Lawrence Berkeley National Laboratory
Recent Work

Title
TOTAL CROSS SECTIONS OF NEGATIVE PIONS IN THE MOMENTUM RANGE 2 to 5 BeV/c

Permalink
https://escholarship.org/uc/item/7db620zq

Authors
Longo, Michael J.
Moyer, Burton J.

Publication Date
1962-08-08

eScholarship.org Powered by the California Digital Library
University of California

UCRL-10174

University of California

Ernest O. Lawrence Radiation Laboratory

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

Berkeley, California

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.

Submitted to Physical Review

UCRL-10174

UNIVERSITY OF CALIFORNIA
Lawrence Radiation Laboratory
Berkeley, California

Contract No. W-7405-eng-48

TOTAL CROSS SECTIONS OF NEGATIVE PIONS IN THE MOMENTUM RANGE 2 TO 5 BeV/c

Michael J. Longo and Burton J. Moyer

August 8, 1962

TOTAL CROSS SECTIONS OF NEGATIVE PIONS IN THE MOMENTUM RANGE 2 TO 5 BeV/c

Michael J. Longo and Burton J. Moyer

Lawrence Radiation Laboratory
University of California
Berkeley, California

August 8, 1962

ABSTRACT

Total cross-section measurements for π^- collisions with protons are presented for the pion momentum range 2 to 5 BeV/c, where data have been meager. Comparison with other data for pion momenta slightly below 2 BeV/c suggests either a disagreement or an unexpected variation in cross sections. Cross sections for π^+ and π^- collisions with carbon nuclei are also compared.

TOTAL CROSS SECTIONS OF NEGATIVE PIONS IN THE MOMENTUM RANGE 2 TO 5 BeV/c*

Michael J. Longo† and Burton J. Moyer

Lawrence Radiation Laboratory
University of California
Berkeley, California

August 8, 1962

Few accurate data are presently available on the total π^--p cross section in the momentum range 2 to 4.5 BeV/c. We present here the results of measurements in this range using counter techniques. In addition, cross sections in good geometry for π^--carbon scattering were measured at 3 and 4 BeV/c in order to investigate a discrepancy between the π^+-C cross sections previously measured by the authors[1] and the π^--C cross sections of Wikner.[2]

The experimental arrangement is shown in Fig. 1. The pion beam was used simultaneously by the University of Michigan spark chamber group to measure π^--p differential cross sections. After passing through their 18-in.-long hydrogen target, the beam was refocused by Q_2 and used for our measurements. The π^--p cross sections were measured by using a CH_2-C subtraction with carefully matched polyethylene and graphite targets, the former containing 2.9 g/cm^2 of hydrogen. Incident pions were counted by measuring $M_1M_2CM_3M_4$ coincidences. The numbers of transmitted pions were measured with three different geometries simultaneously by means of counters S_1, S_2, and S_3, which were respectively 12.0, 10.6, and 9.0 in. in diameter. Measurements were made with two different target positions so that the total range of solid angles covered was 1.7 to 5.8 msr. The quadrupole Q_2 was tuned to produce an image of M_2 at the position of S_3 in order to reduce multiple Coulomb scattering corrections. Muons in the beam were eliminated by rejecting particles that passed through a 36-in.-long iron block with an "anti" counter A, as was done by von Dardel et al.[3]

*Work done under the auspices of the U. S. Atomic Energy Commission.

Total cross sections were obtained by extrapolating the measured cross sections linearly to zero solid angle. This extrapolation represented a correction of approx 0.4 mb to the measured values. At 2.0 BeV/c, a small correction for multiple Coulomb scattering was made to the point at 1.7 msr. Corrections of approx 0.6 mb were made at 2.0 and 3.0 BeV/c for electron contamination in the beam, which was measured with a gas Cerenkov counter. At 2.0 BeV/c it was also necessary to apply a small correction for low-energy muons that stopped in the iron block and thus were not "antied" out. The quoted errors include uncertainties in these corrections as well as the statistical errors.

At each momentum an average of five measurement cycles was made at different times during the experiment, each consisting of a sequence of two runs with the carbon target, four runs with the polyethylene, and two more runs with carbon. The reproducibility of repeated runs was within statistics. Accidental coincidences were monitored constantly and were always negligible. The momentum of the beam was determined from the kinematics of events observed in the Michigan spark chamber experiment. The uncertainty in momentum is about ± 2 %.

The measured cross sections are given in Table I and compared with the results of other experiments in Fig. 2. At the higher momenta our results agree well with those of von Dardel et al.[3] Near 2 BeV/c, however, our result is considerably higher than previous results at somewhat lower momenta.[4,5] Our point at 2.0 BeV/c is an average of five measurements made at different times during the experiment with very good reproducibility, and we believe that no systematic error on our part could explain the difference. We therefore suggest that further studies be made in this momentum region to investigate the possibility of structure in the π^--p total cross section. It is interesting to note that a "bump" near 2 BeV/c is appropriate to the reappearance of the Regge pole for the 600-MeV π-N resonance. See Table I.

Table I. Measured π^--p cross sections.

Momentum (BeV/c)	$\sigma(\pi^-$-p) (mb)
2.00	35.7 ± 0.8
2.95	30.9 ± 0.9
4.00	30.8 ± 1.0
4.90	28.7 ± 1.0

A previous measurement, by the authors,[1] of π^+ cross sections for several nuclei at 3 BeV/c disagreed with the results of Wikner for negative pions at 4 BeV/c.[2] It appeared that the absorption cross sections for π^- and π^+ scattering on nuclei were substantially the same, but that the total cross sections for negative pions were consistently 30% larger. This difference would imply a breakdown of charge symmetry at high energies. We therefore made measurements of π^--C cross sections at 3.0 and 4.0 BeV/c. The results are given in Fig. 3 along with our previous results for π^+-C scattering. The π^+-C results at 3.0 BeV/c are slightly lower than those for π^--C at 3.0 BeV/c. This is probably explained by the fact that there are more charged secondaries (i.e., protons) formed in π^+-C inelastic scattering than in π^--C. Some of these strike the transmission counter, thus increasing the apparent transmission and lowering the apparent cross section. This difference would be expected to diminish as the solid angle subtended by the transmission counter is decreased. By extrapolating the measured cross sections linearly to zero solid angle (as was done with hydrogen) we can estimate the total cross section. This yields a total cross section of 292 mb for π^+ scattering at 3 BeV/c and 294 mb for π^- scattering. This excellent agreement is somewhat fortuitous, but in any case, there is no evidence for a violation of charge symmetry. For π^--C scattering

at 4.0 BeV/c we find a total cross section of 281 mb, in contrast to Wikner's result of 386 ± 20 mb. We also made measurements with a Be target and again found good agreement between the π^+ and π^- results.

ACKNOWLEDGMENTS

We wish to express our gratitude to the University of Michigan spark chamber group, particularly to Dr. Lawrence Jones and Dr. Martin Perl, for their help and cooperation, which made this work possible. We are deeply indebted to Robert A. Profet for his generous assistance in the preparation and execution of the experiment.

FOOTNOTES AND REFERENCES

† Now at Physics Department, University of Michigan.

1. Michael J. Longo and Burton J. Moyer, Phys. Rev. 125, 701 (1962).
2. Fredrick Wikner, Nuclear Cross Sections for 4.2-BeV Negative Pions (Ph.D. thesis), University of California Radiation Laboratory Report UCRL-3639, January 1957 (unpublished).
3. G. von Dardel, R. Mermod, P. A. Piroué, M. Vivargent, G. Weber, and K. Winter, Phys. Rev. Letters 7, 127 (1961).
4. T. J. Devlin, B. J. Moyer, and V. Perez-Mendez, Phys. Rev. 125, 690 (1962).
5. J. C. Brisson, J. F. Detoeuf, P. Falk-Vairant, L. van Rossum, and G. Valladas, Nuovo cimento 19, 210 (1961).

FIGURE CAPTIONS

Fig. 1. Experimental arrangement. The π^- beam was taken off at 0 deg from a target in the Bevatron. The first quadrupole and bending magnet are not shown. The vertical scale is exaggerated twofold for clarity.

Fig. 2. Total π^--p cross sections vs momentum.

Fig. 3. Pion-carbon cross sections as a function of the solid angle subtended by the transmission counter.

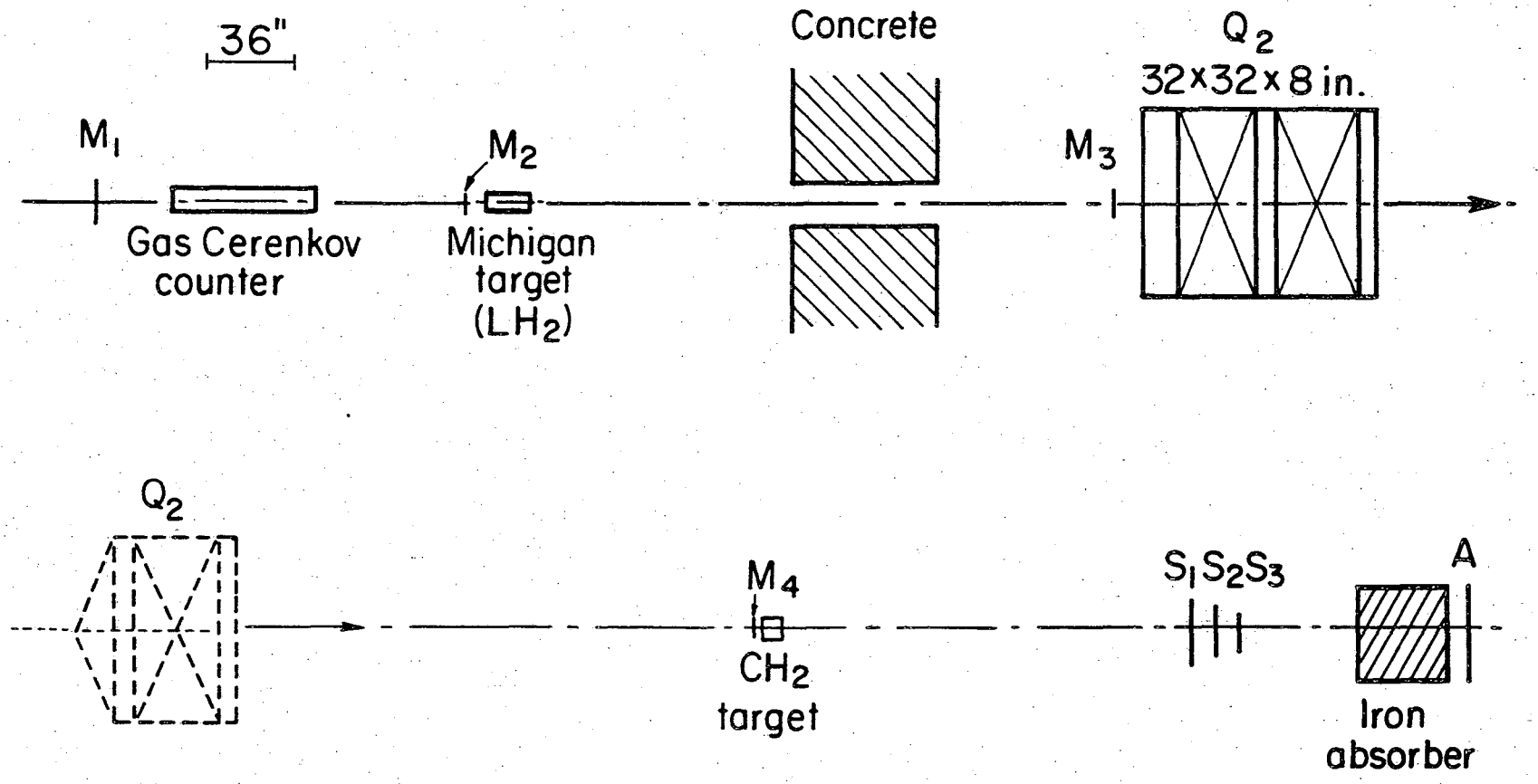
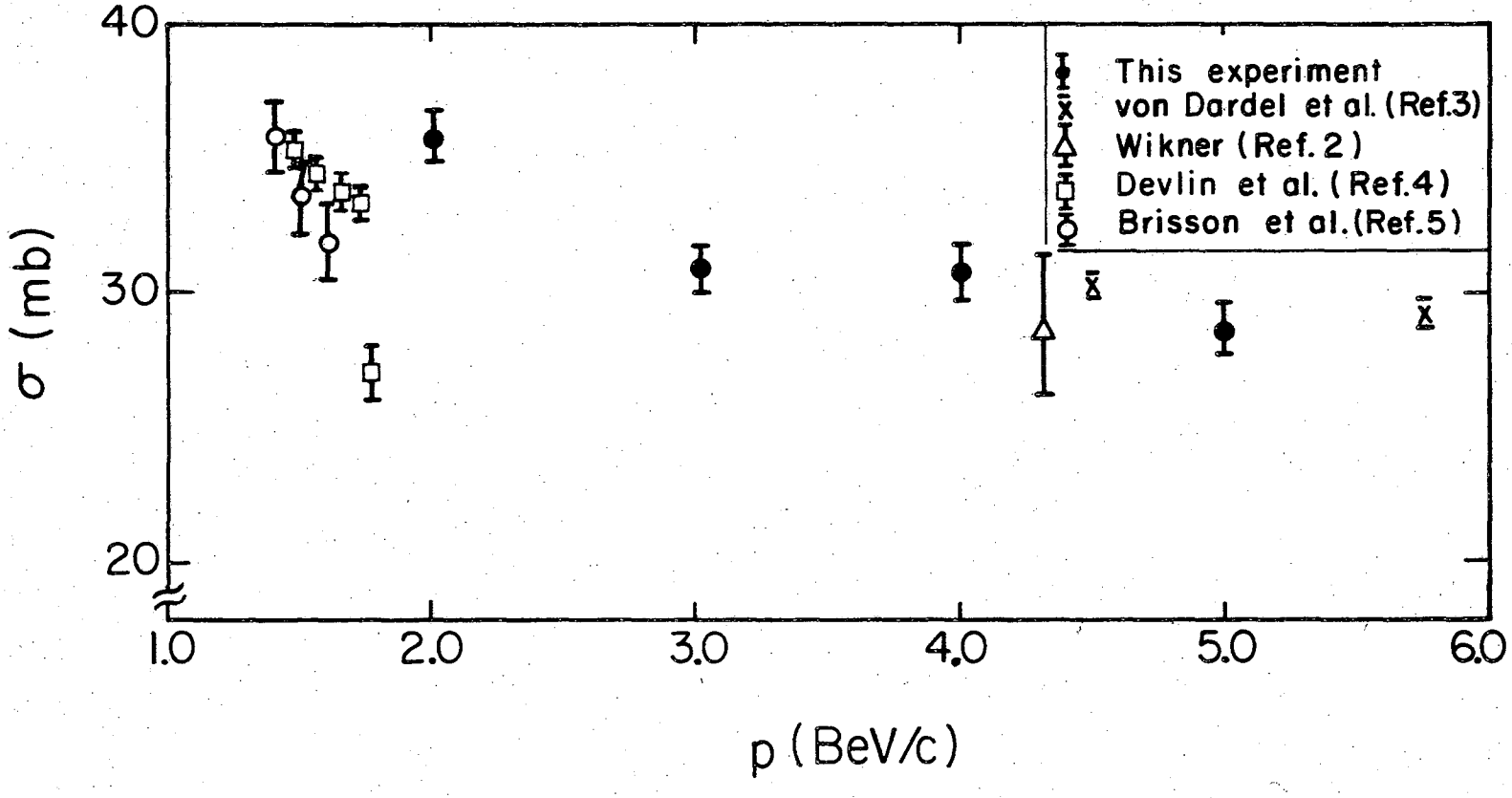


Fig. 1.

MU-26723

UCRL-10174



MU-26724

Fig. 2.

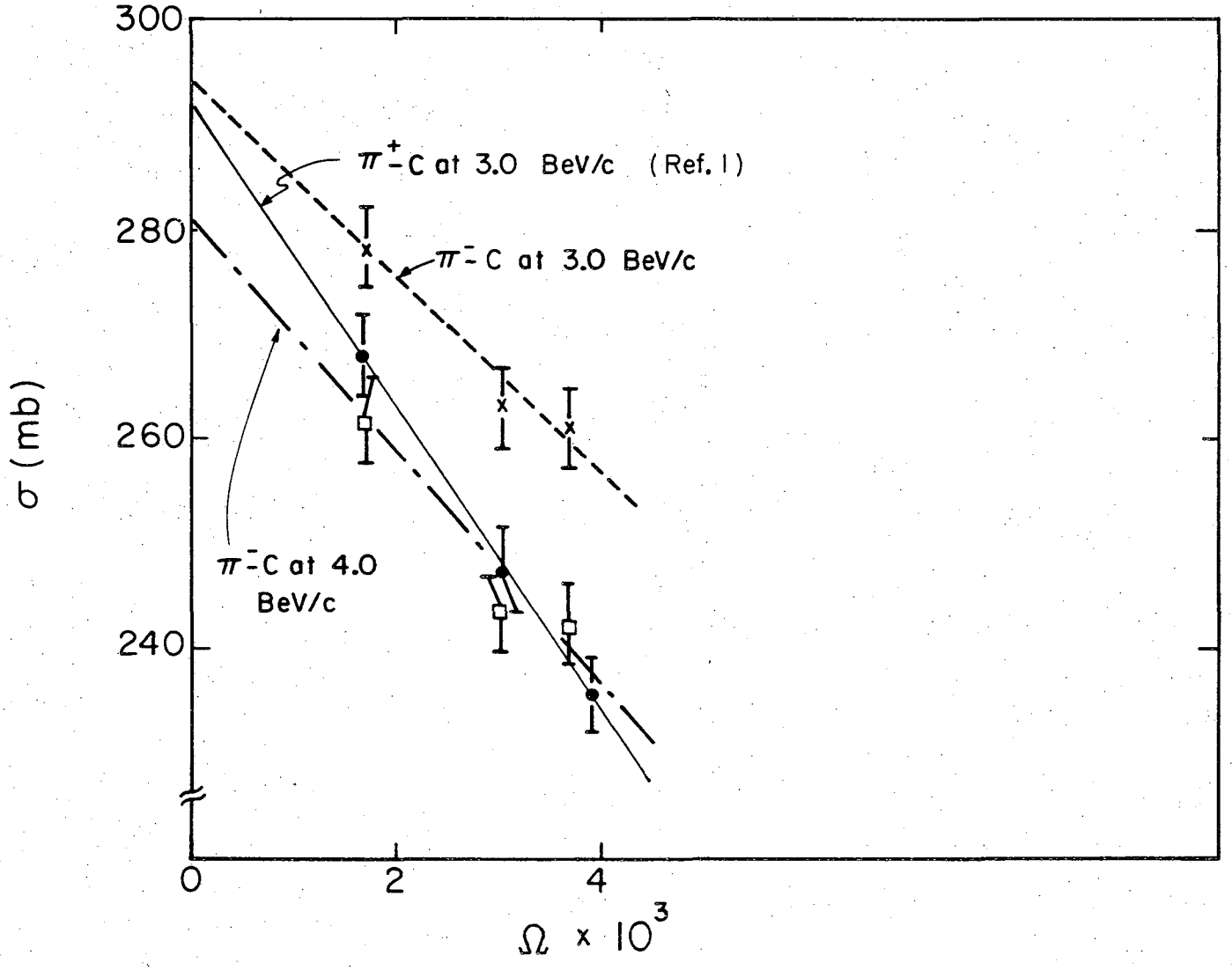


Fig. 3

MU-26725

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.