

## Search for new neutron-rich isotopes with $Z \sim 55\text{--}70$ using a 345 MeV/nucleon $^{238}\text{U}$ beam

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Since the commissioning of the BigRIPS separator<sup>1)</sup> in 2007, an extensive search for new isotopes has been conducted to expand the region of accessible exotic nuclei. By the end of 2013, about 100 new neutron-rich isotopes had been observed using the in-flight fission of a  $^{238}\text{U}$  beam<sup>2-4)</sup>, and 4 new neutron-deficient nuclei had been observed by the projectile fragmentation of a  $^{124}\text{Xe}$  beam<sup>5)</sup>. In April 2014, we searched for new neutron-rich isotopes with the atomic number  $Z \sim 55\text{--}70$  for the second time since the 2011 experiment<sup>3)</sup>, with an increased beam intensity.

The neutron-rich isotopes were produced by the in-flight fission of a  $^{238}\text{U}$  beam at 345 MeV/nucleon. The maximum beam intensity was approximately 12.5 pnA. The fission fragments were collected and separated with the BigRIPS. The experimental conditions are summarized in Table 1. We adopted two different  $B\rho$  settings of the separator, each targeting new isotopes around  $^{161}\text{Pr}$  (Pr setting) and  $^{180}\text{Er}$  (Er setting). The settings were determined using the measured cross sections<sup>6)</sup> and the detailed simulations with the code LISE++<sup>7)</sup>.

Table 1. Summary of the experimental conditions.

Setting	Pr setting	Er setting
Production target	Be 4.0 mm	Be 6.9 mm
Isotope tuned	$^{161}\text{Pr}$	$^{180}\text{Er}^{\text{a}}$
$B\rho$ of D1	7.527 Tm	6.311 Tm
Degrader at F1	Al 1.4 mm	Al 0.98 mm
Degrader at F5	Al 1.4 mm	Al 0.96 mm
F1 slit	$\pm 64.2$ mm	$+32.1/-42.8$ mm
F2 slit	$+10/-3$ mm	$+4/-3$ mm
F5 slit	$\pm 120$ mm	$\pm 120$ mm
F7 slit	$\pm 25$ mm	$\pm 25$ mm
Average intensity	12.6 pnA	3.39 pnA
Running time	54.6 h	44.2 h
Total dose of $^{238}\text{U}$	$1.55 \times 10^{16}$ particles	$3.36 \times 10^{15}$ particles

<sup>a)</sup> Hydrogen-like ( $Q = 67$ ) ions were chosen in the first half of the first stage of BigRIPS.

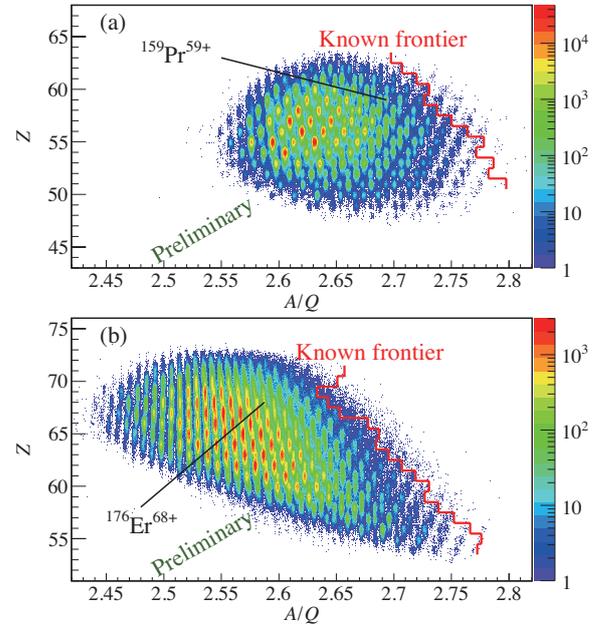


Fig. 1.  $Z$  versus  $A/Q$  particle identification plots obtained in the Pr (a) and Er (b) settings. The known frontiers are indicated by the red lines.

Particle identification (PID) was based on the TOF- $B\rho$ - $\Delta E$  method to deduce  $Z$  and the mass-to-charge ratio ( $A/Q$ )<sup>8)</sup>. The preliminary PID plots of  $Z$  versus  $A/Q$  are shown in Fig. 1. The relative root mean square  $A/Q$  and  $Z$  resolutions are typically 0.037% and 0.45%, respectively, for the  $^{161}\text{Pr}$  setting, and 0.047% and 0.88%, respectively, for the  $^{180}\text{Er}$  setting. A total of 18 new isotopes have preliminarily been identified ranging from  $Z = 56$  to 69. Further analysis is currently in progress.

### References

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