ОБЪЕДИНЕННЫЙ ИНСТИТУТ ЯДЕРНЫХ ИССЛЕДОВАНИЙ

Дубна

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RESONANCE $Y_0^*(1327) \to \Lambda + \gamma$

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The purpose of the present experiment was a study of the "strange" resonance production of which Λ^0 hyperons and gamma-quanta are the final products.

A propane bubble chamber /1/ with a 100x50x40 cm^3 working volume and a 1.7 T magnetic field was exposed to a negative pion beam of momentum $p = 5.1$ GeV/c and $\Delta p/p = \pm 2\%$ /2/. The results given below are based on the treatment of 200000 pictures.

All the pictures were scanned twice. The efficiency after double scanning was 93%. In scanning, events were selected which had at least one V^0 -particle and one electron-position pair directed to the interaction vertex.

According to visual criteria (the number of particles, the signs of their charges and decays) the interactions were divided into two groups: "$\pi^- p$" and "$\pi^- C$" produced by negative pion interactions with hydrogen and carbon, respectively. If in the further treatment of "$\pi^- p$" events two baryons were found among them, then the event was ascribed to the "$\pi^- C$" group.

Thus, the "$\pi^- C$" events are, indeed, on carbon nuclei, but among the "$\pi^- p$" events there is a considerable admixture (up to 30%) of pion interactions with quasi-free protons in carbon nuclei. All the selected pictures were measured, at least twice, with semiautomatic devices and were then analyzed on a computer using programmes for geometrical reconstruction and kinematical fitting of Λ^0 and K^0 -particles and gamma-quanta. The separation between Λ^0 and K^0 for ambiguous V^0 -particles was made using additional criteria (δ - electrons, ionization and the positively charged particle range). As most of the remaining ambiguous V^0 -particles (≈ 90%) were Λ^0 -hyperons [3], all ambiguous V^0 -particles are included in the histograms shown below. Thus, the histograms with Λ^0 hyperons have an admixture of up to 3% of K^0 -mesons.

The resulting distribution of $\Lambda\gamma$ effective mass for "$\pi^- p$" events has two peaks (Fig.1). The first peak corresponds to the Σ^0 -hyperon; the second peak three standard deviations above background, is in the mass region of (1290-1440) MeV, the same as in ref. [3]

The $M_{\Lambda\gamma}$ spectrum for "$\pi^- C$" events (Fig.2) has no second peak.

The background curve in Fig.1 was obtained by the Monte-Carlo method, taking into account the Λ^0 and γ detection efficiencies, using the known cross sections for the reactions (the channels with $Y_1^*(1385)$, $Y_0^*(1405)$ and $Y_0^*(1520)$ were also included) of which the final products are Λ^0 -hyperons and gamma-quanta. The normalization of the histogram was performed excluding the (1290-1440) MeV region. The number of events above the background in the second peak is 35.5 ± 9.9 .

If, following the authors of ref. [3], one attempts to interpret the observed peak by the existence of the resonance

$$Y_0^*(1670) \to \Lambda^0 + \underset{\displaystyle \llcorner_{2\gamma}}{\eta} \qquad (1)$$

then for the events of "$\Lambda^0 2\gamma$" type each combination $\Lambda^0\gamma$ of (1) would give a contribution[4] to the (1290-1440) MeV mass region. In this case the two gamma-quanta effective mass must be close to the η -meson mass $M_{\gamma\gamma} \approx M_\eta$, while $M_{\Lambda 2\gamma} \approx M_{Y^*(1670)}$.

However , in our data there were no events of the "$\Lambda 2\gamma$" type, which gave a double contribution to the (1290-1440) MeV peak. At the same time, there was not a single event in the $M_{\gamma\gamma} \approx M_\eta$ and $M_{\Lambda 2\gamma} \approx M_{Y^*(1670)}$ mass region within 3 standard deviations (Fig.3). The value of the error (55 MeV) corresponds to our experimental resolution in the given $M_{\gamma\gamma}$ and $M_{\Lambda 2\gamma}$ mass region.

Using the detection efficiencies of one and two gamma-quanta one can evaluate the expected number $\bar{n}$ of $\Lambda 2\gamma$ events in the M_η and $M_{Y^*(1670)}$ mass region. Assuming that all the observed combinations above the background in the second peak of the $\Lambda\gamma$ mass spectrum are due to decay (1), one obtains $\bar{n} = 5.0 \pm 1.4$. It follows from the Poisson distribution that the probability to have $n = 0$ at $\bar{n} = 5.0$ is 0.7%. The averaging over the Gaussian distribution gives the probability 1.43 %.

Thus, our experiment within the available statistics allows us to state that the existence of the Y^*_0 (1679) resonance is rather doubtful. This conclusion does not contradict the results of refs./6,7/. Reactions going through the known resonant and non-resonant states as has been shown by calculations /3,4,5/ cannot give a narrow peak in the $\Lambda\gamma$ -mass spectrum. Therefore, we think the appearance of the second peak in the $\Lambda\gamma$ mass spectrum is due to the existence of the $Y^*_0(\Lambda\gamma)$ resonance.

If one assumes that this resonance has only the radiative decay mode, its width is close to zero. Therefore, the location of the $Y^*_0(\Lambda\gamma)$ -resonance can be determined by approximating the spectrum (Fig. 4) of the $\Lambda\gamma$ combination effective masses (in which Λ and γ detection efficiencies have been taken into account) by the following function

$$f(m) = a_1(m - m_\Lambda)\cdot \exp[-b(m - m_\Lambda)] + \frac{a_2}{\sqrt{2\pi}\,d_2}\exp\left[-\frac{(m - c_2)^2}{2d_2^2}\right] + \frac{a_3}{\sqrt{2\pi}\,d_3}\exp\left[-\frac{(m - c_3)^2}{2d_3^2}\right] \qquad (2)$$

the first term of which describes the background of final states and the second term describes the contribution of the Σ^0 hyperon. The least squares method gives for this resonance mass the value of $M_{(\Lambda\gamma)^*} = C_3 = (1327.5 \pm 3.5)$ MeV with a mean square deviation $d_3 = (20 \pm 4.4)$ MeV, for the Σ^0 hyperon the corresponding values are $M_{\Sigma^0} = C_2 = (1191.0 \pm 2.0)$ MeV and $d_2 = (33.0 \pm 2.1)$MeV.

The possibility of the existence of the $Y^*_0(\Lambda\gamma)$ resonance has been discussed earlier by theorists /8,9/. The decay of the Y^*_0 (1327) resonance through a strong channel into $\Lambda\pi$ is forbidden by isospin conservation. The decay into $\Sigma\pi$ is forbidden by energy conservation. With a slight excess of $M_{Y_0^*}$ over $(M_\Sigma + M_\pi)$, the $Y_0^* \to \Lambda^0 + \gamma$ decay channel will be competitive with the $Y_0^* \to \Sigma + \pi$ channel, especially if for this resonance the quantum numbers are taken $J^P = 1/2^+$. In this case in the $\Sigma\pi$ system the orbitral momentum ℓ is odd.

Ascribing all the events above the background in the (1290-1440) MeV mass region to the Y_0^* (1327) resonance, one obtains that its production cross section in the "$\pi^- p$" collisions at 5.1 GeV/c is $(53 \pm 14.6)\ \mu b$.

Thus, the relatively small width of the observed peak and the reasonable value of the obtained cross section are evidence for the existence of the discussed Y^* (1327) resonance.

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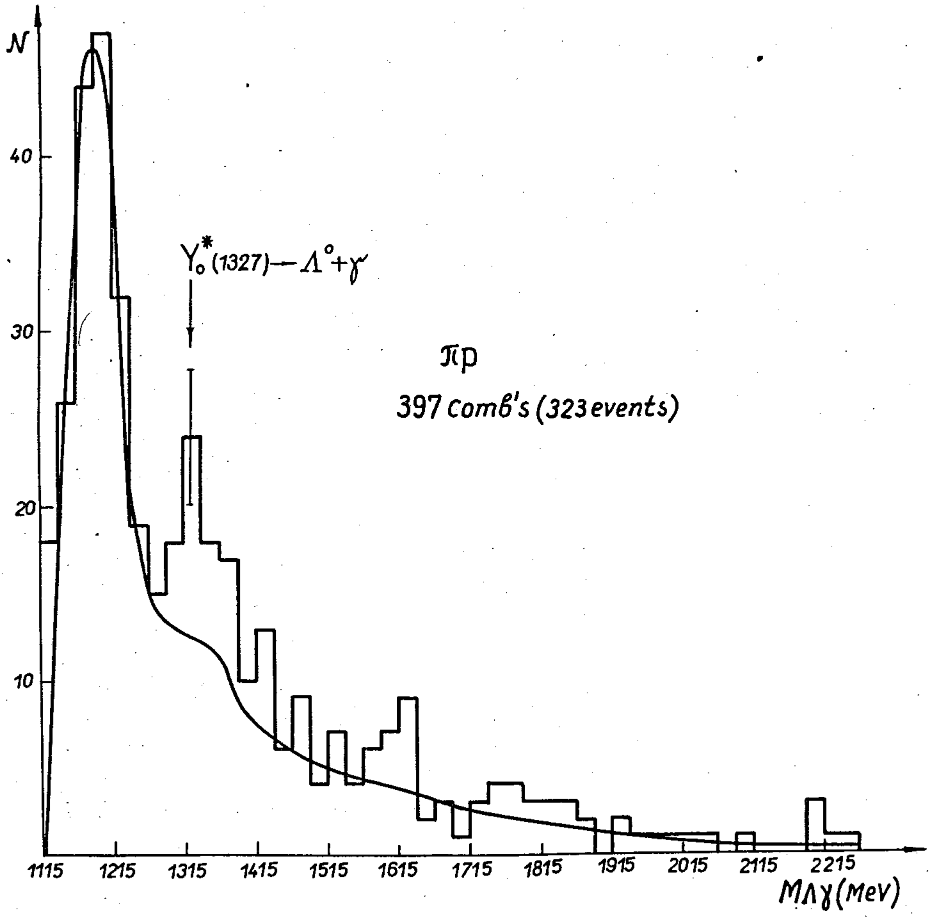

Fig. 1. Spectrum of the effective masses of $\Lambda\gamma$ -combinations in π^-p events without taking into account the Λ and γ detection efficiencies.
The curve has been calculated by the Monte-Carlo method.

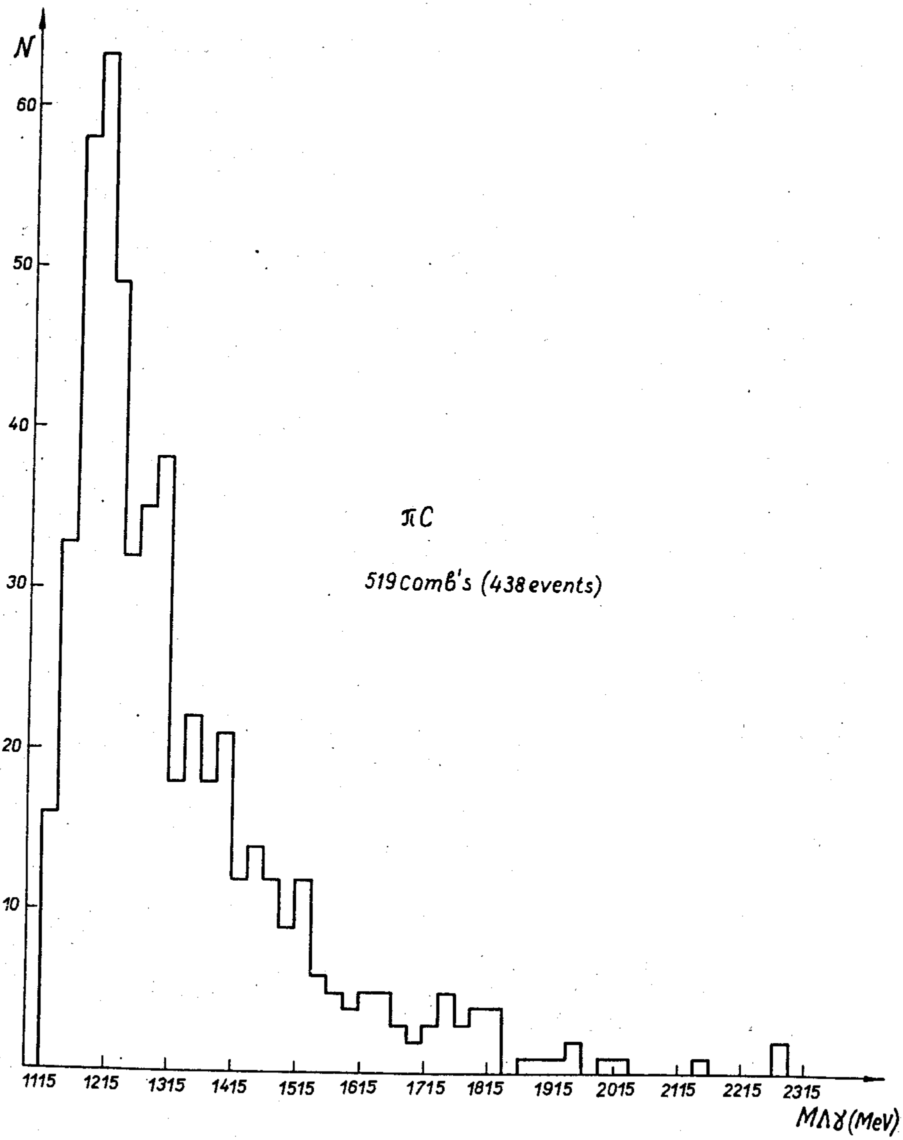

Fig. 2. Spectrum of the effective masses of $\Lambda\gamma$ -combinations in "π^-C" events.

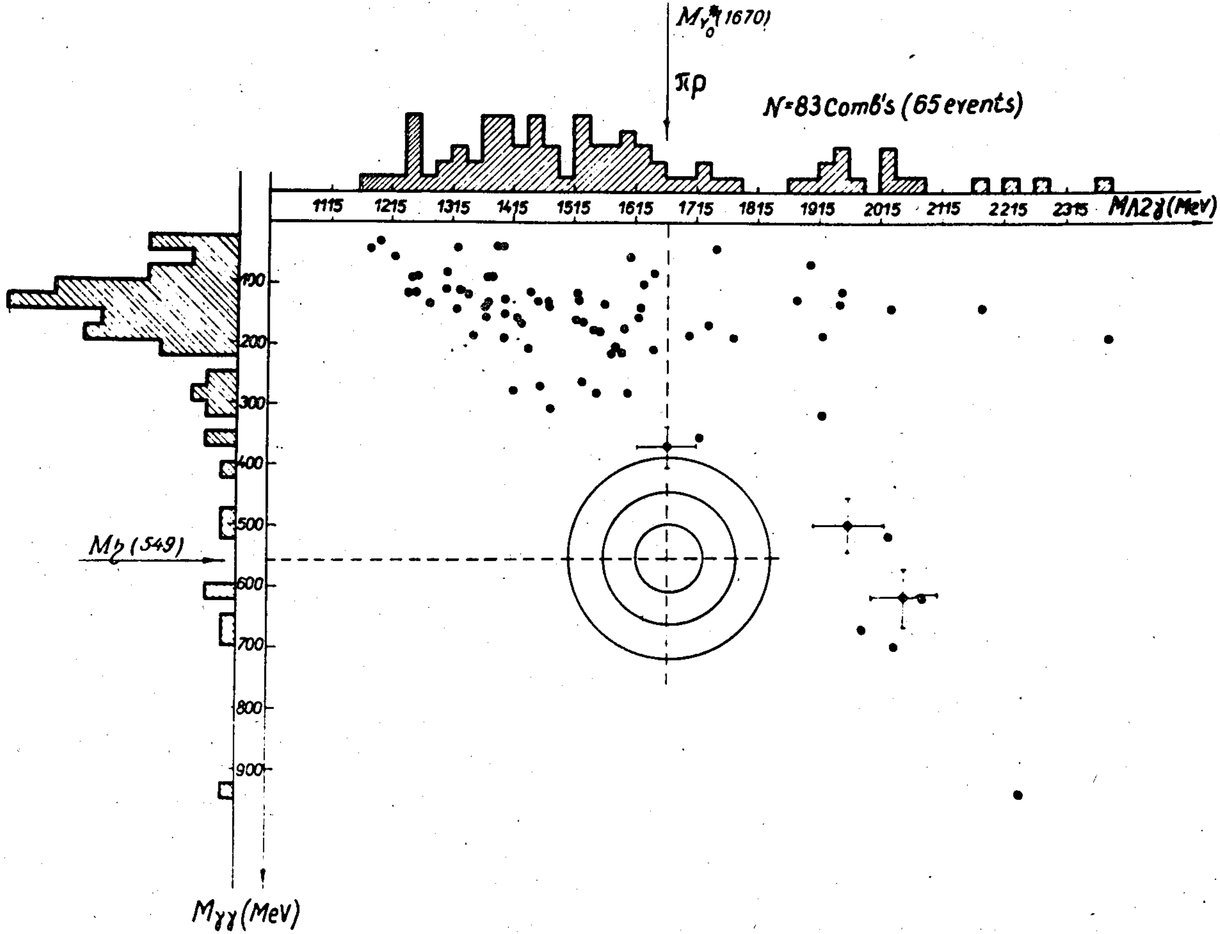

Fig. 3. Effective mass distribution for $\gamma\gamma$ and $\Lambda\,\gamma\gamma$ combinations. Regions in cirles are 1–, 2–, and 3– standard deviations in the masses of $\gamma\gamma$ and $\Lambda\gamma\gamma$ combinations.

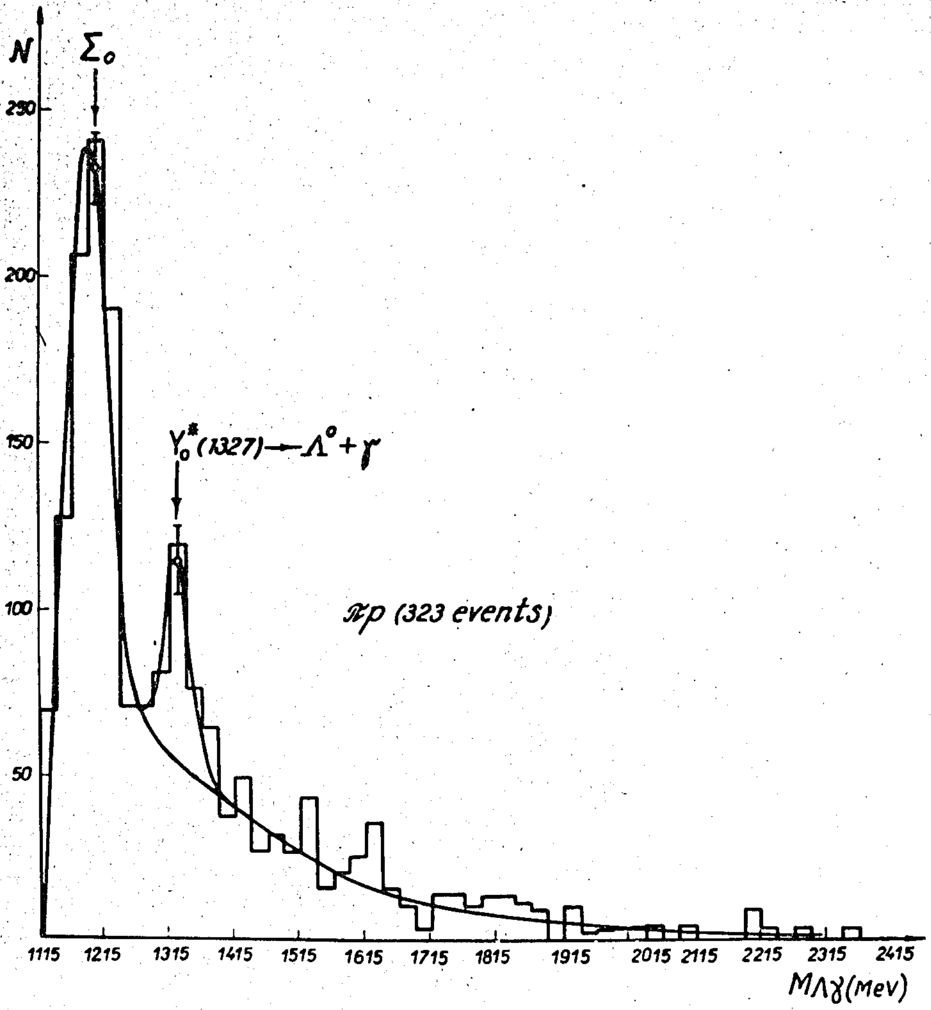

Fig. 4. Spectrum of the effective masses of $\Lambda\ \gamma$ combinations ("π^- p") corrected for the Λ and γ detection efficiencies. The curve has been calculated using formula (2).