$\pi\pi$ INTERACTIONS IN THE MULTIPLE PRODUCTION OF PIONS IN πp COLLISIONS

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Resonance states were found for two π-mesons of the same charge and the mass values of 0.33; 0.44; 0.58; 0.76; and 0.99 BeV in an investigation of $\pi\pi$ interactions in π^-p collisions at an energy of 7.2 BeV. Similar resonances were found for the $\pi^+\pi^-$ and $\pi^-\pi^0$ systems at the same mass values. An assumption is put forward of the possibility of isotopic and mechanical spin degeneracy in strong interactions.

WE investigated the $\pi\pi$ interaction in multiple pion production in π^-p collisions. The energy of the primary negative pions was 7.2 BeV. The energy spread of the negative pions in the primary beam is satisfactorily described by a Gaussian distribution with half width 0.8 BeV. Measurements were made with the aid of a liquid-hydrogen bubble chamber 25 cm in diameter, placed in a 13.5-kG magnetic field.

Altogether 13,000 photographs were obtained. The reactions investigated were

$$\pi^- + p \to 2\pi^- + 2\pi^+ + n + k\pi^0, \quad (1)$$

$$\pi^- + p \to 3\pi^- + 3\pi^+ + n + k\pi^0, \quad (2)$$

where k is the unknown number of π^0 mesons. The reactions

$$\pi^- + p \to 2\pi^- + \pi^+ + p + k\pi^0, \quad (3)$$

$$\pi^- + p \to 3\pi^- + 2\pi^+ + p + k\pi^0 \quad (4)$$

were eliminated by identifying the protons by measuring the momenta and estimating the ionization. In the reactions (1) and (2) segregated in this manner there may be a small admixture of reactions (3) and (4), when the proton momentum exceeds 1.5 BeV/c. For reactions (1) and (2), distributions over the effective masses were plotted (the total energy of two pions in their own c.m.s.) for all possible combinations of two pions. All three possible charge states were investigated (the $\pi^-\pi^-$, $\pi^+\pi^+$, and $\pi^+\pi^-$ meson combinations).

Ideograms corresponding to the distributions over the effective masses for reaction (1) are shown in Fig. 1. The determination of the effective masses was carried out over the measurements of the momenta and angles of emission of the pions. The mean square value of the error in the determination of the effective mass was ± 25 MeV.

As follows from Fig. 1, sharp maxima are observed in the constructed ideograms at mass values 0.33, 0.44, 0.58, 0.76, and 0.99 BeV. Maxima were observed in all three charge states within the limits of errors at the same values of the masses. It must be noted that the first two maxima in the ideogram for the $\pi^+\pi^-$ combinations were not resolved.

The results obtained point to the possibility of realizing resonances in the two-pion system with the mass values indicated above.

To check whether the same pion participates simultaneously in several maxima, the following processing was carried out: two-charge combinations contained in each maximum on the curves of Fig. 1a and b were picked out. For these pions, a distribution was plotted over the effective masses of the $\pi^+\pi^-$ combinations. The distributions obtained turn out to be smooth, within the limits of statistical errors. From the smoothness of the distributions it follows that the same pion does not participate in two maxima.

The distribution over the effective masses for reaction (2) is shown in Fig. 2. What is striking is the presence of almost all maxima observed in the analysis of four-prong events. The relative intensity of the maxima in the case of six-prong stars, however, is appreciably different from the intensity of the maxima in four-prong stars and the maxima at high values of the masses are partially suppressed.

The table lists the values of the masses of the resonances (in BeV) for three charge states of four- and six-prong stars. From the analysis of

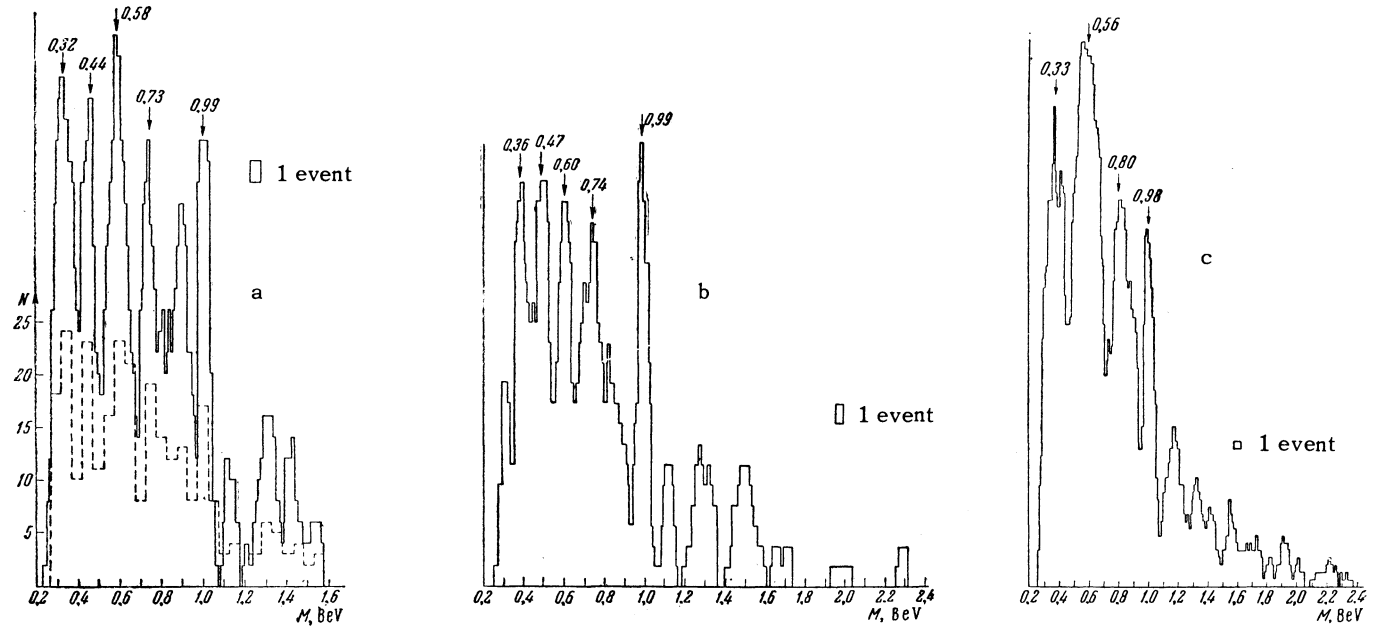

FIG. 1. Distribution over the effective masses for combinations in four-prong stars: a – $\pi^-\pi^-$ combinations, 280 combinations, 280 stars (the dashed line is the histogram); b – $\pi^+\pi^+$ combinations, 247 combinations, 247 stars; c – $\pi^+\pi^-$ combinations, 916 combinations, 229 stars.

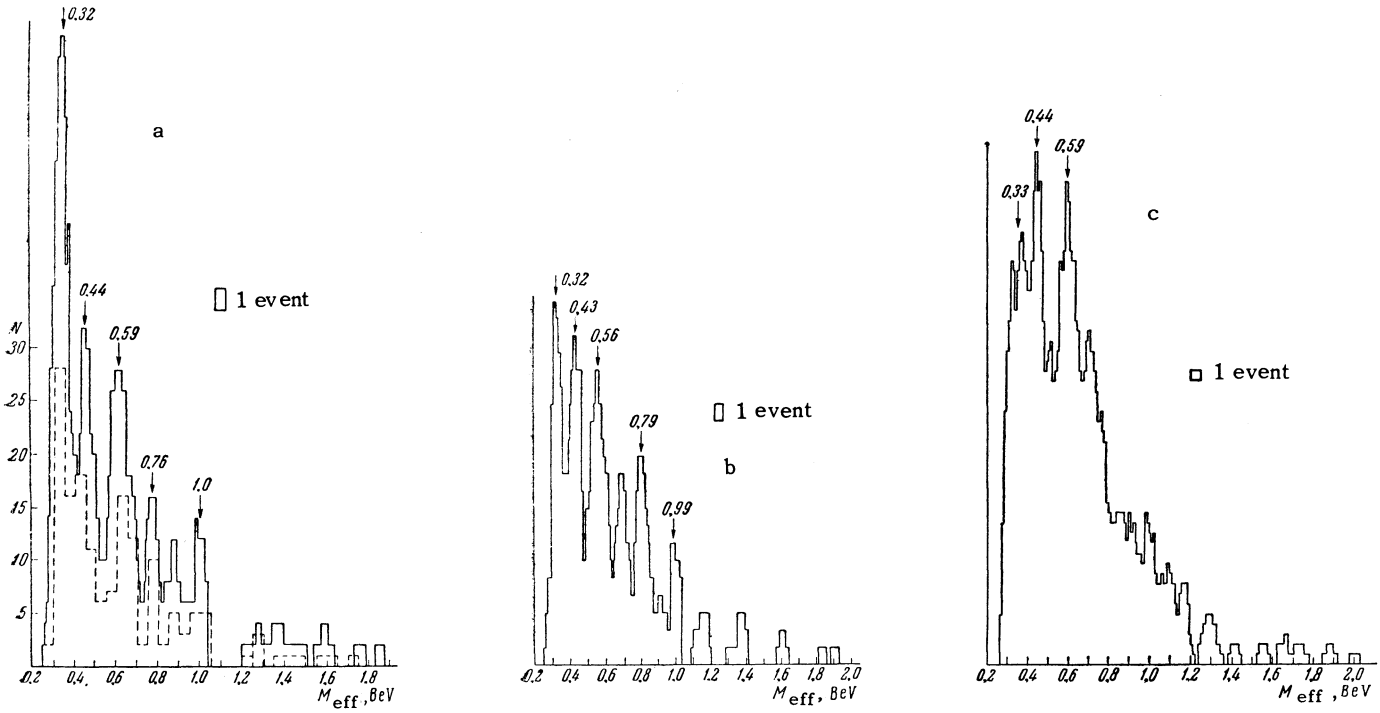

FIG. 2. Distribution over the effective masses for combinations in six-prong stars: a – $\pi^-\pi^-$ combinations (the dashed line is the histogram), 156 combinations, 52 stars; b – $\pi^+\pi^+$ combinations, 156 combinations, 52 stars; c – $\pi^+\pi^-$ combinations, 468 combinations, 52 stars.

the systematic errors it follows that the true value of the masses of the resonances can differ from those listed in the table by not more than 30 MeV.

Resonance maxima are observed at mass values 0.33, 0.44, 0.58, 0.76, and 0.99 BeV. Of these, the three resonances at values of M_{eff} equal to 0.58, 0.76, and 0.99 BeV were observed earlier in the charge states 0 and 1 [1-3]. The maxima at M_{eff} = 0.33 and 0.44 BeV call for an additional analysis aimed at determining whether they are due to resonances in the system.

Four-prong stars			Six-prong stars			$M_{\text{eff. av.}}$
Charge states			Charge states			
(− −)	(+ +)	(+ −)	(− −)	(+ +)	(+ −)	
0.32	0.36	0.33	0.32	0.32	0.33	0.33
0.44	0.47	—	0.44	0.43	0.44	0.44
0.58	0.59	0.56	0.59	0.56	0.59	0.58
0.73	0.74	0.79	0.77	0.79	—	0.76
0.99	0.99	0.98	1.0	0.99	—	0.99

The existence of resonant states in doubly-charged systems of two pions at close values of the masses was also recently observed in πn collisions at 2.8 BeV by Shalamov and Grashin [4].

The available experimental data evidently indicate that there exist two systems of resonances in systems with identical mass values, but with different values of isotopic and mechanical spins, that is, in strong interactions one observes degeneracy in the isotopic and mechanical spins.

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