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SMALL ANGLE NEUTRON-PROTON SCATTERING AT 90 MEV

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February 4, 1954

Berkeley, California

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The relative neutron-proton differential cross section has been measured for several angles near zero degrees. This range of angles has been difficult to investigate because of the very short range of the recoil protons. Previously published work[1-5], done by measurement of proton recoils, has not covered these angles. However, some cloud chamber experiments are currently in progress at this laboratory[6] in which recoil protons are employed in this range.

The neutron beam was obtained by stripping 190 Mev deuterons on a 1/2-in. beryllium target in the 184-inch Berkeley cyclotron. A steel shielding block 6-ft long X 6-in. high X 3-in. thick was placed close to the beam on the same side as the counters to reduce background.

The target was of liquid hydrogen contained in a cylindrical vessel of 5.6-in. diameter with axis vertical. The beam dimensions at the target were 3-in. high X 1-in. wide. A bismuth fission counter was employed as a beam monitor.

Scattered neutrons were counted at small angles to the neutron beam. Fig. 1 shows the neutron counter, which consisted of the following components, listed in the order that they would be traversed by a scattered particle: (a) absorber number 1, 25 g cm^{-2} of copper to prevent protons from reaching the scintillation counters directly; (b) scintillation counter number 1, made of plastic scintillant 4.0 in. X 3.5 in. X 0.080-in. thick; (c) the converter, 1.74 g cm^{-2} of polyethylene; (d) scintillation counter number 2, a liquid counter with active volume 2.2 in. X 1.4 in. X 0.118-in. thick; (e) absorber number 2, which was from 1.0 to 1.6 g cm^{-2} of copper plus a shaped aluminum absorber of maximum thickness 1.8 g cm^{-2}; (f) scintillation counter number 3, made of plastic scintillant 6.6 in. X 4.2 in. X 0.4-in. thick. The distance from the center of the target to the center of the converter was 48 in. for the range of the laboratory scattering angle Θ from 18.5° to 5.0° and 70-in. for the range of 5.0° to 2.5°.

The neutrons actually counted were those that were "converted" in the polyethylene converter or in counter number 2. The term "converted neutron" refers to a neutron that yields a high-energy proton by n-p scattering or nuclear interaction. These recoil protons were counted in coincidence in counters 2 and 3. In order to reject charged particles originating in other processes, counter 1 was connected in anticoincidence. Only events detected in counters 2 and 3 but not 1 were counted.

The thickness of absorber 2 determined the minimum energy which a scattered neutron could have and still be counted. In the present work the minimum energy was adjusted at each scattering angle to be [(80 Mev) $\cos^2\Theta$]. Therefore, a neutron in the beam must have had at least 80 Mev in order to have been counted after scattering, since otherwise the proton yielded at the converter would have had insufficient range to reach counter 3. The shaped portion of absorber number 2 was thickest in the center and was shaped so that to good approximation the minimum neutron energy to count would be independent of the angle with which the recoil proton emerged from the converter. To determine the shape of the absorber we assumed that most of the recoil protons were from n-p scattering processes in the converter. In order to ascertain whether the relative differential cross sections were particularly sensitive to the value of the minimum energy for detection of the scattered neutrons a measurement was made with this minimum energy increased to 66 Mev. The results were in agreement with those obtained for the 60 Mev minimum within the uncertainty of the counting statistics.

The results are tabulated in Table I. Fig. 2 shows the data in their relation to prior work, indicating a marked similarity of the differential cross section in the region of 0° to that in the region of 180°.

Thanks are due to Dr. Martin O. Stern for initial studies of background and design of the neutron collimator.

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[1] Hadley, Kelly, Leith, Segre, Wiegand, and York, Phys. Rev. 75, 351 (1949)

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[3] R. H. Fox, Atomic Energy Commission Report UCRL-867, 1950 (unpublished).

[4] R. Wallace, Phys. Rev. 81, 493 (1951)

[5] Selove, Strauch, and Titus, Phys. Rev. 92, 724 (1953).

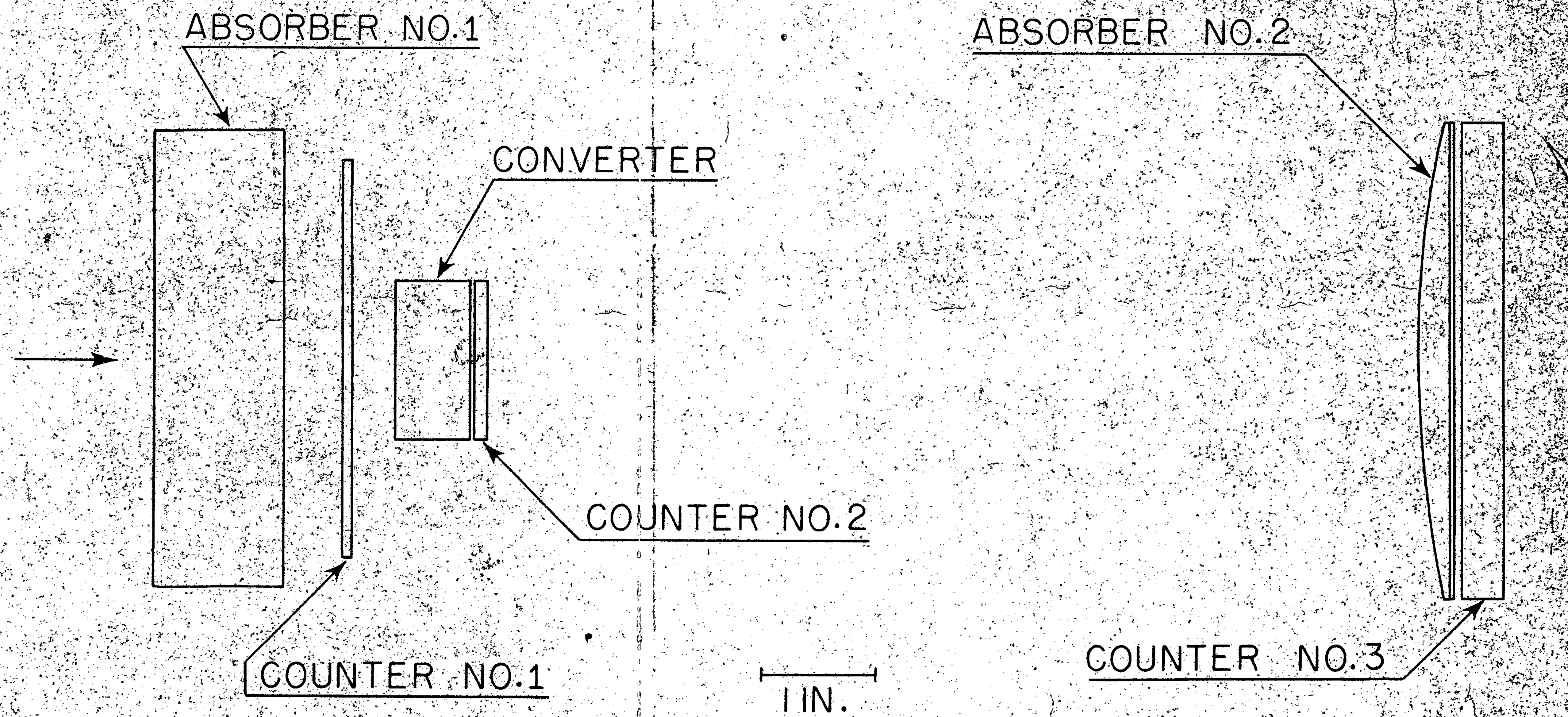
[6] C. Y. Chih and W. M. Powell (private communication).

TABLE I. Experimental data for neutron-proton scattering at 90 Mev. θ is the scattering angle in the center-of-mass system. Column I gives the ratio of the differential cross section in the center-of-mass system at the angle θ to that at 36°. Column II gives the absolute differential cross section obtained by normalizing to the results of Hadley et al (see reference 1). The errors listed are the standard deviations of the counting statistics.

θ	I relative cross section	II absolute cross section (10^{-27} cm^{-2}/steradian)
5.1	1.70 ± .14	12.9 ± 1.2
10.3	1.58 ± .06	12.0 ± 0.7
20.8	1.38 ± .05	10.5 ± 0.6
36.0	1.00	7.6 ± 0.4

FIG. 1. Arrangement of components of neutron counter.

FIG. 2. Differential neutron-proton cross section in the center-of-mass system in 10^{-27} cm^2/steradian.



NEUTRON COUNTER.

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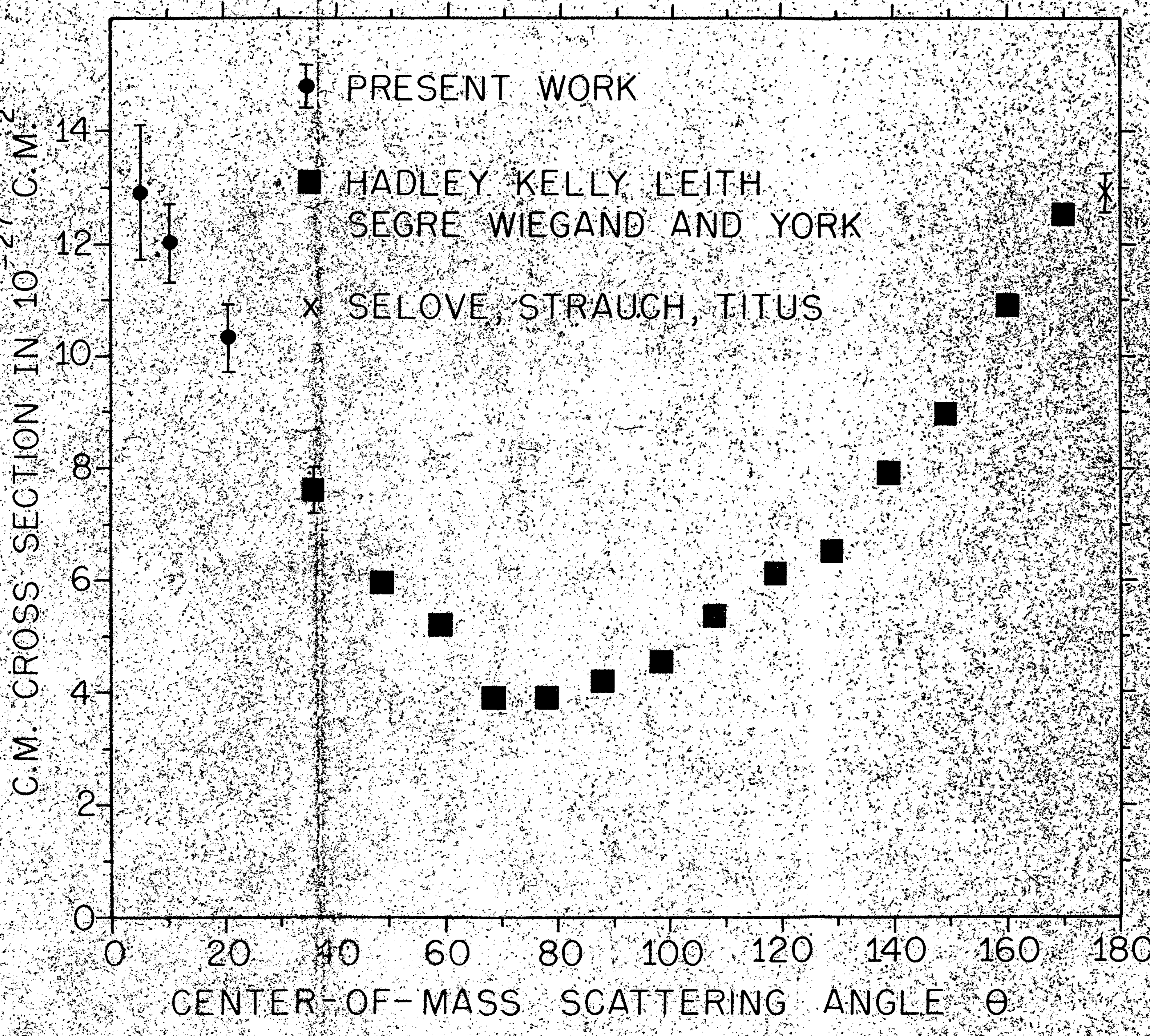
PRESENT WORK
HADLEY KELLY LEITH
SEGRE WIEGAND AND YORK
X SELOVE, STRAUCH, TITUS
C.M. CROSS SECTION IN 10^{-27} C.M.^{2}
0
2
4
6
8
10
12
14
0
20
40
60
80
100
120
140
160
180
CENTER-OF-MASS SCATTERING ANGLE Θ

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