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I - INTRODUCTION

The debate concerning the existence of dibaryons is still going on [1]. Although many claims have been put forward in the last years, a clear cut evidence has never been presented.

Still, the identification of a single genuine dibaryon would be a great triumph of QCD. In particular, narrow non strange dibaryons could be the signature of exotic six-quark states [2] and therefore, it is important to investigate through many different experimental approaches, the most convincing dibaryon candidates to verify that they survive and possibly, to precise their quantum numbers.

Recently, at the "Laboratoire National Saturne" there has been clear experimental indications of narrow (FWHM ≈ 25 MeV), Isovector Dibaryon Resonances (DBR) in the nuclear reactions [3] :

$$^{3}He(p,d)X \qquad (a)$$

The results presented in Ref. [3] are completed and confirmed by more recent data [2.4] . They present two striking features :

i) DBR masses deduced from many different experiments concentrate on the same values ($T = 1$ dibaryon)

ii) those masses can be classified according to a simple rotational like formula

$$M_{DB} = M_0 + M_1 \, J(J + 1).$$

Scepticism and criticism applied to results coming from nuclear reactions like (a) often invoke the complexity of the system which consists of at least four nucleons and is therefore governed by many possible reaction mechanisms, final state interactions (FSI), etc...

We have undertaken a further search of DBR in the elementary pion production channel :

$$P + P \rightarrow P + P + \pi^\circ. \qquad (b)$$

The aim is to measure the excitation function of reaction (b) in small energy steps (typically 5 MeV) spanning the mass region of the reported DBR. Reaction (b) has the advantage to be the simplest inelastic reaction one can think of, involving only pure $T = 1$ isospins in the nucleon-nucleon system.

The method is to measure the π° differential cross sections :

$$(d^2\sigma/d\Omega \, dE)_{LAB}$$

corresponding to a fraction, as large as possible, of the phase space occupied by the π° produced in reaction (b). This includes 0 degree cross-sections which are the easiest to reach with a π° spectrometer. Taking into account that reaction (b) is symmetric in the CM, it is enough to pick-up the laboratory forward angles to cover the whole CM angular range.

There are several ways to look at the cross sections

- As a function of proton incident energies, they depend on a matrix element and a kinematical phase space factor which is a smooth increasing function. Any "accident" in the incident energy dependence indicates a possible DBR. The comparison can be done as well on total cross section as on differential ones.

- The π° angular distributions in the CM may show some anisotropy. The corresponding differential cross sections are obtained from the double differential ones by summation over the π° energies. They take the form

$$(d\sigma_{\pi^\circ}/d\Omega)_{CM} = A + B\cos^2\theta. \qquad (c)$$

  The anisotropy parameter B is related to the weight of $\ell = 1$ angular momenta in the π° production process and can show sharp dependence on the incident energy as suggested in Ref. [5].

- Direct comparison with the π^+ cross sections as produced in the reaction

$$N + P \rightarrow N + N + \pi^+ \qquad (d)$$

  give the "non resonant" partial cross section σ_{01}, where the subscripts 0 and 1 are related to the isospin of the nucleon pairs in the initial and final states respectively. In the 0-1 transition, the reaction cannot proceed through a Δ excitation. We have for (d) :

$$\sigma(NP \rightarrow \pi^\pm) = \frac{1}{2}(\sigma_{01} + \sigma_{11}) \qquad (e)$$

  and (b) is a pure σ_{11} transition. It should be noted that σ_{01} cannot be measured directly but only by difference. It has been pointed out in Ref. [5] that σ_{01} might not be as small as usually expected but cannot be determined accurately at present time because σ_{11} is so badly known.

As a starting point for our experimental investigation we have choosen the DBR of mass = 2.124 MeV reported in Ref. 2-4) ; it corresponds exactly to the incident energies investigated in Ref. [5], namely from 470 MeV to 590 MeV - $\sqrt{s}$ reaches 2.124 MeV at an incident proton energy of 527.6 MeV in reaction (b) - it is one of the most often reported DBR and finally it lies below the N-Δ threshold.

II - THE π° SPECTROMETER SPESO

We have built a π° spectrometer SPESO , which has an excellent capability of π° identification against intense charged particle backgrounds as they are normaly encountered around intermediate energy proton beams. This goal was achieved by an original three layer lead-glass arrangement. The low efficiency of the lead-glass against non relativistic charged particles (≃ 500 MeV protons), the fast timing and the anticoincidence of charged particles by forward scintillation counters were crucial factors.

Fig. 1 shows the experimental arrangement. The π° are detected by their two decay γ rays producing electromagnetic showers into the lead-glass bars. In each left or right detection block a coincidence between the first two shells is required before a left-right one. The trapezoidal lead-glass bars are 69 cm long and viewed at each extremity by a photomultiplier. Behind the first bar which serves as a converter, there is a plane of plastic "Limited Streamer Tubes" [6] of 1 cm^2 cross section. They are sensitive to the leptons of the shower and give the γ rays impact localization in the horizontal plane. The vertical localization is obtained by the time difference of the light pulses at the extremities of each bar. The energy of each decay γ ray is proportional to the total amount of Čerenkov light produced by the leptons of the EM showers in each left or right three layer detection block.

Having the energies of each decay γ ray, their impact localization (and hence their direction) it is possible to calculate the original π° energy and angle through trivial kinematic relations.

The SPESO has a moderate energy resolution (typically 10 MeV FWHM for 100 MeV π°) and angular resolution ($\approx$ 2.5 degrees) which are sufficient for the phase space measurements considered here.

In compensation, acceptances, both angular (± 17 degrees) and energetic (150 MeV for 250 MeV π°) are rather large which allows to perform the above described measurements in a reasonable time.

A very usefull relation to identify π° is given by the invariant mass relation :

$$m_{\pi^\circ} = 2\sqrt{E_{\gamma_L} E_{\gamma_R}}\ \sin(\alpha/2) \qquad (f)$$

m_{π° is the π° mass.
$E_{\gamma_{L,R}}$ are the left and right γ ray energies.
α is the angle between the two γ rays.

Fig. 2 shows a two-dimentional π° identification spectrum. One can see that π° are concentrated on a locus corresponding to equation (f). Charged particles backgrounds, which show-up near the origin of the axis have completely disappeared compared to earlier results [7] .

III - PRELIMINARY RESULTS

The SPESO has been put in operation at the "Laboratoire National Saturne" only one year ago and we can therefore, at present time, show only very preliminary results.

Fig. 3 presents a π° inclusive spectrum measured on ^{12}C as a target bombarded by 800 MeV protons. The π° are emitted between 5 and 10 degrees in the laboratory.

The shape of the spectrum is consistent with corresponding charged π figures (measured at larger Lab. angles).

It is important to note that :

i) there is a good overlap between measurement made at different angular settings of the detector

ii) it has been possible to detect π° till 500 MeV which required to put detectors at angles as small as ± 15 degrees from the beam

iii) the dynamical range from 100 to 500 MeV for the π° could be covered in only 6 angular settings.

Fig. 4 shows our early phase space spectra corresponding to the $P + P \rightarrow P + P + \pi^{\circ}$ reaction investigated at 540 MeV and 750 MeV proton incident energies. At this time, one of the major problems was the signal ratio "target full/target empty" which was not too good (of the order of 5) due to many target windows and air in the beam path. Since phase space measurements on a liquid hydrogen target are always differential : "target full-target empty" it was important to improve this point. We have now demonstrated, by conducting the beam under vacuum all the way through, that figures as good as 80 on row data and 20 on identified π° can be reached which will improve dramatically the quality of coming results.

IV - CONCLUSIONS

Less than one year after its first installation, the π° spectrometer SPESO has evolved to a reliable configuration. The detector in itself was never a problem, most of the improvements have to deal with the beam monitoring, the target and its connexion to the beam transport system. The relevant modifications are underway and it will be possible, in a near future, to measure phase space cross sections with the <u>relative</u> accuracies (from one incident proton energy to the nearby one) of a few percents. This level of accuracy is necessary to hunt for DBR. The absolute efficiency of the system, however, will always rely on a comparison with a known cross section.

REFERENCES

1. Seth, K.K. : "Hadronic Interactions with Nuclei", Proc. of the 3 rd Workshop on Perspectives in Nuclear Physics at Intermediate Energies, International Center for Theoretical Physics
Trieste, 18-22 May 1987
2. Willis, N., et al. : "Possible Signature of Quark Effects Through Experimental Evidence of Narrow Non Strange Dibaryons", Contribution to this Conference
3. Tatischeff, B. et al. : Phys. Rev. Lett. 52 (1984) 2022
Tatischeff, B. : Phys. Lett. 154B (1985) 107
Nucl. Phys. A446 (1985) 355c
4. Tatischeff, B. : "Les Dibaryons étroits : confirmation expérimentale et incertitudes théoriques" ; Quatrièmes journées d'études Saturne, La physique avec Mimas"
La Londe-les-Maures, 10-14 nov. 1986, 74
5. Kleinschmidt, M., et al. : Zeit. für Phys. Al. and Nucl. 298 (1980) 253
6. Battistoni, G., et al. : NIM, 167 (1979) 57
7. Didelez, J-P : "Journées d'études de Physique Nucléaire sur la photoproduction et l'électroproduction de mesons sur le nucléon et les noyaux" ; détection des mesons neutres
Clermont-Ferrand, 24-26 nov. 1986
Comptes rendus, page 29.

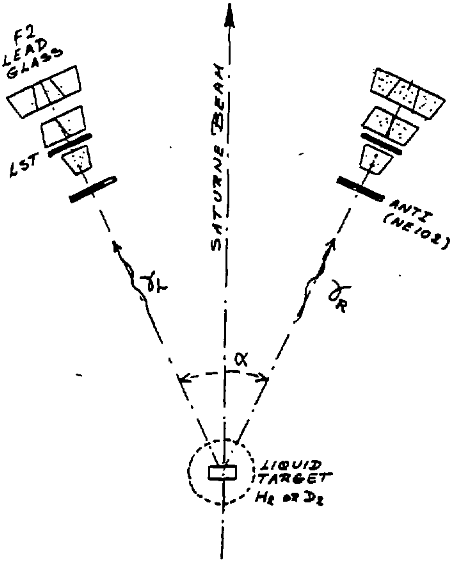
F2 LEAD GLASS
LST
SATURNE BEAM
ANTI (NE102)
γL
γR
α
LIQUID TARGET H2 or D2

Fig. 1

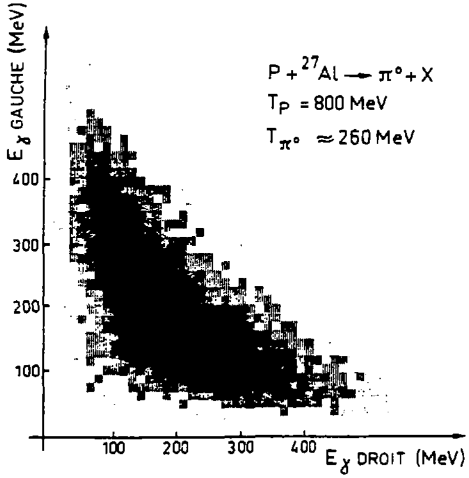
Eγ GAUCHE (MeV)
400
300
200
100
100
200
300
400
Eγ DROIT (MeV)
P + 27Al → π° + X
Tp = 800 MeV
Tπ° ≈ 260 MeV

Fig. 2

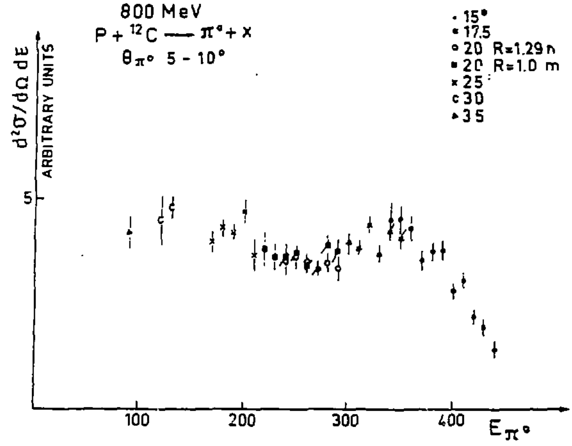

Fig. 3

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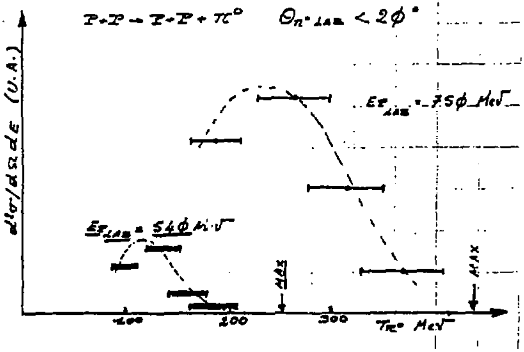

Fig. 4