Hyper-EBIT

A source for heavy highly charged ions

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Motivation

- Highly charged ions : used to test strong field QED
- These QED effects can be observed through:

1. Lamb shift
2. Hyperfine splitting
3. ***g* factor**

In heavy ion regime $Z\alpha$ approaches unity.

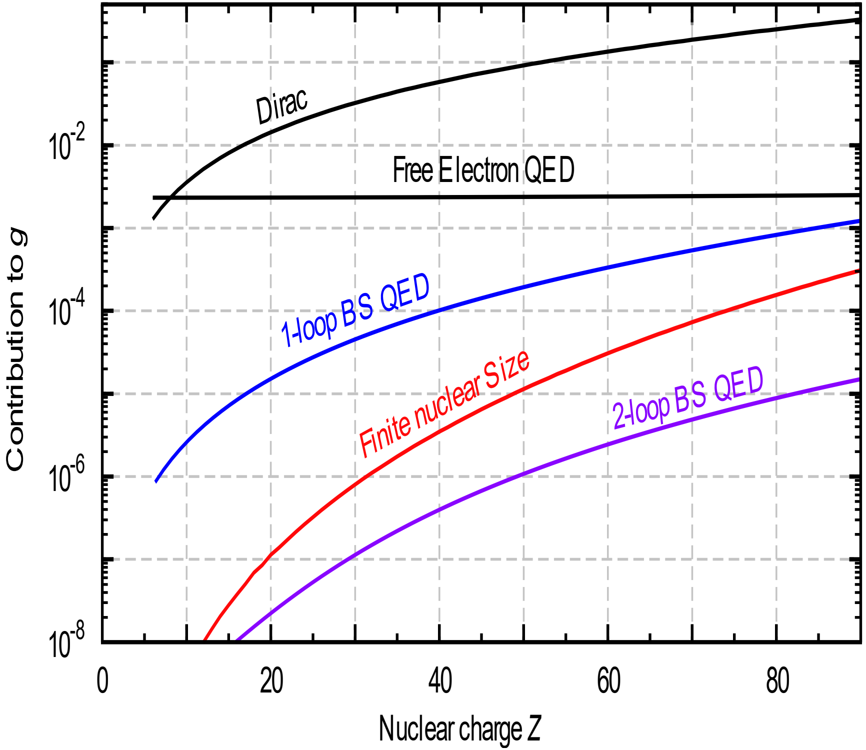

Fig.1: Contributions to the g-factor of the bound electron in hydrogen like ions

- So far *g* factor of Sn^{49+} was measured at ALPHATRAP.

J. Morgner, et al.,
Nature 622, 53–57 (2023)

- Pb is stable, doubly magic and nuclear properties have been thoroughly studied.
- Ionization energy of Pb^{81+} is around 100 keV.

→ EBIT

Collaboration with
Jose Crespo

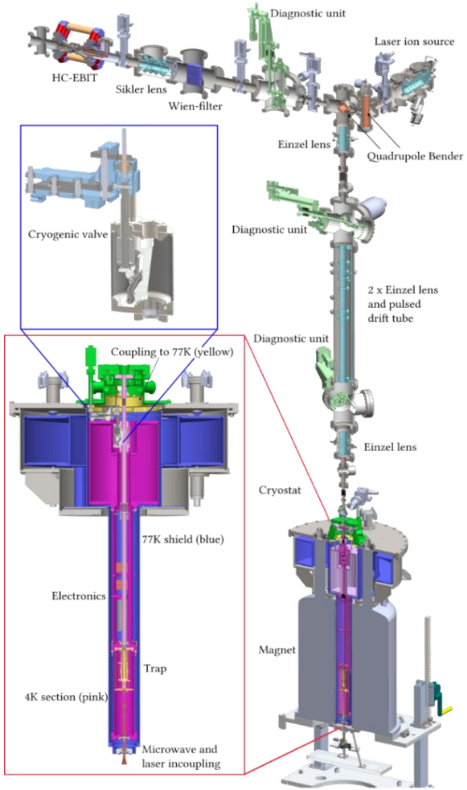

Fig. 2: ALPHATRAP beamline

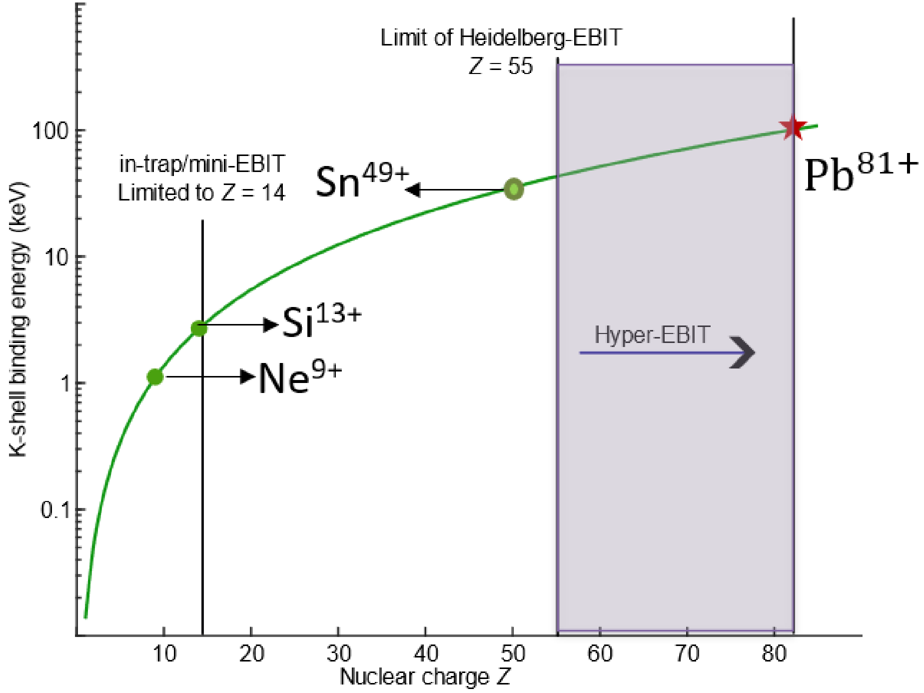

Fig. 3: Binding energy as a function of nuclear charge

Heidelberg EBIT can only go up to 65 keV.

Electron Beam Ion Trap

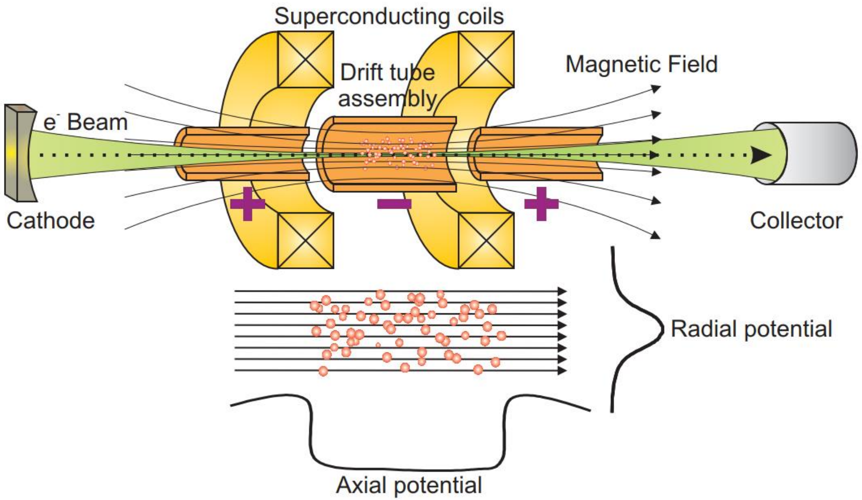

Fig.4: Schematic of an EBIT[2]

- Device for producing highly charged ions[1].
- Uses magnetically compressed electron beam to perform sequential ionization.
- Radial trapping: Magnetic field as well as space charge of electron beams
- Axial trapping:
  Appropriate biasing of drift tubes

[1] Currell, F., & Fussmann, G. (2005). Physics of electron beam ion traps and sources. IEEE Transactions on Plasma Science, 33(6), 1763-1777.
[2]Bruhns, H. (2005). High precision x-ray spectroscopy on highly charged argon ions (Doctoral dissertation).

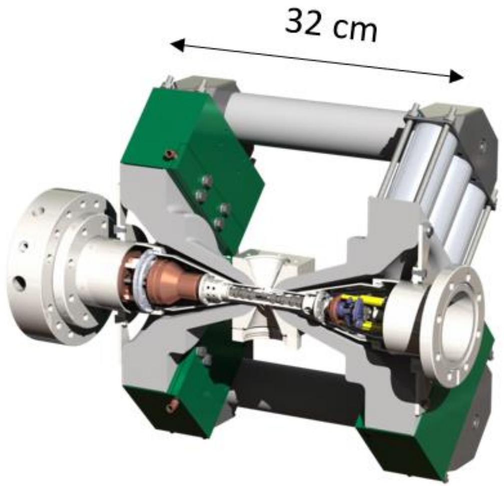

Fig.5: Schematic of mini EBIT

- Operates at room temperature
- Beam energy: 8 keV
- Beam current: 10 mA

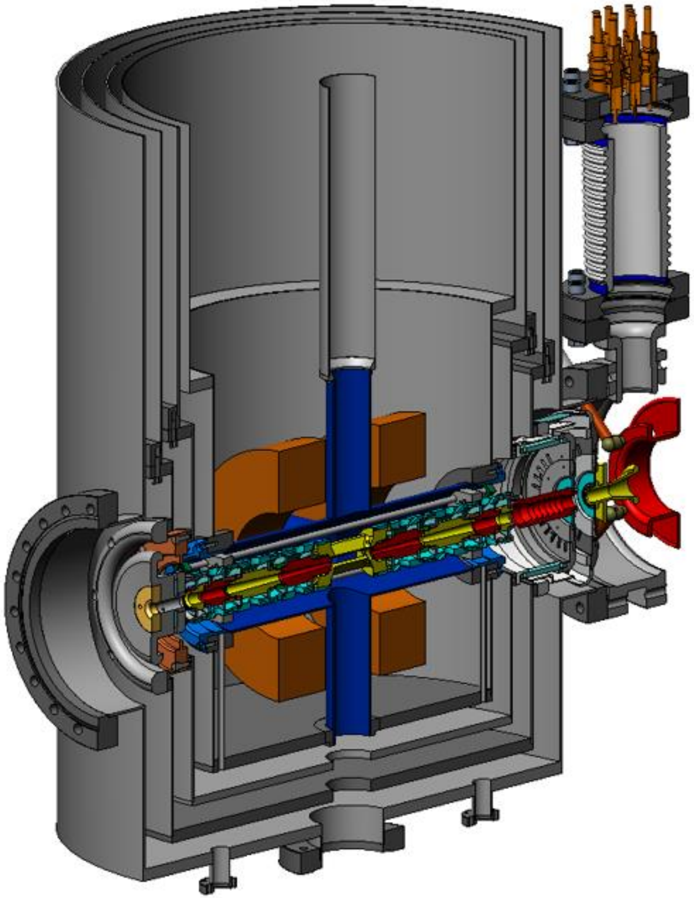

Fig.6: Schematic of Heidelberg EBIT

- Cooling involves cryogenic liquids
- Beam energy: 65 keV
- Beam currents: 450 mA

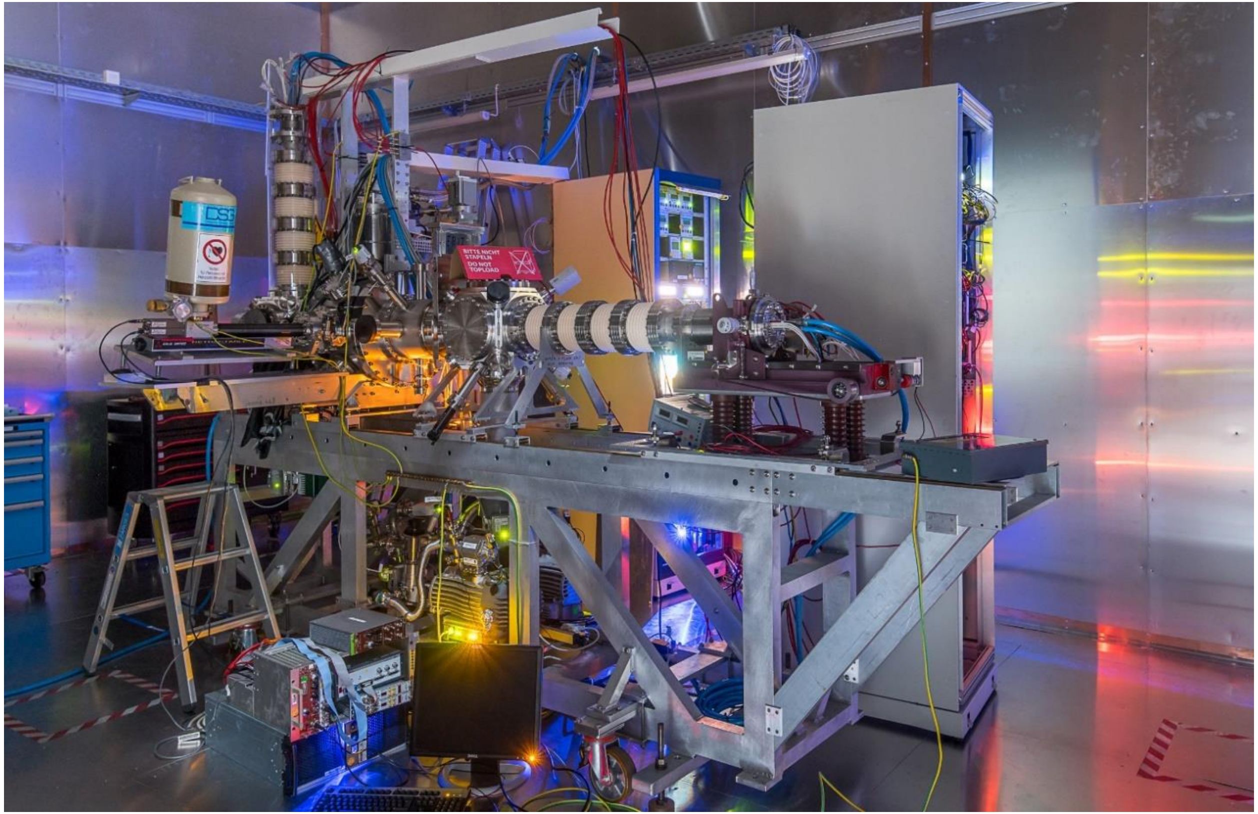

Fig. 7: Existing Hyper-EBIT setup

- First commissioning of Hyper EBIT after long shut down.

- Produced highly charged Argon to test the components.

Bachelor thesis
Simon Marcus Heidrich

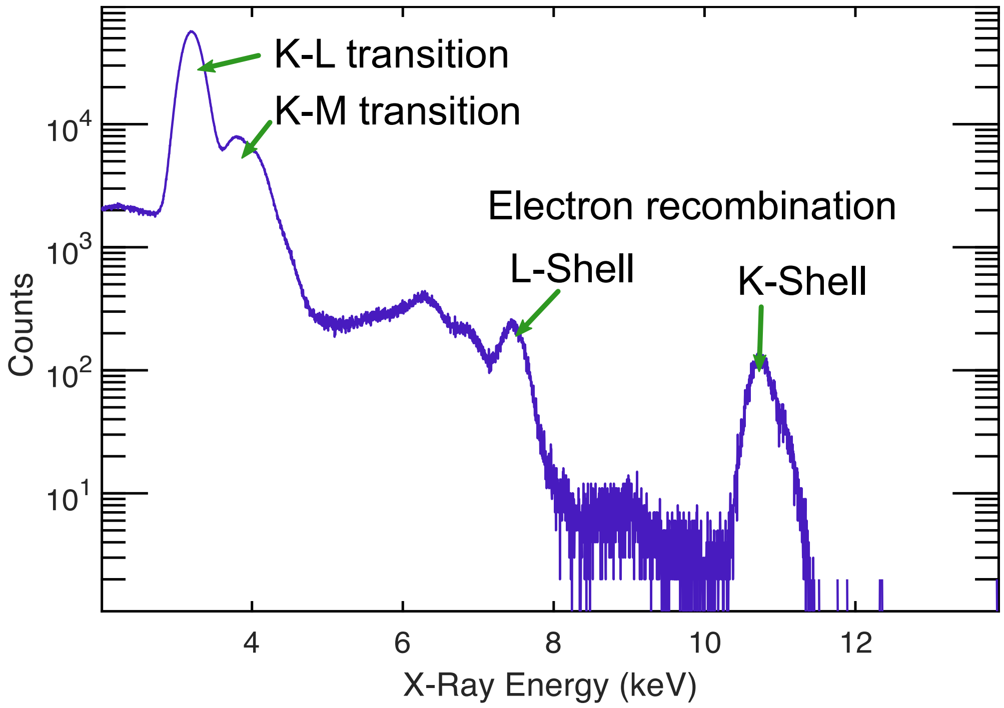

Fig. 8: X-ray spectrum of Argon

Hyper-EBIT: An overview

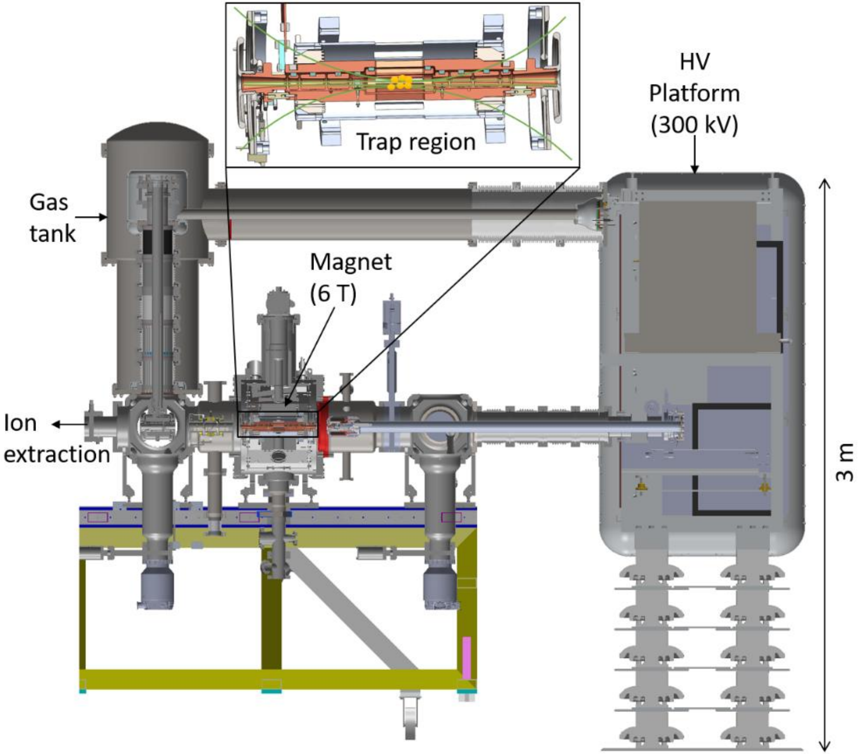

Fig.9: Section view of Hyper-EBIT

Planned specifications:

Beam energy: 300 keV

Beam current: 500 mA

Ongoing projects

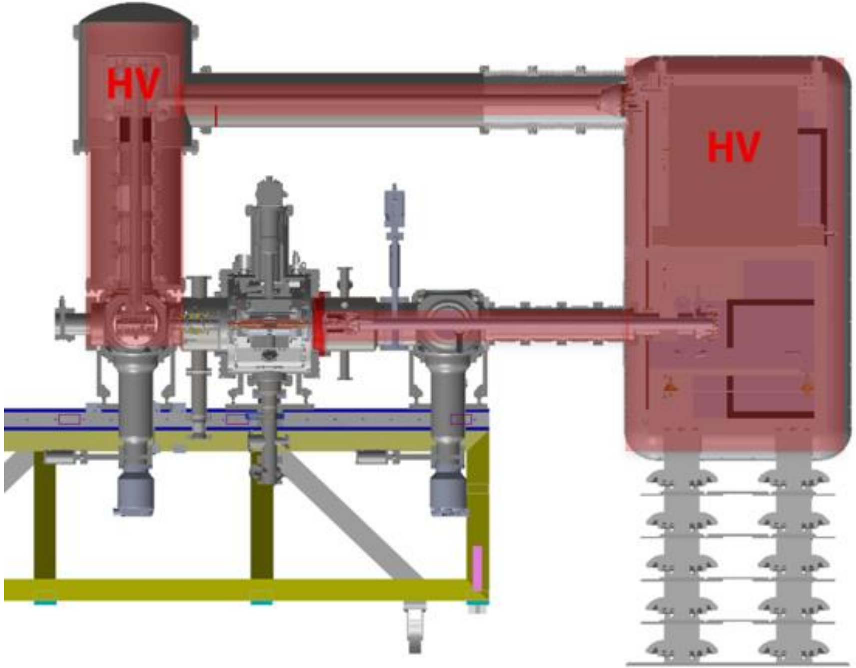

Fig.10: Proposed model of gas tank and HV platform

- Design completed for HV platform as well as the gas tank.
- It is currently being manufactured.

High voltage protection

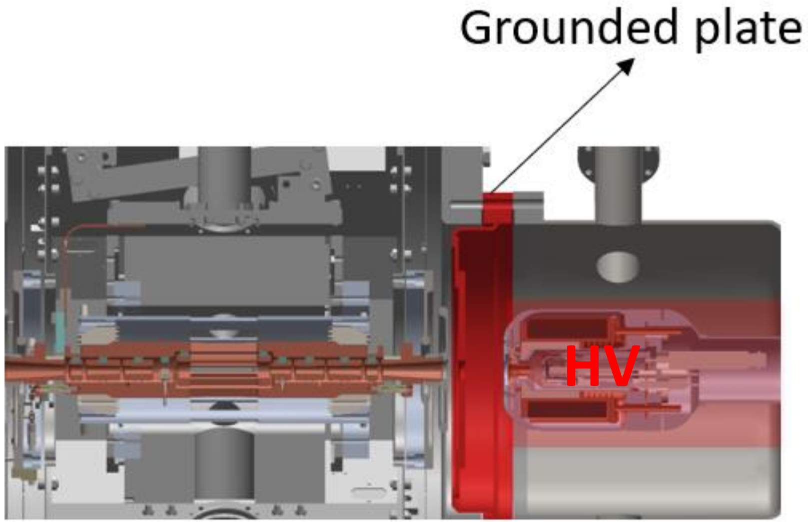

Fig.11: Magnet protection by ground plate

Fig.12: High voltage Faraday cage laboratory

A grounded plate is inserted between the gun and drift tubes to avoid the breakage due to electrical sparks.

Radiation protection

- Bremsstrahlung- Electromagnetic radiation that is produced when accelerating or decelerating charged particles.
- X-rays are emitted.
- Lead is the best solution due to high density (11.34g/cc) making it an effective barrier.
- Insulators cannot be covered in lead due to conductivity problems of the high voltage.
- Lead glass is used.

Simulation results

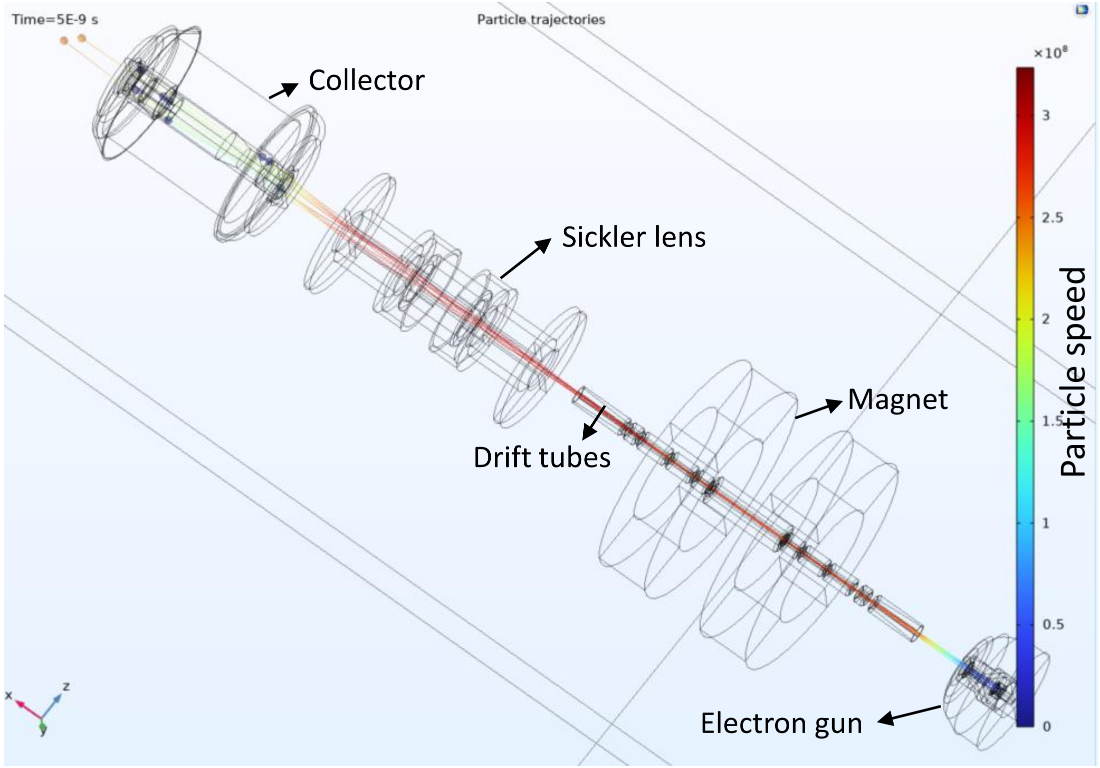

Fig.13: Path of electrons inside Hyper-EBIT

- Electrons are initially accelerated.
- Ions and electrons are guided by the electromagnetic fields.
- Due to high potential on the collector, they decelerate and electrons are collected by the collector .
- The simulation was done in order to study electron beam interaction with ions.

Achieved

- EBIT was moved to new laboratory
- Repaired the broken components
- First operation tests
- Design of HV cage and gas tank completed

To-do

- Upgrade the drift tube set up
- Test HV stability
- Radiation protection
- Interlock system for human safety

Thank you for your attention

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HITRAP

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