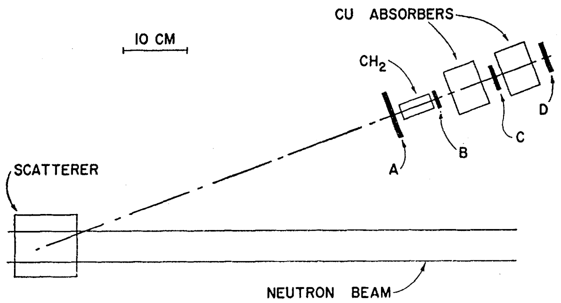

FIG. 1. Plan of neutron beam and detector for small-angle n-p scattering.

cm crystal (C); a second (variable) Cu absorber; and a $5\times10\times\frac{1}{2}$ cm crystal (D). Charged particles produced in the converter were counted by B, C, D in coincidence ($\tau=10^{-8}$ sec). The copper absorber between C and D was adjusted at every angle to the thickness necessary to impose a 365-Mev low-energy cutoff on the primary neutron beam.

At each angle the efficiency of the detector compared with that at 18.5° was computed with the aid of (a) high-energy n-p data,[1–3] (b) the efficiency *vs* proton energy measured for the telescope $B-C-D$ arranged in a sequence similar (but not identical) to that used here. Experimental confirmation of the calculated efficiencies was obtained by comparing the cm scattering from 40°–60° with the previous measurement obtained with a recoil proton telescope. (Column D of Table I).

The results with statistical standard deviations from counting are listed in Table I. Here the observed scattered-neutron counting rates (corrected for detector efficiency) have been transformed into the center-of-mass system and normalized to 1.00 at 40°.

Figure 2 and Table II show all our n-p results, extrapolated to 0° as shown and normalized to a total cross section of 33 mb.[4] The slow angular dependence of the cross section for small θ and its rapid variation near 180° are in qualitative agreement with the cloud-

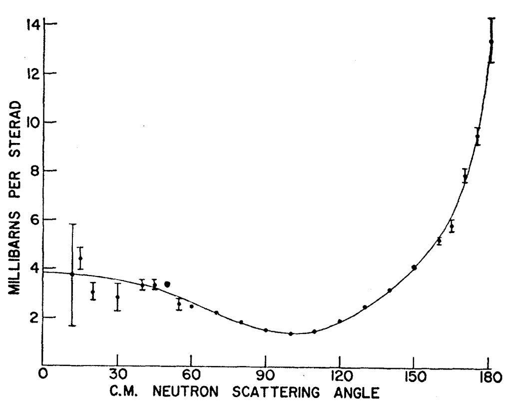

FIG. 2. Differential scattering cross section for 400-Mev neutrons on protons.

TABLE II. Absolute differential n-p scattering cross sections at 400 Mev. Errors are standard deviations computed for all known sources except the uncertainty in the total cross section (33 mb).

C.m. angle θ	$d\sigma/d\Omega$ (mb/sterad)	C.m. angle θ	$d\sigma/d\Omega$ (mb/sterad)
12.7	3.73 ± 2.10	100	1.42 ± 0.06
15	4.43 ± 0.46	110	1.50 ± 0.08
20	3.07 ± 0.37	120	1.94 ± 0.08
30	2.84 ± 0.57	130	2.50 ± 0.09
40	3.33 ± 0.20	140	3.21 ± 0.09
45	3.35 ± 0.20	150	4.17 ± 0.11
50	3.38 ± 0.12	160	5.25 ± 0.14
55	2.56 ± 0.23	165	5.82 ± 0.22
60	2.48 ± 0.08	170	7.93 ± 0.28
70	2.22 ± 0.09	175	9.57 ± 0.34
80	1.85 ± 0.06	180	13.49 ± 0.91
90	1.54 ± 0.06		

chamber work at 300 Mev,[3] but indicate a change from the symmetry about 90° observed at 90 Mev.[5]

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† Fulbright Fellow (1953–1954).

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Negative-to-Positive Ratio of Photomesons from Deuterium*

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PREVIOUS measurements of the yields of positive and negative pions from the interaction of photons with deuterium indicated that the negative-to-positive ratio is about one for photon energies up to 300 Mev.[1] The ratio has now been measured for mesons of various energies and angles produced by the 500-Mev bremsstrahlung of the Caltech synchrotron.

The magnetic spectrometer used earlier in this laboratory for the detection of positive mesons from hydrogen[2] has been employed in this experiment to select particles of a particular momentum, angle, and sign of charge produced in a high pressure deuterium target by the photon beam. The total angular aperture in the plane of the beam was 20°, and the momentum interval selected was 10 percent of the center value.

For the angles and momenta of this work, most of the particles counted were mesons. Those electrons transmitted by the magnet at low fields were distinguished from mesons by their smaller energy loss in the counters. High-energy electrons were few except at the forwardmost angle where they contributed in the worst case about 20 percent of the total counting rate. Since positive and negative electrons of high energy are produced in equal number, and since the negative-to-positive ratio for mesons is close to one, the electron contamination contributes a small error in the observed ratio. Corrections have been made for the effect. Protons that were selected by the spectrometer magnet did not have sufficient energy to penetrate the counters used.

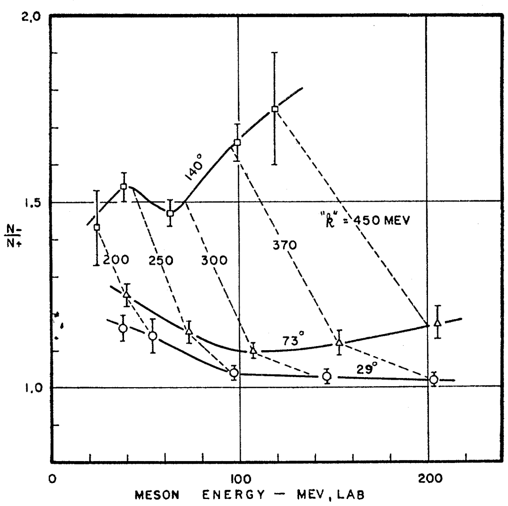

FIG. 1. Ratio of the yields of negative and positive mesons produced in deuterium by 500-Mev bremsstrahlung, plotted against laboratory energy for various laboratory angles. The errors shown are standard deviations due primarily to counting statistics.

The observed counts have been corrected for backgrounds taken without deuterium in the target, for accidental coincidences, and for the effect of 1.4 percent of hydrogen impurity in the target gas. All of the corrections together modify the observed ratios by a few percent, at most.

The decay of the pions in flight smears somewhat the effective momentum resolution of the apparatus. A preliminary estimate of the magnitude of the effect indicates that the distortions in the energy curve amount to less than the statistical errors at any point. More detailed calculations are in progress. Any significant corrections will be made in the final report of this work.

The results for the negative-to-positive ratio, corrected as described, are given in Fig. 1. We plot N_-/N_+, the ratio of the yield of negative mesons to that of positive mesons, against the laboratory energy of the mesons for three laboratory angles. The points which would correspond to the same photon energy "k" if the mesons arose from interactions of photons with free nucleons at rest are connected by broken lines.

The results indicate that the photoproduction of mesons is greater from neutrons than from protons, particularly at backward angles. The qualitative features of the result are predicted by pseudoscalar meson theory in weak-coupling (as well as by other theories).[3] The numerical values predicted for the negative-to-positive ratio are, however, considerably larger than those reported here. The experimental values are, on the other hand, larger than would be expected from coupling solely through the magnetic moments of the nucleons.

The absolute yields observed in these experiments will be included in the final report of this work.

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

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