Study of ^{252}Cf fission fragments with MRTOF-MS: β-decay correlated mass measurement of ^{107}Zr

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Spontaneous fission (SF) of ^{252}Cf can produce neutron-rich nuclides spanning the broad region on the nuclear chart. In the case of Zr, it covers the neutron-rich isotopes around $N = 60$. The shape of neutron-rich Zr isotopes is sensitive to and drastically changes with neutron number. In addition, a spherical sub-shell closure around $N = 70$ is predicted. Thus, the evolution of their ground-state properties has been of interest. Herein, we briefly report new mass measurements of $^{107}Zr_{67}$ with a multi-reflection time-of-flight mass spectrograph (MRTOF-MS) combining with a β-TOF detector,[1] which enables simultaneous time-of-flight (TOF) and β-decay events detection.

The isotope of interest was produced via SF of a 9.25 MBq ^{252}Cf source and collected by a gas cell (GC) cryogenically cooled to 55 K. The GC's He gas pressure was regulated to maintain a density equivalent to 150 mbar at room temperature. The collected ions were converted to extremely low-energy ions and transported to an ejection device to the MRTOF-MS. Thereafter, their masses were measured at the MRTOF-MS.

Figure 1 shows the TOF spectrum of the ions of mass-to-charge ratio $(A/q) = 53.5$. We found a candidate of $^{107}Zr^{2+}$'s peak located approximately 400 keV heavier than the 2020 Atomic Mass Evaluation's extrapolation. To confirm this, we used the β-decay information correlated to the TOF events. To make the correlation, the TOF events were first selected by the fit process with the TOF spectrum, and then all β-decay events that occurred within the time window centered on the selected TOF events were collected as the correlated ones. Figure 2(a) shows the correlated β-decay curve of $^{106}Nb^1H^{2+}$. The fit function comprised the decay curve, which included the contribution of the daughter nuclide and a constant background. The measured half-life, $T_{1/2,\mathrm{meas}}(^{106}\mathrm{Nb}) = 970(40)$ ms, was consistent with the literature value of 1.02(5) s.[2] The correlated β-decay curve of the candidate of $^{107}Zr^{2+}$ is presented in Fig. 2(b). The extracted half-life, assuming ^{107}Zr, was $T_{1/2,\mathrm{meas}} = 128(56)$ ms and consistent with the literature value of 146(4) ms.[2] Thus, we have concluded that the peak is $^{107}Zr^{2+}$ and determined its mass with the uncertainty of 40 keV, previously measured with the uncertainty of 449 keV.[3]

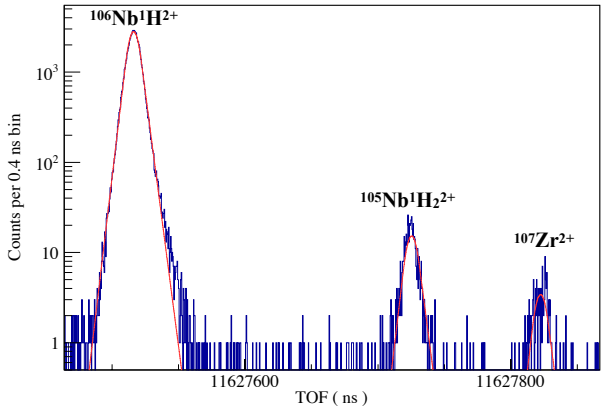

Fig. 1. TOF spectrum of $A/q = 53.5$ ion series. Red lines show the fit results with the phenomenological fitting function.

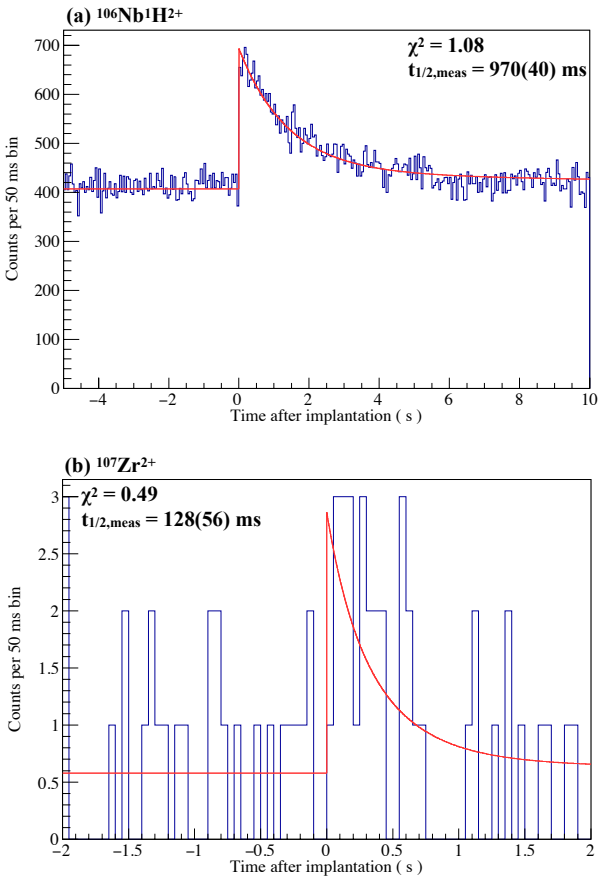

Fig. 2. TOF event correlated β-decay curves. Red lines show the fit results with the decay curve plus a constant background.

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References

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