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P. Gorenstein, M. Grilli, M. Nigro, E. Schiavuta, F. Soso, P. Spillantini and V. Valente : ASYMMETRY RATIOS IN THE PHOTOPRODUCTION OF π^+ BY LINEARLY POLARIZED γ RAYS IN THE ENERGY RANGE 200 - 400 MeV. -

(Nota interna: n. 320)

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P. Gorenstein, M. Grilli, M. Nigro(x), E. Schiavuta(x), F. Soso, P. Spillantini, V. Valente(x): ASYMMETRY RATIOS IN THE PHOTOPRODUCTION OF π^+ BY LINEARLY POLARIZED γ RAYS IN THE ENERGY RANGE 200 - 400 MeV.

(Submitted for publication to Physics Letters)

In the framework of a systematic study of the reaction:

$$\gamma + p = n + \pi^+ \tag{1}$$

around the first resonance, using linearly polarized photons, we are measuring the asymmetry ratio

$$A(\theta) = \frac{\sigma_\perp(\theta) - \sigma_\parallel(\theta)}{\sigma_\perp(\theta) + \sigma_\parallel(\theta)} \tag{2}$$

with the apparatus and technique previously described(1), at different angles and different incident photon energies.

The quantities $\sigma_\perp$($\sigma_\parallel$), in (2), are defined as the differential cross section for the process (1) by photons with the electric vector perpendicular (parallel) to the production plane. The angle θ is the produc-

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tion angle of the π in the c.m. system.

We report here our results for $A(90^o)$ in the energy interval $E_\gamma = 200 - 400$ MeV. A small part of these results have previously been published(1).

A measurement of $A(90^o)$ as a function of E_γ determine the term $Io(90^o)$ of the following expression, as a function of energy:

$$I(\theta) = - \frac{1}{\text{sen}^2\,\theta} \frac{K}{q} \frac{\sigma_\perp(\theta) - \sigma_\parallel(\theta)}{2} = \frac{1}{\text{sen}^2\,\theta} A(\theta)\; \sigma(\theta) = \tag{3}$$

$$= Io(\theta) + I_1(\theta)\cos\theta$$

where

K = γ-ray's momentum in the c.m. system
q = π's momentum in the c.m. system

$$\sigma(\theta) = \frac{\sigma_\perp(\theta) + \sigma_\parallel(\theta)}{2}$$ = differential cross section by unpolarized γ - rays.

The coefficients I_o and I_1 are different functions of the amplitude of the various terms contributing to the reaction (1).

In particular,

$$Io(\theta) = \frac{1}{2}\left\{ |\mathcal{F}_3|^2 + |\mathcal{F}_4|^2 + 2\,\text{Re}(\mathcal{F}_1\mathcal{F}_4^x) + 2\,\text{Re}(\mathcal{F}_2\mathcal{F}_3^x)\right\}, \tag{4}$$ where

the amplitudes $\mathcal{F}_1, \ldots\ldots \mathcal{F}_4$ are defined in (2)

A specific model must be introduced to get definite information from such kind of analysis on I_o: here we want just to note that the quadratic form of the amplitudes $\mathcal{F}_i (i = 1, \ldots.. 4)$ entering I_o is essentially different from the one associated to the differential cross section as given by the following expression:

$$\frac{K}{q}\,\sigma(90^o) =$$

$$= \left[|\mathcal{F}_1|^2 + |\mathcal{F}_2|^2 + \frac{1}{2}|\mathcal{F}_3|^2 + \frac{1}{2}|\mathcal{F}_4|^2 + \text{Re}\,\mathcal{F}_1\mathcal{F}_4^x + \text{Re}\,\mathcal{F}_2\mathcal{F}_3^x \right] \tag{5}$$

The comparison of the expressions (4) and (5) is a clear example of the complementarity of measurements on process (1) by polarized and unpolarized γ rays, as has been extensively discussed by many authors(3,6).

The source of polarized photons in our experiment was the coherent bremsstrahlung beam developed at the Frascati synchrotron by Barbiellini et al.(7).

The polarization of the beam is defined as

(6) $$P = \frac{N_{\perp} - N_{\parallel}}{N_{\perp} + N_{\parallel}}$$

where $N_{\perp}$ ($N_{\parallel}$) is the relative number of photons having their electric vector perpendicular (parallel) to the (γ, π) plane. In our measurements the value of P ranged from 33% to 13%. The values of P are not measured directly, but are obtained from Born approximation calculations of coherent bremsstrahlung. The reliability of the values of P lies on the agreement between the experimental and the computed values of the bremsstrahlung intensity. Such calculations are affected by some factors(8): namely, the incertitude in the knowledge of crystal orientation, the mosaic structure of the crystal, the incoherent background and the atomic form factor. The uncertainties in the calculated values of P due to these factors are, however, certainly smaller than $\Delta P \approx \pm 1\%$.

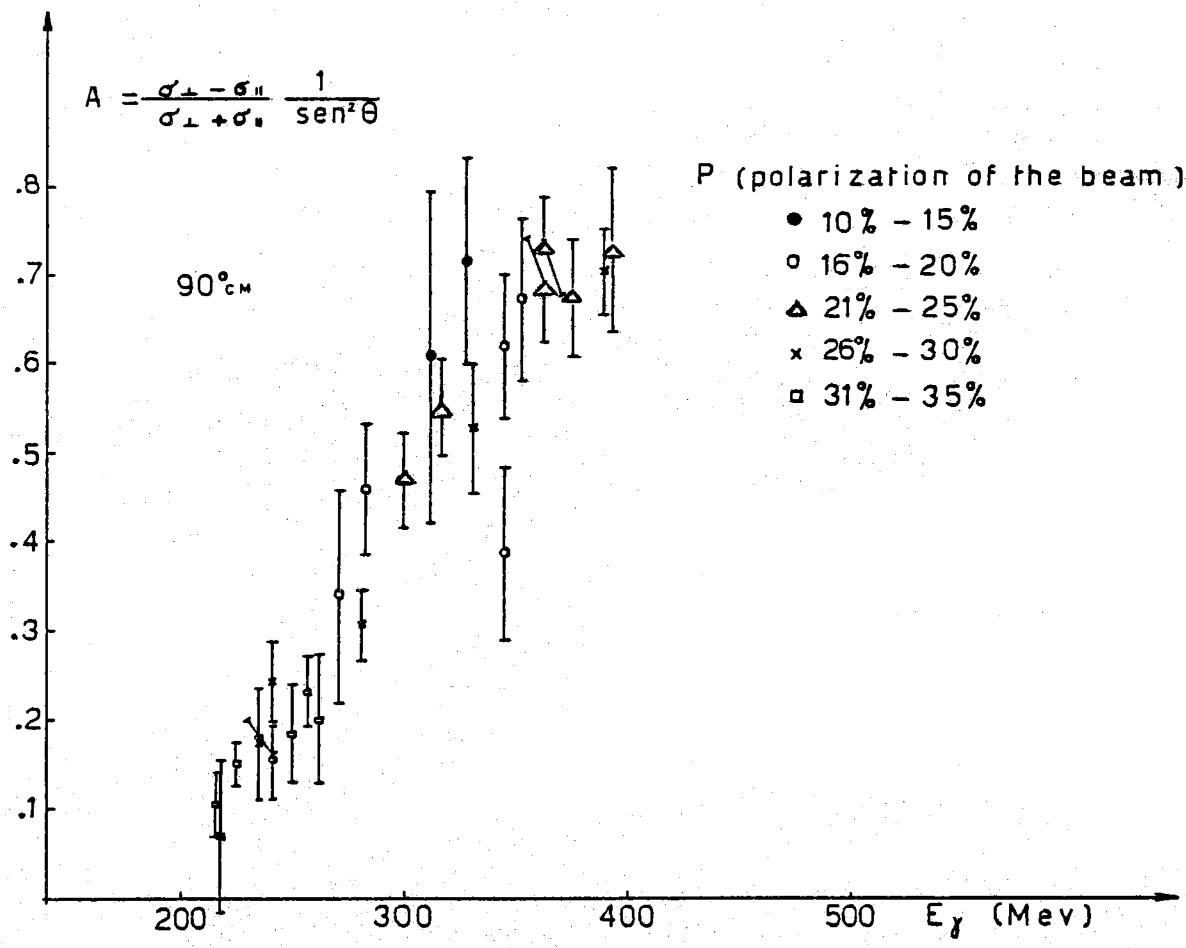

FIG. 1 - All measured points of A(90°) are reported vs γ-ray's energy. Some of the neighboring points have been measured, for comparison, using different values for the polarization of the photon's beam (P).

The data we report for the asymmetry ratio A(90°) have been corrected for the various backgrounds (empty target, electrons, multi-pion photoproduction) as explained in (1). The errors shown are the statistical error only. The total errors, including also the estimated error on P and on the background subtraction, would be at most 1.3 times the statistical errors. Each value of A(90°) has been measured many times in different runs. Moreover some neighboring points have been measured using different values of P. (see fig. 1).

All our measurements are shown in fig. 1. It can be seen that the points taken with different values of P are consistent.

In table I we give our final results for A(90°) at different energies, with points at neighbouring energies lumped together. In the same table we give also previous results of Smith and Mozley[9].

In fig. 2 all these results for A(90°) are compared with the theoretical prevision of W. Schmidt[10] and of A. Donnachie and G. Shaw[3].

It is evident that the results for $E_\gamma >$ 300 MeV give a larger asymmetry than is predicted by the theory.

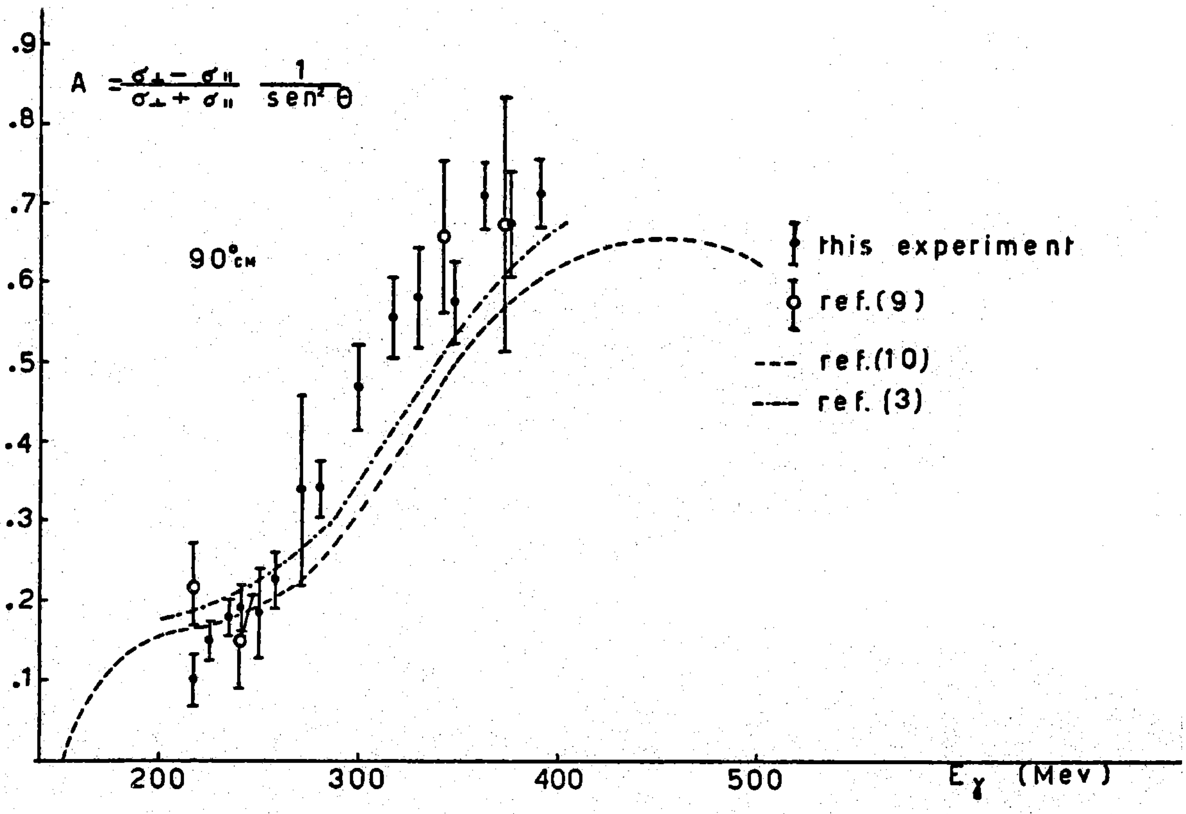

FIG. 2 - Final results for the asymmetry ratio A(90°) at different γ-ray's energies (E_γ). We report also some previous results of Smith and Mozley[9]. For comparison we have indicated the results of the theoretical calculations of Schmidt[10] and of Donnachie and Shaw[3].

TABLE I - Asymmetry ratio A (90°)

E_γ (MeV)	A	Reference
217	.100 ± .033	(x)
225	.150 ± .025	(x)
227	.219 ± .048	(o)
235	.179 ± .023	(x)
240	.191 ± .029	(x)
240	.148 ± .038	(o)
250	.184 ± .056	(x)
260	.226 ± .035	(x)
270	.328 ± .120	(x)
281	.341 ± .035	(x)
300	.469 ± .054	(x)
315	.556 ± .050	(x)
330	.581 ± .062	(x)
342	.664 ± .098	(o)
348	.575 ± .051	(x)
363	.710 ± .043	(x)
373	.671 ± .164	(o)
376	.675 ± .067	(x)
391	.714 ± .044	(x)

(x) Present work

(o) Stanford (see (3)).

A complete discussion of our results and of the comparison of these with the theoretical predictions will be done later on the basis of the data relative not only to $\theta = 90^\circ$ but also to different angles and energies. These measurements and the corresponding analysis is now in progress.

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