A study of ^{6}He + p reaction: elastic scattering and neutron transfer reactions

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The measurement of the ^{6}He + p experiment at 8 MeV/nucleon in inverse kinematics at the CNS Radio-isotope Beam Separator (CRIB) was completed in Feb. 2024. The ^{6}He(p, p)^{6}He, ^{6}He(p, d)^{5}He and ^{6}He(p, t)^{4}He were measured simultaneously in the angle range of 8° to 75° in the laboratory system, and a full description of the processes were obtained. In particular, the one-neutron and two-neutron transfer reactions provide valuable insights into the halo structure of ^{6}He.[1,2)]

The detection setup was identical to the experiment in May 2023 described in a previous report.[3)] The secondary beam ^{6}He was produced by bombarding a cryogenic gas cell filled with deuterium using a $^7Li^{3+}$ beam at 8.3 MeV/nucleon, with a maximum intensity of ∼4.4 electric μA (eμA). The ^{6}He beam energy at the CH_2 target was 7.28 MeV/nucleon, and the intensity reached to 6×10^5 cps with a purity of >87%, with the main contamination obtained from triton due to the same ratio of charge-to-mass. Two multi-wire drift chambers (MWDC)[4)] were used to monitor the beam intensity[5)] and track the beam position event by event. The tracking efficiencies of MWDCa (upstream) and MWDCb (downstream) were 90% and 95%, respectively, for the applied voltages of −895 V and −796 V. Six silicon telescopes were installed in the F3 chamber to detect the reaction products.

Figure 1 shows the energy versus laboratory angle of the protons measured at the telescopes, accumulated for 54 minutes using an intense ^{6}He beam of 2.45×10^5 cps. The kinematical loci of protons calculated for several reactions are also shown in the figure. The locus of the elastic proton (p_0) scattering from ^{6}He is clearly visible (solid curve). We also observe the inelastic protons (p_1) scattering from the ^{6}He(p, p_1)^{6}He, where ^{6}He is at the first excited state ($J^\pi = 2^+$, E_x = 1.8 MeV), as indicated by the dashed curve. The preliminary cross section of the elastic scattering was obtained by considering the geometry of the six telescopes, as shown in Fig. 2.

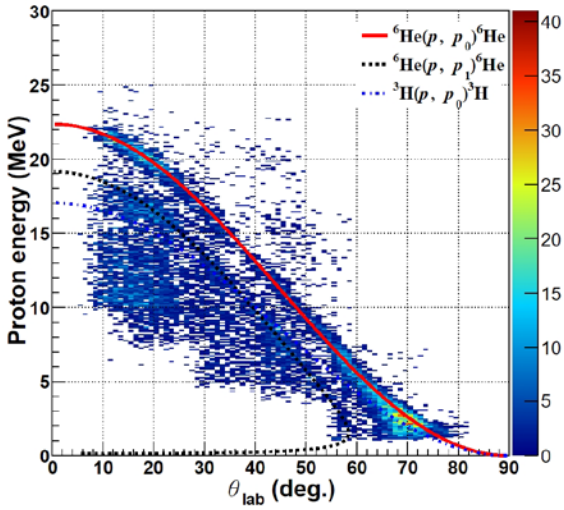

Fig. 1. Energy vs angle of the measured protons (at the telescopes) with the kinematical reaction curves of ^{6}He(p, p_0)^{6}He (solid curve), ^{6}He(p, p_1)^{6}He (dashed curve), and ^{3}H(p, p_0)^{3}H (dashed-dotted curve).

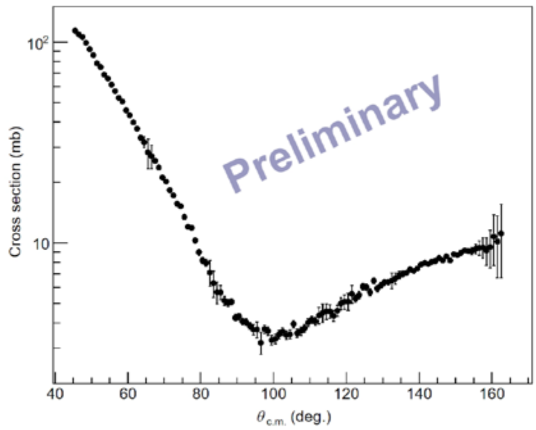

Fig. 2. Cross-section of the ^{6}He(p, p_0)^{6}He reaction.

A detailed analysis is currently in progress. The elastic scattering cross section will be analyzed within the continuum-discretized coupled channels (CDCC) theory to provide the potential optical parameters for further analyses of the ^{6}He(p, t)^{4}He reaction using the distorted wave Born approximation (DWBA) method.

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