Production cross-section measurements for the systematics of Na and Mg isotopes with ^{48}Ca beam

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Na and Mg isotopes were produced by projectile fragmentation of a ^{48}Ca beam at an energy of 345 MeV/nucleon using the BigRIPS separator[1]. We measured the systematics of the production cross-section for Na and Mg isotopes in an unstable isotope region toward a very neutron-rich region. The systematics are useful to predict the production rates of rare isotopes. In addition, we performed a drip-line search of Na isotopes. The drip-line is important to understand the nuclear structure and the benchmark for nuclear models in a very neutron-rich region.

The $B\rho$ was tuned for each isotope in each setting and the ^{39}Na isotope was obtained using the $B\rho$ tuned for the center orbit of ^{36}Ne and ^{39}Na isotopes ("^{36}Ne + ^{39}Na setting"). The same target (Be: 20 mm) and the same thick degraders were used for the F1 (Al: 15 mm) and F5 (Al: 7 mm) degraders. The F5 degrader was used to reject the light particles. Particle identification was performed using the TOF-$B\rho$-ΔE method and the background events were eliminated using various correlations of the difference observable from each beam line detector[2),3)]. The production cross-sections of $^{27\text{-}39}$Na and $^{29\text{-}40}$Mg isotopes were measured and the results for the ^{40}Mg isotope were higher than those obtained with the NSCL[4] measurement. The heaviest known isotopes are ^{37}Na and ^{40}Mg. One event of the ^{39}Na isotope was detected in the "^{36}Ne + ^{39}Na setting" with an irradiation time of 9.4 h. The error of the event is large, hence it is difficult to determine whether ^{39}Na is bound. The nuclear binding of ^{39}Na is still an open question, and more experimental data for the ^{39}Na isotope are needed to unambiguously establish the nuclear binding of ^{39}Na. We obtained the production cross-section for one event for ^{39}Na as a preliminary result. The detailed analysis is in progress. Figure 1 and 2 show the production cross-sections of Na and Mg isotopes, respectively, toward the very neutron-rich region. The red and blue circles represent the experimental results obtained from the 2015 and 2014 experiments in Figure 1 and 2015 and 2010/2014 experiments in Figure2, respectively. These are the preliminary results. The black line represents the empirical formula of the EPAX 2.15[5] parameterizations in the LISE^{++} calculation[6]. Overall, our experimental results of the production cross-sections are in good agreement with the EPAX 2.15 parameterization in the region of $^{27\text{-}37}$Na and $^{29\text{-}38}$Mg. However, the measured production cross-sections of the ^{39}Na and ^{40}Mg isotopes are smaller than the EPAX 2.15 parameterizations and a large discrepancy exists in the production cross-section.

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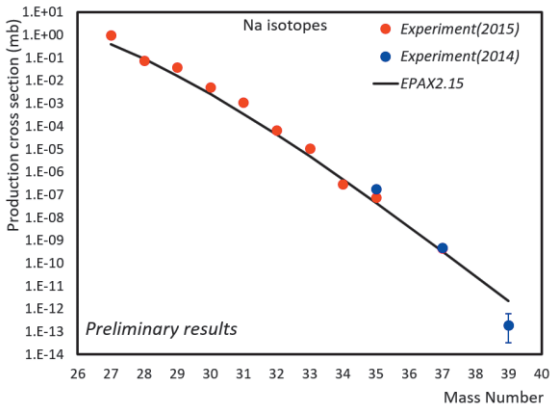

Fig. 1. Preliminary results of production cross-sections of Na isotopes toward the very neutron-rich region. The red and blue circles represent the experimental results obtained from the 2015 and 2014 experiments, respectively. The black line represents the EPAX 2.15 parameterizations.

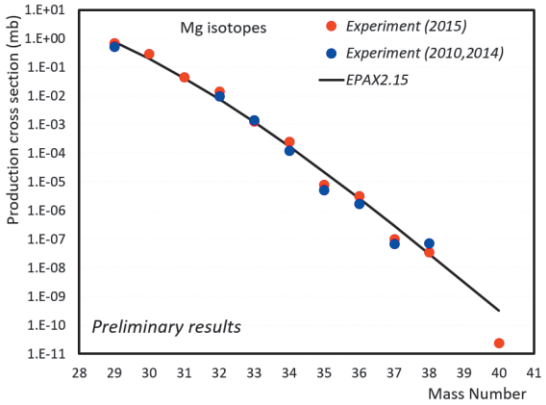

Fig. 2. Preliminary results of production cross-sections of Mg isotopes toward the very neutron-rich region. The red and blue circles represent the experimental results obtained from the 2015 and 2010/2014 experiments, respectively. The black line represents the EPAX 2.15 parameterizations.

References

1) T. Kubo et al., Nucl. Instrum. Meth. Phys. Res. **B204**, 97 (2003).
2) N. Fukuda et al., Nucl. Instrum. Meth. Phys. Res. **B317**, 323 (2013).
3) D. S. Ahn et al., to be submitted.
4) T. Baumann et al., Nature **449**, 1022-1024 (2007).
5) K. Sümmer and B. Blank, Phys. Rev. **C 61**, 034607 (2000)
6) O. B. Tarasov and D. Bazin, Nucl. Instrum. Meth. Phys. Res. **B266**, 4657 (2008).