Status and future plans of the MRTOF MS constructed at the SLOWRI facility

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

A new multi-reflection time-of-flight mass spectrograph (MRTOF MS) for the precise measurement of nuclear masses has been assembled at the SLOWRI facility at RIKEN. The device is designed and sized following the successful apparatus[1–4] presently installed at the gas-filled ion-recoil separator GARIS-II. Two concentric ion mirrors separated by a central drift tube of 26 cm length are facing each other, where each mirror consists of eight electrodes enabling deceleration and reflection of ions and two electrostatic lenses enabling radial confinement (length of each mirror: 35 cm, total length of MRTOF MS: 96 cm). For mass resolving powers in the order of $m/\delta m > 10^5$ (m as the mass and δm as measured FWHM of the mass according to the TOF signal), ion-optical aberrations must be reduced accordingly to allow for a narrow time-of-flight focus. Several measures have been undertaken: As radial aberration coefficients from initial angles and diameters of the beam decrease rapidly with the diameter of the ion optics, the electrode diameter has been chosen as large as 10 cm, while the beam diameter is expected to be at the order of a millimeter for the major part of the trajectory. All electrodes consist of precision-machined stainless steel (providing high stability), and have been coated with gold to ensure an excellent electric-field distribution in the absence of chemical compounds bound to the surfaces. The electrodes are further mounted on a precision-machined single solid piece of alumina, where the position of the electrodes (concentric on the outer side as well) is defined by a V-shape of the ceramic support (see photo). One of the technical goals of this setup is the acceptance and storage of ions with kinetic energies of 5 keV or above present at the position of the drift tube. In presently well-known and successful configurations of the electric fields (for positive ions), this requires negative voltages of up to −15 kV at the electrostatic lenses (the broad electrodes at each mirror). Thus, special attention has been given to the choice of the electric feedthroughs, distances of cables, and vacuum compatible insulation of the wires. The wires inside the vacuum allow for biases of more than 10 kV at zero distance between each two cables. The vacuum system of the MRTOF MS device is presently operational, and ion traps for guidance and preparation of radioactive ions are existing and to be installed in near future.

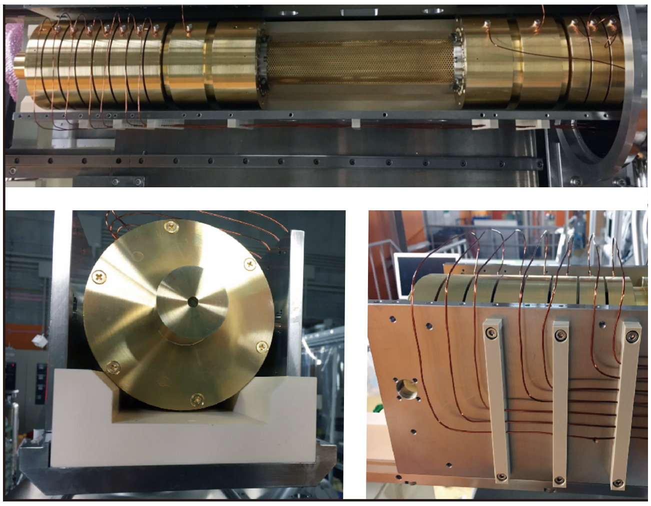

Fig. 1. Top: Photo from the top showing the assembly with gold-coated electrodes. Bottom left: Precision machined ceramic support with V-shape to define the electrode position. Bottom right: Cabling of the electrodes for the suppression of electric discharges.

The new MRTOF device has been constructed for two major purposes, which is a coupling to the gas cell presently developed for SLOWRI[5] to operate in symbiosis with other BigRIPS experiments, and the development and test of novel technologies for MRTOF mass spectrometry. In collaboration with experimental groups operating at BigRIPS, a new project of the SLOWRI facility aims at the installation of a cryogenic helium gas cell at the end of the BigRIPS beam line to accept unused reaction products measured at various in-beam experiments, which are guided to beam dumps otherwise. Application of state-of-the-art technologies as using the in-trap lift technology[6] and an in-trap deflector[7] are further planned for the MRTOF MS operation at SLOWRI in future.

*1 RIKEN Nishina Center
*2 Wako Nuclear Science Center (WNSC), IPNS, KEK
*3 Advanced Science Research Center, JAEA
*4 Institute for Basic Science
*5 Department of Physics, Kyushu University
*6 Department of Chemistry and Biochemistry, New Mexico State University

References

1) P. Schury *et al.*, Nucl. Instrum. Methods Phys. Res. B **376**, 425 (2015).
2) P. Schury *et al.*, Int. J. Mass Spectrom. **359**, 19 (2014).
3) Y. Ito *et al.*, Phys. Rev. Lett. **120**, 152501 (2018).
4) M. Rosenbusch *et al.*, Phys. Rev. C **97**, 064306 (2018).
5) A. Takamine *et al.*, in this report.
6) R. N. Wolf *et al.*, Int. J. Mass Spectrom. **313**, 8 (2012).
7) P. Fischer *et al.*, Int. J. Mass Spectrom. **435**, 305 (2012).