

related, and also because there appear to be several reaction mechanisms with possibly different energy- and A-dependences. The high resolution spectra shown here indicate that the dominant reaction mechanism is determined to a certain extent by the nuclear structure changes that occur during the reaction, and that it may be possible to use nuclear structure

effects to isolate different aspects of the reaction process.

- 1) S. Dahlgren, P. Grafström, B. Höistad, and Å. Asberg, Nucl. Phys. A211, 243 (1973).
- 2) Z. Grossman, F. Lenz, and M.P. Locher, Ann. of Phys. 84, 348 (1974).
- 3) G.A. Miller, Nucl. Phys. A224, 269 (1974).
- 4) S. Cohen and D. Kurath, Nucl. Phys. A101, 1 (1967).

ENERGY DEPENDENCE OF THE $^{12}\text{C}(p, \pi^+)^{13}\text{C}^*$ REACTION TO 2p-1h FINAL STATES

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The reactions $^{12}\text{C}(p, \pi^+)^{13}\text{C}^*$ leading to specific final states have been studied with proton beams in the energy range 166 to 200 MeV. The aim of this work is to shed light on the mechanism of the (p, π^+) reaction by comparing the energy dependence of transitions to 2p-1h states at $E_x = 3.68(3/2^-)$, $6.86(5/2^+)$ and $9.50(9/2^+)$ MeV with that of transitions to single-particle states at $0.0(1/2^-)$, $3.09(1/2^+)$ and $3.85(5/2^+)$ MeV. Angular distributions at several energies have been measured using the QDDM and DD^- pion spectrographs. The close-lying states at 3.68 and 3.85 MeV were cleanly resolved with the QDDM spectrograph (see Fig. 1), and separate angular distributions for these states were obtained for the first time. The measured angular distributions of the differential cross sections are shown in Fig. 2 together with 185 MeV Uppsala data.

A comparison of the angular distributions for transitions to the two $5/2^+$ states (the single-particle $(1d_{5/2})$ state at 3.85 MeV and the core-excited $(1d_{5/2} + 2s_{1/2} \boxtimes 1p_{3/2}^{-1} 1p_{1/2})$ state at 6.86 MeV) indicates that, though the shapes of the angular distributions are similar except for a displacement in position of the minimum, the magnitudes and energy

dependences of the total cross sections are quite different (Fig. 3). The main component of the 3.68 MeV

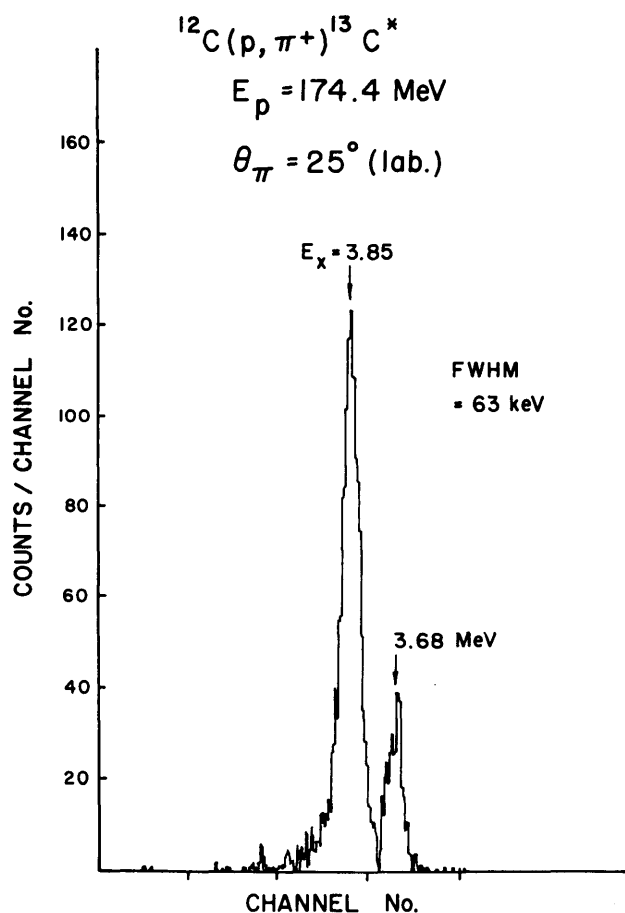


Figure 1. The spectrum for doublet state in $^{12}\text{C}(p, \pi^+)^{13}\text{C}^*$ reaction obtained with the QDDM magnetic spectrograph.

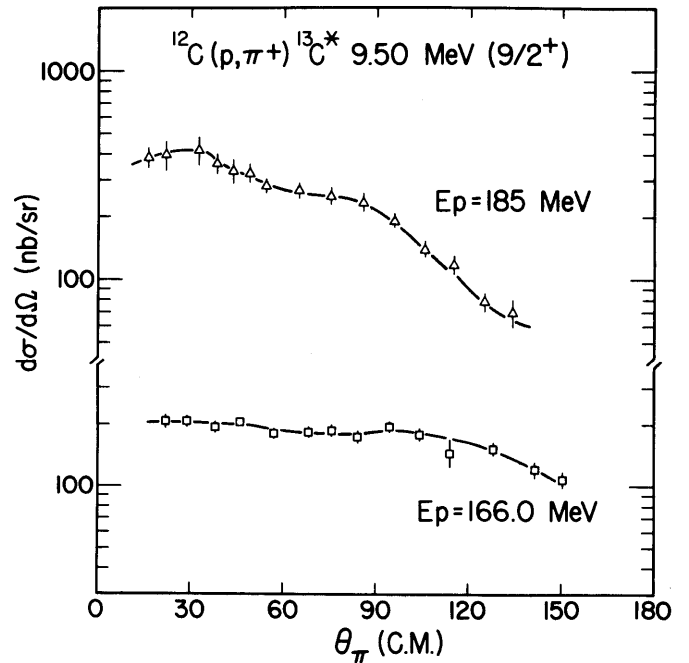
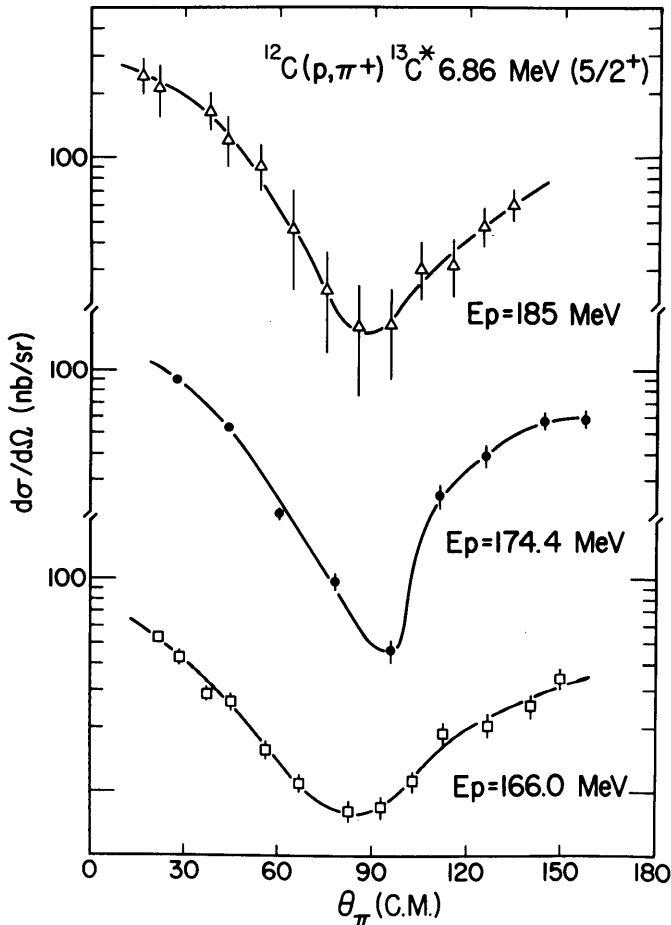
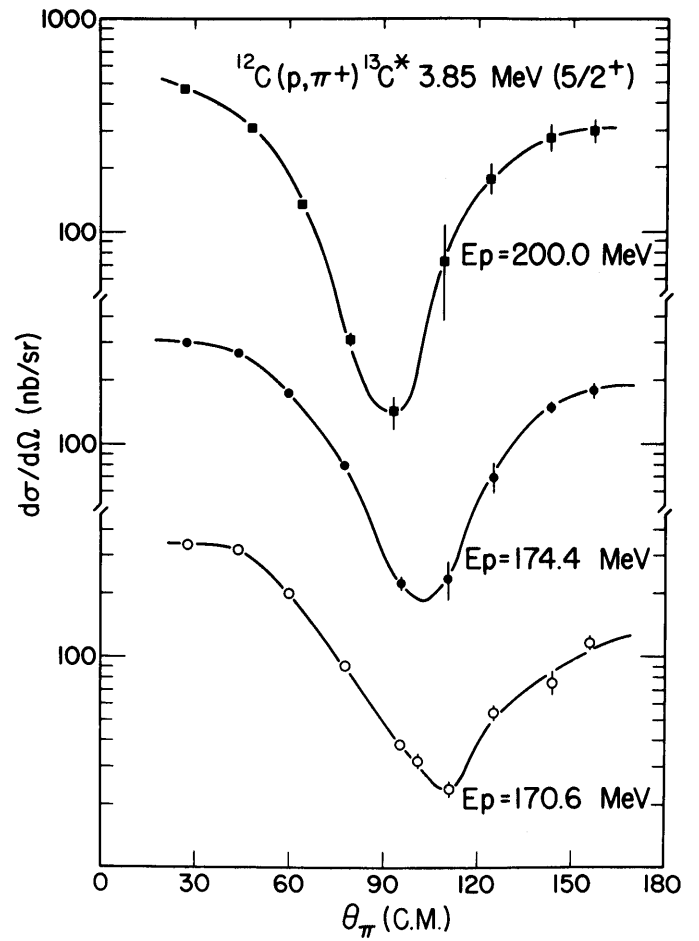
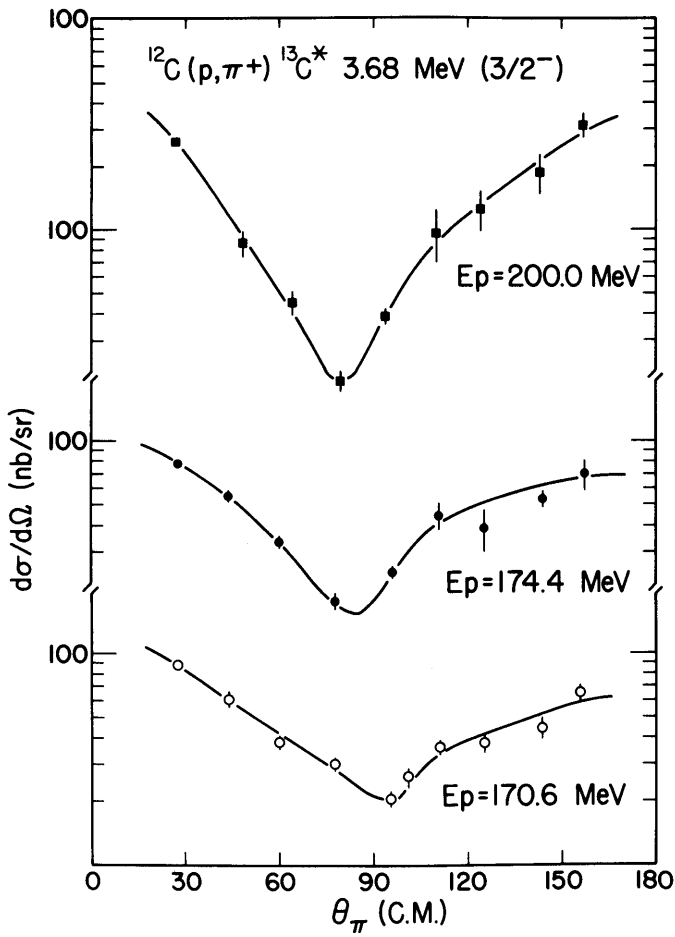
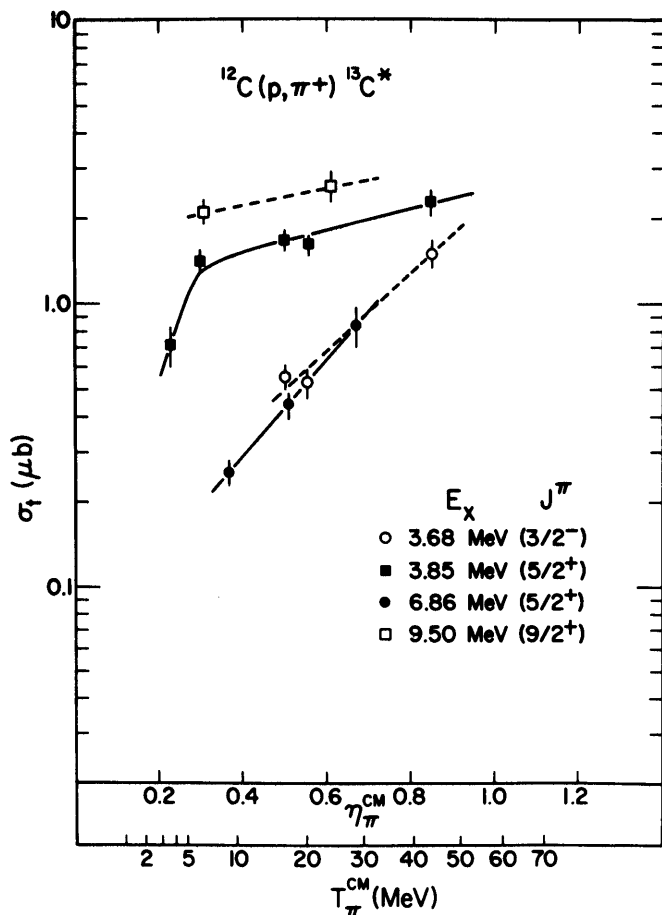


Figure 2. Angular distributions for the 3.68, 3.85, 6.86 and 9.50 MeV states in $^{12}\text{C}(p,\pi^+)^{13}\text{C}$ reactions.



state is the $(1p_{1/2} \otimes 1p_{3/2}^{-1} 1p_{1/2})$ configuration. The different slope of the excitation functions for the 3.68 and 6.86 MeV 2p-1h states compared to that for the 3.85 MeV single-particle state indicates a difference in the reaction mechanism for production of 2p-1h and single-particle final states. The steeper slope for the 2p-1h final states suggests a multistep mechanism involving core excitation by the outgoing pion. On the other hand, the slope of the excitation function for the 9.50 MeV state, which is supposed to be a $(1d_{5/2} \otimes 1p_{3/2}^{-1} 1p_{1/2})$ stretched configuration, appears to be similar to that for the 3.85 MeV single-particle state. The enhancement of transitions to the 9.50 MeV state is probably due to its high spin, which is favored because of the large angular momentum mismatch in the (p, π^+) reaction.

Figure 3. Excitation Function for total cross sections in the $^{12}\text{C}(p, \pi^+)^{13}\text{C}^*$ reactions.

POSITIVE-PION PRODUCTION BY 149-166 MeV PROTONS ON ^{16}O AND ^{28}Si

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Extensive data on the energy dependence of the (p, π^+) reaction exists only for transitions leading to the ^{11}B and ^{41}Ca ground states,¹ which involve the $1p_{3/2}$ and $1f_{7/2}$ neutron orbitals, respectively. Similar data for other cases involving different orbitals would be useful in determining whether the main features of the (p, π^+) angular distributions are due to nuclear structure or the reaction mechanism. It would also be useful to study the energy dependence of transitions to several different final states of the same nucleus, since the pion and proton distortions would be about the same in this case, and such measurements would strongly constrain the

pion and proton optical potentials in DWBA calculations.

Motivated by the above considerations, additional energy dependence studies of the (p, π^+) reaction near threshold have been carried out with ^{16}O and ^{28}Si targets. Angular distributions have been obtained for transitions to the ^{17}O ground state ($5/2^+$) at 154, 157 and 165 MeV bombarding energy and the 0.87 MeV ($1/2^+$) state at 157 MeV; these two states are known to be good single particle states involving the $1d_{5/2}$ and $2s_{1/2}$ neutron orbitals, respectively. For the $^{28}\text{Si}(p, \pi^+)^{29}\text{Si}$ reaction, 149 and 160 MeV protons were used to obtain angular distributions