Laboratori Nazionali di Frascati

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C. Bernardini, R. Querzoli, G. Salvini, A. Silvermann and G. Stoppini:
SEARCH FOR NEW NEUTRAL MESONS. THE ρ^0 MESONS.

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Search for New Neutral Mesons (the ρ^0-Mesons).

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We describe here an experiment we performed with the aim of detecting the new neutral meson frequently quoted in the recent literature as the ρ^0-meson (1). We did not find any evidence for a strong production in H_2 of such a particle.

The method is based on the following line: suppose a neutral particle is photoproduced according to

$$(1) \qquad \gamma + p \to p + X \, .$$

By measuring energy and angle of the recoil proton, all other kinematical parameters are fixed, including the γ-ray energy, for each mass of X. Since the γ-ray source gives a bremsstrahlung spectrum, the excitation curve (that is the number of protons/equivalent quanta as a function of the maximum energy of the spectrum) should appear as a step starting when the energy of the head of the spectrum is the right one to produce a proton at the given angle and momentum. The mass of particle X, if unknown, can be determined by this threshold energy. The situation is sketched in Fig. 1, where the π^0 step and the hypothetical ρ^0 step are shown.

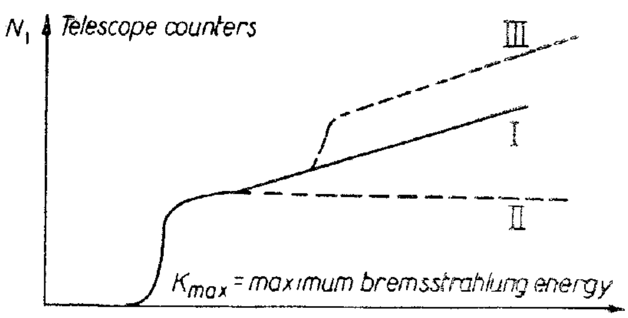

Fig. 1.

The π^0 photoproduction is an example of process (1) and it gave indeed to us a step of the just described type. If a ρ^0 particle exists, a further step should add to the π^0's one, starting at a different energy corresponding to the ρ^0 mass.

The two pion production has to be taken into account in the interpretation of the data. In fact, from a certain energy corresponding to the threshold, in our geometry, of the processes

$$(2) \qquad \gamma + p \to p + \begin{cases} \pi^+ + \pi^- \\ \pi^0 + \pi^0 \end{cases},$$

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(1) Y. Nambu: *Phys. Rev.*, **106**, 1366 (1957); S. N. Gupta: *Phys. Rev.*, **111**, 1436 (1958). For a complete bibliography: A. Alberigi, C. Bernardini and G. Stoppini: Report CNF 2, Lab. Naz. di Frascati, July 1959 (unpublished).

protons of the right energy arising from processes (2) begin to reach the counting apparatus. The number of these protons is generally a slowly increasing function of the maximum energy of the γ-rays because of the three body nature of the final state of the reaction.

A further remark on the method: any step-like behaviour in the curve (Fig. 1) could indicate not only the existence of a new meson of definite mass, but also some particular correlation among the pions ($\pi\pi$ interaction) in processes (2).

Because of the negative result this experimental method allowed us to give only an upper limit for the cross section of process (1), the size of this limit being due to the statistical errors and to the energy and angle resolution of the proton telescope.

In conclusion, the excitation curve should roughly appear as sketched in Fig. 1 where

1) is the sum of π^0 plus two pions contributions;

2) is the π^0 contribution alone;

3) includes the ρ^0 contribution, if any.

We obtained an excitation curve using the scintillation counter apparatus described in Fig. 2. The proton telescope detected particles of energy $T_p=(150\pm10)$ MeV at an angle $\theta_p=42°\pm1.5°$

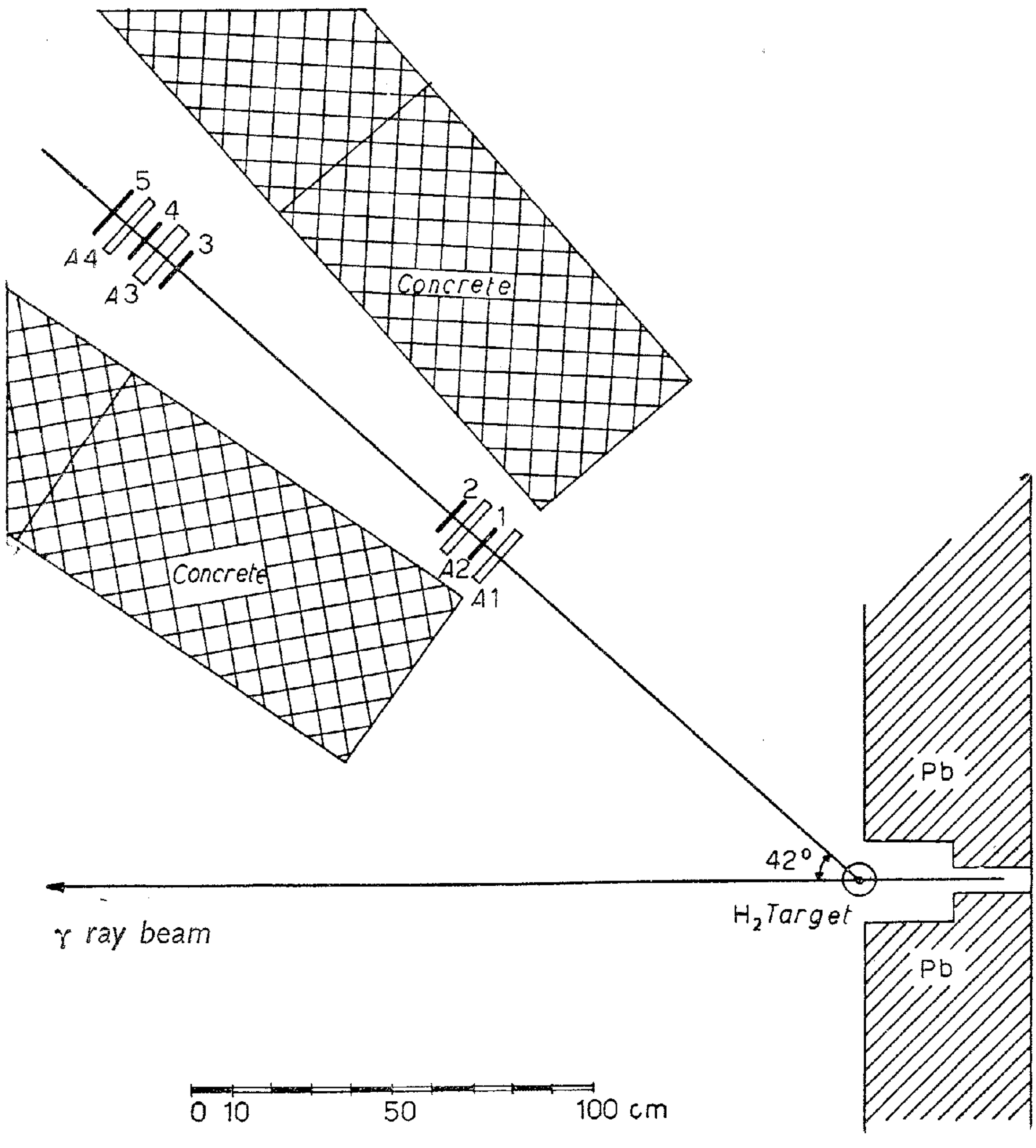

Fig. 2.

(lab. syst.) with the γ-ray beam from the 1.1 GeV Frascati Electronsynchrotron.

An event was detected as a coincidence

$$(1+2)+(2+3+4-5)\,.$$

Discrimination against pions in the telescope was made by pulse height analysis in counters 2+3.

and it is in good agreement with the known value [3,4].

The dotted line in Fig. 3 is the calculated single π^0 contribution, taking into account the angular and momentum spread of our telescope. Its agreement with the experimental results gives confidence to the method.

Because of the two pions contribution we can only say that if a part of

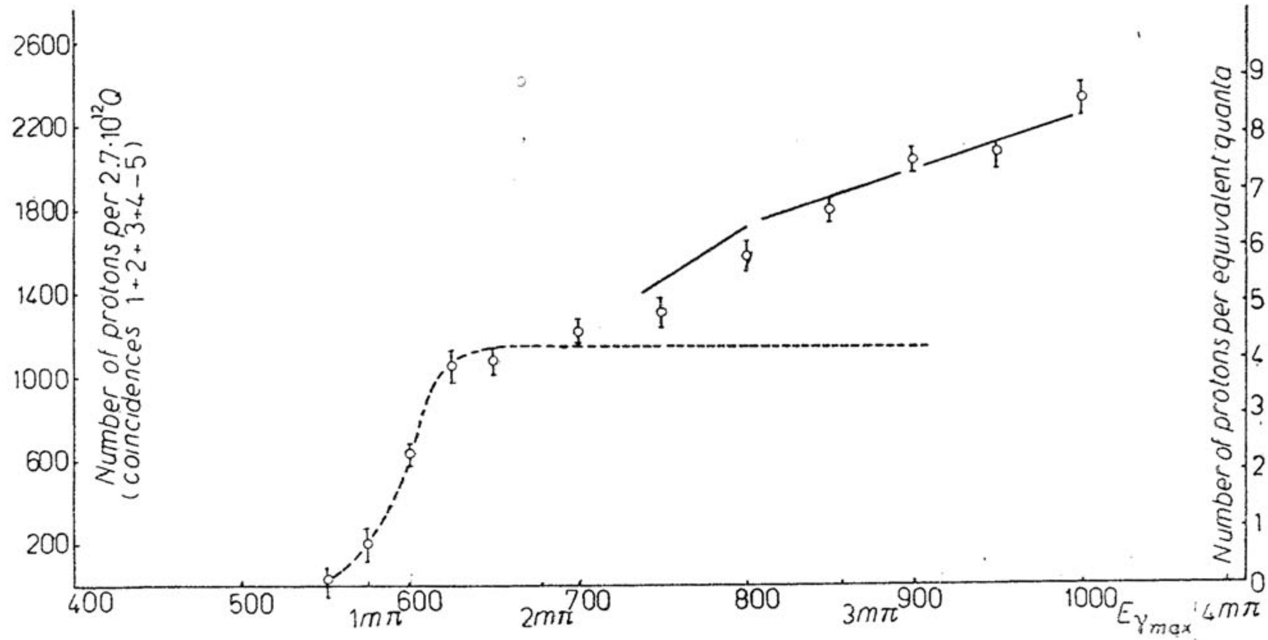

Fig. 3.

The data in Fig. 3 were normalized per equivalent quanta; γ-ray beam monitoring was made by a Wilson quantameter [2].

No evident step (and this is the contribute of the present paper) appears besides the one we ascribe to the well known π^0-mesons.

As a check the cross section for π^0 photoproduction is deduced

$$\frac{d\sigma}{d\Omega}=3.11\cdot10^{-30}\ \text{cm}^2/\text{sr}\,,$$

$$(\theta_{\pi^0}\ \text{c.m.}=90^\circ\,,\quad E_{\gamma\,\text{Lab}}=580\ \text{MeV})\,,$$

the slow increase of the curve were due to ρ^0's, the differential cross section for production of these particle cannot exceed $6\cdot10^{-31}\ \text{cm}^2/\text{ster}$ (at the given angle and energy of the proton).

If one tries to fit the data by assuming that the double π production follows the statistical theory, one obtains a reasonable agreement by assuming

a) that the ratio

$$\frac{\gamma+p\to p+\pi^0+\pi^0}{\gamma+p\to p+\pi^++\pi^-}\ll1\,;$$

([2]) R. Wilson: *Nucl. Instr.*, **1**, 101 (1957).

([3]) J. W. de Wire, H. E. Jackson and R. Littauer: *Phys. Rev.*, **110**, 1208 (1958).

([4]) J. I. Vette: *Phys. Rev.*, **111**, 622 (1958).

b) that the cross section for production of two charged pions decreases smoothly (in the interval (700÷1000) MeV γ-ray energy) by a factor of 3. This is not inconsistent with the results of SELLEN *et al.* (5).

The solid line in Fig. 3 summarizes these calculations; of course, this is only an order of magnitude estimate. Nevertheless, this estimate allows a further reduction of the upper limit on the differential cross section for ρ^0 photoproduction to the value

$$\left(\frac{\mathrm{d}\sigma}{\mathrm{d}\Omega}\right)_{\substack{T_p=105\,\mathrm{MeV}\\ \theta_p=42^\circ}} = (2\div 3)\cdot 10^{-31}\ \mathrm{cm}^2\,.$$

* * *

We want to thank doctor A. ALBERIGI for helpful assistance during the development of this work.

(5) J. M. SELLEN, G. COCCONI, T. V. COCCONI and E. L. HART: *Phys. Rev.*, **113**, 1323 (1959).