Laboratori Nazionali di Frascati

LNF-65/60

G. Barbiellini, G. Capon and G. P. Murtas : COMPTON EFFECT ON PROTON BY LINEARLY POLARIZED GAMMA RAYS AT THE FIRST RESONANCE, AT 90° IN THE CENTER OF MASS.

Estratto da : Proceedings of the Intern. Symp. on Electron and Photon Interactions at High Energies, Hamburg (Deutsches Phys. Gesellschaft, 1965), vol. II, p. 343

V. Compton Scattering

Compton Effect on Proton by Linearly Polarized γ-Rays at the First Resonance, at 90° in the Center of Mass

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The available experimental data on the proton Compton effect near the first resonance (E_γ = 320 MeV) are few and not very accurate.

We believe that an improvement of the experimental data can provide further theoretical insight on this problem, which with photoproduction is important to an understanding of the interactions between photon field and strong interacting particles.

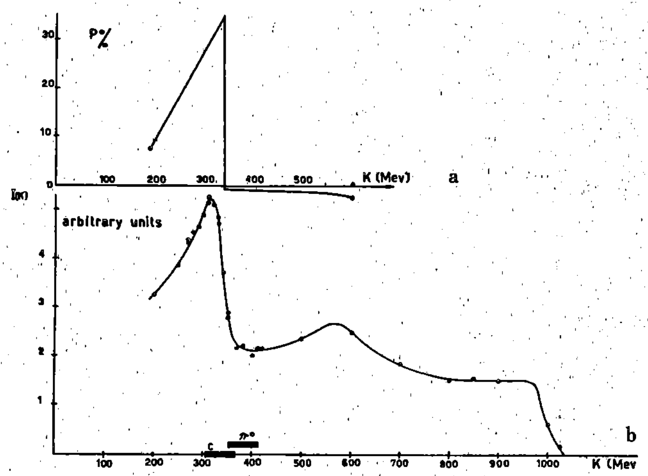

Fig. 1a and b., a) Behaviour of the theoretical photon polarization $P = \frac{N_\perp - N_\parallel}{N_\perp + N_\parallel}$ as function of the photon energy K. b) Experimental measurement of coherent bremsstrahlung intensity $I(K) = N(K) : K$ where $N(K)$ is the number of photons with energy between K and $K + \Delta K$. The energy resolution of the electron pair spectrometer is $\frac{\Delta K}{K} = \pm 4\%$

We will report some preliminary results on the following reaction

$$\gamma + p \rightarrow \gamma' + p' \qquad (1)$$

where the polarization of incident γ rays is known. The γ ray source is the coherent bremsstrahlung beam [1] from a diamond radiator obtained at the 1 GeV Frascati electronsynchrotron.

The energy spectrum of bremsstrahlung intensity is continuously measured by an electron-pair spectrometer, with energy resolution $\frac{\Delta K}{K} = \pm 4\%$. The energy spectrum and polarization of the beam is shown in Fig. 1. In Fig. 2 is shown a detail of such a spectrum. The spectrum n. 10 corresponds to a photon polarization in the energy region K < 340 MeV, perpendicular to the horizontal plane which is our experimental plane.

The spectrum n. 7 corresponds to a parallel polarization.

The two beams with perpendicular and parallel polarization are obtained by using two diamonds with the [110] axis at an angle θ with electron beam, and the [001] axis vertical and horizontal respectively.

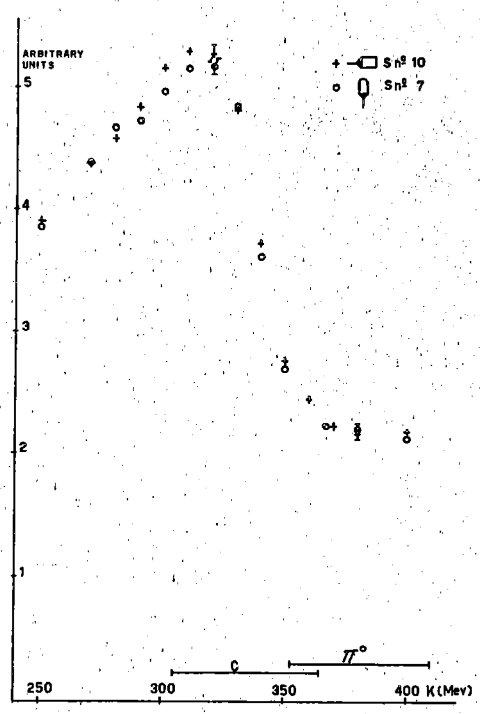

Fig. 2. Detail of the intensity I(K) energy spectrum. The two stressed regions represent the energy range of the incident photon detected by our experimental apparatus for the Compton effect and for the π^0 photoproduction respectively. Label ⊸ ♀ stands for horizontal diamond and horizontal polarization (vertical diamond and vertical polarization). The position of the discontinuity of the spectrum can be reproduced within ~ 2 MeV of photon energy

The experimental analysis of the process (1) is particularly difficult for the concourrence of the π° photoproduction which can simulate an event of reaction (1).

In Fig. 2 are given the energy ranges detected by our apparatus for the two reactions.

The separation between the two processes is obtained looking for the angular correlation between photon and proton as given by the Compton kinematics.

This method has been previously used by Deutsch [2]. The experimental set-up is shown in Fig. 3. The photon counter consists of a shower spark chamber with lead plates of total radiation length 1,7, an integral lead glass Čerenkov counter Č with in front a veto plastic counter A.

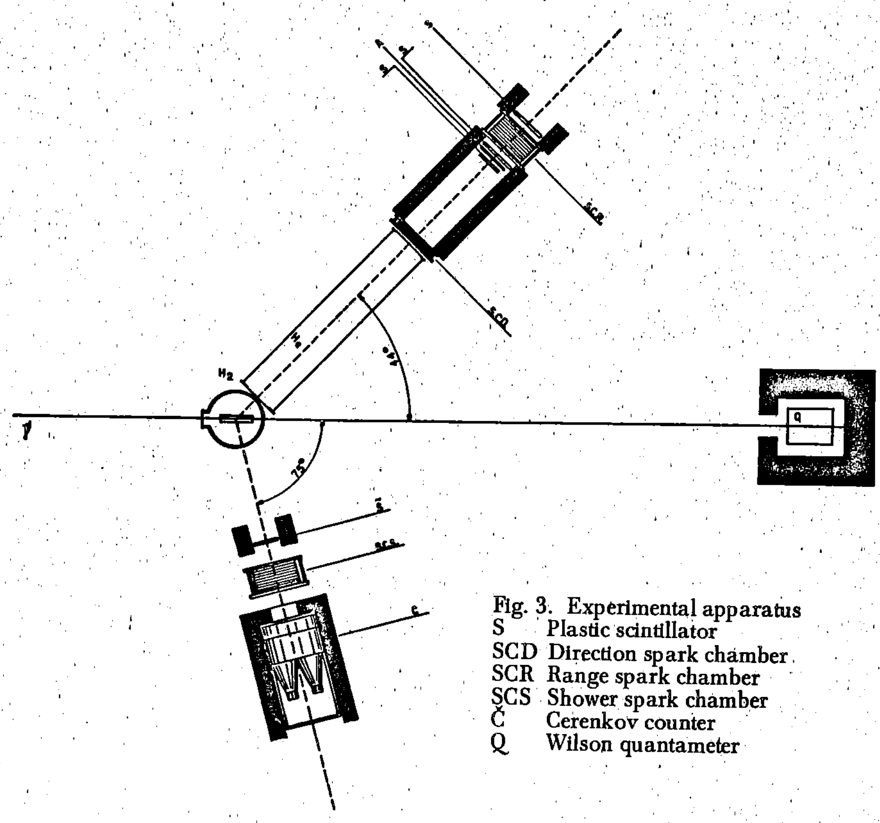

Fig. 3. Experimental apparatus
S Plastic scintillator
SCD Direction spark chamber
SCR Range spark chamber
SCS Shower spark chamber
Č Čerenkov counter
Q Wilson quantameter

The proton hodoscope contains two spark chambers, the first one measures the direction, and the second one the range of the proton. The central direction accepted by the spark chambers corresponds to 90° in the C. M.

Three plastic scintillators define a stopped proton in the range chamber by the coincidence $S_1 S_2 \bar{S}_3$. The S_1 pulse hight is analyzed. The photomultiplier voltage of $S_1 S_2 S_3$ is regulated in order to have small pion contamination.

Spark chambers are triggered by the coincidence $S_1 S_2 \bar{S}_3 \check{C} \bar{A}$. The events are analyzed in the following way [2].

From the two proton spark chambers we measure the proton kinetic energy and angle, to which, in the Compton kinematics, corresponds a certain value of the photon angle $\theta_{\gamma t}$.

From the shower spark chamber we measure the experimental photon angle $\theta_{\gamma s}$, and then we calculate the difference $\Delta\theta = \theta_{\gamma t} - \theta_{\gamma s}$. Likewise, we determine the angle $\Delta\varphi$ between the plane defined by the beam and the proton direction, and that defined by the beam and the photon direction.

The events plotted against $\Delta\theta$, $\Delta\varphi$ show a bump for $\Delta\theta \simeq \Delta\varphi \simeq 0°$ due to the Compton effect, above continuous background due to π^0 photoproduction.

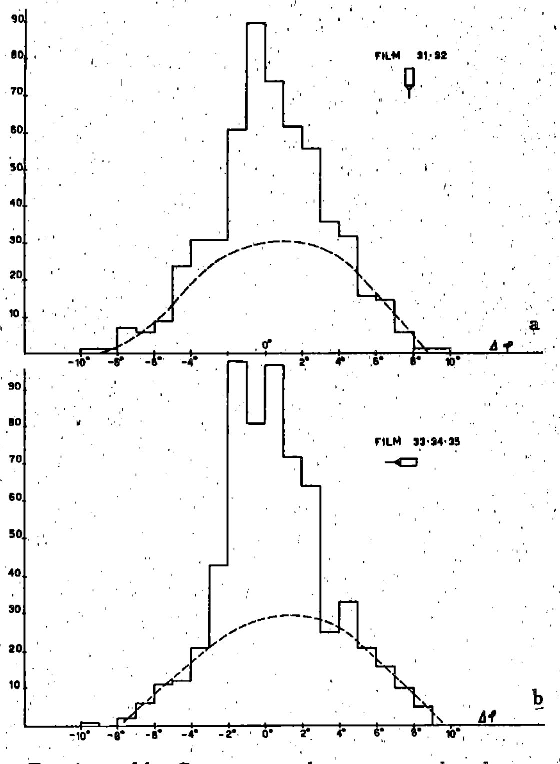

Fig. 4a and b. Compton and π^0 events distribution against $\Delta\varphi$ after integration on $\Delta\theta$ between $\pm$ 3°. a) Photon polarization perpendicular; b) Photon polarization horizontal. Dashed lines give background behaviour

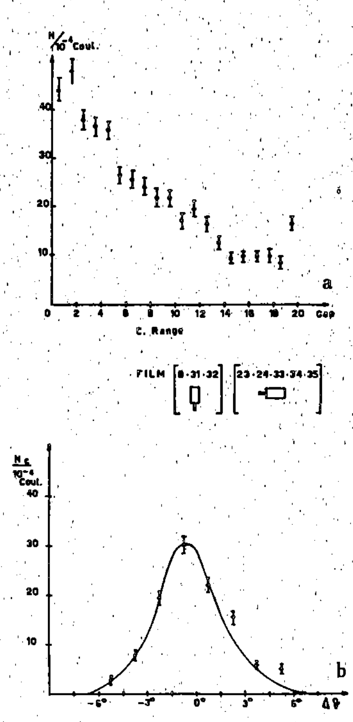

Fig. 5a and b. a) Total events distribution as function of the gap in Range spark chamber. b) Compton events distribution as function of $\Delta\theta$

At present we have analyzed ~ 2600 events of which ~ 600 are Compton events. For the halfwidth of the bump we find $\Delta\theta = 2{,}5°$ $\Delta\varphi = 2°$.

In Fig. 4 events are plotted against $\Delta\varphi$ after having integrated in $\Delta\theta$ from $-3°$ to $+3°$.

The dotted lines show the photoproduction background.

In Fig. 5a we have plotted the events against the proton range; in Fig. 5b is shown the behaviour of the Compton events against $\Delta\theta$

The Compton events are divided in two energy regions of the photon beam:

first region $305 \leq E_\gamma \leq 340$ MeV

second region $340 \leq E_\gamma \leq 375$ MeV.

In the first region we have the maximum polarization of the beam: $P \simeq 30\%$, while the second region the polarization is practically zero as is also shown in Fig. 6.

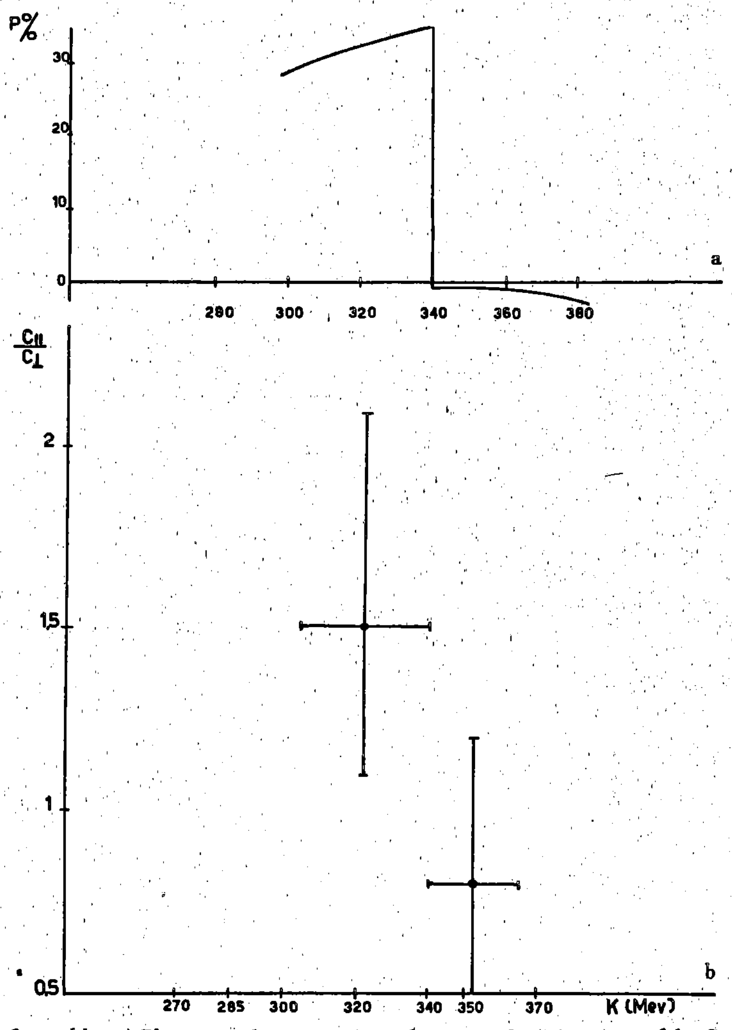

Fig. 6a and b. a) Photons polarization P as function of K; b) Ratio of the Compton events for the two photon polarization as a function of K. $R_C = \frac{C_{\parallel}}{C_{\perp}}$. Horizontal lines mean accepted energy photon

The ratio of the Compton counts for the two positions of the diamond is respectively;

$$R_C = \frac{C_{\parallel}}{C_{\perp}} = 1{,}5 \begin{matrix} +0{,}6 \\ -0{,}4 \end{matrix} \quad \text{for the first region}$$

$$R_C = \frac{C_{\parallel}}{C_{\perp}} = 0{,}8 \begin{matrix} +0{,}4 \\ -0{,}3 \end{matrix} \quad \text{for the second region}$$

From these results and from the mean value of the polarization we calculate the ratio:

$$E_{\sigma} = \frac{d\sigma_{\parallel}}{d\sigma_{\perp}} = \frac{|P|(R_c + 1) + (R_c - 1)}{|P|(R_c + 1) - (R_c - 1)}$$

However, because of the "error" propagation, the upper limit for R_{σ} is infinite so that we obtain:

$$R_{\sigma} = 3{,}9 \begin{matrix} -2{,}6 \\ +\infty \end{matrix} \qquad 305 \leq E_{\gamma} \leq 340 \text{ MeV}.$$

Therefore, with the poor statistics at our disposition, we may only conclude that $d\sigma_{\parallel} > d\sigma_{\perp}$.

Measures are in progress and we hope that soon we will be able to give better results for R_{σ} and also a value of the Compton differential cross section $d\sigma$ at 90° in the center mass system for unpolarized photons, i. e. $\frac{d\sigma_{\parallel} + d\sigma_{\perp}}{2}$.

References

[1] G. Barbiellini, G. Bologna, G. Diambrini and G. P. Murtas, Phys. Rev. Lett., *8*, 112, (1962).
[2] R. F. Stiening, E. Loh and M. Deutsch, Phys. Rev. Lett, *10*, 536, (1963).

Angular Distributions in the Proton Compton Scattering at γ-Ray Energies of 215 and 248 MeV

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I. Introduction

At present the theory of the proton Compton effect is based on dispersion relations. It is worth mentioning that uncertainties of theoretical calculations appear to be minimum at comparatively small photon energies.

The up to date experimental results on the proton Compton effect study are still very poor.