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EXPERIMENTAL SEARCH OF STRUCTURES IN MISSING MASS SPECTRA OF $B = 2$, $T = 1$ SYSTEM : POSSIBLE EVIDENCE FOR NARROW STATES.

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Experimental Search of Structures in Missing Mass Spectra of B = 2, T = 1 system : Possible Evidence for Narrow States

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The missing mass spectra for the transfer reaction $p(^3He,d)X$ (B=2, T=1) have been measured at $T_{^3He}$ = 2.7 GeV. The data show : 1) a narrow structure lying on top of an important continuum, with a mass M = 2.240 ± 0.005 GeV and a width $\Gamma_{1/2}$ = .016 ± .003 GeV ; 2) a large structure with centroid location close to $M_x \cong 2.170 \pm .005$ GeV and width $\Gamma_{1/2} \gtrsim .100 \pm .005$ GeV.

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Since the measurements performed by the Tokyo group[1] revealing structures in the polarization observables of protons resulting from deuteron photodisintegration, the analysis[2] of corresponding data and of many other ones has triggered the interest on the question of the existence of dibaryonic resonances. During past years, several authors analysing various experimental results concluded positively on the existence of broad ($\Gamma_{1/2} \sim .1 - .2$ GeV) resonances, assigning corresponding masses and quantum numbers. However more recently, new experiments or discussions came to contradictory conclusions.

All these studies have been clearly stimulated by the predictions[3] of the MIT bag model and the resulting spectroscopy of many levels, generated by six confined quarks. The width were not calculated. However, since the primary analysis of several measurements indicated large widths, experiments were developped to look for wide resonances in initial state, the incident energy, being varied in quite large steps (few tens of MeV).

Very briefly, three kinds of experiments have been devoted to these studies up to now :

a) elastic and inelastic NN scatterings, using polarized incident beams and/or polarized targets[4]. A lot of data coming from many laboratories were followed by a great number of theoretical works[5]. The general conclusion is that the strong $N\Delta$ coupling is able to describe the experimental results.

b) elastic or inelastic π-d scattering measuring polarisation parameters. Different $\vec{p}p \rightarrow d\pi^+$ studies concluded negatively[6] about the existence of resonances. The t_{20} data[7] from SIN concerning the elastic scattering of pions by deuterium oscillate at .134 GeV, in contradiction to LOS ALAMOS[8] data, where a smooth behaviour is observed at .117 and 151 GeV. For iT_{11} results, many recent data[9] from SIN show a regular and slow variation when the incident pion energy is moved gradually from .325 to .140 GeV. There is up to now no theory able to get a good description for all observables at a given energy. The experimental situation itself is not completely clear[10].

c) photoproduction measurements on light nuclei have been studied at Tokyo[11], Saclay[12] and Bonn[12]. The situation being rather confusing no clear answer could be inferred from these data.

It is generally believed that conventional calculations of the three body problem using Faddeev approach[13] for $NN \to NN$, $NN \to NN\pi$, $NN \rightleftarrows \pi d$, describe more or less quantitatively the data. According to this belief we have to conclude that, since these models do not take into account possible color degrees of freedom, these - if any - could manifest themselves in the experimental results through narrow and weakly excited structures.

A few experiments have been devoted to the search for eventual narrow resonances ($\Gamma \leq \sim .02$ GeV). The n-p total cross section measurement[14] with a missing mass resolution $\Delta M = .0014$ GeV has not been able to show any narrow structure. A broad anomaly was attributed to the $^3F_3(T = 1)$ resonance. Neither the $d(\vec{p},p')np$ reaction at $\theta_{lab} = 18°$ and $T_p = .7$ GeV, nor the $\pi+d \to p+p$ reaction at $\theta_{lab} = 75°$[21] have revealed narrow dibaryon resonance. However in the backward $\pi - d$[15] scattering the t_{20} data from SIN present a peak located around 2.137 GeV and a width $\Gamma_{1/2} \leq .020$ GeV. In the study of deuteron break up reaction at 3.3 GeV/c for non spectator events, structures have been found at 2.020 GeV($\Gamma_{1/2} = .045$ GeV) and 2.13 GeV ($\Gamma_{1/2} = .02$ GeV)[20]. The conditions helping the narrow structures search are : a) inelastic scattering with large momentum transfers, needed to favour some new color distribution among the substructures of the B = 2 system, b) high energy resolution experiment,

c) precise measurements with high statistics in order to pin down the eventual structures above a large background due to non exotic processes. These conditions are fulfilled in a missing mass experiment and one nucleon transfer process on light nuclei. Doubly differential cross sections $d^2\sigma/d\Omega dM$ corresponding to the $p(^3He,d)X$ (B = 2, T = 1) reaction have been measured at the Saturne National Laboratory using the SPESI facility and the standard detection[16]. The ^3He beam had typically an intensity of $2 - 4 \times 10^9$ particles per burst. The calibration was done by means of the activation reaction $C(^3He,X)^{11}C$ [17] using a value of σ = 57 mb for the total cross section at this energy. Due to the extrapolation from low energy calibration[18], this last value is known with a poor precision. There is also an overall absolute uncertainty due to the bad knowledge of the target bulging. These two effects produce an overall uncertainty of ±30%. The continuous monitoring was accomplished by two telescopes and a secondary electron emission chamber. The relative stability between different runs was very good. For example the ratio of countings between a monitor and the secondary emission chamber, for adjacent runs, was always better than ± 1.3 %. The overall energy resolution is $\Delta M_X \gtrsim .0022$ GeV, mainly due to the angular divergence of the incident beam on target (± 2.5 mrad). A cryogenic hydrogen target (ρd = .20 gr/cm²) was used, and the contributions of the windows (empty target) were systematically subtracted. The ratio of empty to full target spectra, at M_X = 2.24 GeV is typically of 14%. The window spectra are flat and do not present any structure. The angles were chosen in order to avoid the production of deuterons having a momentum in the investigated range from substructures of ^3He projectiles as $p(d,d)p$ or $p(p,d)\pi^+$. The horizontal opening angle $\Delta\theta$ = ± .179° was determined by cuts introduced during the analysis of raw data. The results are presented in Fig.1. The errors are purely statistical. The informations extracted from the spectra are summarized in Table 1.

First a large structure is clearly seen. The phase space predictions for $X = pp$, $p\Delta$ ($\Gamma_{1/2}$ = .12 GeV) or $pN\pi$, have a continuous behavior, increasing monotonicaly from low to large missing masses up to 2.3 GeV. These are therefore unable to describe the observed experimental structure. Its mass and width values depend on the assumption done about the background. We have drawn a smooth background connecting data points at M_x = 2.08 GeV to the minimum showing up around M_x = 2.255 GeV. This particular shape is consistent with p-p phase space calculations. We observe that the mass of this large structure is exactly that of the $N\Delta$ system, the width being close to the width of a free Δ.

Second a small and narrow structure is observed at 2.24 GeV. Since the momentum acceptance of the detection is close to 3.5%, each spectrum has been obtained by superposition of many measurements with slightly different central momenta corresponding to appropriate magnetic field settings of the spectrometer. We have checked that the removal of each individual run from the overall data, leaves the results more or less unchanged, the structure remaining always there. To extract location, width and cross section of this weakly excited structure, we have used the following procedure. After removing the five date points lying in the narrow peak region, a best polynomial fit (4^{th} order) has been adjusted to the whole spectra giving a value ≦ .45 for the normalized χ^2. The narrow structure lying on top of this continuum was badly fitted by the polynome. The corresponding χ^2 give the confidence level values quoted in Table 1 (for five data points). Putting back the data corresponding to the narrow structure, a Gaussian fit allows the determination of values (and precisions) of masses, widths and cross sections given in Table 1.

The same experiment had been also done with different kinematical conditions and background by inverting the incident particle with the target : $^3He(p,d)X$. Some preliminary data have already been presented[19] . The data corresponding to these measurements are presently reanalyzed with a new code.

In conclusion, by using the missing mass experiment $p(^3He,d)X$ we have observed in the $B = 2$, $T = 1$ final state : i) a large structure with a mass close to 2.170 ± 0.005 GeV and a full width at half maximum close to $.100 \pm .005$ GeV, ii) a narrow structure at $M_X = 2.240 \pm .005$, $\Gamma_{1/2} = .016 \pm .003$ GeV. The corresponding cross section is $d\sigma/dt = 3.4 \pm .8\ \mu b/GeV^2$ at $\theta_{lab} = 18°$. It is not possible to make definite statements concerning the origin of these structures. Although the common belief is that conventional $NN\pi$ models describe the experimental data in $NN \rightarrow NN$, $NN \rightarrow NN\pi$, $NN \rightleftarrows \pi d$ and $\pi d \rightarrow \pi d$ reactions, the agreement with the data is not very good .We cannot therefore exclude an unpredicted manifestation of the strong $N\Delta$ coupling. However the structure observed at $M_X \approx 2.24$ GeV being narrow, we also cannot exclude completely a possible manifestation of an exotic process dealing with either color degrees of freedom or quantum numbers forbidden for pp state but allowed for 6 quarks.

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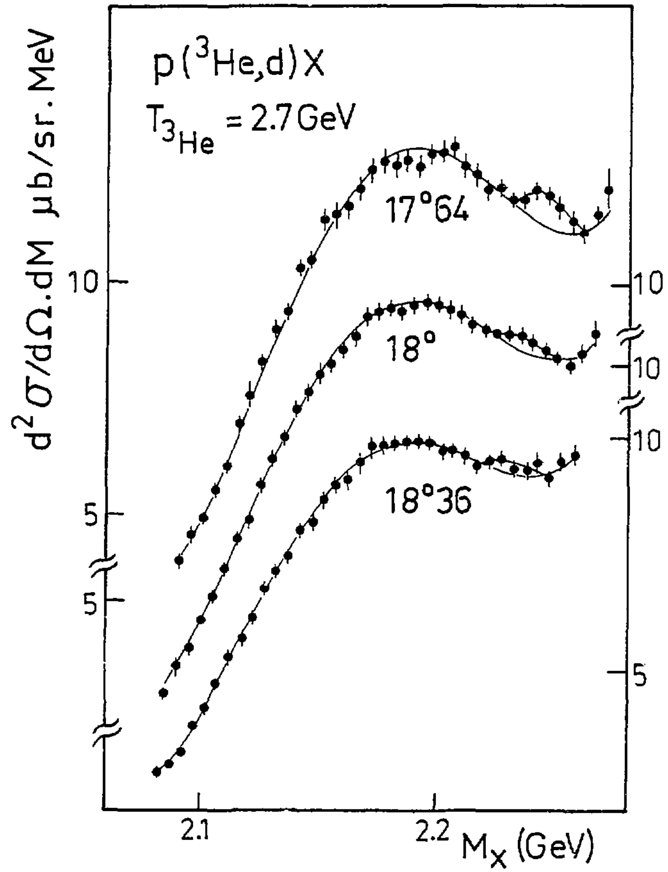
FIGURE CAPTION

Fig.1 - Missing mass spectra in doubly differential cross sections measured in the p(^{3}He,d)X reaction (lab. system). Data have been binned into 5 MeV intervals.



p(^{3}He,d)X
$T_{^3He}$ = 2.7 GeV
17°64
18°
18°36
$d^2\sigma/d\Omega.dM$ μb/sr. MeV
10
5
5
10
10
10
5
2.1
2.2
M_X (GeV)

Angle	Large Structure		Narrow Structure			
	M_X	$\Gamma_{1/2}$	M_X	$\Gamma_{1/2}$	$d\sigma/dt(\mu b/GeV^2)$	CL
17°64	$\approx$2.174 ± .005	.100 ± .005	2.245 ± .0015	.016 ± .0033	7.3 ± 2.0	96%
18°	$\approx$2.167 ± .005	.110 ± .005	2.237 ± .0018	.015 ± .0043	2.8 ± 1.1	65%
18°36	$\approx$2.164 ± .005	.102 ± .005	2.232 ± .0032	.018 ± .0075	2.5 ± 1.4	74%

Table 1 - The masses (M_X) and total width at half maximum ($\Gamma_{1/2}$) are in GeV. The values (and precisions) for the narrow structure have been determined by a gaussian best fit. The last row shows the confidence levels, whose values correspond to the assumption done on the background (see text).