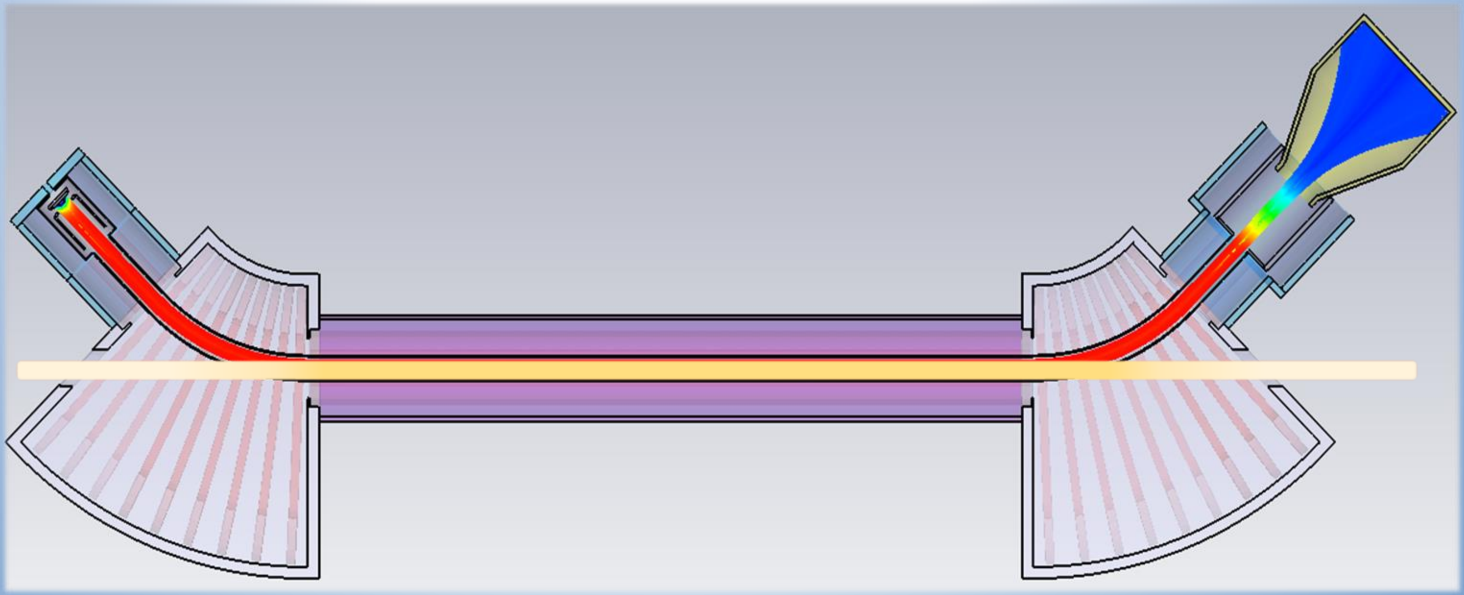
# Status of the Electron Lens for Space Charge Compensation in SIS18

TUPAB200

S. Artikova, D. Ondreka, K. Schulte-Urlichs, P. Spiller (GSI)
M. Droba, O. Meusel, H. Podlech, K. Thoma (GUF)
P. Apse-Apsitis, I. Steiks (RTU)



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# Intensity Increase of Primary Hadron Beams

**Physics Case**

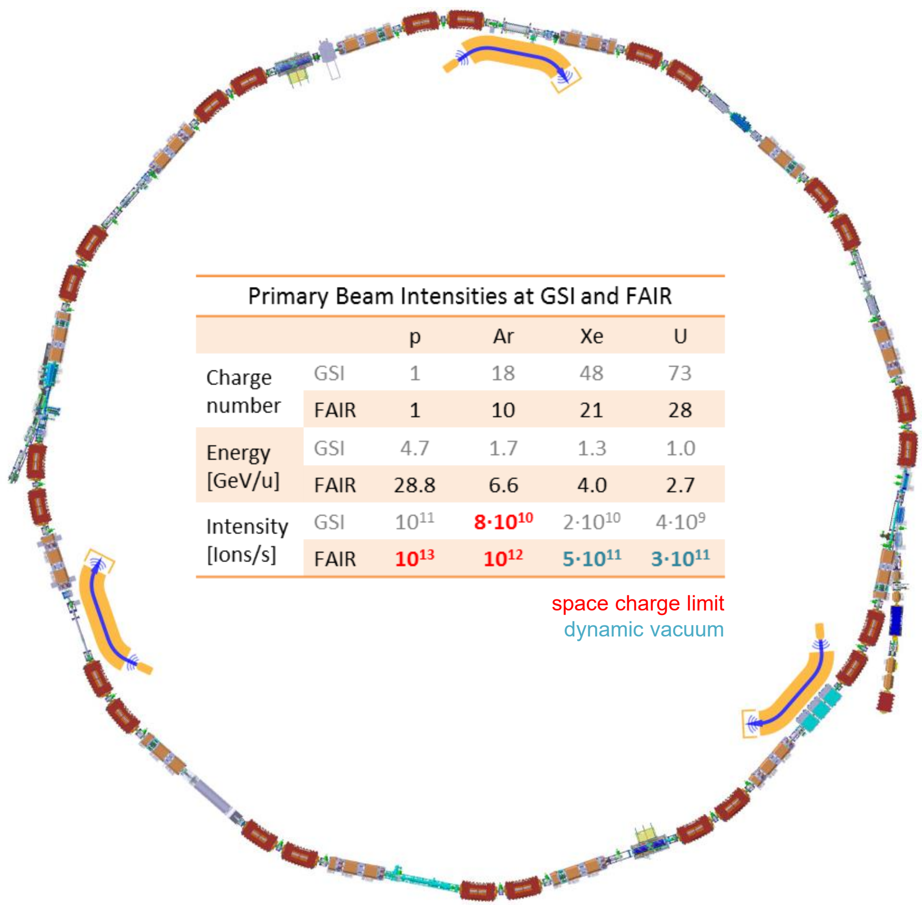
- *Goal:* Intensity increase of heavy ions to enhance physics potential for FAIR
- *Challenge:* Intensity limited by repulsive Coulomb force between ions (space charge)
- *Solution:* Pulsed electron lens matching ion bunch profile to compensate space charge

**Critical Components**

- High-current electron gun with RF modulation to create pulsed e-beam
- Compact high quality magnets providing longitudinal field for e-beam confinement
- Instrumentation for diagnostic of overlap

**Collaborations**

- ARIES WP16 (EU project) for manufacturing of gun among GSI, IAP, CERN, Riga TU
- Cooperation between IAP and SIS100/SIS18



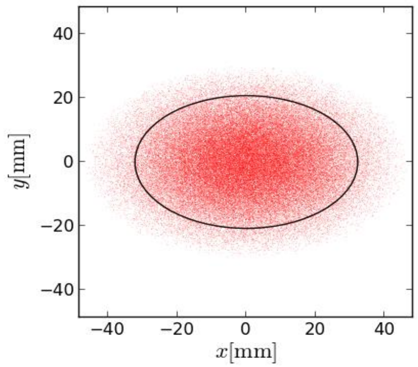
Primary Beam Intensities at GSI and FAIR

| | | p | Ar | Xe | U |
|---|---|---|---|---|---|
| Charge number | GSI | 1 | 18 | 48 | 73 |
| | FAIR | 1 | 10 | 21 | 28 |
| Energy [GeV/u] | GSI | 4.7 | 1.7 | 1.3 | 1.0 |
| | FAIR | 28.8 | 6.6 | 4.0 | 2.7 |
| Intensity [Ions/s] | GSI | $10^{11}$ | **$8\cdot10^{10}$** | $2\cdot10^{10}$ | $4\cdot10^{9}$ |
| | FAIR | **$10^{13}$** | **$10^{12}$** | **$5\cdot10^{11}$** | **$3\cdot10^{11}$** |

space charge limit
dynamic vacuum

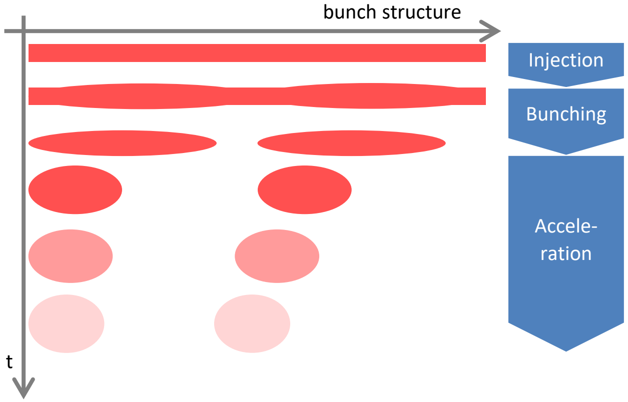
# Requirements for SIS18 Demonstrator Lens

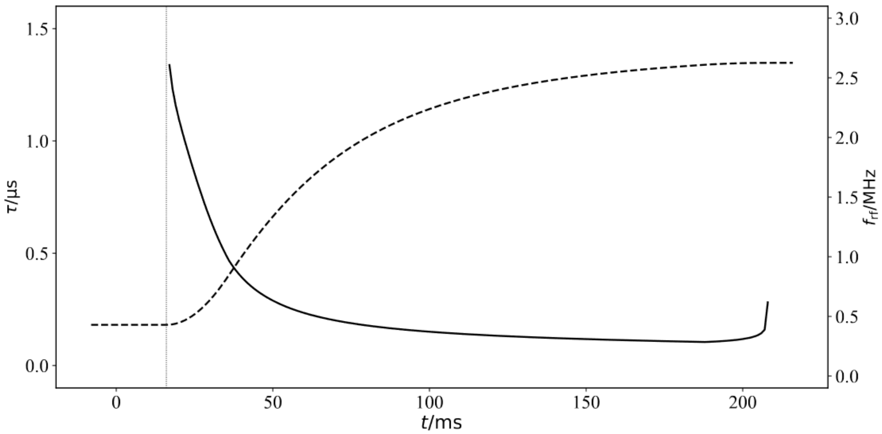
ion beam profile




$$\Delta Q_y^e = 0.1$$

varying bunch length

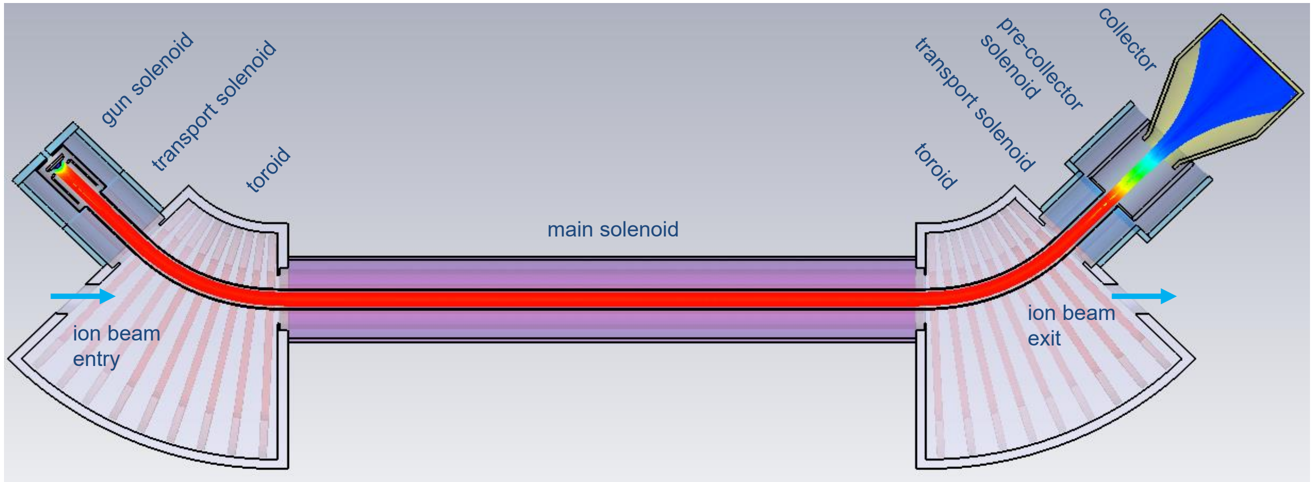


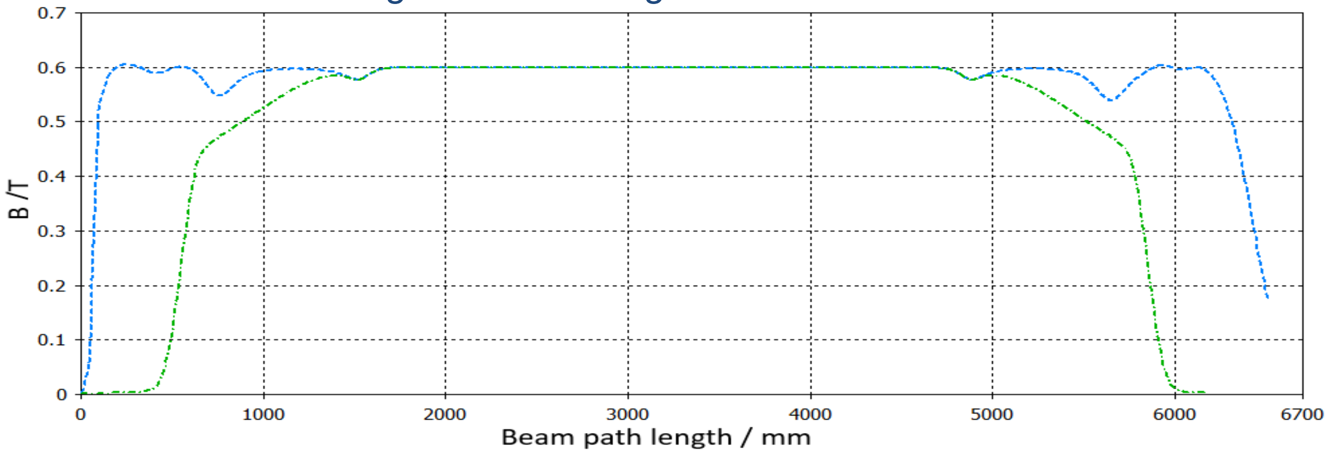

| Requirements | |
|---|---|
| Peak electron current | 10 A |
| Extraction voltage | 30 kV |
| Magnetic field | 0.6 T |
| Interaction length | 3.36 m |
| Horizontal beam radius | 35 mm |
| Vertical beam radius | 20 mm |
| Min. modulation frequency | 0.4 MHz |
| Max. modulation frequency | 1 MHz |
| Modulation bandwidth | 10 MHz |

# GSI SCC E-Lens

## Electron Lens Design Status



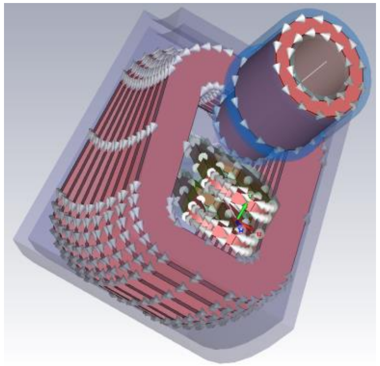

Magnetic field along the SCC electron lens

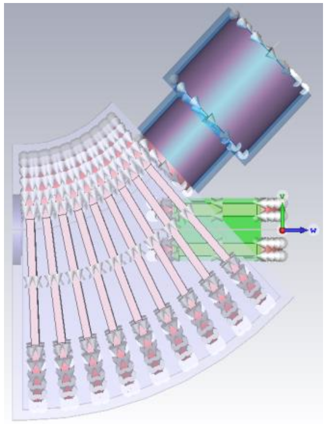


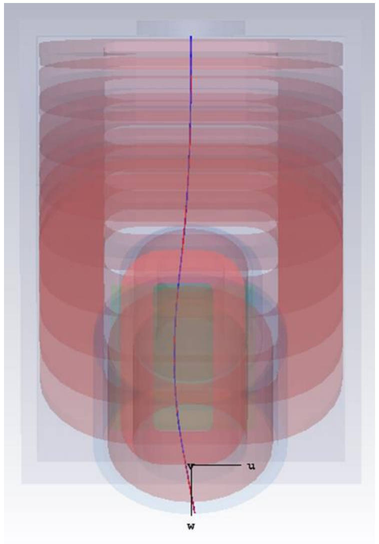
# GSI SCC E-Lens

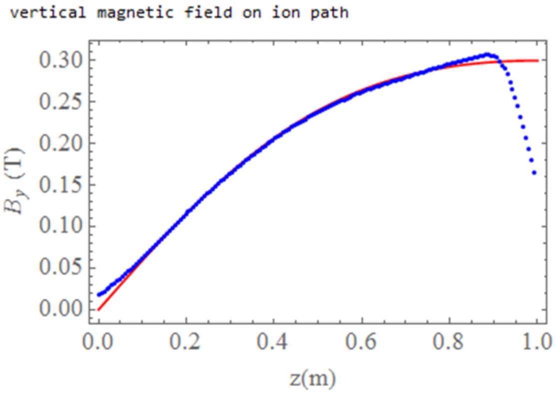
## Electron Lens Design Status

### Dipole Correctors

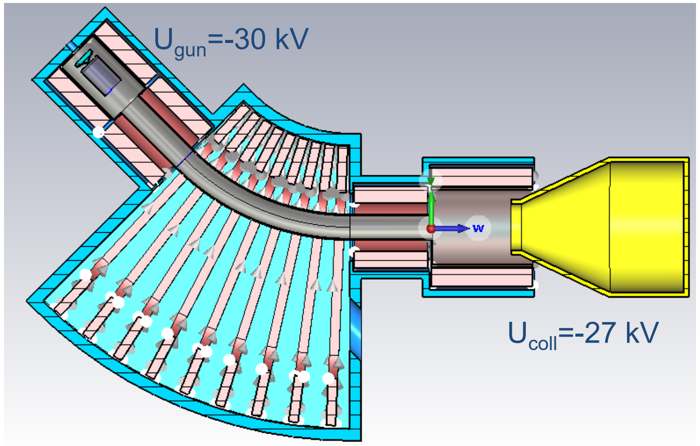









### Collector Design

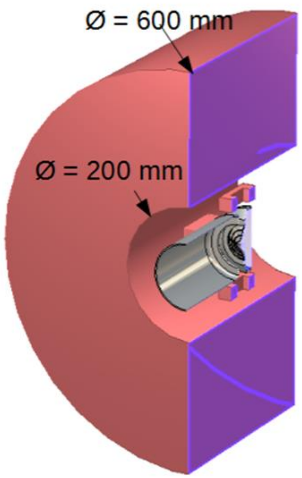


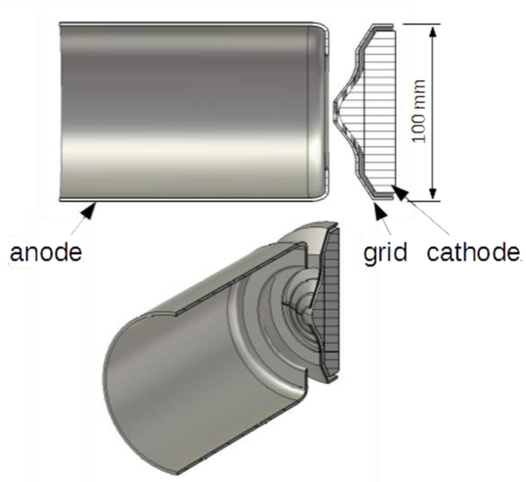

- Layout of major magnets completed
  - Toroids
  - Solenoids
  - Ion beam orbit correctors
- Preliminary collector design
- Electron beam transport simulations ongoing

A more detailed presentation of the electron lens design and beam dynamics will be given by S. Artikova (**WEPAB384**).

# GSI SCC E-Lens

## Conceptual Design of E-Gun

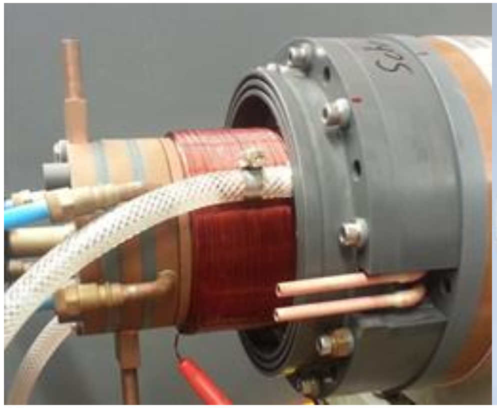


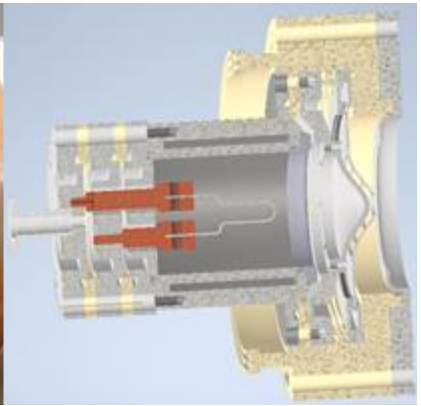



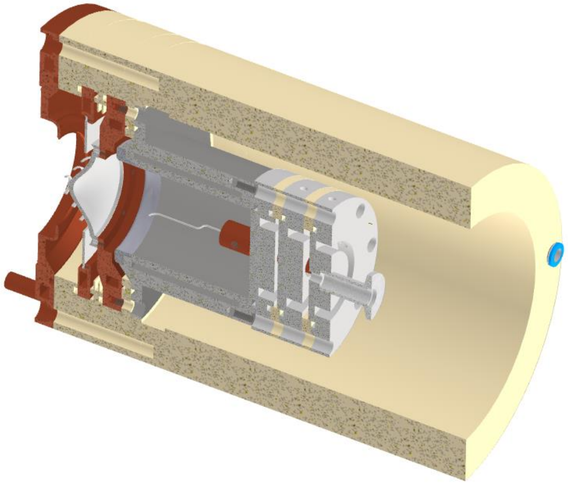

| Electron Gun | |
|---|---|
| Cathode radius $R_c$ [mm] | 26.5 mm |
| Anode voltage $U_A$ | 25 – 30 kV |
| Magnetic field | 0.6 T |
| Distance cathode to anode $d_{ca}$ | 20 mm |
| Max. extracted beam current $I_{max}$ | 10 A |
| Max. grid voltage $U_{g,max}$ | 3 kV |
| Grid capacity $C_g$ | ~75 pF |
| Distance cathode to grid $d_{cg}$ | 3 mm |

## Actual Status of E-Gun Development

### TE$^2$ Tungsten Electron Emitter Gun

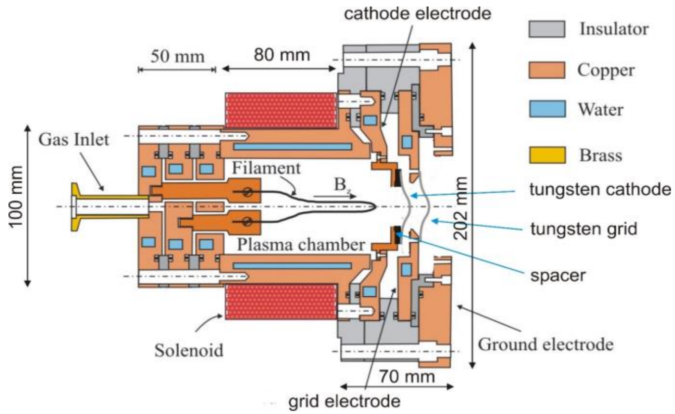






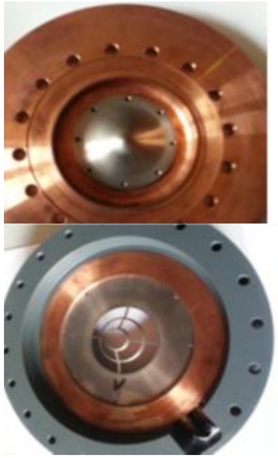
# GSI SCC E-Lens

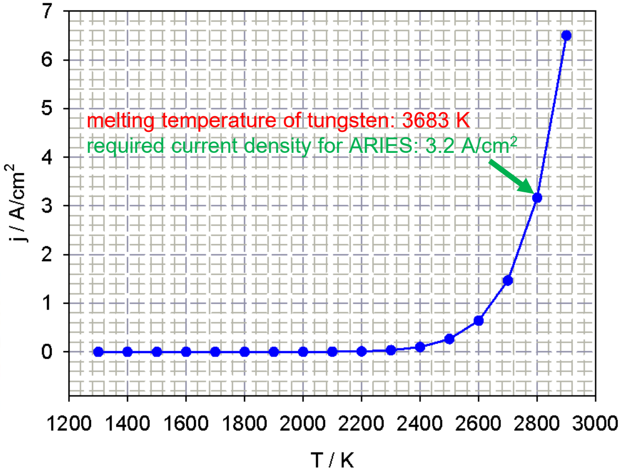
## Construction of Test Model




optimized design concerning HV and heating

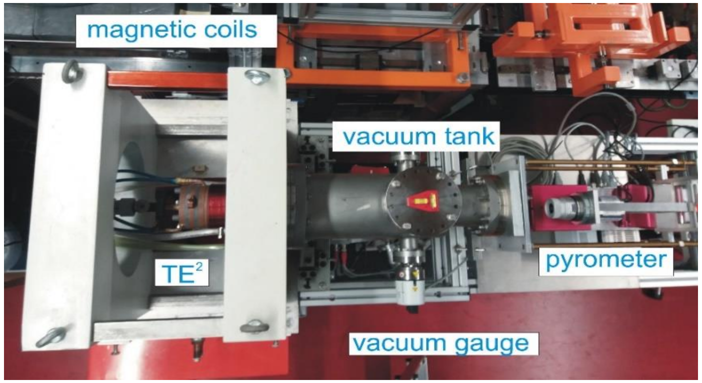
## Tungsten Cathode and Grid






robust with respect to handling and vacuum

## Experiments at GUF to test Tungsten Cathode Heating

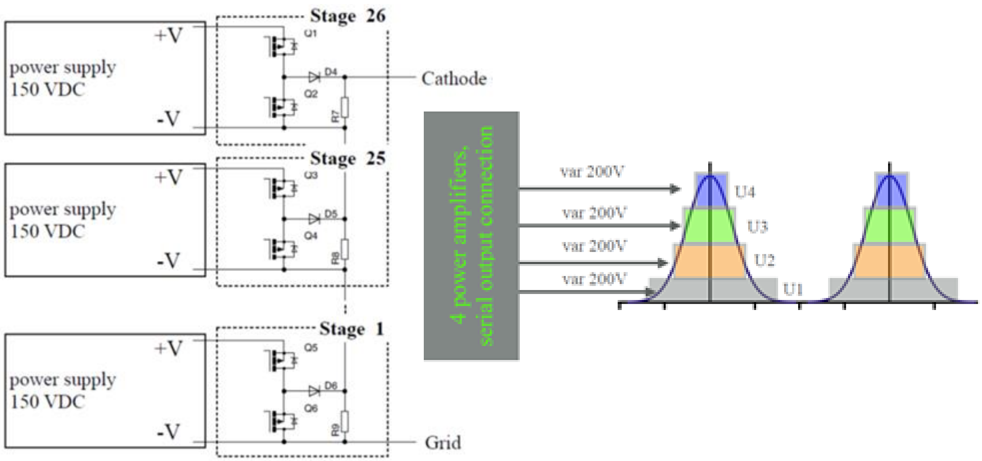



- direct heating by arc discharge
- heat transfer investigations for different material types
- vacuum separation between generator and extractor
- pyrometric measurements could confirm required heating temperatures
- required vacuum conditions and cooling performance could be confirmed

TE²-Gun has a robust and flexibel design.

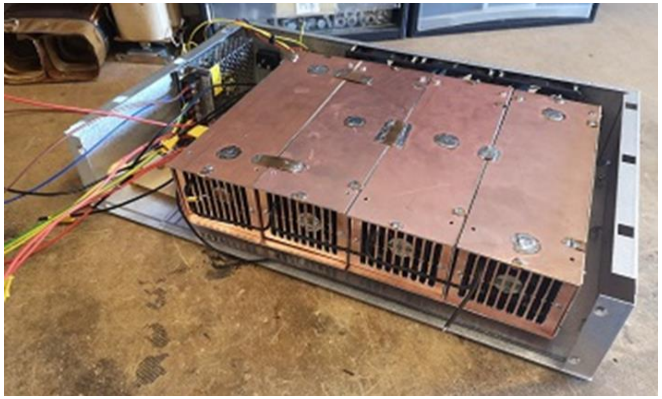
# GSI SCC E-Lens

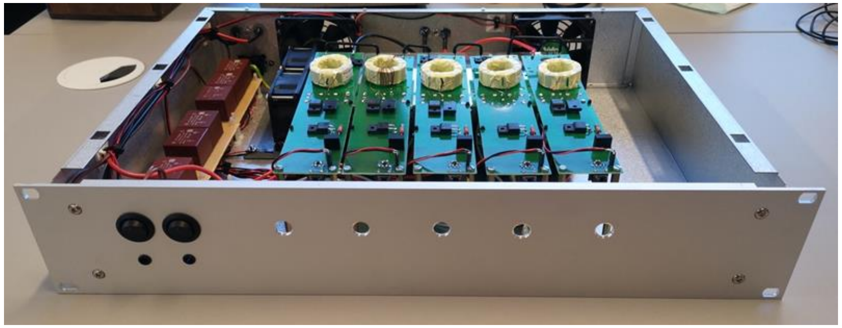
## Conceptual Design of Power Modulator




| Power Modulator | |
|---|---|
| Arbitrary waveform | e.g. Gaussian |
| Modulation voltage, peak-to-peak | 0 - 3200 V |
| Waveform frequency sweep | 400 - 1000 kHz |
| Waveform frequency sweep period | ~ 150 ms |
| Modulation bandwidth | 10 MHz |
| Amplitude compression ratio during the frequency sweep | 0.4 - 1 |
| Grid-cathode capacitance (measured) | 100 - 125 pF |

## Tested Design Stages

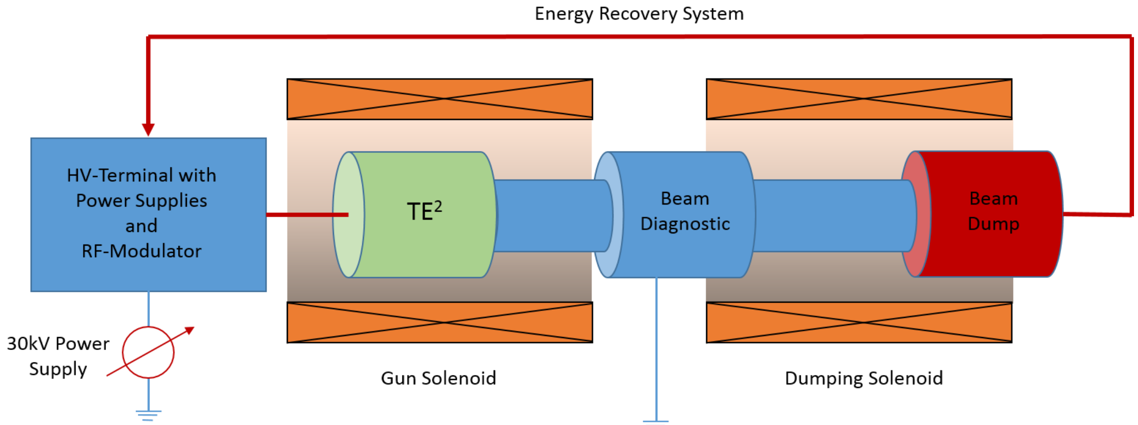




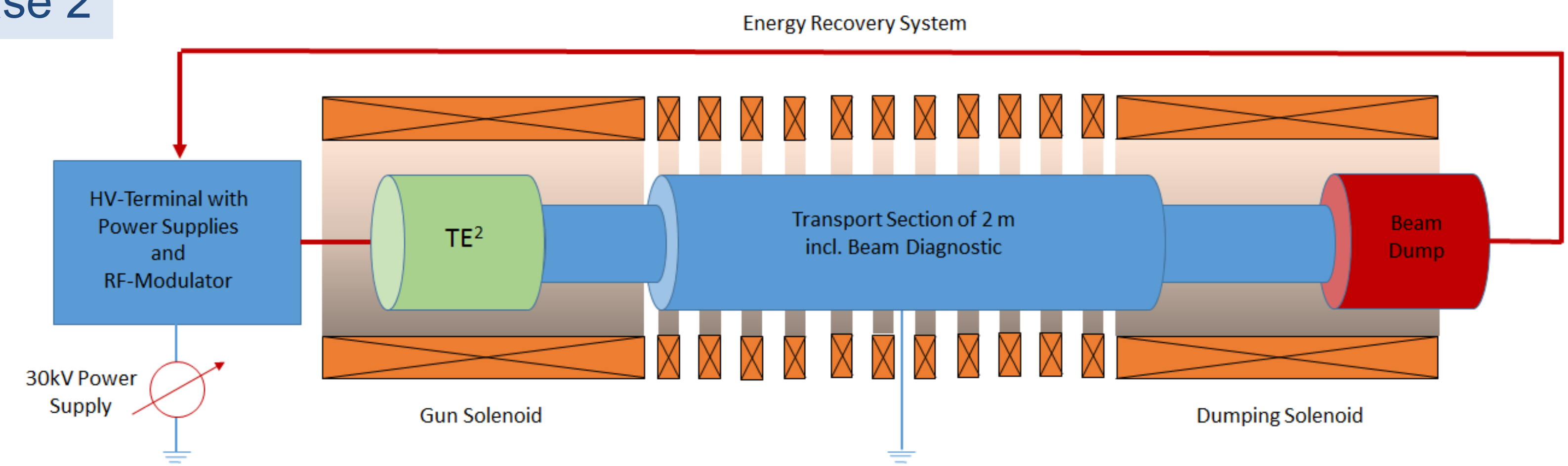
Design and Construction by P. Apse-Apsitis et al., RTU

## Layout of Test Bench at Goethe University of Frankfurt

### Phase 1

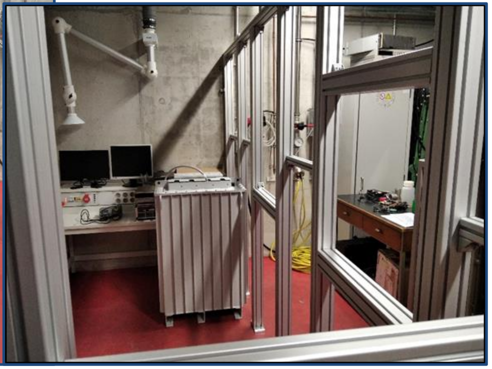



### Phase 2

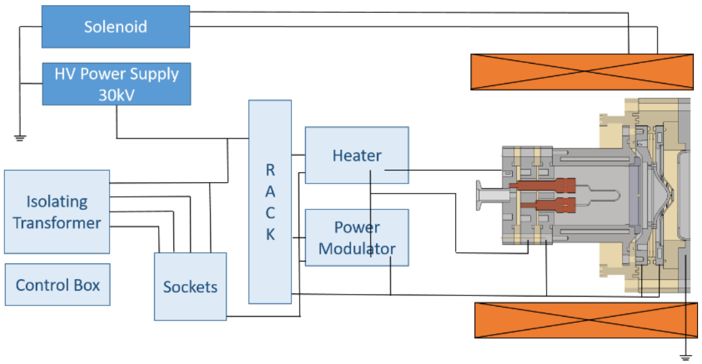


# GSI SCC E-Lens

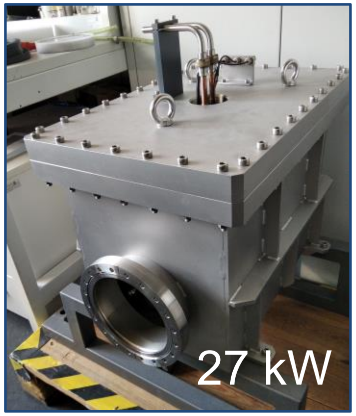
## High Voltage Terminal

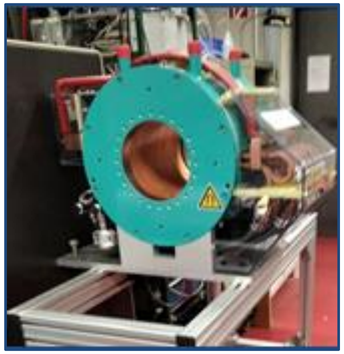


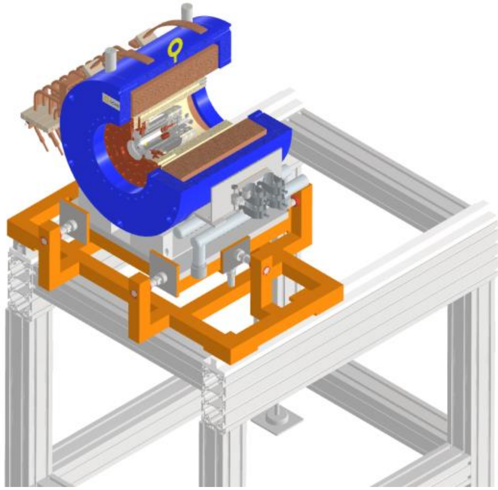
### electrical circuit diagram




## Status of Test Bench Preparation

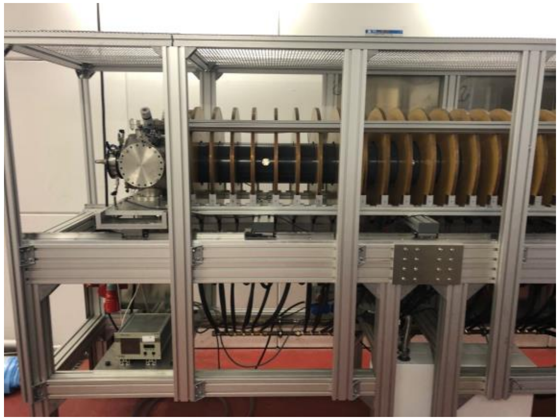


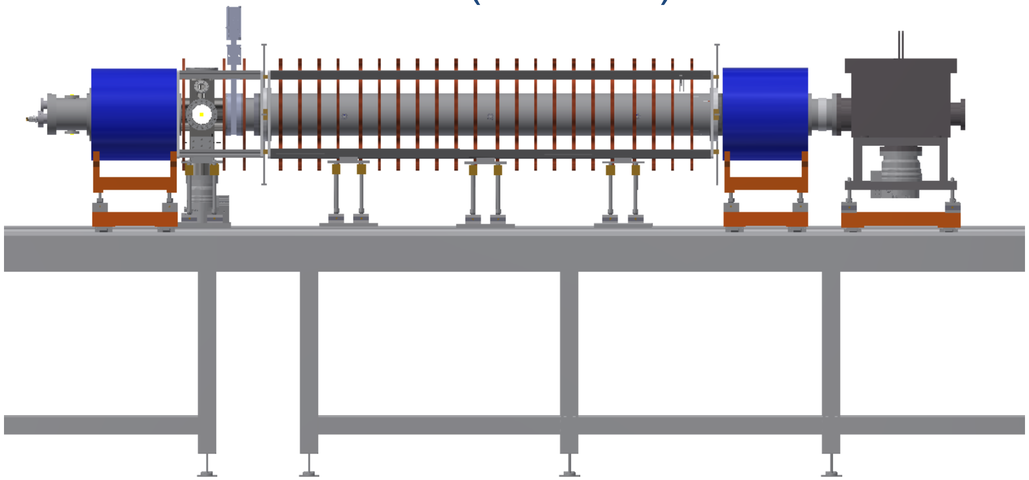


# GSI SCC E-Lens

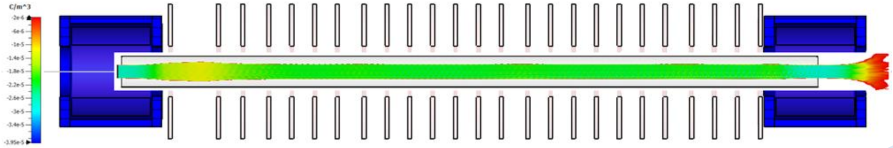
## Preparation of Extended Test Bench (Phase 2)



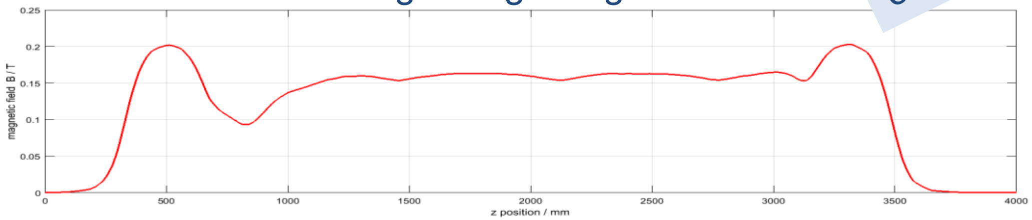
PhD Thesis, K. Thoma, GUF



beam transport simulations



magnetic guiding field




ongoing work