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PROTON-PROTON SCATTERING NEAR 30 Mev

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UNIVERSITY OF CALIFORNIA
Radiation Laboratory

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Proton-Proton Scattering Near 30 Mev

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April 16, 1951

Berkeley, California

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The work reported in an earlier paper¹ has been continued with a few improvements in technique. The entire apparatus was completely overhauled, and mechanical tolerances in the plateholder were carefully checked. The beam collimator was lengthened to a total of 21 inches, and the three graphite diaphragms shown in Fig. 7 of Reference 1 were spaced so that the photographic plates were completely shielded from the 1/16 inch and 3/32 inch diaphragms. The lengthening of the collimator reduced the background of slit scattered tracks, making the observation of low angle tracks in the photographic emulsion more reliable. By using swaths which were less than one inch from the axis of the plate holder it was possible to observe tracks whose scattering angles ranged from 5° to 82° in the laboratory system. Plates from the same photographic emulsion batch were used as in the earlier work.

A set of three runs was made and results of these are reported below. Run 46 was the scattering run. Run 44 was a background run in which the scattering chamber was evacuated, while run 47 was a background run which was in all respects like a scattering run except that a molybdenum tube of 3/4 inch diameter and 0.030 inch wall thickness was inserted axially in the scattering chamber so as to completely surround the beam and thus prevent scattered protons from reaching the plates. Tracks observed in the photo-

* Now with North American Aviation, Inc.

¹ Phys. Rev. 79, 57 (1950).

graphic plates for this run must be due to knock-on protons produced by neutrons in the hydrogen or in the material of the plate holder. The conditions prevailing during each run are summarized in Table I.

The criteria for reading tracks were the same as described in Section III-B of Reference 1. Each swath was 2.300 inches long and 127 ± 0.5 microns wide. The tracks were counted by Mr. R. C. Terzian, to whom the author is greatly indebted, and over half of the counts were checked by the author to determine the reliability of the counting. In order to speed the gathering of data in the region of small scattering angles, it was decided to try counting only tracks whose scattering angles were in the intervals 5° to 26° and 64° to 82° in the laboratory system. However, after twelve swaths had been counted in this manner, it was decided that the increase in speed was too small to justify the decrease in the reliability of counting tracks, so the method was abandoned. This accounts for the low number of tracks shown in Table I for the angular interval from 26° to 64° . All 1129 of the tracks counted in this manner were checked by the author, as were half of the swaths in which all of the tracks were counted. Since the number of tracks missed by Mr. Terzian amounted to only 1.5 percent, it was assumed in the cross section calculation that no tracks were missed on swaths which were counted by both observers. The number of tracks missed by Mr. Terzian on twelve swaths is given in column 3 of Table II. Column 4 is included to show that the two observers disagreed on only 0.56 percent of the tracks checked.

In order to enable the reader to visualize the types of all tracks on the plates a random swath $1/2$ inch long was scanned on each of the six plates of run 46. Of a total of 689 tracks of all kinds observed, 360 were judged to represent bona fide scattered protons, 320 were obviously no good and 9 were spurious tracks which although appearing good failed to conform to all four of the criteria for good tracks.

As was shown in Reference 1, the number of scattered protons should be symmetric about 45° in the laboratory system. Data in column 2 of Table II show that this is so, particularly at low scattering angles. While the data near 45° do not show as good symmetry as one might hope, it is felt that the lack of symmetry is not serious and is accounted for statistically.

The primary energy was determined by the method described in Reference 1. The range and scattering angle was measured for 202 tracks and a plot made from which the mean range at 45° was found to be 1120 ± 4.3 microns. This corresponds to an energy of 30.14 ± 0.08 Mev before scattering.

The cross sections were calculated by reflecting the raw data about 45° in the laboratory system and then applying Equation 20 of Reference 1 to each angular interval. This was done for each pair of swaths and the results averaged to give the uncorrected cross section. Corrections for background and number of tracks missed were then applied, giving the final results which are plotted in Fig. 1. The relative probable errors which are shown in Fig. 1 were obtained from the counting statistics. The probable error of the absolute cross section was found in the manner described in Reference 1 to be 2.68 percent. The error due to lack of beam centering in the scattering chamber was found to be less than 0.2 percent. This correction was not applied to the cross section.

As can be seen from Fig. 1, these results do not conflict with the results reported earlier.^{1,2} The high cross section at low angles which was not investigated in the earlier work is in qualitative agreement with expectations.

This work was performed under the auspices of the Atomic Energy Commission.

² Phys. Rev. 79, 71 (1950).

Table I. Summary of Runs

Run No.	Type of Run	Time for Pressure to Reach 10^{-4} mm (sec.)	Temp. ($^{\circ}$ C)	Pressure (mm of Hg)	Charge Collected (Coulombs $\times 10^8$)	Number of Swaths Scanned
44	background	0.6	--	10^{-4}	1.095	8
46	scattering	0.5	19.1	764.1	1.083	36
47	background	0.4	19.1	764.1	1.065	8

Table II. Summary of Data

Angular Interval (θ_{lab})	Total Number of Tracks Counted	Number of Tracks Missed in 12 Swaths by RCT	Number of Tracks on 12 Swaths on which FLF and RCT Disagreed	Number of Tracks in Both Background Runs
5° to 6°	60	2	0	2
6° to 10°	204	7	0	0
10° to 14°	246	4	2	0
14° to 18°	343	5	0	0
18° to 22°	463	5	0	0
22° to 26°	576	2	2	0
26° to 30°	436	2	1	1
30° to 34°	455	0	0	0
34° to 38°	527	2	0	0
38° to 42°	523	1	0	0
42° to 48°	761	0	0	0
48° to 52°	506	2	1	0
52° to 56°	483	1	1	0
56° to 60°	430	0	1	0
60° to 64°	398	0	1	0
64° to 68°	525	1	2	0
68° to 72°	464	0	4	0
72° to 76°	338	1	3	1
76° to 80°	267	2	0	3
80° to 82°	82	14	1	0
Total	8087	51	19	7

Of the 8087 tracks counted, 1129 were on swaths where tracks with scattering angles from 26° to 64° were omitted, 3432 of the remaining were checked by FLF, and 3526 were unchecked.

DATA BASED ON 8087 TRACKS TABULATED FOR RUN 46.
THE PROBABLE ERRORS INDICATED ON THE GRAPH ARE JUST THOSE DUE TO STATISTICS.

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Fig. 1. Scattering cross section.