Status of UNIST-EBIT and future research plan

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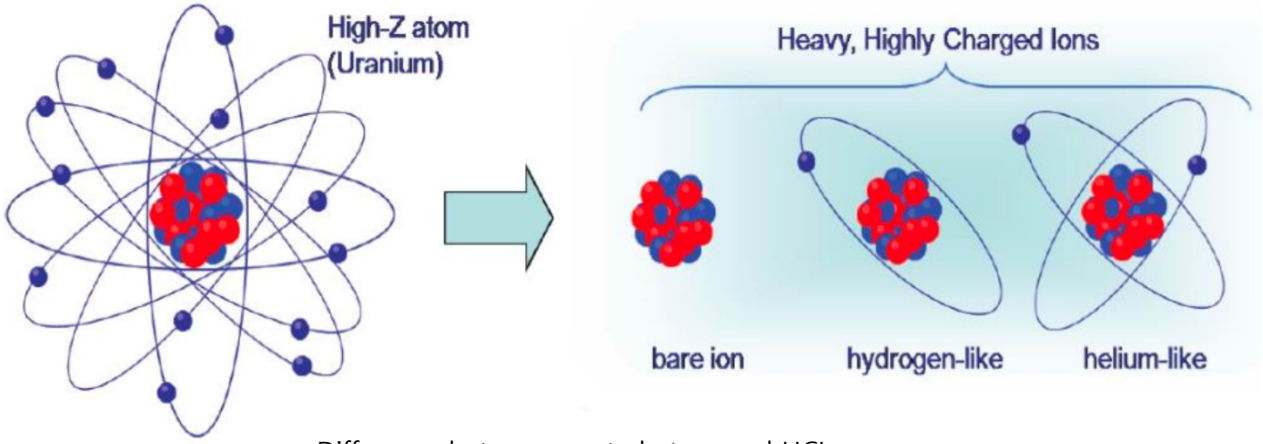
Outline

- Highly Charged Ion
- Electron Beam Ion Trap
- UNIST-EBIT
- Future plan

Highly Charged Ions

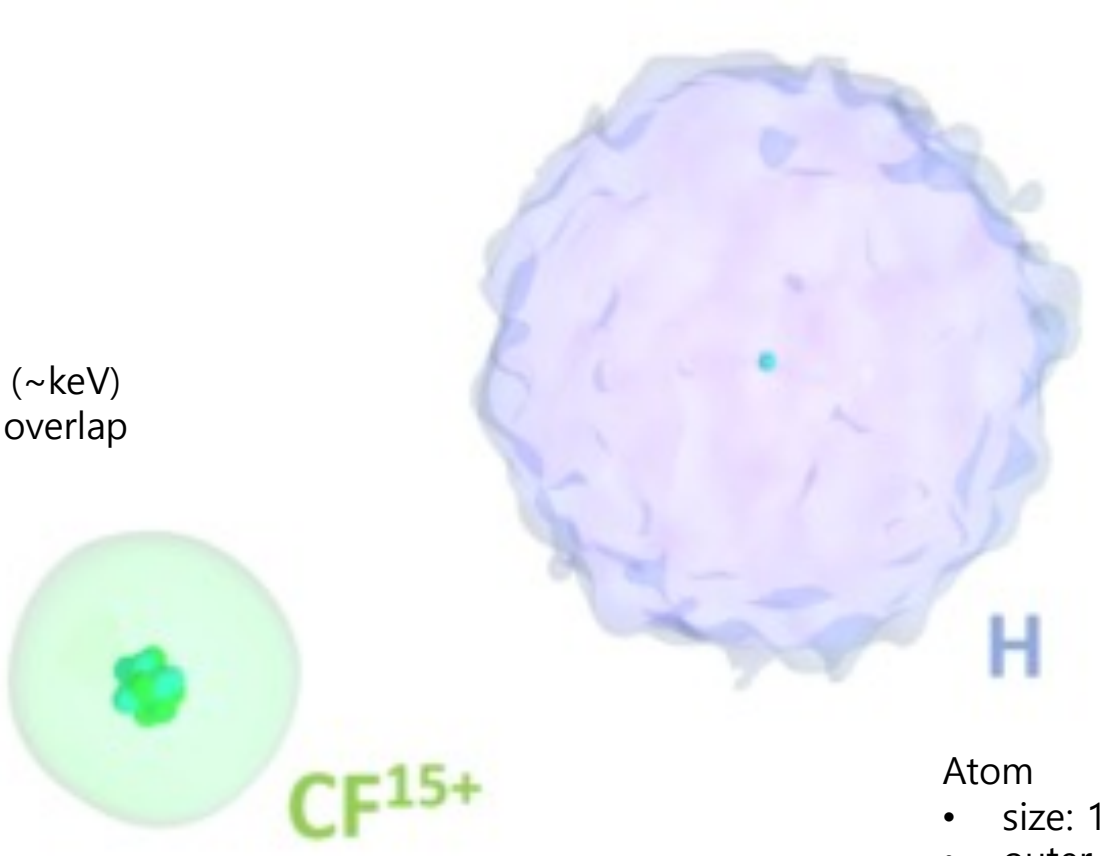


Difference between neutral atom and HCIs

- Atom loses many electrons at high temperatures due to ion-electron collisions.
- Highly Charged Ions (HCIs) constitute a dominant fraction of the visible matter in stars, supernovas, stellar corona, and accretion disks.
- HCIs might have applications in atomic clocks and more accurate measurements of fundamental physical constants.
- Electron Beam Ion Trap (EBIT) is a good laboratory instrument to create, trap, and probe HCIs.

Highly Charged Ions

HCI
- size: few pm
- positive charge
- strongly electron bound (~keV)
- strong electron-nucleus overlap



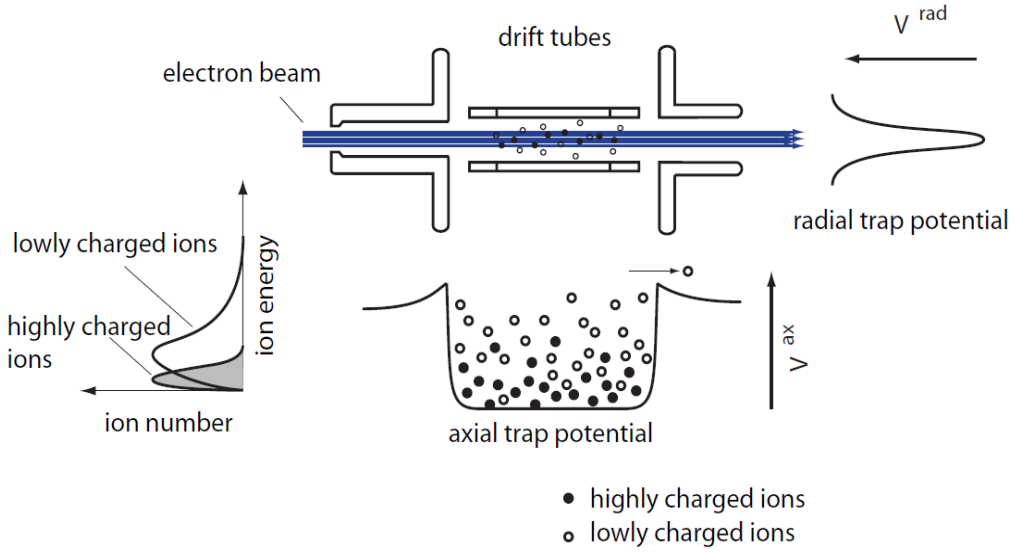
Highly charged CF 15+ and H

Atom
- size: 100 pm
- outer electron weakly bound (~10eV)

What is EBIT?

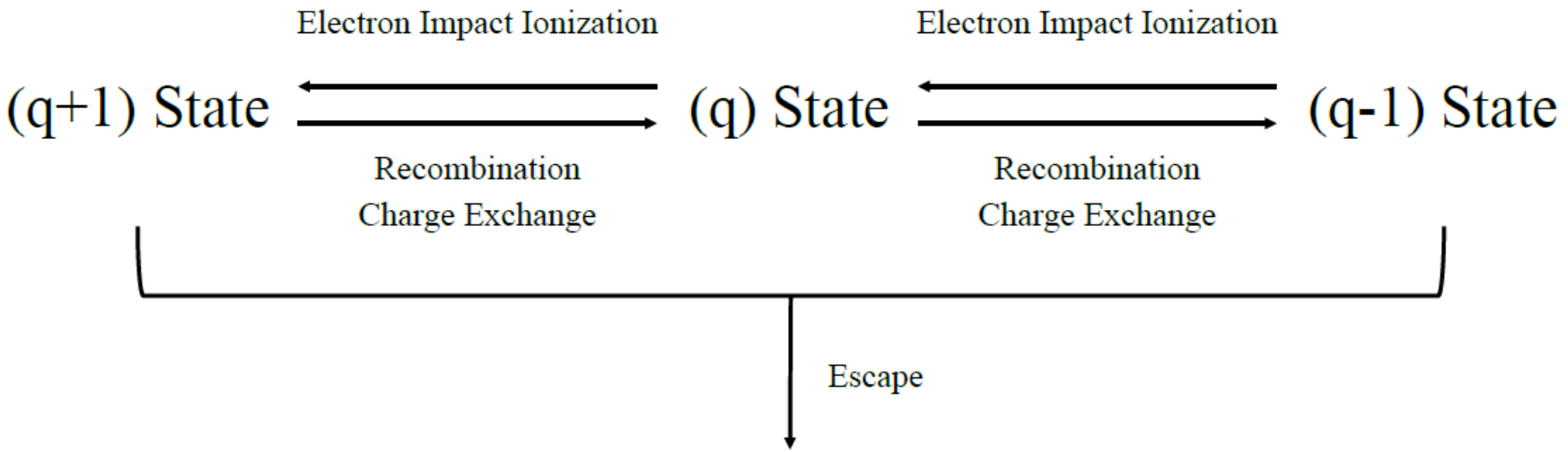
Electron Beam Ion Trap (EBIT)

- Compact in size and can produce uniform and steady-state HCI plasmas
- Selective charge state production by electron beam energy
- Easy detection in trap region by using Helmholtz or permanent magnets



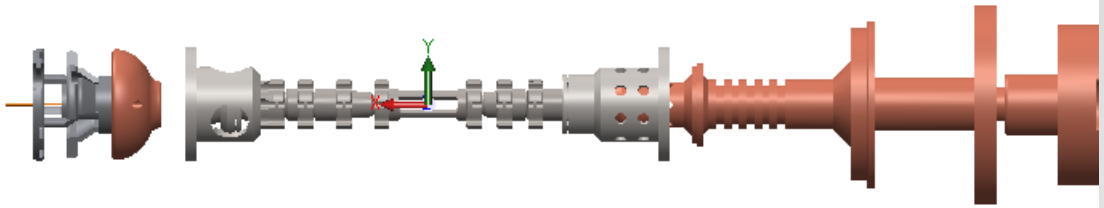
Potential of EBIT [1]

What is EBIT?

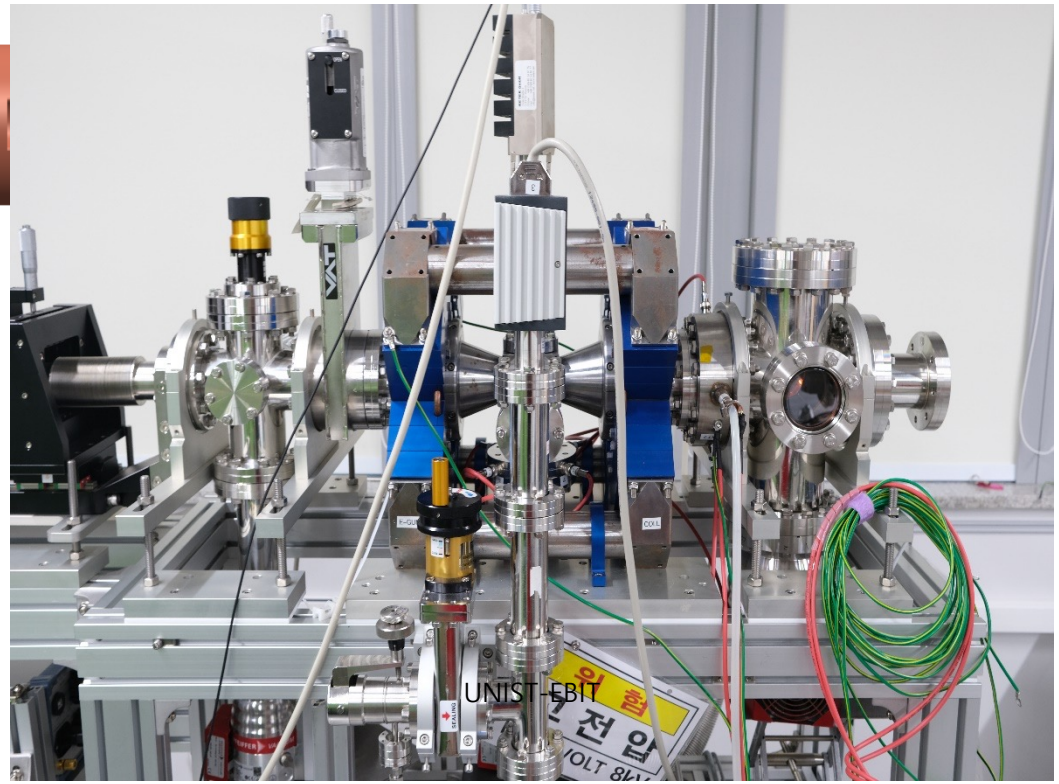


q state will be estimate with Electron Impact Ionization, Radiative Recombination, and Charge Exchange.

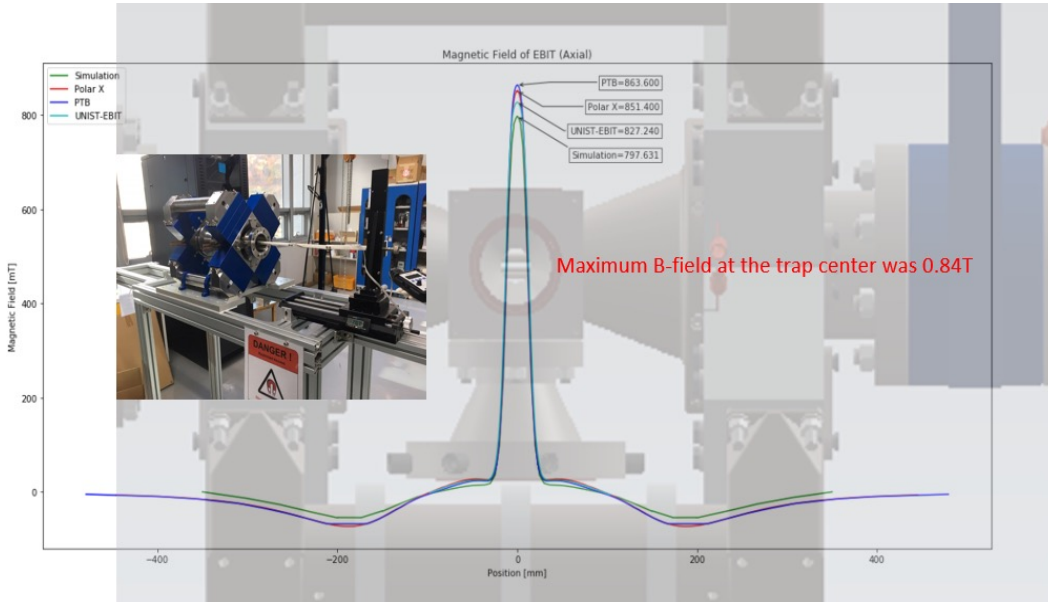
UNIST-EBIT



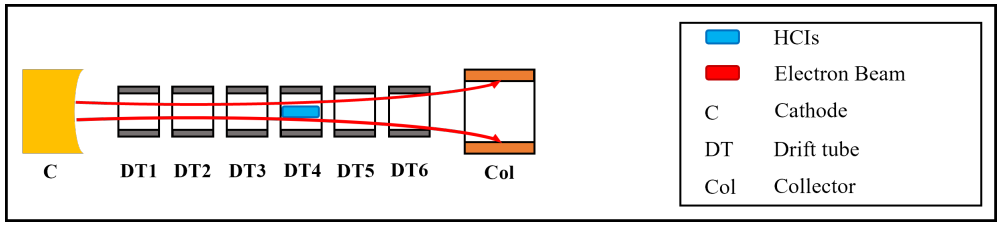
- Compact tabletop device
- Tunable electron beam energy up to 8keV
- Use 72 permanent magnets, soft iron/magnetic yoke
- 0.84T at trap center
- Electron beam current up to > 80mA
- Excellent optical access, opening angle of 58 degree



UNIST-EBIT



Magnetic Field inside the EBIT

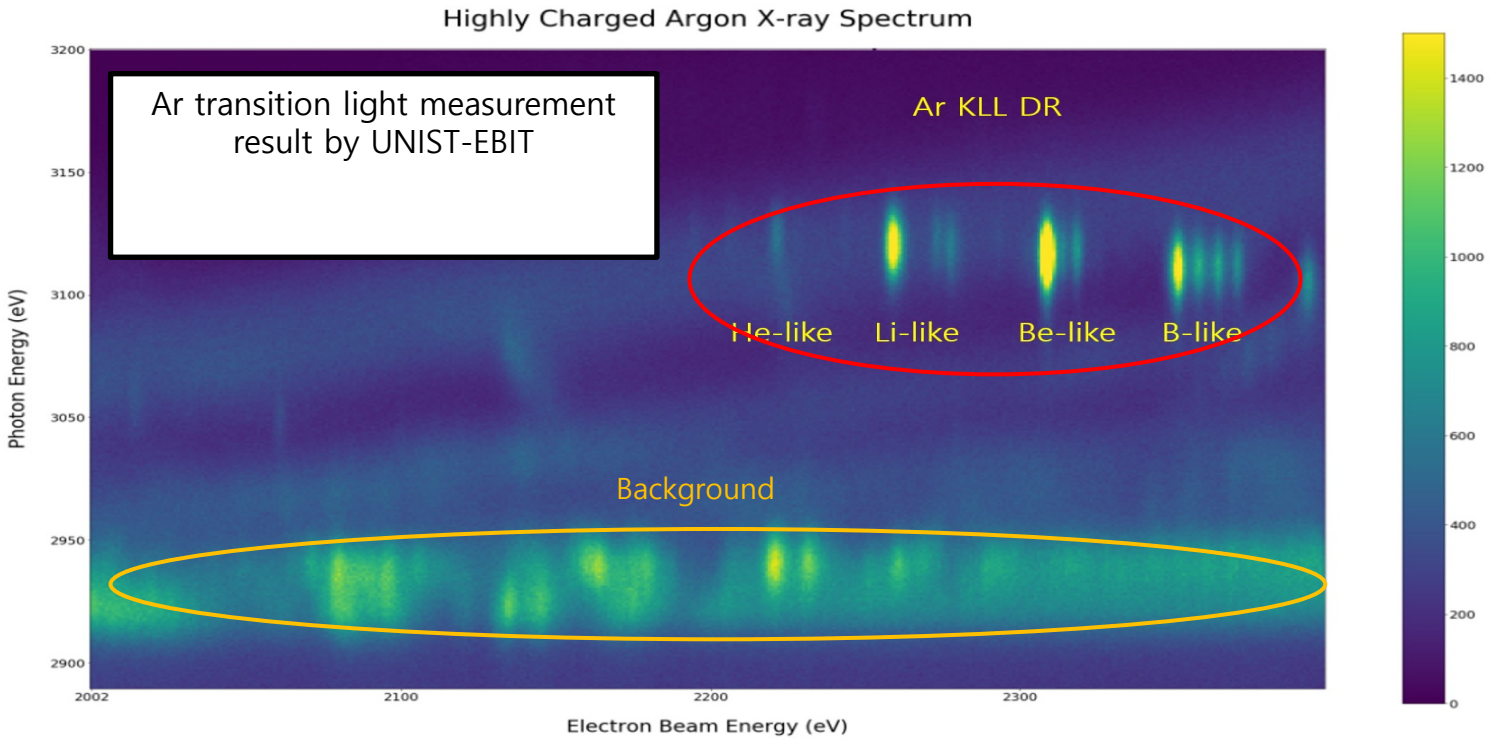


Schematic of UNIST-EBIT

- Maximum at the trap center
- No magnetic field at e-gun

Electron beam radius minimized at trap center by magnetic field

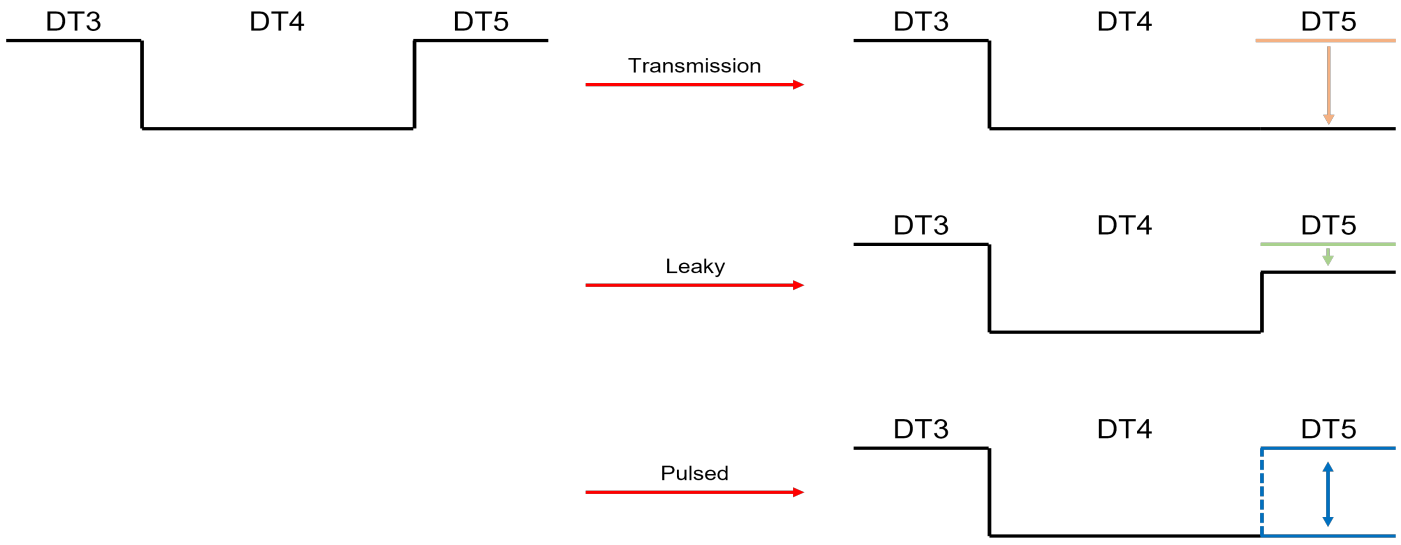
UNIST-EBIT



- With the observation of KLL dielectronic recombination lines, we can specify the charge state of the argon.
- Create up to He-like argon ions

Plan

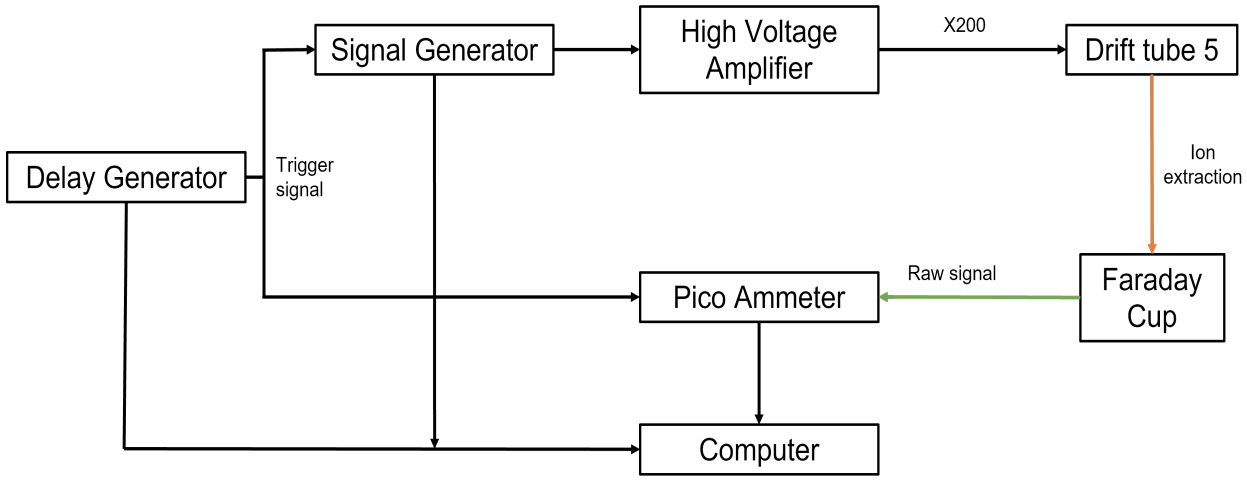
HCIs extraction



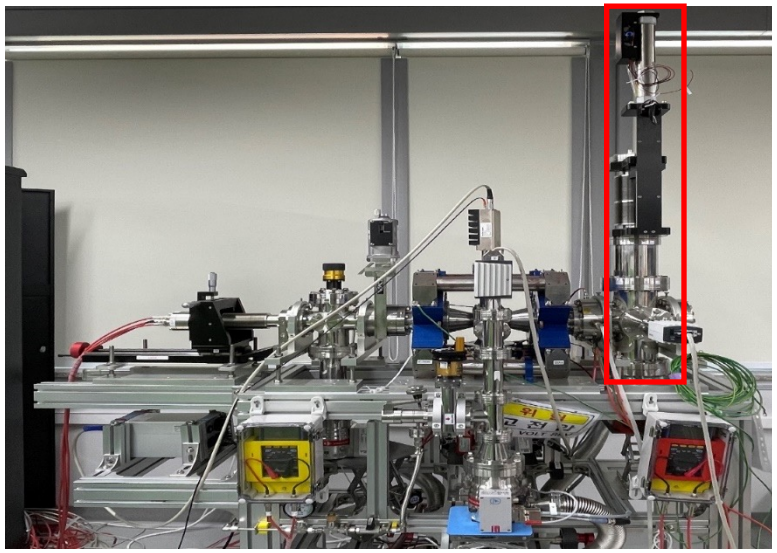
Electrical scheme of extraction mode

- Three extraction modes; Transmission, Leaky, and Pulsed mode.[2]
- Ar HCIs and residual gas constitute a current of 550 pA (continuous).
- Residual gas current is 320 pA (continuous).

Plan



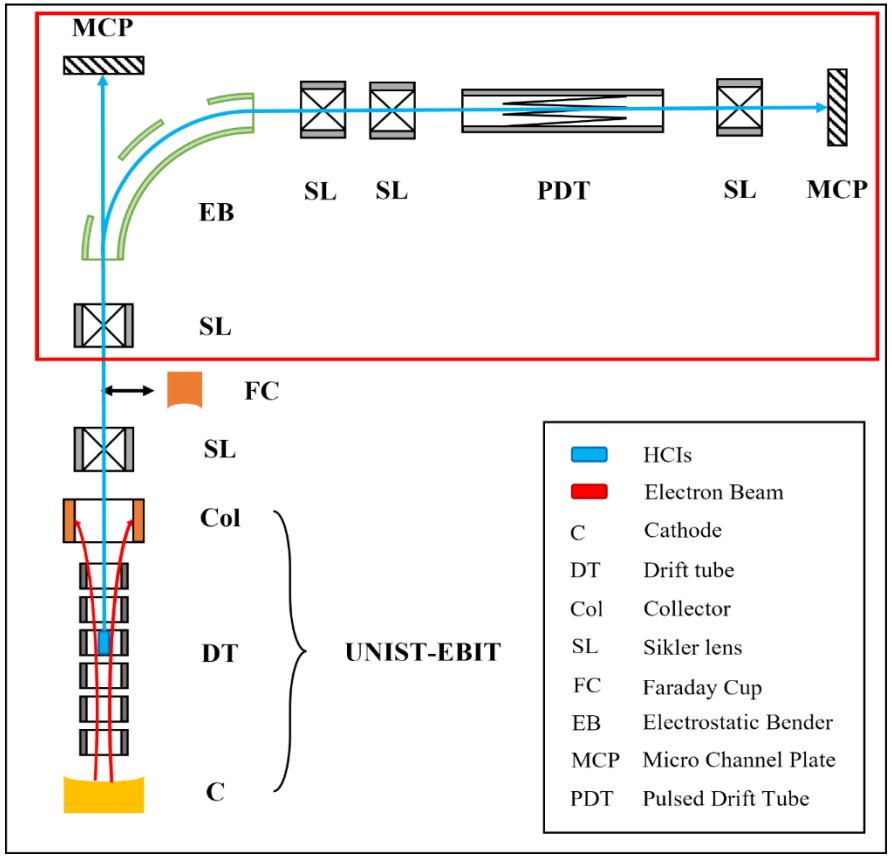
Scheme of measuring the total current of HCIs



UNIST-EBIT with Faraday cup

- Establish the total automatic control system with EPICS.
- Measure the total current of HCIs with a faraday cup.

Plan



Scheme of UNIST-EBIT Upgrade

- We plan to use pulsed mode to offer lower A/q up to iron.
- Accumulate the HCI pulses to measure the current.
- Sikler lens is used for focusing and steering HCIs.[3]
- Electrostatic Bender is used for charge separation.
- UNIST-EBIT extraction beamline will provide a specific charge state with the specific energy needed for other applications.

References

[1] Zschornacka, G., M. Schmidt, and A. Thorn. "Electron beam ion sources." arXiv preprint arXiv:1410.8014 (2014).

[2] P. Micke et al., Rev. Sci. Instrum. 89, 063109 (2018).

[3] M. K. Rosner, “Production and preparation of highly charged ions for retrapping in ultra-cold environments,” M.S. thesis, Ruprecht-Karls-Universität Heidelberg. (2019).