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ЦЕНТРАЛЬНЫЙ НАУЧНО-ИССЛЕДОВАТЕЛЬСКИЙ ИНСТИТУТ ИНФОРМАЦИИ И ТЕХНИКО-ЭКОНОМИЧЕСКИХ ИССЛЕДОВАНИЙ ПО АТОМНОЙ НАУКЕ И ТЕХНИКЕ

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MEASUREMENT OF THE POLARIZATION OF CUMULATIVE PROTONS IN $\gamma A \to pX$ REACTION

The polarization of cumulative protons in $\gamma A \to pX$ reaction is measured in the range of proton energy (190÷270) MeV for C , Cu , Sn , Pb nuclei. The measured polarization is practically independent of the energy of protons and the atomic number of nuclei .

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ИЗМЕРЕНИЕ ПОЛЯРИЗАЦИИ КУМУЛЯТИВНЫХ ПРОТОНОВ В РЕАКЦИИ $\gamma A \rightarrow PX$

Измерена поляризация кумулятивных протонов в реакции $\gamma A \rightarrow PX$ в области энергии протонов (190-270) Мэв для ядер C , Cu , Sn , Pb. Измеренная поляризация практически не зависит от энергии протонов и атомного веса ядра.

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Last years experiments are carried out with different particles beams for measuring the polarization of cumulative protons, which are considered to be independent sources for important information on the mechanism of cumulative particles emission from the nucleus-target.

The dependence of polarization of cumulative protons on the mass number of nuclei, on the proton momentum and the angle of its emission in $p\beta$ interactions has been investigated in [1,2,3,4,5], $\pi\beta$ interactions - in [6,7,8] and in $\gamma\beta$ interactions in [9].

In the present work we [illegible] measurement of cumulative protons polarization in $\gamma\beta \to pX$ reaction in the range of proton momenta $P = 270$ MeV/c on Cu, Pb targets. The measurements were taken at laboratory angle $\theta_{lab}^{\gamma p} = 95^0 \pm 4^0$ on the bremsstrahlung beam of Erevan Synchrotron with maximum energy of 4.5 GeV.

The layout of experimental setup [10], by means of which the dependences of proton polarization on the energy and the atomic member of nucleus target have been measured, is shown in Fig.1. The angles of proton emission from the target were determined with 4 two-coordinate multiwire proportional chambers (MWPC) 1 - 4, while the scattering angles of protons with MWPC 5-7 . The accuracy of angular measurements was ± 3 mrad,

and the detection efficiency was 95% and was constant over all the surface of chambers. The polarization was measured by the asymmetry of proton scattering, and as a scatterer we used 25 mm thick carbon plate. The energy of protons was measured with a range spectrometer consisting of five scintillation counters R_{1-5} and absorbers ab_{1-5} which expanded the energy range of detected particles. The energy spectra of protons, scattered in the carbon plate and stopped in the range spectrometer, were calculated by the Monte-Carlo method [11]. The accuracy in the determination of protons energy at stopping and scattering were respectively about ± 8 MeV and ±11 MeV. To provide high homogeneity in the efficiency of detection, the [illegible]tillation counters R_i were made of two detached parts [illegible]nters, R_i^{up} and R_i^{down} and each detected the passage of a [illegible]ticle with the help of two photomultipli[illegible] [illegible]fficiency of the counters R_i^{up}, R_i^{down} was [illegible] [illegible]espective of the place of particle passage through [illegible] [illegible]ers surface. The threshold Cerenkov counters (C) served [illegible] detection of charged pions, by means of which the [illegible] asymmetry of the experimental setup was determined. [illegible] the required solid angle of setup equal to [illegible] [illegible] we used two similar threshold Cerenkov coun[illegible] [illegible] % efficiency of [illegible] mesons detection [illegible] [illegible] data for [illegible] taken [illegible] [illegible] coinciden[illegible] [illegible] circuit for the simul[illegible] [illegible] of [illegible] determination of false [illegible]

setup) and of cumulative protons. The amplitude analysis of signals from the (dE/dx) counter was made with the help of 8000 channel amplitude converter unit. The information from the converter unit as well as from stroboscopic coincidence unit and MWPC were fed to "Electronica-60" computer with following transmission to ES-1022 computer.

In Fig.2 the (dE/dx) spectrum of protons is shown together with the (dE/dx) spectrum of pions detected as "false" protons taking into account the inefficiency of their detection by TCC equal to 5%. The polarization of protons was determined in the $N(P) \geq A$ region of (dE/dx) spectrum. The value of A was obtained subject to the condition that the contribution of pions in this range didn't exceed 5% of the number of protons. The polarization was determined by the formula

$$P_c = \frac{\Sigma_{LR}}{P_c(T_{p'}, \theta_{pp'}) \cdot \cos\varphi_{pp'}},$$

where $P_c(T_{p'}, \theta_{pp'})$ was the effective analyzing power of carbon; Σ_{LR} was left-right asymmetry of proton scattering obtained by the formula

$$\Sigma_{LR} = \frac{N(180^\circ \pm \Delta\varphi_{pp'}) - N(0^\circ \pm \Delta\varphi_{pp'})}{N(180^\circ \pm \Delta\varphi_{pp'}) + N(0^\circ \pm \Delta\varphi_{pp'})}$$

The azimuthal angle $\varphi_{pp'}$ was taken from the positive direction of X axis; the axes Y and Z of the right coordinate system (XYZ) were directed along the proton momentum $(\vec{P})$ and vector $\vec{n} = \frac{[\vec{P} \cdot \vec{P}']}{|[\vec{P} \cdot \vec{P}']|}$ respectively. The processing of measurement data was made for ranges of polar angles of proton (pion)

scattering in carbon plate $\Delta\theta_{pp'} = 5^\circ - 20^\circ$ and of azimuthal angles $\Delta\varphi_{pp'} = \pm 45^\circ$ relative to $\varphi_{pp'} = 0^\circ$ and 180° with the selection of those scattering events which remained within the solid angle of setup at the mirror reflection (i.e., the replacement of $\varphi_{pp'}$, by $\varphi_{pp'} + \pi$). Left-to-right asymmetry of the setup was determined by messuring the asymmetry of $\pi^\pm$ mesons scattering; for all the energies of detected pions it was in average 0,045 within the statistical accuracy of $\pm$ (1.5 - 2)%. In Fig.3 we give measurement data for Cu nucleus. To increase the statistical accuracy of the data two latter energy ranges were joined. In Fig. 3a we give the up-down asymmetry for pions, in Fig.3b - the left-right asymmetry for pions, in Fig.3c- the up-down asymmetry for protons, in Fig. 3d-the left-right asymmetry for protons and in Fig.3e - the polarization of protons. The errors in the polarization of protons include both the statistical errors and the error due to the determination of $P_c \cdot \cos\varphi_{pp'}$ amounting to $\sim 7\%$.

Analogeus results were obtained for remaining C,Sn,Pb targets. The compilation of data for all the targets is given in Table 1, Table 2, and in Fig.4. One can see that the measured polarization of cumulative protons is almost independent of their energy in the (190 - 270) MeV range and of the atomic number of nuclei in the (12 - 207) range and its average value is (0.55 - 0.60). As a sequel of this work we plan to measure in future the dependences of polarization of cumulative protons on the mass number A and on the kinetic energy of protons in the maximum limiting energy of the beam

$\Sigma_{LR} \pm \sigma(\Sigma_{LR})$

Table 1.

Tp ± (Tp), MeV \ A	C	Cu	Sn	Pb
196,8 ± 7,7	0,212 ± 0,017	0,263 ± 0,023	[illegible] ± 0,020	0,209 ± 0,023
213,6 ± 8,4	0,322 ± 0,026	0,296 ± 0,035	0,275 ± 0,030	0,231 ± 0,036
230,4 ± 9,4	0,278 ± 0,035	0,268 ± 0,049	0,313 ± 0,039	0,227 ± 0,047
255,0 ± 17,5	0,296 ± 0,036	0,306 ± 0,045	[illegible] ± 0,038	0,265 ± 0,045

$P_y \pm \sigma(P_y)$

Table 2.

Tp ± (Tp), MeV \ A	C	Cu	Sn	Pb
196,8 ± 7,7	0,467 ± [illegible]	0,581 ± 0,069	0,355 ± 0,051	0,463 ± 0,056
213,7 ± 8,4	0,706 ± 0,076	0,635 ± 0,087	0,[illegible] ± 0,079	0,503 ± 0,086
230,1 ± 9,4	0,582 ± 0,087	0,534 ± 0,119	0,[illegible] ± 0,096	0,489 ± 0,109
255,0 ± 17,5	0,592 ± 0,085	0,511 ± 0,103	0,[illegible] ± 0,089	0,543 ± 0,099

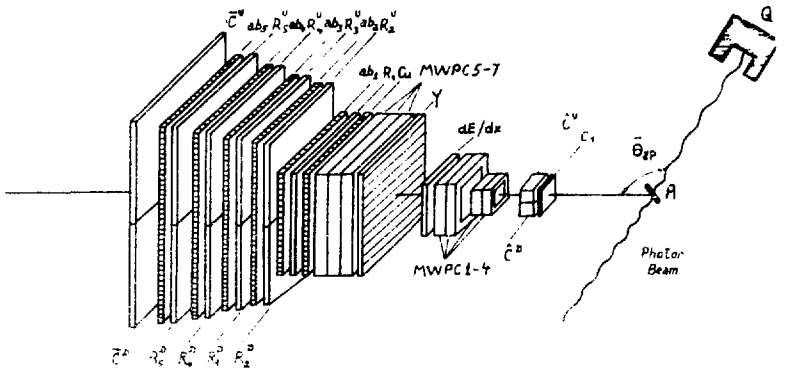
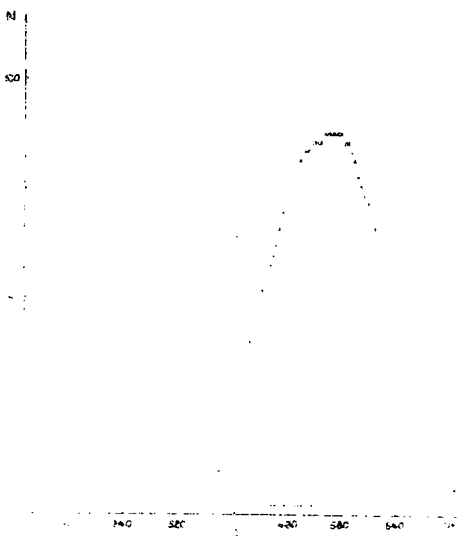


Fig. 1



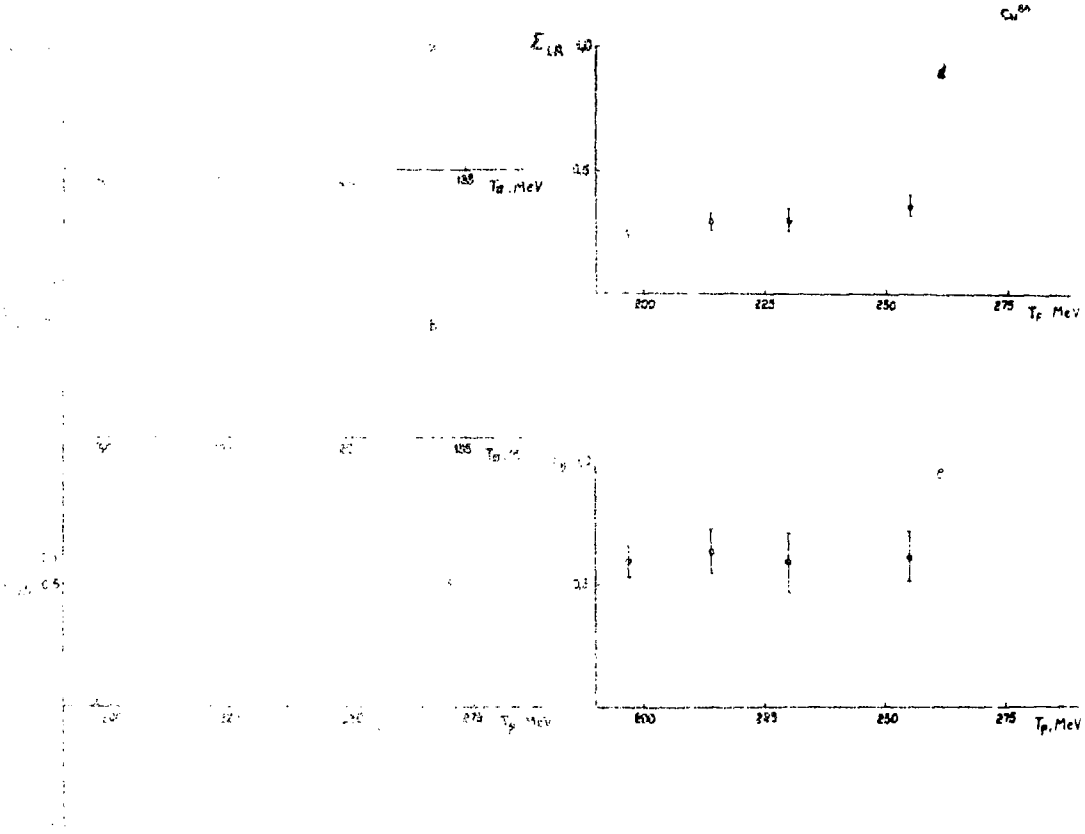


Fig. 3

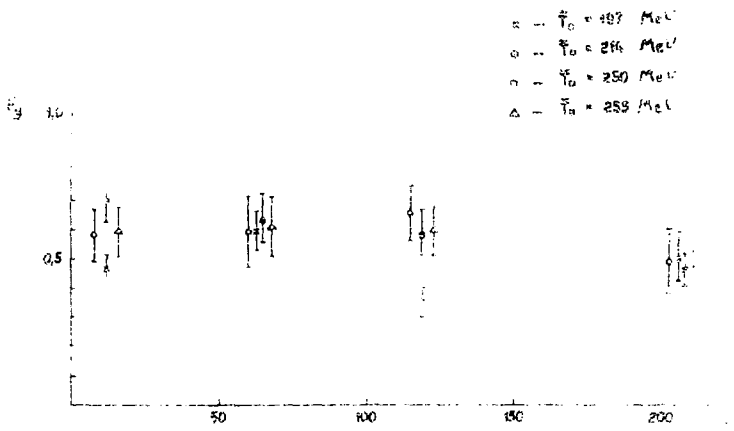


Fig.

FIGURE CAPTIONS

Fig.1 The layout of experimental setup. C_1 is the aperture counter $\hat{C}^{u,d}$ are the Cerenkov counters, MWPC 1-7 are the multiwire proportional chambers, dE/dx - the scintillation counter for amplitude analysis Cu the copper absorber $\tilde{C}^{u,d}$ - the anticoincidence counters, Y the carbon scatterer, A -the target and Q is the quantameter.

Fig.2 (dE/dx) spectrum of protons.

Fig.3 The energy dependences of asymmetry and polarization for Cu nucleus.

a) up-down asymmetry for pions

b) left-right asymmetry for pions

c) up-down asymmetry for protons

d) left-right asymmetry for protons

e) polarization of protons

Fig.4 The dependence of cumulative protons polarization on the atomic number of nucleus.

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ИЗМЕРЕНИЕ ПОЛЯРИЗАЦИИ КУМУЛЯТИВНЫХ ПРОТОНОВ В РЕАКЦИИ $\gamma^{A} \to Px$

(на английском языке, перевод М.Х.Исраеляна)

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