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SEARCH FOR LOW-MASS EXOTIC MESONIC STRUCTURES: I. EXPERIMENTAL RESULTS

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Recently, several papers have discussed the existence of a new low-mass structure at a mass close to $M = 214.3$ MeV. It was suggested that the Σ^+ disintegration $\Sigma^+ \rightarrow pP^0$, $P^0 \rightarrow \mu^-\mu^+$ proceeds through an intermediate particle P^0 having such a mass. The present work intends to look at the other new or available data, in order to observe the eventual existence of small narrow peaks or shoulders in very low mesonic masses. Indeed, narrow structures were already extracted from various data in dibaryons, baryons and mesons (at larger masses than those studied here).

В ряде работ недавнего времени обсуждалось существование новой структуры с малой массой, близкой к $M = 214{,}3$ МэВ. Было предложено, что Σ^+-распад: $\Sigma^+ \rightarrow pP^0$, $P^0 \rightarrow \mu^-\mu^+$ проходит через промежуточную частицу P^0, имеющую такую массу. Настоящая работа направлена на рассмотрение других новых или существующих данных с целью обозреть возможное существование небольших узких пиков при очень малых мезонных массах. В действительности узкие структуры уже извлечены из различных данных по дибарионам, барионам и мезонам (при больших массах, чем рассматриваемые здесь).

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INTRODUCTION

The Σ^+ disintegration $\Sigma^+ \rightarrow pP^0$, $P^0 \rightarrow \mu^-\mu^+$ was studied at Fermilab by H. Park et al. [1]. The data were taken by the HyperCP (E871) Collaboration. The authors observed a narrow range of dimuon masses, and supposed that the decay may proceed via a neutral intermediate state P_0, with mass $M = (214.3 \pm 0.5)$ MeV.

Several theoretical works were done assuming the existence of this new particle. He, Tandean, and Valencia performed a standard-model interpretation of the data [2]. Later on the same authors demonstrate that the new particle could be a pseudoscalar or axial-vector, but neither scalar nor vector [3]. They also suggested that the particle could be a very light pseudoscalar Higgs [4]. Deshpande et al. [5] assume a fundamental spin zero boson, which couples to quarks with flavor changing transition $s \rightarrow d\mu^+\mu^-$. They estimate the scalar and pseudoscalar coupling constants and evaluate several branching ratios. Geng and Hsiao [6]

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found that the P^0 cannot be scalar but pseudoscalar, and determine that the decay width should be as small as $\approx 10^{-7}$ MeV. Gorbunov and Rubakov [7] discuss possible sgoldstino interpretation of this possible particle.

The experimental observation was based on three events. We anticipate that this low counting is due to their observation in a weak disintegration channel. In order to eventually strengthen this result by a direct observation, we look at already existing data and try to observe a possible signature of (a) small peak(s), or (a) small shoulder(s), (at a mass not far from the mass of P^0). Such (a) mass(es) can be observed, either in the invariant masses of two muons, $M_{\mu\mu}$, or in the missing masses of different reactions, studied with incident leptons as well as with incident hadrons. However, the signal, if any, is expected to be small. The spectra are therefore presented in the semi-log scale. The signals will be superposed to a relatively large tail of one-pion missing mass. Therefore, the signal, if any, can only be observed in precise data, with large statistics, good resolution and small binning. Moreover, the mass range studied must be small. Such data are scarce and concern reactions studied at rather low incident energies with good resolution. When we found a hint for a small effect, we read out and reanalyzed the data. Several such structures were selected and presented below.

1. SELECTED DATA SHOWING SMALL STRUCTURES IN THE MASS RANGE ABOVE THE PION MASS

1.1. The Missing Mass of the $pp \to ppX$ Reaction. The $pp \to ppX$ (X — «meson type») reaction was studied at SATURNE (SPES3 beam line), at $T_p = 1520$, 1805, and 2100 MeV [8]. The missing mass displays a broad structure, in the mass range $280 \leqslant M \leqslant 580$ MeV, unstable for different kinematical conditions and slightly oscillating [9], previously called the ABC effect; it was analyzed as being due to a superposition of four narrow mesonic states: $M = 310$, 350, 430, and 495 MeV [9]. Above the η mass, narrow mesonic structures were extracted at the following masses: $M = 550$, 588, 608, 647, 681, 700, 715, and 750 MeV [10].

Since the widths of the missing mass peaks increase for increasing spectrometer angles, we keep only the three lowest angle spectra at $T_p = 1520$ MeV, add them, and show the resulting spectra in Fig. 1, *a*. The high counting rate allows one to extract a clear peak at $M_X = 216.5$ MeV.

The reaction $pp \to pp\pi^0\pi^0$ was studied close to threshold at CELSIUS (Uppsala) [11]. The missing mass data, after integration over two channels, are shown in Fig. 1, *b*. The two-π^0 phase space starts at $M_X \approx 240$ MeV. The events in the range $170 \leqslant M_X \leqslant 240$ MeV, are mostly physical as the background contribution is estimated to less than 10 events/channel. These data are fitted with π^0 peak and two small structures, having the same shape as the π^0 peak, are extracted at $M_X = 182$ and 220 MeV.

The $pp \to ppX$ reaction was also studied at Jülich COSY-TOF [12]. Both protons in the final state were detected in order to study the η production. The data were read and shown in Fig. 1, *c*. Since they are given in the original work as a function of the missing mass squared with constant binning ($\Delta M_X = 0.002$ GeV^2), they are plotted vs M_X as given, up to 210 MeV (open circles), and for larger missing mass they are integrated over two

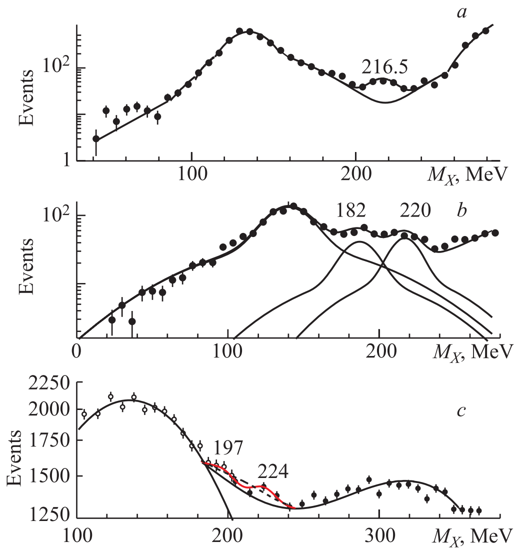

Fig. 1. *a*) Missing mass of the $pp \to ppX$ reaction measured at SATURNE (SPES3 beam line) at $T_p = 1520$ MeV. Three spectra measured at $\theta_{pp} = 0$, 2, and 5° are added. *b*) Same reaction measured at CELSIUS [11]. *c*) Missing mass of the $pp \to ppX$ reaction studied at Jülich COSY-TOF [12]

channels (full circles). The peak corresponding to π^0 missing mass is fitted by a gaussian, at $M_X = 135$ MeV ($\sigma = 67$ MeV), and the data at larger missing mass are fitted with a polynomial. Two structures can be extracted: the first one at $M = 197$ MeV, not valid statistically, and the second one at $M = 224$ MeV. They are very narrow, therefore, if fitted by only one structure, which includes both narrow structures, they result in a broad gaussian centered at $M = 214$ MeV (dashed curve in Fig. 1, *c*).

1.2. The Missing Mass of the $ep \to e'pX$ Reaction. The π^0 electroproduction at threshold for $Q^2 = 0.05$ GeV^2 was measured at MAMI [13]. The missing mass spectrum, up to $M_X = 200$ MeV is given in Fig. 3, *b* of [13], after background subtraction. The data are read, integrated over 4 channels and reported in Fig. 2, *a*. A peak at $M_X = 182$ MeV is clearly observed. Indeed, the resolution in these data is as good as $\mathrm{FWHM} = 2.2$ MeV, as given in the π^0 peak (removed here to enhance the mass range discussed). The increase of the number of events between $48 \leqslant M_X - M_\pi \leqslant 56$ MeV is physical. The contribution from two pion production cannot be large at so low mass value as $M = 180$ MeV.

The Roper resonance was studied at JLAB in Hall A using the $p(\mathbf{e}, e'\mathbf{p})\pi^0$ reaction [14]. Two missing mass spectra were given at $\theta_{\rm cm} = 90°$ and $\theta_{\rm cm} = -90°$. No shoulder is observed in this last spectra. The values of the spectra at $\theta_{\rm cm} = 90°$ are read and shifted in order to put the π^0 peak at his right mass, namely, at $M_X = 135$ MeV. Figure 2, *b* shows this spectrum fitted with a gaussian and two polynomials. A small enhancement is observed at $M_X = 196$ MeV.

The π^0 electroproduction on the proton was studied at JLAB in Hall C [15], in the region of the $\Delta(1232)$ resonance via the $p(e, e'p)\pi^0$ reaction. The authors give in Fig. 1 of [15] an example of missing mass distribution for the reaction $p(e, e'p)X$. These data are read and reported in Fig. 2, *c*. The widths of all π^0 and η peaks are related to their masses (proportional to $1/M$). These widths define the width of the small peak extracted at $M = 220$ MeV. Several other peaks are introduced, following the results of the $pp \to ppX$ reaction studied at SPES3 (SATURNE, Saclay) [9]. After introduction of an arbitrary two-

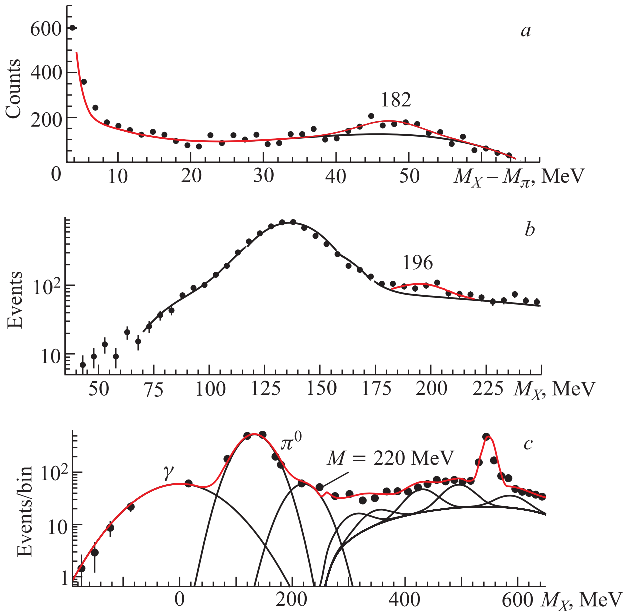

Fig. 2. *a*) π^0 electroproduction at threshold, measured at MAMI [13]. The missing mass spectra are integrated over 4 channels. *b*) Missing mass of the $p(\mathbf{e}, e'\mathbf{p})\pi^0$ reaction studied at JLAB in Hall A at $\theta_{\rm cm} = 90°$ [14]. *c*) Missing mass of the $p(e, e'p)X$ reaction measured at JLAB in Hall C [15]

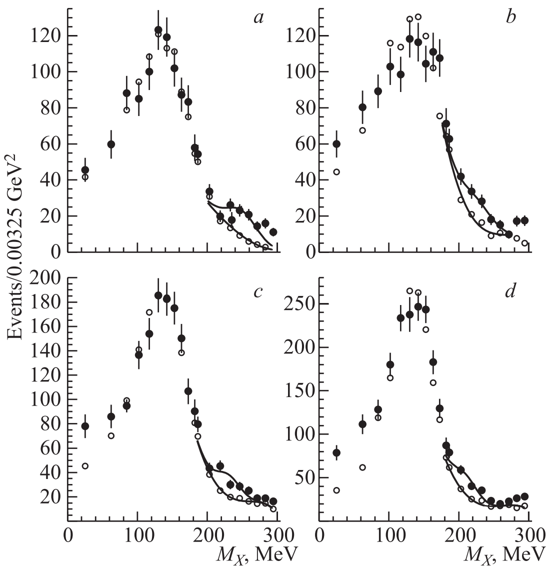

Fig. 3. The missing mass of the $p(e, e'p)X$ reaction [16] studied at JLAB in Hall C at $Q^2 = 4.0$ GeV^2. The open circles correspond to Monte-Carlo simulations; the full circles correspond to data. *a–d* correspond respectively to $p_p^0 = 2$ GeV and $\theta_p^0 = 23°$, $p_p^0 = 2$ GeV and $\theta_p^0 = 20°$, $p_p^0 = 2.2$ GeV and $\theta_p^0 = 17°$, and $p_p^0 = 2.45$ GeV and $\theta_p^0 = 17°$

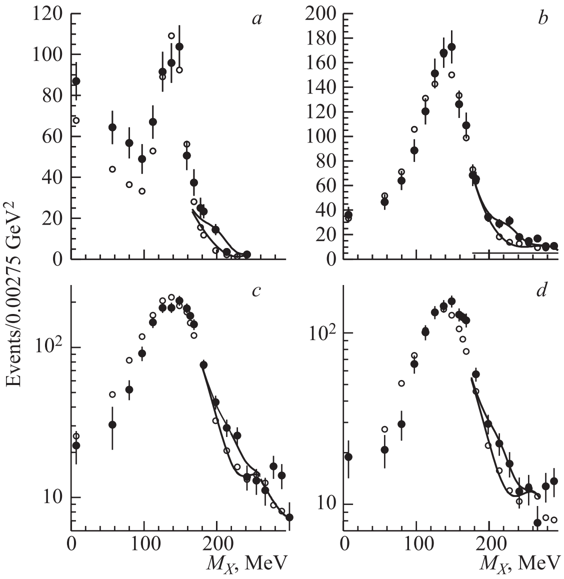

Fig. 4. The missing mass of the $p(e, e'p)X$ reaction [16] studied at JLAB in Hall C at $Q^2 = 2.8$ GeV^2. The open circles correspond to Monte-Carlo simulations; the full circles correspond to data. *a–d* correspond respectively to $p_p^0 = 1.9$ GeV and $\theta_p^0 = 33°$, $p_p^0 = 1.55$ GeV and $\theta_p^0 = 23°$, $p_p^0 = 1.7$ GeV and $\theta_p^0 = 19°$, and $p_p^0 = 1.7$ GeV and $\theta_p^0 = 23°$

pion phase space, a contribution of the $p(e, e'p)\gamma$ reaction is observed around $M_X = 0$. More detailed data from the same experiment [16], are reported in several spectra where structures can be extracted in the same missing mass range. The measurements were performed for two values of the four momentum transfer squared between the initial and the final electron, namely, at $Q^2 = 2.8$ GeV^2 and $Q^2 = 4$ GeV^2. The measurements were performed for a few values of P_p^0 and a few values of θ_p^0. Four spectra are shown in Fig. 3 for $Q^2 = 4$ GeV^2. Figure 4 shows another selection of spectra corresponding to $Q^2 = 2.8$ GeV^2. In both figures open circles correspond to Monte-Carlo simulations [16] and full circles correspond to data. In the missing mass range studied here an excess of counts can be seen between data and the simulation which were fitted by a polynomial. The quantitative informations are given in Table 1. The discrepancy between data and simulation for $M_X \leqslant 60$ MeV has been attributed to the Bethe–Heitler process ($ep \to e'p'\gamma$ reaction).

1.3. Discussion. We have looked at some existing data in order to find evidence for the existence of a new boson. All spectra shown here, display a structure, but at slightly different masses. However, there is an indication of a possible regrouping around several mass values. The statistics is too low for giving an evidence if the results privilege one unstable mass or a few better defined masses. We increase therefore the number of spectra studied, as those shown in Figs. 3 and 4. These spectra are not shown here. The corresponding quantitative information is summarized in Table 1. They favour a regrouping into several values; the same conclusion is favoured by the existence of more than one peak in the same spectrum, as in Fig. 1, *b*. In summary, these narrow structures masses (see Fig. 5), are tentatively observed at:

Table 1. **Masses (in MeV) and number of standard deviations (S.D.) of the narrow peaks extracted around $M \approx 215$ MeV, from the $p(e, e'p)X$ reaction studied at JLAB in Hall C [16] for $Q^2 = 4$ GeV^2 (Fig. 3) and $Q^2 = 2.8$ GeV^2 (Fig. 4). The width of the peak is given by σ (in MeV). p_p^0 is in GeV, and θ is in degrees**

Figure	Set [16]	Q^2	p_p^0	θ_p^0	M	σ	S.D.
3, *a*	10	4.0	2	23	250	22	9.5
3, *b*	11	4.0	2	20	225	22	4.9
3, *c*	21	4.0	2.2	17	230	17	5.2
3, *d*	5	4.0	2.45	17	210	17	6.3
4, *a*	14	2.8	1.9	33	200	17	1.9
4, *b*	19	2.8	1.55	23	225	17	4.0
4, *c*	34	2.8	1.7	19	215	17	3.0
4, *d*	36	2.8	1.7	23	210	17	2.9
	12	4.0	2	17	235	22	5.1
	14	4.0	1.8	17	220	22	2.6
	15	4.0	1.8	20	220	17	4.9
	16	4.0	1.8	23	225	17	1.5
	19	4.0	2.2	23	235	17	5.3
	20	4.0	2.2	20	200	17	5.9
	4	4.0	2.45	14	215	17	3.5
	6	4.0	2.45	20	180	17	3.7
	9	2.8	1.9	23	215	17	3.8
	10	2.8	1.9	25	210	17	3.75
	13	2.8	1.9	31	235	17	1.9
	18	2.8	1.55	25	215	17	3.5
	28	2.8	2.15	23	180	17	11
	29	2.8	2.15	21	180	17	8.6
	30	2.8	2.15	19	200	17	3.4
	33	2.8	1.7	17	215	17	2.8

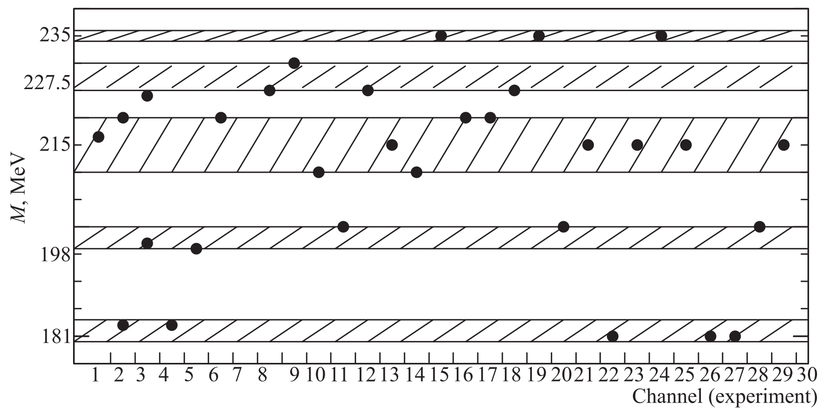

Fig. 5. Masses of the weakly excited structures extracted from several experiments (see text and Table 1)

$M = (181 \pm 2)$ MeV (5 events),
$M = (198 \pm 2)$ MeV (5 events),
$M = (215 \pm 5)$ MeV (12 events),
$M = (227.5 \pm 2.5)$ MeV (5 events),
$M = (235 \pm 1)$ MeV (3 events).

We notice that the range exhibiting the largest number of experimental mass structures, namely, around $M = 215$ MeV, agrees with the value extracted at Fermilab: $M = 214.3$ MeV [1]. There is also an additionnal but qualitative evidence in favour of a structure at $M \approx 214$ MeV. The $pd \to pd\eta$ reaction was studied at CELSIUS [17]. Figure 4 of [17] (lower frame) shows a scatterplot of $M_{\gamma\gamma}$ vs M_{pd}, where a careful observation indicates an excess of counts around $M_{\gamma\gamma} \approx 214$ MeV. Such resonances could decay into two electrons, but the probability of the decay into two leptons is proportional to their mass, so it is strongly disfavoured with respect to muons.

2. SELECTED DATA SHOWING SMALL STRUCTURES IN THE MASS RANGE BELOW THE PION MASS

2.1. The Missing Mass of the $pp \to ppX$ Reaction. The natural question, following the previous result, is to look, in already published data, at (a) possible structure(s) below the mass of the pion ($M = 135$ MeV). All the data reanalyzed below, are read and their mass is recalibrated, when necessary, to adjust the pion peak at $M = 135$ MeV. The pion missing mass peak is described by a gaussian and the structure(s) at lower mass(es) is (are) described by a gaussian with the same width as the one given for π^0. The observed structures are small, therefore a semi-log scale is used. Also the mass(es) extracted is (are) not always stable, since the corresponding statistics is not reached. A small background is arbitrarily drawn. If it will be modified, the results will not change much, since we are in the semi-log scale.

Figure 6 shows the missing mass spectra studied at SATURNE (SPES3 beam line) in the useful range, at $T_p = 1520$ MeV, and at four different spectrometer angles. A small peak is easily extracted at forward angles. When the spectrometer angle increases, the excitation of this exotic structure increases as well relatively to the π^0 excitation, but the resolution gets spoiled and the peak, although still extracted, is no more clearly separated from the π^0 peak. Figure 7 shows another selection of four missing mass spectra. Here again the experimental results are well fitted with introduction of a second peak at a mass close to $M \approx 65$ MeV. Table 2 gives the quantitative information. σ describes the width of the peaks and R is the ratio of the exotic structure excitation relative to the π^0 excitation.

Figure 8 shows a selection of missing mass peaks from CELSIUS in inserts *a*, *b*, and *c*. Figure $8, a$ shows the data from the $pp \to pp\pi^+\pi^-$ reaction studied at CELSIUS [18] at $T_p = 775$ MeV. The σ of the peaks equals 20 MeV, and $R = 17 \cdot 10^{-2}$. Figure $8, b$ shows the data from the $pp \to pp\gamma\gamma$ reaction studied at CELSIUS [19] at $T_p = 1360$ MeV. Here $\sigma = 16$ MeV and $R = 6.6 \cdot 10^{-2}$. Figure $8, c$ shows the data of the $pp \to ppX$ reaction studied at CELSIUS [11] at $T_p = 650$ MeV. Here $\sigma = 17$ MeV and $R = 8.3 \cdot 10^{-2}$ for the ratio of the «60»/«135» peaks and $R = 20 \cdot 10^{-2}$ for the ratio of the «100»/«135» peaks. In all these spectra a peak at $M \approx 65$ MeV is observed, and also another one is extracted at $M = 100$ MeV. Table 2 gives the quantitative information. Several spectra from

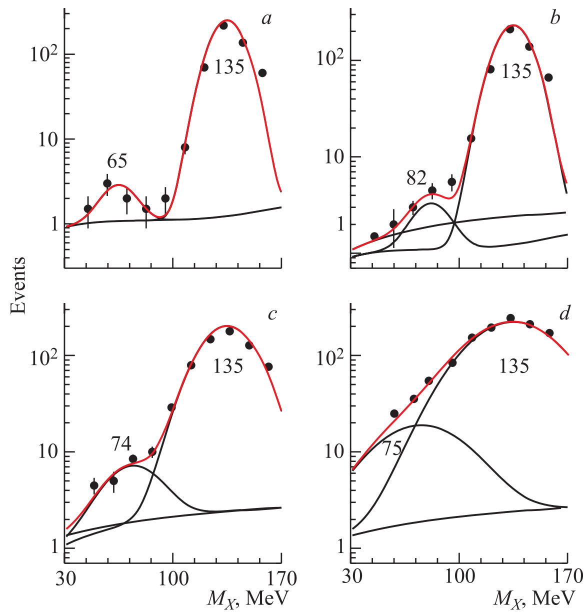

Fig. 6. Missing mass spectra for $pp \to ppX$ measured at SATURNE (SPES3 beam line) at $T_p = 1520$ MeV. *a–d* correspond respectively to the following spectrometer angles: $\theta_{\rm spec} = 0$, 2, 5, and 9°

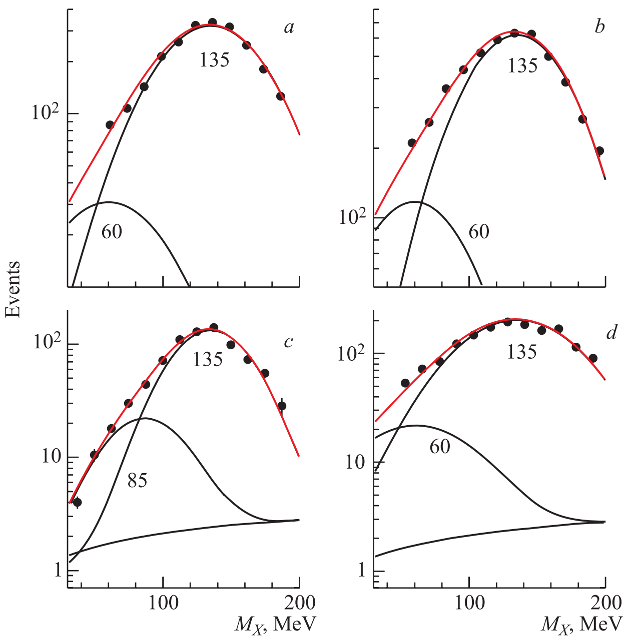

Fig. 7. Missing mass spectra for $pp \to ppX$ measured at SATURNE (SPES3 beam line). *a–d* correspond respectively to the following kinematical conditions: $T_p = 1520$ MeV, $\theta_{\rm spec} = 13°$; $T_p = 1520$ MeV, $\theta_{\rm spec} = 17°$; $T_p = 1805$ MeV, $\theta_{\rm spec} = 9°$; and $T_p = 1805$ MeV, $\theta_{\rm spec} = 13°$

Table 2. **Quantitative information on the small structure extracted from the missing mass spectra studied with $pp \to ppX$ reaction at SATURNE (SPES3 beam line) [8]. The incident proton energies T_p and the mass $M \approx 65$ are in MeV. R is the ratio of the $M \approx 65$ MeV structure excitation over the π^0 excitation**

Figure	T_p	θ_{pp}	σ	$M \approx 65$	R
6, *a*	1520	0	10.3	65	$7.2 \cdot 10^{-3}$
6, *b*	1520	2	11.5	82	$9.6 \cdot 10^{-3}$
6, *c*	1520	5	17	74	$27 \cdot 10^{-3}$
6, *d*	1520	9	28	75	$77 \cdot 10^{-3}$
7, *a*	1520	13	38	60	$9.4 \cdot 10^{-2}$
7, *b*	1520	17	38	60	$18.7 \cdot 10^{-2}$
7, *c*	1805	9	27	85	$13.8 \cdot 10^{-2}$
7, *d*	1805	13	40	60	$10.0 \cdot 10^{-2}$

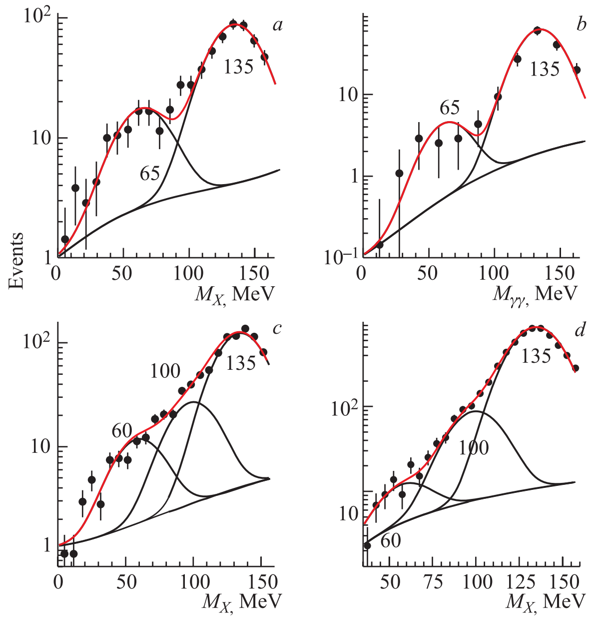

Fig. 8. Missing mass spectra for several different reactions measured at CELSIUS. *a*) $pp \to pp\pi^+\pi^-$ [18]; *b*) $pp \to pp\gamma\gamma$ [19]; *c*) $pp \to ppX$ [11]; *d* shows the missing mass of the $p(\mathbf{e}, e'\mathbf{p})\pi^0$ reaction [14] studied at JLAB in Hall A at $\theta_{\rm cm} = 90°$

COSY-Jülich are reported in Fig. 9. They are all integrated by two channels in order to increase the precision. The effect in the spoiling of the resolution is observed, going from insert (*a*) to insert (*c*). Table 3 gives the quantitative information. Figure 9, *a* shows the data from the $pd \to {}^3\mathrm{He}\pi^0$ reaction measured by the GEM detector at COSY [20] at $T_p = 328$ MeV. Here $\sigma = 13$ MeV and $R = 1.7 \cdot 10^{-2}$ for the ratio of the «60»/«135» peaks and $R = 10.9 \cdot 10^{-2}$ for the ratio of the «100»/«135» peaks. A large statistics missing mass

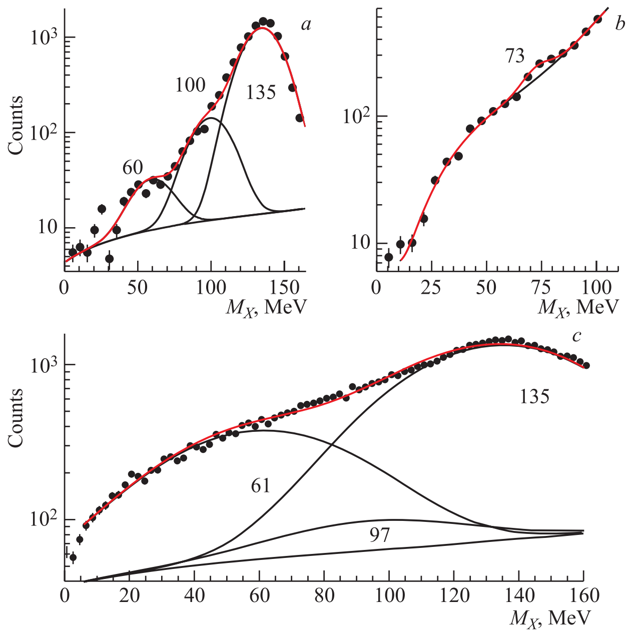

Fig. 9. Missing mass spectra for several different reactions measured at COSY. *a*) $pd \to {}^3\mathrm{He}\pi^0$ [20]; *b*) $pd \to \mathrm{T}\pi^+$ [21]; *c*) $dp \to {}^3\mathrm{He}\eta$ [22]

Table 3. **Quantitative information concerning Figs. 8, 9, and 10**

Figure	Reaction	Ref.	Lab.	$M(R)$	$M(R)$
8, *a*	$pp \to pp\pi^+\pi^-$	[18]	CELSIUS		65 (0.17)
8, *b*	$pp \to pp\gamma\gamma$	[19]	CELSIUS		65 (0.07)
8, *c*	$pp \to pp\pi^0\pi^0$	[11]	CELSIUS	100 (0.2)	60 (0.08)
8, *d*	$p(\mathbf{e}, e'\mathbf{p})\pi^0$	[14]	JLAB A	100 (0.09)	60 (0.01)
9, *a*	$pd \to {}^3\mathrm{He}\pi^0$	[20]	COSY	100 (0.1)	60 (0.02)
9, *b*	$pd \to \mathrm{T}\pi^+$	[21]	COSY		73
9, *c*	$dp \to {}^3\mathrm{He}\eta$	[22]	COSY	97 (0.03)	61(0.25)
10, *a*	$\gamma p \to pX$	[23]	JLAB B	100 (0.33)	55 (0.06)
10, *b*	$\gamma p \to pX$	[23]	JLAB B	100 (0.13)	65 (0.04)
10, *c*	$\gamma p \to pX$	[23]	JLAB B		65 (0.09)
10, *d*	$\gamma p \to pX$	[23]	JLAB B		65 (0.10)

spectra was obtained with the $pd \to {}^3\mathrm{T}\pi^+$ reaction studied at COSY [21] at $T_p = 328$ MeV also. The authors said that «small background was subtracted for each angular bin». The data are read, integrated by two channels, and shown in Fig. 9, *b*. A small peak at $M = 73.6$ MeV is extracted. Figure 9, *c* shows the missing mass spectra of the $dp \to {}^3\mathrm{He}\eta$ reaction at $T_d = 1780$ MeV [22]. Here $\sigma = 29$ MeV and $R = 25.2 \cdot 10^{-2}$ for the ratio of the «61»/«135» peaks and $R = 2.8 \cdot 10^{-2}$ for the ratio of the «97»/«135» peaks.

The missing mass of the $p(\mathbf{e}, e'\mathbf{p})\pi^0$ reaction [14] studied at JLAB in Hall A at $\theta_{\mathrm{cm}} = 90^\circ$ is read and reported in Fig. 8, *d*. Two structures, at $M = 100$ and 60 MeV are extracted.

2.2. The Missing Mass of the $\gamma p \to pX$ Reaction. The missing mass of the $\gamma p \to pX$ reaction was studied at JLAB in Hall B, in an experiment devoted to study the inclusive η photoproduction in nuclei [23] by the CLAS Collaboration. The data at low missing mass range are read and reported in Fig. 10. We observe the good fit obtained with introduction of a structure at $M = 100$ MeV in Fig. 10, *a* and *b* and a structure at $M = 65$ MeV ($M = 55$ MeV in Fig. 10, *a*) in all inserts.

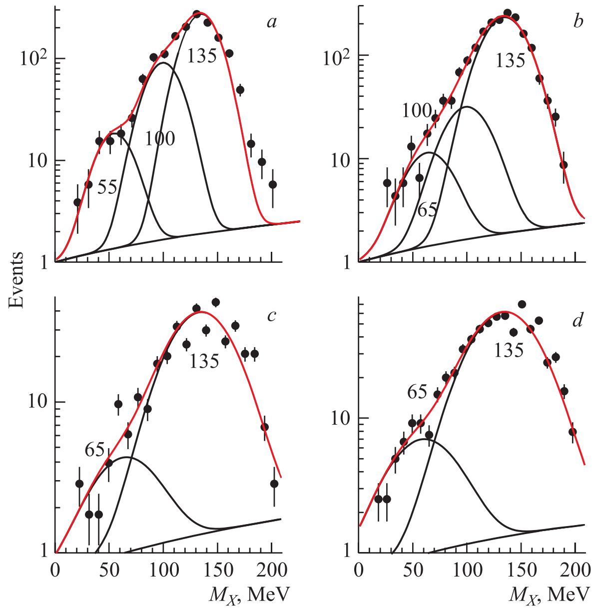

Fig. 10. Missing mass spectra for $\gamma p \to pX$ measured at JLAB in Hall B [23] by the CLAS Collaboration. *a–d* correspond respectively to the following kinematical conditions: $0.8 \leqslant E \leqslant 0.9$ GeV and $-0.75 \leqslant \cos(T) \leqslant -0.50$, $0.8 \leqslant E \leqslant 0.9$ GeV and $-0.25 \leqslant \cos(T) \leqslant -0.00$, $1.2 \leqslant E \leqslant 1.3$ GeV and $-0.50 \leqslant \cos(T) \leqslant -0.25$, and $1.2 \leqslant E \leqslant 1.3$ GeV and $0.50 \leqslant \cos(T) \leqslant 0.75$. E is the beam energy and T is the proton center-of-mass angle

The mean values of the two low mass structures extracted from the various spectra shown are $M = 62$ and $M = 100$ MeV.

CONCLUSION

Figure 11 shows the various exotic masses shown in previous figures. These masses are $M = 62$, 80, 100, 181, 198, 215, 227.5, and 235 MeV, although the last one may be uncertain, since determined by only three data, and being located at the limit of the spectra. A few points, located around $M = 75$ MeV, may be thought as being not resolved structures. Indeed, when they are extracted none of the structures at $M = 100$ MeV or $M = 62$ MeV is observed. However, the symmetry of the masses reported in Fig. 11, may be considered as an indication of their genuine existence.

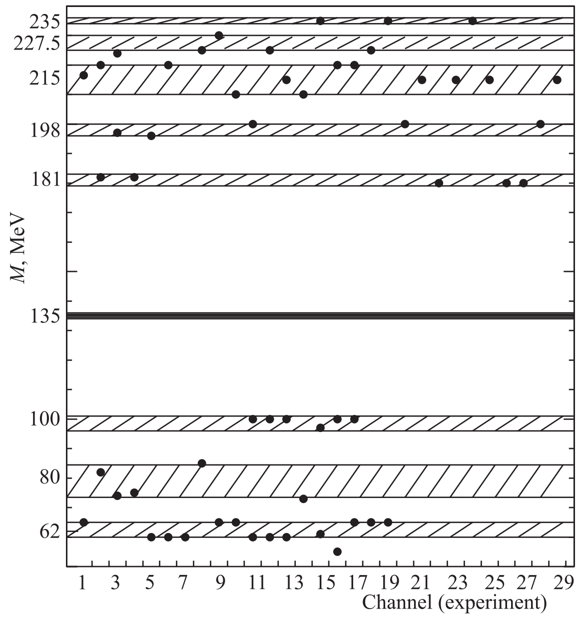

Fig. 11. Masses of the weakly excited structures extracted from several experiments

We have selected some spectra showing these structures. In many other spectra, such an extraction is not possible, either since their experimental resolution is worse, or since the dynamics of the experiment (reaction, incident energy. . .) is less favourable. In Figs. 6 and 7, and Table 2, six spectra obtained at the same incident energy and same reaction, show that R increases with the spectrometer angle (but the resolution gets spoiled, as already indicated). Figures 6 and 7 show that R increases with the incident energy (but again the resolution spoils in that case).

We suggest that the reason for which these narrow, weakly excited structures were not observed till now is due to the lack of experimental precision (resolution and statistics) of previous experiments.

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