Simulating the CANREB radiofrequency quadrupole cooler-buncher

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Introduction

The ARIEL radiofrequency quadrupole cooler buncher (**ARQB**) as a part of TRIUMF's newly commissioned CANadian Rare isotope facility with Electron Beam ion source (**CANREB**) is essential for the preparation of radioactive isotope beams (RIB). The ARQB processes beam for energy matching and injection into the Electron Beam Ion Source (EBIS). Understanding the system is essential for optimized use.

Simulation Setup

- SIMION version 8.1.1.32.
- He gas collisions simulated using a hard-sphere collision model (REV 6-2009-10-02). Collisional cross section calculated using Van der Waals radii.
- Segmented simulation to achieve high resolution:
  - **Entrance** = injection
  - **Body** = cooling
  - **Exit** = bunching/ejection
- Multiple PAs : allowing for variable resolution.
  - **0.5mm/g.u.** boundaries
  - **0.2mm/g.u.** ion pathway

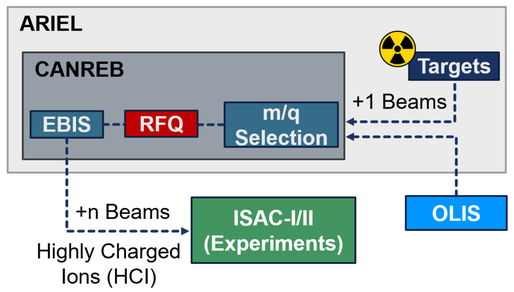


Fig 1: A visual depiction of the ARQB's place in ARIEL.

The SIMION Model

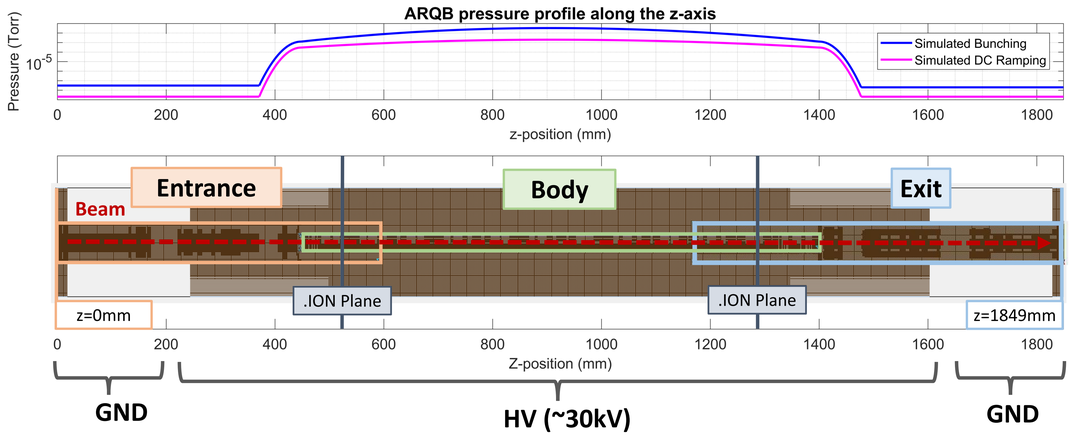
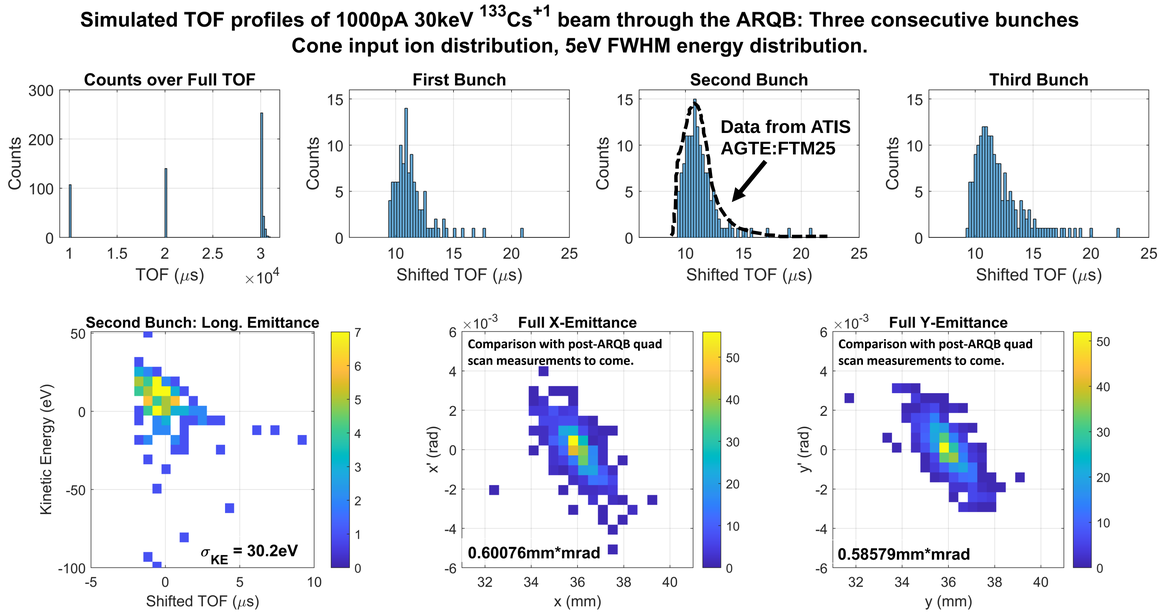


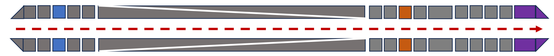
Fig 2: SIMION Simulation of the ARQB, segmented into entrance, body, and exit sections. Geometry from SolidWorks model. Pressure profiles shown for bunching and DC voltage ramping simulations.

Simulated Bunching

- Issues:
  - > ~2/3 ions initialized in the EXIT simulation are not RF phase matched (issues in energy).
  - > Simulated gas pressure significantly higher than in the system.
  - > Simulated trap remains open after ejection of the third bunch.
- Realistic pressure profile is needed to simulate accurate cooling, transmission, and emittance.



ARQB DC Voltage Ramping and the Buffer Gas Pressure Profile



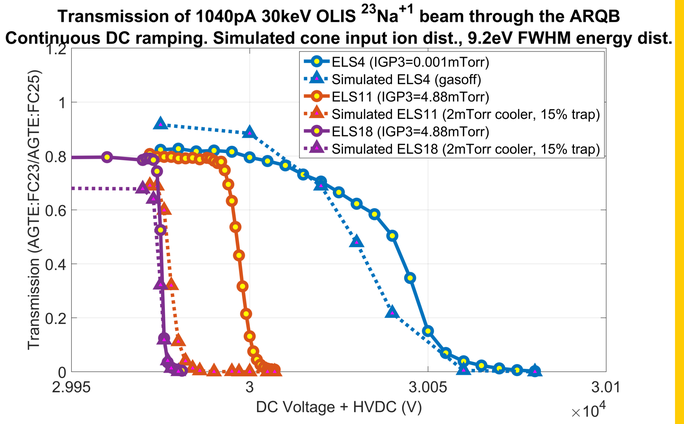


Fig 3: Impact of DC voltage ramping in the ARQB RFQ on transmission, measured and simulated. When not adjusted, default set to operational voltage.

- An appropriate pressure profile is not needed to simulate bunch profiles.

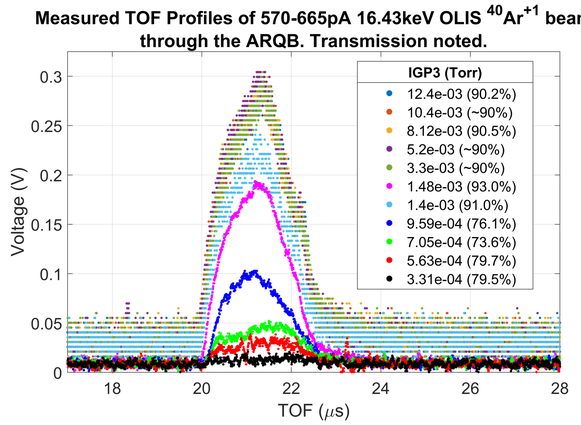


Fig 4: Measured TOF profiles with varied He buffer gas pressure (IGP3 reading). Pressures uncorrected for He. Transmission from AGTE:FC23/25/34.

Remaining Challenges:

- More information is required to definitively set a pressure profile (Molflow+ simulations in progress by Devon Joseph/Christopher Charles)
- Bounce-back ions in bunching – implementation of slew time

Discovery, accelerated