Recent Technical Improvements for the Multiple-Reflection Time-of-Flight Mass Spectrometer at the FRS Ion Catcher*

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The multiple-reflection time-of-flight mass spectrometer (MR-TOF-MS) [1, 2] is part of the FRS Ion Catcher experiment [3], which serves as a test facility for the Low Energy Branch (LEB) of the Super-FRS at FAIR. At the FRS Ion Catcher, range-bunched nuclides from the FRS are stopped in a novel cryogenic stopping cell (CSC)[4], extracted and transported via an RFQ system to the MR-TOF-MS. At the LEB, the MR-TOF-MS will perform mass measurements, isobar separation and broadband mass spectrometry for ion identification and diagnostics purposes.

A unique feature of the MR-TOF-MS is its capability of shifting the potential of the incoming ions [5]. The potential shift is effected by pulsing the storage potential in the injection trap in front of the time-of-flight analyzer within a few tens of nanoseconds by a high voltage (HV) pulser. Thus the MR-TOF-MS can accept ions at different entrance potetials, which may be required e.g. if the MR-TOF-MS is used at different RIB facilities, without the need of placing the MR-TOF-MS on a high-voltage platform. The amplitude of this potential shift has been increased from 750 V to 1300 V. For an ion entrance potential close to ground, the kinetic energy of the ions in the time-of-flight analyzer therefore also was increased increased to 1.3 keV. This increase in kinetic energy will reduce the turn-around time and the emittance of the ions in the analyzer. Hence the mass resolving power and mass accuracy will be increased, while decreasing the time-of-flight required to achieve a given mass-resolving power [5].

The stability of the voltages of the analyzer electrodes are of primary importance for long-term high-accuracy mass measurements. A new voltage stabalization was developed and commissioned together with new high voltage power supplies for the MR-TOF-MS. Fig. 1 shows the voltage stability achieved with the new electronics. Over a measurement period of 330 minutes, the rms deviation of the time-of-flight now amounts to 0.5 ppm only. This exceptional performance will enable direct mass measurement of rare exotic nuclei at very high mass measurement accuracy.

A new data acquisition software has been developed for the MR-TOF-MS. It supports a variety of data acquisition hardware, including different TDCs and ADCs. The software also allows real-time data processing during the measurement such as mass calibration of the time-of-flight spectra, peak detection, and the online identification of masses.

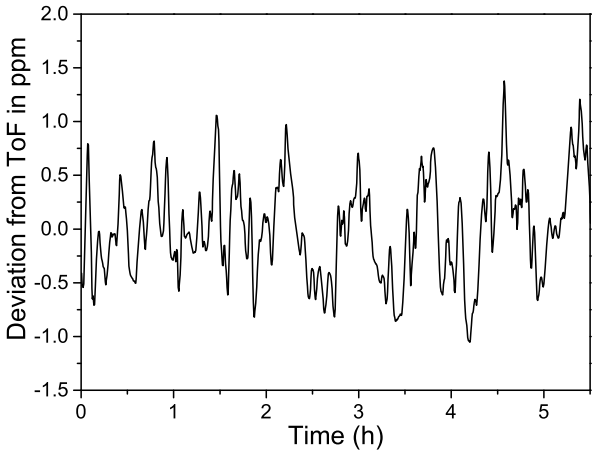

Figure 1: Stability of the mass measurement[6] of ^{133}Cs ions over a time period of 330 minutes. The time-of-flight amounts to 5.843 ms, and a mass resolving power (FWHM) of more than 150,000 is achieved. The rms value of the time-of-flight is about 0.5 ppm.

In an upcoming beam time with the CSC at the FRS Ion Catcher, the MR-TOF-MS will be the key device for the performance characterization of the CSC. In particular, it will be used to identify β-decaying ^{238}U fission fragments extracted from the CSC by their mass values and to perform isobar separation with short-lived nuclei.

References

[1] W. R. Plaß et al., Nucl. Instrum. Methods B 266 (2008) 4560.

[2] T. Dickel, PhD Thesis, 2010, JLU Gießen.

[3] W. R. Plaß et al., Nucl. Instrum. Methods B 317 (2013) 457.

[4] S. Purushothaman et al., Eur. Phys. Lett. 104 (2013) 42001.

[5] W. R. Plaß et al., Int. J. Mass Spectrom. 394 (2013) 134 .

[6] J. Lang, PhD thesis in preparation.

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