

FURTHER EVIDENCE OF NARROW BARYONIC STRUCTURES WITH HADRONIC AS WELL AS LEPTONIC PROBES

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Abstract

Although extracted from several experiments using hadronic probes [1], narrow baryonic structures have been sometimes met with disbelief. New signatures are presented, which appear from already published data, obtained with hadronic probes as well as with leptonic probes. The authors of these results did not take into account the possibility to associate the discontinuities of their spectra with the topic of narrow baryonic low mass structures. The stability of the observed narrow structure masses, represents a confirmation of their genuine existence.

1 Narrow baryons produced by hadrons

Using mainly the $pp \rightarrow p\pi^+X$ and $pp \rightarrow ppX$ reactions, studied at SPES3 (Saturne), a spectrum of narrow baryonic structures was observed [1]. A high statistic missing mass spectrum of the $p(\alpha, \alpha')X$ reaction ($T_\alpha=4.2$ GeV, $\theta=0.8^\circ$) was obtained twelve years ago at SPES4 (Saturne) in order to study the radial excitation of the nucleon in the $P_{11}(1440$ MeV) Roper resonance [2]. A first large peak around $\omega \approx 240$ MeV was associated with the projectile excitation, and a second large peak around $\omega \approx 510$ MeV was associated with the target excitation. Above them lie narrow peaks, defined by a large number of standard deviations (see Fig. 1). Their masses (see table 1) agree fairly well with the masses of narrow structures extracted from $pp \rightarrow p\pi^+$ and $pp \rightarrow ppX$ reactions studied at SPES3 (Saturne) [1]. Fig. 2 shows the spectra of the same reaction at $\theta=2^\circ$ [3]. The empty circles, in both figures, which correspond to the scale, are the published number of events versus the energy loss. The full circles and full squares show the same data in an expanded scale [4]. Table 1 and Fig. 3 give the quantitative informations concerning the masses extracted from the previous figures, and the comparison with the masses previously extracted from SPES3 cross-sections [1]. Nearly all peaks are seen in both experiments. At $\theta=0.8^\circ$, the incident beam enters the SPES4 spectrometer, preventing a possible confirmation of the lower mass structure at $M=1004$ MeV. Above $M=1470$ MeV, a lot of peaks are observed. The same situation is observed in the SPES3 data [5], and all masses observed in both reactions are about the same. The peak at $M=1394$ MeV observed in the SPES4 experiment, was not kinematically accessible in the SPES3 data, since the mass range $1400 \leq M \leq 1470$ MeV lie between two incident proton energies.

We observe a nice agreement between the masses obtained using data from different physicists, studying different reactions with different probes and different experimental equipments.

This correlation is shown in Fig. 3, where the masses of the structures observed at SPES4 are shown versus the ones at SPES3. The straight lines correspond to the same masses, and all points are located along these lines. Peaks observed in one experiment

only are shown as empty circles. Some other structures were observed in a few $p(d,d')X$ spectra, which masses correspond with a high accuracy to the SPES3 masses.

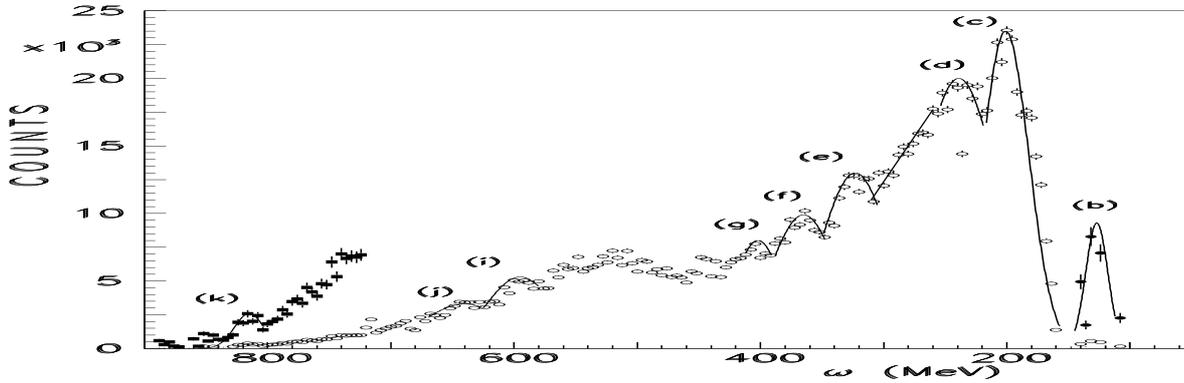


Figure 1: Spectra of the $p(\alpha, \alpha')X$ reaction studied at SPES4 (Saturne) with $T_\alpha=4.2$ GeV and $\theta=0.8^\circ$ [2].

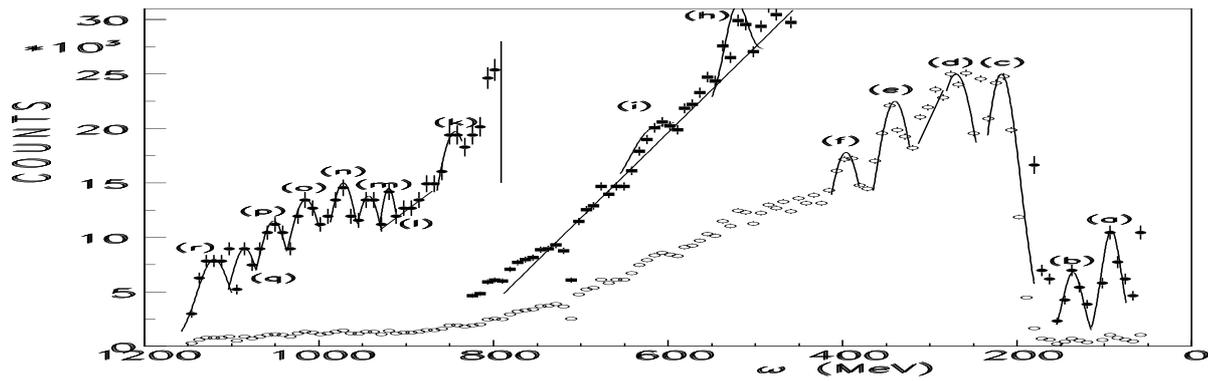


Figure 2: Spectra of the $p(\alpha, \alpha')X$ reaction studied at SPES4 (Saturne) with $T_\alpha=4.2$ GeV and $\theta=2^\circ$ [3].

2 Narrow baryons produced by leptons

Recent precise attempts, fail to point out the narrow baryonic structures observed with leptonic probes below pion threshold [6] [7] [8]. However, at masses above pion threshold, as it was done before with hadronic probes, several narrow structures can be extracted from previous experiments performed to study other topics. A more detailed paper which reviews similar results is in progress [9]. In order to illustrate the previous comment, we show four different data in the next figures.

Among the numerous experiments of Compton scattering on proton, some results from

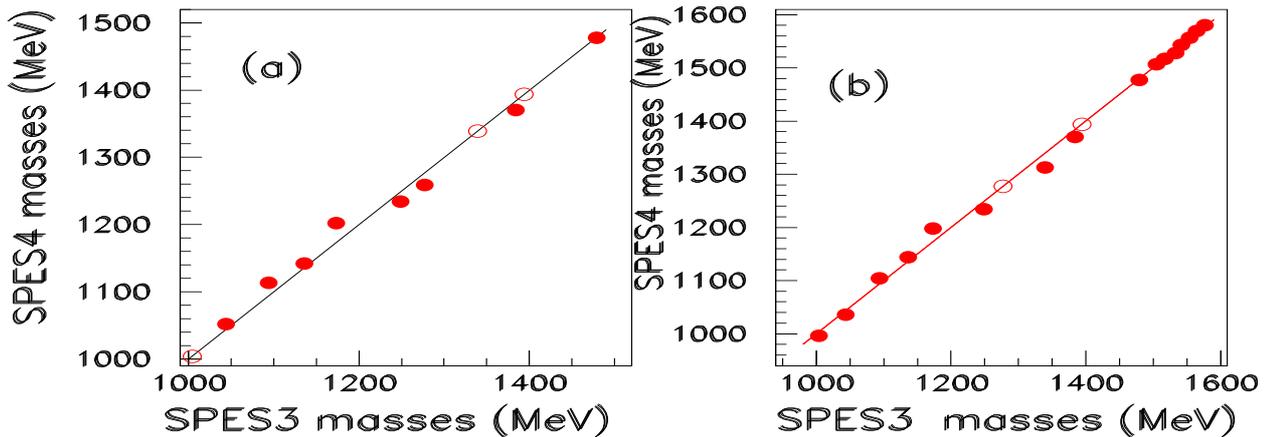


Figure 3: Comparison between masses of narrow baryons extracted from SPES3 and SPES4 data. Inserts (a) and (b) correspond respectively to $\theta=0.8^\circ$ and $\theta=2^\circ$.

Table 1: Masses (in MeV) of narrow exotic baryons, observed previously in SPES3 data and extracted from previous $p(\alpha, \alpha')X$ spectra measured at SPES4 [2] [3].

SPES3 mass	1004	1044	1094	1136	1173	1249	1277	1339	1384	1479
pic marker	(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)	(j)
SPES4 mass 0.8°		1052	1113	1142	1202	1234	1259	1370	1394	1478
SPES4 mass 2°	996	1036	1104	1144	1198	1234	1313	1370		1477
SPES3 mass	1505	1517	1533	1542	(1554)	1564	1577			
pic marker	l	(m)	(n)	(o)	(p)	(q)	(r)			
SPES4 mass 2°	1507	1517	1530	1543	1557	1569	1580			

Saskatchewan [10] are shown in Fig. 4. A peak not discussed by the authors, is easily extracted at $M \approx 1094$ MeV, at the same mass where it was seen before in the $pp \rightarrow p\pi^+X$ reaction at SPES3. Inserts (a) and (b) correspond to $\theta_{c.m.}^0 = 90^\circ$ and 141° respectively, with a peak at $T_\gamma = 166.5$ (169) MeV. The total c.m. energies are respectively $\sqrt{s} = 1092.2$ and 1094.3 MeV, the width of the peaks is $\sigma = 5.7$ (5.2) MeV and the number of standard deviations S.D. = 3.3 (5.5).

Fig. 5 illustrates total cross-sections of two pion photoproduction measured at MAMI, namely $\gamma p \rightarrow \pi^0 \pi^0 p$ [11] and $\gamma n \rightarrow \pi^- \pi^0 p$ [12]. Both peaks correspond to $\sqrt{s} = 1387$ MeV, close to $M = 1384$ MeV (mass of a narrow structure already seen [4]).

Fig. 6 illustrates total cross-sections of one pion photoproduction measured at INS (Tokyo) [13]. Inserts (a) and (b) correspond respectively to the $\gamma p \rightarrow \pi^+ n$ and $\gamma n \rightarrow \pi^- p$ reactions. Insert (a) shows a peak at $M = 1389$ MeV, ($M = 1384$ MeV observed at SPES3). Insert (b) shows peaks at $M = 1171$ MeV (1173), $M = 1252$ MeV (1249), and $M = 1387$ MeV (1384).

Fig. 7 illustrates total cross-sections of one pion photoproduction on ^1H and ^2H targets. The $\gamma n \rightarrow \pi^- p$ total cross-section data are from different laboratories [14], when the $\gamma d \rightarrow \pi^- pp$ total cross-sections are quoted from the CERN-Hera Compilation [15]. Both

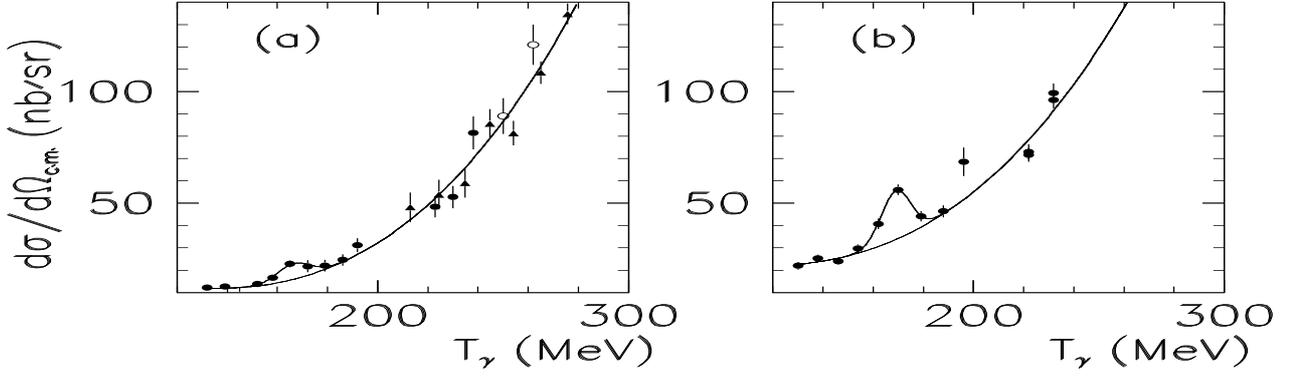


Figure 4: Selection of Compton scattering from the proton data, measured at Saskatchewan [10] (see [9]).

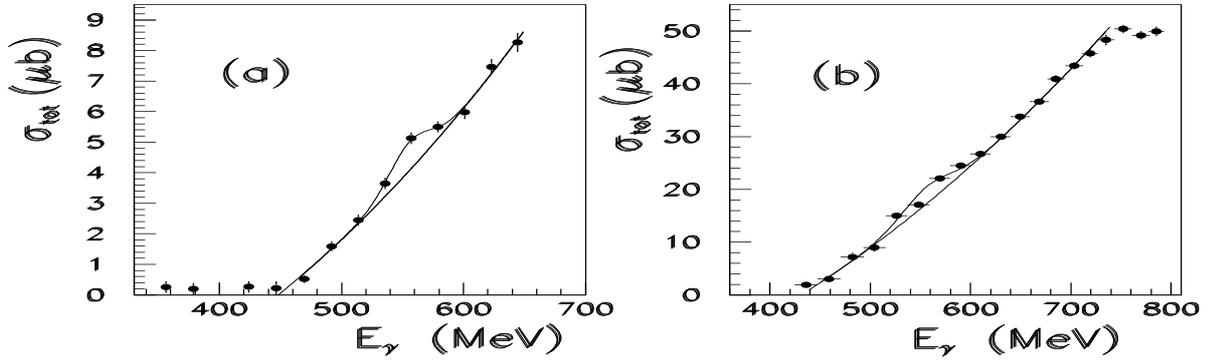


Figure 5: Total cross-sections of two pion production measured at MAMI. Insert (a) shows σ_{tot} of $\gamma p \rightarrow \pi^0 \pi^0 p$ [11]; insert (b) shows σ_{tot} of $\gamma n \rightarrow \pi^- \pi^0 p$ [12]. The quantitative informations are given in [9].

spectra exhibit a peak at $M=1094$ MeV and $M=1095$ MeV, to compare to $M=1094$ MeV (a SPES3 peak mass).

Other examples can be given [9], sometimes the peaks are smaller than those which are illustrated in this paper; they always show an astonishing correspondance with the masses previously extracted with hadronic probes.

Fig. 8 shows a comparison of masses observed with leptons, versus masses observed with hadrons. Here the solid symbols give this comparison and the empty circles show the peak masses not observed with leptonic probes. We observe less structures extracted from reactions with leptonic probes, but when a peak was seen, its mass reproduces well a peak mass from SPES3 experiments.

3 Conclusion

New dedicated precise experiments must be done to confirm the masses of the narrow baryons observed in many previous experiments, mainly performed at Saturne on the SPES3 and SPES4 beam lines. However, the stability of the structures already extracted from data obtained to study other topics, is noteworthy. This comment concerns as

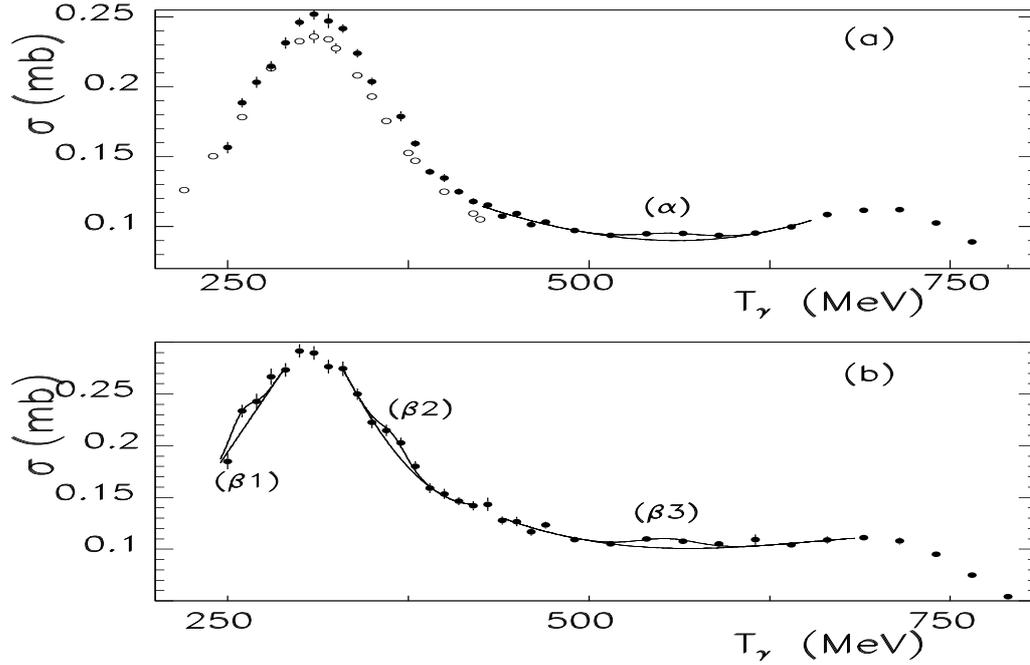


Figure 6: Total cross-sections of the $\gamma p \rightarrow \pi^+ n$ and $\gamma n \rightarrow \pi^- p$ reactions measured at the INS (Tokyo). The quantitative informations are given in [9].

well data obtained with hadronic probes as data obtained with leptonic probes, although these last are less numerous. It is worthwhile to mention that the few baryons with mass lower than the pion threshold, were not seen in recent experiments using leptonic probes. Then it is possible to speculate that the excitation of these baryons is favoured through dibaryonic states.

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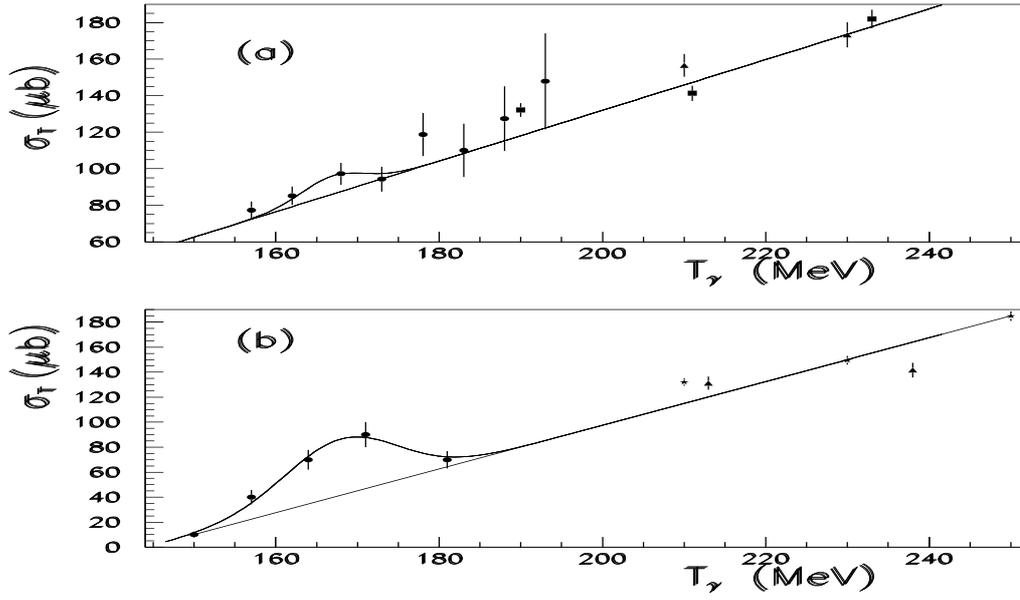


Figure 7: Total cross-sections of the $\gamma n \rightarrow \pi^- p$ (insert (a)) and $\gamma d \rightarrow \pi^- pp$ (insert (b)) reactions measured at various laboratories. The quantitative informations are given in [9].

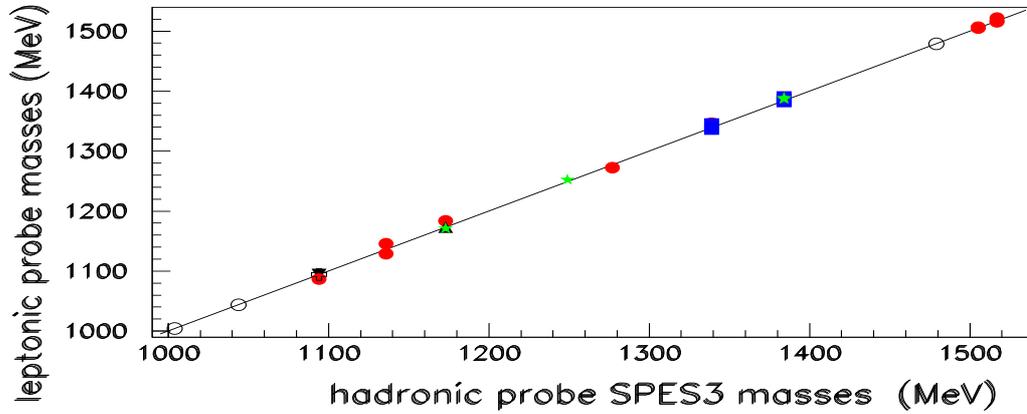


Figure 8: Comparison of masses of narrow baryonic structures observed with leptonic probes, versus masses of narrow baryonic structures observed with hadronic probes. The empty circles show data not seen with incident leptons.