Identification and separation of radioactive isotope beams by the BigRIPS separator at the RIKEN RI Beam Factory†

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We have developed a method for achieving excellent resolving power for in-flight particle identification of radioactive isotope (RI) beams, which is routinely used with the BigRIPS fragment separator[1)] at the RIKEN RI Beam Factory (RIBF)[2)]. In the BigRIPS separator, RI beams are identified by their atomic number Z and mass-to-charge ratio A/Q, which are in turn deduced from the measurements of time of flight (TOF), magnetic rigidity ($B\rho$), and energy loss (ΔE). Such in-flight particle identification is essential for delivering tagged RI beams, making it possible to perform various types of experiments including secondary reaction experiments. Since the total kinetic energy is not measured in this scheme, and consequently A and Q cannot be determined independently, the resolution of A/Q must be adequately high to identify the charge state Q of RI beams. This is achieved in the Z versus A/Q particle identification plot as demonstrated in Fig. 1, where fully stripped and hydrogen-like peaks are very closely located.

We achieved a high A/Q resolution by precisely determing the $B\rho$ and TOF values. Precise $B\rho$ was determined by the trajectory reconstruction method for which ion-optical transfer matrix elements were experimentally determined up to the third-order. The significant improvement in A/Q resolution by our trajectory reconstruction technique is clearly seen in Fig. 2, where comparion of the A/Q resolution among three different transfer matrix elements in the trajectory reconstruction is shown. Precise TOF was determined by the slew correction method for TOF signals. We iteratively carried out the derivation of transfer matrix elements and slew correction such that the A/Q resolution was best optimized. Furthermore we completely removed background events to enhance the reliability of particle identification.

The excellent particle identification thus achieved allows us to supply tagged RI beams to a variety of experiments at RIBF. Furthermore it helps us to reliably identify new isotopes from a very small number of events. Such enhanced capability of the BigRIPS separator is significantly advancing the research on exotic nuclei at RIBF.

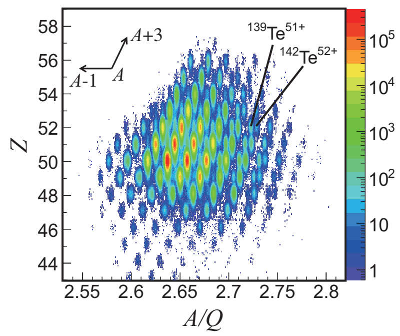

Fig. 1. Z versus A/Q particle identification plot for fission fragments produced in the ^{238}U + Pb reaction at 345 MeV/nucleon. The experimental conditions and BigRIPS setting are given in the G3 Setting section in Ref.[3)].

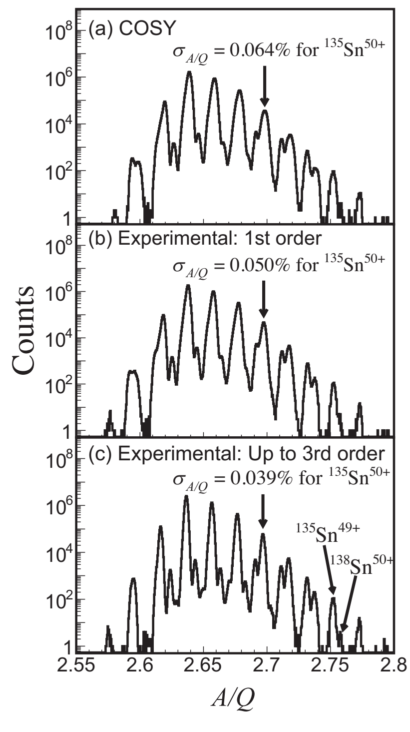

Fig. 2. Comparison of the A/Q resolution among three different transfer matrix elements used in trajectory reconstruction. The comparison is shown for Sn isotopes produced by in-flight fission of a ^{238}U beam at 345 MeV/nucleon. The experimental conditions and BigRIPS settings are the same as those in Fig. 1.

References
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† Condensed from the article in Nucl. Instr. Meth. **B 317**, 323 (2013)

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