

SHE-Mass-II: an MRTOF-MS for Super Heavy Nuclei

M. Wada,^{*1} P. Schury,^{*1} S. Kimura,^{*2} S. Ishizawa,^{*2,*5} T. Niwase,^{*2,*3} Y. Ito,^{*4} M. Rosenbusch,^{*2} D. Kaji,^{*2} K. Morimoto,^{*2} H. Haba,^{*2} H. Miyatake,^{*1} X. Y. Watanabe,^{*1} H. Hirayama,^{*1} J. Y. Moon,^{*7,*1} A. Takamine,^{*2} T. Tanaka,^{*3,*2} K. Morita,^{*3,*2} H. Ishiyama,^{*2} and H. Wollnik^{*6}

The SHE-Mass facility was a system with a multi-reflection time-of-flight mass spectrograph (MRTOF-MS)¹⁾ and a cryogenic gas catcher coupled with the GARIS-II at RILAC. With this setup, we have measured the masses of more than 80 fusion-evaporated products including several trans-fermium nuclides.²⁻⁵⁾ After the shutdown of GARIS-II at RILAC, we rebuilt a similar setup, *i.e.*, the SHE-Mass-II, at the new GARIS-II in the E6 experimental room.

The new setup has a single stage triplet ion trap system, which directly connects the gas catcher to the MRTOF to achieve high efficiency. The whole setup including vacuum pumps, a gas cylinder, and electric circuits is mounted on a single base plate and the plate is movable on rails to ensure quick coupling and decoupling to the GARIS-II. The gas catcher and ion trap chambers are mounted on a two-dimensional rail system that enables easy maintenance of the internal structures of the setup.

A drawback of the new setup is that more contaminant ions could be expected owing to a difficulty of intermediate mass selection. In the previous setup, we had a 5 m-long beam line between the two ion traps where we could place a Bradbury-Nielsen (BN) ion gate⁶⁾ to select a single mass number. However, the new setup has only a 50 cm distance between the trap and MRTOF where a BN gate can be installed. We developed a 10 times finer gate device made of 13 μ -thick wires with 130 μ intervals, which can deflect a 1 keV/ q ion beam by 65 mrad with a ± 100 V pulse. Such fine structure makes sharp cut on the ion beam. In a preliminary test, a resolution of 2 mass units was achieved.

Another improvement in the new setup is the replacement of a sextuple ion beam guide (SPIG) made of rigid molybdenum rods with a segmented micro quadrupole ion beam guide ($S\mu$ QPIG) made of 2 mm-wide, four-layer printed circuit boards. These devices interface the gas catcher with the triplet ion trap through differential pumping sections. In the previous setup, we needed to run an ion source in the gas catcher to have a ‘space-charge cloud’ which pushed the ions in the SPIG, while in the new setup, a DC gradient potential in the $S\mu$ QPIG carries the rare ions without

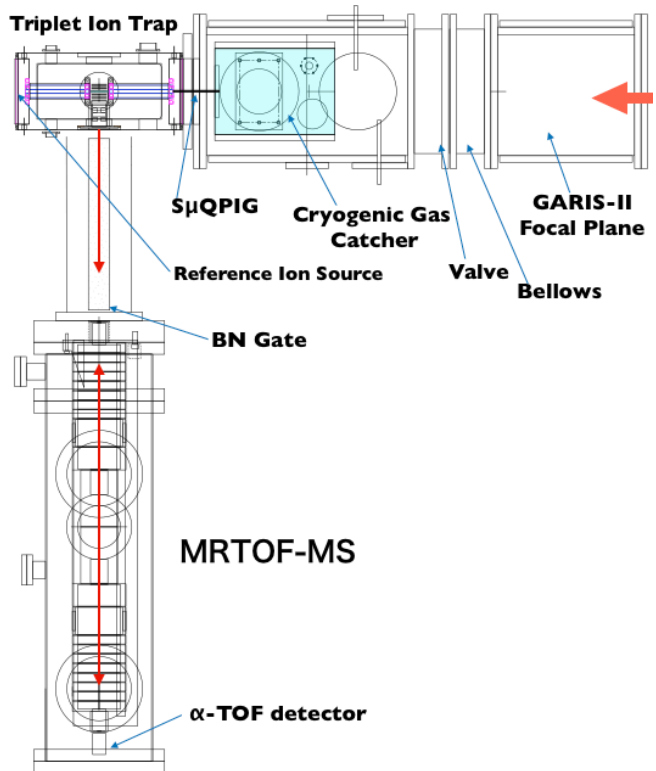


Fig. 1. SHE-Mass-II setup.

support from the space-charge cloud. The new scheme provides cleaner ion beams to the MRTOF.

We also replaced the time-of-flight detector with a newly developed α -TOF detector, which records the time-of-flight signal and the successive α -decay, simultaneously. The first online commissioning of the SHE-Mass-II setup was performed in December 2018 and we found that the α -TOF detector significantly reduced the background level.⁷⁾ An offline experiment using ^{252}Cf fission source is also in progress.

We are ready to start the direct mass measurement of hot-fusion super heavy elements, ^{288}Mc and ^{284}Nh , with the SHE-Mass-II setup.

References

- 1) P. Schury *et al.*, Nucl. Instrum. Methods Phys. Res. B **335** 39, (2014).
- 2) P. Schury *et al.*, Phys. Rev. C **95**, 011305(R) (2017).
- 3) S. Kimura *et al.*, Int. J. Mass Spectrom. **430**, 134 (2018).
- 4) M. Rosenbusch *et al.*, Phys. Rev. C **97**, 064306 (2018).
- 5) Y. Ito *et al.*, Phys. Rev. Lett. **120**, 152501 (2018).
- 6) N. E. Bradbury, R. A. Nielsen, Phys. Rev. **49**, 388 (1936).
- 7) T. Niwase *et al.*, RIKEN Accel. Prog. Rep. **51**, 157 (2018).

^{*1} KEK, Wako Nuclear Science Center

^{*2} RIKEN Nishina Center

^{*3} Department of Physics, Kyushu University

^{*4} JAEA

^{*5} Department of Physics, Yamagata University

^{*6} Department of Chemistry and Biochemistry, New Mexico State University

^{*7} Institute for Basic Science, Rare Isotope Science Project