Development of α-ToF detector for correlation measurement of atomic masses and decay properties of superheavy nuclides

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The atomic mass is a unique quantity for each nucleus. Precise mass measurement allows us to identify the atomic number as well as the mass number of a nucleus. Recently, we measured the masses of fusion-evaporation products[1–4] provided from GARIS-II[5] by using an MRTOF mass spectrograph.[6] We plan to measure the masses of hot-fusion superheavy nuclei (SHN) to identify the nuclides. The expected event rate is of the order of one event per day. We should accurately distinguish a true event from a large number of background events which might have originated from scattered ions or molecular ions. For this purpose, we have developed an α-ToF detector. The time correlation between a time-of-flight (ToF) signal and successive α-decay signals can discriminate such background events.

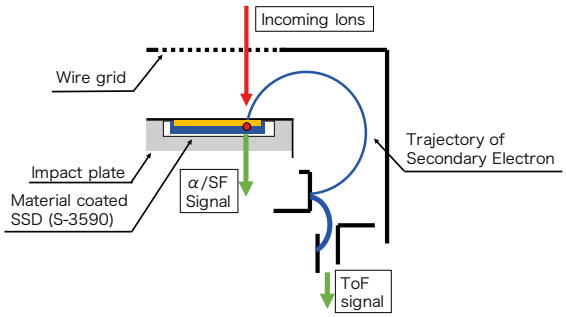

Fig. 1. Schematic of the α-ToF detector. The impact plate is appoximately 3 mm thick.

The α-ToF detector is made of a commercial MagneToF detector (ETP 14DM572) and a Si PIN diode (Hamamatsu S-3590), as shown in Fig. 1. When a heavy ion is incident on the impact plate of the MagneToF, secondary electrons are emitted from the impact plate and the electrons are isochronously transported by a magnetic field and amplified by an electron multiplier to provide a timing signal of the ion. We replaced the impact plate with an Au+MgO-or Au+Al_2O_3-coated Si PIN diode.

We tested the detector by using an ^{241}Am alpha source, and results are shown in Fig. 2. The upper panel shows the count-rate ratio of the coincident timing signal to the α-ray signal. The efficiency of the timing signal was greater than 90% for 5-MeV α-particles with both coating materials when −2100 V was applied to the impact plate. The lower panel of Fig. 2 shows the correlation mapping of ToF and α-ray energy. The start signal of ToF was made by the triangle roof ToF detector[7] and the stop signal was the timing signal of the α-ToF. The vertical axis indicates the α-ray energy measured by the α-ToF. The distance between the triangle-roof ToF and the α-ToF was 27 cm.

We confirmed that the correlation between the timing signal and the decay energy can be measured using the α-ToF. We will use the α-ToF for the mass-measurement experiment of SHN using the GARIS-II+MRTOF setup, which is scheduled for FY2018-2019.

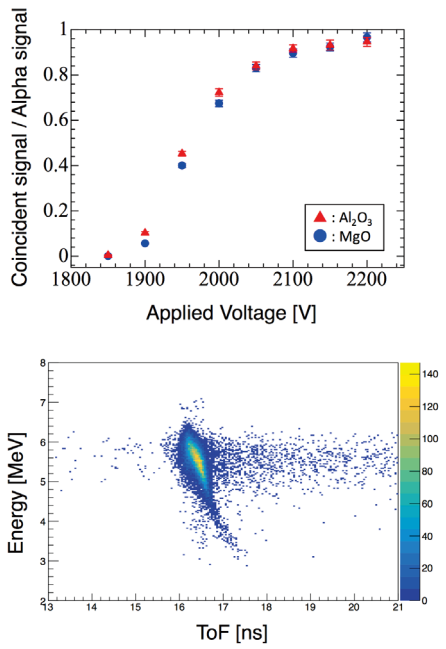

Fig. 2. Count-rate ratio of timing signals coincident with the α-ray signal (upper panel). Correlation mapping of ToF and energy (lower panel).

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References
1) P. Schury *et al.*, Phys. Rev. C **95**, 011305(R) (2017).
2) S. Kimura *et al.*, arXiv: 1706.00186.
3) Y. Ito *et al.*, Phys. Rev. Lett. **120**, 152501 (2018).
4) M. Rosenbusch *et al.*, arXiv: 1801.02823.
5) D. Kaji *et al.*, Nucl. Instrum. Methods Phys. Res. B **317**, 311 (2013).
6) P. Schury *et al.*, Nucl. Instrum. Methods Phys. Res. B **335**, 39 (2014).
7) K. Morimoto *et al.*, RIKEN Accel. Prog. Rep. **46**, 191 (2013).