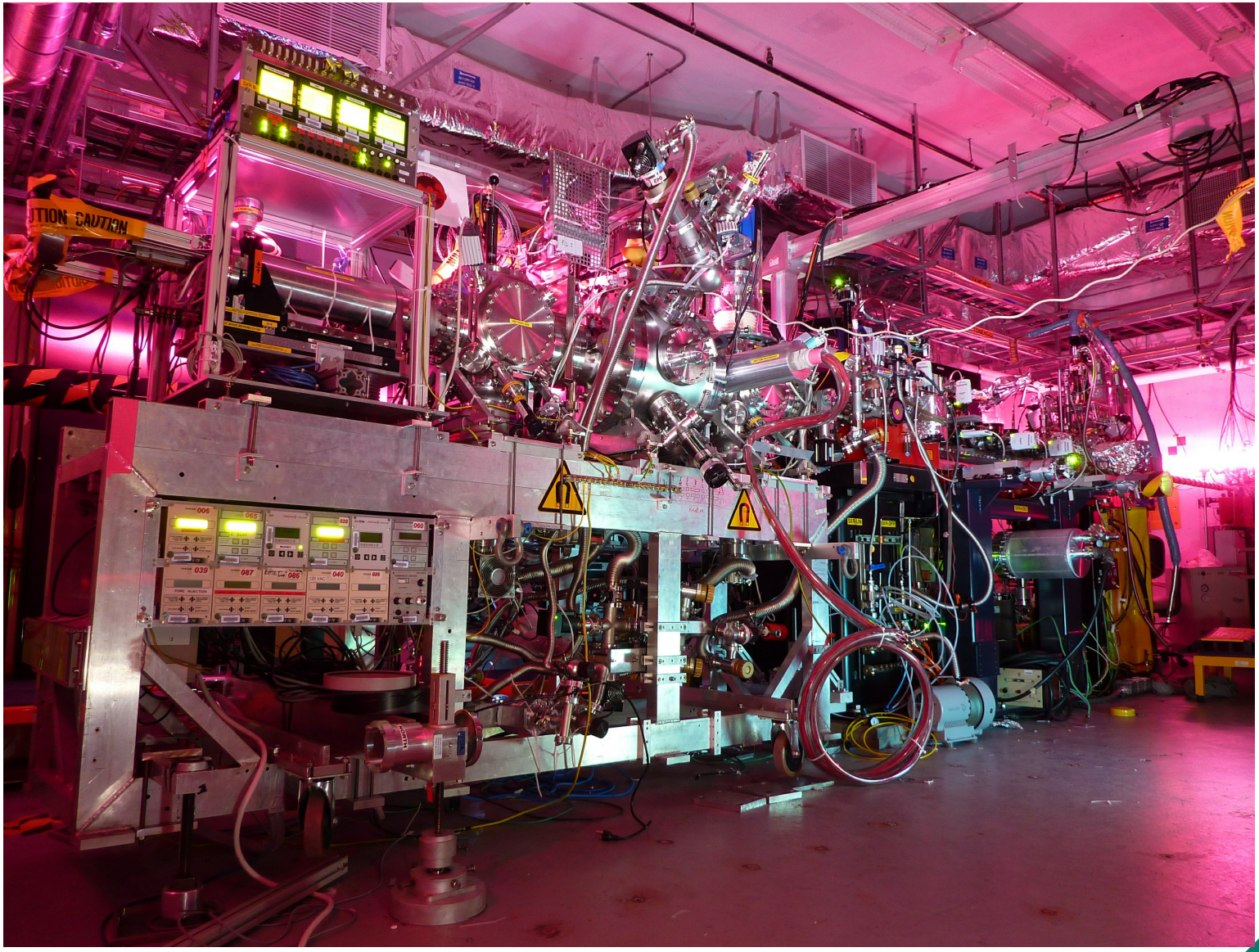
MAX-PLANCK-INSTITUT FÜR KERNPHYSIK

A new electron beam ion source as charge breeder for rare isotope beams at TRIUMF

Stepan Dobrodey

EMILIE Workshop 2016

The Electron Beam Ion Source



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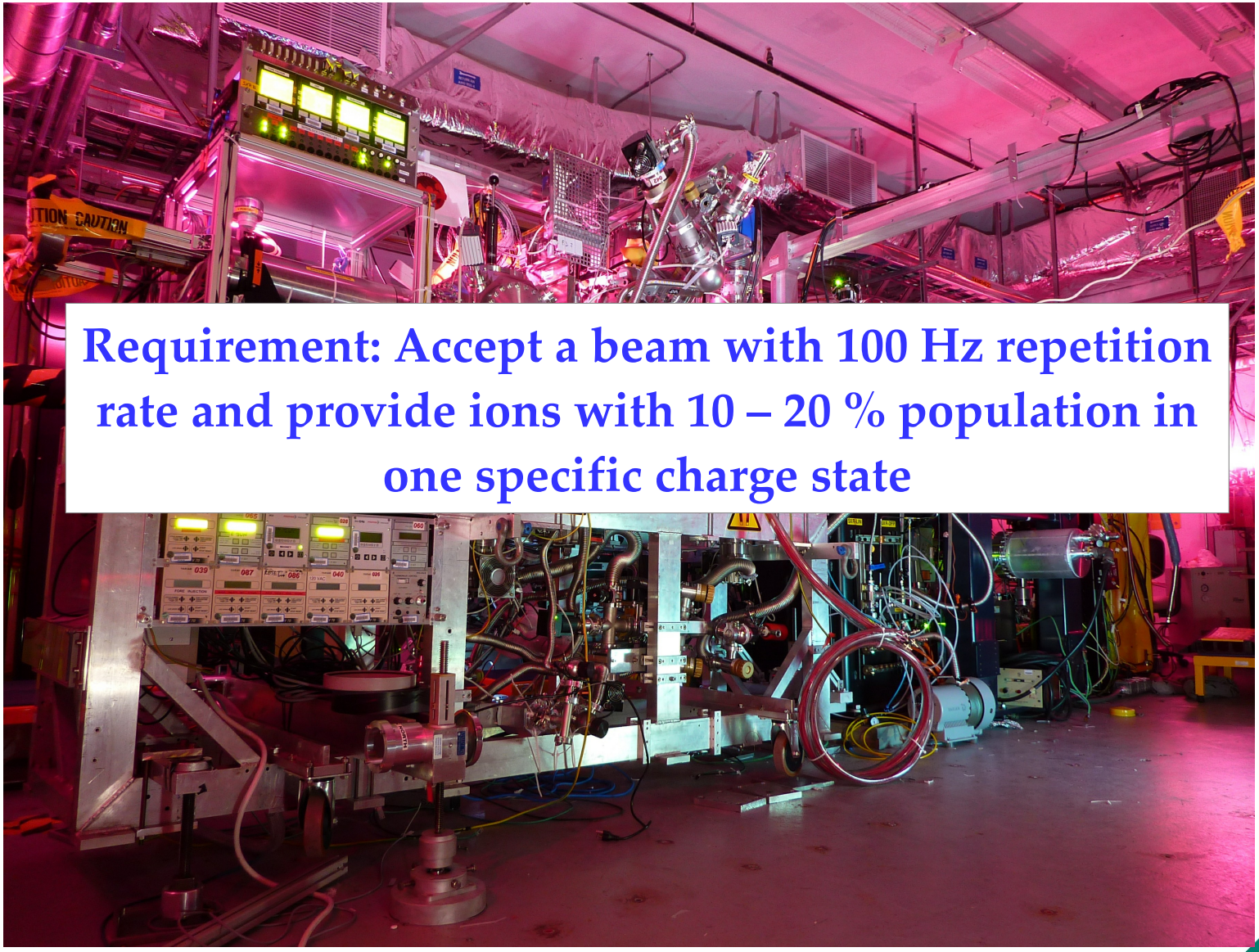
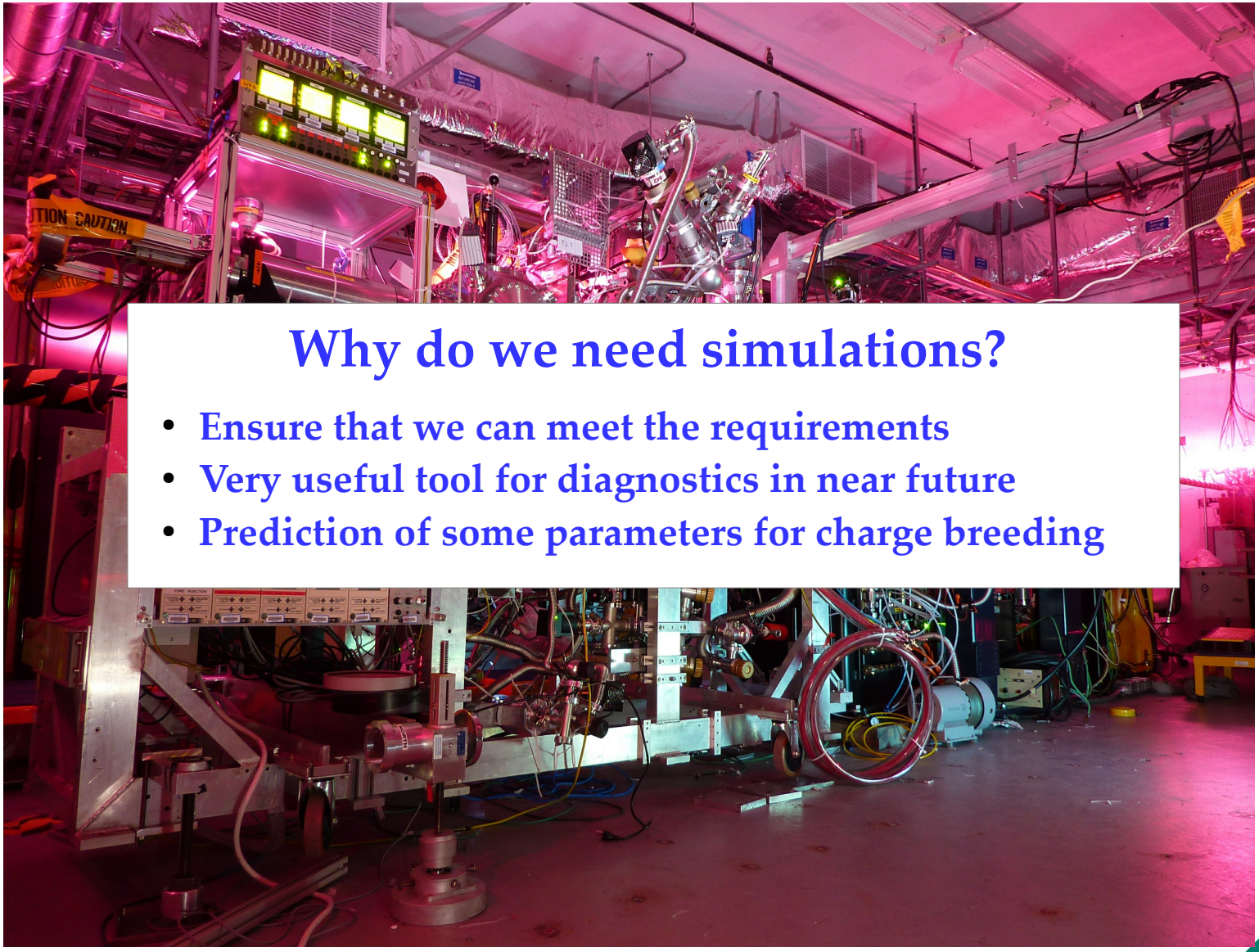


Requirement: Accept a beam with 100 Hz repetition rate and provide ions with 10 – 20 % population in one specific charge state

The Electron Beam Ion Source

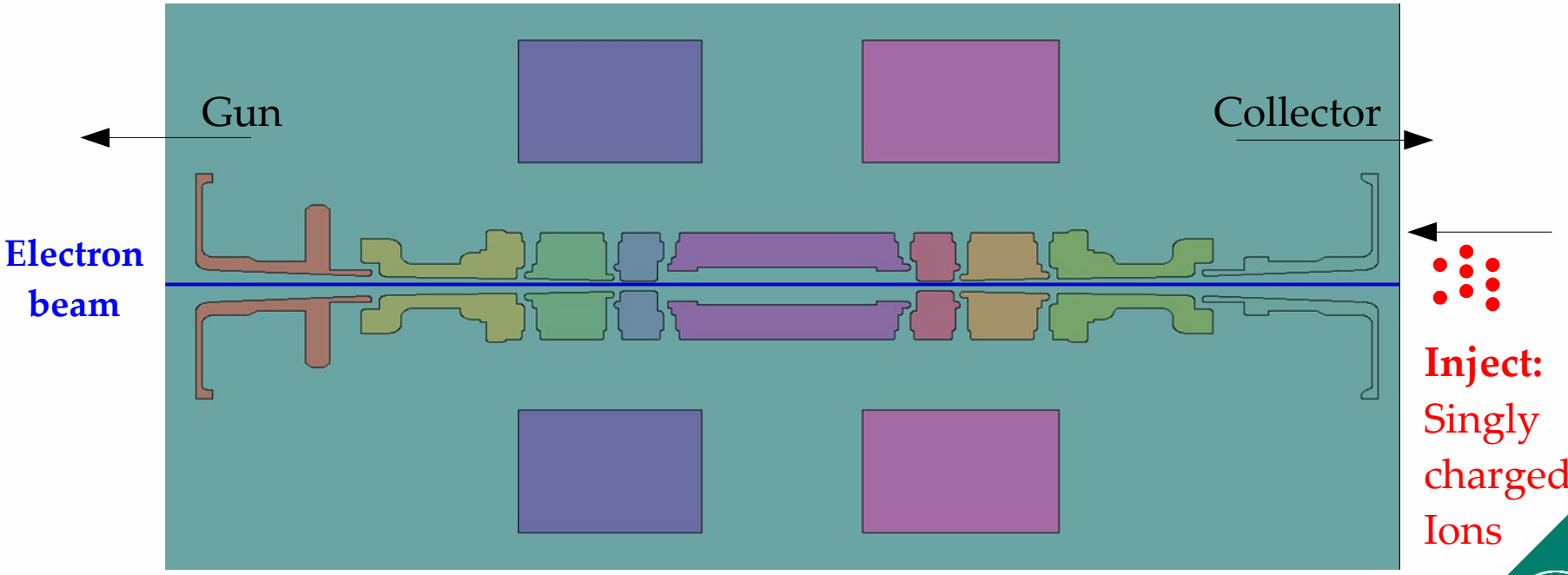


Why do we need simulations?

- Ensure that we can meet the requirements
- Very useful tool for diagnostics in near future
- Prediction of some parameters for charge breeding

Simulation Steps

1) Create electrostatic and magnetic fields with the finite elements method extracted from a 3D model of the EBIS
2) Simulate emission of electron beam and propagation into the trap
3) Obtain axial and radial space charge
4) Inject ions (include charge breeding during injection)
5) Extraction (work in progress)



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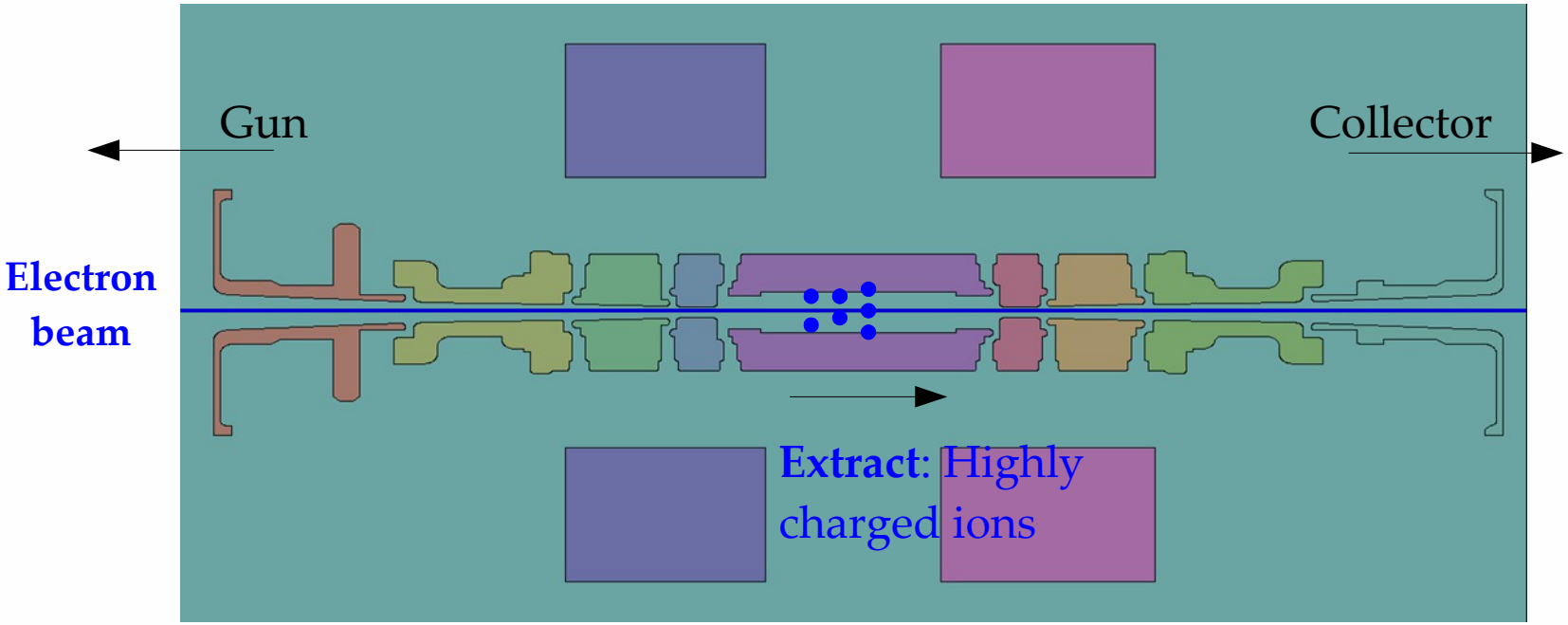
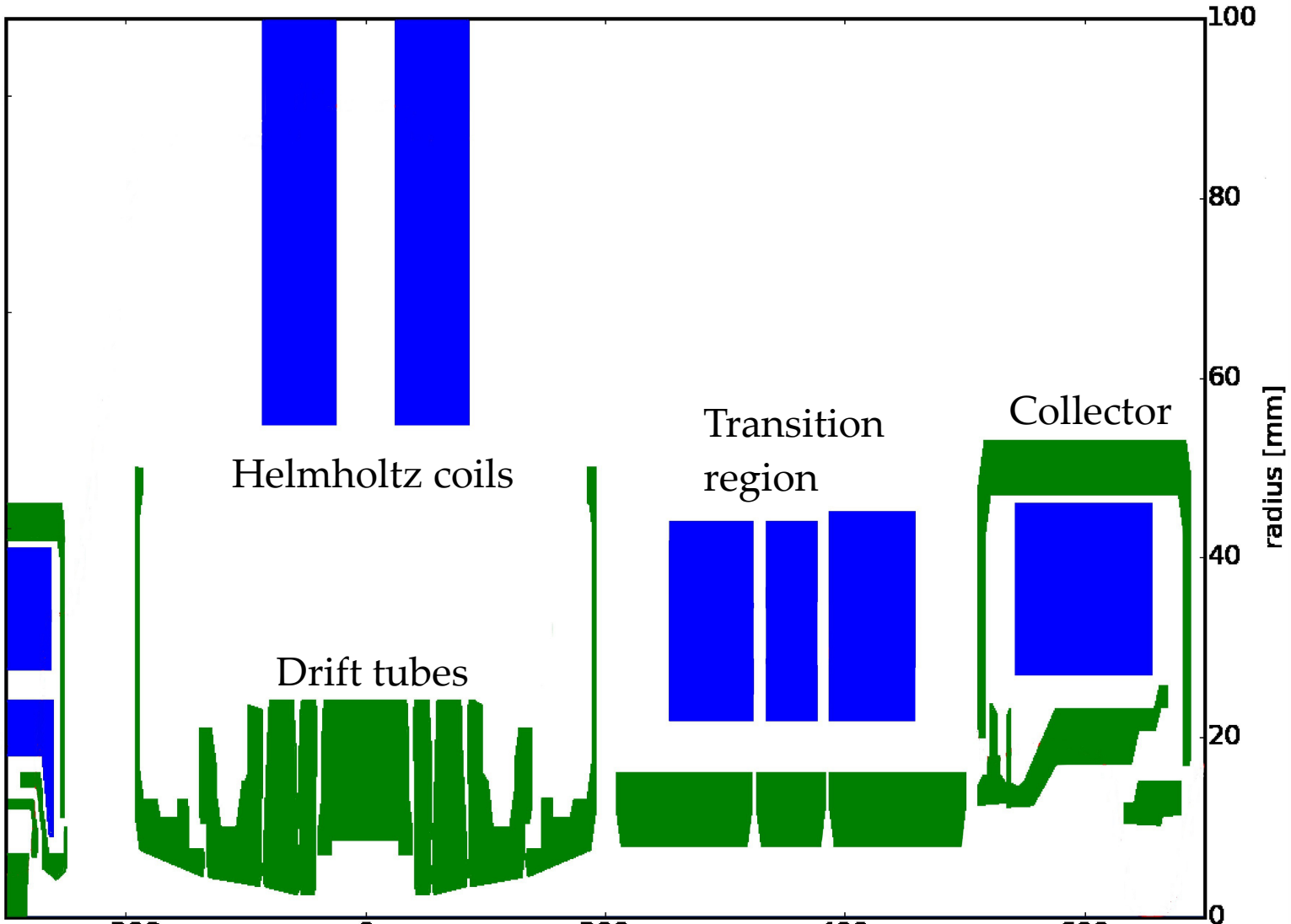


Electric and Magnetic Fields



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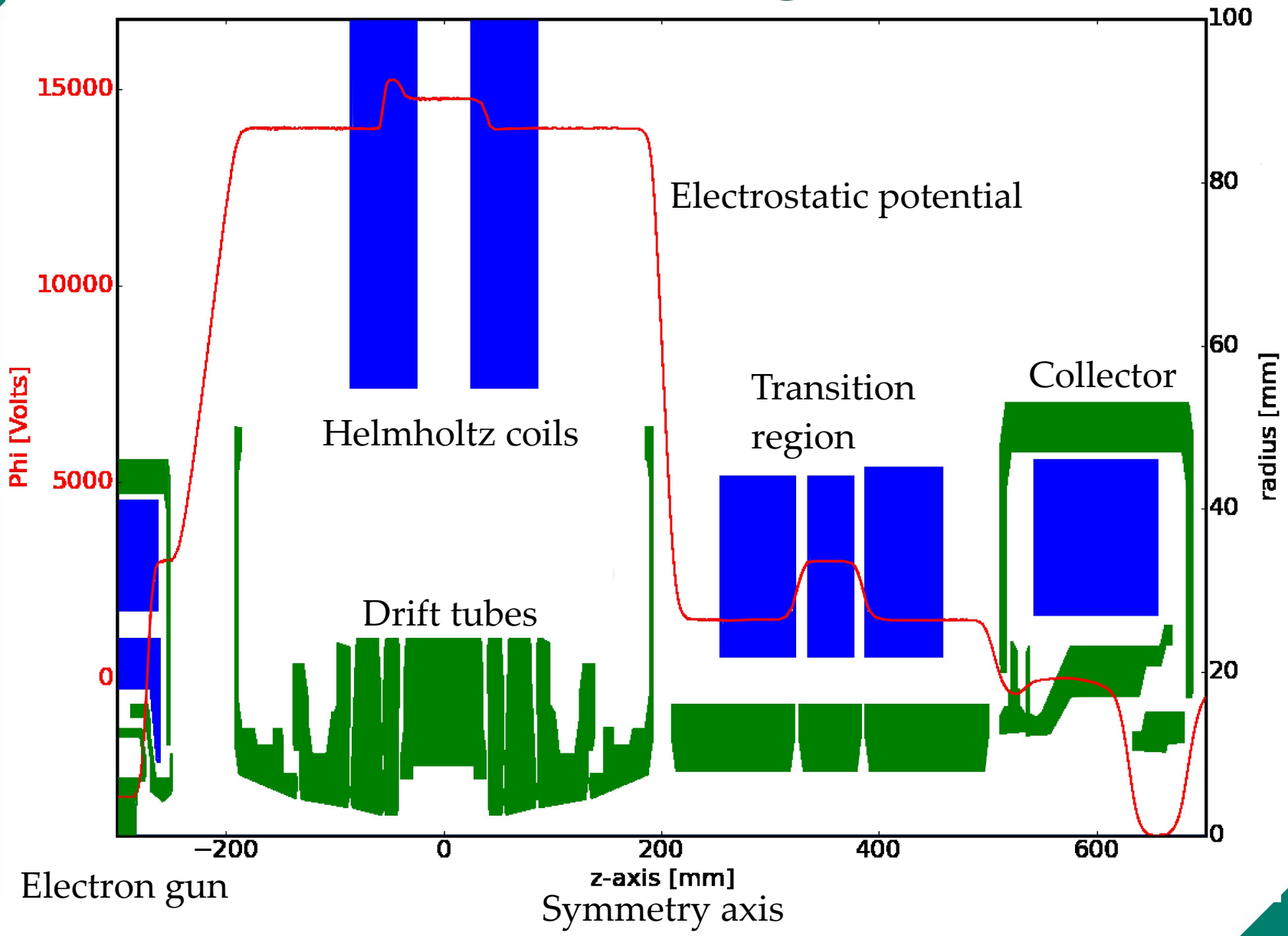
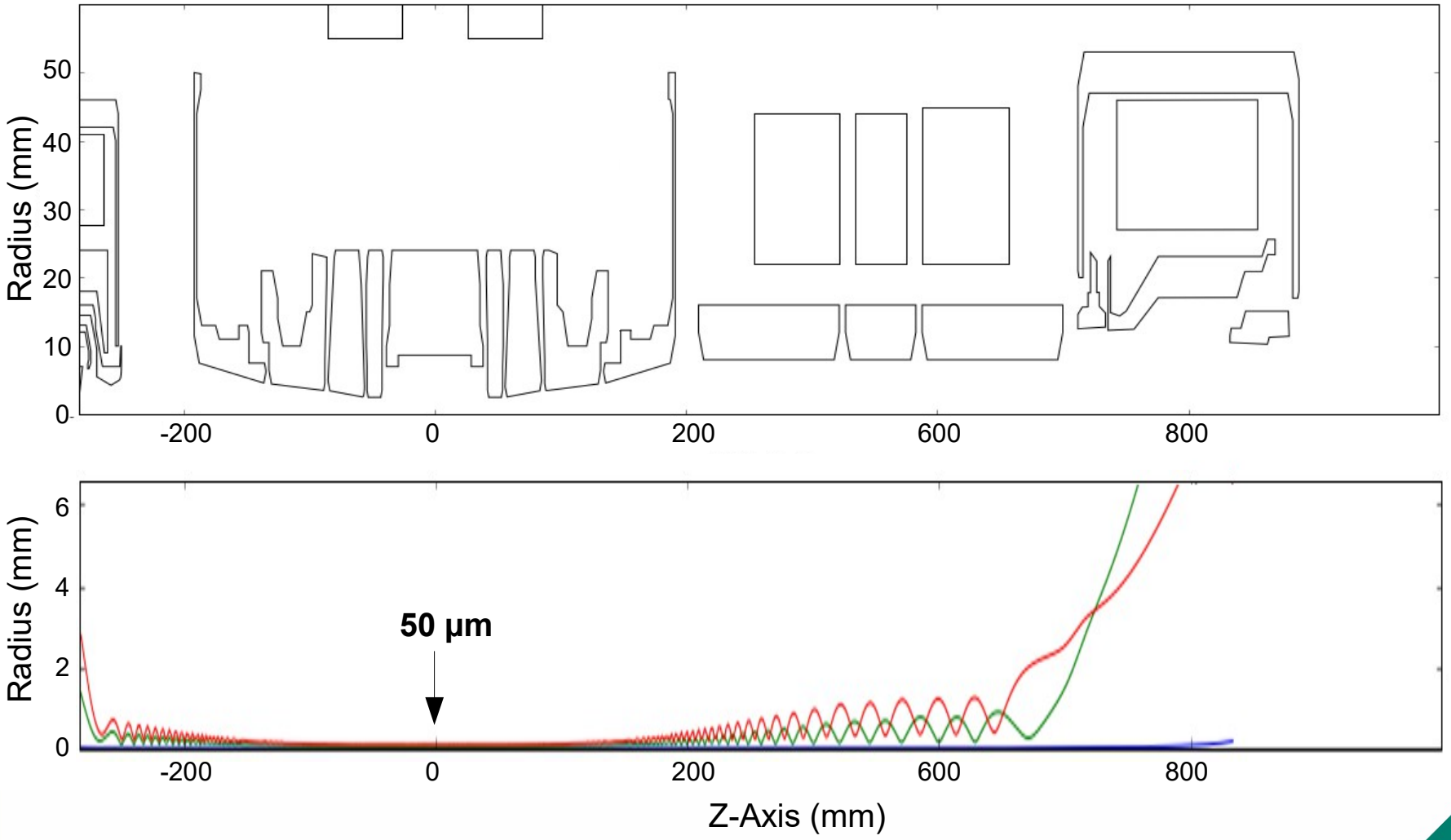


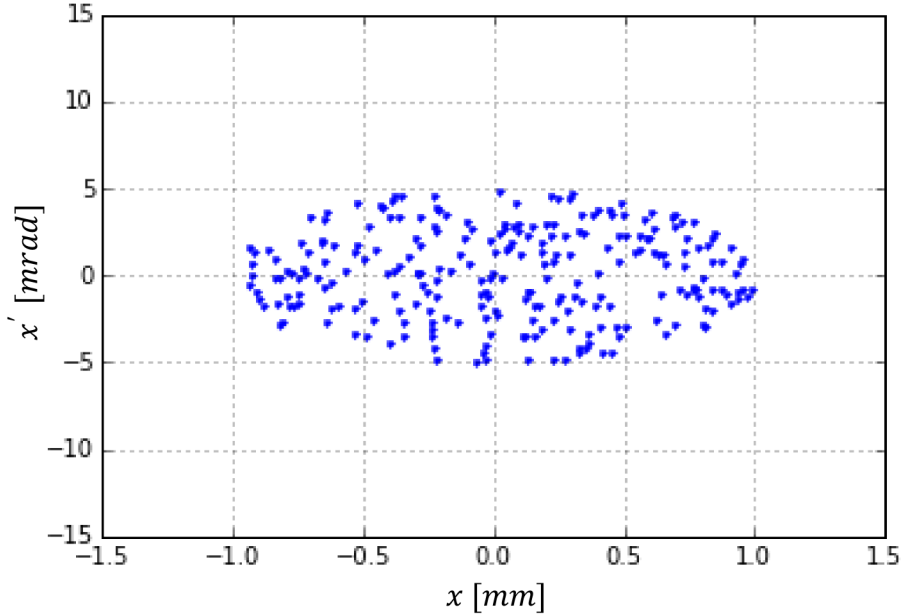
Electron Beam

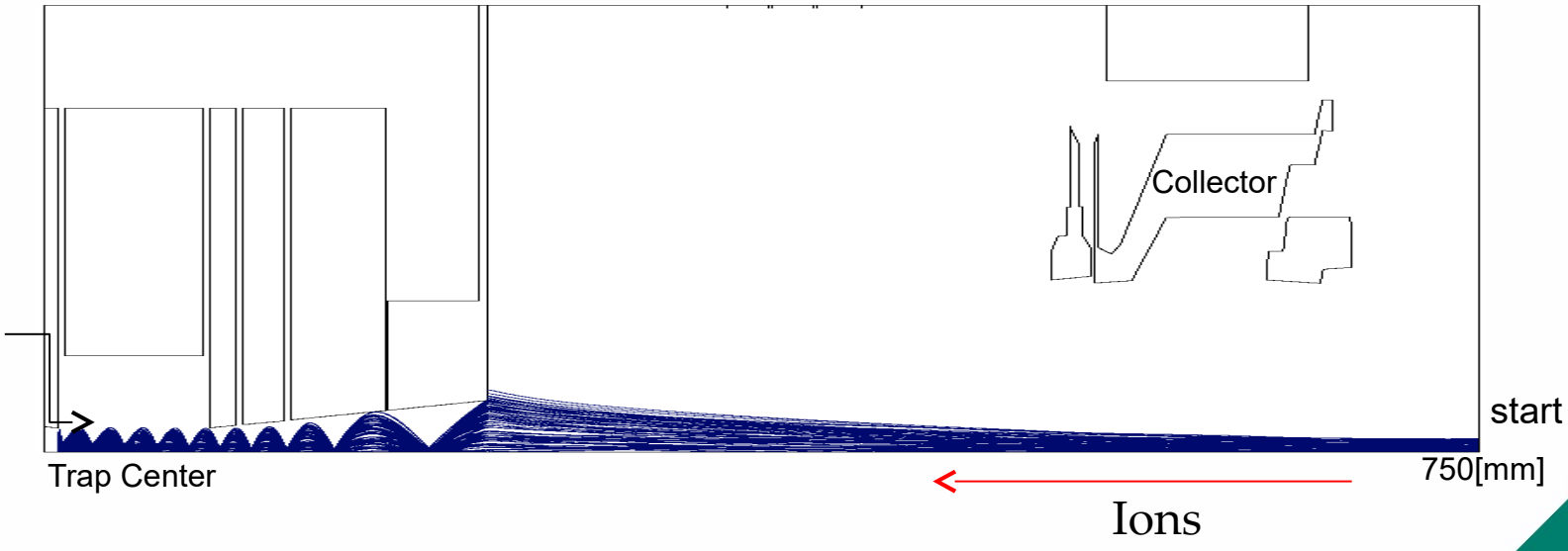


First Injection Simulations

Ion Injection:

- Potassium 1+ ions
- 15 keV beam energy
- ε_{4RMS} = 5 π mm mrad
- Drift Tubes at 14.7 kV





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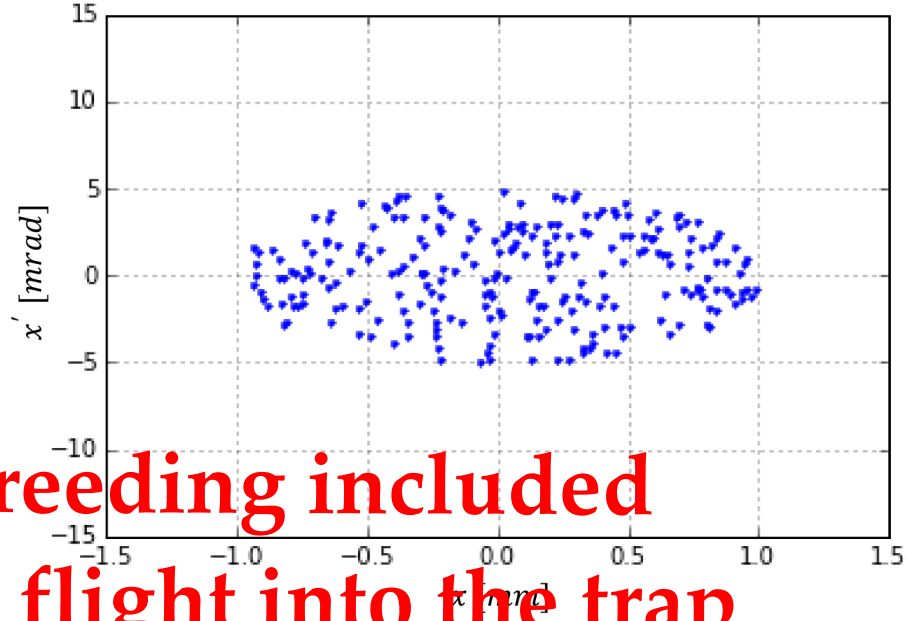
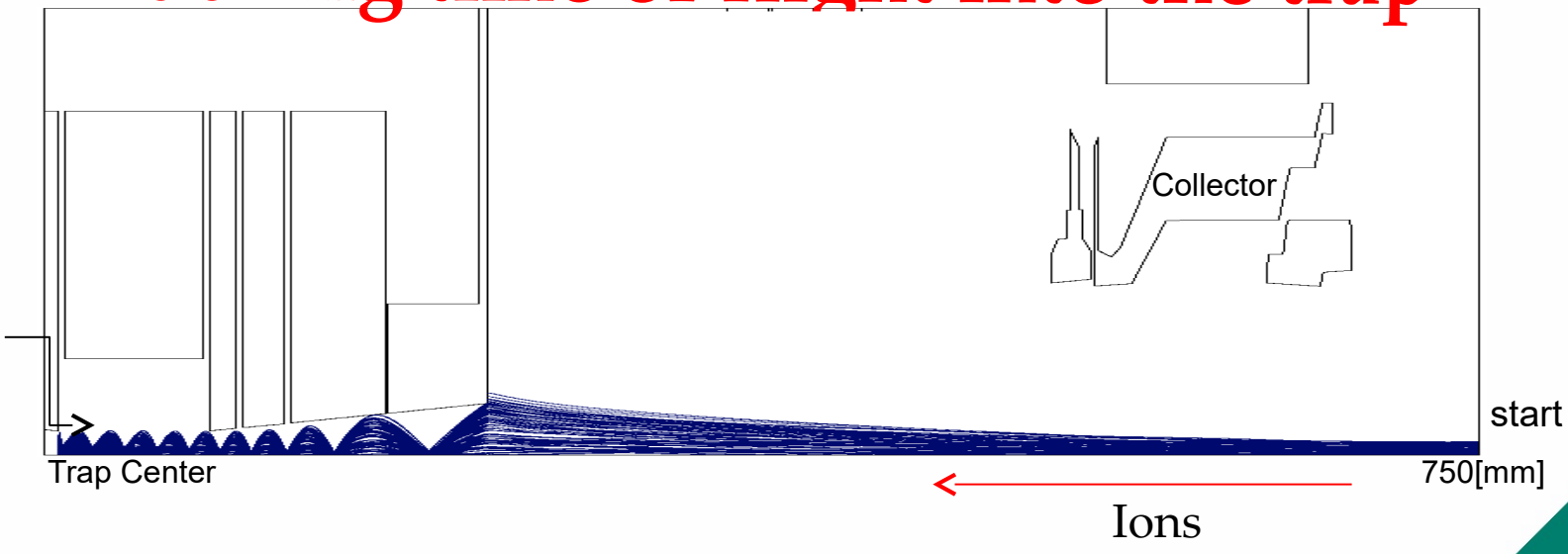
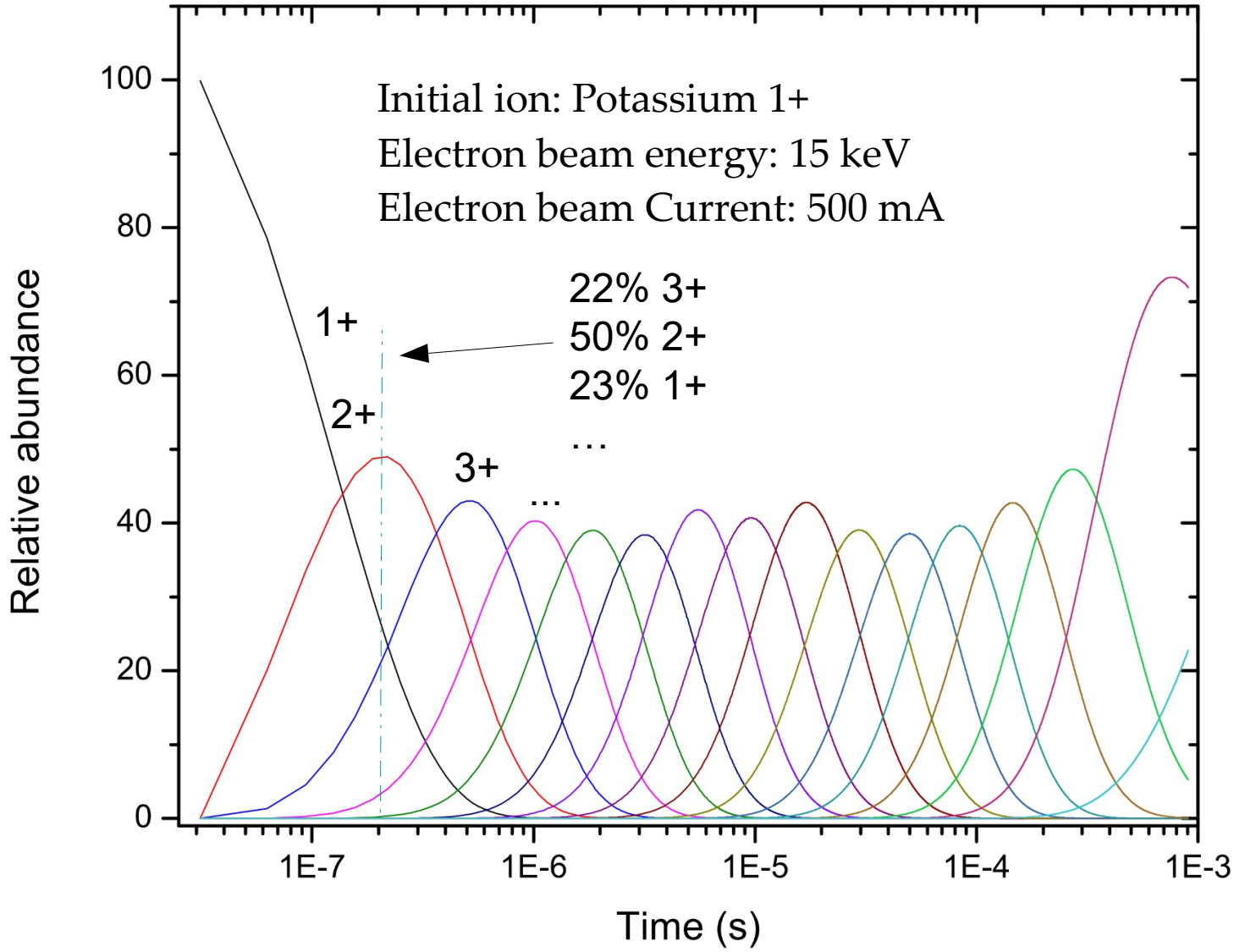


No charge breeding included during time of flight into the trap



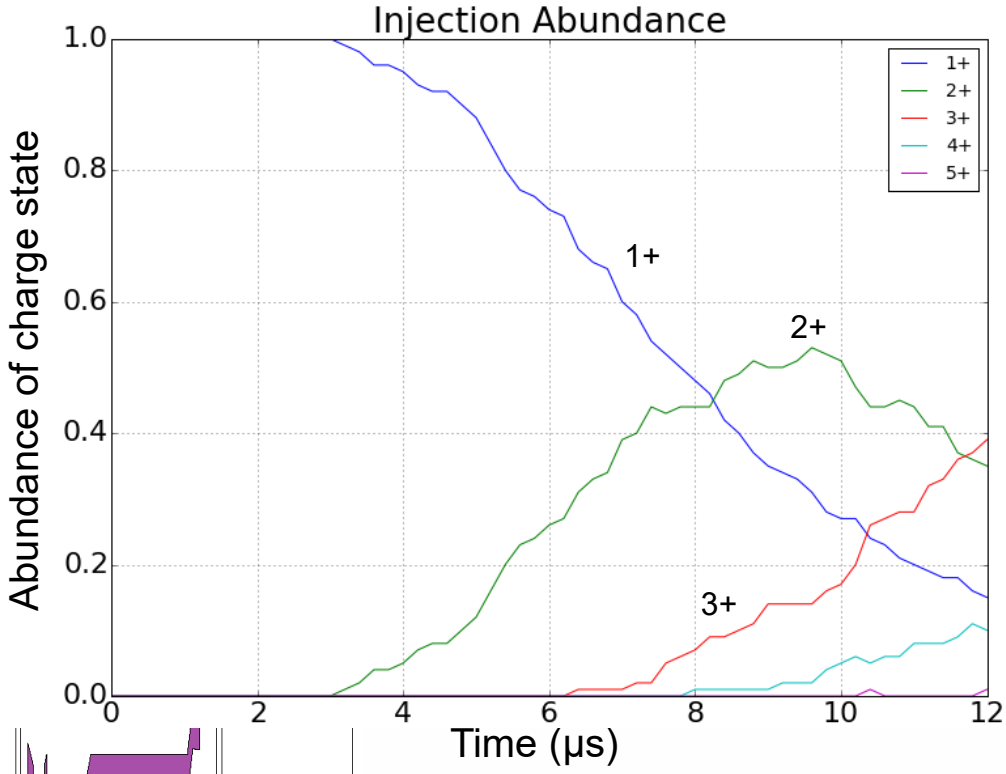
Charge Breeding Simulations

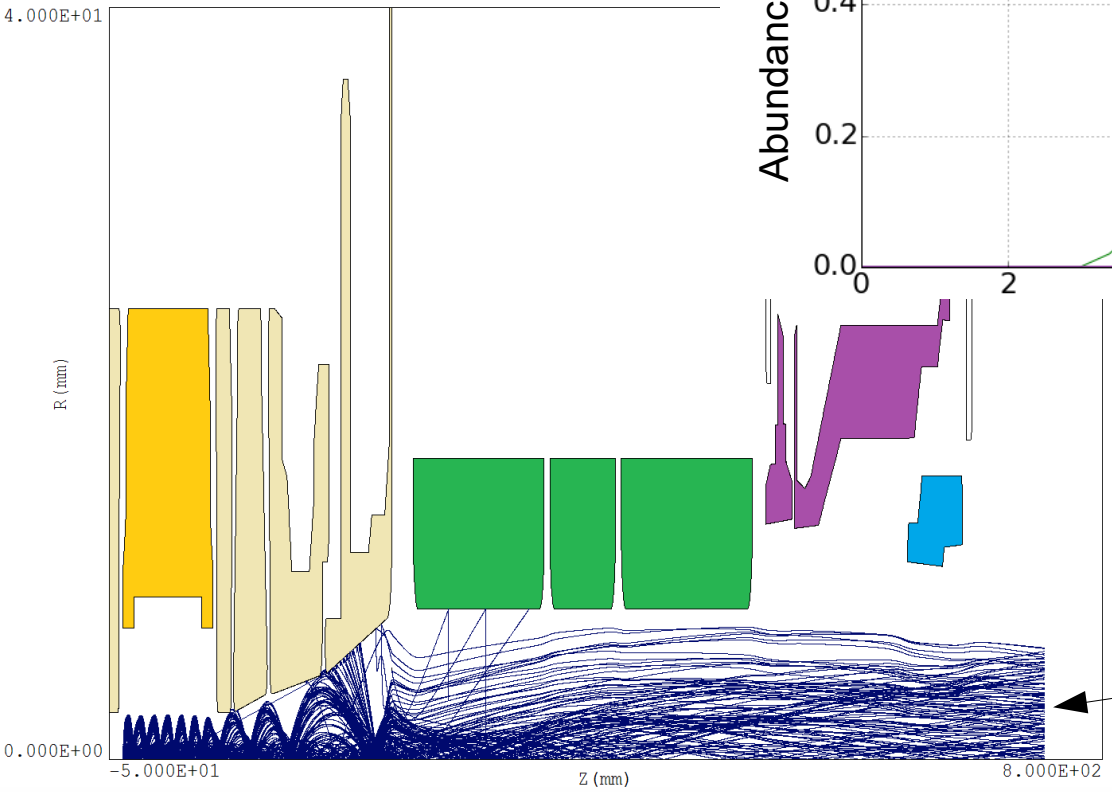


Injection Simulations

Ion Injection:

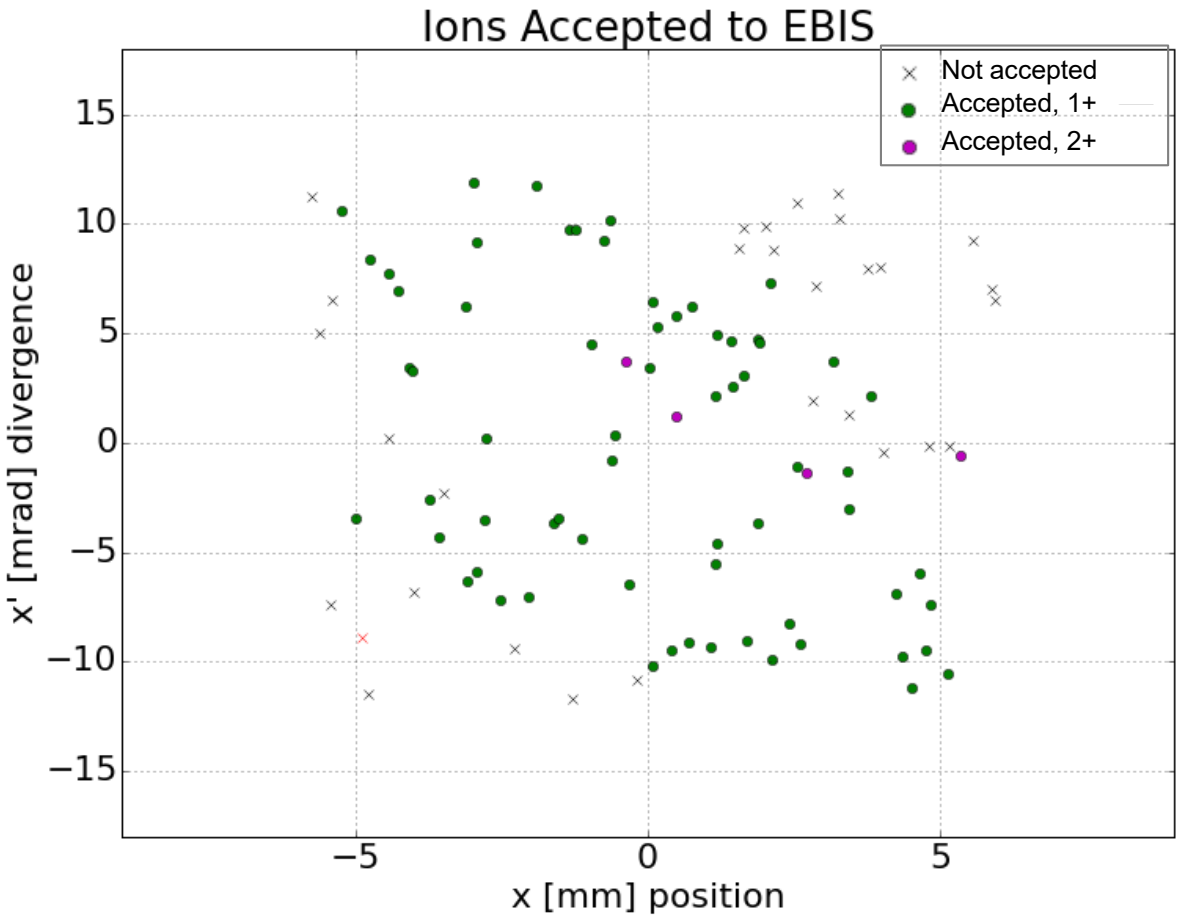
- Potassium 1+ ions
- 15 keV beam energy
- 150 ions
- Drift Tubes at 14.7 kV
- **Charge breeding** during ToF



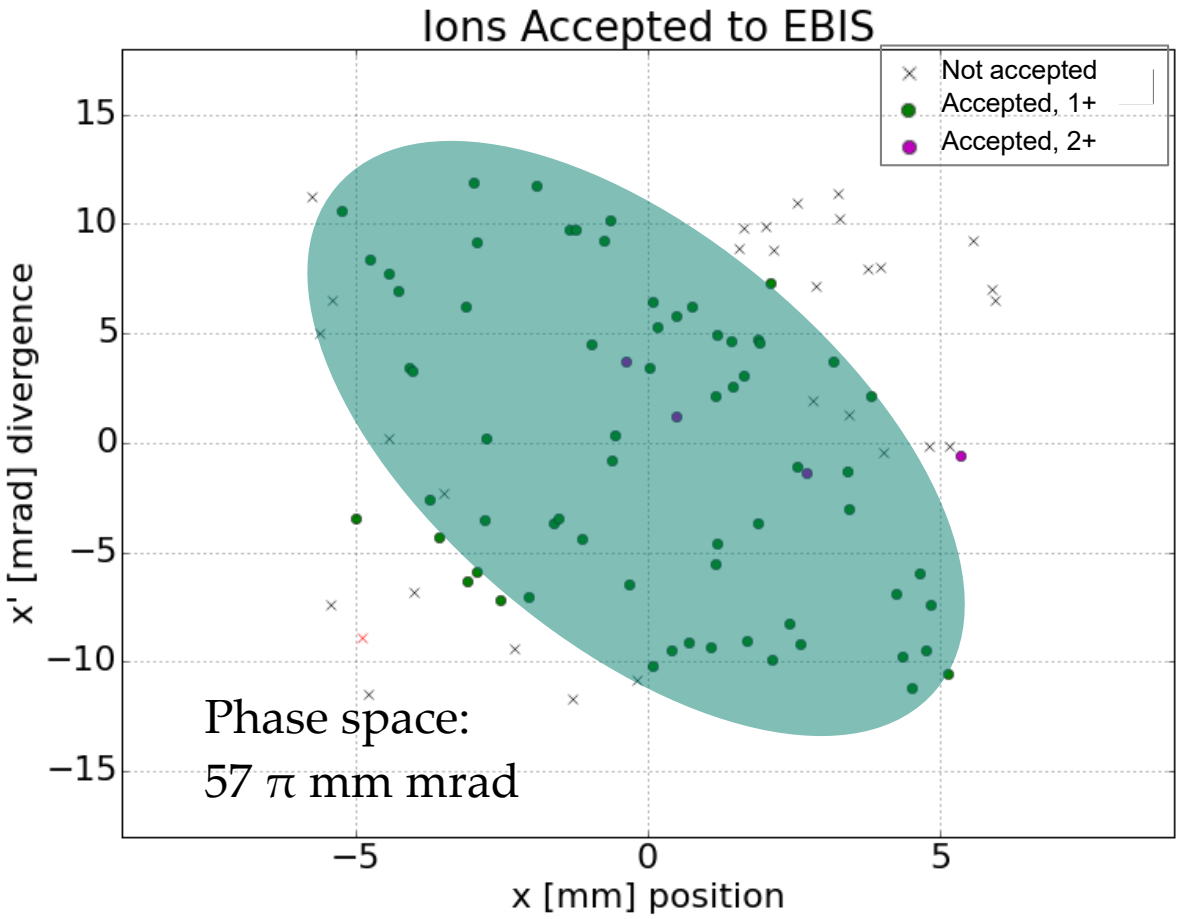


Large rectangular phase space

Injection Simulations



Injection Simulations



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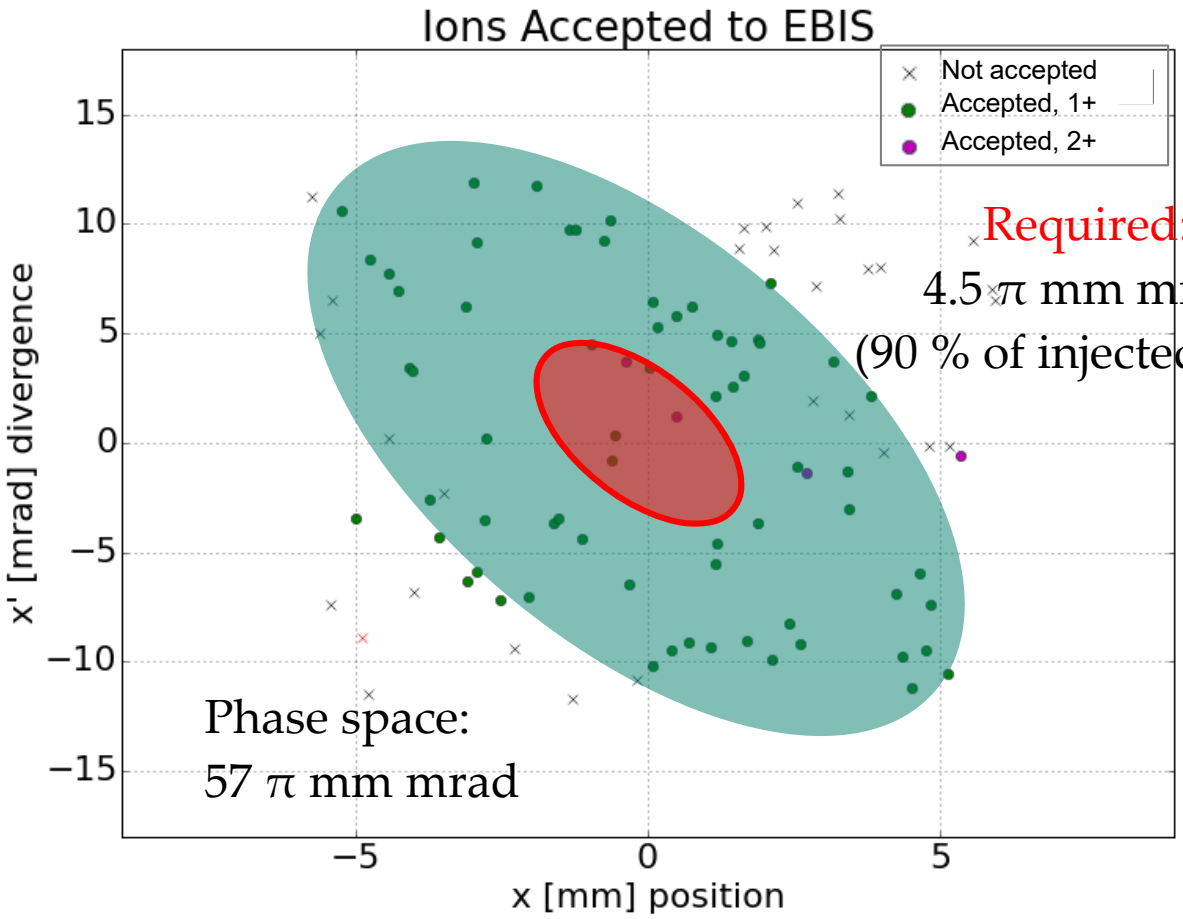


Required:

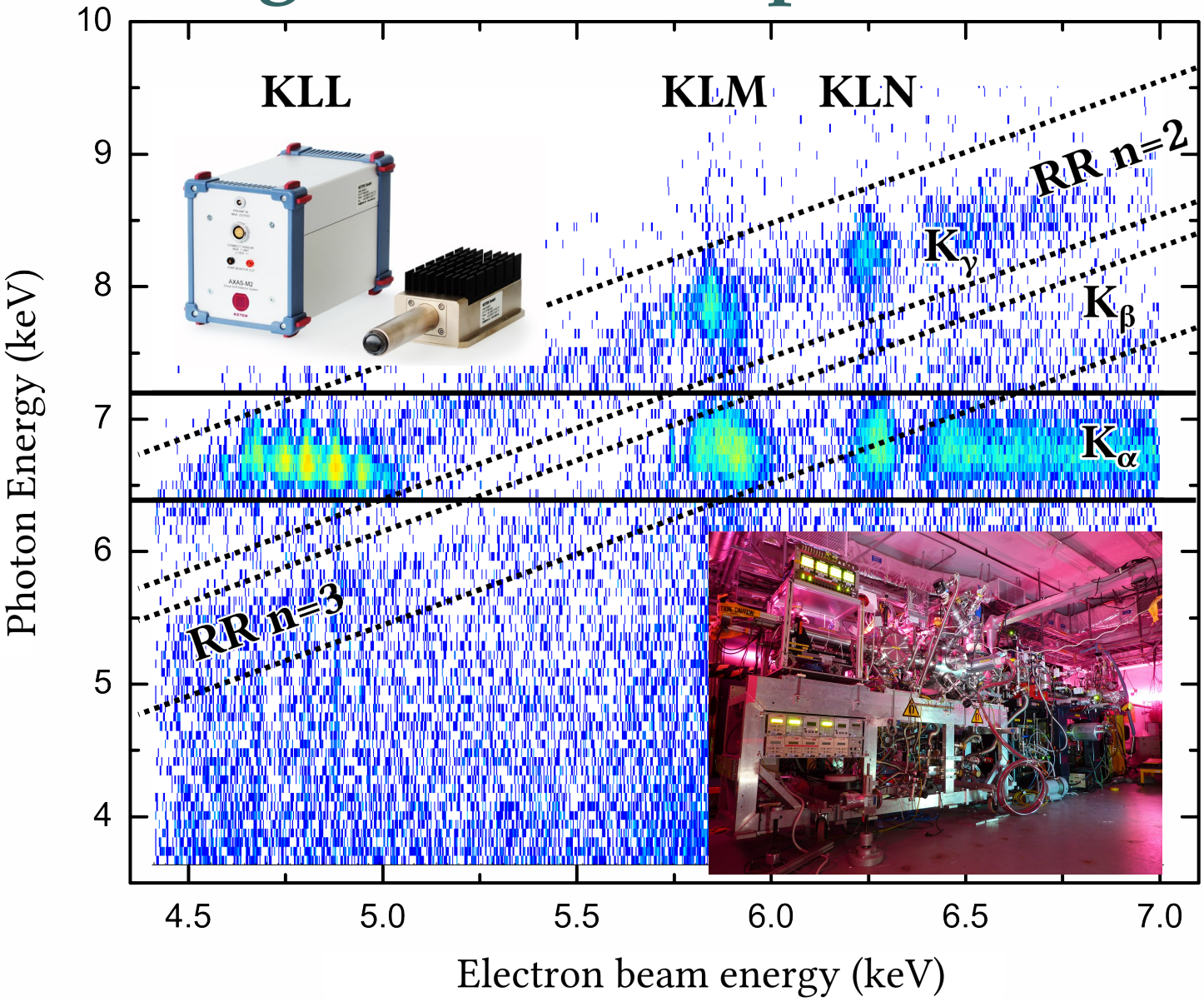
4.5 π mm mrad

(90 % of injected ions)

Phase space:

57 π mm mrad

Diagnostics of trap content



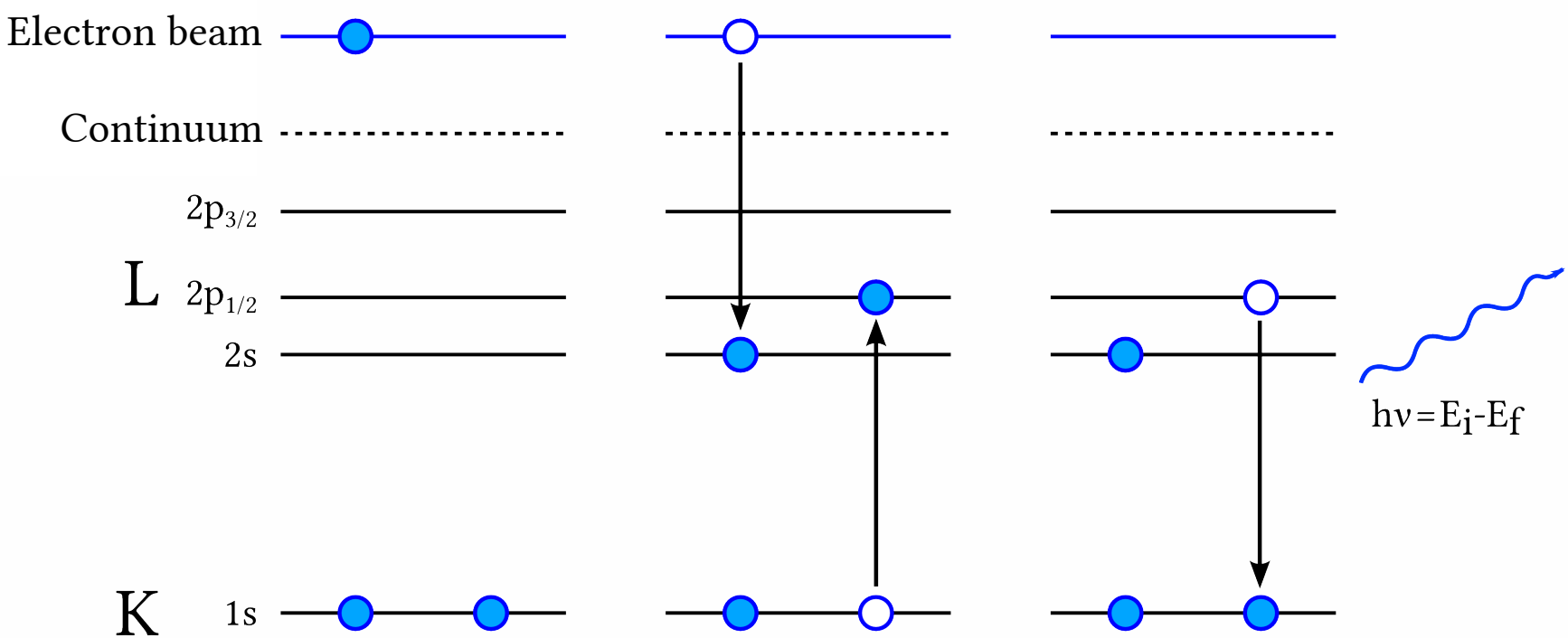
Diagnostics of trap content

- **Processes in an EBIS:**
  - Ionization
  - Electron impact excitation
  - Radiative recombination
  - Charge exchange
  - (Photon excitation → Experiments at ultra brillant light sources)
  - Resonant recombination processes

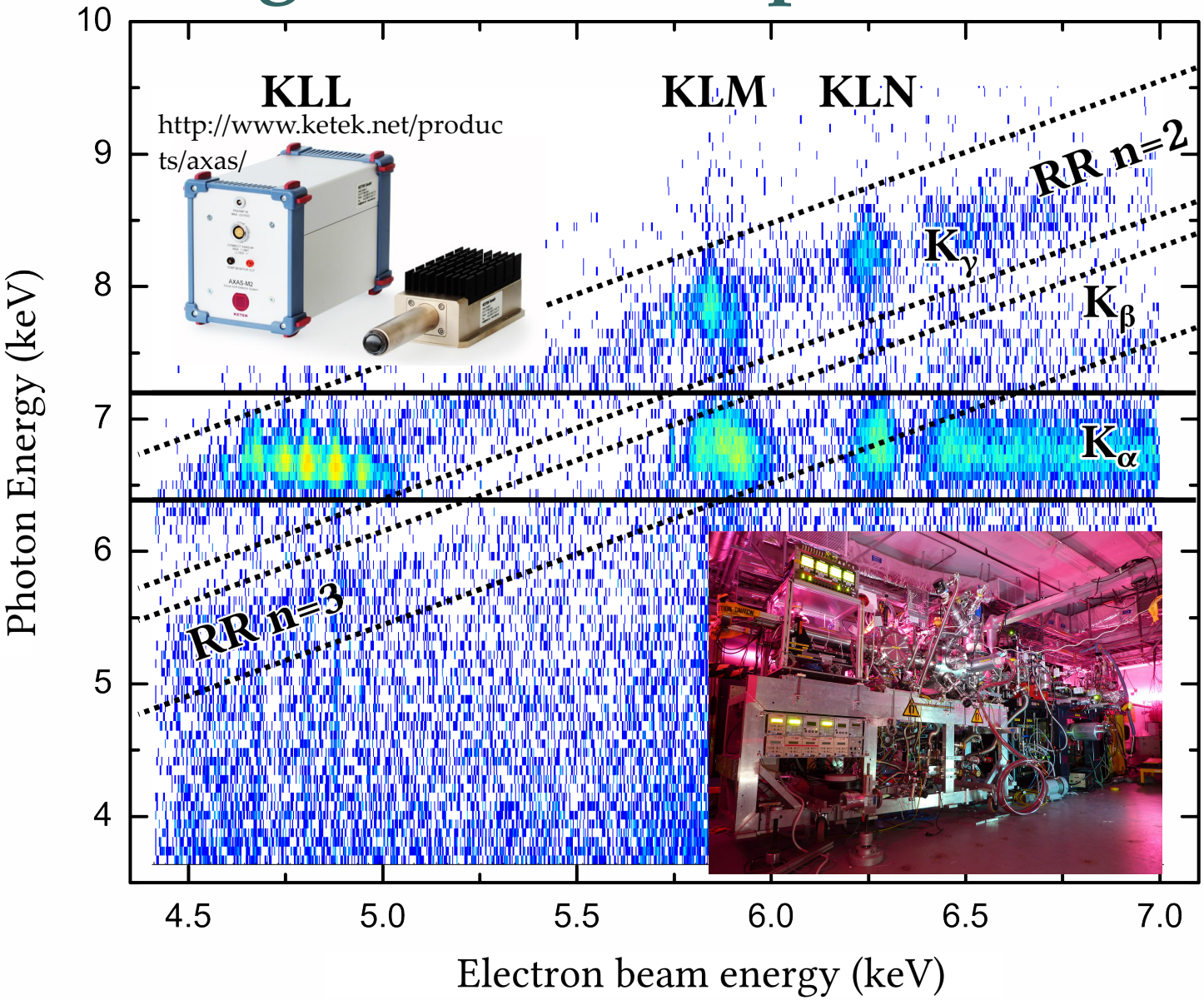
    (e.g. **dielectronic recombination**)

Dielectronic recombination (DR)

- **Example for KLL-DR:** He-like system in initial state



Diagnostics of trap content



Summary and Outlook

- **Summary:**
  - Simulation of electrostatic and magnetic field
  - Electron beam trajectory
  - Injection of ions
- **A tool for diagnostics in the near future:**
  - Full Injection, charge breeding in the trap
  - **Extraction of ions**
  - Explore use of transition region and optimization
  - Assembly of the EBIS and commissioning in Heidelberg
  - Comparison of simulation results with real measurements

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Thank you!

- Special thanks to:
  - José R. Crespo López-Urrutia
  - Jens Dilling
  - Renate Hubele
  - Thomas M. Baumann
  - Michael A. Blessenohl
  - Zachary Hockenbery

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Evolution of Charge State Distribution