Laboratori Nazionali di Frascati

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M. Beneventano, L. Paoluzi, F. Sebastiani, M. Severi and M. Grilli : SINGLE-POSITIVE-PION PHOTOPRODUCTION ON HYDROGEN IN THE ENERGY RANGE (500-800) MeV.

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Single-Positive-Pion Photoproduction on Hydrogen in the Energy Range (500 ÷ 800) MeV.

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Summary. — Cross-sections for the photoproduction of positive pions in hydrogen have been measured at the 1.1 GeV Frascati electron synchrotron for photon energies E_γ between 500 and 800 MeV and for π^+ c.m. angles of $\theta = 30°, 90°$. The cross-sections exhibit a smooth behavior as a function of energy for $E_\gamma = (500 \div 600)$ MeV. No immediate evidence is found of a contribution of the P_{11} resonance.

We report measurements of the differential cross-section of the single-π^+ photoproduction

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

for $\theta = 30°$, $90°$ (c.m. production angle of the pion) in the range of energy $E_\gamma = (500 \div 800)$ MeV.

Preliminary results have been reported at the Meeting of the Italian Physical Society (Trieste, November 1966).

The experiment has been designed in order to add data in the rather poor region between the « 1st » and « 2nd » resonance (1).

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(1) Only very recently extensive measurements have been carried out in this region by: *a*) C. BETOURNE, J. C. BIZOT, J. PEREZ-Y. JORBA and D. TREILLE: *Phys. Lett.*, **243**, 590 (1967); *b*) S. D. ECKLUND and R. L. WALKERS: *Phys. Rev.*, **155**, 1195 (1967).

As is also known the contributions of the P_{11} resonance ([2]) could appear in this region.

1. – The experimental set-up is shown in Fig. 1. Charged positive particles, produced in a liquid hydrogen target ($d = 6$ cm) by the bremsstrahlung beam

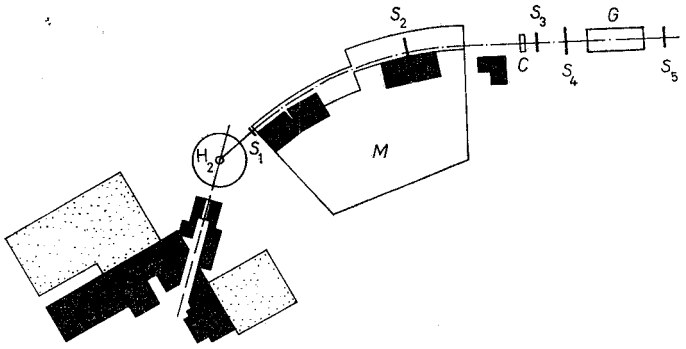

Fig. 1. – The experimental set-up

of the Frascati electronsynchrotron, have been analysed by the strong focusing magnet (M) ([3]) with an angle and momentum acceptance given, respectively, by $\Delta\theta = \pm 2°$ and $\Delta p/p = \pm 8\,\%$ (corresponding to $\pm 2\,\%$ for each channel; see later). The π^+-momentum and angle determine the kinematics of the reaction (1).

The Čerenkov counters G (CO_2, 10 atm) and C (H_2O, $d = 10$ cm) discriminate against the electrons and the protons, respectively.

The rejection factor against these particles was 0.03 (protons), 0.01 (electrons), with a variation over the momentum band accepted certainly less than 0.01.

Simultaneous measurements have been carried out on a large momentum band $\Delta p/p = \pm 8\,\%$, subdivided in four intervals by means of the multichannel logic described in ([4]). To each of these channels correspond a momentum acceptance and separation of $\Delta p/p = \pm 2\,\%$ and 3.1 %, respectively. The electronic block diagram is shown in Fig. 2.

([2]) In regard to this see A. DONNACHIE: *Phys. Lett.*, **24** B, 420 (1967).

([3]) *a*) G. SACERDOTI and L. TAU: *Nucl. Instr. and Meth.*, **16**, 139 (1962); *b*) B. BORGIA, P. JOOS and M. GRILLI: L.N.F. 66/15 (1966).

([4]) M. GRILLI, M. NIGRO, E. SCHIAVUTA, P. SPILLANTINI, F. SOSO and V. VALENTE: *Positive-pion photoproduction by linearly polarized γ-rays*, *Nuovo Cimento* (to be published).

Since we were interested in the energy-dependence of the cross-sections, only relative measurements have been made.

Our measurements have been normalized to the Caltech measurements [5] at $E_\gamma = 600$ MeV.

The counting rates have been corrected by the following effects:

i) empty target contribution $((5 \div 10)\%)$,

ii) the accidentals, measured at same time by means of the delayed fivefold coincidence and oscilloscope presentation, see Fig. 2, result to be $(2 \div 6)\%$ for $\theta = 90°$, and $(10 \div 20)\%$ for $\theta = 30°$,

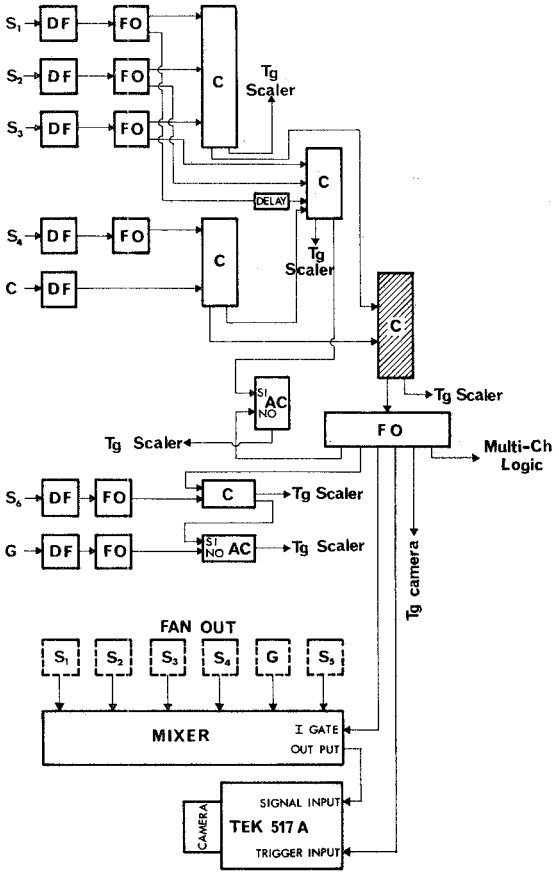

Fig. 2. – The electronic block diagram. *DF*: fast discriminator and shaper, *FO*: fan out, *C*: coincidence.

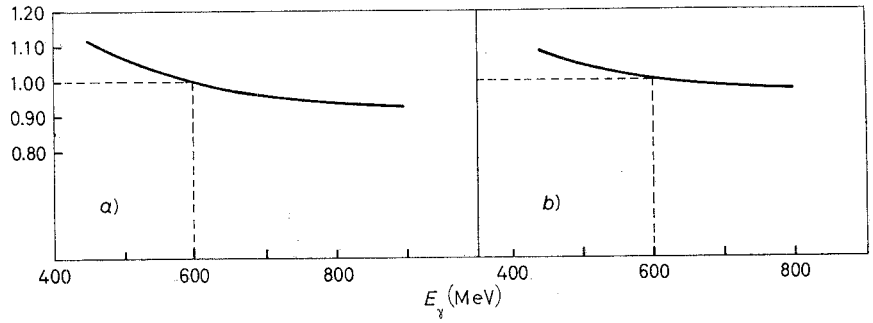

Fig. 3. – The corrective factor F at 90° c.m. (a)) and at 30° c.m. (b)) *vs.* the γ-ray energy.

(5) F. P. DIXON and R. L. WALKER: *Phys. Rev. Lett.*, **1**, 142, 458 (1958).

iii) the shape of the bremsstrahlung spectrum from a thick target ([6]),

iv) decay in flight of the pions between the target and the S_4 counter,

v) nuclear interactions and Coulomb scattering of the pions in the telescope.

The correcting factor (F) due to iv) and v) has been calculated. Setting $F = 1$ for $E_\gamma = 600$ MeV, this factor is included between 1.07 and 0.93 ($\theta = 90°$) and $1.09 \div 0.97$ ($\theta = 30°$) (Fig. 3*a*), *b*)). We have not taken into account the μ^+-contamination, from the π^+-decay. We have estimated that its variation amounts to less than 3% in the kinematic regions of interest.

In order to avoid the multipion background we have worked with $E_{\gamma max}$ sufficiently close to useful photon energy.

2. – The results are reported in Table I and Fig. 4*a*), *b*). The indicated errors include the statistical error on the counting rate and on the background subtractions.

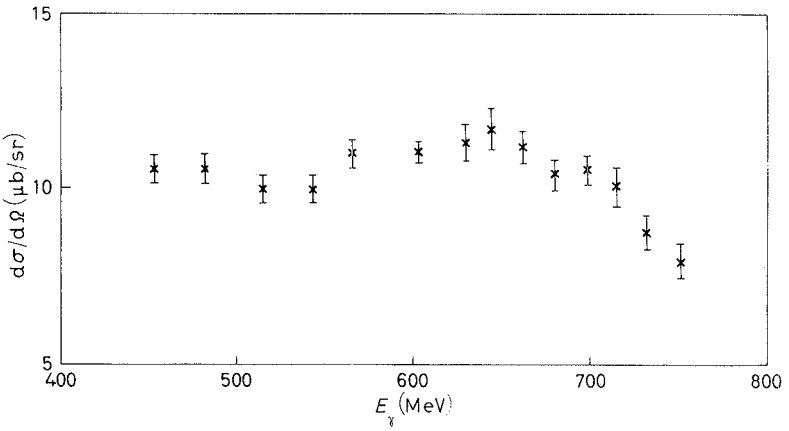

Fig. 4*a*. – The differential cross-section $d\sigma/d\Omega$ at 30° c.m. *vs.* the γ-ray energy.

The precision in the π^+'s momentum (p) is of the order of $\pm 0.9\%$ (ref. ([3b])). The corresponding precision in the energy of incoming photon is $\Delta E_\gamma = \pm 10$ MeV ($\theta = 90°$) and $\Delta E_\gamma = \pm 7$ MeV ($\theta = 30°$) for $E_\gamma = 700$ MeV.

Moreover, owing to an incipient effect of magnetic saturation, the precision in the measurement of p is very probably worse than $\pm 1\%$ for $E_\gamma > 700$ MeV and $\theta = 30°$.

([6]) G. DIAMBRINI, A. S. FIGUERA, B. RISPOLI and A. SERRA: *Nuovo Cimento*, **19**, 250 (1961).

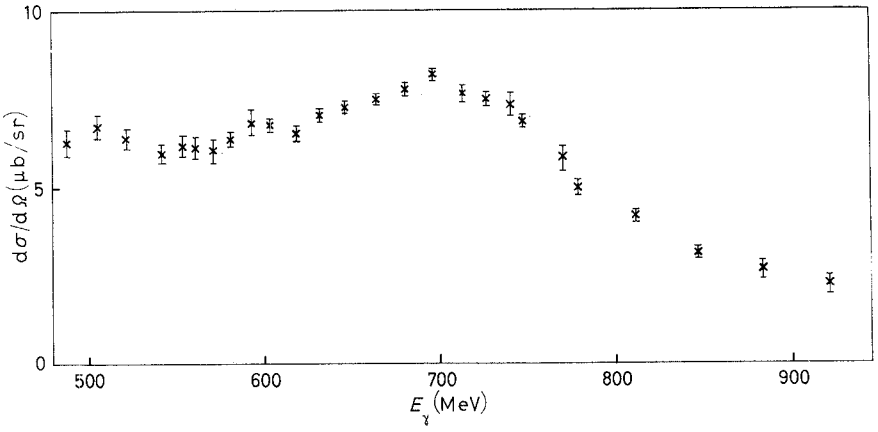

Fig. 4*b*. – The differential cross-section $d\sigma/d\Omega$ at 90° c.m. *vs.* the γ-ray energy.

TABLE I.

$\theta = 30°$		$\theta = 90°$	
E_γ(MeV)	$d\sigma/d\Omega$ (μb/sr)	E_γ (MeV)	$d\sigma/d\Omega$ (μb/sr)
752	8.0 ± 0.5	922	2.14 ± 0.24
732	8.8 ± 0.5	884	2.62 ± 0.18
715	10.1 ± 0.6	848	3.12 ± 0.15
698	10.6 ± 0.6	812	4.13 ± 0.15
680	10.5 ± 0.5	779	4.94 ± 0.18
663	11.2 ± 0.5	771	5.77 ± 0.35
645	11.8 ± 0.6	748	6.86 ± 0.13
629	11.4 ± 0.5	741	7.34 ± 0.34
602	11.1 ± 0.3	728	7.50 ± 0.13
567	11.0 ± 0.4	714	7.66 ± 0.19
542	10.0 ± 0.4	697	8.18 ± 0.12
516	10.0 ± 0.4	681	7.79 ± 0.16
482	10.6 ± 0.4	665	7.51 ± 0.11
453	10.6 ± 0.4	647	7.29 ± 0.16
		632	7.05 ± 0.17
		619	6.54 ± 0.19
		604	6.77 ± 0.18
		593	6.84 ± 0.41
		581	6.38 ± 0.19
		571	6.04 ± 0.39
		561	6.16 ± 0.29
		554	6.17 ± 0.35
		542	5.95 ± 0.26
		522	6.39 ± 0.28
		506	6.76 ± 0.39
		488	6.23 ± 0.39

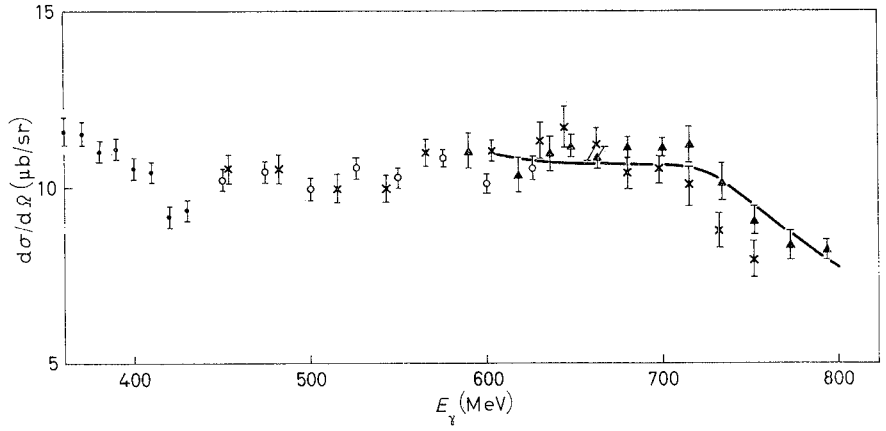

Fig. 5*a*. – Comparison between our results and those of other recent experiments and recent theoretical calculations at 30° c.m. • Bonn, 1965 ([8]); ▲ Caltech, 1967 ([1b]); o Orsay, 1967 ([1a]); × this experiment; ——— SCHMIDT *et al.* ([7]).

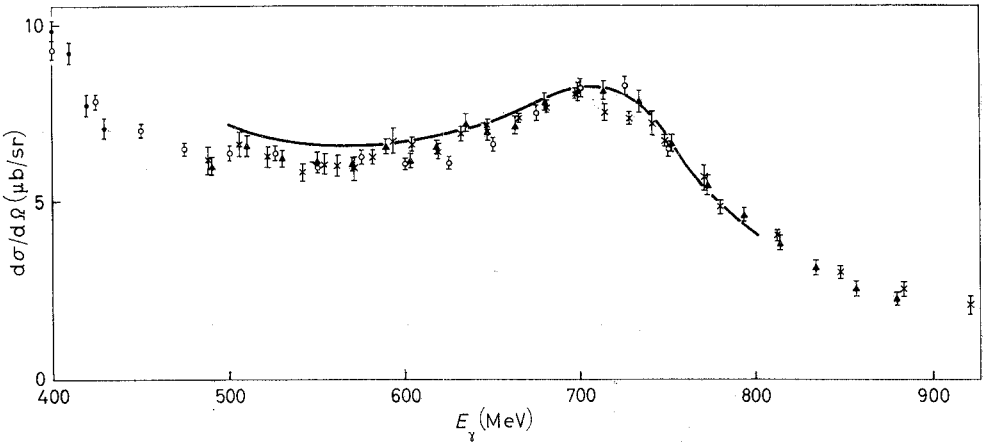

Fig. 5*b*. – Comparison between our results and those of other recent experiments and recent theoretical calculations at 90° c.m. • Bonn, 1965 ([8]); ▲ Caltech, 1967 ([1b]); o Orsay, 1967 ([1a]); × this experiment; ——— SCHMIDT *et al.* ([7]).

3. – For comparison we report in Fig. 5*a*), *b*) our results and those of other recent experiments ([1]), together with recent theoretical calculations ([7]).

We note a good agreement between our data and the other recent measurements (Orsay ([1a]), Caltech ([1b])). In the 700 MeV region, for $\theta = 30°$, our data seem to be systematically lower than the Caltech measurements. An explanation of this fact could be the incipient saturation in our magnetic channel (see above).

([7]) W. SCHMIDT and G. SCHWIDERSKI: *Phenomenological description of pion photoproduction in the region of the D_{13} and F_{15} pion-nucleon resonances* (Dubna, February 1967); and private communications.

The agreement between the theoretical calculations of SCHMIDT *et al.* (7) and the data is good.

As explained in (7), these calculations result from an extrapolation of the P_{33} isobar contribution, with appropriate corrections in the multipoles E_{2-}, M_{2-} connected with the D_{13} resonance. Also contributions of higher resonances are included. From their analysis these authors conclude that no peculiar correction in the multipole $M_{1-}^{(\pi^+)}$, connected with the P_{11} resonance, is necessary. On the contrary there is an important correction for the $M_{1-}^{(\pi^-)}$. This fact is in accordance with the results of BERENDS *et al.* (9). Recently DONNACHIE (2) has shown that in the combination $A^{(0)}+\frac{1}{3}A^{(1)}$ (π^+ and π^0 photoproduction on protons) there is a strong cancellation of the multipoles leading to the P_{11} final state and in the combination $A^{(0)}-\frac{1}{3}A^{(1)}$ (π^- photoproduction on neutrons) a strong enhancement. At present we are working on an experiment for the measurement of the π^- photoproduction cross-section on deuterium (10).

* * *

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(8) D. FREYTAG, W. J. SCHWILLE and R. J. WEDEMEYER: *Zeits. Phys.*, **186**, 1 (1965).

(9) F. A. BERENDS, A. DONNACHIE and D. L. WEAVER: CERN preprint, TH. 744 (1967).

(10) M. BENEVENTANO, M. DEL PRIORI, F. DE NOTARISTEFANI, P. MONACELLI, L. PAOLUZI, F. SEBASTIANI and M. SEVERI: *Proposta di esperienza per la misura della sezione d'urto di fotoproduzione di pioni negativi su deuterio*, Nota Interna Istituto di Fisica dell'Universita di Roma, n. 110 (1966).

RIASSUNTO

Presso l'elettrosincrotrone da 1.1 GeV di Frascati sono state misurate le sezioni d'urto di fotoproduzione di pioni positivi su idrogeno per energie dei fotoni E_γ comprese tra 500 e 800 MeV e per angoli di emissione del π^+ nel c.m. $\theta = 30°$ e 90°. Le sezioni d'urto mostrano un andamento lentamente variabile in funzione dell'energia per $E_\gamma = (500 \div 600)$ MeV. Non si hanno prove immediate di contributi della risonanza P_{11}.

Фоторождение одного положительного пиона на водороде в области энергий (500÷800) МэВ.

Резюме автором не представлено.