PROTON RADIATIVE CAPTURE BY DEUTERIUM AT MEDIUM ENERGIES

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In the last year we have made considerable progress in analyzing the data from $^2H(p,\gamma)^3He$ radiative capture experiment at $E_p$=100, 150 and 200 MeV. The purpose of this experiment was to produce a set of high quality cross section and analyzing power data which may ultimately lead to understanding the relative importance of single vs. multinucleon reaction mechanisms. The data set may also provide a test for the quasi-deuteron mechanism of radiative capture[1] and help to establish the role of meson exchange currents and isobar formation for this process in the IUCF energy range.

The experimental procedure was described in detail in the IUCF 1982 Annual Report. The experimental apparatus (see Fig. 1) detected $^3He$ recoils in coincidence with radiative capture γ-rays. The high-energy photons were detected using eight 15 x 15 x 30-cm³ lead glass Cerenkov counters placed at angles ranging from $\Theta_\gamma$=17°-150° in the lab. The recoil particles were detected using a segmented range telescope made of plastic scintillators of 0.04, 0.16 and 0.32-cm thickness, followed by veto counters. The solid angle of the detection system was determined exclusively by the collimators in front of photon detectors. The targets used were $CD_2$ with thicknesses of 10-20 mg/cm². The deuterium content of the target was monitored during the run by looking at $^2H(p,p')^2H$ scattering in a ΔE-E telescope. We were able to achieve a time resolution in the time-of-flight (TOF) spectrum with respect to the cyclotron rf of better than 600ps for both γ and $^3He$-TOF. This in turn allowed a reduction in the background to below 4%.

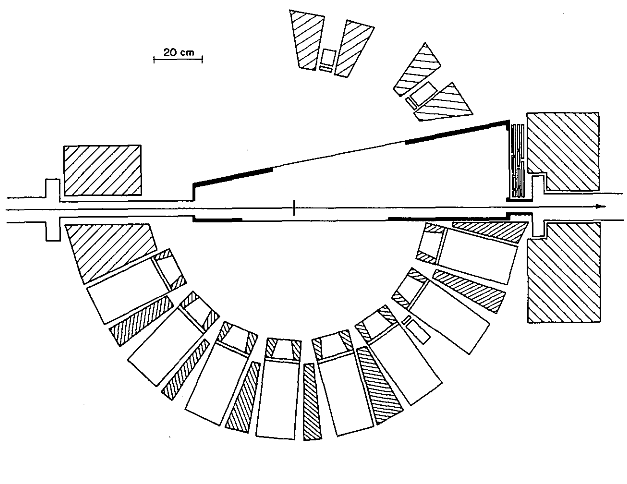


Figure 1. Schematic layout of the experimental setup.

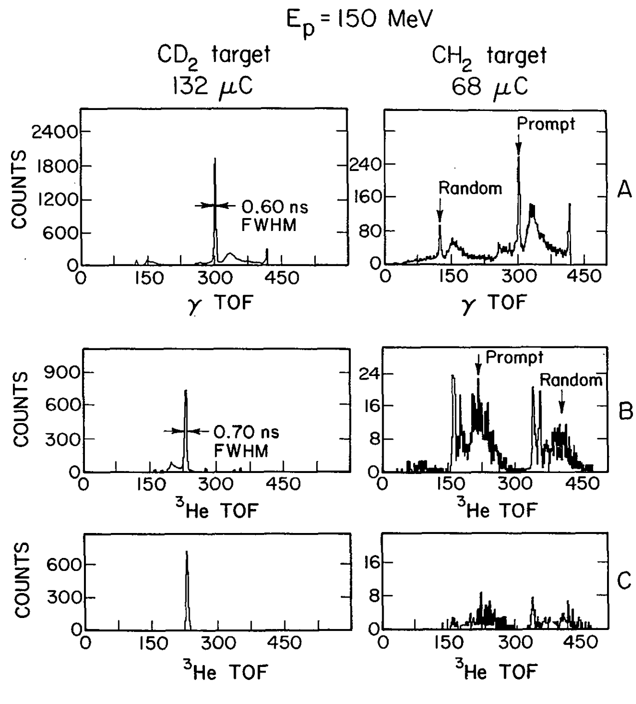


Figure 2. Spectra obtained in 150 MeV proton bombardment of $CD_2$ target (left) and $CH_2$ target (right).
(A) γ TOF spectra with respect to the cyclotron rf.
(b) Charged particle TOF spectra sorted with condition on the prompt peak in the γ TOF spectrum.
(c) charged particle TOF spectra as in (B) but with an additional $^3He$ energy cut.

The events were analyzed off-line by putting the γ energy, γ TOF and $^3He$ energy cuts on $^3He$ time-of-flight spectra (see Fig. 2). Background contributions can be estimated on the basis of spectra collected during bombardment of a $CH_2$ target, sorted under the same experimental conditions (shown on the right hand side of Fig. 2).

The preliminary results of the cross section measurements at three proton energies are shown in Fig. 3 along with recent data from TRIUMF at 200 MeV (Ref. 2) and data from Refs. 3 and 4. Cross sections measured in the present experiment are in good

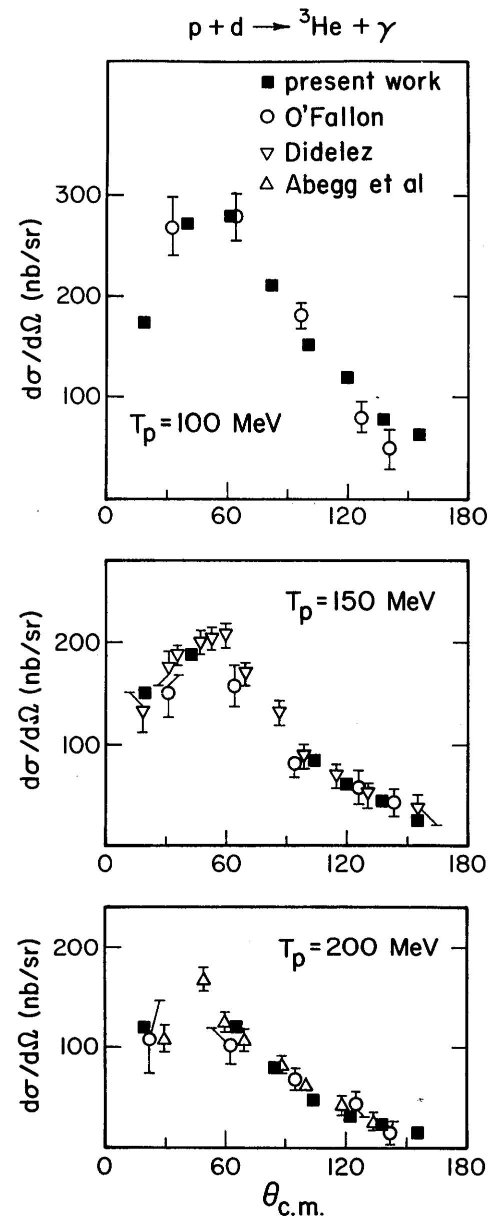


Figure 3. Angular distribution of the differential cross section measured in this experiment. The radiative capture data (Refs. 2,3) are compared to photodisintegration cross sections (Ref. 4) using detailed balance.

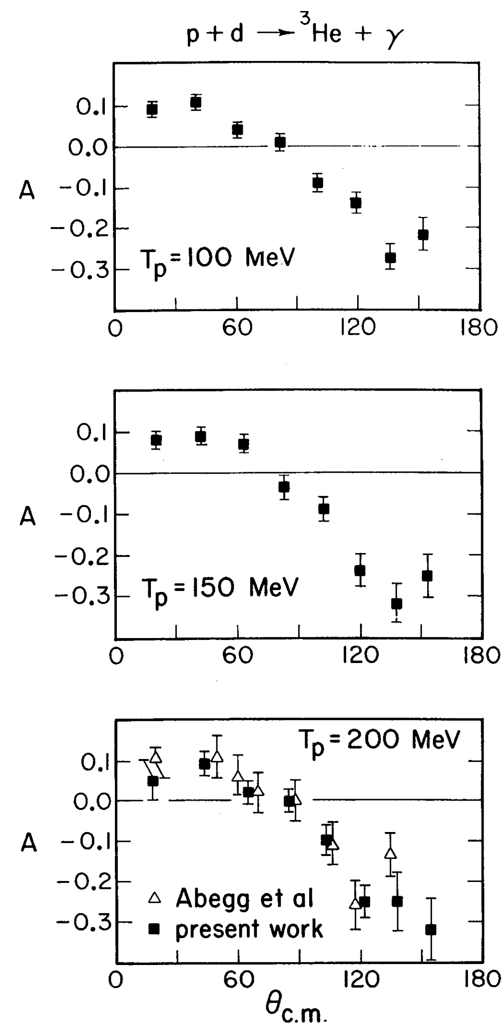


Figure 4. Analyzing powers for $^2H(\vec{p},\gamma)^3He$ radiative capture at three proton bombarding energies.

agreement at all energies with the photo-disintegration data of O'Fallon et al. and with those of Ref. 2. The preliminary results of the analyzing power measurements are shown in Fig. 4. We plan to complete the analysis of the data in the next few months.

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## RADIATIVE CAPTURE OF TENSOR POLARIZED DEUTERONS ON HYDROGEN ISOTOPES


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Radiative capture in few nucleon systems is, by now, an established, ongoing experimental program at IUCF. A variety of physics questions are addressed by such measurements. For example, the $^2H(d,\gamma)^4He$ reaction is interesting in that measurements of the tensor analyzing powers are naturally sensitive to the D-states of the final nucleus.

We took differential cross section vector ($A_y$) and tensor ($A_{yy}$) analyzing power data for deuteron capture at $E_d$ = 80 MeV on both hydrogen and deuterium during a fifteen shift run in October 1983. The $^1H(d,\gamma)^3He$ measurements extended the $^2H(p,\gamma)^3He$ measurements of Exp. #207 to lower energies. In addition the $^1H(d,\gamma)^3He$ reaction serves as a "set-up" reaction for the more difficult $d(d,\gamma)^4He$ measurement, since the former has a cross section which is more than a factor of 100 larger.

The experimental setup was similar to that described in the preceding contribution, but with a modified charged particle telescope to allow detection of the low energy $^{3,4}He$ recoils. Detection of both the photon and the outgoing residual nucleus gave very clean spectra, with the $^3He$ background from competing reactions estimated to be about 2-3%.

While $p(d,\gamma)^3He$ is interesting in its own right, the major purpose of this experiment was the study of the $d(d,\gamma)^4He$ reaction. The salient features of this reaction are:

1) It is the simplest isoscalar process, proceeding via an E2 multipole transition.

2) Many meson exchange currents do not contribute, because of the spin-isospin structure of the reaction. This fact, along with (1), should simplify the theoretical analysis considerably.

3) The measurement of $A_{yy}$ should give a clean measurement of the asymptotic normalization of the D-state probability of $^4He$.

While it has been known for some time that $^4He$ possesses a non-zero D-state probability,[1] previous measurements of the relative D- to S-state probability which relied on $(d,\alpha)$ pick-up reactions[2] are not unambiguous.[3]

Existing data at 20 MeV[4] for the cross section have been in good agreement with theoretical expectations, showing the $\sin^2 2\theta$ distribution expected of an E2 transition. At 376 MeV, where only a small amount of data exists,[5] strong deviations from the $\sin^2 2\theta$ -shaped angular distribution were reported and a maximum in differential cross section was observed at $\theta_{cm}$=90° instead of the expected minimum value.

Preliminary analysis of the data shows a $^4He$ peak