# ON THE ACCCELERATION OF RARE ISOTOPE BEAMS IN THE REACCELERATOR (REA3) AT THE NATIONAL SUPERCONDUCTING CYCLOTRON LABORATORY AT MSU*

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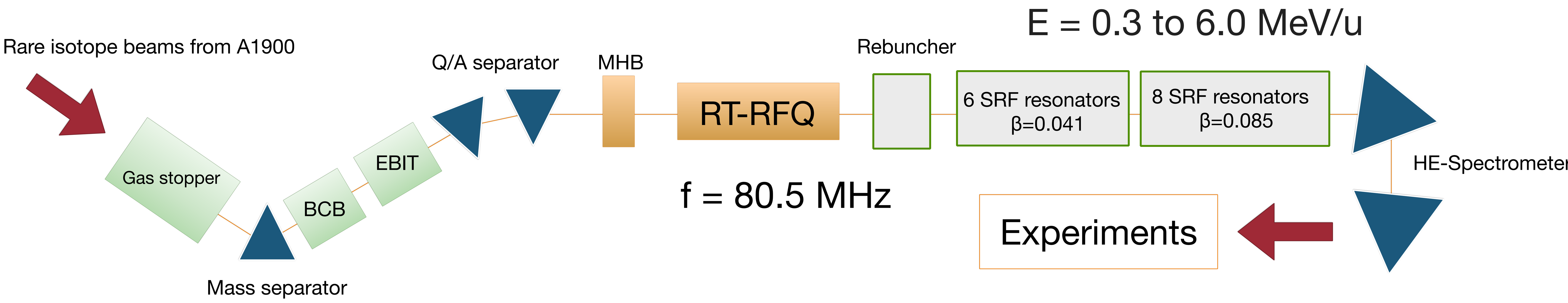


**The ReAccelerator ReA3 has run continuously for one year delivering rare isotopes and stable beams for experiments at the National Superconducting Cyclotron Laboratory (NSCL) at the Michigan State University (MSU) [1]. Beams of rare isotopes are produced and separated in-flight at the NSCL Coupled Cyclotron Facility (CCF) and subsequently stopped in a gas cell [2]. The rare isotopes are then continuously extracted as 1+ (or 2+) ions and transported into a beam cooler and buncher, followed by a charge breeder based on an Electron Beam Ion Trap (EBIT) [3]. In the charge breeder, the ions are ionized to a charge state suitable for acceleration in the superconducting radiofrequency (SRF) linac, extracted in a pulsed mode and mass analyzed. The extracted beam is bunched to 80.5 MHz and then accelerated to energies ranging from 300 keV/u up to 6 MeV/u, depending on their charge-to-mass ratio. Alternatively, ions of stable isotope can be accelerated by injecting stable ions from an external ion source in the EBIT. ReA3 [4] has provided stable 14N, 40Ar, 39K and 78Kr as well as the rare isotope beams of 34,46Ar, 37,46K and 75Ga for a total of 11 experiments since August 2015. This contribution focuses on the properties and techniques used to accelerate and transport the rare-isotope beams and will show average results obtained during the preparation of these experiments in the ReA facility.**

**[1] http://nscl.msu.edu**
**[2] K. Cooper et al, NIM A763 (2014) 543, doi:10.1016/j.nima.2014.06.075**
**[3] A. Lapierre et al, RSI 85 (2014) 02B701, http://dx.doi.org/10.1063/1.4827308**
**[4] W. Wittmer, et al., Proceedings of PAC2013 (2013) 360.**
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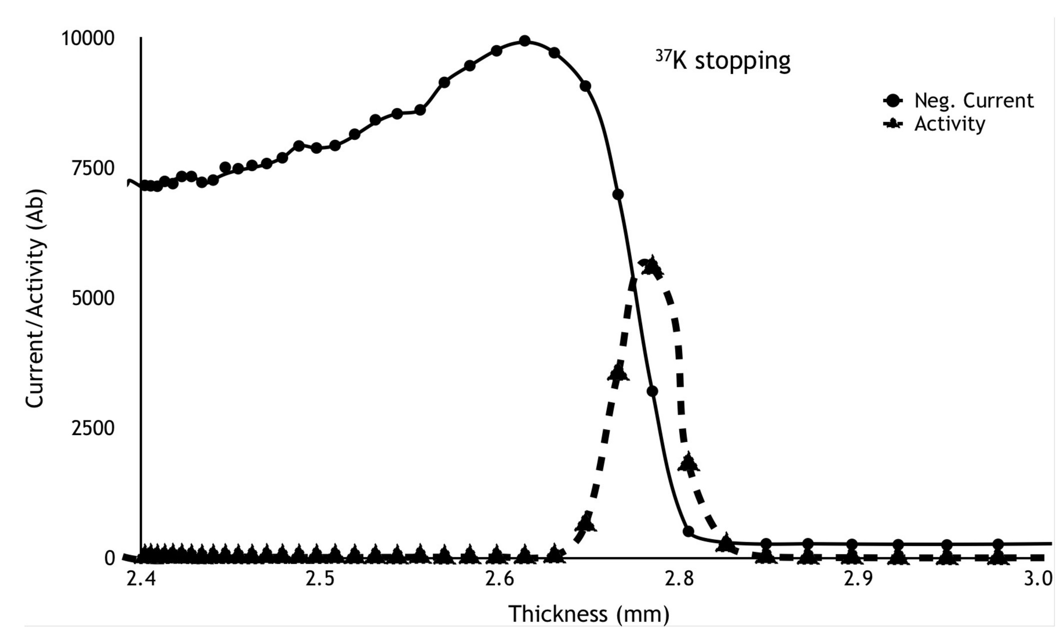
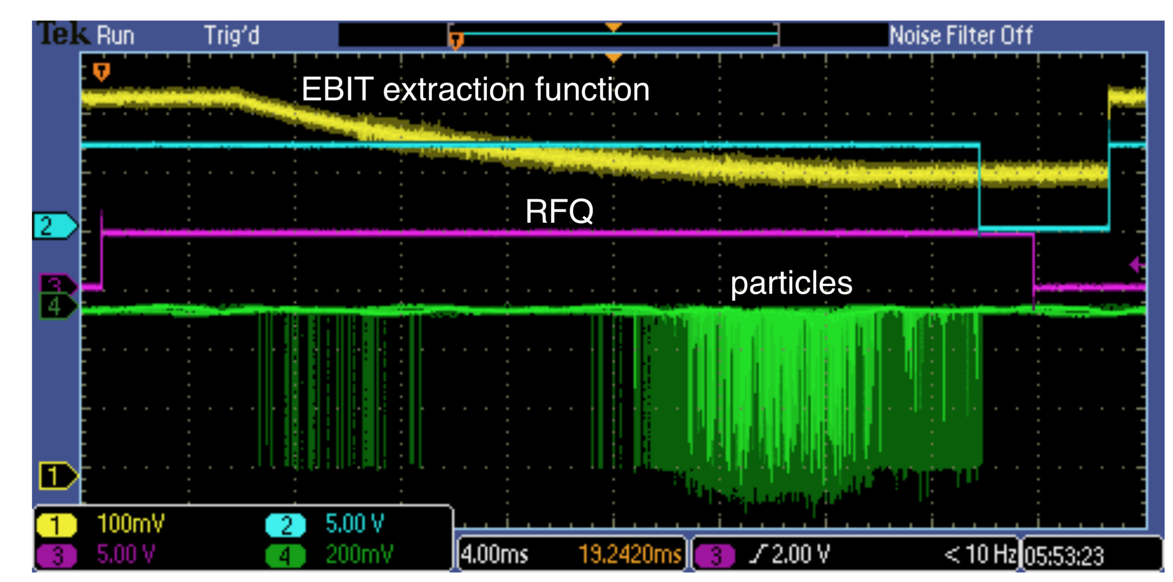
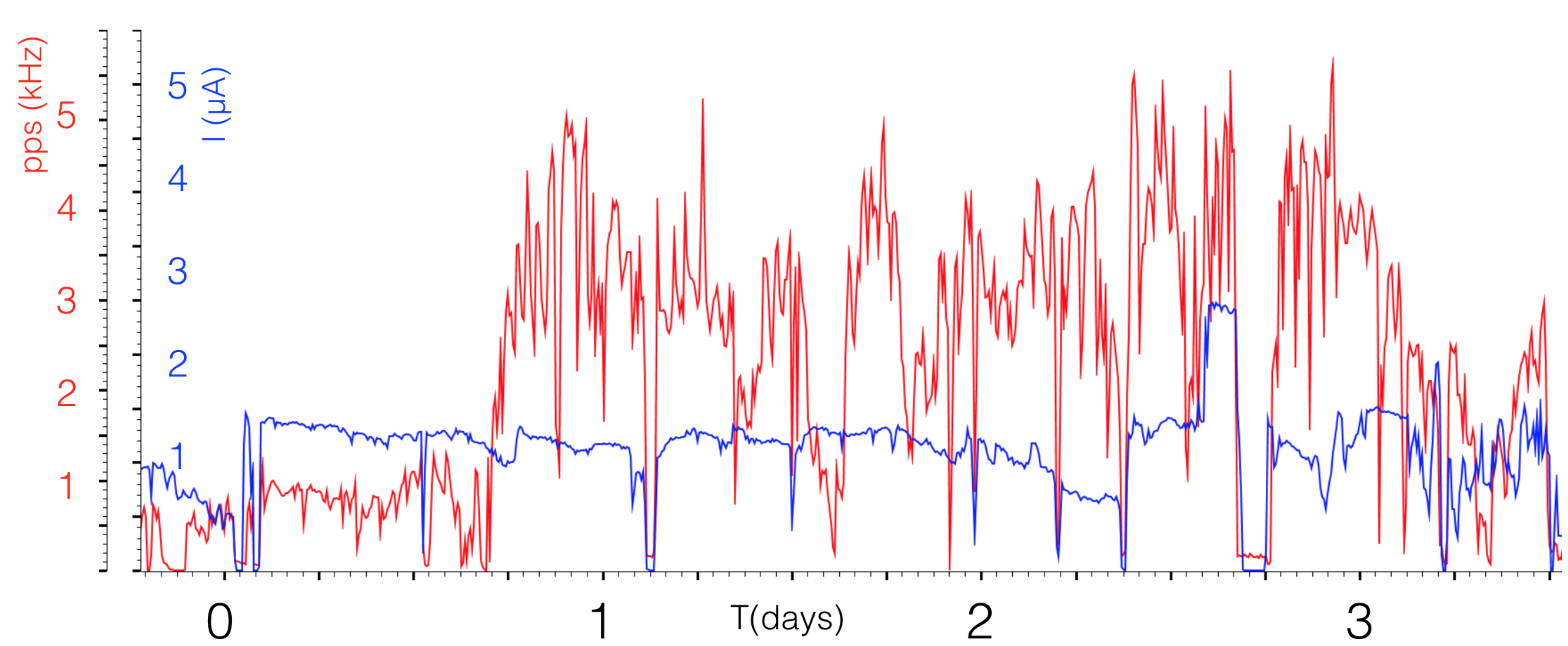



Negative current in the front window of the gas cell (solid curve) and beta activity detected after the gas cell (dashed curve) as a function of the total degrader thickness.




Particle distribution ($^{78}$Kr) extracted from the EBIT and detected in the experiment




Beam intensity of rare isotope $^{37}$K in the experimental set-up (red curve) together with the primary beam intensity of $^{40}$Ca beam (blue curve) provided by the Coupled Cyclotrons of NSCL

| Equipment | Efficiency (%) |
|---|---|
| Gas cell | 15 |
| BCB - EBIT | 12 |
| RFQ-LINAC | 70 |
| Transport to experiment | 90 |

Efficiencies in selected sections of ReA3. Efficiencies vary with beam intensity, half life and charge state. The reference beam is 34Ar (16+) T1/2 = 844ms.

$^{37}$K measured beam spot in the target of the experiment. The beam intensity is 1000 pps and timing macro-structure of 2 Hz. The size of the spot is 2 mm

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FRIB Facility for Rare Isotope Beams
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