The HITRAP Cooler Penning Trap

TRAPPING AND COOLING OF HIGHLY-CHARGED IONS IN A PENNING TRAP

- Introduction
- The low energy beam line
- The Penning trap
- Status + outlook

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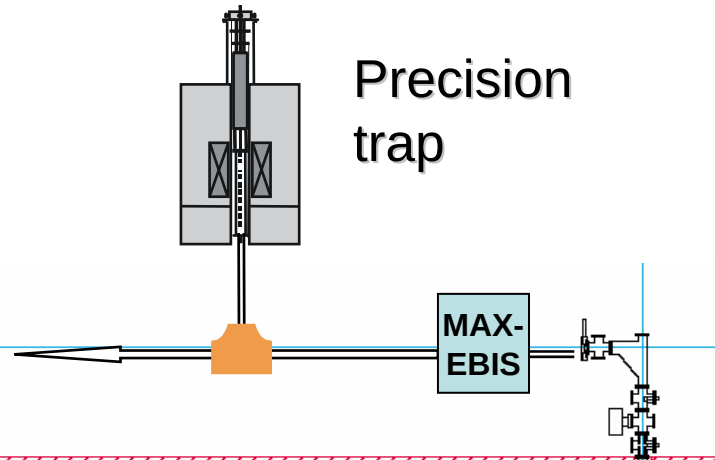
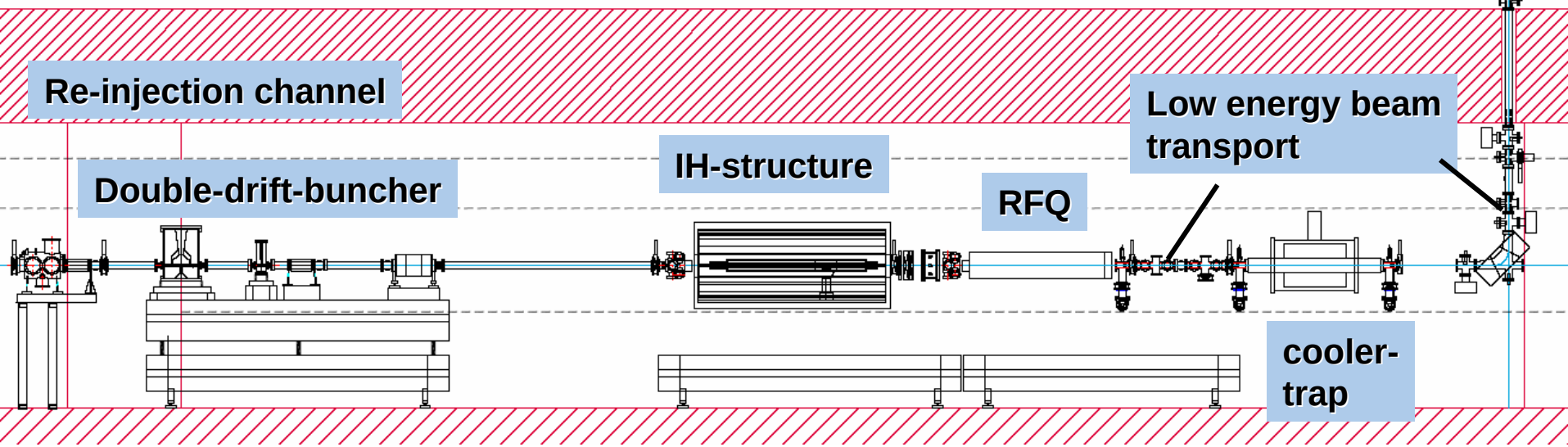
The HITRAP linear Decelerator

Operational Parameters:

- **Deceleration from 4 MeV/u to keV/u**
- **HCI with M/q ≤ 3**
- **Beam intensity: some 10^5 ions/pulse for U^{92+}**
- **Repetition time: 10 s**

Other experimental setups

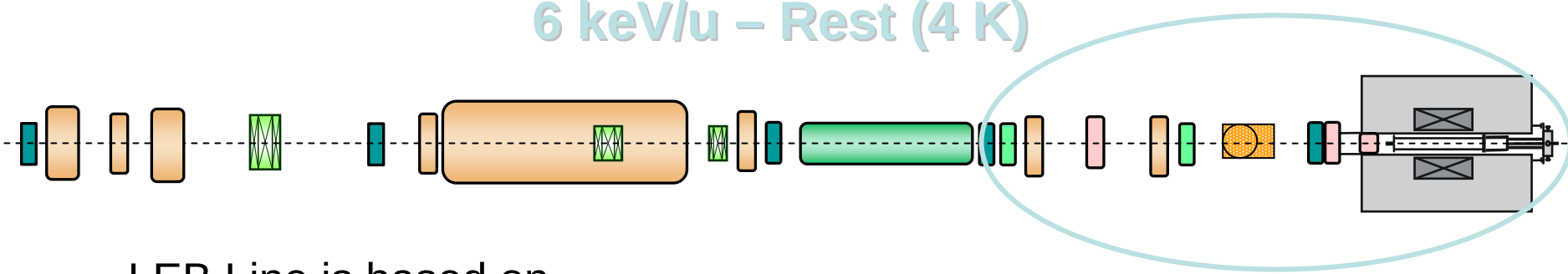




from ESR: 4 MeV/u → 0.5 MeV/u → 6 keV/u

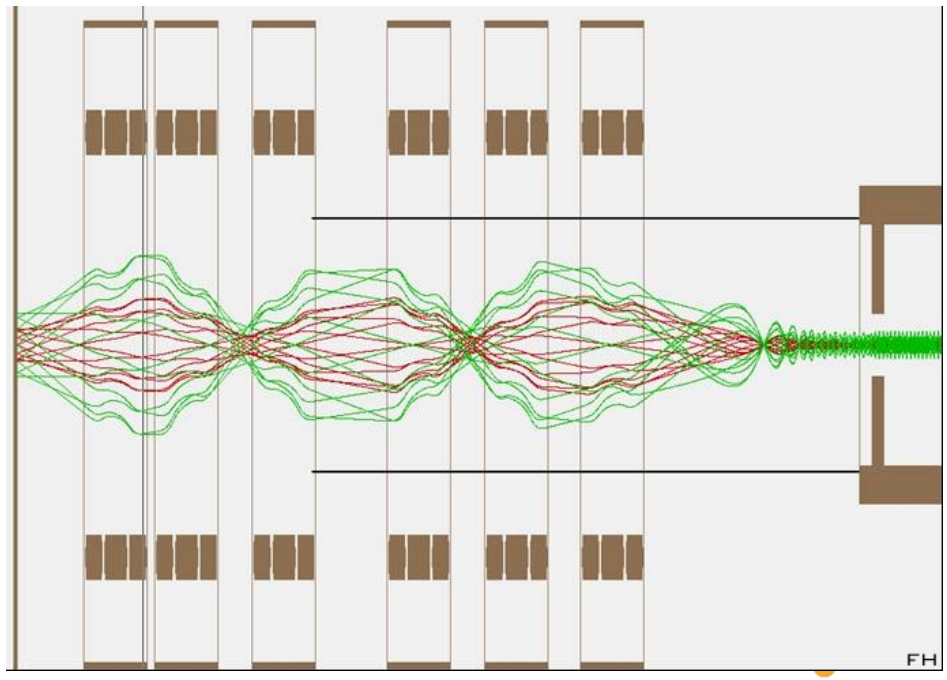
Injection into the Cooler Trap

6 keV/u – Rest (4 K)

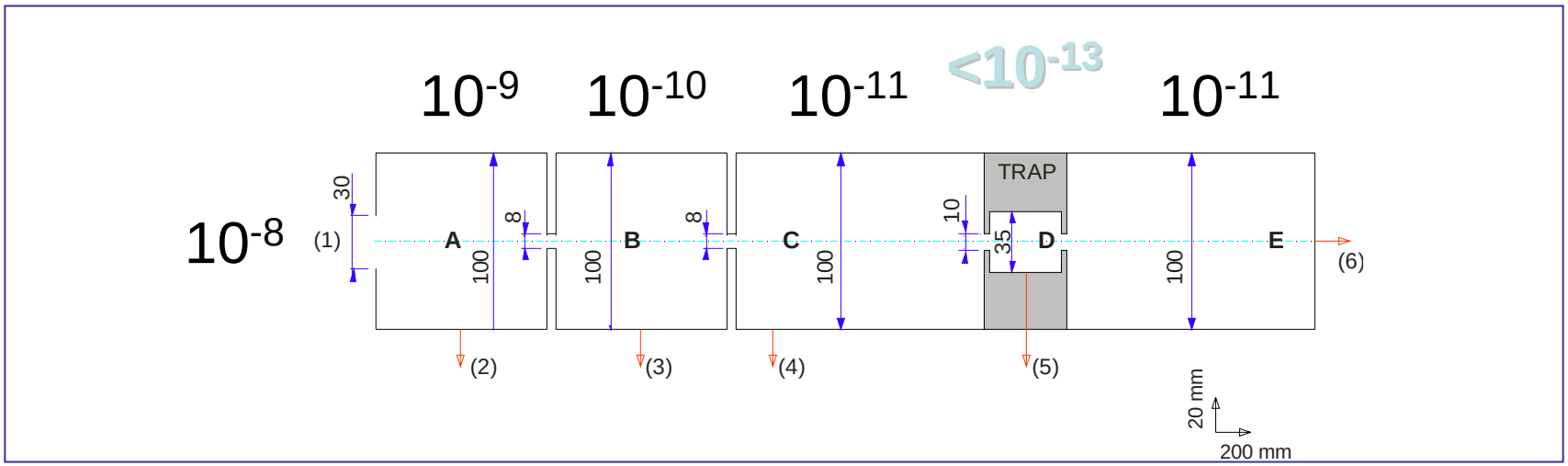


LEB Line is based on
electrostatic Einzel lenses
to cope with energy spread
± 4% and emittance
100 π mm mrad

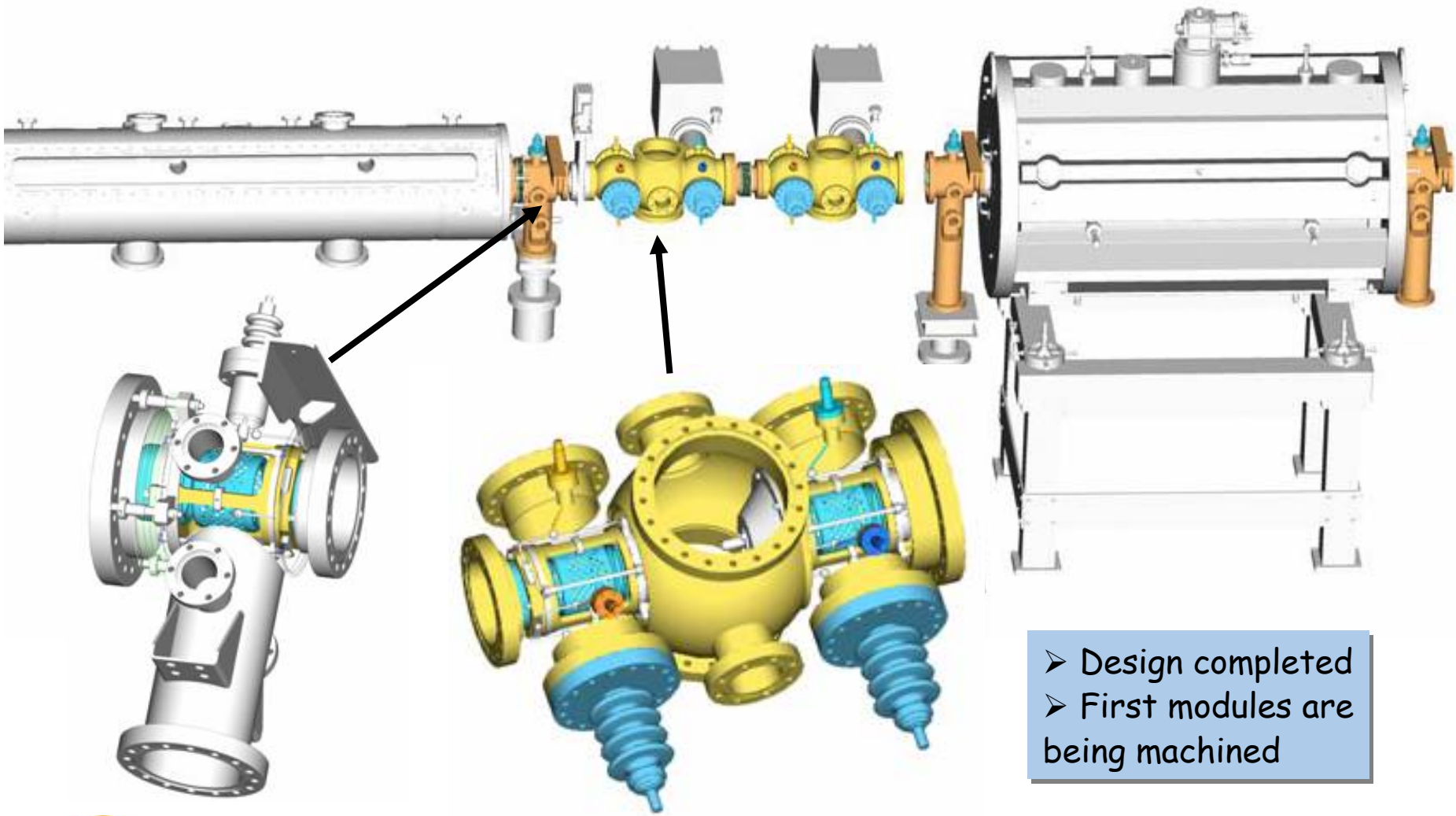
Differential pumping to
achieve $p<10^{-13}$ mbar in
the trap



Injection into the Cooler Trap

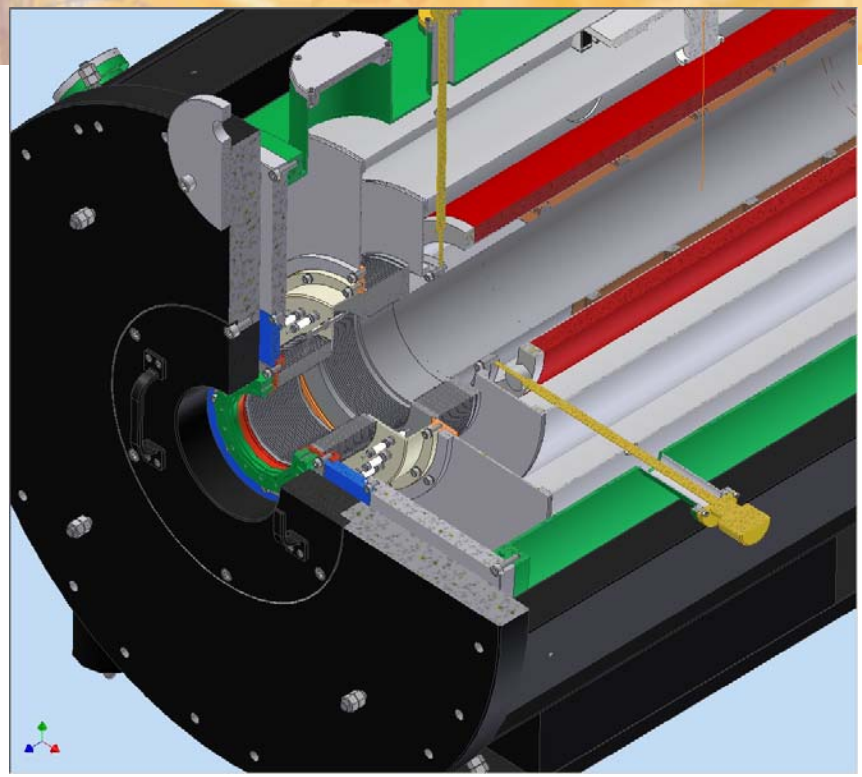


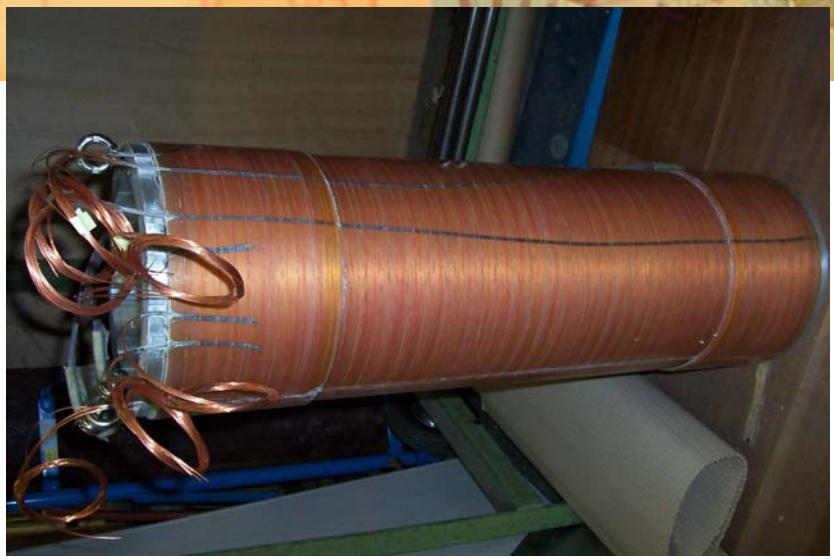
Injection into the Cooler Trap

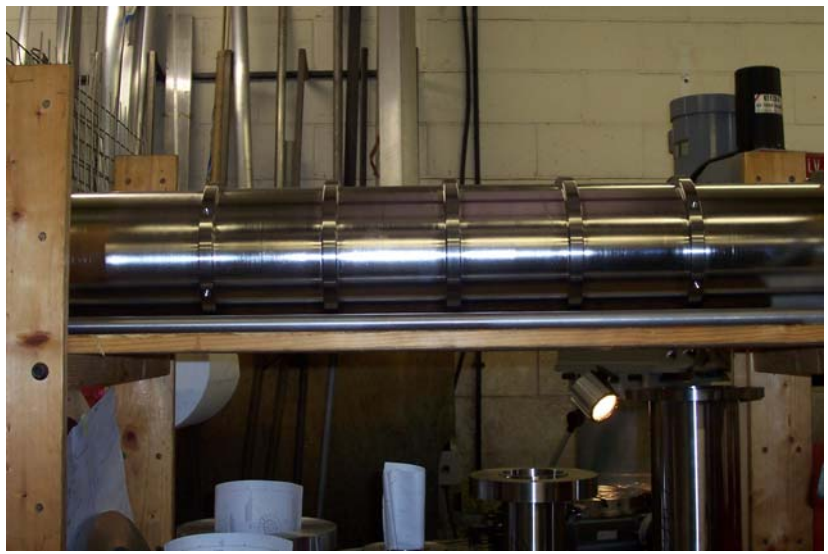


- Design completed
- First modules are being machined

The Solenoid



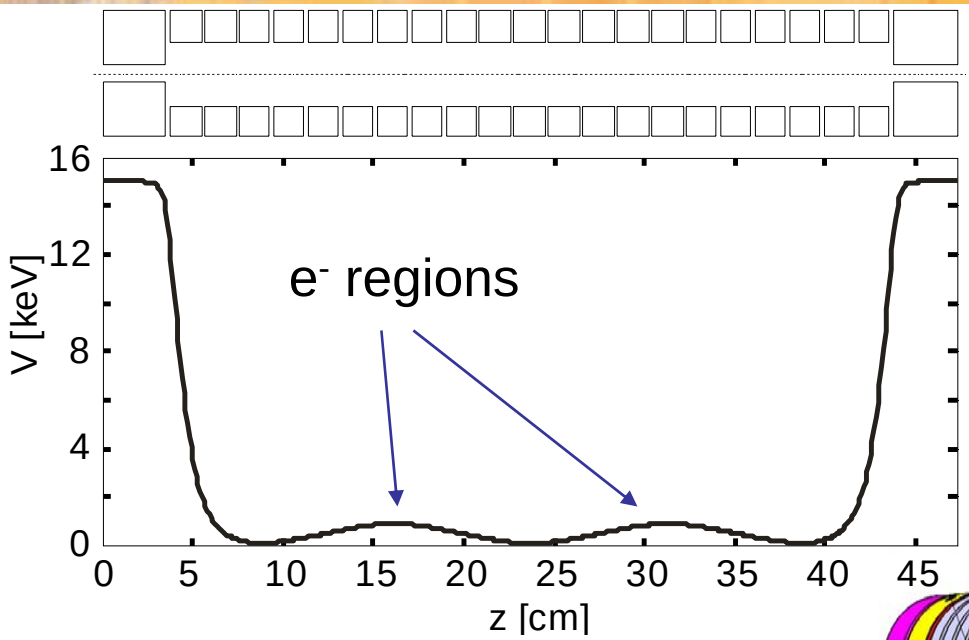




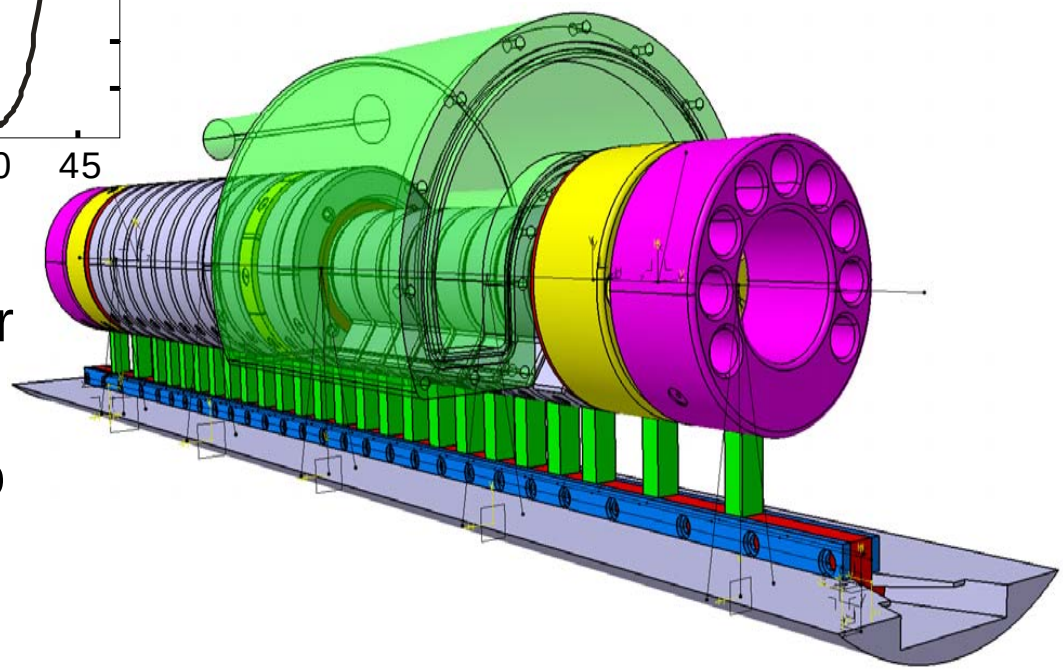
- SC magnet, B = 6 T, 400 mm, 0.1%
- Delivery in November 2006
- Complete trap environment at 4.2 K
- Design drawings of electrodes are ready
- Preparation of electronics and cabling

The Cooler Penning Trap

The electric field along the trap axis



- 4 K
- 6 T



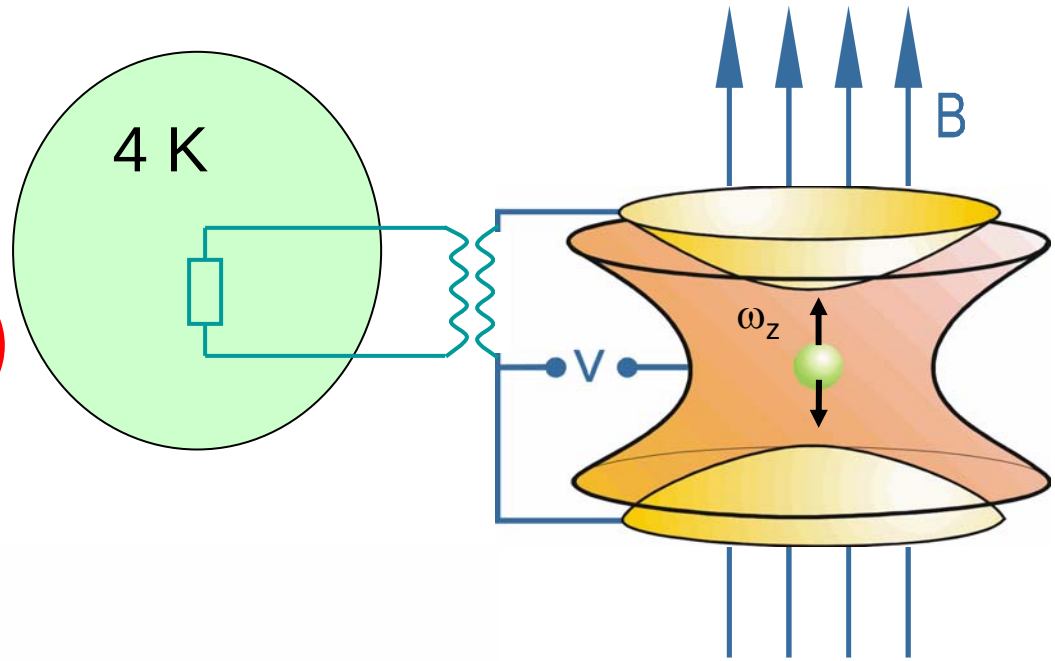
- Five harmonic regions (2 for e^- and 3 for ions)
- 23 equally sized rings + two endcaps + two guard rings

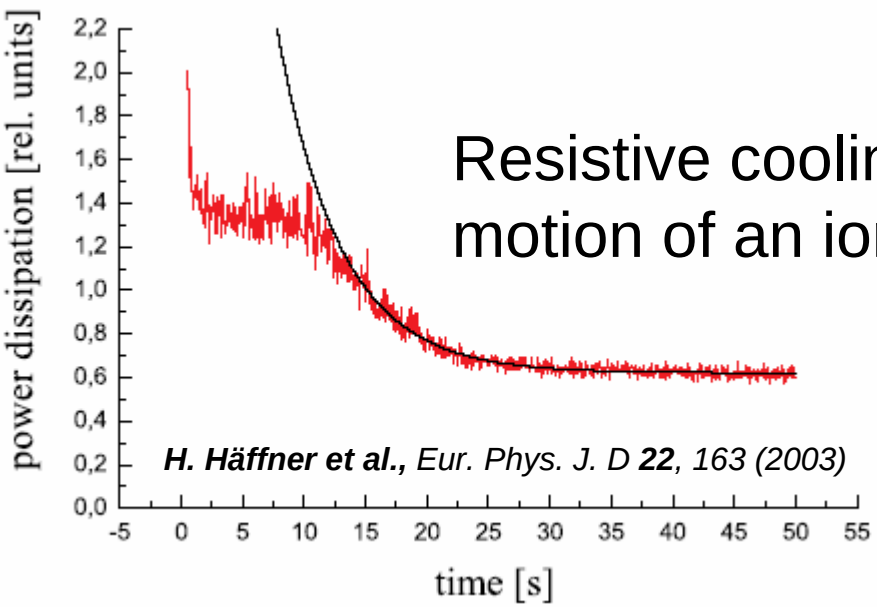
Resistive Cooling

$$\tau = \frac{mD^2}{q^2 R}$$ (Single ion)

$$\tau_{asymm} \approx 750ms$$

$$\tau_{symm} \approx 160ms$$



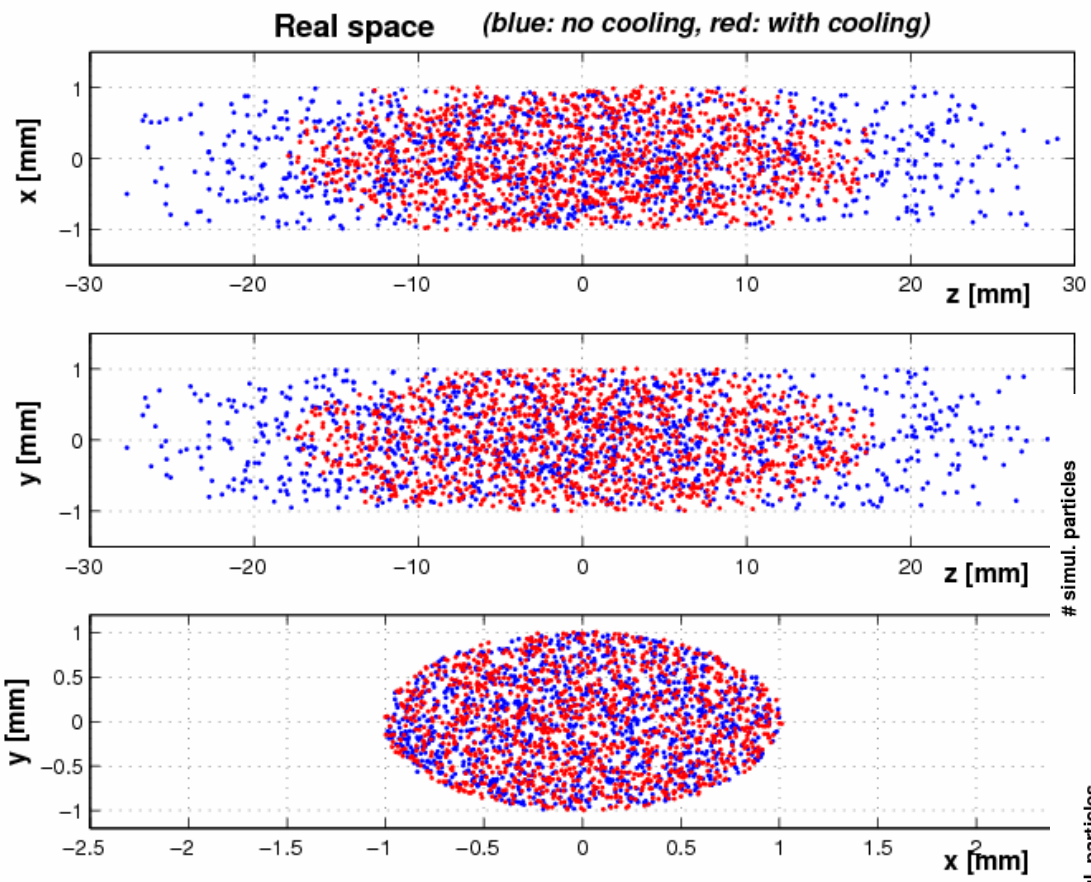


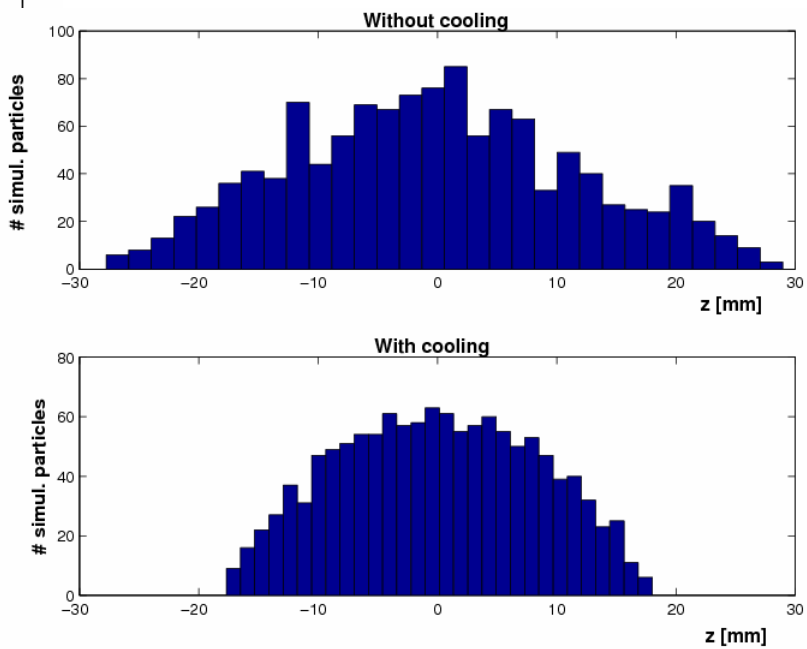
H. Häffner et al., *Eur. Phys. J. D* ***22****, 163 (2003)*

Resistive cooling of the axial motion of an ion cloud (30 $^{12}C^{5+}$)

Ion Cloud Formation

Particle in Cell (PIC) calculations + viscous cooling force + Brownian motion

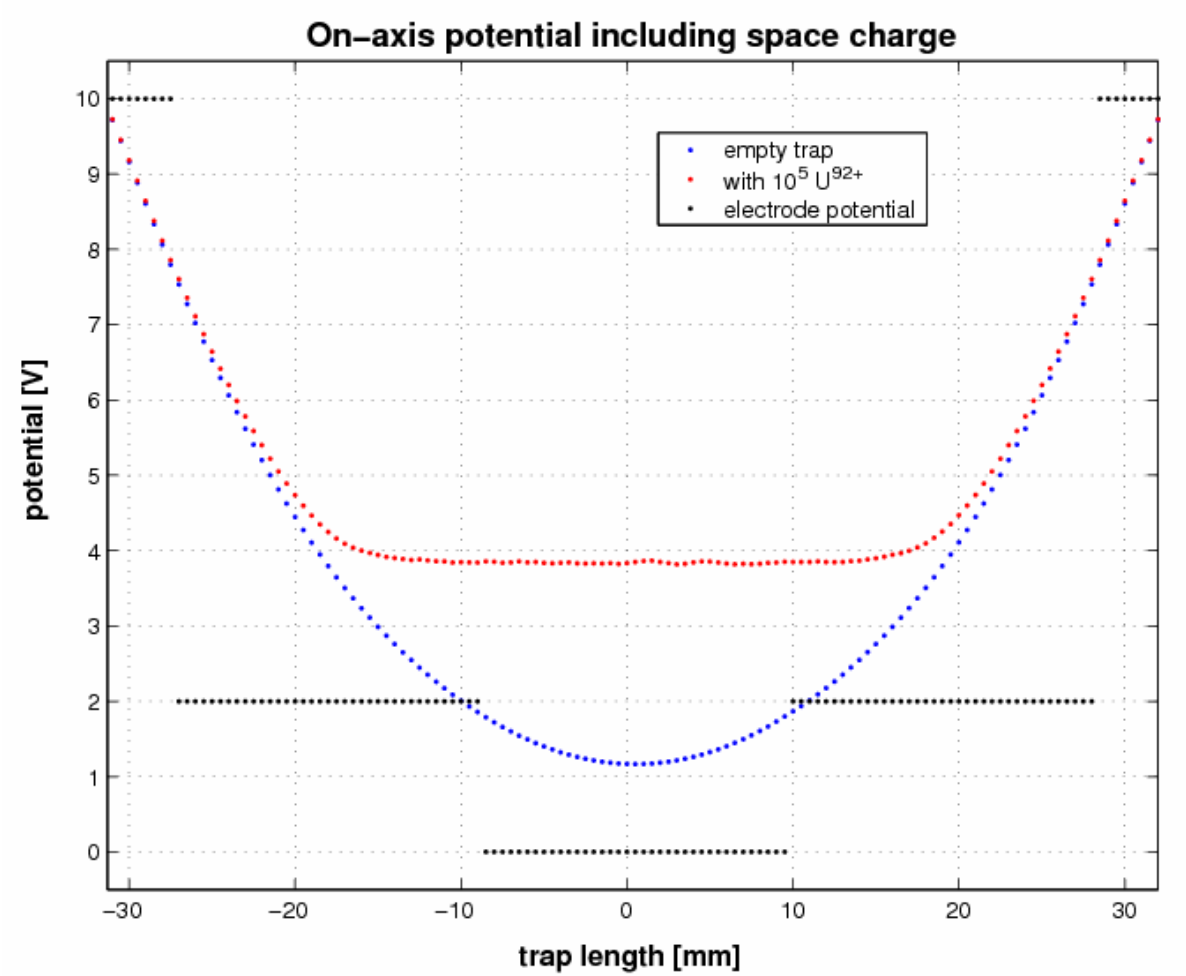




PIC code S. Schwarz NIMA in press, extensions G. Maero

Space Charge Effects

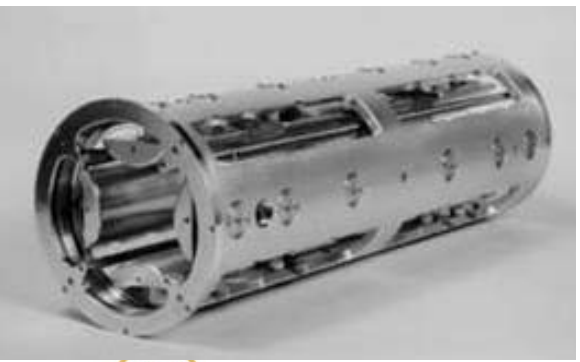
100,000 U^{92+} in a 6 T Penning Trap

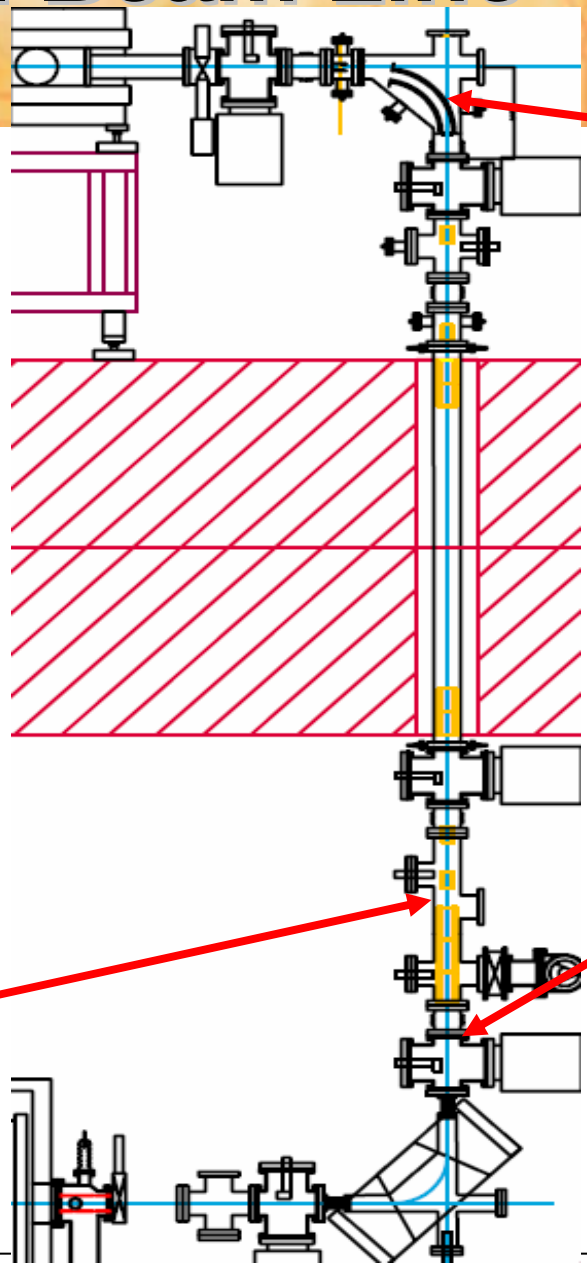


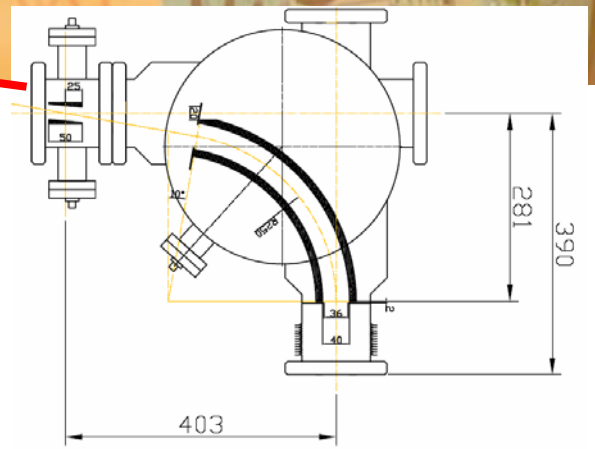
PIC code S. Schwarz, extensions G. Maero

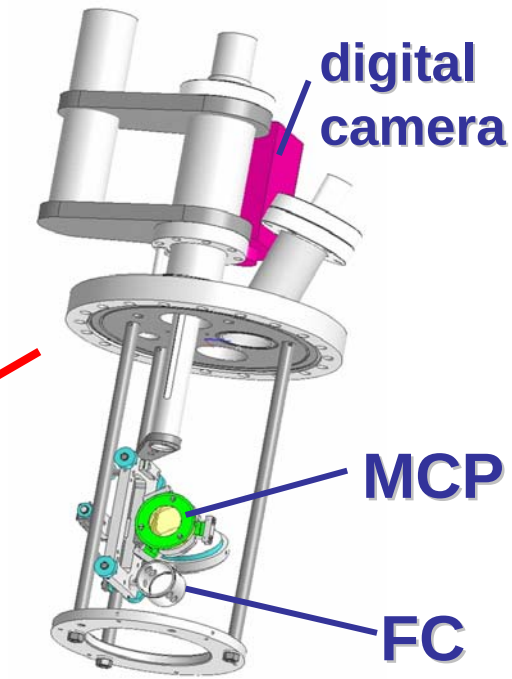
The Vertical Beam Line

- Pressure < 10^{-10} mbar
  → ion pumps, NEG pumps and NEG coating
- Particle optics calculations completed
- Design drawings of quadrupoles and kicker-bender prepared
- Low energy beam diagnostics built at KVI: Fluorescence screen (YAG), MCPs, Faraday cups









Status of the HITRAP cooler Trap

- HITRAP will deliver large amounts of heavy and highly charged ions at low energy
- The Cooler Trap will be the final stage for cooling and shaping the ion bunch to be sent to experiments

- Intensive design work has been carried out since almost two years and is in an advanced stage
- Simulation work of the ion cloud behavior shows first results – next step = extraction

- by the end of the year a preliminary setup (Cooler Trap with MAXEBIS ion source) will be installed to test the trap's properties and capabilities experimentally