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MEASUREMENT OF π° PHOTOPRODUCTION NEAR THRESHOLD ON LIGHT NUCLEI

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ABSTRACT

π° photoproduction on ^1H, ^2H, ^3He and ^4He has been measured in the region of 1 to 10 MeV above threshold. Our measurement confirms the importance of pion rescattering for the reactions on ^2H and ^3He, and yields information on the threshold amplitudes on the nucleons.

The basic motivations of π° photoproduction measurements near threshold on light nuclei are twofold : i) obtain information on the so far poorly determined π° production amplitudes on the nucleons ; ii) learn about photoproduction mechanism in nuclei, especially in the case of deuterium[1] and helium-3 where large contributions of pion rescattering terms dominate the one-body amplitude, whereas they affect weakly the reaction on ^4He.

The experiment consists in the comparison of the π° photoproduction yields on ^1H, ^2H, ^3He and ^4He. Measurements are made for several end-point energies E_e of the bremsstrahlung spectrum ranging up to approximately 10 MeV above threshold. The two gammas from the π° decay (emitted almost back to back) are converted in a lead foil and subsequently detected in two Čerenkov telescopes placed symmetrically at 90° about the photon beam direction. The measured yields are related to the π° photoproduction cross section $d\sigma/d\Omega$ by the relation

$$Y(E) = \int_{E_o}^{E_e} \int_{\Omega_d} B(E,E_e)\, C\varepsilon(E,\theta)\, \frac{d\sigma}{d\Omega}\, dE d\Omega,$$

where $B(E,E_e)$ is the photon spectrum, $\varepsilon(E,\theta)$ the geometrical detection efficiency for photon energy E and π° emission angle θ, E_o the threshold energy and Ω_d the solid angle of the detection system ; the constant factor C accounts for the efficiency of the Cerenkov detectors.

In a preliminary analysis we have compared our data to the predictions of a simple PWIA theoretical model allowing, in addition, for pion rescattering effects in the s-wave.

We have restricted the elementary nucleonic amplitudes to the dominant E_{0+} and M_{1+} multipoles ; the rescattering effects were estimated in a very simple model[2] involving only π - production amplitu-

des and scattering lengths on the nucleons, and the average value of the inverse nucleon separation in ^{2}H and ^{3}He. The resulting cross-sections were folded with the Jabbur and Pratt bremsstrahlung shape and the Monte Carlo simulated detection efficiency ε. For each reaction the ratio of s wave (including rescattering) to p wave production amplitude was left as a free parameter to be adjusted on the data. Assuming the values in units $m_\pi = \hbar = c = 1$,
$M_{1+}(\pi^\circ p) = 0.0085$ qk and
$M_{1+}(\pi^\circ n) = 0.0077$ qk deduced of the multipolar analysis[3] of photoproduction at higher energies, we obtained from the general fit (see fig.) of all data points up to 6 MeV above threshold the following dipole amplitudes :

$E_{0+}(\pi^\circ p) = -0.0020 \pm 0.0002$

$E_{0+}(\pi^\circ n) = 0.0021 \pm 0.0004$

the $E_{0+}(\pi^\circ p)$ value is in agreement with existing data[4]. As for the $E_{0+}(\pi^\circ n)$ determination, it depends critically on the calculated values of the rescattering amplitudes for ^{2}H and ^{3}He ; the quoted error does not include the large theoretical uncertainty. Our preliminary analysis illustrates that using a very simple model we have an overall understanding of the four studied reactions. A more thourough theoretical treatment is now needed to extract from our data a reliable $E_{0+}(\pi^\circ n)$ value.

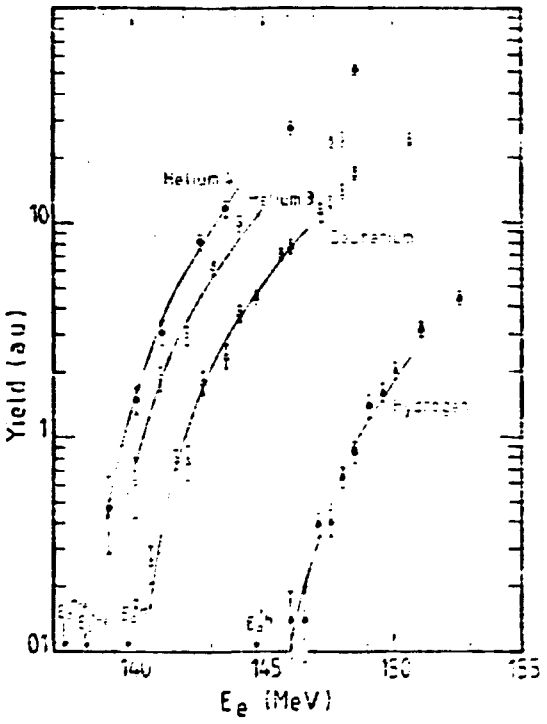

Fig. - The measured photoproduction yields as a function of the bremsstrahlung end-point energy E_e. Curves are theoretical yields adjusted as described in the text.

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