Charge state separation in the ZD spectrometer for the ^{132}Sn region

T. Parry,*1 Zs. Podolyák,*1 G. Bartram,*1 Z. Q. Chen,*1 M. Górska,*2 M. Armstrong,*2 A. Yaneva,*2 K. Wimmer,*3,*4 P. Doornenbal,*4 N. Aoi,*5,*4 H. Baba,*4 F. Browne,*4 C. Campbell,*6 H. Crawford,*6 H. De Witte,*7 C. Fransen,*8 H. Hess,*8 S. Iwazaki,*5,*4 J. Kim,*4 A. Kohda,*5,*4 T. Koiwai,*9,*4 B. Mauss,*4 B. Moon,*4 P. Reiter,*8 D. Suzuki,*4 R. Taniuchi,*10,*4 S. Thiel,*8 and Y. Yamamoto*5,*4

Isotopes produced in charge states become increasingly more common amongst higher mass beams. The ability to separate and identify different charges is important in preventing particle identification contamination. In this report, we briefly outline a commonly used method of charge state separation which was utilised during the analysis of the RIBF-189 experiment conducted in November 2020 during the Hi-CARI campaign.[1,2] The aim of the experiment was to study excited states in $N = 82$ nuclei, focusing on ^{129}Ag. A primary 345 MeV/nucleon beam of ^{238}U was used and the fission fragments were identified in BigRIPS, which was tuned for ^{130}Cd. After the secondary target, the reaction products were identified by the ZeroDegree (ZD) spectrometer. Here the energy of the reaction products was relatively low at around 150 MeV/nucleon, which means that only about 80% of them were fully stripped. Charge state separation is based on magnetic rigidity measurements in the two parts of the separator FP8-FP9 and FP9-FP11. δ is calculated as $\delta = (B\rho - B\rho_0)/B\rho_0$. $B\rho$ denotes the measured magnetic rigidity for individual particles. $B\rho_0$ is the magnetic rigidity for the central path. Figure 1 shows the charge state separation where the structures correspond to different changes of the charge state (ΔQ) in the middle of the ZD spectrometer (FP9). Figure 2, showing Z vs A/Q identification plots, demonstrates the effect of selecting $\Delta Q = 0$ and $\Delta Q = +1$. Note $\Delta Q = 0$ contains ions which are fully stripped (labelled in black) and hydrogen like throughout the ZD spectrometer (red). Similarly $\Delta Q = +1$ includes ions which change from fully stripped to H-like (black) and H-like to He-like (red). Using these identification plots, one obtains γ-ray spectra associated to the nucleus of interest free from the contributions of other isotopes.

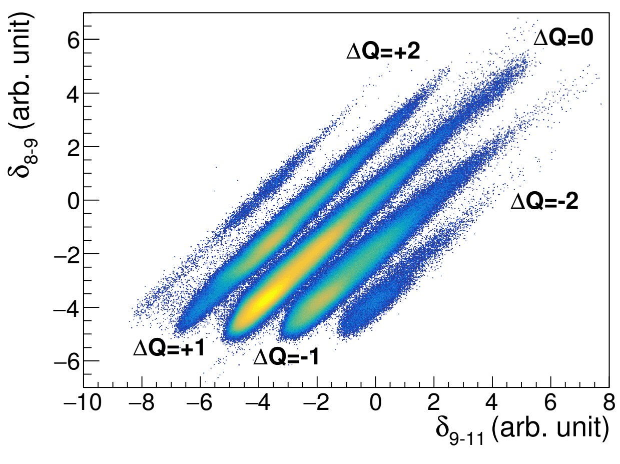

Fig. 1. Charge state separation in ZD spectrometer.

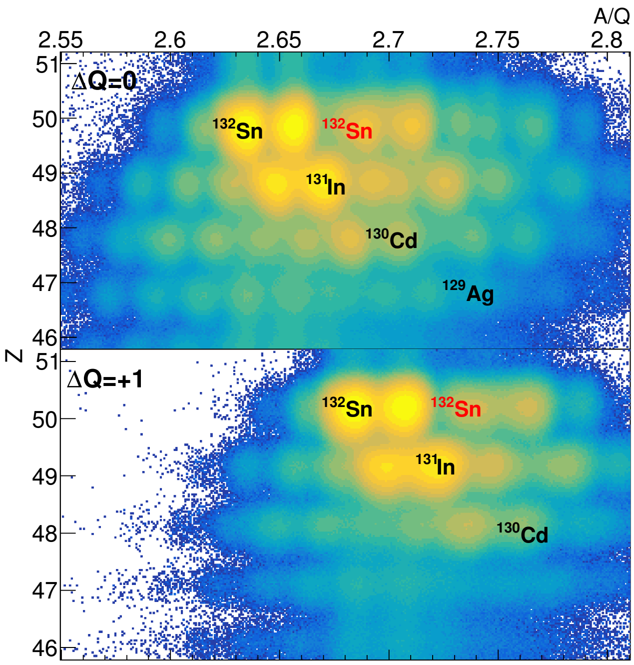

Fig. 2. ZD spectrometer particle identification plots for $\Delta Q = 0$ (upper) and $\Delta Q = +1$ (lower). $N = 82$ nuclei are highlighted.

*1 Department of Physics, University of Surrey
*2 GSI Helmholtzzentrum für Schwerionenforschung GmbH
*3 IEM-CSIC
*4 RIKEN Nishina Center
*5 Research Center for Nuclear Physics, Osaka University
*6 Nuclear Science Division, LBNL
*7 Instituut voor Kern- en Stralingsfysica, KU Leuven
*8 Institut für Kernphysik, Universität zu Köln
*9 Department of Physics, University of Tokyo
*10 Department of Physics, University of York

References

1) T. Parry *et al.*, RIKEN Accel. Prog. Rep. **54**, 9 (2021).
2) K. Wimmer *et al.*, RIKEN Accel. Prog. Rep. **54**, S27 (2021).