Removing non-isobaric ions from an MRTOF-MS by periodic electric pulses

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In the recent SLOWRI/ZD-MRTOF[1)] commissioning run, radioactive ions were extracted with stable molecular ions spanning a wide mass range from impurities in the helium gas cell. Owing to the periodic nature of an MRTOF mass spectrometer (MRTOF-MS), this leads to an overlapping of ions with ions of varying A/q performing different numbers of laps in the TOF spectra. Unwanted stable molecular ions with higher abundance than the ions of interest prevented the identification of exotic isotopes from BigRIPS. Thus, it was necessary to devise a new purification method to remove contaminant ions as much as possible in our online measurement. An in-trap mass separation system for the ZD-MRTOF system was not yet installed during commissioning runs. Such systems are scheduled for the future based on existing knowledge, *e.g.*, selection methods called in-trap potential lift technique[2)] and in-trap deflector technique.[3)] Both techniques apply electric pulses to eject unwanted ions, where a single pulse on the order of a kilovolt is used at the moment of ion ejection (only applicable for isobaric ion separation) in the first method, and periodic low-voltage pulses are applied to a deflector inside the MRTOF device for the wideband ejection of ions in the second method. Here, we implement a new mass filter method based on periodic 600 V pulses of 2–4 μs duration using mirror electrodes that were on the ground potential previously. This periodic rectangular pulse is applied to injection-side mirror electrodes 5–8 (see graphic and simulated potentials in Fig. 1).

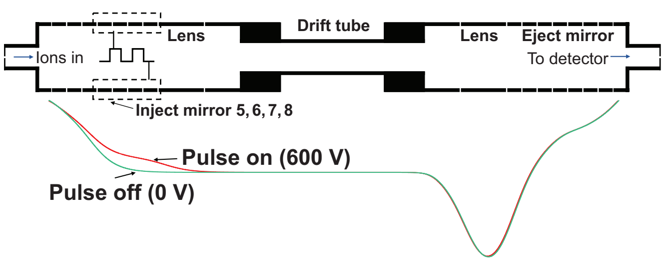

Fig. 1. Schematic of cleaning mode and potential distribution along the axis in MRTOF-MS.

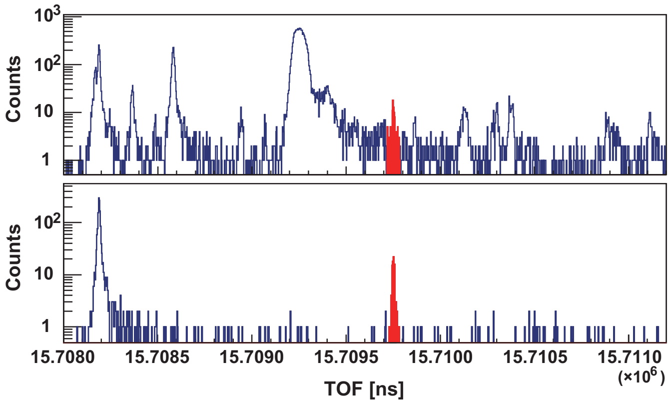

Fig. 2. Measured TOF spectrum without and with the cleaning mode; spectral peak marked in red is ^{82}Ge.

The flight time depends on the mass-to-charge ratio $t \propto \sqrt{(A/q)}$ of the ions. Different ion species of equal initial energy separate during flight in the MRTOF analyzer according to their A/q. The "on"/"off" stage of the pulses is synchronized with the wanted A/q value, and therefore, it is ensured that the ions of interest always experience the "off" stage when crossing the pulsed electrodes. In turn, the unwanted A/q ions are not synchronized, and they cross the pulsed region randomly in time. Being affected by the pulses once or several times changes their kinetic energy and additionally scatters the ions in a radial direction, which leads to unstable trajectories and ejection of ions. This ejection scheme was first tested in a simulation, and then applied in the experiment. After about 100–200 laps, ions of undesirable A/q crossed this region several times, and they could mostly be removed from the system. In our online experiments, the cleaning mode was applied; a comparison without and with the cleaning is shown in Fig. 2. Only the selected mass range is retained, and other mass areas are considerably clean in the spectrum. Although a very slight peak shift may occur due to the fluctuation of mirror potentials, this can be measured and corrected in the mass analysis. The new cleaning method was successful and enabled our first online measurements to determine low count rate nuclides.

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