Title

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May 9, 1950

Berkeley, California

MESONS PRODUCED IN PROTON-PROTON COLLISIONS

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Radiation Laboratory, University of California, Berkeley, California

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A fundamental problem in the study of mesons is the production of mesons in the collisions of protons with free protons, since the analysis is unhindered by considerations of the internal dynamics of complexed nuclei. Such an experiment can be performed using a subtraction technique employing C and CH_2[1], or a pure hydrogen target may be used to study the production directly. We have chosen to construct a liquid hydrogen target and have studied the meson energy distribution at various angles with respect to an incident beam of 345 Mev protons from the Berkeley 184-inch cyclotron.

Since the threshold for meson production in proton-proton collisions is very high (292 Mev in the lab. system) the maximum kinetic energy available to the meson in the center of mass system is only about 25 Mev (for 345 Mev protons incident). Such a meson will have a velocity only slightly greater than the center of mass velocity, and hence the meson flux may be expected to be emitted in a predominantly forward direction in the laboratory system. Furthermore, the upper limit of meson energy decreases rapidly with angle, from 74 Mev at 0° to 7 Mev at 90°. Consequently we have looked at 15° and 30° to the incident beam; the data obtained to date at 30° is reported here.

Fig. 1 shows the geometry of the earlier experiments in which a line source of liquid hydrogen was used to eliminate end window effects. Copper

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[1] Cartwright, Richman, Whitehead, and Wilcox, Phys. Rev. (to be published).

collimators serve to shield the photographic plate detectors from excessive background and also serve to define the observation angle and effective target thickness. Ilford C-2 100 micron plates imbedded in copper absorbers at an angle to the meson flux sample the volume dinsity of mesons stopping at various ranges in the copper. In this manner a complete energy spectrum may be obtained in one plate, eliminating many relative errors possible in taking energy points separately. The incident proton beam passes through an argon ion chamber before striking the target, so that absolute values of the differential cross section may be determined.

Fig. 2 shows the energy spectrum of positive mesons at 30°, based upon 115 π-μ decays observed in one plate exposed using the line source geometry. The most striking feature of this distribution, apparent despite poor statistics, is the concentration of mesons near the upper energy limit. This sharp peak is not predicted by any of the usual meson theories[2] if one assumes that the final proton and neutron do not interact (Born approximation). However, as was first pointed out by Barkas[3] and Chew[4], it is not only possible but also likely that the final nucleons will either interact strongly or even unite to form a real deuteron. In the latter case the reaction becomes a two-body problem, and one would expect a "line" of mesons of a single energy situated about 4 Mev (at 30° observation angle) beyond the continuous spectrum. It is not possible to confirm or deny the existence of this line on the basis of the data in Fig. 2, due to poor statistics and insufficient energy resolution. However, the calculated limits and line positions are shown for the range of angles included.

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[2] K. Brueckner, private communication.
[3] W. Barkas, Phys. Rev. 75, 1109(L), (1949).
[4] G. Chew, private communication.

Since the exclusion principle limits the possible states of the initial proton-proton system, proof of the existence of deuterons in this reaction would impose definite restrictions on the type of meson-nucleon interactions which could be assumed. Therefore, it is of interest to try to improve both statistics and energy resolution in an effort to resolve the line, if it exists, from the continuous distribution. The magnitude of the peak cross section and the lack of negative mesons in the line-source experiments have encouraged us to use a thin-walled (.002 in.) aluminum cylinder of 1-1/2 in. diameter as a "point" source of liquid hydrogen in order to improve the angular resolution. In addition the use of a bending magnet to sort the positive mesons from elastically scattered protons has improved the meson-to-background ratio in the plates by a factor of about 500, with subsequent improved counting rate. Recent data based on 315 π-μ decays obtained in this manner confirm the shape of the peak shown in Fig. 1 but still give no definite indication of fine structure. The estimated energy resolution for this run, however, was only about $\pm$ 4 Mev. Further improvements in the energy resolution of the detection arrangement are being made. The best resolution will be determined by the energy spread of the incident proton beam, which is estimated to have a total spread of less than 4 Mev.

Miss Dora Sherman and Mr. Edwin Iloff have assisted in scanning the plates. This work was sponsored by the AEC.

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Information Division

Figure Captions

Fig. 1 Geometry of the line source of liquid hydrogen. Photographic plates imbedded in copper absorbers at 15°, 30° and 60°.

Fig. 2 Energy spectrum of positive π-mesons from 335 Mev protons on liquid hydrogen. Observation angle $30^{\circ} \pm 3^{\circ}$.

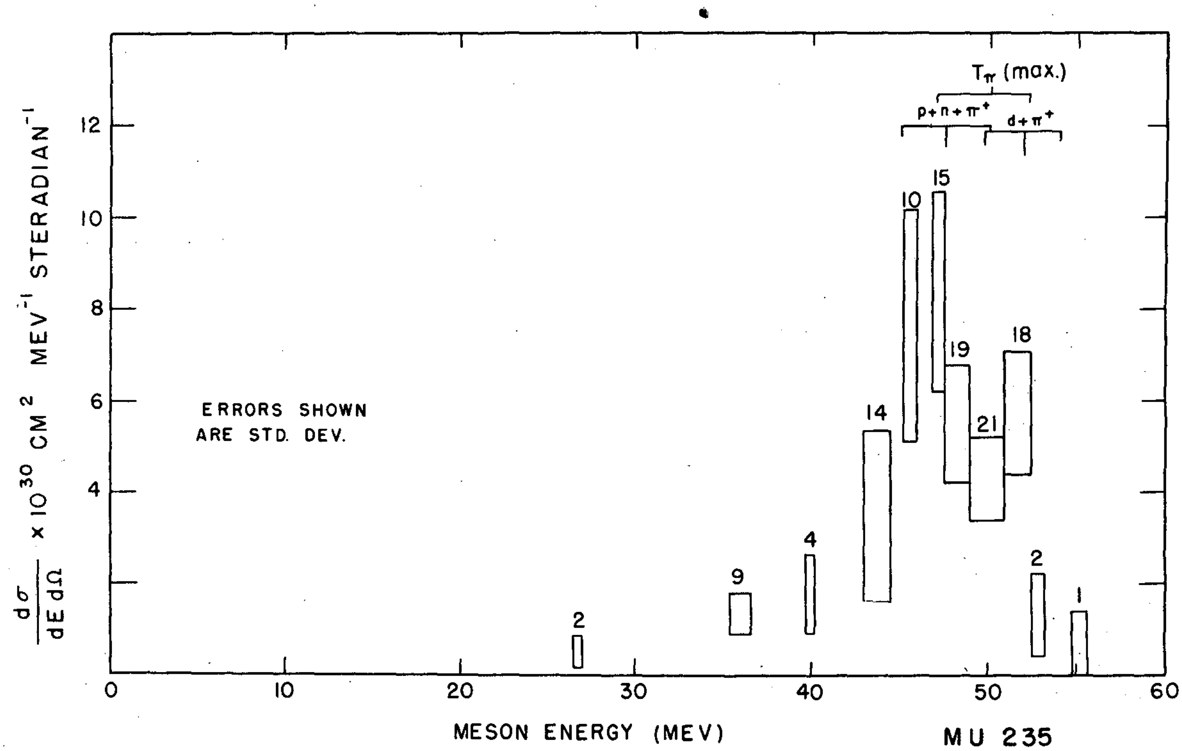
T_π (max.)
$p+n+\pi^+$
$d+\pi^+$
$\frac{d\sigma}{dE\,d\Omega}$ x 10^{30} CM^2 MEV^{-1} STERADIAN^{-1}
ERRORS SHOWN
ARE STD. DEV.
2
9
4
14
10
15
19
21
18
2
1
12
10
8
6
4
0
10
20
30
40
50
60
MESON ENERGY (MEV)
MU 235

Fig. 2

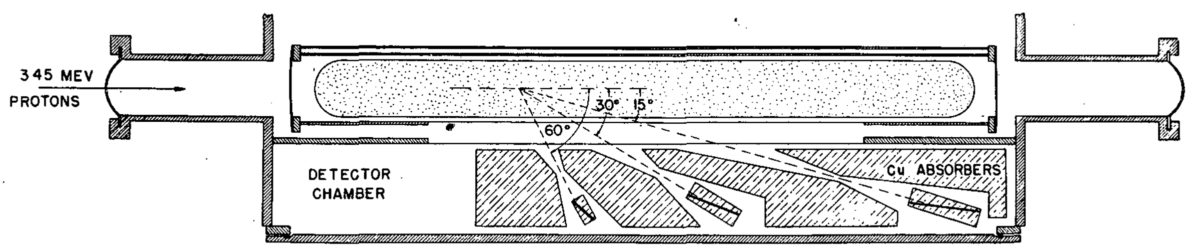
345 MEV
PROTONS
30°
15°
60°
DETECTOR
CHAMBER
Cu ABSORBERS
MU 234

Fig. 1