Production cross-section measurements for very-neutron-deficient Ca and As isotopes produced from a ^{78}Kr beam at 345 MeV/nucleon by BigRIPS separator

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We performed production cross-section measurements using a ^{78}Kr primary beam for the neutron-deficient region around $_{20}$Ca and $_{33}$As isotopes, whose cross sections were not measured in previous ^{78}Kr campaigns in 2015 or 2019. The radioactive isotopes (RIs) were produced by the projectile fragmentation of the 400-particle nA primary beam at 345 MeV/nucleon impinging on a 5-mm-thick Be target in the BigRIPS separator. Particle identification based on the TOF-$B\rho$-ΔE method[1] was performed in the second stage of BigRIPS.

The production cross sections were deduced from the measured production rates at the F7 focal plane and their transmission efficiencies in the separator, which were simulated with the LISE^{++} codes.[2] In the simulation, the momentum distribution was represented by an assymetrical Gaussian distribution instead of the default distribution, *i.e.*, Universal parameterization,[3] which is a combination of a Gaussian distribution in high momentum side and an exponential tail in low momentum side. In the asymmetric Gaussian distribution, the Fermi momentum σ_0 and asymmetry coefficient α[2] were set to be 134.1 MeV/c and 9% (preliminary), respectively, obtained from fitting results of the experimental momentum distribution.

Figure 1 shows the production cross sections of RIs obtained in this study (colored symbols) and the previous measurements (black symbols) under the assumption that their lifetimes are long enough compared to the TOF values through the separator (∼460 ns). The cross sections vary smoothly and exhibit natural behavior, except for ^{68}Br. The apparent small cross-section of ^{68}Br could be caused by a decay loss in the separator due to its very short lifetime. K. Wimmer *et al.*[4] reported a lifetime of 45–57 ns for ^{68}Br produced from neighboring RI beams by secondary fragmentation reaction under the assumption of a systematic cross section of ^{68}Br. Assumming this lifetime value, the cross section of ^{68}Br from ^{78}Kr beam is estimated to be $\sim 10^{-5}$ mb and is on the systematics of the neighboring nuclei. The solid, dashed, and dotted lines show the cross sections predicted by semi-empirical formulae FRACS1.1,[5] EPAX3.1a,[6] and EPAX2.15.[7] Overall, FRACS1.1 provides better agreement with the measured cross sections than the other formulae; however, around the very-neutron-deficient region, the discrepancy between the measured and predicted cross sections becomes larger. A detailed analysis is currently in progress.

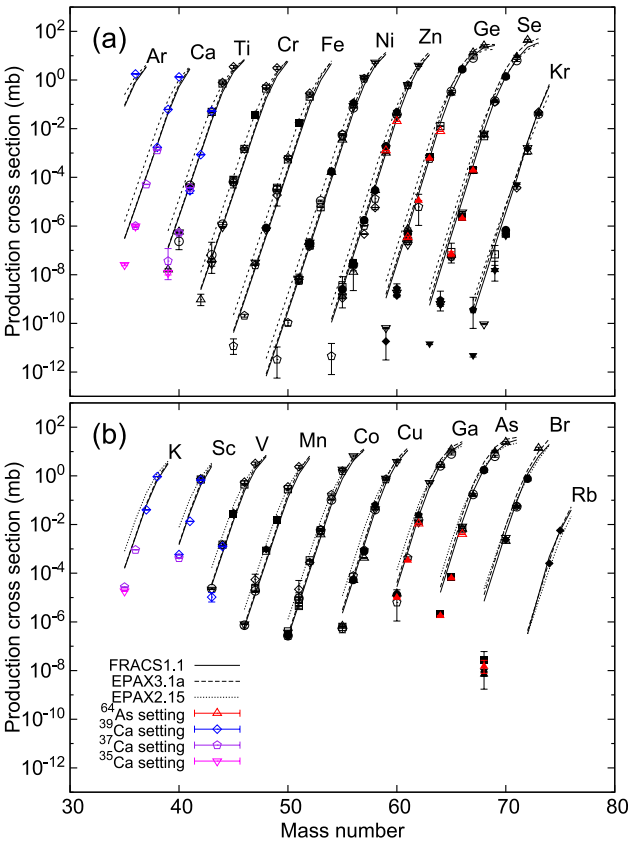

Fig. 1. (Preliminary) Measured production cross sections of RIs produced in the ^{78}Kr + Be reaction at 345 MeV/nucleon with semi-empirical cross-section formulae: (a) results for even-Z isotopes; (b) results for odd-Z isotopes.

References
1) N. Fukuda *et al.*, Nucl. Instrum. Methods Phys. Res. B **317**, 323 (2013).
2) O. B. Tarasov *et al.*, LISE^{++} site, Michigan State University, `https://lise.nscl.msu.edu`.
3) O. B. Tarasov, Nucl. Phys. A **734**, 536 (2004).
4) K. Wimmer *et al.*, Phys. Lett. B **795**, 266 (2019).
5) B. Mei, Phys. Rev. C **95**, 034608 (2017).
6) K. Sümmerer, Phys. Rev. C **86**, 014601 (2012).
7) K. Sümmerer *et al.*, Phys. Rev. C **61**, 034607 (2000).

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