Submitted to Physical Review

UCRL-19442
Preprint

c. 2

RECEIVED
LAWRENCE
RADIATION LABORATORY
MAR 23 1970
LIBRARY AND
DOCUMENTS SECTION

REGGE-POLE FIT TO SERPUKHOV $\pi^- p$ TOTAL CROSS SECTION DATA

William Rarita

January 5, 1970

AEC Contract No. W-7405-eng-48

TWO-WEEK LOAN COPY

This is a Library Circulating Copy which may be borrowed for two weeks. For a personal retention copy, call Tech. Info. Division, Ext. 5545

LAWRENCE RADIATION LABORATORY
UNIVERSITY of CALIFORNIA BERKELEY

UCRL-19442

34 ad

DISCLAIMER

This document was prepared as an account of work sponsored by the United States Government. While this document is believed to contain correct information, neither the United States Government nor any agency thereof, nor the Regents of the University of California, nor any of their employees, makes any warranty, express or implied, or assumes any legal responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by its trade name, trademark, manufacturer, or otherwise, does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof, or the Regents of the University of California. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof or the Regents of the University of California.

UCRL-19442

REGGE-POLE FIT TO SERPUKHOV $\pi^- p$ TOTAL CROSS SECTION DATA*

William Rarita+

Lawrence Radiation Laboratory
University of California
Berkeley, California

January 5, 1970

ABSTRACT

An additional Regge pole with a negative residue and a positive signature is suggested to fit the high energy $\pi^- p$ total cross sections recently measured at Serpukhov. We give some experimental implications for the total cross sections and the ratio of the real to the imaginary part of the forward scattering amplitude of $\pi^{\pm} p$ at high energies.

In Fig. 1, we present the recent Serpukhov[1] data for $\pi^- p$ total cross sections from 20 to 65 GeV/c. Also plotted is an earlier version of the data from Brookhaven[2] at lower energies for both $\pi^- p$ and $\pi^+ p$. In the spirit of former Regge pole analyses,[3] a best χ^2 fit to these data was obtained. For the 38 experimental $\pi^{\pm} p$ points from Refs. 1 and 2, a χ^2 of 131 was the result. Curve (a) in Fig. 1 shows this fit. We see that the fit is poor for $\pi^- p$ above 50 GeV/c. The theoretical curve (a) is characteristically going down smoothly but the experimental points flatten out and even have a suggestion of a rise. In Table I we summarize the fits we have tried. The Regge poles used were P, P', and ρ. The intercepts of P' and ρ were both set at a value of 0.5. Variations of these parameters give little change to our results.

A natural suggestion to improve the situation described above is to introduce an additional Regge pole of positive signature (like P') but of negative residue in the forward direction (t = 0). We find that a large range of allowable intercepts α_N for the negative pole can be made to fit the data. In Fig. 1, we show the solution (b) which was fitted to 29 $\pi^- p$ and 9 $\pi^+ p$ data points. We then calculated the $\pi^+ p$ above 20 GeV/c. A comparison with the measured $\pi^- n$ cross sections[1] (which by charge symmetry should be equal to $\pi^+ p$) gives good agreement. This solution has the same asymptotic total cross section $\sigma_T^{\infty}(\pi^{\pm} p)$ equal to 33.0 mb given by Barger and Phillips[4] for their cut model. As we shall see below, about the same asymptotic value is also preferred by the sum rules discussed later. The χ^2 for curve (b) is given in Table II. Also in Table II are presented other solutions. We notice

that the χ^2 is good until α_N goes below 0.63. The coefficient C_0 in this table is defined in Ref. 3. In Fig. 2, we show the relation between $\sigma_T^{\infty}(\pi^{\pm}p)$ and α_N for 38 data points when $\alpha_{P'} = \alpha_\rho = 0.5$. In Fig. 3 the predicted values of the ratio of the real to the imaginary part of the forward amplitude, $A'(0)$, are shown for two of the solutions. We observe that this ratio goes through zero and becomes positive in the range of pion incoming momenta, P_{lab}, soon to become available. Former Regge pole fits could only approach zero for this ratio asymptotically. In Fig. 4, the same two solutions (a) and (b) are again presented to predict the total cross sections for $\pi^{\pm}p$ from 20 to 800 GeV/c.

This paper can be considered as an extension of Ref. 3 but restricted to the forward direction of the $\pi^{\pm}p$ system. The equations we need of that reference are Eqs. (1) and (5) and also Eqs. (29) and (31). The latter two equations are the sum rules for the positive-signature Regge trajectories, P, P', and N, and for the negative-signature, ρ, Regge trajectory. When these sum rules are used the intercepts of P', N, and ρ become limited in range. An adequate fit gave a χ^2 of 67.5 for 48 σ_T data points. The ten π^-n cross sections were included as π^+p points. The positive sum rule had $\chi^2 = 2.8$, the negative sum rule $\chi^2 = 0$, the χ^2 for σ_T was 64.7, and $\sigma_T^{\infty}(\pi^{\pm}p) = 31.9$ mb, $\alpha_{P'} = 0.71$, $\alpha_N = 0.79$, and $\alpha_\rho = 0.64$.

In conclusion, with a simple extension within the Regge-pole framework, we have shown that the π^-p and π^-n total cross sections measured at Serpukhov can be easily explained. We reserve to a later time whether the N pole has a trajectory with a particle on it or not

and whether factorization is obeyed or not. These questions become important when we expand our considerations to data away from the forward direction.

ACKNOWLEDGMENTS

The author thanks Dr. Donald M. Austin and Dr. William Greiman for valuable assistance in programming and is grateful to Professor Geoffrey F. Chew for the hospitality of the Theoretical Group at the Lawrence Radiation Laboratory.

Table I. Asymptotic limit $\sigma_T^{\infty}(\pi^{\pm}p)$ for $\alpha_{P'} = \alpha_{\rho} = 0.5$.

Number of data points	Type of data	$\sigma_T^{\infty}(\pi^{\pm}p)$	χ^2	References
29	π^-p	22.2 mb	87	1 and 2
9	π^+p	20.5 mb	2	2
19	π^+p and π^-n	21.4 mb	29	1 and 2
38	π^-p and π^+p	22.0 mb	131	1 and 2

Table II. Negative pole solutions assuming $\alpha_{P'} = \alpha_{\rho} = 0.5$ for 38 points.

α_N	$\sigma_T^{\infty}(\pi N)$	C_0 (mb GeV)			χ^2
		N	P'	ρ	
0.9972	1000 mb	-497.8	46.5	2.1	19.4
0.99	290 mb	-143.0	46.7	2.1	19.4
0.95	75.8mb	- 37.4	49.5	2.1	19.6
0.90	48.7mb	- 26.2	53.4	2.1	19.8
0.80	35.6mb	- 28.3	67.1	2.1	20.2
0.767	33.0mb	- 30.1	70.1	2.1	20.8
0.69	28.0mb	- 33.0	70.6	2.1	32.6
0.63	24.6mb	- 29.6	59.2	2.1	67.6

FOOTNOTES AND REFERENCES

* This work was supported in part by the U. S. Atomic Energy Commission.

+ Visiting Scientist.

1. J. V. Allaby, Yu. B. Bushnin, S. P. Denisov, A. N. Diddens, R. W. Dobinson, S. V. Donskov, G. Giacomelli, Yu. P. Gorin, A. Klovning, A. I. Petrukhin, Yu. D. Prokoshkin, R. S. Shuvalov, C. A. Ståhlbrandt, and D. A. Stoyanova, Phys. Letters 30B, 500 (1969).

2. K. J. Foley, R. S. Jones, S. J. Lindenbaum, W. A. Love, S. Ozaki, E. D. Platner, C. A. Quarles, and E. H. Willen, Phys. Rev. Letters 19, 330 (1967).

3. W. Rarita, R. J. Riddell, Jr., C. B. Chiu, and R. J. N. Phillips, Phys. Rev. 165, 1615 (1968).

4. V. Barger and R. J. N. Phillips, University of Wisconsin Preprint COO-881-260, 1969.

FIGURE CAPTIONS

Fig. 1. Total cross sections for $\pi^{\pm}p$ from Refs. 1 and 2 compared with solutions (a) and (b).

● from Ref. 2.

▲ from Ref. 1.

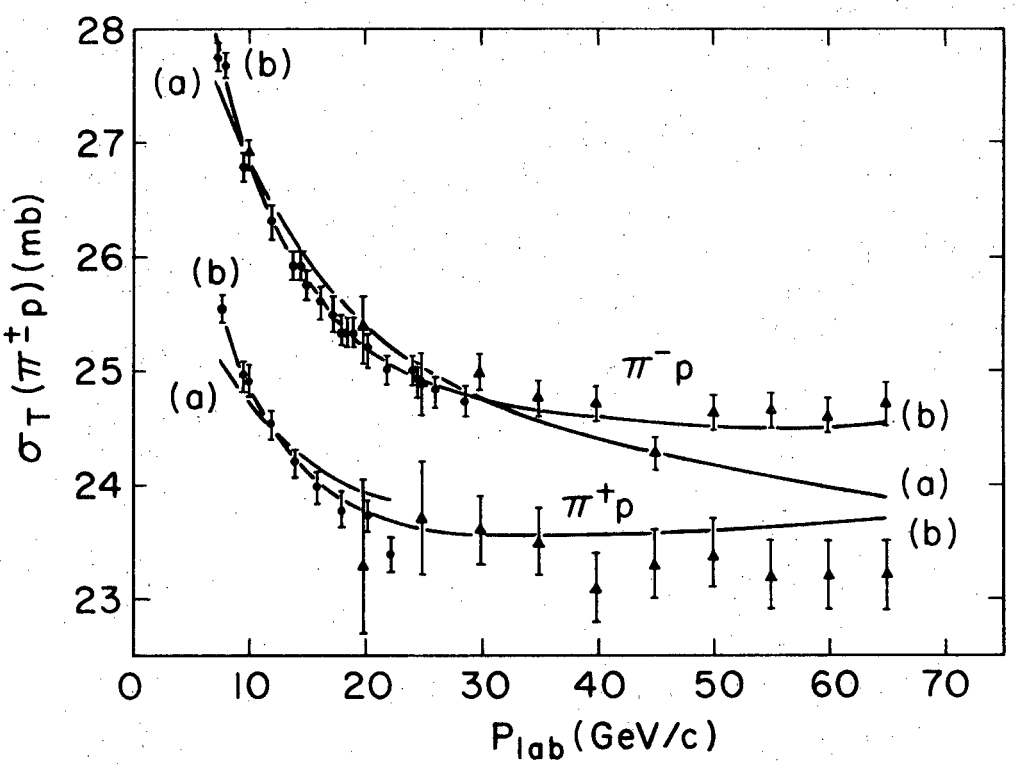
Fig. 2. The asymptotic cross section $\sigma_T^{\infty}(\pi^{\pm}p)$ as a function of the intercept α_N.

Fig. 3. The predicted Re A'(0)/Im A'(0) for two solutions of Table II (a) $\alpha_N = 0.767$, $\alpha_T^{\infty}(\pi^{\pm}p) = 33.0$ mb; (b) $\alpha_N = 0.9973$, $\sigma_T^{\infty}(\pi^{\pm}p) = 1000$ mb.

● π^-p, ▲ π^+p.

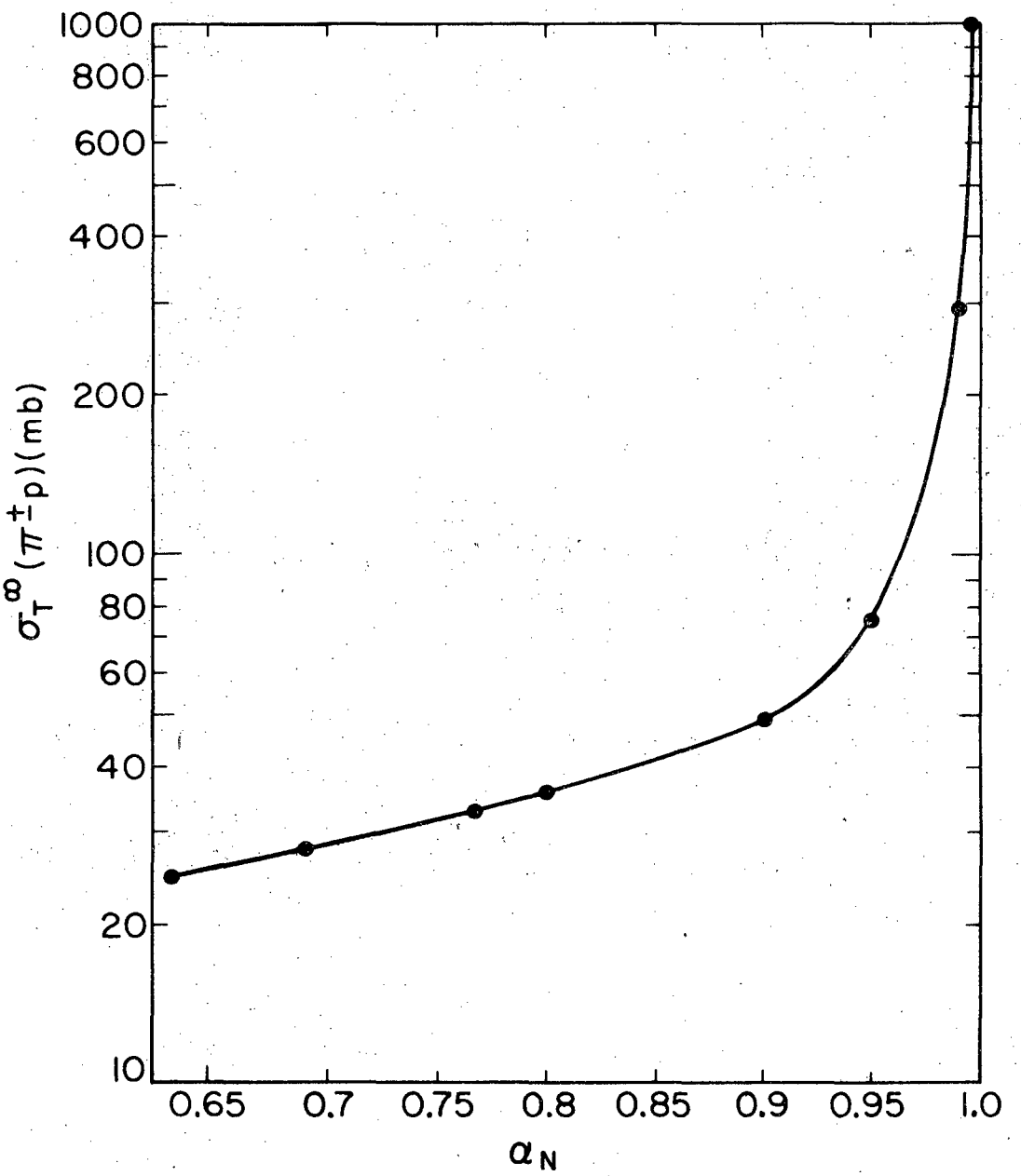
Fig. 4. The predicted total cross sections for the same two solutions (a) and (b) of Fig. 3.

● π^-p, ▲ π^+p.



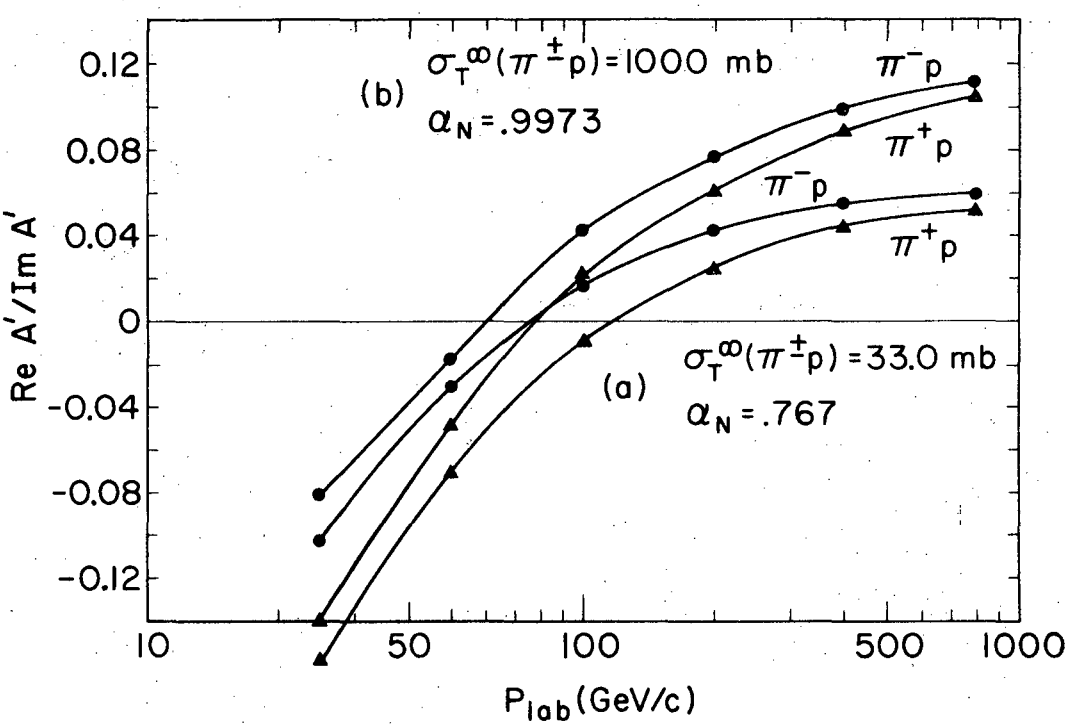
XBL701-2035

Fig. 1



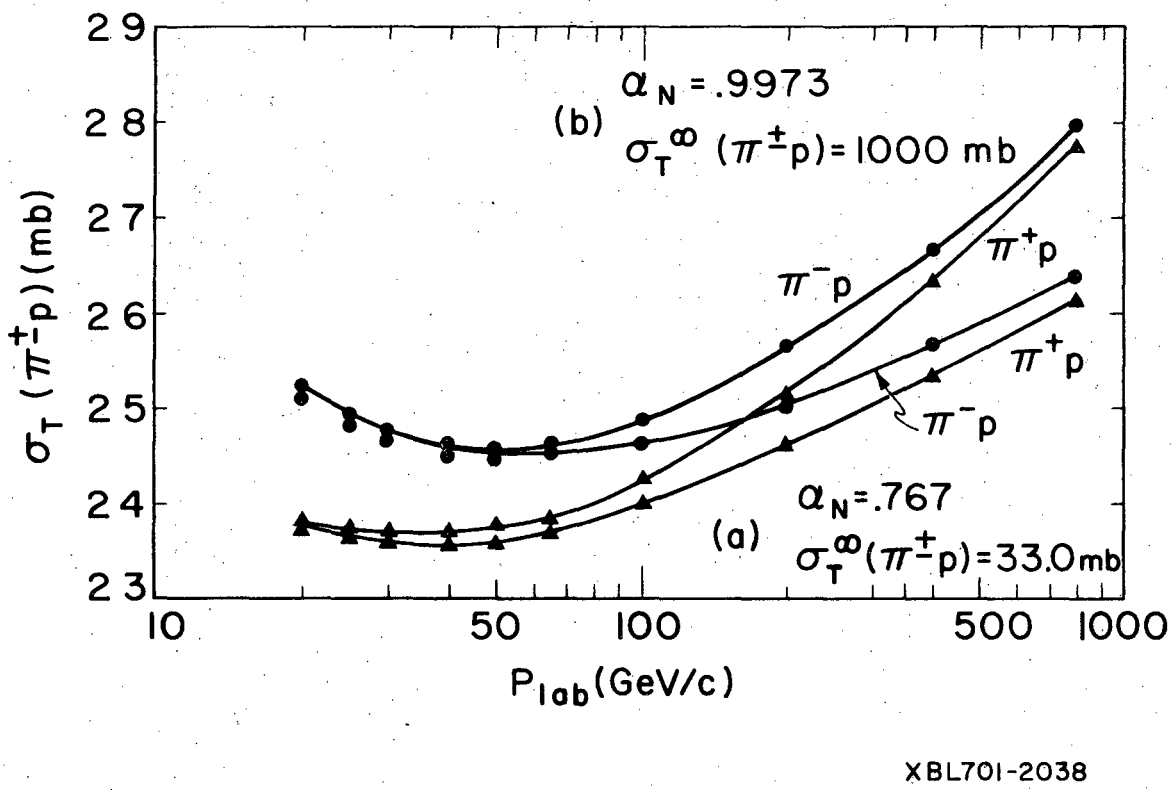
XBL701-2037

Fig. 2



XBL701-2036

Fig. 3



XBL701-2038

Fig. 4

LEGAL NOTICE

This report was prepared as an account of Government sponsored work. Neither the United States, nor the Commission, nor any person acting on behalf of the Commission:

A. Makes any warranty or representation, expressed or implied, with respect to the accuracy, completeness, or usefulness of the information contained in this report, or that the use of any information, apparatus, method, or process disclosed in this report may not infringe privately owned rights; or

B. Assumes any liabilities with respect to the use of, or for damages resulting from the use of any information, apparatus, method, or process disclosed in this report.

As used in the above, "person acting on behalf of the Commission" includes any employee or contractor of the Commission, or employee of such contractor, to the extent that such employee or contractor of the Commission, or employee of such contractor prepares, disseminates, or provides access to, any information pursuant to his employment or contract with the Commission, or his employment with such contractor.

TECHNICAL INFORMATION DIVISION
LAWRENCE RADIATION LABORATORY
UNIVERSITY OF CALIFORNIA
BERKELEY, CALIFORNIA 94720