MEASUREMENT OF DIFFERENTIAL CROSS SECTIONS AND ANALYZING POWERS FOR THE $^3He(p,\pi^+)^4He$ REACTION NEAR THRESHOLD

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Differential cross sections and analyzing powers have been measured for proton-induced, positive pion production from a gaseous ^3He target at two proton energies near threshold. The experiment was motivated by a consideration of the advantages that a light system such as ^3He has to offer. These include:

1) A more tractable microscopic calculation of pion rescattering effects is possible, as a result of the small number of nucleons involved.

2) The initial and final nuclear wave functions are well-known out to large momentum transfer.

3) In a light system such as ^3He the relationship between pion production on a nucleus and pion production in free nucleon-nucleon collisions (e.g. $pp \rightarrow \pi^+d$) may be more readily apparent.

4) The ^3He (p,π^+) ^4He reaction represents a transition between the more elementary processes ($pp \rightarrow \pi^+d$ and $pd \rightarrow \pi^+t$) and pion production on complex nuclei.

In order to perform the measurements, we used a high pressure gas target (Fig. 1), designed to allow the detection of pions with the QDDM magnetic spectrometer. The cell has an 8 mil Havar[1] entrance window for the proton beam and a 1 mil Havar exit window for pions. The exit window is mounted on the front collimator slits. The entrance slits of the QDDM spectrometer serve as the rear collimator for the gas target. The gas target was constructed so that it could be used over the full angular range of the spectrometer (25°-155°). It was tested at pressures up to ≈16 atm.

The gas cell was positioned in the QDDM scattering chamber on a remote-control turntable (Fig. 2) so that it could be rotated to direct the pion exit window toward the spectrometer at each angle. A cryogenic (LN) transfer system was used to recover most of the ^3He gas after the experiment was completed. Prior to

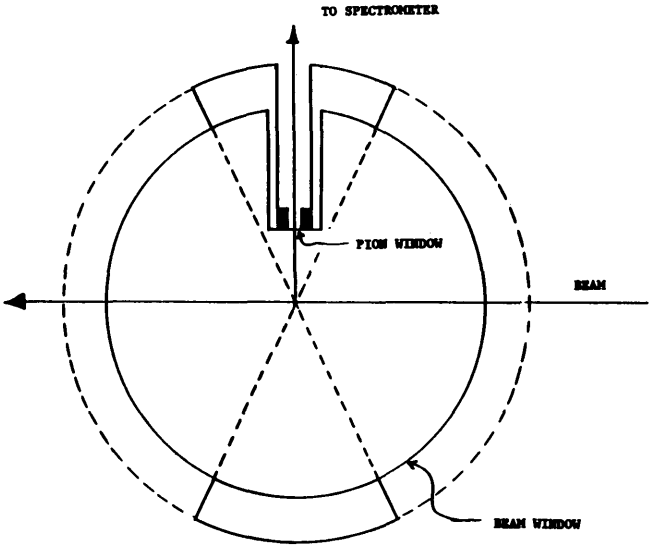


Figure 1. Schematic diagram (top view) of the gas cell showing the entrance (beam) and exit (pion) windows and the front collimator slits.

Figure 2. The high pressure gas target positioned in the QDDM scattering chamber.

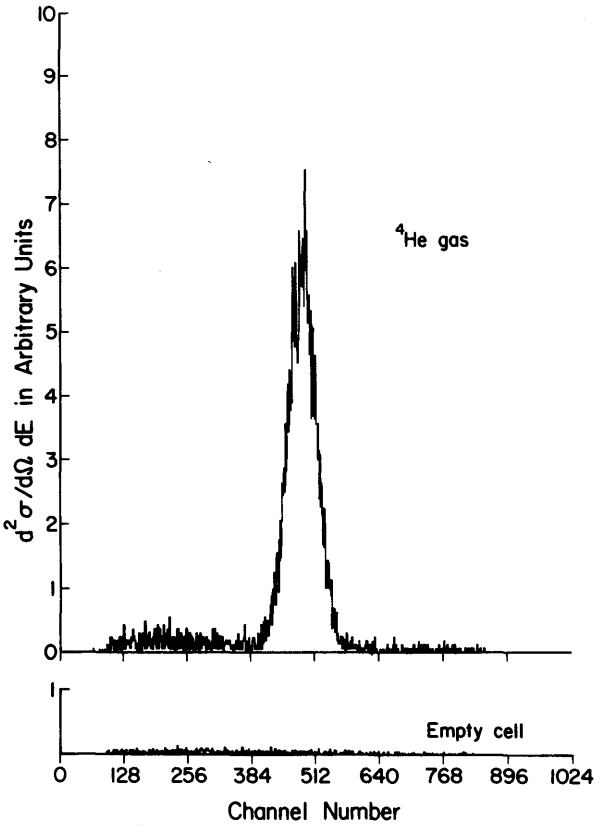
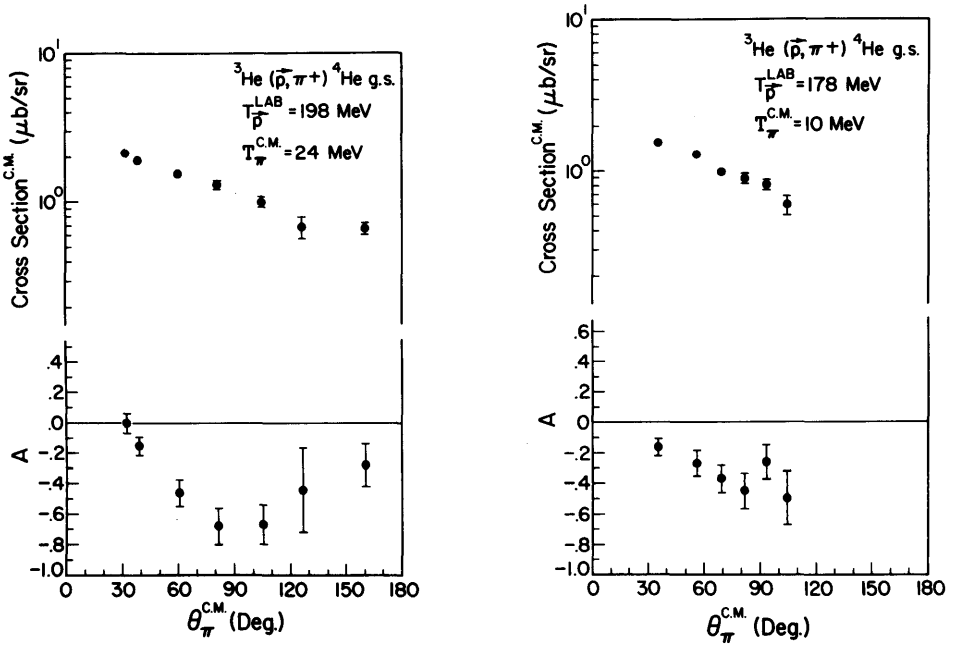


Figure 3. Spectrum of elastically scattered protons from He at a laboratory angle of 45° and the corresponding spectrum taken with an empty gas cell. A similar test with the spectrometer magnetic field set for pions also showed a negligible background contribution from the empty cell.

the measurements, tests were made to check alignment of the gas cell with respect to the spectrometer and also to determine background (Fig. 3.). A test of the active target length (as predicted from geometrical factors) was made by measuring an angular distribution of the elastic scattering cross section from ^{4}He at T_p=198 MeV. Good agreement was obtained with recent measurements from TRIUMF.[2] The sensitivity to beam spot centering was determined and found to be small. The temperature of the gas target (a closed system) was monitored during the experimental runs.

The experimental runs, which were completed in the summer of 1981, consisted of measurements of differential cross sections and analyzing powers at two proton energies; 178 and 198 MeV. Figure 4 shows the results of the measurements. The error bars include only the statistical uncertainties.

Figure 4. Differential cross sections and analyzing powers for the reaction ^{3}He(p,π^+)^{4}He plotted as a function of the center-of-mass angle for T_p=198 MeV (top) and 178 MeV (bottom). These bombarding energies correspond to center of mass pion energies of 24 MeV and 10 MeV, respectively.



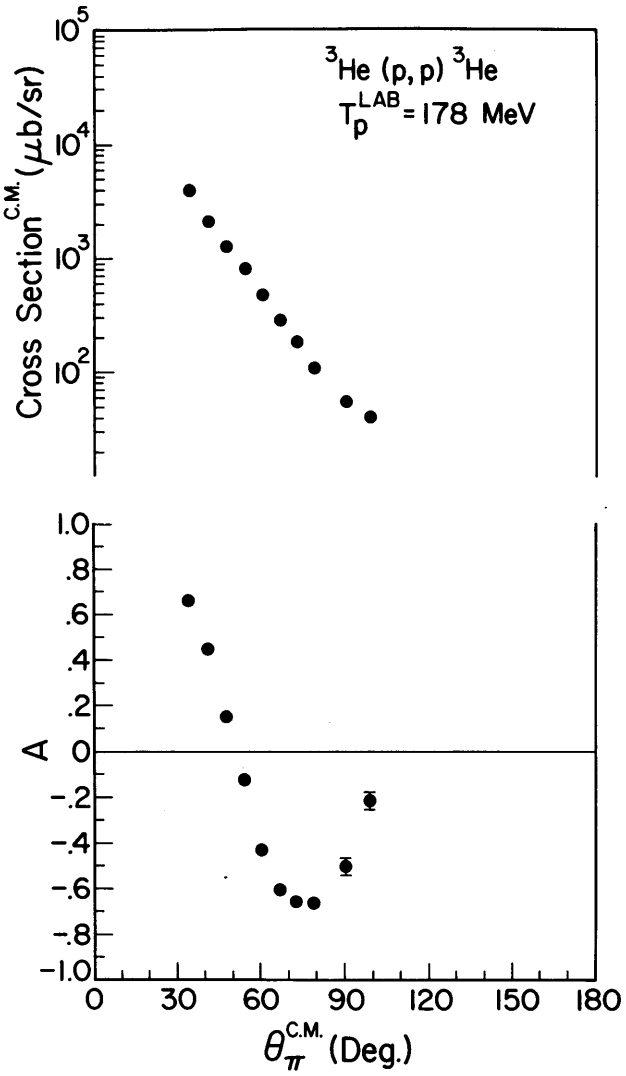


Figure 5. Differential cross sections and analyzing powers for the elastic scattering of 178 MeV polarized protons from ^{3}He.

The cross sections measured here are in good agreement with previous results from Orsay[3] at 201 MeV, but there is a descrepancy between our results and those for the inverse, charge-symmetric reaction ^{4}He(π^-,n) ^{3}H, which has been studied by Källne et al.[4] Our data would predict larger cross sections for this inverse reaction than those reported by Källne et al.

At the conclusion of this experiment, differential cross sections and analyzing powers for p-^{3}He elastic scattering were measured at T_p=178 MeV for 10 angles between 34 and 100° cm (Fig. 5). These data will be used to determine proton optical potential parameters for subsequent calculations.

1) Hamilton Precision Metals, Lancaster, PA 17604, USA

2) G.A. Moss et al., Phys. Rev. C 21, 1932 (1980).

3) Willis, N. et al., J. Phys. G, 7, L195 (1980)

4) J. Källne et al., Phys. Rev. C 24, 1102 (1981)