Re-measurement of the ^{4}He(^{8}He, ^{8}Be) reaction

S. Masuoka,[*1] S. Shimoura,[*1] M. Takaki,[*1] S. Ota,[*1] S. Michimasa,[*1] M. Dozono,[*1] C. Iwamoto,[*1] K. Kawata,[*1] N. Kitamura,[*1] M. Kobayashi,[*1] R. Nakajima,[*1] H. Tokieda,[*1] R. Yokoyama,[*1] D. S. Ahn,[*2] H. Baba,[*2] N. Fukuda,[*2] T. Harada,[*3] E. Ideguchi,[*4] N. Imai,[*1] N. Inabe,[*2] Y. Kondo,[*5] T. Kubo,[*2] Y. Maeda,[*6] F. M. Marqués,[*7] M. Matsushita,[*1] T. Nakamura,[*5] N. Orr,[*7] H. Sakai,[*2] H. Sato,[*2] P. Schrock,[*1] L. Stuhl,[*1,*2] T. Sumikama,[*2] H. Suzuki,[*2] H. Takeda,[*2] K. Taniue,[*6] T. Uesaka,[*2] K. Wimmer,[*8] K. Yako,[*1] Y. Yamaguchi,[*1] Y. Yanagisawa,[*2] K. Yoshida,[*2] and J. Zenihiro[*2]

In our previous study, the candidate resonance of 4n system (tetra-neutron) was found using the ^{4}He(^{8}He, ^{8}Be)4n reaction with a 186 MeV/nucleon ^{8}He beam.[1)] A new measurement with better statistics and better accuracy was performed to evidence the existence of the tetra-neutron system.[2)]

The intensity of the ^{8}He beam (3.5×10^6 particles per second at the liquid helium target) was approximately twice compared to that of the previous experiment. A pair of cathode readout drift chambers (CRDCs) was used at the final focal plane of the SHARAQ spectrometer. To improve the resolution, the positions and angles of the CRDCs were precisely calibrated in the software analysis by using the reference data of a ^{4}He beam. We achieved position resolutions of 0.40 and 0.62 mm FWHM and angular resolutions of 1.12 and 1.87 mrad FWHM in the horizontal and vertical directions, respectively. Ion optical analysis was then performed to evaluate the ion transport matrix elements of both the beam line and the SHARAQ spectrometer. The scattering angle of the reaction was deduced from the angle measured by the CRDCs after taking the ion transport matrix into account. Higher order aberrations were thus corrected for. We obtained a resolution of 4.7 and 2.8 mrad FWHM in the horizontal and vertical directions, respectively.

In the previous experiment, the systematic uncertainty was 1.25 MeV mostly due to the fact that no reference data were measured in the momentum region of the tetra-neutron resonance. In this experiment, we measured the ^{1}H(^{3}H, ^{3}He)n reaction by using a ^{3}H beam at 310 MeV/nucleon (8.3 Tm) and a CH_2 target. The advantage of this reaction is that the rigidity of both the beam and the ejectile are the same as that of the ^{4}He(^{8}He, ^{8}Be)4n reaction at 186 MeV/nucleon. Therefore, the reaction of reference and the reaction of physics can be measured in the same momentum window without changing the magnet settings.

Figure 1 (a) shows the kinematical curve of the ^{1}H(^{3}H, ^{3}He) reaction. The scattering angle is plotted against the missing momentum, which is given by the momentum difference between the ^{3}H beam and the ^{3}He ejectile. Figure 1 (b) shows the spectrum of the missing mass momenta after correcting for the scattering angle dependence. Given the known Q-value of the ^{1}H(^{3}H, ^{3}He) reaction, the missing mass momentum of the peak seen in the figure was taken as a reference. The uncertainty of the excitation energy of $4n$ is evaluated to be 26 keV RMS due to the uncertainty of the peak position in Fig. 1 (b).

Further analysis is ongoing.

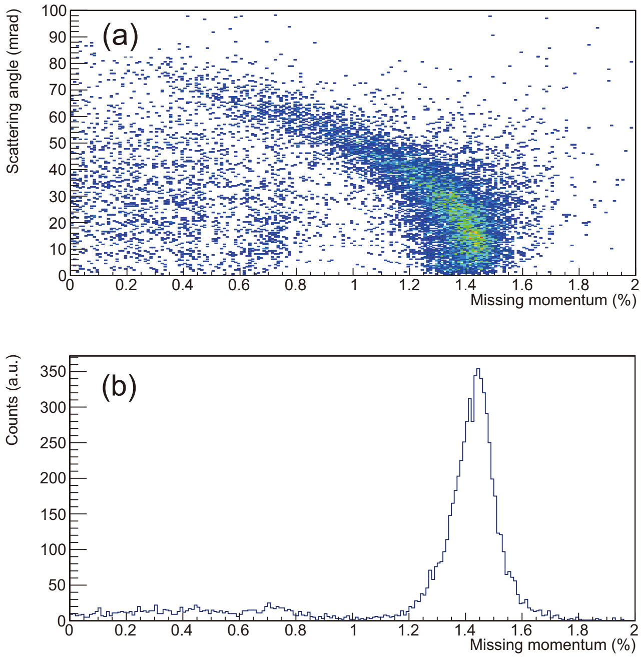

Fig. 1. (a) Plot of the scattering angle against the missing momentum. The kinematical curve of ^{1}H(^{3}H, ^{3}He)n reaction is visible. (b) Missing momentum spectrum after correcting for the scattering angle in (a).

*1 Center for Nuclear Study, the University of Tokyo
*2 RIKEN Nishina Center
*3 Department of Physics, Toho University
*4 Research Center for Nuclear Physics, Osaka University
*5 Department of Physics, Tokyo Institute of Technology
*6 Faculty of Engineering, University of Miyazaki
*7 Laboratorie de Physique Corpusculaire, IN2P3-CNRS, ENSICAEN et Université de Caen
*8 Department of Physics, the University of Tokyo

References

1) K. Kisamori *et al.*, Phys. Rev. Lett. **116**, 052501 (2016).
2) S. Masuoka *et al.*, RIKEN Accel. Prog. Rep. **50**, 198 (2017).