First success of RI-beam separation and particle identification for nuclei with atomic number $Z > 82$ at RIKEN RI beam factory†

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The separation of heavy RI beams is difficult at RIKEN RIBF, because the charge state Q of ions frequently changes in certain materials including a wedge degrader used for the RI-beam separation. In an earlier study,[1] a large amount of in-flight fission fragments prevented the good separation of heavy RI beams. In the present study, the charge-state change in the wedge degrader was taken into consideration in terms of the RI-beam purification. We found that a ^{208}Rn beam can be well separated from the fission fragments when He-like and fully-stripped ions are selected at the first and second dipole magnets, respectively. Figure 1 shows the selected isotopes when an aluminum degrader with a thickness of 2 mm is used at F1 of the BigRIPS separator.[2] This is an extension of a figure for the full-strip ions for both dipole magnets given in Ref. 3). The fission fragments with atomic numbers between 25 and 65 are required to have Li-like or Be-like ions at the first dipole. The probabilities of Li-like and Be-like ions for $^{160}_{85}$Tb was estimated using the Global code[4] to be 4.7×10^{-4} and 1.8×10^{-6}, respectively. Because of these low probabilities, the fission fragments are expected to be well eliminated.

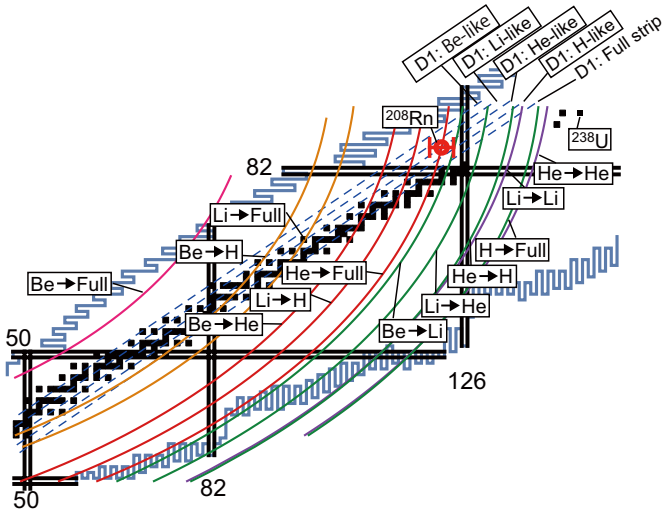

Fig. 1. RI-beam separation scheme at the first stage of the BigRIPS separator in the case of a 2-mm-thick aluminum degrader. The purple, green, red, orange, and pink solid lines show the selected RI beams for the charge-state change $\Delta Q_{F1} = 0$, $+1$, $+2$, $+3$, and $+4$ at F1, respectively. The blue dashed lines show nuclei having the same A/Q as ^{208}Rn with $Q = 84$.

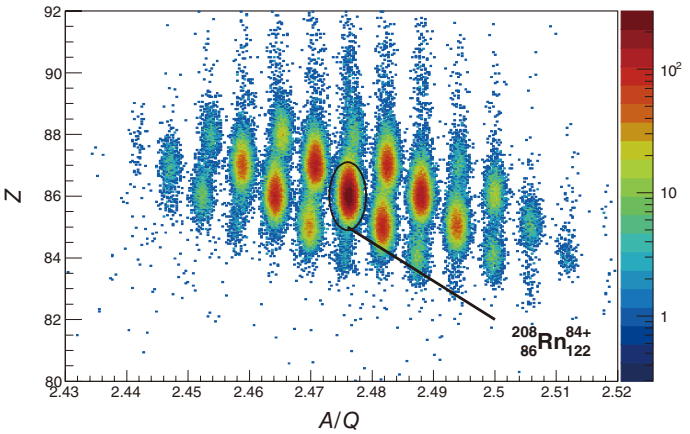

Fig. 2. Particle-identification plot of the RI beams, which was obtained by applying software gates of $-5 < x < 5$ mm on the F3 and F7 positions.

An experiment to produce a ^{208}Rn beam was performed at RIKEN RIBF. The 3-mm-thick beryllium was used as the production target. The thickness of the aluminum wedge degraders at F1 and F5 were 2 and 1 mm, respectively. The He-like and fully-stripped ions were chosen at the first and second halves of the first stage of BigRIPS, respectively. The He-like ions were chosen at the second stage of BigRIPS. To compare the separated RI beams with those in Fig. 1, a wide slit setting of ± 20 mm was applied at the achromatic foci F2 and F7. The fission fragments were not transported to the second stage of BigRIPS even for the wide slit. Software gates were applied to the positions measured at F3 and F7 to simulate the RI beams with a narrow slit setting. Figure 2 shows a particle-identification plot with gates of $-5 < x < 5$ mm at F3 and F7. The purity of ^{208}Rn reached 25%. Therefore, RIKEN RIBF is now ready for user experiments in this region of the nuclear chart.

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