New developments and progress of the ZD-MRTOF system in 2021

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After the successful online commissioning in 2020,[1–3] in the year 2021 the ZD-MRTOF system[4] was subject to new upgrades, further optimization, and new on-line experiments. One of the new major modifications is a novel in-MRTOF deflector in the center region of the MRTOF-MS (see Fig. 1, and also Ref. 5)) and references therein), which allows for the dedicated ejection of contaminant ions at low electric fields of only about 40 V, so that the mass accuracy for the wanted ions is not affected in a measurement. The principle is that the ion deflector is always at 0 V if any ion of interest is crossing the deflection region, so that it can pass the region until a distance is reached beyond the electrically well-shielded area. By a newly developed timing system at the Wako Nuclear Science Center, an electric pulse pattern is programmed and applied to enable the selection of not only one preferred ion mass number, but several ion mass numbers can be selected and survive the separation process at the same time.

With the help of the new deflector system, molecular contaminations coming from the He filled gas cell[6] could be eliminated in online experiments and clean spectra have been observed.

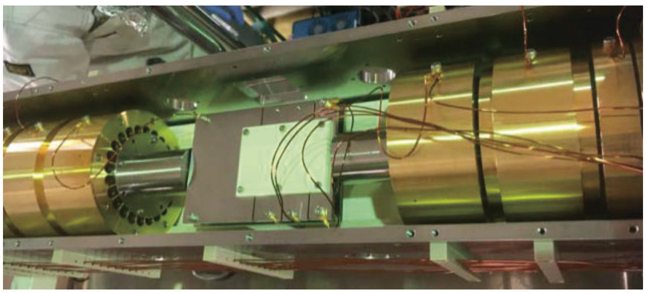

Fig. 1. Photo of the new in-MRTOF deflector at the time of assembly. At the center electrode (held by the white ceramics) the pulsed electric field is applied to deflect unwanted ions. Distances and sizes of the plated are chosen for optimal shielding of the deflection region.

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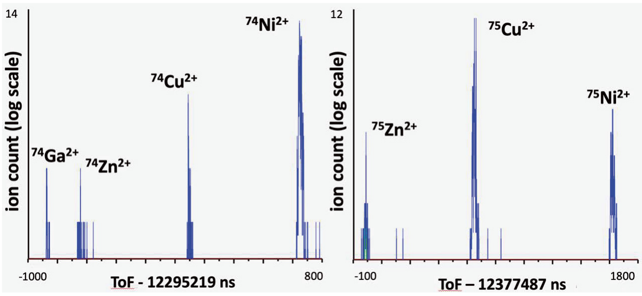

Fig. 2. New ion time-of-flight spectra of the $A = 74$ isobars Ga, Zn, Cu, and Ni in the left part, and $A = 75$ isobars Zn, Cu, and Ni produced from on-line beam centered on ^{79}Ni and also from in-trap decay.

In November and December 2021 the first part of the dedicated experiments for the ZD-MRTOF system have been performed using SRC and BigRIPS+ZeroDegree (NP2012-RIBF 199/202), where due to a high-quality beam from BigRIPS and the recent abilities of the ZD-MRTOF system, new spectra on Ni isotopes could be recorded (see Fig. 2). The preliminary results are under analysis and the experiment will continue after resolving the recent incident at the accelerator facility.

In off-line studies, new efforts for the mirror tuning of the MRTOF-MS have been spent by developing procedures for careful tuning. Together with an advanced algorithm for software drift correction, resolving powers of up to $R_m = 10^6$ have been reached enabling the identification of low-lying nuclear isomers in many isotopes (down to about 40 keV excitation energy for $A \approx 40$ and 190 keV for $A \approx 200$). An initial accuracy test using stable molecules ionized in the gas cell at ten different mass numbers could be performed using data from the online commissioning in 2020 and yielded an relative mean deviation of $\delta m/m = 2.80(99) \cdot 10^{-8}$ from the well known values of the Atomic Mass Evaluation (AME) 2016.[4] A further important development, providing proof of the radioactivity for rare events, is a combined detector for the ion's time-of-flight and their beta decay at the same time called β-ToF detector.[7]

References
1) S. Iimura *et al.*, in this report.
2) W. Xian *et al.*, in this report.
3) D. Hou *et al.*, in this report.
4) M. Rosenbusch *et al.*, arXiv:2110.11507, submitted to Nucl. Instrum. Methods Phys. Res. A (2021).
5) P. Fischer *et al.*, Rev. Sci. Instrum. **89**, 105114 (2018).
6) A. Takamine *et al.*, RIKEN Accel. Prog. Rep. **53**, 108 (2018).
7) T. Niwase *et al.*, in this report.