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SMALL-ANGLE P-P CROSS SECTIONS AND POLARIZATION AT 300 MEV

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Recent experiments[1] in the energy region 100 to 400 Mev have demonstrated the extreme constancy against energy and angle of the proton-proton differential scattering cross-section. Because of the severe experimental difficulties, however, the angles below 20 degrees center-of-mass, where the nuclear and coulomb terms in the cross-section might reasonable be expected to interfere, have not been thoroughly investigated.

Since the major experimental difficulties in the small-angle region arise mainly from the high background, it is either necessary to take unusual care in the collimation, or to define an allowed trajectory for the beam through counters in coincidence. In this experiment we have chosen the latter method. An accompanying paper[2] describes an experiment using the former method.

By using the 312 Mev polarized proton beam[3] from the Berkeley synchrocyclotron, we have been able to measure simultaneously the differential cross-section and the asymmetry for polarized protons scattering off a liquid hydrogen target. The experimental geometry is shown schematically in Fig. 1. Counter No. 3 is a symmetrical ring, divided into two parts along a vertical diameter parallel to the polarization of the incident beam. Provision is made for rotating this counter about an axis parallel to the incident beam in order to verify that the response of the two counter halves is equal.

The incident beam was monitored by a fast coincidence and scaling system reading the output of the beam defining counters, Nos. 1 and 2. The 1-2 counting rate for all the cross-section data and the bulk of the asymmetry data was held at approximately 800 per second. At this level approximately 3-1/2 percent of the 1-2 counting rate was due to pile-up, i. e. two protons passing through the defining system within one resolving time of the counters.

Protons scattered into the left and right halves of counter No. 3 were counted independently, each in coincidence with counters No. 1 and 2. A typical value of the fraction of protons scattered into one half of the counter by the 2.80 grams per square centimeter of hydrogen in the target was 2×10^{-4}. At each angle, data were taken with the target both full and empty. Part of the target empty data was taken with additional absorber inserted in front of counter No. 3 to simulate the stopping power of the hydrogen in the target. The possibility of low energy contamination of the beam was thus checked. No such contamination was found.

The cross-section was obtained by adding the fractions of the beam scattered by hydrogen into the two halves of counter No. 3 and multiplying this by the appropriate geometrical factors for each angle. The results, with statistical errors only, are shown in Fig. 2. Since the relative accuracy is better than the absolute, the values have been adjusted to give 3.7×10^{-27} cm^2 per steradian at 20 degrees center-of-mass[4]. The approximate angular resolution is indicated for the smaller angles where it is of interest. The solid curve is a rough fit to the data, taking the angular resolutions into account.

The asymmetry was obtained from the formula:

$$e = \left[(f_L - f_R)/(f_L + f_R)\right] (\phi/\sin\phi),$$

where f_L, f_R are the fractions of beam protons scattered into the left and right sides of counter No. 3, respectively, and 2ϕ is the azimuthal angle covered by either half of counter No. 3. Since the beam polarization has been previously measured[3] in elastic scattering experiments, we may calculate directly the polarizations arising from the p-p scattering in this experiment through the relation $P = e/P_B$, where P_B has been taken to be $0.74 + .01$. The results are plotted in Fig. 3 in conjunction with previous p-p polarization data taken at larger angles. The solid curve, a fourier analysis of the previous data, seems still in agreement with the new points at smaller angles.

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

REFERENCES

1. For a more complete list of references than is possible here, see for example, R.M. Thaler and J. Bengston, Phys. Rev. 94, 679 (1954)

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3. O. Chamberlain, E. Segrè, R. Tripp, C. Wiegand, and T. Ypsilantis, ("The Mechanism of Proton Polarization in High Energy Collision", Phys. Rev. - in press).

4. O. Chamberlain, G. Pettengill, E. Segrè, and C. Wiegand, Phys. Rev., 93, 1424 (1954)

5. O. Chamberlain, E. Segrè, R. Tripp, C. Wiegand, and T. Ypsilantis, Phys. Rev., 93, 1430 (1954)

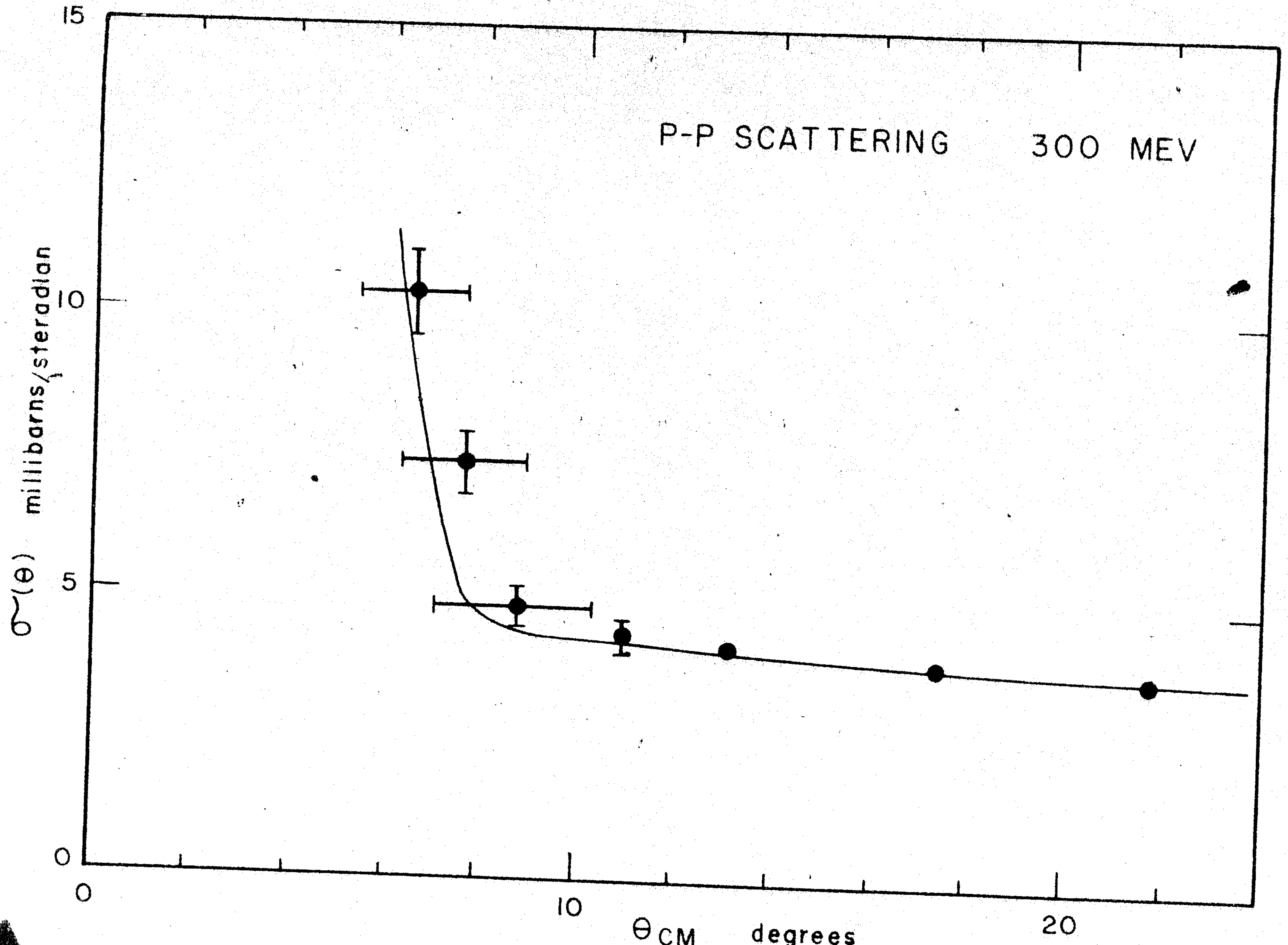
6. O. Chamberlain, R. Donaldson, E. Segrè, R. Tripp, C. Wiegand, and T. Ypsilantis, ("Experiments on Nucleon-Nucleon Scattering with 280 Mev Polarized Protons", Phys. Rev. - in press)

Figure Captions

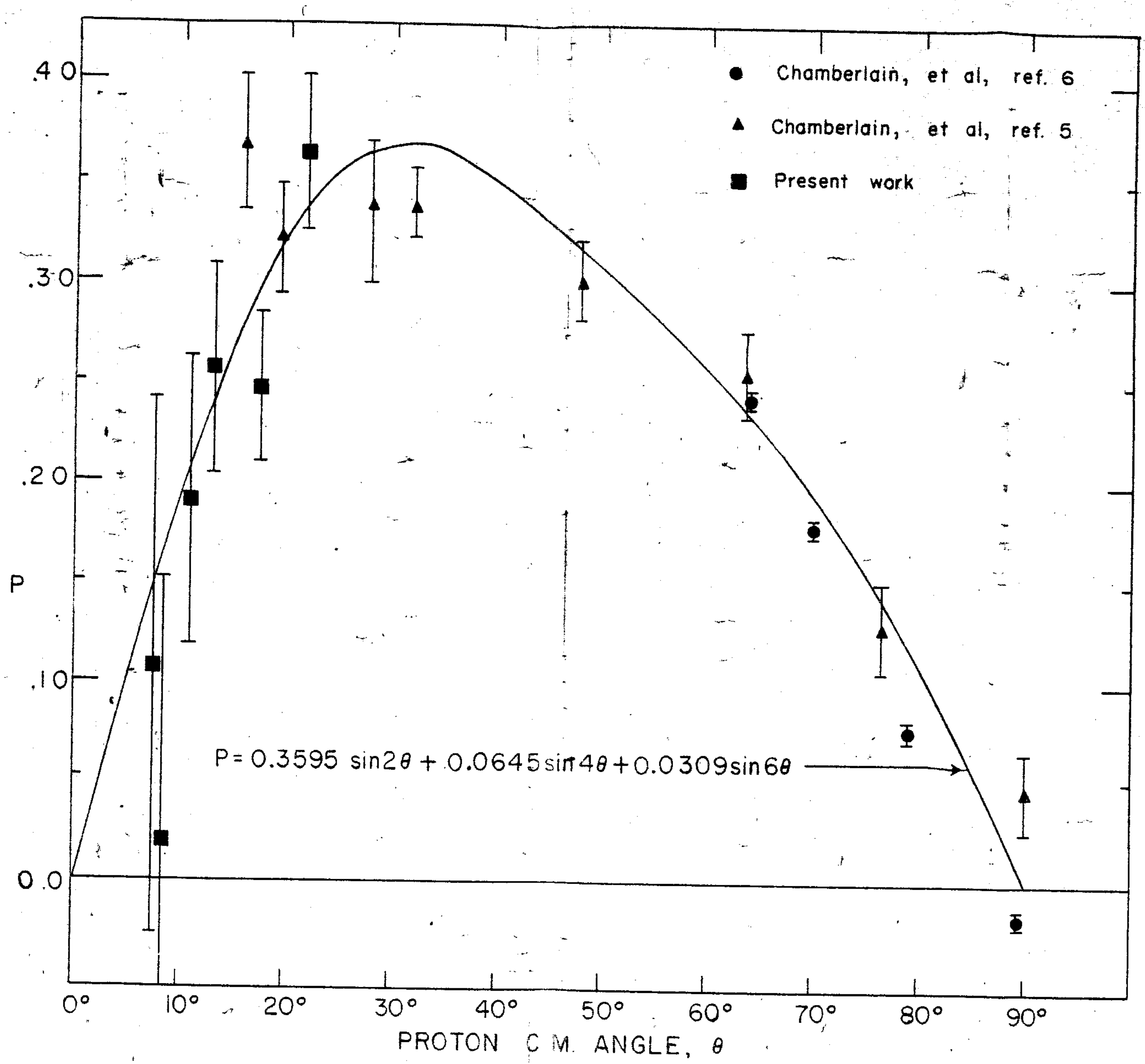
Figure 1: Schematic representation of scattering geometry. Note lateral expansion of scale.

Figure 2: The differential proton-proton scattering cross-section plotted as a function of angle in the center-of-mass system. The solid curve is a visual fit to the data.

Figure 3: Polarization produced by proton-proton scattering at 300 Mev, plotted as a function of center-of-mass scattering angle.


P-P SCATTERING 300 MEV
σ(θ) millibarns/steradian
θ CM degrees
0
5
10
15
0
10
20

MU-7851



Chamberlain, et al, ref. 6
Chamberlain, et al, ref. 5
Present work
.40
.30
.20
.10
0.0
P
P = 0.3595 sin2θ + 0.0645 sin4θ + 0.0309 sin6θ
0°
10°
20°
30°
40°
50°
60°
70°
80°
90°
PROTON C.M. ANGLE, θ

MU-7849