Study of particle identification and RI beam separation for the Z~80 region using projectile fragmentation of ^{238}U

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An atomic number of Z~80 produced through a projectile fragmentation of ^{238}U is the next area for RI beam production at the BigRIPS.[1)] In this area, charge-state distributions are broad, which causes some problems for production concerned with both particle identification (PID) and isotope separation. To study this effect, we performed a test experiment to produce RI beams of high Z.

The test experiment was carried out using a 345 MeV/u ^{238}U beam. To study PID, RI beams were produced by the ^{238}U beam in low counting rates of ~2 x10^5 pps so as to make PID easy by sometimes mixing the ^{238}U primary beam of the charge state 92+ at F1. The production target was 5.79-mm-thick Be and the magnetic rigidity (Bρ) of the first dipole D1 was 6.001 Tm. Degraders were not used at F1 and F5. The F1 slits were set to produce a momentum byte in the range between -3% and 0.1% when the primary beam was not mixed and between -3% and 0.5 % when mixing it. The PID was performed by determining Z and A/Q on an event-by-event basis using the ΔE-TOF-Bρ method. ΔE was measured by MUSIC at F7 and TOF was measured using two plastic scintillators at F3 and F7. Bρ was determined by track reconstruction using positions and angles measured by PPACs located at F3, F5, and F7. Total kinetic energy (TKE) was also measured using by NaI at F7 to determine A.

Figure 1a and b show the PID spectra of A/Q vs. Z for Z > 30 and Z > 85, respectively. We can see not only projectile fragments but also fission fragments below Z~70 in Fig. 1a. Fig. 1c shows the similar plot as Fig. 1b when primary beams are mixed. We can clearly see four charge states of ^{238}U, which are produced by changing the charge state from 92+ in the scintillator at F3. Resolutions of Z are 0.58 % for Z~90 and 0.41 % for Z~50. The worse resolution in the high-Z area might be attributed to charge state straggling, which broadens energy loss spectra when passing through a detector with some charge states.

We performed the PID of U isotopes. Fig. 2 shows an A/Q spectrum of U produced by cutting with Z= 92±0.3. We identified the main peaks of A/Q > 2.55 but could not assign those of low A/Q because of overlap with isotopes of Z=91. The resolution of A/Q is 0.05%. We tried to examine whether other small peaks exist in large peaks, for example, $^{233}U^{89+}$ in the $^{236}U^{90+}$ peak but we could not determine this because of the quenching of the TKE counter.

In order to study isotope separation, we produced RI beam of which the central orbit was $^{226}Bi^{82+}$ with the 7-mm-thick Be target. Bρ of the first dipole was 6.13 Tm. The degrader at F1 of 0.3 mm and momentum acceptance of ±3% were used to produce many types of isotopes at the same time such as a search for new isotopes. The isotopes were not well-separated in this experiment owing to large unexpected contaminants of fission fragments with Z~60 and high counting rates of ~100 kHz/pnA. These phenomena have not been predicted by the simulation.

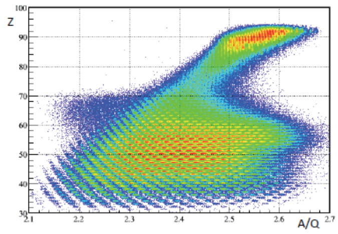

Fig. 1a Z vs. A/Q plot (Z>30)

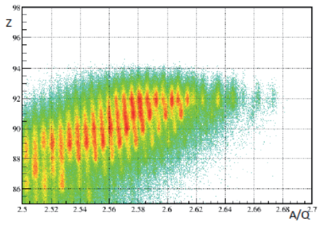

Fig. 1b Z vs. A/Q plot (Z>85)

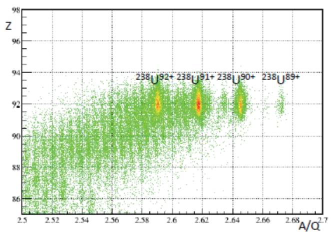

Fig. 1c Z vs. A/Q plot on mixing with the primary beam.

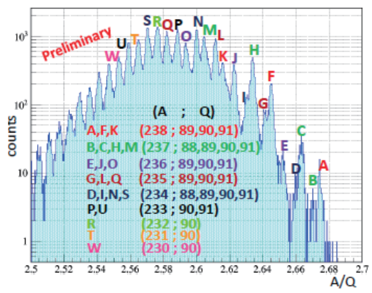

Fig.2 A/Q spectrum of U isotopes

Reference

1) T. Kubo: Nucl. Instr. Meth. **B 204**, 97 (2003).

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