Identification of New Neutron-rich Isotopes in the Rare-Earth Region Produced by 345 MeV/nucleon ^{238}U†

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Searches for new isotopes at the RIKEN RI Beam Factory[1] have been conducted since its commissioning in 2007, expanding the region of accessible nuclei in the nuclear chart.[2–6] To explore the uncharted region of far-from-stability nuclei, we performed a search for new isotopes in the neutron-rich rare-earth region using a 345 MeV/nucleon ^{238}U beam with the BigRIPS in-flight separator.[7] We observed a total of 29 new neutron-rich isotopes: ^{153}Ba, ^{154,155,156}La, ^{156,157,158}Ce, ^{156,157,158,159,160,161}Pr, ^{162,163}Nd, ^{164,165}Pm, ^{166,167}Sm, ^{169}Eu, ^{171}Gd, ^{173,174}Tb, ^{175,176}Dy, ^{177,178}Ho, and ^{179,180}Er.

Neutron-rich nuclei in the rare-earth region were produced by the in-flight fission of a 345 MeV/nucleon ^{238}U beam with a beryllium target. The intensity of the ^{238}U beam was approximately 0.2–0.3 particle nA. The experiment was carried out with two different settings of the BigRIPS separator, each of which was aimed at the discovery of new neutron-rich isotopes in the region of atomic number Z of around 59 and 64, which are referred to as the Pr and Gd settings, respectively. The target thicknesses were 4.0 mm and 4.9 mm for the Pr and Gd settings, respectively. The particle identification (PID) was performed event-by-event based on the ΔE-TOF-$B\rho$ method, deducing Z and the mass-to-charge ratio A/Q of the fragments.[8]

Figures 1(a) and 1(b) show the Z vs A/Q PID plots obtained with the Pr and Gd settings, respectively. New isotopes are clearly identified in the plots, thanks to the excellent relative A/Q resolutions of 0.034% and 0.036% for the Pr and Gd settings, respectively.

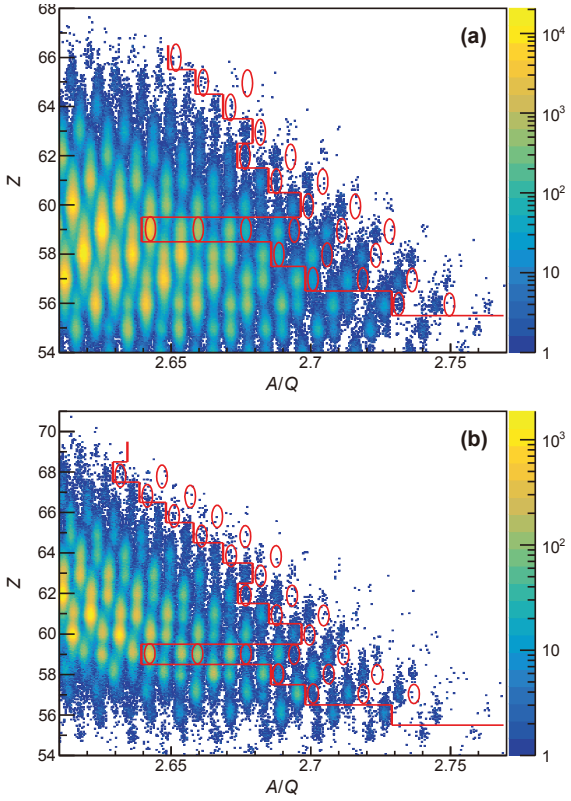

Fig. 1. Particle identification plots of Z vs A/Q for the fragments produced in the ^{238}U + Be reaction at 345 MeV/nucleon: (a) data obtained with the Pr setting during a 54.3-hour measurement period and (b) data obtained with the Er setting during a 45.8-hour measurement period. The red lines indicate the known limit. The new isotopes observed in this work are indicated by the red solid circles.

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