RI-beam production using BigRIPS separator in regions heavier than those belonging to lead isotope

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The regions of the nuclear chart that are heavier in terms of atomic weight, i.e. with an atomic number $Z \sim 80$ and more, are the key to understand the nucleosynthesis of elements up to uranium. In our previous study,[1)] an RI beam with $Z > 80$ was produced using the projectile-fragmentation reaction of a ^{238}U beam at RIBF. A 0.3-mm thick degrader was used in the BigRIPS separator[2)] for the RI beam separation, but a large amount of fission fragments unexpectedly decreased a purity. In the present study, an RI beam heavier than the lead isotope was produced using a thicker degrader, with a thickness of 2 mm, to eliminate the fission fragments.

The RI beam around $^{208}_{86}$Rn was produced via the projectile-fragmentation reaction of a 345-MeV/u ^{238}U beam. The production target was a 3-mm thick Be. To separate the primary ^{238}U beam, the He-like ions (charge-state $Q = Z - 2$) were selected at the first dipole D1. The 2-mm-thick wedge degrader was placed at the first momentum dispersive focal plane F1, and the fully-stripped ions were selected at the second dipole D2 after F1. Under these conditions, the charge-state combination for the fission fragments with $Z < 60$ was restricted to Li-like and fully stripped ions at D1 and D2, respectively, or $Z - Q \geq 4$ at D1. Due to a low probability of these combinations, the fission fragments were separated very well. The second wedge degrader with a thickness of 1 mm was used in the middle of the second stage of BigRIPS for further purification. The He-like ions were selected at all the dipole magnets used in the second stage. The particle-identification (PID) plot measured at the second stage of BigRIPS is shown in Fig. 1 (a). The contaminants in the form of the fission fragments were negligibly eliminated. The PID was confirmed by the γ rays emitted from a known isomeric state in ^{208}Rn, as shown in Fig. 1 (b). The high purity of ^{208}Rn allowed us to complete the γ-ray measurement within 30 minutes. Figure 2 shows the mass to charge ratio for the Rn isotopes. Each Rn isotope was well separated from the others. A small component with a different charge state may be included within the width of the distribution because the A/Q of the nucleus with $A = 208$ and $Q = 84$, for example, is very close to that with $A = 203$ and $Q = 82$ or $A = 213$ and $Q = 86$. To distinguish the charge states, the total kinetic energy was measured by using six stacked Si detectors, each with a thickness of 1 mm. This analysis is still in progress.

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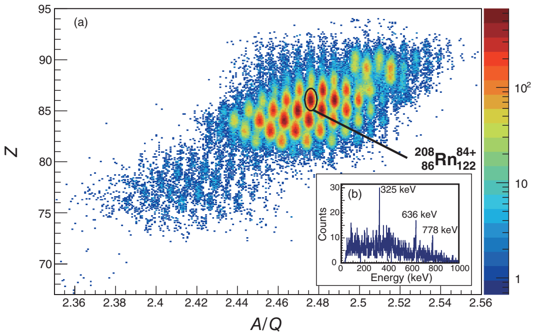

Fig. 1. (a) Particle identification plot for the RI beam measured at the second stage of BigRIPS. The atomic number Z versus the mass to charge ratio is shown. (b) The γ-ray energy spectrum of the known isomeric state in ^{208}Rn, indicated by the circle in (a). Three γ-ray peaks can be clearly observed.

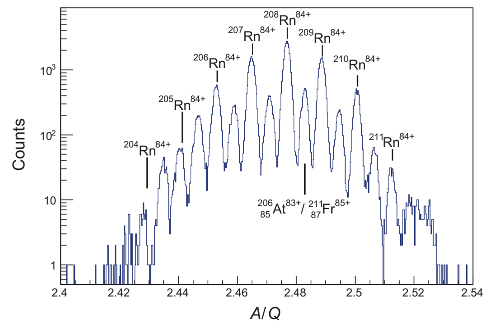

Fig. 2. Mass to charge ratio of the radon isotope ($Z = 86$) obtained from Fig. 1 (a) with the gate of $85.8 < Z < 86.2$. The radon isotopes with $Q = 84$ were observed between the masses 204 and 211, as can be seen for the isotopes labeled using lines. $^{206}_{85}$At^{83+}/$^{211}_{87}$Fr^{85+} shows a typical example of the contaminants for isotopes with $Z = 85$ and 87.

References

1) N. Inabe et al.: RIKEN Accel. Prog. Rep., Vol. 48 (2015), p. 73.
2) T. Kubo et al.: Prog. Theor. Exp. Phys., 03C003 (2012).