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ASYMMETRY RATIOS IN THE PHOTOPRODUCTION OF π^+ BY LINEARLY POLARIZED γ-RAYS IN THE ENERGY RANGE 200-400 MeV

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The asymmetry ratio for the process $\gamma + p \rightarrow n + \pi^+$ by linearly polarized γ rays are reported for E_γ = = 200 - 400 MeV and for θ (production angle of π in the c.m. system) = 90°. The experimental results are compared with some recent theoretical predictions.

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 measured the asymmetric ratio

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

with the apparatus and technique previous described [1], at different angles and different incident photon energies.

The quantities $\sigma_\perp(\sigma_\parallel)$, in eq. (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 production angle of the pion in the c.m. system.

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

A measurement of $A(90^\circ)$ as a function of E_γ determine the term $I_0(90^\circ)$ of the following expression, as a function of energy:

$$I(\theta) = -\frac{1}{\sin^2\theta}\frac{K}{q}\frac{\sigma_\perp(\theta) - \sigma_\parallel(\theta)}{2} = \frac{1}{\sin^2\theta}A(\theta)\,\sigma(\theta) =$$

$$= I_0(\theta) + I_1(\theta)\cos\theta \tag{3}$$

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

Table 1
Asymmetry ratio $A(90^\circ)$

E_γ (MeV)	A	Reference
210	0.183 ± 0.071	(x)
217	0.101 ± 0.033	(x)
225	0.151 ± 0.025	(x)
227	0.219 ± 0.048	(o)
235	0.179 ± 0.023	(x)
240	0.148 ± 0.038	(o)
241	0.191 ± 0.029	(x)
250	0.184 ± 0.056	(x)
258	0.226 ± 0.035	(x)
271	0.328 ± 0.120	(x)
281	0.341 ± 0.035	(x)
300	0.469 ± 0.054	(x)
317	0.560 ± 0.050	(x)
330	0.594 ± 0.063	(x)
342	0.664 ± 0.098	(o)
348	0.606 ± 0.050	(x)
363	0.768 ± 0.042	(x)
373	0.671 ± 0.164	(o)
376	0.736 ± 0.073	(x)
391	0.705 ± 0.050	(x)
416	0.835 ± 0.095	(x)
436	0.641 ± 0.126	(x)

(x) - Present work
(o) - Stanford (see ref. 3).

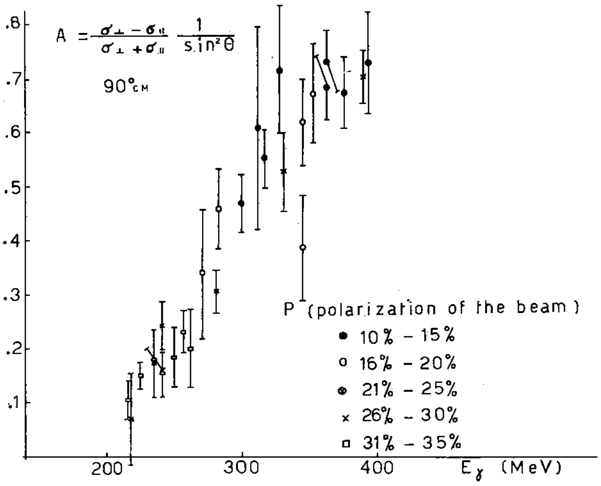

Fig. 1. All measured points of $A(90^o)$ are reported versus γ ray's energy. Some of the neighbouring points have been measured, for comparison, using different values for the polarization of the photon's beam (P).

$\sigma(\theta) = \frac{1}{2}(\sigma_\perp(\theta) + \sigma_\parallel(\theta))$ = differential cross section by unpolarized γ-rays.

The coefficients I_0 and I_1 are different functions of the amplitude of the various terms contributing to the reaction (1).

In particular,

$$I_0(\theta) = \tfrac{1}{2}\{|\mathcal{G}_3|^2 + |\mathcal{G}_4|^2 + 2\,\mathrm{Re}(\mathcal{G}_1\mathcal{G}_4^*) + 2\,\mathrm{Re}(\mathcal{G}_2\mathcal{G}_3^*)\} , \quad (4)$$

where the amplitudes $\mathcal{G}_1, \ldots \mathcal{G}_4$ are defined in ref. 2.

A specific model must be introduced to get definite information from such an analysis of I_0: here we just want to note that the quadratic form of the amplitudes $\mathcal{G}_i (i = 1, \ldots, 4)$ entering I_0 is essentially different from that associated with the differential cross section as given by the following expression:

$$\frac{K}{q}\sigma(90^o) = [\,|\mathcal{G}_1|^2 + |\mathcal{G}_2|^2 + \tfrac{1}{2}|\mathcal{G}_3|^2 + \tfrac{1}{2}|\mathcal{G}_4|^2 + \mathrm{Re}(\mathcal{G}_1\mathcal{G}_4^*) + \mathrm{Re}(\mathcal{G}_2\mathcal{G}_3^*)\,] . \quad (5)$$

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

$$P = (N_\perp - N_\parallel)/(N_\perp + N_\parallel) , \quad (6)$$

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 depends on the agreement between the experimental and the computed values of the bremsstrahlung intensity. Such calculations are affected by some factors [8]: namely, the uncertainty 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 $\Delta P \approx \pm 1\%$.

The data we report for the asymmetry ratio $A(90^o)$ have been corrected for the various backgrounds (empty target, electrons, multi-pion photoproduction) as explained in (1). The errors shown are only the statistical error. The total errors, including also the estimated error in P and in the background subtraction, would be at most 1.3 times the statistical errors. Each value

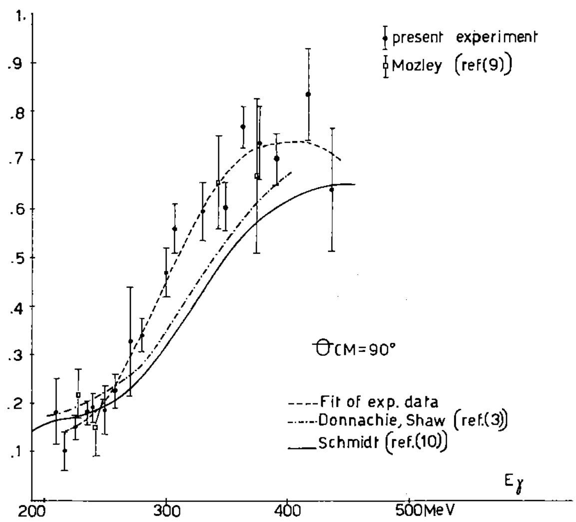

Fig. 2. Final results for the asymmetry ratio $A(90^o)$ at different γ-ray's energies ($E\gamma$). We report also some previous results of Smith and Mozley [9]. For comparison we have indicated the results of the theoretical calculations of Schmidt [10] and of Donnachie and Shaw [3].

of $A(90^o)$ has been measured many times in different runs. Moreover some neighbouring 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 1 we give our final results for $A(90^o)$ at different energies, with points at neighbouring energies lumped together. In the same table we give also the previous results of Smith and Mozley [9].

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

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

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

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