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L.O.ABRAHAMIAN, R.O.AVAKIAN, A.O.AGANIANTS, F.D.ADAMIAN, A.A.ARMAGANIAN, L.G.ARUTUNIAN, N.A.DEMIOKHINA, G.M.ELBAKIAN, G.Kh.KAZARIAN, A.G.KHUDAVERDIAN, L.S.KHURSHUDIAN, A.N.LEBEDEV, J.V.MANUKIAN, R.Kh.MARKARIAN*, E.G.MURADIAN, S.E.PILIPOSSIAN, A.M.SIRUNIAN, H.A.VARTAPETIAN

π^{0} AND π^{+} PRODUCTION WITH POLARIZED PHOTONS IN THE ENERGY RANGE 1-2 GEV

(to be published in Physics Letters B)

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* Yerevan State University

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Научное сообщение ЕФИ-7I(74)

Л.О.Абрамян,Р.О.Авакян,А.О.Аганьянц,Ф.В.Адамян,
А.А.Армаганян,Л.Г.Арутюнян,Г.А.Вартапетян,
Н.А.Демехина,Г.Х.Казарян,А.Н.Лебедев,Ж.В.Манукян,
Р.Х.Маркарян, Э.Г.Мурадян,С.Е.Пилипосян,А.М.Сирунян,
А.Г.Худавердян,Л.С.Хуршудян,Г.М.Элбакян

ФОТОРОЖДЕНИЕ π^0 И π^--МЕЗОНОВ ПОЛЯРИЗОВАННЫМИ ФОТОНАМИ В ОБЛАСТИ ЭНЕРГИИ I - 2 Гэв

Измерена асимметрия фоторождения π^0 и π^+-мезонов на водороде. π^0 - мезоны регистрировались под углом 130^0 в системе Ц.М. при $E_\gamma = 0{,}9 \div I{,}65$ Гэв, а π^+- мезоны под углом 40^0 в системе Ц.М. при $E_\gamma = 0{,}9 \div I{,}2$ Гэв.

Полученные результаты согласуются с предсказаниями модели однопионного фоторождения в резонансной области с использованием дисперсионных соотношений при фиксированном t [4].

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A.M.SIRUNIAN,H.A.VARTAPETIAN

The asymmetry of π^0 and π^+ photoproduction from hydrogen has been measured. The π^0-mesons were detected at 130^0 cms with E_γ ranged from 0.9 to 1.65 GeV, and the π^+-mesons at 40^0 cms with E_γ ranged from 0.9 to 1.2 GeV. The results agree with model prediction of single pion Photoproduction in the resonance region using fixed-t dispersion relations [4].

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To determine the amplitudes of photoproduction reactions and to compare them with different phenomenological model predictions as well as with quark model predictions [1,2,3,4], different polarization experiments are necessary along with the cross-sections measurements. This is particularly essential in the third resonance region and higher where experimental data are lacking in effect [5].

At present , one measurement of the asymmetry of π^0, π^+ photoproduction at 90^0 in the cms is available in this region [6]. In this work we present results on the measurements of π^0 and π^+-meson photoproduction asymmetry in reactions

$$\gamma + p \to p + \pi^0 \qquad (1)$$

$$\gamma + p \to n + \pi^+ \qquad (2)$$

at 130^0 and 40^0 in the cms respectively.

The Process (1) was measured at $E_\gamma = 0.9\text{–}1.65$ GeV in successive 0.15 GeV steps. The process (2) was measured at E_γ =0.9;1.05 and 1.2 GeV. The photon energy resolution as dependent on E_γ made in average $\sigma_{E_\gamma} \cong 30$ MeV for reaction (1) and $\sigma_{E_\gamma} = 20$ MeV for reaction (2). Polarized photons were produced from a diamond crystal using 4.6 and 3.6 electron beam of Yerevan Synchrotron. The vertical and horizontal polarizations were obtained by appropriate orientation of the crystal using the 022 and 02$\bar{2}$ planes respectively. The π^+-mesons and protons were detected with a magnetic spectrometer [7], their separation being by the time of flight. To restrict the measurements to two-body reaction (1), the magnetic spectrometer was brought in coincidence withthe the total-absorption Cerenkov counter [8] the lead defining aperture in front of which made 15 x 15 cm^2 and 100 cm distant from the target. This counter detects one photon from the π^0-meson decay (see Fig.1). When measuring reaction (2) the magnetic spectrometer was coincident with a neutron counter (see Fig.1) consisting of three 18 x 15 x 28 cm^3 scintillator blocks in anticoincidence with thre scintillation counters to reject charged particles.

The photon spectrum and the position of polarized photon peak were periodically checked during the measurements by means of a pair spectrometer. The unknown parameters of the calculated photon spectrum (the angular spread beam collimation) were determined by a fit to the measured spectrum. These parameters were used for the calculation of E -dependence of photon polarization. A typical photon spectrum with the calculated photon polarization curve is shown in fig.2 [9].

The shape of the photon spectrum accepted in our experimental setup as obtained by the detection of secondary particles was

calculated by Monte-Carlo technique and was used for the determination of effective polarization of γ-beam ($\bar{P}_\gamma$).

The contribution of background to reaction (2) was measured by setting the neutron counter at two off angles on either side of its kinematically correct setting, where the detection efficiency for the process (2) is zero (in our case it was enough to change by 6° on both sides the angle of neutron detector). In the case of reaction (1) the angular detection range for π^0-meson was large enough due to the detection of only γ-quantum in coincidence with recoil proton $[p-\pi^0(\gamma)]$. E.g., when investigating the process (1) at E_γ =1,5 GeV and θ_π =90° cms the change of Cerenkov counter angle $\theta_{\pi^0(\gamma)}$ by 14° lead to 16% detection efficiency as compared to the case of kinematically correct orientation. The $\theta_{\pi^0(\gamma)}$-dependence of $p-\pi^0(\gamma)$ coincidence detection efficiency was calculated by Monte Carlo technique. The comparison of Monte-Carlo data with the experimental $\theta_{\pi^0(\gamma)}$-dependence of yield allows to estimate the contribution of background reactions. The contribution of background reactions proved to change from insignificant to 8% depending on E_γ and the reaction studied. The obtained values of asymmetry:

$$\Sigma = \frac{\sigma_\perp - \sigma_\parallel}{\sigma_\perp + \sigma_\parallel} = \frac{1}{\bar{P}_\gamma} \cdot \frac{C_\perp - C_\parallel}{C_\perp + C_\parallel}$$

for reactions (1) and (2) are given in the Table 1. $C_\parallel$ and $C_\perp$ are coincidence counts for a photon beam, polarized in a plane parallel and perpendicular to the meson production plane. The errors on the asymmetry Σ include statistical ones as well as the errors ($\sim$ 10%) on the effective photon polarization ($\bar{P}_\gamma$). From the values of $C_\parallel$ and $C_\perp$, the known acceptance and efficiencies of detectors used the cross sections of reactions (1) and (2) were calculated for unpolarized photons

$$\frac{d\sigma}{d\Omega} = \frac{1}{2}\left(\frac{d\sigma}{d\Omega_{\parallel}} + \frac{d\sigma}{d\Omega_{\perp}}\right)$$

The results are presented in table 2 where the errors are only statistical (we take an additional systematic error of 15%). Our π^{0} and π^{+} cross sections data are in agreement with previously published cross sections measurements with unpolarized photons /1/ /6/ /10/.

The E_{γ} -dependence of asymmetry, Σ, for reaction (1) is given in Fig.3 at E_{γ} =0.9 - 1.65 GeV and θ_{π} =130° in the cms.The resonances F_{15} (1690), D_{15} (1670) and F_{37} (1950) dominate in this energy region. For F_{15} (1690) resonance at E_{γ} =1.05 GeV, the quark model predicts an asymmetry Σ equal to zero due to the fact that in this model the helicity-1/2 amplitude for the production of F_{15} (1690) resonance vanishes/1/. As in the case of θ_{π} =90°cms/6/, our data (Fig.3) show structure, that would require strong interference phenomena to account for this prediction. In this figure the Walker model predictions/1/ are shown together with the curves from recent work of Berkeley group/4/. In the latter work the parametrization of resonances and background is used in the imaginary parts of the amplitudes with real parts being calculated from fixed-t dispersion relation. Three fitted curves satisfactorily agreeing with experimental data in their use are obtained by these authors/4/, which also note the need for polarization measurements. Our data are seen to strongly favour one of these fits.

Table 1. Measured asymmetries Σ in reaction*:

E_γ in GeV	$\gamma+p\to p+\pi^\circ$ $\Theta_\pi=90^\circ$cms	$\gamma+p\to p+\pi^\circ$ $\Theta_\pi=130^\circ$cms	$\gamma+p\to n+\pi^+$ $\Theta_\pi=140^\circ$cms
0.9		0.05$\pm$ 0.047	0.58$\pm$ 0.11
1.05		- 0.37$\pm$ 0.06	0.55$\pm$ 0.12
1.2		- 0.165$\pm$ 0.075	0.46 $\pm$ 0.15
1.35		0.23$\pm$ 0.07	
1.5	0.5$\pm$ 0.07	0.65$\pm$ 0.1	
1.65		0.36$\pm$ 0.1	

*The errors are statistical ones plus 10% for effective photon polarization (see text).

Table 2. Differential cross sections $\frac{d\sigma}{d\Omega\, cms}$ (μb /ster) with unpolarized photons. The errors are statistical ones (see text).

E_γ in GeV	$\gamma+p\to p+\pi^\circ$ $\Theta_\pi=90^\circ$cms	$\gamma+p\to p+\pi^\circ$ $\Theta_\pi=130^\circ$cms	$\gamma+p\to n+\pi^+$ $\Theta_\pi=40^\circ$cms
0,9		2,95 $\pm$ 0,1	7 $\pm$ 0,47
1,05		3 $\pm$ 0,1	7,52 $\pm$ 0,5
1,2		1 $\pm$ 0,056	4,5 $\pm$ 0,39
1,35		1,1 $\pm$ 0,054	
1,5	0,67 $\pm$ 0,023	0,82 $\pm$ 0,037	
1,65		0,6 $\pm$ 0,036	

FIGURE CAPTIONS

Fig.1- Layout of the experiment.

Fig.2- a) A typical measured photon spectrum. The solid line represents a best fit varying the unknown parameters (angular spread and beam collimation).

b) The calculated curve of photon polarization using these parameters.

Fig.3- Asymmetry Σ for reaction $\gamma+p\to p+\pi^\circ$ as a function of E_γ at $\Theta_\pi=130^\circ$ in the cms.

Fig.4- Asymmetry Σ for reaction $\gamma+p\to p+\pi^\circ$ as a function of Θ_π cms at E_γ =1.5 GeV. The curves correspond to the F_{37} (1950) resonance at pure magnetic and electric excitations.

Fig.5- Asymmetry Σ for reaction $\gamma+p\to n+\pi^+$ as a function of E_γ at $\Theta_\pi=40^\circ$ in the cms.

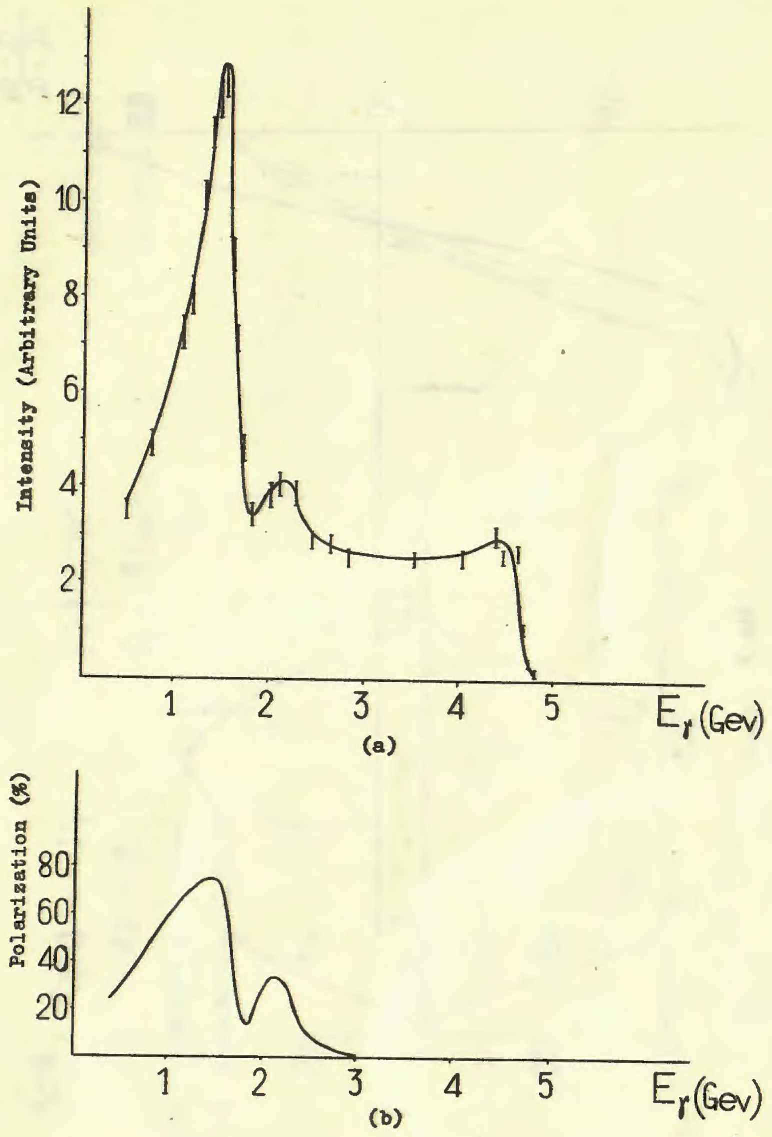
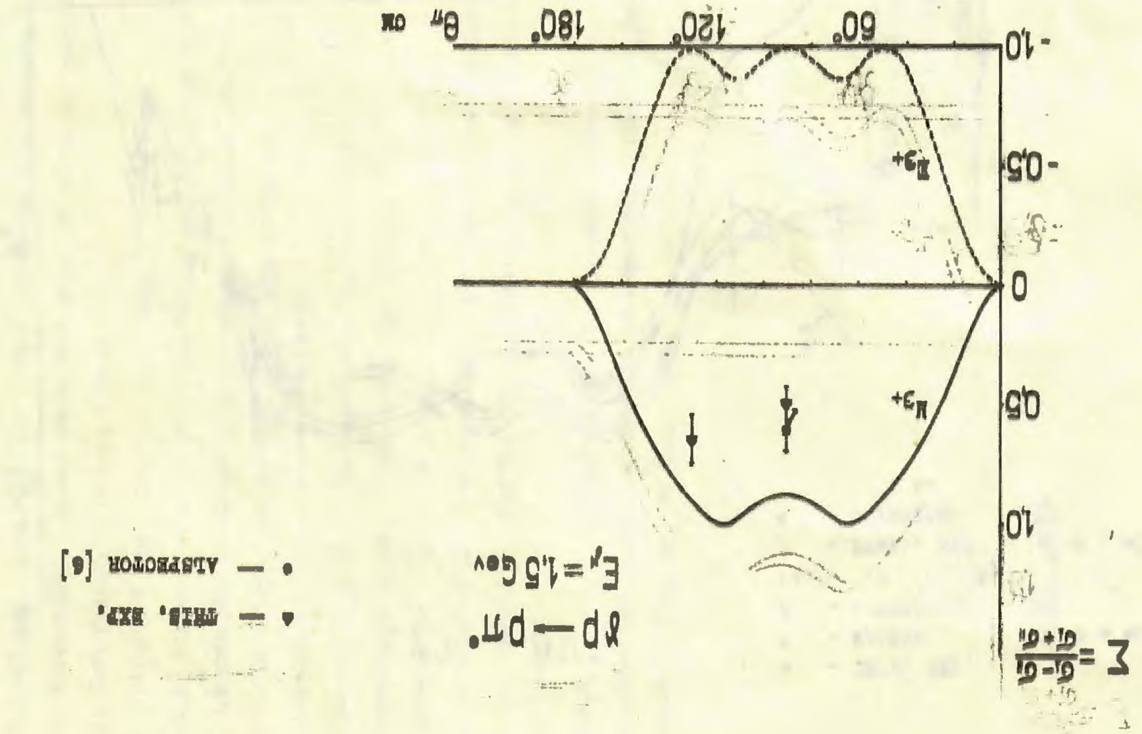

Intensity (Arbitrary Units)
12
10
8
6
4
2
1
2
3
4
5
E_γ(Gev)
(a)
Polarization (%)
80
60
40
20
1
2
3
4
5
E_γ(Gev)
(b)

Fig.2

Fig.4


$\Sigma = \frac{\sigma_\perp - \sigma_\parallel}{\sigma_\perp + \sigma_\parallel}$
1,0
0,5
0
-0,5
-1,0
60°
120°
180°
θ_π cm
N_{3+}
N_{3+}
$\gamma p \to p \pi^\circ$
$E_\gamma = 1,5$ Gev
▲ — THIS. EXP.
● — ALSPECTOR [6]

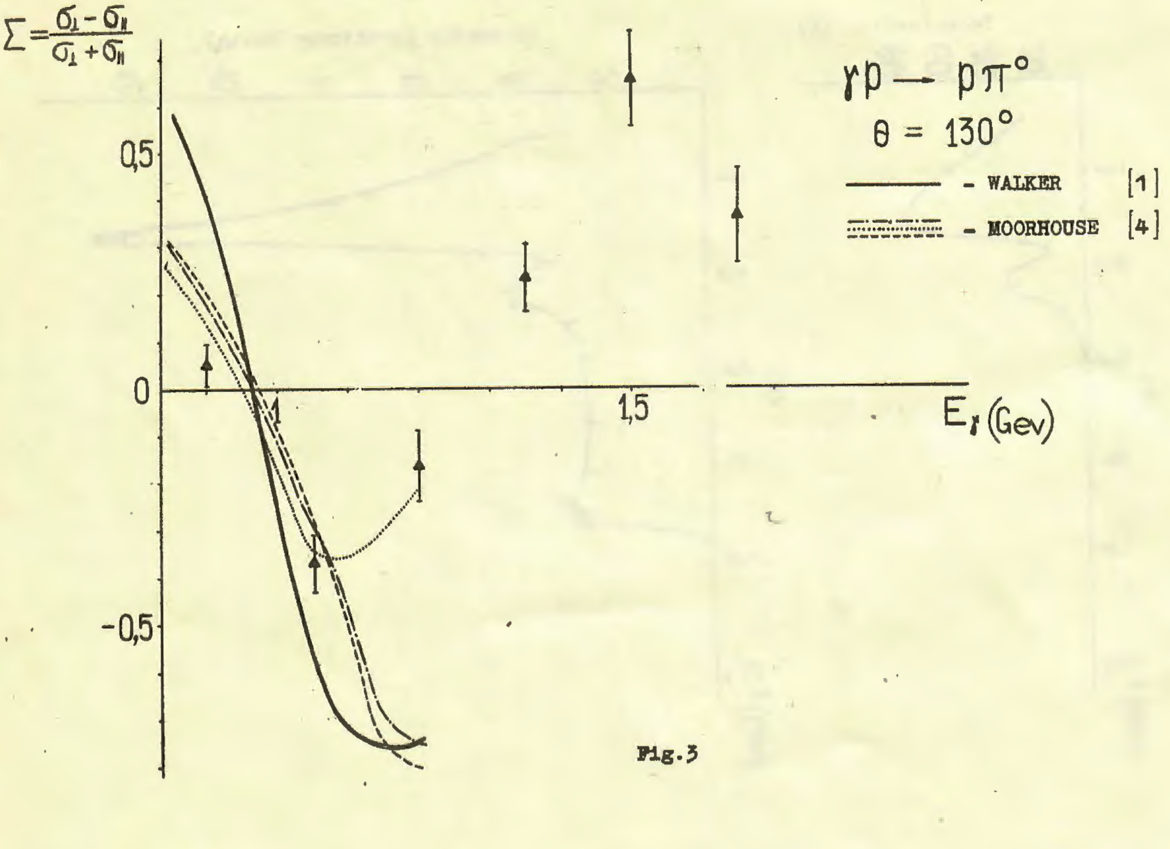

$\Sigma = \frac{\sigma_\perp - \sigma_\parallel}{\sigma_\perp + \sigma_\parallel}$
0,5
0
-0,5
1
1,5
E_γ (Gev)
$\gamma p \to p \pi^\circ$
$\theta = 130°$
- WALKER [1]
- MOORHOUSE [4]

Fig.3

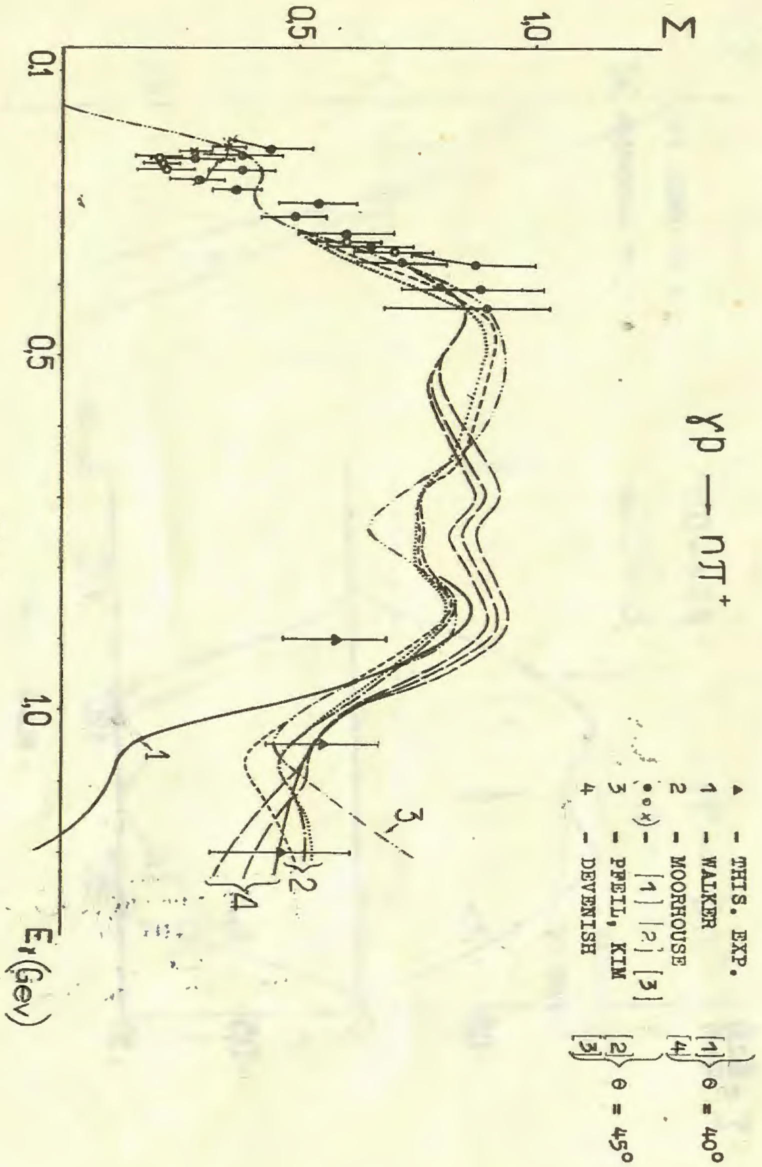


Fig.5

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