Additional Evidence for Low Mass Exotic Baryons

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Using $\vec{\mathrm{p}}\ \mathrm{p} \rightarrow \mathrm{p}\ \pi^+ X$ and $\vec{\mathrm{p}}\ \mathrm{p} \rightarrow \mathrm{p}_f\ \mathrm{p}_s\ \mathrm{X}$ reactions, studied at SPES3 (Saturne), narrow baryonic structures were observed in the mass range $950 \leq \mathrm{M} \leq 1790$ MeV [1]. The results in the mass range $1470 \leq \mathrm{M} \leq 1670$ MeV are shown in figs.1 and 2. In fig.1, full (empty) circles correspond to well-defined (less well-defined) peaks. Each column corresponds to a particular experimental situation (reaction, incident energy, angle, and kinematical condition). The mass ranges studied differ with different reactions; they are indicated by a dashed area. The mean value of several masses of narrow peaks is kept as being a narrow peak mass, and the area is drawn with ± 3 MeV range. The quantitative information is given in Table. Fig.2 shows an attempt to associate these narrow states with broad PDG resonances. Those, where a deexcitation into a Nη final state was observed, were identified as being "fine structures" of $\mathrm{N}^*(1535)S_{11}$ and $\mathrm{N}^*(1650)S_{11}$. Those where a deexcitation into a Nη final state was not observed, were identified as being "fine structures" of $\mathrm{N}^*(1520)D_{13}$ and $\Delta(1600)P_{33}$.

A careful scrutiny was done to look at eventual structures in published data, structures not pointed out by the authors. With hadronic probes, they were observed in different data with fairly stable masses, allowing us to conclude that they are genuine narrow exotic states. An illustration is given in fig.3 showing a spectrum of $\mathrm{p}(\alpha, \alpha')\mathrm{X}$ reaction at T_α=4.2 GeV, $\theta = 2^0$ measured at SPES4 (Saturne) [2]. The table shows the masses extracted from this spectrum, which are close to the masses observed in the SPES3 data.

Structures were also extracted from data obtained with leptonic probes, but only at masses larger than the pion production threshold. Fig.4 shows data from the $\gamma^* N \rightarrow \Delta$ studied with the N(e,e'p)π reaction at Mainz and at LEGS [3]. Three structures are observed at T_γ=483, 546 and 605 MeV. These energies correspond respectively to the following $\sqrt{(s)}$ values (to compare to the masses , into brackets, observed at SPES3): 1338 [1339] MeV, 1381.5 [1384] MeV, and 1421 MeV. This last mass was not studied at SPES3, being located between two incident proton energies. But systematic studies anticipate a structure to be situated at M$\approx$1423 MeV.

We suggest that the broad PDG baryonic resonances are collective states of several narrow resonances. These last can be single-particle-or-quasi-particle states, with more complicated structures than $|q^3>$, not observed previously due to the lack of experimental precision.

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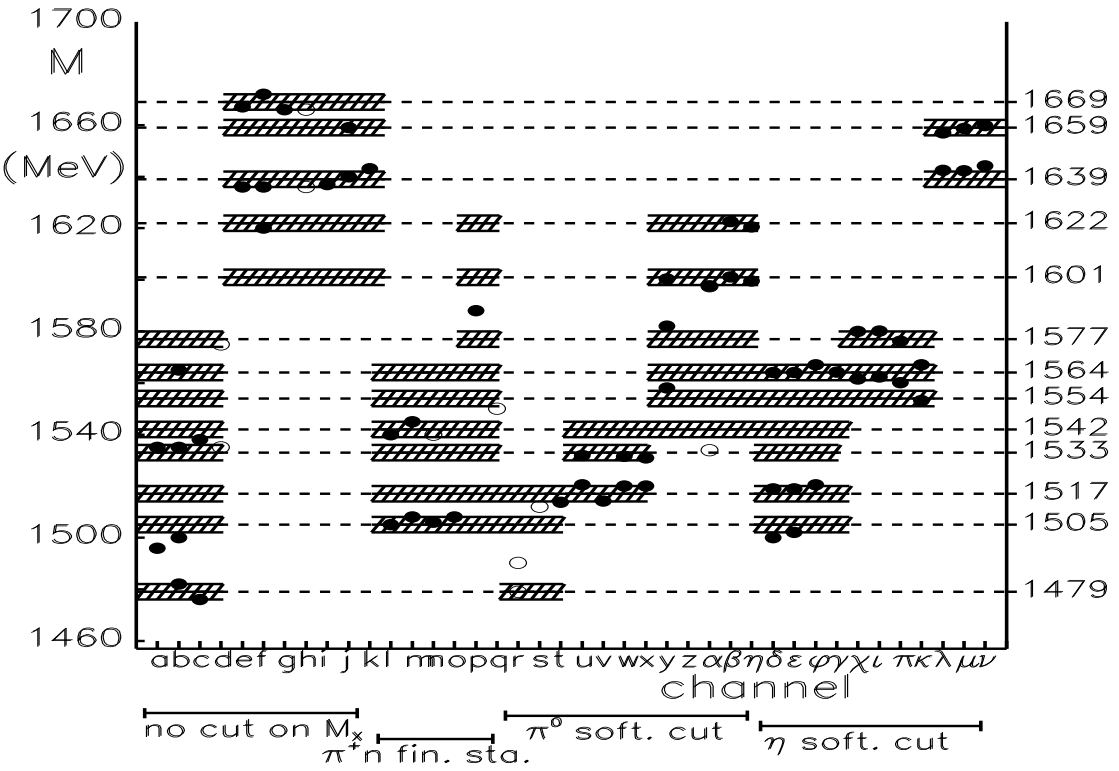

Figure 1:

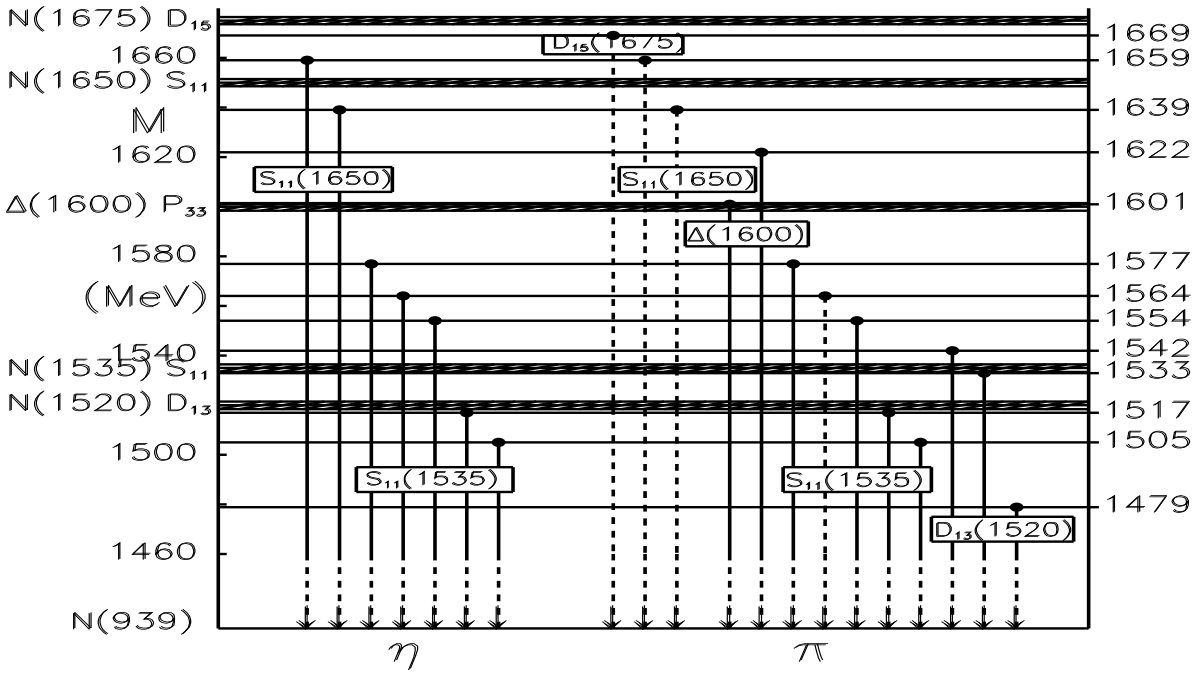

Figure 2:

SPES3 mass	1479	1505	1517	1533	1542	(1554)	1564	1577
peak marker	(l)	(m)	(n)	(o)	(p)	(q)	(r)	(s)
SPES4 mass 2^0	1477	1507	1517	1530	1544	1557	1569	1580

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

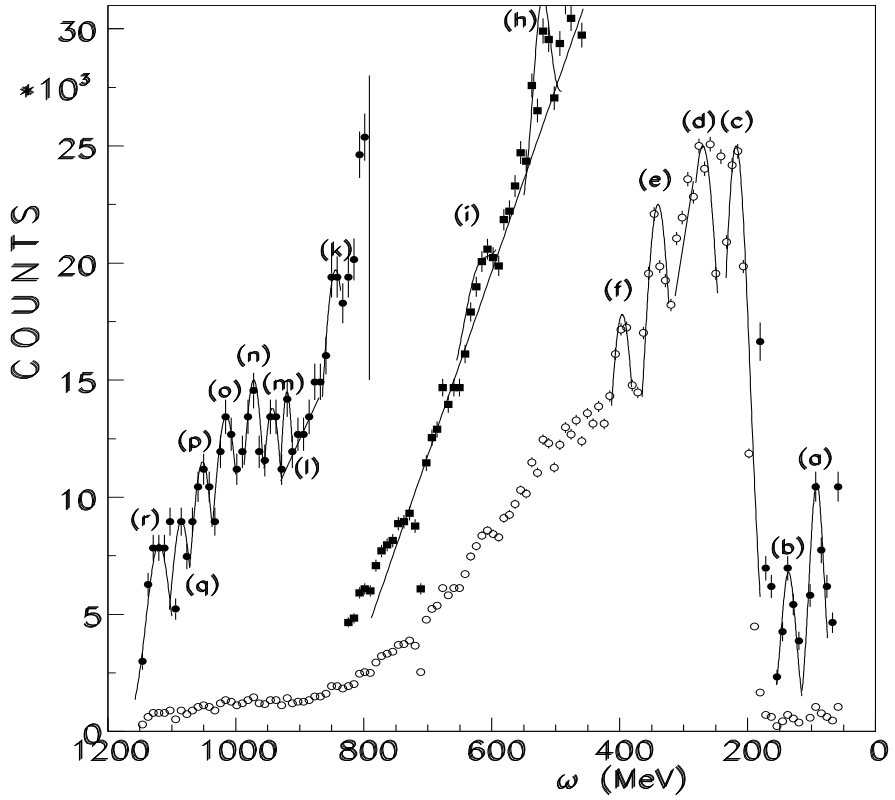

Figure 3: p(α, α')X reaction at T_α=4.2 GeV, $\theta = 2^0$ measured at SPES4 (Saturne) [2].

References

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[3] S.N. Yang and S.S. Kamalov, arXiv:hep-ph/0509318 (2005); R. Beck *et al.*, Phys. Rev. Lett. **78**, 606 (1997); G. Blanpied *et al., Phys. Rev. Lett.* **79**, *4337 (1997).*

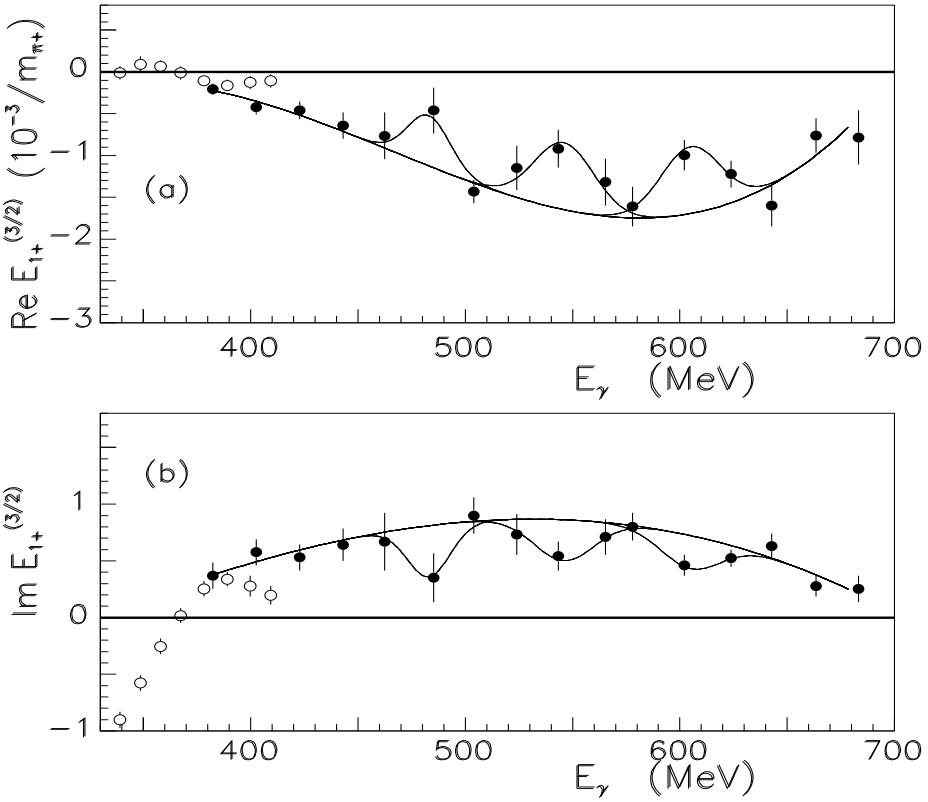
Re $E_{1+}^{(3/2)}$ $(10^{-3}/m_{\pi+})$
0
−1
−2
−3
(a)
400
500
600
700
E_γ (MeV)
Im $E_{1+}^{(3/2)}$
1
0
−1
(b)
400
500
600
700
E_γ (MeV)

Figure 4: