.7)     (0.5)               GIACOMELL 64 EMUL +  MU+BR RVUE, L+=0   1/74
XIA J        (-0.08)    (0.7)               JENSEN    64 XEBC +  DP+BR(KMU3,KE3)    1/74
XIA    2648  (0.0)      (1.1)      (0.9)    CALLAHA1  66 FRBC +  MU, L+=0, T UNKN   1/74
XIA  C 444   +0.72      0.93                CALLAHA1  66 FRBC +  PI, DXI/DL=-17     1/74
XIA      78  (-0.5)     (0.9)               EISLER    68 HLBC +  PI,L+=0,NO DX/DL   1/74
XIA  K2041   -0.5       0.8                 KIJEWSKI  69 OSPK +  PI, DXI/DL=-26     1/74
XIA  H3240   -1.1       0.56                HAIDT     71 HLBC +  DP, DXI/DL=-29     1/74
XIA  A4025   -0.62      0.28                ANKENBRAN 72 ASPK +  PI, DXI/DL=-12     1/74
XIA  B3480   +0.45      0.28                CHIANG    72 OSPK +  DP, DXI/DL=-15     1/74
XIA  D1897   -0.36      0.40                BRAUN1    73 HLBC +  DP, DXI/DL=-19     3/74
XIA  N 490   -0.8       0.8                 ARNOLD    74 HLBC +  DP, DXI/DL=-20    11/75
XIA  M6527   -0.57      0.24                MERLAN    74 ASPK +  DP, DXI/DL= -9     3/74
XIA    3973  -0.27      0.25                WHITMAN   80 SPEC +  DP, DXI/DL=-17     4/82
XIA
XIA AVG      -0.32      0.15   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.3)
XIA FIT      -0.35      0.15  FROM FIT (ERROR INCLUDES SCALE FACTOR OF 2.3)   3/84*
                        (SEE IDEOGRAM BELOW)
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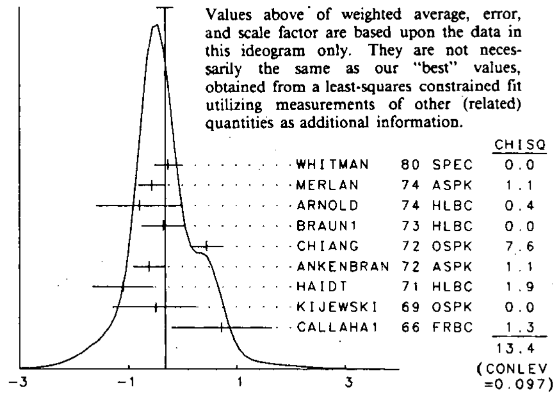
WEIGHTED AVERAGE = -0.32 ± 0.15
ERROR SCALED BY 1.3



XIA = F-/F+ FOR K+MU3 DECAY SPECTRA

```
XIA        FIT DISCUSSED IN NOTE ON KL3 FORM FACTORS IN 1982 EDITION.
XIA J      JENSEN 64 GIVES L+M=L+E=-.020+-.027. DXI/DL UNKNOWN. INCLUDES           1/74
XIA J      SHAKLEE 64 XIB(KMU3/KE3).                                                 1/74
XIA  C     CALLAHAN 66 TABLE 1 (PI ANAL) GIVES DXI/DL=(.72-.05)/(0-.04)=-17,        1/74
XIA  C     ERROR RAISED FROM .80 TO AGREE WITH DXI0=.37 FOR FIXED L+.                1/74
XIA  K     KIJEWSKI 69 FIG. 17 WAS USED TO OBTAIN DXI/DL AND ERRORS.                 1/74
XIA  H     HAIDT 71 TABLE 8 (DP ANAL) GIVES DXI/DL=(-1.1+0.5)/(.050-.029)=-29,      1/74
XIA  H     ERROR RAISED FROM .50 TO AGREE WITH DXI0=.20 FOR FIXED L+.                1/74
XIA  A     ANKENBRANDT 72 FIG. 3 WAS USED TO OBTAIN DXI/DL.                          1/74
XIA  B     CHIANG 72 FIG. 10 WAS USED TO OBTAIN DXI/DL.                              1/74
XIA  B     FIT HAD L-=L+ BUT WOULD NOT CHANGE FOR L-=0.  L.PONDROM,PRIV.COM.74       1/74
XIA  D     BRAUN1 73 GIVES XI(T)=-.34+-.20, DXI(T)/DL+=-14 FOR L+=.027, T=6.6.       3/74
XIA  D     WE CALCULATE ABOVE XI(0) AND DXI(0)/DL+ FOR THEIR L+=.025+-.017 .         3/74
XIA  N     ARNOLD 74 FIG. 4 WAS USED TO OBTAIN XIA AND DXI/DL.                      11/75
XIA  M     MERLAN 74 FIG.5 WAS USED TO OBTAIN DXI/DL.                                3/74

XIB     XIB = F-/F+ (DETERMINED FROM KMU3/KE3)   ---------------------------
XIB        THE KMU3/KE3 BRANCHING RATIO FIXES A RELATIONSHIP BETWEEN XI(0)          1/74
XIB        AND L+.  WE QUOTE THE AUTHORS XI(0) AND ASSOCIATED L+ BUT DO NOT         1/74
XIB        AVERAGE BECAUSE THE L+ VALUES DIFFER.  THE FIT RESULT AND SCALE          1/74
XIB        FACTOR GIVEN IN THE ABOVE NOTE ON KL3 FORM FACTORS ARE NOT OBTAINED      2/76
XIB        FROM THESE XIB VALUES.  INSTEAD THEY ARE OBTAINED DIRECTLY FROM THE      2/76
XIB        FITTED KMU3/KE3 RATIO (R29), WITH THE EXCEPTION OF HEINTZE 77.           4/82
XIB          (-0.17)    (0.75)    (0.99) SHAKLEE   64 XEBC +  BR, L+=0              1/74
XIB          (+0.6)     (0.5)            BISI 1    65 HBC  +  BR, L+=0              1/74
XIB     500  (+0.8)     (0.6)            CUTTS     65 OSPK +  BR, L+=0              1/74
XIB     636  (+0.4)     (0.4)            CALLAHA1  66 FRBC +  BR, L+=0              1/74
XIB     306  (+0.75)    (0.50)           AUERBACH  67 OSPK +  BR, L+=0              1/74
XIB B 5601   (-0.08)    (0.15)           BOTTERIL2 68 ASPK +  BR,L+=.023+-.008      1/74
XIB E 1398   (-0.60)    (0.20)           EICHTEN   68 HLBC +  BR, SEE NOTE E        1/74
XIB     986  (+1.0)     (0.6)            GARLAND   68 OSPK +  BR, L+=0              1/74
XIB          (+0.91)    (0.82)           ZELLER    69 ASPK +  BR, L+=.023           1/74
XIB  B       (-0.35)    (0.22)           BOTTERIL  70 OSPK +  BR,L+=.045+-.015      1/74
XIB  E1505   (-0.81)    (0.27)           HAIDT     71 HLBC +  BR,L+=.028,FIG.8      1/74
XIB   5825   (0.0)      (0.15)           CHIANG    72 OSPK +  BR,L+=.03,FIG.10      1/74
XIB  H 55K   -0.12      0.12             HEINTZE   77 CNTR +  BR,L+=.029            3/78
XIB
XIB FIT      -0.35      0.15   FROM FIT (ERROR INCLUDES SCALE FACTOR OF 2.3)   3/84*

XIB        FIT DISCUSSED IN NOTE ON KL3 FORM FACTORS IN 1982 EDITION.
XIB  B     BOTTERIL 70 IS REEVALUATION OF BOTTERIL 2 68 WITH DIFFERENT L+.          1/74
XIB E      EICHTEN 68 HAS L+=.023+-.008, T=4, INDEP. OF L-. REPL. BY HAIDT 71.      1/74
XIB  H     CALCULATED BY US FROM L0 AND L+ GIVEN BELOW.                             3/78

XIC     XIC = F-/F+ (DETERMINED FROM MU POLARIZATION IN KMU3)   ------------
XIC        THE MU POLARIZATION IS A MEASURE OF XI(T). NO ASSUMPTIONS ON L+-
XIC        NECESSARY, T (WEIGHTED BY SENSITIVITY TO XI) SHOULD BE SPECIFIED.
XIC        IN L+,XI(0) PARAMETERIZATION THIS IS XI(0) FOR L+=0.  DXI/DL=XI*T.
XIC        FOR RAD. CORR. TO MUON POLARIZATION IN KMU3 SEE GINSBERG 71.
XIC T 2100  (+1.2)     (2.4)     (1.8)  BORREANI  65 HLBC +  POLARIZATION        8/67
XIC T  500 BTWN -4.0 AND +1.7           CUTTS     65 OSPK +  LONG. POL.          1/74
XIC T  397  (-1.4)     (1.8)            CALLAHA1  66 FRBC +  TOTAL POL.          8/67
XIC T 2950  (-0.7)     (0.9)     (3.3)  CALLAHA1  66 FRBC +  LONG. POL.          8/67
XIC  B6000   -1.0       0.3             BETTELS   68 HLBC +  TOTAL POL. T=4.9    1/74
XIC  C3133   -0.95      0.3             CUTTS     69 OSPK +  TOTAL POL. T=4.0    1/74
XIC M  40K  (-0.64)    (0.27)           MERLAN    74 ASPK +  POL,DXI/DL=+1.7     3/74
XIC  D1585   -0.25      1.20            BRAUN     75 HLBC +  POL. T=4.2          1/76
XIC
XIC AVG      -0.95      0.21   AVERAGE
XIC FIT      -0.35      0.15   FROM FIT (ERROR INCLUDES SCALE FACTOR OF 2.3)   3/84*

XIC        FIT DISCUSSED IN NOTE ON KL3 FORM FACTORS IN 1982 EDITION.
XIC T      T VALUE NOT GIVEN.
XIC  B     BETTELS 68 DXI/DL=XI*T=-1.0*4.9=-4.9 .
XIC  C     CUTTS 69 T=4.0 WAS CALCULATED FROM FIG.8. DXI/DL=XI*T=-.95*4=-3.8 .       1/74
XIC M      MERLAN 74 POLARIZATION RESULT (FIG.5) NOT POSSIBLE.  SEE DISCUSSION       1/76
XIC M      OF POLARIZATION EXPERIMENTS IN NOTE ON KL3 FORM FACTORS ABOVE.            1/76
XIC  D     BRAUN 75 DXI/DL=XI*T=-.25*4.2=-1.0 .                                      1/76
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Stable Particles
$K^{\pm}$

Data Card Listings

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IXI        IMAGINARY PART OF XI (TEST OF T REVERSAL)  -------------------
IXI   2648    0.0      1.0              CALLAHA1  66 FRBC +  MU                  1/74
IXI    397   +1.6      1.3              CALLAHA1  66 FRBC +  TOTAL POL.          1/74
IXI   2950    0.5      1.4       0.5    CALLAHA1  66 FRBC +  LONG. POL.          1/74
IXI   6000   -0.1      0.3              BETTELS   68 HLBC +  TOTAL POL.          1/74
IXI   3133   -0.3      0.3       0.4    CUTTS     69 OSPK +  TOTAL POL. FIG.7    1/74
IXI    20M   -0.016    0.025            CAMPBELL  81 CNTR +  POL.                1/82
IXI B  32M  (-0.010)  (0.019)           BLATT     83 CNTR    POLARIZATION        2/84*
IXI B   COMBINED RESULT OF MORSE 80 (K0MU3) AND CAMPBELL 81 (K+MU3).             2/84*
IXI          . . . . . . . . . .
IXI AVG      -0.017    0.025   AVERAGE

L+M      LAMBDA +  (LINEAR ENERGY DEPENDENCE OF F+ IN KMU3 DECAY)  ---------
L+M       SEE ALSO THE CORRESPONDING ENTRIES AND FOOTNOTES IN SECTIONS XIA,
L+M       XIC, AND L0.
L+M       FOR RAD.COR. OF KMU3 DP SEE GINSBURG 70 AND BECHERRAWY 70.             3/74
L+M    444    0.0      0.05             CALLAHA1  66 FRBC +  PI                  1/74
L+M   2041    0.009    0.026            KIJEWSKI  69 OSPK +  PI                  1/74
L+M   3240    0.050    0.018            HAIDT     71 HLBC +  DP                  1/74
L+M  A4025    0.024    0.019            ANKENBRAN 72 ASPK +  PI                  1/74
L+M   3480   -0.006    0.015            CHIANG    72 OSPK +  DP                  1/74
L+M   1897    0.025    0.017            BRAUN1    73 HLBC +  DP                  3/74
L+M    490    0.025    0.030            ARNOLD    74 HLBC +  DP                  7/74
L+M   6527    0.027    0.019            MERLAN    74 ASPK +  DP                  3/74
L+M   3973   +0.050    0.013            WHITMAN   80 SPEC +  DP                 10/81
L+M          . . . . . . . . . .
L+M AVG       0.0272   0.0072  AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.1)
L+M FIT       0.032    0.008  FROM FIT (ERROR INCLUDES SCALE FACTOR OF 2.3)  3/84*

L+M       FIT DISCUSSED IN NOTE ON KL3 FORM FACTORS IN 1982 EDITION.
L+M   A   ANKENBRANDT 72 L+ FROM FIG.3 TO MATCH DXI/DL. TEXT GIVES .024+-.022  1/74

L0       LAMBDA 0 (LINEAR ENERGY DEPENDENCE OF F0 IN KMU3 DECAY)  ----------
L0        WHEREVER POSSIBLE, WE HAVE CONVERTED THE ABOVE VALUES OF XI(0) INTO
L0        VALUES OF L0 USING THE ASSOCIATED L+M AND DXI/DL.
L0 W   444   +0.058    0.036            CALLAHA1  66 FRBC +  PI,DL0/DL+=-0.37   1/74
L0 L  6000   -0.063   (0.024)           BETTELS   68 HLBC +  POL,DL0/DL+=+.60   1/74
L0 L  3133   -0.056   (0.024)           CUTTS     69 OSPK +  POL,DL0/DL+=+.69   1/74
L0 W  2041   -0.031    0.045            KIJEWSKI  69 OSPK +  PI,DL0/DL+=-1.10   1/74
L0 W  3240   -0.039    0.029            HAIDT     71 HLBC +  DP,DL0/DL+=-1.34   1/74
L0 W  4025   -0.026    0.013            ANKENBRAN 72 ASPK +  PI,DL0/DL+=+0.03   1/74
L0 W  3480   +0.030    0.014            CHIANG    72 OSPK +  DP,DL0/DL+=-0.21   1/74
L0    D1897  -0.008    0.020            BRAUN1    73 HLBC +  DP,DL0/DL+=-0.53   1/76
L0     490   -0.040    0.040            ARNOLD    74 HLBC +  DP,DL0/DL+=-0.62   7/74
L0   B       (-0.017)  (0.011)          BRAUN     74 HLBC +  KMU3/KE3 VS. T    11/75
L0 M  6527   -0.019    0.015            MERLAN    74 ASPK +  DP,DL0/DL+=+0.27   3/74
L0 L  1585   +0.008    0.097            BRAUN     75 HLBC +  POL,DL0/DL+=+.92   1/76
L0    H 55K  +0.019   (0.010)           HEINTZE   77 SPEC +  BR,DL0/DL+=+0.03 12/77
L0    3973   +0.029    0.011            WHITMAN   80 SPEC +  DP,DL0/DL+=-0.37 10/81
L0           . . . . . . . . . .
L0  AVG       0.0032   0.0099  AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.7)
L0  FIT      +0.004    0.007  FROM FIT (ERROR INCLUDES SCALE FACTOR OF 2.3)  3/84*
                       (SEE IDEOGRAM BELOW)
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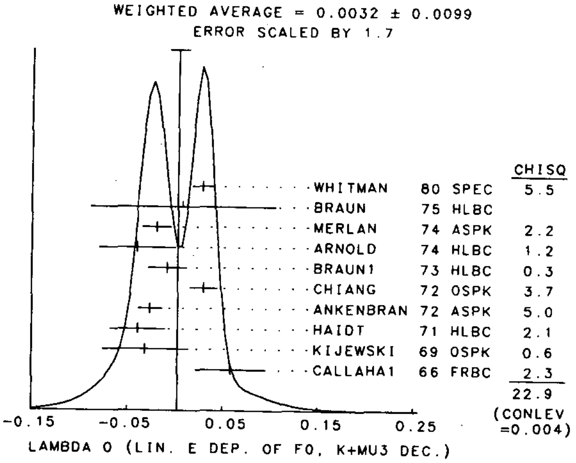


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L0        FIT DISCUSSED IN NOTE ON KL3 FORM FACTORS IN 1982 EDITION.
L0 W      L0 CALCULATED BY US FROM XI0, L+M, AND DXI/DL.                         1/74
L0 L      L0 VALUE IS FOR L+=0.03  CALCULATED BY US FROM XI0 AND DXI/DL.         1/74
L0    D   THIS VALUE AND ERROR ARE TAKEN FROM BRAUN 75 BUT CORRESPOND TO THE     1/76
L0    D   BRAUN1 73 L+M RESULT.  DL0/DL+ IS FROM BRAUN1 73 DXI/DL IN XIA ABV.    1/76
L0   B    BRAUN 74 IS A COMBINED KMU3-KE3 RESULT.  IT IS NOT INDEPENDENT OF     11/75
L0   B    BRAUN1 73 (KMU3) AND BRAUN2 73 (KE3) FORM FACTOR RESULTS.             11/75
L0 M      MERLAN 74 L0 AND DL0/DL+ WERE CALCULATED BY US FROM XIA, L+M, AND      3/74
L0 M      DXI/DL.  THEIR FIG.6 GIVES L0=-0.025+-0.012 AND NO DL0/DL+.            3/74
L0    H   HEINTZE 77 USES L+=0.029+-0.003.  DL0/DL+ ESTIMATED BY US.            12/77

L+E      LAMBDA +  (LINEAR ENERGY DEPENDENCE OF F+ IN KE3 DECAY)  ---------
L+E       FOR RAD.COR. OF KE3 DP SEE GINSBURG 67 AND BECHERRAWY 70.              3/74
L+E    217   +0.036    0.045            BROWN     62 XEBC +  PI, NO RC
L+E    407   -0.010    0.029            JENSEN    64 XEBC +  PI, NO RC           8/67
L+E    230   -0.04     0.05             BORREANI  64 HBC  +  E+, NO RC           8/67
L+E    854    0.045    0.017     0.018  BELLOTT2  67 FBC  +  DP, USES RC        11/67
L+E   1393   +0.016    0.016            IMLAY     67 OSPK +  DP, NO RC           8/67
L+E    515   +0.028    0.013     0.014  KALMUS    67 FBC  +  E+, PI, NO RC       8/67
L+E    960    0.08     0.04             BOTTERIL1 68 ASPK +  E+, USES RC         6/68
L+E     90   -0.02     0.08      0.12   EISLER    68 HLBC +  PI, USES RC         6/68
L+E   1458    0.045    0.015            BOTTERIL  70 OSPK    PI, USES RC        10/69
L+E   2707    0.027    0.010            STEINER   71 HLBC +  DP, USES RC        11/71
L+E   4017    0.029    0.011            CHIANG    72 OSPK +  DP, RC NEGLIGBLE    9/72
L+E  A        0.027    0.008            BRAUN2    73 HLBC +  DP, NO RC           3/74
L+E B        (0.025)  (0.007)           BRAUN     74 HLBC +  KMU3/KE3 VS. T     11/75
L+E  A    BRAUN2 73 STATES THAT RC OF GINSBERG 67 WOULD LOWER L+E BY .002 BUT    3/74
L+E  A    THAT RC OF BECHERRAWY DISAGREES AND WOULD RAISE L+E BY .005 .          1/76
L+E B     BRAUN 74 IS A COMBINED KMU3-KE3 RESULT.  IT IS NOT INDEPENDENT OF     11/75
L+E B     BRAUN1 73 (KMU3) AND BRAUN2 73 (KE3) FORM FACTOR RESULTS.             11/75
L+E          . . . . . . . . . .
L+E AVG       0.0285   0.0043  AVERAGE

FS      FS/F+  RATIO OF SCALAR TO F+ COUPLINGS FOR KE3 DECAY(ABS. VALUE)----
FS             (0.18) OR LESS  CL=.90   BELLOTT2  67 HLBC                       10/69
FS             (0.30) OR LESS  CL=.95   KALMUS    67 HLBC +                     10/69
FS             (0.23) OR LESS  CL=.90   BOTTERIL1 68 ASPK                        8/66
FS     2707     0.14      0.03     0.04 STEINER   71 HLBC +  L+,FS,FT,PHI FIT    2/72
FS     4017    (0.13) OR LESS  CL=.90   CHIANG    72 OSPK +                      9/72
FS     2827     0.00      0.10          BRAUN     75 HLBC +                     12/75
FS           . . . . . . . . . .
FS   AVG        0.125     0.044   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.3)

FT      FT/F+  RATIO OF TENSOR TO F+ COUPLINGS FOR KE3 DECAY(ABS. VALUE)----
FT             (0.58) OR LESS  CL=.90   BELLOTT2  67 HLBC                       10/69
FT             (1.1)  OR LESS  CL=.95   KALMUS    67 HLBC +                     10/69
FT             (0.58) OR LESS  CL=.90   BOTTERIL1 68 ASPK                        8/66
FT     2707     0.24      0.16     0.14 STEINER   71 HLBC +  L+,FS,FT,PHI FIT    2/72
FT     4017    (0.75) OR LESS  CL=.90   CHIANG    72 OSPK +                      9/72
FT     2827     0.07      0.37          BRAUN     75 HLBC +                     12/75
FT           . . . . . . . . . .
FT   AVG        0.22      0.14    AVERAGE

FTM     FT/F+  RATIO OF TENSOR TO F+ COUPLINGS FOR KMU3 DECAY  -----------
FTM    1585     0.02      0.12          BRAUN     75 HLBC                        1/76

KE4     KE4 DECAY FORM FACTORS ARE GIVEN IN THE FOLLOWING PAPERS
KE4                                     BASILE    71 ASPK +                     11/75
KE4                                     BEIER     73 OSPK +-                    11/75
KE4                                     ROSSELET  77 SPEC +                      2/80

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REFERENCES FOR CHARGED K


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BIRGE    56 NC    4   834       BIRGE,PERKINS,PETERSON,STORK,WHITEHEA (LRL)
ILOFF    56 PR 102   927        ILOFF,GOLDHABER,LANNUTTI,GILBERT +     (LRL)
ALEXANDE 57 NC    6   478       ALEXANDER,JOHNSTON,OCEALLAIGH (DUBLIN INST)
COHEN    57 FUND.CONS.PHYS.     +CROWE,DUMOND       (ATOMICS INTER.+LRL+CIT)
EISENBER 58 NC    8  663        EISENBERG,KOCH,LOHRMANN,NIKOLIC +     (BERN)
BURROWES 59 PRL   2  117        BURROWES,CALDWELL,FRISCH,HILL +        (MIT)
TAYLOR   59 PR 114   359        S TAYLOR,HARRIS,OREAR,LEE,BAUMEL (COLUMBIA)

FREDEN   60 PR 118  564         S C FREDEN,F C GILBERT,R S WHITE       (LRL)
BARKAS   61 PR 124 1209         BARKAS,DYER,MASON,NORRIS,NICKOLS,SMIT (LRL)
BHOWMIK  61 NC   20  857        B BHOWMIK,P C JAIN,P C MATHUR  (DELHI UNIV)
FERRO-LU 61 NC    22  1087      FERRO-LUZZI,MILLER,MURRAY,ROSENFELD+  (LRL)
NORDIN   61 PR 123 2166         PAUL NORDIN JR                         (LRL)
ROE      61 PRL  7  346         ROE,SINCLAIR,BROWN,GLASER +       (MICH+LRL)
BOYARSKI 62 PR 128 2398         BOYARSKI,LOH,NIEMELA,RITSON            (MIT)
BROWN    62 PRL  8  450         BROWN,KADYK,TRILLING,ROE+         (LRL,MICH)
BARKAS   63 PRL 11   26         W H BARKAS,J N DYER,H H HECKMAN        (LRL)

BORREANI 64 PL    12 123        G BORREANI,G RINAUDO,A WERBROUCK     (TURIN)
CALLAHAN 64 PR   136 B 1463     A CALLAHAN,R MARCH,R STARK       (WISCONSIN)
CAMERINI 64 PRL  13 318         CAMERINI,CLINE,FRY,POWELL   (WISCONSIN+LRL)
CLINE    64 PRL  13 101         D CLINE, W F FRY                 (WISCONSIN)
GIACOMEL 64 NC 34  1134         GIACOMELLI,MONTI,QUARENI+  (BOLOGNA,MUNICH)
GREINER  64 PRL  13 284         D GREINER, W OSBORNE, W BARKAS         (LRL)
JENSEN   64 PR   136 B1431      JENSEN,SHAKLEE,ROE,SINCLAIR           (MICH)
KALMUS   64 PRL    13   99      +KERNAN,PU,POWELL,DOWD            (LRL,WISC)
SHAKLEE  64 PR   136 B 1423     SHAKLEE,JENSEN,ROE,SINCLAIR           (MICH)

BIRGE    65 PR 139 B 1600       BIRGE,ELY,GIDAL,CAMERINI,CLINE + (LRL+WISC)
BISI     65 NC    35  768       BISI,BORREANI,CESTER,FERRARO +      (TORINO)
BISI 1   65 PR 139 B 1068       BORREANI,MARZARI-CHIESA,RINAUDO+    (TORINO)
BORREANI 65 PR 140 B1686        BORREANI,GIDAL,RINAUDO,CAFORIO+ (BARI,TORI)
CALLAHAN 65 PRL  15  129        A CALLAHAN,D CLINE               (WISCONSIN)
CAMERINI 65 NC 37 1795          +CLINE,GIDAL,KALMUS,KERNAN        (WISC+LRL)
CLINE    65 PL    15  293       A CLINE,W F FRY                  (WISCONSIN)
CUTTS    65 PR 138 B969         CUTTS,ELIOFF,STIENING                  (LRL)

DE MARCO 65 PR 140 B 1430       DE MARCO,GROSSO,RINAUDO        (TORINO+CERN)
FITCH    65 PR 140 B 1088       FITCH,QUARLES,WILKINS(PRINCETON+MT HOLYOKE)
GREINER  65 ARNS  15  67        QUOTED BY BARKAS                       (LRL)
STAMER   65 PR   138 B 440      STAMER,HUETTER,KOLLER,TAYLOR,GRAUMAN (STEV)
TRILLING 65 UCRL 16473          GEORGE H TRILLING                      (LRL)
    UPDATED FROM 1965 ARGONNE CONF., PAGE 5.
YOUNG    65 UCRL 16362          POH-SHIEN YOUNG (THESIS,BERKELEY)      (LRL)
    ALSO 67 PR 156 1464         P-S YOUNG,W.Z.OSBORNE,W.H.BARKAS       (LRL)

CALLAHA1 66 PR 150 1153         CALLAHAN,CAMERINI+(WISC,LRL,RIVERSIDE,BARI)
CALLAHAN 66 NC  44A 90          A C CALLAHAN                     (WISCONSIN)
CESTER   66 PL 21 343           CESTER,ESCHSTRUTH,ONEILL+  (PRINCETON-PENN)
    ALSO 67 AUERBACH, FOOTNOTE 1.

AUERBACH 67 PR 155  1505        +DOBBS,MANN,MCFARLANE,WHITE+     (PENN,PRIN)
    ALSO 74 PR D9 3216          ERRATUM
BELLOTT1 67 HEIDELBERG CONF     BELLOTTI,PULLIA                      (MILAN)
BELLOTT2 67 NC 52A  1287        BELLOTTI,FIORINI,PULLIA              (MILAN)
    ALSO 66 PL  20  690         BELLOTTI,FIORINI,PULLIA+             (MILAN)
BISI     67 PL 25B  572         BISI,CESTER,CHIESA,VIGONE           (TORINO)

BOTTERIL 67 PRL  19  982        BOTTERILL,BROWN,CORBETT,CULLIGAN + (OXFORD)
    ALSO 68 BOTTERIL
BOWEN    67 PR 154 1314         BOWEN,MANN,MCFARLANE,HUGHES+(PENN-PRINCETO)
CLINE1   67 HEIDELBERG CONF     CLINE,HAGGERTY,SINGLETON,FRY+   (WISCONSIN)
CLINE2   67 HERCEG NOVI TBL.4 D.CLINE,PROC.INTL.SCH.ON ELEM.PART.PHYSICS

FLETCHER 67 PRL  19  98         FLETCHER,BEIER,EDWRADS,+         (ILLINOIS)
FORD     67 PRL 18 1214         +LEMONICK,NAUENBERG,PIROUE      (PRINCETON)
IMLAY    67 PR 160  1203        IMLAY,ESCHSTRUTH,FRANKLIN+      (PRINCETON)
KALMUS   67 PR  159  1187       KALMUS,KERNAN                          (LRL)
ZINCHENK 67 RUTGERS(THESIS)     ZINCHENKO                          (RUTGERS)

BETTELS  68 NC 56A 1106         AACHEN-BARI-BERGEN-CERN-EP-NIJMEGEN-ORSAY+
    ALSO 71 HAIDT
BOTTERIL 68 PR 171 1402         BOTTERILL,BROWN,CLEGG,CORBETT +    (OXFORD)
BOTTERI1 68 PR 174 1661         BOTTERILL,BROWN,CLEGG,CORBETT +    (OXFORD)
BOTTERI2 68 PRL 21 766          BOTTERILL,BROWN,CLEGG,CORBETT +    (OXFORD)
BUTLER   68 UCRL-18420          +BLAND,GOLDHABER,GOLDHABER,HIRATA+    (LRL)
CHANG    68 PRL 20  510         CHANG,YODH;EHRLICH,PLANO+(MARYLAND,RUTGERS)

CHEN     68 PRL 20 73           CHEN,CUTTS,KIJEWSKI,STIENING +    (LRL,MIT)
EICHTEN  68 PL 27B 586          AACHEN-BARI-CERN-EP-ORSAY-PADOVA-VALENCIA
EISLER   68 PR   169  1090      EISLER,FUNG,MARATECK,MEYER,PLANO  (RUTGERS)
ESCHSTRU 68 PR   165  1487      ESCHSTRUTH,FRANKLIN,HUGHES+(PRINCETON,PENN)
GARLAND  68 PR   167  1225      +TSIPIS,DEVONS,ROSEN+  (COLUMBIA,RUTG,WISC)
MOSCOSO  68  THESIS             M L MOSCOSO              (UNIV PARIS ORSAY)

CUTTS    69 PR 184 1380         +STIENING,WIEGAND,DEUTSCH         (LRL,MIT)
    ALSO 68 PRL 20 955          CUTTS,STIENING,WIEGAND,DEUTSCH    (LRL,MIT)
DAVISON  69 PR   180 1333       +BACASTOW,BARKAS,EVANS,FUNG,PORTER+   (UCR)
ELY      69 PR   180 1319       ELY,GIDAL,HAGOPIAN,KALMUS+  (LOUC+WISC+LRL)
EMMERSON 69 PRL 23 393          EMMERSON,QUIRK                      (OXFORD)

HERZO    69 PR 186 1403         +BANNER,BEIER,BERTRAM,EDWARDS +        (ILL)
KIJEWSKI 69 UCRL-18433 THESIS P K KIJEWSKI                             (LBL)
LOBKOWIC 69 PR 185 1676         +MELISSINOS,NAGASHIMA,TEWKSBURY+ (ROCH,BNL)
    ALSO 66 PRL 17 548          LOBKOWICZ,MELISSINOS,NAGASHIM+    (ROCH+BNL)
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For notation, see key at front of Listings.

Stable Particles

$K^{\pm}$, K^0, K^0_S

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MACEK    69 PRL  22   32        MACEK,MANN,MC FARLANE,ROBERTS+(PENN,TEMPLE)
MAST     69 PR   183 1200        +GERSHWIN,ALSTON-GARNJOST,BANGERTER+  (LRL)
ZELLER   69 PR   182 1420        ZELLER,HADDOCK,HELLAND,PAHL+      (UCLA,LRL)

BOTTERIL 70 PL 31B 325           +BROWN,CLEGG,CORBETT,CULLIGAN+        (OXF)
FORD     70 PRL 25 1370          +PIROUE,REMMEL,SMITH,SOUDER          (PRIN)
GRAUMAN  70 PR D1 1277           +KOLLER,TAYLOR,PANDOULAS+  (STEV,SETO,LEHI)
    ALSO 69 PRL 23 737           +KOLLER,TAYLOR,PANDOULAS+  (STEV,SETO,LEHI)
MACEK    70 PR D1 1249           +MANN,MCFARLANE,ROBERTS              (PENN)
MALTSEV  70 SJNP 10 678          +PESTOVA,SOLODOVNIKOVA,FADEEV +      (JINR)
PANDOULA 70 PR D2 1205           +TAYLOR,KOLLER,GRAUMAN +        (STEV,SETO)

BASILE   71 PL 36B 619           +BREHIN,DIAMANT-BERGER,KUNZ+    (SACL+GEVA)
BOURQUIN 71 PL 36B 615           +BOYMOND,EXTERMANN,MARASCO+     (GEVA,SACL)
HAIDT    71 PR D3 10             AACHEN+BARI+CERN+EP+NIJMEGEN+ORSAY+PADOVA+
    ALSO 69 PL  29B 691          +(AACH,BARI,CERN,EPOL,NIJM,ORSAY,PADO,TORI)
KLEMS    71 PR D4 66             +HILDEBRAND,STIENING            (CHIC,LRL)
    ALSO 70 PRL 24 1086          KLEMS,HILDEBRAND,STIENING       (LRL,CHIC)
    ALSO 70 PRL 25 473           KLEMS,HILDEBRAND,STIENING       (LRL,CHIC)

KUNSELMA 71 PL 34B 485           R. KUNSELMAN                    (WYOMING)
OTT      71 PR D3 52             OTT,PRITCHARD                       (LOQM)
ROMANO   71 PL 36B 525           +RENTON,AUBERT,BURBAN-LUTZ (BARI,CERN,ORSA)
SCHWEINB 71 PL 36B 246           AACHEN+BELGIUM+CERN+NIJMEGEN+PADOVA COLLAB
STEINER  71 PL 36B 521           AACHEN+BARI+CERN+EPOL+ORSA+NIJM+PADO+TORIN

ABRAMS   72 PRL 29 1118          +CARROLL,KYCIA,LI,MENES,MICHAEL +     (BNL)
ANKENBRA 72 PRL 28 1472          ANKENBRANDT,LARSEN+     (BNL+LASL+FNAL+YALE)
AUBERT   72 NC 12A 509           +HEUSSE,PASCAUD,VIALLE+    (ORSA+BRUX+EPOL)
BEIER    72 PRL 29 678           +BUCHHOLZ,MANN,PARKER      (PENNSYLVANIA)
CHIANG   72 PR D6 1254           +ROSEN,SHAPIRO,MANDLER,OLSEN+   (ROCH+WISC)

CLARK    72 PRL 29 1274          +CORK,ELIOFF,KERTH,MCREYNOLDS,NEWTON+ (LBL)
EDWARDS  72 PR D5 2720           +BEIER,BERTRAM,HERZO,KOESTER +        (ILL)
FORD     72 PL 38B 335           +PIROUE,REMMEL,SMITH,SOUDER     (PRINCETON)
HOFFMAST 72 NP B36 1             HOFFMASTER,KOLLER,TAYLOR+  (STEV+SETO+LEHI)

ABRAMS   73 PRL 30 500           +CARROLL,KYCIA,LI,MENES,MICHAEL +     (BNL)
BACKENST 73 PL 43B 431           BACKENSTOSS,BAMBERGER+(CERN+KARL+HEID+STOH)
BEIER    73 PRL 30 399           +BUCHHOLZ,MANN,PARKER,ROBERTS         (PENN)
BRAUN1   73 PL 47B 182           AACHEN+BARI+BRUSSELS+CERN COLLABORATION
    ALSO 75 BRAUN
BRAUN2   73 PL 47B 185           AACHEN+BARI+BRUSSELS+CERN COLLABORATION
    ALSO 75 BRAUN
CABLE    73 PR D8 3807           +HILDEBRAND,PANG,STIENING         (EFI+LBL)

LJUNG    73 PR D8 1307           D.LJUNG,D.CLINE                     (WISC)
    ALSO 72 PRL 28 523           D.LJUNG                             (WISC)
    ALSO 72 PRL 28 1287          D.CLINE,D.LJUNG                     (WISC)
    ALSO 69 PRL 23 326           CAMERINI,LJUNG,SHEAFF,CLINE         (WISC)
LUCAS1   73 PR D8 719            LUCAS,TAFT,WILLIS                   (YALE)
LUCAS2   73 PR D8 727            LUCAS,TAFT,WILLIS                   (YALE)
PANG     73 PR D8 1989           +HILDEBRAND,CABLE,STIENING   (EFI+ARIZ+LBL)
    ALSO 72 PL 40B 699           CABLE,HILDEBRAND,PANG,STIENING   (EFI+LBL)
SMITH    73 NP B60 411           +BOOTH,RENSHALL,JONES+ (GLAS+LIVP+OXF+RHEL)

ARNOLD   74 PR D9 1221           C L ARNOLD,B P ROE,D SINCLAIR       (MICH)
BRAUN    74 PL 51B 393           +CORNELSSEN,MARTYN +  (AACH+BARI+BRUX+CERN)
CENCE    74 PR D10 776           +HARRIS,JONES,MORGADO +     (HAWA+LBL+WISC)
    ALSO 73 THESIS (UNPUBL.)     D B CLARKE                          (WISC)
KUNSELMA 74 PR C9 2469           R.KUNSELMAN                         (WYOM)
MERLAN   74 PR D9 107            +KASHA,WANDERER,ADAIR+     (YALE+BNL+LASL)
WEISSENB 74 PL 48B 474           WEISSENBERG,EGOROV,MINERVINA +  (ITEP+LEBD)

BLOCH    75 PL 56B 201           +BREHIN,BUNCE,DEVAUX+           (SACL+GEVA)
BRAUN    75 NP B89 210           +CORNELSSEN,MARTYN+   (AACH+BARI+BRUX+CERN)
CHENG    75 NP A254 381          +ASANO,CHEN,DUGAN,HU,WU,HUGHES+ (COLU+YALE)
HEARD1   75 PL 55B 324           +HEINTZE,HEINZELMANN+           (CERN+HEID)
HEARD2   75 PL 55B 327           +HEINTZE,HEINZELMANN+           (CERN+HEID)
SHEAFF   75 PR D12 2570          M. SHEAFF                           (WISC)
SMITH    75 NP B91 45            +BOOTH,RENSHALL,JONES+ (GLAS+LIVP+OXF+RHEL)

BERTRAND 76 NP B114 387          +SACTON +        (BRUX+UBEL+DUUC+LOUC+WARS)
BLOCH    76 PL 60B 393           +BUNCE,DEVAUX,DIAMANT-BERGER+   (GEVA+SACL)
BRAUN    76 LNC 17 521           +MARTYN,ERRIQUEZ +      (AACH+BARI+BELG+CERN)
DIAMANTB 76 PL 62B 485           DIAMANT-BERGER,BLOCH,DEVAUX +   (SACL+GEVA)
HEINTZE  76 PL 60B 302           +HEINZELMANN,IGO-KEMENES,MUNDHENKE+  (HEID)
SMITH    76 NP B109 173          +BOOTH,RENSHALL,JONES+ (GLAS+LIVP+OXF+RHEL)
WEISSENB 76 NP B115 55           WEISSENBERG,EGOROV,MINERVINA+   (ITEP+LEBD)

ABRAMS   77 PR D15 22            +CARROLL,KYCIA,LI,MICHAEL,MOCKETT +   (BNL)
DEVAUX   77 NP B126 11           +BLOCH,DIAMANT-BERGER,MAILLARD+ (SACL+GEVA)
HEINTZE  77 PL 70B 482           +HEINZELMANN,IGO-KEMENES,+      (HEID+CERN)
ROSSELET 77 PR D15 574           +EXTERMANN,FISCHER,GUISAN +     (GEVA+SACL)
BARKOV   79 NP B148 53           +VASSERMAN,ZOLOTOREV,KRUPIN+    (NOVO+KIAE)
HEINTZE  79 NP B149 365          +HEINZELMANN,IGO-KEMENES+       (HEID+CERN)

WHITMAN  80 PR D21 652           +ABRAMS,CARROLL,KYCIA,LI+    (ILLC+BNL+ILL)
ASANO    81 PL 107B 159          +KIKUTANI,KUROKAWA,MIYACHI+ (KEK+TOKY+OSAK)
CAMPBELL 81 PRL 47 1032          +BLACK,BLATT,KASHA,SCHMIDT +     (YALE+BNL)
    ALSO 83 BLATT
LUM      81 PR D23 2522          +WIEGAND,KESSLER,DESLATTES,SEKI+ (LBL+NBS+)
LYONS    81 ZPHY C10 215         +ALBAJAR,MYATT                      (OXF)
ASANO    82 PL 113B 195          +KIKUTANI,KUROKAWA,MIYACHI+ (KEK+TOKY+OSAK)
COOPER   82 PL 112B 97           +GUY,MICHETTE,TYNDEL,VENUS           (RL)
BLATT    83 PR D27 1056          +ADAIR,BLACK,CAMPBELL,KASHA+     (YALE+BNL)

         QUANTUM NUMBER DETERMINATIONS NOT REFERRED TO IN THE DATA CARDS

BLOCK    62 CERN CONF 371        BLOCK,LENDINARA,MONARI       (NWES+BOLOGNA)

                                 PAPERS NOT REFERRED TO IN DATA CARDS

BRENE    61 NP 22 553            BRENE,EGARDT,QVIST                  (NORD)
BIRGE    63 PRL  11  35          BIRGE,ELY,GIDAL,CAMERINI +  (LRL+WISC+BARI)
ADAIR    64 PL 12  67            ADAIR,LEIPUNER                  (YALE,BNL)
CABIBBO  64 PL  9 352            CABIBBO,MAKSYMOWICZ                 (CERN)
    ALSO 64 PL 11 360            CABIBBO,MAKSYMOWICZ                 (CERN)
    ALSO 65 PL 14  72            CABIBBO,MAKSYMOWICZ                 (CERN)

CABIBBO  66 BERKELEY CONF 33     CABIBBO                             (CERN)
GINSBERG 67 PR 162  1570         EDWARD S GINSBERG          (U. MASS BOSTON)
WILLIS   67 HEIDELBERG 273       W J WILLIS -RAPPORTEUR TALK         (YALE)
CRONIN   68 VIENNA CONF 241      RAPPORTEUR TALK                (PRINCETON)
HAIDT 2  69 PL 29B 696           + (AACH,BARI,CERN,EPOL,NIJM,ORSA,PADO,TORI)

BARDIN   70 PL 32B 121           BARDIN,BILENKY,PONTECORVO           (JINR)
BECHERRA 70 PR D1 1452           T.BECHERRAWY                        (ROCH)
FEARING  70 PR D3 542            +FISCHBACK,SMITH              (STOH+BOHR)
GAILLARD 70 CERN 70-14           M K GAILLARD, L M CHOUNET     (CERN+ORSA)
GINSBERG 70 PR D1 229            E S GINSBERG                   (IIT HAIFA)

GINSBERG 71 PR D4 2893           E S GINSBERG                        (MIT)
CHOUNET  72 PL 4C 199            (PHYS. REPTS.)CHOUNET,2*GAILLARD(ORSA+CERN)

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K^0

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                    11  NEUTRAL K(498,JP=0-) I=1/2

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                    11  NEUTRAL K MASS (MEV)

M            498.1      0.4          CHRISTENS 64 OSPK
M     2223   497.44     0.33         KIM       65 HBC    K0 FROM PBAR P    6/66
M     4500   498.9      0.5          BALTAY    66 HBC    K0 FROM PBAR P    6/66
M            497.44     0.50         FITCH     67 OSPK                    11/67
M            . . . . . . . . .
M   AVG      497.87     0.32   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.5)
M   FIT      497.67     0.13   FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.1)  3/84*
                        (SEE IDEOGRAM BELOW)
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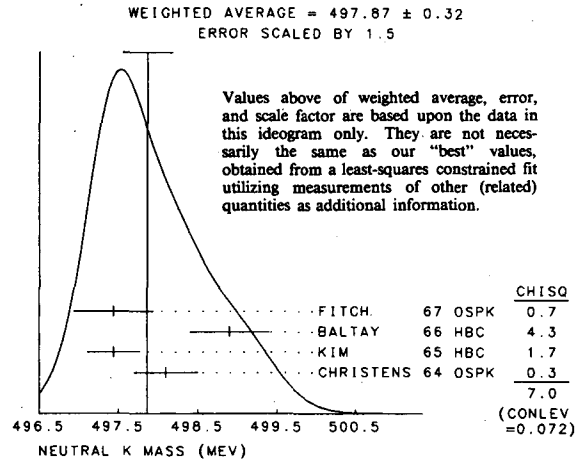


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                    11  (K0) - (K+-) MASS DIFFERENCE (MEV)

D            3.9      0.6          ROSENFELD 59 HBC   -
D            5.4      1.1          CRAWFORD  59 HBC   +
D      9     3.90     0.25         BURNSTEIN 65 HBC   -
D      7     3.71     0.35         KIM       65 HBC   -  K- P TO K0 N     6/68
D    417     3.95     0.21         HILL      68 DBC   +  K+D TO KOPP      3/68
D            . . . . . . . . .
D   AVG      3.92     0.14   AVERAGE
D   FIT      4.01     0.13   FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.1)  3/84*

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                    REFERENCES FOR NEUTRAL K

CRAWFORD 59 PRL   2  112     CRAWFORD,CRESTI,GOOD,STEVENSON,TICHO  (LRL)
ROSENFEL 59 PRL   2  110     A H ROSENFELD,F SOLMITZ,R D TRIPP     (LRL)
CHRISTEN 64 PRL 13 138       CHRISTENSON,CRONIN,FITCH,TURLAY (PRINCETON)
BURNSTEI 65 PR  138 B 895    R A BURNSTEIN,H A RUBIN          (MARYLAND)
KIM      65 PR 140 B 1334    J K KIM,L KIRSCH,D MILLER        (COLUMBIA)

BALTAY   66 PR 142   932     BALTAY,SANDWEISS,STONEHILL +     (YALE+BNL)
FITCH    67 PR 164  1711     FITCH,ROTH,RUSS,VERNON          (PRINCETON)
HILL     68 PR 168  1534     HILL,ROBINSON,SAKITT,CANTER  (BNL,CARNEGIE)

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K^0_S

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                    12  SHORT-LIVED NEUTRAL K(498, JP=0-) I=1/2

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                    12  KS MEAN LIFE (UNITS 10**-10 SEC)

T       KS MEAN LIFE (PRE-1971 EXPERIMENTS)
T   O   90   (1.07)   (0.13)   (0.13) BOLDT      58 CC
T      512    0.94     0.05     0.05  CRAWFORD   59 HBC
T   O   63   (1.09)   (0.18)   (0.15) BOWEN      60 CC
T   O   OLD EXPTS WITH LOW STATISTICS NOT INCLUDED IN AVERAGE.              6/68
T      378    0.94     0.05     0.05  BERTANZA   62 HBC
T      503    0.87     0.05           CHRETIEN   63 HLBC
T      545    0.86     0.04           KREISLER   64 OSPK
T             0.866    0.016          ALFF-STEI  66 OSPK                    9/66
T      572    0.90     0.06     0.05  AUERBACH   66 OSPK                    8/67
T     4500    0.92     0.04           BALTAY     66 HBC                     6/66
T   B        (0.904)  (0.024)         BOTT-BODE  66 OSPK                    9/66
T     5000    0.843    0.013          KIRSCH     66 HBC                     6/66
T    19994    0.856    0.008          DONALD     68 HBC                     6/68
T  H 20000    0.872    0.009          HILL       68 DBC                    11/72
T            . . . . . . . . .
T   AVG       0.8641   0.0065   0.0065 AVERAGE (ERROR INCL. SCALE FACTOR OF 1.3)

T       KS MEAN LIFE (POST-1971 EXPERIMENTS)
T        THESE VALUES ARE USED TO DETERMINE THE STABLE PARTICLE TABLE
T        VALUES OF THE KS MEAN LIFE AND RATES.
T   H   50K    0.8958   0.0045         SKJEGGEST  72 HBC                     1/73
T   F 2173    (0.867)  (0.024)         FACKLER    73 OSPK                   11/73
T     6M      0.8937   0.0048         GEWENIGER  74 ASPK                    3/74
T   C         0.8913   0.0032         CARITHERS  75 SPEC                    7/75
T    26K      0.881    0.009          ARONSON    76 SPEC                   11/76
T   A        (0.905)  (0.007)         ARONSON    82 SPEC    E=30-110 GEV    1/83*
T            . . . . . . . . .
T   AVG       0.8923   0.0022   0.0022 AVERAGE
T   FIT       0.8923   0.0022 FROM FIT
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Stable Particles

K_S^0

Data Card Listings

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                    COMMENTS
T  H    HILL 68 HAS BEEN CHANGED BY THE AUTHORS FROM THE PUBLISHED VALUE    11/72
T  H    (0.865+-0.009) BECAUSE OF A CORRECTION IN THE SHIFT DUE TO ETA+-.   11/72
T  H    SKJEGGESTAD 72 AND HILL 68 GIVE DETAILED DISCUSSIONS OF SYSTEMATICS
T  H    ENCOUNTERED IN THIS TYPE OF EXPERIMENT.
T   B   KS MEAN LIFE NOT THE PRIMARY QUANTITY MEASURED IN THIS EXPT.         6/68
T   F   FACKLER 73 DOES NOT INCLUDE SYSTEMATIC ERRORS.                      11/73
T  C    CARITHERS 75 VALUE IS FOR KL-KS MASS DIFFERENCE DM=.5348+-.0021.   11/75
T  C    THE DM DEPENDENCE OF THE TOTAL DECAY RATE (INVERSE MEAN LIFE) IS    11/75
T  C    GAMMA(KS)=((1.122+-.004)+.16*(DM-.5348)/DM)*10**10 /SEC.            11/75
T  C    VALUE WOULD NOT CHANGE WITH OUR CURRENT DM=.5349+-.0022.             2/76
T   A   ARONSON 82 FIND THAT KS MEAN LIFE MAY DEPEND ON THE KAON ENERGY.    1/83*

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                 12  KS PARTIAL DECAY MODES

                                                        DECAY MASSES
P1      KS INTO PI+ PI-                                 140+ 140
P2      KS INTO PI0 PI0                                 135+ 135
P3      KS INTO MU+ MU-                                 106+ 106
P4      KS INTO E+ E-                                  .511+.511
P5      KS INTO PI+ PI- GAMMA                           140+ 140+   0
P6      KS INTO GAMMA GAMMA                               0+   0
P7      KS INTO 3PI0                                    135+ 135+ 135
P8      KS INTO PI+ PI- PI0                             140+ 140+ 135

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                 12  KS BRANCHING RATIOS

R1      KS INTO (PI+ PI-)/TOTAL                                  (P1)
R1            0.68     0.04            CRAWFORD  59 HBC
R1            0.70     0.08            COLUMBIA  60 HBC
R1  U        (0.740)  (0.024)          ANDERSON  62 HBC
R1 U  3447    0.670    0.010           DOYLE     69 HBC     PI- P TO LAM K0   1/76
R1  U   ANDERSON RESULT NOT PUBLISHED, EVENTS ADDED TO DOYLE SAMPLE           2/71
R1          . . . . . . . . .
R1  AVG       0.6710   0.0096   AVERAGE
R1  FIT       0.6861   0.0024 FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.1)

R2      KS INTO (PI0 PI0)/TOTAL                                  (P2)
R2            0.27     0.11            CRAWFORD  59 HBC
R2            0.26     0.06            BAGLIN    60 HLBC
R2            0.30     0.035           BROWN     61 HLBC
R2    1066    0.335    0.014           BROWN     63 HLBC
R2     198    0.288    0.021           CHRETIEN  63 HLBC
R2          . . . . . . . . .
R2  AVG       0.316    0.014   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.3)
R2  FIT       0.3139   0.0024 FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.1)
                       (SEE IDEOGRAM BELOW)
                  WEIGHTED AVERAGE = 0.316 ± 0.014
                       ERROR SCALED BY 1.3
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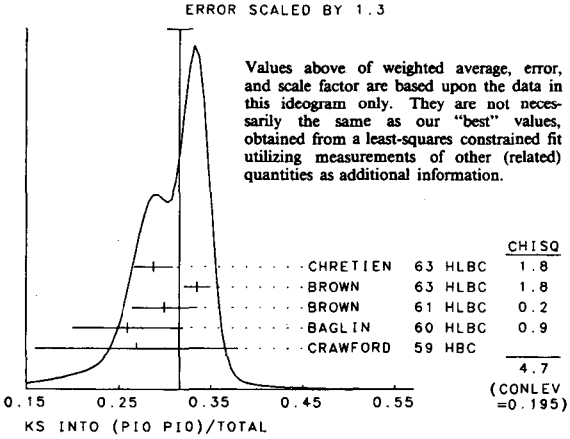


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R3      KS INTO (PI+ PI-)/(PI0 PI0)                              (P1)/(P2)
R3  N  267    (2.12)   (0.17)          BOZOKI    69 HLBC                      5/70
R3  G 3016    (2.285)  (0.055)         GOBBI     69 OSPK    K+N TO K0P        5/69
R3     3700    2.10     0.06            MORFIN    69 HLBC    K+N TO K0P       10/69
R3  G 7944    2.282    0.043           MOFFETT   70 OSPK    K+N TO K0P        2/72
R3  B 6150    2.22     0.095           BALTAY    71 HBC  K-P TO K0 +NEUTRALS 12/71
R3  A 3068    2.22     0.10            ALITTI    72 HBC     K+P TO PI+ P K0   6/72
R3    6380    2.22     0.08            MORSE     72 DBC     K+N TO K0P        2/72
R3  N  701    2.10     0.11            NAGY      72 HLBC    K+N TO K0P        1/73
R3    4799    2.16     0.08            HILL      73 DBC     K+D TO K0 P P     9/73
R3     16K    2.169    0.094           COWELL    74 OSPK    PI- P TO LAM K0   7/75
R3    1315    2.11     0.09            EVERHART  76 WIRE    PI- P TO LAM K0  11/76
R3 N     NAGY 72 IS A FINAL RESULT WHICH INCLUDES BOZOKI 69.                  11/73
R3 G     MOFFETT 70 IS A FINAL RESULT WHICH INCLUDES GOBBI 69.                 2/72
R3 B     THE DIRECTLY MEASURED QUANTITY IS KS TO PI+PI-/ALL K0BAR=.345+-.005 12/71
R3 A     THE DIRECTLY MEASURED QUANTITY IS KS TO PI+ PI-/ALL K0=.345+-.005     6/72
R3          . . . . . . . . .
R3  AVG       2.197    0.026   AVERAGE
R3  FIT       2.186    0.025  FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.1)

R4      KS INTO (MU+ MU-)/CHARGED (UNITS 10**-5)                 (P3)/(P1)
R4           (10.0)  OR LESS  CL=.90   BOTT-BODE 67 OSPK                      8/67
R4           (20.0)  OR LESS  CL=.90   BOHM       69 OSPK                      2/71
R4            (1.07) OR LESS  CL=.90   HYAMS      69 OSPK                     10/69
R4   S       (32.6)  OR LESS  CL=.90   STUTZKE    69 OSPK                      5/69
R4            0.047 OR LESS  CL=.90   GJESDAL    73 ASPK                      7/73
R4   S  VALUE CALCULATED BY US, USING 2.3 INSTEAD OF 1 EVENT, 90 PERC.CL

R5      KS INTO (PI+ PI- GAMMA)/(PI+ PI-) (UN.10**-3)            (P5)/(P1)
R5      27        NO RATIO GIVEN        BELLOTTI  66 HBC     PG GT 50 MEV/C   10/69
R5      10    3.3      1.2              WEBBER    70 HBC     PG GT 50 MEV/C   10/69
R5 B          2.8      0.6              BURGUN    73 HBC     PG GT 50 MEV/C   11/73
R5 C    29   (3.0)    (0.6)             BOBISUT   74 HLBC    PG GT 40 MEV/C   12/75
R5   T        2.68     0.15             TAUREG    76 SPEC    PG GT 50 MEV/C    6/77
R5 B     BURGUN 73 ESTIMATES THAT DIRECT EMISSION CONTRIBUTION IS .3+-.6 .     11/73
R5 C     BOBISUT 74 NOT INCLUDED IN AVERAGE BECAUSE P(GAMMA) CUT DIFFERS.       1/76
R5 C     ESTIMATES DIRECT EMISSION CONTRIBUTION TO BE 0.5 OR LESS, CL=.95.      1/76
R5   T   TAUREG 76 FIND DIRECT EMISSION CONTRIB LT .06,CL=.90.                  6/77
R5          . . . . . . . . .
R5  AVG       2.70     0.14    AVERAGE

R6      KS INTO (E+ E-)/CHARGED (UNITS 10**-5)                   (P4)/(P1)
R6           50.0   OR LESS  CL=.90   BOHM       69 OSPK                      2/71

R7      KS INTO 2 GAMMA/TOTAL (UNITS 10**-3)                     (P6)
R7 R     0  (21.0)  OR LESS  CL=.90   BANNER     69 OSPK                     12/71
R7 R     0   (2.2)  OR LESS  CL=.90   REPELLIN   71 OSPK                     12/71
R7 R     0   (0.71) OR LESS  CL=.90   BANNER     72 OSPK                      8/72
R7       0   (2.0)  OR LESS  CL=.90   MORSE      72 DBC                       2/72
R7       0    0.4   OR LESS  CL=.90   BARMIN2    73 HLBC                      2/74
R7 R    THESE LIMITS ARE FOR MAXIMUM INTERFERENCE IN KS-KL TO 2 GAMMAS       12/71

R8      KS INTO (PI+ PI- PI0)/TOTAL (UNITS 10**-4)               (P8)
R8           0.85   OR LESS  CL=.90   METCALF    72 ASPK                      1/84*

R9      KS INTO (PI0 PI0 PI0)/TOTAL (UNITS 10**-4)               (P7)
R9           (4.3)  OR LESS  CL=.90   BARMIN1    73 HLBC                      2/84*
R9           0.37   OR LESS  CL=.90   BARMIN     83 HLBC                      1/84*

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NOTE ON CP VIOLATION IN $K_S^0 \to 3\pi$

For $K_S^0 \to 3\pi$, the quantities which measure CP violation are the ratios of amplitudes

$$\eta_{+-0} = \frac{A_S(K_S \to \pi^+\pi^-\pi^0)}{A_L(K_L \to \pi^+\pi^-\pi^0)},$$

$$\eta_{000} = \frac{A_S(K_S \to \pi^0\pi^0\pi^0)}{A_L(K_L \to \pi^0\pi^0\pi^0)}.$$

If one assumes that CPT invariance holds and that there are no transitions to I = 3 states, then $\mathrm{Re}(\eta_{+-0})$ and $\mathrm{Re}(\eta_{000})$ can be neglected, and CP violation would be observed as nonzero values of $\mathrm{Im}(\eta_{+-0})$ and $\mathrm{Im}(\eta_{000})$. Sections ET+ and ET0 list the relative rates

$$(\mathrm{Im}\eta_{+-0})^2 = \frac{\Gamma(K_S \to \pi^+\pi^-\pi^0)}{\Gamma(K_L \to \pi^+\pi^-\pi^0)}$$

$$(\mathrm{Im}\eta_{000})^2 = \frac{\Gamma(K_S \to \pi^0\pi^0\pi^0)}{\Gamma(K_L \to \pi^0\pi^0\pi^0)}$$

obtained under the above assumptions.

In the above expressions the three pions are restricted to the dominant symmetric I = 1 state, a CP = −1 state which couples to K_S only if CP is violated. The decay $K_S \to \pi^+\pi^-\pi^0$ also has CP-allowed amplitudes to I = 0 and I = 2 states of the three pions. The angular momenta in these states cannot be S wave so they are strongly suppressed by centrifugal barrier effects, and, for the I = 2 state, by the $\Delta I = 1/2$ rule as well. For comparison with the CP-violating rate, we list in section RSQ the CP-conserving rate relative to $K_L \to \pi^+\pi^-\pi^0$ decay. The CP-conserving limit is large and thus determines the branching ratio limit $\Gamma(K_S \to \pi^+\pi^-\pi^0)/\Gamma(K_S \to \pi^+\pi^-)$ given in section R8.

For notation, see key at front of Listings.

Stable Particles

K^0_S, K^0_L

12 CP VIOLATION PARAMETERS IN KS DECAY

```
ET+      IM(ETA+-0)**2
ET+      WHERE ETA+-0 = A(KS -> PI+ PI- PIO, CP VIOL.)/A(KL -> PI+ PI- PIO).
ET+      CPT ASSUMED VALID - (I.E. RE(ETA+-0)=0)
ET+       18   (3.8)  OR LESS  CL=.90   ANDERSON  65 HBC  INCL. IN WEBBER 70  10/69
ET+            (0.45) OR LESS  CL=.90   BEHR      66 HLBC                      8/66
ET+       71   (0.8)  OR LESS  CL=.90   WEBBER    70 HBC                       8/70
ET+       99   (1.2)  OR LESS  CL=.90   CHO       71 DBC                       4/71
ET+       98   (1.0)  OR LESS  CL=.90   JAMES     71 HBC  INCL. IN JAMES 72    6/71
ET+ M     50   (1.2)  OR LESS  CL=.95   MEISNER   71 HBC     CL=.9 NOT AVAIL.  2/71
ET+      180   (0.66) OR LESS  CL=.90   JAMES     72 HBC                       1/73
ET+       99   (1.2)  OR LESS  CL=.90   JONES     72 OSPK                     10/72
ET+      384    0.12  OR LESS  CL=.90   METCALF   72 ASPK                      2/74
ET+      148   (0.71) OR LESS  CL=.90   MALLARY   73 OSPK    RE(A)=-.05+-.17   8/73
ET+      192   (1.2)  OR LESS  CL=.90   BALDOCEOL 75 HLBC                     12/75
ET+ M     THESE AUTHORS FIND REAL(A)= 2.75+-.65, ABOVE VALUE AT RE(A)=0        2/71

RSQ      RHO**2
RSQ      WHERE RHO=CABS(A(KS -> PI+ PI- PIO, CP CONS.)/A(KL -> PI+ PI- PIO)).
RSQ      CONSERVES CP BUT LISTED HERE FOR COMPARISON WITH SECTION ET+ ABOVE.
RSQ      THIS LIMIT DETERMINES BRANCHING RATIO R8 ABOVE.
RSQ      384    0.42  OR LESS  CL=.90   METCALF   72 ASPK                     11/72

ETO      IM(ETA000)**2
ETO      WHERE ETA000 = A(KS INTO 3PIO, CP VIOLATING)/A(KL INTO 3PIO)
ETO      SEE COMMENTS IN SECTION ET+ ABOVE.
ETO      THIS LIMIT DETERMINES BRANCHING RATIO R9 ABOVE.
ETO       22   (1.2)  OR LESS  CL=.90   BARMIN1   73 HLBC                     11/73
ETO  G         (0.28) OR LESS  CL=.90   GJESDAL   74 SPEC    INDIRECT MEAS.   11/75
ETO  B 632      0.1   OR LESS  CL=.90   BARMIN    83 HLBC                      2/84*
ETO  G  GJESDAL 74 USES K2PI, KMU3 AND KE3 DECAY RESULTS, UNITARITY, AND      11/75
ETO  G  CPT.  CALCULATES ABS(ETA000)=.26+-.20.  WE CONVERT TO UPPER LIMIT.    11/75
ETO  B  BARMIN 83 FIND RE(ETA000)=(-.08+-.18) AND IM(ETA000)=(-.05+-.27) .    11/83*
ETO  B  ASSUMING CPT INVARIANCE THEY OBTAIN THE LIMIT QUOTED ABOVE .          11/83*
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REFERENCES FOR KS


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BOLDT    58 PRL    1  150       E BOLDT,D O CALDWELL,Y PAL                  (MIT)
CRAWFORD 59 PRL    2  266       CRAWFORD,CRESTI,DOUGLASS,GOOD,TICHO + (LRL)

BAGLIN   60 NC    18 1043       BAGLIN,BLOCH,BRISSON,HENNESSY +          (EPOL)
BOWEN    60 PR   119 2030       BOWEN,HARDY,REYNOLDS,SUN,MOORE+      (PRIN+BNL)
COLUMBIA 60 ROCH CONF 727       M SCHWARTZ +                         (COLUMBIA)

BROWN    61 NC    19 1155       BROWN,BRYANT,BURNSTEIN,GLASER,KADYK+ (MICH)
ANDERSON 62 CERN CONF 836       J A ANDERSON,F S CRAWFORD +               (LRL)
BERTANZA 62  PREPRINT D105      BERTANZA,CONNOLLY,CULWICK,EISLER +        (BNL)
    UNPUBLISHED, BUT RECERTIFIED BY AUTHORS, AUGUST 66.

CHRETIEN 63 PR   131 2208       CHRETIEN+      (BRANDEIS+BROWN+HARVARD+ MIT)
BROWN    63 PR   130  769       BROWN,KADYK,TRILLING,ROE +           (LRL+MICH)
KREISLER 64 PR   136 B 1074     M KREISLER,O OVERSETH,J CRONIN    (PRINCETON)
ANDERSON 65 PRL 14 475          +CRAWFOR,GOLDEN,STERN,BINFORD +     (LRL+WISC)

ALFF-STE 66 PL 21 595           ALFF-STEINBERGER,HEUER,KLEINKNECHT + (CERN)
AUERBACH 66 PR 149 1052         AUERBACH,DOBBS,LANDE,MANN,SCIULLI+     (PENN)
    ALSO 65 AUERBACH
BALTAY   66 PR 142   932        BALTAY,SANDWEISS,STONEHILL +        (YALE+BNL)
BEHR     66 PL  22  540         BEHR,BRISSON,PETIAU+ (EPOL,MILA,PADO,ORSAY)
BELLOTTI 66 NC 45A 737          +PULLIA,BALDO-CEOLIN +           (MILAN+PADUA)
BOTT-BOD 66 PL  23 277          BOTT-BODENHAUSEN,DE BOUARD +             (CERN)
KIRSCH   66 PR  147  939        L KIRSCH,P SCHMIDT                   (COLUMBIA)

BOTT-BOD 67 PL 24B 194          BOTT-BODENHAUSEN,DE BOUARD,CASSEL+     (CERN)
DONALD   68 PL 27B  58          DONALD,EDWARDS,NISAR+ (LIVP,CERN,IPNP,CDEF)
HILL     68 PR 171 1418         HILL,ROBINSON,SAKITT +         (BNL,CARNEGIE)

BANNER   69 PR 188 2033         +CRONIN,LIU,PILCHER                (PRINCETON)
BOHM     69 THESIS              A. BOHM                                  (AACH)
BOZOKI   69 PL 30B 498          +FENYVES,GOMBOSI,NAGY,SURANYI+     (BUDAPEST)
DOYLE    69 UCRL 18139-THESIS   J.C. DOYLE                                (LRL)
GOBBI    69 PRL 22 682          GOBBI,GREEN,HAKEL,MOFFETT,ROSEN+(ROCHESTER)
HYAMS    69 PL  29B 521         +KOCH,POTTER,VON LINDERN,LORENZ+ CERN(MPIM)
MORFIN   69 PRL    23  660      MORFIN,SINCLAIR                          (MICH)
STUTZKE  69 PR    177  2009     +ABASHIAN,JONES,MANTSCH,ORR,SMITH(ILLINOIS)

MOFFETT  70 BAPS 15 512         +GOBBI,GREEN,HAKEL,ROSEN          (ROCHESTER)
WEBBER   70 PR D1 1967          +SOLMITZ,CRAWFORD,ALSTON-GARNJOST        (LRL)
    ALSO 69 UCRL 19226 THESIS B R WEBBER                                  (LRL)

BALTAY   71 PRL 27 1678         +BRIDGEWATER,COOPER,GERSHWIN,HABIBI+ (COLU)
    ALSO 71 NEVIS-187 THESIS    WILLIAM A. COOPER                    (COLUMBIA)
CHO      71 PR D3 1557          +DRALLE,CANTER,ENGLER,FISK+ (CARN+BNL+CASE)
JAMES    71 PL 35B 265          +MONTANET,PAUL,PAULI+       (CERN+SACL+OSLO)
MEISNER  71 PR D3 59            +MANN,HERTZBACH,KOFLER +     (MASA+BNL+YALE)
REPELLIN 71 PL 36B 603          +WOLFF,CHOLLET,GAILLARD,JANE+    (ORSA+CERN)

ALITTI   72 PL 39B 568          J ALITTI,E LESQUOY,A MULLER          (SACLAY)
BANNER   72 PRL 29 237          +CRONIN,HOFFMAN,KNAPP,SHOCHET   (PRINCETON)
JAMES    72 NP B49 1            +MONTANET,PAUL,SAETRE+      (CERN+SACL+OSLO)
JONES    72 NC 9A 151           +ABASHIAN,GRAHAM,MANTSCH,ORR,SMITH+     (ILL)

METCALF  72 PL 40B 703          +NEUHOFER,NIEBERGALL+        (CERN+IPN+WIEN)
MORSE    72 PRL 28 388          +NAUENBERG,BIERMAN,SAGER+    (COLO+PRIN+UMD)
NAGY     72 NP B47 94           +TELBISZ,VESZTERGOMBI              (BUDAPEST)
    ALSO 69 PL 30B 498          BOZOKI,FENYVES,GOMBOSI,NAGY+       (BUDAPEST)
SKJEGGES 72 NP B48 343          SKJEGGESTAD,JAMES,MONTANET+(OSLO+CERN+SACL)

BARMIN1  73 PL 46B 465          +BARYLOV,DAVIDENKO,DEMIDOV+            (ITEP)
BARMIN2  73 PL 47B 463          +BARYLOV,DAVIDENKO,DEMIDOV+            (ITEP)
BURGUN   73 PL 46B 481          +BERTRANET,LESQUOY,MULLER,PAULI+(SACL+CERN)
FACKLER  73 PRL 31 847          +FRISCH,MARTIN,SMOOT,SOMPAYRAC          (MIT)
GJESDAL  73 PL 44B 217          +PRESSER,STEFFEN,STEINBERGER+    (CERN+HEID)
HILL     73 PR D8 1290          +SAKITT,SAMIOS,BURRIS,ENGLER+     (BNL+CARN)
MALLARY  73 PR D7 1953          +BINNIE,GALLIVAN,GOMEZ,PECK,SCIULLI+  (CIT)

BOBISUT  74 LNC 11 646          +HUZITA,MATTIOLI,PUGLIERIN             (PADO)
COWELL   74 PR D10 2083         +LEE-FRANZINI,ORCUTT,FRANZINI + (STON+COLU)
GEWENIGE 74 PL 48B 487          GEWENIGER,GJESDAL,PRESSER+       (CERN+HEID)
GJESDAL  74 PL 52B 119          +PRESSER,STEFFEN,STEINBERGER +   (CERN+HEID)

BALDOCEO 75 NC 25A 688          BALDO-CEOLIN,BOBISUT,CALIMANI+  (PADO+WISC)
CARITHER 75 PRL 34 1244         CARITHERS,MODIS,NYGREN,PUN +       (COLU+NYU)
ARONSON  76 NC 32A 236          +MCINTYRE,ROEHRIG +    (WISC+EFI+UCSD+ILLC)
EVERHART 76 PR D14 661          +KRAUS,LANDE,LONG,LOWENSTEIN +         (PENN)
TAUREG   76 PL 65B 92           +ZECH,DYDAK,NAVARRIA+        (HEID+CERN+DORT)
ARONSON  82 PRL 48 1306         +BOCK,CHENG,FISCHBACH         (BNL+CHIC+PURD)
    ALSO 82 PL 116B 73          FISCHBACH,CHENG,ARONSON,BOCK(PURD+BNL+CHIC)
    ALSO 83 PR D28 476          ARONSON,BOCK,CHENG,FISCHBACH(BNL+CHIC+PURD)
    ALSO 83 PR D28 495          ARONSON,BOCK,CHENG,FISCHBACH(BNL+CHIC+PURD)
BARMIN   83 PL 128B 129         +BARYLOV,CHISTYAKOVA,CHUVILO+    (ITEP+PADO)
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PAPERS NOT REFERRED TO IN DATA


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BIRGE    60 ROCH CONF 601       R W BIRGE,P P ELY +            (LRL+WISCONSIN)
MULLER   60 PRL    4  418       MULLER,BIRGE,FOWLER,GOOD,PICCIONI+(LRL+BNL)
FITCH    61 NC    22 1160       V FITCH,P PIROUE,R PERKINS        (PRIN+LASL)
GOOD     61 PR   124 1223       GOOD,MATSEN,MULLER,PICCIONI +           (LRL)

CRAWFORD 62 CERN CONF 827       F S CRAWFORD                            (LRL)
AUERBACH 65 PRL 14 192          AUERBACH,LANDE,MANN,SCIULLI,UTO +     (PENN)
TRILLING 65 UCRL 16473          GEORGE H TRILLING                       (LRL)
    UPDATED FROM 1965 ARGONNE CONF., PAGE 115.
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K^0_L 13 LONG-LIVED NEUTRAL K(498, JP=0-) I=1/2

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13 (KL) - (KS) MASS DIFFERENCE

WE GIVE (KL-KS MASS DIFFERENCE / HBAR) IN UNITS OF 10**10 SEC-1

```
D  TX         (2.20)   (0.35)            FITCH     61 CNTR
D   X         (0.84)   (0.29)     (0.22)GOOD       61 HLBC
D  TXC        (1.02)   (0.23)            CAMERINI  62 HLBC                      8/67
D  TX         (0.55)   (0.24)            AUBERT    65 HLBC                      6/66
D   X         (0.26)   (0.36)     (0.26)BALDO-CEO 65 HLBC   ASSUMES CP CONS.
D  TXA        (0.64)   (0.12)            CHRISTENS 65 OSPK                      6/66
D  TX         (0.70) OR LESS             FITCH     65 OSPK   CF. MEISNER 66    7/66
D   V   130   (0.89)   (0.15)            VISHNEVSK 65 OSPK   CU AND AL REGEN   8/67
D   X         (0.514)  (0.039)           ALFF-STEI 66 OSPK                      6/66
D   X    84   (0.42)   (0.24)     (0.36) BALDO-CEO 66 HLBC   KO+N INTO HYPER.  8/67
D   B         (0.531)  (0.027)           BOTT-BODE 66 OSPK   C REGEN           9/66
D  TX    77   (0.58)   (0.17)            CAMERINI  66 HBC, DBC KO+N INTO HYPER 8/67
D   N    72  (+0.64)   (0.18)            CANTER    66 DBC    KO SCATTER IN D2 11/66
D   X    95   (0.62)   (0.10)     (0.16) CHANG     66 HBC    KO+P INTO HYPER.  8/67
D   X         (0.81)   (0.17)            FUJII     66 OSPK   IRON REGENERATOR  9/66
D   X    59   (0.74)   (0.34)            MEISNER1  66 HBC                      6/66
D           + SIGN FAVORED               MEISNER2  66 HBC                      9/66
D   X         (0.38)   (0.16)            JOVANOVIC 66 OSPK   C+URANIUM REGEN. 11/66
D  TX   136  (+0.64)   (0.19)            CANTER    67 DBC    KO+D INTO HYPER. 11/67
D   X         (0.65)   (0.11)            MISCHKE   67 OSPK                     11/67
D   X   590   (0.59)   (0.13)            BALATZ    68 OSPK   AL REGENERATOR    3/68
D   X         (0.520)  (0.044)           CARNEGIE  68 HBC    GAP METHOD        3/68
D  TX        (+0.487)  (0.046)           MELHOP    68 OSPK   ST.STEEL REGEN    6/68
D  BX         (0.547)  (0.024)           BOTT-BODE 69 OSPK   C REGEN           1/71
D  FX         (0.555)  (0.020)           FAISSNER  69 ASPK   REGEN IN CU      10/69
D              0.542    0.006            CULLEN    70 CNTR                      1/71
D   R         (0.542)  (0.006)           ARONSON   70 ASPK   GAP METHOD        1/71
D   X         (0.481)  (0.052)    (0.075)BALATS    71 OSPK                      9/71
D   R         (0.534)  (0.007)           CARNEGIE  71 ASPK   GAP METHOD        8/71
D  TH   119  (+0.67)   (0.14)            HILL      71 DBC                      10/71
D   S 1757    (0.557)  (0.038)           FACKLER   73 OSPK                     11/73
D              0.5340   0.0030           GEWENIG3  74 SPEC   GAP METHOD       11/75
D              0.5334   0.0040           GJESDAL   74 SPEC   CHG ASYMMETRY    11/75
D   Z         (0.482)  (0.014)           ARONSON2  82 SPEC   E=30-110 GEV      1/83*
D
D  AVG         0.5349   0.0022   AVERAGE
                     COMMENTS
D   X   NO ATTEMPT HAS BEEN MADE TO CORRECT OLDER EXPERIMENTS WITH LARGE     11/75
D   X   ERRORS FOR THE SUBSEQUENT CHANGES IN THE KS MEAN LIFE OR IN ETA+-.    2/76
D  T    A KS MEAN LIFE OF 0.862 10**-10 SEC WAS USED IN CONVERTING THE        1/71
D  T    MASS DIFFERENCE FROM UNITS OF INVERSE KS MEAN LIVES TO ABSOLUTE       1/71
D  T    UNITS. VALUES NOT BEARING THIS FOOTNOTE EITHER WERE GIVEN IN          1/71
D  T    ABSOLUTE UNITS OR WERE CONVERTED USING THE AUTHORS' VALUE OF THE      1/71
D  T    KS MEAN LIFE.                                                         1/71
D    C  CAMERINI 62 VALUE CHANGED FROM 1.7 (SEE TABLE 1 OF CAMERINI 66)       8/67
D    A  CHRISTENSON 65 CORRECTED FOR INTERFERENCE BY FITCH 65 FOOTNOTE.       1/71
D   V   VISHNEVSKY 65 NOT CORRECTED FOR INTERFERENCE EFFECTS.                 3/68
D   N   CANTER 66 ERROR IGNORES UNCERTAINTY OF PHASE SHIFTS.  THESE EVENTS   10/71
D   N   ARE USED IN HILL 71.                                                 10/71
D  B    BOTT-BODENHAUSEN 69 IS A REEVALUATION OF BOTT-BODENHAUSEN 66.         1/71
D  F    FAISSNER 69 HAS ADDNL. SYSTEMATIC ERROR LESS THAN TWO PERCENT.        1/71
D   R   ARONSON 70 AND CARNEGIE 71 USE KS MEAN LIFE=.862+-.006 E-10 SEC.     11/75
D   R   WE HAVE NOT ATTEMPTED TO ADJUST THESE VALUES FOR THE SUBSEQUENT       2/76
D   R   CHANGE IN THE KS MEAN LIFE OR IN ETA+-.                               2/76
D   H   HILL 71 PRIMARY RESULT IS THAT DM IS POSITIVE.                       10/71
D   H   THE MAGNITUDE MAY HAVE AN ADDITIONAL SYSTEMATIC ERROR OF ABOUT 0.12 10/71
D   S   NOT AVERAGED BECAUSE ERROR IS LARGE AND SYSTEMATICS NOT DISCUSSED.    2/76
D   Z   ARONSON 82 FIND THAT DELTA-M MAY DEPEND ON THE KAON ENERGY .          1/83*
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13 KL MEAN LIFE (UNITS 10**-8 SEC)

```
T        KL MEAN LIFE
T       34    8.1      3.2       2.4    BARDON     58 CNTR
T       ASSUMED DS=DQ AND DELTA I=1/2 CRAWFORD   59 HBC
T       15    5.1      2.4       1.3    DARMON     62 FBC
T             5.3      0.6              FUJII      64 OSPK
T     1700    6.1      1.5       1.2    ASTBURY3   65 CNTR
T             5.15     0.14             DEVLIN     67 CNTR
T   L        (5.0)    (0.5)             LOWYS      67 HLBC
T     0.4M    5.154    0.044            VOSBURGH   72 CNTR                2/71
T   L   SUM OF PARTIAL DECAY RATES.
T
T   AVG       5.158    0.042     0.042  AVERAGE
T   FIT       5.183    0.040   FROM FIT
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13 KL PARTIAL DECAY MODES

```
                                                          DECAY MASSES
P1      KL INTO 3PIO                       TAU 0 PRIME    135+ 135+ 135
P2      KL INTO PI+ PI- PIO                TAU 0          140+ 140+ 135
P3      KL INTO PI MU NEUTRINO             KL MU3         140+ 106+   0
P4      KL INTO PI E NEUTRINO              KL E3          140+.511+   0
P5      KL INTO PI+ PI-                    KL PI+ PI-     140+ 140
P6      KL INTO MU+ MU-                    KL 2MU         106+ 106
P7      KL INTO E+ E-                      KL 2E         .511+.511
P8      KL INTO E MU                       KL EMU        .511+ 106
P9      KL INTO TWO GAMMAS                 KL 2GAMMA        0+   0
P10     KL INTO PI+ PI- GAMMA              KL PI+-G       140+ 140+   0
P11     KL INTO PIO PIO                    KL 2PIO        135+ 135
P12     KL INTO PI E NEU GAMMA             KL E3GAM       140+.511+   0+   0
P13     KL INTO PIO TWO GAMMAS             KL PI2GAMMA    135+   0+   0
P14     KL INTO E+ E- GAMMA                KL 2EGAM      .511+.511+   0
P15     KL INTO MU+ MU- GAMMA              KL 2MUGAM      106+ 106+   0
P16     KL INTO MU+ MU- PIO                KL 2MUPIO      106+ 106+ 135
P17     KL INTO PI+ PI- E+ E-              KL 2PI2E       140+ 140+.511+.511
P18     KL INTO PIO PI+- E-+ NEU           KL 2PIENEU     135+ 140+.511+   0
P19     KL INTO (PI MU ATOM) NEU           KL (PIMU)NEU
P20     KL INTO E+ E- PIO                  KL 2EPIO      .511+.511+ 135
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Stable Particles

Data Card Listings

K_L^0

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               NEUTRAL K CONSTRAINED FIT
       OVERALL FIT OF MEAN LIFE, WIDTHS AND BRANCHING
       RATIOS USES 65 DATA POINTS TO DETERMINE SIX                    3/78
       QUANTITIES.  OVERALL FIT HAS CHI-SQUARED=69.9                  3/78
```

FITTED PARTIAL DECAY MODE BRANCHING FRACTIONS

The matrix below is derived from the error matrix for the fitted partial decay mode branching fractions, P_i, as follows: The diagonal elements are $P_i \pm \delta P_i$, where $\delta P_i = \sqrt{\langle \delta P_i \delta P_i \rangle}$, while the off-diagonal elements are the normalized correlation coefficients $\langle \delta P_i \delta P_j \rangle / (\delta P_i \cdot \delta P_j)$. For the definitions of the individual P_i, see the listings above; only those P_i appearing in the matrix are assumed in the fit to be nonzero and are thus constrained to add to 1.

```
       P 1        P 2        P 3        P 4        P 5        P11
P 1 .2147+-.0099
P 2   -.6525  .1239+-.0020
P 3   -.8540      .4407  .2711+-.0042
P 4   -.9098      .4699      .6132  .3873+-.0055
P 5   -.4358      .5469      .3154      .3362  .0020+-.0001
P11    .2287     -.1620     -.2102     -.2241     -.1080  .0009+-.0002
```

FITTED PARTIAL DECAY MODE RATES

The matrix below is the branching fraction matrix above, transformed into rate space; i.e., $G_i \equiv \Gamma_i = \Gamma_{total} P_i$, in appropriate units. In analogy to the matrix above, the diagonal elements are $G_i \pm \delta G_i$, where $\delta G_i = \sqrt{\langle \delta G_i \delta G_i \rangle}$, while the off-diagonal elements are the normalized correlation coefficients $\langle \delta G_i \delta G_j \rangle / (\delta G_i \cdot \delta G_j)$. Note that, because of the error in Γ_{total}, the errors and correlations here are not directly derivable from those above.

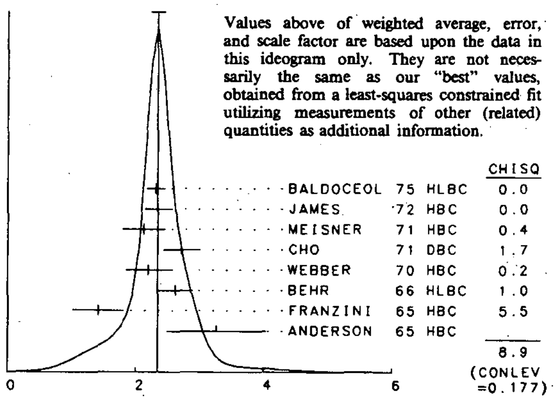
```
       G 1        G 2        G 3        G 4        G 5        G11
G 1 .0414+-.0020
G 2   -.4747  .0239+-.0004
G 3   -.6405      .4950  .0523+-.0009
G 4   -.6736      .5241      .6596  .0747+-.0011
G 5   -.3287      .5695      .3562      .3770  .0004+-.0000
G11    .2375     -.1236     -.1648     -.1734     -.0853  .0002+-.0000
```

13 KL DECAY RATES

```
W1      KL INTO PIO PIO PIO (UNITS 10**6 SEC-1)           (G1)
W1       54   5.22      1.03      0.84  BEHR       66 HLBC    ASSUMES CP       8/66
W1            . . . . . . . . . . .
W1  FIT       4.14      0.20   FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.7)

W2      KL INTO PI+ PI- PO (UNITS 10**6 SEC-1)            (G2)
W2       18   3.26      0.77            ANDERSON   65 HBC                      8/66
W2       14   1.4       0.4             FRANZINI   65 HBC                      6/66
W2      136   2.62      0.28      0.27  BEHR       66 HLBC    ASSUMES CP       8/66
W2       53   2.20      0.35            WEBBER     70 HBC     ASSUMES CP      10/71
W2       99   2.71      0.28            CHO        71 DBC     ASSUMES CP       4/71
W2  J    98  (2.5)     (0.3)            JAMES      71 HBC     ASSUMES CP       6/71
W2       50   2.12      0.33            MEISNER    71 HBC     ASSUMES CP      10/71
W2 J    180   2.35      0.20            JAMES      72 HBC     ASSUMES CP       1/73
W2      192   2.32      0.13      0.15  BALDOCEOL  75 HLBC    ASSUMES CP       1/76
W2        IN THE OVERALL FIT THIS RATE IS WELL DETERMINED BY THE MEAN LIFE AN
W2        THE BRANCHING RATIO R2. FOR THIS REASON THE DISCREPANCY BETWEEN THE
W2        W2 MEASUREMENTS DOES NOT AFFECT THE SCALE FACTOR OF THE OVERALL FIT
W2 J      JAMES 72 IS A FINAL MEASUREMENT AND INCLUDES JAMES 71.              11/73
W2            . . . . . . . . . . .
W2  AVG       2.34      0.11    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.2)
W2  FIT       2.391     0.041  FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.2)
                        (SEE IDEOGRAM BELOW)
```

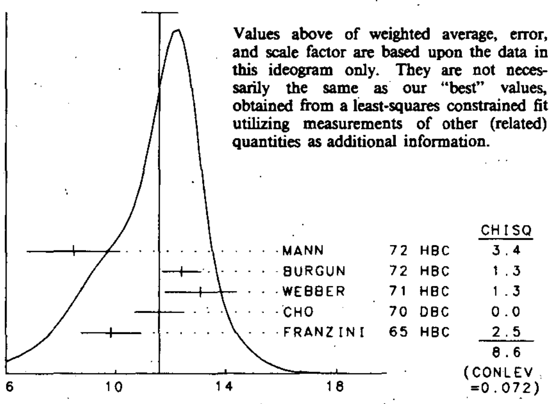
WEIGHTED AVERAGE = 2.34 ± 0.11
ERROR SCALED BY 1.2




```
W3      KL INTO PI E NEUTRINO (UNITS 10**6 SEC-1)          (G4)
W3            7.52      0.85      0.72  AUBERT     65 HLBC   DS=DQ,CP ASSUMED  8/67
W3      620   7.81      0.56            CHAN       71 HBC                      2/72
W3            . . . . . . . . . . .
W3  AVG       7.71      0.46    AVERAGE
W3  FIT       7.47      0.11    FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.3)
W4      KL INTO CHARGED (3-BODY) (UNITS 10**6 SEC-1)      (G2+G3+G4)
W4       98   15.1      1.9             AUERBACH   66 OSPK                     8/67
W4            . . . . . . . . . . .
W4  FIT       15.10     0.21    FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.4)
```

```
W5      KL INTO LEPTONIC (KMU3+KE3) (UNITS 10**6 SEC-1)  (G3+G4)
W5   D 109     9.85     1.15      1.05  FRANZINI   65 HBC                      2/72
W5  C  335   (10.3)    (0.8)            HILL       67 DBC     K+N TO KO P      8/67
W5   D 393    11.6      0.9             CHO        70 DBC     K+N TO KOP      10/70
W5   D 252    13.1      1.3             WEBBER     71 HBC     K- P TO KOBAR N  2/72
W5   D 410    12.4      0.7             BURGUN     72 HBC     K+P TO KOPPI+    1/73
W5   D 126     8.47     1.69            MANN       72 HBC     K- P TO KOBAR N  9/72
W5  C  CHO 70 INCLUDES EVENTS OF HILL 67
W5   D  ASSUMES DS=DQ RULE
W5            . . . . . . . . . . .
W5  AVG       11.60     0.65    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.5)
W5  FIT       12.70     0.18   FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.4)
                        (SEE IDEOGRAM BELOW)
```

WEIGHTED AVERAGE = 11.60 ± 0.65
ERROR SCALED BY 1.5



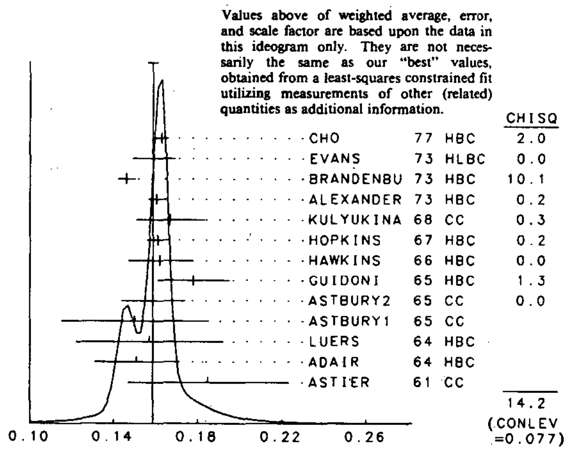

```
W6      KL INTO PI MU NEUTRINO UNITS 10**6 SEC-1)         (G3)
W6       19   4.54      1.24      1.08  LOWYS      67 HLBC                     8/67
W6            . . . . . . . . . . .
W6  FIT       5.232     0.086  FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.3)
```

13 KL BRANCHING RATIOS

```
R1      KL INTO (PIO PIO PIO)/CHARGED                     (P1)/(P2+P3+P4)
R1       24   0.24      0.08            ANIKINA    64 CC                       6/66
R1      549   0.251     0.014           BUDAGOV    68 HLBC    ORSAY MEASUR.   10/68
R1      444   0.277     0.021           BUDAGOV    68 HLBC    EC. POLYTEC.MEAS 10/68
R1       29   0.31      0.07      0.06  KULYUKINA  68 CC                       2/71
R1            . . . . . . . . . . .
R1  AVG       0.260     0.011    AVERAGE
R1  FIT       0.274     0.016   FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.7)

R2      KL INTO (PI+ PI- PIO)/CHARGED                     (P2)/(P2+P3+P4)
R2       59   0.185     0.038           ASTIER     61 CC                       8/66
R2       79   0.151     0.020           ADAIR      64 HBC                      8/66
R2       75   0.157     0.03      0.04  LUERS      64 HBC                      8/66
R2       66   0.15      0.03      0.04  ASTBURY1   65 CC                       8/66
R2      326   0.159     0.015           ASTBURY2   65 CC                       6/66
R2      566   0.178     0.017           GUIDONI    65 HBC                      6/66
R2     1729  (0.144)   (0.004)          HOPKINS    65 HBC     SEE HOPKINS 67   6/66
R2      126   0.162     0.015           HAWKINS    66 HBC                      6/66
R2            0.161     0.005           HOPKINS    67 HBC                      8/67
R2     1402   0.167     0.016           KULYUKINA  68 CC                       2/71
R2     1590   0.1605    0.0038          ALEXANDER  73 HBC                      1/74
R2     3200   0.146     0.004           BRANDENBU  73 HBC                      1/74
R2      558   0.159     0.010           EVANS      73 HLBC                     1/73
R2     6499   0.163     0.003           CHO        77 HBC                     11/77
R2            . . . . . . . . . . .
R2  AVG       0.1587    0.0024  AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.3)
R2  FIT       0.1584    0.0020 FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.2)
                        (SEE IDEOGRAM BELOW)
```

WEIGHTED AVERAGE = 0.1587 ± 0.0024
ERROR SCALED BY 1.3



For notation, see key at front of Listings.

Stable Particles

K^0_L

```
R3     KL INTO (PI MU NEUTRINO)/CHARGED                    (P3)/(P2+P3+P4)
R3  C  251   (0.356)  (0.07)          LUERS      64 HBC
R3  C  172   (0.39)   (0.08)   (0.10) ASTBURY1   65 CC                          7/66
R3  C  330   (0.335)  (0.055)         KULYUKINA  68 CC                          2/71
R3  C THIS MODE NOT MEASURED INDEPENDENTLY FROM R2 AND R4
R3          . . . . . . . . .
R3  FIT       0.3466   0.0028 FROM FIT

R4     KL INTO (PI E NEUTRINO)/CHARGED                     (P4)/(P2+P3+P4)
R4      24    0.46     0.11          NEAGU      61 CC                          2/76
R4     153    0.487    0.05          LUERS      64 HBC
R4     202    0.46     0.08     0.10 ASTBURY1   65 CC                          7/66
R4     500    0.498    0.052         KULYUKINA  68 CC                          2/71
R4          . . . . . . . . .
R4  AVG       0.485    0.032   AVERAGE
R4  FIT       0.4951   0.0029 FROM FIT

R5     KL INTO (PI E NEU)/((PI E NEU)+(PI MU NEU))         (P4)/(P3+P4)
R5     320    0.415    0.120         ASTIER     61 CC
R5          . . . . . . . . .
R5  FIT       0.5882   0.0032 FROM FIT

R6     KL INTO (PI+ PI- PI0)/TOTAL                         (P2)
R6
R6          . . . . . . . . .
R6  FIT       0.1239   0.0020 FROM FIT

R7     KL INTO (LEPTON PI NEUTRINO)/TOTAL                  (P3+P4)
R7
R7          . . . . . . . . .
R7  FIT       0.6585   0.0087 FROM FIT

R8     KL INTO (2 GAMMA)/TOTAL (UN. 10**-4)                (P9)
R8  C        (1.3)    (0.6)          CRIEGEE    66 OSPK                        8/66
R8      32    6.7      2.2           TODOROFF   67 OSPK    REPL.  CRIEGEE66 11/68
R8  K   33   (7.4)    (1.6)          CRONIN 1   67 OSPK                       11/67
R8      90    5.5      1.1           KUNZ       68 OSPK    NORM.TO 3PI(C+N)  2/71
R8      23    4.5      1.0           ENSTROM    71 OSPK    KL 1.5-9 GEV/C    2/72
R8 R          5.0     (1.0)          REPELLIN   71 OSPK                      11/71
R8 B          4.54     0.84          BANNER2    72 OSPK                       8/72
R8 B    THIS VALUE USES (E00/E+-)**2=1.05+-0.14. IN GENERAL, S13R8 =          8/72
R8 B    (4.32+-0.55)*(10**-4)*((E00/E+-)**2).                                 8/72
R8 R    ASSUMES REGEN AMPL IN COPPER AT 2GEV IS 22  MB. TO EVALUATE          11/71
R8 R    FOR A GIVEN REGEN AMPL AND ERROR, MULTIPLY BY (REGEN AMPL/22MB)**2   11/71
R8  C      CRIEGEE 66 REPLACED BY TODOROFF 67                                11/68
R8  K      CRONIN1 67 REPLACED BY KUNZ 68.                                    2/71
R8          . . . . . . . . .
R8  AVG       4.89     0.54    AVERAGE
R8      R21 BELOW GIVES (4.82+-.52)E-4. COMBINED AVG (4.85+-.37)E-4.          4/82

R9     KL INTO (PI+ PI-)/CHARGED (UNIT 10**-3)             (P5)/(P2+P3+P4)
R9  O   45   (2.0)    (0.4)          CHRISTENS 64 OSPK ETA +- = 1.95+-0.20  2/76
R9  O   54   (2.08)   (0.35)          GALBRAITH 65 OSPK ETA +- = 1.99+-0.16  2/76
R9  O        (1.93)   (0.26)          BASILE    66 OSPK ETA +- = 1.92+-0.13  2/76
R9  O        (1.993)  (0.080)         BOTT-BODE 66 OSPK ETA +- = 1.95+-0.04  2/76
R9  M 4200   (2.60)   (0.07)          MESSNER   73 ASPK ETA +- = 2.23+-0.05  6/73
R9  O   OLD EXPERIMENTS EXCLUDED FROM FIT.  SEE SUBSECTION E+- BELOW FOR     2/76
R9  O   AVERAGE ETA+- OF THESE EXPERIMENTS AND FOR NOTE ON DISCREPANCY.      2/76
R9  M   FROM SAME DATA AS R27 MESSNER 73,BUT WITH DIFFERENT NORMALIZATION.   6/73
R9          . . . . . . . . .
R9  FIT       2.589    0.060  FROM FIT

R10    KL INTO (PI MU NEU)/(PI E NEU)                      (P3)/(P4)
R10           0.81     0.19          ADAIR      64 HBC                       6/66
R10           0.82     0.10          DEBOUARD   67 OSPK                     11/67
R10     273   0.7      0.2           HAWKINS    67 HBC                       8/67
R10           0.81     0.08          HOPKINS    67 HBC                       8/67
R10     770   0.71     0.05          BUDAGOV    68 HLBC                     10/68
R10 K        (0.67)   (0.13)         KULYUKINA  68 CC                        3/74
R10 B  569   (0.71)   (0.04)         BEILLIERE  69 HLBC                     10/69
R10   1309   (0.648)  (0.030)         EVANS      69 HLBC REPL. BY EVANS 73    1/73
R10   3548    0.68     0.08          BASILE     70 OSPK                     10/70
R10   6700    0.741    0.044         BRANDENBU  73 HBC                       1/74
R10   1309    0.662    0.030         EVANS      73 HLBC                      1/73
R10    10K    0.662    0.037         WILLIAMS   74 ASPK                     10/74
R10    33K    0.702    0.011         CHO        80 HBC                       2/82
R10 K   KULYUKINA 68 R10 IS NOT MEASURED INDEPENDENTLY FROM R2 AND R4.        1/74
R10 B   BEILLIERE 69 IS A SCANNING EXPT USING SAME EXPOSURE AS BUDAGOV 68
R10         . . . . . . . . .
R10 AVG       0.7001   0.0093  AVERAGE
R10 FIT       0.7001   0.0092 FROM FIT

R11    KL INTO (MU+MU-)/CHARGED (UNITS 10**-6)             (P6)/(P2+P3+P4)
R11         (100.0)  OR LESS              ANIKINA    65 CC                     6/66
R11         (250.0)  OR LESS  CL=.90      ALFF-STEI  66 OSPK                   9/66
R11           (2.0)  OR LESS  CL=.90      BOTT-BODE  67 OSPK                   8/67
R11          (35.0)  OR LESS  CL=.90      FITCH      67 OSPK                   3/68

R12    KL INTO (PI+ PI- GAMMA)/TOTAL (UNITS 10**-3)        (P10)
R12          (15.0)  OR LESS              ANIKINA    65 CC                     6/66
R12       0   (5.0)  OR LESS              BELLOTTI   66 HLBC    GAM KE 40-130 MV  8/67
R12       1   (3.0)  OR LESS              NEFKENS    66 OSPK    GAM KE 120 MEV    6/66
R12           (0.4)  OR LESS  CL=.90      THATCHER   68 OSPK    GAM KE 20-170 MV  2/71
R12           (3.2)  OR LESS  CL=.90      BOBISUT    74 HLBC    GAM KE GT 40 MEV 12/75
R12  D  24   (0.062) (0.021)              DONALDS1   74 SPEC                    10/74
R12          (0.46) OR LESS  CL=.90       WOO        74 SPEC                    12/75
R12 H  516   (0.0152) (0.0016)            CARROLL2   80 SPEC +-0GAM KE GT 20 MEV 12/80
R12 J  546   (0.0289) (0.0028)            CARROLL2   80 SPEC +-0                12/80
R12  K1062    0.0441   0.0032            CARROLL2   80 SPEC +-0GAM KE GT 20 MEV 12/80
R12  D  USES KL TO PI+PI-PI0/ALL KL DECAYS = 0.126                             10/74
R12 H   INTERNAL BREMSSTRAHLUNG COMPONENT ONLY.                                12/80
R12 J   DIRECT GAMMA EMISSION COMPONENT ONLY.                                  12/80
R12  K  BOTH COMPONENTS. USES KL TO PI+PI-PI0/ALL KL DECAYS = 0.1239 .         12/80

R13    KL INTO (E+ E-)/CHARGED (UNITS 10**-6)              (P7)/(P2+P3+P4)
R13         (1000.0) OR LESS              ANIKINA    65 CC                     6/66
R13          (200.0) OR LESS  CL=.90      ALFF-STEI  66 OSPK                   6/66
R13           (23.0) OR LESS  CL=.90      BOTT-BODE  67 OSPK                   8/67

R14    KL INTO (E MU)/CHARGED (UNITS 10**-4)               (P8)/(P2+P3+P4)
R14     TEST OF LEPTON FAMILY NUMBER CONSERVATION.
R14          (10.0) OR LESS               ANIKINA    65 CC                     6/66
R14           (1.0) OR LESS  CL=.90       CARPENTER  66 OSPK                   8/66
R14           (0.1) OR LESS  CL=.90       BOTT-BODE  67 OSPK                   8/67
R14           0.08  OR LESS  CL=.90       FITCH      67 OSPK                   3/68

R15    KL INTO (E+ PI- NEU)/(E- PI+ NEU)
R15 O   97   (0.90)   (0.18)          NEAGU      61 CC
R15 O        (1.01)   (0.16)          LUERS      64 HBC                       8/66
R15 O  894   (0.99)   (0.023)         KULYUKINA  66 CC                        9/66
R15 O 1539   (1.06)   (0.05)          VERHEY     66 OSPK                      8/67
R15 O   LOW PRECISION EXPTS NOT AVERAGED.  FOR MORE PRECISE VALUE,
R15 O   SEE S13A2 IN THE CP VIOLATION SECTION BELOW.

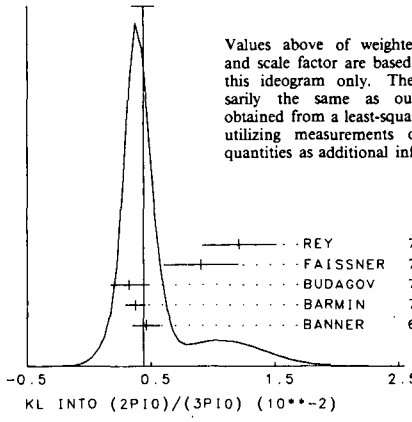
R16    KL INTO (MU+ PI- NEU)/(MU- PI+ NEU)
R16     1M    1.0081   0.0027         DORFAN     67 OSPK                     11/67
R16     SEE ALSO S13A2 AND S13AL IN THE CP VIOLATION SECTION BELOW.            2/71

R17    KL INTO (PI0 PI0)/TOTAL (UNITS 10**-3)              (P11)
R17 C    7   (1.2)    (1.5)    (1.2)  CRIEGEE   66 OSPK                        7/66
R17 C   CRIEGEE EXPT NOT DESIGNED TO MEASURE 2 PIO DECAY MODE
R17 G  189   (2.5)    (0.8)           GAILLARD  69 OSPK    E00=3.6+-0.6        5/69
R17 G   LATEST RESULT OF THIS EXPERIMENT GIVEN BY FAISSNER 70 R19                1/71
R17         . . . . . . . . .
R17 FIT       0.94     0.19   FROM FIT

R18    KL INTO (3PI0)/(PI+PI-PI0)                          (P1)/(P2)
R18    188    2.0      0.6             ALEKSANYA 64 FBC                        9/66
R18   1010    1.80     0.13            BUDAGOV   68 HLBC                      10/68
R18    883   (1.65)   (0.07)           BARMIN2   72 HLBC    ERROR STAT. ONLY  3/74
R18         . . . . . . . . .
R18 AVG       1.81     0.13    AVERAGE
R18 FIT       1.73     0.10   FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.7)

R19    KL INTO (2PI0)/(3PI0) (UNITS 10**-2)                (P11)/(P1)
R19 C  109   (1.89)   (0.31)           CRONIN 1  67 OSPK    ETA00=4.9+-0.5      8/67
R19 C        (1.36)   (0.18)           *CRONIN 2 67 OSPK    ETA00=3.92+-0.3    11/67
R19 C       CRONIN2 IS FURTHER ANALYSIS OF CRONIN1, NOW BOTH WITHDRAWN         11/68
R19     NO EVENTS SEEN                  BARTLETT  68 OSPK    SEE E00 BELOW      11/68
R19     57    0.46     0.11            BANNER    69 OSPK    ETA00=2.2+-0.3      2/72
R19 R  133   (1.31)   (0.31)           CENCE     69 OSPK    ETA00=3.7+-0.5     10/69
R19     29    0.37     0.08            BARMIN    70 HLBC    ETA00=2.02+-0.23   12/70
R19     30    0.32     0.15            BUDAGOV   70 HLBC    ETA00=1.9+-0.5     10/70
R19  F 172    0.90     0.30            FAISSNER  70 OSPK    ETA00=3.2+-0.5     12/70
R19  R 150    1.21     0.30            REY       76 OSPK    ETA00=3.8+-0.5      8/76
R19  F FAISSNER 70 CONTAINS SAME 2PI0 EVENTS AS GAILLARD 69 R17
R19  R  CENCE 69 EVENTS ARE INCLUDED IN REY 76.                                 1/77
R19         . . . . . . . . .
R19 AVG       0.437    0.092   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.6)
R19 FIT       0.437    0.085  FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.5)
                       (SEE IDEOGRAM BELOW)
```

WEIGHTED AVERAGE = 0.437 ± 0.092
ERROR SCALED BY 1.6



Values above of weighted average, error, and scale factor are based upon the data in this ideogram only. They are not necessarily the same as our "best" values, obtained from a least-squares constrained fit utilizing measurements of other (related) quantities as additional information.

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R20    KL INTO (PI+ PI-)/(KE3 + KMU3) (UNITS 10**-3)       (P5)/(P3+P4)
R20 O  309   (2.51)   (0.23)           DEBOUARD  67 OSPK    ETA+-=2.00+-0.09   2/76
R20 O  525   (2.35)   (0.19)           FITCH     67 OSPK    ETA+-=1.94+-0.08   2/76
R20   2703    3.04     0.14            DEVOE     77 SPEC    ETA+-=2.25+-0.05  11/77
R20 O   OLD EXPERIMENTS EXCLUDED FROM FIT.  SEE SUBSECTION E+- BELOW FOR       2/76
R20 O   AVERAGE ETA+- OF THESE EXPERIMENTS AND FOR NOTE ON DISCREPANCY.        2/76
R20         . . . . . . . . .
R20 FIT       3.076    0.075  FROM FIT

R21    KL INTO (2GAMMA)/(3 PI0) (UNITS 10**-3)             (P9)/(P1)
R21     16    2.5      0.7             ARNOLD    68 HLBC    VACUUM DECAY      11/68
R21    115    2.24     0.28            BANNER    69 OSPK                      11/68
R21     28    2.13     0.43            BARMIN    71 HLBC                       8/71
R21         . . . . . . . . .
R21 AVG       2.24     0.22    AVERAGE

R22    KL INTO (MU+MU-)/(PI+PI-) (UNITS 10**-6)            (P6)/(P5)
R22     TEST FOR DELTA-S = 1 WEAK NEUTRAL CURRENT.  ALLOWED BY FIRST ORDER
R22     WEAK INTERACTION COMBINED WITH ELECTROMAGNETIC INTERACTION.
R22      0  (140.)   OR LESS  CL=.90    FOETH     69 SPEC                      5/70
R22      0  (18.)    OR LESS  CL=.90    DARRIULAT 70 SPEC                     11/70
R22 A    0  (1.53) OR LESS  CL=.90      CLARK     71 SPEC                      2/76
R22  C   9    5.8      2.3       1.5   CARITHERS 73 SPEC                      2/76
R22  F   3    4.2      5.1       2.6   FUKUSHIMA 76 SPEC                      2/76
R22     15    4.0      1.4       0.9   SHOCHET   79 SPEC                      7/79
R22 A   CLARK 71 LIMIT RAISED FROM 1.2 E-06 BY FIELD 74 REANALYSIS.            2/76
R22 A   NOT IN AGREEMENT WITH SUBSEQUENT EXPTS. SO NOT AVERAGED.               2/76
R22  C  CARITHERS 73 ERRORS ARE AT CL=0.68, W.CARITHERS, PRIV.COMM. 1979.      2/76
R22  F  FUKUSHIMA 76 ERRORS ARE AT CL=90 PERCENT.                              2/76
R22         . . . . . . . . .
R22 AVG       4.47     0.95    AVERAGE

R23    KL INTO (E+ E- )/(PI+PI-) (UNITS 10**-5)            (P7)/(P5)
R23     TEST FOR DELTA-S = 1 WEAK NEUTRAL CURRENT.  ALLOWED BY FIRST ORDER
R23     WEAK INTERACTION COMBINED WITH ELECTROMAGNETIC INTERACTION.
R23      0   10.0    OR LESS  CL=.90    FOETH     69 ASPK                      5/70
R23 A        (0.10) OR LESS  CL=.90     CLARK     71 ASPK                      6/71
R23 A   POSSIBLE (BUT UNKNOWN) SYSTEMATIC ERRORS.  SEE NOTE A IN R22 ABOVE.   5/82*

R24    KL INTO (E MU)/(PI+PI-) (UNITS 10**-5)              (P8)/(P5)
R24 A        (0.10) OR LESS  CL=.90     CLARK     71 ASPK                      6/71
R24 A   POSSIBLE (BUT UNKNOWN) SYSTEMATIC ERRORS.  SEE NOTE A IN R22 ABOVE.   4/82

R25    KL INTO (PI E NEU GAM)/(KL E3) (UNITS 10**-2)       (P12)/(P3)
R25     10    3.3      2.0             PEACH     71 HLBC GAM KE GT 15 MEV      6/71

R26    KL INTO (PI0 TWO GAMMAS)/(3PI0) (UNITS 10**-3)      (P13)/(P1)
R26      0    1.1    OR LESS  CL=.90   BANNER    69 OSPK                       2/72

R27    KL INTO (PI+ PI-)/TAU (UNITS 10**-2)                (P5)/(P2)          6/73
R27   4200    1.64     0.04            MESSNER   73 ASPK    ETA +- = 2.23      6/73
R27         . . . . . . . . .
R27 FIT       1.635    0.035  FROM FIT
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Stable Particles

K_L^0

Data Card Listings

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R28    KL INTO (E+ E- GAMMA)/TOTAL  (UNITS 10**-5)       (P14)
R28     TEST FOR DELTA-S = 1 WEAK NEUTRAL CURRENT.  ALLOWED BY FIRST ORDER
R28     WEAK INTERACTION COMBINED WITH ELECTROMAGNETIC INTERACTION.
R28  B   0    (2.7)  OR LESS  CL=.90   BARMIN1   72 HLBC                  3/74
R28  C   4     1.74     0.87            CARROLL1  80 SPEC +-0             12/80
R28  B  USES KL TO 3PIO/TOTAL=0.214 .
R28  C  USES KL TO PI+PI-PIO/ALL KL DECAYS = 0.1239 .                     12/80

R29    KL INTO (MU+ MU- GAMMA)/TOTAL (UNITS 10**-6)      (P15)            12/75
R29     TEST FOR DELTA-S = 1 WEAK NEUTRAL CURRENT.  ALLOWED BY FIRST ORDER
R29     WEAK INTERACTION COMBINED WITH ELECTROMAGNETIC INTERACTION.
R29  D        (7.81) OR LESS  CL=.90   DONALDS3  74 SPEC                   6/77
R29  C   1     0.28     0.28            CARROLL1  80 SPEC +-0             12/80
R29  D  USES KL TO PI+PI-PIO/ALL KL DECAYS = 0.126 .                       6/77
R29  C  USES KL TO PI+PI-PIO/ALL KL DECAYS = 0.1239 .                     12/80

R30    KL INTO (MU+ MU- PIO)/TOTAL   (UNITS 10**-5)      (P16)            12/75
R30     TEST FOR DELTA-S = 1 WEAK NEUTRAL CURRENT.  ALLOWED BY FIRST ORDER
R30     WEAK INTERACTION COMBINED WITH ELECTROMAGNETIC INTERACTION.
R30  D        (5.66) OR LESS  CL=.90   DONALDS3  74 SPEC                   6/77
R30  C   0     0.12  OR LESS  CL=.90   CARROLL1  80 SPEC                  12/80
R30  D  USES KL TO PI+PI-PIO/ALL KL DECAYS = 0.126 .                       6/77
R30  C  USES KL TO PI+PI-PIO/ALL KL DECAYS = 0.1239 .                     12/80

R31    KL INTO (PI+PI-E+E-) /TOTAL   (UNITS 10**-6)      (P17)            12/75
R31         (30.)   OR LESS          ANIKINA   73 STRC                    3/78
R31  D        8.81  OR LESS  CL=.90   DONALDSON 76 SPEC                   6/77
R31  D  USES KL TO PI+PI-PIO/ALL KL DECAYS = 0.126 .                       6/77

R32    KL INTO (PIO PI+- E-+ NEU)/TOTAL (UNITS 10**-3)  (P18)            12/75
R32  D        (2.2)  OR LESS  CL=.90   DONALDS3  74 SPEC                   6/77
R32     16     0.062    0.020           CARROLL3  80 SPEC                  9/81
R32  D  DONALDSON3 74 USES KL TO PI+PI-PIO/ALL KL DECAYS = 0.126 .         6/77

R33    KL INTO ((PI MU ATOM)NEU)/(PI MU NEU) (10**-7)   (P19)/(P3)       11/82*
R33     18  SEEN                         COOMBES   76 WIRE                  6/77
R33    155     3.88     0.41            ARONSON   82 SPEC                 11/82*

R34    KL INTO (E+ E- PIO)/TOTAL (UNITS 10**-6)          (P20)
R34     TEST FOR DELTA-S = 1 WEAK NEUTRAL CURRENT.  ALLOWED BY FIRST ORDER
R34     WEAK INTERACTION COMBINED WITH ELECTROMAGNETIC INTERACTION.
R34  C   0     2.3   OR LESS  CL=.90   CARROLL1  80 SPEC                  12/80
R34  C  USES KL TO PI+PI-PIO/ALL KL DECAYS = 0.1239 .                     12/80

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                    13  KL ENERGY DEPENDENCE OF DALITZ PLOT

        FOR DISCUSSION, SEE NOTE ON SLOPE PARAMETERS IN THE CHARGED K
        SECTION OF THE DATA CARD LISTINGS ABOVE.

       MATRIX ELEMENT SQUARED = 1 + G*U + H*U**2 + J*V + K*V**2
       WHERE U=(S3-S0)/(MPI**2) AND V=(S1-S2)/(MPI+**2)

GTO    LINEAR COEFFICIENT G FOR KL --> PI+ PI- PIO MATRIX ELEMENT SQUARED
GTO Q   79   (0.55)   (0.23)          ADAIR     64 HBC  AV=-7.6 +- 1.7     3/71
GTO Q   77   (0.51)   (0.20)          LUERS     64 HBC  AV=-7.3 +- 1.6     3/71
GTO Q   66   (0.32)   (0.13)          ASTBURY1  65 CC   AV=-5.5 +- 1.5     3/71
GTO Q  310   (0.51)   (0.09)          ASTBURY2  65 CC   AV=-(7.3 +.6 -.8)  3/71
GTO Q  280   (0.64)   (0.17)          ANIKINA   66 CC   AV=-(8.2 +.9 -1.3) 3/71
GTO Q  126   (0.70)   (0.12)          HAWKINS   66 HBC  AV=-8.6 +- 0.7     3/71
GTO Q 1350   (0.649)  (0.044)         HOPKINS   67 HBC  AT=-0.294 +- .018 10/69
GTO Q 1198   (0.428)  (0.055)         NEFKENS   67 OSPK AU=-0.204 +- .025  3/71
GTO Q 2446   (0.400)  (0.045)         BASILE2   68 OSPK AT=-0.188 +- .020  3/71
GTO Q  29K   (0.650)  (0.012)         ALBROW    70 ASPK AY=-0.858+-.015    1/79
GTO QB 36K   (0.593)  (0.022)         BUCHANAN  70 SPEC AU=-0.278 +- .010  2/76
GTO Q 4400   (0.664)  (0.056)         SMITH     70 OSPK AT=-0.306 +-0.024  1/79
GTO Q  180   (0.50)   (0.11)          JAMES     72 HBC                     1/73
GTO Q 1486   (0.608)  (0.043)         KRENZ     72 HLBC AT=-0.277 +- .018 11/72
GTO Q  384   (0.688)  (0.074)         METCALF   72 ASPK AT=-0.31  +- .03  11/72
GTO Q        (0.612)  (0.032)         ALEXANDER 73 HBC                     2/76
GTO Q 3200   (0.73)   (0.04)          BRANDENBU 73 HBC                     1/74
GTO QC 20K   (0.619)  (0.027)         BISI      74 ASPK AT=-0.282 +- .011 10/74
GTO    509K   0.677   0.010           MESSNER   74 ASPK AY=-0.917+-.013    7/75
GTO Q  192   (0.69)   (0.07)          BALDOCEOL 75 HLBC                   12/75
GTO Q  56K   (0.590)  (0.022)         BUCHANAN  75 SPEC AU=-0.277 +- .010  7/75
GTO   H6499   0.681   0.024           CHO       77 HBC                    11/77
GTO    4709   0.620   0.023           PEACH     77 HBC                    11/77
GTO Q   QUADRATIC DEPENDENCE REQUIRED BY SOME EXPERIMENTS (SEE SECTIONS
GTO Q   HTO AND KTO BELOW).  CORRELATIONS PREVENT US FROM AVERAGING RESULTS
GTO Q   OF FITS NOT INCLUDING G, H, AND K TERMS.
GTO  B  BUCHANAN 70 RESULT REVISED BY BUCHANAN 75 TO INCLUDE RADIATIVE COR.  2/76
GTO  B  AND TO USE MORE RELIABLE KL MOM.SPECT. OF 2ND EXPT.(HAD SAME BEAM).  2/76
GTO  C  BISI 74 VALUE COMES FROM QUADRATIC FIT WITH QUAD. TERM CONSISTENT   11/75
GTO  C  WITH ZERO.  GTO ERROR IS THUS LARGER THAN IF LINEAR FIT WERE USED.  11/75
GTO        . . . . . . . . .
GTO AVG      0.670   0.014   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.6)
                             (SEE IDEOGRAM BELOW)
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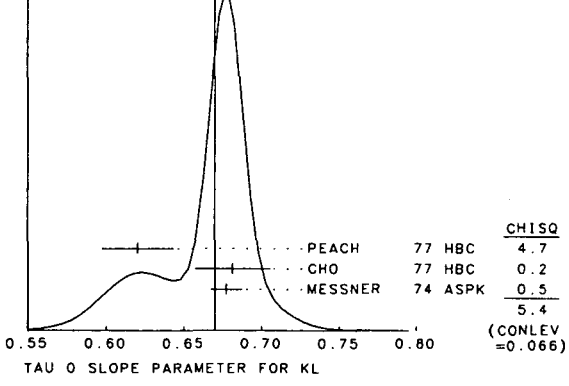


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HTO    QUADRATIC COEFF. H FOR KL --> PI+ PI- PIO MATRIX ELEMENT SQUARED
HTO Q  29K  (-0.011)  (0.018)         ALBROW    70 ASPK                   1/79
HTO Q 4400   (0.043)  (0.052)         SMITH     70 OSPK                   1/79
HTO    509K   0.079   0.007           MESSNER   74 ASPK                   3/78
HTO    6499   0.095   0.032           CHO       77 HBC                    3/78
HTO    4709   0.048   0.036           PEACH     77 HBC                    3/78
HTO     SEE NOTES IN SECTION GTO ABOVE.                                   1/79
HTO        . . . . . . . . .
HTO AVG       0.0786  0.0067  AVERAGE

KTO    QUADRATIC COEFF. K FOR KL --> PI+ PI- PIO MATRIX ELEMENT SQUARED
KTO    509K   0.0097  0.0018          MESSNER   74 ASPK                   3/78
KTO    6499   0.024   0.010           CHO       77 HBC                    3/78
KTO    4709  -0.008   0.012           PEACH     77 HBC                    3/78
KTO        . . . . . . . . .
KTO AVG       0.0098  0.0018  AVERAGE

JTO    LINEAR COEFF. J FOR KL --> PI+ PI- PIO CP VIOLATING TERM           1/79
JTO    LISTED IN CP VIOLATION SECTION BELOW.                              1/79

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                    13  KL FORM FACTORS

        FOR DISCUSSION, SEE NOTE ON FORM FACTORS IN THE CHARGED K
        SECTION OF THE DATA CARD LISTINGS ABOVE.

        IN THE FORM FACTOR COMMENTS, THE FOLLOWING ABBREVIATIONS ARE USED.
        F+ AND F- ARE FORM FACTORS FOR THE VECTOR MATRIX ELEMENT.
        FS AND FT REFER TO THE SCALAR AND TENSOR TERM.
        F0 = (F+) + (F-)*T/(MK**2-MPI**2)
        L+, L- AND L0 ARE THE LINEAR EXPANSION COEFFS. OF F+, F- AND F0.
        L+ REFERS TO THE KMU3 VALUE EXCEPT IN THE KE3 SECTIONS.
        DXI/DL IS THE CORRELATION BETWEEN XI(0) AND L+ IN KMU3.
        DL0/DL+ IS THE CORRELATION BETWEEN L0 AND L+ IN KMU3.
        T  = MOMENTUM TRANSFER TO THE PI IN UNITS OF MPI**2.
        DP = DALITZ PLOT ANALYSIS
        PI = PI SPECTRUM ANALYSIS
        MU = MU SPECTRUM ANALYSIS
        POL= MU POLARIZATION ANALYSIS
        BR = KMU3/KE3 BRANCHING RATIO ANALYSIS
        E  = POSITRON OR ELECTRON SPECTRUM ANALYSIS
        RC = RADIATIVE CORRECTIONS

XIA    XIA = F-/F+ (DETERMINED FROM SPECTRA)  ---------------------------
XIA  A1341   +1.2     (0.8)           CARPENTER 66 OSPK    DP, DXI/DL=-18   1/74
XIA B 3140  (-3.9)    (0.4)           BASILE    70 OSPK    DP, INDEP OF L+  1/74
XIA C  16K  (-0.68)   (0.12)   (0.20) CHIEN     70 ASPK    DP, DXI/DL=-26   1/74
XIA  D9086   -1.5      0.7            ALBROW    72 ASPK    DP, DXI/DL=-28   1/74
XIA C  16K  (+0.50)   (0.61)          DALLY     72 ASPK    DP, DXI/DL UNKN. 1/74
XIA  E1385   -1.00    (0.45)          PEACH     73 HLBC    DP, DXI/DL=-20   1/74
XIA  F1.6M   -0.11     0.07           DONALDS2  74 SPEC    DP, DXI/DL=-17  11/75
XIA  G 32K   -0.25     0.22           BUCHANAN  75 SPEC    DP, DXI/DL=-5.9  2/76
XIA  H 16K   +0.13     0.23           HILL      79 STRC    DP, DXI/DL=-20   4/82
XIA  H 14K   +0.26     0.16           CHO       80 HBC     DP, DXI/DL=-13   4/82
XIA  I150K   -0.10     0.09           BIRULEV   81 SPEC    DP, DXI/DL=-12   4/82
XIA        . . . . . . . . .
XIA AVG      -0.074    0.061   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.2)
XIA FIT      -0.11     0.09    FROM FIT (ERROR INCLUDES SCALE FACTOR OF 2.3)  3/84*
                     (SEE IDEOGRAM BELOW)

XIA     FIT DISCUSSED IN NOTE ON KL3 FORM FACTORS IN 1982 EDITION.
XIA  A  CARPENTER 66 XI(0) IS FOR L+=0.  DXI/DL IS FROM FIG. 9.            1/74
XIA  B  BASILE 70 IS INCOMPATIBLE WITH ALL OTHER RESULTS.  AUTHORS SUGGEST 1/74
XIA  B  THAT EFFICIENCY ESTIMATES MIGHT BE RESPONSIBLE.                    1/74
XIA  C  CHIEN 70 ERRORS ARE STATISTICAL ONLY.  DXI/DL FROM FIG.4.          1/74
XIA  C  DALLY 72 IS A REANALYSIS OF CHIEN 70.  THE DALLY 72 RESULT IS      1/74
XIA  C  NOT COMPATIBLE WITH ASSUMPTION L-=0 SO NOT INCLUDED IN OUR FIT.    2/76
XIA  C  THE NON-ZERO L- VALUE AND THE RELATIVELY LARGE L+ VALUE FOUND BY   1/74
XIA  C  DALLY 72 COME MAINLY FROM A SINGLE LOW T BIN (FIGS.1,2).           1/74
XIA  C  THE (F+,XI) CORRELATION WAS IGNORED.                               1/74
XIA  C  WE ESTIMATE FROM FIG. 2 THAT FIXING L-=0 WOULD GIVE XI(0)=-1.4+-0.3 1/74
XIA  C  AND WOULD ADD 10 TO CHI SQUARED.  DXI/DL IS NOT GIVEN.             1/74
XIA  D  ALBROW 72 FIT HAS L- FREE, GETS L-=-.030+-.060 OR LAM=+.15+.17-.11. 1/74
XIA  E  PEACH 73 GIVES XI0=-.95+-.45 FOR L+=L-=.025 .  THE ABOVE VALUE IS  1/74
XIA  E  FOR L-=0.  K.PEACH, PRIVATE COMMUNICATION(1974).                   1/74
XIA  F  DONALDSON2 74 GIVES XI=-.11+-.02 NOT INCLUDING SYSTEMATICS.  ABOVE 11/75
XIA  F  ERROR AND DXI/DL WERE CALCULATED BY US FROM L0 AND L+ ERRORS (WHICH 11/75
XIA  F  INCLUDE SYSTEMATICS) AND DL0/DL+.                                  11/75
XIA  G  BUCHANAN 75 IS CALCULATED BY US FROM L0, L+ AND DL0/DL+ BECAUSE    2/76
XIA  G  THEIR APPENDIX A VALUE -.20+-22 ASSUMES XI(T) CONSTANT, I.E. L-=L+. 2/76
XIA  H  HILL 79 AND CHO 80 CALCULATED BY US FROM L0, L+, AND DL0/DL+.      4/82
XIA  I  BIRULEV 81 ERROR, DXI/DL CALC. BY US FROM L0, L+.  DL0/DL+=0 USED. 4/82
```
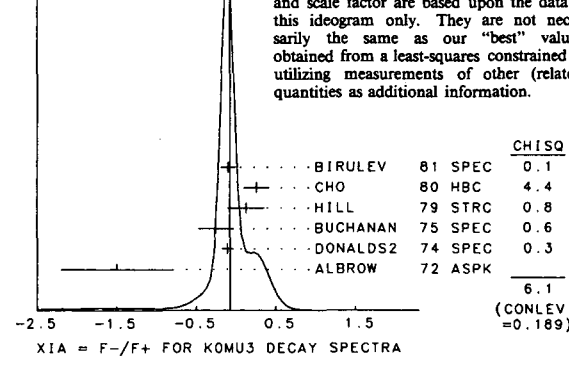



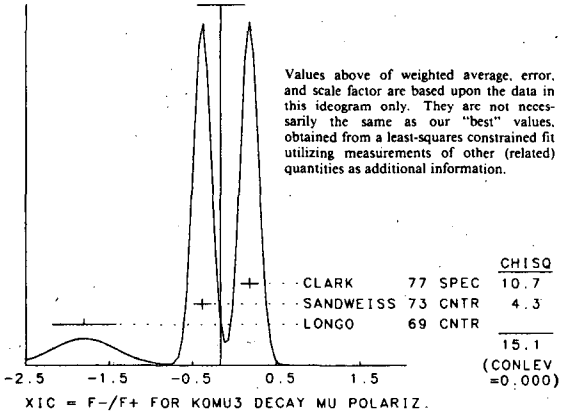
For notation, see key at front of Listings.

Stable Particles

K_L^0

```
XIB     XIB = F-/F+ (DETERMINED FROM KMU3/KE3)  ---------------------------
XIB      THE KMU3/KE3 BRANCHING RATIO FIXES A RELATIONSHIP BETWEEN XI(0)      1/74
XIB      AND L+.  WE QUOTE THE AUTHORS XI(0) AND ASSOCIATED L+ BUT DO NOT     1/74
XIB      AVERAGE BECAUSE THE L+ VALUES DIFFER.  THE FIT RESULT AND SCALE      1/74
XIB      FACTOR GIVEN IN THE NOTE ON KL3 FORM FACTORS IN THE K+- SECTION OF   2/76
XIB      THE DATA CARDS ARE NOT OBTAINED FROM THESE XIB VALUES.  INSTEAD      2/76
XIB      THEY ARE OBTAINED DIRECTLY FROM THE AUTHORS KMU3/KE3 BRANCHING       2/76
XIB      RATIO VIA THE FITTED KMU3/KE3 RATIO (R10).                           2/76
XIB    389  (+1.1)    (1.1)            ADAIR     64 HBC     BR, L+=0          1/74
XIB         (+0.66)   (0.9)    (1.3)   LUERS     64 HBC     BR, L+=0          1/74
XIB         (+0.2)    (0.8)    (1.2)   KULYUKINA 68 CC      BR, L+=0          1/74
XIB    569  (+0.45)   (0.28)           BEILLIERE 69 HLBC    BR, L+=0          1/74
XIB E 1309  (-0.22)   (0.30)           EVANS     69 HLBC                      1/74
XIB   3548  (-0.5)    (0.5)            BASILE    70 OSPK    BR, L+=.02        1/74
XIB   6700  (0.5)     (0.4)            BRANDENBU 73 HBC     BR,L+=.019+-.013  1/74
XIB  E1309  (-0.08)   (0.25)           EVANS     73 HLBC    BR, L+=.02        1/74
XIB         . . . . . . . . .
XIB FIT     -0.11     0.09   FROM FIT (ERROR INCLUDES SCALE FACTOR OF 2.3)  3/84*

XIB     FIT DISCUSSED IN NOTE ON KL3 FORM FACTORS IN 1982 EDITION.
XIB  E  EVANS 73 REPLACES EVANS 69.                                          1/74

XIC     XIC = F-/F+ (DETERMINED FROM MU POLARIZATION IN KMU3)  ------------
XIC     THE MU POLARIZATION IS A MEASURE OF XI(T). NO ASSUMPTIONS ON L+-
XIC     NECESSARY, T (WEIGHTED BY SENSITIVITY TO XI0) SHOULD BE SPECIFIED.
XIC     IN L+,XI(0) PARAMETERIZATION THIS IS XI(0) FOR L+=0.  DXI/DL=XI*T.
XIC      FOR RAD. CORR. TO MUON POLARIZATION IN KMU3, SEE GINSBERG 73.      2/72
XIC T 2608  (-1.2)    (0.5)            AUERBACH  66 OSPK    POLARIZATION      8/67
XIC T  638  (-1.6)    (0.5)            ABRAMS    68 OSPK    POLARIZATION      5/69
XIC  L      -1.81     0.50     0.26    LONGO     69 CNTR    POL. T=3.3        1/74
XIC  S2.2M  -0.385    0.105            SANDWEISS 73 CNTR    POL,DXI/DL=-6     1/74
XIC  H207K  +0.178    0.105            CLARK     77 SPEC    POL,DXI/DL=+.68  11/77
XIC         . . . . . . . . .
XIC AVG     -0.17     0.28    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 3.9)
XIC FIT     -0.11     0.09   FROM FIT (ERROR INCLUDES SCALE FACTOR OF 2.3)  3/84*
                      (SEE IDEOGRAM BELOW)

XIC     FIT DISCUSSED IN NOTE ON KL3 FORM FACTORS IN 1982 EDITION.
XIC T   T VALUE NOT GIVEN.                                                   1/74
XIC  L  LONGO 69 T=3.3 CALC. FROM DXI/DL=-6.0 (TABLE 1) DIVIDED BY XI=-1.81  1/74
XIC  S  SANDWEISS 73 IS FOR L+=0 AND T=0.                                    1/74
XIC  H  CLARK 77 T=+3.80, DXI/DL=XI(T)*T=.178*3.80=+.68 .                   11/77
```

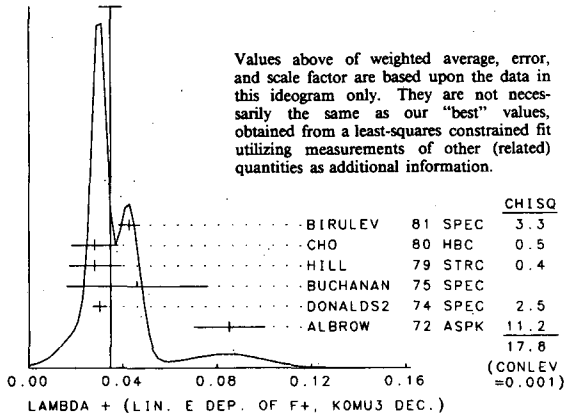
WEIGHTED AVERAGE = -0.17 ± 0.28
ERROR SCALED BY 3.9



XIC = F-/F+ FOR KOMU3 DECAY MU POLARIZ.

```
IXI       IMAGINARY PART OF XI  (TEST OF T REVERSAL)  --------------------
IXI         -0.2      0.6              ABRAMS    68 OSPK    POLARIZATION     10/69
IXI         -0.02     0.08             LONGO     69 CNTR    POL. T=3.3       11/69
IXI   2.2M  -0.060    0.045            SANDWEISS 73 CNTR    POL, T=0          1/74
IXI  S2.2M  -0.085    0.064            SANDWEISS 73 CNTR    POL,T=0          12/79
IXI  C207K   0.35     0.30             CLARK     77 SPEC    POL, T=0         11/77
IXI         (0.012)   (0.026)          SCHMIDT   79 CNTR    REPL.BY MORSE 80 12/79
IXI    12M   0.009     0.030           MORSE     80 CNTR    POLARIZATION     10/81
IXI  S  SANDWEISS 73 VALUE CORRECTED FROM VALUE QUOTED IN THEIR PAPER DUE    12/79
IXI  S  TO NEW VALUE OF RE(XI). SEE FTNOTE 4 OF SCHMIDT 79.                  12/79
IXI  C  CLARK 77 VALUE HAS ADDITIONAL XI0 DEPENDENCE +0.21*RE(XI0).          11/77
IXI         . . . . . . . . .
IXI AVG     -0.020    0.022   AVERAGE

L+M     LAMBDA +  (LINEAR ENERGY DEPENDENCE OF F+ IN KMU3 DECAY)  ---------
L+M      SEE ALSO THE CORRESPONDING ENTRIES AND NOTES IN SECTION XIA AND L0.
L+M      FOR RAD.COR. OF KMU3 DP SEE GINSBURG 70 AND BECHERRAWY 70.          3/74
L+M   16K   (0.07)    (0.02)           CHIEN     70 ASPK REPL. BY DALLY 72    1/74
L+M  A9086   0.085     0.015           ALBROW    72 ASPK    DP                1/74
L+M   16K   (0.11)    (0.04)           DALLY     72 ASPK    DP                1/74
L+M   82K   (0.046)   (0.008)          ALBRECHT  74 WIRE REPL. BY BIRULEV 81 11/75
L+M  1.6M    0.030     0.003           DONALDS2  74 SPEC    DP               10/74
L+M   32K    0.046     0.030           BUCHANAN  75 SPEC    DP                9/75
L+M  129K   (0.0337) (0.0033)          DZHORDZHA 77 SPEC REPL. BY BIRULEV 81 12/79
L+M   16K    0.028     0.011           HILL      79 STRC    DP               12/79
L+M   14K    0.028     0.010           CHO       80 HBC     DP                2/82
L+M  150K    0.0427    0.0044          BIRULEV   81 SPEC    DP                1/82
L+M         . . . . . . . . .
L+M AVG      0.0347    0.0049  AVERAGE (ERROR INCLUDES SCALE FACTOR OF 2.1)
L+M FIT      0.034     0.005  FROM FIT (ERROR INCLUDES SCALE FACTOR OF 2.3)  3/84*
                      (SEE IDEOGRAM BELOW)

L+M     FIT DISCUSSED IN NOTE ON KL3 FORM FACTORS IN 1982 EDITION.
```

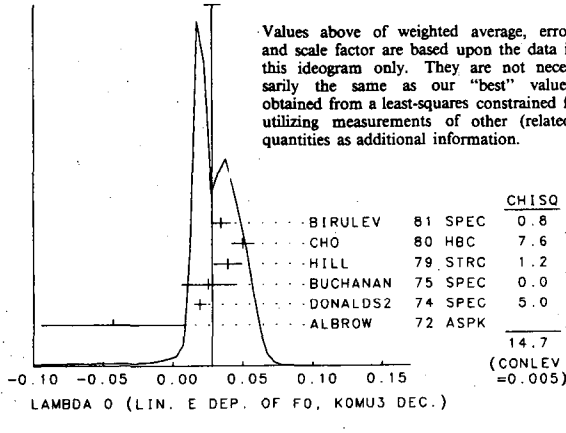
WEIGHTED AVERAGE = 0.0347 ± 0.0049
ERROR SCALED BY 2.1



LAMBDA + (LIN. E DEP. OF F+, KOMU3 DEC.)

```
L0      LAMBDA 0 (LINEAR ENERGY DEPENDENCE OF F0 IN KMU3 DECAY)  ----------
L0       WHEREVER POSSIBLE, WE HAVE CONVERTED THE ABOVE VALUES OF XI(0) INTO
L0       VALUES OF L0 USING THE ASSOCIATED L+M AND DXI/DL.
L0 L  1371   +0.08    (0.07)           CARPENTER 66 OSPK    DP,DL0/DL+=-0.54  1/74
L0 L         -0.140   (0.043)  (0.022)LONGO     69 CNTR    POL,DL0/DL+=+.49  1/74
L0  B 3140  (-0.333)  (0.034)          BASILE    70 OSPK    DP,DL0/DL+=+1.    1/74
L0 A  9086   -0.043    0.052           ALBROW    72 ASPK    DP,DL0/DL+=-1.39  1/74
L0  C  16K  (-0.067)  (0.227)          DALLY     72 ASPK    DP,DL0/DL+ UNKN.  1/74
L0  R 6700  (+0.06)   (0.03)           BRANDENBU 73 HBC     BR,L+=.019+-.013  1/74
L0 P  1385   -0.060   (0.038)          PEACH     73 HLBC    DP,DL0/DL+=-0.71  1/74
L0 L  2.2M   -0.018   (0.009)          SANDWEISS 73 CNTR    POL,DL0/DL+=+.49  1/74
L0     82K  (+0.024)  (0.011)          ALBRECHT  74 WIRE REPL. BY BIRULEV 81 11/75
L0 E  1.6M   +0.019    0.004           DONALDS2  74 SPEC    DP,DL0/DL+=-0.47 10/74
L0   F 32K   +0.025    0.019           BUCHANAN  75 SPEC    DP,DL0/DL+=+0.5   2/76
L0 L  207K   +0.047   (0.009)          CLARK     77 SPEC    POL,DL0/DL+=1.06 11/77
L0     47K  (+0.0485) (0.0076)         DZHORDZHA 77 SPEC REPL. BY BIRULEV 81 12/79
L0     16K   +0.039    0.010           HILL      79 STRC    DP,DL0/DL+=-0.67 12/79
L0     14K   +0.050    0.008           CHO       80 HBC     DP,DL0/DL+=-0.11  2/82
L0  G  14K   (0.041)   (0.008)         CHO       80 HBC     BR, L+=0.028      2/82
L0 H  150K    0.0341   0.0067          BIRULEV   81 SPEC    DP,DL0/DL+=?      4/82
L0          . . . . . . . . .
L0  AVG       0.0279   0.0057  AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.9)
L0  FIT       0.025    0.006  FROM FIT (ERROR INCLUDES SCALE FACTOR OF 2.3)  3/84*
                      (SEE IDEOGRAM BELOW)

L0      FIT DISCUSSED IN NOTE ON KL3 FORM FACTORS IN 1982 EDITION.
L0 L    L0 VALUE IS FOR L+=0.03  CALCULATED BY US FROM XI0 AND DXI/DL.       1/74
L0  B   BASILE 70 L0 IS FOR L+=0.  CALCULATED BY US FROM XIA WITH DXI/DL=0.  1/74
L0  B   BASILE 70 IS INCOMPATIBLE WITH ALL OTHER RESULTS.  AUTHORS SUGGEST   1/74
L0  B   THAT EFFICIENCY ESTIMATES MIGHT BE RESPONSIBLE.                      1/74
L0 A    ALBROW 72 L0 IS CALCULATED BY US FROM XIA,L+ AND DXI/DL.  THEY GIVE  1/74
L0 A    L0=-.043+-.039 FOR L-=0.  WE USE OUR LARGER CALCULATED ERROR.        1/74
L0  C   DALLY 72 GIVES F0=1.20+-.35, L0=-.080+-.272, L0PRIME=-.006+-.045,    1/74
L0  C   BUT WITH A DIFFERENT DEFINITION OF L0.  OUR QUOTED L0 IS HIS L0/F0.  1/74
L0  C   WE CANNOT CALCULATE TRUE L0 ERROR WITHOUT HIS (L0,F0) CORRELATIONS.  1/74
L0  C   SEE ALSO NOTE C IN SECTION XIA.                                      1/74
L0 P    PEACH 73 ASSUMES L+=0.025.  CALCULATED BY US FROM XI0 AND DXI0/DL+.  1/74
L0  R   FIT FOR L0 DOES NOT INCLUDE THIS VALUE BUT INSTEAD INCLUDES THE      2/76
L0  R   KMU3/KE3 RESULT FROM THIS EXPERIMENT.                                2/76
L0 E    DONALDSON2 74 DL0/DL+ OBTAINED FROM FIG. 18.                        11/75
L0   F  BUCHANAN 75 VALUE IS FROM THEIR APPENDIX A AND USES ONLY KMU3 DATA.  2/76
L0   F  DL0/DL+ WAS OBTAINED BY PRIVATE COMMUNICATION, C.BUCHANAN, 1976.    2/76
L0   G  CHO 80 BR RESULT NOT INDEPENDENT OF THEIR DP RESULT.                 4/82
L0   H  BIRULEV 81 GIVES DL0/DL+=-1.5, GIVING AN UNREASONABLY NARROW ERROR   4/82
L0   H  ELLIPSE WHICH DOMINATES ALL OTHER RESULTS.  WE USE DL0/DL+=0.        4/82
```

WEIGHTED AVERAGE = 0.0279 ± 0.0057
ERROR SCALED BY 1.9



LAMBDA 0 (LIN. E DEP. OF F0, KOMU3 DEC.)

Stable Particles

K_L^0

Data Card Listings

```
L+E     LAMBDA +  (LINEAR ENERGY DEPENDENCE OF F+ IN K0 E3 DECAY)      ------
L+E      FOR RAD.COR. OF KE3 DP SEE GINSBURG 67 AND BECHERRAWY 70.          3/74
L+E    153   +0.07     0.06            LUERS     64 HBC     DP, NO RC
L+E    577   +0.15     0.08            FISHER    65 OSPK    DP, NO RC        8/67
L+E    762   -0.01     0.02            FIRESTONE 67 HBC     DP, NO RC        8/67
L+E    531   +0.01     0.015           KADYK     67 HBC     E,PI, NO RC      8/67
L+E    240   +0.08     0.10     0.08   LOWYS     67 FBC     PI               8/67
L+E   1000    0.02     0.013           ARONSON   68 OSPK    PI               5/69
L+E   4800   +0.023    0.012           BASILE    68 OSPK    DP, NO RC        3/68
L+E    42K    0.023    0.005           BISI      71 ASPK    DP              12/71
L+E    16K    0.05     0.01            CHIEN     71 ASPK    DP, NO RC        6/71
L+E   1910    0.022    0.014           NEUHOFER  72 ASPK    PI               1/73
L+E   5600    0.045    0.014           ALBROW    73 ASPK    DP               9/73
L+E   1871    0.019    0.013           BRANDENBU 73 HBC     PI TRANSV.       1/74
L+E   2171    0.040    0.012           WANG      74 OSPK    DP               7/74
L+E    25K    0.0270   0.0028          BLUMENTHA 75 SPEC    DP               7/75
L+E    24K    0.044    0.006           BUCHANAN  75 SPEC    DP               7/75
L+E    48K   (0.032)  (0.0042)         BIRULEV   76 SPEC REPL. BY BIRULEV 81  1/78
L+E   500K    0.0312   0.0025          GJESDAL   76 SPEC    DP               1/77
L+E  E 12K    0.025    0.005           ENGLER    78 HBC     DP               7/79
L+E    18K    0.0348   0.0044          HILL      78 STRC    DP               6/78
L+E    26K   (0.0286) (0.0049)         BIRULEV   79 SPEC REPL. BY BIRULEV 81 10/81
L+E  E 19K   (0.029)  (0.005)           CHO       80 HBC     DP               2/82
L+E    74K    0.0306   0.0034          BIRULEV   81 SPEC    DP               1/82
L+E  E  ENGLER 78 USES UNIQUE KE3 SUBSET OF CHO 80 EVENTS AND IS LESS         2/82
L+E  E  SUBJECT TO SYSTEMATIC EFFECTS.                                        2/82
L+E       . . . . . . . . . .
L+E AVG      0.0300   0.0016  AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.2)
                      (SEE IDEOGRAM BELOW)
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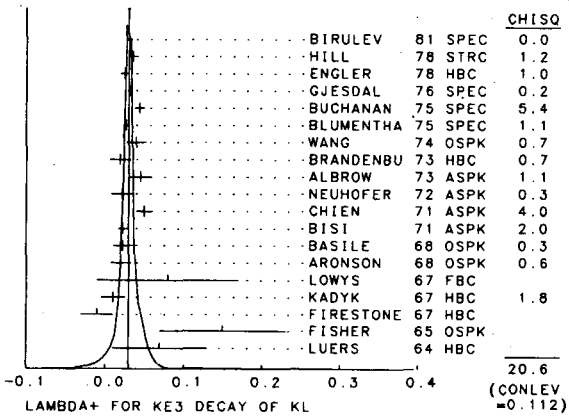
WEIGHTED AVERAGE = 0.0300 ± 0.0016
ERROR SCALED BY 1.2

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FS      FS/F+  RATIO OF SCALAR TO F+ COUPLINGS FOR KE3 DECAY(ABS. VALUE)----
FS           (0.15) OR LESS  CL=.68   KULYUKINA 67 CC                        10/69
FS     5600  (0.19) OR LESS  CL=.95   ALBROW    73 ASPK                       9/73
FS      25K  (0.04) OR LESS  CL=.68   BLUMENTHA 75 SPEC                       7/75
FS      48K  (0.07) OR LESS  CL=.68   BIRULEV   76 SPEC SEE ALSO BIRULEV 81   1/78
FS      18K  (0.095)OR LESS  CL=.95   HILL      78 STRC                       6/78

FT      FT/F+  RATIO OF TENSOR TO F+ COUPLINGS FOR KE3 DECAY(ABS. VALUE)----
FT           (1.0)  OR LESS  CL=.68   KULYUKINA 67 CC                        10/69
FT     5600  (1.0)  OR LESS  CL=.95   ALBROW    73 ASPK                       9/73
FT      25K  (0.23) OR LESS  CL=.68   BLUMENTHA 75 SPEC                       7/75
FT      48K  (0.34) OR LESS  CL=.68   BIRULEV   76 SPEC SEE ALSO BIRULEV 81   1/78
FT      18K  (0.40) OR LESS  CL=.95   HILL      78 STRC                       6/78

FTM     FT/F+  RATIO OF TENSOR TO F+ COUPLINGS FOR KMU3 DECAY(ABS. VALUE)---
FTM          (0.12)   (0.12)          BIRULEV   81 SPEC                       2/82

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```

NOTE ON CP VIOLATION IN K_L^0 DECAY

We list the parameters which measure CP violation in K_L^0 decays and compare them with superweak model predictions.

Parameters

There are three different K_L^0 decays in which CP can be tested (for details, see Okun and Rubbia[1], Steinberger[2], and Wolfenstein[3]).

(a) Charge asymmetry in $K_L \to \pi^+\pi^-\pi^0$ decays. As was discussed in the note on $K \to 3\pi$ decay in the $K^\pm$ section of the Data Card Listings, the Dalitz plot distribution for this decay contains a charge asymmetry term with coefficient j, the presence of which would indicate CP violation. Experimenters have used several forms for this CP-violation term. As described in the "Note on Slope Parameters for $K \to 3\pi$ Decays" in the 1982 edition of this Review,[4] we have converted all results to coefficient j and have listed the results in section JT0 below. The coefficient j is consistent with zero, i.e., absence of CP violation.

(b) Asymmetry in the $K_L \to \pi^\mp \ell^\pm \nu$ decays. The quantity measured and compiled here is

$$\delta = \frac{\Gamma(K_L \to \pi^-\ell^+\nu) - \Gamma(K_L \to \pi^+\ell^-\nu)}{\Gamma(K_L \to \pi^-\ell^+\nu) + \Gamma(K_L \to \pi^+\ell^-\nu)} .$$

This asymmetry violates CP invariance. If CPT is good, for a pure K_L^0 beam, δ can be written as

$$\delta = 2[(1-|x|^2)/(|1-x|^2)]\,\mathrm{Re}\,\epsilon ,$$

where x is defined below in the "Note on the $\Delta S = \Delta Q$ Rule in K^0 Decay," and ϵ is the parameter of the expansion

$$|K_L\rangle = [(1+\epsilon)|K\rangle - (1-\epsilon)|\bar{K}\rangle]/[2(1+|\epsilon|^2)]^{1/2}, \quad (1a)$$

$$|K_S\rangle = [(1+\epsilon)|K\rangle + (1-\epsilon)|\bar{K}\rangle]/[2(1+|\epsilon|^2)]^{1/2}. \quad (1b)$$

We list δ separately for $K_L^0 \to \pi\mu\nu$ and $K_L^0 \to \pi e\nu$ in sections A1 and A2 respectively, and list the combined values in section AL.

(c) $K_L \to 2\pi$ decay. The relevant parameters are

$$\eta_{+-} = A(K_L \to \pi^+\pi^-)/A(K_S \to \pi^+\pi^-)$$

$$= |\eta_{+-}|\exp(i\phi_{+-}) ,$$

$$\eta_{00} = A(K_L \to \pi^0\pi^0)/A(K_S \to \pi^0\pi^0)$$

$$= |\eta_{00}|\exp(i\phi_{00}) ,$$

ϵ, defined in Eqs. (1) above, and

$$\epsilon' = \tfrac{1}{2} i\sqrt{2}\exp[i(\delta_2 - \delta_0)]\,\mathrm{Im}(A_2/A_0) .$$

Here, A_i and δ_i are the amplitude and phase of $\pi\pi$ scattering at the K mass, defined by

$$\langle I{=}0|T|K\rangle = \exp(i\delta_0)A_0 ,$$

$$\langle I{=}2|T|K\rangle = \exp(i\delta_2)A_2 .$$

Wu and Yang[5] have derived the relationships

$$\eta_{+-} = \epsilon + \epsilon' , \quad \eta_{00} = \epsilon - 2\epsilon' .$$

For notation, see key at front of Listings.

Measurements of $|\eta_{+-}|$, $|\eta_{00}|^2$, ϕ_{+-}, and ϕ_{00} are listed in sections E+−, E0S, F+−, and F00. The FIT values given in these sections come from constrained fits which include the $|\eta_{00}|/|\eta_{+-}|$ and $\phi_{00} - \phi_{+-}$ measurements from sections ER and DF, respectively.

Superweak model predictions for $|\eta_{00}/\eta_{+-}|$, ϕ_{+-}, and Re ϵ

The superweak model[6] predicts that[7]

$$|\eta_{00}/\eta_{+-}| = 1 ,$$

$$\phi_{+-} = \phi_{00} = \tan^{-1}\left(\frac{2\Delta m \tau_S}{\hbar}\right) ,$$

and

$$\mathrm{Re}\,\epsilon = |\eta_{+-}| \left[1 + \left(\frac{2\Delta m \tau_S}{\hbar}\right)^2\right]^{-1/2} .$$

The latter two expressions and the values of the $K^0_L - K^0_S$ mass difference $\Delta m = (0.5349 \pm 0.0022)\times 10^{10}\,\hbar$ sec^{-1}, the K^0_S mean life $\tau_S = (0.8923 \pm 0.0022)\times 10^{-10}$ sec, and the magnitude of the $(K^0_L \to \pi^+\pi^-)/(K^0_S \to \pi^+\pi^-)$ amplitude ratio $|\eta_{+-}| = (2.274 \pm 0.022)\times 10^{-3}$, all from the current edition, result in the predictions that

$$\phi_{+-} = \phi_{00} = (43.67 \pm 0.14)^\circ$$

and

$$\mathrm{Re}\,\epsilon = (1.645 \pm 0.016)\times 10^{-3} .$$

The above predictions can be compared with the experimental values

$$|\eta_{00}/\eta_{+-}| = 1.023 \pm 0.036 ,$$

$$\phi_{+-} = (44.6 \pm 1.2)^\circ ,$$

$$\phi_{00} = (54.5 \pm 5.3)^\circ ,$$

$$\mathrm{Re}\,\epsilon = (1.621 \pm 0.088)\times 10^{-3} ,$$

where Re ϵ has been computed using the relation

$$\mathrm{Re}\,\epsilon = \frac{\delta}{2}\left(\frac{|1-x|^2}{1-|x|^2}\right) ,$$

and our current values of the charge asymmetry parameter for leptonic K^0_L decay $\delta = (0.330 \pm 0.012)\%$ and the $\Delta S = -\Delta Q$ amplitude (Rex, Imx) = (0.009 ± 0.020, −0.004 ± 0.026).

The superweak predictions are within one standard deviation of the data except for the measured value of ϕ_{00}, which is two standard deviations above the prediction. This results primarily from the CHRISTENSON1 79 measurement $\phi_{00} = (55.7 \pm 5.8)^\circ$.

References

1. L.B. Okun and C. Rubbia, in *Proceedings Heidelberg Conference on Elementary Particles*, p. 301 (1967).
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                    13  CP VIOLATION PARAMETERS IN KL DECAYS

--------------------13 CHARGE ASYMMETRY IN TAU DECAYS----------------------

JT0    CP VIOL. COEFF. J FOR KL --> PI+ PI- PIO MATRIX ELEMENT SQUARED.
JT0    DEFINED AT BEGINNING OF SECTION GTO ABOVE. SEE ALSO NOTE ON SLOPE
JT0    PARAMETERS IN CHARGED K SECTION AND NOTE ON CP VIOLATION IN KL
JT0    DECAY ABOVE.
JT0   238K    0.001    0.004          BLANPIED  68                          1/79
JT0     3M    0.0013   0.0009         SCRIBANO  70                          1/79
JT0   4400    0.0      0.017          SMITH     70 OSPK                     1/79
JT0   6499    0.001    0.011          CHO       77                          1/79
JT0   4709   -0.001    0.003          PEACH     77                          1/79
JT0          . . . . . . . . . .
JT0 AVG       0.00110  0.00084  AVERAGE

--------------------13  CHARGE ASYMMETRY IN LEPTONIC DECAYS (PERCENT)------

       SUCH ASYMMETRY VIOLATES CP . IT IS RELATED TO REAL(EPSILON).

A1    KL INTO (MU+PI-NU)-(MU-PI+NU)/(MU+PI-NU)+(MU-PI+NU)    (PERCENT)
A1  D   1M    (0.403)  (0.134)          DORFAN    67 OSPK    DERIVED FROM R16 11/67
A1 D    1M    0.57     0.17             PACIOTTI  69 OSPK                     1/73
A1    7.7M    0.278    0.051            PICCIONI  72 ASPK                     1/73
A1    4.1M    0.60     0.14             MCCARTHY  73 CNTR                     6/73
A1     15M    0.313    0.029            GEWENIG1  74 ASPK                     7/74
A1 D    PACIOTTI 69 IS A REANALYSIS OF DORFAN 67 AND IS CORRECTED FOR          1/73
A1 D    MU+ MU- RANGE DIFFERENCE IN MC CARTHY 72.                              1/73
A1          . . . . . . . . . .
A1  AVG       0.319    0.038   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.5)
                       (SEE IDEOGRAM BELOW)
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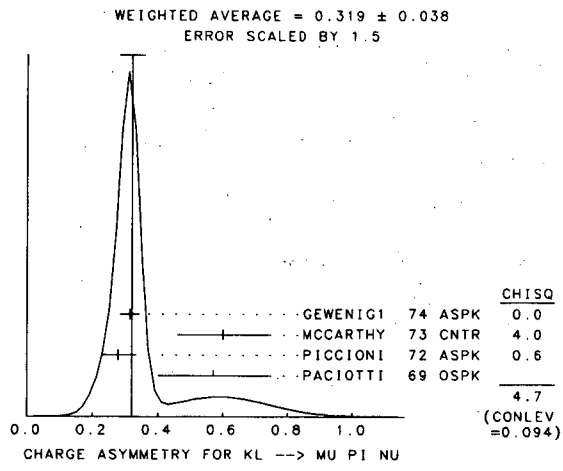

Stable Particles

Data Card Listings

K^0_L

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A2    KL INTO (E+PI-NU)-(E-PI+NU)/(E+PI-NU)+(E-PI+NU)          (PERCENT)
A2  B  10M   (0.224)  (0.036)          BENNETT   67 CNTR                        11/67
A2 B   10M    0.246    0.059           SAAL      69 CNTR                        10/70
A2     10M    0.346    0.033           MARX      70 CNTR                        10/70
A2    600K    0.36     0.18            ASHFORD   72 ASPK                         2/72
A2     40M    0.318    0.038           FITCH     73 ASPK                        12/73
A2     34M    0.341    0.018           GEWENIG1  74 ASPK                         7/74
A2  B SAAL 69 IS A REANALYSIS OF BENNETT 67
A2           . . . . . . . . . .
A2  AVG       0.333    0.014    AVERAGE

AL     KL INTO ((L+)-(L-))/((L+)+(L-))  (COMBINED A1 AND A2) (PERCENT)
AL B   10M    0.246    0.059           SAAL      69 CNTR   KE3                   2/71
AL D    1M    0.57     0.17            PACIOTTI  69 OSPK   KMU3                  1/73
AL     10M    0.346    0.033           MARX      70 CNTR   KE3                   2/71
AL    600K    0.36     0.18            ASHFORD   72 ASPK   KE3                   2/72
AL    7.7M    0.278    0.051           PICCIONI  72 ASPK   KMU3                  1/73
AL     40M    0.318    0.038           FITCH     73 ASPK   KE3                  12/73
AL    4.1M    0.60     0.14            MCCARTHY  73 CNTR   KMU3                  6/73
AL     33M    0.333    0.050           WILLIAMS  73 ASPK   KMU3+KE3             12/73
AL     15M    0.313    0.029           GEWENIG1  74 ASPK   KMU3                  7/74
AL     34M    0.341    0.018           GEWENIG1  74 ASPK   KE3                   7/74
AL      SEE FOOTNOTES IN SECTIONS A1 AND A2 ABOVE.                               1/73
AL           . . . . . . . . . .
AL  AVG       0.330    0.012    AVERAGE

-------------------13  PARAMETERS FOR KL INTO 2PI DECAY-----------------

     ETA+- = A(KL TO PI+PI-)/A(KS TO PI+PI-)
     ETA00 = A(KL TO PI0PI0)/A(KS TO PI0PI0)

     THE FITTED VALUES OF ETA+- AND ETA00 GIVEN BELOW ARE THE RESULTS
     OF A FIT TO ETA+-, ETA00 AND ETA00/ETA+- RESULTS.  THE VALUES LISTED
     BELOW WHICH ARE NOT PARENTHESIZED ENTER THE FIT AS SHOWN.  THE
     VALUES WHICH ARE PARENTHESIZED AND BEAR THE FOOTNOTE X DO NOT ENTER
     THE FIT AS SHOWN.  THESE EXPERIMENTS GIVE BRANCHING RATIOS AND ENTER
     THE FIT VIA THE QUANTITY ACTUALLY MEASURED -- BRANCHING RATIOS
     R9, R20 AND R27 (ETA+-) AND R17 AND R19 (ETA00).  THESE BRANCHING
     RATIOS ARE COMBINED WITH CURRENT NORMALIZATIONS AND CURRENT KL AND KS
     MEAN LIVES TO OBTAIN PI PI RATES.  THE ETA+- AND ETA00 VALUES OBTAINED
     FROM THESE RATES ARE ENTERED BELOW WITH THE NAME 'GKL/GKS'.

EOS     (ETA00)**2 = (A(KL TO 2PI0)/A(KS TO 2PI0))**2  (UNITS 10**-6)   ----
EOS X    0  (-2.)      (7.0)            BARTLETT  68 OSPK                        10/69
EOS X   57   (4.9)     (1.2)            BANNER    69 OSPK                         2/72
EOS XR 133  (14.1)     (3.4)            CENCE     69 OSPK                        10/69
EOS XF 180  (13.)      (4.)             GAILLARD  69 OSPK                        10/69
EOS X   29   (4.08)    (0.9)            BARMIN    70 HLBC                        12/70
EOS X   30   (3.61)    (1.9)            BUDAGOV   70 HLBC                        10/70
EOS  C        8.7       3.7             CHOLLET   70 OSPK    CU REG.,4 GAMMAS   2/72
EOS XF 172   (9.9)     (3.4)            FAISSNER  70 OSPK                        12/70
EOS  C  56    7.4       2.0             WOLFF     71 OSPK    CU REG.,4GAMMAS   12/71
EOS XR 150  (14.1)     (3.4)            REY       76 OSPK                         8/76
EOS           5.43      0.84            CHRISTE1  79 ASPK                        12/79
EOS  X        5.1       1.0             GKL/GKS   84 RVUE BR SCALE FACTOR=1.5   3/84*
EOS X   SEE NOTE ABOVE REGARDING FITTED VALUES OF ETA+- AND ETA00.
EOS  R  CENCE 69 EVENTS ARE INCLUDED IN REY 76.                                   1/77
EOS  F  FAISSNER 70 CONTAINS SAME 2PI0 EVENTS AS GAILLARD 69
EOS  C  CHOLLET 70 GIVES ETA00=(1.23+-0.24)*(REGEN AMPL,2GEV/C CU)/10000MB       2/72
EOS  C  WOLFF 71   GIVES ETA00=(1.13+-0.12)*(REGEN AMPL,2GEV/C CU)/10000MB       2/72
EOS  C  WE COMPUTE BOTH ETA00**2 VALUES FOR (REGEN AMPL,2GEV/C CU)=24+-2MB.      2/72
EOS  C  THIS REGEN AMPL RESULTS FROM AVERAGING OVER FAISSNER 69,                 2/72
EOS  C  EXTRAPOLATED USING OPTICAL MODEL CALCULTIONS OF BOHM ET AL.              2/72
EOS  C  PL 27B 594 (1968) AND THE DATA OF BALATS 71. (FROM H. FAISSNER,          2/72
EOS  C  PRIVATE COMMUNICATION)                                                   2/72
EOS  F  FAISSNER 70 CONTAINS SAME 2PI0 EVENTS AS GAILLARD 69
EOS           . . . . . . . . . .
EOS AVG       5.58      0.60    AVERAGE
EOS FIT       5.41      0.38   FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.1)  3/84*

E00     ETA00 = A(KL TO 2PI0)/A(KS TO 2PI0)  (UNITS 10**-3)   -------------
E00       THE FIT VALUE ABOVE FOR ETA00**2 CORRESPONDS TO ETA00=2.325+-0.082     3/84*

E+-     ETA+-  = A(KL TO PI+PI-)/A(KS TO PI+PI-) UNITS 10**-3  ------------
E+- X   45    (1.95)    (0.20)          CHRISTENS 64 OSPK                         2/76
E+- X   54    (1.99)    (0.16)          GALBRAITH 65 OSPK                         2/76
E+- X         (1.92)    (0.13)          BASILE    66 OSPK                         2/76
E+- X         (1.95)    (0.04)          BOTT-BODE 66 OSPK                         2/76
E+- X         (2.00)    (0.09)          DEBOUARD  67 OSPK                         2/76
E+- X         (1.94)    (0.08)          FITCH     67 OSPK                         2/76
E+- AX        (1.95)    (0.03)          GKL/GKS   71 RVUE    EXPTS. BEFORE 71    2/76
E+- A   AVERAGE OF ABOVE EXPERIMENTS.  THESE ARE EXCLUDED FROM THE GKL/GKS,      1/80
E+- A   AVERAGE, AND FIT VALUES BELOW SINCE THEY DO NOT AGREE WITH MORE          1/80
E+- A   RECENT PRECISE AND IN PRINCIPLE SUPERIOR EXPERIMENTS.                    1/80
E+- X 4200    (2.23)    (0.05)          MESSNER   73 ASPK                        11/75
E+-            2.30      0.035          GEWENIG2  74 ASPK                         3/74
E+- X 2703    (2.25)    (0.05)          DEVOE     77 SPEC                        11/77
E+-            2.27      0.12           CHRISTE2  79 ASPK                        12/79
E+-  X         2.255     0.029          GKL/GKS   84 RVUE    BR EXP. AFTER 71   3/84*
E+- Z         (2.09)    (0.02)          ARONSON2  82 SPEC    E=30-110 GEV        1/83*
E+- Z   ARONSON 82 FIND THAT ETA+- MAY DEPEND ON THE KAON ENERGY .               1/83*
E+- X   SEE NOTE ABOVE REGARDING FITTED VALUES OF ETA+- AND ETA00.
E+-           . . . . . . . . . .
E+- AVG        2.273     0.022  AVERAGE
E+- FIT        2.274     0.022  FROM FIT                                          3/84*

ER      RATIO OF ETA00 OVER ETA+-
ER      124    1.03      0.07           BANNER1   72 OSPK                         8/72
ER      167    1.00      0.06           HOLDER    72 ASPK                         8/72
ER  C         (1.00)    (0.09)          CHRISTE1  79 ASPK                         2/80
ER  C   NOT INDEPENDENT OF E+- AND EOS VALUES WHICH ARE INCLUDED IN FIT.         2/80
ER            . . . . . . . . . .
ER  AVG        1.013     0.046  AVERAGE
ER  FIT        1.023     0.036  FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.1)  3/84*

F+-     PHI+-, THE PHASE OF ETA +-    (DEGREES)  ----------------------
F+-       THE DEPENDENCE OF THE PHASE ON THE KL-KS MASS DIFFERENCE
F+-       IS GIVEN FOR EACH EXPERIMENT IN THE COMMENTS BELOW, WHERE DM IS
F+-       (MASS DIFF./HBAR) IN UNITS 10**10 SEC-1.  WE HAVE EVALUATED THESE
F+-       MASS DEPENDENCES USING OUR APRIL 1982 VALUE, DM=0.5349+-0.0022
F+-       TO OBTAIN THE VALUES AND AVERAGE QUOTED BELOW. WE ALSO GIVE THE
F+-       REGENERATOR PHASE FR IN THE COMMENTS BELOW.
F+- O        (45.0)    (50.0)           FITCH     65 OSPK    BE REGEN           11/67
F+- O        (30.0)    (45.0)           FIRESTONE 66 HBC                        11/67
F+- O        (70.0)    (21.0)           BOTT-BODE 67 OSPK    C REGEN            11/67
F+- O        (25.0)    (35.0)           MISCHKE   67 OSPK    CU REGEN            7/68
F+- O   OLD EXPERIMENTS WITH LARGE ERRORS NOT INCLUDED IN AVERAGE.               2/76
F+- N        (51.0)    (11.0)           BENNETT2  68 CNTR    CU REG. USES        8/68
F+-  C        34.2      10.0            BENNETT   69 CNTR    CU REGEN            2/71
F+-  B        45.3      12.0            BOHM      69 OSPK    VACUUM REGEN        2/71
F+-  F        45.2       7.4            FAISSNER  69 ASPK    CU REGEN            2/71
F+-  J        40.6       4.2            JENSEN    70 ASPK    VACUUM REGEN        2/71
F+-  D        37.2      12.0            BALATS    71 OSPK    CU REGEN            9/71
F+-  P        36.2       6.1            CARNEGIE  72 ASPK    CU REGEN            1/73
F+-  G        46.5       1.6            GEWENIG2  74 ASPK    VACUUM REGEN        3/74
F+-  H        45.5       2.8            CARITHERS 75 SPEC    C REGEN             7/75
F+-           41.7       3.5            CHRISTE2  79 ASPK                       12/79
F+- A        (35.3)     (3.9)           ARONSON2  82 SPEC    E=30-110 GEV        1/83*
F+-          . . . . . . . . . .
F+- AVG       44.6       1.2     AVERAGE
F+- FIT       44.6       1.2    FROM FIT                                         3/84*
                       COMMENTS
F+-  N  BENNETT 69 IS A REEVALUATION OF BENNETT2 68.                            11/69
F+-  C  BENNETT 69 USES MEASUREMENT OF (F+-)-(PHIF) OF ALFF-STEINBERGER 66.     2/71
F+-  C  BENNETT 69  F+-=(34.9+-10.0)+ 69*(DM-.545) DEG.  FR=-49.9+-5.4 DEG.     2/71
F+-  B  BOHM 69     F+-=(41.0+-12.0)+479*(DM-.526) DEG.                          2/71
F+-  F  FAISSNER 69 ERROR ENLARGED TO INCLUDE ERROR IN REGENERATOR PHASE.       11/69
F+-  F  FAISSNER 69 F+-=(49.3+-7.4)+205*(DM-.555) DEG.   FR=-42.7+-5.0 DEG.     2/71
F+-  J  JENSEN 70   F+-=(42.4+-4.0)+576*(DM-.538) DEG.                           2/71
F+-  D  BALATS 71   F+-=(39.0+-12.0)+198*(DM-.544) DEG.  FR=-43.0+-4.0 DEG.     9/71
F+-  P  CARNEGIE 72 F+- IS INSENSITIVE TO DM.            FR=-56.2+-5.2 DEG.     1/73
F+-  G  GEWENIG2 74 F+-=(49.4+-1.0)+565*(DM-.540) DEG.                           3/74
F+-  H  CARITHER 75 F+-=(45.5+-2.8)+224*(DM-.5348) DEG.  FR=-40.9+-2.6 DEG.    11/75
F+- A   ARONSON 82 FIND THAT PHI+- MAY DEPEND ON THE KAON ENERGY .              1/83*

F00     PHI00, THE PHASE OF ETA 00     (DEGREES)    ----------------------
F00         FIRST QUADRANT PREFERRED    GOBBI      69 OSPK                      11/69
F00  C        51.0      30.0            CHOLLET    70 OSPK    CU REG.,4 GAMMAS 10/70
F00  W  56    38.0      25.0            WOLFF      71 OSPK    CU REG.,4 GAMMAS 12/71
F00           55.7       5.8            CHRISTE1   79 ASPK                     12/79
F00  C  CHOLLET 70 USES REGENERATOR PHASE FR=-46.5+-4.4 DEG.                    1/73
F00  W  WOLFF 71   USES REGENERATOR PHASE FR=-48.2+-3.5 DEG.                    1/73
F00          . . . . . . . . . .
F00 AVG       54.7       5.6     AVERAGE
F00 FIT       54.5       5.3    FROM FIT                                         3/84*

DF      PHASE DIFFERENCE PHI00 - PHI+-      (DEGREES)---------------------
DF B           7.6      18.0            BARBIELLI 73 ASPK                        7/73
DF  C        (12.6)     (6.2)           CHRISTE1  79 ASPK                        2/80
DF B    INDEPENDENT OF REGENERATOR MECHANISM,DM,AND LIFETIMES.                   7/73
DF  C   NOT INDEPENDENT OF PHI+- AND PHI00 VALUES WHICH ARE INCLUDED IN FIT     2/80
DF           . . . . . . . . . .
DF  FIT        9.8       5.4     FROM FIT                                        3/84*

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NOTE ON ΔS = ΔQ RULE IN K^0 DECAYS

The relative amount of $\Delta S \neq \Delta Q$ component present is measured by the parameter x, defined as

$$x = A(\overline{K}^0 \to \pi^- \ell^+ \nu)/A(K^0 \to \pi^- \ell^+ \nu)\ .$$

We list Re{x} and Im{x} for K_{e3} and $K_{\mu3}$ combined.

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                 13  X = (DS=-DQ AMPLITUDE)/(DS=+DQ AMPLITUDE)

REX      REAL PART OF X
REX  C 152   0.06      0.18      0.44  BALDO-CE  65 HLBC   K+ CHARGE EXCHNG 11/67
REX    196   0.035     0.11      0.13  AUBERT    65 HLBC   K+ CHARGE EXCHNG 11/67
REX  F 109  -0.08      0.16      0.28  FRANZINI  65 HBC    PBAR P           11/67
REX    116   0.17      0.16      0.35  FELDMAN   67 OSPK   PI-P TO K0 LMBDA 11/67
REX N  335  (0.17)    (0.10)           HILL      67 DBC    K+D YIELDS K0PP  11/67
REX B       (0.03)    (0.03)           BENNETT1  68 CNTR                     7/68
REX    121   0.09      0.07      0.09  JAMES     68 HBC    PBAR P            5/69
REX  B      -0.020     0.025           BENNETT   69 CNTR   CHAR ASYM+ CU RE 10/69
REX    686   0.09      0.14      0.16  LITTENBER 69 OSPK   K+N TO K0P        4/69
REX  N 215   0.12      0.09            CHO       70 DBC    K+D TO K0PP      10/70
REX U  222  (0.04)    (0.07)    (0.08) BURGUN    71 HBC    K+P TO K0PPI+     2/72
REX    252   0.25      0.07      0.09  WEBBER    71 HBC    K-P TO KBAR N    10/69
REX  U 410   0.03      0.06      0.06  BURGUN    72 HBC    K+P TO K0PPI+     1/73
REX    126   0.26      0.10      0.14  MANN      72 HBC    K-P TO K0BAR N    9/72
REX G  342 (-0.13)    (0.11)           MANTSCH   72 OSPK   KE3  FROM K0 LMB  2/72
REX G  100  (0.04)    (0.10)    (0.13) GRAHAM    72 OSPK   KMU3 FROM K0 LMB  2/72
REX  G 442  -0.05      0.09            GRAHAM    72 OSPK   PI-P TO K0 LMBDA  2/72
REX   1757  -0.008     0.044           FACKLER   73 OSPK   KE3 FROM K0       9/73
REX   1367  -0.03      0.07            HART      73 OSPK   KE3 FROM K0 LMB   2/74
REX   1079  -0.070     0.036           MALLARY   73 OSPK   KE3 FROM K0 LM +  6/73
REX   4724   0.04      0.03            NIEBERGA  74 ASPK   K+P TO K0PPI+     7/74
REX     79   0.10      0.18      0.19  SMITH     75 WIRE   PI-P TO K0 LMBDA  8/76
REX  C  BALDO-CE 65 GIVES X AND THETA.CONVERTED BY US TO REX AND IMX.       11/67
REX  F  FRANZINI 65 GIVES X AND THETA.FOR REX AND IMX SEE SCHMIDT 67.       11/67
REX N   CHO 70 IS ANALYSIS OF UNAMBIGUOUS EVENTS IN NEW DATA AND HILL 67.   10/70
REX  U  BURGUN 72 IS A FINAL RESULT WHICH INCLUDES BURGUN 71.              11/73
REX  B  BENNETT 69 IS A REANALYSIS OF BENNETT1 68.                          10/69
REX G   SECOND GRAHAM 72 VALUE IS FIRST GRAHAM 72 VALUE COMBINED WITH        2/72
REX G   MANTSCH 72.                                                          2/72
REX          . . . . . . . . . .
REX AVG      0.009     0.020   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.4)
                               (SEE IDEOGRAM BELOW)

IMX      IMAGINARY PART OF X (ASSUMES M(KL)-M(KS) POSITIVE -- SEE S13D)
IMX  C 152  -0.44      0.32      0.19  BALDO-CE  65 HLBC   K+ CHARGE EXCHNG  3/68
IMX    196  -0.21      0.11      0.15  AUBERT    65 HLBC   K+ CHARGE EXCHNG  3/68
IMX  F 109  +0.24      0.40      0.30  FRANZINI  65 HBC    PBAR P            3/68
IMX    116   0.0       0.25            FELDMAN   67 OSPK   PI-P TO K0 LMBDA 11/67
IMX N  335 (-0.20)    (0.10)           HILL      67 DBC    K+D YIELDS K0PP  11/67
IMX    121  +0.22      0.37      0.29  JAMES     68 HBC    PBAR P            5/69
IMX    686  -0.11      0.10      0.11  LITTENBER 69 OSPK   K+N TO K0P        4/69
IMX  N 215  -0.08      0.07            CHO       70 DBC    K+D TO K0PP      10/70
IMX U  222  (0.12)    (0.08)    (0.09) BURGUN    71 HBC    K+P TO K0PPI+     2/72
IMX    252   0.0       0.08            WEBBER    71 HBC    K-P TO KBAR N    10/69
IMX  U 410   0.07      0.06      0.07  BURGUN    72 HBC    K+P TO K0PPI+     1/73
IMX    126   0.21      0.15      0.12  MANN      72 HBC    K-P TO K0BAR N    9/72
IMX G  342 (-0.04)    (0.16)           MANTSCH   72 OSPK   KE3  FROM K0 LMB  2/72
IMX G  100  (0.12)    (0.17)    (0.16) GRAHAM    72 OSPK   KMU3 FROM K0 LMB  2/72
IMX  G 442   0.05      0.13            GRAHAM    72 OSPK   PI-P TO K0 LMBDA  2/72
IMX   1757  -0.017     0.060           FACKLER   73 OSPK   KE3 FROM K0       9/73
IMX   1367   0.09      0.07            HART      73 OSPK   KE3 FROM K0 LMB   2/74
IMX   1079   0.107     0.092    0.074  MALLARY   73 OSPK   KE3 FROM K0 LM +  6/73
IMX   4724  -0.06      0.05            NIEBERGA  74 ASPK   K+P TO K0PPI+     7/74
IMX     79  -0.10      0.16      0.19  SMITH     75 WIRE   PI-P TO K0 LMBDA  8/76
IMX  C  BALDO-CE 65 GIVES X AND THETA.CONVERTED BY US TO REX AND IMX.       11/67
IMX  F  FRANZINI 65 GIVES X AND THETA.FOR REX AND IMX SEE SCHMIDT 67.       11/67
IMX N   FTNOTE 10 OF HILL 67 SHOULD READ +0.58, NOT -0.58 (PRIV.COMM.).      3/68
IMX N   CHO 70 IS ANALYSIS OF UNAMBIGUOUS EVENTS IN NEW DATA AND HILL 67.   10/70
IMX  U  BURGUN 72 IS A FINAL RESULT WHICH INCLUDES BURGUN 71.              11/73
IMX G   SECOND GRAHAM 72 VALUE IS FIRST GRAHAM 72 VALUE COMBINED WITH        2/72
IMX G   MANTSCH 72.                                                          2/72
IMX          . . . . . . . . . .
IMX AVG     -0.004     0.026   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.1)
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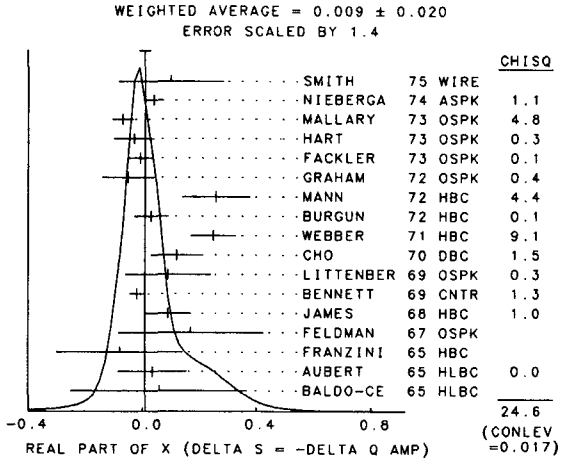
For notation, see key at front of Listings.

Stable Particles

K^0_L



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REFERENCES FOR KL

BARDON 58 ANP 5 156 M BARDON,K LANDE,L LEDERMAN (COLUMBIA+BNL)
CRAWFORD 59 PRL 2 361 CRAWFORD,CRESTI,DOUGLASS,GOOD + (LRL)
ASTIER 61 AIX CONF 1 227 ASTIER,BLASKOVIC,RIVET,SIAUD + (EPOL)
FITCH 61 NC 22 1160 V FITCH,P PIROUE,R PERKINS (PRINCETON)
GOOD 61 PR 124 1223 GOOD,MATSEN,MULLER,PICCIONI,POWELL + (LRL)
NEAGU 61 PRL 6 552 NEAGU,OKONOV,PETROV,ROSANOVA,RUSAKOV (JINR)
ALSO 61 JETP 13 1138 NYAGU,OKONOV,PETROV,ROZANOVA,RUSAKOV (JINR)

CAMERINI 62 PR 128 362 CAMERINI,FRY,GAIDOS,BIRGE,ELY + (WISC+LRL)
DARMON 62 PL 3 57 J DARMON,A ROUSSET,J SIX (EPOL)

ADAIR 64 PL 12 67 R K ADAIR,L B LEIPUNER (YALE+BNL)
ALEKSANY 64 DUBNA 2 102 ALEKSANYAN,ALIKHANYAN,VARTAZARYAN+ (EREVAN)
ALSO 64 JETP 19 1019 ALEKSANYAN+ (LEBEDEV+MOS ENG PHYS+EREVAN)
ANIKINA 64 JETP 19 42 ANIKINA,ZHURAVLEVA+ (GEORG ACAD SCI+ DUBNA)
CHRISTEN 64 PRL 13 138 CHRISTENSON,CRONIN,FITCH,TURLAY (PRINCETON)
FUJII 64 DUBNA 2 146 FUJII,JOVANOVICH,TURKOT+ (BNL,MARYLAND,MIT)
LUERS 64 PR 133 B 1276 LUERS,MITTRA,WILLIS,YAMAMOTO (BNL)

ANIKINA 65 JINR P 2488 ANIKINA,VARDENGA,ZHURAVLEVA,KOTLYA+ (DUBNA)
ANDERSON 65 PRL 14 475 ANDERSON,CRAWFORD,GOLDEN,STERN + (LRL+WISC)
ASTBURY1 65 PL 16 80 ASTBURY,FINOCCHIARO,BEUSCH + (CERN+ZURICH)
ALSO 65 HELV.PH.AC.39 523 M PEPIN
ASTBURY2 65 PL 18 175 ASTBURY,MICHELINI,BEUSCH + (CERN+ZURICH)
ASTBURY3 65 PL 18 178 ASTBURY,MICHELINI,BEUSCH + (CERN+ZURICH)

AUBERT 65 PL 17 59 AUBERT,BEHR,CANAVAN,CHOUNET+ (EPOL+ORSAY)
ALSO 67 LOWYS
BALDO-CE 65 NC 38 684 BALDO-CEOLIN,CALIMANI,CIAMPOLILLO + (PADO)
CHRISTEN 65 PR 140 B 74 CHRISTENSON,CRONIN,FITCH,TURLAY (PRINCETON)
FISHER 65 ANL 7130 83 FISHER,ABASHIAN,ABRAMS,CARPENTER+ (ILL)
FITCH 65 PRL 15 73 FITCH,ROTH,RUSS,VERNON (PRINCETON)

FRANZINI 65 PR 140 B 127 FRANZINI,KIRSCH,PLANO + (COLUMBIA+RUTGERS)
GALBRAIT 65 PRL 14 383 GALBRAITH,MANNING,JONES + (AERE+BRIS+RHEL)
GUIDONI 65 ARGONNE CONF 49 +BARNES,FOELSCHE,FERBEL,FIRESTO+ (BNL+YALE)
HOPKINS 65 ARGONNE CONF 67 H W K HOPKINS,BACON,EISLER (VAND+RUTGERS)
VISHNEVS 65 PL 18 339 VISHNEVSKY,GALANINA,SEMENOV + (ITEP)

ALFF-STE 66 PL 21 595 ALFF-STEINBERGER,HEUER,RUBBIA + (CERN)
ANIKINA 66 SJNP 2 339 ANIKINA, VARDENGA, ZHURAVLEVA+ (JINR)
AUERBACH 66 PRL 17 980 AUERBACH,MANN,MCFARLANE,SCIULLI (PENN)
AUERBACH 66 PR 149 1052 AUERBACH,DOBBS,LANDE,MANN,SCIULLI+ (PENN)
ALSO 65 PRL 14 192 +LANDE,MANN,SCIULLI,UTO,WHITE,YOUNG (PENN)
BALDO-CE 66 NC 45A 733 BALDO-CEOLIN,CALIMANI,CIAMPOLILLO+ (PADUA)
BASILE 66 BALATON CONF BASILE,CRONIN,THEVENET + (SACLAY)

BEHR 66 PL 22 540 +BRISSON,BALDO-CEOLIN,AUBERT+ (PADO,EPOL)
BELLOTTI 66 NC 45A 737 BELLOTTI,PULLIA,BALDO-CEOLIN+ (MILAN,PADUA)
BOTT-BOD 66 PL 23 277 BOTT-BODENHAUSEN,DE BOUARD,CASSEL+ (CERN)
CAMERINI 66 PR 150 1148 CAMERINI,CLINE,ENGLISH,FISCHBEIN+WISCONSIN
CANTER 66 PRL 17 942 +CHO,ENGLER,FISK,HILL + (CARNEGIE+BNL)
CARPENTE 66 PR 142 871 CARPENTER,ABASHAN,ABRAMS,FISHER (ILLINOIS)
CHANG 66 PL 23 702 CHANG,BASSANO,KIKUCHI,DODD+ (SYRACUSE,BNL)

CRIEGEE 66 PRL 17 150 +FOX,FRAUENFELDER,HANSON,MOSCAT+ (ILLINOIS)
FIRESTON 66 PRL 16 556 FIRESTONE,KIM,LACH,SANDWEISS+ (YALE,BNL)
FIRESTON 66 PRL 17 116 FIRESTONE,KIM,LACH,SANDWEISS+ (YALE,BNL)
FUJII 66 PRL 13 253 FUJII,JOVANOVICH,TURKOT,ZORN (BNL+MARYLAND)
FUJII 66 IS THE CORRECTED VALUE GIVEN BY JOVANOVICH+ 66
HAWKINS 66 PL 21 238 C J B HAWKINS (YALE)
ALSO 67 PR 156 1444 C J B HAWKINS (YALE)

JOVANOVI 66 PRL 17 1075 JOVANOVICH,FUJII,TURKOT,ZORN +(BNL+UMD+MIT)
KULYUKIN 66 BERKELEY 28 KULYUKINA,MESTVIRISHVILI,NEAGU,PETR+ (JINR)
MEISNER1 66 PRL 16 278 G W MEISNER,B B CRAWFORD,F CRAWFORD (LRL)
MEISNER2 66 PRL 17 492 G MEISNER,B CRAWFORD,F CRAWFORD (LRL)
NEFKENS 66 PL 19 706 NEFKENS,ABASHIAN,ABRAMS,CARPENTER+ (ILL)
VERHEY 66 PRL 17 669 VERHEY,NEFKENS,ABASHIAN+ (ILL)

BENNETT 67 PRL 19 993 BENNETT,NYGREN,SAAL,STEINBERGER +(COLUMBIA)
BOTT-BOD 67 PL 24B 194 BOTT-BODENHAUSEN,DEBOUARD,CASSEL + (CERN)
BOTT-BOD 67 PL 24B 438 BOTT-BODENHAUSEN,DEBOUARD,DEKKERS+ (CERN)
ALSO 66 PL 20 212 BOTT-BODENHAUSEN,DEBOUARD,CASSEL+ (CERN)
ALSO 66 PL 23 277 BOTT-BODENHAUSEN,DEBOUARD,CASSEL+ (CERN)
CANTER 67 THESIS J.M. CANTER (CARNEGIE)

CRONIN 1 67 PRL 18 25 +KUNZ,RISK,WHEELER (PRINCETON)
CRONIN 2 67 PRINC CONF(11/67) +KUNZ,RISK,WHEELER (PRINCETON)
DEBOUARD 67 NC 52A 662 DEBOUARD,DEKKERS,JORDAN,MERMOD + (CERN)
ALSO 65 PL 15 58 DE BOUARD,DEKKERS,SCHARFF+ (CERN+ORSA+MPIM)
DEVLIN 67 PRL 18 54 DEVLIN,SOLOMON,SHEPARD,BEALL+ (PRIN+UMD)
ALSO 68 PR 169 1045 SAYER,BEALL,DEVLIN,SHEPHARD+ (UMD+PPA+PRIN)

DORFAN 67 PRL 19 987 DORFAN,ENSTROM,RAYMOND,SCHWARTZ +(SLAC+LRL)
FELDMAN 67 PR 155 1611 FELDMAN,FRANKEL,HIGHLAND,SLOAN (PENN)
FIRESTON 67 PRL 18 176 FIRESTONE,KIM,LACH,SANDWEISS,+ (YALE,BNL)
FITCH 67 PR 164 1711 FITCH,ROTH,RUSS,VERNON (PRINCETON)
HAWKINS 67 PR 156 1444 C J B HAWKINS (YALE)
HILL 67 PRL 19 668 HILL,LUERS,ROBINSON,CANTER+ (BNL,CARNEGIE)

HOPKINS 67 PRL 19 185 HOPKINS,BACON,EISLER (BNL)
KADYK 67 PRL 19 597 KADYK,CHAN,DRIJARD,OREN,SHELDON (LRL)
KULYUKIN 67 PREPRINT KULYUKINA+MESTVIRISHVILI+NEAGU + (JINR)
LOWYS 67 PL 24B 75 LOWYS,AUBERT,CHOUNET,PASCAUD+ (EPOL,ORSA)
MISCHKE 67 PRL 18 138 MISCHKE,ABASHIAN,ABRAMS+ (ILLINOIS)
NEFKENS 67 PR 157 1233 +ABASHIAN,ABRAMS,CARPENTER,FISHER+ (ILL)
TODOROFF 67 THESIS JOHN A TODOROFF (ILLINOIS)

ABRAMS 68 PR 176 1603 +ABASHIAN,MISCHKE,NEFKENS,SMITH+ (ILLINOIS)
ARNOLD 68 PL 28B 56 ARNOLD,BUDAGOV,CUNDY,AUBERT+ (CERN+ORSAY)
ARONSON 68 PRL 20 287 S.H.ARONSON, K.W.CHEN (PRINCETON)
ALSO 69 PR 175 1708 S H ARONSON, K W CHEN (PRINCETON)
BALATZ 68 PL 26B 320 BALATZ,BEREZIN,VISHNEVSKY,GALANINA+ (ITEP)
BARTLETT 68 PRL 21 558 BARTLETT,CARNEGIE,FITCH+ (PRINCETON)

BASILE 68 PL 26B 542 BASILE,CRONIN,THEVENET,TURLAY+ (SACLAY)
BASILE2 68 PL 28B 58 +CRONIN,THEVENET,TURLAY,ZYLBERAJCH+(SACLAY)
BENNETT1 68 PL 27B 244 BENNETT,NYGREN,STEINBERGER+ (COLUMBIA+CERN)
BENNETT2 68 PL 27B 248 BENNETT,NYGREN,STEINBERGER+ (COLUMBIA+CERN)
BLANPIED 68 PRL 21 1650 BLANPIED,LEVIT,ENGELS+ (CASE+HARV+MCGI)
BUDAGOV 68 NC 57A 182 BUDAGOV,BURMEISTER,CUNDY+ (CERN,ORSA,IPNP)
ALSO 68 PL 28B 215 +CUNDY,MYATT,NEZRICK+ (CERN,ORSA,EPOL)

CARNEGIE 68 PRINC TR44 THESIS R.K.CARNEGIE (PRINCETON)
JAMES 68 NP B8 365 F JAMES, H BRIAND (IPNP,CERN)
ALSO 68 PRL 21 257 HELLAND,LONGO,YOUNG (UCLA,MICH)
KULYUKIN 68 JETP 26 20 KULYUKINA,MESTVIRISHVILI,NEAGU+ (JINR)
KUNZ 68 THESIS (PU 46) P F KUNZ (PRINCETON)
MELHOP 68 PR 172 1613 MELHOP MURTY BOWLES,BURNETT+ (LA JOLLA)
THATCHER 68 PR 174 1674 THATCHER,ABASHIAN,ABRAMS,CARPENTER + (ILL)

BANNER 69 PR 188 2033 +CRONIN,LIU,PILCHER (PRINCETON)
ALSO 68 PRL 21 1103 BANNER,CRONIN,LIU,PILCHER (PRINCETON)
ALSO 68 PRL 21 1107 BANNER CRONIN,LIU,PILCHER (PRINCETON)
BEILLIER 69 PL 30B 202 BEILLIERE,BOUTANG,LIMON (EPOL)
BENNETT 69 PL 29B 317 +NYGREN,SAAL,STEINBERGER+ (COLU,BNL)
BOHM 69 NP B9 605 +DARRIULAT,GROSSO,KAFTANOV+ (CERN)
ALSO 68 PL 27B 321 BOHM,DARRIULAT,GROSSO,KAFTANOV (CERN)

BOTT-BOD 69 CERN 69-7 329 BOTT-BODENHAUSEN,DE BOUARD,CASSEL+ (CERN)
CENCE 69 PRL 22 1210 CENCE,JONES,PETERSON,STENGER+ (HAWAII,LRL)
EVANS 69 PRL 23 427 EVANS,GOLDEN,MUIR,PEACH+ (EDINBURGH,CERN)
FAISSNER 69 PL 30B 204 +FOETH,STAUDE,TITTEL+ (AACH,CERN,TORI)
FOETH 69 PL 30B 282 +HOLDER,RADERMACHER + (AACHEN,CERN,TORINO)

GAILLARD 69 NC 59A 453 +GALBRAITH,HUSSRI,JANE+ (CERN,RHEL,AACHEN)
ALSO 67 PRL 18 20 +KRIENEN,GALBRAITH,HUSSRI+ (CERN+RHEL+AACH)
GOBBI 69 PRL 22 685 +GREEN,HAKEL,MOFFETT,ROSEN,GOZ+ (ROCH+RUTG)
LITTENBE 69 PRL 22 654 LITTENBERG,FIELD,PICCIONI,MEHLHOP+ (UCSD)
LONGO 69 PR 181 1808 M J LONGO,K K YOUNG,J A HELLAND (MICH,UCLA)
PACIOTTI 69 THESIS,UCRL 19446 M A PACIOTTI (LRL)
SAAL 69 THESIS H J SAAL (COLUMBIA)

ALBROW 70 PL 33B 516 +ASTON,BARBER,BIRD,ELLISON + (MCHS+DARE)
ARONSON 70 PRL 25 1057 +EHRLICH,HOFER,JENSEN+ (EFI,ILLC,SLAC)
BARMIN 70 PL 33B 377 +BARYLON,BORISOV,BYSHEVA+ (ITEP,JINR)
BASILE 70 PR D2 78 +CRONIN,THEVENT,TURLAY,ZYLBERAJCH + (SACL)
BUCHANAN 70 PL 33B 623 +DRICKEY,RUDNICK,SHEPARD+ (SLAC,JHU,UCLA)
ALSO PRIVATE COMMUNICATION, B. COX, FEB. 71

BUDAGOV 70 PR D2 815 +CUNDY,MYATT,NEZRICK+ (CERN, ORSA,EPOL)
ALSO 68 PL 28B 215 +CUNDY,MYATT,NEZRICK+ (CERN,ORSA,EPOL)
CHIEN 70 PL 33B 627 C-Y.CHIEN,COX,ETTLINGER + (JHU+SLAC+UCLA)
ALSO PRIVATE COMMUNICATION, B. COX, FEB. 71.
CHO 70 PR D1 3031 +DRALLE,CANTER,ENGLER,FISK+ (CARN,BNL,CASE)
ALSO 67 PRL 19 668 HILL,LUERS,ROBINSON,SAKITT + (BNL,CARN)

CHOLLET 70 PL 31B 658 +GAILLARD,JANE,RATCLIFFE,REPELLIN + (CERN)
CULLEN 70 PL 32B 523 +DARRIULAT,DEUTSCH,FOETH + (AACH,CERN,TORI)
DARRIULA 70 PL 33B 249 +FERRERO,GROSSO,HOLDER + (AACH,CERN,TORI)
FAISSNER 70 NC 70A 57 +REITHLER,THOME,GAILLARD+ (AACH,CERN,RHEL)
JENSEN 70 THESIS D.A. JENSEN (EFI)
ALSO 69 PRL 23 615 JENSEN,ARONSON,EHRLICH,FRYBERGER+ (EFI,ILL)

MARX 70 PL 32B 219 +NYGREN,PEOPLES,STEINBERGE+(COLU,HARV,CERN)
ALSO 70 THESIS,NEVIS 179 JAY MARX (COLUMBIA)
SCRIBANO 70 PL 32B 224 +MANNELLI,PIERAZZINI,MARX+ (PISA,COLU,HARV)
SMITH 70 PL 32B 133 +WANG,WHATLEY,ZORN,HORNBOSTEL (UMD,BNL)
WEBBER 70 PR D1 1967 +SOLMITZ,CRAWFORD,ALSTON-GARNJOST (LRL)
ALSO 69 UCRL 19226 THESIS B R WEBBER (LRL)
BALATS 71 SJNP 13 53 +BEREZIN,VISHNEVSKII,GALANINA+ (ITEP)
BARMIN 71 PL 35B 604 +BARYLOV,VESELOVSKY,DAVIDENKO+ (ITEP)
BISI 71 PL 36B 533 +DARRIULAT,FERRERO,RUBBIA+ (AACH,CERN,TORI)
BURGUN 71 LNC 2 1169 +LESQUOY,MULLER,PAULI+ (SACL+CERN+OSLO)
CARNEGIE 71 PR D4 1 +CESTER,FITCH,STROVINK,SULAK (PRIN)
CHAN 71 LBL-350 THESIS J.HIONG-SING CHAN (LBL)

CHIEN 71 PL 35B 261 +COX,ETTLINGER,RESVANIS+ (JHU,SLAC,UCLA)
ALSO 72 DALLY
CHO 71 PR D3 1557 +DRALLE,CANTER,ENGLER,FISK+ (CARN,BNL,CASE)
CLARK 71 PRL 26 1667 +ELIOFF,FIELD,FRISCH,JOHNSON,KERTH+ (LRL)
ALSO 70 UCRL 19709-THESIS ROLLAND JOHNSON (LRL)
ALSO 71 UCRL 20264-THESIS HENRY FRISCH (LRL)
ALSO 74 SLAC-PUB-1498 R.C.FIELD (SLAC)

ENSTROM 71 PR D4 2629 +AKAVIA,COOMBES,DORFAN+ (SLAC,STAN)
ALSO 70 THESIS (SLAC 125) J E ENSTROM (STANFORD)
HILL 71 PR D4 7 +SAKITT,SKJEGGESTAD,CANTER+ (BNL,CARN,CASE)
JAMES 71 PL 35B 265 +MONTANET,PAUL,PAULI+ (CERN+SACL+OSLO)
MEISNER 71 PR D3 59 +MANN,HERTZBACH,KOFLER + (MASA+BNL+YALE)
PEACH 71 PL 35B 351 +EVANS,MUIR,BUDAGOV,HOPKINS+ (EDIN,CERN)

REPELLIN 71 PL 36B 603 +WOLFF,CHOLLET,GAILLARD,JANE+ (ORSA,CERN)
WEBBER 71 PR D3 64 +SOLMITZ,CRAWFORD,ALSTON-GARNJOST (LRL)
ALSO 68 PRL 21 498 WEBBER,SOLMITZ,CRAWFORD,ALSTONGARNJOST(LRL)
ALSO 69 UCRL 19266-THESIS B R WEBBER (LRL)
WOLFF 71 PL 36B 517 +CHOLLET,REPELLIN,GAILLARD+ (ORSA,CERN)

ALBROW 72 NP B44 1 +ASTON,BARBER,BIRD,ELLISON+ (MCHS+DARE)
ASHFORD 72 PL 38B 47 +BROWN,MASEK,MAUNG,MILLER,RUDERMAN+ (UCSD)
BANNER1 72 PRL 28 1597 +CRONIN,HOFFMAN,KNAPP,SHOCHET (PRINCETON)
BANNER2 72 PRL 29 237 +CRONIN,HOFFMAN,KNAPP,SHOCHET (PRINCETON)
BARMIN1 72 SJNP 15 636 +DAVIDENKO,DEMIDOV,DOLGOLENKO+ (ITEP)
BARMIN2 72 SJNP 15 638 +BARYLOV,DAVIDENKO,DEMIDOV+ (ITEP)
BURGUN 72 NP B50 194 +LESQUOY,MULLER,PAULI,+ (SACL+CERN+OSLO)
CARNEGIE 72 PR D6 2335 +CESTER,FITCH,STROVINK,SULAK (PRINCETON)

DALLY 72 PL 41B 647 +INNOCENTI,SEPPI,CHIEN,COX+ (SLAC+JHU+UCLA)
ALSO 70 CHIEN
ALSO 71 CHIEN

Stable Particles

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Data Card Listings

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GRAHAM    72 NC 9A 166          +ABASHIAN,JONES,MANTSCH,ORR+      (ILL+NEAS)
HOLDER    72 PL 40B 141         +RADERMACHER,STAUDE+        (AACH+CERN+TORI)
JAMES     72 NP B49 1           +MONTANET,PAUL,SAETRE+      (CERN+SACL+OSLO)
KRENZ     72 LNC 4 213          +HOPKINS,EVANS,MUIR,PEACH  (AACH+CERN+EDIN)

MANN      72 PR D6 137          +KOFLER,MEISNER,HERTZBACH+  (MASA+BNL+YALE)
MANTSCH   72 NC 9A 160          +ABASHIAN,GRAHAM,JONES,ORR+       (ILL+NEAS)
METCALF   72 PL 40B 703         +NEUHOFER,NIEBERGALL+       (CERN+IPN+WIEN)
NEUHOFER  72 PL 41B 642         +NIEBERGALL,REGLER,STIER+  (CERN+ORSA+VIEN)
PICCIONI  72 PRL 29 1412        +COOMBES,DONALDSON,DORFAN,FRYBERGER+ (SLAC)
    ALSO  74 PR D9 2939         PICCIONI,DONALDSON +          (SLAC+UCSC+COLO)
VOSBURGH  72 PR D6 1834         +DEVLIN,ESTERLING,GOZ,BRYMAN +  (RUTG,MASA)
    ALSO  71 PRL 26 866         VOSBURGH,DEVLIN,ESTERLING,GOZ + (RUTG,MASA)

ALBROW    73 NP B58 22          +ASTON,BARBER,BIRD,ELLISON+     (MCHS+DARE)
ALEXANDE  73 NP B65 301         ALEXANDER,BENARY,BOROWITZ,LANDE+(TELA+HEID)
ANIKINA   73  P1-7539 COM.JINR  +BALASHOV,BANNIK +                    (JINR)
BARBIELL  73 PL 43B 529         BARBIELLINI,DARRIULAT,FAINBERG+      (CERN)
BRANDENB  73 PR D8 1978         BRANDENBURG,JOHNSON,LEITH,LOOS+      (SLAC)
CARITHER  73 PRL 31 1025        CARITHERS,NYGREN,GORDON+    (COLU+BNL+CERN)
    ALSO  73 PRL 30 1336        CARITHERS,MODIS,NYGREN,PUN+ (COLU+CERN+NYU)
EVANS     73 PR D7 36           +MUIR,PEACH,BUDAGOV+        (EDINBURGH+CERN)
    ALSO  69 PRL 23 427         EVANS,GOLDEN,MUIR,PEACH+   (EDINBURGH+CERN)

FACKLER   73 PRL 31 847         +FRISCH,MARTIN,SMOOT,SOMPAYRAC       (MIT)
FITCH     73 PRL 31 1524        +HEPP,JENSEN,STROVINK,WEBB      (PRINCETON)
    ALSO  72 COO-3072-13        R.C.WEBB (THESIS)               (PRINCETON)
HART      73 NP B66 317         +HUTTON,FIELD,SHARP,BLACKMORE+  (CAVE+RHEL)
MALLARY   73 PR D7 1953         +BINNIE,GALLIVAN,GOMEZ,PECK,SCIULLI + (CIT)
    ALSO  70 PRL 25 1214        SCIULLI,GALLIVAN,BINNIE,GOMEZ +       (CIT)

MCCARTHY  73 PR D7 687          +BREWER,BUDNITZ,ENTIS,GRAVEN,MILLER+  (LBL)
    ALSO  72 PL 42B 291         MCCARTHY,BREWER,BUDNITZ,ENTIS,GRAVEN+ (LBL)
    ALSO  71 THESIS LBL-550     R.L.MCCARTHY                          (LBL)
MESSNER   73 PRL 30 876         +MORSE,NAUENBERG,HITLIN +  (COLO+SLAC+UCSC)
PEACH     73 PR 43B 441         +EVANS,MUIR,HOPKINS,KRENZ  (EDIN+CERN+AACH)
SANDWEIS  73 PRL 30 1002        +SUNDERLAND,TURNER,WILLIS,KELLER (YALE+ANL)
WILLIAMS  73 PRL 31 1521        +LARSEN,LEIPUNER,SAPP,SESSOMS+   (BNL+YALE)

ALBRECHT  74 PL 48B 393         DUBNA+BERLIN+BUDAPEST+PRAGUE+SERPUKH+SOFIA
BISI      74 PL 50B 504         BISI,FERRERO                          (TORI)
BOBISUT   74 LNC 11 646         +HUZITA,MATTIOLI,PUGLIERIN            (PADO)
DONALDS1  74 PRL 33 554         DONALDSON,HITLIN,KENNELLY,KIRKBY +    (SLAC)
    ALSO  74 DONALDSON 3
    ALSO  76 DONALDSON
DONALDS2  74 PR D9 2960         DONALDSON,FRYBERGER,HITLIN,LIU+ (SLAC+UCSC)
    ALSO  73 PRL 31 337         DONALDSON,FRYBERGER,HITLIN,LIU+ (SLAC+UCSC)
DONALDS3  74 SLAC 184-THESIS    GREGORY J. DONALDSON                  (SLAC)
    ALSO  76 DONALDSON

GEWENIG1  74 PL 48B 483         GEWENIGER,GJESDAL,KAMAE,PRESSER+(CERN+HEID)
    ALSO  74 CERN INT. REPT.    VERA LUTH (THESIS-INT. REPT. 74-4)   (HEID)
GEWENIG2  74 PL 48B 487         GEWENIGER,GJESDAL,PRESSER +      (CERN+HEID)
    ALSO  74 PL 52B 119         GJESDAL,PRESSER,STEFFEN +        (CERN+HEID)
GEWENIG3  74 PL 52B 108         GEWENIGER,GJESDAL,PRESSER +      (CERN+HEID)
GJESDAL   74 PL 52B 113         +PRESSER,KAMAE,STEFFEN+          (CERN+HEID)

MESSNER   74 PRL 33 1458        +FRANKLIN,MORSE,NAUENBERG+ (COLO+SLAC+UCSC)
NIEBERGA  74 PL 49B 103         NIEBERGALL,REGLER,STIER +  (CERN+ORSA+VIEN)
WANG      74 PR D9 540          +SMITH,WHATLEY,ZORN,HORNBOSTEL    (UMD+BNL)
WILLIAMS  74 PRL 33 240         +LARSEN,LEIPUNER,SAPP,SESSOMS +  (BNL+YALE)
WOO       74 LNC 10 38          +BUCHANAN,PEPPER                      (UCLA)

BALDOCEO  75 NC 25A 688         BALDO-CEOLIN,BOBISUT,CALIMANI+  (PADO+WISC)
BLUMENTH  75 PRL 34 164         BLUMENTHAL,FRANKEL,NAGY +  (PENN+CHIC+TEMP)
BUCHANAN  75 PR D11 457         +DRICKEY,PEPPER,RUDNICK +   (UCLA+SLAC+JHU)
CARITHER  75 PRL 34 1244        CARITHERS,MODIS,NYGREN,PUN +     (COLU+NYU)
SMITH     75 UCSD THESIS-UNPUB  JAMES G. SMITH                       (UCSD)

BIRULEV   76 SJNP 24, 178       +VESTERGOMBI,VOVENKO,VOTRUBA,GENCHEV+(JINR)
COOMBES   76 PRL 37 249         +FLEXER,HALL,KENNELLY,KIRKBY +   (STAN+NYU)
DONALDSO  76 PR D14 2839        DONALDSON,HITLIN,KENNELLY,KIRKBY,LIU+(SLAC)
    ALSO  74 SLAC 184-THESIS    GREGORY J. DONALDSON                  (SLAC)
FUKUSHIM  76 PRL 36 348         FUKUSHIMA,JENSEN,SURKO,THALER+  (PRIN+MASA)
GJESDAL   76 NP B109 118        +KAMAE,PRESSER,STEFFEN +         (CERN+HEID)
REY       76 PR D13 1161        +CENCE,JONES,PARKER +       (NDAM+HAWA+LBL)
    ALSO  69 CENCE

CHO       77 PR D15 587         +DERRICK,LISSAUER,MILLER,ENGLER+ (ANL+CARN)
CLARK     77 PR D15 553         +FIELD,HOLLEY,JOHNSON,KERTH,SAH,SHEN  (LBL)
    ALSO  75 LBL-4275 THESIS    GILBERT SHEN                          (LBL)
DEVOE     77 PR D16 565         +CRONIN,FRISCH,GROSSO-PILCHER+    (EFI+ANL)
DZHORDZH  77 SJNP 26 478        DZHORDZHADZE,KEKELIDZE,KRIVOKHIZHIN+ (JINR)
PEACH     77 NP B127 399        +CAMERON +        (BGNA+EDIN+GLAS+PISA+RHEL)

ENGLER    78 PR D18 623         +KEYES,KRAEMER,TANAKA,CHO+       (CARN+ANL)
HILL      78 PL 73B 483         +SAKITT,SNAPE,STEVENS+      (BNL+SLAC+SBER)
BIRULEV   79 SJNP 29 778        +VESTERGOMBI,GVAKHARIYA,GENCHEV+     (JINR)
CHRISTE1  79 PRL 43 1209        CHRISTENSON,GOLDMAN,HUMMEL,ROTH+      (NYU)
CHRISTE2  79 PRL 43 1212        CHRISTENSON,GOLDMAN,HUMMEL,ROTH+      (NYU)
HILL      79 NP B153 39         +SAKITT,SNAPE,STEVENS+      (BNL+SLAC+SBER)
SCHMIDT   79 PRL 43 556         +BLATT,CAMPBELL,GRANNAN+         (YALE+BNL)
SHOCHET   79 PR D19 1965        +LINSAY,GROSSO-PILCHER,FRISCH+    (EFI+ANL)
    ALSO  77 PRL 39 59          SHOCHET,LINSAY,GROSSO-PILCHER,+   (EFI+ANL)

CARROLL1  80 PRL 44 525         +CHIANG,KYCIA,LI,LITTENBERG,MARX+(BNL+ROCH)
CARROLL2  80 PRL 44 529         +CHIANG,KYCIA,LI,LITTENBERG,MARX+(BNL+ROCH)
CARROLL3  80 PL 96B 407         +CHIANG,KYCIA,LI,LITTENBERG,MARX+(BNL+ROCH)
CHO       80 PR D22 2688        +DERRICK,MILLER,SCHLERETH,ENGLER+(ANL+CARN)
MORSE     80 PR D21 1750        +LEIPUNER,LARSEN,SCHMIDT,BLATT+  (BNL+YALE)
BIRULEV   81 NP B182 1          +DZHORDZHADZE,GENCHEV,GRIGALASHVILI+ (JINR)
    ALSO  80 SJNP 31 622        BIRULEV,VESTERGOMBI,GENCHEV +        (JINR)
ARONSON   82 PRL 48 1078        +BERNSTEIN,BOCK +     (BNL+CHIC+STAN+WISC)
ARONSON2  82 PRL 48 1306        +BOCK,CHENG,FISCHBACH       (BNL+CHIC+PURD)
    ALSO  82 PL 116B 73         FISCHBACH,CHENG,ARONSON,BOCK(PURD+BNL+CHIC)
    ALSO  83 PR D28 476         ARONSON,BOCK,CHENG,FISCHBACH(BNL+CHIC+PURD)
    ALSO  83 PR D28 495         ARONSON,BOCK,CHENG,FISCHBACH(BNL+CHIC+PURD)

                                PAPERS NOT REFERRED TO IN DATA CARDS

ALEXANDE  62 PRL 9 69           G ALEXANDER,S ALMEIDA,F CRAWFORD      (LRL)
JOVANOVI  63 BNL CONF 42        JOVANOVIC,FISCHER,BURRIS +   (BNL+MARYLAND)
STERN     64 PRL 12 459         STERN,BINFORD,LIND,ANDERSON +    (WISC+LRL)
BEHR      65 ARGONNE CONF 59    BEHR,BRISSON,BELLOTTI+      (EPOL,MILA,PADO)
MESTVIRI  65 JINR P 2449        MESTVIRISHVILI,NYAGU,PETROV,RUSAKOV+ (JINR)
TRILLING  65 UCRL 16473         GEORGE H TRILLING                     (LRL)
    UPDATED FROM 1965 ARGONNE   CONF., PAGE 115.

GINSBERG  67 PR 162  1570       EDWARD S GINSBERG           (U. MASS BOSTON)
RUBBIA    67 PL  24B  531       C.RUBBIA,J.STEINBERGER            (CERN+COLU)
  ALSO 1  66 PL  20  207        ALFF-STEINBERGER,HEUER,KLEINKNECHT+  (CERN)
  ALSO 2  66 PL  21  595        ALFF-STEINBERGER,HEUER,KLEINKNECHT+  (CERN)
  ALSO 3  66 PL  23  167        C.RUBBIA,J.STEINBERGER            (CERN+COLU)
SCHMIDT   67 NEVIS 160(THESIS)  P. SCHMIDT                        (COLUMBIA)

CRONIN    68 VIENNA CONF P.281  CRONIN,RAPPORTEURS TALK           (PRINCETON)
BECHERRA  70 PR D1 1452         T BECHERRAWY                          (ROCH)
GINSBERG  70 PR D1 229          E S GINSBERG                      (IIT HAIFA)
HEUSSE    70 LNC  3 449         +AUBERT,PASCAUD,VIALLE              (ORSAY)
GINSBERG  73 PR D8 3887         E S GINSBERG, J SMITH             (MIT+STON)
KLEINKNE  76 ARNS 26 1          K. KLEINKNECHT                        (DORT)

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$D^\pm$

31 CHARGED D(1869,JP=0-) I=1/2

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      FOR A RECENT REVIEW SEE. TRILLING 81

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                    31  CHARGED D MASS (MEV)

M        50(1876.)    (15.)            PERUZZI   76 SMAG +- K-+PI+-PI+-      1/77
M          (1874.)     (5.)            GOLDHABER 77 SMAG +- D0,D+ RECOIL SPC 12/77
M    P     (1868.3)    (0.9)           PERUZZI   77 SMAG +- E+E- 3.77GEV ECM 12/77
M          (1874.)    (11.)            PICCOLO   77 SMAG +- E+E-4.03,4.41ECM  1/78
M    P     (1868.4)    (0.5)           SCHINDLER 81 SMK2 +- E+E- 3.77GEV ECM  1/82
M     P      1869.4     0.6            TRILLING  81 RVUE +- E+E- 3.77GEV ECM  1/82
M     P  PERUZZI 77 AND SCHINDLER 81 ERRORS DO NOT INCLUDE THE 0.13 PERCENT   1/82
M     P  UNCERTAINTY IN THE ABSOLUTE SPEAR ENERGY CALIBRATION.  TRILLING 81   1/82
M     P  USES THE HIGH PRECISION PSI AND PSI-PRIME MEASUREMENTS OF            1/82
M     P  ZHOLENTZ 80 TO DETERMINE THIS UNCERTAINTY AND COMBINES THE           1/82
M     P  PERUZZI 77 AND SCHINDLER 81 RESULTS TO OBTAIN THE VALUE QUOTED.      1/82

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                    31  CHARGED D MEAN LIFE   (UNITS 10**-13 SEC)

T            (8.)   OR LESS  CL=.90   ARMENISE  79 HYBR NEU P -->DIMUONS +   1/80
T        4    2.5     2.2     1.1    ALLASIA   80 EMUL NEU WIDEBAND        12/81
T   A      (10.4)   (3.9)   (2.9)    BACINO    80 DLCO E+E- 3.77 GEV ECM    1/81
T        5  (10.3)  (10.5)   (4.1)    USHIDA    80 EMUL NEU WIDEBAND        12/81
T   B    8   (4.4)                    ADAMOVICH 81 EMUL GAM NUC-->           1/82
T   C    1   (2.2)   (2.3)   (1.1)    BALLAGH   81 HYBR FNAL 15FT, NU HE-H2  1/82
T   D    9    8.2     4.5     2.5     ABE       82 HYBR SLAC GAM P 19.5 GEV  2/82
T   E   70    9.5     3.1     1.9     ALBINI    82 SILI CERN GAM SI          2/82
T       15    8.4     3.5     2.2     AGUILAR   83 HYBR PI- P, P P          11/83*
T        7    6.3     5.0     2.7     BADERTSCH 83 HYBR CERN PI- NUCL.      11/83*
T       11   11.5     7.5     3.5     USHIDA    83 EMUL REPL. USHIDA 80      2/84*
T   A   USES THEORETICAL RATE D TO (K E NEU)=1.4*10**11 SEC**-1 .            1/81
T   B   ADAMOVICH 81 VALUE ESTIMATED WITHOUT INFORMATION ON D MOMENTUM .     1/82
T   C   BALLAGH 81 VALUE QUOTED HERE ASSUMES THAT ALL DILEPTON EVENTS        1/82
T   C   CONTAIN DO OR D+, EACH WITH EQUAL NUMBERS OF SEMILEPTONIC DECAYS.    1/82
T   D   ABE 82 CANNOT RULE OUT F+- INTERP., OR ON 2 EVTS. LAMBDA/C+ INTERP.  2/82
T   E   ALBINI 82 ASSUMES D MOMENTUM IS 1/2 BEAM MOMENTUM.                   2/82
T   F   CERN NA16 (LEBC-EHS) EXPT.  PRESENTED AT MORIOND CONF. 82.           4/82
T         . . . . . . . . .
T   AVG      9.2     1.7     1.2    AVERAGE

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                    31  CHARGED D PARTIAL DECAY MODES

                                                        DECAY MASSES
P1      D+ INTO K- PI+ PI+                             494+ 140+ 140
P2      D+ INTO KOBAR PI+                              498+ 140
P3      D+ INTO PI+ PI+ PI-                            140+ 140+ 140
P4      D+ INTO PI+ K+ K-                              140+ 494+ 494
P5      D+ INTO K+ PI+ PI-                             494+ 140+ 140
P6      D+ INTO E+ NUE                                .511+   0
P7      D+ INTO E+ ANYTHING
P8      D+ INTO K- ANYTHING
P9      D+ INTO KOBAR ANYTHING + K0 ANYTHING
P10     D+ INTO K+ ANYTHING
P11     D+ INTO K*(892)OBAR PI+                        892+ 140
P12     D+ INTO KOBAR PI+ PI0                          498+ 140+ 135
P13     D+ INTO KOBAR PI+ PI+ PI-                      498+ 140+ 140+ 140
P14     D+ INTO K- PI+ PI+ PI+ PI-                     494+ 140+ 140+ 140+
P15     D+ INTO PI+ PI0                                140+ 135
P16     D+ INTO KOBAR K+                               498+ 494
P18     D+ INTO KOBAR RHO+                             498+ 769
P19     D+ INTO ETA ANYTHING
P20     D+ INTO MU+ NUMU                               106+   0
P21     D+ INTO K- PI+ PI+ PI0                         494+ 140+ 140+ 135

      D- MODES ARE CHARGE CONJUGATES OF THE ABOVE MODES

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                    31  CHARGED D BRANCHING RATIOS

R1      D+ INTO (K- PI+ PI+)/TOTAL                     (P1)
R1       85     0.039    0.010          PERUZZI   77 SMAG   E+E- 3.77GEV ECM 12/77
R1      239     0.063    0.015          SCHINDLER 81 SMK2 E+E- 3.771 GEV ECM   1/82
R1        . . . . . . . . .
R1  AVG         0.046    0.011   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.3)

R2      D+ INTO (KOBAR PI+)/TOTAL                      (P2)
R2       17     0.015    0.006          PERUZZI   77 SMAG   E+E- 3.77GEV ECM 12/77
R2       36     0.023    0.007          SCHINDLER 81 SMK2 E+E- 3.771 GEV ECM   1/82
R2        . . . . . . . . .
R2  AVG         0.0184   0.0046  AVERAGE

R3      D+ INTO (KOBAR PI+)/(K- PI+ PI+)               (P2)/(P1)
R3  P       (0.45) OR LESS  CL=.90   PICCOLO   77 SMAG +- E+E- 4.03GEV ECM 12/77
R3  P  OBTAINED FROM SIGMA*BR VALUES OF TABLE I.                            12/77

R4      D+ INTO (PI+ PI+ PI-)/(K- PI+ PI+)             (P3)/(P1)
R4  P        0.08  OR LESS  CL=.90   PICCOLO   77 SMAG +- E+E- 4.03GEV ECM 12/77
R4          (0.084)OR LESS  CL=.90   SCHINDLER 81 SMK2 E+E- 3.771 GEV ECM   1/82
R4  P  OBTAINED FROM SIGMA*BR VALUES OF TABLE I.                            12/77

R5      D+ INTO (PI+ K+ K-)/(K- PI+ PI+)               (P4)/(P1)
R5  P        (0.15) OR LESS  CL=.90   PICCOLO   77 SMAG +- E+E- 4.03GEV ECM 12/77
R5           0.14  OR LESS  CL=.90   SCHINDLER 81 SMK2 E+E- 3.771 GEV ECM   1/82
R5  P  OBTAINED FROM SIGMA*BR VALUES OF TABLE I.                            12/77

R6      D+ INTO (K+ PI+ PI-)/(K- PI+ PI+)              (P5)/(P1)
R6  P        0.05  OR LESS  CL=.90   PICCOLO   77 SMAG +- E+E- 4.03GEV ECM 12/77
R6  P  OBTAINED FROM SIGMA*BR VALUES OF TABLE I.                            12/77

R7      (D+ INTO E+ NUE)/(D+ INTO E+ ANYTHING + D0 INTO E+ ANYTHING)
R7           0.10  OR LESS  CL=.90   BRANDELIK 77 DASP E+E- 3.99-4.08 GEV  12/77

R8      D+ AND D0 INTO (E+ ANYTHING)/(TOTAL D+ AND D0)
R8       MEASURED AT THE PSI(3772).  THIS GIVES A WEIGHTED AVERAGE OF        2/82
R8       D+ (44 PCT.) AND D0 (56 PCT.) BRANCHING FRACTIONS.                  2/82
R8           0.072    0.028          FELLER    78 SMAG E+E- 3.772 GEV ECM   2/78
R8          (0.11)   (0.02)          BACINO    78 DLCO REPL. BY BACINO 79   3/78
R8  A       (0.08)   (0.015)         BACINO    79 DLCO E+E- 3.772 GEV ECM   4/82
R8  A   NOT INDEPENDENT OF BACINO 80 R13(D+) AND R13(D0).                   4/82
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For notation, see key at front of Listings.

Stable Particles
D±, D⁰

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R9      D+ INTO (K- ANYTHING)                                    (P8)                 1/79
R9        3    0.10     0.07           VUILLEMIN 78 SMAG E+E- 3.772 GEV ECM   1/79
R9       26    0.19     0.05           SCHINDLER 81 SMK2 E+E- 3.771 GEV ECM   1/82
R9              . . . . . . . . . .
R9  AVG        0.160    0.043    AVERAGE

R10     D+ INTO (KOBAR ANYTHING + KO ANYTHING)/TOTAL             (P9)                 1/79
R10       3    0.39     0.29           VUILLEMIN 78 SMAG E+E- 3.772 GEV ECM   1/79
R10      15    0.52     0.18           SCHINDLER 81 SMK2 E+E- 3.771 GEV ECM   1/82
R10             . . . . . . . . . .
R10 AVG        0.48     0.15     AVERAGE

R11     D+ INTO (K+ ANYTHING)/TOTAL                              (P10)
R11       2    0.06     0.06           VUILLEMIN 78 SMAG E+E- 3.772 GEV ECM   1/79
R11      12    0.06     0.04           SCHINDLER 81 SMK2 E+E- 3.771 GEV ECM   1/82
R11             . . . . . . . . . .
R11 AVG        0.060    0.033    AVERAGE

R12     D+ INTO (K*(892)OBAR PI+)/TOTAL                          (P11)
R12      92 EVENTS SEEN                DRIJARD   79 SFM  + P P,ECM=53 GEV     7/79
R12            0.037 OR LESS  CL=.90   SCHINDLER 81 SMK2 E+E- 3.771 GEV ECM   1/82

R13     D+ INTO (E+ ANYTHING)/TOTAL                              (P7)
R13          (0.220)  (0.044)  (0.022)BACINO     80 DLCO E+E- 3.77 GEV ECM    4/82
R13      23  (0.168)  (0.064)          SCHINDLER 81 SMK2 E+E- 3.771 GEV ECM   4/82
R13            0.19     0.04     0.03  TRILLING  81 RVUE BEST ESTIMATE        4/82

R14     D+ INTO (KOBAR PI+ PIO)/TOTAL                            (P12)                1/82
R14      10    0.129    0.084          SCHINDLER 81 SMK2 E+E- 3.771 GEV ECM   1/82

R15     D+ INTO (KOBAR PI+ PI+ PI-)/TOTAL                        (P13)                1/82
R15      21    0.084    0.035          SCHINDLER 81 SMK2 E+E- 3.771 GEV ECM   1/82

R16     D+ INTO (K- PI+ PI+ PI+ PI-)/TOTAL                       (P14)                1/82
R16            0.041 OR LESS  CL=.90   SCHINDLER 81 SMK2 E+E- 3.771 GEV ECM   1/82

R17     D+ INTO (KOBAR RHO+)/TOTAL                               (P18)                1/82
R17 S        (0.016)OR MORE  CL=.90    SCHINDLER 81 SMK2 E+E- 3.771 GEV ECM   1/82
R17 S   SCHINDLER 81 USE TRIANGLE RELATION FOR AMPLITUDES DO -->KOBAR RHOO,   1/82
R17 S   DO -->K- RHO+ AND D+ -->KOBAR RHO+, AND THEIR D+/DO LIFETIME RATIO.   1/82
R18     D+ INTO (PI+ PIO)/(KOBAR PI+)                            (P15)/(P2)           1/82
R18            0.30  OR LESS  CL=.90   SCHINDLER 81 SMK2 E+E- 3.771 GEV ECM   1/82

R19     D+ INTO (KOBAR K+)/(KOBAR PI+)                           (P16)/(P2)           1/82
R19       6    0.25     0.15           SCHINDLER 81 SMK2 E+E- 3.771 GEV ECM   1/82

R21     D+ AND DO INTO (ETA ANYTHING)/(TOTAL D+ AND DO)
R21  B       (0.02) OR LESS            BRANDELIK 79 DASP    E+E- ECM=4.03GEV  1/82
R21            0.13  OR LESS           PARTRIDGE 81 CBAL    E+E- ECM=3.77GEV  1/82
R21  B BRANDELIK 79 RESULT BASED ON ABSENCE OF ETA SIGNAL AT 4.03 GEV.        1/82
R21  B PARTRIDGE 81 OBSERVE SUBSTANTIALLY HIGHER ETA CROSS SECTION AT 4.03.   1/82

R22     D+ INTO (MU+ NUMU)/TOTAL                                 (P20)               11/83*
R22  A   0     0.02  OR LESS  CL=.90   AUBERT    83 SPEC   MU+ FE, 250 GEV   11/83*
R22  A  AUBERT 83 OBTAIN UPPER LIMIT 0.014 ASSUMING THAT FINAL STATE         11/83*
R22  A  CONTAINS EQUAL MIXTURE OF (D+,D-),(D+,ADO),(D-,DO) AND (DO,ADO) .    11/83*
R22  A  WE QUOTE THE LIMIT WHICH THEY GET UNDER MORE GENERAL ASSUMPTIONS .   11/83*

R23     D+ INTO (K- PI+ PI+ PIO)/(K- PI+ PI+)                    (P21)/(P1)
R23       1    0.57     0.65     0.17  AGUILAR2  83 HYBR    PI- P,360GEV      2/84*

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REFERENCES FOR CHARGED D

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GOLDHABE 76 PRL 37 255        GOLDHABER,PIERRE,ABRAMS,ALAM+     (LBL+SLAC)
PERUZZI  76 PRL 37 569        +PICCOLO,FELDMAN,NGUYEN,WISS+     (SLAC+LBL)
WISS     76 PRL 37 1531       +GOLDHABER,ABRAMS,ALAM,BOYARSKI+ (LBL+SLAC)

BRANDELI 77 PL 70B 387        BRANDELIK +      (AACH+DESY+HAMB+MPIM+TOKY)
GOLDHABE 77 PL 69B 503        GOLDHABER,WISS,ABRAMS,ALAM +      (LBL+SLAC)
PERUZZI  77 PRL 39 1301       +PICCOLO,FELDMAN+      (SLAC+LBL+NWES+HAWA)
PICCOLO  77 PL 70B 260        +PERUZZI,LUTH,NGUYEN,WISS,ABRAMS+(SLAC+LBL)

BACINO   78 PRL 40 671        +BAUMGARTEN,BIRKWOOD +      (SLAC+UCLA+UCI)
FELLER   78 PRL 40 274        +LITKE,MADARAS,RONAN+  (LBL+SLAC+NWES+HAWA)
VUILLEMI 78 PRL 41 1149       VUILLEMIN,FELDMAN +    (LBL+SLAC+NWES+HAWA)

ARMENISE 79 PL 86B 115        +ERRIQUEZ+        (BARI+CERN+EPOL+MILA+ORSA)
BACINO   79 PRL 43 1073       +FERGUSON,NODULMAN+     (UCLA+SLAC+UCI+STON)
BRANDELI 79 PL 80B 412        BRANDELIK+        (AACH+DESY+HAMB+MPIM+TOKY)
DRIJARD  79 PL 81B 250        +FISCHER,GEIST+        (CERN+CDEF+HEID+KARL)

ALLASIA  80 NP B176 13         (ANKA+LIBH+CERN+DUUC+LOUC+KEYN+PISA+ROMA+)
BACINO   80 PRL 45 329        +FERGUSON+           (UCLA+SLAC+STAN+UCI+STON)
USHIDA   80 PRL 45 1053         (AICH+FNAL+KOBE+SEOU+MCGI+NAGO+OSU+OKAY+)
ZHOLENTZ 80 PL 96B 214        +KURDADZE,LELCHUK,MISHNEV,NIKITIN+    (NOVO)
    ALSO 81 YAD.PHYS.34 1471  ZHOLENTZ +                            (NOVO)

ADAMOVIC 81 PL 99B 271        ADAMOVICH+(PHOTON-EMUL,OMEGA-PHOTON COLLS.)
BALLAGH  81 PR D24 7          +BINGHAM+      (LBL+UCB+FNAL+HAWA+WASH+WISC)
    ALSO 80 PL 89B 423        BALLAGH +      (LBL+UCB+FNAL+HAWA+WASH+WISC)
PARTRIDG 81 PRL 47 760        PARTRIDGE,PECK+   (CIT+HARV+PRIN+STAN+SLAC)
SCHINDLE 81 PR D24 78         SCHINDLER,ALAM,BOYARSKY +          (SLAC+LBL)

ABE      82 PRL 48 1526       (SLAC HYBRID FACILITY PHOTON COLLABORATION)
ALBINI   82 PL 110B 339       ALBINI+      (FRAS+MILA+PISA+ROMA+TORI+TRST)
AGUILAR  83 PL 122B 312       AGUILAR-BENITEZ+    LEBC-EHS COLLAB (CERN+)
AGUILAR2 83 PL 123B 98        AGUILAR-BENITEZ+    LEBC-EHS COLLAB (CERN+)
AUBERT   83 NP B213 31        EUROPEAN MUON COLLAB.      (CERN+DESY+FREI+)
BADERTSC 83 PL 123B 471       BADERTSCHER,HAHN,HUGENTOBLER+    (BERN+MPIM)
USHIDA   83 PRL 51 2362         (AICH+FNAL+KOBE+SEOU+MCGI+NAGO+OSU+OKAY+)

                              REVIEWS

BARBAROG 78 LBL-8537          A.BARBARO-GALTIERI (ERICE 1978)        (LBL)
WOJCICKI 78 SLAC-PUB-2232     S.WOJCICKI (SLAC SUMMER INST.1978)    (SLAC)
KIRKBY   79 SLAC-PUB-2419     J.KIRKBY (LEPTON CONF. BATAVIA, 1979)(SLAC)
TRILLING 81 PRPL 75 57        G.H.TRILLING                       (LBL+UCB)J
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D⁰

32 NEUTRAL D(1865,JP=0-) I=1/2

FOR A RECENT REVIEW SEE TRILLING 81

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                    32  NEUTRAL D MASS (MEV)

M       234(1865.)    (15.)             GOLDHABER 76 SMAG   K PI AND K 3PI     1/77
M          (1863.)     (3.)             GOLDHABER 77 SMAG   DO,D+ RECOIL SPC 12/77
M    P     (1863.3)   (0.9)             PERUZZI   77 SMAG   E+E- 3.77GEV ECM 12/77
M          (1868.)    (11.)             PICCOLO   77 SMAG   E+E-4.03,4.41ECM  1/78
M        64(1850.)    (15.)             BALTAY    78 HBC    NEU NUCL,KOPIPI   1/79
M    A   94(1854.)     (6.)             ATIYA     79 SPEC GAM NUC-->DO DOBAR  12/79
M         1(1866.)     (8.)             ADAMOVICH 80 EMUL GAMMA NUC-->DOBAR +  2/80
M       238(1863.0)    (2.5)            ASTON     80 OMEG GAMMA P-->DOBAR     12/81
M    A  143(1860.)     (2.)             AVERY     80 SPEC    GAMMA NUC-->D*+  12/81
M    A   35(1869.)     (4.)             AVERY     80 SPEC    GAMMA NUC-->D*+  12/81
M         1(1847.)     (7.)             FIORINO   81 EMUL GAMMA NUC-->DOBAR +  1/82
M    P     (1863.8)    (0.5)            SCHINDLER 81 SMK2     E+E- 3.77GEV ECM  1/82
M     P     1864.7      0.6             TRILLING  81 RVUE +- E+E- 3.77GEV ECM  1/82
M     P  PERUZZI 77 AND SCHINDLER 81 ERRORS DO NOT INCLUDE THE 0.13 PERCENT    1/82
M     P  UNCERTAINTY IN THE ABSOLUTE SPEAR ENERGY CALIBRATION.  TRILLING 81    1/82
M     P  USES THE HIGH PRECISION PSI AND PSI-PRIME MEASUREMENTS OF             1/82
M     P  ZHOLENTZ 80 TO DETERMINE THIS UNCERTAINTY AND COMBINES THE            1/82
M     P  PERUZZI 77 AND SCHINDLER 81 RESULTS TO OBTAIN THE VALUE QUOTED.       1/82
M     A  ERROR DOES NOT INCLUDE POSSIBLE SYSTEMATIC MASS SCALE SHIFT,          1/81
M     A  ESTIMATED TO BE LESS THAN 5 MEV.                                      1/81

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             32  (DO1) - (DO2) MASS DIFFERENCE (UNITS 10**-4 EV)

D       DO1 AND DO2 ARE THE CP EIGENSTATES OF THE NEUTRAL D MESON.
D        MEASURE OF DELTA-C = 2 DO-DOBAR MIXING.
D     B        6.5   OR LESS  CL=.90   BODEK      82 SPEC    PI-,P FE-->DO     2/84*
D     B  BODEK 82 LIMIT IS FOR THE ABSOLUTE VALUE OF THE MASS DIFFERENCE.     2/84*

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             32  (D+-) - (DO) MASS DIFFERENCE (MEV)

DM    A        5.0      0.8             PERUZZI   77 SMAG +- E+E- 3.77GEV ECM  3/78
DM    A        4.7      0.3             SCHINDLER 81 SMK2 +- E+E- 3.77GEV ECM  1/82
DM    A  NOT INDEPENDENT OF D+- AND DO MASS MEASUREMENTS.                      3/78
DM              . . . . . . . . . .
DM   AVG       4.74     0.28     AVERAGE

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             32  NEUTRAL D MEAN LIFE   (UNITS 10**-13 SEC)

T              (8.0)  OR LESS  CL=.90   ARMENISE  79 HYBR NEU P -->DIMUONS +   1/80
T          1   (0.226)                  ADAMOVICH 80 EMUL INCL IN ADAMOVICH81  2/80
T     E    3   (0.53)   (0.57)   (0.25) ALLASIA   80 EMUL NEU WIDEBAND       12/81
T     C        (2.1)  OR LESS  CL=.95   BACINO    80 DLCO E+E- 3.77 GEV ECM    1/81
T     G    7   (1.00)   (0.52)   (0.31) USHIDA    80 EMUL INCL. IN USHIDA 82  12/81
T     F    3   (0.58)   (0.8)    (0.2)  ADAMOVICH 81 EMUL CERN-SPS GAMMA NUCL  1/82
T     H    1   (0.14)                   ADAMOVI2  81 EMUL CERN-SPS GAMMA NUCL  4/82
T     H    1   (3.4)  OR  (7.5)         ADAMOVI2  81 EMUL CERN-SPS GAMMA NUCL  4/82
T     B    2   (2.8)    (2.2)    (1.3)  BALLAGH   81 HYBR FNAL 15FT, NU NE-H2  1/82
T     A    1   (2.1)                    ADEVA     81 HYBR LEBC CERN-SPS PI- P  1/82
T     A    1   (5.9)                    ADEVA     81 HYBR LEBC CERN-SPS PI- P  1/82
T          5    3.1      2.0      1.6   FUCHI     81 EMUL CERN-SPS PI- NUC     1/82
T         11    6.7      3.5      2.0   ABE       82 HYBR SLAC GAM P 19.5 GEV  2/82
T      G  16    2.3      0.8      0.5   USHIDA    82 EMUL FNAL NU,ANU WIDEBND  2/82
T         16    4.1      1.3      0.9   AGUILAR   83 HYBR PI- P, P P          11/83*
T          9    4.1      2.6      1.4   BADERTSCH 83 HYBR CERN PI- NUCL.      11/83*
T         27    4.2      1.6      1.4   YELTON    84 SMK2 E+E- ECM=29 GEV      2/84*
T     E  ALLASIA 80 ASSUMES NO LONG-LENGTH LOSSES.  VISIBILITY PROBLEMS IN     4/82
T     E  THE EMUL.                                                             4/82
T     C  USES THEORETICAL RATE D TO (K E NEU)=1.4*10**11 SEC**-1 .             1/81
T     F  ADAMOVICH 81 ASSUMES NO LONG-LENGTH LOSSES.                           4/82
T     H  ADAMOVICH2 81 HAS NO CORRECTION FOR DETECTION EFFICIENCY.             4/82
T     B  BALLAGH 81 VALUE QUOTED HERE ASSUMES THAT ALL DILEPTON EVENTS         1/82
T     B  CONTAIN DO OR D+, EACH WITH EQUAL NUMBERS OF SEMILEPTONIC DECAYS.     1/82
T     A  ADEVA 81 FIRST AND SECOND VALUES ARE PROPER LIFETIMES OF DO AND ADO   1/82
T     A  FROM SINGLE EVENT.  DETECTION EFFICIENCY LOW FOR LIFETIMES 10**-13    1/82
T     A  SEC OR LESS.                                                          1/82
T     D  CERN NA16 (LEBC-EHS) EXPT.  PRESENTED AT MORIOND CONF. 82.            4/82
T      G USHIDA 82 HAVE 3 SEMI-LEPTONIC DECAYS NOT INCLUDED IN THIS NUMBER,    4/82
T      G BUT BELIEVED TO HAVE MUCH LONGER LIFETIMES.  SUPERCEDES USHIDA 80.    4/82
T               . . . . . . . . . .
T    AVG        4.40     0.81     0.60   AVERAGE

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             32  ((DO1) - (DO2))/AVG., MEAN LIFE DIFFERENCE

DT      DO1 AND DO2 ARE THE CP EIGENSTATES OF THE NEUTRAL D MESON.
DT    B         0.55  OR LESS  CL=.90   BODEK     82 SPEC    PI-,P FE-->DO     2/84*
DT    B  BODEK 82 LIMIT IS FOR THE ABSOLUTE VALUE OF THE MEAN LIFE             2/84*
DT    B  DIFFERENCE.                                                           2/84*

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             32  (CHARGED D)/(NEUTRAL D) MEAN LIFE RATIO

TR      FROM RATIO OF D+ TO DO SEMILEPTONIC BRANCHING FRACTIONS.
TR       NOT USED BY US TO CONSTRAIN BEST VALUES OF D LIFETIMES FOR TABLE.
TR             (4.3)  OR MORE  CL=.95   BACINO    80 DLCO E+E- 3.77 GEV ECM    1/82
TR             (3.1)    (4.6)    (1.4)  SCHINDLER 81 SMK2 E+E- 3.77 GEV ECM    1/82

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             32  NEUTRAL D PARTIAL DECAY MODES

                                                            DECAY MASSES
P1      DO INTO K- PI+                                      494+ 140
P2      DO INTO K- PI+ PI+ PI-                              494+ 140+ 140+ 140
P3      DO INTO KOBAR PI+ PI-                               498+ 140+ 140
P4      DO INTO KOBAR PI+ PI- PI+ PI-                       498+ 140+ 140+ 140+
P5      DO INTO PI+ PI-                                     140+ 140
P6      DO INTO K+ PI- (VIA DOBAR)                          494+ 140
P7      DO INTO K+ K-                                       494+ 494
P8      DO INTO K- PI+ PIO                                  494+ 140+ 135
P9      DO INTO KOBAR PIO                                   498+ 135
P10     DO INTO E+ ANYTHING
P11     DO INTO K- ANYTHING
P12     DO INTO K+ ANYTHING
P13     DO INTO KOBAR ANYTHING + KO ANYTHING
P14     DO INTO K*(892)- PI+                                892+ 140
P15     DO INTO K*(892)0 PIO                                892+ 135
P16     DO INTO K- RHO+                                     494+ 769
P17     DO INTO KOBAR RHOO                                  498+ 769
P18     DO INTO PI- PI- PI+ PI+                             140+ 140+ 140+ 140
P19     DO INTO UNFITTED MODES (KEEPS FIT PGM. HAPPY)
P20     DO INTO K- PI+ PIO PIO                              494+ 140+ 135+ 135
P21     DO INTO ETA ANYTHING (SEE CHARGED D SECTION R21)
P22     DO INTO K*(892)0 RHOO                               892+ 769
P23     DO INTO K- PI+ RHOO                                 494+ 140+ 769
P24     DO INTO K*(892)0 PI+ PI-                            892+ 140+ 140
P25     DO INTO K- A2(1320)+                                494+1318
P26     DO INTO MU- ANYTHING (VIA DOBAR)
P27     DO INTO MU+ ANYTHING

        DOBAR MODES ARE CHARGE CONJUGATES OF ABOVE MODES

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Stable Particles

Data Card Listings

D^0, $F^{\pm}$

FITTED PARTIAL DECAY MODE BRANCHING FRACTIONS

The matrix below is derived from the error matrix for the fitted partial decay mode branching fractions, P_i, as follows: The diagonal elements are $P_i \pm \delta P_i$, where $\delta P_i = \sqrt{\langle \delta P_i \delta P_i \rangle}$, while the off-diagonal elements are the normalized correlation coefficients $\langle \delta P_i \delta P_j \rangle / (\delta P_i \cdot \delta P_j)$. For the definitions of the individual P_i, see the listings above; only those P_i appearing in the matrix are assumed in the fit to be nonzero and are thus constrained to add to 1.

```
        P 1         P 2         P 3         P 5         P 7         P19
P 1 .0239+-.0038
P 2    .3191   .0456+-.0116
P 3    .1725      .0550   .0420+-.0077
P 5    .3308      .1056      .0571   .0008+-.0004
P 7    .5146      .1642      .0888      .1702   .0027+-.0008
P19   -.5761     -.8195     -.5569     -.2114     -.3343   .8849+-.0164
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                    32  NEUTRAL D BRANCHING RATIOS

R1       DO INTO (K- PI+)/TOTAL                                 (P1)
R1       130     0.022     0.006            PERUZZI    77 SMAG    E+E- 3.77GEV ECM 12/77
R1       263     0.030     0.006            SCHINDLER 81 SMK2 E+E- 3.771 GEV ECM   1/82
R1
R1   AVG         0.0260    0.0042  AVERAGE
R1   FIT         0.0239    0.0038 FROM FIT

R2       DO INTO (K- PI+ PI+ PI-)/TOTAL                         (P2)
R2        44     0.032     0.011            PERUZZI    77 SMAG    E+E- 3.77GEV ECM 12/77
R2       185     0.085     0.021            SCHINDLER 81 SMK2 E+E- 3.771 GEV ECM   1/82
R2
R2   AVG         0.043     0.022   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 2.2)
R2   FIT         0.046     0.012  FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.4)

R3       DO INTO (KOBAR PI+ PI-)/TOTAL                          (P3)
R3        28     0.040     0.013            PERUZZI    77 SMAG    E+E- 3.77GEV ECM 12/77
R3        32     0.038     0.012            SCHINDLER 81 SMK2 E+E- 3.771 GEV ECM   1/82
R3
R3   AVG         0.0389    0.0088  AVERAGE
R3   FIT         0.0420    0.0077 FROM FIT

R4       DO INTO (K- PI+ PI+ PI-)/(K- PI+)                      (P2)/(P1)
R4    P 214      2.2       0.8              PICCOLO    77 SMAG    E+E-4.03,4.41ECM 12/77
R4       10      2.0       1.0              BAILEY     83 SPEC    PI- BE--> DO     2/84*
R4     P THIS CHANNEL DOMINATED BY K- PI+ RHOO (85+-15 PERCENT).                   12/77
R4     P K* PI+ PI- AND K- A2+ CONSISTENT WITH 0, K* RHOO FRAC IS 0.1+-0.1 .      12/77
R4
R4   AVG         2.12      0.62    AVERAGE
R4   FIT         1.91      0.48    FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.2)

R5       DO INTO (KOBAR PI+ PI-)/(K- PI+)                       (P3)/(P1)
R5       116     2.8       1.0              PICCOLO    77 SMAG    E+E-4.03,4.41ECM 12/77
R5        35     1.7       0.8              AVERY      80 SPEC    GAMMA NUC-->D*+  12/81
R5
R5   AVG         2.13      0.62    AVERAGE
R5   FIT         1.76      0.39    FROM FIT

R6       DO INTO (PI+ PI-)/(K- PI+)                             (P5)/(P1)
R6               0.07  OR LESS  CL=.90      PICCOLO    77 SMAG    E+E- 4.03 GEVECM 12/77
R6               0.033     0.015            ABRAMS     79 SMK2    E+E- 3.77GEV ECM 12/79
R6
R6   FIT         0.033     0.015   FROM FIT

R7       DO INTO (K+ K-)/(K- PI+)                               (P7)/(P1)
R7               0.07  OR LESS  CL=.90      PICCOLO    77 SMAG    E+E- 4.03GEV ECM 12/77
R7               0.113     0.030            ABRAMS     79 SMK2    E+E- 3.77GEV ECM 12/79
R7
R7   FIT         0.113     0.030   FROM FIT

R8       DO INTO (K+ PI-, VIA DOBAR)/(K- PI+ + K+ PI-)     (P6)/(P1+P6)
R8        THIS IS THE DO-DOBAR MIXING LIMIT
R8               0.16  OR LESS  CL=.90      FELDMAN    77 SMAG    D*+ TO DO PI+     3/77
R8              (0.18) OR LESS  CL=.90      GOLDHABER 77 SMAG                     12/77

R9       DO INTO (K- PI+ PIO)/TOTAL                             (P8)
R9         7     0.12      0.06             SCHARRE    78 SMAG    E+E- 3.77 GEV     1/78
R9        37     0.085     0.032            SCHINDLER 81 SMK2 E+E- 3.771 GEV ECM   1/82

R10      DO INTO (KOBAR PIO)/TOTAL                              (P9)
R10             (0.06) OR LESS  CL=.90      SCHARRE    78 SMAG    E+E- 3.77 GEV     1/78
R10        8     0.022     0.011            SCHINDLER 81 SMK2 E+E- 3.771 GEV ECM   1/82

R12      DO INTO (KOBAR ANYTHING + KO ANYTHING)/TOTAL           (P13)
R12        6     0.57      0.26             VUILLEMIN 78 SMAG E+E- 3.772 GEV ECM   1/79
R12       13     0.29      0.11             SCHINDLER 81 SMK2 E+E- 3.771 GEV ECM   1/82
R12
R12 AVG          0.33      0.10    AVERAGE

R13      DO INTO (E+ ANYTHING)/TOTAL                            (P10)
R13        0    (0.04) OR LESS  CL=.95      BACINO     80 DLCO E+E- 3.77 GEV ECM    4/82
R13       12     0.055     0.037            SCHINDLER 81 SMK2 E+E- 3.771 GEV ECM   4/82
R13        3     0.051     0.048     0.014 AGUILAR    83 HYBR PI- P, P P          11/83*
R13
R13              0.053     0.029     0.013 AVERAGE                                3/84*

R14      DO INTO (K*(892)- PI+)/TOTAL                           (P14)              1/82
R14       25     0.034     0.014            SCHINDLER 81 SMK2 E+E- 3.771 GEV ECM   1/82

R15      DO INTO (K*(892)0 PIO)/TOTAL                           (P15)              1/82
R15        4     0.014     0.023     0.014 SCHINDLER 81 SMK2 E+E- 3.771 GEV ECM   1/82

R16      DO INTO (K- RHO+)/TOTAL                                (P16)              1/82
R16       31     0.072     0.030     0.031 SCHINDLER 81 SMK2 E+E- 3.771 GEV ECM   1/82

R17      DO INTO (KOBAR RHOO)/TOTAL                             (P17)              1/82
R17        1     0.001     0.006     0.001 SCHINDLER 81 SMK2 E+E- 3.771 GEV ECM   1/82

R18      DO INTO (PI- PI- PI+ PI+)/(K- PI+ PI+ PI-)             (P18)/(P2)         1/82
R18              0.21  OR LESS  CL=.90      SCHINDLER 81 SMK2 E+E- 3.771 GEV ECM   1/82

R19      DO INTO (K- ANYTHING)/TOTAL                            (P11)              1/82
R19       19     0.35      0.10             VUILLEMIN 78 SMAG E+E- 3.772 GEV ECM   1/79
R19      121     0.55      0.11             SCHINDLER 81 SMK2 E+E- 3.771 GEV ECM   1/82
R19
R19 AVG          0.440     0.100   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.3)

R20      DO INTO (K+ ANYTHING)/TOTAL                            (P12)              1/82
R20       25     0.08      0.03             SCHINDLER 81 SMK2 E+E- 3.771 GEV ECM   1/82

R21      DO INTO (K- PI+ PIO PIO)/TOTAL                         (P20)              1/82
R21        1 SEEN                           ADEVA      81 HYBR    PI- P-->DO DOBAR 1/82

R22      DO INTO (K*(892)0 RHOO)/(K- PI+ PI+ PI-)               (P22)/(P4)
R22       FOLLOWED BY DECAY K*(892)0 --> K- PI+
R22       20     0.10      0.11      0.10  PICCOLO    77 SMAG    E+E-4.03,4.41ECM  2/84*
R22        5    (0.5)     (0.2)   CL=.90   BAILEY     83 SPEC    PI BE --> DO      2/84*

R23      DO INTO (K- PI+ RHOO)/(K- PI+ PI+ PI-)                 (P23)/(P4)
R23      180     0.85      0.11      0.22  PICCOLO    77 SMAG    E+E-4.03,4.41ECM  2/84*
R23        2    (0.2)     (0.2)   CL=.90   BAILEY     83 SPEC    PI BE --> DO      2/84*

R24      DO INTO (K*(892)0 PI+ PI-)/(K- PI+ PI+ PI-)            (P24)/(P4)
R24       FOLLOWED BY DECAY K*(892)0 --> K- PI+
R24   P    0     0.0       0.2       0.0   PICCOLO    77 SMAG    E+E-4.03,4.41ECM  2/84*
R24        0    (0.18) OR LESS  CL=.90     BAILEY     83 SPEC    PI BE --> DO      2/84*
R24   P   CORRESPONDS TO 0.33 AT CL=.90.                                           2/82

R25      DO INTO (K- A2(1320)+)/(K- PI+ PI+ PI-)                (P25)/(P4)
R25       FOLLOWED BY DECAY A2+ --> PI+ PI+ PI- (B.R.=0.35)                        2/84*
R25              0.06  OR LESS                 PICCOLO    77 SMAG    E+E-4.03,4.41ECM  2/84*
R26      DO INTO (MU- ANYTHING,VIA DOBAR)/(MU+ ANY + MU- ANY)
R26                                                             (P26)/(P26+P27)
R26              0.044 OR LESS  CL=.90     BODEK      82 SPEC    PI-,P FE-->DO     2/84*
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REFERENCES FOR NEUTRAL D

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GOLDHABE 76 PRL 37 255          GOLDHABER,PIERRE,ABRAMS,ALAM+    (LBL+SLAC)
FELDMAN  77 PRL 38 1313         +PERUZZI,PICCOLO,ABRAMS,ALAM +   (SLAC+LBL)
GOLDHABE 77 PL 69B 503          GOLDHABER,WISS,ABRAMS,ALAM +     (LBL+SLAC)
PERUZZI  77 PRL 39 1301         +PICCOLO,FELDMAN+       (SLAC+LBL+NWES+HAWA)
PICCOLO  77 PL 70B 260          +PERUZZI,LUTH,NGUYEN,WISS,ABRAMS+(SLAC+LBL)

BALTAY   78 PRL 41 73           +CAROUMBALIS,FRENCH,HIBBS,HYLTON+(COLU+BNL)
SCHARRE  78 PRL 40 74           +BARBARO-GALTIERI +     (SLAC+LBL+NWES+HAWA)
VUILLEMI 78 PRL 41 1149         VUILLEMIN,FELDMAN +     (LBL+SLAC+NWES+HAWA)
ABRAMS   79 PRL 43 481          +ALAM,BLOCKER,BOYARSKI+           (SLAC+LBL)
ARMENISE 79 PL 86B 115          +ERRIQUEZ+         (BARI+CERN+EPOL+MILA+ORSA)
ATIYA    79 PRL 43 414          +HOLMES,KNAPP,LEE+            (COLU+ILL+FNAL)

ADAMOVIC 80 PL 89B 427          ADAMOVICH+(PHOTON-EMUL,OMEGA-PHOTON COLLS.)
ALLASIA  80 NP B176 13           (ANKA+LIBH+CERN+DUUC+LOUC+KEYN+PISA+ROMA+)
ASTON    80 PL 94B 113          +(BONN+CERN+EPOL+GLAS+LANC+MCHS+LALO+LPNP+)
AVERY    80 PRL 44 1309         +WISS,BUTLER,GLADDING+        (ILL+FNAL+COLU)
BACINO   80 PRL 45 329          +FERGUSON+          (UCLA+SLAC+STAN+UCI+STON)
USHIDA   80 PRL 45 1049           (AICH+FNAL+KOBE+SEOU+MCGI+NAGO+OSU+OKAY+)
ZHOLENTZ 80 PL 96B 214          +KURDADZE,LELCHUK,MISHNEV,NIKITIN+    (NOVO)
    ALSO 81 YAD.PHYS.34 1471    ZHOLENTZ +                            (NOVO)

ADAMOVIC 81 PL 99B 271          ADAMOVICH+(PHOTON-EMUL,OMEGA-PHOTON COLLS.)
ADAMOVI2 81 JETPL 34 456        (PISMA JETF 34 477)(PHOT.EMUL.,OMEGA-PHOT.)
    ALSO 80 ADAMOVICH
    ALSO 81 FIORINO
ADEVA    81 PL 102B 285         +AGUILAR-BENITEZ + (LEBC-EHS COLLABORATION)
BALLAGH  81 PR D24 7            +BINGHAM+       (LBL+UCB+FNAL+HAWA+WASH+WISC)
    ALSO 80 PL 89B 423          BALLAGH +       (LBL+UCB+FNAL+HAWA+WASH+WISC)
FIORINO  81 LNC 30 166          FIORINO+ (PHOTON-EMUL, OMEGA-PHOTON COLLS.)
FUCHI    81 LNC 31 199          +HOSHINO,MIYANISHI+   (NAGO+AICH+TOKY+YOKO)
SCHINDLE 81 PRD 24 78           SCHINDLER,ALAM,BOYARSKY +          (SLAC+LBL)
ABE      82 PRL 48 1526         (SLAC HYBRID FACILITY PHOTON COLLABORATION)
BODEK    82 PL 113B 82          +BREEDON,COLEMAN+ (ROCH+CIT+CHIC+FNAL+STAN)
USHIDA   82 PRL 48 844            (AICH+FNAL+KOBE+SEOU+MCGI+NAGO+OSU+OKAY+)
AGUILAR  83 PL 122B 312         AGUILAR-BENITEZ+    LEBC-EHS COLLAB (CERN+)
BADERTSC 83 PL 123B 471         BADERTSCHER,HAHN,HUGENTOBLER+   (BERN+MPIM)
BAILEY   83 PL 132B 237         +BARDSLEY,BECKER+    ACCMOR COLLAB. (CERN+)
YELTON   84  SLAC-PUB-3274      +GLADNEY,GOLDHABER,ABRAMS+  (SLAC+LBL+HARV)

        QUANTUM NUMBER DETERMINATIONS NOT REFERRED TO IN THE DATA CARDS

NGUYEN   77 PRL 39 262          +WISS,ABRAMS,ALAM,BOYARSKI+      (LBL+SLAC)J

                                REVIEWS

BARBAROG 78 LBL-8537            A.BARBARO-GALTIERI (ERICE 1978)        (LBL)
WOJCICKI 78 SLAC-PUB-2232       S.WOJCICKI (SLAC SUMMER INST.1978)    (SLAC)
KIRKBY   79 SLAC-PUB-2419       J.KIRKBY (LEPTON CONF. BATAVIA, 1979)(SLAC)
TRILLING 81 PRPL 75 57          G.H.TRILLING                       (LBL+UCB)J
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$F^{\pm}$

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34  F+-(1970,JP=0-)  I=0

QUANTUM NUMBERS NOT MEASURED.  VALUES ARE ASSIGNED
HERE ASSUMING CHARMED-STRANGE GROUND STATE F-MESON.
CHEN 83 OBSERVATIONS ARE CONSISTENT WITH J=0.
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NOTE ON THE F MESON

The strongest evidence for the F meson comes from the CLEO observation (CHEN 83) of a $\phi\pi^{\pm}$ signal of 104 ± 19 events above background with mass $(1970 \pm 5 \pm 5)$ MeV and width consistent with resolution. The decay angular distributions are consistent with a spin-0 F decaying to $\phi\pi$ followed by $\phi \rightarrow K^+K^-$. The observation of a $\phi\pi^{\pm}$ state at this mass has been confirmed by TASSO (ALTHOFF 84) and supported in a preliminary report from ARGUS (ARGUS 83).

The 1970-MeV mass is inconsistent with that found by the OMEGA Spectrometer photoproduction experiment, while the earlier DASP mass (BRANDELIK 77,79) is consistent with both the CLEO and OMEGA

For notation, see key at front of Listings.

results. DASP (BRANDELIK 77,79) observed an $\eta\pi^{\pm}$ signal of 6 events with negligible background at (2030 ± 60) MeV. OMEGA reported signals in $\eta\pi^{\pm}$, $\eta\pi^{\pm}\pi^{+}\pi^{-}$, and $\eta'\pi^{\pm}\pi^{+}\pi^{-}$ at an average mass of $(2020 \pm 10 \pm 20)$ MeV (ASTON 81), in $\phi\rho^{\pm}$ at (2049 ± 15) MeV (ASTON2 81), and later in $\eta\pi^{\pm}$ at (2017 ± 13) MeV (ATKINSON 83). The disagreement between OMEGA and CLEO masses cannot be accounted for by any known systematic errors.

Another apparent disagreement involves the $F \to \phi\pi^{\pm}$ branching fraction. OMEGA sets a limit $\sigma \cdot B < 4$ nb for the $F\bar{F}$ photoproduction cross section times the branching fraction to this mode (ASTON2 81), compared with $\sigma \cdot B = (140 \pm 20)$ nb for the sum of the four modes they reported, i.e., a branching ratio $\Gamma(F^{\pm} \to \phi\pi^{\pm})/\Gamma(F^{\pm} \to \eta\pi^{\pm} + \eta\pi^{\pm}\pi^{+}\pi^{-} + \eta'\pi^{\pm}\pi^{+}\pi^{-} + \phi\rho^{\pm}) < 3\%$. This suggests a much smaller branching ratio to all possible modes: $B(F \to \phi\pi) \equiv \Gamma(F \to \phi\pi)/\Gamma(F \to \text{all}) \ll 3\%$. In contrast CLEO (CHEN 83), using a crude estimate of the level of $F^{\pm}$ production, obtains $B(F \to \phi\pi) \sim 4.4\%$, while TASSO (ALTHOFF 84) finds a somewhat higher value. Theoretical estimates for this branching fraction are 2%-3%.[1]

The hybrid-emulsion spectrometer wide-band neutrino beam experiment at Fermilab (USHIDA 83) cannot be used to establish an F mass because their cuts to eliminate D background effectively require their F candidates to have a mass greater than 2000 MeV. In a second run this group has reduced the mass bias by improved mass resolution and by including ϕ decay modes. Preliminary results for this run reported at Cornell[2] give a mass for 8 $F^{\pm}$ candidates which is in agreement with both the CLEO and the OMEGA results.

The situation is thus by no means clear. In the Stable Particle Table we give the mass determined from $e^{+}e^{-}$ observations of the $\phi\pi^{\pm}$ mode, $m_F = (1971 \pm 6)$ MeV, to which we attach a cautionary footnote pointing out the conflicting results. We list decay modes of the F other than $\phi\pi$ as "possibly seen" because the conflicting mass values suggest that these other modes may not be observations of the 1971-MeV state adopted here as the F.

References

1. L. Maiani, J. Phys. (Paris), Colloq. **43**, C3-631 (1982); and D. Fakirov and B. Stech, Nucl. Phys. **B133**, 315 (1978).
2. N.W. Reay, *Proceedings 1983 International Lepton/Photon Symposium* (Cornell, 1983), eds. D.G. Cassel and D.L. Kreinick, p. 244.

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                    34  F+-(1970) MASS (MEV)

M        4(2030.)    (60.)            BRANDELIK 77 DASP +- IN BRANDELIK 79  12/77
M        6(2030.)    (60.)            BRANDELIK 79 DASP +- E+E- ECM=4.42GEV  1/80
M        1(2017.)    (25.)            AMMAR     80 HYBR +  NEU WIDEBAND      9/81
M        1(2026.)    (56.)            USHIDA    80 EMUL  - FNAL NU WIDEBAND  2/82
M        1(2089.)   (121.)            USHIDA    80 EMUL +  FNAL NU WIDEBAND  2/82
M   A  460(2020.)    (22.)            ASTON     81 OMEG +- GAMMA P-->F +      1/82
M       30(2049.)    (15.)            ASTON2    81 OMEG +- GAMMA P-->F +      2/84*
M         (1970.)    (10.)            ARGUS     83 ARG     PRELIMINARY        2/84*
M   C   17(2017.)    (13.)            ATKINSON  83 OMEG +- GAMMA P-->F +     11/83*
M    S 104 1970.       7.             CHEN      83 CLEO +- E+E- ECM=10.5GEV 10/83*
M    S  49 1975.      14.             ALTHOFF   84 TASS +- E+E- ECM14-25GEV  2/84*
M   A   ERROR QUOTED BY ASTON 81 IS 10 MEV STAT AND <20 MEV SYST.             1/82
M   A   AVERAGE OF THREE MODES LISTED IN SECTIONS R2, R3, AND R4 BELOW.       2/84*
M   C   ATKINSON 83 MASS ERROR INCLUDES SYSTEMATIC UNCERTAINTIES.            11/83*
M    S  STATISTICAL AND SYSTEMATIC ERRORS COMBINED IN QUADRATURE.             2/84*
M        . . . . . . . . .
M   AVG    1971.0      6.3     AVERAGE

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                    34  F+-(1970) MEAN LIFE    (UNITS 10**-13 SEC)

T        2   (2.24)   (2.78)   (1.05) USHIDA    80 EMUL    NEU WIDEBAND     12/81
T        1   (1.4)                   AMMAR     80 HYBR +  NEU WIDEBAND      1/82
T   A    2   (2.1)    (3.6)    (0.8) AGUILAR   83 HYBR PI- P, P P           2/84*
T        4    1.9      1.3      0.7  USHIDA    83 EMUL REPL. USHIDA 80       2/84*
T   A   WITHDRAWN BY AUTHORS.  D INTERPRETATION CANNOT BE RULED OUT WITHOUT  2/84*
T   A   PARTICLE ID.  S.REUCROFT (PRIVATE COMMUNICATION, 1984).              2/84*

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                    34  F+-(1970) PARTIAL DECAY MODES

                                                          DECAY MASSES
P1      F+- INTO ETA PI+-                                 549+ 140
P2      F+- INTO ETA ANYTHING                             549+   0
P3      F+- INTO ETA PI+- PI+ PI-                         549+ 140+ 140+ 140
P4      F+- INTO ETA PRIME PI+- PI+ PI-                   958+ 140+ 140+ 140
P5      F+- INTO PHI RHO+-                               1020+ 769
P6      F+- INTO PHI PI+-                                1020+ 140
P7      F+- INTO MU+- NU                                  106+   0
P8      F+- INTO PHI PI+- PI+ PI-                        1020+ 140+ 140+ 140

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                    34  F+-(1970) BRANCHING RATIOS

R1      F+- INTO (ETA PI+-)/(ETA ANYTHING)                (P1)/(P2)
R1  A    6   (0.09)   (0.06)          BRANDELIK 79 DASP    E+E- ECM=4.42GEV  4/82
R1  A   DENOMINATOR INCONSISTENT WITH PARTRIDGE 81 (CRYSTAL BALL)             4/82

R2      F+- INTO ETA PI+-                                 (P1)
R2     40 +- 9 EVENTS SEEN           ASTON     81 OMEG    GAMMA P-->F +      2/84*
R2     17 +- 6 EVENTS SEEN           ATKINSON  83 OMEG    GAMMA P-->F +      2/84*

R3      F+- INTO ETA PI+- PI+ PI-                         (P3)                1/82
R3    360 +- 90 EVENTS SEEN           ASTON     81 OMEG    GAMMA P-->F +      1/82

R4      F+- INTO ETA PRIME PI+- PI+ PI-                   (P4)                1/82
R4     60 +- 20 EVENTS SEEN           ASTON     81 OMEG    GAMMA P-->F +      1/82

R5      F+- INTO PHI RHO+-                                (P5)                1/82
R5     83 +- 26 EVENTS SEEN           ASTON2    81 OMEG    GAMMA P-->F +      1/82

R6      F+- INTO PHI PI+-                                 (P6)               10/83*
R6         (SEEN)                     ARGUS     83 ARG     PRELIMINARY        2/84*
R6  A  104   (0.044)                  CHEN      83 CLEO +- E+E- ECM=10.5GEV 10/83*
R6  A   49   (0.13)   (0.05)   (0.08) ALTHOFF   84 TASS +- E+E- ECM14-25GEV  2/84*
R6  A   BOTH VALUES BASED ON SAME CRUDE ESTIMATE OF F+- PRODUCTION LEVEL.    2/84*
R6  A   ALTHOFF 84 ERRORS ARE STATISTICAL AND SYSTEMATIC COMBINED IN         2/84*
R6  A   QUADRATURE WITH ADDITIONAL NEGATIVE ERROR FOR F+- FROM PRIMARY B.    2/84*

R7      F+- INTO (MU+- NU)/TOTAL                          (P7)
R7  A    0   (0.03) OR LESS           AUBERT    83 SPEC    MU+ FE, 250 GEV  11/83*
R7  A   AUBERT 83 OBTAIN THIS LIMIT ASSUMING THAT F+- PRODUCTION RATE IS    11/83*
R7  A   20 PERCENT OF TOTAL CHARM PRODUCTION RATE .                         11/83*

R8      F+- INTO PHI PI+- PI+ PI-                         (P8)
R8         (SEEN)                     ARGUS     83 ARG     PRELIMINARY        2/84*

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                          REFERENCES FOR F+-(1970)

BRANDELI 77 PL 70B 132        BRANDELIK +       (AACH+DESY+HAMB+MPIM+TOKY)
BRANDELI 79 PL 80B 412        BRANDELIK+        (AACH+DESY+HAMB+MPIM+TOKY)
AMMAR    80 PL 94B 118        +      (KANS+FNAL+SERP+ITEP+CRAC+JINR+WASH+)
USHIDA   80 PRL 45 1053         (AICH+FNAL+KOBE+SEOU+MCGI+NAGO+OSU+OKAY+)

ASTON    81 PL 100B 91         (BONN+CERN+EPOL+GLAS+LANC+MCHS+LALO+LPNP+)
ASTON2   81 NP B189 205        (BONN+CERN+EPOL+GLAS+LANC+MCHS+LALO+LPNP+)
PARTRIDG 81 PRL 47 760        PARTRIDGE,PECK+   (CIT+HARV+PRIN+STAN+SLAC)

AGUILAR  83 PL 122B 312       AGUILAR-BENITEZ+    LEBC-EHS COLLAB  (CERN)
ARGUS    83 CERN COUR. 23 423 ARGUS COLLABORATION (PRELIMINARY)
ATKINSON 83 ZP C17 1          +   (BONN+CERN+GLAS+LANC+MCHS+LPNP+RL+SHEF)
AUBERT   83 NP B213 31        EUROPEAN MUON COLLAB.     (CERN+DESY+FREI+)
CHEN     83 PRL 51 634        +  (SYRA+VAND+HARV+OSU+CORN+ITHA+ROCH+RUTG)
USHIDA   83 PRL 51 2362         (AICH+FNAL+KOBE+SEOU+MCGI+NAGO+OSU+OKAY+)
ALTHOFF  84 PL 141B TO BE PUB TASSO C.    (AACH+BONN+DESY+HAMB+LOIC+OXF+)

                              REVIEWS

TRILLING 81 PRPL 75 57        G.H.TRILLING                      (LBL+UCB)

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$B^{\pm}$

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                    41  CHARGED B(5271, JP-  )  I-

                    SEE ALSO THE LISTING FOR THE B (FOLLOWING THE ENTRY
                    FOR THE NEUTRAL B) FOR MEASUREMENTS WHICH DO NOT
                    IDENTIFY THE CHARGE STATE.

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                    41  CHARGED B MASS  (MEV)

M    A  6  5270.8      3.0           BEHRENDS  83 CLEO +- D*- PI+ PI+ + CC  4/83*
M    A  STATISTICAL (2.3 MEV) AND SYSTEMATICAL (2.0 MEV) ERRORS COMBINED.    4/83*

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Stable Particles

$B^{\pm}$, B^{0}, B, p

Data Card Listings

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                    41   CHARGED B PARTIAL DECAY MODES

                                                             DECAY MASSES
P1      B+ INTO DOBAR PI+                                   1865+ 140
P2      B+ INTO D*(2010)- PI+ PI+                           2007+ 140+ 140

        B- MODES ARE CHARGE CONJUGATES OF THE ABOVE MODES.

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                    41   CHARGED B BRANCHING RATIOS

R1      B+ INTO DOBAR PI+                                  (P1)
R1       2     0.042    0.042        BEHRENDS  83 CLEO +- E+ E-, UPSIL(4S)  4/83*

R2      B+ INTO D*(2010)- PI+ PI+                          (P2)
R2       6     0.048    0.030        BEHRENDS  83 CLEO +- E+ E-, UPSIL(4S)  4/83*

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                              REFERENCES FOR CHARGED B

BEHRENDS 83 PRL 50 881       +  (ROCH+RUTG+SYRA+VAND+CORN+ITHA+HARV+OSU)

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B⁰

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                    42   NEUTRAL B(5274, JP=  )  I=

                    SEE ALSO THE LISTING FOR THE B (FOLLOWING THIS ENTRY)
                    FOR MEASUREMENTS WHICH DO NOT IDENTIFY THE CHARGE
                    STATE.

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                    42   NEUTRAL B MASS   (MEV)

M     A  5  5274.2       2.8          BEHRENDS  83 CLEO 0  D*- PI+ + CC      4/83*
M     A  STATISTICAL (1.9 MEV) AND SYSTEMATICAL (2.0 MEV) ERRORS COMBINED.   4/83*

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                    42   (B0) - (B+) MASS DIFFERENCE (MEV)

DM    A        3.4       3.6          BEHRENDS  83 CLEO    E+E-, UPSIL(4S)   3/84*
DM    A  STATISTICAL (3.0) AND SYSTEMATICAL (2.0) ERRORS COMBINED.           3/84*

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                    42   NEUTRAL B PARTIAL DECAY MODES

                                                             DECAY MASSES
P1      B0 INTO DOBAR PI+ PI-                               1865+ 140+ 140
P2      B0 INTO D*(2010)- PI+                               2007+ 140

        B0BAR MODES ARE CHARGE CONJUGATES OF THE ABOVE MODES.

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                    42   NEUTRAL B BRANCHING RATIOS
R1      B0 INTO DOBAR PI+ PI-                              (P1)
R1       5     0.13     0.09          BEHRENDS  83 CLEO 0  E+ E-, UPSIL(4S)  4/83*

R2      B0 INTO D*(2010)- PI+                              (P2)
R2       5     0.026    0.019         BEHRENDS  83 CLEO 0  E+ E-, UPSIL(4S)  4/83*

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                              REFERENCES FOR NEUTRAL B

BEHRENDS 83 PRL 50 881       +  (ROCH+RUTG+SYRA+VAND+CORN+ITHA+HARV+OSU)

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B

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                    39   BOTTOM MESON B(5271, JP=  )

                    THIS ENTRY LISTS MEASUREMENTS OF B MESON PARAMETERS
                    FOR WHICH THE CHARGE STATES ARE NOT SEPARATED.
                    MEASUREMENTS IN WHICH THE CHARGE STATE IS CLEARLY
                    IDENTIFIED ARE LISTED IN THE PRECEDING CHARGED B
                    AND NEUTRAL B ENTRIES.

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                    39   B MASS   (MEV)

M     A          5180 TO 5290          ANDREWS   80 CLEO UPSIL(4S) THRESHOLD 12/83*
M     A          5289  OR LESS         FINOCCHIA 80 CUSB UPSIL(4S) THRESHOLD 12/83*
M     AB         5263 TO 5278          SCHAMBERG 82 CUSB UPSIL(4S) THRESHOLD 12/83*
M     A  REDETERMINATION OF THE CESR ENERGY SCALE CHANGED THE ANDREWS 80,    12/83*
M     A  FINOCCHIARO 80, AND SCHAMBERGER 82 LIMITS FROM THEIR PUBLISHED      12/83*
M     A  VALUES TO THOSE GIVEN ABOVE.                                        12/83*
M     AB SCHAMBERGER 82 DEDUCED ABOVE LIMITS FROM NON-OBSERVATION OF 50 MEV  12/83*
M     AB GAMMAS FROM B* --> B GAMMA AND UPSIL(4S) --> B B*.                  12/83*

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                    39   B MEAN LIFE   (UNITS 10**-13 SEC)                    1/83*

T           (14.)    OR LESS  CL=.95   BARTEL    82 JADE E+E-,AVG ECM 34 GEV  1/83*
T     A      18.        7.2            FERNAND2  83 MAC  E+E- AT ECM=29 GEV  12/83*
T     B      12.0       5.4      4.7   LOCKYER   83 SMK2 E+E- AT ECM=29 GEV  12/83*
T     A  THE STATISTICAL AND SYSTEMATIC ERRORS ARE 6 AND 4.                  12/83*
T     B  THE STATISTICAL ERRORS ARE +4.5 AND -3.6, THE SYSTEMATIC ERROR IS   12/83*
T     B  3.0.  THE LIFETIME IS AN AVERAGE OVER BOTTOM PARTICLES PRODUCED.    12/83*
T              . . . . . . . . .                                              3/84*
T    AVG     14.        4.        AVERAGE                                     3/84*

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                    39   B PARTIAL DECAY MODES

                                                             DECAY MASSES
P1      B INTO ELECTRON NEUTRINO HADRONS
P2      B INTO MUON NEUTRINO HADRONS
P3      B INTO E+ E- ANYTHING
P4      B INTO MU+ MU- ANYTHING
P5      B INTO KAON ANYTHING
P6      B INTO J/PSI ANYTHING
P7      B INTO DO ANYTHING
P8      B INTO PROTON ANYTHING
P9      B INTO LAMBDA ANYTHING
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                    39   B BRANCHING RATIOS

R1       B INTO (ELECTRON NEUTRINO HADRONS)/TOTAL          (P1)
R1    A      (0.13)   (0.042)          BEBEK     81 CLEO DIRECT E AT UPS(4S)  4/82
R1    B      (0.136)  (0.039)          SPENCER   81 CUSB DIRECT E AT UPS(4S)  4/82
R1    C       0.127    0.021           CHADWICK  83 CLEO DIRECT E AT UPS(4S) 11/83*
R1    D       0.132    0.016           KLOPFENST 83 CUSB DIRECT E AT UPS(4S)  1/84*
R1    E      (0.116)  (0.027)          NELSON    83 SMK2 E+E-,ECM=29 GEV     11/83*
R1    A  THE STATISTICAL AND SYSTEMATIC ERRORS ARE EACH 0.03.                 4/82
R1    B  THE STATISTICAL AND SYSTEMATIC ERRORS ARE 0.025 AND 0.03.            4/82
R1    AB THE ELECTRON ENERGY SPECTRA IN BOTH BEBEK 81 AND SPENCER 81 FAVOR    4/82
R1    AB B-TO-C OVER B-TO-U QUARK TRANSITIONS.                                4/82
R1    C  THE STATISTICAL AND SYSTEMATIC ERRORS ARE 0.017 AND 0.013.          11/83*
R1    D  STATISTICAL AND SYSTEMATIC ERRORS ARE 0.008 AND 0.014.               1/84*
R1    D  RATIO CS(B-->E NU UP)/CS(B-->E NU CHARM) < 0.055 AT CL=.90.          1/84*
R1    E  THE STATISTICAL AND SYSTEMATIC ERRORS ARE 0.021 AND 0.017.          11/83*
R1
R1       ONLY THE EXPERIMENTS AT THE UPSILON(4S) ARE USED IN THE AVERAGE.
R1
R1           . . . . . . . . . .
R1    AVG     0.130    0.013   AVERAGE

R2       B INTO (MUON NEUTRINO HADRONS)/TOTAL              (P2)
R2           (0.094)  (0.036)          CHADWICK  81 CLEO DIRECT MU AT UP(4S)  4/82
R2    A      (0.105)  (0.020)          ADEVA2    83 MRKJ E+E- ECM=33-38.5GEV 11/83*
R2    B       0.124    0.035           CHADWICK  83 CLEO DIRECT MU AT UP(4S) 11/83*
R2           (0.155)  (0.054) (0.029)  FERNAND1  83 MAC  E+E- AT ECM=29 GEV  12/83*
R2           (0.117)  (0.028)          ALTHOFF   84 TASS E+E-, ECM=34.5 GEV   3/84*
R2    A  THE STATISTICAL AND SYSTEMATIC ERRORS ARE 0.015 AND 0.013.          11/83*
R2    B  THE STATISTICAL AND SYSTEMATIC ERRORS ARE 0.017 AND 0.031.          11/83*
R2
R2       THE AVERAGE OF THE THREE HIGH-ENERGY RESULTS IS 0.113+-0.016.
R2       THESE EXPERIMENTS PRODUCE OTHER BOTTOM PARTICLES IN ADDITION TO
R2       THE B MESON.

R3       B INTO (E+ E- ANYTHING)/TOTAL                     (P3)
R3           (0.05) OR LESS  CL=.90    BEBEK     81 CLEO E+ E- AT UPSIL(4S)   4/82

R4       B INTO (MU+ MU- ANYTHING)/TOTAL                   (P4)
R4           (0.017)OR LESS  CL=.90    CHADWICK  81 CLEO E+ E- AT UPSIL(4S)   4/82
R4            0.007 OR LESS  CL=.95    ADEVA1    83 MRKJ E+E- 30<WCM<38 GEV  11/83*
R4            0.007 OR LESS  CL=.95    BARTEL    83 JADE E+E- 33<WCM<36.7GEV  1/84*
R4           (0.02)  OR LESS  CL=.95   ALTHOFF   84 TASS E+E-, ECM=34.5 GEV   3/84*

R5       B INTO (DILEPTON ANYTHING)                        (P3+P4)
R5            0.008 OR LESS  CL=.90    MATTEUZZI 83 SMK2 E+ E- AT ECM=29 GEV 11/83*

R6       B INTO (KAON ANYTHING)/TOTAL                      (P5)
R6    C        SEEN                    BRODY     82 CLEO KAONS AT UPSIL(4S)   4/82
R6    D        SEEN                    GIANNINI  82 CUSB KAONS AT UPSIL(4S)   2/84*
R6    C  ASSUMING UPSILON(4S) --> B BBAR, A TOTAL OF 3.38+-0.34+-0.68 KAONS   4/82
R6    C  PER UPSILON(4S) DECAY IS FOUND (THE SECOND ERROR IS SYSTEMATIC). IN  4/82
R6    C  THE CONTEXT OF THE STANDARD B-DECAY MODEL, THIS LEADS TO A VALUE     4/82
R6    C  FOR (B-QUARK --> C-QUARK)/(B-QUARK --> ALL) OF 1.09+-0.33+-0.13.     4/82
R6    D  GIANNINI 82 AT CESR-CUSB OBSERVED 1.58+-.35 K0 PER HADRONIC EVENT    2/84*
R6    D  MUCH HIGHER THAN 0.82+-0.10 BELOW THRESHOLD. CONSISTENT WITH         2/84*
R6    D  PREDOMINANT B-->C X DECAY.                                           2/84*

R7       B INTO (J/PSI ANYTHING)/TOTAL                     (P6)
R7           (0.049)OR LESS  CL=.90    MATTEUZZI 83 SMK2 E+ E- AT ECM=29 GEV 11/83*

R8       B INTO (DO ANYTHING)/TOTAL                        (P7)
R8    A       0.8      0.28            GREEN     83 CLEO E+ E- AT UPSIL(4S)  12/83*
R8    A  OBSERVED 0.8+-0.2(STAT.)+-0.2(SYST.) DO PER B DECAY.                12/83*
R9       B INTO (PROTON ANYTHING)/TOTAL                    (P8)
R9    A       0.036 OR MORE            ALAM      83 CLEO PROTONS AT UPSI(4S) 11/83*
R9    A  THE STATISTICAL AND SYSTEMATIC ERRORS ARE 0.006 AND 0.009. VALUES   11/83*
R9    A  ARE FOR (BR(B-->P X)+BR(B-->ANTI-P X)/2. DATA ARE CONSISTENT WITH   11/83*
R9    A  EQUAL YIELDS OF BARYONS AND ANTIBARYONS. USING ASSUMED YIELDS       11/83*
R9    A  BELOW CUT, BR(B-->P+X)=0.03 NOT INCLUDING PROTONS FROM LAM.DECAYS.  11/83*

R10      B INTO (LAMBDA ANYTHING)/TOTAL                    (P9)
R10   A       0.022 OR MORE            ALAM      83 CLEO LAMBDAS AT UPSI(4S) 11/83*
R10   A  THE STATISTICAL AND SYSTEMATIC ERRORS ARE 0.007 AND 0.004. VALUES   11/83*
R10   A  ARE FOR (BR(LAMBDA X)+BR(ANTI-LAMBDA X)/2. DATA ARE CONSISTENT WITH 11/83*
R10   A  EQUAL YIELDS OF BARYONS AND ANTIBARYONS. USING ASSUMED YIELDS       11/83*
R10   A  BELOW CUT, BR(B-->LAMBDA X)=0.03.                                   11/83*

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                       REFERENCES FOR BOTTOM MESON B(5271)

ANDREWS  80 PRL 45 219        +      (CORN+HARV+ITHA+SYRA+ROCH+RUTG+VAND)
FINOCCHI 80 PRL 45 222        FINOCCHIARO,GIANNINI,+       (STON+COLU+LSU)
BEBEK    81 PRL 46 84         +      (HARV+ITHA+SYRA+ROCH+RUTG+VAND+CORN)
CHADWICK 81 PRL 46 88         +GANCI+(ROCH+RUTG+SYRA+VAND+CORN+HARV+ITHA)
SPENCER  81 PRL 47 771        +FINOCCHIARO,+          (STON+COLU+LSU+MPIM)

BARTEL   82 PL 114B 71        JADE C.(DESY+HAMB+HEID+LANC+MCHS+RHEL+TOKY)
BRODY    82 PRL 48 1070       +CHEN,+(SYRA+VAND+CORN+ITHA+HARV+ROCH+RUTG)
GIANNINI 82 NP B206 1         +FINOCCHIARO,FRANZINI+ (STON+COLU+LSU+MPIM)
SCHAMBER 82 PR D26 720        SCHAMBERGER+            (STON+COLU+LSU+MPIM)

ADEVA1   83 PRL 50 799        MARKJ C. (AACH+DESY+MIT+MADR+AIKO+BHEP+CIT)
ADEVA2   83 PRL 51 443        MARKJ C. (AACH+DESY+MIT+MADR+AIKO+BHEP+CIT)
ALAM     83 PRL 51 1143       + (VAND+HARV+OHIO+CORN+ITHA+ROCH+RUTG+SYRA)
BARTEL   83 PL 132B 241       JADE C.(DESY+HAMB+HEID+LANC+MCHS+RHEL+TOKY)
CHADWICK 83 PR D27 475        + (ROCH+RUTG+SYRA+VAND+CORN+HARV+ITHA+OHIO)
FERNAND1 83 PRL 50 2054       +MAC.C.(COLO+FRAS+HOUS+NEAS+SLAC+UTAH+WISC)
FERNAND2 83 PRL 51 1022       +MAC.C.(COLO+FRAS+HOUS+NEAS+SLAC+UTAH+WISC)
GREEN    83 PRL 51 347        + (RUTG+SYRA+VAND+HARV+OHIO+CORN+ITHA+ROCH)
KLOPFENS 83 PL 130B 444       KLOPFENSTEIN+      (STON+COLU+CORN+LSU+MPIM)
LOCKYER  83 PRL 51 1316       +JAROS,NELSON,ABRAMS,+  (SLAC+LBL+UCB+HARV)
MATTEUZZ 83 PL 129B 141       MATTEUZZI,ABRAMS,AMIDEI+(SLAC+LBL+UCB+HARV)
NELSON   83 PRL 50 1542       +BLONDEL,TRILLING+      (LBL+UCB+SLAC+HARV)
ALTHOFF  84 ZPHY C (SUBMITTED)+   (AACH+BONN+DESY+HAMB+LOIC+OXF+RL+SIEG+)

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                    16   PROTON(938,J=1/2) I=1/2
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                    16   PROTON MASS (MEV)

M          (938.256)  (0.005)          COHEN     65 RVUE                      7/66
M          (938.2592) (0.0052)         TAYLOR    69 RVUE   USING NEW E/M      7/70
M           938.2796   0.0027          COHEN     73 RVUE                      3/74

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For notation, see key at front of Listings.

Stable Particles

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                    16  ANTIPROTON MASS  (MEV)
M1          938.3      0.5          BAMBERGER 70 CNTR                    12/79
M1          938.179    0.058        HU        75 CNTR    EXOTIC ATOMS    12/79
M1          938.229    0.049        ROBERSON  77 CNTR                    12/79
M1          938.30     0.13         ROBERTS   78 CNTR                     6/78
M1
M1  AVG     938.216    0.036   AVERAGE
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NOTE ON PROTON MEAN LIFE LIMITS

(by M. Goldhaber, Brookhaven National Laboratory, and F. Reines, University of California, Irvine)

Current ideas on the unification of the weak, electromagnetic, and strong forces suggest that baryon number might not be strictly conserved, so that the proton could decay. In the Particle Properties Tables there are nearly thirty particles listed with a mass smaller than that of the proton (if we count both particles and antiparticles and different members of multiplets separately). Ten of these particles are fermions and the remainder bosons. There are then a great many possible two-body decay modes of the proton and an even larger number of three-body, etc., decay modes which satisfy charge, energy, momentum, and angular momentum conservation. Each decay mode has to contain at least one fermion to satisfy angular momentum conservation.

The "decay signature" distributions as well as the backgrounds depend on detector characteristics (the material from which the detector is made, the method of detection, timing information, time resolution, etc.). The background, due chiefly to atmospheric neutrinos, depends also on the geomagnetic latitude and on the phase of the solar cycle with which the magnetic field of the sun is associated. The depth-dependent cosmic ray background is due to cosmic ray muons and their progeny. For each possible proton decay signature there is a finite probability of a background event with a similar signature, where the probability depends on the detector characteristics.

The Data Card Listings following this note show only published results. The lower limits quoted are partial mean life (mean life divided by branching fraction) for the proton or bound neutron decay mode listed at the right.

Since there are many new unpublished results, we also show a table of the latest (preliminary) results as reported at the ICOBAN '84 Conference at Park City, Utah, Jan. 4-8. This table is based on the summary talk given at the conference by W. Allison, Oxford. The table shows the 90% confidence level lower limits on the partial mean life for decay to the mode shown. The units are 10^{30} years.

The number of candidate events is shown in brackets. A particular event may be listed as a candidate for several modes. The IMB collaboration considers their candidate events to be qualitatively compatible with neutrino background. An initial report on their neutrino background is given in Bionta et al., Phys. Rev. Lett. **51**, 27 (1983). The Kamiokande background estimates are given after the slash (/). The Kolar-Goldfield experiment (KRISHNASWAMY 82, Data Card Listings) has a total of 6 candidates for nucleon decay. Until the above results can be reproduced consistently and above neutrino background, it is too early to draw any conclusions about proton instability.

The simplest grand unified theory, minimal SU(5), predicts $e^+\pi^0$ to be the predominant proton decay mode. The IMB lower limit on the partial mean life for this mode, 2×10^{32} years, is at least a factor of 10 higher

Lower limits on partial mean life (τ/B) for proton or bound neutron decay. (Adapted from W. Allison, summary talk at ICOBAN '84.)

	NUSEX	IMB*	Kamiokande†
Sensitivity (ton-years)	180	2300	324
Mode	τ/B limit, CL=90%, units 10^{30} yr		
$p \to e^+\pi^0$	>10	>200	>26
$\mu^+\pi^0$	>7	>120	>18
$e^+\gamma$		>220	
$\mu^+\gamma$		>160	
$e^+\eta$		>130	>18
$\mu^+\eta$		>40 [2 ev]	>8 [1 ev/0]
e^+K^0		>31	>18
μ^+K^0	>13 1 ev	>26 [2 ev]	>8 [1 ev/0]
$e^+\omega$		>41 [1 ev]	>6 [1 ev/0.2]
$\mu^+\omega$		>51 [2 ev]	
νK^+	>5	>12 [3 ev]	>7 [3 ev/1]
$\nu\pi^+$	>4	—	>3 [5 ev/5.5]
$n \to e^+\pi^-$	>19	—	>9
$\mu^+\pi^-$	>4	—	>11
$\nu\pi^0$	>10	—	>15
νK^0	>6	>8 [3 ev]	>8

*No events observed unless listed in brackets. Background subtraction not made.

†Brackets contain the number of candidates observed followed by estimated background in listed mode.

Stable Particles

Data Card Listings

p, n

than predicted by minimal SU(5) theory.

See also the reviews by Reines and Schultz, Surveys in High Energy Physics **1**, 89 (1980); Goldhaber, Langacker, and Slansky, Science **210**, 851 (1980); and Goldhaber and Sulak, Comments Nucl. Part. Phys. **10**, 215 (1981).

See also the neutron-antineutron oscillations section NAN in the neutron Data Card Listings below for another test of baryon conservation.

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                    16  PROTON MEAN LIFE / BRANCHING FRACTION (UNITS YEARS)

T        TEST OF BARYON CONSERVATION.
T  H        (1.4E20) OR MORE          GOLDHABER 54 TH232   NUC-->ANYTHING
T  H        (1.4E22) OR MORE          REINES    54 CNTR    NUC-->CHGD ANY    9/81
T  H        (6. E23) OR MORE          REINES    57 CNTR    P --> CHGD ANY    9/81
T  H        (3. E23) OR MORE          FLEROV    58 TH232   NUC-->ANYTHING
T  H M      (4. E26) OR MORE          BACKENSTO 60 CNTR    NUC-->MU ANY
T  H M      (9. E27) OR MORE          GIAMATI   62 CNTR    P --> MU GAMMA    9/81
T  H M      (6. E28) OR MORE          KROPP     65 CNTR    P --> MU GAMMA
T  H M      (1.2E30) OR MORE          GURR      67 CNTR    P --> MU GAMMA
T           (3. E23) OR MORE          DIX       70 CNTR    P --> ANYTHING    9/81
T           (1.3E29) OR MORE          BERGAMASC 74 CNTR    P --> CHGD ANY   12/75
T    L      (2. E30) OR MORE          REINES    74 CNTR    NUC-->MU ANY     12/75
T           (1.6E25) OR MORE          EVANS     77 TE130   NUC-->ANYTHING    9/81
T  L M      (6. E30) OR MORE          LEARNED   79 CNTR    NUC-->MU ANY      9/81
T  L        (1. E30) OR MORE          LEARNED   79 CNTR    NUC-->ANYTHING   12/79
T           (1.8E30) OR MORE  CL=.90  COWSIK    80 CNTR    NUC-->MU ANY      4/82
T         0 (1.25E30)OR MORE          ALEKSEEV  81 CNTR    NUC-->ANYTHING    2/82
T  C      2 (3. E31) OR MORE          CHERRY    81 CNTR    NUC-->MU ANY      1/82
T  C        (1.5E30) OR MORE          CHERRY    81 CNTR    NUC-->ANYTHING    1/82
T  K      2 (8. E30) OR MORE          KRISHNASW 81 CNTR REPL.BY KRISHNASW82  1/82
T  B      1 (8. E30) OR MORE          BATTISTON 82 CNTR    SEE COMMENT B    10/83*
T  K      6 (7. E30) OR MORE          KRISHNASW 82 CNTR    NUC-->ANYTHING   11/82*
T         1 (1. E30) OR MORE  CL=.90  BARTELT   83 CNTR    NUC-->ANYTHING   10/83*
T         0  1. E32  OR MORE  CL=.90  BIONTA    83 CNTR    P-->E+ PI0       10/83*
T  H    CONVERTED TO MEAN LIFE BY DIVIDING HALF-LIFE BY LN(2)=.693 .
T    M  REFERENCE ALSO GIVES LIMITS FOR OTHER MODES. WE GIVE HIGHEST LIMIT.
T  L    FIRST LEARNED 79 VALUE SUPERCEDES REINES 74.  SECOND LEARNED 79
T  L    VALUE IS FIRST TIMES B.F.=.15, A GRAND UNIF. GAUGE THEORY ESTIMATE.
T  C    CHERRY 81 SEE (2+-2) EVENTS ABOVE BACKGROUND. SECOND CHERRY 81      1/82
T  C    VALUE IS FIRST TIMES B.F.=.05, A GRAND UNIF. GAUGE THEORY ESTIMATE.  1/82
T  K    KRISHNASWAMY 82 SEE 3 EVENTS IN FIDUCIAL VOLUME OF DETECTOR.        1/82
T  K    TENTATIVE MEAN LIFE ASSUMES B.F. * EFF. =0.5 (FROM GUT) .           1/82
T  K    WE QUOTE THEIR TENTATIVE MEAN LIFE AS A LOWER LIMIT.                1/82
T  B    BATTISTONI 82 EVENT CAN BE INTERPRETED AS EITHER P --> K0 MU+ , OR  10/83*
T  B    P --> K* NU , WITH K* --> K0 PI , OR P --> 3 MU .                   10/83*

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                    16  ANTIPROTON MEAN LIFE / BR. FRACTION  (UNITS HOURS)

        LIMITS SHOWN ARE PARTIAL MEAN LIFE FOR MODE SHOWN AT RIGHT.

T1         (3.3E-8)  OR MORE  CL=.95  GANGULI   78 HBC     PBAR-->ANYTHING   6/78
T1   B     (32.)     OR MORE          BREGMAN   78 CNTR    PBAR-->ANYTHING   7/79
T1   E     (1700.)   OR MORE  CL=.90  BELL      79 CNTR    PBAR-->E- PI0     1/80
T1   G      1. E11   OR MORE          GOLDEN    79 SPEC    PBAR-->ANYTHING  12/79
T1   B  BREGMAN 78 STORED ANTIPROTONS IN ICE STORAGE RING AT CERN 85 HOURS.  7/79
T1   E  BELL 79 STORED ANTIPROTONS IN ICE STORAGE RING FOR 10 DAYS.          1/80
T1   G  GOLDEN 79 VALUE INFERRED FROM PBAR/P RATIO IN COSMIC RAYS.          12/79

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                    16  PROTON MAGNET. MOMENT(E/2MP)

MM         (2.79276)(0.00002)          COHEN     65 RVUE
MM         (2.792782 0.000017)         TAYLOR    69 RVUE    USING NEW E/H     7/70
MM          2.7928456 .0000011         COHEN     73 RVUE                      3/74

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                    16  ANTIPROTON MAGNETIC MOMENT (E/2MP)

MM1 O       (-1.8)    (1.2)            BUTTON    62 CNTR
MM1 R       (-2.83)   (0.10)           FOX       72 CNTR                     11/75
MM1 R       (-2.819)  (0.056)          ROBERTS   74 CNTR                      7/75
MM1          -2.791    0.021           HU        75 CNTR    EXOTIC ATOMS     12/79
MM1  R       -2.817    0.048           ROBERTS   78 CNTR                      6/78
MM1 O   OLD EXPERIMENT WITH LARGE ERROR.  NOT AVERAGED.
MM1  R  ROBERTS 74 IS REANALYSIS OF FOX 72 DATA.  REPLACES OLD FOX VALUE.     7/75
MM1  R  ROBERTS 78 IS A REANALYSIS OF ROBERTS 74.                             6/78
MM1          . . . . . . . . .
MM1 AVG      -2.795    0.019   AVERAGE

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                    16  PROTON ELECTRIC DIPOLE MOMENT (UNITS 10**-23 E CM)

                FORBIDDEN BY BOTH T INVARIANCE AND P INVARIANCE

EDM      1G  (700.)   (900.)           HARRISON  69 MBR                      10/69
EDM        (55000.)  OR LESS           KHRIPLOVI 76                           1/78
EDM           400.   OR LESS           RAMSEY    82 RVUE                      2/84*

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                    16  PROTON ELECTRON CHARGE DIFFERENCE (UNITS E)

        SEE ALSO SECTION Q IN THE NEUTRON DATA CARDS LISTINGS BELOW.

DQ   D      1.0E-21 OR LESS           DYLLA     73       NEUTRALITY OF SF6    2/80
DQ   D   ASSUMES THAT Q(NEUTRON)=Q(PROTON)-Q(E-).  SEE DYLLA 73 FOR A         2/80
DQ   D   SUMMARY OF EXPERIMENTS ON THE NEUTRALITY OF MATTER.                  2/80

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                    REFERENCES FOR PROTON

GOLDHABE 54 PR 96 1157 FNOTE2 REINES,COWAN,GOLDHABER            (LASL+BNL)
REINES   54 PR 96 1157        REINES,COWAN,GOLDHABER            (LASL+BNL)
FLEROV   58 SOV PHYS DOK 3 79 FLEROV,KLOCHKOV,SKOBKIN,TERENTEV      (USSR)
REINES   57 PR 109 609        REINES,COWAN,KRUSE                   (LASL)
BACKENST 60 NC 16 749         BACKENSTOSS,FRAUENFELDER,HYAMS +     (CERN)

BUTTON   62 PR 127 1297       J BUTTON,B MAGLIC                     (LBL)
GIAMATI  62 PR 126 2178       GIAMATI,REINES                       (CASE)
COHEN    65 RMP 37 537        +DUMOND (N.AMER.AVIATION SCIENCE CENT.,CIT)
KROPP    65 PR 137B 740       W R KROPP,F REINES                   (CASE)
GURR     67 PR 158 1321       GURR,KROPP,REINES,MEYER (CASE,JOHANNESBURG)

HARRISON 69 PRL 22 1263       HARRISON,SANDARS,WRIGHT  (CLARENDON OXFORD)
TAYLOR   69 RMP 41 375        +PARKER,LANGENBERG          (PRIN+UCI+PENN)
BAMBERGE 70 PL 33B 233        BAMBERGER,LYNEN,PIEKARZ+   (MPIH+CERN+KARL)
DIX      70 THESIS CASE       F E DIX                              (CASE)
FOX      72 PRL 29 193        +BARNES,EISENSTEIN+(BNL+CARN+VPI+WILL+WYOM)
COHEN    73 J.PHYS.CHEM.REF.DATA 2, P.663, E.R.COHEN,B.N.TAYLOR
DYLLA    73 PR A7 1224        H.F.DYLLA, J.G.KING                   (MIT)

BERGAMAS 74 LNC 11 636        BERGAMASCO,PICCHI              (TORI+FRAS)
REINES   74 PRL 32 493        +CROUCH                         (UCI+CASE)
ROBERTS  74 PRL 33 1181       +COX,ECKHAUSE+ (WILL+VPI+CARN+WYOM+CIT+BNL)
    ALSO 75 PR D12 1232       ROBERTS,COX +  (WILL+VPI+CARN+WYOM+CIT+BNL)
HU       75 NP A254 403       +ASANO,CHEN,CHENG,DUGAN+        (COLU+YALE)

KHRIPLOV 76 JETP 44 25        I.B.KHRIPLOVICH    (NUC.PHYS.INST.,SIBERIA)
EVANS    77 SCIENCE 197 989   +STEINBERG                      (BNL+PENN)
ROBERSON 77 PR C16 1945       +KING,KUNSELMAN+   (WYOM+CIT+CARN+VPI+WILL)
BREGMAN  78 PL 78B 174        +CALVETTI,CARRON,CITTOLIN,HAUER,HERR+(CERN)
GANGULI  78 PL 74B 130        +MALHOTRA,RAGHAVAN,SUBRAMANIAN +     (TIFR)
ROBERTS  78 PR D17 358        B. L. ROBERTS                   (WILL+RHEL)

BELL     79 PL 86B 215        +CALVETTI,CARRON,CHANEY,CITTOLIN+    (CERN)
GOLDEN   79 PRL 43 1196       +HORAN,MAUGER,BADHWAR,LACY+     (NASA+PSLL)
LEARNED  79 PRL 43 907        +REINES,SONI                          (UCI)
COWSIK   80 PR D22 2204       R.COWSIK,V.S.NARASIMHAN              (TIFR)

ALEKSEEV 81 JETPL 33 651      +BAKATANOV,BUTKEVICH,VOEVODSKII +    (LENI)
CHERRY   81 PRL 47 1507       +DEAKYNE,LANDE,LEE,STEINBERG +   (PENN+BNL)
KRISHNAS 81 PL 106B 339       KRISHNASWAMY,MENON,MONDAL+ (TIFR+OSKC+TOKY)
BATTISTO 82 PL 118B 461       BATTISTONI,BELLOTTI+  (FRAS+MILA+LCGT+CERN)
KRISHNAS 82 PL 115B 349       KRISHNASWAMY,MENON,MONDAL+ (TIFR+OSKC+TOKY)
RAMSEY   82 ARNS 32 211       N.F.RAMSEY                      (MHCO+HARV)
BARTELT  83 PRL 50 651        +COURANT,HELLER,JOYCE,MARSHAK+   (MINN+ANL)
BIONTA   83 PRL 51 27         +BLEWITT+ (UCI+MICH+BNL+CIT+CLEV+HAWA+LOUC)

        QUANTUM NUMBER DETERMINATIONS NOT REFERRED TO IN THE DATA CARDS

KALOGERO 76 PRL 37 1037       KALOGEROPOULOS,CHIU,SUDARSHAN   (SYRA+TEXA)P
FRANKLIN 77 PR D16 910        JERROLD FRANKLIN                    (HAIF)P

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                    17  NEUTRON(939,J=1/2) I=1/2

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                    17  NEUTRON MASS (MEV)

M   T       (939.5527) (0.0052)       TAYLOR    69 RVUE    USING NEW E/H     7/70
M   T        939.5731   0.0027        COHEN     73 RVUE                      3/74
M   T       (939.5730) (0.0026)       GREENWOOD 80 CNTR    N P --> D GAMMA   2/84*
M   T    THESE DETERMINATIONS OF NEUTRON MASS NOT INDEPENDENT OF             7/70
M   T    NEUTRON-PROTON MASS DIFFERENCE MEASUREMENTS BELOW.                  7/70

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                    17  (NEUTRON) - (PROTON) MASS DIFFERENCE (MEV)

D   M      (1.29344) (0.00007)        MATTAUCH  65 RVUE                      3/71
D         (1.293429)(0.000036)        COHEN     73 RVUE                      3/74
D   M       1.293330  0.000040        VYLOV     78 CNTR    N P --> D GAMMA   2/84*
D   M       1.293322  0.000017        GREENWOOD 80 CNTR    N P --> D GAMMA   2/84*
D   M    WE HAVE CONVERTED MEASURED NEUTRON-HYDROGEN MASS DIFFERENCE TO      3/71
D   M    NEUTRON-PROTON MASS DIFFERENCE USING CURRENT VALUE OF ELECTRON MASS 3/71
D   M    AND A HYDROGEN BINDING ENERGY OF 13.6 EV.                           3/71
D            . . . . . . . . .
D   AVG     1.293323 0.000016  AVERAGE

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                    17  NEUTRON MEAN LIFE (UNITS 10**3 SEC)

        THE ORIGIN OF THE DISCREPANCIES BETWEEN MEASUREMENTS OF THE
        NEUTRON MEAN LIFE IS NOT KNOWN.  WE AVERAGE THE HIGHEST PRECISION
        MODERN EXPERIMENTS AND INCLUDE THE RESULTING SCALE FACTOR IN THE
        ERROR, AS USUAL.  THE IDEOGRAM SHOWS THE INVERSE MEAN LIFE, THE
        QUANTITY ACTUALLY USED IN CALCULATING OUR AVERAGE VALUE.

T           (1.013)  (0.026)          SOSNOVSKI 59 CNTR                    7/68
T           (0.935)  (0.014)          CHRISTENS 67 CNTR REPL BY CHRISTENS72 3/68
T            0.918    0.014            CHRISTENS 72 CNTR                    6/72
T    A       0.881    0.008            BONDARENK 78 CNTR                    8/81
T            0.937    0.018            BYRNE     80 CNTR                    2/82
T           (0.875)  (0.095)          KOSVINTSE 80 CNTR                   10/81
T    B      (0.902)  (0.010)          WILKINSON 82 RVUE    INFERRED VALUE 11/83*
T    A  INCLUDES CORRECTION FOR RECOIL PROTON SCATTERING SEE BONDARENKO 82. 10/83*
T    B  WILKINSON 82 VALUE INFERRED FROM N DECAY CORRELATIONS.            11/83*
T            . . . . . . . . .
T   AVG      0.898    0.016    0.016  AVERAGE (ERROR INCL. SCALE FACTOR OF 2.4)
                                  (SEE IDEOGRAM BELOW)

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                    17  NEUTRON MAGNETIC MOMENT (MAGNETONS,938.2 MEV)

MM      (-1.913148   0.000066)        COHEN     56 RVUE                      7/66
MM      (-1.91304211 0.00000088)      GREENE    77 MRS  REPL. BY GREENE 79   3/78
MM       -1.91304184 0.00000088       GREENE    79 MRS                      12/79

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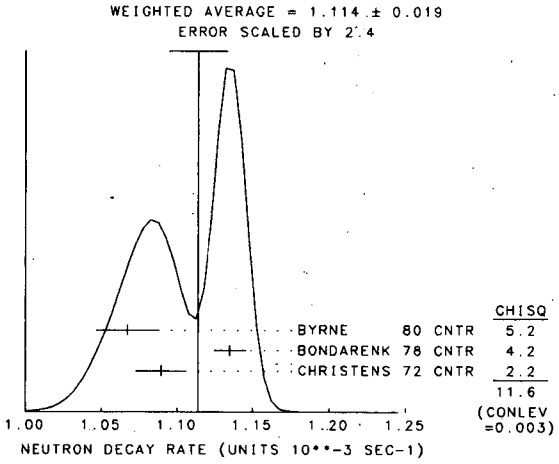
For notation, see key at front of Listings.

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                    17  NEUTRON ELECTRIC DIPOLE MOMENT (UNITS 10**-23 E CM)

              FORBIDDEN BY BOTH T INVARIANCE AND P INVARIANCE

EDM M      (-20.)    (30.)          MILLER    67 MRS                          1/78
EDM         +24.      39.           SHULL     67 CNTR                         1/78
EDM  M     (30.)   OR LESS         DRESS     68 MRS  ABSOLUTE VALUE          1/78
EDM         (5.)   OR LESS          BAIRD     69 MRS  INCLUDED IN DRESS73 10/69
EDM        - 2.      39.           APOSTOLES 70 MRS                          1/78
EDM          0.32     0.75         DRESS     73 MRS  < 10**-23 (CL=.80)    6/73
EDM          0.04     0.15         DRESS     77 MRS  < 3  E-24 (CL=.90)    6/77
EDM  A       0.040    0.075        ALTAREV   79 MRS  < 1.6E-24 (CL=.90)   10/81
EDM  A       0.021    0.024        ALTAREV   81 MRS  < 6  E-25 (CL=.90)    2/82
EDM  M  DRESS 68 INCLUDES DATA OF MILLER 67.                                1/78
EDM  A  ALTAREV 79 AND 81 USE ULTRACOLD NEUTRONS.                          4/82
EDM        . . . . . . . . .
EDM AVG      0.023    0.023   AVERAGE

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                    17  NEUTRON CHARGE

       SEE ALSO SECTION DQ IN THE PROTON DATA CARD LISTINGS ABOVE

Q                   17  NEUTRON CHARGE (UNITS 10**-20 E)                   11/82*
Q            (-1.5)    (2.2)  CL=.90   GAHLER    82 CNTR    REACTOR N BEAM  11/82*

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                    17  LIMIT ON NEUTRON-ANTINEUTRON OSCILLATIONS

NAN     MEAN TIME FOR N-ANTIN TRANSITION IN VACUUM  (UNITS SEC.)
NAN      TEST OF BARYON CONSERVATION.
NAN      LIMITS ARE DERIVED FROM EXPERIMENTAL LIMITS ON DELTA-B = 2 NUCLEAR   3/84*
NAN      DECAY PROCESSES, USING THEORETICAL ASSUMPTIONS FOR NUCLEAR PHYSICS   3/84*
NAN      EFFECTS.  SEE ALSO THE THEORETICAL ANALYSIS OF DOVER, GAL, AND       3/84*
NAN      RICHARDS, PR D27, 1090 (1983).  SEE THE REVIEWS OF H.L. ANDERSON,    3/84*
NAN      PROC. LASL CONF. ON NUCLEAR PARTICLE PHYSICS AT ENERGIES UP TO 31    3/84*
NAN      GEV, 1981.                                                           3/84*
NAN          (1.E8) OR MORE          CHETYRKIN 81 THEO                        1/82
NAN          (3.E7) OR MORE          ALBERICO  82 THEO                        9/83*
NAN          (2.E7) OR MORE          CHERRY    83 CNTR+THY                   12/83*
NAN          (1.E6) OR MORE  CL=.90  PUGLIERIN 83 CNTR REACTOR N, PRELIM.     1/84*
NAN           2.7E7 TO 1.1E8  OR MORE JONES     84 CNTR+THY                   3/84*

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                    17  NEUTRON PARTIAL DECAY MODES

                                                          DECAY MASSES
                                                          DECAY MASSES
P1      NEUTRON INTO PROTON E- ANTI(NUE)                 938+.511+   0
P2      NEUTRON INTO PROTON NUE ANTI(NUE)                938+   0+   0

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                    17  NEUTRON BRANCHING RATIOS

R1      NEUTRON INTO (PROTON NUE ANTI(NUE))/(PROTON E- ANTI(NUE)  (P2)/(P1)
R1       FORBIDDEN BY CHARGE CONSERVATION
R1   S      (3. E-17)OR LESS        SUNYAR    60 CNTR RB87-->SR87M+NEUTRL  2/80
R1          (3. E-19)OR LESS        NORMAN    79 CNTR RB87-->SR87M+NEUTRL  2/80
R1           9. E-24 OR LESS        BARABANOV 80 CNTR GA71-->GE71 + ANY    2/82
R1          (7.9E-21)OR LESS        VAIDYA    83 CNTR RB87-->SR87M+NEUTRL 11/83*
R1   S  WE HAVE CONVERTED SUNYAR 60 MEAN LIFE LIMIT FOR (N --> P + NEUTRLS)  2/80
R1   S  AS DESCRIBED IN NORMAN 79.                                           2/80

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NOTE ON BARYON DECAY PARAMETERS

A/V ratio for baryon leptonic decays

Consider the decay

$$B_i \rightarrow B_f + \ell + \nu .$$

Assuming V, A theory, neglecting "induced" scalar, "induced" pseudoscalar, and axial weak-magnetism terms, and neglecting the q^2 dependence of the form factors, the baryon part of the matrix element for these decays may be written as[1]

$$\overline{B}_f[\gamma_\lambda(g_V - g_A\gamma_5) + (g_W/m_{B_i})\sigma^{\lambda\nu}q_\nu]B_i .$$

Here B_i and $\overline{B}_f$ are spinors which represent initial and final baryons, g_A and g_V are the axial and vector coupling constants, g_W is the weak magnetism coupling constant, and q_ν is the sum of the lepton momenta. The Pauli representation is used for the γ matrices. The ratio g_A/g_V may be written as

$$g_A/g_V = |g_A/g_V|\exp(i\phi) ,$$

where ϕ is 0 plus $n\pi$ if time reversal holds.[2]

Experiments on the leptonic decays of baryons other than the neutron have generally assumed ϕ to be either 0 or π, and have thus measured the magnitude and sign of g_A/g_V. In studying neutron beta decay, however, experiments have been sensitive enough to measure ϕ more precisely, and we include the phase angle in our Listings for this case. It is consistent with time-reversal invariance, and by using the above definition of the matrix element with the Pauli representations, the value of g_A/g_V in neutron beta decay is negative.

Due to statistical limitations, the weak magnetism form factor g_W is usually assumed from CVC and SU(3), so that usually only g_A and g_V are determined experimentally. This determination is accomplished in a variety of ways:

(a) The lepton-neutrino angular correlation provides a measure of the absolute value of g_A/g_V (for relevant formulas, see, e.g., Albright[3]).

(b) The up-down asymmetry of the lepton from polarized baryon decays provides a measure of g_A/g_V with its sign (for relevant formulas, see, e.g., Albright[3]).

(c) The lepton spectrum, given enough statistics, provides a measure of g_A/g_V with its sign (for relevant formulas, see, e.g., Bender et al.[4]). The lepton spectrum also provides a measure of g_W/g_A if the CVC-SU(3) assumption is relaxed.

(d) The polarization of the decay baryon, from polarized or unpolarized initial baryon, also provides g_A/g_V with its sign (for formulas, see, e.g., Willis and Thompson[5]).

(e) The presence of a triple correlation term proportional to

$$\sigma_{B_i}\cdot(\mathbf{p}_e\times\mathbf{p}_\nu)\,,$$

where the initial baryon is polarized or

$$\sigma_{B_f}\cdot(\mathbf{p}_e\times\mathbf{p}_\nu)\,,$$

where the polarization of the decay baryon is observed provides a measure of the deviation of ϕ from 0 or π, and is thus a test of time-reversal invariance (see, e.g., Willis and Thompson[5]).

We compile the ratio g_A/g_V with its sign, for those decays for which it has been measured.

All the coupling constants and decay rates for baryon leptonic decays are related by Cabibbo's theory,[6] extended to six quarks (and three mixing angles) by Kobayashi and Maskawa.[7] A discussion of the Kobayashi-Maskawa mixing matrix is given in Appendix III to this edition.

Asymmetry parameters in nonleptonic hyperon decays

The transition matrix for hyperon decay may be written as

$$M = s + p(\sigma\cdot\mathbf{q})\,, \tag{1}$$

where s and p are the parity-changing and the parity-conserving amplitudes, respectively; σ is the Pauli spin operator, and $\mathbf{q}$ is a unit vector along the direction of the decay baryon in the hyperon rest frame.

The asymmetry parameters are defined by the relations

$$\alpha = 2\,\mathrm{Re}(s^*p)/(|s|^2+|p|^2)\,,$$

$$\beta = 2\,\mathrm{Im}(s^*p)/(|s|^2+|p|^2)\,,$$

$$\gamma = (|s|^2-|p|^2)/(|s|^2+|p|^2)\,.$$

With the transition matrix M given by Eq. (1) above, the angular distribution of the decay baryon, in the hyperon rest system, is of the form

$$I = 1+\alpha\mathbf{P}_Y\cdot\mathbf{q}\,,$$

where $\mathbf{P}_Y = \langle Y|\sigma|Y\rangle$ is the hyperon polarization. In the notation of Lee and Yang,[8] the polarization P_B of the decay baryons is

$$\mathbf{P}_B = \frac{(\alpha+\mathbf{P}_Y\cdot\mathbf{q})\mathbf{q}+\beta(\mathbf{P}_Y\times\mathbf{q})+\gamma\mathbf{q}\times(\mathbf{P}_Y\times\mathbf{q})}{1+\alpha\mathbf{P}_Y\cdot\mathbf{q}}\,,$$

where $\mathbf{P}_B$ is defined in that rest system of the baryon obtained by a Lorentz transformation along $\mathbf{q}$ from the hyperon rest system in which $\mathbf{q}$ and $\mathbf{P}_Y$ are defined. Note that α is the helicity of the decay baryon for unpolarized hyperons.

The three parameters α, β, and γ satisfy the relation

$$\alpha^2+\beta^2+\gamma^2 = 1\,.$$

It is then convenient to describe hyperon nonleptonic decays in terms of the two independent parameters α and the angle ϕ defined by

$$\beta = (1-\alpha^2)^{1/2}\sin\phi\,,$$

$$\gamma = (1-\alpha^2)^{1/2}\cos\phi\,,$$

which has a more nearly Gaussian distribution of measurement error than β or γ. Evidently

$$-\tfrac{1}{2}\pi \leqslant \phi \leqslant \tfrac{1}{2}\pi \quad \text{for } \gamma > 0\,,$$

$$+\tfrac{1}{2}\pi \leqslant \phi \leqslant \tfrac{3}{2}\pi \quad \text{for } \gamma < 0\,.$$

In discussing time-reversal invariance, the quantity of interest is Δ, defined by

$$\alpha = 2|s|\,|p|\cos\Delta/(|s|^2+|p|^2)\,,$$

$$\beta = -2|s|\,|p|\sin\Delta/(|s|^2+|p|^2)\,;$$

that is, Δ is the phase angle of s relative to p. Evidently

$$-\tfrac{1}{2}\pi \leqslant \Delta \leqslant \tfrac{1}{2}\pi \quad \text{for } \alpha > 0\,,$$

$$+\tfrac{1}{2}\pi \leqslant \Delta \leqslant \tfrac{3}{2}\pi \quad \text{for } \alpha < 0\,.$$

Under the assumption of time-reversal invariance, the angle Δ must satisy the relation

$$\Delta = \delta_s - \delta_p\,,$$

modulo π, where δ_s and δ_p are the pion-baryon scattering phase shifts at the appropriate energy and for the appropriate isospin state. For Λ decay, assuming the validity of the $|\Delta I| = ½$ rule,

$$\Delta = \delta_s - \delta_p = (7.0 \pm 1.0)\ \text{deg}.$$ [9]

In the Stable Particle Data Card Listings we give α and ϕ for each decay since they are the most closely related to the experiments and are essentially uncorrelated. Whenever necessary we have changed the signs of the reported values, so as to agree with our conventions. In the Stable Particle Table we give α, ϕ, and Δ with errors; and for convenience we also give the central value of γ, without an error.

For notation, see key at front of Listings.

Stable Particles

n, Λ

References

1. M.L. Goldberger and S.B. Treiman, Phys. Rev. **11**, 354 (1958).
2. J.D. Jackson, S.B. Treiman, and H.W. Wyld Jr., Phys. Rev. **106**, 517 (1957).
3. C.H. Albright, Phys. Rev. **115**, 750 (1959).
4. I. Bender, V. Linke, and H.J. Rothe, Z. Physik **212**, 190 (1968).


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                    17  NEUTRON BETA DECAY PARAMETERS

AV       GA/GV  (SEE NOTE ABOVE FOR SIGN CONVENTION)
AV  C      (-1.250)  (0.044)        CONFORTO  67 RVUE  SEE NOTE C BELOW
AV EP      (-1.23)   (0.01)         CHRISTENS 67 CNTR  N DECAY FT VALUE   11/68
AV  P      (-1.22)   (0.08)         GRIGOREV  68 CNTR  E-NEU ANG CORREL    10/71
AV  P      (-1.26)   (0.02)         CHRISTENS 70 CNTR  PE,NEUT SPIN CORREL 10/71
AV EP      (-1.27)   (0.025)        EROZOLIMS 71 CNTR  REPL.BY EROZOLIMS79 10/71
AV EP      (-1.239)  (0.011)        CHRISTENS 72 CNTR    N DEC.+ FT VALUE  1/73
AV  P      (-1.263)  (0.016)        KROPF     73 RVUE    N DECAY ALONE     1/73
AV  P       -1.250    0.009         KROPF     73 RVUE    N DEC.+ FT VALUE  1/73
AV E       (-1.250)  (0.036)        DOBROZEMS 75 CNTR  REPL.BY STRATOWA 78 12/75
AV  K       -1.253    0.021         KROHN     75 CNTR  PE,NEUT SPIN CORREL  1/77
AV         (-1.263)  (0.015)        EROZOLIMS 77 CNTR  REPL.BY EROZOLIMS79  1/78
AV E        -1.259    0.017         STRATOWA  78 CNTR  PROTON RECOIL SPECT  2/82
AV E        -1.261    0.012         EROZOLIMS 79 CNTR  PE,NEUT SPIN CORREL 10/81
AV          -1.226    0.042         MOSTOVOY  83 RVUE                      2/84*
AV  C    CONFORTO 67 COMBINES FREE NEUTRON DATA TO 1967.  REPL. BY KROPF 73.  1/73
AV E     THESE EXPERIMENTS MEASURE THE ABSOLUTE VALUE OF GA/GV ONLY          10/71
AV  P    KROPF 73 VALUE OBTAINED BY FITTING ALL DATA THROUGH 1972.            1/73
AV  K    KROHN 75 PAPER GIVES -1.258+-.015 INCLUDING EVENTS OF CHRISTENS 70.  1/78
AV  K    THE VALUE QUOTED ABOVE IS DERIVED FROM HIS A,BASED ON NEW EXPT ONLY  1/77
AV          . . . . . . . . .
AV  AVG     -1.2539   0.0063   AVERAGE

F        PHASE ANGLE OF GA RELATIVE TO GV  (DEGREES)
F         TIME REVERSAL INVARIANCE WOULD REQUIRE THIS TO BE 0 OR 180 DEGREES
F  P       (175.)    (10.)         BURGY     60 CNTR    POLAR. NEUTRONS   6/77
F  P       (198.)    (27.)         CLARK     60 CNTR    POLAR. NEUTRONS   6/77
F  C       (176.1)    (6.4)        CONFORTO  67 RVUE                     11/68
F  P       (181.3)    (1.3)        EROZOLIMS 70 CNTR   POLAR. NEUTRON    10/69
F  P        181.1      1.3         KROPF     73 RVUE    N DECAY           1/73
F           180.35     0.43        EROZOLIMS 74 CNTR    POLAR. NEUTRONS   6/77
F           180.14     0.22        STEINBERG 74 CNTR    POLAR. NEUTRONS   6/77
F           179.71     0.39        EROZOLIMS 78 CNTR    POLAR. NEUTRONS   7/79
F  C     CONFORTO 67 COMBINES FREE NEUTRON DATA TO 1967.  REPL. BY KROPF 73.  1/73
F  P     KROPF 73 VALUE OBTAINED BY FITTING ALL DATA THROUGH 1972.            1/73
F           . . . . . . . . .
F  AVG      180.11     0.17    AVERAGE
D1       TRIPLE CORRELATION COEFFICIENT                                      7/76
D1       D1 MEASURES COMPONENT OF NEUTRON SPIN PERPENDICULAR TO THE DECAY    7/76
D1       PLANE IN BETA DECAY. SHOULD BE ZERO IF T-INVARIANCE NOT             7/76
D1       VIOLATED.  SEE NOTE ON BARYON DECAY PARAMETERS ABOVE.               7/76
D1          -0.01     0.01         EROZOLIMS 70 CNTR    POLAR. NEUTRONS   7/76
D1  E       -0.0027   0.0050       EROZOLIMS 74 CNTR    POLAR. NEUTRONS  12/81
D1  E       -0.0011   0.0017       STEINBERG 74 CNTR    POLAR. NEUTRONS  12/81
D1          +0.0022   0.0030       EROZOLIMS 78 CNTR    POLAR. NEUTRONS   7/79
D1  E    EROZOLIMSKII 78 SAYS ASYMMETRIC PROTON LOSSES AND NON-UNIFORM BEAM  12/81
D1  E    POLARIZATION MAY GIVE SYSTEMATIC ERROR UP TO 0.003, THUS INCREASING 12/81
D1  E    THE EROZOLIMSKII 74 ERROR TO 0.005 .  STEINBERG 74, 76 ESTIMATES    12/81
D1  E    THESE SYSTEMATIC ERRORS TO BE INSIGNIFICANT IN THEIR EXPERIMENT.    12/81
D1          . . . . . . . . .
D1  AVG     -0.0007   0.0014   AVERAGE

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                          REFERENCES FOR NEUTRON

COHEN     56 PR 104 283        V W COHEN, CORNGOLD, RAMSEY   (BNL+HARVARD)
SOSNOVSK  59 JETP  9  717      SOSNOVSKII,SPIVAK,PROKOFEV +   (IAE MOSCOW)
BURGY     60 PR 120 1829       +KROHN,NOVEY,RINGO              (ANL+CHIC)
CLARK     60 CJP 38 693        +ROBSON
SUNYAR    60 PR 120 871        A.W.SUNYAR, M.GOLDHABER              (BNL)

MATTAUCH  65 NP 67 1           +THIELE,WAPSTRA     (MAX PLANCK INST.CHEM.)
CHRISTEN  67 PL 26B 11         CHRISTENSEN,NIELSON,BAHNSEN,BROWN+   (RISO)
CONFORTO  67 APAH 22 15        G. CONFORTO                          (CERN)
MILLER    67 PRL 19 381        +DRESS,BAIRD,RAMSEY             (ORNL+HARV)
SHULL     67 PRL 19 384        C.G.SHULL, R.NATHANS              (MIT+BNL)
DRESS     68 PR 170 1200       +BAIRD,MILLER,RAMSEY            (ORNL+HARV)
GRIGOREV  68 SJNP 6 239        +GRISHIN,VLADIMIRSKII,NIKOLAEVSKII + (ITEP)

BAIRD     69 PR  179  1285     +MILLER,DRESS,RAMSEY            (ORNL,HARV)
TAYLOR    69 RMP 41 375        +PARKER,LANGENBERG           (PRIN+UCI+PENN)
APOSTOLE  70 RRP 15 343        APOSTOLESCU,IONESCU,IONESCU-BUJOR +  (BUCH)
CHRISTEN  70 PR C1 1693        CHRISTENSEN,KROHN,RINGO               (ANL)
EROZOLIM  70 SJNP 11 583       EROZOLIMSKI,BONDARENKO,  +           (KIAE)
    ALSO     PL 27B 557        EROZOLIMSKY,BONDARENKO  +            (KIAE)

EROZOLIM  71 JETPL 13 252      EROZOLIMSKII,BONDARENKO              (KIAE)
CHRISTEN  72 PR D5 1628        CHRISTENSEN,NIELSON,BAHNSEN,BROWN+   (RISO)
COHEN     73 J.PHYS.CHEM.REF.DATA 2, P.663, E.R.COHEN,B.N.TAYLOR
DRESS     73 PR D7 3147        DRESS,MILLER,RAMSEY             (ORNL+HARV)
KROPF     73 ZPHY TO BE PUBL.  A KROPF,H PAUL                       (LINZ)
    ALSO  70 NP A154 160       H PAUL                                (VIEN)

EROZOLIM  74 JETPL 20 345      EROZOLIMSKII,MOSTOVOI,FEDUNIN,FRANK+
STEINBER  74 PRL 33 41         STEINBERG,LIAUD,VIGNON,HUGHES   (YALE+GREN)
    ALSO  76 PR D13 2469       STEINBERG,LIAUD,VIGNON,HUGHES   (YALE+GREN)
DOBROZEM  75 PR D11 510        DOBROZEMSKY,KERSCHBAUM,MORAW,PAUL +  (SEIB)
KROHN     75 PL 55B 175        KROHN,RINGO                           (ANL)

DRESS     77 PR D15 9          +MILLER,PENDLEBURY,PERRIN+ (ORNL+GREN+HARV)
EROZOLIM  77 JETPL 23 663      EROZOLIMSKII,FRANK,MOSTOVOI+         (KIAE)
GREENE    77 PL 71B 297        +RAMSEY,MAMPE+   (HARV+ILLG+SUSS+ORNL+CENG)
EROZOLIM  78 SJNP 28 48        EROZOLIMSKII,MOSTOVOI,FEDUNIN,FRANK+ (KIAE)
STRATOWA  78 PR D18 3970       +DOBROZEMSKY,WEINZIERL               (SEIB)
BONDAREN  78 JETPL 28 303      BONDARENKO,KURGUZOV,PROKOFEV+        (KIAE)
    ALSO  82 SMOLENICE CONF.   L.N.BONDARENKO                       (KIAE)
VYLOV     78 SJNP 28 585       +GROMOV,IVANOV,OSIPENKO,FROLOV       (JINR)

ALTAREV   79 JETPL 29 730      +BORISOV,BRANDIN,EGOROV,EZHOV,IVANOV+(LENI)
EROZOLIM  79 SJNP 30 356       EROZOLIMSKII,FRANK,MOSTOVOI+          (KIAE)
GREENE    79 PR D20 2139       +RAMSEY,MAMPE+   (HARV+ILLG+SUSS+ORNL+CENG)
NORMAN    79 PRL 43 1226       E.B.NORMAN, A.G.SEAMSTER              (WASH)

BARABANO  80 JETPL 32 359      BARABANOV,VERETENKIN,GAVRIN +         (LENI)
BYRNE     80 PL 92B 274        +MORSE,SMITH,SHAIKH,GREEN,GREENE  (SUSS+RL)
GREENWOO  80 PR C21 498        R.C.GREENWOOD,R.C.CHRIEN         (INEL+BNL)
KOSVINTS  80 JETPL 31 236      KOSVINTSEV,KUSHNIR,MOROZOV,TEREKHOV  (JINR)

ALTAREV   81 PL 102B 13        +BORISOV,BOROVIKOVA,BRANDIN,EGOROV + (LENI)
CHETYRKI  81 PL 99B 358        CHETYRKIN,KAZARNOVSKY,KUZMIN+         (INRM)
ALBERICO  82 PL 114B 266       +BOTTINO,MOLINARI               (CERN+TORI)
GAHLER    82 PR D25 2887       +KALUS,MAMPE                     (BAYR+ILLG)
WILKINSO  82 NP A377 474       D.H.WILKINSON                     (SUSS+BNL)
CHERRY    83 PRL 50 1354       +LANDE,LEE,STEINBERG,CLEVELAND   (PENN+BNL)
MOSTOVOY  83 JETPL 37 196      YU.A.MOSTOVOY                         (KIAE)
PUGLIERI  83 BRIGHTON CONF.    PUGLIERIN            (CERN+ILL+PADO+RL+SUSS)
VAIDYA    83 PR D27 486        +ROY,EPHRAIM,DATAR,BHATTACHERJEE      (TIFR)
JONES     84 PRL 52 720        IMB COLLAB(ICI+MICH+BNL+CIT+CLEV+HAWA+LOUC)

                               PAPERS NOT REFERRED TO IN DATA CARDS

JACKSON   57 PR 106 517        JACKSON,TREIMAN,WYLD             (PRINCETON)
COHEN     65 RMP 37 537        +DUMOND (N.AMER.AVIATION SCIENCE CENT.,CIT)
BHALLA    66 PL 19  691        C P BHALLA                        (ALABAMA)
BYRNE     82 RPP 45 115        J.BYRNE                              (SUSS)
FRANK     82 SPU 25 280        A.I.FRANK                            (KIAE)
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                    18  LAMBDA(1116,JP=1/2+) I=0

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                    18  LAMBDA MASS (MEV)

M   N   SINCE OUR FINAL VALUES FOR THE SIGMA AND LAMBDA MASSES COME FROM
M   N   DOING AN OVERALL FIT TO ALL MEASURED MASSES AND MASS DIFFERENCES,
M   N   WE HAVE USED THE UNCORRELATED MEASUREMENTS FROM SCHMIDT 65 RATHER
M   N   THAN THE ONES COMING FROM THE OVERALL FIT REPORTED IN THAT PAPER.
M   N   SINCE THERE SEEMS TO BE NO CONVINCING ARGUMENT AS TO WHY ONE SHOULD
M   N   IGNORE DATA USING RANGE MEASUREMENTS, WE HAVE INCLUDED HERE VALUES
M   N   DEPENDING ON PROTON AND PION RANGES.  THE SCHMIDT 65 MASSES HAVE
M   N   BEEN REEVALUATED USING OUR APRIL 1973 PROTON AND CHARGED K AND PI
M   N   MASSES.  P. SCHMIDT, PRIVATE COMMUNICATION, (1974).

M          1115.44     0.12          BHOWMIK   63 RVUE +  SEE NOTE L BELOW
M   L   ABOVE LAMBDA MASS HAS BEEN RAISED 35 KEV TO ACCOUNT FOR 46 KEV
M   L   INCREASE IN PROTON MASS AND 11 KEV DECREASE IN CHARGED PION MASS.
M   S  635(1115.86)   (0.09)        BALTAY    65 HBC   ERROR IS STATIS.   6/66
M      488 1115.65     0.07         SCHMIDT   65 HBC  SEE NOTE N          3/74
M   S 1147(1115.74)   (0.04)        CHIEN     66 HBC    6.9 PBAR P        9/67
M   S  972(1115.69)   (0.05)        CHIEN     66 HBC    6.9 PBAR PANTIL   9/67
M         1115.6      0.4           LONDON    66 HBC                      6/66
M        (1116.0)     (0.2)         BADIER    67 HBC    2.4 PBAR P,LLBAR  8/67
M      195 1115.39     0.12         MAYEUR    67 EMUL                    11/67
M   B 1524(1115.52)   (0.03)        BOHM      70 EMUL                     3/72
M      935 1115.59     0.08         HYMAN     72 HEBC                    11/71
M   B   AVERAGE OF VERY INCONSISTENT DATA. ERROR STATISTICAL ONLY. AUTHORS  3/72
M   B   DETECT SYSTEMATIC EFFECT OF ABOUT .15 MEV, WHICH THEY ATTRIBUTE    3/72
M   B   TO ERROR IN RANGE-ENERGY RELATIONS, IN REGION BETA=0.6-0.7.        3/72
M   B   THIS EFFECT, IF CONFIRMED, WOULD AFFECT VERY LITTLE THE VALUES OF  3/72
M   B   BHOWMICK 63 AND MAYEUR 67.
M   S   ERROR PURELY STATISTICAL.
M          . . . . . . . . .
M   AVG    1115.566    0.056   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.3)
M   FIT    1115.596    0.046  FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.2)  3/84*
                       (SEE IDEOGRAM BELOW)
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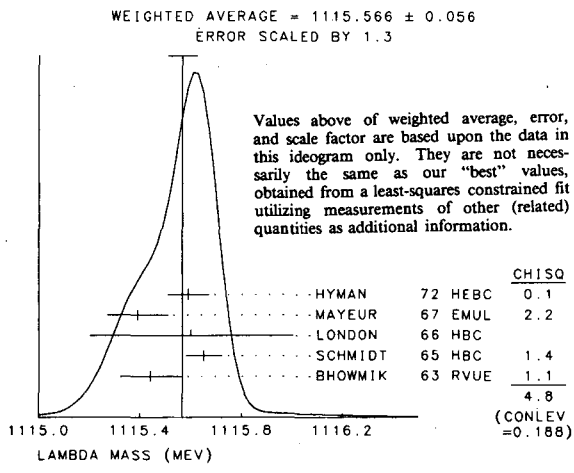


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                    18  LAMBDA - ANTILAMBDA MASS DIFFERENCE (MEV)

DM      TEST OF CPT
DM          0.05     0.06          CHIEN     66 HBC    6.9 PBAR P        9/67
DM          0.29     0.15          BADIER    67 HBC    2.4 PBAR P        8/67
DM          . . . . . . . . .
DM  AVG     0.083    0.083   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.5)

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Stable Particles

Data Card Listings

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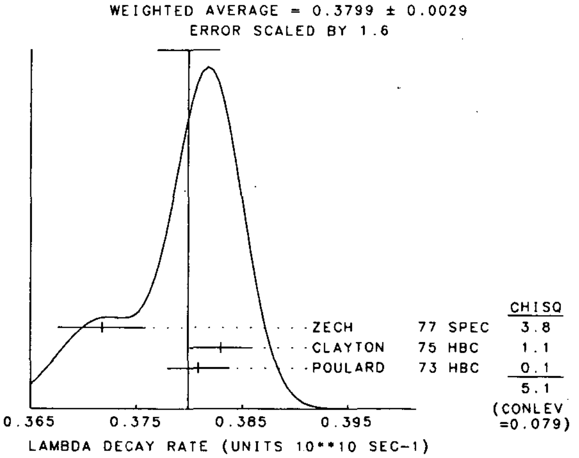
18 LAMBDA MEAN LIFE (UNITS 10**-10 SEC)

T	O	188	(2.63)	(0.21)	(0.21)	BOLDT	58	CC		
T	O	825	(2.72)	(0.16)	(0.16)	CRAWFORD	59	HBC		
T	O	140	(2.72)	(0.29)	(0.27)	BOWEN	60	CC		
T	O	186	(2.60)	(0.28)	(0.20)	CHANG	62	HBC		
T	O	799	(2.69)	(0.11)	(0.11)	HUMPHREY	62	HBC		
T	O	2239	(2.36)	(0.06)	(0.06)	BLOCK	63	HEBC		
T	O	706	(2.76)	(0.20)		CHRETIEN	63	HLBC		
T	O	794	(2.59)	(0.09)		HUBBARD	64	HBC		
T	O	2260	(2.31)	(0.10)		KREISLER	64	OSPK		
T	O	1378	(2.59)	(0.07)		SCHWARTZ	64	HBC		
T	O	635	(2.51)	(0.16)		BALTAY	65	HBC		6/66
T	O	2534	(2.6)	(0.1)		HILL	65	OSPK		
T	O	916	(2.35)	(0.09)		BURAN	66	HLBC		6/66
T	S	1147	(2.50)	(0.14)		CHIEN	66	HBC	6.9 PBAR P	9/67
T	S	972	(2.70)	(0.20)		CHIEN	66	HBC	6.9 PBAR P,ANTI	9/67
T	O	2213	(2.452)	(0.056)	(0.054)	ENGELMANN	66	HBC		9/66
T	O	585	(2.68)	(0.13)	(0.11)	AUERBACH	67	OSPK		8/67
T	O		(2.44)	(0.15)		BADIER	67	HBC	2.4 PBAR P	6/68
T	O		(2.55)	(0.15)		BADIER	67	HBC	2.4 PBAR P,ANTIL	6/68
T	O	8342	(2.535)	(0.035)		GRIMM	68	HBC		6/68
T	O	2600	(2.47)	(0.08)		HEPP	68	HBC		8/68
T	O	1059	(2.39)	(0.10)		DEMIDOV	70	HLBC	PI-P, 3.86 GEV/C	12/70
T	O	4572	(2.54)	(0.04)		BALTAY	71	HBC	K-P AT REST	6/71
T	O	6582	(2.69)	(0.05)		ALTHOFF2	73	OSPK	PI+N TO K+LAMBDA	2/74
T		36K	2.626	0.020		POULARD	73	HBC	K-P,KMOM .4TO2.3	9/73
T		34K	2.611	0.020		CLAYTON	75	HBC	K-P,KMOM .96-1.4	1/77
T		53K	2.69	0.03		ZECH	77	SPEC	NEUTRAL HYP. BEAM	12/77
T	O	OLD LOWER STATISTICS EXPERIMENTS NOT INCLUDED IN AVERAGE.								1/78
T	S	ERROR PURELY STATISTICAL.								
T										
T	AVG		2.632	0.020	0.020	AVERAGE (ERROR INCL. SCALE FACTOR OF 1.6) (SEE IDEOGRAM BELOW)				



18 (LAMBDA - ANTILAMBDA)/AVG., MEAN LIFE DIFFERENCE

DT	TEST OF CPT						
DT	0.044	0.085	BADIER	67	HBC	2.4 PBAR P	8/67

18 LAMBDA MAGNETIC MOMENT (MAGNETONS,938.26 MEV)

MM			-1.5	0.5		COOL	62	OSPK		
MM			0.0	0.6		KERNAN	63	CC		
MM		8553	-1.39	0.72		ANDERSON	64	HBC		
MM		151	-0.5	0.28		CHARRIERE	65	EMUL		
MM		49	(-0.67)	(0.31)	(0.37)	BARKOV	71	EMUL	PRELIM. RESULT	2/72
MM		1300	-0.66	0.07		DAHLJENSE	71	EMUL	MAG FIELD=200KG	6/71
MM		3868	-0.73	0.18		HILL	71	OSPK		10/71
MM		57	-0.65	0.28		BARKOV	72	EMUL	INCLUDES BARKOV 71	3/78
MM		1.2M	-0.57	0.05		BUNCE	76	SPEC		1/78
MM		350K	-0.59	0.07		HELLER	77	SPEC		1/78
MM		3M	-0.6138	0.0047		SCHACHING	78	SPEC		1/79
MM		200K	-0.606	0.015		COX	81	SPEC		12/81
MM										
MM	AVG		-0.6130	0.0044		AVERAGE				

18 LAMBDA ELECTRIC DIPOLE MOMENT (UNITS 10**-14 E CM)

NONZERO VALUE IMPLIES VIOLATION OF T AND P

EDM		(5.0) OR LESS	CL=.95	GIBSON	66	EMUL	2/72
EDM	B	(1.0) OR LESS	CL=.95	BARONI	71	EMUL	2/72
EDM	P	0.015 OR LESS	CL=.95	PONDROM	81	SPEC	1/82
EDM	B	BARONI MEASURES (-5.9+-2.9)*10**-15 E CM					2/72
EDM	P	PONDROM 81 MEASURE (-3.0+-7.4)*10**-17 E CM .					1/82

18 LAMBDA PARTIAL DECAY MODES

		DECAY MASSES
P1	LAMBDA INTO PROTON PI-	938+ 140
P2	LAMBDA INTO NEUTRON PIO	940+ 135
P3	LAMBDA INTO PROTON MU- NEUTRINO	938+ 106+ 0
P4	LAMBDA INTO PROTON E- NEUTRINO	938+.511+ 0
P5	LAMBDA INTO PROTON PI- GAMMA	938+ 140+ 0

18 LAMBDA BRANCHING RATIOS

R1		LAMBDA INTO (P PI-)/((P PI-)+(N PIO))							(P1)/(P1+P2)	
R1			0.627	0.031		CRAWFORD	59	HBC		
R1			0.65	0.05		COLUMBIA	60	HBC		
R1	U		(0.685)	(0.017)		ANDERSON	62	HBC		
R1		903	0.643	0.016		HUMPHREY	62	HBC		
R1	U	6736	0.635	0.007		DOYLE	69	HBC	PI-P TO LAM. KO	2/71
R1		4572	0.646	0.008		BALTAY	71	HBC	K-P AT REST	6/71
R1	U	ANDERSON RESULT NOT PUBLISHED, EVENTS ADDED TO DOYLE SAMPLE.								2/71
R1										
R1	AVG		0.6399	0.0049		AVERAGE				
R1	FIT		0.6419	0.0049		FROM FIT				
R2		LAMBDA INTO (N PIO)/((P PI-)+(N PIO))							(P2)/(P1+P2)	
R2			0.23	0.09		EISLER	57	HLBC		
R2			0.43	0.14		CRAWFORD	59	HBC		
R2			0.28	0.08		BAGLIN	60	HLBC		
R2			0.35	0.05		BROWN	63	HLBC		
R2		75	0.291	0.034		CHRETIEN	63	HLBC		
R2										
R2	AVG		0.304	0.025		AVERAGE				
R2	FIT		0.3581	0.0049		FROM FIT				
R3		LAMBDA INTO (P E- NEU)/TOTAL (UNITS 10**-3)							(P4)/(P1+P2)	
R3	O	15	(2.0)	(0.5)		HUMPHREY	61	RVUE		
R3	O	8	(2.9)	(1.5)	(1.2)	AUBERT	62	FBC		
R3	N	150	(0.82)	(0.12)		ELY	63	FBC	K- AT REST	
R3	N	102	(0.78)	(0.12)	(0.13)	BAGLIN	64	FBC	K- AT 1.45 GEV/C	
R3	O	20	(1.55)	(0.34)		LIND	64	HBC		
R3	N	143	(0.80)	(0.08)		MALONEY	69	HBC		10/69
R3	N	86	(0.78)	(0.09)		CANTER	71	HBC	K-P AT REST	4/71
R3	N	218	(0.88)	(0.10)		LINDQUIST	71	OSPK	PI- P TO KO LAM	2/72
R3	N	THESE VALUES HAVE BEEN CHANGED BY US INTO RATIOS TO PROTON PI-,								3/72
R3	N	BECAUSE THAT IS THE DIRECTLY MEASURED QUANTITY. SEE R5 BELOW								3/72
R3	O	LOW STATISTICS EXPERIMENTS. NOT AVERAGED								7/70
R4		LAMBDA INTO (P MU- NEU)/TOTAL (UNITS 10**-4)							(P3)/(P1+P2)	
R4		1	(0.2)	OR MORE		GOOD	62	HBC		
R4		1	(1.0)	OR LESS		ALSTON	63	HBC		
R4		2	(1.0)	OR LESS		KERNAN	64	FBC		
R4		BETWEEN 1.3 AND 6.0				LIND	64	HBC		
R4		3	1.3	0.7		LIND	64	RVUE		7/66
R4		2	1.5	1.2		RONNE	64	FBC		
R4		9	2.4	0.8		CANTER1	71	HBC	STOPPED K-P	7/71
R4		14	1.4	0.5		BAGGETT2	72	HBC	STOP K-	8/72
R4										
R4	AVG		1.57	0.35		AVERAGE				
R5		LAMBDA INTO (P E- NEU)/(P PI-) (UNITS 10**-3)							(P4)/(P1)	
R5		150	1.23	0.20		ELY	63	FBC		2/72
R5		120	1.17	0.18		BAGLIN	64	FBC		2/72
R5		143	1.20	0.12		MALONEY	69	HBC		2/72
R5		1078	1.31	0.06		ALTHOFF1	71	OSPK		2/72
R5	C	86	1.17	0.13		CANTER	71	HBC	K-P AT REST	3/72
R5	LC	218	(1.32)	(0.15)		LINDQUIST	71	OSPK	PI-P TO KO LAM	3/72
R5	L	544	1.23	0.11		LINDQUIST	77	SPEC	PI-P TO KO LAM	12/77
R5		10K	1.313	0.024		WISE	80	SPEC		8/81
R5		7111	1.335	0.056		BOURQUIN	83	SPEC	SPS HYPERON BEAM	2/84*
R5	C	CALCULATED BY US FROM R3 ASSUMING THE AUTHORS USED (P PI-)/TOT=2/3								3/72
R5	L	LINDQUIST 77 INCLUDES DATA OF LINDQUIST 71.								12/77
R5										
R5	AVG		1.304	0.020		AVERAGE				
R6		LAMBDA INTO (P PI- GAMMA)/(P PI-) (UNITS 10**-3) (P5)/(P1)								1/73
R6		72	1.32	0.22		BAGGETT3	72	HBC	PI- MOM LT 95 MEV/C	1/73

18 LAMBDA DECAY PARAMETERS

SEE NOTE ON BARYON DECAY PARAMETERS IN NEUTRON SECTION ABOVE.

A-		ALPHA LAMBDA- (LAMBDA INTO PI- PROTON)								
A-		1156	0.62	0.07		CRONIN	63	CNTR	LAMBDA FROM PI-P	8/67
A-			(0.663)	(0.022)		BERGE	66	RVUE	INCLUDES ABOVE	9/66
A-		10130	0.645	0.017		OVERSETH	67	OSPK	LAMBDA FROM PI-P	8/67
A-	M	2529	(0.747)	(0.086)		MERRILL	68	HBC	REPL BY DAUBER 68	6/68
A-		3520	0.67	0.06		DAUBER	69	HBC	FROM XI DECAY	6/68
A-		10325	0.649	0.023		CLELAND	72	OSPK	LAMBDA FROM PI-P	5/72
A-		8500	0.584	0.046		ASTBURY	75	SPEC	LAMBDA FROM PI-P	2/78
A-										
A-	AVG		0.642	0.013		AVERAGE				
A0		ALPHAO /ALPHA- FOR LAMBDA (L INTO PIO N/L INTO PI- P)								
A0			1.10	0.27		CORK	60	CNTR		
A0	O	4760	1.000	0.068		OLSEN	70	OSPK	PI+N TO K+ LAMBDA	5/70
A0	O	DONE BY COMPARING PROTON DISTR.WITH N DISTR. FROM LAMBDA DECAY.								
A0										
A0	AVG		1.006	0.066		AVERAGE				
F-		PHI ANGLE (SIN(PHI)/COS(PHI)=BETA/GAMMA) (DEGREES)								
F-		1156	13.0	17.0		CRONIN	63	OSPK	LAMBDA FROM PI-P	11/67
F-		10130	-8.0	6.0		OVERSETH	67	OSPK	LAMBDA FROM PI-P	11/67
F-		7377	(-9.2)	(5.2)		CLELAND	67	OSPK	REPL BY CLELAND 72	5/72
F-		10325	-7.0	4.5		CLELAND	72	OSPK	LAMBDA FROM PI-P	5/72
F-										
F-	AVG		-6.5	3.5		AVERAGE				
AV		GA/GV FOR LAMBDA BETA DECAY								
AV		(FOR SIGN CONVENTION, SEE NOTE ON BARYON DECAY PARAMETERS IN								
AV		NEUTRON SECTION ABOVE.)								
AV	C	22	(-1.03)			LIND	64	HBC		6/68
AV	C	102	(0.6)	OR MORE		BAGLIN	65	HLBC	NO SIGN GIVEN	1/71
AV	C		BETW 0. AND -1.1			BARLOW	65	OSPK		6/68
AV	C	102	(0.7)	OR MORE	CL=.95	ELY	65	HLBC	ABS. VALUE	1/71
AV	C	EXPERIMENTS INCLUDED IN CONFORTO 65, RVUE								6/68
AV			-1.14	0.23	0.33	CONFORTO	65	RVUE		11/67
AV	M	148	-0.72	0.14	0.19	MALONEY	69	HBC		10/69
AV	A	1078	(-0.62)	(0.08)	(0.09)	ALTHOFF2	71	OSPK	POLARIZED LAMBDA	7/73
AV	M	141	-0.75	0.15	0.18	CANTER	71	HBC		4/71
AV	L	173	(-0.40)	(0.13)	(0.17)	LINDQUIST	71	OSPK	E-NEU AND UP-DOWN	9/71
AV	M	352	-0.74	0.09	0.12	BAGGETT1	72	HBC	STOP.K-	2/72
AV	A	817	-0.63	0.06		ALTHOFF1	73	OSPK	POLARIZED LAMBDA	7/73
AV		405	-0.47	0.09		BURNETT	76	SPEC	E-NEU AND SPIN	2/78
AV	L	441	-0.53	0.09	0.11	LINDQUIST	77	SPEC	POL LAMBDA, 3 ASYMM	12/77
AV	M	10K	-0.734	0.031		WISE	81	SPEC	E-NEU ANG. CORREL.	1/82
AV		7111	-0.70	0.03		BOURQUIN	83	SPEC	XI- --> LAMBDA PI-	2/84*
AV	A	ALTHOFF1 73 INCLUDES DATA OF ALTHOFF2 71. USES PROT SPECTRUM AND								7/73
AV	A	THREE SPIN ASYMMETRIES.								7/73
AV	M	EXPT MEASURES ONLY THE ABSOLUTE VALUE OF A/V								7/73
AV	L	LINDQUIST 77 INCLUDES DATA OF LINDQUIST 71.								12/77
AV										
AV	AVG		-0.694	0.025		AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.3) (SEE IDEOGRAM BELOW)				

For notation, see key at front of Listings.

Stable Particles
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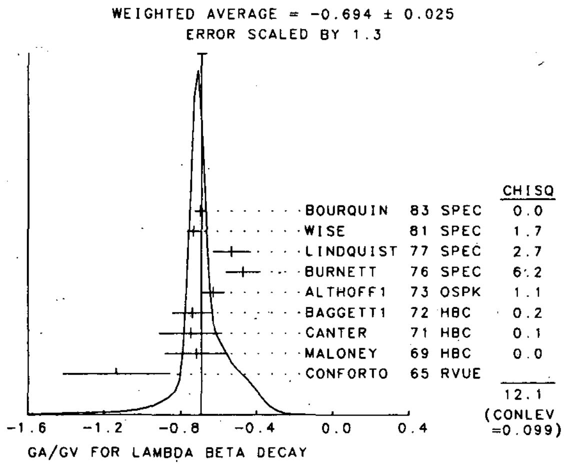

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REFERENCES FOR LAMBDA

EISLER 57 NC 5 1700 — EISLER,PLANO,SAMIOS,SCHWARTZ + (COLU+BNL)
BOLDT 58 PRL 1 148 — E BOLDT,D O CALDWELL,Y PAL (MIT)
CRAWFORD 59 PRL 2 266 — CRAWFORD,CRESTI,DOUGLASS,GOOD + (LRL)

BAGLIN 60 NC 18 1043 — BAGLIN,BLOCH,BRISSON,HENNESSY + (EPOL)
BOWEN 60 PR 119 2030 — BOWEN,HARDY,REYNOLDS,SUN + (PRINCETON)
CORK 60 PR 120 1000 — CORK,KERTH,WENZEL,CRONIN+ (LRL+PRIN+BNL)
COLUMBIA 60 ROCH CONF 726 — M SCHWARTZ + (COLUMBIA)
HUMPHREY 61 PRL 6 478 — HUMPHREY,KIRZ,ROSENFELD,RHEE + (LRL+SYRA)

ANDERSON 62 CERN CONF 832 — ANDERSON,CRAWFORD,GOLDEN,LLOYD + (LRL)
AUBERT 62 NC 25 479 — AUBERT,BRISSON,HENNESSY,SIX + (EPOL)
CHANG 62 THESIS DUKE — CHUEN CHUEN CHANG (DUKE)
COOL 62 PR 127 2223 — COOL,HILL,MARSHALL + (BNL+MIT+NYU+ANL)
GOOD 62 PRL 9 518 — M L GOOD,V G LIND (WISCONSIN)
HUMPHREY 62 PR 127 1305 — W E HUMPHREY,R R ROSS (LRL)

ALSTON 63 UCRL 10926 — ALSTON,KIRZ,NEUFELD,SOLMITZ,WOHLMUT (LRL)
BHOWMIK 63 NC 28 1494 — B BHOWMIK,D P GOYAL (DELHI)
BLOCK 63 PR 130 766 — BLOCK,GESSAROLI,RATTI+(NWES+BGNA+SYRA+ORNL)
BROWN 63 PR 130 769 — BROWN,KADYK,TRILLING,ROE + (LRL+MICH)
CHRETIEN 63 PR 131 2208 — CHRETIEN,CROUCH+ (BRAN+BROWN+HARVARD+MIT)
CRONIN 63 PR 129 1795 — J W CRONIN,O E OVERSETH (PRINCETON)
ELY 63 PR 131 868 — ELY,GIDAL,KALMUS,OSWALD,POWELL + (LRL)
KERNAN 63 PR 129 870 — KERNAN,NOVEY,WARSHAW,WATTENBERG (ANL+ILL)

ANDERSON 64 PRL 13 167 — J A ANDERSON,F S CRAWFORD (LRL)
BAGLIN 64 NC 35 977 — BAGLIN,BINGHAM+ (EPOL+CERN+LOUC+RHEL+BERG)
HUBBARD 64 PR 135 B 183 — HUBBARD,BERGE,KALBFLEISCH,SHAFER + (LRL)
KERNAN 64 PR 133 B 1271 — KERNAN,POWELL,SANDLER + (LRL+LOUC)
KREISLER 64 PR 136 B 1074 — M N KREISLER,O OVERSETH,J CRONIN (PRIN)
LIND 64 PR 135 B 1483 — LIND,BINFORD,GOOD,STERN (WISCONSIN)
RONNE 64 PL 11 357 — RONNE+ (CERN+EPOL+LOUC++UNIV.BERGEN)
SCHWARTZ 64 UCRL 11360 THESIS — JOSEPH ADAM SCHWARTZ (LRL)

BAGLIN 65 NC 35 977 — BAGLIN + (EPOL,CERN,LOUC,RHEL,BERGEN)
BALTAY 65 PR 140 B 1027 — BALTAY,SANDWEISS,CULWICK,KOPP + (YALE+BNL)
BARLOW 65 PL 18 64 — J BARLOW,BLAIR,CONFORTO+ (CERN+RHEL+PENN)
CHARRIER 65 PL 15 66 — CHARRIERE,GIBSON+ (EPOL+BRIS+CERN+MPIM)
ALSO 66 NC 46A 205 — CHARRIERE,GIBSON + (EPOL,BRIS,CERN,MPIM)
CONFORTO 65 EC INT HERZEGNOVI — G CONFORTO (CERN)
ELY 65 PR 137 B1302 — ELY,GIDAL,KALMUS,POWELL + (LRL,LOUC)
HILL 65 PRL 15 85 — HILL,LI,JENKINS,KYCIA,RUDERMAN (MIT,BNL)
SCHMIDT 65 PR 140 B 1328 — P SCHMIDT (COLUMBIA)

BERGE 66 BERKELEY 46 — BERGE,CABIBBO ((RVUE) LRL,CERN)
BURAN 66 PL 20 318 — BURAN,EIVINDSON,SKJEGGESTAD,TOFTE + (OSLO)
CHIEN 66 PR 152 1171 — +LACH,SANDWEISS,TAFT,YEH,OREN + (YALE+BNL)
ENGELMAN 66 NC 45A 1038 — ENGELMANN,FILTHUTH,ALEXANDER+ (HEID,REHO)
GIBSON 66 NC 45A 882 — W M GIBSON,K GREEN (BRIS)
LONDON 66 PR 143 1034 — LONDON,RAU,GOLDBERG,LICHTMAN+ (BNL,SYRA)

AUERBACH 67 NC 47A 19 — AUERBACH,BOWEN,DOBBS,LANDE,MANN+ (PENN)
BADIER 67 PL 25B 152 — +BONNET,BRIANDET,SADOULET (EPOL)
CLELAND 67 PL 26B 45 — CLELAND,BIENLEIN,CONFORTO+ (CERN+GEVA+LUND)
MAYEUR 67 U.LIBR.BRUX.BUL32 — C.MAYEUR,E.TOMPA,J.WICKENS (BELG,LOUC)
OVERSETH 67 PRL 19 391 — O E OVERSETH, R F ROTH (MICH+PRIN)
GRIMM 68 NC 54A 187 — H.-J.GRIMM (HEIDELBERG)
HEPP 68 ZPHYS 214 71 — V.HEPP,H. SCHLEICH (HEIDELBERG)
MERRILL 68 PR 167 1202 — MERRILL,SHAFER (LRL)

DAUBER 69 PR 179 1262 — +BERGE,HUBBARD,MERRILL,MILLER (LRL)
DOYLE 69 UCRL 18139-THESIS — J.C. DOYLE (LRL)
MALONEY 69 PRL 23 425 — MALONEY,SECHI-ZORN (UNIV MARYLAND)
BOHM 70 NC 70A 384 — + KRECKER + (BERL+BRUX+DUUC+LOUC+LOWC+WARS)
DEMIDOV 70 SJNP 10 681 — +KIRILLOV-UGRYUMOV,PONOSOV,PROTASOV+ (ITEP)
OLSEN 70 PRL 24 843 — +PONDROM,HANDLER,LIMON,SMITH + (WISC,MICH)

ALTHOFF1 71 PL 37B 531 — +BROWN,FREYTAG,HEARD,HEINTZE + (CERN,HEID)
ALTHOFF2 71 PL 37B 535 — +BROWN,FREYTAG,HEARD,HEINTZE + (CERN,HEID)
BALTAY 71 PR D4 670 — +BRIDGEWATER,COOPER,HABIBI+ (COLU+BING)
BARKOV 71 JETPL 14 60 — +GUREVICH,MAKARINA,MARTEMYANOV+ (ITEP)
BARONI 71 LNC 2 1256 — G BARONI,S PETRERA,G ROMANO (ROMA)
CANTER 71 PRL 26 868 — +COLE,LEE-FRANZINI,LOVELESS + (STON+COLU)

CANTER1 71 PRL 27 59 — +COLE,LEE-FRANZINI,LOVELESS+ (STON+COLU)
DAHLJENS 71 NC 3A 1 — DAHL-JENSEN + (CERN+ANKA+LAUS+MPIM+ROMA)
HILL 71 PR D4 1979 — +LI,JENKINS,KYCIA,RUDERMAN (MIT,BNL)
ALSO 65 PRL 15 85 — HILL,LI,JENKINS,KYCIA,RUDERMAN (MIT,BNL)
LINDQUIS 71 PRL 27 612 — LINDQUIST,SUMNER+ (EFI,WUSL,OSU,ANL)

BAGGETT1 72 ZPHY 249 279 — +BAGGETT,EISELE,FILTHUTH,FREHSE+ (HEID)
BAGGETT2 72 ZPHY 252 362 — +BAGGETT,EISELE,FILTHUTH,FREHSE+ (HEID)
BAGGETT3 72 PL 42B 379 — +BAGGETT,EISELE,FILTHUTH,FREHSE,HEPP+(HEID)
BARKOV 72 JETPL 16 104 — +GUREVICH,MAKARINA,MARTEMYANOV + (ITEP)
CLELAND 72 NP B40 221 — +CONFORTO,EATON,GERBER+ (CERN+GEVA+LUND)
HYMAN 72 PR D5 1063 — +BUNNELL,DERRICK,FIELDS,KATZ+ (ANL+CARN)

ALTHOFF1 73 PL 43B 237 — +BROWN,FREYTAG,HEARD,HEINTZE+ (CERN+HEID)
ALTHOFF2 73 NP B66 29 — +BROWN,FREYTAG,HEARD,HEINTZE+ (CERN+HEID)
POULARD 73 PL 46B 135 — +GIVERNAUD,BORG (SACL)

ASTBURY 75 NP B99 30 — +GALLIVAN,JAFAR + (LOIC+CERN+ETH+SACL)
CLAYTON 75 NP B95 130 — +BACON,BUTTERWORTH,WATERS + (LOIC+RHEL)
BUNCE 76 PRL 36 1113 — +HANDLER,MARCH,MARTIN + (WISC+MICH+RUTG)
BURNETT 76 NC 34A 14 — +INNES,MASEK,MAUNG,MILLER,RUDERMAN+ (UCSC)

HELLER 77 PL 68B 480 — +OVERSETH,BUNCE,DYDAK + (MICH+WISC+HEID)
LINDQUIS 77 PR D16 2104 — LINDQUIST,SWALLOW,SUMNER + (EFI+OSU+ANL)
ALSO 76 JPG 2 L211 — LINDQUIST,SWALLOW,SUMNER+(EFI+WUSL+OSU+ANL)
ZECH 77 NP B124 413 — +DYDAK,NAVARRIA+ (SIEG+CERN+DORT+HEID)
SCHACHIN 78 PRL 41 1348 — SCHACHINGER,BUNCE,COX + (MICH+RUTG+WISC)

WISE 80 PL 91B 165 — +JENSEN,KREISLER,LOMANNO,POSTER+ (MASA+BNL)
COX 81 PRL 46 877 — +DWORKIN + (MICH+WISC+RUTG+MINN+BNL)
PONDROM 81 PRD 23 814 — +HANDLER,SHEAFF,COX + (WISC+MICH+RUTG+MINN)
WISE 81 PL 98B 123 — +JENSEN,KREISLER,LOMANNO,POSTER+ (MASA+BNL)
BOURQUIN 83 ZPHY C21 1 — +BROWN+ (BRIS+GEVA+HEID+LALO+RL+STRB)

PAPERS NOT REFERRED TO IN DATA CARDS

ARMENTER 62 CERN CONF 236 — ARMENTEROS+ (CERN+EPOL+LOIC+BIRM+CEN-SACLAY)
BALTAY 62 CERN CONF 233 — BALTAY,FOWLER,SANDWEISS,CULWICK+ (YALE+BNL)
BERGE 63 THESIS (BERKELEY) — J PETER BERGE (LRL)

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19 SIGMA+(1189,JP=1/2+) I=1

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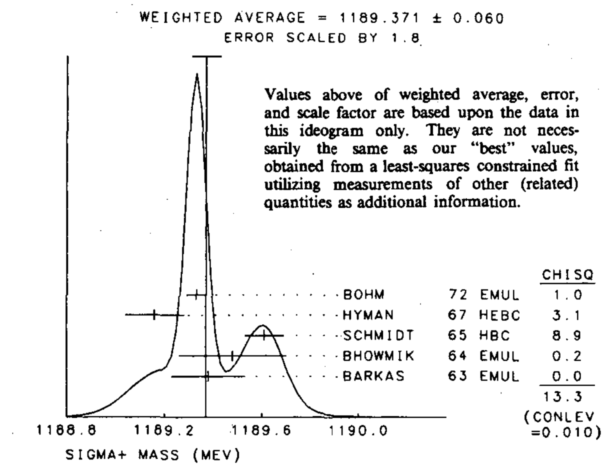
19 SIGMA+ MASS (MEV)

M N SEE NOTE PRECEDING LAMBDA MASS LISTINGS

M		144	1189.38	0.15	BARKAS	63	EMUL + SEE NOTE S BELOW	
M		58	1189.48	0.22	BHOWMIK	64	EMUL + SEE NOTE S BELOW	
M	S	ABOVE SIGMA+ MASSES HAVE BEEN RAISED 30 KEV TO ACCOUNT FOR 46 KEV						
M	S	INCREASE IN PROTON MASS AND 21 KEV DECREASE IN PION MASS						
M		4205	1189.61	0.08	SCHMIDT	65	HBC SEE NOTE N	3/74
M			1189.16	0.12	HYMAN	67	HEBC	6/68
M	B	607	1189.33	0.04	BOHM	72	EMUL	12/73
M	B	BOHM 72 UPDATED WITH PDG APR. 73 K-, PI- AND PI0 MASSES.						12/73
M			. . . .					
M	AVG		1189.371	0.060	AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.8)			
M	FIT		1189.365	0.058	FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.8) (SEE IDEOGRAM BELOW)			3/84*



Values above of weighted average, error, and scale factor are based upon the data in this ideogram only. They are not necessarily the same as our "best" values, obtained from a least-squares constrained fit utilizing measurements of other (related) quantities as additional information.

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19 SIGMA+ MEAN LIFE (UNITS 10-10 SEC)**

T						GLASER	58	RVUE		
T		127	0.98	0.16	0.12	PUSCHEL	60	EMUL		
T		41	0.82	0.34	0.20	EVANS	60	EMUL		
T		117	0.85	0.14	0.11	FREDEN	60	EMUL		
T		54	0.80	0.10	0.067	KAPLON	60	EMUL		
T		23	0.76	0.22	0.14	CHIESA	61	EMUL		
T		49	0.75	0.13	0.09	BERTHELOT	61	HLBC		
T		140	0.82	0.10	0.08	BARKAS	61	EMUL		
T		192	0.749	0.056	0.052	GRARD	62	HBC		
T		456	0.765	0.04		HUMPHREY	62	HBC		
T		203	0.84	0.12	0.08	BHOWMIK	64	EMUL		
T		181	0.84	0.09		BALTAY	65	HBC		6/66
T		900	0.76	0.03		CARAYAN	65	HBC		6/66
T	C	1300	0.83	0.032		CHANG	66	HBC		6/66
T	S	125	(0.86)	(0.15)		CHIEN	66	HBC	+ 6.9 PBAR P	9/67
T	S	117	(1.10)	(0.24)		CHIEN	66	HBC	- 6.9 PBAR P,ANTI	9/67
T		381	0.80	0.07		COOK	66	OSPK		7/66
T		10664	0.803	0.008		BARLOUTAU	69	HBC	K-P .4-1.2 GEV/C	11/69
T		20K	0.795	0.010		EISELE	70	HBC	K-P AT REST	2/71
T		526	0.83	0.04		BAKKER	71	DBC	K-N TO SIG+ 2PI-	10/71
T		5719	0.807	0.013		CONFORTO	76	HBC	K-P 1-1.4 GEV/C	11/77
T		30K	0.798	0.005		MARRAFFIN	80	HBC	K- P TO SIG+ PI-	2/80
T	C	CHANG ERROR 0.018 RAISED BY US. SEE 1970 EDITION, RMP 42,123(1970)								1/73
T	S	ERROR PURELY STATISTICAL								
T			. . . .							
T	AVG		0.7997	0.0036	0.0036	AVERAGE				

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Stable Particles

Data Card Listings

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                    19  SIGMA+ MAGNETIC MOMENT (MAGNETONS,938.26 MEV)

MM      381    1.5       1.1           COOK      66 OSPK                     7/66
MM       52    3.5       1.5           KOTELCHUC 67 EMUL   K-P AT 1.15BEV/C  8/67
MM       51    3.0       1.2           SULLIVAN  67 EMUL   PHOTOPRODUCTION   8/67
MM       69    3.5       1.2           COMBE     68 EMUL                    10/68
MM    29333    2.1       1.0           MAST      68 HBC    K-P AT .4 GEV/C   6/68
MM      955    2.67      0.97          ALLEY     71 OSPK   1.28 GEV/C PI+P  10/70
MM     2651    2.7       0.9           SAHA      73 HLBC   K-P.25TO.55GEV/C  6/73
MM   S 8503   (2.95)    (0.31)         DOBLE     77 HBC    K-P .46 GEV/C    12/77
MM    S 14K    2.30      0.14          SETTLES   79 HBC    K-P.42TO.50GEV/C 12/79
MM      44K    2.38      0.02          ANKENBRAN 83 CNTR   210GEV HYP.BEAM  10/83*
MM    S  SETTLES 79 INCLUDES DOBLE 77 DATA.                                 12/79
MM              . . . . . . . . . . .
MM   AVG       2.379     0.020   AVERAGE

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                    19  SIGMA+ PARTIAL DECAY MODES

                                                              DECAY MASSES
P1      SIGMA+ INTO PROTON PIO                             938+ 135
P2      SIGMA+ INTO NEUTRON PI+                            940+ 140
P3      SIGMA+ INTO NEUTRON PI+ GAMMA                      940+ 140+    0
P4      SIGMA+ INTO LAMBDA E+ NEU                         1116+.511+    0
P5      SIGMA+ INTO PROTON GAMMA                           938+   0
P6      SIGMA+ INTO NEUTRON MU+ NEUTRINO                   940+ 106+    0
P7      SIGMA+ INTO NEUTRON E+ NEUTRINO                    940+.511+    0
P8      SIGMA+ INTO PROTON E+ E-                           938+.511+.511

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                    19  SIGMA+ BRANCHING RATIOS

R1      SIGMA+ INTO (NEUTRON PI+)/(NUCLEON PI)              (P2)/(P1+P2)
R1      308    0.490     0.024          HUMPHREY  62 HBC
R1      534    0.46      0.02           CHANG     66 HBC                     6/66
R1     1331    0.488     0.010          BARLOUTAU 69 HBC    K-P .4-1.2 GEV/C 11/69
R1      537    0.484     0.015          TOVEE     71 EMUL                   12/71
R1     1861    0.488     0.008          NOWAK     78 HBC   BRITISH 1.5M (TST) 7/79
R1    M 10K    0.4828    0.0036         MARRAFFIN 80 HBC    K-P 420-500MEV/C 2/80
R1    M  MARRAFFINO 80 GIVES BR TO (P PIO)/ALL.  WE QUOTE 1-BR.              2/80
R1              . . . . . . . . . . .
R1   AVG       0.4836    0.0030  AVERAGE

R2      SIGMA+ INTO (NEUT PI+ GAM)/(PI+N) (UNITS 10**-3) (P3)/P2)
R2            (1.8)      ABOUT          BAZIN2    65 HBC    PI+ LT 116 MEV/C 8/67
R2       29   (0.27)    (0.05)          ANG       69 HBC    PI+ LT 110 MEV/C 11/68
R2      180    0.93      0.10           EBENHOH   73 HBC    PI+ LT 150 MEV/C 3/74
R2      PI+ MOMENTUM CUTS DIFFER, NOT AVERAGED. LATEST VALUE USED IN TABLE.  4/82

R3      SIGMA+ INTO (LAMBDA E+ NEU)/TOTAL (UNITS 10**-5) (P4)
R3  W     4   (3.3)     (1.7)           WILLIS    64 HBC    STOP. K-         9/66
R3  W                      EVENTS FROM THIS EXPERIMENT,INCLUDED IN EISELE1 69 11/69
R3        6    2.0       0.8            BARASH    67 HBC    STOP K-          8/67
R3        5    1.6       0.7            BALTAY    69 HBC    STOP K-         11/69
R3       10    2.9       1.0            EISELE1   69 HBC    STOP K-         10/69
R3              . . . . . . . . . . .
R3   AVG       2.02      0.47     AVERAGE

R4      SIGMA+ INTO (P GAMMA)/(P PIO) (UNITS 10**-2)      (P5)/(P1)
R4        1   (0.068)OR LESS            CARRARA   64 HBC
R4       24    0.37      0.08           BAZIN     65 HBC
R4        4   (0.17)                    QUARENI   65 EMUL                    6/66
R4       45    0.21      0.03           ANG       69 HBC    STOP K-         10/69
R4       31    0.276     0.051          GERSHWIN  69 HBC                    10/69
R4       46    0.211     0.038          MANZ      80 HBC  K- P-->SIGMA+ PI-  9/81
R4              . . . . . . . . . . .
R4   AVG       0.232     0.025    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.2)
                         (SEE IDEOGRAM BELOW)
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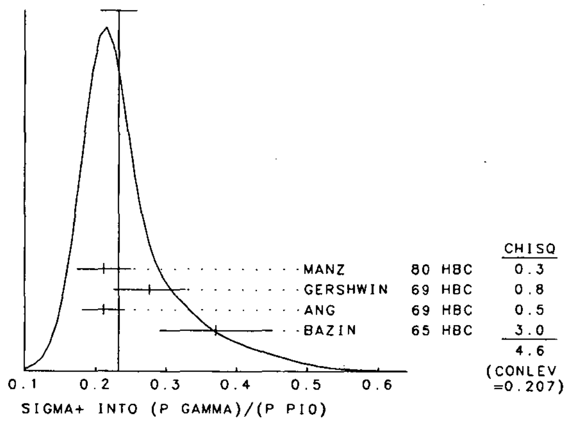
WEIGHTED AVERAGE = 0.232 ± 0.025
ERROR SCALED BY 1.2

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R5      SIGMA+ INTO (N E+ NEU)/(N PI+) (UNITS 10**-5)     (P7)/(P2)
R5       TEST OF DELTA-S = DELTA-Q RULE
R5 EO     0    (16220)EFFECTIVE DENOM.  COURANT    64 HBC      SEE NOTE E     11/67
R5 EO     0     (2720)EFFECTIVE DENOM.  MURPHY     64 HBC      SEE NOTE E     11/67
R5 EO     1     (9690)EFFECTIVE DENOM.  NAUENBERG 64 HBC       SEE NOTE E      6/68
R5  O     0    (32406)EFFECTIVE DENOM.  BIERMAN    68 HBC                      6/68
R5 UA     0    (80400)EFFECTIVE DENOM.  EISELE2    69 HBC      STOP K-         6/68
R5 UO     1    (30000)EFFECTIVE DENOM.  NORTON     69 HBC                     11/69
R5  O    OLDER LOWER STATISTICS EXPTS. NOT INCLUDED IN AVERAGE.               2/76
R5 U      0    105000 EFFECTIVE DENOM.  SECHIZORN 73 HBC       STOP K-         2/76
R5 U A    0    111000 EFFECTIVE DENOM.  EBENHOH    74 HBC      STOP K-         1/76
R5 U                  EFFECTIVE DENOM.  CALCULATED BY US
R5 E                  EFFECTIVE DENOM.  TAKEN FROM EISELE 67                  11/67
R5    A  EISELE2 69 REPLACED BY BY EBENHOH 74.                                 1/76
R5          . . . . . . . . . . .
R5             1.1   OR LESS  CL=.90   OUR AVERAGE (2.3 EVTS)/(EFF.DNOM.SUM)  2/76
R5       NUMBER OF EVENTS INCREASED TO 2.3 FOR 90PC CONFIDENCE LEVEL          2/76

R6      SIGMA+ INTO (N MU+ NEU)/(PI+N) (UNITS 10**-5)     (P6)/(P2)
R6       TEST OF DELTA-S = DELTA-Q RULE
R6        1      (120)ANALYSED EVENTS   GALTIERI  62 EMUL     NO RATIO QUOTED  11/67
R6 E      0     10150 EFFECTIVE DENOM.  COURANT   64 HBC      SEE NOTE E       11/67
R6 E      0      1710 EFFECTIVE DENOM.  NAUENBERG 64 HBC      SEE NOTE E       11/67
R6 U      2     62000 EFFECTIVE DENOM.  EISELE2   69 HBC                        6/68
R6        0     33800 EFFECTIVE DENOM.  BAGGETT   69 HBC                       11/68
R6 E                  EFFECTIVE DENOM.  TAKEN FROM EISELE 67                   11/67
R6 U                  EFFECTIVE DENOM.  CALCULATED BY US
R6          . . . . . . . . . . .
R6             6.2   OR LESS  CL=.90   OUR AVERAGE (6.7 EVTS)/(EFF.DNOM.SUM)  2/76
R6       NUMBER OF EVENTS INCREASED TO 6.7 FOR 90PC CONFIDENCE LEVEL          2/76

R7      (SIGMA+ INTO LEPTONS)/(SIGMA- INTO LEPTONS)
R7       TEST OF DELTA-S = DELTA-Q RULE.
R7        0    (0.034)OR LESS           BAGGETT   67 HBC                        6/68
R7        1    (0.08) OR LESS           NORTON    69 HBC                       10/69
R7          . . . . . . . . . . .
R7             0.043 OR LESS  CL=.90   OUR AVERAGE  USING R5 AND R6            2/76

R8      SIGMA+ INTO (PROTON E+ E-)/TOTAL (UNITS 10**-6)  (P8)
R8             7.0   OR LESS            ANG       69 HBC      STOP K-          10/69
R8    A   ANG 69 FOUND 3 E+E- EVENTS IN AGREEMENT WITH GAMMA CONVERSION OF
R8    A   PROTON GAMMA DECAY -LIMIT GIVEN HERE IS FOR NEUTRAL CURRENT

R9      (SIGMA+ INTO N MU+ NEU)/(SIGMA- INTO N MU- NEU)
R9        2  0.06        0.045      0.03   EISELE2   69 HBC  +- STOP K-        10/69
R9          . . . . . . . . . . .
R9             0.12  OR LESS  CL=.90   OUR AVERAGE  USING R6                   2/71

R10     (SIGMA+ INTO N E+ NEU)/(SIGMA- INTO N E- NEU)
R10 E     0    (0.03) OR LESS  CL=.90   EISELE2   69 HBC  +- STOP K-          10/69
R10       0    (0.12) OR LESS  CL=.95   COLE      71 HBC  +- STOP K-          10/71
R10       0    (0.018)OR LESS  CL=.90   SECHIZORN 73 HBC  +- STOP K-,POISSON   8/73
R10   E   0    (0.019)OR LESS  CL=.90   EBENHOH   74 HBC  +- STOP K-          12/75
R10   E  EISELE2 69 REPLACED BY EBENHOH 74.                                   12/75
R10         . . . . . . . . . . .
R10            0.009 OR LESS  CL=.90   OUR AVERAGE  USING R5                   2/76

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                    19  SIGMA+ DECAY PARAMETERS

        SEE NOTE ON BARYON DECAY PARAMETERS IN NEUTRON SECTION ABOVE.

A+0       ALPHA+/ALPHAO FOR SIGMA+ (SIG+ TO PI+ N)/(SIG+ TO PIO P)
A+0            (+0.04)    (0.11)            CORK      60 CNTR    SIG+ FROM PI+P
A+0            (+0.20)    (0.24)            TRIPP     62 HBC     REPLAC.BY BANGER
A+0 O 3500     (-.014)    (0.052)           BANGERTER 66 HBC     SIG+ FROM K-P     9/66
A+0 O 2600     (-.047)    (0.07)            BERLEY    66 HBC     SIG+ FROM K-P     9/66
A+0     20K    (-0.104)   (0.028)           REUCROFT  77 HBC REPL.BY MARRAFFINO80 6/77
A+0     23K     -0.073     0.021            MARRAFFIN 80 HBC     K- P TO SIG+ PI-  2/80
A+0 O           OLD RESULTS, HAVE BEEN REPLACED. SEE BELOW.
A+0             . . . . . . . . . . .
A+0 FIT         -0.069     0.013   FROM FIT                                     4/82

A+        ALPHA+ FOR SIGMA+ (SIG+ TO PI+ N)
A+    35000     0.069      0.017            BANGERTER 69 HBC     K-P AT 400 MEV/C 11/69
A+     4101     0.037      0.049            BERLEY    70 HBC                     12/70
A+              . . . . . . . . . . .
A+  AVG         0.066      0.016    AVERAGE
A+  FIT         0.068      0.013   FROM FIT                                     4/82

A0        ALPHAO FOR SIGMA+ (SIG+ INTO PIO PROTON)
A0              -0.80      0.16             BEALL     62 CNTR
A0             (-0.90)    (0.25)            TRIPP     62 HBC     REPLAC. BY BANGE
A0  O 5200     (-0.986)   (0.072)           BANGERTER 66 HBC     K-P TO SIG+ PI-   7/66
A0    32000     -0.999     0.022            BANGERTER 69 HBC                     10/69
A0  H  1335     -0.98      0.05      0.02   HARRIS    70 OSPK    PI+P TO SIG+ K+   5/70
A0      16K     -0.940     0.045            BELLAMY   72 ASPK    PI+P TO SIG+ K+  11/72
A0  L  1259     -0.945     0.055     0.042  LIPMAN    73 OSPK    PI+P TO SIG +     7/73
A0  L     DECAY PROTONS SCATTERED OFF ALUMINUM.                                 7/73
A0  H     DECAY PROTONS SCATTERED OFF CARBON.
A0              . . . . . . . . . . .
A0  AVG         -0.979     0.016    AVERAGE
A0  FIT         -0.979     0.016   FROM FIT                                     4/82

F+        PHI+ ANGLE (SIG+ INTO N PI)  SIN(PHI)/COS(PHI)=BETA/GAMMA  (DEGREE)
F+  O  370 (180.)     (30.)                 BERLEY    66 HBC     NEUTRON RESCATT.  9/66
F+     560  143.       29.                  BANGERT1  69 HBC                     10/69
F+   C1054  184.       24.                  BERLEY    70 HBC     K-P AT 400 MEV/C 11/69
F+   C  CHANGED FROM 176 TO 184 TO AGREE WITH SIGN CONVENTION.
F+              . . . . . . . . . . .
F+  AVG        167.3      20.1      AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.1)

AG        ALPHAG FOR SIGMA+ (SIG+ INTO PROTON GAMMA)
AG        61    -1.03      0.52      0.42   GERSHWIN  69 HBC     K-P TO SIG PI    11/69
AG        46    -0.53      0.38      0.36   MANZ      80 HBC  K- P-->SIGMA+ PI-   9/81
AG              . . . . . . . . . . .
AG  AVG         -0.72      0.29     AVERAGE

FO        PHIO ANGLE (SIG+ INTO PIO PROTON) SIN(PHI)/COS(PHI)=BETA/GAMMA (DEG)
FO H            22.0       90.0             HARRIS    70 OSPK PI+P TO SIG+ K+      5/70
FO L  1259      38.1       35.7      37.1   LIPMAN    73 OSPK    PI+P TO SIG+K+    7/73
FO L      DECAY PROTON SCATTERED OFF ALUMINUM.                                  7/73
FO H      DECAY PROTONS SCATTERED OFF CARBON.
FO              . . . . . . . . . . .
FO  AVG         35.8       33.7     AVERAGE

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REFERENCES FOR SIGMA+


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CORK      60 PR 120 1000       CORK,KERTH,WENZEL,CRONIN,COOL(LRL+PRIN+BNL)
EVANS     60 NC 15 873         BRIST+BRUSS+IAS-U.COL-DUBLIN+LON+MILAN+PAD
FREDEN    60 NC 16 611         S FREDEN,H KORNBLUM,R WHITE             (LRL)
KAPLON    60 ANP 9 139         M KAPLON,A MELISSINOS,YAMANOUCHI       (ROCH)
PUSCHEL   60 NP 20 254         W PUSCHEL                   (MAX PLANCK INST)

BARKAS    61 PR 124 1209       BARKAS,DYER,MASON,NICHOLS,SMITH         (LRL)
BERTHELO  61 NC 21 693         BERTHELOT,DAUDIN,GOUSSU +     (SACLAY+ORSAY)
CHIESA    61 NC 19 1171        CHIESA,QUASSIATI,RINAUDO         (INFN-TURIN)
BEALL     62 PRL 8 75          BEALL,CORK,KEEFE,MURPHY,WENZEL          (LRL)
GRARD     62 PR 127 607        F GRARD,G A SMITH                       (LRL)
GALTIERI  62 PRL 9 26          GALTIERI,BARKAS,HECKMAN,PATRICK,SMITH   (LRL)
HUMPHREY  62 PR 127 1305       W E HUMPHREY,R R ROSS                   (LRL)
TRIPP     62 PRL 9 66          R D TRIPP,M B WATSON,M FERRO-LUZZI      (LRL)

BARKAS    63 PRL 11 26         W H BARKAS,J N DYER,H H HECKMANN        (LRL)
    ALSO  61 UCRL 9450         JOHN DYER (THESIS, BERKELEY)            (LRL)

BHOWMIK   64 NP 53 22          B BHOWMIK,P JAIN,P MATHUR,LAKSHMI     (DELHI)
CARRARA   64 PL 12 72          CARRARA,CRESTI,GRIGOLETTO,PERUZZO+ (PADOVA)
COURANT   64 PR 136 B 1791     COURANT,FILTHUTH+    (CERN+HEID+UMD+NRL+BNL)
MURPHY    64 PR 134 B 188      C THORNTON MURPHY                 (WISCONSIN)
NAUENBER  64 PRL 12 679        NAUENBERG,MARATECK,+         (COLU+RUTG+PRIN)
WILLIS    64 PRL 13 291        WILLIS,COURANT,ENGELMAN+(BNL,CERN,HEID,UMD)
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For notation, see key at front of Listings.

Stable Particles

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BALTAY   65 PR 140 B 1027      BALTAY,SANDWEISS,CULWICK,KOPP +  (YALE+BNL)
BAZIN    65 PRL 14 154         BAZIN,BLUMENFELD,NAUENBERG +     (PRIN+COLU)
BAZIN2   65 PR 140  B1358      BAZIN,PLANO,SCHMIDT+          (PRIN,RUTG,COLU)
CARAYAN  65 PR 138 B 433       CARAYANNOPOULOS,TAUTFEST,WILLMANN  (PURDUE)
QUARENI  65 NC 40 A 928        QUARENI,CARTACCI +   (BGNA,FIRZ,GENO,PARMA)
SCHMIDT  65 PR 140 B 1328      P SCHMIDT                        (COLUMBIA)

BANGERTE 66 PRL  17  495       BANGERTER,GALTIERI,BERGE,MURRAY+       (LRL)
BERLEY   66 PRL 17 1071        +HERZBACH,KOFLER,YAMAMOTO + (BNL+MASA+YALE)
CHANG    66 PR  151  1081      CHUNG YUN CHANG                  (COLUMBIA)
    ALSO 65 NEVIS 145  THESIS  CHUNG YUN CHANG                  (COLUMBIA)
CHIEN    66 PR  152  1171      +LACH,SANDWEISS,TAFT,YEH,OREN +  (YALE+BNL)
COOK     66 PRL  17  223       V COOK,EWART,MASEK,ORR,PLATNER (WASHINGTON)

BAGGETT  67 PRL 19 1458        BAGGETT,DAY,GLASSER,KEHOE,KNOP+  (MARYLAND)
    ALSO 68 VIENNA ABS. 374    BAGGETT,KEHOE                    (MARYLAND)
    ALSO 68 PRIVATE COMM.      N. BAGGETT                       (MARYLAND)

BARASH   67 PRL 19  181        BARASH,DAY,GLASSER,KEHOE,KNOP +  (MARYLAND)
EISELE   67 ZPHYS 205 409      +ENGELMANN,FILTHUTH,FOLISH,HEPP+     (HEID)
HYMAN    67 PL 25 B 376        +LOKEN,PEWITT,MCKENZIE,+    (ANL+CARN+NWES)
KOTELCHU 67 PRL 18 1166        KOTELCHUCK,GOZA,SULLIVAN,ROSS  (VANDERBILT)
SULLIVAN 67 PRL 18 1163        SULLIVAN,MCINTURFF,KOTELCHUCH  (VANDERBILT)
    ALSO 64 PRL 13 246         A D MCINTURFF,C E ROOS         (VANDERBILT)

BIERMAN  68 PRL 20 1459        BIERMAN,KOUNOSU,NAUENBERG +     (PRINCETON)
COMBE    68 NC 57A 54          CERN-BRISTOL-LAUSANNE-MUNICH-ROME-COLLABOR
MAST     68 PRL 20 1312        MAST,GERSHWIN,ALSTON-GARNJOST +       (LRL)

ANG      69 ZPHYS 228 151      +EBENHOH,EISELE,ENGELMANN,FILTHUTH+  (HEID)
BAGGETT  69 MDDP-TR-973        N V BAGGETT (THESIS)                  (UMD)
BALTAY   69 PRL 22 615         BALTAY,FRANZINI,NEWMAN,NORTON+  (COLU,STON)
BANGERTE 69 UCRL-19244         ROGER ODELL BANGERTER (THESIS)        (LRL)
BANGERT1 69 PR 187 1821        BANGERTER,GARNJOST,GALTIERI,GERSHWIN+ (LRL)

BARLOUTA 69 NP B14 153         BARLOUTAUD,BELLEFON,GRANET+(SACL+CERN+HEID)
EISELE1  69 ZPHYS 221 1        +ENGELMANN,FILTHUTH,FOHLISCH,HEPP+   (HEID)
EISELE2  69 ZPHYS 221 401      +ENGELMANN,FILTHUTH,FOHLISCH,HEPP+   (HEID)
GERSHWIN 69 PR 188 2077        +ALSTON-GARNJOST,BANGERTER +          (LRL)
    ALSO    UCRL 19246 THESIS  LAWRENCE K GERSHWIN                   (LRL)
NORTON   69 NEVIS 175 (THESIS) HERBERT NORTON                  (COLUMBIA)

BERLEY   70 PR D1 2015         +YAMIN,HERTZBACH,KOFLER +   (BNL,MASA,YALE)
EISELE   70 ZPHY 238 372       +FILTHUTH,HEPP,PRESSER,ZECH   (HEIDELBERG)
HARRIS   70 PRL 24 165         +OVERSETH,PONDROM,DETTMANN      (MICH,WISC)

ALLEY    71 PR  D3  75         +BENBROOK,COOK,GLASS,GREEN,HAGUE +   (WASH)
BAKKER   71 LNC 1 37           +,SABRE COLLAB.  (ZEEM+SACL+BGNA+REHO+EPOL)
COLE     71 PR D4 631          +LEE-FRANZINI,LOVELESS,BALTAY+  (STON,COLU)
TOVEE    71 NP B33 493         LOUC,BELGRADE,BERL,BRUX,DUBLIN,WARS COLLAB
BELLAMY  72 PL 39B 299         +ANDERSON,CRAWFORD,OSMON+  (LOWC+RHEL+SUSS)
BOHM     72 NP B48 1           BERLIN+BELGRADE+BRUX+DUBLIN+LOUC+WARSAW
    ALSO 73 IIHE-73.2 NOV      BRUSSELS BULLETIN, SAME COLLABORATION

EBENHOH  73 ZPHY 264 413       +EISELE,FILTHUTH,HEPP,LEITNER,THOUW+ (HEID)
LIPMAN   73 PL 43B 89          +UTO,WALKER,MONTGOMERY+    (RHEL+SUSS+LOWC)
SAHA     73 PR D7 3295         +FETKOVICH,HEINTZELMAN,MELTZER +     (CARN)
SECHIZOR 73 PR D8 12           B.SECHI-ZORN,G.SNOW                   (UMD)

EBENHOH  74 ZPHY 266 367       +EISELE,ENGELMANN,FILTHUTH,HEPP +    (HEID)
CONFORTO 76 NP B105 189        +GOPAL,KALMUS,LITCHFIELD,ROSS + (RHEL+LOIC)
DOBLE    77 PL 67B 483         +GOTTSTEIN,HANSL,HERYNEK+  (MPIM+BOHR+VAND)
REUCROFT 77 PR D15 5           +ROOS,WATERS,WEBSTER,HANSL +    (VAND+MPIM)
NOWAK    78 NP B139 61         +ARMSTRONG,DAVIS+     (LOUC+BELG+DURH+WARS)

SETTLES  79 PR D20 2154        +MANZ,MATT,HANSL,HERYNEK,DOBLE+ (MPIM+VAND)
MANZ     80 PL 96B 217         +REUCROFT,SETTLES,WOLF +        (MPIM+VAND)
MARRAFFI 80 PR D21 2501        MARRAFFINO,REUCROFT,ROOS,WATERS+(VAND+MPIM)
ANKENBRA 83 PRL 51 863         ANKENBRANDT,BERGE+     (FNAL+IOWA+ISU+YALE)

                               PAPERS NOT REFERRED TO IN DATA CARDS

GLASER   58 CERN CONF 270      GLASER,GOOD,MORRISON             (MICH+LRL)

         QUANTUM NUMBER DETERMINATIONS NOT REFERRED TO IN THE DATA CARDS

TRIPP    62 PRL 8 175          R TRIPP,M WATSON,M FERRO-LUZZI        (LRL) P
ALFF     63 SIENA CONF 1 205   ALFF,NAUENBERG,KIRSCH,+    (COLU+RUTG+BNL)
    ALSO 65 PR 137 B 1105      ALFF,GELFAND,BRUGGER,BERLEY+(COLU+RUTG+BNL)
COURANT  63 SIENA CONF 1 73    COURANT,FILTHUTH,BURNSTEIN,DAY+  (CERN+UMD)
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20 SIGMA-(1197,JP=1/2+) I=1

20 SIGMA- MASS (MEV)

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M   N   SEE NOTE PRECEDING LAMBDA MASS LISTINGS

M     3000 1197.43     0.08          SCHMIDT   65 HBC  SEE NOTE N          3/74
M          1197.24     0.15          DUGAN     75 CNTR    EXOTIC ATOMS     12/79
M          . . . . . . . . . .
M   AVG    1197.388    0.079   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.1)
M   FIT    1197.34     0.05    FROM FIT                                    3/84*
```

20 (SIGMA-) - (SIGMA+) MASS DIFFERENCE (MEV)

```
D       87    8.25     0.40          BARKAS    63 EMUL
D     2500    8.25     0.25          DOSCH     65 HBC
D       86    7.91     0.23          BOHM      72 EMUL                     1/73
D          . . . . . . . . . .
D   AVG        8.09     0.16    AVERAGE
D   FIT        7.97     0.07    FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.3)  3/84*
```

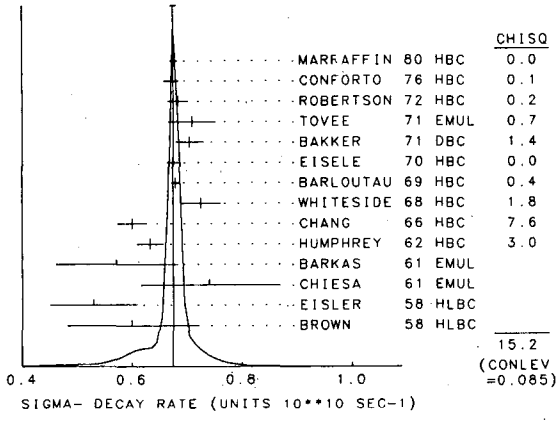
20 (SIGMA-) - (LAMBDA) MASS DIFFERENCE (MEV)

```
DL  N   SEE NOTE PRECEDING LAMBDA MASS LISTINGS.
DL         81.70     0.19          BURNSTEIN 64 HBC                        9/66
DL     85  81.80     0.13          SCHMIDT   65 HBC  SEE NOTE N            3/74
DL   2279  81.64     0.09          HEPP      68 HBC                        8/68
DL         . . . . . . . . . .
DL  AVG    81.693    0.069   AVERAGE
DL  FIT    81.740    0.052   FROM FIT                                      3/84*
```

20 SIGMA- MEAN LIFE (UNITS 10**-10 SEC)

```
T            1.67     0.40     0.28  BROWN     58 HLBC
T            1.89     0.33     0.25  EISLER    58 HLBC
T      45    1.35     0.32     0.17  CHIESA    61 EMUL
T      41    1.75     0.39     0.30  BARKAS    61 EMUL
T    1208    1.58     0.06     0.06  HUMPHREY  62 HBC     STOP. K-
T  C 3267    1.666    0.075          CHANG     66 HBC     STOP. K-          6/66
T  S   61   (2.08)   (0.22)          CHIEN     66 HBC  -   6.9 PBAR P        9/67
T  S   64   (1.46)   (0.31)          CHIEN     66 HBC  +   6.9 PBAR P,ANTI   9/67
T     506    1.38     0.07           WHITESIDE 68 HBC     STOP. K-          6/68
T   10253    1.472    0.016          BARLOUTAU 69 HBC     K-P .4-1.2 GEV/C 11/69
T    0.1M    1.485    0.022          EISELE    70 HBC     K-P AT REST       2/71
T    1383    1.42     0.05           BAKKER    71 DBC     K-N TO SIG- 2PI  10/71
T            1.41     0.09     0.08  TOVEE     71 EMUL                     12/71
T    2400    1.463    0.039          ROBERTSON 72 HBC     K-P .25 GEV/C     3/74
T    8437    1.49     0.03           CONFORTO  76 HBC     K-P 1-1.4 GEV/C  11/77
T     16K    1.480    0.014          MARRAFFIN 80 HBC     K- P TO SIG- PI+  2/80
T  C   CHANG ERROR 0.018 RAISED BY US.  SEE 1970 EDITION, RMP 42,123(1970)  1/73
T  S   ERROR PURELY STATISTICAL.
T          . . . . . . . . . .
T  AVG       1.482    0.011    0.011  AVERAGE (ERROR INCL. SCALE FACTOR OF 1.3)
                      (SEE IDEOGRAM BELOW)
```

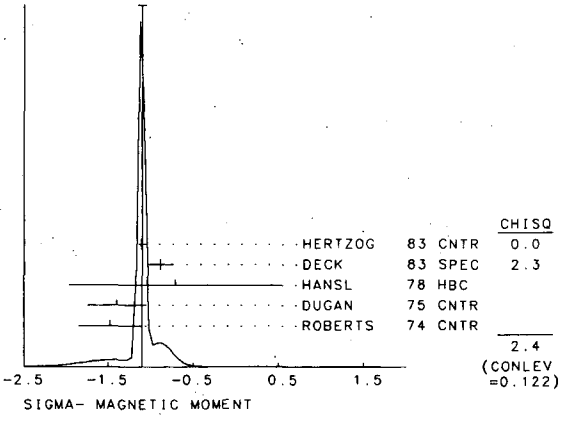
WEIGHTED AVERAGE = 0.6747 ± 0.0050
ERROR SCALED BY 1.3



20 SIGMA- MAGNETIC MOMENT (MAGNETONS,938.26 MEV)

```
MM  R      BTWN -1.6 AND +0.8          FOX       73 CNTR   SIG-ATOM FINE ST  3/74
MM  R        -1.48     0.37            ROBERTS   74 CNTR   SIG-ATOM FINE ST 12/75
MM  D        -1.40     0.41     0.28   DUGAN     75 CNTR   SIG-ATOM FINE ST 12/79
MM  D        (0.65)   (0.28)   (0.40)  DUGAN     75 CNTR   SIG-ATOM FINE ST 12/79
MM     28K   -0.71     1.25            HANSL     78 HBC    K-P-->SIG- PI+    7/79
MM    516K   -0.89     0.14            DECK      83 SPEC   P BE-->SIGMA- X  11/83*
MM           -1.111    0.033           HERTZOG   83 CNTR   SIG-ATOM FINE ST 10/83*
MM  R  ROBERTS 74 INCLUDES DATA FROM FOX 73.                                12/75
MM  D  DUGAN 75 NEGATIVE VALUE AVERAGED SINCE IT AGREES WITH ROBERTS 74.    12/79
MM         . . . . . . . . . .
MM  AVG      -1.104    0.049   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.5)
                      (SEE IDEOGRAM BELOW)
```

WEIGHTED AVERAGE = -1.104 ± 0.049
ERROR SCALED BY 1.5



20 SIGMA- PARTIAL DECAY MODES

```
                                                   DECAY MASSES
P1     SIGMA- INTO NEUTRON PI-                    940+ 140
P2     SIGMA- INTO NEUTRON PI- GAMMA              940+ 140+   0
P3     SIGMA- INTO NEUTRON MU- NEUTRINO           940+ 106+   0
P4     SIGMA- INTO NEUTRON E- NEUTRINO            940+.511+   0
P5     SIGMA- INTO LAMBDA E- NEUTRINO            1116+.511+   0
```

Stable Particles

Σ^-

Data Card Listings

```
                    20  SIGMA- BRANCHING RATIOS

R1     SIGMA- INTO (N MU- NEU)/(N PI-) (UNITS 10**-3)    (P3)/(P1)
R1      22    0.66     0.15            COURANT    64 HBC
R1      11    0.56     0.20            BAZIN      65 HBC      FROM STOP. K-     6/66
R1      56    0.43     0.09            BAGGETT    69 HBC      STOP. K-         10/69
R1      72    0.43     0.06            ANG 1      69 HBC      STOP K-          10/69
R1      13    0.38     0.11            COLE       71 HBC      STOP K-          10/71
R1          . . . . . . . . .
R1  AVG       0.447    0.043   AVERAGE

R2     SIGMA- INTO (N E- NEU)/(N PI-) (UNITS 10**-3)    (P4)/(P1)
R2       9   (1.0)    (0.4)     (0.3)  MURPHY     64 HLBC
R2      16   (1.37)   (0.34)           NAUENBERG  64 HBC
R2      16   (1.15)   (0.4)            MILLER     64 FBC
R2      31   (1.4)    (0.3)            COURANT    64 HBC
R2     180    1.11     0.09            BIERMAN    68 HBC                          6/68
R2     331   (1.02)   (0.08)           ANG 1      69 HBC  REPL. BY EBENHOH 74 10/69
R2      57    0.97     0.15            COLE       71 HBC      STOP K-          10/71
R2   A 455    1.05     0.07     0.13   SECHIZORN  73 HBC      STOP K-           8/73
R2   A 601    1.09     0.06     0.08   EBENHOH    74 HBC      STOP K-           1/76
R2    2847    0.96     0.05            BOURQUI1   83 SPEC SPS HYPERON BEAM     2/84*
R2   A  ADDITIONAL NEGATIVE SYSTEMATIC ERROR INCLUDED FOR INTERNAL              2/84*
R2   A  RADIATIVE CORRECTIONS AND LATEST FORM FACTORS.  SEE BOURQUIN1 83.       2/84*
R2          . . . . . . . . .
R2  AVG       1.022    0.034   AVERAGE

R3     SIGMA- INTO (LAMBDA E- NEU)/(N PI-) (UNITS 10**-4)
R3                                                       (P5)/(P1)
R3      11    0.75     0.28            COURANT    64 HBC      STOP. K-
R3      35    0.64     0.12            BARASH     67 HBC      STOP K-           8/67
R3      31    0.69     0.12            EISELE1    69 HBC      STOP K-          10/69
R3      31    0.52     0.09            BALTAY     69 HBC      STOP K-           4/69
R3   H  122   (0.60)   (0.11)           HERBERT    78 ASPK     HYPERON BEAM      6/78
R3   H 114    0.63     0.11            THOMPSON   80 ASPK     HYPERON BEAM      9/81
R3 B  1620    0.561    0.031           BOURQUIN   82 SPEC     SPS HYPERON BEAM 11/83*
R3  H   HERBERT 78 REPLACED BY THOMPSON 80.
R3 B    VALUE IS FROM BOURQUIN2 83. INCLUDES RAD. CORR. AND NEW ACCEPTANCE. 11/83*
R3          . . . . . . . . .
R3  AVG       0.574    0.027   AVERAGE

R4     SIGMA- INTO (N PI- GAMMA)/(N PI-) (UNITS 10**-3) (P2)/(P1)
R4           (1.1)APPROXIM.               BAZIN      65 HBC      PI- LT 166 MEV/C  8/67
R4      23   (0.10)   (0.02)             ANG 2      69 HBC      PI- LT 110 MEV/C 10/69
R4     292    0.46     0.06             EBENHOH    73 HBC      PI+ LT 150 MEV/C  3/74
R4      PI+ MOMENTUM CUTS DIFFER, NOT AVERAGED. LATEST VALUE USED IN TABLE.      4/82

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                    20  SIGMA- DECAY PARAMETERS

        SEE NOTE ON BARYON DECAY PARAMETERS IN NEUTRON SECTION ABOVE.

A-     ALPHA SIGMA-
A-          (-0.16)  (0.21)           TRIPP      62 HBC      REPL.BY BANGERTE
A-  O 6500  (-0.010) (0.043)          BANGERTER  66 HBC      K-P TO SIG- PI+   7/66
A-  O 6068  (-0.104) (0.04)           BERLEY     67 HBC      K-P TO SIG- PI+  11/67
A-   51000   -0.071   0.012           BANGERTER  69 HBC                      10/69
A-  B 5978  (-0.134) (0.034)          BERLEY     70 HBC      K-P AT 400 MEV/C  2/71
A-   60000   -0.067   0.011           BOGERT     70 HBC      K-P AT 400 MEV/C 12/70
A-     28K   -0.062   0.024           HANSL      78 HBC      K-P-->SIG- PI+    7/79
A-  O   OLD RESULTS.  HAVE BEEN REPLACED.
A-  B   BERLEY 70 REPLACED BY BOGERT 70                                        2/71
A-          . . . . . . . . .
A-  AVG     -0.0681   0.0077  AVERAGE

F-     PHI ANGLE (SIN(PHI)/COS(PHI)=BETA/GAMMA)  (DEGREES)
F-  O 1006 (+22.)    (30.)            BERLEY     67 HBC      K-P TO SIG- PI+  11/67
F-    1385   14.      19.             BANGERT1   69 HBC                      10/69
F-   C1092  + 5.      23.             BERLEY     70 HBC      NEUTRON RESCATT. 11/69
F-  C   CHANGED FROM -5 TO +5 TO AGREE WITH SIGN CONVENTION
F-          . . . . . . . . .
F-  AVG      10.3     14.6    AVERAGE
```

NOTE ON $\Sigma^- \to \Lambda e^- \nu$

(by J.A. Thompson, University of Pittsburgh)

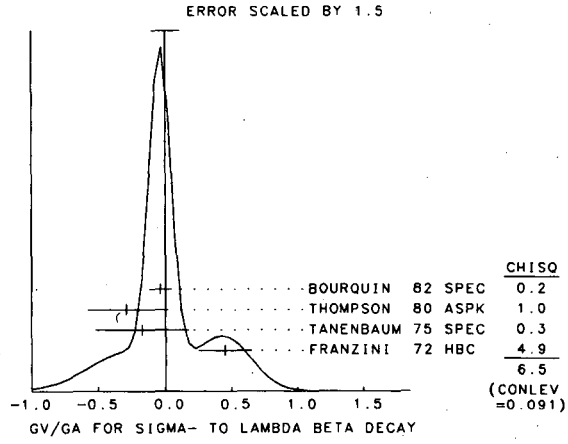
The decay $\Sigma^- \to \Lambda e^- \nu$ is of special interest because its form is predicted by the strong form of CVC and is not sensitive to the current octet assumptions or SU(3) structure constants which enter into Cabibbo's predictions for the other hyperon decays. For $\Delta S = 0$ transitions, the weak interaction vector current is related to the electromagnetic current through a multiplicative constant, set by neutron beta decay, and an isospin rotation.

The decay $\Sigma^0 \to \Lambda\gamma$ (the isospin-rotation analogue of $\Sigma^- \to \Lambda e^- \nu$) is mediated predominantly through the magnetic interaction, assuming there are no inhomogeneities in the Σ^0, Λ charge distributions. Thus we expect the g_{WM} term,

$$g_{WM} \sim \frac{\mu_{\Sigma\Lambda}}{\sqrt{2}} \sim -\frac{\sqrt{3}}{2}\mu_n \text{ [by SU(3)]},$$

to dominate the vector part of the weak current. The strong CVC predictions are thus: $g_V/g_A = 0$ and $g_{WM} \sim 1.6$.

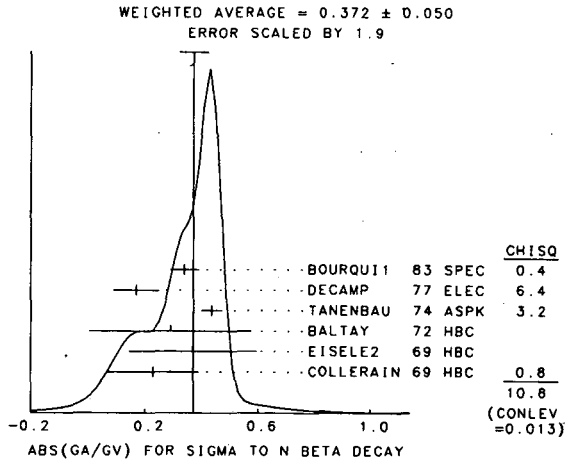
```
AV     GV/GA FOR SIGMA TO LAMBDA BETA DECAY
AV      (FOR SIGN CONVENTION, SEE NOTE ON BARYON DECAY PARAMETERS IN
AV      NEUTRON SECTION ABOVE.)
AV      PREDICTED TO BE ZERO BY CONSERVED VECTOR CURRENT THEORY.
AV      VALUES AVERAGED ASSUME CVC-SU3 WEAK MAGNETISM TERM.
AV  FB  45   (0.31)   (0.30)          BARASH     67 HBC                        11/67
AV  FS  51   (0.7)    (0.4)           BALTAY     69 HBC      USING SIG+-        4/69
AV  FS  81  (+0.22)   (0.28)           EISELE1    69 HBC                        10/68
AV F S 186    0.45     0.20            FRANZINI   72 HBC      USING SIG+-        1/73
AV      55   -0.17     0.35            TANENBAUM  75 SPEC     BNL HYPERON BEAM 12/75
AV     114   -0.29     0.29            THOMPSON   80 ASPK     BNL HYPERON BEAM  1/82
AV S  1620   -0.034    0.080           BOURQUIN   82 SPEC     SPS HYPERON BEAM 11/82*
AV   B  BARASH 67 MEASURED ABSOLUTE VALUE.
AV   S  SIGN CHANGED TO AGREE WITH OUR CONVENTION.
AV F    FRANZINI 72 INCLUDES EVENTS OF BARASH 67, EISELE1 69, BALTAY 69.       1/73
AV          . . . . . . . . .
AV  AVG       0.01     0.10    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.5)
                               (SEE IDEOGRAM BELOW)
```




```
WM     GWM/GA FOR SIGMA TO LAMBDA BETA DECAY
WM      VALUES QUOTED ASSUME THE CVC PREDICTION GV=0.
WM     186    2.4      2.1             FRANZINI   72 HBC      USING SIG+-        1/82
WM      55    3.5      4.5             TANENBAUM  75 SPEC     BNL HYPERON BEAM   1/82
WM     114    1.75     3.5             THOMPSON   80 ASPK     BNL HYPERON BEAM   1/82
WM          . . . . . . . . .
WM  AVG       2.4      1.7     AVERAGE

AV1    GA/GV FOR SIGMA TO NEUTRON BETA DECAY
AV1     (FOR SIGN CONVENTION, SEE NOTE ON BARYON DECAY PARAMETERS IN
AV1     NEUTRON SECTION ABOVE.)
AV1     57   (0.05)   (0.23)   (0.32) GERSHWIN   68 HBC  REPLACED BY GER.69   6/68
AV1     61   +0.19     0.20     0.17  GERSHWIN   69 HBC  POLARIZED SIGMAS     10/69
AV1     63   -0.33     0.30     0.85  BOGERT     70 HBC  K-P AT 400 MEV/C     10/70
AV1     43   -0.4      0.52     1.5   ELLIS      72 ASPK     POLARIZED SIGMAS 10/71
AV1  S 193    0.15  OR LESS  CL=.95   KELLER     82 SPEC     POLARIZED SIGMAS 11/82*
AV1  S4456   +.33 PREF. BY 2.6STD.DEV BOURQUI1    83 SPEC SPS HYPERON BEAM      2/84*
AV1  S  SIGN CHANGED TO AGREE WITH OUR CONVENTION.                             11/82*

AV2    ABSOLUTE VALUE OF GA/GV FOR SIGMA TO NEUTRON BETA DECAY
AV2     49    0.23     0.16            COLLERAIN  69 HBC      NEUTRON SCATTER  10/69
AV2     33    0.37     0.26     0.19   EISELE2    69 HBC      NEUTRON SCATTER  10/69
AV2     36    0.29     0.28     0.29   BALTAY     72 HBC      NEUTRON SCATTER   6/72
AV2   3507    0.435    0.035           TANENBAU   74 ASPK                      10/74
AV2    519    0.17     0.07     0.09   DECAMP     77 ELEC     H.E.HYPERON BEAM 11/77
AV2   4456    0.34     0.05            BOURQUI1   83 SPEC SPS HYPERON BEAM      2/84*
AV2         . . . . . . . . .
AV2 AVG       0.372    0.050   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.9)
                               (SEE IDEOGRAM BELOW)
```



For notation, see key at front of Listings.

Stable Particles
Σ^-, Σ^0, Ξ^-

REFERENCES FOR SIGMA-

BROWN 58 CERN CONF 270 — BROWN,GLASER,GRAVES,PERL,CRONIN + (MICH)
EISLER 58 NC SER10 10 150 — EISLER,BASSI,CONVERSI+ (COLU,BNL,BGNA,PISA)

BARKAS 61 PR 124 1209 — BARKAS,DYER,MASON,NICKOLS,SMITH (LRL)
CHIESA 61 NC 19 1171 — A M CHIESA,B QUASSIATI,G RINAUDO (TURIN)
HUMPHREY 62 PR 127 1305 — W E HUMPHREY,R R ROSS (LRL)
TRIPP 62 PRL 9 66 — R D TRIPP,M WATSON,M FERRO-LUZZI (LRL)

BARKAS 63 PRL 11 26 — W H BARKAS,J N DYER,H H HECKMAN (LRL)
BURNSTEI 64 PRL 13 66 — BURNSTEIN,DAY,KEHOE,SECHI ZORN,SNOW (UMD)
COURANT 64 PR 136 B 1791 — COURANT,FILTHUTH+ (CERN+HEID+UMD+NRL+BNL)
MILLER 64 PL 11 262 — MILLER,STANNARD,BEZAGUET+ (LOUC,EPOL+BERG)
MURPHY 64 PR 134 B 188 — C THORNTON MURPHY (WISCONSIN)
NAUENBER 64 PRL 12 679 — NAUENBERG,SCHMIDT,MARATECK+(COLU+RUTG+PRIN)

BAZIN 65 PR 140 B 1358 — BAZIN,PLANO,SCHMIDT + (PRIN+RUTG+COLU)
DOSCH 65 PL 14 239 — DOSCH,ENGELMANN,FILTHUTH,HEPP,KLUGE+ (HEID)
ALSO 66 PR 151 1081 — CHUNG YUN CHANG (COLUMBIA)
SCHMIDT 65 PR 140 B 1328 — P SCHMIDT (COLUMBIA)
BANGERTE 66 PRL 17 495 — BANGERTER,GALTIERI,BERGE,MURRAY+ (LRL)
CHANG 66 PR 151 1081 — CHUNG YUN CHANG (COLUMBIA)
CHIEN 66 PR 152 1171 — +LACH,SANDWEISS,TAFT,YEH,OREN + (YALE+BNL)

BARASH 67 PRL 19 181 — BARASH,DAY,GLASSER,KEHOE,KNOP + (MARYLAND)
BERLEY 67 PRL 19 979 — BERLEY,HERTZBACH,KOFLER + (BNL,MASA,YALE)
BIERMAN 68 PRL 20 1459 — BIERMAN,KOUNOSU,NAUENBERG + (PRINCETON)
GERSHWIN 68 PRL 20 1270 — GERSHWIN,ALSTON-GARNJOST,BANGERTER+ (LRL)
HEPP 68 ZPHY 214 71 — V.HEPP,H. SCHLEICH (HEIDELBERG)
WHITESID 68 NC 54A 537 — H. WHITESIDE,J. GOLLUB (OBERLIN)

ANG 1 69 ZPHY 223 103 — ANG,EISELE,ENGELMANN,FILTHUTH + (HEID)
ANG 2 69 ZPHY 228 151 — +EBENHOR,EISELE,ENGELMANN,FILTHUTH+ (HEID)
BAGGETT 69 PRL 23 249 — BAGGETT,KEHOE,SNOW (UNIV MARYLAND)
BALTAY 69 PRL 22 615 — BALTAY,FRANZINI,NEWMAN,NORTON+ (COLU,STON)
BANGERTE 69 UCRL-19244 — ROGER ODELL BANGERTER (THESIS) (LRL)
BANGERT1 69 PR 187 1821 — BANGERTER,GARNJOST,GALTIERI,GERSHWIN+ (LRL)

BARLOUTA 69 NP B14 153 — BARLOUTAUD,BELLEFON,GRANET+(SACL+CERN+HEID)
COLLERAI 69 PRL 23 198 — COLLERAINE,DAY,GLASSER,KNOP+(UNIV MARYLAND)
EISELE1 69 ZPHY 221 1 — +ENGELMANN,FILTHUTH,FOHLISCH,HEPP+ (HEID)
EISELE2 69 ZPHY 223 487 — EISELE,ENGELMANN,FILTHUTH,FOHLISCH+ (HEID)
GERSHWIN 69 UCRL-19246 — LAWRENCE KENNETH GERSHWIN (THESIS) (LRL)

BERLEY 70 PR D1 2015 — +YAMIN,HERTZBACH,KOFLER + (BNL,MASA,YALE)
BOGERT 70 PR D2 6 — +LUCAS,TAFT,WILLIS,BERLEY + (BNL,MASA,YALE)
EISELE 70 ZPHY 238 372 — +FILTHUTH,HEPP,PRESSER,ZECH (HEIDELBERG)

BAKKER 71 LNC 1 37 — +,SABRE COLLAB. (ZEEM+SACL+BGNA+REHO+EPOL)
COLE 71 PR D4 631 — +LEE-FRANZINI,LOVELESS,BALTAY+ (STON,COLU)
ALSO 69 NEVIS-175 THESIS — HERBERT NORTON (COLUMBIA)
TOVEE 71 NP B33 493 — LOUC,BELGRADE,BERL,BRUX,DUBLIN,WARS COLLAB

BALTAY 72 PR D5 1569 — +FEINMAN,FRANZINI,NEWMAN,YEH+ (COLU+STON)
BOHM 72 NP B48 1 — BERLIN+BELGRADE+BRUX+DUBLIN+LOUC+WARSAW
ELLIS 72 NP B39 77 — OXF+AERE+RHEL+LOQM+LYON+NWES+ITEP COLLABOR
FRANZINI 72 PR D6 2417 — COLUMBIA+HEIDELBERG+MARYLAND+STONY BROOK
ROBERTSO 72 THESIS — R.M.ROBERTSON (IIT)

EBENHOH 73 ZPHY 264 413 — +EISELE,FILTHUTH,HEPP,LEITNER,THOUW+ (HEID)
FOX 73 PRL 31 1084 — +LAM,BARNES,EISENSTEIN+ (BNL+VPI+WILL+WYOM)
SECHIZOR 73 PR D8 12 — B.SECHI-ZORN,G.SNOW (UMD)

EBENHOH 74 ZPHY 266 367 — +EISELE,ENGELMANN,FILTHUTH,HEPP + (HEID)
ROBERTS 74 PRL 32 1265 — WILL+VPI+CARN+WYOM+CIT COLLABORATION
ALSO 74 PRL 33 122 — ERRATUM TO ROBERTS 74
ALSO 75 PR D12 1232 — ROBERTS,COX + (WILL+VPI+CARN+WYOM+CIT+BNL)
TANENBAU 74 PRL 33 175 — TANENBAUM,HUNGERBUEHLER + (YALE+FNAL+BNL)
ALSO 75 TANENBAUM

DUGAN 75 NP A254 396 — +ASANO,CHEN,CHENG,HU,LIDOFSKY+ (COLU+YALE)
TANENBAU 75 PR D12 1871 — TANENBAUM,HUNGERBUEHLER + (YALE+FNAL+BNL)
CONFORTO 76 NP B105 189 — +GOPAL,KALMUS,LITCHFIELD,ROSS + (RHEL+LOIC)
DECAMP 77 PL 66B 295 — +BADIER,BLAND,CHOLLET,GAILLARD+ (LALO+EPOL)

HANSL 78 NP B132 45 — +MANZ,MATT,REUCROFT,SETTLES + (MPIM+VAND)
HERBERT 78 PRL 40 1230 — +CLELAND,COOPER,DRIS,ENGELS + (PITT+BNL)
MARRAFFI 80 PR D21 2501 — MARRAFFINO,REUCROFT,ROOS,WATERS+(VAND+MPIM)
THOMPSON 80 PR D21 25 — +CLELAND,COOPER,DRIS,ENGELS+ (PITT+BNL)

BOURQUIN 82 ZPHY C12 307 — +BROWN + (BRIS+GEVA+HEID+LALO+RL+STRB)
ALSO 83 BOURQUI2
KELLER 82 PRL 48 971 — +LESNIK,ROMANOWSKI,KEIG + (OSU+CHIC+ANL)
BOURQUI1 83 ZPHY C21 17 — BOURQUIN+ (BRIS+GEVA+HEID+LALO+RL+STRB)
BOURQUI2 83 ZPHY C21 27 — BOURQUIN+ (BRIS+GEVA+HEID+LALO+RL+STRB)
DECK 83 PR D28 1 — +BERETVAS,DEVLIN,LUK+ (RUTG+WISC+MICH+MINN)
HERTZOG 83 PRL 51 1131 — +ECKHAUSE+ (WILL+BOST+CIT+CARN+WYOM)

PAPERS NOT REFERRED TO IN DATA CARDS

BROWN 57 PR 108 1036 — J BROWN, D GLASER, M PERL (MICH+BNL)
NIETO 68 RMP 40 140 — M NIETO (STON)

Σ^0

21 SIGMA0(1193,JP=1/2+) I=1

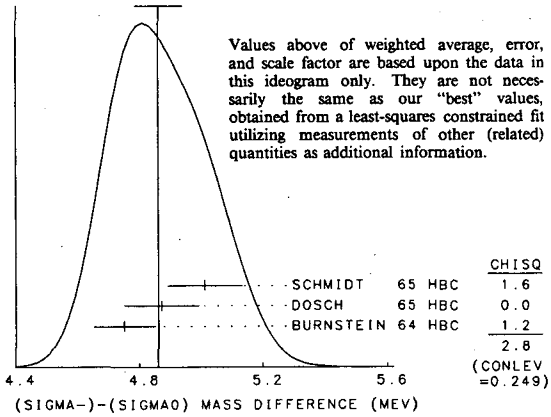
JP NOT MEASURED FOR SIGMA0. ASSUMED SAME AS SIGMA+ AND SIGMA- TO ALLOW ISOTRIPLET ASSOCIATION.

21 (SIGMA-) - (SIGMA0) MASS DIFFERENCE (MEV)

D1 N SEE NOTE PRECEDING LAMBDA MASS LISTINGS.

D1		18	4.75	0.1	BURNSTEIN	64 HBC		
D1		37	4.87	0.12	DOSCH	65 HBC		
D1		12	5.01	0.12	SCHMIDT	65 HBC	SEE NOTE N	3/74
D1			. . . .					
D1	AVG		4.860	0.076	AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.2)			
D1	FIT		4.881	0.063	FROM FIT (SEE IDEOGRAM BELOW)			3/84*

WEIGHTED AVERAGE = 4.860 ± 0.076
ERROR SCALED BY 1.2



Values above of weighted average, error, and scale factor are based upon the data in this ideogram only. They are not necessarily the same as our "best" values, obtained from a least-squares constrained fit utilizing measurements of other (related) quantities as additional information.

21 (SIGMA0) - (LAMBDA) MASS DIFFERENCE (MEV)

DL N SEE NOTE PRECEDING LAMBDA MASS LISTINGS.

DL		208	76.63	0.28	SCHMIDT	65 HBC	SEE NOTE N	6/68
DL		109	76.23	0.55	COLAS	75 HLBC	LAMBDA-GAMMA DEC	12/75
DL			. . . .					
DL	AVG		76.55	0.25	AVERAGE			
DL	FIT		76.86	0.08	FROM FIT			3/84*

21 SIGMA0 MEAN LIFE (UNITS 10-19 SEC)**

T	(E-14 OR LESS)		DAVIS	62 EMUL		6/77
T	0.58	0.13	DYDAK	77 SPEC	PRIMAKOFF EFFECT	6/77

21 SIGMA0 PARTIAL DECAY MODES

		DECAY MASSES
P1	SIGMA0 INTO LAMBDA GAMMA	1116+ 0
P2	SIGMA0 INTO LAMBDA E+ E-	1116+.511+.511
P3	SIGMA0 INTO LAMBDA GAMMA GAMMA	1116+ 0+ 0

21 SIGMA0 BRANCHING RATIOS

R1 SIGMA0 INTO(LAMBDA E+ E-)/TOTAL (P2)/(P1+P2)
R1 0.00545 THEORET. CAL. FEINBERG 58 QUANTUM ELECT. 9/66

R2 SIGMA0 INTO (LAMBDA GAMMA GAMMA)/(LAMBDA GAMMA) (P3)/(P1) 12/75
R2 0.03 OR LESS CL=.90 COLAS 75 HLBC 12/75

REFERENCES FOR SIGMA0

FEINBERG 58 PR 109 1019 — G.FEINBERG (BNL)
DAVIS 62 PR 127 605 — D DAVIS,R SETTI,M RAYMOND,G TOMASIN (EFI)
BURNSTEI 64 PRL 13 66 — BURNSTEIN,DAY,KEHOE,SECHI ZORN,SNOW (UMD)
DOSCH 65 PL 14 239 — DOSCH,ENGELMANN,FILTHUTH,HEPP,KLUGE+ (HEID)
SCHMIDT 65 PR 140 B 1328 — P SCHMIDT (COLUMBIA)

COLAS 75 NP B91 253 — +FARWELL,FERRER,SIX (ORSA)
DYDAK 77 NP B118 1 — +NAVARRIA,OVERSETH,STEFFEN+(CERN+DORT+HEID)

PAPERS NOT REFERRED TO IN DATA CARDS

COURANT 63 PRL 10 409 — COURANT,FILTHUTH,FRANZINI+ (CERN+UMD+NRL)

QUANTUM NUMBER DETERMINATIONS NOT REFERRED TO IN THE DATA CARDS

ALFF 65 PR 137 B1105 — ALFF,GELFAND,NAUENBERG+ (COLUMBIA+RUTG+BNL)P

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22 XI-(1321,JP=1/2) I=1/2

22 XI- MASS (MEV)

M	H	11	(1317.0)	(2.2)	WANG	61 HLBC		
M	H	18	(1317.9)	(1.9)	FOWLER	61 HLBC		
M	H	(OLD DATA AND LOW STATISTICS DROPPED ON SUGGESTION OF J R HUBBARD)						
M		517	1321.4	0.4	JAUNEAU	63 FBC		
M		62	1321.1	0.65	SCHNEIDER	63 HBC		
M		241	1321.1	0.3	BADIER1	64 HBC		
M		ALL MASSES ABOVE WERE RAISED 0.09 MEV BECAUSE LAMBDA MASS RAISED						
M		149	1321.3	0.4	PJERROU	65 HBC		11/67
M		6	1321.67	0.52	CHIEN	66 HBC	- 6.9 PBAR P	9/67
M		299	1321.4	1.1	LONDON	66 HBC		6/66
M	G	195	1321.87	0.51	GOLDWASSE	70 HBC	5.5 K-P	8/70
M	G	USES LAMBDA MASS OF 1115.58-M(XI) IS 1322.18 IF M(LAMBDA)=1115.84						8/70
M		268	1321.12	0.41	WILQUET	72 HLBC		1/73
M		632	1321.46	0.34	DIBIANCA	75 DBC	4.9 GEV/C K-D	1/77
M			. . . .					
M	AVG		1321.34	0.14	AVERAGE			
M	FIT		1321.32	0.13	FROM FIT			3/84*

THE FIT ASSUMES XI AND ANTI-XI MASSES EQUAL.

Stable Particles

Data Card Listings

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                    22  ANTI-XI+ MASS (MEV)

M1        1(1322.0)     (1.3)              BROWN      62 HBC     ANTI-XI-            7/66
M1        5 1320.69      0.93              CHIEN      66 HBC  +   6.9 PBAR P,ANTI    9/67
M1   S   12(1321.7)     (0.6)              SHEN       67 HBC     ANTI-XI-           10/67
M1       34 1321.2       0.4               STONE      70 HBC                        10/70
M1       35 1321.6       0.8               VOTRUBA    72 HBC      10 GEV/C K+ P     11/72
M1   S   THE ERROR IS STATISTICAL ONLY
M1           . . . . . . . . . .
M1   AVG     1321.20     0.33    AVERAGE
M1   FIT     1321.32     0.13    FROM FIT                                            3/84*
         THE FIT ASSUMES XI AND ANTI-XI MASSES EQUAL.

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                    22  (XI-) - (ANTI-XI+) MASS DIFFERENCE (MEV)

DM            1.0       1.1                CHIEN      66 HBC      6.9 PBAR P         9/67
DM       MASS DIFFERENCE FROM SECTIONS M-M1 IS +0.14+-0.36 MEV.                      3/84*

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                    22  XI- MAGNETIC MOMENT (MAGNETONS,938.26 MEV)

MM     2724    -0.1       2.1              BINGHAM    70 OSPK  - 1.8 GEV/C K-P       2/71
MM     2436    -2.1       0.8              COOL       74 OSPK -  1.8 GEV/C K-P      10/74
MM           . . . . . . . . . .
MM   AVG       -1.85      0.75    AVERAGE

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                    22  XI- MEAN LIFE (UNITS 10**-10 SEC)

T    H   11    (3.5)     (3.4)     (1.23) WANG       61 HLBC
T    H   18    (1.28)    (0.41)    (0.25) FOWLER     61 HLBC
T    H   (OLD DATA AND LOW STATISTICS DROPPED ON SUGGESTION OF J R HUBBARD)
T       517     1.86      0.15      0.14  JAUNEAU    63 FBC
T        62     1.55      0.31      0.31  SCHNEIDER 63 HBC
T       356    (1.77)    (0.12)           CARMONY    64 HBC    REP BY PJERROU 65
T       794     1.69      0.07            HUBBARD    64 HBC
T       246     1.70      0.12            PJERROU    65 HBC                         11/67
T    S    6    (1.37)    (0.51)           CHIEN      66 HBC   -  6.9 PBAR P          9/67
T       299     1.80      0.16            LONDON     66 HBC                          6/66
T    S         (1.67)    (0.07)           BURGUN     68 HBC    K-P AT 1.3-1.8        2/71
T      2610     1.61      0.04            DAUBER     69 HBC                          6/68
T       680     1.73      0.08      0.07  MAYEUR     72 HLBC   2.1 GEV/C K-          1/73
T      4303     1.63      0.03            BALTAY     74 HBC    1.75 GEV/C K-         3/74
T    S 2436    (1.637)   (0.050)          COOL       74 OSPK - 1.8 GEV/C K-P        10/74
T               1.67      0.08            DIBIANCA   75 DBC    4.9 GEV/C K-D         1/77
T      4286     1.609     0.028           HEMINGWAY 78 HBC     4.2 GEV/C K- P        7/79
T       41K     1.665     0.065           BOURQUIN   79 SPEC   HYPERON BEAM         12/79
T    S   THE ERROR IS STATISTICAL ONLY
T            . . . . . . . . . .
T    AVG        1.641     0.016     0.016  AVERAGE

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                    22  ANTI-XI+ MEAN LIFE (UNITS 10**-10 SEC)

T1   S    5    (1.51)    (0.55)           CHIEN      66 HBC  +   6.9 PBAR P,ANTI   9/67
T1   S   12    (1.9)     (0.7)     (0.5)  SHEN       67 HBC     ANTI-XI-          10/67
T1       34     1.6       0.3             STONE      70 HBC                       10/70
T1   S   35    (1.55)    (0.35)    (0.20) VOTRUBA    72 HBC      10 GEV/C K+ P    11/72
T1   S   THE ERROR IS STATISTICAL ONLY

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                    22  XI- PARTIAL DECAY MODES

                                                           DECAY MASSES
P1       XI- INTO LAMBDA PI-                             1116+ 140
P2       XI- INTO LAMBDA E- NEUTRINO                     1116+.511+   0
P3       XI- INTO NEUTRON PI-                             940+ 140
P4       XI- INTO LAMBDA MU- NEUTRINO                    1116+ 106+   0
P5       XI- INTO SIGMA0 E- NEUTRINO                     1192+.511+   0
P6       XI- INTO SIGMA0 MU- NEUTRINO                    1192+ 106+   0
P7       XI- INTO NEUTRON E- NEUTRINO                     940+.511+   0
P8       XI- INTO NEUTRON MU- NEUTRINO                    940+ 106+   0
P9       XI- INTO SIGMA- GAMMA                           1197+   0
P10      XI- INTO PROTON PI- PI-                          938+ 140+ 140
P11      XI- INTO PROTON PI- E- NEUTRINO                  938+ 140+.511+   0
P12      XI- INTO PROTON PI- MU- NEUTRINO                 938+ 140+ 106+   0
P13      XI- INTO XI0 E- NEUTRINO                        1315+.511+   0

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                    22  XI- BRANCHING RATIOS

R1       XI- INTO (LAMBDA E- NEU)/(LAMBDA PI-) (UNITS 10**-3)
R1                                                      (P2)/(P1)
R1        1        155 EFFECTIVE DENOM.  CARMONY    63 HBC                         11/67
R1        0        260 EFFECTIVE DENOM.  JAUNEAU    63 HBC                         11/67
R1        0        220 EFFECTIVE DENOM.  BERGE      66 HBC                         11/67
R1        1        155 EFFECTIVE DENOM.  LONDON     66 HBC                         11/67
R1        0        717 EFFECTIVE DENOM.  TRIPPE     67 HBC                         11/67
R1        2       1976 EFFECTIVE DENOM.  HUBBARD    68 HBC                          6/68
R1   H    4    (1.15)    (0.90)    (0.55) HUBBARD   68 RVUE                         6/68
R1   H   HUBBARD 68 (RVUE) INCLUDES ALL ABOVE EVENTS                                6/68
R1        1     0.24      0.24            YEH        74 HBC                          7/75
R1       11    (0.31)    (0.11)           HERBERT    78 ASPK REPL.BY THOMPSON 80    9/81
R1       11     0.30      0.13            THOMPSON   80 ASPK    HYPERON BEAM         9/81
R1     2857     0.564     0.031           BOURQUIN   83 SPEC SPS HYPERON BEAM       2/84*
R1           . . . . . . . . . .
R1   AVG        0.545     0.059    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 2.0)
                          (SEE IDEOGRAM BELOW)

R2       XI- INTO (NEUTRON PI-)/(LAMBDA PI-) (UNITS 10**-3)
R2                                                      (P3)/(P1)
R2             (5.0)   OR LESS                FERRO-LUZ 63 HBC                       6/68
R2             (1.1)   OR LESS                DAUBER    69 HBC                       6/68
R2        0    (3.0)   OR LESS   CL=.90       YEH       74 HBC       760 EFF.DENOM.  7/75
R2              0.019 OR LESS   CL=.90       BIAGI2    82 SPEC CERN-SPS HYPERON BM 11/82*

R3       XI- INTO (LAMBDA MU- NEUTRINO)/TOTAL (UNITS 10**-3)
R3                                                      (P4)
R3            (12.0)   OR LESS                BERGE     66 HBC                       6/68
R3             (1.3)   OR LESS                DAUBER    69 HBC                       6/68
R3        1     0.35      0.35                YEH       74 HBC      2859 EFF.DENOM.  7/75
R3        0    (2.3)   OR LESS    CL=.90      THOMPSON  80 ASPK     1017 EFF.DENOM.  9/81

R4       XI- INTO (SIGMA0 E- NEUTRINO)/TOTAL (UNITS 10**-3)
R4                                                      (P5)
R4             (3.0)   OR LESS                BERGE     66 HBC                       6/68
R4             (0.5)   OR LESS                DAUBER    69 HBC                       6/68
R4        0    (0.53) OR LESS   CL=.90       YEH       74 HBC      4363 EFF.DENOM.  7/75
R4        0    (0.14) OR LESS   CL=.90       THOMPSON  80 ASPK    16000 EFF.DENOM.  9/81
R4      154     0.087     0.017               BOURQUIN  83 SPEC SPS HYPERON BEAM     2/84*
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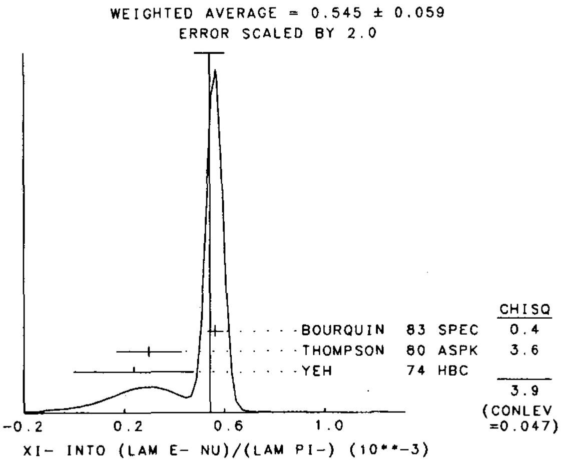


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R5       XI- INTO (SIG0 MU- NEU)/(LAM PI-) (UNITS 10**-3) (P6)/(P1)
R5           (5.0)   OR LESS             BERGE      66 HBC                      7/66
R5       0    0.76   OR LESS   CL=.90    YEH        74 HBC      3026 EFF.DENOM.  7/75

R6       XI- INTO (N E- NEU)/(LAMBDA PI-) (UNITS 10**-3)  (P7)/(P1)
R6        TEST OF DELTA-S = DELTA-Q RULE
R6          (10.0)   OR LESS   CL=.90    BINGHAM    65 RVUE                      9/66
R6       0    3.2    OR LESS   CL=.90    YEH        74 HBC       715 EFF.DENOM.  7/75

R7       XI- INTO (SIGMA0 E- NEU + LAMBDA E- NEU)/TOTAL (10**-3)
R7                                                     (P2+P5)
R7   D   17   (0.68)   (0.22)            DUCLOS     71 OSPK    SEE NOTE D       10/71
R7   B 3011   (0.651)  (0.031)           BOURQUIN   83 SPEC SPS HYPERON BEAM     2/84*
R7   D    THIS EXPERIMENT CANNOT DISTINGUISH SIGMA0 FROM LAMBDA. THE CABIBBO
R7   D    THEORY PREDICTS SIGMA0 RATE ABOUT A FACTOR 6 SMALLER THAN THE
R7   D    LAMBDA.
R7   B    BOURQUIN 83 VALUE IS CORRELATED WITH THEIR RESULT FOR R1 AND R4.      2/84*

R8       XI- INTO (N MU- NEU)/(LAMBDA PI-) (UNITS 10**-3) (P8)/(P1)
R8        TEST OF DELTA-S = DELTA-Q RULE
R8       0   15.3    OR LESS   CL=.90    YEH        74 HBC       150 EFF.DENOM. 11/75

R9       XI- INTO (SIGMA- GAMMA)/(LAM PI-) (UNITS 10**-4) (P9)/(P1)
R9       0   11.5    OR LESS   CL=.90    YEH        74 HBC      2000 EFF.DENOM. 11/75

R10      XI- INTO (P PI- PI-)/(LAMBDA PI-) (UNITS 10**-4) (P10)/(P1)
R10      0    3.7    OR LESS   CL=.90    YEH        74 HBC      6200 EFF.DENOM. 11/75

R11      XI- INTO (P PI- E- NEU)/(LAM PI-) (UNITS 10**-4) (P11)/(P1)
R11       TEST OF DELTA-S = DELTA-Q RULE
R11      0    3.7    OR LESS   CL=.90    YEH        74 HBC      6200 EFF.DENOM. 11/75

R12      XI- INTO (P PI- MU- NEU)/(LAM PI-) (UNITS 10**-4) (P12)/(P1)
R12       TEST OF DELTA-S = DELTA-Q RULE
R12      0    3.7    OR LESS   CL=.90    YEH        74 HBC      6200 EFF.DENOM. 11/75

R13      XI- INTO (XI0 E- NEU)/(LAM PI-) (UNITS 10**-3)   (P13)/(P1)
R13      0    2.3    OR LESS   CL=.90    YEH        74 HBC      1000 EFF.DENOM. 11/75

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                    22  XI- DECAY PARAMETERS

         SEE NOTE ON BARYON DECAY PARAMETERS IN NEUTRON SECTION ABOVE.

A        ALPHA XI-
A    O          (-0.44)    (0.12)            JAUNEAU    63 FBC     SEE NOTE D BELOW  6/68
A    O    62    (-0.73)    (0.23)            SCHNEIDER 63 HBC      SEE NOTE D BELOW  6/68
A        240     -0.5       0.38             BADIER1    64 HBC     SEE NOTE D BELOW  6/68
A        356     -0.62      0.13             CARMONY    64 HBC     SEE NOTE D BELOW  6/68
A       1004     -0.365     0.068            BERGE      66 HBC     SEE NOTE D BELOW  6/68
A    L   364     -0.47      0.13             LONDON     66 HBC     SEE NOTE D BELOW  6/68
A               (-0.391)   (0.032)           BERGE 2    66 RVUE  INCLUDES ALL ABOVE  9/66
A       2529    (-0.375)   (0.051)           MERRILL    68 HBC   REPL. BY DAUBER 69  6/68
A       2781     -0.391     0.045            DAUBER     69 HBC     SEE NOTE A BELOW
A       2724     -0.383     0.065            BINGHAM    70 OSPK                     10/70
A        820     -0.42      0.11             MAYEUR     72 HLBC    2.1 GEV/C K-      1/73
A       4303     -0.376     0.038            BALTAY     74 HBC     1.75 GEV/C K-     3/74
A       2436     -0.39      0.05             COOL       74 OSPK -  1.8 GEV/C K-P    10/74
A      B 414     -0.40      0.19             DIBIANCA   75 DBC     4.9 GEV/C K-D     1/77
A       6599     -0.370     0.032            HEMINGWAY 78 HBC      4.2 GEV/C K- P    7/79
A       9046     -0.49      0.04             CLELAND    80 ASPK   BNL HYPERON BEAM   9/81
A    C  150K     -0.462     0.015            BIAGI      82 SPEC CERN-SPS HYPERON BM  4/82
A    O   OLD DATA NOT INCLUDED IN AVERAGE.
A    D   ERRORS MULTIPLIED BY 1.1 DUE TO APPROXIMATIONS USED FOR XI
A    D   POLARIZATION. (SEE DAUBER 69 FOR DETAILED DISCUSSION)                   6/68
A    L   LONDON 66 USES ALPHA-LAMBDA = 0.62
A     A  USED ALPHA LAMBDA = 0.647 +- 0.020.
A      B DIBIANCA 75 USES ALPHA LAMBDA = 0.647.                                   1/77
A    C   BIAGI 82 USES ALPHA LAMBDA = -0.647+-0.014                               4/82
A             . . . . . . . . . .
A    AVG        -0.434     0.015    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.4)
                           (SEE IDEOGRAM BELOW)

F        PHI ANGLE (SIN(PHI)/COS(PHI)=BETA/GAMMA) (DEGREES)
F    O        (-16.0)     (45.0)             JAUNEAU    63 FBC     SEE NOTE D BELOW  6/68
F    O    62   (45.0)     (36.0)             SCHNEIDER 63 HBC      SEE NOTE D BELOW  6/68
F        356    54.0       30.0              CARMONY    64 HBC     SEE NOTE D BELOW  6/68
F       1004    0.         12.               BERGE      66 HBC     SEE NOTE D BELOW  6/68
F    L   364    0.0        20.4              LONDON     66 HBC     SEE NOTE D BELOW  6/68
F       2529   (9.8)      (11.6)             MERRILL    68 HBC   REPL. BY DAUBER 69  6/68
F       2781   -14.        11.               DAUBER     69 HBC     SEE NOTE A BELOW
F       2724   -26.0       30.0              BINGHAM    70 OSPK                     10/70
F       4303    11.0        9.0              BALTAY     74 HBC     1.75 GEV/C K-     3/74
F       2436     5.0       16.0              COOL       74 OSPK -  1.8 GEV/C K-P    10/74
F    O   OLD DATA NOT INCLUDED IN AVERAGE.
F    D   ERRORS MULTIPLIED BY 1.2 DUE TO APPROXIMATIONS USED FOR XI
F    D   POLARIZATION. (SEE DAUBER 68 FOR DETAILED DISCUSSION)
F    L   LONDON 66 USES ALPHA-LAMBDA = 0.62
F     A  USED ALPHA LAMBDA = 0.647 +- 0.020.
F             . . . . . . . . . .
F    AVG         2.0        5.7     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.1)
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For notation, see key at front of Listings.

Stable Particles

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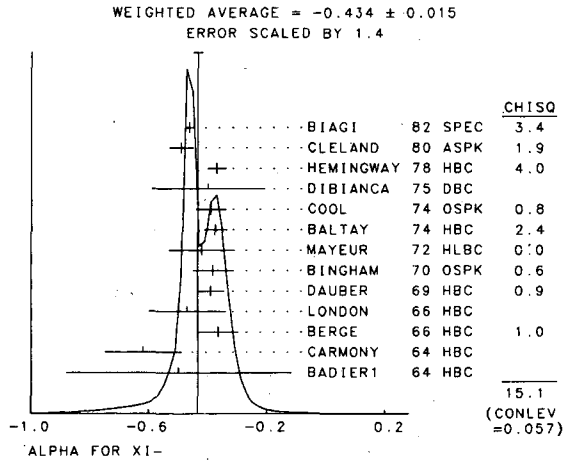


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AV     GA/GV FOR XI- TO LAMBDA BETA DECAY
AV      (FOR SIGN CONVENTION, SEE NOTE ON BARYON DECAY PARAMETERS IN
AV      NEUTRON SECTION ABOVE.)
AV    1992   -0.25     0.05          BOURQUIN  83 SPEC SPS HYPERON BEAM     2/84*

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REFERENCES FOR XI-


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FOWLER    61 PRL 6 134          FOWLER,BIRGE,EBERHARD,ELY,GOOD,POWELL+(LRL)
WANG      61 JETP 13 512        K WANG,T WANG,VIRYASOV,TING,SOLOVEV+ (JINR)
BROWN     62 PRL 8 255          BROWN,CULWICK,FOWLER,GAILLOUD +  (BNL+YALE)

CARMONY   63 PRL  10  381       CARMONY,PJERROU                   (UCLA)
FERRO-LU  63 PR 130 1568        FERRO-LUZZI,ALSTON,ROSENFELD,WOJCICKI (LRL)
JAUNEAU   63 SIENA CONF 4       JAUNEAU+        (EPOL+CERN+LOUC+RHEL+BERGEN)
    ALSO  63 PL  5  261         JAUNEAU,+       (EPOL,CERN,LOUC,RHEL,BERGEN)
SCHNEIDE  63 PL 4 360           H SCHNEIDER                       (CERN)

CARMONY   64 PRL 12 482         CARMONY,PJERROU,SCHLEIN,SLATER,STORK+(UCLA) J
BADIER1   64 DUBNA CONF I 593   BADIER,DEMOULIN,BARLOUTAUD+(EPOL,SACL,ZEEM)
HUBBARD   64 PR 135 B 183       HUBBARD,BERGE,KALBFLEISCH,SHAFER +    (LRL)
BINGHAM   65 PRSL  285  202     H H BINGHAM                       (CERN)
PJERROU   65 PRL 14 275         + SCHLEIN,SLATER,SMITH,STORK,TICHO   (UCLA)
PJERROU   65 THESIS             G M PJERROU                       (UCLA)

BERGE     66 PR  147  945       BERGE,EBERHARD,HUBBARD,MERRILL +      (LRL)
BERGE 2   66 BERKELEY CONF 46   BERGE,CABIBBO                 (LRL,CERN(RVUE))
LONDON    66 PR 143 1034        LONDON,RAU,GOLDBERG,LICHTMAN+(BNL+SYRACUSE)
CHIEN     66 PR  152  1171      +LACH,SANDWEISS,TAFT,YEH,OREN +  (YALE+BNL)
SHEN      67 PL 25 B 443        B.C.SHEN,A.FIRESTONE,G.GOLDHABER  (UCB+LRL)
TRIPPE    67 PRIV. COMM.        T. TRIPPE                         (UCLA)

BURGUN    68 NP B8 447          +MEYER,PAULI,TALLINI, +    (SACL+CDEF+RHEL)
HUBBARD   68 PRL 20 465         HUBBARD,BERGE,DAUBER                 (LRL)
MERRILL   68 PR 167 1202        MERRILL,SHAFER                       (LRL)J

DAUBER    69 PR  179 1262       +BERGE,HUBBARD,MERRILL,MILLER        (LRL)J
BINGHAM   70 PR D1 3010         +COOK,HUMPHREY,SANDER,WILLIAMS+ (UCSD,WASH)
GOLDWASS  70 PR D1 1960         GOLDWASSER, SCHULTZ                  (ILL)
STONE     70 PL 32B 515         +BERLINGHIERI,BROMBERG,COHEN,FERBEL +(ROCH)

DUCLOS    71 NP B32 493         +FREYTAG,HEINTZE,HEINZELMAN,JONES+   (CERN)
MAYEUR    72 NP B47 333         +VAN BINST,WILQUET+   (BRUX+CERN+TUFT+LOUC)
VOTRUBA   72 NP B45 77          VOTRUBA,SAFDER,RATCLIFFE        (BIRM+EDIN)
WILQUET   72 PL 42B 372         +FLIAGINE,GUY,KNIGHT+ (BRUX+CERN+TUFT+LOUC)
BALTAY    74 PR D9 49           +BRIDGEWATER,COOPER,GERSHWIN+   (COLU+BING)J
COOL      74 PR D10 792         +GIACOMELLI,JENKINS,KYCIA,LEONTIC,LI+ (BNL)
    ALSO  72 PRL 29 1630        COOL,GIACOMELLI,JENKINS,KYCIA,LEONTIC+(BNL)
YEH       74 PR D10 3545        +GAIGALAS,SMITH,ZENDLE,BALTAY + (BING+COLU)
DIBIANCA  75 NP B98 137         F.A.DIBIANCA, R.J.ENDORF             (CARN)

HEMINGWA  78 NP B142 205        HEMINGWAY,ARMENTEROS+  (CERN+ZEEM+NIJM+OXF)
HERBERT   78 PRL 40 1230        +CLELAND,COOPER,DRIS,ENGELS +    (PITT+BNL)
BOURQUIN  79 PL 87B 297           (BRIS+GEVA+HEID+ORSA+RHEL+STRB+CERN+MELB)
CLELAND   80 PR D21 12          +COOPER,DRIS,ENGELS,HERBERT+     (PITT+BNL)
THOMPSON  80 PR D21 25          +CLELAND,COOPER,DRIS,ENGELS+     (PITT+BNL)
BIAGI     82 PL 112B 265        +          (BRIS+CAMB+GEVA+HEID+LAUS+LOQM+RL)
BIAGI2    82 PL 112B 277        +          (LOQM+GEVA+RL+HEID+CAMB+LAUS+BRIS)
BOURQUIN  83 ZPHY C21 1         +BROWN+          (BRIS+GEVA+HEID+LALO+RL+STRB)
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23 XI0(1315,JP=1/2) I=1/2

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23 XI0 MASS (MEV)

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M        1 1313.4      1.8            PALMER    68 HBC                     3/68
M       49 1315.2      0.92           WILQUET   72 HLBC                    1/73
M          . . . . . . . . . .
M   AVG    1314.83     0.82    AVERAGE
M   FIT    1314.91     0.55    FROM FIT                                   3/84*

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23 (XI-) - (XI0) MASS DIFFERENCE (MEV)

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D       23    6.8      1.6            JAUNEAU   63 FBC
D       45   (6.1)    (1.6)           CARMONY   64 HBC    REP BY PJERROU 65
D       88    6.1      0.9            PJERROU   65 HBC                    11/67
D       29    6.9      2.2            LONDON    66 HBC                     6/66
D          . . . . . . . . . .
D   AVG       6.34     0.74    AVERAGE
D   FIT       6.41     0.55    FROM FIT                                   3/84*

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23 XI0 MEAN LIFE (UNITS 10-10 SEC)**

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T       24    3.9      1.4      0.80  JAUNEAU   63 FBC
T       45   (3.5)    (1.0)    (0.8) CARMONY   64 HBC    REP BY PJERROU 65
T      101    2.5      0.4       0.3  HUBBARD   64 HBC
T       80    3.0      0.5           PJERROU   65 HBC                    11/67
T      340    3.07     0.22     0.20  DAUBER    69 HBC                     6/68
T  M   157    2.90     0.32     0.27  MAYEUR    72 HLBC    2.1 GEV/C K-    1/74
T      652    2.88     0.21     0.19  BALTAY    74 HBC     1.75 GEV/C K-   3/74
T  Z  6300    2.77     0.16           ZECH      77 SPEC NEUTRAL HYP. BEAM 12/77
T  M    MAYEUR 72 VALUE MODIFIED BY ERRATUM.                                1/74
T  Z    ZECH 77 VALUE IS FOR LAMBDA LIFETIME=2.69E-10. FOR LAM LIFETIME    12/77
T  Z    DIFFERENT FROM THIS, TAUXI0=(2.77-(TAULAMBDA-2.69))E-10.           12/77
T          . . . . . . . . . .
T   AVG       2.903    0.099    0.093  AVERAGE

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23 XI0 MAGNETIC MOMENT (MAGNETONS,938.26 MEV)

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MM     42K   -1.20     0.06           BUNCE     79 SPEC                    1/80
MM    270K   -1.253    0.014          COX       81 SPEC                   12/81
MM          . . . . . . . . . .
MM  AVG      -1.250    0.014   AVERAGE

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23 XI0 PARTIAL DECAY MODES

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                                                          DECAY MASSES
P1     XI0 INTO LAMBDA PI0                               1116+ 135
P2     XI0 INTO PROTON PI-                                938+ 140
P3     XI0 INTO PROTON E- NEU                             938+.511+   0
P4     XI0 INTO SIGMA+ E- NEU                            1189+.511+   0
P5     XI0 INTO SIGMA- E+ NEU                            1197+.511+   0
P6     XI0 INTO SIGMA+ MU- NEU                           1189+ 106+   0
P7     XI0 INTO SIGMA- MU+ NEU                           1197+ 106+   0
P8     XI0 INTO PROTON MU- NEU                            938+ 106+   0
P9     XI0 INTO LAMBDA GAMMA                             1116+   0
P10    XI0 INTO SIGMA0 GAMMA                             1192+   0

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23 XI0 BRANCHING RATIOS

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R1     XI0 INTO (PROTON PI-)/(LAMBDA PI0)  (UNITS 10**-5)
R1                                                        (P2)/(P1)
R1       (2700.)   OR LESS            TICHO     63 HBC                     6/68
R1        (500.)   OR LESS            HUBBARD   66 HBC                     6/68
R1         (90.)   OR LESS            DAUBER    69 HBC                     6/68
R1       0 (180.)  OR LESS  CL=.90    YEH       74 HBC      1300 EFF.DENOM. 11/75
R1           3.6   OR LESS  CL=.90    GEWENIGER 75 SPEC                   11/75

R2     XI0 INTO (PROTON E- NEU)/(LAMBDA PI0) (UNITS 10**-3)
R2                                                        (P3)/(P1)
R2      TEST OF DELTA-S = DELTA-Q RULE
R2         (27.0)  OR LESS            TICHO     63 HBC                     6/68
R2          (6.0)  OR LESS            HUBBARD   66 HBC                     6/68
R2           1.3   OR LESS            DAUBER    69 HBC                     6/68
R2       0   (3.4)  OR LESS  CL=.90   YEH       74 HBC       670 EFF.DENOM. 11/75

R3     XI0 INTO (SIGMA+ E- NEU)/(LAMBDA PI0) (UNITS 10**-3)
R3                                                        (P4)/(P1)
R3         (13.0)  OR LESS            TICHO     63 HBC                     6/68
R3          (7.0)  OR LESS            HUBBARD   66 HBC                     6/68
R3          (1.5)  OR LESS            DAUBER    69 HBC                     6/68
R3       0    1.1   OR LESS  CL=.90   YEH       74 HBC      2100 EFF.DENOM. 11/75

R4     XI0 INTO (SIGMA- E+ NEU)/(LAMBDA PI0) (UNITS 10**-3)
R4                                                        (P5)/(P1)
R4      TEST OF DELTA-S = DELTA-Q RULE
R4          (6.0)  OR LESS            HUBBARD   66 HBC                     6/68
R4          (1.5)  OR LESS            DAUBER    69 HBC                     6/68
R4       0    0.9   OR LESS  CL=.90   YEH       74 HBC      2500 EFF.DENOM. 11/75

R5     XI0 INTO (SIGMA+ MU- NEU)/TOTAL (UNITS 10**-3)   (P6)
R5          (7.0)  OR LESS            HUBBARD   66 HBC                     6/68
R5          (1.5)  OR LESS            DAUBER    69 HBC                     6/68
R5       0    1.1   OR LESS  CL=.90   YEH       74 HBC      2100 EFF.DENOM. 11/75

R6     XI0 INTO (SIGMA- MU+ NEU)/TOTAL (UNITS 10**-3)   (P7)
R6      TEST OF DELTA-S = DELTA-Q RULE
R6          (6.0)  OR LESS            HUBBARD   66 HBC                     6/68
R6          (1.5)  OR LESS            DAUBER    69 HBC                     6/68
R6       0    0.9   OR LESS  CL=.90   YEH       74 HBC      2500 EFF.DENOM. 11/75

R7     XI0 INTO (PROTON MU- NEU)/TOTAL (UNITS 10**-3)   (P8)
R7      TEST OF DELTA-S = DELTA-Q RULE
R7          (7.0)  OR LESS            HUBBARD   66 HBC                     6/68
R7           1.3   OR LESS            DAUBER    69 HBC                     6/68
R7       0   (3.5)  OR LESS  CL=.90   YEH       74 HBC       664 EFF.DENOM. 11/75

R8     XI0 INTO (LAMBDA GAMMA)/(LAM PI0) (UNITS 10**-3) (P9)/(P1)
R8       1    5.       5.             YEH       74 HBC       200 EFF.DENOM. 11/75

R9     XI0 INTO (SIGMA0 GAMMA)/(LAM PI0) (UNITS 10**-2) (P10)/(P1)
R9     0-1    6.5   OR LESS  CL=.90   YEH       74 HBC        60 EFF.DENOM. 11/75

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23 XI0 DECAY PARAMETERS

SEE NOTE ON BARYON DECAY PARAMETERS IN NEUTRON SECTION ABOVE.

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A      ALPHA XI 0
A   X        (-0.09)   (0.46)        PJERROU   65 HBC    SEE NOTE D BELOW  6/68
A   X  146   (-0.13)   (0.17)         BERGE     66 HBC    SEE NOTE D BELOW  6/68
A   X   46   (-0.2)    (0.4)          LONDON    66 HBC    SEE NOTE D BELOW  6/68
A   A  739    -0.43     0.09          DAUBER    69 HBC    1.7-2.6 GEV/C K-
A   X  130   (-0.84)   (0.27)         MAYEUR    72 HLBC   2.1 GEV/C K-      1/73
A   B  652    -0.54     0.10          BALTAY    74 HBC    1.75 GEV/C K-     3/74
A   U 6075    -0.490    0.042         BUNCE     78 SPEC FNAL HYPERON BEAM   7/79
A   H 300K    -0.405    0.012         HANDLER   82 SPEC FNAL HYPERON BEAM   1/82
A   X   LOW STATISTICS EXPERIMENTS EXCLUDED FROM AVERAGE.                   1/82
A   D   ERRORS MULTIPLIED BY 1.1 DUE TO APPROXIMATIONS USED FOR XI
A   D   POLARIZATION. (SEE DAUBER 69 FOR DETAILED DISCUSSION)
A   A   DAUBER 69 USES ALPHA LAMBDA = 0.650 +- 0.019.
A   B   BALTAY 74 USES ALPHA-LAMBDA = 0.645
A   U   BUNCE 78 USES ALPHA-LAMBDA = 0.647                                  7/79
A   H   HANDLER 82 USES ALPHA-LAMBDA=0.642+-0.013                           1/82
A          . . . . . . . . . .
A   AVG      -0.413    0.022   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 2.0)
                                (SEE IDEOGRAM BELOW)
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Stable Particles

Data Card Listings

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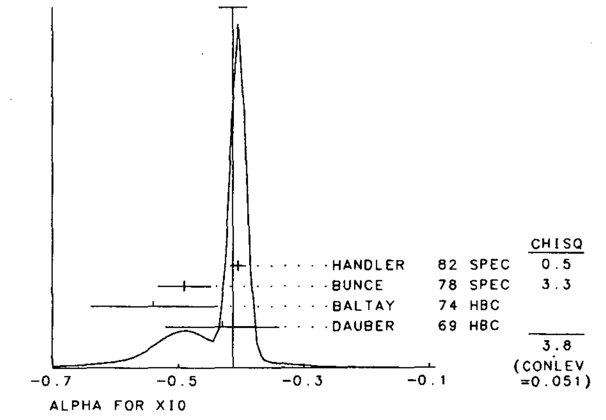

F PHI ANGLE (SIN(PHI)/COS(PHI)=BETA/GAMMA) (DEGREES)
F 146 -8. 30. BERGE 66 HBC SEE NOTE D BELOW 6/68
F A 739 38. 19. DAUBER 69 HBC SEE NOTE A BELOW
F 652 16.0 17.0 BALTAY 74 HBC 1.75 GEV/C K- 3/74
F A USED ALPHA LAMBDA = 0.647 +- 0.020.
F D ERRORS MULTIPLIED BY 1.2 DUE TO APPROXIMATIONS USED FOR XI
F D POLARIZATION. (SEE DAUBER 69 FOR DETAILED DISCUSSION)
F . . . .
F AVG 20.7 11.7 AVERAGE

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REFERENCES FOR XI0

ALVAREZ 59 PRL 2 215 — ALVAREZ,EBERHARD,GOOD,GRAZIANO,TICHO+ (LRL)
JAUNEAU 63 SIENA CONF 1 1 — JAUNEAU+ (EPOL+CERN+LOUC+RHEL+BERGEN)
ALSO 63 PL 4 49 — JAUNEAU+ (EPOL+CERN+LOUC+RHEL+BERGEN)
TICHO 63 BNL CONF 410 — HAROLD K TICHO (UCLA)

CARMONY 64 PRL 12 482 — CARMONY,PJERROU,SCHLEIN,SLATER,STORK+(UCLA)
HUBBARD 64 PR 135 B 183 — HUBBARD,BERGE,KALBFLEISCH,SHAFER + (LRL)
PJERROU 65 PRL 14 275 — + SCHLEIN,SLATER,SMITH,STORK,TICHO (UCLA)
PJERROU 65 THESIS — G M PJERROU (UCLA)

BERGE 66 PR 147 945 — BERGE,EBERHARD,HUBBARD,MERRILL + (LRL)
HUBBARD 66 UCRL 11510 — J RICHARD HUBBARD (THESIS,BERKELEY) (LRL)
LONDON 66 PR 143 1034 — LONDON,RAU,GOLDBERG,LICHTMAN+(BNL+SYRACUSE)

PALMER 68 PL 26B 323 — PALMER,RADOJICIC,RAU,RICHARDSON+ (BNL,SYRA)
DAUBER 69 PR 179 1262 — +BERGE,HUBBARD,MERRILL,MILLER (LRL)
MAYEUR 72 NP B47 333 — +VAN BINST,WILQUET+ (BRUX+CERN+TUFT+LOUC)
ALSO 73 NP B53 268 — ERRATUM TO MAYEUR 72
WILQUET 72 PL 42B 372 — +FLIAGINE,GUY,KNIGHT+ (BRUX+CERN+TUFT+LOUC)

BALTAY 74 PR D9 49 — +BRIDGEWATER,COOPER,GERSHWIN+ (COLU+BING)J
YEH 74 PR D10 3545 — +GAIGALAS,SMITH,ZENDLE,BALTAY + (BING+COLU)
GEWENIGE 75 PL 57B 193 — GEWENIGER,GJESDAL,PRESSER + (CERN+HEID)
ZECH 77 NP B124 413 — +DYDAK,NAVARRIA+ (SIEG+CERN+DORT+HEID)

BUNCE 78 PR D18 633 — +HANDLER,MARCH,MARTIN+ (WISC+MICH+RUTG)
BUNCE 79 PL 86B 386 — +OVERSETH,COX,DWORKIN+ (BNL+MICH+RUTG+WISC)
COX 81 PRL 46 877 — +DWORKIN + (MICH+WISC+RUTG+MINN+BNL)
HANDLER 82 PR D25 639 — +GROBEL,PONDROM+ (WISC+MICH+MINN+RUTG)

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24 OMEGA-(1672,JP=3/2+) I=0

QUANTUM NUMBERS ASSIGNED FROM SU3

24 OMEGA- MASS (MEV)

M E 1(1615.) EISENBERG 54 EMUL 9/73
M F 1 1672.1 1. FRY1 55 EMUL 9/73
M F 1 1670.6 (1.) FRY2 55 EMUL 9/73
M 1 1673.0 8.0 ABRAMS 64 HBC INTO XI- PI0
M 3 1673.3 1.0 PALMER 68 HBC K-P 4.6,5. GEV/C 11/69
M 3 1671.8 0.8 SCHULTZ 68 HBC K-P 5.5 GEV/C 11/69
M 5 1674.2 1.6 SCOTTER 68 HBC K-P 6. GEV/C 11/69
M B 6(1671.9) (1.2) SPETH 69 HBC K-P 10. GEV/C 11/69
M B 13(1671.43) (0.78) ABCLV 73 HBC K-P 10. GEV/C 12/73
M D 4 1673.4 1.7 DIBIANCA 75 DBC 4.9 GEV/C K-D 1/77
M 41 1673.0 0.8 BAUBILLIE 78 HBC 8.25 GEV/C K-P 2/79
M 27 1671.7 0.6 HEMINGWAY 78 HBC 4.2 GEV/C K-P 2/79
M . . . .
M AVG 1672.37 0.34 AVERAGE
M FIT 1672.45 0.32 FROM FIT 3/84*
THE FIT COMBINES OMEGA- AND ANTI-OMEGA- VALUES ASSUMING CPT
M
M E EISENBERG 54 MASS CALCULATED FOR DECAY IN FLIGHT. ALVAREZ 73 HAS 9/73
M E SHOWN THAT THE OMEGA INTERACTED WITH AG NUCLEUS TO GIVE K- XI AG. 9/73
M F BOTH FRY EVENTS IDENTIFIED AS OMEGA- BY ALVAREZ 73. 9/73
M F FRY MASSES ASSUME DECAY TO LAMBDA K- AT REST. DECAY FROM ATOMIC 3/74
M F ORBIT COULD DOPPLER SHIFT THE K- ENERGY AND RESULTING OMEGA- MASS 3/74
M F BY SEVERAL MEV FOR FRY 2. THIS SHIFT IS NEGLIGIBLE FOR FRY 1 3/74
M F BECAUSE THE OMEGA DECAY IS APPROXIMATELY PERPENDICULAR TO ITS 3/74
M F ORBITAL VELOCITY, AS IS KNOWN BECAUSE THE LAMBDA STRIKES THE 3/74
M F NUCLEUS (L.ALVAREZ, PRIVATE COMM. 1973). WE HAVE CALCULATED THE 3/74
M F ERROR ASSUMING THAT ORBITAL N IS 4 OR LARGER. 3/74
M B ABCLV VALUE INCLUDES THE SPETH 69 EVENTS. EXCLUDED FROM AVERAGE. 12/73
M B SEE NOTE D IN THE OMEGA- MEAN LIFE SECTION BELOW. 2/82
M D DIBIANCA 75 GIVES MASS FOR EACH EVENT. WE QUOTE AVERAGE. 1/77

24 ANTI-OMEGA+ MASS (MEV)

MB 1 1673.1 1.0 FIRESTONE 71 HBC 12 GEV/C K+D 3/71
MB . . . .
MB FIT 1672.45 0.32 FROM FIT 3/84*
THE FIT COMBINES OMEGA- AND ANTI-OMEGA- VALUES ASSUMING CPT

24 OMEGA- MEAN LIFE (UNITS 10-10 SEC)**

T 1 (1.63) ABRAMS 64 HBC 7/66
T 1 (0.7) BARNES 1 64 HBC 7/66
T 1 (1.4) BARNES 2 64 HBC 7/66
T 1 (1.85) COLLEY 65 HBC 7/66
T 1 (1.5) RICHARDSO 65 HBC 7/66
T 1 (1.20) SCHULTZ 68 HBC 11/67
T 1 (0.06) SCHULTZ 68 HBC 11/67
T 1 (0.63) SCHULTZ 68 HBC 11/67
T 1 (0.25) SCOTTER 68 HBC 6/68
T 1 (0.30) SCOTTER 68 HBC 6/68
T 1 (0.71) SCOTTER 68 HBC 6/68
T 1 (0.08) SCOTTER 68 HBC 6/68
T 1 (1.04) SCOTTER 68 HBC 6/68
T 1 (2.38) SCOTTER 68 HBC 6/68
T D 16 (1.39) (0.45) (0.31) ABCLV 73 HBC K-P 10. GEV/C 12/73
T 1 (0.135) DIBIANCA 75 DBC 4.9 GEV/C K-D 1/77
T 1 (0.482) DIBIANCA 75 DBC 4.9 GEV/C K-D 1/77
T 1 (0.702) DIBIANCA 75 DBC 4.9 GEV/C K-D 1/77
T 1 (0.228) DIBIANCA 75 DBC 4.9 GEV/C K-D 1/77
T 40 0.80 0.16 0.12 BAUBILLIE 78 HBC 8.25 GEV/C K-P 2/79
T D 101 (1.41) (0.15) (0.24) DEUTSCHMA 78 HBC 10,16 GEV/C K- P 6/78
T 39 0.75 0.14 0.11 HEMINGWAY 78 HBC 4.2 GEV/C K-P 2/79
T 2437 0.822 0.028 BOURQUIN 79 SPEC CERN SPS HYPERON BM 12/79
T D DEUTSCHMANN 78 INCLUDES EVENTS OF ABCLV 73. EXCLUDED FROM AVERAGE 2/80
T D BECAUSE OF SIGNIFICANT DISAGREEMENT WITH OTHER RECENT EXPERIMENTS, 2/80
T D POSSIBLY DUE TO XI- CONTAMINATION. 2/82
T . . . .
T AVG 0.819 0.028 0.026 AVERAGE

24 OMEGA- PARTIAL DECAY MODES

		DECAY MASSES
P1	OMEGA- INTO LAMBDA K-	1116+ 494
P2	OMEGA- INTO XI0 PI-	1315+ 140
P3	OMEGA- INTO XI- PI0	1321+ 135
P4	OMEGA- INTO LAMBDA PI-	1116+ 140
P5	OMEGA- INTO XI- GAMMA	1321+ 0
P6	OMEGA- INTO XI*(1530)0 PI-	1533+ 140
P7	OMEGA- INTO XI0 E- NEU	1315+.511+ 0

24 OMEGA- BRANCHING RATIOS

R1 OMEGA- INTO LAMBDA K- (P1)
R1 F 1 EVENT FRY1 55 EMUL 11/73
R1 F 1 EVENT FRY2 55 EMUL 11/73
R1 F BOTH FRY EVENTS IDENTIFIED BY ALVAREZ 73. 11/73
R1 2 EVENTS PALMER 68 HBC 11/69
R1 3 EVENTS SCHULTZ 68 HBC 11/69
R1 5 EVENTS 1 XI PI DECAY AMB.SCOTTER 68 HBC 11/69
R1 13 EVENTS +2 AMBIG. WITH XI-ABCLV 73 HBC K-P 10. GEV/C 12/73
R1 2 EVENTS DIBIANCA 75 DBC 4.9 GEV/C K-D 1/77
R1 1920 0.686 0.013 BOURQUI2 79 SPEC CERN SPS HYPERON BM 1/80

R2 OMEGA- INTO XI0 PI- (P2)
R2 5 EVENTS PALMER 68 HBC 11/69
R2 3 EVENTS SCOTTER 68 HBC 11/69
R2 3 EVENTS +1 AMBIG.WITH SIG-ABCLV 73 HBC K-P 10. GEV/C 12/73
R2 2 EVENTS DIBIANCA 75 DBC 4.9 GEV/C K-D 1/77
R2 317 0.234 0.013 BOURQUI2 79 SPEC CERN SPS HYPERON BM 1/80

R3 OMEGA- INTO XI- PI0 (P3)
R3 1 EVENT ABRAMS 64 HBC 11/69
R3 1 EVENT PALMER 68 HBC 11/69
R3 1 EVENT SCOTTER 68 HBC 11/69
R3 1 EVENT ABCLV 73 HBC K-P 10. GEV/C 12/73
R3 145 0.080 0.008 BOURQUI2 79 SPEC CERN SPS HYPERON BM 1/80

R4 OMEGA- INTO (LAMBDA PI-)/TOTAL (UNITS 10**-3) (P4)
R4 0 1.3 OR LESS CL=.90 BOURQUI2 79 SPEC CERN SPS HYPERON BM 1/80

R5 OMEGA- INTO (XI- GAMMA)/TOTAL (UNITS 10**-3) (P5)
R5 0 3.1 OR LESS CL=.90 BOURQUI2 79 SPEC CERN SPS HYPERON BM 1/80

R6 OMEGA- INTO (XI(1530)0 PI-)/TOTAL (UNITS 10**-3)(P6)
R6 1 2. APPROX BOURQUI2 79 SPEC CERN SPS HYPERON BM 1/80

R7 OMEGA- INTO (XI0 E- NEU)/TOTAL (UNITS 10**-2) (P7)
R7 3 1. APPROX BOURQUI2 79 SPEC CERN SPS HYPERON BM 1/80

24 OMEGA- DECAY PARAMETERS

SEE NOTE ON BARYON DECAY PARAMETERS IN NEUTRON SECTION ABOVE.

AL ALPHA FOR OMEGA- TO K- LAMBDA
AL K 15 (-0.66) (0.36) (0.30) KOCHER 74 HBC 10 GEV/C K-P 10/74
AL 40 0.58 0.50 BAUBILLIE 78 HBC 8.25 GEV/C K-P 2/79
AL 40 -0.2 0.4 HEMINGWAY 78 HBC 4.2 GEV/C K-P 2/79
AL S 1400 (0.06) (0.14) SAUVAGE 78 SPEC CERN SPS HYPERON BM 4/82
AL K SEE NOTE D IN THE OMEGA- MEAN LIFE SECTION ABOVE. 2/82
AL S SAUVAGE 78 IS PRELIMINARY. 4/82
AL . . . .
AL AVG 0.10 0.38 AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.2)

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REFERENCES FOR OMEGA-

EISENBER 54 PR 96 541 — Y EISENBERG (CORNELL)
FRY1 55 PR 97 1189 — FRY,SCHNEPS,SWAMI (WISC)
FRY2 55 NC 2 346 — FRY,SCHNEPS,SWAMI (WISC)

ABRAMS 64 PRL 13 670 — + BURNSTEIN,GLASSER + (UMD+NRL)
BARNES 1 64 PRL 12 204 — V E BARNES,CONNOLLY,CRENNELL,CULWICK+ (BNL)
BARNES 2 64 PL 12 134 — V E BARNES,CONNOLLY,CRENNELL,CULWICK+ (BNL)
COLLEY 65 PL 19 152 — COLLEY,DODD +(BIRM+GLAS+LOIC+MPIM+OXF+RHEL)
RICHARDS 65 BAPS 10 115 — RICHARDSON,BARNES,CRENNEL+ (BNL+SYRACUSE)
SAMIOS 65 ARGONNE CONF 189 — N P SAMIOS ((RVUE) BNL)

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PALMER   68 PL 26B 323          PALMER,RADOJICIC,RAU,RICHARDSON+ (BNL,SYRA)
SCHULTZ  68 PR  168  1509       SCHULTZ+     (ILL,ARGONNE,NORTHWESTERN,WISC)
SCOTTER  68 PL 26B 474          SCOTTER+      (BIRM,GLASGOW,LOIC,MUNICH,OXF)
SPETH    69 PL  29B 252         SPETH+        (AACHEN,BERLIN,CERN,LOIC,VIEN)

FIRESTON 71 PRL 26 410          +GOLDHABER,LISSAUER,SHELDON,TRILLING  (LRL)
ABCLV    73 NP B61 102          AACHEN+BERLIN+CERN+LONDON+VIENNA COLLABOR.
ALVAREZ  73 PR D8 702           LUIS W. ALVAREZ                       (LBL)
KOCHER   74 PL 51B 193          KOCHER,WERNHARD                 (INNS+VIEN)
DIBIANCA 75 NP B98 137          F.A.DIBIANCA, R.J.ENDORF             (CARN)

BAUBILLI 78 PL 78B 342          BAUBILLIER +       (BIRM+CERN+GLAS+MSU+LPNP)
DEUTSCHM 78 PL 73B 96           DEUTSCHMANN+(AACH+BERL+CERN+INNS+LOIC+VIEN)
HEMINGWA 78 NP B142 205         HEMINGWAY,ARMENTEROS+  (CERN+ZEEM+NIJM+OXF)
SAUVAGE  78  TOKYO CONF P 427 G.SAUVAGE, PROC. 19TH INTL. HEP CONF (ORSA)
BOURQUIN 79 PL 87B 297            (BRIS+GEVA+HEID+ORSA+RHEL+STRB+CERN+MELB)
BOURQUI2 79 PL 88B 192            (BRIS+GEVA+HEID+ORSA+RHEL+STRB+CERN+MELB)
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Λ_c^+

33 LAMBDA/C+(2282,JP=)

FOR THE (SIGMA/C)-(LAMBDA/C) MASS DIFFERENCE SEE THE SIGMA/C SECTION OF THE BARYON DATA CARD LISTINGS.

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33 LAMBDA/C+ MASS (MEV)

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M        1  2260.      20.            CAZZOLI   75 HBC  +  LAMBDA 2PI+ PI-   3/77
M       60  2260.      10.            KNAPP     76 SPEC -  ANTILAM 2PI- PI+  3/77
M        1 (2248.)   OR MORE          BARISH    77 DBC     MODE P15 BELOW    3/77
M        1 (2295.)    (15.)           ANGELINI  79 HYBR REPL. BY ALLASIA 80 12/79
M        6  2257.      10.            BALTAY    79 HLBC +  LAMBDA PI+        7/79
M        1  2254.      12.            CNOPS     79 DBC     P K*(892)- PI+   12/79
M     A 30  2262.      10.            GIBONI    79 SPEC    K- P PI+          2/80
M     A  GIBONI 79 RESULT CHANGED FROM 2255+-4 BY AUTHORS.  SEE KERNAN 79.   2/80
M       39  2285.       6.            ABRAMS    80 SMK2 +- K- P PI+ + C.C.   1/80
M        1  2260.      20.            ALLASIA   80 EMUL    P K- PI+         12/81
M        1  2290.       3.            CALICCHIO 80 HYBR    P K- PI+         12/81
M       19  2275.      10.            KITAGAKI  80 DBC     LAM PI+, KOBAR P 12/81
M        1 (2330.)    (50.)           ADAMOVICH 81 EMUL +  LAMBDA PI+        1/82
M     B  1 (2285.)     (5.)           GRAESSLER 81 HBC  +  P K- PI+          1/82
M     B  1 (2280.)     (3.)           GRAESSLER 81 HBC  +  P K- PI+          1/82
M       55  2284.0      5.0           RUSSELL   81 SPEC +- KOBAR P + C.C.   12/81
M       76  2259.      20.            ALEEV     82 SPEC    P KS PI+ PI-     11/83*
M     B  3  2283.0      3.0           BOSETTI   82 HBC  +  P K- PI+          3/82
M     B  BOSETTI 82 COMBINE ONE NEW EVENT AT 2288+-5 MEV WITH THEIR EARLIER  3/82
M     B  TWO (GRAESSLER 81 ABOVE).                                           3/82
M        3  2270.0     15.0           KITAGAKI  82 DBC     SIGMA0 PI+        2/82
M           . . . . . . . . . . .
M   AVG     2282.0      3.1     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.8)
                         (SEE IDEOGRAM BELOW)
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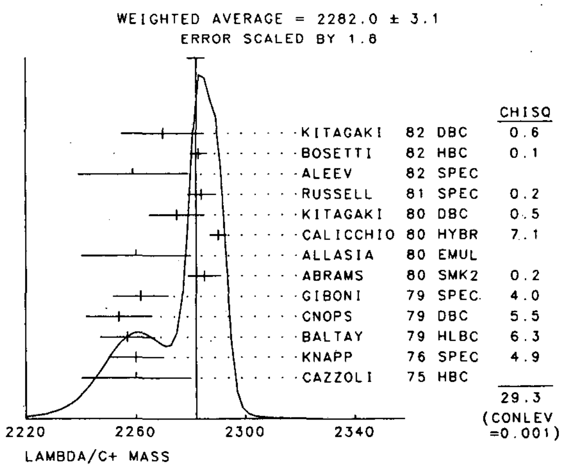

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33 LAMBDA/C+ MEAN LIFE (UNITS 10**-13 SEC)

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T        1   (7.3)                     ANGELINI  79 HYBR P K- PI+              12/79
T        4   (1.14)   (0.90)   (0.44)  USHIDA    80 EMUL LAM 3PI, P KBAR 2PI 12/81
T        1   (0.57)                    ADAMOVICH 81 EMUL LAMBDA PI+             2/82
T        8    2.3      1.0      0.6    USHIDA    83 EMUL REPL. USHIDA 80        2/84*
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33 LAMBDA/C+ PARTIAL DECAY MODES

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                                                          DECAY MASSES
P1      LAMBDA/C+ INTO LAMBDA PI+ PI+ PI-              1116+ 140+ 140+ 140
P2      LAMBDA/C+ INTO LAMBDA PI+                      1116+ 140
P3      LAMBDA/C+ INTO P KOBAR                          938+ 498
P4      LAMBDA/C+ INTO P K- PI+                         938+ 494+ 140
P5      LAMBDA/C+ INTO K*(892)0 P                       892+ 938
P6      LAMBDA/C+ INTO DEL(1232)++ K-                  1232+ 494
P7      LAMBDA/C+ INTO P KOBAR PI- PI+                  938+ 498+ 140+ 140
P8      LAMBDA/C+ INTO P K*(892)- PI+                   938+ 892+ 140
P9      LAMBDA/C+ INTO SIGMA+ PI0                      1189+ 135
P10     LAMBDA/C+ INTO SIGMA0 PI+                      1192+ 140
P11     LAMBDA/C+ INTO SIGMA+ ETA                      1189+ 549
P12     LAMBDA/C+ INTO E+ ANYTHING
P13     LAMBDA/C+ INTO P E+ ANYTHING
P14     LAMBDA/C+ INTO LAMBDA E+ ANYTHING
P15     LAMBDA/C+ INTO P PI- PI0 K0 E+ NEU              938+ 140+ 135+ 498+
P16     LAMBDA/C+ INTO LAMBDA ANYTHING
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33 LAMBDA/C+ BRANCHING RATIOS

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R1      LAMBDA/C+ INTO (P K- PI+)/TOTAL                       (P4)
R1       90   (SEEN)                   DRIJARD   79 SFM  P P AT 62.8 GEV ECM 12/79
R1       98   (SEEN)                   GIBONI    79 SPEC P P AT 63 GEV ECM   12/79
R1       18   (SEEN)                   LOCKMAN   79 SPEC P P 53, 62 GEV ECM  12/79
R1       39    0.022     0.010         ABRAMS    80 SMK2 E+E- 5.2 GEV ECM     1/80
R1        1   (SEEN)                   CALICCHIO 80 HBC  NU P IN BEBC-TST    12/81
R1       74   (SEEN)                   IRION     81 SPEC P P AT 63 GEV ECM    2/82

R2      LAMBDA/C+ INTO (P K*(892)0)/(P K- PI+)                (P5)/(P4)
R2        1   (SEEN)                   ANGELINI  79 HYBR NU EMUL WITH BEBC   12/79
R2       47   (SEEN)                   DRIJARD   79 SFM  P P AT 52.5 GEV ECM 12/79
R2             0.18      0.10          WEISS     80 SMK2 E+ E- 5.2 GEV ECM    4/82
R2       12    0.42      0.24          BASILE    81 CNTR P P -> LAM/C+ E- X   2/82
R2        THE ABOVE RATIOS INCLUDE THE KOBAR PI0 MODE OF THE K*0.             4/82
R2            . . . . . . . . . . .
R2  AVG        0.216     0.092    AVERAGE

R3  .   LAMBDA/C+ INTO (DEL(1232)++ K-)/(P K- PI+)            (P6)/(P4)       1/82
R3       40   (SEEN)                   DRIJARD   79 SFM  P P AT 52.5 GEV ECM 12/79
R3             0.17      0.07          WEISS     80 SMK2 E+ E- 5.2 GEV ECM    4/82
R3       17    0.40      0.17          BASILE    81 CNTR P P -> LAM/C+ E- X   1/82
R3            . . . . . . . . . . .
R3  AVG        0.203     0.081    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.3)

R4      LAMBDA/C+ INTO P KOBAR                                (P3)
R4        5   (SEEN)                   BALTAY    79 HLBC NU NE-H2 IN 15-FT    2/80
R4       10   (SEEN)                   KITAGAKI  80 DBC  NU D IN FNAL 15-FT  12/81
R4       55   (SEEN)             55/75 RUSSELL   81 SPEC PHOTOPRODUCTION      2/82

R5      LAMBDA/C+ INTO (P KOBAR)/(P K- PI+)                   (P3)/(P4)
R5       12    0.5       0.25          WEISS     80 SMK2 E+ E- 5.2 GEV ECM    4/82

R6      LAMBDA/C+ INTO (P K- PI+)/(P KOBAR)                   (P4)/(P3)      12/81
R6       50   (1.5)  OR LESS  CL=.90   RUSSELL   81 SPEC PHOTOPRODUCTION     12/81

R7      LAMBDA/C+ INTO LAMBDA PI+                             (P2)
R7        6   (SEEN)                   BALTAY    79 HLBC NU NE-H2 IN 15-FT    2/80
R7        9   (SEEN)                   KITAGAKI  80 DBC  NU D IN FNAL 15-FT  12/81

R8      LAMBDA/C+ INTO (LAMBDA PI+)/(P K- PI+)                (P2)/(P4)
R8            (0.8)  OR LESS  CL=0.9   WEISS     80 SMK2 E+ E- 5.2 GEV ECM    4/82

R9      LAMBDA/C+ INTO (LAMBDA PI+)/(P KOBAR)                 (P2)/(P3)
R9   K    5    0.67      0.78     0.35 BALTAY    79 HLBC NU NE-H2 IN 15-FT   12/81
R9        9    0.51      0.62     0.27 KITAGAKI  80 DBC  NU D IN FNAL 15-FT  12/81
R9       40   (0.4)  OR LESS  CL=.90   RUSSELL   81 SPEC PHOTOPRODUCTION     12/81
R9   K  CALCULATED BY KITAGAKI 80 FROM BALTAY 79 RESULTS.                    12/81
R9            . . . . . . . . . . .
R9  AVG        0.57      0.35     AVERAGE

R10     LAMBDA/C+ INTO LAMBDA PI+ PI+ PI-                     (P1)
R10       1    SEEN                    CAZZOLI   75 HBC  NU P IN BNL 7-FT     2/80
R10      60    SEEN                    KNAPP     76 SPEC GAMMA BE             2/80
R10       2    SEEN                    BALTAY    79 HLBC NU NE-H2 IN 15-FT    2/80
R10      12    SEEN                    GIBONI    79 SPEC P P AT 63 GEV ECM   12/79
R10      18    SEEN                    LOCKMAN   79 SPEC P P 53, 62 GEV ECM  12/79

R11     LAMBDA/C+ INTO (LAMBDA PI+ PI+ PI-)/(P K- PI+)        (P1)/(P4)
R11            1.4   OR LESS  CL=0.9   WEISS     80 SMK2 E+ E- 5.2 GEV ECM    4/82

R12     LAMBDA/C+ INTO (LAMBDA PI+ PI+ PI-)/ (P KOBAR)        (P1)/(P3)      12/81
R12     220   (3.1)  OR LESS  CL=.90   RUSSELL   81 SPEC PHOTOPRODUCTION     12/81

R13     LAMBDA/C+ INTO P KOBAR PI- PI+                        (P7)
R13      76    SEEN                    ALEEV     82 SPEC N CARBON 40 GEV     12/83*

R14     LAMBDA/C+ INTO (P KOBAR PI- PI+)/(P KOBAR)            (P7)/(P3)      12/81
R14      45    3.3   OR LESS  CL=.90   RUSSELL   81 SPEC PHOTOPRODUCTION     12/81

R15     LAMBDA/C+ INTO SIGMA0 PI+                             (P10)
R15       3    SEEN                    KITAGAKI  82 DBC  NU D IN FNAL 15-FT   2/82

R16     LAMBDA/C+ INTO P K*(892)- PI+                         (P8)
R16       1    SEEN                    CNOPS     79 DBC  NU N IN BNL 7-FT     2/80

R17     LAMBDA/C+ INTO (E+ ANYTHING)/TOTAL                    (P12)           3/82
R17            0.045     0.017         VELLA     82 SMK2 E+ E- 4.5-6.8 GEV    3/82

R18     LAMBDA/C+ INTO (P E+ ANYTHING)/TOTAL                  (P13)           3/82
R18  M         0.018     0.009         VELLA     82 SMK2 E+ E- 4.5-6.8 GEV    3/82
R18  M  THIS INCLUDES PROTONS FROM LAMBDA DECAY.                              3/82

R19     LAMBDA/C+ INTO (LAMBDA E+ ANYTHING)/TOTAL             (P14)           2/82
R19       1   (0.022)OR LESS  CL=.90   BALLAGH   81 HYBR NU NE-H2 IN 15-FT    2/82
R19  N         0.011     0.008         VELLA     82 SMK2 E+ E- 4.5-6.8 GEV    3/82
R19  N  THIS INCLUDES LAMBDAS FROM SIGMA0 DECAY.                              3/82

R20     LAMBDA/C+ INTO (LAMBDA E+ ANY.)/(LAMBDA ANY.)         (P14)/(P16)
R20  S         0.027     0.017         SON       82 DBC  NU D IN FNAL 15-FT  12/83*
R20  V         0.065     0.041         VELLA     82 SMK2 E+E- 4.5-6.8 GEV    12/83*
R20  S  SON 82 USES OWN DATA AND MU- E+ LAMBDA EVENTS OF MURTAGH 79 .        12/83*
R20  V  THIS VALUE DEDUCED BY SON 82 FROM DATA OF VELLA 82.                  12/83*
R20           . . . . . . . . . . .
R20 AVG        0.033     0.016    AVERAGE
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REFERENCES FOR LAMBDA/C+


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CAZZOLI  75 PRL 34 1125         +CNOPS,CONNOLY,LOUTTIT,MURTAGH, +      (BNL)
KNAPP    76 PRL 37 882          +LEE,LEUNG,SMITH +     (COLU+HAWA+ILL+FNAL)
BARISH   77 PR D15 1            +DERRICK,DOMBECK,MUSGRAVE +     (ANL+PURD)

ANGELINI 79 PL 84B 150           (ANKA+LIBH+CERN+DUUC+LOUC+KEYN+PISA+ROMA+)
BALTAY   79 PRL 42 1721         +CAROUMBALIS,FRENCH,HIBBS, +      (COLU+BNL)
CNOPS    79 PRL 42 197          +CONNOLLY,KAHN,KIRK,MURTAGH,PALMER+    (BNL)
DRIJARD  79 PL 85B 452          +FISCHER+   (CERN+CDEF+DORT+HEID+LAPP+WARS)
GIBONI   79 PL 85B 437          +DIBITONTO+  (AACH+CERN+HARV+MUNI+NWES+UCR)
KERNAN   79  LEPTON CONF.FNAL A. KERNAN                               (UCR)
LOCKMAN  79 PL 85B 443          +MEYER,RANDER,SCHLEIN,WEBB+     (UCLA+SACL)
MURTAGH  79 FERMILAB.SYMP.277 M.J. MURTAGH                           (FNAL)

ABRAMS   80 PRL 44 10           +ALAM,BLOCKER,BOYARSKI, +        (SLAC+LBL)
ALLASIA  80 NP B176 13           (ANKA+LIBH+CERN+DUUC+LOUC+KEYN+PISA+ROMA+)
CALICCHI 80 PL 93B 521          + (BARI+BIRM+BRUX+CERN+EPOL+RHEL+SACL+LOUC)
KITAGAKI 80 PRL 45 955          +TANAKA,YUTA,ABE, +(TOHO+IIT+UMD+STON+TUFT)
USHIDA   80 PRL 45 1053           (FNAL+MCGI+NAGO+OSU+OSKC+OTTA+TOKY+TNTO+)
WEISS    80 TORONTO CONF 319   J M WEISS                             (SLAC)

ADAMOVIC 81 PL 99B 271          ADAMOVICH+(PHOTON-EMUL,OMEGA-PHOTON COLLS.)
BALLAGH  81 PR D24 7            +BINGHAM +    (LBL+UCB+FNAL+HAWA+WASH+WISC)
BASILE   81 NC 62A 14           +CARA ROMEO +          (CERN+BGNA+PGIA+FRAS)
FIORINO  81 LNC 30 166           (PHOTON-EMUL COLLAB.+OMEGA-PHOTON COLLAB.)
   -- THE EVENT IN FIORINO 81 IS ALSO IN ADAMOVICH 81.
GRAESSLE 81 PL 99B 159          GRAESSLER,LANSKE+ (AACH+BONN+CERN+MPIM+OXF)
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Stable Particles — Data Card Listings

Λ_c^+, A^+, Λ_b^0, TOP HADRON SEARCHES, FREE QUARK SEARCHES

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IRION    81 PL 99B 495        +SEEBRUNNER, +   (AACH+CERN+HARV+MUNI+NWES)
RUSSELL  81 PRL 46 799        +AVERY,BUTLER,GLADDING +     (ILL+FNAL+COLU)
ALEEV    82 SJNP 35 687       + (JINR+AGDR+BUDA+LEBD+MOSU+PRAG+SOFI+TBLI)
BOSETTI  82 PL 109B 234       +GRAESSLER, +     (AACH+BONN+CERN+MPIM+OXF)
KITAGAKI 82 PRL 48 299        +TANAKA,YUTA,ABE,+ (TOHO+IIT+UMD+STON+TUFT)
SON      82 PRL 49 1128       +SNOW,CHANG,KUNORI+(UMD+IIT+STON+TOHO+TUFT)
VELLA    82 PRL 48 1515       +TRILLING,ABRAMS,ALAM,+      (SLAC+LBL+UCB)
USHIDA   83 PRL 51 2362         (AICH+FNAL+KOBE+SEOU+MCGI+NAGO+OSU+OKAY+)

                              THEORY AND REVIEW

DERUJULA 75 PR D12 147        +GEORGI,GLASHOW                      (HARV)
GAISSER  76 PR D14 3153       T.K.GAISSER,F.HALZEN            (BART+WISC)
LEE      77 PR D15 157        +QUIGG,ROSNER                        (FNAL)
MULLER   79 CERN/EP 79-148    F.MULLER (CARGESE LEC.1979)          (CERN)
DIBITONT 81 MADISON CONF.     D.DIBITONTO                          (CERN)
TRILLING 81 PRPL 75 57        G H TRILLING                          (LBL)

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A^+

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                    45  A+(2460,JP=  )

                    A NARROW SIGNAL (WIDTH COMPATIBLE WITH THE 23-MEV
                    RESOLUTION) INTERPRETED AS A STABLE CHARMED STRANGE
                    BARYON (QUARK CONTENT CSU).

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                    45  A+ MASS (MEV)

M       82 2460.      25.            BIAGI     83 SPEC    SIGMA- BE-->A+ X 11/83*

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                    45  A+ PARTIAL DECAY MODES

                                                          DECAY MASSES
P1      A+ INTO LAMBDA K- PI+ PI+                       1116+ 494+ 140+ 140

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                    45  A+ BRANCHING RATIOS

R1      A+ INTO LAMBDA K- PI+ PI+                          (P1)
R1       82    SEEN                  BIAGI     83 SPEC    SIGMA- BE-->A+ X 11/83*

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                              REFERENCES FOR A+(2460)

BIAGI    83 PL 122B 455       +   (BRIS+CERN+GEVA+HEID+LAUS+LOQM+MELB+RL)

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Λ_b^0

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                    40  LAMBDA/B0(5500, JP=  )

                    THE CLAIM BY BASILE 81 IS HOTLY DISPUTED BY DRIJARD 82.
                    BASILE 82 IS THE REPLY, AND DRIJARD1 82 IS THE REPLY TO
                    THAT.

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                    40  LAMBDA/B0 MASS  (MEV)

M          5425.0    175.0     75.0   BASILE    81 SFM  0  P P 62 GEV ECM    4/82

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                    40  LAMBDA/B0 PARTIAL DECAY MODES

                                                          DECAY MASSES
P1      LAMBDA/B0 INTO P D0 PI-                          938+1865+ 140

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                    40  LAMBDA/B0 BRANCHING RATIOS

R1      LAMBDA/B0 INTO (P D0 PI-)/TOTAL                    (P1)
R1          SEEN                  BASILE    81 SFM  D0 TO K- PI+          4/82

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                              REFERENCES FOR LAMBDA/B0

BASILE   81 LNC 31 97         +BONVICINI,CARA ROMEO+(CERN+BGNA+FRAS+PGIA)
BASILE   82 NC 68A 289        +BONVICINI,CARA ROMEO+      (CERN+BGNA+FRAS)
DRIJARD  82 PL 108B 361       +FISCHER,+  (CERN+CDEF+DORT+HEID+LAPP+WARS)
DRIJARD1 82 CERN/EP 82-31     +FISCHER,+  (CERN+CDEF+DORT+HEID+LAPP+WARS)

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TOP HADRON SEARCHES

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TE      SEARCH FOR TOP HADRON PRODUCTION IN (E+ E-) COLLISONS
TE   A  NONE ECM=22-31.6 GEV          BARTEL1   79 JADE R                    8/81
TE   B  NONE ECM=22-31.6 GEV          BARTEL2   79 JADE <S>                  8/81
TE   C  NONE ECM=31.6 GEV             BARBER    79 MRKJ R,<S>,<T>            6/82*
TE   D  NONE ECM=22-31.6 GEV          BERGER    79 PLUT R,<S>,<T>,MU         8/81
TE   E  NONE ECM=30-36 GEV            BARBER    80 MRKJ R,<T>,MU             8/81
TE   F  NONE ECM=12-31.6 GEV          BERGER    80 PLUT MU                   8/81
TE   G  NONE ECM=33-35.8 GEV          BARTEL    81 JADE MU                   2/82
TE   H  NONE ECM=14-36.7 GEV          BRANDELIK 82 TASS R                   10/83*
TE   I  NONE ECM < 38.54 GEV CL=.99   ADEVA1    83 MRKJ    R,<T>,(MU+MU-X)  11/83*
TE   J  NONE ECM < 38 GEV             ADEVA2    83 MRKJ    PT(MU),<T>       11/83*
TE
TE                                    COMMENTS
TE      ALL ABOVE MEASUREMENTS ARE DONE AT DESY-PETRA. THE LAST COLUMN        8/81
TE      SPECIFIES MEASURED QUANTITIES.                                        8/81
TE   A  BARTEL1 79 SAW NO EVIDENCE OF NEW Q=2/3 QUARK PROD. IN R-RATIO.      6/82*
TE
TE   B  BARTEL2 79 OBSERVE NO SIGNIFICANT ACCUMULATION OF SPHERICAL EVENTS.  8/81
TE
TE   C  BARBER 79 R,THRUST,SPHEROCITY INDICATE TOP-PRODUCTION UNLIKELY.     6/82*
TE
TE   D  BERGER 79 FIND R=3.88+0.22 WHICH ALONG WITH SPHERICITY AND THRUST    8/81
TE   D  BEHAVIORS IS AGAINST OPEN TOP ANTI-TOP CHANNEL BELOW 30GEV. FINAL    8/81
TE   D  MUONS ARE ALSO CONSISTENT WITH EXPECTATION WITHOUT TOP QUARK STATE.  8/81
TE
TE   E  BARBER 80 FIND NO EVIDENCE FOR AN OPEN TOP ANTI-TOP THRESHOLD IN R,  8/81
TE   E  THRUST DIST. AND INCLUSIVE MUONS. ENERGY SCAN IN THE RANGE 29.9<ECM  8/81
TE   E  <31.6GEV REVEALS NO HADRON RESONANCE CORRESPONDING TO A (TOP-QUARK   8/81
TE   E  ANTI-TOP-QUARK) BOUND STATE.                                         8/81
TE
TE   F  BERGER 80  MEASURES INCLUSIVE MUONS WITH MOMENTUM >2 GEV/C. AGREE    8/81
TE   F  WITH EXPECTED SEMILEPTONIC DECAYS FROM CHARMED AND BOTTOM MESONS.    8/81
TE
TE   G  BARTEL 81 MEASURES INCLUSIVE MUONS WITH MOMENTUM  >1.4 GEV/C. AGREE  2/82
TE   G  WITH EXPECTED SEMILEPTONIC DECAYS FROM CHARMED AND BOTTOM MESONS.    2/82
TE
TE   H  BRANDELIK 82 GOT R=4.01+-0.03+-0.2 WITH NO STEP FOR W>14GEV. NARROW 10/83*
TE   H  STATE SEARCH FOR W=33-36.7GEV SETS EE-WIDTH*BR(HAD)<1.5KEV(CL=.95). 10/83*
TE
TE   I  ADEVA1 ENERGY SCAN EXCLUDES OPEN TOP CONTINUUM BELOW 38.54 GEV AND  11/83*
TE   I  TOPONIUM BETWEEN 29.90 AND 38.63 GEV (HAD.BR*E-WIDTH < 2.0 KEV AT   11/83*
TE   I  CL=.95). ALSO SET LIMIT BR(B-->MU+MU-X) < 0.007 (CL=.95) WHICH      11/83*
TE   I  EXCLUDES FLAVOR-CHANGING NEUTRAL CURRENT IN TOPLESS MODELS.          11/83*
TE
TE                                    COMMENT
TE
TE      RECENT UPPER LIMITS ON THE FLAVOR CHANGING NEUTRAL CURRENT DECAY      1/84*
TE      OF BOTTOM MESON ARE IN CONFLICT WITH THE EXPECTED RATE IN THE         1/84*
TE      TOPLESS MODEL AND SERVE AS INDIRECT SUPPORT FOR THE TOP QUARK.        1/84*
TE      SEE PARTIAL DECAY MODE B-->MU+ MU- X OF THE BOTTOM MESON SECTION.     1/84*

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TP      SEARCH FOR TOP HADRON PRODUCTION IN (P PBAR) COLLISIONS
TP   A                                ARNISON   83 CALO    UA1 COLLAB.      11/83*
TP   B                                BARGER    83 RVUE                     11/83*
TP   C                                BASILE    83 RVUE                     11/83*
TP   D                                GODBOLE   83 RVUE                     11/83*
TP
TP   A  ARNISON 83 OBSERVED  11 LARGE-PT ELECTRON EVENTS WITH A JET OPPO-   11/83*
TP   A  SITE TO THE TRACK WITHIN A 30 DEGREE AZIMUTHAL ANGLE.                11/83*
TP   A  INTERPRETATION OF THESE AS T-->E NU JET IS GIVEN BY 3 RVUES BELOW.   11/83*
TP
TP   B  BARGER 83 FIND  MT(E NUE) DISTRIBUTION IS CONSISTENT WITH TOP.       11/83*
TP   B  FIT GIVES M(TOP)=34+-6 GEV.                                          11/83*
TP
TP   C  BASILE 83 MONTE-CARLO ANALYSIS FINDS EVENT-RATE IS CONSISTENT WITH   11/83*
TP   C  BOTH SUPERBEAUTY(M ABOUT 55 GEV) AND TOP (M ABOUT 35 GEV).           11/83*
TP
TP   D  GODBOLE 83 STUDIED EVENT-TOPOLOGY OF TOP DECAY.  ASSOCIATED HADRON   11/83*
TP   D  (B) MAKES A LARGE RELATIVE AZIM.ANGLE TO E AS SEEN BY ARNISON 83.    11/83*
TP
TP                                    NOTE
TP      BULK OF UA1 ELECTRON PLUS JET EVENTS DO NOT APPEAR TO HAVE ADDI-
TP      TIONAL SIGNATURES FROM THE ASSOCIATED TOP DECAY (T-AND BBAR-JET).
TP      SEE E.G. POSTSCRIPT IN BARGER 83.

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                              REFERENCES FOR TOP HADRON SEARCHES

BARTEL1  79 PL 88B 171        JADE C.(DESY+HAMB+HEID+MCHS+LANC+RHEL+TOKY)
BARTEL2  79 PL 89B 136        JADE C.(DESY+HAMB+HEID+MCHS+LANC+RHEL+TOKY)
BARBER   79 PL 85B 463        MARK-J COLLAB.    (AACH+DESY+MIT+AIKO+BHEP)
BERGER   79 PL 86B 413        PLUTO C.(AACH+BERG+DESY+HAMB+UMD+SIEG+WUPP)
BARBER   80 PRL 44 1722       MARK-J COLLAB.    (AACH+DESY+MIT+AIKO+BHEP)
BERGER   80 PRL 45 1533       PLUTO C.(AACH+BERG+DESY+HAMB+UMD+SIEG+WUPP)
BARTEL   81 PL 99B 277        +CORDS+(DESY+HAMB+HEID+LANC+MCHS+RHEL+TOKY)
BRANDELI 82 PL 113B 499       TASSO C.  (AACH+BONN+DESY+HAMB+LOIC+OXF+RL)

ADEVA1   83 PRL 50 799        MARKJ C. (AACH+DESY+MIT+MADR+AIKO+BHEP+CIT)
ADEVA2   83 PRL 51 443        MARKJ C. (AACH+DESY+MIT+MADR+AIKO+BHEP+CIT)
ARNISON  83 PL 122B 103       UA1-C.(AACH+LAPP+BIRM+CERN+HELS+LOQM+CDEF+)
BARGER   83 PL 125B 339       +MARTIN,PHILLIPS            (DURH+WISC+RHEL)
BASILE   83 LNC 37 255        +BERBIERS,BONVICINI,CARA+  (CERN+BGNA+FRAS)
GODBOLE  83 PRL 50 1539       R.M.GODBOLE,S.PAKVASA,D.P.ROY   (BOMB+TIFR)

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FREE QUARK SEARCHES

(by W.P. Trower, Virginia Polytechnic Institute and State University)

The idea that all hadrons are constructed from a set of fractionally charged constituents (quarks) is central to the quantum-chromodynamics description of particle scattering and hadron spectroscopy. Quantum-chromodynamics in its usual form contains the as-yet-unproven restriction that quarks must forever be confined to the mesons and baryons they make up.

Experiments support the conclusion that it is at best difficult to "unglue" quarks. Accelerator searches at increasing energies have produced no evidence for free quarks. Of the several candidate cosmic ray events, one

For notation, see key at front of Listings.

Stable Particles

FREE QUARK SEARCHES

still enjoys the active advocacy of its discoverer.[1] The only positive searches in matter, those of LARUE, have published no new data since November 1980.

This compilation should be used as a directory to the literature since the quoted experimental limits are often only indicative.

Reference

1. C.B.A. McCusker, Aust. J. Phys. **36**, 717 (1983).


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------ --------- --------- --------- --------- --------- --------- --------
C       QUARK PRODUCTION CROSS SECTION  --  ACCELERATOR SEARCHES
C
C       QUARK   X-SECT CHARGE     MASS     REFERENCE  DET       BEAM
C      EVENTS     CM2   1/3E      GEV                          GEV
C
C    G    0     <5E-3      -4      1-8  AIHARA     84 TPC      29E+E-          2/84*
C         0     <1E-36  +-1,2       <9  AUBERT     83 SPEC    200MU           2/84*
C    I    0     <3E-3   +-1,2       <2  BANNER     83 CNTR    540P AP        10/83*
C    H    0     <1E-4   +-1,2        -  LINDGREN   83 CNTR    106FE56         2/84*
C    HI   0     <3E-3  >+-1/6        -  PRICE      83 PLAS     74AR40        10/83*
C    G    0     <1E-2   +-1,2      <14  MARINI1    82 CNTR     29E+E-        10/83*
C    G    0     <8E-2   +-1,2      <12  ROSS       82 CNTR     29E+E-        10/83*
C    C    0     <2E-10  +-2,4      1-3  BUSSIERE   80 CNTR    200PROT         12/81
C    EF   0     <5E-38   +1,2       >5  STEVENSON  79 CNTR    300PROT         12/79
C         0     <1E-33    +-1      <20  BASILE1    78 SPEC     52P P           2/79
C    E    0     <9E-39  +-1,2       <6  ANTREASYA  77 SPEC    400PROT         11/77
C    D    0     <8E-35   +1,2      <20  FABJAN     75 CNTR     52P P           1/77
C         0     <5E-38   -1,2      4-9  NASH       74 CNTR    200PROT          2/77
C         0     <1E-32   +2,4     4-24  ALPER      73 SPEC     52P P           1/76
C         0     <5E-31 +1,2,4      <12  LEIPUNER   73 CNTR    300PROT         2/74
C         0     <6E-34  +-1,2      <13  BOTT       72 CNTR     52P P           2/74
C         0     <1E-36    -4        4  ANTIPOV     71 CNTR     70PROT          1/76
C    B    0     <1E-35  +-1,2       2  ALLABY      69 CNTR     28PROT          1/76
C    C    0     <4E-37    -2       <5  ANTIPOV1     69 CNTR     70PROT          2/74
C    B    0     <3E-37   -1,2      2-5  ANTIPOV2     69 CNTR     70PROT          1/76
C         0     <1E-35   +1,2       <7  DORFAN      65 CNTR     30PROT          2/74
C    A    0     <2E-35     -2   <2.5-5  FRANZINI    65 CNTR     30PROT          3/77
C         0     <5E-35   +1,2     <2.2  BINGHAM     64 HLBC     21PROT          3/77
C         0     <1E-32  +1,+2     <4.0  BLUM        64  HBC     28PROT          3/77
C    A    0     <1E-35  +1,+2     <2.5  HAGOPIAN    64  HBC     31PROT          3/77
C         0     <1E-34     +1       <2  LEIPUNER    64 CNTR     28PROT          3/77
C         0     <1E-33   +1,2     <2.4  MORRISON    64  HBC     24PROT          3/77

C    I - BOUND TO NUCLEI.
C    H - FOR X-SECT READ FRACTION OF FRAGMENTS.
C    G - FOR X-SECTION READ X-SECT(Q-Q X)/X-SECT(MU-MU)
C    F - 3E-5 < LIFETIME < 1E-3 S.
C    E - X-SECTION  CM2/GEV2.
C    D - INCLUDES BOTT 72 RESULTS.
C    C - HADRONIC OR LEPTONIC QUARKS.
C    B - ASSUMES ISOTROPIC CM PRODUCTION.
C    A - CROSS SECTION INFERRED FROM FLUX.

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D       QUARK DIFFERENTIAL PRODUCTION CROSS SECTION  -- ACCELERATOR SEARCHES
D
D       QUARK  X-SECT    CHARGE    MASS     REFERENCE  DET       BEAM
D      EVENTS CM2/SR/GEV 1/3E      GEV                          GEV
D
D         0     <4E-36   -2,4    1.5-6  BALDIN     76 CNTR    70PROT          1/77
D         0     <2E-33    +-4     5-20  ALBROW     75 SPEC    52P P           1/77
D         0     <5E-34     <7     7-15  JOVANOVIC  75 CNTR    44P P          11/75
D    A    0     <5E-35      -        -  GALIK      74 CNTR    20GAMMA         7/76
D         0     <9E-35   -1,2        -  NASH       74 CNTR   200PROT          2/77
D         0     <4E-36     -4  2.3-2.7  ANTIPOV     71 CNTR    70PROT          1/76
D         0     <3E-35  +-1,2     <2.7  ALLABY      69 CNTR    27PROT          1/76
D         0     <7E-38   -1,2     <2.5  ANTIPOV2    69 CNTR    70PROT          1/76

D    A - X-SECTION IN  CM**2/SR/EQUIV. QUANTA .

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FR      QUARK FLUX  --  ACCELERATOR SEARCHES
FR
FR      QUARK   FLUX/  CHARGE     MASS     REFERENCE  DET       BEAM
FR     EVENTS  NUEVENT  1/3E      GEV                          GEV
FR
FR    E    0     <3E-4     +-2    1.8-2  WEISS      81 SMK2     7E+E-          1/82
FR    E    0     <5E-2 +1,2,4,5   2-12  BARTEL     80 JADE    27E+E-          2/82
FR    AB   0     <2E-5     +1,2       -  BASILE     80 CNTR     NU            12/81
FR    D*   0     <3E-10  +-2,4      1-3  BOZZOLI    79 CNTR    200PROT        12/79
FR    *    0     <6E-11    +-1      <21  BASILE1    78 SPEC     52P P          2/79
FR         0     <5E-3       -        -  BASILE2    78 CNTR     NUMU           7/79
FR    *    0     <2E-9     +-1      <26  BASILE     77 SPEC     62P P          1/78
FR    C*   0     <7E-10   +1,2      <20  FABJAN     75 CNTR     52PROT         1/77
FR    AB   0       -      +1,2     >4.5  GALIK      74 CNTR     GAMMA          7/76
FR    AB   0       -      +1,2     >1.5  BELLAMY    68 CNTR     12E-           3/77
FR    A    0       -      +1,2     >0.9  BATHOW     67 CNTR     GAMMA          3/77
FR    A    0       -      +1,2     >0.9  FOSS       67 CNTR     6GAMMA         3/77
FR
FR    E - FOR FLUX READ QUARK PROD. X-SECTION  RATIO TO CSE+E->MU+MU  .
FR    D - QUARK LIFETIMES >1.E-8 S.
FR    C - ONE CANDIDATE M <.17 GEV.
FR    B - HADRONIC QUARK.
FR    A - LEPTONIC QUARK.
FR    * - QUARK FLUX PER CHARGED PARTICLE.

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F       QUARK FLUX  --  COSMIC RAY SEARCHES
F
F       QUARK   FLUX   CHARGE     MASS     REFERENCE  DET    SHIELDING
F      EVENTS /CM2/S/SR 1/3E      GEV                          KG/CM2
F
F         0     <2E-12 +-1,2,3       -  MASHIMO    83 CNTR      -0.3*        10/83*
F         0     <3E-10  +-1,2        -  MARINI2    82 CNTR       0.3         10/83*
F    C    0     <8E-10  +-1,2        -  NAPOLITAN  82 CNTR       0.3         10/83*
F    F    3       -        -         -  YOCK       78 CNTR        -           2/79
F    A    0     <1E-9      -         -  BRIATORE   76 ELEC        -           1/77
F    B    0     <2E-11     +1        -  HAZEN      75 CC          -           7/76
F         0     <2E-10   +1,2        -  KRISOR     75 CNTR        -           3/77
F    BE   0     <1E-7    +1,2        -  CLARK      74 CC          -           1/77
F         0     <3E-10     +1      >20  KIFUNE     74 CNTR        -           7/76
F    B    0     <8E-11     +1        -  ASHTON     73 CNTR        -           3/77
F         0     <2E-8    +1,2        -  HICKS      73 CNTR        -           1/76
F         0     <5E-10     +4        -  BEUCHAMP   72 CNTR      2.8*          3/77
F    B    0     <1E-10   +1,2        -  BOHM       72 CNTR        -           2/74
F         0     <1E-10   +1,2        -  COX        72 ELEC      2.8*          3/77
F         0     <3E-10     +2        -  CROUCH     72 CNTR        -           3/77
F    A    0     <3E-8      -         -  DARDO      72 CNTR        7           3/77
F    B    0     <4E-9      +1        -  EVANS      72 CC          -           1/77
F    A    0     <2E-9      -       >10  TONWAR     72 CNTR        -           3/77
F         0     <2E-10     +1        -  CHIN       71 CNTR      2.8*          3/77
F    B    0     <3E-10   +1,2        -  CLARK      71 CC          -           3/77
F    B    0     <1E-10   +1,2        -  HAZEN      71 CC          -           2/77
F         0     <5E-10   +1,2        -  BOSIA      70 CNTR      3.5*          1/78
F    B    1       (-)    +1,2     <6.5  CHU        70 HLBC        -           5/76
F         0     <2E-9      +1        -  FAISSNER   70 CNTR        -           3/77
F         0     <2E-10   +1,2        -  KRIDER     70 CNTR      0.8*          3/77
F         4     <5E-11     +2        -  CAIRNS     69 CC          -           3/77
F         0     <8E-10   +1,2      <10  FUKUSHIMA  69 CNTR        -           2/74
F    BD   1       -        +2        -  MCCUSKER   69 CC          -           2/74
F    A    0     <1E-10     -        >5  BJORNBOE   68 CNTR     1.7,3.6        2/74
F    C    0     <1E-8 +-1,2,4        -  BRIATORE   68 CNTR      6.3,.2*       5/76
F         0     <3E-8      -        >2  FRANZINI   68 CNTR        -           2/74
F         0     <9E-11   +-1,2        -  GARMIRE    68 CNTR        -           3/77
F         0     <4E-10    +-1        -  HANAYAMA   68 CNTR        -           3/77
F         0     <3E-8      -       >15  KASHA1     68 OSPK        -           2/74
F         0     <2E-10     +2        -  KASHA2     68 CNTR        -           3/77
F         0     <2E-10     +4        -  KASHA3     68 CNTR        -           3/77
F         0     <2E-10     +2        -  BARTON     67 CNTR        6           3/77
F         0     <2E-7      +4        -  BUHLER1    67 CNTR  0.008,0.5*          3/77
F         0     <5E-10     1,2       -  BUHLER2    67 CNTR  0.008,0.5*          3/77
F         0     <4E-10   +1,2        -  GOMEZ      67 CNTR        -           3/77
F         0     <2E-9      +2        -  KASHA      67 CNTR        -           3/77
F         0     <2E-10     +2        -  BARTON     66 CNTR      220           3/77
F         0     <2E-9    +1,2        -  BUHLER     66 CNTR      0.5*          3/77
F         0     <3E-9    +1,2        -  KASHA      66 CNTR        -           3/77
F         0     <2E-9    +1,2        -  LAMB       66 CNTR        -           3/77
F         0     <2E-8    +1,2       >7  DELISE     65 CNTR      2.8*          3/77
F         0     <5E-8      +2     >2.5  MASSAM     65 CNTR      0.5*          3/77
F         0     <2E-8      +1        -  BOWEN      64 CNTR      2.5*          3/77
F         0     <2E-7      +1        -  SUNYAR     64 CNTR      0.8           3/77
F
F    F - LIFETIME >10**-8 S; CHARGE +-.70,.68,.42; AND MASS
F      >4.4, 4.8, AND 20 GEV, RESPECTIVELY.
F    E - ALSO 1/4 AND 1/6E CHARGES.
F    D - NO EVENTS IN SUBSEQUENT EXPTS.
F    C - LEPTONIC QUARKS.
F    B - PROMPT AIR SHOWER SEARCH.
F    A - TIME DELAYED AIR SHOWER SEARCH.
F    * - ALTITUDE IN KM. ALL OTHERS SEALEVEL.

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RHO     QUARK DENSITY  --  MATTER SEARCHES
RHO
RHO     QUARK  QUARKS/ CHARGE     MASS     REFERENCE  MATERIAL/METHOD
RHO    EVENTS  NUCLEON  1/3E      GEV
RHO
RHO       0     <9E-20  +-<13        -  JOYCE      83  WATER/OIL DROP         10/83*
RHO       0     <2E-21  +->1/2       -  LIEBOWITZ  83  LEVITATED STEEL       10/83*
RHO       0     <1E-19  +-1,2        -  VANDESTEE  83  PHOTO ION SPEC        10/83*
RHO  B    0     <2E-20     -         -  HODGES     81  MERCURY/OIL DROP       2/82
RHO       4     <2E-20    -1         -  LARUE      81  LEVITATED NIOBIUM      1/82
RHO       4     <2E-20    +1         -  LARUE      81  LEVITATED NIOBIUM      1/82
RHO       0     <1E-21     -         -  MARINELLI  80  LEVITATED STEEL       12/81
RHO       0     <6E-16     -         -  BOYD       79  HELIUM/MASS SPEC      12/79
RHO       3     <5E-21    +1         -  LARUE      79  LEVITATED NIOBIUM      7/79
RHO       0     <4E-28     -         -  OGORODNIK  79  EARTH+/ION BEAM       10/81
RHO       0     <5E-15    +1         -  BOYD1      78  TUNGSTEN/MASS SPEC     8/78
RHO       0     <5E-16    +3      <1.7  BOYD2      78  HYDROGEN/MASS SPEC     1/79
RHO       0     <1E-21  +-2,4        -  LUND       78  WATER/ION BEAM        12/81
RHO       0     <6E-15   >1/2        -  PUTT       78  LEVITATED TUNGSTEN     2/79
RHO       0     <1E-22     -         -  SCHIFFER   78  METALS/MASS SPEC       2/79
RHO       0     <5E-15     -         -  BLAND      77  LEVITATED TUNGSTEN OX  8/77
RHO       0     <3E-21     -         -  GALLINARO  77  LEVITATED IRON         7/77
RHO       1     (1E-2)    -1         -  LARUE      77  LEVITATED NIOBIUM      7/77
RHO       2     (1E-2)    +1         -  LARUE      77  LEVITATED NIOBIUM      7/77
RHO       0     <1E-13    +3      <7.7  MULLER     77  HYDROGEN/MASS SPECTRA  12/79
RHO       0     <5E-27     -         -  OGORODNIK  77  WATER+/ION BEAM       12/79
RHO       0     <1E-21     -         -  STEVENS    76  LUNAR+/ION SPEC        3/77
RHO       0     <1E-15    +1       <60  ELBERT     70  OXYGEN+/ION SPEC       3/77
RHO       0     <5E-19     -         -  MORPURGO   70  LEVITATED GRAPHITE     3/77
RHO       0     <5E-23     -         -  COOK       69  WATER+/ATOM BEAM       3/77
RHO       0     <1E-17  +-1,2        -  BRAGINSKI  68  LEVITATED GRAPHITE     3/77
RHO       0     <1E-17     -         -  RANK       68  WATER+/UV SPEC         3/77
RHO       0     <3E-19    +-1        -  STOVER     67  LEVITATED IRON         2/74
RHO  A    0     <1E-10     -         -  BENNETT    66  SUN/UV SPEC            3/77
RHO       0     <1E-17    +1,2       -  CHUPKA     66  METORITES+/ION BEAM    3/77
RHO       0     <1E-16    +-1        -  GALLINARO  66  LEVITATED GRAPHITE     3/77
RHO       0     <1E-22     -         -  HILLAS     59  ARGON/ELECTROMETER     3/77
RHO
RHO  B - ALSO SET LIMITS FOR Q=+-1/6E.
RHO  A - LIMIT INFERRED BY JONES 76.

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REFERENCES FOR QUARK SEARCHES

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AIHARA   84 PRL 52 168        +          (LBL+UCLA+UCR+JHU+MASA+TOKY+YALE)
AUBERT   83 PL 133B 461        (CERN+DESY+FREI+KIEL+LANC+LAPP+LIVP+MARS+)
BANNER   83 PL 121B 187        UA2        (BERN+CERN+BOHR+LALO+PAVI+SACL)
JOYCE    83 PRL 51 731        +ABRAMS,BLAND,JOHNSON,LINDGREN+       (SFSU)
LIEBOWIT 83 PRL 50 1640       LIEBOWITZ,BINDER,ZIOCK                (VIRG)
LINDGREN 83 PRL 51 1621       +JOYCE,ABRAMS+ (SFSU+UCR+UCI+SLAC+LBL+LANL)
MASHIMO  83 PL 128B 327       +ORITO,KAWAGOE,NAKAMURA,NOZAKI        (TOKY)
PRICE    83 PRL 50 566        +TINCKNELL,TARLE,AHLEN,FRANKEL+        (UCB)
VANDESTE 83 PRL 50 1234       VANDESTEEG,JONGBLOETS,WYDER           (NIJM)
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Stable Particles

Data Card Listings

FREE QUARK SEARCHES, MAGNETIC MONOPOLE SEARCHES


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MARINI1  82 PRL 48 1649        +PERUZZI,PICCLO+  (FRAS+LBL+NWES+STAN+HAWA)
MARINI2  82 PR D26 1777        +PERUZZI,PICCLO+  (FRAS+LBL+NWES+STAN+HAWA)
NAPOLITA 82 PR D25 2837        NAPOLITANO,BESSET+(STAN+FRAS+LBL+NWES+HAWA)
ROSS     82 PL 118B 199        +RONGA,BESSET+    (FRAS+LBL+NWES+STAN+HAWA)
HODGES   81 PRL 47 1651        +ABRAMS,BADEN,BLAND,JOYCE,ROYER+ (UCR+SFSU)
LARUE    81 PRL 46 967         +PHILLIPS,FAIRBANK                (STAN)
WEISS    81 PL 101B 439        +ABRAMS,ALAM,BLOCKER,BLONDEL+(SLAC+LBL+UCB)
BARTEL   80 ZPHY C6 295         JADE  (DESY+HAMB+HEID+LANC+MCHS+RHEL+TOKY)
BASILE   80 LNC 29 251         +BERBIERS,CONTIN+(BGNA+CERN+FRAS+ROMA+BARI)
BUSSIERE 80 NP B174 1          +GIACOMELLI,LESQUOY+        (BGNA+SACL+LAPP)
MARINELL 80 PL 94B 433         MARINELLI,MORPURGO                (GENO)
    ALSO 80 PL 94B 427         MARINELLI,MORPURGO                (GENO)
BOYD     79 PRL 43 1288        +BLATT,DONOGHUE,DRIES,HAUSMAN,SUITER  (OSU)
BOZZOLI  79 NP B159 363        +BUSSIERE,GIACOMELLI+ (BGNA+LAPP+SACL+CERN)
LARUE    79 PRL 42 142         +FAIRBANK,PHILLIPS                (STAN)
  ERRATA 79 PRL 42 1019        LARUE,FAIRBANK,PHILLIPS
OGORODNI 79 JETP 49 953        OGORODNIKOV,SAMOILOV,SOLNTSEV        (KIAE)
STEVENSO 79 PR D20 82          STEVENSON                             (LBL)
YOCK     78 PR D18 641         YOCK                                 (AUCK)
BASILE1  78 NC 45A 171         +CARAROMEO,CIFARELLI,CONTIN+    (CERN+BGNA)
BASILE2  78 NC 45A 281         +CARAROMEO,CIFARELLI,CONTIN+    (CERN+BGNA)
BOYD1    78 PRL 40 216         +ELMORE,MELISSINOS,SUGARBAKER        (ROCH)
BOYD2    78 PL 72B 484         +ELMORE,NITZ,OLSEN,SUGARBAKER,WARREN+(ROCH)
LUND     78 RAD. ACTA 25 75    +BRANDT,FARES                        (PHIL)
PUTT     78 PR D17 1466        +YOCK                                (AUCK)
SCHIFFER 78 PR D17 2241        +RENNER,GEMMELL,MOORING          (CHIC+ANL)
ANTREASY 77 PRL 39 513         ANTREASYAN,COCCONI,CRONIN,FRISCH+(EFI+PRIN)
BASILE   77 NC 40A 41          +CARA ROMEO,CIFARELLI,GIUSTI+   (CERN+BGNA)
BLAND    77 PRL 39 369         +BOCOBO,EUBANK,ROYER                 (SFSU)
GALLINAR 77 PRL 38 1255        GALLINARO,MARINELLI,MORPURGO         (GENO)
LARUE    77 PRL 38 1011        +FAIRBANK,HEBARD                     (STAN)
MULLER   77 SCI 196 521        +ALVAREZ,HOLLEY+STEPHENSON            (LBL)
OGORODNI 77 JETP 45 857        OGORODNIKOV,SAMOILOV,SOLNTSEV        (KIAE)
BALDIN   76 SJNP 22 264        +VERTOGRADOV,VISHNEVSKII,GRISHKEVICH+(JINR)
BRIATORE 76 NC 31A 553         +DARDO,PIAZZOLI,MANNOCCHI+ (LCGT+FRAS+FREI)
STEVENS  76 PR D14 716         +SCHIFFER,CHUPKA                      (ANL)
ALBROW   75 NP B97 189         +BARBER,BENZ+(CERN+DARE+FOM+LANC+MCHS+UTRE)
FABJAN   75 NP B101 349        +GRUHN,PEAK,SAULI,CALDWELL+     (CERN+MPIM)
HAZEN    75 NP B95 189         +HODSON,WINTERSTEIN,GREEN,KASS+ (MICH+LEED)
JOVANOVI 75 PL 56B 105         JOVANOVICH+ (MANI+AACH+CERN+GENO+HARV+TORI)
KRISOR   75 NC 27A 132         KRISOR                               (AACH)
CLARK    74 PR D10 2721        +FINN,HANSEN,SMITH                    (LLL)
GALIK    74 PR D9 1856         +JORDAN,RICHTER,SEPPI,SIEMANN+  (SLAC+FNAL)
KIFUNE   74 JPSJ 36 629        +HIEDA,KUROKAWA,TSUNEMOTO,KIMURA+(TOKY+KEK)
NASH     74 PRL 32 858         +YAMANOUCHI,NEASE,SCULLI    (FNAL+CORN+NYU)
ALPER    73 PL 46B 265         + (CERN+LIVP+LUND+BOHR+RHEL+STOH+BERG+LOUC)
ASHTON   73 JPA 6 577          +COOPER,PARVARESH,SALEH              (DURH)
HICKS    73 NC 14A 65          +FLINT,STANDIL                       (MANI)
LEIPUNER 73 PRL 31 1226        +LARSEN,SESSOMS,SMITH,WILLIAMS+  (BNL+YALE)
BEUCHAMP 72 PR D6 1211         +BOWEN,COX,KALBACH                   (ARIZ)
BOHM     72 PRL 28 326         +DIEMONT,FAISSNER,FASOLD,KRISOR+     (AACH)
BOTT     72 PL 40B 693         +CALDWELL,FABJAN,GRUHN,PEAK+    (CERN+MPIM)
COX      72 PR D6 1203         +BEUCHAMP,BOWEN,KALBACH              (ARIZ)
CROUCH   72 PR D5 2667         +MORI,SMITH                          (CASE)
DARDO    72 NC 9A 319          +NAVARRA,PENENGO,SITTE               (TORI)
EVANS    72 PRSE A70 143       +FANCEY,MUIR,WATSON             (EDIN+LEED)
TONWAR   72 JPA 5 569          +NARANAN,SREEKANTAN                  (TIFR)
ANTIPOV  71 NP B27 374         +KACHANOV,KUTJIN,LANDSBERG,LEBEDEV+  (SERP)
CHIN     71 NC 2A 419          +HANAYAMA,HARA,HIGASHI,TSUJI         (OSAK)
CLARK    71 PRL 27 51          +ERNST,FINN,GRIFFIN,HANSEN,SMITH+ (LLL+LBL)
HAZEN    71 PRL 26 582         HAZEN                                (MICH)
BOSIA    70 NC 66A 167         +BRIATORE                            (TORI)
CHU      70 PRL 24 917         +KIM,BEAM,KWAK                (OSU+ROSE+KANS)
    ALSO 70 PRL 25 550         ALLISON,DERRICK,HUNT,SIMPSON,VOYVODIC (ANL)
ELBERT   70 NP B20 217         +ERWIN,HERB,NIELSEN,PETRILAK,WEINBERG(WISC)
FAISSNER 70 PRL 24 1357        +HOLDER,KRISOR,MASON,SAWAF,UMBACH    (AACH)
KRIDER   70 PR D1 835          +BOWEN,KALBACH                       (ARIZ)
MORPURGO 70 NIM 79 95          +GALLINARO,PALMIERI                  (GENO)
ALLABY   69 NC 64A 75          +BIANCHINI,DIDDENS,DOBINSON,HARTUNG+ (CERN)
ANTIPOV1 69 PL 29B 245         +KARPOV,KHROMOV,LANDSBERG,LAPSHIN+   (SERP)
ANTIPOV2 69 PL 30B 576         +BOLOTOV,DEVISHEV,DEVISHEVA,ISAKOV+  (SERP)
CAIRNS   69 PR 186 1394        +MCCKUSKER,PEAK,WOOLCOTT             (SYDN)
COOK     69 PR 188 2092        +DEPASQUALI,FRAUENFELDER,PEACOCK +    (ILL)
FUKUSHIM 69 PR 178 2058        FUKUSHIMA,KIFUNE,KONDO,KOSHIBA+      (TOKY)
MCCUSKER 69 PRL 23 658         +CAIRNS                              (SYDN)
BELLAMY  68 PR 166 1391        +HOFSTADTER,LAKIN,PERL,TONER    (STAN+SLAC)
BJORNBOE 68 NC B53 241         +DAMGARD,HANSEN+        (BOHR+TIFR+BERN+BERG)
BRIATORE 68 NC 57A 850         +CASTAGNOLI,BOLLINI,MASSAM+(TORI+CERN+BGNA)
FRANZINI 68 PRL 21 1013        +SHULMAN                             (COLU)
GARMIRE  68 PR 166 166         +LEONG,SREEKATAN                      (MIT)
HANAYAMA 68 CJP 46 S734        +HARA,HIGASHI,KITAMURA,MIONO+        (OSAK)
KASHA1   68 PR 172 1297        +STEFANSKI                      (BNL+YALE)
KASHA2   68 PRL 20 217         +LARSEN,LEIPUNER,ADAIR          (BNL+YALE)
KASHA3   68 CJP 46 S730        +LARSEN,LEIPUNER,ADAIR          (BNL+YALE)
MRAGINSK 68 JEPT 27 51         MRAGINSKII,ZELDOVICH,MARTYNOV,MIGULIN(MOSU)
RANK     68 PR 176 1635        RANK                                 (MICH)
BARTON   67 PRSL 90 87         BARTON                               (NPOL)
BATHOW   67 PL 25B 163         +FREYTAG,SCHULZ,TESCH                (DESY)
BUHLER1  67 NC 49A 209         +FORTUNATO,MASSAM+ZICHICHI      (CERN+BGNA)
BUHLER2  67 NC 51A 837         +DALPIAZ,MASSAM,ZICHICHI   (CERN+BGNA+STRB)
FOSS     67 PL 25B 166         +GARELICK,HOMMA,LOBAR,OSBORNE,UGLUM   (MIT)
GOMEZ    67 PRL 18 1022        +KOBRAK,MOLINE,MULLINS,ORTH,VANPUTTEN+(CIT)
KASHA    67 PR 154 1263        +LEIPUNER,WANGLER,ALSPECTOR,ADAIR(BNL+YALE)
STOVER   67 PR 164 1599        +MORAN,TRISCHKA                      (SYRA)
BARTON   66 PL 21 360          +STOCKEL                             (NPOL)
BENNETT  66 PRL 17 1196        BENNETT                              (YALE)
BUHLER   66 NC 45A 520         +FORTUNATO,MASSAM,MULLER+  (CERN+BGNA+STRB)
CHUPKA   66 PRL 17 60          +SCHIFFER,STEVENS                     (ANL)
GALLINAR 66 PL 23 609          GALLINARO,MORPURGO                   (GENO)
KASHA    66 PR 150 1140        +LEIPUNER,ADAIR                 (BNL+YALE)
LAMB     66 PRL 17 1068        +LUNDY,NOVEY,YOVANOVITCH              (ANL)
MASSAM   65 NC 40A 589         +MULLER,ZICHICHI                     (CERN)
FRANZINI 65 PRL 14 196         +LEONTIC,RAHM,SAMIOS,SCHWARTZ   (BNL+COLU)
DORFAN   65 PRL 14 999         +EADES,LEDERMAN,LEE,TING             (COLU)
DELISE   65 PR 140B 458        +BOWEN                               (ARIZ)
BINGHAM  64 PL 9 201           +DICKINSON,DIEBOLD,KOCH,LEITH+  (CERN+EPOL)
BLUM     64 PRL 13 353A        +BRANDT,COCCONI,CZYZEWSKI,DANYSZ+    (CERN)
BOWEN    64 PRL 13 728         +DELISE,KALBACH,MORTARA              (ARIZ)
HAGOPIAN 64 PRL 13 280         +SELOVE,EHRLICH,LEBOY,LANZA,RAHM+(PENN+BNL)
LEIPUNER 64 PRL 12 423         +CHU,LARSEN,ADAIR               (BNL+YALE)
MORRISON 64 PL 9 199           MORRISON                             (CERN)
SUNYAR   64 PR 136B 1157       +SCHWARZSCHILD,CONNORS                (BNL)
HILLAS   59 NAT 184 B92        +CRANSHAW                            (AERE)

                             REVIEWS

LYONS    81 PPNP 7 157         LYONS                                (OXF)
JONES    76 RMP 69 717         JONES                               (MICH)
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MAGNETIC MONOPOLE SEARCHES

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(by W.P. Trower, Virginia Polytechnic Institute and State University)

Although the usual formulation of Maxwell's equations suggests magnetic monopoles, no observed phenomenon requires them for its explanation.[1] From the assertion that a monopole anywhere in the universe would result in electric charge quantization everywhere followed the prediction of a least magnetic charge $G = e/2\alpha$, the Dirac charge.[2] Observed pure multiphoton events have been attributed to virtual monopole production and annihilation.[3] Monopoles have recently become indispensable to many gauge theories, which endow them with a variety of extraordinarily large masses.

Monopole detectors have predominantly used either induction or ionization. Induction experiments measure the monopole magnetic charge by detecting a change in current when a monopole passes through a loop.[4] These measurements, which are independent of monopole electric charge, mass, and velocity, have produced a solitary monopole candidate event (CABRERA 82), uncorroborated by later searches (e.g., CABRERA 83).

Ionization experiments rely on a magnetic charge producing more ionization than an electrical charge with the same velocity. However, the ability to distinguish a monopole by ionization diminishes with velocity. The theory of monopole energy loss for $\beta \leq 10^{-3}$ is still unsettled.

Cosmic rays are the most likely source of large-mass monopoles, as accelerator energies are insufficient to produce them. Evidence for such monopoles may also be obtained from astrophysical observations.

This compilation should be used as a directory to the literature since the quoted experimental limits are often only indicative.

References

1. J.D. Jackson, CERN-77-17 (1977).
2. P.A.M. Dirac, Proc. Royal Soc. London **A133**, 60 (1931).
3. M.A. Ruderman and D. Zwanziger, Phys. Rev. Lett. **22**, 146 (1969).
4. L.W. Alvarez, LRL Physics Note 470 (1963).

For notation, see key at front of Listings. **Stable Particles**

MAGNETIC MONOPOLE SEARCHES, AXION SEARCHES

MONOPOLE PRODUCTION CROSS SECTION -- ACCELERATOR SEARCHES

		MONOPOLE EVENTS	X-SECT CM**2	MASS GEV	G	REFERENCE		DET	BEAM GEV	
C		0	<1E-31	-	1,3	AUBERT	83	PLAS	540P AP	10/83*
C		0	<4E-38	<10	<6	MUSSET	83	PLAS	34E+E-	10/83*
C	A	0	<8E-36	<20	-	DELL	82	CNTR	52P P	3/83*
C		0	<9E-37	<30	<3	KINOSHITA	82	PLAS	29E+E-	2/82
C		0	<1E-37	<20	<24	CARRIGAN	78	CNTR	63P P	2/79
C		0	<1E-37	<30	<3	HOFFMANN	78	PLAS	56P P	2/79
C	A	0	-	-	-	DELL	76	SPRK	62P P	4/82
C	A	0	<4E-33	-	-	STEVENS	76	SPRK	300PROT	4/82
C	C	0	<1E-40	<5	<2	ZRELOV	76	CNTR	70PROT	1/80
C	A	0	<2E-30	-	-	BURKE	75	OSPK	300NEUT	1/78
C	B	0	<1E-38	-	-	CARRIGAN	75	HLBC	8NU	1/76
C		0	<5E-43	<12	<10	EBERHARD	75	INDU	400PROT	1/75
C		0	<2E-36	<30	<3	GIACOMELL	75	PLAS	60P P	2/76
C		0	<5E-42	<13	<24	CARRIGAN	74	CNTR	400PROT	12/75
C		0	<6E-42	<12	<24	CARRIGAN	73	CNTR	300PROT	3/74
C		0	<1E-41	<5	-	GUREVICH	72	EMUL	70PROT	3/74
C		0	<1E-40	<3	<2	AMALDI	63	EMUL	28PROT	12/75
C		0	<2E-40	<3	<2	PURCELL	63	CNTR	30PROT	12/75
C		0	<1E-35	<3	<4	FIDECARO	61	CNTR	28PROT	4/82
C		0	<2E-35	<1	1	BRADNER	59	EMUL	6PROT	4/82

C C - CHERENKOV RADIATION POLARIZATION.
C B - RE-EXAMINES CERN NEUTRINO EXPTS.
C A - MULTIPHOTON EVENTS.

MONOPOLE FLUX -- COSMIC RAY SEARCHES

		MONOPOLE EVENTS	FLUX /CM2/S/SR	MASS GEV	G	REFERENCE		DET	COMMENTS	
F		0	<4E-13	-	1	TARLE	84	CNTR	6E-4<B<2E-3	2/84*
F	D	7	-	-	-	ANDERSON	83	EMUL		2/84*
F		0	<4E-13	-	1	BARTELT	83	CNTR	E-2<B<E-3	3/83*
F		0	<1E-12	-	1	BARWICK	83	PLAS	7E-3<B<1	2/84*
F		0	<5E-12	-	1	BATTISTON	83	CNTR	1E-4<B<1	2/84*
F		0	<3E-13	-	1	BONARELLI	83	CNTR	1E-3<B<4E-1	10/83*
F	C	0	<3E-12	-	-	BOSETTI	83	CNTR	5E-4<B<5E-2	2/84*
F		0	<4E-11	-	1	CABRERA	83	INDU		2/84*
F		0	<5E-15	-	1	DOKE	83	PLAS	1E-2<B<1	10/83*
F	C	0	<8E-15	-	-	ERREDE	83	CNTR	1E-4<B<1E-1	10/83*
F	C	0	<7E-22	-	-	FREESE	83	COSM	PULSARS	2/84*
F		0	<5E-12	-	1	GROOM	83	CNTR	1E-4<B<3E-2	3/83*
F		0	<2E-12	-	-	MASHIMO	83	CNTR	6E-4<B<1	10/83*
F	C	0	<1E-18	<1E18	1	REPHAELI	83	COSM	INTERGLAC. FIELD	2/84*
F		0	<1E-13	-	1	ALEXEYEV	82	CNTR	B=3E-3	1/83*
F		0	<2E-12	-	1	BONARELLI	82	CNTR	7E-3<B<6E-1	3/83*
F		1	6E-10	-	1	CABRERA	82	INDU	DG=+-.06	4/82
F	C	0	<1E-23	-	-	DIMOPOULO	82	COSM	NEUT STARS	2/84*
F	C	0	<5E-22	-	-	KOLB	82	COSM	NEUT STARS	10/83*
F		0	<2E-11	-	-	MASHIMO	82	CNTR	7E-3<B<3	3/83*
F	B	0	<1E-12	-	1	TURNER	82	COSM	B=3E-3	1/83*
F		0	<2E-15	-	-	BARTLETT	81	PLAS	CONCENTRATOR	2/82
F		0	<2E-40	-	-	BONNARDEA	81	COSM	NEUT STARS	2/82
F		0	<1E-13	>1	-	KINOSHITA	81	PLAS	1E-3<B	2/82
F		0	<5E-11	<1E17	-	ULLMAN	81	CNTR	3E-4<B<1E-3	2/82
F		0	<2E-11	-	-	BARTLETT	78	PLAS	CONCENTRATOR	2/82
F	A	1	(1E-1)	>200	2	PRICE	75	PLAS	-	12/75
F		0	<2E-13	-	>2	FLEISCHER	71	PLAS	-	1/83*
F		0	<1E-16	-	1	PARKER	70	COSM	GALACTIC FIELD	1/83*
F		0	<1E-19	-	>2	FLEISCHER3	69	PLAS	OBSIDIAN, MICA	2/76
F		0	<5E-15	<15	<3	CARITHERS	66	ELEC	CONCENTRATOR	12/75
F		0	<2E-11	-	<1-3	MALKUS	51	EMUL	CONCENTRATOR	4/82

F D - ANOMALOUS LONG-RANGE ALPHA TRACKS.
F C - CATALYSIS OF NUCLEON DECAY.
F B - REEVALUATES PARKER 80 LIMIT FOR GUT MONOPOLES.
F A - ALVAREZ 75, FLEISCHER 75, FRIEDLANDER 75, ROSS 76EXPLAIN AS
F FRAGMENTING NUCLEUS. EBERHARD 75 DISCUSSES CONFLICT WITH OTHER
F EXPTS. HAGSTROM REINTERPRETS AS ANTINUCLEUS. PRICE 78 REASSESSES.

MONOPOLE DENSITY -- MATTER SEARCHES

	MONOPOLE EVENTS	DENSITY	G	REFERENCE		DET	MATERIAL	
D	>1	>1E-14/GRAM	>1/3	MIKHAILOV	83	SPEC	IRON AEROSOLS	2/84*
D	0	<6E-33/NUCL	1	SCHATTEN	83	ELEC	MOON WAKE	10/83*
D	0	<2E-R/GRAM	-	CARRIGAN	80	COSM	EARTH HEAT	10/83*
D	0	<2E-4/PROT	-	BRODERICK	79	COSM	42-CM ABSORPTION	12/81
D	0	<6E-4/GRAM	-	CARRIGAN	76	CNTR	AIR, SEAWATER	1/77
D	0	<5E-1/GRAM	>.04	CABRERA	75	INDU	11 MATERIALS	5/82*
D	0	<2E-4/GRAM	>.05	ROSS	73	INDU	MOON ROCK	2/76
D	0	<6E-7/GRAM	<140	KOLM	71	CNTR	SEAWATER	12/75
D	0	<2E-13/M**3	-	SCHATTEN	70	ELEC	MOON WAKE	4/77
D	0	<1E-4/GRAM	>0	FLEISCH2	69	PLAS	MANGANESE	12/75
D	0	<1E-2/GRAM	<120	FLEISCH1	69	PLAS	MANGANESE NODULES	4/82
D	0	<2E-3/GRAM	<1-3	GOTO	63	EMUL	MAGNETITE, METEOR	12/75
D	0	<2E-2/GRAM	-	PETUKHOV	63	CNTR	METEORITE	12/75

REFERENCES FOR MAGNETIC MONOPOLE SEARCHES

TARLE	84	PRL 52 90	+AHLEN,LISS	(UCB+MICH+IND)
ANDERSON	83	PR D28 2308	+LORD,STRAUSZ,WILKES	(WASH)
AUBERT	83	PL 120B 465	+MUSSET,PRICE,VIALLE	(CERN+LAPP)
BARWICK	83	PR D28 2338	+KINOSHITA,PRICE	(UCB)
BARTELT	83	PRL 50 655	+COURANT,HELLER,JOYCE,MARSHAK+	(MINN+ANL)
BATTISTO	83	PL 133B 454	BATTISTONI,BELLOTTI+	(FRAS+MILA+TORI+CERN)
BONARELL	83	PL 126B 137	BONARELLI,CAPILUPPI,DANTONE	(BGNA)
BOSETTI	83	PL 133B 265	+GORHAM,HARRIS,LEARNED+	(AACH+HAWA+TOKY)
CABRERA	83	PRL 51 1933	+TABER,GARDNER,BOURG	(STAN)
DOKE	83	PL 129B 370	+HAYAHSI,HAMASAKI+	(TWAS+TRIK+TTAM+IPCR)
ERREDE	83	PRL 51 245	+STONE+	(UCI+MICH+BNL+CIT+CLEV+HAWA+LOUC)
FREESE	83	PRL 51 1625	+TURNER,SCHRAMM	(CHIC)
GROOM	83	PRL 50 573	+LOH,NELSON,RITSON	(UTAH+STAN)
MASHIMO	83	PL 128B 327	+ORITO,KAWAGOE,NAKAMURA,NOZAKI	(TOKY)
MIKHAILO	83	PL 130B 331	MIKHAILOV	(KAZA)
MUSSET	83	PL 128B 333	+PRICE,LOHRMANN	(CERN+HAMB)
REPHAELI	83	PL 121B 115	+TURNER	(CHIC)
SCHATTEN	83	PR D27 1525	SCHATTEN	(NASA)
ALEXEYEV	82	LNC 35 413	+BOLIEV,CHUDAKOV,MAKOEV,MIKHEYEV+	(INRM)
BONARELL	82	PL 112B 100	BONARELLI,CAPILUPPI,DANTONE,+	(BGNA)
CABRERA	82	PRL 48 1378	CABRERA	(STAN)
DIMOPOUL	82	PL 119B 320	DIMOPOULOS,PRESKILL,WILCZEK	(HARV+UCSB)
DELL	82	NP B209 45	+YUAN,ROBERTS,DOOHER+AMALDI+	(BNL+ADEL+ROMA)
KINOSHIT	82	PRL 48 77	KINOSHITA,PRICE,FRYBERGER	(UCB+SLAC)
KOLB	82	PRL 49 1373	+COLGATE,HARVEY	(LASL+PRIN)
MASHIMO	82	JPSJ 51 3067	+KAWAGOE,KOSHIBA	(TOKY)
TURNER	82	PR D26 1296	+PARKER,BOGDAN	(CHIC)
BARTLETT	81	PR D24 612	+SOO,FLEISCHER,HART,MOGROCAMPERO	(COLO+GESC)
BONNARDE	81	PR D23 323	BONNARDEAU	(MPIM)
KINOSHIT	81	PR D24 1707	KINOSHITA,PRICE	(UCB)
ULLMAN	81	PRL 47 289	ULLMAN	(LEHM+BNL)
CARRIGAN	80	NAT 288 348	CARRIGAN	(FNAL)
BRODERIC	79	PR D19 1046	BRODERICK,FICENEC,TEPLITZ,TEPLITZ	(VPI)
BARTLETT	78	PR D18 2253	+SOO,WHITE	(COLO+PRIN)
CARRIGAN	78	PR D17 1754	+STRAUSS,GIACOMELLI	(FNAL+BGNA)
HOFFMANN	78	LNC 23 357	+KANTARDJIAN,DILIBERTO,MEDDI+	(CERN+ROMA)
PRICE	78	PR D18 1382	+ SHIRK,OSBORNE,PINSKY	(UCB+HOUS)
HAGSTROM	77	PRL 38 729	HAGSTROM	(LBL)
CARRIGAN	76	PR D13 1823	+NEZRICK,STRAUSS	(FNAL)
DELL	76	LNC 15 269	+UTO,YUAN,AMALDI+	(CERN+BNL+ROMA+ADEL)
ROSS	76	LBL-4665	ROSS	(LBL)
STEVENS	76	PR D14 2207	+COLLINS,FICENEC,TROWER,FISCHER+	(VPI+BNL)
ZRELOV	76	CZJP B26 1306	+KOLLAROVA,KOLLAR,LUPILTSEV,PAVLOVIC+	(JINR)
ALVAREZ	75	LBL-4260	ALVAREZ	(LBL)
BURKE	75	PL 60B 113	+GUSTAFSON,JONES,LONGO	(MICH)
CABRERA	75	PH D THESIS	CABRERA	(STAN)
CARRIGAN	75	NP B91 279	+NEZRICK	(FNAL)
ALSO	71	PR D3 56	+NEZRICK	(FNAL)
EBERHARD	75	LBL-4289	EBERHARD	(LBL)
EBERHARD	75	PR D11 3099	+ROSS,TAYLOR,ALVAREZ,OBERLACK	(LBL+MPIM)
FLEISCHE	75	PRL 35 1412	FLEISCHER,WALKER	(GESC+WUSL)
FRIEDLAN	75	PRL 35 1167	FRIEDLANDER	(WUSL)
GIACOMEL	75	NC 28A 21	GIACOMELLI,ROSSI,+	(BGNA+CERN+SACL+ROMA)
PRICE	75	PRL 35 487	+SHIRK,OSBORNE,PINSKY	(UCB+HOUS)
CARRIGAN	74	PR D10 3867	+NEZRICK,STRAUSS	(FNAL)
CARRIGAN	73	PR D8 3717	+NEZRICK,STRAUSS	(FNAL)
ROSS	73	PR D8 698	+EBERHARD,ALVAREZ,WATT	(LBL+SLAC)
ALSO	71	PR D4 3260	EBERHARD,ROSS,ALVAREZ,WATT	(LBL+SLAC)
ALSO	70	SCI 167 701	ALVAREZ,EBERHARD,ROSS,WATT	(LBL+SLAC)
GUREVICH	72	PL 38B 549	+KHAKIMOV,MARTEMIANOV+	(KIAE+NOVO+SERP)
ALSO	72	JETP 34 917	BARKOV,GUREVICH,ZOLOTAREV	(KIAE+NOVO+SERP)
ALSO	70	PL 31B 394	+KHAKIMOV,MARTEMIANOV	(KIAE+NOVO+SERP)
FLEISCHE	71	PR D4 24	FLEISCHER,HART,NICHOLS,PRICE	(GESC)
KOLM	71	PR D4 1285	+VILLA,ODIAN	(MIT+SLAC)
PARKER	70	APJ 160 383	PARKER	(CHIC)
SCHATTEN	70	PR D1 2245	SCHATTEN	(NASA)
FLEISCH1	69	PR 177 2029	FLEISCHER,JACOBS,SCHWARTZ,PRICE	(GESC+FSU)
FLEISCH2	69	PR 184 1393	FLEISCHER,HART,JACOBS,+	(GESC+UNCS+GSCO)
FLEISCH3	69	PR 184 1398	FLEISCHER,PRICE,WOODS	(GESC)
ALSO	70	JAP 41 958	+HART,JACOBS,PRICE,SCHWARTZ,WOODS	(GESC)
CARITHER	66	PR 149 1070	CARITHERS,STEFANSKI,ADAIR	(YALE+BNL)
AMALDI	63	NC 28 773	+BARONI,MANFREDINI,BRADNER+	(ROMA+UCSD+CERN)
GOTO	63	PR 132 387	+KOLM,FORD	(TOKY+MIT+BRAN)
PETUKHOV	63	NP 49 87	+YAKIMENKO	(LEBD)
PURCELL	63	PR 129 2326	+COLLINS,FUJII,HORNBOSTEL,TURKOT	(HARV+BNL)
FIDECARO	61	NC 22 657	+FINOCCHIARO,GIACOMELLI	(CERN)
BRADNER	59	PR 114 603	+ISBELL	(LBL)
MALKUS	51	PR 83 899	MALKUS	(CHIC)

BIBLIOGRAPHIES

CRAVEN	82	FERMILAB-82/96	+TROWER	(FNAL+VPI)
RUZICKA	80	JINR 2-80-850	+ZRELOV	(JINR)
CRAVEN	81	FERMILAB-81/37	+TROWER,CARRIGAN	(VPI+FNAL)
CARRIGAN	77	FERMILAB-77/42	CARRIGAN	(FNAL)
STEVENS	73	VPI-EPP-73-5	STEVENS	(VPI)

REVIEWS

CARRIGAN	83	NAT 305 673	+TROWER	(FNAL+VPI)

AXION SEARCHES

→

AX **VARIOUS AXION SEARCHES IN PRODUCTION OR DECAY** 1/83*
AX (VALUES QUOTED ARE AXION PRODUCTION RATIO TO PI0 PROD CROSS SEC.) 1/83*
AX FOR THEORY AND REVIEW SEE WEINBERG PRL 40, 223 (1978); WILCZEK
AX PRL 40, 279 (1978); DONNELLY PR D18, 1607 (1978); BARSHAY ET AL.,
AX PRL 46, 1361 (1981); BARROSO+MUKHOPADHYAY PL 106, 91 (1981); AND
AX PECCEI, PROC. INTL. NEUTRINO CONF., MAUI(1981), ED. CENCE (HAWAII).
AX FOR INVISIBLE-AXION THEORY SEE E.G. WISE, GEORGI AND GLASHOW
AX PRL 47, 402 (1981), AND FOR VERY HEAVY AXION THEORY SEE E.G. TYE
AX PRL 47, 1035 (1981). FOR K --> PI A0 SEE ALSO E.G., GOLDMAN
AX AND HOFFMAN, PRL 40, 220 (1978), FRERE ET AL., PL 103B, 129 (1981).

AXP **AXION PRODUCTION IN HADRONIC COLLISIONS AND VARIOUS BEAM DUMP EXPTS.**
AXP LIMITS ARE FOR CS(A0)/CS(PI0).

AXP		1. E-8 OR LESS	CL=.90	ALIBRAN	78	HYBR	BEAM DUMP	6/78
AXP		6. E-9 OR LESS	CL=.95	ASRATYAN	78	CALO	BEAM DUMP	12/79
AXP	A	5.4E-14 OR LESS	CL=.90	BELLOTTI	78	HLBC	FOR MASS=1.5 MEV	1/79
AXP	A	4.1E- 9 OR LESS	CL=.90	BELLOTTI	78	HLBC	FOR MASS=1 MEV	1/79
AXP	A	1.5E- 8 OR LESS	CL=.90	BELLOTTI	78	HLBC	BEAM DUMP	1/79
AXP	B	1. E-8 OR LESS	CL=.90	BOSETTI	78	HYBR	BEAM DUMP	6/78
AXP	C			DONNELLY	78			12/79
AXP		0.5E-8 OR LESS	CL=.90	HANSL1	78	WIRE	BEAM DUMP	6/78
AXP	D			MICELMACH	78			12/79
AXP	E			VYSOTSSKI	78			1/80
AXP	F			BECHIS	79	CNTR		12/79
AXP	G	1. E-8 OR LESS	CL=.90	COTEUS	79	OSPK	BEAM DUMP	7/79
AXP	H	1. E-3 OR LESS	CL=.95	DISHAW	79	CALO	400 GEV P P	12/79
AXP	I	0		FAISSNER	80	OSPK	BEAM DUMP,A0-->E+E-	1/82
AXP	J	1. E-8 OR LESS	CL=.90	JACQUES	80	HLBC	28 GEV PROTONS	9/81
AXP	J	1. E-14 OR LESS	CL=.90	JACQUES	80	HLBC	BEAM DUMP	9/81
AXP	K			SOUKAS	80	CALO	28GEV P B.DUMP	9/81
AXP	L	12		FAISSNE1	81	OSPK	CERN PS NU WIDEBAND	6/82*
AXP	M	15		FAISSNE2	81	OSPK	BEAM DUMP,A0-->2GAM	2/82
AXP	N	8		KIM	81	OSPK	26 GEV P NUC-->A0 X	1/82
AXP	O			FETSCHER	82	RVUE	CF.FAISSNER2 81	11/83*
AXP	P	24		FAISSNER	83	OSPK	BEAM-DUMP,A0-->2GAM	11/83*
AXP	Q			FAISSNER2	83	RVUE	LAMPF BEAM DUMP	1/84*
AXP	R			HOFFMAN	83	CNTR	PI-P-->N(A0-->E+E-)	11/83*

AXP A BELLOTTI 78 FIRST VALUE COMES FROM SEARCH FOR A-->E+E-. SECOND 1/79
AXP A VALUE COMES FROM SEARCH FOR A-->2GAMMA, ASSUMING MASS<2*MASS(E-). 1/79
AXP A FOR ANY MASS SATISFYING THIS,LIMIT IS ABOVE VALUE*(MASS**-4). 1/79
AXP A THIRD VALUE USES DATA OF PL 60B 401 AND QUOTES CS(PROD)*CS(INTER- 1/79
AXP A ACTION)<10**-67 CM**4. 1/79

Stable Particles

Data Card Listings

AXION SEARCHES, OTHER STABLE PARTICLE SEARCHES

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AXP  B  BOSETTI 78 QUOTES CS(PROD)*CS(INTERACT)< 2.E-67 CM**4                 6/78
AXP
AXP  C  DONNELLY 78 EXAMINES DATA FROM REACTOR NEUTRINO EXPTS OF REINES 76   12/79
AXP  C  AND GURR 74 AS WELL AS SLAC BEAM DUMP EXPT. EVIDENCE IS NEGATIVE.    12/79
AXP
AXP  D  MICELMACHER 78 FINDS NO EVIDENCE OF AXION EXISTENCE IN REACTOR       12/79
AXP  D  EXPTS OF REINES 76 AND GURR 74. (SEE REF UNDER DONNELLY 78 BELOW).    12/79
AXP
AXP  E  VYSOTSSKII 78 DERIVED LOWER LIMIT FOR THE AXION MASS. 25 KEV FROM     1/80
AXP  E  LUMINOSITY OF THE SUN AND 200 KEV FROM RED SUPERGIANTS.               1/80
AXP
AXP  F  BECHIS 79 LOOKED FOR THE AXION PRODUCTION IN LOW ENERGY ELECTRON      12/79
AXP  F  BREMSSTRAHLUNG AND THE SUBSEQUENT DECAY INTO EITHER 2 GAMMAS OR       12/79
AXP  F  E+ E-. NO SIGNAL FOUND. C.L.=0.90 LIMITS FOR MODEL PARAMETER(S)       12/79
AXP  F  ARE GIVEN.                                                            12/79
AXP
AXP  G  COTEUS 79 IS A BEAM DUMP EXPERIMENT AT BNL.                           12/79
AXP
AXP  H  DISHAW 79 IS A CALORIMETRIC EXPERIMENT AND LOOKS FOR LOW ENERGY       12/79
AXP  H  TAIL OF ENERGY DISTRIBUTUIONS DUE TO ENERGY LOST TO WEAKLY            12/79
AXP  H  INTERACTING PARTICLES.                                                12/79
AXP
AXP  I  FAISSNER 80 IS SIN BEAM DUMP EXPT WITH 590 MEV PROTONS LOOKING FOR    1/82
AXP  I  A0-->E+ E- DECAY. ASSUMING A0/PI0=5.5E-7,OBTAINED DECAY RATE LIMIT    1/82
AXP  I  20/(A0 MASS) MEV/SEC (CL=.90),WHICH IS ABOUT 10**-7 BELOW THEORY      1/82
AXP  I  AND INTERPRETED AS UPPER LIMIT TO MASS(A0) < 2* MASS(E-).             1/82
AXP
AXP  J  JACQUES 80 IS A BNL BEAM DUMP EXP.  FIRST LIMIT ABOVE COMES FROM      9/81
AXP  J  NON-OBSERVATION OF EXCESS NC-TYPE EVENTS (CS(PROD)*CS(INTERACT) <     9/81
AXP  J  7.E-68 CM**4,CL=0.90).  SECOND LIMIT IS FROM NON-OBSERVATION OF       9/81
AXP  J  AXION DECAYS INTO TWO GAMMAS OR E+E-, AND FOR AXION MASS A FEW MEV.   9/81
AXP
AXP  K  SOUKAS 80 AT BNL OBSERVED NO EXCESS OF NC-TYPE EVENTS IN BEAM DUMP.   9/81
AXP
AXP  L  FAISSNER1 81 SEE EXCESS MU E EVENTS. SUGGEST AXION INTERACTIONS.      6/82*
AXP
AXP  M  FAISSNER2 81 IS SIN 590MEV PROTON BEAM DUMP. OBSERVED 14.5+-5.0 EVS   2/82
AXP  M  OF 2 GAMMA DECAY OF LONG-LIVED NEUTRAL PENETRATING PARTICLE WITH      2/82
AXP  M  M(2 GAMMA) < APPROX. 1 MEV. AXION INTERPR. WITH ETA-A0 MIXING GIVES   2/82
AXP  M  M(A0)=(250+-25)KEV, TAU(2 GAMMA)=(7.3+-3.7)E-3 SEC FROM ABOVE RATE.   2/82
AXP
AXP  N  KIM 81 ANALYZED 8 CANDIDATES FOR A0-->2 GAMMA OBTAINED BY AACHEN-     1/82
AXP  N  PADOVA EXPT AT CERN WITH 26 GEV PROTONS ON BE. ESTIMATED AXION MASS   1/82
AXP  N  IS ABOUT 300 KEV AND LIFE IS (0.86 TO 5.6)E-3 S DEPENDING MODELS.     1/82
AXP  N  FAISSNER, PRIV. COMM, SAYS AXION PROD. UNDERESTIMATED AND MASS        4/82
AXP  N  OVERESTIMATED.  CORRECT VALUE AROUND 200 KEV.                         4/82
AXP
AXP  O  FETSCHER 82 RE-ANALYZES SIN BEAM-DUMP DATA OF FAISSNER 81. CLAIMS     11/83*
AXP  O  NO EVIDENCE FOR AXION SINCE 2-GAMMA PEAK RATE REMARKABLY DECREASES    11/83*
AXP  O  IF IRON WALL IS SET IN FRONT OF THE DECAY REGION.                     11/83*
AXP
AXP  P  FAISSNER 83 OBSERVED 19 1-GAMMA AND 12 2-GAMMA EVENTS WHERE A BKGD    11/83*
AXP  P  OF 4.8 AND 2.3 RESPECTIVELY IS EXPECTED. A SMALL-ANGLE PEAK IS        11/83*
AXP  P  OBSERVED EVEN IF IRON WALL IS SET IN FRONT OF THE DECAY REGION.       11/83*
AXP
AXP  Q  FAISSNER2 83 EXTRAPOLATE SIN GAM SIGNAL TO LAMPF NEU EXP CONDITION.   1/84*
AXP  Q  RESULTING 370 GAMMAS ARE NOT AT VARIANCE WITH LAMPF UPPER LIMIT       1/84*
AXP  Q  OF 450 GAMMAS. DERIVED FROM LAMPF LIMIT THAT (DSIGMA(A0)/DOMEGA AT    1/84*
AXP  Q  90 DEG)*M(A0)/TAU(A0) < 14*10**-35 CM**2*SR**-1*MEV*MILLISEC**-1.     1/84*
AXP
AXP  R  HOFFMAN 83 SET CL=.90 LIMIT DSIGMA/DT*BR(E+E-)<3.5E-32 CM**2/GEV**2   11/83*
AXP  R  FOR 140 <M(A0)<160 MEV. LIMIT ASSUMES TAU(A0) < 10**-9 SEC.           11/83*

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AXD     AXION SEARCHES IN THE DECAY OR TRANSITION OF POSITRONIUM,QUARKONIUM,
AXD     KAON,NUCLEON,AND RADIOACTIVE NUCLEUS. LIMITS ARE FOR BRANCHING RATIO
AXD  A                                CALAPRICE 79          CARBON          9/81
AXD  B                                ZHITNITSK 79          HEAVY AXION     9/81
AXD  C   0                            ASANO     81 CNTR STOPPED K+-->PI+ A0   2/82
AXD  D                                VUILLEUMI 81 CNTR REACTOR,A0--> 2 GAM   1/84*
AXD  E   0                            ZEHNDER   81 CNTR BA*-->(A0-->2GAM)BA   1/82
AXD  F                                ALEKSEEV  82 CNTR LI*,D* TR. A0->2GAM   11/83*
AXD  G   0                            ASANO     82 CNTR STOPPED K+-->PI+ A0   11/83*
AXD  H                                BARROSO   82     PHOTO-PROD.IN STARS   11/83*
AXD  I                                DATAR     82 CNTR LIGHT WATER REACTOR   1/83*
AXD  J      1.4 E-5  OR LESS  CL=.90  EDWARDS   82 CBAL J/PSI-->A0 GAMMA      11/83*
AXD  K                                LEHMANN   82 CNTR CU*-->(A0-->2GAM)CU   1/83*
AXD  L      3.5 E-4  OR LESS  CL=.90  SIVERTZ   82 CUSB UPSI(1S)-->A0 GAMMA   11/83*
AXD  L      1.2 E-4  OR LESS  CL=.90  SIVERTZ   82 CUSB UPSI(3S)-->A0 GAMMA   11/83*
AXD  M   0                            ZEHNDER   82 CNTR LI*,NB*DECAY,N-CAPT   1/83*
AXD  N      3.  E-4  OR LESS  CL=.90  ALAM      83 CLEO UPSI(1S)-->A0 GAMMA   11/83*
AXD  O                                CARBONI   83 CNTR ORTHO-POSITRONIUM     11/83*
AXD  P                                CAVAIGNAC 83 CNTR NB97*,D*TR.A0->2GAM   11/83*
AXD  Q      9.1 E-4  OR LESS  CL=.90  NICZYPORU 83 LENA UPSI(1S)-->A0 GAMMA   11/83*
AXD
AXD  A  CALAPRICE 79 SAW NO AXION EMISSION FROM EXCITED STATES OF CARBON.     9/81
AXD  A  SENSITIVE TO AXION MASS BETWEEN 1 AND 15 MEV.                         9/81
AXD
AXD  B  ZHITNITSKII 79 ARGUE THAT A HEAVY AXION BY YANG (3<M<40 MEV)         9/81
AXD  B  CONTRADICTS EXPERIMENTAL MUON ANOM. MAGNETIC MOMENTS.                 9/81
AXD
AXD  C  ASANO 81 IS KEK EXPT. SET BR(K+ -->PI+ A0) < 3.8E-8 AT CL=.90.        2/82
AXD
AXD
AXD  D  VUILLEUMIER 81 IS AT GRENOBLE REACTOR. SET LIMIT M(A0)<280 KEV.      1/84*

AXD  E  ZEHNDER 81 LOOKED FOR BA*-->A0 BA TRANSITION WITH A0-->2 GAMMA.      1/82
AXD  E  OBTAINED 2GAMMA COINCIDENCE RATE < 2.2E-5 /SEC(CL=.95) EXCLUDING     1/82
AXD  E  MASS(A0)>160 KEV(OR 200 KEV DEPENDING ON HIGGS MIXING).              1/82
AXD  E  HOWEVER, SEE BARROSO + MUKHOPADHYAY, REF. ABOVE.                     4/82
AXD
AXD  F  ALEKSEEV 82 WITH IBR-2 PULSED REACTOR EXCLUDE STANDARD A0 AT CL=.95  11/83*
AXD  F  MASS-RANGES M(A0)<400 KEV (LI* DECAY) AND 330 KEV<M(A0)<2.2MEV       11/83*
AXD  F  (DEUT* DECAY).                                                       11/83*
AXD
AXD  G  ASANO 82 AT KEK SET LIMITS FOR BR(K+-->PI+ A0) FOR M(A0)<100 MEV AS  1/83*
AXD  G  BR <4.E-8 FOR TAU(A0-->N-GAMMAS)>1.E-9S, BR<1.4E-6 FOR TAU<1.E-9S.   1/83*
AXD                                                                          1/83*
AXD  H  BARROSO 82 DERIVE IN DFS-MODEL(PL104B,199)  A0 MASS LIMITS FROM      11/83*
AXD  H  STELLER-ENERGY-LOSS BOUND. ALLOWED MASS REGIONS ARE                  11/83*
AXD  H  M(A0)<10 EV (AXION INVISIBLE DUE TO VERY SMALL COUPLING), AND        11/83*
AXD  H  M(A0) AROUND 200 KEV (CORRESPONDING DFS-A0 PARAM IS HARDLY           11/83*
AXD  H  COMPATIBLE WITH REACTOR DATA OF ZEHNDER 81).                         11/83*
AXD
AXD  I  DATAR 82 LOOKED FOR A0-->2 GAMMA IN NEUTRON CAPTURE (N P-->D A0) AT  1/83*
AXD  I  TARAPUR 500 MW REACTOR. SENSITIVE TO SUM OF I=0 AND I=1 AMPLITUDES.  1/83*
AXD  I  WITH ZEHNDER 81((I=0)-(I=1)) RESULT, ASSERT NON-EX OF STANDARD A0.   1/83*
AXD
AXD  J  EDWARDS 82 LOOKED FOR J/PSI-->GAMMA+AXION DECAYS BY LOOKING FOR      4/82
AXD  J  EVENTS WITH A SINGLE GAMMA (OF ENERGY APPROX. 1/2 THE J/PSI MASS),   4/82
AXD  J  PLUS NOTHING ELSE IN THE DETECTOR. THE LIMIT IS INCONSISTENT WITH    11/83*
AXD  J  THE AXION INTERPRETATION OF THE FAISSNER2 81 RESULT.                 11/83*
AXD                                                                          1/83*
AXD  K  LEHMANN 82 OBTAINED A0-->2GAM RATE<6.2E-5 /SEC (CL=.95) EXCLUDING    1/83*
AXD  K  MASS(AXION) BETWEEN 100 AND 1000 KEV.                                1/83*
AXD  L  SIVERTZ 82 IS CESR EXPT. LOOKED FOR UPSI-->GAMMA A0, A0 UNDETECTED.  11/83*
AXD  L  LIMIT FOR 1S(3S) IS VALID FOR M(A0)<7 GEV (4 GEV).                   11/83*
AXD                                                                          1/83*
AXD  M  ZEHNDER 82 USED GOESGEN 2.8GW LIGHT-WATER REACTOR TO CHECK A0 PROD.  1/83*
AXD  M  NO TWO GAMMA PEAK IN LI*,NB* DECAY(BOTH SINGLE P TRANSITION) NOR IN  1/83*
AXD  M  N CAPTURE(COMB WITH PREVIOUS BA* NEG RESULT) RULES OUT STANDARD A0.  1/83*
AXD  M  SET LIMIT M(A0)<60KEV FOR ANY A0.                                    1/83*
AXD
AXD  N  ALAM 83 IS AT CESR. THIS LIMIT COMBINED WITH LIMIT FOR BR(J/PSI-->   11/83*
AXD  N  A0 GAMMA) (EDWARDS 82) EXCLUDES STANDARD AXION.                      11/83*
AXD
AXD  O  CARBONI 83 LOOKED FOR ORTHOPOSITRONIUM-->A0 GAMMA. SET LIMIT FOR A0  11/83*
AXD  O  ELECTRON COUPLING SQUARED, G(EEA0)**2/(4*PI) < 6.E-10 TO 7.E-9 FOR   1/83*
AXD  O  M(A0)FROM 150 TO 900 KEV(CL=.997). THIS IS ABOUT 1/10 OF G-2 BOUND.  11/83*
AXD
AXD  P  CAVAIGNAC 83 AT BUGEY REACTOR EXCLUDE AXION AT ANY MASS(NB97*DECAY)  11/83*
AXD  P  AND AXION WITH M(A0) BETWEEN 275 AND 288 KEV (DEUTERON* DECAY).      11/83*
AXD
AXD  Q  NICZYPORUK 83 IS DESY-DORIS EXPERIMENT. THIS LIMIT TOGETHER WITH     11/83*
AXD  Q  LOWER LIMIT 9.2 E-4 OF BR(UPSI-->A0 GAMMA)   DERIVED FROM BR(J/PSI    11/83*
AXD  Q  -->A0 GAMMA) LIMIT (EDWARDS 82) EXCLUDES STANDARD AXION.             11/83*

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REFERENCES FOR AXION SEARCHES


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ALIBRAN  78 PL 74B 134        AACH+BARI+BERG+BRUX+CERN+EPOL+MILA+ORSA+
ASRATYAN 78 PL 79B 497        +EPSTEIN,FAKHRUTDINOV+          (ITEP+SERP)
BELLOTTI 78 PL 76B 223        +FIORINI,ZANOTTI                      (MILA)
BOSETTI  78 PL 74B 143        +DEDEN+       (AACH+BONN+CERN+LOIC+OXF+SACL)

DONNELLY 78 PR D18 1607       +FREEDMAN,LYTEL,PECCEI,SCHWARTZ       (STAN)
   ALSO  76 PRL 37 315        REINES,GURR,SOBEL
   ALSO  74 PRL 33 179        GURR,REINES,SOBEL
HANSL1   78 PL 74B 139        +HOLDER,KNOBLOCH+(CERN+DORT+HEID+SACL+BGNA)
MICELMAC 78 LNC 21 441        MICELMACHER,PONTECORVO                (JINR)
VYSOTSSK 78 JETPL 27 502      VYSOTSSKII+(INST.APPL.MATH.,USSR ACA. SCI.)

BECHIS   79 PRL 42 1511       +DOMBECK+    (UMD+COLU+A.F.R.R.I.-BETHESDA)
CALAPRIC 79 PR D20 2708       CALAPRICE,DUNFORD,KOUZES,MILLER+      (PRIN)
COTEUS   79 PRL 42 1438       +DIESBURG,FINE,LEE,SOKOLSKY+ (COLU+ILL+BNL)
DISHAW   79 PL 85B 142        +DIAMANT-BERGER,FAESSLER,LIU+    (SLAC+CIT)
ZHITNITS 79 SJNP 29 517       ZHITNITSKII,SKOVPEN                   (NOVO)

FAISSNER 80 PL 96B 201        +FRENZEL,HEINRIGS,PREUSSGER,SAMM,SAMM(AACH)
JACQUES  80 PR D21 1206       +KALELKAR,MILLER,PLANO+    (RUTG+STEV+COLU)
SOUKAS   80 PRL 44 564        +WANDERER,WENG,BREGMAN+(BNL+HARV+ORNL+PENN)

ASANO    81 PL 107B 159       +KIKUTANI,KUROKAWA+          (KEK+TOKY+OSAK)
FAISSNE1 81 ZPHY C10 95       FAISSNER,FRENZEL,GRIMM,HANSL,HOFFMAN+(AACH)
FAISSNE2 81 PL 103B 234       FAISSNER,FRENZEL,HEINRIGS,PREUSSGER+ (AACH)
KIM      81 PL 105B 55        B.R.KIM,CH.STAMM                      (AACH)
VUILLEUM 81 PL 101B 341       VUILLEUMIER,BOEHM,HAHN,KWON+      (CIT+MUNI)
ZEHNDER  81 PL 104B 494       A.ZEHNDER                               (ETH)

ALEKSEEV 82 JETPL 36 116      +KALININA,KRUGLOV,KULIKOV +      (MOSU+JINR)
ASANO    82 PL 113B 195       +KIKUTANI,KUROKAWA+          (KEK+TOKY+OSAK)
BARROSO  82 PL 116B 247       A.BARROSO,C.BRANCO                    (LISB)
DATAR    82 PL 114B 63        +BABA,BETIGERI,SINGH                  (BHAB)
EDWARDS  82 PRL 48 903        +PARTRIDGE,PECK+  (CIT+HARV+PRIN+STAN+SLAC)

FETSCHER 82 JPG 8 L147        W.FETSCHER                              (ETH)
LEHMANN  82 PL 115B 270       +LESQUOY,MULLER,ZYLBERAJCH            (SACL)
SIVERTZ  82 PR D26 717        +LEE-FRANZINI+          (STON+COLU+LSU+MPIM)
ZEHNDER  82 PL 110B 419       +GABATHULER,VUILLEUMIER       (ETH+SIN+CIT)

ALAM     83 PRD 27 1665       + (VAND+CORN+ITHA+HARV+OHIO+ROCH+RUTG+SYRA)
CARBONI  83 PL 123B 349       G.CARBONI,W.DAHME                (CERN+MUNI)
CAVAIGNA 83 PL 121B 193       CAVAIGNAC,HOUMMADA,KOANG,OST+   (GREN+LAPP)
FAISSNER 83 PRD 28 1198       +HEINRIGS,PREUSSGER,SAMM              (AACH)
FAISSNE2 83 PRD 28 1787       FAISSNER,FRENZEL,HEINRIGS,PRESSGER,+ (AACH)
HOFFMAN  83 PRD 28 660        +FRANK,MISCHKE,MOIR,SCHARDT     (LANL+ARZS)
NICZYPOR 83 ZPHY C17 197      NICZYPORUK+ LENA COLLAB.  (CRAC+ERLA+DESY+)
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OTHER STABLE PARTICLE SEARCHES

We collect here those searches which do not fit neatly into one of the above search categories. These include searches for higgs bosons, technipions, gluinos, photinos, squarks, shadrons, and sleptons (sections H, HGC, EGT, EGP, SLP), trimuon and four-lepton production in neutrino and antineutrino reactions (T, FL), di- and trimuon production in muon interactions (MU), and heavy particle searches in accelerator experiments (EE, CH, CS, D, ICH, RPI, CA, CEN), in cosmic rays (F), and in matter (CON). Searches are also listed for light particles (C), highly-ionizing particles (ION), penetrating non-neutrino-like particles (BD), and tachyons (TCF, TCM, TCD). Note that axion searches now appear in a separate section above.

OTHER STABLE PARTICLE SEARCHES

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BD     PRODUCTION OF NEW PENETRATING NON-NEUTRINO LIKE STATES IN BEAM DUMP
BD   A                                LOSECCO   81 CALO    28 GEV PROTONS     1/82
BD   A  NO EXCESS N.C.EVS LEADS TO CSP*CSI*ACCEPTANCE<2.26E-71 CM**4/NUC**2  1/82
BD   A  (CL=.90)FOR LIGHT NEUTRALS. ACC. DEPENDS ON MODELS (0.1 TO 4.E-4).   1/82

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T      TRIMUON PRODUCTION IN NEUTRINO NUCLEON INTERACTIONS
T       SEE ALSO SECTION 'NEU' IN 'HEAVY LEPTON SEARCHES'.
T       FOR EXTENSIVE DISCUSSION, SEE ALBRIGHT 78 (PR D18, 108), HANSL 78
T       (NP B142, 381), AND KANE 79 (PR D19, 1978).
T
T    A   2 EVENTS MU- MU MU           BARISH    77 SPEC    NEU BEAM         7/77
T    A  BARISH 77 EVENTS CONTAIN FAST MU- AND 2 ADDITIONAL MUONS WITH LOW   7/77
T    A  ENGERY IN DIMUON REST FRAME. SLOW MUONS COULD COME FROM EITHER      7/77
T    A  VIRTUAL PHOTON OR VECTOR MESON OR FROM ASSOC PROD OF CHARMED        7/77
T    A  PARTICLES WHICH DECAY LEPTONICALLY.                                  7/77
T
T    B   6 SEEN                       BENVENUTI 77 NEUL    5/6NEU,1/6NEUBAR 12/77
T    B  BENVENUTI 77 IS FNAL EXPT. CAN BE EXPLAINED BY PROD OF NEW HEAVY    12/77
T    B  LEPTON --> MU- NEUBAR NEW LIGHTER LEPTON --> MU+ MU- NEU.           12/77
T
T    C                                BLETZACKE 77 RVUE                     12/77
T    C  BLETZACKER 77 EXPLAINS TRIMUON AND LIKE SIGN DIMUON PROD AS ASSOC   12/77
T    C  PROD OF CHARM.                                                       12/77
T
T    D   3 SEEN                       HOLDER    77 SPEC                     12/77
T    D  HOLDER 77 EVENTS ARE MU-MU-M+ AND MU-MU+MU+ WITH NEU BEAM, AND      12/77
T    D  MU+MU-MU- WITH NEUBAR BEAM. RATE RELATIVE TO CHARGED CURRENT EVENTS 12/77
T    D  IS 4*10**-5.                                                         12/77
T
T    E                                ALBRIGHT  78 RVUE                     12/79
T    E  ALBRIGHT 78 COMPARES DATA OF TRIMUON AND FOUR-MUON EVENTS LISTED    12/79
T    E  ABOVE WITH SIX MODELS.                                               12/79
T
T    F   7 SEEN                       BENVENUTI 78 NEUL                      8/78
T    F  BENVENUTI 78 IS FNAL EXPT. 6 OF THE EVENTS ARE SEEN USING A 95 PCNT  8/78
T    F  NEU BEAM, 1 USING AN 83 PCNT NEUBAR BEAM. SEE MORI 78 FOR LIMITS     8/78
T    F  OF THE PROB THAT THE TRIMUONS ARE PRODUCED BY A NEW SHORT-LIVED      8/78
T    F  SOURCE OF NEUTRINOS.                                                 8/78
T
T    G  76 EVENTS MU- MU- MU+         HANSL2    78 SPEC    NEU BEAM         1/79
T    G  HANSL2 78 IS CERN SPS EXPT. RATE RELATIVE TO SINGLE MUON EVENTS IS  1/79
T    G  (3.0+-.4)*10**-5 FOR E(NEU)>30 GEV. CAN BE EXPLAINED AS C.C.        1/79
T    G  INTERACTIONS WITH ADDITIONAL LOW MASS MU PAIRS. NO EVIDENCE FOR NEW 1/79
T    G  HEAVY LEPTON.                                                        1/79
T
T    H  39 MU-MU-MU+ SEEN             BENVENUTI 79 NEUL    NEU BEAM         7/79
T    H  BENVENUTI 79 INCLUDES 9 EVENTS FROM BENVENUTI 77 AND 78. RATE       7/79
T    H  RELATIVE TO SINGLE MUON EVENTS IS (1.1+-.5)*10**-4 FOR E(NEU)>100   7/79
T    H  GEV.  CONSISTENT WITH E.M. AND DIRECT PRODUCTION OF MU PAIRS.       7/79
T    H  CHARM ASSOC PROD MAY ACCOUNT FOR 20 PERCENT OF PRODUCTION.  NO      7/79
T    H  EVIDENCE FOR NEW HEAVY LEPTONS OR HEAVY QUARKS.                      7/79
T
T    I   8 MU+MU+MU-                  DEGROOT   79 SPEC    NEUBAR BEAM     12/79
T    I  DEGROOT 79 IS CERN SPS EXPT. RATE RELATIVE TO SINGLE MUON EVENTS    12/79
T    I  IS (1.8+-0.6)E-5 FOR E(NEU)>=30 GEV AND P(MU)>=4.5 GEV/C. COULD BE  12/79
T    I  EXPLAINED AS C.C. INTERACTION ACCOMPANIED BY A MUON PAIR OF EITHER  12/79
T    I  HADRONIC OR E.M. ORIGIN AS IN NEU CASE. NEGATIVE SIGNAL FOR HEAVY   12/79
T    I  LEPTON.                                                              12/79

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FL     FOUR-LEPTON PRODUCTION IN NEUTRINO-NUCLEON INTERACTIONS               2/79
FL   A   1 2MU+ 2MU-                  HOLDER    78 SPEC                      2/79
FL   B   1 2E- E+ MU+                 LOVELESS  78 HBC                       2/79
FL
FL   A  HOLDER 78 EVENT IS FROM CERN-SPS EXPT. RATE RELATIVE TO MU+MU-       2/79
FL   A  EVENTS IS 1.4E-4.                                                    2/79
FL
FL   B  LOVELESS 78 EVENT IS FROM FNAL EXPT. EVENT ALSO HAS 1 KS AND 7       2/79
FL   B  GAMMAS.                                                              2/79

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MU     DI- AND TRI-MUON PRODUCTION IN MU NUCLEON INTERACTIONS
MU     SEE ALSO SECTION 'MU' IN HEAVY LEPTON SEARCHES AND CHARM SEARCHES    10/81
MU   A  11 TRIMUON EVENTS             CHANG     77 SPEC                     12/77
MU   A  32 DIMUON EVENTS              CHANG     77 SPEC                     12/77
MU   B 450 MU+MU-  223 MU-MU- EVENTS  LEBRITTON 80 SPEC WCM(VIRTUAL PHOTON- 12/81
MU   B 158 MU-MU-MU+ EVENTS           LEBRITTON 80 SPEC NUCLEON) < 4.5 GEV  12/81
MU
MU   A  CHANG 77 DIMUON RATE IS GT 5*10**-4 THAT OF INCLUSIVE MUON RATE.    12/77
MU   A  CROSS SECTION UNCORRECTED FOR ACCEPTANCE IS 5*10**-36 CM**2/NUCLEON 12/77
MU
MU   B  LEBRITION 80 IS BNL EXP.  LOOKED FOR MUOPRODUCTION OF SHORT-        12/81
MU   B  LIVED PARTICLES BELOW CHARM THRESHOLD. TRIMUONS ARE CONSISTENT WITH 12/81
MU   B  QED TRIDENT PLUS RHO DECAY AND DIMUONS ALSO WITH KNOWN SOURCES.  AT 12/81
MU   B  CL=.90 CS(MU-N-->M+ X)*BR(M+ -->MU+ X) < 1.64 E-34 CM**2 AND CS(MU- 12/81
MU   B  N-->M- X)*BR(M- -->MU- X)<.81E-34 CM**2 WITH M+- SHORT-LIVED MESON. 12/81

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EE     HEAVY PARTICLE PRODUCTION CROSS-SECTION IN E+ E- REACTION             2/82
EE     (RATIO TO CS(E+E- -->MU+MU-)). SEE ALSO SECTION EE IN QUARK SEARCHES  2/82
EE     AND SECTION EE IN MAGNETIC MONOPOLE SEARCHES.                         2/82
EE   A   0 5.0 E-2  OR LESS  CL=.90   BARTEL    80 JADE Q=(3,4,5)/3 2-12GEV  2/82
EE   B   0 1.6 E-2  OR LESS  CL=.95   KINOSHITA 82 PLAS Q=3-180,M<14.5GEV    2/82
EE
EE   A  BARTEL 80 IS DESY PETRA EXPT WITH WCM=27-35 GEV. ABOVE LIMIT IS FOR  2/82
EE   A  INCLUSIVE PAIR PROD AND RANGES BETWEEN 1.E-1 - 1.E-2 DEPENDING ON    2/82
EE   A  MASS AND PROD MOMENTUM DIST. (SEE THEIR FIGS.9,10,11).               2/82
EE
EE   B  KINOSHITA 82 IS SLAC PEP EXPT AT WCM=29 GEV USING LEXAN AND CR-39    2/82
EE   B  PLASTIC SHEETS SENSITIVE TO HIGHLY IONIZING PARTICLES.               2/82

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CH     HEAVY PARTICLE PRODUCTION CROSS SECTION (CM**2)
CH   A   0  1. E-31 OR LESS           LEIPUNER  73 CNTR +- M=3-11 GEV        5/76
CH   B    0.3-1.3E-31 OR LESS         CARROLL   78 SPEC    M=2.-2.5 GEV      1/79
CH
CH   A  LEIPUNER 73 IS AN NAL 300 GEV P EXPT. WOULD HAVE DETECTED PARTICLES  4/76
CH   A  WITH LIFETIME GREATER THAN 200 NSEC.                                 4/76
CH
CH   B  CARROLL 78 LOOK FOR NEUTRAL, S=-2 DIHYPERON RESONANCE IN             1/79
CH   B  P P --> 2K+ X. CS VARIES WITHIN ABOVE LIMITS OVER MASS RANGE AND     1/79
CH   B  PLAB=5.1-5.9 GEV/C.                                                  1/79

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CS     HEAVY PARTICLE PRODUCTION CROSS-SECTION (CM**2/NUCLEON)
CS   A   0  2.5E-35 OR LESS           GUSTAFSON 76 CNTR 0  TAU GT 10**-7     1/77
CS
CS   A  GUSTAFSON 76 IS A 300 GEV FNAL EXPT LOOKING FOR HEAVY (M GT 2 GEV)   1/77
CS   A  LONGLIVED NEUTRAL HADRONS IN THE M4 NEUTRAL BEAM. THE ABOVE TYPICAL  1/77
CS   A  VALUE IS FOR M=3 GEV AND ASSUMES AN INTERACTION CROSS SECTION OF     1/77
CS   A  1 MB.  VALUES AS A FUNCTION OF MASS AND INTERACTION CROSS SECTION    1/77
CS   A  ARE GIVEN IN FIG. 2.                                                 1/77

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D      HEAVY PARTICLE PRODUCTION DIFFERENTIAL CROSS SECTION (CM**2/SR-GEV)
D    A   0  1.5E-36 OR LESS           DORFAN    65 CNTR BE TARGET  M=3-7GEV  5/76
D    A   0  3.0E-36 OR LESS           DORFAN    65 CNTR FE TARGET  M=3-7GEV  5/76
D        0  2.4E-35 OR LESS  CL=.90   BINON     69 CNTR Q=- M=1-1.8 GEV      3/77
D    B   0  2.4E-35 OR LESS  CL=.90   ANTIPOV1  71 CNTR Q=- M=1.2-1.7,2.1-4  3/77
D    C   0  1.2E-35 OR LESS  CL=.90   ANTIPOV2  71 CNTR Q=- M=2.2-2.8        3/77
D    D   0  5.8E-34 OR LESS  CL=.90   ALPER     73 SPEC +- M=1.5-24 GEV      5/76
D    E   0  1. E-31 OR LESS  CL=.90   APPEL     74 CNTR +- M=3.2-7.2 GEV     2/76
D    F   0  2.2E-33 OR LESS  CL=.90   ALBROW    75 SPEC Q=+-1  M=4-15 GEV    1/77
D    F   0  1.1E-33 OR LESS  CL=.90   ALBROW    75 SPEC Q=+-2  M=6-27 GEV    1/77
D    G   0  8. E-35 OR LESS  CL=.90   JOVANOVIC 75 CNTR +- M=15-26 GEV       2/76
D    G   0  1.5E-34 OR LESS  CL=.90   JOVANOVIC 75 CNTR Q=+-2, M=3-10 GEV    2/76
D    G   0  6. E-35 OR LESS  CL=.90   JOVANOVIC 75 CNTR Q=+-2, M=10-26 GEV   2/76
D    H   0  2.6E-36 OR LESS  CL=.90   BALDIN    76 CNTR Q=-1, M=2.1-9.4 GEV  1/77
D
D    A  DORFAN 65 IS A 30 GEV/C P EXPT AT BNL.  UNITS ARE PER GEV MOMENTUM   5/76
D    A  PER NUCLEUS.                                                         5/76
D
D    B  ANTIPOV1 71 LIMIT INFERRED FROM FLUX RATIO. 70 GEV P EXPERIMENT.     3/77
D
D    C  ANTIPOV2 71 IS FROM SAME 70 GEV P EXP. AS ANTIPOV1 71 AND BINON 69.  3/77
D
D    D  ALPER 73 IS CERN ISR 26+26 GEV P+P EXPT.  P>.9 GEV, .2< BETA <.65.   5/76
D
D    E  APPEL 74 IS NAL 300 GEV P+W EXPERIMENT. STUDIES FORWARD PRODUCTION   2/76
D    E  OF HEAVY (UP TO 24 GEV) CHARGED PARTICLES WITH MOMENTA 24-200GEV(-)  2/76
D    E  AND 40-150GEV (+CHG).  ABOVE TYPICAL VALUE IS FOR 75 GEV AND IS      5/76
D    E  PER GEV MOMENTUM PER NUCLEON.                                        5/76
D
D    F  ALBROW 75 IS A CERN ISR EXPT WITH ECM=53 GEV. THETA=40 MR. SEE       1/77
D    F  FIG. 5 FOR MASS RANGES UP TO 35 GEV.                                 1/77
D
D    G  JOVANOVICH 75 IS A CERN ISR 26+26 AND 15+15 GEV P+P EXPERIMENT.      2/76
D    G  FIG.4 COVERS RANGES Q=1/3 TO 2 AND M=3 TO 26 GEV.                    2/76
D    G  VALUE IS PER GEV MOMENTUM.                                           5/76
D
D    H  BALDIN 76 IS A 70 GEV SERP EXP.  VALUE IS PER AL NUCLEUS AT          1/77
D    H  THETA=0.  FOR OTHER CHARGES IN RANGE -0.5 TO -3.0, CL=.90 LIMIT IS   1/77
D    H  (2.6E-36)/ABS(CHARGE) FOR MASS RANGE (2.1 TO 9.4GEV)*ABS(CHARGE).    1/77
D    H  ASSUMES STABLE PARTICLE INTERACTING WITH MATTER AS DO ANTIPROTONS.   1/77

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ICH    LONGLIVED HEAVY PARTICLE INVARIANT C.S. (CM**2/GEV**2/NUCLEON)        1/79
ICH  A   0  1.1E-37 OR LESS  CL=.90   CUTTS     78 CNTR MASS=4-10 GEV        1/79
ICH  B   0  3.0E-37 OR LESS  CL=.90   VIDAL     78 CNTR MASS=4.5-6 GEV      12/79
ICH  C   0  6. E-33 OR LESS  CL=.90   ARMITAGE  79 SPEC    M=1.87 GEV        7/79
ICH  C   0  1.5E-33 OR LESS  CL=.90   ARMITAGE  79 SPEC    M=1.5-3.0 GEV     7/79
ICH  D   0                            BOZZOLI   79 CNTR Q=+-(2/3,1,4/3,2)    1/80
ICH
ICH  A  CUTTS 78 IS P BE EXPT AT FNAL SENSITIVE TO PARTICLES OF TAU>5E-8SEC  1/79
ICH  A  VALUE IS FOR -.3<X<0 AND PT=0.175.
ICH
ICH  B  VIDAL 78 IS FNAL 400 GEV PROTON EXPT. VALUE IS FOR X=0 AND PT=0.     2/79
ICH  B  PUTS LIFETIME LIMIT OF <5*10**-8 SEC ON PARTICLE IN THIS MASS RANGE  2/79
ICH
ICH  C  ARMITAGE 79 IS CERN-ISR EXPT AT ECM=53 GEV. VALUE IS FOR X=0.1 AND   7/79
ICH  C  PT=0.15. OBSERVED PARTICLES AT M=1.87 GEV ARE FOUND ALL CONSISTENT   7/79
ICH  C  WITH BEING ANTIDEUTERONS.                                            7/79
ICH
ICH  D  BOZZOLI 79 IS CERN-SPS 200 GEV P N EXPERIMENT. LOOKS FOR PARTICLE    1/80
ICH  D  WITH TAU LARGER THAN 10**-8 SEC. SEE THEIR FIG.11-18 FOR PRODUCTION  1/80
ICH  D  CROSS SECTION UPPER LIMITS VS MASS.                                  1/80

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RPI    LONGLIVED HEAVY PARTICLE PRODUCTION (CS(HEAVY PARTICLE)/CS(PION) )   12/81
RPI  A   0                            BUSSIERE  80 CNTR Q=+-(2/3,1,4/3,2)   12/81
RPI
RPI  A  BUSSIERE 80 IS CERN-SPS EXPT WITH 200-240 GEV PROTONS ON BE AND AL  12/81
RPI  A  TARGET. SEE THEIR FIG.6-7 FOR CS RATIO VS MASS.                     12/81

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CA     CROSS-SEC FOR PROD AND CAPT OF LONG-LIVED MASSIVE PARTICLES (CM**2)
CA   A   0  0.1-9E-36 OR LESS         FRANKEL   74 CNTR TAU=1 TO 1000 HRS    7/76
CA   B   0  1.4-9E-36 OR LESS         FRANKEL   75 CNTR TAU=50 MS TO 10 HRS  2/77
CA   C   0   2-20E-34 OR LESS         ALEKSEE1  76 ELEC TAU=100 MS TO 1 DAY  4/77
CA   C   0  0.2-8E-34 OR LESS         ALEKSEE2  76 ELEC TAU=5 MS TO 1 DAY    3/77
CA
CA   A  FRANKEL 74 LOOKS FOR PARTICLES PRODUCED IN THICK AL TARGETS BY       7/76
CA   A  300-400 GEV/C PROTONS.                                               7/76
CA
CA   B  FRANKEL 75 IS EXTENSION OF FRANKEL 74.                               2/77
CA
CA   C  ALEKSEEV(1,2) 76 ARE 61-70 GEV P SERP EXPT. CS IS PER PB NUCLEUS.    3/77

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CEN    CENTAURO PROD. CROSS SECTION IN ACCELARATOR EXPERIMENT (CM**2)
CEN  A   0                            ALPGARD   82 UA5  P PBAR COLLIDER     11/83*
CEN  B   0 (1. E-30)OR LESS           ARNISON   83 UA1  P PBAR COLLIDER     11/83*
CEN  A  ALPGARD 82 IS CERN COLLIDER EXPERIMENT WITH WCM=540 GEV(155 TEV LAB 11/83*
CEN  A  EQUIVALENT). OBSERVED NO LARGE CHGD MULTIPLICITY EVENTS WITH PHOTON 11/83*
CEN  A  MULTIPLICITY CONSISTENT WITH ZERO IN 3600 INELASTIC EVENTS.         11/83*
CEN  B  ARNISON 83 IS CERN COLLIDER EXPT WITH WCM=540GEV. LOOKED FOR EVENTS 11/83*
CEN  B  WITH LARGE HAD. AND LOW EM CONTENT. NONE IN 48000 LOW BIAS EVENTS.  11/83*

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F      HEAVY PARTICLE FLUX IN COSMIC RAYS (NUMBER/CM**2-SEC-SR)
F        0  5.0E-11 OR LESS  CL=.90   JONES     67 ELEC    M=5 TO 15 GEV     3/77
F        0  3.0E-10 OR LESS           BJORNBOE  68 CNTR    M ABOVE 5 GEV     4/77
F        0  3.0E-8  OR LESS           DARDO     72 CNTR                      4/77
F        0  1.5E-9  OR LESS           TONWAR    72 CNTR    M GT 10 GEV       4/77
F    A   5  6. E-9  OR MORE           YOCK      74 CNTR    M GT 6 GEV        1/76
F        0  7. E-10 OR LESS  CL=.90   YOCK      75 ELEC +- Q GT 7 OR LT -7E  9/76
F        0  1.0E-9  OR LESS           BRIATORE  76 ELEC                      4/77
F    B      1.3E-9  OR LESS  CL=.90   BHAT      78 CNTR +- M GT 1 GEV        1/80
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Stable Particles

Data Card Listings

OTHER STABLE PARTICLE SEARCHES

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F        3  4.3+-1.3 E-11              GOODMAN   79 ELEC    M>= 5 GEV          7/79
F    C   3  3.0E-9                     YOCK      80 SPRK    M APPROX.=4.5 MP  10/81
F    D   0  3.5E-11 OR LESS  CL=.90    ULLMAN    81 CNTR PLANCK-MASS E+19GEV  2/82
F    D   0  7. E-11 OR LESS  CL=.90    ULLMAN    81 CNTR M=1.E-16GEV OR LESS  2/82
F    E   3  2. E-9                     YOCK      81 SPRK Q=+-1 M ABOUT 4.5MP  1/82
F    E   3                             YOCK      81 SPRK FRACTIONALLY CHGD    1/82
F    F   0  1.7E-11 OR LESS  CL=.99    BHAT      82 CC                        1/83*
F    G   0  1. E-9  OR LESS  CL=.90    MARINI    82 CNTR Q=+-1 M ABOUT 4.5MP 10/83*
F    H                                 SAKUYAMA  83 PLAS    M ABOUT 1 TEV   11/83*
F
F    A  YOCK 74 EVENTS COULD BE TRITONS.                                       1/76
F
F    B  BHAT 78 IS AT KOLAR GOLD FIELDS. LIMIT IS FOR TAU > 10**-6 SEC.        1/80
F
F    C  YOCK 80 EVENTS ARE WITH CHARGE EXACTLY OR APPROX. EQUAL TO UNITY.     10/81
F
F    D  ULLMAN 81 IS SENSITIVE FOR HEAVY SLOW SINGLY CHARGE PARTICLE           2/82
F    D  REACHING EARTH WITH VERTICAL VELOCITY 100-350 KM/S.                    2/82
F
F    E  YOCK 81 SAW ANOTHER 3 EVENTS WITH Q=+-1 AND M ABOUT 4.5MP AS WELL      1/82
F    E  AS 2 EVS WITH M>5.3MP,Q=+-.75+-.05 AND M>2.8MP,Q=+-.70+-.05 AND 1      1/82
F    E  EVENT WITH M=(9.3+-3.)MP,Q=+-.89+-.06 AS POSSIBLE HEAVY CANDIDATES.    1/82
F
F    F  BHAT 82 OBSERVED 12 EVENTS WITH DELAY>2.E-8 SEC AND WITH MORE THAN     1/83*
F    F  40 PARTICLES. 1 EV HAS GOOD HADRON SHOWER. HOWEVER ALL EVENTS ARE      1/83*
F    F  DELAYED IN ONLY ONE OF TWO DETECTORS IN CLOUD C.,AND COULD NOT BE      1/83*
F    F  DUE TO STRONGLY INTERACTING MASSIVE PARTICLE.                          1/83*
F
F    G  MARINI 82 APPLIED PEP-CNTR FOR TOF. ABOVE LIMIT IS FOR VELOCITY=.54   10/83*
F    G  OF LIGHT. LIMIT IS INCONSISTENT WITH YOCK 80,81 EVENTS IF ISOTROPIC   10/83*
F    G  DEPENDENCE ON ZENITH ANGLE IS ASSUMED.                                10/83*
F
F    H  SAKUYAMA 83  ANALYZED 6000 EXTENDED AIR SHOWER EVENTS. INCREASE OF    11/83*
F    H  DELAYED PARTICLES AND CHANGE OF LATERAL DISTRIBUTION ABOVE 10**17EV   11/83*
F    H  MAY INDICATE PRODUCTION OF VERY HEAVY PARENT AT TOP OF ATOMOSPHERE.   11/83*

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CON    CONCENTRATION OF HEAVY (CHARGE+1) STABLE PARTICLES IN MATTER
CON   2.E-22 TO 1.E-21 OR LESS          SMITH     79 SPEC WATER,M=6-350 MPROT  7/79

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C      LIGHT (BETWEEN MU AND E MASSES) PARTICLE MASS(UNITS-ELECTRON MASSES)
C        0   NONE BETWEEN 6 AND 25     BELOUSOV  60 CNTR  SPINOR,TAU>1 E-8     5/76
C        0   NONE BETWEEN 2 AND 25     GORBUNOV  60 CC    SPINOR,TAU>1 E-9     5/76
C        0   NONE BETWEEN 5 AND 175    COWARD    63 CNTR  SPINOR,TAU>22 E-10   5/76
C        0   NONE BETWEEN 5 AND 175    COWARD    63 CNTR  SCALAR,TAU>68 E-10   5/76
C    A   0   NONE BETWEEN 2 AND 13     BLAGOV    75 CNTR SPINOR,TAU>2E-10SEC   2/76
C    A   0   NONE BETWEEN 2 AND 10.6   BLAGOV    75 CNTR SCALAR,TAU>2E-10SEC   2/76
C    B   0   NONE BETWEEN 110 AND 180  VIERTEL   78 CNTR TAU >2.E-5 SEC        1/80
C
C    A  BLAGOV 75 BOUNDS ON LIFETIME DEPEND ON MASS AND IMPROVE AS MASS        4/77
C    A  DECREASES.  AT 2 GEV THE EXPERIMENT IS SENSITIVE TO TAU>3E-11 SEC      4/77
C    A  FOR SPINOR, TAU>5E-11 SEC FOR SCALAR.                                  4/77
C
C    B  VIERTEL 78 SEARCHES FOR MU+ -->X+ NEU. FINDS BR<8.5E-6 IN MASS         1/80
C    B  RANGE GIVEN ABOVE (CL=.90). BEST LIMIT BR<5.E-7 (CL=.90) IS  FOUND     1/80
C    B  AT MASS=80 MEV.                                                        1/80

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H      HIGGS BOSON MASS LIMIT (GEV)                                            1/82
H    A   0  0.409   OR MORE            DZHELYADI 81      ETAPRIM-->ETA HIGGS   1/82
H    B   0  0.325   OR MORE            WILLEY    82 RVUE K+-->DILEPTON+PI+    11/83*
H    C                                 HOFFMAN   83 CNTR PI-P-->N(HO-->E+E-)  11/83*
H
H    A  DZHELYADIN 81 OBTAINED BR(ETA PRIM-->ETA MU+MU-)<1.5E-5 (CL=.90)       1/82
H    A  WHICH EXCLUDES A LIGHT HIGGS BOSON IN MU+MU- CHANNEL.                  1/82
H
H    B  WILLEY 82 CALCULATED BR(K+-->HO+PI+) BY ONE-LOOP S-->D HO AND QUARK   11/83*
H    B  MODEL. EXCLUDE M(HO) < M(K)-M(PI).                                    11/83*
H
H    C  HOFFMAN 83 LOOKED FOR E+E- PEAK FROM HIGGS PRODUCED IN PI-P CEX AT    11/83*
H    C  300MEV/C. SET CL=.90 LIM. DSIGMA/DT*BR(E+E-)<3.5 E-32 CM**2/GEV**2    11/83*
H    C  FOR  140 < M(HO) < 160 MEV.                                           11/83*

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HGC    CHARGED HIGGS(OR TECHNI-PION) MASS LIMIT IN E+ E- REACTION              1/83*
HGC      SINCE HIGGS COUPLES TO HEAVY PARTICLES, DOMINANT EXPECTED MODES       1/83*
HGC      ARE (TAU NEU) AND (CHARM ANTI-S). EXCLUDED MASS REGION DEPENDS ON     1/83*
HGC      BRANCHING RATIO. SEE GRAPHS IN INDIVIDUAL PAPERS. WE QUOTE ONLY A     1/83*
HGC      SAMPLE LIMIT FOR BR(TAU NEU) SPECIFIED.                               1/83*
HGC  A  NONE 5GEV TO 13GEV   CL=.95   ADEVA     82 MRKJ BR(TAU NEU)=.25        1/83*
HGC  A  NONE 3GEV TO 13GEV   CL=.95   BARTEL    82 JADE BR(TAU NEU)=0.2-1.0    1/83*
HGC  B  NONE 7GEV TO 14GEV   CL=.95   BEHREND   82 CELL BR(TAU NEU)=.80        1/83*
HGC  A  NONE 4GEV TO  9GEV   CL=.90   BLOCKER   82 SMK2 BR(TAU NEU)=.10-.90    1/83*
HGC  C  NONE 5GEV TO 13GEV   CL=.95   ALTHOFF   83 TASS H+ -->C S (C B)       11/83*
HGC  D  NONE BELOW 14 GEV             ADEVA     83 MRKJ H+H- -->MU NAD.JET    11/83*
HGC  E  NONE BELOW M(B-MESON)         CHEN      83 RVUE B DECAY AT UPSI(4S)   11/83*
HGC
HGC  A  STUDIED H+ H- -->(TAU NEU)+(TAU NEU),(TAU NEU)+HADRONS.                1/83*
HGC
HGC  B  BEHREND 82 STUDIED H+ H- -->(TAU NEU)+(TAU NEU). SEE THEIR FIG.3.      1/83*
HGC
HGC  C  ALTHOFF 83 ANALYZED 4-JETS. LIMIT IS FOR H+ DECAYING PREDOMINANTLY    11/83*
HGC  C  INTO HADRONS. COMBINING WITH (TAU NU)RESULTS LIMIT APPLIES TO H+       11/83*
HGC  C  WITH ANY HADRONIC BRANCHING RATIOS.                                    11/83*
HGC
HGC  E  CHEN 83 EXCLUDE A MODEL WHERE B-->H+ LIGHT-QUARK AT BR=1. OBSERVED     11/83*
HGC  E  BR(B-->E X) WOULD REQUIRE BR(H+-->TAU X)=1 BUT THEN CHARGED ENERGY     11/83*
HGC  E  FRACTION WOULD BE SMALLER THAN EXPT VALUE(.60+-.03).(CLEO DATA)        11/83*

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EGT    MASS BOUNDS DERIVED FOR PARTICLES IN EXTENDED GAUGE THEORIES            1/83*
EGT  A  NONE BELOW 2-3GEV             KANE      82 RVUE GLUINO                1/83*
EGT  B  NONE BELOW 0.5TEV(MTOP=20GEV) SHANKER   82 RVUE CHGD-HIGGS             1/83*
EGT  B  NONE BELOW 1. TEV             SHANKER   82 RVUE PS-LEPTOQUARK         1/83*
EGT  B  NONE BELOW 125TEV             SHANKER   82 RVUE VECTOR-LEPTOQUARK     1/83*
EGT  B  NONE BELOW 0.1-1 TEV          SHANKER   82 RVUE SUSY-PARTNER          1/83*
EGT  C  NONE BETWEEN 100MEV AND 13GEV BEHREND   83 CELL E-E+-->PHOTINO PAIR  11/83*
EGT  D                                BERGSMA   83 RVUE GLUINO,SQUARK        11/83*
EGT  B  NONE BELOW 350 GEV            BRYMAN    83 CNTR CHGD-HIGGS            10/83*
EGT  E                                CHANOWITZ 83 RVUE CHARGED SHADRON      11/83*
EGT  F  NONE BELOW 350 TEV            DESHPANDE 83 RVUE PATI-SALAM X-BOSON    1/84*
EGT
EGT  A  KANE 82 INFERED ABOVE GLUINO MASS LIMIT FROM RETROACTIVE ANALYSIS      1/83*
EGT  A  OF  HADRONIC COLLISION AND BEAM DUMP EXPERIMENTS.                      1/83*
EGT
EGT  B  FROM (PI-->E NU)/(PI-->MU NU) RATIO.  BRYMAN 83 BASED ON SHANKER 82    1/83*
EGT  B  MODEL WITH HIGGS-FERMION COUPLINGS PROPORTIONAL TO HEAVY FERMION       1/83*
EGT  B  MASSES.                                                                1/83*
EGT
EGT  C  BEHREND 83 AT DESY-PETRA LOOKED FOR 2 GAM EVTS WITH MISSING ENERGY.   11/83*
EGT  C  LIMITS QUOTED ARE FOR SCALE BREAKING PARAMETER D=(100GEV**2).         11/83*
EGT  D  BERGSMA 83 IS REANALYSIS OF CERN-SPS BEAM-DUMP DATA. DISFAVOURS       11/83*
EGT  D  M(GLUINO)<2 GEV AND M(SQUARK)<100 GEV. SEE THEIR FIG.1.               11/83*
EGT
EGT  E  CHANOWITZ 83 FIND IN BAG-MODEL THAT CHARGED SHADRON (Q QBAR GLUINO    11/83*
EGT  E  -BOUND STATE) IS STABLE AGAINST STRONG DECAY IF M(GLUINO)> 1 GEV.     11/83*
EGT  E  A POSSIBILITY IS OF VERY LIGHT GLUINO WITH LIFE 1.E-11 TO 2.E-8 SEC   11/83*
EGT  E  TOO LONG(SHORT) LIVED TO BE EXCLUDED BY BEAM-DUMP(CONTAM.) EXPTS.     11/83*
EGT
EGT  F  DESHPANDE 83 USED UPPER LIMIT ON KL -->MU E DECAY WITH R.G.EQUATION    1/84*
EGT  F  TO ESTIMATE COUPLING AT THE HEAVY BOSON MASS.                           1/84*
EGT  F  SEE ALSO DIMOPOULOS ET AL., NP B182, 77 (1981).                         1/84*

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EGP    PRODUCTION OF PARTICLES IN EXTENDED GAUGE THEORIES
EGP  A                                BEHREND   83 CELL E-E+-->PHOTINO PAIR 11/83*
EGP  B                                HOFFMAN   83 CNTR PI-P-->N(E+E-)      11/83*
EGP  C                                VERGADOS  82 CNTR 2BETA DECAY, SCALAR 12/83*
EGP
EGP  A  BEHREND 83 AT DESY-PETRA SET CL=.95 LIMIT OF 1.1 PB FOR PHOTINO-      11/83*
EGP  A  ANTIPHOTINO PRODUCTION (M(PHOTINO)<2GEV) AT WCM AROUND 34GEV.         11/83*
EGP
EGP  B  HOFFMAN 83 SET CL=.90 LIMIT DSIGMA/DT*BR(E+E-)<3.5E-32 CM**2/GEV**2   11/83*
EGP  B  FOR SPIN-1 PARTNER OF GOLDSTONE FERMIONS WITH 140<M<160 MEV           11/83*
EGP  B  DECAYING INTO E+E- PAIR.                                              11/83*
EGP
EGP  C  VERGADOS 82 SETS LIMIT GH.LT.4E-3 FOR (DIMENSIONLESS) LEPTON-NUMBER  12/83*
EGP  C  VIOLATING COUPLING, GH, OF SCALAR BOSON TO NEUTRINOS, FROM ANALYSIS  12/83*
EGP  C  OF DATA ON DOUBLE BETA DECAY OF CA48.                                12/83*

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SLP    SCALAR LEPTON MASS LIMIT IN E+ E- REACTIONS                             1/83*
SLP      SCALAR-TAU-->TAU PHOTINO LOOKS IDENTICAL TO CHGD-HIGGS-->TAU NEU IN   1/83*
SLP      SECTION HGC ABOVE. LIMITS BELOW CORRESPOND TO BR(TAU NEU)=1.0 LINE    1/83*
SLP      IN MASS-LIMIT GRAPH FOR CGHD-HIGGS-->(TAU NEU)+(TAU NEU) AND WE       1/83*
SLP      DERIVE LIMIT IN THIS WAY IF NECESSARY.                                1/83*
SLP      NONE 3GEV TO 15GEV    CL=.95  BARBER    80 MRKJ SCALAR MU            10/81
SLP           14GEV  OR MORE   CL=.95  ADEVA     82 MRKJ SCALAR TAU            1/83*
SLP      NONE 4GEV TO 14GEV    CL=.95  BARTEL    82 JADE SCALAR TAU            1/83*
SLP      NONE 2GEV TO 16.8GEV  CL=.95  BEHREND   82 CELL SCALAR E              1/83*
SLP      NONE 3.3GEV TO 16GEV  CL=.95  BEHREND   82 CELL SCALAR MU             1/83*
SLP  A   NONE 6GEV TO 15.3GEV  CL=.95  BEHREND   82 CELL SCALAR TAU            1/83*
SLP  A   NONE M(TAU) TO 3.8GEV CL=.95  BEHREND   82 CELL SCALAR TAU            1/83*
SLP      NONE M(TAU) TO 9.9GEV CL=.90  BLOCKER   82 SMK2 SCALAR TAU            1/83*
SLP  B      NONE BELOW 16.6GEV CL=.95  BRANDELIK 82 TASS SCALAR E             11/83*
SLP  B      NONE BELOW 16.4GEV CL=.95  BRANDELIK 82 TASS SCALAR MU            11/83*
SLP  C      NONE BELOW 13.8GEV CL=.95  FERNANDEZ 83 MAC  SCALAR MU             1/84*
SLP  D      NONE BELOW 22.2GEV CL=.95  GLADNEY   83 SMK2 SCALAR E              1/84*
SLP
SLP  A  BEHREND 82 FIRST LIMIT FOR SCALAR TAU IS FROM PT-CUT TAU-PAIR          1/83*
SLP  A  ANALYSIS, SECOND LIMIT FROM NO EXCESS TAU PAIR EVENTS.                 1/83*
SLP
SLP  B  BRANDELIK 82 LIMITS ARE FROM NO ENHANCEMENT IN EVENTS WITH THETA      11/83*
SLP  B  NEAR 90 DEG(LIGHT SCALAR) AND WITH LARGE ACOPLANARITY(HVY SCALAR).    11/83*
SLP
SLP  C  FERNANDEZ 83 OBSERVED NO EXCESS ACOPLANAR MU+MU- EVENTS.                1/84*
SLP
SLP  D  GLADNEY 83 LOOKED FOR LARGE PT E FROM SINGLY PRODUCED S-ELECTRONS.     1/84*

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ION    HIGHLY IONIZING PARTICLE FLUX  (UNITS NUMBER/M**2-YR)
ION      0    0.4   OR LESS  CL=.95   KINOSHITA 81 PLAS Z/BETA 30-100          2/82

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TCF    TACHYON FLUX IN COSMIC RAYS (NUMBER/CM**2-SEC-SR)
TCF      SEE SMITH 77 FOR A REVIEW OF EARLIER COSMIC RAY AND ACCELERATOR
TCF      EXPERIMENTS.
TCF  A     NONE                        PRESCOTT  76 CNTR                      6/82*
TCF  B     NONE                        SMITH     77 CNTR                      6/82*
TCF  C   0  2.3E-10 OR LESS  CL=.95    BHAT      79 CNTR                     10/81
TCF  D   0  2.4E-9  OR LESS  CL=.90    MARINI    82 CNTR V/C>1.2             10/83*
TCF
TCF  A  PRESCOTT 76 REANALYZED CLAY AND CROUCH(C.C.)74 DATA(NATURE 248,28).   6/82*
TCF  A  FOUND APPARATUS EFFECT,CORRECTION FOR WHICH MUCH REDUCES THE STAT.    6/82*
TCF  A  SIGNIFICANCE OF POSITIVE C.C.RESULT. ALSO PERFORMED TWO NEW EXPTS     6/82*
TCF  A  ONE USING C.C.APPARATUS,ANOTHER WITH NEW APPARATUS. SET UPPER LIMIT   6/82*
TCF  A  AT CL=.95 OF ABOUT 30 TACHYONS PER SHOWER WITH AVERAGE SIZE N=6E+5.   6/82*
TCF
TCF  B  SMITH 77 ANALYZED MORE THAN 200000 SHOWERS(223 DAYS) WITH E>1.E+14    6/82*
TCF  B  EV SCANNING 290 E-6 SEC PERIOD BEFORE EACH SHOWER. OBSERVED EXCESS    6/82*
TCF  B  46+-40 EVS DOES NOT CONSTITUTE STATISTICALLY SIGNIFICANT EVIDENCE.    6/82*
TCF
TCF  C  BHAT 79 IS AT OOTACAMUND(2200M ABOVE SEA). NO SIGNAL IN 3621 HOURS. 10/81
TCF
TCF  D  MARINI 82 IS TOF MEASUREMENT USING PEP-CNTR AT SEA LEVEL.            10/83*

TCM    TACHYON SEARCHES IN E+ E- ANNIHILATION
TCM  A   0  1. E-6  OR LESS  CL=.90    PEREPELIT 77 CNTR V*U(EQ) < 1           6/82*
TCM  A   0  1. E-5  OR LESS  CL=.90    PEREPELIT 77 CNTR 1 < V*U(EQ) < 15      6/82*
TCM
TCM  A  PEREPELITSA 77 IS MICHELSON-TYPE EXPT FOR PAIR-PRODUCED TACHYONS      6/82*
TCM  A  IN E+ E- ANNIHILATION (E+ FROM CU ISOTOPE). ABOVE LIMITS ARE FOR      6/82*
TCM  A  CS(E+E- -->TACHYON PAIR)/CS(E+E- -->2 GAMMA) AND V*U(EQ) IS TACHYON   6/82*
TCM  A  VELOCITIES TIMES EARTH EQUATOR COMPONENT OF VELOCITY OF PREFERRED     6/82*
TCM  A  REFERENCE FRAME.

TCD    SEARCHES FOR TACHYONIC DECAY (LOWER LIMIT FOR MEAN LIFE IN YEARS)
TCD      SEE LJUBICIC 75 FIG. 1 FOR REVIEW OF EARLIER EXPERIMENTS.
TCD  A      4.6E+13 OR MORE            LJUBICIC  75 ELEC M(TACHYON)> 1.1 KEV  6/82*
TCD
TCD  A  LJUBICIC 75 USED LEAD OXIDE CATHODE AND ELECTRON MULTIPLIER LOOKING   6/82*
TCD  A  FOR IONIZATION DUE TO TACHYONIC DECAY (SPONTANEOUS ACQUISITION OF     6/82*
TCD  A  ENERGY) OF BOUND-STATE E-. SENSITIVE TO PROPER TACHYON MASS>1.1KEV.   6/82*
TCD  A  ABOVE LIMIT IS OBTAINED FROM OBSERVED E- EMISSION RATE 3/HOUR.       6/82*

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REFERENCES FOR OTHER NEW PARTICLE SEARCHES


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BELOUSOV 60 JETP 11 1143      +RUSAKOV,TAMM,CERENKOV                  (LEBD)
GORBUNOV 60 JETP 11 51        +SPIRIDONOV,CERENKOV                    (LEBD)
COWARD   63 PR 131 1782       +GITTELMAN,LYNCH,RITSON                 (STAN)
DORFAN   65 PRL 14 999        +EADES,LEDERMAN,LEE,TING                (COLU)
JONES    67 PR 164 1584          (MICH+WISC+LBL+UCLA+MINN+COSU+COLO+MURA)

BJORNBOE 68 NC B53 241        +DAMGARD,HANSEN,CHATTERGEE+     (BOHR+BERN)
BINON    69 PL 30B 510        DUTEIL,KACHANOV,KHROMOV,KUTYIN+         (SERP)
ANTIPOV1 71 PL 34B 164        +DENISOV,DONSKOV,GORIN,KACHANOV+        (SERP)
ANTIPOV2 71 NP B31 235        +DENISOV,DONSKOV,GORIN,KACHANOV+        (SERP)
DARDO    72 NC 9A 319         DARDO,NAVARRA,PENENGO,SITTE             (TORI)
TONWAR   72 JPA 5 569         TONWAR,NARANAN,SREEKANTAN               (TIFR)
ALPER    73 PL 46B 265          (CERN+LIVP+LUND+BOHR+RHEL+STOH+BERG+LOUC)
LEIPUNER 73 PRL 31 1226       +LARSEN,SESSOMS,SMITH,WILLIAMS+  (BNL+YALE)
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For notation, see key at front of Listings.

Stable Particles

OTHER STABLE PARTICLE SEARCHES


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APPEL    74 PRL 32 428          +BOURQUIN,GAINES,LEDERMAN,PAAR+ (COLU+FNAL)
FRANKEL  74 PR D9 1932          +FRATI,RESVANIS,YANG,NEZRICK    (PENN+FNAL)
YOCK     74 NP B76 175          P.C.M.YOCK                      (UNIV OF AUCKLAND)

ALBROW   75 NP B97 189          +BARBER,BENZ+(CERN+DARE+FOM+LANC+MCHS+UTRE)
BLAGOV   75 YAD.FIZ. 21,300     +KOMAR,MURASHOVA,SYREISHCHIKOVA+        (LEBD)
FRANKEL  75 PR D12 2561         +FRATI,RESVANIS,YANG,NEZRICK    (PENN+FNAL)
JOVANOVI 75 PL 56B 105          JOVANOVICH+ (MANI+AACH+CERN+GENO+HARV+TORI)
LJUBICIC 75 PR D11 696          +PAVLOVIC,PISK,LOGAN            (ZAGR+OTTA)
YOCK     75 NP B86 216          P.C.M. YOCK          (UNIV OF AUCKLAND+SLAC)

ALEKSEE1 76 SJNP 22 531         ALEKSEEV,ZAITSEV,KALININA,KRUGLOV+   (JINR)
ALEKSEE2 76 SJNP 23 633         ALEKSEEV,ZAITSEV,KALININA,KRUGLOV+   (JINR)
BALDIN   76 SJNP 22 264         +VERTOGRADOV,VISHNEVSKII,GRISHKEVICH+(JINR)
BRIATORE 76 NC 31A 553          +DARDO,PIAZZOLI,MANNOCCHI+ (LCGT+FRAS+FREI)
GUSTAFSO 76 PRL 37 474          GUSTAFSON,AYRE,JONES,LONGO,MURTHY    (MICH)
PRESCOTT 76 JPG 2 261           J.R.PRESCOTT                    (ADELAIDE)

BARISH   77 PRL 38 577          +BARTLETT,BODEK,BROWN +     (CIT+FNAL+ROCK)
BENVENUT 77 PRL 38 1110         BENVENUTI,CLINE+ (FNAL+HARV+PENN+RUTG+WISC)
BLETZACK 77 PRL 38 1241         BLETZACKER,NIEH,SONI            (STON+UCSB)
CHANG    77 PRL 39 519          +CHEN,VAN GINNEKEN              (MSU+FNAL)
HOLDER   77 PL 70B 393          +KNOBLOCH,MAY+   (CERN+DORT+HEID+SACL+BGNA)
PEREPELI 77 PL 67B 471          V.P.PEREPELITSA                 (ITEP)
SMITH    77 CJP 55 1280         G.R.SMITH,S.STANDIL             (MANI)

ALBRIGHT 78 PR D18 108          +SMITH,VERMASEREN          (FNAL+STON+PURD)
BENVENUT 78 PRL 40 488          BENVENUTI+        (FNAL+HARV+PENN+RUTG+WISC)
BHAT     78 PRAM 10 115         +RAMANA MURTY                   (TIFR)
BOSETTI  78 PL 74B 143          +DEDEN+      (AACH+BONN+CERN+LOIC+OXF+SACL)

CARROLL  78 PRL 41 777          +CHIANG,JOHNSON,KYCIA,KI +      (BNL+PRIN)
CUTTS    78 PRL 41 363          +DULUDE +     (BROW+FNAL+ILL+BARI+MIT+WARS)
HANSL2   78 PL 77B 114          +HOLDER,KNOBLOCH+(CERN+DORT+HEID+SACL+BGNA)
    ALSO 78 NP B142 381         HANSL,HOLDER+    (CERN+DORT+HEID+SACL+BGNA)

HOLDER   78 PL 73B 105          +KNOBLOCH,MAY+   (CERN+DORT+HEID+SACL+BGNA)
LOVELESS 78 PL 78B 505          +BENADA+       (WISC+LBL+UCB+FNAL+HAWA+WASH)
MORI     78 PRL 40 432          +BENVENUTI+       (FNAL+HARV+PENN+RUTG+WISC)
VIDAL    78 PL 77B 344          +HERB,LEDERMAN,SNYDER+ (COLU+FNAL+STON+UCB)
VIERTEL  78 LNC 22 235          +HAHN,SCHACHER                  (BERN)

ARMITAGE 79 NP B150 87          +BENZ,BOBBINK+ (CERN+DARE+FOM+MCHS+UTRECHT)
BHAT     79 JPG 5 L13           BHAT,GOPALAKRISHNAN,GUPTA,TONWAR     (TIFR)
BENVENUT 79 PRL 42 1024         BENVENUTI+   (FNAL+HARV+OSU+PENN+RUTG+WISC)
BOZZOLI  79 NP B159 363         +BUSSIERE,GIACOMELLI  (BGNA+CERN+LAPP+SACL)

DEGROOT  79 PL 85B 131          +HANSL,HOLDER+   (CERN+DORT+HEID+SACL+BGNA)
GOODMAN  79 PR D19 2572         +ELLSWORTH,ITO,MACFALL,SIOHAN +       (UMD)
SMITH    79 NP B149 525         +BENNETT                        (RHEL)

BARBER   80 PRL 45 1904         +BECKER,BEI+      (AACH+DESY+MIT+AIKO+BHEP)
BARTEL   80 ZPHY C6 295         JADE C.(DESY+HAMB+HEID+LANC+MCHS+RHEL+TOKY)
BUSSIERE 80 NP B174 1           +GIACOMELLI,LESQUOY+       (BGNA+SACL+LAPP)
LEBRITTO 80 PL 89B 271          LEBRITTON,MCCAL,MELISSINOS+  (ROCH+BNL+NSF)
YOCK     80 PR D22 61           YOCK                            (AUCK)

DZHELYAD 81 PL 105B 239         +GOLOVKIN,KONSTANTINOV,KONSTANTINOV+ (SERP)
    ALSO 81 SJNP 33 822 (YF 33 1529) VIKTOROV,GOLOVKIN+             (SERP)
KINOSHIT 81 PR D24 1707         K.KINOSHITA,P.B.PRICE           (UCB)
LOSECCO  81 PL 102B 209         +SULAK,GALIK,HORSTKOTTE+    (MICH+PENN+BNL)
ULLMAN   81 PRL 47 289          J.D.ULLMAN                      (LEHM+BNL)
YOCK     81 PR D23 1207         P.C.M.YOCK                      (AUCK)

ADEVA    82 PL 115B 345         MARK-J COLLAB(AACH+DESY+MIT+MADR+ANIK+BHEP)
ALPGARD  82 PL 115B 71          + UA5 COLLAB.    (BONN+BRUX+CAVE+CERN+STON)
BARTEL   82 PL 114B 211         JADE C.  (DESY+HAMB+HEID+LANC+MCHS+RL+TOKY)
BEHREND  82 PL 114B 287         CELLO C.    (DESY+KARL+MPIM+ORSA+LPNP+SACL)
BHAT     82 PR D25 2820         +GUPTA,RAMANA MURTHY,SREEKANTAN+     (TIFR)
BLOCKER  82 PRL 49 517          +MATTEUZZI,ABRAMS+          (HARV+SLAC+LBL)

BRANDELI 82 PL 117B 365         BLANDELIK+ TASSO C.  (AACH+BONN+DESY+HAMB+)
KANE     82 PL 112B 227         G.L.KANE,J.P.LEVEILLE           (MICH)
KINOSHIT 82 PRL 48 77           KINOSHITA,PRICE,FRYBERGER       (UCB+SLAC)
MARINI   82 PR D26 1777         +PERUZZI,PICCOLO+ (FRAS+LBL+NWES+STAN+HAWA)
SHANKER  82 NP B204 375         O.SHANKER                       (TRIU)
VERGADOS 82 PL 109B 96          J.D.VERGADOS                    (CERN)
    ALSO 82 PL 113B 513         J.D.VERGADOS                    (CERN)
    ALSO 83 NP 218B 109         J.D.VERGADOS                    (CERN)
WILLEY   82 PR D26 3287         R.S.WILLEY,H.L.YU               (PITT)

ADEVA    83 PRL 51 443          MARKJ C. (AACH+DESY+MIT+MADR+AIKO+BHEP+CIT)
ALTHOFF  83 PL 122B 95          TASSO C.    (AACH+BONN+DESY+HAMB+LOIC+OXF+)
ARNISON  83 PL 122B 189         + UA1 COLLAB.    (AACH+LAPP+BIRM+CERN+HELS+)
BEHREND  83 PL 123B 127         + CELLO COL.(DESY+KARL+MPIM+ORSA+LPNP+SACL)
BERGSMA  83 PL 121B 429         + CHARM COLLAB.  (ANIK+CERN+HAMB+MOSU+ROMA)
BRYMAN   83 PRL 50 7            +DUBOIS,NUMAO+   (TRIU+VICT+CNRC+BRCO+QUKI)

CHANOWIT 83 PL 126B 225         M.CHANOWITZ,S.SHARPE            (UCB+LBL)
CHEN     83 PL 122B 317         + (SYRA+VAND+CORN+ITHA+HARV+OHIO+ROCH+RUTG)
DESHPAND 83 PR D27 1193         DESHPANDE,JOHNSON               (OREG)
FERNANDE 83 PR D28 2721         FERNANDEZ+ (COLO+FRAS+HOUS+NEAS+SLAC+UTAH+)
GLADNEY  83 PRL 51 2253         +HOLLEBEEK,LECLAIRE,ABRAMS+ (SLAC+LBL+HARV)
HOFFMAN  83 PR D28 660          +FRANK,MISCHKE,MOIR,SCHARDT     (LANL+ARZS)
SAKUYAMA 83 NCL 37 17           H.SAKUYAMA,N.NUZUKI             (MEIS)
    ALSO 83 NCL 36 389          H.SAKUYAMA,K.WATANABE           (MEIS)
    ALSO 83 NC 78A 147          H.SAKUYAMA,K.WATANABE           (MEIS)
    ALSO 83 NC 6C 371           H.SAKUYAMA,K.WATANABE           (MEIS)

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Mesons

$\pi^{\pm}$, π^0, η, $\rho(770)$

Data Card Listings

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        S=0,  C=0,  B=0  MESON  STATES

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$\pi^{\pm}$

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        8  CHARGED PION(140,JPG=0--) I=1

      SEE STABLE PARTICLE DATA CARD LISTINGS

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π^0

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        9  NEUTRAL PION(135,JPG=0--) I=1

      SEE STABLE PARTICLE DATA CARD LISTINGS

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η

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       14  ETA(549,JPG=0-+) I=0

      SEE STABLE PARTICLE DATA CARD LISTINGS

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$\rho(770)$

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        9  RHO(770,JPG = 1-+) I=1
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NOTE ON THE ρ^0 MASS AND WIDTH

Because of the broadness of the ρ meson, its shape is not very well described by a Breit-Wigner formula, which is a narrow-resonance approximation. Although most experimental distributions can be well described by a relativistic Breit-Wigner formula with a P-wave width and an additional shape parameter (PISUT 68), the resulting resonance parameters will clearly depend on this model. A consistent set of such determinations (PISUT 68, ESTABROOKS 74, BARTALUCCI 78, WICKLUND 78, HEYN 80) yields $m_{\rho^0} = (769 \pm 3)$ MeV, $\Gamma_{\rho^0} = (154 \pm 3)$ MeV.

Attempts have been made to determine the ρ pole position in a more model-independent way (LANG 79, BOHACIK 80). It is comforting that these determinations agree with the above mass average (LANG 79, however, finds a somewhat smaller width).

A phenomenological estimate of the ρ mass can be obtained with an SU(4) generalization of the Gell-Mann-Okubo mass formula, which in the limit of ideal mixing can be written (MONTONEN 75)

$$\rho = \frac{2[\psi K^*(892) - \phi D^*] + \omega[D^* - K^*(892)]}{2[\psi - \phi] - [D^* - K^*(892)]} .$$

The masses of the vector mesons on the right-hand side have all been determined to a much better precision than that of the ρ and can be used to predict the mass of the $\rho = (768 \pm 2)$ MeV. The theoretical error due to nonideal mixing is expected to be of the order of $\pm$ 1.5 MeV. The result is consistent with the measured value (769 ± 3) MeV given above.

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                    9  RHO MASS (MEV)

M        WE NO LONGER LIST S-WAVE BREIT-WIGNER FITS, PBAR P DATA WITH HIGH
M        COMBINATORIAL BACKGROUND, AND INSIGNIFICANT OR DOUBTFUL DATA.
M        SEE ALSO THE MINI-REVIEW ABOVE.

M   CHARGED ONLY
M   R        (760.0)    (9.0)          CARMONY    64 HBC  +   3.5 PI+P,TCUT 4
M   R        (768.0)    (5.0)          BLIEDEN    65 MMS  -   3-5 PI- P        6/66
M   R        (765.0)    (5.0)          ALFF-STEI  66 HBC  +   2-3 PI+ P        6/66
M   R        (760.0)    (5.0)          HAGOPIAN1  66 HBC  -   3.0 PI-          6/66
M   R        (765.0)    (5.0)          HAGOPIAN2  66 HBC  -   2.14 PI-,TCUT12  9/67
M   R 2775   (753.5)   (10.5)          JACOBS     66 HBC  -   2-3PI-,T CUT 20  6/68
M   R        (758.0)   (10.0)          JAMES      66 HBC  +   2.1 PI+,TCUT2.5  8/66
M   R        (749.0)    (3.0)          WEST       66 HBC  -   2.1 PI- P       10/66
M   R        (768.0)    (5.0)          MILLER     67 HBC  -   2.7 PI-,T CUT20  9/66
M   R        (773.0)    (2.0)          BATON      68 HBC  -   2.8 PI-,T CUT13  7/69
M
M   Z   900   767.       6.             EISNER     67 HBC  -   4.2 PI-,T CUT10  1/73
M   A  9650   766.8      1.5            PISUT      68 RVUE -   1.7-3.2PI-,CT10  6/68
M   X  6500   766.       7.             BYERLY     73 OSPK -   5. PI- P         2/74
M
M   AVG       766.8      1.4      AVERAGE

MO  NEUTRAL ONLY
MO  R  300   (760.0)   (10.0)          ABOLINS    63 HBC    0 3.5 PI+P
MO  R  500   (770.0)   (10.0)          GOLDHABER  64 HBC    0 3.7 PI+P
MO  R        (750.0)    (5.0)          ALFF-STEI  66 HBC    0 2-3 PI+ P        6/66
MO  R        (775.0)    (5.0)          HAGOPIAN1  66 HBC    0 3.0 PI- P        6/66
MO  R        (770.)     (5.)           HAGOPIAN2  66 HBC    0 2.1 PI-,TCUT 12  2/67
MO  R 4207   (758.0)    (7.5)          JACOBS     66 HBC    0 2-3PI-,T CUT 20  6/68
MO  R        (765.0)    (8.0)          JAMES      66 HBC    0 2.1 PI+ P        6/66
MO  R        (760.0)    (3.0)          WEST       66 HBC    0 2.1 PI- P       10/66
MO  P 4000   (765.)     (5.0)          ASBURY 2   67 CNTR   0 GAMMA + PB       1/73
MO  R        (768.0)    (2.0)          BACON      67 HBC    0 1.7 PI-P         9/67
MO  R        (761.)     (3.)           HUWE       67 HBC    0 2.4 PI- P        7/67
MO  R        (770.0)    (4.0)          MILLER     67 HBC    0 2.7 PI-,T CUT20  9/66
MO  R        (775.0)    (2.0)          ARMENISE   68 DBC    0 5.1 PI+D         6/68
MO  R        (768.4)    (2.4)          MALAMUD    69 RVUE   0 2-4 PI-P         1/73
MO  P        (765.0)   (10.0)          ALVENSLEB  70 CNTR   0 GAMMA A,TCUT.01  1/73
MO  P        (775.)     (5.)           GLADDING   73 CNTR   0 2.9-4.7 GAMMA P  2/74
MO  H        (778.)     (2.)           HYAMS      73 ASPK   0 17.PI-P,PI+PI-N  1/74
MO  H        (770.)     (9.)           ESTABROOK  74 RVUE   0 17 PI-P,PI+PI-N 12/75
MO  G        (775.)     (2.)           GRAYER     74 ASPK   0 17.PI-P,PI+PI-N  2/74
MO  D        (776.3)    (0.4)          ROOS       75 RVUE   0 PHASE SHIFTS    12/75
MO EG        (776.1)    (2.6)          BECKER     79 ASPK   0 17.PI-P POLARIZ 12/79
MO  CH       (769.5)    (0.7)          LANG       79 RVUE   0                  1/82
MO
MO     2250  775.0      3.0            HYAMS      68 OSPK   0  11.2 PI- P       9/68
MO A 13300   769.2      1.5            PISUT      68 RVUE   0 1.7-3.2PI-,CT10  1/73
MO    1700   774.0      3.0            REYNOLDS   69 HBC    0 2.26 PI- P      12/78
MO   140K    767.7      1.9            BIGGS      70 CNTR   0 PHOTOPROD.       1/73
MO    1930   767.0      4.0            BALLAM     72 HBC    0 2.8 GAMMA P      1/73
MO    2430   770.0      4.0            BALLAM     72 HBC    0 4.7 GAMMA P      1/73
MO Z 11200   773.5      1.7            JACOBS     72 HBC    0 2.8 PI- P        1/73
MO    6800   764.0      3.0            RATCLIFF   72 ASPK   0 15. PI-P,TCUT.3  2/74
MO C 32000   775.0      4.0            PROTOPOPE  73 HBC    0 7.1 PI+P,TCUT.4  2/74
MO    4100   767.       4.             ENGLER     74 DBC    0 6. PI+N,PI+PI-P 12/75
MO   76000   768.0      1.0            DEUTSCHMA  76 HBC    0 16. PI+ P        4/78
MO E         767.6      2.7            BARTALUCC  78 CNTR   0 BREMS,E+E-P     12/77
MO X         769.0      3.0            WICKLUND   78 ASPK   0 3,4,6 PI+-PN     4/78
MO C H       768.0      4.0            BOHACIK    80 RVUE   0                  1/82
MO E B       770.       2.             HEYN       80 RVUE    PION FORM FACTOR  9/81
MO G         777.4      2.0            CHABAUD    83 ASPK   0 17 PI-P POLARIZ 12/83*
MO K         775.9      2.0            KURDADZE   83 OLYA     E+E-            1/84*
MO
MO   AVG     770.34     0.86     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.7)
                        (SEE IDEOGRAM BELOW)

M        ----------NOTES----------

M   A    FROM FIT OF 3-PARAMETER RELATIVISTIC P-WAVE BREIT WIGNER TO TOTAL
M   A    MASS DISTRIBUTION.
M   B    HEYN 80 INCLUDES ALL SPACELIKE AND TIMELIKE F(PI)
M   B    VALUES UNTIL 1978.
M   C    FROM POLE EXTRAPOLATION
M   D    ENERGY-DEPENDENT ANALYSIS OF BATON 70, HYAMS 73,
M   D    PROTOPOPESCU 73 PHASE SHIFTS.
M   E    PURE P-WAVE SYSTEM.
M   G    FROM FIT OF 3-PARAMETER RELATIVISTIC BREIT-WIGNER TO
M   G    HELICITY ZERO PART OF P-WAVE INTENSITY. CHABAUD 83 AND BECKER 79
M   G    INCLUDE DATA OF GRAYER 74.
M   H    FROM PHASE SHIFT ANALYSIS OF GRAYER 74 DATA.
M   P    FROM PHOTOPRODUCTION, MODEL DEPENDENT.
M   R    INCLUDED IN PISUT 68 RVUE
M   X    PHASE SHIFT ANALYSIS. SYSTEMATIC ERRORS ADDED CORRESPONDING
M   X    TO SPREAD OF DIFFERENT FITS.
M   Z    MASS ERRORS ENLARGED BY US TO WIDTH/SQRT(N),SEE K* TYPED NOTE
M   K    FROM THE GOUNARIS-SAKURAI PARAMETRIZATION OF THE PION FORM FACTOR
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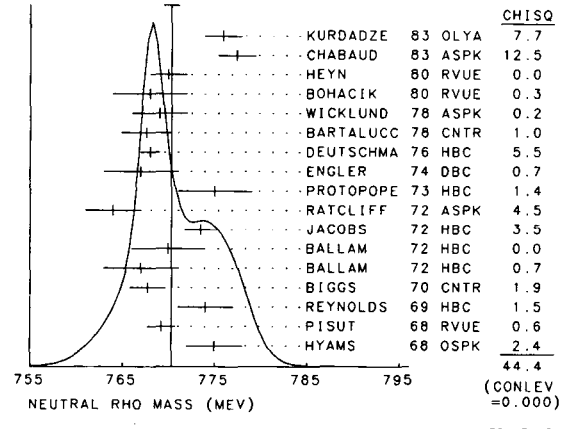
WEIGHTED AVERAGE = 770.34 ± 0.86
ERROR SCALED BY 1.7



For notation, see key at front of Listings.

Mesons
$\rho(770)$

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                    9  (RHO0) - (RHO+-) MASS DIFFERENCE (MEV)

D  A  3600   -5.       5.              FOSTER    68 HBC  +-0 PBAR P AT REST  12/78
D    22950    2.4      2.1             PISUT     68 RVUE     PI N TO RHO N    6/68
D  A  3000   -4.0      4.0             REYNOLDS  69 HBC   -0 2.26 PI- P      12/78
D            . . . . . . . .
D   AVG       0.3      2.2     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.3)

D  A    FROM QUOTED MASSES OF CHARGED AND NEUTRAL MODES

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                    9  RHO RANGE PARAMETER (GEV-1)

R             5.3      0.9      0.7   CHABAUD   83 ASPK  0 17 PI-P POLARIZ  12/83*

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                    9  RHO WIDTH (MEV)

W       WE NO LONGER LIST S-WAVE BREIT-WIGNER FITS, PBAR P DATA WITH HIGH
W       COMBINATORIAL BACKGROUND, AND INSIGNIFICANT OR DOUBTFUL DATA.
W       SEE FURTHER MINI-REVIEW ABOVE.

W   CHARGED ONLY
W   R        (77.0)   (20.0)            CARMONY   64 HBC  +   3.5 PI+P,TCUT 4
W   R       (100.0)                     ALFF-STEI 66 HBC  +   2-3 PI+ P        6/66
W   R       (127.0)    (5.0)            BLIEDEN   66 MMS   -  3-5 PI- P        6/66
W   R       (150.0)   (20.0)            HAGOPIAN1 66 HBC  -   3.0 PI- P        6/66
W   R       (135.0)   (20.0)            HAGOPIAN2 66 HBC  -   2.14 PI-,TCUT12  9/67
W   R 2775  (137.1)   (20.0)            JACOBS    66 HBC  -   2-3PI-,T CUT 20  6/68
W   R       (147.0)   (19.0)            JAMES     66 HBC  +   2.1 PI+,TCUT2.5  8/66
W   R       (149.0)    (13.0)           WEST      66 HBC  -   2.1 PI- P       10/66
W   R       (153.0)   (13.0)            MILLER    67 HBC  -   2.7 PI-,T CUT20  9/66
W   R       (150.0)    (5.0)            BATON     68 HBC  -   2.8 PI- P        7/69
W
W       900  146.      13.              EISNER    67 HBC  -   4.2 PI-,T CUT10  9/67
W   A  9650  148.2      4.1             PISUT     68 RVUE -   1.7-3.2PI-,CT10  6/68
W   X  6500  146.      12.              BYERLY    73 OSPK -   5. PI- P         2/74
W            . . . . . . . .
W   AVG      147.8      3.7     AVERAGE

W0  NEUTRAL ONLY
W0  R  300  (90.0)   (10.0)             ABOLINS   63 HBC   0 3.5 PI+P
W0  R  500 (130.0)                      GOLDHABER 64 HBC   0 3.7 PI+P
W0  R      (100.0)                      ALFF-STEI 66 HBC   0 2-3 PI+ P        6/66
W0  R      (120.0)   (10.0)             HAGOPIAN1 66 HBC   0 3.0 PI- P        6/66
W0  R      (135.0)   (20.0)             HAGOPIAN2 66 HBC   0 2.14 PI-P,LOW T   9/67
W0  R 4207 (122.2)   (15.0)             JACOBS    66 HBC   0 2-3PI-,T CUT 20  6/68
W0  R      (103.0)   (13.0)             JAMES     66 HBC   0 2.1 PI+ P        6/66
W0  R      (173.0)   (13.0)             WEST      66 HBC   0 2.1 PI- P       10/66
W0  P 4000 (130.)     (5.)              ASBURY 2  67 CNTR  0 GAMMA + PB       1/73
W0  R      (148.0)    (8.0)             BACON     67 HBC   0 1.7 PI-P        9/67
W0  R      (152.)    (15.)              HUWE      67 HBC   0 2.4 PI- P       7/67
W0  R      (160.0)   (15.0)             MILLER    67 HBC   0 2.7 PI-,T CUT20  9/66
W0  R      (167.0)    (6.0)             ARMENISE  68 DBC   0 5.1 PI+D        6/68
W0  P      (160.0)   (10.0)             LANZEROTT 68 CNTR  0 GAMMA P          1/73
W0  R      (132.0)   (13.0)             MALAMUD   69 RVUE  0 2-4 PI-P         1/73
W0  P      (140.0)    (5.0)             ALVENSLEB 70 CNTR  0 GAMMA A,TCUT.01   1/73
W0  P      (147.)    (11.)              GLADDING  73 CNTR  0 BREMS.           2/74
W0  H      (152.)     (2.)              HYAMS     73 ASPK  0 17.PI-P,PI+PI-N   1/74
W0  H      (143.)    (13.)              ESTABROOK 74 RVUE  0 17 PI-P,PI+PI-N  12/75
W0  G      (163.)     (4.)              GRAYER    74 ASPK  0 17.PI-P,PI+PI-N   2/74
W0  D      (154.5)    (1.0)             ROOS      75 RVUE  0 PHASE SHIFTS     12/75
W0  G      (161.8)    (7.6)     (7.2)   BECKER    79 ASPK  0 17.PI-P POLARIZ  12/79

W0 Z  2250  145.0      12.0             HYAMS     68 OSPK  0 11.2 PI- P        1/73
W0 A 13300  163.0      15.0             PISUT     68 RVUE  0 1.7-3.2PI-,CT10   1/73
W0    1700  143.0       8.0             REYNOLDS  69 HBC   0 2.26 PI- P       12/78
W0    140K  146.1       2.9             BIGGS     70 CNTR  0 PHOTOPROD.        1/73
W0 Z  2430  155.0      12.0             BALLAM    72 HBC   0 4.7 GAMMA P       1/73
W0 Z  1930  145.0      13.0             BALLAM    72 HBC   0 2.8 GAMMA P       1/73
W0    6800  157.0       8.0             RATCLIFF  72 ASPK  0 15. PI-P,TCUT.3   2/74
W0 C 32000  160.0      10.0             PROTOPOPE 73 HBC   0 7.1 PI+P,TCUT.4   2/74
W0    4100  146.       14.              ENGLER    74 DBC   0 6. PI+N,PI+PI-P  12/75
W0   76000  154.0       2.0             DEUTSCHMA 76 HBC   0 16. PI+ P         4/78
W0 E        150.9       3.0             BARTALUCC 78 CNTR  0 BREMS,E+E-P      12/77
W0 X        152.0       9.0             WICKLUND  78 ASPK  0 3,4,6 PI+-PN      4/78
W0  CH     (148.0)     (1.3)            LANG      79 RVUE  0                  1/82
W0 C H      148.0       6.0             BOHACIK   80 RVUE  0                  1/82
W0 E B      155.        1.              HEYN      80 RVUE  0 PION FORM FACT.  9/81
W0 G        160.0       4.1       4.0   CHABAUD   83 ASPK  0 17 PI-P POLARIZ 12/83*
W0 K        148.8       4.3             KURDADZE  83 OLYA    E+E-            1/84*
W0           . . . . . . . .
W0  AVG     153.7       1.0     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.3)
                        (SEE IDEOGRAM BELOW)

W       ----------NOTES----------

W   A   FROM FIT OF 3-PARAMETER RELATIVISTIC P-WAVE BREIT WIGNER TO TOTAL
W   A   MASS DISTRIBUTION.
W   B   HEYN 80 INCLUDES ALL SPACELIKE AND TIMELIKE F(PI)
W   B   VALUES UNTIL 1978.
W   C   FROM POLE EXTRAPOLATION
W   D   ENERGY-DEPENDENT ANALYSIS OF BATON 70, HYAMS 73,
W   D   PROTOPOPESCU 73 PHASE SHIFTS.
W   E   PURE P-WAVE SYSTEM.
W   G   FROM FIT OF 3-PARAMETER RELATIVISTIC BREIT-WIGNER TO
W   G   HELICITY ZERO PART OF P-WAVE INTENSITY. CHABAUD 83 AND BECKER 79
W   G   INCLUDE DATA OF GRAYER 74.
W   H   FROM PHASE SHIFT ANALYSIS OF GRAYER 74 DATA.
W   P   FROM PHOTOPRODUCTION, MODEL DEPENDENT.
W   R   INCLUDED IN PISUT 68 RVUE
W   X   PHASE SHIFT ANALYSIS. SYSTEMATIC ERRORS ADDED CORRESPONDING
W   X   TO SPREAD OF DIFFERENT FITS.
W   Z   WIDTH ERRORS ENLARGED BY US TO 4*WIDTH/SQRT(N),SEE K* TYPED NOTE
W   K   FROM THE GOUNARIS-SAKURAI PARAMETRIZATION OF THE PION FORM FACTOR

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                    9  RHO PARTIAL DECAY MODES

                                                          DECAY MASSES
P1      RHO INTO 2PI                                     140+ 140
P2      RHO INTO 4PI                                     140+ 140+ 140+ 140
P3      RHO INTO PI GAMMA                                140+   0
P4      RHO INTO E+ E-                                   .511+.511
P5      RHO INTO PI ETA (VIOLATES G)                     140+ 549
P6      RHO INTO MU+ MU-                                 106+ 106
P7      RHO INTO PI+ PI- PI0 (VIOLATES G)                140+ 140+ 135
P8      RHO INTO ETA GAMMA                               549+   0

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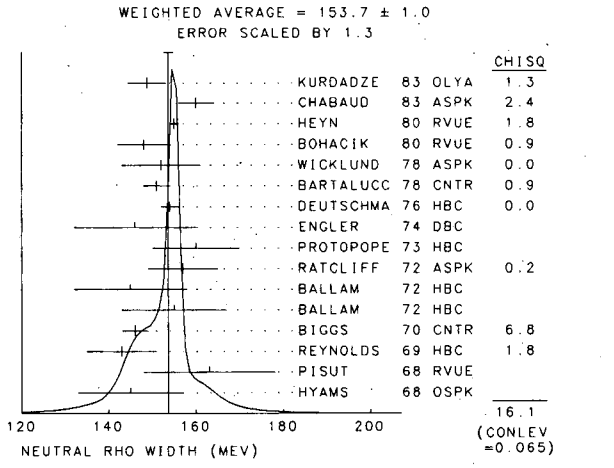


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                    9  RHO PARTIAL WIDTHS (KEV)

W3      RHO INTO (PI GAMMA)                                  (G3)
W3          (35.0)   (10.0)             GOBBI     74 OSPK  - 23. PI-A,PI-PI0A 12/75
W3           71.0     7.0               JENSEN    83 SPEC  - PI-A,PI- PI0 A    9/83*
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                    9  RHO BRANCHING RATIOS

R1      RHO INTO 4PI/2PI                                     (P2)/(P1)

R1      RHO+- INTO (PI+- PI+ PI- PI0) / (PI+- PI0)
R1            (0.002)OR LESS            FERBEL    66 HBC  +- PI+- P ABOVE 2.5 10/66
R1             0.0035   0.004           JAMES     66 HBC  +   2.1 PI+P        11/66

R1      RHO0 INTO (PI+ PI- PI+ PI-) / (PI+ PI-)
R1            (0.008)OR LESS            JAMES     66 HBC    0 2.1 PI+P         6/66
R1            (0.002)OR LESS            CHUNG     68 HBC    0 3.2,4.2 PI-P     7/67
R1            (0.002)OR LESS   CL=.90   HUSON     68 HLBC   0 16.0 PI- P       1/71
R1            (0.0015)R LESS   CL=.90   ERBE      69 HBC    0 2.5-5.8 GAMMA P 10/67
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NOTE ON THE e^+e^- AND $\mu^+\mu^-$ DECAYS

Extraction of a ratio for $\rho^0 \to e^+e^-$ is complicated by interference with ω decay. In photoproduction, $\gamma A \to e^+e^-A$, there is substantial interference between the allowed $(\rho^0, \omega) \to e^+e^-$ decays. The interference in the colliding-beam reaction $e^+e^- \to \pi^+\pi^-$ is due to G-parity-violating mixing of the overlapping ρ^0 and ω resonances; it alters the results for the rate $\Gamma(\rho^0 \to e^+e^-)$ only by a small amount. Therefore at present we average only the values from the $e^+e^- \to \pi^+\pi^-$ experiments.

The same comment applies to the decay $\rho^0 \to \mu^+\mu^-$.

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R3      RHO INTO(E+ E-)/(PI+PI-) (UNITS 10**-4)          (P4)/(P1)
R3
R3       SEE MINI-REVIEW ABOVE.
R3
R3  P   94   (0.65)   (0.14)            ASBURY 1  67 CNTR     PHOTOPRODUCTION  9/67
R3  H        (0.65)   (1.1)     (0.5)   HERTZBACH 67 OSPK ASSUME SU(3)+MIXING 10/66
R3  A   33   (0.53)   (0.11)            ASTVACATU 68 OSPK ASSUME SU(3)+MIXING  6/68
R3           0.50     0.10              AUSLENDER 69 OSPK    E+E- COLLID.BEAM  9/68
R3  F        (0.49)   (0.12)   (0.15)   BIGGS     70 CNTR    PHOTOPRODUCTION   6/70
R3           0.41     0.05              BENAKSAS  72 OSPK     E+E- COLL.BEAMS 12/72
R3           0.462    0.018             KURDADZE  83 OLYA     E+E-             1/84*
R3           . . . . . . . .
R3  AVG      0.457    0.017   AVERAGE

R3  A        NOT SEPARATED FROM OMEGA DECAY. ERROR STATISTICAL ONLY.
R3  F        ASSUMING RHO WIDTH 140 MEV. ERROR STATISTICAL ONLY.
R3  H        NOT SEPARATED FROM OMEGA DECAY.
R3  P        POSSIBLY LARGE RHO-OMEGA INTERFERENCE
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Mesons

$\rho(770)$, $\omega(783)$

Data Card Listings

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R4      RHO INTO (PI ETA)/(2PI)                          (P5)/(P1)
R4            (0.008)OR LESS            FERBEL    66 HBC  +- PI+- P ABOVE 2.5 11/66

R5      RHO INTO (MU+ MU-)/(PI+ PI-) (UNITS 10**-4)      (P6)/(P1)
R5
R5        SEE MINI-REVIEW ABOVE.
R5
R5   H          0.97      0.31      0.33  HYAMS     67 OSPK     11 PI- LI H       6/67
R5   R          0.82      0.16      0.36  ROTHWELL  69 CNTR     PHOTOPRODUCTION   4/70
R5   W          0.56      0.15            WEHMANN   69 OSPK      12 PI- ON C,FE   7/69
R5            . . . . . . . . . .
R5  AVG         0.67      0.12    AVERAGE

R5   H          HYAMS MASS RESOL. IS 20 MEV. THE OMEGA REGION WAS EXCLUDED.
R5   R          POSSIBLY LARGE RHO-OMEGA INTERFERENCE LEADS US TO INCREASE
R5   R          THE MINUS ERROR
R5   W          RESULT CONTAINS (11 +- 11) PER CENT CORRECTION USING SU(3)
R5   W          FOR CENTRAL VALUE. THE ERROR ON THE CORRECTION TAKES ACCOUNT
R5   W          OF POSSIBLE RHO-OMEGA INTERFERENCE AND THE UPPER LIMIT AGREES
R5   W          WITH THE UPPER LIMIT OF (OMEGA INTO MU+ MU-) FROM THIS EXPT.

R6      RHO  INTO (PI+ PI- PI0)/(PI+ PI-)                (P7)/(P1)
R6   G          (0.01) OR LESS  CL=.84    ABRAMS    71 HBC    0 3.7 PI+ P        11/71
R6   G        MODEL DEPENDENT,ASSUMES I = 1,2,OR 3 FOR THE 3PI SYSTEM            11/71

R7      RHO INTO (ETA GAMMA)/TOTAL (UNITS 10**-4)        (P8)
R7   A          (3.6)     (0.9)           ANDREWS   77 CNTR   0 6.7-10 GAMMA CU  12/77
R7   B          (5.4)     (1.1)           ANDREWS   77 CNTR   0 6.7-10 GAMMA CU  12/77
R7   A    SOLUTION CORRESPONDING TO CONSTRUCTIVE OMEGA-RHO INTERFERENCE
R7   A    THE QUARK MODEL PREDICTS A RELATIVE DECAY PHASE OF ZERO.
R7   B    SOLUTION CORRESPONDING TO DESTRUCTIVE OMEGA-RHO INTERFERENCE

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REFERENCES FOR RHO


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ANDERSON 61 PRL 6 365          ANDERSON,BANG,BURKE,CARMONY,SCHMITZ   (LRL)
ERWIN    61 PRL 6 628          A.R.,R.MARCH,W.D.WALKER,E.WEST        (WISC)

KENNEY   62 PR 126 736         V P KENNEY,W D SHEPHARD,C D GALL (KENTUCKY)
SAMIOS   62 PRL 9 139          SAMIOS,BACHMAN,LEA+    (BNL+CUNY+COLU+KNTY)
XUONG    62 PR 128 1849        NGUYEN HUU XUONG,GERALD R LYNCH       (LRL)

ABOLINS  63 PRL 11 381         ABOLINS,LANDER,MEHLHOP,NGUYEN,YAGER  (UCSD)
ALITTI   63 NC 29 515          ALITTI,BATON,ARMENISE+(SACL+ORSA+BARI+BGNA)
CHADWICK 63 PRL 10 62          CHADWICK,DAVIES,DERRICK,CRESTI + (OXF+PADO)
GUIRAGOS 63 PRL 11 85          ZAVEN GUIRAGOSSIAN                    (LRL)
SACLAY   63 SIENA CONF 1 239   SACLAY+ORSAY+BARI + BOLOGNA- COLLABORATION

BONDAR   64 NC 31 729          BONDAR+   (AACHEN+BIRM+BONN+DESY+LOIC+MPIM)
CARMONY  64 DUBNA CONF 1 486   CARMONY,HOA,LANDER,NG.H.XUONG,YAGER  (UCSD)
GOLDHABE 64 PRL 12 336         GOLDHABER,BROWN,KADYK,SHEN+       (LRL+UCB)

ALYEA    65 PL 15 82           ALYEA,CRITTENDEN,MARTIN,RHODE +   (INDIANA)
ARMENISE 65 NC 37 361          SACLAY+ORSAY+BARI+BOLOGNA     COLLABORATION
BLIEDEN  65 PL 19 444          CERN MISSING MASS SPECTROMETER GROUP (CERN)
CLARK    65 PR 139 B 1556      A CLARK,CHRISTENSON,CRONIN,TURLAY(PRINCETO)
GUTAY    65 NC 39 381          GUTAY,LANNUTTI,TULI                   (FSU)
LANZEROT 65 PRL 15 210         LANZEROTTI,BLUMENTHAL,EHN,FAISSLER + (HARV)
ZDANIS   65 PRL 14 721         ZDANIS,MADANSKY,KRAEMER +         (JHU+BNL)

ACCENSI  66 PL 20 557          ACCENSI,ALLES-BORELLI,FRENCH,FRISK+  (CERN)
ALFF-STE 66 PR 145 1072        ALFF-STEINBERGER,BERLEY,BRUGGER+(COLU+RUTG)
BALTAY   66 PR 145 1103        +FRANZINI,LUTJENS,SEVERINS,TYCKO+(COLUMBIA)
BLIEDEN  66 NC 43 71           CERN MISSING MASS SPECTROMETER GROUP (CERN)
CAMBRIDG 66 PR  146  994       CAMBRIDGE BUBBLE CHAMBER GROUP  (MIT+HARV+)
CASON    66 PR  148  1282      N M CASON                       (WISCONSIN)
DEUTSCHM 66 PL 20 82           DEUTSCHMANN,STEINBERG + (AACH+BERLIN+ CERN)
FERBEL   66 PL 21 111          FERBEL                          (ROCHESTER)
FIDECARO 66 PL  23  163        G+M FIDECARO,J POIRIER,P SCHIAVON    (CERN)
HAGOPIAN166 PR 145 1128        HAGOPIAN,SELOVE,ALITTI,BATON+ (PENN+SACLAY)
HAGOPIAN266 PR  152  1183      HAGOPIAN,PAN    (PENNSYLVANIA,LRL-BERKELEY)
HUSON    66 PL 20 91           HUSON,ALLARD,DRIJARD,HENNESSY+ (ORSAY+EPOL)
JACOBS   66 UCRL-16877         L.D.JACOBS                            (LRL)
JAMES    66 PR 142 896         F E JAMES,KRAYBILL          (YALE+BROOKHAVEN)
WEST     66 PR 149 1089        WEST,BOYD,ERWIN,WALKER           (WISCONSIN)

ALLES-BO 67 NC 50 A 776        ALLES-BORELLI,FRENCH,FRISK,+    (CERN+BONN)
ASBURY 1 67 PRL 19 869         +BECKER+BERTRAM+JOOS+JORDAN+    (DESY+COLU)
ASBURY 2 67 PRL 19 865         +BECKER+BERTRAM+JOOS+JORDAN+    (DESY+COLU)
BACON    67 PR 157 1263        +FICKINGER,HILL,HOPKINS,ROBINSON+     (BNL)
BANNER   67 PL  25 B  300      +FAYOUX,HAMEL,ZSEMBERY,CHEZE+ (SACLAY+CAEN)
BARLOW   67 NC 50A 701         +LILLESTOL+MONTANET+  (CERN+CDEF+IRAD+LIVP)
BATON    67 PL 25 B 419        J.BATON,G.LAURENS,J.REIGNIER        (SACLAY)
    ALSO 67 NP B 3  349        J.BATON,G.LAURENS,J.REIGNIER        (SACLAY)
CLEAR    67 NC 49A 399         +JOHNSTON+COOPER+MANNER+    (TNTO+ANL+WISC)
DANYSZ   67 NC 51 A 801        DANYSZ+FRENCH+SIMAK                   (CERN)
EISNER   67 PR 164 1699        +JOHNSON+KLEIN+PETERS+SAHNI+YEN+   (PURDUE)
FRENCH   67 NC 52A 442         +KINSON+MCDONALD+RIDDIFORD+     (CERN+BIRM)
HERTZBAC 67 PR 155  1461       HERTZBACH,KRAEMER,MADANSKI,ZDANIS+(JHU+BNL)
HUWE     67 PL 24B 252         +MARQUIT+OPPENHEIMER+SCHULTZ+WILSON  (COLU)
HYAMS    67 PL 24B 634         +KOCH+PELLETT+POTTER+VONLINDERN+(CERN+MPIM)
MILLER   67 PR 153 1423        MILLER,GUTAY,JOHNSON,LOEFFLER +    (PURDUE)
POIRIER  67 PR 163 1462        +BISWAS,CASON,DERADO,KENNEY+    (NDAM+PENN)

ABC COLL 68 NP B4 501                  AACHEN+BERLIN+CERN COLLABORATION
ARMENISE 68 NC 54A 999         +GMIDINI,FORINO+     (BARI+BGNA+FIRZ+ORSAY)
ASTVACAT 68 PL 27 B  45        ASTVACATUROV,AZIMOV,BALDIN+   (JINR+MOSCOW)
BATON    68 PR 176 1574        J.P. BATON, G. LAURENS              (SACLAY)
BLECHSCH 68 NC  53 A  1045     BLECHSCHMIDT,DOWD,ELSNER,+      (DESY+MCHS)
    ALSO 67 NC  52 A  1348
CHUNG    68 PR 165 1491        S.U.CHUNG,O.I.DAHL,J.KIRZ,D.H.MILLER  (LRL)
DONALD   68 NP B 6 174         +EDWARDS,FRODESEN,BETTINI+ (LIVP+OSLO+PADO)
FOSTER   68 NP B 6 107         +GAVILLET+LABROSSE+MONTANET+    (CERN+CDEF)
HUSON    68 PL 28B 208         +LUBATTI,SIX,VEILLET,+     (ORSA+MILA+UCLA)
HYAMS    68 NP B 7 1           +KOCH,POTTER,WILSON,VON LINDERN+(CERN+MPIM)
JONES    68 PR 166 1405        +BLEULER,CALDWELL,ELSNER,HARTING+    (CERN)
JOHNSON  68 PR 176 1651        +POIRIER,BISWAS,GUTAY+     (NDAM+PURD+SLAC)
KEY      68 PR 166 1430        +PRENTICE+COOPER+MANNER+    (TNTO+ANL+WISC)
LAMSA    68 PR 166 1395        +CASON+BISWAS+DERADO+GROVES+    (NOTREDAME)
LANZEROT 68 PR 166 1365        LANZEROTTI,BLUMENTHAL,EHN,FAISSLER + (HARV)
MARATECK 68 PRL 21 1613        +HAGOPIAN,+  (PENN+LRL+COLO+PURD+TNTO+WISC)
PISUT    68 NP B 6 325         J.PISUT,M.ROOS                        (CERN)

AUGUSTI1 69 PL 28 B 508        +BIZOT+BUON+HAISSINSKI+LALANNE+     (ORSAY)
AUGUSTIZ 69 LNC 2 214          +LEFRANCOIS,LEHMANN,MARIN,+         (ORSAY)
AUSLENDE 69 SJNP 9  69         AUSLENDER,BUDKER,PANTUSOVA,PESTOV+   (NOVO)
ERBE     69 PR 188  2060       GERMAN BUBBLE CHAMBER COLL.          (DESY)
HAISSINS 69 ARGONNE CONF. 373  J.HAISSINSKI                         (ORSAY)
JUHALA   69 PR 184  1461       +LEACOCK,RHODE,KOPELMAN,LIBBY,+  (ISU+COLO)
MALAMUD  69 ARGONNE CONF.P.93  E.MALAMUD, P.SCHLEIN                 (UCLA)
MILLER   69 PR 178 2061        R.MILLER,LICHTMAN,WILLMANN          (PURDUE)
MOTT     69 PR 177 1966        +AMMAR,DAVIS,KROPAC,SLATE,DAGAN+ (NWES+ANL)
REYNOLDS 69 PR 184 1424        +ALBRIGHT,BRADLEY,BRUCKER,HARMS+      (FSU)
ROOS     69 NP B 10 563        M.ROOS,J.PISUT          (CERN+BRATISLAVA)
ROTHWELL 69 PRL 23 1521        +CHASE,EARLES,GETTNER,GLASS,WEINSTEI+(NEAS)
SCHAREN  69 ARGONNE CONF.306   SCHARENGUIVEL                       (PURDUE)
WEHMANN  69 PR 178  2095       +ENGELS,WILSON,+ (HARV+CASE+SLAC+CORN+MCGI)

ALVENSLE 70 PRL 24 786         ALVENSLEBEN,BECKER,BERTRAM,CHEN,COHEN(DESY)
BATON    70 PL 33 B 528        +LAURENS,REIGNIER                   (SACLAY)
BIGGS    70 PRL 24 1197        +BRABEN,CLIFFT,GABATHULER,KITCHING+  (DARE)
BINGHAM  70 PRL 24 955         +FRETTER,MOFFEIT,BALLAM+    (LRL+SLAC+TUFT)
GALLOWAY 70 PR D 1 3077        +MOTT,ALYA,LEE,MARTIN,PRICKETT        (IND)

ABRAMS   71 PR D 4 653         +BARNHAM,BUTLER,COYNE,GOLDHABER,HALL,+(LBL)
BLOODWOR 71 NP B 35 133        BLOODWORTH,JACKSON,PRENTICE,YOON  (TORONTO)
DEERY    71 PR D 3 635         +BISWAS,CASON,GROVES,JOHNSON,+ (NOTRE DAME)

BAILLON  72 PL 38 B 555        +CARNEGIE,KLUGE,LEITH,LYNCH,RATCLIFF+(SLAC)
BALLAM   72 PR D 5 545         +CHADWICK,BINGHAM,MILBURN,+ (SLAC+LBL+TUFT)
BASDEVAN 72 PL 41 B 178        BASDEVANT,FROGGATT,PETERSEN           (CERN)
BENAKSAS 72 PL 39 B 289        +COSME,JEAN-MARIE,JULLIAN,LAPLANCHE,+(ORSA)
DRIVER   72 NP B 38 1          +HEINLOTH,HOHNE,HOFMANN,RATHJE,+(DESY+HAMB)
EISENBER 72 PR D 5 15          EISENBERG,BALLAM,DAGAN,+   (REHO+SLAC+TELA)
GRAYER   72 PHIL.CONF.PROC. 5  +HYAMS,JONES,SCHLEIN,BLUM,DIETL+(CERN+MPIM)
GRAYER   72 NP B 50 29         +HYAMS,JONES,WEILHAMMER,BLUM,+  (CERN+MPIM)
JACOBS   72 PR D 6 1291        L.D.JACOBS                          (SACLAY)
RATCLIFF 72 PL 38 B 345        +BULOS,CARNEGIE,KLUGE,LEITH,LYNCH,+  (SLAC)
TAKAHASH 72 PR D 6 1266        TAKAHASHI,BARISH,+     (TOHO+PENN+NDAM+ANL)

BYERLY   73 PR D 7 637         +ANTHONY,COFFIN,MEANLEY,MEYER,RICE,+ (MICH)
CHARLESW 73 NP B 65 253        CHARLESWORTH,EMMS,BELL,+   (RHEL+BIRM+DURH)
GLADDING 73 PR D 8 3721        +RUSSEL,TANNENBAUM,WEISS,THOMSON     (HARV)
HYAMS    73 NP B 64 134        +JONES,WEILHAMMER,BLUM,DIETL,+  (CERN+MPIM)
PROTOPOP 73 PR D 7 1280        PROTOPOPESCU,GARNJOST,GALTIERI,FLATTE+(LBL)

CARROLL  74 PR D 10 1430       +MATTHEWS,WALKER+     (SLAC+DUKE+WISC+TNTO)
ENGLER   74 PR D 10 2070       +KRAEMER,TOAFF,WEISSER,DIAZ+    (CARN+CASE)
ESTABROO 74 NP B 79 301        P.ESTABROOKS,A.D.MARTIN               (DURH)
GOBBI    74 PRL 33 1450        +ROSEN,SCOTT,SHAPIRO+      (NWES+ROCH+CARN)
GRAYER   74 NP B 75 189        G.GRAYER,HYAMS,BLUM,DIETL,+     (CERN+MPIM)
HABER    74 PR D10 1387        +HODOUS,HULSIZER,KISTIAKOWSKY,LEVY+   (MIT)
NORDBERG 74 PL 51 B 106        +ABRAMSON,ANDREWS,HARVEY,+      (CORN+ROCH)
SPITAL   74 PR D 9 126         R.SPITAL,D.R.YENNIE                   (CORN)

MONTONEN 75 LNC 12 627         C.MONTONEN,M.ROOS,N.TORNQVIST         (HELS)
ROOS     75 NP B 97 165        M.ROOS                                (HELS)

DEUTSCHM 76 NP B 103 426       +KIRK,+(AACH+BERL+BONN+CERN+CRAC+HEID+WARS)

ANDREWS  77 PRL 38 198         +FUKUSHIMA,HARVEY,LOBKOWICZ,MAY,+    (ROCH)

BALTAY   78 PR D 17 62         +CAUTIS,COHEN,CSORNA,SMITH,YEH,+(COLU+BING)
BARTALUC 78 NC 44 A 587        BARTALUCCI,BASINI,BERTOLUCCI,   (DESY+FRAS)
QUENZER  78 PL 76 B 512        +RIBES,RUMPF,BERTRAND,BIZOT,CHASE,+  (LALO)
WICKLUND 78 PRD 17 1197        +AYRES,DIEBOLD,GREENE,KRAMER,PAWLICKI (ANL)

BECKER   79 NP B 151  46       +BLANAR,BLUM,CERRADA+ (MPIM+CERN+ZEEM+CRAC)
LANG     79 PR D 19 956        C.B.LANG,A.MAS-PARAREDA               (GRAZ)

BERG     80 PRL 44 706         +CHANDLEE,BIEL,HEPPELMANN,+(ROCH+FNAL+MINN)
BOHACIK  80 PR D 21 1342       J.BOHACIK,H.KUHNELT        (BRATISLAVA+WIEN)
HEYN     80 ZPHY C 7 169       M.F.HEYN,C.B.LANG                     (GRAZ)

ALEKSEEV 82 JETP 55 591        ALEKSEEVA,KARTAMYSHEV,MAKARIN+        (KIAE)

CHABAUD  83 NP B 223 1         +GORLICH,CERRADA+          (CERN+CRAC+MPIM)
JENSEN   83 PR D 27 26         +BERG,BIEL,COLLICK+        (ROCH+FNAL+MINN)
KURDADZE 83 JETPL 37 613       +LELCHUK,PAKHTUSOVA+                  (NOVO)
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$\omega(783)$

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1  OMEGA(783,JPG-1--) I=0

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                    1  OMEGA MASS (MEV)

M   R 2198 (783.4)    (0.7)          BALTAY    67 HBC     0.0 PBAR P        2/74
M   R      (784.0)    (0.7)          ATHERTON  70 HBC     3.6 PBAR P, 7 PI  2/74
M  SR 4800 (782.0)    (0.8)          OREN      74 HBC     2.3 PBAR P,5PI   12/75
M
M     2400  782.4      0.5           BIZZARRI  69 HBC      0 PBAR P         9/69
M      750  784.1      1.2           ABRAMOVIC 70 HBC     3.9 PI- P         2/74
M    F      783.2      1.6           BIGGS     70 CNTR    PHOTOPRODUCTION   2/74
M      248  783.4      1.0           BIZZARRI  71 HBC     0.0 P PBAR K+K-  11/71
M      510  781.0      0.6           BIZZARRI  71 HBC     0.0 P PBAR K1K1  11/71
M  D        783.7      1.0           COYNE     71 HBC     3.7 PI+ P        11/71
M      418  782.5      0.8           AGUILAR   72 HBC     3.9,4.6 K- P     12/72
M  B  7000  782.4      0.5           KEYNE     76 CNTR    PI-P, OMEGA N    12/75
M     2100  783.5      0.8           GESSAROLI 77 HBC     11 PI-P,OMEGA PI 12/77
M      535  782.7      0.9           APELDOORN 78 HBC     7.2 PB P,PB P OM  4/78
M     1430  781.8      0.6           COOPER    78 HBC     .7-.8 PB P,5 PI   4/78
M     3000  782.6      0.8           BENKHEIRI 79 OMEG    9-12 PI+- P      12/79
M           783.3      0.4           CORDIER   80 WIRE    E+E-,PI+PI-PI0    9/81
M    33260  782.5      0.8           ROOS      80 RVUE    0-3.6 PBAR P     12/79
M           782.4      0.4           KURDADZ2  83 OLYA     E+E-            1/84*
M           . . . . . . . . . .
M   AVG     782.58     0.18    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.1)

M  B    OBSERVED BY THRESHOLD-CROSSING TECHNIQUE. MASS RESOL.=4.8 MEV FWHM
M  D    FROM BEST-RESOLUTION SAMPLE OF COYNE 71
M   F   FROM OMEGA-RHO INTERFERENCE IN THE PI+PI- MASS SPECTRUM
M   F   ASSUMING OMEGA WIDTH 12.6 MEV.
M   R   INCLUDED IN ROOS 77,79 RVUE
M  S    ERROR INCLUDES 0.5 MEV MASS SCALE ERROR
M

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                    1  OMEGA FULL WIDTH (MEV)

W      750    8.8      3.0           ABRAMOVIC 70 HBC     3.9 PI- P         6/70
W            11.2      2.7           ATHERTON  70 HBC     3.6 PBAR P, 7 PI  5/70
W      510   10.3      1.4           BIZZARRI  71 HBC     0.0 P PBAR K1K1  11/71
W      248   12.8      3.0           BIZZARRI  71 HBC     0.0 P PBAR K+K-  11/71
W     4270    9.5      1.0           COYNE     71 HBC     3.7 PI+ P        11/71
W      418   13.3      2.            AGUILAR   72 HBC     3.9,4.6 K- P     12/72
W            9.1       0.8           BENAKSAS1 72 OSPK    E+E- COLL.BEAMS   2/73
W           10.5       1.5           BORENSTEI 72 HBC     2.18 K-P          7/77
W  E   940   7.70      1.65          BROWN     72 MMS     2.5 PI- P,N MMS  12/72
W  B 20000  10.22      0.43          KEYNE     76 CNTR    PI-P, OMEGA N    12/75
W     2100    9.4      2.5           GESSAROLI 77 HBC     11 PI-P,OMEGA PI 12/77
W     1430   12.0      2.0           COOPER    78 HBC     .7-.8 PB P,5 PI   4/78
W            9.0       0.8           CORDIER   80 WIRE    E+E-,PI+PI-PI0    9/81
W            9.8       0.9           KURDADZ2  83 OLYA     E+E-            1/84*
W           . . . . . . . . . .
W   AVG      9.89      0.28    AVERAGE

W  B    OBSERVED BY THRESHOLD-CROSSING TECHNIQUE. MASS RESOL.=4.8 MEV FWHM
W  E    ERROR TAKES ACCOUNT OF SYSTEMATICS ADDED LINEARLY

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1 OMEGA PARTIAL DECAY MODES

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                                                        DECAY MASSES
P1     OMEGA INTO PI+ PI- PIO                          140+ 140+ 135
P2     OMEGA INTO PI+ PI- (VIOLATES G)                 140+ 140
P3     OMEGA INTO PIO GAMMA                            135+   0
P4     OMEGA INTO PI+ PI- GAMMA                        140+ 140+   0
P5     OMEGA INTO 2PIO GAMMA                           135+ 135+   0
P6     OMEGA INTO ETA GAMMA                            549+   0
P7     OMEGA INTO E+ E-                               .511+.511
P8     OMEGA INTO MU+ MU-                              106+ 106
P9     OMEGA INTO ETA PIO (VIOLATES C)                 549+ 135
P10    OMEGA INTO 3 GAMMA                                0+   0+   0
P11    OMEGA INTO PIO MU+ MU-                          135+ 106+ 106
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FITTED PARTIAL DECAY MODE BRANCHING FRACTIONS

The matrix below is derived from the error matrix for the fitted partial decay mode branching fractions, P_i, as follows: The diagonal elements are $P_i \pm \delta P_i$, where $\delta P_i = \sqrt{\langle \delta P_i \delta P_i \rangle}$, while the off-diagonal elements are the normalized correlation coefficients $\langle \delta P_i \delta P_j \rangle / (\delta P_i \cdot \delta P_j)$. For the definitions of the individual P_i, see the listings above; only those P_i appearing in the matrix are assumed in the fit to be nonzero and are thus constrained to add to 1.

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       P 1        P 2       P 3
P 1 .8990+-.0051
P 2   -.3762  .0140+-.0021
P 3   -.9107    -.0400  .0870+-.0047

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1 OMEGA BRANCHING RATIOS

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R1      OMEGA INTO NEUTRAL/(PI+ PI- PIO)                          (P3+...)/(P1)
R1       20    0.11      0.02               BUSCHBECK 63 HBC       1.5 K-P
R1       35    0.08      0.03               KRAEMER   64 DBC       1.2 PI+D
R1       65    0.10      0.04               ALFF-STEI 66 HBC CORR.BY SCHULTZ(COL)  9/66
R1      850    0.134     0.026              DIGIUGNO  66 CNTR      1.4 PI-P        9/66
R1      348    0.097     0.016              FLATTE    66 HBC       1.8 K-P         9/66
R1             0.06      0.05      0.02     JAMES     66 HBC       2.1 PI+P        6/66
R1       19    0.10      0.03               BARASH    67 HBC       0.0 PBAR P      7/67
R1       46    0.15      0.04               AGUILAR   72 HBC      3.9,4.6 K- P    12/72
R1           . . . . . . . . . . .
R1  AVG        0.1033    0.0091  AVERAGE
R1  FIT        0.0968    0.0057 FROM FIT

R2      OMEGA INTO (PI+ PI-)/(PI+ PI- PIO). SEE ALSO R15 (P2)/(P1)
R2 R         (0.011)OR MORE  CL=.95    ABRAMOVIC 70 HBC       3.9 PI- P        6/70
R2 B           0.014     0.005     0.004 BIGGS    70 CNTR    PHOTOPRODUCTION  12/78
R2 R         (0.035)OR LESS  CL=.95    BIZZARRI  70 DBC       PBAR N AT REST  11/71
R2           (0.019)OR MORE  CL=.95    CHAPMAN   70 HBC     1.6-2.2 P PBAR     6/70
R2 R           0.022     0.009     0.01  ROOS     70 RVUE                      6/70
R2 S           0.021     0.028     0.009 RATCLIFF 72 ASPK    15.PI- P,N 2PI   12/72
R2           (0.0115)OR MORE           BURNS     73 HBC     .6-1.1 PBAR P    12/75
R2  C        (0.04)    (0.02)          LYONS     77 HBC     3-4 K-P,LAM OMEG 12/77
R2           . . . . . . . . . . .
R2  AVG        0.0157    0.0040  AVERAGE
R2  FIT        0.0155    0.0024 FROM FIT

R2 B   RE-EVALUATED UNDER R2 BY BEHREND 71 USING MORE ACCURATE OMEGA
R2 B   TO RHO PHOTOPRODUCTION CROSS-SECTION RATIO.
R2  C  ASSUMING COMPLETE RHO-OMEGA COHERENCE
R2 R   ROOS 70 COMBINES ABRAMOVICH 70 AND BIZZARRI 70
R2 S   SIGNIFICANT INTERFERENCE EFFECT OBSERVED.NB OF OMEGA INTO 3PI
R2 S   COMES FROM AN EXTRAPOLATION.

R3      OMEGA INTO (PIO GAMMA) / (PI+ PI- PIO)                    (P3)/(P1)
R3             0.13      0.04               JACQUET   69 HLBC                     10/67
R3             0.081     0.020              BALDIN    71 HLBC    2.9 PI+ P        11/71
R3             0.109     0.025              BENAKSAS2 72 OSPK    E+E- COLL.BEAMS   2/73
R3             0.084     0.013              KEYNE     76 CNTR    PI-P, OMEGA N    12/75
R3           . . . . . . . . . . .
R3  AVG        0.0898    0.0097  AVERAGE
R3  FIT        0.0968    0.0057 FROM FIT

R4      OMEGA INTO (PI+ PI- GAMMA)/(PI+ PI- PIO)                  (P4)/(P1)
R4           (0.05) OR LESS  CL=.90    FLATTE    66 HBC       1.8 K-P          9/66
R4            (.066)OR LESS  CL=.90    KALBFLEI  75 HBC     2.2 K- P,GAMMA + 12/75

R6      OMEGA INTO (MU+ MU-)/(PI+ PI- PIO)(UNITS 10**-3) (P8)/(P1)
R6           (1.2)  OR LESS            GALTIERI  65 HBC       2.7 K-P
R6           (1.7)  OR LESS  CL=.74    FLATTE    66 HBC       1.8 K-P          9/66
R6           (0.2)  OR LESS            WILSON    69 OSPK      12 PI- ON C,FE   9/69

R7      OMEGA INTO (2PIO GAMM)/(PIO GAMMA)                        (P5)/(P3)
R7           (0.1)  OR LESS            BARMIN    64 HLBC     1.3-2.8 PI-P
R7           (0.14) OR LESS            BALDIN    71 HLBC     2.9 PI+ P        11/71
R7           (0.15) OR LESS  CL=.90    BENAKSAS2 72 OSPK     E+E- COLL. BEAMS  2/73
R7           (0.18) OR LESS  CL=0.95   KEYNE     76 CNTR     PI-P,OMEGA N      7/77

R8      OMEGA INTO (ETA PIO + ETA GAMMA)/(PI+ PI- PIO)   (P9+P6)/(P1)
R8           (0.017)OR LESS  CL=.90    FLATTE    66 HBC       1.8 K-P          9/66
R8           (0.045)OR LESS  CL=.95    JACQUET   69 HLBC                       4/70

R9      OMEGA INTO (NEUTRALS) / (CHARGED)                         (P3+...)/(P1+P2...)
R9             0.124     0.021              FELDMAN   67 OSPK      1.2 PI- P        3/67
R9           . . . . . . . . . . .
R9  FIT        0.0953    0.0056 FROM FIT

R10     OMEGA INTO (2PIO GAMMA)/(PI+PI-PIO)                       (P5)/(P1)
R10          (0.08) OR LESS  CL=.95    JACQUET   69 HLBC                       4/70

R11     OMEGA INTO (ETA GAMMA)/(PIO GAMMA)                        (P6)/(P3)
R11            0.010     0.045              APEL      72 OSPK    4-8 PI- P,N 3GAM  2/73

R12     OMEGA INTO (PIO MU+ MU-) / TOTAL (UNITS 10**-3)  (P11)
R12            0.096     0.023              DZHELYADI 81 CNTR    25-33 PI-P,OME N  1/82

R13     OMEGA INTO (E+ E-)/TOTAL (UNITS 10**-4)                   (P7)
R13 A   .33  (0.65)    (0.13)               ASTVACATU 68 OSPK ASSUME SU(3)+MIXING  6/68
R13 Z        (0.40)    (0.21)               BOLLINI1  68 CNTR      1.7 PI-P         9/68
R13 E        (0.92)    (0.07)               AUGUSTI1  69 OSPK    E+E-, 2PI          2/72
R13            0.83      0.10               BENAKSAS1 72 OSPK    E+E-, 3PI          2/73
R13            0.675     0.069              CORDIER   80 WIRE    E+ E-,3PI         12/79
R13            0.64      0.04               KURDADZ2  83 OLYA      E+E-             1/84*
R13          . . . . . . . . . . .
R13 AVG        0.668     0.041   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.2)

R13 A        NOT RESOLVED  FROM  RHO  DECAY. ERROR STATISTICAL ONLY.
R13 E        RESCALED BY US TO CORRESPOND TO OMEGA WIDTH 10.1 MEV.
R13 Z        MASS RESOLUTION OF BOLLINI 1 IS +-10 MEV.HIS ERROR IS +-.15
R13 Z        WITHOUT RHO-OMEGA INTERFERENCE. COMPLETE INTERFERENCE WOULD
R13 Z        CHANGE VALUE BY +-35 PER CENT. THEREFORE WE INCREASED ERROR.

R14     OMEGA INTO NEUTRALS / TOTAL                               (P3+...)
R14            0.084     0.015              BOLLINI   68 CNTR    2.1 PI- P         6/68
R14            0.079     0.019              DEINET    69 OSPK    1.5 PI- P         9/69
R14            0.075     0.025              BIZZARRI  71 HBC      0.0 P PBAR      11/71
R14      42    0.073     0.018              BASILE    72 CNTR    1.67 PI- P        2/73
R14          . . . . . . . . . . .
R14 AVG        0.0788    0.0092  AVERAGE
R14 FIT        0.0870    0.0047 FROM FIT

R15     OMEGA INTO (PI PI)/(TOTAL). SEE ALSO R2                  (P2)
R15            0.032     0.028     0.019 AUGUSTI2  69 OSPK     E+E- COLL.BEAMS  8/69
R15          (0.003)OR MORE  CL=.95    GOLDHABER 69 HBC         3.7-4.0 PI+P  11/69
R15          (0.014)OR MORE  CL=.95    ALLISON   70 HBC      1.3-1.7 PBAR P     6/70
R15 B        (0.0080) (0.0028) (0.0022)IGGS      70 CNTR     PHOTOPRODUCTION  12/78
R15            0.0122    0.0030             ALVENSLEB 71 CNTR     PHOTOPRODUCTION  11/71
R15            0.013     0.012     0.009 MOFFEIT   71 HBC      2.8,4.7 GAMMA P  11/71
R15            0.036     0.024     0.018 BENAKSAS  72 OSPK     E+E- COLL.BEAMS 12/72
R15 F        (0.035)   (0.018)              BRANDENBU 76 ASPK     13.K-P,PI+PI-    12/79
R15 F        (0.04)    (0.03)    (0.02) HOLMGREN  77 HBC      4.2 K-P,PI+PI-   12/79
R15            0.016     0.009     0.007 QUENZER   78 CNTR     E+E- COLL.BEAMS   4/78
R15 F        (0.010)   (0.001)              WICKLUND  78 ASPK     3,4,6 PI+-PN     12/79
R15            0.020     0.06               KURDADZ1  83 OLYA      E+E-             1/84*
R15          . . . . . . . . . . .
R15 AVG        0.0133    0.0027  AVERAGE
R15 FIT        0.0140    0.0021 FROM FIT

R15 B   RE-EVALUATED UNDER R2 BY BEHREND 71 USING MORE ACCURATE OMEGA
R15 B   TO RHO PHOTOPRODUCTION CROSS-SECTION RATIO.
R15 F   FROM A MODEL DEPENDENT ANALYSIS ASSUMING COMPLETE COHERENCE.

R17     OMEGA INTO (2 PIO GAMMA) / (ALL NEUTRALS)         (P5)/(P3+...)
R17          (0.19) OR LESS  CL=.90    DEINET    69 OSPK                       9/69
R17 D        (0.22)    (0.07)               DAKIN     72 OSPK    1.4 PI- P,N MMO  12/72
R17 D      SEE R18

R18     OMEGA INTO (PIO GAMMA) / (ALL NEUTRALS)           (P3)/(P3+...)
R18          (0.81) OR MORE  CL=.90    DEINET    69 OSPK                       9/69
R18 D        (0.78)    (0.07)               DAKIN     72 OSPK    1.4 PI- P,N MMO  12/72
R18 D      ERROR STATISTICAL ONLY.AUTHORS OBTAIN GOOD FIT ALSO ASSUMING
R18 D      PIO GAMMA AS THE ONLY NEUTRAL DECAY.

R19     OMEGA INTO (ETA GAMMA)/TOTAL (UNITS 10**-4)       (P6)
R19 A        (3.0)     (2.5)     (1.8)  ANDREWS   77 CNTR    6.7-10 GAMMA CU  12/77
R19 B       (29.0)     (7.0)            ANDREWS   77 CNTR    6.7-10 GAMMA CU  12/77
R19 A   SOLUTION CORRESPONDING TO CONSTRUCTIVE OMEGA-RHO INTERFERENCE
R19 A   THE QUARK MODEL PREDICTS A RELATIVE DECAY PHASE OF ZERO
R19 B   SOLUTION CORRESPONDING TO DESTRUCTIVE OMEGA-RHO INTERFERENCE

R20     OMEGA INTO (PIO MU+ MU-) / ( MU+ MU-)             (P11)/(P8)          12/78
R20 S   30   (1.2)     (0.6)            DZHELYADI 79 CNTR    25-33 PI- P      12/79
R20 S   SUPERSEDED BY DZHELYADIN 81 RESULT ABOVE.

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REFERENCES FOR OMEGA


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MAGLIC    61 PRL 7 178          B MAGLIC,ALVAREZ,ROSENFELD,STEVENSON  (LRL)
PEVSNER   61 PRL 7 421          PEVSNER,KRAEMER,NUSSBAUM,RICHARD+(JHU+NWES)
XUONG     61 PRL 7 327          NGUYEN HUU XUONG,GERALD R LYNCH       (LRL)

ALFF      62 PRL 9 325          ALFF,BERLEY,COLLEY,GELFAND + (COLU+RUTGERS)
ARMENTER  62 CERN CONF 90       R ARMENTEROS,R BUDDE +      (CERN+CDEF+EPOL)
STEVENSO  62 PR 125 687         STEVENSON,ALVAREZ,MAGLIC,ROSENFELD    (LRL)

ARMENTER  63 SIENA CONF 1 296   ARMENTEROS,EDWARDS,JACOBSEN+    (CERN+CDEF)
BARMIN    63 SIENA CONF 1 207   BARMIN,DOLGOLENKO,KRESTNIKOV+        (ITEP)
BUSCHBEC  63 SIENA CONF 1 166   BUSCHBECK,CZAPP+     (VIENNA+CERN+AMSTERDAM)
GELFAND   63 PRL 11 436         GELFAND,MILLER,NUSSBAUM,RATAU+  (COLU+RUTG)
MURRAY    63 PL 7 358           MURRAY,FERROLUZZI,HUWE,SHAFER,SOLMITZ+(LRL)

BARMIN    64 JETP 18 1289       BARMIN,DOLGOLENKO,KRESTNIKOV +       (ITEP)
KRAEMER   64 PR 136 B 496       KRAEMER,MADANSKY,MEER+      (JHU+NWES+WOOD)

BINNIE    65 PL 18 348          BINNIE,DUANE,JANE,W JONES+       (LOIC+MCHS)
GALTIERI  65 PRL 14 279         A BARBARO GALTIERI,R D TRIPP          (LRL)
MILLER D  65  CU-237/NEVIS-131  DAVID C MILLER  (THESIS)          (COLUMBIA)
ZDANIS    65 PRL 14 721         ZDANIS,MADANSKY,KRAEMER,HERTZBACH+(JHU+BNL)

ALFF-STE  66 PR 145 1072        ALFF-STEINBERGER,BERLEY,BRUGGER+(COLU+RUTG)
DIGIUGNO  66 NC 44A 1272        DI GIUGNO,PERUZZI,TROISE+  (NAPL+FRAS+TRST)
FLATTE    66 PR  145  1050      +HUWE,MURRAY,BUTTON-SHAFER,SOLMITZ+   (LRL)
JAMES     66 PR 142 896         F E JAMES,KRAYBILL        (YALE+BROOKHAVEN)

BALTAY    67 PRL  18  93        +FRANZINI,SEVERIENS,YEH,ZANELLO  (COLUMBIA)
BARASH    67 PR  156  1399      BARASH,KIRSCH,MILLER,TAN          (COLUMBIA)
FELDMAN   67 PR 159 1219        +FRATI,GLEESON,HALPERN,NUSSBAUM+     (PENN)
HERTZBAC  67 PR 155, 1461       HERTZBACH,KRAEMER,MADANSKI,ZDANIS+(JHU+BNL)

ASTVACAT  68 PL 27 B  45        ASTVACATUROV,AZIMOV,BALDIN+   (JINR+MOSCOW)
BOLLINI   68 NC 56 A 531        +BUHLER,DALPIAZ,MASSAM+     (CERN+BGNA+STRB)
BOLLINI1  68 NC 57 A 404        +BUHLER,DALPIAZ,MASSAM+     (CERN+BGNA+STRB)
KEY       68 PR 166 1430        +PRENTICE+COOPER+MANNER      (TNTO+ANL+WISC)
PISUT     68 NP B 6 325         J.PISUT,M.ROOS                       (CERN)
WEHMANN   68 PRL 20 748         +ENGELS+ (HARVARD+CASE+SLAC+CORNELL+MCGILL)

AUGUSTI1  69 PL 28 B 513        +BENAKSAS,BUON,GRACCO,HAISSINSKI,+  (ORSAY)
AUGUSTI2  69 LNC 2 214          +LEFRANCOIS,LEHMANN,MARIN,+         (ORSAY)
BIZZARRI  69 NP B 14 169        +FOSTER,GAVILLET,MONTANET,+     (CERN+CDEF)
DANBURG   69 UCRL-19275         JEROME S. DANBURG, THESIS             (LRL)
DEINET    69 PL 30 B 426        +MENZIONE,MULLER,BUNIATOV+      (KARL+CERN)
ERWIN     69 NP B 9 364         +WALKER,GOSHAW,WEINBERG     (WISC+PRIN+VAND)
GOLDHABE  69 PRL 23,1351        +BUTLER,COYNE,HALL,MACNAUGHTON,TRILING(LRL)
JACQUET   69 NC 63 A 743        +NGUYEN-KHAC,HAATUFT,HALSTEINSLI(EPOL+BERG)
MILLER    69 PR 178 2061        R.MILLER,LICHTMAN,WILLMANN         (PURDUE)
STRUGALS  69 PL 29 B 532        +CHUVILO,FENYVES,+          (WARS+JINR+BUDA)
WILSON    69  PRIVATE COMM.     RICHARD WILSON (SEE ALSO PR 178 2095)(HARV)

ABRAMOVI  70 NP B 20 209        ABRAMOVICH,BLUMENFELD,BRUYANT,+      (CERN)
BIZZARRI  70 PRL 25 1385        +CIAPETTI,DORE,GASPERO,GUIDONI,+(ROMA+SYRA)
ALLISON   70 PRL 24 618         +COOPER,FIELDS,RHINES                 (ANL)
ATHERTON  70 NP B 18 221        +BLAIR,CELNIKER,DOMINGO,FRENCH+  (CERN+IPN)
BIGGS     70 PRL 24 1201        +CLIFFT,GABATHULER,KITCHING,RAND     (DARE)
CASON     70 PR D 1 851         +ANDREWS,BISWAS,GROVES,HARRINGTON,+  (NDAM)
CHAPMAN   70 NP B 24 445        +DAVIDSON,GREEN,LYS,ROE,VANDER VELDE (MICH)
DANBURG   70 PR D 2 2564        +ABOLINS,DAHL,DAVIES,HOCH,KIRZ,MILLER+(LRL)
FLATTE    70 PR D 1 1           STANLEY M. FLATTE                     (LRL)
GOLDHABE  70 PHILA.CONF.P.59    GERSON GOLDHABER,REVIEW               (LRL)
HAGOPIAN  70 PRL 25 1050        S. AND V.HAGOPIAN,BOGART,SELOVE  (FSU+PENN)
ROOS      70 DNPL/R7 P.173      PROC. DARESBURY STUDY WEEKEND NO 1.  (CERN)
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ABRAMS 71 PR D 4 653 +BARNHAM,BUTLER,COYNE,GOLDHABER,HALL,+(LBL)
ALVENSLE 71 PRL 27 888 ALVENSLEBEN,BECKER,BUSZA,CHEN,COHEN,+(DESY)
ANGELOW 71 SJNP 12 427 +GRAMENITSKY,KANASIRSKY,KERATSCHEW,+ (JINR)
BALDIN 71 SJNP 13 758 +YERGAKOV,TREBUKHOVSKY,SHISHOV (ITEP)
BARDADIN 71 PR D4 2711 BARDADIN-OTWINOWSKA,HOFMOKL,MICHEJDA+(WARS)
BEHREND 71 PRL 27 61 +LEE,NORDBERG,WEHMAN,+ (ROCH+CORN+FNAL)
BIZZARRI 71 NP B 27 140 +MONTANET,NILSSON,D-ANDLAU,+ (CERN+CDEF)
BLOODWOR 71 NP B 35 133 BLOODWORTH,JACKSON,PRENTICE,YOON (TORONTO)
CHAPMAN 71 PR D 3 38 +FORTNEY,FOWLER (DUKE)
COYNE 71 NP B 32 333 +BUTLER,FANG-LANDAU,MACNAUGHTON (LRL)
FIELDS 71 PRL 27 1749 +COOPER,RHINES,ALLISON (ANL+OXF)
MATTHEWS 71 PRL 26 400 +PRENTICE,YOON,CARROLL,WALKER,+ (TNTO+WISC)
MOFFEIT 71 NP B 29 349 +BINGHAM,FRETTER,BALLAM+(LRL+UCB+SLAC+TUFT)

AGUILAR 72 PR D 6 29 AGUILAR-BENITEZ,CHUNG,EISNER,SAMIOS (BNL)
APEL 72 PL 41 B 234 +AUSLANDER,MULLER,BERTOLUCCI,+ (KARL+PISA)
BASILE 72 PHIL.CONF.PROC153 +BOLLINI,BROGLIN,DALPIAZ,FRABETTI,+ (CERN)
BENAKSAS 72 PL 39 B 289 +COSME,JEAN-MARIE,JULLIAN,LAPLANCHE,+(ORSA)
BENAKSAS172 PL 42 B 507 +COSME,JEAN-MARIE,JULLIAN,LAPLANCHE+(ORSAY)
BENAKSAS272 PL 42 B 511 +COSME,JEAN-MARIE,JULLIAN,LAPLANCHE+(ORSAY)
BROWN 72 PL 42 B 117 +DOWNING,HOLLOWAY,HULD,BERNSTEIN+(ILL+ILLC)
DAKIN 72 PR D 6 2321 +HAUSER,KREISLER,MISCHKE (PRINCETON)
EISENBER 72 PR D 5 15 EISENBERG,BALLAM,DAGAN,+ (REHO+SLAC+TELA)
RATCLIFF 72 PL 38 B 345 +BULOS,CARNEGIE,KLUGE,LEITH,LYNCH,+ (SLAC)
BORENSTE 72 PR D 5 1559 BORENSTEIN,DANBURG,KALBFLEISCH,+ (BNL+MICH)

BINNIE 73 PR D 8 2789 +CARR,DEBENHAM,DUANE,GARBUTT,+ (LOIC+SHMP)
BURNS 73 PR D 7 1310 +CONDON,KIM,MANDELKERN,PRICE,SCHULTZ (UCI)

ESTABROO 74 NP B 81 70 ESTABROOKS,HYAMS,JONES,BLUM, (CERN+MPIM)
GREGORIO 74 NC 20 A 437 M.A.GREGORIO (ICTP-TRIESTE)
KRAMER 74 PRL 33 505 +AYRES,DIEBOLD,GREENE,PAWLICKI+ (ANL)
OREN 74 NP B 71 189 +COOPER,FIELDS,RHINES,ALLISON+ (ANL+OXF)

EMMS 75 NP B98 1 +KINSON,STACEY,BELL,DALE+ (BIRM+DURH+RHEL)
KALBFLEI 75 PR D 11 987 KALBFLEISCH,STRAND,CHAPMAN (BNL+MICH)
ROOS 75 NP B 97 165 M.ROOS (HELS)

BRANDENB 76 NP B 104 413 BRANDENBURG,CARNEGIE,CASHMORE,DAVIER+(SLAC)
KEYNE 76 PR D 14 28 +BINNIE,CARR,DEBENHAM,GARBUTT,+ (LOIC+SHMP)
ALSO 73 BINNIE

ANDREWS 77 PRL 38 198 +FUKUSHIMA,HARVEY,LOBKOWICZ,MAY,+ (ROCH)
BARTKE 77 NP B 118 360 + (AACH+BERL+BONN+CERN+CRAC+LOIC+WIEN+WARS)
GESSAROL 77 NP B 126 382 GESSAROLI,+ (BGNA+FIRZ+GENO+MILA+OXF+PAVI)
HOLMGREN 77 PL 66 B 191 +JONGEJANS,ENGELEN,+ (CERN+AMST+NIJM+OXF)
LYONS 77 NP B 125 207 +COOPER,CLARK (OXF)
ROOS 77 LNC 19 419 M.ROOS (HELSINKI)

APELDOOR 78 NP B 133 245 VAN APELDOORN,GRUNDEMAN,HARTING,+ (ZEEM)
COOPER 78 NP B 146 1 +GURTU,MONTANET,+ (TIFR+CERN+CDEF+MADR)
QUENZER 78 PL 76 B 512 +RIBES,RUMPF,BERTRAND,BIZOT,CHASE,+ (LALO)
WICKLUND 78 PRD 17 1197 +AYRES,DIEBOLD,GREENE,KRAMER,PAWLICKI (ANL)

BENKHEIR 79 NP B 150 268 BENKHEIRI,EISENSTEIN,+(EPOL+CERN+CDEF+LALO)
DZHELYAD 79 PL 84 B 143 DZHELYADIN,GOLOVKIN,GRITSUK,+ (SERP)

CORDIER 80 NP B 172 13 +DELCOURT,ESCHSTRUTH,FULDA,+ (LALO)
ROOS 80 LNC 27 321 +PELLINEN (HELS)

DZHELYAD 81 PL 102 B 296 DZHELYADIN,GOLOVKIN,KONSTANTINOV,+ (SERP)

KURDADZ1 83 JETPL 37 613 +LELCHUK,PAKHTUSOVA+ (NOVO)
KURDADZ2 83 JETPL 36 274 +PAKHTUSOVA,SIDOROV+ (NOVO)

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$\eta'(958)$

2 ETA PRIME(958,JPG=0-+) I=0

NOTE ON THE J^P ASSIGNMENT OF $\eta'(958)$

From the Dalitz plot analyses of the $\eta' \rightarrow \pi\pi\eta$ and $\eta' \rightarrow \pi^+\pi^-\gamma$ decays and from the observation of an $\eta' \rightarrow \gamma\gamma$ decay mode, all assignments except $J^{PC} = 0^{-+}$ and 2^{-+} are excluded. The Dalitz plot analyses favor spin 0, but cannot rule out spin 2. The indication of anisotropy in the decay of very forward-produced η' (KALBFLEISCH 73) has not been confirmed by BALTAY 74, thus again favoring spin 0, but still not ruling out spin 2 (LEDNICKY 77).

Two analyses, however, seem to have established the spin 0 assignment of the η'.

CERRADA 77 perform a partial-wave analysis of the $\eta\pi\pi$ system produced in the reaction $K^-p \rightarrow \eta'\Lambda$, taking into account the η' and Λ joint decay angular correlations. They conclude that J^P is unambiguously 0^- (see also DELAGUILA 77).

ROUSSARIE 77 analyze a large sample of events from the reaction $\pi^-p \rightarrow \eta'n$ at beam momenta just above threshold. They verify that the η' is produced in a relative S-wave state, and thus the Adair condition is satisfied by their total sample of some 1800 events. The decay angular distribution of the η' is consistent with isotropy, and thus ROUSSARIE 77 conclude that the spin cannot be 2.

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2 ETA PRIME MASS (MEV)

M		957.	1.	RITTENBER	69	HBC	1.7-2.7 K- P	9/69
M	3415	956.1	1.1	BASILE1	71	CNTR	1.6 PI- P,N X0	11/71
M	535	957.4	1.4	BASILE1	71	CNTR	1.6 PI- P,N X0	11/71
M	1414	958.2	0.5	DANBURG	73	HBC	2.2 K-P,LAM X0	2/74
M	400	958.	1.	JACOBS	73	HBC	2.9 K-P,LAM X0	1/74
M		957.46	0.33	DUANE	74	MMS	PI- P,N MM	1/74
M		. . . . . .	. . . . .					
M	AVG	957.57	0.25	AVERAGE				

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2 ETA PRIME WIDTH (MEV)

WE INCLUDE DIRECT MEASUREMENTS OF THE ETA PRIME TOTAL WIDTH AND GAMMA GAMMA PARTIAL WIDTH TOGETHER WITH THE MEASURED BRANCHING RATIOS IN THE FIT FOR THE PARTIAL DECAY RATES.

W	1000	0.28	0.10	BINNIE	79	MMS	0 PI- P,N MM	12/79
W		. . . . . .	. . . . .					
W	FIT	0.291	0.051	FROM FIT				

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2 ETA PRIME PARTIAL DECAY MODES

		DECAY MASSES
P1	ETA PRIME INTO PI+ PI- ETA	140+ 140+ 549
	P1(N) ETAS DECAY INTO ALL NEUTRALS	
	P1(C) ETAS DECAY CHARGED	
P2	ETA PRIME INTO PI0 PI0 ETA	135+ 135+ 549
	P2(N) ETAS DECAY INTO ALL NEUTRALS	
	P2(C) ETAS DECAY CHARGED	
P3	ETA PRIME INTO PI+ PI- GAMMA (INCLUDING RHO GAMMA)	140+ 140+ 0
P4	ETA PRIME INTO GAMMA GAMMA	0+ 0
P5	ETA PRIME INTO OMEGA GAMMA	783+ 0
P6	ETA PRIME INTO RHO0 GAMMA	769+ 0
P10	ETA PRIME INTO PI+ PI- E+ E-	140+ 140+.511+.511
P11	ETA PRIME INTO 2 PI	140+ 140
P12	ETA PRIME INTO 3 PI	140+ 140+ 135
P13	ETA PRIME INTO 4 PI	140+ 140+ 140+ 140
P14	ETA PRIME INTO 5 PI	
P15	ETA PRIME INTO 6 PI	
P16	ETA PRIME INTO PI0 E+ E- (VIOLATES C IN BORN APPROX.)	135+.511+.511
P17	ETA PRIME INTO ETA E+ E- (VIOLATES C IN BORN APPROX.)	549+.511+.511
P18	ETA PRIME INTO PI0 RHO 0 (VIOLATES C)	135+ 769
P19	ETA PRIME INTO PI0 OMEGA (VIOLATES C)	135+ 783
P20	ETA PRIME INTO MU+ MU- GAMMA	106+ 106+ 0
P21	ETA PRIME INTO ETA MU+ MU-	549+ 106+ 106
P22	ETA PRIME INTO PI0 MU+ MU-	135+ 106+ 106

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FITTED PARTIAL DECAY MODE BRANCHING FRACTIONS

The matrix below is derived from the error matrix for the fitted partial decay mode branching fractions, P_i, as follows: The diagonal elements are $P_i \pm \delta P_i$, where $\delta P_i = \sqrt{\langle \delta P_i \delta P_i \rangle}$, while the off-diagonal elements are the normalized correlation coefficients $\langle \delta P_i \delta P_j \rangle / (\delta P_i \cdot \delta P_j)$. For the definitions of the individual P_i, see the listings above; only those P_i appearing in the matrix are assumed in the fit to be nonzero and are thus constrained to add to 1.

	P 1	P 2	P 3	P 4	P 5
P 1	.4266+-.0174				
P 2	-.6480	.2268+-.0206			
P 3	-.2784	-.5030	.3004+-.0160		
P 4	.0323	-.1057	.0043	.0187+-.0016	
P 5	.0672	-.2090	-.1437	-.0029	.0275+-.0054

FITTED PARTIAL DECAY MODE RATES

The matrix below is the branching fraction matrix above, transformed into rate space; i.e., $G_i \equiv \Gamma_i = \Gamma_{total} P_i$, in appropriate units. In analogy to the matrix above, the diagonal elements are $G_i \pm \delta G_i$, where $\delta G_i = \sqrt{\langle \delta G_i \delta G_i \rangle}$, while the off-diagonal elements are the normalized correlation coefficients $\langle \delta G_i \delta G_j \rangle / (\delta G_i \cdot \delta G_j)$. Note that, because of the error in Γ_{total}, the errors and correlations here are not directly derivable from those above.

	G 1	G 2	G 3	G 4	G 5
G 1	.1240+-.0223				
G 2	.8000	.0659+-.0135			
G 3	.9224	.7796	.0873+-.0161		
G 4	.8768	.7630	.8526	.0054+-.0009	
G 5	.6601	.5137	.6024	.5868	.0080+-.0021

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For notation, see key at front of Listings.

NOTE ON $\eta'(958)$ BRANCHING FRACTIONS

In our calculation of the branching fractions of the $\eta'(958)$, we use the decay modes $\eta\pi\pi$ (including $\eta\pi^0\pi^0$), $\rho^0\gamma$, $\omega\gamma$, and $\gamma\gamma$. It is assumed that the rate $\eta \to$ neutrals is 70.9%.

In the fit we do not use the constraint

$$R = \frac{\Gamma(\eta' \to \eta\pi^+\pi^-)}{\Gamma(\eta' \to \eta\pi^0\pi^0)} = 2$$

from isospin conservation. The result of the fit is in agreement with it: R = 1.9 ± 0.2.

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                  2  ETA PRIME PARTIAL WIDTHS (KEV)

W4      ETA PRIME INTO (GAMMA GAMMA)                        (G4)
W4    B  23    (5.8)     (2.3)          ABRAMS    79 SMK2    E+E-,E+E- RHO GA 12/79
W4    C 213     5.0       1.4           BARTEL    82 JADE    E+E-,E+E- RHO GA  8/83*
W4    C  43     6.2       1.9           BEHREND   83 CELL    E+E-,E+E- RHO GA  8/83*
W4    C        (4.1)     (1.9)          FRAZER    83 TASS    E+E-,E+E- RHO GA  9/83*
W4    C  95     5.8       2.3           JENNI     83 SMK2    E+E-,E+E- RHO GA  9/83*
W4             . . . . . . . . . .
W4    AVG       5.5       1.0     AVERAGE
W4    FIT       5.44      0.90    FROM FIT

W4    C THE SYSTEMATIC ERROR HAS BEEN ADDED LINEARLY.
W4    B ABRAMS 79 IS INCLUDED IN JENNI 83.

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                  2  ETA PRIME BRANCHING RATIOS

                  SEE MINI-REVIEW ABOVE.

R1      ETA PRIME INTO (PI+ PI-ETA (NEUTRAL DEC.))/TOTAL (P1N)
R1      281    0.314     0.026          RITTENBER 69 HBC      1.7-2.7 K-P       9/69
R1             . . . . . . . . . .
R1    FIT      0.302     0.012    FROM FIT

R2      ETA PRIME INTO (PI+ PI- NEUTRALS) / TOTAL          (P1N+P2C+P5)
R2       33    0.35      0.06           BADIER    65 HBC      3.0 K-P          10/66
R2       39    0.4       0.1            LONDON    66 HBC      2.2 K-P          10/66
R2             . . . . . . . . . .
R2    AVG      0.363     0.051    AVERAGE
R2    FIT      0.393     0.011    FROM FIT

R3      ETA PRIME INTO (PI+ PI- ETA (CHRGD.DECAY))/TOTAL (P1C)
R3        7    0.07      0.04           BADIER    65 HBC      3.0 K-P          10/66
R3       10    0.1       0.04           LONDON    66 HBC      2.2 K-P          10/66
R3      107    0.123     0.014          RITTENBER 69 HBC      1.7-2.7 K-P       9/69
R3             . . . . . . . . . .
R3    AVG      0.116     0.013    AVERAGE
R3    FIT      0.1241    0.0051 FROM FIT

R4      ETA PRIME INTO (PI+ PI- NEUTRALS (EXCLUDING        (P2C+P5)
R4           PI+ PI- ETA (NEUTR.DEC.))) / TOTAL
R4       42    0.045     0.029          RITTENBER 69 HBC      1.7-2.7 K-P       9/69
R4             . . . . . . . . . .
R4    FIT      0.0908    0.0069 FROM FIT

R5      ETA PRIME INTO (NEUTRALS) / TOTAL                  (P2N+P4)
R5      123    0.189     0.026          RITTENBER 69 HBC      1.7-2.7 K-P       9/69
R5      535    0.185     0.022          BASILE1   71 CNTR    1.6 PI- P,N X0    11/71
R5             . . . . . . . . . .
R5    AVG      0.187     0.017    AVERAGE
R5    FIT      0.182     0.014    FROM FIT

R6      ETA PRIME INTO (PI+ PI- GAMMA (INCLUDING RHO GAMMA))/TOTAL
R6                                                          (P3)
R6       35    0.34      0.09           BADIER    65 HBC      3.0 K-P          10/66
R6       20    0.2       0.1            LONDON    66 HBC      2.2 K-P          10/66
R6      298    0.329     0.033          RITTENBER 69 HBC      1.7-2.7 K-P       9/69
R6             . . . . . . . . . .
R6    AVG      0.319     0.030    AVERAGE
R6    FIT      0.300     0.016    FROM FIT

R7      ETA PRIME INTO (PI+ PI- GAMMA (INCLUDING RHO GAMMA))/(PI PI ETA)
R7                                                          (P3)/(P1+P2)
R7             0.31      0.15           DAVIS     68 HBC      5.5 K- P          9/68
R7             . . . . . . . . . .
R7    FIT      0.460     0.035    FROM FIT

R8      ETA PRIME INTO (PI0 E+ E-)/TOTAL                    (P16)
R8             (0.013)OR LESS           RITTENBER 65 HBC              2.7 K-P  10/66

R9      ETA PRIME INTO (ETA E+ E-)/TOTAL                    (P17)
R9             (0.011)OR LESS           RITTENBER 65 HBC              2.7 K-P  10/66

R10     ETA PRIME INTO (PI0 RHO0)/TOTAL                     (P18)
R10            (0.04) OR LESS           RITTENBER 65 HBC              2.7 K-P  10/66

R12     ETA PRIME INTO (PI+ PI- E+ E-)/TOTAL                (P10)
R12            (0.006)OR LESS           RITTENBER 65 HBC              2.7 K-P  10/66

R13     ETA PRIME INTO (2 PI)/TOTAL                         (P11)
R13            (0.07) OR LESS           LONDON    66 HBC      COMPILATION      10/66

R14     ETA PRIME INTO (3 PI)/TOTAL                         (P12)
R14            (0.07) OR LESS           LONDON    66 HBC      COMPILATION      10/66

R15     ETA PRIME INTO (4 PI)/TOTAL                         (P13)
R15            (0.01) OR LESS           LONDON    66 HBC      COMPILATION      10/66

R16     ETA PRIME INTO (6 PI)/TOTAL                         (P15)
R16            (0.01) OR LESS           LONDON    66 HBC      COMPILATION      10/66

R17     ETA PRIME INTO (OMEGA GAMMA)/(PI+PI-ETA)            (P5)/(P1)
R17      68    0.068     0.013          ZANFINO   77 ASPK     8.4 PI-P         12/77
R17            . . . . . . . . . .
R17 FIT        0.065     0.013    FROM FIT

R18     ETA PRIME INTO (PI+ PI- GAM(INCL.RHO GAM))/(PI PI ETA + OMEGA GAM)
R18                                                         (P3)/(P1+P2+P5)
R18            0.25      0.14           DAUBER    64 HBC      1.95 K-P         10/66
R18            . . . . . . . . . .
R18 FIT        0.441     0.034    FROM FIT

R19     ETA PRIME INTO (2 GAMMA)/TOTAL                      (P4)
R19      31    0.020     0.008    0.006 HARVEY    71 OSPK     3.65 PI- P,N X0  11/71
R19      68    0.0171    0.0033         DALPIAZ   72 CNTR     1.6 PI- P,N X0   12/72
R19            0.025     0.007          DUANE     74 MMS      PI-P,N MM        12/75
R19    6000    0.018     0.002          APEL      79 CNTR     15-40 PI- P      12/79
R19            . . . . . . . . . .
R19 AVG        0.0183    0.0016   AVERAGE
R19 FIT        0.0187    0.0016 FROM FIT

R20     ETA PRIME INTO (PI+PI-)/TOTAL                       (P11)
R20            (0.02) OR LESS           RITTENBER 69 HBC      1.7-2.7 K-P       9/69
R20            (0.08) OR LESS  CL=.95   DANBURG   73 HBC      2.2 K-P,LAM X0    2/74

R21     ETA PRIME INTO (PI+PI-PI0)/TOTAL                    (P12)
R21            (0.05) OR LESS           RITTENBER 69 HBC      1.7-2.7 K-P       9/69
R21            (0.09) OR LESS  CL=.95   DANBURG   73 HBC      2.2 K-P,LAM X0    2/74

R22     ETA PRIME INTO (PI+PI+PI-PI-)/TOTAL                 (P13)
R22            (0.01) OR LESS           RITTENBER 69 HBC      1.7-2.7 K-P       9/69
R22            (0.01) OR LESS  CL=.95   DANBURG   73 HBC      2.2 K-P,LAM X0    2/74

R23     ETA PRIME INTO (PI+PI+PI-PI-PI0)/TOTAL              (P14)
R23            (0.01) OR LESS           RITTENBER 69 HBC      1.7-2.7 K-P

R24     ETA PRIME INTO (PI+PI+PI-PI- NEUTRALS)/TOTAL        (P15+...)
R24            (0.01) OR LESS           RITTENBER 69 HBC      1.7-2.7 K-P       9/69

R25     ETA PRIME INTO (RHO0 GAMMA)/(ALL PI+ PI- GAMMA)     (P6)/(P3)
R25            0.94      0.20           AGUILAR   70 HBC      3.9-4.6K-P        1/71
R25  E 473     1.15      0.10           DANBURG   73 HBC      2.2 K-P,LAM X0    2/74
R25  E 473    (0.95) OR MORE   CL=.95   DANBURG   73 HBC      2.2 K-P,LAM X0    2/74
R25     137    1.01      0.15           JACOBS    73 HBC      2.9 K-P,LAM X0    1/74
R25            . . . . . . . . . .
R25 AVG        1.082     0.077    AVERAGE

R25  E  EQUIVALENT STATEMENTS

R26     ETA PRIME INTO (PI0 PI0 ETA INTO 3 PI0)/TOTAL       (P2N(3PI0))
R26       4    0.11      0.06           BENSINGER 70 DBC      2.2 PI+ D         1/71
R26            . . . . . . . . . .
R26 FIT        0.0680    0.0062 FROM FIT

R27     ETA PRIME INTO (PI+ PI- GAMMA)/(PI+ PI- ETA(NEUTRAL DEC.))
R27                                                         (P3)/(P1N)
R27 K         (0.54)    (0.10)          AGUILAR   72 HBC      3.9,4.6 K- P     12/72
R27 K    NOT AVERAGED DUE TO COMPLICATION WITH M(953).SEE KALBFLEI 74.
R27     473    0.92      0.14           DANBURG   73 HBC      2.2 K-P,LAM X0    2/74
R27     192    1.11      0.18           JACOBS    73 HBC      2.9 K-P,LAM X0    1/74
R27            . . . . . . . . . .
R27 AVG        0.99      0.11     AVERAGE
R27 FIT        0.993     0.075    FROM FIT

R28     ETA PRIME INTO (2 GAMMA)/(PI0 PI0 ETA(NEUTRAL DEC.))
R28                                                         (P4)/(P2(N))
R28      16    0.188     0.058          APEL      72 OSPK     3.8 PI- P,N X0    1/73
R28            . . . . . . . . . .
R28 FIT        0.116     0.015    FROM FIT

R29     ETA PRIME INTO (GAMMA 2MU)/(2GAMMA)(UNITS 10**-3)(P20)/(P4)            12/78
R29      33    4.9       1.2            VIKTOROV  80 CNTR     25,33 PI-P,2MU G  9/81

R30     ETA PRIME INTO (ETA MU+ MU-)/TOTAL (UNITS 10**-5)(P21)                  1/82
R30           (1.5)  OR LESS  CL=.90    DZHELYAD  81 CNTR     30 PI-P,ETAP N    1/82

R31     ETA PRIME INTO (PI0 MU+ MU-)/TOTAL (UNITS 10**-5)(P22)                  1/82
R31           (6.0)  OR LESS  CL=.90    DZHELYAD  81 CNTR     30 PI-P,ETAP N    1/82

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                  2  ETA PRIME C-NONCONSERVING DECAY PARAMETER

        SEE THE NOTE ON ETA DECAY PARAMETERS IN THE STABLE PARTICLE
        LISTINGS FOR DEFINITION OF THIS PARAMETER

A   DECAY ASYMMETRY PARAMETER FOR PI+ PI- GAMMA
A       152     .07       .08           RITTENBE  65 HBC      2.1-2.7 K-P      12/75
A       103     .00       .10           KALBFLEI  75 HBC      2.2 K-P          12/75
A       295    -.069      .078          GRIGORIA  75 STRC     2.1 PI-P         12/75
A              . . . . . . . . . .
A   AVG        -0.001     0.049   AVERAGE

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REFERENCES FOR ETA PRIME


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DAUBER   64 PRL 13 449          DAUBER,SLATER,SMITH,STORK,TICHO      (UCLA)JP
    ALSO 64 DUBNA CONF 1 418    DAUBER,SLATER,L T SMITH,STORK,TICHO  (UCLA)
GOLDBERG 64 PRL 12 546          +GUNDZIK,LICHTMAN,CONNOLLY,HART,+(SYRA+BNL)
GOLDBERG 64 PRL 13 249          +GUNDZIK,LEITNER,CONNOLLY,HART,+ (SYRA+BNL)
KALBFLE1 64 PRL 12 527          KALBFLEISCH,ALVAREZ,BARBARO-GALTIERI,+(LRL)JP
KALBFLE2 64 PRL 13 349          G.R.KALBFLEISCH,O.DAHL,A.RITTENBERG   (LRL)JP

BADIER   65 PL 17 337           BADIER,DEMOULIN,BARLOUTAUD+(EPOL+SACL+AMST)
KIENZLE  65 PL 19 438           KIENZLE,MAGLIC,LEVRAT,LEFEBVRES +    (CERN)
RITTENBE 65 PRL 15 556          RITTENBERG,KALBFLEISCH            (LRL+BNL)
TRILLING 65 PL 19 427           +BROWN,GOLDHABERS,KADYK,SCANIO        (LRL)

COHN     66 PL 21 347           COHN,MCCULLOCH,BUGG,CONDO  (ORNL+TENN+UCND)
LONDON   66 PR 143 1034         LONDON,RAU,SAMIOS,GOLDBERG + (BNL+SYRACUSE)IJP
MARTIN   66 PL 22,352           MARTIN,CRITTENDEN,SCHROEDER     (INDIANA U)I

BARBARO- 68 PRL 20 349          BARBARO-GALTIERI,MATISON,RITTENBERG+  (LRL)I=0
BARLOUTA 68 PL 26 B  674        BARLOUTAUD+     (SACLAY+AMST+BGNA+REHO+EPOL)I=0
BOLLINI  68 NC 58 A  289        +BUHLER,DALPIAZ,MASSAM+     (CERN+BGNA+STRB)
DAVIS    68 PL 27 B 532         +AMMAR,MOTT,DAGAN,DERRICK,FIELDS (NWES+ANL)

DUFEY    69 PL 29 B 605         +GOBBI,POUCHON,CNOPS,+      (ETH+CERN+SACL)IJP
MOTT     69 PR 177 1966         +AMMAR,DAVIS,KROPAC,SLATE,DAGAN+ (NWES+ANL)
RITTENBE 69  UCRL-18863         ALAN RITTENBERG (THESIS)              (LRL)I=0
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Mesons

$\eta'(958)$, S(975) [S*]

Data Card Listings

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AGUILAR  70 PRL 25 1635        AGUILAR-BENITEZ,BASSANO,SAMIOS,BARNES+(BNL)
BENSINGE 70 PL 33 B 505        BENSINGER,ERWIN,THOMPSON,W.D.WALKER  (WISC)

BARDADIN 71 PR D4 2711         BARDADIN-OTWINOWSKA,HOFMOKL,MICHEJDA+(WARS)
BASILE1  71 NC 3 A 371         +BOLLINI,DALPIAZ,FRABETTI,+(CERN+BGNA+STRB)
BASILE2  71 NP B 33 29         +BOLLINI,DALPIAZ,FRABETTI,+(CERN+BGNA+STRB)
HARVEY   71 PRL 27 885         +MARQUIT,PETERSON,RHOADES,+      (MINN+MICH)
OGIEVETS 71 PL 35 B 69         OGIEVETSKY,TYBOR,ZASLAVSKY           (DUBNA)

AGUILAR  72 PR D 6 29          AGUILAR-BENITEZ,CHUNG,EISNER,SAMIOS   (BNL)
APEL     72 PL 40 B 680        +AUSLANDER,MULLER,BERTOLUCCI,+  (KARL+PISA)
BINNIE   72 PL 39 B 275        +CAMILLERI,DUANE,GARBUTT,BURTON+(LOIC+SHMP)
BLOODWOR 72 NP B 39 525        BLOODWORTH,JACKSON,PRENTICE,YOON  (TORONTO)
DALPIAZ  72 PL 42 B 377        +FRABETTI,MASSAM,NAVARRIA,ZICHICHI   (CERN)
RADER    72 PR D 6 3059        +ABOLINS,DAHL,DANBURG,DAVIES,HOCH,+   (LBL)

DANBURG  73 PR D 8 3744        +KALBFLEISCH,BORENSTEIN,CHAPMAN,+(BNL+MICH)  JP
JACOBS   73 PR D 8 18          +CHANG,GAUTHIER,+       (BRAN+UMD+SYRA+TUFT) JP
KALBFLEI 73 PRL 31 333         KALBFLEISCH,CHAPMAN,+         (BNL+MICH+LBL) JP

BALTAY   74 PR D9 2999         +COHEN,CSORNA,HABIBI,KALELKAR,+ (COLU+BING)  JP
DUANE    74 PRL 32 425         +BINNIE,CAMILLERI,CARR,DEBENHAM+(LOIC+SHMP)
GAULT    74 NC 24 A 259        +JONES,SCADRON,THEWS        (DURH+LOIC+ARIZ)
KALBFLEI 74 PR D10 916         G.R.KALBFLEISCH                       (BNL)

GRIGORIA 75 NP B91 232         GRIGORIAN,LADAGE,MELLEMA,RUDNICK,+   (UCLA)
KALBFLEI 75 PR D11 987         KALBFLEISCH,STRAND,CHAPMAN       (BNL+MICH)

CERRADA  77 NP B 126 189       +WAGNER,BLOCKZIJL,+    (CERN+AMST+NIJM+OXF)  JP
DELAGUIL 77 PR D16 2833        F.DEL AGUILA AND M.G.DONCEL      (BARCELONA)  JP
GESSAROL 77 NP B 126 382       GESSAROLI,+  (BGNA+FIRZ+GENO+MILA+OXF+PAVI)
LEDNICKY 77  E2-10521,22,23    R.LEDNICKY                            (JINR)  JP
ROUSSARI 77  PREPRINT          +ERNWEIN,FELTESSE,BORGEAUD,ROUSSARIE+(SACL)  JP
   ALSO  77 BUDAPEST CONF.     HEMINGWAY REVIEW TALK                 (CERN)
ZANFINO  77 PRL 38 930         +BROCKMAN,DANKOWYCH,+ (CARL+MCGI+OHIO+TNTO)

ABRAMS   79 PRL 43 477         +ALAM,BLOCKER,BOYARSKI,+            (SLAC+LBL)
APEL     79 PL 83 B 131        +AUGENSTEIN,BERTOLUCCI(KARL+PISA+SERP+WIEN)
BINNIE   79 PL 83 B 141        +CARR,DEBENHAM,JONES,KARAMI,KEYNE+   (LOIC)
DZHELYAD 79 PL B 88 379        DZHELYADIN,GOLOVKIN,GRITZUK,KACHANOV+(SERP)

VIKTOROV 80 SJNP 32 520        +GOLOVKIN,DZHELYADIN,ZAITSEV,MUKHIN,+(NOVO)

DZHELYAD 81 PL 105 B 239       DZHELYADIN,GOLOVKIN,KONSTANTINOV,+   (SERP)

BARTEL   82 PL 113 B 190       +CORDS+(DESY+HAMB+HEID+LANC+MCHS+RHEL+TOKY)
BICKERST 82 ZPHY C 16 171      BICKERSTAFF,MCKELLAR                  (MELB)

BEHREND  83 PL 125 B 518       +D-AGOSTINI+(DESY+KARL+MPIM+LALO+LPNP+SACL)
   ALSO  82 PL 114 B 378       BEHREND+    (DESY+KARL+MPIM+LALO+LPNP+SACL)
FRAZER   83 AACHEN CONF.       RAPPORTEUR TALK                      (UCSD)
JENNI    83 PR D 27 1031       +BURKE,TELNOW,ABRAMS,BLOCKER+    (SLAC+LBL)
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S(975) or S*

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3  S(975,JPG=0++) I=0

FORMERLY CALLED S*
UNDER THIS ENTRY WE LIST PARAMETERS OF THE POLE IN THE
ISOSCALAR S WAVE. FOR A MINI-REVIEW SEE UNDER EPSILON.

FOR EARLY WORK USING BREIT-WIGNER OR SCATTERING
LENGTH PARAMETRIZATION IN FITS TO THE K KBAR MASS
SPECTRUM, SEE REFERENCE SECTION AND OUR 1972 EDITION.

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3  MASS OR REAL PART OF THE S(975) POLE POSITION (MEV)

M   POLE POSITION DETERMINATIONS
M   R      (997.)     (6.)          PROTOPOPE 73 HBC     PI+ P              12/77
M   A      (997.)                   ESTABROOK 73 ASPK    17 PI-P,PI+PI-N    12/75
M   R     (1012.)     (6.)          GRAYER    73 ASPK    17 PI-P,PI+PI-N    12/77
M   R     (1007.)    (20.)          HYAMS     73 ASPK    17 PI-P,N PI+PI-   12/77
M   A      (986.)     (5.)          FUJII     75 RVUE    17 PI-P,PI+PI-N    12/75
M   AD     (998.0)    (7.0)         BOHACIK   80 RVUE                       9/81
M   E      (988.)                   IRVING    81 RVUE                       3/82
M   F      (966.)                   IRVING    81 RVUE                       3/82

M           987.       7.            BINNIE    73 CNTR    PI- P,MM N         12/77
M           969.0      5.0           LEEPER    77 ASPK    2-2.4 PI-P         12/77
M    C      986.       10.           AGUILAR   78 HBC     .7 PBAR P, KS KS   12/77
M          (986.)                    MARTIN    79 RVUE                       9/81
M           974.0      4.0           GIDAL     81 SMK2    J/PSI DECAY        1/82
M    G      985.0      39.0          ETKIN1    82 MPS     23 PI-P,2K0S N     9/83*
M          . . . . . . . . . .
M   AVG     975.4      3.7     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.4)
                      (SEE IDEOGRAM BELOW)
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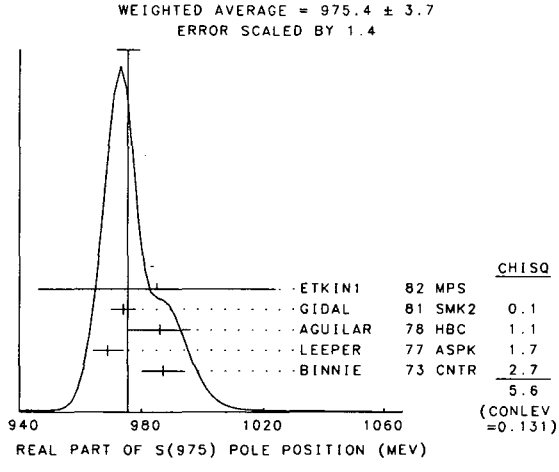


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M   MASS DETERMINATIONS (REAL PART OF MASS MATRIX EIGENVALUE)
M    B     (975.)                   ACHASOV   80 RVUE                       9/81
M    B     (985.)                   TORNQVIST 82 RVUE                       1/82

M   A   FROM SINGLE CHANNEL FIT TO HYAMS 73 DATA.
M    B  COUPLED CHANNEL ANALYSIS WITH FINITE WIDTH CORRECTIONS,SEE MINIREV.
M    D  POLE POSITIONS FROM ALMOST MODEL-INDEPENDENT PARAMETRIZATION
M    C  FROM COUPLED CHANNEL FIT TO HYAMS 73  AND PROTOPOPESCU 73 DATA.
M    C  WITH A SIMULTANEOUS FIT TO  THE PI PI PHASE-SHIFTS,
M    C  INELASTICITY AND TO  THE KS KS INVARIANT MASS.
M    E  FROM COUPLED CHANNEL ANALYSIS OF PI N --> PI PI N OR K KBAR N DATA
M    E  FROM GRAYER 73 AND COHEN 80
M    F  SIMILAR TO (E), BUT OMIT PI N --> PI PI N MOMENTS, AND INCLUDE
M    F  K- P --> PI+ PI- Y DATA
M    R  INCLUDED IN AGUILAR 78 FIT
M     G  ETKIN1 82 QUOTES ERRORS +9/-39 MEV. WE USE +-39 MEV IN THE AVERAGE.

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3  WIDTH OR IMAG. PART OF THE S(975) POLE POSITION (ME

W   POLE POSITION DETERMINATIONS (CORRESPONDS TO HALF-WIDTH,NOT FULL WIDTH)
W   R      (27.)      (8.)          PROTOPOPE 73 HBC     7. PI+ P           12/77
W   A       (5.)                    ESTABROOK 73 ASPK    17 PI-P,PI+PI-N    12/75
W   R      (16.)      (5.)          GRAYER    73 ASPK    17 PI-P,PI+PI-N    12/77
W   R      (15.)      (5.)          HYAMS     73 ASPK    17 PI-P,N PI+PI-   12/77
W   A      (19.)      (3.)          FUJII     75 RVUE    17 PI-P,PI+PI-N    12/75
W   AD     (19.0)     (6.0)         BOHACIK   80 RVUE                       9/81
W   E       (8.)                    IRVING    81 RVUE                       3/82
W   F      (24.)                    IRVING    81 RVUE                       3/82

W           24.        7.            BINNIE    73 CNTR    PI- P,MM N         12/77
W           15.0       4.0           LEEPER    77 ASPK    2-2.4 PI-P         12/77
W    C      50.        40.           AGUILAR   78 HBC     .7 PBAR P, KS KS   12/77
W           (7.)                     MARTIN    79 RVUE                       9/81
W           14.0       5.0           GIDAL     81 SMK2    J/PSI DECAY        1/82
W           60.0       141.0    10.0 ETKIN1    82 MPS     23 PI-P,2K0S N     9/83*
W          . . . . . . . . . .
W   AVG     16.4       2.8     AVERAGE

W   FULL WIDTH DETERMINATIONS (FROM IMAG PART OF MASS MATRIX EIGENVALUE)
W    B      70 TO 300               ACHASOV   80 RVUE                       9/81
W    B     (400.)   APPROX.         TORNQVIST 82 RVUE                       1/82

W  ACR  SEE NOTES UNDER REAL PART
W  EF   SEE NOTES UNDER REAL PART
W    B  COUPLED CHANNEL ANALYSIS WITH FINITE WIDTH CORRECTIONS,SEE MINIREV.
W    D  POLE POSITIONS FROM ALMOST MODEL-INDEPENDENT PARAMETRIZATION

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3  S(975) PARTIAL DECAY MODES

*                                                        DECAY MASSES
P1      S(975) INTO K KBAR                              498+ 498
P2      S(975) INTO PI PI                               140+ 140
P3      S(975) INTO ETA ETA                             549+ 549

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3  S(975) BRANCHING RATIOS

R1      S(975) INTO (PI PI)/TOTAL                    (P2)
R1          (0.71)                  HYAMS     75 ASPK    17.2 PI-P,PI+PI-   9/81
R1           0.78      0.03         WETZEL    76 OSPK    8.9 PI-P,KS KS N   9/81
R1           0.81      0.09    0.04 CASON     78 STRC    7. PI- P,KS KS N   9/81
R1           0.67      0.09         LOVERRE   80 HBC     4. PI- P,K K N     9/81
R1         . . . . . . . . . .
R1  AVG      0.776     0.026   AVERAGE

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                          REFERENCES FOR S(975)

WANG     61 JETP 13 323        WANG TSU-TSENG,VEKSLER,VRANA,+        (JINR)

BIGI     62 CERN CONF 247      A BIGI,S BRANDT, R CARRARA +          (CERN)
BINGHAM  62 CERN CONF 240      H H BINGHAM,M BLOCH +            (EPOL+CERN)
ERWIN    62 PRL 9 34           ERWIN,HOYER,MARCH,WALKER,WANGLER (WISC+BNL)

BALTAY   64 DUBNA CONF 1 409   BALTAY,LACH,CRENNELL,OREN,STUMP +(YALE+BNL)
BARMIN   64 DUBNA CONF 1 433   BARMIN,DOLGOLENKO,YEROFEEV,KRESTNI+  (ITEP)

CRENNELL 66 PRL 16 1025        CRENNELL,KALBFLEISCH,LAI,SCARR,SCHU+  (BNL)
HESS     66 PRL 17 1109        +DAHL+HARDY+KIRZ+MILLER               (LRL)

BARLOW   67 NC 50A 701         +LILLESTOL+MONTANET+  (CERN+CDEF+IRAD+LIVP)
BEUSCH   67 PL 25 B 357        +FISCHER,GOBBI,ASTBURY+          (ETH+CERN)
DAHL     67 PR 163 1377        +HARDY+HESS+KIRZ+MILLER               (LRL)

ALITTI   68 PRL 21 1705        +BARNES,CRENNELL,FLAMINIO,GOLDBERG,+  (BNL)
LAI      68 PHILAD.CONF.P.303  KWAN WU LAI                           (BNL)
PHELAN   68 THESIS             JAMES J. PHELAN          (ANL+ST.LOUIS UNIV)
   ALSO  68 PRL 21 316         HOANG,EARTLY,PHELAN,ROBERTS+(ANL+CHIC+NDAM)

AGUILAR- 69 PL 29 B  241       M.AGUILAR-BENITEZ,J.BARLOW,+    (CERN+CDEF)
   ALSO  69 NP B 14 195        M.AGUILAR-BENITEZ,J.BARLOW,+    (CERN+CDEF)
HOANG    69 NC 61 A 325        T.F.HOANG                             (ANL)
HOANG    69 PR 184  1363       +EARTLY,PHELAN,ROBERTS,+         (ANL+ILLC)

BADIER   70 NP B 22 512        +BONNET,DREVILLON,BAUBILLIER,+  (EPOL+IPNP)
BATON    70 PL 33 B 528        +LAURENS,REIGNIER                    (SACLAY)
BEUSCH   70 PHILA.CONF.P.185   W.BEUSCH                          (ETH+CERN)
HYAMS    70 PHILA.CONF.P.41    +KOCH,BEUSCH,+    (CERN+MPIM+ETH+LOIC+HAWA)
   ALSO  70 NP B 22 189        HYAMS,KOCH,POTTER,VON LINDERN,+ (CERN+MPIM)
OH       70 PR D 1 2494        +GARFINKEL,MORSE,WALKER,PRENTICE(WISC+TNTO)

ALSTON-G 71 PL 36 B 152        ALSTON-GARNJOST,BARBARO-GALTIERI,+    (LBL)

BASDEVAN 72 PL 41 B 178        BASDEVANT,FROGGATT,PETERSEN          (CERN)
DANERI   72 NC 9 A 1           +BORZATTA,GOUSSU,+          (GENO+MILA+SACL)
DUBOC    72 NP B 46 429        +GOLDBERG,MAKOWSKI,DONALD,+     (LPNP+LIVP)
FLATTE   72 PL 38 B 232        +ALSTON-GARNJOST,BARBARO-GALTIERI,+   (LBL)
GRAYER   72 PHIL.CONF.PROC. 5  +HYAMS,JONES,SCHLEIN,BLUM,DIETL+(CERN+MPIM)
WILLIAMS 72 PR D 6 3178        P.K.WILLIAMS                          (FSU)

BINNIE   73 PRL 31 1534        +CARR,DEBENHAM,DUANE,GARBUTT,+  (LOIC+SHMP)
DIAMOND  73 PR D 7 1977        +BINKLEY,+        (WISC+DUKE+COLO+TNTO+OHIO)
ESTABROO 73  TALLAHASSEE       ESTABROOKS,MARTIN,GRAYER,HYAMS+ (CERN+MPIM)
FUJII    73 NC 13 A 311        Y.FUJII,M.KATO                       (TOKYO)
GRAYER   73  TALLAHASSEE       +HYAMS,JONES,BLUM,DIETL,KOCH+   (CERN+MPIM)
HYAMS    73 NP B 64 134        +JONES,WEILHAMMER,BLUM,DIETL,+  (CERN+MPIM)
OCHS     73 THESIS             W.OCHS                               (MPIM)
PROTOPOP 73 PR D 7 1280        PROTOPOPESCU,GARNJOST,GALTIERI,FLATTE+(LBL)
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For notation, see key at front of Listings.

Mesons
S(975) [S*], δ(980)

GRAYER 74 NP B 75 189 +HYAMS,JONES,BLUM,DIETL,KOCH+ (CERN+MPIM)
GRAYER 74 NP B 76 375 +HYAMS,JONES,BLUM,DIETL (CERN+MPIM)
MORGAN 74 PL 51B 71 D.MORGAN (RHEL)

FUJII 75 NP B85 179 Y.FUJII,M.FUKUGITA (TOKY)
HYAMS 75 NP B 100 205 +JONES,WEILHAMMER,BLUM,DIETL+ (CERN+MPIM)
MORGAN 75 ARGONNE CONF. 45 D. MORGAN (RHEL)
PAWLICKI 75 PR D12 631 +AYRES,DIEBOLD,GREENE,KRAMER,WICKLUND (ANL)

BRANDEB 76 NP B 104 413 +CARNEGIE,CASHMORE,DAVIER,LASINSKI,+ (SLAC)
BUTTRAM 76 PR D 13 1153 +CRAWLEY,DUKE,LAMB,LEEPER,PETERSON (ISU)
CERRADA 76 PL 62 B 353 +GONZALEZ-ARROYO,RUBIO,YNDURAIN (CERN+MADR)
FLATTE 76 PL 63 B 228 S.M.FLATTE (CERN)
WETZEL 76 NP B 115 208 +FREUDENREICH,BEUSCH,+ (ETH+CERN+LOIC)
WILKINS 76 PR D 13 1831 +ALBRIGHT,S+V HAGOPIAN,LANNUTTI (FSU)

FROGATT 77 NP B 129 89 +PETERSEN (GLASGOW+COPENHAGEN)
LEEPER 77 PR D 16 2054 +BUTTRAM,CRAWLEY,DUKE,LAMB,PETERSON (ISU)
MARTIN 77 NP B 121 514 +OZMUTLU,SQUIRES (DURHAM)
PAWLICKI 77 PR D 15 3196 +AYRES,COHEN,DIEBOLD,KRAMER,WICKLUND (ANL)I J

AGUILAR 78 NP B 140 73 +CERRADA,+ (MADRID+BOMBAY+CERN+PARIS)
BALAND 78 NP B 140 220 +GRARD,JOHNSON,+ (MONS+BELG+CERN+LOIC+LALO)
CASON 78 PRL 41 271 +BAUMBAUGH,BISHOP,BISWAS,KENNEY,+(NDAM+ANL)

ACHASOV 79 PL 88 B 367 +DEVYANIN,SHESTAKOV (NOVO)
APEL 79 NP B 160 42 +AUSLANDER,MULLER,REHAK+ (KARL+PISA)
BECKER 79 NP B 151 46 +BLANAR,BLUM,CERRADA+ (MPIM+CERN+ZEEM+CRAC)
CORDEN 79 NP B 157 250 +DOWELL,GARVEY,JOBES,+(BIRM+RHEL+TELA+LOWC) JP
ESTABROO 79 PR D 19 2678 P.ESTABROOKS (CARL)
GREENHUT 79 PR D 20 2326 +INTEMANN (SETO)
MARTIN 79 NP B 158 520 +OZMUTLU (DURH)I,JP
POLYCHRO 79 PR D 19 1317 POLYCHRONAKOS,CASON,BISHOP+ (NDAM+ANL)

ACHASOV 80 SJNP 32 566 +DEVYANIN,SHESTAKOV (NOVO)
BOHACIK 80 PR D 21 1342 J.BOHACIK,H.KUHNELT (BRATISLAVA+WIEN)
COHEN 80 PR D 22 2595 +AYRES,DIEBOLD,KRAMER,PAWLICKI+ (ANL)I,JP
LOVERRE 80 ZPHY C 6 187 +ARMENTEROS,DIONISI+ (CERN+CDEF+MADR+STOH)I,JP
WICKLUND 80 PRL 45 1469 +AYRES,COHEN,DIEBOLD,PAWLICKI (ANL)

ACHASOV 81 PL 102 B 196 +DEVYANIN,SHESTAKOV (NOVO)
AGUILAR 81 ZPHY C 10 299 AGUILAR-BENITEZ,DONE,MARTIN (MADR+DURH)
GIDAL 81 PL 107 B 153 +GOLDHABER,GUY,MILLIKAN,ABRAMS,+ (SLAC+LBL)
IRVING 81 ZPHY C 10 45 +MARTIN,DONE (LIVP+DURH)
ROUSSARI 81 PL 105 B 304 ROUSSARIE,BURKE,ABRAMS,ALAM,+ (SLAC+LBL)

BARBER 82 ZPHY C 12 1 +DAINTON,BRODBECK,BROOKES,+(DARE+LANC+SHEF)
ETKIN1 82 PR D 25 1786 +FOLEY,LAI,LINDENBAUM+ (BNL+CUNY+TUFT+VAND)
ETKIN2 82 PR D 25 2446 +FOLEY,LAI,LINDENBAUM+ (BNL+CUNY+TUFT+VAND)
TORNQVIS 82 PRL 49 624 N.A.TORNQVIST (HELS)

MENNESSI 83 ZPHY C 16 241 G.MENNESSIER (MONP)

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δ(980)

36 DELTA(980,JPG=0+-) I=1

The quantum numbers of the δ(980) resonance are: $I^G = 1^-$, deduced from its production in $D^0 \rightarrow \delta\pi$, from its $\eta\pi$ decay, and from the absence of a $\pi\pi$ decay; and $J^P = 0^+$, deduced from the absence of a 3π or $\rho\pi$ decay (LIPKIN 69, GRASSLER 77) and from the decay distributions of the $\eta\pi$ decay. With these quantum numbers, the δ(980) is expected to couple to the I = 1 $K\bar{K}$ system, too, and to explain the nearby $K\bar{K}$ threshold enhancement (ASTIER 67).

The SU(3) and quark-model classification of the δ(980) has been somewhat controversial. The naive quark model would suggest that the lightest 0^{++} states should belong to a 1P $q\bar{q}$ nonet. This conclusion is also supported by models with very general spin-dependent terms (SCHNITZER 82). The unconventional mass spectrum, in particular the near-degeneracy of δ(980) and S(975), has on the other hand led to suggestions for a 4-quark assignment of the δ(980) (JAFFE 79). A 4-quark assignment would predict a very large ("superallowed") coupling to $\eta\pi$ and $K\bar{K}$ (ACHASOV 79,80). A comparatively large coupling is not incompatible with a narrow δ peak width (FLATTE 76), since the $K\bar{K}$ threshold distorts drastically the δ(980) shape.

However, a $q\bar{q}$ interpretation also requires by SU(3) a large $\delta\eta\pi$ coupling, and it has been shown (TORNQVIST 82) that it is possible to understand within the unitarized quark model the unconventional features of the lightest scalar mesons. In this framework, the mass shifts, mixings, and distortions of resonance shapes induced by the nearest SU(3)-related thresholds are crucial for the light 0^{++} states. Thus the δ(980) mass is shifted considerably by the nearby $\pi\eta$, $K\bar{K}$, and $\pi\eta'$ thresholds, whereas, e.g., the κ(1350) is shifted much less by $K\pi$ and $K\eta'$, which lie relatively far from the resonance mass. Possible weaknesses of this approach have been discussed (ACHASOV 83).

A conventional $q\bar{q}$ assignment is also favored by the D(1285)/E(1420) → $\rho\pi$ branching ratio, the decay $\eta' \rightarrow \delta\pi \rightarrow \eta\pi\pi$, and the tadpole contributions to e.m. mass differences and mixings (BRAMON 80,83), although some of these arguments might turn out to be inadequate (ACHASOV 83). Thus it seems plausible (TORNQVIST 82,83) that the δ(980) is a $q\bar{q}$ state with large Fock-space components of $q\bar{q}q\bar{q}$ in the form of virtual $\eta\pi$, $K\bar{K}$, and $\eta'\pi$ pairs. See also the mini-reviews under ε(1300) and κ(1350).

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36 DELTA(980) MASS (MEV)

M	ETA PI FINAL STATE ONLY.									
M		10	(960.)	APPROX.	CHUNG S	68	HBC	-	3.2 PI-P	5/70
M		80	(975.0)		DEFOIX	68	HBC	+-	1.2 PB P,ETA PI	11/77
M		15	(980.0)	(10.0)	MILLER	69	HBC	-	4.5 K-N,ETA PI	7/69
M		21	(948.0)	(7.0)	BARDADIN	71	HBC	+-	8 PI+P,P DO PI	11/77
M										
M		30	980.0	10.0	AMMAR	68	HBC	+-	,5.5K-,ETA PI	2/73
M		20	970.0	15.0	BARNES	69	HBC	-	4-5 K-P,PI-ETA	9/69
M			980.	10.	CAMPBELL	69	DBC	+-	2.7 PI+ D	1/73
M		150	972.	10.	DEFOIX	72	HBC	+-	0.7 PBAR P,7 PI	1/73
M	C	70	989.0	10.0	WELLS	75	HBC	-	3.1-6 K-P,ETA PI	11/77
M		80	981.0	6.0	GAY	76	HBC	-	4.2 K-P,ETA PI	11/77
M			977.0	7.0	GRASSLER	77	HBC	-	16 PI-+P,ETA PI	11/77
M		47	980.	11.	CONFORTO	78	OSPK	-	4.5 PI-P,P X-	4/78
M		50	978.0	16.0	CORDEN	78	OMEG	+-	12-15PI-P,ETA PI	4/78
M	R	145	990.0	7.0	GURTU	79	HBC	+-	4.2 K- P,ETA PI	12/79
M	R	500	986.	3.	EVANGELIS	81	OMEG		12 PI-P,ETA3PIP	1/82
M										
M	REVUE ARTICLES									
M	B		(982.)		ACHASOV1	80	RVUE			9/81
M			(970.)		TORNQVIST	82	RVUE			8/83*
M										
M	AVG		983.4	2.1	AVERAGE					

M C SYSTEMATIC ERROR 6 MEV DUE TO ENERGY CALIBRATION ADDED
M B COUPLED CHANNEL ANALYSIS WITH FINITE WIDTH CORRECTIONS,SEE MINIREV.
M R FROM D(1285) DECAY

M	K KBAR ONLY, SEE THE TYPED NOTE ABOVE									
M		143	(1003.3)	7.0+SYSTEMATIC	ROSENFELD	65	RVUE	+-		8/66
M	A	100	(1016.)	(10.)	ASTIER	67	HBC	+-	0 PBAR P	12/77
M		316	976.	6.	DE BILLY	80	HBC	+-	1.2-2 PB P,D OMG	6/81

M A ASTIER 67 INCLUDES DATA OF BARLOW 67,CONFORTO 67,ARMENTEROS 65.

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36 DELTA(980) WIDTH (MEV)

W	ETA PI FINAL STATE ONLY										
W		80	(25.0)			DEFOIX	68	HBC	+-	1.2 PB P,ETA PI	11/77
W		20	(50.0)	OR LESS		BARNES	69	HBC	-	4-5 K-P,PI-ETA	11/77
W		150	(30.)	(5.)		DEFOIX	72	HBC	+-	0.7 PBAR P,7 PI	2/74
W		70	(16.0)	(25.0)	(16.0)	WELLS	75	HBC	-	3.1-6 K-P,ETA PI	
W											
W		30	80.0	30.0		AMMAR	68	HBC	+-	,5.5K-,ETA PI	2/73
W			40.	15.		CAMPBELL	69	DBC	+-	2.7 PI+ D	1/73
W		15	60.0	30.0		MILLER	69	HBC	-	4.5 K-N,ETA PI	2/74
W		21	31.0	28.0		BARDADIN	71	HBC	+-	8 PI+P,P DO PI	2/74
W	N		55.0	15.0		GAY	76	HBC	-	4.2 K-P ETA PI	11/77
W			44.0	22.0		GRASSLER	77	HBC	-	16 PI-+P,ETA PI	11/77
W		47	60.	50.	30.	CONFORTO	78	OSPK	-	4.5 PI-P,P X-	4/78
W	D	50	86.0	60.0	50.0	CORDEN	78	OMEG	+-	12-15PI-P,ETA PI	4/78
W	R	145	60.0	20.0		GURTU	79	HBC	+-	4.2 K- P,ETA PI	12/79
W	R	500	62.	15.		EVANGELIS	81	OMEG		12 PI-P,ETA3PIP	1/82
W											
W	REVUE ARTICLES										
W	F		80 TO 300			FLATTE	76	RVUE	-	4.2 K-P,ETA PI	11/77
W	B		103 TO 262			ACHASOV1	80	RVUE			9/81
W	B		(500.)	APPROX.		TORNQVIST	82	RVUE			1/82
W											
W	AVG		53.7	6.7		AVERAGE					

Mesons

$\delta(980)$, $\phi(1020)$

Data Card Listings

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W    B  COUPLED CHANNEL ANALYSIS WITH FINITE WIDTH CORRECTIONS,SEE MINIREV.
W    F  USING A TWO CHANNEL RESONANCE PARAMETRIZATION OF GAY 76 DATA.
W    N  THE ERROR IN THE PAPER IS WRONGLY QUOTED AT ONE POINT
W    R  FROM D(1285) DECAY

W  K KBAR ONLY, SEE THE TYPED NOTE ABOVE
W      143  (57.0)    13.0+SYSTEMATIC ROSENFELD 65 RVUE +-                 8/66
W  A   100  (25.)  APPROX.             ASTIER    67 HBC  +- SEE NOTE A ABOVE 9/67
W   M      (120.)  APPROX.             MORGAN    75 RVUE   1.2 PBAR P     12/75

W  A    ASTIER 67 INCLUDES DATA OF BARLOW 67,CONFORTO 67,ARMENTEROS 65.
W   M   FROM COUPLED CHANNEL FIT TO DUBOC 72 DATA

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                    36  DELTA(980) PARTIAL DECAY MODES

                                                        DECAY MASSES
P1      DELTA(980)   INTO ETA PI                        549+ 135
P2      DELTA(980)   INTO RHO PI                        769+ 135
P3      DELTA(980)   INTO K KBAR                        498+ 498
P4      DELTA(980)   INTO PI ETA PRIME                  140+ 958

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                    36  DELTA(980) BRANCHING RATIOS

R1      DELTA(980)   INTO (RHO PI)/(ETA PI)            (P2)/(P1)
R1           (0.25) OR LESS  CL=.70   ANMAR     70 HBC  +- 4.1,5.5K-,ETA PI  5/70

R2      DELTA(980)   INTO (K KBAR)/(ETA PI)            (P3)/(P1)
R2  L        (0.25)   (0.08)          DEFOIX    72 HBC  +-  0.7 PBAR P      11/77
R2         SEEN                        GAY       76 HBC   - 4.2 K-P  ETA PI  11/77
R2   L       (0.7)    (0.3)           CORDEN    78 OMEG    12-15PI-P         4/78
R2  B        (0.75)TO 4.2             ACHASOV1  80 RVUE                      9/81
R2  B   COUPLED CHANNEL ANALYSIS WITH FINITE WIDTH CORRECTIONS,SEE MINIREV.
R2  L   FROM THE DECAY OF D(1285).

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                    REFERENCES FOR DELTA(980)

TURKOT   63 SIENNA CONF 1 661 +COLLINS,FUJII,KEMP+        (BNL+PITTSBURGH)

ARMENTER 65 PL 17 344         ARMENTEROS,EDWARDS, JACOBSEN +  (CERN+CDEF)
BARASH   65 PR  139 B  1659   +FRANZINI,KIRSCH,MILLER,STEINBERGER+ (COLU)
KIENZLE  65 PL  19  438       + MAGLIC,LEVRAT,LEFEBVRES +          (CERN)
ROSENFEL 65 OXFORD CONF 58    A H ROSENFELD                   (LRL--RVUE)

ALLEN D  66 PL 22  543        +GP FISHER,G GODDEN,L MARSHALL,SEARS (COLO)G=+
BALTAY   66 PR  142 B  932    +LACH,SANDWEISS,TAFT,YEH,STONEHILL+  (YALE)
FOCACCI  66 PRL  17  890      + KIENZLE,LEVRAT,MAGLIC,MARTIN       (CERN)
OOSTENS  66 PL  22  708       +CHAVANON,CROZON,TOCQUEVILLE  (SACLAY,CDEF)I=1

ALLISON  67 PL 25B 619        +CRUZ+        (OXF+MPIM+BIRM+RHEL+GLAS+LOIC)
ASTIER   67 PL  25 B  294     +MONTANET,BAUBILLIER,DUBOC+(CDEF+CERN+IRAD)
  ASTIER 67 INCLUDES DATA OF BARLOW 67,CONFORTO 67,ARMENTEROS 65.
BAILLON  67 NC 50A 393        +EDWARDS+D-ANDLAU+ASTIER+   (CERN+CDEF+IRAD)
BANNER 1 67 PL  25 B  300     +FAYOUX,HAMEL,ZSEMBERY,CHEZE+ (SACLAY+CAEN)
BANNER 2 67 PL 25 B 569       +CHEZE,HAMEL,MAREL,TEIGER+       (CDEF+SACL)
BARLOW   67 NC  50 A  701     +MONTANET,D-ANDLAU+    (CERN+CDEF+IRAD+LIVP)
CONFORTO 67 NP B3 469         CONFORTO,MARECHAL+     (CERN+CDEF+IPNP+LIVP)

ANMAR    68 PRL 21 1832       +DAVIS,KROPAC,DERRICK,FIELDS,+   (NWES+ANL)
CHUNG S  68 PR 165 1491        +O.DAHL, J. KIRZ, D.H.MILLER          (LRL)
DEFOIX   68 PL 28 B 253       +RIVET,SIAUD,CONFORTO+      (CDEF+IPNP+CERN)
GALTIERI 68 PRL 20 349        BARBARO-GALTIERI,MATISON,RITTENBERG+  (LRL)
JUHALA   68 PL 27 B 257       +LEACOCK,RHODE,KOPELMAN,LIBBY+  (IOWA+COLO)
SABRE CO 68 PL 26 B 674       BARLOUTAUD+       (SACL+AMST+BGNA+REHO+EPOL)

BARNES   69 PRL 23 610        +CHUNG,EISNER,BASSANO,GOLDBERG+  (BNL+SYRA)
CAMPBELL 69 PRL 22 1204       J.H.CAMPBELL,LICHTMAN,LOEFFLER,+   (PURDUE)
CRENNELL 69 PRL 22 1398       +KARSHON,KWAN WU LAI,+                (BNL+NYU)
JUHALA   69 PR 184  1461      +LEACOCK,RHODE,KOPELMAN,LIBBY,+  (ISU+COLO)
KRUSE    69 PR 177 1951       KRUSE,LOOS,GOLDWASSER              (ILLINOIS)
LIPKIN   69 PRL 22 212        +MESHKOV                           (REHO+NBS)  JP
MILLER   69 PL 29 B  255      D.H.MILLER,S.L.KRAMER,D.D.CARMONY,+(PURDUE)
   ALSO  69 PR 188 2011       YEN,AMMANN,CARMONY,ELSNER,+          (PURDUE)
SCHROEDE 69 PR 188  2081      SCHROEDER,KERNAN,FISHER,LIBBY,+  (ISU+COLO)

ABOLINS  70 PRL 25 469        +GRAVEN,MCCARTHY,G.SMITH,L.SMITH+ (LRL+UCD)
AMMAR    70 PR D 2 430        +KROPAC,DAVIS,DERRICK,+(KANS+NWES+ANL+WISC)
COOPER   70 NP B 23 605       +HANNER,MUSGRAVE,POLLARD,VOYVODIC      (ANL)
YIOU     70  THESIS, A 646    TCHIU-PUNG YIOU                      (ORSAY)

ANDERSON 71 PRL 26 108        +DIXIT,+   (CHIC+ANL+CARL+LASL+CNRC+NAGOYA)
BARDADIN 71 PR D4 2711        BARDADIN-OTWINOWSKA,HOFMOKL,MICHEJDA+(WARS)

BINNIE   72 PL 39 B 275       +CAMILLERI,DUANE,GARBUTT,BURTON+(LOIC+SHMP)
CHESHIRE 72 PRL 28 520        +HOFFMAN,GARFINKEL,+          (IOWA+ANL+PURD)
DEFOIX   72 NP B 44 125       +NASCIMENTO,BIZZARRI,+            (CDEF+CERN)
DUBOC    72 NP B 46 429       +GOLDBERG,MAKOWSKI,DONALD,+      (LPNP+LIVP)
HOLLOWAY 72 PHIL.CONF.PROC.133+HULD,KOETZ,KRUSE,BERNSTEIN,+    (ILL+ILLC)

ATHERTON 73 PL 43 B 249       +FRANEK,FRENCH,GHIDINI,HILPERT,+      (CERN)

BINNIE   74 PRL 32 392        +CAMILLERI,CARR,DEBENHAM,+       (LOIC+SHMP)
KALBFLEI 74 NP B69 279        KALBFLEISCH,VANDERBURG,+      (BNL+RUTG+IND)
MORGAN   74 PL 51B 71         D.MORGAN                             (RHEL)

BUTTRAM  75 PRL 35 970        +CRAWLEY,DUKE,LAMB,LEEPER,PETERSON    (ISU)
MORGAN   75 ARGONNE CONF. 45  D.MORGAN                             (RHEL)
WELLS    75 NP B 101 333      +RADOJICIC,ROSCOE,LYONS               (OXF)

GAY      76 PL 63 B 220       +CHALOUPKA,BLOKZIJL,HEINEN+(CERN+AMST+NIJM)  JP
FLATTE   76 PL 63 B 224       S.M.FLATTE                           (CERN)

GRASSLER 77 NP B 121 189      +       (AACH+BERL+BONN+CERN+CRAC+HEID+WARS)
IRVING   77 PL 70 B 217       A.C.IRVING                        (LIVERPOOL)
MARTIN   77 NP B 121 514      +OZMUTLU,SQUIRES                     (DURHAM)
MAY      77 PR D 16 1983      +ABRAMSON,ANDREWS,BUSNELLO,+    (ROCH+CORN)

CONFORTO 78 LNC 23 419        B+G CONFORTO,KEY+(RHEL+TNTO+CHIC+FNAL+WISC)
CORDEN   78 NP B 144 253      +CORBETT,ALEXANDER,+  (BIRM+RHEL+TELA+LOWC)
MARTIN   78 ANP  114 1        A.D.MARTIN,M.R.PENNINGTON            (CERN)

ACHASOV  79 PL 88 B 367       +DEVYANIN,SHESTAKOV                  (NOVO)
ESTABROO 79 PR D 19 2678      P.ESTABROOKS                         (CARL)
GURTU    79 NP B 151 181      +GAVILLET,BLOKZIJL,+   (CERN+ZEEH+NIJM+OXF)
MARTIN   79 NP B 158 520      +OZMUTLU                             (DURH)

ACHASOV1 80 SJNP 32 566       +DEVYANIN,SHESTAKOV                  (NOVO)
ACHASOV2 80 PL 96 B 168       +DEVYANIN,SHESTAKOV                  (NOVO)
BRAMON   80 PL 93 B 65        +MASSO                               (BARC)
DE BILLY 80 NP B 176 1        +BRIAND,DUBOC,LEVY+   (CURI+LAUS+NEUC+GLAS)

EVANGELI 81 NP B 178 197      EVANGELISTA+(BARI+BONN+CERN+DARE+LIVP+MILA)

ACHASOV  82  TP-20-130        +DEVYANIN,SHESTAKOV                  (NOVO)
BICKERST 82 ZPHY C 16 171     BICKERSTAFF,MCKELLAR                 (MELB)
TORNQVIS 82 PRL 49 624        N.A.TORNQVIST                        (HELS)

BRAMON   83 PL 120 B 240      +MASSO                               (BARC)

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$\phi(1020)$

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4  PHI(1020,JPG=1-- ) I=0

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                    4  PHI MASS (MEV)

M                   WE ONLY AVERAGE MASS AND WIDTH VALUES WHEN THE
M                   SYSTEMATIC ERRORS HAVE BEEN EVALUATED.

M      410 1019.9      0.3          STOTTLEMY 71 HBC     2.9 K-P,Y K KBAR 11/71
M    D 120 1019.6      0.5          AGUILAR   72 HBC     3.9,4.6 K- P     12/75
M    D 100 1019.9      0.5          AGUILAR   72 HBC     3.9,4.6 K- P     12/75
M      131 1020.4      0.5          COLLEY    72 HBC     10.K+ P,K+ P PHI 12/72
M      100 1020.3      0.4          BALLAM    73 HBC     2.8 - 9.3 G P     1/74
M          1019.4      0.7          BINNIE    73 CNTR    PI-P,PHI N        4/78
M   AR 500(1019.5)   (0.6)          AYRES     74 ASPK    3-6PI/K-P,K+K-   12/77
M      984 1019.4      0.8          BESCH     74 CNTR    2 GAMMA P,PK+K-  12/75
M   AR 170(1020.3)   (0.4)          DE GROOT  74 HBC     4.2 K-P,L K+K-   12/77
M      454 1019.7      0.5          KALBFLEIS 76 HBC     2.18 K-P,K KBAR   7/77
M   AR1300(1019.7)   (0.2)          AKERLOF   77 SPEC    400 P+A,K+K-     12/77
M   AR 905(1020.4)   (0.3)          BALDI     77 CNTR    10 K-P,K-PHI P   12/77
M   A  383(1020.0)   (1.0)          BALDI     77 CNTR    10 PI-P,PI-PHI P 12/77
M   AR2504(1020.0)   (0.2)          BALDI     77 CNTR    10 K+P,K+PHI P   12/77
M   AR 721(1022.0)   (1.0)          BALDI     77 CNTR    10 P P,P PHI P   12/77
M      800 1018.9      0.6          COHEN     77 ASPK    6 PI- PN,K+K-PN  12/77
M          1019.52     0.13         BUKIN 1   78 OLYA    E+E- COLL.BEAMS   9/81
M      337 1019.4      0.5          COOPER    78 HBC     .7-.8 PB P,KS K0  4/78
M     1100 1019.54     0.12         BARKOV    79 EMUL    E+E- COLL.BEAMS   3/82
M   R 6730(1019.7)   (0.1)          DAUM      81 SPEC    P BE,K+ K- X      9/81
M  C   766 1019.8      0.7          IVANOV    81 OLYA    1-1.4 E+E-,K+K-   1/82
M     1500 1019.3      0.1          ARENTON   82 AEMS    11.8 POL.P P,KK   9/83*
M    25080 1019.67     0.17         PELLINEN  82 RVUE                     1/82
M   A     (1021.0)   (0.2)          ARMSTRONG 83 OMEG    18.5 K-P,K-K+LAM 12/83*
M   A     (1020.0)   (0.5)          ARMSTRONG 83 OMEG    18.5 K-P,K-K+LAM 12/83*
M   A     (1019.7)   (0.3)          BARATE    83 GOLI    190 PI-BE,2MU     9/83*
M          . . . . . . . . .
M   AVG    1019.513   0.069   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.2)
                              (SEE IDEOGRAM BELOW)

M   A   SYSTEMATIC ERRORS NOT EVALUATED.
M  C    SYSTEMATIC ERROR ADDED LINEARLY BY US.
M    D  MASS ERRORS ENLARGED BY US TO WIDTH/SQRT(N),SEE K* TYPED NOTE
M    R  INCLUDED IN PELLINEN 82 RVUE
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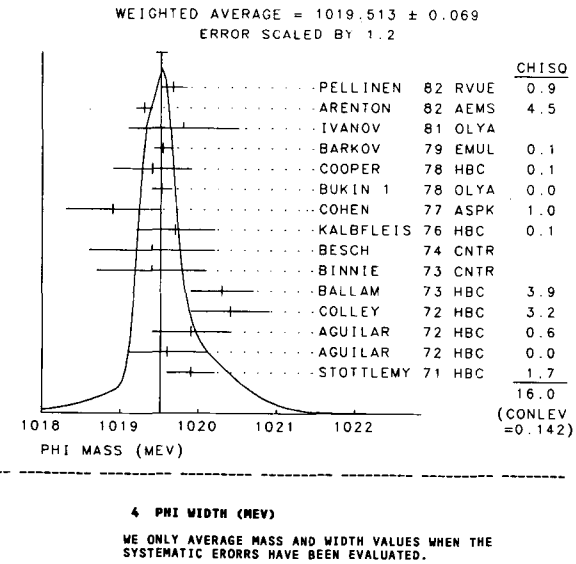


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                    4  PHI WIDTH (MEV)

W                   WE ONLY AVERAGE MASS AND WIDTH VALUES WHEN THE
W                   SYSTEMATIC ERORRS HAVE BEEN EVALUATED.

W    D 150    4.2     1.4          AUGUSTIN  69 OSPK    E+ E- COLL.BEAMS 12/72
W             4.09    0.29         BIZOT     70 OSPK    E+ E- COLL.BEAMS 12/72
W    D 681    4.67    0.72         BALAKIN   71 OSPK     E+ E- COLL.BEAM 12/75
W    D 120    4.6     1.7          AGUILAR   72 HBC     3.9,4.6 K- P     12/75
W    D 100    4.7     1.9          AGUILAR   72 HBC     3.9,4.6 K- P     12/75
W    D 131    5.0     1.8          COLLEY    72 HBC     10.K+ P,K+ P PHI 12/75
W    D 454    3.8     0.7          BORENSTEI 72 HBC     2.18 K-P,K KBAR   7/77
W    D 100    3.8     1.5          BALLAM    73 HBC     2.8 - 9.3 G P    12/75
W             4.5     1.1          BINNIE    73 CNTR    PI-P,PHI N        4/78
W   AD 500   (4.5)   (0.8)          AYRES     74 ASPK    3-6PI/K-P,K+K-   12/75
W    D 984    4.4     0.6          BESCH     74 CNTR    2 GAMMA P,PK+K-  12/75
W             3.81    0.37         COSME 2   74 OSPK    E+E- COLL.BEAMS   2/74
W   AD 170   (4.2)   (1.3)          DE GROOT  74 HBC     4.2 K-P,L K+K-   12/75
W  A D1300    4.5     0.50         AKERLOF   77 SPEC    400 P+A,K+K-     12/77
W  B D3681    4.36    0.29         BUKIN 1   78 OLYA    E+E- COLL.BEAMS   9/81
W    D 337    3.6     0.8          COOPER    78 HBC     .7-.8 PB P,KS K0  4/78
W    D1100    4.58    0.55         BARKOV    79 EMUL    E+E- COLL.BEAMS   3/82
W    D        4.3     0.6          CORDIER   80 WIRE    E+E-,PI+PI-PIO    9/81
W    D 766    4.2     0.6          IVANOV    81 OLYA    1-1.4 E+E-,K+K-   1/82
W     1500    4.5     0.7          ARENTON   82 AEMS    11.8 POL.P P,KK   9/83*
W          . . . . . . . . .
W   AVG      4.22    0.13    AVERAGE

W   A   SYSTEMATIC ERRORS NOT EVALUATED.
W  B    NUMBER OF EVENTS INCLUDES A SMALL BACKGROUND CONTRIBUTION.
W    D  WIDTH ERRORS ENLARGED BY US TO 4*WIDTH/SQRT(N), SEE K* TYPED NOTE

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For notation, see key at front of Listings.

Mesons
$\phi(1020)$

4 PHI PARTIAL DECAY MODES

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                                                            DECAY MASSES
P1     PHI INTO K+ K-                                       494+ 494
P2     PHI INTO KL KS                                       498+ 498
P3     PHI INTO PI+ PI- PIO (INCLUDING RHO PI)              140+ 140+ 135
P4     PHI INTO ETA GAMMA                                   549+   0
P5     PHI INTO E+ E-                                      .511+.511
P6     PHI INTO MU+ MU-                                     106+ 106
P7     PHI INTO PIO GAMMA                                   135+   0
P8     PHI INTO PI+ PI- (VIOLATES G)                        140+ 140
P9     PHI INTO PI+PI-GAMMA                                 140+ 140+   0
P10    PHI INTO OMEGA GAMMA (VIOLATES C)                    783+   0
P11    PHI INTO ETA PIO (VIOLATES C)                        549+ 135
P12    PHI INTO RHO GAMMA (VIOLATES C)                      769+   0
P13    PHI INTO ETA NEUTRALS
P14    PHI INTO 5PI                                         140+ 140+ 140+ 140+
P15    PHI INTO PI+ PI- PI+ PI- (VIOLATES G)                140+ 140+ 140+ 140
P16    PHI INTO RHO PI                                      769+ 140
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FITTED PARTIAL DECAY MODE BRANCHING FRACTIONS

The matrix below is derived from the error matrix for the fitted partial decay mode branching fractions, P_i, as follows: The diagonal elements are $P_i \pm \delta P_i$, where $\delta P_i = \sqrt{\langle \delta P_i \delta P_i \rangle}$, while the off-diagonal elements are the normalized correlation coefficients $\langle \delta P_i \delta P_j \rangle / (\delta P_i \cdot \delta P_j)$. For the definitions of the individual P_i, see the listings above; only those P_i appearing in the matrix are assumed in the fit to be nonzero and are thus constrained to add to 1.

```
        P 1         P 2          P 3          P 4
P 1 .4928+-.0102
P 2   -.7182   .3475+-.0099
P 3   -.3905     -.3328   .1479+-.0073
P 4   -.1109     -.0800     -.0117   .0117+-.0020
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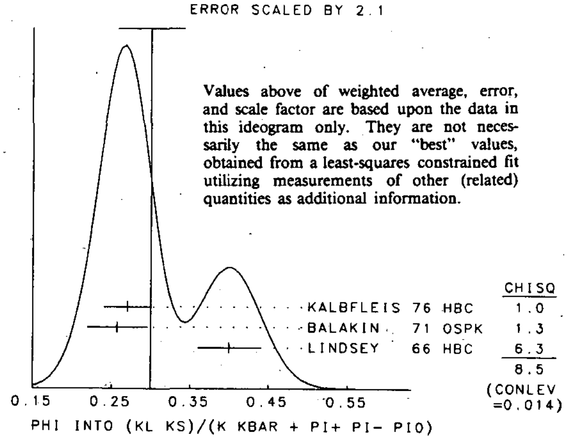
4 PHI BRANCHING RATIOS

```
R1      PHI INTO (K+ K-)/(K KBAR + PI+ PI- PIO)             (P1)/(P1+P2+P3)
R1      252    0.48     0.04        LINDSEY   66 HBC       2.7 K-P          10/66
R1             0.540    0.034       BALAKIN   71 OSPK    E+ E- COLL.BEAM  11/71
R1             0.486    0.044       CHATELUS  71 OSPK   E+ E- COLL.BEAMS  11/71
R1      270    0.49     0.06        DE GROOT  74 HBC    4.2 K-P,L PHI     12/75
R1      321    0.45     0.05        KALBFLEIS 76 HBC    2.18 K-P           7/77
R1             . . . . . . . . . .
R1   AVG       0.497    0.019   AVERAGE
R1   FIT       0.499    0.010  FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.3)

R2      PHI INTO (KL KS)/(K KBAR + PI+ PI- PIO)             (P2)/(P1+P2+P3)
R2      167    0.40     0.04        LINDSEY   66 HBC       2.7 K-P          10/66
R2             0.257    0.038       BALAKIN   71 OSPK   E+ E- COLL.BEAMS   1/73
R2      133    0.27     0.03        KALBFLEIS 76 HBC    2.18 K-P           7/77
R2   A  270   (0.37)   (0.05)       DE GROOT  74 HBC    4.2 K-P,L PHI     12/77
R2   A   SUPERSEDED BY LOSTY 78 UNDER R19.
R2             . . . . . . . . . .
R2   AVG       0.300    0.042   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 2.1)
R2   FIT       0.352    0.010  FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.3)
                               (SEE IDEOGRAM BELOW)
```

WEIGHTED AVERAGE = 0.300 ± 0.042
ERROR SCALED BY 2.1



Values above of weighted average, error, and scale factor are based upon the data in this ideogram only. They are not necessarily the same as our "best" values, obtained from a least-squares constrained fit utilizing measurements of other (related) quantities as additional information.

```
R3      PHI INTO (PI+ PI- PIO (INCL.RHO PI))/TOTAL      (P3)
R3 E          0.139    0.007          PARROUR2  76 OSPK    E+E- COLL.BEAMS    7/77
R3 E    USING TOTAL WIDTH 4.1 MEV. THE 3 PI MODE IS MORE THAN 80 PER CENT
R3 E    RHO PI AT THE 90 PER CENT C.L.
R3            . . . . . . . . . .
R3   FIT      0.1479   0.0073 FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.2)

R5      PHI INTO (KL KS)/(K KBAR)                          (P2)/(P1+P2)
R5       10   0.40     0.10           SCHLEIN   63 HBC       2.0 K-P          10/66
R5       52   0.48     0.07           BADIER    65 HBC       3.0 K-P          11/67
R5            0.44     0.07           LONDON    66 HBC       2.2 K-P          10/66
R5            . . . . . . . . . .
R5   AVG      0.448    0.044   AVERAGE
R5   FIT      0.414    0.011  FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.3)

R6      PHI INTO (PI+ PI- PIO (INCL.RHO PI))/(K KBAR)    (P3)/(P1+P2)
R6            0.30     0.15           LONDON    66 HBC       2.2 K-P          10/66
R6            0.237    0.039          CERRADA   77 HBC     4.2 K-P,LAM 3PI   12/77
R6            . . . . . . . . . .
R6   AVG      0.241    0.038   AVERAGE
R6   FIT      0.176    0.010  FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.2)
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R7      PHI INTO (PI+ PI- PIO (INCL.RHO PI))/(KL KS)     (P3)/(P2)
R7            0.47     0.06          COSME 1   74 OSPK    E+E- COLL.BEAMS    2/74
R7            0.56     0.13          BUKIN 1   78 OLYA    E+ E- COLL.BEAMS   9/81
R7            . . . . . . . . . .
R7   AVG      0.486    0.054   AVERAGE
R7   FIT      0.426    0.028  FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.3)

R10     PHI INTO (MU+ MU-)/TOTAL (UNITS 10**-4)           (P6)
R10           2.34     1.01          MOY       69 CNTR     PHOTOPROD.       11/70
R10           2.17     0.60          EARLES    70 CNTR     6.0 BREMSSTR.    11/70
R10           2.69     0.46          HAYES     71 CNTR    PHOTOPROD.        11/71
R10           . . . . . . . . . .
R10 AVG       2.48     0.34    AVERAGE

R11     PHI INTO (ETA GAMMA)/TOTAL                        (P4)
R11A     25   0.026    0.007         BENAKSAS  72 OSPK     E+E- COLL.BEAMS   2/73
R11A     54   0.015    0.004         COSME     76 OSPK    E+E- COLL.BEAMS   12/75
R11B         (0.024)OR LESS  CL=0.95 COSME     76 OSPK    E+E- COLL.BEAMS    7/77
R11           0.0135   0.0029        ANDREWS   77 CNTR    6.7-10 GAMMA CU  12/77
R11     290   0.0088   0.0020        KURDADZE  83 OLYA     E+E-,3 GAMMA     1/84*
R11           . . . . . . . . . .
R11 AVG       0.0117   0.0023  AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.6)
R11 FIT       0.0117   0.0020 FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.4)

R11A    FROM 2 GAMMA   DECAY MODE OF ETA                                  7/77
R11B    FROM PI+PI-PIO DECAY MODE OF ETA                                  7/77

R12     PHI INTO (PI+ PI- GAMMA)/TOTAL                    (P9)
R12          (0.04) OR LESS          LINDSEY   65 HBC      2.7 K-P           2/74
R12          (0.007)OR LESS  CL=.90  COSME 1   74 OSPK    E+E- COLL.BEAMS    2/74
R12           (.06) OR LESS  CL=.90  KALBFLEI  75 HBC     2.2 K- P,GAMMA + 12/75

R14     PHI INTO (OMEGA GAMMA) / TOTAL                    (P10)
R14          (0.05) OR LESS          LINDSEY   66 HBC      2.7 K-P          10/66

R15     PHI INTO (RHO GAMMA) / TOTAL                      (P12)
R15          (0.02) OR LESS          LINDSEY   66 HBC      2.7 K-P          10/66

R16     PHI INTO (E+ E-)/TOTAL (UNITS 10**-4)             (P5)
R16           2.81     0.25          BALAKIN   71 OSPK    E+ E- COLL.BEAMS 11/71
R16           3.50     0.27          CHATELUS  71 OSPK    E+ E- COLL.BEAMS 11/71
R16           3.3      0.3           COSME 1   74 OSPK    E+ E- COLL.BEAMS  2/74
R16  E        3.10     0.14          PARROUR1  76 OSPK    E+ E- COLL.BEAMS  7/77
R16           3.00     0.21          BUKIN 1   78 OLYA    E+ E- COLL.BEAMS  9/81
R16           . . . . . . . . . .
R16 AVG       3.107    0.096   AVERAGE

R16  E    USING TOTAL WIDTH 4.2 MEV. THEY DETECT 3 PI MODE AND OBSERVE
R16  E    SIGNIFICANT INTERFERENCE WITH OMEGA TAIL. THIS IS ACCOUNTED FOR
R16  E    IN THE RESULT QUOTED ABOVE

R17     PHI INTO (PIO GAMMA)/(TOTAL)                      (P7)
R17       7  (0.0025) (0.0012)       BENAKSAS  72 OSPK    E+E- COLL. BEAMS  2/73
R17      32   0.0014   0.0005        COSME     76 OSPK    E+ E- COLL.BEAMS 12/77

R18     PHI INTO (PI+ PI-)/(TOTAL) (UNITS 10**-4)         (P8)
R18          (2.7)  OR LESS  CL=.95  ALVENSLE  72 OSPK    GAMMA+C           1/72
R18          (4.0)  OR LESS  CL=.95  JULLIAN   76 OSPK    E+ E- COLL.BEAMS  9/81
R18          (6.6)  OR LESS  CL=.95  BUKIN 2   78 OLYA    E+ E- COLL.BEAMS  9/81
R18A          1.94     1.03    0.81  VASSERMAN 81 OLYA    E+ E- COLL.BEAMS  9/81
R18A    USING PHI INTO (E+ E-)/TOTAL = 3.1

R19     PHI INTO (KL KS)/(K+ K-)                          (P2)/(P1)
R19     144   0.89     0.10          AGUILAR   72 HBC     3.9,4.6 K- P     12/72
R19     125  (1.15)   (0.15)         COLLEY    72 HBC     10.K+ P,K+ P PHI 12/72
R19           0.71     0.05          LAVEN     77 HBC     10 K-P,K+K-LAMBD 12/77
R19           0.71     0.08          LYONS     77 HBC     3-4 K-P,LAMB PHI 12/77
R19           0.70     0.05          BUKIN 1   78 OLYA    E+ E- COLL.BEAMS  9/81
R19           0.82     0.08          LOSTY     78 HBC     4.2 K-P,PHI HYP   4/78
R19           . . . . . . . . . .
R19 AVG       0.736    0.030   AVERAGE
R19 FIT       0.705    0.032  FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.3)

R20     PHI INTO (PI+ PI- PIO(INCL.RHO PI)/(K+ K-)        (P3)/(P1)
R20      34   0.28     0.09          AGUILAR   72 HBC     3.9,4.6 K- P     12/72
R20           . . . . . . . . . .
R20 FIT       0.300    0.018  FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.2)

R21     PHI INTO (2PI+ 2PI- PIO)/(K+ K-)                  (P14)/(P1)
R21          (0.02) OR LESS  CL=0.95 AGUILAR   72 HBC     3.9,4.6 K- P     12/72

R22     PHI INTO (PI+ PI- PI+ PI-)/TOTAL (UNITS 10**-4)  (P15)
R22          (8.7)  OR LESS  CL=.90  CORDIER   79 WIRE    E+ E-,4PI        12/79

R23     PHI INTO (RHO PI)/(PI+ PI- PIO)                   (P16)/(P3)
R23          (0.8)  OR MORE  CL=.90  JULLIAN   76 OSPK    E+ E- COLL.BEAM

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REFERENCES FOR PHI


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BERTANZA 62 PRL 9 180            BERTANZA,BRISSON,CONNOLLY,HART + (BNL+SYRA)

ARMENTER 63 SIENA CONF 2 70      ARMENTEROS,EDWARDS,ASTIER+       (CERN+CDEF)
GELFAND  63 PRL 11 438           GELFAND,MILLER,NUSSBAUM,KIRSCH+ (COLU+RUTG)
SCHLEIN  63 PRL 10 368           SCHLEIN,SLATER,SMITH,STORK,TICHO      (UCLA)

BADIER   65 PL 17 337            BADIER,DEMOULIN,BARLOUTAUD+      (SACL+AMST)
BERLEY   65 PR 139 B 1097        D BERLEY,N GELFAND             (BNL+COLUMBIA)
GALTIERI 65 PRL 14 279           A BARBARO GALTIERI,R D TRIPP            (LRL)
LINDSEY  65 PRL 15 221           JAMES S LINDSEY,GERALD A SMITH          (LRL)
   LINDSEY 65 DATA INCLUDED IN LINDSEY 66 BELOW
MILLER D 65 CU-237(NEVIS 131) DAVID C MILLER  (THESIS)             (COLUMBIA)

GRAY, L  66 PRL  17 501          +HAGERTY,BIZZARRI,CIAPETTI +   (SYRA+ROMA)JPG
LINDSEY  66 PR  147  913         JAMES S LINDSEY, GERALD A SMITH         (LRL)
LINDSEY1 66 PL 20 93             J.S.LINDSEY, G.A.SMITH                  (LRL)
LONDON   66 PR 143 1034          LONDON,RAU,SAMIOS,GOLDBERG + (BNL+SYRACUSE)

ABRAMS   67 MD TECH REP 720      GERALD ABRAMS , THESIS             (MARYLAND)
BARLOW   67 NC 50A 701           +LILLESTOL+MONTANET+  (CERN+CDEF+IRAD+LIVP)
CHASE    67 PRL 18 710           R.C.CHASE,P.ROTHWELL,R.WEINSTEIN (CEA+NEAS)
DAHL     67 PR 163 1377          +HARDY+HESS+KIRZ+MILLER                 (LRL)
HERTZBAC 67 PR 155  1461         HERTZBACH,KRAEMER,MADANSKI,ZDANIS+(JHU+BNL)
KHACHATU 67 PL 24B 349           KHACHATURYAN+AZIMOV+BALDIN+BELOUSOV+(DUBNA)

ABRAMS   68 PR 175 1697          +GLASSER,KEHOE,SECHI-ZORN,WOLSKY (MARYLAND)
ASTVACAT 68 PL 27 B  45          ASTVACATUROV,AZIMOV,BALDIN+   (JINR+MOSCOW)
    ALSO 67 PRL 19 869           ASBURY,BECKER,BERTRAM,TING+ (DESY+COLUMBIA)
BECKER   68 PRL 21 1504          +BERTRAM,BINKLEY,JORDAN,KNASEL+  (DESY+MIT)
BINNIE   68 PL 27B 106           +DUANE+FARUQI+HORSEY+             (LOIC+RHEL)
BOLLINI  68 NC 56 A 1171         +BUHLER,DALPIAZ,MASSAM+     (CERN+BGNA+STRB)
MOSTEK   68 PRL 20 1057          +EISENHANDLER,MCCLELLAN,MISTRY+   (CORNELL)
WEHMANN  68 PRL 20 748           +ENGELS+ (HARVARD+CASE+SLAC+CORNELL+MCGILL)
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Mesons

Data Card Listings

ϕ(1020), H(1190), B(1235)

AUGUSTIN 69 PL 28 B 517 +BIZOT,BUON,DELCOURT,HAISSINSKI,+ (ORSAY)
MOY 69 THESIS KEN MIN MOY (NORTHEASTERN UNIVERSITY)
SCOTTER 69 NC 62 A 1057 +ERSKINE,PALER,+ (BIRM+GLAS+LOIC+MPIM+OXF)

BIZOT 70 PL 32 416 +BUON,CHATELUS,JEANJEAN,LALANNE,+ (ORSA)
ALSO 69 PEREZ-Y-JORBA, LIVERPOOL SYMP.69
BIZOT2 70 LNC 4 1273 +DELCOURT,JEANJEAN,LALANNE,+ (ORSAY)
EARLES 70 PRL 25 1312 +FAISSLER,GETTNER,LUTZ,MOY,TANG,+ (NEAS)
HYAMS 70 NP B 22 189 +KOCH,POTTER,V.LINDERN,LORENZ,LUTJENS(CERN)

ALVENSLE 71 PRL 27 441 ALVENSLEBEN,BECKER,BUSZA,CHEN,+ (MIT+DESY)
BALAKIN 71 PL 34 B 328 +BUDKER,PAKHTUSOVA,SIDOROV,SKRINSKY,+(NOVO)
CHATELUS 71 LAL 1247(THESIS) Y.CHATELUS (STRASBOURG)
ALSO 70 BIZOT
DIBIANCA 71 NP B 35 13 +EINSCHLAG,ENDORF,ENGLER,FISK,+ (CORN)
HAYES 71 PR D 4 899 +IMLAY,JOSEPH,KEIZER,STEIN (CORN)
STOTTLEM 71 ORO 2504 170 A.R.STOTTLEMYER,THESIS (MARYLAND)

AGUILAR 72 PR D 6 29 AGUILAR-BENITEZ,CHUNG,EISNER,SAMIOS (BNL)
ALVENSLE 72 PRL 28 66 ALVENSLEBEN,BECKER,BIGGS,BINKLEY+(MIT+DESY)
BALAKIN 72 PL 40 B 431 +BOKIN,PAKHTUSOVA,SIDOROV,+ (NOVOSIBIRSK)
BASILE 72 NP B 44 605 +DALPIAZ,FRABETTI,ZICHICHI+(CERN+BGNA+STRB)
BENAKSAS 72 PL 42 B 511 +COSME,JEAN-MARIE,JULLIAN,LAPLANCHE+(ORSAY)
BORENSTE 72 PR D 5 1559 BORENSTEIN,DANBURG,KALBFLEISCH,+ (BNL+MICH)
COLLEY 72 NP B 50 1 +JOBES,RIDDIFORD,GRIFFITHS,+ (BIRM+GLAS)

BALLAM 73 PR D 7 3150 +CHADWICK,EISENBERG,BINGHAM,+ (SLAC+LBL)
BINNIE 73 PR D 8 2789 +CARR,DEBENHAM,DUANE,GARBUTT,+ (LOIC+SHMP)

AYRES 74 PRL 32 1463 +DIEBOLD,GREENE,KRAMER,LEVINE,+ (ANL)
BESCH 74 NP B70 257 +HARTMANN,KOSE,KRAUTSCHNEIDER,PAUL,+ (BONN)
BIZZARRI 74 NC 20A 393 +CIAPETTI,DIONISI,DORE,GASPERO+ (ROMA)
COSME 1 74 PL 48 B 155 +JEAN-MARIE,JULLIAN,LAPLANCHE,+ (ORSAY)
COSME 2 74 PL 48 B 159 +JEAN-MARIE,JULLIAN,LAPLANCHE,+ (ORSAY)
DE GROOT 74 NP B74 77 +HOOGLAND,JONGEJANS,METZGER+ (AMST+NIJM)

KALBFLEI 75 PR D11 987 KALBFLEISCH,STRAND,CHAPMAN (BNL+MICH)

COSME 76 PL 63 B 352 +COURAU,DUDELZAK,GRELAUD,JEAN-MARIE+(ORSAY)
JULLIAN 76 TBLISI VOL.2 R19 S.JULLIAN (ORSAY)
KALBFLEI 76 PR D 13 22 KALBFLEISCH,STRAND,CHAPMAN (BNL+MICH)
PARROUR1 76 PL 63 B 357 +GRELAUD,COSME,COURAU,DUDELZAK,+ (ORSAY)
PARROUR2 76 PL 63 B 362 +GRELAUD,COSME,COURAU,DUDELZAK,+ (ORSAY)

AKERLOF 77 PRL 39 861 +ALLEY,BINTINGER,DITZLER,+ (FNAL+MICH+PURD)
ANDREWS 77 PRL 38 198 +FUKUSHIMA,HARVEY,LOBKOWICZ,MAY,+ (ROCH)
BALDI 77 PL 68 B 381 +BOHRINGER,DORSAZ,HUNGERBUHLER,+ (GENEVA)
CERRADA 77 NP B 126 241 +BLOCKZIJL,HEINEN,+ (AMST+CERN+NIJM+OXF)
COHEN 77 PRL 38 269 +AYRES,DIEBOLD,KRAMER,PAWLICKI,WICKLUND(ANL)
COURANT 77 PR D 16 1 +MAKDISI,MARSHAK,PETERSON,RUDDICK,+ (MINN)
EVANGEL 77 NP B 127 384 EVANGELISTA,+ (BARI+BONN+CERN+DARE+GLAS+)
LAVEN 77 NP B 127 43 +OTTER,KLEIN,+ (AACH+BERL+CERN+LOIC+WIEN)
LYONS 77 NP B 125 207 +COOPER,CLARK (OXF)

BARTALUC 78 NC 44 A 587 BARTALUCCI,BASINI,BERTOLUCCI+ (DESY+FRAS)
BUKIN 1 78 SJNP 27 516 +KURDADZE,SEREDNYAKOV,SIDOROV+ (NOVO)
BUKIN 2 78 SJNP 27 521 +KURDADZE,SIDOROV,SKRINSKII+ (NOVO)
COOPER 78 NP B 146 1 +GURTU,MONTANET,+ (TIFR+CERN+CDEF+MADR)
LOSTY 78 NP B 133 38 +HOLMGREN,BLOKZIJL,+ (CERN+AMST+NIJM+OXF)

BARKOV 79 IYAF 79-93 +ZOLOTOREV,MAKARINA,MISHAKOVA,+ (NOVO)
CORDIER 79 PL B 81 389 +DELCOURT,ESCHSTRUTH,FULDA,+ (LALO)

CORDIER 80 NP B172 13 +DELCOURT,ESCHSTRUTH,FULDA+ (ORSAY)
ROOS 80 LNC 27 321 +PELLINEN (HELS)

DAUM 81 PL 100 B 439 +BARDSLEY+ (AMST+BRIS+CERN+CRAC+MPIM+RHEL)
IVANOV 81 PL 107 B 297 +KURDADZE,LELCHUK,SIDOROV,SKRINSKY,+ (NOVO)
ALSO 82 PRIVATE COMM. S.I.EIDELMAN (NOVO)
VASSERMA 81 PL 99 B 62 VASSERMAN,KURDADZE,SIDOROV,SKRINSKY+ (NOVO)

ARENTON 82 PR D 25 2241 +AYRES,DIEBOLD,MAY,SWALLOW+ (ANL+ILL)
PELLINEN 82 PS 25 599 A.PELLINEN, M.ROOS (HELS)

ARMSTRON 83 NP B 224 193 ARMSTRONG+ (BARI+BIRM+CERN+MILA+LPNP+PAVI)
BARATE 83 PL 121 B 449 +BAREYRE,ASTBURY,MCEWEN(SACL+LOIC+SHMP+IND)
KURDADZE 83 JETPL 38 306 +LELCHUK,ROOT+ (NOVO)

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H(1190)

30 H(1190,JPG=1+-) I=0

30 H(1190) MASS (MEV)

M	C	1190.	60.	DANKOWYCH 81 SPEC		08 PI P,3 PI N	6/81
M	T	(1175.0)	APPROX	TORNQVIST 82 RVUE			9/83*

M C USES THE MODEL OF BOWLER 75
M T FROM A UNITARIZED QUARK MODEL CALCULATION

30 H(1190) WIDTH (MEV)

W	C	320.	50.	DANKOWYCH 81 SPEC		08 PI P,3 PI N	6/81
W	T	(365.0)	APPROX	TORNQVIST 82 RVUE			9/83*

W C USES THE MODEL OF BOWLER 75
W T FROM A UNITARIZED QUARK MODEL CALCULATION

30 H(1190) PARTIAL DECAY MODES

		DECAY MASSES
P1	H(1190) INTO RHO PI	769+ 135

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REFERENCES FOR H(1190)

BOWLER 75 NP B97 227 +GAME,ATTCHISON,DAINTON (OXF+DARE)

DANKOWYC 81 PRL 46 580 +BROCKMAN,EDWARDS+(TNTO+BNL+CARL+MCGI+OHIO)

TORNQVIS 82 NP B 203 268 TORNQVIST (HELS)

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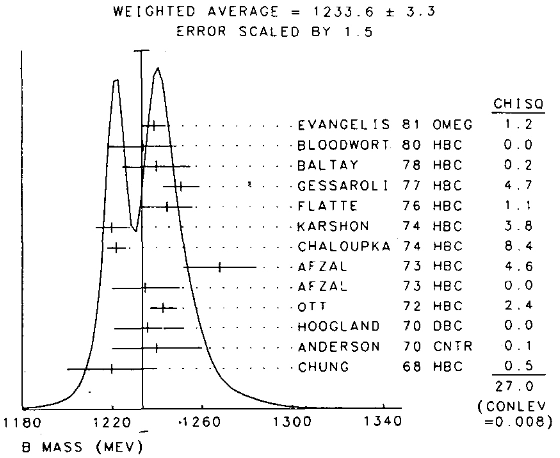
B(1235)

11 B(1235,JPG=1++) I=1

11 B MASS (MEV)

M	W		(1228.)	(5.)	FRENKIEL	72 HBC	+-	0. PBAR PI,5 PI	12/72
M		360	(1208.0)	(18.0)	GAVILLET	78 HBC	+	4.2 K-P,BACKWARD	4/78
M	T		(1243.0)	APPROX	TORNQVIST	82 RVUE			9/83*
M			1220.	20.	CHUNG	68 HBC	-	3.2,4.2 PI- P	9/67
M			1240.0	20.0	ANDERSON	70 CNTR	0	5-18 GAMMA P	11/70
M			1236.0	15.0	HOOGLAND	70 DBC	-	3.0 K- D	2/71
M	O	1163	1243.	6.	OTT	72 HBC	+	7.1 PI+ P,P B+	2/73
M			1235.	15.	AFZAL	73 HBC	+	11.7 PI+ P	2/73
M			1268.	16.	AFZAL	73 HBC	-	11.2 PI- P	2/73
M		1400	1222.	4.	CHALOUPKA	74 HBC	-	3.9 PI-P,P B-	12/75
M		600	1220.	7.	KARSHON	74 HBC	+	4.9 PI+P,P B+	12/75
M		890	1245.0	11.0	FLATTE	76 HBC	-	4.2 K-P,PI-OMEGA	7/77
M		450	1251.0	8.0	GESSAROLI	77 HBC	-	11 PI-P,PI- OME	12/77
M		225	1240.0	15.0	BALTAY	78 HBC	+	15 PI+P,P 4PI	4/78
M		105	1234.0	15.0	BLOODWORT	80 HBC	-	8.2 K- P,Y*+ B-	12/79
M			1239.	5.	EVANGELIS	81 OMEG	-	12 PI-P,OME PI P	1/82
M	AVG		1233.6	3.3	AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.5) (SEE IDEOGRAM BELOW)				

M O FROM FIT OF THE MASS SPECTRUM
M W FIT REQUIRES AN ADDITIONAL JP=1- RESONANCE
M W AT 1256 MEV, WIDTH 129 MEV.
M T FROM A UNITARIZED QUARK MODEL CALCULATION



11 B WIDTH (MEV)

W	W		(126.)	(10.)		FRENKIEL	72 HBC	+-	0. PBAR PI,5 PI	12/72
W		360	(163.0)	(50.8)		GAVILLET	78 HBC	+	4.2 K-P,BACKWARD	4/78
W	T		(118.0)	APPROX		TORNQVIST	82 RVUE			9/83*
W			150.	20.		CHUNG	68 HBC	-	3.2,4.2 PI- P	9/67
W			132.0	20.0		HOOGLAND	70 DBC	-	3.0 K- D	2/71
W	O	1163	134.	23.	26.	OTT	72 HBC	+	7.1 PI+ P,P B+	2/73
W			120.	50.		AFZAL	73 HBC	+	11.7 PI+ P	2/73
W			130.	50.		AFZAL	73 HBC	-	11.2 PI- P	2/73
W		1400	135.	20.		CHALOUPKA	74 HBC	-	3.9 PI-P,P B-	12/75
W		600	156.	22.		KARSHON	74 HBC	+	4.9 PI+P,P B+	12/75
W		890	182.0	45.0		FLATTE	76 HBC	-	4.2 K-P,PI-OMEGA	7/77
W		450	155.0	32.0		GESSAROLI	77 HBC	-	11 PI-P,PI- OME	12/77
W		225	170.0	50.0		BALTAY	78 HBC	+	15 PI+P,P 4PI	4/78
W		105	150.0	50.0		BLOODWORT	80 HBC	-	8.2 K- P,Y*+ B-	12/79
W			170.	15.		EVANGELIS	81 OMEG	-	12 PI-P,OME PI P	1/82
W	AVG		150.0	7.3		AVERAGE				

W O FROM FIT OF THE MASS SPECTRUM
W W SEE NOTE UNDER THE MASS ABOVE.
W T FROM A UNITARIZED QUARK MODEL CALCULATION

11 B PARTIAL DECAY MODES

		DECAY MASSES
P1	B INTO OMEGA+PI	783+ 140
P2	B INTO 2PI+ 2PI-	140+ 140+ 140+ 140
P3	B INTO K KBAR	494+ 494
P4	B INTO PI PI	140+ 140
P5	B INTO PI PHI	135+1020
P6	B INTO ETA PI (FORBIDDEN BY G)	549+ 140
P7	B INTO K KBAR PI	494+ 494+ 140

11 B BRANCHING RATIOS

R10 D/S RATIO FOR B(1235) INTO OMEGA PI

R10		0.3	0.1		CHALOUPKA	74 HBC	-	3.9-7.5 PI-P	1/74
R10	600	0.35	0.25		KARSHON	74 HBC	+	4.9 PI+P,P B+	12/75
R10		0.21	0.08		CHUNG	75 HBC	+	7.1 PI+P	12/75
R10		0.4	0.1	0.1	GESSAROLI	77 HBC	-	11 PI-P,PI- OME	12/77
R10 AVG		0.291	0.052		AVERAGE				

For notation, see key at front of Listings.

Mesons
B(1235), $g_S(1240)$, $\rho(1250)$, f(1270)

R1	B INTO (4PI)/(OMEGA PI)				(P2)/(P1)	
R1	(0.5) OR LESS		ABOLINS	63 HBC	+ 3.5 PI+P	
R2	B INTO (K KBAR)/(OMEGA PI)				(P3)/(P1)	
R2	(0.02) OR LESS		DAHL	67 HBC	- 1.6-4.2 PI- P	10/66
R2	(0.10) OR LESS	CL=.90	BALTAY	67 HBC	+- 0.0 PBAR P	2/67
R2	(0.08) OR LESS	CL=.95	BIZZARRI	69 HBC	+- 0 PBAR P	9/69
R3	B INTO (PI PI)/(PI OMEGA)				(P4)/(P1)	
R3	(0.3) OR LESS		ADERHOLZ	64 HBC	4.0 PI+P	7/66
R3	(0.15) OR LESS	CL=.90	OTT	72 HBC	+ 7.1 PI+ P	12/72
R4	B INTO (PI PHI) / (PI OMEGA)				(P5)/(P1)	
R4	(0.015)OR LESS		DAHL	67 HBC	1.6-4.2 PI- P	10/66
R4	(0.04) OR LESS	CL=.95	BIZZARRI	69 HBC	+- 0 PBAR P	9/69
R5	B INTO (ETA PI) / (PI OMEGA)				(P6)/(P1)	
R5	(0.25) OR LESS	CL=.90	BALTAY	67 HBC	+- 0.0 PBAR P	2/67
R6	B+- INTO ((K KBAR)+- PI0) / (PI OMEGA)					
R6	(0.08) OR LESS	CL=.90	BALTAY	67 HBC	+- 0.0 PBAR P	2/67
R7	B+- INTO (KS KS PI+-) / (PI OMEGA)					
R7	(0.02) OR LESS	CL=.90	BALTAY	67 HBC	+- 0.0 PBA- P	2/67
R8	B+- INTO (KS KL PI+-) / (PI OMEGA)					
R8	(0.06) OR LESS	CL=.90	BALTAY	67 HBC	+- 0.0 PBAR P	2/67

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REFERENCES FOR B

ABOLINS 63 PRL 11 381 — ABOLINS,LANDER,MEHLHOP,XUONG,YAGER (UCSD)
BONDAR 63 PL 5 209 — BONDAR,DODD+ (AACHEN+BIRM+HAMB+LOIC+MPIM)

ADERHOLZ 64 PL 10 240 — AACHEN+BERLIN+BIRM + BONN+HAMBUR+LOIC+MPIM
CARMONY 64 PRL 12 254 — CARMONY,LANDER,RINDFLEISCH,XUONG,YAGER(UCB) JP

GOLDHABE 65 PRL 15 118 — G GOLDHABER,S GOLDHABER,KADYK,SHEN (LRL)

BALTAY 67 PRL 18 93 — +SEVERIENS+YEH+ZANELLO (COLU+BNL)
DAHL 67 PR 163 1377 — +HARDY+HESS+KIRZ+MILLER (LRL)
LEE 67 PR 159 1156 — +MOEBS,ROE,SINCLAIR,VANDERVELDE (MICH)
SLATTERY 67 NC 50A 377 — +KRAYBILL+FORMAN+FERBEL (YALE+ROCH)

ASCOLI 68 PRL 20 1411 — +CRAWLEY,MORTARA,SHAPIRO (ILL) JP
BOESEBEC 68 NP B 4 501 — BOESEBECK,DEUTSCHMANN,+(AACHEN+BERLIN+CERN)
CASO 68 NC 54 A 983 — +CONTE+CORDS+DIAZ+ (GENOVA+HAMB+MILA+SACL)
CHUNG 68 PR 165 1491 — S.U.CHUNG,O.DAHL,J.KIRZ,D.H.MILLER (LRL)

BIZZARRI 69 NP B 14 169 — +FOSTER,GAVILLET,MONTANET,+ (CERN+CDEF)

ANDERSON 70 PR D 1 27 — +GUSTAVSON,JOHNSON,+ (SLAC+CIT+UCSB+NEAS)
CASO 70 LNC 3 707 — +CONTE,TOMASINI,CORDS+(GENO+HAMB+MILA+SACL)
CASON 70 PR D 1 851 — +ANDREWS,BISWAS,GROVES,HARRINGTON,+ (NDAM)
EROFEEV 70 SJNP 11 450 — +VETLITSKY,WLADIMIRSKY,GRIGOREV,+ (ITEP)
HONES 70 PR D 2 827 — +CASON,BISWAS,HELLAND,KENNEY,MCGAHAN+(NDAM)
HOOGLAND 70 PL 33 B 631 — SABRE COLLABOR. (AMST+SACL+BGNA+REHO+EPOL)
MIYASHIT 70 PR D 1 771 — MIYASHITA,VON KROGH,KOPELMAN,LIBBY (COLO)
POLS 70 NP B 25 109 — +BOECKMANN,CIRBA,+ (BONN+DURH+EPOL+TORI)
WERBROUC 70 LNC 4 1267 — WERBROUCK,RINAUDO,+ (TORI+NIJM+BONN+LBL)JP

DEVONS 71 PRL 27 1614 — +KOZLOWSKI,HORWITZ,+ (COLU+SYRA)

FRENKIEL 72 NP B 47 61 — +GHESQUIERE,LILLESTOL,CHUNG,+ (CDEF+CERN)JP
OTT 72 LBL-1547 — R.L.OTT THESIS (LBL)JP
SISTERSO 72 NP B 48 493 — SISTERSON,HARRISON,HEYDA,JOHNSON,+(HARVARD)

AFZAL 73 NCL 15 A 61 — +BASSLER,+ (DURH+GENO+DESY+MILA+SACL) JP
ARMENISE 73 NC 17 A 707 — +FORINO,CARTACCI,+ (BARI+BGNA+FIRZ)
ARMENISE 73 LNC 8 425 — +FORINO,CARTACCI,+ (BARI+BGNA+FIRZ)
ARNOLD 73 LNC 6 707 — +ENGEL,ESCOUBES,KURTZ,LLORET,PATY,+ (STRB)
CASON 73 PR D 7 1971 — +BISWAS,KENNEY,MADDEN,SANDER,SHEPHARD(NDAM)
CASON 1 73 NP B 64 14 — +MADDEN,BISHOP,BISWAS,KENNEY,+ (NDAM)
CHUNG 73 PL 47 B 526 — +PROTOPOPESCU,LYNCH,FLATTE,+ (BNL+LBL+UCSC) JP
COHEN 73 PR D 8 23 — +FERBEL,SLATTERY (ROCHESTER)

BALLAM 74 NP B76 375 — +CHADWICK,BINGHAM,FRETTER+ (SLAC+LBL+MPIM)
CHALOUPK 74 PL 51B 407 — CHALOUPKA,FERRANDO,LOSTY,MONTANET (CERN) JP
KARSHON 74 PR D10 3608 — +MIKENBERG,EISENBERG,PITLUCK,RONAT+ (REHO) JP

CHUNG 75 PR D11 2426 — +PROTOPOPESCU,LYNCH,FLATTE,+ (BNL+LBL+UCSC) JP
DUBOVIKO 75 SJNP 20 229 — M.S.DUBOVIKOV,I.A.EROFEEV (ITEP) JP

FLATTE 76 PL 64 B 225 — +GAY,BLOKZIJL,METZGER,+(CERN+AMST+NIJM+OXF) JP

GESSAROL 77 NP B 126 382 — GESSAROLI,+ (BGNA+FIRZ+GENO+MILA+OXF+PAVI) JP

BALTAY 78 PR D 17 62 — +CAUTIS,COHEN,CSORNA,SMITH,YEH,+(COLU+BING)
GAVILLET 78 PL 78 B 158 — +DIONISI,GURTU,+ (CERN+AMST,NIJM+OXF) JP

BLOODWOR 80 LNC 27 555 — BLOODWORTH,+ (BIRM+CERN+GLAS+MSU+LPNP)

EVANGELI 81 NP B 178 197 — EVANGELISTA+(BARI+BONN+CERN+DARE+LIVP+MILA)
WONG 81 PRL 46 974 — +KEY,FRISKEN,CLINE,DEBONTE+(TNTO+YORK+PURD)

TORNQVIS 82 NP B 203 268 — TORNQVIST (HELS)

ATKINSON 83 CERN-EP/83-179 — + (BONN+CERN+GLAS+LANC+MCHS+LPNP+RHEL+SHEF)

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$g_S(1240)$ →

87 G/S(1240,JPG=0++) I=0

SEEN IN PHASE SHIFT ANALYSIS OF K0S K0S SYSTEM.
NAMED G/S BY ETKIN 82.
NEEDS CONFIRMATION. OMITTED FROM TABLE.

87 G/S(1240) MASS (MEV)

M	A	1240.0	30.0	ETKIN	82 MPS	0 23 PI-P,2K0S N	9/83*

M A FROM AN AMPLITUDE ANALYSIS OF THE K0S K0S SYSTEM. SYSTEMATIC
M A ERROR ADDED LINEARLY BY US.

87 G/S(1240) WIDTH (MEV)

W	A	140.0	30.0	ETKIN	82 MPS	0 23 PI-P,2K0S N	9/83*

W A FROM AN AMPLITUDE ANALYSIS OF THE K0S K0S SYSTEM. SYSTEMATIC
W A ERROR ADDED LINEARLY BY US.

87 G/S(1240) PARTIAL DECAY MODES

		DECAY MASSES
P1	G/S(1240) INTO K KBAR	498+ 498

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REFERENCES FOR G/S(1240)

BAUBILLI 83 ZPHY C 17 309 — BAUBILLIER+ (BIRM+CERN+GLAS+MSU+LPNP)
ETKIN 82 PR D 25 2446 — +FOLEY,LAI,LINDENBAUM+ (BNL+CUNY+TUFT+VAND) JP

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$\rho(1250)$ →

69 RHO(1250,JPG=1-+) I=1

FORMERLY CALLED RHO PRIME
EVIDENCE NOT COMPELLING. OMITTED FROM TABLE.
SEE ALSO THE RHO(1600) MINI-REVIEW.

69 RHO(1250) MASS (MEV)

M		1256.	10.	FRENKIEL	72 HBC	+- 0.PBARP,OMEGA PI	12/77
M		1266.0	5.0	BARTALUCC	79 DASP	07 GAM P,E+E- P	12/79
M	A	(1250.)		ASTON	80 OMEG	20-70G P,OME PI0	9/81
M	A	(1290.)	(40.)	BARBER	80 SPEC	3-5 G P,OMEG PI0	9/81
M	AVG	1264.0	4.5	AVERAGE			

M A NOT SEPARATED FROM B(1235),NOT PURE JP=1- EFFECT

69 RHO(1250) WIDTH (MEV)

W		130.	20.	FRENKIEL	72 HBC	+- 0.PBARP,OMEGA PI	12/77
W		110.0	35.0	BARTALUCC	79 DASP	07 GAM P,E+E- P	12/79
W	A	(300.)		ASTON	80 OMEG	20-70G P,OME PI0	9/81
W	A	(320.)	(100.)	BARBER	80 SPEC	3-5 G P,OMEG PI0	9/81
W	AVG	125.1	17.4	AVERAGE			

W A NOT SEPARATED FROM B(1235),NOT PURE JP=1- EFFECT

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REFERENCES FOR RHO(1250)

ANDERSON 70 PR D 1 27 — +GUSTAVSON,JOHNSON,+ (SLAC+CIT+UCSB+NEAS)

PODOLSKY 71 UCRL 20128 — W.J.PODOLSKY,PH.D. THESIS (LBL)

FRENKIEL 72 NP B 47 61 — +GHESQUIERE,LILLESTOL,CHUNG,+ (CDEF+CERN)JP
WOLF 72 ITHACA N.Y. CONF. — G.WOLF,P.213 (SLAC)

CHUNG 73 PL 47 B 526 — +PROTOPOPESCU,LYNCH,FLATTE,+ (BNL+LBL+UCSC)
BRAMON 73 LNC 8 659 — A.BRAMON (FRASCATI)

BALLAM 74 NP B76 375 — +CHADWICK,BINGHAM,FRETTER+ (SLAC+LBL+MPIM)
CHALOUPK 74 PL 51B 407 — CHALOUPKA,FERRANDO,LOSTY,MONTANET (CERN)
CONVERSI 74 PL 52B 493 — +PAOLUZI,CERADINI,GRILLI+ (ROMA+FRAS)
ESTABROO 74 NP B79 301 — P.ESTABROOKS,A.D.MARTIN (DURH)
KARSHON 74 PR D10 3608 — +MIKENBERG,EISENBERG,PITLUCK,RONAT+ (REHO) JP

ALLES 75 NC 30A 136 — ALLES-BORELLI,BERNARDINI+ (CERN+BGNA+FRAS)
CHUNG 75 PR D11 2426 — +PROTOPOPESCU,LYNCH,FLATTE,+ (BNL+LBL+UCSC)
ESTABROO 75 NP B95 322 — P.ESTABROOKS,A.D.MARTIN (DURH)
FROGGATT 75 NP B91 454 — C.D.FROGGATT,J.L.PETERSEN (GLAS+NORD)
HYAMS 75 NP B100 205 — +JONES,WEILHAMMER,BLUM,DIETL+ (CERN+MPIM)

BASSOMPI 76 PL 65 B 397 — BASSOMPIERRE,BINDER,+ (MULH+STRB+TORI)

BUDNEV 77 PL 70 B 365 — N.M.BUDNEV,V.M.BUDNEV,V.V.SEREBRYAKOV(NOVO)
COSTA 77 PL 67 B 213 — COSTA DE BEAUREGARD,PHAM,PIRE,TRUONG (EPOL)
GESSAROL 77 NP B 126 382 — GESSAROLI,+ (BGNA+FIRZ+GENO+MILA+OXF+PAVI)

BUKIN 78 PL 73 B 226 — +VASSERMAN,KOOP,KURDADZE,SIDOROV,+ (NOVO)

BACCI 79 PL B 86 234 — +DE ZORZI,PENSO,STELLA,+ (ROMA+BGNA+FRAS)
BARTALUC 79 NC 49 A 207 — BARTALUCCI,BASINI,BERTOLUCCI+ (DESY+FRAS)

ASTON 80 PL 92 B 211 — (BONN+CERN+EPOL+GLAS+LANC+MCHS+ORSA+PARIS+)
BARBER 80 ZPHY C 4 169 — +DAINTON,BRODBECK,BROOKES,+(DARE+LANC+SHEF)

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f(1270)

5 F(1270,JPG=2++) I=0

5 F MASS (MEV)

M			(1273.0)	(7.0)		ARMENISE	70 HBC	9 PI+ N -- MM P	1/71
M		600	(1275.0)	(10.0)		OH	70 HBC	1.26 PI- P,P F	1/71
M	E		(1273.0)	(6.0)		STUNTEBEC	70 HBC	8.PI-P,5.4 PI+D	11/71
M		2000	(1261.0)	(10.0)		JACOBS	72 HBC	2.8 PI- P	1/73
M	IH		(1269.)	(4.)		ESTABROOK	75 RVUE	17 PI-P,PI+PI-N	12/75
M	IG		(1275.)	(4.)		HYAMS	75 ASPK	17 PI-P,PI+PI-N	12/75
M	G		(1273.8)	(2.8)	(2.7)	BECKER	79 ASPK	17 PI- P POLARIZ	12/79
M			1276.	11.		RABIN	67 HBC	8.5 PI+ P	9/67
M	T	1960	1261.	5.		ARMENISE	68 DBC	5.1 PI+N,P PI+ -	1/73
M	T	360	1270.	10.		ARMENISE	68 DBC	5.1 PI+N,P PI0 0	1/73
M			1265.	8.		BOESEBECK	68 HBC	8 PI+ P	6/68
M	J		1268.0	6.0		JOHNSON	68 HBC	3.7-4.2 PI- P	7/69
M			1275.0	13.0		ARMENISE	70 HBC	9 PI+ N -- F P	1/71
M		5300	1277.0	4.0		FLATTE	71 HBC	7.0 PI+ P	6/71
M		600	1258.0	10.0		TAKAHASHI	72 HBC	8. PI- P,N 2PI	1/73
M		4600	1272.	4.		ENGLER	74 DBC	6. PI+N,PI+PI-P	12/75
M		16000	1284.0	10.0		DEUTSCHMA	76 HBC	16 PI+P	4/78
M			1282.0	5.0		CORDEN	79 OMEG	12-15PI-P, N 2PI	12/79
M			1281.0	7.0		GIDAL	81 SMK2	J/PSI DECAY	1/82
M			1280.0	4.0		CASON	82 STRC	8 PI+P,PI+2PI0 P	8/83*
M			1273.3	2.3		CHABAUD	83 ASPK	17 PI-P POLARIZ	12/83*
M	AVG		1273.8	1.6	AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.2)				

M G INCLUDED IN CHABAUD 83 ANALYSIS
M H USES SAME DATA AS HYAMS 75
M I ERROR TAKES ACCOUNT OF SPREAD OF DIFFERENT PHASE-SHIFT SOLUTIONS
M J JOHNSON 68 INCLUDES BONDAR 63, LEE 64, DERADO 65, EISNER 67.
M T MASS ERRORS ENLARGED BY US TO WIDTH/SQRT(N),SEE K*(892) TYPED NOTE

Mesons

Data Card Listings

f(1270)

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                          5  F WIDTH (MEV)
W          (131.0)   (25.0)              ARMENISE  70 HBC      9 PI+ N -- MM P  1/71
W  T   600 (120.0)   (20.0)              OH        70 HBC    1.26 PI- P,P F     2/74
W     2000 (130.0)   (25.0)              JACOBS    72 HBC     2.8 PI- P         1/73
W  IH      (209.)    (10.)               ESTABROOK 75 RVUE   17 PI-P,PI+PI-N   12/75
W  IG      (188.)    (4.)                HYAMS     75 ASPK    17 PI-P,PI+PI-N  12/75
W   G      (183.2)   (8.3)     (7.9)     BECKER    79 ASPK   17 PI- P POLARIZ  12/79

W           155.      17.                RABIN     67 HBC    8.5 PI+ P          9/67
W  T  1960  216.      20.                ARMENISE  68 DBC    5.1 PI+N,P PI+ -   1/73
W           128.      23.                BOESEBECK 68 HBC    8 PI+ P            6/68
W    J      176.0     13.0               JOHNSON   68 HBC     3.7-4.2 PI- P     7/69
W  T        173.0     25.0               ARMENISE  70 HBC     9 PI+ N -- F P    2/74
W           196.0     18.0               STUNTEBEC 70 HBC    8.PI-P,5.4 PI+D   11/71
W     5300  183.0     15.0               FLATTE    71 HBC    7.PI+P,DELTA++F    1/71
W  T   600  166.0     28.0               TAKAHASHI 72 HBC    8. PI- P,N 2PI     1/73
W     4600  192.      16.                ENGLER    74 DBC     6. PI+N,PI+P+-P  12/75
W    16000  225.0     38.0               DEUTSCHMA 76 HBC    16 PI+P            4/78
W  T   650  187.0     30.0               ANTIPOV   77 CIBS   25 PI-P,P 3PI      1/82
W           216.0     13.0               CORDEN    79 OMEG   12-15PI-P, N 2PI  12/79
W           186.0     27.0               GIDAL     81 SMK2   J/PSI DECAY        1/82
W           152.0      9.0               CASON     82 STRC   8 PI+P,PI+2PI0 P   8/83*
W           179.2      6.9       6.6     CHABAUD   83 ASPK   17 PI- P POLARIZ  12/83*
W
W   AVG     178.0      5.6      AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.5)
                     (SEE IDEOGRAM BELOW)

W   G   INCLUDED IN CHABAUD 83 ANALYSIS
W   H   USES SAME DATA AS HYAMS 75
W  I    ERROR TAKES ACCOUNT OF SPREAD OF DIFFERENT PHASE-SHIFT SOLUTIONS
W    J  JOHNSON 68 INCLUDES BONDAR 63, LEE 64, DERADO 65, EISNER 67.
W  T    WIDTH ERRORS ENLARGED BY US TO 4*WIDTH/SQRT(N),SEE K*(892) NOTE
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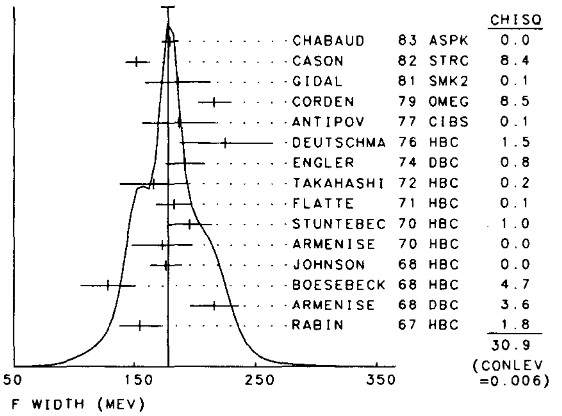
WEIGHTED AVERAGE = 178.0 ± 5.6

ERROR SCALED BY 1.5

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                          5  F PARTIAL DECAY MODES

                                                                  DECAY MASSES
P1      F INTO PI PI                                              140+ 140
P2      F INTO 2PI+ 2PI-                                          140+ 140+ 140+ 140
P3      F INTO PI+ PI- 2PI0                                       140+ 140+ 135+ 135
P4      F INTO K KBAR                                             498+ 498
P5      F INTO K KBAR PI                                          498+ 498+ 140
P6      F INTO ETA PI PI                                          549+ 140+ 140
P7      F INTO ETA ETA                                            549+ 549
P8      F INTO GAMMA GAMMA                                          0+   0
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                          5  F PARTIAL WIDTHS

W8      F INTO GAMMA GAMMA (KEV)                          (G8)                12/78
W8   A          2.3       0.8             BERGER    80 PLUT   E+ E-            9/81
W8 D            3.2       0.8             BRANDELIK 81 TASS   GAM GAM,2PI      1/82
W8 D            3.6       0.8             ROUSSARIE 81 SMK2   GAM GAM,2PI      1/82
W8 D            2.7       0.8             EDWARDS   82 CBAL   GAM GAM,2PI0     2/82
W8 DH          (2.9)     (1.2)    (1.0)   EDWARDS   82 CBAL   GAM GAM,2PI0     2/82
W8 D            2.7       0.4             FRAZER    83 CELL   E+E-,E+E- PI+PI- 9/83*
W8 D            2.3       0.7             FRAZER    83 JADE   E+E-,E+E- PI+PI- 9/83*
W8
W8  AVG         2.75      0.26     AVERAGE

W8   A  USING MASS, WIDTH AND BR(F TO 2PI) FROM PDG 1978
W8 D    SYSTEMATIC ERROR ADDED LINEARLY BY US.
W8  H   IF HELICITY=2 ASSUMPTION IS NOT MADE
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                          5  F BRANCHING RATIOS

R1      F INTO (2PI+ 2PI-)/(PI PI)                         (P2)/(P1)
R1              0.047     0.013           OH        70 HBC    1.26 PI- P,P F     2/73
R1      154     0.037     0.007           ANDERSON  73 DBC    6. PI+N,P F0       1/74
R1             (0.033)OR LESS  C.L.=.90   BUGG      73 DBC    8. PI+N,P F0       1/74
R1       70     0.051     0.025           EISENBERG 74 HBC    4.9 PI+P,DEL++F0  11/75
R1      285     0.043     0.007     .011  LOUIE     74 HBC    3.9 PI- P,N F0    11/75
R1      160     0.024     0.006           EMMS      75 DBC    4.  PI+N,P F0     11/75
R1
R1  AVG         0.0340    0.0045   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.2)

R2      F INTO (PI+ PI- 2PI0)/(PI PI)                      (P3)/(P1)
R2    SHOULD BE TWICE R1 IF DECAY IS RHO-RHO (SEE ASCOLI 68)
R2      600     0.15      0.06            EISENBERG 74 HBC    4.9 PI+P,DEL++F0  11/75
R2             (0.07)                     EMMS      75 DBC    4.  PI+N,P F0     11/75

R3      F INTO (K KBAR)/(PI PI)                            (P4)/(P1)
R3          WE ONLY AVERAGE EXPERIMENTS WHICH EITHER TAKE INTO ACCOUNT F-A2
R3          INTERFERENCE EXPLICITLY OR DEMONSTRATE THAT A2 PRODUCTION IS
R3          NEGLIGIBLE.
R3  W          (0.029)  (0.006)           WETZEL    76 OSPK   8.9 PI-P,KS KS     7/77
R3  BC         (0.047)  (0.005)           PAWLICKI  77 SPEC   6. PI N,K+ K- N   12/77
R3  AN         (0.028)  (0.005)           CASON     78 STRC   7. PI-P,KS KS N   12/78
R3             (0.047)  (0.012)+ SYST.    BEUSCH    67 OSPK   5,7,12 PI-P        9/67
R3      20      0.031    0.012            ADERHOLZ  69 HBC     8 PI+ P,K+K-PI-  12/75
R3              0.025    0.015            EMMS      75 DBC    4.  PI+N,P F0     11/75
R3              0.030    0.005            MARTIN    79 RVUE                     12/79
R3   M          0.027    0.009            POLYCHRON 79 STRC   7. PI-P,KS KS N   12/79
R3   D          0.036    0.005            COSTA     80 OMEG   1-2.2 PI-P,K+K-N   9/81
R3              0.039    0.008            LOVERRE   80 HBC    4. PI-P,K K N     12/79
R3             (0.03) OR LESS  CL=.95     AGUILAR   81 HBC    4.2 K-P,LAM 2K     1/82
R3              0.045    0.009            CHABAUD   81 ASPK   17 PI-P POLARIZ   12/83*
R3              0.037    0.008    0.021   ETKIN     82 MPS    23 PI-P,2K0S N     9/83*
R3
R3  AVG         0.0340   0.0027   AVERAGE

R3   C  THIS DETERMINATION HAS QUANTITATIVELY ACCOUNTED FOR BOTH F-PRIME
R3   C  AND A2 INTERFERENCE EFFECTS.
R3   M  TAKES INTO ACCOUNT THE F-F PRIME INTERFERENCE
R3   N  BY EXTRAPOLATION TO THE PION POLE
R3  W   USING F PRIME WIDTH = 40 MEV
R3  A   INCLUDED IN POLYCHRONAKOS 79.
R3  B   INCLUDED IN MARTIN 79 REVIEW.
R3   D  RE-EVALUATED BY CHABAUD 83.W.

R4      F INTO (K0 K- PI+ AND C.C.)/(PI PI)                (P5)/(P1)
R4             (.004)OR LESS  CL=.95      EMMS      75 DBC    4.  PI+N,P F0     11/75

R5      F INTO (ETA PI PI)/(PI PI)                         (P6)/(P1)
R5             (.010)OR LESS  CL=.95      EMMS      75 DBC    4.  PI+N,P F0     11/75

R6      F INTO (ETA ETA)/(PI PI)                           (P7)/(P1)
R6             (.09) OR LESS  CL=.95      EISENBERG 74 HBC    4.9 PI+P,DEL++F0  11/75
R6             (.016)OR LESS  CL=.95      EMMS      75 DBC    4.  PI+N,P F0     11/75
R6             (.05) OR LESS  CL=.95      EDWARDS   82 CBAL   GAM GAM,4GAMMA     2/82

R10     F INTO (PI PI)/TOTAL                               (P1)
R10     600     0.8       0.04            OH        70 HBC   01.26 PI- P,P F     1/71
R10     250     0.85      0.05            BEAUPRE   71 HBC   08 PI+ P,DELTA++F   1/71
R10IH          (0.82)    (0.01)           ESTABROOK 75 RVUE   17 PI-P,PI+PI-N   12/75
R10IG          (0.803)   (0.003)          HYAMS     75 ASPK    17 PI-P,PI+PI-N  12/75
R10             0.847     0.016           BECKER    79 ASPK   17 PI- P POLARIZ  12/79
R10             0.849     0.025           CHABAUD   83 ASPK   17 PI-P POLARIZ   12/83*
R10
R10 AVG         0.843     0.012    AVERAGE

R10 G   INCLUDED IN BECKER 79 ANALYSIS
R10 H   USES SAME DATA AS HYAMS 75
R10I    ERROR TAKES ACCOUNT OF SPREAD OF DIFFERENT PHASE-SHIFT SOLUTIONS
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REFERENCES FOR F


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SELOVE   62 PRL 9 272          SELOVE,HAGOPIAN,BRODY,BAKER,LEBOY     (PENN)
BONDAR   63 PL 5 153           BONDAR+    (AACHEN+BIRM+BONN+DESY+LOIC+MPIM)
GUIRAGOS 63 PRL 11 85          Z.G.T. GUIRAGOSSIAN                    (LRL)
HAGOPIAN 63 PRL 10 533         V HAGOPIAN,W SELOVE                   (PENN)
VEILLET  63 PRL 10 29          VEILLET,HENNESSY,BINGHAM,BLOCH+(EPOL+MILAN)

ADERHOLZ 64 PL 10 240          AACHEN+BERLIN+BERLIN+BONN+HAMBURG+LOIC+MPI  IJ
BRUYANT  64 PL 10 232          BRUYANT,GOLDBERG,HOLDER,FLEURY+ (CERN+EPOL) I
LEE      64 PRL 12 342         LEE,ROE,SINCLAIR,VANDERVELDE          (MICH)
SODICKSO 64 PRL 12 485         SODICKSON,WAHLIG,MANNELLI,FRISCH+      (MIT) I

BARMIN   65 SJNP 1 230         +DOLGOLENKO,ELENSKY,EROFEEV+  (ITEP MOSCOW) JP
BARMIN   65 SJNP 1 623         +DOLGOLENKO+EROFEEV+KRESTNIKOV+ (ITEP MOSC)
CHUNG    65 PRL 15 325         CHUNG,DAHL,HARDY,HESS,JACOBS,KIRZ       (LRL)
DERADO   65 PRL 14 872         DERADO,KENNEY,POIRIER,SHEPHARD (NOTRE DAME)
GUIRAGOS 65 PRL 11 85          Z G T GUIRAGOSSIAN                      (LRL)
WANGLER  65 PR  137 B 414      T P WANGLER,A R ERWIN,W WALKER  (WISCONSIN)

ACCENSI  66 PL 20 557          ACCENSI,ALLES-BORELLI,FRENCH,FRISK+  (CERN)
JACOBS   66 UCRL-16877         L.D.JACOBS,THESIS                       (LRL)
WAHLIG   66 PR  147  941       +SHIBATA,GORDON,FRISCH,MANNELLI  (MIT+PISA) J

BARLOW   67 NC 50A 701         +LILLESTOL+MONTANET+  (CERN+CDEF+IRAD+LIVP)
BEUSCH   67 PL 25 B 357        +FISCHER,GOBBI,ASTBURY+            (ETH+CERN)
DAHL     67 PR 163 1377        +HARDY+HESS+KIRZ+MILLER                 (LRL)
EISNER   67 PR 164 1699        +JOHNSON+KLEIN+PETERS+SAHNI+YEN+   (PURDUE)
POIRIER  67 PR 163 1462        +BISWAS,CASON,DERADO,KENNEY+    (NDAM+PENN)
RABIN    67 THESIS             M. RABIN                          (RUTGERS)

ARMENISE 68 NC 54 A 999        +FORINO+CARTACCI+ (BARI+BGNA+FIRENZE+ORSAY)
ASCOLI   68 PRL 21 1712        G.ASCOLI,H.B.CRAWLEY,D.W.MORTARA,+    (ILL)
BOESEBEC 68 NP B 4 501         BOESEBECK,DEUTSCHMANN,+(AACHEN+BERLIN+CERN)
FOSTER   68 NP B 6 107         +GAVILLET+LABROSSE+MONTANET+    (CERN+CDEF)
JOHNSON  68 PR 176 1651        +POIRIER,BISWAS,GUTAY+      (NDAM+PURD+SLAC)
LAMSA    68 PR 166 1395        +CASON+BISWAS+DERADO+GROVES+    (NOTREDAME)
WHITEHEA 68 NC 53A 817         +MCEWEN,OTT,AITKEN+         (AERE+SHMP+LOUC)

ADERHOLZ 69 NP B 11 259        +BARTSCH,+          (AACH+BERL+CERN+JAGL+WARS)
AGUILAR  69 PL 29 B  241       M.AGUILAR-BENITEZ,J.BARLOW,+    (CERN+CDEF)
ARMENISE 69 LNC 2 501          +GHIDINI,FORINO,CARTACCI+  (BARI+BGNA+FIRZ)
CASO     69 NC 62 A 755        +CONTE,BENZ,+    (GENO+DESY+HAMB+MILA+SACL)
DONALD   69 NP B 11 551        +EDWARDS,BURAN,BETTINI,+   (LIVP+OSLO+PADO)

AGUILAR  70 PRL 25 58          AGUILAR-BENITEZ,BARNES,BASSANO,+ (BNL+SYRA)
ARMENISE 70 LNC 4  199         +GHIDINI,FORING,CARTACCI,+ (BARI+BGNA+FIRZ)
BADIER   70 NP B 22 512        +BONNET,DREVILLON,BAUBILLIER,+  (EPOL+IPNP)
OH       70 PR D 1 2494        +GARFINKEL,MORSE,WALKER,PRENTICE(WISC+TNTOJ)
STUNTEBE 70 PL 32 B 391        STUNTEBECK,KENNEY,DEERY,BISWAS,CASON+(NDAM)

BARDADIN 71 PR D4 2711         BARDANIN-OTWINOWSKA,HOFMOKL,+          (WARS)
BEAUPRE  71 NP B 28 77         +DEUTSCHMANN,GRAESSLER,+    (AACH+BERL+CERN)
FARBER   71 NP B 29 237        +DE PINTO,BISWAS,CASON,DEERY,KENNEY,+(NDAM)
FLATTE   71 PL 34 B 551        +ALSTON-GARNJOST,BARBARO-GALTIERI,+   (LBL)

AGUILAR  72 PR D 6 29          AGUILAR-BENITEZ,CHUNG,EISNER,SAMIOS   (BNL)
BISWAS   72 PR D 5 1564        +CASON,HARRINGTON,KENNEY,SHEPHARD    (NDAM)
FOGLI    72 NC 8 A 670         FOGLI-MUCIACCIA,PICCIARELLI          (BARI)
GRAYER   72 PHIL.CONF.PROC. 5  +HYAMS,JONES,SCHLEIN,BLUM,DIETL+(CERN+MPIM)
JACOBS   72 PR D 6 1291        L.D.JACOBS                         (SACLAY)
KEMP     72 NC 8 A 611         +MAJOR,CONTRI,+  (DURH+GENO+MILA+EPOL+LPNP)
SCARROTT 72 LNC 3 271          SCARROTT,KEMP                      (DURHAM)
TAKAHASH 72 PR D 6 1266        TAKAHASHI,BARISH,+     (TOHO+PENN+NDAM+ANL)
WHITEHEA 72 NP B 48 365        WHITEHEAD,AULD,+       (AERE+RHEL+SHMP+LOUC)

ANDERSON 73 PRL 31 562         +ENGLER,KRAEMER,TOAF,DIAZ,+     (CARN+CASE)
BUGG     73 PR D 7 3264        +CONDO,HART,COHN,ENDORF,+  (TENN+ORNL+CINC)
CHARLESW 73 NP B 65 253        CHARLESWORTH,EMMS,BELL,+   (RHEL+BIRM+DURH)
HYAMS    73 NP B 64 134        +JONES,WEILHAMMER,BLUM,DIETL,+  (CERN+MPIM)
TOET     73 NP B 63 248        +THUAN,MAJOR,RINAUDO,+(NIJM+BONN+DURH+TORI)

EISENBER 74 PL 52B 239         EISENBERG,ENGLER,HABER,KARSHON+      (REHO)
ENGLER   74 PR D10 2070        +KRAEMER,TOAFF,WEISSER,DIAZ+    (CARN+CASE)
GRAYER   74 NP B 75 189        G.GRAYER,HYAMS,BLUM,DIETL,+     (CERN+MPIM)
HOLLOWAY 74 PR D9 1161         +HULD,JORDAN,KOETZ,BERNSTEIN+    (ILL+ILLC)
LOUIE    74 PL 48B 385         +ALITTI,GANDOIS,CHALOUPKA+      (SACL+CERN)
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For notation, see key at front of Listings.

Mesons

f(1270), A(1270) [A_1]


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EMMS     75 NP B96 155          +KINSON,STACEY,VOTRUBA+    (BIRM+DURH+RHEL)
ESTABROO 75 NP B95 322          P.ESTABROOKS,A.D.MARTIN              (DURH)
HYAMS    75 NP B100 205         +JONES,WEILHAMMER,BLUM,DIETL+   (CERN+MPIM)
PAWLICKI 75 PR D12 631          +AYRES,DIEBOLD,GREENE,KRAMER,WICKLUND (ANL)

DEUTSCHM 76 NP B 103 426        +KIRK,+(AACH+BERL+BONN+CERN+CRAC+HEID+WARS)
WETZEL   76 NP B 115 208        +FREUDENREICH,BEUSCH,+      (ETH+CERN+LOIC)

ALEXANDE 77 NP B 131 365        ALEXANDER,CORDEN,+    (TELA+BIRM+RHEL+LOWC)
ANTIPOV  77 NP B 119 45         +BUSNELLO,DAMGAARD,KIENZLE,+    (SERP+GEVA)
PAWLICKI 77 PR D 15 3196        +AYRES,COHEN,DIEBOLD,KRAMER,WICKLUND  (ANL)

BALTAY   78 PR D 17 62          +CAUTIS,COHEN,CSORNA,SMITH,YEH,+(COLU+BING)
CASON    78 PRL 41 271          +BAUMBAUGH,BISHOP,BISWAS,KENNEY,+(NDAM+ANL)

BECKER   79 NP B 151  46        +BLANAR,BLUM,CERRADA+ (MPIM+CERN+ZEEM+CRAC)
CORDEN   79 NP B 157 250        +DOWELL,GARVEY,JOBES,+(BIRM+RHEL+TELA+LOWC)
MARTIN   79 NP B 158 520        +OZMUTLU                             (DURH)
POLYCHRO 79 PR D 19 1317        POLYCHRONAKOS,CASON,BISHOP+      (NDAM+ANL)

BERGER   80  DESY 80/34         +GENZER+(AACH+BERG+DESY+HAMB+UMD+SIEG+WUPG)
COSTA    80 NP B 175 402        +      (BARI+BONN+CERN+GLAS+LIVP+MILA+WIEN)
GORLICH  80 NP B 174 16         +NICZYPORUK,ROZANSKA+ (CRAC+MPIM+CERN+ZEEM)
LOVERRE  80 ZPHY C 6 187        +ARMENTEROS,DIONISI+  (CERN+CDEF+MADR+STOH)

AGUILAR  81 ZPHY C 8 313        +ALBAJAR,ARMENTEROS,+ (CERN+CDEF+MADR+STOH)
BRANDELI 81 ZPHY C 10 117       BRANDELIK,BOERNER,+   (TASSO COLLABORATION)
CHABAUD  81 APP B 12 575        +NICZYPORUK,BECKER+         (CERN+CRAC+MPIM)
GIDAL    81 PL 107 B 153        +GOLDHABER,GUY,MILLIKAN,ABRAMS,+ (SLAC+LBL)
ROUSSARI 81 PL 105 B 304        ROUSSARIE,BURKE,ABRAMS,ALAM,+    (SLAC+LBL)

CASON    82 PRL 48 1316         +BISWAS,BAUMBAUGH,BISHOP,CANNATA+(NDAM+ANL)
EDWARDS  82 PL 110 B 82         +PARTRIDGE,PECK,+ (CIT+HARV+PRIN+STAN+SLAC)
ETKIN    82 PR D 25 1786        +FOLEY,LAI,LINDENBAUM+ (BNL+CUNY+TUFT+VAND)

ARMSTRON 83 NP B 224 193        ARMSTRONG+  (BARI+BIRM+CERN+MILA+LPNP+PAVI)
CASON    83 PR D 28 1586        +CANNATA,BAUMBAUGH,BISHOP,WATSON+(NDAM+ANL)
CHABAUD  83 NP B 223 1          +GORLICH,CERRADA+           (CERN+CRAC+MPIM)
FRAZER   83 AACHEN CONF.        RAPPORTEUR TALK                      (UCSD)
JENNI    83 PR D 27 1031        +BURKE,TELNOV,ABRAMS,BLOCKER+    (SLAC+LBL)
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A(1270) or A_1

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10  A(1270,JPG=1+-) I=1
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We no longer use the subscript 1 to specify this resonance.

The long-standing question concerning the resonance interpretation of the A(1270) was considerably clarified at the time of our 1982 edition.

The results of the partial-wave analyses obtained in two high-statistics experiments dealing with the diffractive (DAUM 80,81) and charge-exchange (DANKOWYCH 81) production of the 3π system in πp interactions clearly show that the behavior of the 1^+S0^+ intensity with the 3π mass and the phase variation of the 1^+S0^+ ($\rho\pi$) amplitude with respect to other waves [already reported in a study of diffractive production from nuclei (PERNEGR 78)] require the presence of both Deck background and a resonance.

The resonance parameters of the A(1270) are obtained by fitting the data (intensity and relative phases) to a phenomenological amplitude containing direct resonance production and a coherent Deck background which is rescattered through the resonance (BOWLER 75, BASDEVANT 77). In the context of this model-dependent analysis, the Deck background is responsible for making the peak of the 1^+S0^+ intensity occur some 110 MeV below the most-likely resonance mass.

We take the mass values for the A(1270) from the above reactions (1240 ± 80 MeV, DANKOWYCH 81; 1280 ± 30 MeV, DAUM 81). Note, however, the result reported in a study of a backwardly produced 3π system in the reaction $K^-p \to \Sigma^-\pi^+\pi^+\pi^-$ (1041 ± 13 MeV, GAVILLET 77). Based on a small statistical sample, GAVILLET 77 fitted the 3π mass distribution with a relativistic S-wave Breit-Wigner and a background including reflections from all the competing channels.

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                    10  A(1270) MASS (MEV)

M   A      1270. TO 1350.            BOWLER    75 RVUE +- 7-40 PI+- P       6/81
M    B    (1382.)                    BASDEVANT 77 RVUE  - 25,40 PI- P       6/81
M   F     (1041.0)   (13.0)          GAVILLET  77 HBC  +  4.2 K- P,S 3PI   12/77
M    D     1240.0     80.0           DANKOWYCH 81 SPEC   08.45 PI-P,3PI N   6/81
M    D     1280.0     30.0           DAUM      81 CNTR    63,94 PI- P       12/79
M   E     (1230.0)   (30.0)          LONGACRE  82 RVUE                      8/83*
M   T     (1250.0)  APPROX            TORNQVIST 82 RVUE                      9/83*
M          . . . . . . . . .
M   AVG    1275.1     28.1     AVERAGE

M   A   USES DATA OF ANTIPOV 73,ASCOLI 74,OTTER 74,TABAK 74,THOMPSON 74.
M    B  USES ANTIPOV 73 DATA. WE SELECT SOLUTION B OF BASDEVANT 77.
M    D  USES THE MODEL OF BOWLER 75.
M   E   USES MULTICHANNEL AITCHISON-BOWLER MODEL.
M   E   USES DATA FROM GAVILLET 77, DAUM 80 AND DANKOWYCH 81.
M   F   PRODUCED IN K- BACKWARD SCATTERING.
M   T   FROM A UNITARIZED QUARK MODEL CALCULATION

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                    10  A(1270) WIDTH (MEV)

W   A       240. TO  280.            BOWLER    75 RVUE +- 7-40 PI+- P       6/81
W    B     (470.)                    BASDEVANT 77 RVUE  - 25,40 PI- P       6/81
W   F      (230.0)   (50.0)          GAVILLET  77 HBC  +  4.2 K- P,S 3PI   12/77
W    D      380.0    100.0           DANKOWYCH 81 SPEC   08.45 PI-P,3PI N   6/81
W    D      300.0     50.0           DAUM      81 CNTR    63,94 PI- P       1/82
W   E      (330.0)   (60.0)          LONGACRE  82 RVUE                      8/83*
W   T      (234.0)  APPROX            TORNQVIST 82 RVUE                      9/83*
W          . . . . . . . . .
W   AVG     316.0     44.7     AVERAGE

M   A   USES DATA OF ANTIPOV 73,ASCOLI 74,OTTER 74,TABAK 74,THOMPSON 74.
W    B  USES ANTIPOV 73 DATA. WE SELECT SOLUTION B OF BASDEVANT 77.
W    D  USES THE MODEL OF BOWLER 75.
W   E   USES MULTICHANNEL AITCHISON-BOWLER MODEL.
W   E   USES DATA FROM GAVILLET 77, DAUM 80 AND DANKOWYCH 81.
W   F   PRODUCED IN K- BACKWARD SCATTERING.
W   T   FROM A UNITARIZED QUARK MODEL CALCULATION

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                    10  A(1270) PARTIAL DECAY MODES

                                                      DECAY MASSES
P1      A(1270) INTO RHO PI                          769+ 140
P2      A(1270) INTO KBAR K                          494+ 498
P3      A(1270) INTO PI (PI PI) S WAVE               140+ 140+ 140

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                    10  A(1270) BRANCHING RATIOS

R4      A(1270) INTO (PI (PI PI) S WAVE)/(RHO PI)        (P3)/(P1)
R4 E          0.003    0.003          LONGACRE  82 RVUE                    8/83*
R4 E    USES MULTICHANNEL AITCHISON-BOWLER MODEL.
R4 E    USES DATA FROM GAVILLET 77, DAUM 80 AND DANKOWYCH 81.

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                          REFERENCES FOR A(1270)

BELLINI  63 NC 29 896          BELLINI,FIORINI,HERZ,NEGRI,RATTI     (MILAN)

ADERHOLZ 64 PL 10 226          AACH+BERL+BIRM+BONN+DESY+HAMBURG+LOIC+MPIM
GOLDHABE 64 PRL 12 336         GOLDHABER,BROWN,KADYK,SHEN+        (LRL+UCB)
LANDER   64 PRL 13 346 A       LANDER,ABOLINS,CARMONY,HENDRICKS +   (UCSD)  JP

ABOLINS  65 ATHENS(OHIO)CONF. +CARMONY,LANDER,XUONG,YAGER       (LA JOLLA)I=1
ALITTI   65 PL 15 69           ALITTI,BATON,DELER,CRUSSARD+    (SACL+BGNA)

ALLARD   66 NC 46A 737         +DRIJARD+HENNESSY+   (ORSAY+MILAN+SACL+UCB)
DEUTSCHM 66 PL 20 82           DEUTSCHMANN,STEINBERG +  (AACH+BERLIN+CERN)
HESS     66 UCRL-16832         R I HESS (THESIS, BERKELEY)     .      (LRL)

ALLISON  67 PL 25B 619         +CRUZ+       (OXF+MPIM+BIRM+RHEL+GLAS+LOIC)
DAHL     67 PR 163 1377        +HARDY+HESS+KIRZ+MILLER                (LRL)
DANYSZ   67 NC 51 A 801        DANYSZ+FRENCH+SIMAK                   (CERN)
JUHALA   67 PRL 19 1355        +LEACOCK+RHODE+KOPELMAN+         (IOWA+COLO)
SLATTERY 67 NC 50A 377         +KRAYBILL+FORMAN+FERBEL          (YALE+ROCH)  JP

ARMENISE 68 PL 26 B  336       +FORINO+CARTACCI+    (BARI+BGNA+FIRZ+ORSAY)
ASCOLI   68 PRL 21 113         +CRAWLEY,KRUSE,MORTARA,SCHAFER,+ (ILLINOIS)
BALLAM   68 PRL 21 934         +BRODY,CHADWICK,FRIES,GUIRAGOSSIAN+  (SLAC)JP
BOESEBEC 68 NP B 4 501         BOESEBECK,DEUTSCHMANN,+(AACHEN+BERLIN+CERN)
CASO     68 NC 54 A 983        +CONTE+CORDS+DIAZ+  (GENOVA+HAMB+MILA+SACL)
CHUNG    68 PR 165 1491        S.U.CHUNG,O.DAHL,J.KIRZ,D.H.MILLER     (LRL)
CNOPS    68 PRL 21 1609        +HOUGH,COHN,BUGG+ (BNL+ORNL+UCND+TENN+PENN)
FRIDMAN  68 PR 167 1268        +MAURER,MICHALON,OUDET+   (HEID+STRASBOURG)
JUNKMANN 68 NP B8 471          +COCCONI+        (AACH+BERL+BONN+CERN+WARS)
KEY      68 PR 166 1430        +PRENTICE+COOPER+MANNER+    (TNTO+ANL+WISC)

ALEXANDE 69 PR 183 1168        G.ALEXANDER,A.FIRESTONE,G.GOLDHABER    (LRL)
ALLABY   69 PL 29B 198         +BINON+DIDDENS+DUTEIL+KLOVNING+...    (CERN)
ANDERSON 69 PRL 22 1390        +COLLINS,+                        (BNL+CARN)
BERLINGH 69 PRL 23 42          BERLINGHIERI,FARBER,+                 (ROCH)
DONALD   69 NP B 11 551        +EDWARDS,BURAN,BETTINI,+    (LIVP+OSLO+PADO)
FAYOLLE  69 NP B 13 40         +DE MONTAIGNAC,MORAND,STRACHMAN+     (PARIS)
JUHALA   69 PR 184  1461       +LEACOCK,RHODE,KOPELMAN,LIBBY,+  (ISU+COLO)
KENYON   69 PRL 23 146         +KINSON,SCARR,+              (BNL+UCND+ORNL)

ARMENISE 70 LNC 4  199         +GHIDINI,FORING,CARTACCI,+ (BARI+BGNA+FIRZ)
ASCOLI   70 PRL 25 962         +BROCKWAY,CRAWLEY,EISENSTEIN,HANFT,+  (ILL)  JP
BRANDENB 70 NP B16 369         +BRENNER,IOFFREDO,JOHNSON,KIM+     (HARVARD)
CASO     70 LNC 3  707         +CORDS,COSTA+     (GENO+DESY+HAMB+MILA+SACL)
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Mesons

Data Card Listings

A(1270) [A_1], η(1275), D(1285)

CRENNELL 70 PRL 24 781 +KARSHON,LAI,SCARR,SIMS (BNL)
GARELICK 70 PHILAD.CONF.P.205 D.A.GARELICK,REVIEW (NORTHEASTERN)
RABIN 70 PRL 24 925 +GALTIERI,DERENZO,FLATTE,FRIEDMAN+ (LRL)

ASCOLI 71 PRL 26 929 ILLINOIS+GENO+HAMB+MIL+SACL+HARV+TNTO+WISC
BEMPORAD 71 NP B 33 397 +BEUSCH,MELISSINOS,+ (CERN+ETH+LOIC+MILA)
BERGER 71 PHENOMENOLOGY IN PARTICLE PHYSICS, CALTECH 1971 (LRL)
RINAUDO 71 NC 5 A 239 +BOECKMANN,MAJOR+(TORI+BONN+DURH+NIJM+EPOL) JP

BERENYI 72 NP B 37 621 +PRENTICE,STEENBERG,YOON,WALKER (TNTO+WISC)
BLOODWOR 72 NP B 46 402 BLOODWORTH,JACKSON,PRENTICE,YOON (TORONTO)
DIEBOLD 72 BATAV.CONF.3P.17 R.DIEBOLD RAPPORTEUR TALK (ANL)
LAMSA 72 NP B 41 388 +EZELL,GAIDOS,WILLMANN (PURDUE)
MORSE 72 NP B 43 77 +OH,WALKER,JOHNSTON,YOON (WISC+TNTO)

ANTIPOV1 73 NP B 63 153 +ASCOLI,BUSNELLO,FOCACCI,+ (CERN+SERP) JP
ANTIPOV2 73 NP B 63 141 +ASCOLI,BUSNELLO,FOCACCI,+ (CERN+SERP) JP
ARNOLD 73 NC 17 A 393 +ENGEL,ESCOUBES,GEMESY,JANOSSY,+(STRB+BUDA)
ASCOLI 1 73 PR D 8 3894 +JONES,WEINSTEIN,WYLD (ILL)
ASCOLI 2 73 PRL 31 795 +CHAPIN,CUTLER,HOLLOWAY,KOESTER,KRUSE+(ILL) JP
ATHERTON 73 PL 43 B 249 +FRANEK,FRENCH,GHIDINI,HILPERT,+ (CERN)
READ 73 NP B 64 511 B.J.READ (DESY)

ASCOLI 74 PR D9 1963 +CUTLER,JONES,KRUSE,ROBERTS,WEINSTEIN+(ILL)
BOWLER 74 NP B74 493 +DAINTON,KADDOURA,AITCHISON (OXF)
KRUSE 74 PRL 32 1328 +ROBERTS,EDELSTEIN+ (ILL+CARN+NWES+ROCH) JP
LICHTMAN 74 NP B81 31 +BISWAS,CASON,KENNEY,MCGAHAN,+ (NDAM) JP
OTTER 74 NP B80 1 +RUDOLPH+ (AACH+BERL+BONN+CERN+HEID) JP
TABAK 74 BOSTON CONF. P.46 +RONAT,ROSENFELD,LASINSKI+ (LBL+SLAC) JP
THOMPSO1 74 PR D9 560 THOMPSON,GAIDOS,MCILWAIN,WILLMANN (PURD) JP
THOMPSO2 74 NP B69 381 THOMPSON,BADEWITZ,GAIDOS,MCILWAIN+ (PURD) JP

ABASHIAN 75 PRL 34 691 +BEAMER,BROSS,EISENSTEIN,+ (ILL+ANL+ISU)
AITCHISO 75 PL 59 B 288 I.J.R.AITCHISON, R.J.GOLDING (OXFORD)
ASCOLI 75 PR D 12 43 G.ASCOLI, H.W.WYLD (ILLINOIS)
BEUSCH 75 PL 55B 97 +POLGAR,FREUDENREICH+ (CERN+ETH+LOIC+MILA)
BOSETTI 75 NP B 101 304 +OTTER+(AACH+BERL+BONN+CERN+HEID+LOIC+WIEN)
BOWLER 75 NP B97 227 +GAME,AITCHISON,DAINTON (OXF+DARE)
DIAZ 75 PR 12 D 1272 +DIBIANCA,FICKINGER,DADO,ENGLER+(CASE+CARN) JP
EMMS 1 75 NP B93 1 +JONES,KINSON,BELL,DALE+ (BIRM+DURH+RHEL) JP
EMMS 2 75 PL 60 B 109 +JONES,KINSON,BELL,DALE+ (BIRM+DURH+RHEL) JP
HORNE 75 PR D11 996 +S.HAGOPIAN,V.HAGOPIAN,BENSINGER+(FSU+BRAN)
KANE 75 TENTH RENCONTRE DE MORIOND (MICH)
WAGNER 75 PL 58B 201 +TABAK,CHEW (LBL) JP

BAUBILLI 76 NP B 115 237 BAUBILLIER,RIVOAL,ARMENISE + (BARI+LPNP) JP
BENZ 76 NP B 115 385 +BRAUN +(AACHEN+BONN+HAMBURG+HEIDBERG+MPIM)
BRAYSHAW 76 PRL 36 73 D.BRAYSHAW (SLAC)

BALTAY 77 PRL 39 591 +CAUTIS,KALELKAR (COLUMBIA) JP
BASDEVAN 77 PR D 16 657 BASDEVANT,BERGER (FNAL+ANL) JP
CAUTIS 77 THESIS NEVIS 221 C.V.CAUTIS (COLUMBIA) JP
CERRADA 77 NP B 126 241 +BLOCKZIJL,HEINEN+ (AMST+CERN+NIJM+OXF) JP
FERRER 77 THESIS,LAL 1295 A.FERRER SORIA (ORSAY)
GAVILLET 77 PL 69 B 119 +BLOCKZIJL,ENGELEN+ (AMST+CERN+NIJM+OXF) JP
HABER 77 NP B 129 429 H.E.HABER,G.L.KANE (UNIV. OF MICHIGAN)
LONGACRE 77 PRL 38 1509 +AARON (NORTHEASTERN,BOSTON) JP
SCHULT 77 PR D 16 62 + WYLD (ILLINOIS) JP

ALEXANDE 78 PL 73 B 99 ALEXANDER,KNIES,+(DESY+AACH+HAMB+SIEG+WUPG)
BALTAY 78 PR D 17 62 +CAUTIS,COHEN,CSORNA,KALELKAR+ (COLU+BING)
BASDEVAN 78 PRL 40 994 BASDEVANT,BERGER (FNAL+ANL) JP
CORDEN 78 NP B 136 77 DOWELL,GARVEY,JOBES+ (BIRM+RHEL+TELA+LOWC) JP
FERRER 1 78 PL 74 B 287 +TREILLE,RIVET + (ORSAY+CERN+CDEF+LPNP)
FERRER 2 78 NPB 142 77 +TREILLE,RIVET + (ORSAY+CERN+CDEF+LPNP)
JAROS 78 PRL 40 1120 +ABRAMS,ALAM+ (SLAC+LBL+NWES+HAWA)
PERNEGR 78 NP B 134 436 +AEBISCHER+ (ETH+CERN+LOIC+MILA) JP
ROBERTS 78 PR D 18 59 +KRUSE,EDELSTEIN+ (ILL+CARN+NWES+ROCH) JP

CORDIER 79 PL B 81 389 +DELCOURT,ESCHSTRUTH,FULDA,+ (LALO)
KASPER 79 NP B 156 207 +CHAPMAN,DEROACH,GOLD,KLEIN,MARTIN+ (MELB)
MAZZUCAT 79 NP B 156 532 MAZZUCATO,PENNINGTON+ (CERN+ZEEM+NIJM+OXF)

DAUM 80 PL 89 B 281 +HERTZBERGER+(AMST+CERN+CRAC+MPIM+OXF+RHEL) JP
WAGNER 80 ZPHY C 3 193 +ALEXANDER+ (AACH+DESY+HAMB+SIEG+WUPP)

AARON 81 PR D 24 1207 +LONGACRE (NEAS+BNL)
DANKOWYC 81 PRL 46 580 +BROCKMAN,EDWARDS+(TNTO+BNL+CARL+MCGI+OHIO)
DAUM 81 NP B 182 269 +HERTZBERGER+(AMST+CERN+CRAC+MPIM+OXF+RHEL)
FOSTER 81 NP B 187 231 +BLOKZIJL,ARMENTEROS,+ (OXF+ZEEM+CERN+NIJM)

ARMSTRON 82 NP B 202 1 +BACCAR(AACH+BARI+BONN+CERN+GLAS+LIVP+MILA)
BELLINI 82 NP B 199 1 + (CERN+MILA+JINR+BGNA+HELS+PAVI+WARS+VIEN)
ETKIN 82 PR D 25 1786 +FOLEY,LAI,LINDENBAUM+ (BNL+CUNY+TUFT+VAND)
GAVILLET 82 ZPHY C 16 119 +ARMENTEROS,AGUILAR+ (CERN+CDEF+PADO+ROMA)
LONGACRE 82 PR D 26 83 R.S.LONGACRE (BNL)
TORNQVIS 82 NP B 203 268 TORNQVIST (HELS)

LEEDOM 83 PR D 27 1426 +DE BONTE,GAIDOS,KEY,WONG+ (PURD+TNTO)

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η(1275)

37 ETA(1275,JPG=0-+) I=0

SEEN IN PHASE SHIFTS ANALYSIS OF THE ETA PI+ PI-
SYSTEM WITH PI+ PI- IN AN S-WAVE (STANTON 79).
WAIT CONFIRMATION. OMITTED FROM TABLE.

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37 ETA(1275) MASS (MEV)

	Value	Error	Author	Yr	Tech	Comment	Date
M	(1275.)	APPROX.	STANTON	79	CNTR	0 8.4PI-P,ETA 2PI	12/79

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37 ETA(1275) WIDTH (MEV)

	Value	Error	Author	Yr	Tech	Comment	Date
W	(70.)	APPROX.	STANTON	79	CNTR	0 8.4PI-P,ETA 2PI	12/79

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37 ETA(1275) PARTIAL DECAY MODES

	Mode	DECAY MASSES
P1	ETA(1275) INTO DELTA PI	983+ 140
P2	ETA(1275) INTO ETA PI+ PI-	549+ 140+ 140

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37 ETA(1275) BRANCHING RATIOS.

R1 ETA(1275) INTO DELTA PI (P1)

	Value	Author	Yr	Tech	Comment	Date
R1	LARGE	STANTON	79	CNTR	0 8.4PI-P,ETA 2PI	12/79

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REFERENCES FOR ETA(1275)

STANTON 79 PRL 42 346 +BROCKMAN,DANKOWYCH,+ (OSU+CARL+MCGI+TNTO) JP

BARNES 82 PL 116 B 365 T.BARNES AND F.E.CLOSE (RHEL)
TANIMOTO 82 PL 116 B 198 M.TANIMOTO (BIEL)

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D(1285)

8 D(1285,JPG=1++) I=0

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8 D(1285) MASS (MEV)

	Flag	Events	Value	Error	Author	Yr	Tech	Comment	Date
M	S	500	(1280.)	(3.)	THUN	72	MMS	13.4 PI- P	12/72
M		34	(1271.0)	(10.0)	CORDEN	78	OMEG	12-15PI-P,K+K-PI	4/78
M	P	46	(1275.0)	APPROX.	STANTON	79	CNTR	8.5PI-P,2GAM 2PI	12/79
M			1283.0	5.0	DAHL	67	HBC	1.6-4.2 PI- P	10/66
M			1290.	7.	D-ANDLAU	68	HBC	1.2 PBAR P, 5-6 PFS	6/68
M			1270.0	10.0	CAMPBELL	69	DBC	2.7 PI+ D	8/69
M			1285.	7.	LORSTAD	69	HBC	0.7 PB P, 4,5-BODY	9/69
M			1303.0	8.0	BARDADIN	71	HBC	8 PI+ P, P+6PI	9/69
M			1283.0	6.0	BOESEBECK	71	HBC	16.0 PI P,5 PI	6/71
M		150	1292.	10.	DEFOIX	72	HBC	0.7 PBAR P,7 PI	1/73
M		180	1286.	3.	DUBOC	72	HBC	1.2 PBAR P,2K4PI	12/72
M		210	1279.0	5.0	GRASSLER	77	HBC	16. PI-+ P	11/77
M		85	1295.0	12.0	CORDEN	78	OMEG	12-15PI-P, N 5PI	4/78
M		320	1282.0	2.0	NACASCH	78	HBC	.7+.76 PB P,KKBP	4/78
M		200	1288.0	9.0	GURTU	79	HBC	4.2 K- P,ETA 2PI	12/79
M		31	1275.0	6.0	BROMBERG	80	SPEC	100 PI-P,2KPIX	1/82
M		103	1283.0	3.0	DIONISI	80	HBC	4. PI- P,K KB PI	12/79
M			1278.	4.	EVANGELIS	81	OMEG	12 PI-P,ETA3PIP	1/82
M	T		(1279.)	APPROX	TORNQVIST	82	RVUE		9/83*
M			1285.0	2.0	PALANO	83	OMEG	85 PP PI+P,2KPIX	12/83*
M			. . . .	. . . .					
M	AVG		1283.5	1.1	AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.1)				

M P FROM PHASE SHIFT ANALYSIS OF ETA PI+PI- SYSTEM.
M S SEEN IN THE MISSING MASS SPECTRUM
M T FROM A UNITARIZED QUARK MODEL CALCULATION

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8 D(1285) WIDTH (MEV)

	Flag	Events	Value	Error	Author	Yr	Tech	Comment	Date
W	R		(35.0)	(10.0)	DAHL	67	HBC	1.6-4.2 PI- P	11/71
W	R		(60.)	(15.)	LORSTAD	69	HBC	0.7 PB P, 4,5-BODY	11/71
W	R		(44.0)	(24.0)	BARDADIN	71	HBC	8 PI+ P, P+6PI	11/71
W	R	150	(28.)	(5.)	DEFOIX	72	HBC	0.7 PBAR P,7 P9	1/73
W	R	180	(46.)	(9.)	DUBOC	72	HBC	1.2 PBAR P,2K4PI	12/72
W	S	500	(37.)	(5.)	THUN	72	MMS	13.4 PI- P	12/72
W	D	34	(55.0)	(38.0)	CORDEN	78	OMEG	12-15PI-P,K+K-PI	4/78
W	P		(10.0)	APPROX.	STANTON	79	CNTR	8.5PI-P,2GAM 2PI	12/79
W	U		46.	20.	D-ANDLAU	68	HBC	1.2 PBAR P, 5-6 PFS	2/72
W			30.0	15.0	CAMPBELL	69	DBC	2.7 PI+ D	8/69
W			10.0	10.0	BOESEBECK	71	HBC	16.0 PI P,5 PI	6/71
W		210	24.0	18.0	GRASSLER	77	HBC	16. PI-+ P	12/77
W	D	85	70.0	30.0	CORDEN	78	OMEG	12-15PI-P, N 5PI	4/78
W		320	28.3	6.7	NACASCH	78	HBC	.7+.76 PB P,KKBP	4/78
W		200	25.0	15.0	GURTU	79	HBC	4.2 K- P,ETA 2PI	12/79
W		31	22.0	21.0	BROMBERG	80	SPEC	100 PI-P,2KPIX	1/82
W		103	29.0	10.0	DIONISI	80	HBC	4. PI- P,K KB PI	12/79
W			26.	12.	EVANGELIS	81	OMEG	12 PI-P,ETA3PIP	1/82
W			26.	5.	PALANO	83	OMEG	85 PP PI+P,2KPIX	12/83*
W			. . . .	. . . .					
W	AVG		26.2	3.1	AVERAGE				

W D WIDTH ERRORS ENLARGED BY US TO 4*WIDTH/SQRT(N),SEE K*(892) NOTE
W P FROM PHASE SHIFT ANALYSIS OF ETA PI+PI- SYSTEM.
W R RESOLUTION NOT UNFOLDED
W S SEEN IN THE MISSING MASS SPECTRUM
W U UNFOLDED BY DOBRZYNSKI 71

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8 D(1285) PARTIAL DECAY MODES

	Mode	DECAY MASSES
P1	D(1285) INTO K KBAR PI	498+ 498+ 135
P2	D(1285) INTO PI PI RHO	135+ 135+ 769
P3	D(1285) INTO ETA PI PI	549+ 135+ 135
P4	D(1285) INTO DELTA PI	983+ 135
P5	D(1285) INTO 2PI+ 2PI-	140+ 140+ 140+ 140
P6	D(1285) INTO K*(892) KBAR	892+ 498
P7	D(1285) INTO 4PI	140+ 140+ 140+ 140

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FITTED PARTIAL DECAY MODE BRANCHING FRACTIONS

The matrix below is derived from the error matrix for the fitted partial decay mode branching fractions, P_i, as follows: The diagonal elements are $P_i \pm \delta P_i$, where $\delta P_i = \sqrt{\langle \delta P_i \delta P_i \rangle}$, while the off-diagonal elements are the normalized correlation coefficients $\langle \delta P_i \delta P_j \rangle / (\delta P_i \cdot \delta P_j)$. For the definitions of the individual P_i, see the listings above; only those P_i appearing in the matrix are assumed in the fit to be nonzero and are thus constrained to add to 1.

	P 1	P 3	P 7
P 1	.1117+-.0266		
P 3	.2931	.4883+-.0586	
P 7	-.6152	-.9341	.4000+-.0711

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8 D(1285) BRANCHING RATIOS

THE D(1285) BRANCHING RATIOS FIT IS MADE WITH THE ASSUMPTION THAT
THE D(1285) INTO 4PI DECAY IS ALWAYS VIA DECAY INTO I=1 PI PI
PAIRS (E.G., RHO PI PI).

R1 D(1285) INTO (PI PI RHO) / (K KBAR PI) (P2)/(P1)

	Flag	Value		Author	Yr	Tech	Comment	Date
R1		(2.0)	OR LESS	DAHL	67	HBC	CHARGED PI ONLY	10/66
R1	D	(4.0)	OR LESS	DONALD	69	HBC	1.2 PBAR P,5P+	

R1 D THIS IS FOR (RHOO PI+ PI-)/(K KBAR PIO)

For notation, see key at front of Listings.

Mesons

D(1285), ε(1300)

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R2      D(1285) INTO (K KBAR PI)/(ETA PI PI)                (P1)/(P3)
R2            0.16      0.08            CAMPBELL  69 DBC     2.7 PI+ D          1/73
R2 K          0.20      0.08            DEFOIX    72 HBC     0.7 PBAR P,7 PI    1/73
R2            0.5       0.2             CORDEN    78 OMEG    12-15PI-P          4/78
R2            0.42      0.15            GURTU     79 HBC     4.2 K- P          12/79
R2          . . . . . . . . .
R2  AVG       0.229     0.061   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.2)
R2  FIT       0.229     0.053  FROM FIT
                        (SEE IDEOGRAM BELOW)

R2 K     K KBAR SYSTEM CHARACTERIZED BY THE I=1 THRESHOLD
R2 K     ENHANCEMENT (SEE UNDER DELTA(980)).
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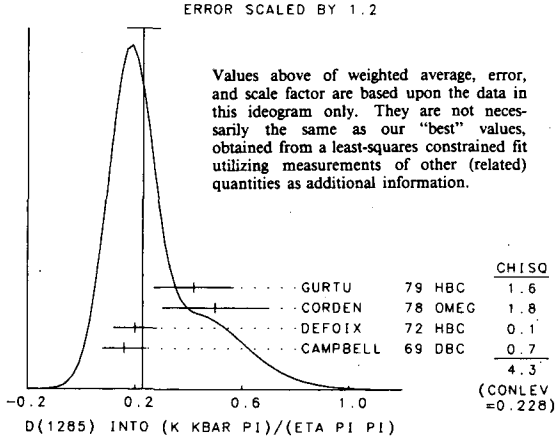


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R3      D(1285) INTO (DELTA PI)/(ETA PI PI)                 (P4)/(P3)
R3          SEEN                          DEFOIX    68 HBC     PBAR P             1/80
R3            1.0       0.3             GRASSLER  77 HBC   0 16. PI-+ P        11/77
R3            0.6       0.3       0.2   CORDEN    78 OMEG    12-15PI-P          4/78
R3            0.72      0.15            GURTU     79 HBC     4.2 K- P          12/79
R3          . . . . . . . . .
R3  AVG       0.74      0.12    AVERAGE

R4      D INTO (2PI+ 2PI- (INCL. RHO PI PI))/(ETA PI+PI-)(P5)/(2/3P3)
R4            0.46      0.15            GRASSLER  77 HBC     16. PI-+ P         11/77
R4            0.32      0.20            GURTU     79 HBC     4.2 K- P          12/79
R4          . . . . . . . . .
R4  AVG       0.41      0.12    AVERAGE
R4  FIT       0.41      0.12   FROM FIT
R5      D(1285) INTO (K*(892) KBAR)/TOTAL                   (P6)
R5          NOT SEEN                      NACASCH   77 HBC     .7+.76 PB P,KKBP 12/77

R6      D(1285) INTO (RHO0 PI+ PI-)/(2PI+ 2PI-)             (1/3P2)/(P5)
R6            1.0       0.4             GRASSLER  77 HBC     16 GEV PI+- P     11/77

R7      D(1285) INTO (RHO PI PI)/(ETA PI PI)                     (P2)/(P3)
R7 C        (0.4)  OR LESS  CL=.95   CORDEN    78 OMEG    12-15PI-P          4/78
R7 C     NOTE THAT CORDEN 78 AND GRASSLER 77 ARE IN DISAGREEMENT.

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REFERENCES FOR D(1285)


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D-ANDLAU 65 PL 17 347          +BARLOW,ADAMSON,+      (CDEF+CERN+IRAD+LIVP)
MILLER   65 PRL 14 1074        +CHUNG,DAHL,HESS,HARDY,KIRZ,+     (LRL+UCB)

BARLOW   67 NC  50 A  701      +MONTANET,D-ANDLAU+   (CERN+CDEF+IRAD+LIVP)
DAHL     67 PR 163 1377        +HARDY+HESS+KIRZ+MILLER                (LRL)I JP

D-ANDLAU 68 NP  B 5  693       +ASTIER,BARLOW+       (CDEF+CERN+IRAD+LIVP)I JP
DEFOIX   68 PL 28 B 353        +RIVET,SIAUD,CONFORTO+     (CDEF+IPNP+CERN)

CAMPBELL 69 PRL 22 1204        +LICHTMAN,+                          (PURD)
DONALD   69 NP B 11 551        +EDWARDS,BURAN,BETTINI,+   (LIVP+OSLO+PADO)
LORSTAD  69 NP B 14 63         B.LORSTAD,D-ANDLAU,ASTIER,+     (CDEF+CERN)  JP
OTWINOWS 69 PL 29 B 529        S.OTWINOWSKI                         (WARSAW)

AMMAR    70 PR D2 430          +KROPAC,DAVIS,DERRICK+ (KANS+NWES+ANL+WISC)

BARDADIN 71 PR D4 2711         BARDADIN-OTWINOWSKA,HOFMOKL,MICHEJDA+(WARS)
BOESEBEC 71 PL 34 B 659                (AACH+BERL+BONN+CERN+CRAC+HEID+WARS)
GOLDBERG 71 LNC 1 627          +MAKOWSKI,TOUCHARD,DONALD,+      (IPN+LIVP)  JP

BERENYI  72 NP B 37 621        +PRENTICE,STEENBERG,YOON,WALKER (TNTO+WISC)
CHAPMAN  72 NP B 42 1          +CHURCH,LYS,MURPHY,RING,VANDER VELDE (MICH)
DEFOIX   72 NP B 44 125        +NASCIMENTO,BIZZARRI,+               (CDEF+CERN)
DUBOC    72 NP B 46 429        +GOLDBERG,MAKOWSKI,DONALD,+      (LPNP+LIVP)
THUN     72 PRL 28 1733        +BLIEDEN,FINOCCHIARO,BOWEN,+     (STON+NEAS)

VUILLEMI 75 LNC 14 165         VUILLEMIN,+       (LAUS+NEUC+LPNP+LIVP+GLAS)  JP
WELLS    75 NP B 101 333       +RADOJICIC,ROSCOE,LYONS,+                (OXF)

HANDLER  76 NP B 110 173       +PLANO,BRUCKER,KOLLER+      (RUTG+STEV+SETO)
VUILLEMI 76 NC 33A 133         VUILLEMIN+        (LAUS+NEUC+LPNP+LIVP+GLAS)

GRASSLER 77 NP B 121 189       +(AACHEN+BERLIN+BONN+CERN+CRACOW+HEID+WARS)

CORDEN   78 NP B 144 253       +CORBETT,ALEXANDER,+  (BIRM+RHEL+TELA+LOWC)  JP
IRVING   78 NP B 139 327       A.C.IRVING,H.R.SEPANGI                (LIVP)
NACASCH  78 NP B 135 203       +DEFOIX,DOBRZYNSKI,+     (PARIS+MADRID+CERN)

GURTU    79 NP B 151 181       +GAVILLET,BLOKZIJL,+    (CERN+ZEEM+NIJM+OXF)
STANTON  79 PRL 42 346         +BROCKMAN,DANKOWYCH,+  (OSU+CARL+MCGI+TNTO)  JP

BROMBERG 80 PR D 22 1513       +HAGGERTY,ABRAMS,DZIERBA(CIT+FNAL+ILLC+IND)
DE BILLY 80 NP B 176 1         +BRIAND,DUBOC,LEVY+    (CURI+LAUS+NEUC+GLAS)  JP
DIONISI  80 NP B 169 1         +GAVILLET,ARMENTEROS+ (CERN+MADR+CDEF+STOH)

EVANGELI 81 NP B 178 197       EVANGELISTA+(BARI+BONN+CERN+DARE+LIVP+MILA)

GAVILLET 82 ZPHY C 16 119      +ARMENTEROS,AGUILAR+  (CERN+CDEF+PADO+ROMA)
TORNQVIS 82 NP B 203 268       TORNQVIST                            (HELS)

PALANO   83  CERN/EP 83-107    +ARMSTRONG,APOSTOLAKIS(ATEN+BARI+BIRM+CERN)
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ε(1300)

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14  EPSILON(1300,JPG=0++) I=0
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NOTE ON S-WAVE ππ AND KK̄ INTERACTIONS

In this note we discuss information on the non-strange $I^G J^{PC} = 0^+0^{++}$ partial wave (S wave) coupled to the $\pi\pi$ and $K\bar{K}$ systems.

The threshold behavior of elastic $\pi^+\pi^-$ scattering involves S, P, and D waves which can be sufficiently well described by the scattering lengths a_0^0, a_0^2, a_1^1, a_2^0, and a_2^2. The determination of these parameters has in the past met with great difficulties (see our 1978 edition). A consistent set of parameters has been proposed (see ALEKSEEVA 82 and references therein).

Up to the ρ meson mass region, the phase shift δ_0^0 is (qualitatively) uniquely determined: it rises monotonically and reaches 60° to 70° near 700 MeV (SONDEREGGER 69, BATON 70, BAILLON 72, CARROL 72, FRENKIEL 72, GAIDOS 72, PROTOPOPESCU 73, HYAMS 73, OCHS 73, ENGLER 74, ESTABROOKS 74,75, GRAYER 74).

In the early phase-shift analyses two solutions for δ_0^0 were found (the "up-down ambiguity") in the 700-900-MeV region. The "up" solution corresponds to an ε resonance under the ρ meson with mass and width similar to the ρ meson, the ε(800). The "down" solution is characterized by an approximately energy-independent phase shift of almost 90°, showing no resonant behavior. This ambiguity was considered resolved in favor of the "down" solution by the observation of a very rapid decrease in the modulus of the S-wave amplitude between 900 MeV and the $K\bar{K}$ threshold, followed by a sharp drop in the elasticity. δ_0^0 is ~90° at about 900 MeV and reaches ~180° around 990 MeV (FLATTE 72, GAIDOS 72, HYAMS 73, BINNIE 73, ENGLER 74). However, the region is complicated by the simultaneous presence of the S(975) resonance and the opening of the $K\bar{K}$ channel, permitting almost discontinuous jumps from one solution to another.

Without polarization information, the reaction $\pi N \to \pi\pi N$ cannot be analyzed unambiguously due to the fact that there are more helicity amplitudes than observables (see, e.g., DONOHUE 75). Thus one is obliged to make some supplementary assumptions.

An amplitude analysis (ESTABROOKS 74) of the

largest π^-p (unpolarized) $\rightarrow \pi^+\pi^-n$ experiment (HYAMS 73, GRAYER 74) still finds both the "up" and "down" solutions. This analysis assumes both spin coherence (the unnatural-parity-exchange, s-channel helicity amplitudes are nucleon spin-flip, i.e., no A(1270)-like exchange) and phase coherence (the S-wave amplitude and the unnatural-parity-exchange, meson helicity-zero P-wave amplitude have the same phase). These assumptions may tend to bias the results (MORGAN 74, DONOHUE 75,79).

The advent of π^-p (polarized) $\rightarrow \pi^+\pi^-n$ data (BECKER 79) has made both the spin coherence and phase coherence assumptions unnecessary. Analyzing their data in a model-independent way, BECKER2 79 also find both the "up" and the "down" solutions.

The reaction $\pi^+p \rightarrow \pi^+\pi^-\Delta^{++}$ has been analyzed in the region 660 to 860 MeV (OWENS 76, DONOHUE 79) and in the region 600 to 920 MeV (GELFAND 78), using all the information carried by the Δ^{++} decay. The conclusion from both analyses is that the $\epsilon(800)$ of the "up" solution cannot be ruled out.

The only way to rule out a narrow ϵ under the ρ meson (the "up" solution) is to study the $\pi^0\pi^0$ system. Many experiments agree that no such narrow resonance is present and that the "down" solution describes the data well (DEINET 69, SONDEREGGER 69, SHIBATA 70, BENSINGER 71, APEL 72,79, BRAUN 73, RIESTER 75, GRIVAZ 76, DAVID 77, BORREANI 79,81). The phase shifts of BISWAS 81 lie much lower than all others in the 300-700-MeV region, thus requiring a sudden phase motion in the ρ region to match the "down" solution above the ρ.

A recent amplitude analysis of the reaction $\pi^+\pi^- \rightarrow \pi^0\pi^0$ (CASON 83) has selected the so-called "down-down" solution as the only one making the $\pi^+\pi^- \rightarrow \pi^0\pi^0$ and $\pi^+\pi^- \rightarrow \pi^+\pi^-$ data consistent (as already noted by SKUJA 73). This solution "leads to a rather rapid phase variation at approximately 750 MeV and a phase shift which goes through 90° at about 800 MeV" (CASON 83) (see Fig. 1).

Additional information on the $\pi\pi$ scalar states is emerging from the study of meson pair production in $\gamma\gamma$ scattering. A recent analysis of available data (MENESSIER 83) argues in favor of a very broad low-mass scalar in the 500-700-MeV region.

The region of elastic $\pi\pi$ scattering is known to extend to about 990 MeV, near the $K\bar{K}$ threshold (BATON 70, CARROLL 72, PROTOPOPESCU 73,

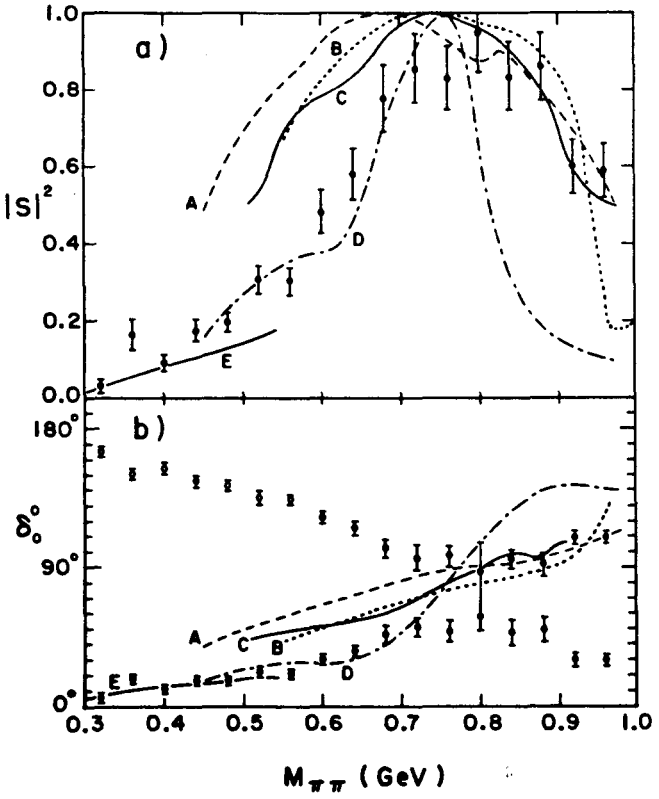

Fig. 1. (a) Extrapolated S-wave intensity as a function of the $\pi^0\pi^0$ mass. (b) I = 0, S-wave phase shifts. From CASON 83.

HYAMS 73, OCHS 73). Beyond 1 GeV we therefore have to consider the two channels $\pi\pi$ and $K\bar{K}$, and beyond 1100 MeV the $\eta\eta$ channel also opens up. In addition, the solutions have inherent ambiguities related to the Barrelet zeros of the amplitudes. Thus HYAMS 75 find four solutions in the region 1.0 to 1.8 GeV, ESTABROOKS 74 find eight solutions, and CORDEN 79, extending the $\pi\pi$ analysis to 2.08 GeV, find another eight solutions.

In the past many of these solutions have been ruled out by imposing continuity in various ways, as well as analyticity and unitarity (FROGGATT 75,77, COMMON 76, MARTIN 78).

One notes that a model-independent partial-wave analysis (BECKER2 79 on polarized target) agrees qualitatively with solutions β and β' (of MARTIN 78).

The β and β' amplitudes describe the experimental moments in each bin without any explicit smoothing; they are analytic in s and approximately analytic in $\cos\theta$. They take into account all waves up to $\ell = 4$. The β solution has a highly elastic S wave, whereas the

For notation, see key at front of Listings.

S wave of solution β' is somewhat inelastic (MARTIN 78). The unique solution of FROGGATT 77, which has explicit smoothness built in and which takes account only of $\ell \leq 3$ waves, is rather similar to β. However, it has problems with unitarity, apparently because of the neglected G wave (MARTIN 78).

The S wave is clearly resonant in the data of BECKER2 79. In the 1150-1400-MeV region both the S-P and S-D phase differences show the presence of a broad resonance, and the intensity of the S wave confirms this by exhibiting a peak at about 1300 MeV with a width of about 300 MeV.

The amplitude analysis of the $\pi^- p \to \pi^+\pi^- n$ experiment of CORDEN 79 has two preferred solutions which are close to β and β', giving some support for an $\epsilon(1300)$. Also the S wave in the $\pi^0\pi^0$ system tends to confirm the $\epsilon(1300)$ by staying near its unitarity limit around 1200 MeV (APEL 79).

The new results on $\pi^+\pi^- \to \pi^0\pi^0$ (CASON 83) establish that the only solutions consistent with the data are the β and β', in agreement with BECKER2 79. That implies a significant $\pi\pi$ coupling of the $\rho(1600)$.

Independent evidence for the $\epsilon(1300)$ comes from studies of the $K\bar{K}$ systems. In the reaction $\pi^- p \to K^0_S K^0_S n$, the S wave exhibits a large intensity in the 1300-MeV region (WETZEL 76, LOVERRE 80, ETKIN 82) with evidence for a bump. Moreover, the Y_0^2 moment shows a large negative excursion indicating S-D interference (CASON 76, WETZEL 76, POLYCHRONAKOS 79, GOTTESMAN 80, LOVERRE 80, ETKIN 82). The main problem was the isospin of the bump: if OPE were the only mechanism, I = 0 would be assured. The new high-statistics data (ETKIN 82), in the restricted t′ region smaller than 0.1 GeV^2, strongly argues in favor of OPE dominance and assigns the observed effects to the $I^G = 0^+$ state.

An enhancement in the intensity of the S wave around 1300 MeV has also been observed in the K^+K^- system produced in $\pi^- p$, $\pi^+ n$, and $\pi^- p$ (polarized) scattering. Again contributions from the I = 0 and I = 1 states may be present (PAWLICKI 77, MARTIN 79, COHEN 80, COSTA 80, GORLICH 80, WICKLUND 80).

To get from the mass-independent S-wave amplitudes and S-D relative phase to resonance parameters and $q\bar{q}$ composition several assumptions have to be made. Various analyses (PAWLICKI 80, ETKIN2 83) reach contradictory results concerning the number and properties of the resonance states coupled to the $I^G = 0^+$ system.

Recently, two fully unitarized coupled-channel analyses have been performed (ACHASOV 79,80,81, TORNQVIST 82) giving fairly consistent results.

The picture emerging (TORNQVIST 82) is that of a dominantly $q\bar{q}$ system with large $q\bar{q}q\bar{q}$ components in the form of virtual two-meson bound states. At the SU(3) level, two isoscalar resonances are needed, a narrow S(975) superimposed on a broad ϵ. The position and width of the S(975) are well determined by the interference with the ϵ, visible as a dip in the $\pi\pi \to \pi\pi$ cross section.

The interpretation of the S(975) as a $q\bar{q}q\bar{q}$ system is another possiblity.

The mass and width of the ϵ, however, are difficult to define in any simple way, its Breit-Wigner shape being completely distorted by hadronic mass-renormalization effects (cusps) from the $\pi\pi$, $K\bar{K}$, and $\eta\eta$ channels (MORGAN 74, ACHASOV 79,80,81, IRVING 81, TORNQVIST 82).

For further discussion of the scalar nonet, see the mini-reviews under $\delta(980)$ and $\kappa(1350)$.

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                    14  EPSILON(1300) MASS (MEV)

M          (1256.0)                   FROGGATT  77 RVUE    PI+PI- CHANNEL   12/77
M          (1270.)  APPROX.           MARTIN    78 RVUE    PI+PI- CHANNEL   12/77
M          (1300.)  APPROX.           POLYCHRON 79 STRC    7. PI-P,KS KS N  12/79
M           1425.     15.             WICKLUND  80 SPEC    6. PI N,K+ K- N   9/81
M          (1394.)                    IRVING    81 RVUE    PI+PI-,K KBAR CH  3/82
M           1463.0     9.0            ETKIN1    82 MPS     23 PI-P,2KOS N    9/83*
M  C        1470.0    30.0            ETKIN2    82 MPS     23 PI-P,2KOS N    9/83*
M          (1237.)   APPROX           TORNQVIST 82 RVUE                      1/82
M
M   AVERAGE MEANINGLESS (SCALE FACTOR = 1.6)

M  C    FIT INCLUDES INTERFERING G/S(1240) RESONANCE. SYSTEMATIC
M  C    ERROR ADDED LINEARLY BY US.

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                    14  EPSILON(1300) WIDTH (MEV)

W   E      (400.)  APPROX.            FROGGATT  77 RVUE    PI+PI- CHANNEL   12/77
W          (150.)  APPROX.            POLYCHRON 79 STRC    7. PI-P,KS KS N  12/79
W           160.     30.              WICKLUND  80 SPEC    6. PI N,K+ K- N   9/81
W P        (220.)                     IRVING    81 RVUE    PI+PI-,K KBAR CH  3/82
W           118.0    138.0     16.0   ETKIN1    82 MPS     23 PI-P,2KOS N    9/83*
W  C        140.0     30.0            ETKIN2    82 MPS     23 PI-P,2KOS N    9/83*
W          (1400.)   APPROX.          TORNQVIST 82 RVUE                      1/82
W   AVERAGE MEANINGLESS

W  C    FIT INCLUDES INTERFERING G/S(1240) RESONANCE. SYSTEMATIC
W  C    ERROR ADDED LINEARLY BY US.
W   E   WIDTH DEFINED AS DISTANCE BETWEEN 45 AND 135 DEGREES PHASE SHIFT.
W P     FROM POLE POSITION


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                    14  EPSILON(1300) PARTIAL DECAY MODES

                                                          DECAY MASSES
P1     EPSILON(1300) INTO PI PI                          140+ 140
P2     EPSILON(1300) INTO K KBAR                         498+ 498
P3     EPSILON(1300) INTO ETA ETA                        549+ 549

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                    14  EPSILON(1300) BRANCHING RATIOS

R1     EPSILON(1300) INTO (PI PI)/TOTAL                 (P1)
R1          (0.73)                 HYAMS     75 ASPK    17.2 PI-P,PI+PI-  9/81
R1           0.936    0.019    0.015 GORLICH  80 ASPK    17,18 PI-P POLAR  9/81
R1          (0.93)                  LOVERRE   80 HBC     4. PI- P,K K N    9/81
R1          (0.93) APPROX.          TORNQVIST 82 RVUE                      1/82

R2     EPSILON(1300) INTO (K KBAR)/(PI PI )             (P2)/(P1)
R2           0.08     0.01          COSTA     80 OMEG  0 10 PI-P,K+ K- N   1/82

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Mesons

Data Card Listings

ε(1300), π(1300)

REFERENCES FOR EPSILON(1300)

Key	Year	Reference	Authors	Institution
SAMIOS	62	PRL 9 139	+BACHMAN,LEA+	(BNL+CUNY+COLU+KNTY)
BLOKHINT	63	JETP 17 80	BLOKHINTSEVA,GREIBINNIK,ZHUKOV +	(DUBNA)
BOOTH	63	PR 132 2314	+ ABASHIAN	(LRL)
KIRZ	63	PR 130 2481	+SCHWARTZ + TRIPP	(LRL)
BARISH	64	PR 135 B 416	BARISH,KURZ,PEREZ-MENDEZ,SOLOMON	(LRL)
CRAWFORD	64	PRL 13 421	+GROSSMAN,LLOYD,PRICE,FOWLER	(LRL)
DEL FABR	64	PRL 12 674	DEL FABRO,DE PRETIS,JONES+	(FRASCATI)
KALMUS	64	PRL 13 99	+KERNAN,PU,POWELL,DOWD	(LRL+WISCONSIN)
BATON	65	NC 36 1149	J.P.BATON, J.REGNIER	(SACLAY)
BIRGE	65	PR 139 B 1600	+ELY+GIDAL+KALMUS+CAMERINI+	(LRL+WISC)
BROWN	65	CORAL GABLES 219	BROWN+FAIER	(NORTHWESTERN)
DURAND	65	PRL 14 329	L. DURAND AND Y.T. CHIU	(YALE)
BETTINI	66	NC 42A 695	+CRESTI,LIMENTANI,LORIA,PERUZZO+	(PADO+PISA)
JACOBS	66	PRL 16 669	+SELOVE	(LRL)
KOPELMAN	66	PL 22 118	+ALLEN,GODDEN,MARSHALL +	(COLORADO+IOWA)
LOVELACE	66	PL 22 332	LOVELACE,HEINZ,DONNACHIE	(CERN)
ANDERSON	67	PRL 18 89	+FUKUI+KESSLER+	(CHIC+ANL+CNRC+MCGILL+LOQM)
BEUSCH	67	PL 25 B 357	+FISCHER,GOBBI,ASTBURY+	(ETH+CERN)
CLEGG	67	PR 163 1664	A.B.CLEGG	(LANCASTER)
CORBETT	67	PR 156 1451	+DAMERELL+MIDDLEMAS+NEWTON	(OXF+RHEL)
GUTAY	67	PRL 18 142	+JOHNSON+LOEFFLER+MCILWAIN+	(PURDUE+LRL)
JOHNSON	67	PR 163 1497	+GUTAY,EISNER,KLEIN,PETERS,SAHNI,YEN+	(PURD)
MALAMUD	67	PRL 19 1056	E.MALAMUD + P.E.SCHLEIN	(UCLA)
WALKER	67	RMP 39 695	W.D.WALKER	(WISCONSIN)
WALKER	67	PRL 18 630	+CARROLL,GARFINKEL,OH	(WISCONSIN)
BANDER	68	PR 168 1679	+SHAW,FULCO	(UC IRVINE+S.BARBARA)
BISWAS	68	PL 27 B 513	+CASON,JOHNSON,KENNEY,POIRIER+	(NDAM)
BRAUN	68	PRL 21 1275	BRAUN,CLINE,SCHERER	(WISCONSIN)
DUTTA-RO	68	PR 169 1357	B. DUTTA-ROY, I.R. LAPIDUS	(STEV)
EISENHAN	68	PRL 20 758	EISENHANDLER,MISTRY,MOSTEK +	(CORNELL)
FOSTER	68	NP B 6 107	+GAVILLET+LABROSSE+MONTANET+	(CERN+CDEF)
HYAMS	68	NP B7 1	+KOCH,POTTER,..VON LINDERN,LOREN	(CERN+MPIM)
JONES	68	PR 166 1405	+CALDWELL+ZACHAROV+HARTING+BLEULER+	(CERN)
JOHNSON	68	PR 176 1651	+POIRIER,BISWAS,GUTAY+	(NDAM+PURD+SLAC)
LOVELACE	68	PL 28 B 264	C.LOVELACE	(CERN)
MARATECK	68	PRL 21 1613	+HAGOPIAN,+	(PENN+LRL+COLO+PURD+TNTO+WISC)
BIZZARRI	69	NP B14 169(SEE P.190)	+FOSTER,GAVILLET,GHESQUIERE+	(CERN+CDEF)
DAVISON	69	PR 180 1333	+BACASTOW,BARKAS,+	(UCR+UCB)
DEINET	69	PL 30 B 359	+MENZIONE,MULLER,STAUDENMAIER,+	(KARL+CERN)
ELY	69	PR 180 1319	+GIDAL,HAGOPIAN,+	(UCB+LOUC+WISC)
FELDMAN	69	PRL 22 316	+FRATI,GLEESON,HALPERN,NUSSBAUM,+	(PENN)
GUTAY	69	NP B 12 31	+CARMONY,CSONKA,LOEFFLER,MEIERE	(PURDUE)
HALL	69	NP B 12 573	+MURRAY,RIDDIFORD	(BIRMINGHAM)
HOPKINSO	69	NC 59 A 181	J.HOPKINSON,R.G.ROBERTS	(CERN)
MALAMUD	69	ARGONNE CONF.P.93	E.MALAMUD, P.SCHLEIN	(UCLA)
MORGAN	69	NP B 10 261	D.MORGAN,G.SHAW	(RHEL)
ROBERTS	69	PL 29 B 368	R.G. ROBERTS, F. WAGNER	(CERN)
SCHAREN1	69	ARGONNE CONF.306	SCHARENGUIVEL	(PURDUE)
SCHAREN2	69	PR 186 1387	SCHARENGUIVEL	(PURD+LRL+CERN+COLO+PENN+TNTO)
SMITH	69	PRL 23 335	G.A.SMITH, R.J.MANNING	(MSU+LRL)
SONDEREG	69	SEE BASDEVANT 72	SONDEREGGER,BONAMY	(SACL)
STRUGALS	69	PL 29 B 518	+CHUVILO,FENYVES,+	(WARS+JINR+BUDA)
ALSO	70	NP B 24 358	STRUGALSKI,CHUVILO,FENYVES,GEMESY,+	(DUBNA)
WAGNER	69	NC 64 A 189	F.WAGNER	(CERN)
BARTSCH	70	NP B 22 1	+KEPPEL,GENSCH,MORRISON,+	(AACH+BERL+CERN)
BATON	70	PL 33 B 528	+LAURENS,REIGNIER	(SACLAY)
BRODY	70	PRL 24 948	+GROVES,VANBERG,MAGLIC+	(PENN+RUTG+UPNJ+ANL)
DIAZ	70	NP B 16 239	+GAVILLET,LABROSSE,MONTANET+	(CERN+CDEF)
HYAMS	70	PHILAD.CONF.P.41	+SCHLEIN,BEUSCH,+	(CERN+MPIM+ETH+LOIC+HAWA)
MAUNG	70	PL 33 B 521	+MASEK,MILLER,RUDERMAN,VERNON,+	(UCSD+LRL)
MORGAN 1	70	SPRINGER TRACTS MOD.PHYS.,VOL.55,P.1.	MORGAN,PISUT	(RHEL+CERN)
MORGAN 2	70	PR D 2 520	D.MORGAN,G.SHAW	(RHEL)
NIELSEN	70	NP B 22 525	+LYNG-PETERSEN,PIETARINEN	(NORDITA)
OH	70	PR D 1 2494	+GARFINKEL,MORSE,WALKER,PRENTICE	(WISC+TNTO)
SCHARENG	70	NP B 22 16	SCHARENGUIVEL,GUTAY,MILLER,+	(PURD+PENN)
SHIBATA	70	PRL 25 1227	+FRISCH,WAHLIG	(MIT)
ALSTON-G	71	PL 36 B 152	ALSTON-GARNJOST,BARBARO-GALTIERI,+	(LBL)
BANAIGS	71	NP B 28 509	+BERGER,DUFLO,GOLDZAHL,COTTEREA+	(SACL+CAEN)
BEAUPRE	71	NP B 28 77	+DEUTSCHMANN,GRAESSLER,+	(AACH+BERL+CERN)
BENSINGE	71	PL 36 B 134	BENSINGER,ERWIN,THOMPSON,W.D.WALKER	(WISC)
DUBAL	71	NP B 32 535	L.DUBAL,D.J.BROWN	(CNRC+CARL)
GUILLOU	71	NC 5 A 659	LE GUILLOU,MOREL,NAVELET	(CERN)
GUTAY	71	NP B 27 486	+SCHARENGUIVEL,FUCHS,GAIDOS,MILLER,+	(PURD)
HAMILTON	71	SPRINGER TRACTS MOD.PHYS.,VOL. 57,P.41	J.HAMILTON	(NORDITA)
KIM	71	PR D 4 265	+BANDER	(UCI)
LYNG PET	71	PHYS.REPRTS 2 155	J.LYNG PETERSEN (REVIEW)	(CERN)
APEL	72	PL 41 B 542	+AUSLANDER,MULLER,BERTOLUCCI,+	(KARL+PISA)
BAILLON	72	PL 38 B 555	+CARNEGIE,KLUGE,LEITH,LYNCH,RATCLIFF+	(SLAC)
BASDEVAN	72	PL 41 B 178	BASDEVANT,FROGGATT,PETERSEN	(CERN)
BRODY 1	72	PRL 28 1215	+GROVES,MAGLICH,NOREM,+	(PENN+RUTG+UPNJ)
BRODY 2	72	PRL 28 1217	H.BRODY	(PENNSYLVANIA)
CARROLL	72	PRL 28 318	+DIAMOND,FIREBAUGH,MATTHEWS,+	(WISC+TNTO)
ELVEKJAE	72	NP B 43 445	F.ELVEKJAER	(AARHUS)
FLATTE	72	PL 38 B 232	+ALSTON-GARNJOST,BARBARO-GALTIERI,	(LBL)
FRENKIEL	72	NP B 47 61	+GHESQUIERE,LILLESTOL,CHUNG,+	(CDEF+CERN)
GAIDOS	72	NP B 46 449	+MCILWAIN,THOMPSON,WILLMANN	(PURDUE)
PRASAD	72	PR D 6 3216	+BREHM	(UNIV.OF MASSACHUSETTS)
NIELSEN	72	NP B 49 586	H.NIELSEN,G.OADES	(NORD+AARHUS)
WHITEHEA	72	NP B 48 365	WHITEHEAD,AULD,+	(AERE+RHEL+SHMP+LOUC)
WILLIAMS	72	PR D 6 3178	P.K.WILLIAMS	(FSU)
ZYLBERSZ	72	PL 38 B 457	ZYLBERSZTEJN,BASILE,BOURQUIN,+	(GEVA+SACL)
ANJOS	73	NP B 67 37	+D.LEVY,A.SANTORO	(SACLAY)
BANAIGS1	73	PL 43 B 535	+COTTEREAU,FABBRI,+	(SACL+CAEN+FRAS)
BANAIGS2	73	NP B 67 1	+BERGER,GOLDZAHL,COTTEREAU,+	(SACL+CAEN)
BASDEVAN	73	AIX CONF.P.220	J.L.BASDEVANT RAPPORTEUR TALK	(PARIS VI)
BEIER	73	PRL 30 399	+BUCHHOLZ,MANN,PARKER,ROBERTS	(PENN)
BINNIE	73	PRL 31 1534	+CARR,DEBENHAM,DUANE,GARBUTT,+	(LOIC+SHMP)
BRAUN	73	PR D 8 3794	+D.CLINE	(WISC)
HYAMS	73	NP B 64 134	+JONES,WEILHAMMER,BLUM,DIETL,+	(CERN+MPIM)
		FOR OTHER RESULTS ON SAME	EXPERIMENT SEE GRAYER 74	
OCHS	73	THESIS	THESIS	(MPIM)
PILKUHN	73	NP B 65 460	+SCHMIDT,MARTIN,+	(KARL+CERN+LOUC+NIJM)
PROTOPOP	73	PR D 7 1280	PROTOPOPESCU,GARNJOST,GALTIERI,FLATTE+	(LBL)
RISSER	73	PL 43 B 68	T.RISSER,M.D.SHUSTER	(SACL)
SKUJA	73	PRL 31 653	+WAHLIG,RISSER,PRIPSTEIN,NELSON,+	(LBL)
BASDEVAN	74	NP B 72 413	BASDEVANT,FROGGATT,PETERSEN	(LPTP+NORD)
BONNIER	74	NP B 83 440	B.BONNIER,N.JOHANNESSON	(CERN)
CARROLL	74	PR D 10 1430	+MATTHEWS,WALKER+	(SLAC+DUKE+WISC+TNTO)
ENGLER	74	PR D 10 2070	+KRAEMER,TOAFF,WEISSER,DIAZ+	(CARN+CASE)
ESTABROO	74	NP B 79 301	P.ESTABROOKS,A.D.MARTIN	(DURH)
GRAYER	74	NP B 76 375	+HYAMS,JONES,BLUM,DIETL	(CERN+MPIM)
JONES	74	NP B 83 93	+ALLISON,SAXON	(OXF)
MORGAN	74	PL 51 B 71	D.MORGAN	(RHEL)
ORITO	74	PL 48 B 380	+FERRER,PAOLUZI,SANTONICO	(FRAS+ROMA)
PASCUAL	74	NP B 83 362	P.PASCUAL,F.J.YNDURAIN	(BARC+MADU)
BAR-NIR	75	NP B 87 109	+RISSER,SHUSTER	(CERN+UCSB+TELA)
BARRY	75	NP B 85 239	G.W.BARRY	(PURD)
BASDEVAN	75	NP B 98 285	BASDEVANT,CHAPELLE,LOPEZ,SIGELLE	(LPTP)
DONOHUE	75	NC 25 A 409	J.T.DONOHUE,Y.LEROYER	(BORD)
ESTABROO	75	NP B 95 322	P.ESTABROOKS,A.D.MARTIN	(DURH)
FROGGATT	75	NP B 91 454	C.D.FROGGATT,J.L.PETERSEN	(GLAS+NORD)
FUJII	75	NP B 85 179	Y.FUJII,M.FUKUGITA	(TOKY)
HYAMS	75	NP B 100 205	+JONES,WEILHAMMER,BLUM,DIETL+	(CERN+MPIM)
MORGAN	75	ARGONNE CONF. 45	D.MORGAN	(RHEL)
RIESTER	75	NP B 96 407	+ARNOLD,ENGEL,PATY	(STRB)
SHIMADA	75	NP B 100 225	T.SHIMADA	(TOKY)
SRINIVAS	75	PR D 12 681	SRINIVASAN,HELLAND,LENNOX,KLEM+	(NDAM+ANL)
BANAIGS	76	NP B 105 52	+BERGER,GOLDZAHL,COTTEREAU+	(SACL+CAEN+FRAS)I,JP
CASON	76	PRL 36 1485	+POLYCHRONAKOS,BISHOP,BISWAS,+	(NDAM+ANL)I J
CERRADA	76	PL 62 B 353	+GONZALEZ-ARROYO,RUBIO,YNDURAIN	(CERN+MADR)
COMMON	76	NP B 103 109	A.K.COMMON	(KENT) JP
FLATTE	76	PL 63 B 228	S.M.FLATTE	(CERN)
GRIVAZ	76	PL 61 B 400	+DAVIS,HALSTEINSLID,IRWIN,+	(LALO+BERG+EPOL)
OWENS	76	NP B 112 514	+EISNER,CHUNG,PROTOPOPESCU	(CASE+BNL)
PAWLICKI	76	PRL 37 1666	+AYRES,COHEN,DIEBOLD,KRAMER,WICKLUND	(ANL)I,JP
WETZEL	76	NP B 115 208	+FREUDENREICH,BEUSCH,+	(ETH+CERN+LOIC)
FROGGATT	77	NP B 129 89	+PETERSEN	(GLASGOW+COPENHAGEN)
DAVID	77	PR D 16 2027	+VILLET,AYED,BAREYRE,BORGEAUD,+	(SACL)
MARTIN	77	NP B 121 514	+OZMUTLU,SQUIRES	(DURHAM)
PAWLICKI	77	PR D 15 3196	+AYRES,COHEN,DIEBOLD,KRAMER,WICKLUND	(ANL)I J
ROSSELET	77	PR D 15 574	+EXTERMANN,FISHER,BERGER,BLOCH,+	(GEVA+SACL)
AGUILAR	78	NP B 140 73	+CERRADA,+	(MADRID+BOMBAY+CERN+PARIS)
GELFAND	78	NP B 138 365	+DAGAN,LISSAUER,OREN,ABRAMS+	(TELA+UCB)
HOLMGREN	78	PL 77 B 304	+PENNINGTON	(STOH+CERN)
MARTIN	78	ANP 114 1	A.D.MARTIN,M.R.PENNINGTON	(CERN)
ACHASOV	79	PL B 88 367	+DEVYANIN,SHESTAKOV	(NOVO)
APEL	79	NP B 160 42	+AUSLANDER,MULLER,REHAK+	(KARL+PISA)
BECKER 1	79	NP B 150 301	+BLANAR,BLUM,CERRADA+	(MPIM+CERN+ZEEM+CRAC)
BECKER 2	79	NP B 151 46	+BLANAR,BLUM,CERRADA+	(MPIM+CERN+ZEEM+CRAC)
BORREANI	79	NP B 147 28	+FISHER,GUY,ELY,LEUTZ,+	(TORI+RHEL+LBL+CERN)
CORDEN	79	NP B 157 250	+DOWELL,GARVEY,JOBES,+	(BIRM+RHEL+TELA+LOWC) JP
DONOHUE	79	NP B 158 123	+LEROYER	(BORD+ANL+OXF)
ESTABROO	79	PR D 19 2678	P.ESTABROOKS	(CARL)
GREENHUT	79	PR D 20 2326	+INTEMANN	(SETO)
JAFFE T	79	PR D 19 2105	R.L.JAFFE,F.E.LOW	(MIT)
MARTIN	79	NP B 158 520	+OZMUTLU	(DURH)I,JP
POLYCHRO	79	PR D 19 1317	POLYCHRONAKOS,CASON,BISHOP+	(NDAM+ANL)I,JP
ACHASOV	80	SJNP 32 566	+DEVYANIN,SHESTAKOV	(NOVO)
BOHACIK	80	PR D 21 1342	J.BOHACIK,H.KUHNELT	(BRATISLAVA+WIEN)
COHEN	80	PR D 22 2595	+AYRES,DIEBOLD,KRAMER,PAWLICKI+	(ANL)I,JP
COSTA	80	NP B 175 402	+	(BARI+BONN+CERN+GLAS+LIVP+MILA+WIEN)
DE BILLY	80	NP B 176 1	+BRIAND,DUBOC,LEVY+	(CURI+LAUS+NEUC+GLAS) JP
GORLICH	80	NP B 174 16	+NICZYPORUK,ROZANSKA+	(CRAC+MPIM+CERN+ZEEM)
GOTTESMA	80	PR D 22 1503	GOTTESMAN,JACOBS,+	(SYRA+BRAN+BNL+CINC)
LOVERRE	80	ZPHY C 6 187	+ARMENTEROS,DIONISI+	(CERN+CDEF+MADR+STOH)I,JP
WICKLUND	80	PRL 45 1469	+AYRES,COHEN,DIEBOLD,PAWLICKI	(ANL)
ACHASOV	81	PL 102 B 196	+DEVYANIN,SHESTAKOV	(NOVO)
AGUILAR	81	ZPHY C 10 299	AGUILAR-BENITEZ,DONE,MARTIN	(MADR+DURH)
AGUILAR2	81	ZPHY C 8 313	+ALBAJAR,ARMENTEROS,+	(CERN+CDEF+MADR+STOH)
BOREANI	81	NP B 187 42	+GUY,MARCHETTO,MAURIZIO,+	(TORI+RHEL+CERN)
BISWAS	81	PRL 47 1378	+CASON,BAUMBAUGH,BISHOP,CANNATA,+	(NDAM+ANL)
BRANDELI	81	ZPHY C 10 117	BRANDELIK+	(AACH+BONN+DESY+HAMB+LOIC+OXF+)
GIDAL	81	PL 107 B 153	+GOLDHABER,GUY,MILLIKAN,ABRAMS,+	(SLAC+LBL)
IRVING	81	ZPHY C 10 45	+MARTIN,DONE	(LIVP+DURH)
ACHASOV	82	TP 20(130)	+DEVYANIN,SHESTAKOV	(NOVO)
ALEKSEEV	82	JETP 55 591	ALEKSEEVA,KARTAMYSHEV,MAKARIN+	(KIAE)
CASON	82	PRL 48 1316	+BISWAS,BAUMBAUGH,BISHOP,CANNATA+	(NDAM+ANL)
ETKIN1	82	PR D 25 1786	+FOLEY,LAI,LINDENBAUM+	(BNL+CUNY+TUFT+VAND)
ETKIN2	82	PR D 25 2446	+FOLEY,LAI,LINDENBAUM+	(BNL+CUNY+TUFT+VAND)
SCHNITZE	82	PR B 117 96	H.SCHNITZER	(BRAN)
TORNQVIS	82	PRL 49 624	N.A.TORNQVIST	(HELS)
BAUBILLI	83	ZPHY C 17 309	BAUBILLIER+	(BIRM+CERN+GLAS+MSU+LPNP)
CASON	83	PR D 28 1586	+CANNATA,BAUMBAUGH,BISHOP,WATSON+	(NDAM+ANL)
HITLIN	83	CORNELL CONF. 746	DAVID HITLIN, RAPPORTEUR'S TALK	(CIT)
MENNESSI	83	ZPHY C 16 241	G.MENNESSIER	(MONP)
TORNQVIS	83	EMS CONFERENCE	N.A.TORNQVIST	(HELS)

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π(1300)

58 PI(1300,JPG=0--) I=1

SEEN IN PARTIAL WAVE ANALYSIS OF THE DIFFRACTIVELY PRODUCED 3 PI SYSTEM.

58 PI(1300) MASS (MEV)

		Value	Error	Author	Year/Type	Comment	Date
M	E	1273.0	50.0	AARON	81 RVUE		1/82
M		1342.	20.	BONESINI	81 OMEG	12 PI-P,3PI P	1/82
M		(1400.)	APPROX.	DAUM	81 SPEC	63,94 PI- P	1/82
M		1240.	30.	BELLINI	82 SPEC	40 PI-A,3PI A	8/83*

M AVERAGE MEANINGLESS (SCALE FACTOR = 2.1)

M E USES MULTICHANNEL AITCHISON-BOWLER MODEL.
M E USES DATA FROM DAUM 80 AND DANKOWYCH 81.

58 PI(1300) WIDTH (MEV)

		Value	Error	Author	Year/Type	Comment	Date
W	E	580.0	100.0	AARON	81 RVUE		1/82
W		220.	70.	BONESINI	81 OMEG	12 PI-P,3PI P	1/82
W		(600.)	APPROX.	DAUM	81 SPEC	63,94 PI- P	1/82
W		360.	120.	BELLINI	82 SPEC	40 PI-A,3PI A	8/83*

W AVERAGE MEANINGLESS (SCALE FACTOR = 2.1)

W E USES MULTICHANNEL AITCHISON-BOWLER MODEL.
W E USES DATA FROM DAUM 80 AND DANKOWYCH 81.

58 PI(1300) PARTIAL DECAY MODES

	Mode	DECAY MASSES
P1	PI(1300) INTO RHO PI	769+ 140
P2	PI(1300) INTO EPSILON(1300) PI	1300+ 140
P3	PI(1300) INTO PI (PI PI) S WAVE	140+ 140+ 140

For notation, see key at front of Listings.

Mesons
$\pi(1300)$, $A_2(1320)$

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                          58  PI(1300) BRANCHING RATIOS

R1      PI(1300) INTO (PI (PI PI) S WAVE/(RHO PI)            (P3)/(P1)
R1 E          (2.12)                    AARON     81 RVUE                         3/82
R1 E     USES MULTICHANNEL AITCHISON-BOWLER MODEL.
R1 E     USES DATA FROM DAUM 80 AND DANKOWYCH 81.

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                                     REFERENCES FOR PI(1300)

DAUM      80 PL 80 B 281           +HERTZBERGER+(AMST+CERN+CRAC+MPIM+OXF+RHEL)

AARON     81 PR D 24 1207          +LONGACRE                         (NEAS+BNL)
BELLINI   81 LISBON CONF. 413      +IVANSHIN,FRABETTI,+          (MILA+JINR+BGNA)
BONESINI  81 PL 103 B 75           +DONALD,+    (MILA+LIVP+DARE+CERN+BARI+BONN)
DANKOWYC  81 PRL 46 580            +BROCKMAN,EDWARDS+(TNTO+BNL+CARL+MCGI+OHIO)
DAUM      81 NP B 182 269          +HERTZBERGER+(AMST+CERN+CRAC+MPIM+OXF+RHEL)
EVANGELI  81 NP B 178 197          EVANGELISTA+(BARI+BONN+CERN+DARE+LIVP+MILA)

BELLINI   82 PRL 48 1697           +FRABETTI,IVANSHIN,LITKIN+ (MILA+BGNA+JINR)

LEEDOM    83 PR D 27 1426          +DE BONTE,GAIDOS,KEY,WONG+       (PURD+TNTO)
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$A_2(1320)$

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12  A2(1320,JPG=2+-) I=1

ONLY EXPERIMENTS GIVING MASS ERROR LESS THAN 15 MEV
ARE KEPT FOR AVERAGING.

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                          12  A2 MASS (MEV),  3PI MODE

M        260 1311.0      6.0            ARMENISE  68 DBC     0 5.1 PI+D          9/67
M        120 1320.      10.             BOESEBECK 68 HBC     0 8 PI+ P  *        6/68
M            1310.0     14.0            EISENBERG 69 HBC   +  4.3,5.3 GAMMA P   12/69
M        941 1306.0      4.0            ALSTON    70 HBC   +  7.0 PI+P,3PI P     1/71
M        280 1313.0      7.0            BOCKMANN  70 HBC     05. PI+P            5/70
M        360 1304.0      4.5            BARNHAM   71 HBC   +  3.7 PI+ P,(3PI)+ 11/71
M      10000 1307.       5.             BINNIE1   71 MMS   - PI-P NEAR A2 THR 11/71
M       5000 1309.       5.             BINNIE1   71 MMS   - PI-P NEAR A2 THR 11/71
M      28000 1299.0      6.0            BOWEN     71 MMS   - 5. PI- P           11/71
M      24000 1300.       6.0            BOWEN     71 MMS   + 5. PI+ P           11/71
M      17000 1309.0      4.0            BOWEN     71 MMS   - 7. PI- P           11/71
M        160 1307.       7.             BLOODWORT 72 HBC   +  5.45 PI+ P,P 3PI   1/73
M  P         1315.       5.             ANTIPOV1  73 CNTR -  25.,40. PI- P       1/74
M       1580 1306.       9.             CHALOUPKA 73 HBC  -   3.9 PI- P,P A2     2/73
M  P    1600 1318.       7.             EMMS      75 DBC     04.  PI+N,P A20    11/75
M  P    1200 1298.       8.             WAGNER    75 HBC     07.  PI+P,DEL++A2 11/75
M       1097 1320.0     10.0            BALTAY 1  78 HBC   +0 15 PI+P,P 4PI      4/78
M   P    490(1343.0)   (11.0)           BALTAY 1  78 HBC    0 15 PI+P,DEL 3PI    4/78
M           (1285.0)    (9.0)           CORDEN 2  78 OMEG  - 12-15 PI-P,3PI N   4/78
M            1306.0      8.0            FERRER    78 OMEG  - 9 PI-P,P 3PI        4/78
M  P 25000   1317.0      2.0            DAUM      80 SPEC  - 63,94 PI- P= 3PI  12/79
M  P         1310.       2.             EVANGELIS 81 OMEG  - 12 PI-P,3PI P       1/82
M                 . . . . . . . . .
M   AVG      1310.7      1.3      AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.3)
                         (SEE IDEOGRAM BELOW)

M  P    FROM A FIT TO JP=2+ RHO PI PARTIAL WAVE
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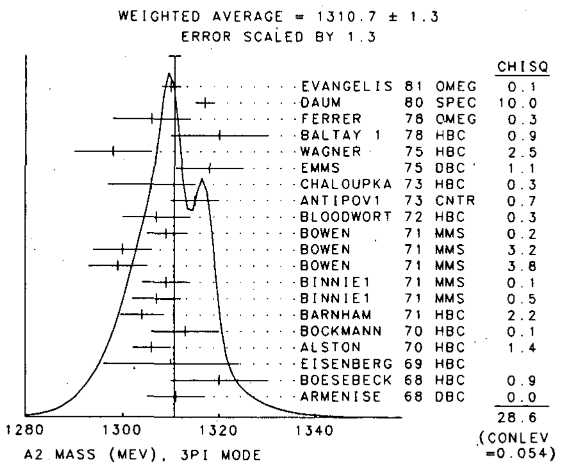


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                      12  A2 MASS (MEV), CHARGED K KBAR MODE

MK S  1500 1319.0       3.0            GRAYER    71 ASPK  - 17.2 PI-P,K-KS P   2/72
MK     730 1313.0       4.0            FOLEY     72 CNTR  - 20.3 PI- P,K- KS 12/72
MK    2724 1320.0       2.0            MARGULIES 76 SPEC  - 23.PI-P,K-KS      12/77
MK   11000 1312.0       4.0            CHABAUD   78 SPEC   -9.8 PI-P,K- KS P   4/78
MK    4730 1316.0       2.0            CHABAUD   78 SPEC  - 18.8PI-P,K- KS P   4/78
MK     350 1324.0       5.0            HYAMS     78 ASPK +  12.7 PI+P,K+KS P   4/78
MK P S     1318.        1.             MARTIN 1  78 SPEC   -10 PI P,KS K- P    4/78
MK    4000 1320.0       2.0            CHABAUD   80 SPEC  - 17PI-NUCLEI,KSK- 12/79
MK P W1000 1330.0      11.0            CLELAND   82 SPEC +  30 PI+P,KS K+ P   8/83*
MK P W4700 1319.0       5.0            CLELAND   82 SPEC +  50 PI+P,KS K+ P   8/83*
MK P W5200 1324.0       6.0            CLELAND   82 SPEC -  50 PI-P,KS K- P   8/83*
MK              . . . . . . . . .
MK  AVG    1318.22      0.70    AVERAGE

MK S    SYSTEMATIC ERROR IN MASS SCALE SUBTRACTED
MK   W  NUMBER OF EVENTS EVALUATED BY US.

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                          12  A2 MASS (MEV),  ETA PI MODE

M  E  1000 1323.        8.             KEY       73 OSPK -  6.PI-P,P PI-ETA    1/74
M  EM 6200(1324.)      (8.)            CONFORTO  73 OSPK -  6.PI-P,P MMS-      1/74
M     2561 1336.2       1.7            DELFOSSE  81 SPEC +  PI+-P,PI+-ETA P    1/82
M     1653 1330.7       2.4            DELFOSSE  81 SPEC -  PI+-P,PI+-ETA P    1/82
M              . . . . . . . . .
M   AVG    1334.0       2.6     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.9)

M  E    ERROR INCLUDES 5 MEV SYSTEMATIC MASS-SCALE ERROR
M   M   MISSING MASS WITH ENRICHED MMS=ETA PI-, ETA = 2 GAMMA

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                          12  A2 WIDTH (MEV), 3PI MODE

W       260   96.0     16.0            ARMENISE  68 DBC     0 5.1 PI+D          9/67
W       941   79.0     12.0            ALSTON    70 HBC   +  7.0 PI+P,3PI P     1/71
W       360  111.4     18.0            BARNHAM   71 HBC   +  3.7 PI+ P,(3PI)+ 11/71
W     10000 (100.)                     BINNIE1   71 MMS   - PI-P NEAR A2 THR 11/71
W      5000   72.      16.             BINNIE1   71 MMS   - PI-P NEAR A2 THR 11/71
W     28000  105.0      5.0            BOWEN     71 MMS   - 5. PI- P           11/71
W     24000   99.0      5.0            BOWEN     71 MMS   + 5. PI+ P           11/71
W     17000  103.0      5.0            BOWEN     71 MMS   - 7. PI- P           11/71
W  P         115.      15.             ANTIPOV1  73 CNTR -  25.,40. PI- P       1/74
W      1580   99.      15.             CHALOUPKA 73 HBC  -   3.9 PI- P,P A2     2/73
W  P   1600  112.      18.             EMMS      75 DBC     04.  PI+N,P A20    11/75
W  P  S1200  122.      14.             WAGNER    75 HBC     07.  PI+P,DEL++A2 11/75
W      1097  110.0     15.0            BALTAY 1  78 HBC   +0 15 PI+P,P 4PI      4/78
W   P   490 (115.0)   (14.0)           BALTAY 1  78 HBC    0 15 PI+P,DEL 3PI    4/78
W           (150.0)   (20.0)           CORDEN 2  78 OMEG  - 12-15 PI-P,3PI N   4/78
W  P  25000   96.0      9.0            DAUM      80 SPEC  - 63,94 PI- P= 3PI  12/79
W  P          97.       5.             EVANGELIS 81 OMEG  - 12 PI-P,3PI P       1/82
W               . . . . . . . . .
W   AVG      100.6      2.2     AVERAGE

W    S  WIDTH ERRORS ENLARGED BY US TO 4*WIDTH/SQRT(N),SEE K*(892) NOTE
W  P    FROM A FIT TO JP=2+ RHO PI PARTIAL WAVE

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                    12  A2 WIDTH (MEV), CHARGED K KBAR MODE

WK    S1500  123.0     13.0            GRAYER    71 ASPK  - 17.2 PI-P,K-KS P 11/71
WK      730  113.0     19.0            FOLEY     72 CNTR  - 20.3 PI- P,K- KS 12/72
WK    S2724  105.0      8.0            MARGULIES 76 SPEC  - 23.PI-P,K-KS      12/77
WK      350  110.0     18.0            HYAMS     78 ASPK +  12.7 PI+P,K+KS P   4/78
WK    11000  126.0     11.0            CHABAUD   78 SPEC   -9.8 PI-P,K- KS P   4/78
WK     4730  101.0      8.0            CHABAUD   78 SPEC  - 18.8PI-P,K- KS P   4/78
WK P S       113.       4.             MARTIN 1  78 SPEC   -10 PI P,KS K- P    4/78
WK     4000  106.0      4.0            CHABAUD   80 SPEC  - 17PI-NUCLEI,KSK- 12/79
WK P W1000   121.0     51.0            CLELAND   82 SPEC +  30 PI+P,KS K+ P   8/83*
WK P W4700   112.0     20.0            CLELAND   82 SPEC +  50 PI+P,KS K+ P   8/83*
WK P W5200   120.0     25.0            CLELAND   82 SPEC -  50 PI-P,KS K- P   8/83*
WK              . . . . . . . . .
WK  AVG      109.8      2.4     AVERAGE

WK  P    FROM A FIT TO JP=2+ PARTIAL WAVE.
WK   S  WIDTH ERRORS ENLARGED BY US TO 4*WIDTH/SQRT(N),SEE K* TYPED NOTE
WK   W  NUMBER OF EVENTS EVALUATED BY US.

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                          12  A2 WIDTH (MEV), ETA PI MODE

W      1000  108.       9.             KEY       73 OSPK -  6.PI-P,P PI-ETA    1/74
W    M 6200 (104.)     (9.)            CONFORTO  73 OSPK -  6.PI-P,P MMS-      1/74
W      2561  112.2      5.7            DELFOSSE  81 SPEC +  PI+-P,PI+-ETA P    1/82
W      1653  116.6      7.7            DELFOSSE  81 SPEC -  PI+-P,PI+-ETA P    1/82
W               . . . . . . . . .
W   AVG      112.6      4.1     AVERAGE

W   M   MISSING MASS WITH ENRICHED MMS=ETA PI-, ETA = 2 GAMMA

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                          12  A2 PARTIAL DECAY MODES

                                                           DECAY MASSES
P1      A2 INTO RHO PI                                   769+ 140
P2      A2 INTO K KBAR                                   494+ 498
P3      A2 INTO ETA PI                                   549+ 140
P4      A2 INTO OMEGA PI PI                              140+ 140+ 783
P5 S    A2 INTO PI+ PI- PI0 EXCL.RHO PI                  140+ 140+ 135
P6 S    A2 INTO PI+ PI- PI- EXCL.RHO PI                  140+ 140+ 140
P7 S    A2 INTO PI GAMMA                                 140+   0
P8 S    A2 INTO ETA PRIME PI                             958+ 140
P9 S    A2 INTO GAMMA GAMMA                                0+   0

P  S    SMALL, NOT USED IN THE FIT

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FITTED PARTIAL DECAY MODE BRANCHING FRACTIONS

The matrix below is derived from the error matrix for the fitted partial decay mode branching fractions, P_i, as follows: The diagonal elements are $P_i \pm \delta P_i$, where $\delta P_i = \sqrt{\langle \delta P_i \delta P_i \rangle}$, while the off-diagonal elements are the normalized correlation coefficients $\langle \delta P_i \delta P_j \rangle / (\delta P_i \cdot \delta P_j)$. For the definitions of the individual P_i, see the listings above; only those P_i appearing in the matrix are assumed in the fit to be nonzero and are thus constrained to add to 1.

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        P 1         P 2         P 3         P 4
P 1 .7006+-.0225
P 2   -.1065   .0487+-.0080
P 3   -.0680     -.0451   .1448+-.0117
P 4   -.8336     -.2037     -.3936   .1058+-.0250

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                          12  A2 PARTIAL WIDTHS

W7      A2 INTO PI+- GAMMA (KEV)                          (G7)
W7  M     (461.)    (110.)          MAY       77 SPEC +- 9.7 GAM N,A2 X    9/83*
W7         295.      60.            CIHANGIR  82 SPEC +  200 PI+Z,Z A2     9/83*
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Mesons

Data Card Listings

$A_2(1320)$

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W9       A2 INTO GAMMA GAMMA (KEV)                                 (69)
W9 E G  22      0.77     0.45             EDWARDS    82 CBAL    E+ E-,PIO ETA       2/82
W9 F E  35      0.81     0.61      0.30   BEHREND    83 CELL    E+E-,E+E- 3 PI      9/83*
W9 F E          0.84     0.22             FRAZER     83 JADE    E+E-,E+E- 3 PI      9/83*
W9
W9  AVG         0.82     0.18      AVERAGE

W  E    SYSTEMATIC ERROR ADDED LINEARLY BY US
W  F    FROM RHO PI DECAY MODE
W   M   MODEL DEPENDENT
W   G   FROM ETA PIO DECAY MODE.
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12 A2 BRANCHING RATIOS

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R1       A2 (CHARGED ONLY) INTO (K KBAR)/(RHO PI)                  (P2)/(P1)
R1  C         (0.054)  (0.022)            CHUNG      68 HBC   -  3.2 PI-P           1/67
R1  C         (0.06)   (0.03)             ABRAMOVIC  70 HBC   -  3.93 PI- P         1/71
R1  C         (0.07)   (0.03)             NEF        70 MMS   -  7.0 PI- P          6/70
R1  C  113    (0.097)  (0.018)            ALSTON     71 HBC   +  7.0 PI+ P          1/71
R1  C   50    (0.056)  (0.014)            CHALOUPKA  73 HBC   -  3.9 PI- P,P A2     2/73
R1             0.078    0.017             CHABAUD    78 RVUE                       12/78
R1  C   INCLUDED IN CHABAUD 78 RVUE.
R1
R1  FIT        0.070    0.012   FROM FIT

R2       A2 INTO (ETA PI)/(RHO PI + K KBAR + ETA PI)               (P3)/(P1+P2+P3)
R2      34     0.15     0.04              BARNHAM    71 HBC   +  3.7 PI+ P         11/71
R2             0.13     0.04              ESPIGAT    72 HBC   +- 0.PBAR P,         11/71
R2
R2  AVG        0.140    0.028   AVERAGE
R2  FIT        0.162    0.012   FROM FIT

R3       A2 INTO (ETA PI) / (RHO PI)                               (P3)/(P1)
R3             0.22     0.09              CONTE      67 HBC   -  11.0 PI-P          8/67
R3      22     0.23     0.08              ASCOLI     68 HBC   -  5 PI-P             6/68
R3             0.12     0.08              CHUNG      68 HBC   -  3.2 PI-P          12/66
R3      15     0.25     0.09              BOCKMANN   70 HBC   +  5.0 PI+P           9/69
R3     167     0.246    0.042             ALSTON     71 HBC   +  7.0 PI+ P          1/71
R3     149     0.211    0.044             CHALOUPKA  73 HBC   -  3.9 PI- P,P A2     2/73
R3      52     0.22     0.05              ANTIPOV    73 CNTR  -  40. PI-P,P A2-     1/74
R3             0.18     0.05              FORINO     76 HBC      11 PI- P,ETA PI   12/77
R3
R3  AVG        0.213    0.020   AVERAGE
R3  FIT        0.207    0.018   FROM FIT

R4       A2 INTO (ETA PRIME PI) / TOTAL                            (P8)
R4            (0.02) OR LESS  CL=.97      BARNHAM    71 HBC   +  3.7 PI+ P          2/72

R5       A2 INTO (ETA PRIME PI)/(RHO PI)                           (P8)/(P1)
R5             0.04     0.03      0.04    BOCKMANN   70 HBC    0 5.0 PI+ P          9/69
R5            (0.04) OR LESS              ALSTON     71 HBC   +  7.0 PI+ P          1/71
R5            (0.011)OR LESS  CL=.90      EISENSTEI  73 HBC   -  5.PI- P,P 6PI      1/74

R8       A2 INTO (K KBAR)/(RHO PI + K KBAR + ETA PI)               (P2)/(P1+P2+P3)
R8      17     0.06     0.03              BARNHAM    71 HBC   +  3.7 PI+ P,KSK+P   11/71
R8  A         (0.020)  (0.004)            ESPIGAT    72 HBC   +- 0.PBAR P,          2/72
R8       8     0.03     0.02              DAMERI     72 HBC   -  11. PI- P         12/72
R8             0.05     0.02              TOET       73 HBC   +  5. PI+ P,P K+ KO  12/75
R8             0.09     0.04              TOET       73 HBC    0 5.PI+P,PI+P K KB  12/75
R8  A   NOT AVERAGED BECAUSE OF DISCREPANCY BETWEEN MASSES
R8  A   FROM  (K KBAR)  AND  (RHO PI)  MODES
R8
R8  AVG        0.048    0.012   AVERAGE
R8  FIT        0.0545   0.0088 FROM FIT

R9       A2 INTO (PI+ PI- PI-)/(RHOO PI-)                          (P6C)/(P1C)
R9            (0.23) OR LESS  CL=.90      ABRAMOVIC  70 HBC   -  3.93 PI- P         1/71

R11      A2 INTO (PI GAMMA)/TOTAL                                  (P7)
R11R           0.005    0.005     0.003 EISENBERG 72 HBC      PHOTOPRODUCTION    11/71
R11R     PION EXCHANGE MODEL USED IN THIS ESTIMATION

R12      A2 INTO (OMEGA PI PI)/(RHO PI)                            (P4)/(P1)
R12           (0.19)   (0.08)             DEFOIX     73 HBC    0 0.7 PBAR P,7 PI   12/77
R12    279     0.10     0.05              CHALOUPKA  73 HBC   -  3.9 PI- P,P A2     2/73
R12     60     0.28     0.09              DIAZ       74 DBC    0 6.PI+N,P(5PI)0     1/74
R12  K 140    (0.29)   (0.08)             KARSHON    74 HBC    0 4.9 PI+P,DEL++A2  12/77
R12  K  60    (0.10)   (0.04)             KARSHON    74 HBC   +  4.9 PI+P,P A2+    12/77
R12  K         0.18     0.08              KARSHON    74 HBC    AVG OF ABOVE TWO    12/77
R12
R12 AVG        0.151    0.049   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.3)
R12 FIT        0.151    0.040   FROM FIT

R12  K  KARSHON 74 SUGGEST AN ADDITIONAL I=0 STATE, STRONGLY COUPLED
R12  K  TO OMEGA PI PI  COULD EXPLAIN DISCREPANCIES IN BRANCHING RATIOS
R12  K  AND MASSES. WE USE A CENTRAL VALUE AND A SYST. SPREAD.
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REFERENCES FOR A2


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ADERHOLZ 64 PL 10 226              (AACHEN+BERLIN+BIRM+BONN+HAMBURG+LOIC+MPIM)
CHUNG    64 PRL 12 621             +DAHL,HARDY,HESS,KALBFLEISCH,KIRZ       (LRL)
GOLDHABE 64 DUBNA CONF   1 480 G GOLDHABER,S GOLDHABER,OHALLORAN,SHEN(LRL)
   ALSO  64 PRL 12 336             G+S.GOLDHABER,BROWN,KADYK,TRILLING,+  (LBL)
LANDER   64 PRL 13 346             +ABOLINS,CARMONY,HENDRIKS,XUONG+ (LA JOLLA)

ABOLINS  65 ATHENS(OHIO)CONF.  +CARMONY,LANDER,XUONG,YAGER      (LA JOLLA)I=1
ADERHOLZ 65 PR 138 B 897               (AACHEN+BERL+BIRM+BONN+HAMB+LOIC+MPIM)
ALITTI   65 PL 15 69               ALITTI,BATON,DELER,CRUSSARD+  (SACLAY+BGNA)  JP
CHUNG    65 PRL  15  325           +DAHL,HARDY,HESS,JACOBS,KIRZ,MILLER   (LRL)
FORINO   65 PL 19 68               +GESSAROLI+      (BGNA+BARI+FIRZ+ORSA+SACL)
LEFEBVRE 65 PL 19 434              CERN MISSING MASS SPECTROMETER GROUP (CERN)
SEIDLITZ 65 PRL 15 217             L SEIDLITZ,O I DAHL,D H MILLER         (LRL)

BARNES   66 PRL 16 41              BARNES,FOWLER,LAI,ORENSTEIN +    (BNL+CUNY)
BENSON   66 MICH COO-1112-4        G.C.BENSON, THESIS                    (MICH)
   ALSO  66 PRL 16 1177            G BENSON,LOVELL,MARQUIT,ROE  +        (MICH)
EHRLICH  66 PR 152 1194            R. EHRLICH,W.SELOVE,H.YUTA            (PENN)
FERBEL   66 PL 21 111              FERBEL                           (ROCHESTER)
LEVRAT   66 PL  22  714            CERN MISSING MASS SPECTROMETER GROUP (CERN)

ARMENISE 67 PL 25B 53              ARMENISE,FORINO,+     (BARI+BGNA+FIRZ+ORSAY)
BALTAY   67 PL 25B 160             +KIRSCH+KUNG+YEH+RABIN   (COLU+BNL+RUTGERS)
BARLOW   67 NC 50A 701             +LILLESTOL+MONTANET+  (CERN+CDEF+IRAD+LIVP)
BARTSCH  67 PL 25B 48              +DEUTSCHMANN+GROTE+COCCONI+(AACH+BERL+CERN)
BEUSCH   67 PL 25 B 357            +FISCHER,GOBBI,ASTBURY+            (ETH+CERN)
CASON    67 PRL 18 880             +LAMSA,BISWAS,DERADO,GROVES,+   (NOTREDAME)
CHIKOVAN 67 PL 25B 44              CERN MISSING MASS SPECTROMETER GROUP (CERN)
CHUNG    67 PRL 18 100             +DAHL,HARDY,HESS,KIRZ,MILLER          (LRL)
   ALSO  66 UCRL-16832             RICHARD I HESS--THESIS,BERKELEY       (LRL)
COHN     67 NP B1 57               +MCCULLOCH+BUGG+CONDO       (ORNL+UNIV.TENN.)
CONFORTO 67 NP B3 469              +MARECHAL,MONTANET+    (CERN+CDEF+IPN+LIVP)
CONTE    67 NC  51 A  175          +TOMASINI,CORDS+(GENOVA+HAMB+MILANO+SACLAY)
DAHL     67 PR 163 1377            +HARDY+HESS+KIRZ+MILLER               (LRL)
DANYSZ   67 NC 51 A 801            DANYSZ+FRENCH+SIMAK                   (CERN)
SLATTERY 67 NC 50A 377             +KRAYBILL+FORMAN+FERBEL        (YALE+ROCH)  JP

ARMENISE 68 PL 26B 336             ARMENISE,FORINO,+     (BARI+BGNA+FIRZ+ORSAY)
ASCOLI   68 PRL 20  1321           +CRAWLEY,MORTARA,SHAPIRO,BRIDGES+(ILLINOIS)  JP
BALLAM   68 PRL 21 934             +BRODY,CHADWICK,FRIES,GUIRAGOSSIAN+  (SLAC)
BENZ     68 PL 28 B 233            CERN MISSING MASS SPECTROMETER GROUP (CERN)
BOESEBEC 68 NP B 4 501             BOESEBECK,DEUTSCHMANN,+(AACHEN+BERLIN+CERN)
CASO     68 NC 54 A 983            +CONTE+CORDS+DIAZ+ (GENOVA+HAMB+MILAN+SACL)
CHUNG    68 PR 165 1491            S.U.CHUNG,O.DAHL,J.KIRZ,D.H.MILLER    (LRL)
CRENNELL 68 PRL 20 1318            +KARSHON+KWAN LAI,SCARR,SKILLICORN    (BNL)
DONALD   68 PL 26 B  327           +FRODESEN+BETTINI+   (LIVERPOOL+OSLO+PADUA)
FOSTER   68 NP B 8 174             +GAVILLET,LABROSSE,MONTANET,+   (CERN+CDEF)
FRIDMAN  68 PR 167 1268            +MAURER,MICHALON,OUDET+(HEID   +STRASBOURG)
JUNKMANN 68 NP B8 471              +COCCONI,+         (AACH+BERL+BONN+CERN+WARS)
KEY      68 PR 166 1430            +PRENTICE+COOPER+MANNER+    (TNTO+ANL+WISC)
LAMSA    68 PR 166 1395            +CASON+BISWAS+DERADO+GROVES+    (NOTREDAME)
VON KROG 68 PL 27 B 253            +MIYASHITA,KOPELMAN,MARSHALL LIBBY   (COLO)

ADERHOLZ 69 NP B 11 259            +BARTSCH,+          (AACH+BERL+CERN+JAGL+WARS)
AGUILAR 169 PL 29 B  62            +BARLOW,JACOBS,DELLA NEGRA+(CERN+CDEF+LIVP)
AGUILAR 269 PL 29 B  241           M.AGUILAR-BENITEZ,J.BARLOW,+    (CERN+CDEF)
ANDERSON 69 PRL 22 1390            +COLLINS,+                       (BNL+CARN)
ARMENISE 69 LNC 2 501              +GHIDINI,FORINO,CARTACCI+  (BARI+BGNA+FIRZ)
CHIKOVAN 69 PL 28 B  526           CERN MISSING MASS SPECTROMETER GROUP (CERN) JP
CRENNELL 69 PRL 22 1327            +KARSHON,KWAN WU LAI,+                (BNL)IJP
DONALD   69 NP B 12 325            +EDWARDS,FOSTER,MOORE           (LIVERPOOL)
EISENBER 69 PRL 23 1322            EISENBERG,HABER,BALLAM,CHADWICK+(REHO+SLAC)
VETLITSK 69 SJNP 9 596             VETLITSKY,GRIGOREYEV,GRISHIN,+       (ITEP)

ABRAMOVI 70 NP B 29 466            ABRAMOVICH,BLUMENFELD,BRUYANT,+      (CERN)  JP
ALSTON   70 PL 33 B 607            +BARBARO,BUHL,DERENZO,EPPERSON,FLATTE+(LRL)
ASCOLI   70 PRL 25 962             +BROCKWAY,CRAWLEY,EISENSTEIN,HANFT,+  (ILL)  JP
BASILE   70 LNC 4 838              +DALPIAZ,FRABETTI,MASSAM,+ (CERN+BGNA+STRB)
BAUD1    70 PL 31B  397            CERN BOSON SPECTROMETER GROUP        (CERN)
BAUD2    70 PHILAD.CONF.P.311 CERN BOSON SPECTROMETER GROUP        (CERN)
BAUD3    70 PL 31 B 401            CERN BOSON SPECTROMETER GROUP        (CERN)
BOCKMANN 70 NP B 16 221            +MAJOR,POLS,+     (BONN+DURH+NIJM+EPOL+TORI)
BUTLER   70  UCRL 19845            THESIS                                (LRL)
CAROLL   70 PRL 25 1393            +FIREBAUGH,GARFINKEL,MORSE,OH,+ (WISC+TNTO)
CASO     70 LNC 3 707              +CONTE,TOMASINI,CORDS+(GENO+HAMB+MILA+SACL)
DIAZ     70 NP B 16 239            +GAVILLET,LABROSSE,MONTANET+    (CERN+CDEF)JP
DZIERBA  70 PR D 2 2544            +SHEPHARD,BISWAS,CASON,JOHNSON,KENNEY(NDAM)
GARFINKE 70 PL 33 B 536            GARFINKEL,AMMANN,CARMONY,YEN         (PURD)JPC
JOHNSTON 70 NP B 24 253            +KEY,PRENTICE,YOON,GARFINKEL,+  (TNTO+WISC)
KRUSE    70 PHILAD.CONF.P.359 U.KRUSE, PARTIAL WAVE ANALYSIS        (ILL)  JP
NEF      70  THESIS+PRIV.COMM.CERN BOSON SPECTROMETER GROUP        (CERN)
SUTHERLA 70 PHILAD.CONF.P.369 G.SUTHERLAND,INTERFERING RESONANCE(GLASGOW)

AGUILAR  71 PR D 4 2583            AGUILAR-BENITEZ,EISNER,KINSON         (BNL)
ALSTON   71 PL 34 B 156            +BARBARO,BUHL,DERENZO,EPPERSON,FLATTE+(LRL)
BARNHAM  71 PRL 26 1494            +ABRAMS,BUTLER,COYNE,GOLDHABER,HALL,+ (LBL)
BEKETOV  71 SJNP 4 765             +SOMBKOWSKY,KONOWALOV,KRUTSCHININ,+  (ITEP)  JP
BINNIE1  71 PL 36 B 257            +CAMILLERI,DUANE,FARUQI,BURTON,+(LOIC+SHMP)
BINNIE2  71 PL 36 B 537            +CAMILLERI,DUANE,FARUQI,BURTON,+(LOIC+SHMP)
BOWEN    71 PRL 26 1663            +FARLES,FAISSLER,BLIEDEN,+       (NEAS+STON)
CRENNEL  71 PL 35 B 185            +GORDON,KWAN-WU LAI,SCARR             (BNL)
FARBER   71 NP B 29 237            +DE PINTO,BISWAS,CASON,DEERY,KENNEY,+(NDAM)
FOLEY    71 PRL 26 413             +LOVE,OZAKI,PLATNER,LINDENBAUM,+ (BNL+CUNY)
GRAYER   71 PL 34 B 333            +HYAMS,JONES,SCHLEIN,BLUM,DIETL+(CERN+MPIM)
LYNCH    71 UCRL 20022 AND 71 AMSTERDAM CONF.  G.LYNCH                (LBL)
RINAUDO  71 NC 5 A 239             +BOECKMANN,MAJOR+(TORI+BONN+DURH+NIJM+EPOL) JP

ANKENBRA 72 PRL 29 1688            ANKENBRANDT,BRABSON,CRITTENDEN,HEINZ,+(IND)
BERENYI  72 NP B 37 621            +PRENTICE,STEENBERG,YOON,WALKER (TNTO+WISC)
BLOODWOR 72 NP B 37 203            BLOODWORTH,JACKSON,PRENTICE,YOON     (TNTO)
DAMERI   72 NC 9 A 1               +BORZATTA,GOUSSU,+         (GENO+MILA+SACL)
DIEBOLD  72 BATAVIA CONF.          R.DIEBOLD  RAPPORTEUR TALK            (ANL)
EISENBER 72 PR D 5 15              EISENBERG,BALLAM,DAGAN,+   (REHO+SLAC+TELA)
ESPIGAT  72 NP B 36 93             +GHESQUIERE,LILLESTOL,MONTANET  (CERN+CDEF)
FOLEY    72 PR D 6 747             +LOVE,OZAKI,PLATNER,LINDENBAUM,+ (BNL+CUNY)
LASSILA  72 PRL 28 1491            LASSILA,YOUNG                        (IOWA)
MORSE    72 NP B 43 77             +OH,WALKER,JOHNSTON,YOON        (WISC+TNTO)

AMMANN   73 PR D 7 1345            +CARMONY,GARFINKEL,GUTAY,MILLER+(PURD+IUPU)
ANKEBRAN 73 PR D 8 2785            ANKEBRANDT,BRABSON,CRITTENDEN,HEINZ,+ (IND)
ANTIPOV  73 NP B 63 175            +ASCOLI,BUSNELLO,FOCACCI,+      (CERN+SERP)  JP
ANTIPOV1 73 NP B 63 153            +ASCOLI,BUSNELLO,FOCACCI,+      (CERN+SERP)  JP
ANTIPOV2 73 NP B 63 141            +ASCOLI,BUSNELLO,FOCACCI,+      (CERN+SERP)  JP
CASON    73 NP B 64 14             +MADDEN,BISHOP,BISWAS,KENNEY,+       (NDAM)
CHALOUPK 73 PL 44 B 211            CHALOUPKA,DOBRZYNSKI,FERRANDO,LOSTY,+(CERN)
CONFORTO 73 PL 45 B 154            +MOBLEY,KEY,PERPOST,+  (EFI+FNAL+TNTO+WISC)
DEFOIX   73 PL 43 B 141            +DOBRZYNSKI,ESPIGAT,NASCIMENTO,+     (CDEF)
EISENSTE 73 PR D 7 278             EISENSTEIN,SCHULTZ,ASCOLI,IOFFREDO,+  (ILL)
KEY      73 PRL 30 503             +CONFORTO,MOBLEY,+      (TNTO+EFI+FNAL+WISC)
TOET     73 NP B 63 248            +THUAN,MAJOR,RINAUDO,+(NIJM+BONN+DURH+TORI)

DIAZ     74 PRL 32 260             +DIBIANCA,FICKINGER,ANDERSON,+  (CASE+CARN)
KARSHON  74 PRL 32 852             +MIKENBERG,PITLUCK,EISENBERG,RONAT+  (REHO)
OTTER    74 NP B80 1               +RUDOLPH+          (AACH+BERL+BONN+CERN+HEID)  JP
TABAK    74  BOSTON P. 46          +RONAT,ROSENFELD,LASINSKI+       (LBL+SLAC)  JP
THOMPSO1 74 PR D9 560              THOMPSON,GAIDOS,MCILWAIN,WILLMANN    (PURD)  JP
THOMPSO2 74 NP B69 381             THOMPSON,BADEWITZ,GAIDOS,MCILWAIN+   (PURD)  JP

ABASHIAN 75 PRL 34 691             +BEAMER,BROSS,EISENSTEIN,+     (ILL+ANL+ISU)
EMMS     75 PL 58B 117             +JONES,KINSON,STACEY,BELL+ (BIRM+DURH+RHEL)  JP
LOSTY    75 PL 56B 96              +CHALOUPKA,MONTANET,GANDOIS+    (CERN+SACL)  JP
UNDERWOO 75 PR D11 2345            UNDERWOOD,CONFORTO,KEY+(EFI+FNAL+TNTO+WISC)
   ALSO  73 CONFORTO, 73 KEY
WAGNER   75 PL 58B 201             +TABAK,CHEW                           (LBL)  JP

FORINO   76 NC A 35 465            +GESSAROLI,+  BGNA+FIRZ+GENO+MILA+OXF+PAV
HANDLER  76 NP B 110 173           +PLANO,BRUCKNER,KOLLER,,+  (RUTG,STEV,SETO)
MARGULIE 76 PR D 14 667            +KRAMER,FOLEY,LOVE,LINDENBAUM,+  (BNL+CUNY)

CERRADA  77 NP B 126 241           +BLOCKZIJL,HEINEN,+     (AMST+CERN+NIJM+OXF)
MAY      77 PR D 16 1983           +ABRAMSON,ANDREWS,BUSNELLO,+    (ROCH+CORN)
PAWLICKI 77 PR D 15 3196           +AYRES,COHEN,DIEBOLD,KRAMER,WICKLUND  (ANL)I J

BALTAY 1 78 PR D 17 62             +CAUTIS,COHEN,CSORNA,SMITH,YEH,+(COLU+BING)
BALTAY 2 78 PRL 40 87              +CAUTIS,KALELKAR                     (COLU)  JP
CHABAUD  78 NP B 145 349           +HYAMS,JONES,WEILHAMMER,BLUM,+  (CERN+MPIM)
CORDEN 1 78 NP B 136 77            DOWELL,GARVEY,JOBES+  (BIRM+RHEL+TELA+LOWC)  JP
CORDEN 2 78 NP B 138 235           +CORBETT,ALEXANDER,+  (BIRM+RHEL+TELA+LOWC)
FERRER   78 PL 74 B 287            +TREILLE,RIVET +      (ORSAY+CERN+CDEF+LPNP)
HYAMS    78 NP B 146 303           +JONES,WEILHAMMER,BLUM,+   (CERN+MPIM+ATEN)
MARTIN 1 78 PL 74 B 417            +OZMUTLU+BALDI,BOHRINGER,DORSAZ+(DURH+GEVA)  JP
MARTIN 2 78 NP B 140 158           +OZMUTLU,BALDI,BOHRINGER,DORSAZ+(DURH+GEVA)

CHABAUD  80 NP B 175 189           +HYAMS,PAPADOPOULOU,+        (CERN+MPIM+AMST)
DAUM     80 PL 89 B 276            +HERTZBERGER+(AMST+CERN+CRAC+MPIM+OXF+RHEL)  JP

DAUM     81 NP B 182 269           +HERTZBERGER+(AMST+CERN+CRAC+MPIM+OXF+RHEL)
DELFOSSE 81 NP B 183 349           +GUISAN,MARTIN,MUHLEMANN,WEILL,+(GEVA+LAUS)
EVANGELI 81 NP B 178 197           EVANGELISTA+(BARI+BONN+CERN+DARE+LIVP+MILA)
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BEHREND 82 PL 114 B 378 +D-AGOSTINI+(DESY+KARL+MPIM+LALO+LPNP+SACL)
CIHANGIR 82 PL 117 B 123 +BERG,BIEL,CHANDLEE,FERBEL+(FNAL+MINN+ROCH)
CLELAND 82 NP B 208 228 +DELFOSSE,DORSAZ,GLOOR(DURH+GEVA+LAUS+PITT)
EDWARDS 82 PL 110 B 82 +PARTRIDGE,PECK,+ (CIT+HARV+PRIN+STAN+SLAC)

BEHREND 83 PL 125 B 518 +D-AGOSTINI+(DESY+KARL+MPIM+LALO+LPNP+SACL)
FRAZER 83 AACHEN CONF. RAPPORTEUR TALK (UCSD)
JENNI 83 PR D 27 1031 +BURKE,TELNOV,ABRAMS,BLOCKER+ (SLAC+LBL)

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E(1420)

6 E(1420,JPG=1++) I=0

NOTE ON THE E(1420) AND ι(1440)

We are tentatively splitting the data on the E(1420)/ι(1440) into two entries according to the proposed J^{PC} assignments.

The $J^{PC} = 1^{++}$ state (DIONISI 80), E(1420), appears to have a dominant decay mode into the $K^*(892)K$ system.

The state with $J^{PC} = 0^{-+}$ is named ι(1440). Under this entry we group the results obtained in the early $\overline{p}p$ annihilation experiment at rest (BAILLON 67) and in the radiative decays of the J/ψ resonance (SCHARRE 80,81, EDWARDS 82). The ι(1440) is largely coupled to the $\delta(980)\pi$ decay channel, although the lack of a signal in the $\eta\pi\pi$ system (EDWARDS 83) is a source of concern.

Note that the experimental situation in this mass region is still confused and that forthcoming results may drastically change present views on the subject (HITLIN 83).

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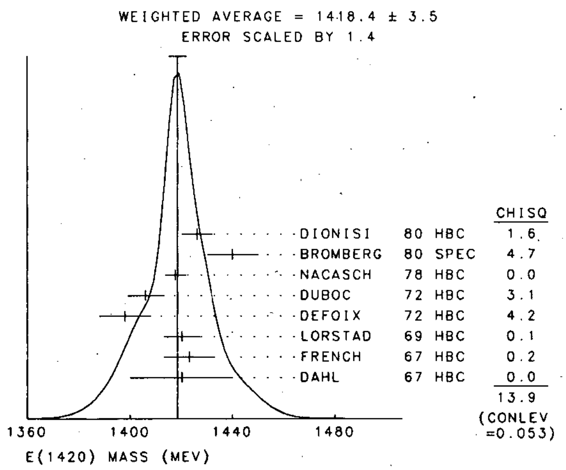
6 E(1420) MASS (MEV)

M			1420.	20.	DAHL	67 HBC	1.6-4.2 PI- P	9/66
M			1423.0	10.0	FRENCH	67 HBC	3-4 PBAR P	6/67
M		310	1420.	7.	LORSTAD	69 HBC	.7PB P,4,5-BODY	9/69
M		170	1398.	10.	DEFOIX	72 HBC	0.7 PBAR P,7 PI	1/73
M		280	1406.	7.	DUBOC	72 HBC	1.2 PBAR P,2K4PI	12/72
M		36	(1397.0)	(10.0)	CORDEN	78 OMEG	12-15PI-P,K+K-PI	4/78
M			1417.5	4.	NACASCH	78 HBC	.7,.76 PBAR P	4/78
M	A		1440.0	10.0	BROMBERG	80 SPEC	100 PI-P,2KPIX	1/82
M		221	1426.0	6.0	DIONISI	80 HBC	4. PI-P,K K PI N	12/79
M	T		(1431.0)	APPROX	TORNQVIST	82 RVUE		9/83*
M			(1432.0)	(3.0)	PALANO	83 OMEG	85 PP PI+P,2KPIX	12/83*
M			. . . . .	. . . . .				
M	AVG		1418.4	3.5	AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.4) (SEE IDEOGRAM BELOW)			

M A MASS ERROR INCREASED TO ACCOUNT FOR DELTA(980) MASS CUT UNCERTAINTIES
M T FROM A UNITARIZED QUARK MODEL CALCULATION



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6 E(1420) WIDTH (MEV)

W			60.0	20.0	DAHL	67 HBC	1.6-4.2 PI- P	10/66
W			45.	20.	FRENCH	67 HBC	3-4 PBAR P	6/67
W		310	60.	20.	LORSTAD	69 HBC	.7PB P,4,5-BODY	9/69
W		170	50.	10.	DEFOIX	72 HBC	0.7 PBAR P,7 PI	1/73
W		280	50.	12.	DUBOC	72 HBC	1.2 PBAR P,2K4PI	12/72
W		36	(45.0)	(30.0)	CORDEN	78 OMEG	12-15PI-P,K+K-PI	4/78
W			53.	20.0	NACASCH	78 HBC	.7,.76 PBAR P	4/78
W			62.0	14.0	BROMBERG	80 SPEC	100 PI-P,2KPIX	1/82
W		221	40.0	15.0	DIONISI	80 HBC	4. PI-P,K K PI N	12/79
W			(58.0)	(9.0)	PALANO	83 OMEG	85 PP PI+P,2KPIX	12/83*
W			. . . . .	. . . . .				
W	AVG		51.7	5.2	AVERAGE			

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6 E(1420) PARTIAL DECAY MODES

		DECAY MASSES
P1	E(1420) INTO K K*(892)	498+ 892
P2	E(1420) INTO K KBAR PI	498+ 498+ 140
P3	E(1420) INTO PI PI RHO	140+ 140+ 769
P4	E(1420) INTO DELTA(980) PI	983+ 140
P5	E(1420) INTO ETA PI PI	549+ 140+ 140
P6	E(1420) INTO 4 PI	140+ 140+ 140+ 140
P7	E(1420) INTO GAMMA GAMMA	0+ 0

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6 E(1420) PARTIAL WIDTHS (KEV)

W7 E(1420) INTO (GAMMA GAMMA)*(P2) (G7)*(P2)
W7 A 8.0 OR LESS CL=0.95 JENNI 83 SMK2 GAM GAM,KKBAR PI 1/84*
W7 A THIS IS THE PARTIAL WIDTH TIMES THE E(1420) BRANCHING FRACTION
W7 A INTO K KBAR PI. SEE ALSO IOTA(1440).

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6 E(1420) BRANCHING RATIOS

R1 E(1420) INTO (KBAR K*(892) + C.C.)/(K KBAR PI) (P1)/(P2)
R1 0.76 0.06 BROMBERG 80 SPEC 100 PI-P,2KPIX 1/82
R1 0.86 0.12 DIONISI 80 HBC 4. PI-P,K K PI N 12/79
R1 AVERAGE MEANINGLESS

R2 E(1420) INTO (PI PI RHO) / (K KBAR PI) (P3)/(P2)
R2 (2.0) OR LESS DAHL 67 HBC 0 1.6-4.2 PI- P 10/66
R2 (0.3) OR LESS CL=.95 CORDEN 78 OMEG 12-15PI-P 4/78

R3 E(1420) INTO (ETA 2 PI)/(K KBAR PI) (P5)/(P2)
R3 (1.5) OR LESS CL=.95 FOSTER 68 HBC - 0.0 PBAR P 9/69
R3 1.5 0.8 DEFOIX 72 HBC 0.7 PBAR P 1/73
R3 (0.5) OR LESS CL=.95 CORDEN 78 OMEG 12-15PI-P 4/78

R4 E(1420) INTO (DELTA(980) PI)/(ETA PI PI) (P4)/(P5)
R4 0.4 0.2 DEFOIX 72 HBC 0.7 PBAR P,7 PI 1/73
R4 NOT SEEN IN EITHER MODE CORDEN 78 OMEG 12-15PI-P 4/78

R5 E(1420) INTO (4PI)/(KBAR K*(892) +C.C.) (P6)/(P1)
R5 (0.90)OR LESS CL=.95 DIONISI 80 HBC 4. PI-P,K K PI N 12/79

R6 E(1420) INTO (P2)/(P1+P4)
R6 (K KBAR PI)/(DELTA PI + KBAR K*(892) +C.C)
R6 C 0.65 0.27 DIONISI 80 HBC 4. PI-P 2/81
R6 C CALCULATED USING,
R6 C (DELTA(980) INTO K KB)/(DELTA(980) INTO ETA PI)=0.24+-0.07

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REFERENCES FOR E(1420)

BARASH 67 PR 156 1399 BARASH,KIRSCH,MILLER,TAN (COLUMBIA)
DAHL 67 PR 163 1377 +HARDY+HESS+KIRZ+MILLER (LRL)I JP
ALSO 65 PRL 14 1074 MILLER,CHUNG,DAHL,HESS,HARDY,KIRZ+(LRL+UCB)
FRENCH 67 NC 52A 438 +KINSON+MCDONALD+RIDDIFORD+ (CERN+BIRM)

FOSTER 68 NP B 8 174 +GAVILLET,LABROSSE,MONTANET,+ (CERN+CDEF)

BETTINI 69 NC 62 A 1038 +CRESTI,LIMENTANI,BERTANZA,BIGI+(PADO+PISA)IC
LORSTAD 69 NP B 14 63 B.LORSTAD,D-ANDLAU,ASTIER,+ (CDEF+CERN) JP

DEVONS 71 PRL 27 1614 +KOZLOWSKI,HORWITZ,+ (COLU+SYRA)

CHAPMAN 72 NP B 42 1 +CHURCH,LYS,MURPHY,RING,VANDER VELDE (MICH)
DEFOIX 72 NP B 44 125 +NASCIMENTO,BIZZARRI,+ (CDEF+CERN)
DUBOC 72 NP B 46 429 +GOLDBERG,MAKOWSKI,DONALD,+ (LPNP+LIVP)

VUILLEMI 75 LNC 14 165 VUILLEMIN,+ (LAUS+NEUC+LPNP+LIVP+GLAS) JP

HANDLER 76 NP B 110 173 +PLANO,BRUCKER,KOLLER+ (RUTG+STEV+SETO)
VUILLEMI 76 NC 33A 133 +VUILLEMIN,+ (LAUS+NEUC+LPNP+LIVP+GLAS)

GRASSLER 77 NP B 121 189 +(AACHEN+BERLIN+BONN+CERN+CRACOW+HEID+WARS)
CORDEN 78 NP B 144 253 +CORBETT,ALEXANDER,+ (BIRM+RHEL+TELA+LOWC)
IRVING 78 NP B 139 327 A.C.IRVING,H.R.SEPANGI (LIVP)
NACASCH 78 NP B 135 203 +DEFOIX,DOBRZYNSKI,+ (PARIS+MADRID+CERN)

STANTON 79 PRL 42 346 +BROCKMAN,DANKOWYCH,+ (OSU+CARL+MCGI+TNTO) JP

BROMBERG 80 PR D 22 1513 +HAGGERTY,ABRAMS,DZIERBA(CIT+FNAL+ILLC+IND)
ALSO 82 PRIVATE COMM. C.BROMBERG (MSU)
DIONISI 80 NP B 169 1 +GAVILLET,ARMENTEROS+ (CERN+MADR+CDEF+STOH)I,JP
LACAZE 81 NP B 186 247 +NAVELET (SACL)

BAILLON 82 PARIS CONFERENCE P.BAILLON (CERN)
GAVILLET 82 ZPHY C 16 119 +ARMENTEROS,AGUILAR+ (CERN+CDEF+PADO+ROMA)
EDWARDS 82 PRL 49 259 +PARTRIDGE,PECK+ (CIT+HARV+PRIN+STAN+SLAC)
ALSO 83 PRL 50 219 EDWARDS+PARTRIDGE+(CIT+HARV+PRIN+STAN+SLAC)
TORNQVIS 82 NP B 203 268 TORNQVIST (HELS)

BAILLON 83 CERN/EP 83-82 P.BAILLON (CERN)
EDWARDS 83 PRL 51 859 +PARTRIDGE,PECK+ (CIT+HARV+PRIN+STAN+SLAC)
HITLIN 83 CORNELL CONF. 746 DAVID HITLIN, RAPPORTEUR'S TALK (CIT)
JENNI 83 PR D 27 1031 +BURKE,TELNOV,ALAM,BOYARSKI+ (SLAC+LBL)
MENNESSI 83 ZPHY C 16 241 G.MENNESSIER (MONP)
PALANO 83 CERN/EP 83-107 +ARMSTRONG,APOSTOLAKIS(ATEN+BARI+BIRM+CERN)

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Mesons

$\iota(1440)$, $f'(1525)$

$\iota(1440)$

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27  IOTA(1440,JPG=0-+) I=0

    CALLED E BY BAILLON 67
    AND IOTA BY SCHARRE 80.
    SEE MINIREVIEW UNDER E(1420)

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                    27  IOTA(1440) MASS (MEV)

M         1425.     7.               BAILLON   67 HBC     0. PBAR P        11/66
M         1440.0   10.0    15.0      SCHARRE   80 SMK2    E+E-,J/PSI,E GAM  6/81
M     174 1440.0   20.0    15.0      EDWARDS   82 CBAL    J/PSI,ETA GAM    12/83*
M         1460.    10.               EINSWEILE 83 SMK3    E+E-,HADRONS GAM 12/83*
M         . . . . . . . . . .
M   AVG   1437.4    8.3    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.7)

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                    27  IOTA(1440) WIDTH (MEV)

W           80.    10.               BAILLON   67 HBC     0. PBAR P        11/66
W           50.0   30.0    20.0      SCHARRE   80 SMK2    E+E-,J/PSI,E GAM  6/81
W     174   55.0   20.0    30.0      EDWARDS   82 CBAL    J/PSI,ETA GAM    12/83*
W           97.    25.               EINSWEILE 83 SMK3    E+E-,HADRONS GAM 12/83*
W         . . . . . . . . . .
W   AVG     75.9    8.2    AVERAGE

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                    27  IOTA(1440) DECAY MODES

                                                          DECAY MASSES
P1      IOTA(1440) INTO K K*(892)                        498+ 892
P2      IOTA(1440) INTO K KBAR PI                        498+ 498+ 140
P3      IOTA(1440) INTO PI PI RHO                        140+ 140+ 769
P4      IOTA(1440) INTO DELTA PI                         983+ 140
P5      IOTA(1440) INTO ETA PI PI                        549+ 140+ 140
P6      IOTA(1440) INTO 4 PI                             140+ 140+ 140+ 140
P7      IOTA(1440) INTO GAMMA GAMMA                        0+   0

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                    27  IOTA(1440) PARTIAL WIDTHS (KEV)

W7      IOTA(1440) INTO (GAMMA GAMMA)*(P2)               (G7)*(P2)
W7    A        8.0   OR LESS  CL=0.95  JENNI      83 SMK2   GAM GAM,KKBAR PI  1/84*
W7    A  THIS IS THE PARTIAL WIDTH TIMES THE IOTA(1440) BRANCHING FRACTION
W7    A  INTO K KBAR PI. SEE ALSO E(1420).

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                    27  IOTA(1440) BRANCHING RATIOS

R1      IOTA(1440) INTO (KBAR K*(892) + C.C.)/(K KBAR PI)(P1)/(P2)
R1              .50      .10          BAILLON   67 HBC      0.0 PBAR P     12/78

R3      IOTA(1440) INTO (ETA 2 PI)/(K KBAR PI)            (P5)/(P2)
R3           (1.1)  OR LESS  CL=.90   SCHARRE   80 SMK2    E+E-,J/PSI,E GAM  2/81
R3           (0.5)  OR LESS  CL=.90   EDWARDS   83 CBAL    J/PSI,HADR GAM  12/83*

R6      IOTA(1440) INTO                                   (P2)/(P1+P4)
R6           (K KBAR PI)/(DELTA PI + KBAR K*(892) + C.C)
R6           (0.25) OR LESS  CL=.90   EDWARDS   82 CBAL    J/PSI,ETA GAM   12/83*
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REFERENCES FOR IOTA(1440)


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BAILLON  67 NC 50A  393          +EDWARDS+D-ANDLAU+ASTIER+  (CERN+CDEF+IRAD)

SCHARRE  80 PL 97 B 329          +TRILLING,ABRAMS,ALAM,BLOCKER+    (SLAC+LBL)

CHANOWIT 81 PRL 46 981           CHANOWITZ                             (LBL)
LIPKIN   81 PL 106 B 114         LIPKIN                               (FNAL)
SCHARRE  81 BONN CONF. 163       D.L.SCHARRE                          (SLAC)
    ALSO 81 SANTA CRUZ CONF.     COYNE,EDWARDS,+   (PRIN+CIT+HARV+STAN+SLAC)
    ALSO 80 MORIOND II 83        ASCHMAN,PARTRIDGE+(PRIN+CIT+HARV+STAN+SLAC)

ALTHOFF  82 ZPHY C 16 13         +BOERNER,BURKHARDT+   (TASSO COLLABORATION)
BAILLON  82 PARIS CONFERENCE     P.BAILLON                            (CERN)
BARNES   82 PL 116 B 365         T.BARNES AND F.E.CLOSE               (RHEL)
BARNES   82 NP B 198 360         +CLOSE,MONAGHAN                  (RHEL+OXF)
DONOGHUE 82 PL 112 B 409         J.F.DONOGHUE AND H.GOMM              (MASA)
EDWARDS  82 PRL 49 259           +PARTRIDGE,PECK+  (CIT+HARV+PRIN+STAN+SLAC)
    ALSO 83 PRL 50 219           EDWARSD+PARTRIDGE+(CIT+HARV+PRIN+STAN+SLAC)
MINAMI   82 PL 113 B 69          S.MINAMI                             (OSKC)
TANIMOTO 82 PL 116 B 198         M.TANIMOTO                           (BIEL)

BAILLON  83  CERN/EP 83-82       P.BAILLON                            (CERN)
EDWARDS  83 PRL 51 859           +PARTRIDGE,PECK+  (CIT+HARV+PRIN+STAN+SLAC)
EINSWEIL 83 BRIGHTON CONF.       K.F.EINSWEILER+MARKIII COLLABORATION (SLAC)
JENNI    83 PR D 27 1031         +BURKE,TELNOV,ABRAMS,BLOCKER+    (SLAC+LBL)
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$f'(1525)$

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13  F PRIME(1525,JPG=2++) I=0

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                    13  F PRIME MASS (MEV)

M   PRODUCED BY PION BEAM
M    N     (1502.0)   (25.0)          CORDEN    79 OMEG    12-15PI-P, N 2PI 12/79
M
M    C      1506.0      7.5           PAWLICKI  77 SPEC    6.PI N,K+K-      12/77
M           1492.0     29.0           GORLICH   80 ASPK    17 PI- P,POLARIZ 12/79
M    D      1496.0      9.     8.     CHABAUD   81 ASPK    6  PI-P          12/83*
M           1497.0      8.     9.     CHABAUD   81 ASPK    18.4 PI-P        12/83*
M           . . . . . . . . . .
M   AVG     1500.0      4.6    AVERAGE

M   PRODUCED BY K+- BEAM
M          (1515.0)    (7.0)          AMMAR     67 HBC      5.5 K-P,K KBAR   9/67
M        46(1514.)     (4.)           COLLEY    72 HBC     10.K+ P,K+ K-    12/72
M        47(1521.)     (7.)           VIDEAU    72 HBC     4.K- P,K KBAR    12/72
M
M       100 1519.       7.            AGUILAR   72 HBC     3.9,4.6 K-,K KB  12/72
M       120 1527.0      3.0           BRANDENBU 76 ASPK    13.K-P,K+K-       7/77
M       123 1522.0      6.0           BARREIRO  77 HBC     4.15 K-P,KS KS    7/77
M       166 1528.       7.            EVANGELIS 77 OMEG    10 K- P          12/77
M       650 1521.0      6.0           AGUILAR   81 HBC     4.2 K-P,LAM 2K    1/82
M       572 1521.0      3.0           ALHARRAN  81 HBC     8.25 K-P,LAM 2K   1/82
M           1529.0      3.0           ARMSTRONG 83 OMEG    18.5 K-P,K-K+LAM 12/83*
M           . . . . . . . . . .
M   AVG     1524.9      1.5    AVERAGE

M     C  WITH A PHASE SHIFT ANALYSIS
M     C  MASS  ERRORS ENLARGED BY US BY FACTOR 1.5.
M     N  FROM AN AMPLITUDE ANALYSIS WHERE THE F PRIME WIDTH AND
M     N  ELASTICITY ARE IN COMPLETE DISAGREEMENT WITH VALUES
M     N  OBTAINED FROM KKBAR CHANNEL MAKING THE SOLUTION DUBIOUS.
M     D  CHABAUD 81 IS A RE-ANALYSIS OF PAWLICKI 77 DATA.

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                    13  F PRIME WIDTH (MEV)

W   PRODUCED BY PION BEAM
W    N     (165.0)   (42.0)            CORDEN    79 OMEG    12-15PI-P, N 2PI 12/79
W          (150.0)   (83.0)   (50.0)   GORLICH   80 ASPK    17 PI- P,POLARIZ 12/79
W
W    C       66.0     15.0             PAWLICKI  77 SPEC    6.PI N,K+K-      12/77
W    M       92.0     39.0     22.0    POLYCHRON 79 STRC    7. PI-P,KS KS N  12/79
W    D       69.0     22.      16.     CHABAUD   81 ASPK    6  PI-P          12/83*
W           137.0     23.      21.     CHABAUD   81 ASPK    18.4 PI-P        12/83*
W          . . . . . . . . . .
W   AVG      83.7     16.0    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.6)

W   PRODUCED BY K+- BEAM
W          (35.0)    (25.0)            AMMAR     67 HBC      5.5 K-P, K KBAR  9/67
W       46 (28.)     (15.)             COLLEY    72 HBC     10.K+ P,K+ K-    12/72
W       47 (40.)     (10.)             VIDEAU    72 HBC     4.K- P,K KBAR    12/72
W
W      100  69.       22.              AGUILAR   72 HBC     3.9,4.6 K-P,K KB 12/72
W      120  61.0       8.0             BRANDENBU 76 ASPK    13.K-P,K+K-       7/77
W      123  62.0      19.0     14.0    BARREIRO  77 HBC     4.15 K-P,KS KS    7/77
W      166  72.0      25.0             EVANGELIS 77 OMEG    10 K- P          12/77
W      650  85.0      16.0             AGUILAR   81 HBC     4.2 K-P,LAM 2K    1/82
W      572  80.0      14.0     11.0    ALHARRAN  81 HBC     8.25 K-P,LAM 2K   1/82
W           83.0      15.0             ARMSTRONG 83 OMEG    18.5 K-P,K-K+LAM 12/83*
W          . . . . . . . . . .
W   AVG      70.3      5.1    AVERAGE

W     C  WITH A PHASE SHIFT ANALYSIS
W     C  WIDTH ERRORS ENLARGED BY US BY FACTOR 1.5.
W     M  FROM A FIT TO THE D WAVE WITH F-F PRIME INTERFERENCE. MASS FIXED
W     M  AT 1516 MEV.
W     N  SEE NOTE N UNDER MASS.
W     D  CHABAUD 81 IS A RE-ANALYSIS OF PAWLICKI 77 DATA.

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                    13  F PRIME PARTIAL DECAY MODES

                                                          DECAY MASSES
P1      F PRIME INTO PI  PI                              140+ 140
P2      F PRIME INTO K KBAR                              498+ 498
P3      F PRIME INTO K K*(892)                           494+ 892
P4      F PRIME INTO ETA ETA                             549+ 549
P5      F PRIME INTO PI PI ETA                           140+ 140+ 549
P6      F PRIME INTO PI K KBAR                           140+ 498+ 498
P7      F PRIME INTO PI+ PI+ PI- PI-                     140+ 140+ 140+ 140
P8      F PRIME INTO GAMMA GAMMA                           0+   0

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                    13  F PRIME PARTIAL WIDTHS                          12/78

W8      F PRIME INTO GAMMA GAMMA (KEV)                   (G8)            12/78
W8 B D         0.77      0.06        ALTHOFF   82 TASS    GAM GAM,2K      9/83*

W8 B    USING BRANCHING RATIO F PRIME INTO K KBAR = 1.                   12/78
W8   D  SYSTEMATIC ERROR ADDED LINEARLY BY US

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                    13  F PRIME BRANCHING RATIOS

R1      F PRIME INTO (PI PI)/TOTAL                         (P1)
R1 C        (0.0086) OR LESS          BEUSCH    75 OSPK    8.9 PI-P,KO KO N 12/77
R1          (0.063)OR LESS  CL=0.90   BRANDENBU 76 ASPK    13.K-P,K+K-       7/77
R1          (0.045)OR LESS  CL=0.95   BARREIRO  77 HBC     4.15 K-P,KS KS    7/77
R1 C         0.012     0.004          PAWLICKI  77 SPEC    6.PI N,K+K-      12/77
R1   N      (0.19)    (0.03)          CORDEN    79 OMEG    12-15PI-P, N 2PI 12/79
R1 C D       0.0075    0.0025         MARTIN    79 RVUE                     12/79
R1           0.007     0.002          COSTA     80 OMEG    10 PI-P,K+ K- N   1/82
R1 C        (0.027)   (0.071)  (0.013)GORLICH   80 ASPK    17,18 PI-P POLAR 12/79
R1          (0.06) OR LESS  CL=.95    AGUILAR   81 HBC     4.2 K-P,LAM 2K    1/82
R1          . . . . . . . . . .
R1  AVERAGE MEANINGLESS

R1 C    ASSUMING THAT THE F PRIME IS PRODUCED BY AN OPE
R1      PRODUCTION MECHANISM.
R1   D  MARTIN 79 USES THE PAWLICKI 77 DATA WITH DIFFERENT INPUT
R1      VALUE OF THE F INTO K KBAR BRANCHING RATIO.
R1   N  SEE NOTE N UNDER MASS.

R3      F PRIME INTO (ETA ETA)/(K KBAR)                   (P4)/(P2)
R3          (0.50) OR LESS            BARNES    67 HBC      4.6, 5.0 K- P   10/67

R4      F PRIME INTO (PI PI ETA)/(K KBAR)                 (P5)/(P2)
R4          (0.3)  OR LESS  CL=.67    AMMAR     67 HBC                      10/67
R4          (0.41) OR LESS  CL=.95    AGUILAR   72 HBC     3.9,4.6 K- P     12/72

R5      F PRIME INTO (PI K KBAR + K K*(892))/(K KBAR)     (P6+P3)/(P2)
R5          (0.4)  OR LESS  CL=.67    AMMAR     67 HBC                      10/67
R5          (0.35) OR LESS  CL=.95    AGUILAR   72 HBC     3.9,4.6 K- P     12/72

R6      F PRIME INTO (PI+ PI+ PI- PI-)/(K KBAR)           (P7)/(P2)
R6          (0.32) OR LESS  CL=.95    AGUILAR   72 HBC     3.9,4.6 K- P     12/72

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REFERENCES FOR F PRIME


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BARNES   65 PRL 15 322          +CULWICK,GUIDONI,KALBFLEISCH,GOZ+(BNL+SYRA)

CRENNELL 66 PRL  16  1025       + KALBFLEISCH,LAI,SCARR,SCHUMANN +    (BNL)I

ABRAMS   67 PRL 18 620          +KEHOE,GLASSER,SECHI-ZORN,WOLSKY (MARYLAND)
AMMAR    67 PRL  19  1071       +DAVIS,HWANG,DAGAN,DERRICK +     (NWES+ANL)  JP
BARNES   67 PRL  19  964        +DORNAN,GOLDBERG,LEITNER +   (BNL+SYRACUSE)ICJP

ALITTI   68 PRL 21 1705         +BARNES,CRENNELL,FLAMINIO,GOLDBERG,+  (BNL)

LORSTAD  69 NP B 14 63          B.LORSTAD,D-ANDLAU,ASTIER,+      (CDEF+CERN)
SCOTTER  69 NC 62 A 1057        +ERSKINE,PALER,+  (BIRM+GLAS+LOIC+MPIM+OXF)

AGUILAR  72 PR D 6 29           AGUILAR-BENITEZ,CHUNG,EISNER,SAMIOS   (BNL)
COLLEY   72 NP B 50 1           +JOBES,RIDDIFORD,GRIFFITHS,+     (BIRM+GLAS)
VIDEAU   72 PL 41 B 213         +VIDEAU,ROUGE,BARRELET,DEBRION,+(EPOL+SACL)

BEUSCH   75 PL 60 B 101         +BIRMAN,WEBSDALE,WETZEL           (CERN+ETH)

BRANDENB 76 NP B 104 413        BRANDENBURG,CARNEGIE,CASHMORE,DAVIER+(SLAC)
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For notation, see key at front of Listings.


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BARREIRO 77 NP B 121 237      +DIAZ,GAY,HEMINGWAY,+  (CERN+AMST+NIJM+OXF)
EVANGELI 77 NP B 127 384      EVANGELISTA,+   (BARI+BONN+CERN+DARE+GLAS+)
LAVEN    77 NP B 127 43       +OTTER,KLEIN,+   (AACH+BERL+CERN+LOIC+WIEN)
PAWLICKI 77 PR D 15 3196      +AYRES,COHEN,DIEBOLD,KRAMER,WICKLUND  (ANL)I JP

BECKER   79 NP B 151  46      +BLANAR,BLUM,CERRADA+ (MPIM+CERN+ZEEM+CRAC)
CORDEN   79 NP B 157 250      +DOWELL,GARVEY,JOBES,+(BIRM+RHEL+TELA+LOWC)  JP
MARTIN   79 NP B 158 520      +OZMUTLU                                (DURH)
POLYCHRO 79 PR D 19 1317      POLYCHRONAKOS,CASON,BISHOP+      (NDAM+ANL)

COSTA    80 NP B 175 402      +      (BARI+BONN+CERN+GLAS+LIVP+MILA+WIEN)
GORLICH  80 NP B 174 16       +NICZYPORUK,ROZANSKA+ (CRAC+MPIM+CERN+ZEEM)

AGUILAR  81 ZPHY C 8 313      +ALBAJAR,ARMENTEROS,+ (CERN+CDEF+MADR+STOH)
ALHARRAN 81 NP B 191 26       +BAUBILLIER,+    (BIRM+CERN+GLAS+MICH+LPNP)
CHABAUD  81 APP B 12 575      +NICZYPORUK,BECKER+        (CERN+CRAC+MPIM)

ALTHOFF  82 PL 121 B 216      +BRANDELIK,BOERNER+   (TASSO COLLABORATION)
ARMSTRON 82 PL 110 B 77       +BAUBILLIER+(BARI+BIRM+CERN+MILA+LPNP+PAVI)
ETKIN    82 PR D 25 1786      +FOLEY,LAI,LINDENBAUM+ (BNL+CUNY+TUFT+VAND)
LUKE     82  DESY 82 73       D.LUKE                                  (DESY)

ARMSTRON 83 NP B 224 193      ARMSTRONG+  (BARI+BIRM+CERN+MILA+LPNP+PAVI)
GRAY     83 PR D 27 307       +KALOGEROPOULOS,NANDY,ROY,ZENONE     (SYRA)
JENNI    83 PR D 27 1031      +BURKE,TELNOV,ABRAMS,BLOCKER+    (SLAC+LBL)
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D(1530) →

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84  D(1530,JPG=1++) I=0

NEEDS CONFIRMATION. OMITTED FROM TABLE.
NAMED D PRIME BY GAVILLET 82

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                 84  D(1530) MASS (MEV)
M      271 1526.0      6.0            GAVILLET  82 HBC   0 4.2 K-P,LAM KKPI  9/83*
------ --------- --------- --------- --------- --------- --------- --------
                 84  D(1530) WIDTH (MEV)
W      271  107.0     15.0            GAVILLET  82 HBC   0 4.2 K-P,LAM KKPI  9/83*
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                 84  D(1530) PARTIAL DECAY MODES
                                                          DECAY MASSES
P1     D(1530) INTO K K*(892)                            494+ 892
****** ********* ********* ********* ********* ********* ********* ********
                          REFERENCES FOR D(1530)
GAVILLET 82 ZPHY C 16 119     +ARMENTEROS,AGUILAR+  (CERN+CDEF+PADO+ROMA)
BAILLON  83  CERN/EP 83-82    P.BAILLON                               (CERN)
****** ********* ********* ********* ********* ********* ********* ********
****** ********* ********* ********* ********* ********* ********* ********
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ρ(1600) or ρ′

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65  RHO(1600,JPG=1-+) I=1
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NOTE ON ρ, ω, φ RADIAL EXCITATIONS

We no longer use primes to distinguish radial excitations: thus the mesons formerly named $\rho'(1250)$, $\rho'(1600)$, and $\phi'(1680)$ have now become $\rho(1250)$, $\rho(1600)$, and $\phi(1680)$, respectively. The not-yet-established radial excitation of the ω is temporarily called ω(rad. excit.).

The $\rho(1600)$ has been seen in the $\rho^0\pi^+\pi^-$ final state in photoproduction (BINGHAM 72, DAVIER 73, SCHACHT 74, ALEXANDER 75, LEE 75, ATIYA 79, RICHARD 79, BARBER 80, ASTON1 81), in e^+e^- annihilation (BARBARINO 72, CONVERSI 74, CORDIER 79, COSME 79, BACCI 80, DELCOURT 81,82, BUON 82, AUGUSTIN 83), in electroproduction (KILLIAN 80), in muoproduction (SHAMBROOM 82), and in a π^+d experiment (DIBIANCA 81). If the $\pi^+\pi^-$ subsystem were in an S wave, as has often been assumed, one would also expect to see the $\rho(1600)$ decaying into $\rho^0\pi^0\pi^0$. This has, however, not been seen (ATKINSON 82). Thus the most likely decay chain is $\rho(1600) \to A(1270)\pi \to \rho\pi\pi \to 4\pi$.

For the determination of the $\rho(1600)$ parameters we turn to its relatively rare $\pi^+\pi^-$ and K^+K^- decays, which do not have the problems of the above decay chain. The $\pi^+\pi^-$ final state has been produced in π^-p interactions (HYAMS 73, BECKER 79), in photoproduction (ATIYA 79, ASTON1 80), and with weaker evidence in e^+e^- annihilation (reviewed by GENSINI 78, HEYN 80). The mass and width in these experiments are consistently 1600 MeV and 300 MeV, respectively. Note, however, that these parameters are the results of very simplified analyses which are not adequate for such a broad resonance. An attempt to determine the $\rho(1600)$ pole position in a more model-independent way (LANG 79) from the HYAMS 73 data yields a mass at 1660 MeV.

The mass determination of BECKER 79 is very well confirmed in the K^+K^- system by CLELAND 82, and in K^+K^- and K_SK_L by BUON 82 in a global fit of all the vector mesons present in this energy range (see below). The $\rho(1600)$ parameters in the Meson Table are based on these three determinations only.

The elusive $\rho(1250)$ has been reclaimed in the diffractively photoproduced $\omega\pi^0$ system (ASTON 80, BARBER 80). However, the J^P determinations are complicated by the simultaneously present B(1235) resonance. In addition, other dynamical effects obscure the interpretation of the $\rho(1250)$ as a resonance.

The radial excitations of the ω and the ϕ have been looked for in the channels K^+K^-, K_SK_L, $K_SK^\mp\pi^\pm$, $\omega\pi^+\pi^-$, and $\pi^+\pi^-\pi^0$, in e^+e^- annihilation and in photoproduction. We list the evidence for a state at 1680 MeV under the name $\phi(1680)$; however, the situation is far from clear. In a global analysis of all the channels above except $\pi^+\pi^-\pi^0$, BUON 82 conclude that the data are well described by the tails of the ρ, ω, and ϕ, the $\rho(1600)$, a conspicuous $\phi(1680)$, and one ω(rad. excit.) hidden under the $\rho(1600)$. This view is confirmed by AUGUSTIN 83 in preliminary K^+K^- data. The $\pi^+\pi^-\pi^0$ system is not yet reliably analyzed.

In photoproduction, however, no $\phi(1680)$ resonance is seen in the $\omega\pi^+\pi^-$ channel, but rather a broad threshold enhancement (ASTON2 80, ATKINSON1 83), and nothing is seen in $K\bar{K}\pi$ (ATKINSON1 83). In the K^+K^- channel, the $\phi(1680)$ has been found (ASTON2 81) with the same parameters as in e^+e^- annihilation, but its interference with the ϕ looks quite different.

A resonance with parameters similar to the $\phi(1680)$

Mesons

Data Card Listings

$\rho(1600)$ $[\rho']$

has been found in the photoproduced $\pi^+\pi^-\pi^0$ system (ATKINSON3,4 83). Its interpretation is, however, complicated, as it may contain both the ω(rad. excit.) and the $\phi(1680)$. So far we list this evidence under the $\phi(1680)$.

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                    65  RHO(1600) MASS (MEV)

M  PI+ PI- MODE
M   H      (1590.)     (20.)              HYAMS      73 ASPK  0 17 PI-P,N PI+PI-   1/74
M  P        1610.      30.                FROGGATT   77 RVUE  0 17 PI-P,PI+PI-N  12/77
M  P       (1575.)                        MARTIN     78 RVUE  0 17 PI-P,PI+PI-N  12/77
M    R      1600.0     10.0               ATIYA      79 SPEC    50 GAM C,2PI     12/79
M           1598.0     24.0      22.0     BECKER     79 ASPK  0 17 PI- P POLARIZ 12/79
M   P      (1659.)    (25.)               LANG       79 RVUE  0                   1/82
M    M      1590.      20.                ASTON 1    80 OMEG    20-70GAM P,2 PI   9/81
M  K KBAR MODE
M     1600 1582.       36.                CLELAND    82 SPEC +- 50 PI P,KS K+-P   8/83*
M  MIXED MODES
M  G        1580.      20.                BUON       82 DM1     E+E-,HADRONS      1/84*
M           . . . . . . . . . .
M   AVG     1595.7      7.3     AVERAGE

M  2(PI+ PI-) MODE
M      400 1430.       50.                BINGHAM    72 HBC   0 9.3 GAM P,P 4PI  12/72
M    M      1550.      60.                CONVERSI   74 OSPK  0 E+ E-,2(PI+PI-)  12/75
M      160 1550.       50.                SCHACHT    74 STRC  0 5.5-9 G P,P 4PI  12/75
M      340 1450.      100.                SCHACHT    74 STRC  0 9-18 G P,P 4PI   12/75
M   D   65(1570.)     (60.)               ALEXANDER  75 HBC   0 7.5 GAM P,P 4PI  12/75
M   C      (1500.)                        ATIYA      79 SPEC    50 GAM C,4 PI+-   9/81
M   A      (1666.)    (39.)               BACCI      80 FRAG    E+ E-, 2(PI+PI-)  9/81
M       34(1780.)                         KILLIAN    80 SPEC    11 E-P,2(PI+PI-)  9/81
M    M      1520.      30.                ASTON 1    81 OMEG    20-70GAM P,4 PI   9/81
M  O        1654.      25.                DIBIANCA   81 DBC   0 PI+D,PP2(PI+PI-)  1/82
M   B      (1540.)                        PENSO      82 RVUE    E+ E-, 2(PI+PI-)  9/81
M           . . . . . . . . . .
M   AVERAGE MEANINGLESS (SCALE FACTOR = 2.2)

M   A    SIMPLE RELATIV. BREIT-WIGNER FIT WITH MODEL DEPENDENT WIDTH
M   B    ASSUMING RHO+EPSILON(1300) DECAY MODE INTERFERES WITH
M   B    A(1270)+PI BACKGROUND
M   C    PARAMETERS ROUGHLY ESTIMATED,NOT FROM A FIT
M   D    SKEW MASS DISTRIBUTION COMPENSATED BY ROSS-STODOLSKY FACTOR
M   H    INCLUDED IN BECKER 79 ANALYSIS
M    M   SIMPLE RELATIV. BREIT WIGNER FIT WITH CONSTANT WIDTH
M  O     ONE PEAK FIT RESULT.
M  P     FROM PHASE SHIFT ANALYSIS OF HYAMS 73 DATA
M    R   AN ADDITIONAL 40 MEV UNCERTAINTY IN BOTH THE MASS AND WIDTH
M    R   IS PRESENT DUE TO THE CHOICE OF THE BACKGROUND SHAPE.
M  G     FROM GLOBAL FIT OF RHO,OMEGA,PHI AND THEIR RADIAL EXCITATIONS TO
M  G     CHANNELS OMEGA PI+PI-,K+K-,KS KL,KS K+- PI-+.

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                    65  RHO(1600) WIDTH (MEV)

W  PI+ PI- MODE
W   H      (180.)      (50.)              HYAMS      73 ASPK  0 17 PI-P,N PI+PI-  12/75
W  P        300.      100.                FROGGATT   77 RVUE  0 17 PI-P,PI+PI-N  12/77
W  P       (340.)                         MARTIN     78 RVUE  0 17 PI-P,PI+PI-N  12/77
W    R      283.0      14.0               ATIYA      79 SPEC    50 GAM C,2PI     12/79
W           175.0      98.0      53.0     BECKER     79 ASPK  0 17 PI- P POLARIZ 12/79
W   P      (232.)     (34.)               LANG       79 RVUE  0                   1/82
W    M      230.0      80.0               ASTON 1    80 OMEG    20-70 GAM P,2PI   9/81
W  K KBAR MODE
W     1600  265.      120.                CLELAND    82 SPEC +- 50 PI P,KS K+-P   8/83*
W  MIXED MODES
W  G        340.       80.                BUON       82 DM1     E+E-,HADRONS      1/84*
W           . . . . . . . . . .
W   AVG     279.9      13.2     AVERAGE

W  2(PI+ PI-) MODE
W      400  650.      100.                BINGHAM    72 HBC   0 9.3 GAM P,P 4PI  12/72
W    M      360.      100.                CONVERSI   74 OSPK  0 E+ E-,2(PI+PI-)  12/75
W  E   160  400.      120.                SCHACHT    74 STRC  0 5.5-9 G P,P 4PI  12/75
W  E   340  850.      200.                SCHACHT    74 STRC  0 9-18 G P,P 4PI   12/75
W   D   65 (340.)    (160.)               ALEXANDER  75 HBC   0 7.5 GAM P,P 4PI  12/75
W   C      (600.)                         ATIYA      79 SPEC    50 GAM C,4 PI+-   9/81
W   A      (700.)    (160.)               BACCI      80 FRAG    E+ E-, 2(PI+PI-)  9/81
W       34 (100.)                         KILLIAN    80 SPEC    11 E-P,2(PI+PI-)  9/81
W   B      (230.)                         PENSO      80 RVUE    E+ E-, 2(PI+PI-)  9/81
W    M      400.       50.                ASTON 1    81 OMEG    20-70GAM P,4 PI   9/81
W  O        400.      146.                DIBIANCA   81 DBC   0 PI+D,PP2(PI+PI-)  1/82
W           . . . . . . . . . .
W   AVERAGE MEANINGLESS (SCALE FACTOR = 1.4)

W   A    SIMPLE RELATIV. BREIT-WIGNER FIT WITH MODEL DEPENDENT WIDTH
M   B    ASSUMING RHO+EPSILON(1300) DECAY MODE INTERFERES WITH
M   B    A(1270)+PI BACKGROUND
W   C    PARAMETERS ROUGHLY ESTIMATED,NOT FROM A FIT
W   D    SKEW MASS DISTRIBUTION COMPENSATED BY ROSS-STODOLSKY FACTOR
W  E     WIDTH ERRORS ENLARGED BY US TO 4*WIDTH/SQRT(N),SEE K*(892) NOTE
W   H    INCLUDED IN BECKER 79 ANALYSIS
W    M   SIMPLE RELATIV. BREIT WIGNER FIT WITH CONSTANT WIDTH
W  O     ONE PEAK FIT RESULT.
W  P     FROM PHASE SHIFT ANALYSIS OF HYAMS 73 DATA
W    R   AN ADDITIONAL 40 MEV UNCERTAINTY IN BOTH THE MASS AND WIDTH
W    R   IS PRESENT DUE TO THE CHOICE OF THE BACKGROUND SHAPE.
W  G     FROM GLOBAL FIT OF RHO,OMEGA,PHI AND THEIR RADIAL EXCITATIONS TO
W  G     CHANNELS OMEGA PI+PI-,K+K-,KS KL,KS K+- PI-+.

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                    65  RHO(1600) PARTIAL DECAY MODES

                                                        DECAY MASSES
P1      RHO(1600) INTO RHO PI+ PI-                     769+ 140+ 140
P2      RHO(1600) INTO 4 PI ALL CHARGED                140+ 140+ 140+ 140
P3      RHO(1600) INTO RHO RHO                         769+ 769
P4      RHO(1600) INTO PI PI                           140+ 140
P5      RHO(1600) INTO KBAR K                          494+ 494
P6      RHO(1600) INTO PI OMEGA                        140+ 783
P7      RHO(1600) INTO RHO0 PI0 PI0                    769+ 135+ 135
P8      RHO(1600) INTO E+ E-                          .511+.511
P9      RHO(1600) INTO RHO+- PI-+ PI0                  769+ 140+ 135
P10     RHO(1600) INTO KBAR K*(892) + C.C.             494+ 892
P11     RHO(1600) INTO PI PI ETA                       140+ 140+ 549
P12     RHO(1600) INTO RHO PI PI                       769+ 140+ 140

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                    65  RHO(1600) PARTIAL WIDTHS (KEV)

W8      RHO(1600) INTO E+ E-                            (G8)

W8  D       (7.5)     (1.5)          DELCOUR2  81 DM1      E+ E-, 2(PI+PI-)  9/81

W8  D   MODEL DEPENDENT, NOT INDEPENDENT OF DELCOUR2 81 WIDTH TIMES E+E-
W8  D   BRANCHING RATIO BELOW

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                    65  RHO(1600) BRANCHING RATIOS

R1      RHO(1600) INTO (RHO PI+ PI-)/(4 PI, ALL CHARGED) (P1)/(P2)
R1 S        (0.80)                   BINGHAM   72  HBC     9.3 GAM P,P 4PI   1/73
R1      500  0.7       0.1           SCHACHT   74 STRC     5.5-18 G P,P 4PI 12/75
R1          (1.0)  APPROX.           DELCOUR2  81 DM1      E+E-,2(PI+PI-)    1/82
R1 S    THE PI PI SYSTEM IS IN S WAVE                                        1/73

R3      RHO(1600) INTO (PI+ PI-)/(4 PI, ALL CHARGED)       (P4)/(P2)
R3          (0.2)  OR LESS  2 SIGMA  BINGHAM   72  HBC     9.3 GAM P,P 2PI   1/73
R3          (0.14) OR LESS  ESTIMATE DAVIER    73 STRC     6-18 G P,P 4PI    1/74
R3           0.13      0.05          ASTON 1   80 OMEG     20-70 GAM P,2PI   9/81

R4      RHO(1600) INTO (KBAR K)/(4 PI, ALL CHARGED)        (P5)/(P2)
R4          (0.04) OR LESS  CL=0.95  BINGHAM   72  HBC  0 9.3 GAM P          1/73
R4   D       0.015     0.010         DELCOUR2  81 DM1      E+E-,KBAR K       1/82
R4   D  ASSUMING RHO(1600) AND OMEGA RAD.EXIT. TO BE DEGENERATE IN MASS.

R5      RHO(1600) INTO (PI+PI-)/TOTAL                      (P4)
R5  E       (0.15) OR LESS           EISENBERG 73 HBC      5 PI+ P,DEL++2PI  1/74
R5  H       (0.25)    (0.05)         HYAMS     73 ASPK     17 PI-P,N PI+PI-  1/74
R5           0.20      0.05          MONTANET  73 HBC      PBAR P AT REST   12/77
R5 C        (0.20) OR LESS           COSTA 2   77 RVUE     E+E-,2 PI + 4 PI 12/77
R5  P       (0.30)    (0.05)         FROGGATT  77 RVUE     17 PI-P,PI+PI-N  12/77
R5 P        (0.15)TO 0.30            MARTIN    78 RVUE     17 PI-P,PI+PI-N  12/77
R5           0.287     0.043   0.042 BECKER    79 ASPK     17 PI- P POLARIZ 12/79
R5           . . . . . . . . . .
R5  AVERAGE MEANINGLESS (SCALE FACTOR = 1.3)

R5 C    ESTIMATE USING UNITARITY,TIME REVERSAL INVARIANCE,BREIT WIGNER
R5  E   ESTIMATED USING OPE MODEL.
R5  H   INCLUDED IN BECKER 79 ANALYSIS
R5 P    FROM PHASE SHIFT ANALYSIS OF HYAMS 73 DATA

R6      RHO(1600) INTO (RHO0 PI0 PI0)/(RHO+- PI-+ PI0)    (P7)/(P9)
R6          (0.15) OR LESS           ATKINSON  82 OMEG  0 20-70GAM P,4PI P   1/82

R7      RHO(1600) INTO (PI+ PI- + NEUTRALS)/(4PI,ALL CHARGED)
R7                                                         (P7+....)/(P2)
R7  U       (2.6)     (0.4)          BALLAM    74 HBC      9.3 GAMMA P      12/75
R7  U   UPPER LIMIT. BACKGROUND NOT SUBTRACTED

R8      RHO(1600) INTO (PI PI ETA)/(4 PI, ALL CHARGED)     (P11)/P2
R8          (0.1)  APPROX.           ASTON 1   80 OMEG     20-70 GAM P       1/82
R8           0.123     0.027         DELCOURT  82 DM1      E+E-,PI+PI-MM     9/83*

R9      RHO(1600) INTO (KBAR K*(892)+C.C.)/(4PI, ALL CHG)(P10)/(P2)
R9   D       0.15      0.03          DELCOUR2  81 DM1      E+E-,KBAR K PI    1/82
R9   D  ASSUMING RHO(1600) AND OMEGA RAD.EXIT. TO BE DEGENERATE IN MASS.

R10     RHO(1600) INTO (KBAR K)/(KBAR K*(892)+C.C.)        (P5)/P10)
R10          0.052     0.026         BUON      82 DM1      E+E-,HADRONS      1/84*

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                    65  RHO(1600)    G(I)*G(E+E-)/G(TOTAL)    (KEV)

        THIS COMBINATION OF A PARTIAL WIDTH WITH THE PARTIAL WIDTH INTO
        E+E- AND WITH THE TOTAL WIDTH IS OBTAINED FROM THE CROSS-SECTION
        INTO CHANNEL(I) IN E+E- ANNIHILATION.

G2      G(4 PI, ALL CHARGED)*G(E+E-)/G(TOTAL)              (G2)*(G8)/TOTAL
G2           2.83      0.42          BACCI     80 FRAG     E+ E-, 2(PI+PI-)  3/82
G2 P        (0.4)                    PENSO     80 RVUE     E+ E-, 2(PI+PI-)  3/82
G2           2.6       0.2           DELCOUR2  81 DM1      E+ E-, 2(PI+PI-)  3/82
G2           . . . . . . . . . .
G2  AVG      2.64      0.18    AVERAGE

G2 P    ASSUMING RHO+EPSILON DECAY MODE INTERFERES WITH A(1270)+PI
G2 P    BACKGROUND.

G5      G(KBAR K)*G(E+E-)/G(TOTAL)                         (G5)*(G8)/TOTAL
G5  M       (0.035)  (0.029)         BIZOT     80 DM1      E+ E-             3/82

G10     G(KBAR K*(892) + C.C.)*G(E+E-)/G(TOTAL)             (G10)*(G8)/TOTAL
G10 M       (0.305)  (0.071)         BIZOT     80 DM1      E+ E-             3/82

G12     G(RHO PI PI)*G(E+E-)/G(TOTAL)                      (G12)*(G8)/TOTAL
G12 M       (3.510)  (0.090)         BIZOT     80 DM1      E+ E-             3/82

G   M   MODEL DEPENDENT

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REFERENCES FOR RHO(1600)


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ALVENSLE 71 PRL 26 273         ALVENSLEBEN,BECKER,BERTRAM,CHEN,+(DESY+MIT) G
BRAUN    71 NP B30 213         +FRIDMAN, GERBER, GIVERNAUD,+  (STRASBOURB) G
BULOS    71 PRL 26 149         +BUSZA,KEHOE,BENISTON,+  (SLAC+UMD+IBM+LBL) G

BACCI    72 PL 38B 551         +PENSO,SALVINI,STELLA,BALDINI-CE(ROMA+FRAS) JPC
BARBARIN 72 LNC 3 689          BARBARINO,CERADINI,+   (FRAS+ROMA+PADO+UMD)IGJP
BARTOLI  72 PR D 6 2374        +FELICETTI,OGREN,+           (FRAS+ROMA+NAPL)IGJP
BINGHAM  72 PL 41B 635         +RABIN,ROSENFELD,SMADJA,YOST+(LBL,UCB,SLAC)IGJP
BRAMON   72 LNC 3 693          +GRECO (THEORETICAL PAPER)        (FRASCATI)
DIEBOLD  72 BATAVIA CONF.      R.DIEBOLD  RAPPORTEUR TALK              (ANL)
EISENBER 72 PR D 5 15          EISENBERG,BALLAM,DAGAN,+   (REHO+SLAC+TELA)
LAYSSAC  72 NC 10A 407         J.LAYSSAC,F.M.RENARD                   (MONP)
SMADJA   72 PHIL.CONF.PROC349 +BINGHAM,FRETTER,BALLAM,CHADWICK+(LBL+SLAC)

CERADINI 73 PL 43 B 341        +CONVERSI,EKSTRAND,GRILLI,+(ROMA+FRAS+PADO)IGJP
CHUNG    73 PL 47 B 526        +PROTOPOPESCU,LYNCH,FLATTE+    (BNL+LBL+USC)
DAVIER   73 NP B 58 31         +DERADO,FRIES,LIU,MOZLEY,ODIAN,PARK,+(SLAC)
EISENBER 73 PL 43 B 149        EISENBERG,KARSHON,MIKENBERG,PITLUCK,+(REHO)
HYAMS    73 NP B 64 134        +JONES,WEILHAMMER,BLUM,DIETL,+  (CERN+MPIM)
KREUZER  73 PR D 8 1431        H.J.KREUZER,A.N.KAMAL     (UNIV. OF ALBERTA)
OCHS     73 THESIS             THESIS                                 (MPIM)
MONTANET 73 ERICE SCHOOL 518   L.MONTANET                             (CERN)
PARK     73 NP B 58 45         J.C.H.PARK                             (MPIM)  JP

BALLAM   74 NP B76 375         +CHADWICK,BINGHAM,FRETTER+  (SLAC+LBL+MPIM)
BERNABEI 74 LNC 11 261         +D.ANGELO,SPILLANTINI,VALENTE   (ROMA+FRAS)
CHALOUPK 74 PL 51 B 407        CHALOUPKA,FERRANDO,LOSTY,MONTANET     (CERN)
CONVERSI 74 PL 52B 493         +PAOLUZI,CERADINI,GRILLI+        (ROMA+FRAS)
ESTABROO 74 NP B79 301         P.ESTABROOKS,A.D.MARTIN                (DURH)
FERBEL   74 PR D9 824          T.FERBEL AND P.SLATTERY                (ROCH)
GRAYER   74 NP B 75 189        G.GRAYER,HYAMS,BLUM,DIETL,+      (CERN+MPIM)
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For notation, see key at front of Listings.

Mesons

$\rho(1600)$ $[\rho']$, $\omega(1670)$, A(1680) $[A_3]$

HIRSHFEL 74 NP B74 211 A.C.HIRSHFELD,G.KRAMER (HAMB)
SCHACHT 74 NP B81 205 +DERADO,FRIES,PARK,YOUNT (MPIM)

ALEXANDE 75 PL 57B 487 ALEXANDER,BENARY,GANDSMAN,LISSAUER+ (TELA)
ALLES 75 NC 30A 136 ALLES-BORELLI,BERNARDINI+ (CERN+BGNA+FRAS)
CHUNG 75 PR D 11 2436 +PROTOPOPESCU,LYNCH,FLATTE+ (BNL+LBL+USC)
ESTABROO 75 NP B95 322 P.ESTABROOKS,A.D.MARTIN (DURH)
FROGGATT 75 NP B91 454 C.D.FROGGATT,J.L.PETERSEN (GLAS+NORD)
HYAMS 75 NP B100 205 +JONES,WEILHAMMER,BLUM,DIETL+ (CERN+MPIM)
LANG 75 PL 58B 450 C.B.LANG,I.S.STEFANESCU (KARL)
LANGACKE 75 PR D 13 697 P.LANGACKER,G.SEGRE (PENN)
LEE 75 STANFORD CONF.213 WONYONG LEE (COLU)
ROOS 75 NP B 97 165 M.ROOS (HELS)

BASSOMPI 76 PL 65 B 397 BASSOMPIERRE,BINDER,+ (MULH+STRB+TORI)
COMMON 76 NP B 103 109 A.K.COMMON (KENT) JP
JOHNSON 76 PL 63 B 95 +MARTIN,PENNINGTON (DURH+CERN) JP

BUDNEV 77 PL 70 B 365 N.M.BUDNEV,V.M.BUDNEV,V.V.SEREBRYAKOV(NOVO)
COSTA 1 77 PL 67 B 213 COSTA DE BEAUREGARD,PHAM,PIRE,TRUONG (EPOL)
COSTA 2 77 PL 71 B 345 COSTA DE BEAUREGARD,PIRE,T.N.TRUONG (EPOL)
FROGGATT 77 NP B 129 89 C.D.FROGGATT,J.L.PETERSEN (GLAS+BOHR)
GESSAROL 77 NP B 126 382 GESSAROLI+ (BGNA+FIRZ+GENO+MILA+OXF+PAVI)

GENSINI 78 PR D 17 1368 PAOLO M GENSINI (SLAC)
MARTIN 78 ANP 114 1 A.D.MARTIN,M.R.PENNINGTON (CERN)

ATIYA 79 PRL 43 1691 +HOLMES,KNAPP,LEE,SETO,+ (COLU+ILL+FNAL)
BACCI 79 PL B 86 234 +DE ZORZI,PENSO,STELLA,+ (ROMA+BGNA+FRAS)
BECKER 79 NP B 151 46 +BLANAR,BLUM,CERRADA+ (MPIM+CERN+ZEEM+CRAC)
CORDEN 79 NP B 157 250 +DOWELL,GARVEY,JOBES,+(BIRM+RHEL+TELA+LOWC) JP
CORDIER 79 PL 81 B 389 +DELCOURT,ESCHSTRUTH,FULDA+ (LALO)
COSME 79 NP B 152 215 +DUDELZAK,GRELAUD,JEAN-MARIE,JULLIAN+ (IPN)
LANG 79 PR D 19 956 C.B.LANG,A.MAS-PARAREDA (GRAZ)
RICHARD 79 FERMILAB SYMP.469 F.RICHARD (LALO)

ASTON 1 80 PL 92 B 215 (BONN+CERN+EPOL+GLAS+LANC+MCHS+ORSA+PARIS+)
ASTON 2 80 NP B 174 269 (BONN+CERN+EPOL+GLAS+LANC+MCHS+ORSA+PARIS+)
BARBER 80 ZPHY C 4 169 +DAINTON,BRODBECK,BROOKES,+(DARE+LANC+SHEF)
BACCI 80 PL 95 B 139 +DE ZORZI,PENSO,BALDINI-CELIO,+ (ROMA+FRAS)
BIZOT 80 MADISON CONF. 546 +BISELLO,BUON,CORDIER,DELCOURT,+(LALO+USTL)
HEYN 80 ZPHY C 7 169 M.F.HEYN,C.B.LANG (GRAZ)
KILLIAN 80 PR D 21 3005 +TREADWELL,AHRENS,BERKELMAN,CASSEL,+ (CORN)
O-DONNEL 80 PR D 22 711 P.J.O-DONNELL (TORONTO)
PENSO 80 PL 95 B 143 G.PENSO,TRAN N.TRUONG (ROMA+EPOL)

ASTON 1 81 NP B 189 15 (BONN+CERN+EPOL+GLAS+LANC+MCHS+ORSA+PARIS+)
ASTON 2 81 PL 104 B 231 (BONN+CERN+EPOL+GLAS+LANC+MCHS+ORSA+PARIS+)
DELCOURT 81 PL 99 B 257 +BISELLO,BIZOT,BUON,CORDIER,MANE (ORSAY)
DELCOUR2 81 BONN CONF. 205 B.DELCOURT (ORSAY)
ALSO 82 PL 109B 129 CORDIER,+ (ORSAY)
DIBIANCA 81 PR D 23 595 +FICKINGER,MALKO,DADO,ENGELER,+ (CASE+CARN)

ATKINSON 82 PL 108 B 55 + (BONN+CERN+GLAS+LANC+MCHS+CURI+RHEL+SHEF)
BUON 82 PL 118 B 221 +BISELLO,BIZOT,CORDIER,DELCOURT+(LALO+MONP)
DELCOURT 82 PL 113 B 93 +BISELLO,BIZOT,BUON,CORDIER,MANE (LALO)
CLELAND 82 NP B 208 228 +DELFOSSE,DORSAZ,GLOOR(DURH+GEVA+LAUS+PITT)
PENSO 82 NC 68 A 213 +PENSO,TRAN N.TRUONG (ROMA+EPOL)
SHAMBROO 82 PR D 26 1 +WILSON,ANDERSON,FRANCIS+(HARV+EFI+ILL+OXF)

AUGUSTIN 83 LAL/83-21 +AYACH,BISELLO,BALDINI+ (LALO+PADO+FRAS)
ATKINSO1 83 NP B 229 269 (BONN+CERN+GLAS+LANC+MCHS+IPNP+RHEL+SHEF)
ATKINSO2 83 CERN-EP/83-80 (BONN+CERN+GLAS+LANC+MCHS+IPNP+RHEL+SHEF)
ATKINSO3 83 PL 127 B 132 (BONN+CERN+GLAS+LANC+MCHS+IPNP+RHEL+SHEF)
ATKINSO4 83 CERN-EP/83-85 (BONN+CERN+GLAS+LANC+MCHS+IPNP+RHEL+SHEF)

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$\omega(1670)$

45 OMEGA(1670,JPG=3--) I=0.

45 OMEGA(1670) MASS (MEV)

M			1636.	20.	ARMENISE	68	DBC	5.1 PI+N,P(3PI)0	9/68
M	Q		1695.0	20.0	BARNES	69	HBC	0 4.6 K-P,OMEG2PI	2/74
M			1670.	20.	KENYON	69	DBC	8. PI+N,P(3PI)0	8/69
M		200	1679.	17.	MATTHEWS	71	DBC	7.0 PI+N,P(3PI)0	1/71
M		500	1678.	14.	DIAZ	74	DBC	6. PI+N,P(3PI)0	1/74
M	Q	200	1660.	13.	DIAZ	74	DBC	6. PI+N,P(5PI)0	1/74
M	P	600	1669.	11.	WAGNER	75	HBC	7. PI+P,DEL++3PI	11/75
M	E	110	(1700.0)	APPROX.	CERRADA	77	HBC	4.2 K-P,LAM 3PI	12/77
M	P E	430	1673.0	12.0	BALTAY	78	HBC	15 PI+P,DEL 3PI	4/78
M			1650.0	12.0	CORDEN	78	OMEG	8-12 PI- P,N 3PI	12/77
M		60	1685.0	20.0	BAUBILLIE	79	HBC	8.2K- P,BACKWARD	12/79
M			. . . . .	. . . . .					
M	AVG		1667.9	4.6	AVERAGE				

M E PHASE ROTATION SEEN FOR JP 3- (RHO PI) WAVE.
M P FROM A FIT TO I=0, JP=3- RHO PI PARTIAL WAVE
M Q FROM (OMEGA PI PI) MODE

45 OMEGA(1670) WIDTH (MEV)

W			112.	60.	ARMENISE	68	DBC	5.1 PI+N,P(3PI)0	9/68
W	Q		(90.)	(20.)	BARNES	69	HBC	0 4.6 K-P,OMEG2PI	1/73
W			100.	40.	KENYON	69	DBC	8. PI+N,P(3PI)0	8/69
W	S	200	155.	40.	MATTHEWS	71	DBC	7.0 PI+N,P(3PI)0	11/75
W		500	167.	40.	DIAZ	74	DBC	6. PI+N,P(3PI)0	1/74
W	Q	200	122.	39.	DIAZ	74	DBC	6. PI+N,P(5PI)0	1/74
W	P S	600	173.	28.	WAGNER	75	HBC	7. PI+P,DEL++3PI	11/75
W	P E	430	173.0	16.0	BALTAY	78	HBC	15 PI+P,DEL 3PI	4/78
W			253.0	39.0	CORDEN	78	OMEG	8-12 PI- P,N 3PI	12/77
W	S	60	160.0	80.0	BAUBILLIE	79	HBC	8.2K- P,BACKWARD	12/79
W			. . . . .	. . . . .					
W	AVG		166.1	12.0	AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.1)				

W E PHASE ROTATION SEEN FOR JP 3- (RHO PI) WAVE.
W P FROM A FIT TO I=0, JP=3- RHO PI PARTIAL WAVE
W S WIDTH ERRORS ENLARGED BY US TO 4*WIDTH/SQRT(N),SEE K*(892) NOTE
W Q FROM (OMEGA PI PI) MODE

45 OMEGA(1670) PARTIAL DECAY MODES

		DECAY MASSES
P1	OMEGA(1670) INTO 3 PI (INCL. RHO PI)	135+ 135+ 135
P2	OMEGA(1670) INTO 5 PI (INCL. OMEGA PI+PI-)	135+ 135+ 135+ 135+
P3	OMEGA(1670) INTO RHO PI	769+ 135
P4	OMEGA(1670) INTO OMEGA 2 PI	783+ 135+ 135
P5	OMEGA(1670) INTO B(1235) PI	1234+ 135

45 OMEGA(1670) BRANCHING RATIOS

R1	OMEGA(1670) INTO (5 PI)/(3 PI)						(P2)/(P1)		
R1	200	0.97	0.28	DIAZ	74	DBC	6. PI+N,P(5PI)0	1/74	
R2	OMEGA(1670) INTO (RHO PI)/(3 PI)						(P3)/(P1)		
R2	200	(0.70) OR MORE		MATTHEWS	71	DBC	7.0 PI+N,P(3PI)0	11/71	
R3	OMEGA(1670) INTO (OMEGA 2 PI)/(RHO PI)						(P4)/(P3)		
R3	100	0.71	0.27	DIAZ	74	DBC	6. PI+N,P(5PI)0	12/78	
R4	OMEGA(1670) INTO (B(1235) PI)/(RHO PI)						(P5)/(P3)		
R4	POSSIBLY SEEN			DIAZ	74	DBC	6. PI+N,P(5PI)0	1/74	
R5	OMEGA(1670) INTO (B(1235)PI)/(OMEGA PI PI)						(P5)/(P4)		
R5	1.0	0.0	0.25	BAUBILLIE	79	HBC	8.2K- P,BACKWARD	12/79	

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REFERENCES FOR OMEGA(1670)

ARMENISE 68 PL 26B 336 +GHIDINI,FORINO+ (BARI+BGNA +FIRZ +ORSAY)

BARNES 69 PRL 23 142 +CHUNG,EISNER,FLAMINIO,+ (BNL)
KENYON 69 PRL 23 146 +KINSON,SCARR,+ (BNL+UCND+ORNL)

ARMENISE 70 LNC 4 199 +GHIDINI,FORINO,CARTACCI,+ (BARI+BGNA+FIRZ)

MATTHEWS 71 PR D 3 2561 +PRENTICE,YOON,CARROLL,+ (TNTO+WISC)
MATTHEW1 71 LNC 1 361 +PRENTICE,YOON,CARROLL,+ (TNTO+WISC)

DIAZ 74 PRL 32 260 +DIBIANCA,FICKINGER,ANDERSON,+ (CASE+CARN)

WAGNER 75 PL 58B 201 +TABAK,CHEW (LBL) JP

CERRADA 77 NP B 126 241 +BLOCKZIJL,HEINEN,+ (AMST+CERN+NIJM+OXF) JP

BALTAY 78 PRL 40 87 +CAUTIS,KALELKAR (COLU) JP
CORDEN 78 NP B 138 235 +CORBETT,ALEXANDER,+ (BIRM+RHEL+TELA+LOWC)

BAUBILLI 79 PL B 89 131 BAUBILLIER+ (BIRM+CERN+GLAS+MSU+LPNP)

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A(1680) or A_3

34 A(1680,JPG=2--) I = 1

We have dropped the subscript 3 on the A_3, and rename this meson A(1680).

Evidence for the existence of the A(1680) meson was previously confused due to its appearance near the $f\pi$ threshold in the diffractive-like process $\pi N \to \pi\pi\pi N$, much like the A(1270) meson. While everybody agreed that there was a ~300-MeV-wide $f\pi$ enhancement in the $J^P LM = 2^- S0$ partial wave at about 1650 MeV, some claimed nonresonant states (ANTIPOV1 73, ASCOLI1 73, BALTAY 77), while others saw evidence for a resonance in the phase variation with respect to other partial waves (OTTER 74, THOMPSON 74).

In the nondiffractive charge-exchange reaction $\pi^- p \to \pi^+\pi^-\pi^0\Delta^{++}$ (WAGNER 75, BALTAY 77, CAUTIS 77) and in the hypercharge-exchange reaction $K^- p \to \pi^+\pi^-\pi^0\Lambda$ at 4.2 GeV/c (CERRADA 77), there is no evidence for A(1680) production.

Definitive proof for the resonant nature of the A(1680) has been given by PERNEGR 78 (3π system diffractively produced on nuclei) and DAUM 80,81 and EVANGELISTA 81 (3π diffraction on proton target). In all these experiments, the $2^- S0^+$ ($f\pi$) partial-wave amplitude exhibits resonance-like phase variation.

In a simultaneous fit to the four 2^- waves ($\epsilon\pi$, $\rho\pi$, twice $f\pi$), DAUM 81 needs a heavier companion to the A(1680) in addition to the Deck background. This fit probably gives the most reliable estimates of the A(1680) and of its heavier companion, which we name A(2100).

Mesons

Data Card Listings

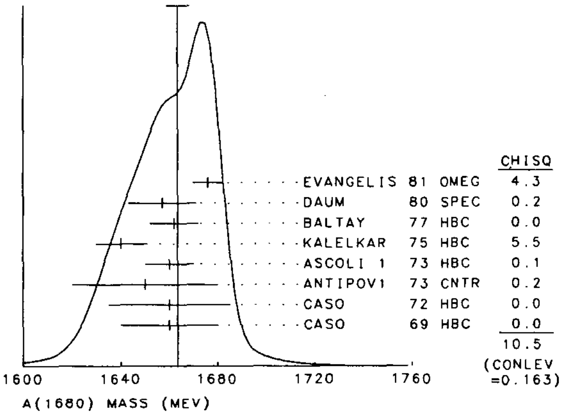
A(1680) [A_3], ϕ(1680) [ϕ']

34 A(1680) MASS (MEV)

M			1660.0	20.0	CASO	69	HBC	-	11 PI-P, PI-F	12/75
M		260	1660.	25.	CASO	72	HBC	+	11.7 PI+ P	12/75
M	P		1650.	30.	ANTIPOV1	73	CNTR	-	25.,40. PI- P	12/75
M	P		1660.	10.	ASCOLI 1	73	HBC	-	5.-25.PI- P,P A3	12/75
M	P E		(1600.)	(10.)	THOMPSON	74	HBC	+	13. PI+ P,P A3+	12/75
M		575	1640.	10.	KALELKAR	75	HBC	+	15 PI+P,P PI+F	12/75
M	P	2M	1662.0	10.0	BALTAY	77	HBC	0	15 PI+ P,P 3PI	12/77
M	R		(1650.0)		PERNEGR	78	CNTR	-	9+13+15,PI- NUC.	4/78
M	P D		1657.0	14.0	DAUM	80	SPEC	-	63-94 PI- P, 3PI	12/79
M	L		(1710.0)	(20.0)	DAUM	81	SPEC	-	63,94 PI- P	1/82
M	P		1676.	6.	EVANGELIS	81	OMEG	-	12 PI-P,3PI P	1/82
M			. . . . .	. . . . .						
M	AVG		1663.5	4.7	AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.2) (SEE IDEOGRAM BELOW)					

M D CLEAR PHASE ROTATION SEEN IN (2-S),(2-P),(2-D) WAVES.
M D WE QUOTE CENTRAL VALUE AND SPREAD OF SINGLE-RESONANCE
M D FITS TO THREE CHANNELS.
M E EVIDENCE FOR A ROTATION OF THE PHASE CLAIMED.
M L FROM A TWO RESONANCE FIT TO FOUR 2-0+ WAVES. THIS SHOULD NOT BE
M L AVERAGED WITH ALL THE SINGLE RESONANCE FITS. SEE MINIREVIEW.
M P FROM A FIT TO JP=2-S (F PI) PARTIAL WAVE
M R CLEAR PHASE ROTATION SEEN IN (2-S) AND (2-P) WAVES

WEIGHTED AVERAGE = 1663.5 ± 4.7
ERROR SCALED BY 1.2



34 A(1680) WIDTH (MEV)

W		297	240.0	50.0	ARMENISE	69	DBC	+	5.1 PI+D,3PI++-	5/70
W			(130.)		CASO	69	HBC	-	11 PI- P	6/68
W			(150.0)		CASO	69	HBC	-	11.0 PI-P,PI- F	6/68
W	P		200. TO 400.		CASO	72	HBC	+	11.7 PI+ P	1/72
W		260	190.	100.	CASO	72	HBC	+	11.7 PI+ P	12/75
W	P		300.	50.	ANTIPOV1	73	CNTR	-	25.,40. PI- P	12/75
W	P		270.	60.	ASCOLI 1	73	HBC	-	5.-25.PI- P,P A3	12/75
W	P E		(310.)	(40.)	THOMPSON	74	HBC	+	13. PI+ P,P A3+	12/75
W		575	240.	30.	KALELKAR	75	HBC	+	15 PI+P,P PI+F	12/75
W	P	2000	285.0	60.0	BALTAY	77	HBC	0	15 PI+ P,P 3PI	12/77
W	R		(400.0)		PERNEGR	78	CNTR	-	9+13+15,PI- NUC.	4/78
W	P D		219.0	20.0	DAUM	80	SPEC	-	63-94 PI- P, 3PI	12/79
W	L		312.0	50.0	DAUM	81	SPEC	-	63,94 PI- P	1/82
W	P		260.	20.	EVANGELIS	81	OMEG	-	12 PI-P,3PI P	1/82
W			. . . . .	. . . . .						
W	AVG		248.3	11.2	AVERAGE					

W D SEE NOTE D UNDER MASS.
W E EVIDENCE FOR A ROTATION OF THE PHASE CLAIMED.
W L FROM A TWO RESONANCE FIT TO FOUR 2-0+ WAVES. THIS SHOULD NOT BE
W L AVERAGED WITH ALL THE SINGLE RESONANCE FITS. SEE MINIREVIEW.
W P FROM A FIT TO JP=2- F PI PARTIAL WAVE
W R CLEAR PHASE ROTATION SEEN IN (2-S) AND (2-P) WAVES

34 A(1680) PARTIAL DECAY MODES

		DECAY MASSES
P1	A(1680) INTO 3 PI	135+ 135+ 135
P2	A(1680) INTO RHO PI	135+ 769
P3	A(1680) INTO ETA PI	135+ 549
P4	A(1680) INTO 5 PI	140+ 140+ 140+ 140+
P5	A(1680) INTO K K*(892)	498+ 892
P6	A(1680) INTO K KBAR PI	498+ 498+ 135
P7	A(1680) INTO K KBAR	498+ 498
P8	A(1680) INTO F PI	1274+ 135
P9	A(1680) INTO OMEGA PI PI	783+ 135+ 135
P10	A(1680) INTO 3 PI	140+ 140+ 140
P11	A(1680) INTO EPSILON(1300) PI	1300+ 140

34 A(1680) BRANCHING RATIOS

R2 A(1680)+- INTO (PI+- RHO0)/(ALL PI+- PI+ PI-) (P2C)/(P1C)

R2		(0.3) OR LESS			BARTSCH	68	HBC	+	8. PI+ P,3PI P	8/69
R2		(0.4) OR LESS			FERBEL	68	RVUE	+-		9/68
R2	L	0.29	0.05		DAUM	81	SPEC		63,94 PI- P	1/82

R2 L FROM A TWO RESONANCE FIT TO FOUR 2-0+ WAVES.

R3 A(1680)+- INTO (PI+- F)/(ALL PI+- PI+ PI-) (P8)/(P1C)
R3 (WITH F INTO PI+ PI-)

R3		(0.59)			BARTSCH	68	HBC	+	8. PI+ P,3PI P	8/69
R3		0.35	0.20		BALTAY	68	HBC	+	7-8.5 PI+P	5/68
R3		0.76	0.24	0.34	ARMENISE	69	DBC	+	5.1 PI+D,3PI++-	5/70
R3	L	0.61	0.04		DAUM	81	SPEC		63,94 PI- P	1/82

R3 L FROM A TWO RESONANCE FIT TO FOUR 2-0+ WAVES.
R3 . . . .
R3 AVG 0.603 0.050 AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.3)

R5 A(1680)+- INTO (PI+- ETA)/(ALL PI+- PI+ PI-) (P3)/(P1C)
R5 (ALL ETA DECAYS)

R5	(0.09) OR LESS	BALTAY	68	HBC	+	7-8.5 PI+P	5/68
R5	(0.10) OR LESS	CRENNELL	70	HBC	-	6. PI- P,F PI	5/70

R6 A+- INTO (PI+- 2PI+ 2PI-)/(ALL PI+- PI+ PI-) (P4C)/(P1C)

R6	(0.1) OR LESS	BALTAY	68	HBC	+	7,8.5 PI+ P	6/68
R6	(0.10) OR LESS	CRENNELL	70	HBC	-	6. P+- P,F P+	5/70

R11 A(1680)+- INTO (PI+- EPSILON)/(ALL PI+- PI+ PI-) (P11)/(P1C)
R11 (WITH EPSILON INTO PI+ PI-)
R11 L 0.10 0.05 DAUM 81 SPEC 63,94 PI- P 1/82
R11 L FROM A TWO RESONANCE FIT TO FOUR 2-0+ WAVES.

R12 D/S RATIO FOR A(1680) INTO F PI
R12 L 0.22 0.10 DAUM 81 SPEC 63,94 PI- P 1/82
R12 L FROM A TWO RESONANCE FIT TO FOUR 2-0+ WAVES.

R13 A(1680)+- INTO K K*(892) / A(1680)+- INTO PI+- F (P5)/(P8)
R13M 0.075 0.025 ARMSTRONG 82 OMEG - 16 PI-P,K+K-PI-P 9/83*
R13M FROM A PARTIAL WAVE ANALYSIS OF K+ K- PI- SYSTEM

REFERENCES FOR A(1680)

FORINO	65 PL 19 68	+GESSAROLI+ (BGNA+BARI+FIRZ+ORSA+SACL)	
FOCACCI	66 PRL 17 890	CERN MISSING MASS SPECTROMETER GROUP (CERN)	
LEVRAT	66 PL 22 714	CERN MISSING MASS SPECTROMETER GROUP (CERN)	
LUBATTI	66 THESIS BERKELEY	H.J.LUBATTI (LRL)	1-2-
VETLITSK	66 PL 21 579	VETLITSKY,GUSZAVIN,KLIGER,ZOLGANOV+ (ITEP)	
DANYSZ	67 NC 51 A 801	DANYSZ+FRENCH+SIMAK (CERN)	
DUBAL	67 NP B3 435	CERN MISSING MASS SPECTROMETER GROUP (CERN)	
ALSO	68 THESIS 1456	L.DUBAL (GENEVE)	
BALTAY	68 PRL 20 887	+KUNG+YEH+FERBEL+ (COLU+ROCH+RUTG+YALE)	I=1
BARTSCH	68 NP B 7 345	+KEPPEL,KRAUS,+ (AACH+BERL+CERN)	JP
CASO	68 NC 54 A 983	+CONTE+CORDS+DIAZ+ (GENOVA+HAMB+MILA+SACL)	
FERBEL	68 PHILA.CONF.335	T.FERBEL (ROCHESTER)	
IOFFREDO	68 PRL 21 1212	+BRANDENBURG,BRENNER,EISENSTEIN+ (HARVARD)	
LAMSA	68 PR 166 1395	+CASON+BISWAS+DERADO+GROVES+ (NOTREDAME)	
ARMENISE	69 LNC 2 501	+GHIDINI,FORINO,CARTACCI+ (BARI+BGNA+FIRZ)	
BARNES	69 PRL 23 142	+CHUNG,EISNER,FLAMINIO,+ (BNL)	
CASO	69 LNC 2 437	+CONTE,TOMASINI,CANTORE+ (GENO+MILA+SACL)	
BRANDENB	70 NP B16 369	+BRENNER,IOFFREDO,JOHNSON,KIM+ (HARVARD)	
CRENNELL	70 PRL 24 781	+KARSHON,LAI,SCARR,SIMS (BNL)	
CHIEN	70 PHILAD.CONF.P.275	C.Y.CHIEN, REVIEW (JOHNS HOPKINS)	
MIYASHIT	70 PR D 1 771	MIYASHITA,VON KROGH,KOPELMAN,LIBBY (COLO)	
BEKETOV	71 SJNP 4 765	+SOMBKOWSKY,KONOWALOV,KRUTSCHININ,+ (ITEP)	JP
PALER	71 PRL 26 1675	+BADEWITZ,BARTON,MILLER,PALFREY,TEBES(PURD)	
ALEXANDE	72 NP B 45 29	ALEXANDER,BAR-NIR,BENARY,DAGAN,+ (TELA)	
ARMENISE	72 LNC 4 201	+FORINO,CARTACCI,+ (BARI+BGNA+FIRZ)	
CASO	72 NP B 36 349	+MADDOCK,BASSLER+(DURH+GENO+DESY+MILA+SACL)	
HARRISON	72 PRL 28 775	+HEYDA,JOHNSON,KIM,LAW,MUELLER,+ (HARV)	
SALZBERG	72 NP B 41 397	+HARRISON,HEYDA,JOHNSON,KIM,LAW,+ (HARV)	
ANTIPOV1	73 NP B 63 153	+ASCOLI,BUSNELLO,FOCACCI,+ (CERN+SERP)	JP
ANTIPOV2	73 NP B 63 141	+ASCOLI,BUSNELLO,FOCACCI,+ (CERN+SERP)	JP
ASCOLI 1	73 PR D 7 669	INTERNAT. COLLABORATION (ILL+)	JP
ASCOLI 2	73 PR D 8 3894	+JONES,WEINSTEIN,WYLD (ILL)	JP
ASCOLI	74 PR D9 1963	+CUTLER,JONES,KRUSE,ROBERTS,WEINSTEIN+(ILL)	
LICHTMAN	74 NP B81 31	+BISWAS,CASON,KENNEY,MCGAHAN,+ (NDAM)	
OTTER	74 NP B80 1	+RUDOLPH+ (AACH+BERL+BONN+CERN+HEID)	JP
TABAK	74 BOSTON CONF.	+RONAT,ROSENFELD,LASINSKI+ (LBL+SLAC)	JP
THOMPSON	74 PRL 32 331	+BADEWITZ,GAIDOS,MCILWAIN,PALER,+ (PURD)	JP
ALSO	74 NP B69 381	THOMPSON,BADEWITZ,GAIDOS,MCILWAIN+ (PURD)	JP
BEKETOV	75 SJNP 20 379	+ZOMBKOVSKII,KAIDALON,KONOVALOV+ (ITEP)	
EMMS	75 PL 60 B 109	+JONES,KINSON,BELL,DALE+ (BIRM+DURH+RHEL)	JP
HORNE	75 PR D11 996	+S.HAGOPIAN,V.HAGOPIAN,BENSINGER+(FSU+BRAN)	
KALELKAR	75 THESIS(NEVIS 207)	M.S.KALELKAR (COLU)	
WAGNER	75 PL 58B 201	+TABAK,CHEW (LBL)	JP
BALTAY	77 PRL 39 591	+CAUTIS,KALELKAR (COLUMBIA)	JP
CAUTIS	77 THESIS NEVIS 221	C.V.CAUTIS (COLUMBIA)	JP
CERRADA	77 NP B 126 241	+BLOCKZIJL,HEINEN,+ (AMST+CERN+NIJM+OXF)	JP
BALTAY	78 PR D 17 52	+CAUTIS,COHEN,CSORNA,KALELKAR+ (COLU+BING)	
CORDEN	78 NP B 136 77	DOWELL,GARVEY,JOBES+ (BIRM+RHEL+TELA+LOWC)	JP
PERNEGR	78 NP B 134 436	+AEBISCHER+ (ETH+CERN+LOIC+MILA)	
ROBERTS	78 PR D 18 59	+KRUSE,EDELSTEIN+ (ILL+CARN+NWES+ROCH)	
DAUM	80 PL 89 B 285	+HERTZBERGER+(AMST+CERN+CRAC+MPIM+OXF+RHEL)	JP
DAUM	81 NP B 182 269	+HERTZBERGER+(AMST+CERN+CRAC+MPIM+OXF+RHEL)	
EVANGELI	81 NP B 178 197	EVANGELISTA+(BARI+BONN+CERN+DARE+LIVP+MILA)	
ALSO	81 NP B 186 594	(ERRATUM)	
ARMSTRON	82 NP B 202 1	+BACCAR(AACH+BARI+BONN+CERN+GLAS+LIVP+MILA)	
BELLINI	82 NP B 199 1	+ (CERN+MILA+JINR+BGNA+HELS+PAVI+WARS+VIEN)	
CHEN	83 PR D 28 2304	+FENKER+(ARIZ+FNAL+FLOR+NDAM+TUFT+VAND+VPI)	
LEEDOM	83 PR D 27 1426	+DE BONTE,GAIDOS,KEY,WONG+ (PURD+TNTO)	

ϕ(1680) or ϕ'

67 PHI(1680,JPG=1--) I=0

FORMERLY CALLED PHI PRIME
FIRST IDENTIFIED USING DALITZ PLOT ANALYSIS OF
E+E- INTO K K*(892) (BIZOT 80, DELCOURT 81)

67 PHI(1680) MASS (MEV)

M			(1652.0)	(17.0)	COSME	79	OSPK	0 E+ E-,3PI	12/79
M		21	1679.	34.	ESPOSITO	80	FRAM	E+E-,3 PI	6/81
M	B		1690.	10.	ASTON	81	OMEG	25-70 GAM P,K+K-	9/81
M	C		1680.	10.	BUON	82	DM1	E+E-,HADRONS	1/84*
M	A		(1670.)	(20.)	ATKINSO3	83	OMEG	20-70 GAM P,3 PI	1/84*
M			. . . . .	. . . . .					
M	AVG		1684.8	6.9	AVERAGE				

For notation, see key at front of Listings.

Mesons

$\phi(1680)$ [ϕ'], g(1690)

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M    B  JP NOT UNAMBIGUOSLY 1-
M  C    FROM GLOBAL FIT OF RHO,OMEGA,PHI AND THEIR RADIAL EXCITATIONS TO
M  C    CHANNELS OMEGA PI+PI-,K+K-,KS KL,KS K+-PI-+. ASSUME MASS 1570 MEV
M  C    AND WIDTH 510 MEV FOR RHO RAD. EXIT.,MASS 1570 AND WIDTH 500 MEV
M  C    FOR OMEGA RADIAL EXCITATION.
M   A   MAY BE PHI OR OMEGA RADIAL EXCITATION. INTERPRETATION COMPLICATED.

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                    67  PHI(1680) WIDTH (MEV)

W           (42.0)   (17.0)          COSME     79 OSPK  0 E+ E-,3PI        12/79

W       21   99.      49.            ESPOSITO  80 FRAM    E+E-,3 PI         6/81
W    B      100.      40.            ASTON     81 OMEG    25-70 GAM P,K+K-  9/81
W  C        185.      22.            BUON      82 DM1     E+E-,HADRONS      1/84*
W   A     (160.)    (20.)            ATKINSO3  83 OMEG    20-70 GAM P,3 PI  1/84*
W           . . . . . . . . .
W   AVG     156.4     28.5     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.6)

W    B  JP NOT UNAMBIGUOSLY 1-
W  C    SEE NOTE C UNDER MASS.
W   A   MAY BE PHI OR OMEGA RADIAL EXCITATION. INTERPRETATION COMPLICATED.

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                    67  PHI(1680) PARTIAL DECAY MODES

                                                          DECAY MASSES
P1      PHI(1680) INTO OMEGA 2 PI                        783+ 140+ 140
P2      PHI(1680) INTO 3 PI                              140+ 140+ 135
P3      PHI(1680) INTO K KBAR                            494+ 494
P4      PHI(1680) INTO K*(892) KBAR + C.C.               892+ 494
P5      PHI(1680) INTO KS K PI                           498+ 494+ 140
P6      PHI(1680) INTO E+ E-                            .511+.511

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                    67  PHI(1680)  BRANCHING RATIOS

R1      PHI(1680) INTO (OMEGA PI+PI-)/(K*(892) KBAR+C.C.)(P1)/(P4)
R1          (0.10) OR LESS           BUON      82 DM1     E+E-              8/83*

R2      PHI(1680) INTO (K KBAR)/(K*(892) KBAR+C.C.)      (P3)/(P4)
R2           0.07     0.01           BUON      82 DM1     E+E-              8/83*

R3      PHI(1680) INTO (K*(892) KBAR)/(KS K+- PI-+)      (P4)/(P5)
R3          DOMINANT                 MANE      82 DM1     E+E-,KS K+- PI-+  8/83*

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                    67  PHI(1680)    G(I)*G(E+E-)/G(TOTAL)    (KEV)

        THIS COMBINATION OF A PARTIAL WIDTH WITH THE PARTIAL WIDTH INTO
        E+E- AND WITH THE TOTAL WIDTH IS OBTAINED FROM THE INTEGRATED
        CROSS SECTION INTO CHANNEL(I) IN E+E- ANNIHILATION.
        WE ONLY LIST DATA NOT HAVING BEEN USED TO DETERMINE THE PARTIAL
        WIDTH G(I) OR THE BRANCHING RATIO G(I)/TOTAL.

G1      G(OMEGA 2PI)*G(E+E-)/G(TOTAL)                    (G1)*(G6)/TOTAL
G1  M       (0.017)APPROX            BIZOT     80 DM1   0 E+ E-             3/82

G3      G(K KBAR)*G(E+E-)/G(TOTAL)                       (G3)*(G6)/TOTAL
G3  M       (0.053)  (0.035)         BIZOT     80 DM1   0 E+ E-             3/82

G4      G(K*(892) KBAR + C/C/)*G(E+E-)/G(TOTAL)          (G4)*(G6)/TOTAL
G4  M       (0.413)  (0.033)         BIZOT     80 DM1   0 E+ E-             3/82

G   M   MODEL DEPENDENT

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                          REFERENCES FOR PHI

COSME     79 NP B 152 215       +DUDELZAK,GRELAUD,JEAN-MARIE,JULLIAN+(IPNP)

ASTON     80 NP B 174 269       (BONN+CERN+EPOL+GLAS+LANC+MCHS+ORSA+IPNP +)
BIZOT     80 MADISON CONF. 546 +BISELLO,BUON,CORDIER,DELCOURT,+(LALO+USTL)
ESPOSITO 80 LNC 28 195          +MARINI,PATTERI,NIGRO+(FRAS+NAPL+PADO+ROMA)

ASTON     81 PL 104 B 231       (BONN+CERN+EPOL+GLAS+LANC+MCHS+ORSA+PARIS+)
CORDIER   81 PL 106 B 155       +BISELLO,BIZOT,BUON,DELCOURT,MANE   (ORSAY)
DELCOURT 81 PL 99 B 257         +BISELLO,BIZOT,BUON,CORDIER,MANE    (ORSAY)
MANE      81 PL 99 B 261        +BISELLO,BIZOT,BUON,CORDIER,DELCOURT(ORSAY)

BUON      82 PL 118 B 221       +BISELLO,BIZOT,CORDIER,DELCOURT+(LALO+MONP)
MANE      82 PL 112 B 178       +BISELLO,BIZOT,BUON,DELCOURT,FAYARD,+(LALO)

AUGUSTIN 83  LAL/83-21          +AYACH,BISELLO,BALDINI+    (LALO+PADO+FRAS)
ATKINSO1 83 NP B 229 269        ATKINSON+  (BONN+CERN+GLAS+LANC+MCHS+IPNP+)
ATKINSO2 83  CERN-EP/83-80      ATKINSON+  (BONN+CERN+GLAS+LANC+MCHS+IPNP+)
ATKINSO3 83 PL 127 B 132        ATKINSON+  (BONN+CERN+GLAS+LANC+MCHS+IPNP+)
ATKINSO4 83  CERN-EP/83-85      ATKINSON+  (BONN+CERN+GLAS+LANC+MCHS+IPNP+)

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g(1690)

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15  G(1690,JPG = 3-+) I=1

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                    15  G MASS (MEV)

M       WE ONLY INCLUDE HIGH STATISTICS EXPERIMENTS IN THE AVERAGE FOR THE
M       2PI AND KKBAR MODES.

M     2 PI MODE
M
M          1670.0     30.0           GOLDBERG  65 HBC    0 6 PI+D, 8 PI-P
M         (1683.)    (13.)           ARMENISE  68 DBC    0 5.1 PI+ D        6/68
M         (1737.0)   (23.0)          ARMENISE  70 DBC    0 9 PI+ N          1/71
M      122 1650.0     35.0           BARTSCH   70 HBC  + 8 PI+ P,2 PI        5/70
M          1687.      21.            STUNTEBEC 70 HDBC  0 8. PI-P,5.4 PI+D   2/72
M          1678.      12.            MATTHEWS  71 DBC   0  7. PI+ N          2/72
M  E   600 1690.       7.            ENGLER    74 DBC   0 6. PI+N,PI+PI-P   12/75
M  G       1693.       8.            GRAYER    74 ASPK  0 17 PI-P,PI+PI-N   2/74
M  GI     (1692.)    (12.)           ESTABROOK 75 RVUE    17 PI-P,PI+PI-N  12/75
M   I     (1722.)    (3.)            HYAMS     75 ASPK  0 17 PI-P,PI+PI-N  12/75
M  E   175 1678.0     12.0           ANTIPOV   77 CIBS  0 25 PI-P,P 3PI     1/82
M      476 1679.0     11.0           BALTAY    78 HBC   0 15 PI+P,PI+PI-    4/78
M    M    (1734.0)   (10.0)          CORDEN    79 OMEG    12-15PI-P, N 2PI 12/79
M          1677.      14.            EVANGELIS 81 OMEG  - 12 PI-P,2PI P     1/82
M  E    MASS ERRORS ENLARGED BY US TO WIDTH/SQRT(N),SEE K*(892) TYPED NOTE
M  G    USES SAME DATA AS HYAMS 75
M   I   FROM PHASE-SHIFT ANALYSIS
M   I   ERROR TAKES ACCOUNT OF SPREAD OF DIFFERENT PHASE-SHIFT SOLUTIONS
M    M  FROM A PHASE SHIFT SOLUTION CONTAINING A F PRIME WIDTH
M    M  TWO TIMES LARGER THAN THE K KBAR RESULT.
M
M     K KBAR + K KBAR PI MODE
M
M          1690.0     16.0           ADERHOLZ  69 HBC  +   8 PI+ P,KKBARPI  8/69
M          1692.       6.            BLUM      75 ASPK   018.4 PI-P,N K+K- 11/75
M  P S  6K 1698.      12.            MARTIN 1  78 SPEC    10 PI P,KS K- P   4/78
M          1699.0      5.0           ALPER     80 CNTR  0 62 PI-P,K+ K- N   1/82
M    L    (1694.0)   (8.0)           COSTA     80 OMEG    10. PI-P,K+ K- N  1/82
M
M    L  THEY CANNOT DISTINGUISH BETWEEN G AND OMEGA(1670).
M  P    FROM A FIT TO JP=3- PARTIAL WAVE.
M    S  SYSTEMATIC ERROR ON MASS SCALE SUBTRACTED
M
M           . . . . . . . . .
M   AVG    1690.9      2.6     AVERAGE

M     (4PI)+- MODE
M
M          1720.      15.            BALTAY    68 HBC  +   7, 8.5 PI+ P      6/68
M      144 1680.0     40.0           BARTSCH   70 HBC  +  8 PI+ P,4 PI       4/71
M  F   102(1689.0)   (20.0)           BARTSCH   70 HBC  +  8 PI+ P,2 RHO      4/71
M          1705.0     21.0           CASO      70 HBC   - 11.2PI-P,RHO 2PI  5/70
M          1630.      15.            HOLMES    72 HBC  +  10.-12. K+ P       1/73
M          1687.      20.            CASON     73 HBC  -  8.,18.5 PI- P      1/74
M  F     (1685.)    (14.)            CASON     73 HBC  -  8.,18.5 PI- P      1/74
M  F    66(1733.)    (9.)            KLIGER    74 HBC  - 4.5 PI-P,P 4PI    12/75
M          1670.      10.            THOMPSON  74 HBC  + 13 PI+ P          12/75
M      177 1665.0     15.0           BALTAY    78 HBC  + 15 PI+P,P 4PI      4/78
M  A     (1694.)    (6.)             EVANGELI  81 OMEG - 12 PI-P,(4PI)-P    3/82
M  B     (1718.)   (10.)             EVANGELI  81 OMEG - 12 PI-P,(4PI)-P    3/82
M  C     (1673.)    (9.)             EVANGELI  81 OMEG - 12 PI-P,(4PI)-P    3/82
M           . . . . . . . . .
M   AVG    1675.2     11.1     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.9)
                               (SEE IDEOGRAM BELOW)

M  A    FROM RHO- RHO0 MODE, NOT INDEPENDENT OF (B), (C)
M  B    FROM (A2)- PI0 MODE, NOT INDEPENDENT OF (A), (C)
M  C    FROM (A2)0 PI- MODE, NOT INDEPENDENT OF (A), (B)
M  F    FROM (RHO+- RHO0) MODE
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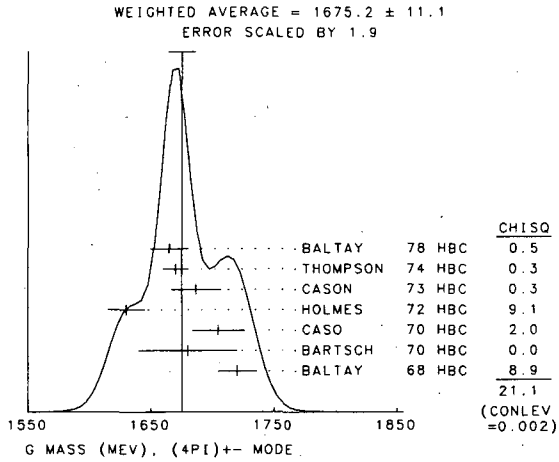


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M     OMEGA PI  MODE
M
M          1654.      24.            BARNHAM   70 HBC  +  10 K+ P,OMEGA PI  6/70
M          1686.       9.            THOMPSON  74 HBC  +  13 PI+ P         12/75
M          1666.0     14.0           GESSAROLI 77 HBC     11 PI-P,OMEGA PI 12/77
M          1690.      15.            EVANGELIS 81 OMEG  - 12 PI-P,OME PI P  1/82
M           . . . . . . . . .
M   AVG    1680.1      6.6     AVERAGE

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                    15  G WIDTH (MEV)

W       WE ONLY INCLUDE HIGH STATISTICS EXPERIMENTS IN THE AVERAGE FOR THE
W       2PI AND KKBAR MODES.

W     2 PI MODE
W
W          180.0      40.0           GOLDBERG  65 HBC    0 6 PI+D, 8 PI-P
W          188.       49.            ARMENISE  68 DBC    0 5.1 PI+ D        6/68
W          171.0      65.0           ARMENISE  70 DBC    0 9 PI+ D          1/71
W      122 180.0      30.0           BARTSCH   70 HBC  + 8 PI+ P,2 PI        5/70
W          267.       72.       46.  STUNTEBEC 70 HDBC  0 8. PI-P,5.4 PI+D   2/72
W          156.       36.            MATTHEWS  71 DBC   0  7. PI+ N          2/72
W      600 167.       40.            ENGLER    74 DBC   0 6. PI+N,PI+PI-P   12/75
W  G       200.       18.            GRAYER    74 ASPK  0 17 PI-P,PI+PI-N   2/74
W  GI     (240.)     (30.)           ESTABROOK 75 RVUE    17 PI-P,PI+PI-N  12/75
W   I     (267.)     (30.)           HYAMS     75 ASPK  0 17 PI-P,PI+PI-N  12/75
W  T   175  162.0     50.0           ANTIPOV   77 CIBS  0 25 PI-P,P 3PI     1/82
W      476  116.0     30.0           BALTAY    78 HBC   0 15 PI+P,PI+PI-    4/78
W          (206.0)  OR MORE  CL=.84  BECKER    79 ASPK  0 17 PI- P POLARIZ 12/79
W    M     (322.0)   (35.0)           CORDEN    79 OMEG    12-15PI-P, N 2PI 12/79
W           246.      37.            EVANGELIS 81 OMEG  - 12 PI-P,2PI P     1/82
W
W   I   FROM PHASE-SHIFT ANALYSIS
W   I   ERROR TAKES ACCOUNT OF SPREAD OF DIFFERENT PHASE-SHIFT SOLUTIONS
W  G    USES SAME DATA AS HYAMS 75 AND BECKER 79
W    M  FROM A PHASE SHIFT SOLUTION CONTAINING A F PRIME WIDTH
W    M  TWO TIMES LARGER THAN THE K KBAR RESULT.
W  T    WIDTH ERRORS ENLARGED BY US TO 4*WIDTH/SQRT(N),SEE K*(892) NOTE
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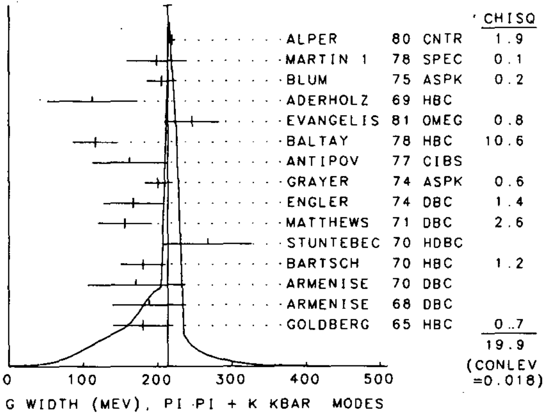
Mesons

Data Card Listings

g(1690)

```
W      K KBAR + K KBAR PI MODE
W
W             112.0      60.0             ADERHOLZ  69 HBC  +    8 PI+ P,KKBARPI   8/69
W             205.       20.              BLUM      75 ASPK   018.4 PI-P,N K+K-  11/75
W   P  6000   199.       40.              MARTIN 1  78 SPEC    10 PI P,KS K- P    4/78
W             219.0       4.0             ALPER     80 CNTR  0 62 PI-P,K+ K- N    1/82
W     L      (186.0)    (11.0)            COSTA     80 OMEG    10. PI-P,K+ K- N   1/82
W
W     L  THEY CANNOT DISTINGUISH BETWEEN G AND OMEGA(1670).
W   P       FROM A FIT TO JP=3- PARTIAL WAVE.
W
W              . . . . . . . . . .
W    AVG      213.5       5.4      AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.5)
                         (SEE IDEOGRAM BELOW)
```

WEIGHTED AVERAGE = 213.5 ± 5.4
ERROR SCALED BY 1.5




```
W      (4PI)+- MODE
W
W             100.       35.              BALTAY    68 HBC  +    7, 8.5 PI+ P     6/68
W       144   135.0      30.0             BARTSCH   70 HBC  +   8 PI+ P,4 PI      4/71
W        90  (180.0)    (30.0)            BARTSCH   70 HBC  +   8 PI+ P,A2 PI     4/71
W   F   102  (160.0)    (30.0)            BARTSCH   70 HBC  +   8 PI+ P,2 RHO
W             130.       30.              HOLMES    72 HBC  +   10.-12. K+ P      1/73
W             169.       70.       48.    CASON     73 HBC  -   8.,18.5 PI- P     1/74
W   F        (125.)     (83.)     (35.)   CASON     73 HBC  -   8.,18.5 PI- P     1/74
W   F    66  (150.)                       KLIGER    74 HBC   - 4.5 PI-P,P 4PI    12/75
W             106.       25.              THOMPSON  74 HBC  +   13 PI+ P         12/75
W       177   105.0      30.0             BALTAY    78 HBC  +   15 PI+P,P 4PI     4/78
W   A        (123.)     (13.)             EVANGELI  81 OMEG  -  12 PI-P,(4PI)-P   3/82
W   B        (230.)     (28.)             EVANGELI  81 OMEG  -  12 PI-P,(4PI)-P   3/82
W   C        (184.)     (33.)             EVANGELI  81 OMEG  -  12 PI-P,(4PI)-P   3/82
W             . . . . . . . . . .
W    AVG      117.8      12.9       AVERAGE

W   A    FROM RHO- RHO0 MODE, NOT INDEPENDENT OF (B), (C)
W   B    FROM (A2)- PI0 MODE, NOT INDEPENDENT OF (A), (C)
W   C    FROM (A2)0 PI- MODE, NOT INDEPENDENT OF (A), (B)
W   F    FROM (RHO+- RHO0) MODE

W      OMEGA PI  MODE
W
W             130.       73.       43.    BARNHAM   70 HBC  +  10 K+ P,OMEGA PI   6/70
W              89.       25.              THOMPSON  74 HBC  +  13 PI+ P          12/75
W             160.0      56.0             GESSAROLI 77 HBC     11 PI-P,OMEGA PI 12/77
W             190.       65.              EVANGELIS 81 OMEG -  12 PI-P,OME PI P  1/82
W             . . . . . . . . . .
W    AVG      112.9      20.6       AVERAGE
```

15 G PARTIAL DECAY MODES

```
                                                          DECAY MASSES
P1      G INTO PI PI                                       140+ 140
P2      G INTO 4PI(INCL. PI0'S)                            140+ 140+ 140+ 140
P3      G INTO K KBAR PI                                   498+ 498+ 140
P4      G INTO K KBAR                                      498+ 498
P5      G INTO PI PI RHO (EXCLUDING 2RHO+A2 PI)            140+ 140+ 769
P6      G INTO A2 PI                                      1318+ 140
P7      G INTO OMEGA PI                                    140+ 783
P8      G INTO 2 RHO                                       769+ 769
P9      G INTO PHI PI                                     1020+ 140
P10     G INTO ETA PI                                      549+ 140
P11     G+- INTO  3 PI CHARGED AND 1 PI0                   140+ 140+ 140+ 140
```

FITTED PARTIAL DECAY MODE BRANCHING FRACTIONS

The matrix below is derived from the error matrix for the fitted partial decay mode branching fractions, P_i, as follows: The diagonal elements are $P_i \pm \delta P_i$, where $\delta P_i = \sqrt{\langle \delta P_i \delta P_i \rangle}$, while the off-diagonal elements are the normalized correlation coefficients $\langle \delta P_i \delta P_j \rangle / (\delta P_i \cdot \delta P_j)$. For the definitions of the individual P_i, see the listings above; only those P_i appearing in the matrix are assumed in the fit to be nonzero and are thus constrained to add to 1.

	P 1	P 2	P 3	P 4
P 1	.2380+-.0129			
P 2	-.7561	.7090+-.0189		
P 3	.1510	-.7415	.0378+-.0122	
P 4	-.1452	-.0478	-.0230	.0151+-.0031

15 G BRANCHING RATIOS

```
R1      G INTO (2PI)/TOTAL                                          (P1)
R1   P         0.22       0.04             MATTHEWS  71 HDBC  0  7. PI+N,PI-P     2/72
R1   G        (0.245)    (0.006)           ESTABROOK 75 RVUE    17 PI-P,PI+PI-N  12/75
R1             0.259      0.018     0.019  BECKER    79 ASPK  0 17 PI- P POLARIZ 12/79
R1             0.23       0.02             CORDEN    79 OMEG    12-15PI-P, N 2PI 12/79
R1           . . . . . . . . . .
R1   AVG       0.243      0.013    AVERAGE
R1   FIT       0.238      0.013   FROM FIT

R1   G   FROM PHASE-SHIFT ANALYSIS OF HYAMS 75 DATA
R1   H   INCLUDED IN BECKER 79 ANALYSIS
R1   P   OPE MODEL USED IN THIS ESTIMATION

R2      G INTO(2 PI)/(4 PI) CHARGED                                 (P1)/(P11)
R2            (0.12) OR LESS               BALLAM    71 HBC  -    16. PI- P       2/72
R2            (0.2)  OR LESS               HOLMES    72 HBC  +  10.-12. K+ P      1/73
R2             0.35       0.11             CASON     73 HBC  -  8.,18.5 PI- P     1/74

R3      GO INTO(2 PI)/(4 PI) ALL                                    (P1)/(P2)
R3             0.30       0.10             BALTAY    78 HBC   0 15 PI+P,P 4PI     4/78
R3           . . . . . . . . . .
R3   FIT       0.336      0.026   FROM FIT

R4      G+- INTO (K KBAR)/(2PI)                                     (P4)/(P1)
R4             0.191      0.040     0.037  GORLICH   80 ASPK  0 17,18 PI-P POLAR 12/79
R4           . . . . . . . . . .
R4   FIT       0.063      0.014   FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.3)
R5      G+- INTO (K KBAR PI)/(2PI)                                  (P3)/(P1)
R5 A           0.16       0.05             BARTSCH   70 HBC  +  8. PI+ P          2/72
R5 A     INCREASED BY US TO CORRESPOND TO G INTO (2PI)=.24
R5           . . . . . . . . . .
R5   FIT       0.159      0.051   FROM FIT

R6      G+- INTO (RHO 2PI)/(4 PI) CHARGED                           (P5+P6+P8)/(P11)
R6             CONSISTENT WITH 1.          CASO      68 HBC   -  11 PI- P         6/68
R6            (1.)       (0.15)            BARTSCH   70 HBC  +  8. PI+ P          2/72
R6             0.88       0.15             BALLAM    71 HBC  -    16. PI- P       2/72
R6             0.96       0.21             BALTAY    78 HBC  +  15 PI+P,P 4PI     4/78
R6           . . . . . . . . . .
R6   AVG       0.91       0.12     AVERAGE

R7      G+- INTO (2RHO)/(4 PI) CHARGED                              (P8)/(P11)
R7            (0.7)      (0.15)            BARTSCH   70 HBC  +  8. PI+ P          2/72
R7       66   (0.56)                       KLIGER    74 HBC   - 4.5 PI-P,P 4PI   12/75
R7   T        (0.13)     (0.09)            THOMPSON  74 HBC  +  13 PI+ P         12/75
R7             0.12       0.11             BALTAY    78 HBC  +  15 PI+P,P 4PI     4/78
R7   T   RHO RHO AND A2 PI MODES ARE INDISTINGUISHABLE

R8      G+- INTO (2 RHO)/(ALL RHO 2PI)                              (P8)/(P5+P6+P8)
R8             0.48       0.16             CASO      68 HBC   -  11 PI- P         6/68

R9      G+- INTO (PI A2)/(4 PI) CHARGED                             (P6)/(P11)
R9            (0.6)                        BALTAY    68 HBC  +    7,8.5 PI+P      6/68
R9            (0.6)      (0.15)            BARTSCH   70 HBC  +  8. PI+ P          2/72
R9             NOT SEEN                    CASON     73 HBC  -  8.,18.5 PI- P     1/74
R9   T        (0.36)     (0.14)            THOMPSON  74 HBC  +  13 PI+P           4/78
R9             0.66       0.08             BALTAY    78 HBC  +  15 PI+P,P 4PI     4/78
R9   T   RHO RHO AND A2 PI MODES ARE INDISTINGUISHABLE

R10     G+- INTO (PI OMEGA)/(4 PI) CHARGED                          (P7)/(P11)
R10            0.25       0.10             BALTAY    68 HBC  +    7-8.5 PI+P      5/68
R10            0.25       0.10             JOHNSTON  68 HBC   -  7.0 PI- P        6/68
R10            0.12       0.07             BALLAM    71 HBC  -    16. PI- P       2/72
R10           (0.09) OR LESS               KLIGER    74 HBC   - 4.5 PI-P,P 4PI   12/75
R10            0.33       0.07             THOMPSON  74 HBC  +  13 PI+ P         12/75
R10           (0.11) OR LESS  CL=0.95      BALTAY    78 HBC  +  15 PI+P,P 4PI     4/78
R10          . . . . . . . . . .
R10 AVG        0.233      0.050    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.2)

R11     G+- INTO (PI PHI)/(4 PI) CHARGED                            (P9)/(P11)
R11           (0.11) OR LESS               BALTAY    68 HBC  +    7,8.5 PI+P      6/68

R12     G+- INTO (PI+- 2PI+ 2PI- PI0)/(4 PI) CH.
R12           (0.15) OR LESS               BALTAY    68 HBC  +    7,8.5 PI+ P     6/68

R13     G+- INTO (PI ETA)/(4 PI) CHARGED                            (P10)/(P11)
R13           (0.02) OR LESS               THOMPSON  74 HBC  +  13 PI+ P         12/75

R14     G+- INTO (K KBAR)/TOTAL                                     (P4)
R14  B         0.013      0.004            MARTIN 2  78 SPEC   -10 PI P,KS K- P   4/78
R14            0.013      0.003            COSTA     80 OMEG  0 10 PI-P,K+ K- N   1/82
R14  B  FROM SQRT(P1*P4)=0.056+-0.034 ASSUMING (2PI)/TOTAL=P1=0.24
R14          . . . . . . . . . .
R14 AVG        0.0130     0.0024  AVERAGE
R14 FIT        0.0151     0.0031 FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.3)

R16     G+- INTO (PI OMEGA)/(PI OMEGA+ 2 RHO)                       (P7)/(P7+P8)
R16            0.22       0.08             CASON     73 HBC  -  8.,18.5 PI- P     1/74
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REFERENCES FOR G


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BELLINI  65 NC 40 A 948        BELLINI,DI CORATO,DUIMIO,FIORINI   (MILANO)
DEUTSCHM 65 PL 18 351          M.DEUTSCHMANN ET AL    (AACHEN+BERLIN+CERN)
FORINO   65 PL 19 65           FORINO,GESSAROLI +   (BOLOGNA+ORSAY+SACLAY)
GOLDBERG 65 PL 17 354          GOLDBERG+ (CERN+EPOL+ORSAY+MILANO+CEA-SACL)

EHRLICH  66 PR 152 1194        R. EHRLICH,W.SELOVE,H.YUTA   (PENNSYLVANIA)
FOCACCI  66 PRL  17  890       CERN MISSING MASS SPECTROMETER GROUP (CERN)
LEVRAT   66 PL  22  714        CERN MISSING MASS SPECTROMETER GROUP (CERN)
SEGUINOT 66 PL 19 712          CERN MISSING MASS SPECTROMETER GROUP (CERN)

ABRAMS   67 PRL 18 620         +KEHOE+GLASSER+SECHI-ZORN+WOLSKY (MARYLAND)
DANYSZ   67 PL 24B 309         +FRENCH+KINSON+SIMAK+       (CERN+LIVERPOOL)
DUBAL    67 NP B3 435          +FOCACCI+KIENZLE+LECHANOINE+LEVRAT+  (CERN)
   ALSO  68 THESIS 1456        L.DUBAL                            (GENEVE)
FRENCH   67 NC 52A 442         +KINSON+MCDONALD+RIDDIFORD+     (CERN+BIRM)

ARMENISE 68 NC 54 A 999        +FORINO+CARTACCI+(BARI+BGNA +FIRENZE+ORSAY)I
BALTAY   68 PRL 20 887         +KUNG+YEH+FERBEL+      (COLU+ROCH+RUTG+YALE)I=1
BISWAS   68 PRL 21 50          +CASON,DZIERBA,GROVES,KENNEY,+        (NDAM)
BOESEBEC 68 NP B 4 501         BOESEBECK,DEUTSCHMANN,+(AACHEN+BERLIN+CERN)
CASO     68 NC 54 A 983        +CONTE+CORDS+DIAZ+  (GENOVA+HAMB+MILA+SACL)
CRENNELL 68 PL 28 B 136        +KARSHON,LAI,SCARR,SKILLICORN          (BNL)
JOHNSTON 68 PRL 20 1414        +PRENTICE,STEENBERG,YOON     (TORONTO+WISC)IJP

ADERHOLZ 69 NP B 11 259        +BARTSCH,+        (AACH+BERL+CERN+JAGL+WARS)
ANDERSON 69 PRL 22 1390        +COLLINS,BLIEDEN+                 (BNL+CARN)
BARISH   69 PR 184  1375       +SELOVE,BISWAS,CASON,+      (PENN+NDAM+ROCH)
CASO     69 NC 62 A 755        +CONTE,BENZ,+    (GENO+DESY+HAMB+MILA+SACL)
VETLITSK 69 SJNP 9 461         +GUZHAVIN,KLIGER,KOLGANOV,LEBEDEV+   (ITEP)
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For notation, see key at front of Listings.

Mesons

g(1690), θ(1690), η(1700), S(1730), π(1770)

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ARMENISE 70 LNC 4  199          +GHIDINI,FORINO,CARTACCI,+ (BARI+BGNA+FIRZ)
BARNHAM  70 PRL 24 1083         +COLLEY,JOBES,KENYON,PATHAK,RIDDIFORD(BIRM)
BARTSCH  70 NP B 22 109         +KRAUS,TSANOS,GROTE,KOTZAN+(AACH+BERL+CERN)
CASO     70 LNC 3 707           +CONTE,TOMASINI,CORDS+(GENO+HAMB+MILA+SACL)
KRAMER   70 PRL 25 396          +BARTOL,GUTAY,LICHTMAN,MILLER,+     (PURDUE)
MAURER   70  THESIS NO.588      G.MAURER                          (STRASBOURG)
STUNTEBE 70 PL 32 B 391         STUNTEBECK,KENNEY,DEERY,BISWAS,CASON+(NDAM)

BALLAM   71 PR D 3 2606         +CHADWICK,GUIRAGOSSIAN,JOHNSON,+     (SLAC)
BRAUN    71 NP B 30 213         +FRIDMAN,GERBER,GIVERNAUD,KAHN,+     (STRB)
GRAYER   71 PL 35 B 610         +HYAMS,JONES,SCHLEIN,BLUM,+     (CERN+MPIM)JP3-
MATTHEWS 71 NP B 331            +PRENTICE,YOON,CARROLL,+        (TNTO+WISC)JP3-

ARMENISE 72 LNC 4 205           +FORINO,CARTACCI,+          (BARI+BGNA+FIRZ)
    ALSO 75 LNC 14 177          +FOGLI-MUCIACCIA,FORINO+   (BARI+BGNA+FIRZ)  JP
BOWEN    72 PRL 29 890          +EARLES,FAISSLER,BLIEDEN,+      (NEAS+STON)
CLAYTON  72 NP B 47 81          +MASON,MUIRHEAD,RIGOPOULOS,+    (LIVP+PATR)
GRAYER   72 PHIL.CONF.PROC. 5 +HYAMS,JONES,SCHLEIN,BLUM,DIETL+(CERN+MPIM)
HOLMES   72 PR D 6 3336         +FERBEL,SLATTERY,WERNER             (ROCH)

ARNOLD   73 LNC 6 707           +ENGEL,ESCOUBES,KURTZ,LLORET,PATY,+  (STRB)
CASON    73 PR D 7 1971         +BISWAS,KENNEY,MADDEN,SANDER,SHEPHARD(NDAM)
CASON 1  73 NP B 64 14          +MADDEN,BISHOP,BISWAS,KENNEY,+       (NDAM)
HYAMS    73 NP B 64 134         +JONES,WEILHAMMER,BLUM,DIETL,+  (CERN+MPIM)
ROBERTSO 73 PR D 7 2554         ROBERTSON,WALKER,DAVIS          (DUKE+WISC)

DUBOVIKO 74 SJNP 19 568         DUBOVIKOV,MATSYUK,NILOV,SOKOLOV      (ITEP)
ENGLER   74 PR D10 2070         +KRAEMER,TOAFF,WEISSER,DIAZ+    (CARN+CASE)
GRAYER   74 NP B 75 189         G.GRAYER,HYAMS,BLUM,DIETL,+     (CERN+MPIM)
KLIGER   74 SJNP 19 428         +BEKETOV,GRECHKO,GUZHAVIN,DUBOVIKOV+ (ITEP)
OREN     74 NP B71 189          +COOPER,FIELDS,RHINES,WHITMORE,+  (ANL+OXF)
THOMPSON 74 NP B69 220          +GAIDOS,MCILWAIN,MILLER,MULERA,+     (PURD)

BLUM     75 PL 57B 403          +CHABAUD,DIETL,GARELICK,GRAYER+ (CERN+MPIM) JP
ESTABROO 75 NP B95 322          P.ESTABROOKS,A.D.MARTIN             (DURH)
HYAMS    75 NP B100 205         +JONES,WEILHAMMER,BLUM,DIETL+   (CERN+MPIM)
KALELKAR 75 THESIS(NEVIS 207) M.S.KALELKAR                         (COLU)I=1
ANTIPOV  77 NP B 119 45         +BUSNELLO,DAMGAARD,KIENZLE+     (CERN+SERP)
GESSAROL 77 NP B 126 382        GESSAROLI,+  (BGNA+FIRZ+GENO+MILA+OXF+PAVI)

BALTAY   78 PR D 17 62          +CAUTIS,COHEN,CSORNA,SMITH,YEH,+(COLU+BING)
FORINO   78 NP B 139 413        +CARTACCI,+  (BGNA+FIRZ+GENO+MILA+OXF+PAVI)  JP
MARTIN 1 78 PL 74 B 417         +OZMUTLU+BALDI,BOHRINGER,DORSAZ+(DURH+GEVA)
MARTIN 2 78 NP B 140 158        +OZMUTLU,BALDI,BOHRINGER,DORSAZ+(DURH+GEVA)
MARTIN 3 78 ANP  114 1          A.D.MARTIN,M.R.PENNINGTON           (CERN)

BECKER   79 NP B 151  46        +BLANAR,BLUM,CERRADA+ (MPIM+CERN+ZEEM+CRAC)
CORDEN   79 NP B 157 250        +DOWELL,GARVEY,JOBES,+(BIRM+RHEL+TELA+LOWC)  JP
EVANGELI 79 NP B 154 381        + (BARI+BONN+CERN+DARE+GLAS+LIVP+MILA+WIEN)

ALPER    80 PL 94 B 422         +BECKER,+    (AMST+CERN+CRAC+MPIM+OXF+RHEL)
COSTA    80 NP B 175 402        +      (BARI+BONN+CERN+GLAS+LIVP+MILA+WIEN)
GORLICH  80 NP B 174 16         +NICZYPORUK,ROZANSKA+ (CRAC+MPIM+CERN+ZEEM)

EVANGELI 81 NP B 178 197        EVANGELISTA+(BARI+BONN+CERN+DARE+LIVP+MILA)

BARNETT  83 PL 120 B 455        +BLOCKUS,BURKA,CHIEN,CHRISTIAN+       (JHU)

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θ(1690)

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68  THETA(1690,JPG=2++) I=0

NAMED THETA BY EDWARDS 82
SEEN IN J/PSI INTO GAMMA THETA(1690), THEREFORE C=+.
THETA(1690) DECAYS INTO 2 ETA, THEREFORE IG=0+.
JP=2+ IS PREFERRED OVER 0+, HIGHER SPINS NOT
STUDIED.
MASS AND WIDTH DETERMINATION COMPLICATED BY OVERLAP WITH F PRIME
IN MASS SPECTRA. POSSIBLE CONNECTION OF THIS STATE WITH STRUCTURE
SEEN IN J/PSI TO GAMMA RHO RHO AND IN J/PSI TO GAMMA ETA PI PI
IS UNCLEAR (SEE HITLIN 83).

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                    68  THETA(1690) MASS (MEV)

M          1640.      50.            EDWARDS   82 CBAL  0 J/PSI,GAM 2ETA    1/82
M          1708.0     30.0           FRANKLIN  82 SMK2    E+E-,GAM K+ K-   12/83*
M         (1719.0)    (6.0)          EINSWEILE 83 SMK3    E+E-,HADRONS GAM 12/83*
M          . . . . . . . . .
M   AVG    1690.0     30.0     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.2)

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                    68  THETA(1690) WIDTH (MEV)

W           220.      100.      70.   EDWARDS   82 CBAL  0 J/PSI,GAM 2ETA    1/82
W           156.0      60.0          FRANKLIN  82 SMK2    E+E-,GAM K+ K-   12/83*
W          (117.0)    (23.0)         EINSWEILE 83 SMK3    E+E-,HADRONS GAM 12/83*
W          . . . . . . . . .
W   AVG     177.3      49.0     AVERAGE

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                    68  THETA(1690) PARTIAL DECAY MODES

                                                        DECAY MASSES
P1     THETA(1690) INTO ETA ETA                        549+ 549
P2     THETA(1690) INTO K KBAR                         498+ 498

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                          REFERENCES FOR THETA(1690)

ALTHOFF  82 PL 121 B 216        +BRANDELIK,BOERNER+   (TASSO COLLABORATION)
ALTHOFF  82 ZPHY C 16 13        +BOERNER,BURKHARDT+   (TASSO COLLABORATION)
BARNES   82 PL 116 B 365        T.BARNES AND F.E.CLOSE              (RHEL)
BARNES   82 NP B 198 360        +CLOSE,MONAGHAN                  (RHEL+OXF)
EDWARDS  82 PRL 48 458          +PARTRIDGE,PECK,+ (CIT+HARV+PRIN+STAN+SLAC)
FRANKLIN 82  SLAC-254           M.E.B.FRANKLIN                      (SLAC)
TANIMOTO 82 PL 116 B 198        M.TANIMOTO                          (BIEL)

BARNETT  83 PL 120 B 455        +BLOCKUS,BURKA,CHIEN,CHRISTIAN+       (JHU)
EINSWEIL 83 BRIGHTON CONF.      K.F.EINSWEILER+MARKIII COLLABORATION (SLAC)
HITLIN   83 CORNELL CONF.       D. HITLIN                           (CIT)

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η(1700)

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63  ETA(1700,JPG=++) I=EVEN

ENHANCEMENT SEEN IN THE ETA PI PI SYSTEM
PRODUCED IN THE RADIATIVE DECAY OF THE J/PSI(3100).
MAY CONTAIN SIGNIFICANT SUB-STRUCTURE. RELATION TO
OTHER ENHANCEMENTS SEEN IN RADIATIVE J/PSI DECAY
UNCLEAR (SEE HITLIN 83).
TENTATIVELY CALLED ETA(1700) BY US.
OMITTED FROM TABLE.

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                    63  ETA(1700) MASS (MEV)

M          1700.0     45.            EDWARDS   83 CBAL    J/PSI,ETA 2PIGAM 12/83*

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                    63  ETA(1700) WIDTH (MEV)

W           520.     110.            EDWARDS   83 CBAL    J/PSI,ETA 2PIGAM 12/83*

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                          REFERENCES FOR ETA(1700)

EDWARDS  83 PRL 51 859          +PARTRIDGE,PECK+  (CIT+HARV+PRIN+STAN+SLAC)
HITLIN   83 CORNELL CONF.       D. HITLIN                           (CIT)

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S(1730)

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86  S(1730,JPG=0++) I=0

NAMED S* PRIME BY ETKIN 82
SEEN IN PHASE SHIFT ANALYSIS OF KOS KOS SYSTEM.
NEEDS CONFIRMATION. OMITTED FROM TABLE.

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                    86  S(1730) MASS (MEV)

M  AB     (1771.0)   (77.0)   (53.0)  ETKIN1    82 MPS   0 23 PI-P,2KOS N    9/83*
M  A S     1730.0     30.0            ETKIN2    82 MPS   0 23 PI-P,2KOS N    2/84*

M  A    FROM AN AMPLITUDE ANALYSIS OF THE KOS KOS SYSTEM.
M   B   SUPERSEDED BY ETKIN2 82.
M    S  SYSTEMATIC ERROR ADDED LINEARLY BY US.

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                    86  S(1730) WIDTH (MEV)

W  A        200.0    156.0      9.0  ETKIN1    82 MPS   0 23 PI-P,2KOS N    9/83*

W  A    FROM AN AMPLITUDE ANALYSIS OF THE KOS KOS SYSTEM.

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                    86  S(1730) PARTIAL DECAY MODES

                                                        DECAY MASSES
P1     S(1730) INTO K KBAR                             498+ 498

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                          REFERENCES FOR S(1730)

ETKIN1   82 PR D 25 1786        +FOLEY,LAI,LINDENBAUM+ (BNL+CUNY+TUFT+VAND)  JP
ETKIN2   82 PR D 25 2446        +FOLEY,LAI,LINDENBAUM+ (BNL+CUNY+TUFT+VAND)

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π(1770)

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75  PI(1770,JPG=0--) I=1

SEEN IN PARTIAL WAVE ANALYSIS OF THE DIFFRACTIVELY
PRODUCED 3 PI SYSTEM.
NEEDS CONFIRMATION. OMITTED FROM TABLE.

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                    75  PI(1770) MASS (MEV)

M     1100 1770.      30.            BELLINI   82 SPEC -  40 PI-A,3PI A     8/83*

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                    75  PI(1770) WIDTH (MEV)

W     1100  310.      50.            BELLINI   82 SPEC -  40 PI-A,3PI A     8/83*

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                    75  PI(1770) PARTIAL DECAY MODES

                                                        DECAY MASSES
P1     PI(1770) INTO EPSILON PI                       1300+ 140
P2     PI(1770) INTO RHO PI                            769+ 140

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                    75  PI(1770) BRANCHING RATIOS

R1     PI(1770) INTO (EPSILON PI)/TOTAL                    (P1)
R1         DOMINANT                BELLINI   82 SPEC -  40 PI-A,3PI A     8/83*

R2     PI(1770) INTO (RHO PI)/TOTAL                        (P2)
R2         NOT SEEN                BELLINI   82 SPEC -  40 PI-A,3PI A     8/83*

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                          REFERENCES FOR PI(1770)

BELLINI  82 PRL 48 1697         +FRABETTI,IVANSHIN,LITKIN+ (MILA+BGNA+JINR)

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Mesons

f(1810), ϕ(1850), S(1935)

Data Card Listings

f(1810)

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38  F(1810,JPG=2++) I=0

FORMERLY CALLED X(1850).
FROM AN AMPLITUDE ANALYSIS OF THE K+K- SYSTEM SEEN IN
PI- P INTO K+ K- N AT 10 GEV/C. NOT CONFIRMED BY
ETKIN 82. SEEN ALSO IN PI+PI- TO 2PI0 AMPLITUDE
ANALYSIS (CASON 82),BUT NOT SEEN IN THE PARTIAL
WAVE ANALYSIS OF THE PI+PI- SYSTEM.
NEEDS CONFIRMATION. OMITTED FROM TABLE.

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                    38  F(1810) MASS (MEV)

M    A     1857.0     35.0     24.0   COSTA     80 OMEG  0 10 PI-P,K+ K- N   1/82
M          1799.0     15.0            CASON     82 STRC  0 8 PI+P,PI+2PI0 P  8/83*
M          . . . . . . . . .
M   AVERAGE MEANINGLESS (SCALE FACTOR = 1.8)

M    A  ERROR INCREASED BY SPREAD OF TWO SOLUTIONS.

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                    38  F(1810) WIDTH (MEV)

W    A      185.0    102.0    139.0   COSTA     80 OMEG  0 10 PI-P,K+ K- N   1/82
W           280.0     42.0     35.0   CASON     82 STRC  0 8 PI+P,PI+2PI0 P  8/83*
W   AVERAGE MEANINGLESS

W    A  ERROR INCREASED BY SPREAD OF TWO SOLUTIONS.

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                    38  F(1810) PARTIAL DECAY MODES

                                                          DECAY MASSES
P1      F(1810) INTO K+ K-                              494+ 494
P2      F(1810) INTO PI PI                              140+ 140

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                    38  F(1810) BRANCHING RATIOS

R1      F(1810) INTO ( K+ K- )/TOTAL                        (P1)
R1          SEEN                        COSTA     80 OMEG  0 10 PI-P,K+ K- N   1/82

R2      F(1810) INTO (PI PI)/TOTAL                          (P2)
R2            0.44      0.03            CASON     82 STRC  0 8 PI+P,PI+2PI0 P  8/83*

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                          REFERENCES FOR F(1810)

COSTA    80 NP B 175 402       +      (BARI+BONN+CERN+GLAS+LIVP+MILA+WIEN)

CASON    82 PRL 48 1316        +BISWAS,BAUMBAUGH,BISHOP,CANNATA+(NDAM+ANL)
ETKIN    82 PR D 25 1786       +FOLEY,LAI,LINDENBAUM+ (BNL+CUNY+TUFT+VAND)

CASON    83 PR D 28 1586       +CANNATA,BAUMBAUGH,BISHOP,WATSON+(NDAM+ANL)

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ϕ(1850)

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54  PHI(1850,JPG=   ) I=0

SEEN IN THE K KBAR AND K KBAR PI MASS
DISTRIBUTIONS.

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                    54  PHI(1850) MASS (MEV)

M      123 1850.0     10.0            ALHARRAN  81 HBC     8.25 K-P,LAM 2K   1/82
M      430 1870.0     30.0     20.0   ARMSTRONG 82 OMEG    18.5 K-P,K-K+LAM  8/83*
M          . . . . . . . . .
M   AVG    1852.8      9.3    AVERAGE

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                    54  PHI(1850) WIDTH (MEV)

W      123   80.0     40.0     30.0   ALHARRAN  81 HBC     8.25 K-P,LAM 2K   1/82
W      430  160.0     90.0     50.0   ARMSTRONG 82 OMEG    18.5 K-P,K-K+LAM  8/83*
W          . . . . . . . . .
W   AVG      96.0     32.0    AVERAGE

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                    54  PHI(1850) PARTIAL DECAY MODES

                                                          DECAY MASSES
P1      PHI(1850) INTO K KBAR                           494+ 494
P2      PHI(1850) INTO K*(892) K + C.C.                 892+ 494

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                    54  PHI(1850) BRANCHING RATIOS

R1      PHI(1850) INTO (K*(892) K+C.C.)/(K KBAR)            (P2)/(P1)
R1            0.8       0.4            ALHARRAN  81 OMEG    8.25 K-P,LAM 2K   1/82

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                          REFERENCES FOR PHI(1850)

ASTON    80 PL 92 B 219        (BONN+CERN+EPOL+GLAS+LANC+MCHS+ORSA+PARIS+)

ALHARRAN 81 PL 101 B 357       +AMIRZADEH,+     (BIRM+CERN+GLAS+MICH+LPNP)

ARMSTRON 82 PL 110 B 77        +BAUBILLIER+(BARI+BIRM+CERN+MILA+LPNP+PAVI)  JP
CORDIER  82 PL 110 B 335       +BISELLO,BIZOT,BUON,DELCOURT,FAYARD,+(LALO)

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S(1935)

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31  S(1935,JPG=  )
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A narrow enhancement called the S(1935) has been observed in the antiproton-proton total cross section (CARROLL 74, CHALOUPKA 76, BRUCKNER 77, SAKAMOTO 79).

This observation has not been confirmed by other experiments (ALLEN 80, KAMAE 80, JASTRZEMBSKI 81, LOWENSTEIN 81), or the effect was found to be smaller in magnitude and larger in width (HAMILTON 80).

A recent experiment (SUMIYOSHI 82) has measured with high precision the $\bar{p}p$ total cross section, by an improved transmission method, rejecting both the narrow- (CARROLL 74) and broad- (HAMILTON 80) S hypotheses.

No significant signal is observed for a narrow S(1935) in backward antiproton-proton elastic scattering (GARNJOST 79), nor in the charge-exchange cross section (GARNJOST 75, CHALOUPKA 76, HAMILTON 80).

The nonexistence of the S is also confirmed by recent hadroproduction experiments (DAUM 81, BENSINGER 83, BARNETT 83).

The only observation in favor of a narrow S which remains unchallenged is the one of ASTON 80 in a photoproduction experiment. The weak statistical significance of the signal does not warrant taking the S(1935) as a well-established narrow resonance.

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                    31  S MASS (MEV)

M        S CHANNEL NBAR N
M    C     (1940.)     (8.)                CLINE     70 HBC   0  .25-.74 PBAR P   2/72
M    B     (1968.)                         BENVENUTI 71 HBC   0  .1 - .8 PBAR P   2/72
M   S       1932.       2.                 CARROLL   74 CNTR    S CHAN.PBAR P,D  12/75
M    C     (1942.)     (5.)                D-ANDLAU  75 HBC   0 .175-.750 PBAR P 12/75
M    Z     (1934.4)    (2.6)     (1.4)     KALOGERO  75 DBC   - PBAR N ANNIH     12/75
M   S       1935.9      1.0                CHALOUPKA 76 HBC   0 PBAR P TOT,ELAS  12/75
M           1939.0      3.0                BRUCKNER  77 SPEC  0 .4-.85 PBAR P     7/77
M           1935.5      1.0                SAKAMOTO  79 HBC   0 .37-.73 PB P     12/79
M           1930.0      2.0                ASTON     80 OMEG    GAM P,P PBAR X     1/82
M    A     (1949.)    (10.)                DEFOIX    80 HBC   0 PBAR P,5PI        1/80
M     M     1939.0      2.0                HAMILTO2  80 CNTR  0 S CHAN,PBAR P    12/79
M
M        PRODUCTION EXPERIMENTS
M        36(1940.0)    (1.0)               DAUM      80 CNTR  0 93 P P,PB P + X  12/79
M          . . . . . . . . .
M   AVERAGE MEANINGLESS (SCALE FACTOR = 1.7)

M    A   FROM ENERGY DEPENDENCE OF 5PI CROSS-SECTION.IG=1- FROM OBSERVATION
M    A   OF OMEGA RHO DECAY. P=+ AND J>1. A2 PI PI ALSO SEEN.
M    B   SEEN AS A BUMP IN THE PBAR P - KS KL  CROSS SECTION WITH JPC=1--.
M        NOT SEEN BY CARSON 72 WITH EQUAL STATISTICS.
M    C   FROM ENERGY DEPENDENCE OF FAR BACKWARD ELASTIC SCATTERING.
M        SOME INDICATION OF ADDITIONAL STRUCTURE.
M     M  I=0 FAVORED,J=0 OR 1,SEEN IN TOTAL PBAR P TOTAL CROSS-SECTION,
M     M  PRIMARLY FROM ANNIH. REACTIONS.  NOT SEEN IN PBAR D TOTAL AND
M     M  ANNIH. CROSS SECTIONS.
M    N   SEEN IN 3 CHARGED MODE. NOT SEEN BY BOWEN 73 WITH 6X STATISTICS.
M    S   NARROW BUMP SEEN IN TOTAL PBAR P,D CROSS-SECTIONS.ISOSPIN UNCERTAIN
M        NOT SEEN IN PBAR P CEX BY GARNJOST 75,CHALOUPKA 76. INTEGRATED
M        CROSS-SECTION 3X LARGER THAN BRUCKNER 77.
M    Z   NOT SEEN BY ALBERI 79 WITH COMPARABLE STATISTICS.


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For notation, see key at front of Listings.

Mesons

S(1935), h(2030), δ(2040)

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                    31  S WIDTH (MEV)

W        S CHANNEL NBAR N
W   C        (49.)     (9.)              CLINE      70 HBC   0  .25-.74 PBAR P   2/72
W   B        (35.)                       BENVENUTI 71 HBC   0  .1 - .8 PBAR P   2/72
W   S          9.        4.        3.    CARROLL    74 CNTR     S CHAN.PBAR P,D  12/75
W   C        (57.5)    (5.)              D-ANDLAU   75 HBC   0 .175-.750 PBAR P 12/75
W   Z        (11.)    (11.)      (4.)    KALOGERO   75 DBC   - PBAR N ANNIH    12/75
W   S          8.8      4.3       3.2    CHALOUPKA 76 HBC   0 PBAR P TOT,ELAS  12/75
W             (4.0)  OR LESS              BRUCKNER   77 SPEC  0 .4-.85 PBAR P    7/77
W              2.8      1.4                SAKAMOTO   79 HBC   0 .37-.73 PB P    12/79
W             12.0      7.0                ASTON      80 OMEG    GAM P,P PBAR X   1/82
W   A        (80.)    (20.)                DEFOIX     80 HBC   0 PBAR P,5PI      1/80
W    M        22.0      6.0                HAMILTO2   80 CNTR  0 S CHAN,PBAR P    12/79
W
W        PRODUCTION EXPERIMENTS
W             (6.0)  APPROX.              DAUM       80 CNTR    93 P P,PB P + X  12/79
W
W   AVERAGE MEANINGLESS (SCALE FACTOR = 1.9)

W   SEE FOOTNOTES UNDER S MASS ABOVE

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                    31  S PARTIAL DECAY MODES

                                                          DECAY MASSES
P1      S INTO PBAR P                                   938+ 938

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                          REFERENCES FOR S(1935)

CLINE     68 PRL 21 1268          +ENGLISH,REEDER,TERRELL,TWITTY  (WISCONSIN)

CLINE     70  PREPRINT            D.CLINE,J.ENGLISH,D.D.REEDER          (WISC)J
   ALSO   70 KIEV CONF.           ASTIER RAPPORTEUR TALK

BENVENUT 71 PRL 27 283            BENVENUTI,CLINE,RUTZ,REEDER,SCHERER  (WISC)
PINSKI    71 PRL 27 1548          STEPHEN S. PINSKY                (UTAH+ARGONNE)

BIZZARRI 72 PR D 6 160            +GUIDONI,MARZANO,CASTELLI,+      (ROMA+TRST)
BOWEN 1   72 PRL 29 890           +EARLES,FAISSLER,BLIEDEN,+       (NEAS+STON)

BOWEN     73 PRL 30 332           +EARLES,FAISSLER,BLIEDEN,+       (NEAS+STON)
BURNS     73 PR D 8 1286          +CONDON,DONAHUE,MANDELKERN,PRICE,+     (UCI)
KIENZLE   73 PR D 7 3520          W.KIENZLE                             (CERN)

BURNS     74 NC 20A 463           +CONDON,MANDELKERN,PRICE,SCHULTZ       (UCI)
CARROLL   74 PRL 32 247           +CHIANG,KYCIA,LI,MAZUR,MICHAEL,+       (BNL)

ABASHIAN 75 PRL 34 691            +BEAMER,BROSS,EISENSTEIN,+     (ILL+ANL+ISU)
D-ANDLAU 75 PL 58B 223            +COHEN-GANOUNA,LALOUM,LUTZ,PETRI(CDEF+PISA)  JP
DEFOIX    75 PALERMO  CONF.       B.FRENCH, RAPPORTEURS TALK            (CDEF)
DONNACHI 75 NC 26 A 317           A.DONNACHIE,P.R.THOMAS         (MANCHESTER)
GARNJOST 75 PRL 35 1685           +KENNEY,POLLARD,ROSS,TRIPP,+     (LBL+MHCO)
KALOGERO 75 PRL 34 1047           KALOGEROPOULOS,TZANAKOS               (SYRA)
WEINGART 75 PRL 34 1201           WEINGARTEN,OKUBO                      (ROCH)

ABASHIAN 76 PR D 13 5             +WATSON,GELFAND,BUTTRAM,+(ILL+ANL+CHIC+ISU)
DEFOIX    76 STOCK.SYMP.NBAR-N    +LADRON DE GUEVARA,ANGELINI,+   (CDEF+PISA)
DOVER     76 PL 62 B 293          +KAHANA                               (BNL)
CHALOUPK 76 PL 61 B 487           CHALOUPKA,+ (CERN+LIVP+MONS+PADO+ROMA+TRST)

BENKHEIR 77 PL B 68 483           BENKHEIR1,BOUCROT,+   (CERN+CDEF+EPOL+LALO)
BRUCKNER 77 PL 67 B 222           +GRANZ,INGHAM,KILIAN,LYNEN+(MPIH+HEID+CERN)
MONTANET 77 BOSTON CONF. 260      L.MONTANET                            (CERN)
ROSSI     77 PL 70 B 255          G.C.ROSSI,G.VENEZIANO                 (CERN)

CARTER    78 NP B 132 176         A.A.CARTER                            (LOQM)  JP
CUTTS     78 PR D 17 16           +GOOD,GRANNIS,GREEN,LEE,PITTMAN+(STON+WISC)
PENNINGT 78 NP B 137 77           M.R. PENNINGTON                       (CERN)

ALBERI    79 PL 83 B 247          +ALVEAR,CASTELLI,POROPAT+  (TRST+CERN+IFRJ)
ALSTON-G 79 PRL 43 1901           ALSTON-GARNJOST,HAMILTON+    (LBL+MTHO+BNL)
CARROLL   79 PR D 19 1950         +CHIANG,KYCIA,LI,LITTENBERG,+     (BNL+ROCH)
DELCOURT 79 PL B 86 395           +DERADO,BERTRAND,BISELLO,BIZOT,BUON,+(LALO)
GIBBARD   79 PRL 42 1593          +AHRENS,BERKELMAN,CASSEL,DAY,HARDING+(CORN)
KLUYVER   79 ZPHY C 2 351         J.C. KLUYVER                          (AMST)
RICHARD   79 BATAVIA CONF. 469    F. RICHARD                            (LALO)
SAKAMOTO 79 NP B 158 410          +HASHIMOTO,SAI,YAMAMOTO+              (TOKY)

ALLEN     80 BRESSANONE 175       5TH EUROPEAN SYMPOSIUM ON N-NBAR INTS.
ASTON     80 PL 93 B 517          (BONN+CERN+EPOL+GLAS+LANC+MCHS+ORSA+PARIS+)
BIONTA    80 PRL 46 970           +CARROLL,EDELSTEIN,+   (BNL+CARN+FNAL+SMAS)
CHUNG     80 PRL 45 1611          +ETKIN,BENSINGER,+(BNL+BRAN+CUNY+SMAS+MASA)
DAUM      80 PL 90 B 475          +HERTZBERGER+(AMST+CERN+CRAC+MPIM+OXF+RHEL)
DEFOIX    80 NP B 162 12          +DOBRZYNSKI,ANGELINI,BIGI,+     (CDEF+PISA)
    ALSO  80 NP B 162 41          ESPIGAT,DEFOIX,DOBRZYNSKI+      (CDEF+PISA)
HAMILTO1 80 PRL 44 1179           HAMILTON,PUN,TRIPP,LAZARUS,+ (LBL+BNL+MTHO)
HAMILTO2 80 PRL 44 1182           HAMILTON,PUN,TRIPP,LAZARUS,+ (LBL+BNL+MTHO)
KAMAE     80 PRL 44 1439          +AIHARA,CHIBA,FUJII,IWASAKI,+   (TOKY+HIRO)

DAUM      81 PL 100 B 439         +HERTZBERGER+(AMST+CERN+CRAC+MPIM+OXF+RHEL)
GANGULI   81 NP B 183 295         +CERRADA,DEFOIX,+(TIFR+CERN+CDEF+MADR+PISA)
JASTRZEM 81 PR D 23 2784          JASTRZEMBSKI,MANDELKERN,+    (TEMP+UCI+UNM)
LOWENSTE 81 PR D 23 2788          LOWENSTEIN,PEASLEE,+     (BNL+DOE+MSU+SYRA)

SUMIYOSH 82 PRL 49 628            +CHIBA,FUJII,IKEDA,TAKADA,+ (TOKY+KEK+TSUK)

BARNETT   83 PR D 27 493          +BLOCKUS,BURKA,CHIEN,CHRISTIAN+       (JHU)
BENSINGE 83 PR D 27 1417          BENSINGER,CHUNG    (BRAN+BNL+CINC+FSU+SMAS)

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h(2030)

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                    16  H(2030,JPG=4++) I=0

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                    16  H MASS (MEV)

M       700 2020.      30.              APEL       75 CNTR    40.  PI-P,N 2PI0 11/75
M           2050.      25.              BLUM       75 ASPK    18.4 PI-P,N K+K- 11/75
M   T      (1922.0)   (14.0)            ANTIPOV    77 CIBS  0 25 PI-P,P 3PI     1/82
M   M      (1935.0)   (13.0)            CORDEN     79 OMEG    12-15PI-P, N 2PI 12/79
M          (1988.0)    (7.0)            EVANGELIS 79 OMEG    10. PI-P,K+ K- N 12/79
M    M     (2040.0)   (10.0)            ROZANSKA   80 SPRK    18.PI-P,P PB N   12/79
M   M      (1978.0)    (5.0)            ALPER      80 CNTR    62 PI-P,K+ K- N   1/82
M   N       2015.0     28.0             CASON      82 STRC  0 8 PI+P,PI+2PI0 P  8/83*
M   E       2031.0     36.0             ETKIN      82 MPS   0 23 PI-P,2K0S N    9/83*
M   N   40K 2020.0     20.0             BINON      83 SPEC  0 38 PI-P,N 2PI0    9/83*
M
M   AVG     2026.9     11.7     AVERAGE

M    M  I=0,JP=4+ FROM AMPLITUDE ANALYSIS ASSUMING ONE PION EXCHANGE
M   T   WIDTH ERRORS ENLARGED BY US TO 4*WIDTH/SQRT(N),SEE K* TYPED NOTE
M   E   ETKIN 82 QUOTES ERRORS +25/-36 MEV. WE USE +-36 MEV IN THE AVERAGE.
M   N   FROM AMPLITUDE ANALYSIS OF REACTION PI+PI- TO 2PI0

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                    16  H WIDTH (MEV)

W       700  180.      60.              APEL       75 CNTR    40.  PI-P,N 2PI0 11/75
W            225.      120.     70.     BLUM       75 ASPK    18.4 PI-P,N K+K- 11/75
W   T       (107.0)   (56.0)            ANTIPOV    77 CIBS  0 25 PI-P,P 3PI     1/82
W   M       (263.0)   (57.0)            CORDEN     79 OMEG    12-15PI-P, N 2PI 12/79
W           (100.0)   (28.0)            EVANGELIS 79 OMEG    10. PI-P,K+ K- N 12/79
W    M      (140.0)   (15.0)            ROZANSKA   80 SPRK    18.PI-P,P PB N   12/79
W   M       (243.0)   (16.0)            ALPER      80 CNTR    62 PI-P,K+ K- N   1/82
W   N        186.0    103.0     58.0    CASON      82 STRC  0 8 PI+P,PI+2PI0 P  8/83*
W   E        305.0    119.0             ETKIN      82 MPS   0 23 PI-P,2K0S N    9/83*
W   N   40K 240.0     40.0              BINON      83 SPEC  0 38 PI-P,N 2PI0    9/83*
W
W   AVG      222.2     28.4     AVERAGE

W    M  I=0,JP=4+ FROM AMPLITUDE ANALYSIS ASSUMING ONE PION EXCHANGE
W   E   ETKIN 82 QUOTES ERRORS +36/-119 MEV. WE USE +-119 MEV.
W   N   FROM AMPLITUDE ANALYSIS OF REACTION PI+PI- TO 2PI0

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                    16  H PARTIAL DECAY MODES

                                                          DECAY MASSES
P1      H INTO PI PI                                    140+ 140
P2      H INTO K KBAR                                   498+ 498

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                    16  H BRANCHING RATIOS

R1      H INTO (PI PI)/TOTAL                                  (P1)
R1           0.17      0.02            CORDEN     79 OMEG    12-15PI-P, N 2PI 12/79
R1           0.16      0.03            CASON      82 STRC  0 8 PI+P,PI+2PI0 P  8/83*
R1
R1  AVG      0.167     0.017    AVERAGE

R2      H INTO (K KBAR)/(PI PI)                               (P2)/(P1)
R2           0.04      0.02     0.01   ETKIN      82 MPS   0 23 PI-P,2K0S N    9/83*

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                          REFERENCES FOR H(2030)

WAGNER    74 LONDON CONF.         F. WAGNER, RAPPORTEURS TALK           (MPIM)

APEL      75 PL 57B 398           +AUGENSTEIN+     (KARL+PISA+SERP+WIEN+CERN)  JP
BLUM      75 PL 57B 403           +CHABAUD,DIETL,GARELICK,GRAYER+ (CERN+MPIM)  JP

ANTIPOV   77 NP B 119 45          +BUSNELLO,DAMGAARD,KIENZLE+     (CERN+SERP)

CORDEN    79 NP B 157 250         +DOWELL,GARVEY,JOBES,+(BIRM+RHEL+TELA+LOWC)  JP
EVANGELI 79 NP B 154 381          + (BARI+BONN+CERN+DARE+GLAS+LIVP+MILA+WIEN)

ALPER     80 PL 94 B 422          +BECKER,+    (AMST+CERN+CRAC+MPIM+OXF+RHEL)

GOTTESMA 81 PR D 22 1503          GOTTESMAN,JACOBS,+     (SYRA+BRAN+BNL+CINC)
ROZANSKA 80 NP B 162 505          +BLUM,DIETL,GRAYER,LORENZ+      (MPIM+CERN)

CASON     82 PRL 48 1316          +BISWAS,BAUMBAUGH,BISHOP,CANNATA+(NDAM+ANL)
ETKIN     82 PR D 25 1786         +FOLEY,LAI,LINDENBAUM+ (BNL+CUNY+TUFT+VAND)

BINON     83  CERN-EP/83-98       +DONSKOV,DUTEIL,GOUANERE+  (SERP+BELG+LAPP)
CASON     83 PR D 28 1586         +CANNATA,BAUMBAUGH,BISHOP,WATSON+(NDAM+ANL)

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δ(2040)

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                    17  DELTA(2040,JPG=4+-) I=1

                    SEEN IN PARTIAL WAVE ANALYSIS OF THE K KBAR AND
                    PI+PI-PI0 SYSTEMS.
                    NEEDS CONFIRMATION. OMITTED FROM TABLE.

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                    17  DELTA(2040) MASS (MEV)

M   Y     (1903.0)   (10.0)            BALDI      78 SPEC -  10 PI-P,P KS K-  12/77
M    M     2030.0     50.0             CORDEN     78 OMEG  0 15 PI- P,3 PI N  12/78
M    C     2040.0     30.0             CLELAND    82 SPEC +- 50 PI P,KS K+-P   8/83*
M
M   AVG    2037.4     25.7     AVERAGE

M    M  JP=4+ IS FAVORED , THOUGH 2+ CANNOT BE EXCLUDED.
M   Y   FROM A FIT TO THE Y(8,0) MOMENT. LIMITED BY PHASE SPACE.
M    C   FROM AN AMPLITUDE ANALYSIS
M

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                    17  DELTA(2040) WIDTH (MEV)

W   Y     (166.0)   (43.0)            BALDI      78 SPEC -  10PI-P,P KS K-   12/77
W    M     510.0    200.0             CORDEN     78 OMEG  0 15 PI- P,3 PI N  12/78
W    C     380.0    150.0             CLELAND    82 SPEC +- 50 PI P,KS K+-P   8/83*
W
W   AVG    426.8    120.0     AVERAGE

W    M  JP=4+ IS FAVORED , THOUGH 2+ CANNOT BE EXCLUDED.
W   Y   FROM A FIT TO THE Y(8,0) MOMENT. LIMITED BY PHASE SPACE.
W    C   FROM AN AMPLITUDE ANALYSIS
W

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                    17  DELTA(2040) PARTIAL DECAY MODES

                                                          DECAY MASSES
P1      DELTA(2040) INTO K KBAR                         494+ 494
P2      DELTA(2040) INTO PI+ PI- PI0                    140+ 140+ 135

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                    17  DELTA(2040) BRANCHING RATIOS

R1      DELTA(2040) INTO (K KBAR)/TOTAL                       (P1)
R1          SEEN                     BALDI      78 SPEC +- 10 PI-P,KS K- P   8/83*
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Mesons

Data Card Listings

δ(2040), A(2050), A(2100), T and U Regions, ρ(2150)

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R2      DELTA(2040) INTO (PI+ PI- PIO)/TOTAL                    (P2)
R2          SEEN                        CORDEN    78 OMEG  0 15 PI- P,3 PI N   6/81

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                          REFERENCES FOR DELTA(2040)

BALDI     78 PL 74 B 413        +BOHRINGER,DORSAZ,HUNGERBULER,+    (GENEVA)  JP
CORDEN    78 NP B 136 77        DOWELL,GARVEY,JOBES+  (BIRM+RHEL+TELA+LOWC)  JP

DELFOSSE 81 NP B 183 349        +DORSAZ,EXTERMANN,GLOOR,WEILL,+ (GEVA+LAUS)

CLELAND  82 NP B 208 228        +DELFOSSE,DORSAZ,GLOOR(DURH+GEVA+LAUS+PITT)

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A(2050) →

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                43  A(2050,JPG=3+-)  I=1

                FORMERLY CALLED A4 OR PI.
                NEEDS CONFIRMATION. OMITTED FROM TABLE.

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                43  A(2050) MASS  (MEV)

M       208 2080.     40.            KALELKAR  75 HBC  +  15 PI+P,P PI+G   12/75
M          (2100.)  APPROX          ANTIPOV   77 CIBS -  25PI-P,P PI-G    12/77
M          (2214.)   (15.)          BALTAY    77 HBC   0 15PI-P,DEL++3PI  12/77

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                43  A(2050) WIDTH  (MEV)

W       208  340.     80.            KALELKAR  75 HBC  +  15 PI+P,P PI+G   12/75
W          (500.)  APPROX.          ANTIPOV   77 CIBS -  25PI-P,P PI-G    12/77
M          (355.)   (21.)           BALTAY    77 HBC   0 15PI-P,DEL++3PI  12/77

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                43  A(2050) PARTIAL DECAY MODES

                                                          DECAY MASSES
P1      A(2050) INTO 3PI                                 140+ 140+ 140
P2      A(2050) INTO G PI                               1691+ 140

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                43  A(2050) BRANCHING RATIOS

R1      A(2050) INTO (G PI)/(ALL 3PI)                           (P2)/(P1)
R1          DOMINANT                    KALELKAR  75 HBC  +  15 PI+P,P 3PI    12/75

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                          REFERENCES FOR A(2050)

HUSON     68 PL 28 B 208        +LUBATTI,BELLINI,BINGHAM,+  (ORSA+MILA+LBL)

BEMPORAD 71 NP B 33 397         +DUFEY,CODLING,+       (CERN+ETH+LOIC+MILA)

CLAYTON   72 NP B 47 81         +MASON,MUIRHEAD,RIGOPOULOS,+    (LIVP+PATR)

BASTIEN   73 UPPSALA CONF. 73   +DUNN,HARRIS,LUBATTI,BINGHAM,+   (SEAT+UCB)

OREN      74 NP B71 189         +COOPER,FIELDS,RHINES,WHITMORE,+  (ANL+OXF)

DEUTSCHM 75 NP B99 397          DEUTSCHMANN,+       (ABBCCHW COLLABORATION)
KALELKAR 75 THESIS(NEVIS 207) M.S.KALELKAR                          (COLU)

ANTIPOV   77 NP B 119 45        +BUSNELLO,DAMGAARD,KIENZLE+     (CERN+SERP)
BALTAY    77 PRL 39 591         +CAUTIS,KALELKAR                 (COLUMBIA)  JP

HARRIS    81 ZPHY C 9 275       +DUNN,LUBATTI,MORIYASU,PODOLSKY+ (SEAT+UCB)
CAUTIS    77 THESIS NEVIS 221 C.V.CAUTIS                         (COLUMBIA)  JP

BALTAY    78 PR D 17 52         +CAUTIS,COHEN,CSORNA,KALELKAR+  (COLU+BING)

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A(2100) →

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                20  A(2100,JPG=2--) I=1

                FORMERLY CALLED PI.
                SEEN IN THE (RHO PI), (EPSILON(1300) PI) AND (F PI)
                JP = 2- WAVES OF THE DIFFRACTIVELY PRODUCED 3 PI
                SYSTEM. NEEDS CONFIRMATION. OMITTED FROM TABLE.

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                20  A(2100) MASS (MEV)

M    L     2100.     150.            DAUM      81 CNTR    63,94 PI- P,3PI   1/82

M    L  FROM A TWO RESONANCE FIT TO FOUR 2-0+ WAVES.

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                20  A(2100) WIDTH (MEV)

W    L      651.      50.            DAUM      81 CNTR    63,94 PI- P,3PI   1/82

W    L  FROM A TWO RESONANCE FIT TO FOUR 2-0+ WAVES.

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                20  A(2100) PARTIAL DECAY MODES

                                                          DECAY MASSES
P1      A(2100) INTO 3PI                                 140+ 140+ 140
P2      A(2100) INTO RHO PI                              769+ 140
P3      A(2100) INTO F PI                               1274+ 140
P4      A(2100) INTO EPSILON(1300) PI                   1300+ 140

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                20  A(2100) BRANCHING RATIOS

R1      A(2100) INTO (RHO PI)/(ALL 3PI)                         (P2)/(P1)
R1   L       0.19      0.05           DAUM      81 CNTR    63,94 PI- P       1/82

R2      A(2100) INTO (F PI)/(ALL 3PI)                           (P3)/(P1)
R2   L       0.36      0.09           DAUM      81 CNTR    63,94 PI- P       1/82

R3      A(2100) INTO (EPSILON(1300) PI)/(ALL 3PI)               (P4)/(P1)
R3   L       0.45      0.07           DAUM      81 CNTR    63,94 PI- P       1/82

R4      D/S RATIO FOR A(2100) INTO F PI
R4   L       0.39      0.23           DAUM      81 CNTR    63,94 PI- P       1/82

R    L  FROM A TWO RESONANCE FIT TO FOUR 2-0+ WAVES.

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                          REFERENCES FOR A(2100)

DAUM      81 NP B 182 269       +HERTZBERGER+(AMST+CERN+CRAC+MPIM+OXF+RHEL)

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NOTE ON THE T AND U REGIONS

The observation of broad enhancements at 2190 and 2350 MeV comes from $\bar{p}p$ total cross-section measurements (ABRAMS 67), $\bar{p}p$ annihilation measurements (ALSPECTOR 73), $\bar{p}p$ elastic cross-section measurements (COUPLAND 77), and $\bar{p}p$ charge-exchange cross-section measurements (CUTTS 78). The mass regions centered around 2190 MeV and 2350 MeV have been called T and U regions, respectively.

Searches for resonances in exclusive $\bar{p}p$ annihilation channels which could be coupled to the enhancements observed in the $\bar{p}p$ total cross section and in $\bar{p}p$ elastic scattering have been unsuccessful, except for the two-body annihilation channels $\pi^+\pi^-$ and $\pi^0\pi^0$, where partial-wave analyses have shown that resonances are formed in the 2100-2500-MeV mass region (CARTER 77, DULUDE 78, MARTIN A 80, MARTIN B 80). We have listed the results of these analyses under the headings $\epsilon(2150)$ for the I=0, $J^P=2^+$ wave; $\rho(2150)$ for the I=1, $J^P=1^-$ wave; $\rho(2250)$ for the I=1, $J^P=3^-$ wave; $\epsilon(2300)$ for the I=0, $J^P=4^+$ wave; and $\rho(2350)$ for the I=1, $J^P=5^-$ wave.

Various structures coupled to $\bar{p}p$ and observed in production experiments are listed under the heading $\bar{N}N$(1200-3600).

ρ(2150) →

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                32  RHO(2150,JPG=1-+) I=1

                THIS ENTRY WAS PREVIOUSLY CALLED T1(2190).
                CONTAINS ONLY RESULTS FROM FORMATION EXPERIMENTS, FOR
                PRODUCTION EXPERIMENTS SEE THE NBAR N(1200-3600) ENTRY.
                SEE ALSO T,U MINI-REVIEWS.
                OMITTED FROM TABLE.

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                32  RHO(2150) MASS (MEV)

M       PBAR P INTO PI PI
M
M    P    (2100.0)  APPROX.           MARTIN A  80 RVUE                     1/82
M    P    (2170.0)  APPROX.           MARTIN B  80 RVUE                     1/82

M    P  I=1,JP=1- FROM SIMULTANEOUS ANALYSIS OF P PB --> PI-PI+ AND PIO PIO
M       S CHANNEL NUCLEON ANTINUCLEON
M
M  B       2190.      10.             ABRAMS    70 CNTR    S CHANNEL PBAR N  1/73
M    I     2193.       2.             ALSPECTOR 73 CNTR    S CHANNEL PBAR P  1/74
M  E I     2155.0     15.0            COUPLAND  77 CNTR  0 .7-2.4PB-P,PB-P  12/77
M    I    (2190.0)  APPROX.           CUTTS     78 CNTR    .97-3. PB P,NB N 12/78
M   AVERAGE MEANINGLESS

M  B    SEEN AS BUMP IN I=1 STATE. SEE ALSO COOPER 68.
M  B    PEASLEE 75 CONFIRM PBAR P RESULTS OF ABRAMS 70,NO NARROW STRUCTURE
M  E    FROM A FIT TO THE TOTAL ELASTIC CROSS SECTION.
M    I  ISOSPINS 0 AND 1 NOT SEPARATED

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For notation, see key at front of Listings.

Mesons

$\rho(2150)$, $\epsilon(2150)$, $\xi(2220)$, $g_T(2240)$

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                    32  RHO(2150) WIDTH (MEV)

W       PBAR P INTO PI PI
W
W    P     (200.0)  APPROX.          MARTIN A  80 RVUE                      1/82
W    P     (250.0)  APPROX.          MARTIN B  80 RVUE                      1/82

W    P  I=1,JP=1- FROM SIMULTANEOUS ANALYSIS OF P PB --> PI-PI+ AND PIO PIO

W       S CHANNEL NUCLEON ANTINUCLEON
W
W  B        (85.)   APPROX.          ABRAMS    70 CNTR    S CHANNEL PBAR N  7/67
W    I       98.      8.              ALSPECTOR 73 CNTR    S CHANNEL PBAR P  1/74
W  E I      135.0     75.0            COUPLAND  77 CNTR  0 .7-2.4PB-P,PB-P  12/77
W   AVERAGE MEANINGLESS

W  B    SEE NOTE B ABOVE.
W  E    FROM A FIT TO THE TOTAL ELASTIC CROSS SECTION.
W    I  ISOSPINS 0 AND 1 NOT SEPARATED

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                         REFERENCES FOR RHO(2150)

ABRAMS   67 PRL 18 1209       +COOL,GIACOMELLI,KYCIA,LEONTIC,LI,+   (BNL)

COOPER   68 PRL 20 1059       +HYMAN,MANNER,MUSGRAVE,VOYVODIC       (ANL)

BRICMAN  69 PL 29 B 451       +FERRO-LUZZI,BIZARD,+       (CERN+CAEN+SACL)

ABRAMS   70 PR D 1 1917       +COOL,GIACOMELLI,KYCIA,LEONTIC,LI,+   (BNL)

BACON    71 NP B 32 66        +BUTTERWORTH,MILLER,PHELAN,+    (RHEL+LIVP)
FIELDS   71 PRL 27 1749       +COOPER,RHINES,ALLISON            (ANL+OXF)
YOH      71 PRL 26 922        +BARISH,CAROLL,LOBKOVICZ+    (CIT+BNL+ROCH)

ALEXANDE 72 NP B 45 29        ALEXANDER,BAR-NIR,BEVARY,DAGAN,+      (TELA)
DONALD   72 PL 40 B 586       +GALLETLY,EDWARDS,DE BILLY,+    (LIVP+LPNP)

ALSPECTO 73 PRL 30 511        ALSPECTOR,COHEN,CVIJANOVICH,+   (RUTG+UPNJ)
BACON    73 PR D 7 577        +BUTTERWORTH,                   (RHEL+LIVP)
BETTINI  73 NC 15 A 563       +GARNJOST,BIGI,+        (PADO+LBL+PISA+TORI)
DONALD   73 NP B 61 333       +EDWARDS,GIBBINS,BRIAND,DUBOC,+ (LIVP+LPNP)
NICHOLSO 73 PR D 7 2572       NICHOLSON,DELORME,CARROLL,+  (CIT+ROCH+BNL)

BERTANZA 74 NC 23A 209        +BIGI,CASALI,LARICCIA,+    (PISA+PADO+TORI)
HYAMS    74 NP B 73 202       +JONES,WEILHAMMER,BLUM,+        (CERN+MPIM)

DONNACHI 75 NC 26 A 317       A.DONNACHIE,P.R.THOMAS          (MANCHESTER)
EISENHAN 75 NP B 96 109       EISENHANDLER,GIBSON,+ (LOQM+LIVP+DARE+RHEL)
HANDLER  75 NP B101 35        +JACQUES,JONES,PANDOULAS,+ (RUTG+STEV+ALBA)
HUESMAN  75 NC 25A  91        +GARNJOST,ROSS,+        (LBL+PADO+PISA+TORI)
PEASLEE  75 PL 57B 189        +DEMARZO,GUERRIERO,+   (CANB+BARI+BROW+MIT)

GAY      76 NC 31 A 593       +JEANNERET,BOGDANSKI,+(NEUC+LAUS+LIVP+LPNP)
ZEMANY   76 NP B 103 537      +MING MA,MOUNTZ,SMITH                 (MSU)

CARTER 1 77 PL 67 B 117       +COUPLAND,EISENHANDLER,ASTBURY,+(LOQM+RHEL)  JP
CARTER 2 77 PL 67 B 122       A.A.CARTER                            (LOQM)  JP
CARTER 3 77 NP B 127 202      +COUPLAND,ATKINSON,ARNISON+(LOQM+DARE+RHEL)
COUPLAND 77 PL 71 B 460       +EISENHANDLER,GIBSON,ASTBURY,+  (LOQM+RHEL)
JONES    77 NP B 119 476      M.D.JONES,R.J.PLANO                   (RUTG)
MONTANET 77 BOSTON CONF. 260  L.MONTANET                            (CERN)

CARTER 1 78 NP B 132 176      A.A.CARTER                            (LOQM)  JP
CARTER 2 78 NP B 141 467      A.A.CARTER                            (LOQM)
CUTTS    78 PR D 17 16        +GOOD,GRANNIS,GREEN,LEE,PITTMAN+(STON+WISC)

MARTIN   79 PL 86 B 93        A.D. MARTIN,M.R. PENNINGTON           (DURH)

MARTIN A 80 NP B 169 216      A.D. MARTIN,M.R. PENNINGTON           (DURH)  JP
MARTIN B 80 NP B 176 355      B.R.MARTIN,D.MORGAN                (LOUC+RHEL)  JP

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$\epsilon(2150)$ →

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                    42  EPSILON(2150,JPG=2++) I=0

                    THIS ENTRY WAS PREVIOUSLY CALLED TO.
                    CONTAINS ONLY RESULTS FROM FORMATION EXPERIMENTS, FOR
                    PRODUCTION EXPERIMENTS SEE THE NBAR N(1200-3600) ENTRY.
                    SEE ALSO T,U MINI-REVIEWS.
                    OMITTED FROM TABLE.

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                    42  EPSILON(2150) MASS (MEV)

M       PBAR P INTO PI PI
M
M    L    (2150.0)  APPROX.          DULUDE2   78 OSPK    1.-2.PB P,PIOPIO 12/78
M    P    (2150.0)  APPROX.          MARTIN A  80 RVUE                      1/82
M    P    (2170.0)  APPROX.          MARTIN B  80 RVUE                      1/82

M    L  IG=0+,JP=2+ FROM PARTIAL WAVE AMPLITUDE ANALYSIS
M    P  I=0,JP=2+ FROM SIMULTANEOUS ANALYSIS OF P PB --> PI-PI+ AND PIO PIO

M       S CHANNEL PBAR P OR NBAR N
M
M    I     2193.       2.            ALSPECTOR 73 CNTR    S CHANNEL PBAR P  1/74
M  E I     2155.0     15.0           COUPLAND  77 CNTR  0 .7-2.4PB-P,PB-P  12/77
M    I    (2190.0)  APPROX.          CUTTS     78 CNTR    .97-3. PB P,NB N 12/78
M   AVERAGE MEANINGLESS

M  E    FROM A FIT TO THE TOTAL ELASTIC CROSS SECTION.
M    I  ISOSPINS 0 AND 1 NOT SEPARATED

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                    42  EPSILON(2150) WIDTH (MEV)

W       PBAR P INTO PI PI
W
W    L     (250.0)  APPROX.          DULUDE2   78 OSPK    1.-2.PB P,PIOPIO 12/78
W    P     (250.0)  APPROX.          MARTIN A  80 RVUE                      1/82
W    P     (250.0)  APPROX.          MARTIN B  80 RVUE                      1/82

W    L  IG=0+,JP=2+ FROM PARTIAL WAVE AMPLITUDE ANALYSIS
W    P  I=0,JP=2+ FROM SIMULTANEOUS ANALYSIS OF P PB --> PI-PI+ AND PIO PIO

W       S CHANNEL PBAR P OR NBAR N
W
W    I       98.       8.            ALSPECTOR 73 CNTR    S CHANNEL PBAR P  1/74
W  E I      135.0     75.0           COUPLAND  77 CNTR  0 .7-2.4PB-P,PB-P  12/77
W   AVERAGE MEANINGLESS

W  E    FROM A FIT TO THE TOTAL ELASTIC CROSS SECTION.
W    I  ISOSPINS 0 AND 1 NOT SEPARATED

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                    42  EPSILON(2150) PARTIAL DECAY MODES

                                                          DECAY MASSES
P1      EPSILON(2150) INTO PI PI                        140+ 140

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                         REFERENCES FOR EPSILON(2150)

FIELDS   71 PRL 27 1749       +COOPER,RHINES,ALLISON            (ANL+OXF)
YOH      71 PRL 26 922        +BARISH,CAROLL,LOBKOVICZ+    (CIT+BNL+ROCH)

DONALD   72 PL 40 B 586       +GALLETLY,EDWARDS,DE BILLY,+    (LIVP+LPNP)

ALSPECTO 73 PRL 30 511        ALSPECTOR,COHEN,CVIJANOVICH,+   (RUTG+UPNJ)
BACON    73 PR D 7 577        +BUTTERWORTH,                   (RHEL+LIVP)
DONALD   73 NP B 61 333       +EDWARDS,GIBBINS,BRIAND,DUBOC,+ (LIVP+LPNP)
NICHOLSO 73 PR D 7 2572       NICHOLSON,DELORME,CARROLL,+  (CIT+ROCH+BNL)

GAY      76 NC 31 A 593       +JEANNERET,BOGDANSKI,+(NEUC+LAUS+LIVP+LPNP)

COUPLAND 77 PL 71 B 460       +EISENHANDLER,GIBSON,ASTBURY,+  (LOQM+RHEL)

CUTTS    78 PR D 17 16        +GOOD,GRANNIS,GREEN,LEE,PITTMAN+(STON+WISC)
DULUDE1  78 PL 79 B 329       +LANOU,MASSIMO,PEASLEE+     (BROW+MIT+BARI)  JP
DULUDE2  78 PL 79 B 335       +LANOU,MASSIMO,PEASLEE+     (BROW+MIT+BARI)  JP

MARTIN   79 PL 86 B 93        A.D. MARTIN,M.R. PENNINGTON           (DURH)

BOWCOCK  80 LNC 28 21         J.E.BOWCOCK,D.C.HODGSON               (BIRM)
MARTIN A 80 NP B 169 216      A.D. MARTIN,M.R. PENNINGTON           (DURH)  JP
MARTIN B 80 NP B 176 355      B.R.MARTIN,D.MORGAN                (LOUC+RHEL)  JP

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$\xi(2220)$ →

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                    82  XI(2220,JP=EVEN +) I=0

                    THIS STATE HAS BEEN SEEN IN THE K KBAR SYSTEM
                    PRODUCED IN THE RADIATIVE DECAY OF J/PSI(3100)
                    NEEDS CONFIRMATION. OMITTED FROM TABLE.

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                    82  XI(2220) MASS (MEV)

M    A     (2220.)    (35.)          EINSWEILE 83 SMK3    E+E-,HADRONS GAM 12/83*
M    A  SYSTEMATIC ERROR ADDED LINEARLY BY US.

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                    82  XI(2220) WIDTH (MEV)

W    A      (30.)    (30.)          HITLIN    83 SMK3    E+E-,HADRONS GAM 12/83*
W    A  SYSTEMATIC ERROR ADDED LINEARLY BY US.

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                         REFERENCES FOR XI(2220)

EINSWEIL 83 BRIGHTON CONF.    K.F.EINSWEILER+MARKIII COLLABORATION (SLAC)
HITLIN   83 CORNELL CONF.     D.HITLIN                              (CIT)

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$g_T(2240)$ →

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                    83  G/T(2240,JPG=2++) I=0

                    THIS ENTRY CONTAINS VARIOUS STATES OBSERVED IN
                    PARTIAL WAVE ANALYSES OF THE PHI PHI SYSTEM.
                    NEEDS CONFIRMATION. OMITTED FROM TABLE.

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                    83  G/T(2240) MASS (MEV)

M1   D    2160.0     50.0           ETKIN     82 MPS   0 16 PI-P,2PHI N    9/83*
M1   D  D/S RATIO IS 0.02 APPROXIMATELY

M2        2320.0     40.0           ETKIN     82 MPS   0 16 PI-P,2PHI N    9/83*

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                    83  G/T(2240) WIDTH (MEV)

W1         310.0     70.0           ETKIN     82 MPS   0 16 PI-P,2PHI N    9/83*

W2         220.0     70.0           ETKIN     82 MPS   0 16 PI-P,2PHI N    9/83*

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                    83  G/T(2240) PARTIAL DECAY MODES

                                                          DECAY MASSES
P1      G/T(2240) INTO PHI PHI                          1020+1020

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                         REFERENCES FOR G/T(2240)

ETKIN    82 PRL 49 1620       +FOLEY,LONGACRE,LINDENBAUM,CHAN+ (BNL+CUNY)I JP
    ALSO 83 BRIGHTON CONF.    LINDENBAUM                       (BNL+CUNY)I JP

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Mesons

$\rho(2250)$, $\epsilon(2300)$, $\rho(2350)$

Data Card Listings

$\rho(2250)$ →

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44  RHO(2250,JPG=3-+) I=1

CONTAINS ONLY RESULTS FROM FORMATION EXPERIMENTS, FOR
PRODUCTION EXPERIMENTS SEE THE NBAR N(1200-3600) ENTRY.
SEE ALSO T,U MINI-REVIEWS.
OMITTED FROM TABLE.

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                44  RHO(2250) MASS (MEV)

M       PBAR P INTO PI PI OR K KB
M
M  J      (2150.0)  APPROX.          CARTER 1  77 CNTR  0 .7-2.4PB P,PIPI  12/77
M    K    (2140.0)  APPROX.          CARTER 2  78 CNTR  0 .7-2.4PB P,K-K+  12/78
M    P    (2300.0)  APPROX.          MARTIN A  80 RVUE                      1/82
M    P    (2250.0)  APPROX.          MARTIN B  80 RVUE                      1/82

M  J    I=1,JP=3- FROM AMPLITUDE ANALYSIS.
M    K  I=0,1.JP=3- FROM BARRELET ZERO ANALYSIS.
M    P  I=1,JP=3- FROM SIMULTANEOUS ANALYSIS OF P PB --> PI-PI+ AND PIO PIO

M       S CHANNEL NUCLEON ANTINUCLEON
M
M  B       2190.      10.            ABRAMS    70 CNTR    S CHANNEL PBAR N  1/73
M    I     2193.       2.            ALSPECTOR 73 CNTR    S CHANNEL PBAR P  1/74
M  E I     2155.0     15.0           COUPLAND  77 CNTR  0 .7-2.4PB-P,PB-P  12/77
M    I    (2190.0)  APPROX.          CUTTS     78 CNTR    .97-3. PB P,NB N 12/78
M   AVERAGE MEANINGLESS

M  B    SEEN AS BUMP IN I=1 STATE. SEE ALSO COOPER 68.
M  B    PEASLEE 75 CONFIRM PBAR P RESULTS OF ABRAMS 70,NO NARROW STRUCTURE
M  E    FROM A FIT TO THE TOTAL ELASTIC CROSS SECTION.
M    I  ISOSPINS 0 AND 1 NOT SEPARATED

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                44  RHO(2250) WIDTH (MEV)

W       PBAR P INTO PI PI OR K KB
W
W  J      (200.0)  APPROX.           CARTER 1  77 CNTR  0 .7-2.4PB P,PIPI  12/77
W    K    (150.0)  APPROX.           CARTER 2  78 CNTR  0 .7-2.4PB P,K-K+  12/78
W    P    (200.0)  APPROX.           MARTIN A  80 RVUE                      1/82
W    P    (250.0)  APPROX.           MARTIN B  80 RVUE                      1/82

W  J    I=1,JP=3- FROM AMPLITUDE ANALYSIS.
W    K  I=0,1.JP=3- FROM BARRELET ZERO ANALYSIS.
W    P  I=1,JP=3- FROM SIMULTANEOUS ANALYSIS OF P PB --> PI-PI+ AND PIO PIO

W       S CHANNEL NUCLEON ANTINUCLEON
W
W  B       (85.)    APPROX.           ABRAMS    70 CNTR    S CHANNEL PBAR N  7/67
W    I     98.       8.               ALSPECTOR 73 CNTR    S CHANNEL PBAR P  1/74
W  E I     135.0     75.0             COUPLAND  77 CNTR  0 .7-2.4PB-P,PB-P  12/77
W   AVERAGE MEANINGLESS

W  B    SEE NOTE B ABOVE.
W  E    FROM A FIT TO THE TOTAL ELASTIC CROSS SECTION.
W    I  ISOSPINS 0 AND 1 NOT SEPARATED

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                REFERENCES FOR RHO(2250)

ABRAMS   67 PRL 18 1209       +COOL,GIACOMELLI,KYCIA,LEONTIC,LI,+   (BNL)

COOPER   68 PRL 20 1059       +HYMAN,MANNER,MUSGRAVE,VOYVODIC       (ANL)

ABRAMS   70 PR D 1 1917       +COOL,GIACOMELLI,KYCIA,LEONTIC,LI,+   (BNL)

FIELDS   71 PRL 27 1749       +COOPER,RHINES,ALLISON            (ANL+OXF)
YOH      71 PRL 26 922        +BARISH,CAROLL,LOBKOVICZ+    (CIT+BNL+ROCH)

ALSPECTO 73 PRL 30 511        ALSPECTOR,COHEN,CVIJANOVICH,+   (RUTG+UPNJ)
BETTINI  73 NC 15 A 563       +GARNJOST,BIGI,+          (PADO+LBL+PISA+TORI)
DONNACHI 73 LNC 7 285         A.DONNACHIE,P.R.THOMAS          (MANCHESTER)
NICHOLSO 73 PR D 7 2572       NICHOLSON,DELORME,CARROLL,+  (CIT+ROCH+BNL)

BERTANZA 74 NC 23A 209        +BIGI,CASALI,LARICCIA,+    (PISA+PADO+TORI)

ZEMANY   76 NP B 103 537      +MING MA,MOUNTZ,SMITH                 (MSU)

CARTER 1 77 PL 67 B 117       +COUPLAND,EISENHANDLER,ASTBURY,+(LOQM+RHEL)  JP
CARTER 2 77 PL 67 B 122       A.A.CARTER                            (LOQM)  JP
CARTER 3 77 NP B 127 202      +COUPLAND,ATKINSON,ARNISON+(LOQM+DARE+RHEL)
COUPLAND 77 PL 71 B 460       +EISENHANDLER,GIBSON,ASTBURY,+  (LOQM+RHEL)
MONTANET 77 BOSTON CONF. 260  L.MONTANET                            (CERN)

CARTER 1 78 NP B 132 176      A.A.CARTER                            (LOQM)  JP
CARTER 2 78 NP B 141 467      A.A.CARTER                            (LOQM)
CUTTS    78 PR D 17 16        +GOOD,GRANNIS,GREEN,LEE,PITTMAN+(STON+WISC)

MARTIN   79 PL 86 B 93        A.D. MARTIN,M.R. PENNINGTON           (DURH)

MARTIN A 80 NP B 169 216      A.D. MARTIN,M.R. PENNINGTON           (DURH)  JP
MARTIN B 80 NP B 176 355      B.R.MARTIN,D.MORGAN              (LOUC+RHEL)  JP

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$\epsilon(2300)$ →

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41  EPSILON(2300,JPG=4++) I=0

THIS ENTRY WAS PREVIOUSLY CALLED U0(2350).
CONTAINS ONLY RESULTS FROM FORMATION EXPERIMENTS, FOR
PRODUCTION EXPERIMENTS SEE THE NBAR N(1200-3600) ENTRY.
SEE ALSO T,U MINI-REVIEWS.
OMITTED FROM TABLE.

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                41  EPSILON(2300) MASS (MEV)

M       PBAR P INTO PI PI OR KB K
M
M  J      (2310.0)  APPROX.          CARTER 1  77 CNTR  0 .7-2.4PB P,PIPI  12/77
M    K    (2340.0)  APPROX.          CARTER 2  78 CNTR  0 .7-2.4PB P,K-K+  12/78
M         (2330.0)  APPROX.          DULUDE2   78 OSPK    1.-2.PB P,PIOPIO  1/82
M    P    (2300.0)  APPROX.          MARTIN A  80 RVUE                      1/82
M    P    (2300.0)  APPROX.          MARTIN B  80 RVUE                      1/82

M  J    I=0,JP=4+ FROM AMPLITUDE ANALYSIS.
M    K  I=0,JP=4+ FROM BARRELET ZERO ANALYSIS
M    P  I=0,JP=4+ FROM SIMULTANEOUS ANALYSIS OF P PB --> PI-PI+ AND PIO PIO

M       S CHANNEL PBAR P OR NBAR N
M
M          2375.      10.            ABRAMS    70 CNTR    S CHANNEL NBAR N  1/71
M  I      (2359.)     (2.)           ALSPECTOR 73 CNTR    S CHANNEL PBAR P  1/74
M  EI     (2345)     (15.0)          COUPLAND  77 CNTR  0 .7-2.4PB-P,PB-P  12/77
M  I      (2380.0)  APPROX.          CUTTS     78 CNTR    .97-3. PB P,NB N 12/78

M  E    FROM A FIT TO THE TOTAL ELASTIC CROSS SECTION.
M  I    ISOSPINS 0 AND 1 NOT SEPARATED

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                41  EPSILON(2300) WIDTH (MEV)

W       PBAR P INTO PI PI OR KB K
W
W  J      (210.0)  APPROX.           CARTER 1  77 CNTR  0 .7-2.4PB P,PIPI  12/77
W    K    (150.0)  APPROX.           CARTER 2  78 CNTR  0 .7-2.4PB P,K-K+  12/78
W    P    (200.)   APPROX.           MARTIN A  80 RVUE                      3/82

W  J    I=0,JP=4+ FROM AMPLITUDE ANALYSIS.
W    K  I=0,JP=4+ FROM BARRELET ZERO ANALYSIS
W    P  I=0,JP=4+ FROM SIMULTANEOUS ANAL. OF P PBAR --> PI-PI+ AND PIO PIO

W       S CHANNEL PBAR P OR NBAR N
W
W          (190.)   APPROX.           ABRAMS    70 CNTR    S CHANNEL NBAR N  1/71
W  I       (165.)    (18.)     (8.)   ALSPECTOR 73 CNTR    S CHANNEL PBAR P  1/74
W  EI      (135.0)  (150.0)   (65.0)  COUPLAND  77 CNTR  0 .7-2.4PB-P,PB-P  12/77

W  E    FROM A FIT TO THE TOTAL ELASTIC CROSS SECTION.
W  I    ISOSPINS 0 AND 1 NOT SEPARATED

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                REFERENCES FOR EPSILON(2300)

BRICMAN  69 PL 29 B 451       +FERRO-LUZZI,BIZARD,+      (CERN+CAEN+SACL)

ABRAMS   70 PR D 1 1917       +COOL,GIACOMELLI,KYCIA,LEONTIC,LI,+   (BNL)

FIELDS   71 PRL 27 1749       +COOPER,RHINES,ALLISON            (ANL+OXF)
YOH      71 PRL 26 922        +BARISH,CAROLL,LOBKOVICZ+    (CIT+BNL+ROCH)

EASTMAN  72 NP B 51 29        +MING MA,OH,PARKER,SMITH,SPRAFKA      (MSU)

ALSPECTO 73 PRL 30 511        ALSPECTOR,COHEN,CVIJANOVICH,+   (RUTG+UPNJ)
DONNACHI 73 LNC 7 285         A.DONNACHIE,P.R.THOMAS          (MANCHESTER)
NICHOLSO 73 PR D 7 2572       NICHOLSON,DELORME,CARROLL,+  (CIT+ROCH+BNL)

HYAMS    74 NP B 73 202       +JONES,WEILHAMMER,BLUM,+         (CERN+MPIM)
MING MA  74 NP B68 214        +MOUNTZ,ZEMANY,SMITH                  (MICH)

DONNACHI 75 NC 26 A 317       A.DONNACHIE,P.R.THOMAS          (MANCHESTER)
EISENHAN 75 NP B 96 109       EISENHANDLER,GIBSON,+ (LOQM+LIVP+DARE+RHEL)

CARTER 1 77 PL 67 B 117       +COUPLAND,EISENHANDLER,ASTBURY,+(LOQM+RHEL)  JP
CARTER 2 77 PL 67 B 122       A.A.CARTER                            (LOQM)  JP
CARTER 3 77 NP B 127 202      +COUPLAND,ATKINSON,ARNISON+(LOQM+DARE+RHEL)
COUPLAND 77 PL 71 B 460       +EISENHANDLER,GIBSON,ASTBURY,+  (LOQM+RHEL)
MONTANET 77 BOSTON CONF. 260  L.MONTANET                            (CERN)

CARTER 1 78 NP B 132 176      A.A.CARTER                            (LOQM)  JP
CARTER 2 78 NP B 141 467      A.A.CARTER                            (LOQM)
CUTTS    78 PR D 17 16        +GOOD,GRANNIS,GREEN,LEE,PITTMAN+(STON+WISC)
DULUDE1  78 PL 79 B 329       +LANOU,MASSIMO,PEASLEE+     (BROW+MIT+BARI)  JP
DULUDE2  78 PL 79 B 335       +LANOU,MASSIMO,PEASLEE+     (BROW+MIT+BARI)  JP

MARTIN   79 PL 86 B 93        A.D. MARTIN,M.R. PENNINGTON           (DURH)

BOWCOCK  80 LNC 28 21         J.E.BOWCOCK,D.C.HODGSON               (BIRM)
MARTIN A 80 NP B 169 216      A.D. MARTIN,M.R. PENNINGTON           (DURH)  JP
MARTIN B 80 NP B 176 355      B.R.MARTIN,D.MORGAN              (LOUC+RHEL)  JP

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$\rho(2350)$ →

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33  RHO(2350,JPG=5-+) I=1

THIS ENTRY WAS PREVIOUSLY CALLED U1(2400).
CONTAINS ONLY RESULTS FROM FORMATION EXPERIMENTS, FOR
PRODUCTION EXPERIMENTS SEE THE NBAR N(1200-3600) ENTRY.
SEE ALSO T,U MINI-REVIEWS.
OMITTED FROM TABLE.

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                33  RHO(2350) MASS (MEV)

M       PBAR P INTO PI PI OR KB K
M  J      (2480.0)  APPROX.          CARTER 1  77 CNTR  0 .7-2.4PB P,PIPI  12/77
M    K    (2500.0)  APPROX.          CARTER 2  78 CNTR  0 .7-2.4PB P,K-K+  12/78
M    P    (2250.0)  APPROX.          MARTIN A  80 RVUE                      1/82
M    P    (2300.0)  APPROX.          MARTIN B  80 RVUE                      1/82

M  J    I=1,JP=5- FROM AMPLITUDE ANALYSIS.
M    K  I=0,1.JP=5- FROM BARRELET ZERO ANALYSIS.
M    P  I=1,JP=5- FROM SIMULTANEOUS ANALYSIS OF P PB --> PI-PI+ AND PIO PIO

M       S CHANNEL NUCLEON ANTINUCLEON
M
M  A       2350.      10.            ABRAMS    70 CNTR    S CHANNEL NBAR N  1/73
M  N      (2360.0)   (25.0)          OH        70 HDBC   -OPBAR(P,N),K*K2PI  1/73
M  I      (2359.)     (2.)           ALSPECTOR 73 CNTR    S CHANNEL PBAR P  1/74
M  EI     (2345.0)   (15.0)          COUPLAND  77 CNTR  0 .7-2.4PB-P,PB-P  12/77
M  I      (2380.0)  APPROX.          CUTTS     78 CNTR    .97-3. PB P,NB N 12/78

M  A    FOR I=1 NBAR N
M  E    FROM A FIT TO THE TOTAL ELASTIC CROSS SECTION.
M  I    ISOSPINS 0 AND 1 NOT SEPARATED
M  N    NO EVIDENCE FOR THIS BUMP SEEN IN THE PBAR P DATA OF CHAPMAN 71
M  N    NARROW STATE NOT CONFIRMED BY OH 73 WITH MORE DATA.

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                33  RHO(2350) WIDTH (MEV)

W       PBAR P INTO PI PI OR KB K
W  J      (210.0)  APPROX.           CARTER 1  77 CNTR  0 .7-2.4PB P,PIPI  12/77
W    K    (150.0)  APPROX.           CARTER 2  78 CNTR  0 .7-2.4PB P,K-K+  12/78
W    P    (300.0)  APPROX.           MARTIN A  80 RVUE                      1/82
W    P    (250.0)  APPROX.           MARTIN B  80 RVUE                      1/82

W  J    I=1,JP=5- FROM AMPLITUDE ANALYSIS.
W    K  I=0,1.JP=5- FROM BARRELET ZERO ANALYSIS.
W    P  I=1,JP=5- FROM SIMULTANEOUS ANALYSIS OF P PB --> PI-PI+ AND PIO PIO
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For notation, see key at front of Listings. **Mesons**

$\rho(2350)$, $\delta(2450)$, r(2510), $e^+e^-(1100-2200)$, $\bar{N}N(1200-3600)$

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W       S CHANNEL NUCLEON ANTINUCLEON
W
W          (140.)   APPROX.          ABRAMS    67 CNTR    S CHANNEL PBAR N  1/73
W  N        (60.)   OR LESS          OH        70 HDBC   -OPBAR(P,N),K*K2PI 11/71
W  I       (165.)    (18.)     (8.)  ALSPECTOR 73 CNTR    S CHANNEL PBAR P  1/74
W  EI      (135.0)  (150.0)   (65.0) COUPLAND  77 CNTR  0 .7-2.4PB-P,PB-P  12/77

W  E    FROM A FIT TO THE TOTAL ELASTIC CROSS SECTION.
W  I    ISOSPINS 0 AND 1 NOT SEPARATED
W  N    NO EVIDENCE FOR THIS BUMP SEEN IN THE PBAR P DATA OF CHAPMAN 71
W  N    NARROW STATE NOT CONFIRMED BY OH 73 WITH MORE DATA.

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REFERENCES FOR RHO(2350)


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ABRAMS    67 PRL 18 1209        +COOL,GIACOMELLI,KYCIA,LEONTIC,LI,+   (BNL)

BRICMAN   69 PL 29 B 451        +FERRO-LUZZI,BIZARD,+       (CERN+CAEN+SACL)
CASO      69 LNC 3 707          +CONTE,BENZ,+     (GENO+DESY+HAMB+MILA+SACL)

ABRAMS    70 PR D 1 1917        +COOL,GIACOMELLI,KYCIA,LEONTIC,LI,+   (BNL)
OH        70 PRL 24 1257        +PARKER,EASTMAN,SMITH,SPRAFKA,MA      (MSU)

CHAPMAN   71 PR D4 1275         +GREEN,LYS,MURPHY,RING,+             (MICH)
FIELDS    71 PRL 27 1749        +COOPER,RHINES,ALLISON            (ANL+OXF)
YOH       71 PRL 26 922         +BARISH,CAROLL,LOBKOVICZ+    (CIT+BNL+ROCH)

EASTMAN   72 NP B 51 29         +MING MA,OH,PARKER,SMITH,SPRAFKA      (MSU)
MING MA   72 NP B 51 77         +EASTMAN,OH,PARKER,SMITH,SPRAFKA      (MSU)
OH        72 NP B 51 57         +EASTMAN,MING MA,PARKER,SMITH,+       (MSU)

ALSPECTO  73 PRL 30 511         ALSPECTOR,COHEN,CVIJANOVICH,+   (RUTG+UPNJ)
NICHOLSO  73 PR D 7 2572        NICHOLSON,DELORME,CARROLL,+  (CIT+ROCH+BNL)

HYAMS     74 NP B 73 202        +JONES,WEILHAMMER,BLUM,+        (CERN+MPIM)
MING MA   74 NP B68 214         +MOUNTZ,ZEMANY,SMITH                 (MICH)

DONNACHI  75 NC 26 A 317        A.DONNACHIE,P.R.THOMAS          (MANCHESTER)
EISENHAN  75 NP B 96 109        EISENHANDLER,GIBSON,+ (LOQM+LIVP+DARE+RHEL)

CARTER 1  77 PL 67 B 117        +COUPLAND,EISENHANDLER,ASTBURY,+(LOQM+RHEL)  JP
CARTER 2  77 PL 67 B 122        A.A.CARTER                           (LOQM)  JP
CARTER 3  77 NP B 127 202       +COUPLAND,ATKINSON,ARNISON+(LOQM+DARE+RHEL)
COUPLAND  77 PL 71 B 460        +EISENHANDLER,GIBSON,ASTBURY,+  (LOQM+RHEL)
MONTANET  77 BOSTON CONF. 260   L.MONTANET                           (CERN)

CARTER 1  78 NP B 132 176       A.A.CARTER                           (LOQM)  JP
CARTER 2  78 NP B 141 467       A.A.CARTER                           (LOQM)
CUTTS     78 PR D 17 16         +GOOD,GRANNIS,GREEN,LEE,PITTMAN+(STON+WISC)

MARTIN    79 PL 86 B 93         A.D. MARTIN,M.R. PENNINGTON          (DURH)

BOWCOCK   80 LNC 28 21          J.E.BOWCOCK,D.C.HODGSON              (BIRM)
MARTIN A  80 NP B 169 216       A.D. MARTIN,M.R. PENNINGTON          (DURH)  JP
MARTIN B  80 NP B 176 355       B.R.MARTIN,D.MORGAN               (LOUC+RHEL)  JP
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$\delta(2450)$

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24  DELTA(2450,JPG=6+-) I=1

SEEN IN PARTIAL WAVE ANALYSIS OF THE K KBAR
SYSTEM. NEEDS CONFIRMATION. OMITTED FROM TABLE.

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24 DELTA(2450) MASS (MEV)

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M    C     2450.     130.            CLELAND   82 SPEC +- 50 PI P,KS K+-P   8/83*
M    C   FROM AN AMPLITUDE ANALYSIS
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24 DELTA(2450) WIDTH (MEV)

```
W    C      400.     250.            CLELAND   82 SPEC +- 50 PI P,KS K+-P   8/83*
M    C   FROM AN AMPLITUDE ANALYSIS
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24 DELTA(2450) PARTIAL DECAY MODES

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                                                        DECAY MASSES
P1     DELTA(2450) INTO K KBAR                        498+ 498
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REFERENCES FOR DELTA(2450)


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CLELAND   82 NP B 208 228       +DELFOSSE,DORSAZ,GLOOR(DURH+GEVA+LAUS+PITT)
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r(2510)

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89  R(2510,JPG=6++) I=0

SEEN IN PIO PIO.
NEEDS CONFIRMATION. OMITTED FROM TABLE.

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89 R(2510) MASS (MEV)

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M          2510.0     30.0            BINON     83 SPEC  0 38 PI-P,N 2PIO   9/83*
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89 R(2510) WIDTH (MEV)

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W           240.0     60.0            BINON     83 SPEC  0 23 PI-P,N 2PIO   9/83*
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89 R(2510) PARTIAL DECAY MODES

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                                                        DECAY MASSES
P1     R(2510) INTO PI PI                             135+ 135
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REFERENCES FOR R(2510)


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BINON     83  CERN-EP/83-98     +DONSKOV,DUTEIL,GOUANERE+  (SERP+BELG+LAPP)  JP
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$e^+e^-(1100-2200)$

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7  E+ E-(1100-2200,JPG=1- ) I=

THIS ENTRY CONTAINS NON-STRANGE
VECTOR MESONS COUPLED TO E+ E-(PHOTON)
BETWEEN PHI AND J/PSI MASS REGION.
SEE ALSO RHO(1250) AND RHO(1600)
MINI-REVIEW.
SEE ALSO PHI(1670)
OMITTED FROM TABLE.

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7 E+ E-(1100-2200) MASSES AND WIDTHS (MEV)

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M          (1097.0)   (16.0)   (19.0)  BARTALUCC 79 OSPK    7 GAM P,E+ E- P  12/79
W            (31.0)   (24.0)   (20.0)  BARTALUCC 79 OSPK    7 GAM P,E+ E- P  12/79

M          (1830.0)  APPROX.           PETERSON  78 SPEC    GAM P,K+ K- P
W           (120.0)  APPROX.           PETERSON  78 SPEC    GAM P,K+ K- P

M  C       (2130.)   APPROX.           ESPOSIT1  78 FRAM    E+E-,K*(892)+..  12/78
W  C         (30.)   APPROX.           ESPOSIT1  78 FRAM    E+E-,K*(892)+..  12/78

M  A       (1820.)   APPROX.           SPINETTI  79 RVUE    E+E-,4 PI+- 2GAM  1/82
W  A         (30.)   APPROX.           SPINETTI  79 RVUE    E+E-,4 PI+- 2GAM  1/82

   A    INTEGRATED CROSS-SECTION OF BARBIELLINI 77,BACCI 77,ESPOSITO 77.
   C    NOT SEEN BY DELCOURT 79.

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REFERENCES FOR E+ E-(1100-2200)


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BACCI     75 PL 58 B 481        +BIDOLI,PENSO,STELLA,BALDINI,+  (ROMA+FRAS)

BACCI     76 PL 64 B 356        +BIDOLI,PENSO,STELLA,BALDINI,+  (ROMA+FRAS)

BACCI     77 PL B 68 393        +DE ZORZI,PENSO,STELLA,BALDINI,+(ROMA+FRAS)
BARBIELL  77 PL B 68 397        BARBIELLINI,BARLETTA,+(FRAS+NAPL+PISA+SANI)
BARTALUC  77 NC A 39 374        BARTALUCCI BERTOLUCCI,BRADASCHIA(DESY+FRAS)
ESPOSITO  77 PL B 68 389        +FELICETTI,MARINI,+   (FRAS+NAPL+PADO+ROMA)

AMBROSIO  78 PL 80 B 141        +CERRITO,BEMPORAD,BROSCO,+ (NAPL+PISA+ROMA)
BALDINI   78 PL 78 B 167        +BATTISTONI,CAPON,BACCI,DEZORZI+(FRAS+ROMA)
ESPOSIT1  78 LNC 22 305         ESPOSITO,FELICETTI+   (FRAS+NAPL+PADO+ROMA)
ESPOSIT2  78 LNC 23 604         ESPOSITO,FELICETTI+   (FRAS+NAPL+PADO+ROMA)
PETERSON  78 PR D 18 3955       +DIXON,EHRLICH,GALIK,LARSON+    (CORN+HARV)

BARTALUC  79 NC 49 A 207        BARTALUCCI,BASINI,BERTOLUCCI+   (DESY+FRAS)
DELCOURT  79 BATAVIA CONF.499   +BERTRAND,BISELLO,BIZOT,BUON,CORDIER+(LALO)
ESPOSITO  79 LNC 25 5           +MARINI,PALLOTTA+       (FRAS+UMD+PADO+ROMA)
SPINETTI  79 BATAVIA CONF.506   M. SPINETTI                          (FRAS)

BALDINI   81 LNC 30 337         +BATTISTONI,CAPON,BACCI,DEZORZI+(FRAS+ROMA)
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$\bar{N}N(1200-3600)$

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51  NBAR N(1200-3600)

THIS ENTRY CONTAINS VARIOUS
HIGH MASS, NON-STRANGE STRUCTURES
COUPLED TO THE BARYON-ANTIBARYON
SYSTEM AS WELL AS QUASI-NUCLEAR
BOUND STATES BELOW THRESHOLD.
SEE ALSO S,T,U  DATA CARD LISTINGS AND MINIREVIEWS.
EVIDENCE FOR STRUCTURES COUPLED TO THE ANTI-HYPERON
NUCLEON (OR C.C.) SYSTEM IS LISTED UNDER K(2200).
OMITTED FROM TABLE.

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51 NBAR N(1200-3600) MASSES AND WIDTHS (MEV)

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M  W G      1210.       5.0            RICHTER   83 CNTR  0 STOPPED PBARS     9/83*

M  W G     (1395.)                     PAVLOPOUL 78 CNTR    STOPPED PBARS     1/78

M  W G      1638.       3.0            RICHTER   83 CNTR  0 STOPPED PBARS     9/83*

M  W G     (1646.)                     PAVLOPOUL 78 CNTR    STOPPED PBARS     1/78

M  W G     (1684.)                     PAVLOPOUL 78 CNTR    STOPPED PBARS     1/78
M  W G      1694.       2.0            RICHTER   83 CNTR  0 STOPPED PBARS     9/83*

M  W G      1771.       1.0            RICHTER   83 CNTR  0 STOPPED PBARS     9/83*
   W     OBSERVED WIDTHS CONSISTENT WITH EXPERIMENTAL RESOLUTION.
     G   THEY LOOKED FOR RADIATIVE TRANSITIONS TO BOUND P PBAR STATES,
     G   MONO-ENERGETIC GAMMA RAYS DETECTED.

M   ZD    (1794.5)    (1.4)            GRAY      71 DBC  -  0.PBAR D          1/72
W   ZD       (8.)   OR LESS  CL=.95    GRAY      71 DBC  -  0.PBAR D          1/72
     D   DECAYS TO FOUR OR MORE PIONS,I=1.
     Z   NOT SEEN BY AMSLER 80.

M   Z     (1897.)     (1.)             KALOGERO  75 DBC  -  PBAR N ANNIH     12/75
W   Z       (25.)     (6.)             KALOGERO  75 DBC  -  PBAR N ANNIH     12/75
     Z   NOT SEEN BY ALBERI 79, AMSLER 80.

M  B      (1897.0)   (17.0)            ABASHIAN  76 STRC    8PI-P,P 3PI     12/77
W  B       (110.0)   (82.0)            ABASHIAN  76 STRC    8PI-P,P 3PI     12/77
     B   PRODUCED BACKWARDS.

M    R    (1920.0)  APPROX.            EVANGELIS 79 OMEG    10,16 PI-P,PB P 12/79
W         (190.0)  APPROX.            EVANGELIS 79 OMEG    10,16 PI-P,PB P 12/79
     R   I=1,JP=1- FROM A MASS DEPENDENT PARTIAL WAVE ANALYSIS TAKING
     R   SOLUTION A.

M    I      1949.      10.             DEFOIX    80 HBC   0 0-1.2 PB P,5 PI 12/79
W    I        80.      20.             DEFOIX    80 HBC   0 0-1.2 PB P,5 PI 12/79
     I   ISOSPIN = 1 FAVORED
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Mesons

$\bar{N}N(1200-3600)$, X(1900-3600)

Data Card Listings

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M   Z  153(2020.0)    (3.0)          BENKHEIRI 77 OMEG  0 9,12PI-P,PPPBPI- 12/77
W   Z  153  (24.0)   (12.0)          BENKHEIRI 77 OMEG  0 9,12PI-P,PPPBPI- 12/77
    Z   NOT SEEN BY BIONTA 80, CARROLL 80, HAMILTON 80, BANKS 81, CHUNG 81,
    Z   BARNETT 83.
M    T    (2020.0)  APPROX.          EVANGELIS 79 OMEG    10,16 PI-P,PB P  12/79
W         (160.0)  APPROX.           EVANGELIS 79 OMEG    10,16 PI-P,PB P  12/79
     T  I=0,JP=2+ FROM A MASS DEPENDENT PARTIAL WAVE ANALYSIS TAKING
     T  SOLUTION A.

M   Z     (2022.0)    (6.0)          AZOOZ     83 HYBR +  6 PBARP,PNBAR3PI  9/83*
W   Z       (14.0)   (13.0)          AZOOZ     83 HYBR +  6 PBARP,PNBAR3PI  9/83*

M   Z     (2026.0)    (5.0)          AZOOZ     83 HYBR -  4 PBARP,PBARN3PI  9/83*
W   Z       (20.0)   (11.0)          AZOOZ     83 HYBR -  4 PBARP,PBARN3PI  9/83*

M  K       2080.      10.            KREYMER   80 STRC  0 13 PI-D,PPBN(N)   4/82
W  K        110.      20.            KREYMER   80 STRC  0 13 PI-D,PPBN(N)   4/82
   K    NEUTRON SPECTATOR. SEE ALSO NPPBPI-(P) CHANNEL FOLLOWING.

M  L       2090.0     20.0           KREYMER   80 STRC    13 PI-D,NPPBPI-P  1/82
W  L        170.0     50.0           KREYMER   80 STRC    13 PI-D,NPPBPI-P  1/82
   L    PROTON  SPECTATOR. SEE ALSO PPBN(N) CHANNEL ABOVE.

M    R    (2110.0)  APPROX.          EVANGELIS 79 OMEG    10,16 PI-P,PB P  12/79
W    R     (330.0)  APPROX.          EVANGELIS 79 OMEG    10,16 PI-P,PB P  12/79
     R  I=1,JP=3- FROM A MASS DEPENDENT PARTIAL WAVE ANALYSIS TAKING
     R  SOLUTION A.

M    N     2110.0     10.0           ROZANSKA  80 SPRK    18.PI-P,P PB N   12/79
W    N      190.0     10.0           ROZANSKA  80 SPRK    18.PI-P,P PB N   12/79
     N  I=1,JP=3- FROM AMPLITUDE ANALYSIS ASSUMING ONE PION EXCHANGE

M    S    (2141.)                    DONALD    73 HBC   0 S CHANNEL PBAR P  1/74
W    S      (14.)                    DONALD    73 HBC   0 S CHANNEL PBAR P  1/74
     S  SEEN IN FINAL STATE (OMEGA PI+ PI-)

M    M     2180.0     10.0           ROZANSKA  80 SPRK    18.PI-P,P PB N   12/79
W    M      270.0     10.0           ROZANSKA  80 SPRK    18.PI-P,P PB N   12/79
     M  I=0,JP=2+ FROM AMPLITUDE ANALYSIS ASSUMING ONE PION EXCHANGE.

M   K     (2190.0)                   KALBFLEIS 69 HBC    0 S-CHANNEL PBARP  7/69
W   K       BETWEEN 20 AND 80 MEV    KALBFLEIS 69 HBC    0 S-CHANNEL PBARP  7/69
    K   SEEN IN PBAR P TO RHOO RHOO PIO. IG=1-.
    K   NOT SEEN BY BACON 73, DONALD 73.
    K   NOT SEEN BY ZEMANY 76 IN RHOO RHOO PI-.

M   Z   58(2204.0)    (5.0)          BENKHEIRI 77 OMEG -  9,12PI-P,PPPBPI- 12/77
W   Z   58  (16.)   OR LESS           BENKHEIRI 77 OMEG -  9,12PI-P,PPPBPI- 12/77
    Z   NOT SEEN BY BIONTA 80, BANKS 81, CHUNG 81, BARNETT 83.

M   A     (2207.)    (13.)           ALLES-BOR 67 HBC    0 5.7 PBAR P      12/66
W   A       (62.)    (52.)           ALLES-BOR 67 HBC    0 5.7 PBAR P      12/66
    A   ALLES-BORELLI 67 SEE NEUTRAL MODE ONLY (PI+PI-PIO)

M         2210.0     79.0     21.0   EVANGEL2  79 OMEG    10. PI-P,K+ K- N 12/79
W         (203.0)  APPROX.           EVANGEL2  79 OMEG    10. PI-P,K+ K- N 12/79

M    R    (2260.0)  APPROX.          EVANGELIS 79 OMEG    10,16 PI-P,PB P  12/79
W    R     (440.0)  APPROX.          EVANGELIS 79 OMEG    10,16 PI-P,PB P  12/79
     R  I=0,JP=4+ FROM A MASS DEPENDENT PARTIAL WAVE ANALYSIS TAKING
     R  SOLUTION A.

M         2307.0      6.0            ALPER     80 CNTR  0 62 PI-P,K+ K- N   1/82
W          245.0     20.0            ALPER     80 CNTR  0 62 PI-P,K+ K- N   1/82

M    M     2380.0     10.0           ROZANSKA  80 SPRK    18.PI-P,P PB N   12/79
W    M      380.0     20.0           ROZANSKA  80 SPRK    18.PI-P,P PB N   12/79
     M  I=0,JP=4+ FROM AMPLITUDE ANALYSIS ASSUMING ONE PION EXCHANGE

M    M    (2450.0)   (10.0)          ROZANSKA  80 SPRK    18.PI-P,P PB N    1/80
W    M     (280.0)   (20.0)          ROZANSKA  80 SPRK    18.PI-P,P PB N   12/80
     M  I=1,JP=5- FROM AMPLITUDE ANALYSIS ASSUMING ONE PION EXCHANGE

M  J      (2480.0)   (30.0)          CARTER    77 CNTR  0 .7-2.4PB P,PIPI  12/77
W  J       (210.0)   (25.0)          CARTER    77 CNTR  0 .7-2.4PB P,PIPI  12/77
   J    I=1,JP=5- FROM AMPLITUDE ANALYSIS OF PABAR P INTO PI PI.

M    K    (2500.0)  APPROX.          CARTER    78 CNTR  0 .7-2.4PB P,K-K+  12/78
W    K     (150.0)  APPROX.          CARTER    78 CNTR  0 .7-2.4PB P,K-K+  12/78
     K  I=0,1.JP=5- FROM BARRELET ZERO ANALYSIS.

M         (2710.0)   (20.0)          ROZANSKA  80 SPRK    18.PI-P,P PB N   12/79
W          (170.0)   (40.0)          ROZANSKA  80 SPRK    18.PI-P,P PB N   12/79

M  V      (2850.0)    (5.0)          BRAUN     76 DBC  -  5.5PBAR D,N NBP+ 12/77
W  V        (39.)   OR LESS          BRAUN     76 DBC  -  5.5PBAR D,N NBP+ 12/77
   V    DECAYS TO NBAR N AND NBAR N PI. NOT SEEN BY BARNETT 83.

M  W      (3080.)    (20.)           ALEXANDER 72 HBC   0 6.94 PBAR P        1/73
W  W      (220.)     (70.)           ALEXANDER 72 HBC   0 6.94 PBAR P        1/73
   W    DECAYS TO 3PI+ 3PI-
   W    NOT SEEN BY KALELKAR 75 WITH 1.5 TIMES MORE DATA

M  X      (3370.)    (10.)           ALEXANDER 72 HBC   0 6.94 PBAR P        1/73
W  X       (150.)    (40.)           ALEXANDER 72 HBC   0 6.94 PBAR P        1/73
   X    DECAYS TO 4PI+ 4PI-

M  Y      (3390.)    (20.)           ALEXANDER 72 HBC   0 6.94 PBAR P        1/73
W  Y       (220.)   (100.)           ALEXANDER 72 HBC   0 6.94 PBAR P        1/73
   Y    DECAYS TO 3PI+ 3PI-
   Y    NOT SEEN BY KALELKAR 75 WITH 1.5 TIMES MORE DATA

M  Z      (3600.)    (20.)           ALEXANDER 72 HBC   0 6.94 PBAR P        1/73
W  Z       (140.)    (20.)           ALEXANDER 72 HBC   0 6.94 PBAR P        1/73
   Z    DECAYS TO 4PI+ 4PI-

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REFERENCES FOR NBAR N(1200-3600)


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ALLES-BO 67 NC 50 A 776        ALLES-BORELLI,FRENCH,FRISK,+    (CERN+BONN)G=-

KALBFLEI 69 PL 29 B  259       G.KALBFLEISCH,R.STRAND,V.VANDERBURG   (BNL)

ALEXANDE 70 PRL 25 63          +BAR-NIR,DAGAN,GIDAL,GRUNHAUS+   (TEL-AVIV)
KALBFLEI 70 PHILAD.CONF.P.409 G.KALBFLEISCH AND D.MILLER REVUES     (BNL)

GRAY     71 PRL 26 1491         +HAGERT,KALOGEROPOULOS                (SYRA)

ALEXANDE 72 NP B 45 29         ALEXANDER,BAR-NIR,BEVARY,DAGAN,+     (TELA)
BOGDANOV 72 PRL 28 1418        BOGDANOVA,DALKAROV,SHAPIRO           (ITEP)
BUGG     72 PR D 6 3047        +CONDO,HART,CONN,ENDORF,+  (TENN+ORNL+CINC)
CLAYTON  72 NP B 47 81         +MASON,MUIRHEAD,RIGOPOULOS,+    (LIVP+PATR)

BOWEN    73 PRL 30 332         +EARLES,FAISSLER,BLIEDEN,+       (NEAS+STON)
DONALD   73 NP B 61 333        +EDWARDS,GIBBINS,BRIAND,DUBOC,+ (LIVP+LPNP)
GRAY     73 PRL 30 1091        +PAPADOPOULOU,KARAGEROPOULOS,+  (ATEN+SYRA)
NICHOLSO 73 PR D 7 2572        NICHOLSON,DELORME,CARROLL,+  (CIT+ROCH+BNL)

HYAMS    74 NP B 73 202        +JONES,WEILHAMMER,BLUM,+         (CERN+MPIM)
DONNACHI 75 NC 26 A 317        A.DONNACHIE,P.R.THOMAS          (MANCHESTER)
EISENHAN 75 NP B 96 109        EISENHANDLER,GIBSON,+ (LOQM+LIVP+DARE+RHEL)
KALOGERO 75 PRL 34 1047        KALOGEROPOULOS,TZANAKOS                (SYRA)

ABASHIAN 76 PR D 13 5          +WATSON,GELFAND,BUTTRAM+(ILL+ANL+CHIC+IOWA)
BRAUN    76 PL B 60 481        +BRICK,FRIDMAN,GERBER,JUILLOT,MAURER+(STRB)
ZEMANY   76 NP B 103 537       +MING MA,MOUNTZ,SMITH                   (MSU)

BENKHEIR 77 PL B 68 483        BENKHEIRI,BOUCROT,+   (CERN+CDEF+EPOL+LALO)
CARTER   77 PL 67 B 117        +COUPLAND,EISENHANDLER,ASTBURY,+(LOQM+RHEL)  JP
EVANGELI 77 PL B 72 139        EVANGELISTA+    (BARI+BONN+CERN+DARE+GLAS+)

BALTAY   78 PR D 17 62         +CAUTIS,COHEN,CSORNA,KALELKAR+  (COLU+BING)
CARTER   78 NP B 141 467       A.A.CARTER                            (LOQM)
PAVLOPOU 78 PL 72 B 415        PAVLOPOULOS+      (KARL+BASL+CERN+STOH+STRB)
PENNINGT 78 NP B 137 77        M.R. PENNINGTON                       (CERN)

ALBERI   79 PL 83 B 247        +ALVEAR,CASTELLI,POROPAT+  (TRST+CERN+IFRJ)
ALSTON-G 79 PRL 43 1901        ALSTON-GARNJOST,HAMILTON+     (LBL+MTHO+BNL)
ARMSTRON 79 PL B 85 304        ARMSTRONG+ (AACH+BARI+BONN+CERN+GLAS+LIVP+)
BENKHEIR 79 PL 81 B 380        BENKHEIRI,BOUCROT,+      (EPOL+LALO+CDEF+CERN)
CARROLL  79 PR D 19 1950       +CHIANG,KYCIA,LI,LITTENBERG,+    (BNL+ROCH)
DELCOURT 79 PL B 86 395        +DERADO,BERTRAND,BISELLO,BIZOT,BUON,+(LALO)
EVANGELI 79 NP B 153 253       + (BARI+BONN+CERN+DARE+GLAS+LIVP+MILA+WIEN)
EVANGEL2 79 NP B 154 381       + (BARI+BONN+CERN+DARE+GLAS+LIVP+MILA+WIEN)
GIBBARD  79 PRL 42 1593        +AHRENS,BERKELMAN,CASSEL,DAY,HARDING+(CORN)
MARTIN   79 PL B 86 93         A.D. MARTIN,M.R. PENNINGTON           (DURH)

ALPER    80 PL 94 B 422        +BECKER,+     (AMST+CERN+CRAC+MPIM+OXF+RHEL)
AMSLER   80 PRL 44 853         +AUERBACH,MANDELKERN,+        (UNM+TEMP+UCI)
BIONTA   80 PRL 44 909         +CARROLL,EDELSTEIN,+    (BNL+CARN+FNAL+SMAS)
BIONTA 2 80 PRL 46 970         +CARROLL,EDELSTEIN,+    (BNL+CARN+FNAL+SMAS)
CARROLL  80 PRL 44 1572        +CHIANG,JOHNSON,CESTER,WEBB,+    (BNL+PRIN)
CHUNG    80 PRL 45 1611        +ETKIN,BENSINGER,+(BNL+BRAN+CUNY+SMAS+MASA)
DEFOIX   80 NP B 162 12        +DOBRZYNSKI,ANGELINI,BIGI,+      (CDEF+PISA)
HAMILTON 80 PRL 44 1179        +PUN,TRIPP,LAZARUS,NICHOLSON (LBL+BNL+MTHO)
KREYMER  80 PR D 22 36         +BAGGETT,FIEGUTH,ALAM,+(IND+PURD+SLAC+VAND)
ROZANSKA 80 NP B 162 505       +BLUM,DIETL,GRAYER,LORENZ+      (MPIM+CERN)

BANKS    81 PL 100 B 191       +BOOTH,CAMPBELL,ARMSTRONG,+      (LIVP+CERN)
CHUNG    81 PRL 46 395         +BENSINGER,+        (BNL+BRAN+CINC+FSU+SMAS)

AJALTOUN 82 NP B 209 301       AJALTOUNI,BACHMAN+    (CERN+NEUC+EPOL+CDEF)

AZOOZ    83 PL 122 B 471       +BUTTERWORTH(LOIC+RHEL+SACL+SLAC+TOHO+TUFT)
BARNETT  83 PR D 27 493        +BLOCKUS,BURKA,CHIEN,CHRISTIAN+      [illegible]
BENSINGE 83 PR D 27 1417       BENSINGER,CHUNG    (BRAN+BNL+CINC+FSU+S[illegible]
RICHTER  83 PL 126 B 284       +ADIELS            (BASL+KARL+STOH+STRB+TH[illegible]
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X(1900-3600)

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46  X(1900-3600)

THIS ENTRY CONTAINS VARIOUS HIGH-MASS
NON-STRANGE PEAKS. OMITTED FROM TABLE.
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The high-mass region is covered nearly continuously by evidence for peaks of various widths and decay modes. As a satisfactory grouping into particles is not yet possible, we list all the Y = 0 bumps coupled neither to $\bar{N}N$ nor to e^+e^-, and having M > 1900 MeV, together, ordered by increasing mass. Note that ANTIPOV 72 ($\pi^- p \rightarrow p MM^-$ at 25 and 40 GeV/c) see no narrow bumps.

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                    46  X(1900-3600)  MASSES AND WIDTHS  (MEV)

M       100(1898.)    (18.)            THOMPSON  74 HBC  +  13 PI+ P,2RHO    12/75
W       100 (108.)    (41.)    (27.)   THOMPSON  74 HBC  +  13 PI+ P,2RHO    12/75

M       100(1900.)    (40.)            BOESEBECK 68 HBC  +   8 PI+ P,PI+ PIO 12/75
W       100 (216.)   (105.)            BOESEBECK 68 HBC  +   8 PI+ P,PI+ PIO 12/75

M         (1970.)    (10.)            CHLIAPNIK 80 HBC   0 32 K+ P,2KS 2PI  12/79
W         (1970.)    (10.)            CHLIAPNIK 80 HBC   0 32 K+ P,2KS 2PI  12/79

M       30(1973.0)   (15.0)            CASO      70 HBC   - 11.2PI-P,RHO 2PI 12/75
W       30  (80.0)                     CASO      70 HBC   - 11.2PI-P,RHO 2PI 12/75

M   K   40(1975.0)   (12.0)            KRAMER    70 HBC  +  13.1 PI+ P,2PI   11/70
W   K   40  (52.0)  OR LESS  CL=.90    KRAMER    70 HBC  +  13.1 PI+ P,2PI   12/75
    K   2PI PEAK OF KRAMER NOT SEEN IN SAME EXP WITH MORE DATA(THOMPSON 74)

M       50(2070.)                      TAKAHASHI 72 HBC     8. PI-P,N 2PI    12/75
W       50 (160.)                      TAKAHASHI 72 HBC     8. PI-P,N 2PI    12/75

M  A    24(2145.)    (10.)             AJINENKO  80 HBC  +  32 K+P,PHI PI+ X  3/82
M  AW   10(2100.)    (20.)             BARTH     82 BEBC +  70 K+P,PHI PI+ P  9/83*
W  AW   24  (25.)   OR LESS            AJINENKO  80 HBC  +  32 K+P,PHI PI+ X  3/82
   A    ASTON 81 SEES NO PEAK, HAS 850 EVENTS IN AJINENKO+BARTH BINS.
   A    ARESTOV 80 SEES NO PEAK.
    W   COMPATIBLE WITH ESTIMATED EXPERIMENTAL RESOLUTION

M  E      (2157.0)   (10.0)            KRAMER    70 HBC  +  13.1 PI+ P,2PI   11/70
W  E        (68.0)   (22.0)            KRAMER    70 HBC  +  13.1 PI+ P,2PI   11/70
   E    EVIDENCE OF KRAMER 70 DISAPPEARED WITH MORE STATISTICS(THOMPSON 74)

M         (2190.0)   (10.0)            CLAYTON   67 HBC  +- 2.5PBAR,A2+OMEGA 10/67

M   C     (2207.0)   (22.0)            CASO      70 HBC   - 11.2PI- P,NOTE C  5/70
W   C       (130.0)                    CASO      70 HBC   - 11.2PI- P,NOTE C  5/70
    C   SEEN IN RHO- PI+ PI- (OMEGA AND ETA ANTISELECTED IN 4 PI SYSTEM)
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For notation, see key at front of Listings.

Mesons

X(1900–3600), Charmonium, $\eta_c(2980)$

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M  B   126(2340.)    (20.)          BALTAY    75 HBC +   15 PI+P,P5PI      12/75
W  B   126 (180.)    (60.)          BALTAY    75 HBC +   15 PI+P,P5PI      12/75
   B    DOMINANT DECAY INTO RHO0 RHO0 PI+. BALTAY 78 FINDS CONFIRMATION
   B    IN 2PI+PI-2PI0 EVENTS WHICH CONTAIN RHO+ RHO0 PI0 AND 2RHO+PI-.

M        (2500.0)   (32.0)          ANDERSON  69 MMS   -  16 PI- P,BACKW9  8/69
W          (87.0)                   ANDERSON  69 MMS   -  16 PI- P,BACKW9  8/69

M      550(2620.)    (20.)          BAUD      69 MMS   -  8.-10. PI- P     9/69
W      550  (85.)    (30.)          BAUD      69 MMS   -  8.-10. PI- P     9/69

M        (2676.0)   (27.0)          CASO      70 HBC   - 11.2PI- P,NOTE C  5/70
W          (150.0)                  CASO      70 HBC   - 11.2PI- P,NOTE C  5/70
    C   SEEN IN RHO- PI+ PI- (OMEGA AND ETA ANTISELECTED IN 4 PI SYSTEM)

M      640(2800.)    (20.)          BAUD      69 MMS   -  8.-10. PI- P     9/69
W      640  (46.)    (10.)          BAUD      69 MMS   -  8.-10. PI- P     9/69

M  C    15(2820.)    (10.)          SABAU     71 HBC  +  8. PI+ P        11/71
W  C    15  (50.)    (10.)          SABAU     71 HBC  +  8. PI+ P        11/71
   C    SEEN IN (K KBAR PI PI)+ MASS DISTRIBUTION

M      230(2880.)    (20.)          BAUD      69 MMS   -  8.-10. PI- P     9/69
W      230  (15.)   OR LESS         BAUD      69 MMS   -  8.-10. PI- P     9/69

M  Y    43(3013.)     (5.)          YOST      71 HBC  +  11.PI+ P,P(8PI)+ 11/71
W  Y    43  (40.)   OR LESS         YOST      71 HBC  +  11.PI+ P,P(8PI)   5/71
   Y    4.3 S.D. EFFECT  . DECAY TO 7 PIONS
   Y    NOT SEEN BY KALELKAR 75 WITH 5 TIMES MORE DATA
M        (3025.0)   (20.0)          BAUD      70 MMS   - 10.5-13 PI- P     5/70
W          (25.0)  APPROX.          BAUD      70 MMS   - 10.5-13 PI- P     5/70

M        (3075.0)   (20.0)          BAUD      70 MMS   - 10.5-13 PI- P     5/70
W          (25.0)  APPROX.          BAUD      70 MMS   - 10.5-13 PI- P     5/70

M        (3145.0)   (20.0)          BAUD      70 MMS   - 10.5-15 PI- P     5/70
W          (10.0)  OR LESS          BAUD      70 MMS   - 10.5-15 PI- P     5/70

M        (3475.0)   (20.0)          BAUD      70 MMS   - 14-15.5 PI- P     5/70
W          (30.0)  APPROX.          BAUD      70 MMS   - 14-15.5 PI- P     5/70

M        (3535.0)   (20.0)          BAUD      70 MMS   - 14-15.5 PI- P     5/70
W          (30.0)  APPROX.          BAUD      70 MMS   - 14-15.5 PI- P     5/70

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                                REFERENCES FOR X(1900-3600)

CLAYTON  67 HEIDBG.CONF.P.57   +MASON,MUIRHEAD,FILIPPAS+(LIVERPOOL+ATHENS)

BOESEBEC 68 NP B 4 501         BOESEBECK,DEUTSCHMANN,+(AACHEN+BERLIN+CERN)

ANDERSON 69 PRL 22 1390        +COLLINS,+                        (BNL+CARN)
BAUD     69 PL  30B 129        CERN BOSON SPECTROMETER GROUP          (CERN)

BAUD     70 PL 31 B 549        CERN BOSON SPECTROMETER GROUP          (CERN)
CASO     70 LNC 3 707          +CONTE,TOMASINI,CORDS+(GENO+HAMB+MILA+SACL)
KRAMER   70 PRL 25 396         +BARTON,GUTAY,LICHTMAN,MILLER,+     (PURDUE)

SABAU    71 LNC 1 514          +URETSKY                          (BUCH+ANL)
YOST     71 PR D 3 642         +MORRIS,ALBRIGHT,BRUCKER,LANNUTTI      (FSU)

TAKAHASH 72 PR D 6 1266        TAKAHASHI,BARISH,+      (TOHO+PENN+NDAM+ANL)

THOMPSON 74 NP B69 220         +GAIDOS,MCILWAIN,MILLER,MULERA,+      (PURD)

BALTAY   75 PRL 35 891         +CAUTIS,COHEN,KALELKAR,PISELLO,+(COLU+BING)
KALELKAR 75 THESIS(NEVIS 207) M.S.KALELKAR                            (COLU)
KEMP     75 NC 27 A 155        +LOTTS,CONTRI,TEODORO+(DURH+GENO+MILA+LPNP)

BALTAY   78 PR D 17 52         +CAUTIS,COHEN,CSORNA,KALELKAR+  (COLU+BING)
BLANAR   79 PR D 20 615        +BOYER,EARLES,FAISSLER,GARELICK+      (NEAS)
CLINE    79 PRL 43 1771        +DE BONTE,GAIDOS,LEEDOM,KEY,+    (PURD+TNTO)

AJINENKO 80 PL 95 B 451        +CHLIAPNIKOV,+          (SERP+BELG+MONS+SACL)
CHLIAPNI 80 ZPHY C 3 285       CHLIAPNIKOV,GERDYUKOV,+     (SERP+BRUX+MONS)

ASTON    81 NP B 189 205       (BONN+CERN+EPOL+GLAS+LANC+MCHS+ORSA+RHEL++)

BARTH    82 PL 117 B 267       +DREVERMANN+(BELG+CERN+GENO+MONS+NIJM+SERP)

ATKINSON 83  CERN-EP/83-106    + (BONN+CERN+GLAS+LANC+MCHS+IPNP+RHEL+SHEF)

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NOTE ON THE CHARMONIUM SYSTEM

We group into this system those meson states commonly believed to consist of charmed-quark-charmed-antiquark pairs. Since the discovery of the $J/\psi(3100)$ (AUBERT 74, AUGUSTIN 74), this family has increased to 11, of which we tabulate 10 as well-established particles. Figure 1 shows the states of charmonium below the $\psi(3685)$, interpreted by the charmonium model, as of January 1984.

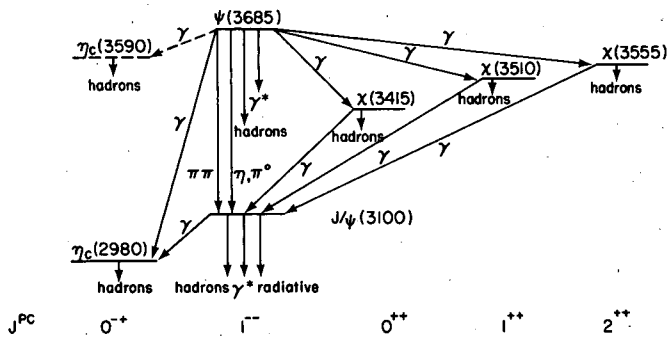

Fig. 1. The current state of knowledge of the charmonium system and transitions, as interpreted by the charmonium model. Uncertain states and transitions are indicated by dashed lines. The notation γ^* refers to decay processes involving intermediate virtual photons, including decays to e^+e^- and $\mu^+\mu^-$.

$\eta_c(2980)$

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26  ETA/C(2980,JPG=0-+) I=0

OBSERVED IN THE INCLUSIVE GAMMA SPECTRUM GENERATED FROM
PSI(3685) DECAY, THEREFORE C=+. FROM THE 4 PI DECAY
G=+, THEREFORE I=0.
FROM ANGULAR DISTRIBUTION IN J/PSI TO ETA/C, ETA/C TO
PHI PHI, JP=0- (HITLIN 83).

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                    26  ETA/C(2980) MASS (MEV)

M  M    18 2982.       8.            HIMEL     80 SMK2     E+ E-          9/81
M  M       2980.       9.            PARTRIDGE 80 CBAL     E+ E-          9/81
M         (2980.)     (5.)           EINSWEILE 83 SMK3    PSI3685,ETAC GAM 12/83*
M         (2978.)     (5.)           EINSWEILE 83 SMK3    PSI3685,ETAC GAM 12/83*
M          . . . . . . . . .
M   AVG    2981.1      6.0     AVERAGE

M  M    MASS ADJUSTED BY US TO CORRESPOND TO J/PSI(3100) MASS = 3097.

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                    26  ETA/C(2980) WIDTH (MEV)

W       18  (40.)   OR LESS  CL=.90   HIMEL     80 SMK2     E+ E-          9/81
W           (20.)   OR LESS  CL=.90   PARTRIDGE 80 CBAL     E+ E-          9/81
W           (33.)   OR LESS  CL=.90   EINSWEILE 83 SMK3    PSI3685,ETAC GAM 12/83*
W           (36.)   OR LESS  CL=.90   EINSWEILE 83 SMK3                     12/83*

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                    26  ETA/C(2980) PARTIAL DECAY MODES

P       HADRONIC DECAYS
P       ---------------
P11     ETA/C(2980) INTO 2(PI+PI-)                          140+ 140+ 140+ 140
P12     ETA/C(2980) INTO P PBAR                             938+ 938
P13     ETA/C(2980) INTO PI+ PI- P PBAR                     140+ 140+ 938+ 938
P14     ETA/C(2980) INTO K KBAR PI                          498+ 498+ 140
P15     ETA/C(2980) INTO PI+ PI- K+ K-                      140+ 140+ 494+ 494
P16     ETA/C(2980) INTO ETA PI+ PI-                        549+ 140+ 140
P17     ETA/C(2980) INTO PHI PHI                           1275+1275

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                    26  ETA/C(2980) BRANCHING RATIOS

R1      ETA/C(2980) INTO (2(PI+PI-))/TOTAL                 (P11)
R1 A          0.013    0.009    0.006 HIMEL     80 SMK2    PSI3685,ETAC GAM  9/81

R2      ETA/C(2980) INTO (PBAR P)/TOTAL                    (P12)
R2 A          0.002    0.002    0.001 HIMEL     80 SMK2    PSI3685,ETAC GAM  9/81
R2            0.018    0.009          EINSWEILE 83 SMK3    PSI3685,ETAC GAM 12/83*
R2          . . . . . . . . .
R2  AVG       0.0024   0.0015  AVERAGE

R3      ETA/C(2980) INTO (2PI PBAR P)/TOTAL                (P13)
R3           (0.012)OR LESS  CL=.90   HIMEL     80 SMK2    PSI3685,ETAC GAM  9/81

R4      ETA/C(2980) INTO (K KBAR PI)/TOTAL                 (P14)
R4 A B        0.14     0.07     0.06  HIMEL     80 SMK2    PSI3685,ETAC GAM  9/81

R5      ETA/C(2980) INTO (2PI 2K)/TOTAL                    (P15)
R5 A          0.009    0.014    0.006 HIMEL     80 SMK2    PSI3685,ETAC GAM  9/81

R7      ETA/C(2980) INTO PHI PHI/TOTAL                     (P17)
R7           (0.01)   (0.004)          EINSWEILE 83 SMK3    PSI3685,ETAC GAM 12/83*

R  A    ESTIMATED USING BR ( PSI(3685) INTO ETA/C(2980) GAMMA) = .0043
R  A    THE ERRORS DO NOT CONTAIN THE UNCERTAINTY IN THE PSI(3685) DECAY.
R    B  NOT SEEN BY PARTRIDGE IN K+ K- PI0.
R    D  SYSTEMATIC ERROR ADDED LINEARLY BY US.

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Mesons

$\eta_c(2980)$, $J/\psi(3100)$

Data Card Listings

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                    REFERENCES FOR ETA/C(2980)

BLOOM     79 FERMILAB SYMP.92  E.D.BLOOM          (CIT+HARV+PRIN+SLAC+STAN)

HIMEL     80 PRL 45 1146       +TRILLING,ABRAMS,ALAM+       (SLAC+LBL+UCB)
PARTRIDG  80 PRL 45 1150       PARTRIDGE,PECK+   (CIT+HARV+PRIN+STAN+SLAC)

EINSWEIL 83 BRIGHTON CONF.     K.F.EINSWEILER+MARKIII COLLABORATION (SLAC)
HITLIN   83 CORNELL CONF.      D. HITLIN                              (CIT)
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$J/\psi(3100)$

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70  J/PSI(3100,JPG=1--) I=0
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                 70  J/PSI(3100) MASS (MEV)

                 WE USE INDEPENDENT MEASUREMENTS OF THE J/PSI(3100)
                 MASS, THE PSI(3685) MASS AND THE MASS DIFFERENCE TO
                 PERFORM A CONSTRAINED FIT.

M          (3100.)                  AUBERT    74 SPEC    28. PP(E+E-)      2/75
M   L      (3105.)     (3.)         AUGUSTIN  74 SMAG        E+E-          2/75
M           3103.       6.          BEMPORAD  75 FRAB        E+E-          1/76
M   O       3095.       4.          BOYARSKI  75 SMAG        E+E-          3/75
M   S       3089.5     31.          CRIEGEE   75 PLUT        E+E-          2/75
M           3098.       6.          PREPOST   75 SPEC    13.-21.GAMMA D    1/76
M           3096.0     30.0         SNYDER    76 SPEC    400 P BE,E+E-     1/77
M   F       3097.0      1.          BRANDELIK 79 DASP    E+ E-            12/79
M      9000(3095.44)   (0.46)       LEMOIGNE  79 GOLI    150 PI-BE,2MU    12/79
M       502 3096.93     0.09        ZHOLENTZ  80 OLYA    E+E- COLL.BEAMS   9/81
M       38K 3098.4      2.0         LEMOIGNE  82 GOLI    190 PI-BE,2MU     9/83*
M           . . . . . . . . .
M   AVG     3096.934    0.090   AVERAGE
M   FIT     3096.93     0.09    FROM FIT

M   E    SYSTEMATIC ERROR ADDED LINEARLY BY US
M   F    FROM A SIMULTANEOUS FIT TO E+ E-,MU+ MU- AND HADRONIC CHANNELS
M   F    ASSUMING G(E+ E-) = G(MU+ MU-)
M
M   L    BOYARSKI 75 IS A REEVALUATION OF AUGUSTIN 74 BASED
M   L    ON A RECALIBRATION OF THE SPEAR BEAM ENERGY.
M
M   O    MASS, WIDTH, PARTIAL WIDTHS, AND BRANCHING RATIOS ALL OBTAINED
M   O    FROM ONE OVERALL FIT TO DATA OF THIS EXPERIMENT.
M
M   S    ERROR OF ABOUT 1 PER CENT FROM THE UNCERTAINTY IN CALIBRATION OF
M   S    THE BEAM ENERGY.
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                 70  J/PSI(3100) WIDTH (KEV)

W            69.       15.          BOYARSKI  75 SMAG        E+E-          3/75
W            68.       26.          BALDINI1  75 FRAG        E+E-          1/76
W            60.       25.          ESPOSITO  75 FRAM        E+E-          1/76
W   F        58.       13.          BRANDELIK 79 DASP    E+ E-            12/79
W   F    FROM A SIMULTANEOUS FIT TO E+ E-,MU+ MU- AND HADRONIC CHANNELS
W   F    ASSUMING G(E+ E-) = G(MU+ MU-)
W           . . . . . . . . .
W   AVG      63.0       8.6     AVERAGE
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                 70  J/PSI(3100) PARTIAL DECAY MODES

                                                          DECAY MASSES
P1      J/PSI(3100) INTO E+ E-                           .511+.511
P2      J/PSI(3100) INTO MU+ MU-                          106+ 106
P3      J/PSI(3100) INTO HADRONS
P4      J/PSI(3100) INTO VIRTUAL GAMMA INTO HADRONS

P       HADRONIC DECAYS
P       ---------------
P11     J/PSI(3100) INTO PI+ PI-                          140+ 140
P12     J/PSI(3100) INTO PI+ PI- PI0                      140+ 140+ 135
P13     J/PSI(3100) INTO 2(PI+ PI-)                       140+ 140+ 140+ 140
P14     J/PSI(3100) INTO 2(PI+ PI-) PI0                   140+ 140+ 140+ 140+
P15     J/PSI(3100) INTO 3(PI+ PI-)
P16     J/PSI(3100) INTO 3(PI+ PI-) PI0
P17     J/PSI(3100) INTO 4(PI+ PI-)
P18     J/PSI(3100) INTO 4(PI+ PI-) PI0
P19     J/PSI(3100) INTO K KBAR                           498+ 498
P20     J/PSI(3100) INTO K KBAR PI                        498+ 498+ 140
P21     J/PSI(3100) INTO PI+ PI- K+ K-                    140+ 140+ 494+ 494
P22     J/PSI(3100) INTO 2(PI+ PI-) K+ K-
P23     J/PSI(3100) INTO PI+ PI- PI0 K+ K-                140+ 140+ 135+ 494+
P24     J/PSI(3100) INTO RHO PI                           769+ 140
P25     J/PSI(3100) INTO RHO PI PI PI                     769+ 140+ 140+ 140
P26     J/PSI(3100) INTO OMEGA PI PI                      783+ 140+ 140
P27     J/PSI(3100) INTO OMEGA 4PI                        783+ 140+ 140+ 140+
P28     J/PSI(3100) INTO OMEGA K KBAR                     783+ 498+ 498
P29     J/PSI(3100) INTO OMEGA F                          783+1274
P30     J/PSI(3100) INTO OMEGA F PRIME                    783+1525
P31     J/PSI(3100) INTO PHI PI PI                       1020+ 140+ 140
P32     J/PSI(3100) INTO PHI 2(PI+ PI-)                  1020+ 140+ 140+ 140+
P33     J/PSI(3100) INTO PHI K KBAR                      1020+ 498+ 498
P34     J/PSI(3100) INTO PHI ETA                         1020+ 549
P35     J/PSI(3100) INTO PHI ETA PRIME                   1020+ 958
P36     J/PSI(3100) INTO PHI F                           1020+1274
P37     J/PSI(3100) INTO PHI F PRIME                     1020+1525
P38     J/PSI(3100) INTO A2 PI                           1318+ 140
P39     J/PSI(3100) INTO A2 RHO                          1318+ 769
P40     J/PSI(3100) INTO K K*BAR(892) + C.C.              498+ 892
P41     J/PSI(3100) INTO K K*BAR(1430) + C.C.             498+1425
P42     J/PSI(3100) INTO K*(892) K*BAR(892)               892+ 892
P43     J/PSI(3100) INTO K*(1430) K*BAR(1430)            1425+1425
P44     J/PSI(3100) INTO K*(892) K*BAR(1430) + C.C.      892+1425
P45     J/PSI(3100) INTO P PBAR                          938+ 938
P46     J/PSI(3100) INTO P PBAR PI0                      938+ 938+ 135
P47     J/PSI(3100) INTO P NBAR PI-                      938+ 940+ 140
P48     J/PSI(3100) INTO P PBAR PI+ PI-                  938+ 938+ 140+ 140
P49     J/PSI(3100) INTO P PBAR PI+ PI- PI0              938+ 938+ 140+ 140+
P50     J/PSI(3100) INTO P PBAR ETA                      938+ 938+ 549
P51     J/PSI(3100) INTO P PBAR OMEGA                    938+ 938+ 783
P52     J/PSI(3100) INTO LAMBDA ANTILAMBDA              1116+1116
P53     J/PSI(3100) INTO LAMBDA ANTISIGMA               1116+1192
P54     J/PSI(3100) INTO XI ANTIXI                      1315+1315
P55     J/PSI(3100) INTO PI B                            140+1234
P56     J/PSI(3100) INTO P PBAR ETA PRIME                938+ 938+ 958
P57     J/PSI(3100) INTO SIGMA0 SIGMABAR0               1192+1192
P58     J/PSI(3100) INTO 2(K+ K-)                        494+ 494+ 494+ 494
P59     J/PSI(3100) INTO N NBAR                          940+ 940
P60     J/PSI(3100) INTO N NBAR PI+ PI-                  940+ 940+ 140+ 140
P61     J/PSI(3100) INTO SIGMA- SIGMABAR-               1192+1192
P62     J/PSI(3100) INTO N*(1232)++ N*(1232)--          1232+1232
P63     J/PSI(3100) INTO Y*(1385)- Y*(1385)+            1385+1385
P64     J/PSI(3100) INTO Y*(1385)+ Y*(1385)-            1385+1385
P65     J/PSI(3100) INTO Y*(1385)- SIGMABAR+            1385+ 135
P66     J/PSI(3100) INTO Y*(1385)+ SIGMABAR-            1385+1197
P67     J/PSI(3100) INTO PBAR N*(1440-1535)+             938+1440
P68     J/PSI(3100) INTO N*(1232)++ PBAR PI-            1232+ 938+ 140
P69     J/PSI(3100) INTO LAMBDA SIGMABAR+ PI-           1116+ 135+ 140
P70     J/PSI(3100) INTO LAMBDA SIGMABAR- PI+           1116+1197+ 140
P90     J/PSI(3100) INTO PHI S(975)                     1020+ 975
P91     J/PSI(3100) INTO P PBAR RHO                      938+ 938+ 769
P92     J/PSI(3100) INTO P K- ANTILAMBDA                 938+ 494+1116
P93     J/PSI(3100) INTO P K- ANTISIGMA0                 938+ 494+1192
P94     J/PSI(3100) INTO P K- Y*(1385)0                  938+ 494+1385

P       RADIATIVE DECAYS
P       ----------------
P70     J/PSI(3100) INTO GAMMA GAMMA                       0+   0
P71     J/PSI(3100) INTO 3 GAMMA                           0+   0+   0
P72     J/PSI(3100) INTO PI0 GAMMA                       135+   0
P73     J/PSI(3100) INTO ETA GAMMA                       549+   0
P74     J/PSI(3100) INTO ETA PRIME GAMMA                 958+   0
P75     J/PSI(3100) INTO ETA/C(2980) GAMMA              2981+   0
P76     J/PSI(3100) INTO F GAMMA                        1274+   0
P77     J/PSI(3100) INTO F PRIME GAMMA                  1525+   0
P78     J/PSI(3100) INTO D(1285) GAMMA                  1283+   0
P79     J/PSI(3100) INTO IOTA(1440) GAMMA               1440+   0
P80     J/PSI(3100) INTO P PBAR GAMMA                    938+ 938+   0
P81     J/PSI(3100) INTO THETA(1690) GAMMA              1690+   0
P83     J/PSI(3100) INTO P PBAR PI+ PI- GAMMA            938+ 938+ 140+ 140+
P84     J/PSI(3100) INTO RHO RHO GAMMA                   769+ 769+   0
P85     J/PSI(3100) INTO 2PI+ 2PI- GAMMA                 140+ 140+ 140+ 140+
P86     J/PSI(3100) INTO ETA PI+ PI- GAMMA               549+ 140+ 140+   0
P87     J/PSI(3100) INTO ETA PI0 PI0 GAMMA               549+ 135+ 135+   0
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                 70  J/PSI(3100) PARTIAL WIDTHS

W1      J/PSI(3100) INTO E+ E- (KEV)                                (G1)
W1           4.8       0.6          BOYARSKI  75 SMAG        E+E-          3/75
W1 B        (4.6)     (.8)          BALDINI1  75 FRAG        E+E-          1/76
W1           4.6       1.0          ESPOSITO  75 FRAM        E+E-          1/76
W1 B   ASSUMING EQUAL PARTIAL WIDTHS FOR (E+E-) AND (MU+MU-)
W1 F         4.4       0.6          BRANDELIK 79 DASP    E+ E-            12/79
W1 F    FROM A SIMULTANEOUS FIT TO E+ E-,MU+ MU- AND HADRONIC CHANNELS
W1 F    ASSUMING G(E+ E-) = G(MU+ MU-)
W1          . . . . . . . . .
W1  AVG      4.60      0.39    AVERAGE

W2      J/PSI(3100) INTO MU+ MU- (KEV)                              (G2)
W2           4.8       0.6          BOYARSKI  75 SMAG        E+E-          3/75
W2           5.0       1.0          ESPOSITO  75 FRAM        E+E-          1/76
W2          . . . . . . . . .
W2  AVG      4.85      0.51    AVERAGE

W3      J/PSI(3100) INTO HADRONS (KEV)                              (G3)
W3          59.       14.          BOYARSKI  75 SMAG        E+E-          3/75
W3          59.       24.          BALDINI1  75 FRAG        E+E-          1/76
W3          50.       25.          ESPOSITO  75 FRAM        E+E-          1/76
W3          . . . . . . . . .
W3  AVG     57.3      10.9    AVERAGE

W4      J/PSI(3100) INTO GAMMA INTO HADRONS (KEV)                   (G4)
W4 C        12.        2.          BOYARSKI  75 SMAG        E+E-          1/76
W4 C    INCLUDED IN W3

W70     J/PSI(3100) INTO GAMMA GAMMA  (EV)                          (G70)
W70         (5.4)  OR LESS CL=0.90  BRANDELIK 79 DASP    E+ E-            12/79
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                 70  J/PSI(3100) BRANCHING RATIOS

        FOR THE BRANCHING RATIOS R1 - R4, SEE ALSO THE PARTIAL
        WIDTHS ABOVE, AND (PARTIAL WIDTHS)*R1 BELOW.

R1      J/PSI(3100) INTO (E+ E-)/TOTAL                              (P1)/(P1+P2+P3)
R1          0.069     0.009          BOYARSKI  75 SMAG        E+E-          3/75

R2      J/PSI(3100) INTO (MU+ MU-)/TOTAL                            (P2)/(P1+P2+P3)
R2          0.069     0.009          BOYARSKI  75 SMAG        E+E-          3/75

R3      J/PSI(3100) INTO (HADRONS)/TOTAL                            (P3)/(P1+P2+P3)
R3          0.86      0.02           BOYARSKI  75 SMAG        E+E-          3/75

R4      J/PSI(3100) INTO (E+ E-)/(MU+ MU-)                          (P1)/(P2)
R4          1.00      0.05           BOYARSKI  75 SMAG        E+E-          3/75
R4          0.93      0.10           FORD      75 SPEC        E+E-          2/75
R4           .91       .15           ESPOSITO  75 FRAM        E+E-          1/76
R4          . . . . . . . . .
R4  AVG     0.980     0.043   AVERAGE

R5      J/PSI(3100) INTO (GAMMA INTO HADRONS)/TOTAL                 (P4)
R5 C         .17       .02           BOYARSKI  75 SMAG        E+E-          1/76
R5 C    INCLUDED IN R3


R       HADRONIC DECAYS
R       ---------------

R8      J/PSI(3100) INTO (PI+ PI-)/TOTAL (UNITS 10**-4)             (P11)
R8       1    1.6       1.6          VANNUCCI  77 SMAG        E+E-          1/77
R8       5    1.0       0.5          BRANDELIK 78 DASP        E+E-         12/78
R8          . . . . . . . . .
R8  AVG      1.05      0.48    AVERAGE

R9      J/PSI(3100) INTO (2(PI+ PI-))/TOTAL                         (P13)
R9      76    .004      .001         JEAN-MARI 76 SMAG        E+E-          1/76

R10     J/PSI(3100) INTO (2(PI+ PI-) PI0)/TOTAL                     (P14)
R10     675    .04       .01          JEAN-MARI 76 SMAG        E+E-          1/76
R10    1500   0.0364    0.0052        BURMESTER 77 PLUT        E+E-         12/77
R10     147  (0.0317) (0.0042)        FRANKLIN  83 SMK2    E+E-,HADRONS      9/83*
R10         . . . . . . . . .
R10 AVG     0.0372    0.0046  AVERAGE

R11     J/PSI(3100) INTO (3(PI+ PI-)/TOTAL                          (P15)
R11      32    .004      .002         JEAN-MARI 76 SMAG        E+E-          1/76

R12     J/PSI(3100) INTO (3(PI+ PI-) PI0)/TOTAL                     (P16)
R12     181    .029      .007         JEAN-MARI 76 SMAG        E+E-          1/76
R12      11  (0.028)  (0.009)         FRANKLIN  83 SMK2    E+E-,HADRONS      9/83*

R13     J/PSI(3100) INTO (4(PI+ PI-) PI0)/TOTAL                     (P18)
R13      13    .009      .003         JEAN-MARI 76 SMAG        E+E-          1/76
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For notation, see key at front of Listings.

Mesons

J/ψ(3100)

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R14      J/PSI(3100) INTO (PI+ PI- K+ K-)/TOTAL                  (P21)
R14      205    0.0072   0.0023         VANNUCCI   77 SMAG            E+E-         1/77

R15      J/PSI(3100) INTO (2(PI+ PI-) K+ K-)/TOTAL               (P22)
R15       30    0.0031   0.0013         VANNUCCI   77 SMAG            E+E-         1/77

R16      J/PSI(3100) INTO (RHO PI)/(PI+ PI- PI0)                 (P24)/(P12)
R16             (.7)  OR MORE  CL=0.90  JEAN-MARI 76 SMAG            E+E-         1/76

R17      J/PSI(3100) INTO (RHO0 PI0)/(RHO+- PI-+)
R17             0.63     0.22           BARTEL 1   76 CNTR            E+E-         1/77
R17             0.59     0.17           JEAN-MARI  76 SMAG            E+E-         1/76
R17             0.53     0.15           ALEXANDER  78 PLUT       E+ E-             4/78
R17             0.46     0.14           BRANDELIK  78 DASP       E+E-,PI+PI-GAMMA  4/78
R17            (0.56)   (0.06)          SCHARRE    79 SMAG       E+E-             12/79
R17           . . . . . . . . . .
R17 AVG         0.534    0.081    AVERAGE

R18      J/PSI(3100) INTO (RHO PI)/TOTAL                         (P24)
R18      543    0.010    0.002          BARTEL 1   76 CNTR            E+E-         1/77
R18      153    0.013    0.003          JEAN-MARI  76 SMAG            E+E-         1/76
R18      183    0.016    0.004          ALEXANDER  78 PLUT       E+ E-             4/78
R18             0.0133   0.0021         BRANDELIK  78 DASP       E+E-,PI+PI-GAMMA  4/78
R18      150   (0.013)  (0.003)         FRANKLIN   83 SMK2       E+E-,HADRONS      9/83*
R18           . . . . . . . . . .
R18 AVG         0.0122   0.0012   AVERAGE

R19      J/PSI(3100) INTO (OMEGA PI PI)/(2(PI+ PI-) PI0)  (P26)/(P14)
R19   J         (.2)                    JEAN-MARI  76 SMAG            E+E-         1/76
R19   J  FINAL STATE  2(PI+PI-)PI0

R20      J/PSI(3100) INTO (RHO PI PI PI)/(2 (PI+ PI-) PI0)(P25)/(P14)
R20   J         (.3)                    JEAN-MARI  76 SMAG            E+E-         1/76
R20   J  FINAL STATE  2(PI+PI-)PI0

R21      J/PSI(3100) INTO (PHI PI+ PI-)/TOTAL                    (P31)
R21       23    0.0021   0.0009         FELDMAN    77 SMAG            E+E-        12/77

R22      J/PSI(3100) INTO (K+ K-)/TOTAL      (UNITS 10**-4) (P19)
R22        2    2.0      1.6            VANNUCCI   77 SMAG            E+E-         1/77
R22        7    2.2      0.9            BRANDELIK  79 DASP            E+E-        12/79
R22           . . . . . . . . . .
R22 AVG         2.15     0.78     AVERAGE

R23      J/PSI(3100) INTO (K0S K0L)/TOTAL  (UNITS 10**-4) (P19)
R23            (0.89) OR LESS  CL=0.90  VANNUCCI   77 SMAG            E+E-         1/77

R24      J/PSI INTO (K+- K*(892)-+)/TOTAL (UNITS 10**-4)  (P40)
R24       39   41.      12.             BRAUNSCHW  76 DASP            E+E-         1/77
R24       48   32.       6.             VANNUCCI   77 SMAG            E+E-         1/77
R24       24  (26.4)    (5.7)           FRANKLIN   83 SMK2       E+E-,HADRONS      9/83*
R24           . . . . . . . . . .
R24 AVG        33.8      5.4      AVERAGE

R25      J/PSI(3100) INTO (K0 K*(892)0)/TOTAL                    (P40)
R25                                   (UNITS 10**-4)
R25       45   27.       6.             VANNUCCI   77 SMAG            E+E-         1/77

R26      J/PSI(3100) INTO (K+- K*(1430-+)/TOTAL                  (P41)
R26          (0.0033)OR LESS  CL=0.90  BRAUNSCHW  76 DASP            E+E-         1/77

R27      J/PSI(3100) INTO (K0 K*(1430)0)/TOTAL                   (P41)
R27          (0.002) OR LESS  CL=0.90  VANNUCCI   77 SMAG            E+E-         1/77

R28      J/PSI(3100) INTO (K*(892)0 K*(892)0)/TOTAL              (P42)
R28          (0.0005)OR LESS  CL=0.90  VANNUCCI   77 SMAG            E+E-         1/77

R29      J/PSI(3100) INTO (K*(1430)0 K*(1430)0)/TOTAL            (P43)
R29          (0.0029)OR LESS  CL=0.90  VANNUCCI   77 SMAG            E+E-         1/77

R30      J/PSI(3100) INTO (K*(892)0 K*(1430)0)/TOTAL             (P44)
R30       40    0.0067   0.0026         VANNUCCI   77 SMAG            E+E-         1/77

R31      J/PSI(3100) INTO (PBAR P)/TOTAL (UNITS 10**-3)          (P45)
R31             2.0      0.5            BESCH      78 BONA            E+E-         4/78
R31   A 331     2.2      0.2            PERUZZI    78 SMAG            E+E-         4/78
R31     133     2.5      0.4            BRANDELIK  79 DASP       E+ E-            12/79
R31S   1420    (2.16)   (0.22)          EATON      83 SMK2       E+E-,HADRONS GAM 12/83*
R31           . . . . . . . . . .
R31 AVG         2.23     0.17     AVERAGE

R31S     SYSTEMATIC ERROR ADDED LINEARLY BY US.
R31   A  ASSUMING ANGULAR DISTRIBUTION (1.+COS(THETA)**2)

R32      J/PSI(3100) INTO (PBAR P)/(MU+ MU-)                     (P45)/(P2)
R32   A  20    (.051)   (.02)           WIIK       75 PLUT            E+E-         1/76
R32   A  ASSUMING ANGULAR DISTRIBUTION (1.+COS(THETA)**2)

R33      J/PSI INTO (LAMBDA ANTILAMBDA)/TOT (UNITS 10**-3)(P52)
R33      196    1.1      0.2            PERUZZI    78 SMAG       E+E-,L X,LBAR L   4/78
R33        5    2.6      1.6            BESCH      81 BONA            E+E-         1/82
R33S     365   (1.58)   (0.27)          EATON      83 SMK2       E+E-,HADRONS GAM 12/83*
R33S     SYSTEMATIC ERROR ADDED LINEARLY BY US.
R33           . . . . . . . . . .
R33 AVG         1.12     0.20     AVERAGE

R34      J/PSI(3100) INTO (P PBAR PI0)/TOT (UNITS 10**-3) (P46)
R34      109    1.00     0.15           PERUZZI    78 SMAG       E+E-,P PB         4/78
R34             1.4      0.4            BRANDELIK  79 DASP       E+ E-            12/79
R34       16   (1.0)    (0.3)           FRANKLIN   83 SMK2       E+E-,HADRONS      9/83*
R34S     685   (1.13)   (0.18)          EATON      83 SMK2       E+E-,HADRONS GAM 12/83*
R34S     SYSTEMATIC ERROR ADDED LINEARLY BY US.
R34           . . . . . . . . . .
R34 AVG         1.05     0.14     AVERAGE

R35      J/PSI(3100) INTO (P PBAR PI+PI-)/TOT(UNTS 10**-3)(P48)
R35      533    5.5      0.6            PERUZZI    78 SMAG       E+E-,P PB 1-2PI   4/78
R35       48    3.8      1.6            BESCH      81 BONA            E+E-         1/82
R35S    1435   (6.46)   (0.60)          EATON      83 SMK2       E+E-,HADRONS GAM 12/83*
R35S     SYSTEMATIC ERROR ADDED LINEARLY BY US.
R35           . . . . . . . . . .
R35 AVG         5.29     0.56     AVERAGE

R36      J/PSI INTO (P PBAR PI+ PI- PI0)/TOT (UNTS 10**-3)(P49)
R36      INCLUDING P PBAR PI+PI- GAMMA AND EXCLUDING OMEGA,ETA,ETA PRIME
R36       39    1.6      0.6            PERUZZI    78 SMAG       E+E-,P PB 2PI     4/78
R36S     364   (3.36)   (0.93)          EATON      83 SMK2       E+E-,HADRONS     12/83*
R36S     SYSTEMATIC ERROR ADDED LINEARLY BY US.

R37      J/PSI INTO (LAMBDA ANTISIGMA)/TOT (UNITS 10**-3) (P53)
R37            (0.15) OR LESS  CL=0.90  PERUZZI    78 SMAG       E+E-,LAMBDA X     4/78

R38      J/PSI(3100) INTO (PI+- A2)/TOTAL
R38          (0.0043)OR LESS  CL=0.90  BRAUNSCHW  76 DASP            E+E-         1/77

R39      J/PSI(3100) INTO (OMEGA PI PI)/TOTAL                    (P26)
R39      215    0.0078   0.00216        BURMESTER  77 PLUT            E+E-        12/77
R39      348    0.0068   0.0019         VANNUCCI   77 SMAG            E+E-         1/77
R39           . . . . . . . . . .
R39 AVG         0.0068   0.0019   AVERAGE

R40      J/PSI(3100) INTO 2(K+ K-)/TOTAL                         (P58)
R40             0.0007   0.0003         VANNUCCI   77 SMAG            E+E-         1/77

R41      J/PSI(3100) INTO (OMEGA K KBAR)/TOTAL                   (P28)
R41       22    0.0016   0.0010         FELDMAN    77 SMAG            E+E-        12/77

R42      J/PSI(3100) INTO (PHI K KBAR)/TOTAL                     (P33)
R42       14    0.0018   0.0008         FELDMAN    77 SMAG            E+E-        12/77
R43      J/PSI(3100) INTO (PHI ETA)/TOTAL                        (P34)
R43        5    0.0010   0.0006         VANNUCCI   77 SMAG            E+E-         1/77

R44      J/PSI(3100) INTO (PHI ETA PRIME)/TOTAL                  (P35)
R44          (0.0013)OR LESS  CL=0.90  VANNUCCI   77 SMAG            E+E-         1/77

R45      J/PSI(3100) INTO (PHI F PRIME)/TOT (UNITS 10**-4)(P35)
R45B       6    8.0      5.0            VANNUCCI   77 SMAG            E+E-         1/77
R45B      46    3.4      1.3            GIDAL      81 SMK2            E+E-         2/84*
R45B     ASSUMES F PRIME INTO K KBAR IS 100 PER CENT.
R45           . . . . . . . . . .
R45 AVG         3.7      1.3      AVERAGE

R70      J/PSI(3100) INTO (PHI S(975))/TOT (UNITS 10**-4) (P90)
R70       50    2.6      0.6            GIDAL      81 SMK2            E+E-         2/84*

R46      J/PSI(3100) INTO (P NBAR PI-)/TOT (UNITS 10**-3) (P47)
R46      194    2.16     0.29           PERUZZI    78 SMAG       E+E-,P PI-        4/78
R46B     204    2.04     0.27           PERUZZI    78 SMAG       E+E-,P PI+        4/78
R46       32    1.7      0.7            BESCH      81 BONA            E+E-         1/82
R46B       5    1.6      1.2            BESCH      81 BONA            E+E-         1/82
R46S    1288   (2.02)   (0.23)          EATON      83 SMK2       E+E-,HADRONS GAM 12/83*
R46S B1191     (1.93)   (0.23)          EATON      83 SMK2       E+E-,HADRONS GAM 12/83*
R46           . . . . . . . . . .
R46 AVG         2.06     0.19     AVERAGE

R46S     SYSTEMATIC ERROR ADDED LINEARLY BY US.
R46B     FROM ANTI-CHANNEL (PBAR N PI+)

R47      J/PSI(3100) INTO (P PBAR ETA)/TOT (UNITS 10**-3) (P50)
R47      197    2.3      0.4            PERUZZI    78 SMAG       E+E-,P PB 0-2PI   4/78
R47             2.5      1.2            BRANDELIK  79 DASP       E+ E-            12/79
R47S     826   (2.03)   (0.28)          EATON      83 SMK2       E+E-,HADRONS GAM 12/83*
R47S     SYSTEMATIC ERROR ADDED LINEARLY BY US.
R47           . . . . . . . . . .
R47 AVG         2.32     0.38     AVERAGE

R48      J/PSI(3100) INTO (P PBAR OMEGA)/TOT(UNITS 10**-3)(P51)
R48       77    1.6      0.3            PERUZZI    78 SMAG       E+E-,P PB 1-2PI   4/78
R48S     486   (1.10)   (0.35)          EATON      83 SMK2       E+E-,HADRONS GAM 12/83*
R48S     SYSTEMATIC ERROR ADDED LINEARLY BY US.

R49      J/PSI(3100) INTO (K0S K+- PI-+)/TOTAL
R49      126    0.0026   0.0007         VANNUCCI   77 SMAG            E+E-         1/77

R50      J/PSI(3100) INTO (PHI F)/TOTAL (UNITS 10**-4)     (P36)
R50            (3.7)  OR LESS  CL=0.90  VANNUCCI   77 SMAG            E+E-         1/77

R51      J/PSI(3100) INTO (PHI 2(PI+PI-))/TOTAL                  (P32)
R51          (0.0015)OR LESS  CL=0.90  VANNUCCI   77 SMAG            E+E-         1/77

R52      J/PSI(3100) INTO (OMEGA F)/TOTAL                        (P29)
R52       81    0.0019   0.0008         VANNUCCI   77 SMAG            E+E-         1/77
R52       70    0.0040   0.0016         BURMESTER  77 PLUT            E+E-        12/77
R52           . . . . . . . . . .
R52 AVG         0.00232  0.00084  AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.2)

R53      J/PSI(3100) INTO (OMEGA F PRIME)/TOT(UNTS 10**-4)(P30)
R53            (1.6)  OR LESS  CL=0.90  VANNUCCI   77 SMAG            E+E-         1/77

R54      J/PSI(3100) INTO (PI+ PI- PI0 K+ K-)/TOTAL              (P23)
R54      309    0.012    0.003          VANNUCCI   77 SMAG            E+E-         1/77

R55      J/PSI(3100) INTO (RHO A2)/TOTAL                         (P39)
R55       36    0.0084   0.0045         VANNUCCI   77 SMAG            E+E-         1/77

R56      J/PSI(3100) INTO (OMEGA 2PI+ 2PI-)/TOTAL                (P27)
R56      140    0.0085   0.0034         VANNUCCI   77 SMAG            E+E-         1/77

R57      J/PSI(3100) INTO (XI- ANTIXI-)/TOTAL (10**-3)     (P54)
R57       51    1.4      0.5            PERUZZI    78 SMAG       E+E-,XI-X         4/78
R57 C     71   (3.2)    (0.8)           PERUZZI    78 SMAG       E+E-,L LBAR       4/78
R57S     194   (1.14)   (0.28)          EATON      83 SMK2       E+E-,HADRONS GAM 12/83*

R57S     SYSTEMATIC ERROR ADDED LINEARLY BY US.
R57 C    INCLUDES CHANNEL (XI0 ANTIXI0)

R58      J/PSI(3100) INTO (RHO+- PI-+)/(K*(892)+- K-+)     (P24)/(P40)
R58            (0.26)   (0.09)          PIERRE     76 SMAG            E+E-         4/77

R59      J/PSI(3100) INTO (B+- PI-+)/TOTAL                       (P55)
R59       87    0.0029   0.0007         BURMESTER  77 PLUT            E+E-        12/77

R60      J/PSI(3100) INTO (N NBAR)/TOTAL (UNITS 10**-2)    (P59)
R60             0.18     0.09           BESCH      78 BONA            E+E-         4/78

R61      J/PSI INTO (SIGMA0 SIGMABAR0)/TOT (UNITS 10**-3) (P57)
R61       52    1.3      0.4            PERUZZI    78 SMAG       E+E-,L LBAR       4/78
R61S      90   (1.58)   (0.41)          EATON      83 SMK2       E+E-,HADRONS GAM 12/83*
R61S     SYSTEMATIC ERROR ADDED LINEARLY BY US.

R62      J/PSI INTO (P PBAR ETA PRIME)/TOT (UNITS 10**-3) (P56)
R62       19    1.8      0.6            PERUZZI    78 SMAG       E+E-,P PB 1-2PI   4/78
R62S      19   (0.68)   (0.40)          EATON      83 SMK2       E+E-,HADRONS GAM 12/83*
R62S     SYSTEMATIC ERROR ADDED LINEARLY BY US.

R63      J/PSI INTO (N NBAR PI+ PI-)/TOTAL (UNITS 10**-3) (P60)
R63        5    3.8      3.6            BESCH      81 BONA            E+E-         1/82

R64      J/PSI INTO (SIGMA- SIGMABAR-)/TOT (UNITS 10**-3) (P61)
R64        3    2.4      2.6            BESCH      81 BONA            E+E-         1/82

R65      J/PSI(3100) INTO (K+ K- PI0)/TOTAL (UNITS 10**-4)(P20)
R65       25   (9.2)    (2.0)           FRANKLIN   83 SMK2       E+E-,HADRONS      9/83*

R66      J/PSI(3100) INTO (PI+PI-PI0)/TOTAL                      (P12)
R66      168   (0.015)  (0.002)         FRANKLIN   83 SMK2       E+E-,HADRONS      9/83*
R66            (0.0149) (0.0022)        EINSWEILE  83 SMK3       E+E-,HADRONS     12/83*

R67      J/PSI(3100) INTO N*(1232)++N*(1232)--/TOT *10**-3(P62)
R67S     233   (1.10)   (0.37)          EATON      83 SMK2       E+E-,HADRONS GAM  9/83*
R67S     SYSTEMATIC ERROR ADDED LINEARLY BY US.
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Mesons

$J/\psi(3100)$

Data Card Listings

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R68     J/PSI(3100) INTO Y*(1385)- Y*(1385)+ /TOT *10**-3(P63)
R68S     56   (0.86)   (0.40)          EATON     83 SMK2    E+E-,HADRONS GAM  9/83*
R68S    SYSTEMATIC ERROR ADDED LINEARLY BY US.

R69     J/PSI(3100) INTO Y*(1385)+ Y*(1385)- /TOT *10**-3(P64)
R69S     68   (1.03)   (0.49)          EATON     83 SMK2    E+E-,HADRONS GAM  9/83*
R69S    SYSTEMATIC ERROR ADDED LINEARLY BY US.

R70     J/PSI(3100) INTO Y*(1385)- SIGMABAR+ /TOT *10**-3(P65)
R70S     26   (0.29)   (0.21)          EATON     83 SMK2    E+E-,HADRONS GAM  9/83*
R70S    SYSTEMATIC ERROR ADDED LINEARLY BY US.

R71     J/PSI(3100) INTO Y*(1385)+ SIGMABAR+ /TOT *10**-3(P66)
R71S     28   (0.31)   (0.22)          EATON     83 SMK2    E+E-,HADRONS GAM  9/83*
R71S    SYSTEMATIC ERROR ADDED LINEARLY BY US.

R72     J/PSI(3100) INTO PBAR N*(1440-1535)+ /TOT *10**-3(P67)
R72S    189   (0.93)   (0.47)          EATON     83 SMK2    E+E-,HADRONS GAM  9/83*
R72S    SYSTEMATIC ERROR ADDED LINEARLY BY US.

R73     J/PSI(3100) INTO N*(1232)++ PBAR PI- /TOT *10**-3(P68)
R73S    332   (1.58)   (0.63)          EATON     83 SMK2    E+E-,HADRONS GAM  9/83*
R73S    SYSTEMATIC ERROR ADDED LINEARLY BY US.

R74     J/PSI(3100) INTO LAMBDA SIGMABAR+ PI-/TOT *10**-3(P69)
R74S    135   (1.53)   (0.55)          EATON     83 SMK2    E+E-,HADRONS GAM  9/83*
R74S    SYSTEMATIC ERROR ADDED LINEARLY BY US.

R75     J/PSI(3100) INTO LAMBDA SIGMABAR- PI+/TOT *10**-3(P70)
R75S    118   (1.38)   (0.56)          EATON     83 SMK2    E+E-,HADRONS GAM  9/83*
R75S    SYSTEMATIC ERROR ADDED LINEARLY BY US.

R76     J/PSI(3100) INTO P PBAR RHO          /TOT *10**-3(P91)
R76S     38   (0.31) OR LESS  CL=.90   EATON     83 SMK2    E+E-,HADRONS GAM  9/83*
R76S    SYSTEMATIC ERROR ADDED LINEARLY BY US.

R77     J/PSI(3100) INTO P K- ANTILAMBDA     /TOT *10**-3(P92)
R77S    307   (0.89)   (0.21)          EATON     83 SMK2    E+E-,HADRONS GAM  9/83*
R77S    SYSTEMATIC ERROR ADDED LINEARLY BY US.

R78     J/PSI(3100) INTO P K- ANTISIGMA0     /TOT *10**-3(P93)
R78S     90   (0.29)   (0.11)          EATON     83 SMK2    E+E-,HADRONS GAM  9/83*
R78S    SYSTEMATIC ERROR ADDED LINEARLY BY US.

R79     J/PSI(3100) INTO P K- Y*(1385)0      /TOT *10**-3(P94)
R79S     89   (0.51)   (0.44)          EATON     83 SMK2    E+E-,HADRONS GAM  9/83*
R79S    SYSTEMATIC ERROR ADDED LINEARLY BY US.


R       RADIATIVE DECAYS
R       ----------------

R71     J/PSI(3100) INTO (2 GAMMA)/TOTAL  (UNITS 10**-3) (P70)
R71          (0.5)  OR LESS  CL=0.90  BARTEL    77 CNTR          E+E-          4/77

R72     J/PSI(3100) INTO (PI0 GAMMA)/TOTAL (UNITS 10**-3)(P72)
R72      10    0.073    0.047          BRANDELIK 79 DASP    E+ E-            12/79

R73     J/PSI(3100) INTO (ETA GAMMA)/TOTAL (UNITS 10**-3)(P73)
R73      21     1.3      0.4           BARTEL    77 CNTR    E+E-,3 GAMMA      1/77
R73            0.82     0.10           BRANDELIK 79 DASP    E+ E-            12/79
R73E           0.88     0.19           KONIGSMAN 82 CBAL    E+ E-,3 GAMMA     4/82
R73E    SYSTEMATIC ERROR ADDED LINEARLY BY US.
R73     . . . . . . . . . .
R73 AVG        0.855    0.086   AVERAGE

R74     J/PSI(3100) INTO (ETA PRIME GAM)/TOT(UNTS 10**-3)(P74)
R74          (3.2)  OR LESS  CL=.90   MURTAS     76 FRAG          E+E-          4/77
R74      57  (2.4)    (0.7)           BARTEL 1  76 CNTR    E+E-,2 GAMMA RHO  1/77
R74       6   2.9      1.1            BRANDELIK 79 DASP    E+E-,3 GAMMA     12/79
R74B          3.8      1.3            SCHARRE   79 SMAG    E+E-, GAMMA X    12/79
R74           3.4      0.7            SCHARRE   79 SMAG    E+E-,2 PI 2GAMMA 12/79
R74E          4.1      0.9            KONIGSMAN 82 CBAL    E+ E-             4/82
R74E         (4.6)    (1.0)           EINSWEILE 83 SMK3    E+E-,HADRONS GAM 12/83*
R74E         (4.7)    (1.2)           EINSWEILE 83 SMK3    E+E-,HADRONS GAM 12/83*
R74     . . . . . . . . . .
R74 AVG        3.55     0.46   AVERAGE

R74B    FROM THE INCLUSIVE GAMMA DECAY SPECTRUM
R74E    SYSTEMATIC ERROR ADDED LINEARLY BY US.


R78     J/PSI(3100) INTO (3 GAMMA)/TOTAL  (UNITS 10**-3) (P71)
R78          (0.055)OR LESS  CL=0.90  PARTRIDGE 80 CNTR    E+E-,3 GAMMA     12/79

R80     J/PSI(3100) INTO (GAMMA + 2 OR MORE NEUTRALS)/TOTAL   (UNITS 10**-3)
R80            7.0      2.0           BARTEL    77 CNTR          E+E-          1/77

R81     J/PSI(3100) INTO (F GAMMA)/TOTAL (UNITS 10**-3)  (P76)
R81      35    2.0      0.7           ALEXANDER 78 PLUT  0 E+E-               4/78
R81  T   30    1.2      0.6           BRANDELIK 78 DASP    E+E-,PI+PI-GAMMA  4/78
R81A    178    1.48     0.55          EDWARDS1  82 CBAL    E+E-,2 PI0 GAMMA  2/82
R81A         (1.7)    (0.3)           EINSWEILE 83 SMK3    E+E-,HADRONS GAM 12/83*
R81     . . . . . . . . . .
R81 AVG        1.51     0.35   AVERAGE

R81  T  RE-STATED BY US TO TAKE ACCOUNT OF SPREAD OF E1,M2,E3 TRANSITIONS.
R81A    SYSTEMATIC ERROR ADDED LINEARLY BY US

R82     J/PSI(3100) INTO (F PRIME GAM)/TOT (UNITS 10**-3)(P77)
R82       3   (0.23) OR LESS  CL=0.90  ALEXANDE2 78 PLUT    E+E-,K+K- GAMMA   4/78
R82  S    4   (0.34) OR LESS  CL=0.90  BRANDELIK 79 DASP    E+E-,PI+PI-GAMMA 12/79
R82          (0.16)   (0.065)           EINSWEILE 83 SMK3    E+E-,HADRONS GAM 12/83*
R82  S  ASSUMING ISOTROPIC PRODUCTION AND DECAY OF THE F PRIME,AND ISOSPIN.

R84     J/PSI(3100) INTO (P PBAR GAM)/TOT (UNITS 10**-3) (P80)
R84          (0.11) OR LESS  CL=0.90  PERUZZI    78 SMAG    E+E-,P PB SHOWER  4/78
R84S     49   (0.38)   (0.14)          EATON     83 SMK2    E+E-,HADRONS GAM 12/83*
R84S    SYSTEMATIC ERROR ADDED LINEARLY BY US.

R85     J/PSI(3100) INTO (D(1285) GAM)/TOTAL              (P78)
R85  D       (0.006)OR LESS  CL=.90   SCHARRE   80 SMK2    E+E-                2/81
R85  D  USING BR(D INTO K KBAR PI)=0.12

R86     J/PSI(3100) INTO (IOTA(1440) GAM)/TOTAL           (P79)
R86C B         0.0043   0.0017         SCHARRE   80 SMK2    E+E-                2/81
R86S B         0.0040   0.0017         EDWARDS1  83 CBAL    J/PSI,ETA GAM    12/83*
R86S B       (0.0053) (0.0025)         EINSWEILE 83 SMK3    E+E-,HADRONS GAM 12/83*
R86     . . . . . . . . . .
R86 AVG        0.0042   0.0012  AVERAGE

R86  B  INCLUDES UNKNOWN BRANCHING FRACTION IOTA(1440) INTO K KBAR PI.
R86C    CORRECTED FOR SPIN-ZERO HYPOTHESIS FOR IOTA(1440).
R86S    SYSTEMATIC ERROR ADDED LINEARLY BY US.

R87     J/PSI(3100) INTO (THETA(1690) GAM)/TOT (10**-4)  (P81)
R87 A        (3.8)    (1.6)           EDWARDS2  82 CBAL    E+E-,ETA ETA GAM  2/84*
R87SB        (4.8)    (1.6)           EINSWEILE 83 SMK3    E+E-,K+K- GAMMA  12/83*
R87SB        (6.0)    (3.4)           FRANKLI2  83 SMK2    E+E-,K+K- GAMMA   2/84*
R87 A   INCLUDES UNKNOWN BRANCHING FRACTION TO ETA ETA.
R87 B   INCLUDES UNKNOWN BRANCHING FRACTION TO K+K-.
R87S    SYSTEMATIC ERROR ADDED LINEARLY BY US.

R88     J/PSI(3100) INTO (XI(2220) GAM)/TOT UNITS 10**-4 (P82)
R88SB        (1.6)    (0.72)          EINSWEILE 83 SMK3    E+E-,HADRONS GAM 12/83*
R88 B   INCLUDES UNKNOWN BRANCHING FRACTION INTO K KBAR.
R88S    SYSTEMATIC ERROR ADDED LINEARLY BY US.

R89     J/PSI(3100) INTO P PBAR PI+ PI- GAMMA/TOT *10**-3(P83)
R89S     12    (.79) OR LESS  CL=.90   EATON     83 SMK2                      12/83*
R89S    SYSTEMATIC ERROR ADDED LINEARLY BY US.

R90     J/PSI(3100) INTO RHO0 RHO0 GAM/TOT (UNITS 10**-3)(P84)
R90S M         1.25     0.75           BURKE     82 SMK2    E+E-,HADRONS GAM 12/83*
R90  M  RHO RHO MASS LESS THAN 2.0 GEV.
R90S    SYSTEMATIC ERROR ADDED LINEARLY BY US.

R91     J/PSI(3100) INTO 2PI+ 2PI- GAM/TOT (UNITS 10**-3)(P85)
R91S M         4.85     1.65           BURKE     82 SMK2    E+E-,HADRONS GAM 12/83*
R91  M  4PI MASS LESS THAN 2.5 GEV.
R91S    SYSTEMATIC ERROR ADDED LINEARLY BY US.

R92     J/PSI(3100) INTO ETA PI+ PI-GAM/TOT(UNITS 10**-3)(P86)
R92S M         3.9      0.9            EDWARDS2  83 CBAL    J/PSI,HADR GAM   12/83*
R92  M  BROAD ENHANCEMENT AT 1700 MEV.
R92S    SYSTEMATIC ERROR ADDED LINEARLY BY US.

R93     J/PSI(3100) INTO ETA 2PI0 GAM/TOT  (UNITS 10**-3)(P87)
R93S M         2.6      1.2            EDWARDS2  83 CBAL    J/PSI,HADR GAM   12/83*
R93  M  BROAD ENHANCEMENT AT 1700 MEV.
R93S    SYSTEMATIC ERROR ADDED LINEARLY BY US.

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                    70  J/PSI(3100)   G(I)*G(E+E-)/G(TOTAL)  (KEV)

        THIS COMBINATION OF A PARTIAL WIDTH WITH THE PARTIAL WIDTH
        INTO E+E- AND WITH THE TOTAL WIDTH IS OBTAINED FROM THE INTEGRATED
        CROSS-SECTION INTO CHANNEL(I) IN THE E+E- ANNIHILATION.

G1      G(E+E-)*G(E+E-)/G(TOTAL)
G1 S           .32      .07            BALDINI1  75 FRAG          E+E-          1/76
G1             .34      .14            BEMPORAD  75 FRAB          E+E-          1/76
G1 S           .34      .09            ESPOSITO  75 FRAM          E+E-          1/76
G1 S           .36      .10            FORD      75 SPEC          E+E-
G1            0.35     0.02            BRANDELIK 79 DASP          E+E-         12/79
G1      . . . . . . . . . .
G1  AVG       0.348    0.018   AVERAGE

G2      G(MU+MU-)*G(E+E-)/G(TOTAL)
G2             .31      .09            BEMPORAD  75 FRAB          E+E-          1/76
G2             .51      .09            DASP1     75 DASP          E+E-          1/76
G2 S           .38      .05            ESPOSITO  75 FRAM          E+E-          1/76
G2 S           .46      .10            LIBERMAN  75 SPEC          E+E-          1/76
G2      . . . . . . . . . .
G2  AVG       0.401    0.037   AVERAGE

G3      G(HADRONIC)*G(E+E-)/G(TOTAL)
G3 S           4.       .8             BALDINI1  75 FRAG          E+E-          1/76
G3 S           3.9      .8             ESPOSITO  75 FRAM          E+E-          1/76
G3      . . . . . . . . . .
G3  AVG        3.95     0.57    AVERAGE

G  S    DATA REDUNDANT WITH BRANCHING RATIOS OR PARTIAL WIDTHS ABOVE

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                                REFERENCES FOR J/PSI(3100)

CHRISTEN 70 PRL 25 1523         CHRISTENSON,HICKS,LEDERMAN+ (COLU+BNL+CERN)

ABRAMS   74 PRL 33 1453         +BRIGGS,AUGUSTIN,BOYARSKI+        (LBL+SLAC)
ASH      74 NCL 11 705          +ZORN,BARTOLI+     (FRAS+UMD+NAPL+PADO+ROMA)
AUBERT   74 PRL 33 1404         +BECKER,BIGGS,BURGER,CHEN,EVERHART(MIT+BNL)
AUGUSTIN 74 PRL 33 1406         +BOYARSKI,ABRAMS,BRIGGS+          (SLAC+LBL)
BACCI    74 PRL 33 1408         +BARTOLI,BARBARINO,BARBIELLINI+  (FRASCATI)
    ALSO 74 PRL 33 1649         FOR ERRATA
BALDINI- 74 NCL 11 711          BALDINI-CELIO,BACCI+        (FRASCATI+ROMA)
BARBIELL 74 NCL 11 718          BARBIELLINI,BEMPORAD+ (FRAS+NAPL+PISA+ROMA)
BRAUNSCH 74 PL 53B 393          BRAUNSCHWEIG+    (AACHEN+HAMB+MUNICH+TOKYO)

ANDREWS  75 PRL 34 231          +HARVEY,LOBKOWICZ,MAY,NORDBERG  (ROCH+CORN)
AUBERT   75 NP B 89 1           +BECKER,BIGGS,BURGER,GLENN,+       (MIT+BNL)
BACCI    75 NCL 12 269          +PENSO,STELLA,BALDINI-CELIO,+   (ROMA+FRAS)
BALDINI1 75 PL 58B 471          BALDINI-CELIO,BOZZO,CAPON,BACCI+(FRAS+ROMA)
BALDINI2 75 PL 58B 475          BALDINI-CELIO,CAPON,DEL FABBRO+ (FRAS+ROMA)
BEMPORAD 75 STANFORD SYMP.113   C.BEMPORAD                 (PISA+FRASCATI)
BLANAR   75 PRL 35 346          +BOYER,FAISSLER,GARELICK,GETTNER,+     (NEAS)
BOYARSKI 75 PRL 34 1357         +BREIDENBACH,BULOS,FELDMAN,+     (SLAC+LBL)JPC
BRAUNSCH 75 PL 53B 491          BRAUNSCHWEIG+    (AACHEN+HAMB+MUNICH+TOKYO)
BUSSER   75 PL 56 B 482         +BLUMENFELD,BANNER,+  (CERN+COLU+ROCK+SACL)
CAMERINI 75 PRL 35 483          +LEARNED,PREPOST,ASH,ANDERSON,+ (WISC+SLAC)
CRIEGEE  75 PL 53B 489          +DEHNE,FRANKE,HORLITZ,KRECHLOCK+     (DESY)
DAKIN    75 PL 56 B 405         +KREISLER,BOLON,HEILE+       (MASA+MIT+SLAC)
DASP1    75 PL 56B 491          BRAUNSCHWEIG,KONIGS,+ (AACH+DESY+MPIM+TOKY)
DASP2    75 PL 57B 297          BRAUNSCHWEIG,KONIGS,+ (AACH+DESY+MPIM+TOKY)
ESPOSITO 75 NCL 14 73           +BARTOLI,BISELLO,+    (FRAS+NAPL+PADO+ROMA)
FORD     75 PRL 34 604          +BERON,HILGER,HOFSTADTER+       (SLAC+PENN)
GITTELMA 75 PRL 35 1616         GITTELMAN+HANSON+LARSON+LOH+          (CORN)
GRECO    75 PL 56B 367          +PANCHERI-SRIVASTAVA,SRIVASTAVA       (FRAS)
HEINTZE  75 STANFORD SYMP.97    J.HEINTZE                     (HEIDELBERG)
JACKSON  75 NIM 128 13          J.D.JACKSON,D.SCHARRE                  (LBL)
KNAPP1   75 PRL 34 1040         +LEE,BRONSTEIN+   (COLU+HAWA+CORN+ILL+FNAL)
KNAPP2   75 PRL 34 1044         +LEE,BRONSTEIN+   (COLU+HAWA+CORN+ILL+FNAL)
LIBERMAN 75 STANFORD SYMP.55    A.D.LIBERMAN                     (STANFORD)
MARTIN   75 PRL 34 288          +BOLON,DAKIN,FELDMAN,HANSON+(MIT+MASA+SLAC)
PREPOST  75 STANFORD SYMP.241   R.PREPOST                      (WISCONSIN)
SIMPSON  75 PRL 35 699          +BERON,FORD,HILGER,HOFSTADTER,+ (STAN+PENN)
WIIK     75 STANFORD SYMP.69    B.H.WIIK                            (DESY)
YENNIE   75 PRL 34 239          D.R.YENNIE                        (CORNELL)

ANTIPOV  76 TBILISI CONF.N 8    +BESSUBOV,BUDANOV,BUSHNIN,DENISOV,+  (SERP)
BACCI    76  LNF-76/60(P)       +BALDINI-CELIO,CAPON+      (FRAS+ROMA+GENO)
BARTEL 1 76 PL 66 B 483         +DUINKER,OLSSON,STEFFEN,HEINTZE+(DESY+HEID)
BRAUNSCH 76 PL 63 B 487         BRAUNSCHWEIG,+    (AACH+DESY+HAMB+MPIM+TOKY)
BUSSER   76 NP B 113 189        +BLUMENFELD,BANNER,+  (CERN+COLU+ROCK+SACL)
JEAN-MAR 76 PRL 36 291          +ABRAMS,BOYARSKI,BREIDENBACH,+   (SLAC+LBL)IG
MURTAS   76 TBLISI CONF. N60    G.P.MURTAS                           (FRAS)
PIERRE   76 TBILISI CONF. N46   F.PIERRE                        (SLAC+LBL)
SNYDER   76 PRL 36 1415         +HOM,LEDERMAN,APPEL,KAPLAN+(COLU+FNAL+STON)
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For notation, see key at front of Listings.

Mesons

$J/\psi(3100)$, $\chi(3415)$, $\chi(3510)$


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BARTEL   77 PL 66 B 489        +DUINKER,OLSSON,HEINTZE,+        (DESY+HEID)
BIDDICK  77 PRL 38 1324        +BURNETT+     (UCSD+UMD+PAVI+PRIN+SLAC+STAN)
BURMESTE 77 PL 72 B 135        BURMESTER,CRIEGEE,+    (DESY+HAMB+SIEG+WUPP)
CORDEN   77 PL 68 B 96         +DOWELL,+    (BIRM+CERN+MPIM+NEUC+EPOL+RHEL)
FELDMAN  77 PL 33 C 285        +PERL                            (LBL+SLAC)
VANNUCCI 77 PR D 15 1814       +ABRAMS,ALAM,BOYARSKI,+          (SLAC+LBL)
YAMADA   77 HAMB. CONF. P. 69 YAMADA                           (DESY+TOKY)

ALEXANDE 78 PL 72 B 493        ALEXANDER,CRIEGEE,+    (DESY+HAMB+SIEG+WUPP)
BESCH    78 PL 78 B 347        +EISERMANN,KOWALSKI,V EYSS+(BONN+DESY+MANZ)
BRANDELI 78 PL 74 B 292        BRANDELIK,CORDS+ (AACH+DESY+HAMB+MPIM+TOKY)
PERUZZI  78 PR D 17 2901       +PICCOLO,ALAM,BOYARSKI,GOLDHABER+(SLAC+LBL)

BRANDELI 79 ZPHY C 1 233       BRANDELIK,CORDS,+(AACH+DESY+HAMB+MPIM+TOKY)
KIRK     79 PRL 42 619         +GOODMAN,ALVERSON,+(FNAL+HARV+ILL+OXF+TUFT)
LEMOIGNE 79 FERMILAB CONF.524 +ABOLINS,BARATE,+       (SACL+LOIC+SHMP+IND)
SCHARRE  79  SLAC-PUB-2321     D.L. SCHARRE                     (SLAC+LBL)
    ALSO 79  LBL 9502           ABRAMS,ALAM,BLOCKER,BOYARSKI,+  (SLAC+LBL)

PARTRIDG 80 PRL 44 712         PARTRIDGE,PECK,+  (CIT+HARV+PRIN+SLAC+STAN)
SCHARRE  80 PL 97 B 329        +TRILLING,ABRAMS,ALAM,BLOCKER+   (SLAC+LBL)
ZHOLENTZ 80 PL 96 B 214        +KURDADZE,LELCHUK,MISHNEV,NIKITIN+   (NOVO)
    ALSO 81 YAD.PHYS. 34 1471 ZHOLENTZ ET AL.                       (NOVO)

BESCH    81 ZPHY C 8 1         +EISERMANN,LOHR,KOWALSKI,+ (BONN+DESY+MANZ)
GIDAL    81 PL 107 B 153       +GOLDHABER,GUY,MILLIKAN,ABRAMS+  (SLAC+LBL)

BURKE    82 PRL 49 632         +TRILLING,ABRAMS,ALAM,BLOCKER+   (SLAC+LBL)
EDWARDS1 82 PR D 25 3065       +PARTRIDGE,PECK,+ (CIT+HARV+PRIN+STAN+SLAC)
EDWARDS2 82 PRL 48 458         +PARTRIDGE,PECK,+ (CIT+HARV+PRIN+STAN+SLAC)
KONIGSMA 82 MORIOND CONF.      KONIGSMANN,+      (STAN+CIT+HARV+PRIN+SLAC)
LEMOIGNE 82 PL 113 B 509       +BARATE,ASTBURY,MCEWEN+(SACL+LOIC+SHMP+IND)

BARATE   83 PL 121 B 449       +BAREYRE,ASTBURY,MCEWEN(SACL+LOIC+SHMP+IND)
EATON    83  SLAC-PUB-3122     +GOLDHABER,ABRAMS,ALAM,BOYARSKI+ (LBL+SLAC)
EDWARDS1 83 PRL 49 259         +PARTRIDGE,PECK+  (CIT+HARV+PRIN+STAN+SLAC)
EDWARDS2 83 PRL 51 859         +PARTRIDGE,PECK+  (CIT+HARV+PRIN+STAN+SLAC)
EINSWEIL 83 BRIGHTON CONF.     K.F.EINSWEILER+MARKIII COLLABORATION (SLAC)
FRANKLIN 83  SLAC-PUB-3092     +FRANKLIN,FELDMAN,ABRAMS,ALAM+   (LBL+SLAC)
FRANKLI2 83 SLAC-254 THESIS    M.E.B.FRANKLIN                       (STAN)
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$\chi(3415)$

56 CHI(3415,JPG=0++) I=0

OBSERVED IN THE RADIATIVE DECAY OF PSI(3685) INTO CHI(3415) GAMMA. THEREFORE C=+. THE OBSERVED DECAY INTO PI+ PI- OR K+ K- IMPLIES G=+, JP=0+,2+,... . THE ANGULAR DISTRIBUTION IS CONSISTENT WITH J=0. JP ABNORMAL EXCLUDED BY PI+ PI- AND K+ K- DECAYS. JP=0+ PREFERRED (FELDMAN 77) .

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56 CHI(3415) MASS (MEV)

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M        2(3407.0)    (8.0)          WIIK      75 DASP    E+E-,J/PSI 2 GAM  1/77
M  D       3415.0      9.0          BIDDICK   77 CNTR    E+E-,MONOCHR.GAM  3/77
M  D       3422.0     10.0          BARTEL    78 CNTR    E+E-,J/PSI 2 GAM  4/78
M  D M     3416.0      4.0          TANENBAUM 78 SMAG    E+ E-            12/78
M  D E     3414.8      1.1          HIMEL     79 SMK2    E+E-,HADRONS      3/82
M                . . . . . . . .
M   AVG    3415.0      1.0     AVERAGE

M  D    MASS VALUE SHIFTED BY US BY AMOUNT APPROPRIATE FOR
M  D                PSI(3685) MASS=3686 AND PSI(3100) MASS=3097.
M    E  SYSTEMATIC ERROR ADDED LINEARLY BY US
M    M  FROM A SIMULTANEOUS FIT TO RADIATIVE AND HADRONIC DECAY CHANNELS
M    M               SYSTEMATIC ERROR ADDED LINEARLY BY US

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56 CHI(3415) PARTIAL DECAY MODES

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                                                      DECAY MASSES
P1      CHI(3415) INTO PI+ PI-                       140+ 140
P2      CHI(3415) INTO K+ K-                         494+ 494
P3      CHI(3415) INTO 2(PI+ PI-)                    140+ 140+ 140+ 140
P4      CHI(3415) INTO 3(PI+ PI-)
P5      CHI(3415) INTO PI+ PI- K+ K-                 140+ 140+ 494+ 494
P6      CHI(3415) INTO J/PSI(3100) GAMMA            3097+   0
P7      CHI(3415) INTO 2 GAMMA                        0+   0
P8      CHI(3415) INTO PI+ PI- P PBAR                140+ 140+ 938+ 938
P9      CHI(3415) INTO RHO0 PI+ PI-                  769+ 140+ 140
P10     CHI(3415) INTO K*(892)0 K+/- PI-/+           892+ 494+ 140
P11     CHI(3415) INTO P PBAR                        938+ 938

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56 CHI(3415) BRANCHING RATIOS

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R1      CHI(3415) INTO (2 GAMMA)/TOTAL                    (P7)
R1 T          (0.0017)OR LESS  CL=0.90 YAMADA    77 DASP    E+ E-,3 GAMMA    12/77

R2      CHI(3415) INTO 2(PI+ PI-)/TOTAL                   (P3)
R2 T          0.043     0.009          TANENBAUM 78 SMAG PSI(3685)TO GAM CHI 12/78

R3      CHI(3415) INTO (PI+ PI- K+ K-)/TOTAL              (P5)
R3 T          0.034     0.009          TANENBAUM 78 SMAG PSI(3685)TO GAM CHI 12/78

R4      CHI(3415) INTO 3(PI+ PI-)/TOTAL                   (P4)
R4 T          0.017     0.006          TANENBAUM 78 SMAG PSI(3685)TO GAM CHI 12/77

R5      CHI(3415) INTO (PI+ PI-)/TOTAL                    (P1)
R5 T          0.009     0.003          TANENBAUM 78 SMAG PSI(3685)TO GAM CHI 12/77
R5 T          0.008     0.003          BRANDEL2  79 DASP PSI(3685)TO GAM CHI 12/79
R5          . . . . . . . . . .
R5  AVG       0.0085    0.0021  AVERAGE

R6      CHI(3415) INTO (K+ K-)/TOTAL                      (P2)
R6 T          0.01      0.004          TANENBAUM 78 SMAG PSI(3685)TO GAM CHI 12/77
R6 T          0.007     0.003          BRANDEL2  79 DASP PSI(3685)TO GAM CHI 12/79
R6          . . . . . . . . . .
R6  AVG       0.0081    0.0024  AVERAGE

R7      CHI(3415) INTO (PI+ PI- P PBAR)/TOTAL             (P8)
R7 T          0.006     0.002          TANENBAUM 78 SMAG PSI(3685)TO GAM CHI 12/78

R8      CHI(3415) INTO (J/PSI(3100) GAMMA)/TOTAL          (P6)
R8 T          0.024     0.024          TANENBAUM 78 SMAG PSI(3685)TO GAM CHI 12/77
R8 T          0.017     0.011          BARTEL    78 CNTR PSI(3685)TO GAM CHI  4/78
R8 T          0.037     0.024          BRANDEL2  79 DASP PSI(3685)TO GAM CHI 12/79
R8 T         (0.068)OR LESS  CL=0.90   HIMEL     80 SMK2 PSI(3685)TO GAM CHI  9/81
R8 T S  17    0.0072    0.0029         OREGLIA   82 CBAL PSI(3685)TO GAM CHI  2/82
R8          . . . . . . . . . .
R8  AVG       0.0084    0.0028  AVERAGE

R9      CHI(3415) INTO (RHO0 PI+ PI-)/TOTAL               (P9)
R9 T          0.017     0.006          TANENBAUM 78 SMAG PSI(3685)TO GAM CHI 12/78

R10     CHI(3415) INTO (K*(892)0 K+ - PI- +)/TOTAL        (P10)
R10T          0.014     0.005          TANENBAUM 78 SMAG PSI(3685)TO GAM CHI 12/78

R11     CHI(3415) INTO (P PBAR)/TOTAL (UNITS 10**-2)      (P11)
R11T         (0.11) OR LESS  CL=0.90  BRANDEL2  79 DASP PSI(3685)TO GAM CHI  3/82

R    S  SYSTEMATIC ERROR ADDED LINEARLY BY US.
R   T   CALCULATED USING PSI(3685) TO (GAMMA CHI(3415))/TOTAL=0.082          3/82
R   T   THE ERRORS DO NOT CONTAIN THE UNCERTAINTY IN THE PSI(3685) DECAY.

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REFERENCES FOR CHI(3415)


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FELDMAN  75 PRL 35 821         +JEAN-MARIE,SADOULET,VANNUCCI,+  (LBL+SLAC)
    ALSO 75 PRL 35 1189  (ERRATA)
TANENBAU 75 PRL 35 1323        TANENBAUM,WHITAKER,ABRAMS,+      (LBL+SLAC)
WIIK     75 STANFORD SYMP.69   B.H.WIIK                            (DESY)

BIDDICK  77 PRL 38 1324        +BURNETT+     (UCSD+UMD+PAVI+PRIN+SLAC+STAN)
FELDMAN  77 PL 33 C 285        +PERL                            (LBL+SLAC)
YAMADA   77 HAMB. CONF. P. 69 YAMADA                           (DESY+TOKY)

BARTEL   78 PL 79 B 492        DITTMANN,DUINKER,OLSSON,O?NEILL+(DESY+HEID)
TANENBAU 78 PR D 17 1731       TANENBAUM,ALAM,BOYARSKI,+        (SLAC+LBL)
    ALSO 82  PRIVATE COMM.     G.H.TRILLING                      (LBL+UCB)

BRANDEL1 79 ZPHY C 1 233       BRANDELIK,CORDS,+(AACH+DESY+HAMB+MPIM+TOKY)
BRANDEL2 79 NP B 160 426       BRANDELIK,CORDS,+(AACH+DESY+HAMB+MPIM+TOKY)
HIMEL    79 THESIS  SLAC-223   T.M.HIMEL                          (SLAC)
    ALSO 82  PRIVATE COMM.     G.H.TRILLING                      (LBL+UCB)
KIRK     79 PRL 42 619         +GOODMAN,ALVERSON,+(FNAL+HARV+ILL+OXF+TUFT)

HIMEL    80 PRL 44 920         +ABRAMS,ALAM,BLOCKER,+           (LBL+SLAC)

OREGLIA  82 PR D 25 2259       +PARTRIDGE,BLOOM,+(SLAC+CIT+HARV+PRIN+STAN)
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$\chi(3510)$

55 CHI(3510,JPG=1++) I=0

FORMERLY CALLED PC.
OBSERVED IN THE RADIATIVE SEQUENTIAL DECAY OF THE PSI(3685) INTO CHI(3510) GAMMA, CHI(3510) INTO J/PSI(3100) GAMMA. THEREFORE, C=+.
THE LACK OF DECAYS INTO PI+ PI- OR K+K- IS SUGGESTIVE OF JP = ABNORMAL. THE DECAYS INTO 4PI AND 6PI IMPLY G=+, THUS I=0. J=0,2 EXCLUDED BY ANGULAR DISTRIBUTION IN THE (GAMMA J/PSI) DECAY. JP=1+ PREFERRED (FELDMAN 77, OREGLIA 82)

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55 CHI(3510) MASS (MEV)

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M       40(3500.)    (10.)          TANENBAUM 75 SMAG          HADRONS GAM 12/77
M        7(3507.0)    (7.0)         WIIK      75 DASP    E+E-,J/PSI 2 GAM  1/77
M        (3510.0)    (20.0)         BARTEL    76 CNTR    E+E-,J/PSI 2 GAM  1/77
M  D   367 3513.0      7.0          BIDDICK   77 CNTR    E+E-,MONOCHR.GAM  3/77
M  D      3507.0      3.0          BARTEL    78 CNTR    E+E-,J/PSI 2 GAM  4/78
M  D M    3505.0      5.0          TANENBAUM 78 SMAG    E+ E-            12/78
M       21 3509.0     11.0          BRANDEL2  79 DASP    E+E-,J/PSI 2GAM  12/79
M       15(3520.)                   LEMOIGNE  79 GOLI     150 PI-BE,2MU   12/79
M  D F 254 3510.1      1.1          HIMEL     80 SMK2    E+E-,J/PSI 2 GAM  9/81
M  P    91 3507.4      1.7          LEMOIGNE  82 GOLI     190 PI-BE,GAM2MU  3/82
M  E F     3510.4      0.6          OREGLIA   82 CBAL    E+E-,J/PSI 2 GAM  9/83*
M                . . . . . . . .
M   AVG    3509.95     0.55    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.1)

M  D    MASS VALUE SHIFTED BY US BY AMOUNT APPROPRIATE FOR
M  D                PSI(3685) MASS=3686 AND PSI(3100) MASS=3097
M  E    ASSUMING PSI(3685) MASS=3686 AND PSI(3100) MASS=3097.
M    F  SYSTEMATIC ERROR ADDED LINEARLY BY US
M    M  FROM A SIMULTANEOUS FIT TO RADIATIVE AND HADRONIC DECAY CHANNELS
M    M               SYSTEMATIC ERROR ADDED LINEARLY BY US
M  P    J/PSI MASS CONSTRAINED TO 3097.

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55 CHI(3510) PARTIAL DECAY MODES

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                                                      DECAY MASSES
P1      CHI(3510) INTO J/PSI(3100) GAMMA            3097+   0
P2      CHI(3510) INTO PI+ PI-                       140+ 140
P3      CHI(3510) INTO K+ K-                         494+ 494
P4      CHI(3510) INTO GAMMA GAMMA                     0+   0
P5      CHI(3510) INTO 2(PI+ PI-)                    140+ 140+ 140+ 140
P6      CHI(3510) INTO 3(PI+ PI-)
P7      CHI(3510) INTO PI+ PI- K+ K-                 140+ 140+ 494+ 494
P8      CHI(3510) INTO PI+ PI- P PBAR                140+ 140+ 938+ 938
P9      CHI(3510) INTO RHO0 PI+ PI-                  769+ 140+ 140
P10     CHI(3510) INTO K*(892)0 K+/- PI-/+           892+ 494+ 140
P11     CHI(3510) INTO P PBAR                        938+ 938

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55 CHI(3510) BRANCHING RATIOS

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R1      CHI(3510) INTO (J/PSI(3100) GAMMA)/TOTAL          (P1)
R1 T         (0.63)    (0.19)         BIDDICK   77 CNTR PSI(3685)TO GAM CHI 12/77
R1 T          0.31      0.05          BARTEL    78 CNTR PSI(3685)TO GAM CHI  4/78
R1 T          0.30      0.10          TANENBAUM 78 SMAG PSI(3685)TO GAM CHI 12/78
R1 T          0.21      0.05          BRANDEL2  79 DASP PSI(3685)TO GAM CHI 12/79
R1 T          0.30      0.08          HIMEL     80 SMK2 PSI(3685)TO GAM CHI  9/81
R1 T S 943    0.30      0.06          OREGLIA   82 CBAL PSI(3685)TO GAM CHI  2/82
R1          . . . . . . . . . .
R1  AVG       0.276     0.027   AVERAGE

R2      CHI(3510) INTO (PI+PI- AND K+K-)/TOTAL            (P2+P3)
R2 T         (0.0019)OR LESS          FELDMAN   77 SMAG PSI(3685) TO GAM PC 12/77
R2 T         (0.0041)OR LESS CL=0.90  BRANDEL2  79 DASP PSI(3685)TO GAM CHI 12/79

R3      CHI(3510) INTO (GAMMA GAMMA)/TOTAL                (P4)
R3 T         (0.0016)OR LESS CL=0.90  YAMADA    77 DASP    E+ E-,3 GAMMA    12/77

R4      CHI(3510) INTO 2(PI+ PI-)/TOTAL                   (P5)
R4 T          0.018     0.005          TANENBAUM 78 SMAG PSI(3685) TO GAM PC 12/78

R5      CHI(3510) INTO (PI+ PI- K+ K-)/TOTAL              (P7)
R5 T          0.010     0.004          TANENBAUM 78 SMAG PSI(3685) TO GAM PC 12/78
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Mesons

$\chi(3510)$, $\chi(3555)$, $\eta_c(3590)$

Data Card Listings

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R6      CHI(3510) INTO 3(PI+ PI-)/TOTAL                    (P6)
R6 T          0.024    0.009          TANENBAUM 78 SMAG PSI(3685) TO GAM PC 12/78

R7      CHI(3510) INTO (PI+ PI- P PBAR)/TOTAL              (P8)
R7 T          0.0015   0.0010         TANENBAUM 78 SMAG PSI(3685) TO GAM PC 12/78

R8      CHI(3510) INTO (RHO0 PI+ PI-)/TOTAL                (P9)
R8 T          0.0043   0.0038         TANENBAUM 78 SMAG PSI(3685) TO GAM PC 12/78

R9      CHI(3510) INTO (K*(892)0 K+ - PI- +)/TOTAL         (P10)
R9 T          0.0035   0.0023         TANENBAUM 78 SMAG PSI(3685) TO GAM PC 12/78

R11     CHI(3510) INTO (P PBAR)/TOTAL                      (P11)
R11T          (0.0013)OR LESS CL=0.90  BRANDEL2  79 DASP PSI(3685)TO GAM CHI 12/79

R    S  SYSTEMATIC ERROR ADDED LINEARLY BY US.
R   T   ESTIMATED USING PSI(3685) TO (GAMMA PC)/TOTAL=0.080                  3/82
R   T   THE ERRORS DO NOT CONTAIN THE UNCERTAINTY IN THE PSI(3685) DECAY.

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REFERENCES FOR CHI(3510)


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DASP      75 PL 57B 407          BRAUNSCHWEIG,KONIGS,+ (AACH+DESY+MPIM+TOKY)
FELDMAN   75 STANFORD SYMP.39    G.J.FELDMAN                          (SLAC)
HEINTZE   75 STANFORD SYMP.97    J.HEINTZE                        (HEIDELBERG)
SIMPSON   75 PRL 35 699          +BERON,FORD,HILGER,HOFSTADTER,+ (STAN+PENN)
TANENBAU  75 PRL 35 1323         TANENBAUM,WHITAKER,ABRAMS,+       (LBL+SLAC)
WIIK      75 STANFORD SYMP.69    B.H.WIIK                             (DESY)

BARTEL    76 TBILISI CONF.N75    +DUINKER,OLSSON,HEINTZE,+        (DESY+HEID)

BIDDICK   77 PRL 38 1324         +BURNETT+     (UCSD+UMD+PAVI+PRIN+SLAC+STAN)
FELDMAN   77 PL 33 C 285         +PERL                             (LBL+SLAC)
YAMADA    77 HAMB. CONF. P. 69   YAMADA                           (DESY+TOKY)

BARTEL    78 PL 79 B 492         +DITTMANN,DUINKER,OLSSON,ONEILL+(DESY+HEID)
TANENBAU  78 PR D 17 1731        TANENBAUM,ALAM,BOYARSKI,+        (SLAC+LBL)
    ALSO  82  PRIVATE COMM.      G.H.TRILLING                      (LBL+UCB)

BRANDEL1  79 ZPHY C 1 233        BRANDELIK,CORDS,+(AACH+DESY+HAMB+MPIM+TOKY)
BRANDEL2  79 NP B 160 426        BRANDELIK,CORDS,+(AACH+DESY+HAMB+MPIM+TOKY)
KIRK      79 PRL 42 619          +GOODMAN,ALVERSON,+(FNAL+HARV+ILL+OXF+TUFT)
LEMOIGNE  79 FERMILAB CONF.524   +ABOLINS,BARATE,+       (SACL+LOIC+SHMP+IND)

HIMEL     80 PRL 44 920          +ABRAMS,ALAM,BLOCKER,+            (LBL+SLAC)
    ALSO  82  PRIVATE COMM.      G.H.TRILLING                      (LBL+UCB)

LEMOIGNE  82 PL 113 B 509        +BARATE,ASTBURY,MCEWEN+(SACL+LOIC+SHMP+IND)
OREGLIA   82 PR D 25 2259        +PARTRIDGE,BLOOM,+(SLAC+CIT+HARV+PRIN+STAN)
   ALSO   82  PRIVATE COMM.      M. OREGLIA                           (EFI)

BARATE    83 PL 121 B 449        +BAREYRE,ASTBURY,MCEWEN(SACL+LOIC+SHMP+IND)
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$\chi(3555)$

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57  CHI(3555,JPG=2++) I=0

        OBSERVED IN RADIATIVE DECAY OF PSI(3685) INTO
      CHI(3555) GAMMA. THEREFORE C=+. THE OBSERVED DECAY INTO 4PI
      AND 6PI IMPLY G=+, THUS I=0.
      J=0 IS EXCLUDED BY THE ANGULAR DISTRIBUTION IN THE HADRONIC
      DECAYS. JP ABNORMAL EXCLUDED BY PI+ PI- AND K+ K- DECAYS.
      JP=2+ PREFERRED (FELDMAN 77, OREGLIA 82).

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57 CHI(3555) MASS (MEV)

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M          (3550.0)   (10.0)          TRILLING  76 SMAG    E+E-,HADRONS GAM  1/77
M         4(3543.0)   (10.0)          WHITAKER  76 SMAG    E+E-,J/PSI 2 GAM  1/77
M   D   360 3563.0      7.0           BIDDICK   77 CNTR    E+E-,MONOCHR.GAM  3/77
M   D       3553.0      4.0           BARTEL    78 CNTR    E+E-,J/PSI 2 GAM  4/78
M   D M     3553.0      5.0           TANENBAUM 78 SMAG    E+ E-            12/78
M        15 3551.0     11.0           BRANDEL2  79 DASP    E+E-,J/PSI 2GAM  12/79
M   D F  69 3557.       1.5           HIMEL     80 SMK2    E+E-,J/PSI 2 GAM  9/81
M   P    66 3553.4      2.2           LEMOIGNE  82 GOLI    190 PI-BE,GAM2MU  3/82
M   E F     3555.9      0.7           OREGLIA   82 CBAL    E+E-,J/PSI 2 GAM  9/83*
M           . . . . . . . . .
M   AVG     3555.82     0.60    AVERAGE

M   D    MASS VALUE SHIFTED BY US BY AMOUNT APPROPRIATE FOR
M   D              PSI(3685) MASS=3686 AND PSI(3100) MASS=3097.
M   E    ASSUMING PSI(3685) MASS=3686 AND PSI(3100) MASS=3097.
M     F  SYSTEMATIC ERROR ADDED LINEARLY BY US.
M     M  FROM A SIMULTANEOUS FIT TO RADIATIVE AND HADRONIC DECAY CHANNELS
M     M          SYSTEMATIC ERROR ADDED LINEARLY BY US
M   P    J/PSI MASS CONSTRAINED TO 3097

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57 CHI(3555) PARTIAL DECAY MODES

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                                                      DECAY MASSES
P1      CHI(3555) INTO PI+ PI-                       140+ 140
P2      CHI(3555) INTO K+ K-                         494+ 494
P3      CHI(3555) INTO 2(PI+ PI-)                    140+ 140+ 140+ 140
P4      CHI(3555) INTO 3(PI+ PI-)
P5      CHI(3555) INTO PI+ PI- K+ K-                 140+ 140+ 494+ 494
P6      CHI(3555) INTO J/PSI(3100) GAMMA            3097+   0
P7      CHI(3555) INTO 2 GAMMA                         0+   0
P8      CHI(3555) INTO PI+ PI- P PBAR                140+ 140+ 938+ 938
P9      CHI(3555) INTO RHO0 PI+ PI-                  769+ 140+ 140
P10     CHI(3555) INTO K*(892)0 K+/- PI-/+           892+ 494+ 140
P11     CHI(3555) INTO P PBAR                        938+ 938
P12     CHI(3555) INTO J/PSI(3100) PI+ PI- PI0      3097+ 140+ 140+ 135

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57 CHI(3555) BRANCHING RATIOS

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R1      CHI(3555) INTO (2 GAMMA)/TOTAL                     (P7)
R1 T          (0.0006)OR LESS  CL=0.90 YAMADA    77 DASP    E+ E-,3 GAMMA    12/77

R2      CHI(3555) INTO 2(PI+ PI-)/TOTAL                    (P3)
R2 T          0.023    0.005          TANENBAUM 78 SMAG PSI(3685)TO GAM CHI 12/78

R3      CHI(3555) INTO (PI+ PI- K+ K-)/TOTAL               (P5)
R3 T          0.020    0.005          TANENBAUM 78 SMAG PSI(3685)TO GAM CHI 12/78

R4      CHI(3555) INTO 3(PI+ PI-)/TOTAL                    (P4)
R4 T          0.012    0.008          TANENBAUM 78 SMAG PSI(3685)TO GAM CHI 12/78

R5      CHI(3555) INTO (PI+ PI- AND K+ K-)/TOTAL           (P1+P2)
R5 T          0.0026   0.0011         TANENBAUM 78 SMAG PSI(3685)TO GAM CHI 12/78

R6      CHI(3555) INTO (PI+ PI- P PBAR)/TOTAL              (P8)
R6 T          0.0035   0.0014         TANENBAUM 78 SMAG PSI(3685)TO GAM CHI 12/78

R7      CHI(3555) INTO (J/PSI(3100) GAMMA)/TOTAL           (P6)
R7 T        (0.30)   (0.14)           BIDDICK   77 CNTR PSI(3685)TO GAM CHI 12/77
R7 T         0.14     0.03            BARTEL    78 CNTR PSI(3685)TO GAM CHI  4/78
R7 T         0.12     0.14     0.07   SPITZER   78 PLUT PSI(3685)TO GAM CHI 12/78
R7 T         0.14     0.08            TANENBAUM 78 SMAG PSI(3685)TO GAM CHI 12/78
R7 T         0.19     0.05            BRANDEL2  79 DASP PSI(3685)TO GAM CHI 12/79
R7 T         0.15     0.04            HIMEL     80 SMK2 PSI(3685)TO GAM CHI  9/81
R7 T S 479   0.170    0.038           OREGLIA   82 CBAL PSI(3685)TO GAM CHI  2/82
R7          . . . . . . . . .
R7  AVG      0.155    0.018    AVERAGE

R8      CHI(3555) INTO (RHO0 PI+ PI-)/TOTAL                (P9)
R8 T          0.0071   0.0042         TANENBAUM 78 SMAG PSI(3685)TO GAM CHI 12/78

R9      CHI(3555) INTO (K*(892)0 K+ - PI- +)/TOTAL         (P10)
R9 T          0.0050   0.0029         TANENBAUM 78 SMAG PSI(3685)TO GAM CHI 12/78

R10     CHI(3555) INTO (PI+ PI-)/TOTAL (UNITS 10**-3)      (P1)
R10T     4    2.0      1.1            BRANDEL1  79 DASP PSI(3685)TO GAM CHI 12/79

R11     CHI(3555) INTO (K+ K-)/TOTAL (UNITS 10**-3)        (P2)
R11T     2    1.6      1.2            BRANDEL1  79 DASP PSI(3685)TO GAM CHI 12/79

R12     CHI(3555) INTO (P PBAR)/TOTAL (UNITS 10**-3)       (P11)
R12T          (1.0)  OR LESS CL=0.90   BRANDEL2  79 DASP PSI(3685)TO GAM CHI 12/79

R13     CHI(3555) INTO (J/PSI PI+PI-PI0)/TOTAL             (P12)
R13           (0.015)OR LESS  CL=.90   BARATE    81 SPEC    190 PI-BE,2PI2MU  1/82

R    S  SYSTEMATIC ERROR ADDED LINEARLY BY US.
R   T   ESTIMATED USING PSI(3685) TO (GAMMA CHI(3555))/TOTAL=0.074           3/82
R   T   THE ERRORS DO NOT CONTAIN THE UNCERTAINTY IN THE PSI(3685) DECAY.

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REFERENCES FOR CHI(3555)


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FELDMAN   75 PRL 35 821          +JEAN-MARIE,SADOULET,VANNUCCI,+  (LBL+SLAC)
    ALSO  75 PRL 35 1189  (ERRATA)
TANENBAU  75 PRL 35 1323         TANENBAUM,WHITAKER,ABRAMS,+      (LBL+SLAC)

TRILLING  76 STANFORD SYMP.437   G. H. TRILLING                        (LBL)
WHITAKER  76 PRL 37 1596         +TANENBAUM,ABRAMS,ALAM,BOYARSKI,+(SLAC+LBL)

BIDDICK   77 PRL 38 1324         +BURNETT+     (UCSD+UMD+PAVI+PRIN+SLAC+STAN)
FELDMAN   77 PL 33 C 285         +PERL                             (LBL+SLAC)
YAMADA    77 HAMB. CONF. P. 69   YAMADA                           (DESY+TOKY)

BARTEL    78 PL 79 B 492         DITTMANN,DUINKER,OLSSON,O?NEILL+(DESY+HEID)
SPITZER   78 KYOTO SUM.INST.47   H. SPITZER                           (HAMB)
TANENBAU  78 PR D 17 1731        TANENBAUM,ALAM,BOYARSKI,+        (SLAC+LBL)
    ALSO  82  PRIVATE COMM.      G.H.TRILLING                      (LBL+UCB)

BRANDEL1  79 ZPHY C 1 233        BRANDELIK,CORDS,+(AACH+DESY+HAMB+MPIM+TOKY)
BRANDEL2  79 NP B 160 426        BRANDELIK,CORDS,+(AACH+DESY+HAMB+MPIM+TOKY)
KIRK      79 PRL 42 619          +GOODMAN,ALVERSON,+(FNAL+HARV+ILL+OXF+TUFT)

HIMEL     80 PRL 44 920          +ABRAMS,ALAM,BLOCKER,+            (LBL+SLAC)
    ALSO  82  PRIVATE COMM.      G.H.TRILLING                      (LBL+UCB)

BARATE    81 PR D 24 2994        +ASTBURY,MCEWEN,+ (SACL+LOIC+SHMP+CERN+IND)

LEMOIGNE  82 PL 113 B 509        +BARATE,ASTBURY,MCEWEN+(SACL+LOIC+SHMP+IND)
OREGLIA   82 PR D 25 2259        +PARTRIDGE,BLOOM,+(SLAC+CIT+HARV+PRIN+STAN)
    ALSO  82  PRIVATE COMM.      M. OREGLIA                           (EFI)

BARATE    83 PL 121 B 449        +BAREYRE,ASTBURY,MCEWEN(SACL+LOIC+SHMP+IND)
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$\eta_c(3590)$

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59  ETA/C(3590,JPG=   ) I=
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Evidence for the $\eta_c(3590)$ is based on the observation of a monochromatic gamma line in the inclusive photon spectrum for $\psi(3685)$ decays (EDWARDS 82). No exclusive decay modes are known at this time. A signal had been reported for a state at similar mass in the decay $\psi(3685) \rightarrow \gamma\gamma J/\psi(3100)$ (BARTEL 78), but this signal was not confirmed in an experiment with higher statistics (OREGLIA 82).

This particle needs confirmation, and thus is omitted from the Meson Table.

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59 ETA/C(3590) MASS (MEV)

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M    A     3594.0      5.0            EDWARDS   82 CBAL    E+E-,GAM INCL     1/82

M    A  ASSUMING MASS OF PSI(3685) = 3686 MEV.

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59 ETA/C(3590) WIDTH (MEV)

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W            (8.0)  OR LESS  CL=.95   EDWARDS   82 CBAL    E+E-,GAM INCL     1/82

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For notation, see key at front of Listings.


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                    59  ETA/C(3590) PARTIAL DECAY MODES

                                                          DECAY MASSES
P1      ETA/C(3590) INTO HADRONS

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                    59  ETA/C(3590) BRANCHING RATIOS

R1      ETA/C(3590) INTO HADRONS                     (P1)
R1        SEEN                     EDWARDS   82 CBAL   E+E-,GAM INCL     1/82

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                          REFERENCES FOR ETA/C(3590)

BARTEL   78 PL 79 B 492        +DITTMANN,DUINKER,OLSSON,+       (DESY+HEID)

PORTER   81 SLAC SUM.CONF.355 +EDWARDS,+         (CIT+HARV+PRIN+STAN+SLAC)

EDWARDS  82 PRL 48 70          +PARTRIDGE,PECK,+ (CIT+HARV+PRIN+STAN+SLAC)
OREGLIA  82 PR D 25 2259       +PARTRIDGE,BLOOM,+(SLAC+CIT+HARV+PRIN+STAN)
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ψ(3685)

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                    71  PSI(3685,JPG=1--) I=0

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                    71  PSI(3685) MASS (MEV)

                    WE USE INDEPENDENT MEASUREMENTS OF THE J/PSI(3100)
                    MASS, THE PSI(3685) MASS, AND THE MASS DIFFERENCE TO
                    PERFORM A CONSTRAINED FIT.

M  S       3680.3     37.            CRIEGEE   75 PLUT        E+E-      2/75
M   R     (3684.)     (5.)           LUTH      75 SMAG        E+E-      1/76
M          3684.      9.             PREPOST   75 SPEC   21. GAMMA D    1/76
M      140(3683.0)    (6.0)          LEMOIGNE  79 GOLI  0 150 PI-BE,2MU 12/79
M  F       3686.      3.             BRANDEL1  79 DASP   E+ E-         12/79
M      413 3686.00    0.10           ZHOLENTZ  80 OLYA   E+E- COLL.BEAMS 9/81
M           . . . . . . . . .
M  AVG    3686.000    0.100   AVERAGE
M  FIT    3686.00     0.10   FROM FIT

M  F    FROM A SIMULTANEOUS FIT TO E+ E-,MU+ MU- AND HADRONIC CHANNELS
M  F    ASSUMING G(E+ E-) = G(MU+ MU-)
M   R   REDUNDANT WITH DATA IN MASS DIFFERENCE BELOW
M   S   ERROR OF ABOUT 1 PER CENT FROM THE UNCERTAINTY IN CALIBRATION OF
M   S   THE BEAM ENERGY.

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                    71  PSI(3685) - J/PSI(3100) MASS DIFFERENCE (MEV)

DM          588.7       .8           LUTH      75 SMAG                  1/76
DM  R     (589.07)   (0.13)          ZHOLENTZ  80 OLYA   E+E-           3/82
DM          589.7      1.2           LEMOIGNE  82 GOLI   190 PI-BE,2MU  9/83*
DM          . . . . . . . . .
DM  AVG     589.01     0.67   AVERAGE
DM  FIT     589.06     0.13  FROM FIT

DM  R   REDUNDANT WITH DATA IN MASS ABOVE

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                    71  PSI(3685) WIDTH (KEV)

W           228.       56.           LUTH      75 SMAG
W  F        202.       57.           BRANDEL1  79 DASP   E+ E-         12/79
W  F    FROM A SIMULTANEOUS FIT TO E+ E-,MU+ MU- AND HADRONIC CHANNELS
W  F    ASSUMING G(E+ E-) = G(MU+ MU-)
W           . . . . . . . . .
W  AVG      215.2      39.9       AVERAGE

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                    71  PSI(3685) PARTIAL DECAY MODES

                                                         DECAY MASSES
P1      PSI(3685) INTO E+ E-                         .511+.511
P2      PSI(3685) INTO MU+ MU-                        106+ 106
P3      PSI(3685) INTO HADRONS
P4      PSI(3685) INTO VIRTUAL GAMMA INTO HADRONS

P       DECAYS INTO J/PSI(3100) + ANYTHING
P       --------------------------------
P11     PSI(3685) INTO J/PSI(3100) + ANYTHING
P12     PSI(3685) INTO J/PSI(3100) + NEUTRALS
P13     PSI(3685) INTO J/PSI(3100) PI+ PI-           3097+ 140+ 140
P14     PSI(3685) INTO J/PSI(3100) PI0 PI0           3097+ 135+ 135
P15     PSI(3685) INTO J/PSI(3100) ETA               3097+ 549
P16     PSI(3685) INTO J/PSI(3100) GAMMA GAMMA       3097+   0+   0
P17     PSI(3685) INTO J/PSI(3100) PI0               3097+ 135
P17                    SMALL -- NOT USED IN FIT

P       HADRONIC DECAYS
P       ---------------
P21     PSI(3685) INTO PI+ PI-                        140+ 140
P22     PSI(3685) INTO RHO PI                         769+ 140
P23     PSI(3685) INTO K+ K-                          494+ 494
P24     PSI(3685) INTO 2(PI+ PI-)                     140+ 140+ 140+ 140
P25     PSI(3685) INTO 2(PI+ PI-) PI0                 140+ 140+ 140+ 140+
P26     PSI(3685) INTO PI+ PI- K+ K-                  140+ 140+ 494+ 494
P27     PSI(3685) INTO PBAR P                         938+ 938
P28     PSI(3685) INTO LAMBDA ANTILAMBDA             1116+1116
P29     PSI(3685) INTO XI ANTIXI                     1321+1321
P31     PSI(3685) INTO PI+ PI- P PBAR                 140+ 140+ 938+ 938
P32     PSI(3685) INTO  3(PI+ PI-)
P33     PSI(3685) INTO RHO0 PI+ PI-                   769+ 140+ 140
P34     PSI(3685) INTO K*(892)0 K+- PI-+              892+ 494+ 140
P35     PSI(3685) INTO PBAR P PI0                     938+ 938+ 135
P36     PSI(3685) INTO PI+ PI- PI0                    140+ 140+ 135
P37     PSI(3685) INTO 3(PI+ PI-) PI0
P38     PSI(3685) INTO K+ K- PI0                      494+ 494+ 135
P39     PSI(3685) INTO K+- K*(892)-+                  494+ 892

P       RADIATIVE DECAYS
P       ----------------
P51     PSI(3685) INTO GAMMA GAMMA                      0+   0
P52     PSI(3685) INTO PI0 GAMMA                      135+   0
P53     PSI(3685) INTO ETA GAMMA                      549+   0
P54     PSI(3685) INTO ETA PRIME GAMMA                958+   0
P56     PSI(3685) INTO CHI(3415) GAMMA               3415+   0
P58     PSI(3685) INTO CHI(3510) GAMMA               3510+   0
P59     PSI(3685) INTO CHI(3555) GAMMA               3556+   0
P60     PSI(3685) INTO CHI(3510) + ANYTHING
P61     PSI(3685) INTO ETA/C(2980) GAMMA             2981+   0
P62     PSI(3685) INTO IOTA(1440) GAMMA              1440+   0
P63     PSI(3685) INTO ETA/C(3590) GAMMA             3594+   0

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FITTED PARTIAL DECAY MODE BRANCHING FRACTIONS

The matrix below is derived from the error matrix for the fitted partial decay mode branching fractions, P_i, as follows: The diagonal elements are $P_i \pm \delta P_i$, where $\delta P_i = \sqrt{\langle \delta P_i \delta P_i \rangle}$, while the off-diagonal elements are the normalized correlation coefficients $\langle \delta P_i \delta P_j \rangle / (\delta P_i \cdot \delta P_j)$. For the definitions of the individual P_i, see the listings above; only those P_i appearing in the matrix are assumed in the fit to be nonzero and are thus constrained to add to 1.

	$J/\psi\,\pi^+\pi^-$	$J/\psi\,\pi^0\pi^0$	$J/\psi\,\eta$	J/ψ+OTHER	NON-J/ψ
$J/\psi\,\pi^+\pi^-$	.3260+-.0238				
$J/\psi\,\pi^0\pi^0$	.4579	.1725+-.0176			
$J/\psi\,\eta$	-.0151	-.0069	.0278+-.0037		
J/ψ+OTHER	.2147	-.4634	-.0840	.0389+-.0248	
NON-J/ψ	-.8960	-.4103	-.0265	-.5165	.4348+-.0415

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                    71  PSI(3685) PARTIAL WIDTHS

W1      PSI(3685) INTO E+ E- (KEV)                         (G1)
W1           2.1       .3            LUTH      75 SMAG        E+E-        1/76
W1 F         2.        0.3           BRANDEL1  79 DASP   E+ E-           12/79
W1 F    FROM A SIMULTANEOUS FIT TO E+ E-,MU+ MU- AND HADRONIC CHANNELS
W1 F    ASSUMING G(E+ E-) = G(MU+ MU-)
W1          . . . . . . . . .
W1  AVG      2.05      0.21     AVERAGE

W3      PSI(3685) INTO HADRONS (KEV)                       (G3)
W3          224.       56.           LUTH      75 SMAG        E+E-        1/76

W51     PSI(3685) INTO GAMMA GAMMA (EV)                    (G51)
W51          43. OR LESS CL=0.90     BRANDEL1  79 DASP   E+ E-           12/79

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                    71  PSI(3685) BRANCHING RATIOS

R1      PSI(3685) INTO (E+ E-)/TOTAL                       (P1)
R1 L        .0088     .0013          FELDMAN   77 RVUE        E+E-       12/77
R1 L    FROM AN OVERALL FIT ASSUMING EQUAL PARTIAL WIDTHS FOR (E+E-)
R1 L    AND (MU+MU-). FOR A MEASUREMENT OF THE RATIO SEE THE ENTRY R4 BELOW
R1 L    INCLUDES LUTH 75,HILGER 75,BURMESTER 77

R2      PSI(3685) INTO (MU+ MU-)/TOTAL                     (P2)
R2 H        .0077     .0017          HILGER    75 SPEC        E+E-        1/76
R2 H    RE-STATED BY US USING (J/PSI(3100)+ANYTHING)/TOTAL =0.55

R3      PSI(3685) INTO (HADRONS)/TOTAL                     (P3)
R3   P      .981      .003           LUTH      75 SMAG        E+E-        1/76
R3   P  INCLUDES CASCADE DECAY INTO J/PSI(3100)                           4/77

R4      PSI(3685) INTO (MU+ MU-)/(E+ E-)                   (P2)/(P1)
R4          .89       .16            BOYARSKI  75 SMAG        E+E-       12/77

R5      PSI(3685) INTO (GAMMA INTO HADRONS)/TOTAL          (P4)
R5 C        .029      .004           LUTH      75 SMAG        E+E-        1/76
R5 C    INCLUDED IN R3


R       DECAYS INTO J/PSI(3100) + ANYTHING
R       --------------------------------

R10     PSI(3685) INTO (J/PSI(3100) + ANYTHING)/TOTAL      (P11)
R10         .57       .08            ABRAMS    75 SMAG        E+E-        1/76
R10        0.51      0.12            BRANDEL1  79 DASP   E+ E-           12/79
R10         . . . . . . . . .
R10 AVG    0.552     0.067   AVERAGE
R10 FIT    0.565     0.041  FROM FIT

R11     PSI(3685) INTO (J/PSI+NEU)/(J/PSI+ANYTHING)        (P12)/(P11)
R11         .41       .02            TANENBAUM 76 SMAG        E+E-        2/76
R11         . . . . . . . . .
R11 FIT    0.409     0.019  FROM FIT

R12     PSI(3685) INTO (J/PSI(3100) PI+ PI-)/TOTAL         (P13)
R12         .32       .04            ABRAMS1   75 SMAG        E+E-        1/76
R12         .36       .06            WIIK      75 DASP        E+E-        1/76
R12         . . . . . . . . .
R12 AVG    0.332     0.033   AVERAGE
R12 FIT    0.326     0.024  FROM FIT
R13     PSI(3685) INTO (J/PSI(3100) PI0 PI0)/TOTAL         (P14)
R13        0.17      0.029           ABRAMS1   75 SMAG        E+E-        1/77
R13         .18       .06            WIIK      75 DASP        E+E-        1/76
R13         . . . . . . . . .
R13 AVG    0.172     0.026   AVERAGE
R13 FIT    0.172     0.018  FROM FIT

R14     PSI(3685) INTO (J/PSI PI0 PI0)/(J/PSI PI+ PI-)     (P14)/(P13)
R14 H      (.64)     (.15)           HILGER    75 SPEC        E+E-        1/76
R14        0.53      0.06            TANENBAUM 76 SMAG        E+E-        1/77
R14 H   IGNORING THE (J/PSI ETA) AND (J/PSI GAMMA GAMMA) DECAYS
R14         . . . . . . . . .
R14 FIT    0.529     0.050  FROM FIT

R15     PSI(3685) INTO (J/PSI(3100) ETA)/TOTAL             (P15)
R15 S   44  (.043)    (.008)         TANENBAUM 76 SMAG        E+E-        1/76
R15    164  0.036     0.005          BARTEL    78 CNTR   E+E-             4/78
R15 S   17  (0.035)   (0.009)        BRANDEL2  79 DASP   E+E-,PSI 2GAM   12/79
R15    166  0.025     0.006          HIMEL     80 SMK2   E+E-             9/81
R15  D 386  0.0218    0.0049         OREGLIA   80 CBAL   E+E-,PSI 2GAM    9/81
R15         . . . . . . . . .
R15 AVG     0.0278    0.0045  AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.5)
R15 FIT     0.0278    0.0037 FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.2)
                      (SEE IDEOGRAM BELOW)
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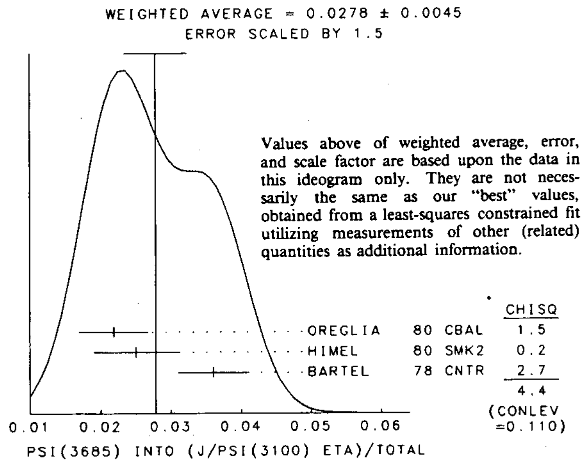
Mesons

Data Card Listings

ψ(3685)

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R16     PSI(3685) INTO (J/PSI(3100) PI0)/TOTAL             (P17)
R16       7    0.0015   0.0006          HIMEL      80 SMK2    E+E-              9/81
R16   D  23    0.0009   0.0003          OREGLIA    80 CBAL    PSI3685,PSI 2GAM  9/81
R16          . . . . . . . . .
R16 AVG        0.00102  0.00027  AVERAGE

R       HADRONIC DECAYS
R       ---------------

R20     PSI(3685) INTO (PI+ PI-)/TOTAL  (UNITS 10**-4)     (P21)
R20            (0.5)  OR LESS  CL=0.90  FELDMAN    77 SMAG         E+E-        12/77
R20             0.8      0.5            BRANDEL1   79 DASP    E+ E-            12/79

R22     PSI(3685) INTO (2(PI+ PI-) PI0)/TOTAL              (P25)
R22             .0035    .0015          ABRAMS     75 SMAG         E+E-         1/76
R22      42    (0.003)  (0.0008)        FRANKLIN   83 SMK2    E+E-,HADRONS      9/83*

R23     PSI(3685) INTO (K+ K-)/TOTAL  (UNITS 10**-4)       (P23)
R23            (0.5)  OR LESS  CL=0.90  FELDMAN    77 SMAG         E+E-        12/77
R23             1.0      0.7            BRANDEL1   79 DASP    E+ E-            12/79

R24     PSI(3685) INTO (PI+ PI- K+ K-)/TOTAL               (P26)
R24K           0.0016   0.0004          TANENBAUM 78 SMAG          E+E-        12/78
R24K     ASSUMING ENTIRELY STRONG DECAY                                         12/78

R25     PSI(3685) INTO (PBAR P)/TOTAL  (UNITS 10**-4)      (P27)
R25             2.3      0.7            FELDMAN    77 SMAG         E+E-        12/77
R25       4     1.4      0.8            BRANDEL1   79 DASP    E+ E-            12/79
R25          . . . . . . . . .
R25 AVG         1.91     0.53     AVERAGE

R26     PSI(3685) INTO (RHO PI)/TOTAL (UNITS 10**-4)       (P22)
R26   N        (10.)    OR LESS  CL=.90   ABRAMS     75 SMAG         E+E-         1/76
R26            (10.)    OR LESS CL=0.90   BARTEL 1   76 CNTR         E+E-         1/77
R26       1    (0.83) OR LESS CL=0.90     FRANKLIN   83 SMK2    E+E-,HADRONS      9/83*
R26   N  FINAL STATE RHO0 PI0

R27     PSI(3685) INTO 2(PI+PI-)/TOTAL                     (P24)
R27            0.00045  0.0001          TANENBAUM 78 SMAG          E+E-        12/78

R28     PSI(3685) INTO (LAMBDA ANTILAMBDA)/TOTAL           (P28)
R28            (0.0004)OR LESS  CL=0.90 FELDMAN    77 SMAG         E+E-        12/77

R29     PSI(3685) INTO (XI- ANTIXI-)/TOTAL                 (P29)
R29            (0.0002)                 FELDMAN    77 SMAG         E+E-        12/77

R31     PSI(3685) INTO (PI+ PI- P PBAR)/TO (UNITS 10**-3)(P31)
R31S            0.8      0.2            TANENBAUM 78 SMAG    E+ E-             12/78
R31S     ASSUMING ENTIRELY STRONG DECAY

R32     PSI(3685) INTO  3(PI+ PI-)/TOTAL (UNITS 10**-3)  (P32)
R32S            0.15     0.1            TANENBAUM 78 SMAG    E+ E-             12/78

R33     PSI(3685) INTO (RHO0 PI+ PI-)/TOT (UNITS 10**-3) (P33)
R33             0.42     0.15           TANENBAUM 78 SMAG    E+ E-             12/78

R34     PSI(3685) INTO(K*(892)0K+-PI-+)/TOT(UNTS 10**-3) (P34)
R34             0.67     0.25           TANENBAUM 78 SMAG    E+ E-             12/78

R35     PSI(3685) INTO (P PBAR PI0)/TOTAL (UNITS 10**-4) (P35)
R35       9   (1.4)     (0.5)           FRANKLIN  83 SMK2    E+E-,HADRONS       9/83*

R36     PSI(3685) INTO (PI+PI-PI0)/TOTAL (UNITS 10**-5)  (P36)
R36       4   (8.5)     (4.6)           FRANKLIN  83 SMK2    E+E-,HADRONS       9/83*

R37     PSI(3685) INTO (3(PI+PI-)PI0)/TOTAL              (P37)
R37       6   (.0035)  (.0016)          FRANKLIN  83 SMK2    E+E-,HADRONS       9/83*

R38     PSI(3685) INTO (K+K-PI0)/TOTAL (UNITS 10**-5)    (P38)
R38       1   (2.96) OR LESS CL=0.90    FRANKLIN  83 SMK2    E+E-,HADRONS       9/83*

R39     PSI(3685) INTO (K+-K*(892)-+)/TOTAL (UNTS 10**-5)(P39)
R39       0   (1.79) OR LESS CL=0.90    FRANKLIN  83 SMK2    E+E-,HADRONS       9/83*

R       RADIATIVE DECAYS
R       ----------------

R42     PSI(3685) INTO (PI0 GAMMA)/TOTAL                 (P52)
R42   U        (.0054)R LESS  CL=.95    LIBERMAN  75 SPEC         E+E-          1/76
R42            (.01) OR LESS  CL=.90    WIIK      75 DASP         E+E-          1/76

R43     PSI(3685) INTO (ETA GAMMA)/TOTAL (UNITS 10**-2)  (P53)
R43            (0.02)OR LESS  CL=0.90   YAMADA    77 DASP    E+ E-,3 GAMMA     12/77

R44     PSI(3685) INTO (ETA PRIME GAM)/TOT (UNTS 10**-2) (P54)
R44C           (0.023)OR LESS  CL=0.90  BARTEL 2  76 CNTR         E+E-         12/77
R44   R        (0.6)  OR LESS  CL=0.90  BRAUNSCHW 77 DASP         E+E-         12/77
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R55     PSI(3685) INTO (CHI(3415) GAM)/TOT (UNITS 10**-2)(P56)
R55   A        7.5       2.6            WHITAKER  76 SMAG        E+E-          1/77
R55   A        7.2       2.3            BIDDICK   77 CNTR    E+E-,MONOCHR.GAM  3/77
R55D  A        9.7       2.2            GAISER    82 CBAL    E+E-,MONOCHR.GAM  3/82
R55          . . . . . . . . .
R55 AVG        8.2       1.4      AVERAGE

R58     PSI(3685) INTO (CHI(3510) GAM)/TOT (UNITS 10**-2)(P58)
R58   B        7.1       1.9            BIDDICK   77 CNTR    E+E-,MONOCHR.GAM  3/77
R58D  G        8.8       1.9            GAISER    82 CBAL    E+E-,MONOCHR.GAM  3/82
R58          . . . . . . . . .
R58 AVG        8.0       1.3      AVERAGE

R59     PSI(3685) INTO (CHI(3555) GAM)/TOT (UNITS 10**-2)(P59)
R59   B        7.0       2.0            BIDDICK   77 CNTR    E+E-,MONOCHR.GAM  3/77
R59D  F        7.7       1.7            GAISER    82 CBAL    E+E-,MONOCHR.GAM  3/82
R59          . . . . . . . . .
R59 AVG        7.4       1.3      AVERAGE

R60     PSI(3685) INTO (ETA/C(2980) GAM)/TOT(UNTS 10**-2)(P61)
R60   D        0.43      0.26           PARTRIDGE 80 CBAL    E+E-,MONOCHR.GAM  9/81

R61     PSI(3685) INTO (IOTA(1440) GAM)/TOT (UNTS 10**-3)(P62)
R61   E       (0.12) OR LESS  CL=.90    SCHARRE   80 SMAG    E+E-              2/81

R62     PSI(3685) INTO (ETA/C(3590) GAM)/TOT(UNTS 10**-2)(P63)
R62           (0.2) TO  1.3   CL=.95    EDWARDS   82 CBAL    E+E-,MONOCHR.GAM  1/82

R     A  ANGULAR DISTRIBUTION (1+COS**2) ASSUMED
R     B  VALID FOR ISOTROPIC DISTRIBUTION OF THE PHOTON
R  C     THE VALUE IS NORMALIZED TO THE BRANCHING RATIO FOR PSI(3685)
R  C     INTO (J/PSI(3100) ETA)/TOTAL.
R     D  SYSTEMATIC ERROR ADDED LINEARLY BY US.
R     E  INCLUDES UNKNOWN BRANCHING FRACTION IOTA(1440) INTO K KBAR PI.
R     F  ANGULAR DISTRIBUTION (1-0.052*COS**2) ASSUMED
R     G  ANGULAR DISTRIBUTION (1-0.189*COS**2) ASSUMED
R     U  RE-STATED BY US USING (MU+MU-)/TOTAL = .0077
R     R  RE-STATED BY US USING TOTAL DECAY WIDTH 228 KEV.
R   S    LOW STATISTICS DATA REMOVED FROM AVERAGE.

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                 71  PSI(3685)     G(I)*G(E+E-)/G(TOTAL)  (KEV)

      THIS COMBINATION OF A PARTIAL WIDTH WITH THE PARTIAL WIDTH
      INTO E+E- AND WITH THE TOTAL WIDTH IS OBTAINED FROM THE INTEGRATED
      CROSS-SECTION INTO CHANNEL(I) IN THE E+E- ANNIHILATION.
      WE ONLY LIST DATA NOT HAVING BEEN USED TO DETERMINE THE PARTIAL
      WIDTH G(I) OR THE BRANCHING RATIO G(I)/TOTAL.

G3      G(HADRONIC)*G(E+E-)/G(TOTAL)
G3             2.2       .4             ABRAMS    75 SMAG        E+E-          1/76

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REFERENCES FOR PSI(3685)


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ABRAMS   74 PRL 33 1453          +BRIGGS,AUGUSTIN,BOYARSKI+       (LBL+SLAC)

ABRAMS   75 STANFORD SYMP.25   G.S.ABRAMS                             (LBL)
ABRAMS1  75 PRL 34 1181          +BRIGGS,CHINOWSKY,FRIEDBERG,+    (LBL+SLAC)
AUBERT   75 PRL 33 1624          +BECKER,BIGGS,BURGER,GLENN+       (MIT+BNL)
BOYARSKI 75 PALERMO CONF. 54     +BREIDENBACH,BULOS,ABRAMS,BRIGGS+(SLAC+LBL)
CAMERINI 75 PRL 35 483           +LEARNED,PREPOST,ASH,ANDERSON,+ (WISC+SLAC)
CRIEGEE  75 PL 53B 489           +DEHNE,FRANKE,HORLITZ,KRECHLOCK+     (DESY)
DASP3    75 PL 57B 407         BRAUNSCHWEIG,KONIGS,+ (AACH+DESY+MPIM+TOKY)
FELDMAN  75 PRL 35 821           +JEAN-MARIE,SADOULET,VANNUCCI,+  (LBL+SLAC)
GRECO    75 PL 56B 367           +PANCHERI-SRIVASTAVA,SRIVASTAVA      (FRAS)
JACKSON  75 NIM 128 13         J.D.JACKSON,D.SCHARRE                  (LBL)
HILGER   75 PRL 35 625           +BERON,FORD,HOFSTADTER,HOWELL,+ (STAN+PENN)
LIBERMAN 75 STANFORD SYMP.55   A.D.LIBERMAN                      (STANFORD)
LUTH     75 PRL 35 1124          +BOYARSKI,LYNCH,BREIDENBACH,+    (SLAC+LBL)JPC
PREPOST  75 STANFORD SYMP.241  R.PREPOST                         (WISCONSIN)
SIMPSON  75 PRL 35 699           +BERON,FORD,HILGER,HOFSTADTER,+ (STAN+PENN)
WIIK     75 STANFORD SYMP.69   B.H.WIIK                               (DESY)
BARTEL 1 76 PL 64 B 483          +DUINKER,OLSSON,STEFFEN,HEINTZE+(DESY+HEID)
BARTEL 2 76 TBILISI CONF.N56     +DUINKER,OLSSON,HEINTZE,+       (DESY+HEID)
SNYDER   76 PRL 36 1415          +HOM,LEDERMAN,APPEL,KAPLAN+(COLU+FNAL+STON)
TANENBAU 76 PRL 36 402         TANENBAUM,ABRAMS,BOYARSKI,BULOS,+(SLAC+LBL)IG
WHITAKER 76 PRL 37 1596          +TANENBAUM,ABRAMS,ALAM,BOYARSKI,+(SLAC+LBL)

BIDDICK  77 PRL 38 1324          +BURNETT+    (UCSD+UMD+PAVI+PRIN+SLAC+STAN)
BRAUNSCH 77 PL 67 B 249        BRAUNSCHWEIG,+   (AACH+DESY+HAMB+MPIM+TOKY)
BURMESTE 77 PL 66 B 395        BURMESTER,CRIEGEE,+   (DESY+HAMB+SIEG+WUPP)
FELDMAN  77 PL 33 C 285          +PERL                            (LBL+SLAC)
YAMADA   77 HAMB. CONF. P. 69  YAMADA                            (DESY+TOKY)

BARTEL   78 PL 79 B 492        DITTMANN,DUINKER,OLSSON,O?NEILL+(DESY+HEID)
TANENBAU 78 PR D 17 1731       TANENBAUM,ALAM,BOYARSKI,+          (SLAC+LBL)

BRANDEL1 79 ZPHY C 1 233       BRANDELIK,CORDS,+(AACH+DESY+HAMB+MPIM+TOKY)
BRANDEL2 79 NP B 160 426       BRANDELIK,CORDS,+(AACH+DESY+HAMB+MPIM+TOKY)
LEMOIGNE 79 FERMILAB CONF.524    +ABOLINS,BARATE,+     (SACL+LOIC+SHMP+IND)

HIMEL    80 PRL 44 920           +ABRAMS,ALAM,BLOCKER,+           (LBL+SLAC)
OREGLIA  80 PRL 45 959           +PARTRIDGE+         (SLAC+CIT+HARV+PRIN+STAN)
PARTRIDG 80 PRL 45 1150        PARTRIDGE,PECK+     (CIT+HARV+PRIN+STAN+SLAC)
SCHARRE  80 PL 97 B 329          +TRILLING,ABRAMS,ALAM,BLOCKER+   (SLAC+LBL)
ZHOLENTZ 80 PL 96 B 214          +KURDADZE,LELCHUK,MISHNEV,NIKITIN+   (NOVO)
    ALSO 81 YAD.PHYS. 34 1471  ZHOLENTZ ET AL.                        (NOVO)

BARATE   81 PR D 24 2994         +ASTBURY,MCEWEN,+ (SACL+LOIC+SHMP+CERN+IND)

EDWARDS  82 PRL 48 70            +PARTRIDGE,PECK,+ (CIT+HARV+PRIN+STAN+SLAC)
GAISER   82 MORIOND CONF.        +EDWARDS,+        (CIT+HARV+PRIN+STAN+SLAC)
LEMOIGNE 82 PL 113 B 509         +BARATE,ASTBURY,MCEWEN+(SACL+LOIC+SHMP+IND)

BARATE   83 PL 121 B 449         +BAREYRE,ASTBURY,MCEWEN(SACL+LOIC+SHMP+IND)
FRANKLIN 83  SLAC-PUB-3092       +FRANKLIN,FELDMAN,ABRAMS,ALAM+   (LBL+SLAC)
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For notation, see key at front of Listings.

Mesons

$\psi(3770)$, $\psi(4030)$, $\psi(4160)$, $\psi(4415)$

$\psi(3770)$

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53  PSI(3770,JPG=1- ) I=

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                    53  PSI(3770) MASS (MEV)

M  E       3772.0     (6.0)          RAPIDIS   77 SMAG  0 E+E-          12/77
M  E       3770.      (6.0)          BACINO    78 DLCO  0 E+E-           4/78
M  E       3764.0     (5.0)          SCHINDLER 80 SMAG    E+ E-         12/79
M  E    ERRORS INCLUDE SYSTEMATIC COMMON TO ALL EXPERIMENTS
M          . . . . . . . . . .
M   MASS   3769.9      2.5      FROM PSI(3685) MASS AND MASS DIFFERENCE
M                               BELOW

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                    53  PSI(3770) - PSI(3685) MASS DIFFERENCE (MEV)
DM           88.0      3.0          RAPIDIS   77 SMAG    E+E-          12/77
DM S         86.0      2.0          BACINO    78 DLCO    E+E-           2/82
DM S    SPEAR PSI PRIME MASS (3684) SUBTRACTED (SEE SCHINDLER 80)
DM           80.0      2.0          SCHINDLER 80 SMAG    E+ E-         12/79
DM         . . . . . . . . . .
DM  AVG      83.9      2.4      AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.8)

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                    53  PSI(3770) WIDTH (MEV)
W            28.0      5.0          RAPIDIS   77 SMAG  0 E+E-          12/77
W            24.0      5.0          BACINO    78 DLCO  0 E+E-           4/78
W            24.0      5.0          SCHINDLER 80 SMAG    E+ E-         12/79
W          . . . . . . . . . .
W   AVG      25.3      2.9      AVERAGE

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                    53  PSI(3770) PARTIAL DECAY MODES

                                                        DECAY MASSES
P1     PSI(3770) INTO E+ E-                            .511+.511
P2     PSI(3770) INTO D DBAR                          1869+1869

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                    53  PSI(3770) PARTIAL WIDTHS (KEV)

W1     PSI(3770) INTO E+E-                            (61)
W1 R         0.37      0.09          RAPIDIS   77 SMAG  0 E+E-          12/77
W1           0.18      0.06          BACINO    78 DLCO  0 E+E-           4/78
W1           0.276     0.050         SCHINDLER 80 SMAG    E+ E-          1/82
W1 R    SEE ALSO R2 BELOW
W1         . . . . . . . . . .
W1  AVG      0.257     0.046    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.3)

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                    53  PSI(3770) BRANCHING RATIOS

R1     PSI(3770) INTO (D DBAR)/TOTAL                  (P2)
R1        DOMINANT                   PERUZZI   77 SMAG    E+E-,D DBAR   12/77

R2     PSI(3770) INTO (E+ E-)/TOTAL (UNITS 10**-5)    (P1)
R2           1.3       0.2          RAPIDIS   77 SMAG  0 E+E-          12/77

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                        REFERENCES FOR PSI(3770)

PERUZZI  77 PRL 39 1301       +PICCOLO,FELDMAN,PERL,+(SLAC,LBL,NWES+HAWA)
RAPIDIS  77 PRL 39 526        +GOBBI,LUKE,PERL,+(STAN+SLAC+LBL+NWES+HAWA)

BACINO   78 PRL 40 671        +BAUMGARTEN,BIRKWOOD,+ (SLAC+STAN+UCLA+UCI)

SCHINDLE 80 PR D 21 2716      SCHINDLER,SIEGRIST,ALAM,BOYARSKI+(SLAC+LBL)

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$\psi(4030)$

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72  PSI(4030,JPG=1- ) I=

SEEN CLEARLY SEPARATED FROM THE PSI(4160)
BY DASP AND CONFIRMED WITH LESS STATISTICS BY PLUTO
SEEN ALSO BY MARK I, DELCO AND THE CRYSTAL BALL
(KIRKBY 79).

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                    72  PSI(4030) MASS (MEV)

M          4028.0      2.5          GOLDHABER 77 SMAG        E+E-      12/77
M          4040.0     10.0          BRANDELIK 78 DASP    E+E-           4/78
M          . . . . . . . . . .
M   AVG    4028.7      2.8      AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.2)

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                    72  PSI(4030) WIDTH (MEV)

W            52.0     10.0          BRANDELIK 78 DASP    E+E-           4/78

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                    72  PSI(4030) PARTIAL DECAY MODES

                                                        DECAY MASSES
P1     PSI(4030) INTO D DBAR                          1869+1869
P2     PSI(4030) INTO D* DBAR AND D*BAR D             2007+1865
P3     PSI(4030) INTO D* D*BAR                        2007+2007
P4     PSI(4030) INTO J/PSI(3100) HADRONS
P5     PSI(4030) INTO E+ E-                            .511+.511
P6     PSI(4030) INTO MU+ MU-                          106+ 106

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                    72  PSI(4030) PARTIAL WIDTHS (KEV)

W5     PSI(4030) INTO E+E-                            (G5)
W5           0.75      0.15          BRANDELIK 78 DASP    E+ E-         12/78

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                    72  PSI(4030) BRANCHING RATIOS

R1     PSI(4030) INTO (D0 D0BAR)/(D0* D0BAR+D0*BAR D0)  (P1)/(P2)
R1  P        0.05      0.03          GOLDHABER 77 SMAG  0 E+ E-        12/77

R2     PSI(4030) INTO (D0* D0*BAR)/(D0* D0BAR+D0*BAR D0)(P3)/(P2)
R2  P       32.0      12.0          GOLDHABER 77 SMAG  0 E+ E-        12/77

R   P  PHASE-SPACE FACTOR (P**3) EXPLICITLY REMOVED.

R3     PSI(4030) INTO J/PSI(3100) HADRONS              (P4)
R3        LOOKED FOR                 BURMESTER 77 PLUT        E+E-       4/77

R4     PSI(4030) INTO (E+ E-)/TOTAL  (UNITS 10**-5)     (P5)
R4          (1.0) APPROX.            FELDMAN   77 SMAG    E+ E-       12/77
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                        REFERENCES FOR PSI(4030)

AUGUSTIN 75 PRL 34 764        +BOYARSKI,ABRAMS,BRIGGS+          (SLAC+LBL)
BACCI    75 PL 58B 481        +BIDOLI,PENSO,STELLA,+           (ROMA+FRAS)
BOYARSKI 75 PRL 34 762        +BREIDENBACH,ABRAMS,BRIGGS,+      (SLAC+LBL)
ESPOSITO 75 PL 58B 478        +FELICETTI,PERUZZI,+  (FRAS+NAPL+PADO+ROMA)

PERUZZI  76 PRL 37 569        +PICCOLO,FELDMAN,NGUYEN,WISS,+    (SLAC+LBL)

BURMESTE 77 PL 66 B 395       +CRIEGEE,DEHNE+        (DESY+HAMB+SIEG+WUPP)
GOLDHABE 77 PL 69 B 503       GOLDHABER,WISS,ABRAMS,ALAM,LUTH,+(LBL+SLAC)
FELDMAN  77 PL 33 C 285       +PERL                             (LBL+SLAC)
LUTH     77 PL 70 B 120       +PIERRE,ABRAMS,ALAM,BOYARSKI,+    (LBL+SLAC)

BRANDELI 78 PL 76 B 361       BRANDELIK,CORDS+ (AACH+DESY+HAMB+MPIM+TOKY)
    ALSO 79 ZPHY C 1 233      BRANDELIK,CORDS,+(AACH+DESY+HAMB+MPIM+TOKY)

KIRKBY   79 FERMILAB SYMP.107 J. KIRKBY RAPPORTEUR                (SLAC)

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$\psi(4160)$

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25  PSI(4160,JPG=1- ) I=

SEEN CLEARLY SEPARATED FROM THE PSI(4030)
BY DASP AND CONFIRMED WITH LESS STATISTICS BY PLUTO .
MARK I,DELCO AND THE CRYSTAL BALL SEE A PROMINENT
SHOULDER BUT NO SEPARATION (KIRKBY 79)

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                    25  PSI(4160) MASS (MEV)

M          4159.0     20.0          BRANDELIK 78 DASP    E+E-           4/78

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                    25  PSI(4160) WIDTH (MEV)

W            78.0     20.0          BRANDELIK 78 DASP    E+E-           4/78

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                    25  PSI(4160) PARTIAL DECAY MODES

                                                        DECAY MASSES
P1     PSI(4160) INTO E+ E-                            .511+.511

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                    25  PSI(4160) PARTIAL WIDTHS (KEV)

W1     PSI(4160) INTO E+ E-                           (G1)
W1           0.77      0.23          BRANDELIK 78 DASP    E+ E-         12/78

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                        REFERENCES FOR PSI(4160)

BURMESTE 77 PL 66 B 395       +CRIEGEE,DEHNE+        (DESY+HAMB+SIEG+WUPP)

BRANDELI 78 PL 76 B 361       BRANDELIK,CORDS+ (AACH+DESY+HAMB+MPIM+TOKY)

KIRKBY   79 FERMILAB SYMP.107 J. KIRKBY RAPPORTEUR                (SLAC)

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$\psi(4415)$

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73  PSI(4415,JPG=1- ) I=

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                    73  PSI(4415) MASS (MEV)

M           4414.      7.           SIEGRIST  76 SMAG        E+E-       2/76
M          (4400.)  APPROX.          KNIES     77 PLUT  0 E+E-,MU+ MU-  12/77
M           4417.0    10.0           BRANDELIK 78 DASP    E+E-           4/78
M          . . . . . . . . . .
M   AVG    4415.0     5.7      AVERAGE

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                    73  PSI(4415) WIDTH (MEV)

W            33.      10.           SIEGRIST  76 SMAG        E+E-       2/76
W            66.0     15.0          BRANDELIK 78 DASP    E+E-           4/78
W          . . . . . . . . . .
W   AVG      43.2     15.2     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.8)

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                    73  PSI(4415) PARTIAL DECAY MODES

                                                        DECAY MASSES
P1     PSI(4415) INTO E+ E-                            .511+.511

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                    73  PSI(4415) PARTIAL WIDTHS (KEV)

W1     PSI(4415) INTO E+ E-                           (G1)
W1           0.49      0.13          BRANDELIK 78 DASP    E+ E-         12/78

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Mesons

Data Card Listings

$\psi(4415)$, $\Upsilon(9460)$ $[\Upsilon(1S)]$, $\chi_b(9875)$ $[\chi_b(1^3P_0)]$, $\chi_b(9895)$ $[\chi_b(1^3P_1)]$

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                    73  PSI(4415) BRANCHING RATIOS

R1      PSI(4415) INTO (E+ E-)/TOTAL (UNITS 10**-5)
R1            1.3       .3            SIEGRIST  76 SMAG          E+E-          2/76

R2      PSI(4415) INTO HADRONS/TOTAL
R2         DOMINANT                   SIEGRIST  76 SMAG          E+E-          1/77

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                              REFERENCES FOR PSI(4415)

SIEGRIST 76 PRL 36 700          +ABRAMS,BOYARSKI,BREIDENBACH,+   (LBL+SLAC)

BURMESTE 77 PL 66 B 395         +CRIEGEE,DEHNE+        (DESY+HAMB+SIEG+WUPP)
KNIES    77 HAMBURG SYMP.93     G.KNIES HAMBURG TALK ON PLUTO COLLAB.(DESY)
LUTH     77 PL 70 B 120         +PIERRE,ABRAMS,ALAM,BOYARSKI,+   (LBL+SLAC)

BRANDELI 78 PL 76 B 361         BRANDELIK,CORDS+ (AACH+DESY+HAMB+MPIM+TOKY)

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$\Upsilon(9460)$ or $\Upsilon(1S)$

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49  UPSILON(9460,JPG=1- ) I=

REFLECTING COLLOQUIAL USAGE, WE GIVE ALSO THE SPECTRO-
SCOPIC NAMES OF THE UPSILON SYSTEM RESONANCES. AS IS
MOST COMMON IN THE LITERATURE, WE GIVE THE RADIAL
QUANTUM NUMBER RATHER THAN THE PRINCIPAL QUANTUM
NUMBER (I.E. THE RADIAL QUANTUM NUMBER PLUS THE
ORBITAL ANGULAR MOMENTUM). THUS, THE LOWEST CHI/B STATES ARE 1 3PJ
RATHER THAN 2 3PJ. NOTE THAT THE SPECTROSCOPIC ASSIGNMENT OF SOME
OF THE PARTICLES IS ONLY TENTATIVE AT THIS TIME.

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                    49  UPSILON(9460) MASS  (MEV)

M       FIXED TARGET EXPERIMENTS
M   I     (9410.)    (13.)            INNES     77 SPEC  0 400 P+A,MU+MU-   12/77

M       E+E- EXPERIMENTS
M         (9460.)    (10.)            BIENLEIN  78 CNTR    E+E-               4/78
M   D     (9456.3)   (11.0)           BERGER    79 PLUT    E+E-              12/79
M         (9457.)    (10.)            DARDEN    79 DASP    E+E-              12/79
M   D     (9433.)    (30.)            ANDREWS   80 CLEO    E+E-,HADRONS       9/81
M   D     (9434.5)   (30.0)           BOHRINGER 80 CUSB    E+E-,HADRONS       9/81
M   D     (9461.6)   (10.6)           NICZYPORU 81 LENA    E+E-,HADRONS       9/81
M   D     (9462.0)   (10.6)           ALBRECHT  82 DASP    E+E-,MU+MU-       8/83*
M          9460.6     0.4             ARTAMONOV 83 REDE    E+E-,HADRONS      8/83*
M          9459.9     0.2             GITTELMAN 83 REDE    E+E-,HADRONS      2/84*
M          . . . . . . . . .
M   AVG    9460.04    0.28    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.6)

M   D    SYSTEMATIC ERROR ADDED LINEARLY BY US.
M   I    FROM 2-PEAK FIT

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                    49  UPSILON(9460) WIDTH (KEV)

W    B       45.       38.       14.    BERGER    80 PLUT    E+E-              9/81
W    B       38.       27.       11.    ALBRECHT  82 DASP    E+E-,MU+MU-      8/83*
W   D B      30.       23.       14.    NICZYPORU 82 LENA    E+E-,MU+MU-,HADR 8/83*
W   D B      48.        8.            ANDREWS   83 CLEO    E+E-,MU+MU-      9/83*
W          . . . . . . . . .
W   AVG      44.3      6.6     AVERAGE

W    B   FROM R1,R2,W2 BELOW AND ASSUMING E-MU-TAU UNIVERSALITY
W   D    SYSTEMATIC ERRORS ADDED LINEARLY BY US.

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                    49  UPSILON(9460) PARTIAL DECAY MODES

                                                          DECAY MASSES
P1      UPSILON(9460)  INTO MU+ MU-                      106+ 106
P2      UPSILON(9460)  INTO  E+  E-                      .511+.511
P3      UPSILON(9460) INTO TAU+ TAU-                    1784+1784

P       HADRONIC DECAYS
P       ---------------
P11     UPSILON(9460)  INTO RHO PI                       769+ 140
P12     UPSILON(9460)  INTO J/PSI(3100) ANYTHING

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                    49  UPSILON(9460) PARTIAL WIDTHS (KEV)

W2      UPSILON(9460)  INTO  E+  E-                    (G2)
W2  E        (1.33)    (0.14)          BERGER    79 PLUT    E+E-             12/79
W2            1.08      0.25           BOCK      80 CNTR    E+E-,HADRONS      9/81
W2 D          1.07      0.23           MAGERAS   81 CUSB    E+E-,E+E-PI+PI-   9/81
W2 D         (1.23)    (0.20)          ALBRECHT  82 DASP    E+E-,MU+MU-      8/83*
W2 D A        1.13      0.17           NICZYPORU 82 LENA    E+E-,MU+MU-,HADR 8/83*
W2         . . . . . . . . .
W2  AVG       1.10      0.12    AVERAGE

W2   A  ASSUMING E-MU-TAU UNIVERSALITY
W2 D    SYSTEMATIC ERRORS ADDED LINEARLY BY US.
W2  E   ASSUMING HADRONIC PARTIAL WIDTH EQUAL TO TOTAL WIDTH

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                    49  UPSILON(9460) BRANCHING RATIOS

R1      UPSILON(9460)  INTO(MU+ MU-)/TOTAL              (P1)
R1            0.022     0.020          BERGER    79 PLUT    E+E-             12/79
R1   A        0.025     0.021          DARDEN    79 DASP    E+E-             12/79
R1            0.014     0.034    0.014 BOCK      80 CNTR    E+E-,MU+MU-       9/81
R1      17    0.039     0.011          MUELLER   81 CLEO    E+E-,PI+PI-E+E-   9/81
R1   A       (0.032)   (0.016)         ALBRECHT  82 DASP    E+E-,MU+MU-      8/83*
R1 D A        0.038     0.017          NICZYPORU 82 LENA    E+E-,MU+MU-,HADR 8/83*
R1 D  1652    0.027     0.006          ANDREWS   83 CLEO    E+E-,MU+MU-      8/83*
R1         . . . . . . . . .
R1  AVG       0.0291    0.0047  AVERAGE

R1   A  ASSUMING E-MU-TAU UNIVERSALITY

R2      UPSILON(9460)  INTO (E+  E-)/TOTAL              (P2)
R2            0.051     0.030          BERGER    80 PLUT    E+E-              9/81

R3      UPSILON(9460) INTO (TAU+ TAU-)/TOTAL            (P3)
R3 D          0.034     0.008          GILES     83 CLEO    E+E-,TAU+TAU-     9/83*

R11     UPSILON(9460)  INTO (RHO PI)/TOTAL              (P11)
R11          (.021)OR LESS             NICZYPORU 83 LENA    E+E-,HADRONS      9/83*

R12     UPSILON(9460)  INTO (J/PSI(3100) ANYTHING)/TOTAL (P12)
R12          (.02) OR LESS             NICZYPORU 83 LENA    E+E-,HADRONS      9/83*

R  D    SYSTEMATIC ERRORS ADDED LINEARLY BY US.

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                              REFERENCES FOR UPSILON(9460)

COBB     77 PL 72 B 273         +IWATA,FABJAN,GOLDBERG+(BNL+CERN+SYRA+YALE)
HERB     77 PRL 39 252          +HOM,LEDERMAN,APPEL,ITO,+  (COLU+FNAL+STON)
INNES    77 PRL 39 1240         +APPEL,BROWN,HERB,HOM,FISK+(COLU+FNAL+STON)

BERGER   78 PL 76 B 243         +ALEXANDER,DAUM,+(AACH+DESY+HAMB+SIEG+WUPG)
BIENLEIN 78 PL 78 B 360         +GLAWE,BOCK,BLANAR,+  (DESY+HAMB+HEID+MPIM)
DARDEN   78 PL 76 B 246         +HOFMANN,ALBRECHT,+   (DESY+DORT+HEID+LUND)
GARELICK 78 PR D 18 945         +GAUTHIER,HICKS,OLIVER,+   (NEAS+WASH+TUFT)
KAPLAN   78 PRL 40 435          +APPEL,HERB,HOM,LEDERMAN,+ (STON+FNAL+COLU)
YOH      78 PRL 41 684          +HERB,HOM,LEDERMAN,UENO,+  (COLU+FNAL+STON)

ANGELIS  79 PL 87 B 398         +BESCH,BLUMENFELD,+    (CERN+COLU+OXF+ROCK)
BADIER   79 PL 86 B 98          +BOUCROT,BURGUN+ (SACL+CERN+CDEF+EPOL+LALO)
BERGER   79 ZPHY C 1 343        +ALEXANDER+      (AACH+DESY+HAMB+SIEG+WUPG)
DARDEN   79 PL 80 B 419         +HOFMANN,ALBRECHT,+   (DESY+DORT+HEID+LUND)

ALBRECHT 80 PL 93 B 500         +CHILDERS,DARDEN+(DESY+DORT+HEID+LUND+ITEP)
ANDREWS  80 PRL 44 1108         + (CORN+HARV+ITHA+LEMO+ROCH+RUTG+SYRA+VAND)
BERGER   80 PL 93 B 497         +LACKAS,RAUPACH,+(AACH+DESY+HAMB+SIEG+WUPP)
BOCK     80 ZPHY C 6 125        +BLANAR,BLUM,BIENLEIN+(HEID+MPIM+DESY+HAMB)
BOHRINGE 80 PRL 44 1111         BOHRINGER,COSTANTINI,FINOCCHIARO(COLU+STON)
KOURKOUM 80 PL 91 B 481         KOURKOUMELIS+(ATHU+NTUA+BNL+CERN+SYRA+YALE)

MAGERAS  81 PRL 46 1115         +BOHRINGER,FINOCCHIARO+(COLU+STON+LSU+MPIM)
MUELLER  81 PRL 46 1181         + (RUTG+SYRA+LEMO+VAND+CORN+ITHA+HARV+ROCH)
NICZYPOR 81 PRL 46 92           NICZYPORUK,CHEN,VOGEL,WEGENER+(LENA COLLAB)

ALBRECHT 82 PL 116 B 383        +HOFMANN,SHUBERT+(DESY+DORT+HEID+LUND+ITEP)
ARTAMONO 82 PL 118 B 225        +BARU,BLINOV,BONDAR,BUKIN,GROSHEV+   (NOVO)
NICZYPOR 82 ZPHY 15 C 299       NICZYPORUK,FOLGER,BIENLEIN+   (LENA COLLAB)

ALBRECHT 83  DESY 83-101        +DREWS,HASEMANN+      (ARGUS COLLABORATION)
ANDREWS  83 PRL 50 807          +  (CORN+ITHA+HARV+OSU+ROCH+RUTG+SYRA+VAND)
ARTAMONO 83  PREPR.83-84        +BARU,BLINOV,BONDAR,BUKIN,GROSHEV+   (NOVO)
GILES    83 PRL 50 877          +  (HARV+OSU+ROCH+RUTG+SYRA+VAND+CORN+ITHA)
GITTELMA 83 CORNELL CONF.       B. GITTELMA                          (CORN)
NICZYPOR 83 ZPHY 17 C 197       + (CRAC+ERLA+DESY+NIJM+PITT+SACL+TELA+WURZ)

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$\chi_b(9875)$ or $\chi_b(1^3P_0)$

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76  CHI/B(9875,JPG=   ) J=0 PREFERRED

OBSERVED IN RADIATIVE DECAY OF THE UPSILON(10025).
INTO CHI/B GAMMA, THEREFORE C=+.

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                    76  CHI/B(9875) MASS (MEV)

M    U     9872.9      5.8            KLOPFENST 83 CUSB    E+E-,GAMMAS HADR  9/83*

M    U  FROM GAMMA ENERGY BELOW, ASSUMING UPSILON(10025) MASS = 10023.4 MEV

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                    76  GAMMA ENERGY IN UPSILON(10025) DECAY (MEV)

DM   S      149.4      5.7            KLOPFENST 83 CUSB    E+E-,GAMMAS HADR  9/83*

DM   S  SYSTEMATIC ERROR ADDED LINEARLY BY US.

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                    76  CHI/B(9875) PARTIAL DECAY MODES

                                                          DECAY MASSES
P1      CHI/B(9875) INTO UPSILON(9460) GAMMA             9460+   0

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                    76  CHI/B(9875) BRANCHING RATIOS

R1      CHI/B(9875) INTO (UPSILON(9460) GAMMA)/TOTAL     (P1)
R1  T        (0.11) OR LESS  CL=.90   PAUSS      83 CUSB    E+E-,GAMMAS LEPT 12/83*
R1  T   CALCULATED USING UPSILON(10025)INTO CHI/B(9895)GAM/TOT = 0.035

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                              REFERENCES FOR CHI/B(9875)

KLOPFENS 83 PRL 51 160          KLOPFENSTEIN,HAN+ (STON+COLU+CORN+LSU+MPIM)
PAUSS    83 PL 130 B 439        +DIETL,EIGEN+     (MPIM+COLU+CORN+LSU+STON)

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$\chi_b(9895)$ or $\chi_b(1^3P_1)$

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77  CHI/B(9895,JPG=   ) J=1 PREFERRED

OBSERVED IN RADIATIVE DECAY OF THE UPSILON(10025).
INTO CHI/B GAMMA, THEREFORE C=+.

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                    77  CHI/B(9895) MASS (MEV)

M    U     9894.5      3.5                                                   9/83*

M    U  FROM GAMMA ENERGY BELOW ASSUMING UPSILON(10025) MASS = 10023.4 MEV

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For notation, see key at front of Listings. **Mesons**

$\chi_b(9895)$ $[\chi_b(1^3P_1)]$, $\chi_b(9915)$ $[\chi_b(1^3P_2)]$, $\Upsilon(10025)$ $[\Upsilon(2S)]$

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                    77  GAMMA ENERGY IN UPSILON(10025) DECAY (MEV)

DM   S      128.1      0.4            KLOPFENST 83 CUSB    E+E-,GAMMAS HADR  9/83*
DM   G     (127.5)    (5.2)           GAISER    83 CBAL    E+E-,HADRONS GAM 12/83*
DM   S      128.0      1.5            PAUSS     83 CUSB    E+E-,GAMMAS LEPT 12/83*
DM          . . . . . . . . .

DM   AVG    128.1      3.4     AVERAGE
DM     A SYSTEMATIC ERROR OF 3 MEV FROM THE CUSB RESULTS HAS BEEN ADDED
DM     LINEARLY BY US TO THE STATISTICAL ERROR ON THE AVERAGE.

DM   G  SYSTEMATIC ERROR ADDED LINEARLY BY US.
DM   S  STATISTICAL ERROR ONLY.

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                    77  CHI/B(9895) PARTIAL DECAY MODES

                                                          DECAY MASSES
P1      CHI/B(9895) INTO UPSILON(9460) GAMMA            9460+   0

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                    77  CHI/B(9895) BRANCHING RATIOS

R1      CHI/B(9895) INTO (UPSILON(9460) GAMMA)/TOTAL      (P1)
R1           0.47      0.18           KLOPFENST 83 CUSB    E+E-,GAMMAS HADR  9/83*
R1   T       0.41      0.14           PAUSS     83 CUSB    E+E-,GAMMAS LEPT 12/83*
R1          . . . . . . . . .
R1  AVG      0.43      0.11    AVERAGE

R1   T   CALCULATED USING UPSILON(10025)TO CHI/B(9915) GAM/TOT=0.059+-0.014

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                    REFERENCES FOR CHI/B(9895)

GAISER   83  SLAC-PUB-3232     J.E.GAISER+CRYSTAL BALL COLLABORATION(SLAC)
KLOPFENS 83 PRL 51 160         KLOPFENSTEIN,HAN+ (STON+COLU+CORN+LSU+MPIM)
PAUSS    83 PL 130 B 439       +DIETL,EIGEN+     (MPIM+COLU+CORN+LSU+STON)

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$\chi_b(9915)$ or $\chi_b(1^3P_2)$

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78  CHI/B(9915,JPG=   ) J=2 PREFERRED

OBSERVED IN RADIATIVE DECAY OF THE UPSILON(10025).
INTO CHI/B GAMMA, THEREFORE C=+.

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                    78  CHI/B(9915) MASS (MEV)

M    U     9914.6      2.4                                                 9/83*

M    U  FROM GAMMA ENERGY BELOW ASSUMING UPSILON(10025) MASS = 10023.4 MEV

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                    78  GAMMA ENERGY IN UPSILON(10025) DECAY (MEV)

DM   S      108.2      0.3            KLOPFENST 83 CUSB    E+E-,GAMMAS HADR  9/83*
DM   G     (108.3)    (3.9)           GAISER    83 CBAL    E+E-,HADRONS GAM 12/83*
DM   S      107.0      2.0      2.5   PAUSS     83 CUSB    E+E-,GAMMAS LEPT 12/83*
DM          . . . . . . . . .

DM   AVG    108.2      2.3     AVERAGE
DM     A SYSTEMATIC ERROR OF 2 MEV FROM THE CUSB RESULTS HAS BEEN ADDED
DM     LINEARLY BY US TO THE STATISTICAL ERROR ON THE AVERAGE.

DM   G  SYSTEMATIC ERROR ADDED LINEARLY BY US.
DM   S  STATISTICAL ERROR ONLY.

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                    78  CHI/B(9915) PARTIAL DECAY MODES

                                                          DECAY MASSES
P1      CHI/B(9915) INTO UPSILON(9460) GAMMA            9460+   0

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                    78  CHI/B(9915) BRANCHING RATIOS

R1      CHI/B(9915) INTO (UPSILON(9460) GAMMA)/TOTAL      (P1)
R1           0.20      0.05           KLOPFENST 83 CUSB    E+E-,GAMMAS HADR  9/83*
R1   T       0.20      0.09           PAUSS     83 CUSB    E+E-,GAMMAS LEPT 12/83*
R1          . . . . . . . . .
R1  AVG      0.200     0.044   AVERAGE

R1   T   CALCULATED USING UPSILON(10025)TO CHI/B(9915) GAM/TOT=0.061+-0.014

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                    REFERENCES FOR CHI/B(9915)

GAISER   83  SLAC-PUB-3232     J.E.GAISER+CRYSTAL BALL COLLABORATION(SLAC)
KLOPFENS 83 PRL 51 160         KLOPFENSTEIN,HAN+ (STON+COLU+CORN+LSU+MPIM)
PAUSS    83 PL 130 B 439       +DIETL,EIGEN+     (MPIM+COLU+CORN+LSU+STON)

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$\Upsilon(10025)$ or $\Upsilon(2S)$

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52  UPSILON(10025,JPG=1- ) I=

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                    52  UPSILON(10025) MASS  (GEV)

M  I        (10.060)  (0.030)        INNES     77 SPEC    400 P+A,MU+MU-   12/77
M   R       (10.020)  (0.020)        BIENLEIN  78 CNTR    E+E-              4/78
M   R       (10.012)  (0.020)        DARDEN    78 DASP    E+E-              4/78
M  DR       (10.0136) (0.0112)       NICZYPO1  81 LENA    E+E-,HADRONS      9/81
M            10.0231   0.0004        BARBER    83 REDE    E+E-              9/83*
M            10.0238   0.0005        ARTAMONOV 83 REDE    E+E-,HADRONS     12/83*
M           . . . . . . . . .
M   AVG     10.02337  0.00034  AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.1)

M  D    SYSTEMATIC ERRORS ADDEED LINEARLY BY US
M  I    FROM 2-PEAK FIT
M  R    REDUNDANT WITH DATA IN MASS DIFFERENCE BELOW

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                    52  UPSILON(10025) WIDTH (KEV)

W  B         31.       9.       7.    MAGERAS   81 CUSB    E+E-,HADRONS      8/83*
W   M        31.      10.       7.    NICZYPO2  81 LENA    E+E-,L+L-PI+PI-   9/81
W  B D       27.       8.             ANDREWS   83 CLEO    E+E-,MU+MU-       9/83*
W           . . . . . . . . .
W   AVG      29.6      4.7     AVERAGE

W  B    FROM W2 AND R1 BELOW AND ASSUMING E-MU-TAU UNIVERSALITY
W    D  SYSTEMATIC ERRORS ADDED LINEARLY BY US
W    M  FROM W1 AND R1 ABOVE AND ASSUMING A LOG QUARKONIUM POTENTIAL

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                    52  UPSILON(10025)-UPSILON(9460) MASS DIFFERENCE (MEV)

DM   E      563.3      0.4                                                 2/84*
DM   E  EVALUATED BY US USING DIRECT MEASUREMENTS OF THE UPSILON(9460) AND
DM   E  UPSILON(10025) MASSES ABOVE.

DM          560.0     10.0            BIENLEIN  78 CNTR    E+E-              4/78
DM          555.0     11.0            DARDEN    78 DASP    E+E-              4/78
DM  A       574.0     27.0            UENO      79 SPEC    400 P PT,MU+MU-  12/79
DM   D      560.7      3.8            ANDREWS   80 CLEO    E+E-,HADRONS      9/81
DM   D      559.       4.             BOHRINGER 80 CUSB    E+E-,HADRONS      9/81
DM   D      552.      11.             NICZYPO1  81 LENA    E+E-,HADRONS      9/81
DM          556.      10.             ALBRECHT  82 DASP    E+E-,MU+MU-       8/83*
DM         (562.0)    (3.0)           ALBRECHT  83 ARG     E+E-,HADRONS     12/83*
DM   B     (562.5)    (0.6)           BARBER    83 REDE    E+E-              9/83*
DM          . . . . . . . . .
DM  AVG     559.2      2.4     AVERAGE

DM  A    FIXING THE UPSILON(9460) MASS AT 9460 MEV
DM   B   USING THE UPSILON(9460) MASS OF ARTAMONOV 82.
DM    D  SYSTEMATIC ERROR ADDED LINEARLY BY US.

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                    52  UPSILON(10025) PARTIAL DECAY MODES

                                                          DECAY MASSES
P1      UPSILON(10025) INTO MU+ MU-                      106+ 106
P2      UPSILON(10025) INTO  E+  E-                     .511+.511
P3      UPSILON(10025) INTO UPSILON(9460) PI PI         9460+ 140+ 140
P4      UPSILON(10025) INTO CHI/B(9915) GAMMA           9915+   0
P5      UPSILON(10025) INTO CHI/B(9895) GAMMA           9895+   0
P6      UPSILON(10025) INTO CHI/B(9875) GAMMA           9873+   0

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                    52  UPSILON(10025) PARTIAL WIDTHS (KEV)

W2      UPSILON(10025) INTO  E+  E-                     (G2)
W2  E        (0.35)    (0.14)         DARDEN    78 DASP    E+E-              4/78
W2 D S        0.49      0.11          ANDREWS   80 CLEO    E+E-,HADRONS      9/81
W2  E        (0.37)    (0.16)         BOCK      80 CNTR    E+E-,HADRONS      9/81
W2 D S        0.43      0.13          BOHRINGER 80 CUSB    E+E-,HADRONS      9/81
W2   S        0.56      0.08          MAGERAS   81 CUSB    E+E-,E+E-PI+PI-   9/81
W2 D S        0.48      0.13     0.09 NICZYPO1  81 LENA    E+E-,MU+MU-,HADR  9/81
W2          . . . . . . . . .
W2  AVG       0.507     0.051   AVERAGE

W2 D    SYSTEMATIC ERROR ADDED LINEARLY BY US.
W2  E   ASSUMING HADRONIC PARTIAL WIDTH EQUAL TO TOTAL WIDTH
W2   S  USING UPSILON(9460) PARTIAL WIDTH TO E+E- = 1.10 KEV

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                    52  UPSILON(10025) BRANCHING RATIOS

R1      UPSILON(10025) INTO(MU+ MU-)/TOTAL                (P1)
R1           (0.038)OR LESS CL=0.90   NICZYPO1  81 LENA    E+E-,MU+MU-       9/81
R1 D   176    0.019     0.018         ANDREWS   83 CLEO    E+E-,MU+MU-       8/83*

R2      UPSILON(10025) INTO (E+  E-)/TOTAL                (P2)
R2          SEEN                       COBB      77 SPEC     P P,E+ E- X     12/78

R3      UPSILON(10025) INTO (UPSILON(9460) PI PI)/TOTAL   (P3)
R3   E  23    0.23      0.08          MAGERAS   81 CUSB    E+E-,E+E-PI+PI-   9/81
R3   E   7    0.24      0.08          NICZYPO2  81 LENA    E+E-,L+L-PI+PI-   9/81
R3 D          0.191     0.018         GREEN     82 CLEO    E+E-,2PI MM/2MU   8/83*
R3 D         (0.179)   (0.030)        ALBRECHT  83 ARG     E+E-,HADRONS     12/83*
R3          . . . . . . . . .
R3  AVG       0.195     0.017   AVERAGE

R4      UPSILON(10025) INTO (CHI/B(9915) GAMMA)/TOTAL     (P4)
R4            0.061     0.014         KLOPFENST 83 CUSB    E+E-,GAMMA HADR   9/83*
R4 D         (0.063)   (0.027)        GAISER    83 CBAL    E+E-,GAMMA HADR  12/83*

R5      UPSILON(10025) INTO (CHI/B(9895) GAMMA)/TOTAL     (P5)
R5             .059      .014         KLOPFENST 83 CUSB    E+E-,GAMMA HADR   9/83*
R5 D         (0.060)   (0.027)        GAISER    83 CBAL    E+E-,GAMMA HADR  12/83*

R6      UPSILON(10025) INTO (CHI/B(9875) GAMMA)/TOTAL     (P6)
R6             .035      .014         KLOPFENST 83 CUSB    E+E-,GAMMA HADR   9/83*

R  D    SYSTEMATIC ERRORS ADDED LINEARLY BY US
R    E  ASSUMING THE BRANCHING RATIO OF UPSILON(9460) TO E+E- TO BE 0.025

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                    REFERENCES FOR UPSILON(10025)

COBB      77 PL 72 B 273        +IWATA,FABJAN,GOLDBERG+(BNL+CERN+SYRA+YALE)
HERB      77 PRL 39 252         +HOM,LEDERMAN,APPEL,ITO,+  (COLU+FNAL+STON)
INNES     77 PRL 39 1240        +APPEL,BROWN,HERB,HOM,FISK+(COLU+FNAL+STON)

BIENLEIN  78 PL 78 B 360        +GLAWE,BOCK,BLANAR,+  (DESY+HAMB+HEID+MPIM)
DARDEN    78 PL 78 B 364        +HOFMANN,ALBRECHT,+   (DESY+DORT+HEID+LUND)
KAPLAN    78 PRL 40 435         +APPEL,HERB,HOM,LEDERMAN,+ (STON+FNAL+COLU)
YOH       78 PRL 41 684         +HERB,HOM,LEDERMAN,UENO,+  (COLU+FNAL+STON)

UENO      79 PRL 42 486         +BROWN,HERB,HOM,FISK,ITO,+ (FNAL+COLU+STON)

ANDREWS   80 PRL 44 1108        + (CORN+HARV+ITHA+LEMO+ROCH+RUTG+SYRA+VAND)
ARESTOV   80 IHEP 80-165        +BOGOLJUBSKI,+                      (SERP)
BOCK      80 ZPHY C 6 125       +BLANAR,BLUM,BIENLEIN+(HEID+MPIM+DESY+HAMB)
BOHRINGE  80 PRL 44 1111        BOHRINGER,COSTANTINI,FINOCCHIARO(COLU+STON)
KOURKOUM  80 PL 91 B 481        KOURKOUMELIS+(ATHU+NTUA+BNL+CERN+SYRA+YALE)

MAGERAS   81 PRL 46 1115        +BOHRINGER,FINOCCHIARO+(COLU+STON+LSU+MPIM)
MUELLER   81 PRL 46 1181        + (RUTG+SYRA+LEMO+VAND+CORN+ITHA+HARV+ROCH)
NICZYPO1  81 PL 99 B 169        NICZYPORUK,CHEN,VOGEL,WEGENER+(LENA COLLAB)
NICZYPO2  81 PL 100 B 95        NICZYPORUK,CHEN,FOLGER,LURZ,+ (LENA COLLAB)

ALBRECHT  82 PL 116 B 383       +HOFMANN,SHUBERT+(DESY+DORT+HEID+LUND+ITEP)
GREEN     82 PRL 49 617         +(RUTG+SYRA+VAND+CORN+ITHACA+HARV+OSU+ROCH)
    ALSO  83 CORNELL CONF.      +(RUTG+SYRA+VAND+CORN+ITHACA+HARV+OSU+ROCH)
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Mesons

Data Card Listings

$\chi_b(10235)$ [$\chi_b(2^3P_0)$], $\chi_b(10255)$ [$\chi_b(2^3P_1)$], $\chi_b(10270)$ [$\chi_b(2^3P_2)$], $\Upsilon(10355)$ [$\Upsilon(3S)$]


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ALBRECHT 83  DESY 83-101        +DREWS,HASEMANN+       (ARGUS COLLABORATION)
ANDREWS  83 PRL 50 807          +  (CORN+ITHA+HARV+OSU+ROCH+RUTG+SYRA+VAND)
ARTAMONO 83  PREPR.83-84        +BARU,BLINOV,BONDAR,BUKIN,GROSHEV+   (NOVO)
    ALSO 83 CORNELL CONF.       B. GITTTELMAN                        (CORN)
BARBER   83  DESY 83-067        +(DESY,ARGUS COLLAB+CRYSTAL BALL COLLABOR.)
    ALSO 83  SUB. TO PL         +(DESY,ARGUS COLLAB+CRYSTAL BALL COLLABOR.)
GAISER   83  SLAC-PUB-3232      J.E.GAISER+CRYSTAL BALL COLLABORATION(SLAC)
KLOPFENS 83 PRL 51 160          KLOPFENSTEIN,HAN+ (STON+COLU+CORN+LSU+MPIM)
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$\chi_b(10235)$ or $\chi_b(2^3P_0)$

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79  CHI/B(10235,JPG=   ) J=0 PREFERRED

OBSERVED IN RADIATIVE DECAY OF THE UPSILON(10355).
INTO CHI/B GAMMA, THEREFORE C=+.
OMITTED FROM TABLE.
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                 79  CHI/B(10235) MASS (GEV)

M    U       10.2328   .0058                                          9/83*

M    U  FROM GAMMA ENERGY BELOW ASSUMING UPSILON(10355) MASS = 10355.5 MEV

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                 79  GAMMA ENERGY IN UPSILON(10355) DECAY (MEV)

DM   S      119.0      5.0          EIGEN     82 CUSB    E+E-,2 GAM L+L-   9/83*
DM  CD     (117.2)    (5.0)         HAN       82 CUSB    E+E-,GAMMAS HADR  9/83*
DM   S      122.1      0.7          LEE-FRANZ 83 RVUE    E+E-,GAMMAS HADR  9/83*
DM          . . . . . . . .

DM   AVG    122.0      5.7     AVERAGE
DM     A SYSTEMATIC ERROR OF 5 MEV FROM THE CUSB RESULTS HAS BEEN ADDED
DM     LINEARLY BY US TO THE STATISTICAL ERROR ON THE AVERAGE.

DM   D  SYSTEMATIC ERROR ADDED LINEARLY BY US.
DM   S  STATISTICAL ERROR ONLY.
DM  C   SUPERSEDED BY LEE-FRANZINI 83.

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                 79  CHI/B(10235) PARTIAL DECAY MODES

                                                        DECAY MASSES
P1     CHI/B(10235) INTO UPSILON(9460) GAMMA           9460+   0
P2     CHI/B(10235) INTO UPSILON(10025) GAMMA          10023+    0

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                 REFERENCES FOR CHI/B(10235)

EIGEN    82 PRL 49 1616        +BOHRINGER,HERB+  (MPIM+COLU+CORN+STON+LSU)
HAN      82 PRL 49 1612        +HORSTKOTTE,IMLAY+(COLU+STON+CORN+LSU+MPIM)

LEE-FRAN 83 EMS 83 CONF.       LEE-FRANZINI                        (COLU)
    ALSO 83 CORNELL CONF. 284 P. MICHAEL TUTS                      (COLU)

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$\chi_b(10255)$ or $\chi_b(2^3P_1)$

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80  CHI/B(10255,JPG=   ) J=1 PREFERRED

OBSERVED IN RADIATIVE DECAY OF THE UPSILON(10355).
INTO CHI/B GAMMA, THEREFORE C=+.

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                 80  CHI/B(10255) MASS (GEV)
M    U       10.2537   .0034                                          9/83*

M    U  FROM GAMMA ENERGY BELOW ASSUMING UPSILON(10355) MASS = 10355.5 MEV.

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                 80  GAMMA ENERGY IN UPSILON(10355) DECAY (MEV)

DM   S       99.0      2.0          EIGEN     82 CUSB    E+E-,2 GAM L+L-   9/83*
DM  CD      (99.5)    (3.2)         HAN       82 CUSB    E+E-,GAMMAS HADR  9/83*
DM   S      101.4      0.3          LEE-FRANZ 83 RVUE    E+E-,GAMMAS HADR  9/83*
DM          . . . . . . . .

DM   AVG    101.3      3.3     AVERAGE
DM     A SYSTEMATIC ERROR OF 3 MEV FROM THE CUSB RESULTS HAS BEEN ADDED
DM     LINEARLY BY US TO THE STATISTICAL ERROR ON THE AVERAGE.

DM   S  STATISTICAL ERROR ONLY.
DM   D  SYSTEMATIC ERROR ADDED LINEARLY BY US.
DM  C   SUPERSEDED BY LEE-FRANZINI 83.

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                 80  CHI/B(10255) PARTIAL DECAY MODES

                                                        DECAY MASSES
P1     CHI/B(10255) INTO UPSILON(9460) GAMMA           9460+   0
P2     CHI/B(10255) INTO UPSILON(10025) GAMMA          10023+    0

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                 REFERENCES FOR CHI/B(10255)

EIGEN    82 PRL 49 1616        +BOHRINGER,HERB+  (MPIM+COLU+CORN+STON+LSU)
HAN      82 PRL 49 1612        +HORSTKOTTE,IMLAY+(COLU+STON+CORN+LSU+MPIM)

LEE-FRAN 83 EMS 83 CONF.       LEE-FRANZINI                        (COLU)
    ALSO 83 CORNELL CONF. 284 P. MICHAEL TUTS                      (COLU)

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$\chi_b(10270)$ or $\chi_b(2^3P_2)$

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81  CHI/B(10270,JPG=   ) J=2 PREFERRED

OBSERVED IN RADIATIVE DECAY OF THE UPSILON(10355).
INTO CHI/B GAMMA, THEREFORE C=+.

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                 81  CHI/B(10270) MASS (GEV)

M    U       10.2710   .0024                                          9/83*

M    U  FROM GAMMA ENERGY BELOW ASSUMING UPSILON(10355) MASS = 10355.5 MEV.

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                 81  GAMMA ENERGY IN UPSILON(10355) DECAY (MEV)

DM   S       84.0      3.0          EIGEN     82 CUSB    E+E-,2 GAM L+L-   9/83*
DM  CD      (84.4)    (2.0)         HAN       82 CUSB    E+E-,GAMMAS HADR  9/83*
DM   S       84.2      0.3          LEE-FRANZ 83 RVUE    E+E-,GAMMAS HADR  9/83*
DM          . . . . . . . .

DM   AVG     84.2      2.3     AVERAGE
DM     A SYSTEMATIC ERROR OF 2 MEV FROM THE CUSB RESULTS HAS BEEN ADDED
DM     LINEARLY BY US TO THE STATISTICAL ERROR ON THE AVERAGE.

DM   S  STATISTICAL ERROR ONLY.
DM   D  SYSTEMATIC ERROR ADDED LINEARLY BY US.
DM  C   SUPERSEDED BY LEE-FRANZINI 83.

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                 81  CHI/B(10270) PARTIAL DECAY MODES

                                                        DECAY MASSES
P1     CHI/B(10270) INTO UPSILON(9460) GAMMA           9460+   0
P2     CHI/B(10270) INTO UPSILON(10025) GAMMA          10023+    0

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                 REFERENCES FOR CHI/B(10270)

EIGEN    82 PRL 49 1616        +BOHRINGER,HERB+  (MPIM+COLU+CORN+STON+LSU)
HAN      82 PRL 49 1612        +HORSTKOTTE,IMLAY+(COLU+STON+CORN+LSU+MPIM)

LEE-FRAN 83 EMS 83 CONF.       LEE-FRANZINI                        (COLU)
    ALSO 83 CORNELL CONF. 284 P. MICHAEL TUTS                      (COLU)

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$\Upsilon(10355)$ or $\Upsilon(3S)$

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48  UPSILON(10355,JPG=1- ) I=

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                 48  UPSILON(10355) MASS  (GEV)

M   R       (10.351)  (0.004)  FROM UPSILON(9460) MASS AND MASS DIFF. BELOW
M            10.3555   0.0005        ARTAMONOV 83 REDE    E+E-,HADRONS    12/83*

M   R   REDUNDANT WITH DATA ON MASS DIFFERENCE BELOW.

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                 48  UPSILON(10355) WIDTH (KEV)

W  B         23.0      9.0      6.0  PETERSON  82 CUSB    E+E-,GAMMAS HADR  8/83*
W  F D       13.0      7.0           ANDREWS   83 CLEO    E+E-,MU+MU-       9/83*
W          . . . . . . . .
W   AVG      17.7      5.1     AVERAGE

W  B    MODEL DEPENDENT VALUE
W    D  SYSTEMATIC ERROR ADDED LINEARLY BY US.
W F     FROM W2 AND R1 BELOW AND ASSUMING E-MU-TAU UNIVERSALITY.

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                 48  UPSILON(10355)-UPSILON(9460) MASS DIFFERENCE (MEV)

DM    E     895.5      0.6                                             2/84*
DM    E  EVALUATED BY US USING DIRECT MEASUREMENTS OF THE UPSILON(9460) AND
DM    E  UPSILON(10355) MASSES ABOVE.

DM A        950.0     30.0          UENO      79 SPEC    400 P PT,MU+MU-  12/79
DM   D      891.1      5.7          ANDREWS   80 CLEO    E+E-,HADRONS      9/81
DM   D      889.       6.           BOHRINGER 80 CUSB    E+E-,HADRONS      9/81
DM          . . . . . . . .
DM  AVG     891.2      4.1     AVERAGE

DM A    FIXING THE UPSILON(9460) MASS AT 9460 MEV AND THE
DM A    UPSILON(10025)-UPSILON(9460) MASS DIFFERENCE AT 558 MEV.
DM   D  SYSTEMATIC ERROR ADDED LINEARLY BY US.

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                 48  UPSILON(10355) PARTIAL DECAY MODES

                                                        DECAY MASSES
P1     UPSILON(10355) INTO MU+ MU-                     106+ 106
P2     UPSILON(10355) INTO  E+  E-                    .511+.511
P3     UPSILON(10355) INTO PI+PI- UPSILON(9460)        140+ 140+9460
P4     UPSILON(10355) INTO PI+ PI- UPSILON(10025)       140+  140+10023
P5     UPSILON(10355) INTO CHI/B(10270) GAMMA          10271+    0
P6     UPSILON(10355) INTO CHI/B(10255) GAMMA          10254+    0
P7     UPSILON(10355) INTO CHI/B(10235) GAMMA          10233+    0

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                 48  UPSILON(10355) PARTIAL WIDTHS (KEV)

W2     UPSILON(10355) INTO (E+ E-)                     (G2)
W2 D S        0.39      0.09          ANDREWS   80 CLEO    E+E-,HADRONS      9/81
W2 D S        0.35      0.06          BOHRINGER 80 CUSB    E+E-,HADRONS      9/81
W2         . . . . . . . .
W2  AVG       0.362     0.050   AVERAGE

W2 D    SYSTEMATIC ERROR ADDED LINEARLY BY US.
W2   S  USING UPSILON(9460) PARTIAL WIDTH TO E+E- = 1.10 KEV

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For notation, see key at front of Listings. **Mesons**

$\Upsilon(10355)$ [$\Upsilon(3S)$], $\Upsilon(10575)$ [$\Upsilon(4S)$], $K^{\pm}$, K^0, $K^*(892)$

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                    48  UPSILON(10355) BRANCHING RATIOS

R1      UPSILON(10355) INTO (MU+ MU-)/TOTAL                (P1)
R1 D  1096    0.033    0.02          ANDREWS   83 CLEO    E+E-,MU+MU-        8/83*

R3      UPSILON(10355) INTO (PI+PI- UPSILON(9460))/TOTAL (P3)
R3                                   (UNITS 10**-2)
R3 D  1680    4.9      1.4           GREEN     82 CLEO    E+E-,2PI MM/2MU    8/83*
R3 E    22    5.6      2.0           MAGERAS   82 CUSB    E+E-,HADRONS       8/83*
R3          . . . . . . . . .
R3  AVG       5.1      1.1     AVERAGE

R4      UPSILON(10355) INTO UPSILON(10025) PI+ PI-/TOTAL (P4)
R4                                   (UNITS 10**-2)
R4 G     5    3.1      3.1           MAGERAS   82 CUSB    E+E-,HADRONS       8/83*

R5      UPSILON(10355) INTO (CHI/B(10270) GAMMA)/TOTAL   (P5)
R5            0.127    0.041         LEE-FRANZ 83 RVUE    E+E-,GAMMA HADR   12/83*

R6      UPSILON(10355) INTO (CHI/B(10255) GAMMA)/TOTAL   (P6)
R6            0.156    0.042         LEE-FRANZ 83 RVUE    E+E-,GAMMA HADR   12/83*

R7      UPSILON(10355) INTO (CHI/B(10235) GAMMA)/TOTAL   (P7)
R7            0.076    0.035         LEE-FRANZ 83 RVUE    E+E-,GAMMA HADR   12/83*

R  D    SYSTEMATIC ERRORS ADDED LINEARLY BY US
R    E  ASSUMING THE BRANCHING RATIO OF UPSILON(9460) TO E+E- TO BE 0.025
R  G    ASSUMING THE BRANCHING RATIO OF UPSILON(10025) TO E+E- TO BE 0.016

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                          REFERENCES FOR UPSILON(10355)

COBB      77 PL 72 B 273        +IWATA,FABJAN,GOLDBERG+(BNL+CERN+SYRA+YALE)
HERB      77 PRL 39 252         +HOM,LEDERMAN,APPEL,ITO,+  (COLU+FNAL+STON)
INNES     77 PRL 39 1240        +APPEL,BROWN,HERB,HOM,FISK+(COLU+FNAL+STON)

KAPLAN    78 PRL 40 435         +APPEL,HERB,HOM,LEDERMAN,+ (STON+FNAL+COLU)
YOH       78 PRL 41 684         +HERB,HOM,LEDERMAN,UENO,+  (COLU+FNAL+STON)

UENO      79 PRL 42 486         +BROWN,HERB,HOM,FISK,ITO,+ (FNAL+COLU+STON)

ANDREWS   80 PRL 44 1108        + (CORN+HARV+ITHA+LEMO+ROCH+RUTG+SYRA+VAND)
BOHRINGE  80 PRL 44 1111        BOHRINGER,COSTANTINI,FINOCCHIARO(COLU+STON)

GREEN     82 PRL 49 617         +(RUTG+SYRA+VAND+CORN+ITHACA+HARV+OSU+ROCH)
HAN       82 PRL 49 1612        +HORSTKOTTE,IMLAY+(COLU+STON+CORN+LSU+MPIM)
MAGERAS   82 PL 118 B 453       +HERB,IMLAY+      (COLU+CORN+LSU+MPIM+STON)
PETERSON  82 PL 114 B 277       +GIANNINI,LEE-FRANZINI+(COLU+STON+LSU+MPIM)

ANDREWS   83 PRL 50 807         +  (CORN+ITHA+HARV+OSU+ROCH+RUTG+SYRA+VAND)
ARTAMONO  83  PREPR.83-84       +BARU,BLINOV,BONDAR,BUKIN,GROSHEV+   (NOVO)
LEE-FRAN  83 EMS 83 CONF.       LEE-FRANZINI                         (COLU)

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$\Upsilon(10575)$ or $\Upsilon(4S)$

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47  UPSILON(10575,JPG=1- ) I=

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                    47  UPSILON(10575) MASS  (GEV)

M   R       (10.573)  (0.004)  FROM UPSILON(9460) MASS AND MASS DIFF. BELOW
M   R   REDUNDANT WITH DATA ON MASS DIFFERENCE BELOW.

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                    47  UPSILON(10575) WIDTH (MEV)

W    D       19.8     10.5          ANDREWS   80 CLEO    E+E-,HADRONS       9/81
W            12.6      6.0          FINOCCHIA 80 CUSB    E+E-,HADRONS       9/81
W          . . . . . . . . .
W   AVG      14.4      5.2     AVERAGE

W    D  SYSTEMATIC ERROR ADDED LINERALY BY US.

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                    47  UPSILON(10575)-UPSILON(9460) MASS DIFFERENCE (MEV)

DM          1112.       5.          ANDREWS   80 CLEO    E+E-,HADRONS       9/81
DM    D     1114.       7.          FINOCCHIA 80 CUSB    E+E-,HADRONS       9/81
DM         . . . . . . . . .
DM  AVG     1112.7      4.1     AVERAGE

DM   D  SYSTEMATIC ERROR ADDED LINERALY BY US.

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                    47  UPSILON(10575) PARTIAL DECAY MODES

                                                      DECAY MASSES
P1      UPSILON(10575) INTO MU+ MU-                  106+ 106
P2      UPSILON(10575) INTO  E+  E-                 .511+.511

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                    47  UPSILON(10575) PARTIAL WIDTHS (KEV)

W2      UPSILON(10575) INTO (E+ E-)                  (G2)
W2   S       0.21      0.07          ANDREWS   80 CLEO    E+E-,HADRONS       9/81
W2   S       0.28      0.08          FINOCCHIA 80 CUSB    E+E-,HADRONS       9/81
W2         . . . . . . . . .
W2  AVG      0.240     0.053   AVERAGE

W2   S  USING UPSILON(9460) PARTIAL WIDTH TO E+E- = 1.10 KEV

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                          REFERENCES FOR UPSILON(10575)

ANDREWS   80 PRL 45 219         + (CORN+HARV+ITHA+LEMO+ROCH+RUTG+SYRA+VAND)
FINOCCHI  80 PRL 45 222         FINOCCHIARO,GIANNINI,BOHRINGER,+(COLU+STON)

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S=±1, C=0, B=0 MESON STATES

$K^{\pm}$

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10  CHARGED K(494,JP=0-) I=1/2

SEE STABLE PARTICLE DATA CARD LISTINGS
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K^0

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11  NEUTRAL K(498,JP=0-) I=1/2

SEE STABLE PARTICLE DATA CARD LISTINGS
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$K^*(892)$

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18  K*(892,JP=1-) I=1/2

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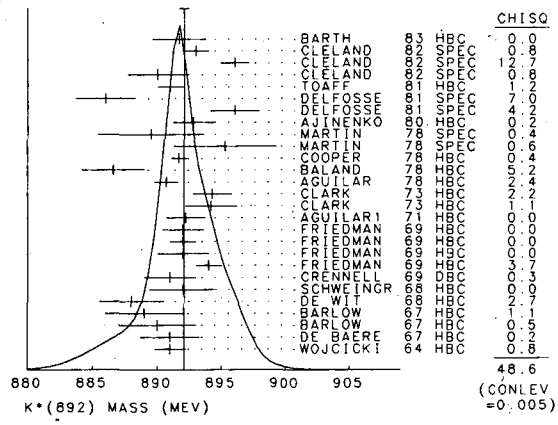
                    18  K*(892) MASS (MEV)

M  CHARGED ONLY. THIS IS WHAT APPEARS ON MESON TABLE
M  W  1700   891.0      1.2          WOJCICKI  64 HBC   -  1.7 K-P(K0 PI-) 12/75
M    D 620   891.       2.3          DE BAERE  67 HBC  +  3.5 K+P (K0 PI+) 12/75
M      720   890.       3.0          BARLOW    67 HBC  +- 1.2 PBARP(K0 PI) 12/75
M      600   889.       3.0          BARLOW    67 HBC  +- 1.2 PBARP(K PI)  12/75
M    D 540   888.       2.5          DE WIT    68 HBC  - 3.0 K-P          12/75
M    D 341   892.0      2.6          SCHWEINGR 68 HBC  -  5.5 K-P(K0 PI-) 12/75
M     1000   891.0      2.0          CRENNELL  69 DBC  -  3.9 K-N (K0PI-) 12/75
M     2886   894.       1.0          FRIEDMAN  69 HBC  -  2.1 K-P(K0 PI-) 12/75
M      728   892.       2.           FRIEDMAN  69 HBC  - 2.45 K-P(K0 PI-) 12/75
M     3229   892.       1.0          FRIEDMAN  69 HBC  - 2.6  K-P(K0 PI-) 12/75
M    D1027   892.       1.6          FRIEDMAN  69 HBC  - 2.7  K-P(K0 PI-) 12/75
M     4404   892.2      1.5          AGUILAR1  71 HBC  -  3.9,4.6 K- P   11/71
M    D 765   894.2      2.0          CLARK     73 HBC  - 3.13 K-P(K0 PI-) 12/75
M  W D1150   894.3      1.5          CLARK     73 HBC  - 3.3 K-P,P PI- K0 12/75
M   I 9000 (891.9)    (0.7)          PALER     75 HBC  - 14.3 K-P,K*- X+  12/75
M     1800   890.7      0.9          AGUILAR   78 HBC  +- .76 PB P,K KS PI 12/78
M     1225   886.6      2.4          BALAND    78 HBC  +- 12 PB P,INCLUSIV  4/78
M     6706   891.7      0.6          COOPER    78 HBC  +- .76 PB P,INCLUSV  4/78
M  X         895.3      4.0          MARTIN    78 SPEC +  10 K+-P,KS PI P   12/78
M  X         889.5      4.1          MARTIN    78 SPEC -  10 K+-P,KS PI P   12/78
M            892.8      1.6          AJINENKO  80 HBC  +  32 K+P            9/81
M      380   896.0      1.9          DELFOSSE  81 SPEC +  K+-P,K+- PI0 P    1/82
M      187   886.0      2.3          DELFOSSE  81 SPEC -  K+-P,K+- PI0 P    1/82
M     4100   891.0      1.0          TOAFF     81 HBC  -  6.5 K-P,K0 PI- P  1/82
M  W D 800   890.0      2.3          CLELAND   82 SPEC +  30 K+P,KS PI+P    8/83*
M  W D3200   896.0      1.1          CLELAND   82 SPEC +  50 K+P,KS PI+P    8/83*
M  W D3600   893.0      1.0          CLELAND   82 SPEC -  50 K+P,KS PI-P    8/83*
M     3700   891.7      2.1          BARTH     83 HBC  +  70 K+P,K0 PI+ X   12/83*
M          . . . . . . . . .
M   AVG     892.08     0.37    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.4)
                       (SEE IDEOGRAM BELOW)
```

WEIGHTED AVERAGE = 892.08 ± 0.37

ERROR SCALED BY 1.4

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M  NEUTRAL ONLY.
M    D1040   894.7      1.4          DAUBER    67 HBC    02.0 K-P(K-PI+)    12/75
M      10K   893.7      2.0          DAVIS     69 HBC    0 12. K+P(K+PI-)   12/75
M  W  4300   895.0      1.0          HABER     70 DBC    0 3. K-N (K-PI+)   12/75
M    D2934   897.9      1.1          AGUILAR1  71 HBC    0 3.9,4.6 K- P     12/75
M    D5362   898.0      0.7          AGUILAR1  71 HBC    0 3.9,4.6 K- P     12/75
M    D1700   898.4      1.3          BUCHNER   72 DBC    04.6 K+ N,K+ PI-   12/72
M     3186   896.0      1.0          LEWIS     73 HBC    02.1-2.7 K+P        2/74
M     C      894.0      1.3          LINGLIN   73 HBC    02-13 K+P,K+PI-    12/75
M      10K   896.0      0.6          FOX       74 RVUE   0 2 K-P,K-PI+N      12/75
M            896.0      0.6          FOX       74 RVUE   0 2 K+N,K+PI-P      12/75
M     C      896.       2.           MATISON   74 HBC    012 K+P,K+PI-       12/75
M     3600   895.5      1.0          MCCUBBIN  75 HBC    0 3.6 K-P,K-PI+N    12/75
M   I  22K (897.1)    (0.7)          PALER     75 HBC    014.3 K-P,K*0 X0    12/75
M            897.6      0.9          BOWLER    77 DBC    05.4 K+D,K+PI-P P   12/77
M     1180   898.4      1.4          AGUILAR   78 HBC    0 .76 PB P,K KS PI  12/78
M  P       (895.7)    (0.3)          ESTABROOK 78 ASPK   013 K+-P,K+-PI+-    12/77
M            894.9      1.6          WICKLUND  78 ASPK   0 3,4,6 PI+-PN       4/78
M  C       (892.8)    (1.3)          LANG      79 RVUE   0                    1/82
M     28K   897.       1.           EVANGELIS 80 OMEG   0 10 PI-P            9/81
M            894.6      .8           ASTON     81 LASS   0 11 K-P,K- PI+ N    1/82
M     5900   900.7      1.1          BARTH     83 HBC    0 70 K+P,K+ PI- X   12/83*
M          . . . . . . . . .
M   AVG     896.45     0.37    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.6)
                       (SEE IDEOGRAM BELOW)
```
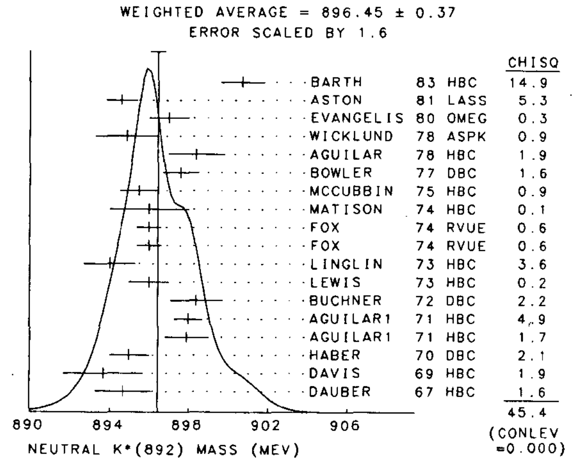

Mesons

Data Card Listings

K*(892)



M C FROM POLE EXTRAPOLATION.
M D MASS ERRORS ENLARGED BY US TO GAMMA/SQRT(N). SEE TYPED NOTE.
M I INCLUSIVE REACTION. COMPLICATED BACKGROUND AND PHASE-SPACE EFFECTS
M P FROM PHASE SHIFT ANALYSIS OF 155000 EVENTS.
M W NUMBER OF EVENTS IN PEAK REEVALUATED BY US
M X SYSTEMATIC ERROR ADDED

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NOTE ON K*(892) MASSES AND MASS DIFFERENCES

Unrealistically small errors are reported by some experiments. We use simple "realistic" tests for the minimum errors on the determination of mass and width from a sample of N events:

$$\delta_{\min}(m) = \frac{\Gamma}{\sqrt{N}}, \quad \delta_{\min}(\Gamma) = 4\frac{\Gamma}{\sqrt{N}}.$$

(For a detailed discussion, see the 1971 edition of this note.) We consistently increase unrealistic errors before averaging.

18 K*(0) - K*(+-) MASS DIFF. (MEV)

D	W 283	6.3	4.1	BARASH	67	HBC	0 PBAR P	12/75
D	SD1400	(6.5)	(5.0)	FICENEC1	68	HBC	1.3 K- P	12/75
D	SD1600	(9.5)	(5.0)	FICENEC2	68	HBC	2.7 K- P	12/75
D	7338	5.7	1.7	AGUILAR1	71	HBC	-0 3.9,4.6 K- P	11/71
D	2980	7.7	1.7	AGUILAR	78	HBC	+- .76 PB P,K KS PI	12/78
D		. . . . .	. . . . .					
D	AVG	6.7	1.2	AVERAGE				

D D MASS ERRORS ENLARGED BY US TO GAMMA/SQRT(N). SEE TYPED NOTE.
D S DATA WITH MASS ERROR OF 3 MEV OR MORE NOT AVERAGED
D W NUMBER OF EVENTS IN PEAK REEVALUATED BY US

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18 K*(892) WIDTH (MEV)

W CHARGED ONLY. THIS IS WHAT APPEARS ON MESON TABLE

W	W D1700	46.0	5.0		WOJCICKI	64	HBC	- 1.7 K-P(K0 PI-)	12/75
W	D 620	56.0	9.0		DE BAERE	67	HBC	+ 3.5 K+P(K0 PI+)	12/75
W	720	43.	9.0		BARLOW	67	HBC	+- 1.2 PBARP(K0 PI)	12/75
W	D 600	53.	9.0		BARLOW	67	HBC	+- 1.2 PBARP(K PI)	12/75
W	D 540	44.0	8.0		DE WIT	68	DBC	- 3. K- D	12/75
W	D2886	53.	4.0		FRIEDMAN	69	HBC	- 2.1 K-P(K0 PI-)	12/75
W	D 728	49.	7.3		FRIEDMAN	69	HBC	- 2.45K-P(K0 PI-)	12/75
W	D3229	46.	3.2		FRIEDMAN	69	HBC	- 2.6 K-P(K0 PI-)	12/75
W	D1027	49.	6.1		FRIEDMAN	69	HBC	- 2.7 K-P(K0 PI-)	12/75
W	D4404	54.3	3.3		AGUILAR1	71	HBC	- 3.9,4.6 K- P	12/75
W	D 765	46.3	6.7		CLARK	73	HBC	- 3.13K-P,P PI- K0	12/75
W	W D1150	48.2	5.7		CLARK	73	HBC	- 3.3 K-P,P PI- K0	12/75
W	I 9000	(52.1)	(2.2)		PALER	75	HBC	- 14.3 K-P,K*- X+	12/75
W	1800	45.8	3.6		AGUILAR	78	HBC	+- .76 PB P,K KS PI	12/78
W	1225	43.0	8.4		BALAND	78	HBC	+- 12 PB P,INCLUSIV	4/78
W	D6706	52.0	2.5		COOPER	78	HBC	+- .76 PB P,INCLUSV	4/78
W		50.9	2.3		MARTIN	78	SPEC	+ 10 K+-P,KS PI P	12/78
W		50.5	5.6		AJINENKO	80	HBC	+ 32 K+P	9/81
W	380	62.6	3.8		DELFOSSE	81	SPEC	+ K+-P,K+- PI0 P	1/82
W	187	50.5	3.9		DELFOSSE	81	SPEC	- K+-P,K+- PI0 P	1/82
W	4100	51.0	2.0		TOAFF	81	HBC	- 6.5 K-P,K0 PI- P	1/82
W	W D 800	64.0	9.2		CLELAND	82	SPEC	+ 30 K+P,KS PI+P	8/83*
W	W D3200	62.0	4.4		CLELAND	82	SPEC	+ 50 K+P,KS PI+P	8/83*
W	W D3600	55.0	4.0		CLELAND	82	SPEC	- 50 K+P,KS PI-P	8/83*
W	3700	42.8	7.1		BARTH	83	HBC	+ 70 K+P,K0 PI+ X	12/83*
W		. . . . .	. . . . .						
W	AVG	51.26	0.95		AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.1)				

W NEUTRAL ONLY.

W	D1040	44.	5.5		DAUBER	67	HBC	0 2.0 K- P	12/75
W	D 10K	53.2	2.1		DAVIS	69	HBC	0 12. K+P(K+PI-)	12/75
W	W D4300	54.0	3.3		HABER	70	DBC	0 3. K-N (K-PI+)	12/75
W	2934	55.8	4.2	3.4	AGUILAR1	71	HBC	0 3.9,4.6 K- P	11/71
W	D5362	48.5	2.7		AGUILAR1	71	HBC	0 3.9,4.6 K- P	12/75
W	D1700	51.4	5.0		BUCHNER	72	DBC	04.6 K+ N,K+ PI-P	12/72
W	D3186	46.0	3.3		LEWIS	73	HBC	02.1-2.7 K+P	12/75
W	C	(46.5)	(1.5)		LINGLIN	73	HBC	02-13 K+P,K+PI-	1/74
W	10K	47.	2.		FOX	74	RVUE	0 2 K-P,K-PI+N	12/75
W		51.	2.		FOX	74	RVUE	0 2 K+N,K+PI-P	12/75
W	C	(47.)	(3.)		MATISON	74	HBC	012 K+P,K+PI-	12/75
W	3600	48.	3.	2.	MCCUBBIN	75	HBC	0 3.6 K-P,K-PI+N	12/75
W	I 22K	(50.6)	(2.5)		PALER	75	HBC	014.3 K-P,K*0 X0	12/75
W		48.9	2.5		BOWLER	77	DBC	05.4 K+D,K+PI-P P	12/77
W	1180	45.9	4.8		AGUILAR	78	HBC	0 .76 PB P,K KS PI	12/78
W	P	(52.9)	(0.4)		ESTABROOK	78	ASPK	013 K+-P,K+-PI+-	12/77
W		51.2	1.7		WICKLUND	78	ASPK	0 3,4,6 PI+-PN	4/78
W	C	(40.1)	(6.0)		LANG	79	RVUE	0	1/82
W	28K	54.	2.		EVANGELIS	80	OMEG	0 10 PI-P	9/81
W		49.8	1.2		ASTON	81	LASS	0 11 K-P,K- PI+ N	1/82
W	5900	46.5	4.3		BARTH	83	HBC	0 70 K+P,K+ PI- X	12/83*
W		. . . . .	. . . . .						
W	AVG	50.24	0.65		AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.1)				

W C FROM POLE EXTRAPOLATION.
W D WIDTH ERRORS ENLARGED BY US TO 4*GAMMA/SQRT(N). SEE TYPED NOTE.
W I INCLUSIVE REACTION. COMPLICATED BACKGROUND AND PHASE-SPACE EFFECTS
W P FROM PHASE SHIFT ANALYSIS OF 155000 EVENTS.
W W NUMBER OF EVENTS IN PEAK REEVALUATED BY US

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18 K*(892) PARTIAL DECAY MODES

		DECAY MASSES
P1	K*(892) INTO K PI	494+ 140
P2	K*(892) INTO K PI PI	494+ 140+ 140
P3	K*(892) INTO K GAMMA	494+ 0

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18 K*(892) PARTIAL WIDTHS (KEV)

W3	K*(892) INTO (K GAMMA)						(G3)	
W3		48.0	11.0	BERG	83	SPEC	- 156 K-A,K PI A	1/82
W3		51.0	5.0	CHANDLEE	83	SPEC	+ 200 K+A,K PI A	9/83*
W3		. . . . .	. . . . .					
W3	AVG	50.5	4.6	AVERAGE				

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18 K*(892) BRANCHING RATIOS

R1	K*(892) INTO (K PI PI)/(K PI)						(P2)/(P1)	
R1	0	(0.002)OR LESS		WOJCICKI2	64	HBC	- 1.7 K-P	
R1	0	(0.0007)R LESS	CL=0.95	JONGEJANS	78	HBC	4 K-P,P K0 2PI	4/78
R2	K*(892) INTO (K GAMMA)/TOTAL		(UNITS 10**-3)				(P3)	
R2		(1.6) OR LESS	CL=.95	BEMPORAD	72	CNTR	+ 10.-16. K+A,COUL	1/73
R2		1.5	0.7	CARITHERS	75	CNTR	0 8-16K0BAR A,COUL	12/75

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REFERENCES FOR K*(892)

ALSTON 61 PRL 6 300 — ALSTON,ALVAREZ,EBERHARD,GOOD,GRAZIANO+(LRL)

ALEXANDE 62 PRL 8 447 — ALEXANDER,KALBFLEISCH,MILLER,G SMITH (LRL)
COLLEY 62 CERN CONF 315 — D COLLEY,N GELFAND + (COLUMBIA+RUTGERS)

CHADWICK 63 PL 6 309 — CHADWICK,CRENNELL,DAVIES,BETTINI+(OXF+PADO)
GOLDHABE 63 ATHENS CONF 92 — SULAMITH GOLDHABER (LRL)

WOJCICKI 64 PR 135 B 484 — STANLEY G WOJCICKI (LRL)

ADELMAN 65 ATHENS 527 — STUART LEE ADELMAN (CAVENDISH)
FERRO-LU 65 NC 36 1101 — FERRO-LUZZI,GEORGE,HENRI,JONGEJANS (CERN)
FERRO-LU 65 NC 39 417 — FERRO-LUZZI,GEORGE,GOLDSCHMIDT-CLER+ (CERN)
GELSEMA 65 THESIS — E.S.GELSEMA (SEE ALSO PL 10 341)(AMSTERDAM)
WANGLER 65 PR 137 B 414 — WANGLER,ERWIN,WALKER (WISCONSIN)

BARASH 67 PR 156 1399 — BARASH,KIRSCH,MILLER,TAN (COLUMBIA)
BARLOW 67 NC 50 A 701 — +MONTANET,D-ANDLAU+ (CERN+CDEF+IRAD+LIVP)
BOMSE 67 PR 158 1298 — +BORENSTEIN+COLE+GILLESPIE+ (JOHN HOPKINS)
CONFORTO 67 NP B3 469 — +MARECHAL,MONTANET+CERN+CDEF+IPN+LIVERPOOL
DAUBER 67 PR 153 1403 — +SCHLEIN,SLATER,TICHO (UCLA)
DE BAERE 67 NC 51 A 401 — +GOLDSCHMIDT-CLERMONT,HENRI+ (BRUX+CERN)
FRENCH 67 NC 42A 442 — +KINSON+MCDONALD+RIDDIFORD+ (CERN+BIRM)
GEORGE 67 NC 49A 9 — +GOLDSCHMIDT-CLERMONT+HENRI+ (CERN+BRUX)
SALLSTRO 67 NC 49A 348 — SALLSTROM+OTTER+EKSPONG (STOCKHOLM)

DE WIT 68 THESIS — S. DE WIT (AMSTERDAM)
FICENEC1 68 PR 169 1034 — +HULSIZER+SWANSON+TROWER (ILL)
FICENEC2 68 PR 175 1725 — FICENEC, GORDON, TROWER (ILLINOIS)
KANG 68 PR 176 1587 — Y.W.KANG (IOWA)
SCHWEING 68 PR 166 1317 — SCHWEINGRUBER,DERRICK,FIELDS+ (ANL+NWES)

CRENNELL 69 PRL 22 487 — +KARSHON,LAI,ONEALL,SCARR (BNL)
DAVIS 69 PRL 23 1071 — +DERENZO,FLATTE,ALSTON,LYNCH,SOLMITZ (LRL)
DE BAERE 69 NC 61 A 397 — +GOLDSCHMIDT-CLERMONT,HENRI,+ (BELG+CERN)
FRIEDMAN 69 UCRL-18860 — J.FRIEDMAN,PH.D. THESIS (LRL)
JUHALA 69 PR 184 1461 — +LEACOCK,RHODE,KOPELMAN,LIBBY,+ (ISU+COLO)
LIND 69 NP B 14 1 — +ALEXANDER,FIRESTONE,FU,GOLDHABER (LRL) JP

ATHERTON 70 NP B 16 416 — +FRANEK,FRENCH,FRISK,BEDNAR+ (CERN+PRAG)
HABER 70 NP B 17 289 — +SHAPIRA,ALEXANDER+ (REHO+SACL+BGNA+EPOL)

AGUILAR 71 PRL 26 466 — +BARNES,BASSANO,EISNER,KINSON,SAMIOS (BNL)
AGUILAR1 71 PR D 4 2583 — +EISNER,KINSON (BNL)
BARNHAM 71 NP B 28 171 — +COLLEY,JOBES,GRIFFITHS,HUGHES,+(BIRM+GLAS)
BUCHNER 71 NP B 29 381 — +DEHM,GOEBEL,GOLDSCHMIDT,+ (MPIM+CERN+BELG)
CORDS 71 PR D 4 1974 — +CARMONY,ERWIN,MEIERE,+ (PURD+UCD+IUPU)
MERCER 71 NP B32 381 — +ANTICH,CALLAHAN,CHIEN,COX,+ (JOHN HOPKINS)
YUTA 71 PRL 26 1502 — +DERRICK,ENGELMANN,MUSGRAVE (ANL+EFI)

ABRAMOVI 72 NP B 39 189 — ABRAMOVICH,CHALOUPKA,CHUNG,HILPERT,+ (CERN)
BINGHAM 72 NP B 41 1 — + (INTERNATIONAL K+ COLLABORATION)
BEMPORAD 72 NP B 51 1 — +BEUSCH,FREUDENREICH,+ (CERN+ETH+LOIC)
BRUNET 72 NP B 37 114 — +DANYSZ,GOLDSACK,+ (CDEF+SACL+LOIC+LOWC)
BUCHNER 72 NP B 45 333 — +DEHM,CHARRIERE,CORNET,+ (MPIM+CERN+BRUX)
CRENNELL 72 PR D 6 1220 — +GORDON,KWAN-WU LAI,SCARR (BNL)
DEUTSCHM 72 NP B 36 373 — DEUTSCHMANN,+ (ABCLV COLLABORATION)
ENGELMAN 72 PR D 5 2162 — ENGELMANN,MUSGRAVE,FORMAN,+ (ANL+EFI)
ROUGE 72 NP B 46 29 — +VIDEAU,VOLTE,DE BRION,+ (EPOL+SACL)
TIECKE 72 NP B 39 596 — +GRIJNS,HEINEN,DE GROOT,+ (NIJM+AMST)

For notation, see key at front of Listings.

Mesons

$K^*(892)$, Q(1280) [Q_1]


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BERTHON  73 NP B 63 54        +MONTANET,PAUL,BERTRANET,+      (CERN+SACL)
CHARRIER 73 NP B 51 317       CHARRIERE,DRIJARD,DE BAERE,+    (CERN+BELG)
CLARK    73 NP B 54 432       +LYONS,RADOJICIC                (OXFORD)
LEWIS    73 NP B 60 283       +ALLEN,JACOBS,DANYSZ,BORG,+(LOWC+LOIC+CDEF)
LINGLIN  73 NP B 55 408       D.LINGLIN                       (CERN)
WALUCH   73 PR D 8 2837       +FLATTE,FRIEDMAN                (LBL)

FOX      74 NP B80 403        G.C.FOX,M.L.GRISS               (CIT)
MATISON  74 PR D9 1872        +GALTIERI,GARNJOST,FLATTE,FRIEDMAN,+  (LBL)

BRANDENB 75 PL 59 B 405       BRANDENBURG,CARNEGIE,CASHMORE,DAVIER+(SLAC)
CARITHER 75 PRL 35 349        CARITHERS,MUHLEMANN,UNDERWOOD,+ (ROCH+MCGI)
MCCUBBIN 75 NP B86 13         N.A.MCCUBBIN,L.LYONS            (OXF)
PALER    75 NP B96 1          +TOVEY,SHAH,SPIRO,CHAURAND+(RHEL+SACL+EPOL)

KIRK     76 NP B 116 99       +KLEIN,COUNIHAN,+(AACH+BERL+CERN+LOIC+WIEN)

BOWLER   77 NP B 126 31       +DAINTON,DRAKE,WILLIAMS         (OXFORD)

AGUILAR  78 NP B 141 101      +FERNANDEZ,COOPER,+   (MADR+TIFR+CERN+CDEF)
BALAND   78 NP B 140 220      +GRARD,JOHNSON,+ (MONS+BELG+CERN+LOIC+LALO)
BALDI    78 NP B 134 365      +BOHRINGER,DORSAZ,HUNGERBUHLER+     (GEVA)
COOPER   78 NP B 136 365      +GURTU,DOBRZYNSKI,+   (TIFR+CERN+CDEF+MADR)
ENGELEN  78 NP B 134 14       +JONGEJANS,HEMINGWAY,+ (NIJM+ZEEM+CERN+OXF)
ESTABROO 78 NP B 133 490      ESTABROOKS,CARNEGIE,+ (MONT+CARL+DURH+SLAC)
   ALSO  78 PR D 17 658       ESTABROOKS,CARNEGIE+  (MONT+CARL+DURH+SLAC)
JONGEJAN 78 NP B 139 383      JONGEJANS,CERRADA,+    (ZEEM+CERN+NIJM+OXF)
MARTIN   78 NP B 134 392      +SHIMADA,BALDI,BOHRINGER,DORSAZ+(DURH+GEVA)
WICKLUND 78 PRD 17 1197       +AYRES,DIEBOLD,GREENE,KRAMER,PAWLICKI (ANL)
LANG     79 PR D 19 956       C.B.LANG,A.MAS-PARAREDA         (GRAZ)

AJINENKO 80 ZPHY 5 177        +BARTH,DUJARDIN,+     (SERP+LIBH+MONS+SACL)
EVANGELI 80 NP B 165 383      + (BARI+BONN+CERN+DARE+GLAS+LIVP+MILA+WIEN)

ASTON    81 PL 106 B 235      +CARNEGIE,DUNWOODIE,DURKIN+(SLAC+CARL+OTTA)  JP
BERG     81 PL 98 B 119       +CHANDLEE,BIEL,HEPPELMANN,+(ROCH+FNAL+MINN)
DELFOSSE 81 NP B 183 349      +GUISAN,MARTIN,MUHLEMANN,WEILL,+(GEVA+LAUS)
TOAFF    81 PR D 23 1500      +MUSGRAVE,AMMAR,DAVIS,ECKLUND,+  (ANL+KANS)

CLELAND  82 NP B 208 189      +DELFOSSE,DORSAZ,GLOOR(DURH+GEVA+LAUS+PITT)

BARTH    83 NP B 223 296      +DREVERMANN+(BRUX+CERN+GENO+MONS+NIJM+SERP)
BERG     83  THESIS           D.BERG                          (ROCH)
CHANDLEE 83  COO 3065 354     +BERG,CIHANGIR,COLLICK+    (ROCH+FNAL+MINN)
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Q(1280) or Q_1

28 Q(1280,JP=1+) I=1/2

NOTE ON THE Q(1280) AND Q(1400)

We no longer use the subscripts 1 and 2 on the Q states.

Since all the recent high-statistics experiments investigating the partial-wave contents of the $K\pi\pi$ system diffractively produced on protons (BRANDENBURG 76, OTTER 76, VERGEEST 79, DAUM 81) give consistent evidence for the existence of two strangeness-one axial vector mesons, we have split the "Q region" entry into two entries: one for the Q(1280) resonance, with a mass around 1280 MeV, a width of the order of 100 MeV, and coupled mainly to the $K\rho$ channel; and another one for the Q(1400) resonance, with a mass around 1400 MeV, a width of the order of 180 MeV, and coupled mainly to the $K^*(892)\pi$ channel.

Notice that, whereas both Q(1280) and Q(1400) are produced in diffractive processes, the nondiffractive reactions (ARMENTEROS 64, CRENNELL 67,72, ASTIER 69, GAVILLET 78, ETKIN 80, RODEBACK 81, BAUBILLIER 82) select preferentially the production of one of the two states.

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28 Q(1280) MASS (MEV)

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M   PRODUCED BY BEAMS OTHER THAN K MESONS
M  A      1242.0      9.0      10.0   ASTIER     69 HBC    0 PBAR P          9/69
M  A   THIS IS THE C MESON.
M        45(1300.)                    CRENNELL   67 HBC    0 6 PI- P,LK2PI   7/67
M        40(1300.)                    CRENNELL   72 HBC    0 4.5PI-P,LK2PI  12/72
M       310(1294.)     (10.)           RODEBACK   81 HBC     4 PI-P,LAM K 2PI  1/82
M   PRODUCED BY K-, BACKWARDS SCATTERING, HYPERON EXCHANGE
M       700 1275.0     10.0            GAVILLET   78 HBC  +  4.2 K-P,XI-KPIPI  4/78

M   PRODUCED BY K BEAMS
M         (1260.)                     DAVIS      72 HBC  +  12. K+ P         12/72
M         (1234.)     (12.)           FIRESTONE  72 DBC  +  12. K+ D          2/73
M         (1300.)    APPROX.          BRANDENB   76 ASPK +- 13 K+-P,(KPIPI)P 12/75
M   E     (1289.0)    (25.0)          CARNEGIE   77 ASPK +- 13 K+-P,P KPIPI  12/77
M         (1270.0)   APPROX.          OTTER      76 HBC   - 10-14-16K-P      12/77
M         (1300.0)   APPROX.          VERGEEST   79 HBC  +- 4.2 K-P,K PI PI  12/79
M          1270.       10.            DAUM       81 CNTR -  63 K-P,K 2PI P    1/82
M   T     (1276.0)   APPROX            TORNQVIST  82 RVUE                     9/83*

M   E   FROM A MODEL DEPENDENT FIT WITH GAUSSIAN BACKGROUND TO
M   E   BRANDENBURG 76 DATA.
M   T   FROM A UNITARIZED QUARK MODEL CALCULATION
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28 Q(1280) WIDTH (MEV)

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W   PRODUCED BY BEAMS OTHER THAN K MESONS
W        127.0       7.0      25.0   ASTIER     69 HBC    0 PBAR P          9/69
W       45  (60.)                    CRENNELL   67 HBC    0 6 PI- P         7/67
W       40  (60.)                    CRENNELL   72 HBC    0 4.5PI-P,LK2PI  12/72
W      310  (66.)     (15.)           RODEBACK   81 HBC     4 PI-P,LAM K 2PI  1/82
W   PRODUCED BY K-, BACKWARDS SCATTERING, HYPERON EXCHANGE
W       700   75.0     15.0           GAVILLET   78 HBC  +  4.2 K-P,XI-KPIPI  4/78

W   PRODUCED BY K BEAMS
W         (120.)                      DAVIS      72 HBC  +  12. K+ P         12/72
W         (188.)     (21.)            FIRESTONE  72 DBC  +  12. K+ D         12/75
W         (200.)    APPROX.           BRANDENB   76 ASPK +- 13 K+-P,(KPIPI)P 12/75
W   E     (150.00)   (71.0)           CARNEGIE   77 ASPK +- 13 K+-P,P KPIPI  12/77
W         (150.0)   APPROX.           VERGEEST   79 HBC  +- 4.2 K-P,K PI PI  12/79
W           90.        8.             DAUM       81 CNTR -  63 K-P,K 2PI P    1/82

W   E   SEE NOTE E ABOVE.
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28 Q(1280) PARTIAL DECAY MODES

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                                                          DECAY MASSES
P1     Q(1280) INTO K*(892) PI                           892+ 140
P2     Q(1280) INTO K RHO                                498+ 769
P3     Q(1280) INTO K PI                                 498+ 140
P4     Q(1280) INTO K ETA                                498+ 549
P5     Q(1280) INTO K OMEGA                              498+ 783
P6     Q(1280) INTO K PI PI                              498+ 140+ 140
P7     Q(1280) INTO KAPPA(1350) PI                      1350+ 140
P8     Q(1280) INTO K EPSILON(1300)                      498+1300
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28 Q(1280) PARTIAL WIDTHS (MEV)

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W1     Q(1280) INTO K*(892) PI                           (G1)
W1          2.0       2.0            CARNEGIE1 77 ASPK +- 13 K+-P,(KPIPI)P 12/78
W1         14.0      11.0            MAZZUCATO 79 HBC  +  4.2 K-P,XI-KPIPI 12/79
W1       . . . . . . . . .
W1  AVG     2.4       2.0     AVERAGE

W2     Q(1280) INTO K RHO                                (G2)
W2         75.0       6.0            CARNEGIE1 77 ASPK +- 13 K+-P,(KPIPI)P 12/78
W2         57.0       5.0            MAZZUCATO 79 HBC  +  4.2 K-P,XI-KPIPI 12/79
W2       . . . . . . . . .
W2  AVG    64.4       8.9     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 2.3)

W5     Q(1280) INTO K OMEGA                              (G5)
W5         24.0       3.0            CARNEGIE1 77 ASPK +- 13 K+-P,(KPIPI)P 12/78
W5          4.0       4.00           MAZZUCATO 79 HBC  +  4.2 K-P,XI-KPIPI 12/79
W5       . . . . . . . . .
W5  AVG    16.8       9.6     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 4.0)

W7     Q(1280) INTO KAPPA(1350) PI                       (G7)
W7         26.0       6.0            CARNEGIE1 77 ASPK +- 13 K+-P,(KPIPI)P 12/78

W8     Q(1280) INTO EPSILON(1300) K                      (G8)
W8         22.0       5.0            CARNEGIE1 77 ASPK +- 13 K+-P,(KPIPI)P 12/78
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28 Q(1280) BRANCHING RATIOS

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R1     Q(1280) INTO K*(892) PI                           (P1)
R1 F        0.16      0.05            DAUM       81 CNTR    63 K-P,K 2PI P    1/82

R2     Q(1280) INTO K RHO                                (P2)
R2 F        0.42      0.06            DAUM       81 CNTR    63 K-P,K 2PI P    1/82
R2        DOMINANT                    RODEBACK   81 HBC     4 PI-P,LAM K 2PI  1/82

R3     Q(1280) INTO K OMEGA                              (P5)
R3 F        0.11      0.02            DAUM       81 CNTR    63 K-P,K 2PI P    1/82

R4     Q(1280) INTO KAPPA(1350) PI                       (P7)
R4 F        0.28      0.04            DAUM       81 CNTR    63 K-P,K 2PI P    1/82

R5     Q(1280) INTO K EPSILON(1300)                      (P8)
R5 F        0.03      0.02            DAUM       81 CNTR    63 K-P,K 2PI P    1/82

R6     Q(1280) INTO (K OMEGA)/(K RHO)                    (P5)/(P2)
R6        (0.30) OR LESS  CL=.95      RODEBACK   81 HBC     4 PI-P,LAM K 2PI  1/82

R9     D/S RATIO FOR Q(1280) INTO K*(892) PI
R9 F        1.0       0.7             DAUM       81 CNTR    63 K-P,K 2PI P    1/82

R  F   AVERAGE FROM LOW AND HIGH T DATA.
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REFERENCES FOR Q(1280)


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ARMENTER 64 DUBNA CONF 1 577  ARMENTEROS,EDWARDS,D-ANDLAU +   (CERN+CDEF)
   ALSO  64 DUBNA CONF 1 617  R ARMENTEROS (RAPPORTEUR)
ARMENTER 64 PL 9 207          ARMENTEROS,EDWARDS,D-ANDLAU,+   (CERN+CDEF)
   ALSO  66 PR  145  1095     BARASH,KIRSCH,MILLER,TAN         (COLUMBIA)

ALMEIDA  65 PL 16 184         ALMEIDA,ATHERTON,BYER,DORNAN,FORSON+ (CAVE)

SHEN     66 PRL  17  726      +BUTTERWORTH,FU,GOLDHABERS,TRILLING   (LRL)
   ALSO  66  PRIVATE COMM.   GERSON GOLDHABER                       (LRL)
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Mesons

Q(1280) [Q_1], κ(1350)

Data Card Listings


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BASSOMPI 67 PL 26B 30          BASSOMPIERRE,GOLDSCHMIDT+  (CERN+BRUX+BIRM)IJP
BERLINGH 67 PRL 18 1087        BERLINGHIERI+FARBER+FERBEL+FORMAN    (ROCH)IJP
CRENNELL 67 PRL 19  44         +KALBFLEISCH,LAI,SCARR,SCHUMANN       (BNL)I
DE BAERE 67 NC 49A 374         +DEBAISIEUX+FAST+FILIPPAS+      (CERN+BRUX)
   ALSO PRIVATE COMMUNICATION BY B. JONGEJANS
GOLDHABE 67 PRL 19 976         G.GOLDHABER                           (LBL)

BARTSCH  68 NP B8 9            +COCCONI,+        (AACH+BERL+CERN+LOIC+VIEN)
BOMSE    68 PRL 20 1519        +BORENSTEIN,CALLAHAN,COLE,COX,+  (JOHNHOPK)  1+
DENEGRI  68 PRL 20 1194        +CALLAHAN+ETTLINGER+GILLESPIE+   (JOHNHOPK)  1+

ALEXANDE 69 NP B 13 503        G.ALEXANDER,FIRESTONE,GOLDHABER,+     (LRL)
ANDREWS  69 PRL 22 731         +LACH,LUDLAM,SANDWEISS,BERGER,+  (YALE+LRL)
ASTIER   69 NP B 10 65         +MARECHAL,MONTANET,+  (CDEF+CERN+IPNP+LIVP)IJP
BARBARO  69 PRL 22 1207        BARBARO-GALTIERI,DAVIS,FLATTE,+       (LRL)
BETTINI  69 NC 62 A 1038       +CRESTI,LIMENTANI,BERTAUZA,BIGI+(PADO+PISA)I
BISHOP   69 NP B 9 403         +GOSHAW,ERWIN,WALKER                 (WISC)
CHIEN    69 PL 29B 433         +MALAMUD,MELLEMA,RUDNICK,SCHLEIN+    (UCLA)
CHUNG    69 PR 182 1443        +EISNER+BALI+LUERS                    (BNL)
COLLEY   69 NC A 59 519        +EASTWOOD,+   (BIRM+GLAS+LOIC+MPIM+OXF+RHEL)
ERWIN    69 NP B 9 364         +WALKER,GOSHAW,WEINBERG    (WISC+PRIN+VAND)
FRIEDMAN 69  UCRL-18860        J.FRIEDMAN,PH.D. THESIS               (LRL)
WERNER   69 PR 188 2023        +AMMAR,DAVIS,KROPAC,YARGER,CHO,+ (NWES+ANL) 1+

ABRAMS   70 PR D 1 2433        +EISENSTEIN,KIM,MARSHALL,O-HALLORAN,+ (ILL)
ANTICH   70 NP B 20 201        +CARSON,CHIEN,COX,DENEGRI,ETTLINGER,+ (JHU)  1+
BOWLER   70 PL 31 B 318        M.G.BOWLER                          (OXFORD)
FARBER   70 PR D 1 78          +FERBEL,SLATTERY,YUTA                 (ROCH)  1+

BARNHAM  71 NP B25 49          +COLLEY,GRIFFITHS,ALPER, +  (BIRM+GLAS+OXF)
DENEGRI  71 NP B 28 13         +ANTICH,CALLAHAN,CARSON,CHIEN,COX,+   (JHU)  1+
FORMAN   71 PR D 3 2610        +GELFAND,LEARY,MOSER,SEIDL,WOLFSON    (EFI)
GARFINKE 71 PRL 26 1505        GARFINKEL,HOLLAND,CARMONY,LANDER+(PURD+UCD)  1+

ANDERSON 72 PR D 6 1823        +FRANKLIN,GODDEN,KOPELMAN,LIBBY,TAN  (COLO)
BINGHAM  72 NP B 48 589        +EISENSTEIN,GRARD,HERQUET,+     (CERN+BRUX)
BRANDENB 72 NP B 45 397        BRANDENBURG,BRODY,JOHNSON,LEITH,LOOS+(SLAC)
BRANDENB 72 PRL 28 932         BRANDENBURG,JOHNSON,LEITH,LOOS,LUSTE+(SLAC)
CRENNELL 72 PR D 6 1220        +GORDON,KWAN-WU LAI,SCARR             (BNL)
DAVIS    72 PR D 5 2688        +ALSTON,BARBARO,FLATTE,FRIEDMAN,LYNCH+(LBL)
FIRESTON 72 PR D 5 505         FIRESTONE,GOLDHABER,LISSAUER,TRILLING (LBL)
FIRESTON172 NP B 47 348        A.FIRESTONE                           (CIT)
FRATI    72 PR D 6 2361        +HALPERN,HARGIS,SNAPE,CARNAHAN,+(PENN+CINC)
HAATUFT  72 NP B 48 78         +ARNOLD,HAGUENAUER,+  (BERG+STRB+EPOL+MADR)

BARLOUTA 73 NP B 59 374        +DREVILLON,SHAH,+          (SACL+EPOL+RHEL)  JP
BINGHAM  73 NP B 52 31         +FARWEL,+        (LBL+ORSAY+BNL+SACLAY+MILAN)  JP
DE JONGH 73 NP B 58 110        +CORNET,CHARRIERE,+   (BRUX+MONS+CERN+MPIM)
JONES    73 NP B 52 383        G.T.JONES                             (CERN)  JP
LEWIS    73 NP B 60 283        +ALLEN,JACOBS,DANYSZ,BORG,+(LOWC+LOIC+CDEF)
WERNER   73 PR D 7 1275        +SLATTERY,FERBEL                   (ROCHESTER)

ANGELOPO 74 NC 20A 49          ANGELOPOULOS,FILIPPAS+(ATHU+ATEN+LIVP+VIEN)  JP
BOWLER   74 NP B74 493         +DAINTON,KADDOURA,AITCHISON           (OXF)
DAVIDSON 74 PR D9 77           +CHAPMAN,GREEN,LYS,ROE               (MICH)
DEUTSCHM 74 PL 49B 388         DEUTSCHMANN,+    (AACH+BERL+CERN+LOIC+VIEN)  JP

ANTIPOV  75 NP B86 381         +ASCOLI,BUSNELLO,KIENZLE+   (SERP+CERN+ILL)  JP
BOWLER   75 NP B97 227         +GAME,AITCHISON,DAINTON          (OXF+DARE)
DORE     75 LNC 13 265         +GUIDONI,LAAKSO,MARINI,CONFORTO+(ROMA+RHEL)
DREVILLO 75 PL 55 B 245        DREVILLON,BORENSTEIN+      (EPOL+BOHR+CDEF)  JP
DUNWOODI 75 NP B91 189         DUNMOODIE,GRANT+       (CERN+BELG+MONS+MPIM)  JP
OTTER1   75 NP B84 333         + (AACH+BERL+CERN+LOIC+VIEN+ATHU+ATEN+LIVP)  JP
OTTER2   75 NP B93 365         +RUDOLPH,RUMPF+  (AACH+BERL+CERN+LOIC+VIEN)  JP
OTTER3   75 NP B96 29          +RUDOLPH,SEYFERT+(AACH+BERL+CERN+LOIC+VIEN)I,JP
TOVEY    75 NP B95 109         +HANSEN,BORENSTEIN,BORG+   (RHEL+EPOL+SACL)I,JP

BASDEVAN 76 PRL 37 977         BASDEVANT,BERGER                  (FNAL+ANL)
BOAL     76 PR D 14 2998       +EDWARDS,KAMAL,TORGESON            (ALBERTA)
BOWLER   76 JPG 3 775          M.G.BOWLER                          (OXFORD)
BRANDENB 76 PRL 26 703         BRANDENBURG,CARNEGIE,CASHMORE,DAVIER+(SLAC)  JP
OTTER    76 NP B 106 77        + (AACH+BERL+CERN+LOIC+VIEN+LPNP+RHEL+SACL)  JP
VERGEEST 76 PL 62 B 471        +ENGELEN,JONGEJANS,+   (AMST+CERN+NIJM+OXF)  JP

CARNEGIE 77 NP B 127 509       +CASHMORE,DAVIER,DUNWOODIE,LASINSKI+ (SLAC)
CARNEGIE177 PL B 68 287        +CASHMORE,DUNWOODIE,LASINSKI,+        (SLAC)

BEUSCH   78 PL 74 B 282        +BIRMAN,KONIGS,OTTER,+       (CERN+AACH+ETH)  JP
GAVILLET 78 PL 76 B 517        +DIAZ,DIONISI,+         (AMST+CERN+NIJM+OXF)  JP
WOHL     78 NP B 132 401       +PALER,CHAURAND,+         (LPNP+RHEL+SACLAY)

BASDEVAN 79 PR D 19 246        BASDEVANT,BERGER                      (ANL)
MAZZUCAT 79 NP B 156 532       MAZZUCATO,PENNINGTON+  (CERN+ZEEM+NIJM+OXF)
VERGEEST 79 NP B 158 265       +JONGEJANS,DIONISI,+   (NIJM+AMST+CERN+OXF)

BACON    80 NP B 162 189       +BARREY,BUTTERWORTH,ANSORGE,+   (LOIC+CAVE)
DIONISI  80 NP B 169 1         +GAVILLET,ARMENTEROS+ (CERN+MADR+CDEF+STOH)
ETKIN    80 PR D 22 42         +FOLEY,LINDENBAUM,KRAMER,+       (BNL+CUNY)  JP
IRVING   80 JPG 6 153          A.C.IRVING                           (LIVP)
RADFORD  80 NP B 167 181       RADFORD,BRANDENBURG                   (MIT)

DAUM     81 NP B 187 1         +HERTZBERGER+(AMST+CERN+CRAC+MPIM+OXF+RHEL)
OTTER    81 NP B 181 1           (AACH+BERL+LOIC+VIEN+BIRM+BELG+CERN+MONS)
RODEBACK 81 ZPHY C 9 9         +SJOGREN,ARMENTEROS,+ (CERN+CDEF+MADR+STOH)

BAUBILLI 82 NP B 202 21        BAUBILLIER+        (BIRM+CERN+GLAS+MSU+LPNP)
FERNANDE 82 ZPHY C 16 95       FERNANDEZ,AGUILAR+     (MADR+CERN+CDEF+STOH)  JP
GAVILLET 82 ZPHY C 16 119      +ARMENTEROS,AGUILAR+  (CERN+CDEF+PADO+ROMA)
TORNQVIS 82 NP B 203 268       TORNQVIST                            (HELS)
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κ(1350)

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19  KAPPA(1350,JP=0+) I=1/2
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The isodoublet S-wave $K\pi$ phase shift δ_0^1 is compatible with elastic unitarity up to the $K\eta'$ threshold. It grows monotonically, reaching 90° at about 1350 MeV (MERCER 71, BINGHAM 72, FIRESTONE 71,72, MATISON 72,74, GALTIERI 73, YUTA 73, FOX 74, BAKER 75, LAUSCHER 75, BOWLER 77, ESTABROOKS 78, ASTON 81). The ambiguous "up" solution in the region of the $K^*(892)$ has been ruled out conclusively (MATISON 72,74, GALTIERI 73, BOWLER 77, ESTABROOKS 78).

The first inelastic two-body threshold is $K\eta$, which, however, is very weakly coupled to the κ(1350), in accordance with the SU(3) prediction for the $\kappa(1350)K\eta$ coupling.

In the energy range 1350-1450 MeV, the phase shift exhibits rapid motion (BOWLER 77, ESTABROOKS 78, MARTIN 78), which has been taken as an indication of a κ resonance at 1500 MeV (ESTABROOKS 79). However, the phase-shift behavior can also be understood as a cusp effect due to the nearby $K\eta'$ threshold at 1455 MeV (TORNQVIST 82). Above this energy the inelasticity due to $K\eta'$ is important. The phase shift can be fitted up to about 1500 MeV in a unitary coupled-channel analysis with proper analytic structure with one resonance, the κ(1350), without background (TORNQVIST 82). This supports earlier interpretations (FIRESTONE 71,72, FRATI 72, ROUGE 72, CORDS 73, LAUSCHER 75, MORGAN 75, ENGELEN 78, ASTON 81) that this κ mass is indeed where δ_0^1 passes through 90°.

At still higher energies some evidence for a second scalar resonance exists (ASTON 81).

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                    19  KAPPA(1350) MASS (MEV)

M   C      (1425.)   APPROX.          ESTABROOK 78 ASPK    13 K+- P          12/77
M          (1450.0)  APPROX.          MARTIN    78 SPEC    10 K+-P,KS PI P   12/78
M   P      (1278.)    (50.)           LANG      79 RVUE  0                   1/82
M          (1400.)   APPROX.          ASTON     81 LASS  0 11 K-P,K- PI+ N   1/82
M   T      (1350.)                    TORNQVIST 82 RVUE    13 K+- P          1/82

M   C   FROM ELASTIC K PI PARTIAL WAVE ANAL. (SEE KAPPA(1350) MINI-REVIEW)
M   P   POLE EXTRAPOLATION USING FIRESTONE 72 AND MATISON 74 DATA.
M   T   FROM A UNITARIZED QUARK MODEL CALCULATION

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                    19  KAPPA(1350) WIDTH (MEV)

W   C       200-300 APPROX.          ESTABROOK 78 ASPK    13 K+- P          12/77
W   P      (540.)   (106.)           LANG      79 RVUE  0                   1/82
W          (250.)   APPROX.          ASTON     81 LASS  0 11 K-P,K- PI+ N   1/82
W   T      (430.)   OR MORE          TORNQVIST 82 RVUE    13 K+- P          1/82

W   C   FROM ELASTIC K PI PARTIAL WAVE ANAL. (SEE KAPPA(1350) MINI-REVIEW)
W   P   POLE EXTRAPOLATION USING FIRESTONE 72 AND MATISON 74 DATA.
W   T   FROM A UNITARIZED QUARK MODEL CALCULATION

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                    19  KAPPA(1350) PARTIAL DECAY MODES

                                                        DECAY MASSES
P1      KAPPA(1350) INTO K PI                          498+ 135
P2      KAPPA(1350) INTO K ETA                         498+ 549
P3      KAPPA(1350) INTO K ETA PRIME                   498+ 958

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                    19  KAPPA(1350) BRANCHING RATIOS

R1      KAPPA(1350) INTO (K PI)/TOTAL                  (P1)
R1          (0.85) APPROX.           ASTON     81 LASS  0 11 K-P,K- PI+ N   1/82
R1  T       (0.93) APPROX.           TORNQVIST 82 RVUE    13 K+-P           1/82

R1  T   FROM A UNITARIZED QUARK MODEL CALCULATION

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                    REFERENCES FOR KAPPA(1350)

TRIPPE   68 PL 28 B 203        +CHIEN,MALAMUD,MELLEMA,SCHLEIN,+      (UCLA)

CRENNELL 69 PRL 22 487         +KARSHON,LAI,O.NEALL,SCARR            (BNL)
DODD     69 PR 177 1994        +JOLDERSMA,PALMER,SAMIOS              (BNL)
GOLDBERG 69 PL 30 B 434        SABRE COLLABOR.  (SACL+AMST+BGNA+REHO+EPOL)
SCHLEIN  69 ARGONNE CONF. 446  P.SCHLEIN                            (UCLA)

FIRESTON 71 PRL 26 1460        A.FIRESTONE,G.GOLDHABER,D.LISSAUER    (LRL)
MERCER   71 NP B32 381         +ANTICH,CALLAHAN,CHIEN,COX,+ (JOHN HOPKINS)
YUTA     71 PRL 26 1502        +DERRICK,ENGELMANN,MUSGRAVE       (ANL+EFI)
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AGUILAR 72 PR D 6 11 AGUILAR-BENITEZ,CHUNG,EISNER (BNL)
BINGHAM 72 NP B 41 1 + (INTERNATIONAL K+ COLLABORATION)
BUCHNER 72 NP B 45 333 +DEHM,CHARRIERE,CORNET,+ (MPIM+CERN+BRUX)
CHUNG 72 PRL 29 1570 +EISNER,AGUILAR-BENITEZ (BNL)
CRENNELL 72 PR D 6 1220 +GORDON,KWAN-WU LAI,SCARR (BNL)
DIEBOLD 72 BATAV.CONF. V.3 17R.DIEBOLD RAPPORTEUR TALK (ANL)
ENGELMAN 72 PR D 5 2162 ENGELMANN,MUSGRAVE,FORMAN,+ (ANL+EFI)
FIRESTON 72 PR D 5 2188 +GOLDHABER, LISSAUER, TRILLING (LBL)PWA
FRATI 72 PR D 6 2361 +HALPERN,HARGIS,SNAPE,CARNAHAN,+(PENN+CINC)
MATISON 72 LBL 1537 (THESIS) REVISED VERSION WILL GO TO PHYS.REV. LBL
ROUGE 72 NP B 46 29 +VIDEAU,VOLTE,DE BRION,+ (EPOL+SACL)

CORDS 73 NP B 54 109 +CARMONY,LANDER,MEIERE,+ (PURD+UCD+IUPU)
GALTIERI 73 LBL 1772 +MATISON,GARNJOST,FLATTE,FRIEDMAN+ (LBL)
LINGLIN 73 NP B 55 408 D.LINGLIN (CERN)
YUTA 73 NP B 52 70 +ENGELMANN,MUSGRAVE,FORMAN,+ (ANL+EFI)

FOX 74 NP B80 403 G.C.FOX,M.L.GRISS (CIT)
MATISON 74 PR D9 1872 +GALTIERI,GARNJOST,FLATTE,FRIEDMAN,+ (LBL)
MORGAN 74 PL 51B 71 D.MORGAN (RHEL)

BAKER 75 NP B99 211 +BANERJEE,CAMPBELL,ALLEN,MARCH+ (LOIC+LOWC)
LAUSCHER 75 NP B86 189 +OTTER,WIECZOREK,+ (ABCLV COLLABORATION)
MORGAN 75 ARGONNE CONF. 45 D.MORGAN (RHEL)

CHIEN 76 NP B 106 355 +FEIOCK,LUCAS,PEVSNER,ZOANIS (BALTIMORE)

BOWLER 77 NP B 126 31 +DAINTON,DRAKE,WILLIAMS (OXFORD)
SPIRO 77 NP B 125 162 +BARLOUTAUD,COMBER,PALER,+ (SACL+RHEL+EPOL)

BALDI 78 NP B 134 365 +BOHRINGER,DORSAZ,HUNGERBUHLER+ (GEVA)
ENGELEN 78 NP B 134 14 +JONGEJANS,HEMINGWAY,+ (NIJM+ZEEM+CERN+OXF)
ESTABROO 78 NP B 133 490 ESTABROOKS,CARNEGIE,+ (MONT+CARL+DURH+SLAC)
MARTIN 78 NP B 134 392 +SHIMADA,BALDI,BOHRINGER,DORSAZ+(DURH+GEVA)

ESTABROO 79 PR D 19 2678 P.ESTABROOKS (CARL)
LANG 79 PR D 19 956 C.B.LANG,A.MAS-PAREREDA (GRAZ)

ASTON 81 PL 106 B 235 +CARNEGIE,DUNWOODIE,DURKIN+(SLAC+CARL+OTTA) JP
TOAFF 81 PR D 23 1500 +MUSGRAVE,AMMAR,DAVIS,ECKLUND,+ (ANL+KANS)

TORNQVIS 82 PRL 49 624 N.A.TORNQVIST (HELS)

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Q(1400) or Q_2

64 Q(1400,JP=1+) I=1/2

SEE MINI-REVIEW UNDER Q(1280)

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64 Q(1400) MASS (MEV)

M		(1420.)		DAVIS	72	HBC	+	12. K+ P	12/72
M		(1368.)	(18.)	FIRESTONE	72	DBC	+	12. K+ D	12/77
M		(1400.)	APPROX.	BRANDENB	76	ASPK	+-	13 K+-P,(KPIPI)P	12/75
M	E	(1404.0)	(10.0)	CARNEGIE	77	ASPK	+-	13 K+-P,P KPIPI	12/77
M		(1400.0)	APPROX.	VERGEEST	79	HBC	+-	4.2 K-P,K PI PI	12/79
M		1415.	15.	ETKIN	80	MPS	0	6 K-P,K0 PI+ PI-	1/82
M		1410.	25.	DAUM	81	CNTR	-	63 K-P,K 2PI P	1/82
M		1392.	18.	BAUBILLIE	82	HBC	0	8.25 K-P,KS 2PIN	9/83*
M	T	(1350.)	APPROX	TORNQVIST	82	RVUE			9/83*
M		. . . . .	. . . . .						
M	AVG	1406.3	10.5	AVERAGE					

M E FROM A MODEL DEPENDENT FIT WITH GAUSSIAN BACKGROUND TO
M E BRANDENBURG 76 DATA.
M T FROM A UNITARIZED QUARK MODEL CALCULATION

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64 Q(1400) WIDTH (MEV)

W		(80.)		DAVIS	72	HBC	+	12. K+ P	12/72
W		(241.)	(30.)	FIRESTONE	72	DBC	+	12. K+ D	12/75
W		(160.)	APPROX.	BRANDENB	76	ASPK	+-	13 K+-P,(KPIPI)P	12/75
W	E	(142.0)	(16.0)	CARNEGIE	77	ASPK	+-	13 K+-P,P KPIPI	12/77
W		(200.0)	APPROX.	VERGEEST	79	HBC	+-	4.2 K-P,K PI PI	12/79
W		180.	10.	ETKIN	80	MPS	0	6 K-P,K0 PI+ PI-	1/82
W		195.	25.	DAUM	81	CNTR	-	63 K-P,K 2PI P	1/82
W		276.	65.	BAUBILLIE	82	HBC	0	8.25 K-P,KS 2PIN	9/83*
W		. . . . .	. . . . .						
W	AVG	183.9	9.2	AVERAGE					

W E SEE NOTE E ABOVE.

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64 Q(1400) PARTIAL DECAY MODES

		DECAY MASSES
P1	Q(1400) INTO K*(892) PI	892+ 140
P2	Q(1400) INTO K RHO	498+ 769
P3	Q(1400) INTO K PI	498+ 140
P4	Q(1400) INTO K ETA	498+ 549
P5	Q(1400) INTO K OMEGA	498+ 783
P6	Q(1400) INTO K PI PI	498+ 140+ 140
P7	Q(1400) INTO KAPPA(1350) PI	1350+ 140
P8	Q(1400) INTO K EPSILON(1300)	498+1300

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64 Q(1400) PARTIAL WIDTHS (MEV)

W1 Q(1400) INTO K*(892) PI (G1)
W1 117.0 10.0 CARNEGIE1 77 ASPK +- 13 K+-P,(KPIPI)P 12/78

W2 Q(1400) INTO K RHO (G2)
W2 2.0 1.0 CARNEGIE1 77 ASPK +- 13 K+-P,(KPIPI)P 12/78

W5 Q(1400) INTO K OMEGA (G5)
W5 23.0 12.0 CARNEGIE1 77 ASPK +- 13 K+-P,(KPIPI)P 12/78

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64 Q(1400) BRANCHING RATIOS

R1 Q(1400) INTO K*(892) PI (P1)
R1 F 0.94 0.06 DAUM 81 CNTR 63 K-P,K 2PI P 1/82

R2 Q(1400) INTO K RHO (P2)
R2 F 0.03 0.03 DAUM 81 CNTR 63 K-P,K 2PI P 1/82

R3 Q(1400) INTO K OMEGA (P5)
R3 F 0.01 0.01 DAUM 81 CNTR 63 K-P,K 2PI P 1/82

R4 Q(1400) INTO KAPPA(1350) PI (P7)
R4 F (0.00) APPROX. DAUM 81 CNTR 63 K-P,K 2PI P 1/82

R5 Q(1400) INTO K EPSILON(1300) PI (P8)
R5 F 0.02 0.02 DAUM 81 CNTR 63 K-P,K 2PI P 1/82

R9 D/S RATIO FOR Q INTO K*(892) PI
R9 F 0.04 0.01 DAUM 81 CNTR 63 K-P,K 2PI P 1/82

R F AVERAGE FROM LOW AND HIGH T DATA.

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REFERENCES FOR Q(1400)

ARMENTER 64 DUBNA CONF 1 577 ARMENTEROS,EDWARDS,D-ANDLAU + (CERN+CDEF)
ALSO 64 DUBNA CONF 1 617 R ARMENTEROS (RAPPORTEUR)
ARMENTER 64 PL 9 207 ARMENTEROS,EDWARDS,D-ANDLAU,+ (CERN+CDEF)
ALSO 66 PR 145 1095 BARASH,KIRSCH,MILLER,TAN (COLUMBIA)

ALMEIDA 65 PL 16 184 ALMEIDA,ATHERTON,BYER,DORNAN,FORSON+ (CAVE)

SHEN 66 PRL 17 726 +BUTTERWORTH,FU,GOLDHABERS,TRILLING (LRL)
ALSO 66 PRIVATE COMM. GERSON GOLDHABER (LRL)

BASSOMPI 67 PL 26B 30 BASSOMPIERRE,GOLDSCHMIDT+ (CERN+BRUX+BIRM)IJP
BERLINGH 67 PRL 18 1087 BERLINGHIERI+FARBER+FERBEL+FORMAN (ROCH)IJP
CRENNELL 67 PRL 19 44 +KALBFLEISCH,LAI,SCARR,SCHUMANN (BNL)I
DE BAERE 67 NC 49A 374 +DEBAISIEUX+FAST+FILIPPAS+ (CERN+BRUX)
ALSO PRIVATE COMMUNICATION BY B. JONGEJANS
GOLDHABE 67 PRL 19 976 G.GOLDHABER (LBL)

BARTSCH 68 NP B8 9 +COCCONI,+ (AACH+BERL+CERN+LOIC+VIEN)
BOMSE 68 PRL 20 1519 +BORENSTEIN,CALLAHAN,COLE,COX,+ (JOHNHOPK) 1+
DENEGRI 68 PRL 20 1194 +CALLAHAN+ETTLINGER+GILLESPIE+ (JOHNHOPK) 1+

ALEXANDE 69 NP B 13 503 G.ALEXANDER,FIRESTONE,GOLDHABER,+ (LRL)
ANDREWS 69 PRL 22 731 +LACH,LUDLAM,SANDWEISS,BERGER,+ (YALE+LRL)
ASTIER 69 NP B 10 65 +MARECHAL,MONTANET,+ (CDEF+CERN+IPNP+LIVP)IJP
BARBARO 69 PRL 22 1207 BARBARO-GALTIERI,DAVIS,FLATTE,+ (LRL)
BETTINI 69 NC 62 A 1038 +CRESTI,LIMENTANI,BERTAUZA,BIGI+(PADO+PISA)I
BISHOP 69 NP B 9 403 +GOSHAW,ERWIN,WALKER (WISC)
CHIEN 69 PL 29B 433 +MALAMUD,MELLEMA,RUDNICK,SCHLEIN+ (UCLA)
CHUNG 69 PR 182 1443 +EISNER+BALI+LUERS (BNL)
COLLEY 69 NC A 59 519 +EASTWOOD,+ (BIRM+GLAS+LOIC+MPIM+OXF+RHEL)
ERWIN 69 NP B 9 364 +WALKER,GOSHAW,WEINBERG (WISC+PRIN+VAND)
FRIEDMAN 69 UCRL-18860 J.FRIEDMAN,PH.D. THESIS (LRL)
WERNER 69 PR 188 2023 +AMMAR,DAVIS,KROPAC,YARGER,CHO,+ (NWES+ANL) 1+

ABRAMS 70 PR D 1 2433 +EISENSTEIN,KIM,MARSHALL,O-HALLORAN,+ (ILL)
ANTICH 70 NP B 20 201 +CARSON,CHIEN,COX,DENEGRI,ETTLINGER,+ (JHU) 1+
BOWLER 70 PL 31 B 318 M.G.BOWLER (OXFORD)
FARBER 70 PR D 1 78 +FERBEL,SLATTERY,YUTA (ROCH) 1+

BARNHAM 71 NP B25 49 +COLLEY,GRIFFITHS,ALPER, + (BIRM+GLAS+OXF)
DENEGRI 71 NP B 28 13 +ANTICH,CALLAHAN,CARSON,CHIEN,COX,+ (JHU) 1+
FORMAN 71 PR D 3 2610 +GELFAND,LEARY,MOSER,SEIDL,WOLFSON (EFI)
GARFINKE 71 PRL 26 1505 GARFINKEL,HOLLAND,CARMONY,LANDER+(PURD+UCD) 1+

ANDERSON 72 PR D 6 1823 +FRANKLIN,GODDEN,KOPELMAN,LIBBY,TAN (COLO)
BINGHAM 72 NP B 48 589 +EISENSTEIN,GRARD,HERQUET,+ (CERN+BRUX)
BRANDENB 72 NP B 45 397 BRANDENBURG,BRODY,JOHNSON,LEITH,LOOS+(SLAC)
BRANDENB 72 PRL 28 932 BRANDENBURG,JOHNSON,LEITH,LOOS,LUSTE+(SLAC)
CRENNELL 72 PR D 6 1220 +GORDON,KWAN-WU LAI,SCARR (BNL)
DAVIS 72 PR D 5 2688 +ALSTON,BARBARO,FLATTE,FRIEDMAN,LYNCH+(LBL)
FIRESTON 72 PR D 5 505 FIRESTONE,GOLDHABER,LISSAUER,TRILLING (LBL)
FIRESTON172 NP B 47 348 A.FIRESTONE (CIT)
FRATI 72 PR D 6 2361 +HALPERN,HARGIS,SNAPE,CARNAHAN,+(PENN+CINC)
HAATUFT 72 NP B 48 78 +ARNOLD,HAGUENAUER,+ (BERG+STRB+EPOL+MADR)

BARLOUTA 73 NP B 59 374 +DREVILLON,SHAH,+ (SACL+EPOL+RHEL) JP
BINGHAM 73 NP B 52 31 +FARWEL,+ (LBL+ORSAY+BNL+SACLAY+MILAN) JP
DE JONGH 73 NP B 58 110 +CORNET,CHARRIERE,+ (BRUX+MONS+CERN+MPIM)
JONES 73 NP B 52 383 G.T.JONES (CERN) JP
LEWIS 73 NP B 60 283 +ALLEN,JACOBS,DANYSZ,BORG,+(LOWC+LOIC+CDEF)
WERNER 73 PR D 7 1275 +SLATTERY,FERBEL (ROCHESTER)

ANGELOPO 74 NC 20A 49 ANGELOPOULOS,FILIPPAS+(ATHU+ATEN+LIVP+VIEN) JP
BOWLER 74 NP B74 493 +DAINTON,KADDOURA,AITCHISON (OXF)
DAVIDSON 74 PR D9 77 +CHAPMAN,GREEN,LYS,ROE (MICH)
DEUTSCHM 74 PL 49B 388 DEUTSCHMANN,+ (AACH+BERL+CERN+LOIC+VIEN) JP

ANTIPOV 75 NP B86 381 +ASCOLI,BUSNELLO,KIENZLE+ (SERP+CERN+ILL) JP
BOWLER 75 NP B97 227 +GAME,AITCHISON,DAINTON (OXF+DARE)
DORE 75 LNC 13 265 +GUIDONI,LAAKSO,MARINI,CONFORTO+(ROMA+RHEL)
DREVILLO 75 PL 55 B 245 DREVILLON,BORENSTEIN+ (EPOL+BOHR+CDEF) JP
DUNWOODI 75 NP B91 189 DUNMOODIE,GRANT+ (CERN+BELG+MONS+MPIM) JP
OTTER1 75 NP B84 333 + (AACH+BERL+CERN+LOIC+VIEN+ATHU+ATEN+LIVP) JP
OTTER2 75 NP B93 365 +RUDOLPH,RUMPF+ (AACH+BERL+CERN+LOIC+VIEN) JP
OTTER3 75 NP B96 29 +RUDOLPH,SEYFERT+(AACH+BERL+CERN+LOIC+VIEN)I,JP
TOVEY 75 NP B95 109 +HANSEN,BORENSTEIN,BORG+ (RHEL+EPOL+SACL)I,JP

BASDEVAN 76 PRL 37 977 BASDEVANT,BERGER (FNAL+ANL)
BOAL 76 PR D 14 2998 +EDWARDS,KAMAL,TORGESON (ALBERTA)
BOWLER 76 JPG 3 775 M.G.BOWLER (OXFORD)
BRANDENB 76 PRL 26 703 BRANDENBURG,CARNEGIE,CASHMORE,DAVIER+(SLAC) JP
OTTER 76 NP B 106 77 + (AACH+BERL+CERN+LOIC+VIEN+LPNP+RHEL+SACL) JP
VERGEEST 76 PL 62 B 471 +ENGELEN,JONGEJANS,+ (AMST+CERN+NIJM+OXF) JP

CARNEGIE 77 NP B 127 509 +CASHMORE,DAVIER,DUNWOODIE,LASINSKI+ (SLAC)
CARNEGIE177 PL B 68 287 +CASHMORE,DUNWOODIE,LASINSKI,+ (SLAC)

BEUSCH 78 PL 74 B 282 +BIRMAN,KONIGS,OTTER,+ (CERN+AACH+ETH) JP
GAVILLET 78 PL 76 B 517 +DIAZ,DIONISI,+ (AMST+CERN+NIJM+OXF) JP
WOHL 78 NP B 132 401 +PALER,CHAURAND,+ (LPNP+RHEL+SACLAY)

BASDEVAN 79 PR D 19 246 BASDEVANT,BERGER (ANL)
MAZZUCAT 79 NP B 156 532 MAZZUCATO,PENNINGTON+ (CERN+ZEEM+NIJM+OXF)
VERGEEST 79 NP B 158 265 +JONGEJANS,DIONISI,+ (NIJM+AMST+CERN+OXF)

BACON 80 NP B 162 189 +BARREY,BUTTERWORTH,ANSORGE,+ (LOIC+CAVE)
DIONISI 80 NP B 169 1 +GAVILLET,ARMENTEROS+ (CERN+MADR+CDEF+STOH)
ETKIN 80 PR D 22 42 +FOLEY,LINDENBAUM,KRAMER,+ (BNL+CUNY) JP
IRVING 80 JPG 6 153 A.C.IRVING (LIVP)
RADFORD 80 NP B 167 181 RADFORD,BRANDENBURG (MIT)

DAUM 81 NP B 187 1 +HERTZBERGER+(AMST+CERN+CRAC+MPIM+OXF+RHEL)
OTTER 81 NP B 181 1 (AACH+BERL+LOIC+VIEN+BIRM+BELG+CERN+MONS)
RODEBACK 81 ZPHY C 9 9 +SJOGREN,ARMENTEROS,+ (CERN+CDEF+MADR+STOH)

BAUBILLI 82 NP B 202 21 BAUBILLIER+ (BIRM+CERN+GLAS+MSU+LPNP)
FERNANDE 82 ZPHY C 16 95 FERNANDEZ,AGUILAR+ (MADR+CERN+CDEF+STOH)
TORNQVIS 82 NP B 203 268 TORNQVIST (HELS)

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Mesons

K(1400) [K′], K*(1430)

Data Card Listings

K(1400) or K′

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21  K(1400,JP=0-) I=1/2

FORMERLY CALLED K PRIME.
OBSERVED IN K PI PI PARTIAL-WAVE ANALYSIS.
NOT SEEN BY VERGEEST 79.
WAIT CONFIRMATION. OMITTED FROM TABLE.

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                    21  K(1400) MASS (MEV)

M  A      (1400.)   APPROX.          BRANDENBU 76 ASPK +- 13 K+-P,KPIPI    12/77
M         (1460.)   APPROX.          DAUM      81 CNTR -  63 K-P,K 2PI P    1/82

M  A      COUPLED MAINLY TO K EPSILON(1300). DECAY INTO K*(892) PI SEEN.
M

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                    21  K(1400) WIDTH (MEV)

W  A       (250.)   APPROX.          BRANDENBU 76 ASPK +- 13 K+-P,KPIPI    12/77
W          (260.)   APPROX.          DAUM      81 CNTR -  63 K-P,K 2PI P    1/82

W  A      COUPLED MAINLY TO K EPSILON(1300). DECAY INTO K*(892) PI SEEN.

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                    21  K(1400) PARTIAL DECAY MODES

                                                          DECAY MASSES
P1      K(1400) INTO K*(892) PI                          892+ 140
P2      K(1400) INTO K RHO                               494+ 769
P3      K(1400) INTO KAPPA(1350) PI                     1350+ 140

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                    21  K(1400) PARTIAL WIDTHS (MEV)

W1      K(1400) INTO K*(892) PI                          (G1)
W1         (109.)   APPROX.          DAUM      81 CNTR    63 K-P,K 2PI P    1/82

W2      K(1400) INTO K RHO                               (G2)
W2          (34.)   APPROX.          DAUM      81 CNTR    63 K-P,K 2PI P    1/82

W3      K(1400) INTO KAPPA(1350) PI                      (G3)
W3         (117.)   APPROX.          DAUM      81 CNTR    63 K-P,K 2PI P    1/82

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                        REFERENCES FOR K(1400)

BRANDENB 76 PRL 36 1239        BRANDENBURG,CARNEGIE,CASHMORE,DAVIER+(SLAC)  JP

VERGEEST 79 NP B 158 265       +JONGEJANS,DIONISI,+   (NIJM+AMST+CERN+OXF)

DAUM     81 NP B 187 1         +HERTZBERGER+(AMST+CERN+CRAC+MPIM+OXF+RHEL)

BARNES   82 PL 116 B 365       T.BARNES AND F.E.CLOSE                (RHEL)
TANIMOTO 82 PL 116 B 198       M.TANIMOTO                            (BIEL)

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K*(1430)

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22  K*(1430,JP=2+) I=1/2

WE CONSIDER THAT PHASE-SHIFT ANALYSES PROVIDE MORE
RELIABLE DETERMINATIONS OF THE MASS AND WIDTH.
SEE RHO(770) MINI-REVIEW.

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                    22  K*(1430) MASS (MEV)

M   CHARGED ONLY, WITH FINAL STATE K PI
M    D  39 1423.      11.0            BASSANO   67 HBC   - 4.6-5.0K-P,K0PI-  12/75
M    D  63 1427.0     12.0            SCHWEINGR 68 HBC   -  5.5 K- P (K PI)  12/77
M      220 1416.0     10.0            CRENNELL  69 DBC   -  3.9 K-N (K0PI-)   7/69
M    D  60 1414.      13.0            LIND      69 HBC  +   9. K+ P(K0 PI+)  12/77
M     1400 1420.0      3.1            AGUILAR1  71 HBC   -  3.9,4.6 K- P     11/71
M  W D 225 1425.       8.0            BARNHAM   71 HBC  +  K+ P,K0 PI+ P     12/75
M    B     1428.0      4.6            MARTIN    78 SPEC + 10 K+-P,KS PI P N
M    B     1423.8      4.6            MARTIN    78 SPEC - 10 K+-P,KS PI P N
M    D 579(1448.5)    (5.0)           DELFOSSE  81 SPEC +  K+-P,K+- PI0 P     1/82
M    D 292(1431.8)    (5.6)           DELFOSSE  81 SPEC -  K+-P,K+- PI0 P     1/82
M      935 1423.0      5.0            TOAFF     81 HBC  -  6.5 K-P,K0 PI- P   1/82
M  W D 400 1436.       5.5            CLELAND   82 SPEC + 30 K+P,KS PI+P      8/83*
M  W D1500 1430.       3.2            CLELAND   82 SPEC + 50 K+P,KS PI+P      8/83*
M  W D1200 1430.       3.2            CLELAND   82 SPEC - 50 K+P,KS PI-P      8/83*
M
M   AVG    1426.3      1.5     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.1)

M   NEUTRAL ONLY
M     2200 1421.1      2.6            DAVIS     69 HBC    0 12. K+ P(K+PI-)  9/69
M     1800 1419.1      3.7            AGUILAR1  71 HBC    0 3.9,4.6 K- P     11/71
M      600 1416.       6.             CORDS     71 DBC   0 9. K+ N,K+ PI- P  2/72
M     1100 1427.       3.             BUCHNER   72 DBC   0 4.6 K+ N,K+ PI-P  12/72
M    C     1420.1      4.3            LINGLIN   73 HBC   0 2-13 K+P,K+PI-    12/75
M      800 1421.6      4.2            MCCUBBIN  75 HBC    0 3.6 K-P,K-PI+N   12/75
M    E    (1423.0)    (3.0)           ETKIN     76 SPEC   06.K-P,K0 PI+PI-   7/77
M      300 1420.0      7.0            HENDRICKX 76 DBC     8.25 K+N,K+PI     7/77
M  P      1440.0      10.0            BOWLER    77 DBC   0 5.5 K+D,K PI P P  12/77
M    P    (1434.0)    (2.0)           ESTABROOK 78 ASPK  0 13K+-P,P K PI     12/77
M          1450.      30.             ETKIN     80 SPEC  0 6.K-P,K0 PI+PI-N  3/82
M          1428.       3.             ASTON     81 LASS  0 11 K-P,K- PI+ N   1/82
M    P    (1471.)    (12.)            BAUBILLIE 82 HBC   0 8.25 K-P,KS 2PIN  9/83*
M
M   AVG    1423.2      1.5     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.2)

M    B  SYSTEMATIC ERROR ADDED BY US.
M    C  FROM POLE EXTRAPOLATION, USING WORLD K+P DST
M    D  ERRORS ENLARGED BY US TO   GAMMA/SQRT(N). SEE TYPED NOTE ON K*(892)
M    E  SEE MORE RECENT PARTIAL WAVE ANALYSIS (ETKIN 80)
M    P  FROM PHASE SHIFT OR PARTIAL WAVE ANALYSIS.
M    W  NUMBER OF EVENTS IN PEAK REEAVALUATED BY US

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                    22  K*(1430) WIDTH (MEV)

W   CHARGED ONLY, WITH FINAL STATE K PI
W     1400   94.7     15.1     12.5   AGUILAR1  71 HBC   -  3.9,4.6 K- P     11/71
W            96.5      3.8            MARTIN    78 SPEC +  10 K+-P,KS PI P   12/78
W            97.7      4.0            MARTIN    78 SPEC -  10 K+-P,KS PI P   12/78
W    D 579  118.9     20.0            DELFOSSE  81 SPEC +  K+-P,K+- PI0 P     1/82
W    D 292   96.0     22.5            DELFOSSE  81 SPEC -  K+-P,K+- PI0 P     1/82
W      935   85.0     16.0            TOAFF     81 HBC  -  6.5 K-P,K0 PI- P   1/82
W  W D 400  109.      22.             CLELAND   82 SPEC + 30 K+P,KS PI+P      8/83*
W  W D1500  124.      12.8            CLELAND   82 SPEC + 50 K+P,KS PI+P      8/83*
W  W D1200  113.      12.8            CLELAND   82 SPEC - 50 K+P,KS PI-P      8/83*
W
W   AVG     98.8      2.5     AVERAGE

W   NEUTRAL ONLY
W     2200  101.      10.             DAVIS     69 HBC    0 12. K+ P (K PI)  9/69
W     1800  116.6     10.3     15.5   AGUILAR1  71 HBC    0 3.9,4.6 K- P     11/71
W    D1100  109.      14.0            BUCHNER   72 DBC   0 4.6 K+ N,K+ PI-P  12/75
W    C      (61.0)   (14.0)           LINGLIN   73 HBC   0 2-13 K+P,K+PI-    1/74
W      800  116.      18.             MCCUBBIN  75 HBC    0 3.6 K-P,K-PI+N   12/75
W  P       (170.0)   (20.0)           BOWLER    77 DBC   0 5.5 K+D,K PI P P  12/77
W  P        (98.0)    (5.0)           ESTABROOK 78 ASPK  0 13K+-P,P K PI     12/77
W  P        140.      30.             ETKIN     80 SPEC  0 6.K-P,K0 PI+PI-N  3/82
W           98.        8.             ASTON     81 LASS  0 11 K-P,K- PI+ N   1/82
W   P      (143.)    (34.)            BAUBILLIE 82 HBC   0 8.25 K-P,KS 2PIN  9/83*
W
W   AVG    105.3      4.9     AVERAGE

W   C   FROM POLE EXTRAPOLATION, USING WORLD K+P DST
W    D  ERRORS ENLARGED BY US TO 4*GAMMA/SQRT(N). SEE K*(892) TYPED NOTE.
W   P   FROM PHASE SHIFT OR PARTIAL WAVE ANALYSIS.
W   W   NUMBER OF EVENTS IN PEAK REEAVALUATED BY US

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                    22  K*(1430) PARTIAL DECAY MODES

                                                          DECAY MASSES
P1      K*(1430) INTO K PI                               494+ 140
P2      K*(1430) INTO K*(892) PI                         892+ 140
P3      K*(1430) INTO K RHO                              494+ 769
P4      K*(1430) INTO K OMEGA                            494+ 783
P5      K*(1430) INTO K ETA                              494+ 549
P6      K*(1430) INTO K*(892) PI PI                      892+ 140+ 140
P7      K*(1430) INTO K OMEGA PI                         494+ 783+ 140
P8      K*(1430) INTO K GAMMA                            494+   0

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FITTED PARTIAL DECAY MODE BRANCHING FRACTIONS

The matrix below is derived from the error matrix for the fitted partial decay mode branching fractions, P_i, as follows: The diagonal elements are $P_i \pm \delta P_i$, where $\delta P_i = \sqrt{\langle \delta P_i \delta P_i \rangle}$, while the off-diagonal elements are the normalized correlation coefficients $\langle \delta P_i \delta P_j \rangle / (\delta P_i \cdot \delta P_j)$. For the definitions of the individual P_i, see the listings above; only those P_i appearing in the matrix are assumed in the fit to be nonzero and are thus constrained to add to 1.

	P 1	P 2	P 3	P 4	P 5	P 6
P 1	.4479+-.0225					
P 2	.0734	.2455+-.0198				
P 3	.0193	.5320	.0883+-.0099			
P 4	-.1591	-.2417	-.1909	.0415+-.0152		
P 5	-.4419	-.4449	-.3453	-.0922	.0470+-.0265	
P 6	-.3919	-.4399	-.3434	-.0991	-.1164	.1298+-.0255

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                    22  K*(1430) PARTIAL WIDTHS

W8      K*(1430) INTO K GAMMA (KEV)                      (G8)
W8         240.      45.             CIHANGIR  82 SPEC +  200 PI+Z,Z A2      9/83*

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                    22  K*(1430) BRANCHING RATIOS

R1      K*(1430) INTO (K PI)/TOTAL                       (P1)
R1 P          0.49      0.02          ESTABROOK 78 ASPK +- 13K+-P,P K PI     12/77
R1 P          0.43      0.01          ASTON     81 LASS  0 11 K-P,K- PI+ N   1/82
R1 P    FROM PHASE SHIFTS ANALYSIS.
R1
R1  AVG       0.442     0.024   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 2.7)
R1  FIT       0.448     0.023  FROM FIT (ERROR INCLUDES SCALE FACTOR OF 2.7)

R2      K*(1430) INTO (K*(892) PI)/(K PI + K PI PI)      (P2)/(P1+P2+P3)
R2  QR       (0.45)    (0.13)          BADIER    65 HBC   -  3.0 K-P          1/78
R2  Q        (0.47)    (0.10)          BASSANO   67 HBC   -0 4.6, 5.0 K- P   10/67

R3      K*(1430) INTO (K RHO)/(K PI + K PI PI)           (P3)/(P1+P2+P3)
R3  QR       (0.14)    (0.07)          BADIER    65 HBC   -  3.0 K-P          1/78
R3  Q        (0.14)    (0.10)          BASSANO   67 HBC   -0 4.6, 5.0 K- P   10/67

R4      K*(1430) INTO (K*(892) PI) / (K PI)              (P2)/(P1)
R4           0.65      0.20            SHEN      66 HBC    0  N* PRODUCED     10/66
R4  Q       (0.63)    (0.20)           SHEN      66 HBC  +    NO N* PRODUCED  10/66
R4           0.52      0.12            SCHWEINGR 68 HBC    0 4.1+5.5 K- P     10/67
R4  Q   84  (0.93)    (0.11)           BISHOP    69 HBC      3.5 K+ P          9/69
R4           0.47      0.08            AGUILAR1  71 HBC      3.9,4.6 K- P     11/71
R4 AQ  150  (0.65)    (0.25)           ANTIPOV   75 ASPK  - 40 K-P,K*- P      12/75
R4           0.54      0.16            DEHM      74 DBC   0 4.6 K+ N          12/75
R4           0.62      0.19            LAUSCHER  75 HBC    010,16 K-P,K-PI+N  12/75
R4 A    K*(892) PI SIGNAL FROM PARTIAL WAVE ANALYSIS OF (K-PI+PI-) SYSTEM
R4
R4  AVG      0.517     0.056   AVERAGE
R4  FIT      0.548     0.050  FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.2)

R5      K*(1430) INTO (K OMEGA) / K PI                   (P4)/(P1)
R5   R       0.19      0.16            BADIER    65 HBC   -  3.0 K-P          1/78
R5          (0.08) OR LESS            SHEN      66 HBC     4.6 K+P           8/66
R5          (0.2)  OR LESS            BASSOMPIE 69 HBC   +  5 K+ P           9/69
R5           0.13      0.07            BASSOMPIE 69 HBC    0 5 K+ P          9/69
R5           0.05      0.04            AGUILAR1  71 HBC      3.9-4.6 K- P     11/71
R5          (0.2)  OR LESS  CL=.95    CHUNG     74 HBC   - 7.3 K-P,K*- P     12/75
R5
R5  AVG      0.075     0.034   AVERAGE
R5  FIT      0.093     0.035  FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.1)
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```
R6      K*(1430) INTO (K RHO) / (K PI)                      (P3)/(P1)
R6            (0.09) OR LESS          CHUNG     65 HBC  + 0  3.9-4.2 PI- P    8/66
R6             0.26      0.16         SCHWEINGR 68 HBC   0 4.1+5.5 K- P     10/67
R6            (0.2)  OR LESS          BASSOMPIE 69 HBC  +   5 K+ P           9/69
R6            (0.3)  OR LESS          BASSOMPIE 69 HBC   0 5 K+ P            9/69
R6  Q    15   (0.11)    (0.06)        BISHOP    69 HBC      3.5 K+ P         9/69
R6             0.16      0.05         AGUILAR1  71 HBC      3.9,4.6 K- P    11/71
R6             0.02      0.10    0.02 DEHM      74 DBC   0 4.6 K+ N         12/75
R6            . . . . . . . . . .
R6  AVG        0.111     0.054   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.4)
R6  FIT        0.197     0.024  FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.3)
                        (SEE IDEOGRAM BELOW)
R6  S   USES RESULTS OF OTTER 75 (SEE R7 BELOW). WE DO NOT AVERAGE THIS
R6  S   STATISTICALLY REDUNDANT RATIO, BUT KEEP THE LAUSCHER 75 RESULT
R6  S   FOR R4 ABOVE.
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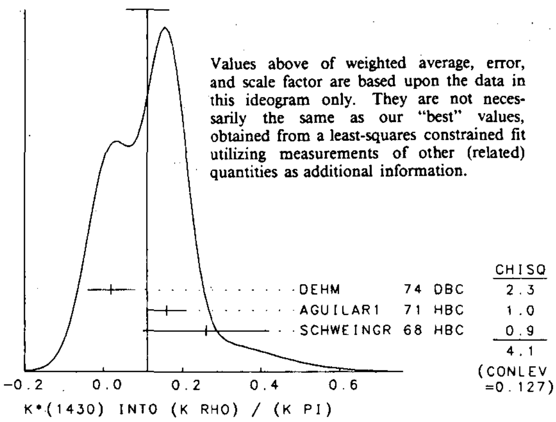
WEIGHTED AVERAGE = 0.111 ± 0.054
ERROR SCALED BY 1.4

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R7      K*(1430) INTO (K RHO) / (K*(892) PI)                (P3)/(P2)
R7            (0.39) OR LESS          BASSOMPIE 67 HBC  +   5. K+ P          9/67
R7            (0.40) OR LESS  CL=.90  FIELD     67 HBC  - 3.8 K- P           6/67
R7 P   130     0.13      0.09         OTTER     75 HBC   08,10,16 K-P,K* N 12/75
R7 AN         (0.03)    (0.03)        ANTIPOV   75 ASPK - 40 K-P,K*- P     12/75
R7 P           0.36      0.10         VERGEEST  76 HBC  0 4.2 K-P,P KOPIPI 12/77
R7 P          (0.33) APPROX.          ETKIN     80 SPEC 0 6.K-P,KO PI+PI-N  3/82
R7             0.39      0.03         DAUM      81 CNTR   63 K-P,K 2PI P    1/82
R7             0.38      0.09         BAUBILLIE 82 HBC  0 8.25 K-P,KS 2PIN  9/83*
R7            (0.20)     APPROX.      FERNANDEZ 82 HBC   -4 PI-P,LAM K 2PI  9/83*
R7            . . . . . . . . . .
R7  AVG        0.365     0.042   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.6)
R7  FIT        0.360     0.035  FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.4)
                        (SEE IDEOGRAM BELOW)
R7  N   K RHO MODE NOT OBSERVED
R7 A    FROM PARTIAL WAVE ANALYSIS OF (K-PI+PI-) SYSTEM
R7 P    FROM PARTIAL WAVE ANALYSIS OF (KO PI+ PI-) SYSTEM
```
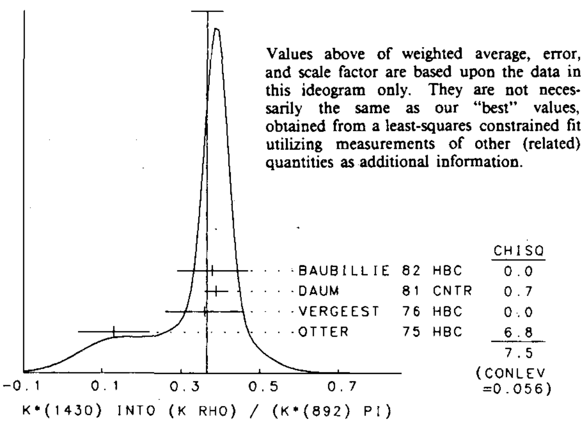

WEIGHTED AVERAGE = 0.365 ± 0.042
ERROR SCALED BY 1.6

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R8      K*(1430) INTO (K OMEGA) / (K*(892) PI)              (P4)/(P2)
R8  Q         (0.10)    (0.04)        FIELD     67 HBC  - 3.8 K- P           6/67

R9      K*(1430) INTO (K ETA) / (K*(892) PI)                (P5)/(P2)
R9  Q         (0.07)    (0.04)        FIELD     67 HBC  - 3.8 K- P           6/67

R10     K*(1430) INTO (K ETA) / (K PI)                      (P5)/(P1)
R10  R         0.05      0.06         BADIER    65 HBC  -   3.0 K-P          1/78
R10  R        (0.065)OR LESS          BASSOMPIE 69 HBC      5.0 K+P          1/78
R10           (0.02) OR LESS          BISHOP    69 HBC      3.5 K+ P         9/69
R10           (0.04) OR LESS  CL=.95  AGUILAR1  71 HBC      3.9-4.6 K- P    11/71
R10           . . . . . . . . . .
R10 FIT        0.105     0.062  FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.2)

R11     K*(1430) INTO (K*(892) PI PI)/TOTAL                 (P6)
R11T           0.12      0.04         GOLDBERG  76 HBC  -   3 K-P,P KOPIPIPI 12/77
R11           . . . . . . . . . .
R11 FIT        0.130     0.026  FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.1)

R12     K*(1430) INTO (K*(892) PI PI)/(K PI)                (P6)/(P1)
R12T R         0.21      0.08            JONGEJANS 78 HBC  -  4K-P,P KOOPIPIPI  4/78
R12           . . . . . . . . . .
R12 FIT        0.290     0.064  FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.2)

R13     K*(1430) INTO (K OMEGA PI)/TOTAL  (UNITS 10**-3) (P7)
R13       0   (0.72) OR LESS  CL=0.95  JONGEJANS 78 HBC     4 K-P,P KO 4PI     4/78

R   Q   FOLLOWING SUGGESTION BY AGUILAR 70, WE DO NOT MAKE USE OF MEASURE-
R   Q   MENTS WHERE THE (K PI PI) BACKGROUND SUBTRACTION IS DIFFICULT DUE
R   Q   TO THE NEARBY Q REGION.
R    R  RESTATED BY US.
R   T   ASSUMING PI PI SYSTEM HAS ISO-SPIN 1, WHICH IS SUPPORTED BY
R   T   THE DATA

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REFERENCES FOR K*(1430)


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BADIER    65 PL 19 612          BADIER,DEMOULIN,GOLDBERG+  (EPOL+SACL+AMST)
CHUNG     65 PRL  15  325       +DAHL,HARDY,HESS,JACOBS,KIRZ,MILLER   (LRL)
FOCARDI   65 PL 16 351          FOCARDI,MINGUZZI RANZI,SERRA+(BOLOGNA+SACL)

SHEN      66 PRL  17  726       +BUTTERWORTH,FU,GOLDHABERS,TRILLING   (LRL)
   ALSO   66  PRIVATE COMM.    GERSON GOLDHABER                       (LRL)

BASSANO   67 PRL  19  968       +GOLDBERG,GOZ,BARNES,LEITNER+(BNL+SYRACUSE)
BASSOMPI  67 PL 26B 30          BASSOMPIERRE,GOLDSCHMIDT+  (CERN+BRUX+BIRM)IJP
CRENNELL  67 PRL 19  44         +KALBFLEISCH,LAI,SCARR,SCHUMANN       (BNL)
DAHL      67 PR 163 1377        +HARDY+HESS+KIRZ+MILLER               (LRL)
   ALSO   65 PRL 14 401         HARDY,CHUNG,DAHL,HESS,KIRZ,MILLER     (LRL)
DE BAERE  67 NC 51 A 401        +GOLDSCHMIDT-CLERMONT,HENRI+    (BRUX+CERN)
FIELD     67 PL 24B 638         +HENDRICKS+PICCIONI+YAGER         (LAJOLLA)
GOLDHABE  67 PRL 19  972        G.GOLDHABER,FIRESTONE,SHEN            (LRL)

ADERHOLZ  68 NP B 5  567        +DEUTSCHMANN+  (AACH+BERL+CERN+LOIC+VIENNA)
   ALSO   66 PL 22 357          BARTSCH,DEUTSCHMANN,MORRISON+   (ABCL(IC)V)
ANTICH    68 PRL 21 1842       +CALLAHAN,CARSON,COX,DENEGRI,+         (JHU)
DUBAL     68 THESIS    1456     L.DUBAL                            (GENEVE)
KANG      68 PR 176 1587        Y.W.KANG                             (IOWA)
SCHWEING  68 PR 166 1317        SCHWEINGRUBER,DERRICK,FIELDS+   (ANL+NWES)
   ALSO   67  THESIS            F.L.SCHWEINGRUBER  (NORTHWESTERN,EVANSTON)

BASSOMPI  69 NP  B13 189        BASSOMPIERE,GOLDSCHMIDT-CLERM.+ (CERN+BRUX) JP
BISHOP    69 NP B 9 403         +GOSHAW,ERWIN,WALKER                 (WISC)
CRENNELL  69 PRL 22  487        +KARSHON,LAI,ONEALL,SCARR             (BNL)
DAVIS     69 PRL 23 1071        +DERENZO,FLATTE,ALSTON,LYNCH,SOLMITZ  (LRL)
DE BAERE  69 NC 61 A 397        +GOLDSCHMIDT-CLERMONT,HENRI,+   (BELG+CERN)
FRIEDMAN  69  UCRL-18860        J.FRIEDMAN,PH.D. THESIS               (LRL)
LIND      69 NP B 14 1          +ALEXANDER,FIRESTONE,FU,GOLDHABER     (LRL) JP

ABRAMS    70 PR D 1 2433        +EISENSTEIN,KIM,MARSHALL,O.HALLORAN,+ (ILL)
AGUILAR   70 PRL 25 1362        AGUILAR-BENITEZ,BASSANO,EISNER,+ (BNL+PURD)

AGUILAR1  71 PR D 4 2583        +EISNER,KINSON                        (BNL)
BARNHAM   71 NP B 28 171        +COLLEY,JOBES,GRIFFITHS,HUGHES,+(BIRM+GLAS)
CORDS     71 PR D 4 1974        +CARMONY,ERWIN,MEIERE,+     (PURD+UCD+IUPU)

BUCHNER   72 NP B 45 333        +DEHM,CHARRIERE,CORNET,+   (MPIM+CERN+BRUX)
CRENNELL  72 PR D 6 1220        +GORDON,KWAN-WU LAI,SCARR             (BNL)
DEUTSCHM  72 NP B 36 373        DEUTSCHMANN,+           (ABCLV COLLABORATION)
ENGELMAN  72 PR D 5 2162        ENGELMANN,MUSGRAVE,FORMAN,+       (ANL+EFI)
FRATI     72 PR D 6 2361        +HALPERN,HARGIS,SNAPE,CARNAHAN,+(PENN+CINC)
ROUGE     72 NP B 46 29         +VIDEAU,VOLTE,DE BRION,+        (EPOL+SACL)
TIECKE    72 NP B 39 596        +GRIJNS,HEINEN,DE GROOT,+       (NIJM+AMST)

CHARRIER  73 NP B 51 317        CHARRIERE,DRIJARD,DE BAERE,+    (CERN+BELG)
   ALSO   75  PRIVATE COMM.     GOLDSCHMIDT-CLERMONT                 (CERN)
CLARK     73 NP B 54 432        +LYONS,RADOJICIC                   (OXFORD)
DE JONGH  73 NP B 58 110        +CORNET,CHARRIERE,+  (BRUX+MONS+CERN+MPIM)
LINGLIN   73 NP B 55 408        D.LINGLIN                            (CERN)
WALUCH    73 PR D 8 2837        +FLATTE,FRIEDMAN                      (LBL)

CHUNG     74 PL 51B 413         +EISNER,PROTOPOPESCU,SAMIOS,STRAND    (BNL)
DEHM      74 NP B75 47          +GOEBEL,WITTEK,WOLF,+ (MPIM+BRUX+MONS+CERN)

ANTIPOV   75 NP B86 381         +ASCOLI,BUSNELLO,KIENZLE+    (SERP+CERN+ILL)
LAUSCHER  75 NP B86 189         +OTTER,WIECZOREK,+   (ABCLV COLLABORATION)  JP
MCCUBBIN  75 NP B86 13          N.A.MCCUBBIN,L.LYONS                  (OXF)
OTTER     75 NP B84 333         + (AACH+BERL+CERN+LOIC+VIEN+ATHU+ATEN+LIVP)

ETKIN     76 PRL 36 1482        +FOLEY,GOLDMAN,LINDENBAUM,KIM,+  (BNL+CUNY)
GOLDBERG  76 LNC 17 253         J.GOLDBERG                          (HAIFA)
HENDRICK  76 NP B 112 189       +VIGNAUD,BURLAUD,+     (MONS+SACL+LPNP+BELG)
KIRK      76 NP B 116 99        +KLEIN,COUNIHAN,+(AACH+BERL+CERN+LOIC+WIEN)
VERGEEST  76 PL 62 B 471        +ENGELEN,JONGEJANS,+  (AMST+CERN+NIJM+OXF)  JP

BOWLER    77 NP B 126  31       +DAINTON,DRAKE,WILLIAMS            (OXFORD)

BALDI     78 NP B 134 365       +BOHRINGER,DORSAZ,HUNGERBUHLER+      (GEVA)
BOHM      78 PRL 41 1761        +VAN DALEN,+ (AACH,UCR+CERN+HARV+MUNI+NWES)
ENGELEN   78 NP B 134 14        +JONGEJANS,HEMINGWAY,+ (NIJM+ZEEM+CERN+OXF)
ESTABROO  78 NP B 133 490       ESTABROOKS,CARNEGIE,+ (MONT+CARL+DURH+SLAC)
   ALSO   78 PR D 17 658        ESTABROOKS,CARNEGIE+  (MONT+CARL+DURH+SLAC)
JONGEJAN  78 NP B 139 383       JONGEJANS,CERRADA,+    (ZEEM+CERN+NIJM+OXF)
MARTIN    78 NP B 134 392       +SHIMADA,BALDI,BOHRINGER,DORSAZ+(DURH+GEVA)

ETKIN     80 PR D 22 42         +FOLEY,LINDENBAUM,KRAMER,+       (BNL+CUNY)  JP

ASTON     81 PL 106 B 235       +CARNEGIE,DUNWOODIE,DURKIN+(SLAC+CARL+OTTA)  JP
DAUM      81 NP B 187 1         +HERTZBERGER+(AMST+CERN+CRAC+MPIM+OXF+RHEL)
DELFOSSE  81 NP B 183 349       +GUISAN,MARTIN,MUHLEMANN,WEILL,+(GEVA+LAUS)
TOAFF     81 PR D 23 1500       +MUSGRAVE,AMMAR,DAVIS,ECKLUND,+  (ANL+KANS)

BAUBILLI  82 NP B 202 21        BAUBILLIER+        (BIRM+CERN+GLAS+MSU+LPNP)
CIHANGIR  82 PL 117 B 123       +BERG,BIEL,CHANDLEE,FERBEL+(FNAL+MINN+ROCH)
CLELAND   82 NP B 208 189       +DELFOSSE,DORSAZ,GLOOR(DURH+GEVA+LAUS+PITT)
FERNANDE  82 ZPHY C 16 95       FERNANDEZ,AGUILAR+    (MADR+CERN+CDEF+STOH)
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L(1580) →

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39  L(1580,JP=2-) I=1/2

SEEN IN PARTIAL WAVE ANALYSIS OF THE K-PI+PI- SYSTEM
(OTTER 78). SEE L(1770) MINIREVIEW.
NEED CONFIRMATION OMITTED FROM TABLE.

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                    39  L(1580) MASS (MEV)

M         (1580.)   APPROX.          OTTER    79       -  10,14,16 K- P    12/79

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Mesons

L(1580), K*(1650), L(1770)

Data Card Listings

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                    39  L(1580) WIDTH (MEV)
W          (110.)   APPROX.          OTTER     79      -  10,14,16 K- P    12/79

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                    39  L(1580) PARTIAL DECAY MODES

                                                          DECAY MASSES
P1      L(1580) INTO K*(892) PI                          892+ 140
P2      L(1580) INTO K*(1430) PI                        1425+ 140

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                    39  L(1580) BRANCHING RATIOS
W1      L(1580) INTO K*(892) PI                         (P1)
W1          SEEN                  OTTER     79 HBC  -  10,14,16 K- P    12/79

W2      L(1580) INTO K*(1430) PI                        (P2)
W2          POSSIBLY SEEN         OTTER     79 HBC  -  10,14,16 K- P    12/79

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                          REFERENCES FOR L(1580)

OTTER    79 NP B 147 1        +RUDOLPH,+       (AACH+BERL+CERN+LOIC+WIEN)  JP

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K*(1650) → 29 K*(1650,JP=1-) I=1/2

THIS ENTRY CONTAINS VARIOUS PEAKS OBSERVED IN THE 1- WAVE OF THE K PI AND K PI PI SYSTEMS. WAIT CONFIRMATION.OMITTED FROM TABLE.

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                    29  K*(1650) MASS (MEV)

M         (1660.)                 CHARRIERE 73 HBC   0 5. K+ P,K P 3PI   1/73
M         (1650.)   APPROX.       ESTABROOK 78 ASPK  0 13 K+-P,K+-PI+-N 12/78
M          1500.      30.         ETKIN     80 MPS   0 6 K-P,K0 PI+ PI-  1/82
M          1800.      70.         ETKIN     80 MPS   0 6 K-P,K0 PI+ PI-  1/82
M         (1700.)   APPROX.        ASTON     81 LASS  0 11 K-P,K- PI+ N  1/82
M          1474.      25.         BAUBILLIE 82 HBC   0 8.25 K-P,KS 2PIN  9/83*
M          . . . . . . . . .
M   AVERAGE MEANINGLESS (SCALE FACTOR = 3.1)

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                    29  K*(1650) WIDTH (MEV)

W          (60.)                   CHARRIERE 73 HBC   0 5. K+ P,K P 3PI   1/73
W          250-300 APPROX.          ESTABROOK 78 ASPK  0 13 K+-P,K+-PI+-N 12/78
W          170.       30.          ETKIN     80 MPS   0 6 K-P,K0 PI+ PI-  1/82
W          500.      100.          ETKIN     80 MPS   0 6 K-P,K0 PI+ PI-  1/82
W         (200.)   APPROX.         ASTON     81 LASS  0 11 K-P,K- PI+ N  1/82
W          275.       65.          BAUBILLIE 82 HBC   0 8.25 K-P,KS 2PIN  9/83*
W          . . . . . . . . .
W   AVERAGE MEANINGLESS (SCALE FACTOR = 2.4)

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                    29  K*(1650) PARTIAL DECAY MODES

                                                          DECAY MASSES
P1      K*(1650) INTO K PI                               498+ 135
P2      K*(1650) INTO K ETA                              498+ 549

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                    29  K*(1650) BRANCHING RATIOS
R1      K*(1650) INTO (K PI)/TOTAL                      (P1)
R1          (0.35) APPROX.        ASTON     81 LASS  0 11 K-P,K- PI+ N  1/82

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                          REFERENCES FOR K*(1650)

CHARRIER 73 NP B 51 317       CHARRIERE,DRIJARD,DE BAERE,+     (CERN+BELG)

ESTABROO 78 NP B 133 490      ESTABROOKS,CARNEGIE,+ (MONT+CARL+DURH+SLAC)

ETKIN    80 PR D 22 42        +FOLEY,LINDENBAUM,KRAMER,+       (BNL+CUNY)  JP

ASTON    81 PL 106 B 235      +CARNEGIE,DUNWOODIE,DURKIN+(SLAC+CARL+OTTA)  JP

BAUBILLI 82 NP B 202 21       BAUBILLIER+       (BIRM+CERN+GLAS+MSU+LPNP)

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L(1770) 23 L(1770, JP=2-) I = 1/2

The L(1770) is seen as a bump at a mass ~1.8 GeV in the diffractive-like processes KN → (Kππ)N. The effect is largely dominated by the $J^P=2^-$ partial waves.

The long-standing questions concerning the resonant nature of the enhancement as well as its possible decay modes have been largely clarified. A detailed partial-wave analysis based on 200,000 diffractive $K^-p \rightarrow K^-\pi^+\pi^-p$ events (DAUM 81) establishes resonance-like phase variations and isolates several decay modes. The behavior of the extracted 2^- waves requires the existence of at least one L meson, but there are indications suggesting the presence of a second state in this mass region.

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                    23  L(1770) MASS (MEV)

M          1745.0     20.0          AGUILAR   70 HBC   -  4.6 K- P        6/70
M          1780.0     15.0          BARTSCH   70 HBC   -  10.1 K- P       1/71
M         (1760.0)   (15.0)         LUDLAM    70 HBC   -  12.6 K- P       1/73
M   X      1765.0     40.0          COLLEY    71 HBC  + 10.K+P,K 2PI      1/73
M         (1740.0)                  DENEGRI   71 DBC   - 12.6 K-D,K 2PI D  5/71
M          1767.       6.           BLIEDEN   72 MMS  -  11.-16. K- P    12/72
M   P  306 1730.      20.           FIRESTONE 72 DBC  +  12. K+ D         1/73
M       60 1710.      15.           CHUNG     74 HBC   - 7.3K-P,K-OMEGA P 12/75
M         (1820.)   APPROX.         DAUM      81 CNTR -  63 K-P,K 2PI P   1/82
M         (1730.)   APPROX.         ARMSTRONG 83 OMEG -  18.5 K-P,3K P    9/83*
M          . . . . . . . . .
M   AVG    1758.9     10.0     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 2.1)
                        (SEE IDEOGRAM BELOW)

M  P    PRODUCED IN CONJUNCTION WITH EXCITED DEUTERON.
M  X    SYSTEMATIC ERRORS ADDED CORRESP. TO SPREAD OF DIFFERENT FITS.
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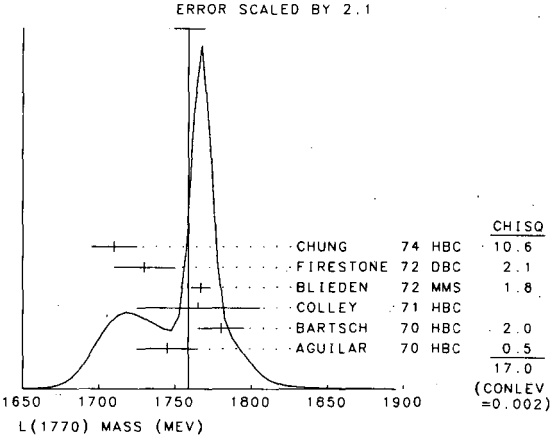
WEIGHTED AVERAGE = 1758.9 ± 10.0
ERROR SCALED BY 2.1

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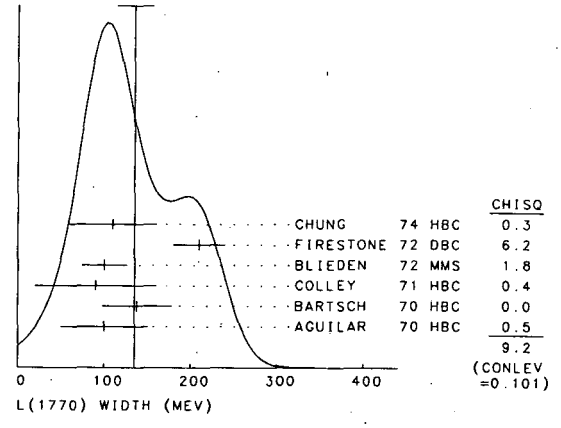
                    23  L(1770) WIDTH (MEV)

W          100.0     50.0          AGUILAR   70 HBC   -  4.6 K- P        6/70
W          138.0     40.0          BARTSCH   70 HBC   -  10.1 K- P       1/71
W          (50.0)   (40.0)   (20.0) LUDLAM    70 HBC   -  12.6 K- P       1/73
W   X       90.      70.           COLLEY    71 HBC  + 10.K+P,K 2PI      1/73
W         (130.0)                  DENEGRI   71 DBC   - 12.6 K-D,K 2PI D  5/71
W          100.      26.           BLIEDEN   72 MMS  -  11.-16. K- P    12/72
W   P  306 210.      30.           FIRESTONE 72 DBC  +  12. K+ D        12/72
W       60 110.      50.           CHUNG     74 HBC   - 7.3K-P,K-OMEGA P 12/75
W         (200.)   APPROX.         DAUM      81 CNTR -  63 K-P,K 2PI P   1/82
W         (220.)   APPROX.         ARMSTRONG 83 OMEG -  18.5 K-P,3K P    9/83*
W          . . . . . . . . .
W   AVG    135.1     20.9     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.4)
                        (SEE IDEOGRAM BELOW)

W  P    PRODUCED IN CONJUNCTION WITH EXCITED DEUTERON
W  X    SYSTEMATIC ERRORS ADDED CORRESP. TO SPREAD OF DIFFERENT FITS.
```

WEIGHTED AVERAGE = 135.1 ± 20.9
ERROR SCALED BY 1.4



For notation, see key at front of Listings.

Mesons

L(1770), K*(1780)

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                    23  L(1770) PARTIAL DECAY MODES

                                                          DECAY MASSES
P1      L(1770) INTO K PI PI                              498+ 135+ 135
P2      L(1770) INTO K*(1430) PI                          135+1425
P3      L(1770) INTO K PI PI PI                           498+ 135+ 135+ 135
P4      L(1770) INTO K*(892) PI                           892+ 135
P5      L(1770) INTO K*(892) RHO                          892+ 769
P6      L(1770) INTO K*(892) OMEGA                        892+ 783
P7      L(1770) INTO K*(892) PI PI                        892+ 135+ 135
P8      L(1770) INTO K OMEGA                              498+ 783
P9      L(1770) INTO K F                                  498+1274
P10     L(1770) INTO K PHI                                494+   0

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                    23  L(1770) BRANCHING RATIOS

R1      L(1770) INTO (K*(1430) PI) / (K PI PI )           (P2)/(P1)
R1                    (K*(1430) INTO K PI)
R1            (1.0)                 BARBARO   69 HBC  +   12.0 K+ P        1/71
R1             0.2       0.2        AGUILAR   70 HBC   -  4.6 K- P         1/71
R1            (1.0)  OR  LESS        BARTSCH   70 HBC   -  10.1 K- P        1/71
R1            (1.0)  OR LESS         COLLEY    71 HBC     10. K+ P        11/71
R1  P         (1.0)  APPROX.         FIRESTONE 72 DBC  +  12. K+ D        12/72
R1            (0.6)  APPROX.         DAUM      81 CNTR    63 K-P,K 2PI P    1/82
R1  P   PRODUCED IN CONJUNCTION WITH EXCITED DEUTERON
R1   R  FOR DISCUSSION OF THE EXPERIMENTAL EVIDENCE ON OTHER DECAY
R1   R  MODES SEE HUGHES 71,SLATTERY 71,EISNER 74.

R2      L(1770) INTO (K OMEGA)/TOTAL                      (P8)
R2          SEEN                   CHUNG     74 HBC  -  7.3K-P,K-OMEGAP   1/82
R2          SEEN                   OTTER     81 HBC  +- 8.25,10,16 K+-P   1/82

R3      L(1770) INTO (K*(892) PI)/(K PI PI)               (P4)/(P1)
R3            (0.24) APPROX.         DAUM      81 CNTR    63 K-P,K 2PI P    1/82

R4      L(1770) INTO (K F)/(K PI PI)                      (P9)/(P1)
R4                    (F INTO PI PI)
R4            (0.16) APPROX.         DAUM      81 CNTR    63 K-P,K 2PI P    1/82

R5      L(1770) INTO (K PHI)/TOTAL                        (P10)
R5          SEEN                   ARMSTRONG 83 OMEG -  18.5 K-P,K-PHI    9/83*

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                          REFERENCES FOR L(1770)

BARTSCH  66 PL 22 357          +DEUTSCHMANN,+   (AACH+BERL+CERN+LOIC+VIEN)

BERLINGH 67 PRL 18 1087        BERLINGHIERI+FARBER+FERBEL+FORMAN+   (ROCH)I
CARMONY  67 PRL  18  615       D.CARMONY,T.HENDRICKS,L.LANDER   (LA JOLLA)
JOBES    67 PL 26B 49          +BASSOMPIERRE,DE BAERE +   (BIRM+CERN+BRUX)

BARTSCH  68 NP B8 9            +COCCONI,+       (AACH+BERL+CERN+LOIC+VIEN)
DENEGRI  68 PRL 20 1194        +CALLAHAN+ETTLINGER+GILLESPIE+        (JHU)

ANDREWS  69 PRL 22 731         +LACH,LUDLAM,SANDWEISS,BERGER,+  (YALE+LRL)
BARBARO  69 PRL 22 1207        BARBARO-GALTIERI,DAVIS,FLATTE,+       (LRL)
COLLEY   69 NC A 59 519        +EASTWOOD,+  (BIRM+GLAS+LOIC+MPIM+OXF+RHEL)

AGUILAR  70 PRL 25 54          AGUILAR-BENITEZ,BARNES,BASSANO,CHUNG,+(BNL)
BARTSCH  70 PL 33 B 186        +DEUTSCHMANN,+   (AACH+BERL+CERN+LOIC+VIEN)
LUDLAM   70 PR D 2 1234        +SANDWEISS,SLAUGHTER                  (YALE)

COLLEY   71 NP B 26 71         +JOBES,KENYON,PATHAK,HUGHES,+   (BIRM+GLAS)
DENEGRI  71 NP B 28 13         +ANTICH,CALLAHAN,CARSON,CHIEN,COX,+   (JHU)  JP

ANDERSON 72 PR D 6 1823        +FRANKLIN,GODDEN,KOPELMAN,LIBBY,TAN  (COLO)
BLIEDEN  72 PL 39 B 668        +FINOCCHIARO,BOWEN,EARLES,+     (STON+NEAS)
FIRESTON 72 PR D 5 505         FIRESTONE,GOLDHABER,LISSAUER,TRILLING (LBL)

BARLOUTA 73 NP B 59 374        +DREVILLON,SHAH,+            (SACL+EPOL+RHEL)
BINGHAM  73 NP B 52 31         +FARWEL,+      (LBL+ORSAY+BNL+SACLAY+MILAN)
CHARRIER 73 NP B 51 317        CHARRIERE,DRIJARD,DE BAERE,+    (CERN+BELG)

CHUNG    74 PL 51B 412         +EISNER,PROTOPOPESCU,SAMIOS,STRAND    (BNL)
DEUTSCHM 74 PL 49B 388         DEUTSCHMANN,+    (AACH+BERL+CERN+LOIC+VIEN)  JP
EISNER   74 BOSTON CONF.       R.L.EISNER  REVIEW TALK               (BNL)

ANTIPOV  75 NP B86 381         +ASCOLI,BUSNELLO,KIENZLE+   (SERP+CERN+ILL)  JP
OTTER    75 NP B93 365         +RUDOLPH,RUMPF+  (AACH+BERL+CERN+LOIC+VIEN)  JP

OTTER    79 NP B 147 1         +RUDOLPH,+       (AACH+BERL+CERN+LOIC+WIEN)  JP

DAUM     81 NP B 187 1         +HERTZBERGER+(AMST+CERN+CRAC+MPIM+OXF+RHEL)
OTTER    81 NP B 181 1           (AACH+BERL+LOIC+VIEN+BIRM+BELG+CERN+MONS)

ARMSTRON 83 NP B 221 1         ARMSTRONG+  (BARI+BIRM+CERN+MILA+LPNP+PAVI)

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K*(1780)

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60  K*(1780,JP=3-) I = 1/2
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All the recent high-statistics experiments studying the $K\pi$ system in $KN \to K\pi N$ interactions have shown clear evidence for the existence of a resonant effect at ~1800 MeV in the $J^P=3^-$ partial wave (BALDI 76, BRANDENBURG 76, CHUNG 78, CLELAND 80, ASTON 81). The intensity of the 3^- partial wave of the $K\pi\pi$ system produced in the charge-exchange process $K^-p \to K^0\pi^+\pi^-n$ also shows resonance-like behavior at ~1800 MeV (BEUSCH 78, ETKIN 80, BAUBILLIER 82). Since the mass values quoted for the $K\pi$ and $K\pi\pi$ modes are not significantly different, it seems natural to consider them as alternative decay modes of a single resonance.

There appears to be some disagreement in the values of the width obtained using the $K\pi$ channel. The measured values tend to become larger when the number of angular moments included in the fit increases. For the time being the observed discrepancies seem to originate from the explicit parametrization of the experimental distributions rather than from the data themselves.

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                    60  K*(1780) MASS (MEV)

M    M      1779.0      11.0            BALDI     76 SPEC +  10 K+P,K0 PI+P   12/77
M    A      1776.       26.             BRANDENB  76 ASPK   013 K+-P,K+-PI-+  12/75
M           1812.0      28.0            BEUSCH    78 OMEG    10K-P,K0 PI+PI-N  4/78
M           1786.0       8.0            CHUNG     78 MPS   0 K-P,K-PI+N 6 GEV  1/78
M           1850.       50.             ETKIN     80 MPS   0 6 K-P,K0 PI+ PI-  1/82
M    J      1786.       15.             ASTON 1   81 SPEC   011.K-P,K- PI+ N   2/81
M    K      1753.       25.       18.   ASTON 2   81 LASS  0 11 K-P,K- PI+ N   1/82
M      190 1762.0        9.0            TOAFF     81 HBC  -  6.5 K-P,K0 PI- P  1/82
M     2060 1784.0        9.0            BAUBILLIE 82 HBC   0 8.25 K-P,KS2PIN   9/83*
M          . . . . . . . . .
M   AVG    1779.8       4.1     AVERAGE

M    A  CONFIRMED BY PHASE SHIFT ANALYSIS OF ESTABROOKS 77,YIELDS JP=3-
M    J  FROM A FIT TO Y(6,0) MOMENT.
M    K  FROM ENERGY INDEPENDENT PWA.
M    M  FROM A FIT TO Y(6,2) MOMENT. JP=3- FOUND.

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                    60  K*(1780) WIDTH (MEV)

W    M       135.0      22.0            BALDI     76 SPEC +  10 K+P,K0 PI+P   12/77
W   E       (270.)     (70.)            BRANDENB  76 ASPK   013 K+-P,K+-PI-+  12/75
W  D         181.0      44.0            BEUSCH    78 OMEG    10K-P,K0 PI+PI-N  4/78
W             96.0      31.0            CHUNG     78 MPS   0 K-P,K-PI+N 6 GEV  1/78
W            240.       50.             ETKIN     80 MPS   0 6 K-P,K0 PI+ PI-  1/82
W    J       225.       60.             ASTON 1   81 SPEC   011.K-P,K- PI+ N   2/81
W    K       300.      170.       80.   ASTON 2   81 LASS  0 11 K-P,K- PI+ N   1/82
W      190  (80.)    APPROX.            TOAFF     81 HBC  -  6.5 K-P,K0 PI- P  1/82
W           (130.0)  APPROX             BAUBILLIE 82 HBC   0 8.25 K-P,KS2PIN   9/83*
W     2060  191.0      24.0             CLELAND   82 SPEC +- 50 K+P,KS PI+-P   8/83*
W          . . . . . . . . .
W   AVG     160.9      19.2     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.5)
                      (SEE IDEOGRAM BELOW)

W    D  ERRORS ENLARGED BY US TO 4*GAMMA/SQRT(N). SEE K*(892) TYPED NOTE.
W   E   ESTABROOKS 77 FIND THAT BRANDENBURG 76 DATA ARE CONSISTENT
W   E   WITH 175 MEV WIDTH.NOT AVERAGED.
W    J  FROM A FIT TO Y(6,0) MOMENT.
W    K  FROM ENERGY INDEPENDENT PWA.
W    M  FROM A FIT TO Y(6,2) MOMENT. JP=3- FOUND.
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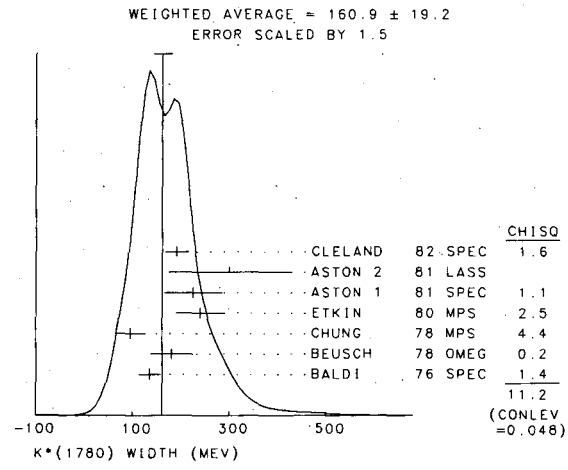


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                    60  K*(1780) PARTIAL DECAY MODES

                                                          DECAY MASSES
P1      K*(1780) INTO K PI                                494+ 140
P2      K*(1780) INTO K*(892) PI                          892+ 140
P3      K*(1780) INTO K RHO                               494+ 769
P4      K*(1780) INTO K*(1430) PI                        1425+ 140
P5      K*(1780) INTO K PI PI                             494+ 140+ 140
P6      K*(1780) INTO K*(892) RHO                        1275+ 769

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Mesons

$K^*(1780)$, $K(1830)$, $K^*(2060)$, $K(2250)$, $K(2320)$

Data Card Listings

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                    60  K*(1780) BRANCHING RATIOS

R4     K*(1780) INTO (K PI )/TOTAL                          (P1)
R4           0.19     0.02          ESTABROO  78 ASPK  0 13 K+-P,K PI      12/77
R4           0.16     0.01          ASTON 2   81 LASS  0 11 K-P,K- PI+ N   1/82
R4          . . . . . . . . .
R4  AVG      0.166    0.012   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.3)

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                         REFERENCES FOR K*(1780)

CARMONY  71 PRL 27 1160       +CORDS,CLOPP,ERWIN,MEIERE,+ (PURD+UCD+IUPU)
FIRESTON 71 PL 36 B 513       FIRESTONE,GOLDHABER,LISSAUER,TRILLING (LBL)

AGUILAR  73 PRL 30 672        +CHUNG,EISNER,PROTOPOPESCU,SAMIOS,+   (BNL)
WALUCH   73 PR D 8 2837       +FLATTE,FRIEDMAN                      (LBL)

BALDI    76 PL 63 B 344       +BOEHRINGER,DORSAZ,HUNGERBUHLER,+  (GENEVA)  JP
BRANDENB 76 PL 60 B 478       BRANDENBURG,CARNEGIE,CASHMORE,DAVIER+(SLAC)  JP
SPIRO    76 PL 60 B 389       +BARLOUTAUD,PALER,CHAURAND+(SACL+RHEL+EPOL)  JP

BOWLER   77 NP B 126 31       +DAINTON,DRAKE,WILLIAMS           (OXFORD)   JP
CARMONY  77 PRD 16 1251       +CLOPP,LANDER,MEIERE,YEN,+  (PURD+UCD+IUPU)
GRASSLER 77 NP B 125 189      +KLUGOW,+  (AACHEN+BERLIN+CERN+LOIC+VIENNA)

BEUSCH   78 PL 74 B 282       +BIRMAN,KONIGS,OTTER,+       (CERN+AACH+ETH)  JP
CHUNG    78 PRL 40 355        +ETKIN,FLAMINO+   (BNL+BRAN+CUNY+MASA+PENN)  JP
ESTABROO 78 NP B 133 490      ESTABROOKS,CARNEGIE,+ (MONT+CARL+DURH+SLAC)  JP
    ALSO 78 PR D 17 658       ESTABROOKS,CARNEGIE+  (MONT+CARL+DURH+SLAC)

CLELAND  80 PL 97B 465        +DORSAZ,MARTIN,NEF,+  (PITT+GEVA+LAUS+DURH)  JP
ENGELEN  80 NP B 167 61       +JONGEJANS,DIONISI+    (NIJM+AMST+CERN+OXF)  JP
ETKIN    80 PR D 22 42        +FOLEY,LINDENBAUM,KRAMER,+       (BNL+CUNY)  JP

ASTON 1  81 PL 99 B 502       +DUNWOODIE,DURKIN,FIEGUTH+ (SLAC+CARL+OTTA)JP
ASTON 2  81 PL 106 B 235      +CARNEGIE,DUNWOODIE,DURKIN+(SLAC+CARL+OTTA)  JP
TOAFF    81 PR D 23 1500      +MUSGRAVE,AMMAR,DAVIS,ECKLUND,+  (ANL+KANS)

BAUBILLI 82 NP B 202 21       BAUBILLIER+        (BIRM+CERN+GLAS+MSU+LPNP)
CLELAND  82 NP B 208 189      +DELFOSSE,DORSAZ,GLOOR(DURH+GEVA+LAUS+PITT)

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K(1830)

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88  K(1830,JP=0-) I=1/2

SEEN IN PARTIAL WAVE ANALYSIS OF K- PHI SYSTEM.
NEEDS CONFIRMATION. OMITTED FROM TABLE.

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                    88  K(1830) MASS (MEV)

M          (1830.0)  APPROX            ARMSTRONG 83 OMEG -  18.5 K-P,3K P     9/83*

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                    88  K(1830) WIDTH (MEV)

W           (250.0)  APPROX            ARMSTRONG 83 OMEG -  18.5 K-P,3K P     9/83*

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                    88  K(1830) PARTIAL DECAY MODES

                                                          DECAY MASSES
P1     K(1830) INTO K PHI                                494+1020

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                         REFERENCES FOR K(1830)

ARMSTRON 83 NP B 221 1        ARMSTRONG+  (BARI+BIRM+CERN+MILA+LPNP+PAVI)  JP

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$K^*(2060)$

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35  K*(2060,JP=4+) I=1/2

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                    35  K*(2060) MASS (MEV)

M      488 2115.      46.            CARMONY   77 HBC   0 9 K+D,K+ PIONS   12/78
M   C     (2092.)    (21.)           ASTON 1   81 LASS   011.K-P,K- PI+ N   1/82
M    D      2070.     100.      40.  ASTON 2   81 LASS   011.K-P,K- PI+ N   1/82
M      650 2088.       20.            BAUBILLIE 82 HBC  -  8.25 K-P,KS PI-P  8/83*
M  W B 400 2039.       10.            CLELAND   82 SPEC +- 50 K+P,KS PI+-P   8/83*
M          . . . . . . . . . .
M   AVERAGE MEANINGLESS (SCALE FACTOR = 1.8)

M    B  FROM A FIT TO 8 MOMENTS.
M  W    NUMBER OF EVENTS EVALUATED BY US.
M    C  FROM A FIT TO Y(5,0), Y(7,0) AND Y(8,0) MOMENTS.
M    D  FROM ENERGY INDEPENDENT PWA.

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                    35  K*(2060) WIDTH (MEV)

W          300.     200.            CARMONY   77 HBC   0 9 K+D,K+ PIONS   12/78
W   C     (205.)    (70.)     (55.) ASTON 1   81 LASS   011.K-P,K- PI+ N   1/82
W    D      240.     500.      100. ASTON 2   81 LASS   011.K-P,K- PI+ N   1/82
W      650  170.     100.       50. BAUBILLIE 82 HBC  -  8.25 K-P,KS PI-P  8/83*
W  W B 400  189.      35.            CLELAND   82 SPEC +- 50 K+P,KS PI+-P   8/83*
W   AVERAGE MEANINGLESS

W    B  FROM A FIT TO 8 MOMENTS.
W  W    NUMBER OF EVENTS EVALUATED BY US.
W    C  FROM A FIT TO Y(5,0), Y(7,0) AND Y(8,0) MOMENTS.
W    D  FROM ENERGY INDEPENDENT PWA.

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                    35  K*(2060) PARTIAL DECAY MODES

                                                          DECAY MASSES
P1     K*(2060) INTO K PI                                494+ 140
P2     K*(2060) INTO K*(892) PI PI                       892+ 140+ 140
P3     K*(2060) INTO RHO K PI                            769+ 498+ 140
P4     K*(2060) INTO OMEGA K PI                          783+ 498+ 140
P5     K*(2060) INTO K*(892) PI PI PI                    892+ 140+ 140+ 135

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                    35  K*(2060) BRANCHING RATIOS

R1     K*(2060) INTO (K PI )/TOTAL                          (P1)
R1           0.07     0.01          ASTON 2   81 LASS  0 11 K-P,K- PI+ N   1/82

R2     K*(2060) INTO (K*(892) PI PI)/TOTAL                  (P2)
R2          SEEN                    BAUBILLIE 82 HBC  -  8.25K-P,KS 3PI P  8/83*

R3     K*(2060) INTO (RHO K PI)/TOTAL                       (P3)
R3          SEEN                    BAUBILLIE 82 HBC  -  8.25K-P,KS 3PI P  8/83*

R4     K*(2060) INTO (OMEGA K PI)/TOTAL                     (P4)
R4          SEEN                    BAUBILLIE 82 HBC  -  8.25K-P,KS 3PI P  8/83*

R5     K*(2060) INTO (K*(892) 3 PI)/TOTAL                   (P5)
R5          POSSIBLY SEEN           BAUBILLIE 82 HBC  -  8.25K-P,KS 3PI P  8/83*

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                         REFERENCES FOR K*(2060)

CARMONY  71 PRL 27 1160       +CORDS,CLOPP,ERWIN,MEIERE,+  (PURD+UCD+IND)

CARMONY  77 PRD 16 1251       +CLOPP,LANDER,MEIERE,YEN,+  (PURD+UCD+IUPU)

BROMBERG 80 PR D 22 1513      +HAGGERTY,ABRAMS,DZIERBA(CIT+FNAL+ILLC+IND)
CLELAND  80 PL 97B 465        +DORSAZ,MARTIN,NEF,+  (PITT+GEVA+LAUS+DURH)JP

ASTON 1  81 PL 99 B 502       +DUNWOODIE,DURKIN,FIEGUTH+ (SLAC+CARL+OTTA)JP
ASTON 2  81 PL 106 B 235      +CARNEGIE,DUNWOODIE,DURKIN+(SLAC+CARL+OTTA)  JP
BAUBILLI 82 PL 118 B 447      BAUBILLIER,BURNS+ (BIRM+CERN+GLAS+MSU+LPNP)
CLELAND  82 NP B 208 189      +DELFOSSE,DORSAZ,GLOOR(DURH+GEVA+LAUS+PITT)

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K(2250)

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40  K(2250,JP=2-) I=1/2

FORMERLY CALLED K*.
THIS ENTRY CONTAINS VARIOUS PEAKS IN STRANGE MESON
SYSTEMS REPORTED IN THE 2100-2300 MEV REGION AS WELL AS
ENHANCEMENTS SEEN IN ANTIHYPERON NUCLEON SYSTEM,EITHER
IN THE MASS SPECTRA OR IN THE JP=2- WAVE.
OMITTED FROM TABLE.

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                    40  K(2250) MASS (MEV)

M       20(2240.)    (20.)           LISSAUER  70 HBC     9. K+ P          11/71
M   C     (2200.)   APPROX.          SLATTERY  71 RVUE    8-13 K+ P        11/71
M      37(2147.)     (4.)            CHLIAPNIK 79 HBC  +  K+P TO LAM-BAR P  1/80
M    Q    2235.      50.             BAUBILLIE 81 HBC  -  8. K-P,LAM PBAR   1/82
M    Q    2260.      20.             CLELAND   81 SPEC +- 50 K+P,LAM PBAR   1/82
M    Q    2200.0     40.0            ARMSTRONG 83 OMEG  - 18 K-P,LAM PBAR  12/83*
M         . . . . . . . . . .
M   AVG   2246.5     16.8     AVERAGE

M   C   COMPILATION OF (ANTIHYP.-NUCLEON) MASS IN K+ P 8.-13.  GEV/C
M    Q  JP=2- FROM MOMENTS ANALYSIS.

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                    40  K(2250) WIDTH (MEV)

W       20  (80.)    (20.)           LISSAUER  70 HBC     9. K+ P          11/71
W   C     (200.)   APPROX.          SLATTERY  71 RVUE    8-13 K+ P        11/71
W      37  (40.)   APPROX.          CHLIAPNIK 79 HBC  +  K+P TO LAM-BAR P  1/80
W    Q    (200.)   APPROX.          BAUBILLIE 81 HBC  -  8. K-P,LAM PBAR   1/82
W    Q     210.      30.             CLELAND   81 SPEC +- 50 K+P,LAM PBAR   1/82
W    Q     150.0     30.0            ARMSTRONG 83 OMEG  - 18 K-P,LAM PBAR  12/83*
W         . . . . . . . . . .
W   AVG    180.0     30.0     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.4)

W   C   COMPILATION OF (ANTIHYP.-NUCLEON) MASS IN K+ P 8.-13.  GEV/C
W    Q  JP=2- FROM MOMENTS ANALYSIS.

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                    40  K(2250) PARTIAL DECAY MODES

                                                          DECAY MASSES
P1     K(2250) INTO K PI PI                              498+ 135+ 135
P2     K(2250) INTO LAMBDA PBAR                         1116+ 938

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                         REFERENCES FOR K(2250)

ALEXANDE 68 PRL 20 755        ALEXANDER,FIRESTONE,GOLDHABER,SHEN    (LRL)

LISSAUER 70 NP B 18 491       +ALEXANDER,FIRESTONE,GOLDHABER        (LBL)

SLATTERY 71  UR-875-332(PREP) P.SLATTERY,A REVIEW OF STRANGE MESONS(ROCH)

CHLIAPNI 79 NP B 158 253      CHLIAPNIKOV,GERDYUKOV+     (CERN+BELG+MONS)

BAUBILLI 81 NP B 183 1        BAUBILLIER,+       (BIRM+CERN+GLAS+MSU+LPNP)  JP
CLELAND  81 NP B 184 1        +NEF,MARTIN,+          (PITT+GEVA+LAUS+DURH)  JP

ARMSTRON 83 NP B 227 365      ARMSTRONG+  (BARI+BIRM+CERN+MILA+LPNP+PAVI)

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K(2320)

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90  K(2320,JP=3+) I=1/2

THIS ENTRY CONTAINS ENHANCEMENTS SEEN IN THE
JP=3+ WAVE OF THE ANTIHYPERON NUCLEON SYSTEM
OMITTED FROM TABLE.

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                    90  K(2320) MASS (MEV)

M    P     2320.0     30.0            CLELAND   81 SPEC +- 50 K+P,LAM PBAR  12/83*
M    P     2330.0     40.0            ARMSTRONG 83 OMEG  - 18 K-P,LAM PBAR  12/83*
M          . . . . . . . . . .
M   AVG    2323.6     24.0     AVERAGE

M    P  JP=3+ FROM MOMENTS ANALYSIS

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                    90  K(2320) WIDTH (MEV)

W     P      (250.0)  APPROX.          CLELAND   81 SPEC +- 50 K+P,LAM PBAR  12/83*
W     P       150.0     30.0           ARMSTRONG 83 OMEG  - 18 K-P,LAM PBAR  12/83*

W     P  JP=3+ FROM MOMENTS ANALYSIS

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                    90  K(2320) PARTIAL DECAY MODES

                                                              DECAY MASSES
P1      K(2320) INTO LAMBDA PBAR                          1116+ 938

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                              REFERENCES FOR K(2320)
CLELAND  81 NP B 184 1        +NEF,MARTIN,+          (PITT+GEVA+LAUS+DURH)

ARMSTRON 83 NP B 227 365      ARMSTRONG+  (BARI+BIRM+CERN+MILA+LPNP+PAVI)

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K(2500)

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                    91  K(2500,JP=4-) I=1/2

                    THIS ENTRY CONTAINS ENHANCEMENTS SEEN IN THE
     ------>        JP=4- WAVE OF THE ANTIHYPERON NUCLEON SYSTEM
                    OMITTED FROM TABLE.

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                    91  K(2500) MASS (MEV)

M     R      2490.0     20.0           CLELAND   81 SPEC +- 50 K+P,LAM PBAR  12/83*

M     R  JP=4- FROM MOMENTS ANALYSIS

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                    91  K(2500) WIDTH (MEV)

W     R      (250.0)  APPROX.          CLELAND   81 SPEC +- 50 K+P,LAM PBAR  12/83*

W     R  JP=4- FROM MOMENTS ANALYSIS

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                              REFERENCES FOR K(2500)

CLELAND  81 NP B 184 1        +NEF,MARTIN,+          (PITT+GEVA+LAUS+DURH)

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C=±1 MESON STATES

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$D^{\pm}$

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                    31  CHARGED D(1869,JP=0-) I=1/2

                    SEE STABLE PARTICLE DATA CARD LISTINGS

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D^{0}

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                    32  NEUTRAL D(1865,JP=0-) I=1/2

                    SEE STABLE PARTICLE DATA CARD LISTINGS

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$D^{*\pm}(2010)$

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                    62  CHARGED D*(2010,JP=1-) I=1/2

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                    62  CHARGED D*(2010) MASS (MEV)

M    G     (2008.)     (3.)            GOLDHABE  77 SMAG +- E+E-             12/77
M    P     (2008.6)    (1.0)           PERUZZI   77 SMAG +- E+E-             12/77
M          . . . . . . . . . .
M    MASS   2010.1      0.7   FROM DO MASS (TRILLING 81 RVUE) AND
M                             MASS DIFFERENCE BELOW

M    G    FROM SIMULTANEUS FIT TO D*+,D*0,D+,AND DO,NOT INDEPENDENT OF
M    G    FELDMAN 77 MASS DIFFERENCE BELOW.
M    P    PERUZZI 77 MASS NOT INDEPENDENT OF FELDMAN 77 MASS DIFFERENCE
M    P    BELOW AND PERUZZI 77 DO MASS VALUE.

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                    62  (D*+) - (DO) MASS DIFFERENCE (MEV)

DM        30  145.3      0.5           FELDMAN   77 SMAG    D*+ TO DO PI+     12/77
DM         2  145.2      0.6           BLIETSCHA 79 BEBC    NEUTRINO P        12/79
DM           (145.5)  APPROX.          AVERY     80 SPEC    GAMMA A            1/82
DM        60  145.5      0.3           FITCH     81 SPEC    PI- A              1/82
DM        14  145.5      0.5           YELTON    82 SMK2    29 E+E-,K-PI+      8/83*
DM        16  145.8      1.5           AHLEN     83 HRS     D*+ TO DO PI+     12/83*
DM        12  145.1      1.8           BAILEY    83 SPEC    D*+- TO DO PI+-    9/83*
DM        28  145.5      0.3           BAILEY    83 SPEC    D*+- TO DO PI+-   12/83*
DM        14  145.1      0.5           BAILEY    83 SPEC    D*+- TO DO PI+-   12/83*
DM            . . . . . . . . . .
DM   AVG      145.41     0.16    AVERAGE

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                    62  (D*+) - (D*0) MASS DIFFERENCE (MEV)

EM    P         2.6      1.8           PERUZZI   77 SMAG +- E+E-             12/77
EM    P  NOT INDEPENDENT OF FELDMAN 77 MASS DIFFERENCE ABOVE, PERUZZI 77
EM    P  DO MASS, AND GOLDHABER 77 D*0 MASS.
EM            . . . . . . . . . .
EM   DMASS      2.9      1.3    FROM (D*+)-(DO) AND (D*0)-(DO)
EM                              MASS DIFFERENCES

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                    62  CHARGED D*(2010) WIDTH (MEV)

W        30   (2.0)  OR LESS  CL=.90   FELDMAN   77 SMAG    D*+ TO DO PI+     12/77
W             (2.2)  OR LESS           YELTON    82 SMK2    29 E+E-,K-PI+PI-   8/83*

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                    62  CHARGED D*(2010) PARTIAL DECAY MODES

                                                              DECAY MASSES
P1      D*+(2010) INTO DO PI+                             1865+ 140
P2      D*+(2010) INTO D+ GAMMA                           1869+   0
P3      D*+(2010) INTO D+ PI0                             1869+ 135

P       D*-(2010) MODES ARE CHARGE CONJUGATES OF ABOVE MODES

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                    62  CHARGED D*(2010) BRANCHING RATIOS

R1      D*+(2010) INTO (DO PI+)/TOTAL                      (P1)
R1 G           0.6      0.15           GOLDHABE  77 SMAG +  E+E-             12/77
R1 G     ASSUMING THAT ISOSPIN IS CONSERVED IN THE DECAY

R2      D*+(2010) INTO (D+ GAMMA)/TOTAL                    (P2)
R2             0.08     0.07           KIRKBY    79 RVUE    E+ E-            12/79

R3      D*+(2010) INTO (D+ PI0)/TOTAL                      (P3)
R3   G         0.28     0.09           KIRKBY    79 RVUE    E+ E-            12/79

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                              REFERENCES FOR CHARGED D*(2010)

PERUZZI  76 PRL 37 569        +PICCOLO,FELDMAN,NGUYEN,WISS,+   (SLAC+LBL)

FELDMAN  77 PRL 38 1313       +PERUZZI,PICCOLO,ABRAMS,ALAM+    (SLAC+LBL)
PERUZZI  77 PRL 39 1301       +PICCOLO,FELDMAN,PERL,+(SLAC,LBL,NWES+HAWA)
GOLDHABE 77 PL 69 B 503       +WISS,ABRAMS,ALAM,BOYARSKI,+     (LBL+SLAC)

BLIETSCH 79 PL 86 B 108       BLIETSCHAU,+       (AACH+BONN+CERN+MPIM+OXF)
KIRKBY   79 BATAVIA CONF.107  J. KIRKBY                            (SLAC)

AVERY    80 PRL 44 1309       +WISS,BINKLEY,ATIYA,+       (ILL+FNAL+COLU)

FITCH    81 PRL 46 761        +DEVAUX,CAVAGLIA,MAY,+ (PRIN+SACL+TORI+BNL)
TRILLING 81 PRPL 75 57        G.H.TRILLING                      (LBL+UCB)

BEBEK    82 PRL 49 610        +(HARV+OSU+ROCH+RUTG+SYRA+VAND+CORN+ITHACA)
YELTON   82 PRL 49 430        +FELDMAN,GOLDHABER,+     (SLAC+LBL+UCB+HARV)

AHLEN    83 PRL 51 1147       +AKERLOF+       (ANL+IND+LBL+MICH+PURD+SLAC)
ALTHOFF  83 PL 126 B 493      +FISCHER,BURKHARDT+   (TASSO COLLABORATION)
BAILEY   83 PL 132 B 230      +BARDSLEY+  (AMST+BRIS+CERN+CRAC+MPIM+RHEL)
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$D^{*0}(2010)$

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                    61  NEUTRAL D*(2010,JP=1-) I=1/2

                    J CONSISTENT WITH 1, VALUE 0 RULED OUT (NGUYEN 77).

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                    61  NEUTRAL D*(2010) MASS (MEV)

M    G     (2006.)     (1.5)           GOLDHABE  77 SMAG    E+E-             12/77
M    G    FROM SIMULTANEUS FIT TO D*+, D*0, D+, AND DO.
M          . . . . . . . . . .
M    MASS   2007.2      2.1   FROM DO MASS (TRILLING 81 RVUE) AND
M                             MASS DIFFERENCE BELOW

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                    61  (D*0) - (DO) MASS DIFFERENCE (MEV)

DM G          142.7      1.7           GOLDHABE  77 SMAG  0 E+E-              3/82
DM            142.2      2.0           SADROZIN  80 CBAL  0 D*0 TO DO PI0     3/82
DM G     FROM SIMULTANEOUS FIT TO D*+, D*0, D+, AND DO.
DM            . . . . . . . . . .
DM  AVG       142.5      1.3     AVERAGE

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                    61  NEUTRAL D*(2010) WIDTH (MEV)

W             (5.)   OR LESS           GOLDHAB2  76 SMAG    E+E- TO D*D*      3/77
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                    61  NEUTRAL D*(2010) PARTIAL DECAY MODES

                                                              DECAY MASSES
P1      D*0(2010) INTO DO PI0                             1865+ 135
P2      D*0(2010) INTO DO GAMMA                           1865+   0

P       D*0(2010)BAR MODES ARE CHARGE CONJUGATES OF ABOVE MODES

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                    61  NEUTRAL D*(2010) BRANCHING RATIOS

R1      D*0(2010) INTO (DO GAMMA)/(DO PI0 + DO GAMMA)     (P2)/(P1+P2)
R1   G         0.45     0.15           GOLDHABE  77 SMAG    E+E-             12/77
R1   G   WE QUOTE THE NORMAL FIT VALUE FROM TABLE 1. THE ISO-SPIN
R1   G   CONSTRAINED FIT IS NOW KNOWN TO GIVE A DO GAMMA FRACTION WHICH IS
R1   G   TOO LARGE. SEE DETAILS IN FOOTNOTE 21 OF FELDMAN 77 REVIEW.

R2      D*0(2010) INTO (DO PI0)/TOTAL                      (P1)
R2   G         0.55     0.15           KIRKBY    79 RVUE    E+ E-            12/79

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                              REFERENCES FOR NEUTRAL D*(2010)

GOLDHAB1 76 PRL 37 255        GOLDHABER,PIERRE,ABRAMS,ALAM,+   (LBL+SLAC)
GOLDHAB2 76 SLAC CONF. 379    G.GOLDHABER (AVAIL. AS LBL-5534) (LBL+SLAC)

GOLDHABE 77 PL 69 B 503       GOLDHABER,ABRAMS,ALAM+           (LBL+SLAC)
    ALSO 77 BANFF SUM.INST 75 G.J.FELDMAN                          (SLAC)
NGUYEN   77 PRL 39 262        +WISS,ABRAMS,ALAM,BOYARSKI,+     (LBL+SLAC)  J

KIRKBY   79 BATAVIA CONF.107  J. KIRKBY                            (SLAC)

SADROZIN 80 MADISON CONF. 681 SADROZINSKI,+     (PRIN+CIT+HARV+SLAC+STAN)
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Mesons

$D^{*0}(2010)$, $F^{\pm}$, $F^{*}(2140)$, $B^{\pm}$, B^{0}, Exotic Mesons

Data Card Listings

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TRILLING 81 PRPL 75 57        G.H.TRILLING                    (LBL+UCB)

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$F^{\pm}$

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                34  F+-(1970,JP=0-) I=0

                SEE STABLE PARTICLE DATA CARD LISTINGS

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$F^{*}(2140)$

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                74  F*(2140,JPG=   ) I=

                OMITTED FROM TABLE.

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                74  F* MASS (MEV)

M          2140.0     60.            BRANDELIK 77 DASP +- E+E-,PI 3 GAMMA  12/77

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                74  (F*+) - (F0) MASS DIFFERENCE (MEV)

DM          110.      46.            BRANDELIK 79 DASP +- E+E-,F GAMMA     12/79

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                74  F* PARTIAL DECAY MODES

                                                      DECAY MASSES
P1     F* INTO F GAMMA                              1971+   0

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                74  F* BRANCHING RATIOS

R1     F* INTO (F GAMMA)/TOTAL                     (P1)
R1      PROBABLY SEEN                BRANDELIK 77 DASP    E+E-          12/77

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                          REFERENCES FOR F*(2140)

BRANDELI 77 PL 70 B 132       BRANDELIK,CORDS,+(AACH+DESY+HAMB+MPIM+TOKY)

BRANDELI 78 PL 76 B 361       BRANDELIK,CORDS,+(AACH+DESY+HAMB+MPIM+TOKY)

BRANDELI 79 PL 80 B 412       BRANDELIK,CORDS,+(AACH+DESY+HAMB+MPIM+TOKY)

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B=±1 MESON STATES

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$B^{\pm}$

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                41  CHARGED B(5271,JP=  ) I=

                SEE STABLE PARTICLE DATA CARD LISTINGS

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B^{0}

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                42  NEUTRAL B(5274,JP=  ) I=

                SEE STABLE PARTICLE DATA CARD LISTINGS

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EXOTIC MESON STATES

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EXOTICS

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                50  EXOTICS

                THE PURPOSE OF THIS ENTRY IS TO PROVIDE A LIST OF
                REFERENCES FOR EXOTIC MESON SEARCHES (SEE THE SECTION
                ON THE NONRELATIVISTIC QUARK MODEL IN THE MISCELLANEOUS
                SECTION OF THIS REVIEW), AS WELL AS THEORETICALLY BASED
                SUGGESTIONS FOR EXPERIMENTS. NOTE THAT LIPKIN 73
                PROPOSES EXPERIMENTS WHICH ARE CONCLUSIVE EVEN IF
                NEGATIVE RESULTS ARE OBTAINED.

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                          REFERENCES FOR EXOTICS

                          REPORTS ON SEARCHES

ROSENFEL 68 PHILA.CONF.P.455  A.H.ROSENFELD                          (LRL)

DODD     69 PR 177 1991       +JOLDERSMA, PALMER, SAMIOS             (BNL)

CHO      70 PL 32 B 409       +DERRICK,JOHNSON,MUSGRAVE,+ (ANL+NWES+KANS)
GIACOMEL 70 PL  33 B 373      G.GIACOMELLI +   (BGNA+SACL+AMST+REHO+EPOL)
LYS      70 PR D 2 2525       J.LYS+                                (MICH)
ROSNER   70 EXP.MESON SPECTROSCOPY,ED. C.BALTAY AND A.H.ROSENFELD,P.499

BUHL     72 NP B 37 421       +CLINE,TERRELL                  (WISCONSIN)

COHEN    73 NP B 53 1         +FERBEL,SLATTERY,WERNER         (ROCHESTER)
DURUSOY  73 PL 45 B 517       +BAUBILLIER,GEORGE,ARMENISE,+   (LPNP+BARI)

ALAM     74 PL 53B 207        +BRABSON,GALLOWAY,+    (IND+PURD+SLAC+VAND)
COHEN    74  BOSTON           D.COHEN  REVIEW TALK                 (COLU)
OREN     74 NP B71 189        +COOPER,FIELDS,RHINES,WHITMORE,+  (ANL+OXF)
BALTAY   75 PL 57B 293        +CAUTIS,COHEN,KALELKAR,PISELLO,+(COLU+BING)
DAVIS    75 NP B96 426        +AMMAR,KROPAC,YARGER,+       (KANS+CCAC+ANL)

BRUNDIER 76 PL 64 B 107       BRUNDIERS,BRUN,FLURI,+  (FREIBURG+SACL+ETH)

BOUCROT  77 NP B 121 251      +NAVACH,RIVET,+       (LALO+CERN+CDEF+EPOL)
HOOGLAND 77 NP B 126 109      +GRAYER,HYAMS,BLUM,DITL,+  (AMST+CERN+MPIM)
HOOGLAND 77 NP B 126 109      +GRAYER,HYAMS,BLUM,DITL,+  (AMST+CERN+MPIM)
MOSER    77 NP B 129 28       F.L.MOSER                             (EFI)

ALAM     78 PRL 40 1685       +BAGGETT,BAGLIN,BONAMY+(IND+PURD+SLAC+VAND)
ARMSTRON 78 PL 77 B 447       ARMSTRONG,FRAME,HUGHES,BIENLEIN+(GLAS+DESY)

LEMOIGNE 79 BATAVIA CONF.524  +ABOLINS,BARATE+       (SACL+LOIC+SHMP+IND)

KOOIJMAN 80 PRL 45 316        +ARENTON,AYRES,DIEBOLD,MAY+       (ANL+EFI)

AGUILAR  81 ZPHY C 6 109      +ALBAJAR,SJOGREN,+    (CERN+CDEF+MADR+STOH)
APEL     81 NP B 193 269      +AUGENSTEIN,BERTOLUCCI,DONSKOV,+(SERP+CERN)
BIONTA   81 PRL 46 970        +CARROLL,EDELSTEIN,+   (BNL+CARN+FNAL+SMAS)
EVANGELI 81 NP B 178 197      EVANGELISTA+(BARI+BONN+CERN+DARE+LIVP+MILA)
FRAME    81 PL 107 B 301      +HUGHES,COLLEY,ARMSTRONG,+ (GLAS+BIRM+CERN)
IRVING   81 NP B 193 1        +LOVERRE,AGUILAR,+    (CERN+CDEF+MADR+STOH)

                              SUGGESTIONS FOR SEARCHES

ROSNER   68 PRL 21 950,1468   J.L.ROSNER                        (TEL-AVIV)

ROSNER   70 EXP.MESON SPECTROSCOPY,ED. C.BALTAY AND A.H.ROSENFELD,P.499

FAIMAN   73 PL 43 B 307       D.FAIMAN,G.GOLDHABER,Y.ZARMI          (CERN)
LIPKIN   73 PR D 7 2262       H.J.LIPKIN                     (ARGONNE+FNAL)

HOLMGREN 78 PL 77 B 304       +PENNINGTON                     (STOH+CERN)

ARENTON  82 PR D 25 2241      +AYRES,DIEBOLD,MAY,SWALLOW+       (ANL+ILL)

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For notation, see key at front of Listings.

NOTE ON N AND Δ RESONANCES

I. Introduction

The excited states of the nucleon have been studied in a large number of formation and production experiments. Production experiments are not suitable for an accurate determination of resonance parameters, but they are of interest in searching for the many predicted nucleon resonances that decouple from the πN channel.[1]

The masses, widths, and elasticities of the N and Δ resonances in the main Baryon Table have been determined almost entirely from partial-wave analyses of πN elastic and charge-exchange scattering data (Sec. II). Similar methods of analysis have been used to get the branching fractions for decay into Nη, ΛK, and ΣK. The remaining branching fractions are from analyses of $\pi N \to N\pi\pi$ data, which so far have only taken into account the contributions from quasi-2-body intermediate states (Sec. III).

In addition to the usual Breit-Wigner parameters, the Data Card Listings give the locations and the residues of the poles of the resonant partial waves on the second sheet of the complex energy plane as obtained from πN partial-wave analyses and from the isobar model analyses of $\pi N \to N\pi\pi$. The Listings also give γN decay amplitudes of the resonances (Sec. IV), and there are brief remarks on electroproduction of nucleon resonances (Sec. V) and on nucleon resonances as seen in production experiments (Sec. VI).

Table 1 lists all the entries in the Listings and gives our evaluation of the status of each, both overall and channel by channel. We have made a number of changes since the 1982 edition. Four N and three Δ resonances have been removed from the main Baryon Table: the N(1990), N(2080), N(2200), and Δ(1600) have been reduced from 3-star to 2-star status, and the N(3030), Δ(2850), and Δ(3230) have been killed altogether [see the notes in the Listings for the N(~3000) and the Δ(~3000) for the reasons for this]. A resonance is considered to be well established only if it has been seen in at least two independent analyses and if its partial wave does not behave erratically or have large errors. Good reason for a cautious attitude is the fact that some recent data[2] differ appreciably from earlier data and from predictions of the analyses. Only the established resonances (overall status 3 or 4 stars) appear in the main Baryon Table.

Table 1. The status of the N and Δ resonances. Only those with an overall status of *** or **** are included in the main Baryon Table.

			Status as seen in --					
Particle	$L_{2I\cdot 2J}$	Overall status	Nπ	Nη	ΛK	ΣK	Δπ	Nγ
N(939)	P_{11}	****						
N(1440)	P_{11}	****	****	*			***	***
N(1520)	D_{13}	****	****	*			***	***
N(1535)	S_{11}	****	****	****			*	***
N(1540)	P_{13}	*					*	
N(1650)	S_{11}	****	****	*	***	**	***	***
N(1675)	D_{15}	****	****	*	*		***	***
N(1680)	F_{15}	****	****				***	***
N(1700)	D_{13}	***	***	*	**	*	**	**
N(1710)	P_{11}	***	***	*	**	*	***	**
N(1720)	P_{13}	****	****	*	**	*	*	*
N(1990)	F_{17}	**	**	*	*	*		*
N(2000)	F_{15}	**	**	*	*	*		
N(2080)	D_{13}	**	**	*	*			*
N(2090)	S_{11}	*	*					
N(2100)	P_{11}	*	*					
N(2190)	G_{17}	****	****	*	*	*		*
N(2200)	D_{15}	**	**	*	*			
N(2220)	H_{19}	****	****	*				
N(2250)	G_{19}	****	****	*				
N(2600)	I_{111}	***	***					
N(2700)	K_{113}	**	**					
N(~3000)								
Δ(1232)	P_{33}	****	****	F				****
Δ(1550)	P_{31}	*		o			*	
Δ(1600)	P_{33}	**	**	r			***	*
Δ(1620)	S_{31}	****	****	b			***	**
Δ(1700)	D_{33}	****	****	i		*	***	***
Δ(1900)	S_{31}	***	***	d		*		
Δ(1905)	F_{35}	****	****	d		*	**	**
Δ(1910)	P_{31}	****	****	e		*	*	*
Δ(1920)	P_{33}	***	***	n		*		
Δ(1930)	D_{35}	***	***	F		*	*	*
Δ(1940)	D_{33}	*	*	o				
Δ(1950)	F_{37}	****	****	r		*	**	***
Δ(2150)	S_{31}	*	*	b				
Δ(2200)	G_{37}	*	*	i				
Δ(2300)	H_{39}	**	**	d				
Δ(2350)	D_{35}	*	*	d				
Δ(2390)	F_{37}	*	*	e				
Δ(2400)	G_{39}	**	**	n				
Δ(2420)	H_{311}	****	****					
Δ(2750)	I_{313}	**	**					
Δ(2950)	K_{315}	**	**					
Δ(~3000)								

**** Good, clear, and unmistakable.
*** Good, but in need of clarification or not absolutely certain.
** Not established; needs confirmation.
* Evidence weak; could disappear.

The Data Card Listings in this edition have been much shortened by the omission of many now-obsolete results. Nearly all of the omitted results were published before 1975. There also used to be separate entries for bumps seen in production experiments — bumps with masses in the 1440-MeV region, the 1520-MeV region, etc. — but these have been removed. All the omitted material may be found in our 1982 edition.[3]

There are two recent extensive reviews of nucleon resonances.[4,5]

References for section I

1. R. Koniuk and N. Isgur, Phys. Rev. **D21**, 1868 (1980).

2. πN Newsletter No. 1 (1984), eds. G. Höhler and B.M.K. Nefkens.
3. Particle Data Group, Phys. Lett. **111B** (1982).
4. G. Höhler, *Pion-Nucleon Scattering*, Landolt-Börnstein Vol. **I/9b** (1983), ed. H. Schopper, Springer Verlag.
5. A.J.G. Hey and R.L. Kelly, Phys. Reports **96**, 71 (1983).

II. Two-body partial-wave analyses and determination of resonance parameters

(by G. Höhler, University of Karlsruhe)

πN partial-wave analysis: Even if all measurable πN → πN scattering data were measured with infinite accuracy, it would not be possible in the inelastic region to determine a unique set of partial waves from the data alone. It is essential to add theoretical constraints, and unitarity, analyticity, and isospin invariance are chosen in order to avoid using a specific model or parametrization that might bias the solution.

Atkinson et al.,[1] in a continuation of earlier work, have recently investigated how much the amplitudes are restricted by unitarity if the $d\sigma/d\Omega$ and P angular distributions for π^+p elastic scattering are given at a certain energy with very high precision. They found a variety of solutions, which differ from one another substantially in some of the lower partial waves and strongly in the tail of high partial waves. They concluded that cutting off the partial-wave expansion sharply (which was done in many early and some recent analyses[2,3,4]) is not justified.

In QCD, isospin is not exactly conserved in strong interactions because the masses of the up and down quarks are different. At present, the only experimental evidence for a violation is in the Δ(1232) region, where one expects an effect because of the splitting of the Δ^{++} and Δ^0 masses. Other cases reported in the literature turned out to be caused by errors in the data or the analysis.

The uniqueness problem remains serious even if one includes data for all three reactions and isospin invariance. Therefore it is necessary to add analyticity constraints. Many analyses used as input predictions for the forward amplitudes, which follow from total-cross-section data, the optical theorem, and forward dispersion relations, but this is still not nearly enough.

Constraints based on Mandelstam's 2-variable analyticity have so far been used successfully only in the analyses of the CMU-LBL[5] and Karlsruhe-Helsinki[6] groups. In both, long tails of high partial waves were admitted, but only some global effects of these waves should be taken seriously, not the value of a single high partial wave. The resonance masses, widths, and elasticities in the Baryon Table are mainly determined by these two analyses, whose partial-wave amplitudes are shown in Fig. 1.

Results from other recent analyses are suspect due to sharp cutoff of the partial waves and for other reasons (see Sec. 2.1 in Ref. 7). It is necessary to check if Hendry's solution[8] is compatible with analyticity.

Substantial progress in partial-wave analysis may be expected in 1984/85 when the final results of several experiments[9] will become available. Furthermore, the analysis will be simplified and improved if predictions for the tail of high partial waves, based on new evaluations of the nearby parts of the Mandelstam double spectral function[10] and of the left-hand cut singularities of the partial-wave dispersion relation,[11] are used. A good test of predictions for the highest resonances (masses > 2.2 GeV) is not yet possible because the data are still too poor. Evidence for resonances in this range has been reported by Koch[6] and by Hendry.[8]

Determination of resonance parameters: Since a dynamical theory of πN scattering does not yet exist, the "resonance parameters" are not defined in a unique way. One can fit the partial-wave amplitudes to a phenomenological ansatz consisting of a generalized Breit-Wigner form combined with a background term, and most of the earlier analyses, including the first CMU-LBL analysis and the KH 78 analysis,[6] used a prescription of this type. A more sophisticated multichannel coupled resonance scheme was applied in the recent work of the CMU-LBL group.[5] The parameters listed in the Baryon Table have been derived by these methods.

This approach has a difficulty which becomes more and more important as the energy increases: some "background terms" such as diffraction and ρ-exchange give contributions to the partial waves which resemble highly inelastic resonances (see Sec. 2.4.1.1 in Ref. 7). It is true that the energy dependence is different, but at high energies the speed with which an amplitude

For notation, see key at front of Listings.

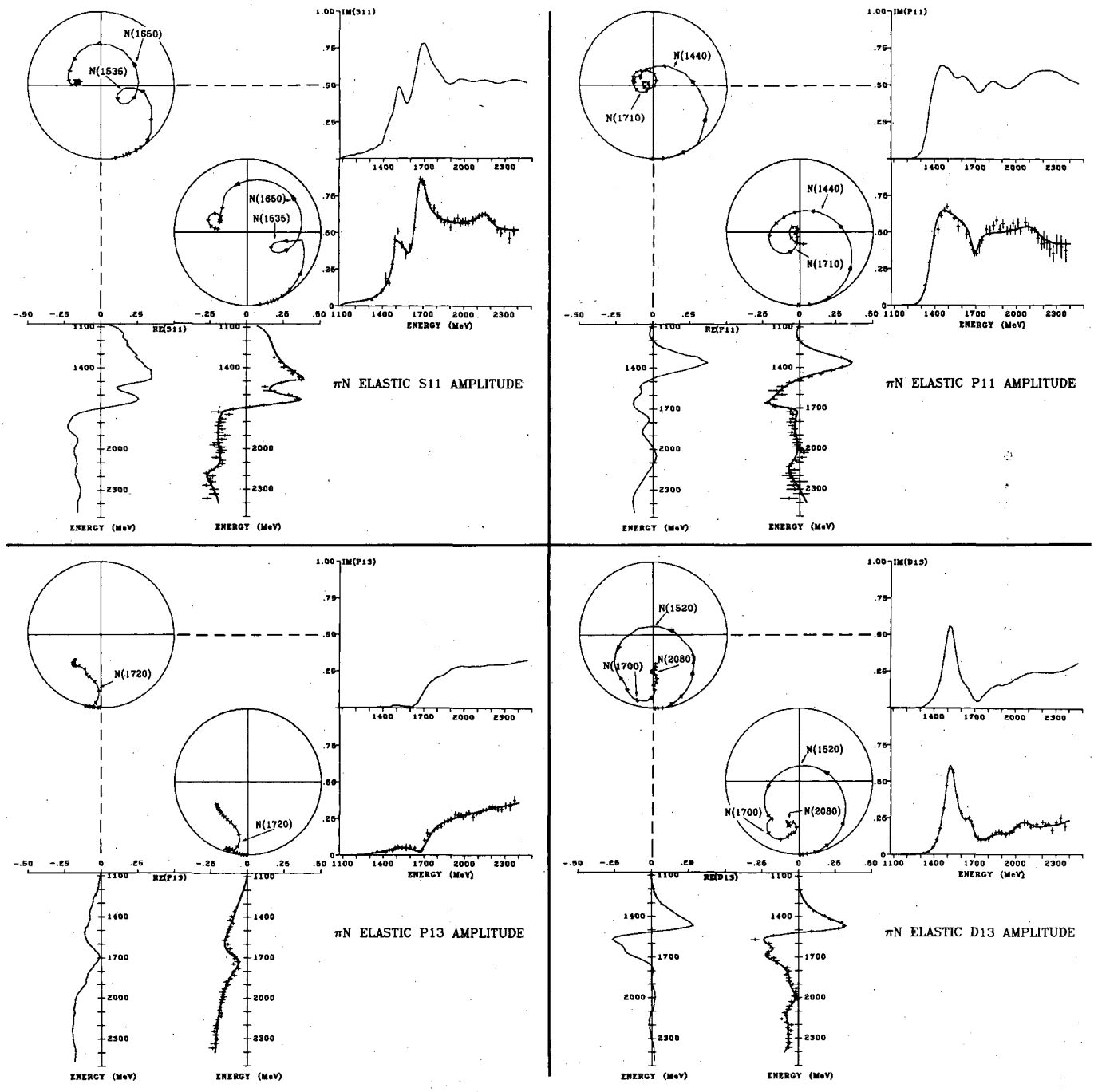

Fig. 1(a). The $L_{2I\cdot 2J} = S_{11}$, P_{11}, P_{13}, and D_{13} partial-wave amplitudes for πN elastic scattering. The upper plot for each amplitude is from HOEHLER 79 and the lower one is from CUTKOSKY 80. In the Argand plots, the ticks are at integral multiples of 50 MeV, and the established resonances are shown at their nominal positions. The real and imaginary parts of the amplitudes as functions of energy are shown projected in alignment with the Argand plots (in the projections of the CUTKOSKY 80 amplitudes, the "data points" are results of energy-independent fits, and the curves are from an energy-dependent fit to join them).

Baryons
N's and Δ's

Data Card Listings

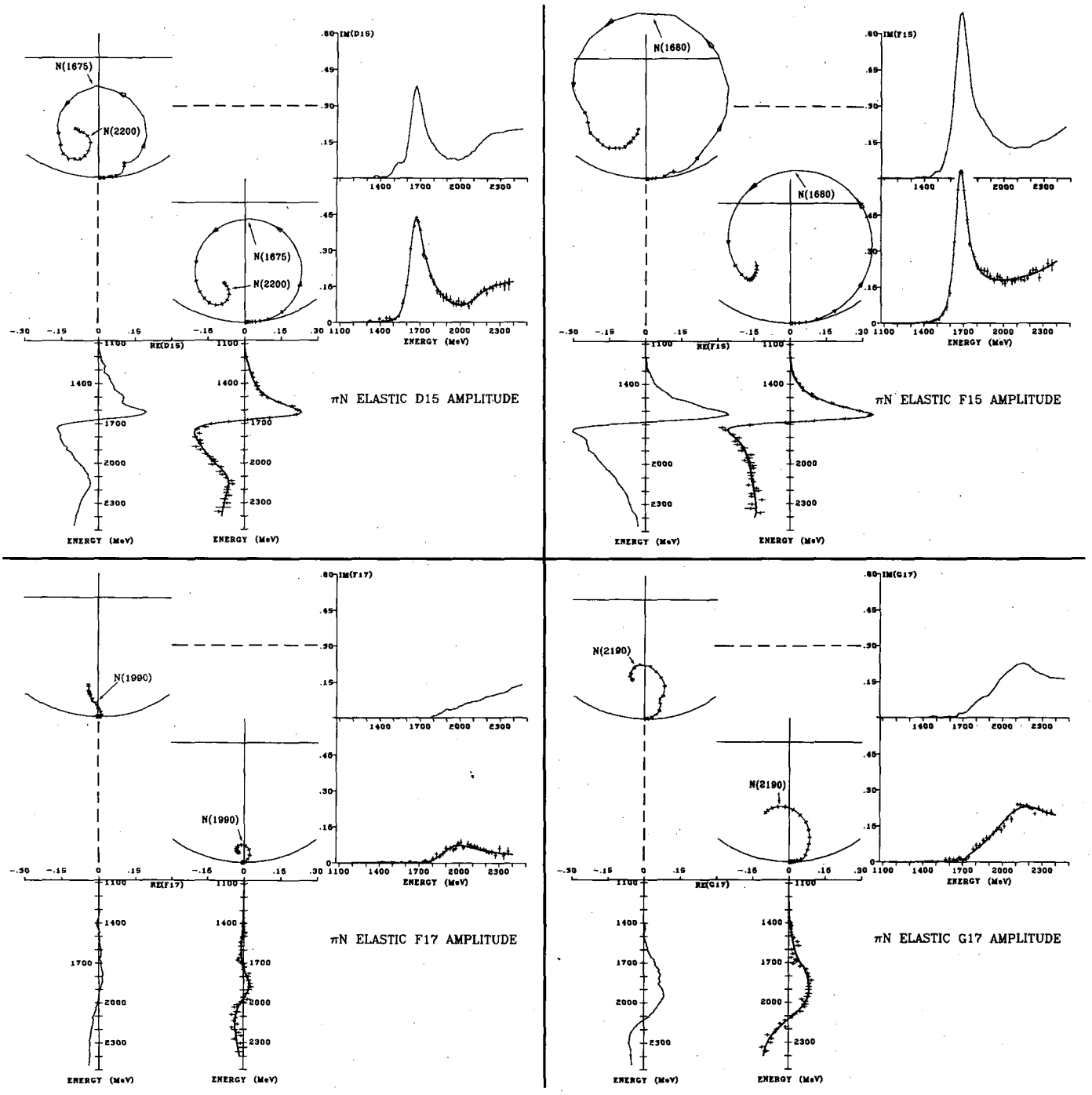

Fig. 1(b). The $L_{2I\cdot 2J} = D_{15}$, F_{15}, F_{17}, and G_{17} partial-wave amplitudes for πN elastic scattering. The upper plot for each amplitude is from HOEHLER 79 and the lower one is from CUTKOSKY 80. In the Argand plots, the ticks are at integral multiples of 50 MeV, and the established resonances are shown at their nominal positions. The real and imaginary parts of the amplitudes as functions of energy are shown projected in alignment with the Argand plots (in the projections of the CUTKOSKY 80 amplitudes, the "data points" are results of energy-independent fits, and the curves are from an energy-dependent fit to join them).

For notation, see key at front of Listings.

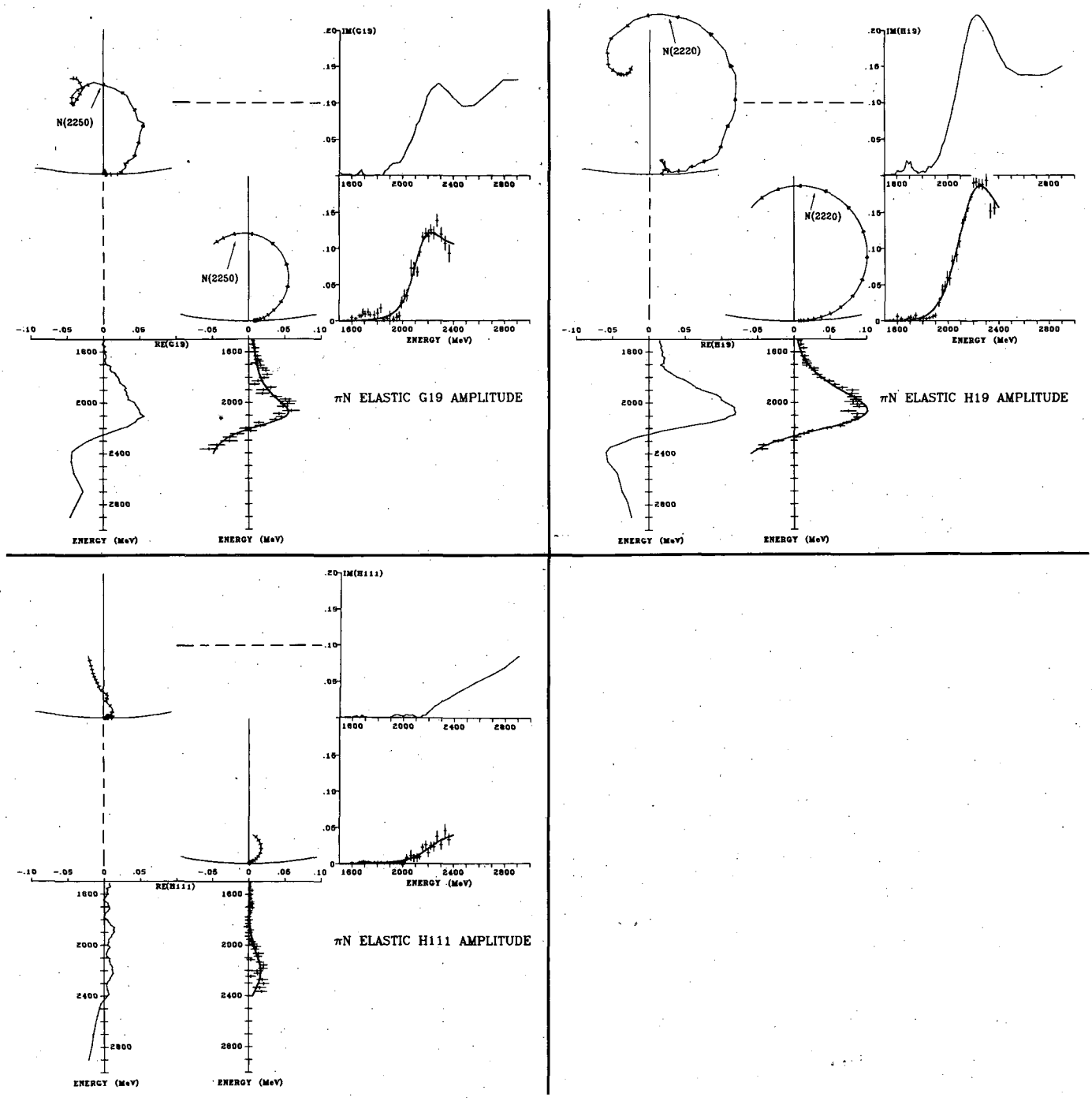

Fig. 1(c). The $L_{2I\cdot 2J} = G_{19}$, H_{19}, and H_{111} partial-wave amplitudes for πN elastic scattering. The upper plot for each amplitude is from HOEHLER 79 and the lower one is from CUTKOSKY 80. In the Argand plots, the ticks are at integral multiples of 50 MeV, and the established resonances are shown at their nominal positions. The real and imaginary parts of the amplitudes as functions of energy are shown projected in alignment with the Argand plots (in the projections of the CUTKOSKY 80 amplitudes, the "data points" are results of energy-independent fits, and the curves are from an energy-dependent fit to join them).

Baryons
N's and Δ's

Data Card Listings

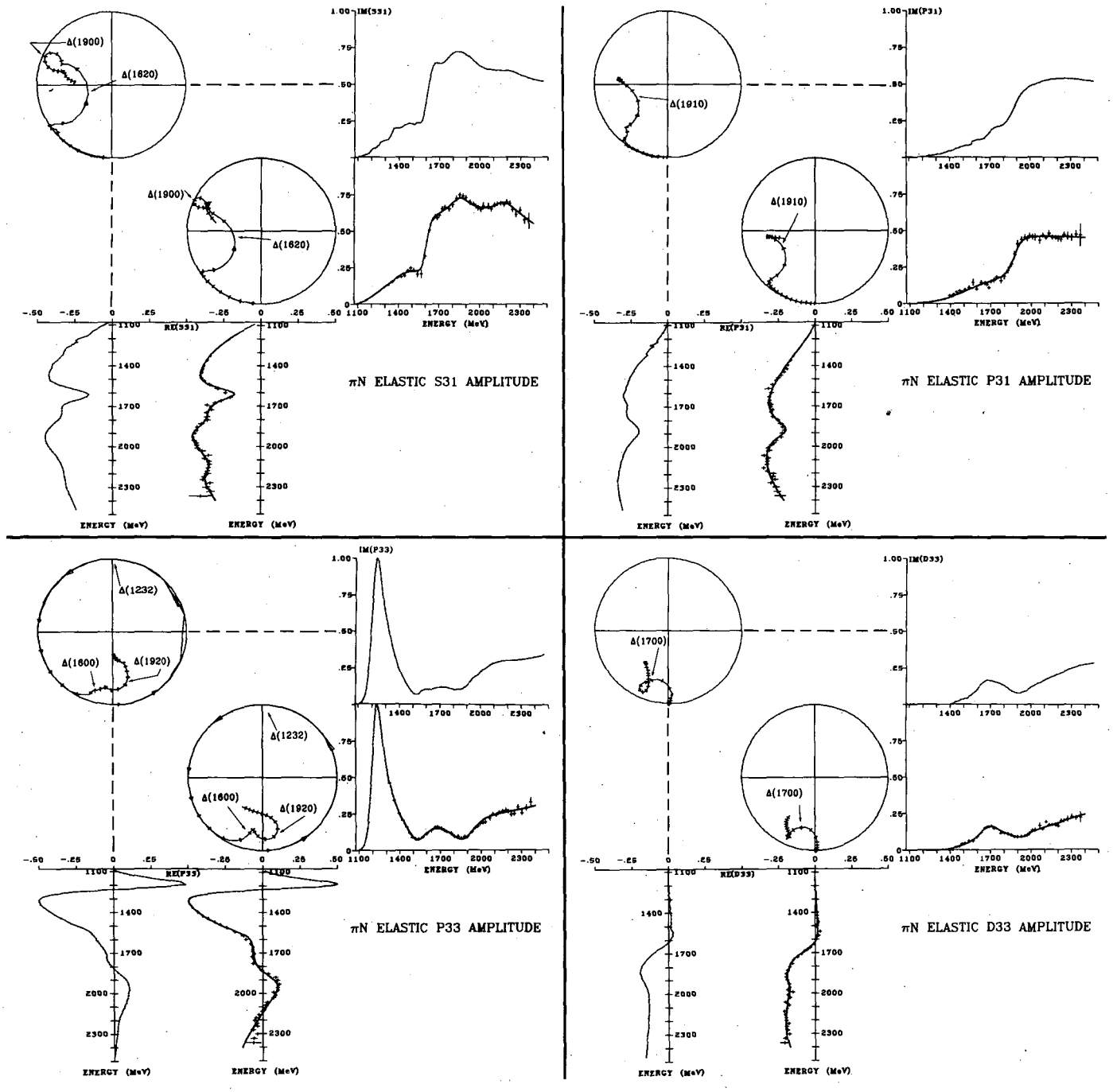

Fig. 1(d). The $L_{2I\cdot 2J} = S_{31}$, P_{31}, P_{33}, and D_{33} partial-wave amplitudes for πN elastic scattering. The upper plot for each amplitude is from HOEHLER 79 and the lower one is from CUTKOSKY 80. In the Argand plots, the ticks are at integral multiples of 50 MeV, and the established resonances are shown at their nominal positions. The real and imaginary parts of the amplitudes as functions of energy are shown projected in alignment with the Argand plots (in the projections of the CUTKOSKY 80 amplitudes, the "data points" are results of energy-independent fits, and the curves are from an energy-dependent fit to join them).

For notation, see key at front of Listings.

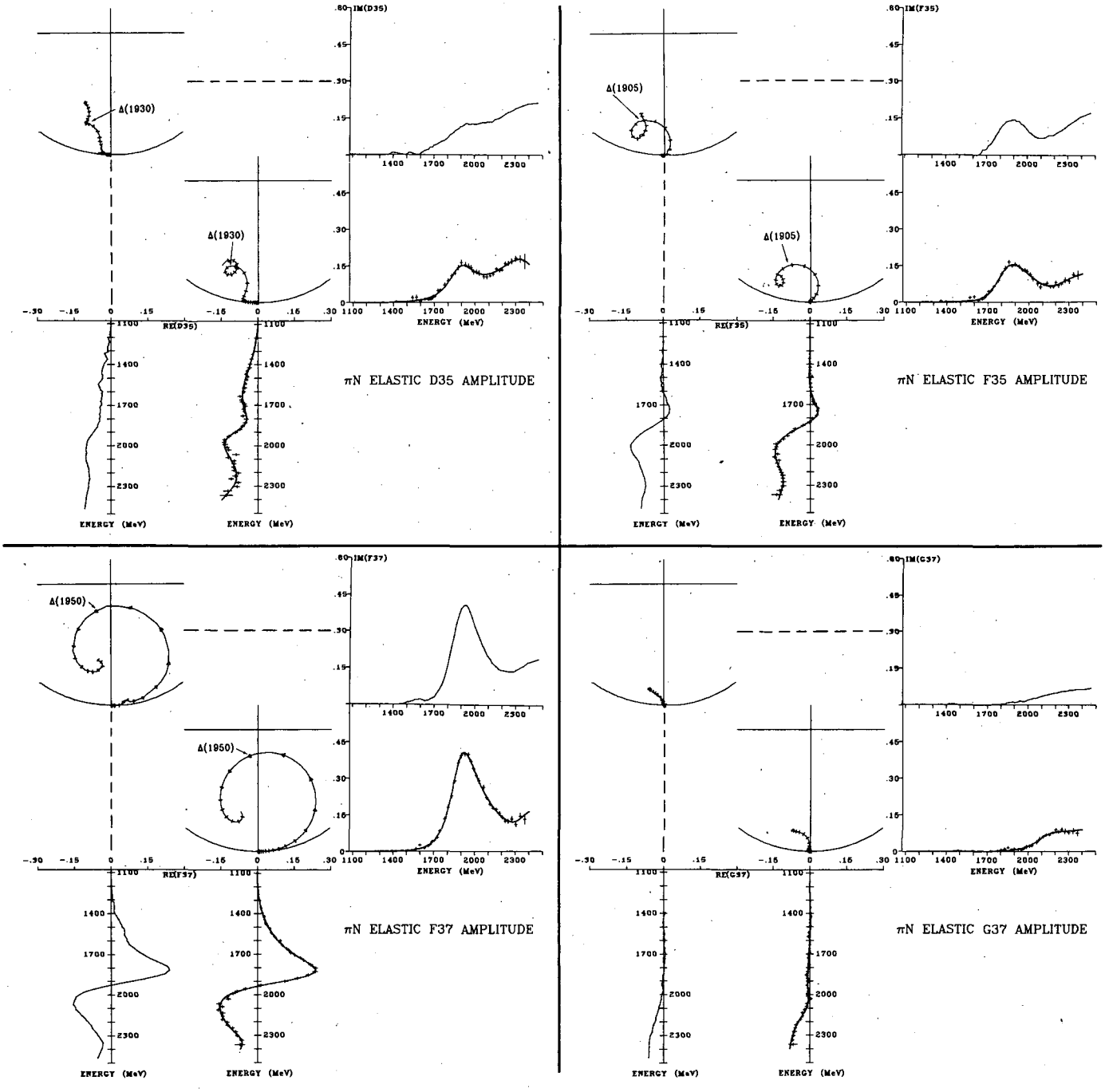

Fig. 1(e). The $L_{2I\cdot 2J} = D_{35}$, F_{35}, F_{37}, and G_{37} partial-wave amplitudes for πN elastic scattering. The upper plot for each amplitude is from HOEHLER 79 and the lower one is from CUTKOSKY 80. In the Argand plots, the ticks are at integral multiples of 50 MeV, and the established resonances are shown at their nominal positions. The real and imaginary parts of the amplitudes as functions of energy are shown projected in alignment with the Argand plots (in the projections of the CUTKOSKY 80 amplitudes, the "data points" are results of energy-independent fits, and the curves are from an energy-dependent fit to join them).

Baryons
N's and Δ's

Data Card Listings

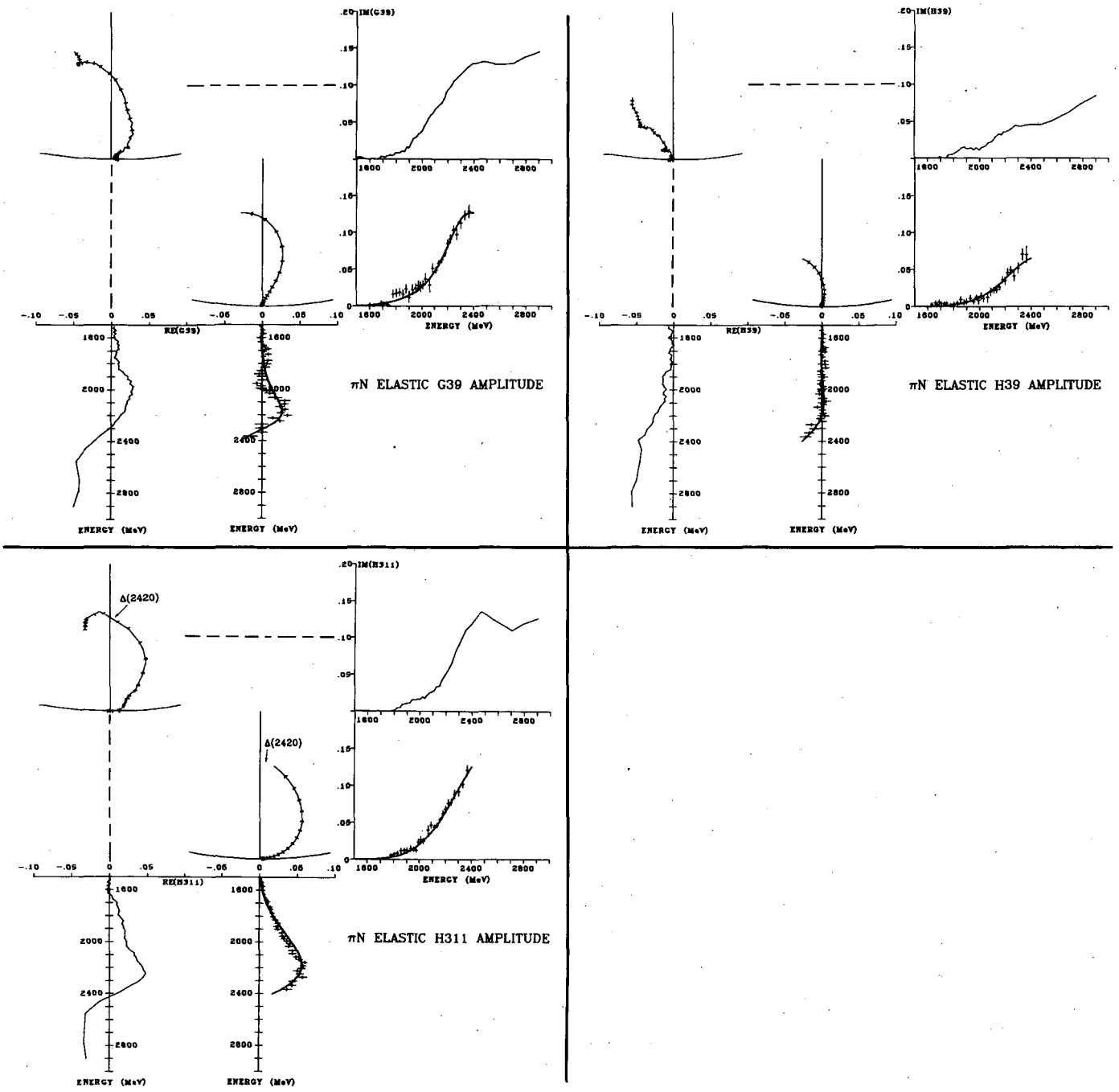

Fig. 1(f). The $L_{2I\cdot 2J} = G_{39}$, H_{39}, and H_{311} partial-wave amplitudes for πN elastic scattering. The upper plot for each amplitude is from HOEHLER 79 and the lower one is from CUTKOSKY 80. In the Argand plots, the ticks are at integral multiples of 50 MeV, and the established resonances are shown at their nominal positions. The real and imaginary parts of the amplitudes as functions of energy are shown projected in alignment with the Argand plots (in the projections of the CUTKOSKY 80 amplitudes, the "data points" are results of energy-independent fits, and the curves are from an energy-dependent fit to join them).

For notation, see key at front of Listings.

traverses the complex plane cannot be accurately determined due to insufficient data. Furthermore, it is a dynamical question whether this background is part of the resonance mechanism.

If the resonances are ordered according to the shapes of their Argand plots, one finds a continuous transition from textbook-type resonances to tiny wiggles superimposed on a huge background. The Baryon Table lists all objects which have a "resonance-like" shape of the Argand diagram and a maximum of the speed. We have to leave it to the reader to decide which of these objects are "resonances" in the framework of his or her model.

The above discussion shows that a comparison of the resonance masses listed in the Baryon Table with predictions from quark-shell or -bag models or from lattice calculations has appreciable uncertainties, in particular where small mass splittings are concerned, since the models cannot yet treat the scattering process including the background.

The Data Card Listings contain a second set of resonance parameters: the locations and residues of the resonance poles on the second sheet of the s-plane. These numbers can be determined in a (more or less) model-independent way. However, it is a warning that Fonda et al.[12] were able to fit the resonant P_{33} amplitude *without a pole.* One needs a theoretical assumption that excludes parametrizations of this type.

It is remarkable that there exist families of resonances in each of which the splittings of the pole positions are comparable with the errors; i.e., a degeneracy is not excluded.[7] For example, all six isospin-1/2 partial waves from S_{11} to F_{15} have a well-established resonance with a pole near $\sqrt{s}$ = (1665-60i) MeV, and at least six of the seven possible isospin-3/2 resonances from S_{31} to F_{37} have a pole near (1880-120i) MeV.

Inelastic 2-body reactions: Partial-wave analyses of the inelastic 2-body reactions $\pi N \to N\eta$, ΛK, and ΣK may be carried out in a way similar to the analysis of $\pi N \to \pi N$. However, since the data are less complete and accurate, energy-dependent parametrizations must be used.

The most accurate results, which include information on the resonance masses and widths, follow from the $\pi^- p \to \Lambda K^0$ data of the Rutherford group.[13] In an energy-dependent analysis, the nonresonant and high waves were represented by a reggeized K^* exchange term.[13,14] Another analysis used a Lagrangian model for the long range forces.[15] In general, agreement with the $\pi N \to \pi N$ analyses is good, but there are discrepancies for the widths of the P_{11} N(1710) and the D_{15} N(1675) and for the mass of the D_{15} N(2200).

In the analysis of the less accurate $\pi^- p \to n\eta$ data,[16] the partial waves were parametrized as Breit-Wigner resonances without background. The resonance spectrum was assumed and the data were used to determine the couplings to the $n\eta$ channel. In some cases of relatively large couplings, the masses and widths were varied in a second step.

The results derived from the bubble chamber data for $\pi^+ p \to \Sigma^+ K^+$ [17] have larger uncertainties. Values of the resonance masses were assumed and Breit-Wigner formulas and an empirical ansatz for the background were used for partial waves up to F waves (the G waves are probably not negligible at 1.7 GeV/c). The recent addition of precise data from 1820 to 2350 MeV[18] has allowed an improved analysis.[19] The solution found is unique. Above 2 GeV, all the resonances with two or more stars are seen, but none of the 1-star states is supported.

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III. The $\pi N \to N\pi\pi$ channel

(by R.L. Crawford, University of Glasgow)

The $\pi N \to N\pi\pi$ reaction has been analyzed using isobar models, which are prompted by the observation that almost all $\pi N \to N\pi\pi$ events in the resonance region lie in quasi-2-body bands in the Dalitz plot. Thus it is assumed that any purely 3-body interaction is negligible and that the reaction proceeds entirely through quasi-2-body intermediate states.

The resulting parametrization contains the couplings of a number of the N and Δ resonances to these quasi-2-body states, and it is these which are given in the Listings. A more complete description of the analyses and of the definition of the couplings may be found in our 1982 edition.[1]

The Listings give the results from four analyses, none new to this edition.

LONGACRE 75 (LBL-SLAC)[2] is based on an analysis of 200,000 $\pi^- p \to p\pi^-\pi^0$, $\pi^- p \to n\pi^-\pi^+$, and $\pi^+ p \to p\pi^+\pi^0$ events with the c.m. energy between 1300 and 2000 MeV. It includes the intermediate states $\Delta(1232)\pi$, $N\rho$, and $N\epsilon$ (where ϵ is the isospin-0 S-wave $\pi\pi$ enhancement). The couplings and the T-matrix poles of 14 resonances are given.

LONGACRE 77 (Saclay)[3] is a similar analysis that fits 100K data points between 1380 and 1740 MeV. The couplings and pole positions of 16 resonances are given, including a P_{13} N(1540) and a P_{31} Δ(1550) suggested for the first time by this analysis.

NOVOSELLER 78 (Cal Tech)[4] is an analysis of $\pi^- p \to p\pi^-\pi^0$, $\pi^- p \to n\pi^-\pi^+$, and $\pi^+ p \to p\pi^+\pi^0$ events from 1650 to 1970 MeV and is based on the earlier LBL-SLAC energy-independent analysis.[5] Two solutions are given, with the second including the effects of single-pion exchange. They are noted in the Listings as being fits to Longacre 75 and Novoseller 78.

BARNHAM 80 (Imperial College)[6] is an analysis of 44,000 $\pi^+ p \to p\pi^+\pi^0$ and $\pi^+ p \to n\pi^+\pi^+$ events between 1440 and 1700 MeV. It thus gives information only about Δ resonances. Decays into $\Delta(1232)\pi$, $N\rho$, and $N(1440)\pi$ are considered. It again finds evidence for the P_{31} Δ(1550), but since it uses data also used by Longacre 77 it is not clear that it confirms this resonance.

It is difficult to assess the systematic uncertainties of the results from these analyses. Again, the reader is referred to our 1982 edition for more details.

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IV. Photoproduction and Compton Scattering

(by R.L. Crawford, University of Glasgow)

Most of the information about the γN couplings of the N and Δ resonances is obtained from partial-wave analyses of single-pion photoproduction. There is now a large amount of data, including many measurements from single and double polarization experiments giving up to six independent experimental observables in some energy ranges. Recently, some couplings have also been obtained from proton Compton scattering. All photoproduction analyses rely heavily on $\pi N \to \pi N$ analyses for knowledge about the existence, masses, and widths of the resonances; there are few photoproduction analyses that treat the masses and widths as free param-

eters, although the results obtained are of some interest since they give access to the charge +1 states. The results may be found in the appropriate sections of the Data Card Listings. We refer to an earlier edition of this Review[1] for more about the formalism of single-pion photoproduction.

There are three main methods for the partial-wave analysis of single-pion photoproduction.

(*a*) ***The simple isobar model***: This is the simplest form of energy-dependent partial-wave analysis (DPWA): the partial waves are parametrized as Breit-Wigner resonances plus smooth background. The method is sufficiently flexible to give good fits to data, but there are possible problems concerned with the uniqueness of the solutions. This is overcome by the form of the parametrization, but it is not clear how this may introduce bias into the solution.

The Listings contain the couplings from isobar analyses of photoproduction from METCALF 74, TAKEDA 80, and BRATASHEVSKIJ 80. ISHII 80 is an isobar analysis of proton Compton scattering in the second resonance region.

(*b*) ***Fixed-t dispersion relations (FTDR)***: In this method, the real parts of the production amplitudes are not parametrized directly but are calculated from the imaginary parts using fixed-t dispersion relations. The latter can be assumed to be resonance dominated and thus can be given a relatively simple parametrization in terms of Breit-Wigner resonances with a little background in the low-angular-momentum partial waves. Alternatively, a K-matrix formalism can be used. Compared to the isobar model, there are fewer parameters and the results may be less sensitive to the details of the parametrization. The method gives fewer problems in obtaining a unique solution than does the isobar model, but it is less flexible and tends to give poorer fits.

The Listings contain the results from the FTDR analyses of AZNAURYAN 77, BARBOUR 78, ARAI 80, CRAWFORD 80, FUJII 81, and AWAJI 81. NOELLE 78 is a hybrid analysis using FTDR in a coupled-channel isobar calculation.

(*c*) ***Energy-independent analyses (IPWA)***: These evaluate the partial waves by fitting at a set of essentially single energies and should be the least biased of all the forms of analysis. At low energies, Watson's theorem[2] is used to fix the complex phases of many of the partial waves in order to get a single solution. This becomes more difficult as the energy increases due to the onset of inelasticity, and only BERENDS 77 uses this method up to the second resonance region. CRAWFORD 83 is an energy-independent analysis for energies below 1750 MeV, based on the CRAWFORD 80 FTDR analysis. It is described below.

New analyses in the Listings: The most recent FTDR analysis, AWAJI 81 (Nagoya), is a revision of the 1979 Tokyo analysis (ARAI 80), and uses new data and more recent resonance parameters from πN elastic partial-wave analyses. It treats the production amplitudes differently depending on the energy. Below 2200 MeV a 3-channel K-matrix formalism is used, and above 2200 MeV a Regge parametrization is used for the dispersion integrals. Pseudo-resonances are used to describe the imaginary background, The couplings for resonances up to the F_{17} N(1990) are determined for both proton and neutron targets.

CRAWFORD 83 is an energy-independent analysis using only proton data for energies between 1200 and 1920 MeV. A unique solution is obtained at each energy by requiring that it not differ radically from the FTDR analysis of CRAWFORD 80. Although the constraints thus applied were the loosest possible that still gave stability of the energy-independent solutions, the two analyses are therefore not totally independent. However, CRAWFORD 83 gives a useful extension of the FTDR solution and achieves a significant improvement in the quality of the fits at all the single energies. The two analyses agree well and again there is weak evidence for the P_{31} Δ(1550).

Resonance couplings in the Listings: The Listings in this edition omit a number of analyses that are now obsolete due to later analyses that used improved data sets. The omitted analyses are ROSSI 73, HEMMI1 73, HEMMI2 73, BENEVENTANO 74, KRIVETS 75 (isobar model), MOORHOUSE 73, DEVENISH 73, KNIES 74, MOORHOUSE 74, DEVENISH2 74, CRAWFORD 75, and BARBOUR 76 (FTDR). They may all be found in our 1982 edition.[3]

The errors for the couplings given in the Listings vary very widely for the different analyses since they have been obtained in different ways and are not comparable. METCALF 74, FELLER 76, AZNAURYAN 77, and ARAI 80 quote errors obtained from the sensi-

tivity of the "best possible" χ^2 to the value of each coupling and thus give only statistical errors based on the data. In BARBOUR 78, CRAWFORD 80, and CRAWFORD 83, it is considered that systematic errors that depend on different forms of parametrization, including that for the background, are more important, and the errors given are an estimate of these. The errors given in AWAJI 81 also include a contribution from the uncertainty in the πN elasticity used to calculate the couplings from the partial waves.

Table 2 gives a compilation of the couplings obtained from BARBOUR 78, ARAI 80, CRAWFORD 80, FUJII 81, AWAJI 81, and CRAWFORD 83. The errors quoted are a combination of the statistical errors from the analyses and of the systematic differences between them. They are compared with the range of predictions from recent quark models.[4-7] There is qualitative agreement in that (1) any coupling whose sign is the same in all the quark models also has the same sign in the analyses, and (2) those couplings which are predicted to be zero or small do seem to be small.

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V. Electroproduction

The excitation of the N and Δ resonances by virtual photons has been investigated using pion and η electroproduction data. For example, a recent measurement of π^+ electroproduction[1] gives additional information about the switching in importance of the helicity 3/2 and 1/2 amplitudes for the D_{13} N(1520) and F_{15} N(1680) resonances. Such information provides tests of the single-quark transition model.[2] However, there is not much new information for the present Review of Particle Properties, so we refer to our last edition for a

Table 2. A compilation of measured γN decay couplings and predictions of the quark model. Sources are given in the text.

(a) Proton target couplings

Resonance	Helicity	Couplings ($GeV^{-1/2}\times10^{-3}$) Partial-wave analyses	Status	Quark-model predictions
N(1440) P_{11}	1/2	−69 ± 7	good	−50 to −5
N(1520) D_{13}	1/2	−22 ± 10	good	−41 to +6
	3/2	+167 ± 10	good	+95 to+174
N(1535) S_{11}	1/2	+73 ± 14	good	+97 to+147
N(1650) S_{11}	1/2	+48 ± 16	fair	−9 to +95
N(1675) D_{15}	1/2	+19 ± 12	good, ≠0	0 to +12
	3/2	+19 ± 12	good, ≠0	0 to +16
N(1680) F_{15}	1/2	−17 ± 10	good, ≠0	−7 to +24
	3/2	+127 ± 12	good	+47 to+154
N(1700) D_{13}	1/2	−22 ± 13	good, ≈0	−7 to +9
	3/2	0 ± 19	fair, ≈0	−12 to +33
N(1710) P_{11}	1/2	+5 ± 16	fair, ≈0	−47 to −7
N(1720) P_{13}	1/2	+52 ± 39	poor	−133 to +74
	3/2	−35 ± 24	fair	−65 to +46
N(1990) F_{17}	1/2	+24 ± 30	poor	−10 to −8
	3/2	31 ± 55	bad	−13 to −10
Δ(1232) P_{33}	1/2	−141 ± 5	good	−127 to −94
	3/2	−258 ± 11	good	−220 to−162
Δ(1550) P_{31}	1/2	+16 ± 16	?	?
Δ(1600) P_{33}	1/2	−20 ± 29	poor, ≈0	−61 to +2
	3/2	+1 ± 22	fair, ≈0	−107 to +4
Δ(1620) S_{31}	1/2	+19 ± 16	fair	+43 to +86
Δ(1700) D_{33}	1/2	+116 ± 17	fair	+78 to+106
	3/2	+77 ± 28	fair	+79 to+105
Δ(1900) S_{31}	1/2	+10 ± ?	?	−3
Δ(1905) F_{35}	1/2	+27 ± 13	good	−10 to +44
	3/2	−47 ± 19	fair	−41 to +15
Δ(1910) P_{31}	1/2	−12 ± 30	poor	−16 to +15
Δ(1920) P_{33}	1/2	+40 ± ?	?	—
	3/2	+23 ± ?	?	—
Δ(1930) D_{35}	1/2	−30 ± 40	poor	−17
	3/2	−10 ± 35	poor	−24
Δ(1950) F_{37}	1/2	−73 ± 14	good	−50 to −25
	3/2	−90 ± 13	good	−69 to −32

(b) Neutron target couplings

Resonance	Helicity	Couplings ($GeV^{-1/2}\times10^{-3}$) Partial-wave analyses	Status	Quark-model predictions
N(1440) P_{11}	1/2	+37 ± 19	fair	+4 to +38
N(1520) D_{13}	1/2	−65 ± 13	good	−52 to −23
	3/2	−144 ± 14	good	−144 to−102
N(1535) S_{11}	1/2	−76 ± 32	fair	−119 to −83
N(1650) S_{11}	1/2	−17 ± 37	poor	−45 to +4
N(1675) D_{15}	1/2	−47 ± 23	fair	−55 to −31
	3/2	−69 ± 19	fair	−78 to −44
N(1680) F_{15}	1/2	+31 ± 13	good	−32 to +27
	3/2	−30 ± 14	good	−25 to +2
N(1700) D_{13}	1/2	0 ± 56	bad	−15 to +23
	3/2	−2 ± 44	bad	−76 to −17
N(1710) P_{11}	1/2	−5 ± 23	fair	−21 to +29
N(1720) P_{13}	1/2	−2 ± 26	fair	−23 to +57
	3/2	−43 ± 94	bad	−61 to +12
N(1990) F_{17}	1/2	−49 ± 45	poor	−19 to −18
	3/2	−122 ± 55	poor	−25 to −23

For notation, see key at front of Listings.

Baryons

N's and Δ's, p, n, N(1440)

brief review[3] and to a recent article for an extensive review[4] of electroproduction.

References for section V

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VI. Production experiments

Partial-wave analyses of course separate partial waves, whereas a peak in a cross section or an invariant mass distribution usually cannot be disentangled from background and analyzed for its quantum numbers; and more than one resonance may be contributing to the peak. We used to have separate entries in the Listings for bumps seen in production experiments in the 1440-MeV region, the 1520-MeV region, etc., but these have been removed from this edition. They may be found in the 1982 edition.[1]

Reference for section VI

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      S=0  I=1/2  NUCLEON  STATES  (N)

****** ********* ********* ********* ********* ********* ********* ********
****** ********* ********* ********* ********* ********* ********* ********

p                16  PROTON(938, JP=1/2+)  I=1/2

                 SEE STABLE PARTICLE DATA CARD LISTINGS

****** ********* ********* ********* ********* ********* ********* ********
****** ********* ********* ********* ********* ********* ********* ********

n                17  NEUTRON(939, JP=1/2+)  I=1/2

                 SEE STABLE PARTICLE DATA CARD LISTINGS

****** ********* ********* ********* ********* ********* ********* ********
****** ********* ********* ********* ********* ********* ********* ********

N(1440) P'11     Status: ****

                 61  N(1440, JP=1/2+) I=1/2   P'11

                 MOST OF THE RESULTS PUBLISHED BEFORE 1975 ARE NOW
                 OBSOLETE AND HAVE BEEN OMITTED.  THEY MAY BE FOUND IN
                 OUR 1982 EDITION (PHYSICS LETTERS 111B).  HOWEVER,
                 ALL THE REFERENCES HAVE BEEN RETAINED.

   IN ADDITION, RESULTS IN THIS REGION FROM PRODUCTION EXPERIMENTS,
   WHICH USED TO BE LISTED SEPARATELY AS THE NEXT ENTRY, HAVE BEEN
   ENTIRELY REMOVED.

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                 61  N(1440) MASS (MEV)

M     A      1415. OR 1390.            LONGACRE  75 IPWA    PI N TO 2PI N    11/75
M     A  THE 2 SETS OF PARAMETERS ARE FROM METHODS 1 AND 2 OF LONGACRE 75.   11/75
M          (1460.0)                    BERENDS   77 IPWA    PI-N PHOTOPROD.   1/78
M     B    (1380.0)                    LONGACRE  77 IPWA    PI N TO 2PI N    11/77
M     B  ALL LONGACRE77 PARAMETERS ARE FROM SOLUTION S2, EXCEPT FOR THE POLE 11/77
M     B  POSITION WHICH IS FROM SOLUTIONS S1 AND C1.                         11/77
M          (1417.0)                    BARBOUR   78 DPWA    PI-N PHOTOPROD.   3/79
M     C    (1472.0)                    BAKER     79 DPWA  0 PI- P TO ETA N   12/79
M          (1450.0)   (30.0)           CUTKOSKY  79 IPWA    PI N TO PI N     12/79
M           1410.0     12.0            HOEHLER   79 IPWA    PI N TO PI N     12/79
M          (1411.0)                    CRAWFORD  80 DPWA    PI N PHOTOPROD.  12/81
M           1440.0     30.0            CUTKOSKY  80 IPWA    PI N TO PI N      1/82

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                 61  N(1440) WIDTH (MEV)

W     A      180. OR  200.             LONGACRE  75 IPWA    PI N TO 2PI N    11/75
W          (279.0)                     BERENDS   77 IPWA    PI-N PHOTOPROD.   1/78
W     B    (200.0)                     LONGACRE  77 IPWA    PI N TO 2PI N    11/77
W          (331.0)                     BARBOUR   78 DPWA    PI-N PHOTOPROD.   3/79
W     C    (113.0)                     BAKER     79 DPWA  0 PI- P TO ETA N   12/79
W          (370.0)   (80.0)            CUTKOSKY  79 IPWA    PI N TO PI N     12/79
W           135.0     10.0             HOEHLER   79 IPWA    PI N TO PI N     12/79
W          (334.0)                     CRAWFORD  80 DPWA    PI N PHOTOPROD.  12/81
W           340.0     70.0             CUTKOSKY  80 IPWA    PI N TO PI N      1/82

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                 61  N(1440) REAL PART OF POLE POSITION (MEV)

RE         (1381.0)                    LONGACRE  75 IPWA    PI N TO 2PI N    11/75
RE    B     1360. OR 1333.             LONGACRE  77 IPWA    PI N TO 2PI N    11/77
RE         (1369.0)                    CUTKOSKY  79 IPWA    PI N TO PI N     12/79
RE          1375.0     30.0            CUTKOSKY  80 IPWA    PI N TO PI N      1/82

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                 61  N(1440) -2*IMAG PART OF POLE POSITION (MEV)

IM         (209.0)                     LONGACRE  75 IPWA    PI N TO 2PI N    11/75
IM    B     167. OR 234.               LONGACRE  77 IPWA    PI N TO 2PI N    11/77
IM         (178.0)                     CUTKOSKY  79 IPWA    PI N TO PI N     12/79
IM          180.0     40.0             CUTKOSKY  80 IPWA    PI N TO PI N      1/82

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                 61  N(1440) REAL PART OF ELASTIC POLE RESIDUE (MEV)

RER         (-9.0)                     CUTKOSKY  79 IPWA    PI N TO PI N     12/79
RER          -9.0     31.0             CUTKOSKY  80 IPWA    PI N TO PI N      1/82

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                 61  N(1440) IMAG PART OF ELASTIC POLE RESIDUE (MEV)

IMR        (-48.0)                     CUTKOSKY  79 IPWA    PI N TO PI N     12/79
IMR         -51.0      7.0             CUTKOSKY  80 IPWA    PI N TO PI N      1/82

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                 61  N(1440) ABSOLUTE VALUE OF POLE RESIDUE (MEV)

ABS          52.0      5.0             CUTKOSKY  80 IPWA    PI N TO PI N      1/82

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                 61  N(1440) PHASE OF POLE RESIDUE (RADIANS)

PH          -1.75      0.61            CUTKOSKY  80 IPWA    PI N TO PI N      1/82

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                 61  N(1440) PARTIAL DECAY MODES

                                                          DECAY MASSES
P1     N(1440) INTO N PI                                  938+ 140
P2     N(1440) INTO N EPSILON                             938+1300
P3     N(1440) INTO DELTA(1232) PI                       1232+ 140
P4     N(1440) INTO N PI PI                               938+ 140+ 140
P5     N(1440) INTO N GAMMA                               938+   0
P6     N(1440) INTO N RHO                                 938+ 769
P7     N(1440) INTO P GAMMA, HELICITY=1/2                 938+   0
P8     N(1440) INTO N GAMMA, HELICITY=1/2                 940+   0
P9     N(1440) INTO N ETA                                 940+ 549
P10    N(1440) INTO LAMBDA K                             1116+ 498
P11    N(1440) INTO N RHO, S=1/2, P-WAVE                  938+ 769
P12    N(1440) INTO N RHO, S=3/2, P-WAVE                  938+ 769

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                 61  N(1440) BRANCHING RATIOS

R1     N(1440) INTO (N PI)/TOTAL                         (P1)
R1          (0.65)   (0.05)            CUTKOSKY  79 IPWA    PI N TO PI N     12/79
R1           0.51     0.05             HOEHLER   79 IPWA    PI N TO PI N     12/79
R1           0.68     0.04             CUTKOSKY  80 IPWA    PI N TO PI N      1/82

R2     N(1440) FROM N PI INTO N ETA                      SQRT(P1*P9)
R2     D       (+0.328)                FELTESSE  75 DPWA  0 1488 TO 1745 MEV 11/75
R2     D  AN ALTERNATIVE WHICH CAN NOT BE DISTINGUISHED FROM THIS IS TO HAVE  11/75
R2     D  A P13 RESONANCE WITH M=1530, W=79, AND COUPLING=+.271               11/75
R2     C  BAKER 79 FINDS A COUPLING OF THE N(1440) TO THE N ETA CHANNEL       12/79
R2     C  NEAR (BUT SLIGHTLY BELOW) THRESHOLD.                                12/79

R3     N(1440) FROM N PI TO DELTA(1232) PI               SQRT(P1*P3)
R3     A       -0.30 OR -0.37          LONGACRE  75 IPWA    PI N TO 2PI N    11/75
R3     B       (-0.41)                 LONGACRE  77 IPWA    PI N TO 2PI N    11/77
R3     B  LONGACRE 77 CONSIDER THIS COUPLING TO BE WELL DETERMINED.

R4     N(1440) FROM N PI TO N RHO, S=1/2, P-WAVE         SQRT(P1*P11)
R4     A        0.0  OR -0.23          LONGACRE  75 IPWA    PI N TO 2PI N    11/75
R4     B       (+0.11)                 LONGACRE  77 IPWA    PI N TO 2PI N    11/77

R5     N(1440) FROM N PI TO N RHO, S=3/2, P-WAVE         SQRT(P1*P12)
R5     B       (-0.18)                 LONGACRE  77 IPWA    PI N TO 2PI N    11/77
R5     B  LONGACRE 77 CONSIDER THIS COUPLING TO BE WELL DETERMINED.

R6     N(1440) FROM N PI TO N EPSILON                    SQRT(P1*P2)
R6     A        0.18 OR +0.23          LONGACRE  75 IPWA    PI N TO 2PI N    11/75
R6     B       (+0.18)                 LONGACRE  77 IPWA    PI N TO 2PI N    11/77

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                 61  N(1440) PHOTON DECAY AMPLITUDES (GEV**-1/2)

        FOR DEFINITION OF GAMMA-NUCLEON DECAY AMPLITUDES, SEE MINI-
      REVIEW PRECEDING THE BARYON LISTINGS.

A1     N(1440) INTO P GAMMA, HELICITY=1/2 (GEV**-1/2)
A1          -0.070    0.023            METCALF   74 DPWA    PI N PHOTOPROD.   2/74
A1          -0.087    0.006            FELLER    76 DPWA    PI N PHOTOPROD.   2/77
A1          -0.038    0.013            AZNAURYAN 77 DPWA    PIO PHTPRD,SOL 1 12/79
A1          -0.019    0.011            AZNAURYAN 77 DPWA    PIO PHTPRD,SOL 2 12/79
A1         (-0.076)                    BERENDS   77 IPWA    PI-N PHOTOPROD.   1/78
A1          -0.075    0.015            BARBOUR   78 DPWA    PI-N PHOTOPROD.   3/79
A1     N   (-0.125)                    NOELLE    78         PI-N PHOTOPROD.   1/80
A1     N  CONVERTED TO OUR CONVENTIONS USING M=1.486, W=.613 FROM NOELLE 78.  1/80
A1          -0.069    0.004            ARAI      80 DPWA    PI N PHOTO FIT 1 12/81
A1          -0.066    0.004            ARAI      80 DPWA    PI N PHOTO FIT 2 12/81
A1          -0.079    0.009            BRATASHEV 80 DPWA    PI N PHOTOPROD.  12/81
A1          -0.068    0.015            CRAWFORD  80 DPWA    PI N PHOTOPROD.  12/81
A1          -0.0584   0.0148           ISHII     80 DPWA    P COMPTON SCAT   12/81
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Baryons — Data Card Listings

N(1440), N(1520)

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A1           -0.063     0.008              AWAJI      81 DPWA    PI N PHOTOPROD.    1/84*
A1           -0.069     0.018              CRAWFORD   83 IPWA    PI N PHOTOPROD.    1/84*

A2     N(1440) INTO N GAMMA, HELICITY=1/2 (GEV**-1/2)
A2            0.043     0.035              METCALF    74 DPWA    PI N PHOTOPROD.    2/74
A2           +0.059     0.016              BARBOUR    78 DPWA    PI-N PHOTOPROD.    3/79
A2     N     (0.062)                       NOELLE     78         PI-N PHOTOPROD.    1/80
A2            0.023     0.009              ARAI       80 DPWA    PI N PHOTO FIT 1 12/81
A2            0.019     0.012              ARAI       80 DPWA    PI N PHOTO FIT 2 12/81
A2            0.056     0.015              CRAWFORD   80 DPWA    PI N PHOTOPROD.   12/81
A2           -0.029     0.035              TAKEDA     80 DPWA    PI N PHOTOPROD.   12/81
A2            0.037     0.010              AWAJI      81 DPWA    PI N PHOTOPROD.    1/84*
A2            0.030     0.003              FUJII      81 DPWA    PI N PHOTOPROD.   12/81

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REFERENCES FOR N(1440)


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BAREYRE  64 PL 8 137           +BRICMAN,VALLADAS,VILLET, +     (SACL+CAEN) IJ
BAREYRE  65 PL 18 342          +BRICMAN, STIRLING, VILLET           (SACL)IJP
BRANDSEN 65 PR 139 B1566       +ODONNELL, MOORHOUSE            (DURH+RHEL)IJP
DALITZ   65 PL 14 159          R H DALITZ, R G MOORHOUSE         (OXF+RHEL)
ROPER    65 PR 138 B190        L D ROPER,R M WRIGHT,B T FELD     (LLL+MIT)IJP
THURNAUE 65 PRL 14 985         P G THURNAUER                         (ROCH)
NAMYSLOW 66 PR 157 1328        NAMYSLOWSKI,RAZMI,ROBERTS  (STAN+EDIN+LOIC)
JOHNSON  67 UCRL-17683 THESIS C H JOHNSON                            (LRL)
ROSENFEL 67 IRVINE CONF        A H ROSENFELD, P SODING                (LRL)

BAREYRE  68 PR 165 1731        P BAREYRE, C BRICMAN, G VILLET       (SACL)IJP
DONNACH1 68 PL 26B 161         A DONNACHIE, R G KIRSOPP, C LOVELACE (CERN)IJP
    ALSO 68 VIENNA 139         DONNACHIE  RAPPORTEUR.S TALK         (GLAS)
    ALSO 68 THESIS             R G KIRSOPP                          (EDIN)
MORGAN   68 PR 166 1731        D MORGAN                             (RHEL)
DONNACHI 69 NP 10B 433         A DONNACHIE, R KIRSOPP          (GLAS+EDIN)
WALKER   69 PR 182 1729        R L WALKER                            (CIT)IJP

AYED     70 KIEV CONF          R AYED,P BAREYRE, G VILLET           (SACL)IJP
AYED2    70 PL 31B 598         +BAREYRE,VILLET                      (SACL)
BERARDO  70 PRL 24 419         +HADDOCK,NEFKENS,..,PARSONS+..   (UCLA+LRL)
DAVIES   70 NP B21 359         A DAVIES                             (GLAS)
DIEM     70 KIEV CONF.         + SMADJA, CHAVANON, DELER, DOLBEAU+  (SACL)
SAXON    70 PR D2 1790         SAXON, MULVEY, CHINOWSKY          (OXF+LRL)
MAKAROV  71 SJNP 13 510        +GASILOVA,NELYUBIN,++                (IOFF)IJP
MICKENS  71 LNC  1  707        R E MICKENS                          (FISK)
ALMEHED  72 NP B40 157         +LOVELACE                       (LUND+RUTG)IJP
AYED     72 BATAVIA CONF       R AYED,P BAREYRE, Y LEMOIGNE         (SACL)

DEVENISH 73 PL 47B 53          DEVENISH,RANKIN,LYTH         (LOUC+BONN+LANC)IJP
HEMMI1   73 PL 43B 79          HEMMI,INAGAKI+            (KYOT+SAGA+KEK+TOKY)IJP
HEMMI2   73 NP B55 333         +INAGAKI,KIKUCHI,MAKI,MIYAKE+  (KYOT+TOKY)IJP
LEE      73 PRL 31 1029        LEE,SHAW         (UCI+ROYAL HOLLOWAY COLLEGE)IJP
LEMOIGNE 73 PURDUE CONF. 93    +GRANET,MARTY,AYED,BAREYRE,BORGEAUD,+(SACL)IJP
MOORHOUS 73 PL 43B 44          MOORHOUSE, OBERLACK              (GLAS+LBL)IJP
ROSSI    73 NC 13A 59          +PIAZZA,SUSINNO,+        (ROMA+FRAS+NAPL+PAVI)IJP
    ALSO 71 LNC 2 1183         CARBONARA,FIORE,+        (NAPL+FRAS+PAVI+ROMA)IJP
BENEVENT 74 NC 19A 529         BENEVENTANO,DANGELO,NOTARISTEFANI,+  (ROMA)IJP
DEVENISH 74 NP B81 330         DEVENISH,FROGGATT,MARTIN   (DESY+NORD+LOUC)
DEVENIS2 74 PL 52B 227         DEVENISH,LYTH,RANKIN       (DESY+LANC+BONN)IJP
KNIES    74 PR D9 2680         KNIES,MOORHOUSE,OBERLACK         (LBL+GLAS)IJP
METCALF  74 NP B76 253         W J METCALF,R L WALKER                (CIT)IJP
MOORHOUS 74 PR D9 1            MOORHOUSE,OBERLACK,ROSENFELD     (GLAS+LBL)IJP

CRAWFORD 75 NP B97 125         R L CRAWFORD                         (GLAS)IJP
FELTESSE 75 NP B93 242         +AYED,BAREYRE,BORGEAUD,DAVID,ERNWEIN+(SACL)IJP
KRIVETS  75 SJNP 20 430        +MIROSHNICHENKO,NIKIFOROV,SANIN+     (KIEV)IJP
    ALSO 74 SJNP 19 112        KRIVETS,NIKIFOROV,SANIN,SHALATSKII   (KIEV)IJP
LONGACRE 75 PL 55B 415         +ROSENFELD,LASINSKI,SMADJA+      (LBL+SLAC)IJP
    ALSO 78 PR D17 1795        LONGACRE,LASINSKI,ROSENFELD+     (LBL+SLAC)
AYED     76 CEA-N-1921         AYED (THESIS)                        (SACL)IJP
BARBOUR  76 NP B111 358        I M BARBOUR,R L CRAWFORD             (GLAS)IJP
FELLER   76 NP B104 219        +FUKUSHIMA,HORIKAWA,KAJIKAWA+   (NAGO+OSAK)IJP
AZNAURYA 77  EFI-264(57)-77    +AKOPOV,BAGDASARYAN                  (YERE)IJP
BERENDS  77 NP B136 317        F A BERENDS,A DONNACHIE         (LEID+MCHS)IJP
LONGACRE 77 NP B122 493        LONGACRE,DOLBEAU                     (SACL)IJP
    ALSO 76 NP B108 365        DOLBEAU,TRIANTIS,NEVEU,CADIET        (SACL)IJP

BARBOUR  78 NP B141 253        BARBOUR,CRAWFORD,PARSONS             (GLAS)
NOELLE   78 PTP 60 778         P NOELLE                             (NAGO)
BAKER    79 NP B156 93         +BROWN,CLARK,DAVIES,DEPAGTER,EVANS+  (RHEL)IJP
CUTKOSKY 79 PR D20 2839        +FORSYTH,HENDRICK,KELLY          (CARN+LBL)IJP
HOEHLER  79 HANDBOOK OF PI-N SCATTERING, PHYSIK DATEN VOL.12-1
                               +KAISER,KOCH,PIETARINEN        (KARL)     IJP
    ALSO 80  TORONTO CONF 3    R KOCH                               (KARL)IJP

ARAI     80  TORONTO CONF 93   I ARAI                               (TOKY)
    ALSO 82 NP B194 251        I ARAI, H FUJII                      (TOKY)
BRATASHE 80 NP B166 525        BRATASHEVSKIJ,GORBENKO,DEREBCHINSKIJ+(KHAR)
CRAWFORD 80  TORONTO CONF 107 R L CRAWFORD                          (GLAS)
CUTKOSKY 80  TORONTO CONF 19   +FORSYTH,BABCOCK,KELLY,HENDRICK  (CARN+LBL)IJP
ISHII    80 NP B165 189        ISHII,EGAWA,KATO,MIYACHI+        (KYOT+TOKY)
TAKEDA   80 NP B168 17         TAKEDA,ARAI,FUJII,IKEDA,IWASAKI+     (TOKY)
AWAJI    81  BONN CONF 352     R KAJIKAWA (TALK)                    (NAGO)
    ALSO 82 NP B197 365        FUJII,HAYASHII,IWATA,KAJIKAWA+       (NAGO)
FUJII    81 NP B187 53         FUJII,HAYASHII,IWATA,KAJIKAWA+       (TOKY)
CRAWFORD 83 NP B211 1          R L CRAWFORD, W T MORTON             (GLAS)
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N(1520) D'_{13} Status: ****

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                       62  N(1520, JP=3/2-) I=1/2   D'13

                       MOST OF THE RESULTS PUBLISHED BEFORE 1975 ARE NOW
                       OBSOLETE AND HAVE BEEN OMITTED.  THEY MAY BE FOUND IN
                       OUR 1982 EDITION (PHYSICS LETTERS 111B).  HOWEVER,
                       ALL THE REFERENCES HAVE BEEN RETAINED.

           IN ADDITION, RESULTS IN THIS REGION FROM PRODUCTION EXPERIMENTS,
           WHICH USED TO BE LISTED SEPARATELY AS THE NEXT ENTRY, HAVE BEEN
           ENTIRELY REMOVED.

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                       62  N(1520) MASS (MEV)

M      A     1524. OR 1520.              LONGACRE   75 IPWA    PI N TO 2PI N     11/75
M      A  THE 2 SETS OF PARAMETERS ARE FROM METHODS 1 AND 2 OF LONGACRE 75.    11/75
M            (1510.0)                    BERENDS    77 IPWA    PI-N PHOTOPROD.    1/78
M      B     (1510.0)                    LONGACRE   77 IPWA    PI N TO 2PI N     11/77
M      B  ALL LONGACRE77 PARAMETERS ARE FROM SOLUTION S2, EXCEPT FOR THE POLE 11/77
M      B  POSITION WHICH IS FROM SOLUTIONS S1 AND C1.                          11/77
M            (1503.0)                    BARBOUR    78 DPWA    PI-N PHOTOPROD.    3/79
M            (1525.0)    (15.0)          CUTKOSKY   79 IPWA    PI N TO PI N      12/79
M             1519.0       4.0           HOEHLER    79 IPWA    PI N TO PI N      12/79
M            (1504.0)                    CRAWFORD   80 DPWA    PI N PHOTOPROD.   12/81
M             1525.0      10.0           CUTKOSKY   80 IPWA    PI N TO PI N       1/82

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                       62  N(1520) WIDTH (MEV)

W      A      120. OR  150.              LONGACRE   75 IPWA    PI N TO 2PI N     11/75
W            (105.0)                     BERENDS    77 IPWA    PI-N PHOTOPROD.    1/78
W      B     (110.0)                     LONGACRE   77 IPWA    PI N TO 2PI N     11/77
W            (135.0)                     BARBOUR    78 DPWA    PI-N PHOTOPROD.    3/79
W            (183.0)                     BAKER      79 DPWA  0 PI- P TO ETA N    12/79
W            (125.0)     (25.0)          CUTKOSKY   79 IPWA    PI N TO PI N      12/79
W             114.0       7.0            HOEHLER    79 IPWA    PI N TO PI N      12/79
W            (124.0)                     CRAWFORD   80 DPWA    PI N PHOTOPROD.   12/81
W             120.0      15.0            CUTKOSKY   80 IPWA    PI N TO PI N       1/82

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                       62  N(1520) REAL PART OF POLE POSITION (MEV)

RE           (1514.0)                    LONGACRE   75 IPWA    PI N TO 2PI N     11/75
RE     B      1508. OR 1505.             LONGACRE   77 IPWA    PI N TO 2PI N     11/77
RE           (1510.0)                    CUTKOSKY   79 IPWA    PI N TO PI N      12/79
RE            1510.0       5.0           CUTKOSKY   80 IPWA    PI N TO PI N       1/82

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                       62  N(1520) -2*IMAG PART OF POLE POSITION (MEV)

IM           (146.0)                     LONGACRE   75 IPWA    PI N TO 2PI N     11/75
IM     B      109.  OR 107.              LONGACRE   77 IPWA    PI N TO 2PI N     11/77
IM           (114.0)                     CUTKOSKY   79 IPWA    PI N TO PI N      12/79
IM            114.0      10.0            CUTKOSKY   80 IPWA    PI N TO PI N       1/82

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                       62  N(1520) REAL PART OF ELASTIC POLE RESIDUE (MEV)

RER           (34.0)                     CUTKOSKY   79 IPWA    PI N TO PI N      12/79
RER            34.0       2.0            CUTKOSKY   80 IPWA    PI N TO PI N       1/82

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                       62  N(1520) IMAG PART OF ELASTIC POLE RESIDUE (MEV)

IMR           (-8.0)                     CUTKOSKY   79 IPWA    PI N TO PI N      12/79
IMR            -7.0       3.0            CUTKOSKY   80 IPWA    PI N TO PI N       1/82

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                       62  N(1520) PARTIAL DECAY MODES

                                                            DECAY MASSES
P1     N(1520) INTO N PI                                   938+ 140
P2     N(1520) INTO DELTA(1232) PI                        1232+ 140
P3     N(1520) INTO N PI PI                                938+ 140+ 140
P4     N(1520)+ INTO NEUTRON PI+                           940+ 140
P5     N(1520)+ INTO P PI+ PI-                             938+ 140+ 140
P6     N(1520) INTO N ETA                                  940+ 549
P7     N(1520) INTO N EPSILON                              938+1300
P8     N(1520) INTO N RHO                                  938+ 769
P9     N(1520) INTO P GAMMA, HELICITY=1/2                  938+   0
P10    N(1520) INTO P GAMMA, HELICITY=3/2                  938+   0
P11    N(1520) INTO N GAMMA, HELICITY=1/2                  940+   0
P12    N(1520) INTO N GAMMA, HELICITY=3/2                  940+   0
P13    N(1520) INTO LAMBDA K                              1116+ 498
P14    N(1520) INTO DELTA(1232) PI, S-WAVE                1232+ 140
P15    N(1520) INTO DELTA(1232) PI, D-WAVE                1232+ 140
P16    N(1520) INTO N RHO, S=3/2, S-WAVE                   938+ 769

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                       62  N(1520) BRANCHING RATIOS

R1     N(1520) INTO (N PI)/TOTAL                                (P1)
R1           (0.56)   (0.06)             CUTKOSKY   79 IPWA    PI N TO PI N      12/79
R1            0.54     0.03              HOEHLER    79 IPWA    PI N TO PI N      12/79
R1            0.58     0.03              CUTKOSKY   80 IPWA    PI N TO PI N       1/82

R2     N(1520) FROM N PI TO N ETA                               SQRT(P1*P6)
R2          +0.011 OR +0.058             FELTESSE   75 DPWA  0 1488 TO 1745 MEV  1/76
R2          (0.02)                       BAKER      79 DPWA  0 PI- P TO ETA N    12/79

R3     N(1520) FROM N PI TO DELTA(1232) PI, S-WAVE      SQRT(P1*P14)
R3     A     +0.27 OR +0.24              LONGACRE   75 IPWA    PI N TO 2PI N     11/75
R3     B    (+0.26)                      LONGACRE   77 IPWA    PI N TO 2PI N     11/77
R3     B  LONGACRE 77 CONSIDER THIS COUPLING TO BE WELL DETERMINED.

R4     N(1520) FROM N PI TO DELTA(1232) PI, D-WAVE      SQRT(P1*P15)
R4     A     +0.24 OR +0.30              LONGACRE   75 IPWA    PI N TO 2PI N     11/75
R4     B    (+0.21)                      LONGACRE   77 IPWA    PI N TO 2PI N     11/77
R4     B  LONGACRE 77 CONSIDER THIS COUPLING TO BE WELL DETERMINED.

R5     N(1520) FROM N PI TO N RHO, S=3/2, S-WAVE        SQRT(P1*P16)
R5     A     +0.32 OR +0.24              LONGACRE   75 IPWA    PI N TO 2PI N     11/75
R5     B    (+0.35)                      LONGACRE   77 IPWA    PI N TO 2PI N     11/77
R5     B  LONGACRE 77 CONSIDER THIS COUPLING TO BE WELL DETERMINED.

R6     N(1520) FROM N PI INTO N EPSILON                        SQRT(P1*P7)
R6     A      0.0  OR +0.17              LONGACRE   75 IPWA    PI N TO 2PI N     11/75
R6     B    (+0.13)                      LONGACRE   77 IPWA    PI N TO 2PI N     11/77

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                       62  N(1520) PHOTON DECAY AMPLITUDES (GEV**-1/2)

         FOR DEFINITION OF GAMMA-NUCLEON DECAY AMPLITUDES, SEE MINI-
       REVIEW PRECEDING THE BARYON LISTINGS.

A1     N(1520) INTO P GAMMA, HELICITY=1/2 (GEV**-1/2)
A1           -0.006     0.006            METCALF    74 DPWA    PI N PHOTOPROD.    2/74
A1           -0.005     0.005            FELLER     76 DPWA    PI N PHOTOPROD.    2/77
A1           -0.003     0.003            AZNAURYAN 77 DPWA    PI0 PHTPRD,SOL 1 12/79
A1           -0.030     0.002            AZNAURYAN 77 DPWA    PI0 PHTPRD,SOL 2 12/79
A1          (-0.021)                     BERENDS    77 IPWA    PI-N PHOTOPROD.    1/78
A1           -0.016     0.008            BARBOUR    78 DPWA    PI-N PHOTOPROD.    3/79
A1     N    (-0.008)                     NOELLE     78         PI-N PHOTOPROD.    1/80
A1     N  CONVERTED TO OUR CONVENTIONS USING M=1.528, W=.187 FROM NOELLE 78.    1/80
A1           -0.032     0.005            ARAI       80 DPWA    PI N PHOTO FIT 1 12/81
A1           -0.032     0.004            ARAI       80 DPWA    PI N PHOTO FIT 2 12/81
A1           -0.031     0.009            BRATASHEV 80 DPWA    PI N PHOTOPROD.   12/81
A1           -0.019     0.007            CRAWFORD   80 DPWA    PI N PHOTOPROD.   12/81
A1           -0.0430    0.0063           ISHII      80 DPWA    P COMPTON SCAT    12/81
A1           -0.007     0.004            AWAJI      81 DPWA    PI N PHOTOPROD.    1/84*
A1           -0.028     0.014            CRAWFORD   83 IPWA    PI N PHOTOPROD.    1/84*
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For notation, see key at front of Listings.

Baryons
N(1520), N(1535)

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A2     N(1520) INTO P GAMMA, HELICITY=3/2 (GEV**-1/2)
A2          +0.165    0.011          METCALF   74 DPWA    PI N PHOTOPROD.   2/74
A2          +0.164    0.008          FELLER    76 DPWA    PI N PHOTOPROD.   2/77
A2          +0.182    0.006          AZNAURYAN 77 DPWA    PIO PHTPRD,SOL 1 12/79
A2          +0.133    0.002          AZNAURYAN 77 DPWA    PIO PHTPRD,SOL 2 12/79
A2         (+0.075)                   BERENDS   77 IPWA    PI-N PHOTOPROD.   1/78
A2          +0.157    0.007          BARBOUR   78 DPWA    PI-N PHOTOPROD.   3/79
A2   N     (0.206)                    NOELLE    78         PI-N PHOTOPROD.   1/80
A2          0.178    0.003           ARAI      80 DPWA    PI N PHOTO FIT 1 12/81
A2          0.162    0.003           ARAI      80 DPWA    PI N PHOTO FIT 2 12/81
A2          0.166    0.005           BRATASHEV 80 DPWA    PI N PHOTOPROD.  12/81
A2          0.167    0.010           CRAWFORD  80 DPWA    PI N PHOTOPROD.  12/81
A2          0.1695   0.0014          ISHII     80 DPWA    P COMPTON SCAT   12/81
A2          0.168    0.013           AWAJI     81 DPWA    PI N PHOTOPROD.   1/84*
A2          0.156    0.022           CRAWFORD  83 IPWA    PI N PHOTOPROD.   1/84*

A3     N(1520) INTO N GAMMA, HELICITY=1/2 (GEV**-1/2)
A3         -0.066    0.010          METCALF   74 DPWA    PI N PHOTOPROD.   2/74
A3         -0.055    0.014          BARBOUR   78 DPWA    PI-N PHOTOPROD.   3/79
A3   N    (-0.060)                   NOELLE    78         PI-N PHOTOPROD.   1/80
A3         -0.076    0.006          ARAI      80 DPWA    PI N PHOTO FIT 1 12/81
A3         -0.071    0.011          ARAI      80 DPWA    PI N PHOTO FIT 2 12/81
A3         -0.056    0.011          CRAWFORD  80 DPWA    PI N PHOTOPROD.  12/81
A3         -0.050    0.014          TAKEDA    80 DPWA    PI N PHOTOPROD.  12/81
A3         -0.066    0.013          AWAJI     81 DPWA    PI N PHOTOPROD.   1/84*
A3         -0.067    0.004          FUJII     81 DPWA    PI N PHOTOPROD.  12/81

A4     N(1520) INTO N GAMMA, HELICITY=3/2 (GEV**-1/2)
A4         -0.118    0.013          METCALF   74 DPWA    PI N PHOTOPROD.   2/74
A4         -0.141    0.015          BARBOUR   78 DPWA    PI-N PHOTOPROD.   3/79
A4   N    (-0.127)                   NOELLE    78         PI-N PHOTOPROD.   1/80
A4         -0.147    0.008          ARAI      80 DPWA    PI N PHOTO FIT 1 12/81
A4         -0.148    0.009          ARAI      80 DPWA    PI N PHOTO FIT 2 12/81
A4         -0.144    0.015          CRAWFORD  80 DPWA    PI N PHOTOPROD.  12/81
A4         -0.118    0.011          TAKEDA    80 DPWA    PI N PHOTOPROD.  12/81
A4         -0.124    0.009          AWAJI     81 DPWA    PI N PHOTOPROD.   1/84*
A4         -0.158    0.003          FUJII     81 DPWA    PI N PHOTOPROD.  12/81

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REFERENCES FOR N(1520)

FOR VERY EARLY REFERENCES, SEE RMP 37, 633 (1965).


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KIRZ     63 PR 130 2481        J KIRZ, J SCHWARTZ, R D TRIPP          (LRL)
BAREYRE  65 PL 18 342          + BRICMAN, STIRLING, VILLET          (SACL)IJP
BRANDSEN 65 PR 139 B1566       +ODONNELL, MOORHOUSE            (DURH+RHEL)IJP
CROUCH   65 DESY CONF II 21    +              (BROW+CEA+HARV+MIT+PADO+REHO)
DERADO   65 ATHENS CONF 244    +KENNEY,LAMSA, +                (NDAM+KNTY)
ROPER    65 PR 138 B190        L D ROPER,R M WRIGHT,B T FELD     (LLL+MIT)IJP
THURNAUE 65 PRL 14 985         P G THURNAUER                         (ROCH)
KIRZ     66 PRIVATE COMM       J KIRZ                                 (LRL)
    NUMBER EXTRACTED FROM DATA DISCUSSED IN KIRZ 63.
MERLO    66 P ROY SOC 289 489  J P MERLO, G VALLADAS                  (SACL)
NAMYSLOW 66 PR 157 1328        NAMYSLOWSKI,RAZMI,ROBERTS  (STAN+EDIN+LOIC)
OLSSON   66 PR 145 1309        M G OLSSON, G B YODH              (WISC+UMD)

DAVIES   67 NC 52A 1112        A T DAVIES, R G MOORHOUSE       (GLAS+RHEL)
JOHNSON  67 UCRL-17683 THESIS  C H JOHNSON                           (LRL)
ROBERTS  67 PREPRINT           R G ROBERTS                         (DURH)
ROSENFEL 67 IRVINE CONF        A H ROSENFELD, P SODING              (LRL)
BAREYRE  68 PR 165 1731        P BAREYRE, C BRICMAN, G VILLET      (SACL)IJP
DONNACH1 68 PL 26B 161         A DONNACHIE, R G KIRSOPP, C LOVELACE (CERN)IJP
    ALSO 68 VIENNA 139         DONNACHIE  RAPPORTEUR.S TALK          (GLAS)
    ALSO 68 THESIS             R G KIRSOPP                           (EDIN)
MORGAN   68 PR 166 1731        D MORGAN                              (RHEL)

BOTKE    69 PR 180 1417        J C BOTKE                            (UCSB)
DEANS    69 PR 185 1797        S DEANS, J WOOTEN                    (SFLA)
DEANS2   69 PR 177 2623        S R DEANS                            (SFLA)
DONNACH1 69 NP 10B 433         A DONNACHIE, R KIRSOPP          (GLAS+EDIN)
WALKER   69 PR 182 1729        R L WALKER                           (CIT)IJP
AYED     70 KIEV CONF          R AYED,P BAREYRE, G VILLET          (SACL)IJP
AYED2    70 PL 31B 598         +BAREYRE,VILLET                      (SACL)
CARRERAS 70 NP 16B 35          B CARRERAS, A DONNACHIE         (DARE+MCHS)
DAVIES   70 NP B21 359         A DAVIES                             (GLAS)
DIEM     70 KIEV CONF.         + SMADJA, CHAVANON, DELER, DOLBEAU+  (SACL)
ALMEHED  72 NP B40 157         +LOVELACE                       (LUND+RUTG)IJP

DEVENISH 73 PL 47B 53          DEVENISH,RANKIN,LYTH       (LOUC+BONN+LANC)IJP
HEMMI1   73 PL 43B 79          HEMMI,INAGAKI+             (KYOT+SAGA+KEK+TOKY)IJP
HEMMI2   73 NP B55 333         +INAGAKI,KIKUCHI,MAKI,MIYAKE+   (KYOT+TOKY)IJP
LEMOIGNE 73 PURDUE CONF. 93    +GRANET,MARTY,AYED,BAREYRE,BORGEAUD,+(SACL)IJP
MOORHOUS 73 PL 43B 44          MOORHOUSE, OBERLACK                 (GLAS+LBL)IJP
ROSSI    73 NC 13A 59          +PIAZZA,SUSINNO,+     (ROMA+FRAS+NAPL+PAVI)IJP
    ALSO 71 LNC 2 1183         CARBONARA,FIORE,+     (NAPL+FRAS+PAVI+ROMA)IJP
BENEVENT 74 NC 19A 529         BENEVENTANO,DANGELO,NOTARISTEFANI,+  (ROMA)IJP
DEVENISH 74 NP B81 330         DEVENISH,FROGGATT,MARTIN   (DESY+NORD+LOUC)
DEVENIS2 74 PL 52B 227         DEVENISH,LYTH,RANKIN       (DESY+LANC+BONN)IJP
KNIES    74 PR D9 2680         KNIES,MOORHOUSE,OBERLACK          (LBL+GLAS)IJP
METCALF  74 NP B76 253         W J METCALF,R L WALKER                (CIT)IJP
MOORHOUS 74 PR D9 1            MOORHOUSE,OBERLACK,ROSENFELD     (GLAS+LBL)IJP

CRAWFORD 75 NP B97 125         R L CRAWFORD                         (GLAS)IJP
FELTESSE 75 NP B93 242         +AYED,BAREYRE,BORGEAUD,DAVID,ERNWEIN+(SACL)IJP
KRIVETS  75 SJNP 20 430        +MIROSHNICHENKO,NIKIFOROV,SANIN+    (KIEV)IJP
    ALSO 74 SJNP 19 112        KRIVETS,NIKIFOROV,SANIN,SHALATSKII  (KIEV)IJP
LONGACRE 75 PL 55B 415         +ROSENFELD,LASINSKI,SMADJA+      (LBL+SLAC)IJP
    ALSO 78 PR D17 1795        LONGACRE,LASINSKI,ROSENFELD+     (LBL+SLAC)
AYED     76 CEA-N-1921         AYED (THESIS)                        (SACL)IJP
BARBOUR  76 NP B111 358        I M BARBOUR,R L CRAWFORD             (GLAS)IJP
FELLER   76 NP B104 219        +FUKUSHIMA,HORIKAWA,KAJIKAWA+   (NAGO+OSAK)IJP

AZNAURYA 77  EFI-264(57)-77    +AKOPOV,BAGDASARYAN                 (YERE)IJP
BERENDS  77 NP B136 317        F A BERENDS,A DONNACHIE         (LEID+MCHS)IJP
LONGACRE 77 NP B122 493        LONGACRE,DOLBEAU                     (SACL)IJP
    ALSO 76 NP B108 365        DOLBEAU,TRIANTIS,NEVEU,CADIET        (SACL)IJP
BARBOUR  78 NP B141 253        BARBOUR,CRAWFORD,PARSONS             (GLAS)
NOELLE   78 PTP 60 778         P NOELLE                             (NAGO)
BAKER    79 NP B156 93         +BROWN,CLARK,DAVIES,DEPAGTER,EVANS+  (RHEL)IJP
CUTKOSKY 79 PR D20 2839        +FORSYTH,HENDRICK,KELLY          (CARN+LBL)IJP
HOEHLER  79 HANDBOOK OF PI-N SCATTERING, PHYSIK DATEN VOL.12-1
                               +KAISER,KOCH,PIETARINEN        (KARL)      IJP
    ALSO 80  TORONTO CONF 3    R KOCH                              (KARL)IJP

ARAI     80  TORONTO CONF 93   I ARAI                               (TOKY)
    ALSO 82 NP B194 251        I ARAI, H FUJII                      (TOKY)
BRATASHE 80 NP B166 525        BRATASHEVSKIJ,GORBENKO,DEREBCHINSKIJ+(KHAR)
CRAWFORD 80  TORONTO CONF 107  R L CRAWFORD                         (GLAS)
CUTKOSKY 80  TORONTO CONF 19   +FORSYTH,BABCOCK,KELLY,HENDRICK  (CARN+LBL)IJP
ISHII    80 NP B165 189        ISHII,EGAWA,KATO,MIYACHI+        (KYOT+TOKY)
TAKEDA   80 NP B168 17         TAKEDA,ARAI,FUJII,IKEDA,IWASAKI+     (TOKY)
AWAJI    81  BONN CONF 352     R KAJIKAWA (TALK)                    (NAGO)
    ALSO 82 NP B197 365        FUJII,HAYASHII,IWATA,KAJIKAWA+       (NAGO)
FUJII    81 NP B187 53         FUJII,HAYASHII,IWATA,KAJIKAWA+       (TOKY)
CRAWFORD 83 NP B211 1          R L CRAWFORD, W T MORTON             (GLAS)
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N(1535) S_{11} Status: ****

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63  N(1535, JP=1/2-) I=1/2   S'11

MOST OF THE RESULTS PUBLISHED BEFORE 1975 ARE NOW
OBSOLETE AND HAVE BEEN OMITTED.  THEY MAY BE FOUND IN
OUR 1982 EDITION (PHYSICS LETTERS 111B).  HOWEVER,
NEARLY ALL THE REFERENCES HAVE BEEN RETAINED.

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                    63  N(1535) MASS (MEV)

M    A     1520. OR 1510.            LONGACRE  75 IPWA    PI N TO 2PI N    11/75
M    A  THE 2 SETS OF PARAMETERS ARE FROM METHODS 1 AND 2 OF LONGACRE 75.  11/75
M        (1500.0)                    BERENDS   77 IPWA    PI-N PHOTOPROD.   1/78
M         1547.0      6.0            BHANDARI  77 DPWA  0 USES ETA N CUSP   1/78
M    B   (1520.0)                    LONGACRE  77 IPWA    PI N TO 2PI N    11/77
M    B  ALL LONGACRE77 PARAMETERS ARE FROM SOLUTION S2, EXCEPT FOR THE POLE 11/77
M    B  POSITION WHICH IS FROM SOLUTIONS S1 AND C1.                        11/77
M        (1511.0)                    BARBOUR   78 DPWA    PI-N PHOTOPROD.   3/79
M        (1540.0)   (20.0)           CUTKOSKY  79 IPWA    PI N TO PI N     12/79
M         1526.0      7.0            HOEHLER   79 IPWA    PI N TO PI N     12/79
M        (1513.0)                    CRAWFORD  80 DPWA    PI N PHOTOPROD.  12/81
M         1550.0     40.0            CUTKOSKY  80 IPWA    PI N TO PI N      1/82

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                    63  N(1535) WIDTH (MEV)

W    A       75. OR  100.            LONGACRE  75 IPWA    PI N TO 2PI N    11/75
W           (57.0)                   BERENDS   77 IPWA    PI-N PHOTOPROD.   1/78
W           139.0     33.0           BHANDARI  77 DPWA  0 USES ETA N CUSP   1/78
W    B     (135.0)                   LONGACRE  77 IPWA    PI N TO 2PI N    11/77
W           (132.0)                  BARBOUR   78 DPWA    PI-N PHOTOPROD.   3/79
W           (180.0)                  BAKER     79 DPWA  0 PI- P TO ETA N   12/79
W           (270.0)   (50.0)         CUTKOSKY  79 IPWA    PI N TO PI N     12/79
W            120.0     20.0          HOEHLER   79 IPWA    PI N TO PI N     12/79
W           (136.0)                  CRAWFORD  80 DPWA    PI N PHOTOPROD.  12/81
W            240.0     80.0          CUTKOSKY  80 IPWA    PI N TO PI N      1/82

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                    63  N(1535) REAL PART OF POLE POSITION (MEV)

RE          (1496.0)                 LONGACRE  75 IPWA    PI N TO 2PI N    11/75
RE           1519.0      4.0         BHANDARI  77 DPWA  0 USES ETA N CUSP   1/78
RE   B       1525. OR 1527.          LONGACRE  77 IPWA    PI N TO 2PI N    11/77
RE          (1465.0)                 CUTKOSKY  79 IPWA    PI N TO PI N     12/79
RE           1510.0     50.0         CUTKOSKY  80 IPWA    PI N TO PI N      1/82

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                    63  N(1535) -2*IMAG PART OF POLE POSITION (MEV)

IM          (103.0)                  LONGACRE  75 IPWA    PI N TO 2PI N    11/75
IM           140.0     32.0          BHANDARI  77 DPWA  0 USES ETA N CUSP   1/78
IM   B       135. OR 123.            LONGACRE  77 IPWA    PI N TO 2PI N    11/77
IM          (256.0)                  CUTKOSKY  79 IPWA    PI N TO PI N     12/79
IM           260.0     80.0          CUTKOSKY  80 IPWA    PI N TO PI N      1/82

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                    63  N(1535) REAL PART OF ELASTIC POLE RESIDUE (MEV)

RER          20.0     21.0          BHANDARI  77 DPWA  0 USES ETA N CUSP   1/78
RER         (48.0)                  CUTKOSKY  79 IPWA    PI N TO PI N     12/79
RER         116.0     46.0          CUTKOSKY  80 IPWA    PI N TO PI N      1/82

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                    63  N(1535) IMAG PART OF ELASTIC POLE RESIDUE (MEV)

IMR          13.0      8.0          BHANDARI  77 DPWA  0 USES ETA N CUSP   1/78
IMR         (-67.0)                  CUTKOSKY  79 IPWA    PI N TO PI N     12/79
IMR          31.0     92.0          CUTKOSKY  80 IPWA    PI N TO PI N      1/82

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                    63  N(1535) PARTIAL DECAY MODES

                                                          DECAY MASSES
P1      N(1535) INTO N PI                                 938+ 140
P2      N(1535) INTO N ETA                                940+ 549
P3      N(1535) INTO N PI PI                              938+ 140+ 140
P4      N(1535) INTO N EPSILON                            938+1300
P5      N(1535) INTO DELTA(1232) PI                      1232+ 140
P6      N(1535) INTO N RHO                                938+ 769
P7      N(1535) INTO P GAMMA, HELICITY=1/2                938+   0
P8      N(1535) INTO N GAMMA, HELICITY=1/2                940+   0
P9      N(1535) INTO LAMBDA K                            1116+ 498
P10     N(1535) INTO N RHO, S=1/2, S-WAVE                 938+ 769

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                    63  N(1535) BRANCHING RATIOS

R1      N(1535) INTO (N PI)/TOTAL                        (P1)
R1           0.297     0.026        BHANDARI  77 DPWA  0 USES ETA N CUSP   1/78
R1          (0.45)    (0.06)        CUTKOSKY  79 IPWA    PI N TO PI N     12/79
R1           0.38      0.04         HOEHLER   79 IPWA    PI N TO PI N     12/79
R1           0.50      0.10         CUTKOSKY  80 IPWA    PI N TO PI N      1/82

R2      N(1535) FROM N PI INTO N ETA                     SQRT(P1*P2)
R2          (+0.48)                  FELTESSE  75 DPWA  0 1488 TO 1745 MEV 11/75
R2          (+0.33)                  BAKER     79 DPWA  0 PI- P TO ETA N   12/79

R3      N(1535) FROM N PI TO DELTA(1232) PI              SQRT(P1*P5)
R3   A       0.0  OR -0.06           LONGACRE  75 IPWA    PI N TO 2PI N    11/75
R3   B      (0.00)                   LONGACRE  77 IPWA    PI N TO 2PI N    11/77

R4      N(1535) FROM N PI TO N RHO, S=1/2, S-WAVE        SQRT(P1*P10)
R4   A      +0.12 OR +0.09           LONGACRE  75 IPWA    PI N TO 2PI N    11/75
R4   B      (+0.10)                  LONGACRE  77 IPWA    PI N TO 2PI N    11/77
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Baryons

N(1535), N(1540), N(1650)

Data Card Listings

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R5      N(1535) FROM N PI TO N EPSILON                          SQRT(P1*P4)
R5   A        0.1  OR -0.09          LONGACRE  75 IPWA    PI N TO 2PI N    11/75
R5   B       (-0.08)                 LONGACRE  77 IPWA    PI N TO 2PI N    11/77

R6      N(1535) INTO (P GAMMA)/TOTAL                            (P7)
R6   C          0.0042   0.0014      DEANS     72 MPWA    P ETA PHOTOPROD.  9/73
R6   C  BR=(DEANS72 RADIATIVE WIDTH)/(NOMINAL FULL WIDTH=100 MEV)           9/73
R6   C  THE HICKS73 ENTRY UNDER R7 IS A MORE RECENT RESULT BY SAME GROUP.   9/73

R7      N(1535) FROM P GAMMA TO P ETA                           SQRT(P2*P7)
R7           (0.0366)                 HICKS     73 MPWA    GAM P-ETA P       9/73

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                    63  N(1535) PHOTON DECAY AMPLITUDES (GEV**-1/2)

        FOR DEFINITION OF GAMMA-NUCLEON DECAY AMPLITUDES, SEE MINI-
      REVIEW PRECEDING THE BARYON LISTINGS.

A1      N(1535) INTO P GAMMA, HELICITY-1/2 (GEV**-1/2)
A1           +0.063    0.013          METCALF   74 DPWA    PI N PHOTOPROD.   2/74
A1           +0.070    0.004          FELLER    76 DPWA    PI N PHOTOPROD.   2/77
A1           +0.046    0.007          AZNAURYAN 77 DPWA    PIO PHTPRD,SOL 1 12/79
A1           +0.101    0.012          AZNAURYAN 77 DPWA    PIO PHTPRD,SOL 2 12/79
A1          (+0.034)                  BERENDS   77 IPWA    PI-N PHOTOPROD.   1/78
A1           +0.082    0.019          BARBOUR   78 DPWA    PI-N PHOTOPROD.   3/79
A1   N      (0.046)                   NOELLE    78         PI-N PHOTOPROD.   1/80
A1   N  CONVERTED TO OUR CONVENTIONS USING M=1.548, W=.073 FROM NOELLE 78.   1/80
A1           0.083    0.007          ARAI      80 DPWA    PI N PHOTO FIT 1 12/81
A1           0.080    0.007          ARAI      80 DPWA    PI N PHOTO FIT 2 12/81
A1           0.029    0.007          BRATASHEV 80 DPWA    PI N PHOTOPROD.  12/81
A1           0.065    0.016          CRAWFORD  80 DPWA    PI N PHOTOPROD.  12/81
A1           0.0704   0.0091         ISHII     80 DPWA    P COMPTON SCAT   12/81
A1           0.077    0.021          AWAJI     81 DPWA    PI N PHOTOPROD.   1/84*
A1           0.053    0.015          CRAWFORD  83 IPWA    PI N PHOTOPROD.   1/84*

A2      N(1535) INTO N GAMMA, HELICITY-1/2 (GEV**-1/2)
A2           -0.051    0.021          METCALF   74 DPWA    PI N PHOTOPROD.   2/74
A2           -0.112    0.034          BARBOUR   78 DPWA    PI-N PHOTOPROD.   3/79
A2   N      (-0.048)                  NOELLE    78         PI-N PHOTOPROD.   1/80
A2           -0.075    0.019          ARAI      80 DPWA    PI N PHOTO FIT 1 12/81
A2           -0.075    0.018          ARAI      80 DPWA    PI N PHOTO FIT 2 12/81
A2           -0.098    0.026          CRAWFORD  80 DPWA    PI N PHOTOPROD.  12/81
A2           -0.011    0.017          TAKEDA    80 DPWA    PI N PHOTOPROD.  12/81
A2            0.035    0.014          AWAJI     81 DPWA    PI N PHOTOPROD.   1/84*
A2           -0.062    0.003          FUJII     81 DPWA    PI N PHOTOPROD.  12/81

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                          REFERENCES FOR N(1535)

BAREYRE  65 PL 18 342          + BRICMAN, STIRLING, VILLET          (SACL)IJP
BRANDSEN 65 PR 139 B1566       +ODONNELL, MOORHOUSE            (DURH+RHEL)IJP
HENDRY   65 PL 18 171          A W HENDRY, R G MOORHOUSE            (RHEL)
MICHAEL  66 PL 21 93           C MICHAEL                             (OXF)
UCHIYAMA 66 PR 149 1220        F UCHIYAMA-CAMPBELL, R K LOGAN        (ILL)IJP
DAVIES   67 NC 52A 1112        A T DAVIES, R G MOORHOUSE       (GLAS+RHEL)
JOHNSON  67 UCRL-17683 THESIS  C H JOHNSON                           (LRL)
LOVELACE 67 HEIDELBERG C. 79   C LOVELACE                          (CERN)IJP

BAREYRE  68 PR 165 1731        P BAREYRE, C BRICMAN, G VILLET       (SACL)IJP
DONNACHI 68 PL 26B 161         A DONNACHIE, R G KIRSOPP, C LOVELACE (CERN)IJP
    ALSO 68 VIENNA 139         DONNACHIE  RAPPORTEUR.S TALK         (GLAS)
    ALSO 68 THESIS             R G KIRSOPP                          (EDIN)
DEANS    69 PR 185 1797        S DEANS, J WOOTEN                    (SFLA)
DELCOURT 69 PL 29B 75          DELCOURT,LEFRANCOIS,PEREZ-Y-JORBA,+  (ORSA)
DONNACHI 69 NP 10B 433         A DONNACHIE, R KIRSOPP          (GLAS+EDIN)
AYED     70 KIEV CONF          R AYED,P BAREYRE, G VILLET           (SACL)IJP
AYED2    70 PL 31B 598         +BAREYRE,VILLET                      (SACL)
CARRERAS 70 NP 16B 35          B CARRERAS, A DONNACHIE         (DARE+MCHS)
DAVIES   70 NP B21 359         A DAVIES                             (GLAS)
DIEM     70 KIEV CONF.         + SMADJA, CHAVANON, DELER, DOLBEAU+  (SACL)

ALMEHED  72 NP B40 157         +LOVELACE                       (LUND+RUTG)IJP
DEANS    72 PN 3 217           +JACOBS, LYONS, HICKS            (SFLA+CARN)
DEVENISH 73 PL 47B 53          DEVENISH,RANKIN,LYTH        (LOUC+BONN+LANC)IJP
HEMMI1   73 PL 43B 79          HEMMI,INAGAKI+          (KYOT+SAGA+KEK+TOKY)IJP
HICKS    73 PR D7 2614         +DEANS,JACOBS,LYONS+        (CARN+ORNL+SFLA)IJP
LEMOIGNE 73 PURDUE CONF. 93    +GRANET,MARTY,AYED,BAREYRE,BORGEAUD,+(SACL)IJP
MOORHOUS 73 PL 43B 44          MOORHOUSE, OBERLACK             (GLAS+LBL)IJP
ROSSI    73 NC 13A 59          +PIAZZA,SUSINNO,+     (ROMA+FRAS+NAPL+PAVI)IJP
    ALSO 71 LNC 2 1183         CARBONARA,FIORE,+     (NAPL+FRAS+PAVI+ROMA)IJP
BENEVENT 74 NC 19A 529         BENEVENTANO,DANGELO,NOTARISTEFANI,+  (ROMA)IJP
DEVENISH 74 NP B81 330         DEVENISH,FROGGATT,MARTIN   (DESY+NORD+LOUC)
DEVENIS2 74 PL 52B 227         DEVENISH,LYTH,RANKIN       (DESY+LANC+BONN)IJP
KNIES    74 PR D9 2680         KNIES,MOORHOUSE,OBERLACK        (LBL+GLAS)IJP
METCALF  74 NP B76 253         W J METCALF,R L WALKER               (CIT)IJP
MOORHOUS 74 PR D9 1            MOORHOUSE,OBERLACK,ROSENFELD    (GLAS+LBL)IJP

CRAWFORD 75 NP B97 125         R L CRAWFORD                         (GLAS)IJP
FELTESSE 75 NP B93 242         +AYED,BAREYRE,BORGEAUD,DAVID,ERNWEIN+(SACL)IJP
KRIVETS  75 SJNP 20 430        +MIROSHNICHENKO,NIKIFOROV,SANIN+     (KIEV)IJP
    ALSO 74 SJNP 19 112        KRIVETS,NIKIFOROV,SANIN,SHALATSKII   (KIEV)IJP
LONGACRE 75 PL 55B 415         +ROSENFELD,LASINSKI,SMADJA+     (LBL+SLAC)IJP
    ALSO 78 PR D17 1795        LONGACRE,LASINSKI,ROSENFELD+    (LBL+SLAC)

AYED     76 CEA-N-1921         AYED (THESIS)                        (SACL)IJP
BARBOUR  76 NP B111 358        I M BARBOUR,R L CRAWFORD             (GLAS)IJP
FELLER   76 NP B104 219        +FUKUSHIMA,HORIKAWA,KAJIKAWA+   (NAGO+OSAK)IJP
AZNAURYA 77  EFI-264(57)-77    +AKOPOV,BAGDASARYAN                  (YERE)IJP
BERENDS  77 NP B136 317        F A BERENDS,A DONNACHIE         (LEID+MCHS)IJP
BHANDARI 77 PR D15 192         R BHANDARI,Y-A CHAO                  (CARN)IJP
LONGACRE 77 NP B122 493        LONGACRE,DOLBEAU                     (SACL)IJP
    ALSO 76 NP B108 365        DOLBEAU,TRIANTIS,NEVEU,CADIET        (SACL)IJP

BARBOUR  78 NP B141 253        BARBOUR,CRAWFORD,PARSONS             (GLAS)
NOELLE   78 PTP 60 778         P NOELLE                             (NAGO)
BAKER    79 NP B156 93         +BROWN,CLARK,DAVIES,DEPAGTER,EVANS+  (RHEL)IJP
CUTKOSKY 79 PR D20 2839        +FORSYTH,HENDRICK,KELLY         (CARN+LBL)IJP
HOEHLER  79 HANDBOOK OF PI-N SCATTERING, PHYSIK DATEN VOL.12-1
                               +KAISER,KOCH,PIETARINEN         (KARL)    IJP
    ALSO 80  TORONTO CONF 3    R KOCH                               (KARL)IJP

ARAI     80  TORONTO CONF 93   I ARAI                               (TOKY)
    ALSO 82 NP B194 251        I ARAI, H FUJII                      (TOKY)
BRATASHE 80 NP B166 525        BRATASHEVSKIJ,GORBENKO,DEREBCHINSKIJ+(KHAR)
CRAWFORD 80  TORONTO CONF 107  R L CRAWFORD                         (GLAS)
CUTKOSKY 80  TORONTO CONF 19   +FORSYTH,BABCOCK,KELLY,HENDRICK  (CARN+LBL)IJP
ISHII    80 NP B165 189        ISHII,EGAWA,KATO,MIYACHI+       (KYOT+TOKY)
TAKEDA   80 NP B168 17         TAKEDA,ARAI,FUJII,IKEDA,IWASAKI+     (TOKY)

AWAJI    81  BONN CONF 352     R KAJIKAWA (TALK)                    (NAGO)
    ALSO 82 NP B197 365        FUJII,HAYASHII,IWATA,KAJIKAWA+       (NAGO)
FUJII    81 NP B187 53         FUJII,HAYASHII,IWATA,KAJIKAWA+       (TOKY)
CRAWFORD 83 NP B211 1          R L CRAWFORD, W T MORTON             (GLAS)
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   SEE HERE IN THE 1982 EDITION (PHYSICS LETTERS 111B) FOR ADDITIONAL
   EARLY REFERENCES (NONE AFTER 1973) ON THE N ETA THRESHOLD.

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N(1540) P'_{13} Status: *

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                    109  N(1540, JP=3/2+) I=1/2   P'13

                    THIS RESONANCE HAS NOT BEEN SEEN IN PI N --> PI N
                    ANALYSES, AND ITS EXISTENCE IS THUS DOUBTFUL.

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                    109  N(1540) MASS (MEV)

M    A    (1540.0)                  LONGACRE  77 IPWA    PI N TO 2PI N    11/77
M    A  ALL LONGACRE77 PARAMETERS ARE FROM SOLUTION S2, EXCEPT FOR THE POLE 11/77
M    A  POSITION WHICH IS FROM SOLUTIONS S1 AND C1.                       11/77

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                    109  N(1540) WIDTH (MEV)

W    A    (200.0)                   LONGACRE  77 IPWA    PI N TO 2PI N    11/77

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                    109  N(1540) REAL PART OF POLE POSITION (MEV)

RE   A    1535. OR 1482.            LONGACRE  77 IPWA    PI N TO 2PI N    11/77

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                    109  N(1540) -2*IMAG PART OF POLE POSITION (MEV)

IM   A     207. OR 314.             LONGACRE  77 IPWA    PI N TO 2PI N    11/77

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                    109  N(1540) PARTIAL DECAY MODES

                                                          DECAY MASSES
P1      N(1540) INTO N PI                                 938+ 140
P2      N(1540) INTO N RHO, S=1/2, P-WAVE                 938+ 769
P3      N(1540) INTO N RHO, S=3/2, P-WAVE                 938+ 769
P4      N(1540) INTO DELTA(1232) PI,P-WAVE               1232+ 140
P5      N(1540) INTO N EPSILON                            938+1300

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                    109  N(1540) BRANCHING RATIOS

R1      N(1540) FROM N PI TO N RHO, S=1/2, P-WAVE        SQRT(P1*P2)
R1   A     (-0.08)                   LONGACRE  77 IPWA    PI N TO 2PI N    11/77

R2      N(1540) FROM N PI TO N RHO, S=3/2, P-WAVE        SQRT(P1*P3)
R2   A     (0.00)                    LONGACRE  77 IPWA    PI N TO 2PI N    11/77

R3      N(1540) FROM N PI TO DELTA(1232) PI, P-WAVE      SQRT(P1*P4)
R3   A     (+0.11)                   LONGACRE  77 IPWA    PI N TO 2PI N    11/77

R4      N(1540) FROM N PI TO N EPSILON                   SQRT(P1*P5)
R4   A     (0.00)                    LONGACRE  77 IPWA    PI N TO 2PI N    11/77

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                    109  N(1540) PHOTON DECAY AMPLITUDES (GEV**-1/2)

        FOR DEFINITION OF GAMMA-NUCLEON DECAY AMPLITUDES, SEE MINI-
      REVIEW PRECEDING THE BARYON LISTINGS.

A1      N(1540) INTO P GAMMA, HELICITY-1/2 (GEV**-1/2)
A1          -0.014    0.028          CRAWFORD  83 IPWA    PI N PHOTOPROD.   1/84*

A2      N(1540) INTO P GAMMA, HELICITY-3/2 (GEV**-1/2)
A2           0.009    0.027          CRAWFORD  83 IPWA    PI N PHOTOPROD.   1/84*

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                          REFERENCES FOR N(1540)

LONGACRE 77 NP B122 493        LONGACRE,DOLBEAU                     (SACL)IJP
    ALSO 76 NP B108 365        DOLBEAU,TRIANTIS,NEVEU,CADIET        (SACL)IJP
CRAWFORD 83 NP B211 1          R L CRAWFORD, W T MORTON             (GLAS)
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N(1650) S''_{11} Status: ****

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                    66  N(1650, JP=1/2-) I=1/2   S''11

                    MOST OF THE RESULTS PUBLISHED BEFORE 1975 ARE NOW
                    OBSOLETE AND HAVE BEEN OMITTED.  THEY MAY BE FOUND IN
                    OUR 1982 EDITION (PHYSICS LETTERS 111B).  HOWEVER,
                    ALL THE REFERENCES HAVE BEEN RETAINED.

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                    66  N(1650) MASS (MEV)

M         (1675.0)                  KNASEL    75 DPWA  0 PI- P TO K0 LAM  11/75
M    A     1675. OR 1660.           LONGACRE  75 IPWA    PI N TO 2PI N    11/75
M    A  THE 2 SETS OF PARAMETERS ARE FROM METHODS 1 AND 2 OF LONGACRE 75.  11/75
M    B    (1700.0)    (5.0)          BAKER     77 IPWA  0 PI- P TO K LAM.  1/78
M    B    (1680.0)                   BAKER     77 DPWA  0 PI- P TO K LAM.  1/78
M    B  THE TWO ENTRIES FOR BAKER 77 ARE FOR AN IPWA USING THE BARRELET    1/78
M    B  ZERO METHOD AND A CONVENTIONAL ENERGY-DEPENDENT ANALYSIS.          1/78
M    C    (1700.0)                   LONGACRE  77 IPWA    PI N TO 2PI N    11/77
M    C  ALL LONGACRE77 PARAMETERS ARE FROM SOLUTION S2, EXCEPT FOR THE POLE 11/77
M    C  POSITION WHICH IS FROM SOLUTIONS S1 AND C1.                       11/77
M         (1680.0)                  BAKER     78 DPWA  0 PI- P TO K LAM   3/79
M         (1694.0)                  BARBOUR   78 DPWA    PI-N PHOTOPROD.   3/79
M         (1640.0)    (30.0)        CUTKOSKY  79 IPWA    PI N TO PI N     12/79
M          1670.0      8.0          HOEHLER   79 IPWA    PI N TO PI N     12/79
M         (1688.0)                  CRAWFORD  80 DPWA    PI N PHOTOPROD.  12/81
M          1650.0     30.0          CUTKOSKY  80 IPWA    PI N TO PI N      1/82
M         (1672.0)                  MUSETTE   80 IPWA  0 PI- P TO K LAM    1/82
M         (1680.0)                  SAXON     80 DPWA  0 PI- P TO K LAM   12/79

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For notation, see key at front of Listings.

Baryons

N(1650), N(1675)

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                    66  N(1650) WIDTH (MEV)

W          (170.0)                    KNASEL    75 DPWA  0 PI- P TO K0 LAM  11/75
W    A      150. OR  130.            LONGACRE  75 IPWA    PI N TO 2PI N    11/75
W    B     (130.0)   (10.0)          BAKER     77 IPWA  0 PI- P TO K LAM.   1/78
W    B      (90.0)                   BAKER     77 DPWA  0 PI- P TO K LAM.   1/78
W    C     (170.0)                   LONGACRE  77 IPWA    PI N TO 2PI N    11/77
W           (90.0)                   BAKER     78 DPWA  0 PI- P TO K LAM    3/79
W          (193.0)                   BARBOUR   78 DPWA    PI-N PHOTOPROD.    3/79
W          (140.0)   (40.0)          CUTKOSKY  79 IPWA    PI N TO PI N     12/79
W           180.0     20.0           HOEHLER   79 IPWA    PI N TO PI N     12/79
W          (183.0)                   CRAWFORD  80 DPWA    PI N PHOTOPROD.  12/81
W           150.0     40.0           CUTKOSKY  80 IPWA    PI N TO PI N      1/82
W          (179.0)                   MUSETTE   80 IPWA  0 PI- P TO K LAM    1/82
W          (120.0)                   SAXON     80 DPWA  0 PI- P TO K LAM   12/79

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                    66  N(1650) REAL PART OF POLE POSITION (MEV)

RE        (1648.0)                   LONGACRE  75 IPWA    PI N TO 2PI N    11/75
RE   C     1699. OR 1698.0           LONGACRE  77 IPWA    PI N TO 2PI N    11/77
RE        (1639.0)                   CUTKOSKY  79 IPWA    PI N TO PI N     12/79
RE         1640.0     20.0           CUTKOSKY  80 IPWA    PI N TO PI N      1/82

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                    66  N(1650) -2*IMAG PART OF POLE POSITION (MEV)

IM         (117.0)                   LONGACRE  75 IPWA    PI N TO 2PI N    11/75
IM   C      174. OR 173.             LONGACRE  77 IPWA    PI N TO 2PI N    11/77
IM        (140.0)                    CUTKOSKY  79 IPWA    PI N TO PI N     12/79
IM          150.0     30.0           CUTKOSKY  80 IPWA    PI N TO PI N      1/82

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                    66  N(1650) REAL PART OF ELASTIC POLE RESIDUE (MEV)

RER         (3.0)                    CUTKOSKY  79 IPWA    PI N TO PI N     12/79
RER         16.0     25.0            CUTKOSKY  80 IPWA    PI N TO PI N      1/82

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                    66  N(1650) IMAG PART OF ELASTIC POLE RESIDUE (MEV)

IMR        (-58.0)                   CUTKOSKY  79 IPWA    PI N TO PI N     12/79
IMR         -58.0     12.0           CUTKOSKY  80 IPWA    PI N TO PI N      1/82

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                    66  N(1650) PARTIAL DECAY MODES

                                                          DECAY MASSES
P1      N(1650) INTO N PI                                 938+ 140
P2      N(1650) INTO N ETA                                940+ 549
P3      N(1650) INTO LAMBDA K                            1116+ 498
P4      N(1650) INTO P GAMMA, HELICITY=1/2                938+   0
P5      N(1650) INTO N GAMMA, HELICITY=1/2                940+   0
P6      N(1650) INTO N PI PI                              938+ 140+ 140
P7      N(1650) INTO N EPSILON                            938+1300
P8      N(1650) INTO N RHO                                938+ 769
P9      N(1650) INTO SIGMA K                             1189+ 494
P10     N(1650) INTO N RHO, S=1/2, S-WAVE                 938+ 769
P11     N(1650) INTO N RHO, S=3/2, D-WAVE                 938+ 769
P12     N(1650) INTO DELTA(1232) PI                      1232+ 140

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                    66  N(1650) BRANCHING RATIOS

R1      N(1650) INTO (N PI)/TOTAL                        (P1)
R1         (0.60)   (0.05)           CUTKOSKY  79 IPWA    PI N TO PI N     12/79
R1          0.61     0.04            HOEHLER   79 IPWA    PI N TO PI N     12/79
R1          0.65     0.10            CUTKOSKY  80 IPWA    PI N TO PI N      1/82

R2      N(1650) FROM N PI TO N ETA                       SQRT(P1*P2)
R2  E      (-0.09)                   BAKER     79 DPWA  0 PI- P TO ETA N   12/79
R2  E   THIS COUPLING WAS FIXED DURING FITTING, BUT THE NEGATIVE SIGN      12/79
R2  E   RELATIVE TO N(1535) IS WELL DETERMINED.                            12/79

R3      N(1650) FROM N PI TO LAMBDA K                    SQRT(P1*P3)
R3         (0.12)                    KNASEL    75 DPWA  0 PI- P TO K0 LAM  11/75
R3   B     (-0.23)   (0.01)          BAKER     77 IPWA  0 PI- P TO K LAM.   1/78
R3   B     (-0.25)                   BAKER     77 DPWA  0 PI- P TO K LAM.   1/78
R3   F     (-0.25)                   BAKER     78 DPWA  0 PI- P TO K LAM    3/79
R3   F  THE (UNDETERMINED) OVERALL PHASE OF ALL COUPLINGS HAS BEEN          3/79
R3   F  CHANGED TO AGREE WITH PREVIOUS CONVENTIONS. SUPERSEDED BY SAXON 80.  3/79
R3         (-0.22)                   SAXON     80 DPWA  0 PI- P TO K LAM   12/79
R3         (-0.22)                   BELL      83 DPWA  0 PI- P TO LAM K0   2/84*

R4      N(1650) FROM N PI TO SIGMA K                     SQRT(P1*P9)
R4   D        0.066 TO 0.137         DEANS     75 DPWA    PI N TO K SIGMA  11/75
R4   D  RANGE GIVEN IS FROM FOUR BEST SOLUTIONS.                           11/75
R4         (0.20)                    KNASEL    75 DPWA  0                  11/75
R4         (-0.254)                  LIVANOS   80 DPWA    PI P TO K SIGMA   1/82

R5      N(1650) FROM N PI TO DELTA(1232) PI              SQRT(P1*P12)
R5   A       -0.16 OR -0.15          LONGACRE  75 IPWA    PI N TO 2PI N    11/75
R5   C     (-0.29)                   LONGACRE  77 IPWA    PI N TO 2PI N    11/77
R5   C  LONGACRE 77 CONSIDER THIS COUPLING TO BE WELL DETERMINED.

R6      N(1650) FROM N PI TO N RHO, S=1/2, S-WAVE        SQRT(P1*P10)
R6   A       0.23 OR +0.16           LONGACRE  75 IPWA    PI N TO 2PI N    11/75
R6   C     (-0.17)                   LONGACRE  77 IPWA    PI N TO 2PI N    11/77

R7      N(1650) FROM N PI TO N RHO, S=3/2, D-WAVE        SQRT(P1*P11)
R7   C     (-0.29)                   LONGACRE  77 IPWA    PI N TO 2PI N    11/77
R7   C  LONGACRE 77 CONSIDER THIS COUPLING TO BE WELL DETERMINED.

R8      N(1650) FROM N PI TO N EPSILON                   SQRT(P1*P7)
R8   A       -0.23 OR -0.25          LONGACRE  75 IPWA    PI N TO 2PI N    11/75
R8   C     (0.00)                    LONGACRE  77 IPWA    PI N TO 2PI N    11/77

R9      N(1650) FROM P GAMMA TO P ETA                    SQRT(P2*P4)
R9         (0.0101)                  HICKS     73 MPWA    GAM P-ETA P       9/73
R10     N(1650) FROM P GAMMA TO LAMBDA K                 SQRT(P3*P4)
R10        (0.002)OR LESS            ORITO2    69 CNTR    K LAM PHOTOPRO   10/71
R10        (0.0072)                  SCHORSCH  70 DPWA    K LAM PHOTOPRO.  10/71
R10        (0.0060)                  DEANS     72 MPWA    GAM P-K LM,SOL D  9/73

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                    66  N(1650) PHOTON DECAY AMPLITUDES (GEV**-1/2)

      FOR DEFINITION OF GAMMA-NUCLEON DECAY AMPLITUDES, SEE MINI-
    REVIEW PRECEDING THE BARYON LISTINGS.

A1      N(1650) INTO P GAMMA, HELICITY=1/2 (GEV**-1/2)
A1         +0.012    0.015           METCALF   74 DPWA    PI N PHOTOPROD.   2/74
A1         +0.068    0.009           FELLER    76 DPWA    PI N PHOTOPROD.   2/77
A1         +0.004    0.004           AZNAURYAN 77 DPWA    PI0 PHTPRD,SOL 1 12/79
A1         +0.003    0.004           AZNAURYAN 77 DPWA    PI0 PHTPRD,SOL 2 12/79
A1         +0.048    0.017           BARBOUR   78 DPWA    PI-N PHOTOPROD.   3/79
A1          0.065    0.005           ARAI      80 DPWA    PI N PHOTO FIT 1 12/81
A1          0.061    0.005           ARAI      80 DPWA    PI N PHOTO FIT 2 12/81
A1          0.031    0.017           CRAWFORD  80 DPWA    PI N PHOTOPROD.  12/81
A1          0.050    0.010           AWAJI     81 DPWA    PI N PHOTOPROD.   1/84*
A1          0.033    0.015           CRAWFORD  83 IPWA    PI N PHOTOPROD.   1/84*

A2      N(1650) INTO N GAMMA, HELICITY=1/2 (GEV**-1/2)
A2         -0.019    0.022           METCALF   74 DPWA    PI N PHOTOPROD.   2/74
A2         -0.045    0.024           BARBOUR   78 DPWA    PI-N PHOTOPROD.   3/79
A2          0.010    0.020           ARAI      80 DPWA    PI N PHOTO FIT 1 12/81
A2          0.008    0.019           ARAI      80 DPWA    PI N PHOTO FIT 2 12/81
A2         -0.068    0.040           CRAWFORD  80 DPWA    PI N PHOTOPROD.  12/81
A2         -0.011    0.011           TAKEDA    80 DPWA    PI N PHOTOPROD.  12/81
A2         -0.008    0.004           AWAJI     81 DPWA    PI N PHOTOPROD.   1/84*
A2          0.004    0.004           FUJII     81 DPWA    PI N PHOTOPROD.  12/81

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REFERENCES FOR N(1650)


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BAREYRE  65 PL 18 342          + BRICMAN, STIRLING, VILLET          (SACL)IJP
BRANDSEN 65 PL 19 420          +ODONNELL, MOORHOUSE            (DURH+RHEL)IJP
MICHAEL  66 PL 21 93           C MICHAEL                             (OXF)
JOHNSON  67 UCRL-17683 THESIS  C H JOHNSON                           (LRL)
BAREYRE  68 PR 165 1731        P BAREYRE, C BRICMAN, G VILLET       (SACL)IJP
DONNACH1 68 PL 26B 161         A DONNACHIE, R G KIRSOPP, C LOVELACE (CERN)IJP
    ALSO 68 VIENNA 139         DONNACHIE  RAPPORTEUR.S TALK         (GLAS)
    ALSO 68 THESIS             R G KIRSOPP                          (EDIN)
RUSH     68 PR 173 1776        J E RUSH                             (ALAH)

BOTKE    69 PR 180 1417        J C BOTKE                            (UCSB)
DEANS    69 PR 185 1797        S DEANS, J WOOTEN                    (SFLA)
DEANS2   69 PR 177 2623        S R DEANS                            (SFLA)
DONNACHI 69 NP 10B 433         A DONNACHIE, R KIRSOPP          (GLAS+EDIN)
ORITO    69 LNC 1 936          S ORITO,S SASAKI                (TOKY+OSAK)
ORITO2   69 INS J 113          S ORITO (THESIS)                     (TOKY)
AYED     70 KIEV CONF          R AYED,P BAREYRE, G VILLET           (SACL)IJP
AYED2    70 PL 31B 598         +BAREYRE,VILLET                      (SACL)
CARRERAS 70 NP 16B 35          B CARRERAS, A DONNACHIE         (DARE+MCHS)
DAVIES   70 NP B21 359         A DAVIES                             (GLAS)
SCHORSCH 70 NP  B25 179        +TIETGE,WEILNBOECK                   (MPIM)

WAGNER   71 NP B25 411         F WAGNER, C LOVELACE                 (CERN)
ALMEHED  72 NP B40 157         +LOVELACE                       (LUND+RUTG)IJP
DEANS    72 PR D6 1906         DEANS,JACOBS, LYONS,MONTGOMERY       (SFLA)IJP
DEVENISH 73 PL 47B 53          DEVENISH,RANKIN,LYTH       (LOUC+BONN+LANC)IJP
HICKS    73 PR D7 2614         +DEANS,JACOBS,LYONS+       (CARN+ORNL+SFLA)IJP
LANGBEIN 73 NP B53 251         LANGBEIN,WAGNER                      (MUNI)IJP
MOORHOUS 73 PL 43B 44          MOORHOUSE, OBERLACK             (GLAS+LBL)IJP
DEVENISH 74 NP B81 330         DEVENISH,FROGGATT,MARTIN   (DESY+NORD+LOUC)
DEVENIS2 74 PL 52B 227         DEVENISH,LYTH,RANKIN       (DESY+LANC+BONN)IJP
KNIES    74 PR D9 2680         KNIES,MOORHOUSE,OBERLACK        (LBL+GLAS)IJP
METCALF  74 NP B76 253         W J METCALF,R L WALKER               (CIT)IJP
MOORHOUS 74 PR D9 1            MOORHOUSE,OBERLACK,ROSENFELD    (GLAS+LBL)IJP

CRAWFORD 75 NP B97 125         R L CRAWFORD                         (GLAS)IJP
DEANS    75 NP B96 90          +MITCHELL,MONTGOMERY,+          (SFLA+ALAH)IJP
KNASEL   75 PR D11 1           +LINDQUIST,NELSON+     (CHIC+WUSL+OSU+ANL)IJP
LONGACRE 75 PL 55B 415         +ROSENFELD,LASINSKI,SMADJA+      (LBL+SLAC)IJP
    ALSO 78 PR D17 1795        LONGACRE,LASINSKI,ROSENFELD+     (LBL+SLAC)
AYED     76 CEA-N-1921         AYED (THESIS)                        (SACL)IJP
BARBOUR  76 NP B111 358        I M BARBOUR,R L CRAWFORD             (GLAS)IJP
FELLER   76 NP B104 219        +FUKUSHIMA,HORIKAWA,KAJIKAWA+   (NAGO+OSAK)IJP

AZNAURYA 77  EFI-264(57)-77    +AKOPOV,BAGDASARYAN                  (YERE)IJP
BAKER    77 NP B126 365        +BLISSET,BLOODWORTH,BROOME,HART+     (RHEL)IJP
LONGACRE 77 NP B122 493        LONGACRE,DOLBEAU                     (SACL)IJP
    ALSO 76 NP B108 365        DOLBEAU,TRIANTIS,NEVEU,CADIET        (SACL)IJP
WINNIK   77 NP B128 66         +TOAFF,REVEL,GOLDBERG,BERNY          (HAIF)I
BAKER    78 NP B141 29         +BLISSET,BLOODWORTH,BROOME+     (RL+CAMB)IJP
BARBOUR  78 NP B141 253        BARBOUR,CRAWFORD,PARSONS             (GLAS)
BAKER    79 NP B156 93         +BROWN,CLARK,DAVIES,DEPAGTER,EVANS+  (RHEL)IJP
CUTKOSKY 79 PR D20 2839        +FORSYTH,HENDRICK,KELLY         (CARN+LBL)IJP
HOEHLER  79 HANDBOOK OF PI-N SCATTERING, PHYSIK DATEN VOL.12-1
                               +KAISER,KOCH,PIETARINEN         (KARL)    IJP
    ALSO 80  TORONTO CONF 3    R KOCH                               (KARL)IJP

ARAI     80  TORONTO CONF 93   I ARAI                               (TOKY)
    ALSO 82 NP B194 251        I ARAI, H FUJII                      (TOKY)
CRAWFORD 80  TORONTO CONF 107  R L CRAWFORD                         (GLAS)
CUTKOSKY 80  TORONTO CONF 19   +FORSYTH,BABCOCK,KELLY,HENDRICK  (CARN+LBL)IJP
LIVANOS  80  TORONTO CONF 35   +BATON,COUTURES,KOCHOWSKI,NEVEU      (SACL)IJP
MUSETTE  80 NC 57A 37          M MUSETTE                            (BRUX)IJP
SAXON    80 NP B162 522        +BAKER,BELL,BLISSETT,BLOODWORTH+(RHEL+BRIS)IJP
TAKEDA   80 NP B168 17         TAKEDA,ARAI,FUJII,IKEDA,IWASAKI+     (TOKY)

AWAJI    81  BONN CONF 352     R KAJIKAWA (TALK)                    (NAGO)
    ALSO 82 NP B197 365        FUJII,HAYASHII,IWATA,KAJIKAWA+       (NAGO)
FUJII    81 NP B187 53         FUJII,HAYASHII,IWATA,KAJIKAWA+       (TOKY)
BELL     83 NP B222 389        +BLISSET,BROOME,DALEY,HART,LINTERN,+   (RL)IJP
CRAWFORD 83 NP B211 1          R L CRAWFORD, W T MORTON             (GLAS)
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N(1675) D'_{15} Status: ****

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                    64  N(1675, JP=5/2-) I=1/2   D'15

                    MOST OF THE RESULTS PUBLISHED BEFORE 1975 ARE NOW
                    OBSOLETE AND HAVE BEEN OMITTED.  THEY MAY BE FOUND IN
                    OUR 1982 EDITION (PHYSICS LETTERS 111B).  HOWEVER,
                    ALL THE REFERENCES HAVE BEEN RETAINED.

    IN ADDITION, RESULTS IN THIS REGION FROM PRODUCTION EXPERIMENTS,
    WHICH USED TO BE LISTED SEPARATELY IN AN ENTRY FOLLOWING THE
    N(1700), HAVE BEEN ENTIRELY REMOVED.

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Baryons
N(1675)

Data Card Listings

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                    64  N(1675) MASS (MEV)
M    A      1660. OR 1660.            LONGACRE  75 IPWA    PI N TO 2PI N    11/75
M    A  THE 2 SETS OF PARAMETERS ARE FROM METHODS 1 AND 2 OF LONGACRE 75.   11/75
M    B    (1650.0)                    LONGACRE  77 IPWA    PI N TO 2PI N    11/77
M    B  ALL LONGACRE77 PARAMETERS ARE FROM SOLUTION S2, EXCEPT FOR THE POLE 11/77
M    B  POSITION WHICH IS FROM SOLUTIONS S1 AND C1.                         11/77
M         (1680.0)                    BARBOUR   78 DPWA    PI-N PHOTOPROD.   3/79
M         (1680.0)   (15.0)           CUTKOSKY  79 IPWA    PI N TO PI N     12/79
M          1679.0     8.0             HOEHLER   79 IPWA    PI N TO PI N     12/79
M         (1685.0)                    CRAWFORD  80 DPWA    PI N PHOTOPROD.  12/81
M          1675.0    10.0             CUTKOSKY  80 IPWA    PI N TO PI N      1/82
M         (1670.0)                    SAXON     80 DPWA  0 PI- P TO K LAM   12/79

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                    64  N(1675) WIDTH (MEV)

W    A      145. OR  150.             LONGACRE  75 IPWA    PI N TO 2PI N    11/75
W    B     (130.0)                    LONGACRE  77 IPWA    PI N TO 2PI N    11/77
W          (192.0)                    BARBOUR   78 DPWA    PI-N PHOTOPROD.   3/79
W           (88.0)                    BAKER     79 DPWA  0 PI- P TO ETA N   12/79
W          (180.0)   (30.0)           CUTKOSKY  79 IPWA    PI N TO PI N     12/79
W           120.0     15.0             HOEHLER   79 IPWA    PI N TO PI N     12/79
W          (191.0)                    CRAWFORD  80 DPWA    PI N PHOTOPROD.  12/81
W           160.0     20.0             CUTKOSKY  80 IPWA    PI N TO PI N      1/82
W           (40.0)                     SAXON     80 DPWA  0 PI- P TO K LAM   12/79

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                    64  N(1675) REAL PART OF POLE POSITION (MEV)

RE        (1663.0)                     LONGACRE  75 IPWA    PI N TO 2PI N    11/75
RE   B     1649. OR 1650.              LONGACRE  77 IPWA    PI N TO 2PI N    11/77
RE        (1663.0)                     CUTKOSKY  79 IPWA    PI N TO PI N     12/79
RE         1660.0    10.0              CUTKOSKY  80 IPWA    PI N TO PI N      1/82

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                    64  N(1675) -2*IMAG PART OF POLE POSITION (MEV)

IM        (146.0)                      LONGACRE  75 IPWA    PI N TO 2PI N    11/75
IM   B     127.  OR 127.               LONGACRE  77 IPWA    PI N TO 2PI N    11/77
IM        (150.0)                      CUTKOSKY  79 IPWA    PI N TO PI N     12/79
IM         140.0    10.0               CUTKOSKY  80 IPWA    PI N TO PI N      1/82

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                    64  N(1675) REAL PART OF ELASTIC POLE RESIDUE (MEV)

RER        (33.0)                      CUTKOSKY  79 IPWA    PI N TO PI N     12/79
RER         27.0      5.0              CUTKOSKY  80 IPWA    PI N TO PI N      1/82

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                    64  N(1675) IMAG PART OF ELASTIC POLE RESIDUE (MEV)

IMR       (-11.0)                      CUTKOSKY  79 IPWA    PI N TO PI N     12/79
IMR        -16.0      5.0              CUTKOSKY  80 IPWA    PI N TO PI N      1/82

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                    64  N(1675) PARTIAL DECAY MODES

                                                          DECAY MASSES
P1      N(1675) INTO N PI                                 938+ 140
P2      N(1675) INTO N ETA                                940+ 549
P3      N(1675) INTO LAMBDA K                            1116+ 498
P4      N(1675) INTO DELTA(1232) PI                      1232+ 140
P5      N(1675) INTO N PI PI                              938+ 140+ 140
P6      N(1675) INTO P GAMMA, HELICITY=1/2                938+   0
P7      N(1675) INTO P GAMMA, HELICITY=3/2                938+   0
P8      N(1675) INTO N GAMMA, HELICITY=1/2                940+   0
P9      N(1675) INTO N GAMMA, HELICITY=3/2                940+   0
P10     N(1675) INTO SIGMA K                             1189+ 494
P11     N(1675) INTO DELTA(1232) PI, D-WAVE              1232+ 140
P12     N(1675) INTO N RHO, S=3/2, D-WAVE                 938+ 769
P13     N(1675) INTO N EPSILON                            938+1300

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                    64  N(1675) BRANCHING RATIOS

R1      N(1675) INTO (N PI)/TOTAL                        (P1)
R1          (0.35)   (0.06)           CUTKOSKY  79 IPWA    PI N TO PI N     12/79
R1           0.38     0.03             HOEHLER   79 IPWA    PI N TO PI N     12/79
R1           0.38     0.05             CUTKOSKY  80 IPWA    PI N TO PI N      1/82

R2      N(1675) FROM N PI TO N ETA                       SQRT(P1*P2)
R2          0.0 OR  +0.009            FELTESSE  75 DPWA  0 1488 TO 1745 MEV 11/75
R2         (-0.07)                    BAKER     79 DPWA  0 PI- P TO ETA N   12/79

R3      N(1675) FROM N PI TO LAMBDA K                    SQRT(P1*P3)
R3          -0.034   0.006            DEVENISH  74       0 FIXED T DISP REL  4/75
R3       COUPLING TO LAMBDA K NOT REQUIRED IN THE ANALYSES OF BAKER 77 AND   3/79
R3       BAKER 78                                                            3/79
R3  C       (+0.036)                  SAXON     80 DPWA  0 PI- P TO K LAM   12/79
R3  C    SUPERSEDES BAKER 78.  COUPLING PHASE IS NEAR 90 DEGREES.           12/79
R3          (-0.01)                   BELL      83 DPWA 0  PI- P TO LAM KO   2/84*

R4      N(1675) FROM N PI TO SIGMA K                     SQRT(P1*P10)
R4  D       LESS THAN 0.003           DEANS     75 DPWA    PI N TO K SIGMA  11/75
R4  D    RANGE GIVEN IS FROM FOUR BEST SOLUTIONS.  DEANS 75 DISAGREES       11/75
R4  D    WITH PI+ P TO K+ SIGMA+ DATA OF WINNIK 77 AROUND 1920 MEV.          1/78

R5      N(1675) FROM N PI TO DELTA(1232) PI, D-WAVE      SQRT(P1*P11)
R5  A       -0.45 OR -0.50            LONGACRE  75 IPWA    PI N TO 2PI N    11/75
R5  B       (-0.46)                   LONGACRE  77 IPWA    PI N TO 2PI N    11/77
R5  B    LONGACRE 77 CONSIDER THIS COUPLING TO BE WELL DETERMINED.
R5  E       (-0.5)                    NOVOSELLE 78 IPWA    PI N TO 2PI N     3/79
R5  E    BW FIT TO LONGACRE 75 IPWA.                                         3/79

R6      N(1675) FROM N PI INTO N RHO, S=3/2, D-WAVE      SQRT(P1*P12)
R6  B       (+0.15)                   LONGACRE  77 IPWA    PI N TO 2PI N    11/77
R6  B    LONGACRE 77 CONSIDER THIS COUPLING TO BE WELL DETERMINED.

R7      N(1675) FROM N PI INTO N EPSILON                 SQRT(P1*P13)
R7  B       (-0.03)                   LONGACRE  77 IPWA    PI N TO 2PI N    11/77

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                    64  N(1675) PHOTON DECAY AMPLITUDES (GEV**-1/2)

      FOR DEFINITION OF GAMMA-NUCLEON DECAY AMPLITUDES, SEE MINI-
    REVIEW PRECEDING THE BARYON LISTINGS.

A1      N(1675) INTO P GAMMA, HELICITY=1/2 (GEV**-1/2)
A1          +0.010    0.013           METCALF   74 DPWA    PI N PHOTOPROD.   2/74
A1          +0.034    0.004           FELLER    76 DPWA    PI N PHOTOPROD.   2/77
A1          +0.034    0.003           AZNAURYAN 77 DPWA    PIO PHTPRD,SOL 1 12/79
A1          +0.071    0.002           AZNAURYAN 77 DPWA    PIO PHTPRD,SOL 2 12/79
A1          +0.022    0.010           BARBOUR   78 DPWA    PI-N PHOTOPROD.   3/79
A1           0.006    0.005           ARAI      80 DPWA    PI N PHOTO FIT 1 12/81
A1           0.006    0.004           ARAI      80 DPWA    PI N PHOTO FIT 2 12/81
A1           0.023    0.015           CRAWFORD  80 DPWA    PI N PHOTOPROD.  12/81
A1           0.034    0.005           AWAJI     81 DPWA    PI N PHOTOPROD.   1/84*
A1           0.021    0.011           CRAWFORD  83 IPWA    PI N PHOTOPROD.   1/84*

A2      N(1675) INTO P GAMMA, HELICITY=3/2 (GEV**-1/2)
A2          +0.042    0.024           METCALF   74 DPWA    PI N PHOTOPROD.   2/74
A2          +0.019    0.009           FELLER    76 DPWA    PI N PHOTOPROD.   2/77
A2          +0.010    0.010           AZNAURYAN 77 DPWA    PIO PHTPRD,SOL 1 12/79
A2          +0.002    0.021           AZNAURYAN 77 DPWA    PIO PHTPRD,SOL 2 12/79
A2          +0.015    0.006           BARBOUR   78 DPWA    PI-N PHOTOPROD.   3/79
A2           0.030    0.004           ARAI      80 DPWA    PI N PHOTO FIT 1 12/81
A2           0.029    0.004           ARAI      80 DPWA    PI N PHOTO FIT 2 12/81
A2           0.003    0.012           CRAWFORD  80 DPWA    PI N PHOTOPROD.  12/81
A2           0.024    0.008           AWAJI     81 DPWA    PI N PHOTOPROD.   1/84*
A2           0.015    0.009           CRAWFORD  83 IPWA    PI N PHOTOPROD.   1/84*

A3      N(1675) INTO N GAMMA, HELICITY=1/2 (GEV**-1/2)
A3           0.004    0.015           METCALF   74 DPWA    PI N PHOTOPROD.   2/74
A3          -0.066    0.020           BARBOUR   78 DPWA    PI-N PHOTOPROD.   3/79
A3          -0.039    0.017           ARAI      80 DPWA    PI N PHOTO FIT 1 12/81
A3          -0.025    0.027           ARAI      80 DPWA    PI N PHOTO FIT 2 12/81
A3          -0.059    0.015           CRAWFORD  80 DPWA    PI N PHOTOPROD.  12/81
A3          -0.021    0.011           TAKEDA    80 DPWA    PI N PHOTOPROD.  12/81
A3          -0.057    0.024           AWAJI     81 DPWA    PI N PHOTOPROD.   1/84*
A3          -0.033    0.004           FUJII     81 DPWA    PI N PHOTOPROD.  12/81

A4      N(1675) INTO N GAMMA, HELICITY=3/2 (GEV**-1/2)
A4          -0.009    0.029           METCALF   74 DPWA    PI N PHOTOPROD.   2/74
A4          -0.073    0.014           BARBOUR   78 DPWA    PI-N PHOTOPROD.   3/79
A4          -0.066    0.026           ARAI      80 DPWA    PI N PHOTO FIT 1 12/81
A4          -0.071    0.022           ARAI      80 DPWA    PI N PHOTO FIT 2 12/81
A4          -0.059    0.020           CRAWFORD  80 DPWA    PI N PHOTOPROD.  12/81
A4          -0.030    0.012           TAKEDA    80 DPWA    PI N PHOTOPROD.  12/81
A4          -0.077    0.018           AWAJI     81 DPWA    PI N PHOTOPROD.   1/84*
A4          -0.069    0.004           FUJII     81 DPWA    PI N PHOTOPROD.  12/81

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REFERENCES FOR N(1675)


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BAREYRE  65 PL 18 342          + BRICMAN, STIRLING, VILLET          (SACL)IJP
BRANDSEN 65 PL 19 420          +ODONNELL, MOORHOUSE            (DURH+RHEL)IJP
DUKE     65 PRL 15 468         +JONES,KEMP,MURPHY,PRENTICE, +   (RHEL+OXF)IJP
JOHNSON  67 UCRL-17683 THESIS C H JOHNSON                            (LRL)
TRIPP    67 NP B3 10           + LEITH, +          (LRL+SLAC+CERN+HEID+SACL)

BAREYRE  68 PR 165 1731        P BAREYRE, C BRICMAN, G VILLET       (SACL)IJP
DONNACH1 68 PL 26B 161         A DONNACHIE, R G KIRSOPP, C LOVELACE (CERN)IJP
    ALSO 68 VIENNA 139         DONNACHIE  RAPPORTEUR.S TALK          (GLAS)
    ALSO 68 THESIS             R G KIRSOPP                           (EDIN)
DUKE     68 PR 166 1448        +JONES,KEMP,MURPHY,THRESHER, +   (RHEL+OXF)IJP
    INSIGHTFUL QUALITATIVE ARGUMENTS CONCERNING EXISTENCE AND IJP.
RUSH     68 PR 173 1776        J E RUSH                              (ALAH)

BOTKE    69 PR 180 1417        J C BOTKE                             (UCSB)
DEANS    69 PR 185 1797        S DEANS, J WOOTEN                     (SFLA)
DEANS2   69 PR 177 2623        S R DEANS                             (SFLA)
DONNACHI 69 NP 10B 433         A DONNACHIE, R KIRSOPP          (GLAS+EDIN)

AYED     70 KIEV CONF          R AYED,P BAREYRE, G VILLET           (SACL)IJP
AYED2    70 PL 31B 598         +BAREYRE,VILLET                      (SACL)
CARRERAS 70 NP 16B 35          B CARRERAS, A DONNACHIE         (DARE+MCHS)
DAVIES   70 NP B21 359         A DAVIES                              (GLAS)
BRODY    71 PL 34B 665         +CASHMORE+..+HERNDON+..          (SLAC+LRL)
WAGNER   71 NP B25 411         F WAGNER, C LOVELACE                  (CERN)

ALMEHED  72 NP B40 157         +LOVELACE                       (LUND+RUTG)IJP
DEVENISH 73 PL 47B 53          DEVENISH,RANKIN,LYTH       (LOUC+BONN+LANC)IJP
HEMMI1   73 PL 43B 79          HEMMI,INAGAKI+          (KYOT+SAGA+KEK+TOKY)IJP
MOORHOUS 73 PL 43B 44          MOORHOUSE, OBERLACK              (GLAS+LBL)IJP
DEVENISH 74 NP B81 330         DEVENISH,FROGGATT,MARTIN   (DESY+NORD+LOUC)
DEVENIS2 74 PL 52B 227         DEVENISH,LYTH,RANKIN       (DESY+LANC+BONN)IJP
KNIES    74 PR D9 2680         KNIES,MOORHOUSE,OBERLACK         (LBL+GLAS)IJP
METCALF  74 NP B76 253         W J METCALF,R L WALKER                (CIT)IJP
MOORHOUS 74 PR D9 1            MOORHOUSE,OBERLACK,ROSENFELD     (GLAS+LBL)IJP

CRAWFORD 75 NP B97 125         R L CRAWFORD                          (GLAS)IJP
DEANS    75 NP B96 90          +MITCHELL,MONTGOMERY,+          (SFLA+ALAH)IJP
FELTESSE 75 NP B93 242         +AYED,BAREYRE,BORGEAUD,DAVID,ERNWEIN+(SACL)IJP
KRIVETS  75 SJNP 20 430        +MIROSHNICHENKO,NIKIFOROV,SANIN+      (KIEV)IJP
    ALSO 74 SJNP 19 112        KRIVETS,NIKIFOROV,SANIN,SHALATSKII    (KIEV)IJP
LONGACRE 75 PL 55B 415         +ROSENFELD,LASINSKI,SMADJA+      (LBL+SLAC)IJP
    ALSO 78 PR D17 1795        LONGACRE,LASINSKI,ROSENFELD+     (LBL+SLAC)

AYED     76 CEA-N-1921         AYED (THESIS)                         (SACL)IJP
BARBOUR  76 NP B111 358        I M BARBOUR,R L CRAWFORD              (GLAS)IJP
FELLER   76 NP B104 219        +FUKUSHIMA,HORIKAWA,KAJIKAWA+   (NAGO+OSAK)IJP
AZNAURYA 77  EFI-264(57)-77    +AKOPOV,BAGDASARYAN                   (YERE)IJP
BAKER    77 NP B126 365        +BLISSET,BLOODWORTH,BROOME,HART+      (RHEL)IJP
LONGACRE 77 NP B122 493        LONGACRE,DOLBEAU                      (SACL)IJP
    ALSO 76 NP B108 365        DOLBEAU,TRIANTIS,NEVEU,CADIET         (SACL)IJP
WINNIK   77 NP B128 66         +TOAFF,REVEL,GOLDBERG,BERNY           (NAIF)I
BAKER    78 NP B141 29         +BLISSET,BLOODWORTH,BROMME+      (RL+CAMB)IJP
BARBOUR  78 NP B141 253        BARBOUR,CRAWFORD,PARSONS              (GLAS)
NOVOSELL 78 NP B137 509        D E NOVOSELLER                         (CIT)IJP
    ALSO 78 NP B137 445        D E NOVOSELLER                         (CIT)IJP

BAKER    79 NP B156 93         +BROWN,CLARK,DAVIES,DEPAGTER,EVANS+  (RHEL)IJP
CUTKOSKY 79 PR D20 2839        +FORSYTH,HENDRICK,KELLY         (CARN+LBL)IJP
HOEHLER  79 HANDBOOK OF PI-N SCATTERING, PHYSIK DATEN VOL.12-1
                               +KAISER,KOCH,PIETARINEN          (KARL)    IJP
    ALSO 80  TORONTO CONF 3    R KOCH                                (KARL)IJP

ARAI     80  TORONTO CONF 93   I ARAI                                (TOKY)
    ALSO 82 NP B194 251        I ARAI, H FUJII                       (TOKY)
CRAWFORD 80  TORONTO CONF 107 R L CRAWFORD                           (GLAS)
CUTKOSKY 80  TORONTO CONF 19  +FORSYTH,BABCOCK,KELLY,HENDRICK  (CARN+LBL)IJP
SAXON    80 NP B162 522        +BAKER,BELL,BLISSETT,BLOODWORTH+(RHEL+BRIS)IJP
TAKEDA   80 NP B168 17         TAKEDA,ARAI,FUJII,IKEDA,IWASAKI+      (TOKY)

AWAJI    81  BONN CONF 352     R KAJIKAWA (TALK)                     (NAGO)
    ALSO 82 NP B197 365        FUJII,HAYASHII,IWATA,KAJIKAWA+        (NAGO)
FUJII    81 NP B187 53         FUJII,HAYASHII,IWATA,KAJIKAWA+        (TOKY)
BELL     83 NP B222 389        +BLISSET,BROOME,DALEY,HART,LINTERN,+   (RL)IJP
CRAWFORD 83 NP B211 1          R L CRAWFORD, W T MORTON              (GLAS)

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For notation, see key at front of Listings.

Baryons
N(1680)

N(1680) F'_{15} Status: ****

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65  N(1680, JP=5/2+) I=1/2   F'15

MOST OF THE RESULTS PUBLISHED BEFORE 1975 ARE NOW
OBSOLETE AND HAVE BEEN OMITTED.  THEY MAY BE FOUND IN
OUR 1982 EDITION (PHYSICS LETTERS 111B).  HOWEVER,
ALL THE REFERENCES HAVE BEEN RETAINED.

IN ADDITION, RESULTS IN THIS REGION FROM PRODUCTION EXPERIMENTS,
WHICH USED TO BE LISTED SEPARATELY IN AN ENTRY FOLLOWING THE
N(1700), HAVE BEEN ENTIRELY REMOVED.

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65  N(1680) MASS (MEV)

M          (1685.0)                  KNASEL    75 DPWA  0 PI- P TO K0 LAM  11/75
M     A     1680. OR 1670.           LONGACRE  75 IPWA    PI N TO 2PI N    11/75
M     A  THE 2 SETS OF PARAMETERS ARE FROM METHODS 1 AND 2 OF LONGACRE 75.  11/75
M     B    (1660.0)                  LONGACRE  77 IPWA    PI N TO 2PI N    11/77
M     B  ALL LONGACRE77 PARAMETERS ARE FROM SOLUTION S2, EXCEPT FOR THE POLE 11/77
M     B  POSITION WHICH IS FROM SOLUTIONS S1 AND C1.                       11/77
M         (1680.0)                  BARBOUR   78 DPWA    PI-N PHOTOPROD.   3/79
M         (1680.0)    (15.0)        CUTKOSKY  79 IPWA    PI N TO PI N     12/79
M          1684.0      3.0          HOEHLER   79 IPWA    PI N TO PI N     12/79
M         (1682.0)                  CRAWFORD  80 DPWA    PI N PHOTOPROD.  12/81
M          1680.0     10.0          CUTKOSKY  80 IPWA    PI N TO PI N      1/82

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65  N(1680) WIDTH (MEV)

W          (155.0)                   KNASEL    75 DPWA  0 PI- P TO K0 LAM  11/75
W     A     125. OR  130.            LONGACRE  75 IPWA    PI N TO 2PI N    11/75
W     B    (150.0)                   LONGACRE  77 IPWA    PI N TO 2PI N    11/77
W         (119.0)                   BARBOUR   78 DPWA    PI-N PHOTOPROD.   3/79
W         (120.0)    (25.0)         CUTKOSKY  79 IPWA    PI N TO PI N     12/79
W          128.0      8.0           HOEHLER   79 IPWA    PI N TO PI N     12/79
W         (121.0)                   CRAWFORD  80 DPWA    PI N PHOTOPROD.  12/81
W          120.0     10.0           CUTKOSKY  80 IPWA    PI N TO PI N      1/82

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65  N(1680) REAL PART OF POLE POSITION (MEV)

RE         (1688.0)                  LONGACRE  75 IPWA    PI N TO 2PI N    11/75
RE    B     1656. OR 1653.           LONGACRE  77 IPWA    PI N TO 2PI N    11/77
RE         (1666.0)                  CUTKOSKY  79 IPWA    PI N TO PI N     12/79
RE          1667.0      5.0          CUTKOSKY  80 IPWA    PI N TO PI N      1/82

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65  N(1680) -2*IMAG PART OF POLE POSITION (MEV)

IM         (132.0)                   LONGACRE  75 IPWA    PI N TO 2PI N    11/75
IM    B     145. OR 143.             LONGACRE  77 IPWA    PI N TO 2PI N    11/77
IM         (112.0)                   CUTKOSKY  79 IPWA    PI N TO PI N     12/79
IM          110.0     10.0           CUTKOSKY  80 IPWA    PI N TO PI N      1/82

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65  N(1680) REAL PART OF ELASTIC POLE RESIDUE (MEV)

RER         (31.0)                   CUTKOSKY  79 IPWA    PI N TO PI N     12/79
RER          31.0      2.0           CUTKOSKY  80 IPWA    PI N TO PI N      1/82

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65  N(1680) IMAG PART OF ELASTIC POLE RESIDUE (MEV)

IMR        (-15.0)                   CUTKOSKY  79 IPWA    PI N TO PI N     12/79
IMR         -14.0      3.0           CUTKOSKY  80 IPWA    PI N TO PI N      1/82

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65  N(1680) PARTIAL DECAY MODES

                                                   DECAY MASSES
P1     N(1680) INTO N PI                            938+ 140
P2     N(1680) INTO N ETA                           940+ 549
P3     N(1680) INTO LAMBDA K                       1116+ 498
P4     N(1680) INTO DELTA(1232) PI                 1232+ 140
P5     N(1680) INTO N PI PI                         938+ 140+ 140
P6     N(1680) INTO P GAMMA, HELICITY=1/2           938+   0
P7     N(1680) INTO P GAMMA, HELICITY=3/2           938+   0
P8     N(1680) INTO N GAMMA, HELICITY=1/2           940+   0
P9     N(1680) INTO N GAMMA, HELICITY=3/2           940+   0
P10    N(1680) INTO N EPSILON                       938+1300
P11    N(1680) INTO N RHO                           938+ 769
P12    N(1680) INTO DELTA(1232) PI, P-WAVE         1232+ 140
P13    N(1680) INTO DELTA(1232) PI, F-WAVE         1232+ 140
P14    N(1680) INTO N RHO, S=3/2, P-WAVE            938+ 769
P15    N(1680) INTO N RHO, S=3/2, F-WAVE            938+ 769
P16    N(1680) INTO SIGMA K                        1189+ 494

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65  N(1680) BRANCHING RATIOS

R1     N(1680) INTO (N PI)/TOTAL                   (P1)
R1         (0.62)    (0.06)         CUTKOSKY  79 IPWA    PI N TO PI N     12/79
R1          0.65      0.02          HOEHLER   79 IPWA    PI N TO PI N     12/79
R1          0.62      0.05          CUTKOSKY  80 IPWA    PI N TO PI N      1/82

R2     N(1680) FROM N PI TO N ETA                  SQRT(P1*P2)
R2         NOT SEEN                  BAKER     79 DPWA  0 PI- P TO ETA N   12/79

R3     N(1680) INTO (N ETA)/TOTAL                  (P2)
R3  C      (0.0004)                  BOTKE     69 MPWA    T POLE + RESON.  10/69
R3  C      (0.003)   (0.002)         DEANS     69 MPWA    T POLE + RESON.   5/70
R3  C       0.0005 OR 0.001          CARRERAS  70 MPWA    T POLE + RESON.   5/70
R3  C   PARAMETRIZATION USED COULD BE IN DANGER OF DOUBLE COUNTING

R4     N(1680) INTO (N ETA)/(N PI)                 (P2)/(P1)
R4         (0.027)OR LESS            HEUSCH    66 RVUE +  PI0, ETA PHOTO    9/66

R5     N(1680) FROM N PI TO LAMBDA K               SQRT(P1*P3)
R5         -0.009    0.009           DEVENISH  74       0 FIXED T DISP REL  4/75
R5         (0.01)                    KNASEL    75 DPWA  0 PI- P TO K0 LAM  11/75
R5     COUPLING TO LAMBDA K NOT REQUIRED IN THE ANALYSES OF BAKER 77,        2/84*
R5     SAXON 80, OR BELL 83.                                                 2/84*

R6     N(1680) FROM N PI TO SIGMA K                SQRT(P1*P16)
R6  D      LESS THAN 0.001           DEANS     75 DPWA    PI N TO K SIGMA  11/75
R6  D  RANGE GIVEN IS FROM 3 OF 4 BEST SOLUTIONS, NOT PRESENT IN SLTN.1.   11/75
R6  D  DEANS75 DISAGREES WITH PI+ P TO K+ SIGMA+ DATA OF WINNIK77           1/78
R6  D  AROUND 1920 MEV.                                                     1/78

R7     N(1680) FROM N PI TO DELTA(1232) PI, P-WAVE SQRT(P1*P12)
R7  A      +0.26 OR +0.25            LONGACRE  75 IPWA    PI N TO 2PI N    11/75
R7  B      (+0.27)                   LONGACRE  77 IPWA    PI N TO 2PI N    11/77
R7  B  LONGACRE 77 CONSIDER THIS COUPLING TO BE WELL DETERMINED.
R7  E      (+0.38)                   NOVOSELLE 78 IPWA    PI N TO 2PI N     3/79
R7  E  BW FIT TO LONGACRE 75 IPWA.                                          3/79

R8     N(1680) FROM N PI TO DELTA(1232) PI, F-WAVE SQRT(P1*P13)
R8  A       0.  OR  -0.08            LONGACRE  75 IPWA    PI N TO 2PI N    11/75
R8  B      (-0.07)                   LONGACRE  77 IPWA    PI N TO 2PI N    11/77
R8  E      (-0.05)                   NOVOSELLE 78 IPWA    PI N TO 2PI N     3/79

R9     N(1680) FROM N PI TO N RHO, S=3/2, P-WAVE   SQRT(P1*P14)
R9  A      +0.27 OR +0.30            LONGACRE  75 IPWA    PI N TO 2PI N    11/75
R9  B      (+0.23)                   LONGACRE  77 IPWA    PI N TO 2PI N    11/77
R9  B  LONGACRE 77 CONSIDER THIS COUPLING TO BE WELL DETERMINED.
R9  E      (+0.34)                   NOVOSELLE 78 IPWA    PI N TO 2PI N     3/79

R10    N(1680) FROM N PI TO N RHO, S=3/2, F-WAVE   SQRT(P1*P15)
R10 B      (+0.15)                   LONGACRE  77 IPWA    PI N TO 2PI N    11/77
R10 B  LONGACRE 77 CONSIDER THIS COUPLING TO BE WELL DETERMINED.

R11    N(1680) FROM N PI TO N EPSILON              SQRT(P1*P10)
R11 A      -0.28 OR -0.30            LONGACRE  75 IPWA    PI N TO 2PI N    11/75
R11 B      (-0.31)                   LONGACRE  77 IPWA    PI N TO 2PI N    11/77
R11 B  LONGACRE 77 CONSIDER THIS COUPLING TO BE WELL DETERMINED.
R11 E      (-0.42)                   NOVOSELLE 78 IPWA    PI N TO 2PI N     3/79

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65  N(1680) PHOTON DECAY AMPLITUDES (GEV**-1/2)

     FOR DEFINITION OF GAMMA-NUCLEON DECAY AMPLITUDES, SEE MINI-
   REVIEW PRECEDING THE BARYON LISTINGS.

A1     N(1680) INTO P GAMMA, HELICITY=1/2 (GEV**-1/2)
A1         -0.008    0.011           METCALF   74 DPWA    PI N PHOTOPROD.   2/74
A1         -0.009    0.002           FELLER    76 DPWA    PI N PHOTOPROD.   2/77
A1         -0.007    0.002           AZNAURYAN 77 DPWA    PIO PHTPRD,SOL 1 12/79
A1         +0.010    0.001           AZNAURYAN 77 DPWA    PIO PHTPRD,SOL 2 12/79
A1         -0.005    0.015           BARBOUR   78 DPWA    PI-N PHOTOPROD.   3/79
A1         -0.028    0.003           ARAI      80 DPWA    PI N PHOTO FIT 1 12/81
A1         -0.026    0.003           ARAI      80 DPWA    PI N PHOTO FIT 2 12/81
A1         -0.018    0.014           CRAWFORD  80 DPWA    PI N PHOTOPROD.  12/81
A1         -0.009    0.006           AWAJI     81 DPWA    PI N PHOTOPROD.   1/84*
A1         -0.017    0.018           CRAWFORD  83 IPWA    PI N PHOTOPROD.   1/84*

A2     N(1680) INTO P GAMMA, HELICITY=3/2 (GEV**-1/2)
A2          0.129    0.016           METCALF   74 DPWA    PI N PHOTOPROD.   2/74
A2         +0.121    0.010           FELLER    76 DPWA    PI N PHOTOPROD.   2/77
A2         +0.112    0.002           AZNAURYAN 77 DPWA    PIO PHTPRD,SOL 1 12/79
A2         +0.114    0.002           AZNAURYAN 77 DPWA    PIO PHTPRD,SOL 2 12/79
A2         +0.138    0.021           BARBOUR   78 DPWA    PI-N PHOTOPROD.   3/79
A2          0.115    0.003           ARAI      80 DPWA    PI N PHOTO FIT 1 12/81
A2          0.122    0.003           ARAI      80 DPWA    PI N PHOTO FIT 2 12/81
A2          0.141    0.014           CRAWFORD  80 DPWA    PI N PHOTOPROD.  12/81
A2          0.115    0.008           AWAJI     81 DPWA    PI N PHOTOPROD.   1/84*
A2          0.132    0.010           CRAWFORD  83 IPWA    PI N PHOTOPROD.   1/84*

A3     N(1680) INTO N GAMMA, HELICITY=1/2 (GEV**-1/2)
A3          0.008    0.018           METCALF   74 DPWA    PI N PHOTOPROD.   2/74
A3         +0.037    0.010           BARBOUR   78 DPWA    PI-N PHOTOPROD.   3/79
A3          0.026    0.005           ARAI      80 DPWA    PI N PHOTO FIT 1 12/81
A3          0.028    0.014           ARAI      80 DPWA    PI N PHOTO FIT 2 12/81
A3          0.044    0.012           CRAWFORD  80 DPWA    PI N PHOTOPROD.  12/81
A3          0.025    0.010           TAKEDA    80 DPWA    PI N PHOTOPROD.  12/81
A3          0.017    0.014           AWAJI     81 DPWA    PI N PHOTOPROD.   1/84*
A3          0.032    0.003           FUJII     81 DPWA    PI N PHOTOPROD.  12/81

A4     N(1680) INTO N GAMMA, HELICITY=3/2 (GEV**-1/2)
A4          0.00     0.030           METCALF   74 DPWA    PI N PHOTOPROD.   2/74
A4         -0.038    0.018           BARBOUR   78 DPWA    PI-N PHOTOPROD.   3/79
A4         -0.024    0.009           ARAI      80 DPWA    PI N PHOTO FIT 1 12/81
A4         -0.029    0.017           ARAI      80 DPWA    PI N PHOTO FIT 2 12/81
A4         -0.033    0.015           CRAWFORD  80 DPWA    PI N PHOTOPROD.  12/81
A4         -0.035    0.012           TAKEDA    80 DPWA    PI N PHOTOPROD.  12/81
A4         -0.033    0.013           AWAJI     81 DPWA    PI N PHOTOPROD.   1/84*
A4         -0.023    0.005           FUJII     81 DPWA    PI N PHOTOPROD.  12/81

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REFERENCES FOR N(1680)

FOR VERY EARLY REFERENCES, SEE RMP 37, 633 (1965).


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BAREYRE  65 PL 18 342          + BRICMAN, STIRLING, VILLET          (SACL)IJP
BRANDSEN 65 PL 19 420          +ODONNELL, MOORHOUSE              (DURH+RHEL)IJP
CROUCH   65 DESY CONF II 21    +              (BROW+CEA+HARV+MIT+PADO+REHO)
DERADO   65 ATHENS CONF 244    +KENNEY,LAMSA, +                  (NDAM+KNTY)
DUKE     65 PRL 15 468         +JONES,KEMP,MURPHY,PRENTICE, +   (RHEL+OXF)IJP
HEUSCH   66 PRL 17 1019        C A HEUSCH, C Y PRESCOTT, R F DASHEN  (CIT)
MERLO    66 P ROY SOC 289 489  J P MERLO, G VALLADAS                (SACL)
ROBERTS  67 PREPRINT           R G ROBERTS                        (DURH)
TRIPP    67 NP B3 10           + LEITH, +        (LRL+SLAC+CERN+HEID+SACL)

BANNER   68 PR 166 1347        +DETOEUF,FAYOUX,HAMEL, +          (SACL+CAEN)
BAREYRE  68 PR 165 1731        P BAREYRE, C BRICMAN, G VILLET       (SACL)IJP
DONNACH1 68 PL 26B 161         A DONNACHIE, R G KIRSOPP, C LOVELACE (CERN)IJP
    ALSO 68 VIENNA 139         DONNACHIE  RAPPORTEUR.S TALK         (GLAS)
    ALSO 68 THESIS             R G KIRSOPP                          (EDIN)
DUKE     68 PR 166 1448        +JONES,KEMP,MURPHY,THRESHER, +   (RHEL+OXF)IJP
RUSH     68 PR 173 1776        J E RUSH                             (ALAH)
BOTKE    69 PR 180 1417        J C BOTKE                            (UCSB)
DEANS    69 PR 185 1797        S DEANS, J WOOTEN                    (SFLA)
DEANS2   69 PR 177 2623        S R DEANS                            (SFLA)
DONNACH1 69 NP 10B 433         A DONNACHIE, R KIRSOPP            (GLAS+EDIN)

AYED     70 KIEV CONF          R AYED,P BAREYRE, G VILLET           (SACL)IJP
AYED2    70 PL 31B 598         +BAREYRE,VILLET                      (SACL)
CARRERAS 70 NP 16B 35          B CARRERAS, A DONNACHIE           (DARE+MCHS)
DAVIES   70 NP B21 359         A DAVIES                             (GLAS)
BRODY    71 PL 34B 253         +CASHMORE+..+HERNDON+..           (SLAC+LRL)
WAGNER   71 NP B25 411         F WAGNER, C LOVELACE                 (CERN)
ALMEHED  72 NP B40 157         +LOVELACE                         (LUND+RUTG)IJP
DEVENISH 73 PL 47B 53          DEVENISH,RANKIN,LYTH          (LOUC+BONN+LANC)IJP
HEMMI1   73 PL 43B 79          HEMMI,INAGAKI+             (KYOT+SAGA+KEK+TOKY)IJP
MOORHOUS 73 PL 43B 44          MOORHOUSE, OBERLACK                (GLAS+LBL)IJP
DEVENISH 74 NP B81 330         DEVENISH,FROGGATT,MARTIN   (DESY+NORD+LOUC)
DEVENIS2 74 PL 52B 227         DEVENISH,LYTH,RANKIN       (DESY+LANC+BONN)IJP
KNIES    74 PR D9 2680         KNIES,MOORHOUSE,OBERLACK          (LBL+GLAS)IJP
METCALF  74 NP B76 253         W J METCALF,R L WALKER                (CIT)IJP
MOORHOUS 74 PR D9 1            MOORHOUSE,OBERLACK,ROSENFELD      (GLAS+LBL)IJP
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Baryons
N(1680), N(1700)


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CRAWFORD 75 NP B97 125          R L CRAWFORD                          (GLAS)IJP
DEANS    75 NP B96 90           +MITCHELL,MONTGOMERY,+            (SFLA+ALAH)IJP
KNASEL   75 PR D11 1            +LINDQUIST,NELSON+        (CHIC+WUSL+OSU+ANL)IJP
KRIVETS  75 SJNP 20 430         +MIROSHNICHENKO,NIKIFOROV,SANIN+    (KIEV)IJP
    ALSO 74 SJNP 19 112         KRIVETS,NIKIFOROV,SANIN,SHALATSKII  (KIEV)IJP
LONGACRE 75 PL 55B 415          +ROSENFELD,LASINSKI,SMADJA+       (LBL+SLAC)IJP
    ALSO 78 PR D17 1795         LONGACRE,LASINSKI,ROSENFELD+      (LBL+SLAC)

AYED     76 CEA-N-1921          AYED (THESIS)                         (SACL)IJP
BARBOUR  76 NP B111 358         I M BARBOUR,R L CRAWFORD              (GLAS)IJP
FELLER   76 NP B104 219         +FUKUSHIMA,HORIKAWA,KAJIKAWA+   (NAGO+OSAK)IJP
AZNAURYA 77  EFI-264(57)-77     +AKOPOV,BAGDASARYAN                   (YERE)IJP
BAKER    77 NP B126 365         +BLISSET,BLOODWORTH,BROOME,HART+      (RHEL)IJP
LONGACRE 77 NP B122 493         LONGACRE,DOLBEAU                      (SACL)IJP
    ALSO 76 NP B108 365         DOUBEAU,TRIANTIS,NEVEU,CADIET         (SACL)IJP
WINNIK   77 NP B128 66          +TOAFF,REVEL,GOLDBERG,BERNY           (HAIF)I
BARBOUR  78 NP B141 253         BARBOUR,CRAWFORD,PARSONS              (GLAS)
NOVOSELL 78 NP B137 509         D E NOVOSELLER                         (CIT)IJP
    ALSO 78 NP B137 445         D E NOVOSELLER                         (CIT)IJP

BAKER    79 NP B156 93          +BROWN,CLARK,DAVIES,DEPAGTER,EVANS+   (RHEL)IJP
CUTKOSKY 79 PR D20 2839         +FORSYTH,HENDRICK,KELLY           (CARN+LBL)IJP
HOEHLER  79 HANDBOOK OF PI-N SCATTERING, PHYSIK DATEN VOL.12-1
                                +KAISER,KOCH,PIETARINEN        (KARL)      IJP
    ALSO 80  TORONTO CONF 3     R KOCH                                (KARL)IJP
ARAI     80  TORONTO CONF 93    I ARAI                                (TOKY)
    ALSO 82 NP B194 251         I ARAI, H FUJII                       (TOKY)
CRAWFORD 80  TORONTO CONF 107 R L CRAWFORD                            (GLAS)
CUTKOSKY 80  TORONTO CONF 19  +FORSYTH,BABCOCK,KELLY,HENDRICK  (CARN+LBL)IJP
SAXON    80 NP B162 522         +BAKER,BELL,BLOODWORTH+           (RHEL+BRIS)IJP
TAKEDA   80 NP B168 17          TAKEDA,ARAI,FUJII,IKEDA,IWASAKI+      (TOKY)

AWAJI    81  BONN CONF 352      R KAJIKAWA (TALK)                     (NAGO)
    ALSO 82 NP B197 365         FUJII,HAYASHII,IWATA,KAJIKAWA+        (NAGO)
FUJII    81 NP B187 53          FUJII,HAYASHII,IWATA,KAJIKAWA+        (TOKY)
BELL     83 NP B222 389         +BLISSET,BROOME,DALEY,HART,LINTERN,+   (RL)IJP
CRAWFORD 83 NP B211 1           R L CRAWFORD, W T MORTON              (GLAS)

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N(1700) D''_{13} Status: ***

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                18  N(1700, JP=3/2-) I=1/2   D''13

                MOST OF THE RESULTS PUBLISHED BEFORE 1975 ARE NOW
                OBSOLETE AND HAVE BEEN OMITTED.  THEY MAY BE FOUND IN
                OUR 1982 EDITION (PHYSICS LETTERS 111B).  HOWEVER,
                ALL THE REFERENCES HAVE BEEN RETAINED.

   IN ADDITION, RESULTS IN THIS REGION FROM PRODUCTION EXPERIMENTS,
   WHICH USED TO BE LISTED SEPARATELY AS THE NEXT ENTRY, HAVE BEEN
   ENTIRELY REMOVED.

   THE VARIOUS PARTIAL-WAVE ANALYSES DO NOT AGREE VERY WELL.

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                18  N(1700) MASS  (MEV)

M    A     1710. OR 1710.            LONGACRE  75 IPWA    PI N TO 2PI N    11/75
M    A  THE 2 SETS OF PARAMETERS ARE FROM METHODS 1 AND 2 OF LONGACRE 75.  11/75
M    B    (1670.0)   (10.0)          BAKER     77 IPWA  0 PI- P TO K LAM.   1/78
M    C    (1690.0)                   BAKER     77 DPWA  0 PI- P TO K LAM.   1/78
M    B  THE TWO ENTRIES FOR BAKER 77 ARE FOR AN IPWA USING THE BARRELET     1/78
M    C  ZERO METHOD AND A CONVENTIONAL ENERGY-DEPENDENT ANALYSIS.           1/78
M    D    (1660.0)                   LONGACRE  77 IPWA    PI N TO 2PI N    11/77
M    D  ALL LONGACRE77 PARAMETERS ARE FROM SOLUTION S2, EXCEPT FOR THE POLE 11/77
M    D  POSITION WHICH IS FROM SOLUTIONS S1 AND C1.                         11/77
M         1690. TO 1710.            BAKER     78 DPWA  0 PI- P TO K LAM    3/79
M        (1719.0)                   BARBOUR   78 DPWA    PI-N PHOTOPROD.   3/79
M    E   (1880.0)                   BAKER     79 DPWA  0 PI- P TO ETA N   12/79
M    E  THE HIGH MASS FOUND BY BAKER 79 MAY BE INFLUENCED BY THE N(2080).  12/79
M        (1670.0)   (25.0)          CUTKOSKY  79 IPWA    PI N TO PI N     12/79
M         1731.0     15.0           HOEHLER   79 IPWA    PI N TO PI N     12/79
M        (1709.0)                   CRAWFORD  80 DPWA    PI N PHOTOPROD.  12/81
M         1675.0     25.0           CUTKOSKY  80 IPWA    PI N TO PI N      1/82
M        (1650.0)                   SAXON     80 DPWA  0 PI- P TO K LAM   12/79

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                18  N(1700) WIDTH (MEV)

W    A      100. OR  300.            LONGACRE  75 IPWA    PI N TO 2PI N    11/75
W    B      (90.0)   (25.0)          BAKER     77 IPWA  0 PI- P TO K LAM.   1/78
W    C     (100.0)                   BAKER     77 DPWA  0 PI- P TO K LAM.   1/78
W    D     (600.0)                   LONGACRE  77 IPWA    PI N TO 2PI N    11/77
W           70. TO  100.             BAKER     78 DPWA  0 PI- P TO K LAM    3/79
W         (126.0)                    BARBOUR   78 DPWA    PI-N PHOTOPROD.  3/79
W    E     (87.0)                    BAKER     79 DPWA  0 PI- P TO ETA N   12/79
W          (80.0)   (40.0)           CUTKOSKY  79 IPWA    PI N TO PI N     12/79
W          110.0     30.0            HOEHLER   79 IPWA    PI N TO PI N     12/79
W         (166.0)                    CRAWFORD  80 DPWA    PI N PHOTOPROD.  12/81
W           90.0     40.0            CUTKOSKY  80 IPWA    PI N TO PI N      1/82
W          (70.0)                    SAXON     80 DPWA  0 PI- P TO K LAM   12/79

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                18  N(1700) REAL PART OF POLE POSITION (MEV)

RE        (1710.0)                   LONGACRE  75 IPWA    PI N TO 2PI N    11/75
RE   D     1616. OR 1613.            LONGACRE  77 IPWA    PI N TO 2PI N    11/77
RE        (1660.0)                   CUTKOSKY  79 IPWA    PI N TO PI N     12/79
RE         1660.0     30.0           CUTKOSKY  80 IPWA    PI N TO PI N      1/82

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                18  N(1700) -2*IMAG PART OF POLE POSITION (MEV)

IM        (607.0)                    LONGACRE  75 IPWA    PI N TO 2PI N    11/75
IM   D     577.  OR 575.             LONGACRE  77 IPWA    PI N TO 2PI N    11/77
IM         (76.0)                    CUTKOSKY  79 IPWA    PI N TO PI N     12/79
IM          90.0     40.0            CUTKOSKY  80 IPWA    PI N TO PI N      1/82

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                18  N(1700) REAL PART OF ELASTIC POLE RESIDUE (MEV)

RER         (4.0)                    CUTKOSKY  79 IPWA    PI N TO PI N     12/79
RER          6.0      3.0            CUTKOSKY  80 IPWA    PI N TO PI N      1/82

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                18  N(1700) IMAG PART OF ELASTIC POLE RESIDUE (MEV)

IMR         (-0.3)                   CUTKOSKY  79 IPWA    PI N TO PI N     12/79
IMR          0.0      5.0            CUTKOSKY  80 IPWA    PI N TO PI N      1/82

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                18  N(1700) PARTIAL DECAY MODES

                                                          DECAY MASSES
P1     N(1700) INTO N PI                                  938+ 140
P2     N(1700) INTO LAMBDA K                             1116+ 498
P3     N(1700) INTO P GAMMA, HELICITY=3/2                 938+   0
P4     N(1700) INTO P GAMMA, HELICITY=1/2                 938+   0
P5     N(1700) INTO N GAMMA, HELICITY=3/2                 940+   0
P6     N(1700) INTO N GAMMA, HELICITY=1/2                 940+   0
P7     N(1700) INTO SIGMA K                              1189+ 494
P8     N(1700) INTO N EPSILON                             938+1300
P9     N(1700) INTO DELTA(1232) PI, S-WAVE               1232+ 140
P10    N(1700) INTO DELTA(1232) PI, D-WAVE               1232+ 140
P11    N(1700) INTO N RHO, S=3/2, S-WAVE                 938+ 769
P12    N(1700) INTO N ETA                                940+ 549

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                18  N(1700) BRANCHING RATIOS

R1     N(1700) INTO (N PI)/TOTAL                         (P1)
R1          (0.10)   (0.02)          CUTKOSKY  79 IPWA    PI N TO PI N     12/79
R1           0.08     0.03           HOEHLER   79 IPWA    PI N TO PI N     12/79
R1           0.11     0.05           CUTKOSKY  80 IPWA    PI N TO PI N      1/82

R2     N(1700) FROM N PI TO N ETA                        SQRT(P1*P12)
R2          (0.065)                  BAKER     79 DPWA  0 PI- P TO ETA N   12/79

R3     N(1700) FROM N PI TO LAMBDA K                     SQRT(P1*P2)
R3          +0.026    0.019          DEVENISH  74       0 FIXED T DISP REL  4/75
R3   B      (-0.03)   (0.004)        BAKER     77 IPWA  0 PI- P TO K LAM.   1/78
R3   C      (-0.03)                  BAKER     77 DPWA  0 PI- P TO K LAM.   1/78
R3   F      (-0.04)                  BAKER     78 DPWA  0 PI- P TO K LAM    3/79
R3   F  THE (UNDETERMINED) OVERALL PHASE OF ALL COUPLINGS HAS BEEN          3/79
R3   F  CHANGED TO AGREE WITH PREVIOUS CONVENTIONS. SUPERSEDED BY SAXON 80. 3/79
R3          (-0.012)                 SAXON     80 DPWA  0 PI- P TO K LAM   12/79
R3          (-0.012)                 BELL      83 DPWA 0  PI- P TO LAM KO   2/84*

R4     N(1700) FROM N PI TO SIGMA K                      SQRT(P1*P7)
R4   G     LESS THAN 0.017           DEANS     75 DPWA    PI N TO K SIGMA  11/75
R4   G  RANGE GIVEN IS FROM FOUR BEST SOLUTIONS.                            11/75
R4            NOT SEEN               LIVANOS   80 DPWA    PI P TO K SIGMA   2/84*

R5     N(1700) FROM N PI TO DELTA(1232) PI, S-WAVE       SQRT(P1*P9)
R5   A      +0.15 OR +0.16           LONGACRE  75 IPWA    PI N TO 2PI N    11/75
R5   D      (0.00)                   LONGACRE  77 IPWA    PI N TO 2PI N    11/77

R6     N(1700) FROM N PI TO DELTA(1232) PI, D-WAVE       SQRT(P1*P10)
R6   A      -0.10 OR -0.14           LONGACRE  75 IPWA    PI N TO 2PI N    11/75
R6   D      (+0.12)                  LONGACRE  77 IPWA    PI N TO 2PI N    11/77

R7     N(1700) FROM N PI TO N RHO, S=3/2, S-WAVE         SQRT(P1*P11)
R7   A       0.  OR  -0.07           LONGACRE  75 IPWA    PI N TO 2PI N    11/75
R7   D      (+0.07)                  LONGACRE  77 IPWA    PI N TO 2PI N    11/77

R8     N(1700) FROM N PI TO N EPSILON                    SQRT(P1*P8)
R8   A      -0.2  OR -0.2            LONGACRE  75 IPWA    PI N TO 2PI N    11/75
R8   D      (0.00)                   LONGACRE  77 IPWA    PI N TO 2PI N    11/77

R9     N(1700) FROM P GAMMA TO LAMBDA K                  SQRT((P3+P4)*P2)
R9          (0.0077)                 DEANS     72 MPWA    GAM P-K LM,SOL D  9/73

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                18  N(1700) PHOTON DECAY AMPLITUDES (GEV**-1/2)

        FOR DEFINITION OF GAMMA-NUCLEON DECAY AMPLITUDES, SEE MINI-
      REVIEW PRECEDING THE BARYON LISTINGS.

A1     N(1700) INTO P GAMMA, HELICITY=1/2 (GEV**-1/2)
A1          0.0      0.034           METCALF   74 DPWA    PI N PHOTOPROD.   2/74
A1         -0.014    0.025           FELLER    76 DPWA    PI N PHOTOPROD.   2/77
A1         +0.078    0.008           AZNAURYAN 77 DPWA    PIO PHTPRD,SOL 1 12/79
A1         +0.038    0.005           AZNAURYAN 77 DPWA    PIO PHTPRD,SOL 2 12/79
A1         -0.033    0.021           BARBOUR   78 DPWA    PI-N PHOTOPROD.   3/79
A1         -0.028    0.007           ARAI      80 DPWA    PI N PHOTO FIT 1 12/81
A1         -0.029    0.006           ARAI      80 DPWA    PI N PHOTO FIT 2 12/81
A1         -0.024    0.019           CRAWFORD  80 DPWA    PI N PHOTOPROD.  12/81
A1         -0.002    0.013           AWAJI     81 DPWA    PI N PHOTOPROD.   1/84*
A1         -0.016    0.014           CRAWFORD  83 IPWA    PI N PHOTOPROD.   1/84*

A2     N(1700) INTO P GAMMA, HELICITY=3/2 (GEV**-1/2)
A2          0.0      0.029           METCALF   74 DPWA    PI N PHOTOPROD.   2/74
A2          0.0      0.014           FELLER    76 DPWA    PI N PHOTOPROD.   2/77
A2         -0.066    0.007           AZNAURYAN 77 DPWA    PIO PHTPRD,SOL 1 12/79
A2         -0.048    0.007           AZNAURYAN 77 DPWA    PIO PHTPRD,SOL 2 12/79
A2         -0.014    0.025           BARBOUR   78 DPWA    PI-N PHOTOPROD.   3/79
A2         -0.002    0.005           ARAI      80 DPWA    PI N PHOTO FIT 1 12/81
A2          0.014    0.005           ARAI      80 DPWA    PI N PHOTO FIT 2 12/81
A2         -0.017    0.014           CRAWFORD  80 DPWA    PI N PHOTOPROD.  12/81
A2          0.029    0.014           AWAJI     81 DPWA    PI N PHOTOPROD.   1/84*
A2         -0.009    0.012           CRAWFORD  83 IPWA    PI N PHOTOPROD.   1/84*

A3     N(1700) INTO N GAMMA, HELICITY=1/2 (GEV**-1/2)
A3          0.0      0.034           METCALF   74 DPWA    PI N PHOTOPROD.   2/74
A3         +0.050    0.042           BARBOUR   78 DPWA    PI-N PHOTOPROD.   3/79
A3         -0.052    0.030           ARAI      80 DPWA    PI N PHOTO FIT 1 12/81
A3         -0.055    0.030           ARAI      80 DPWA    PI N PHOTO FIT 2 12/81
A3          0.052    0.035           CRAWFORD  80 DPWA    PI N PHOTOPROD.  12/81
A3          0.006    0.024           AWAJI     81 DPWA    PI N PHOTOPROD.   1/84*
A3         -0.002    0.013           FUJII     81 DPWA    PI N PHOTOPROD.  12/81

A4     N(1700) INTO N GAMMA, HELICITY=3/2 (GEV**-1/2)
A4          0.0      0.044           METCALF   74 DPWA    PI N PHOTOPROD.   2/74
A4         +0.035    0.030           BARBOUR   78 DPWA    PI-N PHOTOPROD.   3/79
A4         -0.037    0.036           ARAI      80 DPWA    PI N PHOTO FIT 1 12/81
A4         -0.035    0.024           ARAI      80 DPWA    PI N PHOTO FIT 2 12/81
A4          0.041    0.030           CRAWFORD  80 DPWA    PI N PHOTOPROD.  12/81
A4         -0.033    0.017           AWAJI     81 DPWA    PI N PHOTOPROD.   1/84*
A4          0.018    0.018           FUJII     81 DPWA    PI N PHOTOPROD.  12/81

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For notation, see key at front of Listings.

Baryons
N(1700), N(1710)

REFERENCES FOR N(1700)

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DONNACH2 68 VIENNA 139          DONNACHIE  RAPPORTEUR.S TALK          (GLAS)
KIRSOPP  68 THESIS              R G KIRSOPP                           (EDIN)
WAGNER   71 NP B25 411          F WAGNER, C LOVELACE                  (CERN)
DEANS    72 PR D6 1906          DEANS,JACOBS, LYONS,MONTGOMERY        (SFLA)IJP
HERNDON  72 LBL 1065            +....ROSENFELD....+CASHMORE+....   (LBL+SLAC)
DEVENISH 73 PL 47B 53           DEVENISH,RANKIN,LYTH          (LOUC+BONN+LANC)IJP
LANGBEIN 73 NP B53 251          LANGBEIN,WAGNER                      (MUNI)IJP
DEVENISH 74 NP B81 330          DEVENISH,FROGGATT,MARTIN   (DESY+NORD+LOUC)
DEVENIS2 74 PL 52B 227          DEVENISH,LYTH,RANKIN       (DESY+LANC+BONN)IJP
KNIES    74 PR D9 2680          KNIES,MOORHOUSE,OBERLACK          (LBL+GLAS)IJP
METCALF  74 NP B76 253          W J METCALF,R L WALKER                (CIT)IJP
MOORHOUS 74 PR D9 1             MOORHOUSE,OBERLACK,ROSENFELD     (GLAS+LBL)IJP

CRAWFORD 75 NP B97 125          R L CRAWFORD                          (GLAS)IJP
DEANS    75 NP B96 90           +MITCHELL,MONTGOMERY,+           (SFLA+ALAH)IJP
LONGACRE 75 PL 55B 415          +ROSENFELD,LASINSKI,SMADJA+      (LBL+SLAC)IJP
    ALSO 78 PR D17 1795         LONGACRE,LASINSKI,ROSENFELD+     (LBL+SLAC)
AYED     76 CEA-N-1921          AYED (THESIS)                         (SACL)IJP
BARBOUR  76 NP B111 358         I M BARBOUR,R L CRAWFORD              (GLAS)IJP
FELLER   76 NP B104 219         +FUKUSHIMA,HORIKAWA,KAJIKAWA+   (NAGO+OSAK)IJP
AZNAURYA 77  EF1-264(57)-77     +AKOPOV,BAGDASARYAN                   (YERE)IJP
BAKER    77 NP B126 365         +BLISSET,BLOODWORTH,BROOME,HART+      (RHEL)IJP
LONGACRE 77 NP B122 493         LONGACRE,DOLBEAU                      (SACL)IJP
    ALSO 76 NP B108 365         DOLBEAU,TRIANTIS,NEVEU,CADIET         (SACL)IJP
WINNIK   77 NP B128 66          +TOAFF,REVEL,GOLDBERG,BERNY           (HAIF)I

BAKER    78 NP B141 29          +BLISSET,BLOODWORTH,BROOME+       (RL+CAMB)IJP
BARBOUR  78 NP B141 253         BARBOUR,CRAWFORD,PARSONS              (GLAS)
BAKER    79 NP B156 93          +BROWN,CLARK,DAVIES,DEPAGTER,EVANS+   (RHEL)IJP
CUTKOSKY 79 PR D20 2839         +FORSYTH,HENDRICK,KELLY          (CARN+LBL)IJP
HOEHLER  79 HANDBOOK OF PI-N SCATTERING, PHYSIK DATEN VOL.12-1
                                +KAISER,KOCH,PIETARINEN               (KARL)IJP
    ALSO 80  TORONTO CONF 3     R KOCH                                (KARL)IJP

ARAI     80  TORONTO CONF 93    I ARAI                                (TOKY)
    ALSO 82 NP B194 251         I ARAI, M FUJII                       (TOKY)
CRAWFORD 80  TORONTO CONF 107   R L CRAWFORD                          (GLAS)
CUTKOSKY 80  TORONTO CONF 19    +FORSYTH,BABCOCK,KELLY,HENDRICK  (CARN+LBL)IJP
LIVANOS  80  TORONTO CONF 35    +BATON,COUTURES,KOCHOWSKI,NEVEU       (SACL)IJP
SAXON    80 NP B162 522         +BAKER,BELL,BLISSETT,BLOODWORTH+(RHEL+BRIS)IJP

AWAJI    81  BONN CONF 352      R KAJIKAWA (TALK)                     (NAGO)
    ALSO 82 NP B197 365         FUJII,HAYASHII,IWATA,KAJIKAWA+        (NAGO)
FUJII    81 NP B187 53          FUJII,HAYASHII,IWATA,KAJIKAWA+        (TOKY)
BELL     83 NP B222 389         +BLISSET,BROOME,DALEY,HART,LINTERN,+   (RL)IJP
CRAWFORD 83 NP B211 1           R L CRAWFORD, W T MORTON              (GLAS)
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N(1710) P''_{11} Status: ***

14 N(1710, JP=1/2+) I=1/2 P''11

MOST OF THE RESULTS PUBLISHED BEFORE 1975 ARE NOW OBSOLETE AND HAVE BEEN OMITTED. THEY MAY BE FOUND IN OUR 1982 EDITION (PHYSICS LETTERS 111B). HOWEVER, ALL THE REFERENCES HAVE BEEN RETAINED.

THE VARIOUS PARTIAL-WAVE ANALYSES DO NOT AGREE VERY WELL.

14 N(1710) MASS (MEV)

```
M        (1670.0)                   KNASEL    75 DPWA  0 PI- P TO K0 LAM  11/75
M    A    1730. OR 1710.            LONGACRE  75 IPWA    PI N TO 2PI N    11/75
M    A  THE 2 SETS OF PARAMETERS ARE FROM METHODS 1 AND 2 OF LONGACRE 75.  11/75
M    B    (1625.0)   (10.0)         BAKER     77 IPWA  0 PI- P TO K LAM.   1/78
M    C    (1650.0)                  BAKER     77 DPWA  0 PI- P TO K LAM.   1/78
M    B  THE TWO ENTRIES FOR BAKER 77 ARE FOR AN IPWA USING THE BARRELET     1/78
M    C  ZERO METHOD AND A CONVENTIONAL ENERGY-DEPENDENT ANALYSIS.           1/78
M    D    (1720.0)                  LONGACRE  77 IPWA    PI N TO 2PI N    11/77
M    D  ALL LONGACRE77 PARAMETERS ARE FROM SOLUTION S2, EXCEPT FOR THE POLE 11/77
M    D  POSITION WHICH IS FROM SOLUTIONS S1 AND C1.                        11/77
M         1650. TO 1680.           BAKER     78 DPWA  0 PI- P TO K LAM    3/79
M        (1721.0)                  BARBOUR   78 DPWA    PI-N PHOTOPROD.    3/79
M        (1690.0)                  BAKER     79 DPWA  0 PI- P TO ETA N   12/79
M        (1710.0)   (60.0)         CUTKOSKY  79 IPWA    PI N TO PI N     12/79
M         1723.0     9.0           HOEHLER   79 IPWA    PI N TO PI N     12/79
M        (1692.0)                  CRAWFORD  80 DPWA    PI N PHOTOPROD.  12/81
M         1700.0    50.0           CUTKOSKY  80 IPWA    PI N TO PI N      1/82
M        (1730.0)                  SAXON     80 DPWA  0 PI- P TO K LAM   12/79
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14 N(1710) WIDTH (MEV)

```
W        (174.0)                    KNASEL    75 DPWA  0 PI- P TO K0 LAM  11/75
W    A    165.  OR  75.             LONGACRE  75 IPWA    PI N TO 2PI N    11/75
W    B    (160.0)    (6.0)          BAKER     77 IPWA  0 PI- P TO K LAM.   1/78
W    C    (95.0)                    BAKER     77 DPWA  0 PI- P TO K LAM.   1/78
W    D    (120.0)                   LONGACRE  77 IPWA    PI N TO 2PI N    11/77
W         90. TO  150.             BAKER     78 DPWA  0 PI- P TO K LAM    3/79
W        (167.0)                   BARBOUR   78 DPWA    PI-N PHOTOPROD.    3/79
W        (97.0)                    BAKER     79 DPWA  0 PI- P TO ETA N   12/79
W        (100.0)    (50.0)         CUTKOSKY  79 IPWA    PI N TO PI N     12/79
W         120.0     15.0           HOEHLER   79 IPWA    PI N TO PI N     12/79
W        (200.0)                   CRAWFORD  80 DPWA    PI N PHOTOPROD.  12/81
W         90.0      30.0           CUTKOSKY  80 IPWA    PI N TO PI N      1/82
W        (550.0)                   SAXON     80 DPWA  0 PI- P TO K LAM   12/79
W        (540.0)                   BELL      83 DPWA 0  PI- P TO LAM K0   2/84*
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14 N(1710) REAL PART OF POLE POSITION (MEV)

```
RE       (1708.0)                   LONGACRE  75 IPWA    PI N TO 2PI N    11/75
RE   D    1720. OR 1711.            LONGACRE  77 IPWA    PI N TO 2PI N    11/77
RE       (1692.0)                   CUTKOSKY  79 IPWA    PI N TO PI N     12/79
RE        1690.0     20.0           CUTKOSKY  80 IPWA    PI N TO PI N      1/82
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14 N(1710) -2*IMAG PART OF POLE POSITION (MEV)

```
IM        (17.0)                    LONGACRE  75 IPWA    PI N TO 2PI N    11/75
IM   D    123.  OR 115.             LONGACRE  77 IPWA    PI N TO 2PI N    11/77
IM        (88.0)                    CUTKOSKY  79 IPWA    PI N TO PI N     12/79
IM         80.0     20.0            CUTKOSKY  80 IPWA    PI N TO PI N      1/82
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14 N(1710) REAL PART OF ELASTIC POLE RESIDUE (MEV)

```
RER        (-9.0)                   CUTKOSKY  79 IPWA    PI N TO PI N     12/79
RER         -8.0      2.0           CUTKOSKY  80 IPWA    PI N TO PI N      1/82
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14 N(1710) IMAG PART OF ELASTIC POLE RESIDUE (MEV)

```
IMR         (0.1)                   CUTKOSKY  79 IPWA    PI N TO PI N     12/79
IMR          1.0      5.0           CUTKOSKY  80 IPWA    PI N TO PI N      1/82
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14 N(1710) PARTIAL DECAY MODES

		DECAY MASSES
P1	N(1710) INTO N PI	938+ 140
P2	N(1710) INTO LAMBDA K	1116+ 498
P3	N(1710) INTO N ETA	940+ 549
P4	N(1710) INTO P GAMMA, HELICITY=1/2	938+ 0
P5	N(1710) INTO N GAMMA, HELICITY=1/2	940+ 0
P6	N(1710) INTO N PI PI	938+ 140+ 140
P7	N(1710) INTO N EPSILON	938+1300
P8	N(1710) INTO N RHO	938+ 769
P9	N(1710) INTO SIGMA K	1189+ 494
P10	N(1710) INTO DELTA(1232) PI	1232+ 140
P11	N(1710) INTO N RHO, S=1/2, P-WAVE	938+ 769
P12	N(1710) INTO N RHO, S=3/2, P-WAVE	938+ 769

14 N(1710) BRANCHING RATIOS

```
R1     N(1710) INTO (N PI)/TOTAL                              (P1)
R1        (0.19)    (0.05)          CUTKOSKY  79 IPWA    PI N TO PI N     12/79
R1         0.12      0.04           HOEHLER   79 IPWA    PI N TO PI N     12/79
R1         0.20      0.04           CUTKOSKY  80 IPWA    PI N TO PI N      1/82

R2     N(1710) FROM N PI TO N ETA                         SQRT(P1*P3)
R2        (0.22)                    BAKER     79 DPWA  0 PI- P TO ETA N   12/79

R3     N(1710) FROM N PI TO LAMBDA K                      SQRT(P1*P2)
R3        (0.10)                    KNASEL    75 DPWA  0 PI- P TO K0 LAM  11/75
R3   B    (-0.05)   (0.03)          BAKER     77 IPWA  0 PI- P TO K LAM.   1/78
R3   C    (-0.10)                   BAKER     77 DPWA  0 PI- P TO K LAM.   1/78
R3   E    (-0.12)                   BAKER     78 DPWA  0 PI- P TO K LAM    3/79
R3   E  THE (UNDETERMINED) OVERALL PHASE OF ALL COUPLINGS FROM BAKER 78     3/79
R3   E  HAS BEEN CHANGED TO AGREE WITH PREVIOUS CONVENTIONS.  SUPERSEDED    3/79
R3   E  BY SAXON 80.                                                        3/79
R3        (+0.14)                   SAXON     80 DPWA  0 PI- P TO K LAM   12/79
R3        (+0.16)                   BELL      83 DPWA 0  PI- P TO LAM K0   2/84*

R4     N(1710) FROM N PI TO SIGMA K                       SQRT(P1*P9)
R4   F        0.075 TO 0.203        DEANS     75 DPWA    PI N TO K SIGMA  11/75
R4   F  RANGE GIVEN IS FROM FOUR BEST SOLUTIONS.                            11/75
R4        (-0.034)                  LIVANOS   80 DPWA    PI P TO K SIGMA   1/82

R5     N(1710) FROM N PI TO DELTA(1232) PI                SQRT(P1*P10)
R5   A        0.13 OR -0.20         LONGACRE  75 IPWA    PI N TO 2PI N    11/75
R5   D    (+0.17)                   LONGACRE  77 IPWA    PI N TO 2PI N    11/77

R6     N(1710) FROM N PI TO N RHO, S=1/2, P-WAVE          SQRT(P1*P11)
R6   A       +0.32 OR +0.20         LONGACRE  75 IPWA    PI N TO 2PI N    11/75
R6   D    (-0.19)                   LONGACRE  77 IPWA    PI N TO 2PI N    11/77

R7     N(1710) FROM N PI TO N RHO, S=3/2, P-WAVE          SQRT(P1*P12)
R7   D    (-0.31)                   LONGACRE  77 IPWA    PI N TO 2PI N    11/77

R8     N(1710) FROM N PI TO N EPSILON                     SQRT(P1*P7)
R8   A       +0.18 OR +0.28         LONGACRE  75 IPWA    PI N TO 2PI N    11/75
R8   D    (+0.26)                   LONGACRE  77 IPWA    PI N TO 2PI N    11/77

R9     N(1710) FROM P GAMMA TO P ETA                      SQRT(P3*P4)
R9        (0.0075)                  HICKS     73 MPWA    GAM P-ETA P       9/73

R10    N(1710) FROM P GAMMA TO LAMBDA K                   SQRT(P2*P4)
R10       (0.0027)                  ORITO2    69 CNTR    K LAM PHOTOPRO   10/71
R10       (0.0088)                  SCHORSCH  70 DPWA    K LAM PHOTOPRO.  10/71
R10       (0.0104)                  DEANS     72 MPWA    GAM P-K LM,SOL D  9/73
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14 N(1710) PHOTON DECAY AMPLITUDES (GEV**-1/2)

FOR DEFINITION OF GAMMA-NUCLEON DECAY AMPLITUDES, SEE MINI-REVIEW PRECEDING THE BARYON LISTINGS.

```
A1     N(1710) INTO P GAMMA, HELICITY=1/2 (GEV**-1/2)
A1        -0.068     0.024          METCALF   74 DPWA    PI N PHOTOPROD.   2/74
A1        +0.053     0.019          FELLER    76 DPWA    PI N PHOTOPROD.   2/77
A1        +0.001     0.039          BARBOUR   78 DPWA    PI-N PHOTOPROD.   3/79
A1        -0.009     0.006          ARAI      80 DPWA    PI N PHOTO FIT 1 12/81
A1        -0.012     0.005          ARAI      80 DPWA    PI N PHOTO FIT 2 12/81
A1         0.015     0.025          CRAWFORD  80 DPWA    PI N PHOTOPROD.  12/81
A1         0.028     0.009          AWAJI     81 DPWA    PI N PHOTOPROD.   1/84*
A1         0.006     0.018          CRAWFORD  83 IPWA    PI N PHOTOPROD.   1/84*

A2     N(1710) INTO N GAMMA, HELICITY=1/2 (GEV**-1/2)
A2         0.048     0.045          METCALF   74 DPWA    PI N PHOTOPROD.   2/74
A2        -0.028     0.045          BARBOUR   78 DPWA    PI-N PHOTOPROD.   3/79
A2         0.005     0.013          ARAI      80 DPWA    PI N PHOTO FIT 1 12/81
A2         0.011     0.021          ARAI      80 DPWA    PI N PHOTO FIT 2 12/81
A2        -0.017     0.020          CRAWFORD  80 DPWA    PI N PHOTOPROD.  12/81
A2         0.000     0.018          AWAJI     81 DPWA    PI N PHOTOPROD.   1/84*
A2        -0.001     0.003          FUJII     81 DPWA    PI N PHOTOPROD.  12/81
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REFERENCES FOR N(1710)

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DONNACH1 68 PL 26B 161          A DONNACHIE, R G KIRSOPP, C LOVELACE (CERN)IJP
    ALSO 68 VIENNA 139          DONNACHIE  RAPPORTEUR.S TALK          (GLAS)
    ALSO 68 THESIS              R G KIRSOPP                           (EDIN)
RUSH     68 PR 173 1776         J E RUSH                              (ALAH)
BOTKE    69 PR 180 1417         J C BOTKE                             (UCSB)
DEANS    69 PR 185 1797         S DEANS, J WOOTEN                     (SFLA)
DEANS2   69 PR 177 2623         S R DEANS                             (SFLA)
DONNACH1 69 NP 10B 433          A DONNACHIE, R KIRSOPP           (GLAS+EDIN)
ORITO    69 LNC 1 936           S ORITO,S SASAKI                 (TOKY+OSAK)
ORITO2   69 INS J 113           S ORITO (THESIS)                      (TOKY)

AYED     70 KIEV CONF           R AYED,P BAREYRE, G VILLET            (SACL)IJP
AYED2    70 PL 31B 598          +BAREYRE,VILLET                       (SACL)
CARRERAS 70 NP 16B 35           B CARRERAS, A DONNACHIE          (DARE+MCHS)
DAVIES   70 NP B21 359          A DAVIES                              (GLAS)
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Baryons

N(1710), N(1720)


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SCHORSCH 70 NP  B25 179        +TIETGE,WEILNBOECK                    (MPIM)
WAGNER   71 NP B25 411         F WAGNER, C LOVELACE                  (CERN)
ALMEHED  72 NP B40 157         +LOVELACE                        (LUND+RUTG)IJP
DEANS    72 PR D6 1906         DEANS,JACOBS, LYONS,MONTGOMERY        (SFLA)IJP

DEVENISH 73 PL 47B 53          DEVENISH,RANKIN,LYTH        (LOUC+BONN+LANC)IJP
HICKS    73 PR D7 2614         +DEANS,JACOBS,LYONS+        (CARN+ORNL+SFLA)IJP
LANGBEIN 73 NP B53 251         LANGBEIN,WAGNER                       (MUNI)IJP
MOORHOUS 73 PL 43B 44          MOORHOUSE, OBERLACK              (GLAS+LBL)IJP

DEVENISH 74 NP B81 330         DEVENISH,FROGGATT,MARTIN   (DESY+NORD+LOUC)
DEVENIS2 74 PL 52B 227         DEVENISH,LYTH,RANKIN       (DESY+LANC+BONN)IJP
KNIES    74 PR D9 2680         KNIES,MOORHOUSE,OBERLACK         (LBL+GLAS)IJP
METCALF  74 NP B76 253         W J METCALF,R L WALKER                (CIT)IJP
MOORHOUS 74 PR D9 1            MOORHOUSE,OBERLACK,ROSENFELD     (GLAS+LBL)IJP

CRAWFORD 75 NP B97 125         R L CRAWFORD                          (GLAS)IJP
DEANS    75 NP B96 90          +MITCHELL,MONTGOMERY,+           (SFLA+ALAH)IJP
FELTESSE 75 NP B93 242         +AYED,BAREYRE,BORGEAUD,DAVID,ERNWEIN+(SACL)IJP
KNASEL   75 PR D11 1           +LINDQUIST,NELSON+       (CHIC+WUSL+OSU+ANL)IJP
LONGACRE 75 PL 55B 415         +ROSENFELD,LASINSKI,SMADJA+      (LBL+SLAC)IJP
    ALSO 78 PR D17 1795        LONGACRE,LASINSKI,ROSENFELD+     (LBL+SLAC)
AYED     76 CEA-N-1921         AYED (THESIS)                         (SACL)IJP
BARBOUR  76 NP B111 358        I M BARBOUR,R L CRAWFORD              (GLAS)IJP
FELLER   76 NP B104 219        +FUKUSHIMA,HORIKAWA,KAJIKAWA+   (NAGO+OSAK)IJP
BAKER    77 NP B126 365        +BLISSET,BLOODWORTH,BROOME,HART+      (RHEL)IJP
LONGACRE 77 NP B122 493        LONGACRE,DOLBEAU                      (SACL)IJP
    ALSO 76 NP B108 365        DOLBEAU,TRIANTIS,NEVEU,CADIET         (SACL)IJP
WINNIK   77 NP B128 66         +TOAFF,REVEL,GOLDBERG,BERNY           (HAIF)I

BAKER    78 NP B141 29         +BLISSET,BLOODWORTH,BROOME+       (RL+CAMB)IJP
BARBOUR  78 NP B141 253        BARBOUR,CRAWFORD,PARSONS              (GLAS)
BAKER    79 NP B156 93         +BROWN,CLARK,DAVIES,DEPAGTER,EVANS+   (RHEL)IJP
CUTKOSKY 79 PR D20 2839        +FORSYTH,HENDRICK,KELLY          (CARN+LBL)IJP
HOEHLER  79 HANDBOOK OF PI-N SCATTERING, PHYSIK DATEN VOL.12-1
                               +KAISER,KOCH,PIETARINEN               (KARL)IJP
    ALSO 80  TORONTO CONF 3    R KOCH                                (KARL)IJP

ARAI     80  TORONTO CONF 93   I ARAI                                (TOKY)
    ALSO 82 NP B194 251        I ARAI, H FUJII                       (TOKY)
CRAWFORD 80  TORONTO CONF 107  R L CRAWFORD                          (GLAS)
CUTKOSKY 80  TORONTO CONF 19   +FORSYTH,BABCOCK,KELLY,HENDRICK  (CARN+LBL)IJP
LIVANOS  80  TORONTO CONF 35   +BATON,COUTURES,KOCHOWSKI,NEVEU       (SACL)IJP
SAXON    80 NP B162 522        +BAKER,BELL,BLISSETT,BLOODWORTH+(RHEL+BRIS)IJP

AWAJI    81  BONN CONF 352     R KAJIKAWA (TALK)                     (NAGO)
    ALSO 82 NP B197 365        FUJII,HAYASHII,IWATA,KAJIKAWA+        (NAGO)
FUJII    81 NP B187 53         FUJII,HAYASHII,IWATA,KAJIKAWA+        (TOKY)
BELL     83 NP B222 389        +BLISSET,BROOME,DALEY,HART,LINTERN,+   (RL)IJP
CRAWFORD 83 NP B211 1          R L CRAWFORD, W T MORTON              (GLAS)

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N(1720) P''_{13} Status: ****

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                    15  N(1720, JP=3/2+) I=1/2   P''13

                    MOST OF THE RESULTS PUBLISHED BEFORE 1975 ARE NOW
                    OBSOLETE AND HAVE BEEN OMITTED.  THEY MAY BE FOUND IN
                    OUR 1982 EDITION (PHYSICS LETTERS 111B).  HOWEVER,
                    ALL THE REFERENCES HAVE BEEN RETAINED.

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                    15  N(1720) MASS (MEV)

M          (1850.0)                  KNASEL    75 DPWA  0 PI- P TO K0 LAM  11/75
M     A     1695. OR 1720.           LONGACRE  75 IPWA    PI N TO 2PI N    11/75
M     A  THE 2 SETS OF PARAMETERS ARE FROM METHODS 1 AND 2 OF LONGACRE 75.  11/75
M     B    (1640.0)   (10.0)         BAKER     77 IPWA  0 PI- P TO K LAM.   1/78
M     C    (1710.0)                  BAKER     77 DPWA  0 PI- P TO K LAM.   1/78
M     B  BAKER 77 IS BASED ON AN IPWA USING THE BARRELET ZERO METHOD.        1/78
M     D    (1750.0)                  LONGACRE  77 IPWA    PI N TO 2PI N    11/77
M     D  ALL LONGACRE77 PARAMETERS ARE FROM SOLUTION S2, EXCEPT FOR THE POLE 11/77
M     D  POSITION WHICH IS FROM SOLUTIONS S1 AND C1.                        11/77
M          1710. TO 1790.           BAKER     78 DPWA  0 PI- P TO K LAM    3/79
M          (1809.0)                 BARBOUR   78 DPWA    PI-N PHOTOPROD.    3/79
M          (1740.0)   (80.0)        CUTKOSKY  79 IPWA    PI N TO PI N     12/79
M           1710.0     20.0         HOEHLER   79 IPWA    PI N TO PI N     12/79
M          (1785.0)                 CRAWFORD  80 DPWA    PI N PHOTOPROD.  12/81
M           1700.0     50.0         CUTKOSKY  80 IPWA    PI N TO PI N      1/82
M          (1690.0)                 SAXON     80 DPWA  0 PI- P TO K LAM   12/79

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                    15  N(1720) WIDTH (MEV)

W          (327.0)                  KNASEL    75 DPWA  0 PI- P TO K0 LAM  11/75
W     A     115. OR  150.            LONGACRE  75 IPWA    PI N TO 2PI N    11/75
W     B    (200.0)   (50.0)          BAKER     77 IPWA  0 PI- P TO K LAM.   1/78
W     C    (500.0)                   BAKER     77 DPWA  0 PI- P TO K LAM.   1/78
W     D    (130.0)                   LONGACRE  77 IPWA    PI N TO 2PI N    11/77
W           300. TO  400.            BAKER     78 DPWA  0 PI- P TO K LAM    3/79
W          (285.0)                   BARBOUR   78 DPWA    PI-N PHOTOPROD.    3/79
W          (447.0)                   BAKER     79 DPWA  0 PI- P TO ETA N  12/79
W          (210.0)   (80.0)          CUTKOSKY  79 IPWA    PI N TO PI N     12/79
W           190.0     30.0           HOEHLER   79 IPWA    PI N TO PI N     12/79
W          (308.0)                   CRAWFORD  80 DPWA    PI N PHOTOPROD.  12/81
W           125.0     70.0           CUTKOSKY  80 IPWA    PI N TO PI N      1/82
W          (120.0)                   SAXON     80 DPWA  0 PI- P TO K LAM   12/79

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                    15  N(1720) REAL PART OF POLE POSITION (MEV)

RE         (1716.0)                  LONGACRE  75 IPWA    PI N TO 2PI N    11/75
RE    D     1745. OR 1748.0          LONGACRE  77 IPWA    PI N TO 2PI N    11/77
RE         (1702.0)                  CUTKOSKY  79 IPWA    PI N TO PI N     12/79
RE          1680.0     30.0          CUTKOSKY  80 IPWA    PI N TO PI N      1/82

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                    15  N(1720) -2*IMAG PART OF POLE POSITION (MEV)

IM         (124.0)                   LONGACRE  75 IPWA    PI N TO 2PI N    11/75
IM    D     135. OR 123.             LONGACRE  77 IPWA    PI N TO 2PI N    11/77
IM         (158.0)                   CUTKOSKY  79 IPWA    PI N TO PI N     12/79
IM          120.0     40.0           CUTKOSKY  80 IPWA    PI N TO PI N      1/82

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                    15  N(1720) REAL PART OF ELASTIC POLE RESIDUE (MEV)

RER         (-6.0)                   CUTKOSKY  79 IPWA    PI N TO PI N     12/79
RER          -8.0      2.0           CUTKOSKY  80 IPWA    PI N TO PI N      1/82

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                    15  N(1720) IMAG PART OF ELASTIC POLE RESIDUE (MEV)

IMR         (-8.0)                   CUTKOSKY  79 IPWA    PI N TO PI N     12/79
IMR          -3.0      4.0           CUTKOSKY  80 IPWA    PI N TO PI N      1/82

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                    15  N(1720) PARTIAL DECAY MODES

                                                          DECAY MASSES
P1     N(1720) INTO N PI                                  938+ 140
P2     N(1720) INTO LAMBDA K                             1116+ 498
P3     N(1720) INTO N ETA                                 940+ 549
P4     N(1720) INTO N PI PI                               938+ 140+ 140
P5     N(1720) INTO P GAMMA, HELICITY=3/2                 938+   0
P6     N(1720) INTO P GAMMA, HELICITY=1/2                 938+   0
P7     N(1720) INTO N GAMMA, HELICITY=3/2                 940+   0
P8     N(1720) INTO N GAMMA, HELICITY=1/2                 940+   0
P9     N(1720) INTO SIGMA K                              1189+ 494
P10    N(1720) INTO N RHO, S=1/2, P-WAVE                  938+ 769
P11    N(1720) INTO N RHO, S=3/2, P-WAVE                  938+ 769
P12    N(1720) INTO DELTA(1232) PI, P-WAVE               1232+ 140
P13    N(1720) INTO N EPSILON                             938+1300

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                    15  N(1720) BRANCHING RATIOS

R1     N(1720) INTO (N PI)/TOTAL                         (P1)
R1          (0.19)   (0.05)          CUTKOSKY  79 IPWA    PI N TO PI N     12/79
R1           0.14     0.03           HOEHLER   79 IPWA    PI N TO PI N     12/79
R1           0.10     0.04           CUTKOSKY  80 IPWA    PI N TO PI N      1/82

R2     N(1720) FROM N PI TO N ETA                        SQRT(P1*P3)
R2          (-0.08)                  BAKER     79 DPWA  0 PI- P TO ETA N  12/79

R3     N(1720) FROM N PI TO LAMBDA K                     SQRT(P1*P2)
R3     B    (-0.06)   (0.02)         BAKER     77 IPWA  0 PI- P TO K LAM.   1/78
R3     C    (-0.09)                  BAKER     77 DPWA  0 PI- P TO K LAM.   1/78
R3     E    (-0.09)                  BAKER     78 DPWA  0 PI- P TO K LAM    3/79
R3     E  THE (UNDETERMINED) OVERALL PHASE OF ALL COUPLINGS FROM HAS BEEN    3/79
R3     E  CHANGED TO AGREE WITH PREVIOUS CONVENTIONS. SUPERSEDED BY SAXON 80.  3/79
R3          (-0.11)                  SAXON     80 DPWA  0 PI- P TO K LAM   12/79
R3          (-0.09)                  BELL      83 DPWA 0  PI- P TO LAM K0   2/84*

R4     N(1720) FROM N PI TO SIGMA K                      SQRT(P1*P9)
R4     F          0.051 TO 0.087     DEANS     75 DPWA    PI N TO K SIGMA  11/75
R4     F   RANGE GIVEN IS FROM FOUR BEST SOLUTIONS.  DEANS 75 DISAGREES WITH  11/75
R4     F   PI+ P TO K+ SIGMA+ DATA OF WINNIK 77 AROUND 1920 MEV.              1/78

R5     N(1720) FROM N PI TO DELTA(1232)PI, P-WAVE        SQRT(P1*P12)
R5     D    (+0.17)                  LONGACRE  77 IPWA    PI N TO 2PI N    11/77

R6     N(1720) FROM N PI TO N RHO, S=1/2, P-WAVE         SQRT(P1*P10)
R6     A       -0.35 OR -0.40        LONGACRE  75 IPWA    PI N TO 2PI N    11/75
R6     D    (+0.26)                  LONGACRE  77 IPWA    PI N TO 2PI N    11/77

R7     N(1720) FROM N PI TO N RHO, S=3/2, P-WAVE         SQRT(P1*P11)
R7     D    (-0.15)                  LONGACRE  77 IPWA    PI N TO 2PI N    11/77

R8     N(1720) FROM N PI TO N EPSILON                    SQRT(P1*P13)
R8     D    (+0.19)                  LONGACRE  77 IPWA    PI N TO 2PI N    11/77

R9     N(1720) FROM P GAMMA TO P ETA                     SQRT((P5+P6)*P3)
R9          (0.0052)                 HICKS     73 MPWA    GAM P-ETA P       9/73

R10    N(1720) FROM P GAMMA TO LAMBDA K                  SQRT((P5+P6)*P2)
R10         (0.0082)                 DEANS     72 MPWA    GAM P-K LM,SOL D  9/73

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                    15  N(1720) PROTON DECAY AMPLITUDES (GEV**-1/2)

                  FOR DEFINITION OF GAMMA-NUCLEON DECAY AMPLITUDES, SEE MINI-
                REVIEW PRECEDING THE BARYON LISTINGS.

A1     N(1720) INTO P GAMMA, HELICITY=1/2 (GEV**-1/2)
A1           0.0      0.025          METCALF   74 DPWA    PI N PHOTOPROD.   2/74
A1          +0.122    0.018          AZNAURYAN 77 DPWA    PI0 PHTPRD,SOL 1 12/79
A1          +0.054    0.012          AZNAURYAN 77 DPWA    PI0 PHTPRD,SOL 2 12/79
A1          +0.111    0.047          BARBOUR   78 DPWA    PI-N PHOTOPROD.   3/79
A1           0.051    0.009          ARAI      80 DPWA    PI N PHOTO FIT 1 12/81
A1           0.071    0.010          ARAI      80 DPWA    PI N PHOTO FIT 2 12/81
A1           0.038    0.050          CRAWFORD  80 DPWA    PI N PHOTOPROD.  12/81
A1          -0.004    0.007          AWAJI     81 DPWA    PI N PHOTOPROD.   1/84*
A1           0.044    0.066          CRAWFORD  83 IPWA    PI N PHOTOPROD.   1/84*

A2     N(1720) INTO P GAMMA, HELICITY=3/2 (GEV**-1/2)
A2           0.0      0.022          METCALF   74 DPWA    PI N PHOTOPROD.   2/74
A2          +0.034    0.015          AZNAURYAN 77 DPWA    PI0 PHTPRD,SOL 1 12/79
A2          +0.000    0.016          AZNAURYAN 77 DPWA    PI0 PHTPRD,SOL 2 12/79
A2          -0.063    0.032          BARBOUR   78 DPWA    PI-N PHOTOPROD.   3/79
A2          -0.058    0.010          ARAI      80 DPWA    PI N PHOTO FIT 1 12/81
A2          -0.011    0.011          ARAI      80 DPWA    PI N PHOTO FIT 2 12/81
A2          -0.014    0.040          CRAWFORD  80 DPWA    PI N PHOTOPROD.  12/81
A2          -0.040    0.016          AWAJI     81 DPWA    PI N PHOTOPROD.   1/84*
A2          -0.024    0.006          CRAWFORD  83 IPWA    PI N PHOTOPROD.   1/84*

A3     N(1720) INTO N GAMMA, HELICITY=1/2 (GEV**-1/2)
A3           0.0      0.050          METCALF   74 DPWA    PI N PHOTOPROD.   2/74
A3          +0.007    0.020          BARBOUR   78 DPWA    PI-N PHOTOPROD.   3/79
A3          -0.019    0.033          ARAI      80 DPWA    PI N PHOTO FIT 1 12/81
A3           0.001    0.038          ARAI      80 DPWA    PI N PHOTO FIT 2 12/81
A3          -0.003    0.034          CRAWFORD  80 DPWA    PI N PHOTOPROD.  12/81
A3           0.002    0.005          AWAJI     81 DPWA    PI N PHOTOPROD.   1/84*

A4     N(1720) INTO N GAMMA, HELICITY=3/2 (GEV**-1/2)
A4           0.0      0.044          METCALF   74 DPWA    PI N PHOTOPROD.   2/74
A4          +0.051    0.051          BARBOUR   78 DPWA    PI-N PHOTOPROD.   3/79
A4          -0.139    0.039          ARAI      80 DPWA    PI N PHOTO FIT 1 12/81
A4          -0.134    0.044          ARAI      80 DPWA    PI N PHOTO FIT 2 12/81
A4           0.018    0.028          CRAWFORD  80 DPWA    PI N PHOTOPROD.  12/81
A4          -0.015    0.019          AWAJI     81 DPWA    PI N PHOTOPROD.   1/84*

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REFERENCES FOR N(1720)


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DONNACH1 68 PL 26B 161        A DONNACHIE, R G KIRSOPP, C LOVELACE (CERN)IJP
    ALSO 68 VIENNA 139        DONNACHIE  RAPPORTEUR.S TALK          (GLAS)
    ALSO 68 THESIS            R G KIRSOPP                           (EDIN)
RUSH     68 PR 173 1776       J E RUSH                              (ALAH)

BOTKE    69 PR 180 1417       J C BOTKE                             (UCSB)
DEANS    69 PR 185 1797       S DEANS, J WOOTEN                     (SFLA)
DEANS2   69 PR 177 2623       S R DEANS                             (SFLA)
DONNACHI 69 NP 10B 433        A DONNACHIE, R KIRSOPP          (GLAS+EDIN)
LEA      69 PL 29B 584        LEA,OADES,WARD,COWAN,+     (RHEL+BRIS+DARE)
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AYED 70 KIEV CONF R AYED,P BAREYRE, G VILLET (SACL)IJP
AYED2 70 PL 31B 598 +BAREYRE,VILLET (SACL)
CARRERAS 70 NP 16B 35 B CARRERAS, A DONNACHIE (DARE+MCHS)
DAVIES 70 NP B21 359 A DAVIES (GLAS)

APLIN 71 NP B32 253 +COWAN,GIBSON,GILMORE++ (RHEL+BRIS)
WAGNER 71 NP B25 411 F WAGNER, C LOVELACE (CERN)

ALMEHED 72 NP B40 157 +LOVELACE (LUND+RUTG)IJP
DEANS 72 PR D6 1906 DEANS,JACOBS, LYONS,MONTGOMERY (SFLA)IJP
DEVENISH 73 PL 47B 53 DEVENISH,RANKIN,LYTH (LOUC+BONN+LANC)IJP
HICKS 73 PR D7 2614 +DEANS,JACOBS,LYONS+ (CARN+ORNL+SFLA)IJP

DEVENISH 74 NP B81 330 DEVENISH,FROGGATT,MARTIN (DESY+NORD+LOUC)
DEVENIS2 74 PL 52B 227 DEVENISH,LYTH,RANKIN (DESY+LANC+BONN)IJP
KNIES 74 PR D9 2680 KNIES,MOORHOUSE,OBERLACK (LBL+GLAS)IJP
METCALF 74 NP B76 253 W J METCALF,R L WALKER (CIT)IJP

CRAWFORD 75 NP B97 125 R L CRAWFORD (GLAS)IJP
DEANS 75 NP B96 90 +MITCHELL,MONTGOMERY,+ (SFLA+ALAH)IJP
KNASEL 75 PR D11 1 +LINDQUIST,NELSON+ (CHIC+WUSL+OSU+ANL)IJP
LONGACRE 75 PL 55B 415 +ROSENFELD,LASINSKI,SMADJA+ (LBL+SLAC)IJP
ALSO 78 PR D17 1795 LONGACRE,LASINSKI,ROSENFELD+ (LBL+SLAC)

AYED 76 CEA-N-1921 AYED (THESIS) (SACL)IJP
BARBOUR 76 NP B111 358 I M BARBOUR,R L CRAWFORD (GLAS)IJP
MA 76 PR D13 3027 E MA,G L SHAW (OREG+UCI)IJP

AZNAURYA 77 EFI-264(57)-77 +AKOPOV,BAGDASARYAN (YERE)IJP
BAKER 77 NP B126 365 +BLISSET,BLOODWORTH,BROOME,HART+ (RHEL)IJP
LONGACRE 77 NP B122 493 LONGACRE,DOLBEAU (SACL)IJP
ALSO 76 NP B108 365 DOLBEAU,TRIANTIS,NEVEU,CADIET (SACL)IJP
WINNIK 77 NP B128 66 +TOAFF,REVEL,GOLDBERG,BERNY (HAIF)I

BAKER 78 NP B141 29 +BLISSET,BLOODWORTH,BROOME+ (RL+CAMB)IJP
BARBOUR 78 NP B141 253 BARBOUR,CRAWFORD,PARSONS (GLAS)

BAKER 79 NP B156 93 +BROWN,CLARK,DAVIES,DEPAGTER,EVANS+ (RHEL)IJP
CUTKOSKY 79 PR D20 2839 +FORSYTH,HENDRICK,KELLY (CARN+LBL)IJP
HOEHLER 79 HANDBOOK OF PI-N SCATTERING, PHYSIK DATEN VOL.12-1
+KAISER,KOCH,PIETARINEN (KARL)IJP
ALSO 80 TORONTO CONF 3 R KOCH (KARL)IJP

ARAI 80 TORONTO CONF 93 I ARAI (TOKY)
ALSO 82 NP B194 251 I ARAI, H FUJII (TOKY)
CRAWFORD 80 TORONTO CONF 107 R L CRAWFORD (GLAS)
CUTKOSKY 80 TORONTO CONF 19 +FORSYTH,BABCOCK,KELLY,HENDRICK (CARN+LBL)IJP
SAXON 80 NP B162 522 +BAKER,BELL,BLISSETT,BLOODWORTH+(RHEL+BRIS)IJP

AWAJI 81 BONN CONF 352 R KAJIKAWA (TALK) (NAGO)
ALSO 82 NP B197 365 FUJII,HAYASHII,IWATA,KAJIKAWA+ (NAGO)
BELL 83 NP B222 389 +BLISSET,BROOME,DALEY,HART,LINTERN,+ (RL)IJP
CRAWFORD 83 NP B211 1 R L CRAWFORD, W T MORTON (GLAS)

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N(1990) F_{17} Status: **

→ **17 N(1990, JP=7/2+) I=1/2 F17**

MOST OF THE RESULTS PUBLISHED BEFORE 1975 ARE NOW OBSOLETE AND HAVE BEEN OMITTED. THEY MAY BE FOUND IN OUR 1982 EDITION (PHYSICS LETTERS 111B). HOWEVER, ALL THE REFERENCES HAVE BEEN RETAINED.

THE VARIOUS ANALYSES DO NOT AGREE VERY WELL WITH ONE ANOTHER.

17 N(1990) MASS (MEV)

M	(1999.0)		BARBOUR	78	DPWA	PI-N PHOTOPROD.	3/79
M	(1970.0)	(80.0)	CUTKOSKY	79	IPWA	PI N TO PI N	12/79
M	2005.0	150.0	HOEHLER	79	IPWA	PI N TO PI N	12/79
M	(2018.0)		CRAWFORD	80	DPWA	PI N PHOTOPROD.	12/81
M	1970.0	50.0	CUTKOSKY	80	IPWA	PI N TO PI N	1/82

17 N(1990) WIDTH (MEV)

W	(216.0)		BARBOUR	78	DPWA	PI-N PHOTOPROD.	3/79
W	(325.0)	(150.0)	CUTKOSKY	79	IPWA	PI N TO PI N	12/79
W	350.0	100.0	HOEHLER	79	IPWA	PI N TO PI N	12/79
W	(295.0)		CRAWFORD	80	DPWA	PI N PHOTOPROD.	12/81
W	350.0	120.0	CUTKOSKY	80	IPWA	PI N TO PI N	1/82

17 N(1990) REAL PART OF POLE POSITION (MEV)

RE	(1899.0)		CUTKOSKY	79	IPWA	PI N TO PI N	12/79
RE	1900.0	30.0	CUTKOSKY	80	IPWA	PI N TO PI N	1/82

17 N(1990) -2*IMAG PART OF POLE POSITION (MEV)

IM	(208.0)		CUTKOSKY	79	IPWA	PI N TO PI N	12/79
IM	260.0	60.0	CUTKOSKY	80	IPWA	PI N TO PI N	1/82

17 N(1990) REAL PART OF ELASTIC POLE RESIDUE (MEV)

RER	(3.0)		CUTKOSKY	79	IPWA	PI N TO PI N	12/79
RER	5.0	4.0	CUTKOSKY	80	IPWA	PI N TO PI N	1/82

17 N(1990) IMAG PART OF ELASTIC POLE RESIDUE (MEV)

IMR	(-6.0)		CUTKOSKY	79	IPWA	PI N TO PI N	12/79
IMR	-8.0	4.0	CUTKOSKY	80	IPWA	PI N TO PI N	1/82

17 N(1990) PARTIAL DECAY MODES

		DECAY MASSES
P1	N(1990) INTO N PI	938+ 140
P2	N(1990) INTO N PI PI	938+ 140+ 140
P3	N(1990) INTO N ETA	940+ 549
P4	N(1990) INTO LAMBDA K	1116+ 498
P5	N(1990) INTO P GAMMA, HELICITY=3/2	938+ 0
P6	N(1990) INTO P GAMMA, HELICITY=1/2	938+ 0
P7	N(1990) INTO N GAMMA, HELICITY=3/2	940+ 0
P8	N(1990) INTO N GAMMA, HELICITY=1/2	940+ 0
P9	N(1990) INTO SIGMA K	1189+ 494

17 N(1990) BRANCHING RATIOS

R1		N(1990) INTO (N PI)/TOTAL					(P1)		
R1		(0.06)	(0.02)	CUTKOSKY	79	IPWA		PI N TO PI N	12/79
R1		0.04	0.02	HOEHLER	79	IPWA		PI N TO PI N	12/79
R1		0.06	0.02	CUTKOSKY	80	IPWA		PI N TO PI N	1/82
R2		N(1990) FROM N PI TO N ETA					SQRT(P1*P3)		
R2		(-0.043)		BAKER	79	DPWA	0	PI- P TO ETA N	12/79
R3		N(1990) FROM N PI TO LAMBDA K					SQRT(P1*P4)		
R3		-0.021	0.033	DEVENISH	74		0	FIXED T DISP REL	4/75
R3		NOT SEEN		SAXON	80	DPWA	0	PI- P TO K LAM	12/79
R3		(+0.01)		BELL	83	DPWA	0	PI- P TO LAM K0	2/84*
R4		N(1990) FROM N PI TO SIGMA K					SQRT(P1*P9)		
R4		(0.06)		LANGBEIN	73	IPWA		PI N-K SIG,SOL 1	9/73
R4	A	0.010 TO 0.023		DEANS	75	DPWA		PI N TO K SIGMA	11/75
R4	A	RANGE GIVEN IS FROM FOUR BEST SOLUTIONS.							11/75
R5		N(1990) FROM P GAMMA TO P ETA					SQRT((P5+P6)*P3)		
R5		(0.0045)		HICKS	73	MPWA		GAM P-ETA P	9/73
R6		N(1990) FROM P GAMMA TO LAMBDA K					SQRT((P5+P6)*P4)		
R6		(0.0034)		DEANS	72	MPWA		GAM P-K LM,SOL D	9/73

17 N(1990) PHOTON DECAY AMPLITUDES (GEV-1/2)**

FOR DEFINITION OF GAMMA-NUCLEON DECAY AMPLITUDES, SEE MINI-REVIEW PRECEDING THE BARYON LISTINGS.

A1	N(1990) INTO P GAMMA, HELICITY=1/2 (GEV**-1/2)						
A1	(0.040)		BARBOUR	78	DPWA	PI-N PHOTOPROD.	3/79
A1	0.001	0.040	CRAWFORD	80	DPWA	PI N PHOTOPROD.	12/81
A1	0.030	0.029	AWAJI	81	DPWA	PI N PHOTOPROD.	1/84*
A2	N(1990) INTO P GAMMA, HELICITY=3/2 (GEV**-1/2)						
A2	(+0.004)		BARBOUR	78	DPWA	PI-N PHOTOPROD.	3/79
A2	0.004	0.025	CRAWFORD	80	DPWA	PI N PHOTOPROD.	12/81
A2	0.086	0.060	AWAJI	81	DPWA	PI N PHOTOPROD.	1/84*
A3	N(1990) INTO N GAMMA, HELICITY=1/2 (GEV**-1/2)						
A3	(-0.069)		BARBOUR	78	DPWA	PI-N PHOTOPROD.	3/79
A3	-0.078	0.030	CRAWFORD	80	DPWA	PI N PHOTOPROD.	12/81
A3	(-0.001)		AWAJI	81	DPWA	PI N PHOTOPROD.	1/84*
A4	N(1990) INTO N GAMMA, HELICITY=3/2 (GEV**-1/2)						
A4	(-0.072)		BARBOUR	78	DPWA	PI-N PHOTOPROD.	3/79
A4	-0.116	0.045	CRAWFORD	80	DPWA	PI N PHOTOPROD.	12/81
A4	(-0.178)		AWAJI	81	DPWA	PI N PHOTOPROD.	1/84*

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REFERENCES FOR N(1990)

DONNACH1 68 PL 26B 161 A DONNACHIE, R G KIRSOPP, C LOVELACE (CERN)IJP
KIRSOPP 68 THESIS R G KIRSOPP (EDIN)
DEANS 69 PR 185 1797 S DEANS, J WOOTEN (SFLA)
DEANS2 69 PR 177 2623 S R DEANS (SFLA)
LEA 69 PL 29B 584 LEA,OADES,WARD,COWAN,+ (RHEL+BRIS+DARE)
AYED 70 PL 31B 598 +BAREYRE,VILLET (SACL)
APLIN 71 NP B32 253 +COWAN,GIBSON,GILMORE++ (RHEL+BRIS)
ALMEHED 72 NP B40 157 +LOVELACE (RUTG)IJP
DEANS 72 PR D6 1906 DEANS,JACOBS, LYONS,MONTGOMERY (SFLA)IJP
HICKS 73 PR D7 2614 +DEANS,JACOBS,LYONS+ (CARN+ORNL+SFLA)IJP
LANGBEIN 73 NP B53 251 LANGBEIN,WAGNER (MUNI)IJP
DEVENISH 74 NP B81 330 DEVENISH,FROGGATT,MARTIN (DESY+NORD+LOUC)
DEANS 75 NP B96 90 +MITCHELL,MONTGOMERY,+ (SFLA+ALAH)IJP

AYED 76 CEA-N-1921 AYED (THESIS) (SACL)IJP
BARBOUR 76 NP B111 358 I M BARBOUR,R L CRAWFORD (GLAS)IJP
MA 76 PR D13 3027 E MA,G L SHAW (OREG+UCI)IJP
WINNIK 77 NP B128 66 +TOAFF,REVEL,GOLDBERG,BERNY (HAIF)I
BARBOUR 78 NP B141 253 BARBOUR,CRAWFORD,PARSONS (GLAS)
BAKER 79 NP B156 93 +BROWN,CLARK,DAVIES,DEPAGTER,EVANS+ (RHEL)IJP
CUTKOSKY 79 PR D20 2839 +FORSYTH,HENDRICK,KELLY (CARN+LBL)IJP
HOEHLER 79 HANDBOOK OF PI-N SCATTERING, PHYSIK DATEN VOL.12-1
+KAISER,KOCH,PIETARINEN (KARL)IJP
ALSO 80 TORONTO CONF 3 R KOCH (KARL)IJP

CRAWFORD 80 TORONTO CONF 107 R L CRAWFORD (GLAS)
CUTKOSKY 80 TORONTO CONF 19 +FORSYTH,BABCOCK,KELLY,HENDRICK (CARN+LBL)IJP
SAXON 80 NP B162 522 +BAKER,BELL,BLISSETT,BLOODWORTH+(RHEL+BRIS)IJP
AWAJI 81 BONN CONF 352 R KAJIKAWA (TALK) (NAGO)
ALSO 82 NP B197 365 FUJII,HAYASHII,IWATA,KAJIKAWA+ (NAGO)
BELL 83 NP B222 389 +BLISSET,BROOME,DALEY,HART,LINTERN,+ (RL)IJP
CRAWFORD 83 NP B211 1 R L CRAWFORD, W T MORTON (GLAS)

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N(2000) F''_{15} Status: **

→ **06 N(2000, JP=5/2+) I=1/2 F''15**

OLDER RESULTS HAVE BEEN RETAINED SIMPLY BECAUSE THERE IS LITTLE INFORMATION AT ALL ABOUT THIS STATE.

06 N(2000) MASS (MEV)

M		(2175.0)		ALMEHED	72	IPWA		2/72
M		(1930.0)		DEANS	72	MPWA	GAM P-K LM,SOL D	9/73
M	A	(1970.0)		LANGBEIN	73	IPWA	PI N-K SIG,SOL 2	9/73
M	A	NOT SEEN IN SOLUTION 1 OF LANGBEIN 73.						9/73
M		(2025.0)		AYED	76	IPWA		11/77
M		1882.0	10.0	HOEHLER	79	IPWA	PI N TO PI N	12/79

Baryons

N(2000), N(2080)

Data Card Listings

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                    06  N(2000) WIDTH (MEV)

W          (150.0)                    ALMEHED   72 IPWA                          2/72
W          (112.0)                    DEANS     72 MPWA    GAM P-K LM,SOL D      9/73
W    A     (170.0)                    LANGBEIN  73 IPWA    PI N-K SIG,SOL 2      9/73
W          (157.0)                    AYED      76 IPWA                         11/77
W            95.0      20.0           HOEHLER   79 IPWA    PI N TO PI N         12/79

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                    06  N(2000) PARTIAL DECAY MODES

                                                          DECAY MASSES
P1      N(2000) INTO N PI                                938+ 140
P2      N(2000) INTO LAMBDA K                           1116+ 498
P3      N(2000) INTO P GAMMA, HELICITY=3/2               938+   0
P4      N(2000) INTO P GAMMA, HELICITY=1/2               938+   0
P5      N(2000) INTO N GAMMA, HELICITY=3/2               940+   0
P6      N(2000) INTO N GAMMA, HELICITY=1/2               940+   0
P7      N(2000) INTO SIGMA K                            1189+ 494
P8      N(2000) INTO N ETA                               940+ 549

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                    06  N(2000) BRANCHING RATIOS

R1      N(2000) INTO (N PI)/TOTAL                        (P1)
R1          (0.25)                     ALMEHED   72 IPWA                          2/72
R1          (0.08)                     AYED      76 IPWA                         11/77
R1           0.04      0.02            HOEHLER   79 IPWA    PI N TO PI N         12/79

R2      N(2000) FROM N PI TO N ETA                       SQRT(P1*P8)
R2          (+0.03)                    BAKER     79 DPWA  0 PI- P TO ETA N       12/79

R3      N(2000) FROM N PI TO LAMBDA K                    SQRT(P1*P2)
R3          NOT SEEN                   SAXON     80 DPWA  0 PI- P TO K LAM       12/79

R4      N(2000) FROM N PI TO SIGMA K                     SQRT(P1*P7)
R4   A      (0.05)                     LANGBEIN  73 IPWA    PI N-K SIG,SOL 2      9/73
R4   B      (0.022)                    DEANS     75 DPWA    PI N TO K SIGMA      11/75
R4   B   VALUE GIVEN IS FROM SOLUTION 1, NOT PRESENT IN SOLUTIONS 2,3,4.         11/75

R5      N(2000) FROM P GAMMA TO LAMBDA K                 SQRT((P3+P4)*P2)
R5          (0.0022)                   DEANS     72 MPWA    GAM P-K LM,SOL D      9/73

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                    REFERENCES FOR N(2000)

ALMEHED  72 NP B40 157        +LOVELACE                                (RUTG)IJP
DEANS    72 PR D6 1906        DEANS,JACOBS, LYONS,MONTGOMERY           (SFLA)IJP
LANGBEIN 73 NP B53 251        LANGBEIN,WAGNER                          (MUNI)IJP
DEANS    75 NP B96 90         +MITCHELL,MONTGOMERY,+                (SFLA+ALAH)IJP
AYED     76 CEA-N-1921        AYED (THESIS)                            (SACL)IJP
MA       76 PR D13 3027       E MA,G L SHAW                         (OREG+UCI)IJP

BAKER    79 NP B156 93        +BROWN,CLARK,DAVIES,DEPAGTER,EVANS+      (RHEL)IJP
HOEHLER  79 HANDBOOK OF PI-N SCATTERING, PHYSIK DATEN VOL.12-1
                              +KAISER,KOCH,PIETARINEN                  (KARL)IJP
    ALSO 80  TORONTO CONF 3   R KOCH                                   (KARL)IJP
SAXON    80 NP B162 522       +BAKER,BELL,BLISSETT,BLOODWORTH+(RHEL+BRIS)IJP

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N(2080) D'''_{13} Status: **

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                    16  N(2080, JP=3/2-) I=1/2   D'''13

                THERE IS SOME EVIDENCE THAT TWO RESONANCES EXIST IN
                THIS WAVE BETWEEN 1800 AND 2200 MEV (SEE CUTKOSKY 80).
                THE SOLUTION OF HOEHLER 79 IS QUITE DIFFERENT.

    MOST OF THE RESULTS PUBLISHED BEFORE 1975 ARE NOW OBSOLETE AND HAVE
    BEEN OMITTED.  THEY MAY BE FOUND IN OUR 1982 EDITION (PHYSICS LETTERS
    1118).  HOWEVER, ALL THE REFERENCES HAVE BEEN RETAINED.

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                    16  N(2080) MASS (MEV)

M    A    (1830.0)   (50.0)           CUTKOSKY  79 IPWA    PI N TO PI N         12/79
M    B    (2100.0)   (80.0)           CUTKOSKY  79 IPWA    PI N TO PI N         12/79
M   AB  CUTKOSKY 79 FIND A LOWER MASS D13 RESONANCE, AS WELL AS ONE IN THIS 12/79
M   AB  MASS REGION. BOTH ARE LISTED HERE, AND LABELED A AND B.               12/79
M         2081.0     20.0            HOEHLER   79 IPWA    PI N TO PI N         12/79
M    C    1880.0    100.0            CUTKOSKY  80 IPWA    PI N TO PI N          1/82
M    D    2060.0     80.0            CUTKOSKY  80 IPWA    PI N TO PI N          1/82
M   CD  CUTKOSKY 80 AGAIN FINDS A LOWER MASS D13 RESONANCE, AS WELL AS ONE       1/82
M   CD  IN THIS MASS REGION.  BOTH ARE LISTED HERE, LABELED C AND D.            1/82
M        (1900.0)                    SAXON     80 DPWA  0 PI- P TO K LAM        12/79
M        (1920.0)                    BELL      83 DPWA 0  PI- P TO LAM K0        2/84*

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                    16  N(2080) WIDTH (MEV)

W    A    (125.0)   (50.0)            CUTKOSKY  79 IPWA    PI N TO PI N         12/79
W    B    (300.0)  (100.0)            CUTKOSKY  79 IPWA    PI N TO PI N         12/79
W         265.0     40.0             HOEHLER   79 IPWA    PI N TO PI N         12/79
W    C    180.0     60.0             CUTKOSKY  80 IPWA    PI N TO PI N          1/82
W    D    300.0    100.0             CUTKOSKY  80 IPWA    PI N TO PI N          1/82
W        (240.0)                     SAXON     80 DPWA  0 PI- P TO K LAM        12/79
W        (320.0)                     BELL      83 DPWA 0  PI- P TO LAM K0        2/84*

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                    16  N(2080) REAL PART OF POLE POSITION  (MEV)

RE   A   (1818.0)                     CUTKOSKY  79 IPWA    PI N TO PI N         12/79
RE   B   (2053.0)                     CUTKOSKY  79 IPWA    PI N TO PI N         12/79
RE   C    1880.0    100.0             CUTKOSKY  80 IPWA    PI N TO PI N          1/82
RE   D    2050.0     70.0             CUTKOSKY  80 IPWA    PI N TO PI N          1/82

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                    16  N(2080) -2*IMAG PART OF POLE POSITION  (MEV)

IM   A   (122.0)                      CUTKOSKY  79 IPWA    PI N TO PI N         12/79
IM   B   (308.0)                      CUTKOSKY  79 IPWA    PI N TO PI N         12/79
IM   C    160.0     80.0              CUTKOSKY  80 IPWA    PI N TO PI N          1/82
IM   D    200.0     80.0              CUTKOSKY  80 IPWA    PI N TO PI N          1/82

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                    16  N(2080) REAL PART OF ELASTIC POLE RESIDUE (MEV)

RER  A     (3.0)                      CUTKOSKY  79 IPWA    PI N TO PI N         12/79
RER  B    (24.0)                      CUTKOSKY  79 IPWA    PI N TO PI N         12/79
RER  C     -2.0      14.0             CUTKOSKY  80 IPWA    PI N TO PI N          1/82
RER  D     30.0      20.0             CUTKOSKY  80 IPWA    PI N TO PI N          1/82

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                    16  N(2080) IMAG PART OF ELASTIC POLE RESIDUE (MEV)

IMR  A    (-3.0)                      CUTKOSKY  79 IPWA    PI N TO PI N         12/79
IMR  B   (-10.0)                      CUTKOSKY  79 IPWA    PI N TO PI N         12/79
IMR  C     10.0       5.0             CUTKOSKY  80 IPWA    PI N TO PI N          1/82
IMR  D      0.0      52.0             CUTKOSKY  80 IPWA    PI N TO PI N          1/82

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                    16  N(2080) PARTIAL DECAY MODES

                                                          DECAY MASSES
P1      N(2080) INTO N PI                                938+ 140
P2      N(2080) INTO N PI PI                             938+ 140+ 140
P3      N(2080) INTO N ETA                               940+ 549
P4      N(2080) INTO LAMBDA K                           1116+ 498
P5      N(2080) INTO P GAMMA, HELICITY=3/2               938+   0
P6      N(2080) INTO P GAMMA, HELICITY=1/2               938+   0
P7      N(2080) INTO N GAMMA, HELICITY=3/2               940+   0
P8      N(2080) INTO N GAMMA, HELICITY=1/2               940+   0
P9      N(2080) INTO SIGMA K                            1189+ 494

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                    16  N(2080) BRANCHING RATIOS

R1      N(2080) INTO (N PI)/TOTAL                        (P1)
R1   A      (0.06)    (0.03)          CUTKOSKY  79 IPWA    PI N TO PI N         12/79
R1   B      (0.13)    (0.05)          CUTKOSKY  79 IPWA    PI N TO PI N         12/79
R1           0.06      0.02           HOEHLER   79 IPWA    PI N TO PI N         12/79
R1   C       0.10      0.04           CUTKOSKY  80 IPWA    PI N TO PI N          1/82
R1   D       0.14      0.07           CUTKOSKY  80 IPWA    PI N TO PI N          1/82

R2      N(2080) FROM N PI TO N ETA                       SQRT(P1*P3)
R2          NOT SEEN                   BAKER     79 DPWA  0 PI- P TO ETA N       12/79

R3      N(2080) FROM N PI TO LAMBDA K                    SQRT(P1*P4)
R3          (+0.03)                    SAXON     80 DPWA  0 PI- P TO K LAM       12/79
R3          (+0.04)                    BELL      83 DPWA 0  PI- P TO LAM K0       2/84*

R4      N(2080) FROM N PI TO SIGMA K                     SQRT(P1*P9)
R4   E          0.014 TO 0.037         DEANS     75 DPWA    PI N TO K SIGMA      11/75
R4   E   RANGE GIVEN IS FROM FOUR BEST SOLUTIONS.  DISAGREES WITH PI+ P TO      11/75
R4   E   K+ SIGMA+ DATA OF WINNIK 77 AROUND 1920 MEV.                            1/78

R5      N(2080) FROM P GAMMA TO P ETA                    SQRT((P5+P6)*P3)
R5          (0.0037)                   HICKS     73 MPWA    GAM P-ETA P           9/73

R6      N(2080) FROM P GAMMA TO LAMBDA K                 SQRT((P5+P6)*P4)
R6          (0.0070)                   DEANS     72 MPWA    GAM P-K LM,SOL D      9/73

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                    16  N(2080) PHOTON DECAY AMPLITUDES (GEV**-1/2)

       FOR DEFINITION OF GAMMA-NUCLEON DECAY AMPLITUDES, SEE MINI-
     REVIEW PRECEDING THE BARYON LISTINGS.

A1      N(2080) INTO P GAMMA, HELICITY=1/2 (GEV**-1/2)
A1           0.026     0.052          DEVENIS2  74 DPWA    PI N PHOTOPROD.       4/75
A1          -0.020     0.008          AWAJI     81 DPWA    PI N PHOTOPROD.       1/84*

A2      N(2080) INTO P GAMMA, HELICITY=3/2 (GEV**-1/2)
A2           0.128     0.057          DEVENIS2  74 DPWA    PI N PHOTOPROD.       4/75
A2           0.017     0.011          AWAJI     81 DPWA    PI N PHOTOPROD.       1/84*

A3      N(2080) INTO N GAMMA, HELICITY=1/2 (GEV**-1/2)
A3           0.053     0.083          DEVENIS2  74 DPWA    PI N PHOTOPROD.       4/75
A3           0.007     0.013          AWAJI     81 DPWA    PI N PHOTOPROD.       1/84*

A4      N(2080) INTO N GAMMA, HELICITY=3/2 (GEV**-1/2)
A4           0.100     0.141          DEVENIS2  74 DPWA    PI N PHOTOPROD.       4/75
A4          -0.053     0.034          AWAJI     81 DPWA    PI N PHOTOPROD.       1/84*

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                    REFERENCES FOR N(2080)

DONNACH1 68 PL 26B 161        A DONNACHIE, R G KIRSOPP, C LOVELACE (CERN)IJP
DONNACH2 68 VIENNA 139        DONNACHIE  RAPPORTEUR.S TALK            (GLAS)
KIRSOPP  68 THESIS            R G KIRSOPP                             (EDIN)
LEA      69 PL 29B 584        LEA,OADES,WARD,COWAN,+       (RHEL+BRIS+DARE)
DONNACHI 69 NP 10B 433        A DONNACHIE, R KIRSOPP            (GLAS+EDIN)
AYED     70 PL 31B 598        +BAREYRE,VILLET                         (SACL)
CARRERAS 70 NP 16B 35         B CARRERAS, A DONNACHIE           (DARE+MCHS)
APLIN    71 NP  B32 253       +COWAN,GIBSON,GILMORE++           (RHEL+BRIS)
ALMEHED  72 NP B40 157        +LOVELACE                        (LUND+RUTG)IJP
DEANS    72 PR D6 1906        DEANS,JACOBS, LYONS,MONTGOMERY          (SFLA)IJP
HICKS    73 PR D7 2614        +DEANS,JACOBS,LYONS+         (CARN+ORNL+SFLA)IJP
DEVENIS2 74 PL 52B 227        DEVENISH,LYTH,RANKIN         (DESY+LANC+BONN)IJP
DEANS    75 NP B96 90         +MITCHELL,MONTGOMERY,+            (SFLA+ALAH)IJP
AYED     76 CEA-N-1921        AYED (THESIS)                           (SACL)IJP
MA       76 PR D13 3027       E MA,G L SHAW                        (OREG+UCI)IJP
WINNIK   77 NP B128 66        +TOAFF,REVEL,GOLDBERG,BERNY             (HAIF)I
BAKER    79 NP B156 93        +BROWN,CLARK,DAVIES,DEPAGTER,EVANS+      (RHEL)IJP
CUTKOSKY 79 PR D20 2839       +FORSYTH,HENDRICK,KELLY          (CARN+LBL)IJP
HOEHLER  79 HANDBOOK OF PI-N SCATTERING, PHYSIK DATEN VOL.12-1
                              +KAISER,KOCH,PIETARINEN                  (KARL)IJP
    ALSO 80  TORONTO CONF 3   R KOCH                                   (KARL)IJP

CUTKOSKY 80  TORONTO CONF 19  +FORSYTH,BABCOCK,KELLY,HENDRICK  (CARN+LBL)IJP
SAXON    80 NP B162 522       +BAKER,BELL,BLISSETT,BLOODWORTH+(RHEL+BRIS)IJP
AWAJI    81  BONN CONF 352    R KAJIKAWA (TALK)                       (NAGO)
    ALSO 82 NP B197 365       FUJII,HAYASHII,IWATA,KAJIKAWA+          (NAGO)
BELL     83 NP B222 389       +BLISSET,BROOME,DALEY,HART,LINTERN,+      (RL)IJP

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For notation, see key at front of Listings.

Baryons

N(2090), N(2100), N(2190)

N(2090) S_{11}''' Status: *

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04  N(2090, JP=1/2-) I=1/2   S'''11

ANY STRUCTURE IN THIS WAVE ABOVE 1800 MEV IS LISTED
HERE.  A FEW EARLY RESULTS THAT ARE NOW OBSOLETE HAVE
BEEN OMITTED.

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04  N(2090) MASS (MEV)

M        1880.0     20.0          HOEHLER   79 IPWA    PI N TO PI N     12/79
M        2180.0     80.0          CUTKOSKY  80 IPWA    PI N TO PI N      1/82

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04  N(2090) WIDTH (MEV)

W          95.0     30.0          HOEHLER   79 IPWA    PI N TO PI N     12/79
W         350.0    100.0          CUTKOSKY  80 IPWA    PI N TO PI N      1/82

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04  N(2090) REAL PART OF POLE POSITION  (MEV)

RE       2150.0     70.0          CUTKOSKY  80 IPWA    PI N TO PI N      1/82

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04  N(2090) -2*IMAG PART OF POLE POSITION  (MEV)

IM        350.0    100.0          CUTKOSKY  80 IPWA    PI N TO PI N      1/82

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04  N(2090) REAL PART OF ELASTIC POLE RESIDUE (MEV)

RER        40.0     20.0          CUTKOSKY  80 IPWA    PI N TO PI N      1/82

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04  N(2090) IMAG PART OF ELASTIC POLE RESIDUE (MEV)

IMR         0.0     60.0          CUTKOSKY  80 IPWA    PI N TO PI N      1/82

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04  N(2090) PARTIAL DECAY MODES

                                                      DECAY MASSES
P1     N(2090) INTO N PI                             938+ 140
P2     N(2090) INTO LAMBDA K                        1116+ 498

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04  N(2090) BRANCHING RATIOS

R1     N(2090) INTO (N PI)/TOTAL                          (P1)
R1          0.09      0.05         HOEHLER   79 IPWA    PI N TO PI N     12/79
R1          0.18      0.08         CUTKOSKY  80 IPWA    PI N TO PI N      1/82

R2     N(2090) FROM N PI TO LAMBDA K                   SQRT(P1*P2)
R2        NOT SEEN                 SAXON     80 DPWA  0 PI- P TO K LAM   12/79

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                    REFERENCES FOR N(2090)

ROYCHOUD 71 NP B27 125        R K ROYCHOUDHURY,B H BRANSDEN        (DURH)IJP
ALMEHED  72 NP B40 157        +LOVELACE                        (LUND+RUTG)IJP
AYED     76 CEA-N-1921        AYED (THESIS)                        (SACL)IJP
MA       76 PR D13 3027       E MA,G L SHAW                    (OREG+UCI)IJP
HOEHLER  79 HANDBOOK OF PI-N SCATTERING, PHYSIK DATEN VOL.12-1
                              +KAISER,KOCH,PIETARINEN              (KARL)IJP
    ALSO 80  TORONTO CONF 3   R KOCH                               (KARL)IJP
CUTKOSKY 80  TORONTO CONF 19  +FORSYTH,BABCOCK,KELLY,HENDRICK  (CARN+LBL)IJP
SAXON    80 NP B162 522       +BAKER,BELL,BLISSETT,BLOODWORTH+(RHEL+BRIS)IJP

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N(2100) P_{11}''' Status: *

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132  N(2100, JP=1/2+) I=1/2   P'''11

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132  N(2100) MASS (MEV)

M        2050.0     20.0          HOEHLER   79 IPWA    PI N TO PI N      1/82
M        2125.0     75.0          CUTKOSKY  80 IPWA    PI N TO PI N      1/82

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132  N(2100) WIDTH (MEV)

W         200.0     30.0          HOEHLER   79 IPWA    PI N TO PI N      1/82
W         260.0    100.0          CUTKOSKY  80 IPWA    PI N TO PI N      1/82

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132  N(2100) REAL PART OF POLE POSITION  (MEV)

RE       2120.0     40.0          CUTKOSKY  80 IPWA    PI N TO PI N      1/82

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132  N(2100) -2*IMAG PART OF POLE POSITION  (MEV)

IM        240.0     80.0          CUTKOSKY  80 IPWA    PI N TO PI N      1/82

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132  N(2100) REAL PART OF ELASTIC POLE RESIDUE (MEV)

RER        11.0      7.0          CUTKOSKY  80 IPWA    PI N TO PI N      1/82

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132  N(2100) IMAG PART OF ELASTIC POLE RESIDUE (MEV)

IMR         8.0      6.0          CUTKOSKY  80 IPWA    PI N TO PI N      1/82

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132  N(2100) PARTIAL DECAY MODES

                                                      DECAY MASSES
P1     N(2100) INTO N PI                             938+ 140

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132  N(2100) BRANCHING RATIOS

R1     N(2100) INTO (N PI)/TOTAL                          (P1)
R1          0.10      0.04         HOEHLER   79 IPWA    PI N TO PI N      1/82
R1          0.12      0.03         CUTKOSKY  80 IPWA    PI N TO PI N      1/82

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                    REFERENCES FOR N(2100)

HOEHLER  79 HANDBOOK OF PI-N SCATTERING, PHYSIK DATEN VOL.12-1
                              +KAISER,KOCH,PIETARINEN              (KARL)IJP
KOCH     80  TORONTO CONF 3   R KOCH                               (KARL)IJP
CUTKOSKY 80  TORONTO CONF 19  +FORSYTH,BABCOCK,KELLY,HENDRICK  (CARN+LBL)IJP

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N(2190) G_{17} Status: ****

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71  N(2190, JP=7/2-) I=1/2   G17

MOST OF THE RESULTS PUBLISHED BEFORE 1975 ARE NOW
OBSOLETE AND HAVE BEEN OMITTED.  THEY MAY BE FOUND IN
OUR 1982 EDITION (PHYSICS LETTERS 111B).  HOWEVER,
ALL THE REFERENCES HAVE BEEN RETAINED.

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71  N(2190) MASS (MEV)

M       (2117.0)                   BARBOUR   78 DPWA    PI-N PHOTOPROD.   3/79
M        2140.0     40.0          HENDRY    78 MPWA    PI N TO PI N     12/79
M       (2140.0)                   BAKER     79 DPWA  0 PI- P TO ETA N   12/79
M       (2150.0)  (100.0)          CUTKOSKY  79 IPWA    PI N TO PI N     12/79
M        2140.0     12.0          HOEHLER   79 IPWA    PI N TO PI N     12/79
M       (2098.0)                   CRAWFORD  80 DPWA    PI N PHOTOPROD.  12/81
M        2200.0     70.0          CUTKOSKY  80 IPWA    PI N TO PI N      1/82
M       (2180.0)                   SAXON     80 DPWA  0 PI- P TO K LAM   12/79

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71  N(2190) WIDTH (MEV)

W        (220.0)                   BARBOUR   78 DPWA    PI-N PHOTOPROD.   3/79
W         270.0     50.0          HENDRY    78 MPWA    PI N TO PI N     12/79
W        (319.0)                   BAKER     79 DPWA  0 PI- P TO ETA N   12/79
W        (300.0)  (100.0)          CUTKOSKY  79 IPWA    PI N TO PI N     12/79
W         390.0     30.0          HOEHLER   79 IPWA    PI N TO PI N     12/79
W        (238.0)                   CRAWFORD  80 DPWA    PI N PHOTOPROD.  12/81
W         500.0    150.0          CUTKOSKY  80 IPWA    PI N TO PI N      1/82
W         (80.0)                   SAXON     80 DPWA  0 PI- P TO K LAM   12/79

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71  N(2190) REAL PART OF POLE POSITION  (MEV)

RE      (2111.0)                   CUTKOSKY  79 IPWA    PI N TO PI N     12/79
RE       2100.0     50.0          CUTKOSKY  80 IPWA    PI N TO PI N      1/82

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71  N(2190) -2*IMAG PART OF POLE POSITION  (MEV)

IM       (308.0)                   CUTKOSKY  79 IPWA    PI N TO PI N     12/79
IM        400.0    160.0          CUTKOSKY  80 IPWA    PI N TO PI N      1/82

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71  N(2190) REAL PART OF ELASTIC POLE RESIDUE (MEV)

RER       (24.0)                   CUTKOSKY  79 IPWA    PI N TO PI N     12/79
RER        22.0     14.0          CUTKOSKY  80 IPWA    PI N TO PI N      1/82

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71  N(2190) IMAG PART OF ELASTIC POLE RESIDUE (MEV)

IMR      (-12.0)                   CUTKOSKY  79 IPWA    PI N TO PI N     12/79
IMR       -13.0     20.0          CUTKOSKY  80 IPWA    PI N TO PI N      1/82

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71  N(2190) PARTIAL DECAY MODES

                                                      DECAY MASSES
P1     N(2190) INTO N PI                             938+ 140
P2     N(2190) INTO LAMBDA K                        1116+ 494
P3     N(2190) INTO N PI PI                          938+ 140+ 140
P4     N(2190) INTO P GAMMA, HELICITY=3/2            938+   0
P5     N(2190) INTO P GAMMA, HELICITY=1/2            938+   0
P6     N(2190) INTO N GAMMA, HELICITY=3/2            940+   0
P7     N(2190) INTO N GAMMA, HELICITY=1/2            940+   0
P8     N(2190) INTO N ETA                            940+ 549
P9     N(2190) INTO SIGMA K                         1189+ 494

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71  N(2190) BRANCHING RATIOS

R1     N(2190) INTO (N PI)/TOTAL                          (P1)
R1          0.16      0.04         HENDRY    78 MPWA    PI N TO PI N     12/79
R1         (0.16)    (0.07)        CUTKOSKY  79 IPWA    PI N TO PI N     12/79
R1          0.14      0.02         HOEHLER   79 IPWA    PI N TO PI N     12/79
R1          0.12      0.06         CUTKOSKY  80 IPWA    PI N TO PI N      1/82

R2     N(2190) FROM N PI TO N ETA                      SQRT(P1*P8)
R2        (+0.052)                  BAKER     79 DPWA  0 PI- P TO ETA N   12/79
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Baryons
Data Card Listings

N(2190), N(2200), N(2220)

R3	N(2190) FROM N PI TO LAMBDA K				SQRT(P1*P2)		
R3		(-0.02)	SAXON	80 DPWA	0 PI- P TO K LAM	12/79	
R3		(-0.02)	BELL	83 DPWA	0 PI- P TO LAM K0	2/84*	
R4	N(2190) FROM N PI TO SIGMA K				SQRT(P1*P9)		
R4	A	0.014 TO 0.019	DEANS	75 DPWA	PI N TO K SIGMA	11/75	
R4	A	RANGE GIVEN IS FROM FOUR BEST SOLUTIONS. DISAGREES WITH PI+ P TO				11/75	
R4	A	K+ SIGMA+ DATA OF WINNIK 77 AROUND 1920 MEV.				1/78	
R5	N(2190) FROM P GAMMA TO P ETA				SQRT((P4+P5)*P8)		
R5		(0.0094)	HICKS	73 MPWA	GAM P-ETA P	9/73	
R6	N(2190) FROM P GAMMA TO LAMBDA K				SQRT((P4+P5)*P2)		
R6		(0.0161)	DEANS	72 MPWA	GAM P-K LM,SOL D	9/73	

71 N(2190) PHOTON DECAY AMPLITUDES (GEV**-1/2)

FOR DEFINITION OF GAMMA-NUCLEON DECAY AMPLITUDES, SEE MINI-REVIEW PRECEDING THE BARYON LISTINGS.

A1	N(2190) INTO P GAMMA, HELICITY=1/2 (GEV**-1/2)				
A1	(-0.030)	BARBOUR	78 DPWA	PI-N PHOTOPROD.	3/79
A1	(-0.055)	CRAWFORD	80 DPWA	PI N PHOTOPROD.	12/81
A2	N(2190) INTO P GAMMA, HELICITY=3/2 (GEV**-1/2)				
A2	(+0.180)	BARBOUR	78 DPWA	PI-N PHOTOPROD.	3/79
A2	(0.081)	CRAWFORD	80 DPWA	PI N PHOTOPROD.	12/81
A3	N(2190) INTO N GAMMA, HELICITY=1/2 (GEV**-1/2)				
A3	(-0.085)	BARBOUR	78 DPWA	PI-N PHOTOPROD.	3/79
A3	(-0.042)	CRAWFORD	80 DPWA	PI N PHOTOPROD.	12/81
A4	N(2190) INTO N GAMMA, HELICITY=3/2 (GEV**-1/2)				
A4	(+0.007)	BARBOUR	78 DPWA	PI-N PHOTOPROD.	3/79
A4	(-0.126)	CRAWFORD	80 DPWA	PI N PHOTOPROD.	12/81

REFERENCES FOR N(2190)

DIDDENS 63 PRL 10 262 +JENKINS, KYCIA, RILEY (BNL) I
HOEHLER 64 PL 12 149 G HOEHLER, J GIESECKE (KARL) I
BARGER 66 PRL 16 913 V BARGER, D CLINE (WISC) P
CARROLL 66 PRL 16 288 +CORBETT,DAMERELL,MIDDLEMAS, + (RHEL+OXF)J-L
CARROLL 66 PRL 17 1274 +CORBETT,DAMERELL,MIDDLEMAS, + (RHEL+OXF)J-L
ERRATUM CHANGING THE RATHER WEAK DETERMINATION OF J-L TO +1 (2.)
KORMANYO 66 PRL 16 709 KORMANYOS,KRISCH,OFALLON, + (MICH+ANL) P
YOKOSAWA 66 PRL 16 714 +SUWA,HILL,ESTERLING, BOOTH (ANL+CHIC) JP
BUSZA 67 NC 52A 331 +DAVIS,DUFF,HEYMANN, + (LOUC+LOWC)

DONNACH1 68 PL 26B 161 A DONNACHIE, R G KIRSOPP, C LOVELACE (CERN)IJP
ALSO 68 VIENNA 139 DONNACHIE RAPPORTEUR.S TALK (GLAS)
ALSO 68 THESIS R G KIRSOPP (EDIN)
LEA 69 PL 29B 584 LEA,OADES,WARD,COWAN,+ (RHEL+BRIS+DARE)
ANDERSON 70 PRL 25 699 +BLESER,BLIEDEN,COLLINS,+ (BNL+CARN)
AYED 70 KIEV CONF R AYED,P BAREYRE, G VILLET (SACL)IJP
AYED2 70 PL 31B 598 +BAREYRE,VILLET (SACL)
HULL 70 PR D2 1783 J HULL, R LEACOCK (ISU)

AMALDI 71 PL 34B 435 +BIANCASTELLI,BOSIO,+ (SANI+CERN)
BRANSDEN 71 NP B26 511 +OGDEN (DURH)IJP
ALSO 70 NP B16 461 ROYCHOUDHURY,PERRIN,BRANSDEN (DURH)IJP
ROYCHOUD 71 NP B27 125 R K ROYCHOUDHURY,B H BRANSDEN (DURH)IJP
ALMEHED 72 NP B40 157 +LOVELACE (LUND+RUTG)IJP
DEANS 72 PR D6 1906 DEANS,JACOBS, LYONS,MONTGOMERY (SFLA)IJP
OTT 72 PL 42B 133 +TRISCHUK,VAVRA,RICHARDS,+ (MCGI+STLO+IOWA)IJP
ALSO 72 MCGILL THESIS J VAVRA (MCGI) JP
HICKS 73 PR D7 2614 +DEANS,JACOBS,LYONS+ (CARN+ORNL+SFLA)IJP

ABE 74 PL 53B 114 +ALSPECTOR,BOMBEROWITZ+ (RUTG+UPNJ+FSU)
DEANS 75 NP B96 90 +MITCHELL,MONTGOMERY,+ (SFLA+ALAH)IJP
AYED 76 CEA-N-1921 AYED (THESIS) (SACL)IJP
MA 76 PR D13 3027 E MA,G L SHAW (OREG+UCI)IJP
WINNIK 77 NP B128 66 +TOAFF,REVEL,GOLDBERG,BERNY (HAIF)I
BARBOUR 78 NP B141 253 BARBOUR,CRAWFORD,PARSONS (GLAS)
HENDRY 78 PRL 41 222 A W HENDRY (IND+LBL)IJP
-- THE ANALYSIS AND RESULTS ARE DISCUSSED MORE FULLY IN HENDRY 81.
BAKER 79 NP B156 93 +BROWN,CLARK,DAVIES,DEPAGTER,EVANS+ (RHEL)IJP
CUTKOSKY 79 PR D20 2839 +FORSYTH,HENDRICK,KELLY (CARN+LBL)IJP
HOEHLER 79 HANDBOOK OF PI-N SCATTERING, PHYSIK DATEN VOL.12-1
+KAISER,KOCH,PIETARINEN (KARL)IJP
ALSO 80 TORONTO CONF 3 R KOCH (KARL)IJP

CRAWFORD 80 TORONTO CONF 107 R L CRAWFORD (GLAS)
CUTKOSKY 80 TORONTO CONF 19 +FORSYTH,BABCOCK,KELLY,HENDRICK (CARN+LBL)IJP
SAXON 80 NP B162 522 +BAKER,BELL,BLISSETT,BLOODWORTH+(RHEL+BRIS)IJP
HENDRY 81 ANP 136 1 A W HENDRY (IND)
BELL 83 NP B222 389 +BLISSET,BROOME,DALEY,HART,LINTERN,+ (RL)IJP
CRAWFORD 83 NP B211 1 R L CRAWFORD, W T MORTON (GLAS)

N(2200) D''_{15} Status: **

→ 05 N(2200, JP=5/2-) I=1/2 D''15

THE MASS IS NOT WELL DETERMINED. A FEW EARLY RESULTS HAVE BEEN OMITTED.

05 N(2200) MASS (MEV)

M	2228.0	30.0	HOEHLER	79 IPWA	PI N TO PI N	12/79
M	2180.0	80.0	CUTKOSKY	80 IPWA	PI N TO PI N	1/82
M	(1920.0)		SAXON	80 DPWA	0 PI- P TO K LAM	12/79
M	(1900.0)		BELL	83 DPWA	0 PI- P TO LAM K0	2/84*

05 N(2200) WIDTH (MEV)

W	310.0	50.0	HOEHLER	79 IPWA	PI N TO PI N	12/79
W	400.0	100.0	CUTKOSKY	80 IPWA	PI N TO PI N	1/82
W	(220.0)		SAXON	80 DPWA	0 PI- P TO K LAM	12/79
W	(130.0)		BELL	83 DPWA	0 PI- P TO LAM K0	2/84*

05 N(2200) REAL PART OF POLE POSITION (MEV)

RE	2100.0	60.0	CUTKOSKY	80 IPWA	PI N TO PI N	1/82

05 N(2200) -2*IMAG PART OF POLE POSITION (MEV)

IM	360.0	80.0	CUTKOSKY	80 IPWA	PI N TO PI N	1/82

05 N(2200) REAL PART OF ELASTIC POLE RESIDUE (MEV)

RER	0.0	17.0	CUTKOSKY	80 IPWA	PI N TO PI N	1/82

05 N(2200) IMAG PART OF ELASTIC POLE RESIDUE (MEV)

IMR	-20.0	10.0	CUTKOSKY	80 IPWA	PI N TO PI N	1/82

05 N(2200) PARTIAL DECAY MODES

		DECAY MASSES
P1	N(2200) INTO N PI	938+ 140
P2	N(2200) INTO N ETA	940+ 549
P3	N(2200) INTO LAMBDA K	1116+ 498

05 N(2200) BRANCHING RATIOS

R1	N(2200) INTO (N PI)/TOTAL				(P1)	
R1	0.07	0.02	HOEHLER	79 IPWA	PI N TO PI N	12/79
R1	0.10	0.03	CUTKOSKY	80 IPWA	PI N TO PI N	1/82
R2	N(2200) FROM N PI TO N ETA				SQRT(P1*P2)	
R2	(0.066)		BAKER	79 DPWA	0 PI- P TO ETA N	12/79
R3	N(2200) FROM N PI TO LAMBDA K				SQRT(P1*P3)	
R3	(-0.05)		SAXON	80 DPWA	0 PI- P TO K LAM	12/79
R3	(-0.03)		BELL	83 DPWA	0 PI- P TO LAM K0	2/84*

REFERENCES FOR N(2200)

ALMEHED 72 NP B40 157 +LOVELACE (LUND+RUTG)IJP
AYED 76 CEA-N-1921 AYED (THESIS) (SACL)IJP
MA 76 PR D13 3027 E MA,G L SHAW (OREG+UCI)IJP
BAKER 77 NP B126 365 +BLISSET,BLOODWORTH,BROOME,HART+ (RHEL)IJP
BAKER 79 NP B156 93 +BROWN,CLARK,DAVIES,DEPAGTER,EVANS+ (RHEL)IJP
HOEHLER 79 HANDBOOK OF PI-N SCATTERING, PHYSIK DATEN VOL.12-1
+KAISER,KOCH,PIETARINEN (KARL)IJP
ALSO 80 TORONTO CONF 3 R KOCH (KARL)IJP
CUTKOSKY 80 TORONTO CONF 19 +FORSYTH,BABCOCK,KELLY,HENDRICK (CARN+LBL)IJP
SAXON 80 NP B162 522 +BAKER,BELL,BLISSETT,BLOODWORTH+(RHEL+BRIS)IJP
BELL 83 NP B222 389 +BLISSET,BROOME,DALEY,HART,LINTERN,+ (RL)IJP

N(2220) H_{19} Status: ****

90 N(2220, JP=9/2+) I=1/2 H19

MOST OF THE RESULTS PUBLISHED BEFORE 1975 ARE NOW OBSOLETE AND HAVE BEEN OMITTED. THEY MAY BE FOUND IN OUR 1982 EDITION (PHYSICS LETTERS 111B). HOWEVER, ALL THE REFERENCES HAVE BEEN RETAINED.

90 N(2220) MASS (MEV)

M	2300.0	100.0	HENDRY	78 MPWA	PI N TO PI N	12/79
M	(2050.0)		BAKER	79 DPWA	0 PI- P TO ETA N	12/79
M	(2250.0)		CUTKOSKY	79 IPWA	PI N TO PI N	12/79
M	2205.0	10.0	HOEHLER	79 IPWA	PI N TO PI N	12/79
M	2230.0	80.0	CUTKOSKY	80 IPWA	PI N TO PI N	1/82

90 N(2220) WIDTH (MEV)

W	450.0	150.0	HENDRY	78 MPWA	PI N TO PI N	12/79
W	(450.0)		CUTKOSKY	79 IPWA	PI N TO PI N	12/79
W	365.0	30.0	HOEHLER	79 IPWA	PI N TO PI N	12/79
W	500.0	150.0	CUTKOSKY	80 IPWA	PI N TO PI N	1/82

90 N(2220) REAL PART OF POLE POSITION (MEV)

RE	(2180.0)		CUTKOSKY	79 IPWA	PI N TO PI N	12/79
RE	2160.0	80.0	CUTKOSKY	80 IPWA	PI N TO PI N	1/82

90 N(2220) -2*IMAG PART OF POLE POSITION (MEV)

IM	(400.0)		CUTKOSKY	79 IPWA	PI N TO PI N	12/79
IM	480.0	100.0	CUTKOSKY	80 IPWA	PI N TO PI N	1/82

90 N(2220) REAL PART OF ELASTIC POLE RESIDUE (MEV)

RER	(37.0)		CUTKOSKY	79 IPWA	PI N TO PI N	12/79
RER	32.0	20.0	CUTKOSKY	80 IPWA	PI N TO PI N	1/82

90 N(2220) IMAG PART OF ELASTIC POLE RESIDUE (MEV)

IMR	(-21.0)		CUTKOSKY	79 IPWA	PI N TO PI N	12/79
IMR	-32.0	20.0	CUTKOSKY	80 IPWA	PI N TO PI N	1/82

For notation, see key at front of Listings.

Baryons
N(2220), N(2250), N(2600), N(2700)

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                    90  N(2220) PARTIAL DECAY MODES

                                                         DECAY MASSES
P1      N(2220) INTO N PI                               938+ 140
P2      N(2220) INTO N ETA                              940+ 549
P3      N(2220) INTO LAMBDA K                          1116+ 498

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                    90  N(2220) BRANCHING RATIOS

R1      N(2220) INTO (N PI)/TOTAL                        (P1)
R1            0.12      0.04        HENDRY    78 MPWA    PI N TO PI N     12/79
R1           (0.20)                 CUTKOSKY  79 IPWA    PI N TO PI N     12/79
R1            0.18      0.015       HOEHLER   79 IPWA    PI N TO PI N     12/79
R1            0.15      0.03        CUTKOSKY  80 IPWA    PI N TO PI N      1/82
R2      N(2220) FROM N PI TO N ETA                      SQRT(P1*P2)
R2           (0.034)                BAKER     79 DPWA  0 PI- P TO ETA N   12/79

R3      N(2220) FROM N PI TO LAMBDA K                   SQRT(P1*P3)
R3               NOT SEEN           SAXON     80 DPWA  0 PI- P TO K LAM   12/79
R3               NOT REQUIRED       BELL      83 DPWA 0  PI- P TO LAM K0   2/84*

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                              REFERENCES FOR N(2220)

BUSZA    67 NC 52A 331        +DAVIS,DUFF,HEYMANN,NIMMON +    (LOUC+LOWC)
AYED     70 KIEV CONF         R AYED,P BAREYRE, G VILLET           (SACL)IJP
AYED2    70 PL 31B 598        +BAREYRE,VILLET                      (SACL)
HULL     70 PR D2 1783        J HULL, R LEACOCK                     (ISU)
AYED     76 CEA-N-1921        AYED (THESIS)                        (SACL)IJP
MA       76 PR D13 3027       E MA,G L SHAW                   (OREG+UCI)IJP
HENDRY   78 PRL 41 222        A W HENDRY                       (IND+LBL)IJP
         -- THE ANALYSIS AND RESULTS ARE DISCUSSED MORE FULLY IN HENDRY 81.

BAKER    79 NP B156 93        +BROWN,CLARK,DAVIES,DEPAGTER,EVANS+  (RHEL)IJP
CUTKOSKY 79 PR D20 2839       +FORSYTH,HENDRICK,KELLY         (CARN+LBL)IJP
HOEHLER  79 HANDBOOK OF PI-N SCATTERING, PHYSIK DATEN VOL.12-1
                              +KAISER,KOCH,PIETARINEN              (KARL)IJP
    ALSO 80  TORONTO CONF 3   R KOCH                               (KARL)IJP

CUTKOSKY 80  TORONTO CONF 19  +FORSYTH,BABCOCK,KELLY,HENDRICK  (CARN+LBL)IJP
SAXON    80 NP B162 522       +BAKER,BELL,BLISSETT,BLOODWORTH+(RHEL+BRIS)IJP
HENDRY   81 ANP 136 1         A W HENDRY                            (IND)
BELL     83 NP B222 389       +BLISSET,BROOME,DALEY,HART,LINTERN,+   (RL)IJP

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N(2250) G'_{19} Status: ****

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                    113  N(2250, JP=9/2-) I=1/2   G'19


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                    113  N(2250) MASS (MEV)

M           2200.0    100.0         HENDRY    78 MPWA    PI N TO PI N     12/79
M          (2200.0)                 CUTKOSKY  79 IPWA    PI N TO PI N     12/79
M           2268.0     15.0         HOEHLER   79 IPWA    PI N TO PI N     12/79
M           2250.0     80.0         CUTKOSKY  80 IPWA    PI N TO PI N      1/82

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                    113  N(2250) WIDTH (MEV)

W            350.0    100.0         HENDRY    78 MPWA    PI N TO PI N     12/79
W           (330.0)                 CUTKOSKY  79 IPWA    PI N TO PI N     12/79
W            300.0     40.0         HOEHLER   79 IPWA    PI N TO PI N     12/79
W            480.0    120.0         CUTKOSKY  80 IPWA    PI N TO PI N      1/82

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                    113  N(2250) REAL PART OF POLE POSITION  (MEV)

RE         (2169.0)                 CUTKOSKY  79 IPWA    PI N TO PI N     12/79
RE          2150.0     50.0         CUTKOSKY  80 IPWA    PI N TO PI N      1/82

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                    113  N(2250) -2*IMAG PART OF POLE POSITION  (MEV)

IM          (290.0)                 CUTKOSKY  79 IPWA    PI N TO PI N     12/79
IM           360.0    100.0         CUTKOSKY  80 IPWA    PI N TO PI N      1/82

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                    113  N(2250) REAL PART OF ELASTIC POLE RESIDUE (MEV)

RER          (15.0)                 CUTKOSKY  79 IPWA    PI N TO PI N     12/79
RER           13.0      7.0         CUTKOSKY  80 IPWA    PI N TO PI N      1/82

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                    113  N(2250) IMAG PART OF ELASTIC POLE RESIDUE (MEV)

IMR          (-7.0)                 CUTKOSKY  79 IPWA    PI N TO PI N     12/79
IMR          -15.0      6.0         CUTKOSKY  80 IPWA    PI N TO PI N      1/82

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                    113  N(2250) PARTIAL DECAY MODES

                                                         DECAY MASSES
P1      N(2250) INTO N PI                               938+ 140
P2      N(2250) INTO LAMBDA K                          1116+ 498
P3      N(2250) INTO N ETA                              940+ 549

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                    113  N(2250) BRANCHING RATIOS

R1      N(2250) INTO (N PI)/TOTAL                        (P1)
R1            0.09      0.02        HENDRY    78 MPWA    PI N TO PI N     12/79
R1           (0.10)                 CUTKOSKY  79 IPWA    PI N TO PI N     12/79
R1            0.10      0.02        HOEHLER   79 IPWA    PI N TO PI N     12/79
R1            0.10      0.02        CUTKOSKY  80 IPWA    PI N TO PI N      1/82

R2      N(2250) FROM N PI TO N ETA                      SQRT(P1*P3)
R2           (-0.043)               BAKER     79 DPWA  0 PI- P TO ETA N   12/79

R3      N(2250) FROM N PI TO LAMBDA K                   SQRT(P1*P2)
R3           NOT SEEN               SAXON     80 DPWA  0 PI- P TO K LAM   12/79
R3            (-0.02)               BELL      83 DPWA 0  PI- P TO LAM K0   2/84*

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                              REFERENCES FOR N(2250)

AYED     76  CEA-N-1921       AYED (THESIS)                        (SACL)IJP
HENDRY   78 PRL 41 222        A W HENDRY                       (IND+LBL)IJP
         -- THE ANALYSIS AND RESULTS ARE DISCUSSED MORE FULLY IN HENDRY 81.
BAKER    79 NP B156 93        +BROWN,CLARK,DAVIES,DEPAGTER,EVANS+  (RHEL)IJP
CUTKOSKY 79 PR D20 2839       +FORSYTH,HENDRICK,KELLY         (CARN+LBL)IJP
HOEHLER  79 HANDBOOK OF PI-N SCATTERING, PHYSIK DATEN VOL.12-1
                              +KAISER,KOCH,PIETARINEN              (KARL)IJP
    ALSO 80  TORONTO CONF 3   R KOCH                               (KARL)IJP
CUTKOSKY 80  TORONTO CONF 19  +FORSYTH,BABCOCK,KELLY,HENDRICK  (CARN+LBL)IJP
SAXON    80 NP B162 522       +BAKER,BELL,BLISSETT,BLOODWORTH+(RHEL+BRIS)IJP
HENDRY   81 ANP 136 1         A W HENDRY                            (IND)
BELL     83 NP B222 389       +BLISSET,BROOME,DALEY,HART,LINTERN,+   (RL)IJP

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N(2600) I_{111} Status: ***

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                    120  N(2600, JP=11/2-) I=1/2   I1 11


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                    120  N(2600) MASS  (MEV)

M           2700.0    100.0         HENDRY    78 MPWA    PI N TO PI N     12/79
M           2577.0     50.0         HOEHLER   79 IPWA    PI N TO PI N     12/79

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                    120  N(2600) WIDTH  (MEV)

W            900.0    100.0         HENDRY    78 MPWA    PI N TO PI N     12/79
W            400.0    100.0         HOEHLER   79 IPWA    PI N TO PI N     12/79

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                    120  N(2600) PARTIAL DECAY MODES

                                                         DECAY MASSES
P1      N(2600) INTO N PI                               938+ 140

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                    120  N(2600) BRANCHING RATIOS

R1      N(2600) INTO (N PI)/TOTAL                        (P1)
R1            0.08      0.02        HENDRY    78 MPWA    PI N TO PI N     12/79
R1            0.05      0.01        HOEHLER   79 IPWA    PI N TO PI N     12/79

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                              REFERENCES FOR N(2600)

HENDRY   78 PRL 41 222        A W HENDRY                       (IND+LBL)IJP
         -- THE ANALYSIS AND RESULTS ARE DISCUSSED MORE FULLY IN HENDRY 81.
HOEHLER  79 HANDBOOK OF PI-N SCATTERING, PHYSIK DATEN VOL.12-1
                              +KAISER,KOCH,PIETARINEN              (KARL)IJP
    ALSO 80  TORONTO CONF 3   R KOCH                               (KARL)IJP
HENDRY   81 ANP 136 1         A W HENDRY                            (IND)

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N(2700) K_{113} Status: **

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                    121  N(2700, JP=13/2+) I=1/2   K1 13


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                    121  N(2700) MASS  (MEV)

M           3000.0    100.0         HENDRY    78 MPWA    PI N TO PI N     12/79
M           2612.0     45.0         HOEHLER   79 IPWA    PI N TO PI N     12/79

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                    121  N(2700) WIDTH  (MEV)
W            900.0    150.0         HENDRY    78 MPWA    PI N TO PI N     12/79
W            350.0     50.0         HOEHLER   79 IPWA    PI N TO PI N     12/79

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                    121  N(2700) PARTIAL DECAY MODES

                                                         DECAY MASSES
P1      N(2700) INTO N PI                               938+ 140

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                    121  N(2700) BRANCHING RATIOS

R1      N(2700) INTO (N PI)/TOTAL                        (P1)
R1            0.07      0.02        HENDRY    78 MPWA    PI N TO PI N     12/79
R1            0.04      0.01        HOEHLER   79 IPWA    PI N TO PI N     12/79

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                              REFERENCES FOR N(2700)

HENDRY   78 PRL 41 222        A W HENDRY                       (IND+LBL)IJP
         -- THE ANALYSIS AND RESULTS ARE DISCUSSED MORE FULLY IN HENDRY 81.
HOEHLER  79 HANDBOOK OF PI-N SCATTERING, PHYSIK DATEN VOL.12-1
                              +KAISER,KOCH,PIETARINEN              (KARL)IJP
    ALSO 80  TORONTO CONF 3   R KOCH                               (KARL)IJP
HENDRY   81 ANP 136 1         A W HENDRY                            (IND)

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# Baryons
N(~3000), Δ(1232)

Data Card Listings

~3000 MEV REGION - FORMATION EXPERIMENTS

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                    128  N(~3000) I=1/2

                    WE LIST HERE MISCELLANEOUS HIGH-MASS CANDIDATES FOR
                    ISOSPIN-1/2 RESONANCES FOUND IN PARTIAL-WAVE ANALYSES.
                    SO FAR, NO ANALYSIS OF THIS REGION HAS USED ALL THE
                    AVAILABLE DATA OR INCORPORATED ANALYTICITY CONSTRAINTS.

   OUR 1982 EDITION ALSO HAD AN N(3030), AN N(3245), AN N(3690), AND
   AN N(3755).  NOTHING HAS BEEN HEARD FROM THEM SINCE THE 1960'S,
   AND UNDER THE AUTHORITY GRANTED UNTO US BY THE STATUTE OF LIMITATIONS
   WE DECLARE THEM TO BE DEAD.  THE LAST THREE WERE NARROW PEAKS SEEN
   IN PRODUCTION EXPERIMENTS.  THE N(3030) WAS DEDUCED FROM TOTAL-CROSS-
   SECTION AND 180-DEG-ELASTIC-CROSS-SECTION MEASUREMENTS; PLACED
   IN THE MAIN BARYON TABLE IN THE ANYTHING-GOES 1960'S, IT REMAINED
   THERE DUE TO INATTENTION UNTIL THIS EDITION.

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                    128  N(~3000) MASS  (MEV)

M          3500.0    200.0            HENDRY    78 MPWA    PI N  L115      12/79
M          3800.0    200.0            HENDRY    78 MPWA    PI N  M117      12/79
M          4100.0    200.0            HENDRY    78 MPWA    PI N  N119      12/79
M         (2600.0)                     KOCH      80 IPWA    PI N  D13        2/84*
M         (3100.0)                     KOCH      80 IPWA    PI N  L115       2/84*
M         (3500.0)                     KOCH      80 IPWA    PI N  M117       2/84*
M          3500.0 TO 4000.0            KOCH      80 IPWA    PI N  N119       2/84*

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                    128  N(~3000) WIDTH  (MEV)

W          1300.0    200.0            HENDRY    78 MPWA    PI N  L115      12/79
W          1600.0    200.0            HENDRY    78 MPWA    PI N  M117      12/79
W          1900.0    300.0            HENDRY    78 MPWA    PI N  N119      12/79

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                    128  N(~3000) PARTIAL DECAY MODES

                                                          DECAY MASSES
P1     N(~3000) INTO N PI                                938+ 140

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                    128  N(~3000) BRANCHING RATIOS

R1     N(~3000) INTO (N PI)/TOTAL                    (P1)
R1          0.055    0.02            HENDRY    78 MPWA    PI N  L115      12/79
R1          0.040    0.015           HENDRY    78 MPWA    PI N  M117      12/79
R1          0.030    0.015           HENDRY    78 MPWA    PI N  N119      12/79

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                    REFERENCES FOR N(~3000)

HENDRY   78 PRL 41 222          A W HENDRY                        (IND+LBL)IJP
         -- THE ANALYSIS AND RESULTS ARE DISCUSSED MORE FULLY IN HENDRY 81.
KOCH     80  TORONTO CONF 3     R KOCH                                (KARL)IJP
HENDRY   81 ANP 136 1           A W HENDRY                             (IND)IJP

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S=0 I=3/2 NUCLEON STATES (Δ)

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Δ(1232) P'_{33} Status: ****

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                    33  DELTA(1232, JP=3/2+) I=3/2   P'33

                    MOST OF THE RESULTS PUBLISHED BEFORE 1977 ARE NOW
                    OBSOLETE AND HAVE BEEN OMITTED.  THEY MAY BE FOUND IN
                    OUR 1982 EDITION (PHYSICS LETTERS 111B).  HOWEVER,
                    ALL THE REFERENCES HAVE BEEN RETAINED.

   IN ADDITION, RESULTS IN THIS REGION FROM PRODUCTION EXPERIMENTS,
   WHICH USED TO BE LISTED SEPARATELY AS THE NEXT ENTRY, HAVE BEEN
   ENTIRELY REMOVED.

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                    33  DELTA(1232) MASS (MEV)

M          1233.0     2.0             HOEHLER   79 IPWA    PI N TO PI N     12/79
M          1232.0     3.0             CUTKOSKY  80 IPWA    PI N TO PI N      1/82

M++        1231.1     0.2             PEDRONI   78 DPWA ++ PI N 70-370 MEV  3/82
M++        1230.9     0.3             KOCH      80 IPWA ++ PI N TO PI N     1/82
M++        1230.6     0.2             ZIDELL    80 DPWA ++ PI N  0-350 MEV  1/82

M+        (1231.8)                     BERENDS   75 IPWA +  GAM P TO PI NUC  4/75
M+        (1231.2)                     BARBOUR   78 DPWA    PI-N PHOTOPROD.  3/79
M+         1234.9     1.4             MIROSHNIC 79      +  FIT PHOTOPROD.  12/79
M+        (1231.6)                     CRAWFORD  80 DPWA    PI N PHOTOPROD. 12/81

M0         1233.8     0.2             PEDRONI   78 DPWA  0 PI N 70-370 MEV  3/82
M0         1233.6     0.5             KOCH      80 IPWA  0 PI N TO PI N     1/82
M0         1232.5     0.3             ZIDELL    80 DPWA  0 PI N  0-350 MEV  1/82

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                    33  DELTA(1232) WIDTH (MEV)

W          116.0     5.0             HOEHLER   79 IPWA    PI N TO PI N     12/79
W          120.0     5.0             CUTKOSKY  80 IPWA    PI N TO PI N      1/82

W++        111.3     0.5             PEDRONI   78 DPWA ++ PI N 70-370 MEV  3/82
W++        111.0     1.0             KOCH      80 IPWA ++ PI N TO PI N     1/82
W++        113.2     0.3             ZIDELL    80 DPWA ++ PI N  0-350 MEV  1/82

W+        (111.0)                     BARBOUR   78 DPWA    PI-N PHOTOPROD.  3/79
W+         131.1     2.4             MIROSHNIC 79      +  FIT PHOTOPROD.  12/79
W+        (111.2)                     CRAWFORD  80 DPWA    PI N PHOTOPROD. 12/81

W0         117.9     0.9             PEDRONI   78 DPWA  0 PI N 70-370 MEV  3/82
W0         113.0     1.5             KOCH      80 IPWA  0 PI N TO PI N     1/82
W0         121.3     0.4             ZIDELL    80 DPWA  0 PI N  0-350 MEV  1/82

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                    33  (DELTA0) - (DELTA++) MASS DIFFERENCE (MEV)

D   A        (2.7)    (0.3)           PEDRONI   78 DPWA    PI N 70-370 MEV  3/82
D   A   REDUNDANT WITH DATA IN MASS LISTING.                                 3/82
D   A   USING PI+-D AS WELL, PEDRONI 78 DETERMINE (M- - M++)+(M0 - M+)/3 =   3/82
D   A   4.6+-0.2 MEV.                                                        3/82

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                    33  (DELTA0) - (DELTA++) WIDTH DIFFERENCE (MEV)

WD  A        (6.6)    (1.0)           PEDRONI   78 DPWA    PI N 70-370 MEV  3/82
WD  A   REDUNDANT WITH DATA IN MASS LISTING.                                 2/84*

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                    33  DELTA(1232) REAL PART OF POLE POSITION (MEV)

RE         1210.0     1.0             CUTKOSKY  80 IPWA    PI N TO PI N      1/82

R++  B     1209.6     0.5             VASAN     76      ++ FIT CARTER 73     1/76
R++  B  FROM FITS TO COULOMB-BARRIER-CORRECTED CARTER 73 PHASE SHIFT.        3/79
R++  C     1210.5 TO 1210.8           VASAN     76      ++ FIT CARTER 73     1/76
R++  C  FROM FITS TO CARTER 73 NUCLEAR PHASE SHIFT WITHOUT COULOMB BARRIER   3/79
R++  C  CORRECTIONS.                                                         3/79
R++  D    (1210.4)   (0.17)           ZIDELL    78      ++ FIT ZIDELL 78     3/79
R++  D  FIT TO ZIDELL 78 NUCLEAR PHASE SHIFT WITHOUT COULOMB                 3/79
R++  D  BARRIER CORRECTIONS.                                                 3/79
R++  E     1210.70    0.16            ZIDELL    80 DPWA ++ PI N  0-350 MEV  1/82
R++  E  FIT TO ZIDELL 80 NUCLEAR PHASE SHIFTS.  THE ACCURACY CLAIMED ON THE  2/84*
R++  E  REAL PART IS CONSIDERABLY BETTER THAN IS ALLOWED BY UNCERTAINTIES    2/84*
R++  E  IN THE BEAM MOMENTUM.                                                2/84*

RE+        1208.0     2.0             CAMPBELL  76       +  FIT PHOTOPROD.   2/77
RE+        1206.9+-0.9 TO 1210.5+-1.8 MIROSHNIC 79       +  FIT PHOTOPROD.  12/79

RE0  B     1210.75    0.6             VASAN     76       0 FIT CARTER 73     1/76
RE0  C    (1210.2)                    VASAN     76       0 FIT CARTER 73     1/76
RE0  D    (1209.5)   (0.41)           ZIDELL    78       0 FIT ZIDELL 78     3/79
RE0  E     1210.30    0.36            ZIDELL    80 DPWA  0 PI N  0-350 MEV  1/82

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                    33  DELTA(1232) -IMAG PART OF POLE POSITION (MEV)

IM          50.0      1.0             CUTKOSKY  80 IPWA    PI N TO PI N      1/82

I++  B      50.4      0.5             VASAN     76      ++ FIT CARTER 73     1/76
I++  C      49.9 TO  50.0             VASAN     76      ++ FIT CARTER 73     1/76
I++  D     (49.745)  (0.14)           ZIDELL    78      ++ FIT ZIDELL 78     3/79
I++  E      49.61     0.12            ZIDELL    80 DPWA ++ PI N  0-350 MEV  1/82

IM+         53.0      2.0             CAMPBELL  76       +  FIT PHOTOPROD.   2/77
IM+         55.6+-1.0 TO 58.3+-1.1    MIROSHNIC 79       +  FIT PHOTOPROD.  12/79

IM0  B      52.8      0.6             VASAN     76       0 FIT CARTER 73     1/76
IM0  C      52.9 TO  53.1             VASAN     76       0 FIT CARTER 73     1/76
IM0  D     (52.45)   (0.2)            ZIDELL    78       0 FIT ZIDELL 78     3/79
IM0  E      54.0      0.26            ZIDELL    80 DPWA  0 PI N  0-350 MEV  1/82

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                    33  DELTA(1232) ABSOLUTE VALUE OF ELASTIC
                                    POLE RESIDUE (MEV)

ABS         53.0      2.0             CUTKOSKY  80 IPWA    PI N TO PI N      1/82

A++  B      52.4 TO  53.2             VASAN     76      ++ FIT CARTER 73     1/76
A++  C      52.1 TO  52.4             VASAN     76      ++ FIT CARTER 73     1/76

AB0  B      54.8 TO  55.0             VASAN     76      ++ FIT CARTER 73     1/76
AB0  C      55.2 TO  55.3             VASAN     76      ++ FIT CARTER 73     1/76

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                    33  DELTA(1232) PHASE OF ELASTIC POLE RESIDUE (RADIANS)

PH          -0.82     0.02            CUTKOSKY  80 IPWA    PI N TO PI N      1/82

P++  B      -0.822 TO -0.833          VASAN     76      ++ FIT CARTER 73     1/76
P++  C      -0.823 TO -0.830          VASAN     76      ++ FIT CARTER 73     1/76

PH0  B      -0.840 TO -0.847          VASAN     76      ++ FIT CARTER 73     1/76
PH0  C      -0.848 TO -0.856          VASAN     76      ++ FIT CARTER 73     1/76

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                    33  DELTA(1232) PHASE OF M1+(3/2) PHOTOPRODUCTION
                                    MULTIPOLE AMPLITUDE POLE RESIDUE

M1P     INFORMATION ON THE PHASE (AND MAGNITUDE) OF THE M1+(3/2) MULTIPOLE  12/79
M1P     AMPLITUDE POLE RESIDUE IS CONTAINED IMPLICITLY IN THE PAPER OF      12/79
M1P     MIROSHNICHENKO 79.  THEY FIND THAT THE PHASE IS CONSISTENT WITH     12/79
M1P     BEING EQUAL TO THAT OF THE ELASTIC POLE RESIDUE.                    12/79

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                    33  DELTA(1232) MAGNETIC MOMENT  (NUCLEAR MAGNETONS)

MM          +4.7 TO  +6.7             NEFKENS   78          PI P TO PI P GAM 12/79

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                    33  DELTA(1232) PARTIAL DECAY MODES

                                                          DECAY MASSES
P1      DELTA(1232) INTO N PI                             938+ 140
P2      DELTA(1232) INTO N GAMMA                          938+   0
P3      DELTA(1232) INTO N PI PI                          938+ 140+ 140
P4      DELTA(1232) INTO NUCLEON GAMMA, HELICITY=1/2      938+   0
P5      DELTA(1232) INTO NUCLEON GAMMA, HELICITY=3/2      938+   0

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                    33  DELTA(1232) BRANCHING RATIOS

R1      DELTA(1232)0 INTO (N PI)/TOTAL                (P1)
R1          (1.0)                     HOEHLER   79 IPWA    PI N TO PI N     12/79
R1          (1.0)                     CUTKOSKY  80 IPWA    PI N TO PI N      1/82

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For notation, see key at front of Listings.

Baryons
Δ(1232), Δ(1550), Δ(1600)

33 DELTA(1232) PHOTON DECAY AMPLITUDES (GEV-1/2)**

FOR DEFINITION OF GAMMA-NUCLEON DECAY AMPLITUDES, SEE MINI-REVIEW PRECEDING THE BARYON LISTINGS.

A1 DELTA(1232) INTO NUCLEON GAMMA, HELICITY=1/2 (GEV-1/2)**

A1		-0.140	0.006	METCALF	74	DPWA	PI N PHOTOPROD.	2/74
A1		-0.141	0.004	FELLER	76	DPWA	PI N PHOTOPROD.	2/77
A1		-0.136	0.002	AZNAURYAN	77	DPWA	PIO PHTPRD,SOL 1	12/79
A1		-0.139	0.002	AZNAURYAN	77	DPWA	PIO PHTPRD,SOL 2	12/79
A1		-0.142	0.007	BARBOUR	78	DPWA	PI-N PHOTOPROD.	3/79
A1	N	(-0.140)		NOELLE	78		PI-N PHOTOPROD.	1/80
A1	N	CONVERTED TO OUR CONVENTIONS USING M=1.232, W=.110 FROM NOELLE 78.						1/80
A1		-0.147	0.001	ARAI	80	DPWA	PI N PHOTO FIT 1	12/81
A1		-0.145	0.001	ARAI	80	DPWA	PI N PHOTO FIT 2	12/81
A1		-0.136	0.006	CRAWFORD	80	DPWA	PI N PHOTOPROD.	12/81
A1		-0.138	0.004	AWAJI	81	DPWA	PI N PHOTOPROD.	1/84*
A1		-0.145	0.015	CRAWFORD	83	IPWA	PI N PHOTOPROD.	1/84*

A2 DELTA(1232) INTO NUCLEON GAMMA, HELICITY=3/2 (GEV-1/2)**

A2		-0.254	0.007	METCALF	74	DPWA	PI N PHOTOPROD.	2/74
A2		-0.256	0.003	FELLER	76	DPWA	PI N PHOTOPROD.	2/77
A2		-0.255	0.002	AZNAURYAN	77	DPWA	PIO PHTPRD,SOL 1	12/79
A2		-0.256	0.002	AZNAURYAN	77	DPWA	PIO PHTPRD,SOL 2	12/79
A2		-0.271	0.010	BARBOUR	78	DPWA	PI-N PHOTOPROD.	3/79
A2	N	(-0.247)		NOELLE	78		PI-N PHOTOPROD.	1/80
A2		-0.264	0.002	ARAI	80	DPWA	PI N PHOTO FIT 1	12/81
A2		-0.261	0.002	ARAI	80	DPWA	PI N PHOTO FIT 2	12/81
A2		-0.247	0.010	CRAWFORD	80	DPWA	PI N PHOTOPROD.	12/81
A2		-0.259	0.006	AWAJI	81	DPWA	PI N PHOTOPROD.	1/84*
A2		-0.263	0.026	CRAWFORD	83	IPWA	PI N PHOTOPROD.	1/84*

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REFERENCES FOR DELTA(1232)

OLSSON 65 PRL 14 118 — M G OLSSON (WISC)
ROPER 65 PR 138 B190 — L D ROPER, R M WRIGHT, B T FELD (LRL+MIT)IJP
DALITZ 66 PR 146 1180 — DALITZ,SUTHERLAND (OXF)
MICHAEL 67 PR 156 1677 — MICHAEL (RHEL)IJP
DONNACHI 68 PL 26B 161 — DONNACHIE,LOVELACE,KIRSOPP (CERN)
BERENDS 71 NP B30 575 — +WEAVER (CEA+MIT+TUFT)
CARTER 71 NP B26 445 — +WILLIAMS, BUGG, BUSSEY, DANCE (CAVE+RHEL)

ALMEHED 72 NP B40 157 — +LOVELACE (LUND+RUTG)IJP
BALL 72 PRL 28 1143 — +CAMPBELL,LEE,SHAW (UTAH+BOIS+UCI)
PDG 72 PL 39B 103 — SODING,BARTELS,+ (DESY+LBL+BRAN+CERN+HELS)IJP
BALL 73 PR D7 2789 — BALL,LEE,SHAW (UTAH+UCI)IJP
CARTER 73 NP B58 378 — CARTER,BUGG,CARTER (CAVE+LOQM)IJP
CHENG 73 PR D7 2249 — CHENG,LICHTENBERG (IND)IJP
DEVENISH 73 PL 47B 53 — DEVENISH,RANKIN,LYTH (LOUC+BONN+LANC)IJP
FONDA 73 PR D8 353 — FONDA,GHIRARDI,SHAW (ICTP-TRIESTE+TRST)IJP
MOORHOUS 73 PL 43B 44 — MOORHOUSE, OBERLACK (GLAS+LBL)IJP
NOGOVA 73 NP B61 445 — NOGOVA,PISUT(IP SLOVAK ACAD SCI+COMENIUS U)IJP
ALSO 73 NP B61 438 — NOGOVA,PISUT+(IP SLOVK ACAD SCI+COMENIUS U)IJP
ALSO 73 NP B65 544 — NOGOVA,PISUT+(IP SLOVK ACAD SCI+COMENIUS U)IJP
TSCHANG 73 NP B59 445 — TSCHANG,PARKINSON (FLOR+GAINESVILLE)IJP

HENYEY 74 PR D9 302 — HENYEY,KANE (MICH)IJP
KNIES 74 PR D9 2680 — KNIES,MOORHOUSE,OBERLACK (LBL+GLAS)IJP
METCALF 74 NP B76 253 — W J METCALF,R L WALKER (CIT)IJP
MOORHOUS 74 PR D9 1 — MOORHOUSE,OBERLACK,ROSENFELD (GLAS+LBL)IJP
OLSSON 74 LNC 10 333 — OLSSON (CERN)IJP
PFEIL 74 NP B73 166 — PFEIL,RÖLLNIK,STANKOWSKI (BONN)
SPEARMAN 74 PR D10 1660 — T D SPEARMAN (TRIN)
SUZUKI 74 NP B68 413 — SUZUKI,KUROKAWA,KONDO (TOKY)

BALL 75 PR D11 1171 — J S BALL,R L GOBLE (UTAH)IJP
BERENDS 75 NP B84 342 — BERENDS,DONNACHIE (LEID+MCHS)
CRAWFORD 75 NP B97 125 — R L CRAWFORD (GLAS)IJP
GANENKO 75 SJNP 22 522 — +KRIVETS,MIROSHNICHENKO,NIKIFOROV+ (KIEV)IJP
KRIVETS 75 SJNP 20 430 — +MIROSHNICHENKO,NIKIFOROV,SANIN+ (KIEV)IJP
ALSO 74 SJNP 19 112 — KRIVETS,NIKIFOROV,SANIN,SHALATSKII (KIEV)IJP
LICHTENB 75 LNC 12 616 — D B LICHTENBERG (IND)IJP
NIGRO 75 NP B84 201 — NIGRO,SPILLANTINI,VALENTE (PADO+FRAS)

AYED 76 CEA-N-1921 — AYED (THESIS) (SACL)IJP
BARBOUR 76 NP B111 358 — I M BARBOUR,R L CRAWFORD (GLAS)IJP
CAMPBELL 76 PR D14 2431 — CAMPBELL,SHAW,BALL (BOIS+UCI+UTAH)IJP
FELLER 76 NP B104 219 — +FUKUSHIMA,HORIKAWA,KAJIKAWA+ (NAGO+OSAK)IJP
GANENKO1 76 SJNP 24 284 — +KRIVETS,MIROSHNICHENKO,NIKIFOROV+ (KIEV)IJP
GANENKO2 76 SJNP 24 594 — +GORBENKO,KRIVETS,KOLESNIKOV+ (KIEV)IJP
VASAN 76 NP B106 535 — S S VASAN (CARN)IJP
ALSO 76 NP B106 526 — S S VASAN (CARN)IJP
ZABEV 76 SJNP 24 70 — ZABEV,KUZNETSOV,STUKOV (TMSK)IJP

AZNAURYA 77 EFI-264(57)-77 — +AKOPOV,BAGDASARYAN (YERE)IJP
BARBOUR 78 NP B141 253 — BARBOUR,CRAWFORD,PARSONS (GLAS)
NEFKENS 78 PR D18 3911 — +ARMAN,BALLAGH,GLODIS,HADDOCK+ (UCLA+CATH)IJP
NOELLE 78 PTP 60 778 — P NOELLE (NAGO)
PEDRONI 78 NP A300 321 — +GABATHULER,DOMINGO,HIRT+ (SIN+GREN+KARL++)IJP
ZIDELL 78 LNC 21 140 — V S ZIDELL,R A ARNDT,L D ROPER (VPI)IJP
HOEHLER 79 HANDBOOK OF PI-N SCATTERING, PHYSIK DATEN VOL.12-1 — +KAISER,KOCH,PIETARINEN (KARL)IJP
ALSO 80 TORONTO CONF 3 — R KOCH (KARL)IJP
MIROSHNI 79 SJNP 29 94 — MIROSHNICHENKO,NIKIFOROV,SANIN+ (KHAR)IJP

ARAI 80 TORONTO CONF 93 — I ARAI (TOKY)
ALSO 82 NP B194 251 — I ARAI, H FUJII (TOKY)
CRAWFORD 80 TORONTO CONF 107 — R L CRAWFORD (GLAS)
CUTKOSKY 80 TORONTO CONF 19 — +FORSYTH,BABCOCK,KELLY,HENDRICK (CARN+LBL)IJP
KOCH 80 NP A336 331 — R KOCH, E PIETARINEN (KARL)IJP
ZIDELL 80 PR D21 1255 — V S ZIDELL,R A ARNDT,L D ROPER (VPI)IJP

AWAJI 81 BONN CONF 352 — R KAJIKAWA (TALK) (NAGO)
ALSO 82 NP B197 365 — FUJII,HAYASHII,IWATA,KAJIKAWA+ (NAGO)
CRAWFORD 83 NP B211 1 — R L CRAWFORD, W T MORTON (GLAS)

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Δ(1550) P'_{31} Status: *

110 DELTA(1550, JP=1/2+) I=3/2 P'31

THIS RESONANCE HAS NOT BEEN SEEN IN PI N --> PI N ANALYSES, AND ITS EXISTENCE IS THUS DOUBTFUL.

110 DELTA(1550) MASS (MEV)

M	A	(1550.0)		LONGACRE	77	IPWA	PI N TO 2PI N	11/77
M	A	ALL LONGACRE77 PARAMETERS ARE FROM SOLUTION S2, EXCEPT FOR THE POLE						11/77
M	A	POSITION WHICH IS FROM SOLUTIONS S1 AND C1.						11/77
M		(1525.0)		BARNHAM	80	IPWA	++ PI N TO 2PI N	12/79
M		(1506.0)		CRAWFORD	80	DPWA	PI N PHOTOPROD.	12/81

110 DELTA(1550) WIDTH (MEV)

W	A	(110.0)		LONGACRE	77	IPWA	PI N TO 2PI N	11/77
W		(40.0)		BARNHAM	80	IPWA	++ PI N TO 2PI N	12/79
W		(137.0)		CRAWFORD	80	DPWA	PI N PHOTOPROD.	12/81

110 DELTA(1550) REAL PART OF POLE POSITION (MEV)

RE	A	1554. OR 1553.		LONGACRE	77	IPWA	PI N TO 2PI N	11/77

110 DELTA(1550) -2*IMAG PART OF POLE POSITION (MEV)

IM	A	105. OR 104.		LONGACRE	77	IPWA	PI N TO 2PI N	11/77

110 DELTA(1550) PARTIAL DECAY MODES

		DECAY MASSES
P1	DELTA(1550) INTO N PI	938+ 140
P2	DELTA(1550) INTO DELTA(1232) PI	1232+ 140
P3	DELTA(1550) INTO N RHO, S=3/2	938+ 769

110 DELTA(1550) BRANCHING RATIOS

R1 DELTA(1550) FROM N PI TO DELTA(1232) PI SQRT(P1*P2)

R1	A	(+0.11)		LONGACRE	77	IPWA	PI N TO 2PI N	11/77
R1		0.13	0.05	BARNHAM	80	IPWA	++ PI N TO 2PI N	12/79

R2 DELTA(1550) FROM N PI TO N RHO, S=3/2 SQRT(P1*P3)

R2	A	(+0.08)		LONGACRE	77	IPWA	PI N TO 2PI N	11/77
R2		0.17	0.05	BARNHAM	80	IPWA	++ PI N TO 2PI N	12/79

110 DELTA(1550) PHOTON DECAY AMPLITUDES (GEV-1/2)**

FOR DEFINITION OF GAMMA-NUCLEON DECAY AMPLITUDES, SEE MINI-REVIEW PRECEDING THE BARYON LISTINGS.

A1 DELTA(1550) INTO NUCLEON GAMMA, HELICITY=1/2 (GEV-1/2)**

A1	(0.013)		CRAWFORD	80	DPWA	PI N PHOTOPROD.	12/81
A1	0.016	0.016	CRAWFORD	83	IPWA	PI N PHOTOPROD.	1/84*

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REFERENCES FOR DELTA(1550)

LONGACRE 77 NP B122 493 — LONGACRE,DOLBEAU (SACL)IJP
ALSO 76 NP B108 365 — DOLBEAU,TRIANTIS,NEVEU,CADIET (SACL)IJP
BARNHAM 80 NP B168 243 — BARNHAM,GLICKMAN,MIER-JEDRZEJOWICZ+ (LOIC)
CRAWFORD 80 TORONTO CONF 107 — R L CRAWFORD (GLAS)
CRAWFORD 83 NP B211 1 — R L CRAWFORD, W T MORTON (GLAS)

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Δ(1600) P''_{33} Status: **

19 DELTA(1600, JP=3/2+) I=3/2 P''33

MOST OF THE RESULTS PUBLISHED BEFORE 1975 ARE NOW OBSOLETE AND HAVE BEEN OMITTED. THEY MAY BE FOUND IN OUR 1982 EDITION (PHYSICS LETTERS 111B). HOWEVER, ALL THE REFERENCES HAVE BEEN RETAINED.

THE AGREEMENT AMONG THE VARIOUS ANALYSES IS NOT VERY GOOD.

19 DELTA(1600) MASS (MEV)

M	A	1900. OR 1640.		LONGACRE	75	IPWA	PI N TO 2PI N	11/75
M	A	THE 2 SETS OF PARAMETERS ARE FROM METHODS 1 AND 2 OF LONGACRE 75.						11/75
M	B	(1560.0)		LONGACRE	77	IPWA	PI N TO 2PI N	11/77
M	B	ALL LONGACRE77 PARAMETERS ARE FROM SOLUTION S2, EXCEPT FOR THE POLE						11/77
M	B	POSITION WHICH IS FROM SOLUTIONS S1 AND C1.						11/77
M		(1640.0)	(50.0)	CUTKOSKY	79	IPWA	PI N TO PI N	12/79
M		1522.0	13.0	HOEHLER	79	IPWA	PI N TO PI N	12/79
M		(1690.0)		BARNHAM	80	IPWA	++ PI N TO 2PI N	12/79
M		1600.0	50.0	CUTKOSKY	80	IPWA	PI N TO PI N	1/82

19 DELTA(1600) WIDTH (MEV)

W	A	205. OR 300.		LONGACRE	75	IPWA	PI N TO 2PI N	11/75
W	B	(180.0)		LONGACRE	77	IPWA	PI N TO 2PI N	11/77
W		(370.0)	(70.0)	CUTKOSKY	79	IPWA	PI N TO PI N	12/79
W		220.0	40.0	HOEHLER	79	IPWA	PI N TO PI N	12/79
W		(250.0)		BARNHAM	80	IPWA	++ PI N TO 2PI N	12/79
W		300.0	100.0	CUTKOSKY	80	IPWA	PI N TO PI N	1/82

19 DELTA(1600) REAL PART OF POLE POSITION (MEV)

RE		(1609.0)		LONGACRE	75	IPWA	PI N TO 2PI N	11/75
RE	B	1541. OR 1542.		LONGACRE	77	IPWA	PI N TO 2PI N	11/77
RE		(1547.0)		CUTKOSKY	79	IPWA	PI N TO PI N	12/79
RE		1550.0	40.0	CUTKOSKY	80	IPWA	PI N TO PI N	1/82

Baryons

Δ(1600), Δ(1620)


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                    19  DELTA(1600) -2*IMAG PART OF POLE POSITION (MEV)

IM          (323.0)                 LONGACRE  75 IPWA    PI N TO 2PI N    11/75
IM  B        178. OR 178.0          LONGACRE  77 IPWA    PI N TO 2PI N    11/77
IM          (230.0)                 CUTKOSKY  79 IPWA    PI N TO PI N     12/79
IM           200.0     60.0         CUTKOSKY  80 IPWA    PI N TO PI N      1/82
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                    19  DELTA(1600) REAL PART OF ELASTIC POLE RESIDUE (MEV)

RER         (-18.0)                 CUTKOSKY  79 IPWA    PI N TO PI N     12/79
RER          -15.0      6.0         CUTKOSKY  80 IPWA    PI N TO PI N      1/82
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                    19  DELTA(1600) IMAG PART OF ELASTIC POLE RESIDUE (MEV)

IMR         (-11.0)                 CUTKOSKY  79 IPWA    PI N TO PI N     12/79
IMR            8.0      8.0         CUTKOSKY  80 IPWA    PI N TO PI N      1/82
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                    19  DELTA(1600) PARTIAL DECAY MODES

                                                          DECAY MASSES
P1      DELTA(1600) INTO N PI                            938+ 140
P2      DELTA(1600) INTO SIGMA K                        1189+ 494
P3      DELTA(1600) INTO DELTA(1232) PI, P-WAVE         1232+ 140
P4      DELTA(1600) INTO DELTA(1232) PI, F-WAVE         1232+ 140
P5      DELTA(1600) INTO N RHO, S=1/2, P-WAVE            938+ 769
P6      DELTA(1600) INTO N RHO, S=3/2, P-WAVE            938+ 769
P7      DELTA(1600) INTO N(1440) PI                     1440+ 140
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                    19  DELTA(1600) BRANCHING RATIOS

R1      DELTA(1600) INTO (N PI)/TOTAL                        (P1)
R1           (0.20)   (0.04)        CUTKOSKY  79 IPWA    PI N TO PI N     12/79
R1            0.21     0.06         HOEHLER   79 IPWA    PI N TO PI N     12/79
R1            0.18     0.04         CUTKOSKY  80 IPWA    PI N TO PI N      1/82

R2      DELTA(1600) FROM N PI TO SIGMA K                  SQRT(P1*P2)
R2  C          0.006 TO 0.042      DEANS     75 DPWA    PI N TO K SIGMA  11/75
R2  C   RANGE GIVEN IS FROM FOUR BEST SOLUTIONS.                         11/75
R2  C   DEANS75 DISAGREES WITH PI+ P TO K+ SIGMA+ DATA OF WINNIK77        1/78
R2  C   AROUND 1920 MEV.                                                 1/78

R3      DELTA(1600) FROM N PI TO DELTA(1232) PI, P-WAVE  SQRT(P1*P3)
R3  A        -0.36 OR -0.30         LONGACRE  75 IPWA    PI N TO 2PI N    11/75
R3  B       (-0.34)                 LONGACRE  77 IPWA    PI N TO 2PI N    11/77
R3  B   LONGACRE 77 CONSIDER THIS COUPLING TO BE WELL DETERMINED.
R3  D        (0.3)                  NOVOSELLE 78 IPWA    PI N TO 2PI N     3/79
R3  D   BW FIT TO LONGACRE 75 IPWA, PHASE IS NEAR -90 DEGREES.            3/79
R3  E        (0.27)                 NOVOSELLE 78 IPWA    PI N TO 2PI N     3/79
R3  E   BW FIT TO NOVOSELLER 78 IPWA, PHASE IS NEAR -90 DEGREES. THIS FIT 12/79
R3  E   ASSUMES THE MASS IS NEAR 1900 MEV.                               12/79
R3  F        -0.24     0.05         BARNHAM   80 IPWA ++ PI N TO 2PI N  12/79
R3  F   THE COUPLING SIGNS (WHERE DETERMINED) OF BARNHAM 79 HAVE BEEN    12/79
R3  F   CHANGED TO AGREE WITH THE CONVENTION OF LONGACRE 77.             12/79

R4      DELTA(1600) FROM N PI TO DELTA(1232) PI, F-WAVE  SQRT(P1*P4)
R4  B       (+0.07)                 LONGACRE  77 IPWA    PI N TO 2PI N    11/77

R5      DELTA(1600) FROM N PI TO N RHO, S=1/2, P-WAVE    SQRT(P1*P5)
R5  B       (-0.10)                 LONGACRE  77 IPWA    PI N TO 2PI N    11/77

R6      DELTA(1600) FROM N PI TO N RHO, S=3/2, P-WAVE    SQRT(P1*P6)
R6  B       (-0.10)                 LONGACRE  77 IPWA    PI N TO 2PI N    11/77

R7      DELTA(1600) FROM N PI TO N(1440) PI              SQRT(P1*P7)
R7  F        -0.23     0.04         BARNHAM   80 IPWA ++ PI N TO 2PI N  12/79
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                    19  DELTA(1600) PHOTON DECAY AMPLITUDES (GEV**-1/2)

        FOR DEFINITION OF GAMMA-NUCLEON DECAY AMPLITUDES, SEE MINI-
      REVIEW PRECEDING THE BARYON LISTINGS.

A1      DELTA(1600) INTO NUCLEON GAMMA, HELICITY=1/2 (GEV**-1/2)
A1           0.0      0.038        METCALF   74 DPWA    PI N PHOTOPROD.   2/74
A1           0.0      0.020        FELLER    76 DPWA    PI N PHOTOPROD.   2/77
A1          +0.006    0.018        AZNAURYAN 77 DPWA    PIO PHTPRD,SOL 1 12/79
A1          -0.119    0.014        AZNAURYAN 77 DPWA    PIO PHTPRD,SOL 2 12/79
A1           0.000    0.030        BARBOUR   78 DPWA    PI-N PHOTOPROD.   3/79
A1           0.005    0.020        CRAWFORD  80 DPWA    PI N PHOTOPROD.  12/81
A1          -0.046    0.013        AWAJI     81 DPWA    PI N PHOTOPROD.   1/84*
A1          -0.039    0.030        CRAWFORD  83 IPWA    PI N PHOTOPROD.   1/84*

A2      DELTA(1600) INTO NUCLEON GAMMA, HELICITY=3/2 (GEV**-1/2)
A2           0.0      0.033        METCALF   74 DPWA    PI N PHOTOPROD.   2/74
A2           0.0      0.015        FELLER    76 DPWA    PI N PHOTOPROD.   2/77
A2          -0.133    0.042        AZNAURYAN 77 DPWA    PIO PHTPRD,SOL 1 12/79
A2          -0.088    0.037        AZNAURYAN 77 DPWA    PIO PHTPRD,SOL 2 12/79
A2           0.000    0.045        BARBOUR   78 DPWA    PI-N PHOTOPROD.   3/79
A2          -0.009    0.020        CRAWFORD  80 DPWA    PI N PHOTOPROD.  12/81
A2           0.025    0.031        AWAJI     81 DPWA    PI N PHOTOPROD.   1/84*
A2          -0.013    0.014        CRAWFORD  83 IPWA    PI N PHOTOPROD.   1/84*

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REFERENCES FOR DELTA(1600)


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DONNACH2 68 VIENNA 139          DONNACHIE  RAPPORTEUR'S TALK          (GLAS)
KIRSOPP  68 THESIS              R G KIRSOPP                           (EDIN)
AYED     70 KIEV CONF           R AYED,P BAREYRE, G VILLET            (SACL)IJP
AYED2    70 PL 31B 598          +BAREYRE,VILLET                       (SACL)
BOWLER   70 NP 17B 331          +CASHMORE                              (OXF)
FEUERBAC 70 NP 16B 85           FEUERBACHER+HOLLADAY                  (VAND)
ALMEHED  72 NP B40 157          +LOVELACE                       (LUND+RUTG)IJP
DEVENISH 73 PL 47B 53           DEVENISH,RANKIN,LYTH        (LOUC+BONN+LANC)IJP
DEVENIS2 74 PL 52B 227          DEVENISH,LYTH,RANKIN        (DESY+LANC+BONN)IJP
KNIES    74 PR D9 2680          KNIES,MOORHOUSE,OBERLACK          (LBL+GLAS)IJP
METCALF  74 NP B76 253          W J METCALF,R L WALKER                 (CIT)IJP

DEANS    75 NP B96 90           +MITCHELL,MONTGOMERY,+          (SFLA+ALAH)IJP
LONGACRE 75 PL 55B 415          +ROSENFELD,LASINSKI,SMADJA+       (LBL+SLAC)IJP
    ALSO 78 PR D17 1795         LONGACRE,LASINSKI,ROSENFELD+      (LBL+SLAC)
AYED     76 CEA-N-1921          AYED (THESIS)                         (SACL)IJP
FELLER   76 NP B104 219         +FUKUSHIMA,HORIKAWA,KAJIKAWA+   (NAGO+OSAK)IJP
AZNAURYA 77  EFI-264(57)-77     +AKOPOV,BAGDASARYAN                   (YERE)IJP
LONGACRE 77 NP B122 493         LONGACRE,DOLBEAU                      (SACL)IJP
    ALSO 76 NP B108 365         DOLBEAU,TRIANTIS,NEVEU,CADIET         (SACL)IJP
WINNIK   77 NP B128 66          +TOAFF,REVEL,GOLDBERG,BERNY           (HAIF)I
BARBOUR  78 NP B141 253         BARBOUR,CRAWFORD,PARSONS              (GLAS)
NOVOSELL 78 NP B137 509         D E NOVOSELLER                         (CIT)IJP
    ALSO 78 NP B137 445         D E NOVOSELLER                         (CIT)IJP
CUTKOSKY 79 PR D20 2839         +FORSYTH,HENDRICK,KELLY           (CARN+LBL)IJP
HOEHLER  79 HANDBOOK OF PI-N SCATTERING, PHYSIK DATEN VOL.12-1
                                +KAISER,KOCH,PIETARINEN                (KARL)IJP
    ALSO 80  TORONTO CONF 3     R KOCH                                 (KARL)IJP
BARNHAM  80 NP B168 243         BARNHAM,GLICKMAN,MIER-JEDRZEJOWICZ+    (LOIC)
CRAWFORD 80  TORONTO CONF 107 R L CRAWFORD                             (GLAS)
CUTKOSKY 80  TORONTO CONF 19  +FORSYTH,BABCOCK,KELLY,HENDRICK  (CARN+LBL)IJP

AWAJI    81  BONN CONF 352      R KAJIKAWA (TALK)                      (NAGO)
    ALSO 82 NP B197 365         FUJII,HAYASHII,IWATA,KAJIKAWA+         (NAGO)
CRAWFORD 83 NP B211 1           R L CRAWFORD, W T MORTON               (GLAS)
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Δ(1620) S_{31} Status: ****

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                    82  DELTA(1620, JP=1/2-) I=3/2   S'31

                    MOST OF THE RESULTS PUBLISHED BEFORE 1975 ARE NOW
                    OBSOLETE AND HAVE BEEN OMITTED.  THEY MAY BE FOUND IN
                    OUR 1982 EDITION (PHYSICS LETTERS 111B).  HOWEVER,
                    ALL THE REFERENCES HAVE BEEN RETAINED.

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                    82  DELTA(1620) MASS (MEV)

M    A     1625. OR 1600.           LONGACRE  75 IPWA    PI N TO 2PI N    11/75
M    A  THE 2 SETS OF PARAMETERS ARE FROM METHODS 1 AND 2 OF LONGACRE 75.  11/75
M    B    (1580.0)                  LONGACRE  77 IPWA    PI N TO 2PI N    11/77
M    B  ALL LONGACRE77 PARAMETERS ARE FROM SOLUTION S2, EXCEPT FOR THE POLE 11/77
M    B  POSITION WHICH IS FROM SOLUTIONS S1 AND C1.                       11/77
M        (1662.0)                  BARBOUR   78 DPWA    PI-N PHOTOPROD.   3/79
M        (1620.0)   (20.0)         CUTKOSKY  79 IPWA    PI N TO PI N     12/79
M         1610.0     7.0           HOEHLER   79 IPWA    PI N TO PI N     12/79
M        (1620.0)                  BARNHAM   80 IPWA ++ PI N TO 2PI N   12/79
M    C   (1712.8)    (6.0)         CHEW      80 BPWA ++ PI+P TO PI+P    1/82
M    D   (1786.7)    (2.0)         CHEW      80 BPWA ++ PI+P TO PI+P    1/82
M    CD  CHEW 80 REPORTS TWO S31 RESONANCES AT SOMEWHAT HIGHER MASSES THAN  2/84*
M    CD  OTHER ANALYSES.  THEY ARE LISTED HERE, AS C AND D.  PROBLEMS WITH  2/84*
M    CD  THIS ANALYSIS ARE DISCUSSED IN SEC.2.1.11 OF HOEHLER 83.           2/84*
M        (1657.0)                  CRAWFORD  80 DPWA    PI N PHOTOPROD.  12/81
M         1620.0    20.0           CUTKOSKY  80 IPWA    PI N TO PI N      1/82

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                    82  DELTA(1620) WIDTH (MEV)

W    A     160. OR  150.            LONGACRE  75 IPWA    PI N TO 2PI N    11/75
W    B    (120.0)                   LONGACRE  77 IPWA    PI N TO 2PI N    11/77
W         (180.0)                   BARBOUR   78 DPWA    PI-N PHOTOPROD.   3/79
W         (140.0)   (20.0)          CUTKOSKY  79 IPWA    PI N TO PI N     12/79
W          139.0    18.0            HOEHLER   79 IPWA    PI N TO PI N     12/79
W         (120.0)                   BARNHAM   80 IPWA ++ PI N TO 2PI N   12/79
W    C    (228.3)   (18.0)          CHEW      80 BPWA ++ PI+P TO PI+P    1/82
W    D     (30.0)    (6.4)          CHEW      80 BPWA ++ PI+P TO PI+P    1/82
W         (161.0)                   CRAWFORD  80 DPWA    PI N PHOTOPROD.  12/81
W          140.0    20.0            CUTKOSKY  80 IPWA    PI N TO PI N      1/82

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                    82  DELTA(1620) REAL PART OF POLE POSITION (MEV)

RE        (1583.0)                  LONGACRE  75 IPWA    PI N TO 2PI N    11/75
RE   B     1575. OR 1572.           LONGACRE  77 IPWA    PI N TO 2PI N    11/77
RE        (1597.0)                  CUTKOSKY  79 IPWA    PI N TO PI N     12/79
RE         1600.0    15.0           CUTKOSKY  80 IPWA    PI N TO PI N      1/82

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                    82  DELTA(1620) -2*IMAG PART OF POLE POSITION (MEV)

IM        (143.0)                   LONGACRE  75 IPWA    PI N TO 2PI N    11/75
IM   B     119. OR 128.0            LONGACRE  77 IPWA    PI N TO 2PI N    11/77
IM        (120.0)                   CUTKOSKY  79 IPWA    PI N TO PI N     12/79
IM         120.0    20.0            CUTKOSKY  80 IPWA    PI N TO PI N      1/82

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                    82  DELTA(1620) REAL PART OF ELASTIC POLE RESIDUE (MEV)

RER        (-6.0)                   CUTKOSKY  79 IPWA    PI N TO PI N     12/79
RER         -5.0      5.0           CUTKOSKY  80 IPWA    PI N TO PI N      1/82

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                    82  DELTA(1620) IMAG PART OF ELASTIC POLE RESIDUE (MEV)

IMR       (-15.0)                   CUTKOSKY  79 IPWA    PI N TO PI N     12/79
IMR        -14.0     3.0            CUTKOSKY  80 IPWA    PI N TO PI N      1/82

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                    82  DELTA(1620) PARTIAL DECAY MODES

                                                          DECAY MASSES
P1      DELTA(1620) INTO N PI                            938+ 140
P2      DELTA(1620) INTO N PI PI                         938+ 140+ 140
P3      DELTA(1620) INTO NUCLEON GAMMA, HELICITY=1/2     938+   0
P4      DELTA(1620) INTO DELTA(1232) PI                 1232+ 140
P5      DELTA(1620) INTO N RHO                           938+ 769
P6      DELTA(1620) INTO N RHO, S=1/2, S-WAVE            938+ 769
P7      DELTA(1620) INTO N RHO, S=3/2, D-WAVE            938+ 769
P8      DELTA(1620) INTO N(1440) PI                     1440+ 140

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                    82  DELTA(1620) BRANCHING RATIOS

R1      DELTA(1620) INTO (N PI)/TOTAL                        (P1)
R1           (0.25)   (0.04)        CUTKOSKY  79 IPWA    PI N TO PI N     12/79
R1            0.35     0.06         HOEHLER   79 IPWA    PI N TO PI N     12/79
R1   C       (0.60)                 CHEW      80 BPWA ++ PI+P TO PI+P    1/82
R1   D       (0.36)                 CHEW      80 BPWA ++ PI+P TO PI+P    1/82
R1            0.25     0.03         CUTKOSKY  80 IPWA    PI N TO PI N      1/82

R2      DELTA(1620) FROM N PI TO DELTA(1232) PI          SQRT(P1*P4)
R2   A       +0.40 OR +0.40         LONGACRE  75 IPWA    PI N TO 2PI N    11/75
R2   B      (+0.39)                 LONGACRE  77 IPWA    PI N TO 2PI N    11/77
R2   B  LONGACRE 77 CONSIDER THIS COUPLING TO BE WELL DETERMINED.
R2   E       +0.33     0.06         BARNHAM   80 IPWA ++ PI N TO 2PI N   12/79
R2   E  THE COUPLING SIGNS (WHERE DETERMINED) OF BARNHAM 80 HAVE BEEN    12/79
R2   E  CHANGED TO AGREE WITH THE CONVENTION OF LONGACRE 77.             12/79
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For notation, see key at front of Listings.

Baryons

Δ(1620), Δ(1700)

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R3     DELTA(1620) FROM N PI TO N RHO, S=1/2, S-WAVE     SQRT(P1*P6)
R3   A        0.18 OR -0.28          LONGACRE  75 IPWA    PI N TO 2PI N    11/75
R3   B      (-0.08)                  LONGACRE  77 IPWA    PI N TO 2PI N    11/77
R3   E       -0.40      0.10         BARNHAM   80 IPWA ++ PI N TO 2PI N    12/79

R4     DELTA(1620) FROM N PI TO N RHO, S=3/2, D-WAVE     SQRT(P1*P7)
R4   B      (+0.13)                  LONGACRE  77 IPWA    PI N TO 2PI N    11/77

R5     DELTA(1620) FROM N PI TO N(1440) PI               SQRT(P1*P8)
R5   E        0.11      0.05         BARNHAM   80 IPWA ++ PI N TO 2PI N    12/79

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                 82  DELTA(1620) PHOTON DECAY AMPLITUDES (GEV**-1/2)

       FOR DEFINITION OF GAMMA-NUCLEON DECAY AMPLITUDES, SEE MINI-
      REVIEW PRECEDING THE BARYON LISTINGS.

A1     DELTA(1620) INTO NUCLEON GAMMA, HELICITY=1/2 (GEV**-1/2)
A1          0.105     0.038          METCALF   74 DPWA    PI N PHOTOPROD.   2/74
A1         -0.005     0.016          FELLER    76 DPWA    PI N PHOTOPROD.   2/77
A1         -0.014     0.030          AZNAURYAN 77 DPWA    PIO PHTPRD,SOL 1 12/79
A1          0.000     0.014          AZNAURYAN 77 DPWA    PIO PHTPRD,SOL 2 12/79
A1         +0.034     0.028          BARBOUR   78 DPWA    PI-N PHOTOPROD.   3/79
A1         -0.022     0.007          ARAI      80 DPWA    PI N PHOTO FIT 1 12/81
A1         -0.026     0.008          ARAI      80 DPWA    PI N PHOTO FIT 2 12/81
A1          0.021     0.020          CRAWFORD  80 DPWA    PI N PHOTOPROD.  12/81
A1          0.126     0.021          TAKEDA    80 DPWA    PI N PHOTOPROD.  12/81
A1          0.010     0.015          AWAJI     81 DPWA    PI N PHOTOPROD.   1/84*
A1          0.035     0.010          CRAWFORD  83 IPWA    PI N PHOTOPROD.   1/84*

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                          REFERENCES FOR DELTA(1620)

CARRUTHE 60 PRL 4 303          P CARRUTHERS                          (CORN) I
DEVLIN   62 PR 125 690         T J DEVLIN, B J MOYER, V PEREZ-MENDEZ (LRL) I
BAREYRE  65 PL 18 342          + BRICMAN, STIRLING, VILLET          (SACL)IJP
DEVLIN   65 PRL 14 1031        T J DEVLIN,J SOLOMON,G BERTSCH       (PRIN) I

JOHNSON  67 UCRL-17683 THESIS C H JOHNSON                            (LRL)
BAREYRE  68 PR 165 1731        P BAREYRE, C BRICMAN, G VILLET       (SACL)IJP
DONNACH1 68 PL 26B 161         A DONNACHIE, R G KIRSOPP, C LOVELACE (CERN)IJP
    ALSO 68 VIENNA 139         DONNACHIE  RAPPORTEUR'S TALK         (GLAS)
    ALSO 68 THESIS             R G KIRSOPP                          (EDIN)

DONNACHI 69 NP 10B 433         A DONNACHIE, R KIRSOPP          (GLAS+EDIN)
AYED     70 KIEV CONF          R AYED,P BAREYRE, G VILLET           (SACL)IJP
AYED2    70 PL 31B 598         +BAREYRE,VILLET                      (SACL)
BOWLER   70 NP 17B 331         +CASHMORE                             (OXF)
DAVIES   70 NP B21 359         A DAVIES                             (GLAS)
ALMEHED  72 NP B40 157         +LOVELACE                       (LUND+RUTG)IJP
DEVENISH 73 PL 47B 53          DEVENISH,RANKIN,LYTH        (LOUC+BONN+LANC)IJP
HEMMI1   73 PL 43B 79          HEMMI,INAGAKI+              (KYOT+SAGA+KEK+TOKY)IJP
MOORHOUS 73 PL 43B 44          MOORHOUSE, OBERLACK             (GLAS+LBL)IJP

DEVENIS2 74 PL 52B 227         DEVENISH,LYTH,RANKIN        (DESY+LANC+BONN)IJP
KNIES    74 PR D9 2680         KNIES,MOORHOUSE,OBERLACK        (LBL+GLAS)IJP
METCALF  74 NP B76 253         W J METCALF,R L WALKER                (CIT)IJP
MOORHOUS 74 PR D9 1            MOORHOUSE,OBERLACK,ROSENFELD    (GLAS+LBL)IJP
CRAWFORD 75 NP B97 125         R L CRAWFORD                         (GLAS)IJP
DEANS    75 NP B96 90          +MITCHELL,MONTGOMERY,+          (SFLA+ALAH)IJP
KRIVETS  75 SJNP 20 430        +MIROSHNICHENKO,NIKIFOROV,SANIN+     (KIEV)IJP
    ALSO 74 SJNP 19 112        KRIVETS,NIKIFOROV,SANIN,SHALATSKII   (KIEV)IJP
LONGACRE 75 PL 55B 415         +ROSENFELD,LASINSKI,SMADJA+      (LBL+SLAC)IJP
    ALSO 78 PR D17 1795        LONGACRE,LASINSKI,ROSENFELD+     (LBL+SLAC)

AYED     76 CEA-N-1921         AYED (THESIS)                        (SACL)IJP
BARBOUR  76 NP B111 358        I M BARBOUR,R L CRAWFORD             (GLAS)IJP
FELLER   76 NP B104 219        +FUKUSHIMA,HORIKAWA,KAJIKAWA+   (NAGO+OSAK)IJP
AZNAURYA 77  EFI-264(57)-77    +AKOPOV,BAGDASARYAN                  (YERE)IJP
LONGACRE 77 NP B122 493        LONGACRE,DOLBEAU                     (SACL)IJP
    ALSO 76 NP B108 365        DOLBEAU,TRIANTIS,NEVEU,CADIET        (SACL)IJP
BARBOUR  78 NP B141 253        BARBOUR,CRAWFORD,PARSONS             (GLAS)
CUTKOSKY 79 PR D20 2839        +FORSYTH,HENDRICK,KELLY         (CARN+LBL)IJP
HOEHLER  79 HANDBOOK OF PI-N SCATTERING, PHYSIK DATEN VOL.12-1
                               +KAISER,KOCH,PIETARINEN              (KARL)IJP
    ALSO 80  TORONTO CONF 3    R KOCH                               (KARL)IJP

ARAI     80  TORONTO CONF 93   I ARAI                               (TOKY)
    ALSO 82 NP B194 251        I ARAI, H FUJII                      (TOKY)
BARNHAM  80 NP B168 243        BARNHAM,GLICKMAN,MIER-JEDRZEJOWICZ+  (LOIC)
CHEW     80  TORONTO CONF 123  D M CHEW                             (LBL)IJP
CRAWFORD 80  TORONTO CONF 107  R L CRAWFORD                         (GLAS)
CUTKOSKY 80  TORONTO CONF 19   +FORSYTH,BABCOCK,KELLY,HENDRICK  (CARN+LBL)IJP
TAKEDA   80 NP B168 17         TAKEDA,ARAI,FUJII,IKEDA,IWASAKI+     (TOKY)
AWAJI    81  BONN CONF 352     R KAJIKAWA (TALK)                    (NAGO)
    ALSO 82 NP B197 365        FUJII,HAYASHI,IWATA,KAJIKAWA+        (NAGO)
CRAWFORD 83 NP B211 1          R L CRAWFORD, W T MORTON             (GLAS)
HOEHLER  83 LANDOLT-BORNSTEIN VOL I 9B2      G HOEHLER              (KARL)
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Δ(1700) D'_{33} Status: ****

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                 10  DELTA(1700, JP=3/2-) I=3/2   D'33

                 MOST OF THE RESULTS PUBLISHED BEFORE 1975 ARE NOW
                 OBSOLETE AND HAVE BEEN OMITTED.  THEY MAY BE FOUND IN
                 OUR 1982 EDITION (PHYSICS LETTERS 111B).  HOWEVER,
                 ALL THE REFERENCES HAVE BEEN RETAINED.

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                 10  DELTA(1700) MASS (MEV)

M    A     1725. OR 1680.            LONGACRE  75 IPWA    PI N TO 2PI N    11/75
M    A  THE 2 SETS OF PARAMETERS ARE FROM METHODS 1 AND 2 OF LONGACRE 75.  11/75
M    B     (1600.0)                  LONGACRE  77 IPWA    PI N TO 2PI N    11/77
M    B  ALL LONGACRE77 PARAMETERS ARE FROM SOLUTION S2, EXCEPT FOR THE POLE 11/77
M    B  POSITION WHICH IS FROM SOLUTIONS S1 AND C1.                        11/77
M        (1629.0)                   BARBOUR   78 DPWA    PI-N PHOTOPROD.   3/79
M        (1730.0)    (30.0)         CUTKOSKY  79 IPWA    PI N TO PI N     12/79
M         1680.0      70.0          HOEHLER   79 IPWA    PI N TO PI N     12/79
M        (1650.0)                   BARNHAM   80 IPWA ++ PI N TO 2PI N    12/79
M    C   (1718.4)   (13.0)   (13.0) CHEW      80 BPWA ++ PI+P TO PI+P      1/82
M    C  PROBLEMS WITH THIS ANALYSIS ARE DISCUSSED IN SEC.2.1.11 OF         2/84*
M    C  HOEHLER 83.                                                        2/84*
M        (1622.0)                   CRAWFORD  80 DPWA    PI N PHOTOPROD.  12/81
M         1710.0      30.0          CUTKOSKY  80 IPWA    PI N TO PI N      1/82

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                 10  DELTA(1700) WIDTH (MEV)

W    A      190. OR  240.            LONGACRE  75 IPWA    PI N TO 2PI N    11/75
W    B     (200.0)                   LONGACRE  77 IPWA    PI N TO 2PI N    11/77
W          (216.0)                   BARBOUR   78 DPWA    PI-N PHOTOPROD.   3/79
W          (300.0)   (100.0)         CUTKOSKY  79 IPWA    PI N TO PI N     12/79
W           230.0      80.0          HOEHLER   79 IPWA    PI N TO PI N     12/79
W          (160.0)                   BARNHAM   80 IPWA ++ PI N TO 2PI N    12/79
W    C     (193.3)   (26.0)          CHEW      80 BPWA ++ PI+P TO PI+P      1/82
W          (209.0)                   CRAWFORD  80 DPWA    PI N PHOTOPROD.  12/81
W           280.0      80.0          CUTKOSKY  80 IPWA    PI N TO PI N      1/82

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                 10  DELTA(1700) REAL PART OF POLE POSITION (MEV)

RE         (1681.0)                  LONGACRE  75 IPWA    PI N TO 2PI N    11/75
RE   B      1600. OR 1594.           LONGACRE  77 IPWA    PI N TO 2PI N    11/77
RE         (1691.0)                  CUTKOSKY  79 IPWA    PI N TO PI N     12/79
RE          1675.0      25.0         CUTKOSKY  80 IPWA    PI N TO PI N      1/82

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                 10  DELTA(1700) -2*IMAG PART OF POLE POSITION (MEV)

IM         (245.0)                   LONGACRE  75 IPWA    PI N TO 2PI N    11/75
IM   B      208. OR 201.0            LONGACRE  77 IPWA    PI N TO 2PI N    11/77
IM         (292.0)                   CUTKOSKY  79 IPWA    PI N TO PI N     12/79
IM          220.0      40.0          CUTKOSKY  80 IPWA    PI N TO PI N      1/82

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                 10  DELTA(1700) REAL PART OF ELASTIC POLE RESIDUE (MEV)

RER         (24.0)                   CUTKOSKY  79 IPWA    PI N TO PI N     12/79
RER          12.0       3.0          CUTKOSKY  80 IPWA    PI N TO PI N      1/82

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                 10  DELTA(1700) IMAG PART OF ELASTIC POLE RESIDUE (MEV)

IMR         (-2.0)                   CUTKOSKY  79 IPWA    PI N TO PI N     12/79
IMR          -4.0       5.0          CUTKOSKY  80 IPWA    PI N TO PI N      1/82

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                 10  DELTA(1700) PARTIAL DECAY MODES

                                                          DECAY MASSES
P1     DELTA(1700) INTO N PI                              938+ 140
P2     DELTA(1700) INTO N PI PI                           938+ 140+ 140
P3     DELTA(1700) INTO SIGMA K                          1189+ 494
P4     DELTA(1700) INTO NUCLEON GAMMA, HELICITY=1/2       938+   0
P5     DELTA(1700) INTO NUCLEON GAMMA, HELICITY=3/2       938+   0
P6     DELTA(1700) INTO DELTA(1232) PI                   1232+ 140
P7     DELTA(1700) INTO DELTA(1232) PI, S-WAVE           1232+ 140
P8     DELTA(1700) INTO DELTA(1232) PI, D-WAVE           1232+ 140
P9     DELTA(1700) INTO N RHO, S=3/2, S-WAVE              938+ 769
P10    DELTA(1700) INTO N RHO, S=1/2, D-WAVE              938+ 769
P11    DELTA(1700) INTO N RHO, S=3/2, D-WAVE              938+ 769

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                 10  DELTA(1700) BRANCHING RATIOS

R1     DELTA(1700) INTO (N PI)/TOTAL                     (P1)
R1          (0.12)    (0.04)         CUTKOSKY  79 IPWA    PI N TO PI N     12/79
R1           0.20      0.03          HOEHLER   79 IPWA    PI N TO PI N     12/79
R1   C      (0.16)                   CHEW      80 BPWA ++ PI+P TO PI+P      1/82
R1           0.12      0.03          CUTKOSKY  80 IPWA    PI N TO PI N      1/82

R2     DELTA(1700) FROM N PI TO SIGMA K                  SQRT(P1*P3)
R2   D        0.001 TO 0.011         DEANS     75 DPWA    PI N TO K SIGMA  11/75
R2   D   RANGE GIVEN IS FROM FOUR BEST SOLUTIONS.                          11/75
R2   D   DEANS75 DISAGREES WITH PI+ P TO K+ SIGMA+ DATA OF WINNIK77         1/78
R2   D   AROUND 1920 MEV.                                                   1/78
R2            (.002)                  LIVANOS   80 DPWA    PI P TO K SIGMA   1/82

R3     DELTA(1700) FROM N PI TO DELTA(1232) PI, S-WAVE   SQRT(P1*P7)
R3   A       -0.25 OR -0.24           LONGACRE  75 IPWA    PI N TO 2PI N    11/75
R3   B      (-0.30)                   LONGACRE  77 IPWA    PI N TO 2PI N    11/77
R3   B   LONGACRE 77 CONSIDER THIS COUPLING TO BE WELL DETERMINED.
R3   E       -0.18      0.04          BARNHAM   80 IPWA ++ PI N TO 2PI N    12/79
R3   E  THE COUPLING SIGNS (WHERE DETERMINED) OF BARNHAM 80 HAVE BEEN       12/79
R3   E  CHANGED TO AGREE WITH THE CONVENTION OF LONGACRE 77.                12/79

R4     DELTA(1700) FROM N PI TO DELTA(1232) PI, D-WAVE   SQRT(P1*P8)
R4   A        0.  OR  -0.10           LONGACRE  75 IPWA    PI N TO 2PI N    11/75
R4   B      (-0.05)                   LONGACRE  77 IPWA    PI N TO 2PI N    11/77
R4   E        0.14      0.04          BARNHAM   80 IPWA ++ PI N TO 2PI N    12/79

R5     DELTA(1700) FROM N PI TO N RHO, S=3/2, S-WAVE     SQRT(P1*P9)
R5   A        0.20 OR +0.30           LONGACRE  75 IPWA    PI N TO 2PI N    11/75
R5   B      (-0.04)                   LONGACRE  77 IPWA    PI N TO 2PI N    11/77

R6     DELTA(1700) FROM N PI TO N RHO, S=1/2, D-WAVE     SQRT(P1*P10)
R6   E       -0.17      0.05          BARNHAM   80 IPWA ++ PI N TO 2PI N    12/79

R7     DELTA(1700) FROM N PI TO N RHO, S=3/2, D-WAVE     SQRT(P1*P11)
R7   E        0.18      0.07          BARNHAM   80 IPWA ++ PI N TO 2PI N    12/79

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                 10  DELTA(1700) PHOTON DECAY AMPLITUDES (GEV**-1/2)

       FOR DEFINITION OF GAMMA-NUCLEON DECAY AMPLITUDES, SEE MINI-
      REVIEW PRECEDING THE BARYON LISTINGS.

A1     DELTA(1700) INTO NUCLEON GAMMA, HELICITY=1/2 (GEV**-1/2)
A1           0.0      0.048          METCALF   74 DPWA    PI N PHOTOPROD.   2/74
A1          +0.072    0.033          FELLER    76 DPWA    PI N PHOTOPROD.   2/77
A1          +0.147    0.013          AZNAURYAN 77 DPWA    PIO PHTPRD,SOL 1 12/79
A1          +0.136    0.013          AZNAURYAN 77 DPWA    PIO PHTPRD,SOL 2 12/79
A1          +0.130    0.037          BARBOUR   78 DPWA    PI-N PHOTOPROD.   3/79
A1           0.112    0.006          ARAI      80 DPWA    PI N PHOTO FIT 1 12/81
A1           0.130    0.006          ARAI      80 DPWA    PI N PHOTO FIT 2 12/81
A1           0.123    0.022          CRAWFORD  80 DPWA    PI N PHOTOPROD.  12/81
A1           0.089    0.033          AWAJI     81 DPWA    PI N PHOTOPROD.   1/84*
A1           0.111    0.017          CRAWFORD  83 IPWA    PI N PHOTOPROD.   1/84*

A2     DELTA(1700) INTO NUCLEON GAMMA, HELICITY=3/2 (GEV**-1/2)
A2           0.0      0.041          METCALF   74 DPWA    PI N PHOTOPROD.   2/74
A2          +0.087    0.023          FELLER    76 DPWA    PI N PHOTOPROD.   2/77
A2          +0.053    0.003          AZNAURYAN 77 DPWA    PIO PHTPRD,SOL 1 12/79
A2          +0.022    0.003          AZNAURYAN 77 DPWA    PIO PHTPRD,SOL 2 12/79
A2          +0.098    0.036          BARBOUR   78 DPWA    PI-N PHOTOPROD.   3/79
A2           0.047    0.007          ARAI      80 DPWA    PI N PHOTO FIT 1 12/81
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Baryons
Δ(1700), Δ(1900), Δ(1905)

Data Card Listings

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A2          0.050    0.007        ARAI      80 DPWA    PI N PHOTO FIT 2 12/81
A2          0.102    0.015        CRAWFORD  80 DPWA    PI N PHOTOPROD.  12/81
A2          0.060    0.015        AWAJI     81 DPWA    PI N PHOTOPROD.   1/84*
A2          0.107    0.015        CRAWFORD  83 IPWA    PI N PHOTOPROD.   1/84*

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                          REFERENCES FOR DELTA(1700)

DONNACH1 68 PL 26B 161       A DONNACHIE, R G KIRSOPP, C LOVELACE (CERN)IJP
    ALSO 68 VIENNA 139       DONNACHIE  RAPPORTEUR'S TALK         (GLAS)
    ALSO 68 THESIS           R G KIRSOPP                          (EDIN)
DONNACHI 69 NP 10B 433       A DONNACHIE, R KIRSOPP          (GLAS+EDIN)

AYED     70 KIEV CONF        R AYED,P BAREYRE, G VILLET           (SACL)IJP
AYED2    70 PL 31B 598       +BAREYRE,VILLET                      (SACL)
BOWLER   70 NP 17B 331       +CASHMORE                             (OXF)
DAVIES   70 NP B21 359       A DAVIES                             (GLAS)
FEUERBAC 70 NP 16B 85        FEUERBACHER+HOLLADAY                 (VAND)

ALMEHED  72 NP B40 157       +LOVELACE                      (LUND+RUTG)IJP
DEVENISH 73 PL 47B 53        DEVENISH,RANKIN,LYTH       (LOUC+BONN+LANC)IJP
MOORHOUS 73 PL 43B 44        MOORHOUSE, OBERLACK             (GLAS+LBL)IJP

DEVENIS2 74 PL 52B 227       DEVENISH,LYTH,RANKIN       (DESY+LANC+BONN)IJP
KNIES    74 PR D9 2680       KNIES,MOORHOUSE,OBERLACK        (LBL+GLAS)IJP
METCALF  74 NP B76 253       W J METCALF,R L WALKER               (CIT)IJP
MOORHOUS 74 PR D9 1          MOORHOUSE,OBERLACK,ROSENFELD    (GLAS+LBL)IJP

CRAWFORD 75 NP B97 125       R L CRAWFORD                         (GLAS)IJP
DEANS    75 NP B96 90        +MITCHELL,MONTGOMERY,+          (SFLA+ALAH)IJP
GAIDOS   75 PR D12 2565      GAIDOS,MILLER                        (PURD)IJP
LONGACRE 75 PL 55B 415       +ROSENFELD,LASINSKI,SMADJA+     (LBL+SLAC)IJP
    ALSO 78 PR D17 1795      LONGACRE,LASINSKI,ROSENFELD+    (LBL+SLAC)

AYED     76 CEA-N-1921       AYED (THESIS)                        (SACL)IJP
BARBOUR  76 NP B111 358      I M BARBOUR,R L CRAWFORD             (GLAS)IJP
FELLER   76 NP B104 219      +FUKUSHIMA,HORIKAWA,KAJIKAWA+   (NAGO+OSAK)IJP

AZNAURYA 77  EFI-264(57)-77  +AKOPOV,BAGDASARYAN                  (YERE)IJP
LONGACRE 77 NP B122 493      LONGACRE,DOLBEAU                     (SACL)IJP
    ALSO 76 NP B108 365      DOLBEAU,TRIANTIS,NEVEU,CADIET        (SACL)IJP
WINNIK   77 NP B128 66       +TOAFF,REVEL,GOLDBERG,BERNY          (HAIF)I

BARBOUR  78 NP B141 253      BARBOUR,CRAWFORD,PARSONS             (GLAS)
CUTKOSKY 79 PR D20 2839      +FORSYTH,HENDRICK,KELLY         (CARN+LBL)IJP
HOEHLER  79 HANDBOOK OF PI-N SCATTERING, PHYSIK DATEN VOL.12-1
                             +KAISER,KOCH,PIETARINEN              (KARL)IJP
    ALSO 80  TORONTO CONF 3  R KOCH                               (KARL)IJP

ARAI     80  TORONTO CONF 93 I ARAI                               (TOKY)
    ALSO 82 NP B194 251      I ARAI, H FUJII                      (TOKY)
BARNHAM  80 NP B168 243      BARNHAM,GLICKMAN,MIER-JEDRZEJOWICZ+  (LOIC)
CHEW     80  TORONTO CONF 123 D M CHEW                            (LBL)IJP
CRAWFORD 80  TORONTO CONF 107 R L CRAWFORD                        (GLAS)
CUTKOSKY 80  TORONTO CONF 19  +FORSYTH,BABCOCK,KELLY,HENDRICK  (CARN+LBL)IJP
LIVANOS  80  TORONTO CONF 35  +BATON,COUTURES,KOCHOWSKI,NEVEU     (SACL)IJP

AWAJI    81  BONN CONF 352    R KAJIKAWA (TALK)                    (NAGO)
    ALSO 82 NP B197 365      FUJII,HAYASHII,IWATA,KAJIKAWA+       (NAGO)
CRAWFORD 83 NP B211 1        R L CRAWFORD, W T MORTON             (GLAS)
HOEHLER  83 LANDOLT-BORNSTEIN VOL I 9B2      G HOEHLER            (KARL)

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Δ(1900) S_{31}'' Status: ***

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                30  DELTA(1900, JP=1/2-) I=3/2   S''31

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                30  DELTA(1900) MASS (MEV)

M        (1850.0)   (35.0)          CUTKOSKY  79 IPWA    PI N TO PI N     12/79
M         1908.0     30.0          HOEHLER   79 IPWA    PI N TO PI N     12/79
M        (1918.5)   (23.0)          CHEW      80 BPWA ++ PI+P TO PI+P      1/82
M        (1803.0)                   CRAWFORD  80 DPWA    PI N PHOTOPROD.  12/81
M         1890.0     50.0          CUTKOSKY  80 IPWA    PI N TO PI N      1/82

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                30  DELTA(1900) WIDTH (MEV)

W        (130.0)   (40.0)          CUTKOSKY  79 IPWA    PI N TO PI N     12/79
W         140.0     40.0          HOEHLER   79 IPWA    PI N TO PI N     12/79
W         (93.5)   (54.0)          CHEW      80 BPWA ++ PI+P TO PI+P      1/82
W        (137.0)                   CRAWFORD  80 DPWA    PI N PHOTOPROD.  12/81
W         170.0     50.0          CUTKOSKY  80 IPWA    PI N TO PI N      1/82

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                30  DELTA(1900) REAL PART OF POLE POSITION  (MEV)

RE       (1844.0)                   CUTKOSKY  79 IPWA    PI N TO PI N     12/79
RE        1870.0     40.0          CUTKOSKY  80 IPWA    PI N TO PI N      1/82

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                30  DELTA(1900) -2*IMAG PART OF POLE POSITION  (MEV)

IM       (142.0)                    CUTKOSKY  79 IPWA    PI N TO PI N     12/79
IM        180.0     50.0          CUTKOSKY  80 IPWA    PI N TO PI N      1/82

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                30  DELTA(1900) REAL PART OF ELASTIC POLE RESIDUE (MEV)

RER        (7.0)                    CUTKOSKY  79 IPWA    PI N TO PI N     12/79
RER         9.0      4.0          CUTKOSKY  80 IPWA    PI N TO PI N      1/82

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                30  DELTA(1900) IMAG PART OF ELASTIC POLE RESIDUE (MEV)

IMR       (-1.0)                    CUTKOSKY  79 IPWA    PI N TO PI N     12/79
IMR         3.0      7.0          CUTKOSKY  80 IPWA    PI N TO PI N      1/82

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                30  DELTA(1900) PARTIAL DECAY MODES

                                                          DECAY MASSES
P1     DELTA(1900) INTO N PI                             938+ 140
P2     DELTA(1900) INTO SIGMA K                         1189+ 494

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                30  DELTA(1900) BRANCHING RATIOS

R1     DELTA(1900) INTO (N PI)/TOTAL                        (P1)
R1          (0.08)   (0.03)          CUTKOSKY  79 IPWA    PI N TO PI N     12/79
R1           0.08     0.04          HOEHLER   79 IPWA    PI N TO PI N     12/79
R1          (0.28)                   CHEW      80 BPWA ++ PI+P TO PI+P      1/82
R1           0.10     0.03          CUTKOSKY  80 IPWA    PI N TO PI N      1/82

R2     DELTA(1900) FROM N PI TO SIGMA K                  SQRT(P1*P2)
R2          (0.11)                   LANGBEIN  73 IPWA    PI N-K SIG,SOL 1  9/73
R2          (0.12)                   LANGBEIN  73 IPWA    PI N-K SIG,SOL 2  9/73
R2  A       (0.076)                  DEANS     75 DPWA    PI N TO K SIGMA  11/75
R2  A   VALUE GIVEN IS FROM SOLUTION 1, NOT PRESENT IN SOLUTIONS 2,3,4.    11/75

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                30  DELTA(1900) PHOTON DECAY AMPLITUDES (GEV**-1/2)

        FOR DEFINITION OF GAMMA-NUCLEON DECAY AMPLITUDES, SEE MINI-
      REVIEW PRECEDING THE BARYON LISTINGS.

A1     DELTA(1900) INTO NUCLEON GAMMA, HELICITY=1/2 (GEV**-1/2)
A1         -0.006 TO -0.025         CRAWFORD  80 DPWA    PI N PHOTOPROD.  12/81
A1          0.029     0.008         AWAJI     81 DPWA    PI N PHOTOPROD.   1/84*
A1         -0.004     0.016         CRAWFORD  83 IPWA    PI N PHOTOPROD.   1/84*
A1        . . . . . . . . . . .
A1  AVG     0.022     0.013   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.8)

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                          REFERENCES FOR DELTA(1900)

LANGBEIN 73 NP B53 251       LANGBEIN,WAGNER                      (MUNI)IJP
DEANS    75 NP B96 90        +MITCHELL,MONTGOMERY,+          (SFLA+ALAH)IJP
AYED     76 CEA-N-1921       AYED (THESIS)                        (SACL)IJP
WINNIK   77 NP B128 66       +TOAFF,REVEL,GOLDBERG,BERNY          (HAIF)I
CUTKOSKY 79 PR D20 2839      +FORSYTH,HENDRICK,KELLY         (CARN+LBL)IJP
HOEHLER  79 HANDBOOK OF PI-N SCATTERING, PHYSIK DATEN VOL.12-1
                             +KAISER,KOCH,PIETARINEN              (KARL)IJP
    ALSO 80  TORONTO CONF 3  R KOCH                               (KARL)IJP

CHEW     80  TORONTO CONF 123 D M CHEW                            (LBL)IJP
CRAWFORD 80  TORONTO CONF 107 R L CRAWFORD                        (GLAS)
CUTKOSKY 80  TORONTO CONF 19  +FORSYTH,BABCOCK,KELLY,HENDRICK  (CARN+LBL)IJP

AWAJI    81  BONN CONF 352    R KAJIKAWA (TALK)                    (NAGO)
    ALSO 82 NP B197 365      FUJII,HAYASHII,IWATA,KAJIKAWA+       (NAGO)
CRAWFORD 83 NP B211 1        R L CRAWFORD, W T MORTON             (GLAS)

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Δ(1905) F_{35} Status: ****

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                11  DELTA(1905, JP=5/2+) I=3/2   F35

                MOST OF THE RESULTS PUBLISHED BEFORE 1975 ARE NOW
                OBSOLETE AND HAVE BEEN OMITTED.  THEY MAY BE FOUND IN
                OUR 1982 EDITION (PHYSICS LETTERS 111B).  HOWEVER,
                ALL THE REFERENCES HAVE BEEN RETAINED.

    CUTKOSKY 80 ALSO FINDS WEAK EVIDENCE FOR A HIGHER MASS F35 RESONANCE
    IN ADDITION TO THIS STATE.  BOTH RESONANCES ARE LISTED HERE FOR NOW.

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                11  DELTA(1905) MASS (MEV)

M    A     1870. OR 1830.           LONGACRE  75 IPWA    PI N TO 2PI N    11/75
M    A  THE 2 SETS OF PARAMETERS ARE FROM METHODS 1 AND 2 OF LONGACRE 75.  11/75
M         (1892.0)                   BARBOUR   78 DPWA    PI-N PHOTOPROD.   3/79
M         (1920.0)   (30.0)          CUTKOSKY  79 IPWA    PI N TO PI N     12/79
M          1905.0     20.0          HOEHLER   79 IPWA    PI N TO PI N     12/79
M         (1787.0)    (6.0)    (5.7) CHEW      80 BPWA ++ PI+P TO PI+P      1/82
M         (1880.0)                   CRAWFORD  80 DPWA    PI N PHOTOPROD.  12/81
M    B     1910.0     30.0          CUTKOSKY  80 IPWA    PI N TO PI N      1/82
M    C     2200.0    125.0          CUTKOSKY  80 IPWA    PI N TO PI N      1/82
M   BC  CUTKOSKY 80 FINDS A HIGHER MASS F35 RESONANCE AS WELL AS THE ONE IN  1/82
M   BC  THIS MASS REGION.  THEY ARE LISTED HERE AS B AND C.                  1/82

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                11  DELTA(1905) WIDTH (MEV)

W    A      255. OR  220.           LONGACRE  75 IPWA    PI N TO 2PI N    11/75
W         (159.0)                   BARBOUR   78 DPWA    PI-N PHOTOPROD.   3/79
W         (340.0)   (80.0)          CUTKOSKY  79 IPWA    PI N TO PI N     12/79
W          260.0     20.0          HOEHLER   79 IPWA    PI N TO PI N     12/79
W           (66.0)  (24.0)   (16.0) CHEW      80 BPWA ++ PI+P TO PI+P      1/82
W         (193.0)                   CRAWFORD  80 DPWA    PI N PHOTOPROD.  12/81
W    B     400.0    100.0          CUTKOSKY  80 IPWA    PI N TO PI N      1/82
W    C     400.0    125.0          CUTKOSKY  80 IPWA    PI N TO PI N      1/82

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                11  DELTA(1905) REAL PART OF POLE POSITION (MEV)

RE       (1813.0)                   LONGACRE  75 IPWA    PI N TO 2PI N    11/75
RE       (1865.0)                   CUTKOSKY  79 IPWA    PI N TO PI N     12/79
RE   B    1830.0     40.0          CUTKOSKY  80 IPWA    PI N TO PI N      1/82
RE   C    2150.0    100.0          CUTKOSKY  80 IPWA    PI N TO PI N      1/82

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                11  DELTA(1905) -2*IMAG PART OF POLE POSITION (MEV)

IM        (193.0)                   LONGACRE  75 IPWA    PI N TO 2PI N    11/75
IM        (266.0)                   CUTKOSKY  79 IPWA    PI N TO PI N     12/79
IM   B    280.0     60.0          CUTKOSKY  80 IPWA    PI N TO PI N      1/82
IM   C    350.0    100.0          CUTKOSKY  80 IPWA    PI N TO PI N      1/82

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For notation, see key at front of Listings.

Baryons

Δ(1905), Δ(1910)

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                    11  DELTA(1905) REAL PART OF ELASTIC POLE RESIDUE (MEV)

RER          (20.0)                  CUTKOSKY  79 IPWA    PI N TO PI N     12/79
RER  B        16.0       8.0         CUTKOSKY  80 IPWA    PI N TO PI N      1/82
RER  C       -14.0      13.0         CUTKOSKY  80 IPWA    PI N TO PI N      1/82

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                    11  DELTA(1905) IMAG PART OF ELASTIC POLE RESIDUE (MEV)

IMR          (-5.0)                  CUTKOSKY  79 IPWA    PI N TO PI N     12/79
IMR  B       -19.0       8.0         CUTKOSKY  80 IPWA    PI N TO PI N      1/82
IMR  C         8.0      22.0         CUTKOSKY  80 IPWA    PI N TO PI N      1/82

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                    11  DELTA(1905) PARTIAL DECAY MODES

                                                          DECAY MASSES
P1      DELTA(1905) INTO N PI                            938+ 140
P2      DELTA(1905) INTO N PI PI                         938+ 140+ 140
P3      DELTA(1905) INTO SIGMA K                        1189+ 494
P4      DELTA(1905) INTO DELTA(1232) PI                 1232+ 140
P5      DELTA(1905) INTO NUCLEON GAMMA, HELICITY=1/2     938+   0
P6      DELTA(1905) INTO NUCLEON GAMMA, HELICITY=3/2     938+   0
P7      DELTA(1905) INTO N RHO                           938+ 769
P8      DELTA(1905) INTO DELTA(1232) PI, P-WAVE         1232+ 140
P9      DELTA(1905) INTO DELTA(1232) PI, F-WAVE         1232+ 140
P10     DELTA(1905) INTO N RHO, S=3/2, P-WAVE            938+ 769

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                    11  DELTA(1905) BRANCHING RATIOS

R1      DELTA(1905) INTO (N PI)/TOTAL                          (P1)
R1           (0.15)    (0.02)         CUTKOSKY  79 IPWA    PI N TO PI N     12/79
R1            0.15      0.02          HOEHLER   79 IPWA    PI N TO PI N     12/79
R1           (0.11)                   CHEW      80 BPWA ++ PI+P TO PI+P     1/82
R1   B        0.08      0.03          CUTKOSKY  80 IPWA    PI N TO PI N      1/82
R1   C        0.07      0.04          CUTKOSKY  80 IPWA    PI N TO PI N      1/82

R2      DELTA(1905) FROM N PI TO SIGMA K                     SQRT(P1*P3)
R2   D          0.021 TO 0.054        DEANS     75 DPWA    PI N TO K SIGMA  11/75
R2   D    RANGE GIVEN IS FROM FOUR BEST SOLUTIONS.                          11/75
R2          (-0.013)                  LIVANOS   80 DPWA    PI P TO K SIGMA   1/82

R3      DELTA(1905) FROM N PI TO DELTA(1232) PI, F-WAVE  SQRT(P1*P9)
R3   A        -0.12 OR -0.20          LONGACRE  75 IPWA    PI N TO 2PI N    11/75
R3   E       (-0.17)                  NOVOSELLE 78 IPWA    PI N TO 2PI N     3/79
R3   E   BW FIT TO LONGACRE 75 IPWA.                                         3/79
R3   F       (-0.06)                  NOVOSELLE 78 IPWA    PI N TO 2PI N     3/79
R3   F   BW FIT TO NOVOSELLER 78 IPWA.                                       3/79

R4      DELTA(1905) FROM N PI TO N RHO, S=3/2, P-WAVE    SQRT(P1*P10)
R4   A        -0.28 OR -0.33          LONGACRE  75 IPWA    PI N TO 2PI N    11/75
R4   E       (-0.26)                  NOVOSELLE 78 IPWA    PI N TO 2PI N     3/79
R4   G        -0.11 TO -0.33          NOVOSELLE 78 IPWA    PI N TO 2PI N     3/79
R4   G   BW FIT TO NOVOSELLER 78 IPWA, PHASE IS NEAR 90 DEGREES.             12/79

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                    11  DELTA(1905) PHOTON DECAY AMPLITUDES (GEV**-1/2)

        FOR DEFINITION OF GAMMA-NUCLEON DECAY AMPLITUDES, SEE MINI-
      REVIEW PRECEDING THE BARYON LISTINGS.

A1      DELTA(1905) INTO NUCLEON GAMMA, HELICITY=1/2 (GEV**-1/2)
A1           +0.047    0.067          METCALF   74 DPWA    PI N PHOTOPROD.   2/74
A1           -0.001    0.012          AZNAURYAN 77 DPWA    PI0 PHTPRD,SOL 1 12/79
A1           +0.063    0.018          AZNAURYAN 77 DPWA    PI0 PHTPRD,SOL 2 12/79
A1           +0.033    0.018          BARBOUR   78 DPWA    PI-N PHOTOPROD.   3/79
A1            0.022    0.010          ARAI      80 DPWA    PI N PHOTO FIT 1 12/81
A1            0.031    0.009          ARAI      80 DPWA    PI N PHOTO FIT 2 12/81
A1            0.024    0.014          CRAWFORD  80 DPWA    PI N PHOTOPROD.  12/81
A1            0.043    0.020          AWAJI     81 DPWA    PI N PHOTOPROD.   1/84*
A1            0.021    0.010          CRAWFORD  83 IPWA    PI N PHOTOPROD.   1/84*

A2      DELTA(1905) INTO NUCLEON GAMMA, HELICITY=3/2 (GEV**-1/2)
A2           -0.028    0.066          METCALF   74 DPWA    PI N PHOTOPROD.   2/74
A2           -0.094    0.027          AZNAURYAN 77 DPWA    PI0 PHTPRD,SOL 1 12/79
A2           -0.101    0.018          AZNAURYAN 77 DPWA    PI0 PHTPRD,SOL 2 12/79
A2           -0.055    0.019          BARBOUR   78 DPWA    PI-N PHOTOPROD.   3/79
A2           -0.029    0.007          ARAI      80 DPWA    PI N PHOTO FIT 1 12/81
A2           -0.045    0.006          ARAI      80 DPWA    PI N PHOTO FIT 2 12/81
A2           -0.072    0.035          CRAWFORD  80 DPWA    PI N PHOTOPROD.  12/81
A2           -0.025    0.023          AWAJI     81 DPWA    PI N PHOTOPROD.   1/84*
A2           -0.056    0.028          CRAWFORD  83 IPWA    PI N PHOTOPROD.   1/84*

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                          REFERENCES FOR DELTA(1905)

DONNACH1 68 PL 26B 161          A DONNACHIE, R G KIRSOPP, C LOVELACE (CERN)IJP
    ALSO 68 VIENNA 139          DONNACHIE  RAPPORTEUR'S TALK         (GLAS)
    ALSO 68 THESIS              R G KIRSOPP                          (EDIN)

AYED     70 KIEV CONF           R AYED,P BAREYRE, G VILLET           (SACL)IJP
AYED2    70 PL 31B 598          +BAREYRE,VILLET                      (SACL)
DAVIES   70 NP B11 359          A DAVIES                             (GLAS)
FEUERBAC 70 NP 16B 85           FEUERBACHER+HOLLADAY                 (VAND)
KALMUS   70 PR D2 1824          G KALMUS, G BORREANI, J LOUIE         (LRL)

ALMEHED  72 NP B40 157          +LOVELACE                       (LUND+RUTG)IJP
MEHTANI  72 PRL 29 1634         +FUNG, KERNAN, SCHALK, +          (UCR +LBL)
LANGBEIN 73 NP B53 251          LANGBEIN,WAGNER                     (MUNI)IJP
DEVENIS2 74 PL 52B 227          DEVENISH,LYTH,RANKIN        (DESY+LANC+BONN)IJP
KNIES    74 PR D9 2680          KNIES,MOORHOUSE,OBERLACK          (LBL+GLAS)IJP
METCALF  74 NP B76 253          W J METCALF,R L WALKER                (CIT)IJP

CRAWFORD 75 NP B97 125          R L CRAWFORD                         (GLAS)IJP
DEANS    75 NP B96 90           +MITCHELL,MONTGOMERY,+            (SFLA+ALAM)IJP
LONGACRE 75 PL 55B 415          +ROSENFELD,LASINSKI,SMADJA+        (LBL+SLAC)IJP
    ALSO 78 PR D17 1795         LONGACRE,LASINSKI,ROSENFELD+       (LBL+SLAC)

AYED     76 CEA-N-1921          AYED (THESIS)                        (SACL)IJP
BARBOUR  76 NP B111 358         I M BARBOUR,R L CRAWFORD             (GLAS)IJP
CUTKOSKY 76 PRL 37 645          CUTKOSKY,HENDRICK,KELLY           (CARN+LBL)IJP
    ALSO 76 OXFORD CONF. 49     CUTKOSKY,HENDRICK,CHAO+      (CARN+LBL+BRIS)IJP
AZNAURYA 77  EFI-264(57)-77     +AKOPOV,BAGDASARYAN                  (YERE)IJP
WINNIK   77 NP B128 66          +TOAFF,REVEL,GOLDBERG,BERNY          (HAIF)I

BARBOUR  78 NP B141 253         BARBOUR,CRAWFORD,PARSONS             (GLAS)
NOVOSELL 78 NP B137 509         D E NOVOSELLER                        (CIT)IJP
    ALSO 78 NP B137 445         D E NOVOSELLER                        (CIT)IJP
CUTKOSKY 79 PR D20 2839         +FORSYTH,HENDRICK,KELLY          (CARN+LBL)IJP
HOEHLER  79 HANDBOOK OF PI-N SCATTERING, PHYSIK DATEN VOL.12-1
                                +KAISER,KOCH,PIETARINEN              (KARL)IJP
    ALSO 80  TORONTO CONF 3     R KOCH                               (KARL)IJP

ARAI     80  TORONTO CONF 93    I ARAI                               (TOKY)
    ALSO 82 NP B194 251         I ARAI, H FUJII                      (TOKY)
CHEW     80  TORONTO CONF 123 D M CHEW                                (LBL)IJP
CRAWFORD 80  TORONTO CONF 107 R L CRAWFORD                            (GLAS)
CUTKOSKY 80  TORONTO CONF 19  +FORSYTH,BABCOCK,KELLY,HENDRICK  (CARN+LBL)IJP
LIVANOS  80  TORONTO CONF 35  +BATON,COUTURES,KOCHOWSKI,NEVEU        (SACL)IJP

AWAJI    81  BONN CONF 352     R KAJIKAWA (TALK)                    (NAGO)
    ALSO 82 NP B197 365         FUJII,HAYASHII,IWATA,KAJIKAWA+       (NAGO)
CRAWFORD 83 NP B211 1           R L CRAWFORD, W T MORTON             (GLAS)

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Δ(1910) P_{31}'' Status: ****

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                    12  DELTA(1910, JP=1/2+) I=*/2   P''31

                    MOST OF THE RESULTS PUBLISHED BEFORE 1975 ARE NOW
                    OBSOLETE AND HAVE BEEN OMITTED.  THEY MAY BE FOUND IN
                    OUR 1982 EDITION (PHYSICS LETTERS 111B).  HOWEVER,
                    ALL THE REFERENCES HAVE BEEN RETAINED.

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                    12  DELTA(1910) MASS (MEV)

M    A     (1790.0)                  LONGACRE  77 IPWA    PI N TO 2PI N    11/77
M    A   ALL LONGACRE77 PARAMETERS ARE FROM SOLUTION S2, EXCEPT FOR THE POLE 11/77
M    A   POSITION WHICH IS FROM SOLUTIONS S1 AND C1.                       11/77
M         (1899.0)                  BARBOUR   78 DPWA    PI-N PHOTOPROD.   3/79
M         (1920.0)   (50.0)         CUTKOSKY  79 IPWA    PI N TO PI N     12/79
M          1888.0     20.0          HOEHLER   79 IPWA    PI N TO PI N     12/79
M    B     (1715.2)   (21.0)         CHEW      80 BPWA ++ PI+P TO PI+P     1/82
M    C     (1778.4)    (9.0)         CHEW      80 BPWA ++ PI+P TO PI+P     1/82
M    D     (1960.1)   (21.0)         CHEW      80 BPWA ++ PI+P TO PI+P     1/82
M    E     (2121.4)   (13.0)   (14.3) CHEW     80 BPWA ++ PI+P TO PI+P     1/82
M   BC   CHEW 80 REPORTS FOUR RESONANCES IN THE P31 WAVE.  ALL ARE LISTED  2/84*
M   DE   HERE LABELED B-E.  PROBLEMS WITH THIS ANALYSIS ARE DISCUSSED IN   2/84*
M   DE   SEC.2.1.11 OF HOEHLER 83.                                         2/84*
M         (1921.0)                  CRAWFORD  80 DPWA    PI N PHOTOPROD.  12/81
M          1910.0     40.0          CUTKOSKY  80 IPWA    PI N TO PI N      1/82

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                    12  DELTA(1910) WIDTH (MEV)

W    A     (170.0)                   LONGACRE  77 IPWA    PI N TO 2PI N    11/77
W          (230.0)                   BARBOUR   78 DPWA    PI-N PHOTOPROD.   3/79
W          (300.0)   (100.0)         CUTKOSKY  79 IPWA    PI N TO PI N     12/79
W           280.0     50.0           HOEHLER   79 IPWA    PI N TO PI N     12/79
W    B      (93.3)    (55.0)         CHEW      80 BPWA ++ PI+P TO PI+P     1/82
W    C      (23.0)    (29.0)         CHEW      80 BPWA ++ PI+P TO PI+P     1/82
W    D     (152.9)    (60.0)         CHEW      80 BPWA ++ PI+P TO PI+P     1/82
W    E     (172.2)    (37.0)         CHEW      80 BPWA ++ PI+P TO PI+P     1/82
W          (351.0)                   CRAWFORD  80 DPWA    PI N PHOTOPROD.  12/81
W           225.0     50.0           CUTKOSKY  80 IPWA    PI N TO PI N      1/82

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                    12  DELTA(1910) REAL PART OF POLE POSITION (MEV)

RE   A    1792. OR 1801.0             LONGACRE  77 IPWA    PI N TO 2PI N    11/77
RE        (1871.0)                    CUTKOSKY  79 IPWA    PI N TO PI N     12/79
RE         1880.0     30.0            CUTKOSKY  80 IPWA    PI N TO PI N      1/82

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                    12  DELTA(1910) -2*IMAG PART OF POLE POSITION (MEV)

IM   A     172.  OR 165.              LONGACRE  77 IPWA    PI N TO 2PI N    11/77
IM        (200.0)                     CUTKOSKY  79 IPWA    PI N TO PI N     12/79
IM         200.0     40.0             CUTKOSKY  80 IPWA    PI N TO PI N      1/82

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                    12  DELTA(1910) REAL PART OF ELASTIC POLE RESIDUE (MEV)

RER        (-0.6)                     CUTKOSKY  79 IPWA    PI N TO PI N     12/79
RER          0.0     10.0             CUTKOSKY  80 IPWA    PI N TO PI N      1/82

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                    12  DELTA(1910) IMAG PART OF ELASTIC POLE RESIDUE (MEV)

IMR       (-18.0)                     CUTKOSKY  79 IPWA    PI N TO PI N     12/79
IMR        -20.0      4.0             CUTKOSKY  80 IPWA    PI N TO PI N      1/82

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                    12  DELTA(1910) PARTIAL DECAY MODES

                                                          DECAY MASSES
P1      DELTA(1910) INTO N PI                            938+ 140
P2      DELTA(1910) INTO N PI PI                         938+ 140+ 140
P3      DELTA(1910) INTO SIGMA K                        1189+ 494
P4      DELTA(1910) INTO DELTA(1232) PI                 1232+ 140
P5      DELTA(1910) INTO NUCLEON GAMMA, HELICITY=1/2     938+   0
P6      DELTA(1910) INTO N RHO,S=*/2                     938+ 769

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                    12  DELTA(1910) BRANCHING RATIOS

R1      DELTA(1910) INTO (N PI)/TOTAL                          (P1)
R1           (0.19)    (0.04)         CUTKOSKY  79 IPWA    PI N TO PI N     12/79
R1            0.24      0.06          HOEHLER   79 IPWA    PI N TO PI N     12/79
R1   B       (0.18)                   CHEW      80 BPWA ++ PI+P TO PI+P     1/82
R1   C       (0.20)                   CHEW      80 BPWA ++ PI+P TO PI+P     1/82
R1   D       (0.17)                   CHEW      80 BPWA ++ PI+P TO PI+P     1/82
R1   E       (0.40)                   CHEW      80 BPWA ++ PI+P TO PI+P     1/82
R1            0.19      0.03          CUTKOSKY  80 IPWA    PI N TO PI N      1/82

R2      DELTA(1910) FROM N PI TO SIGMA K                     SQRT(P1*P3)
R2   F         0.082 TO 0.184         DEANS     75 DPWA    PI N TO K SIGMA  11/75
R2   F   RANGE GIVEN IS FROM FOUR BEST SOLUTIONS.                          11/75
R2          (-0.019)                  LIVANOS   80 DPWA    PI P TO K SIGMA   1/82
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Baryons

Δ(1910), Δ(1920), Δ(1930)

Data Card Listings

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R3      DELTA(1910) FROM N PI TO DELTA(1232) PI          SQRT(P1*P4)
R3  A        (-0.06)                LONGACRE  77 IPWA    PI N TO 2PI N     11/77

R4      DELTA(1910) FROM N PI TO N RHO, S=3/2            SQRT(P1*P6)
R4  A        (-0.29)                LONGACRE  77 IPWA    PI N TO 2PI N     11/77
R4   G       (-0.17)                NOVOSELLE 78 IPWA    PI N TO 2PI N      3/79
R4   G  EVIDENCE FOR THIS COUPLING IS WEAK, SEE NOVOSELLER 78. THIS        12/79
R4   G  COUPLING ASSUMES THE MASS IS NEAR 1820 MEV.                        12/79

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                12  DELTA(1910) PHOTON DECAY AMPLITUDES (GEV**-1/2)

      FOR DEFINITION OF GAMMA-NUCLEON DECAY AMPLITUDES, SEE MINI-
    REVIEW PRECEDING THE BARYON LISTINGS.

A1      DELTA(1910) INTO NUCLEON GAMMA, HELICITY=1/2 (GEV**-1/2)
A1          -0.032    0.065        METCALF   74 DPWA    PI N PHOTOPROD.    2/74
A1          +0.040    0.013        AZNAURYAN 77 DPWA    PIO PHTPRD,SOL 1 12/79
A1          +0.039    0.012        AZNAURYAN 77 DPWA    PIO PHTPRD,SOL 2 12/79
A1          -0.035    0.021        BARBOUR   78 DPWA    PI-N PHOTOPROD.    3/79
A1          -0.012    0.005        ARAI      80 DPWA    PI N PHOTO FIT 1 12/81
A1          -0.031    0.004        ARAI      80 DPWA    PI N PHOTO FIT 2 12/81
A1          -0.005    0.030        CRAWFORD  80 DPWA    PI N PHOTOPROD.   12/81
A1           0.025    0.011        AWAJI     81 DPWA    PI N PHOTOPROD.    1/84*
A1           0.014    0.030        CRAWFORD  83 IPWA    PI N PHOTOPROD.    1/84*

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                          REFERENCES FOR DELTA(1910)

CARYANN  65 PR 138 B433        CARAYANNOPOULOS,TAUTFEST,WILLMANN    (PURD)
DONNACH1 68 PL 26B 161         A DONNACHIE, R G KIRSOPP, C LOVELACE (CERN)IJP
    ALSO 68 VIENNA 139         DONNACHIE  RAPPORTEUR'S TALK         (GLAS)
    ALSO 68 THESIS             R G KIRSOPP                          (EDIN)
AYED     70 KIEV CONF          R AYED,P BAREYRE, G VILLET           (SACL)IJP
AYED2    70 PL 31B 598         +BAREYRE,VILLET                      (SACL)
DAVIES   70 NP B21 359         A DAVIES                             (GLAS)
FEUERBAC 70 NP 16B 85          FEUERBACHER+HOLLADAY                 (VAND)
ALMEHED  72 NP B40 157         +LOVELACE                       (LUND+RUTG)IJP
LANGBEIN 73 NP B53 251         LANGBEIN,WAGNER                      (MUNI)IJP

DEVENIS2 74 PL 52B 227         DEVENISH,LYTH,RANKIN        (DESY+LANC+BONN)IJP
KNIES    74 PR D9 2680         KNIES,MOORHOUSE,OBERLACK          (LBL+GLAS)IJP
METCALF  74 NP B76 253         W J METCALF,R L WALKER                (CIT)IJP
CRAWFORD 75 NP B97 125         R L CRAWFORD                         (GLAS)IJP
DEANS    75 NP B96 90          +MITCHELL,MONTGOMERY,+           (SFLA+ALAH)IJP
AYED     76 CEA-N-1921         AYED (THESIS)                        (SACL)IJP
BARBOUR  76 NP B111 358        I M BARBOUR,R L CRAWFORD             (GLAS)IJP
CUTKOSKY 76 PRL 37 645         CUTKOSKY,HENDRICK,KELLY          (CARN+LBL)IJP
    ALSO 76 OXFORD CONF. 49    CUTKOSKY,HENDRICK,CHAO+      (CARN+LBL+BRIS)IJP

AZNAURYA 77  EFI-264(57)-77    +AKOPOV,BAGDASARYAN                  (YERE)IJP
LONGACRE 77 NP B122 493        LONGACRE,DOLBEAU                     (SACL)IJP
    ALSO 76 NP B108 365        DOLBEAU,TRIANTIS,NEVEU,CADIET        (SACL)IJP
WINNIK   77 NP B128 66         +TOAFF,REVEL,GOLDBERG,BERNY          (HAIF)I
BARBOUR  78 NP B141 253        BARBOUR,CRAWFORD,PARSONS             (GLAS)
NOVOSELL 78 NP B137 509        D E NOVOSELLER                        (CIT)IJP
    ALSO 78 NP B137 445        D E NOVOSELLER                        (CIT)IJP
CUTKOSKY 79 PR D20 2839        +FORSYTH,HENDRICK,KELLY          (CARN+LBL)IJP
HOEHLER  79 HANDBOOK OF PI-N SCATTERING, PHYSIK DATEN VOL.12-1
                               +KAISER,KOCH,PIETARINEN              (KARL)IJP
    ALSO 80  TORONTO CONF 3    R KOCH                               (KARL)IJP

ARAI     80  TORONTO CONF 93   I ARAI                               (TOKY)
    ALSO 82 NP B194 251        I ARAI, H FUJII                      (TOKY)
CHEW     80  TORONTO CONF 123 D M CHEW                              (LBL)IJP
CRAWFORD 80  TORONTO CONF 107 R L CRAWFORD                          (GLAS)
CUTKOSKY 80  TORONTO CONF 19  +FORSYTH,BABCOCK,KELLY,HENDRICK  (CARN+LBL)IJP
LIVANOS  80  TORONTO CONF 35  +BATON,COUTURES,KOCHOWSKI,NEVEU      (SACL)IJP

AWAJI    81  BONN CONF 352     R KAJIKAWA (TALK)                    (NAGO)
    ALSO 82 NP B197 365        FUJII,HAYASHI,IWATA,KAJIKAWA+        (NAGO)
CRAWFORD 83 NP B211 1          R L CRAWFORD, W T MORTON             (GLAS)
HOEHLER  83 LANDOLT-BORNSTEIN VOL I 9B2      G HOEHLER              (KARL)

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Δ(1920) P'''_{33} Status: ***

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                117  DELTA(1920, JP=3/2+) I=3/2   P'''33

                MOST OF THE RESULTS PUBLISHED BEFORE 1975 ARE NOW
                OBSOLETE AND HAVE BEEN OMITTED.  THEY MAY BE FOUND IN
                OUR 1982 EDITION (PHYSICS LETTERS 111B).  HOWEVER,
                ALL THE REFERENCES HAVE BEEN RETAINED.

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                117  DELTA(1920) MASS  (MEV)

M          (1960.0)   (80.0)            CUTKOSKY  79 IPWA    PI N TO PI N     12/79
M           1868.0     10.0             HOEHLER   79 IPWA    PI N TO PI N     12/79
M    A     (1955.0)   (13.0)            CHEW      80 BPWA ++ PI+P TO PI+P     1/82
M    B     (2065.0)   (13.6)   (12.9)   CHEW      80 BPWA ++ PI+P TO PI+P     1/82
M   AB  CHEW 80 REPORTS TWO P33 RESONANCES IN THIS MASS REGION.  BOTH ARE     2/84*
M   AB  LISTED HERE, LABELED A AND B.  PROBLEMS WITH THIS ANALYSIS ARE        2/84*
M   AB  DISCUSSED IN SEC.2.1.11 OF HOEHLER 83.                                2/84*
M           1920.0     80.0             CUTKOSKY  80 IPWA    PI N TO PI N     1/82

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                117  DELTA(1920) WIDTH  (MEV)

W          (300.0)  (100.0)             CUTKOSKY  79 IPWA    PI N TO PI N     12/79
W           220.0     80.0              HOEHLER   79 IPWA    PI N TO PI N     12/79
W    A      (88.3)   (35.0)             CHEW      80 BPWA ++ PI+P TO PI+P     1/82
W    B      (62.0)   (44.0)             CHEW      80 BPWA ++ PI+P TO PI+P     1/82
W           300.0    100.0              CUTKOSKY  80 IPWA    PI N TO PI N     1/82

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                117  DELTA(1920) REAL PART OF POLE POSITION  (MEV)

RE         (1933.0)                     CUTKOSKY  79 IPWA    PI N TO PI N     12/79
RE          1900.0     80.0              CUTKOSKY  80 IPWA    PI N TO PI N     1/82

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                117  DELTA(1920) -2*IMAG PART OF POLE POSITION  (MEV)

IM         (280.0)                      CUTKOSKY  79 IPWA    PI N TO PI N     12/79
IM          300.0    100.0              CUTKOSKY  80 IPWA    PI N TO PI N     1/82

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                117  DELTA(1920) REAL PART OF ELASTIC POLE RESIDUE (MEV)

RER        (-10.0)                      CUTKOSKY  79 IPWA    PI N TO PI N     12/79
RER         -21.0      7.0              CUTKOSKY  80 IPWA    PI N TO PI N     1/82

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                117  DELTA(1920) IMAG PART OF ELASTIC POLE RESIDUE (MEV)

IMR        (-27.0)                      CUTKOSKY  79 IPWA    PI N TO PI N     12/79
IMR         -12.0     11.0              CUTKOSKY  80 IPWA    PI N TO PI N     1/82

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                117  DELTA(1920) PARTIAL DECAY MODES

                                                          DECAY MASSES
P1      DELTA(1920) INTO N PI                            938+ 140
P2      DELTA(1920) INTO SIGMA K                        1189+ 494

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                117  DELTA(1920) BRANCHING RATIOS

R1      DELTA(1920) INTO (N PI)/TOTAL                        (P1)
R1          (0.17)   (0.04)              CUTKOSKY  79 IPWA    PI N TO PI N     12/79
R1           0.14     0.04               HOEHLER   79 IPWA    PI N TO PI N     12/79
R1   A      (0.24)                       CHEW      80 BPWA ++ PI+P TO PI+P     1/82
R1   B      (0.18)                       CHEW      80 BPWA ++ PI+P TO PI+P     1/82
R1           0.20     0.05               CUTKOSKY  80 IPWA    PI N TO PI N     1/82

R2      DELTA(1920) FROM N PI TO SIGMA K                     SQRT(P1*P2)
R2   C          0.048 TO 0.120           DEANS     75 DPWA    PI N TO K SIGMA  11/75
R2   C   RANGE GIVEN IS FROM FOUR BEST SOLUTIONS.                             11/75
R2         (-0.049)                     LIVANOS   80 DPWA    PI P TO K SIGMA  1/82

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                117  DELTA(1920) PHOTON DECAY AMPLITUDES (GEV**-1/2)

      FOR DEFINITION OF GAMMA-NUCLEON DECAY AMPLITUDES, SEE MINI-
    REVIEW PRECEDING THE BARYON LISTINGS.

A1      DELTA(1920) INTO NUCLEON GAMMA, HELICITY=1/2 (GEV**-1/2)
A1           0.040    0.014             AWAJI     81 DPWA    PI N PHOTOPROD.  1/84*

A2      DELTA(1920) INTO NUCLEON GAMMA, HELICITY=3/2 (GEV**-1/2)
A2           0.023    0.017             AWAJI     81 DPWA    PI N PHOTOPROD.  1/84*

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                          REFERENCES FOR DELTA(1920)

KIRSOPP  68 THESIS             R G KIRSOPP                          (EDIN)
ROYCHOUD 71 NP B27 125         R K ROYCHOUDHURY,B H BRANSDEN        (DURH)IJP
ALMEHED  72 NP B40 157         +LOVELACE                       (LUND+RUTG)IJP
LANGBEIN 73 NP B53 251         LANGBEIN,WAGNER                      (MUNI)IJP
DEANS    75 NP B96 90          +MITCHELL,MONTGOMERY,+           (SFLA+ALAH)IJP
CUTKOSKY 79 PR D20 2839        +FORSYTH,HENDRICK,KELLY          (CARN+LBL)IJP
HOEHLER  79 HANDBOOK OF PI-N SCATTERING, PHYSIK DATEN VOL.12-1
                               +KAISER,KOCH,PIETARINEN              (KARL)IJP
    ALSO 80  TORONTO CONF 3    R KOCH                               (KARL)IJP

CHEW     80  TORONTO CONF 123 D M CHEW                              (LBL)IJP
CUTKOSKY 80  TORONTO CONF 19  +FORSYTH,BABCOCK,KELLY,HENDRICK  (CARN+LBL)IJP
LIVANOS  80  TORONTO CONF 35  +BATON,COUTURES,KOCHOWSKI,NEVEU      (SACL)IJP
AWAJI    81  BONN CONF 352     R KAJIKAWA (TALK)                    (NAGO)
    ALSO 82 NP B197 365        FUJII,HAYASHI,IWATA,KAJIKAWA+        (NAGO)
HOEHLER  83 LANDOLT-BORNSTEIN VOL I 9B2      G HOEHLER              (KARL)

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Δ(1930) D'_{35} Status: ***

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                13  DELTA(1930, JP=5/2-) I=3/2   D'35

                MOST OF THE RESULTS PUBLISHED BEFORE 1975 ARE NOW
                OBSOLETE AND HAVE BEEN OMITTED.  THEY MAY BE FOUND IN
                OUR 1982 EDITION (PHYSICS LETTERS 111B).  HOWEVER,
                ALL THE REFERENCES HAVE BEEN RETAINED.

    THE AGREEMENT AMONG THE VARIOUS ANALYSES IS NOT VERY GOOD.

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                13  DELTA(1930) MASS (MEV)

M          (2024.0)                     BARBOUR   78 DPWA    PI-N PHOTOPROD.  3/79
M          (1930.0)   (20.0)            CUTKOSKY  79 IPWA    PI N TO PI N     12/79
M           1901.0     15.0             HOEHLER   79 IPWA    PI N TO PI N     12/79
M          (1910.0)   (15.0)   (17.2)   CHEW      80 BPWA ++ PI+P TO PI+P     1/82
M          (2000.0)                     CRAWFORD  80 DPWA    PI N PHOTOPROD.  12/81
M           1940.0     30.0             CUTKOSKY  80 IPWA    PI N TO PI N     1/82

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                13  DELTA(1930) WIDTH (MEV)

W          (462.0)                      BARBOUR   78 DPWA    PI-N PHOTOPROD.  3/79
W          (280.0)   (90.0)             CUTKOSKY  79 IPWA    PI N TO PI N     12/79
W           195.0     60.0              HOEHLER   79 IPWA    PI N TO PI N     12/79
W           (74.8)   (17.0)   (16.0)    CHEW      80 BPWA ++ PI+P TO PI+P     1/82
W          (442.0)                      CRAWFORD  80 DPWA    PI N PHOTOPROD.  12/81
W           320.0     60.0              CUTKOSKY  80 IPWA    PI N TO PI N     1/82

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                13  DELTA(1930) REAL PART OF POLE POSITION (MEV)

RE         (1908.0)                     CUTKOSKY  79 IPWA    PI N TO PI N     12/79
RE          1890.0     50.0              CUTKOSKY  80 IPWA    PI N TO PI N     1/82

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                13  DELTA(1930) -2*IMAG PART OF POLE POSITION (MEV)

IM         (226.0)                      CUTKOSKY  79 IPWA    PI N TO PI N     12/79
IM          260.0     60.0              CUTKOSKY  80 IPWA    PI N TO PI N     1/82

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                13  DELTA(1930) REAL PART OF ELASTIC POLE RESIDUE (MEV)

RER        (13.0)                       CUTKOSKY  79 IPWA    PI N TO PI N     12/79
RER         17.0      7.0              CUTKOSKY  80 IPWA    PI N TO PI N     1/82

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For notation, see key at front of Listings.

Baryons

Δ(1930), Δ(1940), Δ(1950)

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                    13  DELTA(1930) IMAG PART OF ELASTIC POLE RESIDUE (MEV)

IMR          (2.0)                  CUTKOSKY  79 IPWA    PI N TO PI N     12/79
IMR          -6.0      12.0         CUTKOSKY  80 IPWA    PI N TO PI N      1/82

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                    13  DELTA(1930) PARTIAL DECAY MODES

                                                          DECAY MASSES
P1     DELTA(1930) INTO N PI                             938+ 140
P2     DELTA(1930) INTO SIGMA K                         1189+ 494

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                    13  DELTA(1930) BRANCHING RATIOS

R1     DELTA(1930) INTO (N PI)/TOTAL                   (P1)
R1           (0.12)   (0.03)        CUTKOSKY  79 IPWA    PI N TO PI N     12/79
R1            0.04     0.03          HOEHLER   79 IPWA    PI N TO PI N     12/79
R1           (0.11)                  CHEW      80 BPWA ++ PI+P TO PI+P     1/82
R1            0.14     0.04          CUTKOSKY  80 IPWA    PI N TO PI N      1/82

R2     DELTA(1930) FROM N PI TO SIGMA K                SQRT(P1*P2)
R2  A        0.018 TO 0.035          DEANS     75 DPWA    PI N TO K SIGMA  11/75
R2  A   RANGE GIVEN IS FROM FOUR BEST SOLUTIONS.                            11/75
R2          (-0.031)                 LIVANOS   80 DPWA    PI P TO K SIGMA   1/82

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                    13  DELTA(1930) PHOTON DECAY AMPLITUDES (GEV**-1/2)

       FOR DEFINITION OF GAMMA-NUCLEON DECAY AMPLITUDES, SEE MINI-
     REVIEW PRECEDING THE BARYON LISTINGS.

A1     DELTA(1930) INTO NUCLEON GAMMA, HELICITY=1/2 (GEV**-1/2)
A1           -0.062    0.064        BARBOUR   78 DPWA    PI-N PHOTOPROD.   3/79
A1           -0.038    0.047        CRAWFORD  80 DPWA    PI N PHOTOPROD.  12/81
A1            0.009    0.009        AWAJI     81 DPWA    PI N PHOTOPROD.   1/84*

A2     DELTA(1930) INTO NUCLEON GAMMA, HELICITY=3/2 (GEV**-1/2)
A2           +0.019    0.054        BARBOUR   78 DPWA    PI-N PHOTOPROD.   3/79
A2           -0.023    0.080        CRAWFORD  80 DPWA    PI N PHOTOPROD.  12/81
A2           -0.025    0.011        AWAJI     81 DPWA    PI N PHOTOPROD.   1/84*

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                          REFERENCES FOR DELTA(1930)

DONNACH1 68 PL 26B 161        A DONNACHIE, R G KIRSOPP, C LOVELACE (CERN)IJP
KIRSOPP  68 THESIS            R G KIRSOPP                          (EDIN)

DONNACHI 69 NP 10B 433        A DONNACHIE, R KIRSOPP          (GLAS+EDIN)
LEA      69 PL 29B 584        LEA,OADES,WARD,COWAN,+     (RHEL+BRIS+DARE)
AYED     70 PL 31B 598        +BAREYRE,VILLET                      (SACL)
FEUERBAC 70 NP 16B 85         FEUERBACHER+HOLLADAY                 (VAND)
APLIN    71 NP B32 253        +COWAN,GIBSON,GILMORE++         (RHEL+BRIS)
ALMEHED  72 NP B40 157        +LOVELACE                      (LUND+RUTG)IJP
LANGBEIN 73 NP B53 251        LANGBEIN,WAGNER                      (MUNI)IJP

CRAWFORD 75 NP B97 125        R L CRAWFORD                         (GLAS)IJP
DEANS    75 NP B96 90         +MITCHELL,MONTGOMERY,+          (SFLA+ALAH)IJP

AYED     76 CEA-N-1921        AYED (THESIS)                        (SACL)IJP
BARBOUR  76 NP B111 358       I M BARBOUR,R L CRAWFORD             (GLAS)IJP
CUTKOSKY 76 PRL 37 645        CUTKOSKY,HENDRICK,KELLY         (CARN+LBL)IJP
    ALSO 76 OXFORD CONF. 49   CUTKOSKY,HENDRICK,CHAO+     (CARN+LBL+BRIS)IJP
WINNIK   77 NP B128 66        +TOAFF,REVEL,GOLDBERG,BERNY          (HAIF)I
BARBOUR  78 NP B141 253       BARBOUR,CRAWFORD,PARSONS             (GLAS)
CUTKOSKY 79 PR D20 2839       +FORSYTH,HENDRICK,KELLY         (CARN+LBL)IJP
HOEHLER  79 HANDBOOK OF PI-N SCATTERING, PHYSIK DATEN VOL.12-1
                              +KAISER,KOCH,PIETARINEN              (KARL)IJP
    ALSO 80  TORONTO CONF 3   R KOCH                               (KARL)IJP
CHEW     80  TORONTO CONF 123 D M CHEW                             (LBL)IJP
CRAWFORD 80  TORONTO CONF 107 R L CRAWFORD                         (GLAS)
CUTKOSKY 80  TORONTO CONF 19  +FORSYTH,BABCOCK,KELLY,HENDRICK  (CARN+LBL)IJP
LIVANOS  80  TORONTO CONF 35  +BATON,COUTURES,KOCHOWSKI,NEVEU      (SACL)IJP

AWAJI    81  BONN CONF 352     R KAJIKAWA (TALK)                   (NAGO)
    ALSO 82 NP B197 365        FUJII,HAYASHII,IWATA,KAJIKAWA+      (NAGO)
CRAWFORD 83 NP B211 1          R L CRAWFORD, W T MORTON            (GLAS)

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Δ(1940) D''_{33} Status: *

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                    136  DELTA(1940, JP=3/2-)  I=3/2  D''33

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                    136  DELTA(1940) MASS (MEV)

M          1940.0    100.0          CUTKOSKY  80 IPWA    PI N TO PI N      1/82
M         (2058.1)   (34.5)         CHEW      80 BPWA ++ PI+P TO PI+P     1/82

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                    136  DELTA(1940) WIDTH (MEV)

W           200.0    100.0          CUTKOSKY  80 IPWA    PI N TO PI N      1/82
W          (198.4)   (45.5)         CHEW      80 BPWA ++ PI+P TO PI+P     1/82

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                    136  DELTA(1940) REAL PART OF POLE POSITION (MEV)

RE         1900.0    100.0          CUTKOSKY  80 IPWA    PI N TO PI N      1/82

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                    136  DELTA(1940) -2*IMAG PART OF POLE POSITION (MEV)

IM          200.0     60.0          CUTKOSKY  80 IPWA    PI N TO PI N      1/82

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                    136  DELTA(1940) REAL PART OF ELASTIC POLE RESIDUE (MEV)

RER          -6.0      5.0          CUTKOSKY  80 IPWA    PI N TO PI N      1/82

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                    136  DELTA(1940) IMAG PART OF ELASTIC POLE RESIDUE (MEV)

IMR           6.0      5.0          CUTKOSKY  80 IPWA    PI N TO PI N      1/82

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                    136  DELTA(1940) PARTIAL DECAY MODES

                                                          DECAY MASSES
P1     DELTA(1940) INTO N PI                             938+ 140

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                    136  DELTA(1940) BRANCHING RATIOS

R1     DELTA(1940) INTO (N PI)/TOTAL                   (P1)
R1           0.05     0.02          CUTKOSKY  80 IPWA    PI N TO PI N      1/82
R1          (0.18)                  CHEW      80 BPWA ++ PI+P TO PI+P     1/82

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                    136  DELTA(1940) PHOTON DECAY AMPLITUDES (GEV**-1/2)

       FOR DEFINITION OF GAMMA-NUCLEON DECAY AMPLITUDES, SEE MINI-
     REVIEW PRECEDING THE BARYON LISTINGS.

A1     DELTA(1940) INTO NUCLEON GAMMA, HELICITY=1/2 (GEV**-1/2)
A1          -0.036    0.058          AWAJI     81 DPWA    PI N PHOTOPROD.   1/84*

A2     DELTA(1940) INTO NUCLEON GAMMA, HELICITY=3/2 (GEV**-1/2)
A2          -0.031    0.012          AWAJI     81 DPWA    PI N PHOTOPROD.   1/84*

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                          REFERENCES FOR DELTA(1940)

CHEW     80  TORONTO CONF 123 D M CHEW                             (LBL)IJP
CUTKOSKY 80  TORONTO CONF 19  +FORSYTH,BABCOCK,KELLY,HENDRICK  (CARN+LBL)IJP
AWAJI    81  BONN CONF 352     R KAJIKAWA (TALK)                   (NAGO)
    ALSO 82 NP B197 365        FUJII,HAYASHII,IWATA,KAJIKAWA+      (NAGO)

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Δ(1950) F'_{37} Status: ****

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                    83  DELTA(1950, JP=7/2+) I=3/2   F'37

                    MOST OF THE RESULTS PUBLISHED BEFORE 1975 ARE NOW
                    OBSOLETE AND HAVE BEEN OMITTED.  THEY MAY BE FOUND IN
                    OUR 1982 EDITION (PHYSICS LETTERS 111B).  HOWEVER,
                    ALL THE REFERENCES HAVE BEEN RETAINED.

   IN ADDITION, RESULTS IN THIS REGION FROM PRODUCTION EXPERIMENTS,
   WHICH USED TO BE LISTED SEPARATELY AS THE NEXT ENTRY, HAVE BEEN
   ENTIRELY REMOVED.

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                    83  DELTA(1950) MASS (MEV)

M    A     1930. OR 1925.           LONGACRE  75 IPWA    PI N TO 2PI N    11/75
M    A  THE 2 SETS OF PARAMETERS ARE FROM METHODS 1 AND 2 OF LONGACRE 75.  11/75
M        (1912.0)                   BARBOUR   78 DPWA    PI-N PHOTOPROD.   3/79
M        (1950.0)   (20.0)          CUTKOSKY  79 IPWA    PI N TO PI N     12/79
M         1913.0     8.0            HOEHLER   79 IPWA    PI N TO PI N     12/79
M        (1855.0)   (11.0)   (10.0) CHEW      80 BPWA ++ PI+P TO PI+P     1/82
M        (1902.0)                   CRAWFORD  80 DPWA    PI N PHOTOPROD.  12/81
M         1950.0    15.0            CUTKOSKY  80 IPWA    PI N TO PI N      1/82

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                    83  DELTA(1950) WIDTH (MEV)

W    A     235. OR  240.            LONGACRE  75 IPWA    PI N TO 2PI N    11/75
W        (198.0)                    BARBOUR   78 DPWA    PI-N PHOTOPROD.   3/79
W        (340.0)   (60.0)           CUTKOSKY  79 IPWA    PI N TO PI N     12/79
W         224.0    10.0             HOEHLER   79 IPWA    PI N TO PI N     12/79
W        (157.2)   (22.0)   (19.0)  CHEW      80 BPWA ++ PI+P TO PI+P     1/82
W        (225.0)                    CRAWFORD  80 DPWA    PI N PHOTOPROD.  12/81
W         340.0    50.0             CUTKOSKY  80 IPWA    PI N TO PI N      1/82

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                    83  DELTA(1950) REAL PART OF POLE POSITION (MEV)

RE       (1924.0)                   LONGACRE  75 IPWA    PI N TO 2PI N    11/75
RE       (1892.0)                   CUTKOSKY  79 IPWA    PI N TO PI N     12/79
RE        1890.0    15.0            CUTKOSKY  80 IPWA    PI N TO PI N      1/82

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                    83  DELTA(1950) -2*IMAG PART OF POLE POSITION (MEV)

IM        (258.0)                   LONGACRE  75 IPWA    PI N TO 2PI N    11/75
IM        (248.0)                   CUTKOSKY  79 IPWA    PI N TO PI N     12/79
IM         260.0    40.0            CUTKOSKY  80 IPWA    PI N TO PI N      1/82

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                    83  DELTA(1950) REAL PART OF ELASTIC POLE RESIDUE (MEV)

RER       (43.0)                    CUTKOSKY  79 IPWA    PI N TO PI N     12/79
RER        42.0     7.0             CUTKOSKY  80 IPWA    PI N TO PI N      1/82

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                    83  DELTA(1950) IMAG PART OF ELASTIC POLE RESIDUE (MEV)

IMR       (-24.0)                   CUTKOSKY  79 IPWA    PI N TO PI N     12/79
IMR        -27.0     7.0             CUTKOSKY  80 IPWA    PI N TO PI N      1/82

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                    83  DELTA(1950) PARTIAL DECAY MODES

                                                          DECAY MASSES
P1     DELTA(1950) INTO N PI                             938+ 140
P2     DELTA(1950) INTO SIGMA K                         1189+ 494
P3     DELTA(1950) INTO DELTA(1232) PI                  1232+ 140
P4     DELTA(1950) INTO SIGMA(1385) K                   1385+ 494
P5     DELTA(1950) INTO DELTA(1232) RHO                 1232+ 769
P6     DELTA(1950) INTO NEUTRON PI+ PI+                  940+ 140+ 140
P7     DELTA(1950) INTO DELTA(1232) PI PI (NOT RHO)     1232+ 140+ 140
P8     DELTA(1950) INTO NUCLEON GAMMA, HELICITY=1/2      938+   0
P9     DELTA(1950) INTO NUCLEON GAMMA, HELICITY=3/2      938+   0
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Baryons

Data Card Listings

Δ(1950), Δ(2150), Δ(2200)

P10	DELTA(1950) INTO N RHO	938+ 769	
P11	DELTA(1950) INTO DELTA(1232) PI, F-WAVE	1232+ 140	
P12	DELTA(1950) INTO DELTA(1232) PI, H-WAVE	1232+ 140	
P13	DELTA(1950) INTO N RHO, S=3/2, F-WAVE	938+ 769	

83 DELTA(1950) BRANCHING RATIOS

R1		DELTA(1950) INTO (N PI)/TOTAL					(P1)	
R1		(0.40)	(0.02)	CUTKOSKY	79	IPWA	PI N TO PI N	12/79
R1		0.38	0.02	HOEHLER	79	IPWA	PI N TO PI N	12/79
R1		(0.44)		CHEW	80	BPWA	++ PI+P TO PI+P	1/82
R1		0.39	0.04	CUTKOSKY	80	IPWA	PI N TO PI N	1/82
R2		DELTA(1950) FROM N PI TO SIGMA K					SQRT(P1*P2)	
R2	B	0.022 TO 0.040		DEANS	75	DPWA	PI N TO K SIGMA	11/75
R2	B	RANGE GIVEN IS FROM FOUR BEST SOLUTIONS.						11/75
R2	B	DEANS75 AND LANGBEIN73 DISAGREE WITH PI+ P TO K+ SIGMA+ DATA OF						1/78
R2	B	WINNIK77 AROUND 1920 MEV.						1/78
R3		DELTA(1950) FROM N PI TO DELTA(1232) PI, F-WAVE					SQRT(P1*P11)	
R3	A	-0.25 OR -0.32		LONGACRE	75	IPWA	PI N TO 2PI N	11/75
R3	C	(0.21)		NOVOSELLE	78	IPWA	PI N TO 2PI N	3/79
R3	C	BW FIT TO LONGACRE 75 IPWA, PHASE IS NEAR -60 DEGREES.						3/79
R3	D	(0.38)		NOVOSELLE	78	IPWA	PI N TO 2PI N	3/79
R3	D	BW FIT TO NOVOSELLER 78 IPWA, PHASE IS NEAR -60 DEGREES.						3/79
R4		DELTA(1950) FROM N PI TO N RHO, S=3/2, F-WAVE					SQRT(P1*P13)	
R4	A	0.18 OR -0.24		LONGACRE	75	IPWA	PI N TO 2PI N	11/75
R4	E	(0.24)		NOVOSELLE	78	IPWA	PI N TO 2PI N	3/79
R4	E	BW FIT TO LONGACRE 75 IPWA, PHASE IS NEAR 120 DEGREES.						3/79
R4	F	(0.43)		NOVOSELLE	78	IPWA	PI N TO 2PI N	3/79
R4	F	BW FIT TO NOVOSELLER 78 IPWA, PHASE IS NEAR 120 DEGREES.						3/79

83 DELTA(1950) PHOTON DECAY AMPLITUDES (GEV-1/2)**

FOR DEFINITION OF GAMMA-NUCLEON DECAY AMPLITUDES, SEE MINI-REVIEW PRECEDING THE BARYON LISTINGS.

A1	DELTA(1950) INTO NUCLEON GAMMA, HELICITY=1/2 (GEV**-1/2)						
A1	-0.059	0.029	METCALF	74	DPWA	PI N PHOTOPROD.	2/74
A1	-0.078	0.008	AZNAURYAN	77	DPWA	PI0 PHTPRD,SOL 1	12/79
A1	-0.132	0.015	AZNAURYAN	77	DPWA	PI0 PHTPRD,SOL 2	12/79
A1	-0.058	0.013	BARBOUR	78	DPWA	PI-N PHOTOPROD.	3/79
A1	-0.091	0.005	ARAI	80	DPWA	PI N PHOTO FIT 1	12/81
A1	-0.083	0.005	ARAI	80	DPWA	PI N PHOTO FIT 2	12/81
A1	-0.067	0.014	CRAWFORD	80	DPWA	PI N PHOTOPROD.	12/81
A1	-0.068	0.007	AWAJI	81	DPWA	PI N PHOTOPROD.	1/84*
A2	DELTA(1950) INTO NUCLEON GAMMA, HELICITY=3/2 (GEV**-1/2)						
A2	-0.093	0.024	METCALF	74	DPWA	PI N PHOTOPROD.	2/74
A2	-0.160	0.016	AZNAURYAN	77	DPWA	PI0 PHTPRD,SOL 1	12/79
A2	-0.169	0.015	AZNAURYAN	77	DPWA	PI0 PHTPRD,SOL 2	12/79
A2	-0.075	0.020	BARBOUR	78	DPWA	PI-N PHOTOPROD.	3/79
A2	-0.101	0.005	ARAI	80	DPWA	PI N PHOTO FIT 1	12/81
A2	-0.100	0.005	ARAI	80	DPWA	PI N PHOTO FIT 2	12/81
A2	-0.082	0.017	CRAWFORD	80	DPWA	PI N PHOTOPROD.	12/81
A2	-0.094	0.016	AWAJI	81	DPWA	PI N PHOTOPROD.	1/84*

REFERENCES FOR DELTA(1950)

HOEHLER 63 NP 48 470 — G HOEHLER, G EBEL (KARL) I
LAYSON 63 NC 27 724 — W M LAYSON (CERN) IJ
AUVIL 64 NC 33 473 — P AUVIL, C LOVELACE (LOIC)IJP
HELLAND 64 PR 134 B1062 — +DEVLIN,HAGGE,LONGO,MOYER,WOOD (LRL) IJ
HOEHLER 64 PL 12 149 — G HOEHLER, J GIESECKE (KARL) I
DUKE 65 PRL 15 468 — +JONES,KEMP,MURPHY,PRENTICE, + (RHEL+OXF)IJP
HOLLADAY 65 PR 139 B1348 — W G HOLLADAY (VAND)
YOKOSAWA 66 PRL 16 714 — +SUWA, HILL, ESTERLING, BOOTH (ANL+CHIC)IJP
JOHNSON 67 UCRL-17683 THESIS — C H JOHNSON (LRL)
BAREYRE 68 PR 165 1731 — P BAREYRE, C BRICMAN, G VILLET (SACL)IJP
BORREANI 68 UCRL 18350 — BORREANI,KALMUS (LRL)
DONNACH1 68 PL 26B 161 — A DONNACHIE, R G KIRSOPP, C LOVELACE (CERN)IJP
ALSO 68 VIENNA 139 — DONNACHIE RAPPORTEUR'S TALK (GLAS)
ALSO 68 THESIS — R G KIRSOPP (EDIN)
DONNACHI 69 NP 10B 433 — A DONNACHIE, R KIRSOPP (GLAS+EDIN)

AYED 70 KIEV CONF — R AYED,P BAREYRE, G VILLET (SACL)IJP
AYED2 70 PL 31B 598 — +BAREYRE,VILLET (SACL)
DAVIES 70 NP B21 359 — A DAVIES (GLAS)
FEUERBAC 70 NP 16B 85 — FEUERBACHER+HOLLADAY (VAND)
KALMUS 70 PR D2 1824 — G KALMUS, G BORREANI, J LOUIE (LRL)
ROYCHOUD 71 NP B27 125 — R A ROYCHOUDHURY,B H BRANSDEN (DURH)IJP
ALMEHED 72 NP B40 157 — +LOVELACE (LUND+RUTG)IJP
MEHTANI 72 PRL 29 1634 — +FUNG, KERNAN, SCHALK, + (UCR +LBL)
LANGBEIN 73 NP B53 251 — LANGBEIN,WAGNER (MUNI)IJP
DEVENIS2 74 PL 52B 227 — DEVENISH,LYTH,RANKIN (DESY+LANC+BONN)IJP
AYED 74 PRIVATE COMM. — AYED,BAREYRE (SACL)IJP
ALSO 73 AIX CONFERENCE — AYED,BAREYRE (SACL)IJP
KNIES 74 PR D9 2680 — KNIES,MOORHOUSE,OBERLACK (LBL+GLAS)IJP
METCALF 74 NP B76 253 — W J METCALF,R L WALKER (CIT)IJP
MOORHOUS 74 PR D9 1 — MOORHOUSE,OBERLACK,ROSENFELD (GLAS+LBL)IJP

CRAWFORD 75 NP B97 125 — R L CRAWFORD (GLAS)IJP
DEANS 75 NP B96 90 — +MITCHELL,MONTGOMERY,+ (SFLA+ALAH)IJP
LONGACRE 75 PL 55B 415 — +ROSENFELD,LASINSKI,SMADJA+ (LBL+SLAC)IJP
ALSO 78 PR D17 1795 — LONGACRE,LASINSKI,ROSENFELD+ (LBL+SLAC)
AYED 76 CEA-N-1921 — AYED (THESIS) (SACL)IJP
BARBOUR 76 NP B111 358 — I M BARBOUR,R L CRAWFORD (GLAS)IJP
CUTKOSKY 76 PRL 37 645 — CUTKOSKY,HENDRICK,KELLY (CARN+LBL)IJP
ALSO 76 OXFORD CONF. 49 — CUTKOSKY,HENDRICK,CHAO+ (CARN+LBL+BRIS)IJP
VASAN2 76 NP B106 526 — S S VASAN (CARN)IJP
AZNAURYA 77 EFI-264(57)-77 — +AKOPOV,BAGDASARYAN (YERE)IJP
WINNIK 77 NP B128 66 — +TOAFF,REVEL,GOLDBERG,BERNY (HAIF)I
BARBOUR 78 NP B141 253 — BARBOUR,CRAWFORD,PARSONS (GLAS)
NOVOSELL 78 NP B137 509 — D E NOVOSELLER (CIT)IJP
ALSO 78 NP B137 445 — D E NOVOSELLER (CIT)IJP

CUTKOSKY 79 PR D20 2839 — +FORSYTH,HENDRICK,KELLY (CARN+LBL)IJP
HOEHLER 79 HANDBOOK OF PI-N SCATTERING, PHYSIK DATEN VOL.12-1 — +KAISER,KOCH,PIETARINEN (KARL)IJP
ALSO 80 TORONTO CONF 3 — R KOCH (KARL)IJP
ARAI 80 TORONTO CONF 93 — I ARAI (TOKY)
ALSO 82 NP B194 251 — I ARAI, H FUJII (TOKY)
CHEW 80 TORONTO CONF 123 — D M CHEW (LBL)IJP
CRAWFORD 80 TORONTO CONF 107 — R L CRAWFORD (GLAS)
CUTKOSKY 80 TORONTO CONF 19 — +FORSYTH,BABCOCK,KELLY,HENDRICK (CARN+LBL)IJP

AWAJI 81 BONN CONF 352 — R KAJIKAWA (TALK) (NAGO)
ALSO 82 NP B197 365 — FUJII,HAYASHII,IWATA,KAJIKAWA+ (NAGO)
CRAWFORD 83 NP B211 1 — R L CRAWFORD, W T MORTON (GLAS)

Δ(2150) S'''_{31} Status: *

→ 137 DELTA(2150, JP=1/2-) I=3/2 S'''31

137 DELTA(2150) MASS (MEV)

M		2150.0	100.0	CUTKOSKY	80	IPWA	PI N TO PI N	1/82
M	A	(2047.4)	(27.0)	CHEW	80	BPWA	++ PI+P TO PI+P	1/82
M	B	(2203.2)	(8.4)	CHEW	80	BPWA	++ PI+P TO PI+P	1/82
M	AB	CHEW 80 REPORTS TWO S31 RESONANCES IN THIS MASS REGION LABELED						1/82
M	AB	A AND B. PROBLEMS WITH THIS ANALYSIS ARE DISCUSSED IN SEC.2.1.11						2/84*
M	AB	HOEHLER 83.						2/84*

137 DELTA(2150) WIDTH (MEV)

W		200.0	100.0	CUTKOSKY	80	IPWA	PI N TO PI N	1/82
W	A	(121.6)	(62.0)	CHEW	80	BPWA	++ PI+P TO PI+P	1/82
W	B	(120.5)	(45.0)	CHEW	80	BPWA	++ PI+P TO PI+P	1/82

137 DELTA(2150) REAL PART OF POLE POSITION (MEV)

RE	2140.0	80.0	CUTKOSKY	80	IPWA	PI N TO PI N	1/82

137 DELTA(2150) -2*IMAG PART OF POLE POSITION (MEV)

IM	200.0	80.0	CUTKOSKY	80	IPWA	PI N TO PI N	1/82

137 DELTA(2150) REAL PART OF ELASTIC POLE RESIDUE (MEV)

RER	4.0	10.0	CUTKOSKY	80	IPWA	PI N TO PI N	1/82

137 DELTA(2150) IMAG PART OF ELASTIC POLE RESIDUE (MEV)

IMR	-6.0	6.0	CUTKOSKY	80	IPWA	PI N TO PI N	1/82

137 DELTA(2150) PARTIAL DECAY MODES

		DECAY MASSES
P1	DELTA(2150) INTO N PI	938+ 140

137 DELTA(2150) BRANCHING RATIOS

R1		DELTA(2150) INTO (N PI)/TOTAL					(P1)	
R1		0.08	0.02	CUTKOSKY	80	IPWA	PI N TO PI N	1/82
R1	A	(0.41)		CHEW	80	BPWA	++ PI+P TO PI+P	1/82
R1	B	(0.37)		CHEW	80	BPWA	++ PI+P TO PI+P	1/82

REFERENCES FOR DELTA(2150)

CHEW 80 TORONTO CONF 123 — D M CHEW (LBL)IJP
CUTKOSKY 80 TORONTO CONF 19 — +FORSYTH,BABCOCK,KELLY,HENDRICK (CARN+LBL)IJP
HOEHLER 83 LANDOLT-BORNSTEIN VOL I 9B2 — G HOEHLER (KARL)

Δ(2200) G_{37} Status: *

→ 135 DELTA(2200, JP=7/2-) I=3/2 G37

THE AGREEMENT AMONG THE VARIOUS ANALYSES IS NOT VERY GOOD.

135 DELTA(2200) MASS (MEV)

M	2280.0	80.0	HENDRY	78	MPWA	PI N TO PI N	1/82
M	(2200.0)		CUTKOSKY	79	IPWA	PI N TO PI N	1/82
M	2215.0	60.0	HOEHLER	79	IPWA	PI N TO PI N	1/82
M	2200.0	80.0	CUTKOSKY	80	IPWA	PI N TO PI N	1/82

135 DELTA(2200) WIDTH (MEV)

W	400.0	150.0	HENDRY	78	MPWA	PI N TO PI N	1/82
W	(350.0)		CUTKOSKY	79	IPWA	PI N TO PI N	1/82
W	400.0	100.0	HOEHLER	79	IPWA	PI N TO PI N	1/82
W	450.0	100.0	CUTKOSKY	80	IPWA	PI N TO PI N	1/82

135 DELTA(2200) REAL PART OF POLE POSITION (MEV)

RE	(2094.0)		CUTKOSKY	79	IPWA	PI N TO PI N	1/82
RE	2100.0	50.0	CUTKOSKY	80	IPWA	PI N TO PI N	1/82

135 DELTA(2200) -2*IMAG PART OF POLE POSITION (MEV)

IM	(294.0)		CUTKOSKY	79	IPWA	PI N TO PI N	1/82
IM	340.0	80.0	CUTKOSKY	80	IPWA	PI N TO PI N	1/82

135 DELTA(2200) REAL PART OF ELASTIC POLE RESIDUE (MEV)

RER	(2.0)		CUTKOSKY	79	IPWA	PI N TO PI N	1/82
RER	3.0	5.0	CUTKOSKY	80	IPWA	PI N TO PI N	1/82

For notation, see key at front of Listings.

Baryons

Δ(2200), Δ(2300), Δ(2350), Δ(2390)

```
                    135  DELTA(2200) IMAG PART OF ELASTIC POLE RESIDUE (MEV)
IMR        (-7.0)                    CUTKOSKY  79 IPWA    PI N TO PI N      1/82
IMR         -8.0       3.0           CUTKOSKY  80 IPWA    PI N TO PI N      1/82
------ --------- --------- --------- --------- --------- --------- --------
                    135  DELTA(2200) PARTIAL DECAY MODES
                                                              DECAY MASSES
P1     DELTA(2200) INTO N PI                                 938+ 140
------ --------- --------- --------- --------- --------- --------- --------
                    135  DELTA(2200) BRANCHING RATIOS
R1     DELTA(2200) INTO (N PI)/TOTAL                    (P1)
R1          0.09       0.02          HENDRY    78 MPWA    PI N TO PI N      1/82
R1         (0.05)                    CUTKOSKY  79 IPWA    PI N TO PI N      1/82
R1          0.05       0.02          HOEHLER   79 IPWA    PI N TO PI N      1/82
R1          0.06       0.02          CUTKOSKY  80 IPWA    PI N TO PI N      1/82
****** ********* ********* ********* ********* ********* ********* ********
                    REFERENCES FOR DELTA(2200)
HENDRY   78 PRL 41 222        A W HENDRY                          (IND+LBL)IJP
         -- THE ANALYSIS AND RESULTS ARE DISCUSSED MORE FULLY IN HENDRY 81.
CUTKOSKY 79 PR D20 2839       +FORSYTH,HENDRICK,KELLY             (CARN+LBL)IJP
HOEHLER  79 HANDBOOK OF PI-N SCATTERING, PHYSIK DATEN VOL.12-1
                              +KAISER,KOCH,PIETARINEN             (KARL)IJP
    ALSO 80  TORONTO CONF 3   R KOCH                              (KARL)IJP
CUTKOSKY 80  TORONTO CONF 19  +FORSYTH,BABCOCK,KELLY,HENDRICK     (CARN+LBL)IJP
HENDRY   81 ANP 136 1         A W HENDRY                          (IND)
****** ********* ********* ********* ********* ********* ********* ********
****** ********* ********* ********* ********* ********* ********* ********
```

Δ(2300) H_{39} Status: **

```
                    123  DELTA(2300, JP=9/2+) I=3/2   H39
------ --------- --------- --------- --------- --------- --------- --------
                    123  DELTA(2300) MASS  (MEV)
M        2450.0     100.0           HENDRY    78 MPWA    PI N TO PI N     12/79
M        2217.0      80.0           HOEHLER   79 IPWA    PI N TO PI N     12/79
M       (2204.5)     (3.4)          CHEW      80 BPWA ++ PI+P TO PI+P      1/82
M        2400.0     125.0           CUTKOSKY  80 IPWA    PI N TO PI N      1/82
------ --------- --------- --------- --------- --------- --------- --------
                    123  DELTA(2300) WIDTH  (MEV)
W         500.0     200.0           HENDRY    78 MPWA    PI N TO PI N     12/79
W         300.0     100.0           HOEHLER   79 IPWA    PI N TO PI N     12/79
W        (32.3)     (1.0)           CHEW      80 BPWA ++ PI+P TO PI+P      1/82
W         425.0     150.0           CUTKOSKY  80 IPWA    PI N TO PI N      1/82
------ --------- --------- --------- --------- --------- --------- --------
                    123  DELTA(2300) REAL PART OF POLE POSITION  (MEV)
RE       2370.0      80.0           CUTKOSKY  80 IPWA    PI N TO PI N      1/82
------ --------- --------- --------- --------- --------- --------- --------
                    123  DELTA(2300) -2*IMAG PART OF POLE POSITION  (MEV)
IM        420.0     160.0           CUTKOSKY  80 IPWA    PI N TO PI N      1/82
------ --------- --------- --------- --------- --------- --------- --------
                    123  DELTA(2300) REAL PART OF ELASTIC POLE RESIDUE (MEV)
RER         9.0       4.0           CUTKOSKY  80 IPWA    PI N TO PI N      1/82
------ --------- --------- --------- --------- --------- --------- --------
                    123  DELTA(2300) IMAG PART OF ELASTIC POLE RESIDUE (MEV)
IMR        -3.0       5.0           CUTKOSKY  80 IPWA    PI N TO PI N      1/82
------ --------- --------- --------- --------- --------- --------- --------
                    123  DELTA(2300) PARTIAL DECAY MODES
                                                              DECAY MASSES
P1     DELTA(2300) INTO N PI                                 938+ 140
------ --------- --------- --------- --------- --------- --------- --------
                    123  DELTA(2300) BRANCHING RATIOS
R1     DELTA(2300) INTO (N PI)/TOTAL                    (P1)
R1          0.08       0.02          HENDRY    78 MPWA    PI N TO PI N     12/79
R1          0.03       0.02          HOEHLER   79 IPWA    PI N TO PI N     12/79
R1         (0.05)                    CHEW      80 BPWA ++ PI+P TO PI+P      1/82
R1          0.06       0.02          CUTKOSKY  80 IPWA    PI N TO PI N      1/82
****** ********* ********* ********* ********* ********* ********* ********
                    REFERENCES FOR DELTA(2300)
HENDRY   78 PRL 41 222        A W HENDRY                          (IND+LBL)IJP
         -- THE ANALYSIS AND RESULTS ARE DISCUSSED MORE FULLY IN HENDRY 81.
HOEHLER  79 HANDBOOK OF PI-N SCATTERING, PHYSIK DATEN VOL.12-1
                              +KAISER,KOCH,PIETARINEN             (KARL)IJP
    ALSO 80  TORONTO CONF 3   R KOCH                              (KARL)IJP
CHEW     80  TORONTO CONF 123 D M CHEW                            (LBL)IJP
CUTKOSKY 80  TORONTO CONF 19  +FORSYTH,BABCOCK,KELLY,HENDRICK     (CARN+LBL)IJP
HENDRY   81 ANP 136 1         A W HENDRY                          (IND)
****** ********* ********* ********* ********* ********* ********* ********
****** ********* ********* ********* ********* ********* ********* ********
```

Δ(2350) D''_{35} Status: *

```
                    134  DELTA(2350, JP=5/2-) I=3/2   D''35
------ --------- --------- --------- --------- --------- --------- --------
                    134  DELTA(2350) MASS (MEV)
M        2305.0      26.0           HOEHLER   79 IPWA    PI N TO PI N      1/82
M        2400.0     125.0           CUTKOSKY  80 IPWA    PI N TO PI N      1/82
------ --------- --------- --------- --------- --------- --------- --------
                    134  DELTA(2350) WIDTH (MEV)
W         300.0      70.0           HOEHLER   79 IPWA    PI N TO PI N      1/82
W         400.0     150.0           CUTKOSKY  80 IPWA    PI N TO PI N      1/82
------ --------- --------- --------- --------- --------- --------- --------
                    134  DELTA(2350) REAL PART OF POLE POSITION  (MEV)
RE       2400.0     125.0           CUTKOSKY  80 IPWA    PI N TO PI N      1/82
------ --------- --------- --------- --------- --------- --------- --------
                    134  DELTA(2350) -2*IMAG PART OF POLE POSITION  (MEV)
IM        400.0     150.0           CUTKOSKY  80 IPWA    PI N TO PI N      1/82
------ --------- --------- --------- --------- --------- --------- --------
                    134  DELTA(2350) REAL PART OF ELASTIC POLE RESIDUE (MEV)
RER         5.0      17.0           CUTKOSKY  80 IPWA    PI N TO PI N      1/82
------ --------- --------- --------- --------- --------- --------- --------
                    134  DELTA(2350) IMAG PART OF ELASTIC POLE RESIDUE (MEV)
IMR       -14.0      10.0           CUTKOSKY  80 IPWA    PI N TO PI N      1/82
------ --------- --------- --------- --------- --------- --------- --------
                    134  DELTA(2350) PARTIAL DECAY MODES
                                                              DECAY MASSES
P1     DELTA(2350) INTO N PI                                 938+ 140
------ --------- --------- --------- --------- --------- --------- --------
                    134  DELTA(2350) BRANCHING RATIOS
R1     DELTA(2350) INTO (N PI)/TOTAL                    (P1)
R1          0.04       0.02          HOEHLER   79 IPWA    PI N TO PI N      1/82
R1          0.20       0.10          CUTKOSKY  80 IPWA    PI N TO PI N      1/82
****** ********* ********* ********* ********* ********* ********* ********
                    REFERENCES FOR DELTA(2350)
HOEHLER  79 HANDBOOK OF PI-N SCATTERING, PHYSIK DATEN VOL.12-1
                              +KAISER,KOCH,PIETARINEN             (KARL)IJP
    ALSO 80  TORONTO CONF 3   R KOCH                              (KARL)IJP
CUTKOSKY 80  TORONTO CONF 19  +FORSYTH,BABCOCK,KELLY,HENDRICK     (CARN+LBL)IJP
****** ********* ********* ********* ********* ********* ********* ********
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```

Δ(2390) F''_{37} Status: *

```
                    133  DELTA(2390, JP=7/2+) I=3/2   F''37
------ --------- --------- --------- --------- --------- --------- --------
                    133  DELTA(2390) MASS (MEV)
M        2425.0      60.0           HOEHLER   79 IPWA    PI N TO PI N      1/82
M        2350.0     100.0           CUTKOSKY  80 IPWA    PI N TO PI N      1/82
------ --------- --------- --------- --------- --------- --------- --------
                    133  DELTA(2390) WIDTH (MEV)
W         300.0      80.0           HOEHLER   79 IPWA    PI N TO PI N      1/82
W         300.0     100.0           CUTKOSKY  80 IPWA    PI N TO PI N      1/82
------ --------- --------- --------- --------- --------- --------- --------
                    133  DELTA(2390) REAL PART OF POLE POSITION  (MEV)
RE       2350.0     100.0           CUTKOSKY  80 IPWA    PI N TO PI N      1/82
------ --------- --------- --------- --------- --------- --------- --------
                    133  DELTA(2390) -2*IMAG PART OF POLE POSITION  (MEV)
IM        260.0     100.0           CUTKOSKY  80 IPWA    PI N TO PI N      1/82
------ --------- --------- --------- --------- --------- --------- --------
                    133  DELTA(2390) REAL PART OF ELASTIC POLE RESIDUE (MEV)
RER         0.0      13.0           CUTKOSKY  80 IPWA    PI N TO PI N      1/82
------ --------- --------- --------- --------- --------- --------- --------
                    133  DELTA(2390) IMAG PART OF ELASTIC POLE RESIDUE (MEV)
IMR       -12.0       6.0           CUTKOSKY  80 IPWA    PI N TO PI N      1/82
------ --------- --------- --------- --------- --------- --------- --------
                    133  DELTA(2390) PARTIAL DECAY MODES
                                                              DECAY MASSES
P1     DELTA(2390) INTO N PI                                 938+ 140
------ --------- --------- --------- --------- --------- --------- --------
```

Baryons

Data Card Listings

Δ(2390), Δ(2400), Δ(2420), Δ(2750)

133 DELTA(2390) BRANCHING RATIOS

```
R1     DELTA(2390) INTO (N PI)/TOTAL                   (P1)
R1            0.07      0.04        HOEHLER   79 IPWA    PI N TO PI N       1/82
R1            0.08      0.04        CUTKOSKY  80 IPWA    PI N TO PI N       1/82
```

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REFERENCES FOR DELTA(2390)


```
HOEHLER  79 HANDBOOK OF PI-N SCATTERING, PHYSIK DATEN VOL.12-1
                              +KAISER,KOCH,PIETARINEN               (KARL)IJP
   ALSO 80  TORONTO CONF 3    R KOCH                                (KARL)IJP
CUTKOSKY 80  TORONTO CONF 19  +FORSYTH,BABCOCK,KELLY,HENDRICK  (CARN+LBL)IJP
```


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Δ(2400) G_{39} Status: **

→ 124 DELTA(2400, JP=9/2-) I=3/2 G39

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124 DELTA(2400) MASS (MEV)

```
M          2200.0    100.0          HENDRY    78 MPWA    PI N TO PI N      12/79
M          2468.0     50.0          HOEHLER   79 IPWA    PI N TO PI N      12/79
M          2300.0    100.0          CUTKOSKY  80 IPWA    PI N TO PI N       1/82
```

------ -------- -------- -------- -------- -------- -------- --------

124 DELTA(2400) WIDTH (MEV)

```
W           450.0    200.0          HENDRY    78 MPWA    PI N TO PI N      12/79
W           480.0    100.0          HOEHLER   79 IPWA    PI N TO PI N      12/79
W           330.0    100.0          CUTKOSKY  80 IPWA    PI N TO PI N       1/82
```

------ -------- -------- -------- -------- -------- -------- --------

124 DELTA(2400) REAL PART OF POLE POSITION (MEV)

```
RE         2260.0     60.0          CUTKOSKY  80 IPWA    PI N TO PI N       1/82
```

------ -------- -------- -------- -------- -------- -------- --------

124 DELTA(2400) -2*IMAG PART OF POLE POSITION (MEV)

```
IM          320.0    160.0          CUTKOSKY  80 IPWA    PI N TO PI N       1/82
```

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124 DELTA(2400) REAL PART OF ELASTIC POLE RESIDUE (MEV)

```
RER           7.0      4.0          CUTKOSKY  80 IPWA    PI N TO PI N       1/82
```

------ -------- -------- -------- -------- -------- -------- --------

124 DELTA(2400) IMAG PART OF ELASTIC POLE RESIDUE (MEV)

```
IMR          -3.0      3.0          CUTKOSKY  80 IPWA    PI N TO PI N       1/82
```

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124 DELTA(2400) PARTIAL DECAY MODES

```
                                                          DECAY MASSES
P1     DELTA(2400) INTO N PI                             938+ 140
```

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124 DELTA(2400) BRANCHING RATIOS

```
R1     DELTA(2400) INTO (N PI)/TOTAL                   (P1)
R1            0.10      0.03        HENDRY    78 MPWA    PI N TO PI N      12/79
R1            0.06      0.03        HOEHLER   79 IPWA    PI N TO PI N      12/79
R1            0.05      0.02        CUTKOSKY  80 IPWA    PI N TO PI N       1/82
```

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REFERENCES FOR DELTA(2400)


```
AYED     76 CEA-N-1921        AYED (THESIS)                         (SACL)IJP
HENDRY   78 PRL 41 222        A W HENDRY                        (IND+LBL)IJP
         -- THE ANALYSIS AND RESULTS ARE DISCUSSED MORE FULLY IN HENDR
HOEHLER  79 HANDBOOK OF PI-N SCATTERING, PHYSIK DATEN VOL.12-1
                              +KAISER,KOCH,PIETARINEN               (KARL)IJP
   ALSO 80  TORONTO CONF 3    R KOCH                                (KARL)IJP
CUTKOSKY 80  TORONTO CONF 19  +FORSYTH,BABCOCK,KELLY,HENDRICK  (CARN+LBL)IJP
HENDRY   81 ANP 136 1         A W HENDRY                             (IND)
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Δ(2420) H_{311} Status: ****

84 DELTA(2420, JP=11/2+) I=3/2 H3 11

MOST OF THE RESULTS PUBLISHED BEFORE 1975 ARE NOW OBSOLETE AND HAVE BEEN OMITTED. THEY MAY BE FOUND IN OUR 1982 EDITION (PHYSICS LETTERS 111B). HOWEVER, ALL THE REFERENCES HAVE BEEN RETAINED.

IN ADDITION, RESULTS IN THIS REGION FROM PRODUCTION EXPERIMENTS, WHICH USED TO BE LISTED SEPARATELY AS THE NEXT ENTRY, HAVE BEEN ENTIRELY REMOVED.

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84 DELTA(2420) MASS (MEV)

```
M          2400.0     60.0          HENDRY    78 MPWA    PI N TO PI N      12/79
M          2416.0     17.0          HOEHLER   79 IPWA    PI N TO PI N      12/79
M         (2358.0)    (9.0)         CHEW      80 BPWA ++ PI+P TO PI+P       1/82
M          2400.0    125.0          CUTKOSKY  80 IPWA    PI N TO PI N       1/82
```

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84 DELTA(2420) WIDTH (MEV)

```
W           460.0    100.0          HENDRY    78 MPWA    PI N TO PI N      12/79
W           340.0     28.0          HOEHLER   79 IPWA    PI N TO PI N      12/79
W          (202.2)   (45.0)         CHEW      80 BPWA ++ PI+P TO PI+P       1/82
W           450.0    150.0          CUTKOSKY  80 IPWA    PI N TO PI N       1/82
```

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84 DELTA(2420) REAL PART OF POLE POSITION (MEV)

```
RE         2360.0    100.0          CUTKOSKY  80 IPWA    PI N TO PI N       1/82
```

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84 DELTA(2420) -2*IMAG PART OF POLE POSITION (MEV)

```
IM          420.0    100.0          CUTKOSKY  80 IPWA    PI N TO PI N       1/82
```

------ -------- -------- -------- -------- -------- -------- --------

84 DELTA(2420) REAL PART OF ELASTIC POLE RESIDUE (MEV)

```
RER          16.0      8.0          CUTKOSKY  80 IPWA    PI N TO PI N       1/82
```

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84 DELTA(2420) IMAG PART OF ELASTIC POLE RESIDUE (MEV)

```
IMR          -9.0     11.0          CUTKOSKY  80 IPWA    PI N TO PI N       1/82
```

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84 DELTA(2420) PARTIAL DECAY MODES

```
                                                          DECAY MASSES
P1     DELTA(2420) INTO N PI                             938+ 140
P2     DELTA(2420) INTO SIGMA K                         1197+ 494
```

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84 DELTA(2420) BRANCHING RATIOS

```
R1     DELTA(2420) INTO (N PI)/TOTAL                   (P1)
R1            0.11      0.02        HENDRY    78 MPWA    PI N TO PI N      12/79
R1            0.08      0.015       HOEHLER   79 IPWA    PI N TO PI N      12/79
R1           (0.22)                 CHEW      80 BPWA ++ PI+P TO PI+P       1/82
R1            0.08      0.03        CUTKOSKY  80 IPWA    PI N TO PI N       1/82
```

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REFERENCES FOR DELTA(2420)


```
BELLAMY  67 PRL 19 476        +BUCKLEY,DOBINSON, +             (LOWC+LOUC) JP
AYED     70 KIEV CONF         R AYED,P BAREYRE, G VILLET            (SACL)IJP
AYED2    70 PL 31B 598        +BAREYRE,VILLET                       (SACL)
BRANSDEN 71 NP B26 511        +OGDEN                                (DURH)IJP
   ALSO 70 NP B16 461         ROYCHOUDHURY,PERRIN,BRANSDEN          (DURH)IJP
ROYCHOUD 71 NP B27 125        R K ROYCHOUDHURY,B H BRANSDEN         (DURH)IJP
OTT      72 PL 42B 133        +TRISCHUK,VAVRA,RICHARDS,+ (MCGI+STLO+IOWA)IJP
   ALSO 72 MCGILL THESIS      J. VAVRA                              (MCGI) JP
REY      74 PRL 32 908        REY,LENNOX,POIRIER,PRETZL        (NDAM+MPIM)IP
   ALSO 74 PRL 33 250         REY,LENNOX,POIRIER,PRETZL        (NDAM+MPIM)IP
   ALSO 75 PR D11 1777        LENNOX,POIRIER,REY,SANDER+  (NDAM+FNAL+ANL)IP

AYED     76 CEA-N-1921        AYED (THESIS)                         (SACL)IJP
HENDRY   78 PRL 41 222        A W HENDRY                        (IND+LBL)IJP
         -- THE ANALYSIS AND RESULTS ARE DISCUSSED MORE FULLY IN HENDRY 81.
HOEHLER  79 HANDBOOK OF PI-N SCATTERING, PHYSIK DATEN VOL.12-1
                              +KAISER,KOCH,PIETARINEN               (KARL)IJP
   ALSO 80  TORONTO CONF 3    R KOCH                                (KARL)IJP
CHEW     80  TORONTO CONF 123 D M CHEW                               (LBL)IJP
CUTKOSKY 80  TORONTO CONF 19  +FORSYTH,BABCOCK,KELLY,HENDRICK  (CARN+LBL)IJP
HENDRY   81 ANP 136 1         A W HENDRY                             (IND)
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Δ(2750) I_{313} Status: **

→ 125 DELTA(2750, JP=13/2-) I=3/2 I3 13

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125 DELTA(2750) MASS (MEV)

```
M          2650.0    100.0          HENDRY    78 MPWA    PI N TO PI N      12/79
M          2794.0     80.0          HOEHLER   79 IPWA    PI N TO PI N      12/79
```

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125 DELTA(2750) WIDTH (MEV)

```
W           500.0    100.0          HENDRY    78 MPWA    PI N TO PI N      12/79
W           350.0    100.0          HOEHLER   79 IPWA    PI N TO PI N      12/79
```

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125 DELTA(2750) PARTIAL DECAY MODES

```
                                                          DECAY MASSES
P1     DELTA(2750) INTO N PI                             938+ 140
```

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125 DELTA(2750) BRANCHING RATIOS

```
R1     DELTA(2750) INTO (N PI)/TOTAL                   (P1)
R1            0.05      0.01        HENDRY    78 MPWA    PI N TO PI N      12/79
R1            0.04      0.015       HOEHLER   79 IPWA    PI N TO PI N      12/79
```

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REFERENCES FOR DELTA(2750)


```
HENDRY   78 PRL 41 222        A W HENDRY                        (IND+LBL)IJP
         -- THE ANALYSIS AND RESULTS ARE DISCUSSED MORE FULLY IN HENDRY 81.
HOEHLER  79 HANDBOOK OF PI-N SCATTERING, PHYSIK DATEN VOL.12-1,
                              +KAISER,KOCH,PIETARINEN               (KARL)IJP
   ALSO 80  TORONTO CONF 3    R KOCH                                (KARL)IJP
HENDRY   81 ANP 136 1         A W HENDRY                             (IND)
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For notation, see key at front of Listings.

Baryons

$\Delta(2950)$, $\Delta(\sim3000)$, Z's, $Z_0(1780)$

$\Delta(2950)$ K_{315} Status: **

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                    126  DELTA(2950, JP=15/2+) I=3/2   K3 15

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                    126  DELTA(2950) MASS  (MEV)

M          2850.0    100.0            HENDRY    78 MPWA    PI N TO PI N      12/79
M          2990.0    100.0            HOEHLER   79 IPWA    PI N TO PI N      12/79

------ --------- --------- --------- --------- --------- --------- --------

                    126  DELTA(2950) WIDTH  (MEV)

W           700.0    200.0            HENDRY    78 MPWA    PI N TO PI N      12/79
W           330.0    100.0            HOEHLER   79 IPWA    PI N TO PI N      12/79

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                    126  DELTA(2950) PARTIAL DECAY MODES

                                                          DECAY MASSES
P1     DELTA(2950) INTO N PI                             938+ 140

------ --------- --------- --------- --------- --------- --------- --------

                    126  DELTA(2950) BRANCHING RATIOS

R1     DELTA(2950) INTO (N PI)/TOTAL                   (P1)
R1           0.03      0.01           HENDRY    78 MPWA    PI N TO PI N      12/79
R1           0.04      0.02           HOEHLER   79 IPWA    PI N TO PI N      12/79

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                         REFERENCES FOR DELTA(2950)

HENDRY   78 PRL 41 222        A W HENDRY                          (IND+LBL)IJP
         -- THE ANALYSIS AND RESULTS ARE DISCUSSED MORE FULLY IN HENDRY 81.
HOEHLER  79 HANDBOOK OF PI-N SCATTERING, PHYSIK DATEN VOL.12-1
                              +KAISER,KOCH,PIETARINEN            (KARL)IJP
    ALSO 80  TORONTO CONF 3   R KOCH                             (KARL)IJP
HENDRY   81 ANP 136 1         A W HENDRY                           (IND)

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~3000 MEV REGION - FORMATION EXPERIMENTS

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                    127  DELTA(~3000) I=3/2

                     WE LIST HERE MISCELLANEOUS HIGH-MASS CANDIDATES FOR
                     ISOSPIN-3/2 RESONANCES FOUND IN PARTIAL-WAVE ANALYSES.
                     SO FAR, NO ANALYSIS OF THIS REGION HAS USED ALL THE
                     AVAILABLE DATA OR INCORPORATED ANALYTICITY CONSTRAINTS.

    OUR 1982 EDITION ALSO HAD A DELTA(2850) AND A DELTA (3230).
    NOTHING HAS BEEN HEARD FROM THEM IN 10 YEARS, AND UNDER THE
    AUTHORITY GRANTED UNTO US BY THE STATUTE OF LIMITATIONS, WE
    DECLARE THEM TO BE DEAD.  THE EVIDENCE FOR THEM WAS DEDUCED FROM
    TOTAL-CROSS-SECTION AND 180-DEG-ELASTIC-CROSS-SECTION MEASUREMENTS.
    PLACED IN THE MAIN BARYON TABLE IN THE ANYTHING-GOES 1960'S, THEY
    REMAINED THERE DUE TO INATTENTION UNTIL THIS EDITION.

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                    127  DELTA(~3000) MASS  (MEV)

M          2850.0    150.0            HENDRY    78 MPWA    PI N  I311        12/79
M          3200.0    200.0            HENDRY    78 MPWA    PI N  K313        12/79
M          3300.0    200.0            HENDRY    78 MPWA    PI N  L317        12/79
M          3700.0    200.0            HENDRY    78 MPWA    PI N  M319        12/79
M          4100.0    300.0            HENDRY    78 MPWA    PI N  N321        12/79
M         (3300.0)                     KOCH      80 IPWA    PI N  L317         2/84*
M         (3500.0)                     KOCH      80 IPWA    PI N  M315         2/84*
M       IN ADDITION, KOCH 80 REPORT SOME EVIDENCE FOR AN S31 DELTA(2700)       2/82
M       AND A P33 DELTA(2800).                                                 2/84*

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                    127  DELTA(~3000) WIDTH  (MEV)

W           700.0    200.0            HENDRY    78 MPWA    PI N  I311        12/79
W          1000.0    300.0            HENDRY    78 MPWA    PI N  K313        12/79
W          1100.0    300.0            HENDRY    78 MPWA    PI N  L317        12/79
W          1300.0    400.0            HENDRY    78 MPWA    PI N  M319        12/79
W          1600.0    500.0            HENDRY    78 MPWA    PI N  N321        12/79

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                    127  DELTA(~3000) PARTIAL DECAY MODES

                                                          DECAY MASSES
P1     DELTA(~3000) INTO N PI                            938+ 140

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                    127  DELTA(~3000) BRANCHING RATIOS

R1     DELTA(~3000) INTO (N PI)/TOTAL                  (P1)
R1           0.06      0.02           HENDRY    78 MPWA    PI N  I311        12/79
R1           0.045     0.02           HENDRY    78 MPWA    PI N  K313        12/79
R1           0.03      0.01           HENDRY    78 MPWA    PI N  L317        12/79
R1           0.025     0.01           HENDRY    78 MPWA    PI N  M319        12/79
R1           0.018     0.01           HENDRY    78 MPWA    PI N  N321        12/79

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                         REFERENCES FOR DELTA(~3000)

HENDRY   78 PRL 41 222        A W HENDRY                          (IND+LBL)IJP
         -- THE ANALYSIS AND RESULTS ARE DISCUSSED MORE FULLY IN HENDRY 81.
KOCH     80  TORONTO CONF 3   R KOCH                               (KARL)IJP
HENDRY   81 ANP 136 1         A W HENDRY                           (IND)

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NOTE ON THE S = +1 BARYON SYSTEM

The evidence for strangeness +1 baryon resonances was thoroughly reviewed in our 1976 edition,[1] and has been reviewed more recently by Kelly[2] and by Oades.[3] One new partial-wave analysis[4] has been published since our 1982 edition. As usual, the results permit no definite conclusion — the same story heard for 15 years. The general feeling, supported by the prejudice against baryons not make up of three quarks, is that the suggestive counterclockwise movement in the Argand diagram of some of the partial waves is not real evidence for true Breit-Wigner resonances. But until the dynamics of the KN system is better understood, the possibility that Z* resonances exist will not be finally laid to rest.

References

1. Particle Data Group, Rev. Mod. Phys. **48**, S188 (1976).
2. R.L. Kelly, in *Proceedings of the Meeting on Exotic Resonances* (Hiroshima, 1978), ed. I. Endo et al.
3. G.C. Oades, in *Low and Intermediate Energy Kaon-Nucleon Physics* (1981), ed. E. Ferrari and G. Violini.
4. K. Nakajima et al., Phys. Lett. **112B**, 80 (1982).


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S=1 EXOTIC STATES (Z)

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$Z_0(1780)$ P_{01} Status: *

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                    95  Z0(1780, JP=1/2+) I=0       P01

                     WILSON 72, GIACOMELLI 74, AND NAKAJIMA 82 FIND SOME
                     SOLUTIONS WITH RESONANT-LIKE BEHAVIOR IN THE P01
                     PARTIAL WAVE.  THE EFFECT SEEN IN THE I=0 TOTAL CROSS
                     SECTION, IF A RESONANCE, MUST HAVE SPIN=1/2, BECAUSE
                     THE INELASTIC CROSS SECTION IS VERY SMALL AND THE
                     TOTAL CROSS SECTION IS ABOUT 4*PI/K**2.

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                    95  Z0(1780) MASS (MEV)

M           1780.0     10.0            COOL      70 CNTR +  K+P, D TOTAL      1/71
M   A       SEEN                       DOWELL    70 CNTR     K+P,D TOTAL      7/70
M   A       SEE ALSO DISCUSSION OF LYNCH 70.                                  7/70
M   B      (1800.0)                    WILSON    72 PWA     K+N P01 WAVE      3/72
M   B    ESTIMATE OF PARAMETERS FROM BW + QUADRATIC BACKGROUND FIT TO P01.    3/72
M    C     (1750.0)                    CARROLL   73 CNTR    KN I=0 TCS,FIT 1  9/73
M    C     (1825.0)                    CARROLL   73 CNTR    KN I=0 TCS,FIT 2  9/73
M    C  FIT 1=FIT OF SINGLE L=1 BW+BACKGROUND TO I=0 TCS FROM 0.4-1.1 GEV/C  9/73
M    C  FIT 2=FIT OF L=1 AND L=2 BWS TO SAME DATA,SEE Z0(1865) FOR L=2 PART  9/73
M         (1740.0)                    GIACOMEL  74 PWA     0.38-1.51 GEV/C  10/74
M         (1778.0)                    NAKAJIMA  82 PWA     KN 0.2-1.6 GEV/C  1/84*

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                    95  Z0(1780) WIDTH (MEV)

W         (565.0)                     COOL      70 CNTR +  K+P, D TOTAL      1/71
W   B     (300.0)                     WILSON    72 PWA     K+N P01 WAVE      3/72
W    C    (600.0)                     CARROLL   73 CNTR    KN I=0 TCS,FIT 1  9/73
W    C    (845.0)                     CARROLL   73 CNTR    KN I=0 TCS,FIT 2  9/73
W         (300.0)                     GIACOMEL  74 PWA     0.38-1.51 GEV/C  10/74
W         (662.0)                     NAKAJIMA  82 PWA     KN 0.2-1.6 GEV/C  1/84*

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                    95  Z0(1780) PARTIAL DECAY MODES

                                                          DECAY MASSES
P1     Z0(1780) INTO N K                                 940+ 494

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Baryons

Data Card Listings

$Z_0(1780)$, $Z_0(1865)$, $Z_1(1900)$

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                    95  Z0(1780) BRANCHING RATIOS

R1      Z0(1780) INTO (N K)/TOTAL                     (P1)
R1            (0.95)                   COOL      70 CNTR +  K+P, D TOTAL       1/71
R1   B        (0.85)                   WILSON    72 PWA     K+N P01 WAVE       3/72
R1     C      (0.75)                   CARROLL   73 CNTR    IF J=1/2,FIT 1     9/73
R1     C      (0.91)                   CARROLL   73 CNTR    IF J=1/2,FIT 2     9/73
R1            (0.85)                   GIACOMEL  74  PWA    .38-1.51 GEV/C    10/74
R1            (0.56)                   NAKAJIMA  82 PWA     KN 0.2-1.6 GEV/C   1/84*

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                         REFERENCES FOR Z0(1780)

COOL      70 DUKE CONF 47        R L COOL                                  (BNL)
    ALSO 69 PL 30B 564           ABRAMS,COOL,GIACOMELLI,KYCIA,LI +         (BNL)
    ALSO 70 PR D1 1887           COOL,GIACOMELLI,KYCIA,LEONTIC,LI +        (BNL)
DOWELL    70 DUKE 53             J D DOWELL                               (BIRM)
WILSON    72 NP B42 445          +GRIFFITHS,HIRATA +    (BGNA+GLAS+ROMA+TRST)
CARROLL   73 PL 45B 531          +KYCIA,LI,MICHAEL,MOCKETT,RAHM+          (BNL)I
GIACOMEL  74 NP B71 138          GIACOMELLI,+           (BGNA+GLAS+ROMA+TRST)IJP
NAKAJIMA  82 PL 112B 80          +KIM,KOBAYASHI,MASAIKE,MURAKAMI,+       (KEK)IJP
                                 PAPERS NOT REFERRED TO IN DATA CARDS

LYNCH     70 DUKE 9              G LYNCH (REVIEWER)                        (LRL)
HIRATA    71 NP B30 157          +GOLDHABER,HALL,SEEGER,TRILLING,WOHL  (LBL)IJP
BOWEN     73 PR D7 22            +JENKINS,KALBACH,PETERSEN +       (ARIZ+MICH)
JOHNSON   74 PL 50B 343          JOHNSON,VLASSOPULOS               (CERN+DURH)
CAMERON   75 PALERMO CONF.       +CAPILUPPI+       (BGNA+EDIN+GLAS+PISA+RHEL)IJP
BIGI      76 NP B110 25          +CAMERON+         (BGNA+EDIN+GLAS+PISA+RHEL)IJP
ROIESNEL  79 PR D20 1646         C ROIESNEL                                (MIT)
MARTIN    80 TORONTO CONF. 355 B R MARTIN,G C OADES                (LOUC+AARH)
OADES     81 ROME CONF. 53       LOW + INTERMEDIATE ENERGY KN PHYSICS (AARH)
CORDEN    82 PR D25 720          +COX,KELSEY,LAWRENCE,WATKINS+     (BIRM+LPNP)

         SEE OUR 1982 EDITION (PHYS. LETT. 111B) FOR A NUMBER OF OTHER
         REFERENCES TO EXPERIMENTAL WORK IN THIS REGION.

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$Z_0(1865)$ D_{03} Status: *

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                    96  Z0(1865, JP=3/2-) I=0         D03

                    THIS EFFECT IS STRONGLY ASSOCIATED WITH THE K* N
                    THRESHOLD.  SEE ALSO THE Z0(1780).

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                    96  Z0(1865) MASS (MEV)

M            (1860.0)   (15.0)         CARTER    67 THEO    DISPERSION REL.    8/67
M            (1868.0)   (10.0)         COOL      70 CNTR    K+P, D TOTAL       8/67
M            (1830.0)                  AARON     73 MPWA    I=0 KN .6-1.6G/C   9/73
M     A      (1840.0)                  CARROLL   73 CNTR    KN I=0 TCS,FIT 2   9/73
M     A   FIT2=FIT OF L=1 AND L=2 BWS TO I=0 TCS FROM 0.4-1.1 GEV/C.         9/73
M     A   SEE Z0(1780) FOR FIT 1 AND L=1 PART OF FIT 2.                      9/73
M            (1907.0)                  NAKAJIMA  82 PWA     KN 0.2-1.6 GEV/C   1/84*

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                    96  Z0(1865) WIDTH (MEV)

W             (200.0)   (50.0)         CARTER    67 THEO                       8/67
W             (160.0)   (30.0)         COOL      70 CNTR                       8/67
W             (100.0)                  AARON     73 MPWA    I=0 KN .6-1.6G/C   9/73
W     A        (75.0)                  CARROLL   73 CNTR    KN I=0 TCS,FIT 2   9/73
W             (291.0)                  NAKAJIMA  82 PWA     KN 0.2-1.6 GEV/C   1/84*

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                    96  Z0(1865) PARTIAL DECAY MODES

                                                          DECAY MASSES
P1      Z0(1865) INTO N K                                940+ 494
P2      Z0(1865) INTO N K*(892)                          938+ 892

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                    96  Z0(1865) BRANCHING RATIOS

R1      Z0(1865) INTO (N K)/TOTAL                     (P1)
R1            (0.155)  (0.025)         CARTER    67 THEO    IF J=3/2           9/73
R1            (0.115)  (0.025)         COOL      70 CNTR    IF J=3/2           9/73
R1    A       (0.085)                  CARROLL   73 CNTR    IF J=3/2,FIT 2     9/73
R1            (0.35)                   NAKAJIMA  82 PWA     KN 0.2-1.6 GEV/C   1/84*

R2      Z0(1865) INTO (N K*(892))/TOTAL               (P2)
R2              MAIN INELASTIC DECAY   HIRATA    68 HBC                       11/68

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                         REFERENCES FOR Z0(1865)

CARTER    67 PRL 18 801          A A CARTER                               (CAVE)
HIRATA    68 PRL 21 1485         HIRATA, WOHL, GOLDHABER, TRILLING         (LRL)
COOL      70 PR D1 1887          COOL,GIACOMELLI,KYCIA,LEONTIC,LI +        (BNL)
    ALSO 66 PRL 17 102           +GIACOMELLI,KYCIA,LEONTIC,LI,LUNDBY,+ (BNL) I
    ALSO 69 PL 30B 564           ABRAMS,COOL,GIACOMELLI,KYCIA,LI +         (BNL)
AARON     73 PR D7 1401          AARON,RICH,HOGAN,SRIVASTAVA      (LASL+NEAS)IJP
CARROLL   73 PL 45B 531          +KYCIA,LI,MICHAEL,MOCKETT,RAHM+          (BNL)I
NAKAJIMA  82 PL 112B 80          +KIM,KOBAYASHI,MASAIKE,MURAKAMI,+       (KEK)IJP

                                 PAPERS NOT REFERRED TO IN DATA CARDS

HIRATA    70 DUKE    429         +GOLDHABER,SEEGER,TRILLING,WOHL           (LRL)
AARON     71 PRL 26 407          +AMADO+SILBAR               (NEAS+PENN+LASL)IJP
HIRATA-1 71 NP B33 445           +GOLDHABER,HALL,SEEGER,TRILLING,WOHL (LBL)
GIACOMEL  72 NP B37 577          GIACOMELLI,+           (BGNA+GLAS+ROMA+TRST)
WILSON    72 NP B42 445          +GRIFFITHS,HIRATA +    (BGNA+GLAS+ROMA+TRST)

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$Z_1(1900)$ P_{13} Status: *

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                    97  Z1(1900, JP=3/2+) I=1         P13

                    THIS EFFECT IS STRONGLY ASSOCIATED WITH THE K-DELTA
                    THRESHOLD.

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                    97  Z1(1900) MASS (MEV)

M    A      (1932.0)                   AYED      70 IPWA    P13,SOL.I          6/70
M    A      (1899.0)                   AYED      70 IPWA    P13,SOL.II         6/70
M    A      (2030.0)                   AYED      70 IPWA    S11,SOL.III        6/70
M    A       THREE SOLNS IN ORDER OF DECREASING SIGNIFICANCE. THOUGH AYED 70
M    A       GIVE PARAMETERS,THEY CONCLUDE RESONANT INTERPRETATION DOUBTFUL.
M     B     (1830.0)                   BARNETT   70 IPWA    P13,SOLN III       9/73
M     B      RESONANCE SIGNAL BARELY ABOVE BACKGROUND DUE TO THE LARGE ERRORS
M     B      IN THE AMPLITUDES RESULTING FROM THE ANALYSIS
M            1900.0     10.0           COOL      70 CNTR ++ K+P TOTAL          1/71
M           (1880.0)                   ALBROW    71 IPWA ++  SOL. GAMMA       10/71
M    C      (1890.0)                   KATO      71 IPWA    SOL  I(FIT BW)    10/71
M    C      (2040.0)                   KATO      71 IPWA    SOL II(FIT BW)    10/71
M    C   KATO 71 ESTIMATE RESONANCE PARAMETERS -- UPDATED PHASE SHIFTS        3/72
M    C   PUBLISHED IN MILLER 72.                                               3/72
M           (1931.0)                   NAKAJIMA  82 PWA     KN 0.2-1.6 GEV/C   1/84*

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                    97  Z1(1900) WIDTH (MEV)

W    A       (520.0)                   AYED      70 IPWA    K+P                6/70
W    A       (397.0)                   AYED      70 IPWA    K+P                6/70
W    A       (557.0)                   AYED      70 IPWA    K+P                6/70
W     B      (120.0)                   BARNETT   70 IPWA    P13,SOLN III       9/73
W            (240.0)                   COOL      70 CNTR ++ K+- TOTAL          1/71
W            (190.0)                   ALBROW    71 IPWA ++ SOL. GAMMA        10/71
W    C       (280.0)                   KATO      71 IPWA    SOL  I(FIT BW)    10/71
W    C       (260.0)                   KATO      71 IPWA    SOL II(FIT BW)    10/71
W            (347.0)                   NAKAJIMA  82 PWA     KN 0.2-1.6 GEV/C   1/84*

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                    97  Z1(1900) REAL PART OF POLE POSITION                4/75

RE   D      (1787.0)                   ARNDT     74 DPWA    K+ P ELASTIC       4/75
RE   D   SUPERSEDED BY ARNDT 78.                                               3/79
RE          (1796.0)                   ARNDT     78 DPWA    K+ P               3/79

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                    97  Z1(1900) -IMAGINARY PART OF POLE POSITION          4/75

IM   D       (100.0)                   ARNDT     74 DPWA    K+ P ELASTIC       4/75
IM           (101.0)                   ARNDT     78 DPWA    K+ P               3/79

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                    97  Z1(1900) PARTIAL DECAY MODES

                                                          DECAY MASSES
P1      Z1(1900) INTO N K                                938+ 494
P2      Z1(1900) INTO DELTA(1232) K                     1232+ 494

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                    97  Z1(1900) BRANCHING RATIOS

R1      Z1(1900) INTO (N K)/TOTAL                     (P1)
R1            (0.10) OR LESS           CARTER    67 THEO    DISPERSION REL.    8/67
R1   A        (0.16)                   AYED      70 IPWA                       6/70
R1   A        (0.20)                   AYED      70 IPWA                       6/70
R1   A        (0.17)                   AYED      70 IPWA                       6/70
R1    B       (0.12)                   BARNETT   70 IPWA    P13,SOLN III       9/73
R1            (0.12) (ASSUMING J=3/2)  COOL      70 CNTR ++ K+P TOTAL          1/71
R1            (0.15)                   ALBROW    71 IPWA ++ SOL. GAMMA        10/71
R1   C        (0.22)                   KATO      71 IPWA    SOL  I(FIT BW)    10/71
R1   C        (0.27)                   KATO      71 IPWA    SOL II(FIT BW)    10/71
R1            (0.24)                   NAKAJIMA  82 PWA     KN 0.2-1.6 GEV/C   1/84*

R2      Z1(1900) INTO (DELTA(1232) K)/TOTAL           (P2)
R2              MAIN INELASTIC DECAY   BLAND     67 HBC  ++                    8/67
R2        NO EVIDENCE, SPEED HAS MINIM. GRIFFITHS 72 HBC    K+P .9-1.5 GEV/C   3/72

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                         REFERENCES FOR Z1(1900)

BLAND     67 PRL 18 1077         +BOWLER,BROWN,G+S GOLDHABER,SEEGER,+  (LRL)
CARTER    67 PRL 18 801          A A CARTER                            (CAVE)

AYED      70 PL 32B 404          +BAREYRE, FELTESSE, VILLET            (SACL)IJP
BARNETT   70 U MD,RPT 70-101     BARNETT,GOLDMAN,LAASANEN,STEINBERG     (UMD)IJP
    ALSO 70 DUKE 443             BARNETT,GOLDMAN,LAASANEN,STEINBERG     (UMD)IJP
COOL      70 PR D1 1887          +GIACOMELLI, KYCIA, LEONTIC, LI, +     (BNL) I
    ALSO 66 PRL 17 102           COOL,GIACOMELLI,KYCIA,LEONTIC,LI +     (BNL)

ALBROW    71 NP  B30 273         +ANDERSON,ALMEHED,...,UDO,WAGNER      (CERN)IJP
    ALSO 70 DUKE  375            ERNE,SENS,WAGNER                      (CERN)IJP
KATO      71 MORIOND             +KOEHLER,...,YOKOSAWA,BURLESON   (ANL+NWES)IJP
    ALSO 70 DUKE 367             A YOKOSAWA                             (ANL)IJP
    ALSO 70 PRL 24 615           KATO,KOEHLER,NOVEY,YOKOSAWA+     (ANL+NWES)IJP

GRIFFITH 72 NP B38 365           +HIRATA,HUGHES +        (BGNA+GLAS+ROMA+TRST)
MILLER    72 NP B37 401          +NOVEY,YOKOSAWA,CUTKOSKY +  (ANL+CARN+NWES)IJP
ARNDT     74 PRL 33 987          ARNDT,HACKMAN,ROPER,STEINBERG      (VPI+UMD)IJP
ARNDT     78 PR D18 3278         ARNDT,ROPER,STEINBERG              (VPI+UMD)
NAKAJIMA 82 PL 112B 80           +KIM,KOBAYASHI,MASAIKE,MURAKAMI,+      (KEK)IJP

      REVIEW TALKS AND PAPERS ---
LEVISETT 69 LUND CONF 341        R LEVI SETTI  (RAPPORTEUR)            (CHIC)
GOLDHABE 70 DUKE   407           G GOLDHABER (REVIEWER)                 (LRL)
DOWELL    72  NAL REVIEW         REVIEW TALK IN BARYON SESSION         (BIRM)
LOVELACE 72  NAL REVIEW          RAPPORTEUR'S TALK                     (RUTG)
DOWELL    73 PURDUE CONF. 157  DOWELL                                  (BIRM)
CUTKOSKY 74 LONDON CONF II-54  CUTKOSKY                                (CARN)
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For notation, see key at front of Listings.


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KELLY    75 ANL-HEP-CP-75-58  REVIEW TALK IN BARYON SESSION          (LBL)
URBAN    75 PL 60B 77         URBAN                                  (LBL)
MARTIN   76 OXFORD CONF. 409  RAPPORTEUR'S TALK                     (LOUC)
KELLY    78 HUPD-7813 44      MTG. ON EXOTIC RESONANCES, HIROSHIMA   (LBL)
OADES    81 ROME CONF. 53     LOW + INTERMEDIATE ENERGY KN PHYSICS (AARH)

        SEE ALSO OUR 1982 EDITION (PHYS. LETT. 111B) FOR A LARGE NUMBER OF
        OTHER REFERENCES TO THEORETICAL AND EXPERIMENTAL WORK IN THIS REGION.

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$Z_1(2150)$ BUMPS Status: *

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                 93  Z1(2150, JP=    ) I=1
                 A SMALL BUMP IN THE TOTAL CROSS SECTION AT 1.8 GEV/C.
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                 93  Z1(2150) MASS (MEV)
M        2150.0     20.0          ABRAMS    70 CNTR ++ K+P TOTAL       10/71
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                 93  Z1(2150) WIDTH (MEV)
W        (175.0)                  ABRAMS    70 CNTR +  K+P TOTAL       10/71
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                 93  Z1(2150) PARTIAL DECAY MODES
                                                      DECAY MASSES
P1     Z1(2150) INTO N K                            938+ 494
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                 93  Z1(2150) BRANCHING RATIOS
R1     Z1(2150) INTO (N K)/TOTAL                    (P1)
R1      J IS NOT KNOWN, THE FOLLOWING IS (J+1/2)*P1
R1        (0.04)                   ABRAMS    70 CNTR +  K+P TOTAL       10/71
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                         REFERENCES FOR Z1(2150)

ABRAMS   70 PR  D1 1917       +COOL,GIACOMELLI,KYCIA,LEONTIC,LI +   (BNL)
    ALSO 67 PRL 19 257        ABRAMS,COOL,GIACOMELLI,KYCIA,LEONTIC+ (BNL)
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$Z_1(2500)$ BUMPS Status: *

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                 94  Z1(2500, JP=    ) I=1
                 A SMALL BUMP IN THE TOTAL CROSS SECTION AT 2.7 GEV/C.
------ --------- --------- --------- --------- --------- --------- --------
                 94  Z1(2500) MASS (MEV)
M        2500.0     20.0          ABRAMS    70 CNTR ++ K+P TOTAL       10/71
------ --------- --------- --------- --------- --------- --------- --------
                 94  Z1(2500) WIDTH (MEV)
W        (160.0)                  ABRAMS    70 CNTR ++ K+P TOTAL       10/71
------ --------- --------- --------- --------- --------- --------- --------
                 94  Z1(2500) PARTIAL DECAY MODES
                                                      DECAY MASSES
P1     Z1(2500) INTO N K                            938+ 494
------ --------- --------- --------- --------- --------- --------- --------
                 94  Z1(2500) BRANCHING RATIOS
R1     Z1(2500) INTO (N K)/TOTAL                    (P1)
R1      J IS NOT KNOWN, THE FOLLOWING IS (J+1/2)*P1
R1        (0.03)                   ABRAMS    70 CNTR ++ K+P TOTAL       10/71
****** ********* ********* ********* ********* ********* ********* ********

                         REFERENCES FOR Z1(2500)

ABRAMS   70 PR  D1 1917       +COOL,GIACOMELLI,KYCIA,LEONTIC,LI +   (BNL)
    ALSO 67 PRL 19 257        ABRAMS,COOL,GIACOMELLI,KYCIA,LEONTIC+ (BNL)
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NOTE ON Λ AND Σ RESONANCES

I. Introduction

Progress in Y^*'s has ground to a halt. Whether the field is dead or is merely in suspended animation, to be revived eventually at the lower energy accelerators such as KEK and TRIUMF, remains to be seen. Since the 1982 edition, there has been a paper giving new data on K^-n elastic scattering,[1] and that is it: no new partial-wave analyses, no new Y^*'s promoted to the Baryon Table (in fact, we have removed three — see below). Nor does there appear to be a single new experiment on Y^*'s, planned or in progress, anywhere in the world.

Table 1 is an attempt to evaluate the status, both overall and channel by channel, of each Y^* in the Listings; the evaluations are of course partly subjective. A blank indicates there is no evidence at all: either the relevant couplings are small or the resonance does not really exist. The main Baryon Table includes only the established resonances (overall status 3 or 4 stars). We have reduced the Λ(2585), the Σ(2455), and the Σ(2620)

Table 1. The status of the Λ and Σ resonances. Only those with an overall status of *** or **** are included in the main Baryon Table.

Particle	$L_{I\cdot 2J}$	Overall status	Status as seen in -- $N\bar{K}$	$\Lambda\pi$	$\Sigma\pi$	Other channels
Λ(1116)	P_{01}	****				$N\pi$ (weakly)
Λ(1405)	S_{01}	****	****	F	****	
Λ(1520)	D_{03}	****	****	o	****	$\Lambda\pi\pi$, $\Lambda\gamma$
Λ(1600)	P_{01}	***	***	r	**	
Λ(1670)	S_{01}	****	****	b	****	$\Lambda\eta$
Λ(1690)	D_{03}	****	****	i	****	$\Lambda\pi\pi$, $\Sigma\pi\pi$
Λ(1800)	S_{01}	***	***	d	**	$N\bar{K}^*$, Σ(1385)π
Λ(1800)	P_{01}	***	***	d	**	$N\bar{K}^*$
Λ(1820)	F_{05}	****	****	e	****	Σ(1385) π
Λ(1830)	D_{05}	****	***	n	****	Σ(1385) π
Λ(1890)	P_{03}	****	****	F	**	$N\bar{K}^*$, Σ(1385)π
Λ(2000)		*		o	*	Λω, $N\bar{K}^*$
Λ(2020)	F_{07}	*	*	r	*	
Λ(2100)	G_{07}	****	****	b	***	Λω, $N\bar{K}^*$
Λ(2110)	F_{05}	***	**	i	*	Λω, $N\bar{K}^*$
Λ(2325)	D_{03}	*	*	d		Λω
Λ(2350)		***	***	d	*	
Λ(2585)		**	**	e n		
Σ(1193)	P_{11}	****				$N\pi$ (weakly)
Σ(1385)	P_{13}	****		****	****	
Σ(1480)		*	*	*	*	
Σ(1560)		**		**	**	
Σ(1580)	D_{13}	**	*	*		
Σ(1620)	S_{11}	**	**	*	*	
Σ(1660)	P_{11}	***	***	*	**	
Σ(1670)	D_{13}	****	****	****	****	several others
Σ(1690)		**	*	**	*	Λππ
Σ(1750)	S_{11}	***	***	**	*	Ση
Σ(1770)	P_{11}	*				
Σ(1775)	D_{15}	****	****	****	***	several others
Σ(1840)	P_{13}	*	*	**	*	
Σ(1880)	P_{11}	**	**	**		$N\bar{K}^*$
Σ(1915)	F_{15}	****	***	****	***	Σ(1385)π
Σ(1940)	D_{13}	***	*	***	**	quasi-2-body
Σ(2000)	S_{11}	*		*		$N\bar{K}^*$, Λ(1520)π
Σ(2030)	F_{17}	****	****	****	**	several others
Σ(2070)	F_{15}	*	*		*	
Σ(2080)	P_{13}	**		**		
Σ(2100)	G_{17}	*		*	*	
Σ(2250)		***	***	*	*	
Σ(2455)		**	*			
Σ(2620)		**	*			
Σ(3000)		*	*	*		
Σ(3170)		*				multi-body

**** Good, clear, and unmistakable.
*** Good, but in need of clarification or not absolutely certain.
** Not established; needs confirmation.
* Evidence weak; could disappear.

from 3-star to 2-star status and removed them from the main Table: they are seen only as ripples in isospin-unfolded total cross sections, and nothing at all has been learned about them since 1970. Several of the 1- and 2-star resonances may eventually disappear, but there are probably many resonances yet to be discovered underlying the established ones.

None of the Y^*'s proposed in the last decade couple strongly to the main 2-body decay channels $N\bar{K}$, $\Lambda\pi$, and $\Sigma\pi$, and thus they seldom appear in cross sections or invariant mass distributions. However, when the reactions $\bar{K}N \to \bar{K}N$, $\bar{K}N \to \Lambda\pi$, and $\bar{K}N \to \Sigma\pi$ are partial-wave analyzed, some of the amplitudes are found to traverse small, more-or-less resonance-like counter-clockwise circles. The question in each case is: Is this really a resonance, or is it an idle meander? Is the effect even real, or is it the result of imperfect data and analysis procedures?

What follows is the review of Y^*'s, somewhat revised, that appeared in the 1982 edition: it summarizes "recent" progress and problems. (For another brief overview, see Tripp.[2]) In the Data Card Listings, some obsolete results, nearly all from before 1975, have been removed. This has been done only for the established Y^*'s, where the addition of much improved data to partial-wave analyses has really made obsolete the older results. Where little new has been learned in the last decade [such as for the Λ(1405)], or where the situation is uncertain, nothing has been removed.

II. Formation experiments

(by G.P. Gopal, Rutherford Appleton Laboratory)

Partial-wave analyses have been made mainly for the $N\bar{K}$, $\Lambda\pi$, and $\Sigma\pi$ channels, but there are also a few results for the ΞK, $\Lambda\omega$, and some quasi-2-body channels. The early analyses usually covered only the range of a single bubble chamber experiment. Although the amplitudes obtained often did not join smoothly with those from analyses in neighboring mass ranges, they did give fairly reliable information about the strongly coupled resonances. The more recent analyses have used the Breit-Wigner forms of these dominant resonances as input to provide constraints in determining the overall amplitudes and thus to get information about the less strongly coupled resonances. Besides covering wider ranges, some of the more ambitious of the analyses at the lower energies have treated several channels simultaneously, so that unitarity constraints are automatically satisfied and only a single mass and width is obtained for each resonance.

In the mid and late 1970's, a large amount of new data became available. Results from several large K^-p bubble chamber experiments were published.[3-6] Other bubble chamber experiments studied K^-n reactions[7] and $K^0_L p$ reactions.[8] Counter experiments measured the $K^-p \to \bar{K}^0 n$ total and differential cross sections at low energies,[9] the K^-p polarizations down to 1630 MeV for the first time,[10] the K^-p polarizations from 1700 to 1900 MeV with an order of magnitude increase in statistics,[11] the K^-n elastic angular distributions from 1600 to 1800 MeV[12] and from 1900 to 2300 MeV,[13] and the 180° K^-p and 0° $\Sigma^-\pi^+$ differential cross sections from 1550 to 1900 MeV.[14]

In the following, we compare the more recent partial-wave analyses with each other and with the data. Some of the data have yet to be incorporated into any analysis.

The $N\bar{K}$ channel: The most recent analysis[15] is an update of the old Rutherford Lab-Imperial College (RLIC 77) analysis.[16] As before, it is a conventional energy-dependent analysis with the added constraint that the masses and widths of the resonances had to be consistent with those determined in the inelastic channels analyzed previously — $\Lambda\pi$, $\Sigma\pi$, $\Lambda(1520)\pi$, $\Sigma(1385)\pi$, and $N\bar{K}^*(892)$. The analysis also goes closer to threshold: the range covered is 1470 to 2170 MeV. It includes all the $N\bar{K}$ data mentioned above except for the high-statistics charge-exchange counter measurements[9] (which disagree with both the earlier and the latest[4] high-statistics bubble chamber measurements), the backward elastic data,[14] and the most recent K^-n elastic data.[1] As before, angular distributions (a total of 5110 data points) were fit directly. The new amplitudes are not very different from the RLIC 77 amplitudes for this channel. However, the K^-n data removed some of the uncertainties in the Σ spectrum.

The LBL-Mt. Holyoke-CERN analysis[17] covers the narrower range of 1500 to 1940 MeV and also includes most of the new data. It is an energy-dependent analysis using a unitary background parametrized in terms of scattering lengths. The cusp effects at the $\Lambda\eta$ and $\Sigma\eta$ thresholds are included by introducing a square-root singularity in the energy variation of the widths of the appropriate resonances. This group's own high-

statistics charge-exchange data[9] (which do not agree with bubble chamber measurements) all but kill the less well-established resonances.

The University College, London (UCL) K-matrix energy-dependent analysis[18] covers from 1540 to 2000 MeV. The NK amplitudes are consistent with those of the other analyses over most of this range. However, at the low end there are major differences, indicating the absence of constraints from the Λ(1520), which lies just outside the range covered. The K^-n angular distributions and K^-p polarization measurements are not very well described by this analysis.

The above analyses, all below 2200 MeV, are complemented by the College de France-Saclay (CdF-S) energy-dependent analysis[6] covering from 2070 to 2440 MeV. Besides the conventional polynomial parametrization of the background amplitudes, also tried is a parametrization using constraints imposed by the duality hypothesis (that s-channel backgrounds come exclusively from the t-channel Pomeron exchange amplitude). With 30 fewer free parameters, the results are consistent with the conventional approach.

The Σπ channel: There is very little agreement, particularly in the lower partial waves, between the two multichannel analyses.[16,18] The low-energy $K^0_L p \to \Sigma^0\pi^+$ data[8] are better explained by the RLIC 77 amplitudes than by the UCL amplitudes. At the high end, there is good continuity between the RLIC 77 amplitudes and those from the single-channel analysis of the CdF-S collaboration[6] covering from 2070 to 2440 MeV. The Λ(1520) and Λ(2110) resonances, which lie outside the range covered by the UCL analysis, clearly provide strong constraints on the amplitudes.

The Λπ channel: This isospin-1 channel has been the subject of many energy-dependent and -independent analyses (for example, RLIC 77,[16] UCL,[18] Baillon-Litchfield,[19] de Bellefon-Berthon,[20] and Van Horn[21]). However, even the widespread use of the method of Barrelet zeroes has not helped to resolve the Σ spectrum — probably because most Σ resonances simply do not couple strongly to the initial $N\bar{K}$ channel.

Quasi-2-body channels: The RLIC group has made energy-dependent analyses of the Λ(1520)π, Σ(1385)π, and $N\bar{K}^*(892)$ channels over the widest ranges for which data are available. The data were extracted from the appropriate 3-particle final states by making 4-variable fits to an incoherent superposition of quasi-2-body final states and 3-particle Lorentz-invariant phase space. The quality of the fits suggests a maximum model-dependent systematic uncertainty of 10%. The Λω channel has been analyzed from threshold to 2440 MeV by the CdF-S collaboration.[6]

Sign conventions for resonance couplings: In terms of the isospin-0 and -1 elastic scattering amplitudes A_0 and A_1, the amplitude for $K^-p \to \bar{K}^0 n$ scattering is $\pm(A_1-A_0)/2$, where the sign depends on conventions used in conjunction with the Clebsch-Gordan coefficients (such as, is the baryon or the meson the "first" particle). If this reaction is partial-wave analyzed and if the overall phase is chosen so that, say, the D_{15} Σ(1775) amplitude at resonance points along the positive imaginary axis (points "up"), then any Σ at resonance will point "up" and any Λ at resonance will point "down" (along the negative imaginary axis). Thus the phase at resonance determines the isospin. The above ignores background amplitudes in the resonating partial waves.

That is the basic idea. In a similar but somewhat more complicated way, the phases of the $\bar{K}N \to \Lambda\pi$ and $\bar{K}N \to \Sigma\pi$ amplitudes for a resonating partial wave help determine the SU(3) multiplet to which the resonance belongs. Again, a convention has to be adopted for some overall arbitrary phases: which way is "up"? Our convention is that of Levi-Setti[22] and is shown in Fig. 1, which also compares experimental results with theoretical predictions for the signs of several other resonances. In the Listings, a + or − sign in front of a measurement of an inelastic resonance coupling indicates the sign (the *absence* of a sign means that the sign is not determined, *not* that it is positive). For more details, see Appendix II of our 1982 edition.[23]

Argand plots: Figure 2 shows some representative Argand plots of partial-wave amplitudes. For the $N\bar{K}$ channel we show the amplitudes from RLIC 77[16] and from LBL-Mt. Holyoke-CERN,[17] and for the Λπ and Σπ channels we show those from RLIC 77[16] and from UCL.[18]

Errors on masses and widths: The errors quoted on resonance parameters from partial-wave analyses are often only statistical, and the parameters can change by more than these errors when a different parametrization

of the waves is used. Furthermore, the different analyses use more or less the same data, so it is not really appropriate to treat the different determinations of the resonance parameters as independent or to average them together. In any case, the spread of the masses, widths, and branching fractions from the different analyses is certainly a better indication of the uncertainties than are the quoted errors. In the Baryon Table, usually a range reflecting the spread of the values is given rather than a particular value with error.

For three states, the Λ(1520), the Λ(1820), and the Σ(1775), there is enough information to make an overall fit to the various branching fractions. It is then necessary to use the quoted errors, but the errors obtained from the fit should not be taken seriously.

III. Production experiments

Partial-wave analyses of course separate partial waves, whereas a peak in a cross section or an invariant mass distribution usually cannot be disentangled from background and analyzed for its quantum numbers; and more than one resonance may be contributing to the peak. Results from partial-wave analyses and from production experiments are generally kept separate in the Listings, and in the Baryon Table results from production experiments are used only for the low mass states: the Σ(1385) and Λ(1405) of course lie below the $\bar{K}N$ threshold and everything about them comes from production experiments; and production and formation experiments agree quite well in the case of Λ(1520) and results have been combined. There is some disagreement between production and formation experiments in the 1600-1700-MeV region: see the Note on the Σ(1670).

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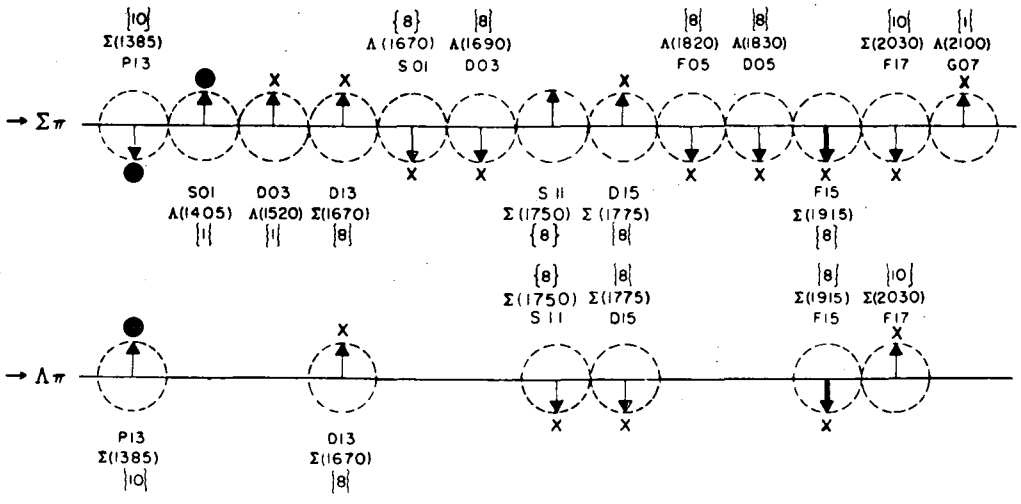


Fig. 1. The signs of the imaginary parts of resonating amplitudes in the $\bar{K}N \to \Lambda\pi$ and $\Sigma\pi$ channels. The signs of the Σ(1385) and Λ(1405), marked with a •, are set by convention, and then the others are determined relative to them. The signs required by the SU(3) assignments of the resonances are shown with an arrow, and the experimentally determined signs are shown with an ×.

For notation, see key at front of Listings.

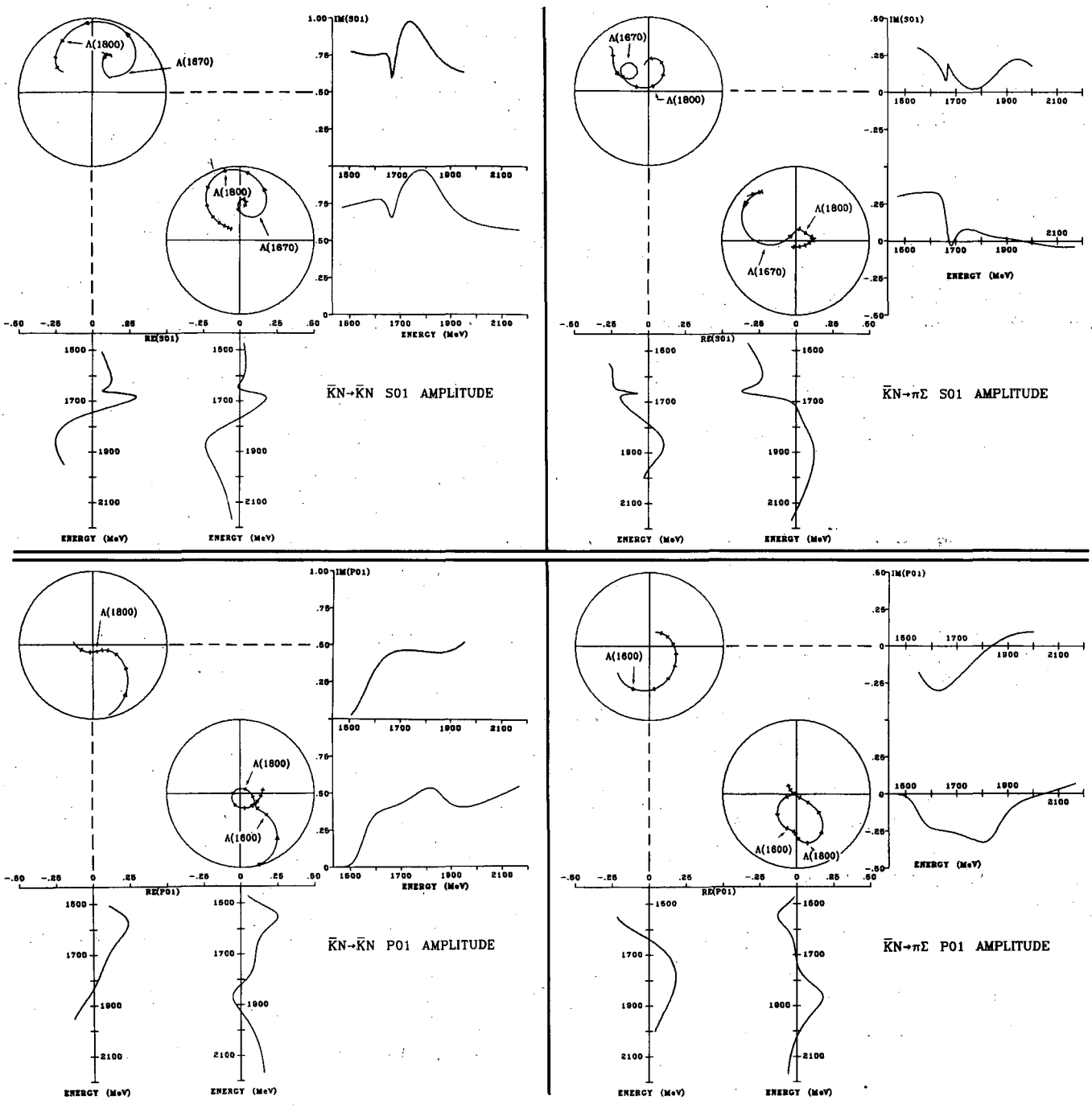


Fig. 2(a). The $L_{I\cdot 2J} = S_{01}$ and P_{01} partial-wave amplitudes for $\bar{K}N$ scattering in the elastic and $\Sigma\pi$ channels. The lower plot for each amplitude is from RLIC 77, the upper plots for the elastic amplitudes are from ALSTON 78, and the upper plots for the $\Sigma\pi$ amplitudes are from MARTIN 77. In the Argand plots, the ticks are at integral multiples of 50 MeV, and the established resonances are shown at their nominal positions [the S_{01} Λ(1405) is of course below threshold and is not shown]. The real and imaginary parts of the amplitudes as functions of energy are shown projected in alignment with the Argand plots.

Baryons
Λ's and Σ's

Data Card Listings

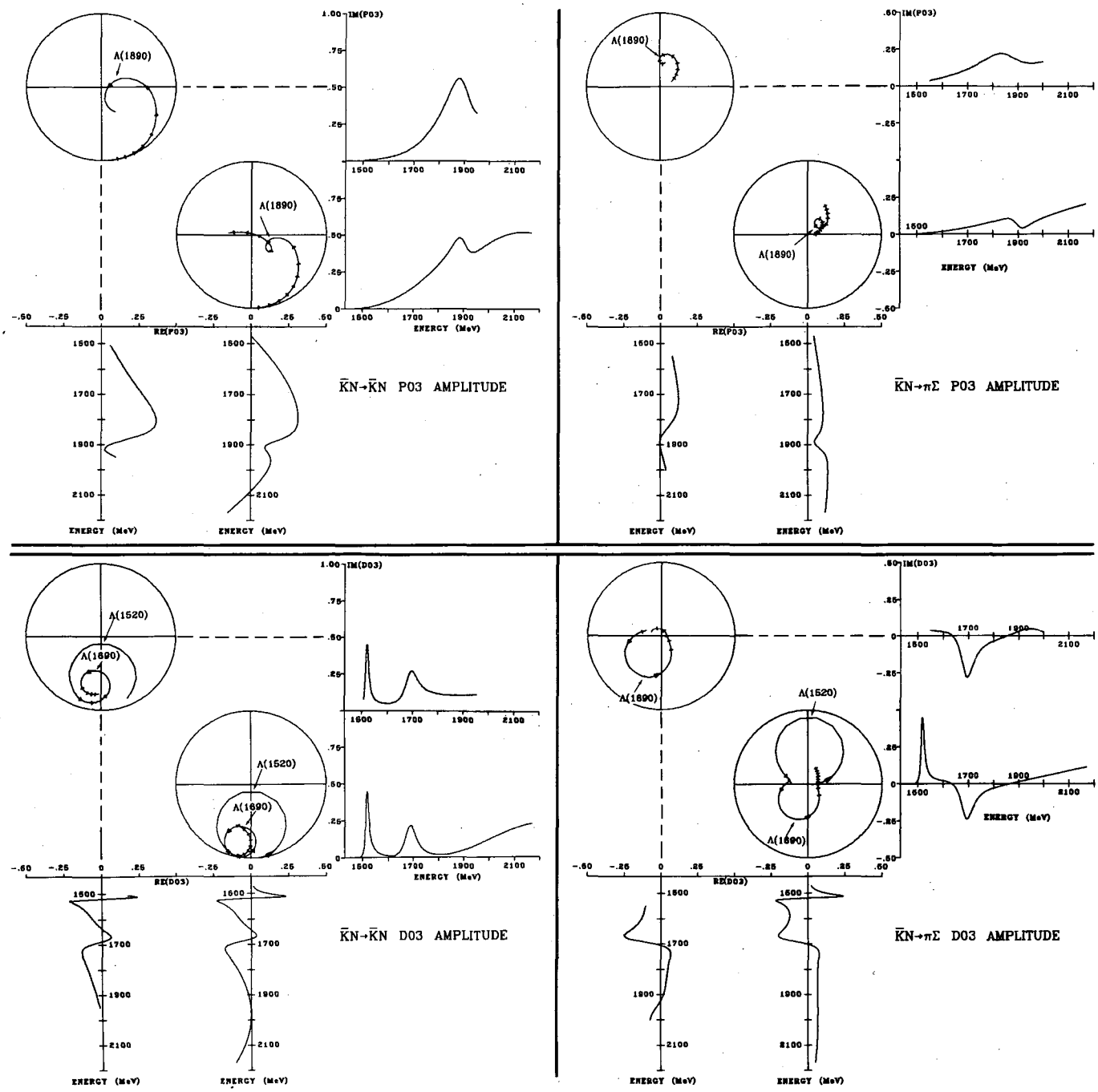


Fig. 2(b). The $L_{I\cdot 2J} = P_{03}$ and D_{03} partial-wave amplitudes for $\bar{K}N$ scattering in the elastic and $\Sigma\pi$ channels. The lower plot for each amplitude is from RLIC 77, the upper plots for the elastic amplitudes are from ALSTON 78, and the upper plots for the $\Sigma\pi$ amplitudes are from MARTIN 77. In the Argand plots, the ticks are at integral multiples of 50 MeV, and the established resonances are shown at their nominal positions. The real and imaginary parts of the amplitudes as functions of energy are shown projected in alignment with the Argand plots.

For notation, see key at front of Listings.

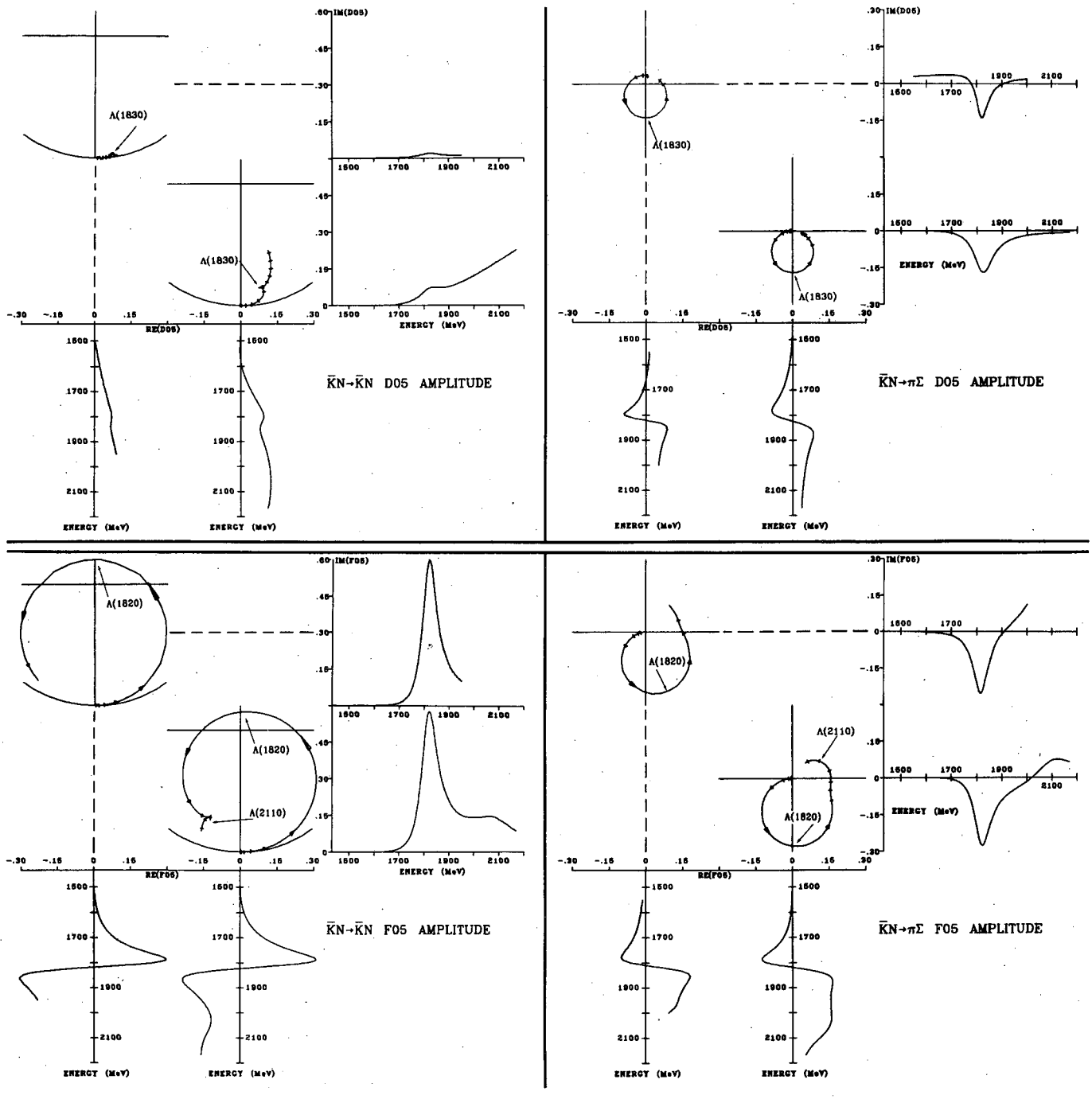


Fig. 2(c). The $L_{I\cdot 2J} = D_{05}$ and F_{05} partial-wave amplitudes for $\bar{K}N$ scattering in the elastic and $\Sigma\pi$ channels. The lower plot for each amplitude is from RLIC 77, the upper plots for the elastic amplitudes are from ALSTON 78, and the upper plots for the $\Sigma\pi$ amplitudes are from MARTIN 77. In the Argand plots, the ticks are at integral multiples of 50 MeV, and the established resonances are shown at their nominal positions. The real and imaginary parts of the amplitudes as functions of energy are shown projected in alignment with the Argand plots.

Baryons
Λ's and Σ's

Data Card Listings

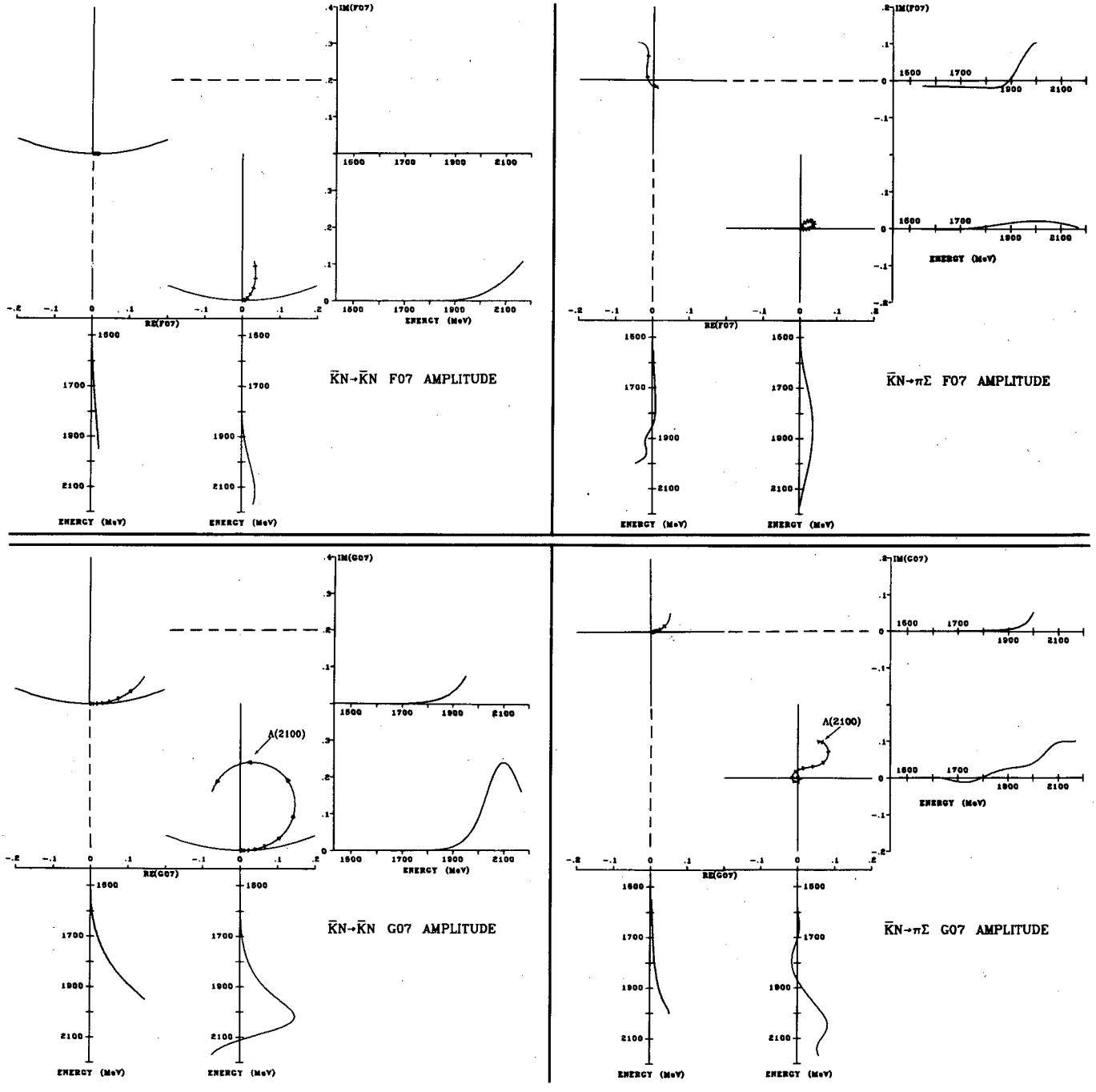
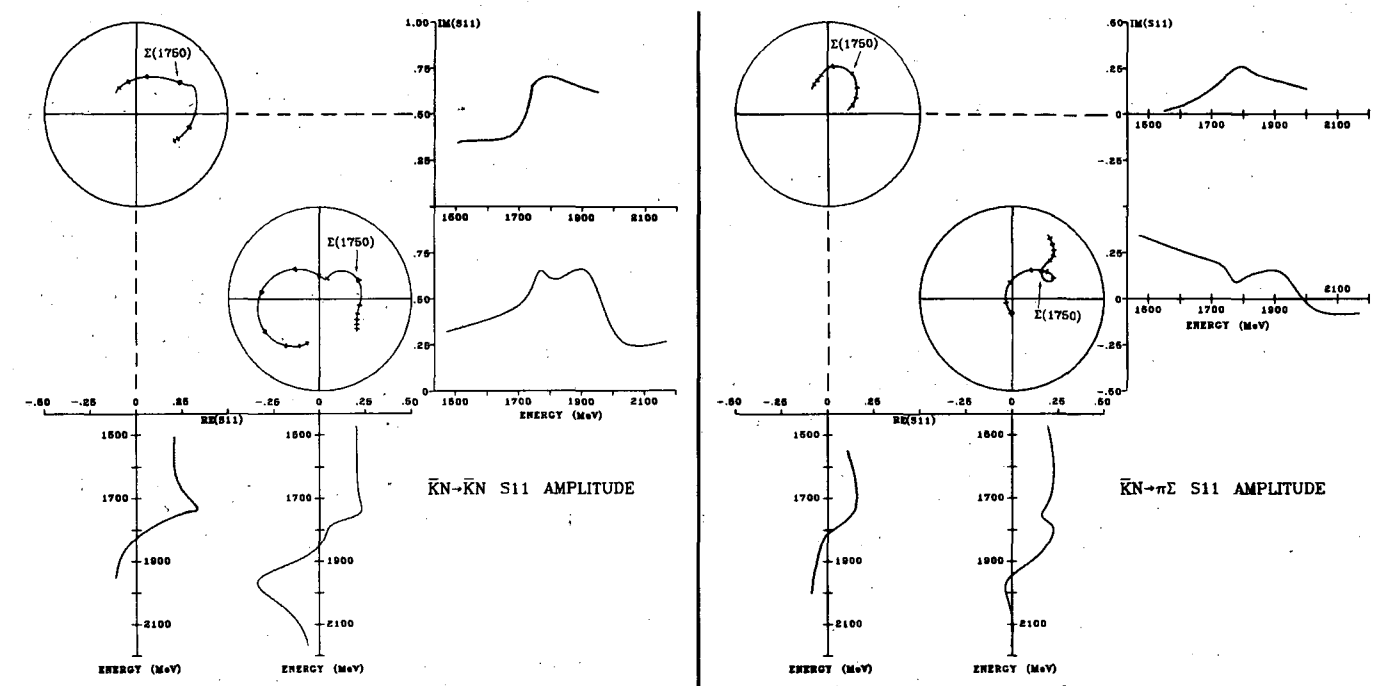


Fig. 2(d). The $L_{I\cdot 2J} = F_{07}$ and G_{07} partial-wave amplitudes for $\bar{K}N$ scattering in the elastic and $\Sigma\pi$ channels. The lower plot for each amplitude is from RLIC 77, the upper plots for the elastic amplitudes are from ALSTON 78, and the upper plots for the $\Sigma\pi$ amplitudes are from MARTIN 77. In the Argand plots, the ticks are at integral multiples of 50 MeV, and the established resonance is shown at its nominal position. The real and imaginary parts of the amplitudes as functions of energy are shown projected in alignment with the Argand plots.

For notation, see key at front of Listings.



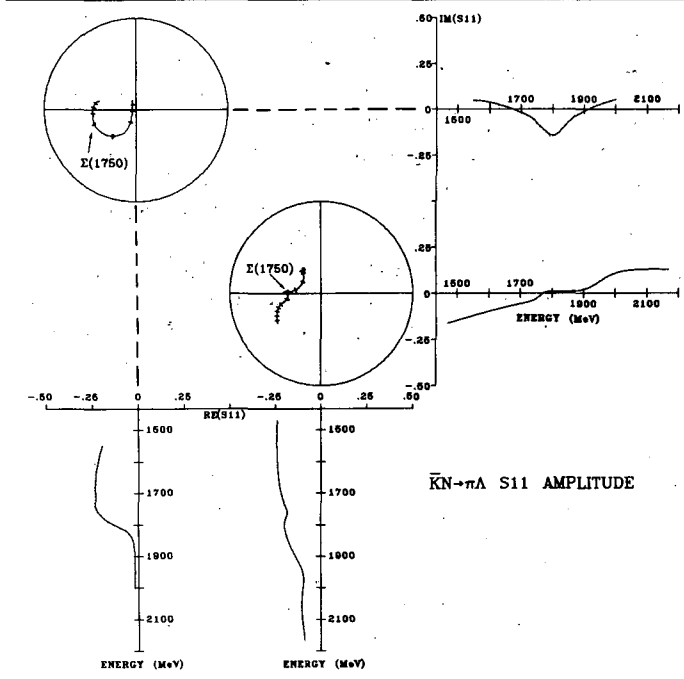
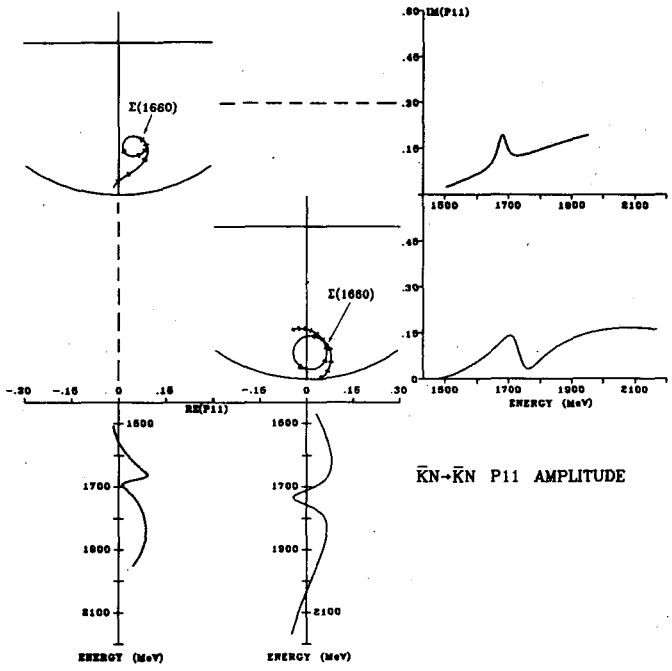
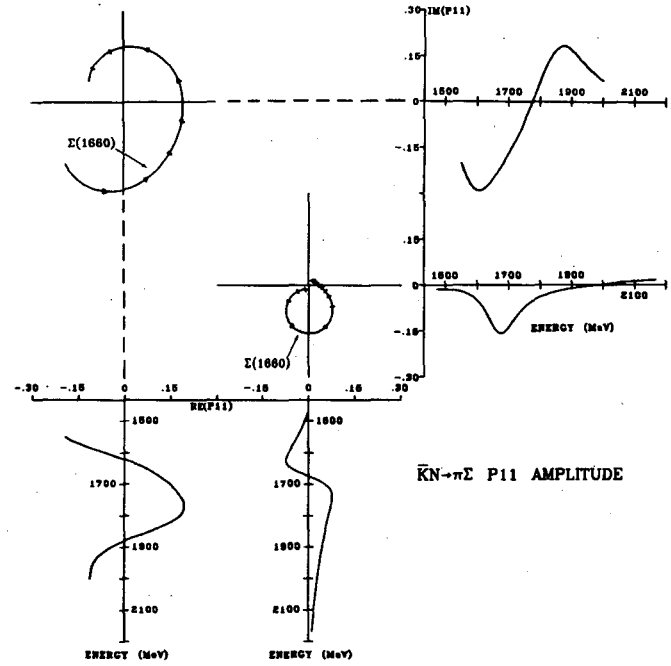


Fig. 2(e). The $L_{I\cdot 2J} = S_{11}$ partial-wave amplitudes for $\bar{K}N$ scattering in the elastic, $\Lambda\pi$, and $\Sigma\pi$ channels. The lower plot for each amplitude is from RLIC 77, the upper plot for the elastic amplitude is from ALSTON 78, and the upper plots for the $\Lambda\pi$ and $\Sigma\pi$ channels are from MARTIN 77. In the Argand plots, the ticks are at integral multiples of 50 MeV, and the established resonance is shown at its nominal position. The real and imaginary parts of the amplitudes as functions of energy are shown projected in alignment with the Argand plots.

Baryons
Λ's and Σ's

Data Card Listings





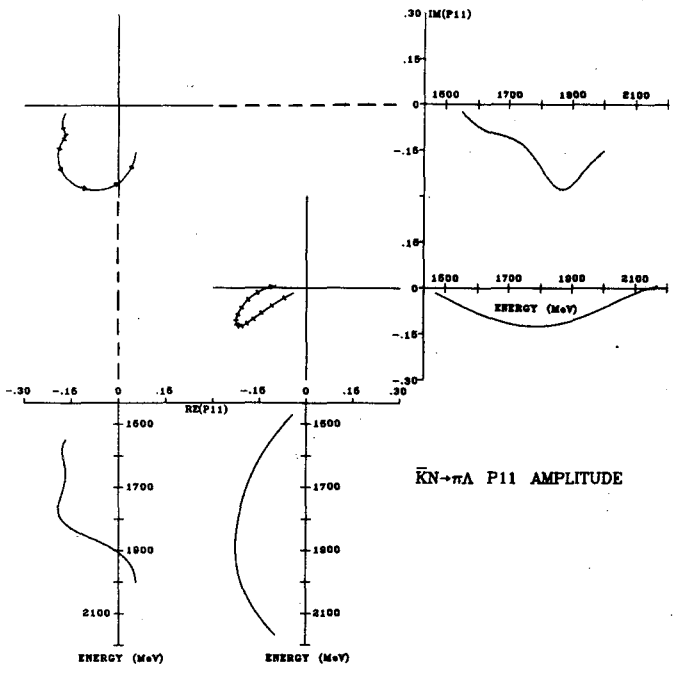
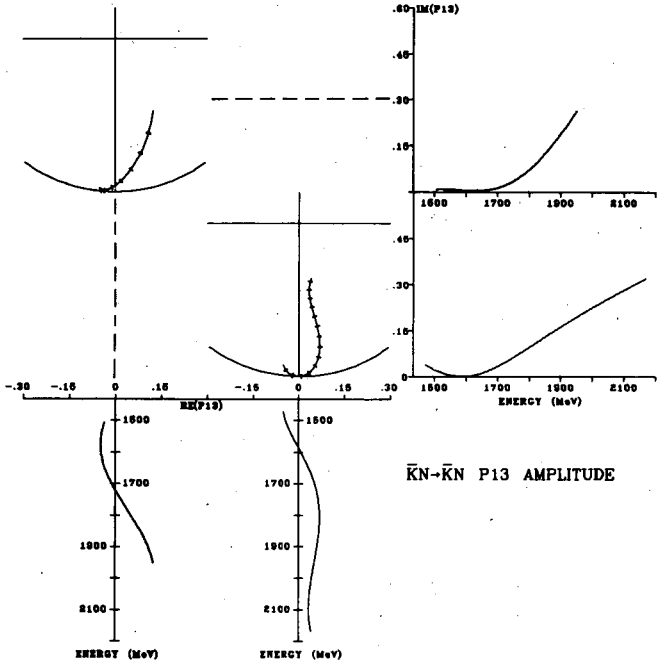
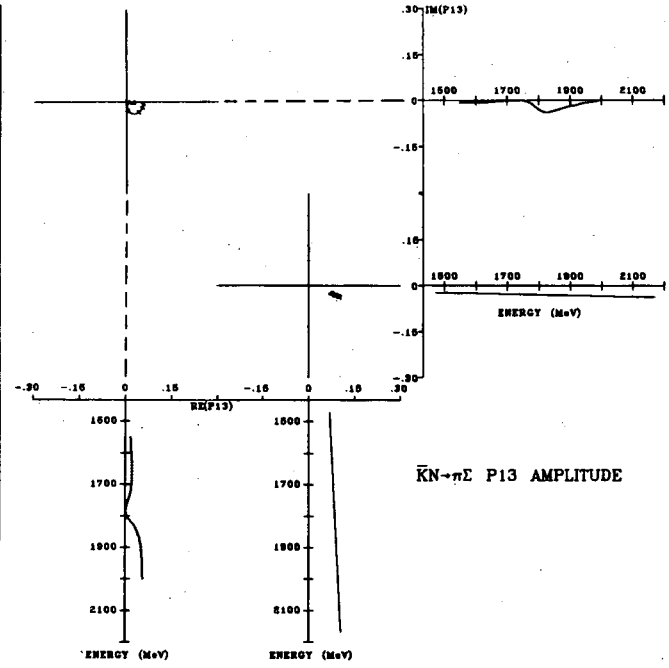


Fig. 2(f). The $L_{I\cdot 2J} = P_{11}$ partial-wave amplitudes for $\bar{K}N$ scattering in the elastic, $\Lambda\pi$, and $\Sigma\pi$ channels. The lower plot for each amplitude is from RLIC 77, the upper plot for the elastic amplitude is from ALSTON 78, and the upper plots for the $\Lambda\pi$ and $\Sigma\pi$ channels are from MARTIN 77. In the Argand plots, the ticks are at integral multiples of 50 MeV, and the established resonance is shown at its nominal position. The real and imaginary parts of the amplitudes as functions of energy are shown projected in alignment with the Argand plots.

For notation, see key at front of Listings.





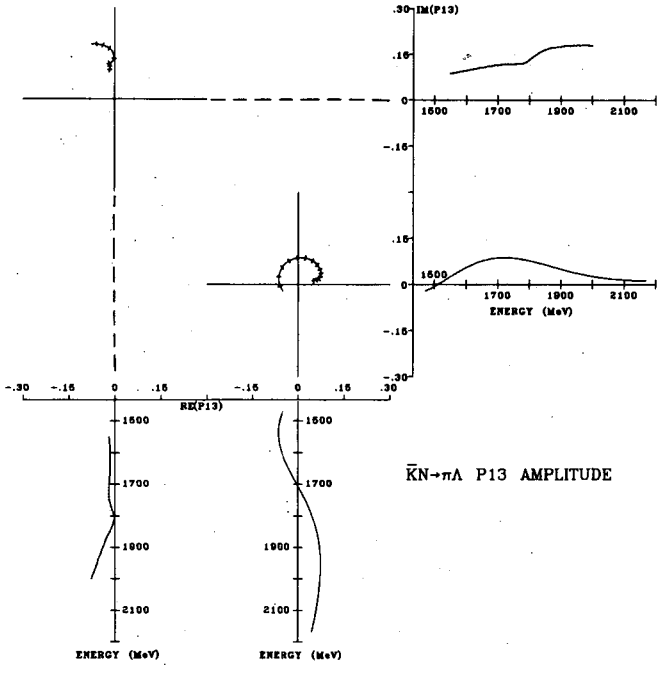


Fig. 2(g). The $L_{I,2J} = P_{13}$ partial-wave amplitudes for $\bar{K}N$ scattering in the elastic, $\Lambda\pi$, and $\Sigma\pi$ channels. The lower plot for each amplitude is from RLIC 77, the upper plot for the elastic amplitude is from ALSTON 78, and the upper plots for the $\Lambda\pi$ and $\Sigma\pi$ channels are from MARTIN 77. In the Argand plots, the ticks are at integral multiples of 50 MeV [the Σ(1385) is of course below threshold and is not shown]. The real and imaginary parts of the amplitudes as functions of energy are shown projected in alignment with the Argand plots.

Baryons

Λ's and Σ's

Data Card Listings

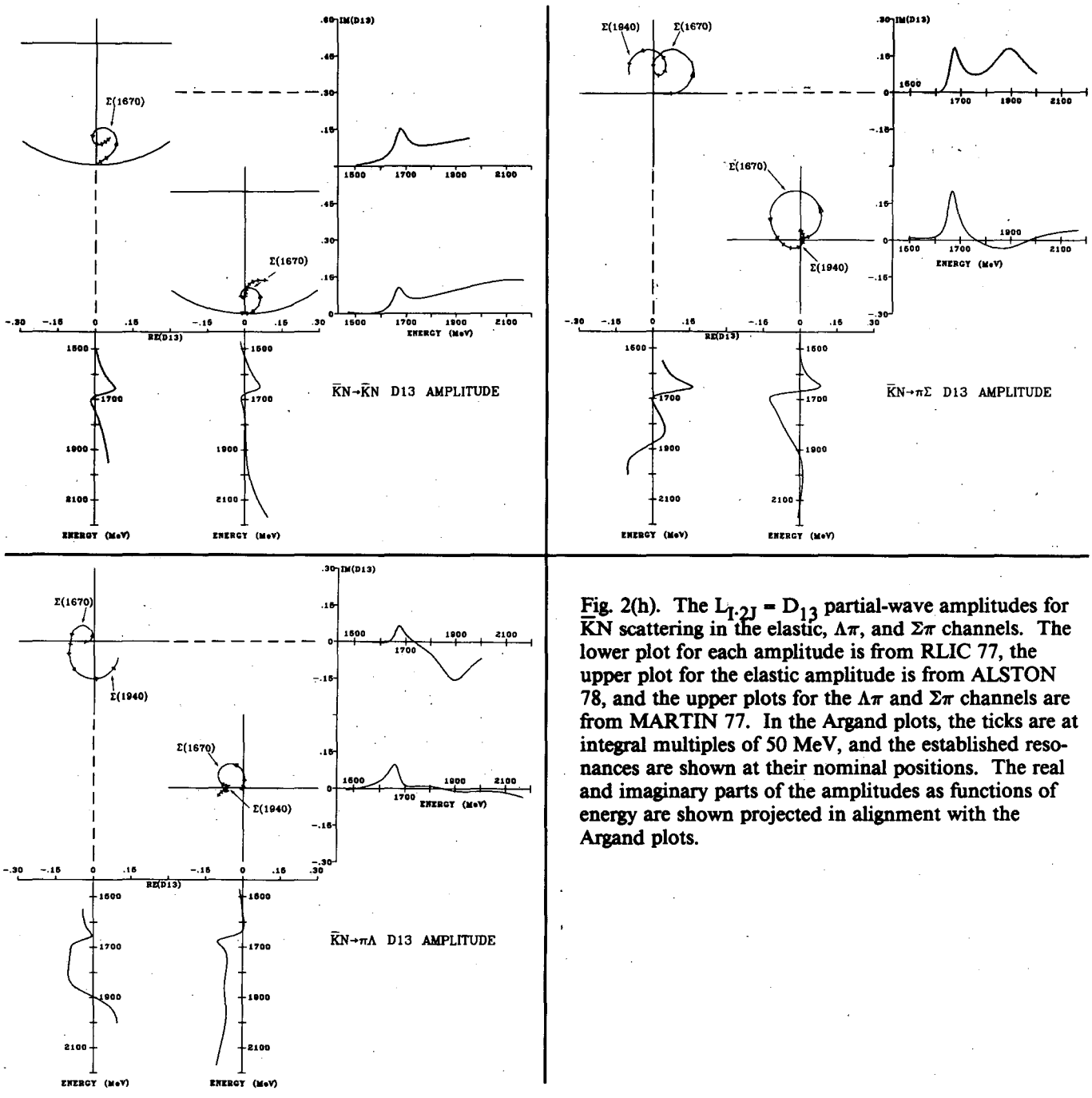


Fig. 2(h). The $L_{I\cdot 2J} = D_{13}$ partial-wave amplitudes for $\bar{K}N$ scattering in the elastic, $\Lambda\pi$, and $\Sigma\pi$ channels. The lower plot for each amplitude is from RLIC 77, the upper plot for the elastic amplitude is from ALSTON 78, and the upper plots for the $\Lambda\pi$ and $\Sigma\pi$ channels are from MARTIN 77. In the Argand plots, the ticks are at integral multiples of 50 MeV, and the established resonances are shown at their nominal positions. The real and imaginary parts of the amplitudes as functions of energy are shown projected in alignment with the Argand plots.

For notation, see key at front of Listings.

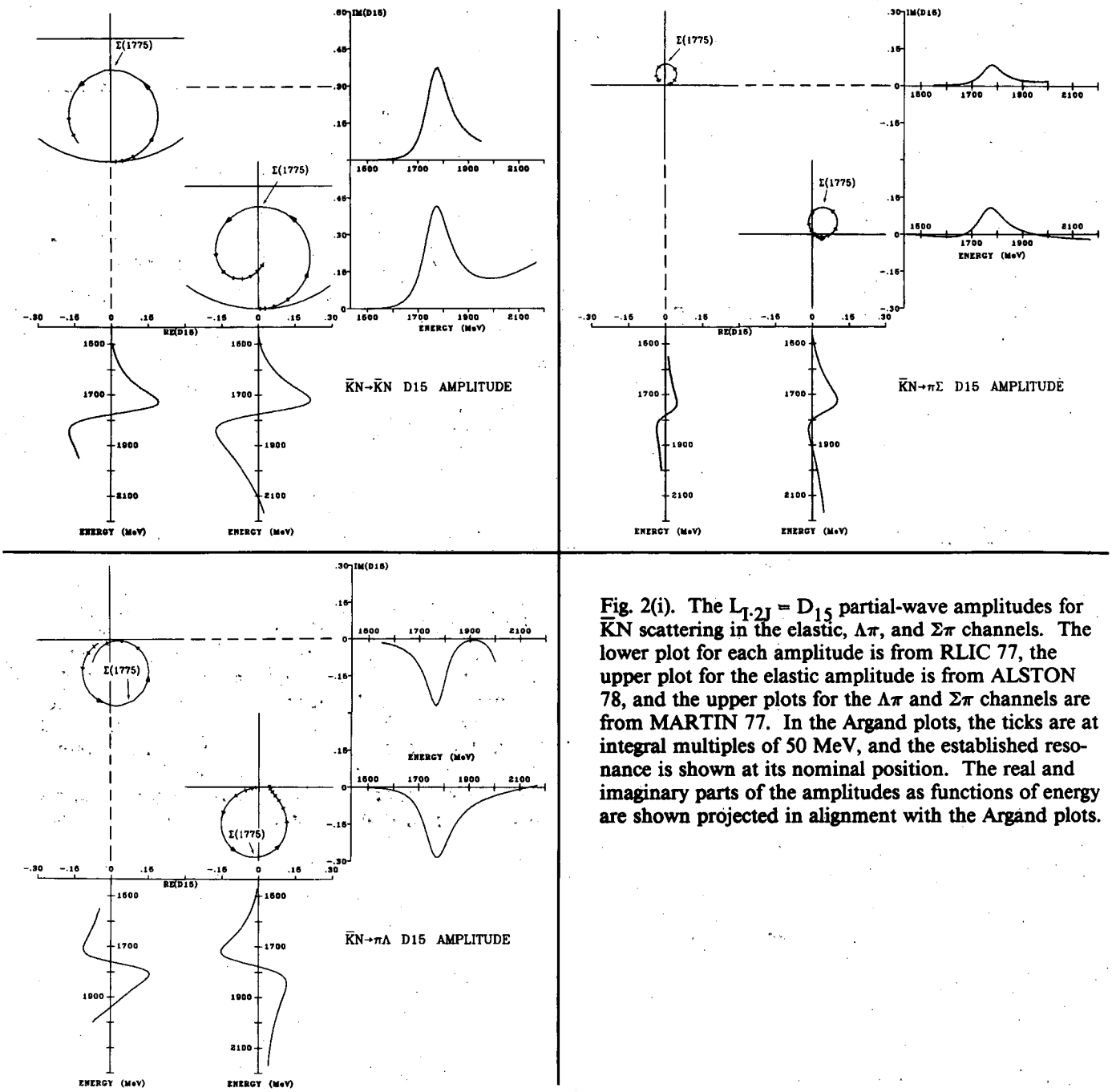
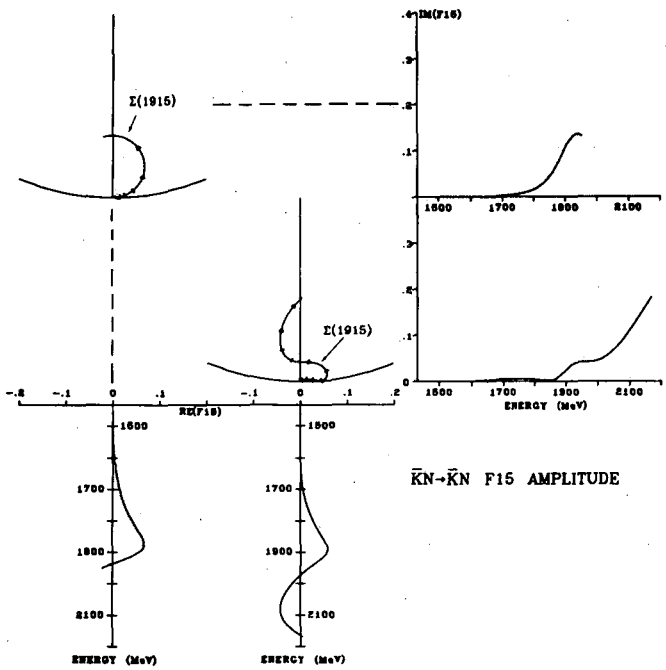
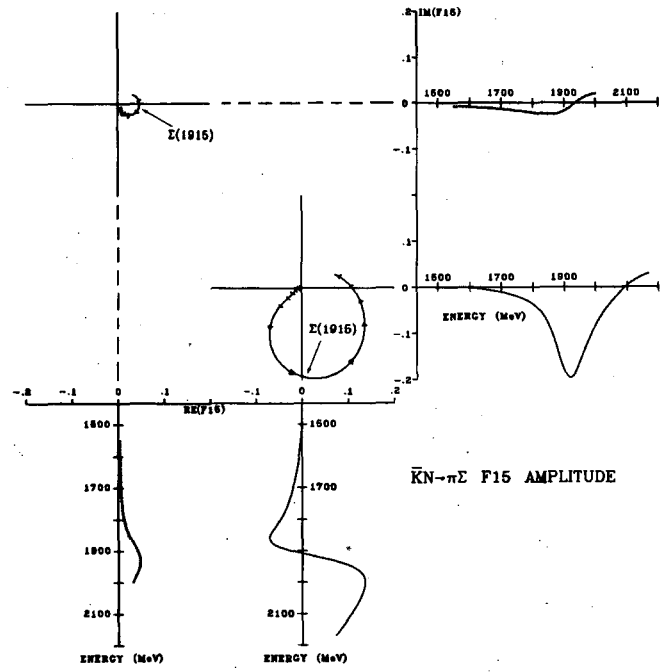


Fig. 2(i). The $L_{I\cdot 2J} = D_{15}$ partial-wave amplitudes for $\bar{K}N$ scattering in the elastic, $\Lambda\pi$, and $\Sigma\pi$ channels. The lower plot for each amplitude is from RLIC 77, the upper plot for the elastic amplitude is from ALSTON 78, and the upper plots for the $\Lambda\pi$ and $\Sigma\pi$ channels are from MARTIN 77. In the Argand plots, the ticks are at integral multiples of 50 MeV, and the established resonance is shown at its nominal position. The real and imaginary parts of the amplitudes as functions of energy are shown projected in alignment with the Argand plots.

Baryons

Λ's and Σ's





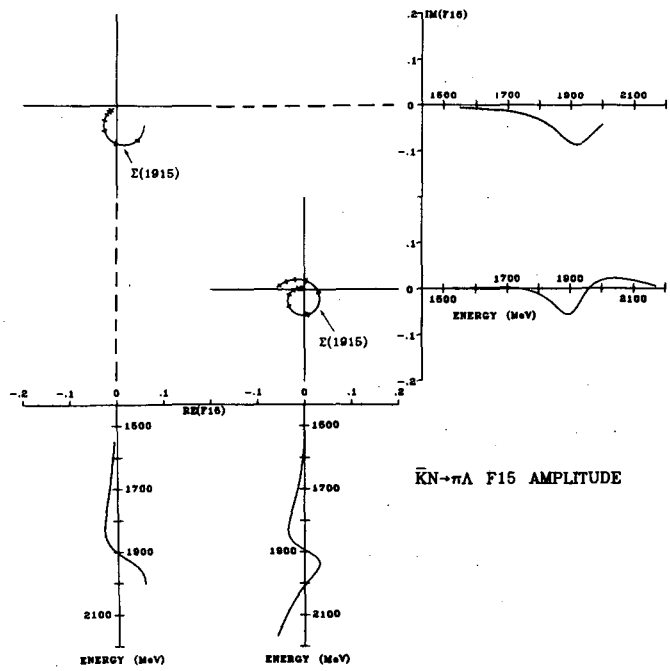
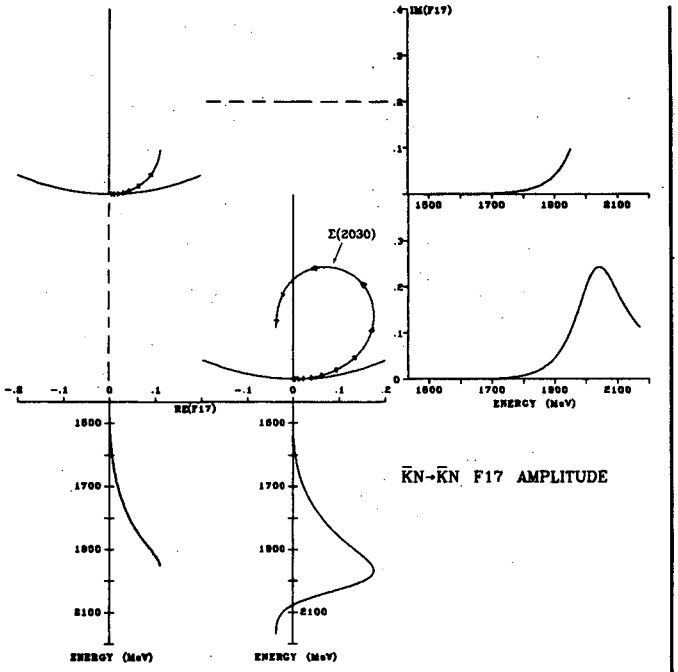
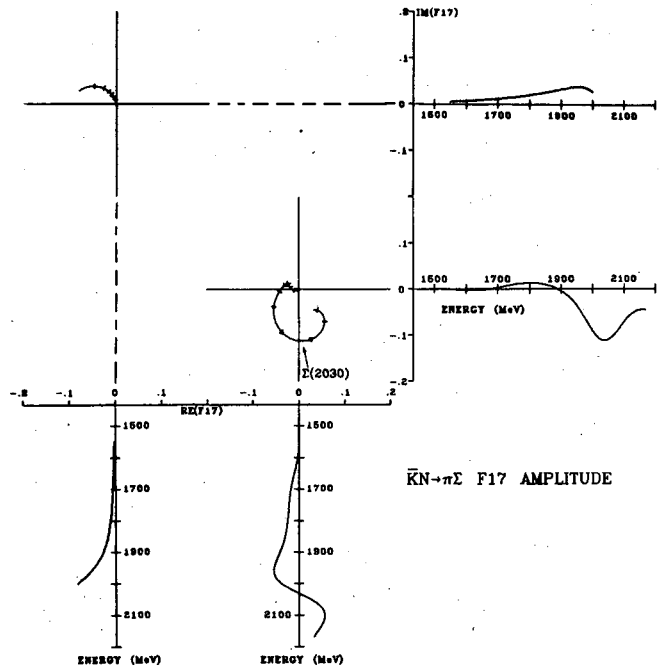


Fig. 2(j). The $L_{I\cdot 2J} = F_{15}$ partial-wave amplitudes for $\bar{K}N$ scattering in the elastic, $\Lambda\pi$, and $\Sigma\pi$ channels. The lower plot for each amplitude is from RLIC 77, the upper plot for the elastic amplitude is from ALSTON 78, and the upper plots for the $\Lambda\pi$ and $\Sigma\pi$ channels are from MARTIN 77. In the Argand plots, the ticks are at integral multiples of 50 MeV, and the established resonance is shown at its nominal position. The real and imaginary parts of the amplitudes as functions of energy are shown projected in alignment with the Argand plots.

For notation, see key at front of Listings.





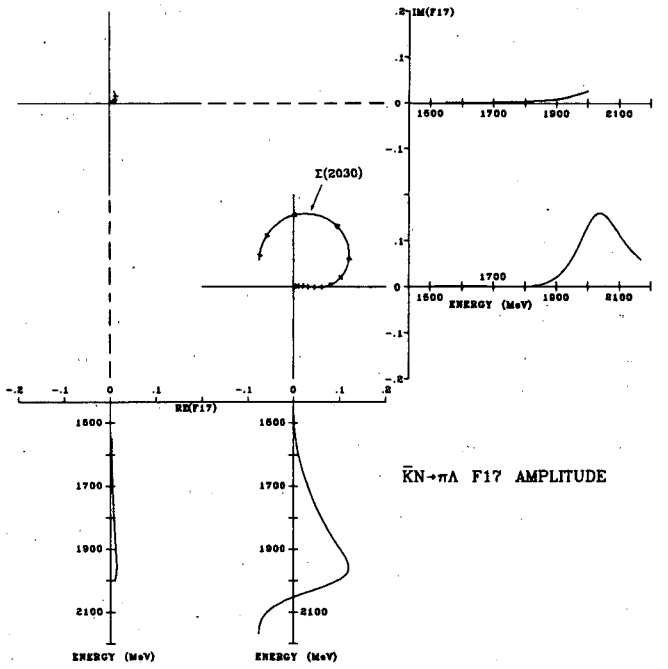


Fig. 2(k). The $L_{I\cdot 2J} = F_{17}$ partial-wave amplitudes for $\bar{K}N$ scattering in the elastic, $\Lambda\pi$, and $\Sigma\pi$ channels. The lower plot for each amplitude is from RLIC 77, the upper plot for the elastic amplitude is from ALSTON 78, and the upper plots for the $\Lambda\pi$ and $\Sigma\pi$ channels are from MARTIN 77. In the Argand plots, the ticks are at integral multiples of 50 MeV, and the established resonance is shown at its nominal position. The real and imaginary parts of the amplitudes as functions of energy are shown projected in alignment with the Argand plots.

Baryons

Λ's and Σ's, Λ, Λ(1405), Λ(1520)

Data Card Listings

12. C.J.S. Damerell et al., Nucl. Phys. **B155**, 13 (1979).
13. Y. Declais et al., CERN 77-16 (1977).
14. M. Alston-Garnjost et al., Phys. Rev. **D21**, 1191 (1980).
15. G.P. Gopal, in *Proceedings of the IVth International Conference on Baryon Resonances* (Toronto, 1980), edited by N. Isgur, p. 159.
16. G.P. Gopal et al., Nucl. Phys. **B119**, 362 (1977).
17. M. Alston-Garnjost et al., Phys. Rev. **D18**, 182 (1978).
18. B.R. Martin et al., Nucl. Phys. **B126**, 266 (1977); **B126**, 285 (1977); and **B127**, 349 (1977).
19. P. Baillon and P.J. Litchfield, Nucl. Phys. **B94**, 39 (1975).
20. A. de Bellefon and A. Berthon, Nucl. Phys. **B109**, 129 (1976).
21. A.J. Van Horn, Nucl. Phys. **B87**, 145 (1975).
22. R. Levi-Setti, in *Proceedings of the Lund International Conference on Elementary Particles* (Lund, 1969), p. 339.
23. Particle Data Group, Phys. Lett. **111B** (1982).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S=−1 I=0 HYPERON STATES (Λ)

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Λ

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                    18  LAMBDA(1116, JP=1/2+)  I=0

                    SEE STABLE PARTICLE DATA CARD LISTINGS

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Λ(1405) S'_{01} Status: ****

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                    37  LAMBDA(1405, JP=1/2-) I=0
                        PRODUCTION EXPERIMENTS

                    THIS RESONANCE IS IDENTIFIED WITH THE VIRTUAL BOUND
                    STATE IN THE N-KBAR SYSTEM FOUND IN THE ANALYSIS OF
                    LOW ENERGY K-P INTERACTIONS.  WE LIST THOSE RESULTS
                    SEPARATELY IN THE NEXT ENTRY.  WE USE ONLY PRODUCTION
                    EXPERIMENTS FOR GETTING THE MASS AND WIDTH FOR THE
                    BARYON TABLE.

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                    37  LAMBDA(1405) MASS (MEV) (PROD. EXP.)

M        (1405.0)                  ALSTON    61 HBC     K-P 1.15 GEV/C
M        (1410.0)                  ALEXANDER 62 HBC     PI-P 2.1 GEV/C
M        (1405.0)                  ALSTON    62 HBC     K-P 1.2-.5 GEV/C
M        (1382.0)    (8.0)         ENGLER    65 HDBC    PI-P, PI+D 1.68    7/66
M         1400.0    24.0           MUSGRAVE  65 HBC     PBAR P 3-4 GEV/C   7/66
M      67 1400.0     5.0           BIRMINGHA 66 HBC     K-P 3.5            9/67
M     120 1405.0     5.0           GALTIERI  68 DBC     K-D 2.1-2.7GEV/C   6/68
M         . . . . . . . . .
M   AVG   1402.4     3.5    AVERAGE

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                    37  LAMBDA(1405) WIDTH (MEV) (PROD. EXP.)

W         (20.0)                    ALSTON    61 HBC                        7/66
W          35.0      5.0            ALEXANDER 62 HBC
W         (50.0)                    ALSTON    62 HBC
W         (89.0)   (20.0)           ENGLER    65 HDBC                       7/66
W          60.0    20.0             MUSGRAVE  65 HBC                        7/66
W      67  50.0    10.0             BIRMINGHA 66 HBC     K-P 3.5            9/67
W     120  35.0     8.0             GALTIERI  68 DBC     K-D 2.1-2.7GEV/C   6/68
W         . . . . . . . . .
W   AVG   38.1     3.9    AVERAGE

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                    37  LAMBDA(1405) PARTIAL DECAY MODES (PROD. EXP.)
                                                          DECAY MASSES
P1     LAMBDA(1405) INTO SIGMA PI                        1189+ 140

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                    REFERENCES FOR LAMBDA(1405) (PROD. EXP.)

ALSTON   61 PRL 6 698          +ALVAREZ,EBERHARD,GOOD,GRAZIANO, +     (LRL) I
ALEXANDE 62 PRL 8 447          ALEXANDER,KALBFLEISCH,MILLER,SMITH     (LRL) I
ALSTON   62 CERN CONF 311      +ALVAREZ,FERRO-LUZZI,ROSENFELD, +      (LRL) I
ENGLER   65 PRL 15 224         +FISK,KRAEMER,MELTZER,WESTGARD,+ (CARN+BNL) IJ
MUSGRAVE 65 NC 35 735          +PETMEZAS,+       (BIRM+CERN+EPOL+LOIC+SACL)

BIRMINGH 66 PR 152 1148                     (BIRM+GLAS+LOIC+OXF+RHEL)
GALTIERI 68 PRL 21 573         BARBARO-GALTIERI,CHADWICK +       (LRL+SLAC)
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1405 MEV REGION: EXTRAPOLATIONS BELOW THRESHOLD

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                    24  LAMBDA(1405, JP=1/2-) I=0       S'01
                        EXTRAPOLATIONS BELOW THRESHOLD

                    SEE THE NOTE IN THE PREVIOUS ENTRY.  THE DIF-
                    FICULTIES IN EXTRAPOLATING FROM THE PHYSICAL REGION TO
                    THE RESONANCE LOCATION ARE DISCUSSED BY DALITZ 67.

                    THE QUESTION ON WHETHER LAMBDA(1405) IS AN N-KBAR
   BOUND STATE OR A CDD POLE (DALITZ 70, RAJASEKARAN 72) HAS BEEN
   INVESTIGATED BY CLINE 71, MARTIN 71, GALTIERI 72, AND DOBSON 72.  THE
   LAST TWO PAPERS CONCLUDE THAT THE DATA CANNOT TELL THE DIFFERENCE.

   THE (N KBAR)/(SIGMA PI) COUPLING RATIO IS DISCUSSED BY OADES 77.

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                    24  LAMBDA(1405) MASS (MEV)

M          1410.7     (1.0)          KIM       65 HBC     O-EFF-RANGE FIT    7/66
M          1409.6     (1.7)          SAKITT    65 HBC     O-EFF-RANGE FIT    7/66
M                          DATA OF SAKITT ARE USED IN FIT BY KITTEL.
M          1407.5     (1.2)          KITTEL    66 HBC     O-EFF-RANGE FIT    7/66
M          1403.0     (3.0)          KIM       67 HBC     K MATRIX FIT(KP)   8/67
M          1416.0     (4.0)          MARTIN    69 HBC     CONST. K MATRIX   10/69
M         (1421.0)                   MARTIN    70 RVUE    CONST. K MATRIX    6/70
M    A    (1406.0)                   CHAO      73 DPWA    O-RNG. FIT.SOL B   9/73
M    A  SEE ALSO THE ACCOMPANYING PAPER OF THOMAS 73.                       9/73

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                    24  LAMBDA(1405) WIDTH (MEV)

W           37.0     (3.2)          KIM       65 HBC                        7/66
W           28.2     (4.1)          SAKITT    65 HBC                        7/66
W           34.1     (4.1)          KITTEL    66 HBC                        7/66
W           50.0     (5.0)          KIM       67 HBC     K MATRIX FIT(KP)   8/67
W           29.0     (6.0)          MARTIN    69 HBC     CONST. K MATRIX   10/69
W          (20.0)                   MARTIN    70 RVUE    CONST. K MATRIX    6/70
W    B     (55.0)                   CHAO      73 DPWA    O-RNG. FIT.SOL B   9/73
W    B  ASYMMETRIC SHAPE, W/2=41 MEV BELOW RESONANCE, 14 MEV ABOVE.         9/73

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                    REFERENCES FOR LAMBDA(1405) (EXTRAPOLATIONS)

KIM      65 PRL 14 29          J K KIM                                (COLU)IJP
SAKITT   65 PR 139 B719        +DAY,GLASSER,SEEMAN,FRIEDMAN, +   (UMD+LRL)IJP
KITTEL   66 PL 21 349          W KITTEL, G OTTER, I WACEK             (VIEN)IJP
KIM      67 PRL 19 1074        J KIM                                  (YALE)JP
MARTIN   69 PR 183 1352        B R MARTIN, M SAKITT              (LOUC+BNL)
MARTIN   70 NP B16 479         A D MARTIN, G G ROSS                   (DURH)IJP
CHAO     73 NP B56 46          CHAO,KRAEMER,THOMAS,MARTIN (RHEL+CARN+LOUC)IJP
    ALSO 73 NP B56 15          THOMAS,ENGLER,FISK,KRAEMER             (CARN)IJ

                               PAPERS NOT REFERRED TO IN DATA CARDS

ABRAMS   65 PR 139 B454        G S ABRAMS, B SECHI-ZORN                (UMD)IJP
DONALD   66 PL 22 711          + EDWARDS, LYS, NISAR, MOORE           (LIVP)
KADYK    66 PRL 17 599         +OREN, G+S GOLDHABER, TRILLING          (LRL)IJP
DALITZ   67 PR 153 1617        DALITZ, WONG, RAJASEKARAN          (OXF+BOMB)
DALITZ   70 DUKE-HR 70 03      R D DALITZ                              (OXF)
CLINE    71 PRL 26 1194        D CLINE,R LAUMANN,J MAPP               (WISC)
MARTIN   71 PL 35B 62          A D MARTIN,B R MARTIN,ROSS (DURH+LOUC+RHEL)
DOBSON   72 PR D6 3256         P N DOBSON,R MCELHANEY                 (HAWA)
GALTIERI 72 LBL 555            A BARBARO-GALTIERI                      (LBL)
RAJASEKA 72 PR D5 610          RAJASEKARAN                            (TIFR)
    ALSO EARLIER PAPERS CITED IN RAJASEKARAN72
SHAW     73 PURDUE CONF. 417   SHAW                                   (UCI)IJP
OADES    77 NC 42A 462         G C OADES,G RASCHE                (AARH+ZURI)IJP

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Λ(1520) D'_{03} Status: ****

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                    38  LAMBDA(1520, JP=3/2-) I=0       D'03

                    THE MEASUREMENTS OF THE MASS, WIDTH, AND ELASTICITY
                    THAT WERE PUBLISHED BEFORE 1975 ARE NOW OBSOLETE AND
                    HAVE BEEN REMOVED.  THEY WERE LAST LISTED IN OUR 1982
                    EDITION (PHYSICS LETTERS 111B).  ALL THE REFERENCES
                    HAVE BEEN RETAINED.

                    PRODUCTION AND FORMATION EXPERIMENTS AGREE QUITE WELL
                    WITH EACH OTHER, SO THE TWO ARE LISTED TOGETHER HERE.

                    THE DECAY MODE LAMBDA PI PI IS LARGELY DUE TO
   SIGMA(1385) PI.  ONLY THE VALUES OF (SIGMA(1385) PI)/(LAMBDA 2PI) GIVEN
   BY MAST 72 AND CORDEN 75 ARE BASED ON REAL 3-BODY PARTIAL WAVE ANALYSES
   (THE OLDER RESULTS USED CRUDER METHODS).  THE DISCREPANCY BETWEEN THE
   TWO RESULTS IS ESSENTIALLY DUE TO THE DIFFERENT HYPOTHESES MADE
   CONCERNING THE SHAPE OF THE EPSILON MESON.

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                    38  LAMBDA(1520) MASS (MEV)

M     2000 1519.4      0.3           CORDEN    75 DBC     K- D 1.4-1.8GV/C   4/75
M       4K 1519.7      0.3           CAMERON   77 HBC     K-P 0.96-1.36GEV   1/78
M          1519.0      1.0           RLIC      77 DPWA    KBAR N MULTICHNL   1/76
M          1520.0      0.5           ALSTON    78 DPWA    KBAR N ELASTIC     1/78
M       5K 1517.8      1.2           BARLAG    79 HBC     K-P AT 4.2 GEV/C  12/79
M     300 1517.3      1.5            BARBER    80 SPEC    GAM P TO K+ Y*     2/82
M          1519.0      1.0           GOPAL     80 DPWA    KBAR N ELASTIC    12/81
M          . . . . . . . . .
M   AVG   1519.50     0.18    AVERAGE

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For notation, see key at front of Listings.

Baryons

Λ(1520), Λ(1600)

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                    38  LAMBDA(1520) WIDTH (MEV)

W      2000   15.5      1.6          CORDEN    75 DBC     K- D 1.4-1.8GV/C  4/75
W        4K   16.3      0.5          CAMERON   77 HBC     K-P 0.96-1.36GEV  1/78
W             15.0      0.5          RLIC      77 DPWA    KBAR N MULTICHNL  1/76
W             15.4      0.5          ALSTON    78 DPWA    KBAR N ELASTIC    1/78
W  A   677    14.0      3.0          BARLAG    79 HBC     K-P AT 4.2 GEV/C 12/79
W  A    FROM BEST-RESOLUTION SAMPLE OF LAMBDA PI PI EVENTS ONLY.           12/79
W      300   16.3      3.3          BARBER    80 SPEC    GAM P TO K+ Y*    2/82
W            16.0      1.0          GOPAL     80 DPWA    KBAR N ELASTIC   12/81
W            . . . . . . . . .
W   AVG      15.59     0.27    AVERAGE

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                    38  LAMBDA(1520) PARTIAL DECAY MODES

                                                          DECAY MASSES
P1      LAMBDA(1520) INTO N KBAR                          938+ 494
P2      LAMBDA(1520) INTO SIGMA PI                       1189+ 140
P3      LAMBDA(1520) INTO LAMBDA PI PI                   1116+ 140+ 140
P4      LAMBDA(1520) INTO LAMBDA GAMMA                   1116+   0
P5      LAMBDA(1520) INTO SIGMA0 GAMMA                   1192+   0
P6      LAMBDA(1520) INTO SIGMA PI PI                    1192+ 140+ 140
P7      LAMBDA(1520) INTO SIGMA(1385) PI                 1385+ 140
P8      LAMBDA(1520) INTO SIGMA(1385) PI (TO LAMBDA PI PI)1116+ 140+ 140
P9      LAMBDA(1520) INTO LAMBDA EPSILON                 1520+1300

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FITTED PARTIAL DECAY MODE BRANCHING FRACTIONS

The matrix below is derived from the error matrix for the fitted partial decay mode branching fractions, P_i, as follows: The diagonal elements are $P_i \pm \delta P_i$, where $\delta P_i = \sqrt{\langle \delta P_i \delta P_i \rangle}$, while the off-diagonal elements are the normalized correlation coefficients $\langle \delta P_i \delta P_j \rangle / (\delta P_i \cdot \delta P_j)$. For the definitions of the individual P_i, see the listings above; only those P_i appearing in the matrix are assumed in the fit to be nonzero and are thus constrained to add to 1.

	P 1	P 2	P 3	P 4	P 5	P 6
P 1	.4475+-.0066					
P 2	-.6724	.4214+-.0067				
P 3	-.2834	-.3058	.0952+-.0043			
P 4	-.0895	-.0870	-.0370	.0079+-.0014		
P 5	-.2280	-.2217	-.0942	-.0180	.0195+-.0034	
P 6	-.0342	-.0333	-.0141	-.0027	-.0069	.0086+-.0005

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                    38  LAMBDA(1520) BRANCHING RATIOS

R1      LAMBDA(1520) INTO (SIGMA PI)/(N KBAR)            (P2)/(P1)
R1            1.72      0.78          MUSGRAVE  65 HBC                    8/67
R1            0.96      0.20          DAHL      67 HBC     PI-P 1.6-4 GEV/C  9/66
R1            0.73      0.11          DAUBER    67 HBC     K-P AT 2.GEV/C    8/67
R1            1.06      0.14          SCHEUER   68 DBC   0 K-N 3 GEV/C      10/69
R1            0.82      0.08          BURKHARDT 69 HBC     K-P .8-1.2 GEV/C 10/69
R1           (1.06)    (0.12)         BERTHON   74 HBC   0 QUASI 2 BODY CS  10/74
R1   B        0.98      0.03          RLIC      77 DPWA    KBAR N MULTICHNL  1/76
R1   B  N KBAR TO SIGMA PI AMPLITUDE AT RESONANCE IS +0.46 +/- 0.01.        1/76
R1            . . . . . . . . .
R1  AVG       0.951     0.044   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.7)
R1  FIT       0.942     0.026  FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.3)

R2      LAMBDA(1520) INTO (LAMBDA PI PI)/(N KBAR)        (P3)/(P1)
R2            0.17      0.05          DAHL      67 HBC     PI-P 1.6-4 GEV/C  9/66
R2            0.21      0.18          DAUBER    67 HBC     K-P AT 2.GEV/C    8/67
R2            0.19      0.04          SCHEUER   68 DBC   0 K-N 3 GEV/C      10/69
R2            0.22      0.03          BURKHARDT 69 HBC     K-P .8-1.2 GEV/C 10/69
R2           (0.2)                    KIM       71 DPWA    K-MATRIX ANAL.    3/71
R2           (0.27)    (0.13)         BERTHON   74 HBC   0 QUASI 2 BODY CS  10/74
R2            . . . . . . . . .
R2  AVG       0.202     0.021   AVERAGE
R2  FIT       0.213     0.011  FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.1)

R3      LAMBDA(1520) INTO (SIGMA PI)/(LAMBDA PI PI)      (P2)/(P3)
R3            4.5       1.0           ARMENTERO 65 HBC                    7/66
R3            3.3       1.1           BIRMINGHA 66 HBC     K-P 3.5        9/67
R3            3.9       1.0           UHLIG     67 HBC     K-P .9-1.0 GEV/C 9/66
R3            . . . . . . . . .
R3  AVG       3.94      0.59    AVERAGE
R3  FIT       4.43      0.23   FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.1)

R4      LAMBDA(1520) INTO (LAMBDA GAMMA)/TOTAL (PERCENT) (P4)
R4      238   0.80      0.14          MAST      68 HBC   0 USING ELAST=.45  11/68
R4            . . . . . . . . .
R4  FIT       0.79      0.14   FROM FIT

R5      LAMBDA(1520) INTO (SIGMA0 GAMMA)/TOTAL (PERCENT) (P5)
R5   C        2.0       0.35          MAST      68 HBC     SEE NOTE S       10/69
R5   C     RATIOS CALCULATED FROM R4, ASSUMING SU(3). NEEDED TO CONSTRAIN
R5   C     ALL THE LAMBDA(1520) BRANCHING RATIOS TO BE UNITY.
R5            . . . . . . . . .
R5  FIT       1.95      0.34   FROM FIT

R6      LAMBDA(1520) INTO (N KBAR)/TOTAL                 (P1)
R6            0.448     0.014         CORDEN    75 DBC     K- D 1.4-1.8GV/C  4/75
R6           (0.42)                   MAST      76 HBC   0 K- P CEX          1/76
R6   D       (0.47)    (0.01)         RLIC      77 DPWA    KBAR N MULTICHNL  1/76
R6   D  (N KBAR)/TOTAL FROM RLIC 77 IS SUPERSEDED BY GOPAL 80.
R6            0.45      0.03          ALSTON    78 DPWA    KBAR N ELASTIC    1/78
R6            0.47      0.02          GOPAL     80 DPWA    KBAR N ELASTIC   12/81
R6            . . . . . . . . .
R6  AVG       0.455     0.011   AVERAGE
R6  FIT       0.4475    0.0066 FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.2)
R7      LAMBDA(1520) INTO (SIGMA PI)/TOTAL               (P2)
R7            0.55      0.09          WATSON    63 HBC     K-P ALL CHANNELS 10/71
R7            0.418     0.017         GALTIERI  69 HBC   0 K-P .28-.45GEV/C  6/69
R7           (0.46)                   KIM       71 DPWA    K-MATRIX ANAL.    3/71
R7            0.426     0.014         CORDEN    75 DBC     K- D 1.4-1.8GV/C  4/75
R7            . . . . . . . . .
R7  AVG       0.425     0.011   AVERAGE
R7  FIT       0.4214    0.0067 FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.2)

R8      LAMBDA(1520) INTO (SIGMA PI PI)/TOTAL            (P6)
R8            0.010     0.0015        GALTIERI  69 HBC   0 K-P .28-.45GEV/C 10/69
R8   E        0.0085    0.0006        MAST2     73 MPWA    K-P TO 2PI SIG    9/73
R8   E  BASED ON ASSUMED ELASTICITY OF 0.46.                               9/73
R8   F        0.007     0.002         CORDEN    75 DBC     K- D 1.4-1.8GV/C  4/75
R8   F  MUCH OF THE SIGMA PI PI DECAY PROCEEDS VIA SIGMA(1385) PI.         4/75
R8            . . . . . . . . .
R8  AVG       0.00858   0.00054  AVERAGE
R8  FIT       0.00857   0.00054 FROM FIT

R9      LAMBDA(1520) TO SIGMA(1385) PI TO LN 2PI/LN 2PI  (P8)/(P3)
R9          MORE THAN   0.10                CLINE     69 DBC     K-D TO 2PI LAM N  9/69
R9   G        0.39      0.10          BURKHARDT 71 HBC     LAM. 3PI PROD.    3/71
R9   G  CENTRAL BIN(1514-1524) GIVES .74+-.10 -- OTHER BINS LOWER BY 2-5SIG
R9   H       (1.0)                    CHAN      72 IPWA    K-P TO LAM 2PI    2/73
R9   H  ONLY THE SIGMA(1385) DS03 SEEMS TO CONTRIBUTE.
R9   I        0.82      0.10          MAST      73 IPWA    K-P TO 2PI LAM   12/72
R9   I  BOTH SIGMA(1385) DS03 AND SIGMA (PI PI) DP03 CONTRIBUTE.
R9            0.58      0.22          CORDEN    75 DBC     K- D 1.4-1.8GV/C  4/75

R10     LAMBDA(1520) INTO (SIGMA(1385) PI)/TOTAL         (P7)
R10           0.041     0.005         CHAN      72 HBC     K-P TO LAM 2PI    3/71

R11     LAMBDA(1520) INTO (LAMBDA PI PI)/TOTAL           (P3)
R11  J        0.11      0.01          MAST      73 IPWA    K-P TO 2PI LAM    9/73
R11  J  BASED ON ASSUMED ELASTICITY OF 0.46+/-0.02.                         9/73
R11           0.091     0.006         CORDEN    75 DBC     K- D 1.4-1.8GV/C  4/75
R11           . . . . . . . . .
R11 AVG       0.0960    0.0084  AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.6)
R11 FIT       0.0952    0.0043 FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.1)

R12     LAMBDA(1520) INTO (LAMBDA EPSILON)/TOTAL         (P9)
R12           0.20      0.08          CORDEN    75 DBC     K- D 1.4-1.8GV/C  4/75

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REFERENCES FOR LAMBDA(1520)


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FERRO-LU 62 PRL 8 28          M FERRO-LUZZI,R D TRIPP,M B WATSON    (LRL)IJP
GALTIERI 63 PL 6 296          A BARBARO-GALTIERI,A HUSSAIN,RD TRIPP (LRL)
WATSON   63 PR 131 2248       M B WATSON, M FERRO-LUZZI, R D TRIPP  (LRL)IJP
ALMEIDA  64 PL 9 204          S P ALMEIDA, G R LYNCH                (CERN)
ARMENTER 65 PL 19 338         ARMENTEROS,F-LUZZI, +       (CERN+HEID+SACL)
MUSGRAVE 65 NC 35 735         +PETMEZAS,+       (BIRM+CERN+EPOL+LOIC+SACL)

BIRMINGH 66 PR 152 1148                         (BIRM+GLAS+LOIC+OXF+RHEL)
DAHL     67 PR 163 1377       DAHL,HARDY,HESS,KIRZ,MILLER           (LRL)
DAUBER   67 PL 24B 525        +MALAMUD,SCHLEIN,SLATER,STORK        (UCLA)
UHLIG    67 PR 155 1448       +CHARLTON,CONDON,GLASSER,YODH,+   (UMD+NRL)
MAST     68 PRL 21 1715       MAST,ALSTON,BANGERTER,GALTIERI+       (LRL)
SCHEUER  68 NP 8B 503         SABRE COLLAB.    (SACL+AMST+BGNA+REHO+EPOL)

BURKHARD 69 NP B14 106        +FILTHUTH,KLUGE+       (HEID+EFI+CERN+SACL)
CLINE    69 LNC 2 407         +LAUMANN,MAPP                        (WISC)
GALTIERI 69 LUND 352          BARBARO-GALTIERI,BANGERTER,MAST,TRIPP (LRL)
    ALSO 70 DUKE 95           R D TRIPP                             (LRL)
BERLEY   70 PR D1 1996        +YAMIN,KOFLER,MANN,MEISNER+ (BNL+MASA+YALE)IJP

BURKHARDT71 NP  B27 64        +FILTHUTH,KLUGE,OBERLACK++ (HEID+CERN+SACL)
COLLEY   71 NP  B31 61        +COX,EASTWOOD,FRY+..  (BIRM+EDIN+GLAS+LOIC)
KIM      71 PRL 27 356        J K KIM                              (HARV)IJP
    ALSO 70 DUKE 161          J K KIM                              (HARV)IJP

CHAN     72 PRL 28 256        +BUT.-SHAFER,HERTZBACH,KOFLER++ (MASA+YALE)
MAST     73 PR D7 5           +ALSTON-GARNJOST,BANGERTER,+          (LBL)IJP
MAST2    73 PRD 7 3212        +BANGERTER,ALSTON-GARNJOST,+          (LBL)IJP
BERTHON  74 NC 21A 146        BERTHON,TRISTRAM,+    (CDEF+RHEL+SACL+STRB)
GOLOWICH 74 PRD 10 3861       E GOLOWICH                            (SLAC)
CORDEN   75 NP B84 306        CORDEN,COX,DARTNELL,KENYON,ONEALE,+  (BIRM)

MAST     76 PRD 14 13         MAST,ALSTON-GARNJOST,BANGERTER+       (LBL)
CAMERON  77 NP B131 399       +FRANEK,GOPAL,KALMUS,MCPHERSON+ (RHEL+LOIC)IJP
RLIC     77 NP B119 362       GOPAL,ROSS,VAN HORN,MCPHERSON+  (LOIC+RHEL)IJP
ALSTON   78 PR D18 182        +KENNEY,POLLARD,ROSS+       (LBL+MTHO+CERN)IJP
    ALSO 77 PRL 38 1007       ALSTON-GARNJOST,KENNEY,+    (LBL+MTHO+CERN)IJP
BARLAG   79 NP B149 220       +BLOKZIJL,JONGEJANS+   (AMST+CERN+NIJM+OXF)
BARBER   80 ZPHY C7 17        +DAINTON,LEE,MARSHALL+      (DARE+LANC+SHEF)
GOPAL    80  TORONTO CONF 159 G P GOPAL                            (RHEL)IJP
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Λ(1600) P'_{01} Status: ***

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                    101  LAMBDA(1600, JP=1/2+) I=0       P'01

                    SEE THE NOTE FOR THE LAMBDA(1800, JP=1/2+) P''01.
                    SOMEWHERE IN THIS REGION THERE IS PROBABLY ONE,
                    AND PERHAPS TWO, P01 STATES.

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                    101  LAMBDA(1600) MASS (MEV)

M   1     (1570.0)                    KIM       71 DPWA    K-MATRIX ANAL.    1/76
M   1  POSSIBLE EFFECT IN SIGMA PI AND N KBAR CHANNELS.
M          1620.0     10.0            LANGBEIN  72 IPWA    MULTICHANNEL      1/76
M          1596.0     (6.0)           KANE      74 DPWA    K-P TO PI SIG    12/81
M    2     1646.0      7.0            CARROLL   76 DPWA    I=0 TOTAL CS      2/77
M    2  TOTAL CROSS SECTION BUMP WITH (J+1/2)X=0.04.
M    3     1572. OR 1617.             MARTIN    77 DPWA    KBAR N MULTICHNL 11/77
M    3  THE TWO ENTRIES FOR MARTIN 77 CORRESPOND TO EXTRACTION OF RESONANCE
M    3  PARAMETERS FROM THE T-MATRIX POLE AND FROM A B-W FIT, RESPECTIVELY.
M          1573.0     25.0            RLIC      77 DPWA    KBAR N MULTICHNL  1/76
M          1703.0    100.0            ALSTON    78 DPWA    KBAR N ELASTIC    1/78
M          1568.0    (20.0)           GOPAL     80 DPWA    KBAR N ELASTIC   12/81

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                    101  LAMBDA(1600) WIDTH (MEV)

W   1      (50.0)                     KIM       71 DPWA    K-MATRIX ANAL.    1/76
W           60.0      10.0            LANGBEIN  72 IPWA    MULTICHANNEL      1/76
W          175.0     (20.0)           KANE      74 DPWA    K-P TO PI SIG    12/81
W    2     (20.0)                     CARROLL   76 DPWA    I=0 TOTAL CS      2/77
W    3     247. OR 271.               MARTIN    77 DPWA    KBAR N MULTICHNL 11/77
W          147.0      50.0            RLIC      77 DPWA    KBAR N MULTICHNL  1/76
W          593.0     200.0            ALSTON    78 DPWA    KBAR N ELASTIC    1/78
W          116.0     (20.0)           GOPAL     80 DPWA    KBAR N ELASTIC   12/81

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                    101  LAMBDA(1600) PARTIAL DECAY MODES

                                                          DECAY MASSES
P1      LAMBDA(1600) INTO N KBAR                          938+ 494
P2      LAMBDA(1600) INTO SIGMA PI                       1189+ 140

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Baryons

Data Card Listings

Λ(1600), Λ(1670), Λ(1690)

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                    101  LAMBDA(1600) BRANCHING RATIOS

R1      LAMBDA(1600) INTO (N KBAR)/TOTAL                   (P1)
R1            0.25      0.15          LANGBEIN  72 IPWA    MULTICHANNEL      1/76
R1    3       0.30 OR  0.29           MARTIN    77 DPWA    KBAR N MULTICHNL 11/77
R1    C      (0.24)   (0.04)          RLIC      77 DPWA    KBAR N MULTICHNL  1/76
R1    C  (N KBAR)/TOTAL FROM RLIC 77 IS SUPERSEDED BY GOPAL 80.
R1            0.14      0.05          ALSTON    78 DPWA    KBAR N ELASTIC    1/78
R1            0.23     (0.04)         GOPAL     80 DPWA    KBAR N ELASTIC   12/81

R2      LAMBDA(1600) FROM N KBAR TO SIGMA PI               SQRT(P1*P2)
R2            0.28      0.09          LANGBEIN  72 IPWA    MULTICHANNEL      1/76
R2           -0.33     (0.11)         KANE      74 DPWA    K-P TO PI SIG    12/81
R2          NOT SEEN                  HEPP2     76 DPWA -0 K- NUC TO SIG PI  2/77
R2    3      -0.39 OR -0.39           MARTIN    77 DPWA    KBAR N MULTICHNL 11/77
R2           -0.16      0.04          RLIC      77 DPWA    KBAR N MULTICHNL  1/76

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REFERENCES FOR LAMBDA(1600)


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KIM      71 PRL 27 356          J K KIM                                (HARV)IJP
    ALSO 70 DUKE 161            J K KIM                                (HARV)IJP

LANGBEIN 72 NP B47 477          +WAGNER                                (MPIM)IJP
KANE     74  LBL-2452           D F KANE                                (LBL)IJP

CARROLL  76 PRL 37 806          +CHIANG,KYCIA,LI,MAZUR,MICHAEL+        (BNL)I
HEPP2    76 PL 65B 487          +BRAUN,GRIMM,STROBELE,THOL+(CERN+HEID+MPIM)IJP

MARTIN   77 NP B127 349         MARTIN,PIDCOCK,MOORHOUSE          (LOUC+GLAS)IJP
    ALSO 77 NP B126 266         MARTIN,PIDCOCK                         (LOUC)
    ALSO 77 NP B126 285         MARTIN,PIDCOCK                         (LOUC)IJP
RLIC     77 NP B119 362         GOPAL,ROSS,VAN HORN,MCPHERSON+  (LOIC+RHEL)IJP
ALSTON   78 PR D18 182          +KENNEY,POLLARD,ROSS+          (LBL+MTHO+CERN)IJP
    ALSO 77 PRL 38 1007         ALSTON-GARNJOST,KENNEY,+       (LBL+MTHO+CERN)IJP
GOPAL    80  TORONTO CONF 159 G P GOPAL                                (RHEL)IJP
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Λ(1670) S''_{01} Status: ****

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                    40  LAMBDA(1670, JP=1/2-) I=0        S''01

                    THE MEASUREMENTS OF THE MASS, WIDTH, AND ELASTICITY
                    THAT WERE PUBLISHED BEFORE 1974 ARE NOW OBSOLETE AND
                    HAVE BEEN REMOVED.  THEY WERE LAST LISTED IN OUR 1982
                    EDITION (PHYSICS LETTERS 111B).  ALL THE REFERENCES
                    HAVE BEEN RETAINED.

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                    40  LAMBDA(1670) MASS (MEV)

M          1679.0     (1.0)          KANE      74 DPWA    K-P TO PI SIG    12/81
M          1665.0     (5.0)          PREVOST   74 DPWA 0- K-N TO S(1385)PI 10/74
M          1675.0     (2.0)          HEPP2     76 DPWA -0 K- NUC TO SIG PI  2/77
M     A   (1664.0)                   MARTIN    77 DPWA    KBAR N MULTICHNL 11/77
M     A  MARTIN 77 OBTAINS IDENTICAL RESONANCE PARAMETERS FROM THE
M     A  T-MATRIX POLE AND FROM A B-W FIT.
M          1670.0     (5.0)          RLIC      77 DPWA    KBAR N MULTICHNL  1/76
M          1671.0     (3.0)          ALSTON    78 DPWA    KBAR N ELASTIC    1/78
M          1667.0     (5.0)          GOPAL     80 DPWA    KBAR N ELASTIC   12/81

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                    40  LAMBDA(1670) WIDTH (MEV)

W            40.0     (3.0)          KANE      74 DPWA    K-P TO PI SIG    12/81
W            19.0     (5.0)          PREVOST   74 DPWA 0- K-N TO S(1385)PI 10/74
W            46.0     (5.0)          HEPP2     76 DPWA -0 K- NUC TO SIG PI  2/77
W     A     (12.0)                   MARTIN    77 DPWA    KBAR N MULTICHNL 11/77
W            45.0    (10.0)          RLIC      77 DPWA    KBAR N MULTICHNL  1/76
W            29.0     (5.0)          ALSTON    78 DPWA    KBAR N ELASTIC    1/78
W            29.0     (5.0)          GOPAL     80 DPWA    KBAR N ELASTIC   12/81

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                    40  LAMBDA(1670) PARTIAL DECAY MODES

                                                          DECAY MASSES
P1      LAMBDA(1670) INTO N KBAR                        938+ 494
P2      LAMBDA(1670) INTO LAMBDA ETA                   1116+ 549
P3      LAMBDA(1670) INTO SIGMA PI                     1189+ 140
P4      LAMBDA(1670) INTO SIGMA(1385) PI               1385+ 140

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                    40  LAMBDA(1670) BRANCHING RATIOS

R1      LAMBDA(1670) INTO (N KBAR)/TOTAL                   (P1)
R1    A      (0.15)                   MARTIN    77 DPWA    KBAR N MULTICHNL 11/77
R1    B      (0.20)   (0.03)          RLIC      77 DPWA    KBAR N MULTICHNL  1/76
R1    B  (N KBAR)/TOTAL FROM RLIC 77 IS SUPERSEDED BY GOPAL 80.
R1            0.17    (0.03)          ALSTON    78 DPWA    KBAR N ELASTIC    1/78
R1            0.18    (0.03)          GOPAL     80 DPWA    KBAR N ELASTIC   12/81

R2      LAMBDA(1670) FROM N KBAR TO LAMBDA ETA             SQRT(P1*P2)
R2    C       0.20  OR 0.23           BERLEY    65 HBC   0                   7/66
R2    C    THE FIRST VALUE ASSUMES THE BRANCHING RATIO INTO LAMBDA ETA IS
R2    C  SMALL, THE SECOND THAT IT IS LARGE.  BECAUSE THE RESONANCE IS NEAR
R2    C  THE LAMBDA ETA THRESHOLD, THE BRANCHING RATIO AFFECTS THE MOMENTUM
R2    C  DEPENDENCE OF THE TOTAL WIDTH, AND THUS ALSO THE RESONANCE PARA-
R2    C  METERS OBTAINED BY FITTING TO THE DATA.
R2           (0.26)                   ARMENT-3  69 HBC   0                   9/69
R2           (0.24)                   KIM       71 DPWA    K-MATRIX ANAL.    3/71
R2           +0.20    (0.05)          BAXTER    73 DPWA  0 K- P TO NEUTRALS 10/74

R3      LAMBDA(1670) FROM N KBAR TO SIGMA PI               SQRT(P1*P3)
R3           -0.27    (0.02)          KANE      74 DPWA    K-P TO PI SIG    12/81
R3           -0.23    (0.03)          LONDON    75 HLBC  0 K- P TO SIG0 PI0  4/75
R3           -0.29    (0.03)          HEPP2     76 DPWA -0 K- NUC TO SIG PI  2/77
R3    A     (-0.13)                   MARTIN    77 DPWA    KBAR N MULTICHNL 11/77
R3           -0.31    (0.03)          RLIC      77 DPWA    KBAR N MULTICHNL  1/76

R4      LAMBDA(1670) FROM N KBAR TO SIGMA(1385) PI         SQRT(P1*P4)
R4           -0.18      0.05          PREVOST   74 DPWA 0- K-N TO S(1385)PI 10/74

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REFERENCES FOR LAMBDA(1670)


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BERLEY   65 PRL 15 641          +CONNOLLY, HART, RAUM, STONEHILL, +    (BNL)IJP
BIRMINGH 66 PR 152 1148                  (BIRM+GLAS+LOIC+OXF+RHEL)
ARMENT-1 68 NP B8 195           ARMENTEROS, BAILLON, +      (CERN+HEID+SACL)IJP
ARMENT-2 68 NP B8 223           ARMENTEROS, BAILLON, +      (CERN+HEID+SACL)IJP

ARMENT-3 69 LUND PAPER 229      ARMENTEROS, BAILLON, +      (CERN+HEID+SACL)IJP
    VALUES ARE QUOTED IN LEVI SETTI 69.
ARMENT-4 69 NP B14 91           ARMENTEROS, BAILLON, +      (CERN+HEID+SACL)IJP
BERLEY   69 PL 30B 430          + HART, RAHM, WILLIS, YAMAMOTO         (BNL)IJP
LEVISETT 69 LUND 339            R LEVI SETTI  (RAPPORTEUR)            (CHIC)
GALTIERI 70 DUKE 173            A BARBARO GALTIERI                     (LRL)IJP

CONFORTO 71 NP  B34  41         +LEVI SETTI,LASINSKI..OBERLACK++ (EFI+HEID)IJP
KIM      71 PRL 27 356          J K KIM                               (HARV)IJP
    ALSO 70 DUKE 161            J K KIM                               (HARV)IJP
LANGBEIN 72 NP B47 477          +WAGNER                               (MPIM)IJP
BAXTER   73 NP B67 125          BAXTER,BUCKINGHAM,CORBETT,DUNN,+       (OXF)IJP
HART     73 PURDUE CONF. 311    +RICE,BACASTOW,FUNG,+  (TENN+UCR+MASA+BUFF)IJP
KANE     74  LBL-2452           D F KANE                               (LBL)IJP
PREVOST  74 NP B69 246          PREVOST,BARLOUTAUD,+        (SACL+CERN+HEID)
LONDON   75 NP B85 289          LONDON,YU,BOYD,+  (BNL+CERN+EPOL+ORSA+TORI)

HEPP2    76 PL 65B 487          +BRAUN,GRIMM,STROBELE,THOL+(CERN+HEID+MPIM)IJP
MARTIN   77 NP B127 349         MARTIN,PIDCOCK,MOORHOUSE         (LOUC+GLAS)IJP
    ALSO 77 NP B126 266         MARTIN,PIDCOCK                        (LOUC)
    ALSO 77 NP B126 285         MARTIN,PIDCOCK                        (LOUC)IJP
RLIC     77 NP B119 362         GOPAL,ROSS,VAN HORN,MCPHERSON+  (LOIC+RHEL)IJP
ALSTON   78 PR D18 182          +KENNEY,POLLARD,ROSS+         (LBL+MTHO+CERN)IJP
    ALSO 77 PRL 38 1007         ALSTON-GARNJOST,KENNEY,+      (LBL+MTHO+CERN)IJP
GOPAL    80  TORONTO CONF 159 G P GOPAL                               (RHEL)IJP
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Λ(1690) D''_{03} Status: ****

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                    55  LAMBDA(1690, JP=3/2-) I=0        D''03

                    THE MEASUREMENTS OF THE MASS, WIDTH, AND ELASTICITY
                    THAT WERE PUBLISHED BEFORE 1974 ARE NOW OBSOLETE AND
                    HAVE BEEN REMOVED.  THEY WERE LAST LISTED IN OUR 1982
                    EDITION (PHYSICS LETTERS 111B).  ALL THE REFERENCES
                    HAVE BEEN RETAINED.

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                    55  LAMBDA(1690) MASS (MEV)

M          1689.0     (1.0)          KANE      74 DPWA    K-P TO PI SIG    12/81
M          1692.0     (4.0)          CARROLL   76 DPWA    I=0 TOTAL CS      2/77
M          1690.0     (3.0)          HEPP2     76 DPWA -0 K- NUC TO SIG PI  2/77
M     A    1687. OR 1689.            MARTIN    77 DPWA    KBAR N MULTICHNL 11/77
M     A  THE TWO ENTRIES FOR MARTIN 77 CORRESPOND TO EXTRACTION OF RESONANCE
M     A  PARAMETERS FROM THE T-MATRIX POLE AND FROM A B-W FIT, RESPECTIVELY.
M     A  ANOTHER 3/2- LAMBDA AT 1966 MEV IS ALSO SUGGESTED BY MARTIN 77,
M     A  BUT IS VERY UNCERTAIN.
M          1690.0     (5.0)          RLIC      77 DPWA    KBAR N MULTICHNL  1/76
M          1692.0     (5.0)          ALSTON    78 DPWA    KBAR N ELASTIC    1/78
M          1690.0     (5.0)          GOPAL     80 DPWA    KBAR N ELASTIC   12/81

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                    55  LAMBDA(1690) WIDTH (MEV)

W            60.0     (4.0)          KANE      74 DPWA    K-P TO PI SIG    12/81
W           (38.0)                   CARROLL   76 DPWA    I=0 TOTAL CS      2/77
W            82.0     (8.0)          HEPP2     76 DPWA -0 K- NUC TO SIG PI  2/77
W     A      62. OR 62.              MARTIN    77 DPWA    KBAR N MULTICHNL 11/77
W            60.0     (5.0)          RLIC      77 DPWA    KBAR N MULTICHNL  1/76
W            64.0    (10.0)          ALSTON    78 DPWA    KBAR N ELASTIC    1/78
W            61.0     (5.0)          GOPAL     80 DPWA    KBAR N ELASTIC   12/81

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                    55  LAMBDA(1690) PARTIAL DECAY MODES

                                                          DECAY MASSES
P1      LAMBDA(1690) INTO N KBAR                        938+ 494
P2      LAMBDA(1690) INTO SIGMA PI                     1189+ 140
P3      LAMBDA(1690) INTO LAMBDA PI PI                 1116+ 140+ 140
P4      LAMBDA(1690) INTO SIGMA PI PI                  1192+ 140+ 140
P5      LAMBDA(1690) INTO SIGMA(1385) PI, S-WAVE       1385+ 140
P6      LAMBDA(1690) INTO LAMBDA ETA                   1116+ 549

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                    55  LAMBDA(1690) BRANCHING RATIOS

        THE SUM OF ALL THE QUOTED BRANCHING RATIOS IS MORE THAN 1.0.  THE
     TWO-BODY RATIOS ARE FROM PARTIAL WAVE ANALYSES, AND THUS PROBABLY ARE
     MORE RELIABLE THAN THE THREE-BODY RATIOS, WHICH ARE DETERMINED FROM
     BUMPS IN CROSS SECTIONS.  OF THE LATTER, THE SIGMA PI PI BUMP LOOKS
     MORE SIGNIFICANT (THE ERROR GIVEN FOR THE LAMBDA PI PI RATIO LOOKS UN-
     REASONABLY SMALL).  HARDLY ANY OF THE SIGMA PI PI DECAY CAN BE VIA
     SIGMA(1385), FOR THEN NINE TIMES AS MUCH LAMBDA PI PI DECAY WOULD BE
     REQUIRED.

R1      LAMBDA(1690) INTO (N KBAR)/TOTAL                   (P1)
R1    A       0.28 OR  0.26           MARTIN    77 DPWA    KBAR N MULTICHNL 11/77
R1    B      (0.24)   (0.03)          RLIC      77 DPWA    KBAR N MULTICHNL  1/76
R1    B  (N KBAR)/TOTAL FROM RLIC 77 IS SUPERSEDED BY GOPAL 80.
R1            0.22    (0.03)          ALSTON    78 DPWA    KBAR N ELASTIC    1/78
R1            0.23    (0.03)          GOPAL     80 DPWA    KBAR N ELASTIC   12/81

R2      LAMBDA(1690) FROM N KBAR TO SIGMA PI               SQRT(P1*P2)
R2           -0.28    (0.02)          KANE      74 DPWA    K-P TO PI SIG    12/81
R2           -0.28    (0.03)          LONDON    75 HLBC  0 K- P TO SIG0 PI0  4/75
R2           -0.29    (0.03)          HEPP2     76 DPWA -0 K- NUC TO SIG PI  2/77
R2    A      -0.30 OR -0.28           MARTIN    77 DPWA    KBAR N MULTICHNL 11/77
R2           -0.25    (0.03)          RLIC      77 DPWA    KBAR N MULTICHNL  1/76

R3      LAMBDA(1690) FROM N KBAR TO LAMBDA PI PI           SQRT(P1*P3)
R3    C      (0.25)   (0.02)          BARTLEY   68 HDBC  0 LAM 2PI CROS SEC 11/68
R3    C   ONLY CROSS-SECTION DATA USED. ENHANCEMENT NOT SEEN BY PREVOST 71,   3/72

R4      LAMBDA(1690) FROM N KBAR TO SIGMA PI PI            SQRT(P1*P4)
R4           (0.21)                   ARMENT-2  68 HDBC  0 K-N TO SIG PI PI 11/68

R5      LAMBDA(1690) FROM N KBAR TO LAMBDA ETA             SQRT(P1*P6)
R5            0.00    (0.03)          BAXTER    73 DPWA  0 K- P TO NEUTRALS 10/74
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For notation, see key at front of Listings.

Baryons

Λ(1690), Λ(1800)

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R6      LAMBDA(1690) FROM N KBAR TO SIGMA(1385) PI S-WAVESQRT(P1*P5)
R6          +0.27     0.04          PREVOST   74 DPWA 0- K-N TO S(1385)PI 10/74

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REFERENCES FOR LAMBDA(1690)


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ARMENT-1 68 NP B8 195          ARMENTEROS, BAILLON, +      (CERN+HEID+SACL)IJP
ARMENT-2 68 NP B8 216          ARMENTEROS, BAILLON, +      (CERN+HEID+SACL) I
ARMENT-3 68 NP B8 223          ARMENTEROS, BAILLON, +      (CERN+HEID+SACL)IJP
BARTLEY  68 PRL 21 1111        +CHU,DOWD,GREENE,+           (TUFT+FSU+BRAN) I
BUGG     68 PR 168 1466        +GILMORE, KNIGHT, +         (BIRM+CAVE+RHEL) I
    ALSO 67 PRL 18 62          DAVIES,DOWELL,+             (BIRM+CAVE+RHEL) I
CONFORTO 68 NP B8 265          +HARMSEN, LASINSKI, +            (CMIC+HEID)IJP

ARMENT-4 69 NP B14 91          ARMENTEROS, BAILLON, +      (CERN+HEID+SACL)IJP
BERLEY   69 PL 30B 430         + HART, RAHM, WILLIS, YAMAMOTO          (BNL)IJP
BERTANZA 69 PR 177 2036        +BIGI,CARRARA,CASALI, +     (PISA+BNL+YALE)IJP

GALTIERI 70 DUKE 173           A BARBARO GALTIERI                      (LRL)IJP
CONFORTO 71 NP  B34  41        +LEVI SETTI,LASINSKI..OBERLACK+  (EFI+HEID)IJP
KIM      71 PRL 27 356         J K KIM                                (HARV)IJP
    ALSO 70 DUKE 161           J K KIM                                (HARV)IJP
PREVOST  71  AMSTERDAM CONF    + CHS COLLABORATION         (CERN+HEID+SACL)
LANGBEIN 72 NP B47 477         +WAGNER                                (MPIM)IJP
BAXTER   73 NP B67 125         BAXTER,BUCKINGHAM,CORBETT,DUNN,+        (OXF)IJP
HART     73 PURDUE CONF. 311   +RICE,BACASTOW,FUNG,+  (TENN+UCR+MASA+BUFF)IJP
KANE     74  LBL-2452          D F KANE                                (LBL)IJP
PREVOST  74 NP B69 246         PREVOST,BARLOUTAUD,+        (SACL+CERN+HEID)

LONDON   75 NP B85 289         LONDON,YU,BOYD,+  (BNL+CERN+EPOL+ORSA+TORI)
CARROLL  76 PRL 37 806         +CHIANG,KYCIA,LI,MAZUR,MICHAEL+         (BNL)I
HEPP2    76 PL 65B 487         +BRAUN,GRIMM,STROBELE,THOL+(CERN+HEID+MPIM)IJP

MARTIN   77 NP B127 349        MARTIN,PIDCOCK,MOORHOUSE        (LOUC+GLAS)IJP
    ALSO 77 NP B126 266        MARTIN,PIDCOCK                          (LOUC)
    ALSO 77 NP B126 285        MARTIN,PIDCOCK                          (LOUC)IJP
RLIC     77 NP B119 362        GOPAL,ROSS,VAN HORN,MCPHERSON+  (LOIC+RHEL)IJP
ALSTON   78 PR D18 182         +KENNEY,POLLARD,ROSS+       (LBL+MTHO+CERN)IJP
    ALSO 77 PRL 38 1007        ALSTON-GARNJOST,KENNEY,+    (LBL+MTHO+CERN)IJP
GOPAL    80  TORONTO CONF 159 G P GOPAL                            (RHEL)IJP
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Λ(1800) S_{01}''' Status: ***

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36  LAMBDA(1800, JP=1/2-) I=0      S'''01

THE S01 AMPLITUDE SHOWS A RATHER CLEAR SECOND RESONANCE
BEHAVIOR IN THE 1700-1900 MEV REGION.  THERE ARE MAJOR
DISAGREEMENTS ABOUT THE MASS, WIDTH, AND COUPLINGS.

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36 LAMBDA(1800) MASS (MEV)

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M          (1872.0)   (10.0)          BRICMAN   70 DPWA    TOT, ELAS, CHEX   1/71
M          (1780.0)                   KIM       71 DPWA    K-MATRIX ANAL.    3/71
M           1830.0    (20.0)          LANGBEIN  72 IPWA    MULTICHANNEL     12/72
M     1     1767. OR 1842.            MARTIN    77 DPWA    KBAR N MULTICHNL 11/77
M     1  THE TWO ENTRIES FOR MARTIN 77 CORRESPOND TO EXTRACTION OF RESONANCE
M     1  PARAMETERS FROM THE T-MATRIX POLE AND FROM A B-W FIT, RESPECTIVELY.
M           1825.0    (20.0)          RLIC      77 DPWA    KBAR N MULTICHNL  1/76
M           1725.0    (20.0)          ALSTON    78 DPWA    KBAR N ELASTIC    1/78
M           1841.0    (10.0)          GOPAL     80 DPWA    KBAR N ELASTIC   12/81

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36 LAMBDA(1800) WIDTH (MEV)

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W          (100.0)   (20.0)           BRICMAN   70 DPWA    TOT, ELAS, CHEX   1/71
W           (40.0)                    KIM       71 DPWA    K-MATRIX ANAL.    3/71
W            70.0    (15.0)           LANGBEIN  72 IPWA    MULTICHANNEL     12/72
W     1      435. OR 473.             MARTIN    77 DPWA    KBAR N MULTICHNL 11/77
W           230.0    (20.0)           RLIC      77 DPWA    KBAR N MULTICHNL  1/76
W           185.0    (20.0)           ALSTON    78 DPWA    KBAR N ELASTIC    1/78
W           228.0    (20.0)           GOPAL     80 DPWA    KBAR N ELASTIC   12/81

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36 LAMBDA(1800) PARTIAL DECAY MODES

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                                                        DECAY MASSES
P1      LAMBDA(1800) INTO N KBAR                       938+ 494
P2      LAMBDA(1800) INTO SIGMA PI                    1189+ 140
P3      LAMBDA(1800) INTO SIGMA(1385) PI              1385+ 140
P4      LAMBDA(1800) INTO N K*(892), S1 WAVE           940+ 892
P5      LAMBDA(1800) INTO N K*(892), D3 WAVE           940+ 892

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36 LAMBDA(1800) BRANCHING RATIOS

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R1      LAMBDA(1800) INTO (N KBAR)/TOTAL                    (P1)
R1          (0.18)   (0.02)           BRICMAN   70 DPWA    TOT, ELAS, CHEX   1/71
R1          (0.80)                    KIM       71 DPWA    K-MATRIX ANAL.    3/71
R1           0.35    (0.15)           LANGBEIN  72 IPWA    MULTICHANNEL     12/72
R1    1      1.21 OR  0.70            MARTIN    77 DPWA    KBAR N MULTICHNL 11/77
R1    C     (0.37)   (0.05)           RLIC      77 DPWA    KBAR N MULTICHNL  1/76
R1    C  (N KBAR)/TOTAL FROM RLIC 77 IS SUPERSEDED BY GOPAL 80.
R1           0.28    (0.05)           ALSTON    78 DPWA    KBAR N ELASTIC    1/78
R1           0.36    (0.04)           GOPAL     80 DPWA    KBAR N ELASTIC   12/81

R2      LAMBDA(1800) FROM N KBAR TO SIGMA PI              SQRT(P1*P2)
R2          (0.24)                    KIM       71 DPWA    K-MATRIX ANAL.    3/71
R2    1     -0.74 OR -0.43            MARTIN    77 DPWA    KBAR N MULTICHNL 11/77
R2          -0.08    (0.05)           RLIC      77 DPWA    KBAR N MULTICHNL  1/76

R3      LAMBDA(1800) FROM N KBAR TO SIGMA(1385) PI        SQRT(P1*P3)
R3    2     +0.056    0.028           CAMERON   78 DPWA  0 K-P TO S(1385)PI  1/78
R3    2  SIGN CHANGED TO BE IN ACCORD WITH THE BARYON-FIRST CONVENTION.     12/79

R4      LAMBDA(1800) FROM N KBAR TO N K*(892), S1 WAVE    SQRT(P1*P4)
R4    3     -0.17     0.03            CAMERON2  78 DPWA    K-P TO K*N       12/79
R4    3  THE SIGN HERE IS CHANGED TO BE IN ACCORD WITH THE BARYON-FIRST     12/79
R4    3  CONVENTION.                                                        12/79

R5      LAMBDA(1800) FROM N KBAR TO N K*(892), D3 WAVE    SQRT(P1*P5)
R5          -0.13     0.04            CAMERON2  78 DPWA    K-P TO K*N       12/79

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REFERENCES FOR LAMBDA(1800)


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BRICMAN  70 PL 33B 511         C BRICMAN, M FERRO-LUZZI, J P LAGNAUX(CERN)IJP
KIM      71 PRL 27 356         J K KIM                                (HARV)IJP
    ALSO 70 DUKE 161           J K KIM                                (HARV)IJP
LANGBEIN 72 NP B47 477         +WAGNER                                (MPIM)IJP

MARTIN   77 NP B127 349        MARTIN,PIDCOCK,MOORHOUSE        (LOUC+GLAS)IJP
    ALSO 77 NP B126 266        MARTIN,PIDCOCK                          (LOUC)
    ALSO 77 NP B126 285        MARTIN,PIDCOCK                          (LOUC)IJP
RLIC     77 NP B119 362        GOPAL,ROSS,VAN HORN,MCPHERSON+  (LOIC+RHEL)IJP
ALSTON   78 PR D18 182         +KENNEY,POLLARD,ROSS+       (LBL+MTHO+CERN)IJP
    ALSO 77 PRL 38 1007        ALSTON-GARNJOST,KENNEY,+    (LBL+MTHO+CERN)IJP
CAMERON  78 NP B143 189        +FRANEK,GOPAL,BACON,BUTTERWORTH+(RHEL+LOIC)IJP
CAMERON2 78 NP B146 327        +FRANEK,GOPAL,KALMUS,MCPHERSON,+(RHEL+LOIC)IJP
GOPAL    80  TORONTO CONF 159 G P GOPAL                            (RHEL)IJP
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Λ(1800) P_{01}'' Status: ***

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77  LAMBDA(1800, JP=1/2+) I=0      P''01

THE EVIDENCE FOR THIS STATE IS SOMEWHAT CONFUSED.  IT
WAS FIRST SUGGESTED IN A PARTIAL WAVE ANALYSIS OF
N KBAR DATA BY THE BEHAVIOUR OF THE P01 AMPLITUDE
WHEN IT WAS PARAMETRIZED AS A TWO-STRAIGHT-LINE
BACKGROUND (ARMENTEROS 68).

  ALMOST ALL THE RECENT ANALYSES CONTAIN A P01 STATE, AND SOMETIMES
 TWO, BUT THE MASSES, WIDTHS, AND BRANCHING RATIOS VARY GREATLY.
 SEE ALSO THE LAMBDA(1600) P01 LISTING.

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77 LAMBDA(1800) MASS (MEV)

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M          (1745.0)                  ARMENTERO 68 HBC   0 ELASTIC, CH EXCH 11/68
M          (1740.0)                  BAILEY    69 DPWA  0 ELASTIC, CH EXCH 10/70
M          (1800.0)                  ARMENTERO 70 HBC   0 ELASTIC, CH EX    6/70
M          (1750.0)                  ARMENTERO 70 HBC   0 SIGMA PI          6/70
M    N     (1690.0)   (10.0)         GALTIERI  70 HBC   0 SIG PI,EDPWA      7/70
M    N   ERROR STATIST. ONLY- NO ERROR DUE TO PARTICULAR P.W.ANAL. INCLUDED  1/71
M          (1755.0)                  KIM       71 DPWA    K-MATRIX ANAL.    3/71
M           1780.0     20.0          LANGBEIN  72 IPWA    MULTICHANNEL     12/72
M           1746.0     10.0          PREVOST   74 DPWA 0- K-N TO S(1385)PI 10/74
M     1     1735.0      5.0          CARROLL   76 DPWA    I=0 TOTAL CS      2/77
M     3     1861. OR 1953.           MARTIN    77 DPWA    KBAR N MULTICHNL 11/77
M     3  THE TWO ENTRIES FOR MARTIN 77 CORRESPOND TO EXTRACTION OF RESONANCE
M     3  PARAMETERS FROM THE T-MATRIX POLE AND FROM A B-W FIT, RESPECTIVELY.
M           1853.0     20.0          RLIC      77 DPWA    KBAR N MULTICHNL  1/76
M           1841.0    (20.0)         GOPAL     80 DPWA    KBAR N ELASTIC   12/81

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77 LAMBDA(1800) WIDTH (MEV)

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W          (147.0)                   ARMENTERO 68 HBC   0
W          (300.0)                   BAILEY    69 DPWA  0 ELASTIC, CH EXCH 10/70
W           (30.0)                   ARMENTERO 70 HBC   0 ELASTIC, CH EX    6/70
W           (70.0)                   ARMENTERO 70 HBC   0 SIGMA PI          6/70
W    N      (22.0)                   GALTIERI  70 HBC   0 SIG PI,EDPWA      7/70
W           (35.0)                   KIM       71 DPWA    K-MATRIX ANAL.    3/71
W           120.0     10.0           LANGBEIN  72 IPWA    MULTICHANNEL     12/72
W            46.0     20.0           PREVOST   74 DPWA 0- K-N TO S(1385)PI 10/74
W     1     (28.0)                   CARROLL   76 DPWA    I=0 TOTAL CS      2/77
W     3     535. OR 585.             MARTIN    77 DPWA    KBAR N MULTICHNL 11/77
W           166.0     20.0           RLIC      77 DPWA    KBAR N MULTICHNL  1/76
W            90.0     20.0           CAMERON2  78 DPWA    K-P TO K*(892) N 12/79
W           164.0    (20.0)          GOPAL     80 DPWA    KBAR N ELASTIC   12/81

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77 LAMBDA(1800) PARTIAL DECAY MODES

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                                                        DECAY MASSES
P1      LAMBDA(1800) INTO N KBAR                       938+ 494
P2      LAMBDA(1800) INTO SIGMA PI                    1189+ 140
P3      LAMBDA(1800) INTO SIGMA(1385) PI              1385+ 140
P4      LAMBDA(1800) INTO N K*(892), P1 WAVE           940+ 892
P5      LAMBDA(1800) INTO N K*(892), P3 WAVE           940+ 892

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77 LAMBDA(1800) BRANCHING RATIOS

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R1      LAMBDA(1800) INTO (N KBAR)/TOTAL                    (P1)
R1          (0.4)                     ARMENTERO 68 DPWA  0 ELASTIC, CH EXCH 11/68
R1          (0.55)                    BAILEY    69 DPWA  0 ELASTIC, CH EXCH 10/70
R1          (0.15)                    ARMENTERO 70 DPWA  0 ELASTIC, CH EXCH 10/70
R1          (0.30)                    KIM       71 DPWA    K-MATRIX ANAL.    3/71
R1           0.36     0.05            LANGBEIN  72 IPWA    MULTICHANNEL     12/72
R1    3      0.52 OR  0.49            MARTIN    77 DPWA    KBAR N MULTICHNL 11/77
R1    C     (0.21)   (0.04)           RLIC      77 DPWA    KBAR N MULTICHNL  1/76
R1    C  (N KBAR)/TOTAL FROM RLIC 77 IS SUPERSEDED BY GOPAL 80.
R1           0.24    (0.04)           GOPAL     80 DPWA    KBAR N ELASTIC   12/81

R2      LAMBDA(1800) FROM N KBAR TO SIGMA PI              SQRT(P1*P2)
R2    2     (+0.20)                   ARMENTERO 70 DPWA  0 K-P TO SIGMA PI    6/70
R2    2  PUBLISHED SIGN CHANGED TO AGREE WITH LUND 1969 CONVENTION (SEE NOTE  10/74
R2    2  ON LAMBDA AND SIGMA RESONANCES).                                    10/74
R2    N     (-0.13)   (0.03)          GALTIERI  70 DPWA  0 K-P TO SIGMA PI    7/70
R2          (0.17)                    KIM       71 DPWA    K-MATRIX ANAL.    3/71
R2          (0.01) OR LESS            LANGBEIN  72 IPWA    MULTICHANNEL     12/72
R2    3     +0.25 OR +0.23            MARTIN    77 DPWA    KBAR N MULTICHNL 11/77
R2          -0.24     0.04            RLIC      77 DPWA    KBAR N MULTICHNL  1/76

R3      LAMBDA(1800) FROM N KBAR TO SIGMA(1385) PI        SQRT(P1*P3)
R3          +0.18     0.10            PREVOST   74 DPWA 0- K-N TO S(1385)PI 10/74

R4      LAMBDA(1800) FROM N KBAR TO N K*(892), P1 WAVE    SQRT(P1*P4)
R4    4     -0.14     0.03            CAMERON2  78 DPWA    K-P TO K*N       12/79
R4    4  THE SIGN HERE IS CHANGED TO BE IN ACCORD WITH THE BARYON-FIRST     12/79
R4    4  CONVENTION.                                                        12/79

R5      LAMBDA(1800) FROM N KBAR TO N K*(892), P3 WAVE    SQRT(P1*P5)
R5          +0.35     0.06            CAMERON2  78 DPWA    K-P TO K*N       12/79

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Baryons

Λ(1800), Λ(1820), Λ(1830)

Data Card Listings

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                    REFERENCES FOR LAMBDA(1800)

ARMENTER 68 NP B8 195          ARMENTEROS, BAILLON, +      (CERN+HEID+SACL)IJP
BAILEY   69 THESIS UCRL-50617  DAVID SAAL BAILEY                     (LLL)IJP
ARMENTER 70 DUKE CONF 123      ARMENTEROS, BAILLON, +          (CERN+HEID)IJP
GALTIERI 70 DUKE CONF 173      A BARBARO-GALTIERI                   (LRL)IJP
KIM      71 PRL 27 356         J K KIM                             (HARV)IJP
   ALSO  70 DUKE 161           J K KIM                             (HARV)IJP
LANGBEIN 72 NP B47 477         +WAGNER                             (MPIM)IJP

PREVOST  74 NP B69 246         PREVOST,BARLOUTAUD,+        (SACL+CERN+HEID)
CARROLL  76 PRL 37 806         +CHIANG,KYCIA,LI,MAZUR,MICHAEL+      (BNL)I
MARTIN   77 NP B127 349        MARTIN,PIDCOCK,MOORHOUSE        (LOUC+GLAS)IJP
   ALSO  77 NP B126 266        MARTIN,PIDCOCK                      (LOUC)
   ALSO  77 NP B126 285        MARTIN,PIDCOCK                      (LOUC)IJP
RLIC     77 NP B119 362        GOPAL,ROSS,VAN HORN,MCPHERSON+  (LOIC+RHEL)IJP
CAMERON2 78 NP B146 327        +FRANEK,GOPAL,KALMUS,MCPHERSON,+(RHEL+LOIC)IJP
GOPAL    80  TORONTO CONF 159 G P GOPAL                          (RHEL)IJP

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Λ(1820) F'_{05} Status: ****

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                    39  LAMBDA(1820, JP=5/2+) I=0       F'05

                    FOR MOST RESULTS PUBLISHED BEFORE 1973 (THEY ARE
                    NOW OBSOLETE), SEE OUR 1982 EDITION (PHYSICS LETTERS
                    111B).  ALL THE REFERENCES HAVE BEEN RETAINED.

                    THIS STATE IS WELL ESTABLISHED.  MOST OF THE QUOTED ER-
                    RORS ARE STATISTICAL ONLY.  THE SYSTEMATIC ERRORS DUE
                    TO THE PARTICULAR PARAMETRIZATIONS USED IN THE P.W.A.
   ARE NOT INCLUDED.  FOR THIS REASON WE DO NOT CALCULATE WEIGHTED
   AVERAGES FOR THE MASS AND WIDTH.

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                    39  LAMBDA(1820) MASS (MEV)

M          1821.0     (2.0)          KANE      74 DPWA    K-P TO PI SIG    12/81
M         (1830.0)                   DECLAIS   77 DPWA    KBAR N TO KBAR N  1/78
M    A     1817. OR 1819.            MARTIN    77 DPWA    KBAR N MULTICHNL 11/77
M    A  THE TWO ENTRIES FOR MARTIN 77 CORRESPOND TO EXTRACTION OF RESONANCE
M    A  PARAMETERS FROM THE T-MATRIX POLE AND FROM A B-W FIT, RESPECTIVELY.
M          1822.0     (2.0)          RLIC      77 DPWA    KBAR N MULTICHNL  1/76
M          1819.0     (2.0)          ALSTON    78 DPWA    KBAR N ELASTIC    1/78
M          1823.0     (3.0)          GOPAL     80 DPWA    KBAR N ELASTIC   12/81

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                    39  LAMBDA(1820) WIDTH (MEV)

W           87.0      (3.0)          KANE      74 DPWA    K-P TO PI SIG    12/81
W          (82.0)                    DECLAIS   77 DPWA    KBAR N TO KBAR N  1/78
W    A      76. OR 76.               MARTIN    77 DPWA    KBAR N MULTICHNL 11/77
W           81.0      (5.0)          RLIC      77 DPWA    KBAR N MULTICHNL  1/76
W           72.0      (5.0)          ALSTON    78 DPWA    KBAR N ELASTIC    1/78
W           77.0      (5.0)          GOPAL     80 DPWA    KBAR N ELASTIC   12/81

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                    39  LAMBDA(1820) PARTIAL DECAY MODES

                                                          DECAY MASSES
P1      LAMBDA(1820) INTO N KBAR                         938+ 494
P2      LAMBDA(1820) INTO SIGMA PI                      1189+ 140
P3      LAMBDA(1820) INTO SIGMA PI PI                   1192+ 140+ 140
P4      LAMBDA(1820) INTO LAMBDA ETA                    1116+ 549
P5      LAMBDA(1820) INTO SIGMA(1385) PI, P-WAVE        1385+ 140
P6      LAMBDA(1820) INTO SIGMA(1385) PI, F-WAVE        1385+ 140

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FITTED PARTIAL DECAY MODE BRANCHING FRACTIONS

The matrix below is derived from the error matrix for the fitted partial decay mode branching fractions, P_i, as follows: The diagonal elements are $P_i \pm \delta P_i$, where $\delta P_i = \sqrt{\langle \delta P_i \delta P_i \rangle}$, while the off-diagonal elements are the normalized correlation coefficients $\langle \delta P_i \delta P_j \rangle / (\delta P_i \cdot \delta P_j)$. For the definitions of the individual P_i, see the listings above; only those P_i appearing in the matrix are assumed in the fit to be nonzero and are thus constrained to add to 1.

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        P 1       P 2       P 3       P 4       P 5       P 6
P 1 .5940+-.0304
P 2   -.2306  .1320+-.0288
P 3   -.2081     .0481  .1046+-.0293
P 4   -.3697    -.5263    -.5507  .1468+-.0447
P 5   -.0910     .0210     .0190    -.1571  .0155+-.0086
P 6   -.0568     .0131     .0118    -.1198     .0052  .0071+-.0063

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                    39  LAMBDA(1820) BRANCHING RATIOS

        ERRORS QUOTED BY EXPERIMENTERS DO NOT INCLUDE UNCERTAINTY DUE
        TO PARAMETRIZATION USED IN THE P.W.A.  THEY SHOULD BE INCREASED.

R1      LAMBDA(1820) INTO (N KBAR)/TOTAL                    (P1)
R1          (0.51)                    DECLAIS   77 DPWA    KBAR N TO KBAR N  1/78
R1   A       0.59 OR  0.58            MARTIN    77 DPWA    KBAR N MULTICHNL 11/77
R1   B      (0.57)    (0.02)          RLIC      77 DPWA    KBAR N MULTICHNL  1/76
R1   B  (N KBAR)/TOTAL FROM RLIC 77 IS SUPERSEDED BY GOPAL 80.
R1           0.60      0.03           ALSTON    78 DPWA    KBAR N ELASTIC    1/78
R1           0.58     (0.02)          GOPAL     80 DPWA    KBAR N ELASTIC   12/81
R1        . . . . . . . . . .
R1  FIT      0.594     0.030  FROM FIT

R2      LAMBDA(1820) FROM N KBAR TO SIGMA PI                SQRT(P1*P2)
R2          -0.28     (0.01)          KANE      74 DPWA    K-P TO PI SIG    12/81
R2   A      -0.25 OR -0.25            MARTIN    77 DPWA    KBAR N MULTICHNL 11/77
R2          -0.28      0.03           RLIC      77 DPWA    KBAR N MULTICHNL  1/76
R2        . . . . . . . . . .
R2  FIT      0.280     0.030  FROM FIT

R3      LAMBDA(1820) FROM N KBAR TO LAMBDA ETA              SQRT(P1*P4)
R3          -0.096    0.040    0.020 RADER     73 MPWA                      9/73
R3        . . . . . . . . . .
R3  FIT      0.096     0.026  FROM FIT

R4      LAMBDA(1820) INTO (SIGMA(1385) PI)/TOTAL            (P5)
R4           0.20      0.05           BIRGE     65 HBC   0 K-P TO LAM PI PI  7/66
R4        . . . . . . . . . .
R4  FIT      0.105     0.029  FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.5)

R5      LAMBDA(1820) INTO (SIGMA PI PI)/TOTAL               (P3)
R5   C      NO CLEAR SIGNAL              ARMENT-4  68 HDBC  0 K-N TO SIG PI PI 11/68
R5   C   THERE IS A SUGGESTION OF A BUMP, ENOUGH TO BE CONSISTENT WITH
R5   C   WHAT IS EXPECTED FROM SIGMA(1385) TO SIGMA PI DECAY -- ABOUT 0.02.
R5        . . . . . . . . . .
R5  FIT      0.147     0.045  FROM FIT

R6      LAMBDA(1820) FROM N KBAR TO SIGMA(1385) PI P-WAVESQRT(P1*P5)
R6          +0.27      0.03           PREVOST   74 DPWA  0- K-N TO S(1385)PI 10/74
R6   D      -0.167     0.054          CAMERON   78 DPWA  0 K-P TO S(1385)PI  1/78
R6   D  THE SIGN HERE AND IN R7 IS CHANGED TO BE IN ACCORD WITH THE          12/79
R6   D  BARYON-FIRST CONVENTION.                                             12/79
R6        . . . . . . . . . .
R6  AVG MOD  0.246     0.044   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.7)
R6  FIT      0.249     0.034  FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.5)

R7      LAMBDA(1820) FROM N KBAR TO SIGMA(1385) PI F-WAVESQRT(P1*P6)
R7   D      +0.065     0.029          CAMERON   78 DPWA  0 K-P TO S(1385)PI  1/78
R7        . . . . . . . . . .
R7  FIT      0.065     0.029  FROM FIT

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                    REFERENCES FOR LAMBDA(1820)

CHAMBERL 62 PR 125 1696        CHAMBERLAIN,CROWE,KEEFE,KERTH, +       (LRL) I
GALTIERI 63 PL 6 296           A BARBARO-GALTIERI,A HUSSAIN,R D TRIPP(LRL)IJ
SODICKSO 64 PR 133 B757        SODICKSON,MANNELLI,FRISCH,WAHLIG  (MIT+BNL) J
BIRGE    65 ATHENS CONF  296   +ELY,KALMUS,KERNAN,LOUIE,SAHOURIA, +  (LRL)IJP
HOLLEY   65 UCRL-16274 THESIS W R HOLLEY                             (LRL) J
BIRMINGH 66 PR 152 1148                     (BIRM+GLAS+LOIC+OXF+RHEL)
COOL     66 PRL 16 1228        +GIACOMELLI,KYCIA,LEONTIC,LUNDBY +     (BNL)I
GELFAND  66 PRL 17 1224        +HARMSEN,LEVI-SETTI,PREDAZZI+     (EFI+ANL)

ARMENTER 67 NP B3 592          ARMENTEROS,FERRO-LUZZI+     (CERN+HEID+SACL)IJP
ARMENT-1 67 PL 24B 198         ARMENTEROS, F LUZZI, +      (CERN+HEID+SACL)IJP
ARMENT-2 67 ZEIT PHYS 202 486  ARMENTEROS, F LUZZI, +      (CERN+HEID+SACL)IJP
BELL     67 PRL 19 936         R B BELL                             (LRL)IJP
ARMENT-3 68 NP B8 195          ARMENTEROS, BAILLON, +      (CERN+HEID+SACL)IJP
ARMENT-4 68 NP B8 216          ARMENTEROS, BAILLON, +      (CERN+HEID+SACL) I
BUGG     68 PR 168 1466        +GILMORE, KNIGHT,    +      (RHEL+BIRM+CAVE) I
CONFORTO 68 NP B8 265          +HARMSEN, LASINSKI, +            (CHIC+HEID)IJP
LASINSKI 68 PR 163 1792        LASINSKI, LEVI SETTI, PREDAZZI       (CHIC) JP

BRICMAN  70 PL 31B 152         +FERRO LUZZI, PERREAU,+     (CERN+CAEN+SACL)
BRICMAN1 70 PL 33B 511         +FERRO-LUZZI,LAGNAUX                   (CERN)
COOL     70 PR D1 1887         +GIACOMELLI, KYCIA, LEONTIC, LI, +     (BNL) I
GALTIERI 70 DUKE CONF 173      A BARBARO-GALTIERI                     (LRL)IJP
CONFORTO 71 NP  B34  41        +LEVI SETTI,LASINSKI..OBERLACK+  (EFI+HEID)IJP
KIM      71 PRL 27 356         J K KIM                               (HARV)IJP
   ALSO  70 DUKE 161           J K KIM                               (HARV)IJP

PREVOST  71  AMSTERDAM CONF    + CHS COLLABORATION         (CERN+HEID+SACL)
KANE     72 PR D5 1583         D F KANE                               (LBL)IJP
LANGBEIN 72 NP B47 477         +WAGNER                               (MPIM)IJP
RADER    73 NC 16A 178         +BARLOUTAUD,+     (SACL+HEID+CERN+RHEL+CDEF)
KANE     74  LBL-2452          D F KANE                               (LBL)IJP
PREVOST  74 NP B69 246         PREVOST,BARLOUTAUD,+        (SACL+CERN+HEID)

DECLAIS  77  CERN 77-16        +DUCHON,LOUVEL,PATRY,SEGUINOT+  (CAEN+CERN)IJP
MARTIN   77 NP B127 349        MARTIN,PIDCOCK,MOORHOUSE        (LOUC+GLAS)IJP
   ALSO  77 NP B126 266        MARTIN,PIDCOCK                      (LOUC)
   ALSO  77 NP B126 285        MARTIN,PIDCOCK                      (LOUC)IJP
RLIC     77 NP B119 362        GOPAL,ROSS,VAN HORN,MCPHERSON+  (LOIC+RHEL)IJP
ALSTON   78 PR D18 182         +KENNEY,POLLARD,ROSS+       (LBL+MTHO+CERN)IJP
   ALSO  77 PRL 38 1007        ALSTON-GARNJOST,KENNEY,+    (LBL+MTHO+CERN)IJP
CAMERON  78 NP B143 189        +FRANEK,GOPAL,BACON,BUTTERWORTH+(RHEL+LOIC)IJP
GOPAL    80  TORONTO CONF 159 G P GOPAL                          (RHEL)IJP

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Λ(1830) D_{05} Status: ****

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                    56  LAMBDA(1830, JP=5/2-) I=0       D05

                    FOR RESULTS PUBLISHED BEFORE 1973 (THEY ARE
                    NOW OBSOLETE), SEE OUR 1982 EDITION (PHYSICS LETTERS
                    111B).  ALL THE REFERENCES HAVE BEEN RETAINED.

                    THE BEST EVIDENCE FOR THIS RESONANCE COMES FROM THE
                    SIGMA PI CHANNEL.  IT IS WELL ESTABLISHED.

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                    56  LAMBDA(1830) MASS (MEV)

M          1825.0     (1.0)          KANE      74 DPWA    K-P TO PI SIG    12/81
M    A     1817. OR 1818.            MARTIN    77 DPWA    KBAR N MULTICHNL 11/77
M    A  THE TWO ENTRIES FOR MARTIN 77 CORRESPOND TO EXTRACTION OF RESONANCE
M    A  PARAMETERS FROM THE T-MATRIX POLE AND FROM A B-W FIT, RESPECTIVELY.
M          1825.0    (10.0)          RLIC      77 DPWA    KBAR N MULTICHNL  1/76
M          1831.0    (10.0)          GOPAL     80 DPWA    KBAR N ELASTIC   12/81

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                    56  LAMBDA(1830) WIDTH (MEV)

W          119.0      (3.0)          KANE      74 DPWA    K-P TO PI SIG    12/81
W    A      56. OR 56.               MARTIN    77 DPWA    KBAR N MULTICHNL 11/77
W           94.0     (10.0)          RLIC      77 DPWA    KBAR N MULTICHNL  1/76
W          100.0     (10.0)          GOPAL     80 DPWA    KBAR N ELASTIC   12/81

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                    56  LAMBDA(1830) PARTIAL DECAY MODES

                                                          DECAY MASSES
P1      LAMBDA(1830) INTO N KBAR                         938+ 494
P2      LAMBDA(1830) INTO SIGMA PI                      1189+ 140
P3      LAMBDA(1830) INTO SIGMA(1385) PI, D-WAVE        1385+ 140
P4      LAMBDA(1830) INTO LAMBDA ETA                    1116+ 549

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For notation, see key at front of Listings.


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                  56  LAMBDA(1830) BRANCHING RATIOS

R1      LAMBDA(1830) INTO (N KBAR)/TOTAL                (P1)
R1   A        0.04 OR  0.04          MARTIN     77 DPWA    KBAR N MULTICHNL 11/77
R1   B       (0.04)   (0.03)         RLIC       77 DPWA    KBAR N MULTICHNL  1/76
R1   B  (N KBAR)/TOTAL FROM RLIC 77 IS SUPERSEDED BY GOPAL 80.
R1            0.02    (0.02)         ALSTON     78 DPWA    KBAR N ELASTIC    1/78
R1            0.08    (0.03)         GOPAL      80 DPWA    KBAR N ELASTIC   12/81

R2      LAMBDA(1830) FROM N KBAR TO SIGMA PI            SQRT(P1*P2)
R2           -0.15    (0.01)         KANE       74 DPWA    K-P TO PI SIG    12/81
R2   A       -0.17 OR -0.17          MARTIN     77 DPWA    KBAR N MULTICHNL 11/77
R2           -0.17    (0.03)         RLIC       77 DPWA    KBAR N MULTICHNL  1/76

R3      LAMBDA(1830) FROM N KBAR TO LAMBDA ETA          SQRT(P1*P4)
R3           -0.044    0.020         RADER      73 MPWA                      9/73

R4      LAMBDA(1830) FROM N KBAR TO SIGMA(1385) PI D-WAVESQRT(P1*P3)
R4           +0.13     0.03          PREVOST    74 DPWA 0- K-N TO S(1385)PI 10/74
R4   C       +0.141    0.014         CAMERON    78 DPWA  0 K-P TO S(1385)PI  1/78
R4   C  CAMERON  78 UPPER LIMIT ON G-WAVE DECAY IS 0.03.  THE SIGN HERE IS  12/79
R4   C  CHANGED TO BE IN ACCORD WITH THE BARYON-FIRST CONVENTION.           12/79

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                          REFERENCES FOR LAMBDA(1830)

ARMENTER 67 PL 24B 198        ARMENTEROS, F-LUZZI, +     (CERN+HEID+SACL)IJP
BELL     67 PRL 19 936        R B BELL                              (LRL)IJP
ARMENTER 68 NP B8 195         ARMENTEROS, BAILLON, +     (CERN+HEID+SACL)IJP
CONFORTO 68 NP B8 265         +HARMSEN, LASINSKI, +           (CHIC+HEID)IJP
   IS SUPERSEDED BY CONFORTO 71.
BRICMAN1 70 PL 33B 511        +FERRO-LUZZI,LAGNAUX                  (CERN)
GALTIERI 70 DUKE CONF 173     A BARBARO-GALTIERI                    (LRL)IJP

CONFORTO 71 NP  B34  41       +LEVI SETTI,LASINSKI..OBERLACK++ (EFI+HEID)IJP
KIM      71 PRL 27 356        J K KIM                              (HARV)IJP
   ALSO 70 DUKE 161           J K KIM                              (HARV)IJP
KANE     72 PR D5 1583        D F KANE                              (LBL)IJP
LANGBEIN 72 NP B47 477        +WAGNER                              (MPIM)IJP
RADER    73 NC 16A 178        +BARLOUTAUD,+     (SACL+HEID+CERN+RHEL+CDEF)

KANE     74  LBL-2452         D F KANE                              (LBL)IJP
PREVOST  74 NP B69 246        PREVOST,BARLOUTAUD,+       (SACL+CERN+HEID)

MARTIN   77 NP B127 349       MARTIN,PIDCOCK,MOORHOUSE        (LOUC+GLAS)IJP
   ALSO 77 NP B126 266        MARTIN,PIDCOCK                       (LOUC)
   ALSO 77 NP B126 285        MARTIN,PIDCOCK                       (LOUC)IJP
RLIC     77 NP B119 362       GOPAL,ROSS,VAN HORN,MCPHERSON+  (LOIC+RHEL)IJP
ALSTON   78 PR D18 182        +KENNEY,POLLARD,ROSS+       (LBL+MTHO+CERN)IJP
   ALSO 77 PRL 38 1007        ALSTON-GARNJOST,KENNEY,+    (LBL+MTHO+CERN)IJP
CAMERON  78 NP B143 189       +FRANEK,GOPAL,BACON,BUTTERWORTH+(RHEL+LOIC)IJP
GOPAL    80  TORONTO CONF 159 G P GOPAL                            (RHEL)IJP
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Λ(1890) P_{03} Status: ****

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                  60  LAMBDA(1890, JP=3/2+) I=0       P03

                  FOR RESULTS PUBLISHED BEFORE 1974 (THEY ARE
                  NOW OBSOLETE), SEE OUR 1982 EDITION (PHYSICS LETTERS
                  111B).  ALL THE REFERENCES HAVE BEEN RETAINED.

                  THE JP=3/2+ ASSIGNMENT IS CONSISTENT WITH ALL
                  AVAILABLE DATA (INCLUDING POLARIZATION) AND RECENT
                  PARTIAL WAVE ANALYSES.  THE DOMINANT INELASTIC
                  MODES REMAIN UNKNOWN.

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                  60  LAMBDA(1890) MASS (MEV)

M          1894.0      10.0          HEMINGWA   75 DPWA  0 K- P TO KBAR N   11/75
M    A    (1900.0)                   NAKKASYA   75 DPWA  0 K-P TO LAM. OMG.  1/76
M    A  FOUND IN ONE OF TWO BEST SOLUTIONS.                                  1/76
M         SEEN                       BACCARI    77 IPWA  0 K-P TO LAM. OMG.  1/78
M    B     1856. OR 1868.            MARTIN     77 DPWA    KBAR N MULTICHNL 11/77
M    B  THE TWO ENTRIES FOR MARTIN 77 CORRESPOND TO EXTRACTION OF RESONANCE
M    B  PARAMETERS FROM THE T-MATRIX POLE AND FROM A B-W FIT, RESPECTIVELY.
M          1900.0       5.0          RLIC       77 DPWA    KBAR N MULTICHNL  1/76
M          1908.0      10.0          ALSTON     78 DPWA    KBAR N ELASTIC    1/78
M          1897.0      (5.0)         GOPAL      80 DPWA    KBAR N ELASTIC   12/81

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                  60  LAMBDA(1890) WIDTH (MEV)

W           107.0      10.0          HEMINGWA   75 DPWA  0 K- P TO KBAR N   11/75
W    A     (100.0)                   NAKKASYA   75 DPWA  0 K-P TO LAM. OMG.  1/76
W    B      191. OR 193.             MARTIN     77 DPWA    KBAR N MULTICHNL 11/77
W            72.0      10.0          RLIC       77 DPWA    KBAR N MULTICHNL  1/76
W           119.0      20.0          ALSTON     78 DPWA    KBAR N ELASTIC    1/78
W            74.0     (10.0)         GOPAL      80 DPWA    KBAR N ELASTIC   12/81

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                  60  LAMBDA(1890) PARTIAL DECAY MODES

                                                           DECAY MASSES
P1      LAMBDA(1890) INTO N KBAR                         938+ 494
P2      LAMBDA(1890) INTO SIGMA PI                      1189+ 140
P3      LAMBDA(1890) INTO LAMBDA OMEGA                  1116+ 783
P4      LAMBDA(1890) INTO SIGMA(1385) PI, P-WAVE        1385+ 140
P5      LAMBDA(1890) INTO SIGMA(1385) PI, F-WAVE        1385+ 140
P6      LAMBDA(1890) INTO N K*(892), P1 WAVE             940+ 892

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                  60  LAMBDA(1890) BRANCHING RATIOS

R1      LAMBDA(1890) INTO (N KBAR)/TOTAL                (P1)
R1            0.24     0.04          HEMINGWA   75 DPWA  0 K- P TO KBAR N   11/75
R1   B        0.36 OR  0.34          MARTIN     77 DPWA    KBAR N MULTICHNL 11/77
R1   C       (0.18)   (0.02)         RLIC       77 DPWA    KBAR N MULTICHNL  1/76
R1   C  (N KBAR)/TOTAL FROM RLIC 77 IS SUPERSEDED BY GOPAL 80.
R1            0.34     0.05          ALSTON     78 DPWA    KBAR N ELASTIC    1/78
R1            0.20    (0.02)         GOPAL      80 DPWA    KBAR N ELASTIC   12/81

R2      LAMBDA(1890) INTO (SIGMA PI)/TOTAL              (P2)
R2           (0.03) OR LESS          LANGBEIN   72 IPWA    MULTICHANNEL     12/72

R3      LAMBDA(1890) FROM N KBAR TO SIGMA PI            SQRT(P1*P2)
R3   B       +0.15 OR +0.14          MARTIN     77 DPWA    KBAR N MULTICHNL 11/77
R3           -0.09     0.03          RLIC       77 DPWA    KBAR N MULTICHNL  1/76

R4      LAMBDA(1890) FROM N KBAR TO LAMBDA OMEGA        SQRT(P1*P3)
R4   A       (0.032)                 NAKKASYA   75 DPWA  0 K-P TO LAM. OMG.  1/76

R5      LAMBDA(1890) FROM N KBAR TO SIGMA(1385) PI P-WAVESQRT(P1*P4)
R5        LESS THAN 0.03             CAMERON    78 DPWA  0 K-P TO S(1385)PI  1/78

R6      LAMBDA(1890) FROM N KBAR TO SIGMA(1385) PI F-WAVESQRT(P1*P5)
R6   D       -0.126    0.055         CAMERON    78 DPWA  0 K-P TO S(1385)PI  1/78
R6   D  SIGN CHANGED TO BE IN ACCORD WITH THE BARYON-FIRST CONVENTION.      12/79

R7      LAMBDA(1890) FROM N KBAR TO N K*(892), P1 WAVE  SQRT(P1*P6)
R7   E       -0.07     0.03          CAMERON2   78 DPWA    K-P TO K*N       12/79
R7   E  THE SIGN HERE IS CHANGED TO BE IN ACCORD WITH THE BARYON-FIRST      12/79
R7   E  CONVENTION.  UPPER LIMITS ON THE P3 AND F3 WAVES ARE EACH 0.03.     12/79

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                          REFERENCES FOR LAMBDA(1890)

ARMENTER 67 NP B3 592         ARMENTEROS, F-LUZZI, +     (CERN+HEID+SACL)IJP
ARMENTERO68 NP B8 195         ARMENTEROS, BAILLON, +     (CERN+HEID+SACL)IJP
BUGG     68 PR 168 1466       +GILMORE, KNIGHT, +        (RHEL+BIRM+CAVE) I
CONFORTO 68 NP B8 265         +HARMSEN, LASINSKI, +           (CHIC+HEID)IJP
GALTIERI 68 PRL 21 573        BARBARO-GALTIERI, MATISON, +    (LRL+SLAC)
LEVISETT 69 LUND 339          R.LEVI SETTI  (RAPPORTEUR)             (EFI)

BRICMAN  70 PL 31B 152        +FERRO LUZZI, PERREAU,+    (CERN+CAEN+SACL)
BRICMAN1 70 PL 33B 511        +FERRO-LUZZI,LAGNAUX                  (CERN)
ALBROW   71 NP  B29 413       +ANDERSON,BOSNJAKOVIC,DAUM,ERNZ,+     (CERN)
CONFORTO 71 NP  B34  41       +LEVI SETTI,LASINSKI..OBERLACK++ (EFI+HEID)IJP
KIM      71 PRL 27 356        J K KIM                              (HARV)IJP
   ALSO 70 DUKE 161           J K KIM                              (HARV)IJP
LANGBEIN 72 NP B47 477        +WAGNER                              (MPIM)IJP

LEA      73 NP B56 77         +MARTIN,MOORHOUSE+    (RHEL+LOUC+GLAS+AARH)IJP
HEMINGWA 75 NP B91 12         HEMINGWAY,EADES,HARMSEN+   (CERN+HEID+MPIM)IJP
NAKKASYA 75 NP B93 85         A NAKKASYAN                          (CERN)IJP

BACCARI  77 NC 41A 96         +POULARD,REVEL,TALLINI+         (SACL+CDEF)IJP
MARTIN   77 NP B127 349       MARTIN,PIDCOCK,MOORHOUSE        (LOUC+GLAS)IJP
   ALSO 77 NP B126 266        MARTIN,PIDCOCK                       (LOUC)
   ALSO 77 NP B126 285        MARTIN,PIDCOCK                       (LOUC)IJP
RLIC     77 NP B119 362       GOPAL,ROSS,VAN HORN,MCPHERSON+  (LOIC+RHEL)IJP
ALSTON   78 PR D18 182        +KENNEY,POLLARD,ROSS+       (LBL+MTHO+CERN)IJP
   ALSO 77 PRL 38 1007        ALSTON-GARNJOST,KENNEY,+    (LBL+MTHO+CERN)IJP
CAMERON  78 NP B143 189       +FRANEK,GOPAL,BACON,BUTTERWORTH+(RHEL+LOIC)IJP
CAMERON2 78 NP B146 327       +FRANEK,GOPAL,KALMUS,MCPHERSON,+(RHEL+LOIC)IJP
GOPAL    80  TORONTO CONF 159 G P GOPAL                            (RHEL)IJP
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Λ(2000)   Status: *

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                  89  LAMBDA(2000,         ) I=0

                  WE LIST HERE ALL THE AMBIGUOUS RESONANCE POSSIBLITIES
                  WITH A MASS AROUND 2 GEV.  THE PROPOSED QUANTUM NUMBERS
                  ARE D3 (GALTIERI 70 IN SIGMA PI), D3+F5, P3+D5, OR
                  P1+D3 (BRANDSTETTER 72 IN LAMBDA OMEGA), AND S1
    (CAMERON2 78 IN N K*).  THE FIRST TWO OF THE ABOVE ANALYSES SHOULD NOW
    BE CONSIDERED OBSOLETE.

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                  89  LAMBDA(2000) MASS (MEV)

M          (2010.0)   (30.0)         GALTIERI   70 DPWA  0 K-P TO SIGMA PI   7/70
M    1      1935. TO 1971.           BRANDSTE   72 DPWA  0 K-P TO LAM. OMG.  1/74
M    1      1951. TO 2034.           BRANDSTE   72 DPWA  0 K-P TO LAM. OMG.  1/74
M    1  PARAMETERS QUOTED ARE RANGES FROM THREE BEST FITS, THE LOWER        11/75
M    1  (HIGHER) MASS STATE PROBABLY HAS J.LE.3/2(5/2).                     11/75
M           2030.0     30.0          CAMERON2   78 DPWA    K-P TO K*(892) N 12/79

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                  89  LAMBDA(2000) WIDTH (MEV)

W          (130.0)    (50.0)         GALTIERI   70 DPWA  0 K-P TO SIGMA PI   7/70
W    1      180. TO  240. (LWR. MASS) BRANDSTE  72 DPWA  0 K-P TO LAM. OMG.  1/74
W    1       73. TO  154. (HGR. MASS) BRANDSTE  72 DPWA  0 K-P TO LAM. OMG.  1/74
W           125.0      25.0          CAMERON2   78 DPWA    K-P TO K*(892) N 12/79

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                  89  LAMBDA(2000) PARTIAL DECAY MODES

                                                           DECAY MASSES
P1      LAMBDA(2000) INTO N KBAR                         938+ 494
P2      LAMBDA(2000) INTO SIGMA PI                      1189+ 140
P3      LAMBDA(2000) INTO LAMBDA OMEGA                  1116+ 783
P4      LAMBDA(2000) INTO N K*(892), S1 WAVE             940+ 892
P5      LAMBDA(2000) INTO N K*(892), D3 WAVE             940+ 892

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                  89  LAMBDA(2000) BRANCHING RATIOS

R1      LAMBDA(2000) FROM N KBAR TO SIGMA PI            SQRT(P1*P2)
R1          (-0.20)   (0.04)         GALTIERI   70 DPWA  0 K-P TO SIGMA PI   7/70

R2      LAMBDA(2000) FROM N KBAR TO LAMBDA OMEGA        SQRT(P1*P3)
R2   1        0.17  TO 0.25 (LWR.)   BRANDSTE   72 DPWA  0 K-P TO LAM. OMG.  1/74
R2   1        0.04  TO 0.15 (HGR.)   BRANDSTE   72 DPWA  0 K-P TO LAM. OMG.  1/74

R3      LAMBDA(2000) FROM N KBAR TO N K*(892), S1 WAVE  SQRT(P1*P4)
R3   2       -0.12     0.03          CAMERON2   78 DPWA    K-P TO K*N       12/79
R3   2  THE SIGN HERE IS CHANGED TO BE IN ACCORD WITH THE BARYON-FIRST      12/79
R3   2  CONVENTION.                                                         12/79
R4      LAMBDA(2000) FROM N KBAR TO N K*(892), D3 WAVE  SQRT(P1*P5)
R4           +0.09     0.03          CAMERON2   78 DPWA    K-P TO K*N       12/79

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                          REFERENCES FOR LAMBDA(2000)

GALTIERI 70 DUKE CONF 173     A BARBARO-GALTIERI                    (LRL)IJP
BRANDSTE 72 NP B39 13         BRANDSTETTER,BUTTERWORTH,+ (RHEL+CDEF+SACL)
CAMERON2 78 NP B146 327       +FRANEK,GOPAL,KALMUS,MCPHERSON,+(RHEL+LOIC)IJP
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Baryons

Λ(2000), Λ(2020), Λ(2100)

Data Card Listings

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                    PAPERS NOT REFERRED TO IN DATA CARDS

NAKKASYA 75 NP B93 85        A NAKKASYAN                          (CERN)IJP

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Λ(2020) F_{07} Status: *

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                    27  LAMBDA(2020, JP=7/2+) I=0       F07

                    EFFECTS IN THIS PARTIAL WAVE HAVE BEEN OBSERVED AT
                    DIFFERENT ENERGIES IN TWO CHANNELS.  IN LITCHFIELD 71,
                    NEED FOR THE STATE RESTS SOLELY ON POSSIBLY
                    INCONSISTENT POLARIZATION MEASUREMENT AT 1.784 GEV/C.
                    HEMINGWAY 75 ANALYSIS OF N KBAR DOES NOT REQUIRE THIS
   STATE.  RLIC 77 DO NOT NEED IT IN EITHER N KBAR OR SIGMA PI.  WITH NEW
   K- NEUTRON ANGULAR DISTRIBUTIONS INCLUDED, DECLAIS 77 SEE THIS STATE.
   HOWEVER, THIS AND OTHER NEW DATA ARE INCLUDED IN GOPAL 80 AND THIS
   STATE IS NOT REQUIRED.  BACARI 77 WEAKLY SUPPORTS THIS STATE.

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                    27  LAMBDA(2020) MASS (MEV)

M         (2020.0)   (20.0)          GALTIERI  70 DPWA  0 K-P TO SIGMA PI   7/70
M         (2100.0)   (30.0)          LITCHFIE  71 DPWA    K-P TO KBAR N    10/71
M         (2140.0)                   BACCARI   77 DPWA  0 K-P TO LAM. OMG.  1/78
M         (2117.0)                   DECLAIS   77 DPWA    KBAR N TO KBAR N  1/78

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                    27  LAMBDA(2020) WIDTH (MEV)

W          (160.0)   (30.0)          GALTIERI  70 DPWA  0 K-P TO SIGMA PI   7/70
W          (120.0)   (30.0)          LITCHFIE  71 DPWA    K-P TO KBAR N    10/71
W          (128.0)                   BACCARI   77 DPWA  0 K-P TO LAM. OMG.  1/78
W          (167.0)                   DECLAIS   77 DPWA    KBAR N TO KBAR N  1/78

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                    27  LAMBDA(2020) PARTIAL DECAY  MODES

                                                        DECAY MASSES
P1     LAMBDA(2020) INTO N KBAR                        938+ 494
P2     LAMBDA(2020) INTO SIGMA PI                     1189+ 140
P3     LAMBDA(2020) INTO LAMBDA OMEGA                 1116+ 783

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                    27  LAMBDA(2020) BRANCHING RATIOS

R1     LAMBDA(2020) INTO (N KBAR)/TOTAL                (P1)
R1          (0.05)   (0.02)          LITCHFIE  71 DPWA    K-P TO KBAR N    10/71
R1          (0.05)                   DECLAIS   77 DPWA    KBAR N TO KBAR N  1/78

R2     LAMBDA(2020) FROM N KBAR TO SIGMA PI            SQRT(P1*P2)
R2         (-0.15)   (0.02)          GALTIERI  70 DPWA  0 K-P TO SIGMA PI   7/70

R3     LAMBDA(2020) FROM N KBAR TO LAMBDA OMEGA        SQRT(P1*P3)
R3          LESS THAN 0.05           BACCARI   77 DPWA  0 K-P TO LAM. OMG.  1/78

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                    REFERENCES FOR LAMBDA(2020)

GALTIERI 70 DUKE CONF 173      A BARBARO-GALTIERI                     (LRL)IJP
LITCHFIE 71 NP  B30 125        LITCHFIELD,...+LESQUOY,+.. (RHEL+CDEF+SACL)IJP

BACCARI  77 NC 41A 96          +POULARD,REVEL,TALLINI+          (SACL+CDEF)IJP
DECLAIS  77  CERN 77-16        +DUCHON,LOUVEL,PATRY,SEGUINOT+  (CAEN+CERN)IJP

                               PAPERS NOT REFERRED TO IN DATA CARDS

HEMINGWA 75 NP B91 12          HEMINGWAY,EADES,HARMSEN+   (CERN+HEID+MPIM)IJP

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Λ(2100) G_{07} Status: ****

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                    41  LAMBDA(2100, JP=7/2-) I=0       G07

                    FOR MOST RESULTS PUBLISHED BEFORE 1973 (THEY ARE
                    NOW OBSOLETE), SEE OUR 1982 EDITION (PHYSICS LETTERS
                    111B).  ALL THE REFERENCES HAVE BEEN RETAINED.

                    THIS ENTRY ONLY INCLUDES RESULTS FROM PARTIAL-WAVE
                    ANALYSES.  PARAMETERS OF PEAKS SEEN IN CROSS SECTIONS
                    AND INVARIANT-MASS DISTRIBUTIONS AROUND 2100 MEV ARE
                    GIVEN IN A SEPARATE ENTRY BELOW.

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                    41  LAMBDA(2100) MASS (MEV)

M          2115.0    (10.0)          KANE      74 DPWA    K-P TO PI SIG    12/81
M          2105.0    (10.0)          HEMINGWAY 75 DPWA  0 K-  P TO KBAR N  11/75
M     A    2110. OR 2089.            NAKKASYA  75 DPWA  0 K-P TO LAM. OMG. 11/75
M     A  QUOTED PARAMETERS CORRESPOND TO THE TWO BEST SOLUTIONS FOUND.      11/75
M     A  EACH HAS THE LAMBDA(2100) AND ONE ADDITIONAL RESONANCE (P3 OR F5).  11/75
M         (2094.0)                   BACCARI   77 DPWA  0 K-P TO LAM. OMG.  1/78
M         (2094.0)                   DECLAIS   77 DPWA    KBAR N TO KBAR N  1/78
M          2110.0    (10.0)          RLIC      77 DPWA    KBAR N MULTICHNL  1/76
M          2106.0    (30.0)          BELLEFON  78 DPWA  0 KBAR N TO KBAR N  1/78
M          2104.0    (10.0)          GOPAL     80 DPWA    KBAR N ELASTIC   12/81

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                    41  LAMBDA(2100) WIDTH (MEV)

W           152.0    (15.0)          KANE      74 DPWA    K-P TO PI SIG    12/81
W           241.0    (30.0)          HEMINGWAY 75 DPWA  0 K-  P TO KBAR N  11/75
W     A     244. OR  302.            NAKKASYA  75 DPWA  0 K-P TO LAM. OMG. 11/75
W           (98.0)                   BACCARI   77 DPWA  0 K-P TO LAM. OMG.  1/78
W          (250.0)                   DECLAIS   77 DPWA    KBAR N TO KBAR N  1/78
W           250.0    (30.0)          RLIC      77 DPWA    KBAR N MULTICHNL  1/76
W           157.0    (40.0)          BELLEFON  78 DPWA  0 KBAR N TO KBAR N  1/78
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                    41  LAMBDA(2100) PARTIAL DECAY MODES

                                                        DECAY MASSES
P1     LAMBDA(2100) INTO N KBAR                        938+ 494
P2     LAMBDA(2100) INTO SIGMA PI                     1189+ 140
P3     LAMBDA(2100) INTO LAMBDA ETA                   1321+ 498
P4     LAMBDA(2100) INTO LAMBDA OMEGA                 1116+ 783
P5     LAMBDA(2100) INTO LAMBDA ETA                   1116+ 549
P6     LAMBDA(2100) INTO N K*(892), D3 WAVE            940+ 892
P7     LAMBDA(2100) INTO N K*(892), G1 WAVE            940+ 892

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                    41  LAMBDA(2100) BRANCHING RATIOS

R1     LAMBDA(2100) INTO (N KBAR)/TOTAL                (P1)
R1          0.31     (0.03)          HEMINGWA  75 DPWA  0 K- P TO KBAR N   11/75
R1         (0.29)                    DECLAIS   77 DPWA    KBAR N TO KBAR N  1/78
R1   C     (0.30)    (0.03)          RLIC      77 DPWA    KBAR N MULTICHNL  1/76
R1   C  (N KBAR)/TOTAL FROM RLIC 77 IS SUPERSEDED BY GOPAL 80.
R1          0.24     (0.06)          BELLEFON  78 DPWA  0 KBAR N TO KBAR N  1/78
R1          0.34     (0.03)          GOPAL     80 DPWA    KBAR N ELASTIC   12/81

R2     LAMBDA(2100) FROM N KBAR TO SIGMA PI            SQRT(P1*P2)
R2         +0.11     (0.01)          KANE      74 DPWA    K-P TO PI SIG    12/81
R2         +0.12     (0.04)          RLIC      77 DPWA    KBAR N MULTICHNL  1/76

R3     LAMBDA(2100) FROM N KBAR TO XI K                SQRT(P1*P3)
R3          (0.05)                   TRIPP     67 RVUE  0 K-P TO XI K        8/67
R3          (0.003)                  MULLER    69 DPWA  0                    7/70
R3           0.035     0.018         LITCHFIE  71 DPWA    K-P TO XI K       3/72

R4     LAMBDA(2100) FROM N KBAR TO LAMBDA OMEGA        SQRT(P1*P4)
R4   A       0.122 OR 0.154          NAKKASYA  75 DPWA  0 K-P TO LAM. OMG. 11/75
R4   D      (-0.070)                 BACCARI   77 DPWA  0 GD37-WAVE          1/78
R4   D      (+0.011)                 BACCARI   77 DPWA  0 GG17-WAVE          1/78
R4   D      (+0.008)                 BACCARI   77 DPWA  0 GG37-WAVE          1/78
R4   D   NOTE THAT THE 3 ENTRIES FOR BACCARI77 ARE FOR 3 DIFFERENT WAVES.    1/78

R5     LAMBDA(2100) FROM N KBAR TO LAMBDA ETA          SQRT(P1*P5)
R5         -0.050     0.020         RADER     73 MPWA                       9/73

R6     LAMBDA(2100) FROM N KBAR TO N K*(892), D3 WAVE  SQRT(P1*P6)
R6         +0.21      0.04          CAMERON2  78 DPWA    K-P TO K*N       12/79

R7     LAMBDA(2100) FROM N KBAR TO N K*(892), G1 WAVE  SQRT(P1*P7)
R7   E     -0.04      0.03          CAMERON2  78 DPWA    K-P TO K*N       12/79
R7   E  THE SIGN HERE IS CHANGED TO BE IN ACCORD WITH THE BARYON-FIRST      12/79
R7   E  CONVENTION.  THE UPPER LIMIT ON THE G3 WAVE IS 0.03.               12/79

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                    REFERENCES FOR LAMBDA(2100)

WOHL     66 PRL 17 107         C G WOHL, F T SOLMITZ, M L STEVENSON  (LRL)IJP
TRIPP    67 NP B3 10           + LEITH, +      (LRL+SLAC+  CERN+HEID+SACL)
BURGUN   68 NP B8 447          +MEYER,PAULI, +                (SACL+CDEF+RHEL)
DAUM     68 NP B7 19           +ERNE, LAGNAUX, SENS, STEUER, UDO     (CERN)JP
MULLER   69 THESIS,UCRL 19372 R A MULLER                                (LRL)

BERTHON1 70 NP B24 417         +VRANA, BUTTERWORTH, +     (CDEF+RHEL+SACL)IJP
GALTIERI 70 DUKE CONF 173      A BARBARO-GALTIERI                     (LRL)IJP
LITCHFIE 71 NP  B30 125        LITCHFIELD,...+LESQUOY,+   (RHEL+CDEF+SACL)IJP
BRANDSTE 72 NP B39 13          BRANDSTETTER+...+TALLINI   (RHEL+CDEF+SACL)IJP
KANE     72 PR D5 1583         D F KANE                               (LBL)IJP
RADER    73 NC 16A 178         +BARLOUTAUD,+    (SACL+HEID+CERN+RHEL+CDEF)
KANE     74  LBL-2452          D F KANE                               (LBL)IJP

HEMINGWA 75 NP B91 12          HEMINGWAY,EADES,HARMSEN+   (CERN+HEID+MPIM)IJP
NAKKASYA 75 NP B93 85          A NAKKASYAN                           (CERN)IJP

BACCARI  77 NC 41A 96          +POULARD,REVEL,TALLINI+          (SACL+CDEF)IJP
DECLAIS  77  CERN 77-16        +DUCHON,LOUVEL,PATRY,SEGUINOT+  (CAEN+CERN)IJP
RLIC     77 NP B119 362        GOPAL,ROSS,VAN HORN,MCPHERSON+  (LOIC+RHEL)IJP
BELLEFON 78 NC 42A 403         +BERTHON,BILLOIR,BRUNET+         (CDEF+SACL)IJP
CAMERON2 78 NP B146 327        +FRANEK,GOPAL,KALMUS,MCPHERSON,+(RHEL+LOIC)IJP
GOPAL    80  TORONTO CONF 159 G P GOPAL                                (RHEL)IJP

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2100 MEV REGION – PRODUCTION AND σ_{TOTAL} EXP'TS

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                    25  LAMBDA(2100, JP=    ) I=0    PRODUCTION EXPERIMENTS

                    SEE THE NOTE TO THE G07 LAMBDA(2100), IN FRONT OF THIS
                    ENTRY.  HERE WE LIST ONLY PARAMETERS OF PEAKS IN CROSS
                    SECTIONS AND INVARIANT-MASS DISTRIBUTIONS.  THE CROSS-
   SECTION PEAKS ARE AT LEAST DOMINANTLY ASSOCIATED WITH THE LAMBDA(2100),
   BUT MAY CONTAIN A SMALL CONTRIBUTION FROM THE SUGGESTED BUT NOT ESTAB-
   LISHED OTHER RESONANCES IN THIS REGION.

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                    25  LAMBDA(2100) MASS (MEV) (PROD. EXP.)

M         (2097.0)    (6.0)          BOCK      65 HBC     PBAR P 5.7 GEV/C  7/66
M          2100.0     (7.0)          BUGG      68 CNTR    K-P, D TOTAL      6/68
M          2121.0     (5.0)          BRICMAN   70 CNTR  0 TOTAL AND CH EX   6/70
M          2107.0    (10.0)          COOL      70 CNTR    K-P, D TOTAL     10/70
M         (2135.0)   (20.0)          LU        70 CNTR  0 GAMMA P TO K+ Y*  1/71

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                    25  LAMBDA(2100) WIDTH (MEV) (PROD. EXP.)

W           (24.0)   (14.0)   (24.0)  BOCK      65 HBC     INTO KBAR N (PI)  7/66
W           140.0    (15.0)          BUGG      68 CNTR                      6/68
W           147.0    (15.0)          BRICMAN   70 CNTR  0 TOTAL AND CH EX   6/70
W           185.0                    COOL      70 CNTR    K-P, D TOTAL     10/70
W           (40.0)                   LU        70 CNTR  0 GAMMA P TO K+ Y*  1/71

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                    25  LAMBDA(2100) PARTIAL DECAY MODES (PROD. EXP.)

                                                        DECAY MASSES
P1     LAMBDA(2100) INTO N KBAR                        938+ 494
P2     LAMBDA(2100) INTO N KBAR PI                     938+ 498+ 140
P3     LAMBDA(2100) INTO LAMBDA ETA                   1116+ 549
P4     LAMBDA(2100) INTO LAMBDA OMEGA                 1116+ 783

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For notation, see key at front of Listings.

Baryons

Λ(2100), Λ(2110), Λ(2325), Λ(2350)

25 LAMBDA(2100) BRANCHING RATIOS (PROD. EXP.)

R1		**LAMBDA(2100) INTO (N KBAR)/TOTAL**					**(P1)**	
R1		THESE VALUES OF ELASTICITIES ASSUME J=7/2 --						
R1		0.305		BUGG	68	CNTR		6/68
R1		0.24	(0.02)	BRICMAN	70	CNTR	0 TOTAL AND CH EX	6/70
R1		0.4		COOL	70	CNTR	K-P, D TOTAL	10/70
R2		**LAMBDA(2100) INTO (N KBAR PI)/TOTAL**					**(P2)**	
R2		SEEN		BOCK	65	HBC		
R3		**LAMBDA(2100) FROM N KBAR TO LAMBDA ETA**					**SQRT(P1*P3)**	
R3		(0.09) OR LESS		FLATTE 2	67	HBC	0 K-P TO LAM ETA	6/68
R4		**LAMBDA(2100) INTO (LAMBDA OMEGA)/TOTAL**					**(P4)**	
R4		(0.1) OR LESS		FLATTE 1	67	HBC	0 K-P TO LAM OMEGA	8/67

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REFERENCES FOR LAMBDA(2100) (PROD. EXP.)

BOCK 65 PL 17 166 +COOPER,FRENCH,KINSON, + (CERN+SACL)
COOL 66 PRL 16 1228 +GIACOMELLI,KYCIA,LEONTIC,LI,LUNDBY,+ (BNL) I
SUPERSEDED BY COOL 70.
FLATTE 1 67 PR 155 1517 S M FLATTE (LRL)
FLATTE 2 67 PR 163 1441 S M FLATTE, C G WOHL (LRL)
BUGG 68 PR 168 1466 +GILMORE,KNIGHT, + (RHEL+BIRM+CAVE) I

BRICMAN 70 PL 31B 152 +FERRO LUZZI, PERREAU,+ (CERN+CAEN+SACL)
COOL 70 PR D1 1887 +GIACOMELLI, KYCIA, LEONTIC, LI, + (BNL) I
LU 70 PR D2 1846 +GREENBERG, HUGHES, MINEHART, MORI,+ (YALE)

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Λ(2110) F''_{05} Status: ***

35 LAMBDA(2110, JP=5/2+) I=0 F''05

FOR RESULTS PUBLISHED BEFORE 1974 (THEY ARE NOW OBSOLETE), SEE OUR 1982 EDITION (PHYSICS LETTERS 111B). ALL THE REFERENCES HAVE BEEN RETAINED.

THIS RESONANCE IS IN THE BARYON TABLE, BUT THE EVIDENCE FOR IT COULD BE IMPROVED.

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35 LAMBDA(2110) MASS (MEV)

M		2112.0	7.0	KANE	74	DPWA	K-P TO PI SIG	12/81
M	A	(2103.0)		NAKKASYA	75	DPWA	0 K-P TO LAM. OMG.	1/76
M	A	FOUND IN ONE OF TWO BEST SOLUTIONS.						1/76
M		(2137.0)		BACCARI	77	DPWA	0 K-P TO LAM. OMG.	1/78
M		2140.0	(20.0)	BELLEFON	77	DPWA	0 K- P TO SIG PI	11/77
M		2100.0	(50.0)	RLIC	77	DPWA	KBAR N MULTICHNL	1/76
M		2106.0	(50.0)	BELLEFON	78	DPWA	0 KBAR N TO KBAR N	1/78
M		2125.0	(25.0)	CAMERON2	78	DPWA	K-P TO K*(892) N	12/79
M		2092.0	(25.0)	GOPAL	80	DPWA	KBAR N ELASTIC	12/81

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35 LAMBDA(2110) WIDTH (MEV)

W		190.0	(30.0)	KANE	74	DPWA	K-P TO PI SIG	12/81
W	A	(391.0)		NAKKASYA	75	DPWA	0 K-P TO LAM. OMG.	1/76
W		(132.0)		BACCARI	77	DPWA	0 K-P TO LAM. OMG.	1/78
W		140.0	(20.0)	BELLEFON	77	DPWA	0 K- P TO SIG PI	11/77
W		200.0	(50.0)	RLIC	77	DPWA	KBAR N MULTICHNL	1/76
W		251.0	(50.0)	BELLEFON	78	DPWA	0 KBAR N TO KBAR N	1/78
W		160.0	(30.0)	CAMERON2	78	DPWA	K-P TO K*(892) N	12/79
W		245.0	(25.0)	GOPAL	80	DPWA	KBAR N ELASTIC	12/81

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35 LAMBDA(2110) PARTIAL DECAY MODES

		DECAY MASSES
P1	LAMBDA(2110) INTO N KBAR	938+ 494
P2	LAMBDA(2110) INTO SIGMA PI	1189+ 140
P3	LAMBDA(2110) INTO LAMBDA OMEGA	1116+ 783
P4	LAMBDA(2110) INTO SIGMA(1385) PI, P-WAVE	1385+ 140
P5	LAMBDA(2110) INTO N K*(892), F1 WAVE	940+ 892

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35 LAMBDA(2110) BRANCHING RATIOS

R1		**LAMBDA(2110) FROM N KBAR TO SIGMA PI**					**SQRT(P1*P2)**	
R1		+0.20	(0.03)	KANE	74	DPWA	K-P TO PI SIG	12/81
R1		+0.14	(0.01)	BELLEFON	77	DPWA	0 K- P TO SIG PI	1/76
R1		(+0.10)	(0.03)	RLIC	77	DPWA	KBAR N MULTICHNL	1/76
R2		**LAMBDA(2110) INTO (N KBAR)/TOTAL**					**(P1)**	
R2	B	(0.07)	(0.03)	RLIC	77	DPWA	KBAR N MULTICHNL	1/76
R2	B	(N KBAR)/TOTAL FROM RLIC 77 IS SUPERSEDED BY GOPAL 80.						
R2	C	0.27	(0.06)	BELLEFON	78	DPWA	0 KBAR N TO KBAR N	1/78
R2	C	THE PUBLISHED ERROR OF 0.6 WAS A MISPRINT.						12/79
R2		0.07	(0.03)	GOPAL	80	DPWA	KBAR N ELASTIC	12/81
R3		**LAMBDA(2110) FROM N KBAR TO LAMBDA OMEGA**					**SQRT(P1*P3)**	
R3	A	(0.112)		NAKKASYA	75	DPWA	0 K-P TO LAM. OMG.	1/76
R3		LESS THAN 0.05		BACCARI	77	DPWA	0 K-P TO LAM. OMG.	1/78
R4		**LAMBDA(2110) FROM N KBAR TO SIGMA(1385) PI P-WAVE**					**SQRT(P1*P4)**	
R4	D	+0.071	0.025	CAMERON	78	DPWA	0 K-P TO S(1385)PI	1/78
R4	D	CAMERON 78 UPPER LIMIT ON F-WAVE DECAY IS 0.03. THE SIGN HERE IS						12/79
R4	D	CHANGED TO BE IN ACCORD WITH THE BARYON-FIRST CONVENTION.						12/79
R5		**LAMBDA(2110) FROM N KBAR TO N K*(892), F1 WAVE**					**SQRT(P1*P5)**	
R5	E	-0.17	0.04	CAMERON2	78	DPWA	K-P TO K*N	12/79
R5	E	THE SIGN HERE IS CHANGED TO BE IN ACCORD WITH THE BARYON-FIRST						12/79
R5	E	CONVENTION. UPPER LIMITS ON THE P3 AND F3 WAVES ARE EACH 0.03.						12/79

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REFERENCES FOR LAMBDA(2110)

BERTHON1 70 NP B24 417 +VRANA,BUTTERWORTH,+ (CDEF+RHEL+SACL)IJP
LITCHFIE 71 NP B30 125 LITCHFIELD,...+LESQUOY,+.. (RHEL+CDEF+SACL)IJP
KANE 72 PR D5 1583 D F KANE (LBL)IJP
KANE 74 LBL-2452 D F KANE (LBL)IJP
NAKKASYA 75 NP B93 85 A NAKKASYAN (CERN)IJP
BACCARI 77 NC 41A 96 +POULARD,REVEL,TALLINI+ (SACL+CDEF)IJP
BELLEFON 77 NC 37A 175 DE BELLEFON,BERTHON,BILLOIR+ (CDEF+SACL)IJP
RLIC 77 NP B119 362 GOPAL,ROSS,VAN HORN,MCPHERSON+ (LOIC+RHEL)IJP

BELLEFON 78 NC 42A 403 +BERTHON,BILLOIR,BRUNET+ (CDEF+SACL)IJP
CAMERON 78 NP B143 189 +FRANEK,GOPAL,BACON,BUTTERWORTH+(RHEL+LOIC)IJP
CAMERON2 78 NP B146 327 +FRANEK,GOPAL,KALMUS,MCPHERSON,+(RHEL+LOIC)IJP
GOPAL 80 TORONTO CONF 159 G P GOPAL (RHEL)IJP

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Λ(2325) D''_{03} Status: *

→ **112 LAMBDA(2325, JP=3/2-) I=0 D''03**

BACCARI 77 FIND THIS STATE WITH JP EITHER 3/2- OR 3/2+ IN A DPWA OF K- P TO LAMBDA OMEGA FROM 2070 TO 2436 MEV. A SUBSEQUENT SEMI-ENERGY-INDEPENDENT PWA FROM THRESHOLD TO 2436 MEV SELECTS 3/2-. BELLEFON 78 (SAME GROUP) ALSO SEE THIS STATE IN A DPWA OF K- P ELASTIC AND CHARGE-EXCHANGE DATA IN THE SAME ENERGY RANGE, AND FIND JP=3/2- OR 3/2+. THEY AGAIN PREFER JP=3/2-, BUT ONLY ON THE BASIS OF MODEL DEPENDENT CONSIDERATIONS.

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112 LAMBDA(2325) MASS (MEV)

M	2327.0	20.0	BACCARI	77	DPWA	0 K-P TO LAM. OMG.	1/78
M	2342.0	30.0	BELLEFON	78	DPWA	0 KBAR N TO KBAR N	1/78

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112 LAMBDA(2325) WIDTH (MEV)

W	160.0	40.0	BACCARI	77	IPWA	0 K-P TO LAM. OMG.	1/78
W	177.0	40.0	BELLEFON	78	DPWA	0 KBAR N TO KBAR N	1/78

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112 LAMBDA(2325) PARTIAL DECAY MODES

		DECAY MASSES
P1	LAMBDA(2325) INTO N KBAR	938+ 494
P2	LAMBDA(2325) INTO LAMBDA OMEGA	1116+ 783

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112 LAMBDA(2325) BRANCHING RATIOS

R1		**LAMBDA(2325) FROM N KBAR TO LAMBDA OMEGA**					**SQRT(P1*P2)**	
R1	3	0.06	0.02	BACCARI	77	IPWA	0 DS33-WAVE	1/78
R1	3	0.05	0.02	BACCARI	77	DPWA	0 DD13-WAVE	1/78
R1	3	0.08	0.03	BACCARI	77	DPWA	0 DD33-WAVE	1/78
R1	3	NOTE THAT THE 3 ENTRIES FOR BACCARI77 ARE FOR 3 DIFFERENT WAVES.						1/78
R2		**LAMBDA(2325) INTO (N KBAR)/TOTAL**					**(P1)**	
R2		0.19	0.06	BELLEFON	78	DPWA	0 KBAR N TO KBAR N	1/78

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REFERENCES FOR LAMBDA(2325)

BACCARI 77 NC 41A 96 +POULARD,REVEL,TALLINI+ (SACL+CDEF)IJP
BELLEFON 78 NC 42A 403 +BERTHON,BILLOIR,BRUNET+ (CDEF+SACL)IJP

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Λ(2350) BUMPS Status: ***

42 LAMBDA(2350, JP=) I=0 PRODUCTION EXPERIMENTS

DAUM 68 FAVORS JP=7/2- OR 9/2+. BRICMAN 70 FAVORS 9/2+. LASINSKI 71 SUGGESTS THREE STATES IN THIS REGION USING A POMERON + RESONANCES MODEL. THERE ARE NOW ALSO THREE FORMATION EXPERIMENTS FROM THE COLLEGE DE FRANCE-SACLAY GROUP WHICH WE INCLUDE HERE, BELEFON 77, BACCARI 77, AND BELLEFON 78, WHICH FIND 9/2+ IN DPWAS OF KBAR N TO SIGMA PI, LAMBDA OMEGA, AND KBAR N.

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42 LAMBDA(2350) MASS (MEV) (PROD. EXP.)

M	2340.0	(7.0)	BUGG	68	CNTR	K-P, D TOTAL	6/68
M	2358.0	(6.0)	BRICMAN	70	CNTR	0 TOTAL AND CH EX	6/70
M	2344.0	(15.0)	COOL	70	CNTR	K-P, D TOTAL	10/70
M	(2360.0)	(20.0)	LU	70	CNTR	0 GAMMA P TO K+ Y*	1/71
M	(2372.0)		BACCARI	77	DPWA	0 K-P TO LAM. OMG.	1/78
M	2365.0	20.0	BELLEFON	77	DPWA	0 K- P TO SIG PI	11/77
M	2370.0	50.0	BELLEFON	78	DPWA	0 KBAR N TO KBAR N	1/78

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42 LAMBDA(2350) WIDTH (MEV) (PROD. EXP.)

W	140.0	(20.0)	BUGG	68	CNTR	K-P, D TOTAL	6/68
W	324.0	(30.0)	BRICMAN	70	CNTR	0 TOTAL AND CH EX	6/70
W	(190.0)		COOL	70	CNTR	K-P, D TOTAL	10/70
W	(55.0)		LU	70	CNTR	0 GAMMA P TO K+ Y*	1/71
W	(257.0)		BACCARI	77	DPWA	0 K-P TO LAM. OMG.	1/78
W	110.0	20.0	BELLEFON	77	DPWA	0 K- P TO SIG PI	11/77
W	204.0	50.0	BELLEFON	78	DPWA	0 KBAR N TO KBAR N	1/78

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42 LAMBDA(2350) PARTIAL DECAY MODES (PROD. EXP.)

		DECAY MASSES
P1	LAMBDA(2350) INTO N KBAR	938+ 494
P2	LAMBDA(2350) INTO SIGMA PI	1189+ 140
P3	LAMBDA(2350) INTO LAMBDA OMEGA	1116+ 783

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42 LAMBDA(2350) BRANCHING RATIOS (PROD. EXP.)

R1	**LAMBDA(2350) INTO (N KBAR)/TOTAL**					**(P1)**	
R1	0.12	0.04	BELLEFON	78	DPWA	0 KBAR N TO KBAR N	1/78

Baryons

Data Card Listings

Λ(2350), Λ(2585), Σ^+, Σ^-, Σ^0, Σ(1385)

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R2     LAMBDA(2350) FROM N KBAR TO SIGMA PI                  SQRT(P1*P2)
R2          -0.11      0.02         BELLEFON  77 DPWA  0 K- P TO SIG PI    11/77

R3     LAMBDA(2350) FROM N KBAR TO LAMBDA OMEGA              SQRT(P1*P3)
R3          LESS THAN 0.05          BACCARI   77 DPWA  0 K-P TO LAM. OMG.  1/78

R4     LAMBDA(2350) INTO (N KBAR)/TOTAL                     (J+1/2)*(P1)
R4        J IS NOT DETERMINED IN THESE EXPTS.  THE FOLLOWING IS (J+1/2)*P1
R4          (0.57)                  BUGG      68 CNTR   K-P, D TOTAL      3/78
R4           1.1       0.25         BRICMAN   70 CNTR  0 TOTAL AND CH EX  3/78
R4          (1.0)                   COOL      70 CNTR   K-P, D TOTAL      3/78

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                              REFERENCES FOR LAMBDA(2350) (PROD. EXP.)

BUGG      68 PR 168 1466       +GILMORE,KNIGHT, +          (RHEL+BIRM+CAVE) I
DAUM      68 NP B7 19          +ERNE, LAGNAUX, SENS, STEUER, UDO    (CERN)JP
BRICMAN   70 PL 31B 152        +FERRO LUZZI, PERREAU,+    (CERN+CAEN+SACL)
COOL      70 PR D1 1887        +GIACOMELLI, KYCIA, LEONTIC, LI, +    (BNL) I
LU        70 PR D2 1846        +GREENBERG, HUGHES, MINEHART, MORI,+ (YALE)

BACCARI  77 NC 41A 96          +POULARD,REVEL,TALLINI+          (SACL+CDEF)IJP
BELLEFON 77 NC 37A 175         DE BELLEFON,BERTHON,BILLOIR+     (CDEF+SACL)IJP
BELLEFON 78 NC 42A 403         +BERTHON,BILLOIR,BRUNET+         (CDEF+SACL)IJP

                               PAPERS NOT REFERRED TO IN DATA CARDS
COOL      66 PRL 16 1228       +GIACOMELLI,KYCIA,LEONTIC,LI,LUNDBY,+ (BNL) I
   SUPERSEDED BY COOL 70.
LASINSKI 71 NP  B29  125       T A LASINSKI                           (EFI)IJP
BELLEFO2 75 NC 28A 289         DE BELLEFON,BERTHON,BILLOIR+    (CDEF+SACL)
   PRESENTLY LISTED UNDER SIGMA(2250), BUT ISOSPIN UNDETERMINED.

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Λ(2585) BUMPS   Status: **

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→           7  LAMBDA(2585, JP=    ) I=0    PRODUCTION EXPERIMENTS

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                7  LAMBDA(2585) MASS (MEV) (PROD. EXP.)

M         2585.0     45.0          ABRAMS    70 CNTR   K-P, D TOTAL      10/70
M        (2530.0)   (25.0)         LU        70 CNTR  0 GAMMA P TO K+ Y*  1/71

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                7  LAMBDA(2585) WIDTH (MEV) (PROD. EXP.)

W         (300.0)                  ABRAMS    70 CNTR   K-P, D TOTAL      10/70
W         (150.0)                  LU        70 CNTR  0 GAMMA P TO K+ Y*  1/71

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                7  LAMBDA(2585) PARTIAL DECAY MODES (PROD. EXP.)

                                                          DECAY MASSES
P1     LAMBDA(2585) INTO N KBAR                          938+ 494

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                7  LAMBDA(2585) BRANCHING RATIOS (PROD. EXP.)

R1     LAMBDA(2585) INTO (N KBAR)/TOTAL                   (P1)
R1        J IS NOT KNOWN.  THE FOLLOWING IS (J+1/2)*P1.
R1          (1.0)                  ABRAMS    70 CNTR   K-P, D TOTAL      10/70
R1  C       (0.12)   (0.12)        BRICMAN   70 CNTR   TOTAL AND CH EX   10/70
R1  C    RESONANCE AT END OF REGION ANALYZED -- NO CLEAR SIGNAL.

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                        REFERENCES FOR LAMBDA(2585) (PROD. EXP.)

COOL      66 PRL 16 1228       +GIACOMELLI,KYCIA,LEONTIC,LUNDBY +     (BNL)I
   SUPERSEDED BY ABRAMS 70.
ABRAMS    70 PR 1D 1917        +COOL, GIACOMELLI, KYCIA, LEONTIC, +  (BNL) I
BRICMAN   70 PL 31B 152        +FERRO LUZZI, PERREAU,+    (CERN+CAEN+SACL)
LU        70 PR D2 1846        +GREENBERG, HUGHES, MINEHART, MORI,+ (YALE)
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S=−1 I=1 HYPERON STATES (Σ)

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Σ^+

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                19  SIGMA+(1189, JP=1/2+) I=1

                SEE STABLE PARTICLE DATA CARD LISTINGS

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Σ^-

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                20  SIGMA-(1197, JP=1/2+) I=1

                SEE STABLE PARTICLE DATA CARD LISTINGS

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Σ^0

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                21  SIGMA0(1193, JP=1/2+) I=1

                SEE STABLE PARTICLE DATA CARD LISTINGS

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Σ(1385) P'_{13} Status: ****

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                43  SIGMA(1385, JP=3/2+) I=1        P'13

                SERIOUS INCOMPATIBILITIES EXIST BETWEEN DIFFERENT
                MEASUREMENTS OF THE SIGMA(1385) MASS AND WIDTH. THESE
                INCOMPATIBILITIES ARE AT LEAST PARTIALLY ACCOUNTED FOR
                BY SOME EXPERIMENTS QUOTING UNREALISTICALLY SMALL
ERRORS. WE CONSISTENTLY INCREASE UNREALISTIC ERRORS BEFORE AVERAGING
(SEE THE TYPED NOTE ON K*(892)).

IN THE LISTINGS BELOW WE ATTEMPT TO OBTAIN THE BEST VALUES FOR THE
SEPARATE CHARGE STATE MASSES AND WIDTHS. THUS WE DO NOT USE RESULTS
QUOTED FOR MIXED CHARGES.

WE NO LONGER USE EVERY PUBLISHED VALUE, BUT AVERAGE ONLY THE MOST
SIGNIFICANT DETERMINATIONS. NEITHER DO WE AVERAGE RESULTS FROM
INCLUSIVE EXPERIMENTS WITH LARGE BACKGROUNDS OR RESULTS WHICH ARE NOT
ACCOMPANIED BY AT LEAST A DISCUSSION ON EXPERIMENTAL RESOLUTION.
NEVERTHELESS SYSTEMATIC DIFFERENCES BETWEEN EXPERIMENTS REMAIN (SEE
THE IDEOGRAMS INSERTED IN THE DATA CARD LISTINGS BELOW). THESE
DIFFERENCES COULD ARISE FROM INTERFERENCE EFFECTS THAT CHANGE WITH
PRODUCTION MECHANISM AND/OR BEAM MOMENTUM. THEY CAN ALSO BE ACCOUNTED
FOR IN PART BY DIFFERENCES IN THE PARAMETRIZATIONS EMPLOYED (SEE
BORENSTEIN 74 FOR A DISCUSSION ON THIS POINT). THUS BORENSTEIN 74 USE A
BREIT-WIGNER WITH ENERGY INDEPENDENT WIDTH, SINCE A P-WAVE WAS FOUND
TO GIVE UNSATISFACTORY FITS. CAMERON 78 USE THE SAME FORM.
ON THE OTHER HAND HOLMGRAN 77 OBTAIN A GOOD FIT TO THEIR LAMBDA PI MASS
SPECTRUM WITH A P-WAVE BREIT-WIGNER, BUT INCLUDE THE PARTIAL WIDTH FOR
THE SIGMA PI DECAY MODE IN THE PARAMETRIZATION.

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                43  SIGMA(1385) MASS (MEV)

M        141(1384.0)                ALSTON    60 HBC  +- K-P 1.15 GEV/C
M           (1385.0)                BERGE     61 HBC  +- K-P .4-.85 GEV/C
M         38(1384.0)                MARTIN    61 HBC  +0 K20 P .98 GEV/C
M           (1392.0)     (7.0)      COLLEY    62 HLBC -0 PI- PRP 2. GEV/C
M           (1389.0)     (3.0)      BALTAY    65 HBC  +- PBAR P 3.7 GEV/C  7/66
M           (1392.0)    (10.0)      MUSGRAVE  65 HBC  +-0PBAR P 3-4 GEV/C  7/66
M        200(1384.8)     (2.0)      ATHERTON  71 HBC  +- LAM PI+ + C.C.   11/77
M        190(1380.0)     (5.0)      AMMANN    73 DBC  +- K-N 4.5GEV/C     11/77
M        200(1386.0)                ATHERTO1  75 HBC  +-0PBAR P 5.7 GEV/C  1/76
M        242(1394.0)     (5.0)      DIONISI   78 HBC  +- K-P TO Y* K KBAR  3/79
M    I    1K(1383.0)     (1.0)      BANERJEE  79 HBC  +- LAM PI+ + C.C.    1/80
M    I   500(1388.0)     (2.0)      BANERJEE  79 HBC  +- LAM PI- + C.C.    1/80
M    I    FROM FIT TO INCLUSIVE LAMBDA PI + C.C. SPECTRA

M0       106(1381.0)     (4.0)      CURTIS    63 OSPK  0 PI-P 1.5 GEV/C
M0 E     240 1385.1       2.5       THOMAS    73 HBC   0 PI-P TO PIOKOLM  11/77
M0 E      ERROR ENLARGED BY US TO GAMMA/SQRT(N). SEE TYPED NOTE ON K* MASS.
M0 2    3100 1380.0       2.0       BORENSTE  74 HBC   0 K-P TO(1385)+PIS 11/77
M0 2      FROM FIT TO LAM PIO MASS SPECTRUM (IN LAM PI+ PI- PIO EVENTS) WITH
M0 2      WO FIXED AT 34 MEV.
M0   F   500(1389.0)     (3.0)      BAUBILLIE 79 HBC   0 K-P AT 8.25 GEV   1/80
M0   F    FROM FIT TO INCLUSIVE LAMBDA PIO SPECTRUM WITH WIDTH FIXED AT
M0   F    40 MEV.
M0             . . . . . . . . . . .
M0   AVG       1382.0      2.5      AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.6)

M+ E     154(1376.0)     (3.9)      ELY       61 HLBC +  K-P 1.11 GEV/C   11/77
M+       170(1375.0)     (3.9)      COOPER    64 HBC  +  K-P 1.45 GEV/C   11/77
M+       859 1381.0       1.6       HUWE      64 HBC  +  K-P 1.22 GEV/C
M+       750 1382.0       1.0       ARMENTERO 65 HBC  +  K-P .9-1.2 GEV/C
M+ E     250(1384.3)     (1.9)      SMITH     65 HBC  +  K-P 1.8 GEV/C    11/77
M+ E     250(1382.6)     (2.1)      SMITH     65 HBC  +  K-P 1.95 GEV/C   11/77
M+ E      62(1383.0)     (8.0)      BIRMINGHA 66 HBC  +  K-P 3.5 GEV/C    11/77
M+       135(1378.0)     (5.0)      LONDON    66 HBC  +  K-P 2.24 GEV/C   11/77
M+      1260 1384.4       1.0       SIEGEL    67 HBC  +  K-P AT 2.1 GEV/C 10/69
M+        46(1390.0)     (6.0)      AGUILAR   70 HBC  +  K-P 4 GEV/SIG.PI 11/77
M+       400 1382.0       2.0       AGUILAR   72 HBC  +  K-P TO LAM+PIS   10/74
M+      2300 1383.5       0.85      HABIBI    73 HBC  +  K-P TO 2PI LAM    9/73
M+   R 3740(1382.0)      (1.0)      BERTHON   74 HBC  +  K-P 1263-1843MEV 10/74
M+   R    ERRORS STATISTICAL ONLY. RESOLUTION NOT UNFOLDED.
M+      6846 1381.0       1.0       BORENSTE  74 HBC  +  K-P TO(1385)+PIS 10/74
M+   I      (1380.0)     (2.0)      BARDADIN  75 HBC  +  K- P 14.3 GEV/C  11/77
M+ HI    22K(1385.0)     (3.0)      BARREIRO  77 HBC  +  K-P AT 4.2 GEV   11/77
M+ H      INCLUDES DATA OF HOLMGREN 77
M+      2594 1385.0       1.0       HOLMGREN  77 HBC  +  K-P AT 4.2 GEV   11/77
M+      6900 1381.9       0.3       CAMERON   78 HBC  +  K-P 0.96-1.36GEV 11/77
M+   I    7K(1381.0)     (2.0)      BAUBILLIE 79 HBC  +  K-P AT 8.25 GEV   1/80
M+        2K(1391.0)     (2.0)      CAUTIS    79 HYBR +  PI+/K-P 11.5 GEV  1/80
M+   I   100(1390.0)     (2.0)      SUGAHARA  79 HBC  +  PI-P AT 6 GEV/C   1/80
M+       600(1385.1)     (1.2)      BAKER     80 HYBR +  PI+P 7 GEV/C      2/82
M+       750(1383.2)     (1.0)      BAKER     80 HYBR +  K-P 7 GEV/C       2/82
M+
M+   I    FROM FIT TO INCLUSIVE LAMBDA PI SPECTRUM
M+ E      ERROR ENLARGED BY US TO GAMMA/SQRT(N). SEE TYPED NOTE ON K* MASS.
M+             . . . . . . . . . . .
M+   AVG       1382.29     0.39     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.6)
                          (SEE IDEOGRAM BELOW)
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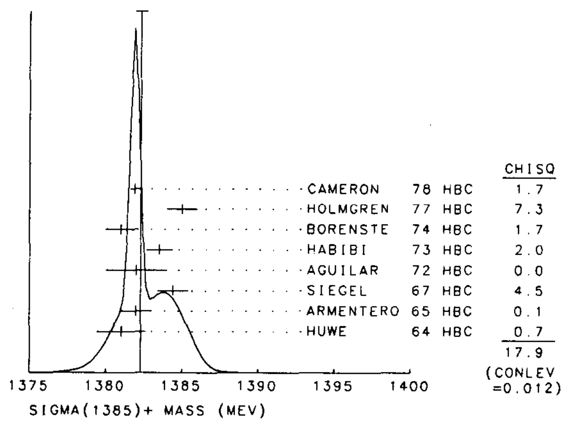
WEIGHTED AVERAGE = 1382.29 ± 0.39
ERROR SCALED BY 1.6



For notation, see key at front of Listings.

Baryons
Σ(1385)

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M-        93(1382.0)     (3.0)          DAHL       61 DBC  -  K-D 0.45 GEV/C    11/77
M- E     224(1376.0)     (4.4)          ELY        61 HLBC -  K-P 1.11 GEV/C    11/77
M-       200(1392.0)     (6.2)          COOPER     64 HBC  -  K-P 1.45 GEV/C    11/77
M- E   1086 1385.3        1.9           HUWE       64 HBC  -  K-P 1.15-1.30GEV  11/77
M-     1380 1384.0        1.0           ARMENTERO  65 HBC  -  K-P .9-1.2 GEV/C
M- E     120(1391.5)     (2.6)          SMITH      65 HBC  -  K-P 1.8 GEV/C     11/77
M- E      58(1399.8)     (2.2)          SMITH      65 HBC  -  K-P 1.95 GEV/C    11/77
M-        15(1389.0)     (9.0)          LONDON     66 HBC  -  K-P AT 2.24 GEV   11/77
M-       370 1390.7       2.0           SIEGEL     67 HBC  -  K-P AT 2.1 GEV/C  10/69
M-      1900 1390.7       1.2           HABIBI     73 HBC  -  K-P TO 2PI LAM     9/73
M- E     630 1387.1       1.9           THOMAS     73 HBC  -  PI-P TO PI-K+LM   11/77
M-  R 3060(1389.0)       (1.0)          BERTHON    74 HBC  -  K-P 1263-1843MEV  10/74
M-  R   ERRORS STATISTICAL ONLY. RESOLUTION NOT UNFOLDED.
M-     2303 1383.0        2.0           BORENSTE   74 HBC  -  K-P TO(1385)+PIS  10/74
M-  I       (1383.0)     (2.0)          BARDADIN   75 HBC  -  K- P 14.3 GEV/C   11/77
M- HI  12K(1387.0)       (3.0)          BARREIRO   77 HBC  -  K-P AT 4.2 GEV    11/77
M- H    INCLUDES DATA OF HOLMGREN 77
M-       193 1391.0       3.0           HOLMGREN   77 HBC  -  K-P AT 4.2 GEV    11/77
M-      9720 1387.6       0.3           CAMERON    78 HBC  -  K-P 0.96-1.36GEV  11/77
M-  I 4.5K(1383.0)       (1.0)          BAUBILLIE  79 HBC  -  K-P AT 8.25 GEV    1/80
M-  I  150(1380.0)       (6.0)          SUGAHARA   79 HBC  -  PI-P AT 6 GEV/C    1/80
M-
M-  I   FROM FIT TO INCLUSIVE LAMBDA PI SPECTRUM
M- E    ERROR ENLARGED BY US TO GAMMA/SQRT(N). SEE TYPED NOTE ON K* MASS.
M-
M-  AVG      1387.44      0.58   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 2.2)
                                 (SEE IDEOGRAM BELOW)
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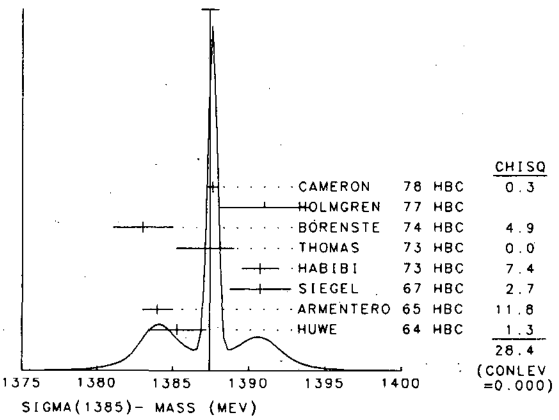

43 (SIGMA(1385)-)-(SIGMA(1385)+) MASS DIFFERENCE (MEV)

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D-+ R      (0.0)      (4.2)          ELY        61 HLBC +- K-P 1.11 GEV/C      8/66
D-+ R     (17.0)      (7.0)          COOPER     64 HBC  +- K-P 1.45 GEV/C     10/69
D-+ R      (4.3)      (2.2)          HUWE       64 HBC  +- K-P 1.22 GEV/C      8/66
D-+ R      (2.0)      (1.5)          ARMENTERO  65 HBC  +- K-P .9-1.2 GEV/C    8/66
D-+ R      (7.2)      (2.1)          SMITH      65 HBC  +- K-P 1.8 GEV/C       9/66
D-+ R     (17.2)      (2.0)          SMITH      65 HBC  +- K-P 1.95 GEV/C      9/66
D-+ R     (11.0)      (9.0)          LONDON     66 HBC  +- K-P 2.24 GEV/C      8/66
D-+        9.0         6.0           LONDON     66 HBC  +- LAMBDA 3 PI EVTS    7/66
D-+ R      (6.3)      (2.0)          SIEGEL     67 HBC  +- K-P AT 2.1 GEV/C   10/69
D-+ R      (7.2)      (1.4)          HABIBI     73 HBC  +- K-P TO 2PI LAM      9/73
D-+ R    BETWEEN -2 AND +6 CL=.95    BORENSTE   74 HBC  +- K-P TO(1385)+PIS   11/77
D-+
D-+ R   REDUNDANT WITH DATA IN MASS LISTINGS
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43 (SIGMA(1385)0) - (SIGMA(1385)+) MASS DIFFER. (MEV)

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DO+ R    BETWEEN -4 AND +4 CL=.95    BORENSTE   74 HBC  +0 K-P TO(1385)+PIS 11/77
DO+ R   REDUNDANT WITH DATA IN MASS LISTINGS
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43 (SIGMA(1385)-) - (SIGMA(1385)0) MASS DIFFER. (MEV)

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D-0 R      (2.0)      (2.4)          THOMAS     73 HBC  -0 PI-P TO PI-K+LM  11/77
D-0 R   REDUNDANT WITH DATA IN MASS LISTINGS
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43 SIGMA(1385) WIDTH (MEV)

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W       141  (64.0)                  ALSTON     60 HBC  +- K-P 1.15 GEV/C
W            (40.0)                  BERGE      61 HBC  +- K-P .4-.85 GEV/C
W        38  (20.0)  OR LESS         MARTIN     61 HBC  +0 K20 P .98 GEV/C
W            (80.0)    (10.0)        COLLEY     62 HLBC -0 PI- PRP 2. GEV/C
W            (26.0)     (5.0)        BALTAY     65 HBC  +- PBAR P 3.7 GEV/C  7/66
W            (38.0)     (9.0)        MUSGRAVE   65 HBC  +-0PBAR P 3-4 GEV/C  7/66
W     T 200  (20.0)     (4.0)        ATHERTON   71 HBC  +- LAM PI+ + C.C.   11/77
W     T  FIT B.W. + PHASE SPACE BCKGRD
W     R 200  (35.0)     (5.0)        ATHERTON   71 HBC  +- LAM PI+ + C.C.   11/77
W     R  FIT B.W. AND NO BCKGRD
W       190  (61.0)    (10.0)        AMMANN     73 DBC  +- K-N 4.5GEV/C     11/77
W       200  (89.0)    (23.0)        ATHERTON1  75 HBC  +-0PBAR P 5.7 GEV/C 11/77
W   D        (20.0)    (10.0)        ALSTON     78 DPWA -0 KBAR N ONLY       1/78
W   D    WITH MASS FIXED AT 1385 MEV.  FROM RESULTS OF PARTIAL WAVE ANALYSIS 1/78
W   D    OF KBAR N SYSTEM EXTRAPOLATED BELOW THRESHOLD.                      1/78
W       242  (53.0)    (14.0)        DIONISI    78 HBC  +- K-P TO Y* K KBAR  3/79
W   I    1K  (35.0)     (2.0)        BANERJEE   79 HBC  +- LAM PI+ + C.C.    1/80
W   I   500  (36.0)     (4.0)        BANERJEE   79 HBC  +- LAM PI- + C.C.    1/80
W   I    FROM FIT TO INCLUSIVE LAMBDA PI + C.C. SPECTRA

WO      106  (30.0)     (9.0)        CURTIS     63 OSPK  0 PI-P 1.5 GEV/C
WO E    240   39.3     10.2          THOMAS     73 HBC   0 PI-P TO PIOKOLM  11/77
WO E     ERROR ENLARGED BY US TO 4*GAMMA/SQRT(N). SEE TYPED NOTE ON K* MASS.
WO   C 3100  (53.0)     (8.0)        BORENSTE   74 HBC   0 K-P TO(1385)+PIS 11/77
WO   C 3100 CONSISTENT WITH WO=W+=W-  BORENSTE  74 HBC   0 K-P TO(1385)+PIS 11/77
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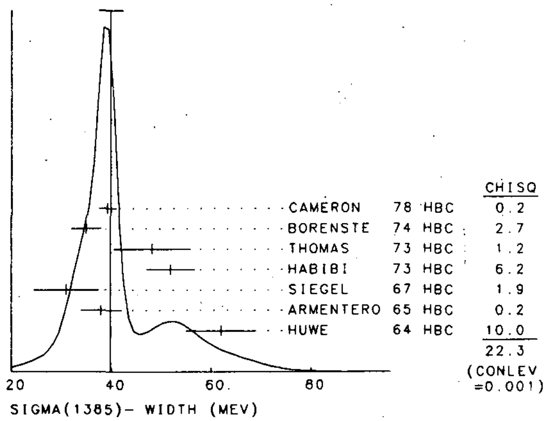
W+ E    154  (48.0)    (16.0)        ELY        61 HLBC +  K-P 1.11 GEV/C    11/77
W+ E    170  (51.0)    (16.0)        COOPER     64 HBC  +  K-P 1.45 GEV/C    11/77
W+ E    859   46.5       6.4         HUWE       64 HBC  +  K-P 1.15-1.30GEV  11/77
W+ E    750   32.0       4.7         ARMENTERO  65 HBC  +  K-P .95-1.20 GEV  11/77
W+ E    250  (30.3)     (7.5)        SMITH      65 HBC  +  K-P 1.8 GEV/C     11/77
W+ E    250  (33.1)     (8.3)        SMITH      65 HBC  +  K-P 1.95 GEV/C    11/77
W+ E     62  (25.0)    (32.0)        BIRMINGHA  66 HBC  +  K-P 3.5 GEV/C     11/77
W+ E   1260   36.0       4.0         SIEGEL     67 HBC  +  K-P AT 2.1 GEV/C  11/77
W+ E     46  (33.0)    (20.0)        AGUILAR    70 HBC  +  K-P 4 GEV/SIG.PI  11/77
W+      400   32.5       6.0         AGUILAR    72 HBC  +  K-P TO LAM+PIS    10/74
W+ E   2300   38.3       3.2         HABIBI     73 HBC  +  K-P TO 2PI LAM    11/77
W+   R 3740  (48.0)     (3.0)        BERTHON    74 HBC  +  K-P 1263-1843MEV  10/74
W+   R   ERRORS STATISTICAL ONLY. RESOLUTION NOT UNFOLDED.
W+ 1   6846   34.0       1.6         BORENSTE   74 HBC  +  K-P TO(1385)+PIS  11/77
W+ 1   RESULTS FROM LAM PI+ PI- AND LAM PI+ PI- PIO COMBINED BY US.
W+  I        (40.0)     (3.2)        BARDADIN   75 HBC  +  K- P 14.3 GEV/C   11/77
W+ HI   22K  (43.0)     (5.0)        BARREIRO   77 HBC  +  K-P AT 4.2 GEV    11/77
W+ H     INCLUDES DATA OF HOLMGREN 77
W+     2594   34.0       2.0         HOLMGREN   77 HBC  +  K-P AT 4.2 GEV    11/77
W+     6900   35.5       1.9         CAMERON    78 HBC  +  K-P 0.96-1.36GEV  11/77
W+  I    7K  (37.0)     (2.0)        BAUBILLIE  79 HBC  +  K-P AT 8.25 GEV    1/80
W+       2K  (30.0)     (4.0)        CAUTIS     79 HYBR +  PI+/K-P 11.5 GEV   1/80
W+  I   100  (30.0)     (6.0)        SUGAHARA   79 HBC  +  PI-P AT 6 GEV/C    1/80
W+      600  (40.0)     (3.0)        BAKER      80 HYBR +  PI+P 7 GEV/C       2/82
W+      750  (37.0)     (2.0)        BAKER      80 HYBR +  K-P 7 GEV/C        2/82
W+
W+  I    FROM FIT TO INCLUSIVE LAMBDA PI SPECTRUM
W+ E     ERROR ENLARGED BY US TO 4*GAMMA/SQRT(N). SEE TYPED NOTE ON K* MASS.
W+
W+  AVG       34.96      0.92    AVERAGE

W-           (40.0)                  DAHL       61 DBC  -  K-D 0.45 GEV/C
W- E    224  (66.0)    (18.0)        ELY        61 HLBC -  K-P 1.11 GEV/C    11/77
W- E    200  (88.0)    (24.0)        COOPER     64 HBC  -  K-P 1.45 GEV/C    11/77
W-     1086   62.0       7.0         HUWE       64 HBC  -  K-P 1.15-1.30GEV
W- E   1382   38.0       4.1         ARMENTERO  65 HBC  -  K-P .95-1.20 GEV  11/77
W- E    120  (29.2)    (10.6)        SMITH      65 HBC  -  K-P 1.80 GEV/C    11/77
W- E     58  (17.1)     (8.9)        SMITH      65 HBC  -  K-P 1.95 GEV/C    11/77
W- E    370   31.0       6.5         SIEGEL     67 HBC  -  K-P AT 2.1 GEV/C  11/77
W- E   1900   51.9       4.8         HABIBI     73 HBC  -  K-P TO 2PI LAM    11/77
W- E    630   48.2       7.7         THOMAS     73 HBC  -  PI-P TO PI-KOLM   11/77
W-   R 3060  (40.0)     (3.0)        BERTHON    74 HBC  -  K-P 1263-1843MEV  10/74
W-   R   ERRORS STATISTICAL ONLY. RESOLUTION NOT UNFOLDED.
W- 1   2303   35.0       3.0         BORENSTE   74 HBC  -  K-P TO(1385)+PIS  11/77
W- 1   RESULTS FROM LAM PI+ PI- AND LAM PI+ PI- PIO COMBINED BY US.
W-  I        (47.0)     (6.0)        BARDADIN   75 HBC  -  K- P 14.3 GEV/C   11/77
W- HI   12K  (45.0)     (5.0)        BARREIRO   77 HBC  -  K-P AT 4.2 GEV    11/77
W- H     INCLUDES DATA OF HOLMGREN 77
W-      193  (35.0)    (10.0)        HOLMGREN   77 HBC  -  K-P AT 4.2 GEV    11/77
W-     9720   39.2       1.7         CAMERON    78 HBC  -  K-P 0.96-1.36GEV  11/77
W-  I  4.5K  (44.0)     (4.0)        BAUBILLIE  79 HBC  -  K-P AT 8.25 GEV    1/80
W-  I   150  (58.0)     (4.0)        SUGAHARA   79 HBC  -  PI-P AT 6 GEV/C    1/80
W-
W-  I    FROM FIT TO INCLUSIVE LAMBDA PI SPECTRUM
W- E     ERROR ENLARGED BY US TO 4*GAMMA/SQRT(N). SEE TYPED NOTE ON K* MASS.
W-
W-  AVG       39.9       2.4     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.9)
                                 (SEE IDEOGRAM BELOW)
```



43 SIGMA(1385) REAL PART OF POLE POSITION

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RE+       1379.0      1.0            LICHTENB  74     +  EXTRAP HABIBI73    4/75
RE-       1383.0      1.0            LICHTENB  74     -  EXTRAP HABIBI73    4/75
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43 SIGMA(1385) IMAGINARY PART OF POLE POSITION

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IM+         17.5      1.5            LICHTENB  74     +  EXTRAP HABIBI73    4/75
IM-         22.5      1.5            LICHTENB  74     -  EXTRAP HABIBI73    4/75
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43 SIGMA(1385) PARTIAL DECAY MODES

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                                                      DECAY MASSES
P1     SIGMA(1385) INTO LAMBDA PI                    1116+ 140
P2     SIGMA(1385) INTO SIGMA PI                     1189+ 140
P3     SIGMA(1385) INTO LAMBDA GAMMA                 1116+   0
P4     SIGMA(1385) INTO N KBAR                        938+ 494
P5     SIGMA(1385) INTO SIGMA GAMMA                  1197+   0
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Baryons

Σ(1385), Σ(1480), Σ(1560)

Data Card Listings

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                    43  SIGMA(1385) BRANCHING RATIOS

R1      SIGMA(1385) INTO (SIGMA PI)/(LAMBDA PI)           (P2)/(P1)
R1            (0.04)   (0.04)          BASTIEN    61 HBC  +-
R1            (0.04) OR LESS           ALSTON     62 HBC  +-0K-P 1.15 GEV/C
R1             0.09     0.04           HUWE       64 HBC  +- K-P 1.2-1.7 GEV
R1             0.163    0.041          ARMENTERO  65 HBC  +- K-P .95-1.20 GEV  7/66
R1             0.08     0.06           LONDON     66 HBC  +  K-P 2.24 GEV/C    7/66
R1             0.13     0.04           PAN        69 HBC  +  PI+ P - K Y PI   12/72
R1             0.13     0.04           COLLEY     71 DBC  -0 K-N 1.5 GEV PROD 10/71
R1             0.16     0.07           AGUILAR    72 HBC  +  K-P 3.9,4.6 GEV  10/74
R1             0.18     0.04           MAST2      73 MPWA +- K-P - 2PI SIG/LM  9/73
R1             0.10     0.05           THOMAS     73 HBC  -  PI-P TO PI K Y    9/73
R1             0.16     0.03           BERTHON    74 HBC  +  K-P 1263-1843MEV 11/77
R1             0.11     0.02           BERTHON    74 HBC  -  K-P 1263-1843MEV 11/77
R1             0.21     0.05           BORENSTE   74 HBC  +  K-P TO(1385)+PIS 10/74
R1             0.20     0.06           DIONISI    78 HBC  +- K-P TO Y* K KBAR  3/79
R1           . . . . . . . . .
R1  AVG        0.135    0.011   AVERAGE

R2      SIGMA(1385) INTO (LAMBDA GAMMA)/TOTAL             (P3)
R2        1    (0.17)   (0.17)          MEISNER    72 HBC  0  1 EVENT ONLY      1/73

R3      SIGMA(1385) FROM N KBAR TO LAMBDA PI              SQRT(P1*P4)
R3 C          +0.586    0.319           DEVENISH   74       0 FIXED T DISP REL  4/75
R3 C     EXTRAPOLATION OF PARAMETRIZED AMPLITUDE BELOW THRESHOLD                 4/75

R4      SIGMA(1385) INTO (LAMBDA GAMMA)/(LAMBDA PI)       (P3)/(P1)
R4            (0.06) OR LESS  CL=.90   COLAS      75 HLBC  0 K-P 575-970 MEV   1/76

R5      SIGMA(1385) INTO (SIGMA GAMMA)/(LAMBDA PI)        (P5)/(P1)
R5            (0.05) OR LESS  CL=.90   COLAS      75 HLBC  0 K-P 575-970 MEV   1/76

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REFERENCES FOR SIGMA(1385)


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ALSTON   60 PRL 5 520          +ALVAREZ,EBERHARD,GOOD,GRAZIANO, +     (LRL) I
BASTIEN  61 PRL 6 702          P BASTIEN,M FERRO-LUZZI,A H ROSENFELD (LRL)
BERGE    61 PRL 6 557          +BASTIEN,DAHL,FERRO-LUZZI,KIRZ, +      (LRL)
DAHL     61 PRL 6 142          +HORWITZ,MILLER,MURRAY,WHITE           (LRL)
ELY      61 PRL 7 461          +FUNG,GIDAL,PAN,POWELL,WHITE           (LRL) J
MARTIN   61 PRL 6 283          +LEIPUNER,CHINOWSKY,SHIVELY, +   (BNL+YALE)

ALSTON   62 CERN CONF 311      +ALVAREZ,FERRO-LUZZI,ROSENFELD, +      (LRL)
COLLEY   62 PR 128 1930        +GELFAND,NAUENBERG, +            (COLU+RUTG) JP
CURTIS   63 PR 132 1771        +COFFIN,MEYER,TERWILLIGER             (MICH) J
COOPER   64 PL 8 365           +FILTHUTH,FRIDMAN,MALAMUD, +    (CERN+AMST)
HUWE     64 UCRL-11291 THESIS D O HUWE                               (LRL) JP
    ALSO 69 PR 180 1824        D O HUWE                               (LRL)

ARMENTER 65 PL 19 75           ARMENTEROS, +                 (CERN+HEID+SACL)
BALTAY   65 PR 140 B1027       +SANDWEISS,TAFT,CULWICK,KOPP, +  (YALE+BNL)
MUSGRAVE 65 NC 35 735          +PETMEZAS,+       (BIRM+CERN+EPOL+LOIC+SACL)
SMITH    65 THESIS (UCLA)      L T SMITH                             (UCLA)

BIRMINGH 66 PR 152 1148                        (BIRM+GLAS+LOIC+OXF+RHEL)
LONDON   66 PR 143 1034        +RAU,SAMIOS,YAMAMOTO,GOLDBERG,+  (BNL+SYRA) J
SIEGEL   67 UCRL 18041 THESIS D M SIEGEL                             (LRL)
PAN      69 PRL 23 808         +FORMAN                             (PENN) I
AGUILAR  70 PRL 25 58          +BARNES, BASSANO, CHUNG, EISNER,+(BNL+SYRA)
ATHERTON 71 NP B29 477         +CELNIKIER,CLAYTON,FRENCH,FRISK,+    (CERN)
COLLEY   71 NP  B31 61         +COX,EASTWOOD,FRY+..  (BIRM+EDIN+GLAS+LOIC)

AGUILAR  72 PR D6 29           AGUILAR-BENITEZ,CHUNG,EISNER,SAMIOS   (BNL)
MEISNER  72 NC 12A 62          G MEISNER                (U NC GREENSBORO+LBL)
AMMANN   73 PRD 7 1345         +CARMONY,GARFINKEL,GUTAY,+      (PURD+IUPU)
MAST2    73 PRD 7 3212         +BANGERTER,ALSTON-GARNJOST,+          (LBL)IJP
    ALSO 73 PRD 7 5            MAST,BANGERTER,ALSTON-GARNJOST,+      (LBL)IJP
HABIBI   73 NEVIS 199(THESIS) M HABIBI                              (COLU)
    ALSO 73 PURD73, PG. 387    BALTAY,BRIDGEWATER,COOPER,+     (COLU+BING)
THOMAS   73 NP B56 15          THOMAS,ENGLER,FISK,KRAEMER            (CARN) JP

BERTHON  74 NC 21A 146         BERTHON,TRISTRAM,+    (CDEF+RHEL+SACL+STRB)
BORENSTE 74 PR D9 3006         BORENSTEIN,KALBFLEISCH,STRAND,+  (BNL+MICH)
DEVENISH 74 NP B81 330         DEVENISH,FROGGATT,MARTIN   (DESY+NORD+LOUC)
LICHTENB 74 PRD 10 3865        D B LICHTENBERG                       (IND)
    ALSO 74 PRIV. COMM.        D B LICHTENBERG                       (IND)

ATHERTO1 75 NC 25A 1           ATHERTON,BAR-NIR,FRENCH               (CERN)
BARDADIN 75 NP B98 418         BARDADIN-OTWINOWSKA+       (SACL+EPOL+RHEL)
COLAS    75 NP B91 253         COLAS,FARWELL,FERRER,SIX              (ORSA)

BARREIRO 77 NP B126 319        +BERGE,GANGULI,BLOKZIJL+   (CERN+AMST+NIJM)
HOLMGREN 77 NP B119 261        +AGUILAR-BENITEZ,KLUYVER+  (CERN+AMST+NIJM)
ALSTON   78 PR D18 182         ALSTON-GARNJOST,KENNEY+     (LBL+MHCO+CERN)
CAMERON  78 NP B143 189        +FRANEK,GOPAL,BACON,BUTTERWORTH+(RHEL+LOIC)
DIONISI  78 PL 78B 154         +ARMENTEROS,DIAZ       (CERN+AMST+NIJM+OXF)

BANERJEE 79 ZPHY C3 1          +GANGULI,MALHOTRA,RAGHAVAN,SUDHAKAR  (TIFR)
BAUBILLI 79 NP B148 18         BAUBILLIER+       (BIRM+CERN+GLAS+MSU+LPNP)
CAUTIS   79 NP B156 507        +BALLAM,BOUCHEZ,CARROLL,CHADWICK+    (SLAC)
SUGAHARA 79 NP B156 237        +OCHIAI,FUKUI,COOPER+       (KEK+OSKC+KINK)
BAKER    80 NP B166 207        +CHIMA,DORNAN,GIBBS,HALL,MILLER+     (LOIC)

                               PAPERS NOT REFERRED TO IN DATA CARDS

MALAMUD  64 PL 10 145          E MALAMUD, P E SCHLEIN           (CERN+UCLA) JP
SHAFER   64 PR 134 B1372       J B SHAFER, D O HUWE                  (LRL) JP
HUNGERBU 74 PRD 10 2051        HUNGERBUHLER,MAJKA,+   (YALE+FNAL+BNL+PITT)
WALTER   79 ZPHY C3 89         +BECKER+    (BERL+AACH+CERN+SERP+SACL+VIEN)
AGUILAR  80 ZPHY C6 109        AGUILAR-BENITEZ+       (MADR+STOH+CERN+CDEF)
BALAND   80 ZPHY C3 187        +POIRET+(MONS+SERP+SACL+ALMA-ATA+MOSU+BELG)
BIAGI    81 ZPHY C9 305        +      (BRIS+CAMB+GEVA+HEID+LAUS+LOQM+RHEL)
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Σ(1480) BUMPS Status: *

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                    23  SIGMA(1480, JP=    ) I=1     PRODUCTION EXPERIMENTS

                    PEAKS ARE SEEN IN LAMBDA PI AND SIGMA PI SPECTRA IN
                    THE REACTION PI+P TO K+ PI Y AT 1.7 GEV/C.  ALSO THE
                    Y POLARIZATION OSCILLATES IN THE SAME REGION.

    SEE MILLER 70 FOR A DISCUSSION OF THIS STATE.  HE SUGGESTS A POSSIBLE
    ALTERNATE EXPLANATION IN TERMS OF A REFLECTION OF N(1675) DECAY
    TO LAMBDA K. HOWEVER, SUCH AN EXPLANATION FOR THE K+ SIGMA+ PIO
    CHANNEL SEEMS UNLIKELY (SEE PAN 70) IN TERMS OF KNOWN DELTA(1650)
    DECAY INTO SIGMA K. IN ADDITION SUCH REFLECTIONS WOULD ALSO HAVE
    TO ACCOUNT FOR THE OSCILLATION OF THE Y POLARIZATION IN THE 1480
    MASS REGION.

    HANSON 71, WITH FEWER DATA THAN PAN 70, CAN NEITHER CONFIRM NOR
    DENY THE EXISTENCE OF THIS STATE.  MAST 75 SEES NO STRUCTURE IN THIS
    MASS REGION IN K- P TO LAMBDA PIO.

    ENGELEN 81 PERFORM A MULTI-CHANNEL ANALYSIS OF K-P --> K0 PI- P AT
    4.2 GEV/C.  THEY OBSERVE A 3.5 STD. DEV. SIGNAL AT 1480 MEV IN P KOBAR
    WHICH CANNOT BE EXPLAINED AS A REFLECTION OF ANY COMPETING CHANNEL.

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                    23  SIGMA(1480) MASS (MEV) (PROD. EXP.)

M          1479.0     10.0            PAN        70 HBC  +  PI+P TO K PI LAM  3/71
M          1465.0     15.0            PAN        70 HBC  +  PI+P TO K PI SIG  3/71
M          1485.0     10.0            CLINE      73 MPWA    K- D TO LM PI- P  9/73
M      120(1480.0)                    ENGELEN    80 HBC  +  K-P TO K0 PI- P   2/82

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                    23  SIGMA(1480) WIDTH (MEV) (PROD. EXP.)

W            31.0     15.0            PAN        70 HBC  +  PI+P TO K PI LAM  3/71
W            30.0     20.0            PAN        70 HBC  +  PI+P TO K PI SIG  3/71
W            40.0     20.0            CLINE      73 MPWA    K- D TO LM PI- P  9/73
W      120   80.0     20.0            ENGELEN    80 HBC  +  K-P TO K0 PI- P   2/82

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                    23  SIGMA(1480) PARTIAL DECAY MODES (PROD. EXP.)

                                                          DECAY MASSES
P1      SIGMA(1480) INTO N KBAR                          938+ 494
P2      SIGMA(1480) INTO LAMBDA PI                      1116+ 140
P3      SIGMA(1480) INTO SIGMA PI                       1189+ 140

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                    23  SIGMA(1480) BRANCHING RATIOS (PROD. EXP.)

R1      SIGMA(1480) INTO (SIGMA PI)/(LAMBDA PI)           (P3)/(P2)
R1           0.82     0.51            PAN        70 HBC  +                   3/71

R2      SIGMA(1480) INTO (PROTON KOBAR)/(LAMBDA PI)       (P1)/(P2)
R2           0.36     0.25            PAN        70 HBC  +                   3/71

R3      SIGMA(1480) INTO (N KBAR)/TOTAL                   (P1)
R3          SMALL                     CLINE      73 MPWA    K- D TO LM PI- P  9/73

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REFERENCES FOR SIGMA(1480) (PROD. EXP.)


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PAN      70 PR D2, 49          +FORMAN,KO,HAGOPIAN,SELOVE            (PENN)
CLINE    73 LNC 6 205          CLINE,LAUMANN,MAPP                    (WISC)IJP
ENGELEN  80 NP B167 61         +HEINEN,KITTEL,METZGER+(NIJM+AMST+CERN+OXF)

                               PAPERS NOT REFERRED TO IN DATA CARDS

YU-LI PA 69 PRL 23 806         YU-LI PAN, F L FORMAN                 (PENN) I
YU-LI PA 69 PRL 23 808         YU-LI PAN, F L FORMAN                 (PENN) I
MILLER   70 DUKE 229           D H MILLER       (REVIEW TALK)        (PURD)
HANSON   71 PR D4 1296         +KALMUS,LOUIE                          (LBL) I
MAST     75 PRD 11 3078        +ALSTON-GARNJOST,BANGERTER+            (LBL)
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Σ(1560) BUMPS Status: **

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                    80  SIGMA(1560, JP=    ) I=1     PRODUCTION EXPERIMENTS

                    THIS ENTRY LISTS PEAKS REPORTED IN MASS SPECTRA AROUND
                    1560 MEV WITHOUT IMPLYING THAT THEY ARE NECESSARILY
                    RELATED.

                    DIONISI 78 OBSERVE A 6 STD. DEV. ENHANCEMENT AT 1553
                    MEV IN THE CHARGED (LAMBDA/SIGMA PI) MASS SPECTRA
                    FROM K-P --> LAMBDA/SIGMA PI K KBAR AT 4.2 GEV/C.
                    IN A CERN ISR EXPERIMENT, LOCKMAN 78 REPORT A NARROW
    6 STD. DEV. ENHANCEMENT AT 1572 MEV IN THE LAMBDA PI+/PI- SYSTEMS
    FROM THE REACTION PP --> LAMBDA PI+ PI- + ANYTHING AT C.M. ENERGIES
    OF 53 AND 62 GEV.

    THESE ENHANCEMENTS ARE UNLIKELY TO BE ASSOCIATED WITH THE SIGMA(1580)
    (WHICH HAS NOT BEEN CONFIRMED BY SEVERAL RECENT EXPERIMENTS - SEE
    THE DATA CARD LISTINGS BELOW).

    CARROLL 76 OBSERVE A BUMP AT 1550 MEV (AS WELL AS AT 1580 MEV) IN THE
    K-N I=1 TOTAL CROSS SECTION, BUT UNCERTAINTIES IN CROSS SECTION
    MEASUREMENTS OUTSIDE THE MASS RANGE OF THE EXPERIMENT PRECLUDE
    ESTIMATING ITS SIGNIFICANCE.

    SEE ALSO MEADOWS 80 FOR A REVIEW OF THIS STATE.

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                    80  SIGMA(1560) MASS (MEV) (PROD. EXP.)

M      121 1553.0      7.0            DIONISI    78 HBC  +- K-P TO Y* K KBAR  3/79
M       40 1572.0      4.0            LOCKMAN    78 SPEC +- PP TO L PI PI X  12/79

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                    80  SIGMA(1560) WIDTH (MEV) (PROD. EXP.)

W      121   79.0     30.0            DIONISI    78 HBC  +- K-P TO Y* K KBAR  3/79
W  C    40   15.0      6.0            LOCKMAN    78 SPEC +- PP TO L PI PI X  12/79
W  C    OBSERVED WIDTH CONSISTENT WITH EXPERIMENTAL RESOLUTION.

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                    80  SIGMA(1560) PARTIAL DECAY MODES (PROD. EXP.)

                                                          DECAY MASSES
P1      SIGMA(1560) INTO LAMBDA PI                      1116+ 140
P2      SIGMA(1560) INTO SIGMA PI                       1189+ 140

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                    80  SIGMA(1560) BRANCHING RATIOS (PROD. EXP.)

R1      SIGMA(1560) INTO SIGMA PI/(SIGMA PI + LAMBDA PI) (P2)/(P1+P2)
R1           0.35     0.12            DIONISI    78 HBC  +- K-P TO Y* K KBAR  3/79

R2      SIGMA(1560) INTO (LAMBDA PI)/TOTAL                (P1)
R2          SEEN                      LOCKMAN    78 SPEC +- PP TO L PI PI X  12/79

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For notation, see key at front of Listings.

Baryons

Σ(1560), Σ(1580), Σ(1620)

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                    REFERENCES FOR SIGMA(1560) (PROD. EXP.)

DIONISI  78 PL 78B 154        +ARMENTEROS,DIAZ+      (CERN+AMST+NIJM+OXF)I
LOCKMAN  78  CEN DPHPE 78-01  +MEYER,RANDER,POSTER,SCHLEIN+   (UCLA+SACL)

                    PAPERS NOT REFERRED TO IN DATA CARDS

CARROLL  76 PRL 37 806        +CHIANG,KYCIA,LI,MAZUR,MICHAEL+       (BNL)I
MEADOWS  80 TORONTO CONF. 283 B T MEADOWS                          (CINC)

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Σ(1580) D'_{13} Status: **

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                    00  SIGMA(1580, JP=3/2-) I=1       D'13

                    OBSERVED IN K- N I=1 TOTAL CS WITHOUT JP ASSIGNMENT AT
                    BNL(LI 73, CARROLL 73, CARROLL 76) AND IN PWA OF K- P
                    --> LAMBDA PI FOR CM ENERGIES=1560-1600 MEV BY
                    LITCHFIELD 74.  LITCHFIELD 74 FINDS JP=3/2-.  NOT SEEN
                    BY ENGLER 78 OR BY CAMERON 78 (WITH LARGER STATISTICS),
                    IN KLONG P TO PI+ LAMBDA AND PI+ SIGMA0.

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                    00  SIGMA(1580) MASS (MEV)

M  L       1582.0      4.0          LITCHFIEL 74 DPWA  0 K- P TO LAM PI    4/75
M    C     1583.0      4.0          CARROLL   76 DPWA    I=1 TOTAL CS      2/77

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                    00  SIGMA(1580) WIDTH (MEV)

W  L         11.0      4.0          LITCHFIEL 74 DPWA  0 K- P TO LAM PI    4/75
W    C      (15.0)                  CARROLL   76 DPWA    I=1 TOTAL CS      2/77

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                    00  SIGMA(1580) PARTIAL DECAY MODES

                                                          DECAY MASSES
P1      SIGMA(1580) INTO N KBAR                          938+ 494
P2      SIGMA(1580) INTO LAMBDA PI                      1116+ 140
P3      SIGMA(1580) INTO SIGMA PI                       1189+ 140

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                    00  SIGMA(1580) BRANCHING RATIOS

R1      SIGMA(1580) INTO (N KBAR)/TOTAL                 (P1)
R1 L         +0.03     0.01         LITCHFIEL 74 DPWA    KBAR N MULTICHNL  4/75
R1 L     MAIN EFFECT OBSERVED BY LITCHFIELD 74 IS IN PI LAMBDA FINAL STATE,  4/75
R1 L     KBAR N AND SIGMA PI COUPLINGS ALSO ESTIMATED FROM MULTICHANNEL FIT  4/75
R1 L     INCLUDING TOTAL CROSS SECTION DATA (LI 73).                         4/75
R1   C   TOTAL CROSS SECTION BUMP WITH (J+1/2)X=.06   SEEN BY CARROLL 76     2/77

R2      SIGMA(1580) FROM N KBAR TO LAMBDA PI            SQRT(P1*P2)
R2 L         +0.10     0.02         LITCHFIEL 74 DPWA  0 K- P TO LAM PI    4/75
R2          NOT SEEN                CAMERON   78 HBC  +  KL P TO PI+ LAM   1/78
R2          NOT SEEN                ENGLER    78  HBC +  KL P TO PI+ LAM   2/77

R3      SIGMA(1580) FROM N KBAR TO SIGMA PI             SQRT(P1*P3)
R3 L         +0.03     0.04         LITCHFIEL 74 DPWA    KBAR N MULTICHNL  4/75
R3          NOT SEEN                CAMERON   78 HBC  +  KL P TO PI+ SIGO  1/78
R3          NOT SEEN                ENGLER    78  HBC +  KL P TO PI+ SIGO  2/77

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                    REFERENCES FOR SIGMA(1580)

LITCHFIE 74 PL 51B 509        LITCHFIELD                          (CERN)IJP
CARROLL  76 PRL 37 806        +CHIANG,KYCIA,LI,MAZUR,MICHAEL+        (BNL)I
ENGLER   76 PL 63B 231        +KEYES,KRAEMER,SCHLERETH,TANAKA+ (CARN+ANL)I
CAMERON  78 NP B132 189       +CAPILUPPI+       (BGNA+EDIN+GLAS+PISA+RHEL)I
ENGLER   78 PR D18 3061       +KEYES,KRAEMER,TANAKA,CHO,+       (CARN+ANL)

                    PAPERS NOT REFERRED TO IN DATA CARDS

CARROLL  73 APS BRKLY MTG 208 CARROLL,CHIANG,KYCIA,LI,MAZUR,MICHAEL+(BNL)I
LI       73 PURDUE CONF. 283  LI                                   (BNL)I

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Σ(1620) S'_{11} Status: **

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                    32  SIGMA(1620, JP=1/2-) I=1       S'11

                    THE S11 STATE AT 1697 MEV REPORTED BY VANHORN 75 IS
                    INTERMEDIATE IN MASS BETWEEN THE SIGMA(1620) AND
                    SIGMA(1750).  WE TENTATIVELY LIST IT UNDER SIGMA(1750).
                    CARROLL 76 SEES TWO BUMPS IN THE I=1 TOTAL CROSS
                    SECTIONS NEAR THIS MASS.

   PRODUCTION EXPERIMENTS ARE LISTED SEPARATELY IN THE NEXT ENTRY.

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                    32  SIGMA(1620) MASS (MEV)

M          (1620.0)                 KIM       71 DPWA    K-MATRIX ANAL.    3/71
M           1630.0    (10.0)        LANGBEIN  72 IPWA    MULTICHANNEL     12/72
M    L      1608.0     5.0          CARROLL   76 DPWA    I=1 TOTAL CS      2/77
M    H      1633.0    10.0          CARROLL   76 DPWA    I=1 TOTAL CS      2/77
M   1       (1600.0)   (6.0)        MORRIS    78 DPWA -  K- N TO LAM PI-   3/79
M   1    AN EQUALLY GOOD FIT IS OBTAINED WITHOUT INCLUDING THIS RESONANCE.  3/79

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                    32  SIGMA(1620) WIDTH (MEV)

W           (40.0)                  KIM       71 DPWA    K-MATRIX ANAL.    3/71
W            65.0    (20.0)         LANGBEIN  72 IPWA    MULTICHANNEL     12/72
W    L      (15.0)                  CARROLL   76 DPWA    I=1 TOTAL CS      2/77
W    H      (10.0)                  CARROLL   76 DPWA    I=1 TOTAL CS      2/77
W   1       (87.0)    (19.0)        MORRIS    78 DPWA -  K- N TO LAM PI-   3/79

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                    32  SIGMA(1620) PARTIAL DECAY MODES

                                                          DECAY MASSES
P1      SIGMA(1620) INTO N KBAR                          938+ 494
P2      SIGMA(1620) INTO SIGMA PI                       1189+ 140
P3      SIGMA(1620) INTO LAMBDA PI                      1116+ 135

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                    32  SIGMA(1620) BRANCHING RATIOS

R1      SIGMA(1620) INTO (N KBAR)/TOTAL                 (P1)
R1           (0.05)                  KIM       71 DPWA    K-MATRIX ANAL.    3/71
R1 A          0.05  OR LESS          WONG      71 DPWA    K-+P--LAM+PI     10/71
R1            0.22    (0.02)         LANGBEIN  72 IPWA    MULTICHANNEL     12/72
R1   L  TOTAL CROSS SECTION BUMP WITH (J+1/2)X=.06   SEEN BY CARROLL 76     2/77
R1   H  TOTAL CROSS SECTION BUMP WITH (J+1/2)X=.04   SEEN BY CARROLL 76     2/77
R1 A    K-MATRIX FIT(NEGLECTS 3-BODY CHANNELS) REQUIRES NO RESONANCE      10/71

R2      SIGMA(1620) FROM N KBAR TO SIGMA PI             SQRT(P1*P2)
R2           (0.08)                  KIM       71 DPWA    K-MATRIX ANAL.    3/71
R2            0.40    (0.06)         LANGBEIN  72 IPWA    MULTICHANNEL     12/72
R2          NOT SEEN                 HEPP2     76 DPWA -0 K- NUC TO SIG PI  2/77

R3      SIGMA(1620) FROM N KBAR TO LAMBDA PI            SQRT(P1*P3)
R3           (0.15)                  KIM       71 DPWA    K-MATRIX ANAL.    3/71
R3          NOT SEEN                 BAILLON   75 IPWA    KBAR N TO LAM PI 11/75
R3  1        (0.12)    (0.02)        MORRIS    78 DPWA -  K- N TO LAM PI-   3/79

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                    REFERENCES FOR SIGMA(1620)

KIM       71 PRL 27 356        J K KIM                              (HARV)IJP
   ALSO   70 DUKE 161          J K KIM                              (HARV)IJP
WONG      71 NC 2A 353         N S WONG                             (YALE)IJP
LANGBEIN  72 NP B47 477        +WAGNER                              (MPIM)IJP

BAILLON   75 NP B94 39         P BAILLON, P J LITCHFIELD       (CERN+RHEL)IJP
CARROLL   76 PRL 37 806        +CHIANG,KYCIA,LI,MAZUR,MICHAEL+        (BNL)I
HEPP2     76 PL 65B 487        +BRAUN,GRIMM,STROBELE,THOL+(CERN+HEID+MPIM)IJP
MORRIS    78 PR D17 55         +ALBRIGHT,COLLERAINE,KIMEL,LANNUTTI   (FSU)IJP

                    PAPERS NOT REFERRED TO IN DATA CARDS

VANHORN   75 NP B87 145        A J VAN HORN                           (LBL)IJP
   ALSO   75 NP B87 157        A J VAN HORN                           (LBL)IJP

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1620 MEV REGION - PRODUCTION EXPERIMENTS

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                    78  SIGMA(1620, JP=    ) I=1     PRODUCTION EXPERIMENTS

                    FORMATION EXPERIMENTS ARE LISTED SEPARATELY IN THE
                    PREVIOUS ENTRY.

                    THIS RESONANCE NEEDS CONFIRMATION. THE RESULTS OF
                    CRENNELL 69 AT 3.9 GEV/C ARE NOT CONFIRMED BY THE SABRE
   COLLABORATION AT 3.0 GEV/C (SABRE 70).  HOWEVER IN AN EXPERIMENT AT
   4.5 GEV/C, AMMANN 70 SEE A PEAK AT 1642 MEV WHICH ON THE BASIS OF
   BRANCHING RATIOS THEY DO NOT ASSOCIATE WITH THE SIGMA(1670). SEE MILLER
   70 FOR A REVIEW OF THESE CONFLICTS.

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                    78  SIGMA(1620) MASS (MEV) (PROD. EXP.)

M   N     (1616.0)    (8.0)          CRENNELL  68 DBC  +- K-D 3.9 GEV/C   11/68
M   N    EVENTS OF CRENNELL 68 ARE IN THE LARGER SAMPLE OF CRENNELL 69.
M       20 1618.0      3.0          BLUMENFEL 69 HBC  +  KO LONG + PROTON  9/69
M          1619.0      8.0          CRENNELL  69 DBC  +- K-N TO LAM 3 PI   9/69
M          1642.0     12.0          AMMANN    70 DBC     K-N 4.5 GEV/C    9/73

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                    78  SIGMA(1620) WIDTH (MEV) (PROD. EXP.)

W   N       (66.0)   (16.0)          CRENNELL  68 DBC  +- SEE NOTE N ABOVE 11/68
W       20   30.0     10.0           BLUMENFEL 69 HBC  +                   9/69
W            72.0     22.0     15.0  CRENNELL  69 DBC  +-                  9/69
W            55.0     24.0           AMMANN    70 DBC     K-N 4.5 GEV/C    9/73

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                    78  SIGMA(1620) PARTIAL DECAY MODES (PROD. EXP.)

                                                          DECAY MASSES
P1      SIGMA(1620) INTO N KBAR                          938+ 494
P2      SIGMA(1620) INTO LAMBDA PI                      1116+ 140
P3      SIGMA(1620) INTO SIGMA(1385) PI                 1385+ 140
P4      SIGMA(1620) INTO LAMBDA PI PI                   1116+ 140+ 140
P5      SIGMA(1620) INTO SIGMA PI                       1189+ 140
P6      SIGMA(1620) INTO LAMBDA(1405) PI                1405+ 140

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                    78  SIGMA(1620) BRANCHING RATIOS (PROD. EXP.)

R1      SIGMA(1620) INTO (LAMBDA PI PI)/(LAMBDA PI)     (P4)/(P3)
R1       14   (2.5)  APPROX          BLUMENFEL 69 HBC  +

R2      SIGMA(1620) INTO (N KBAR)/(LAMBDA PI)           (P1)/(P2)
R2           (0.0)    (0.1)          CRENNELL  68 DBC  +
R2            0.4      0.4           AMMANN    70 DBC     K-P 4.5 GEV/C    6/70

R3      SIGMA(1620) INTO (LAMBDA PI)/TOTAL              (P2)
R3           LARGE                   CRENNELL  68 DBC  +-                 11/68

R4      SIGMA(1620) INTO (SIGMA(1385) PI)/(LAMBDA PI)   (P3)/(P2)
R4           (0.2)    (0.1)          CRENNELL  68 DBC  +-                 11/68
R4           (0.3)  OR LESS  CL=.95  AMMANN    70 DBC     K-P 4.5 GEV/C    6/70

R5      SIGMA(1620) INTO (SIGMA PI)/(LAMBDA PI)         (P5)/(P2)
R5          (1.1)(95 PC UPPER LIMIT) AMMANN     70 DBC     K-N 4.5 GEV/C    9/73

R6      SIGMA(1620) INTO (LAMBDA(1405) PI)/(LAMBDA PI)  (P6)/(P2)
R6            0.7      0.4           AMMANN    70 DBC     K-P 4.5 GEV/C    6/70

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Baryons

$\Sigma(1620)$, $\Sigma(1660)$, $\Sigma(1670)$


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                                REFERENCES FOR SIGMA(1620) (PROD. EXP.)

CRENNELL 68 PRL 21 648          +DELANEY, FLAMINIO, KARSHON, +   (BNL+CUNY) I
BLUMENFE 69 PL 29B 58           BLUMENFELD, KALBFLEISCH              (BNL) I
CRENNELL 69 LUND PAPER 183      +KARSHON, LAI, ONEIL, SCARR, +   (BNL+CUNY) I
    RESULTS ARE QUOTED IN LEVI SETTI 69.

AMMANN   70 PRL 24 327          + GARFINKEL, CARMONY, GUTAY,+    (PURD+IND)
    ALSO 73 PR D7 1345          AMMANN,CARMONY,GARFINKEL,       (PURD+IUPU)

                                PAPERS NOT REFERRED TO IN DATA CARDS

ARMENTER 68 NP B8 183           ARMENTEROS,BAILLON +        (CERN+HEID+SACL)
LEVISETT 69 LUND CONF           R LEVI SETTI    (RAPPORTEUR)          (EFI)
TRIPP    69 UCRL 19361          R D TRIPP                             (LRL)
ARMENTER 70 DUKE 123            ARMENTEROS,BAILLON +        (CERN+HEID+SACL)
MILLER   70 DUKE 229            D H MILLER   (REVIEW TALK)            (PURD)
SABRE    70 NP B16 201          SABRE COLLAB.    (SACL+AMST+BGNA+REHO+EPOL)
HUNGERBU 74 PR D10 2051         HUNGERBUHLER,MAJKA,+   (YALE+FNAL+BNL+PITT)

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$\Sigma(1660)$ P'_{11} Status: ***

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                    79  SIGMA(1660, JP=1/2+) I=1       P'11

                    FOR RESULTS PUBLISHED BEFORE 1974 (THEY ARE
                    NOW OBSOLETE), SEE OUR 1982 EDITION (PHYSICS LETTERS
                    111B).  ALL THE REFERENCES HAVE BEEN RETAINED.

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                    79  SIGMA(1660) MASS (MEV)

M          1670.0    (20.0)           KANE      74 DPWA    K-P TO PI SIG    12/81
M   A     (1660.0)   (30.0)           BAILLON   75 IPWA    KBAR N TO LAM PI 11/75
M   A  FROM SOLUTION 1 OF BAILLON 75, NOT PRESENT IN SOLUTION 2             11/75
M   B     (1671.0)    (2.0)           PONTE     75 DPWA  0 K- P TO LAM PI    1/76
M   B   FROM SOLUTION 2 OF PONTE 75, NOT PRESENT IN SOLUTION 1.              1/76
M          1668.0    (25.0)           VANHORN   75 DPWA  0 K- P TO LAM PIO  11/75
M    C     1565. OR 1597.             MARTIN    77 DPWA    KBAR N MULTICHNL 11/77
M    C  THE TWO ENTRIES FOR MARTIN 77 CORRESPOND TO EXTRACTION OF RESONANCE
M    C  PARAMETERS FROM THE T-MATRIX POLE AND FROM A B-W FIT, RESPECTIVELY.
M          1676.0    (15.0)           RLIC      77 DPWA    KBAR N MULTICHNL  1/76
M          1679.0    (10.0)           ALSTON    78 DPWA    KBAR N ELASTIC    1/78
M          1670.0    (10.0)           GOPAL     80 DPWA    KBAR N ELASTIC   12/81

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                    79  SIGMA(1660) WIDTH (MEV)

W           250.0   (110.0)           KANE      74 DPWA    K-P TO PI SIG    12/81
W   A       (80.0)   (40.0)           BAILLON   75 IPWA    KBAR N TO LAM PI 11/75
W   B       (81.0)   (10.0)           PONTE     75 DPWA  0 K- P TO LAM PI    1/76
W           230.0   (165.0)   (60.0)  VANHORN   75 DPWA  0 K- P TO LAM PIO  11/75
W    C      202. OR 217.              MARTIN    77 DPWA    KBAR N MULTICHNL 11/77
W           120.0    (20.0)           RLIC      77 DPWA    KBAR N MULTICHNL  1/76
W            38.0    (10.0)           ALSTON    78 DPWA    KBAR N ELASTIC    1/78
W           152.0    (20.0)           GOPAL     80 DPWA    KBAR N ELASTIC   12/81

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                    79  SIGMA(1660) PARTIAL DECAY MODES

                                                        DECAY MASSES
P1     SIGMA(1660) INTO N KBAR                        938+ 494
P2     SIGMA(1660) INTO SIGMA PI                     1189+ 140
P3     SIGMA(1660) INTO LAMBDA PI                    1116+ 140

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                    79  SIGMA(1660) BRANCHING RATIOS

R1     SIGMA(1660) FROM N KBAR TO SIGMA PI                SQRT(P1*P2)
R1          -0.11    (0.01)           KANE      74 DPWA    K-P TO PI SIG    12/81
R1        NOT SEEN                    HEPP2     76 DPWA -0 K- NUC TO SIG PI  2/77
R1   C      -0.34 OR -0.37            MARTIN    77 DPWA    KBAR N MULTICHNL 11/77
R1          -0.16    (0.03)           RLIC      77 DPWA    KBAR N MULTICHNL  1/76

R2     SIGMA(1660) INTO (N KBAR)/TOTAL                    (P1)
R2   C       0.27 OR  0.29            MARTIN    77 DPWA    KBAR N MULTICHNL 11/77
R2   D      LESS THAN 0.04            RLIC      77 DPWA    KBAR N MULTICHNL  1/76
R2   D  (N KBAR)/TOTAL FROM RLIC 77 IS SUPERSEDED BY GOPAL 80.
R2           0.10    (0.05)           ALSTON    78 DPWA    KBAR N ELASTIC    1/78
R2           0.12    (0.03)           GOPAL     80 DPWA    KBAR N ELASTIC   12/81

R3     SIGMA(1660) FROM N KBAR TO LAMBDA PI               SQRT(P1*P3)
R3   A      (-0.04)   (0.02)          BAILLON   75 IPWA    KBAR N TO LAM PI 11/75
R3   B      (+0.16)   (0.01)          PONTE     75 DPWA  0 K- P TO LAM PI    1/76
R3           0.12    (0.12)   (0.04)  VANHORN   75 DPWA  0 K- P TO LAM PIO  11/75
R3   C      -0.10 OR -0.11            MARTIN    77 DPWA    KBAR N MULTICHNL 11/77
R3          LESS THAN 0.04            RLIC      77 DPWA    KBAR N MULTICHNL  1/76

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                                REFERENCES FOR SIGMA(1660)

ARMENTER 70 DUKE 123            ARMENTEROS, BAILLON, +          (CERN+HEID)IJP
KIM      71 PRL 27 356          J K KIM                                (HARV)IJP
    ALSO 70 DUKE 161            J K KIM                                (HARV)IJP
HART     73 PURDUE CONF. 311    +RICE,BACASTOW,FUNG,+  (TENN+UCR+MASA+BUFF)IJP
LEA      73 NP B56 77           +MARTIN,MOORHOUSE+    (RHEL+LOUC+GLAS+AARH)IJP
KANE     74  LBL-2452           D F KANE                               (LBL)IJP

BAILLON  75 NP B94 39           P BAILLON, P J LITCHFIELD       (CERN+RHEL)IJP
PONTE    75 PRD 12 2597         +HERTZBACH,BUTTON-SHAFER+   (MASA+TENN+UCR)IJP
VANHORN  75 NP B87 145          A J VAN HORN                           (LBL)IJP
    ALSO 75 NP B87 157          A J VAN HORN                           (LBL)IJP

HEPP2    76 PL 65B 487          +BRAUN,GRIMM,STROBELE,THOL+(CERN+HEID+MPIM)IJP
MARTIN   77 NP B127 349         MARTIN,PIDCOCK,MOORHOUSE        (LOUC+GLAS)IJP
    ALSO 77 NP B126 266         MARTIN,PIDCOCK                         (LOUC)
    ALSO 77 NP B126 285         MARTIN,PIDCOCK                         (LOUC)IJP
RLIC     77 NP B119 362         GOPAL,ROSS,VAN HORN,MCPHERSON+  (LOIC+RHEL)IJP
ALSTON   78 PR D18 182          +KENNEY,POLLARD,ROSS+        (LBL+MTHO+CERN)IJP
    ALSO 77 PRL 38 1007         ALSTON-GARNJOST,KENNEY,+     (LBL+MTHO+CERN)IJP
GOPAL    80  TORONTO CONF 159 G P GOPAL                                (RHEL)IJP

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NOTE ON THE $\Sigma(1670)$

Production experiments: The measured $\Sigma\pi/\Sigma\pi\pi$ branching ratio for produced $\Sigma(1670)$'s is strongly dependent on momentum transfer. This was first discovered by EBERHARD 69, who suggested that there exist two Σ resonances with the same mass and quantum numbers: one with a large $\Sigma\pi\pi$ [mainly $\Lambda(1405)\pi$] decay mode produced peripherally, and the other with a large $\Sigma\pi$ decay mode produced at larger angles. These results were confirmed by AGUILAR-BENITEZ 70, ASPELL 74, ESTES 74, and TIMMERMANS 76. The most likely quantum numbers for both the $\Sigma\pi$ and the $\Lambda(1405)\pi$ states are D_{13}. There is also possibly a third Σ, the $\Sigma(1690)$ in the Listings, the main evidence for which is a large $\Lambda\pi/\Sigma\pi$ branching ratio. These topics have been reviewed by EBERHARD 73 and by MILLER 70.

Formation experiments: Two states are also observed near this mass in formation experiments. One of these, the D_{13} $\Sigma(1670)$, has the same quantum numbers as those observed in production and has a large $\Sigma\pi/\Sigma\pi\pi$ branching ratio. It may well be the $\Sigma(1670)$ produced at larger angles (see TIMMERMANS 76). The other state, the P_{11} $\Sigma(1660)$, has different quantum numbers from those seen in production, and its $\Sigma\pi/\Sigma\pi\pi$ branching ratio is unknown. Thus its relation to the produced $\Sigma(1670)$'s remains obscure.

$\Sigma(1670)$ D''_{13} Status: ****

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                    44  SIGMA(1670, JP=3/2-) I=1       D''13

                    FOR MOST RESULTS PUBLISHED BEFORE 1974 (THEY ARE
                    NOW OBSOLETE), SEE OUR 1982 EDITION (PHYSICS LETTERS
                    111B).  ALL THE REFERENCES HAVE BEEN RETAINED.

                    RESULTS FROM PRODUCTION EXPERIMENTS ARE LISTED
                    SEPARATELY IN THE NEXT ENTRY.

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                    44  SIGMA(1670) MASS (MEV)

M          1670.0     (2.0)           KANE      74 DPWA    K-P TO PI SIG    12/81
M          1685.0    (20.0)           BAILLON   75 IPWA    KBAR N TO LAM PI 11/75
M   A     (1671.0)    (3.0)           PONTE     75 DPWA  0 K- P TO LAM PI    1/76
M   A   FROM SOLUTION 1 OF PONTE 75.                                         1/76
M   B     (1655.0)    (2.0)           PONTE     75 DPWA  0 K- P TO LAM PI    1/76
M   B   FROM SOLUTION 2 OF PONTE 75.                                         1/76
M          1659.0    (12.0)    (5.0)  VANHORN   75 DPWA  0 K- P TO LAM PIO  11/75
M         (1650.0)                    BELLEFON  76 IPWA  0 K- P TO LAM PI    2/77
M          1670.0     (6.0)           HEPP2     76 DPWA -0 K- NUC TO SIG PI  2/77
M    C     1667. OR 1668.             MARTIN    77 DPWA    KBAR N MULTICHNL 11/77
M    C  THE TWO ENTRIES FOR MARTIN 77 CORRESPOND TO EXTRACTION OF RESONANCE
M    C  PARAMETERS FROM THE T-MATRIX POLE AND FROM A B-W FIT, RESPECTIVELY.
M          1670.0     (5.0)           RLIC      77 DPWA    KBAR N MULTICHNL  1/76
M          1679.0    (10.0)           ALSTON    78 DPWA    KBAR N ELASTIC    1/78
M          1682.0     (5.0)           GOPAL     80 DPWA    KBAR N ELASTIC   12/81

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                    44  SIGMA(1670) WIDTH (MEV)

W            79.0     (6.0)           KANE      74 DPWA    K-P TO PI SIG    12/81
W            85.0    (25.0)           BAILLON   75 IPWA    KBAR N TO LAM PI 11/75
W   A       (44.0)   (11.0)           PONTE     75 DPWA  0 K- P TO LAM PI    1/76
W   B       (76.0)    (5.0)           PONTE     75 DPWA  0 K- P TO LAM PI    1/76
W            32.0    (11.0)           VANHORN   75 DPWA  0 K- P TO LAM PIO  11/75
W           (80.0)                    BELLEFON  76 IPWA  0 K- P TO LAM PI    2/77
W            56.0     (3.0)           HEPP2     76 DPWA -0 K- NUC TO SIG PI  2/77
W    C      46. OR 46.                MARTIN    77 DPWA    KBAR N MULTICHNL 11/77
W            50.0     (5.0)           RLIC      77 DPWA    KBAR N MULTICHNL  1/76
W            56.0    (20.0)           ALSTON    78 DPWA    KBAR N ELASTIC    1/78
W            79.0    (10.0)           GOPAL     80 DPWA    KBAR N ELASTIC   12/81

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For notation, see key at front of Listings.

Baryons
Σ(1670)

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                    44  SIGMA(1670) PARTIAL DECAY MODES

                                                          DECAY MASSES
P1      SIGMA(1670) INTO N KBAR                          938+ 494
P2      SIGMA(1670) INTO LAMBDA PI                      1116+ 140
P3      SIGMA(1670) INTO SIGMA PI                       1189+ 140
P4      SIGMA(1670) INTO LAMBDA PI PI                   1116+ 140+ 140
P5      SIGMA(1670) INTO SIGMA PI PI                    1192+ 140+ 140
P6      SIGMA(1670) INTO SIGMA(1385) PI, S-WAVE         1385+ 140
P7      SIGMA(1670) INTO LAMBDA(1405) PI                1405+ 140
P8      SIGMA(1670) INTO LAMBDA(1520) PI                1520+ 140

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                    44  SIGMA(1670) BRANCHING RATIOS

R1      SIGMA(1670) INTO (N KBAR)/TOTAL                 (P1)
R1   C        0.07 OR  0.07          MARTIN    77 DPWA    KBAR N MULTICHNL 11/77
R1   D       (0.08)   (0.03)         RLIC      77 DPWA    KBAR N MULTICHNL  1/76
R1   D  (N KBAR)/TOTAL FROM RLIC 77 IS SUPERSEDED BY GOPAL 80.
R1            0.11    (0.03)         ALSTON    78 DPWA    KBAR N ELASTIC    1/78
R1            0.10    (0.03)         GOPAL     80 DPWA    KBAR N ELASTIC   12/81

R2      SIGMA(1670) INTO (LAMBDA PI PI)/TOTAL           (P4)
R2           (0.11) OR LESS          ARMENTE3  68 HBC     K-P (P1=.09)      9/69

R3      SIGMA(1670) INTO (SIGMA PI PI)/TOTAL            (P5)
R3   E       (0.14) OR LESS          ARMENTE3  68 HBC     K-P AND D-P1=.09 11/68
R3   E   ONLY FOR (SIG2PI) SYSTEM IN I=1, WHICH CANNOT BE SIGMA(1385)  11/68

R4      SIGMA(1670) INTO (LAMBDA(1405) PI)/TOTAL        (P7)
R4           (0.06) OR LESS          ARMENTE3  68 HBC     K-P AND D-P1=.09 11/68

R5      SIGMA(1670) FROM N KBAR TO LAMBDA PI            SQRT(P1*P2)
R5           +0.018    0.060         DEVENISH  74         0 FIXED T DISP REL  4/75
R5           +0.06    (0.02)         BAILLON   75 IPWA     KBAR N TO LAM PI 11/75
R5   A       (0.08)   (0.01)         PONTE     75 DPWA  0 K- P TO LAM PI     1/76
R5   B       (0.17)   (0.01)         PONTE     75 DPWA  0 K- P TO LAM PI     1/76
R5           +0.09    (0.02)         VANHORN   75 DPWA  0 K- P TO LAM PI0   11/75
R5          (+0.05)                  BELLEFON  76 IPWA  0 K- P TO LAM PI     2/77
R5   C       +0.08 OR +0.08          MARTIN    77 DPWA     KBAR N MULTICHNL 11/77
R5           +0.10    (0.02)         RLIC      77 DPWA     KBAR N MULTICHNL  1/76
R5   F        0.17    (0.03)         MORRIS    78 DPWA -   K- N TO LAM PI-   3/79
R5   F        0.13    (0.02)         MORRIS    78 DPWA -   K- N TO LAM PI-   3/79
R5   F  RESULTS ARE WITH AND WITHOUT AN S11 SIG(1620) IN THE FIT.

R6      SIGMA(1670) FROM N KBAR TO SIGMA PI             SQRT(P1*P3)
R6           +0.21    (0.03)         KANE      74 DPWA     K-P TO PI SIG    12/81
R6           +0.20    (0.01)         HEPP2     76 DPWA -0 K- NUC TO SIG PI  2/77
R6   C       +0.18 OR +0.17          MARTIN    77 DPWA     KBAR N MULTICHNL 11/77
R6           +0.21    (0.02)         RLIC      77 DPWA     KBAR N MULTICHNL  1/76

R7      SIGMA(1670) FROM N KBAR TO SIGMA(1385) PI, S-WAVESQRT(P1*P6)
R7   G       (0.17)   (0.02)         SIMS      68 DBC   -  LAM 2PI CROS.SEC 10/71
R7   G   SIMS 68 USES ONLY CROSS-SECT. DATA. RESULT USED AS UPPER LIMIT ONLY  3/72
R7           +0.11     0.03          PREVOST   74 DPWA 0- K-N TO S(1385)PI 10/74

R8      SIGMA(1670) INTO (LAM(1405)PI)*(N KBAR)/TOTAL**2 (P7*P1)
R8           (0.03) OR LESS          BERLEY    69 HBC    0 K-P .6-.82 GEV/C  5/70
R8   H        0.007   (0.002)        BRUCKER   70 DBC   -  K-N TO SIG 2PI   10/71
R8   H  ASSUMING LAMBDA(1405) PI CROSS SECTION BUMP DUE ONLY TO 3/2- RESON. 10/71

R9      SIGMA(1670) INTO (LAM(1405) PI)/(SIGMA(1385) PI) (P7)/(P6)
R9            0.23    (0.08)         BRUCKER   70 DBC   -  K-N TO SIG 2PI   10/71

R10     SIGMA(1670) FROM N KBAR TO LAMBDA(1520) PI      SQRT(P1*P8)
R10  I        0.081    0.016         CAMERON   77 DPWA  0 P-WAVE DECAY       1/78
R10  I  CAMERON77 UPPER LIMIT ON F-WAVE DECAY IS 0.03                        1/78
R10  I  ASSUMES LAMBDA(1520) ELASTICITY=.46.                                 1/78

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                    REFERENCES FOR SIGMA(1670)

BASTIEN1 63 PRL 10 188 P L8BASTIEN, J P BERGE                      (LRL) IJ
BASTIEN2 63 UCRL-10779 THESIS P L BASTIEN                          (LRL) IJ
T-ZADEH  63 PRL 11 470         TAHER-ZADEH,PROWSE,SCHLEIN,SLATER,+ (UCLA) JP
BERLEY   64 DUBNA CONF I 565   +CONNOLLY,HART,RAHM,STONEHILL, +     (BNL)IJP
SCHLEIN  66 UCLA-1016          P E  SCHLEIN, T G  TRIPPE           (UCLA) JP
SMART    66 PRL 17 556         W M SMART,A KERNAN,G E KALMUS,R P ELY (LRL)IJP
ARMENTER 67 NP B3 592          ARMENTEROS,FERRO-LUZZI+     (CERN+HEID+SACL)
ARMENTER 68 NP B8 195          ARMENTEROS,BAILLON +        (CERN+HEID+SACL)IJP
ARMENTE1 68 NP B8 183          ARMENTEROS,BAILLON +        (CERN+HEID+SACL)IJP
ARMENTE2 68 NP B8 223          ARMENTEROS+BAILLON +        (CERN+HEID+SACL)IJP
ARMENTE3 68 PL 28B 521         ARMENTEROS,BAILLON +        (CERN+HEID+SACL)I
SIMS     68 PRL 21 1413        SIMS,ALBRIGHT,BARTLEY,MEER+ (FSU+TUFT+BRAN)

ARMENTE4 69 NP B10 459         ARMENTEROS,BAILLON,MINTEN +      (CERN+SACL) J
ARMENT-5 69 NP B14 91          ARMENTEROS, BAILLON, +      (CERN+HEID+SACL)IJP
BERLEY   69 PL 30B 430         BERLEY,HART,RAHM,WILLIS,YAMAMOTO       (BNL)

ARMENTER 70 DUKE 123           ARMENTEROS, BAILLON, +           (CERN+HEID)
BRUCKER  70 DUKE 155           +HARRISON,SIMS,ALBRIGHT,CHANDLER++     (FSU)I
GALTIERI 70 DUKE 173           A BARBARO GALTIERI                      (LRL)IJP
BUDGEN   71 LNC 2  85          D BUDGEN                               (DURH)IJP
KIM      71 PRL 27 356         J K KIM                                (HARV)IJP
    ALSO 70 DUKE 161           J K KIM                                (HARV)IJP
PREVOST  71  AMSTERDAM CONF    + CHS COLLABORATION         (CERN+HEID+SACL)

LANGBEIN 72 NP B47 477         +WAGNER                                (MPIM)IJP
BAXTER   73 NP B67 125         BAXTER,BUCKINGHAM,CORBETT,DUNN,+       (OXF)IJP
HART     73 PURDUE CONF. 311   +RICE,BACASTOW,FUNG,+  (TENN+UCR+MASA+BUFF)IJP
DEVENISH 74 NP B81 330         DEVENISH,FROGGATT,MARTIN   (DESY+NORD+LOUC)
KANE     74  LBL-2452          D F KANE                                (LBL)IJP
PREVOST  74 NP B69 246         PREVOST,BARLOUTAUD,+       (SACL+CERN+HEID)

BAILLON  75 NP B94 39          P BAILLON, P J LITCHFIELD       (CERN+RHEL)IJP
PONTE    75 PRD 12 2597        +HERTZBACH,BUTTON-SHAFER+   (MASA+TENN+UCR)IJP
VANHORN  75 NP B87 145         A J VAN HORN                            (LBL)IJP
    ALSO 75 NP B87 157         A J VAN HORN                            (LBL)IJP

BELLEFON 76 NP B109 129        DE BELLEFON,BERTHON                    (CDEF)IJP
HEPP2    76 PL 65B 487         +BRAUN,GRIMM,STROBELE,THOL+(CERN+HEID+MPIM)IJP
CAMERON  77 NP B131 399        +FRANEK,GOPAL,KALMUS,MCPHERSON+ (RHEL+LOIC)IJP
MARTIN   77 NP B127 349        MARTIN,PIDCOCK,MOORHOUSE        (LOUC+GLAS)IJP
    ALSO 77 NP B126 266        MARTIN,PIDCOCK                          (LOUC)
    ALSO 77 NP B126 285        MARTIN,PIDCOCK                          (LOUC)IJP
RLIC     77 NP B119 362        GOPAL,ROSS,VAN HORN,MCPHERSON+  (LOIC+RHEL)IJP

ALSTON   78 PR D18 182         +KENNEY,POLLARD,ROSS+       (LBL+MTHO+CERN)IJP
    ALSO 77 PRL 38 1007        ALSTON-GARNJOST,KENNEY,+    (LBL+MTHO+CERN)IJP
MORRIS   78 PR D17 55          +ALBRIGHT,COLLERAINE,KIMEL,LANNUTTI    (FSU)IJP
GOPAL    80  TORONTO CONF 159 G P GOPAL                          (RHEL)IJP

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Σ(1670) BUMPS

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                    51  SIGMA(1670, JP=     ) I=1 PROD. AND CROSS SECT. EXPS

                    FORMATION EXPERIMENTS ARE LISTED SEPARATELY IN THE
                    PRECEDING ENTRY.

                    PROBABLY THERE ARE TWO STATES AT SAME MASS WITH SAME
                    QUANTUM NUMBERS, ONE DECAYING INTO SIGMA PI AND LAMBDA
                    PI, THE OTHER INTO LAMBDA(1405) PI.  SEE THE NOTE
                    PRECEDING THE PRECEDING ENTRY.

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                    51  SIGMA(1670) MASS (MEV) (PROD. EXP.)

M          (1685.0)                ALEXANDER 62 HBC  -0 PI-P 2-2.2 GEV/C
M           1660.0     10.0        ALVAREZ   63 HBC  +  K-P 1.51 GEV/C
M          (1665.0)    (5.0)       BUGG      68 CNTR    K-P, D TOTAL C.S
M   A   70(1661.0)    (9.0)        PRIMER    68 HBC  +  K-P 4.6-5. GEV/C  7/68
M   A      SEE BARNES 69 FOR NEW ANALYSIS OF DATA (3 TIMES MORE DATA)    10/69
M           1670.0      6.0        AGUILAR   70 HBC     SIG.PI K-P 4 GEV  5/70
M           1668.0     10.0        AGUILAR   70 HBC     SIG.2PI K-P 4GEV  5/70
M           1665.0      1.0        APSELL    74 HBC     K- P 2.87 GEV/C   4/75
M     1200 1688+/-2. OR 1683+/-5.   BERTHON   74 HBC   0 QUASI 2 BODY CS   4/75
M    B      1670.0      4.0        CARROLL   76 DPWA    I=1 TOTAL CS      2/77
M    B  TOTAL CROSS SECTION BUMP WITH (J+1/2)X=.23                        2/77
M    C      1675.0     10.0        HEPP1     76 DBC   - K-N 1.6-1.75 GEV  2/77
M    C  ENHANCEMENTS IN SIG P1 AND SIG P1 P1 CHANNEL CROSS SECTIONS.      2/77
M           1655. TO 1677.          TIMMERMA  76 HBC  +  K- P 4.2 GEV/C   2/77
M    D  150(1668.0)   (10.0)        FERRER    81 OMEG -  PI-P 9,12 GEV/C  2/82
M    D  BACKWARD PRODUCTION IN LAMBDA PI- K+ FINAL STATE.

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                    51  SIGMA(1670) WIDTH (MEV) (PROD. EXP.)

W           (45.0)                 ALEXANDER 62 HBC  -0
W            40.0     10.0         ALVAREZ   63 HBC  +
W           (30.0)   (15.0)         BUGG      68 CNTR                    11/66
W   A   70  (60.0)   (20.0)         PRIMER    68 HBC  +  K-P 4.6-5. GEV/C  7/68
W           110.0     12.0         AGUILAR   70 HBC     SIG.PI K-P 4 GEV  5/70
W           135.0     40.0    30.0 AGUILAR   70 HBC     SIG.2PI K-P 4GEV  5/70
W            67.0      2.4         APSELL    74 HBC     K- P 2.87 GEV/C   4/75
W    B      (52.0)                 CARROLL   76 DPWA    I=1 TOTAL CS      2/77
W            48. TO 63.            TIMMERMA  76 HBC  +  K- P 4.2 GEV/C   2/77
W   D  150  (90.0)   (20.0)         FERRER    81 OMEG -  PI-P 9,12 GEV/C  2/82

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                    51  SIGMA(1670) PARTIAL DECAY MODES (PROD. EXP.)

                                                          DECAY MASSES
P1      SIGMA(1670) INTO N KBAR                          938+ 494
P2      SIGMA(1670) INTO LAMBDA PI                      1116+ 140
P3      SIGMA(1670) INTO SIGMA PI                       1189+ 140
P4      SIGMA(1670) INTO LAMBDA PI PI                   1116+ 140+ 140
P5      SIGMA(1670) INTO SIGMA PI PI                    1192+ 140+ 140
P6      SIGMA(1670) INTO SIGMA(1385) PI                 1385+ 140
P7      SIGMA(1670) INTO LAMBDA(1405) PI                1405+ 140

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                    51  SIGMA(1670) BRANCHING RATIOS (PROD. EXP.)

R1      SIGMA(1670) INTO (N KBAR)/(SIGMA PI)            (P1)/(P3)
R1       0   (0.19) OR LESS         ALVAREZ   63 HBC  +  K-P 1.15 GEV/C
R1           (0.5)+- 0.25 OR MORE   SMITH     63 HBC  -0
R1           (0.6)  OR LESS         LONDON    66 HBC  +  K-P 2.25 GEV/C    7/66
R1           (0.025)                BUGG      68 CNTR  0 ASSUMING J=3/2   11/66
R1       0   (0.24) OR LESS         PRIMER    68 HBC  +  K-P 4.6-5. GEV/C  7/68
R1           (0.26) OR LESS         BARNES    69 HBC  +  K-P 3.9-5 GEV/C  10/69
R1           (0.2)  OR LESS         AGUILAR   70 HBC                      5/70
R1           (0.10) OR LESS         BERTHON   74 HBC   0 QUASI 2 BODY CS   4/75
R1           (0.03) OR LESS         TIMMERMA  76 HBC  +  K- P 4.2 GEV/C    2/77

R2      SIGMA(1670) INTO (LAMBDA PI)/(SIGMA PI)         (P2)/(P3)
R2     130   (1.20)                 ALVAREZ   63 HBC  +  K-P 1.15 GEV/C
R2           (1.2)                  SMITH     63 HBC  -0
R2            0.15      0.07        HUWE      64 HBC  +
R2            0.6   OR LESS         LONDON    66 HBC  +  K-P 2.25 GEV/C    7/66
R2      33    0.11      0.06        BUTTON-S  68 HBC  +  K-P AT 1.7 GEV/C 10/69
R2  A    0   (0.0)                  PRIMER    68 HBC  +  K-P 3.9-5 GEV/C  10/69
R2  A   PRIMER 68 ASSUMED THIS DECAY TO BE ALL SIGMA(1690) - SEE BARNES 69
R2  A   FOR NEWW INTERPRATATION OF DATA.(3 TIMES MORE DATA) -
R2            0.45      0.15        BARNES    69 HBC  +  K-P 3.9-5 GEV/C  10/69
R2           (0.55)   (0.11)        BERTHON   74 HBC   0 QUASI 2 BODY CS   4/75
R2            0.76      0.09        ESTES     74 HBC   0 K-P,2.1+2.6GEV/C 11/75
R2           (0.45)+/- 0.07 OR LESS TIMMERMA  76 HBC  +  K- P 4.2 GEV/C    2/77
R3      SIGMA(1670) INTO (LAMBDA PI PI)/(SIGMA PI)      (P4)/(P3)
R3      90   (0.56)                 ALVAREZ   63 HBC  +  K-P 1.15 GEV/C
R3           (0.17)                 SMITH     63 HBC  -0
R3           (0.6)  OR LESS         LONDON    66 HBC  + K-P AT 2.25 GEV/C  7/66

R4      SIGMA(1670) INTO (SIGMA PI PI)/(SIGMA PI)       (P5)/(P3)
R4     180   (0.56)                 ALVAREZ   63 HBC  +  K-P 1.15 GEV/C
R4          LARGEST AT SMALL ANGLES ESTES     74 HBC   0 K-P,2.1+2.6GEV/C 11/75
R4   C       (0.2)OR LESS           HEPP1     76 DBC   - K-N 1.6-1.75 GEV  2/77

R5      SIGMA(1670) INTO (LAMBDA(1405) PI)/(SIGMA PI)   (P7)/(P3)
R5      50    3.0       1.6         LONDON    66 HBC  +  K-P 2.25 GEV/C    7/66
R5  A   17   (0.58)   (0.20)         PRIMER    68 HBC  +  K-P 4.6-5. GEV/C  7/68
R5          LARGEST AT SMALL ANGLES  ESTES     74 HBC  +- K-P 2.1+2.6GEV/C 11/75
R5 DE      1.8+/-0.3 TO 0.02+/-0.07  TIMMERMA  76 HBC  +  K-P 4.2 GEV/C    11/77
R5  E   DEPENDING ON PRODUCTION ANGLE

R6      SIGMA(1670) INTO (SIGMA PI)/(SIGMA PI PI)       (P3)/(P5)
R6            0.4   OR LESS         BIRMINGHA 66 HBC  +  K-P AT 3.5 GEV/C 11/67
R6            0.30      0.15        LONDON    66 HBC  +  K-P 2.25 GEV/C    7/66
R6  F       BETWEEN 2.5 AND 0.24    EBERHARD  69 HBC     K-P AT 2.6 GEV/C  9/69
R6  F   DEPENDING ON THE PRODUCTION ANGLE
R6 G        VARIES WITH PROD. ANGLE APSELL    74 HBC  +  K-P 2.87 GEV/C    4/75
R6           (1.39)   (0.16)        BERTHON   74 HBC   0 QUASI 2 BODY CS   4/75
R6 G    APSELL 74, ESTES 74 AND TIMMERMANS 76 FIND STRONG BRANCHING RATIO
R6 G    DEPENDENCE ON PRODUCTION ANGLE, AS IN EARLIER PROD. EXPERIMENTS.

R7      SIGMA(1670) INTO (LAMBDA(1405) PI)/(SIGMA PI PI) (P7)/(P5)
R7            0.90      0.10    0.16 EBERHARD  65 HBC  +  K-P 2.45 GEV/C    7/66
R7            1.00      0.02        APSELL    74 HBC     K- P 2.87 GEV/C   4/75
R7            0.97      0.08        TIMMERMA  76  HBC    K- P 4.2 GEV/C    2/77

R8      SIGMA(1670) INTO (LAM(1405) PI)/(SIGMA(1385) PI) (P7)/(P6)
R8           (0.8)  OR LESS          EBERHARD  65 HBC  +  K-P 2.45 GEV/C    7/66
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Baryons

Σ(1670), Σ(1690), Σ(1750)

Data Card Listings

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R9      SIGMA(1670) INTO (LAMBDA PI PI)/(SIGMA PI PI)     (P4)/(P5)
R9            0.35     0.2            BIRMINGHA 66 HBC  +  K-P AT 3.5 GEV/C 11/67

R10     SIGMA(1670) INTO (LAMBDA PI)/(SIGMA PI PI)        (P2)/(P5)
R10           (0.2)  OR LESS          BIRMINGHA 66 HBC  +  K-P AT 3.5 GEV/C 11/67

R11     SIGMA(1670) INTO (LAMBDA PI)/(LAMBDA PI + SIG PI)(P2)/(P2+P3)
R11           (0.6)  OR LESS          AGUILAR   70 HBC                      5/70

R12     SIGMA(1670) INTO (SIGMA(1385) PI)/(SIGMA PI)      (P6)/(P3)
R12           (0.21)+/- 0.05 OR LESS  TIMMERMA  76  HBC    K- P 4.2 GEV/C    2/77

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                    51  SIGMA(1670) QUANTUM NUMBERS (PROD. EXP.)

Q1                JP=3/2+             LEVEQUE   65 HBC     INTO Y*(1405)+PI 11/68
Q3                JP=3/2-             EBERHARD  67 HBC  +  INTO Y*(1405) PI 11/68
Q4      400       JP=3/2-             BUTTON-SH 68 HBC  +- INTO SIGZERO+PI  11/68

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                          REFERENCES FOR SIGMA(1670) (PROD. EXP.)

ALEXANDE 62 CERN CONF 320      ALEXANDER,JACOBS,KALBFLEISCH,MILLER,+ (LRL) I
ALVAREZ  63 PRL 10 184         +ALSTON,FERRO-LUZZI,HUWE, +           (LRL) I
SMITH    63 ATHENS CONF 67     G A SMITH                             (LRL)
HUWE     64 PR 180 1824(1969)  D O HUWE                              (LRL)
EBERHARD 65 PRL 14 466         +SHIVELY,ROSS,SIEGAL,FICENEC, +   (LRL+ILL) I

BIRMINGH 66 PR 152 1148                        (BIRM+GLAS+LOIC+OXF+RHEL)
LONDON   66 PR 143 1034        +RAU,SAMIOS,YAMAMOTO,GOLDBERG,+  (BNL+SYRA) IJ
BUGG     68 PR 168 1466        +GILMORE,KNIGHT,DAVIES+     (BIRM+CAVE+RHEL)I
BUTTON-S 68 PRL 21 1123        J BUTTON-SHAFER                  (MASA+LRL) JP
PRIMER   68 PRL 20 610         +GOLDBERG,JAEGER,BARNES,DORNAN + (SYRA+BNL)

BARNES   69 BNL 13823          +CHUNG,EISNER,FLAMINIO+          (BNL+SYRA)
EBERHARD 69 PRL 22 200         +FRIEDMAN,PRIPSTEIN,ROSS              (LRL)
AGUILAR  70 PRL 25 58          +BARNES, BASSANO, CHUNG, EISNER,+(BNL+SYRA)

APSELL   74 PRD 10 1419        APSELL,FORD,GOUREVITCH+(BRAN+UMD+SYRA+TUFT)I
BERTHON  74 NC 21A 146         BERTHON,TRISTRAM,+    (CDEF+RHEL+SACL+STRB)
ESTES    74 LBL-3827 (THESIS)  R D ESTES                             (LBL)

CARROLL  76 PRL 37 806         +CHIANG,KYCIA,LI,MAZUR,MICHAEL+       (BNL)I
HEPP1    76 NP B115 82         +BRAUN,GRIMM,STROBELE,THOL+(CERN+HEID+MPIM)I
TIMMERMA 76 NP B112 77         TIMMERMANS,ENGELEN+    (NIJM+CERN+AMST+OXF) JP
FERRER   81 NP B178 373        +TREILLE,RIVET,VOLTE+ (CERN+CDEF+EPOL+LALO)

                               PAPERS NOT REFERRED TO IN DATA CARDS

LEVEQUE  65 PL 18 69           +            (SACL+EPOL+GLAS+LOIC+OXF+RHEL) JP
LEE      66 PRL 17 45          Y Y LEE, D D REEDER, R W HARTUNG     (WISC) JP
EBERHARD 67 PR 163 1446        +PRIPSTEIN,SHIVELY,KRUSE,SWANSON  (LRL+ILL)IJP
MILLER   70 DUKE 229           D H MILLER   (REVIEW TALK)           (PURD)
EBERHARD 73 PURDUE CONF. 247   P EBERHARD                            (LBL)IJP
HUNGERBU 74 PRD 10 2051        HUNGERBUHLER,MAJKA,+   (YALE+FNAL+BNL+PITT)

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Σ(1690) BUMPS Status: **

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                    58  SIGMA(1690, JP=    ) I=1     PRODUCTION EXPERIMENTS

                    SEE THE NOTE PRECEDING THE SIGMA(1670) LISTINGS.  SEEN
                    IN PRODUCTION EXPERIMENTS ONLY, MAINLY IN LAMBDA PI.

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                    58  SIGMA(1690) MASS (MEV) (PROD. EXP.)

M        30(1715.0)   (12.0)          COLLEY    67 HBC  +  K-P 6 GEV/C       8/67
M    A   60(1694.0)   (24.0)          PRIMER    68 HBC  +  K-P 4.6-5 GEV/C   7/68
M    A    SEE SIGMA(1670) LISTING-AGUILAR 70 WITH THREE TIMES THE DATA OF
M    A    PRIMER 68  SHOW THAT THEY HAVE NO EVIDENCE FOR SIGMA(1690)
M     B    (1700.0)    (6.0)          SIMS      68 HBC  -  K-N TO LAM PI PI 11/68
M     B    THIS ANALYSIS, WHICH IS DIFFICULT AND REQUIRES SEVERAL ASSUMPTIONS
M     B    AND SHOWS NO UNAMBIGUOUS SIGMA(1690) SIGNAL, SUGGESTS JP=5/2+.
M     B    SUCH A Y* WOULD LEAD ALL PREVIOUSLY KNOWN Y* TRAJECTORIES.
M        15(1698.0)   (20.0)          ADERHOLZ  69 HBC  +  PI+P 8 GEV/C     12/79
M        46(1682.0)    (2.0)          BLUMENFEL 69 HBC  +  K0 LONG + PROTON  9/69
M         (1700.0)   (20.0)           MOTT      69 HBC  +  K-P 5.5 GEV/C     9/69
M    C   70(1698.0)   (20.0)          GODDARD   79 HBC  +  PI+P 10.3 GEV/C  12/79
M    C    FROM (LAMBDA PI+) K+ FINAL STATE. J>1/2 NOT REQUIRED BY DATA.
M    D   40(1707.0)   (20.0)          GODDARD   79 HBC  +  PI+P 10.3 GEV/C  12/79
M    D    FROM (LAMBDA PI+) (K PI)+ FINAL STATE. J>1/2 INDICATED, BUT LARGE
M    D    BACKGROUND PRECLUDES DEFINITE CONCLUSION.

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                    58  SIGMA(1690) WIDTH (MEV) (PROD. EXP.)

W        30 (100.0)   (35.0)          COLLEY    67 HBC  +                    8/67
W    A   60 (105.0)   (35.0)          PRIMER    68 HBC  +                    7/68
W     B     (62.0)    (14.0)          SIMS      68 HBC  -  SEE NOTE N ABOVE 11/68
W        15 (142.0)   (40.0)          ADERHOLZ  69 HBC  +  PI+P 8 GEV/C     12/79
W        46  (25.0)   (10.0)          BLUMENFEL 69 HBC  +                    9/69
W          (130.0)    (25.0)          MOTT      69 HBC  +                    9/69
W    C   70 (240.0)   (60.0)          GODDARD   79 HBC  +  PI+P 10.3 GEV/C  12/79
W    D   40 (130.0)  (100.0)   (60.0) GODDARD   79 HBC  +  PI+P 10.3 GEV/C  12/79

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                    58  SIGMA(1690) PARTIAL DECAY MODES (PROD. EXP.)

                                                          DECAY MASSES
P1      SIGMA(1690) INTO N KBAR                          938+ 494
P2      SIGMA(1690) INTO LAMBDA PI                      1116+ 140
P3      SIGMA(1690) INTO SIGMA PI                       1189+ 140
P4      SIGMA(1690) INTO SIGMA(1385) PI                 1385+ 140
P5      SIGMA(1690) INTO LAMBDA PI PI (INCLUDING P4)    1116+ 140+ 140

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                    58  SIGMA(1690) BRANCHING RATIOS (PROD. EXP.)

R1      SIGMA(1690) INTO (N KBAR)/(LAMBDA PI)            (P1)/(P2)
R1      18     0.4      0.25         COLLEY    67 HBC  +  6/30 EVENTS       8/67
R1           (0.2)  OR LESS          MOTT      69 HBC  +                    9/69
R1        SMALL                      GODDARD   79 HBC  +  PI+P 10.2 GEV/C  12/79

R2      SIGMA(1690) INTO (SIGMA PI)/(LAMBDA PI)          (P3)/(P2)
R2            0.3      0.3           COLLEY    67 HBC  +  4/30 EVENTS       8/67
R2           (0.4)  OR LESS  CL=.90  MOTT      69 HBC  +                    9/69
R2        SMALL                      GODDARD   79 HBC  +  PI+P 10.2 GEV/C  12/79

R3      SIGMA(1690) INTO (SIGMA(1385) PI)/(LAMBDA PI)    (P4)/(P2)
R3           (0.5)  OR LESS          MOTT      69 HBC  +                    9/69

R4      SIGMA(1690) INTO (LAMBDA PI PI)/(LAMBDA PI)      (P5)/(P2)
R4            0.5      0.25          COLLEY    67 HBC  +  15/30 EVENTS      8/67
R4            2.0      0.6           BLUMENFEL 69 HBC  +  31/15 EVENTS      9/69
R4          . . . . . . . .
R4  AVG       0.72     0.53    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 2.3)

R5      SIGMA(1690) INTO (SIGMA(1385) PI)/(LAMBDA PI PI) (P4)/(P5)
R5          SMALL                     COLLEY    67 HBC  +                    8/67
R5          LARGE                     SIMS      68 HBC  -  K-N TO L2PI      11/68

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                          REFERENCES FOR SIGMA(1690) (PROD. EXP.)

COLLEY   67 PL 24B 489                 (BIRM+GLAS+LOIC+MUNI+OXF+RHEL) I
DERRICK  67 PRL 18 266         +FIELDS, LOKEN, AMMAR,            (ANL+NWES) I
    REPLACED BY MOTT 69.
PRIMER   68 PRL 20 610         +GOLDBERG, JAEGER, BARNES, + (SYRACUSE+BNL) I
SIMS     68 PRL 21 1413        +ALBRIGHT, +                  (FSU+TUFT+BRAN) I

ADERHOLZ 69 NP B11 259         +BARTSCH,SCHULTE+(AACH+BERL+CERN+CRAC+WARS)I
BLUMENFE 69 PL 29B 58          B J BLUMENFELD, G R KALBFLEISCH       (BNL) I
MOTT     69 PR 177 1966        +AMMAR, DAVIS, KROPAC, +          (NWES+ANL) I

GODDARD  79 PR D19 1350        +KEY,LUSTE,PRENTICE,YOON,GORDON+ (TNTO+BNL)I,J

                               PAPERS NOT REFERRED TO IN DATA CARDS

AGUILAR  70 PRL 25 58          AGUILAR-BENITEZ,BARNES,BASSANO+  (BNL+SYRA)
COOPER   70 NP B23 605         +MANNER,MUSGRAVE,POLLARD,VOYVODIC     (ANL)I

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Σ(1750) S''_{11} Status: ***

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                    57  SIGMA(1750, JP=1/2-) I=1       S''11

                    FOR MOST RESULTS PUBLISHED BEFORE 1974 (THEY ARE
                    NOW OBSOLETE), SEE OUR 1982 EDITION (PHYSICS LETTERS
                    111B).  ALL THE REFERENCES HAVE BEEN RETAINED.

                    THERE IS EVIDENCE FOR THIS STATE IN MANY PARTIAL-
                    WAVE ANALYSES, BUT WITH RATHER WIDE VARIATIONS IN
                    THE MASS, WIDTH AND COUPLINGS.  THE LATEST ANALYSES
    INDICATED SIGNIFICANT COUPLINGS TO N KBAR AND LAMBDA PI, AS WELL AS
    SIGMA ETA WHOSE THRESHOLD IS NEARBY AT 1746 MEV (JONES 74).

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                    57  SIGMA(1750) MASS (MEV)

M         (1785.0)   (12.0)           CHU       74 DBC  - FIT SIG- ETA CS  10/74
M    A    (1760.0)    (5.0)           JONES     74 HBC  0 FIT SIG0 ETA CS   1/74
M    A  S-WAVE BW FIT TO THRSHLD C.S., NO BKGND. ERRORS STATISTICAL ONLY     1/74
M         (1739.0)   (10.0)           PREVOST   74 DPWA 0- K-N TO S(1385)PI 10/74
M    B    (1780.0)   (30.0)           BAILLON   75 IPWA   KBAR N TO LAM PI  11/75
M    B  FROM SOLUTION 1 OF BAILLON 75.                                      11/75
M    C    (1700.0)   (30.0)           BAILLON   75 IPWA   KBAR N TO LAM PI   1/76
M    C  FROM SOLUTION 2 OF BAILLON 75.                                       1/76
M         (1697.0)   (20.0)   (10.0)  VANHORN  75 DPWA  0 K- P TO LAM PI0   11/75
M         (1730.0)                    BELLEFON  76 IPWA  0 K- P TO LAM PI    2/77
M    D     1715.0     10.0            CARROLL   76 DPWA   I=1 TOTAL CS      2/77
M    D  A TOTAL CROSS SECTION BUMP WITH (J+1/2)X=0.30.
M    E     1800. OR 1813.             MARTIN    77 DPWA   KBAR N MULTICHNL 11/77
M    E  THE TWO ENTRIES FOR MARTIN 77 CORRESPOND TO EXTRACTION OF RESONANCE
M    E  PARAMETERS FROM THE T-MATRIX POLE AND FROM A B-W FIT, RESPECTIVELY.
M          1770.0     15.0            RLIC      77 DPWA   KBAR N MULTICHNL  1/76
M          1770.0     10.0            ALSTON    78 DPWA   KBAR N ELASTIC    1/78
M          1756.0    (10.0)           GOPAL     80 DPWA   KBAR N ELASTIC   12/81

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                    57  SIGMA(1750) WIDTH (MEV)

W          (89.0)   (33.0)            CHU       74 DBC  - FIT SIG- ETA CS  10/74
W    A     (92.0)    (7.0)            JONES     74 HBC  0 FIT SIG+ETA CS    1/74
W         (108.0)   (20.0)            PREVOST   74 DPWA 0- K-N TO S(1385)PI 10/74
W    B    (140.0)   (30.0)            BAILLON   75 IPWA   KBAR N TO LAM PI 11/75
W    C    (160.0)   (50.0)            BAILLON   75 IPWA   KBAR N TO LAM PI  1/76
W     (66.0)   (14.0)   (12.0)        VANHORN   75 DPWA  0 K- P TO LAM PI0  11/75
W         (110.0)                     BELLEFON  76 IPWA  0 K- P TO LAM PI    2/77
W    D    (10.0)                      CARROLL   76 DPWA   I=1 TOTAL CS      2/77
W    E     117. OR 119.               MARTIN    77 DPWA   KBAR N MULTICHNL 11/77
W           60.0     10.0             RLIC      77 DPWA   KBAR N MULTICHNL  1/76
W          161.0     20.0             ALSTON    78 DPWA   KBAR N ELASTIC    1/78
W           64.0    (10.0)            GOPAL     80 DPWA   KBAR N ELASTIC   12/81

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                    57  SIGMA(1750) PARTIAL DECAY MODES

                                                          DECAY MASSES
P1      SIGMA(1750) INTO N KBAR                          938+ 494
P2      SIGMA(1750) INTO SIGMA ETA                      1192+ 549
P3      SIGMA(1750) INTO LAMBDA PI                      1116+ 135
P4      SIGMA(1750) INTO SIGMA PI                       1189+ 140
P5      SIGMA(1750) INTO SIGMA(1385) PI                 1385+ 140
P6      SIGMA(1750) INTO LAMBDA(1520) PI                1520+ 140

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                    57  SIGMA(1750) BRANCHING RATIOS

R1      SIGMA(1750) INTO (N KBAR)/TOTAL                  (P1)
R1   E       0.06 OR  0.05            MARTIN    77 DPWA   KBAR N MULTICHNL 11/77
R1   F      (0.15)   (0.03)           RLIC      77 DPWA   KBAR N MULTICHNL  1/76
R1   F  (N KBAR)/TOTAL FROM RLIC 77 IS SUPERSEDED BY GOPAL 80.
R1           0.33     0.05            ALSTON    78 DPWA   KBAR N ELASTIC    1/78
R1           0.14    (0.03)           GOPAL     80 DPWA   KBAR N ELASTIC   12/81

R2      SIGMA(1750) FROM N KBAR TO SIGMA ETA             SQRT(P1*P2)
R2           SEEN                    CLINE     69 DBC  -  THRESHOLD BUMP    9/69
R2   A      (0.23)   (0.01)           JONES     74 HBC  0 FIT SIG+ETA CS    1/74
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R3      SIGMA(1750) FROM N KBAR TO LAMBDA PI              SQRT(P1*P3)
R3           (-0.120)  (0.077)       DEVENISH  74          0 FIXED T DISP REL  4/75
R3  B        (-0.12)   (0.02)        BAILLON   75 IPWA      KBAR N TO LAM PI 11/75
R3  C        (-0.13)   (0.03)        BAILLON   75 IPWA      KBAR N TO LAM PI  1/76
R3           (-0.13)   (0.04)        VANHORN   75 DPWA   0 K- P TO LAM PI0  11/75
R3           (-0.12)                 BELLEFON  76 IPWA   0 K- P TO LAM PI    2/77
R3   E        -0.10 OR -0.09         MARTIN    77 DPWA      KBAR N MULTICHNL 11/77
R3            (0.04)   (0.03)        RLIC      77 DPWA      KBAR N MULTICHNL  1/76

R4      SIGMA(1750) FROM N KBAR TO SIGMA PI               SQRT(P1*P4)
R4            (0.13)   (0.02)        LANGBEIN  72 IPWA      MULTICHANNEL     12/72
R4   E        +0.06 OR +0.06         MARTIN    77 DPWA      KBAR N MULTICHNL 11/77
R4            -0.09     0.05         RLIC      77 DPWA      KBAR N MULTICHNL  1/76

R5      SIGMA(1750) FROM N KBAR TO SIGMA(1385) PI         SQRT(P1*P4)
R5            +0.18     0.15         PREVOST   74 DPWA 0- K-N TO S(1385)PI 10/74

R6      SIGMA(1750) FROM N KBAR TO LAMBDA(1520) PI        SQRT(P1*P6)
R6  G          0.032    0.021        CAMERON   77 DPWA  0 P-WAVE DECAY       1/78
R6  G  ASSUMES LAMBDA(1520) ELASTICITY=.46                                   1/78

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REFERENCES FOR SIGMA(1750)


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FERRO-LU 66 BERKELEY CONF 183 M FERRO LUZZI  (RAPPORTEUR)            (CERN)
CLINE    67 PL 25B 41         CLINE, OLSSON                          (WISC)IJP
MEYER    67 HEIDELBERG C 117  J MEYER  (RAPPORTEUR)                  (SACL)IJP
ARMENTER 68 NP B8 183         ARMENTEROS, BAILLON, +     (CERN+HEID+SACL)IJP
ARMENTER 69 LUND CONF PAPER   ARMENTEROS, BAILLON, +     (CERN+HEID+SACL)IJP
ARMENTER 70 DUKE 123          ARMENTEROS, BAILLON, +          (CERN+HEID)IJP
HARRISON 70 FSU-HEP 70 3 1    W C HARRISON (THESIS)                  (FSU)
CONFORTO 71 NP  B34  41       +LEVI SETTI,LASINSKI..OBERLACK++ (EFI+HEID)IJP
KIM      71 PRL 27 356        J K KIM                                (HARV)IJP
    ALSO 70 DUKE 161          J K KIM                                (HARV)IJP
LANGBEIN 72 NP B47 477        +WAGNER                                (MPIM)IJP

BAXTER   73 NP B67 125        BAXTER,BUCKINGHAM,CORBETT,DUNN,+        (OXF)IJP
CHU      74 NC 20A 35         CHU,BARTLEY,+  (SUNY PLATTSBURGH+TUFT+BRAN)IJP
JONES    74 NP B73 141        JONES                                  (CHIC)IJP
DEVENISH 74 NP B81 330        DEVENISH,FROGGATT,MARTIN    (DESY+NORD+LOUC)
PREVOST  74 NP B69 246        PREVOST,BARLOUTAUD,+        (SACL+CERN+HEID)

BAILLON  75 NP B94 39         P BAILLON, P J LITCHFIELD         (CERN+RHEL)IJP
VANHORN  75 NP B87 145        A J VAN HORN                            (LBL)IJP
    ALSO 75 NP B87 157        A J VAN HORN                            (LBL)IJP

BELLEFON 76 NP B109 129       DE BELLEFON,BERTHON                    (CDEF)IJP
CARROLL  76 PRL 37 806        +CHIANG,KYCIA,LI,MAZUR,MICHAEL+         (BNL)I
CAMERON  77 NP B131 399       +FRANEK,GOPAL,KALMUS,MCPHERSON+ (RHEL+LOIC)IJP
MARTIN   77 NP B127 349       MARTIN,PIDCOCK,MOORHOUSE         (LOUC+GLAS)IJP
    ALSO 77 NP B126 266       MARTIN,PIDCOCK                         (LOUC)
    ALSO 77 NP B126 285       MARTIN,PIDCOCK                         (LOUC)IJP
RLIC     77 NP B119 362       GOPAL,ROSS,VAN HORN,MCPHERSON+  (LOIC+RHEL)IJP

ALSTON   78 PR D18 182        +KENNEY,POLLARD,ROSS+       (LBL+MTHO+CERN)IJP
    ALSO 77 PRL 38 1007       ALSTON-GARNJOST,KENNEY,+    (LBL+MTHO+CERN)IJP
GOPAL    80  TORONTO CONF 159 G P GOPAL                              (RHEL)IJP
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Σ(1770) P''11 Status: *

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                  100  SIGMA(1770, JP=1/2+) I=1        P''11

                  EVIDENCE FOR THIS STATE NOW RESTS SOLELY ON SOLUTION 1
                  OF BAILLON 75 - BUT THE LAMBDA PI PARTIAL WAVE
                  AMPLITUDES OF THIS SOLUTION ARE IN DISAGREEMENT WITH
                  AMPLITUDES FROM MOST OTHER LAMBDA PI ANALYSES.

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                  100  SIGMA(1770) MASS  (MEV)

M   3    (1772.0)                   KANE      72 DPWA   K-P TO SIGMA PI  11/77
M   3  STATE IS NOT REQUIRED IN KANE 74 WHICH SUPERSEDES KANE 72.          12/81
M    1    1770.0    20.0            BAILLON   75 IPWA   KBAR N TO PI LAM 11/75
M    1  FROM SOLUTION 1 OF BAILLON 75, NOT PRESENT IN SOLUTION 2.           1/76
M   2    (1738.0)   (10.0)          RLIC      77 DPWA   KBAR N MULTICHNL  1/76
M   2  STATE REQUIRED TO FIT I=1 TOTAL X-SECTION OF CARROLL 76 IN KBAR N   12/81
M   2  CHANNEL. NEW K-P POLARIZATION AND K- NEUTRON DIFFERENTIAL X-SECTION 12/81
M   2  DATA MORE CONSISTENT WITH SIGMA(1660) P'11 IN GOPAL 80 ANALYSIS.    12/81

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                  100  SIGMA(1770) WIDTH (MEV)

W   3      (80.0)                   KANE      72 DPWA   K-P TO SIGMA PI  11/77
W    1      80.0      30.0          BAILLON   75 IPWA   KBAR N TO PI LAM 11/75
W   2      (72.0)    (10.0)         RLIC      77 DPWA   KBAR N MULTICHNL  1/76

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                  100  SIGMA(1770) PARTIAL DECAY MODES

                                                           DECAY MASSES
P1      SIGMA(1770) INTO N KBAR                          938+ 494
P2      SIGMA(1770) INTO LAMBDA PI                      1116+ 140
P3      SIGMA(1770) INTO SIGMA PI                       1189+ 140

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                  100  SIGMA(1770) BRANCHING RATIOS

R1      SIGMA(1770) INTO (N KBAR)/TOTAL                  (P1)
R1  2       (0.14)   (0.04)         RLIC      77 DPWA   KBAR N MULTICHNL  1/76

R2      SIGMA(1770) FROM N KBAR TO LAMBDA PI             SQRT(P1*P2)
R2   1      -0.08     0.02          BAILLON   75 IPWA   KBAR N TO PI LAM 11/75
R2          LESS THAN 0.04          RLIC      77 DPWA   KBAR N MULTICHNL  1/76

R3      SIGMA(1770) FROM N KBAR TO SIGMA PI              SQRT(P1*P3)
R3  3      (-0.108)                 KANE      72 DPWA   K-P TO SIGMA PI  11/77
R3          LESS THAN 0.04          RLIC      77 DPWA   KBAR N MULTICHNL  1/76

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REFERENCES FOR SIGMA(1770)


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KANE     72 PR D5 1583        D F KANE                                (LBL)
BAILLON  75 NP B94 39         P BAILLON, P J LITCHFIELD         (CERN+RHEL)IJP
RLIC     77 NP B119 362       GOPAL,ROSS,VAN HORN,MCPHERSON+  (LOIC+RHEL)IJP
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PAPERS NOT REFERRED TO IN DATA CARDS


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KANE      74  LBL-2452          D F KANE                               (LBL)IJP
CARROLL   76 PRL 37 806         +CHIANG,KYCIA,LI,MAZUR,MICHAEL,+       (BNL)I
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Σ(1775) D15 Status: ****

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                  45  SIGMA(1775, JP=5/2-) I=1        D15

                  FOR MOST RESULTS PUBLISHED BEFORE 1974 (THEY ARE
                  NOW OBSOLETE), SEE OUR 1982 EDITION (PHYSICS LETTERS
                  111B).  ALL THE REFERENCES HAVE BEEN RETAINED.

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                  45  SIGMA(1775) MASS (MEV)

M           1772.0    (6.0)         KANE      74 DPWA    K-P TO PI SIG    12/81
M           1775.0    10.0          BAILLON   75 IPWA    KBAR N TO LAM PI 11/75
M           1774.0    10.0          VANHORN   75 DPWA  0 K- P TO LAM PI0  11/75
M          (1765.0)                 BELLEFON  76 IPWA  0 K- P TO LAM PI    2/77
M     A     1772. OR 1777.          MARTIN    77 DPWA    KBAR N MULTICHNL 11/77
M     A  THE TWO ENTRIES FOR MARTIN 77 CORRESPOND TO EXTRACTION OF RESONANCE
M     A  PARAMETERS FROM THE T-MATRIX POLE AND FROM A B-W FIT, RESPECTIVELY.
M           1774.0     5.0          RLIC      77 DPWA    KBAR N MULTICHNL  1/76
M           1777.0     5.0          ALSTON    78 DPWA    KBAR N ELASTIC    1/78
M           1778.0    (5.0)         GOPAL     80 DPWA    KBAR N ELASTIC   12/81

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                  45  SIGMA(1775) WIDTH (MEV)

W            154.0   (10.0)         KANE      74 DPWA    K-P TO PI SIG    12/81
W            125.0    15.0          BAILLON   75 IPWA    KBAR N TO LAM PI 11/75
W            146.0    18.0          VANHORN   75 DPWA  0 K- P TO LAM PI0  11/75
W           (120.0)                 BELLEFON  76 IPWA  0 K- P TO LAM PI    2/77
W     A      102. OR 103.           MARTIN    77 DPWA    KBAR N MULTICHNL 11/77
W            130.0    10.0          RLIC      77 DPWA    KBAR N MULTICHNL  1/76
W            116.0    10.0          ALSTON    78 DPWA    KBAR N ELASTIC    1/78
W            137.0   (10.0)         GOPAL     80 DPWA    KBAR N ELASTIC   12/81
W           . . . . . . . . .
W   AVG      125.9     6.0      AVERAGE

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                  45  SIGMA(1775) PARTIAL DECAY MODES

                                                           DECAY MASSES
P1      SIGMA(1775) INTO N KBAR                          938+ 494
P2      SIGMA(1775) INTO LAMBDA PI                      1116+ 135
P3      SIGMA(1775) INTO LAMBDA(1520) PI                1520+ 140
P4      SIGMA(1775) INTO SIGMA(1385) PI, D-WAVE         1385+ 140
P5      SIGMA(1775) INTO SIGMA PI                       1189+ 140
P6      SIGMA(1775) INTO SIGMA ETA                      1192+ 549
P7      SIGMA(1775) INTO SIGMA PI PI                    1192+ 140+ 140

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FITTED PARTIAL DECAY MODE BRANCHING FRACTIONS

The matrix below is derived from the error matrix for the fitted partial decay mode branching fractions, P_i, as follows: The diagonal elements are $P_i \pm \delta P_i$, where $\delta P_i = \sqrt{\langle \delta P_i \delta P_i \rangle}$, while the off-diagonal elements are the normalized correlation coefficients $\langle \delta P_i \delta P_j \rangle / (\delta P_i \cdot \delta P_j)$. For the definitions of the individual P_i, see the listings above; only those P_i appearing in the matrix are assumed in the fit to be nonzero and are thus constrained to add to 1.

	P 1	P 2	P 3	P 4	P 5	P 6
P 1	.4520+-.0333					
P 2	-.1658	.1497+-.0139				
P 3	-.7170	.1184	.1869+-.0259			
P 4	-.5842	.0969	.4174	.0790+-.0099		
P 5	-.2374	.0394	.1695	.1387	.0374+-.0121	
P 6	-.1406	-.4778	-.3639	-.1568	-.3887	.0950+-.0270

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                  45  SIGMA(1775) BRANCHING RATIOS

        ERRORS QUOTED BY EXPERIMENTERS DO NOT INCLUDE UNCERTAINTY DUE
        TO PARAMETRIZATION USED IN THE P.W.A.  THEY SHOULD BE INCREASED.

R1      SIGMA(1775) INTO (N KBAR)/TOTAL                  (P1)
R1   A       0.37 OR  0.36          MARTIN    77 DPWA    KBAR N MULTICHNL 11/77
R1   B      (0.41)   (0.03)         RLIC      77 DPWA    KBAR N MULTICHNL  1/76
R1   B  (N KBAR)/TOTAL FROM RLIC 77 IS SUPERSEDED BY GOPAL 80.
R1           0.37     0.03          ALSTON    78 DPWA    KBAR N ELASTIC    1/78
R1           0.40    (0.02)         GOPAL     80 DPWA    KBAR N ELASTIC   12/81
R1          . . . . . . . . .
R1  FIT      0.452    0.033   FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.9)

R2      SIGMA(1775) FROM N KBAR TO LAMBDA PI             SQRT(P1*P2)
R2          -0.259    0.048         DEVENISH  74          0 FIXED T DISP REL  4/75
R2          -0.25     0.02          BAILLON   75 IPWA    KBAR N TO LAM PI 11/75
R2          -0.28     0.04    0.05  VANHORN   75 DPWA  0 K- P TO LAM PI0  11/75
R2         (-0.30)                  BELLEFON  76 IPWA  0 K- P TO LAM PI    2/77
R2   A      -0.29 OR -0.28          MARTIN    77 DPWA    KBAR N MULTICHNL 11/77
R2          -0.28     0.03          RLIC      77 DPWA    KBAR N MULTICHNL  1/76
R2          . . . . . . . . .
R2  AVG MOD  0.261    0.015   AVERAGE
R2  FIT      0.260    0.014   FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.1)

R3      SIGMA(1775) FROM N KBAR TO LAMBDA(1520) PI       SQRT(P1*P3)
R3           0.27     0.03          ARMENTERO 65 HBC   0 K-P TO Y*1520 PI  9/66
R3           0.31     0.02          BARLETTA  72 DPWA  0 K-P TO Y*1520 PI 12/72
R3   C      -0.305    0.010         CAMERON   77 DPWA  0 K-P TO L(1520)PI  1/78
R3   C  LISTED RATE COMBINES P- AND F-WAVE DECAYS AND ASSUMES LAMBDA(1520)   1/78
R3   C  ELASTICITY=.46. THE CAMERON 77 RESULTS FOR THE SEPARATE P- AND       1/78
R3   C  F-WAVE DECAYS ARE -0.303+/-.010 AND -0.037+/-.014, RESPECTIVELY.    12/79
R3   C  THE SIGNS ARE CHANGED HERE TO BE IN ACCORD WITH THE BARYON-FIRST    12/79
R3   C  CONVENTION.                                                         12/79
R3          . . . . . . . . .
R3  AVG MOD  0.3031   0.0086  AVERAGE
R3  FIT      0.291    0.015   FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.7)
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Baryons

Σ(1775), Σ(1840), Σ(1880)

Data Card Listings

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R4     SIGMA(1775) FROM N KBAR TO SIGMA(1385) PI, D-WAVESQRT(P1*P4)
R4          (0.24)   (0.03)          ARMENT-2  67 HBC   0 K-P TO LAM PI PI  8/67
R4  D       (0.32)   (0.06)          SIMS      68 DBC  -  K-N TO LAM PI PI 11/68
R4  D   SIMS 68 USES ONLY CROSS-SECT. DATA. RESULT USED AS UPPER LIMIT ONLY  3/72
R4          +0.20     0.02           PREVOST   74 DPWA 0- K-N TO S(1385)PI 10/74
R4  C       -0.184    0.011          CAMERON   78 DPWA  0 K-P TO S(1385)PI  1/78
R4  C  CAMERON  78 UPPER LIMIT ON G-WAVE DECAY IS 0.03.                     1/78
R4
R4  AVG MOD   0.1877   0.0096  AVERAGE
R4  FIT       0.1889   0.0096 FROM FIT

R5     SIGMA(1775) FROM N KBAR TO SIGMA PI              SQRT(P1*P5)
R5           0.09    (0.01)          KANE      74 DPWA    K-P TO PI SIG     12/81
R5   A      +0.08 OR +0.08           MARTIN    77 DPWA    KBAR N MULTICHNL 11/77
R5          +0.13     0.02           RLIC      77 DPWA    KBAR N MULTICHNL  1/76
R5
R5  FIT       0.130    0.020  FROM FIT

R6     SIGMA(1775) INTO (LAMBDA PI)/(N KBAR)            (P2)/(P1)
R6           0.33     0.05           UHLIG     67 HBC   0 K-P,.9 GEV/C      9/66
R6
R6  FIT       0.331    0.042  FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.2)

R7     SIGMA(1775) INTO (LAMBDA(1520)PI)/(N KBAR)       (P3)/(P1)
R7           0.28     0.05           UHLIG     67 HBC   0 K-P,.9 GEV/C      9/66
R7
R7  FIT       0.413    0.082  FROM FIT (ERROR INCLUDES SCALE FACTOR OF 2.5)

R8     SIGMA(1775) INTO (SIGMA(1385)PI)/(N KBAR)        (P4)/(P1)
R8           0.25     0.09           UHLIG     67 HBC   0 K-P,.9 GEV/C      9/66
R8
R8  FIT       0.175    0.031  FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.4)

R9     SIGMA(1775) INTO (SIGMA PI PI)/TOTAL             (P7)
R9  E        (0.12)                  ARMENT-2  68 HDBC -0 K-N TO SIG PI PI 11/68
R9  E   FOR ABOUT 3/4 OF THIS, THE SIGMA PI SYSTEM HAS I=0 AND IS ALMOST
R9  E ENTIRELY LAMBDA(1520).  FOR THE REST, THE SIGMA PI HAS I=1.  THIS
R9  E IS ABOUT WHAT IS EXPECTED FROM THE KNOWN RATE SIGMA(1775) TO
R9  E SIGMA(1385) PI, AS SEEN IN LAMBDA PI PI.

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REFERENCES FOR SIGMA(1775)


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GALTIERI 63 PL 6 296          A BARBARO-GALTIERI,A HUSSAIN,R D TRIPP(LRL)IJ
ARMENTER 65 PL 19 338         ARMENTEROS, +              (CERN+HEID+SACL)IJP
BELL 1   66 PRL 16 203        R B BELL, R W BIRGE, Y-L PAN, R T PU  (LRL)IJP
BELL 2   66 UCRL-16936 THESIS R B BELL                              (LRL)IJP
FENSTER  66 PRL 17 841        +GELFAND,HARMSEN,L-SETTI,+  (CHIC+ANL+CERN)IJP
      -- FENSTER 66 IS SUPERSEDED BY BARLETTA 72
ARMENTER 67 PL 24B 198        ARMENTEROS,FERRO-LUZZI+     (CERN+HEID+SACL)IJP
ARMENT-2 67 ZEIT.PHYS.202 486 ARMENTEROS,FERRO-LUZZI+     (CERN+HEID+SACL)
UHLIG    67 PR 155 1448       +CHARLTON,CONDON,GLASSER,YODH,+   (UMD+NRL)

ARMENT-1 68 NP B8 195         ARMENTEROS, BAILLON, +      (CERN+HEID+SACL)IJP
ARMENT-2 68 NP B8 216         ARMENTEROS, BAILLON, +      (CERN+HEID+SACL) I
BUGG     68 PR 168 1466       +GILMORE,KNIGHT,DAVIES+     (BIRM+CAVE+RHEL)I
CONFORTO 68 NP B8 265         +HARMSEN, LASINSKI, +             (CHIC+HEID)IJP
    SUPERSEDED BY CONFORTO 71.
SIMS     68 PRL 21 1413       SIMS,ALBRIGHT,BARTLEY,MEER+ (FSU+TUFT+BRAN)
SMART    68 PR 169 1330       W M SMART                                (LRL)IJP

BRICMAN1 70 PL 33B 511        +FERRO-LUZZI,LAGNAUX                    (CERN)
COOL     70 PR D1 1887        +GIACOMELLI, KYCIA, LEONTIC, LI, +      (BNL) I
GALTIERI 70 DUKE CONF 173     A BARBARO-GALTIERI                       (LRL)IJP
HARRISON 70 FSU-HEP 70 3 1    W C HARRISON (THESIS)                    (FSU)

CONFORTO 71 NP  B34  41       +LEVI SETTI,LASINSKI..OBERLACK++ (EFI+HEID)IJP
KIM      71 PRL 27 356        J K KIM                                 (HARV)IJP
    ALSO 70 DUKE 161          J K KIM                                 (HARV)IJP
PREVOST  71  AMSTERDAM CONF   + CHS COLLABORATION          (CERN+HEID+SACL)

BARLETTA 72 NP B40 45         W A BARLETTA                             (EFI) IJP
KANE     72 PR D5 1583        D F KANE                                 (LBL)IJP
LANGBEIN 72 NP B47 477        +WAGNER                                 (MPIM)IJP
DEVENISH 74 NP B81 330        DEVENISH,FROGGATT,MARTIN   (DESY+NORD+LOUC)
KANE     74  LBL-2452         D F KANE                                 (LBL)IJP
PREVOST  74 NP B69 246        PREVOST,BARLOUTAUD,+       (SACL+CERN+HEID)

BAILLON  75 NP B94 39         P BAILLON, P J LITCHFIELD        (CERN+RHEL)IJP
VANHORN  75 NP B87 145        A J VAN HORN                             (LBL)IJP
    ALSO 75 NP B87 157        A J VAN HORN                             (LBL)IJP


BELLEFON 76 NP B109 129       DE BELLEFON,BERTHON                     (CDEF)IJP
CAMERON  77 NP B131 399       +FRANEK,GOPAL,KALMUS,MCPHERSON+ (RHEL+LOIC)IJP
MARTIN   77 NP B127 349       MARTIN,PIDCOCK,MOORHOUSE         (LOUC+GLAS)IJP
    ALSO 77 NP B126 266       MARTIN,PIDCOCK                          (LOUC)
    ALSO 77 NP B126 285       MARTIN,PIDCOCK                          (LOUC)IJP
RLIC     77 NP B119 362       GOPAL,ROSS,VAN HORN,MCPHERSON+  (LOIC+RHEL)IJP

ALSTON   78 PR D18 182        +KENNEY,POLLARD,ROSS+        (LBL+MTHO+CERN)IJP
    ALSO 77 PRL 38 1007       ALSTON-GARNJOST,KENNEY,+     (LBL+MTHO+CERN)IJP
CAMERON  78 NP B143 189       +FRANEK,GOPAL,BACON,BUTTERWORTH+(RHEL+LOIC)IJP
GOPAL    80  TORONTO CONF 159 G P GOPAL                            (RHEL)IJP
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Σ(1840) P''_{13} Status: *

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01  SIGMA(1840, JP=3/2+) I=1        P''13

FOR THE TIME BEING, WE LIST ALL RESONANCE CLAIMS IN THE
P13 WAVE IN THE 1700-1900 MEV MASS REGION TOGETHER
UNDER THIS HEADING.

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01 SIGMA(1840) MASS (MEV)

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M          1840.0    (10.0)          LANGBEIN  72 IPWA    MULTICHANNEL     12/72
M    1    (1720.0)   (30.0)          BAILLON   75 IPWA    KBAR N TO LAM PI 11/75
M    1   FROM SOLUTION 1 OF BAILLON 75, NOT PRESENT IN SOLUTION 2.          1/76
M          1925.0   (200.0)          VANHORN   75 DPWA  0 K- P TO LAM PI0  11/75
M    2     1798. OR 1802.            MARTIN    77 DPWA    KBAR N MULTICHNL 11/77
M    2  THE TWO ENTRIES FOR MARTIN 77 CORRESPOND TO EXTRACTION OF RESONANCE
M    2  PARAMETERS FROM THE T-MATRIX POLE AND FROM A B-W FIT, RESPECTIVELY.

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01 SIGMA(1840) WIDTH (MEV)

```
W           120.0    (10.0)          LANGBEIN  72 IPWA    MULTICHANNEL     12/72
W    1     (120.0)   (30.0)          BAILLON   75 IPWA    KBAR N TO LAM PI 11/75
W           65.0    (50.0)   (20.0)  VANHORN   75 DPWA  0 K- P TO LAM PI0  11/75
W    2      93. OR 93.               MARTIN    77 DPWA    KBAR N MULTICHNL 11/77

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01 SIGMA(1840) PARTIAL DECAY MODES

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                                                        DECAY MASSES
P1     SIGMA(1840) INTO N KBAR                          938+ 494
P2     SIGMA(1840) INTO SIGMA PI                       1189+ 140
P3     SIGMA(1840) INTO LAMBDA PI                      1116+ 135

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01 SIGMA(1840) BRANCHING RATIOS

```
R1     SIGMA(1840) INTO (N KBAR)/TOTAL                  (P1)
R1           0.37    (0.13)          LANGBEIN  72 IPWA    MULTICHANNEL     12/72
R1   2       0.0 OR 0.0               MARTIN    77 DPWA    KBAR N MULTICHNL 11/77

R2     SIGMA(1840) FROM N KBAR TO SIGMA PI              SQRT(P1*P2)
R2           0.15    (0.04)          LANGBEIN  72 IPWA    MULTICHANNEL     12/72
R2   2      -0.04 OR -0.04            MARTIN    77 DPWA    KBAR N MULTICHNL 11/77

R3     SIGMA(1840) FROM N KBAR TO LAMBDA PI             SQRT(P1*P3)
R3           0.20    (0.04)          LANGBEIN  72 IPWA    MULTICHANNEL     12/72
R3          +0.122    0.078          DEVENISH  74       0 FIXED T DISP REL  4/75
R3   1      (+0.11)   (0.02)          BAILLON   75 IPWA    KBAR N TO LAM PI 11/75
R3          +0.06     (0.04)          VANHORN   75 DPWA  0 K- P TO LAM PI0  11/75
R3   2      +0.03 OR +0.03            MARTIN    77 DPWA    KBAR N MULTICHNL 11/77

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REFERENCES FOR SIGMA(1840)


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LANGBEIN 72 NP B47 477        +WAGNER                                 (MPIM)IJP
DEVENISH 74 NP B81 330        DEVENISH,FROGGATT,MARTIN   (DESY+NORD+LOUC)
BAILLON  75 NP B94 39         P BAILLON, P J LITCHFIELD        (CERN+RHEL)IJP
VANHORN  75 NP B87 145        A J VAN HORN                             (LBL)IJP
    ALSO 75 NP B87 157        A J VAN HORN                             (LBL)IJP

MARTIN   77 NP B127 349       MARTIN,PIDCOCK,MOORHOUSE         (LOUC+GLAS)IJP
    ALSO 77 NP B126 266       MARTIN,PIDCOCK                          (LOUC)
    ALSO 77 NP B126 285       MARTIN,PIDCOCK                          (LOUC)IJP
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Σ(1880) P''_{11} Status: **

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67  SIGMA(1880, JP=1/2+) I=1        P''11

A RESONANCE IS SUGGESTED BY SEVERAL PARTIAL-WAVE
ANALYSES ACROSS THIS REGION, BUT WITH WIDE VARIATIONS
IN THE MASS AND OTHER PARAMETERS.  WE LIST HERE
ALL CLAIMS WHICH LIE WELL ABOVE THE SIGMA(1770).

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67 SIGMA(1880) MASS (MEV)

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M          1882.0     40.0           SMART     68 DPWA -0 K- N TO LAM PI    7/68
M         (1850.0)                   BAILEY    69 DPWA  0 ELASTIC, CH EXCH 10/70
M          ABOUT 1850.0              ARMENTERO 70 IPWA -0 ELASTIC, CH EXCH  6/70
M          1950.0     50.0           GALTIERI  70 DPWA -0 K- N TO LAM PI    7/70
M          1920.0     30.0           LITCHFIEL 70 DPWA -0 K- N TO LAM PI    6/70
M    2    (1898.0)                   LEA       73 DPWA    MULTICHNL K-MTRX  9/73
M    2  ONLY UNCONSTRAINED STATES FROM TABLE 1 OF LEA73 ARE IN LISTINGS.    9/73
M    1    (1960.0)   (30.0)          BAILLON   75 IPWA    KBAR N TO LAM PI 11/75
M    1   FROM SOLUTION 1 OF BAILLON 75, NOT PRESENT IN SOLUTION 2.          1/76
M          1985.0     50.0           VANHORN   75 DPWA  0 K- P TO LAM PI0  11/75
M    3     1847. OR 1863.            MARTIN    77 DPWA    KBAR N MULTICHNL 11/77
M    3  THE TWO ENTRIES FOR MARTIN 77 CORRESPOND TO EXTRACTION OF RESONANCE
M    3  PARAMETERS FROM THE T-MATRIX POLE AND FROM A B-W FIT, RESPECTIVELY.
M          1870.0     10.0           CAMERON2  78 DPWA    K-P TO K*(892) N 12/79
M          1826.0    (20.0)          GOPAL     80 DPWA    KBAR N ELASTIC   12/81

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67 SIGMA(1880) WIDTH (MEV)

```
W           222.0    150.0           SMART     68 DPWA -0 K- N TO LAM PI    7/68
W          (200.0)                   BAILEY    69 DPWA  0 ELASTIC, CH EXCH 10/70
W          ABOUT 30.0                ARMENTERO 70 IPWA -0 ELASTIC, CH EXCH  6/70
W           200.0     50.0           GALTIERI  70 DPWA -0 K- N TO LAM PI    7/70
W           170.0     40.0           LITCHFIEL 70 DPWA -0 K- N TO LAM PI    6/70
W    2     (222.2)                   LEA       73 DPWA    MULTICHNL K-MTRX  9/73
W    1     (260.0)   (40.0)          BAILLON   75 IPWA    KBAR N TO LAM PI 11/75
W           220.0    140.0           VANHORN   75 DPWA  0 K- P TO LAM PI0  11/75
W    3      216. OR 220.             MARTIN    77 DPWA    KBAR N MULTICHNL 11/77
W           80.0      10.0           CAMERON2  78 DPWA    K-P TO K*(892) N 12/79
W           86.0     (15.0)          GOPAL     80 DPWA    KBAR N ELASTIC   12/81

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67 SIGMA(1880) PARTIAL DECAY MODES

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                                                        DECAY MASSES
P1     SIGMA(1880) INTO N KBAR                          938+ 494
P2     SIGMA(1880) INTO LAMBDA PI                      1116+ 135
P3     SIGMA(1880) INTO SIGMA PI                       1197+ 140
P4     SIGMA(1880) INTO N K*(892), P1 WAVE              940+ 892
P5     SIGMA(1880) INTO N K*(892), P3 WAVE              940+ 892

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67 SIGMA(1880) BRANCHING RATIOS

```
R1     SIGMA(1880) INTO (N KBAR)/TOTAL                  (P1)
R1          (0.22)                   BAILEY    69 DPWA  0 ELASTIC, CH EXCH 10/70
R1          (0.20)                   ARMENTERO 70 IPWA -0 ELASTIC, CH EXCH  6/70
R1   2      (0.31)                   LEA       73 DPWA    MULTICHNL K-MTRX  9/73
R1   3       0.27 OR  0.27           MARTIN    77 DPWA    KBAR N MULTICHNL 11/77
R1           0.06    (0.02)          GOPAL     80 DPWA    KBAR N ELASTIC   12/81
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```
R2      SIGMA(1880) FROM N KBAR TO LAMBDA PI                SQRT(P1*P2)
R2           -0.11        0.03              SMART      68 DPWA -0 K- N TO LAM PI     7/68
R2           -0.09        0.04              GALTIERI   70 DPWA -0 K- N TO LAM PI     7/70
R2           -0.14        0.03              LITCHFIEL  70 DPWA -0 K- N TO LAM PI     6/70
R2    2     (-0.30)                         LEA        73 DPWA    MULTICHNL K-MTRX   9/73
R2           -0.169       0.119             DEVENISH   74       0 FIXED T DISP REL   4/75
R2    1     (-0.12)     (0.02)              BAILLON    75 IPWA    KBAR N TO LAM PI 11/75
R2           +0.05        0.07       0.02   VANHORN    75 DPWA  0 K- P TO LAM PI0  11/75
R2    3      -0.24 OR -0.24                 MARTIN     77 DPWA    KBAR N MULTICHNL 11/77

R3      SIGMA(1880) FROM N KBAR TO SIGMA PI                 SQRT(P1*P3)
R3    2        NOT SEEN                     LEA        73 DPWA    MULTICHNL K-MTRX   9/73
R3    3      +0.30 OR +0.29                 MARTIN     77 DPWA    KBAR N MULTICHNL 11/77

R4      SIGMA(1880) FROM N KBAR TO N K*(892), P1 WAVE    SQRT(P1*P4)
R4    4      -0.05        0.03              CAMERON2   78 DPWA    K-P TO K*N        12/79
R4    4  THE SIGN HERE IS CHANGED TO BE IN ACCORD WITH THE BARYON-FIRST            12/79
R4    4  CONVENTION.                                                               12/79

R5      SIGMA(1880) FROM N KBAR TO N K*(892), P3 WAVE    SQRT(P1*P5)
R5           +0.11        0.03              CAMERON2   78 DPWA    K-P TO K*N        12/79

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REFERENCES FOR SIGMA(1880)


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SMART    68 PR 169 1330       W M SMART                                    (LRL)IJP
BAILEY   69 THESIS UCRL-50617 DAVID SAAL BAILEY                            (LLL)IJP
ARMENTER 70 DUKE CONF 123     ARMENTEROS, BAILLON, +                 (CERN+HEID)IJP
GALTIERI 70 DUKE CONF 173     A BARBARO-GALTIERI                           (LRL)IJP
LITCHFIE 70 NP B22 269        P J LITCHFIELD                              (RHEL)IJP

LEA      73 NP B56 77         +MARTIN,MOORHOUSE+    (RHEL+LOUC+GLAS+AARH)IJP
DEVENISH 74 NP B81 330        DEVENISH,FROGGATT,MARTIN   (DESY+NORD+LOUC)
BAILLON  75 NP B94 39         P BAILLON, P J LITCHFIELD              (CERN+RHEL)IJP
VANHORN  75 NP B87 145        A J VAN HORN                                 (LBL)IJP
    ALSO 75 NP B87 157        A J VAN HORN                                 (LBL)IJP

MARTIN   77 NP B127 349       MARTIN,PIDCOCK,MOORHOUSE               (LOUC+GLAS)IJP
    ALSO 77 NP B126 266       MARTIN,PIDCOCK                              (LOUC)
    ALSO 77 NP B126 285       MARTIN,PIDCOCK                              (LOUC)IJP
CAMERON2 78 NP B146 327       +FRANEK,GOPAL,KALMUS,MCPHERSON,+(RHEL+LOIC)IJP
GOPAL    80  TORONTO CONF 159 G P GOPAL                                   (RHEL)IJP
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Σ(1915) F'_{15} Status: ****

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                    46  SIGMA(1915, JP=5/2+) I=1        F'15

                    FOR RESULTS PUBLISHED BEFORE 1974 (THEY ARE
                    NOW OBSOLETE), SEE OUR 1982 EDITION (PHYSICS LETTERS
                    111B).  ALL THE REFERENCES HAVE BEEN RETAINED.

                    THIS RESONANCE WAS FIRST SEEN IN THE TOTAL-CROSS-SEC-
                    TION MEASUREMENTS OF COOL 66.  IN THIS ENTRY, HOWEVER,
                    WE LIST ONLY THE RESULTS FROM PARTIAL-WAVE ANALYSES.
      SEE THE NEXT ENTRY FOR THE PARAMETERS OF PEAKS SEEN AROUND 1900-1950
      MEV IN CROSS SECTIONS AND INVARIANT-MASS DISTRIBUTIONS.  WE MAKE THIS
      SEPARATION BECAUSE ONLY THE PARTIAL-WAVE ANALYSES ISOLATE THE F15 WAVE.
      SEE ALSO THE NOTE TO THE NEXT ENTRY.

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                    46  SIGMA(1915) MASS (MEV)

M          1920.0      (5.0)              KANE       74 DPWA    K-P TO PI SIG     12/81
M          1920.0      30.0               BAILLON    75 IPWA    KBAR N TO LAM PI 11/75
M        * 1914.0      10.0               HEMINGWA   75 DPWA  0 K- P TO KBAR N   11/75
M          1920.0      15.0       20.0    VANHORN    75 DPWA  0 K- P TO LAM PI0  11/75
M         (1915.0)                        BELLEFON   76 IPWA  0 K- P TO LAM PI    2/77
M     A    1900.0       4.0               CORDEN     76 DPWA  - K- N TO PI- LAM   2/77
M     A  PREFERRED SOLUTION 3, SEE CORDEN 76 FOR OTHER POSSIBLILITES.            2/77
M     A  CORDEN 76 INCLUDES THE DATA OF COX 70 AS A SUBSAMPLE
M     B    1894.0       5.0               CORDEN1    77       - K- N TO PI SIG   11/77
M     B    1909.0       5.0               CORDEN1    77       - K- N TO PI SIG   11/77
M     B  THE 2 ENTRIES FOR CORDEN177 ARE FROM 2 DIFFERENT ACCEPTABLE SLTNS.      11/77
M        NOT SEEN                         DECLAIS    77 DPWA    KBAR N TO KBAR N  1/78
M     C    1925. OR 1933.                 MARTIN     77 DPWA    KBAR N MULTICHNL 11/77
M     C  THE TWO ENTRIES FOR MARTIN 77 CORRESPOND TO EXTRACTION OF RESONANCE
M     C  PARAMETERS FROM THE T-MATRIX POLE AND FROM A B-W FIT, RESPECTIVELY.
M          1920.0      10.0               RLIC       77 DPWA    KBAR N MULTICHNL  1/76
M          1937.0      20.0               ALSTON     78 DPWA    KBAR N ELASTIC    1/78

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                    46  SIGMA(1915) WIDTH (MEV)

W           162.0     (25.0)              KANE       74 DPWA    K-P TO PI SIG     12/81
W            70.0      20.0               BAILLON    75 IPWA    KBAR N TO LAM PI 11/75
W            85.0      15.0               HEMINGWA   75 DPWA  0 K- P TO KBAR N   11/75
W           102.0      18.0               VANHORN    75 DPWA  0 K- P TO LAM PI0  11/75
W           (60.0)                        BELLEFON   76 IPWA  0 K- P TO LAM PI    2/77
W     A      75.0      14.0               CORDEN     76 DPWA  - K- N TO PI- LAM   2/77
W     B     107.0      14.0               CORDEN1    77       - K- N TO PI SIG   11/77
W     B      85.0      13.0               CORDEN1    77       - K- N TO PI SIG   11/77
W     C     171. OR 173.                  MARTIN     77 DPWA    KBAR N MULTICHNL 11/77
W           130.0      10.0               RLIC       77 DPWA    KBAR N MULTICHNL  1/76
W           161.0      20.0               ALSTON     78 DPWA    KBAR N ELASTIC    1/78

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                    46  SIGMA(1915) PARTIAL DECAY MODES

                                                               DECAY MASSES
P1      SIGMA(1915) INTO N KBAR                               938+ 494
P2      SIGMA(1915) INTO LAMBDA PI                           1116+ 140
P3      SIGMA(1915) INTO SIGMA PI                            1189+ 140
P4      SIGMA(1915) INTO SIGMA(1385) PI, P-WAVE              1385+ 140
P5      SIGMA(1915) INTO SIGMA(1385) PI, F-WAVE              1385+ 140

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                    46  SIGMA(1915) BRANCHING RATIOS

R1      SIGMA(1915) INTO (N KBAR)/TOTAL                      (P1)
R1            0.11      (0.04)            HEMINGWA   75 DPWA  0 K- P TO KBAR N   11/75
R1    C       0.08 OR  0.08               MARTIN     77 DPWA    KBAR N MULTICHNL 11/77
R1    D      (0.05)    (0.03)             RLIC       77 DPWA    KBAR N MULTICHNL  1/76
R1    D  (N KBAR)/TOTAL FROM RLIC 77 IS SUPERSEDED BY GOPAL 80.
R1            0.14      (0.05)            ALSTON     78 DPWA    KBAR N ELASTIC    1/78
R1    E       0.03      (0.02)            GOPAL      80 DPWA    KBAR N ELASTIC   12/81
R1    E  MASS AND WIDTH FIXED TO RLIC 77 VALUES DUE TO LOW ELASTICITY.           12/81

R2      SIGMA(1915) FROM N KBAR TO LAMBDA PI                SQRT(P1*P2)
R2           -0.087     (0.056)           DEVENISH   74       0 FIXED T DISP REL  4/75
R2           -0.06      (0.02)            BAILLON    75 IPWA    KBAR N TO LAM PI 11/75
R2           -0.09      (0.02)            VANHORN    75 DPWA  0 K- P TO LAM PI0  11/75
R2          (-0.10)                       BELLEFON   76 IPWA  0 K- P TO LAM PI    2/77
R2    A      -0.10       0.01             CORDEN     76 DPWA  - K- N TO PI- LAM   2/77
R2    C      -0.09 OR -0.09               MARTIN     77 DPWA    KBAR N MULTICHNL 11/77
R2           -0.09      (0.03)            RLIC       77 DPWA    KBAR N MULTICHNL  1/76

R3      SIGMA(1915) FROM N KBAR TO SIGMA PI                 SQRT(P1*P3)
R3           -0.16      (0.03)            KANE       74 DPWA    K-P TO PI SIG     12/81
R3    B      -0.17       0.01             CORDEN1    77       - K- N TO PI SIG   11/77
R3    B      -0.15       0.02             CORDEN1    77       - K- N TO PI SIG   11/77
R3    C      -0.05 OR -0.05               MARTIN     77 DPWA    KBAR N MULTICHNL 11/77
R3           -0.19      (0.03)            RLIC       77 DPWA    KBAR N MULTICHNL  1/76
R3              . . . . . . . . . .
R3  AVG MOD   0.1660    0.0089   AVERAGE

R4      SIGMA(1915) FROM N KBAR TO SIGMA(1385) PI, P-WAVESQRT(P1*P4)
R4           LESS THAN 0.01               CAMERON    78 DPWA  0 K-P TO S(1385)PI  1/78

R5      SIGMA(1915) FROM N KBAR TO SIGMA(1385) PI, F-WAVESQRT(P1*P5)
R5    F     +0.039      0.009             CAMERON    78 DPWA  0 K-P TO S(1385)PI  1/78
R5    F  THE SIGN IS CHANGED TO BE IN ACCORD WITH THE BARYON-FIRST               12/79
R5    F  CONVENTION.                                                             12/79

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REFERENCES FOR SIGMA(1915)


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SMART    66 PRL 17 556        W M SMART,A KERNAN,G E KALMUS,R P ELY (LRL)IJP
ARMENTER 67 PL 24B 198        ARMENTEROS,FERRO-LUZZI+      (CERN+HEID+SACL)
ARMENTE1 67 NP B3 592         ARMENTEROS,FERRO-LUZZI+      (CERN+HEID+SACL)
CONFORTO 68 NP B8 265         +HARMSEN, LASINSKI, +              (CHIC+HEID)
SMART    68 PR 169 1330       W M SMART                                 (LRL)IJP

BERTHON  70 NP B20 476        +RANGAN, VRANA,          +  (CDEF+RHEL+SACL)IJP
BERTHON1 70 NP B24 417        +VRANA, BUTTERWORTH, +      (CDEF+RHEL+SACL)IJ
BRICMAN1 70 PL 33B 511        +FERRO-LUZZI,LAGNAUX                    (CERN)
COX      70 NP B19 61         +ISLAM, COLLEY, +      (BIRM+EDIN+GLAS+LOIC)IJP
GALTIERI 70 DUKE CONF 173     A BARBARO-GALTIERI                        (LRL)IJP
LITCHFIE 70 NP B22 269        P J LITCHFIELD                           (RHEL)IJP

CONFORTO 71 NP  B34  41       +LEVI SETTI,LASINSKI..OBERLACK++ (EFI+HEID)IJP
LITCHFIE 71 NP  B30 125       LITCHFIELD,...+LESQUOY,+.. (RHEL+CDEF+SACL)IJP
KANE     72 PR D5 1583        D F KANE                                  (LBL)IJP
DEVENISH 74 NP B81 330        DEVENISH,FROGGATT,MARTIN    (DESY+NORD+LOUC)
KANE     74  LBL-2452         D F KANE                                  (LBL)IJP

BAILLON  75 NP B94 39         P BAILLON, P J LITCHFIELD           (CERN+RHEL)IJP
HEMINGWA 75 NP B91 12         HEMINGWAY,EADES,HARMSEN+    (CERN+HEID+MPIM)IJP
VANHORN  75 NP B87 145        A J VAN HORN                              (LBL)IJP
    ALSO 75 NP B87 157        A J VAN HORN                              (LBL)IJP

BELLEFON 76 NP B109 129       DE BELLEFON,BERTHON                      (CDEF)IJP
CORDEN   76 NP B104 382       +COX,DARTNELL,KENYON,ONEALE,SUMOROK+ (BIRM)IJP

CORDEN1  77 NP B125 61        +COX,KENYON,ONEALE,STUBBS,SUMOROK+    (BIRM)IJP
DECLAIS  77  CERN 77-16       +DUCHON,LOUVEL,PATRY,SEGUINOT+  (CAEN+CERN)IJP
MARTIN   77 NP B127 349       MARTIN,PIDCOCK,MOORHOUSE            (LOUC+GLAS)IJP
    ALSO 77 NP B126 266       MARTIN,PIDCOCK                           (LOUC)
    ALSO 77 NP B126 285       MARTIN,PIDCOCK                           (LOUC)IJP
RLIC     77 NP B119 362       GOPAL,ROSS,VAN HORN,MCPHERSON+  (LOIC+RHEL)IJP
ALSTON   78 PR D18 182        +KENNEY,POLLARD,ROSS+          (LBL+MTHO+CERN)IJP
    ALSO 77 PRL 38 1007       ALSTON-GARNJOST,KENNEY,+       (LBL+MTHO+CERN)IJP
CAMERON  78 NP B143 189       +FRANEK,GOPAL,BACON,BUTTERWORTH+(RHEL+LOIC)IJP
GOPAL    80  TORONTO CONF 159 G P GOPAL                                (RHEL)IJP
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1915 MEV REGION – PRODUCTION AND σ_{TOTAL} EXP'TS

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                    29  SIGMA(1915, JP=    ) I=1     PRODUCTION EXPERIMENTS

                    SEE THE NOTES TO THE SIGMA(1915) AND SIGMA(1940), WHICH
                    IMMEDIATELY PRECEDE AND FOLLOW THIS ENTRY.  HERE WE
                    LIST ONLY PARAMETERS OF PEAKS SEEN IN CROSS SECTIONS
      AND INVARIANT-MASS DISTRIBUTIONS.  THE CROSS-SECTION PEAKS ARE ALMOST
      CERTAINLY ASSOCIATED WITH THE F15 SIGMA(1915) SEEN IN PARTIAL-WAVE
      ANALYSES.  THE INVARIANT-MASS PEAKS SEEM MORE LIKELY TO BE ASSOCIATED
      WITH THE D13 SIGMA(1940).

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                    29  SIGMA(1915) MASS (MEV) (PROD. EXP.)

M          CROSS-SECTION PEAKS --
M            1905.0       5.0             BUGG       68 CNTR    K-P, D TOTAL     11/66
M            1906.0       6.0             BRICMAN    70 CNTR  0 TOTAL AND CH EX   6/70
M            1912.0      10.0             COOL       70 CNTR    K-P, D TOTAL     10/70
M          INVARIANT-MASS-DISTRIBUTION PEAKS --
M          (1942.0)     (9.0)             BOCK       65 HBC     PBAR P 5.7 GEV/C
M            1940.0      11.0             AGUILAR    70 HBC  +  3.9-4.6 GEV/C K-  5/70
M         42 1979.0      14.0             BRIEFEL    77 HBC  +  XI K MODE 2.9K-P  1/78
M     B  200(1910.0)    (17.0)            FERRER     81 OMEG -  PI-P 9,12 GEV/C   2/82
M     B   BACKWARD PRODUCTION IN LAMBDA PI- K+ FINAL STATE.
M          ELASTIC DCS --                                                         2/73
M     1      1931.0   9.0                 DADO       72 HBC   0 K-P ELSTC DCS     2/73
M     1   G7 INDICATED BY LEGENDRE COEFFS.,G9 NOT RULED OUT.                      2/73

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                    29  SIGMA(1915) WIDTH (MEV) (PROD. EXP.)

W          CROSS-SECTION PEAKS --
W             60.0       10.0             BUGG       68 CNTR                     11/66
W             50.0       12.0             BRICMAN    70 CNTR  0 TOTAL AND CH EX   6/70
W            (30.0)                       COOL       70 CNTR    K-P, D TOTAL     10/70
W          INVARIANT-MASS-DISTRIBUTION PEAKS --
W            (36.0)    (20.0)    (36.0)   BOCK       65 HBC
W             90.0      20.0              AGUILAR    70 HBC  +  3.9-4.6 GEV/C K-  5/70
W        42   69.0      32.0              BRIEFEL    77 HBC  +  XI K MODE 2.9K-P  1/78
W     B  200  (87.0)   (25.0)             FERRER     81 OMEG -  PI-P 9,12 GEV/C   2/82
W          ELASTIC DCS --                                                         2/73
W     1       70.0      14.0              DADO       72 HBC   0 K-P ELSTC DCS     2/73

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Baryons

Σ(1915), Σ(1940), Σ(2000)

Data Card Listings

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                    29  SIGMA(1915) PARTIAL DECAY MODES (PROD. EXP.)

                                                              DECAY MASSES
P1      SIGMA(1915) INTO N KBAR                              938+ 494
P2      SIGMA(1915) INTO LAMBDA PI                          1116+ 135
P3      SIGMA(1915) INTO SIGMA PI                           1189+ 140
P4      SIGMA(1915) INTO XI K                               1315+ 494

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                    29  SIGMA(1915) BRANCHING RATIOS (PROD. EXP.)

R1      SIGMA(1915) INTO (N KBAR)/TOTAL                    (P1)
R1         THESE VALUES OF ELASTICITIES ASSUME J=5/2 --
R1            0.06                    BUGG      68 CNTR    ASSUMING J=5/2    6/68
R1            0.07      0.02          BRICMAN   70 CNTR  0 TOTAL AND CN EX   6/70
R1            0.07                    COOL      70 CNTR    K-P, D TOTAL     10/70
R1    1  THIS ELASTICITY ASSUMES J=7/2                                        2/73
R1    1       0.62      0.08          DADO      72 HBC   0 K-P ELSTC DCS     2/73
R1          . . . . . . . . . .
R1  AVG       0.10      0.13     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 6.7)

R2      SIGMA(1915) INTO (N KBAR)/(SIGMA PI)               (P1)/(P3)
R2            (0.37) OR LESS          BARNES    69 HBC  +  1 STAN. DEV.     10/69

R3      SIGMA(1915) INTO (LAMBDA PI)/(SIGMA PI)            (P2)/(P3)
R3            (0.28) OR LESS          BARNES    69 HBC  +  1 STAN. DEV.     10/69

R4      SIGMA(1915) INTO (XI K)/TOTAL                      (P4)
R4       42   SEEN                   BRIEFEL   77 HBC  +  K-P 2.87 GEV      1/78

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                          REFERENCES FOR SIGMA(1915) (PROD. EXP.)

BOCK      65 PL 17 166          +COOPER,FRENCH,KINSON, +          (CERN+SACL) I
COOL      66 PRL 16 1228        +GIACOMELLI,KYCIA,LEONTIC,LI,LUNDBY,+ (BNL) I
    SUPERSEDED BY COOL 70.
BUGG      68 PR 168 1466        +GILMORE,KNIGHT,DAVIES+     (BIRM+CAVE+RHEL)I
PRIMER    68 PRL 20 610         +GOLDBERG,JAEGER,BARNES,DORNAN + (SYRA+BNL)
    SUPERSEDED BY BARNES 69 AND AGUILAR-BENITEZ 70.
BARNES    69 PRL 22 479         +FLAMINIO,MONTANET,SAMIOS +       (BNL+SYRA)

AGUILAR   70 PRL 25 58          AGUILAR-BENITEZ, BARNES, +        (BNL+SYRA)
BRICMAN   70 PL 31B 152         +FERRO LUZZI, PERREAU,+    (CERN+CAEN+SACL)
COOL      70 PR D1 1887         +GIACOMELLI, KYCIA, LEONTIC, LI, +     (BNL) I
DADO      72 PRL 29 1695        +BIRMAN,GOLDBERG,WEISS             (HAIF)JP
BRIEFEL   77 PRD 16 2706        +GOUREVITCH,CHANG+     (BRAN+UMD+SYRA+TUFT)
FERRER    81 NP B178 373        +TREILLE,RIVET,VOLTE+ (CERN+CDEF+EPOL+LALO)

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Σ(1940) D_{13}''' Status: ***

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                    98  SIGMA(1940, JP=3/2-) I=1       D'''13

                    FOR RESULTS PUBLISHED BEFORE 1974 (THEY ARE
                    NOW OBSOLETE), SEE OUR 1982 EDITION (PHYSICS LETTERS
                    111B).  ALL THE REFERENCES HAVE BEEN RETAINED.

                    SOME, NOT ALL, PARTIAL WAVE ANALYSES SUGGEST A STATE IN
                    THIS REGION.  IT IS PERHAPS ASSOCIATED WITH THE BUMPS
                    SEEN IN PRODUCTION EXPERIMENTS NEAR THIS MASS (SEE THE
                    PRECEDING ENTRY).  THIS STATE IS NOT REQUIRED IN
                    K- NEUTRON TO (PI SIGMA)- ANALYSIS OF GOYAL 77.  KBAR N
                    ANALYSIS (GOPAL 80) WITH K- NEUTRON ELASTIC DATA
                    DOES NOT REQUIRE THIS STATE.

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                    98  SIGMA(1940) MASS (MEV)

M          1935.0    (80.0)           KANE      74 DPWA    K-P TO PI SIG    12/81
M          1940.0     20.0            LITCHFI2  74 DPWA  0 K-P TO L(1520)PI 10/74
M          1950.0     20.0            LITCHFI3  74 DPWA  0 K-P TO KBAR DEL  10/74
M          1950.0     30.0            BAILLON   75 IPWA    KBAR N TO LAM PI 11/75
M          1949.0     40.0      60.0  VANHORN   75 DPWA  0 K- P TO LAM PIO  11/75
M   A     (1940.0)                    BELLEFON  76 IPWA  0 K- P TO LAM PI    2/77
M   A   SLIGHT BUMP IN MODULUS OF F7 WAVE.                                   2/77
M    B     1886. OR 1893.             MARTIN    77 DPWA    KBAR N MULTICHNL 11/77
M    B  THE TWO ENTRIES FOR MARTIN 77 CORRESPOND TO EXTRACTION OF RESONANCE
M    B  PARAMETERS FROM THE T-MATRIX POLE AND FROM A B-W FIT, RESPECTIVELY.
M          1920.0     50.0            RLIC      77 DPWA    KBAR N MULTICHNL  1/76

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                    98  SIGMA(1940) WIDTH (MEV)

W           330.0    (80.0)           KANE      74 DPWA    K-P TO PI SIG    12/81
W            60.0     20.0            LITCHFI2  74 DPWA  0 K-P TO L(1520)PI 10/74
W            70.0     30.0      20.0  LITCHFI3  74 DPWA  0 K-P TO KBAR DEL  10/74
W           150.0     75.0            BAILLON   75 IPWA    KBAR N TO LAM PI 11/75
W           160.0     70.0      40.0  VANHORN   75 DPWA  0 K- P TO LAM PIO  11/75
W    B      157. OR 159.              MARTIN    77 DPWA    KBAR N MULTICHNL 11/77
W           300.0     80.0            RLIC      77 DPWA    KBAR N MULTICHNL  1/76
W           170.0     25.0            CAMERON2  78 DPWA    K-P TO K*(892) N 12/79

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                    98  SIGMA(1940) PARTIAL DECAY MODES

                                                              DECAY MASSES
P1      SIGMA(1940) INTO N KBAR                              938+ 494
P2      SIGMA(1940) INTO LAMBDA PI                          1116+ 140
P3      SIGMA(1940) INTO SIGMA PI                           1189+ 140
P4      SIGMA(1940) INTO LAMBDA(1520) PI, P-WAVE            1520+ 135
P5      SIGMA(1940) INTO LAMBDA(1520) PI, F-WAVE            1520+ 135
P6      SIGMA(1940) INTO DELTA(1232) KBAR, S-WAVE           1232+ 494
P7      SIGMA(1940) INTO DELTA(1232) KBAR, D-WAVE           1232+ 494
P8      SIGMA(1940) INTO SIGMA(1385) PI, S-WAVE             1385+ 140
P9      SIGMA(1940) INTO N K*(892), S3 WAVE                  940+ 892

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                    98  SIGMA(1940) BRANCHING RATIOS

R1      SIGMA(1940) INTO (N KBAR)/TOTAL                    (P1)
R1   B        0.14 OR  0.13           MARTIN    77 DPWA    KBAR N MULTICHNL 11/77
R1          LESS THAN 0.04            RLIC      77 DPWA    KBAR N MULTICHNL  1/76
R1      NO SIGNAL FOR THIS STATE WITH X LARGER THAN ABOUT 0.03 IN THE        11/75
R1      ANALYSIS OF HEMINGWAY 75.                                            11/75

R2      SIGMA(1940) FROM N KBAR TO LAMBDA PI               SQRT(P1*P2)
R2          -0.153     0.070          DEVENISH  74        0 FIXED T DISP REL  4/75
R2          -0.04      0.02           BAILLON   75 IPWA    KBAR N TO LAM PI 11/75
R2          -0.05      0.03      0.02 VANHORN   75 DPWA  0 K-P TO LAM PIO   11/75
R2   B      -0.15 OR -0.14            MARTIN    77 DPWA    KBAR N MULTICHNL 11/77
R2          -0.06      0.03           RLIC      77 DPWA    KBAR N MULTICHNL  1/76

R3      SIGMA(1940) FROM N KBAR TO SIGMA PI                SQRT(P1*P3)
R3          -0.14    (0.04)           KANE      74 DPWA    K-P TO PI SIG    12/81
R3   B      +0.16 OR +0.16            MARTIN    77 DPWA    KBAR N MULTICHNL 11/77
R3          -0.08      0.04           RLIC      77 DPWA    KBAR N MULTICHNL  1/76

R4      SIGMA(1940) FROM N KBAR TO LAMBDA(1520) PI P-WAVESQRT(P1*P4)
R4   C      -0.11      0.04           LITCHFI2  74 DPWA  0 K-P TO L(1520)PI 10/74
R4   C  ASSUMES LAMBDA(1520) ELASTICITY=.45,SIGN RLTV. TO SIG(2030) DECAY.  10/74
R4   D      LESS THAN 0.03            CAMERON   77 DPWA  0 K-P TO L(1520)PI  1/78
R4   D  ASSUMES LAMBDA(1520) ELASTICITY=.46.                                 1/78

R5      SIGMA(1940) FROM N KBAR TO LAMBDA(1520) PI F-WAVESQRT(P1*P5)
R5   C      -0.08      0.04           LITCHFI2  74 DPWA  0 K-P TO L(1520)PI 10/74
R5   D       0.062     0.021          CAMERON   77 DPWA  0 K-P TO L(1520)PI  1/78

R6      SIGMA(1940) FROM N KBAR TO DEL(1232) KBAR,S-WAVE SQRT(P1*P6)
R6   E      -0.16      0.05           LITCHFI3  74 DPWA  0 K-P TO KBAR DEL  10/74
R6   E  SIGN RELATIVE TO SIGMA(2030) DECAY                                  10/74

R7      SIGMA(1940) FROM N KBAR TO DEL(1232) KBAR,D-WAVE SQRT(P1*P7)
R7   E      -0.14      0.05           LITCHFI3  74 DPWA  0 K-P TO KBAR DEL  10/74

R8      SIGMA(1940) FROM N KBAR TO SIGMA(1385) PI, S-WAVESQRT(P1*P8)
R8   F      +0.066     0.025          CAMERON   78 DPWA  0 K-P TO S(1385)PI  1/78
R8   F  SIGN CHANGED TO BE IN ACCORD WITH THE BARYON-FIRST CONVENTION.      12/79

R9      SIGMA(1940) FROM N KBAR TO N K*(892), S3 WAVE    SQRT(P1*P9)
R9   G      -0.09      0.02           CAMERON2  78 DPWA    K-P TO K*N       12/79
R9   G  UPPER LIMITS ON THE D1 AND D3 WAVES ARE EACH 0.03.                  12/79

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                          REFERENCES FOR SIGMA(1940)

GALTIERI 70 DUKE CONF 173     A BARBARO-GALTIERI                     (LRL)IJP
LITCHFIE 70 NP B22 269        P J LITCHFIELD                        (RHEL)IJP
KANE     72 PR D5 1583        D F KANE                               (LBL)IJP
LEA      73 NP B56 77         +MARTIN,MOORHOUSE+    (RHEL+LOUC+GLAS+AARH)IJP

DEVENISH 74 NP B81 330        DEVENISH,FROGGATT,MARTIN   (DESY+NORD+LOUC)
KANE     74  LBL-2452         D F KANE                               (LBL)IJP
LITCHFI2 74 NP B74 19         LITCHFIELD,HEMINGWAY,BAILLON,+  (CERN+HEID)IJP
LITCHFI3 74 NP B74 39         LITCHFIELD,HEMINGWAY,BAILLON,+  (CERN+HEID)IJP

BAILLON  75 NP B94 39         P BAILLON, P J LITCHFIELD       (CERN+RHEL)IJP
HEMINGWA 75 NP B91 12         HEMINGWAY,EADES,HARMSEN+   (CERN+HEID+MPIM)IJP
VANHORN  75 NP B87 145        A J VAN HORN                           (LBL)IJP
    ALSO 75 NP B87 157        A J VAN HORN                           (LBL)IJP

BELLEFON 76 NP B109 129       DE BELLEFON,BERTHON                   (CDEF)IJP
CAMERON  77 NP B131 399       +FRANEK,GOPAL,KALMUS,MCPHERSON+ (RHEL+LOIC)IJP
GOYAL    77 PR D16 2746       +SODHI                                 (DELH)
MARTIN   77 NP B127 349       MARTIN,PIDCOCK,MOORHOUSE         (LOUC+GLAS)IJP
    ALSO 77 NP B126 266       MARTIN,PIDCOCK                         (LOUC)
    ALSO 77 NP B126 285       MARTIN,PIDCOCK                         (LOUC)IJP
RLIC     77 NP B119 362       GOPAL,ROSS,VAN HORN,MCPHERSON+  (LOIC+RHEL)IJP
CAMERON  78 NP B143 189       +FRANEK,GOPAL,BACON,BUTTERWORTH+(RHEL+LOIC)IJP
CAMERON2 78 NP B146 327       +FRANEK,GOPAL,KALMUS,MCPHERSON,+(RHEL+LOIC)IJP

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Σ(2000) S_{11}''' Status: *

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                    02  SIGMA(2000, JP=1/2-) I=1       S'''11

                    WE LIST HERE ALL REPORTED S11 STATES LYING ABOVE
                    THE SIGMA(1750).

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                    02  SIGMA(2000) MASS (MEV)

M          2004.0     40.0           VANHORN   75 DPWA  0 K-P TO LAM PIO   11/75
M    1     1755. OR 1834.            MARTIN    77 DPWA    KBAR N MULTICHNL 11/77
M    1  THE TWO ENTRIES FOR MARTIN 77 CORRESPOND TO EXTRACTION OF RESONANCE
M    1  PARAMETERS FROM THE T-MATRIX POLE AND FROM A B-W FIT, RESPECTIVELY.
M          1955.0     15.0           RLIC      77 DPWA    KBAR N MULTICHNL  1/76
M          1944.0    (15.0)          GOPAL     80 DPWA    KBAR N ELASTIC   12/81

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                    02  SIGMA(2000) WIDTH (MEV)

W           116.0     40.0           VANHORN   75 DPWA  0 K-P TO LAM PIO   11/75
W    1      413. OR 450.              MARTIN    77 DPWA    KBAR N MULTICHNL 11/77
W           170.0     40.0           RLIC      77 DPWA    KBAR N MULTICHNL  1/76
W           215.0    (25.0)          GOPAL     80 DPWA    KBAR N ELASTIC   12/81

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                    02  SIGMA(2000) PARTIAL DECAY MODES

                                                              DECAY MASSES
P1      SIGMA(2000) INTO N KBAR                              938+ 494
P2      SIGMA(2000) INTO LAMBDA PI                          1116+ 135
P3      SIGMA(2000) INTO SIGMA PI                           1197+ 140
P4      SIGMA(2000) INTO LAMBDA(1520) PI                    1520+ 140
P5      SIGMA(2000) INTO N K*(892), S1 WAVE                  940+ 892
P6      SIGMA(2000) INTO N K*(892), D3 WAVE                  940+ 892

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                    02  SIGMA(2000) BRANCHING RATIOS

R1      SIGMA(2000) INTO (N KBAR)/TOTAL                    (P1)
R1   1       0.62 OR  0.57           MARTIN    77 DPWA    KBAR N MULTICHNL 11/77
R1   C      (0.44)   (0.05)          RLIC      77 DPWA    KBAR N MULTICHNL  1/76
R1   C  (N KBAR)/TOTAL FROM RLIC 77 IS SUPERSEDED BY GOPAL 80.
R1          0.51     (0.05)          GOPAL     80 DPWA    KBAR N ELASTIC   12/81

R2      SIGMA(2000) FROM N KBAR TO LAMBDA PI               SQRT(P1*P2)
R2        NOT SEEN                   BAILLON   75 IPWA    KBAR N TO LAM PI 11/75
R2          +0.07      0.02      0.01 VANHORN   75 DPWA  0 K-P TO LAM PIO   11/75
R2   1      -0.19 OR -0.18            MARTIN    77 DPWA    KBAR N MULTICHNL 11/77
R2           0.08      0.03           RLIC      77 DPWA    KBAR N MULTICHNL  1/76
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For notation, see key at front of Listings.

Baryons

Σ(2000), Σ(2030)

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R3     SIGMA(2000) FROM N KBAR TO SIGMA PI                SQRT(P1*P3)
R3   1       +0.26 OR +0.24          MARTIN    77 DPWA    KBAR N MULTICHNL 11/77
R3           +0.20     0.04          RLIC      77 DPWA    KBAR N MULTICHNL  1/76

R4     SIGMA(2000) FROM N KBAR TO LAMBDA(1520) PI         SQRT(P1*P4)
R4   2       +0.081    0.021         CAMERON   77 DPWA  0 P-WAVE DECAY      1/78
R4   2  ASSUMES LAMBDA(1520) ELASTICITY=0.46.  THE SIGN IS CHANGED HERE TO  12/79
R4   2  BE IN ACCORD WITH THE BARYON-FIRST CONVENTION.                      12/79

R5     SIGMA(2000) FROM N KBAR TO N K*(892), S1 WAVE      SQRT(P1*P5)
R5   3       +0.10     0.02          CAMERON2  78 DPWA    K-P TO K*N       12/79
R5   3  THE SIGN HERE IS CHANGED TO BE IN ACCORD WITH THE BARYON-FIRST      12/79
R5   3  CONVENTION.                                                         12/79

R6     SIGMA(2000) FROM N KBAR TO N K*(892), D3 WAVE      SQRT(P1*P6)
R6           -0.07     0.03          CAMERON2  78 DPWA    K-P TO K*N       12/79

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                          REFERENCES FOR SIGMA(2000)

BAILLON  75 NP B94 39          P BAILLON, P J LITCHFIELD        (CERN+RHEL)IJP
VANHORN  75 NP B87 145         A J VAN HORN                          (LBL)IJP
    ALSO 75 NP B87 157         A J VAN HORN                          (LBL)IJP

CAMERON  77 NP B131 399        +FRANEK,GOPAL,KALMUS,MCPHERSON+ (RHEL+LOIC)IJP
MARTIN   77 NP B127 349        MARTIN,PIDCOCK,MOORHOUSE        (LOUC+GLAS)IJP
    ALSO 77 NP B126 266        MARTIN,PIDCOCK                       (LOUC)
    ALSO 77 NP B126 285        MARTIN,PIDCOCK                       (LOUC)IJP
RLIC     77 NP B119 362        GOPAL,ROSS,VAN HORN,MCPHERSON+  (LOIC+RHEL)IJP
CAMERON2 78 NP B146 327        +FRANEK,GOPAL,KALMUS,MCPHERSON,+(RHEL+LOIC)IJP
GOPAL    80  TORONTO CONF 159 G P GOPAL                         (RHEL)IJP

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Σ(2030) F_{17} Status: ****

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                 47  SIGMA(2030, JP=7/2+) I=1        F17

                 FOR MOST RESULTS PUBLISHED BEFORE 1974 (THEY ARE
                 NOW OBSOLETE), SEE OUR 1982 EDITION (PHYSICS LETTERS
                 111B).  ALL THE REFERENCES HAVE BEEN RETAINED.

                 THIS ENTRY ONLY INCLUDES RESULTS FROM PARTIAL-WAVE
                 ANALYSES.  PARAMETERS OF PEAKS SEEN IN CROSS SECTIONS
                 AND INVARIANT-MASS DISTRIBUTIONS AROUND 2030 MEV ARE
                 GIVEN IN THE NEXT ENTRY.

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                 47  SIGMA(2030) MASS (MEV)

M          2020.0     (6.0)          KANE      74 DPWA    K-P TO PI SIG    12/81
M          2025.0     10.0           LITCHFI1  74 DPWA  0 K-P TO L(1820)PI 10/74
M          2035.0     10.0           LITCHFI2  74 DPWA  0 K-P TO L(1520)PI 10/74
M          2020.0     30.0           LITCHFI3  74 DPWA  0 K-P TO KBAR DEL  10/74
M          2035.0     15.0           BAILLON   75 IPWA    KBAR N TO LAM PI 11/75
M          2038.0     10.0           HEMINGWA  75 DPWA  0 K- P TO KBAR N   11/75
M          2042.0     11.0           VANHORN   75 DPWA  0 K-P TO LAM PIO   11/75
M         (2030.0)                   BELLEFON  76 IPWA  0 K- P TO LAM PI   2/77
M    A     2030.0      3.0           CORDEN    76 DPWA  - K- N TO PI- LAM  2/77
M    A  PREFERRED SOLUTION 3, SEE CORDEN 76 FOR OTHER POSSIBILITIES.       2/77
M          2038.0     10.0           CORDEN2   77       - K- N TO K* N    11/77
M          2027. TO 2057.            GOYAL     77 DPWA  - K- N TO SIG PI   1/78
M          2040.0      5.0           RLIC      77 DPWA    KBAR N MULTICHNL  1/76
M          2036.0     (5.0)          GOPAL     80 DPWA    KBAR N ELASTIC   12/81

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                 47  SIGMA(2030) WIDTH (MEV)

W           111.0     (5.0)          KANE      74 DPWA    K-P TO PI SIG    12/81
W            70. TO  125.            LITCHFI1  74 DPWA  0 K-P TO L(1820)PI 10/74
W           160.0     20.0           LITCHFI2  74 DPWA  0 K-P TO L(1520)PI 10/74
W           200.0     30.0           LITCHFI3  74 DPWA  0 K-P TO KBAR DEL  10/74
W           180.0     20.0           BAILLON   75 IPWA    KBAR N TO LAM PI 11/75
W           172.0     15.0           HEMINGWA  75 DPWA  0 K- P TO KBAR N   11/75
W           178.0     13.0           VANHORN   75 DPWA  0 K-P TO LAM PIO   11/75
W          (160.0)                   BELLEFON  76 IPWA  0 K- P TO LAM PI   2/77
W    A     201.0      9.0           CORDEN    76 DPWA  - K- N TO PI- LAM  2/77
W           137.0     40.0           CORDEN2   77       - K- N TO K* N    11/77
W          (260.0)                   DECLAIS   77 DPWA    KBAR N TO KBAR N  1/78
W           126. TO  195.            GOYAL     77 DPWA  - K- N TO SIG PI   1/78
W           190.0     10.0           RLIC      77 DPWA    KBAR N MULTICHNL  1/76
W           172.0    (10.0)          GOPAL     80 DPWA    KBAR N ELASTIC   12/81

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                 47  SIGMA(2030) PARTIAL DECAY MODES

                                                          DECAY MASSES
P1     SIGMA(2030) INTO N KBAR                            938+ 494
P2     SIGMA(2030) INTO LAMBDA PI                        1116+ 135
P3     SIGMA(2030) INTO SIGMA PI                         1189+ 140
P4     SIGMA(2030) INTO XI K                             1321+ 498
P5     SIGMA(2030) INTO LAMBDA(1820) PI, P-WAVE          1820+ 135
P6     SIGMA(2030) INTO LAMBDA(1520) PI, D-WAVE          1520+ 135
P7     SIGMA(2030) INTO LAMBDA(1520) PI, G-WAVE          1520+ 135
P8     SIGMA(2030) INTO DELTA(1232) KBAR, F-WAVE         1232+ 494
P9     SIGMA(2030) INTO DELTA(1232) KBAR, H-WAVE         1232+ 494
P10    SIGMA(2030) INTO SIGMA(1385) PI, F-WAVE           1385+ 140
P11    SIGMA(2030) INTO N K*(892), F1 WAVE                940+ 892
P12    SIGMA(2030) INTO N K*(892), F3 WAVE                940+ 892

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                 47  SIGMA(2030) BRANCHING RATIOS

R1     SIGMA(2030) INTO (N KBAR)/TOTAL                   (P1)
R1           0.18     0.03           HEMINGWA  75 DPWA  0 K- P TO KBAR N   11/75
R1          (0.15)                   DECLAIS   77 DPWA    KBAR N TO KBAR N  1/78
R1   B      (0.24)   (0.02)          RLIC      77 DPWA    KBAR N MULTICHNL  1/76
R1   B  (N KBAR)/TOTAL FROM RLIC 77 IS SUPERSEDED BY GOPAL 80.
R1           0.19    (0.03)          GOPAL     80 DPWA    KBAR N ELASTIC   12/81

R2     SIGMA(2030) FROM N KBAR TO LAMBDA PI               SQRT(P1*P2)
R2          +0.195    0.053          DEVENISH  74         0 FIXED T DISP REL  4/75
R2          +0.18     0.02           BAILLON   75 IPWA    KBAR N TO LAM PI 11/75
R2          +0.20     0.01           VANHORN   75 DPWA  0 K-P TO LAM PIO   11/75
R2         (0.20)                    BELLEFON  76 IPWA  0 K- P TO LAM PI   2/77
R2   A      +0.20     0.01           CORDEN    76 DPWA  - K- N TO PI- LAM  2/77
R2          +0.18     0.02           RLIC      77 DPWA    KBAR N MULTICHNL  1/76

R3     SIGMA(2030) FROM N KBAR TO SIGMA PI                SQRT(P1*P3)
R3          -0.10    (0.01)          KANE      74 DPWA    K-P TO PI SIG    12/81
R3   C      -0.09     0.01           CORDEN1   77       - K- N TO PI SIG   11/77
R3   C      -0.06     0.01           CORDEN1   77       - K- N TO PI SIG   11/77
R3   C  THE 2 ENTRIES FOR CORDEN177 ARE FROM 2 DIFFERENT ACCEPTABLE SLTNS.  11/77
R3   D     (-0.085)  (0.02)          GOYAL     77 DPWA  - K- N TO SIG PI    1/78
R3   D  THIS COUPLING IS EXTRACTED FROM UNNORMALIZED DATA.                  1/78
R3          -0.15     0.03           RLIC      77 DPWA    KBAR N MULTICHNL  1/76

R4     SIGMA(2030) FROM N KBAR TO XI K                    SQRT(P1*P4)
R4         (0.05) OR LESS            TRIPP     67 RVUE  0 K-P TO XI K        8/67
R4         (0.05) OR LESS            BURGUN    68 DPWA  0 K-P TO XI K       10/69
R4         (0.023)                   MULLER    69 DPWA  0                    7/70

R5     SIGMA(2030) FROM N KBAR TO LAMBDA(1820) PI P-WAVESQRT(P1*P5)
R5   E      0.18      0.04           LITCHFI1  74 DPWA  0 K-P TO L(1820)PI 10/74
R5   E  ASSUMES LAMBDA(1820) ELASTICITY=.6                                  10/74
R5          0.14      0.02           CORDEN2   75 DBC   - KBAR PI- NUCLEON 11/75
R5          . . . . . . . . .
R5  AVG     0.148     0.018   AVERAGE

R6     SIGMA(2030) FROM N KBAR TO LAMBDA(1520) PI D-WAVESQRT(P1*P6)
R6   F      0.14      0.03           LITCHFI2  74 DPWA  0 K-P TO L(1520)PI 10/74
R6   F  ASSUMES LAMBDA(1520) ELASTICITY=.45                                 10/74
R6   G     (0.10)    (0.03)          CORDEN2   75 DBC   - KBAR PI- NUCLEON 11/75
R6   G  UPPER LIMIT                                                         11/75
R6   H      +0.114    0.010          CAMERON   77 DPWA  0 K-P TO L(1520)PI  1/78
R6   H  ASSUMES LAMBDA(1520) ELASTICITY=.46.  THE SIGN IS CHANGED HERE TO   12/79
R6   H  BE IN ACCORD WITH THE BARYON-FIRST CONVENTION.                      12/79
R6          . . . . . . . . .
R6  AVG     0.1166    0.0095  AVERAGE

R7     SIGMA(2030) FROM N KBAR TO LAMBDA(1520) PI G-WAVESQRT(P1*P7)
R7   F      0.02      0.02           LITCHFI2  74 DPWA  0 K-P TO L(1520)PI 10/74
R7   H      +0.146    0.010          CAMERON   77 DPWA  0 K-P TO L(1520)PI  1/78
R7          . . . . . . . . .
R7  AVG     0.121     0.050   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 5.6)

R8     SIGMA(2030) FROM N KBAR TO DEL(1232) KBAR,F-WAVE SQRT(P1*P8)
R8          0.16      0.03           LITCHFI3  74 DPWA  0 K-P TO KBAR DEL  10/74
R8   G     (0.17)    (0.03)          CORDEN2   75 DBC   - KBAR PI- NUCLEON 11/75
R8   G  UPPER LIMIT                                                         11/75

R9     SIGMA(2030) FROM N KBAR TO DEL(1232) KBAR,H-WAVE SQRT(P1*P9)
R9          0.00      0.02           LITCHFI3  74 DPWA  0 K-P TO KBAR DEL  10/74

R10    SIGMA(2030) FROM N KBAR TO SIGMA(1385) PI, F-WAVESQRT(P1*P10)
R10  I      +0.153    0.026          CAMERON   78 DPWA  0 K-P TO S(1385)PI  1/78
R10  I  THE SIGN IS CHANGED HERE TO BE IN ACCORD WITH THE BARYON-FIRST      12/79
R10  I  CONVENTION.                                                         12/79

R11    SIGMA(2030) FROM N KBAR TO N K*(892), F1 WAVE     SQRT(P1*P11)
R11         -0.02     0.01           CORDEN2   77         K-D TO K*N       12/79
R11  J      +0.06     0.03           CAMERON2  78 DPWA    K-P TO K*N       12/79
R11  J  THE SIGN HERE IS CHANGED TO BE IN ACCORD WITH THE BARYON-FIRST      12/79
R11  J  CONVENTION.                                                         12/79
R11         . . . . . . . . .
R11 AVG MOD  0.024    0.012   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.3)

R12    SIGMA(2030) FROM N KBAR TO N K*(892), F3 WAVE     SQRT(P1*P12)
R12         -0.12     0.02           CORDEN2   77         K-D TO K*N       12/79
R12  K      +0.04     0.03           CAMERON2  78 DPWA    K-P TO K*N       12/79
R12  K  THE UPPER LIMIT ON THE G3 WAVE IS 0.03.                             12/79
R12         . . . . . . . . .
R12 AVG MOD  0.095    0.037   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 2.2)

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                          REFERENCES FOR SIGMA(2030)

WOHL     66 PRL 17 107         C G WOHL, F T SOLMITZ, M L STEVENSON  (LRL)IJP
TRIPP    67 NP B3 10           + LEITH, +      (LRL+SLAC+  CERN+HEID+SACL)
BURGUN   68 NP B8 447          +MEYER,PAULI,TALLINI +      (SACL+CDEF+RHEL)
DAUM     68 NP B7 19           +ERNE,LAGNAUX,SENS,STEUER,UDO         (CERN)JP
SMART    68 PR 169 1336        W M SMART                              (LRL)IJP
MULLER   69 THESIS,UCRL 19372 R A MULLER                              (LRL)

BERTHON  70 NP B20 476         +RANGAN, VRANA,       +    (CDEF+RHEL+SACL)IJP
BERTHON1 70 NP B24 417         +VRANA, BUTTERWORTH, +     (CDEF+RHEL+SACL)IJP
COX      70 NP B19 61          +ISLAM, COLLEY, +     (BIRM+EDIN+GLAS+LOIC)IJP
GALTIERI 70 DUKE CONF 173      A BARBARO-GALTIERI                     (LRL)IJP
LITCHFIE 70 NP B22 269         P J LITCHFIELD                        (RHEL)IJP

CAMPBELL 71 NP B25 75          +MORTON, NEGUS, GOYAL, MILLER   (GLAS+LOIC)IJP
LITCHFIE 71 NP  B30 125        LITCHFIELD,...+LESQUOY,+.. (RHEL+CDEF+SACL)IJP
KANE     72 PR D5 1583         D F KANE                               (LBL)IJP

DEVENISH 74 NP B81 330         DEVENISH,FROGGATT,MARTIN   (DESY+NORD+LOUC)
KANE     74  LBL-2452          D F KANE                               (LBL)IJP
LITCHFI1 74 NP B74 12          LITCHFIELD,HEMINGWAY,BAILLON,+  (CERN+HEID)IJP
LITCHFI2 74 NP B74 19          LITCHFIELD,HEMINGWAY,BAILLON,+  (CERN+HEID)IJP
LITCHFI3 74 NP B74 39          LITCHFIELD,HEMINGWAY,BAILLON,+  (CERN+HEID)IJP

BAILLON  75 NP B94 39          P BAILLON, P J LITCHFIELD        (CERN+RHEL)IJP
CORDEN2  75 NP B92 365         +COX,DARTNELL,KENYON,ONEALE,SUMOROK+ (BIRM)IJP
HEMINGWA 75 NP B91 12          HEMINGWAY,EADES,HARMSEN+   (CERN+HEID+MPIM)IJP
VANHORN  75 NP B87 145         A J VAN HORN                           (LBL)IJP
    ALSO 75 NP B87 157         A J VAN HORN                           (LBL)IJP
BELLEFON 76 NP B109 129        DE BELLEFON,BERTHON                   (CDEF)IJP
CORDEN   76 NP B104 382        +COX,DARTNELL,KENYON,ONEALE,SUMOROK+ (BIRM)IJP

CAMERON  77 NP B131 399        +FRANEK,GOPAL,KALMUS,MCPHERSON+ (RHEL+LOIC)IJP
CORDEN1  77 NP B125 61         +COX,KENYON,ONEALE,STUBBS,SUMOROK+   (BIRM)IJP
CORDEN2  77 NP B121 365        +COX,KENYON,ONEALE,STUBBS,SUMOROK+   (BIRM)IJP
DECLAIS  77  CERN 77-16        +DUCHON,LOUVEL,PATRY,SEGUINOT+  (CAEN+CERN)IJP
GOYAL    77 PRD 16 2746        D P GOYAL,A V SODHI                    (DELH)IJP
RLIC     77 NP B119 362        GOPAL,ROSS,VAN HORN,MCPHERSON+  (LOIC+RHEL)IJP
CAMERON  78 NP B143 189        +FRANEK,GOPAL,BACON,BUTTERWORTH+(RHEL+LOIC)IJP
CAMERON2 78 NP B146 327        +FRANEK,GOPAL,KALMUS,MCPHERSON,+(RHEL+LOIC)IJP
GOPAL    80  TORONTO CONF 159 G P GOPAL                         (RHEL)IJP

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Baryons

Σ(2030), Σ(2070), Σ(2080), Σ(2100)

Data Card Listings

2030 MEV REGION - PRODUCTION AND σ_{TOTAL} EXP'TS

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                    28  SIGMA(2030, JP=    ) I=1      PRODUCTION EXPERIMENTS

                    SEE THE NOTE ON THE F17 SIGMA(2030), IN FRONT OF THIS
                    ENTRY.  HERE WE LIST ONLY PARAMETERS OF PEAKS IN CROSS
                    SECTIONS AND INVARIANT-MASS DISTRIBUTIONS.  THE CROSS-
   SECTION PEAKS ARE AT LEAST DOMINANTLY ASSOCIATED WITH THE SIGMA(2030),
   BUT MAY CONTAIN A SMALL CONTRIBUTION FROM THE SUGGESTED BUT NOT ESTAB-
   LISHED OTHER RESONANCES IN THIS REGION.

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                    28  SIGMA(2030) MASS (MEV) (PROD. EXP.)

M         (2022.0)   (20.0)          BLANPIED  65 CNTR   0 GAMMA P TO K+ Y*
M          2020.0     7.0            BUGG      68 CNTR     K-P, D TOTAL      6/68
M          2049.0     4.0            BRICMAN   70 CNTR   0 TOTAL AND CH EX   6/70
M          2025.0    10.0            COOL      70 CNTR     K-P, D TOTAL     10/70
M         (2025.0)   (20.0)          LU        70 CNTR   0 GAMMA P TO K+ Y*  1/71

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                    28  SIGMA(2030) WIDTH (MEV) (PROD. EXP.)

W          (120.0)   (20.0)          BLANPIED  65 CNTR   0
W           130.0    10.0            BUGG      68 CNTR                       6/68
W           126.0    11.0            BRICMAN   70 CNTR   0 TOTAL AND CH EX   6/70
W           165.0                    COOL      70 CNTR     K-P, D TOTAL     10/70
W           (80.0)                   LU        70 CNTR   0 GAMMA P TO K+ Y*  1/71

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                    28  SIGMA(2030) PARTIAL DECAY MODES (PROD. EXP.)

                                                          DECAY MASSES
P1      SIGMA(2030) INTO N KBAR                          938+ 494
P2      SIGMA(2030) INTO N KBAR PI                       938+ 498+ 140

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                    28  SIGMA(2030) BRANCHING RATIOS (PROD. EXP.)

R1      SIGMA(2030) INTO (N KBAR)/TOTAL                  (P1)
R1         THESE VALUES OF ELASTICITIES ASSUME J=7/2 --
R1           0.131                  BUGG      68 CNTR                       6/68
R1           0.27     (0.02)        BRICMAN   70 CNTR   0 TOTAL AND CH EX   6/70
R1           0.12                   COOL      70 CNTR     K-P, D TOTAL     10/70

R2      SIGMA(2030) INTO (N KBAR PI)/TOTAL               (P2)
R2              SEEN                BOCK      HBC

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                    REFERENCES FOR SIGMA(2030) (PROD. EXP.)

BLANPIED 65 PRL 14 741          +GREENBERG,HUGHES,KITCHING,LU,+  (YALE+CEA)
COOL     66 PRL 16 1228         +GIACOMELLI,KYCIA,LEONTIC,LI,LUNDBY,+ (BNL) I
   SUPERSEDED BY COOL 70.
BUGG     68 PR 168 1466         +GILMORE,KNIGHT, +          (RHEL+BIRM+CAVE) I

BRICMAN  70 PL 31B 152          +FERRO LUZZI, PERREAU,+     (CERN+CAEN+SACL)
COOL     70 PR D1 1887          +GIACOMELLI, KYCIA, LEONTIC, LI, +    (BNL) I
LU       70 PR D2 1846          +GREENBERG, HUGHES, MINEHART, MORI,+ (YALE)

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Σ(2070) F''_{15} Status: *

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                    34  SIGMA(2070, JP=5/2+) I=1       F''15

                    THIS STATE SUGGESTED BY BERTHON 70 NOW FINDS
                    CONFIRMATION IN GOPAL 80 WITH NEW K-P POLARIZATION AND
                    K- NEUTRON ANGULAR DISTRIBUTIONS.  THE VERY BROAD STATE
                    SEEN IN KANE 72 IS NOT REQUIRED IN THE LATER (KANE 74)
                    ANALYSIS OF PI SIGMA.

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                    34  SIGMA(2070) MASS (MEV)

M         (2070.0)   (10.0)          BERTHON1  70 DPWA -  K- P TO SIG PI    1/71
M         (2057.0)                   KANE      72 DPWA    K-P TO SIGMA PI   1/73
M          2051.0    (25.0)          GOPAL     80 DPWA    KBAR N ELASTIC   12/81

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                    34  SIGMA(2070) WIDTH (MEV)

W          (140.0)   (20.0)          BERTHON1  70 DPWA -  K- P TO SIG PI    1/71
W          (906.0)                   KANE      72 DPWA    K-P TO SIGMA PI   1/73
W           300.0    (30.0)          GOPAL     80 DPWA    KBAR N ELASTIC   12/81

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                    34  SIGMA(2070) PARTIAL DECAY MODES

                                                          DECAY MASSES
P1      SIGMA(2070) INTO N KBAR                          938+ 494
P2      SIGMA(2070) INTO SIGMA PI                        1189+ 140

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                    34  SIGMA(2070) BRANCHING RATIOS

R1      SIGMA(2070) FROM N KBAR TO SIGMA PI              SQRT(P1*P2)
R1         (+0.12)   (0.02)          BERTHON1  70 DPWA -  K- P TO SIG PI    1/71
R1         (+0.104)                  KANE      72 DPWA    K-P TO SIGMA PI   1/73

R2      SIGMA(2070) INTO (N KBAR)/TOTAL                  (P1)
R2           0.08     (0.03)         GOPAL     80 DPWA    KBAR N ELASTIC   12/81

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                    REFERENCES FOR SIGMA(2070)

BERTHON1 70 NP B24 417          +VRANA,BUTTERWORTH,+        (CDEF+RHEL+SACL)IJP
KANE     72 PR D5 1583          D F KANE                          (LBL)
GOPAL    80  TORONTO CONF 159 G P GOPAL                          (RHEL)IJP

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Σ(2080) P'''_{13} Status: **

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                    88  SIGMA(2080, JP=3/2+) I=1       P'''13

                    SUCH A RESONANCE IS SUGGESTED BY SOME BUT NOT ALL
                    PARTIAL-WAVE ANALYSES ACROSS THIS REGION.  UNTIL THERE
                    IS MORE EVIDENCE, WE OMIT THIS STATE FROM THE MAIN
                    BARYON TABLE.

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                    88  SIGMA(2080) MASS (MEV)

M         (2082.0)   (4.0)           COX       70 DPWA -  K- N TO LAM PI    6/70
M         (2070.0)   (30.0)          LITCHFIEL 70 DPWA -0 K- N TO LAM PI    6/70
M    1     2120.0    40.0            BAILLON   75 IPWA    KBAR N TO LAM PI 11/75
M    1  FROM SOLUTION 1 OF BAILLON 75.                                      1/76
M    2     2140.0    40.0            BAILLON   75 IPWA    KBAR N TO LAM PI  1/76
M    2  FROM SOLUTION 2 OF BAILLON 75.                                      1/76
M          2140.0    30.0            BELLEFO1  75 DPWA  0 K- P TO LAM PI0 11/75
M    3     2070. TO 2120.            BELLEFON  76 IPWA  0 K- P TO LAM PI    2/77
M    3  SUPERSEDES BELLEFO1 75.                                             2/77
M    4     2091.0     7.0            CORDEN    76 DPWA  - K- N TO PI- LAM   2/77
M    4  PREFERRED SOLUTION 3, SEE CORDEN 76 FOR OTHER POSSIBLILITES,        2/77
M    4  INCLUDING A D15 AT THIS MASS.                                       2/77
M    4  CORDEN 76 INCLUDES THE DATA OF COX 70 AS A SUBSAMPLE.

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                    88  SIGMA(2080) WIDTH (MEV)

W          (87.0)   (20.0)           COX       70 DPWA -  K- N TO LAM PI    6/70
W         (250.0)   (40.0)           LITCHFIEL 70 DPWA -0 K- N TO LAM PI    6/70
W    1     240.0     50.0            BAILLON   75 IPWA    KBAR N TO LAM PI 11/75
W    2     200.0     50.0            BAILLON   75 IPWA    KBAR N TO LAM PI  1/76
W          180.0     20.0            BELLEFO1  75 DPWA  0 K- P TO LAM PI0 11/75
W    3    (100.0)                    BELLEFON  76 IPWA  0 K- P TO LAM PI    2/77
W    4     186.0     48.0            CORDEN    76 DPWA  - K- N TO PI- LAM   2/77

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                    88  SIGMA(2080) PARTIAL DECAY MODES

                                                          DECAY MASSES
P1      SIGMA(2080) INTO N KBAR                          938+ 494
P2      SIGMA(2080) INTO LAMBDA PI                       1116+ 140

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                    88  SIGMA(2080) BRANCHING RATIOS

R1      SIGMA(2080) FROM N KBAR TO LAMBDA PI             SQRT(P1*P2)
R1         (-0.16)   (0.03)          COX       70 DPWA -  K- N TO LAM PI    6/70
R1         (-0.09)   (0.03)          LITCHFIEL 70 DPWA -0 K- N TO LAM PI    6/70
R1    1     -0.13     0.04            BAILLON   75 IPWA    KBAR N TO LAM PI 11/75
R1    2     -0.13     0.04            BAILLON   75 IPWA    KBAR N TO LAM PI  1/76
R1          +0.19     0.03            BELLEFO1  75 DPWA  0 K- P TO LAM PI0 11/75
R1    3    (-0.10)                    BELLEFON  76 IPWA  0 K- P TO LAM PI    2/77
R1    4     -0.10     0.03            CORDEN    76 DPWA  - K- N TO PI- LAM   2/77

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                    REFERENCES FOR SIGMA(2080)

COX      70 NP B19 61           +ISLAM, COLLEY, +     (BIRM+EDIN+GLAS+LOIC)IJP
LITCHFIE 70 NP B22 269          P J LITCHFIELD                     (RHEL)IJP
BAILLON  75 NP B94 39           P BAILLON, P J LITCHFIELD        (CERN+RHEL)IJP
BELLEFO1 75 NP B90 1            DE BELLEFON,BERTHON,BRUNET+      (CDEF+SACL)IJP

BELLEFON 76 NP B109 129         DE BELLEFON,BERTHON                (CDEF)IJP
CORDEN   76 NP B104 382         +COX,DARTNELL,KENYON,ONEALE,SUMOROK+ (BIRM)IJP

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Σ(2100) G_{17} Status: *

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                    26  SIGMA(2100, JP=7/2-) I=1       G17

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                    26  SIGMA(2100) MASS (MEV)

M         (2060.0)   (20.0)          GALTIERI  70 DPWA  0 K-P TO LAMBDA PI  7/70
M         (2120.0)   (30.0)          GALTIERI  70 DPWA  0 K-P TO SIGMA PI   7/70

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                    26  SIGMA(2100) WIDTH (MEV)

W          (70.0)   (30.0)           GALTIERI  70 DPWA  0 K-P TO LAMBDA PI  7/70
W         (135.0)   (30.0)           GALTIERI  70 DPWA  0 K-P TO SIGMA PI   7/70

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                    26  SIGMA(2100) PARTIAL DECAY MODES

                                                          DECAY MASSES
P1      SIGMA(2100) INTO N KBAR                          938+ 494
P2      SIGMA(2100) INTO LAMBDA PI                       1116+ 135
P3      SIGMA(2100) INTO SIGMA PI                        1189+ 140

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                    26  SIGMA(2100) BRANCHING RATIOS

R1      SIGMA(2100) FROM N KBAR TO LAMBDA PI             SQRT(P1*P2)
R1         (-0.07)   (0.02)          GALTIERI  70 DPWA  0 K-P TO LAMBDA PI  7/70

R2      SIGMA(2100) FROM N KBAR TO SIGMA PI              SQRT(P1*P3)
R2         (+0.13)   (0.02)          GALTIERI  70 DPWA  0 K-P TO SIGMA PI   7/70

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                    REFERENCES FOR SIGMA(2100)

GALTIERI 70 DUKE CONF 173       A BARBARO-GALTIERI                 (LRL)IJP

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For notation, see key at front of Listings.

Baryons

Σ(2250), Σ(2455), Σ(2620)

Σ(2250) BUMPS Status: ***

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                    48  SIGMA(2250, JP=    ) I=1     PRODUCTION EXPERIMENTS

                    THE PARTIAL-WAVE ANALYSIS RESULTS ARE TOO WEAK TO
                    WARRANT SEPARATING THEM FROM THE PRODUCTION AND CROSS-
                    SECTION EXPERIMENTS.
      LASINSKI 71 IN KBAR N, USING A POMERON+RESONANCES MODEL, AND
   BELLEFON1 76, BELLEFON 77, AND BELLEFON 78 (COLLEGE DE FRANCE-
   SACLAY GROUP) IN DPWA'S OF KBAR N TO LAMBDA PI, SIGMA PI, AND KBAR N,
   RESPECTIVELY, SUGGEST THE PRESENCE OF TWO RESONANCES AROUND THIS
   MASS VALUE.

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                    48  SIGMA(2250) MASS (MEV) (PROD. EXP.)

M         (2245.0)                  BLANPIED  65 CNTR    GAMMA P TO K+ Y*
M         (2299.0)    (6.0)         BOCK      65 HBC     PBAR P 5.7 GEV/C
M          2250.0      7.0          BUGG      68 CNTR    K-P, D TOTAL      6/68
M          2280.0     14.0          AGUILAR   70 HBC  +  K- 3.9-4.6 GEV/C  5/70
M          2237.0     11.0          BRICMAN   70 CNTR  0 TOTAL AND CH EX   6/70
M          2255.0     10.0          COOL      70 CNTR    K-P, D TOTAL     10/70
M         (2250.0)   (20.0)         LU        70 CNTR  0 GAMMA P TO K+ Y*  1/71
M    B    (2260.0)   (30.0)         BELLEFO1  75 DPWA    D5 WAVE          11/75
M    B    (2215.0)   (10.0)         BELLEFO1  75 DPWA    G9 OR H11 WAVE   11/75
M    B   EVIDENCE FOR 2 RESONANCES IN THIS LAMBDA PI DPWA                 11/75
M     1   2300.0     30.0           BELLEFO2  75 HBC   0 K- P TO XI*0 K0  11/75
M     V   2251.0     30.0     20.0  VANHORN   75 DPWA  0 K-P TO LAM PI0   11/75
M     V   VANHORN72 VALUE FROM A DPWA THAT FINDS JP=5/2+.
M     2   (2260.0)                  BELLEFON  76 IPWA  0 D5 WAVE           2/77
M     2   (2215.0)                  BELLEFON  76 IPWA  0 G9 WAVE           2/77
M     2   SUPERSEDES BELLEFO1 75.                                          2/77
M         2275.0     20.0           BELLEFON  77 DPWA  0 D5 WAVE          11/77
M         2215.0     20.0           BELLEFON  77 DPWA  0 G9 WAVE          11/77
M         2270.0     50.0           BELLEFON  78 DPWA  0 D5 WAVE           1/78
M         2210.0     30.0           BELLEFON  78 DPWA  0 G9 WAVE           1/78

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                    48  SIGMA(2250) WIDTH (MEV) (PROD. EXP.)

W         (150.0)                   BLANPIED  65 CNTR    GAMMA P TO K+ Y*
W          (21.0)    (17.0)   (21.0) BOCK      65 HBC     PBAR P 5.7 GEV/C
W          230.0      20.0          BUGG      68 CNTR    K-P, D TOTAL      6/68
W          100.0      20.0          AGUILAR   70 HBC  +  K- 3.9-4.6 GEV/C  5/70
W          164.0      50.0          BRICMAN   70 CNTR  0 TOTAL AND CH EX   6/70
W         (170.0)                   COOL      70 CNTR    K-P, D TOTAL     10/70
W         (125.0)                   LU        70 CNTR  0 GAMMA P TO K+ Y*  1/71
W    B    (100.0)   (20.0)          BELLEFO1  75 DPWA    D5 WAVE          11/75
W    B     (60.0)   (40.0)   (20.0) BELLEFO1  75 DPWA    G9 OR H11 WAVE   11/75
W     1    130.0      20.0          BELLEFO2  75 HBC   0 K- P TO XI*0 K0  11/75
W     V    192.0      30.0          VANHORN   75 DPWA  0 K-P TO LAM PI0   11/75
W     2   (100.0)                   BELLEFON  76 IPWA  0 D5 WAVE           2/77
W     2   (140.0)                   BELLEFON  76 IPWA  0 G9 WAVE           2/77
W          70.0      20.0           BELLEFON  77 DPWA  0 D5 WAVE          11/77
W          60.0      20.0           BELLEFON  77 DPWA  0 G9 WAVE          11/77
W         120.0      40.0           BELLEFON  78 DPWA  0 D5 WAVE           1/78
W          80.0      20.0           BELLEFON  78 DPWA  0 G9 WAVE           1/78

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                    48  SIGMA(2250) PARTIAL DECAY MODES (PROD. EXP.)

                                                          DECAY MASSES
P1     SIGMA(2250) INTO N KBAR                            938+ 494
P2     SIGMA(2250) INTO LAMBDA PI                        1116+ 135
P3     SIGMA(2250) INTO SIGMA PI                         1189+ 140
P4     SIGMA(2250) INTO N KBAR PI                         938+ 498+ 140
P5     SIGMA(2250) INTO XI(1530) K                       1533+ 498

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                    48  SIGMA(2250) BRANCHING RATIOS (PROD. EXP.)

R1     SIGMA(2250) INTO (N KBAR)/TOTAL                   (P1)
R1          0.08      0.02           BELLEFON  78 DPWA  0 D5 WAVE           1/78
R1          0.02      0.01           BELLEFON  78 DPWA  0 G9 WAVE           1/78

R2     SIGMA(2250) FROM N KBAR TO LAMBDA PI              SQRT(P1*P2)
R2         -0.18 (FOR JP=9/2-)       GALTIERI  70 DPWA    K-P TO LAMBDA PI 10/70
R2  B     (+0.12)    (0.03)          BELLEFO1  75 DPWA    D5 WAVE          11/75
R2  B     (-0.09)    (0.02)          BELLEFO1  75 DPWA    G9 OR H11 WAVE   11/75
R2  V      -0.16      0.03           VANHORN   75 DPWA  0 K-P TO LAM PI0   11/75
R2  2     (+0.11)                    BELLEFON  76 IPWA  0 D5 WAVE           2/77
R2  2     (-0.10)                    BELLEFON  76 IPWA  0 G9 WAVE           2/77

R3     SIGMA(2250) FROM N KBAR TO SIGMA PI               SQRT(P1*P3)
R3         +0.07 (FOR JP=9/2-)       GALTIERI  70 DPWA    K-P TO SIGMA PI  10/70
R3         +0.06      0.02           BELLEFON  77 DPWA  0 D5 WAVE          11/77
R3         -0.03      0.02           BELLEFON  77 DPWA  0 G9 WAVE          11/77

R4     SIGMA(2250) INTO (N KBAR)/(SIGMA PI)              (P1)/(P3)
R4         (0.18) OR LESS            BARNES    69 HBC  +  1 STAN DEV LIMIT 10/69

R5     SIGMA(2250) INTO (LAMBDA PI)/(SIGMA PI)           (P2)/(P3)
R5         (0.18) OR LESS            BARNES    69 HBC  +  1 STAN DEV LIMIT 10/69

R6     SIGMA(2250) FROM K- P TO XI(1530)0 K0             SQRT(P1*P5)
R6  1       0.09      0.02           BELLEFO2  75 HBC   0 K- P TO XI*0 K0  11/75
R6  1  SEEN IN DD5 WAVE IN NEUTRAL CHANNEL ONLY, ISOSPIN UNDETERMINED.     11/75

R7     SIGMA(2250) INTO (N KBAR)/TOTAL                   (J+1/2)*(P1)
R7       J IS NOT DETERMINED IN THESE EXPTS.  THE FOLLOWING IS (J+1/2)*P1.
R7         (0.47)                    BUGG      68 CNTR                      3/78
R7         (0.16)    (0.12)          BRICMAN   70 CNTR  0 TOTAL AND CH EX   3/78
R7         (0.42)                    COOL      70 CNTR    K-P, D TOTAL     3/78

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                         REFERENCES FOR SIGMA(2250) (PROD. EXP.)

BLANPIED 65 PRL 14 741        +GREENBERG,HUGHES,KITCHING, +    (YALE+CEA)
BOCK     65 PL 17 166         +COOPER,FRENCH,KINSON, +        (CERN+SACL)
BUGG     68 PR 168 1466       +GILMORE,KNIGHT, +        (RHEL+BIRM+CAVE) I
BARNES   69 PRL 22 479        +FLANINIO,MONTANET,SAMIOS +      (BNL+SYRA)

AGUILAR  70 PRL 25 58         AGUILAR-BENITEZ, BARNES, +       (BNL+SYRA)
BRICMAN  70 PL 31B 152        +FERRO LUZZI, PERREAU,+    (CERN+CAEN+SACL)
COOL     70 PR D1 1887        +GIACOMELLI, KYCIA, LEONTIC, LI, +    (BNL) I
GALTIERI 70 DUKE CONF 173     A BARBARO-GALTIERI                   (LRL)IJP
LU       70 PR D2 1846        +GREENBERG, HUGHES, MINEHART, MORI,+ (YALE)

BELLEFO1 75 NP B90 1          DE BELLEFO2,BERTHON,BRUNET+     (CDEF+SACL)IJP
BELLEFO2 75 NC 28A 289        DE BELLEFO2,BERTHON,BILLOIR+    (CDEF+SACL)
VANHORN  75 NP B87 145        A J VAN HORN                          (LBL)IJP
   ALSO  75 NP B87 157        A J VAN HORN                          (LBL)IJP

BELLEFON 76 NP B109 129       DE BELLEFON,BERTHON                  (CDEF)IJP
BELLEFON 77 NC 37A 175        DE BELLEFON,BERTHON,BILLOIR+    (CDEF+SACL)IJP
BELLEFON 78 NC 42A 403        +BERTHON,BILLOIR,BRUNET+        (CDEF+SACL)IJP

                              PAPERS NOT REFERRED TO IN DATA CARDS

COOL     66 PRL 16 1228       +GIACOMELLI,KYCIA,LEONTIC,LI,LUNDBY,+ (BNL) I
   SUPERSEDED BY COOL 70.
DAUBER   66 PL 23 154         +SCHLEIN, SLATER, STORK, TICHO   (UCLA+LRL) J
   SUGGESTS J=9/2 RESONANT BEHAVIOR IN SIGMA- PI+, BUT APPEARS
        INCONSISTENT WITH PARAMETERS OF COOL 66.
DAUM     68 NP B7 19          +ERNE, LAGNAUX, SENS, STEUER, UDO    (CERN)JP
LASINSKI 71 NP  B29  125      T A LASINSKI                          (EFI)IJP
HEMINGWA 75 NP B91 12         HEMINGWAY,EADES,HARMSEN+   (CERN+HEID+MPIM)IJP
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Σ(2455) BUMPS Status: **

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                    53  SIGMA(2455, JP=    ) I=1     PRODUCTION EXPERIMENTS

                    THERE IS ALSO SOME SLIGHT EVIDENCE FOR Y* STATES IN
                    THIS MASS REGION FROM THE REACTION GAMMA + P TO K+
                    + MISSING MASS -- SEE GREENBERG 68.

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                    53  SIGMA(2455) MASS (MEV) (PROD. EXP.)

M          2455.0      7.0           BUGG      68 CNTR    K-P, D TOTAL      6/68
M          2455.0     10.0           ABRAMS    70 CNTR    K-P, D TOTAL     10/70
M          . . . . . . . . . .
M   AVG    2455.0      5.7     AVERAGE

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                    53  SIGMA(2455) WIDTH (MEV) (PROD. EXP.)

W          100.0     20.0           BUGG      68 CNTR                      6/68
W          140.0                    ABRAMS    70 CNTR    K-P, D TOTAL     10/70

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                    53  SIGMA(2455) PARTIAL DECAY MODES (PROD. EXP.)

                                                          DECAY MASSES
P1     SIGMA(2455) INTO N KBAR                            938+ 494

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                    53  SIGMA(2455) BRANCHING RATIOS (PROD. EXP.)

R1     SIGMA(2455) INTO (N KBAR)/TOTAL                   (P1)
R1       J IS NOT KNOWN.  THE FOLLOWING IS (J+1/2)*P1.
R1         (0.3)                     BUGG      68 CNTR                      6/68
R1          0.39                     ABRAMS    70 CNTR    K-P, D TOTAL     10/70
R1  C      (0.05)   (0.05)           BRICMAN   70 CNTR  0 TOTAL AND CH EX   6/70
R1  C    FIT OF TOTAL CROSS SECTION GIVEN BY BRICMAN 70 IS POOR IN
R1  C    THIS REGION.

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                         REFERENCES FOR SIGMA(2455) (PROD. EXP.)

BUGG     68 PR 168 1466       +GILMORE,KNIGHT, +        (RHEL+BIRM+CAVE) I
ABRAMS   70 PR 1D 1917        +COOL, GIACOMELLI, KYCIA, LEONTIC, +  (BNL) I
BRICMAN  70 PL 31B 152        +FERRO LUZZI, PERREAU,+    (CERN+CAEN+SACL)

                              PAPERS NOT REFERRED TO IN DATA CARDS
ABRAMS   67 PRL 19 678        +COOL,GIACOMELLI,KYCIA,LEONTIC,LI, +  (BNL)
   SUPERSEDED BY ABRAMS 70.
GREENBER 68 PRL 20 221        GREENBERG, HUGHES, LU, MINEHART, +   (YALE)
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Σ(2620) BUMPS Status: **

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                    54  SIGMA(2620, JP=    ) I=1     PRODUCTION EXPERIMENTS

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                    54  SIGMA(2620) MASS (MEV) (PROD. EXP.)

M          2620.0     15.0           ABRAMS    70 CNTR    K-P, D TOTAL     10/70
M          2542.0     22.0           DIBIANCA  75 DBC     XI K PI           1/76

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                    54  SIGMA(2620) WIDTH (MEV) (PROD. EXP.)

W         (175.0)                    ABRAMS    70 CNTR    K-P, D TOTAL     10/70
W          221.0     81.0           DIBIANCA  75 DBC     XI K PI           1/76

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                    54  SIGMA(2620) PARTIAL DECAY MODES (PROD. EXP.)

                                                          DECAY MASSES
P1     SIGMA(2620) INTO N KBAR                            938+ 494

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                    54  SIGMA(2620) BRANCHING RATIOS (PROD. EXP.)

R1     SIGMA(2620) INTO (N KBAR)/TOTAL                   (P1)
R1       J IS NOT KNOWN.  THE FOLLOWING IS (J+1/2)*P1.
R1         (0.32)                    ABRAMS    70 CNTR    K-P, D TOTAL     10/70
R1          0.36      0.12           BRICMAN   70 CNTR  0 TOTAL AND CH EX   6/70

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Baryons

Σ(2620), Σ(3000), Σ(3170), Ξ's

Data Card Listings

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                                REFERENCES FOR SIGMA(2620) (PROD. EXP.)

ABRAMS   67 PRL 19 678          +COOL,GIACOMELLI,KYCIA,LEONTIC,LI, +  (BNL)
    SUPERSEDED BY ABRAMS 70.
ABRAMS   70 PR 1D 1917          +COOL, GIACOMELLI, KYCIA, LEONTIC, +  (BNL) I
BRICMAN  70 PL 31B 152          +FERRO LUZZI, PERREAU,+    (CERN+CAEN+SACL)

DIBIANCA 75 NP B98 137          DIBIANCA,ENDORFR                     (CARN)

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Σ(3000) BUMPS Status: *

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                    59  SIGMA(3000, JP=    ) I=1     PRODUCTION EXPERIMENTS

                    ENHANCEMENT IN LAMBDA PI AND KBAR N INVARIANT MASS
                    SPECTRA AND IN MISSING MASS OF NEUTRALS RECOILING
                    AGAINST KO.  EVIDENCE NOT CONCLUSIVE.  OMITTED FROM
                    TABLE.

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                    59  SIGMA(3000) MASS (MEV) (PROD. EXP.)

M         (3000.0)                   EHRLICH   66 HBC   0 PI-P 7.91 GEV/C   9/66

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                    59  SIGMA(3000) PARTIAL DECAY MODES (PROD. EXP.)

                                                          DECAY MASSES
P1     SIGMA(3000) INTO N KBAR                           938+ 494
P2     SIGMA(3000) INTO LAMBDA PI                       1116+ 140

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                                REFERENCES FOR SIGMA(3000) (PROD. EXP.)

EHRLICH  66 PR 152 1194         R EHRLICH, W SELOVE, H YUTA      (PENN+BNL) I

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Σ(3170) BUMPS Status: *

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                    118  SIGMA(3170, JP=    ) I=1     PRODUCTION EXPERIMENTS

                    SEEN BY AMIRZADEH 79 AS A NARROW 6.5 STD. DEV.
                    ENHANCEMENT IN THE REACTION K-P --> Y* PI- USING DATA
                    FROM TWO INDEPENDENT HIGH STATISTICS BUBBLE CHAMBER
                    EXPERIMENTS AT 8.25 AND 6.5 GEV/C.  THE DOMINANT DECAY
                    MODES ARE INTO MULTI-BODY, MULTI-STRANGE FINAL STATES
                    AND THE PRODUCTION IS VIA I=3/2 BARYON EXCHANGE.  I=1
                    IS FAVORED.
                    IN NEED OF CONFIRMATION.  OMITTED FROM TABLES.

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                    118  SIGMA(3170) MASS  (MEV) (PROD. EXP.)

M       35 3170.0      5.0            AMIRZAD   79 HBC  +  K-P TO Y* PI-    12/79

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                    118  SIGMA(3170) WIDTH  (MEV) (PROD. EXP.)

W  C    35  (20.0)  OR LESS           AMIRZAD   79 HBC  +  K-P TO Y* PI-    12/79
W  C    OBSERVED WIDTH CONSISTENT WITH EXPERIMENTAL RESOLUTION.

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                    118  SIGMA(3170) PARTIAL DECAY MODES (PROD. EXP.)

                                                          DECAY MASSES
P1     SIGMA(3170) INTO LAMBDA K KBAR + PIONS
P2     SIGMA(3170) INTO SIGMA K KBAR + PIONS
P3     SIGMA(3170) INTO XI K + PIONS

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                    118  SIGMA(3170) BRANCHING RATIOS (PROD. EXP.)

R1     SIGMA(3170) INTO (LAMBDA K KBAR + PIONS)/TOTAL    (P1)
R1         SEEN                       AMIRZAD   79 HBC  +  K-P TO Y* PI-    12/79

R2     SIGMA(3170) INTO (SIGMA K KBAR + PIONS)/TOTAL     (P2)
R2         SEEN                       AMIRZAD   79 HBC  +  K-P TO Y* PI-    12/79

R3     SIGMA(3170) INTO (XI K + PIONS)/TOTAL             (P3)
R3         SEEN                       AMIRZAD   79 HBC  +  K-P TO Y* PI-    12/79

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                                REFERENCES FOR SIGMA(3170) (PROD. EXP.)

AMIRZAD  79 PL 89B 125          AMIRZADEH+  (BIRM+CERN+GLAS+MSU+LPNP+CAMB+)I
    ALSO 80 TORONTO CONF. 263 J B KINSON+ (BIRM+CERN+GLAS+MSU+LPNP+CAMB+)I

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NOTE ON Ξ RESONANCES

The Ξ resonance situation has always been unhappy. This is because: (1) Ξ resonances can only be produced as a part of a final state, and so the analysis is more complicated than if direct formation were possible; (2) they are produced with small cross sections (typically a few μb); and (3) the final states are topologically complicated and difficult to study with electronic techniques. Thus our early knowledge of Ξ resonances came entirely from bubble chamber experiments, where the numbers of events are small, and our best information about Ξ resonances is still from bubble chamber experiments.

Until fairly recently only the Ξ(1530) was really well established. However, the late 1970's saw a major improvement with the results of GAY 76 and HEMINGWAY 77. The Ξ(1820) and Ξ(2030) were firmly established as narrow states (widths of about 20 MeV), and the spin of the Ξ(1820) was found to be 3/2 (TEODORO 78).

Since then, however, not much has changed, although there is some improved evidence for the Ξ(2250) and the Ξ(2370). There is probably at least one other Ξ in the 1850-2000-MeV region, and there are indications of several others above 2000 MeV. Indeed, there should be many Ξ resonances below 2500 MeV, and the broad (and not completely established) Ξ(1940) could well be a mixture of several of them. For now we are forced to group together disparate observations and await new results. The disagreements among experiments are shown in ideograms in the Listings.

Results from experiments using electronic methods have recently become available. BIAGI 81 used the CERN hyperon beam to study inclusive $\Lambda\bar{K}$ and $\Xi\pi$ mass spectra from 102 and 135 GeV/c Ξ^- incident on hydrogen and deuterium. They saw a large Ξ(1820) signal in $\Lambda\bar{K}$ as well as a peak at about 1700 MeV, which might be associated with the threshold enhancement seen by DIONISI 78. The Ξ(1940) appears as a broad bump in the $\Xi\pi$ mass spectrum, and there is a very clean Ξ(1530) signal. And Brookhaven multiparticle spectrometer measurements of $K^-p \rightarrow K^+$ anything at 5 GeV/c (JENKINS 83) have seen all the well-established Ξ resonances and also the less well-established Ξ(2250), Ξ(2370), and Ξ(2500).

The table below gives our evaluation of the present status of the Ξ resonances. For a detailed review, see Meadows.[1]

Reference

1. B.T. Meadows, in *Proceedings of the IVth International Conference on Baryon Resonances* (Toronto, 1980), ed. N. Isgur, p. 283.

For notation, see key at front of Listings.

Baryons

Ξ's, Ξ^-, Ξ^0, Ξ(1530)

Table 1. The status of the Ξ resonances. Only those with an overall status of *** or **** are included in the main Baryon Table.

Particle	$L_{2I\cdot 2J}$	Overall status	Status as seen in -- Ξπ	ΛK	ΣK	Ξ(1530)π	Other channels
Ξ(1318)	P_{11}	****					Weak to Λπ
Ξ(1530)	P_{13}	****	****				
Ξ(1630)		*	*				
Ξ(1680)		**		*	**		
Ξ(1820)	13	***	*	***	**	***	
Ξ(1940)		**	**			**	
Ξ(2030)	1	***		**	***		
Ξ(2120)		*		*			
Ξ(2250)		**					3-body decays
Ξ(2370)	1	**					3-body decays
Ξ(2500)		*		*	*		3-body decays

**** Good, clear, and unmistakable.
*** Good, but in need of clarification or not absolutely certain.
** Not established; needs confirmation.
* Evidence weak; could disappear.

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S=-2 I=1/2 HYPERON STATES (Ξ)

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Ξ^-

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22  XI-(1321, JP=1/2 ) I=1/2

SEE STABLE PARTICLE DATA CARD LISTINGS

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Ξ^0

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23  XI0(1315, JP=1/2 ) I=1/2

SEE STABLE PARTICLE DATA CARD LISTINGS

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Ξ(1530) P_{13} Status: ****

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49  XI(1530, JP=3/2+) I=1/2  P13

THIS IS THE ONLY XI RESONANCE WHOSE PROPERTIES ARE
ALL AT LEAST REASONABLY WELL KNOWN.  SPIN-PARITY 3/2+
IS FAVORED BY THE DATA.

WE DO NOT USE DETERMINATIONS OF THE MASS AND THE WIDTH OF THIS
STATE UNLESS THEY ARE ACCOMPANIED BY SOME DISCUSSION OF SYSTEMATICS
AND RESOLUTION.

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                49  XI(1530) MASS (MEV)

M   MIXED CHARGES
M       20(1535.0)                  BERTANZA  62 HBC  -0 K-P 2.3 GEV/C
M       55(1529.0)    (5.0)         PJERROU   62 HBC  -0 K-P 1.8 GEV/C
M         (1532.0)    (2.0)         BADIER    64 HBC  -0 K-P 3 GEV/C

M-  NEGATIVE CHARGE ONLY
M-      38 1535.7      3.2          LONDON    66 HBC  -  K-P 2.24 GEV/C    7/66
M-     334(1534.7)    (1.1)         BALTAY    72 HBC  -  K-P 1.75 GEV      1/73
M-     185 1536.2      1.6          KIRSCH    72 HBC  -  K-P 2.87GEV/C     2/72
M-         1535.3      2.0          ROSS2     73 HBC  -  XI KBAR PI (PI)   2/74
M-      48(1540.0)    (3.0)         BERTHON   74 HBC  -  QUASI 2 BODY CS   10/74
M-         1534.5      1.2          BELLEFO2  75 HBC  -  K-P TO XI- K PI   11/75
M-      . . . . . . . . . .
M-  AVG    1535.18     0.84    AVERAGE
M-  FIT    1534.97     0.63   FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.0)

M0  NEUTRAL CHARGE ONLY
M0      76 1528.7      1.1          LONDON    66 HBC   0 K-P 2.24 GEV/C    7/66
M0      59 1531.4      0.8          BADIER    72 HBC   0 K-P AT 3.95GEV/C 10/71
M0    1262 1532.0      0.4          BALTAY    72 HBC   0 K-P 1.75 GEV      1/73
M0     324 1531.3      0.6          BORENSTEI 72 HBC   0 K-P 2.2GEV/C      2/72
M0     286 1532.3      0.7          KIRSCH    72 HBC   0 K-P 2.87GEV/C     2/72
M0         1533.0      1.0          ROSS2     73 HBC     XI KBAR PI (PI)   2/74
M0      97(1533.6)    (1.4)         BERTHON   74 HBC   0 QUASI 2 BODY CS   10/74
M0         1532.2      0.7          BELLEFO2  75 HBC   0 K-P TO XI- K PI   11/75
M0      80(1527.0)    (6.0)         SIXEL     79 HBC   0 INCL. K-P 10 GEV  1/80
M0     100(1535.0)    (4.0)         SIXEL     79 HBC   0 INCL. K-P 16 GEV  1/80
M0  A 2700(1532.1)    (0.6)         BAUBILLIE 81 HBC   0 K-P AT 8.25 GEV   2/82
M0  A   FIT TO INCLUSIVE SPECTRUM.  RESOLUTION (5 MEV) NOT UNFOLDED.
M0      450(1530.0)    (1.0)         BIAGI     81 SPEC -  HYPERON BEAM     2/82
M0      . . . . . . . . . .
M0  AVG    1531.78     0.34    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.4)
M0  FIT    1531.80     0.31   FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.3)
                       (SEE IDEOGRAM BELOW)
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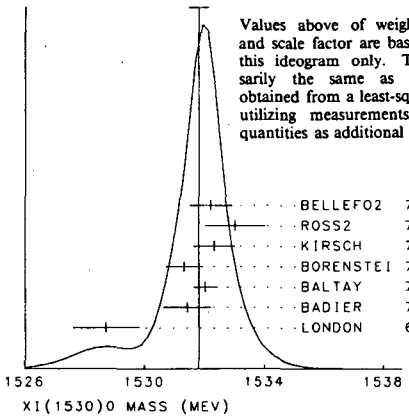
WEIGHTED AVERAGE = 1531.78 ± 0.34
ERROR SCALED BY 1.4



Values above of weighted average, error, and scale factor are based upon the data in this ideogram only. They are not necessarily the same as our "best" values, obtained from a least-squares constrained fit utilizing measurements of other (related) quantities as additional information.

		CHISQ
BELLEFO2	75 HBC	0.4
ROSS2	73 HBC	1.5
KIRSCH	72 HBC	0.5
BORENSTEI	72 HBC	0.6
BALTAY	72 HBC	0.3
BADIER	72 HBC	0.2
LONDON	66 HBC	7.9
		11.4
		(CONLEV =0.077)

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                49  (XI(1530)-) - (XI(1530)0) MASS DIFFERENCE (MEV)

D            5.7      3.0            PJERROU   65 HBC  -0 1.8-1.95 GEV/C    7/66
D   B       (7.0)    (4.0)           LONDON    66 HBC  -0 2.24 GEV/C       7/66
D            2.0      3.2            MERRILL   66 HBC  -0 1.7-2.7 GEV/C    7/66
D            2.7      1.0            BALTAY    72 HBC  -0 K-P 1.75 GEV      1/73
D   B       (3.9)    (1.8)           KIRSCH    72 HBC  -0 K- P 2.87 GEV/C  2/72
D   B      REDUNDANT WITH DATA IN MASS LISTING.
D           . . . . . . . . .
D   AVG      2.92     0.91    AVERAGE
D   FIT      3.17     0.64   FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.0)

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                49  XI(1530) WIDTH (MEV)

W   MIXED CHARGES
W       20  (35.0)  OR LESS         BERTANZA  62 HBC  -0 K-P 2.3 GEV/C

W-  NEGATIVE CHARGE ONLY
W-           7.8      3.5      7.8  BALTAY    72 HBC  -  K-P 1.75 GEV      1/73
W-          16.2      4.6           KIRSCH    72 HBC  -  XI- PI0,XI0 PI-   2/72
W-           8.3      3.6           ROSS2     73 HBC  -  XI KBAR PI (PI)   2/74
W-           9.6      2.8           BELLEFO2  75 HBC  -  K-P TO XI- K PI   11/75
W-          . . . . . . . . .
W-  AVG     10.1      1.9     AVERAGE

W0  NEUTRAL CHARGE ONLY
W0           7.0      2.0           SCHLEIN   63 HBC   0 1.8, 1.95 GEV/C
W0           7.0      2.0           BERGE     66 HBC   0 1.5-1.7 GEV/C     7/66
W0           8.5      3.5           LONDON    66 HBC   0 2.24 GEV/C        7/66
W0          11.0      2.0           BADIER    72 HBC   0 K-P AT 3.95GEV/C 10/71
W0           9.0      0.7           BALTAY    72 HBC   0 K-P 1.75 GEV      1/73
W0           8.4      1.4           BORENSTEI 72 HBC   0 XI- PI+ MODE      2/72
W0          11.0      1.8           KIRSCH    72 HBC   0 XI- PI+           2/72
W0           9.1      2.4           ROSS2     73 HBC   0 XI KBAR PI (PI)   2/74
W0           9.5      1.2           BELLEFO2  75 HBC   0 K-P TO XI- K PI   11/75
W0  C    80  (19.0)   (6.0)          SIXEL     79 HBC   0 INCL. K-P 10 GEV  1/80
W0  C   100  (14.0)   (5.0)          SIXEL     79 HBC   0 INCL. K-P 16 GEV  1/80
W0  C     EXPERIMENTAL RESOLUTION OF 15 MEV NOT UNFOLDED.
W0  D 2700  (12.8)   (1.0)           BAUBILLIE 81 HBC   0 K-P AT 8.25 GEV   2/82
W0  D   FIT TO INCLUSIVE SPECTRUM.  RESOLUTION (5 MEV) NOT UNFOLDED.
W0          . . . . . . . . .
W0  AVG     9.14      0.48    AVERAGE

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                49  XI(1530) REAL PART OF POLE POSITION

REO       1531.6      0.4            LICHTENB  74        0 EXTRAP HABIBI73   4/75
RE-       1534.4      1.1            LICHTENB  74       -  EXTRAP HABIBI73   4/75

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                49  XI(1530) IMAGINARY PART OF POLE POSITION

IMO          4.45     0.35           LICHTENB  74        0 EXTRAP HABIBI73   4/75
IM-          3.9      1.75     3.9   LICHTENB  74       -  EXTRAP HABIBI73   4/75

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                49  XI(1530) PARTIAL DECAY MODES

                                                          DECAY MASSES
P1      XI(1530) INTO XI PI                              1321+ 140
P2      XI(1530) INTO XI GAMMA                           1321+   0

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                49  XI(1530) BRANCHING RATIOS (MEV)

R1      XI(1530) INTO (XI GAMMA)/TOTAL                   (P2)
R1          (0.04) OR LESS  CL=.90   KALBFLEI  75 HBC  -  K-P AT 2.18 GEV   1/76

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REFERENCES FOR XI(1530)


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BERTANZA 62 PRL 9 180          +BRISSON,CONNOLLY,GOLDBERG,GRAY,+(BNL+SYRA) IJ
PJERROU  62 PRL 9 114          +PROWSE,SCHLEIN,SLATER,STORK,TICHO   (UCLA) I
SCHLEIN  63 PRL 11 167         +CARMONY,PJERROU,SLATER,STORK,TICHO  (UCLA)IJP
BADIER   64 DUBNA I 593        +DEMOULIN,GOLDBERG, +      (EPOL+SACL+AMST) I
PJERROU  65 PRL 14 275         +SCHLEIN,SLATER,SMITH,STORK,TICHO    (UCLA)
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Baryons

Ξ(1530), Ξ(1630), Ξ(1680), Ξ(1820)

Data Card Listings

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BERGE    66 PR 147 945          +EBERHARD,HUBBARD,MERRILL,B-SHAFER,+  (LRL) I
LONDON   66 PR 143 1034         +RAU,SAMIOS,YAMAMOTO,GOLDBERG,+  (BNL+SYRA) IJ
MERRILL  66 UCRL-16455 THESIS D W MERRILL                            (LRL) JP

BADIER   72 NP B37 429          +BARRELET,CHARLTON,VIDEAU                (EPOL)
BALTAY   72 PL 42B 129          +BRIDGEWATER,COOPER,GERSHWIN,+  (COLU+BING)
    ALSO 73 NEVIS 199 THESIS    HABIBI                                   (COLU)
BORENSTE 72 PR D5 1559          BORENSTEIN,DANBURG,KALBFLEISCH++ (BNL+MICH) I
KIRSCH   72 NP B40 349          SCHMIDT+CHANG,HEMINGWAY(BRAN+UMD+SYRA+TUFT) I

ROSS2    73 PURDUE CONF. 355    ROSS,LLOYD,RADOJICIC                     (OXF)
BERTHON  74 NC 21A 146          BERTHON,TRISTRAM,+    (CDEF+RHEL+SACL+STRB)
LICHTENB 74 PRD 10 3865         D B LICHTENBERG                          (IND)
    ALSO 74 PRIV. COMM.         D B LICHTENBERG                          (IND)

BELLEFO2 75 NC 28A 289          DE BELLEFON,BERTHON,BILLOIR+    (CDEF+SACL)
KALBFLEI 75 PRD 11 987          KALBFLEISCH,STRAND,CHAPMAN       (BNL+MICH)
SIXEL    79 NP B159 125         +BOTTCHER,KLEIN+ (AACH+BERL+CERN+LOIC+VIEN)
BAUBILLI 81 NP B192 1           BAUBILLIER+       (BIRM+CERN+GLAS+MSU+LPNP)
BIAGI    81 ZPHY C9 305         +      (BRIS+CAMB+GEVA+HEID+LAUS+LOQM+RHEL)

                                PAPERS NOT REFERRED TO IN DATA CARDS

SHAFER   66 PR 142 883          BUTTON-SHAFER,LINDSEY,MURRAY,SMITH    (LRL) JP
HUNGERBU 74 PRD 10 2051         HUNGERBUHLER,MAJKA,+   (YALE+FNAL+BNL+PITT)
BRIEFEL  75 PRD 12 1859         +GOUREVITCH,KIRSCH+    (BRAN+UMD+SYRA+TUFT)
BRIEFEL  77 PRD 16 2706         +GOUREVITCH,CHANG+     (BRAN+UMD+SYRA+TUFT)
MAZZUCAT 81 NP B178 1           MAZZUCATO,PENNINO+     (AMST+CERN+NIJM+OXF)
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Ξ(1630) Status: *

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21  XI(1630, JP=    ) I=1/2

SEEN ONLY IN THE XI PI CHANNEL.

BARTSCH 69 SEE A SMALL, BROAD ENHANCEMENT NEAR
1650 MEV - IT IS NOT CLEAR THAT IT IS THE SAME
PHENOMENON AS BRIEFEL 77, WHO FIND CS=2.6+-0.9
MICROBARNS AT 2.87 GEV/C INCIDENT K- MOMENTUM.
BORENSTEIN 72 SEE NO EFFECT IN THIS REGION.  THEY FIND
CS<2 MICROBARNS AT 2.18 GEV/C.

   ROSS 72 ARGUE THAT THE EFFECT THEY SEE IS NOT THE SAME AS THAT
SEEN BY BRIEFEL 77 (WHOSE PRELIMINARY RESULTS WERE REPORTED IN
BMST 70), AND FIND CS=2+-1 MICROBARNS AT 3.3 GEV/C.
BELLEFON 75 FIND A CS OF AROUND 10 MICROBARNS NEAR 2 GEV/C,
BUT LESS THAN 3 MICROBARNS AROUND 2.3 GEV/C.
  NOT SEEN BY HASSALL 81 IN A HIGH STATISTICS BUBBLE CHAMBER
EXPERIMENT (46 EVENTS/MICROBARN) AT 6.5 GEV/C.

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                    21  XI(1630) MASS (MEV)

M       29 1606.0      6.0          ROSS      72 HBC   0 K-P AT 3.1-3.7    3/72
M       34 1633.0     12.0          BELLEFO2  75 HBC   0 K-P TO XI- K PI  11/75
M       31 1624.0      3.0          BRIEFEL   77 HBC   0 K-P 2.87 GEV/C    1/78

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                    21  XI(1630) WIDTH (MEV)

W       29   21.0      7.0          ROSS      72 HBC   0 XI-PI+ K*0(890)   3/72
W       34   40.0     15.0          BELLEFO2  75 HBC   0 K-P TO XI- K PI  11/75
W  A    31  (22.5)                  BRIEFEL   77 HBC   0 K-P 2.87 GEV/C    1/78
W  A    GOODNESS OF FIT INSENSITIVE TO VALUES BETWEEN 15 AND 30 MEV.

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                    21  XI(1630) PARTIAL DECAY MODES

                                                        DECAY MASSES
P1      XI(1630) INTO XI PI                             1321+ 140

        SEEN IN K- P TO XI- PI+ K0 AND XI- PI0 K+.

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                    REFERENCES FOR XI(1630)

ROSS     72 PL 38B 177          +BURAN,LLOYD,MULVEY,RADOJICIC            (OXF) I
BELLEFO2 75 NC 28A 289          DE BELLEFON,BERTHON,BILLOIR+    (CDEF+SACL)
BRIEFEL  77 PRD 16 2706         +GOUREVITCH,CHANG+     (BRAN+UMD+SYRA+TUFT)
    ALSO 70 DUKE CONF. 317      BMST                   (BRAN+UMD+SYRA+TUFT)

                                PAPERS NOT REFERRED TO IN DATA CARDS

APSELL   69 PRL 23 884          +                      (BRAN+UMD+SYRA+TUFT)
    SUPERSEDED BY BMST 70.
BARTSCH  69 PL 28B 439          +                (AACH+BERL+CERN+LOIC+VIEN)
KALBFLEI 70 DUKE CONF 331       G R KALBFLEISCH                       (BNL) I
    SUMMARIZES EVIDENCE FOR ISOSPIN ONE-HALF.
BORENSTE 72 PR D5 1559          BORENSTEIN,DANBURG,KALBFLEISCH++ (BNL+MICH) I
SCHMIDT  73 PURDUE CONF. 363    SCHMIDT                                (BRAN)
HUNGERBU 74 PRD 10 2051         HUNGERBUHLER,MAJKA,+   (YALE+FNAL+BNL+PITT)
BRIEFEL  75 PRD 12 1859         +GOUREVITCH,KIRSCH+    (BRAN+UMD+SYRA+TUFT)
HASSALL  81 NP B189 397         +ANSORGE,CARTER,NEALE,RUSHBROOKE+(CAMB+MSU)
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Ξ(1680) Status: **

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5  XI(1680, JP=1/2-) I=1/2

SEEN BY DIONISI 78 AS A THRESHOLD ENHANCEMENT IN BOTH
THE NEUTRAL AND NEGATIVELY CHARGED SIGMA KBAR MASS
SPECTRA FROM THE REACTIONS K-P --> (SIGMA KBAR) K PI
AT 4.2 GEV/C.  THE DATA FROM THE SIGMA KBAR CHANNELS
ALONE CANNOT DISTINGUISH BETWEEN A RESONANCE
INTERPRETATION AND A LARGE SCATTERING LENGTH.

  WEAKER EVIDENCE FOR AN ENHANCEMENT AT THE SAME MASS IS SEEN IN THE
CORRESPONDING LAMBDA KBAR CHANNELS AND A COUPLED CHANNEL ANALYSIS
YIELDS RESULTS CONSISTENT WITH A NEW XI.

  THE HYPERON BEAM EXPERIMENT OF BIAGI 81 OBSERVE AN ENHANCEMENT AT
1700 MEV IN THE DIFFRACTIVELY PRODUCED LAMBDA K- SYSTEM.  A PEAK IS
ALSO OBSERVED IN THE LAMBDA K0 MASS SPECTRUM AT 1660 MEV WHICH IS
CONSISTENT WITH A RESONANCE OF MASS 1720 MEV DECAYING INTO SIGMA0
K0, WITH THE GAMMA FROM THE SIGMA0 DECAY NOT DETECTED.
IN NEED OF FUTHER CONFIRMATION.  OMITTED FROM THE TABLES.

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                    5  XI(1680) MASS (MEV)

M0  NEUTRAL CHARGE
M0  A  175(1699.0)    (5.0)          DIONISI   78 HBC   0 K-P AT 4.2 GEV/C  3/79
M0  A   FROM FIT TO SIGMA+ K- SPECTRUM                                      3/79
M0  B  183(1684.0)    (5.0)          DIONISI   78 HBC   0 K-P AT 4.2 GEV/C  3/79
M0  B   FROM COUPLED CHANNEL ANALYSIS OF SIGMA+ K- AND LAMBDA K0 SPECTRA    3/79

M-  NEGATIVE CHARGE
M-  C   45(1694.0)    (6.0)          DIONISI   78 HBC  -  K-P AT 4.2 GEV/C  3/79
M-  C   FROM COUPLED CHANNEL ANALYSIS OF SIGMA0 K- AND LAMBDA K- SPECTRA    3/79
M-  D  150(1700.0)   (10.0)          BIAGI     81 SPEC -  HYPERON BEAM      2/82
M-  D   FIT TO INCLUSIVE SPECTRUM FROM XI-N --> LAM K- X
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                    5  XI(1680) WIDTH (MEV)

W0  NEUTRAL CHARGE
W0  A  175  (44.0)   (23.0)          DIONISI   78 HBC   0 K-P AT 4.2 GEV/C  3/79
W0  B  183  (20.0)    (4.0)          DIONISI   78 HBC   0 K-P AT 4.2 GEV/C  3/79

W-  NEGATIVE CHARGE
W-  C   45  (26.0)    (6.0)          DIONISI   78 HBC  -  K-P AT 4.2 GEV/C  3/79
W-  D  150  (47.0)   (14.0)          BIAGI     81 SPEC -  HYPERON BEAM      2/82

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                    5  XI(1680) PARTIAL DECAY MODES

                                                        DECAY MASSES
P1      XI(1680) INTO SIGMA KBAR                        1192+ 498
P2      XI(1680) INTO LAMBDA KBAR                       1116+ 498
P3      XI(1680) INTO XI PI                             1315+ 135
P4      XI(1680) INTO XI(1530) PI                       1533+ 135
P5      XI(1680) INTO XI PI PI (INCLUDING P4)           1315+ 135+ 135

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                    5  XI(1680) BRANCHING RATIOS

R1      XI(1680) INTO (SIGMA KBAR)/(LAMBDA KBAR)        (P1)/(P2)
R1  E        (2.7)    (0.9)          DIONISI   78 HBC   0 K-P AT 4.2 GEV/C  3/79
R1  E    NEUTRAL CHARGE
R1  F        (3.1)    (1.4)          DIONISI   78 HBC  -  K-P AT 4.2 GEV/C  3/79
R1  F    NEGATIVE CHARGE

R2      XI(1680) INTO (XI PI)/(SIGMA KBAR)              (P3)/(P1)
R2           (0.09) OR LESS          DIONISI   78 HBC   0 K-P AT 4.2 GEV/C  3/79

R3      XI(1680) INTO (XI- PI+ PI0)/(SIGMA KBAR)        (P5)/(P1)
R3           (0.04) OR LESS          DIONISI   78 HBC   0 K-P AT 4.2 GEV/C  3/79

R4      XI(1680) INTO (XI- PI+ PI-)/(SIGMA KBAR)        (P5)/(P1)
R4           (0.03) OR LESS          DIONISI   78 HBC  -  K-P AT 4.2 GEV/C  3/79

R5      XI(1680) INTO (XI(1530) PI)/(SIGMA KBAR)        (P4)/(P1)
R5           (0.06) OR LESS          DIONISI   78 HBC  -  K-P AT 4.2 GEV/C  3/79

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                    REFERENCES FOR XI(1680)

DIONISI  78 PL 80B 145          +DIAZ,ARMENTEROS+      (CERN+AMST+NIJM+OXF)I,JP
BIAGI    81 ZPHY C9 305         +      (BRIS+CAMB+GEVA+HEID+LAUS+LOQM+RHEL)

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Ξ(1820) Status: ***

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50  XI(1820, JP=3/2 ) I=1/2

WE LIST HERE EVERYTHING REPORTED IN THE MASS RANGE
1750-1875 MEV.
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The clearest evidence for this state comes from GAY 76, who saw an 8-standard-deviation peak in ΛK^- as well as signals in $\Xi(1530)\pi$ and $\Sigma\bar{K}$. The peak is narrow ($\Gamma = 21 \pm 7$ MeV), whereas earlier (and much smaller) experiments found widths of up to 100 MeV (see the Listings below). A spin-parity analysis of the GAY 76 data, but with more events (TEODORO 78), favors spin 3/2 but cannot make a parity discrimination.

BIAGI 81 used the CERN hyperon beam to study Ξ^- interactions in hydrogen and deuterium. The diffractively produced ΛK^- system has a broad peak ($\Gamma = 72 \pm 20$ MeV) at 1830 MeV on top of a substantial background. There is also a smaller peak in the inclusive ΛK^0_S spectrum.

Neither GAY 76 nor BIAGI 81 saw a peak in the $\Xi\pi$ channel. It is possible that $\Xi\pi$ peaks seen in this region by some lower momentum experiments are at least partly due to the $\Xi(1940)$, with a shape distorted by the limited phase space available (SMITH 65). The situa-

For notation, see key at front of Listings.

tion is further confused because some of the experiments were forced to add several different channels together to overcome poor statistics (CRENNELL 70, BADIER 71).

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                          50  XI(1820) MASS (MEV)

M          (1770.0)                       HALSTEINS 63 FBC  -0 K-FR 3.5 GEV/C
M       30 1814.0      4.0                BADIER    65 HBC   0 LAMBDA KOBAR
M       29 1817.0      7.0                SMITH 1   65 HBC  -0 LAMBDA KBAR
M       40 1830.0     10.0                ALITTI    69 HBC  -  LAM, SIG KBAR     9/69
M  A    25 1830.0     10.0                CRENNELL  70 DBC  -0 3.6, 3.9 GEV/C   10/70
M  A    FROM FIT TO INCLUSIVE XI PI, XI PI PI AND LAMBDA K- SPECTRA
M   B      (1826.0)   (12.0)              CRENNELL  70 DBC  -0 3.6, 3.9 GEV/C   11/77
M   B   FROM FIT TO INCLUSIVE XI PI AND XI PI PI SPECTRA ONLY
M  C    28 1762.0      8.0                BADIER    72 HBC  -0 XI PI,XI2PI,K Y  10/71
M  C    38 1838.0      5.0                BADIER    72 HBC   -0XI PI,XI2PI,K Y  10/71
M  C    BADIER 72 ADDS ALL CHANNELS AND DIVIDES PEAK IN LOWER AND HIGHER
M  C    MASS REGIONS. THE DATA CAN ALSO BE FITTED WITH A SINGLE BREIT-
M  C    WIGNER OF MASS 1800 AND WIDTH 150 MEV.
M    D  30 1821.0      5.0                ROSS1     73 HBC  -0 LAMBDA K-/KBAR0   2/74
M    D  LESS SIGNIFICANT ENHANCEMENTS SEEN IN XI(1530) PI (M=1825,W=100)
M    D  AND SIGMA KBAR (M=1810+-9,W=16+-11).
M          1807.0     27.0                DIBIANCA  75 DBC  -0 XI 2PI, XI* PI    1/76
M      130 1823.0      2.0                GAY       76 HBC  -  K- P AT 4.2 GEV   2/77
M       74 1797.0     19.0                BRIEFEL   77 HBC   0 XI PI (2.87 K-P)  1/78
M       68 1829.0      9.0                BRIEFEL   77 HBC  -0 XI(1530) PI       1/78
M       39 1860.0     14.0                BRIEFEL   77 HBC  -  SIGMA- KOBAR      1/78
M       44 1870.0      9.0                BRIEFEL   77 HBC   0 LAMBDA KOBAR      1/78
M       57 1813.0      4.0                BRIEFEL   77 HBC  -  LAMBDA K-         1/78
M    E 300 1830.0      6.0                BIAGI     81 SPEC -  HYPERON BEAM      2/82
M    E  FIT TO INCLUSIVE SPECTRUM FROM XI-N --> LAM K- X
M          1822.0      6.0                JENKINS   83 MPS  -  K- P TO K+ MM     1/84*
                    (SEE IDEOGRAM BELOW)
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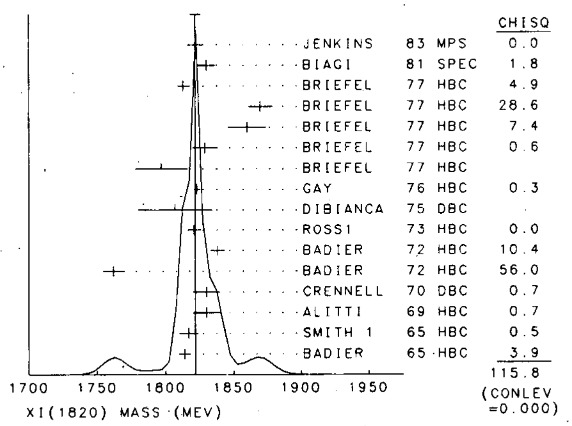


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                          50  XI(1820) WIDTH (MEV)

W            (80.0)   OR LESS             HALSTEINS 63 FBC  -0 K-FR 3.5 GEV/C
W            (12.0)    (4.0)              BADIER    65 HBC   0 LAMBDA KOBAR
W             30.0      7.0               SMITH2    65 HBC  -0 LAMBDA KBAR
W             55.0     40.0      20.0     ALITTI    69 HBC  -  LAM, SIG KBAR     9/69
W  A         103.0     38.0      24.0     CRENNELL  70 DBC  -0 3.6, 3.9 GEV/C   10/70
W   B        (48.0)   (36.0)    (19.0)    CRENNELL  70 DBC  -0 3.6, 3.9 GEV/C   11/77
W  C          51.0     13.0               BADIER    72 HBC  -0 LOWER MASS       10/71
W  C          58.0     13.0               BADIER    72 HBC  -0 HIGHER MASS      10/71
W    D  30    12.0      4.0               ROSS1     73 HBC  -0 LAMBDA K-/KBAR0   2/74
W             85.0     58.0               DIBIANCA  75 DBC  -0 XI 2PI, XI* PI    1/76
W      130    21.0      7.0               GAY       76 HBC  -  K- P AT 4.2 GEV   2/77
W       74    99.0     57.0               BRIEFEL   77 HBC   0 XI PI (2.87 K-P)  1/78
W       68    52.0     34.0               BRIEFEL   77 HBC  -0 XI(1530) PI       1/78
W       39    72.0     17.0               BRIEFEL   77 HBC  -  SIGMA- KOBAR      1/78
W       44    44.0     11.0               BRIEFEL   77 HBC   0 LAMBDA KOBAR      1/78
W       57    26.0     11.0               BRIEFEL   77 HBC  -  LAMBDA K-         1/78
W    E 300    72.0     20.0               BIAGI     81 SPEC -  HYPERON BEAM      2/82
                    (SEE IDEOGRAM BELOW)
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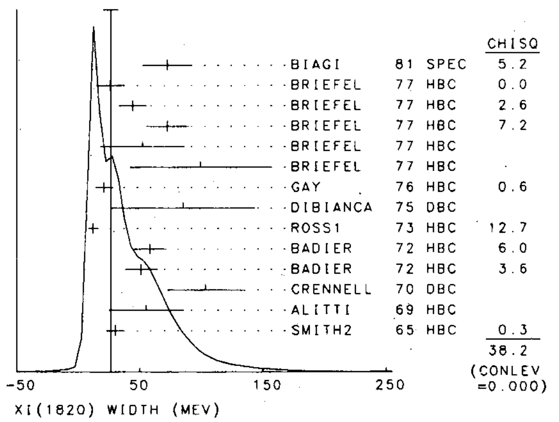


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                    50  XI(1820) PARTIAL DECAY MODES

                                                            DECAY MASSES
P1      XI(1820) INTO LAMBDA KBAR                           1116+ 498
P2      XI(1820) INTO XI PI                                 1321+ 140
P3      XI(1820) INTO SIGMA KBAR                            1197+ 498
P4      XI(1820) INTO XI(1530) PI                           1533+ 140
P5      XI(1820) INTO XI PI PI (EXCLUDING P4)               1321+ 140+ 140
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FITTED PARTIAL DECAY MODE BRANCHING FRACTIONS

The matrix below is derived from the error matrix for the fitted partial decay mode branching fractions, P_i, as follows: The diagonal elements are $P_i \pm \delta P_i$, where $\delta P_i = \sqrt{\langle \delta P_i \delta P_i \rangle}$, while the off-diagonal elements are the normalized correlation coefficients $\langle \delta P_i \delta P_j \rangle / (\delta P_i \cdot \delta P_j)$. For the definitions of the individual P_i, see the listings above; only those P_i appearing in the matrix are assumed in the fit to be nonzero and are thus constrained to add to 1.

	P 1	P 2	P 3	P 4
P 1	.4974+-.0871			
P 2	-.7612	.1889+-.0529		
P 3	.1335	-.5080	.1463+-.0477	
P 4	-.8220	.5813	-.5009	.1674+-.0647

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                    50  XI(1820) BRANCHING RATIOS

R1      XI(1820) INTO (LAMBDA KBAR)/TOTAL                    (P1)
R1            0.30      0.15              ALITTI    69 HBC  -  K-P 3.9-5.0 GEV   9/69
R1
R1  FIT       0.497     0.087   FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.8)

R2      XI(1820) INTO (XI PI)/TOTAL                          (P2)
R2            0.10      0.10              ALITTI    69 HBC  -  K-P 3.9-5.0 GEV   9/69
R2
R2  FIT       0.189     0.053   FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.2)
R21     XI(1820) INTO (XI PI)/(LAMBDA KBAR)                  (P2)/(P1)
R21           0.20      0.20              BADIER    65 HBC   0 K-P AT 3 GEV      7/66
R21          (0.36) OR LESS  CL=.95       GAY       76 HBC  -  K- P AT 4.2 GEV   2/77
R21
R21 FIT       0.38      0.16    FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.5)

R22     XI(1820) INTO (XI PI)/(XI(1530) PI)                  (P2)/(P4)
R22           1.5       0.6       0.4     APSELL    70 HBC   0 K-P AT 2.87 GEV   6/70
R22
R22 FIT       1.13      0.36    FROM FIT

R3      XI(1820) INTO (SIGMA KBAR)/TOTAL                     (P3)
R3           (0.02) OR LESS               TRIPP     67 RVUE                      8/67
R3            0.30      0.15              ALITTI    69 HBC  -  K-P 3.9-5.0 GEV   9/69
R3
R3  FIT       0.146     0.048   FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.1)

R31     XI(1820) INTO (SIGMA KBAR)/(LAMBDA KBAR)             (P3)/(P1)
R31           0.24      0.10              GAY       76 HBC  -  K- P AT 4.2 GEV   2/77
R31
R31 FIT       0.29      0.10    FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.1)

R4      XI(1820) INTO (XI(1530) PI)/TOTAL                    (P4)
R4            0.30      0.15              ALITTI    69 HBC  -  K-P 3.9-5.0 GEV   9/69
R4   F       (0.25) OR LESS               DAUBER    69 HBC     K-P 2.7 GEV/C     9/69
R4   F  USES IN PART THE SAME DATA AS SMITH 65
R4    G       NOT SEEN                    HASSALL   81 HBC     K-P 6.5 GEV/C     2/82
R4    G  INCLUDING XI PI PI
R4
R4  FIT       0.167     0.065   FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.6)

R41     XI(1820) INTO (XI(1530) PI)/(LAMBDA KBAR)            (P4)/(P1)
R41           0.26      0.13              SMITH1    65 HBC  -0 K-P 2.45-2.70GEV
R41           1.0       0.3               GAY       76 HBC  -  K- P AT 4.2 GEV   2/77
R41
R41 AVG       0.38      0.27     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 2.3)
R41 FIT       0.34      0.18    FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.7)

R51     XI(1820) INTO (XI PI PI)/(LAMBDA KBAR)               (P5)/(P1)
R51          (0.1)  OR MORE               SMITH1    65 HBC  -0 K-P 2.45-2.70GEV

R52     XI(1820) INTO (XI PI PI)/(XI(1530) PI)               (P5)/(P4)
R52 H        (0.3)     (0.5)              APSELL    70 HBC   0 K-P AT 2.87 GEV   6/70
R52 H   OR LESS. UPPER LIMIT FOR THE 3-BODY DECAY
R52         CONSISTENT WITH ZERO          GAY       76 HBC  -  K-P AT 4.2 GEV   11/77

R53     XI(1820) INTO (XI PI PI (INCL. XI(1530) PI)/(LAMBDA KBAR)
R53                                                          (P4+P5)/(P1)
R53  I       (0.14) OR LESS               BADIER    65 HBC   0 1 STD.DEV.LIMIT  11/77
R53  I  FOR THE DECAY MODE (XI- PI+ PI0) ONLY
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REFERENCES FOR XI(1820)


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HALSTEIN 63 SIENA CONF 173     HALSTEINSLID,+    (BERG+CERN+EPOL+RHEL+LOUC) I
BADIER   65 PL 16 171          +DEMOULIN,GOLDBERG, +       (EPOL+SACL+AMST) I
SMITH1   65 PRL 14 25          +LINDSEY,BUTTON-SHAFER,MURRAY           (LRL)IJP
SMITH2   65 ATHENS CONF 251    G A SMITH, J S LINDSEY                  (LRL)
TRIPP    67 NP B3 10           + LEITH, +          (LRL+SLAC+CERN+HEID+SACL)
    USES DATA OF SMITH1.

ALITTI   69 PRL 22 79          +BARNES,FLAMINIO,METZGER, +      (BNL+SYRA) I
DAUBER   69 PR 179 1262        +BERGE, HUBBARD, MERRILL, MULLER       (LRL)
APSELL   70 PRL 24 777         +                     (BRAN+UMD+SYRA+TUFT) I
CRENNELL 70 PR 1D 847          +KARSHON, LAI, ONEALL, SCARR, SCHUMANN(BNL)
BADIER   72 NP B37 429         +BARRELET,CHARLTON,VIDEAU             (EPOL)
ROSS1    73 PURDUE CONF. 345   ROSS,LLOYD,RADOJICIC                   (OXF)

DIBIANCA 75 NP B98 137         DIBIANCA,ENDORF                       (CARN)
GAY      76 PL 62B 477         +ARMENTEROS,BERGE,GAVILLET+(AMST+CERN+NIJM)IJ
BRIEFEL  77 PRD 16 2706        +GOUREVITCH,CHANG+     (BRAN+UMD+SYRA+TUFT)
    ALSO 70 DUKE CONF. 317     BMST                   (BRAN+UMD+SYRA+TUFT)
BIAGI    81 ZPHY C9 305        +       (BRIS+CAMB+GEVA+HEID+LAUS+LOQM+RHEL)
HASSALL  81 NP B189 397        +ANSORGE,CARTER,NEALE,RUSHBROOKE+(CAMB+MSU)
JENKINS  83 PRL 51 951         +ALBRIGHT,DIAMOND,+(FSU+BRAN+LBL+CINC+SMAS)

                               PAPERS NOT REFERRED TO IN DATA CARDS

SMITH    64 PRL 13 61          +LINDSEY,MURRAY,BUTTON-SHAFER+        (LRL) IJP
MERRILL  68 PR 167 1202        D W MERRILL, J BUTTON-SHAFER           (LRL)
APSELL   69 PRL 23 884         +                      (BRAN+UMD+SYRA+TUFT)
    SUPERSEDED BY BRIEFEL 77.
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Baryons

Ξ(1820), Ξ(1940), Ξ(2030)

Data Card Listings

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SCHMIDT  73 PURDUE CONF. 363  SCHMIDT                              (BRAN)
BRIEFEL  75 PRD 12 1859       +GOUREVITCH,KIRSCH+     (BRAN+UMD+SYRA+TUFT)
TEODORO  78 PL 77B 451        +DIAZ,DIONISI,BLOKZIJL+(AMST+CERN+NIJM+OXF)  JP

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Ξ(1940) Status: **

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52  XI(1940, JP=    ) I=1/2

WE LIST UNDER XI(1940) EVERYTHING REPORTED IN THE MASS
RANGE 1875-2000 MEV.

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52  XI(1940) MASS (MEV)

M       35 1933.0     16.0          BADIER    65 HBC   0 XI- PI+
M       27 1930.0     20.0          ALITTI    68 HBC   0 XI- PI+          11/68
M       66 1894.0     18.0          DAUBER    69 HBC  -  XI PI            11/68
M       21 1955.0     14.0          GOLDWASSE 70 HBC  -  XI PI            10/70
M       29 1956.0      6.0          BADIER    72 HBC     XI PI,XI2PI,K Y   10/71
M       25 1952.0     11.0          ROSS1     73         (XI PI)-           2/74
M          1900.0     12.0          DIBIANCA  75 DBC     XI PI              1/76
M      139 1961.0     18.0          BRIEFEL   77 HBC   0 XI-PI+(2.87 K-P)   1/78
M       44 1936.0     22.0          BRIEFEL   77 HBC  - XIOPI-(2.87 K-P)   1/78
M       56 1964.0     10.0          BRIEFEL   77 HBC -0 XI(1530) PI         1/78
M     A 150 1937.0     7.0          BIAGI     81 SPEC  0 HYPERON BEAM       2/82
M     A  FIT TO INCLUSIVE SPECTRUM FROM XI-N --> XI- PI+ X
                 (SEE IDEOGRAM BELOW)
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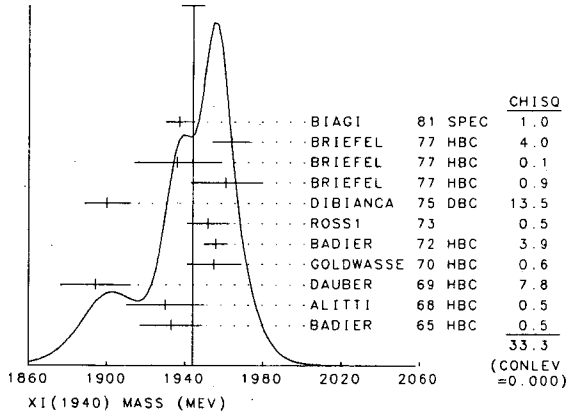


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52  XI(1940) WIDTH (MEV)

W       35  140.0     35.0          BADIER    65 HBC   0 XI- PI+
W       27   80.0     40.0          ALITTI    68 HBC   0 XI- PI+          11/68
W       66   98.0     23.0          DAUBER    69 HBC  -  XI PI            11/68
W       21   56.0     26.0          GOLDWASSE 70 HBC  -  XI PI            10/70
W       29   35.0     11.0          BADIER    72 HBC     XI PI,XI2PI,K Y   10/71
W            38.0     10.0          ROSS1     73         (XI PI)-           2/74
W            63.0     78.0          DIBIANCA  75 DBC     XI PI              1/76
W      139  159.0     57.0          BRIEFEL   77 HBC   0 XI-PI+(2.87 K-P)   1/78
W       44   87.0     26.0          BRIEFEL   77 HBC  - XIOPI-(2.87 K-P)   1/78
W       56   60.0     39.0          BRIEFEL   77 HBC -0 XI(1530) PI         1/78
W     A 150   60.0      8.0          BIAGI     81 SPEC  0 HYPERON BEAM       2/82
                 (SEE IDEOGRAM BELOW)
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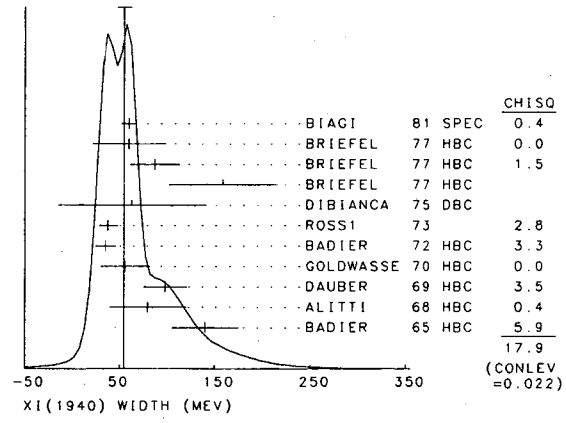


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52  XI(1940) PARTIAL DECAY MODES

                                                        DECAY MASSES
P1      XI(1940) INTO XI PI                             1321+ 140
P2      XI(1940) INTO XI(1530) PI                       1533+ 140
P3      XI(1940) INTO XI PI PI (EXCLUDING P2)           1321+ 140+ 140
P4      XI(1940) INTO XI0 PI-                           1315+ 140
P5      XI(1940) INTO XI- PI0                           1321+ 135
P6      XI(1940) INTO SIGMA KBAR                        1197+ 498

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52  XI(1940) BRANCHING RATIOS

   THE XI(1940) IS SEEN MAINLY IN XI PI AND SOME IN XI(1530) PI.  IT
 HAS BEEN LOOKED FOR IN OTHER CHANNELS BUT ONLY OBSERVED BY HASSALL 81
 WHO SEE A 3 SIGMA EFFECT IN SIGMA KBAR.

R1      XI(1940) INTO (XI PI)/(XI(1530) PI)             (P1)/(P2)
R1            2.8      0.7      0.6   APSELL    70 HBC   0                  6/70

R2      XI(1940) INTO (XI PI PI)/(XI(1530) PI)          (P3)/(P2)
R2            0.0      0.3            APSELL    70 HBC   0                  6/70

R3      XI(1940) INTO (XI0 PI-)/(XI- PI0)               (P4)/(P5)
R3       25    2.6      6.0      1.6   ROSS1     73         (XI PI)-        2/74

R4      XI(1940) INTO (SIGMA KBAR)/TOTAL                (P6)
R4       17   POSSIBLY SEEN            HASSALL   81 HBC  -  K-P AT 6.5 GEV/C  2/82

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                          REFERENCES FOR XI(1940)

BADIER    65 PL 16 171        +DEMOULIN,GOLDBERG, +       (EPOL+SACL+AMST) I
ALITTI    68 PRL 21 1119      +FLAMINIO,METZGER,RADOJICIC,+    (BNL+SYRA) I
DAUBER    69 PR 179 1262      +BERGE, HUBBARD, MERRILL, MULLER      (LRL) I
APSELL    70 PRL 24 777       +                      (BRAN+UMD+SYRA+TUFT) I
GOLDWASS  70 PR 1D 1960       E L GOLDWASSER, P F SCHULTZ      (ILLINOIS)
BADIER    72 NP B37,429       +BARRELET,CHARLTON,VIDEAU             (EPOL)
ROSS1     73 PURDUE CONF. 345 ROSS,LLOYD,RADOJICIC                  (OXF)

DIBIANCA  75 NP B98 137       DIBIANCA,ENDORF                       (CARN)
BRIEFEL   77 PRD 16 2706      +GOUREVITCH,CHANG+     (BRAN+UMD+SYRA+TUFT)
   ALSO   70 DUKE CONF. 317   BMST                   (BRAN+UMD+SYRA+TUFT)
BIAGI     81 ZPHY C9 305      +      (BRIS+CAMB+GEVA+HEID+LAUS+LOQM+RHEL)
HASSALL   81 NP B189 397      +ANSORGE,CARTER,NEALE,RUSHBROOKE+(CAMB+MSU)

                              PAPERS NOT REFERRED TO IN DATA CARDS

APSELL    69 PRL 23 884       +                      (BRAN+UMD+SYRA+TUFT)
   SUPERSEDED BY BMST  70.
SCHMIDT   73 PURDUE CONF. 363 SCHMIDT                               (BRAN)
BRIEFEL   75 PRD 12 1859      +GOUREVITCH,KIRSCH+    (BRAN+UMD+SYRA+TUFT)

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Ξ(2030) Status: ***

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68  XI(2030, JP=5/2 OR GREATER) I=1/2
THE EVIDENCE FOR THIS STATE HAS BEEN MUCH IMPROVED
BY HEMINGWAY 77, WHO SEE AN 8 STD. DEV. ENHANCEMENT
IN SIGMA KBAR AND A WEAKER COUPLING TO LAMBDA KBAR.
ALITTI 68 AND HEMINGWAY 77 OBSERVE NO SIGNALS IN THE
 XI PI PI (OR XI(1530) PI) CHANNEL, IN CONTRAST TO DIBIANCA 75. THE
 DECAY INTO LAMBDA/SIGMA KBAR PI REPORTED BY BARTSCH 69 IS ALSO NOT
 CONFIRMED BY HEMINGWAY 77.

 A MOMENTS ANALYSIS OF THE HEMINGWAY 77 DATA INDICATES THAT THE SPIN
 IS GREATER THAN OR EQUAL TO 5/2 AT A LEVEL OF 3 STD. DEVIATIONS.

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68  XI(2030) MASS (MEV)

M       42 2030.0     10.0          ALITTI    69 HBC  -  K-P 3.9-5 GEV/C   9/69
M       40 2058.0     17.0          BARTSCH   69 HBC -0 K-P 10 GEV/C       9/69
M       15 2019.0      7.0          ROSS1     73 HBC -0 SIGMA KBAR         2/74
M          2044.0      8.0          DIBIANCA  75 DBC -0 XI 2PI, XI* PI     1/76
M      200 2024.0      2.0          HEMINGWAY 77 HBC  -  K-P AT 4.2 GEV   11/77
M          2022.0      7.0          JENKINS   83 MPS  -  K- P TO K+ MM    1/84*
                 (SEE IDEOGRAM BELOW)
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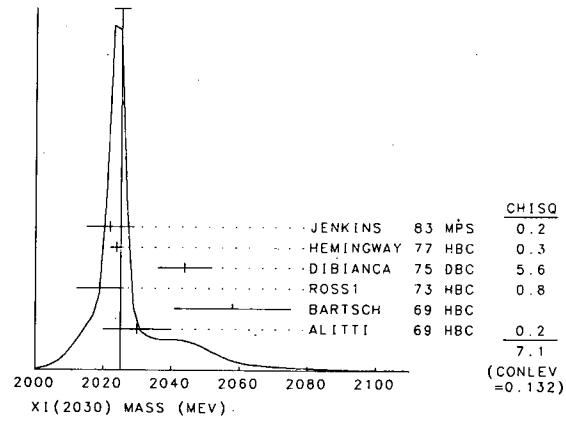


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68  XI(2030) WIDTH (MEV)

W            45.0     40.0     20.0  ALITTI    69 HBC  -  K-P 3.9-5 GEV/C   9/69
W            57.0     30.0           BARTSCH   69 HBC -0 K-P 10 GEV/C       9/69
W       15   33.0     17.0           ROSS1     73 HBC -0 SIGMA KBAR         2/74
W            60.0     24.0           DIBIANCA  75 DBC -0 XI 2PI, XI* PI     1/76
W      200   16.0      5.0           HEMINGWAY 77 HBC  -  K-P AT 4.2 GEV   11/77
                 (SEE IDEOGRAM BELOW)
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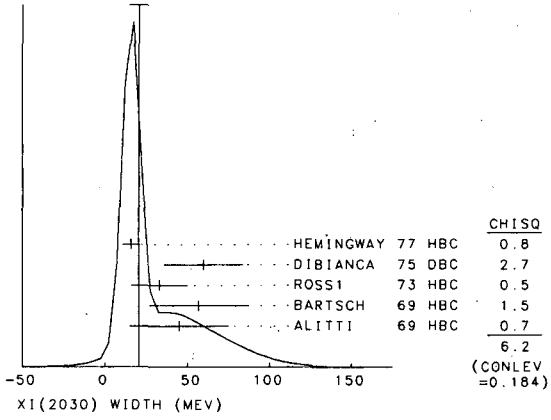
For notation, see key at front of Listings.

Baryons

Ξ(2030), Ξ(2120), Ξ(2250), Ξ(2370)

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                    68  XI(2030) PARTIAL DECAY MODES

                                                          DECAY MASSES
P1      XI(2030) INTO XI PI                              1321+ 140
P2      XI(2030) INTO LAMBDA KBAR                        1116+ 498
P3      XI(2030) INTO SIGMA KBAR                         1197+ 498
P4      XI(2030) INTO XI(1530) PI                        1533+ 140
P5      XI(2030) INTO XI PI PI (EXCLUDING P4)            1321+ 140+ 140
P6      XI(2030) INTO LAMBDA KBAR PI                     1116+ 498+ 140
P7      XI(2030) INTO SIGMA KBAR PI                      1189+ 498+ 140

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                    68  XI(2030) BRANCHING RATIOS

R1      XI(2030) INTO (XI PI)/(MODES P1 TO P4)           (P1)/(P1+P2+P3+P4)
R1            (0.30) OR LESS            ALITTI    69 HBC  -  1 STD DEV LIMIT   9/69

R11     XI(2030) INTO (XI PI)/(SIGMA KBAR)               (P1)/(P3)
R11           (0.19) OR LESS  CL=.95    HEMINGWAY 77 HBC  -  K-P AT 4.2 GEV   11/77

R2      XI(2030) INTO (LAMBDA KBAR)/(MODES P1 TO P4)     (P2)/(P1+P2+P3+P4)
R2            0.25    0.15              ALITTI    69 HBC  -  K-P 3.9-5 GEV/C   9/69

R21     XI(2030) INTO (LAMBDA KBAR)/(SIGMA KBAR)         (P2)/(P3)
R21           0.22    0.09              HEMINGWAY 77 HBC  -  K-P AT 4.2 GEV   11/77

R3      XI(2030) INTO (SIGMA KBAR)/(MODES P1 TO P4)      (P3)/(P1+P2+P3+P4)
R3            0.75    0.20              ALITTI    69 HBC  -  K-P 3.9-5 GEV/C   9/69

R4      XI(2030) INTO (XI(1530) PI)/(MODES P1 TO P4)     (P4)/(P1+P2+P3+P4)
R4            (0.15) OR LESS            ALITTI    69 HBC  -  1 STD DEV LIMIT   9/69

R41     XI(2030) INTO (XI PI PI INCL. XI(1530) PI)/(SIGMA KBAR)
R41                                                      (P4+P5)/(P3)
R41  A        (0.11) OR LESS  CL=.95    HEMINGWAY 77 HBC  -  K-P AT 4.2 GEV   11/77
R41  A  FOR THE DECAY MODE (XI- PI+ PI-) ONLY

R6      XI(2030) INTO (LAMBDA KBAR PI)/TOTAL             (P6)
R6            SEEN                      BARTSCH   69 HBC     K-P AT 10 GEV    11/77

R61     XI(2030) INTO (LAMBDA KBAR PI)/(SIGMA KBAR)      (P6)/(P3)
R61           (0.32) OR LESS  CL=.95    HEMINGWAY 77 HBC  -  K-P AT 4.2 GEV   11/77

R7      XI(2030) INTO (SIGMA KBAR PI)/TOTAL              (P7)
R7            SEEN                      BARTSCH   69 HBC     K-P AT 10 GEV    11/77

R71     XI(2030) INTO (SIGMA KBAR PI)/(SIGMA KBAR)       (P7)/(P3)
R71  B        (0.04) OR LESS  CL=.95    HEMINGWAY 77 HBC  -  K-P AT 4.2 GEV   11/77
R71  B  FOR THE DECAY MODE (SIGMA+- K- PI-+) ONLY

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                         REFERENCES FOR XI(2030)

ALITTI   69 PRL 22 79          +BARNES,FLAMINIO,METZGER, +       (BNL+SYRA) I
BARTSCH  69 PL 28B 439         +                  (AACH+BERL+CERN+LOIC+VIEN)
ROSS1    73 PURDUE CONF. 345   ROSS,LLOYD,RADOJICIC                    (OXF)

DIBIANCA 75 NP B98 137         DIBIANCA,ENDORF                        (CARN)
HEMINGWA 77 PL 68B 197         HEMINGWAY,ARMENTEROS+  (AMST+CERN+NIJM+OXF) IJ
    ALSO 76 PL 62B 477         GAY,ARMENTEROS,BERGE+      (AMST+CERN+NIJM)
JENKINS  83 PRL 51 951         +ALBRIGHT,DIAMOND,+(FSU+BRAN+LBL+CINC+SMAS)

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Ξ(2120) Status: *

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                    103  XI(2120, JP=    ) I=1/2

                    THIS EFFECT IS REPORTED IN GAY 76 AS A
                    FOUR STANDARD DEVIATION ENHANCEMENT IN
                    LAMBDA K-. AN ANALYSIS OF THE SAME DATA BY
                    HEMINGWAY 77, BUT WITH ADDITIONAL STATISTICS,
  POINTS OUT THAT THE SIGNIFICANCE OF THE ENHANCEMENT IS GREATLY REDUCED
  IF A RESTRICTIVE FOUR-MOMENTUM CUT (U-CUT) IS MADE. THIS SUGGESTS
  AN ANOMALOUS PRODUCTION MECHANISM IF THE STATE IS GENUINE.

  CHLIAPNIKOV 79 REPORT A BUMP OF 18 EVENTS AT 2137 MEV IN AN INCLUSIVE
  ANTI-LAMBDA K+ SPECTRUM FROM K+P INTERACTIONS AT 32 GEV/C.  THE K+ ARE
  NOT UNIQUELY IDENTIFIED. BUMPS WITH LOWER NUMBERS OF EVENTS ARE ALSO
  REPORTED AT 2240, 2830, AND 2540 MEV.

  IN NEED OF CONFIRMATION, OMITTED FROM TABLES.

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                    103  XI(2120) MASS (MEV)

M          2123.0      7.0            GAY       76 HBC  -  K- P AT 4.2 GEV   2/77
M       18(2137.0)    (4.0)           CHLIAPNIK 79 HBC  +  ANTI-LAMBDA K+    1/80

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                    103  XI(2120) WIDTH (MEV)

W            25.0     12.0            GAY       76 HBC  -  K- P AT 4.2 GEV   2/77
W       18  (20.0)  OR LESS            CHLIAPNIK 79 HBC  +  ANTI-LAMBDA K+    1/80

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                    103  XI(2120) PARTIAL DECAY MODES

                                                          DECAY MASSES
P1      XI(2120) INTO LAMBDA KBAR                        1116+ 498

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                    103  XI(2120) BRANCHING RATIOS

R1      XI(2120) INTO (LAMBDA KBAR)/TOTAL                (P1)
R1            SEEN                      GAY       76 HBC  -  K- P AT 4.2 GEV   2/77

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                         REFERENCES FOR XI(2120)

GAY      76 PL 62B 477         +ARMENTEROS,BERGE,GAVILLET+(AMST+CERN+NIJM)I
HEMINGWA 77 PL 68B 197         HEMINGWAY,ARMENTEROS+  (AMST+CERN+NIJM+OXF)
CHLIAPNI 79 NP B158 253        CHLIAPNIKOV,GERDYUKOV+     (SERP+BELG+MONS)

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Ξ(2250) Status: **

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                    22  XI(2250, JP=    )

                    THE EVIDENCE FOR THIS STATE IS MIXED.  BARTSCH 69 SEE
                    A BUMP OF NOT MUCH STATISTICAL SIGNIFICANCE IN LAMBDA-
                    KBAR-PI, SIGMA-KBAR-PI, AND XI-PI-PI MASS SPECTRA.
                    GOLDWASSER 70 SEE A NARROWER BUMP IN XI-PI-PI AT A
                    HIGHER MASS.  NOT SEEN BY HASSALL 81 WITH 45
                    EVENTS/MICROBARN AT 6.5 GEV/C.  SEEN BY JENKINS 83.

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                    22  XI(2250) MASS (MEV)

M       35 2244.0     52.0            BARTSCH   69 HBC     K-P 10 GEV/C      9/69
M       18 2295.0     15.0            GOLDWASSE 70 HBC  -  K-P 5.5 GEV/C    10/70
M          2214.0      5.0            JENKINS   83 MPS  -  K- P TO K+ MM     1/84*

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                    22  XI(2250) WIDTH (MEV)

W           130.0     80.0            BARTSCH   69 HBC                       9/69
W         LESS THAN  30.0             GOLDWASSE 70 HBC  -  K-P 5.5 GEV/C    10/70

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                    22  XI(2250) PARTIAL DECAY MODES

                                                          DECAY MASSES
P1      XI(2250) INTO XI PI PI                           1321+ 140+ 140
P2      XI(2250) INTO LAMBDA KBAR PI                     1116+ 498+ 140
P3      XI(2250) INTO SIGMA KBAR PI                      1197+ 498+ 140

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                         REFERENCES FOR XI(2250)

BARTSCH  69 PL 28B 439         +                  (AACH+BERL+CERN+LOIC+VIEN)
GOLDWASS 70 PR 1D 1960         E L GOLDWASSER, P F SCHULTZ            (ILL)
JENKINS  83 PRL 51 951         +ALBRIGHT,DIAMOND,+(FSU+BRAN+LBL+CINC+SMAS)

                               PAPERS NOT REFERRED TO IN DATA CARDS

HASSALL  81 NP B189 397        +ANSORGE,CARTER,NEALE,RUSHBROOKE+(CAMB+MSU)

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Ξ(2370) Status: **

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                    131  XI(2370, JP=    ) I=1/2

                    SEEN BY AMIRZADEH 80 AND HASSALL 81 IN THE CHARGED AND
                    NEUTRAL LAMBDA/SIGMA KBAR PI MASS SPECTRA FROM THE
                    REACTIONS K-P --> XI(1530) K AND XI(1530) K PI.
                    AMIRZADEH 80 ALSO OBSERVE A SMALL EFFECT AT THE SAME
  MASS IN THE OMEGA- K MASS SPECTRUM.  KINSON 80 RE-ANALYSE THE DATA OF
  AMIRZADEH 80 BUT WITH 50 PER CENT MORE STATISTICS.
  IN NEED OF FURTHER CONFIRMATION.  OMITTED FROM TABLES.

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                    131  XI(2370) MASS (MEV)

M          2392.0     27.0            DIBIANCA  75 DBC     XI 2PI            1/76
M       94 2373.0      8.0            AMIRZAD   80 HBC  -0 K-P AT 8.25 GEV   1/80
M       50(2370.0)                    HASSALL   81 HBC  -0 K-P AT 6.5 GEV/C  2/82
M          2356.0     10.0            JENKINS   83 MPS  -  K- P TO K+ MM     1/84*
M          . . . . . . . . . .
M   AVG    2367.7      7.0     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.1)

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                    131  XI(2370) WIDTH (MEV)

W            75.0     69.0            DIBIANCA  75 DBC     XI 2PI            1/76
W       94   80.0     25.0            AMIRZAD   80 HBC  -0 K-P AT 8.25 GEV   1/80
W       50  (80.0)                    HASSALL   81 HBC  -0 K-P AT 6.5 GEV/C  2/82
W          . . . . . . . . . .
W   AVG     79.4     23.5     AVERAGE

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Baryons

$\Xi(2370)$, $\Xi(2500)$, Ω^-, Λ_c^+, $\Sigma_c(2450)$, A^+, Λ_b^0, DIBARYONS

Data Card Listings

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                    131  XI(2370) PARTIAL DECAY MODES

                                                          DECAY MASSES
P1      XI(2370) INTO LAMBDA KBAR PI (INCL. P4+P6)       1116+ 498+ 140
P2      XI(2370) INTO SIGMA KBAR PI (INCL. P5+P6)        1197+ 498+ 140
P3      XI(2370) INTO OMEGA- K                           1672+ 498
P4      XI(2370) INTO LAMBDA ANTI-K*(892)                1116+ 892
P5      XI(2370) INTO SIGMA ANTI-K*(892)                 1197+ 892
P6      XI(2370) INTO SIGMA(1385) KBAR                   1385+ 498

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                    131  XI(2370) BRANCHING RATIOS

R1      XI(2370) INTO (LAMBDA KBAR PI)/TOTAL             (P1)
R1          SEEN                    AMIRZAD   80 HBC  -0 K-P AT 8.25 GEV   1/80

R2      XI(2370) INTO (SIGMA KBAR PI)/TOTAL              (P2)
R2          SEEN                    AMIRZAD   80 HBC  -0 K-P AT 8.25 GEV   1/80

R3      XI(2370) INTO (LAMBDA/SIGMA KBAR PI)/TOTAL       (P1+P2)
R3       50 SEEN                    HASSALL   81 HBC  -0 K-P AT 6.5 GEV/C  2/82

R4      XI(2370) INTO (OMEGA- K)/TOTAL                   (P3)
R4          0.09     0.04           KINSON    80 HBC  -  K-P AT 8.25 GEV   2/82

R5      XI(2370) INTO (LAMBDA/SIGMA ANTI-K*(892))/TOTAL  (P4+P5)
R5          0.22     0.13           KINSON    80 HBC  -  K-P AT 8.25 GEV   2/82

R6      XI(2370) INTO (SIGMA(1385) KBAR)/TOTAL           (P6)
R6          0.12     0.08           KINSON    80 HBC  -  K-P AT 8.25 GEV   2/82

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                    REFERENCES FOR XI(2370)

DIBIANCA 75 NP B98 137        DIBIANCA,ENDORF                        (CARN)
AMIRZAD  80 PL 90B 324        AMIRZADEH+          (BIRM+CERN+GLAS+MSU+LPNP)I
KINSON   80 TORONTO CONF. 263 J B KINSON+         (BIRM+CERN+GLAS+MSU+LPNP)I
HASSALL  81 NP B189 397       +ANSORGE,CARTER,NEALE,RUSHBROOKE+(CAMB+MSU)
JENKINS  83 PRL 51 951        +ALBRIGHT,DIAMOND,+(FSU+BRAN+LBL+CINC+SMAS)

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$\Xi(2500)$ Status: *

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                    99  XI(2500, JP=    ) I=1/2

                    THE ALITTI 69 PEAK MIGHT BE INSTEAD THE XI(2370)
                    OR MIGHT BE NEITHER THE XI(2370) NOR THE
                    XI(2500).

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                    99  XI(2500) MASS (MEV)

M       30 2430.0     20.0           ALITTI    69 HBC  -  K-P 4.6-5 GEV/C   9/69
M       45 2500.0     10.0           BARTSCH   69 HBC  -0 K-P 10 GEV/C      9/69
M          2505.0     10.0           JENKINS   83 MPS  -  K- P TO K+ MM     1/84*

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                    99  XI(2500) WIDTH (MEV)

W           150.0     60.0     40.0  ALITTI    69 HBC  -                    9/69
W            59.0     27.0           BARTSCH   69 HBC  -0                   9/69

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                    99  XI(2500) PARTIAL DECAY MODES

                                                          DECAY MASSES
P1      XI(2500) INTO XI PI                              1321+ 140
P2      XI(2500) INTO LAMBDA KBAR                        1116+ 498
P3      XI(2500) INTO SIGMA KBAR                         1197+ 498
P4      XI(2500) INTO XI(1530) PI                        1533+ 140
P5      XI(2500) INTO LAMBDA (OR SIGMA) KBAR PI          1116+ 498+ 140
P6      XI(2500) INTO XI PI PI                           1321+ 140+ 140

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                    99  XI(2500) BRANCHING RATIOS

R1      XI(2500) INTO (XI PI)/(MODES P1 THRU P4)         (P1)/(P1+P2+P3+P4)
R1          (0.5)  OR LESS         ALITTI    69 HBC     1 STD DEV LIMIT   9/69

R2      XI(2500) INTO (LAMBDA KBAR)/(MODES P1 THRU P4)   (P2)/(P1+P2+P3+P4)
R2          0.5      0.2           ALITTI    69 HBC  -                    9/69

R3      XI(2500) INTO (SIGMA KBAR)/(MODES P1 THRU P4)    (P3)/(P1+P2+P3+P4)
R3          0.5      0.2           ALITTI    69 HBC  -                    9/69

R4      XI(2500) INTO (XI(1530) PI)/(MODES P1 THRU P4)   (P4)/(P1+P2+P3+P4)
R4          (0.2)  OR LESS         ALITTI    69 HBC     1 STD DEV LIMIT   9/69

R5      XI(2500) INTO (LAMBDA (OR SIGMA) KBAR PI)/TOTAL  (P5)
R5          SEEN                   BARTSCH   69 HBC  -0                   9/69

R6      XI(2500) INTO (XI PI PI)/TOTAL                   (P6)
R6          SEEN                   BARTSCH   69 HBC  -0                   9/69

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                    REFERENCES FOR XI(2500)

ALITTI   69 PRL 22 79         +BARNES,FLAMINIO,METZGER, +      (BNL+SYRA) I
BARTSCH  69 PL 28B 439        +                   (AACH+BERL+CERN+LOIC+VIEN)
JENKINS  83 PRL 51 951        +ALBRIGHT,DIAMOND,+(FSU+BRAN+LBL+CINC+SMAS)

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S=−3 I=0 HYPERON STATE (Ω)

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Ω^-

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                    24  OMEGA-(1672, JP=    ) I=0

                    SEE STABLE PARTICLE DATA CARD LISTINGS

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CHARMED BARYONS

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Λ_c^+

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                    33  LAMBDA/C+(2282, JP=    )

                    SEE STABLE PARTICLE DATA CARD LISTINGS

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$\Sigma_c(2450)$ Status: **

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                    104  SIGMA/C(2450, JP=    )
                    THE SIGMA/C DECAYS TO LAMBDA/C PI, AND THE SCHISM IN
                    MASSES HERE REFLECTS THAT IN MEASUREMENTS OF THE
                    LAMBDA/C MASS (THE HIGHER MASSES ARE PRESENTLY
                    FAVORED).  THE IMPRESSIVE AGREEMENT ON THE SIGMA/C-
                    LAMBDA/C MASS DIFFERENCE STRONGLY INDICATES THIS TO
   BE THE CASE, RATHER THAN THAT TWO STATES (THE SIGMA/C AND Y*/C)
   ARE BEING OBSERVED.

        THIS PARTICLE IS AT ABOUT THE 2-AND-1/2-STAR LEVEL.  A DEFINITIVE
   EXPERIMENT IS NEEDED.

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                    104  SIGMA/C(2450) MASS  (MEV)

M       1  2426.0      12.0          CAZZOLI   75 HBC  ++ NU P IN BNL 7-FT  3/77
M       9 (2460.0)                   KNAPP     76 SPEC -  GAMMA BE         11/81
M       1 (2439.0)  OR MORE          BARISH    77 DBC  ++ NU D IN 12-FT     3/77
M       6  2425.0      10.0          BALTAY    79 HLBC ++ NU NE-H IN 15-FT 12/79
M       1  2457.0       4.0          CALICCHIO 80 HBC  +  NU P IN BEBC-TST 11/81
M       1  2454.0       5.0          BOSETTI   82 HBC  ++ NU P IN BEBC      3/82

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                    104  (SIGMA/C)-(LAMBDA/C+) MASS DIFFERENCE  (MEV)

D       1   166.0      15.0          CAZZOLI   75 HBC  ++ NU P IN BNL 7-FT 11/81
D       6   168.0       3.0          BALTAY    79 HLBC ++ NU NE-H IN 15-FT 12/79
D       1   168.0       3.0          CALICCHIO 80 HBC  +  NU P IN BEBC-TST 11/81
D       1   166.0       1.0          BOSETTI   82 HBC  ++ NU P IN BEBC      3/82

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                    104  SIGMA/C(2450) PARTIAL DECAY MODES

                                                          DECAY MASSES
P1      SIGMA/C(2450) INTO LAMBDA/C+ PI                  2282+ 140

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                    REFERENCES FOR SIGMA/C(2450)

CAZZOLI  75 PRL 34 1125       +CNOPS,CONNOLLY,LOUTTIT,MURTAGH, +     (BNL)
KNAPP    76 PRL 37 882        +LEE,LEUNG,SMITH, +     (COLU+HAWA+ILL+FNAL)
BARISH   77 PR D15 1          +DERRICK,DOMBECK,MUSGRAVE, +      (ANL+PURD)
BALTAY   79 PRL 42 1721       +CAROUMBALIS,FRENCH,HIBBS, +      (COLU+BNL)I
CALICCHI 80 PL 93B 521        + (BARI+BIRM+BRUX+CERN+EPOL+RHEL+SACL+LOUC)
BOSETTI  82 PL 109B 234       +GRAESSLER, +     (AACH+BONN+CERN+MPIM+OXF)

                              THEORY AND REVIEW

DERUJULA 75 PR D12 147        +GEORGI,GLASHOW                      (HARV)
LEE      77 PR D15 157        +QUIGG,ROSNER                        (FNAL)
TRILLING 81 PRPL 75 57        G H TRILLING                          (LBL)

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A^+

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                    45  A+(2460, JP=    )

                    SEE STABLE PARTICLE DATA CARD LISTINGS

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BOTTOM (BEAUTY) BARYON

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Λ_b^0

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                    40  LAMBDA/B0(5500, JP=    )

                    SEE STABLE PARTICLE DATA CARD LISTINGS

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NOTE ON DIBARYON RESONANCES

(by L.D. Roper, Virginia Polytechnic Institute and State University)

The first modern theoretical discussion of dibaryon resonances was probably by Oakes.[1] The first experimental hint of them was in a Λp invariant mass distribution by Dahl,[2] and in a pp partial-wave analysis by

For notation, see key at front of Listings.

Arndt[3] for the $^1D_2$ state. [The notation is $^{(2S+1)}L_J$, where S is the total spin, L is the orbital angular momentum, and J is the total angular momentum. The Pauli principle restricts two nucleons to be in one of the following states:

$$I=0:\ (^3S_1,^3D_1),^1P_1,^3D_2,(^3D_3,^3G_3),^1F_3,^3G_4,\cdots$$

$$I=1:\ ^1S_0,^3P_0,^3P_1,(^3P_2,^3F_2),^1D_2,^3F_3,\cdots .$$

Here the states that couple together (same J^P) are grouped together in parentheses. Similarly, only certain states are allowed for ΛΛ, etc.]

Interest in dibaryons rose dramatically in 1977 when strong energy dependence was unexpectedly observed in pp polarization experiments at Argonne.[4] Also, in that year and the next, Hoshizaki claimed the existence of dibaryon resonances in a pp partial-wave analysis.[5] In the same year Jaffe gave a detailed theoretical treatment of multiquark states.[6] There is now a vast literature on dibaryon resonances.

However, there is still disagreement about what "dibaryon resonances" are. There is little doubt of the existence of distinct structures in NN partial-wave amplitudes that look very much like ordinary highly inelastic resonances, such as are seen in πN scattering. The question is whether these structures are caused by resonance poles in the complex energy plane or by some other structure of the scattering amplitude.

One aspect of the arguments about dibaryon resonances is whether they are calculable in terms of quark theory or should instead be calculated using some hadron interaction theory without reference to the underlying quarks. Both approaches have had successes and failures, so possibly both will make contributions to unraveling the mysteries of dibaryon resonances.

The idea that dibaryon resonances are "pseudo-resonances"[7] has taken some new turns. The idea is that box diagrams (e.g., involving NΔ in NN scattering) create resonance-like loops in the Argand diagram without resonance poles actually existing. The problem with believing this is whether poles would be created when one unitarizes the box-diagram calculations in order to calculate physical scattering amplitudes. Kloet and Tjon[8] have recently shown that a model exists in which, indeed, this is the case. However, resonance hunters should definitely report pole positions rather than looping Argand diagrams in the future. All who suggest that the NN $^1D_2$ or $^3F_3$ resonance-like structure is a resonance or is instead due to some other dynamics must take their case to the world collection of NN scattering data in the form of a detailed partial-wave analysis, and should report the existence or nonexistence of resonance poles.

Closely related to the work described above is that by Ueda,[9] in which Faddeev πNN dynamics is fitted to the NN partial-wave amplitudes. Although the fit is not good, the approximately correct structure is present. The interesting point is that poles do occur on the "resonance" sheets in the complex energy plane. Ueda claims this work is important because many claims for resonance poles assume that the poles exist, but the Faddeev approach does not make such prior assumptions.

VerWest[10] recently reported separable potential model fits to the $^1D_2$ and $^3F_3$ NN amplitudes and claims some solutions had no resonance poles, but Kloet and Tjon[11] have shown that these potential model fits all do, indeed, have resonance poles.

The dinucleon resonances also communicate with the γd and πd channels. There is not much γd data, and the multipole analysis does not yield much certainty about which dibaryons are involved. In the πd case, uncertainties abound, and the partial-wave analysis yields poor fits compared to the NN analyses. In addition to NN analyses, results from partial-wave analyses of πd → πd, πd → πpn, pp → πd, and γd → pn scattering are listed below. Most of these strongly indicate the existence of dibaryon resonances in the $^1D_2$ and $^3F_3$ NN states, and some indicate possible resonances in the $^1S_0$, $^3S_1$, $^3P_1$, $^3P_2$, $^3D_3$, $^1F_3$, and $^1G_4$ states.

Since our last edition, many papers have been published about dibaryon resonances, but very little new hard information has emerged. There are ten new references for dinucleons and only one new reference for strange dibaryons giving new values for the resonance-pole (or Breit-Wigner) parameters. However, most of the new references for dinucleons are merely new fits to NN partial-wave amplitudes.

A notable paper is that of Semianczuk et al.,[12] in which two prominent peaks are seen in the np invariant mass spectrum from dp → (np)p deuteron breakup. However, a recent preprint by Katayama et al.[13] claims to have done a similar experiment and did not see the peaks.

Since our last edition, only one paper has appeared giving data for the strange dibaryon states. It appears

Baryons
DIBARYONS

Data Card Listings

that the strangeness −1 dominant resonance is in the $^3S_1$ state, an SU(3) partner of the deuteron. An excellent review is given by Dalitz.[14] He concludes that the S = −1 $^3S_1$ resonance pole probably exists. However, May et al.[15] report no enhancements in the Σ^+n, Σ^0p, or Λp invariant mass spectra in the $K^-d \to \pi^-X$ reaction, and Arenton et al.[16] report no enhancement in the Λp spectrum in the $pp \to \Lambda pK^+$ reaction.

In the Listings below, we separate the determinations of pole positions and Breit-Wigner parameters. To be a resonance, the pole must occur on the lower half of the second sheet for the elastic channel; it may be a bound state or resonance for inelastic channels.

In summary, this reviewer feels that the evidence, both experimental and theoretical, for the $^1D_2$ and $^3F_3$ dinucleon resonances is now very strong. The theoretical calculations almost all now agree that resonance poles occur in the NN amplitudes. The disagreement among production experiments is inherent in the difficulties of that kind of experiment; overlapping highly inelastic resonances are very difficult to see in final states.

For more detailed reviews of dibaryons, with a wide variety of opinions, see Hoshizaki,[17] Bugg,[18] Kamae,[19] Vinh Mau,[20] Kroll,[21] and Locher.[22]

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DIBARYONS

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S=0 DIBARYONS

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                    106  BARYON NUMBER 2, STRANGENESS 0 STATES

        IN THIS SECTION WE USE THE FOLLOWING ABBREVIATIONS FOR TYPES
        OF ANALYSES--

        DB        D P -> P P N (DEUTERON BREAKUP); INVARIANT MASSES
        GDPN      GAMMA D -> P N PARTIAL-WAVE ANALYSIS RESONANCE
                  PARAMETRIZATION
        NN        FIT TO NN ELASTIC PARTIAL-WAVE ANALYSIS RESULTS
        NNF       FIT TO NN FORWARD AMPLITUDES
        NPT       NP TOTAL CROSS SECTION BREIT-WIGNER FIT
        PID       PI- D ELASTIC PARTIAL-WAVE ANALYSIS RESONANCE
                  PARAMETRIZATION
        PIDC      PI D DIFFERENTIAL CROSS SECTION BREIT-WIGNER FIT
        PIDI      PI D -> PI P N AMPLITUDE ANALYSIS RESONANCE
                  PARAMETRIZATION
        PNI       P N -> P P PI- CROSS SECTIONS BREIT-WIGNER FIT
        PPPD      P P -> PI+ D PARTIAL-WAVE ANALYSIS RESONANCE
                  PARAMETRIZATION
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NN(2170) I=1, $^1D_2$ Status: **

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                    106  B=2, S=0, 1D2 -- BREIT-WIGNER MASS (MEV)

        BREIT-WIGNER MASS APPROXIMATELY EQUALS RE(POLE POSITION).

M          (2170.0)                HOSHIZAKI 79 NN   1D2 ASSUMED BCDGRND  1/82
M          (2180.0)                ARVIEUX   80 PID  1D2                 1/82
M     A    (2185.0)                KAMO      80 PPPD 1D2                 1/82
M          (2170.0)                HOFTIEZE  81 PIDI 1D2                 1/82
M     B    (2140.0)                KANAI     81 PID  1D2 SOL. B AND C    1/82
M           2140. TO 2160.         DAKHNO    82 PNI  1D2                12/83*
M     C    (2116.0)                UEDA      82 NN   1D2 FADDEEV ''FIT'' 12/83*
M
M     A  KAMO 80 DID NOT TRY FITS WITH FEWER THAN SIX RESONANCES.         1/82
M     B  KANAI 81 FIT WITH NO RESONANCES WAS VERY POOR AND DID NOT TRY    1/82
M     B  OTHER FITS WITH FEWER THAN FOUR RESONANCES.                      1/82
M     C  UEDA 82 REPORTS AS ''MASS'' BUT DOES NOT EXPLAIN HOW CALCULATED  12/83*
M     C  FROM POLE POSITION.                                             12/83*

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                    106  B=2, S=0, 1D2 -- BREIT-WIGNER WIDTH (MEV)

        BREIT-WIGNER WIDTH APPROXIMATELY EQUALS 2 TIMES IM(POLE POSITION).

W           100. TO 150.           HOSHIZAKI 79 NN   1D2 ASSUMED BCKGRND  1/82
W     A    (134.0)                 KAMO      80 PPPD 1D2                 1/82
W          (75.0)                  HOFTIEZE  81 PIDI 1D2                 1/82
W     B    (56.0)                  KANAI     81 PID  1D2 SOL. B          1/82
W     B    (54.0)                  KANAI     81 PID  1D2 SOL. C          1/82
W           50. TO 100.            DAKHNO    82 PNI                     12/83*
W     C    (61.0)                  UEDA      82 NN   1D2 FADDEEV ''FIT'' 12/83*

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                    106  B=2, S=0, 1D2 -- BREIT-WIGNER ELASTICITY

        BREIT-WIGNER ELASTICITY APPROXIMATELY EQUALS
        ABS(RESIDUE OF POLE)/IM(POLE POS.).

R1          (0.1)                  HOSHIZAKI 79 NN   1D2                 1/82

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For notation, see key at front of Listings.

Baryons
DIBARYONS

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                    106  B=2, S=0, 1D2 -- RE(POLE POSITION) (MEV)

        RE(POLE POSITION) APPROXIMATELY EQUALS BREIT-WIGNER MASS.

RE        (2045.0)                  BHANDARI  81 NN   1D2 K-MATRIX FIT     1/82
RE        (2135.0)                  BHANDARI  81 NN   1D2 M-MATRIX FIT     1/82
RE        (2150.0)                  EDWARDS   81 NN   1D2 K-MATRIX FIT     1/82
RE   D    (2153.0)                  KLOET     81 NN   1D2 POT. MODEL FIT   1/82
RE   E    (2110.0)                  UEDA      82 NN   1D2 FADDEEV ''FIT''  12/83*
RE   F     2120. TO 2150.           BHANDARI  83 NN   1D2 M-MATRIX FIT    12/83*
RE   E     2149. TO 2150.           KLOET     83 NN   1D2 COUP. CHAN. FIT 12/83*
RE
RE   D  KLOET 81 DOES NOT SHOW GOODNESS OF FIT TO 1D2.                     1/82
RE   E  NOT A GOOD FIT TO PARTIAL-WAVE AMPLITUDES.                        12/83*
RE   F  BHANDARI 83 CLAIMS 1D2 IS AN N-DELTA BOUND STATE.                 12/83*

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                    106  B=2, S=0, 1D2 -- IM(POLE POSITION) (MEV)

        IM(POLE POSITION) APPROXIMATELY EQUALS ONE-HALF BREIT-WIGNER WIDTH.

IM         (110.0)                  BHANDARI  81 NN   1D2 K-MATRIX FIT     1/82
IM          (90.0)                  BHANDARI  81 NN   1D2 M-MATRIX FIT     1/82
IM          (56.0)                  EDWARDS   81 NN   1D2 K-MATRIX FIT     1/82
IM   D      (46.0)                  KLOET     81 NN   1D2 POT. MODEL FIT   1/82
IM   E      (54.0)                  UEDA      82 NN   1D2 FADDEEV ''MDFIT
IM   F       80. TO 100.            BHANDARI  83 NN   1D2 M-MATRIX FIT    12/83*
IM   E       39. TO  45.            KLOET     83 NN   1D2 COUP. CHAN. FIT 12/83*

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                    106  B=2, S=0, 1D2 -- ABS(RESIDUE)/IM(POLE POSITION)
        ABS(RES)/IM(POLE POSITION) APPROXIMATELY EQUALS BREIT-WIGNER
        ELASTICITY.

RES          (0.175)                BHANDARI  81 NN   1D2 K-MATRIX FIT     1/82
RES          (0.2)                  BHANDARI  81 NN   1D2 M-MATRIX FIT     1/82
RES          (0.29)                 EDWARDS   81 NN   1D2 K-MATRIX FIT     1/82
RES  F        0.1 TO 0.3            BHANDARI  83 NN   1D2 M-MATRIX FIT    12/83*

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NN(2250) I=1, $^3F_3$ Status: **

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                    106  B=2, S=0, 3F3 -- BREIT-WIGNER MASS (MEV)

M    G    (2390.0)                  GREIN     78 NNF  3F3                  1/82
M         (2220.0)                  HOSHIZAKI 78 NN   3F3 ASSUMED BCKGRND   1/82
M    H     2260. (FIXED)            IKEDA     80 GDPN 3F3 SOL. A           1/82
M          2296.0      11.0         IKEDA     80 GDPN 3F3 SOL. A'          1/82
M          2307.0      12.0         IKEDA     80 GDPN 3F3 SOL. B''         1/82
M    A    (2185.0)                  KAMO      80 PPPD 3F3                  1/82
M    B    (2260.0)                  KANAI     81 PID  3F3 SOL. B AND C     1/82
M          2251. TO 2266.           BHANDARI  82 NN   3F3                 12/83*
M          2220. TO 2260.           DAKHNO    82 PNI  3F3(OR 3D3/3G3)   M
M    G    (2310.0)                  GREIN     82 NNF  3F3                 12/83*
M    I     2200.0    10.0           SHAMU     82 NPT  3F3                 12/83*
M    C    (2155.0)                  UEDA      82 NN   3F3 FADDEEV ''FIT'' 12/83*
M
M    G  GREIN 78 AND GREIN 82 SEE NO 1D2 RESONANCE.                         1/82
M    H  IKEDA 80 GIVES TWO OTHER SOLUTIONS WITH POORER FITS TO DATA.        1/82
M    I  THIS IS AN N P RESONANCE.                                          12/83*

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                    106  B=2, S=0, 3F3 -- BREIT-WIGNER WIDTH (MEV)

W    G    (290.0)                   GREIN     78 NNF  3F3                  1/82
W          50. TO 100.              HOSHIZAKI 78 NN   3F3 ASSUMED BCKGRND   1/82
W    H     200. (FIXED)             IKEDA     80 GDPN 3F3 SOL. A           1/82
W          177.0       32.0         IKEDA     80 GDPN 3F3 SOL. A'          1/82
W          213.0       54.0         IKEDA     80 GDPN 3F3 SOL. B''         1/82
W    A    (81.0)                    KAMO      80 PPPD 3F3                  1/82
W    B    (181.0)                   KANAI     81 PID  3F3 SOL. B           1/82
W    B    (171.0)                   KANAI     81 PID  3F3 SOL. C           1/82
W          70. TO 100.              BHANDARI  82 NN   3F3                 12/83*
W          100. TO 200.             DAKHNO    82 PNI  3F3(OR 3D3/3G3)     12/83*
W    I     134.0       9.0          SHAMU     82 NPT  3F3                 12/83*
W    C    (60.0)                    UEDA      82 NN   3F3 FADDEEV ''FIT'' 12/83*

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                    106  B=2, S=0, 3F3 -- BREIT-WIGNER ELASTICITY

R1         (0.2)                     HOSHIZAKI 78 NN   3F3                  1/82
R1   J     0.11 TO 0.13              BHANDARI  82 NN   3F3                 12/83*
R1   K     0.096      0.012          SHAMU     82 NPT  3F3                 12/83*

R1   J BHANDARI 82 REPORTS R(PI D)=0.2 TO 0.3 AND R(N DELTA)=0.6 TO 0.7.   12/83*
R1   K THIS NP VALUE IS EQUIVALENT TO (0.19+-0.02) FOR PP.                 12/83*

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                    106  B=2, S=0, 3F3 -- RE(POLE POSITION) (MEV)

RE        (2190.0)                  BHANDARI  81 NN   3F3 K-MATRIX FIT     1/82
RE        (2215.0)                  BHANDARI  81 NN   3F3 M-MATRIX FIT     1/82
RE        (2185.0)                  EDWARDS   81 NN   3F3 K-MATRIX FIT     1/82
RE        (2175.0)                  KLOET     81 NN   3F3 POT. MODEL FIT   1/82
RE         2218. TO 2200.           BHANDARI  82 NN   3F3 BREIT-WIG. FIT  12/83*
RE   E    (2134.0)                  UEDA      82 NN   3F3 FADDEEV ''FIT'' 12/83*
RE   E    (2211.0)                  VERWEST   82 NN   3F3 POT. MODEL FIT  12/83*
RE   L     2210. TO 2220.           BHANDARI  83 NN   3F3 M-MATRIX FIT    12/83*
RE   E     2148. TO 2149.           KLOET     83 NN   3F3 COUP. CHAN. FIT 12/83*
RE   M     2162. TO 2173.           KLOET     83 NN   3F3 COUP. CHAN. FIT 12/83*

RE   L  BHANDARI 83 CLAIMS 3F3 IS NOT AN N-DELTA BOUND STATE.             12/83*
RE   M  KLOET 83 FOUND TWO NEARBY 3F3 POLES.                              12/83*

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                    106  B=2, S=0, 3F3 -- IM(POLE POSITION) (MEV)

IM         (65.0)                    BHANDARI  81 NN   3F3 K-MATRIX FIT     1/82
IM         (70.0)                    BHANDARI  81 NN   3F3 M-MATRIX FIT     1/82
IM         (70.0)                    EDWARDS   81 NN   3F3 K-MATRIX FIT     1/82
IM         (43.0)                    KLOET     81 NN   3F3 POT. MODEL FIT   1/82
IM          45. TO 60.               BHANDARI  82 NN   3F3 BREIT-WIG. FIT  12/83*
IM   E     (52.0)                    UEDA      82 NN   3F3 FADDEEV ''FIT'' 12/83*
IM   E     (35.0)                    VERWEST   82 NN   3F3 POT. MODEL FIT  12/83*
IM   L      60. TO 80.               BHANDARI  83 NN   3F3 M-MATRIX FIT    12/83*
IM   E      33. TO 38.               KLOET     83 NN   3F3 COUP. CHAN. FIT 12/83*
IM   M      43. TO 48.               KLOET     83 NN   3F3 COUP. CHAN. FIT 12/83*

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                    106  B=2, S=0, 3F3 -- ABS(RESIDUE)/IM(POLE POSITION)

RES          (0.15)                  BHANDARI  81 NN   3F3 K-MATRIX FIT     1/82
RES          (0.15)                  BHANDARI  81 NN   3F3 M-MATRIX FIT     1/82
RES          (0.30)                  EDWARDS   81 NN   3F3 K-MATRIX FIT     1/82
RES           0.08 TO 0.13           BHANDARI  82 NN   3F3 BREIT-WIG. FIT  12/83*
RES  L        0.1 TO 0.2             BHANDARI  83 NN       M-MATRIX FIT    12/83*

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OTHER NN Status: *

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                    106  B=2, S=0 MISCELL. -- BREIT-WIGNER MASS (MEV)

M    N    (2170.0) (10.0)           ALADASHVI 76 DB   PP INVARIANT MASS   12/83*
M         (2250.0)                  GREIN     80 NNF  3S1 OR 3D3           1/82
M         (2190.0)                  HASHIMOTO 80 NN   1F3 ASSUMED BCKGRND   1/82
M         (2352.0)   (69.0)         IKEDA     80 GDPN 3S1 SOL. A           1/82
M          2380. (FIXED)            IKEDA     80 GDPN 3S1 SOL. A'          1/82
M         (2290.0)   (14.0)         IKEDA     80 GDPN 3P2 SOL. C           1/82
M          2380. (FIXED)            IKEDA     80 GDPN 3S1 SOL. C           1/82
M         (2377.0)   (17.0)         IKEDA     80 GDPN 3D3 SOL. B''         1/82
M    A    (2100.0)                  KAMO      80 PPPD 1S0                  1/82
M    A    (2117.0)                  KAMO      80 PPPD 3P2                  1/82
M    A    (2148.0)                  KAMO      80 PPPD 3F2                  1/82
M    A    (2159.0)                  KAMO      80 PPPD 3P1                  1/82
M    B    (2290.0)                  KANAI     81 PID  3P2 SOL. B           1/82
M    B    (2300.0)                  KANAI     81 PID  3P2 SOL. C           1/82
M    B    (2510.0)                  KANAI     81 PID  1G4 SOL. B           1/82
M    B    (2530.0)                  KANAI     81 PID  1S0 SOL. C           1/82
M         (2250.0)                  GREIN     82 NNF  3S1 OR 3D3          12/83*
M         (2362.0)                  AKEMOTO   83 PIDC                      12/83*
M         (2429.0)                  AKEMOTO   83 PIDC                      12/83*
M         (2722.0)                  AKEMOTO   83 PIDC                      12/83*
M    N    (2020.0)                  SIEMIARC  83 DB   NP INVARIANT MASS   12/83*
M    N    (2130.0)                  SIEMIARC  83 DB   NP INVARIANT MASS   12/83*
M
M    N  KATAYAMA 83 DOES NOT SEE THESE ENHANCEMENTS.                       12/83*

                    106  B=2, S=0 MISCELL. -- BREIT-WIGNER WIDTH (MEV)

W    N     (50.0)                   ALADASHVI 76 DB , PP INVARIANT MASS   12/83*
W         (100.0)                   GREIN     80 NNF  3S1 OR 3D3           1/82
W          (50.0)                   HASHIMOTO 80 NN   1F3 ASSUMED BCKGRND   1/82
W         (342.0)   (69.0)          IKEDA     80 GDPN 3S1 SOL. A           1/82
W          200. (FIXED)             IKEDA     80 GDPN 3S1 SOL. A'          1/82
W         (263.0)   (55.0)          IKEDA     80 GDPN 3P2 SOL. C           1/82
W          200. (FIXED)             IKEDA     80 GDPN 3S1 SOL. C           1/82
W         (214.0)   (52.0)          IKEDA     80 GDPN 3D3 SOL. B''         1/82
W    A    (315.0)                   KAMO      80 PPPD 1S0                  1/82
W    A     (58.0)                   KAMO      80 PPPD 3P2                  1/82
W    A      (5.0)                   KAMO      80 PPPD 3F2                  1/82
W    A     (51.0)                   KAMO      80 PPPD 3P1                  1/82
W    B    (139.0)                   KANAI     81 PID  3P2 SOL. B           1/82
W    B    (150.0)                   KANAI     81 PID  3P2 SOL. C           1/82
W    B    (122.0)                   KANAI     81 PID  1G4 SOL. B           1/82
W    B     (60.0)                   KANAI     81 PID  1S0 SOL. C           1/82
W         (317.0)                   AKEMOTO   83 PIDC                      12/83*
W         (103.0)                   AKEMOTO   83 PIDC                      12/83*
W         (223.0)                   AKEMOTO   83 PIDC                      12/83*
W    N     (45.0)   (20.0)          SIEMIARC  83 DB   NP INVARIANT MASS   12/83*
W    N     (20.0)   (10.0)          SIEMIARC  83 DB   NP INVARIANT MASS   12/83*

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                    106  B=2, S=0 MISCELL. -- BREIT-WIGNER ELASTICITY

R1         (0.12)                    HASHIMOTO 80 NN   1F3 ASSUMED BCKGRND  1/82

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                          REFERENCES FOR B=2, S=0  STATES

ALADASHV 76 NP A274 486     ALADASHVILI,GLAGOLEV+       (JINR+WARS+WINR)
GREIN    78 NP B137 173     W GREIN,P KROLL                (KARL+WUPP)
HOSHIZAK 78 PTP 60 1796     N HOSHIZAKI                        (KYOT)
HOSHIZAK 79 PTP 61 129      N HOSHIZAKI                        (KYOT)
ARVIEUX  80 NP A350 205     J ARVIEUX,A S RINAT         (GREN+REHO+SACL)
GREIN    80 PL 96B 176      W GREIN,A KRONIG,P KROLL        (SIN+WUPP)
HASHIMOT 80 PTP 64 1693     K HASHIMOTO,N HOSHIZAKI            (KYOT)
IKEDA    80 NP B172 509     +ARAI,FUJII,FUJII,IWASAKI+  (TOKY+KEK+INUS)
KAMO     80 LNC 29 289      H KAMO,W WATARI                    (OSAK)
    ALSO 80 PTP 64 2144     KAMO,WATARI,YONEZAWA            (OSAK+HIRO)

BHANDARI 81 PRL 46 1111     +ARNDT,ROPER,VERWEST             (VPI+TAMU)
EDWARDS  81 PR D23 1978     B J EDWARDS                         (ANL)
HOFTIEZE 81 PR C23 407      +BAKER,CLEMENT,DRAGOSET+   (RICE+HOUS+BONN)
KANAI    81 PTP 65 266      +MINAKA,NAKAMURA+       (TMU+KAGO+TWAS+SAGA)
KLOET    81 PL 106B 24      W M KLOET,J A TJON              (RUTG+UTRE)

BHANDARI 82 LNC 34 65       R BHANDARI                          (VPI)
DAKHNO   82 PL 114B 409     +KRAVTSOV,LOBACHEV,MAKAROV,MEDVEDEV+ (LENI)
    ALSO 82 SJNP 36(1) 83   +KRAVTSOV,LOBACHEV,MAKAROV,MEDVEDEV+ (LENI)
GREIN    82 NP A377 505     W GREIN,P KROLL                 (SIN+WUPP)
SHAMU    82 PR D25 2008     +SOGA,SHILTS,LISOWSKI           (WMIU+LASL)
UEDA     82 PL 119B 281     T UEDA                              (OSAK)
VERWEST  82 PR C25 482      B J VERWEST                         (TAMU)

AKEMOTO  83 PRL 50 400      +BABA,ENDO,HIMENIYA,INOUE+      (HIRO+UOEH)
BHANDARI 83 PR D27 296      R BHANDARI                          (VPI)
KLOET    83 NP A392 271     W M KLOET,T A TJON                  (ITPU)
SIEMIARCZUK 83 PL 128B 367  SIEMIARCZUK,STEPANIAK,ZIELINSKI     (WINR)

                            PAPERS NOT REFERRED TO IN DATA CARDS

HIDAKA   77 PL 70B 479      +BERETVAS,NIELD,SPINKA+             (ANL)
FRASCARI 80 PL 91B 345      +BRISSAUD,DIDELEZ,PERRIN+   (IPN+GREN+NEUC)
KUBODERA 80 JPG 6 171       +LOCHER,MYHRER,THOMAS       (SIN+NORD+TRIU)
ARGAN    81 PRL 46 96       +AUDIT,DEBOTTON,FAURE,MARTIN        (SACL)
ARVIEUX  81 PL 103B 99      J ARVIEUX                       (GREN+SACL)
BOLGER   81 PRL 46 167      +BOSCHITZ,PROBSTLE,SMITH  (KARL+SIN+ERLA+)
GREIN    81 JPG 7 1355      W GREIN,M LOCHER                    (SIN)
HOLT     81 PRL 47 472      +SPECHT,STEPHENSON,ZEIDMAN+     (ANL+LASL+)
KLOET    81 NP A364 346     W KLOET,R SILBAR                (RUTG+LASL)
MINEHART 81 PRL 46 1185     +BOSWELL,DAVIS,DAY,MCCARTHY+    (VIRG+LASL)
MIZUTANI 81 PL 107B 177     +FAYARD,LAMOT,NAHABETIAN        (LYON+REGE)
RINAT    81 PL 104B 182     A RINAT,J ARVIEUX           (GREN+REHO+SACL)
TAMAS    81 NP A358 347     G TAMAS                             (SACL)
LISOWSKI 82 PRL 49 255      +SHAMU,AUCHAMPAUGH,KING,MOORE+      (LASL)
ABLEEV   83 NP A393 491     +ABDUSHUKUROV,AVRAMENKO,DIMITROV+   (JINR)
KATAYAMA 83 PREPRINT        +KAJITA,KOISO,KUBOTA,SAI,SAKAMOTO+  (TOKY)
KLOET    83 PR C27 430      W M KLOET,T A TJON                  (ITPU)

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Baryons
DIBARYONS

Data Card Listings

S=−1 DIBARYON

107 BARYON NUMBER 2, STRANGENESS -1 STATES

IN THIS SECTION WE USE THE FOLLOWING ABBREVIATIONS FOR TYPES OF ANALYSES--

BB	BARYON-BARYON SCATTERING COMBINED AMPLITUDE ANALYSIS
LNIM	LAMBDA-N INVARIANT MASS
LPIM	LAMBDA-P INVARIANT MASS
LPPIM	LAMBDA-P-PI INVARIANT MASS
SPIM	SIGMA-P INVARIANT MASS

ΛN(2130) I=1/2, $^3S_1$ Status: **

107 B=2, S=-1 -- BREIT-WIGNER MASS (MEV)

BREIT-WIGNER MASS APPROXIMATELY EQUALS RE(POLE POSITION).

M	A	2098.0	6.0	COHN	64	LNIM	Q=0	1/82
M	B	(2126.0)		CLINE	68	LPIM 3S1	Q=1	1/82
M	B	(2130.0)		ALEXANDER	69	LPIM	Q=1	1/82
M	C	(2130.0)		JAIN	69	LPIM	Q=1	1/82
M	B	2128.7	0.2	TAN	69	LPIM	Q=1	1/82
M	B	(2138.8)	(0.7)	TAN	69	LPIM	Q=1	1/82
M	B	(2129.0)		EASTWOOD	71	LPIM	Q=1	1/82
M	D	2127.0	1.0	SIMS	71	LPIM LNIM	Q=0,1	1/82
M	E	2125.2	2.5	SHAHBAZI	73	LPIM	Q=1	1/82
M	E	(2251.4)	(3.9)	SHAHBAZI	73	LPIM	Q=1	1/82
M	F	(2115.0)		SODHI	75	LPIM	Q=1	1/82
M	B	2129.0	0.4	BRAUN	77	LPIM	Q=1	1/82
M	G	(2130.0)		GOYAL	78	LPIM	Q=1	1/82
M	H	(2320.0)		GOYAL	80	SPIM	Q=0	1/82
M	I	(2255.5)	(0.4)	SHAHBAZIA	82	LPIM	Q=1 FIT 1	12/83*
M	I	(2257.4)	(2.3)	SHAHBAZIA	82	LPIM	Q=1 FIT 2	12/83*
M	I	(2350.8)	(2.4)	SHAHBAZIA	82	LPIM	Q=1 FIT 1	12/83*
M	I	(2358.4)	(1.3)	SHAHBAZIA	82	LPIM	Q=1 FIT 2	12/83*
M	I	(2495.2)	(8.7)	SHAHBAZIA	82	LPIM	Q=0,1	12/83*

M A SIGMA- D TO LAMBDA N X. 1/82
M B K- D TO PI- LAMBDA P. 1/82
M C GOYAL 71 RAISES DOUBTS ABOUT THE EXPERIMENTAL PROCEDURE USED 1/82
M C IN JAIN 69. JAIN STUDIED K- EMULSION TO LAMBDA P. 1/82
M D K- D TO PI- LAMBDA P, PI- LAMBDA PI+ N, AND PI- LAMBDA PI0 P. 1/82
M E N P TO LAMBDA P X FOR P IN CARBON 12. 1/82
M F K- D TO PI- PI0 LAMBDA P. 1/82
M G GOYAL 78 SEES ANOTHER UNCERTAIN PEAK AT 2195-2210 MEV. 1/82
M H K- D TO 2PI- PI+ LAMBDA P. 1/82
M H K- D TO PI+ PI- SIGMA- P. 1/82
M I SIMULTANEOUS FIT TO INVARIANT MASS AND LAMBDA-P ELASTIC 12/83*
M I SCATTERING EFFECTIVE CROSS SECTION. 12/83*

107 B=2, S=-1 -- BREIT-WIGNER WIDTH (MEV)

BREIT-WIGNER WIDTH APPROXIMATELY EQUALS 2 TIMES IM(POLE POSITION).

W	A	20.0	10.0	COHN	64	LPIM	Q=0	1/82
W	B	10. OR LESS		CLINE	68	LPIM 3S1	Q=1	1/82
W	C	(20.0)		JAIN	69	LPIM	Q=1	1/82
W	B	7.0	0.6	TAN	69	LPIM	Q=1	1/82
W	B	(9.1)	(2.4)	TAN	69	LPIM	Q=1	1/82
W	B	(10.)		EASTWOOD	71	LPIM	Q=1	1/82
W	D	8.0	1.0	SIMS	71	LPIM	Q=1	1/82
W	E	20.6	5.2	SHAHBAZI	73	LPIM	Q=1 2125 PEAK	1/82
W	E	(21.1)	(5.4)	SHAHBAZI	73	LPIM	Q=1 2251 PEAK	1/82
W	F	(150.0)		SODHI	75	LPIM	Q=1	1/82
W	B	5.9	1.6	BRAUN	77	LPIM	Q=1	1/82
W	H	(25.0)		GOYAL	80	SPIM	Q=0	1/82
W	I	(15.6)	(0.8)	SHAHBAZIA	82	LPIM	Q=1 FIT 1	12/83*
W	I	(18.1)	(1.1)	SHAHBAZIA	82	LPIM	Q=1 FIT 2	12/83*
W	I	(44.2)	(2.2)	SHAHBAZIA	82	LPIM	Q=1 FIT 1	12/83*
W	I	(77.2)	(6.6)	SHAHBAZIA	82	LPIM	Q=1 FIT 2	12/83*
W	I	(204.7)	(5.6)	SHAHBAZIA	82	LPIM	Q=0,1	12/83*

107 B=2, S=-1 -- RE(POLE POSITION) (MEV)

RE(POLE POSITION) APPROXIMATELY EQUALS BREIT-WIGNER MASS.

RE	J	(2132.0)	NAGELS	79	BB	3S1	Q=1	1/82
RE	J	(2137.0)	NAGELS	79	BB	3S1	Q=0	1/82
RE	B	(2129.0)	DOSCH	80	LPIM	3S1	Q=1	1/82
RE		(2127.0)	TAKAHASHI	80	BB	3S1	Q=0,1,2	1/82
RE		(2148.0)	TAKAHASHI	80	BB	1P	Q=0,1,2	1/82
RE								
RE	J	NAGELS 79 REPORTS POLE POSITION FOR TWO DIFFERENT 3S1 CHARGE						1/82
RE	J	STATES.						1/82

107 B=2, S=-1 -- IM(POLE POSITION) (MEV)

IM(POLE POSITION) APPROXIMATELY EQUALS ONE-HALF BREIT-WIGNER WIDTH.

IM	J	(2.4)	NAGELS	79	BB	3S1	Q=1	1/82
IM	J	(2.6)	NAGELS	79	BB	3S1	Q=0	1/82
IM	B	(5.0)	DOSCH	80	LPIM	3S1	Q=1	1/82
IM		(9.0)	TAKAHASHI	80	BB	3S1	Q=0,1,2	1/82
IM		(8.0)	TAKAHASHI	80	BB	1P	Q=0,1,2	1/82

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REFERENCES FOR B=2, S=-1 STATES

COHN	64	PRL 22 668	H O COHN,K H BHATT,W M BUGG	(ORNL+TENN)
CLINE	68	PRL 20 1452	D CLINE,R LAUMANN,J MAPP	(WISC)
ALEXANDE	69	PRL 22 483	ALEXANDER,HALL,JEW,KALMUS,KERNAN	(LBL+UCR)
JAIN	69	PR 187 1816	P L JAIN	(BUFF)
TAN	69	PRL 23 395	T H TAN	(SLAC)
EASTWOOD	71	PR D3 2603	+FRY,HEATHCOTE,ISLAN+	(BIRM+EDIN+GLAS+LOIC)
SIMS	71	PR D3 1162	+O'NEAL,ALBRIGHT,BRUCKER,LANUTTI	(FSU)
SHAHBAZI	73	NP B53 19	B SHAHBAZIAN,A TIMONINA	(JINR)
SODHI	75	NP B97 403	A SODHI,D GOYAL	(DELH)
BRAUN	77	NP B124 45	+GRIMM,HEPP,STROEBELE,THOEL+	(HEID+MPIM)
GOYAL	78	PR D18 948	D GOYAL,A SODHI	(DELH)
NAGELS	79	PR D20 1633	M NAGELS,T RIJKEN,J DESWART	(NIJM)
DOSCH	80	ZPC 3 249	H DOSCH,I STAMATESCU	(HEID)
GOYAL	80	PTP 64 700	D GOYAL,J MISRA	(DELH)
TAKAHASH	80	NP A336 347	TAKAHASHI,IWAMURA,KIMURA,KUME	(TOKY)
SHAHBAZI	82	NP A374 73C	SHAHBAZIAN,TEMNIKOV,TIMONINA	(JINR)

PAPERS NOT REFERRED TO IN DATA CARDS

PIROUE	64	PL 11 164	P A PIROUE	(PRIN)
ALEXANDE	68	PR 173 1452	+KASHORN,SHAPIRA+	(REHO+HEID)
BUNNEL	70	PR D2 98	+DERRICK,FIELDS,HYMAN,KEYES	(NWES+ANL)
GOYAL	71	PR D3 1259	D P GOYAL	(DELH)
KADYK	71	NP B27 13	+ALEXANDER,CHAN,GAPOSCHKIN,TRILLING	(LBL)
DOSCH	78	PR D18 4071	H G DOSCH,V HEPP	(HEID)
MIZUNO	79	PTP 62 1691	T MIZUNO	(TOKY)
ROOSEN	79	NC B49 217	+VANDERVELDE-WILQUET,WICKENS+	(LOUC+BRUX)
D'AGOSTI	81	PL 104B 330		(ROMA+SACL+VAND)
KIMURA	81	PTP 65 649	M KIMURA,Y IWAMURA,Y TAKAHASHI	(TOKY)
TOKER	81	NP A362 405	G TOKER,A GAL,J EISENBERG	(HEBR+TELA)

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S=−2 DIBARYON Status: *

108 BARYON NUMBER 2, STRANGENESS -2 STATES

IN THIS SECTION WE USE THE FOLLOWING ABBREVIATIONS FOR MEASURED QUANTITIES--

LLIM	LAMBDA-LAMBDA INVARIANT MASS
LLPI	LAMBDA-LAMBDA-PI INVARIANT MASS
XPIM	XI-P INVARIANT MASS

108 B=2, S=-2 -- MASS (MEV)

M	A	(2367.0)	(4.0)	BEILLIERE	72	LLIM	Q=0 GAUSSIAN FIT	1/82
M	B	(2365.3)	(9.6)	SHAHBAZIA	73	LLIM	Q=0	1/82
M	C	(2480.0)		GOYAL	80	XPIM	Q=0	1/82
M	B	(3568.3)		SHAHBAZIA	82	LPPI	Q=1	12/83*
M								
M	A	K- D TO XI- P K0.						1/82
M	B	N P TO LAMBDA LAMBDA X AND PI- P TO LAMBDA LAMBDA X FOR P IN C12.						1/82
M	C	GOYAL 80 ALSO SEES A SHOULDER AT 2360 MEV.						1/82

108 B=2, S=0 -- WIDTH (MEV)

W	A	(15.0)	(4.0)	BEILLIERE	72	LLIM	Q=0 GAUSSIAN FIT	1/82
W	B	(47.0)	(15.7)	SHAHBAZIA	73	LLIM	Q=0	1/82

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REFERENCES FOR B=2, S=-2 STATES

BEILLIER	72	PL 39B 671	BEILLIERE,MAYEUR+	(BRUX+CERN+TUFT+LOUC)
SHAHBAZI	73	NP B53 19	B SHAHBAZIAN,A TIMONINA	(JINR)
GOYAL	80	PR D21 607	D GOYAL,J MISRA,A SODHI	(DELH)
SHAHBAZI	82	NP A374 73C	SHAHBAZIAN,TEMNIKOV,TIMONINA	(JINR)

PAPERS NOT REFERRED TO IN DATA CARDS

CARROLL	78	PRL 41 777	+CHIANG,JOHNSON,KYCIA,KI,+	(BNL+PRIN)
D'AGOSTI	82	NP B209 1		(INFN+SACL+VAND+CERN)

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APPENDIX I

THE STATUS OF THE STANDARD MODEL OF ELECTROWEAK INTERACTIONS

(by R.N. Cahn, LBL)

The standard SU(2)×U(1) model of electroweak interactions has (aside from the masses of the fermions and the Higgs boson) three fundamental parameters.[1] Thus the model is fully specified by measuring three independent constants. Two of these are well established: $G_F = 1.16637\times10^{-5}\ \mathrm{GeV}^{-2}$ and $\alpha = 1/137.036$. The measurement of one more parameter suffices to determine all the predictions of the theory, assuming that quark distributions in the hadrons are known and that radiative corrections can be dealt with. For the present we ignore radiative corrections.

Prior to the discoveries of the W and Z, the third measurement was made in neutral-current experiments and conventionally expressed in terms of $\sin^2\theta_W$. See the section on the Standard Model of Electroweak Interactions. The usual model, which has only doublet Higgs bosons, has the value unity for the parameter $\rho = M_W^2/(M_Z^2\cos^2\theta_W)$, ignoring radiative corrections. A multitude of neutral-current experiments have produced values for the mixing angle which are in good agreement and thus provide strong evidence for the standard model. Among the experiments are:

1. Neutrino and antineutrino deep inelastic scattering from isosinglet targets.
2. Neutrino and antineutrino deep inelastic scattering by protons.
3. Elastic $\nu_\mu p$ and $\bar{\nu}_\mu p$ scattering.
4. Exclusive and inclusive π production in neutral-current events.
5. Neutrino disintegration of the deuteron: $\bar{\nu}_e d \to \bar{\nu}_e np$.
6. Polarized-electron deuteron deep inelastic scattering.
7. Forward-backward asymmetry in $e^+e^- \to \mu^+\mu^-$.
8. Elastic νe scattering.

The data for these processes and a comparison with the predictions of the standard model are given in two extensive reviews.[2,3] The conclusion of these and all similar studies is that all available data are consistent with the standard model. Moreover, if it is treated as a free parameter, the value of ρ is consistent with unity, the value it has in the simplest model. For example, Kim et al. find $\rho = 1.002 \pm 0.015 \pm (0.011)$ and $\sin^2\theta_W = 0.234 \pm 0.013 \pm (0.009)$, where the parentheses indicate a theoretical uncertainty. If only the data from deep inelastic scattering and from the e-d experiment are used, the results are $\rho = 0.992 \pm 0.017 \pm (0.011)$ and $\sin^2\theta_W = 0.224 \pm 0.015 \pm (0.012)$.

Some of the most precise data are used in the accompanying figure, which shows the region of the ρ—$\sin^2\theta_W$ plane allowed by data for deep inelastic scattering from an isoscalar target and for the scattering of polarized electrons by deuterons. It is important to notice that the allowed values of the two variables are correlated. The curves were obtained from the following formulas:

$$R_{\nu N} = \frac{\sigma^{NC}_{\nu N}}{\sigma^{CC}_{\nu N}} = \rho\frac{\frac{1}{2} - \sin^2\theta_W + \frac{20}{27}\sin^4\theta_W + \epsilon(\frac{1}{6} - \frac{1}{3}\sin^2\theta_W + \frac{20}{27}\sin^4\theta_W)}{1 + \frac{1}{3}\epsilon},$$

$$R_{\bar{\nu}N} = \frac{\sigma^{NC}_{\bar{\nu}N}}{\sigma^{CC}_{\bar{\nu}N}} = \rho\frac{\frac{1}{6} - \frac{1}{3}\sin^2\theta_W + \frac{20}{27}\sin^4\theta_W + \epsilon(\frac{1}{2} - \sin^2\theta_W + \frac{20}{27}\sin^4\theta_W)}{\frac{1}{3} + \epsilon}.$$

The parameter ϵ is the ratio of antiquark momentum to quark momentum in the nucleon. It is related to the ratio of the neutrino charged-current cross section to the antineutrino charged-current cross section:

$$\frac{\sigma^{CC}_{\nu N}}{\sigma^{CC}_{\bar{\nu}N}} = \frac{1 + \frac{1}{3}\epsilon}{\frac{1}{3} + \epsilon}.$$

The curves correspond to the limits $R_{\nu N} = 0.31 - 0.33$, $R_{\bar{\nu}N} = 0.357 - 0.397$, indicative of the results of the CHARM collaboration,[4] with ϵ taken to be 0.20.

The polarized-electron deuteron scattering experiment measured the asymmetry in the cross section for left-handed (σ_L) and right-handed (σ_R) electrons:

$$A = \frac{\sigma_R - \sigma_L}{\sigma_R + \sigma_L}.$$

In the quark parton model, this has the form (with $q^2 > 0$ for deep inelastic scattering)

$$\frac{A}{q^2} = a_1 + a_2\left[\frac{1-(1-y)^2}{1+(1-y)^2}\right],$$

where y is the fraction of the incident lepton's energy lost in the collision. For an isoscalar target like the deuteron, and ignoring the antiquarks, the standard model gives

$$a_1 = -\frac{G_F}{2\sqrt{2}\pi\alpha}\frac{9}{10}\rho\left(1 - \frac{20}{9}\sin^2\theta_W\right)$$

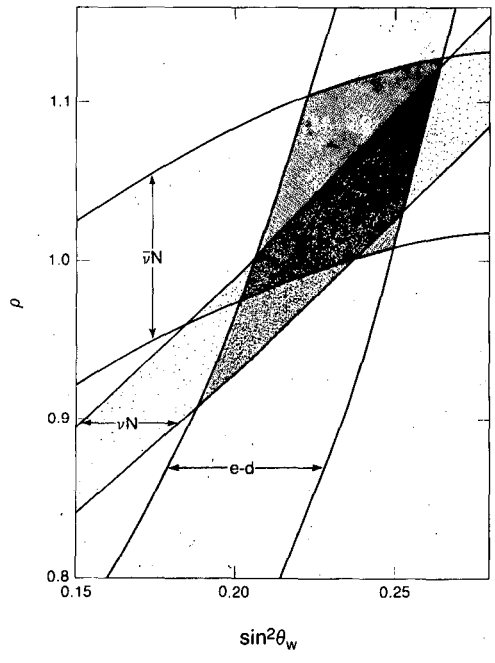
$$a_2 = -\frac{G_F}{2\sqrt{2}\pi\alpha}\frac{9}{10}\rho\left(1 - 4\sin^2\theta_W\right).$$

The best determined linear combination of the parameters a_1 and a_2 is

$$0.24a_2 + 0.97a_1 = (-8.1 \pm 1.1)\times10^{-5}\ \mathrm{GeV}^{-2}.$$

This is inferred from Ref. 5, and the uncertainty corresponds to 1σ. The 1σ extremes are shown in the figure.

Once the masses of the W and Z are known, either one or their ratio (or any other single combination) can be used as the third



measured parameter, replacing the neutral-current data. For example, we can use the ratio of the masses as the third parameter. Then $\sin^2\theta_W$ is simply a parameter derived from the measured quantities G_F and α. It can always be eliminated from any expression in favor of G_F, α, and M_W/M_Z. It is convenient, however, to retain it by defining:

$$\cos^2\theta_W = M_W^2/M_Z^2 .$$

This is now a definition and is not modified by radiative corrections.[6] However, the lowest order prediction for M_W^2 is modified by corrections of order α:

$$M_W^2 = \frac{\pi\alpha}{\sqrt{2}G_F \sin^2\theta_W(1-\Delta r)} .$$

The quantity Δr is of order α and depends on the masses of the leptons, quarks, and Higgs boson. The dominant terms are due to vacuum polarization by light fermions. If the t quark mass is set to 36 GeV and the Higgs boson mass to the mass of the Z, the value of Δr is 0.0696 ± 0.0020. This value is not very sensitive to these last two assumed values.

As of this writing (December 1983) the most recent results[7,8] from the UA-1 and and UA-2 experiments at the CERN SPS collider for the W and Z masses are (in GeV)

	M_W	M_Z
UA-1	$80.9 \pm 1.5(stat)$	$95.6 \pm 1.4(stat)$
UA-2	$81.0 \pm 2.5 \pm 1.3$	$91.9 \pm 1.3 \pm 1.4$

Thus we find from the definition of $\cos^2\theta_W$

	$\sin^2\theta_W$
UA-1	$0.284 \pm 0.016(stat)$
UA-2	$0.223 \pm 0.027(stat)$

The systematic uncertainties may make the total uncertainty about twice as large as the indicated statistical uncertainties.

Given the uncertainties in the data above, a detailed test of the model is not possible. That the neutral-current data are consistent with $\rho = 1$ and with a single value of $\sin^2\theta_W$ is important evidence for the model. Moreover, the W and Z masses are consistent with this value for the weak mixing angle. A detailed test of the model awaits higher precision data on the weak boson masses. Such data will permit a single test involving the four measured parameters α, G_F, M_W, and M_Z, and one additional test comparing the derived quantity $\sin^2\theta_W$ with the value obtained in neutral-current experiments. In making this comparison, it will be necessary to include radiative corrections for the neutral-current experiments.[9] Their effect is to lower the values of $\sin^2\theta_W$ discussed in connection with the neutral-current experiments to a value 0.217 ± 0.014.

Should such a high-precision test reveal a discrepancy with the radiatively corrected theory, it could indicate that the model needs fundamental modification. Small deviations from the predictions described above could arise if the t quark mass or Higgs boson mass is far from the value assumed or if there are additional generations of fermions. At present there is no indication of the need for a modification of the theory, but the tests are not yet very stringent.

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APPENDIX II

THE PERTURBATIVE QCD COUPLING CONSTANT

(by I. Hinchliffe, LBL)

This note is concerned with the definition of the running coupling constant and of the scale parameter Λ in QCD. It is intended to be pedagogical rather than rigorous; one of the many excellent reviews can be consulted for more details.[1]. Comments will be made on the theoretical uncertainties inherent in attempts to extract Λ from the data, but no critique of individual experiments will be given.

In the limit of zero quark masses QCD contains only one fundamental parameter, its coupling constant (α_s). In a field theory it is necessary to define a coupling constant order by order in perturbation theory. If a process is calculated beyond leading order, divergences can arise in the integrations over momenta flowing in closed loops of Feynman diagrams. These divergences are removed by absorbing them into a renormalized coupling constant (α). In order to do this, α is defined in terms of some quantity calculated to the same order in perturbation theory. This constitutes the renormalization scheme.

In the familiar case of QED, the coupling constant (α_{EM}) is defined to be the value of the photon-electron-electron coupling in the limit of zero photon momentum when the electrons are on their mass shells (mass-shell renormalization scheme). This definition is readily related to the scattering rate for low-energy electrons off a static source. Notice that the relevant energy scale characterizing the coupling constant definition is the electron mass (m_e). If some other QED process with momentum scale Q is calculated (e.g., $e^+e^- \to e^+e^-$ at wide angle and with center-of-mass energy $\sqrt{s} = Q \gg m_e$), the cross section can be written as a power series in α_{EM} and will have the following form

$$A\left[1 + \frac{B\alpha_{EM}}{\pi}\log(Q^2/m_e^2) + \cdots\right].$$

Here the term A is the rate calculated to lowest nontrivial order in α_{EM}, and B is constant. In the $e^+e^- \to e^+e^-$ case, $A \propto \alpha_{EM}^2/s$. In the asymptotic limit $Q \gg m_e$, the term $\frac{B\alpha_{EM}}{\pi}\log(Q^2/m_e^2)$ could become of order one, and the perturbation series would fail to converge. Fortunately these terms, and all terms of order $\alpha_{EM}^N \log^N(Q^2/m_e^2)$, can be summed. This summation leads to the introduction of a coupling constant which depends on Q. This running coupling constant $\alpha_{REM}(Q)$ is such that $\alpha_{REM}(m_e) = \alpha_{EM}$, and if $\alpha_{REM}(Q)$ is expanded as a power series in α_{EM} and inserted

into the term A, all the terms $\alpha_{EM}^N \log^N(Q^2/m_e^2)$ are reproduced.

In QED, $\alpha_{REM}(Q)$ is a rather slow function of Q increasing with Q so that $\alpha_{REM}(m_w) \approx 1/128$.[2] In contrast, the running coupling constant in QCD decreases relatively rapidly as Q rises due to the self-interactions of the gluons.[3] The coupling constant is large at $Q \approx m_\pi$, the scale of hadronic binding. A perturbation expansion will not therefore enable one to calculate the hadron spectrum and obtain α_s from the values of the hadron masses.

In the absence of strong coupling techniques we are restricted to using perturbation theory to calculate processes from QCD and to determine α_s. We can only use processes which have a large momentum scale and hence a small α_s. As an illustration consider the ratio

$$R = \frac{\sigma(e^+e^- \to \text{hadrons})}{\sigma(e^+e^- \to \mu^+\mu^-)}$$

$$\equiv 3\sum_i Q_i^2\left(1 + \frac{\alpha_s(s)}{\pi} + N\frac{\alpha_s^2(s)}{\pi^2} + \cdots\right). \quad (1)$$

Here we are assuming that $\sqrt{s}$, the center-of-mass energy, is large compared to quark masses; the sum i runs over all quarks of charge Q_i and N is a numerical factor. We have used $\alpha_s(s)$ since $\sqrt{s}$ is the only scale present in the problem. If we assume that $N\alpha_s(s)/\pi \ll 1$, then, by comparing with data to leading order in $\alpha_s(s)$ [the $\alpha_s(s)/\pi$ term], we could determine $\alpha_s(Q)$, confident that the leading terms reproduce the full perturbation series fairly well.

It is usual to introduce the parameter Λ to parametrize the Q^2 dependence of $\alpha_s(Q^2)$:[3]

$$\alpha_s(Q^2) = \frac{12\pi}{(33-2f)\log(Q^2/\Lambda^2)}, \quad (2)$$

where f is the number of quark flavors with mass less than Q/2. Λ now appears as the fundamental parameter in QCD. Unfortunately if we do not know the coefficient N in Eq. (1), then Λ is arbitrary in the following sense. Rescale $\Lambda = x\Lambda'$; then

$$\alpha_s(Q^2,\Lambda) = \alpha_s(Q^2,\Lambda')\left[1 + \frac{(33-2f)}{6\pi}\alpha_s(Q^2,\Lambda')\log x + O(\alpha_s^2)\right].$$

If Eq. (1) is now rewritten as a series in $\alpha_s(Q^2,\Lambda')$, then the coefficient N will change. If we have neglected this term, then Λ and Λ' are equivalent! A fit to the data to leading order can of course still be used to determine a Λ_{LO} defined by Eq. (2), but we have no guarantee that another process will yield the same Λ_{LO}. The situation only clarifies (or becomes more muddled depending on one's point of view) when we know the coefficient N.

We should of course check that $N\alpha_s(s)/\pi \ll 1$, so that the perturbation series is reliable. Unfortunately N is not well defined; it depends on the renormalization scheme. We cannot define α_s in the same way as α_{EM} was defined in QED, since perturbation theory is unreliable in that region of momenta. One possibility is to define $\alpha_s(Q^2)$ as the value of the three-gluon vertex (or quark-quark-gluon vertex) when the invariant masses of the particles are $-Q^2$. This is the momentum-space scheme,[4] and α_s is denoted by $\alpha_{MOM}(Q^2)$. $\alpha_{MOM}(Q^2)$ is not related directly to any physical process. The scheme is difficult to calculate with and produces a gauge-dependent $\alpha_s(Q^2)$; much more convenient is the minimal-subtraction scheme (MS). Here loop integrals are evaluated in n dimensions. The divergences appear as singularities of the form $1/(n-4)$. These terms are dropped and $\alpha_{MS}(Q^2)$ so defined.[5] These singularities are always accompanied by log 4π and the Euler constant $\gamma_E = 0.577\cdots$; these can be dropped also (the $\overline{MS}$ scheme) and an $\alpha_{\overline{MS}}(Q^2)$ defined.[6] The coupling constants in all these schemes are related as follows (α_{MOM} is defined in Feynman gauge):

$$\alpha_{MOM}(Q^2) = \alpha_{MS}(Q^2)[1 + x\alpha_{MS}(Q^2)\cdots],$$

$$x = 3.57 - 0.38f;$$

$$\alpha_{MOM}(Q^2) = \alpha_{\overline{MS}}(Q^2)[1 + x'\alpha_{\overline{MS}}(Q^2)\cdots],$$

$$x' = 1.86 - 0.48f.$$

The $\overline{MS}$ and MOM schemes are most frequently used. Other schemes are also possible; for example we could define $\alpha_R(Q^2)$ so that

$$R \equiv 3\sum Q_i^2\left[1 + \frac{\alpha_R(Q^2)}{\pi}\right]$$

with no correction at $Q^2 = s_0$. Then

$$\alpha_R(s_0) = \alpha_{\overline{MS}}(s_0)\left[1 + N'\frac{\alpha_{\overline{MS}}(s_0)}{\pi}\right]$$

with $N' = 2 - 0.1f$.[7]

It is now clear that N will depend on the scheme so that the size of $N\alpha_s/\pi$ is a scheme dependent. This simple fact can lead to long discussions about which scheme is best and which processes have reliable perturbation expansions.[8]

Beyond leading order Eq. (2) does not accurately represent the Q^2 dependence of $\alpha_s(Q^2)$. To next order we have

$$\alpha_s(Q^2) = \frac{12\pi}{(33-2f)\log(Q^2/\Lambda^2)} \times\left\{1 - \frac{6(153-19f)}{(33-2f)^2}\frac{\log[\log(Q^2/\Lambda^2)]}{\log(Q^2/\Lambda^2)} + \frac{D}{\log(Q^2/\Lambda^2)}\right\} \quad (3)$$

where D is arbitrary to this order. If $\alpha = \alpha_{\overline{MS}}$, it is customary[6] to define $\Lambda_{\overline{MS}}$ from Eq. (3) with D = 0; but other definitions are possible. It seems that some confusion could be avoided by abolishing Λ and simply quoting $\alpha_s(Q^2)$ in some scheme at some $Q^2 = Q_0^2$.

There are several more theoretical complications in QCD predictions. In the case of R the scale Q^2 was unambiguous; this is not always the case. For example, the production of three jets in e^+e^- collisions is predicted by QCD but is Q^2 equal to s or to the invariant mass of a jet pair? To leading order in QCD, we cannot tell. The coefficient of the next-to-leading term will change if Q^2 is changed (c.f., the shift in N as Λ was rescaled above), further complicating the issue of whether the perturbation series is reliable.

Many processes are also subject to "higher twist corrections." For example, if we retain quark masses, R receives corrections depending on m_q^2/s so that extra parameters enter QCD predictions. Some higher twist corrections are purely kinematic in origin and can be calculated if the quark masses are known. Unfortunately other higher twist corrections cannot be calculated (e.g., those in deep inelastic scattering); they are all of order $1/Q^2$ relative to the perturbation theory, but the coefficients are unknown.

In comparing quoted values for α_s or Λ, the following must be considered:

1. What order in perturbation theory was used?
2. What renormalization scheme was used?
3. What scale Q^2 was used?
4. If the Q range of the experiment covers some quark masses, how were thresholds dealt with?
5. How were higher twist terms parametrized?

For example, attempts have been made to extract α_s (or Λ) from data on 3-jet events in e^+e^- annihilation. Issues 1 and 5 appear to be pertinent here. The perturbation expansion is not very reliable[9] so the value of Λ depends on the order used. Issue 5 manifests itself in the dependence of α_s upon Monte Carlo program parameters used to parametrize jet fragmentation.[10] Values of α_s quoted from these data range from 0.12 to 0.21.[10] In contrast, data on deep inelastic scattering do not suffer from problems concerning the perturbation theory, and values of Λ_{LO} range from 125 to 275 MeV.[11]

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APPENDIX III

THE KOBAYASHI-MASKAWA MIXING MATRIX

(by F.J. Gilman, SLAC)

In the "standard model" with SU(2)×U(1) as the gauge group of electroweak interactions, both the quarks and leptons are assigned to be left-handed doublets and right-handed singlets. The quark mass eigenstates are not the same as the weak eigenstates, and the matrix connecting them has become known as the Kobayashi-Maskawa matrix[1] since an explicit parametrization in the six-quark case was first published by them in 1973.

By convention, the three charge 2/3 quarks (u, c, and t) are unmixed, and all the mixing is expressed in terms of a 3×3 unitary matrix V operating on the charge −1/3 quarks (d, s, b):

$$\begin{pmatrix} d' \\ s' \\ b' \end{pmatrix} = \begin{pmatrix} V_{ud} & V_{us} & V_{ub} \\ V_{cd} & V_{cs} & V_{cb} \\ V_{td} & V_{ts} & V_{tb} \end{pmatrix} \begin{pmatrix} d \\ s \\ b \end{pmatrix} . \tag{1}$$

Kobayashi and Maskawa[1] themselves used a parameterization involving four angles, θ_1, θ_2, θ_3, δ:

$$\begin{pmatrix} d' \\ s' \\ b' \end{pmatrix} = \begin{pmatrix} c_1 & -s_1c_3 & -s_1s_3 \\ s_1c_2 & c_1c_2c_3 - s_2s_3e^{i\delta} & c_1c_2s_3 + s_2c_3e^{i\delta} \\ s_1s_2 & c_1s_2c_3 + c_2s_3e^{i\delta} & c_1s_2s_3 - c_2c_3e^{i\delta} \end{pmatrix} \begin{pmatrix} d \\ s \\ b \end{pmatrix} , \tag{2}$$

where $c_i = \cos\theta_i$ and $s_i = \sin\theta_i$ for i = 1,2,3. In the limit $\theta_2 = \theta_3 = 0$, this reduces to the usual Cabibbo mixing with θ_1 identified with the Cabibbo angle (up to a sign). The angles θ_1, θ_2, θ_3 can all be made to lie in the first quadrant (so that all s_i, c_i are positive) by an appropriate redefinition of quark field phases.

Slightly different forms of the Kobayashi-Maskawa parametrization are found in the literature. The K-M matrix used in the 1982 Review of Particle Properties is obtained by letting $s_1 \to -s_1$ and $\delta \to \delta+\pi$ in the matrix given above. An alternative used in another review[2] is to change Eq. (2) by $s_1 \to -s_1$ but leave δ unchanged. With this change in s_1, θ_1 becomes the usual Cabibbo angle, with the "correct" sign (i.e., $d' = d\cos\theta_1 + s\sin\theta_1$), in the limit $\theta_2 = \theta_3 = 0$. The angles θ_1, θ_2, θ_3 can, as before, all be taken to lie in the first quadrant by adjusting quark field phases. Since all these parametrizations are referred to as "the" Kobayashi-Maskawa form, some care about which one is being used is needed when the quadrant in which δ lies is under discussion.

A quite different parametrization is due to Maiani[3] in terms of angles θ, β, γ, and δ':

$$V = \begin{pmatrix} c_\beta c_\theta & c_\beta s_\theta & s_\beta \\ -s_\gamma c_\theta s_\beta e^{i\delta'} - s_\theta c_\gamma & c_\gamma c_\theta - s_\gamma s_\beta s_\theta e^{i\delta'} & s_\gamma c_\beta e^{i\delta'} \\ -s_\beta c_\gamma c_\theta + s_\gamma s_\theta e^{-i\delta'} & -c_\gamma s_\beta s_\theta - s_\gamma c_\theta e^{-i\delta'} & c_\gamma c_\beta \end{pmatrix} \tag{3}$$

where $c_\beta = \cos\beta$, $s_\beta = \sin\beta$, etc. With $\beta = \gamma = 0$, the first two generations of quarks decouple from the third, and θ is directly the Cabibbo angle. No physics can depend on which of the above parametrizations (or any other) is used as long as it is used consistently and care is taken to be sure that no other choice of phases is in conflict.

The values of individual Kobayashi-Maskawa matrix elements can in principle all be determined from weak decays of the relevant quarks, or, in some cases, from deep inelastic neutrino scattering. Our present knowledge comes from the following sources:

(1) Nuclear beta decay, when compared to muon decay, gives

$$|V_{ud}| = 0.9737 \pm 0.0025 \tag{4}$$

in one evaluation[4] and

$$|V_{ud}| = 0.9730 \pm 0.0024 \tag{5}$$

in another.[5]

(2) An analysis of hyperon and $K_{\ell 3}$ decays yielded[4]

$$|V_{us}| = 0.219 \pm 0.011 , \tag{6}$$

where the quoted uncertainty includes a statistical minimization error of ±0.003 and an estimate of ~5% theoretical uncertainty due to SU(3) symmetry breaking. For the hyperon decays this involved a simultaneous χ^2 fit to $|V_{us}|$ and the SU(3) parameter $\alpha_D = D/(D+F)$. A subsequent analysis using some new data on hyperon decays and similar theoretical inputs for form factors, etc., gave[5]

$$|V_{us}| = 0.227 \pm 0.003 \pm 0.013 . \tag{7}$$

The first error is statistical and the second represents an estimate of the effect of SU(3) symmetry breaking. A recent CERN hyperon experiment carried out a series of different Cabibbo fits with various experimental and theoretical inputs.[6] Results are quoted for the effective "vector" and "axial-vector" Cabibbo angles and the overall Cabibbo angles (see Table III of Ref. 6). A representative value is

$$|V_{us}| = 0.231 \pm 0.003 , \tag{8}$$

where the quoted error is statistical and does not include an estimate of the uncertainty due to SU(3) symmetry breaking.

(3) From neutrino and antineutrino production of charm, the CDHS group has deduced[7]

$$|V_{cd}| = 0.24 \pm 0.03 . \tag{9}$$

Values of $|V_{cs}|$ from such experiments are dependent on assumptions about the strange quark density in the parton-sea and are not well enough constrained to give information which is not already in hand from $|V_{cd}|$ and $|V_{cb}|$ (see below), plus unitarity.

(4) The ratio $|V_{ub}/V_{cb}|$ is obtained from the semileptonic decay of B mesons by fitting to the lepton energy spectrum as a sum of contributions involving $b \to u$ and $b \to c$. The relative overall phase space factor between the two processes is calculated from the usual four-fermion interaction with one massive fermion

(c quark or u quark) in the final state. The value of this factor is between 0.4 and 0.5, depending on the quark masses used. We use 0.45, in which case the experimental lack of observation of the hard lepton spectrum characteristic of $b \to u\ell\bar{\nu}_\ell$, which is quoted as a limit[8]

$$\frac{\Gamma(b \to u\ell\bar{\nu}_\ell)}{\Gamma(b \to c\ell\bar{\nu}_\ell)} < 0.05 , \tag{10}$$

translates to

$$\frac{|V_{ub}|}{|V_{uc}|} < 0.15 . \tag{11}$$

There are some theoretical uncertainties in this analysis stemming from the fact that the physical decays involve actual hadrons, primarily pseudoscalar B mesons, and not free quarks as is assumed in the calculations of the lepton spectra for $b \to u\ell\bar{\nu}_\ell$ and $b \to c\ell\bar{\nu}_\ell$.

(5) The magnitude of V_{cb} itself can be determined if the measured semileptonic bottom hadron partial width is assumed to be that of a b quark decaying through the usual V-A interaction:

$$\Gamma(b \to c\ell\bar{\nu}_\ell) = \frac{BR(b \to c\ell\bar{\nu}_\ell)}{\tau_b} = \frac{G_F^2 m_b^5}{192\pi^3} F(m_b, m_c) |V_{cb}|^2 , \tag{12}$$

where τ_b is the b lifetime and $F(m_b, m_c)$ is the phase space factor chosen above as 0.45. Following S. Stone[8] and using an average semileptonic branching ratio of 0.116 ± 0.006 (which from Eq. (10) is $BR(b \to c\ell\bar{\nu}_\ell)$ to withing 5%), a bottom hadron lifetime between 0.6 and 1.4×10^{-12} sec, and m_b between 4.8 and 5.2 GeV/c^2:

$$0.036 < |V_{cb}| < 0.070 . \tag{13}$$

Using Eqs. (4), (6), (11), and (13) together with unitarity and the assumption that there are only three generations, the 90% confidence limits on the magnitude of matrix elements of the complete matrix are:[8]

$$\begin{pmatrix} 0.9705 \text{ to } 0.9770 & 0.21 \text{ to } 0.24 & 0. \text{ to } 0.014 \\ 0.21 \text{ to } 0.24 & 0.971 \text{ to } 0.973 & 0.036 \text{ to } 0.070 \\ 0. \text{ to } 0.024 & 0.036 \text{ to } 0.069 & 0.997 \text{ to } 0.999 \end{pmatrix} .$$

Similar values for these matrix elements, are found in several other analyses.[9,10] The ranges shown are for the individual matrix elements. The constraints of unitarity connect different elements, so choosing a specific value for one element restricts the range of the others. The data do not preclude there being more than three generations. However, the entries deduced from unitarity might be altered when the K-M matrix is expanded to accommodate more generations.

Further information on the angles requires theoretical assumptions. In particular, as CP-violating amplitudes involve $\sin\delta$, assuming that observed CP violation is solely related to a nonzero value of δ allows additional constraints to be brought to bear. While hadronic matrix elements whose values are imprecisely known now enter, the constraints from CP violation in the neutral kaon system are tight enough that there may be no solution at all for certain quark masses, values of δ, etc. See Refs. 11, 12, and 13. Additional correlated bounds on quark masses and mixing angles can be obtained from $K_L^0 \to \mu^+\mu^-$, which involves a hadronic matrix element known from $K_{\ell 3}$ decay.[14]

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ACCESSING AND USING PARTICLE PHYSICS DATABASES

A number of publicly accessible computer databases containing particle physics information now exist at various institutions. Some of these databases are for literature searching, allowing the user to locate papers of interest, while others contain actual numerical data. The following discussion gives some idea of what is available and how to get started using these databases. The two locations covered are SLAC and Rutherford Appleton Laboratory (RAL).

The SLAC Particle Physics Databases

The databases of interest at SLAC are: (1) HEP, a literature-searching guide for all particle physics journal articles, preprints, reports, theses, etc., indexed by the standard bibliographic quantities and, starting sometime in mid-1984, also indexed by accelerator, detector, beam momentum, reactions and particles studied, etc.; (2) RPP, containing the Data Card Listings from the Review of Particle Properties, indexed by particle property; and (3) EXPERIMENTS, a guide to current and past particle physics experiments, indexed similarly to the HEP database. In addition, it is hoped that the Durham-RAL databases discussed below will also be available at SLAC in the near future.

All these databases are managed by the SPIRES database management system, which runs interactively under VM/CMS on SLAC's mainframe IBM computers. To enter SPIRES, once you are logged onto the computer, key in CALL SPIRES. You can then obtain information about the database you are interested in by typing in, say, EXPLAIN RPP. To actually access the database, enter, for example, SELECT RPP. You may then find out what terms are available for searching on by keying in SHOW INDEXES. To see the form of the contents of a particular index, say the PP (particle property) index of the RPP database, key in BROWSE PP; this will give you an idea of what kinds of expressions appear in this index, and thus will suggest what form you should use in your search. Then to do an actual search for information, say for the RPP Data Card Listings on the η meson mass, you would key in a command like FIND PP ETA MASS, followed by the command TYPE; this would print out the Listings for the η mass. At any time, you may get help by typing in such commands as EXPLAIN EXPLAIN, EXPLAIN SHOW INDEXES, EXPLAIN BROWSE, EXPLAIN FIND, EXPLAIN TYPE, etc. When you are finished searching, key in EXIT, which gets you out of SPIRES.

Anyone who has an account on the SLAC computing system can access these databases online. If you do not have an account and cannot find anyone who does (at main laboratories, ask at the library), please contact SLAC directly. An extensive wall poster, "A Guide to VM Spires," is available from the SLAC library. For more information, contact Alan Rittenberg at LBL (CMS-id AXRVX, tel. 415-486-4723, or 451-4723 on FTS), or Louise Addis at SLAC (CMS-id ADDIS, tel. 415-854-3300, ext. 2411).

The Durham-RAL Particle Physics Databases

These databases contain compilations of current and past experimental particle physics data (e.g., reaction cross sections), and are available for interactive searching under CMS on Rutherford Appleton Laboratory's mainframe IBM computer. The topics included are: (1) two-body (and quasi-two-body) reactions; (2) hadron and photon one- and two-particle inclusive distributions; (3) lepton-produced inclusive data (i.e., deep inelastic scattering, structure functions, etc.); and (4) data from e^+e^- annihilations. The databases also contain complete bibliographic information on these and other related topics, plus status information of current particle physics experiments. To insure that the databases are up to date, experimentalists are urged to send their data to the compilers immediately on completion.

The databases can be easily used by anyone having network access to the RAL computers; a guest identifier PDG (password PDG) is available for those who do not have their own CMS account. An EXEC file, HEPDATA, on the UDISK gives direct access to the databases, and contains an extensive built-in HELP facility to assist the unfamiliar user. Data is retrieved using a simple keyword-based search, and can be displayed in either tabular or graphical form.

For more information, or a guide to the service, please contact Michael Whalley at Durham University, England (CMS-id MRW; tel. 0385-64971, ext. 591), or Richard Roberts at RAL (CMS-id RGR; tel. 0235-21900, ext. 5259).

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