HELMHOLTZ GEMEINSCHAFT

Helmholtz-Institut Mainz

OPERATIONAL EXPERIENCE WITH THE HESR ELECTRON COOLER TEST SET-UP

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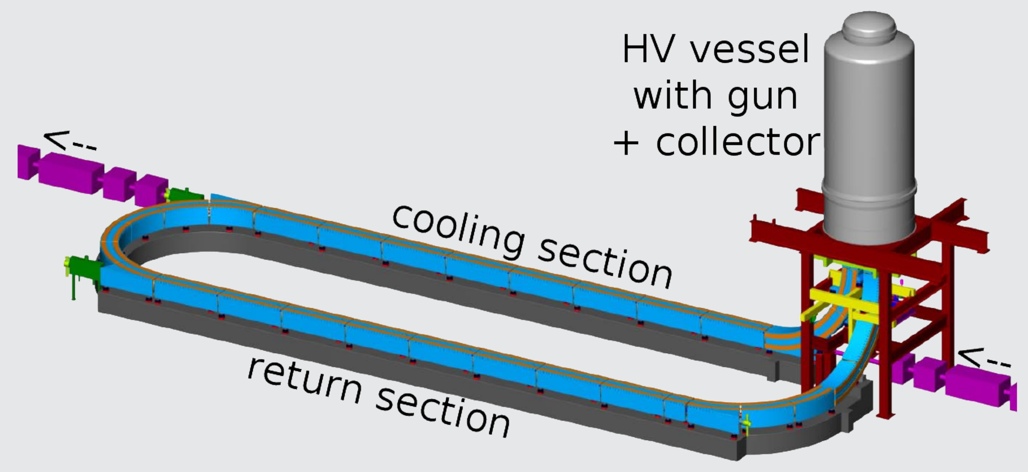
Motivation



- New magnetized high energy electron cooler is planned (HESR)
- High magnetic fields (up to 0.2 T)
- Relativistic electron energies (up to 8 MeV)
- Long cooling sections (24 m)
- Special demands on beam diagnostics, power supplies and electron optics

Electron cooler test bench at Helmholtz Institute Mainz

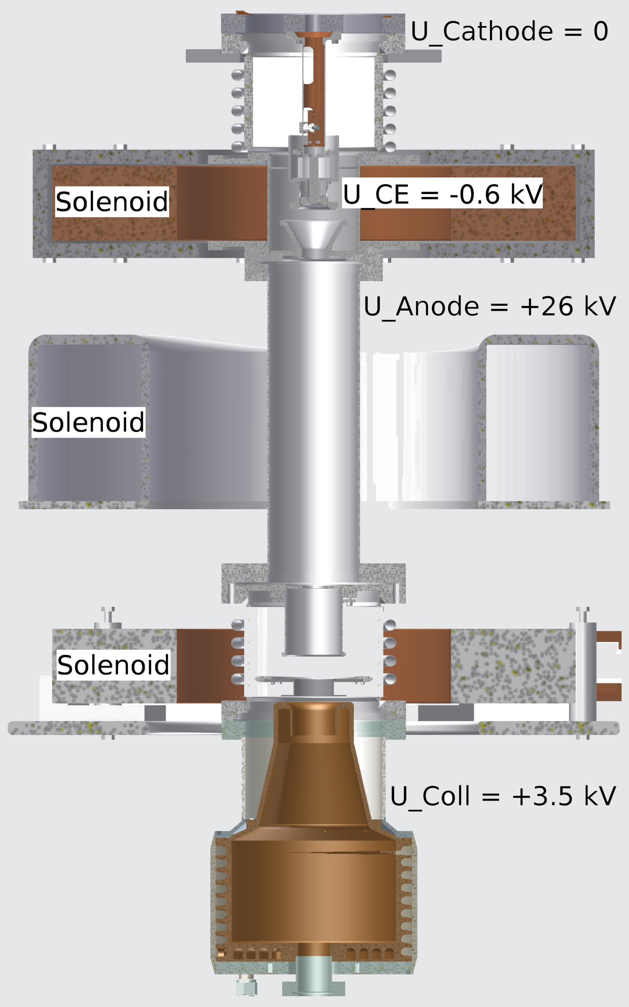


Figure: Schematic drawing of test bench

- Test bench for long-term stability tests of gun and collector under construction
- $U_{\text{Anode}} = 26\,\text{kV}$, $U_{\text{Coll}} = 3.5\,\text{kV}$, $I = 1\,\text{A}$
- Prototypes of HV solenoid and pancake solenoid employed
- Collector efficiency measurement and optimization necessary to avoid beam losses at high energy
- Additional suppression of secondary electrons using a Wien filter

Operation of the electron source

Electron source design

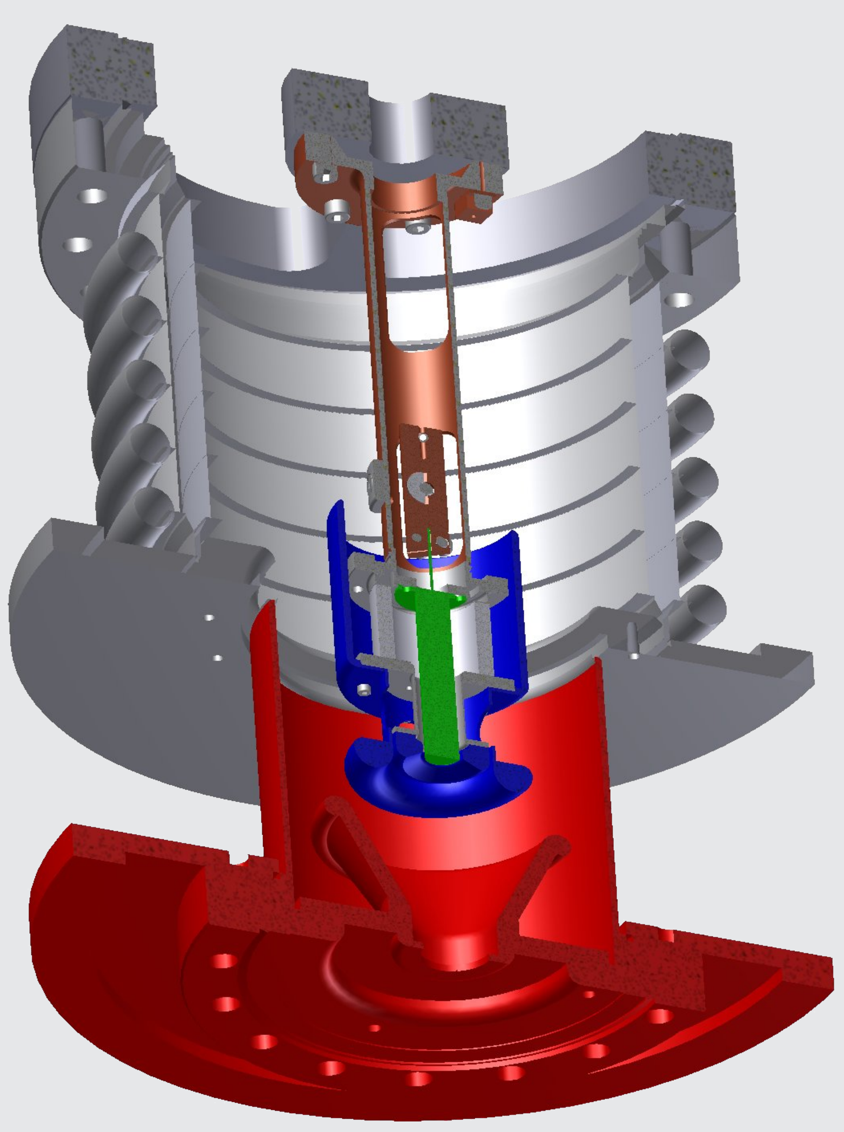


Figure: Schematic view of the electron source. Green: cathode, red: anode, blue: control electrode.

Gas discharge problems

- $\vec{E} \times \vec{B}$ gas discharge limits anode voltage and/or magnetic field to unacceptably low values
- Best parameters achieved up to now: $U = 10.0\,\text{kV}$ at $B = 200\,\text{mT}$
- At higher values, all HV supplies are spontaneously shorted and the cathode is destroyed
- Breakdown voltage depends on control electrode in a counterintuitive way

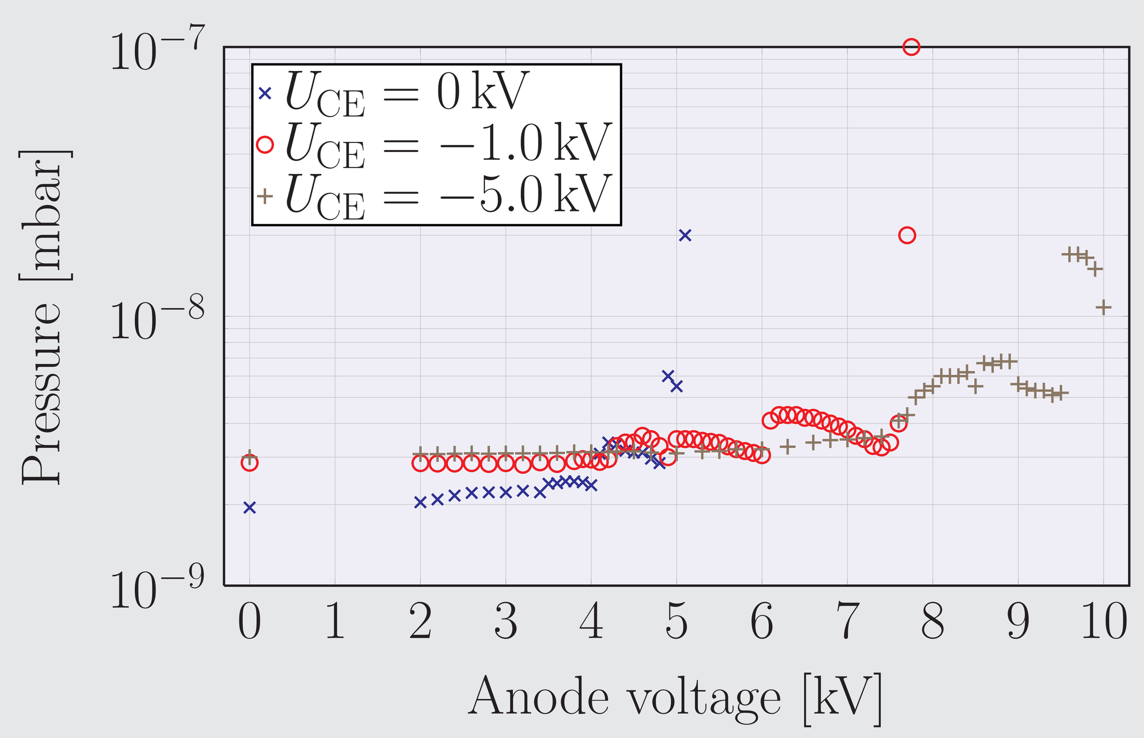


Figure: Control electrode voltage dependence of gas discharge effects at $B_{\parallel} = 200\,\text{mT}$.

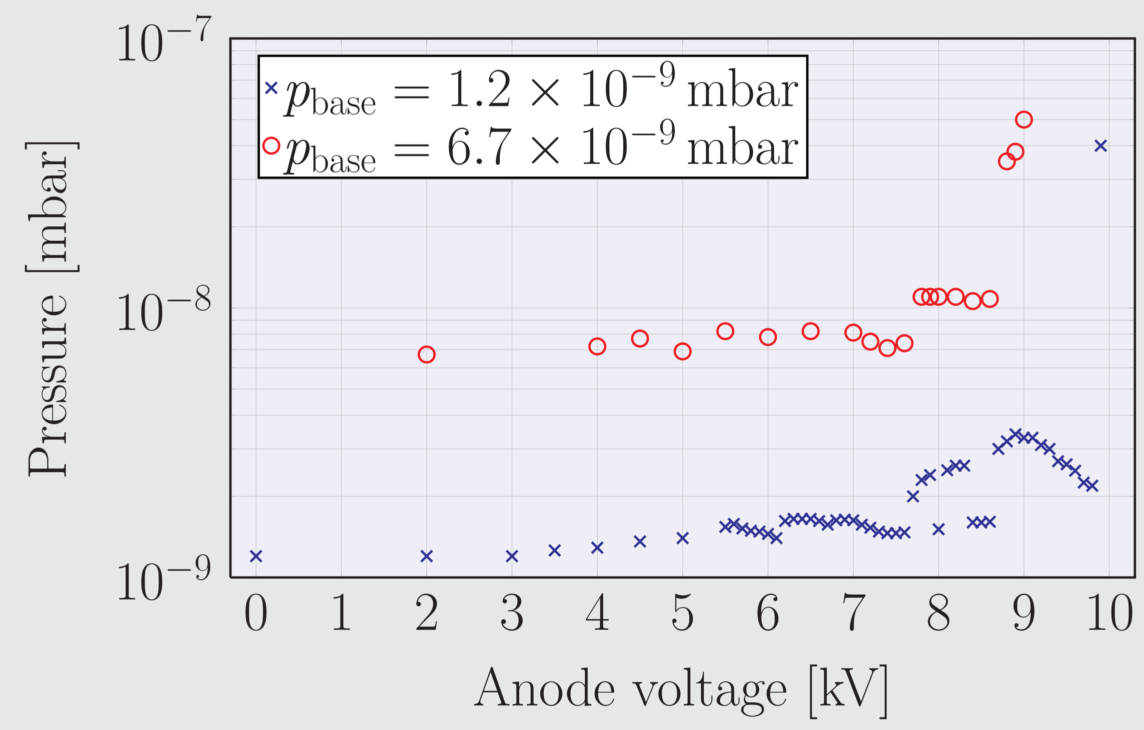


Figure: Base pressure dependence of gas discharge effects at $U_{\text{CE}} = -0.6\,\text{kV}$, $B_{\parallel} = 200\,\text{mT}$.

- Breakdown voltage also depends non-proportionally on the residual gas pressure
- Minimizing the transverse electric field while maintaining optimal field geometry in the accelerating section is difficult
- Better vacuum conditions will be achieved by employing additional pumps and by replacing the remaining suboptimal components (e.g. glued insulator)

Collection efficiency measurement using a Wien filter

- Efficient capturing of secondary electrons possible with Wien velocity filter
- Deflecting force: $\vec{F} = q(\vec{E} + \vec{v} \times \vec{B}) = 0$ for primary beam, non-zero otherwise
- Construction of Wien filter in progress
- CST simulation of complete test bench with Wien filter has been carried out (preliminary)

Table: Parameters for CST Simulation of the Test Bench

Number of particles	40 000
Number of mesh cells	15 million
Anode voltage	26.0 kV
Control electrode voltage	0 kV
Suppressor electrode voltage	3.5 kV
Collector voltage	3.5 kV
Wien filter voltage	± 8.0 kV
Wien filter B_y	3.2 mT
Wien filter B_z	52 mT
Beam current	1.05 A

Wien filter design

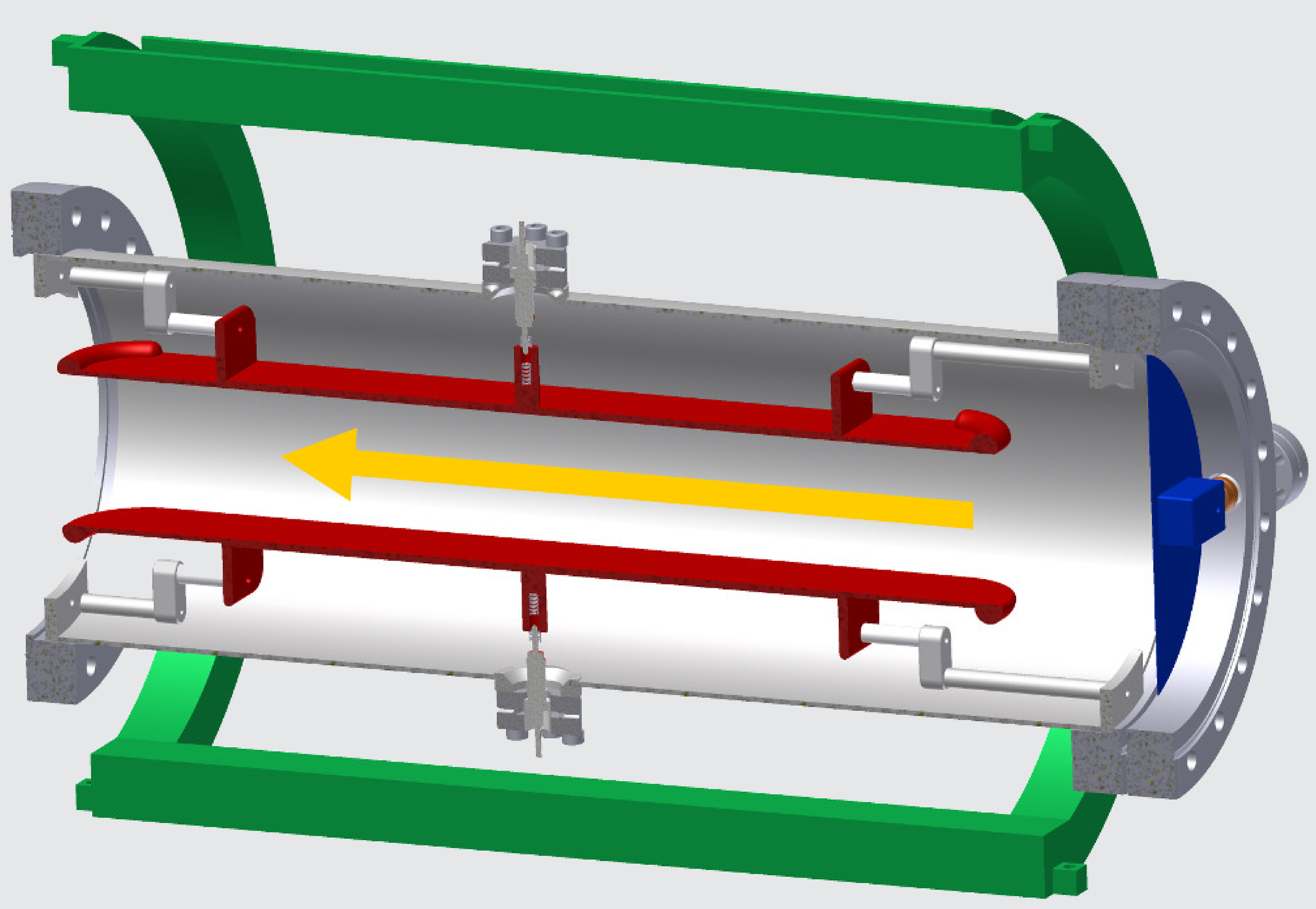


Figure: Schematic view of the Wien filter design. Red: electrostatic plates, green: coil for transverse magnetic field, blue: dump for deflected electrons, yellow: primary beam.

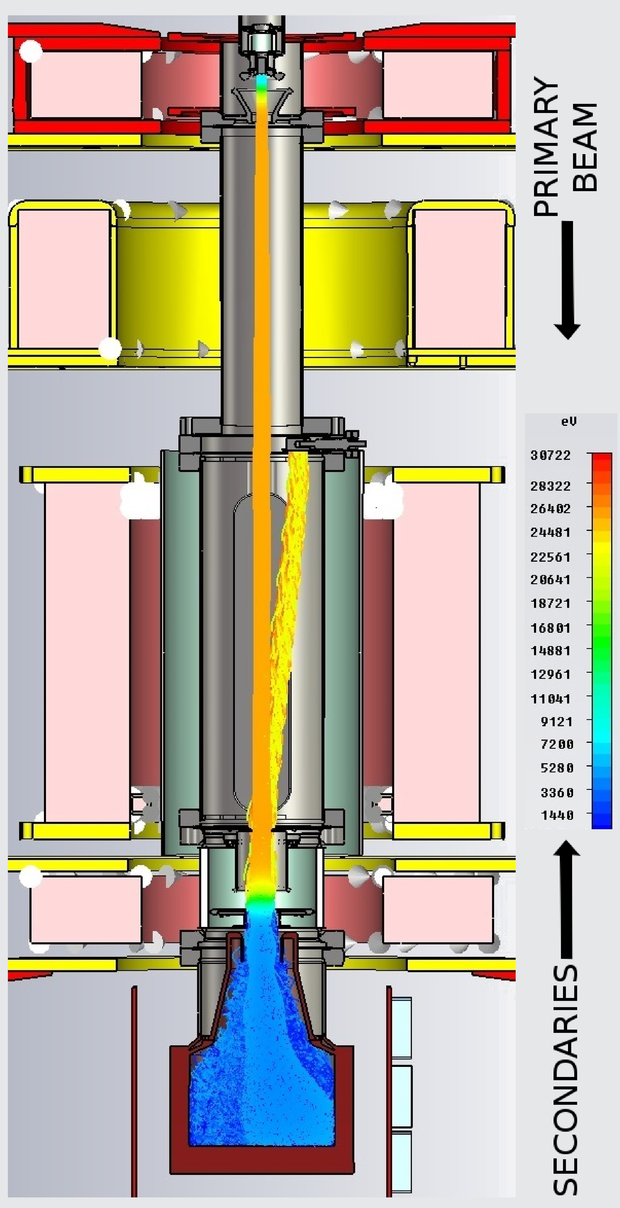


Figure: Simulation of beam trajectories inside the test bench including Wien filter. Top: source, bottom: collector.