Slow Extraction of Charged Ion Pulses from the REXEBIS

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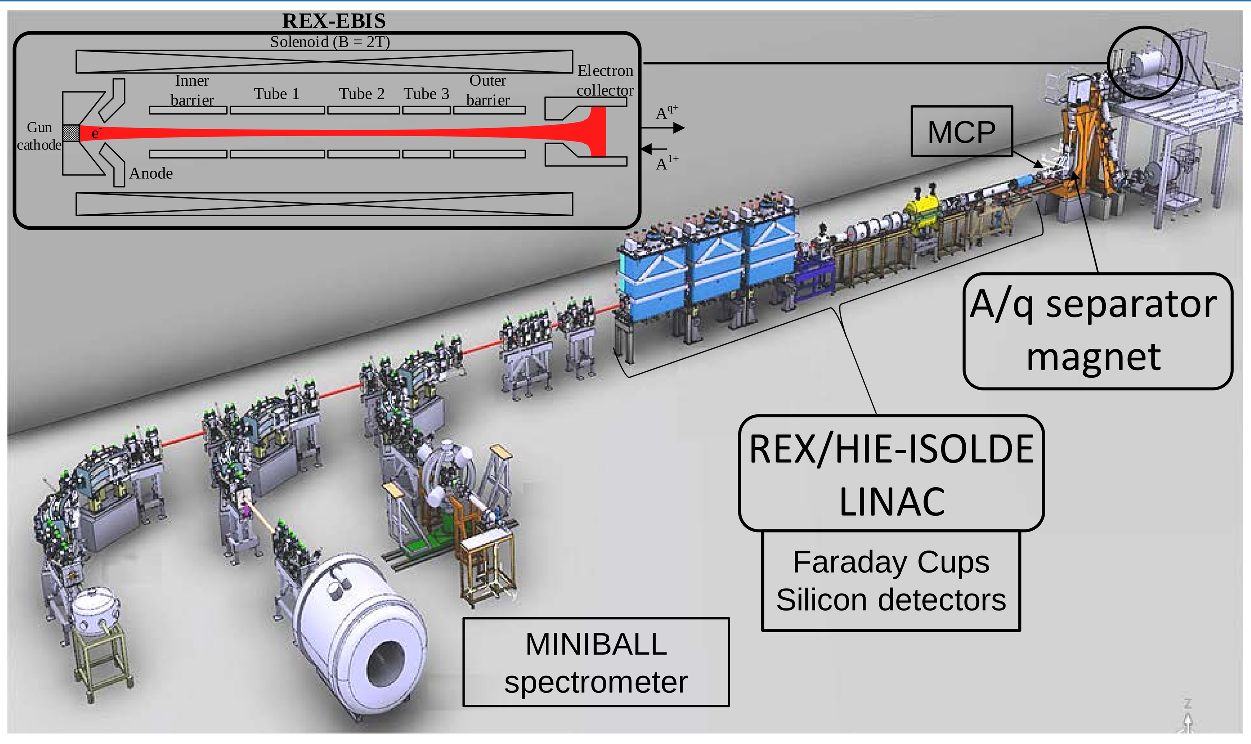
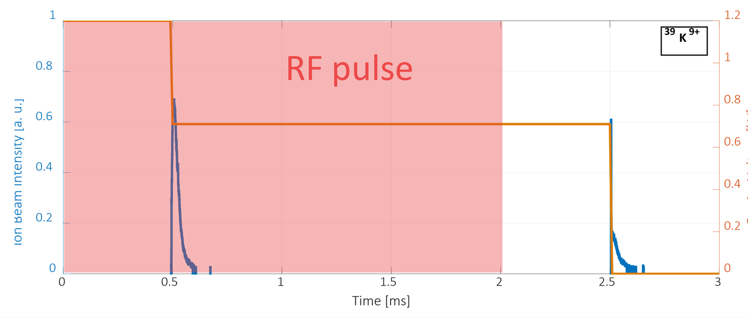
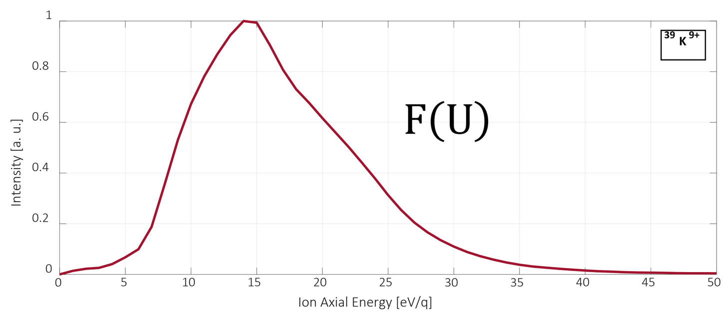
Commissioning of the Ion Pulse Shaping



The Isotope mass Separator On-Line DEvice (ISOLDE) facility located at CERN, produces and transports Radioactive Ion Beams (RIBs) at low or high energy through the REX/HIE-ISOLDE linear accelerator, for nuclear physics, astrophysics, solid-state physics and applied-physics purposes. Respectively to the will of increasing the detection efficiency at the experimental stations, the time structure of the ion beam extracted from the REXEBIS and transported has been deemed necessary to be lengthen. At the end of each charge-breeding sequence, a new extraction approach designated as Slow Extraction is conducted to achieve an ion pulse length in the millisecond range.

- REX/HIE-ISOLDE acceptance 2.5 < A/q < 4.4
- Duty cycle of REX-ISOLDE RF systems 10%: 2ms long pulse @ 50 Hz
- REXEBIS trapping barriers at 1.2kV, drift tube at 0.7kV, axial magnetic field at 2T, electron cathode operated at around 200mA and 4000V



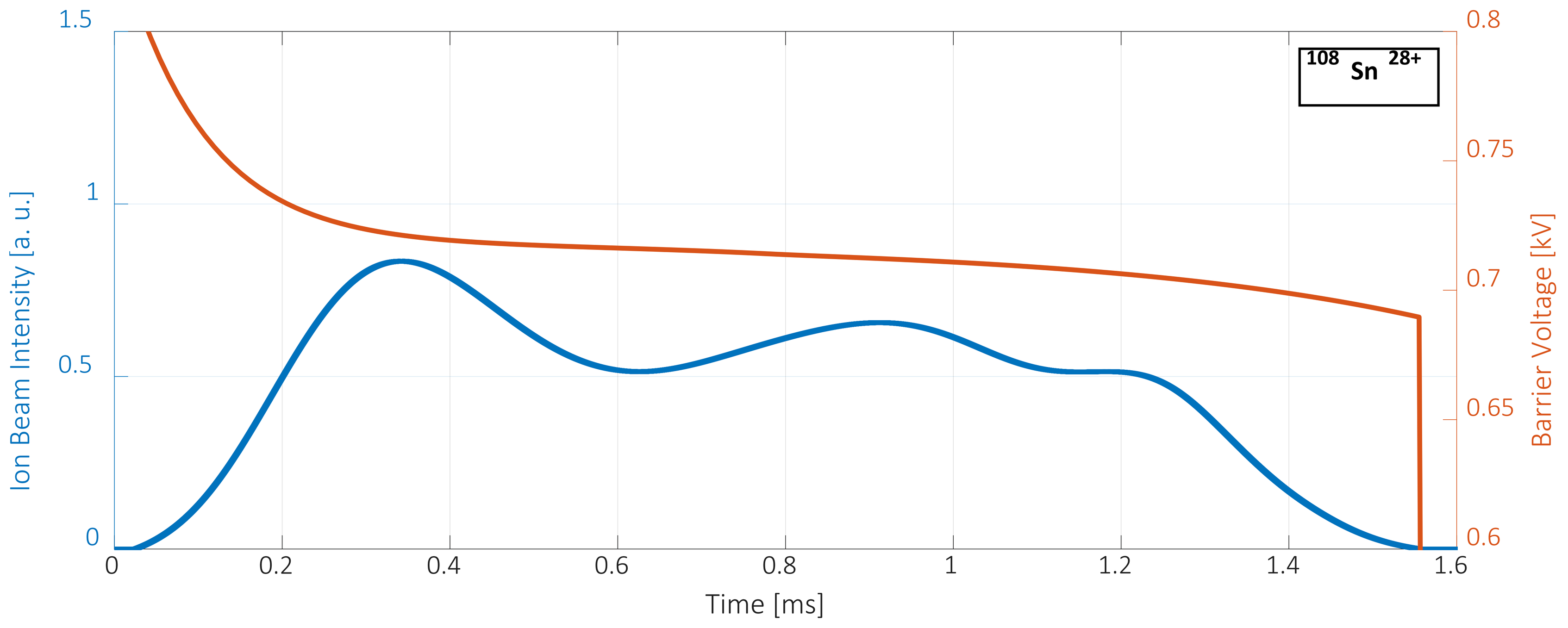


Barrier voltage modulation calculation:

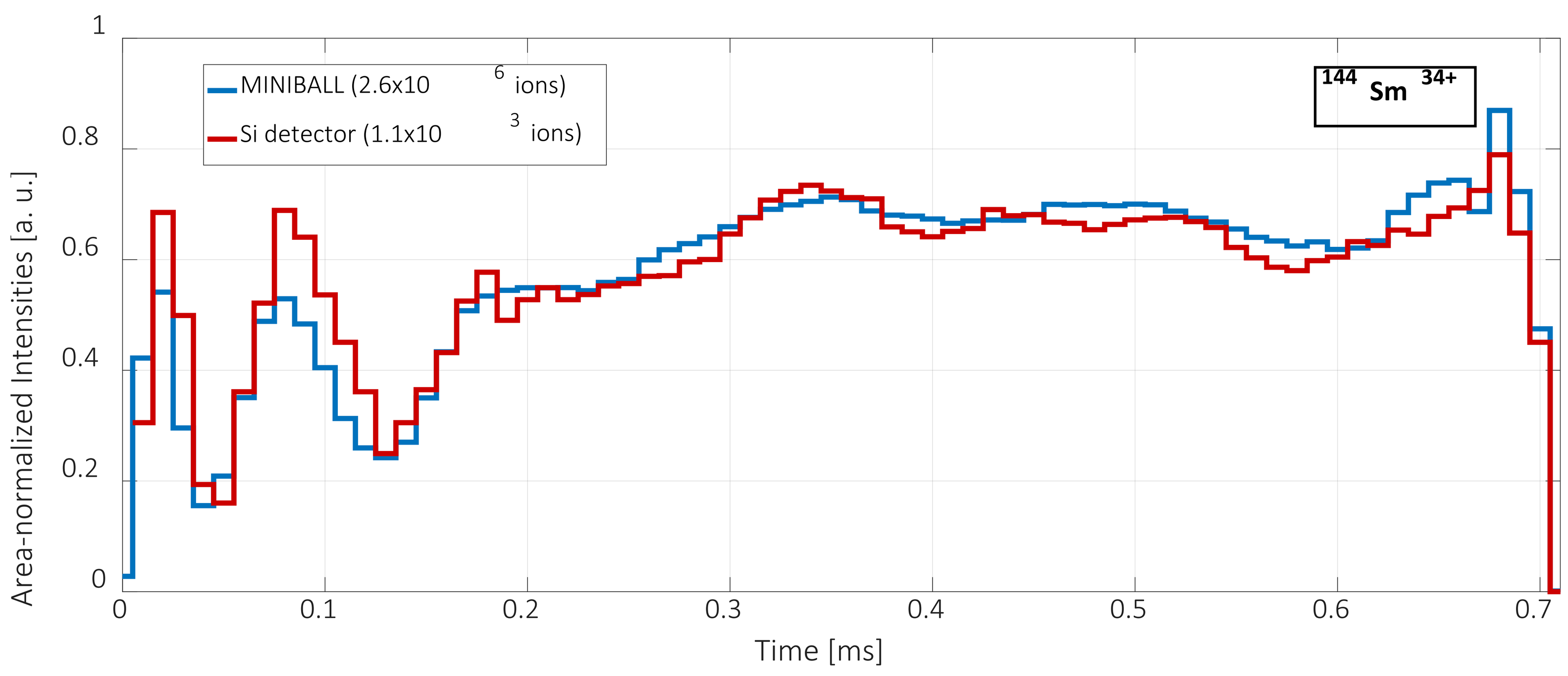
$$\int_{V_{t_i}}^{V_{t_{i+1}}} F(U)dU = \frac{\Delta t}{T_p}\int_0^{V_{t_0}} F(U)dU \quad (1)$$

$$V_{t_0} = 1.2kV$$

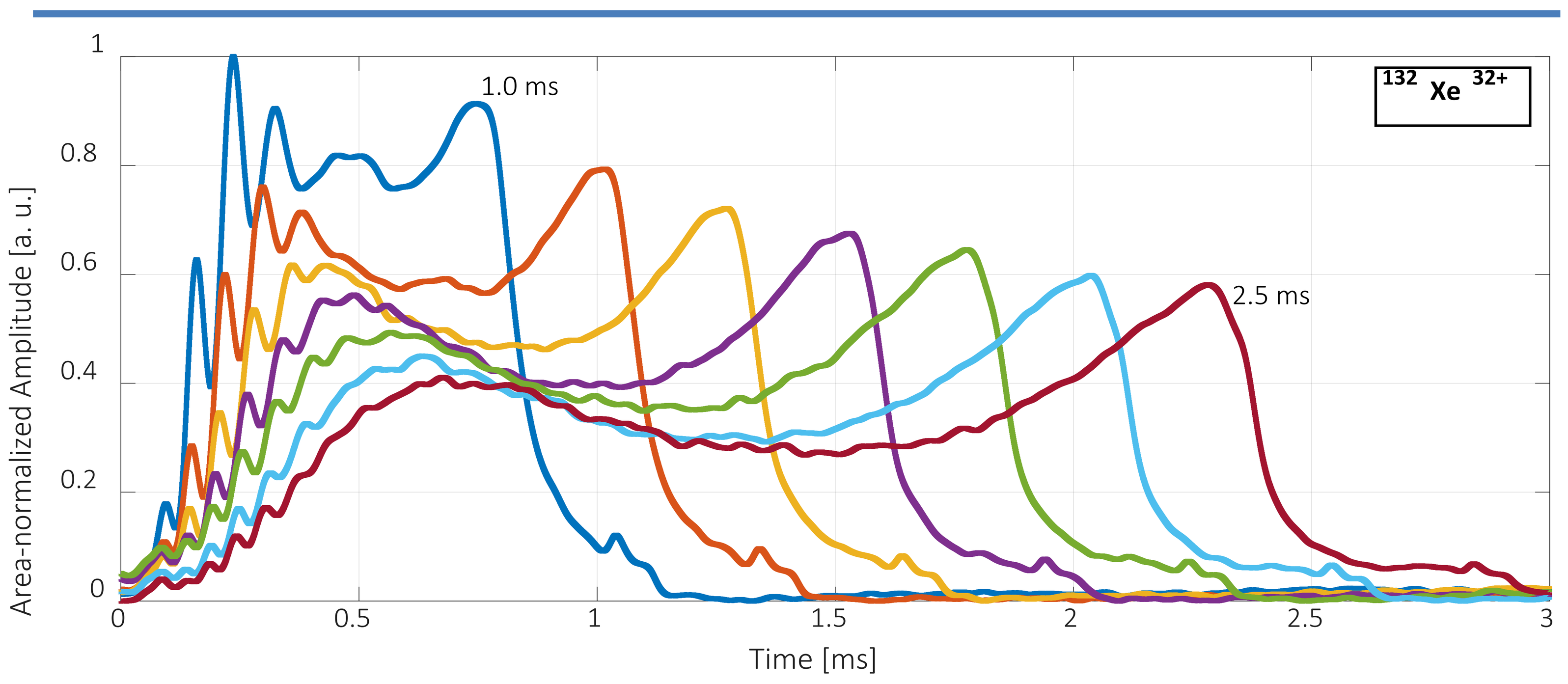
Time Structure Results



The MINIBALL spectrometer at the end of the first out of three High Energy Beam Transfer lines can provide information related to the characterization of the time-of-flight¨. The barrier modulation may be fit with a two-exponential function and adjusted to meet a desired shape.

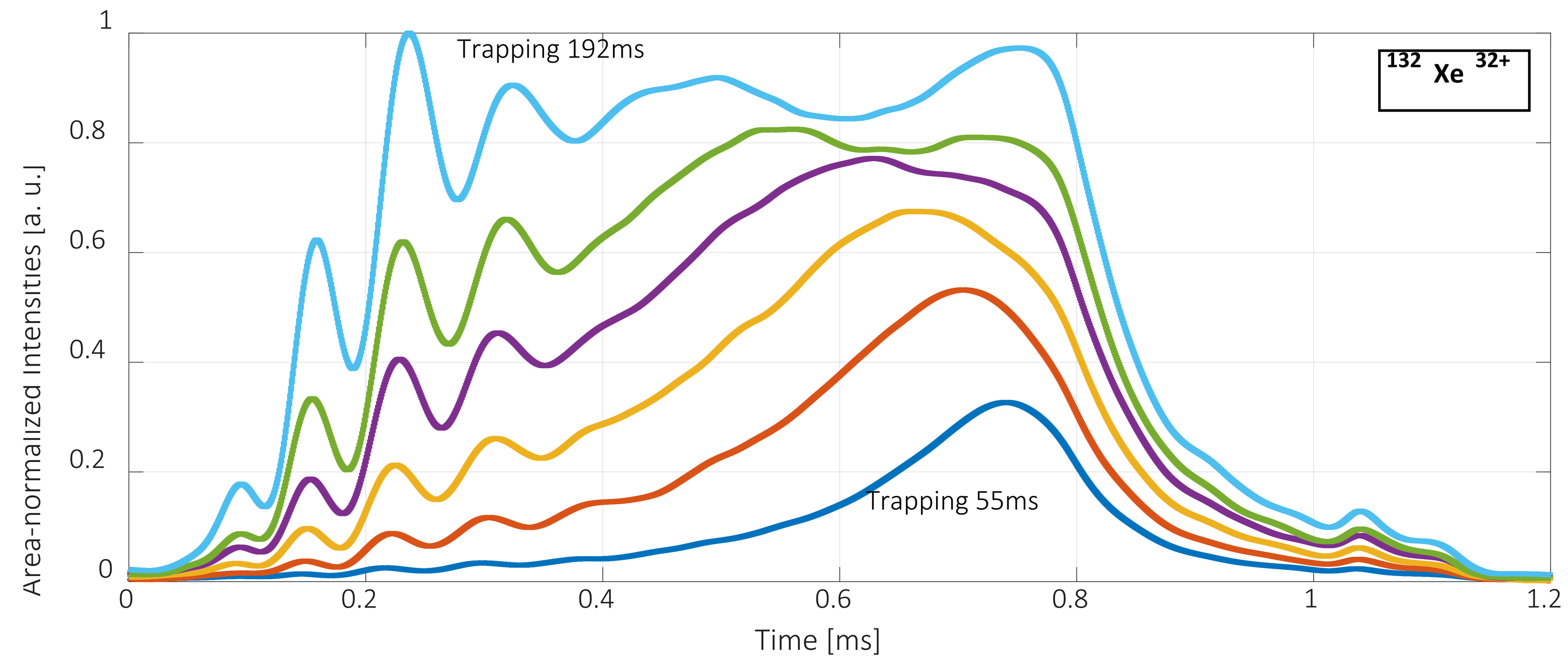


The time structure displayed, acquired with a Silicon detector and the MINIBALL spectrometer, is directly obtained from the application of Equation (1), without refinement nor fitting of the barrier voltage function. The ripples in the beginning of the ion pulse distribution are the consequences of potential differences between the drift tubes.

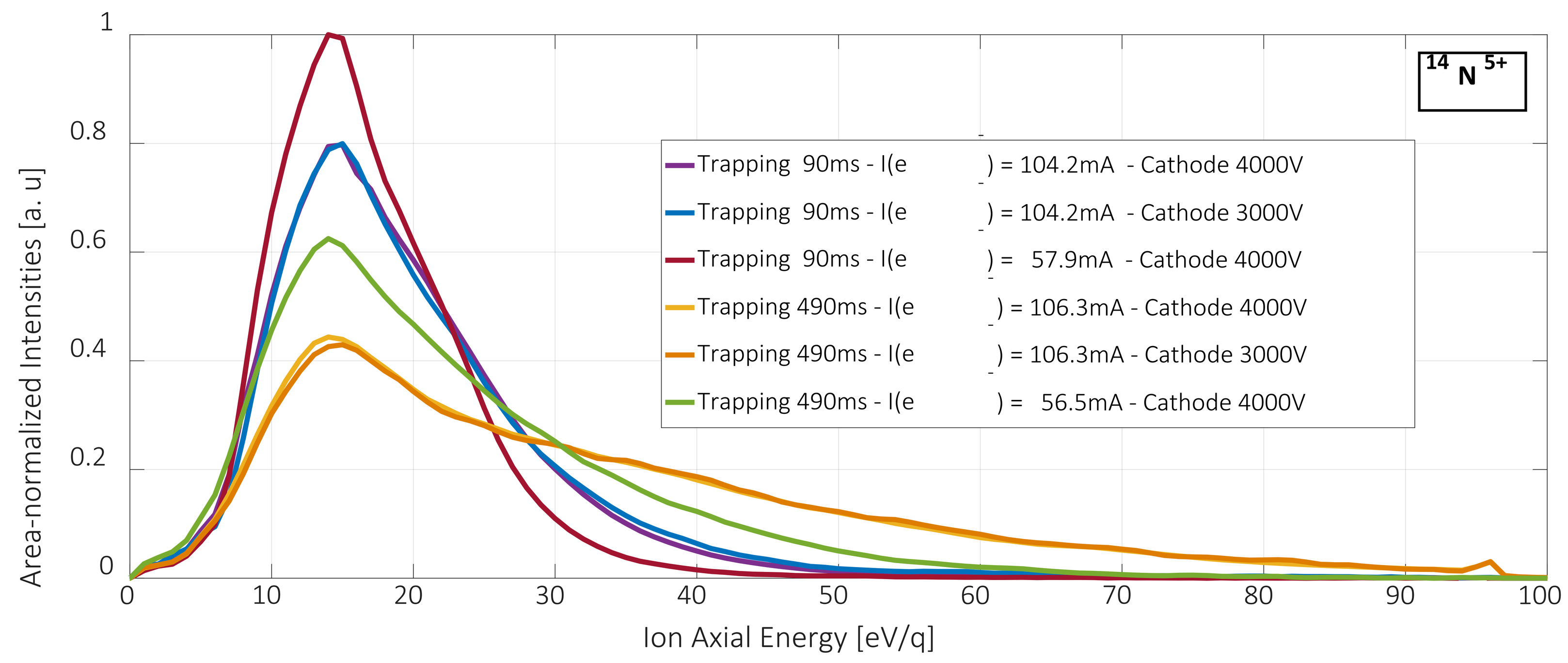


The possibility to adapt the ion pulse to a desired length is also demonstrated, notably if the prospects are to increase the Radio-Frequency systems pulse length. During the experimental runs in 2016, the average power limitation of the 9-gap IH resonator (2.5 kW), constrained the RF pulse length to be 0.7ms long. In 2017, the ensemble of REX/HIE-ISOLDE RF systems were operated with a pulse length of 1.5ms.

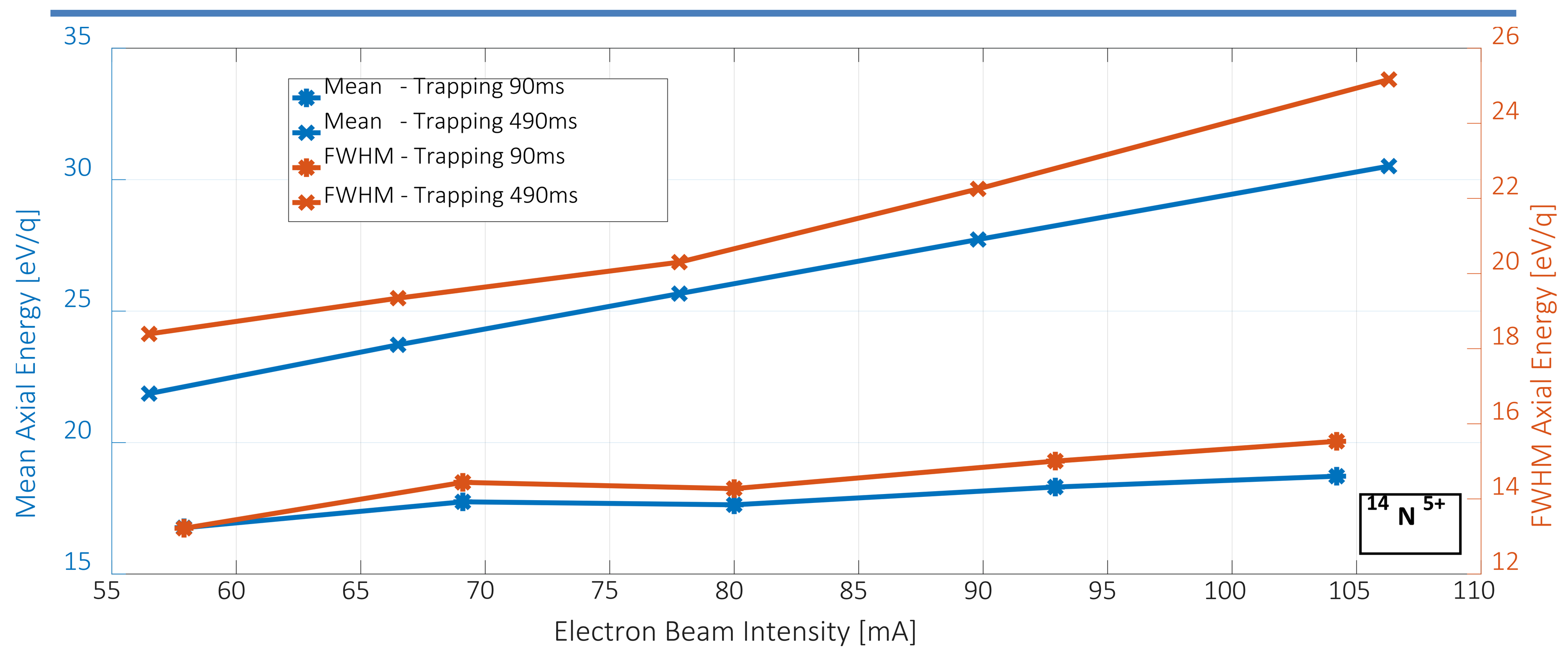
REXEBIS Operational Parameters Influence on the Time Structure



After having commissioned the Slow Extraction, several operational parameters of the REXEBIS still might be adjusted during experimental runs. The trapping time may for instance be accustomed in the case of a change of radioactive isotope to study.



The variations of the electron beam energy within the typical range of values operated during operation, from 3keV to 4keV, were not measured to have a significant influence on the ion pulse shape. However, the trapping time and the intensity of the electron beam play a role on the ion axial energy distribution.



By fitting the mean axial energy as a linear function of the electron beam intensity, one obtains a ratio of 4.50 between the slopes at 490ms trapping time and 90ms. The compensation factor was measured to increase by 4.45 between 490ms trapping time and 90 ms, which can be correlated with the change in proportionality coefficients between the two linear fit functions.

Conclusion

Since the commissioning of the new Slow Extraction method in March 2016, time structure shaping from 0.7 ms to 5 ms has been achieved for more than thirty different radioactive or stable ion beams, satisfying the A/q range requirement. The Slow Extraction scheme allows to overcome saturation issues at the experimental stations. Two essential operational parameters of the REXEBIS were identified as influencing the ionic temperature and the ion axial energy spread and thus the ion pulse shape at fixed extraction voltage modulation.

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