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PROPOSAL FOR AN EXPOSURE OF A DEUTERIUM BUBBLE CHAMBER TO 700 MeV PROTONS

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Recent experiments[1][2] seem to indicate the existence of a new particle, or of a $\pi\pi$ resonant state, with $J = 1$, $T = 0$, and a lifetime of about 10^{-17} sec. The best evidence of such a state comes from the counter experiment by Abashian, Booth and Crowe[2]. We propose to repeat, in a deuterium bubble chamber, the study of the reaction:

$$p + d \rightarrow He^3 + \omega^o \qquad (1)$$

The proposed decay modes of ω^o are:

$$\omega^o \rightarrow \pi^+ + \pi^- + \gamma$$
$$\rightarrow \pi^o + \gamma$$
$$\rightarrow n\gamma$$

Therefore, reaction (1) will be seen in a bubble chamber picture as an event with one or three secondary prongs, one of which is identified as a He^3.

The competing reactions are the following:

$$p + d \rightarrow He^3 + \pi^o \qquad (2)$$
$$He^3 + 2\pi^o \qquad (3)$$
$$He^3 + \pi^+ + \pi^- \qquad (4)$$

One way to separate the contribution of reaction (1) from the competing reactions could be to compute, for each event, the missing mass, starting from an accurate measurement of the He^3 momentum and angle of emission. The missing mass distribution should show a peak due to reaction (2) at π^o mass, and a peak due to reaction (1) at ω^o mass, superimposed to a continuous background due to reactions (3) and (4).

The advantage of such an experiment over a counter experiment is the possibility of giving informations about the decay modes of ω^o, and their branching ratios.

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(1) Hofstadter, Bumiller, Croissiaux: Proc. of the 1960 Annual International Conference on High Energy Physics at Rochester (pag. 762).
Hermann, Hofstadter: Proc. of the 1960 Ann. International Conference on High Energy Phys. at Rochester (pag. 767).

(2) Abashian, Booth and Crowe: Proc. of the 1960 Annual Intern. Conference on High Energy Phys. at Rochester (pag. 55).

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In order to produce reaction (1), a proton energy T_p = 600 MeV is sufficient. However, because of the uncertainty in the mass of the ω^o particle (or the energy of the resonant state) we choose for the incident beam an energy T_p = 700 MeV. This energy is just above threshold for reaction (1) even if ω^o should have a mass equal to about 3 pion masses (Hofstadter).

From the kinematics of reaction (1), with m_{ω^o} = 310 MeV (Crowe), we obtain the following informations: the He^3 particle is emitted with maximum kinetic energy of 370 MeV and minimum kinetic energy 129 MeV, in the laboratory system. The emission angle varies between 0^o and 30^o. In a deuterium bubble chamber (density 0,14 g/cm^2), the He^3 produced in reaction (1) will have a range varying from 29,3 to 4,1 cm.

We calculated the cross-section for production of He^3 with momentum and angle compatible with the kinematics of reaction (1). Using the value of $\frac{d\sigma}{d\omega \; dp}$ given by Crowe for 743 MeV incident protons, and taking into account both the energy spread of the He^3 from reaction (1) and the solid angle in which it is emitted, we obtain σ = 30 μb. The uncertainty in the cross section is of a factor 2.

If we assume for reaction p + d a total cross section σ_{tot} = 60 mb, we would have an "interesting" event in 2000 interactions.

We therefore propose the following exposure:

Beam	:	700 MeV protons 80 cm deuterium bubble chamber
number of protons per picture	:	20
number of pictures	:	100.000

With a density of 0,14 g/cm^2, the interaction mean free path for protons in deuterium is 5 m. We would expect a total of 30.000 interactions, and consequently 150 cases in which the He^3 particle is emitted with emission angle and energy within the said intervals.

Crowe's experiment indicates that the contribution of reaction (1) for events compatible with the kinematics of such reaction is 20 o/o of the background of the two-pion reactions, and that it is due either to a particle with a well-defined mass, or to a very narrow resonance (width ~ 10 MeV). We estimate that if indeed it is a particle, the bubble chamber technique (allowing accurate measurements of both emission angle and He^3 range) will give a very good resolution for reaction (1), so that the number of expected "good" events should allow us to draw some conclusions outside the statistical fluctuation.

Another possible exposure for the same experiment would be:

pencil beam of 700 MeV protons
80 cm deuterium bubble chamber
n^{o} of protons per picture : 100

Comparing to the precedent kind of exposure, one would gain a factor 5 in the total number of events, but one should ascertain that the width of the beam is of the order of 1 mm, in order not to lose in precision in the measurements.

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