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PROPOSAL FOR AN EXTENSION OF THE $\pi^- p \to \gamma n$ AND $\pi^- p \to \pi^0 n$ CROSS SECTION MEASUREMENTS IN THE REGION OF THE (3,3) RESONANCE

by

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I. Radiative Capture ($\pi^- p \to \gamma n$).

Recently our group has measured the cross section for the reaction $\pi^- p \to \gamma n$ at CM γ angle of about 30° as a function of the incident energy between 100 - 270 MeV (7).

Since the beginning of this experiment, new and more precise data concerning π photoproduction on protons have been obtained, both in Bonn and Orsay. On the basis of these results, theoreticians from Bonn University have performed a model-independent multipole analysis (1) yielding a set of multipoles smoothly changing with the energy and not in contradiction with the π N scattering results; this solution has confirmed the results of the previous theoretical approach of D. Schwela (2) based on dispersion relations. Some of these multipoles, particularly the M_{1-} and M_{1+}, differ appreciably from the previous analysis of Berends, Donnachie and Weaver (BDW) (3).

New results on π^- photoproduction deduced from $\gamma d \to \pi^- pp$ have also been obtained (4) which, contrary to previous bubble-chamber results (5) seem now to agree with the set of multipoles of the Bonn group.

The photoproduction cross sections, deduced by application of detailed balance, from our radiative-capture experiment are in nearly perfect agreement with this theory (cf Fig. 1).

Simultaneously, a Berkeley group (6) has performed measurements similar to ours, but at larger γ angles and at only one incident energy (T_{π^-} = 207 MeV) in the region of the (3,3) resonance. They obtained a nearly isotropic angular distribution, which disagrees both with the experimental results concerning the inverse reaction (4) (γ d) and with the theory (cf Fig. 2).

Indeed, if the Berkeley results are correct, major revisions of basic theoretical hypotheses would be necessary. As discussed by the authors a strong (about 20 %) $\Delta I = 2$ isotensor contribution to the electromagnetic current could explain the particular shape of the angular distribution obtained, while an important violation of time reversal might be required to resolve the discrepancy between their measurements and the γ d experiment (4).

In order to throw more light on these problems we propose to extend our previous measurements to larger angles. First we should like to repeat the Berkeley experiment at T_{π^-} = 207 MeV and at 6 angles between 30° and 90° CM γ angle. Moreover excitation curves at 2 or 3 angles over the range of the (3,3) resonance would be very useful to extend the model-independent multipole analysis and thus strengthen our understanding of the basic problems of pion photoproduction.

The experiment could be performed on the new beam line at the 125 MeV π^- channel with a 35° bending toward Salève, which we have tested. In this area we have enough room to allow a 5 m flight path for the neutron.

We intend to use the same technique as in our previous experiment (7); the ten neutron detectors, which have been calibrated in the energy range from 30 to 150 MeV, will be used simultaneously with the assembly of lead-glass Cerenkov γ detectors. The separation of background from good events will again be based on the angular correlation between neutrons and γ. Due to the longer flight path and the calibration of the neutron detectors at higher energies we shall be able to extend our measurements to the angular range $30 < \theta_\gamma^{CM} < 90°$.

To carry out the full measurement (6 angles of the angular distribution at 207 MeV and excitation curves at 2 fixed angles and 9 incident energies) we shall need 100 shifts, half of which will be main user shifts and the second half of which can be sharing or parasitic shifts.

II. Charge Exchange ($\pi^- p \to \pi^0 n$).

At present our group is engaged in the measurement of the cross section for the reaction $\pi^- p \to \pi^0 n$ in the region of the (3,3) resonance. The neutron-detection technique adopted for these measurements permits us to cover the π^0 CM angles between about 30° and 170°. The recent CERN measurements of Bugg et al. on the total pion-nucleon cross sections indicate a substantial discrepancy between the directly measured $I = \frac{1}{2}$ combination of total cross sections and that deduced from phase shift analyses (Fig. 3). The most probable reason for the discrepancy are electromagnetic corrections (8). Since no reliable theory of these correct-ions exists at the moment, further experimental tests are desirable. One of them (8) is the determination of the forward charge-exchange cross section which can be written, assuming charge independance

$$\frac{d\sigma_{ex}}{d\Omega}(0^\circ) = 2\left\{\left(\mathrm{Re}\ F^-\right)^2 + \left[\frac{k}{8\pi}\left(\sigma_- - \sigma_+\right)\right]^2\right\} \qquad (1)$$

where k is the momentum of the pion and σ_- and σ_+ are the $\pi^- p$ and $\pi^+ p$ total cross sections, respectively. The $\mathrm{Re}\ F^-$ can be expressed in terms of the pion-nucleon coupling constant and dispersion integrals involving high-energy pion-nucleon cross sections. A systematic discrepancy between the left-hand and right-hand sides of expression (1) would present a valuable indication for further theoretical work. In particular, since $\mathrm{Re}\ F^-$ passes through zero around k_{lab} = 270 MeV/c, it would be interesting to determine where exactly this happens according to expression (1), as compared to phase shift analyses.

We propose to extend our charge-exchange measurements to π^0 CM angles smaller than 30°. This can be done using a large Na I (Tl) crystal for the detection of high-energy gamma rays. If necessary, small angles can be reached by magnetic deflection of the incident beam after passing through the target. The relatively high event rate and the geometric compatibility permit to perform this experiment in parallel with the proposed extension of the $\pi^- p \rightarrow \gamma n$ measurements. Of the order of 15 additional parasitic shifts, partly in the proton and partly in the neutron hall, will be required to test and calibrate the crystal. They should be allocated in May and June 1971.

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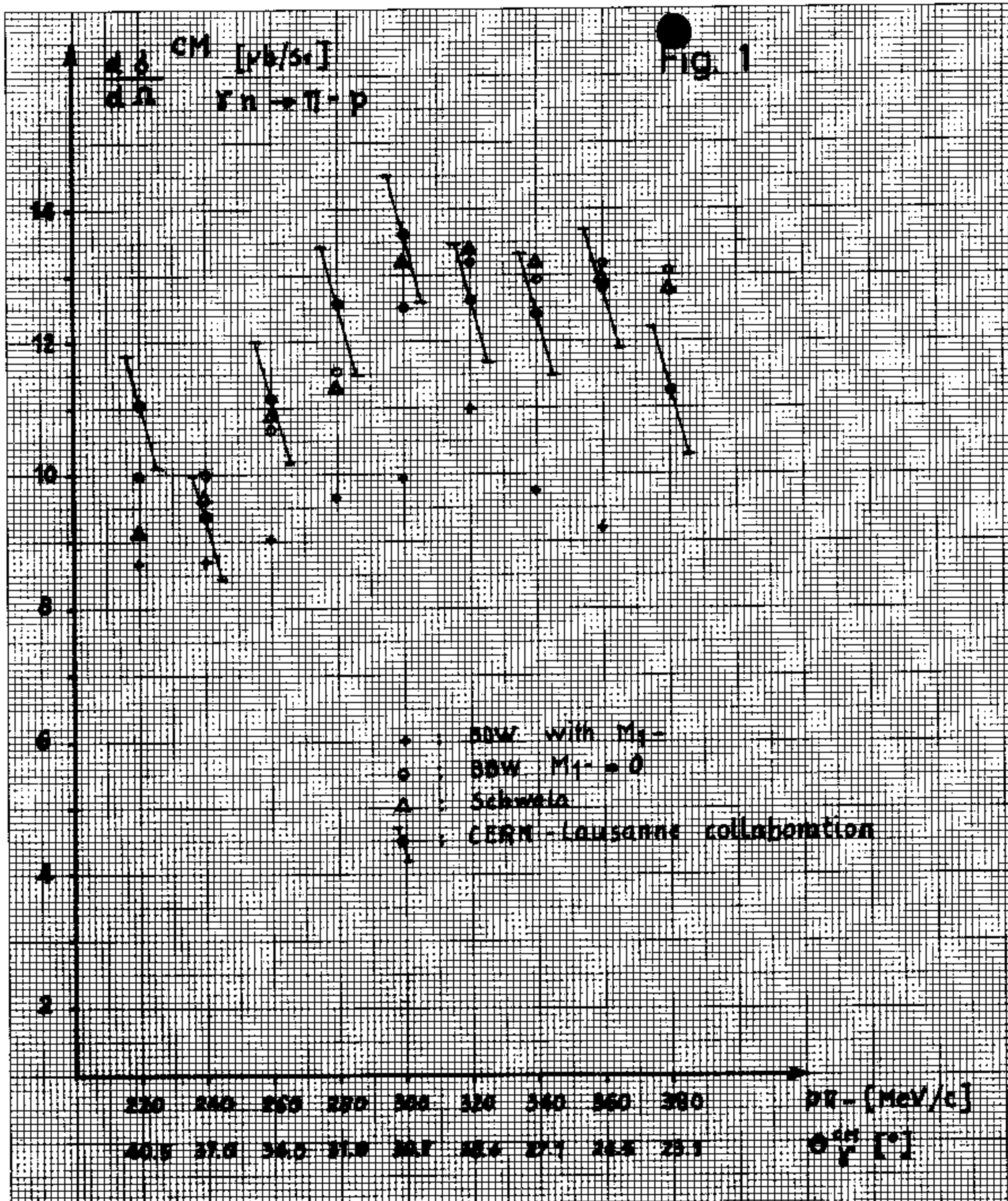

$\frac{d\sigma}{d\Omega}^{CM}$ [μb/sr]
γn → π⁻p
BDW with M1-
BDW M1- = 0
Schwela
CERN - Lausanne collaboration
pπ- [MeV/c]
220 240 260 280 300 320 340 360 380
Θ_γ^{CM} [°]

Fig. 1

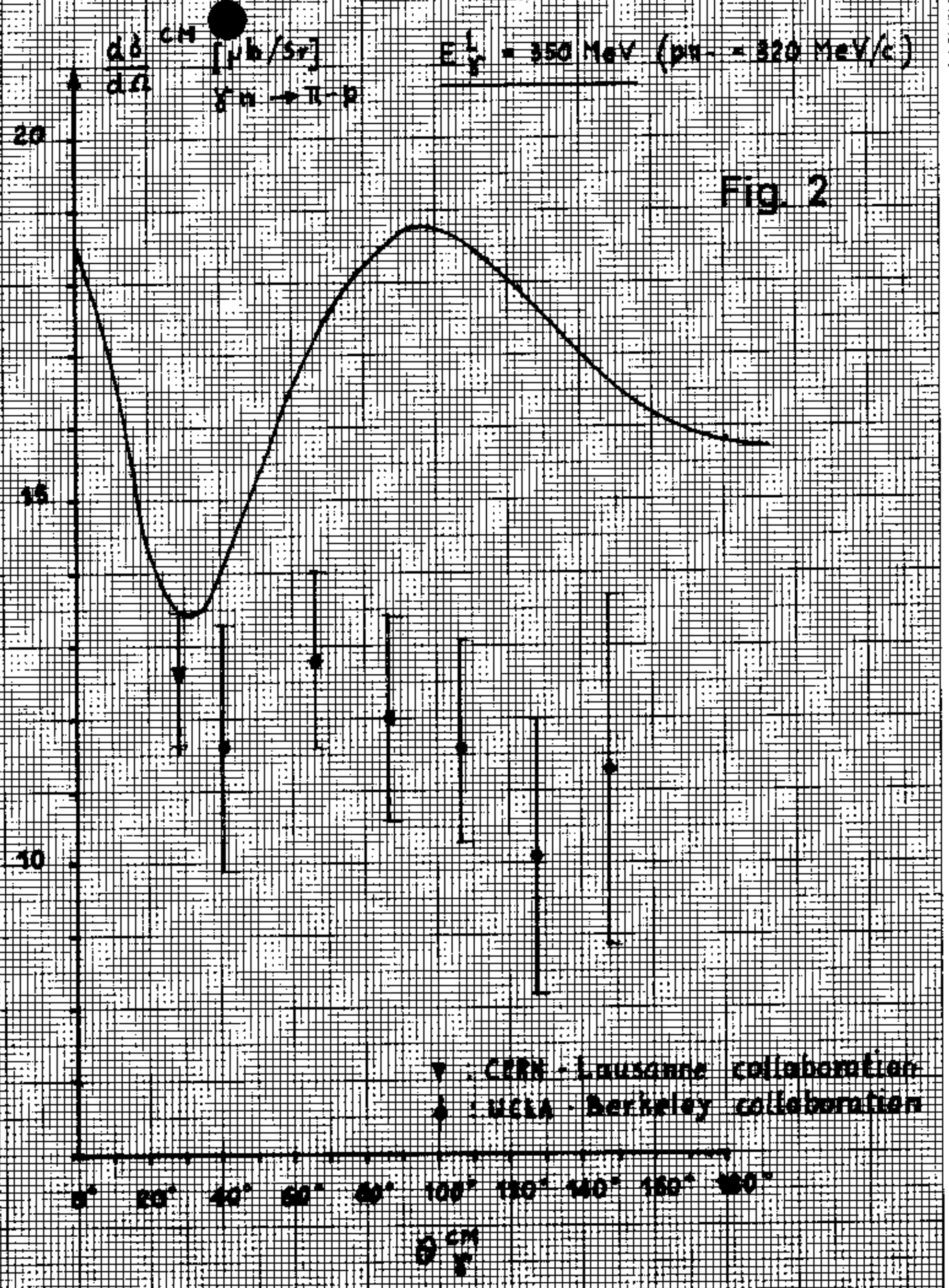
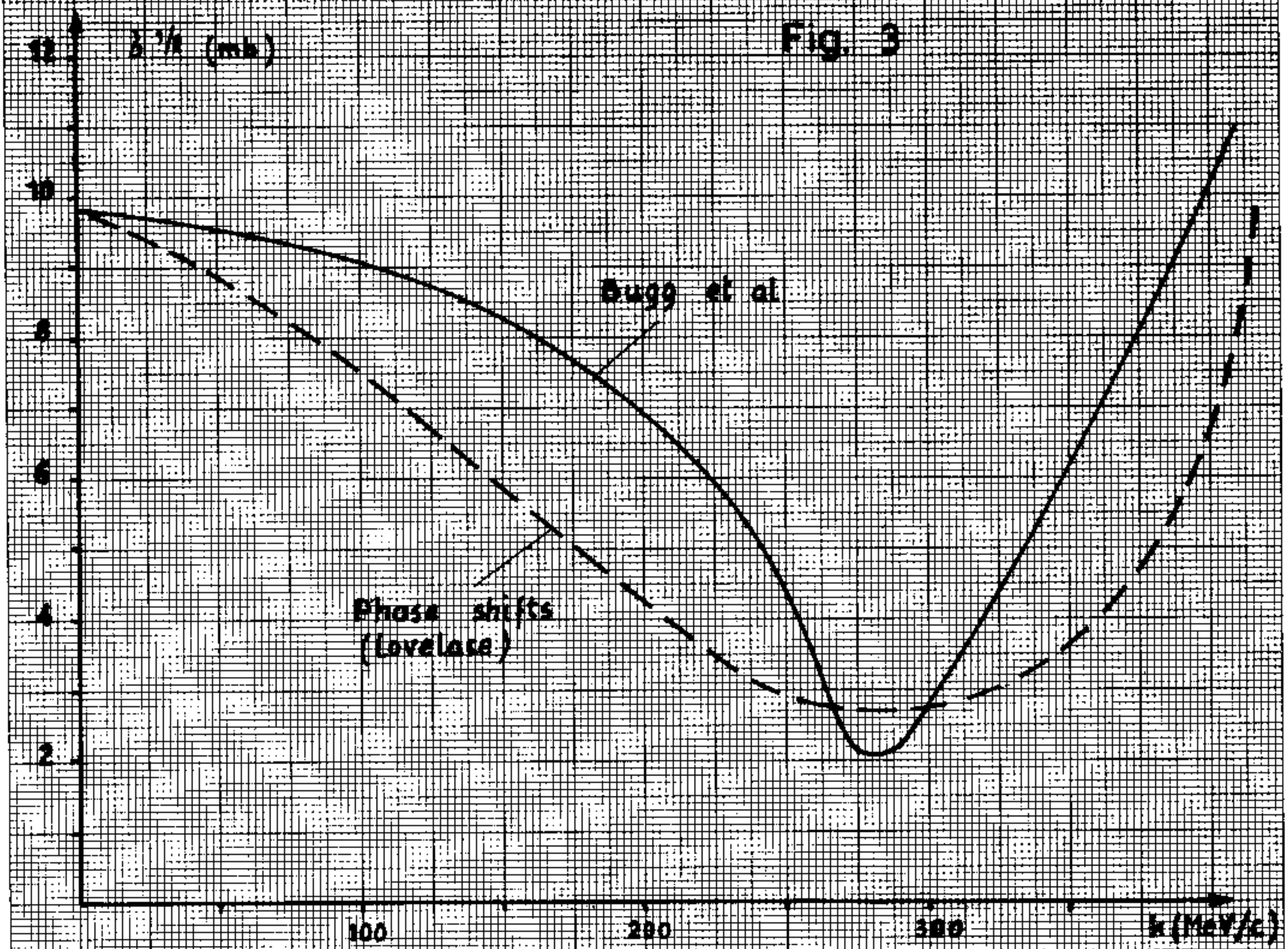

$\frac{d\sigma}{d\Omega}^{CM}$ [μb/sr]
γn → π⁻p
E_γ^L = 350 MeV (pπ- = 320 MeV/c)
CERN - Lausanne collaboration
UCLA - Berkeley collaboration
0° 20° 40° 60° 80° 100° 120° 140° 160° 180°
θ_γ^{CM}

Fig. 2

Fig. 3



σ 1/1 (mb)
12
10
8
6
4
2
100
200
300
k (MeV/c)
Bugg et al.
Phase shifts
(Lovelace)