# Development of an automatic particle identification system for the BigRIPS separator

Y. Shimizu,[*1] N. Fukuda,[*1] H. Takeda,[*1] H. Suzuki,[*1] M. Yoshimoto,[*1] Y. Togano,[*1] T. Sumikama,[*1] H. Baba,[*1] and K. Yoshida[*1]

We are developing a fully automatic system for radioactive-isotope (RI) beam production based on our technological developments and experiences to reduce the operation time. In the present study, we aimed to automate particle identification (PID) for RI beams.

PID was performed event-by-event using the $\Delta E$-TOF-$B\rho$ method to determine the mass-to-charge ratio $A/Q$ and atomic number $Z$ of RI beams.[1)] PID was confirmed by measuring the delayed $\gamma$-rays emitted from isomers. A PID analysis has been performed with the following procedure:

1. Find the isomers among RI beams,
2. Detect the peak energies from the delayed $\gamma$-ray spectra of the isomers,
3. Identify the isomers by comparing the detected $\gamma$ energies with the known isomeric $\gamma$ energies, and
4. Determine the calibration parameters for $A/Q$ and $Z$.

This analysis procedure was automated using the BYACO ecosystem.[2)] The information on the isomeric nuclei observed at RIBF was stored in a relational database (RDB) based on Microsoft Access 2010.[3)] To use this information in the BYACO ecosystem, the RDB was transferred to a PostgreSQL database on a Linux server.

The automatic PID system was tested online during the $^{132}$Sn-beam production required for MS-EXP22-04.[4)] Figures 1(a) and 1(b) show the PID plots without and with the delayed $\gamma$ coincidence, respectively. The observation of isomers enhanced the fraction of blobs in Fig. 1(b) compared with that in Fig. 1(a). PID gates for the enhanced blobs were created and the delayed $\gamma$-ray spectra were obtained, as shown in Fig. 2. The isomers were identified by scanning the RDB for the measured peak energies, *e.g.*, blob No. 13 was identified as $^{132}$Sn. The calibration parameters for PID were determined using $A/Q$ and $Z$ of the identified isomers. This automatic PID system was successfully demonstrated. As a result, the operation time became shorter than that of conventional manual tuning by 15 min.

The current system requires the RI-beam physicist to confirm that sufficient data have been acquired to obtain some $\gamma$-ray spectra. In future work, we will fully automate PID for RI beams.

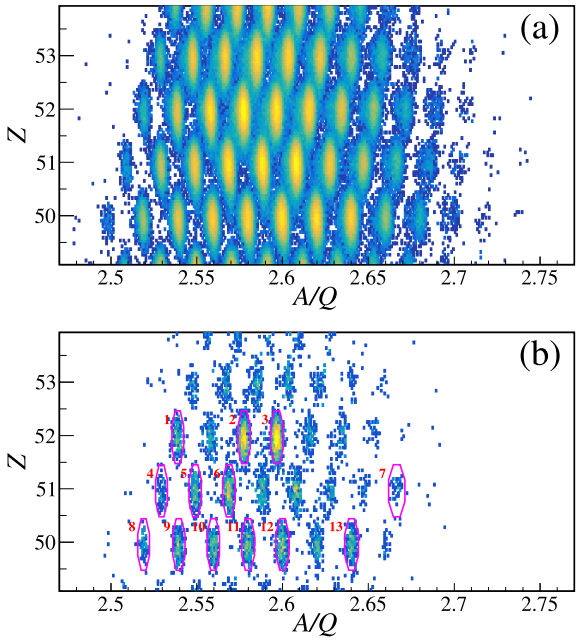


Fig. 1. $Z$ versus $A/Q$ PID plots (a) without and (b) with the delayed $\gamma$ coincidence. The automatically generated gates for the isomers are labeled as 1: $^{132}$Te, 2: $^{134}$Te, 3: $^{135}$Te, 4: $^{129}$Sb, 5: $^{130}$Sb, 6: $^{131}$Sb, 7: $^{136}$Sb, 8: $^{126}$Sn, 9: $^{127}$Sn, 10: $^{128}$Sn, 11: $^{129}$Sn, 12: $^{130}$Sn, and 13: $^{132}$Sn.

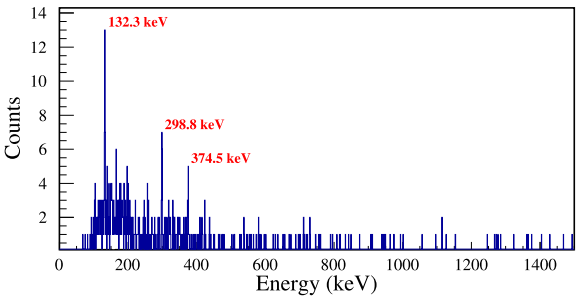


Fig. 2. Delayed $\gamma$-ray energy spectrum in coincidence with blob No. 13, which was found to be $^{132}$Sn using the automatic PID system.

References

1) N. Fukuda *et al.*, Nucl. Instrum. Methods Phys. Res. B **317**, 323 (2013).
2) T. Sumikama *et al.*, RIKEN Accel. Prog. Rep. **54**, 82 (2021).
3) Y. Shimizu *et al.*, RIKEN Accel. Prog. Rep. **47**, 166 (2013).
4) Y. Shimizu *et al.*, in this report.

*1 RIKEN Nishina Center