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Results of an Experiment to Test for an $I = 2$ Term in the Electromagnetic Current.

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In this paper we report on an experiment made at the Frascati 1.1 GeV electron-synchrotron to measure the ratio r between the differential cross-sections of the reactions

$$\gamma+d\to\pi^0+n+p_s\,, \tag{1}$$

$$\gamma+d\to\pi^0+p+n_s\,. \tag{2}$$

Reactions (1) and (2) have been studied simultaneously in the γ energy region between 270 MeV and 370 MeV, around the P_{33}-resonance, and at an angle in the centre of mass of the pion-nucleon system $\theta^*_\pi \sim 115°$.

The ratio r gives information about the possible presence of an isotensor term in the electromagnetic current [1,2].

Our results show that in our energy region r is ≈ 1, thus giving evidence against a large isotensor term.

A sketch of our experimental apparatus is shown in Fig. 1 *a*). The γ-ray beam was incident on a cylindrical liquid-deuterium target 10 cm long. Both γ-rays from

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(1) L. SANDA and G. SHAW: *Phys. Rev. Lett.*, **24**, 1310 (1970).
(2) F. BERENDS and D. WEAVER: *Phys. Rev. D*, **4**, 1997 (1971).

the π^0 decay were detected in coincidence by two γ detectors. Each detector consisted of a veto scintillation counter and three triangular sandwiches. These, in turn, were made by a 0.6 cm lead plate, 3 magnetostrictive wire spark chambers and a 2 cm thick plastic scintillator. Each side of a triangular detector was 83 cm long. The efficiency of each γ detector has been measured as a function of the γ energy (see Fig. 1 *b*)).

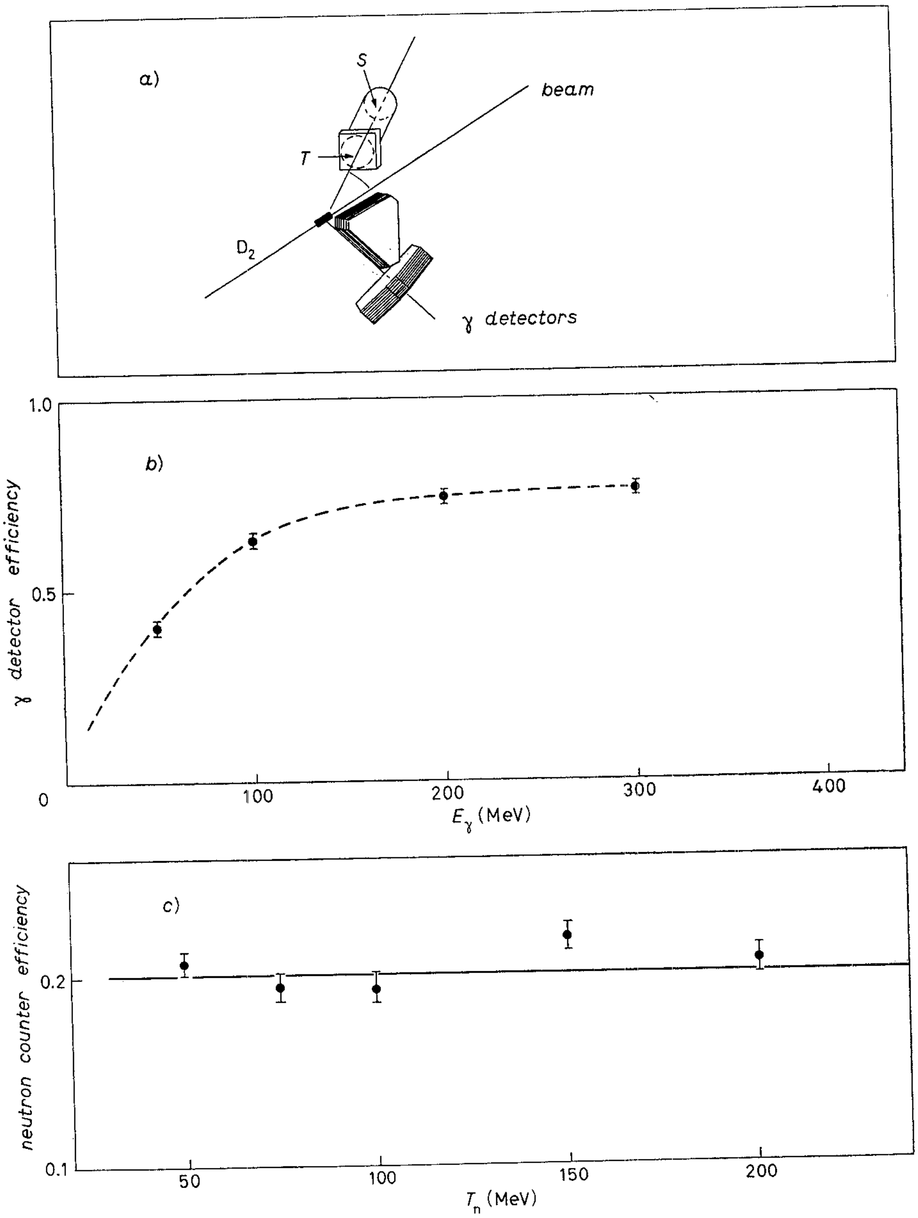

Fig. 1. – *a*) The experimental arrangement. *b*) The measured efficiency of one γ detector as a function of the γ energy. *c*) Neutron counter detection efficiency. Quoted errors are statistical only.

The recoil nucleon was detected by a telescope consisting of a thin (0.5 cm thickness) scintillation counter T, which identified the recoil nucleon as a proton or a neutron, and of a cylindrical (30 cm thickness, 30 cm diameter) scintillator S.

The neutron detection efficiency of the counter S as a function of the neutron kinetic energy (in the range $(50 \div 200)$ MeV) was measured by using the reaction $\gamma p \to n\pi^+$.

The π^+ was analysed in momentum and angle by a magnetic channel [3]. The neutron detection efficiency was nearly constant (see Fig. 1 *c*)) in our energy range with an average value of $\varepsilon = 0.204 \pm 0.007$. The error quoted for ε is statistical only. Unfortunately we must also take into account a systematic error on ε of $\pm 10\%$. This is an upper limit which comes out from some measurements made to evaluate edge and shielding effects on the neutron detection efficiency.

An 1800 IBM computer was on line to the experiment, and the identified events were recorded on a magnetic tape. Among the recorded information were the time of flight of the nucleon over a path of 3.50 m, the pulse height in the S-counter and the co-ordinates of the sparks in the spark chambers of the γ detectors. The time-of-flight resolution was ± 1.5 ns. In order to evaluate the differential cross-section from our data, the overall detection efficiency has been calculated with a Monte Carlo program by taking into account all the details of the experimental set-up. We assumed the validity of the spectator model and a momentum distribution of the target nucleons as given by the Hulthèn wave function [4]. In our conditions the detection efficiency drops rapidly for momenta of the target nucleons greater than 100 MeV/c.

Since the upper end of the bremsstrahlung spectrum was set at 450 MeV, no contamination due to multiple pion production has been considered.

As a check of our apparatus we measured, in the same energy range and with identical experimental procedure, the differential cross-section of the reaction

$$\gamma p \to \pi^0 p \tag{3}$$

in hydrogen. The ratio between the results of our measurement and the expected values [5] is shown in Fig. 2 *a*).

The experimental time-of-flight spectra of the nucleons have been converted into spectra of the variable E'_γ:

$$E'_\gamma = (E^{*2}_{\pi\mathcal{N}} - M^2_{\mathcal{N}})/2M_{\mathcal{N}}\,,$$

where E'_γ is the energy of a photon which, interacting with a free nucleon, would give the same mass $E^*_{\pi\mathcal{N}}$ of the $\pi\mathcal{N}$ system as that produced in deuterium. Because of the Fermi motion of the target nucleon, E'_γ was determined with a resolution of ± 30 MeV, while the corresponding resolution in hydrogen was ± 15 MeV.

In Fig. 2 *b*) we report the ratio between the differential cross-sections relative to reactions (2) and (3). The deviation from 1 of the ratio could be interpreted as a final-state interaction effect.

In Fig. 2 *c*) is shown the ratio R between the counting rates of $\pi^0 n$ and $\pi^0 p$ events as a function of E'_γ. The number of $\pi^0 p$ events has been corrected for the losses due

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(4) G. F. Chew and H. Lewis: *Phys. Rev.*, **84**, 779 (1951).
(5) P. Spillantini and V. Valente: CERN HERA 70-1.

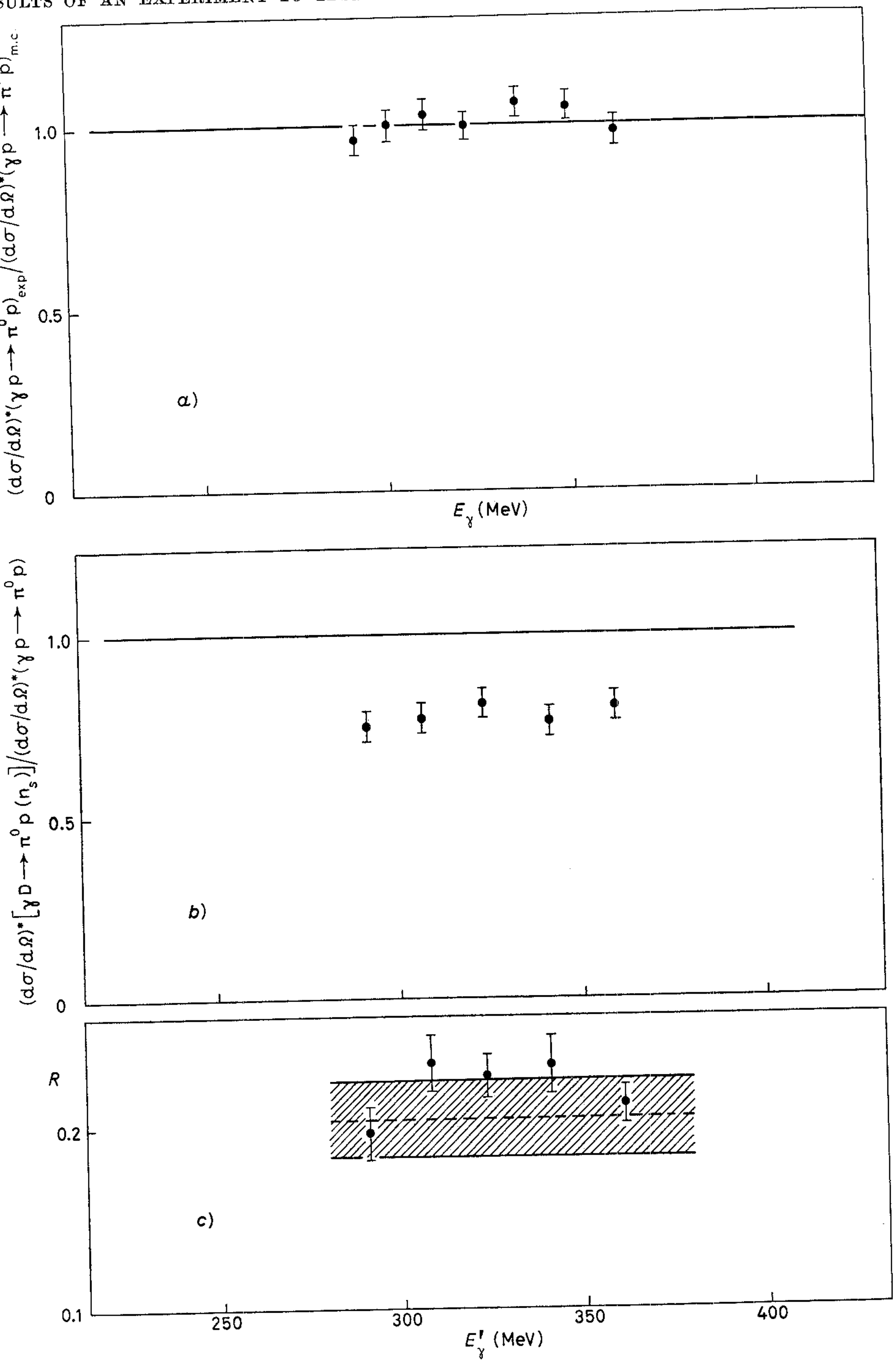

Fig. 2. – *a*) Ratio between measured and expected values for the differential cross-section of the reaction $\gamma p \to p\pi^0$ on a free nucleon. *b*) Ratio between measured differential cross-sections for the reaction $\gamma p \to p\pi^0$ on a bound (in D_2) and on a free nucleon. *c*) Ratio of measured $\pi^0 n$ to $\pi^0 p$ events in D_2. The dashed area represents the neutron counter efficiency with total errors. • *R*: events $\pi^0 n/\pi^0 p$.

to the target and other materials. The errors quoted are statistical only. The dashed area in Fig. 2 *c*) is the neutron counter efficiency with the total error.

Since $r = R/\varepsilon$, our data are clearly consistent with the hypothesis $r = 1$. We find $r = 1.08 \pm 0.11$ and a lower limit $r_{min} = 0.93$ with 90% confidence level.

Under the hypothesis that in the absence of any isotensor term the cross-sections of processes (1) and (2) would be equal, we can give an upper limit for the amplitude of the $I = 2$ term of about 3%.

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