# First online experiment of $\alpha$-ToF detector with MRTOF-MS

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We have the measured masses of more than 80 short-lived nuclei using a multi reflection time-of-flight mass spectrograph (MRTOF-MS)[1)] and plan to measure super heavy nuclei. For this purpose, we developed a new innovative detector, named $\alpha$-ToF,[2)] which is capable of performing correlation measurement of the time-of-flight signal and successive $\alpha$ decay signals. It can reliably discriminate true events from background events.

The first online experiment of the $\alpha$-ToF detector was performed at SHE-Mass-II[3)] coupled with the gas-filled recoil Ion Separator GARIS-II.[4)] A short-lived radium isotope was produced in the $^{159}$Tb($^{51}$V, 5n)$^{207}$Ra reaction by a 219.1 MeV primary beam with an intensity of 1.0 p$\mu$A. The 460 $\mu$g/cm$^2$ thick Tb target was produced by sputtering of the target material on a 3.0 $\mu$m thick Ti backing foil. The reaction products (fusion-evaporation residues: ERs) were separated in-flight from the projectiles and other background products. The ERs were captured in a cryogenic He gas catcher through Mylar foil windows, and the thermalized ions were extracted from the gas catcher by an rf-carpet and further transported to the MRTOF-MS via multiple ion traps.

The SHE-Mass-II facility has a single triplet ion trap, which directly connects the gas catcher to the MRTOF to achieve high efficiency. However, such configuration might suffer from contaminant ions from the gas catcher, therefore, we placed a Bradbury-Nielsen ion gate between the trap and the MRTOF to reduce the contamination. Unfortunately, the gate was broken just before the measurement due to a discharge accident. A preliminary time-of-flight spectrum for $^{207}$Ra$^{2+}$ is shown in Fig. 1. Many background counts are seen in the raw spectrum (Fig. 1 (a)). On gating the spectrum by the $\alpha$-ray energy of $^{207}$Ra with a coincident time of two half-life periods, such backgrounds were reduced by a factor of 40 (Fig. 1 (b)), while the true event number was preserved with 36% efficiency, which agrees with the solid angle of the Si detector and the limited coincidence time.

Figure 2 (a) shows a part of the two-dimensional spectrum for the time-of-flight and the $\alpha$-energy while Fig. 2 (b) shows a decay time spectrum of $^{207}$Ra. The decay time is the interval between the time-of-flight signal and the $\alpha$-ray signal. From this spectrum, the half-life of $^{207}$Ra is found to be 1.33(50) s, which agrees with the literature value.[5)] We also observed a few early events, which are consistent with the decay from the isomeric state of $^{207m}$Ra having a half-life of 59 ms.

In this first online experiment, we confirmed that the $\alpha$-ToF detector can reduce the background in a time-of-flight spectrum and obtain decay properties of short-lived nuclei.

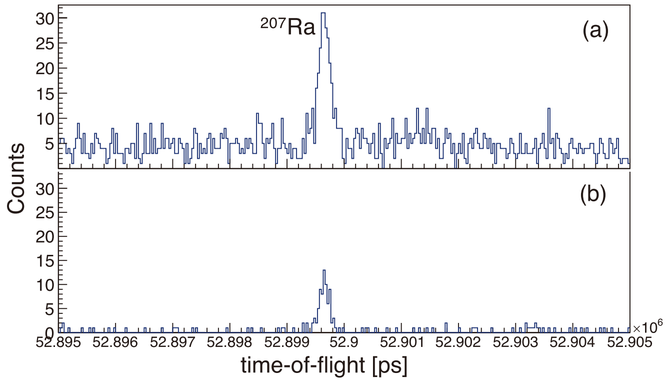


Fig. 1. A part of the time-of-flight spectrum of $^{207}$Ra. (a) is a raw spectrum while (b) shows coincident events with $\alpha$-rays from $^{207}$Ra for a coincident time of two half-lives of $^{207}$Ra.

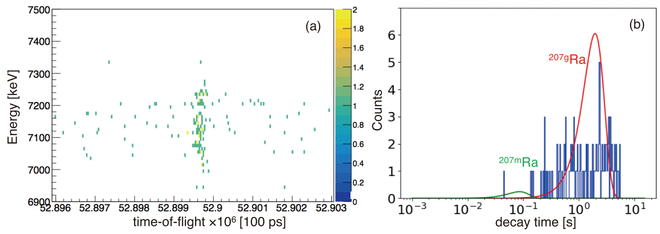


Fig. 2. (a)Two-dimensional spectrum of the time-of-flight and $\alpha$-decay energy. (b) decay spectrum of $^{207}$Ra. The solid lines indicate the literature values of the decay profiles, namely $T_{1/2}$ =1.3 s and 59 ms with an intensity ratio of 1:20.


References

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