# THE (p,d) REACTION AT $E_p$=121 MeV

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Use of the (p,d) reaction as a spectroscopic tool has been rather extensive at low bombarding energies ($E_p \leq 50$ MeV). The utility of this reaction rests, to a large extent, on a rather firm theoretical understanding of both the reaction mechanism and the approximations which are used in calculating the reaction cross sections. However, it remains to be seen whether or not the standard DWBA treatment which suffices at the low bombarding energies will remain valid at intermediate energies.

Recent (p,d) studies at 700 MeV[1,2] and 185 MeV[3] have suggested that a much more careful treatment is necessary. In particular, study of the $^{12}C(p,d)^{11}C$ reaction at 700 MeV has shown[1,2] important effects which can be attributed to both a two-step reaction mechanism and to the deuteron D-state. Since the deuteron D state effects can be correctly treated only by using a proper deuteron wave function in a full finite range calculation, the standard zero range treatment will be rendered invalid if such effects are present. In order to study these effects, a proposal to study the (p,d) reaction at 120 and 220 MeV was submitted to and accepted by the Indiana University Cyclotron Facility. The first portion of this experiment has been completed.

Data were obtained for the (p,d) reaction on $^{12}C$.$^{58}Ni$, $^{90}Zr$ and $^{208}Pb$ at a bombarding energy of 121 MeV with a typical resolution of 125 keV (FWHM). The $^{58}Ni$, $^{90}Zr$ and $^{208}Pb$ targets were selected in order to minimize two-step processes while the $^{12}C$ target was selected to provide a comparison with the small amounts of intermediate energy (p,d) data previously available.

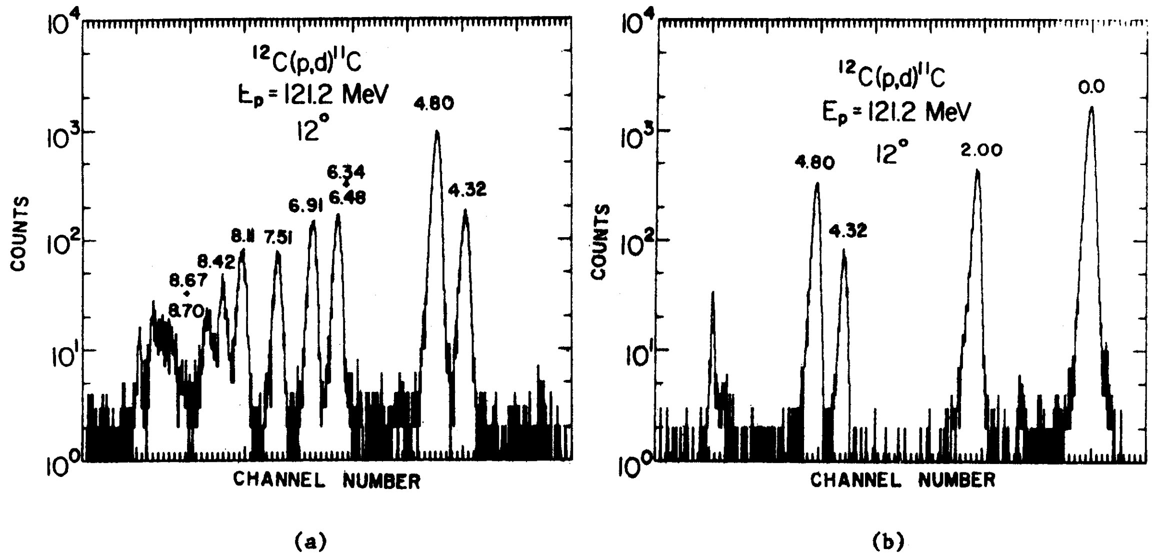


Figure 1. Deuteron spectra from the $^{12}C(p,d)^{11}C$ reaction at $E_p$=121.2 MeV.

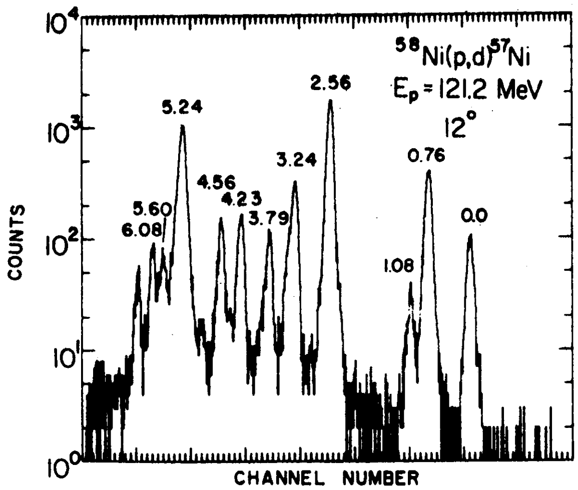


Figure 2. Deuteron spectrum from the $^{58}Ni(p,d)^{57}Ni$ reaction at $E_p$=121.2 MeV.

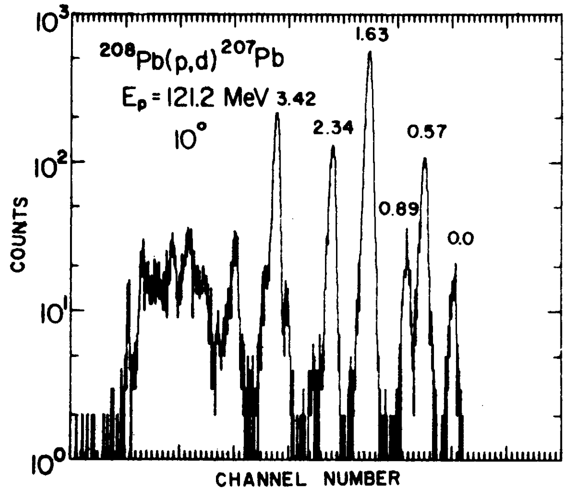


Figure 3. Deuteron spectrum from the $^{208}Pb(p,d)^{207}Pb$ reaction at $E_p$= 121.2 MeV.

Spectra for the $^{12}C$, $^{58}Ni$ and $^{208}Pb(p,d)$ reactions are shown in Figures 1, 2 and 3. Angular distributions were obtained between lab angles of 6° and 50° in 2° steps. Because the shapes as well as the magnitudes of the angular distributions are affected by both two-step processes and deuteron D-state effects, care was taken to obtain good statistics for even the weaker transitions.

While the data analysis is only beginning, several features can immediately be noted. First, the states in $^{11}C$ which are expected to be populated two-step processes (e.g. $7/2^-$ and $5/2^-$ states) show rather flat angular distributions distinctly different from the sharply dropping distributions for predominantly single-particle states (e.g. $3/2^-$ and $1/2^-$ states). Secondly, in all nuclei studied, the $p_{3/2}$ orbitals are more diffractive and the oscillations are out of phase with those of the $p_{1/2}$ orbitals. As expected, the high momentum orbitals ($j \geq 7/2$) are distinctly preferred in the (p,d) reactions at this energy.


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