Production rates of new neutron-rich rare-earth nuclei via in-flight fission of a 345 MeV/nucleon ^{238}U beam

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The reaction mechanism of in-flight fission is not clear yet due to the complexity of the abrasion fission process, in which many kinds of fissile nuclei can contribute to the production of fission fragments. The measurement of the production rates of various fission fragments is useful not only to plan various experiments but also to understand such a reaction mechanism. In 2011, using a 345 MeV/nucleon ^{238}U beam with a Be target, we searched for new isotopes and isomers whose atomic numbers roughly range from 56 to 68.[1)] Here, we report on the production rates of new isotopes, in addition to the improvements in particle identification (PID) compared to our previous report.[2)]

Fission fragments were separated and analyzed using the BigRIPS separator. We adopted two settings that targeted the regions of nuclei around ^{159}Pr and ^{168}Gd. The mass-to-charge ratio (A/Q) was deduced from the time of flight (TOF) and magnetic rigidity measurements obtained using BigRIPS. The atomic number (Z) was deduced from the TOF and energy losses, which were measured using a stack of Si detectors in the focal plane. The PID plot in the region of ^{159}Pr is presented in Fig. 1. Since our previous report,[2)] we have modified the gate conditions to remove background events and improved the resolutions of A/Q and Z by carrying out detailed analysis. As a result, in the two settings, we identified a total of 26 new isotopes: ^{153}Ba, ^{154,155,156}La, ^{156,157158}Ce, ^{156,157,158,159,160}Pr, ^{162,163}Nd, ^{164,165}Pm, ^{166,167}Sm, ^{169}Eu, ^{171}Gd, ^{173,174}Tb, ^{175,176}Dy, ^{177}Ho, and ^{179}Er.

The production rates of fully stripped fragments are presented in Fig. 2 along with the LISE++ calculations.[3)] Here, for the LISE++ abrasion fission (AF) model, we adopted the same parameters as those used in the previous experiment.[4)] This AF model reproduced the production rates in the region of Z = 20 to 49 fairly well.[4,5)] In the present region of Z = 56 to 65, however, the calculations are orders of magnitudes smaller than the measured rates. This difference might be due to the AF model parameters, which were optimized to reproduce limited cross-section data for Z = 20 to 46.[3)] Further systematic studies are now in progress.

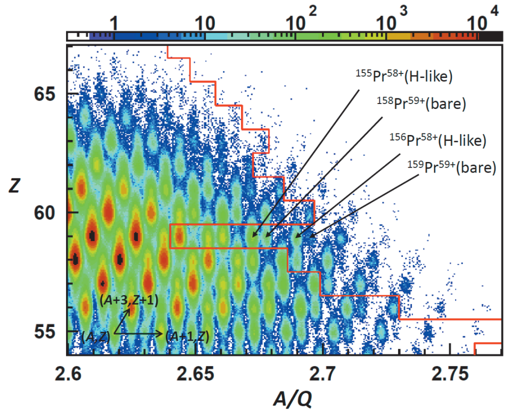

Fig. 1. Z versus A/Q PID plot in the region of ^{159}Pr. The red lines indicate the known limits of neutron-rich isotopes.

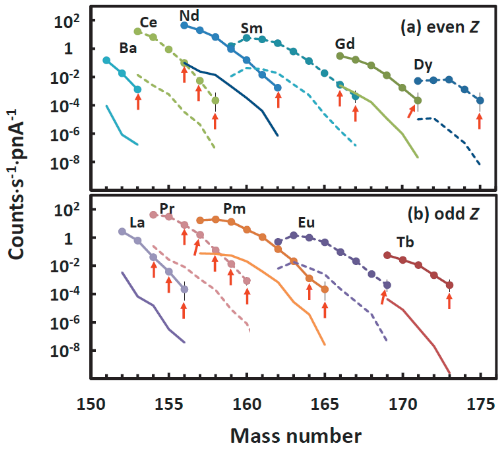

Fig. 2. Measured production rates of (a) even-Z and (b) odd-Z isotopes in the region of ^{159}Pr. The red arrows indicate the production rates of new isotopes. The LISE++ calculations are denoted by the dashed or solid curves without circles (see text).

References

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