Redesign of the GANIL GTS ECRIS for 1+/n+ studies

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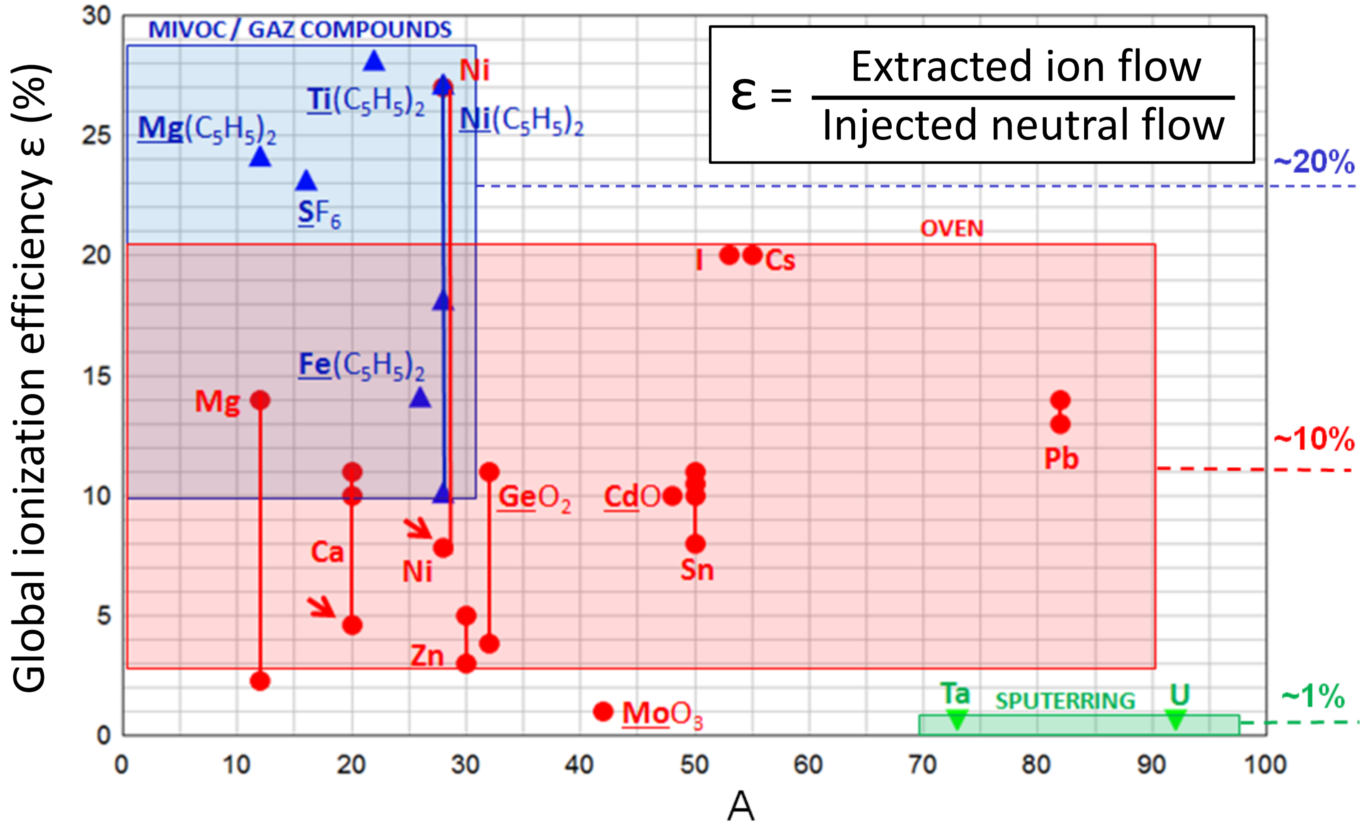
Motivation – Metal ion production

- Metal ion beams widely used (e.g. over half of GANIL beams), continued development important
- With conventional methods (ovens, sputtering, MIVOC) the **global ionization efficiencies** are low

Motivation – Metal ion production



MIVOC

Oven

Sputtering

Most of the injected material is wasted

C. Barué et al., in Proc. of 22nd Intl. Workshop on ECR Ion Sources, Busan, Korea, 2016

Motivation – Metal ion production

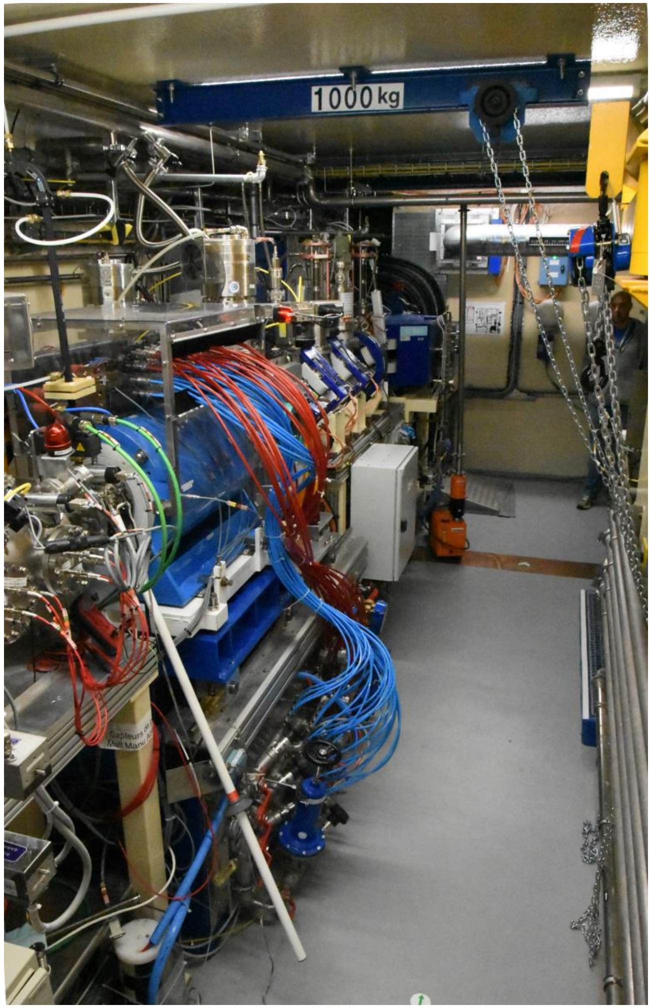
- Metal ion beams widely used (e.g. over half of GANIL beams), continued development important
- With conventional methods (ovens, sputtering, MIVOC) the **global ionization efficiencies** are low
- 1+/n+ method: efficiencies >50% have been demonstrated
  - Decreased material consumption and chamber contamination
  - Decoupling of metal ion production and multi-ionization process
- Challenges:
  - High intensity operation needs to be demonstrated
  - Very high efficiency production of the initial 1+ beams

➡ Experimental work required to validate the potential of 1+/n+ method for metal ion production

Motivation – Support for SPIRAL1 Charge Breeder

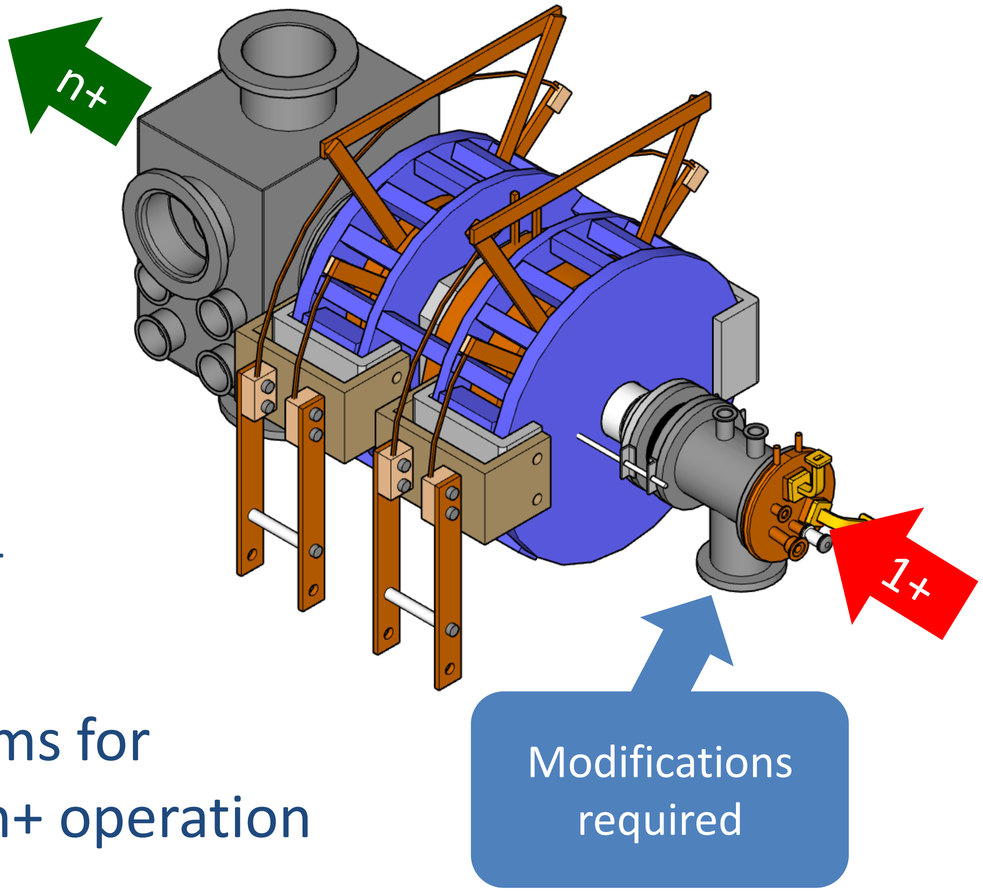
- Recently commissioned at GANIL RIB facility SPIRAL1
- Operational machine in high radiation dose area
- Limited access, restricts the future charge breeder R&D at GANIL

➡ Offline test stand desirable, results transferred to SPIRAL1 CB



GTS 14.5 GHz ECRIS
a future 1+/n+ R&D platform

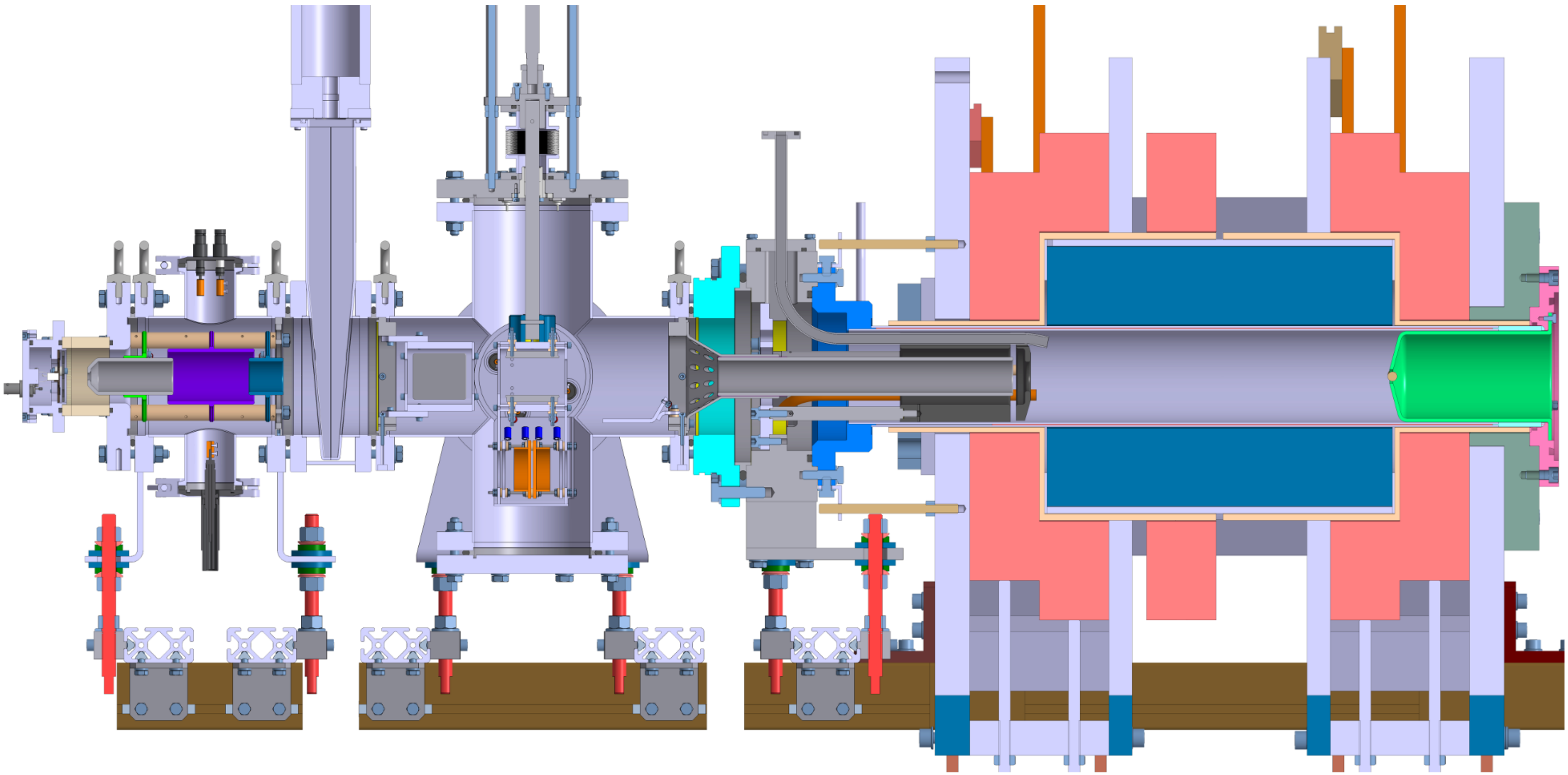
- 2017: extraction upgrade, new center coil
  - Up to 3x more beam
- 2018: new injection system
  - Double frequency operation
  - E.g. 8x more Xe^{30+}
- Next: operation + CB R&D
  - Quick transition between conventional ECRIS and 1+/n+ operation modes required



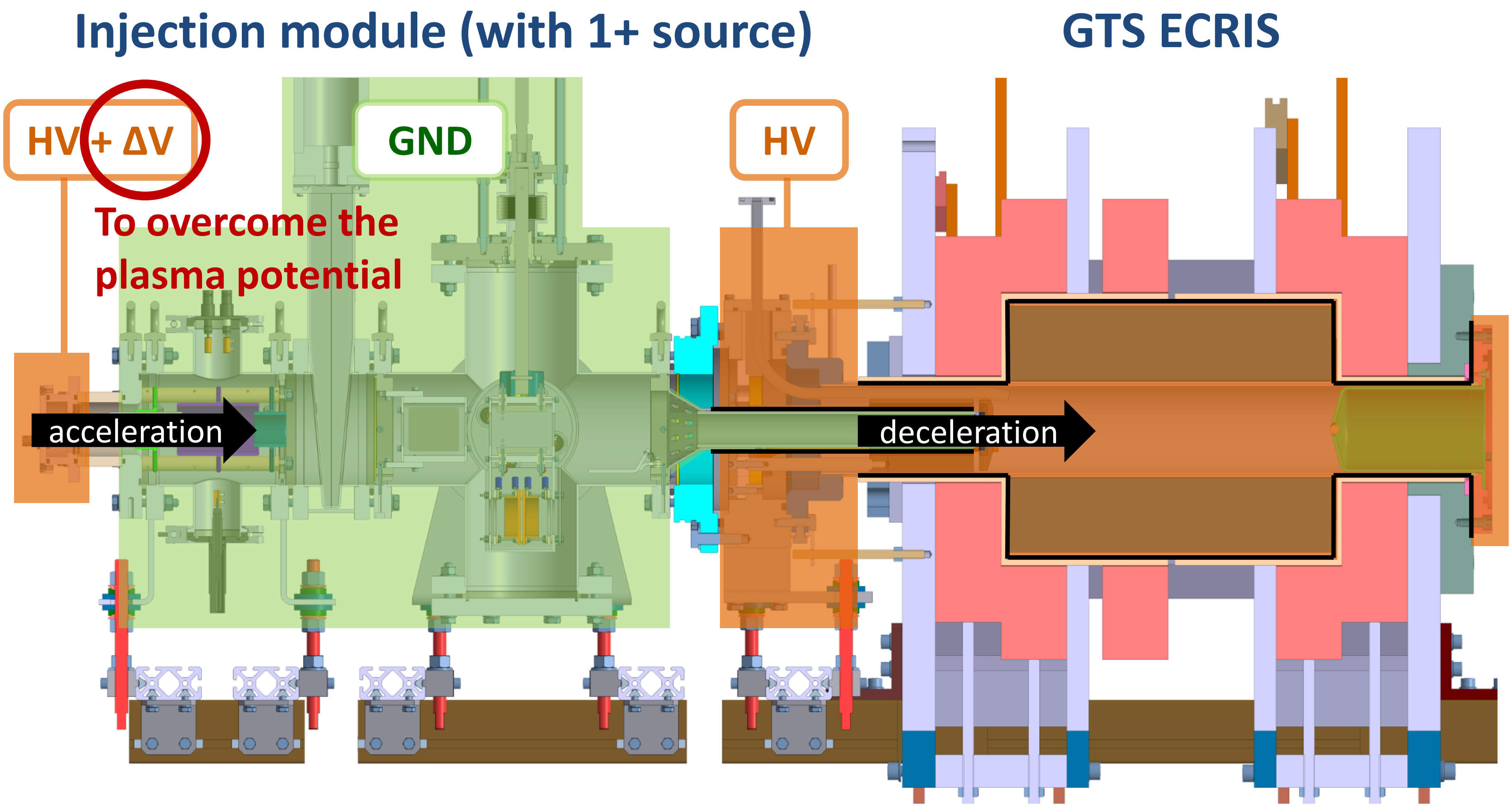
➡ Dedicated injection systems for conventional and for 1+/n+ operation

New injection system for 1+/n+ operation

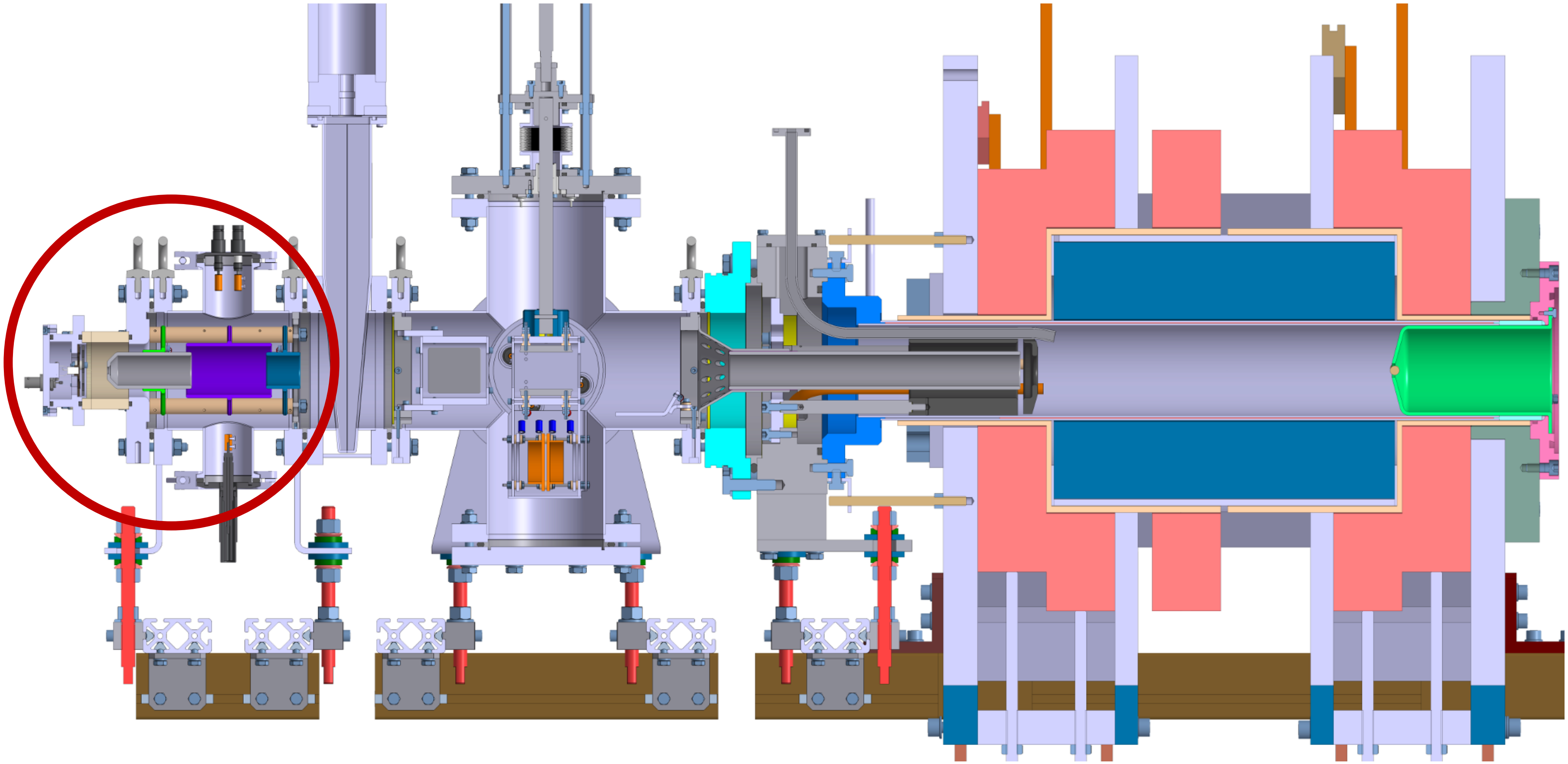
Injection module (with 1+ source) **GTS ECRIS**



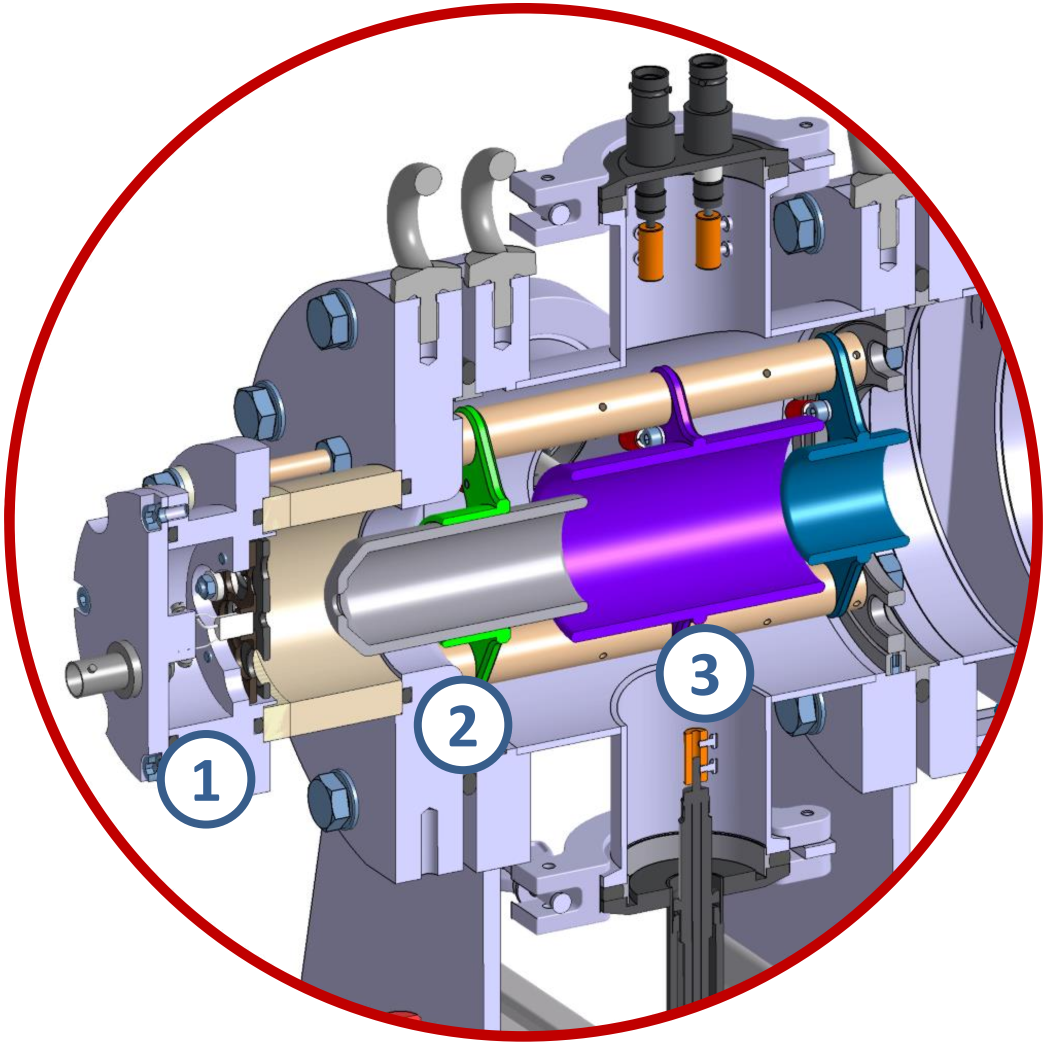
New injection system for 1+/n+ operation



Injection module design



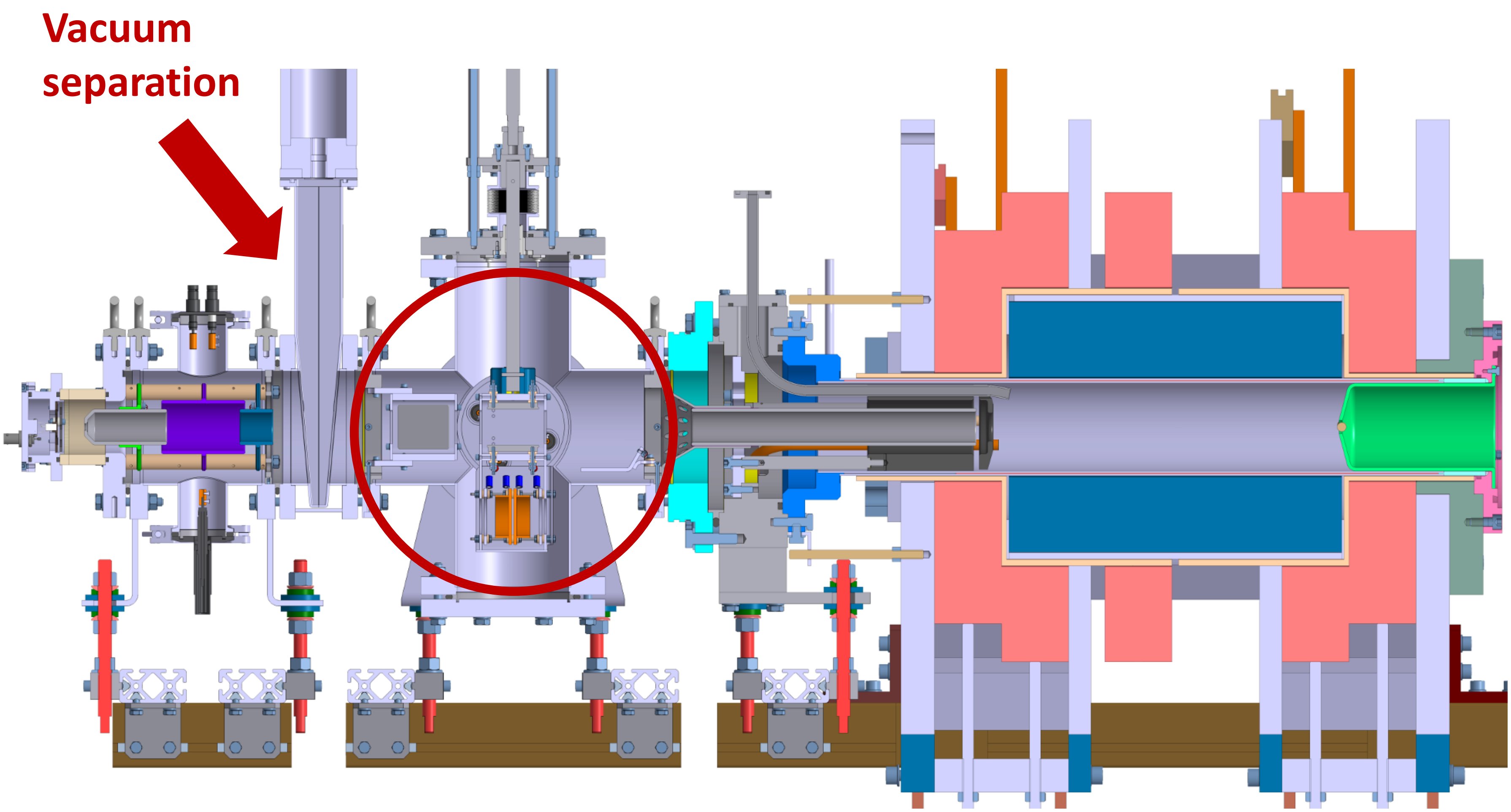
Injection module design



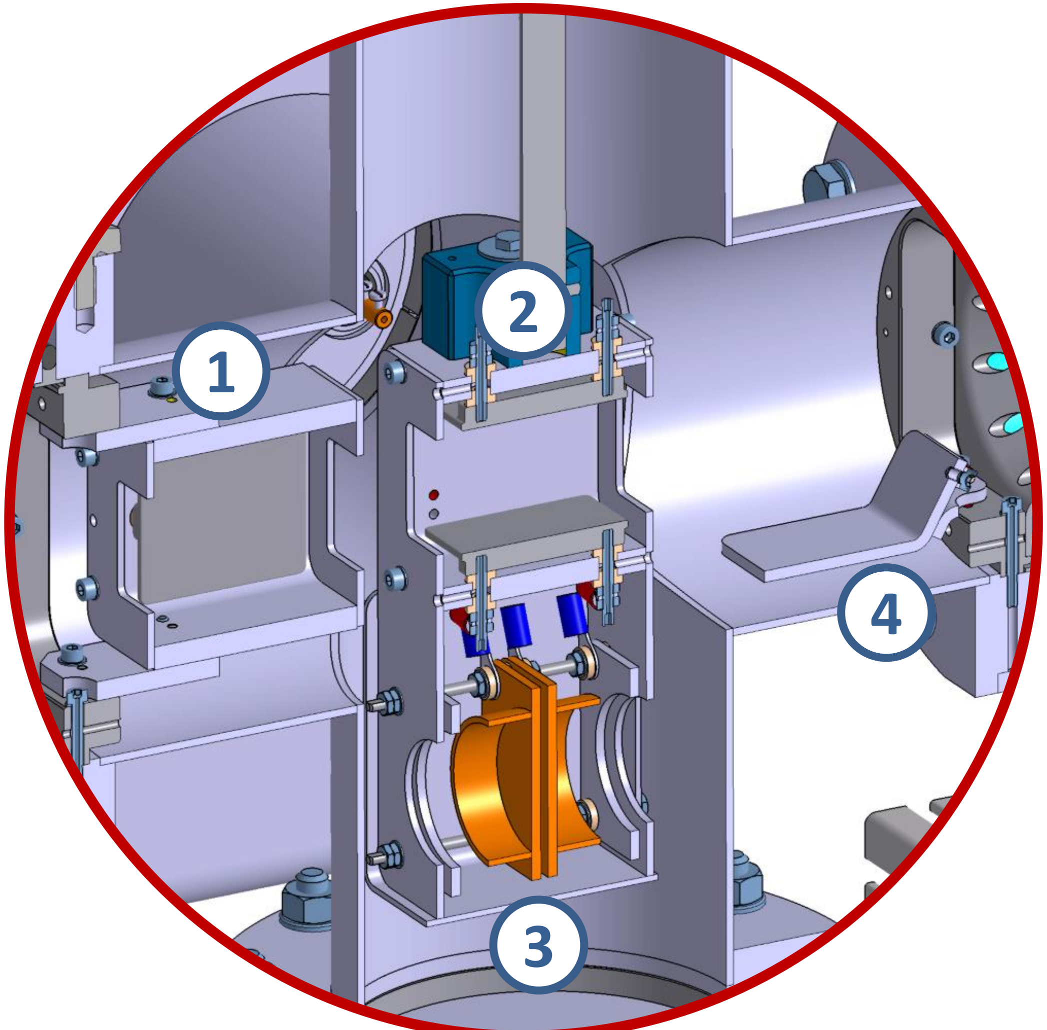
1+ beam production and main ion optics

1. 1+ ion source
   - First: thermionic alkali ion source
   - Later other sources to expand capabilities
2. Puller electrode
3. Einzel lens

Injection module design



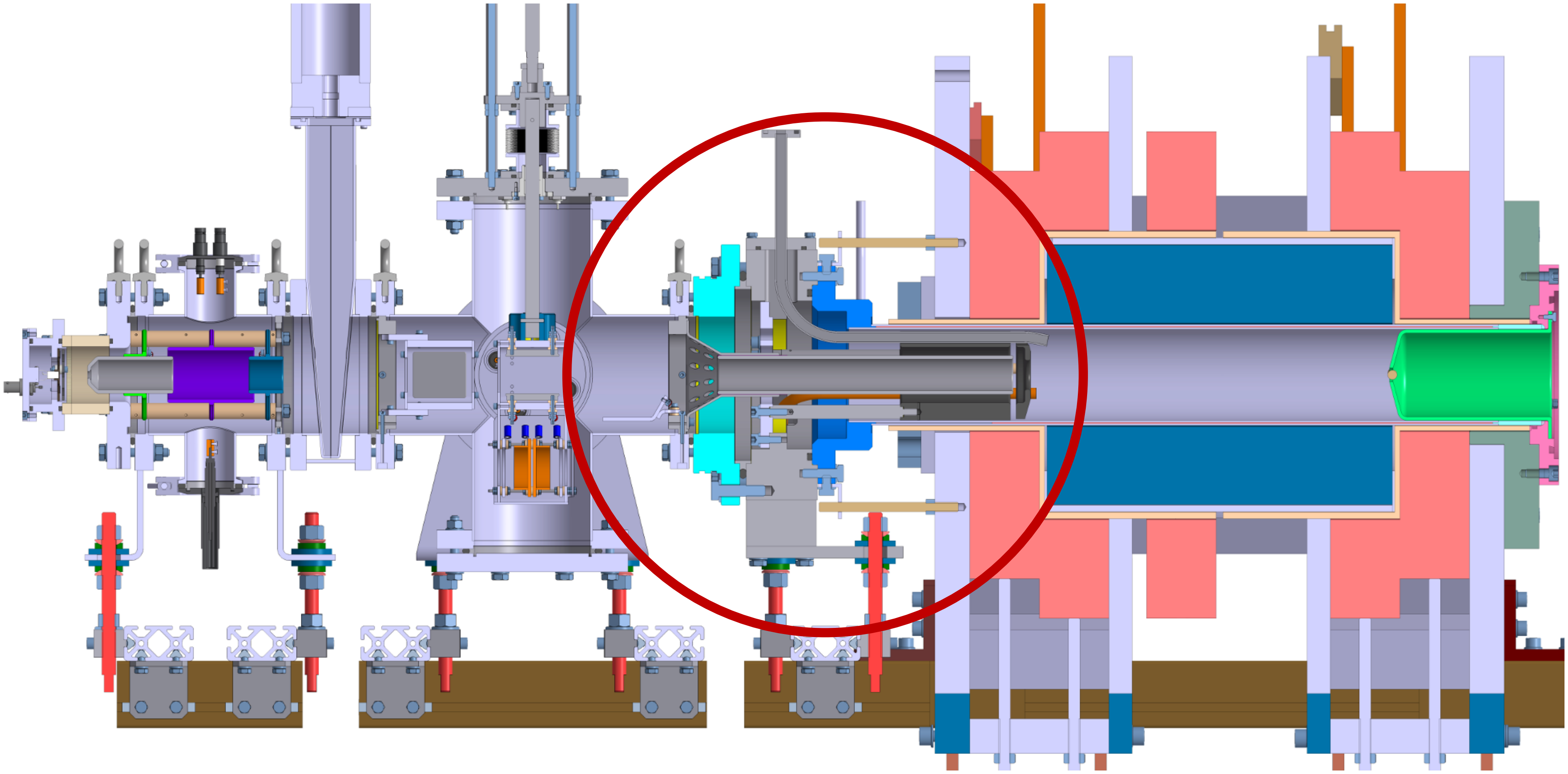
Injection module design



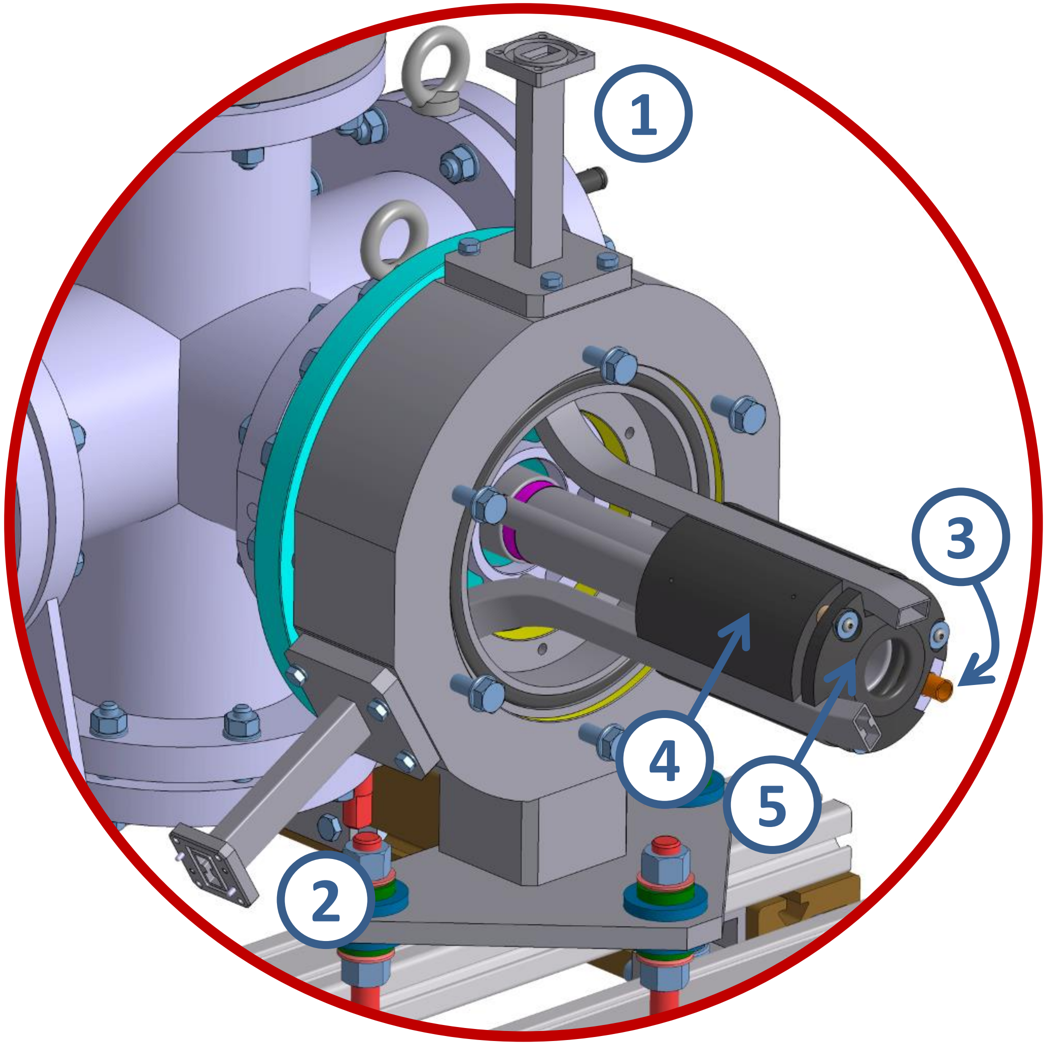
Beam manipulation and diagnostics

1. Horizontal steerer
2. Vertical steerer
3. 2-sided Faraday cup
4. Beam dump for pulsed operation

Injection module design



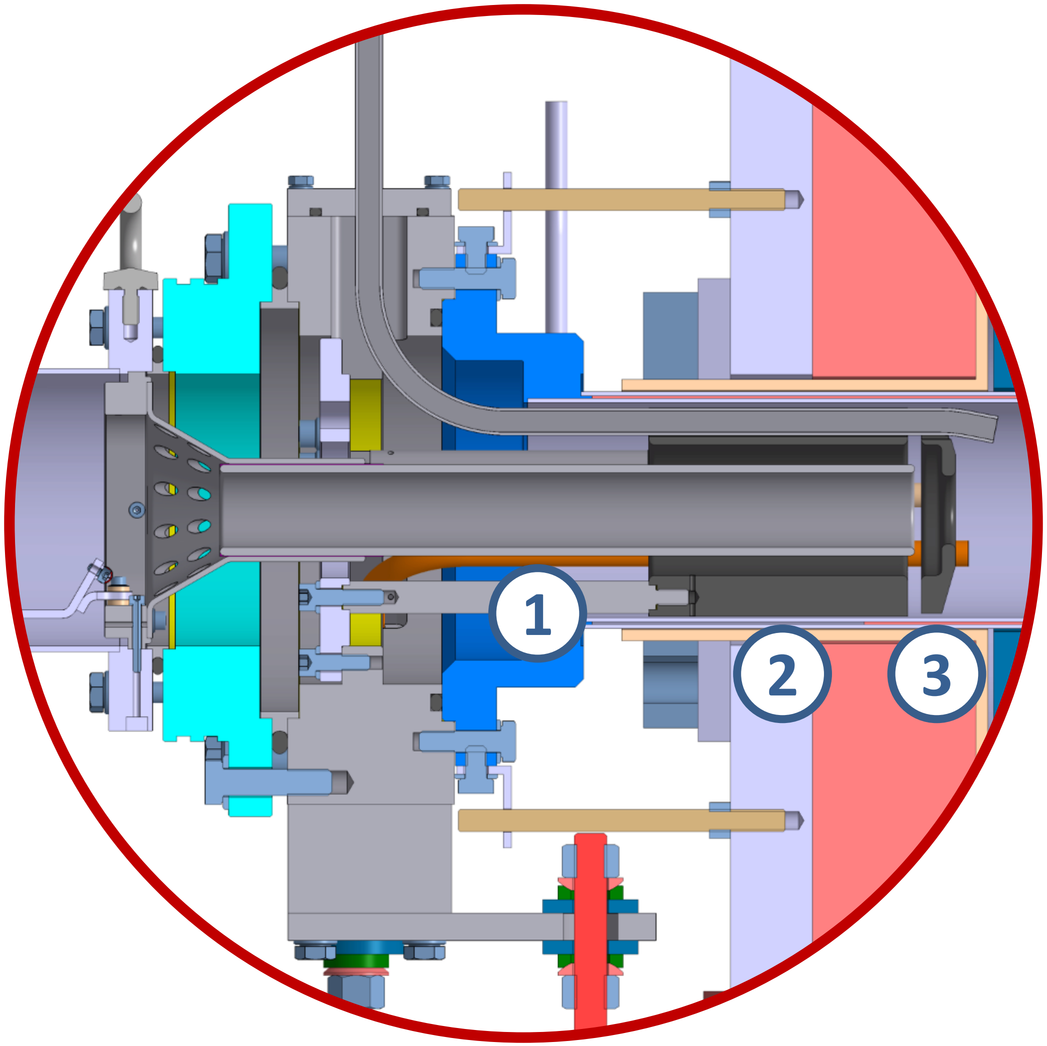
Injection module design



Microwave and gas injection, B field modification

1. WR62 wave guide
2. WRD750 wave guide
3. Gas injection pipe
4. ARMCO cylinder
5. Injection aperture electrode (ARMCO, can be biased)

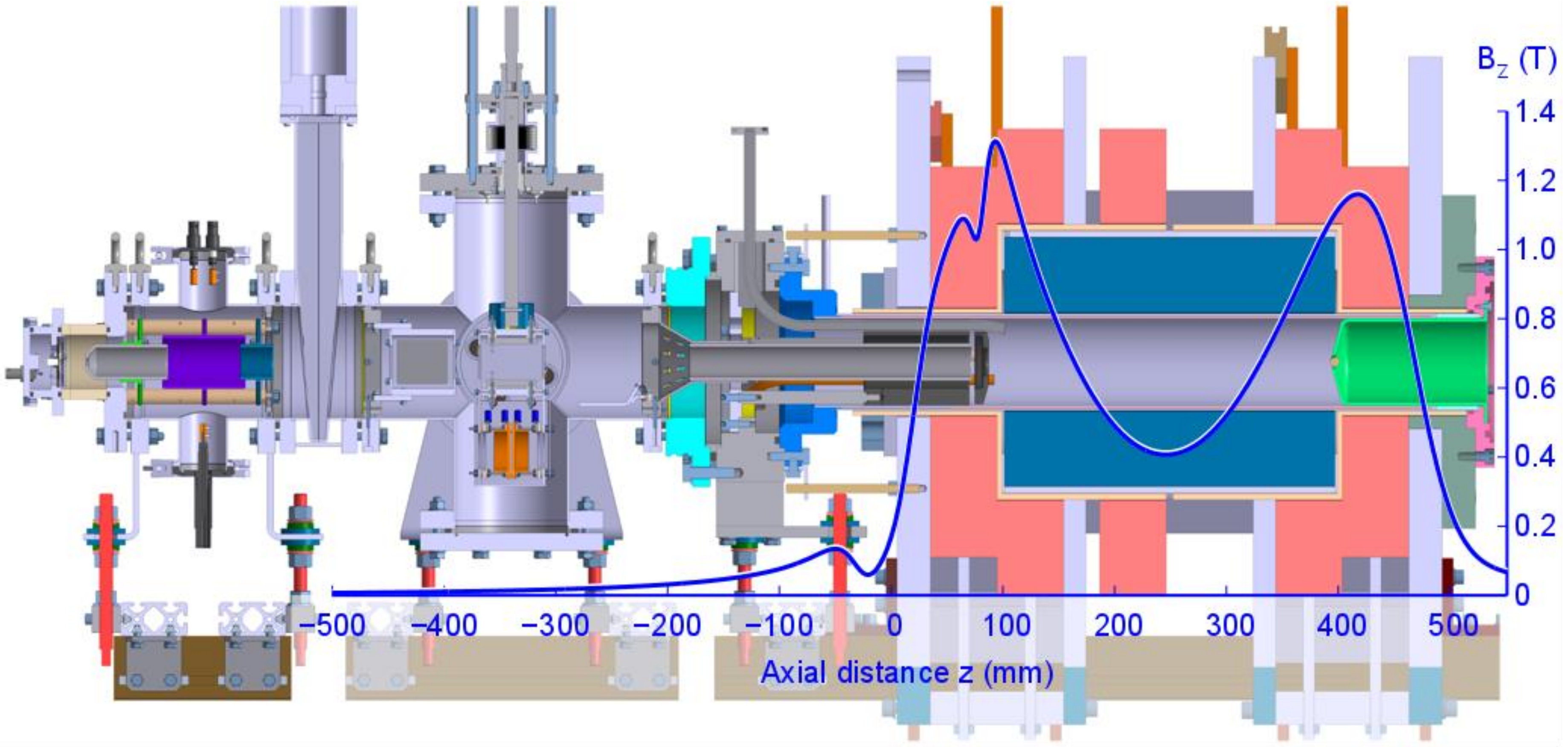
Injection module design



1+ beam deceleration and injection into the plasma chamber

1. Grounded tube
2. ARMCO cylinder (V_{GTS})
3. ARMCO injection aperture electrode ($V_{GTS}+V_{IAE}$)

Magnetic field



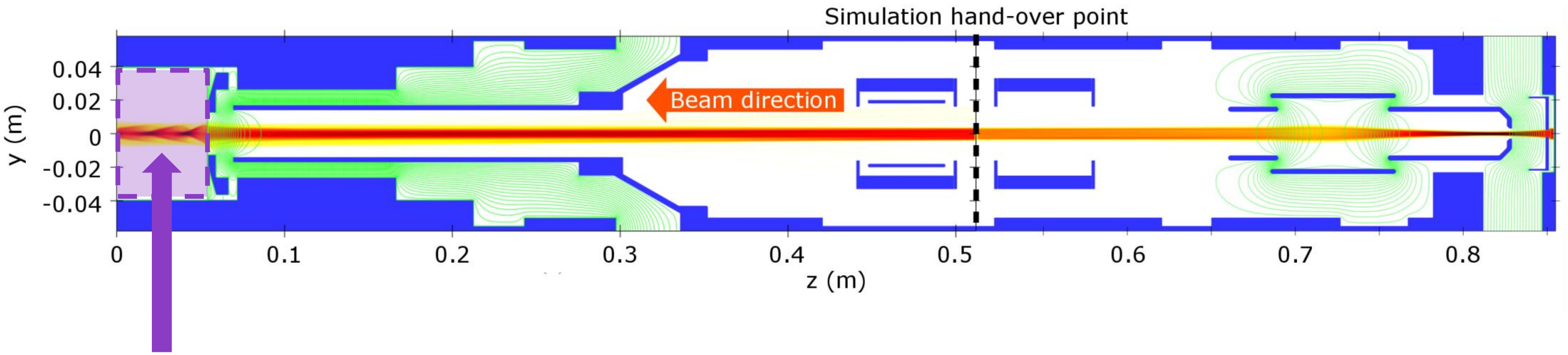
B field design and calculations performed with **Radia** software

Ion optical simulations

- <u>Simulation tools:</u>
  - *IBSimu* ion optical code, 3D geometry
  - 3D magnetic field maps from *Radia*
  - Simplified model for GTS plasma: fixed plasma potential, no particle interactions
  - Beam: 10 µA of $^{39}K^{+}$ with ε_{4rms} = 20 mm mrad

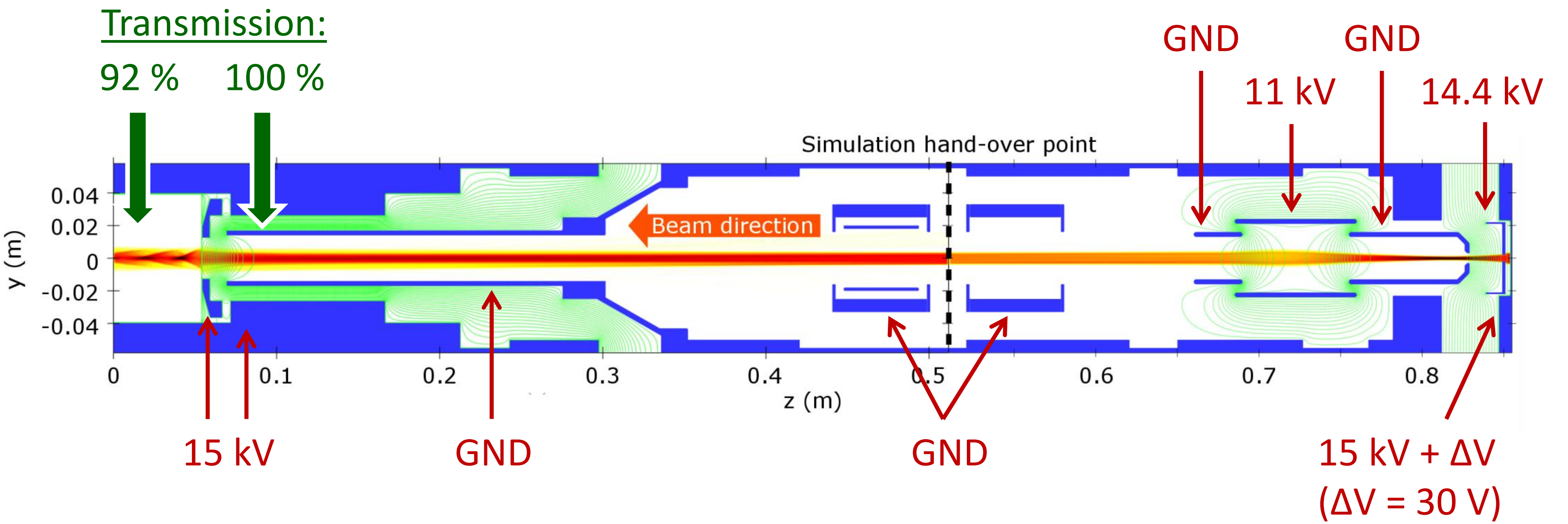
- <u>Main goal:</u> verify transmission through the injection module
- <u>Secondary:</u> injection efficiency into the plasma chamber (only suggestive results possible due to simplified plasma model)

Ion optical simulations

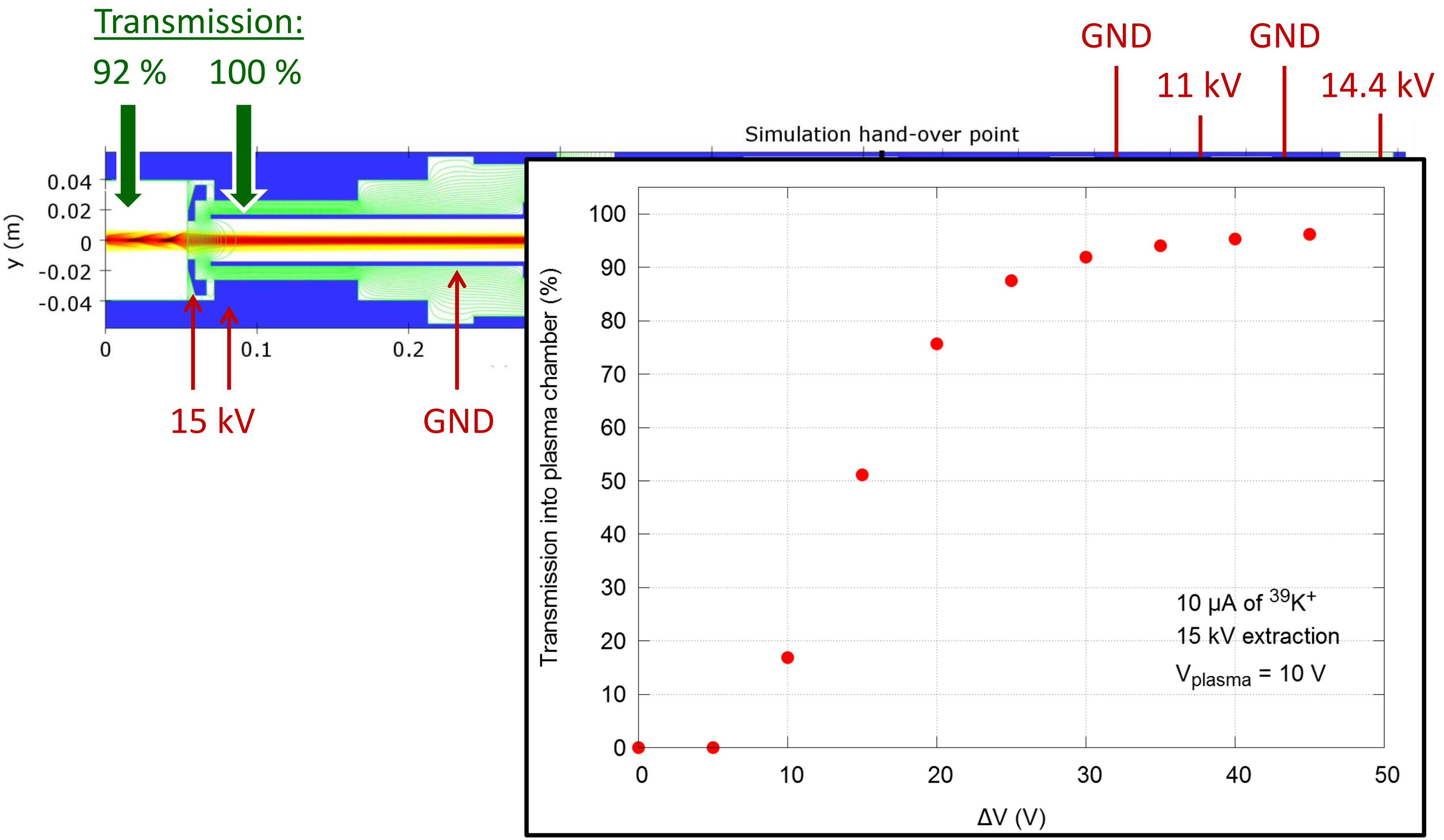


Plasma volume
(V_{plasma} = 10 V)

Ion optical simulations



Ion optical simulations



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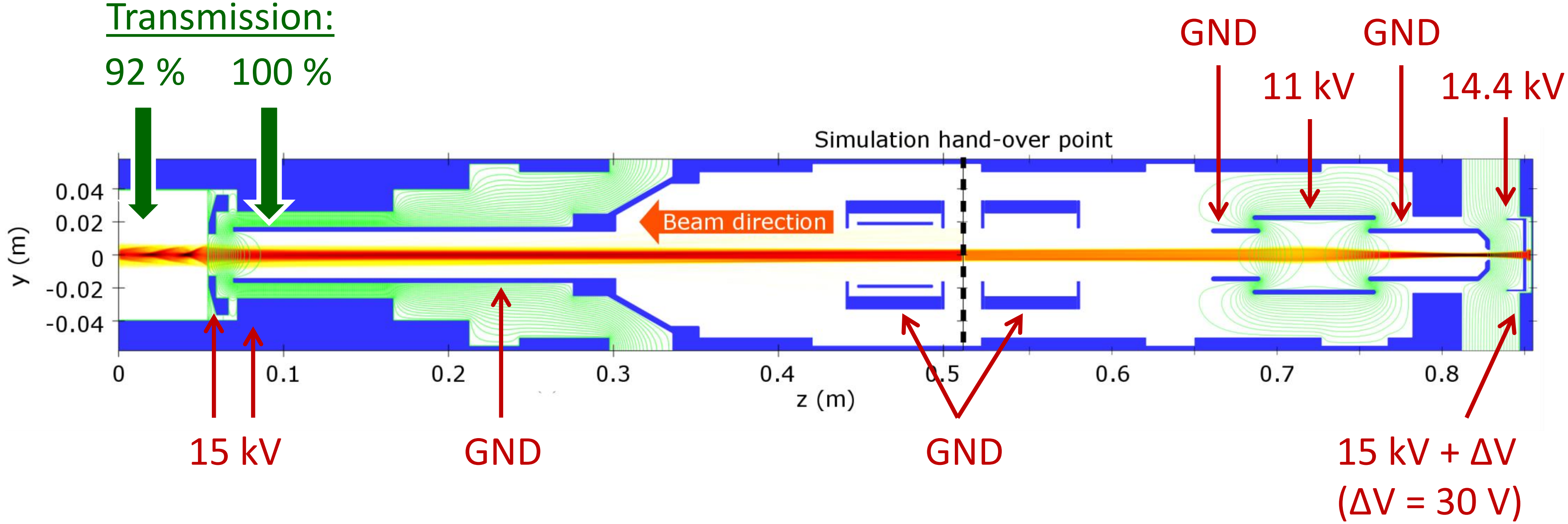
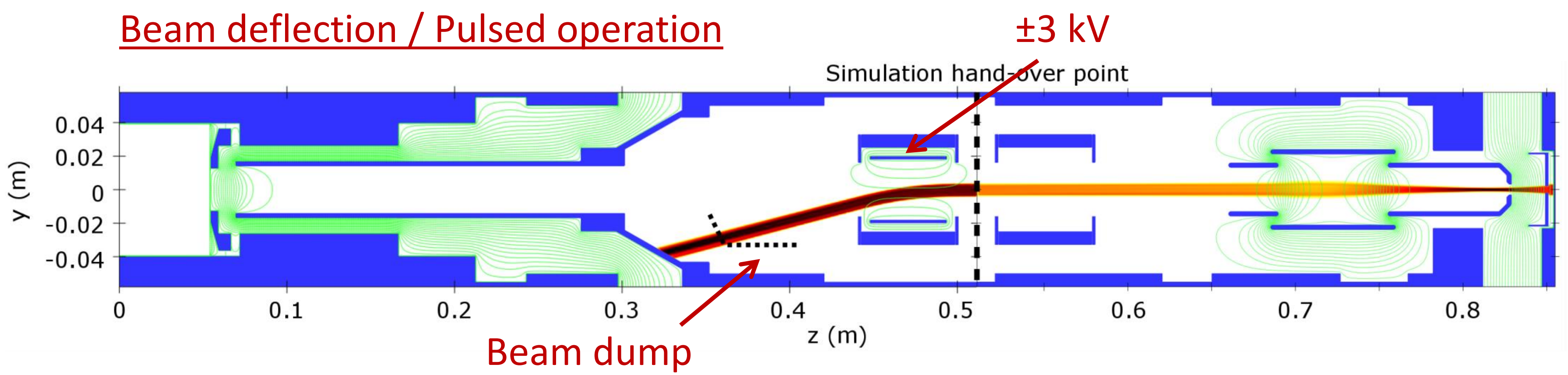
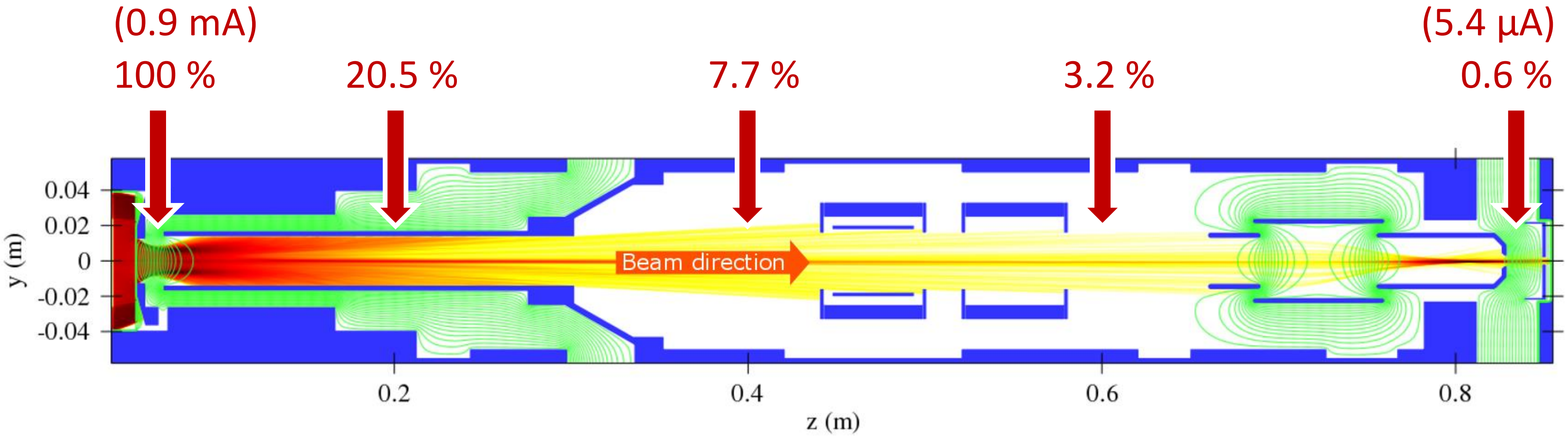




Ion optical simulations

- Potential issue: ions extracted from plasma towards injection
- Simulation: 0.9 mA of extracted oxygen ions (1+ … 8+)



➡ Not expected to be a significant issue for operation

Summary and conclusions

- The design to transform GTS into a charge breeder is ready
- The included features should provide good capabilities for charge breeder R&D
- The simulation results look promising – no showstoppers expected
- Parts procurement on-going, installation and commissioning expected in 2019

EXTRA SLIDES

Magnetic field