Production of very neutron-rich nuclei via two-proton knockout reaction with deuterium operation of MINOS

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The production of neutron-rich nuclei through one-nucleon knockout $(p, 2p)$ reactions has been successfully demonstrated with the MINOS setup.[1)] In future RIBF experiments, a method to remove more than one proton with a reasonable rate will be required for the production of more neutron-rich nuclei. At present there is no consensus on the best reaction for two-proton removal. In this work, the performance of the $(d, 3pn)$ reaction with the MINOS setup as a candidate of the two-proton knockout driver in future RIBF experiments is discussed. the results of a recent nuclear transmutation experiment at RIBF[2)] show an encouraging indication that the production cross sections of neutron-rich nuclei are larger with a deuteron target than with a proton target. In this report, cross sections of the $(p, 3p)$ and $(d, 3pn)$ reactions on a ^{58}Ti beam are shown and discussed.

The experiment was carried out using the SAMURAI spectrometer after the third SEASTAR campaign[3)] in May 2017. A secondary cocktail beam including ^{58}Ti was produced with projectile fragmentation reactions of a primary ^{70}Zn beam at 345 MeV/u impinging on a beryllium target. The experimental setup was the same as that of the SEASTAR experiment, except for the target material. The target was liquid deuterium with a thickness of 2.6 g/cm^2. The ^{58}Ti beam with an initial energy of 240 MeV/u loses its energy by 90 MeV/u in the target. The measured cross section is the one averaged over 150–240 MeV/u. The secondary beam and fragments were identified event by event using the ΔE–TOF–$B\rho$ method.

Figure 1 summarizes preliminary results of the cross-section ratio for a deuteron target to a proton target. The ratio of interaction cross sections is greater than one and less than two. This is due to a well-known eclipse effect proposed by Glauber.[4)] The result for two-proton removal cross sections shows a significantly larger value of ~ 3, while that for one-proton removal is not so different from the interaction cross section result. This fact implies possible advantages of a deuteron target to produce neutron-rich nuclei.

Data for other isotopes in the cocktail beam will provide us with a global feature of the cross section ratio and reaction analyses for the data will reveal why a deuteron target is so efficient removing two protons from neutron-rich nuclei.

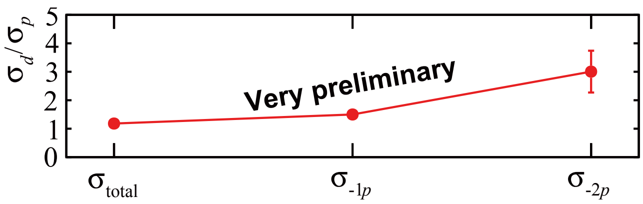

Fig. 1. Ratio of cross sections for a deuteron target to a proton target. $\sigma_{\rm total}$: interaction cross section (σ_d/σ_p). σ_{-1p}: one proton removal cross section. σ_{-2p}: two-proton removal cross section.

References
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