PION PRODUCTION IN A(p,pπ) REACTIONS

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Numerous measurements of (p,π^+) and (p,π^-) reactions on nuclei have pointed up our basic inability to obtain a consistent and systematic description of the data with any of the current theoretical models. Measurements of the three-body (p,pπ) reaction can provide additional detailed information on the pion production mechanism. The flexibility afforded by the three body final state allows one to isolate the dependence of the cross section on various kinematic variables, which cannot be studied in the two-body reaction. Furthermore theoretical calculations of the (p,pπ) reaction are simplified, since one less vertex is involved in the model, and the occurrence of the emitted proton in a scattered state can lead to small nuclear momentum transfers.

Experiment 187 was an initial run to examine the difficulties involved in such a (p,pπ) measurement at the relatively low bombarding energy of 205 MeV. The emergent pions were detected in the QQSP spectrometer using a solid angle of approximately 20 msr and a momentum bite of approximately 30%. The protons were detected in two plastic scintillator telescopes $\Delta E \cdot E \cdot \overline{\text{Veto}}$ (solid angle ≃ 10 msr) which stopped about 75 MeV protons in the first two detector elements. In addition a 12.7 cm × 12.7 cm liquid scintillator neutron detector was placed approximately 2 meters from the target to examine the (n−π) coincidence rate.

Theoretical estimates suggested that at this low bombarding energy the cross section should be peaked in the forward direction. Therefore the pion spectrometer was fixed at −30° and one proton telescope was placed at +25° (or +35°). In order to examine the angular dependence, the second proton telescope was placed at 90°. In addition coincidences were recorded for events stopping in the 90° ΔE detector to measure the cross section for the emission of low energy protons (< 10 MeV). Measurements were made of both $(p-\pi^+)$ and $(p-\pi^-)$ coincidences. Targets of ^{10}B[$Q(p,p\pi^+)$= −140.6 MeV and $Q(p,p\pi^-)$= −142.6 MeV] and ^{12}C[$Q(p,p\pi^+)$= −153.4 MeV and $Q(p,p\pi^-)$= −156.4 MeV] were used.

The major difficulty in the measurements was the accidental rate. A reasonable count rate required running with a real to accidental ratio of 1/10. As a result subtractions were large, and there is essentially no detailed energy information in the present measurements. At best this experiment will provide cross section information integrated over the acceptance limits set by the detectors.

Analysis is in progress. However, two preliminary observations can be made. Although somewhat smaller, the $(p,p\pi^-)$ cross sections are comparable to $(p,p\pi^+)$. Furthermore the integrated cross section for T_p>10 MeV falls by roughly a factor of five from 35° to 90°. Future work depends on our ability to design an experiment which will significantly improve the real to accidental ratio.

ACTIVATION MEASUREMENTS OF THE $^{208}Pb(^{3}He,\pi^{-}xn)^{211-x}n$At REACTION

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Several recent experimental[1-4] and theoretical[5,6] studies of pion production with complex projectiles below the threshold for production in free nucleon-nucleus reactions have attracted wide interest. Wall et al.[1] measured the $^{208}Pb(^{3}He,\pi^{\circ})$ inclusive cross section at 200 MeV to be 6.0×10^{-2} nb/sr-MeV. Doubly-coherent pion production[2] by 910 MeV ^{3}He on ^{6}Li yielded 0.42×10^{-3} nb/sr for the differential cross section. The heavy-ion study by Benenson et al.[3] has prompted several new investigations of pion production below the free threshold. More recently, LeBornec et al.[4] have studied coherent pion production near threshold in ^{3}He-^{3}He reactions at 270 and 283 MeV incident energies. In particular, they observed the $^{3}He(^{3}He,\pi^{+})^{6}Li$ reaction to discrete states with sizeable cross sections. Klingenbeck, Dillig and Huber[5] have developed a microscopic model for the complete fusion of two nuclei and subsequent pion production. The model adequately describes the $^{3}He(^{3}He,\pi^{+})^{6}Li$ process near 280 MeV. Bertsch[6] has calculated the $(^{3}He,\pi)$ reaction cross section at 70 MeV/nucleon in an independent particle model. The calculation gives zero if collective Fermi motion is neglected and about 1 nb if the internal momentum of the ^{3}He nucleons is included.

In the present study we have measured the $^{208}Pb(^{3}He,\pi^{-}xn)$At cross sections in the energy range of 130-230 MeV using activation and radiochemical techniques. No new results have been obtained since our report[7] last year due to either scheduling conflicts or cyclotron availability. The results to date are given in Table I. The relative uncertainty in these measurements are ±15-30%, whereas the absolute uncertainty is estimated at ±50%. Our detection limit is about 0.1-0.5 nb. The below threshold measurement at 130 MeV did not produce a detectable amount of Astatine. We hope to complete this study in 1983 by performing new measurements below threshold to determine well our secondary contributions and to perform additional measurements at higher energies, preferrably 230-270 MeV.

TABLE I

E_{He}(MeV)	σ_{207}(nb)	σ_{211}(nb)	Target mg/cm^2 Thickness
130	<0.5	<0.5	10
158	9.7	8.0	63
198	5.3	7.6	144
200	7.8	11.6	71
230	<2.5	4.4	75

1) N.S. Wall, J.N. Craig and D. Ezrow, Nucl. Phys. A268, 459 (1976).

2) E. Aslanides et al., Phys. Rev. Lett. 43, 1466 (1979).

3) W. Benenson et al., Phys. Rev. Lett. 43, 683 (1979).

4) Y. LeBornec, L. Bimbot, N. Koori, F. Reide, A. Willis, N. Willis and C. Wilkin, to be published in Phys. Rev. Lett. (1982).

5) K. Klingenbeck, M. Dillig and M. Huber, to be published in Phys. Rev. Lett (1982), and A.I.P. Conference Proceedings No. 79 "Pion Production and Absorption in Nuclei - 1981", American Institute of Physics, New York, 1982.

6) G.F. Bertsch, Phys. Rev. C 15, 713 (1977).

7) IUCF Scientific and Technical Report 1981, p. 50.