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THE Σ/Λ BRANCHING RATIO OF Y_1^* †

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Recently a $T = 1$ resonance in the $\Lambda\pi$ system called Y_1^* has been observed with a mass of 1385 Mev.[1-6] Two types of resonances have been predicted that might relate this observation to other elementary-particle interactions: (1) P 3/2 resonances in the $\Lambda\pi$ and $\Sigma\pi$ systems predicted by global symmetry[7,8] corresponding to the (3/2, 3/2) resonance of the πN system, (2) a spin-1/2 Y-π resonance resulting from a bound state in the $\bar{K}N$ system.[9,10] The position and width of the observed Y_1^* resonance agree with both theories, but since the spin and parity have not yet been determined, it is impossible at present to distinguish between the two theoretical interpretations.

Global symmetry[11] predicts a theoretical branching ratio $(Y_1^{*+} \to \Sigma^0 + \pi^+)/(Y_1^{*+} \to \Lambda + \pi^+) = 1/4$ for the $T = 1$ resonance. The phase-space factor $(P_\Sigma/P_\Lambda)^3 = (126/207)^3 = 0.225$ reduces the expected branching ratio for this process to $R = (1/4) \times 0.225 \sim 5\%$. Furthermore, as a consequence of charge independence the rates $Y_1^{*\pm} \to \Sigma^\pm + \pi^0$, $Y_1^{*\pm} \to \Sigma^0 + \pi^\pm$, and $Y_1^{*0} \to \Sigma^\pm + \pi^\mp$ are equal. In addition to the $T = 1$ resonance, a $T = 2$ Σ-π resonance with a total energy of 1540 Mev and a half width, $\Gamma/2$, of 60 Mev is predicted by global symmetry.[8]

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The $\overline{K}$-N bound-state model suggests values of R considerably larger than 5%. However, when non-zero effective ranges are taken into account[12], R can become quite small, especially if the $(\Sigma\Lambda)$ parity should be odd.

To investigate these possibilities, we have continued our study of $K^- - p$ interactions at 1.15 Bev/c in the Lawrence Radiation Laboratory 15-in. hydrogen bubble chamber by studying events in which a Σ is observed. The total cross sections for these interactions are shown in Table I; only statistical errors are indicated. The separation of $\Sigma^{\pm} + \pi^{\mp} + \pi^0$ and $\Sigma^{\pm} + \pi^{\mp} + 2\,\pi^0$ events was difficult because many of the latter events can also be fitted to the first hypothesis. The numbers given in Table I and in the Dalitz and mass plots below were corrected to account for this ambiguity. The correction factor was estimated by using our $\Sigma^{\pm} + \pi^{\mp} + \pi^+ + \pi^-$ events.

Dalitz plots for the three-body reactions are shown in Fig. 1. The Y_1^* resonance of mass 1385 Mev should appear as a bunching of events about both horizontal and vertical lines corresponding to $T_\pi = 282$ Mev. To obtain an upper limit for the branching ratio R, we combined the events into different charge states of the $\Sigma\pi$ system. All charged Σ were observed; however, in the Σ^0 cases only two-thirds of the events were observable because of the neutral decays of the Λ^0. Furthermore, we had estimated that about one-third of the $\Sigma^0\,\pi^+ + \pi^-$ events also fitted a $\Lambda\pi^+\pi^-$ interpretation and had been included in already published data.[1] Consequently each $\Sigma^0\,\pi^+\pi^-$ event was given a weight of 2.25. The resultant mass spectra are shown in Fig. 2. In the cases of $(\Sigma\pi)^+$ and $(\Sigma\pi)^-$ there appears to be no excess of events in the region of M = 1385 Mev. Using the number of $(\Lambda\pi^+)$ and $(\Lambda\pi^-)$ events with 1355 Mev $< M_{\Lambda\pi} <$ 1415 Mev from reference 1, and assuming that all $\Sigma\pi$ events in the same regions of Fig. 2 are Y_1^*, we obtain $R_{max} \leq 8\%$.

This treatment yields an unrealistic upper limit, since there is no evidence of any peaking above background. The results are consistent with $R = 0$. The $\Sigma^{\pm} + \pi^{+} + 2\pi^{0}$ events possibly misidentified as $\Sigma^{\pm} + \pi^{\mp} + \pi^{0}$ (or vice versa) do not fall into the mass band used in this analysis, since they yield apparently high masses of the $\Sigma^{\pm}\pi^{0}$ system.

We conclude that the Σ/Λ branching ratio R for the strong decay of the $T = 1$ Y_1^* is at most a few percent and is consistent with zero. This result agrees with the value of R obtained by Berge.[3] As indicated above this value of R does not rule out either the global symmetry or the $\bar{K}N$ bound-state model of the Y_1^* resonance. No evidence for the resonance with $T = 2$ predicted by global symmetry at $M = 1540$ Mev is observed; however, this wide resonance would be hard to separate from background.

The authors wish to thank the many members of the Bevatron and 15-in. bubble chamber crews and the scanners who made this experiment possible. One of us, Philippe Eberhard, wishes to thank the Philippe Foundation, Inc. and the Commisariat à L'Energie Atomique for a fellowship.

Table I. Cross sections for the Σ producing interactions at 1.15 Bev/c

Reaction	No. of events (uncorrected)	Cross sections (mb)
$K^- + p \rightarrow \Sigma^- + \pi^+$	87	1.40 ± 0.16
$\rightarrow \Sigma^+ + \pi^-$	84	1.34 ± 0.18
$\rightarrow \Sigma^+ + \pi^- + \pi^0$	57	0.97 ± 0.16
$\rightarrow \Sigma^- + \pi^+ + \pi^0$	54	0.83 ± 0.20
$\rightarrow \Sigma^0 + \pi^+ + \pi^-$	27	0.97 ± 0.20
$\rightarrow \Sigma^+ + \pi^- + \pi^0 + \pi^0$	13	0.18 ± 0.06
$\rightarrow \Sigma^- + \pi^+ + \pi^0 + \pi^0$	9	0.12 ± 0.05
$\rightarrow \Sigma^+ + \pi^+ + \pi^- + \pi^-$	19	0.19 ± 0.06
$\rightarrow \Sigma^- + \pi^- + \pi^+ + \pi^+$	13	0.12 ± 0.05

FOOTNOTES

1. M. Alston, L. Alvarez, P. Eberhard, M. Good, W. Graziano, H. Ticho, and S. Wojcicki, Phys. Rev. Letters 5, 520 (1960).
2. O. Dahl, N. Horwitz, D. Miller, J. Murray, and P. White, Phys. Rev. Letters 6, 142 (1961).
3. J.P. Berge, P. Bastien, O. Dahl, M. Ferro-Luzzi, J. Kirz, D.H. Miller, J.J. Murray, A.H. Rosenfeld, R.D. Tripp, and M. Watson, (submitted to Phys. Rev. Letters).
4. H. Martin, L. Leipuner, W. Chinowsky, F. Shively, and R. Adair, Phys. Rev. Letters 6, 283 (1961).
5. M. M. Block, E.B. Brucker, R. Gessaroli, T. Kikuchi, A. Kovacs, C.M. Meltzer, R. Kraemer, M. Nussbaum, A. Pevsner, P. Schlein, R. Strand, H.O. Cohn, E.M. Harth, J. Leitner, L. Lendinara, L. Monari, and G. Puppi, (submitted to Nuovo cimento).
6. R. Ely, S. Fung, G. Gidal, Y. Pan, W. Powell, and H. White, Bull. Am. Phys. Soc. 6, 291 (1961).
7. M. Gell-Mann, Phys. Rev. 106, 1297 (1957).
8. P. Amati, A. Stanghellini, and B. Vitali, Phys. Rev. Letters 5, 524 (1960), Nuovo cimento 13, 1143 (1959).
9. R. Dalitz and S.F. Tuan, Phys. Rev. Letters 2, 425 (1959).
10. R. Dalitz, Phys. Rev. Letters 6, 239 (1961).
11. Ph. Meyer, J. Prentki, and Y. Yamaguchi, Phys. Rev. Letters 5, 442 (1960).
12. J. L. Shaw, University of California at La Jolla (private communication).

FIGURE LEGENDS

Fig. 1. Dalitz plots for the reactions:

(a) $K^- + p \rightarrow \Sigma^+ + \pi^- + \pi^0$ (57 events)

(b) $K^- + p \rightarrow \Sigma^- + \pi^+ + \pi^0$ (54 events)

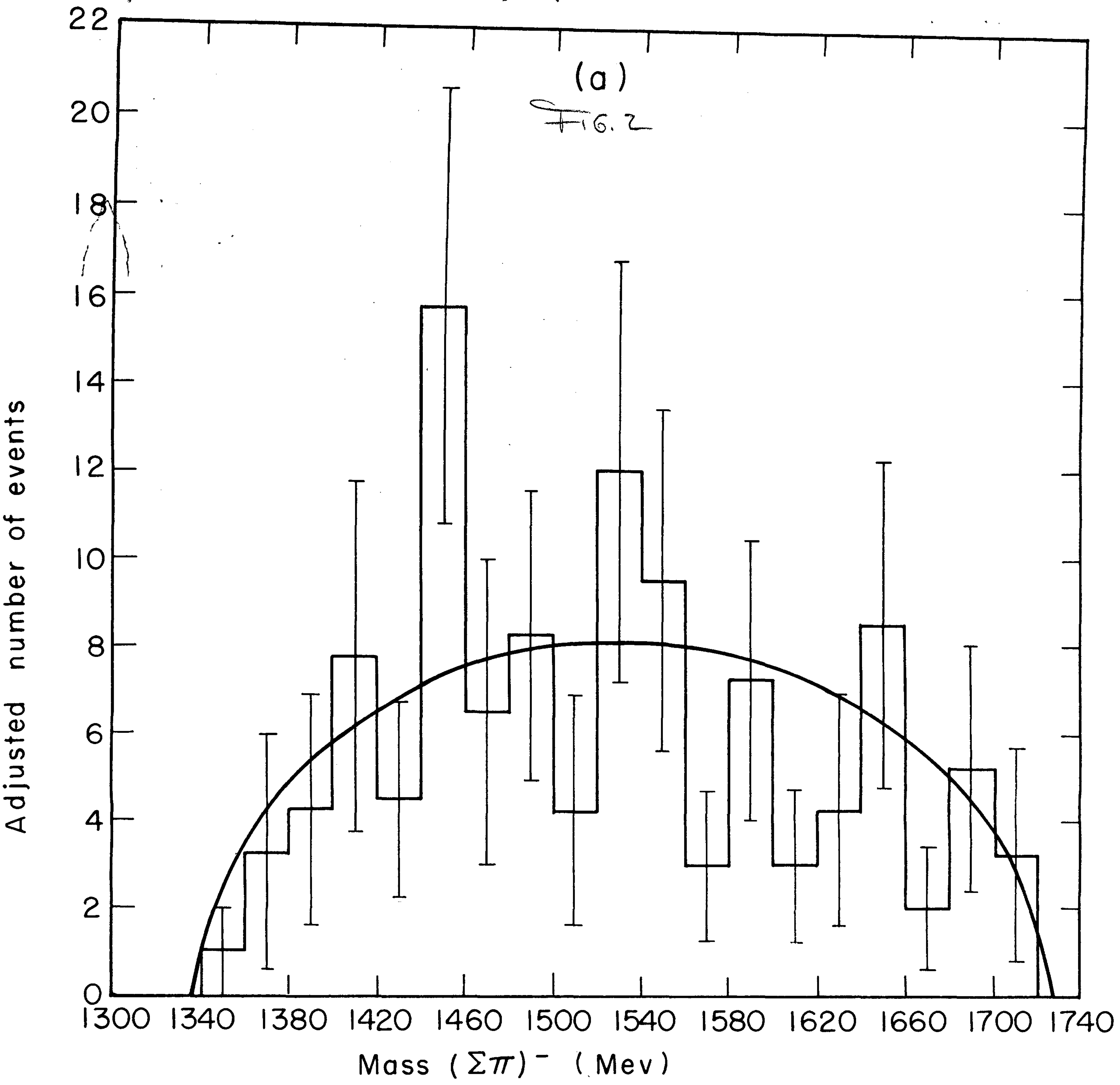
(c) $K^- + p \rightarrow \Sigma^0 + \pi^+ + \pi^-$ (27 events).

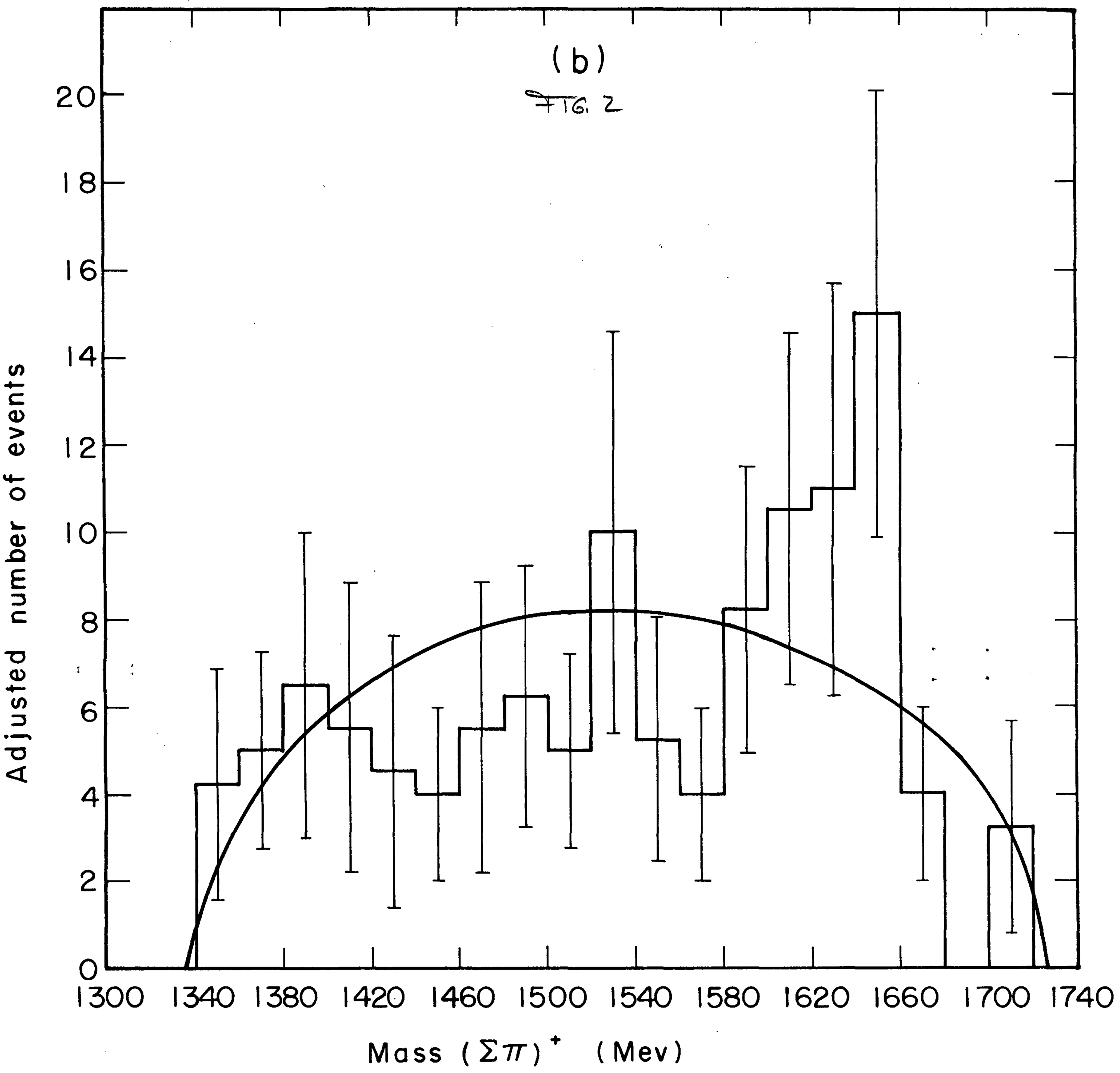
Fig. 2. Mass plots of the charged and neutral Σ-π systems, including curves representing phase-space distributions.

(a) Mass of $(\Sigma\pi)^-$, from the reactions: $K^- + p \rightarrow \Sigma^0 + \pi^- + \pi^+$
$\rightarrow \Sigma^- + \pi^0 + \pi^+$

(b) Mass of $(\Sigma\pi)^+$, from the reactions: $K^- + p \rightarrow \Sigma^0 + \pi^+ + \pi^-$
$\rightarrow \Sigma^+ + \pi^0 + \pi^-$

(c) Mass of $(\Sigma\pi)^0$, from the reactions: $K^- + p \rightarrow \Sigma^+ + \pi^- + \pi^0$
$\rightarrow \Sigma^- + \pi^+ + \pi^0$.


(a)
FIG. 2
Adjusted number of events
0
2
4
6
8
10
12
14
16
18
20
22
1300 1340 1380 1420 1460 1500 1540 1580 1620 1660 1700 1740
Mass $(\Sigma\pi)^-$ (Mev)


(b)
FIG. 2
Adjusted number of events
0
2
4
6
8
10
12
14
16
18
20
1300 1340 1380 1420 1460 1500 1540 1580 1620 1660 1700 1740
Mass $(\Sigma\pi)^+$ (Mev)

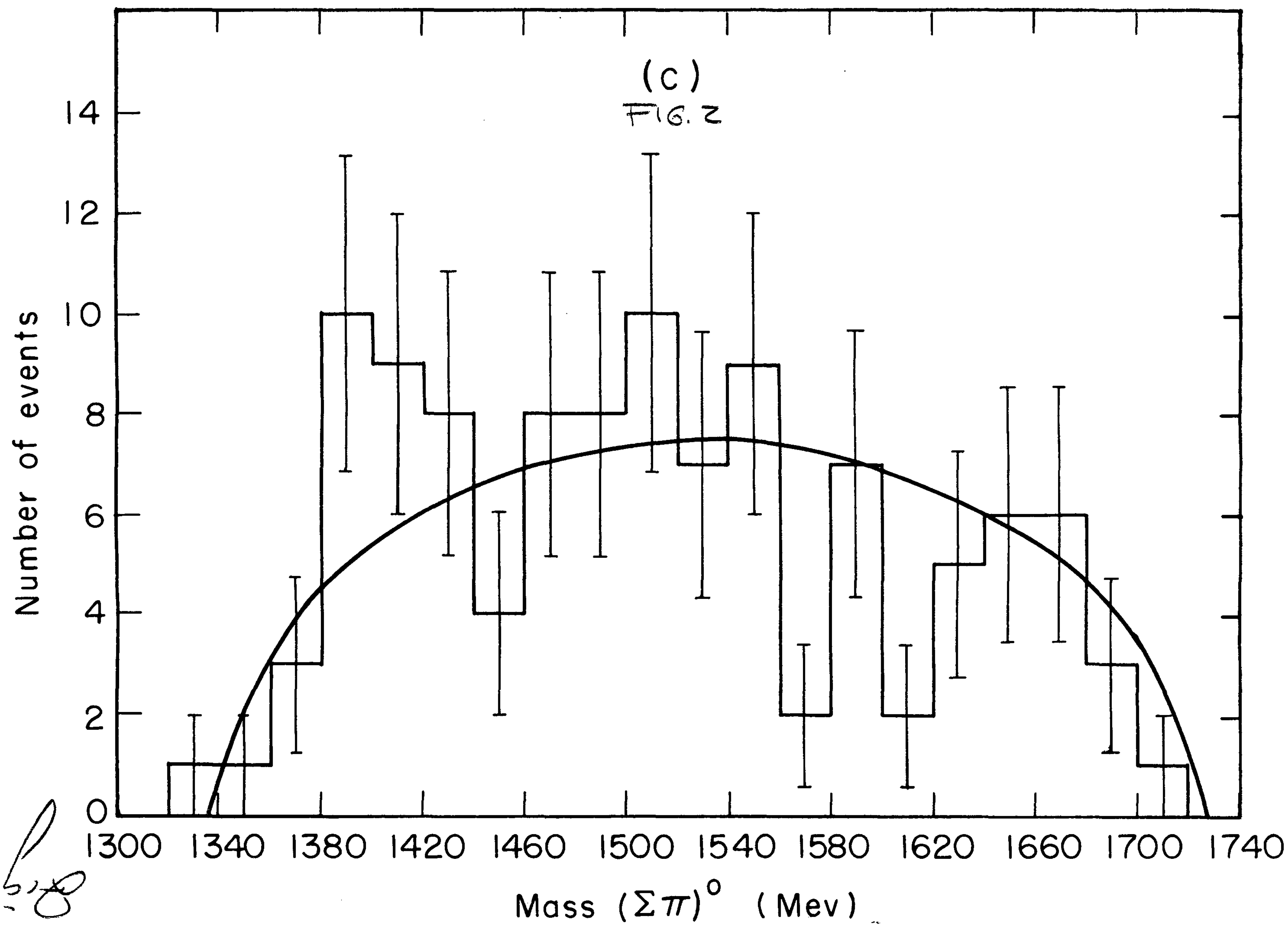

(c)
FIG. 2
Number of events
0
2
4
6
8
10
12
14
1300 1340 1380 1420 1460 1500 1540 1580 1620 1660 1700 1740
Mass $(\Sigma\pi)^0$ (Mev)

FIG. 1

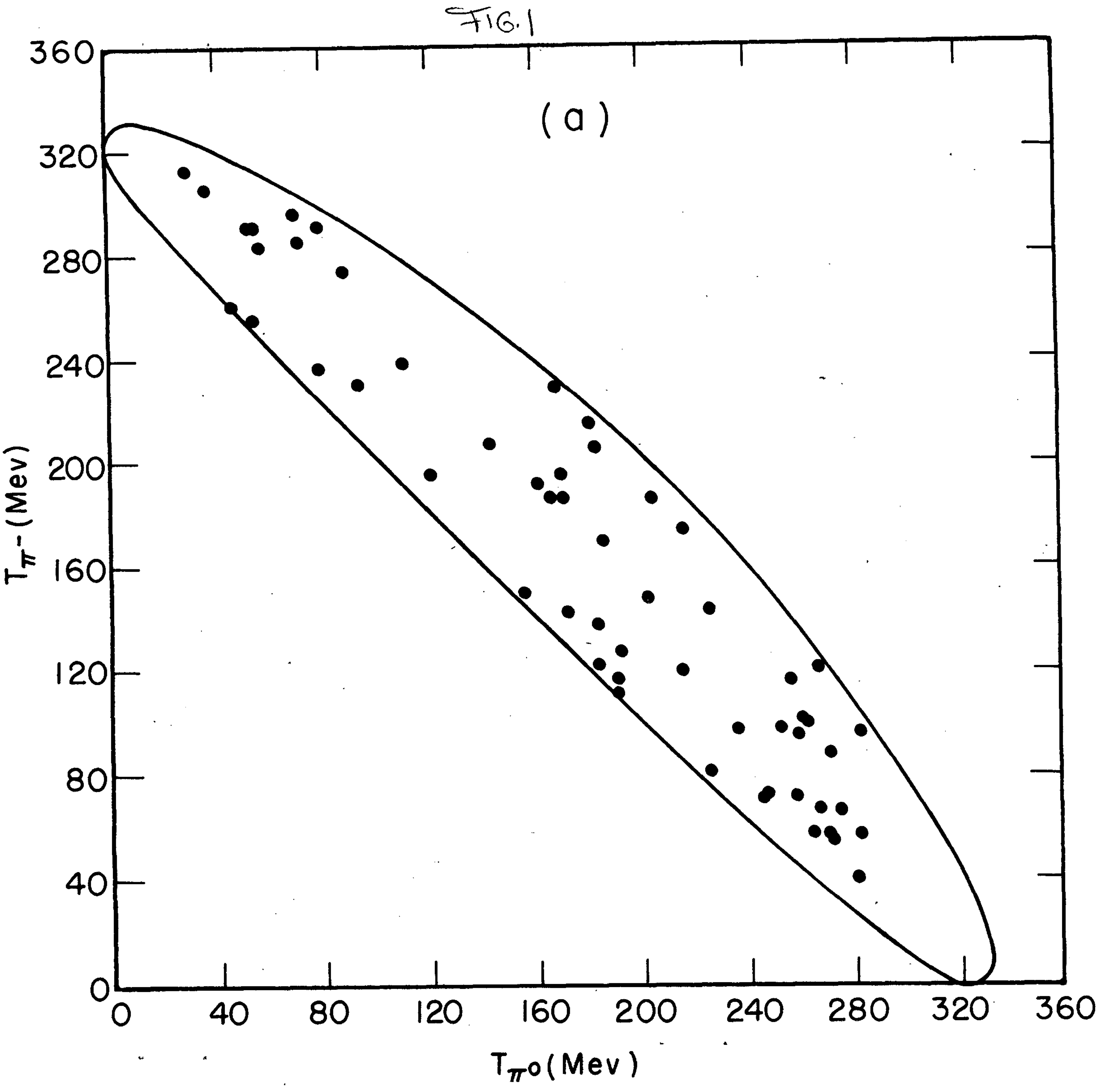


FIG. 1

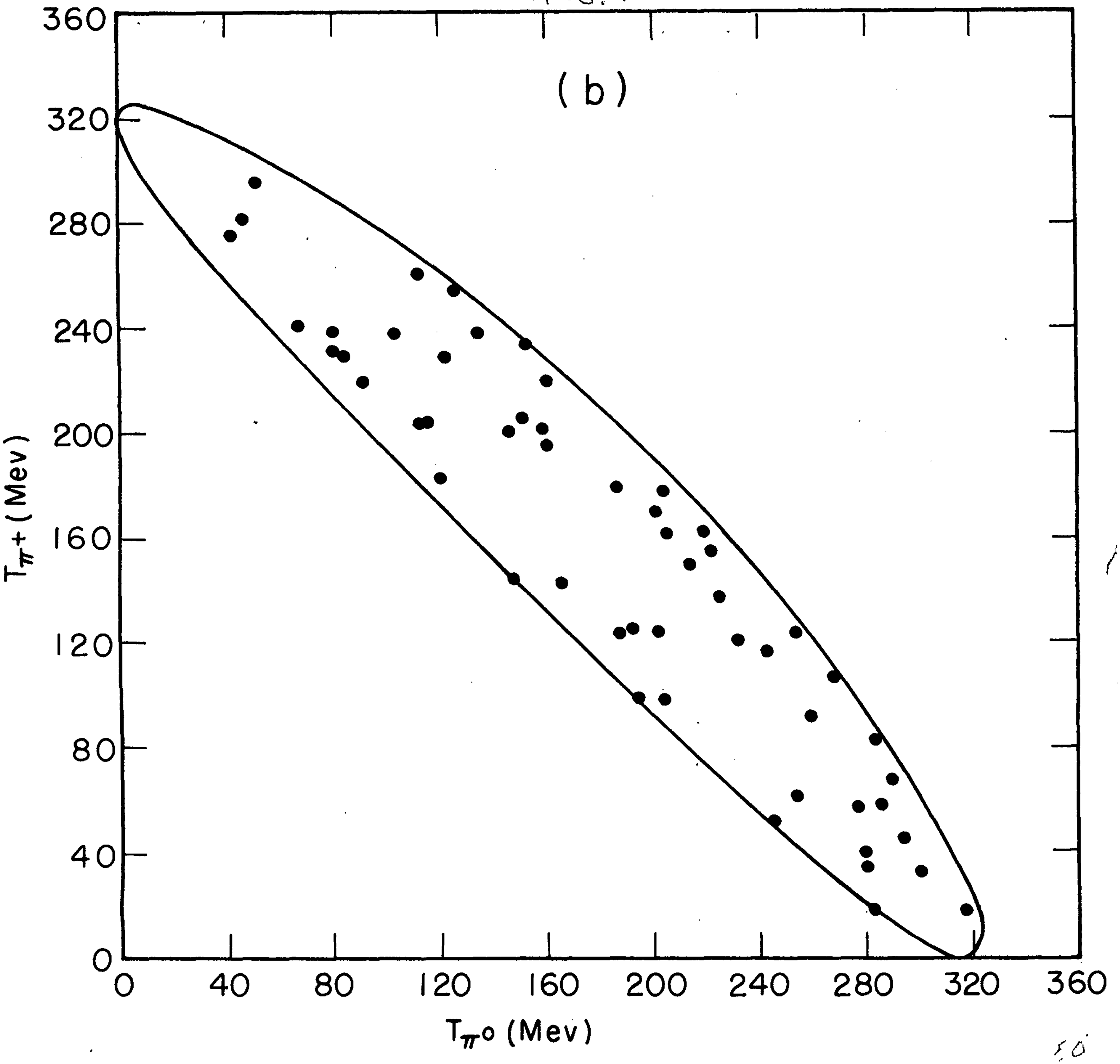


FIG. 1