First Electron Beam and Status of the High-Current EBIS Charge Breeder for the FRIB

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❑ Introduction

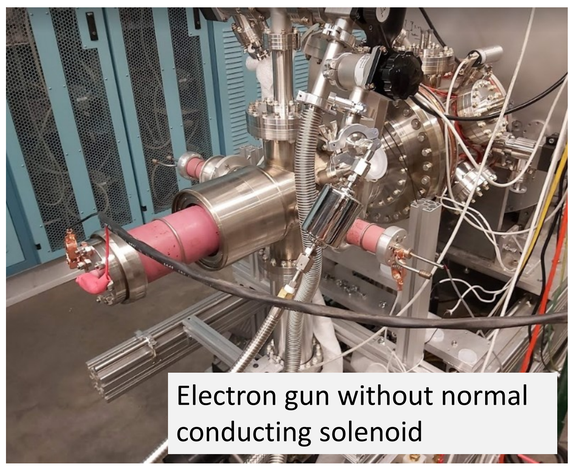
The The ReA post-accelerator of the National Superconducting Cyclotron Laboratory employs an Electron-Beam Ion Trap (EBIT) as a charge breeder to reaccelerate rare-isotope beams to several MeV/u. The Facility for Rare-Isotope Beams (FRIB) is near completion and will provide RIB rates expected to exceed in some cases 10^{10} particles/s. The ReA EBIT operates with an electron current of 300 – 600 mA, corresponding to an electron current density of 170 – 340 A/cm^2 and maximum trap capacity of 10^{10} elementary charges, which can be insufficient to handle high FRIB rates. A High Current Electron-Beam Ion Source (HCEBIS) has been constructed based on the backbones of the TestEBIS from Brookhaven National Laboratory. By using a 4 A electron beam, a beam current density of 298 A/cm^2 and a maximum trap capacity of 2.4×10^{11} elementary charges can be achieved. This paper presents the status of the HCEBIS, including the simulation results and first electron-beam tests.

- HCEBIS specification

Electron-beam current	≤ 4 A
Electron-beam energy	≤ 20 keV
Magnetic field (trap center)	≤ 5 T
Electron-beam current density	≤ 300 A/cm^2
Trap length	0.7 m
Trap Capacity	~2×10^{11} charges

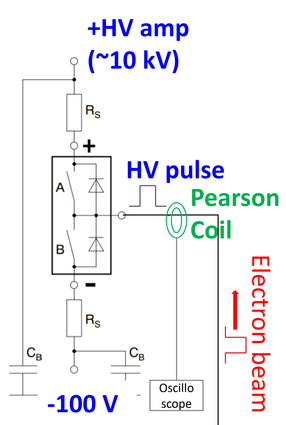
❑ Cathode tests

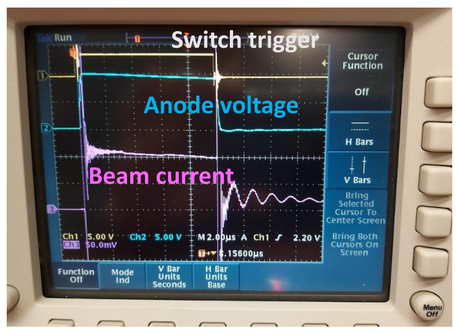
- ✓ Cathode material : LaB6
- ✓ Cathode diameter : 9.2 mm
- ✓ Electron beam current : ~ 10



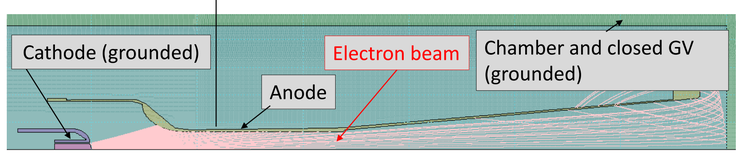
Cathode assembly

- Pulsing circuit for measurement

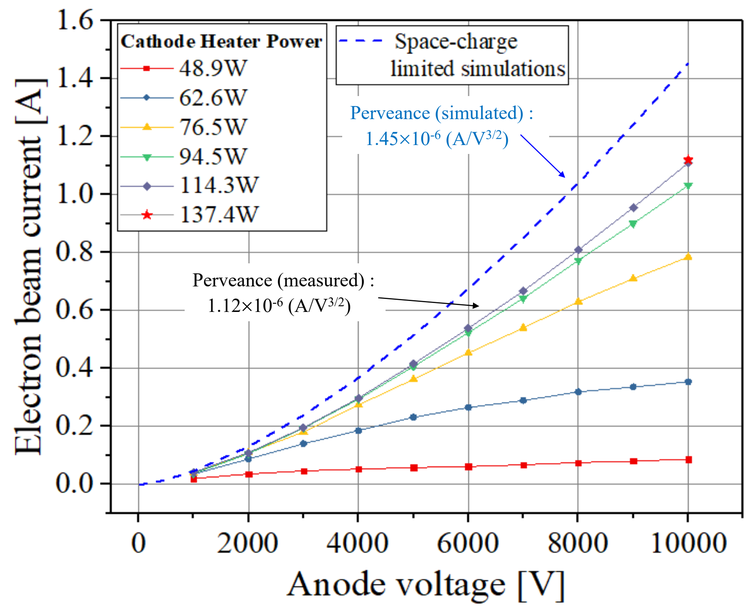




- Anode Voltage: 10 kV
- Pulse width: 1 ~ 10 us
- Cathode Heater Power : 114.3 W



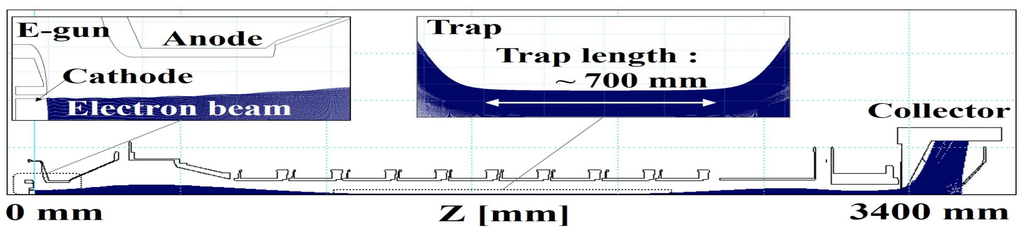
- Electron beam current measurement



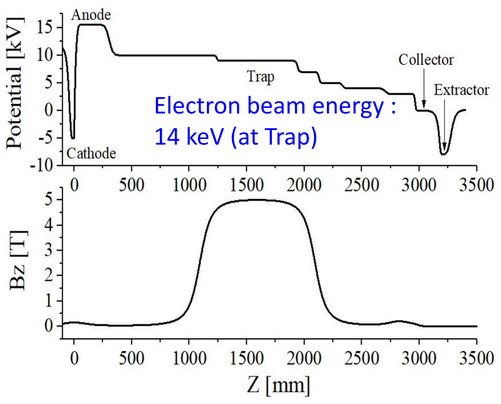
❑ Simulations

❖ Electron beam simulation

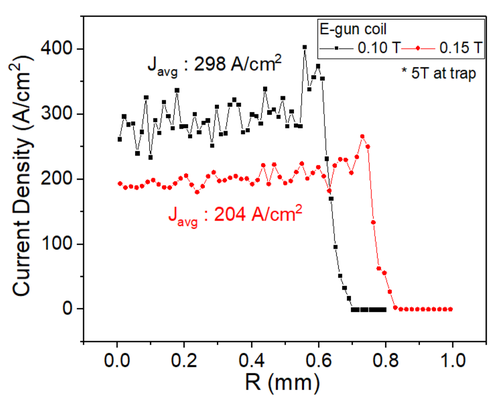
- Electron beam trajectory



- Potential & B field distribution

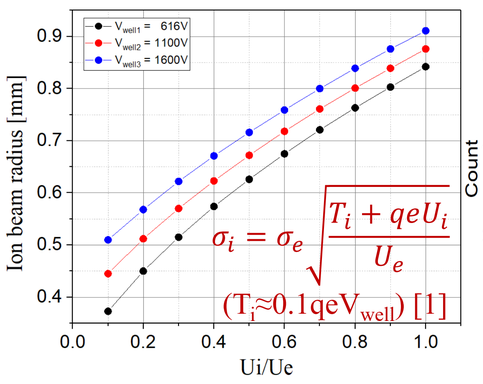


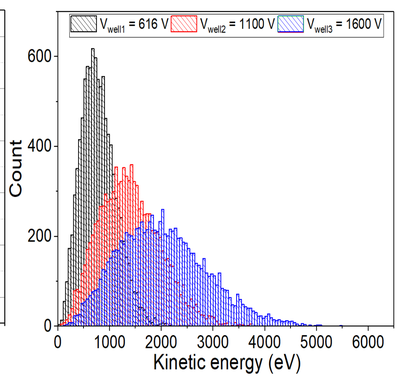
- Current density at Trap

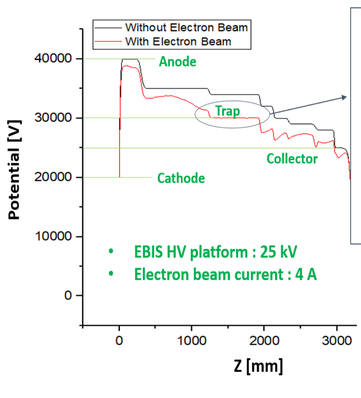


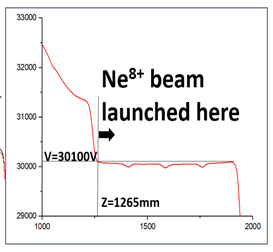
❖ Ne^{8+} extraction simulation

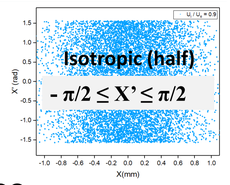
- Initial Ne^{8+} beam conditions



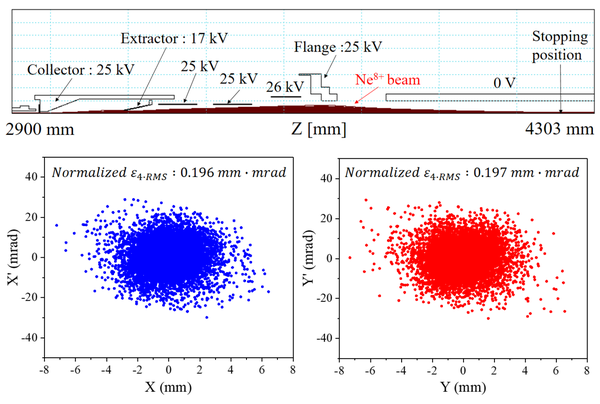




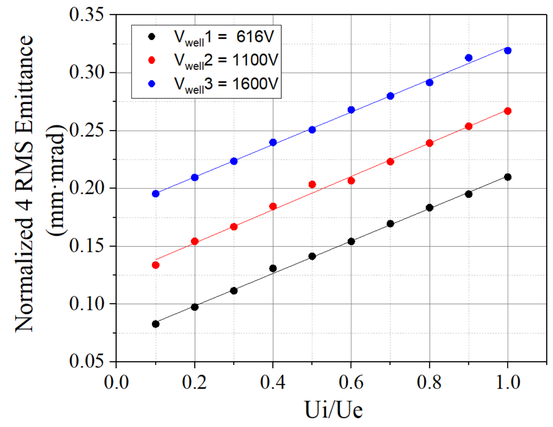




- Ne^{8+} extraction results



- Extracted Ne^{8+} beam emittance

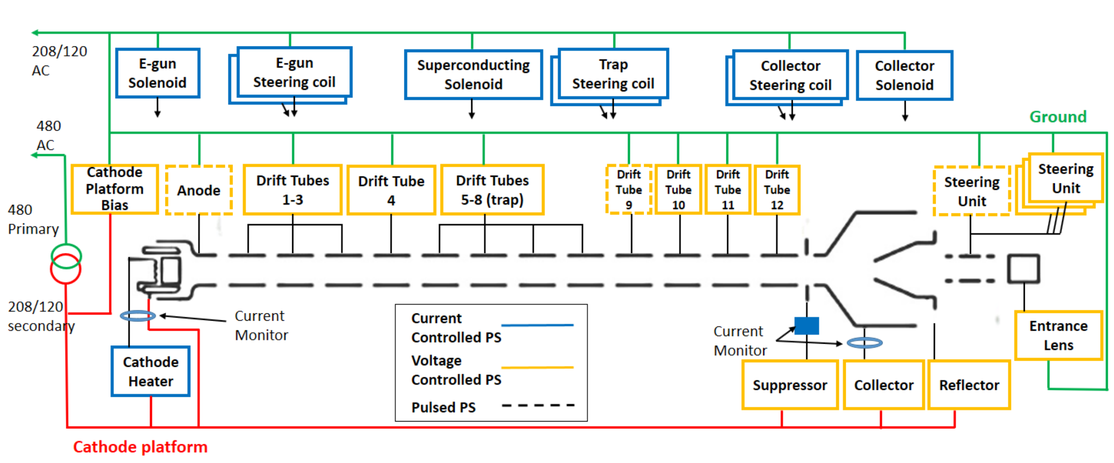


In Ref [2], normalized rms emittance values for 1-3mA extracted ion beams have been in the range of 0.08-0.1 π mm· mrad. (TestEBIS, BNL)

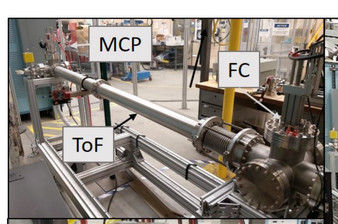
[1] R.E. Marrs / Nucl. Instr. and Meth. In Phys. Res. B, 149, 182-194 (1999)
[2] E. N. Beebe et al., Journal of Physics: Conference Series 2, pp. 164–173 (2004)

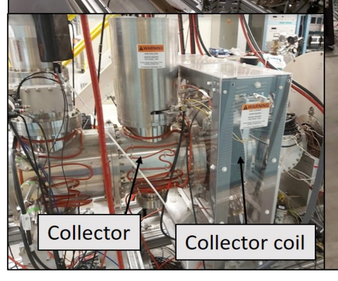
❑ Power supplies and high-voltage schematic, and plans for electron-beam commissioning

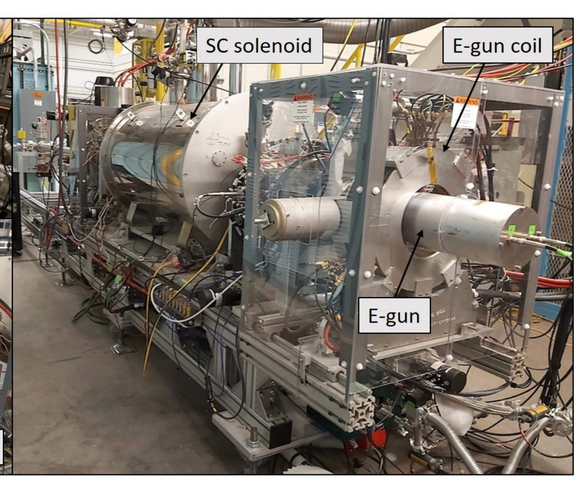
- Power supplies and platform schematic



- Photos of HCEBIS charge breeder and sub-system







- The assembly of the HCEBIS has been completed from the electron gun to the corrector with the diagnostic beamline.
- The power supplies, controls, and vacuum system have been implemented and being finalized respecting safety regulations and access procedures.
- The first electron beam commissioning and charge breeding test with residual gas are expected to be performed by the end of the calendar year.

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