ИНДЕКС 3649

ЕРЕВАНСКИЙ ФИЗИЧЕСКИЙ ИНСТИТУТ

Preprint YERPHI-1283(69)-90

ԵՐԵՎԱՆԻ ՖԻԶԻԿԱՅԻ ԻՆՍՏԻՏՈՒՏ
ЕРЕВАНСКИЙ ФИЗИЧЕСКИЙ ИНСТИТУТ
YEREVAN PHYSICS INSTITUTE

R.O.AVAKIAN, R.A.ASATRIAN, A.S.BAGDASARIAN, Yu.A.GARIBIAN, K.P.DALLAKIAN, S.S.DANAGULIAN, V.S.EGANOV, A.P.KARAPETIAN, I.A.KEROPIAN, O.S.KIZOGIAN, G.O.MARUKIAN, E.M.MATEVOSIAN, A.A.OGANESIAN, G.M.PETROSIAN, Zh.V.PETROSIAN, I.P.PROKHORENKO, Zh.S.SAAKIAN, Yu.Z.SUKIASIAN, E.M.SKHTORIAN, S.P.TAROYAN, G.M.ELBAKIAN

MEASUREMENT OF P_x , P_y , P_z COMPONENTS OF PROTON POLARIZATION VECTOR IN REACTION $\gamma p \to p\pi^0$ ON LINEARLY POLARIZED PHOTONS

ЦНИИатоминформ
ЕРЕВАН-1990

Նախնատիպ ԵրՖԻ-1283(69)-90

Ռ.Ա.ԱՍԱՏՐՅԱՆ, Ռ.Հ.ԱՎԱԳՅԱՆ, Ա.Ս.ԲԱՂԴԱՍԱՐՅԱՆ,
Կ.Ռ.ԴԱԼԼԱՔՅԱՆ, Ս.Ս.ԴԱՆԱԳՈՒԼՅԱՆ, Վ.Ս.ԵՂԱՆՈՎ,
Գ.Մ.ԷԼԲԱԿՅԱՆ, Ս.Պ.ԹԱՌՈՅԱՆ, Ա.Պ.ԿԱՐԱՊԵՏՅԱՆ,
Հ.Ս.ԿԻԶՈՂԼՅԱՆ, Ա.Ա.ՀՈՎՀԱՆՆԻՍՅԱՆ, ՅՈՒ.Հ.ՂԱՐԻԲՅԱՆ,
Հ.Հ.ՄԱՐՈՒՔՅԱՆ, Է.Մ.ՄԱԹԵՎՈՍՅԱՆ, Գ.Մ.ՊԵՏՐՈՍՅԱՆ,
Ժ.Վ.ՊԵՏՐՈՍՅԱՆ, Ի.Պ.ՊՐՈԽՈՐԵՆԿՈ, Ժ.Ս.ՍԱՀԱԿՅԱՆ,
Յու.Զ.ՍՈՒՔԻԱՍՅԱՆ, Ե.Մ.ՍԽՏՈՐՅԱՆ, Ի.Ա.ՔԵՐՈԲՅԱՆ

$\gamma p \to p\pi^0$ ՌԵԱԿՑԻԱՅՈՒՄ ՊՐՈՏՈՆՆԵՐԻ ԲԵՎԵՌԱՑՄԱՆ ՎԵԿՏՈՐԻ P_x, P_y, P_z ԲԱՂԱԴՐԻՉՆԵՐԻ ՉԱՓՈՒՄՆԵՐԸ ԳԾԱՅԻՆ-ԲԵՎԵՌԱՑՎԱԾ ՖՈՏՈՆՆԵՐԻ ՎՐԱ

Բերված են $\gamma p \to p\pi^0$ ռեակցիայի պրոտոնների բևեռացման վեկտորի P_x , P_y , P_z բաղադրիչների էներգետիկ կախման չափման արդյունքները, π^0 -մեզոնի ծնման $\theta^*_{\pi^0} = 60^0$ անկյան համար, ֆոտոնների էներգիայի $E_\gamma = 875 \div 1175$ ՄէՎ տիրույթում: Փորձնական տվյալները համեմատվում են տարբեր տեսական կանխատեսումների արդյունքների հետ:

Երևանի Ֆիզիկայի Ինստիտուտ

Երևան 1990

Препринт ЕФИ-I283(69)-90

Р.О.АВАКЯН, Р.А.АСАТРЯН, А.С.БАГДАСАРЯН, Ю.А.ГАРИБЯН,
К.Р.ДАЛЛАКЯН, С.С.ДАНАГУЛЯН, В.С.ЕГАНОВ, А.П.КАРАПЕТЯН ,
И.А.КЕРОПЯН, О.С.КИЗОГЛЯН, Г.О.МАРУКЯН, Э.М.МАТЕВОСЯН,
А.А.ОГАНЕСЯН, Г.М.ПЕТРОСЯН, Ж.В.ПЕТРОСЯН, И.П.ПРОХОРЕНКО,
Ж.С.СААКЯН, Ю.З.СУКИАСЯН, Е.М.СХТОРЯН, С.П.ТАРОЯН,
Г.М.ЭЛБАКЯН

ИЗМЕРЕНИЕ P_x , P_y , P_z - СОСТАВЛЯЮЩИХ ВЕКТОРА ПОЛЯРИЗАЦИИ ПРОТОНОВ В РЕАКЦИИ $\gamma p \to p\pi^0$ НА ЛИНЕЙНО--ПОЛЯРИЗОВАННЫХ ФОТОНАХ

Приведены результаты измерения энергетической зависимости P_x , P_y , P_z - составляющих вектора поляризации протонов в реакции $\gamma p \to p\pi^0$ для угла рождения π^0 - мезонов $\theta^*_{\pi^0} = 60^0$ в области энергии фотонов $E_\gamma = 875 \div 1175$ МэВ. Экспериментальные данные сравниваются с результатами различных теоретических предсказаний.

Ереванский физический институт

Ереван I99I

Preprint YERPHI-1283(69)-90

R.O.AVAKIAN, R.A.ASATRIAN, A.S.BAGDASARIAN,
Yu.A.GARIBIAN, K.P.DALLAKIAN, S.S.DANAGULIAN,
V.S.EGANOV, A.P.KARAPETIAN, I.A.KEROPIAN,
O.S.KIZOGIAN, G.O.MARUKIAN, E.M.MATEVOSIAN,
A.A.OGANESIAN, G.M.PETROSIAN, Zh.V.PETROSIAN,
I.P.PROKHORENKO, Zh.S.SAAKIAN, Yu.Z.SUKIASIAN,
E.M.SKHTORIAN, S.P.TAROYAN, G.M.ELBAKIAN

MEASUREMENT OF P_x, P_y, P_z COMPONENTS OF PROTON POLARIZATION VECTOR IN REACTION $\gamma p \to p\pi^o$ ON LINEARLY POLARIZED PHOTONS

The present paper reports results of measurements of energy dependence of P_x, P_y, P_z components of proton polarization vector in the reaction $\gamma p \to p\pi^o$ for π^o- meson production angle $\theta^*_{\pi^o} = 60^o$ in the photon energy range E_γ =875-1175 MeV. Experimental data are compared with results of different theoretical predictions.

Yerevan Physics Institute
Yerevan 1990

According to the analysis of [1] on the realization of the complete experiments in the reaction of pseudoscalar meson photoproduction on a nucleon

$$\gamma N \to N\pi \qquad (1)$$

there is a possibility in a double-polarization experiment of the type of "polarized beam - nucleon polarization" to perform measurements of O_x and O_z components of the recoil nucleon polarization vector when the angle between the photon polarization vector and the reaction plane is 45°. In this case a new relationship between the independent helicity amplitudes of reaction (1) and experimentally observed quantities is of the form:

$$O_x = \frac{q}{K} \frac{1}{d\sigma/d\Omega} \operatorname{Im}\left[H_4 H_3^* + H_1 H_2^*\right] \qquad (2)$$

$$O_z = \frac{q}{K} \frac{1}{d\sigma/d\Omega} \operatorname{Im}\left[H_4 H_1^* + H_2 H_3^*\right] \qquad (3)$$

where K and q are photon and pion momenta in the c.m.s.; H_1, H_2, H_3, H_4 are helicity amplitudes in the terms of Ref. [2] .

The performance of systematic measurements of O_x and O_z polarizations, together with the measured quantities $d\sigma/d\Omega$ (differential cross section), Σ ("beam asymmetry"), P_y (transverse polarization), T ("target asymmetry") in a wide photon energy range (E_γ) and the pion production angles in the c.m.s. (θ^*_π) implies an essential progress in the solution of the problem of the complete experiment. Before the realization of the program of the complete experiment the experimental data on new polarization parameters, in particular O_x and O_z, will serve for specification of phenomenological analyses predictions, since the analyses hitherto performed were based on results of single-polarization experiments on measurement of $d\sigma/d\Omega$, Σ , P_y , T .

On a linearly polarized photon beam for the reaction of π°-meson photoproduction on a proton

$$\gamma p \to p\pi^\circ \qquad (4)$$

we have been carrying out systematic measurements of cross section asymmetry, proton polarization in the reaction plane (P_{xz}) and in the perpendicular plane (P_y) in the photon energy range E_γ =0.7 - 1.5 GeV at pion production angles $\theta^*_{\pi^\circ}$ =40° - 80° in the c.m.s. Measurements of P_{xz} and P_y polarizations were performed simultaneously on a polarized photon beam with the photon polarization vector oriented under 45° to the reaction plane. In the experiment the possibility of obtaining the values of P_x and P_z polarizations separately is based on the phenomenon of proton spin precession in the constant magnetic field as the proton is passing across it.

The precession angle relative to the proton momentum $\vec{p}$ is determined by the relation [3] :

$$\theta_{pr} = \gamma(g/2 - 1)\,\theta_{bend} \qquad (5)$$

where γ is the proton γ -factor; $g/2$ is the proton magnetic moment; θ_{bend} is the proton bending angle in the magnetic field.

Performing two independent measurements of P_{xz} which correspond to two different bending angles of the protons in the magnetic field perpendicular to the reaction plane and solving a system of two equations for P_{xz} we can separate P_x and P_y components of the proton polarization vector.

On the basis of this method of separation of P_{xz} into P_x and P_z it is planned to perform measurements of proton polarization in reaction (4) in a wide range of E_γ and $\theta^*_{\pi^\circ}$.

In the present work we report our for the first time obtained results of measurements of P_x , P_y , P_z components of the proton polarization vector in reaction (4) in the range E_γ =875-1175 MeV for the angle $\theta^*_{\pi^\circ}$ = 60° in the c.m.s.

The experiment was performed on a linearly polarized photon beam of the Yerevan synchrotron. Polarized photons were obtained using coherent bremsstrahlung of electrons with a maximum energy of 4.5 GeV on a diamond crystal [4] , the crystal axis [0$\bar{1}$1] being directed under 45° to the reaction plane.

The layout of the experimental setup is given in Fig.1. The identification of the reaction $\gamma p \to p\pi^\circ$ was realized by detecting one of the γ-quanta from the π°-meson decay in coincidence with the recoil proton. The γ- quanta detection was done using a hodoscopic array of total absorption counters based on 16 NaI(Tl) single crystals, and the recoil protons detection - by means of five scintillation counters $R_1 - R_5$ of a range spectrometer. The proton energy was determined by the range-energy relation. Energy spectra of the protons at their stopping in the range spectrometer counters and scattering in the carbon plate were obtained by the Monte Carlo simulation [5] . The accuracy of determination of proton energy at stopping was $\sim \pm 3$ MeV, and at scattering $\sim \pm 10$ MeV. The protons were identified from the accompanying π^+- mesons by means of the amplitude analysis of signals from the counters C_1 and C_2. The admixture of π^+- mesons in the impulse tract of the protons with $\bar{P}_p = (595 \pm 45)$ MeV/c in the deflecting magnetic field was no more than 1%. The emission angles of the protons from the target were found by the method of inverse matrix of angle transformation after finding in the MWPC 1 - 4 system the proton trajectory continuation through the deflecting magnetic field. The MWPC 5 - 8 served for finding the protons scattering angles. The MWPC systems allowed to determine the proton angles before and after scattering with an accuracy of ±2.5 mrad. In the chosen kinematic conditions of the reaction under study the energy resolution of the primary photons was ±25 MeV. Photon polarization was calculated by the method described in Ref.[6] . The experimental setup operated in line with the "Elektronika-60" and ES-1022 computers. The setup description and characteristics are given in Ref.[7] . We note

only that the empty target effect was 2%, and the number of accidental coincidences of the setup two-arm masters was 8%.

Physical measurements were done for four versions: $\theta_{bend} = \pm 13^\circ$ and $\alpha_\gamma = \pm 45^\circ$. The measurements of proton polarization for the angles $\pm 45^\circ$ allowed us to find artificial asymmetry of the setup. The average over photon energy range value of the setup artificial asymmetry was -0.012 for $\theta_{bend} = 13^\circ$ and -0.020 for $\theta_{bend} = -13^\circ$. Measurements for the bending angles $\pm 13^\circ$ enabled us to determine separately P_x and P_z components of the proton polarization vector. The polarization value was determined by the maximum likelihood method. The cases of "left-right" and "down-up" proton scattering in the region of polar scattering angles $\Delta\theta_{pp'} = 5^\circ - 20^\circ$ were analyzed.

Fig.2 shows relative position of the coordinate systems, direction of the photon beam, axis of the proton arm of the experimental setup (Z_H), the coordinate system of polarization measurement. The polarization was measured in the X_H , Y_H , Z_H coordinate system.

Table 1 presents emission angles of protons and precessions with their dispersions versus the photon energy range.

Table 1

ΔE_γ , MeV	$\bar{\theta}_{\gamma p} \pm \sigma(\theta_{\gamma p})$, degrees	$\bar{\theta}_{pr} \pm (\theta_{pr})$, degrees
875 - 925	54.2 ± 0.79	28.6 ± 0.38
925 - 975	54.9 ± 0.96	28.3 ± 0.53
975 - 1025	55.2 ± 1.19	27.9 ± 0.69
1025 - 1075	55.5 ± 1.26	27.5 ± 0.76
1075 - 1125	55.8 ± 1.23	27.1 ± 0.77
1125 - 1175	56.3 ± 1.12	26.9 ± 0.74

These values of angles $\bar{\theta}_{\gamma p}$ and $\bar{\theta}_{pr}$ are necessary to determine P_x and P_z polarizations versus ΔE_γ by solving the set of equations:

$$P_{xz}^{+13} = P_x \cos(\bar{\theta}_{\gamma p} - \bar{\theta}_{pr}) - P_z \sin(\bar{\theta}_{\gamma p} - \bar{\theta}_{pr})$$

$$P_{xz}^{-13} = P_x \cos(\bar{\theta}_{\gamma p} + \bar{\theta}_{pr}) - P_z \sin(\bar{\theta}_{\gamma p} + \bar{\theta}_{pr}) \qquad (6)$$

Results of experimental measurements of P_x , P_y , P_z components of the proton polarization vector in the reaction $\gamma p \to p\pi^0$ are chosen in Figs 3,5,4, respectively, as well as in Table 2.

Table 2

$\bar{E}_\gamma \pm \sigma(E_\gamma)$ MeV	$\bar{\theta}^*_{\pi^0} \pm \sigma(\theta^*_{\pi^0})$ degrees	$P_x \pm \sigma(P_x)$	$P_y \pm \sigma(P_y)$	$P_z \pm \sigma(P_z)$
900±25	62.5±1.6	−0.260±0.208	+0.039±0.096	0.352±0.163
950±25	60.9±1.9	−0.084±0.166	−0.048±0.088	0.436±0.132
1000±25	60.0±2.3	−0.106±0.126	−0.053±0.077	0.080±0.108
1050±25	59.2±2.4	+0.014±0.112	−0.095±0.079	0.017±0.102
1100±25	58.4±2.3	−0.074±0.127	−0.047±0.089	0.058±0.113
1150±25	57.1±2.1	−0.270±0.176	−0.050±0.108	−0.012±0.157

The measurement errors presented are statistical. The maximum error in the determination of photon polarization inside the region $\Delta E_\gamma \sim \pm 6\%$, and the error in the determination of quantity $P_c \sin \varphi_{pp'}$ or $P_c \cos \varphi_{pp'}$, where P_c is the analyzing power of carbon , $\varphi_{pp'}$ is azimuth angle of proton scattering in carbon, does not exceed ±6%.

Figs 3-5 present together with experimental data the results of phenomenological analyses [8] and [9] . While the

analyses [8] and [9] at $\theta^*_{\pi^0} = 60^\circ$ predict a coincident result for the dependence $P_{xz}(E_\gamma)$ in the range E_γ =800-1050 MeV, the same analyses in the same photon energy range predict for the dependences $P_x(E_\gamma)$ and $P_z(E_\gamma)$ essentially different polarization results both in magnitude and sign. Figs 3 and 4 show that as distinct from the analysis [8] which in the range E_γ = 875-1025 MeV does not describe the measured dependences $P_x(E_\gamma)$ and $P_z(E_\gamma)$, the analysis [9] describes quantitatively the dependence $P_z(E_\gamma)$ and qualitatively - $P_x(E_\gamma)$

From the results of the present experiment there evidently follows the importance of performing measurements of new polarization parameters which will allow one to choose between predictions of different phenomenological analyses.

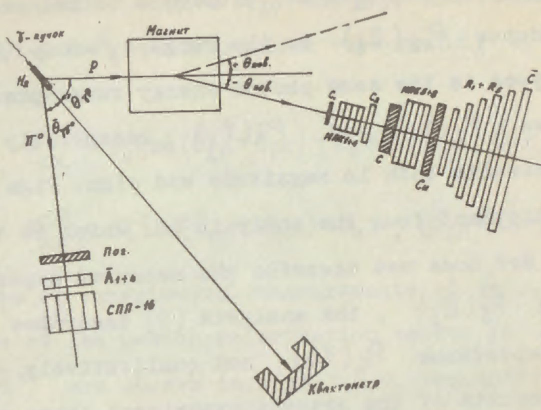

Fig.1

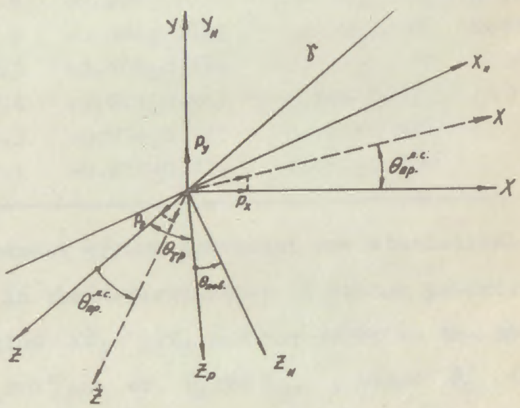

Fig.2

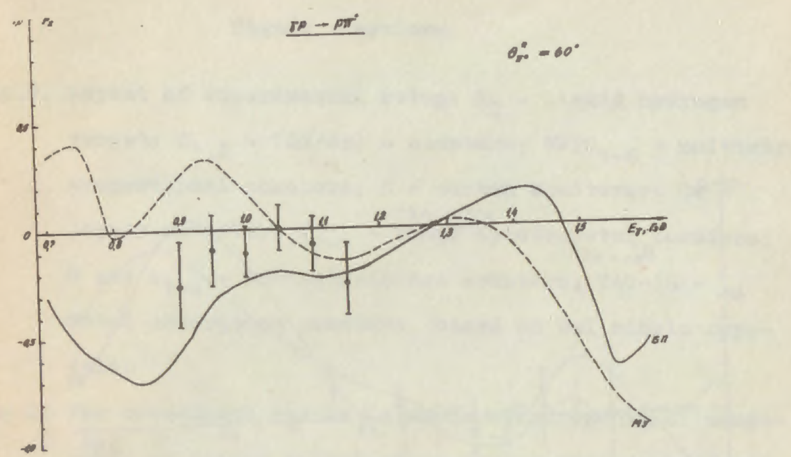

Fig.3

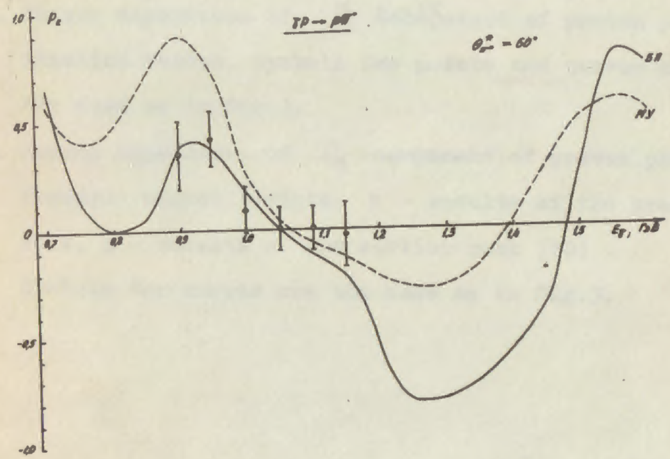

Fig.4

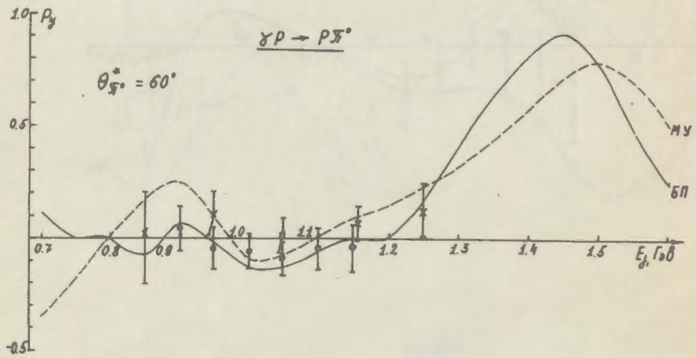

Fig.5

Figure Captions

Fig.1. Layout of experimental setup: H_2 - liquid hydrogen target; $C_{1,2}$ - (dE/dx) - counters; $MWPC_{1-8}$ - multiwire proportional chambers; C - carbon scatterer; Cu - copper absorber; R_{1-5} - range spectrometer counters; C and A_{1-4} - anticoincidence counters; TAC-16 - total absorption counters based on NaI single crystals.

Fig.2. The coordinate system in which measurements of components of proton polarization vector were carried out.

Fig.3. Energy dependence of P_x - component of proton polarization vector. Points - results of this work, dotted curve - results of analysis [8] , solid curve - analysis [9] .

Fig.4. Energy dependence of P_z -component of proton polarization vector. Symbols for points and curves are the same as in Fig.3.

Fig.5. Energy dependence of P_y -component of proton polarization vector. Points: ● - results of the present work, x - results of our earlier work [10] . Symbols for curves are the same as in Fig.3.

REFERENCES

1. Barker I.S., Donnachie A., Storrow J.K. Nucl.Phys., 1975, V.B95, P.347-356.
2. Walker R.L. Phys.Rev., 1969, V.182, N 5, P.1729.
3. Bargman V., Louis Michel, Telegdi V.L. Phys.Rev.Lett., 1959, V.2, N 10, P.435.
4. Р.О.Авакян, А.А.Армаганян, Л.Г.Арутюнян и др. Межд.конф.по аппаратуре в физике высоких энергий (Дубна,1971), Атомиздат, 1972, с.740.
5. И.А.Керопян, А.А.Оганесян, Ж.В.Петросян. Препринт ЕФИ -1281(67)-90.
6. Р.О.Авакян, Н.З.Акопов, А.П.Безверхая, С.М.Дарбинян. Препринт ЕФИ-265(58)-77.
7. Л.О.Абрамян, А.Э.Аветисян, К.Ш.Агабабаян и др. Препринт ЕФИ-1282(68)-90.
8. Metcalf W.J., Walker R.L. Nucl.Phys., 1974, V.B76, P.253.
9. А.С.Багдасарян, Ж.В.Петросян. Препринт ЕФИ-1216(2)-90.
10. Р.О.Авакян, Э.О.Авакян, А.Э.Аветисян и др. ЯФ,1983, т.37, вып.2, с.334.

The manuscript was received 5 July 1990

The address for requests:
Information Department
Yerevan Physics Institute
Alikhanian Brothers 2,
Yrevan, 375036
Armenia, USSR

Р.О.АВАКЯН, Р.А.АСАТРЯН, А.С.БАГДАСАРЯН, Ю.А.ГАРИБЯН, К.Р.ДАЛЛАКЯН, С.С.ДАНАГУЛЯН, В.С.ЕГАНОВ, А.П.КАРАПЕТЯН, И.А.КЕРОПЯН, О.С.КИЗОГЛЯН, Г.О.МАРУКЯН, Э.М.МАТЕВОСЯН, А.А.ОГАНЕСЯН, Г.М.ПЕТРОСЯН, Ж.В.ПЕТРОСЯН, И.П.ПРОХОРЕНКО, Ж.С.СААКЯН, Ю.З.СУКИАСЯН, Е.М.СХТОРЯН, С.П.ТАРОЯН, Г.М.ЭЛБАКЯН

ИЗМЕРЕНИЕ P_x, P_y, P_z - СОСТАВЛЯЮЩИХ ВЕКТОРА ПОЛЯРИЗАЦИИ ПРОТОНОВ В РЕАКЦИИ $\gamma p \to p\pi^0$ НА ЛИНЕЙНО-ПОЛЯРИЗОВАННЫХ ФОТОНАХ

(на английском языке перевод, З.Н.Асланян)

Редактор Л.П.Мукаян

Технический редактор А.С.Абрамян

Подписано в печать 24/XII-90. Формат 60x84/16
Офсетная печать. Уч.изд.л. 0,8 Тираж 299 экз. Ц. 10 к.
Зак.тип.№ 360 Индекс 3649

Отпечатано в Ереванском физическом институте
Ереван 36, ул.Братьев Алиханян,2