MEASUREMENT OF THE (^{3}He, π) AND (p, γ) REACTIONS BY RECOIL DETECTION

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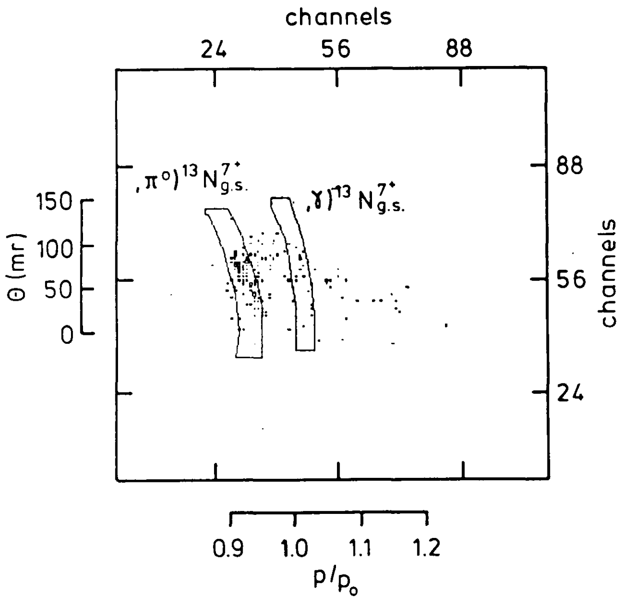
Measurements of the $^{12}C(^3He, \pi^+)^{15}N$ reaction by recoil detection using the large solid angle IUCF QQSP spectrometer at 0°, in conjunction with a heavy-ion focal-plane detector, were continued at incident particle energies of 170.2 and 236.25 MeV. In addition the radiative capture reaction $^{12}C(p,\gamma)^{13}N_{g.s}$ and the reaction $^{12}C(p,\pi^\circ)^{13}N_{g.s.}$ have been observed at 190.75 MeV proton energy using the same technique. Simultaneously in the proton work, the reaction $^{12}C(p,\pi^+)^{13}C$, which has been studied previously at IUCF by pion detection[1], was measured as a calibration.

A new detector with an enlarged active area of 0.6 by 0.05 meters was constructed for the 1985 measurements. The increased momentum acceptance permitted the simultaneous measurement of both Q=6 and Q=7 charge states of the recoil ^{13}N ion. Compared with the previous detector[2], the number of Mylar foils (of thickness 0.257 mg/cm^2) was reduced from twelve to four by substituting wire grids for foils where possible. This change reduced the minimum detected recoil energy to 2 MeV/amu for Z = 7 over the full incident angle range (about 30° to 60°), allowing the detection of proton-induced high momentum transfer processes.

The feasibility of the recoil technique had been established by a previous measurement of the $^{12}C(^3He,\pi^+)^{15}N$ reaction at $T_{^3He}$=181.4 MeV, 19.0 MeV above threshold for the ground state transition. The angle-integrated differential cross section for populating states in the excitation range where the largest yield was observed ($6.5 < E_x < 10.5$ MeV) was found to be about 1.3 nanobarns. The angular distribution is forward peaked. The 1985 run gave data at two additional energies to study the energy dependence of the production cross section. Analysis of these data is continuing.

Figure 1 shows a plot of a sample of the data for the $^{12}C(p,\gamma)^{13}N$ and $^{12}C(p,\pi^\circ)^{13}N$ reactions. The focal plane position and arrival angle, which are displayed, map rather directly into recoil longitudinal and transverse momenta. The spectrograph is located near 0° corresponding to backward angle emission of the unobserved light neutral product. The higher momentum group, which lies to the right in this figure, is attributable to the (p,γ) reaction which yields the larger neutral particle momentum. An ellipse is the distinctive signature of a two-body final state. The windows show the positions expected for events arising from the (p,π°) and the (p,γ) processes. The events have been selected by time of flight through the spectrometer and energy loss corresponding to A/Q = 13/7 and Z = 7. A second flight timing between the two

PPAC planes removes an ambiguity from the cyclotron rf microstructure (pulse selection of 1:2 gives a beam burst separation less than the range of flight times through the magnet.)



<u>Figure 1.</u> Emission angle versus relative magnetic rigidity of $^{13}N^{7+}$ recoil ions. The spectrograph rigidity p_0/Q is set at 0.37 Tesla-meters, where Q is the ion charge. The beam enters the spectrometer at θ = -60 mrad, so the kinematic ellipse for a two-body final state must be symmetric about this line. The events shown have been gated by two times-of-flight and a dE/dx window to select A/Q = 13/7 and Z = 7 (see text). Each run also yields events for A/Q = 13/7 and A/Q = 13/6, Z =6 (not shown here), which allow internal consistency checks.

The observed differential cross sections in the angular emission range of about 155° to 175° is found to be about 3 nb/sr for the (p,π°) reaction. The analysis of the (p,γ) data is not yet finished. The (p, π°) cross section can be compared to the (p,π^{+}) data of Green[1] using isospin symmetry, and the agreement is good. A previous study[3] of the $^{16}O(\gamma, p)^{15}N$ reaction had led us (by detailed balance and the assumption that the cross section would not change rapidly with mass and energy in this region) to expect a (p,γ) cross section somewhat smaller than the present data show. Analysis is continuing and a run is planned to repeat the measurement at several beam energies down to the recoil energy limit set by the detector windows.

1) F. Soga et al., Phys. Rev. C <u>24</u>, 570 (1981); M.C. Green, Ph.D Thesis, Indiana University 1983.

2) R.D. Bent et al., 1983 IUCF Scientific and Technical Report, p. 90.

3) M.J. Leitch et al., Phys. Rev. C <u>31</u> 1633 (1985).