Pulse stretching out of the CANREB EBIS

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Overview

The CANadian Rare isotope facility with Electron-Beam ion source (CANREB) at TRIUMF is set to deliver beam of rare isotopes. High charge states, a requirement for post-acceleration, are obtained by charge breeding via electron-ion collision in an Electron Beam Ion Source (EBIS)[1].

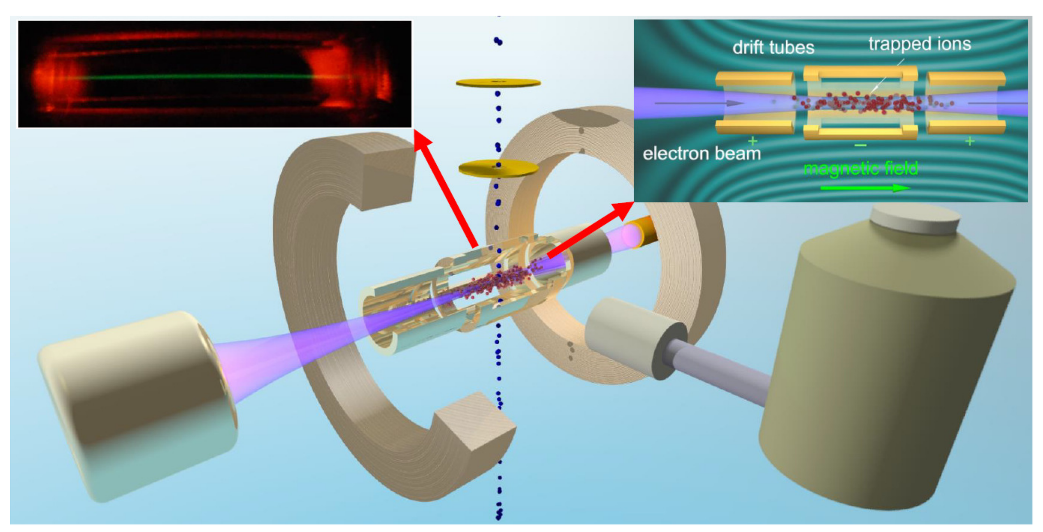

Figure 1: Schematics of the CANREB EBIS[1]

Ion pulses are captured and later extracted by switching trapping electrodes between high and low potentials. The pulse length and ion distribution depend on the size of the trap and the energy distribution of the ions inside it.

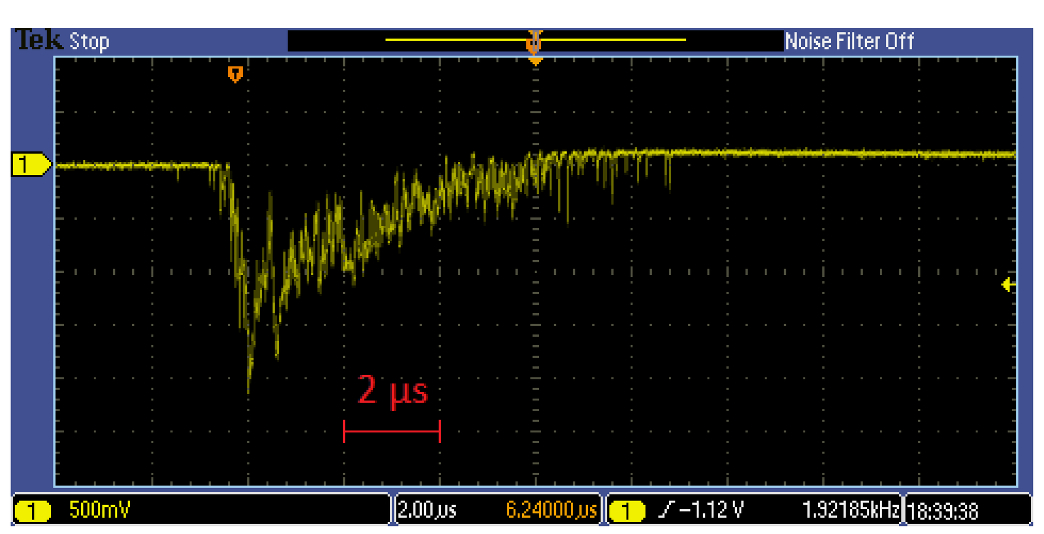

Figure 2: $^{36}Ar^{12+}$ pulse as seen downstream of the CANREB EBIS

The length of pulses extracted out of the CANREB EBIS with this method is to the order of a few (2-10) μs. Consisting of up to 10^6 ions, such pulses saturate detectors in experiments. A different extraction scheme is required to distribute the ions in time ie stretch the pulse.

Pulse stretching principle

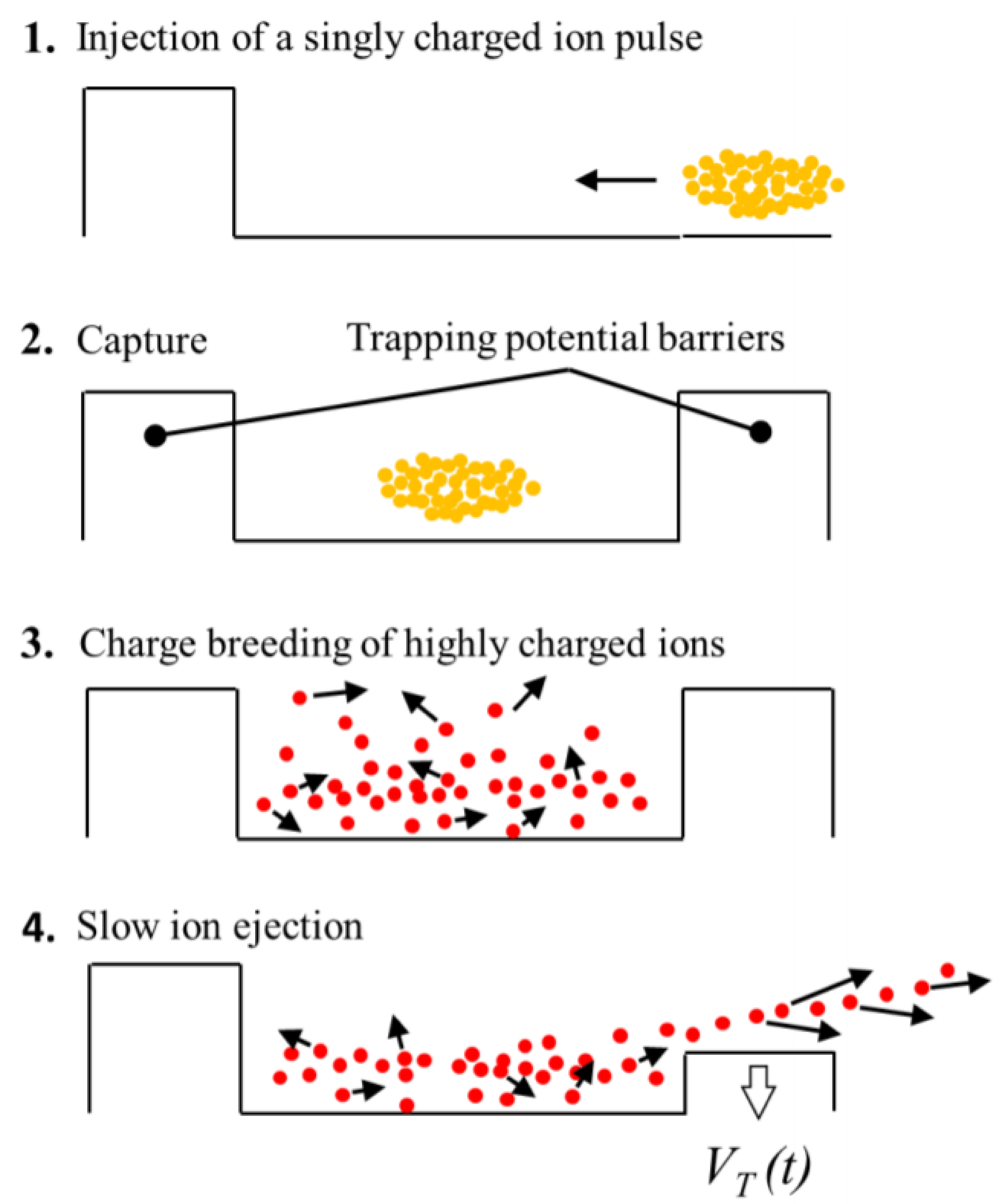

Figure 3: Illustration of the pulse stretching principle[2]

First test

- First test: proof of principle with linear ramp as extraction function
- Measurement done at the ISAC Charged Particle Reaction Spectroscopy Station (IRIS) with $^{85}Rb^{27+}$ ions
- Low intensity to accommodate the IRIS data acquisition system

The first experimental result is presented in fig.4. The red line shows the average pulse time profile resulting of fast extraction, the blue line the pulse profile after extraction with a 10 μs ramp. The time delay these pulses is an indication of the ion energy inside the trap. The more homogeneous distribution in blue is a promising indication of pulse stretching.

Method

Pulse stretching can be achieved by opening the trap with a slow varying function, as shown in fig.3.Extraction over the barrier by raising the floor of the trap is also a possibility.

- Usual functions like ramps and exponentials already produce longer pulses compared to switching
- Ideal slow extraction potential $V_T^*(t)$ gives rise to a constant rate of ion release
- Extraction rate of ion in charge state i can be written[2]:

$$R_i(t) = -\frac{d}{dt}\int_0^{E_i^{max}(t)} F(E_i)dE_i$$

  where $F(E_i)$ is the ion energy distribution inside the trap
- $V_T^*(t)$ is such that the successive intervals dE_i contain the same number of ions
- Extraction with known function also allows for the calculation of $V_T^*(t)$[2]

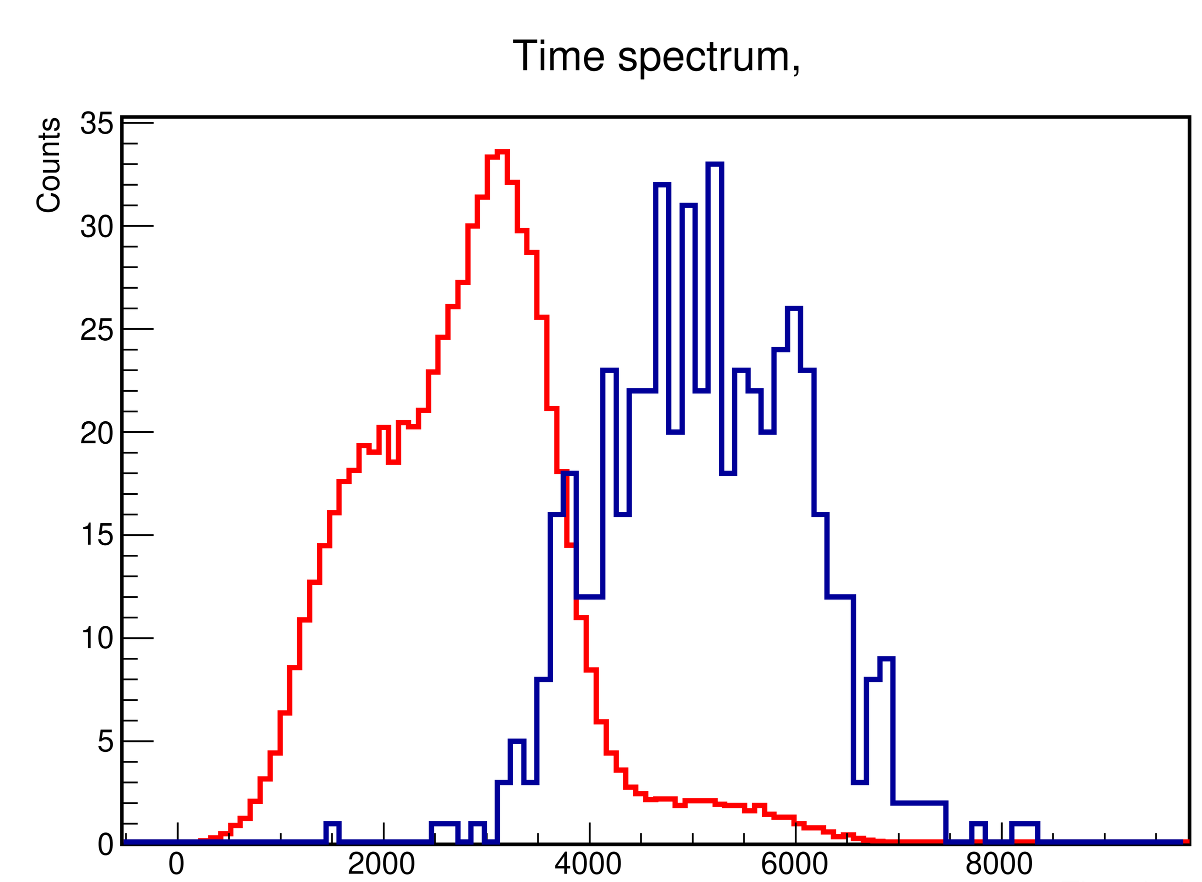

Figure 4: $^{85}Rb^{27+}$ pulse profile comparison between fast extraction in red and ramp extraction in blue

Notes and timeline

- The method has been used and proven to work at CRY-EBIS, ReA EBIT/S and REXEBIS[3]
- The novelty here comes from the shorter natural length of the ion pulse because of the relatively short trap length
- Testing will also be done using the TITAN EBIS while development work continues in the CANREB EBIS[4]

References

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Canreb ebis commissioning at triumf, icis2021 conference proceedings, to be published.

Acknowledgements

TRIUMF receives federal funding via a contribution agreement with the National Research Council of Canada. CANREB is funded by the Canada Foundation for Innovation (CFI), Research Nova Scotia and Manitoba Research and Innovation Fund.