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FURTHER EVIDENCE CONCERNING NARROW ISOVECTOR NONSTRANGE DIBARYONS

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The missing-mass spectra for the $^3He(p,d)X$ reaction ($B_x = 2$, $T_x = 1$) have been measured at $T_p = 1.2$ GeV for $\theta_d = 33°$. Narrow structures have been observed at $M_x = 2.122$, 2.198 and possibly 2.233 GeV with FWHM respectively equal to 5.2, 8.1 and 13 MeV. These results which were obtained in new kinematical conditions, confirm our previous data$^{1)}$.

For a few years, an intensive search for narrow dibaryons has been undertaken with the hope to find a signature of quark degrees of freedom in nuclear physics. This hunt in a pure T = 0 channel where it would not be contaminated by some new N-Δ narrow quasi bound states, was up to now unsuccessful2). However in a pure T = 1 channel, the situation is much more debated. Many experimental results3), have been reported. Some of them, especially when N-N scattering data have been involved, concluded to the non observation of any narrow resonance. Other results however reported the observation of such resonances, giving corresponding masses and widths. Since the number of these studies is too large, we will send back the reader to the references quoted in3) except for the data more recent than july 1985.

A continuous measurement of the energy dependence of the pp elastic cross section at 90° c.m., between 0.5 and 1.2 GeV ($2.114 \leq \sqrt{S} \leq 2.401$ GeV) has been performed at Laboratoire National Saturne (LNS)4) using an internal hydrogen jet target crossing the proton beam during its acceleration. The authors concluded that there is no evidence for narrow structure in the excitation function. No narrow structure has also been found at LNS in the analyzing power for the pp elastic scattering in the range $0.655 < T_p < 1.017$ GeV, ($2.178 < \sqrt{S} < 2.326$ GeV) in an experiment5) where ten excitation functions between 17 and 35 degrees lab. have been measured.

In a previous experiment1), the missing mass spectra measured for the reaction ^{3}He(p,d)X at $T_p = 0.75$ and 0.925 GeV, and for p(^{3}He,d)X at $T^3\mathrm{He} = 2.7$ GeV, showed structures at $M_x = 2.124$, 2.192 and 2.240 GeV (≅ 20 MeV wide). Structures which could be good candidates for narrow isovector dibaryons in the invariant mass (M_{pp}) range equivalent to that of our measurements $2.09 < M_x < 2.31$ GeV were observed by the study of the correlated emission of proton pairs with large transverse momenta. Such structures have been observed at $M_{inv.} = 2.15$ and 2.23 GeV by Agakishiev et al.6) in (C,2p) reactions on carbon, and at $M_{inv.} = 2.015$, 2.035, 2.115, 2.155 and 2.235 GeV by Andronenko et al.7) in (p,2p) reactions on carbon.

We report here a continuation of our previous experiment[1]) in new kinematical conditions, in order to eliminate possible systematic effects. We will summarize briefly the main aspects of the experiment and describe the few improvements introduced since the previous experiment[1]) in the data analysis. The missing mass M_x was measured by detecting the deuterons in the spectrometer SPES 1. The procedure and checks were discussed in detail elsewhere[1]). The proton energy was $T_p = 1.2$ GeV, and the spectrometer angle $\theta_d = 33°$. The proton beam had typically an intensity of 1.5×10^{11} particles per burst. A cryogenic target (509 mg/cm^2) was used. The contributions of the windows (empty target) were systematically studied in order to check that the corresponding M_x spectra were flat. The thickness of the target accounts for the main effect of broadening the experimental energy resolution. At 33° it produces a calculated full width at half maximum $\Delta M_x \approx 2.4$ MeV. The data were therefore binned into 3 MeV intervals. The relative statistical errors range between 6 and 9.10^{-3} for one bin.

The missing mass domain explored for a given spectrometer field setting, was roughly equal to 35 MeV. Consequently many runs were taken at different field values to explore a wide missing mass domain (see Fig. 1). A fair overlap in M_x between different runs was ensured. The beam monitoring done using a secondary electron emission chamber and two telescopes was very stable. The large overlap between different runs allowed us to check that no renormalization was needed to get the best continuity between the different spectra corresponding to data projected in the same aperture. A small shift in masses (between 2 and 3 MeV) accounts for p and (or) d energy loss in the target for the entire spectrum. At 33°, there is no deuterons produced by the quasi free $pp \rightarrow d\pi^+$ reaction. The backward $pd \rightarrow dp$ scattering on a d substructure from the ^{3}He target, peaks at $p_d = 1.795$ GeV/c corresponding to $M_x = 2.1$ GeV. The corresponding peak should have a FWHM of the order of 50-80 MeV. After applying cuts to select the angular range ($\Delta\theta = 1.5°$), the bidimensional spectrum is projected to get the missing mass spectrum shown in Fig. 1

Narrow structures appear at 2.122, 2.198 and possibly 2.233 GeV. The results are summarized in table 1. Following the procedure already used¹⁾, around each structure a polynomial fit has been carried out after having removed the data points corresponding to structures, leading to chi-squares of the order of 1. per degree of freedom.Then, with all experimental points, a gaussian fit in addition to the polynom determines the values of mass and width. The corresponding errors due to the fitting procedure are typically better than 1.5 MeV for M_x and 3.3 MeV for the widths. This last effect is taken into account in Table 1. For the three structures we observe at this angle that the standard deviations (S.D.) range from 3.7 to 7.7. The structure at 2.233 GeV is however less certain since the peak over background ratio is equal to 2 % only. In Fig. 2, we have displayed the missing mass region observed at both angles and the appearing structures. We observe a very good agreement with our previous results¹⁾ obtained in different kinematical conditions (incident energies and angles).

We have proposed a tentative spin assignment for the observed narrow structures in non strange isovector dibaryon states³⁾. The method was to display the masses versus a rotational-like mass formula $M = M_0 + M_1J(J + 1)$ as in Fig. 3 for masses above 2 GeV. Our present data (black circles) are in agreement with our previous¹⁾ results (black squares) and with a large number of different results quoted in the litterature⁶⁻¹⁵⁾.

In the framework of a MIT spherical six quark bag model, many P matrix poles have been predicted¹⁶⁾ in the energy range explored in this experiment. When quarks are allowed to be in 1 s, 1 p and 2 s states, many poles have been predicted starting at 2.1 GeV. Very simple calculations¹⁸⁾ lead to predictions of widths between 10 and 50 MeV. Our experimental determination of M_0 and M_1 (respectively 2.014 and 0.0182 GeV) is close to the theoretical values predicted by Mulders¹⁹⁾ in the framework of a MIT spherical quark bag model in order to reproduce the M_Δ-M_N mass difference and the spectra of a few hadrons.

However recent calculations$^{17)}$ done in the framework of the cloudy bag model lead to larger masses for six-quark resonances. The $^1S_0$ resonance corresponds to $\sqrt{s}$ = 2.7 GeV, and the $^3D_3$ resonance to $\sqrt{s}$ = 2.64 GeV. The widths also (≈ 50 MeV) are larger than the widths of our experimental structures. These calculations are more consistent$^{17)}$ with NN phase shifts than those performed in the MIT bag model. An important mass reduction could possibly be obtained by introducing collective $q\bar{q}$ pair configurations into 6 q states$^{20)}$, but it is not clear what will happen to the widths. An alternative explanation$^{20)}$ would be that the structures presented in Fig. 3 are induced by the opening of NNπ (2.017 GeV) and NNππ (2.156 GeV) thresholds. Indeed there are structures at these two energies. This however would not explain the narrow widths observed$^{20)}$. The lack of corresponding N-Δ effect has also to be explained.

In summary very precise missing mass spectra have been measured. We have confirmed the existence of narrow structures in the B = 2, T = 1 states weakly excited over the physical background NN, NNπ, NΔ... These structures could have been created by the opening of two nucleon pionic channels, but both the observed masses and widths do not favor such an explanation. There are also indications that these dibaryons could correspond to quark degrees of freedom. The spin assignment is still more dubious, nevertheless the slope and threshold parameters of a rotational -like mass formula are in good agreement with the corresponding values found in a MIT six quark bag model.

Acknowledgments

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T_p = 1.2 GeV			
	θd = 33° lab.		
M_x (GeV)	2.122 ± 0.001	2.198 ± 0.001	2.233 ± 0.0016
FWHM (GeV)	0.0052 ± 0.0008	0.0081 ± 0.0011	0.013 ± 0.0032
dσ/dΩ nb/sr	30 ± 6	112 ± 20	75 ± 24
dσ/dt nb/GeV^2	25.7 ± 5.1	98 ± 18	67 ± 21
t(GeV^2)	-.93	-.97	-.99
S.D.	3.8	7.7	3.7

Table 1 : Number of standard deviations (S.D.) from the background of the narrow structures. The masses (M_X), FWHM and cross sections (dσ/dt) for corresponding t values, are for the found structures.

FIGURE CAPTIONS

1) - Missing mass spectrum for T_p = 1.2 GeV, θ_d = $33°_{lab.}$ and $\Delta\theta_d$ = 1°5. The error bars are included in the black circles. Data have been binned into 3 MeV intervals. The curves correspond to polynomial and polynomial plus Gaussian fits. Under the 2.233 GeV are displayed data minus polynomial fit and the corresponding gaussian fit with an enhanced scale.

2) - The figure shows the masses of the dibaryonic states found in this work (black squares), and previously$^{1)}$ (black circles). The lines correspond to the missing mass range studied.

3) - Display of the narrow state masses found in the different experiments. The evidence for a rotational - like mass formula $M = M_0 + M_1\,J(J+1)$ is clear with as a consequence this tentative spin assignement.
The data are from : ● this work ; ■ B. Tatischeff et al. (1) ;
○ H.N. Agakishiev et al. (6) ; ≠ M.N. Andronenko et al. (7) ;
◬ V.V. Glagolev et al. (8) ; ⊙ C. Besliu et al. (9) ;
Δ V.V. Glagolev et al. (10) ; × A.A. Baïramov et al. (11) ;
⛛ T. Siemiarczuk et al. (12) ; ⊠ P. Zielinski et al. (13) ;
▽ T. Siemiarczuk et al. (14); ⊖ B. Bock et al. (15) and
⊗ J. Saudinos et al. (21)

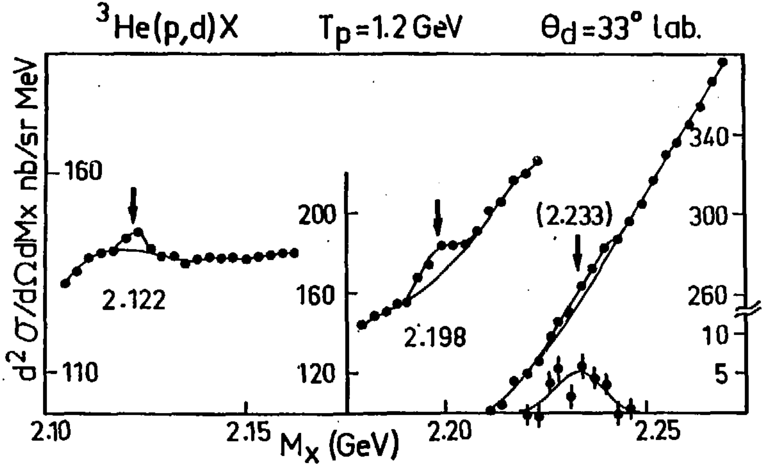
^{3}He(p,d)X
T_p=1.2 GeV
θ_d=33° lab.
$d^2\sigma/d\Omega dM_x$ nb/sr MeV
160
110
200
160
120
340
300
260
10
5
2.122
2.198
(2.233)
2.10
2.15
2.20
2.25
M_x (GeV)

Fig 1

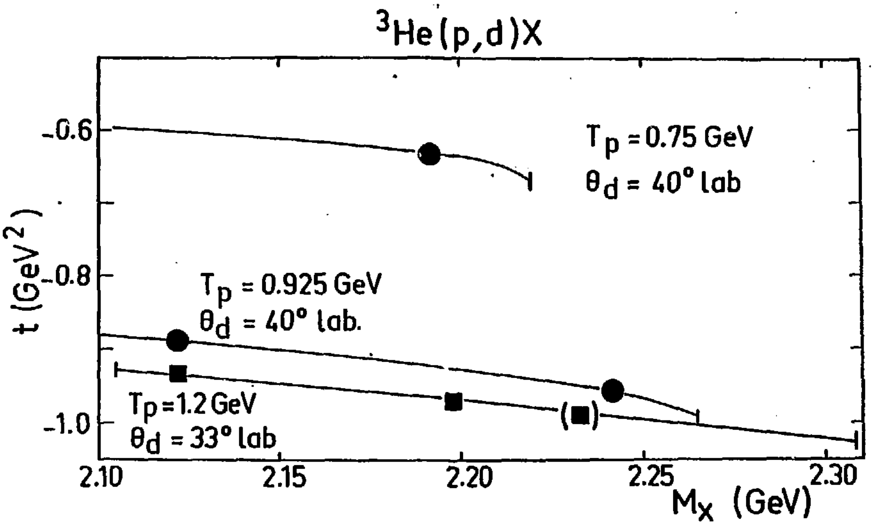
$^3He(p,d)X$
T_p = 0.75 GeV
θ_d = 40° lab
T_p = 0.925 GeV
θ_d = 40° lab.
T_p = 1.2 GeV
θ_d = 33° lab
t (GeV^2)
-0.6
-0.8
-1.0
2.10
2.15
2.20
2.25
2.30
M_X (GeV)

Fig. 2

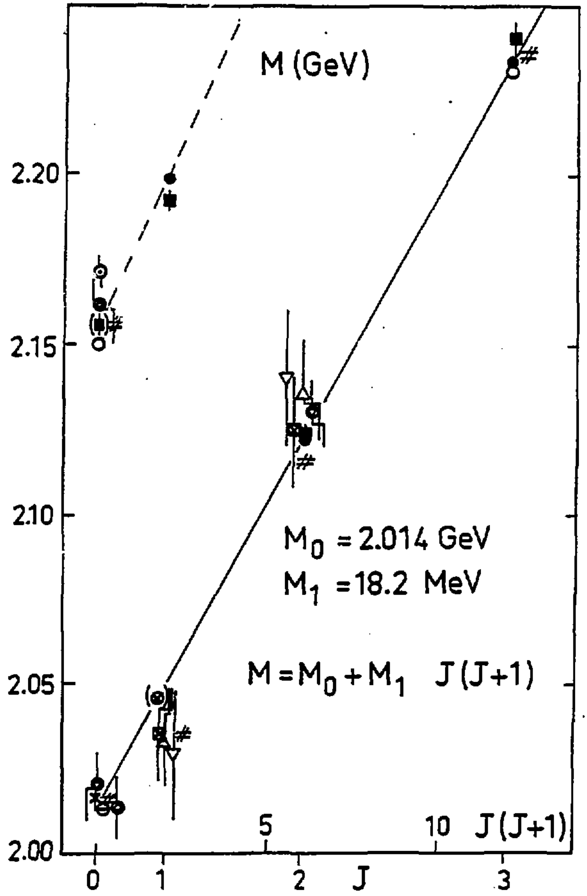
M (GeV)
2.20
2.15
2.10
2.05
2.00
M0 = 2.014 GeV
M1 = 18.2 MeV
M = M0 + M1 J (J+1)
5
10
J (J+1)
0
1
2
J
3

Fig 3.