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A series of counter experiments is being carried out at the Berkeley Bevatron and 184-inch cyclotron to measure total and differential scattering cross sections for pions at energies above the first resonance.[1,2,3] In this letter we report the results of measurements of the total cross section for positive and negative pions on protons in the energy range from 450 Mev to 1650 Mev pion kinetic energy (lab).

The experimental arrangement is shown in Fig. 1. The pions were produced in an internal Pt target, plunged into the circulating proton beam of the Bevatron. The Pt target was located in the field-free tangent tank, allowing us to examine both positive and negative pions with the same experimental setup. Our magnet system consisted of an 8-in.-bore focusing quadrupole doublet, an 18x36-in. bending magnet which deflected the particles through an angle of 23 deg, and a 4-in.-bore focusing quadrupole triplet, used as a field lens. The absorber was a 48-in. target of liquid hydrogen.[4]

The beam incident on the liquid hydrogen target was monitored by coincidence of a set of plastic scintillation counters, M (1.5 and 2 in. in diameter), and a gas Čerenkov counter,[5] for discrimination against protons

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

in the positive beam. In the energy range in which protons of the same momentum had a velocity less than 0.8 c, a liquid nitrogen Čerenkov counter was used in place of the gas counter. The transmission of pions was measured by a set of scintillation counters, S_1 to S_6, in coincidence with the monitor telescope. The scintillation counter, S_0, was placed in coincidence with S_1 to S_6 to reduce the accidental background. Counters S_1 to S_6 subtended different solid angles from the target, ranging from 1.5 to 7.1 millisteradians. The cross section was determined for each of these counters and extrapolated to zero solid angle. Eight transmission measurements were made at each energy, four with the hydrogen target empty and four with it full.

The momentum of the pion beam was determined by deflection through the bending magnet. It was measured by the current-carrying-wire method at four different times, before, during, and after the experiment. The consistency of these measurements was of the order of 1%. The momentum was also measured with a gas Čerenkov counter pressure curve. This gave the same result, but with somewhat less accuracy. The momentum spread determined by the counter telescope and the uncertainty in momentum were both 1.5%.

It was necessary to make several corrections to the data. Several species of accidental counts were monitored continuously during the experiment. These were negligible for negative pions. A fairly significant accidental rate was observed in the monitor telescope for positive pions. This was due to the high flux of protons in the beam, and can be corrected for with the known proton-proton cross section.

The beam is also contaminated by muons from π decay, and by electrons. The muon contamination originates from two regions: before the bending magnet, and after it. The contribution from pion decays before the bending magnet was measured directly by means of a gas Čerenkov counter pressure curve. An exact calculation of this contribution is difficult, and we were forced to make some simplifying approximations. The measured contamination agreed very well with the approximate calculations. The contribution from decays after the bending magnet was not measurable by the pressure-curve method, but it is calculable in a simple straightforward manner. The total muon contamination varied from $2.5 \pm 1.0\%$ at 1650 Mev to $9.5 \pm 1.0\%$ at 450 Mev. The electron contamination was also measured by the pressure curves, and it was estimated to be less than 1%.

The effect of Coulomb scattering in the hydrogen target was taken into account in the extrapolation of the cross section to zero solid angle. At higher energies, the effect was negligible at all solid angles; at lower energies, the smaller solid angles were affected. Where necessary, the cross sections were corrected by a method similar to that of Sternheimer.[6]

The number of counts taken in each measurement gave a statistical uncertainty of 1% or less in the cross section at each solid angle. The fluctuations in the series of eight transmission measurements for each particular cross section were consistent with this. The errors on the points in Fig. 2 include the systematic errors due to muon, Coulomb, and accidentals corrections in addition to counting statistics.

The total cross sections for positive and negative pions on protons are shown in Fig. 2. Our results show peaks in the π^- cross section at 600 ± 15 Mev and at 900 ± 15 Mev. These are somewhat lower energies than indicated earlier by MIT experiment,[7] but they are in substantial agreement, within statistics, with the measurements of the group at Saclay,[8] which are also plotted in Fig. 2. The existence of a maximum in the π^+ cross section was indicated earlier by an experiment at Brookhaven.[9] Our results, in this and in a previously reported experiment,[2] confirm its existence and show it to be centered about 1350 Mev.

We wish to acknowledge our indebtedness to Professors Burton J. Moyer and A. C. Helmholz for their constant help and encouragement; to Michael Longo and John Atkinson for their valuable aid in all phases of the experiment, and to the Bevatron staff and crew.

1. Victor Perez-Mendez, Bull. Am. Phys. Soc. 8, 451 (1959).

2. Longo, Helland, Hess, Moyer, and Perez-Mendez, Phys. Rev. Letters 3, 568 (1959).

3. Goodwin, Kenney, and Perez-Mendez, Phys. Rev. Letters 3, 522 (1959).

4. Duane B. Newhart, Victor Perez-Mendez, and William H. Pope, Liquid Hydrogen Target, Lawrence Radiation Laboratory Report UCRL-8857, Aug. 1959. (unpublished).

5. John H. Atkinson and Victor Perez-Mendez, Rev. Sci. Instr. 30, 865 (1959).

6. R. M. Sternheimer, Rev. Sci. Instr. 25, 1070 (1954).

7. Burrowes, Caldwell, Frisch, Hill, Ritson, Schluter, and Wahlig, Phys. Rev. Letters 2, 119 (1959).

8. Brisson, Detoef, Falk-Vairant, van Rossum, Valladas, and Yuan, Phys. Rev. Letters 3, 561 (1959).

9. Cool, Piccioni, and Clark, Phys. Rev. 103, 1082 (1956).

FIGURE LEGENDS

Fig. 1. Experimental arrangement.

Fig. 2. Total $\pi^{\pm}$ + p cross sections vs. pion kinetic energy.

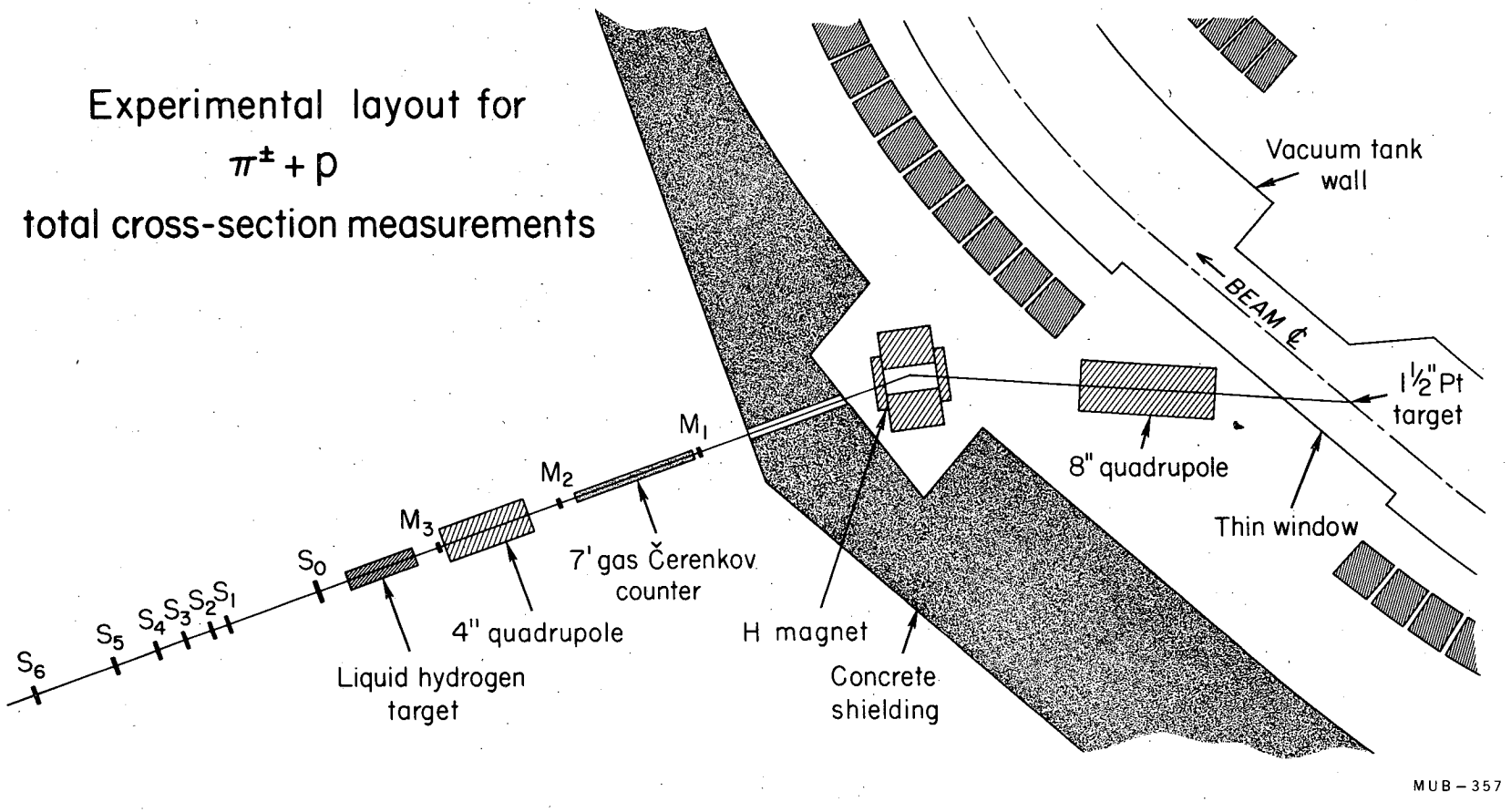
Experimental layout for
$\pi^{\pm} + p$
total cross-section measurements
Vacuum tank wall
BEAM ℄
1½" Pt target
8" quadrupole
Thin window
M1
M2
M3
S0
S1
S2
S3
S4
S5
S6
7' gas Čerenkov counter
4" quadrupole
H magnet
Liquid hydrogen target
Concrete shielding
MUB – 357

Fig. 1

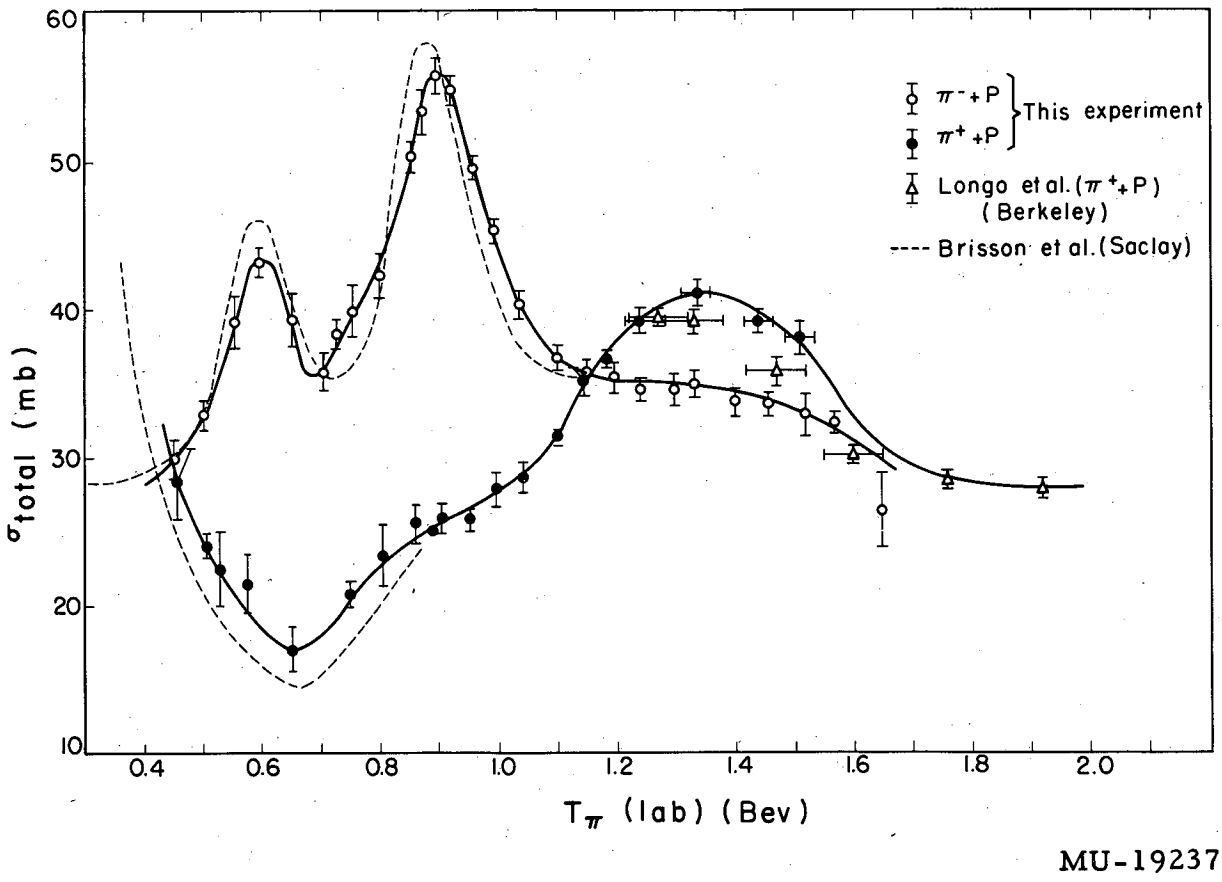
60
50
40
30
20
10
0.4
0.6
0.8
1.0
1.2
1.4
1.6
1.8
2.0
σtotal (mb)
Tπ (lab) (Bev)
π⁻+P
π⁺+P
This experiment
Longo et al. (π⁺+P)
(Berkeley)
---- Brisson et al. (Saclay)
MU-19237

Fig. 2