## Title
Rotation of Polarization Vector and Depolarization in P-P Scattering



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# ROTATION OF POLARIZATION VECTOR AND DEPOLARIZATION IN P-P SCATTERING*

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February 14, 1955

It has been pointed out by Wolfenstein[1] that triple scattering experiments can give information beyond that obtainable with simple double scattering polarization measurements. The difference between these varieties of experiments can be stated as follows: in a typical double scattering experiment a polarized beam is incident on a hydrogen target and the intensities of the scattered protons in various directions are measured, whereas in a triple scattering experiment the change in the state of polarization caused by the scattering on hydrogen is measured.

The two simplest independent cases are those in which the triple scattering experiments are performed as indicated schematically in Figs. 1 and 2. In the configuration represented by Fig. 1 all the scattering processes occur in the same plane and, in an oversimplified schematization, one measures the probability of flipping the spin in the collision occurring at target 2. Targets 1 and 3 act as a polarizer and analyser, respectively. The asymmetry $e_{3n}$ observed after the scattering on target 3 is connected with a coefficient D (for depolarization) defined by Wolfenstein as

$$e_{3n} = P_3 (P_2 + DP_1) / (1 + P_1P_2), \quad (1)$$

where $P_i$ is the polarization generated by scattering an unpolarized beam on target i.

Figure 2 represents the triple scattering experiment in which the second scattering plane is perpendicular to the first. The scattering on target 2 rotates the spin in a complicated way and by analyzing the polarization by scattering on target 3 we find the component of the spin $P_s$ in the direction $n_3$ perpendicular to the plane $\pi'$. The asymmetry after the scattering on target 3 is given by

$$e_{3s} = P_1P_3R \quad (2)$$

which defines R (for Rotation).

* The contents of this letter were presented at the 1954 Winter Meeting of the Am. Phys. Soc. (Berkeley December, 1954)

1 L. Wolfenstein, Phys. Rev. 96, 1654 (1954)

The experiments have been performed using the polarized beam of the 184-inch Berkeley cyclotron and will be described in a later paper. The average energy of the protons incident on target 2 was 310 Mev in the laboratory system and their polarization was 0.74.

Figures 3 and 4 give graphs of D and R as obtained in our measurements. The differential cross section $I_o$, the polarization P, R, and D are connected with the elements of the p-p scattering matrix as indicated by Wolfenstein, loc. cit. (Eq. 3, 5.)

The information obtained from our investigation should be sufficient to determine the phase shifts of the various partial waves up to F waves inclusive. Expressions for the observable quantities in terms of the phase shifts have been obtained by Mr. Henry P. Stapp[2] and the numerical calculation with an electronic computing machine has been initiated.

The two varieties of triple scattering experiments discussed here have in common the property that, (a) the beam incident on the second target is polarized perpendicular to the direction of incidence, and (b) the direction of analysis of the polarization is perpendicular to the scattering direction. Other independent triple scattering experiments would involve auxiliary magnetic fields that would alter in a known fashion the relative orientation of the directions of the beam and of the polarization.

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

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[2] H. P. Stapp, unpublished, UCRL-2825.

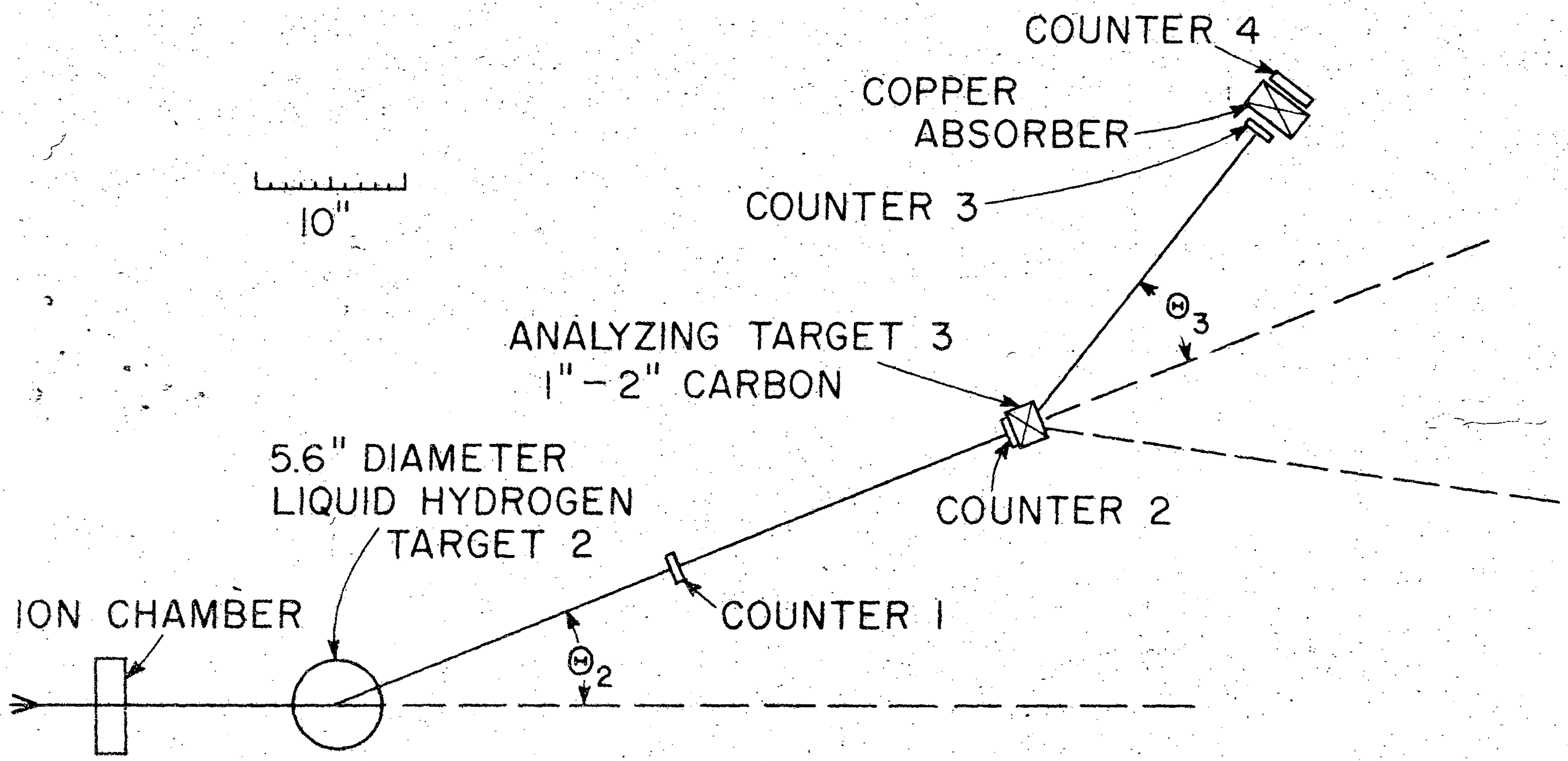
## LEGENDS

Fig. 1 Scale drawing of targets and counters for measurement of the depolarization parameter D. Target 1, a beryllium target inside the cyclotron, is not shown in this figure.

Fig. 2 Perspective drawing showing the orientations of the successive scattering planes in the triple scattering experiment to measure the rotation parameter R. The positions of targets 1, 2, and 3 are indicated by spheres 1, 2, and 3. The plane of scattering at target 2 (indicated $\pi'$) is perpendicular to the plane of scattering at target 1 ($\pi$). The plane of scattering at target 3 ($\pi''$) is perpendicular to the plane $\pi'$. The figure is not to scale.

Fig. 3 Depolarization factor D plotted against center-of-mass scattering angle $\theta$ for proton-proton scattering at 310 Mev.

Fig. 4 Rotation factor R plotted against center-of-mass scattering angle $\theta$ for proton-proton scattering at 310 Mev.


COUNTER 4
COPPER
ABSORBER
COUNTER 3
10"
ANALYZING TARGET 3
1" - 2" CARBON
$\Theta_3$
5.6" DIAMETER
LIQUID HYDROGEN
TARGET 2
COUNTER 2
COUNTER 1
ION CHAMBER
$\Theta_2$

22995-1

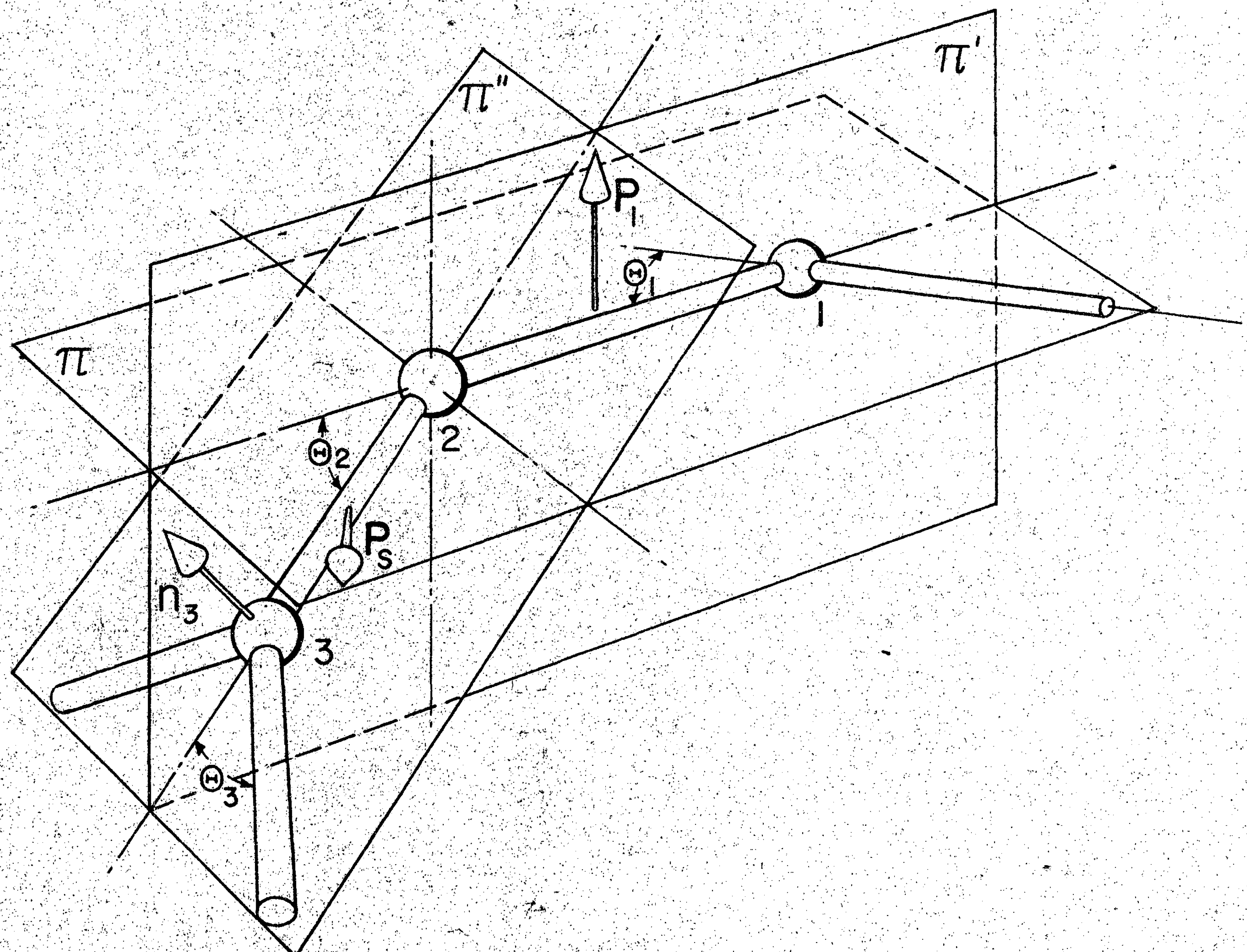
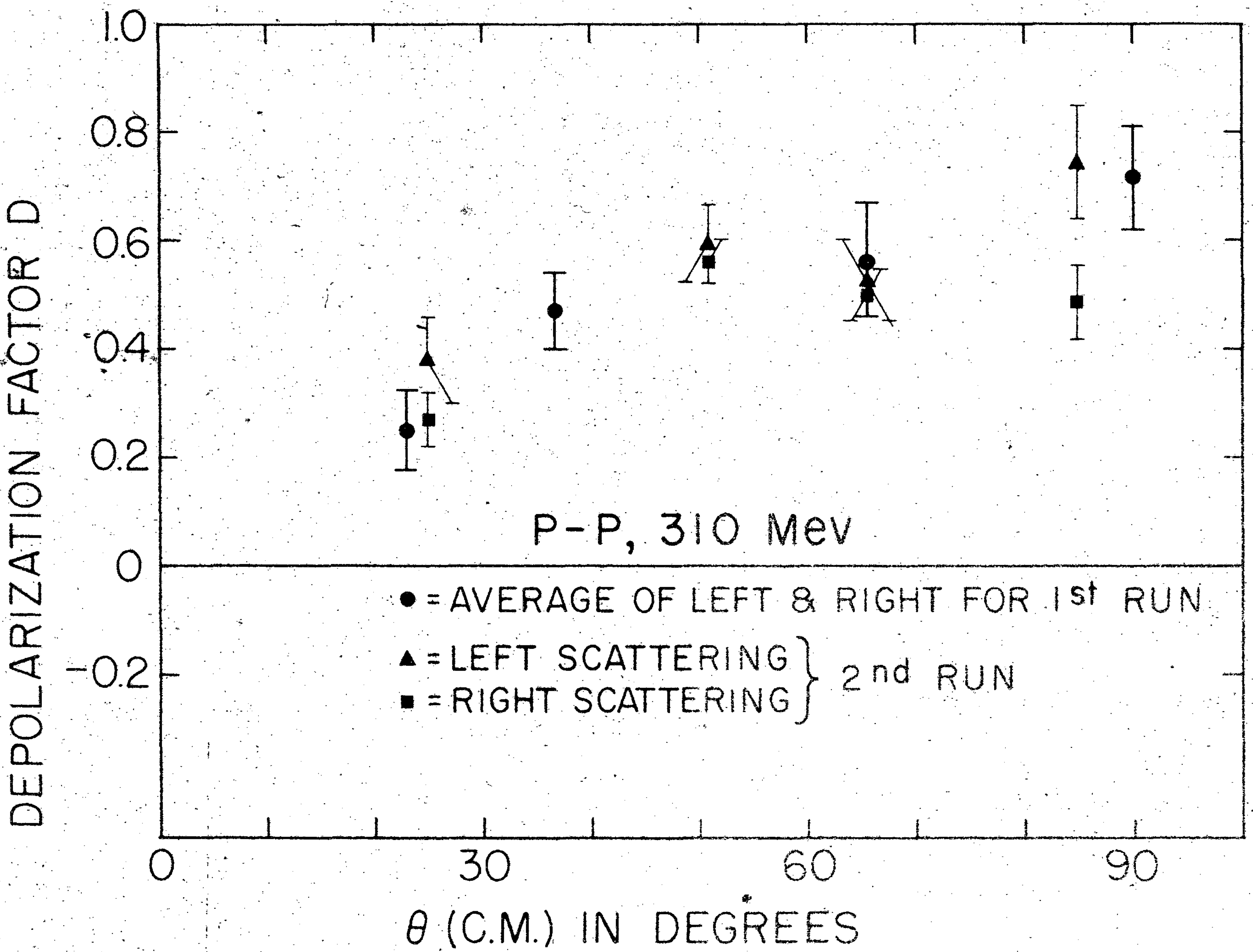



Fig 2



DEPOLARIZATION FACTOR D
1.0
0.8
0.6
0.4
0.2
0
-0.2
0
30
60
90
θ (C.M.) IN DEGREES
P-P, 310 Mev
● = AVERAGE OF LEFT & RIGHT FOR 1st RUN
▲ = LEFT SCATTERING
■ = RIGHT SCATTERING
2nd RUN


22979-1

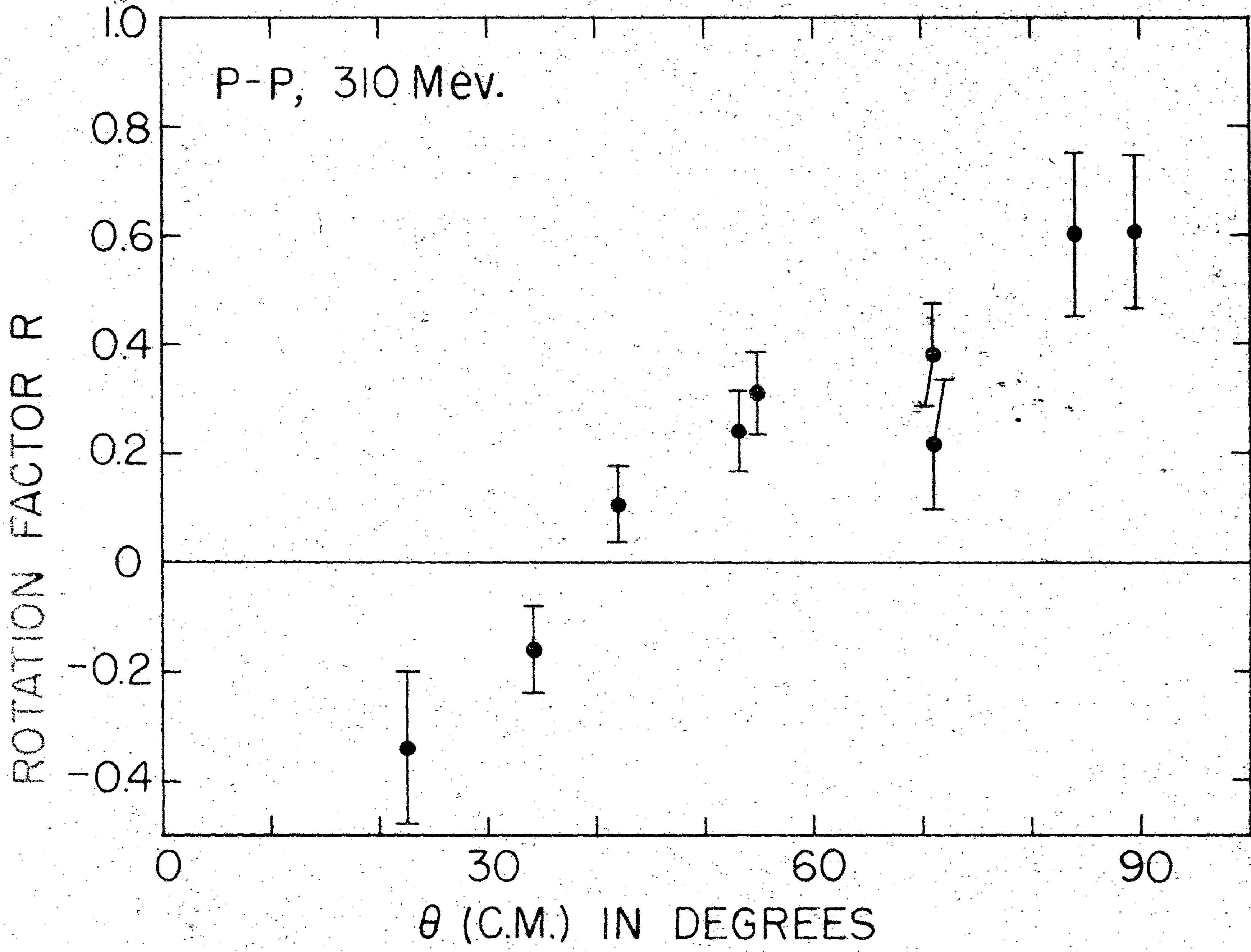

P-P, 310 Mev.
ROTATION FACTOR R
1.0
0.8
0.6
0.4
0.2
0
-0.2
-0.4
0
30
60
90
θ (C.M.) IN DEGREES

Fig 4