In the last year we have made considerable progress in analyzing the data from \( ^2\text{H}(p,\gamma)^3\text{He} \) 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 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 \(^3\text{He} \) recoils in coincidence with radiative capture \( \gamma \)-rays. The high-energy photons were detected using eight 15 x 15 x 30-cm\(^3\) lead glass Cerenkov counters placed at angles ranging from \( \theta_{\gamma}=17^\circ-150^\circ \) 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 \( \text{CD}_2 \) with thicknesses of 10-20 mg/cm\(^2\). The deuterium content of the target was monitored during the run by looking at \( ^2\text{H}(p,p')^2\text{H} \) scattering in a \( \Delta E-E \) 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 \( \gamma \) and \( ^3\text{He}-\text{TOF} \). This in turn allowed a reduction in the background to below 4%.

![Figure 1. Schematic layout of the experimental setup.](image)

![Figure 2. Spectra obtained in 150 MeV proton bombardment of \( \text{CD}_2 \) target (left) and \( \text{CH}_2 \) target (right).](image)

(A) \( \gamma \)-TOF spectra with respect to the cyclotron rf.
(b) Charged particle TOF spectra sorted with condition on the prompt peak in the \( \gamma \)-TOF spectrum.
(c) charged particle TOF spectra as in (B) but with an additional \(^3\text{He} \) 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 CH₂ 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 agreement.

**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(⁴He)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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4) N.M. O'Fallon, L.J. Koester, and J.M. Smith, Phys.

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,γ)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,γ)3He
measurements extended the 2H(p,γ)3He measurements of
Exp. #207 to lower energies. In addition the
1H(d,γ)3He reaction serves as a "set-up" reaction for the
more difficult d(d,γ)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 3,4He 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,γ)3He is interesting in its own right,
the major purpose of this experiment was the study of
the d(d,γ)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,a) pick-up reactions2 are not
unambiguous.3

Existing data at 20 MeV4 for the cross section
have been in good agreement with theoretical
expectations, showing the sin^22θ distribution expected
of an E2 transition. At 376 MeV, where only a small
amount of data exists,5 strong deviations from the
sin^22θ -shaped angular distribution were reported and a
maximum in differential cross section was observed at
θ_cm=90° instead of the expected minimum value.

Preliminary analysis of the data shows a 4He peak