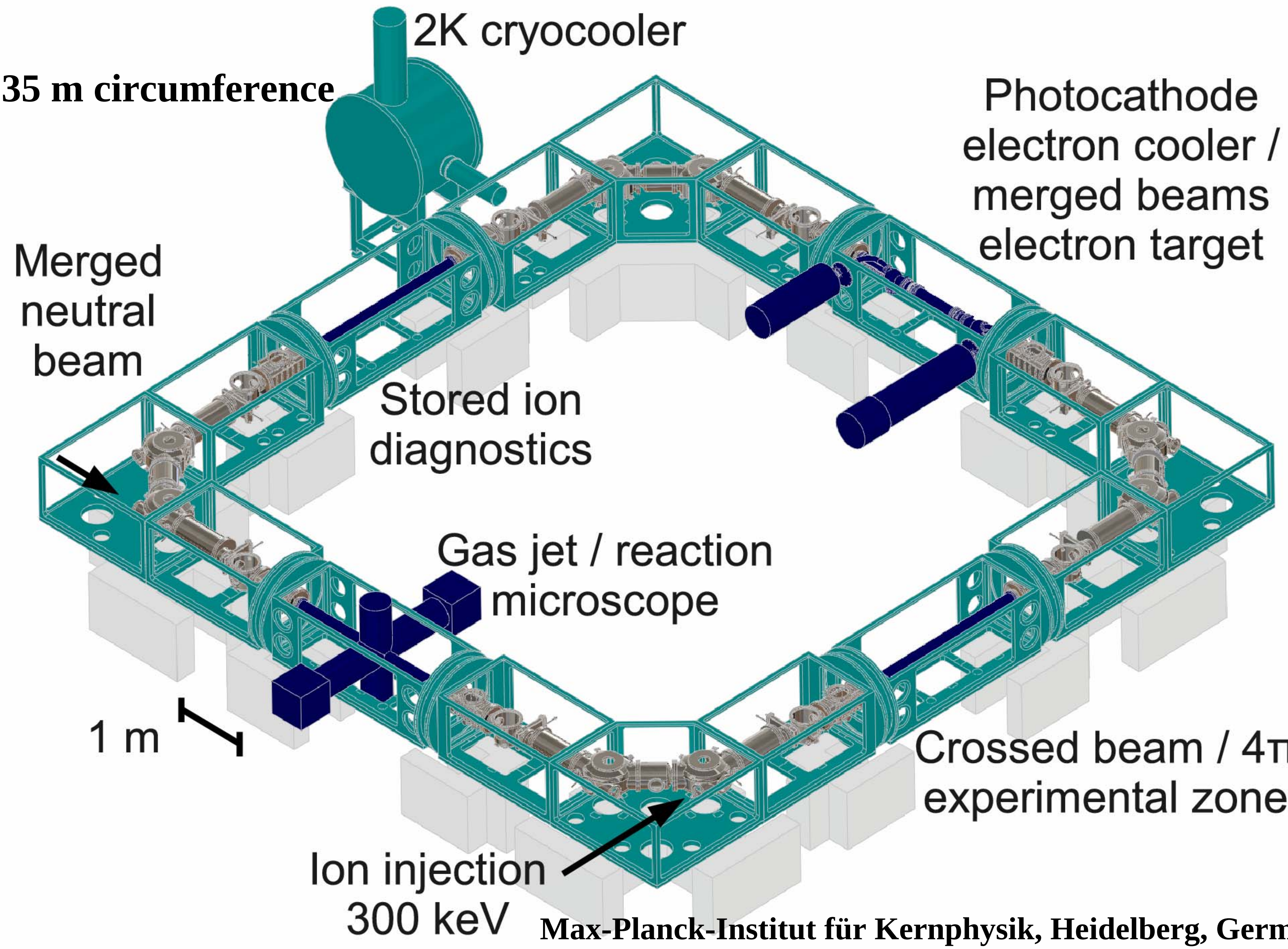
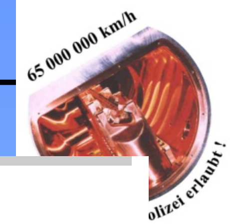
Overview of the CSR

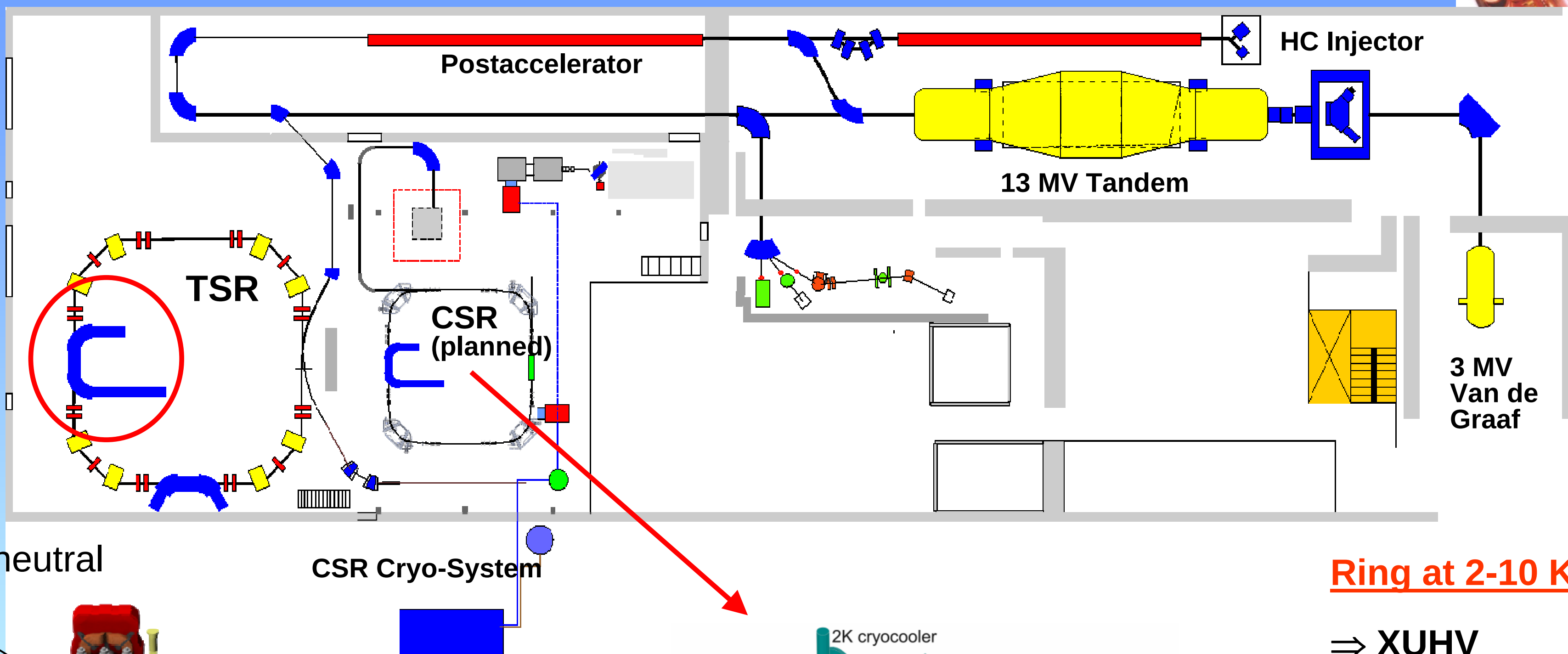
35 m circumference



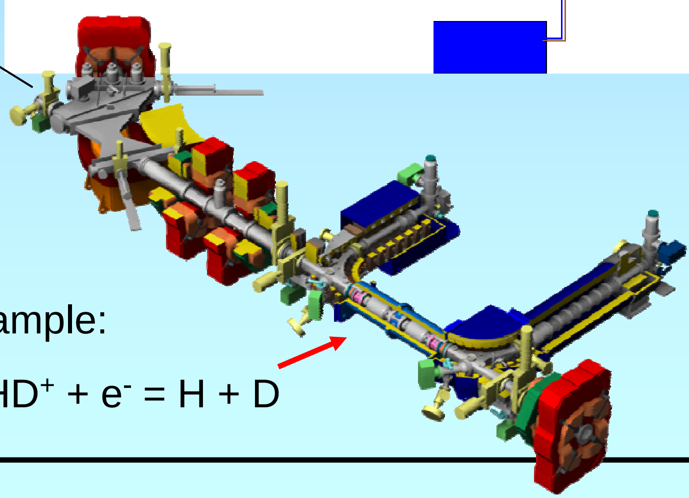
Max-Planck-Institut für Kernphysik, Heidelberg, Germany

The CSR Project at MPI-K



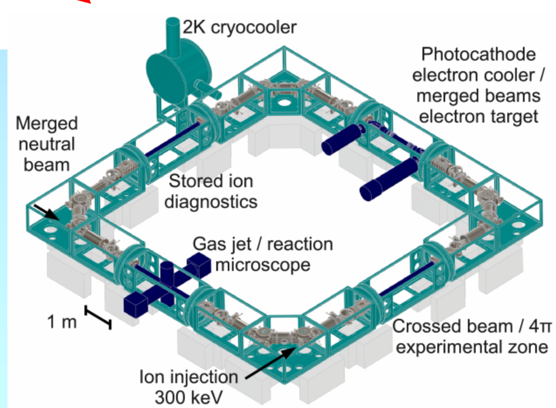


H D neutral



Example:

$HD^+ + e^- = H + D$



Ring at 2-10 K ?

- ⇒ **XUHV**
- ⇒ **τ ~ 1000s**
- ⇒ **υ = 0**
  J = 0

Electrostatic ?

- ⇒ **Heavy molecules**

Requirements for the CSR

- **Beam energy variable between 20 keV and 300 keV (*q),**
- **Very large mass range up to bio molecules**

⇒ CSR should be electrostatic

- **Long life time, molecules in ground state**

⇒ Vacuum at low temperatures: $1*10^{-13}$ mbar (RT equivalent)

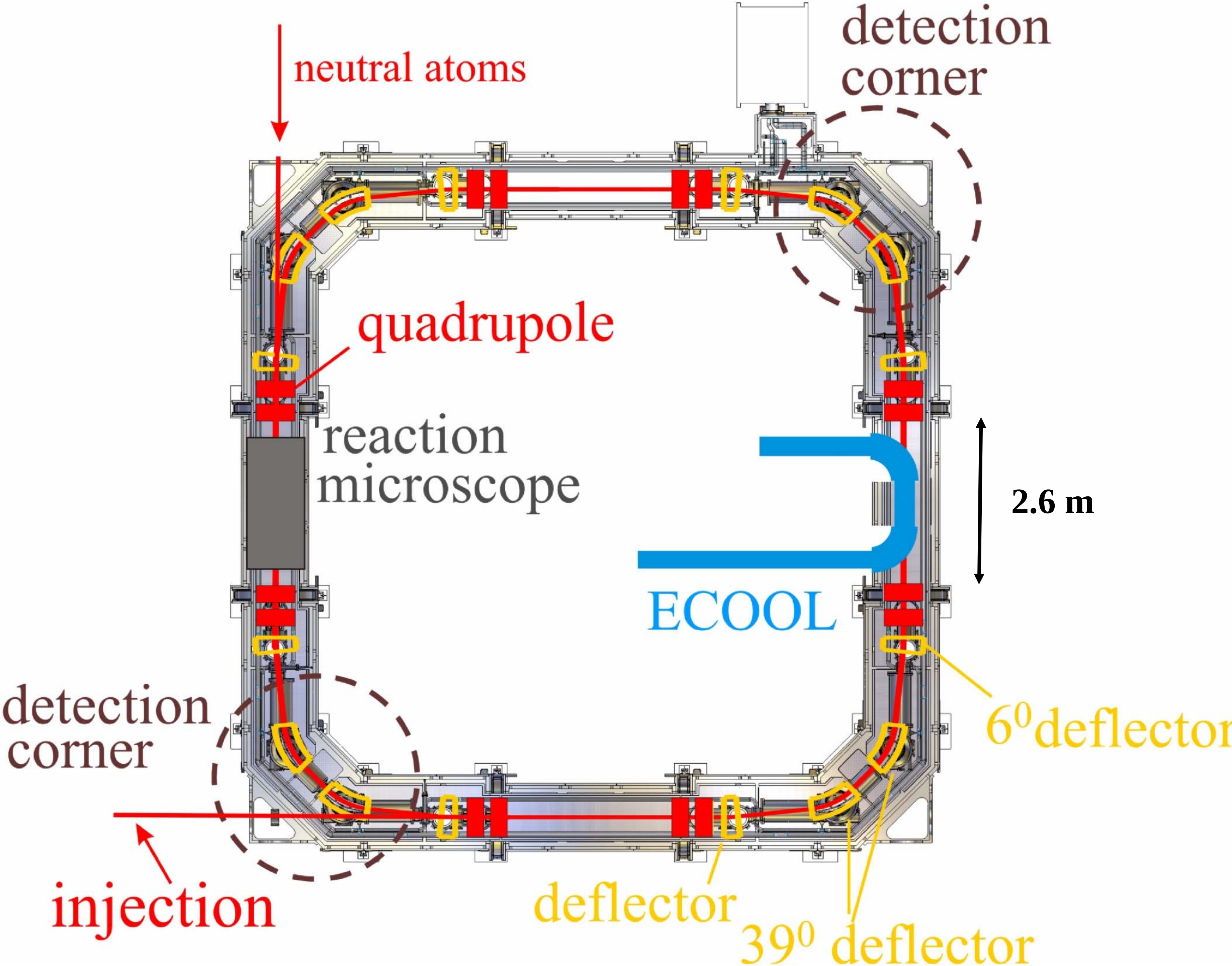
⇒ CSR must be cryogenic (10 K),
For H_2 2 K must be available at a determined number of positions

- **Operation temperatures between 10 and 300 K**

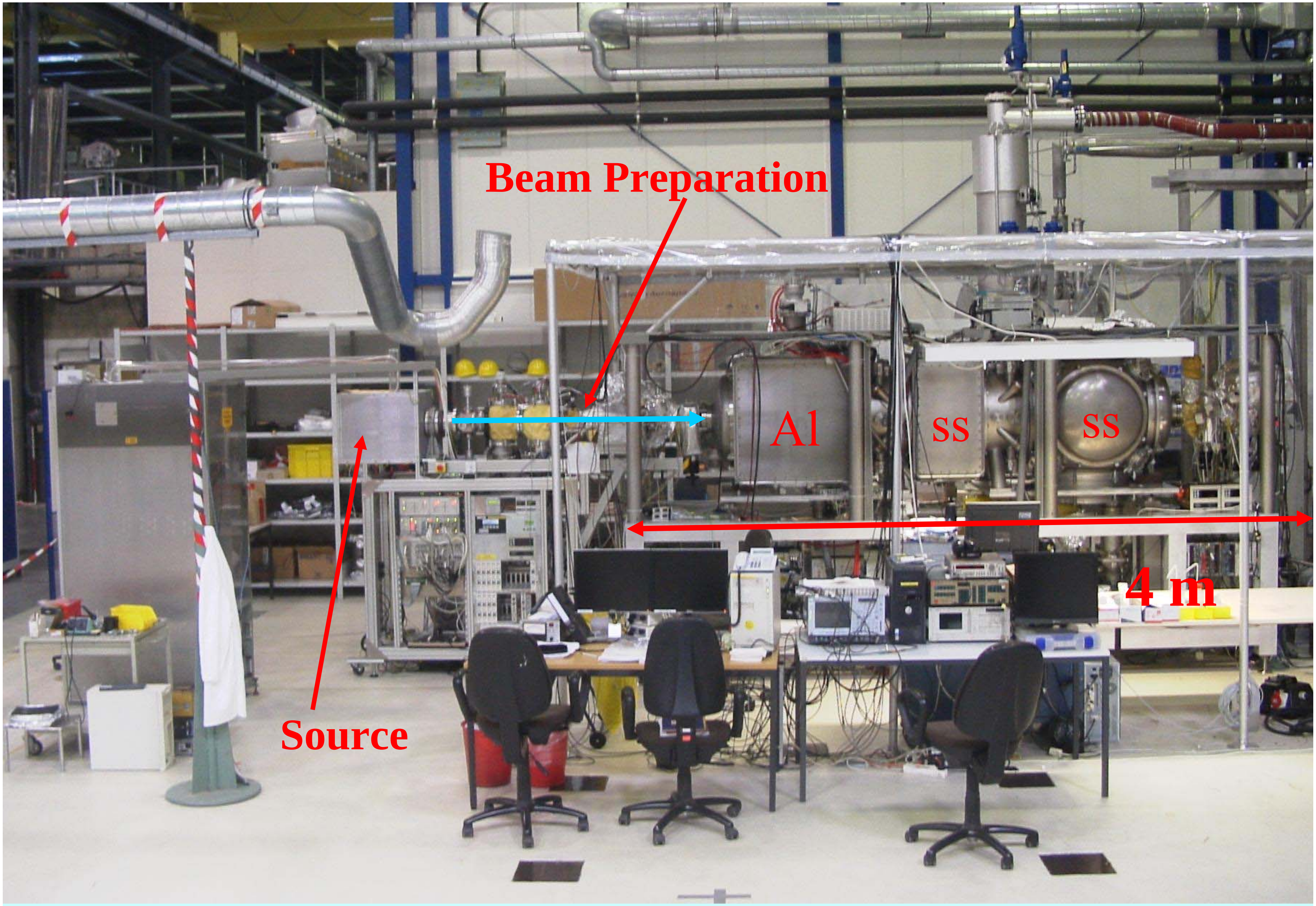
⇒ Usage of a Helium refrigerator delivering 2 K Helium

- **Vacuum at room temperature: $1*10^{-11}$ mbar**

⇒ The ring must be baked up to 600 K

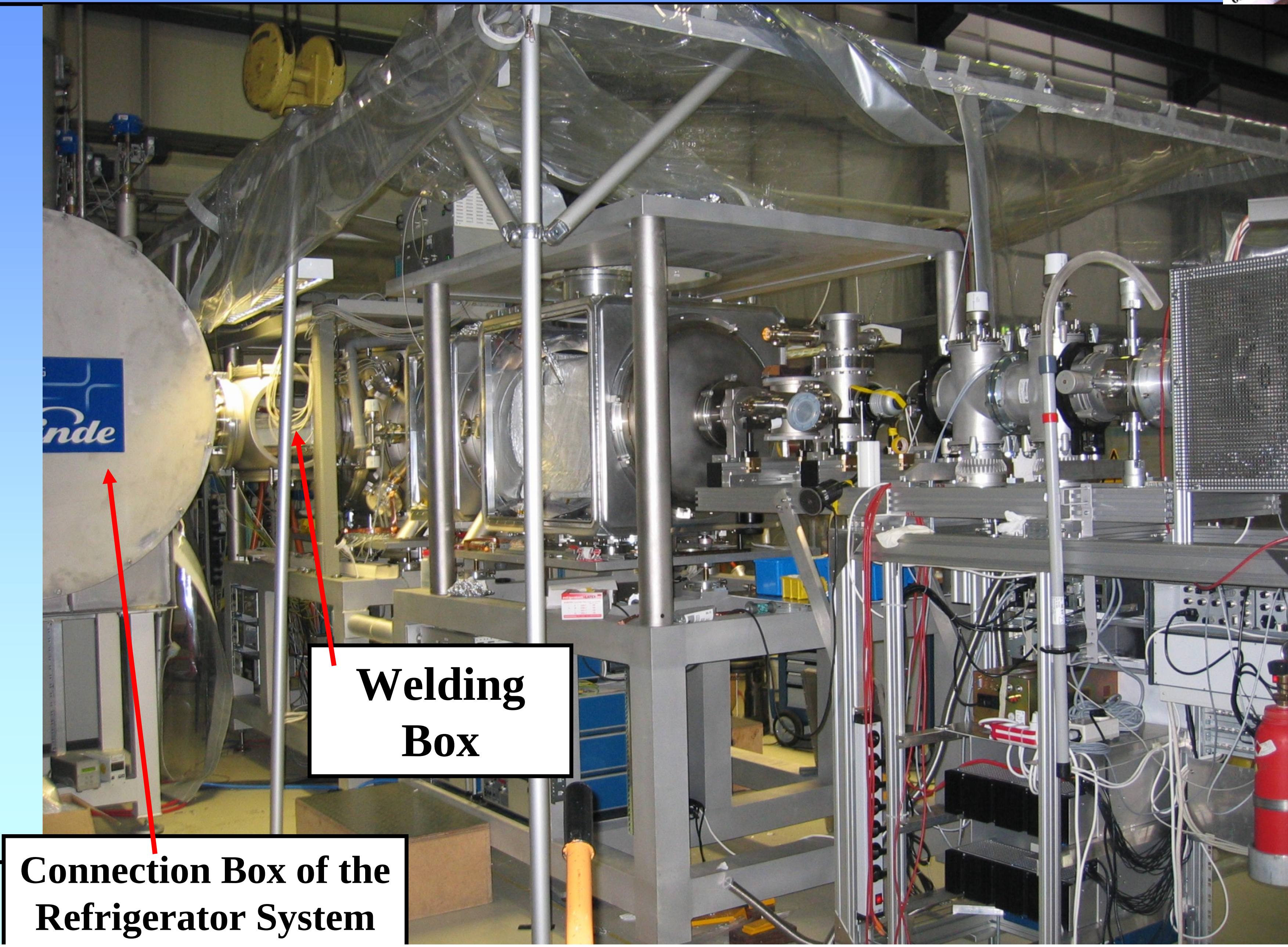


neutral atoms
detection
corner
quadrupole
reaction
microscope
2.6 m
ECOOL
detection
corner
6⁰deflector
injection
deflector
39⁰ deflector

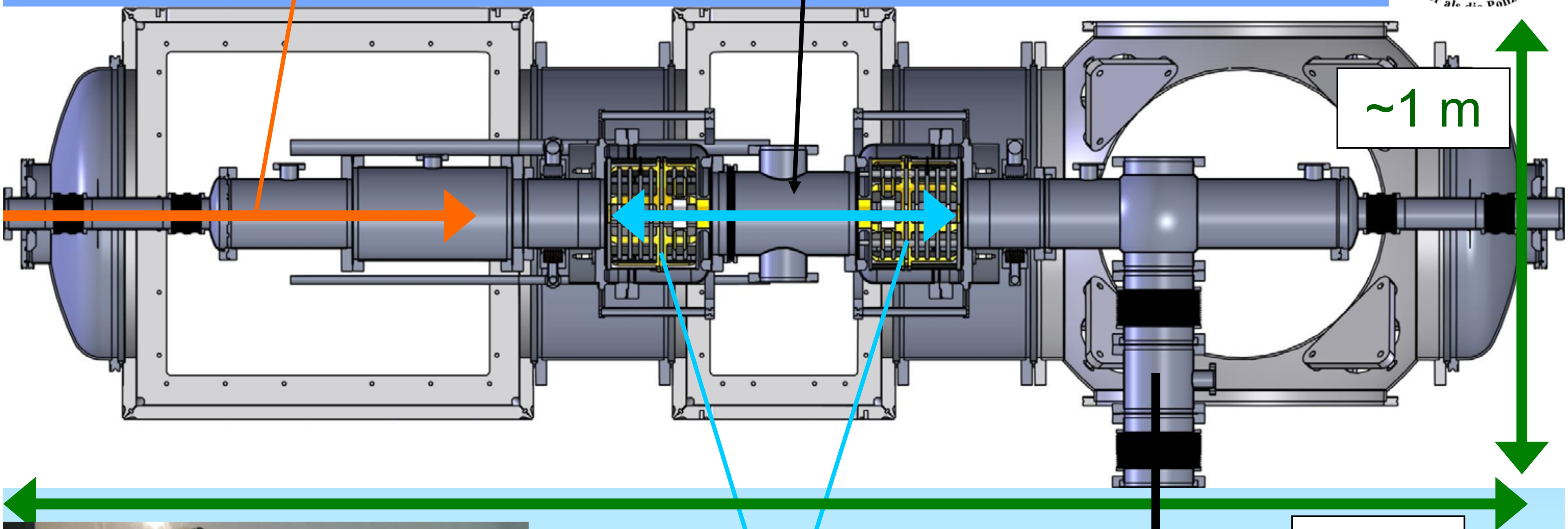


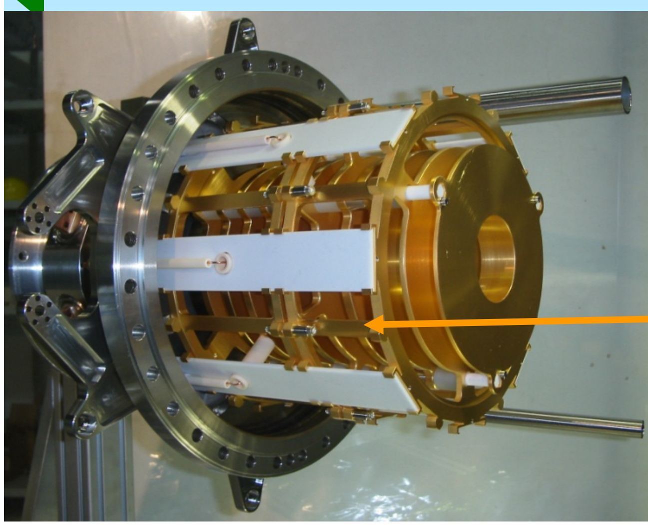
Assembly and measurements mainly by: M. Lange, M. Froese, S. Menk

Prototype and Refrigerator

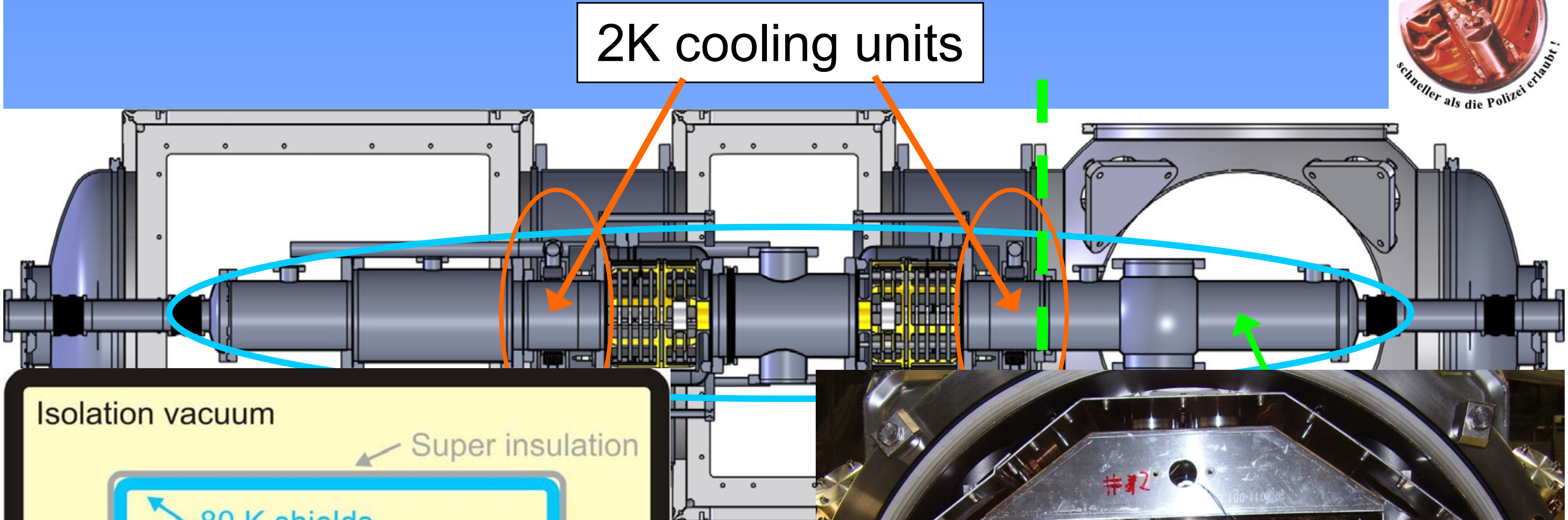


Linear Electrostatic Ion Trap



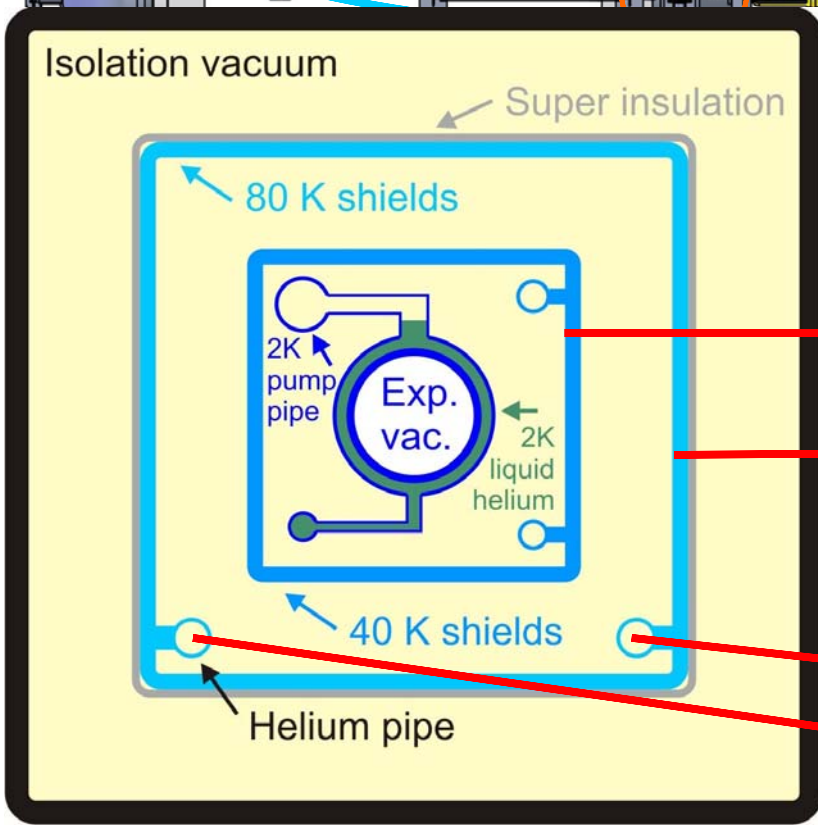


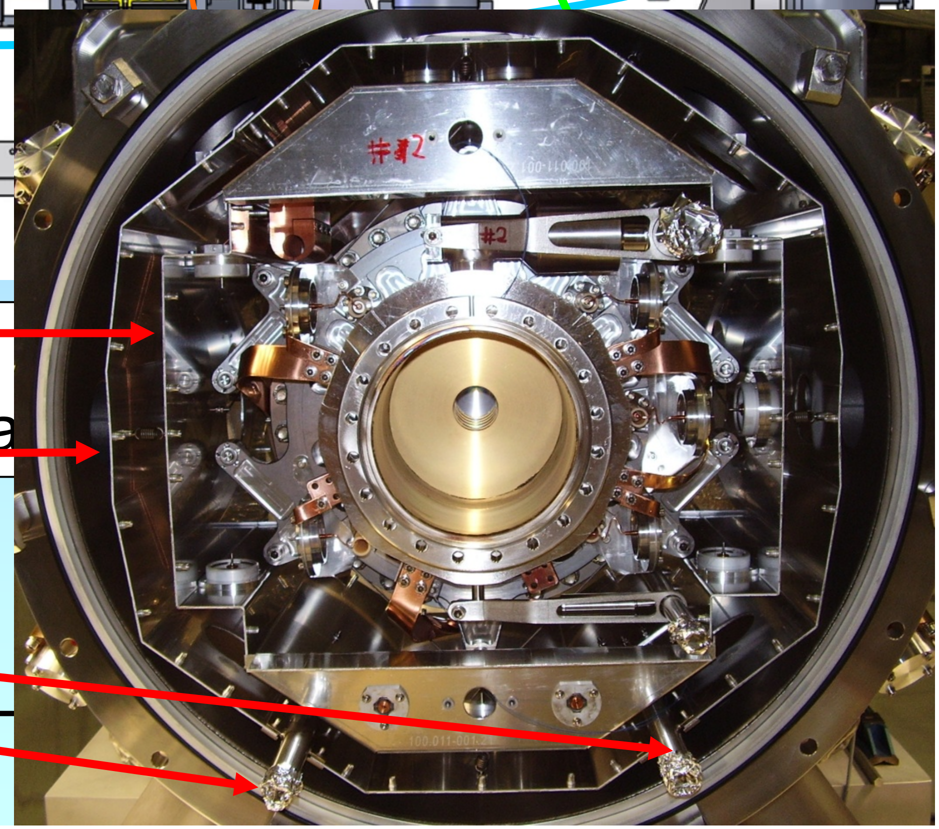
Cooling techniques and thermal shielding



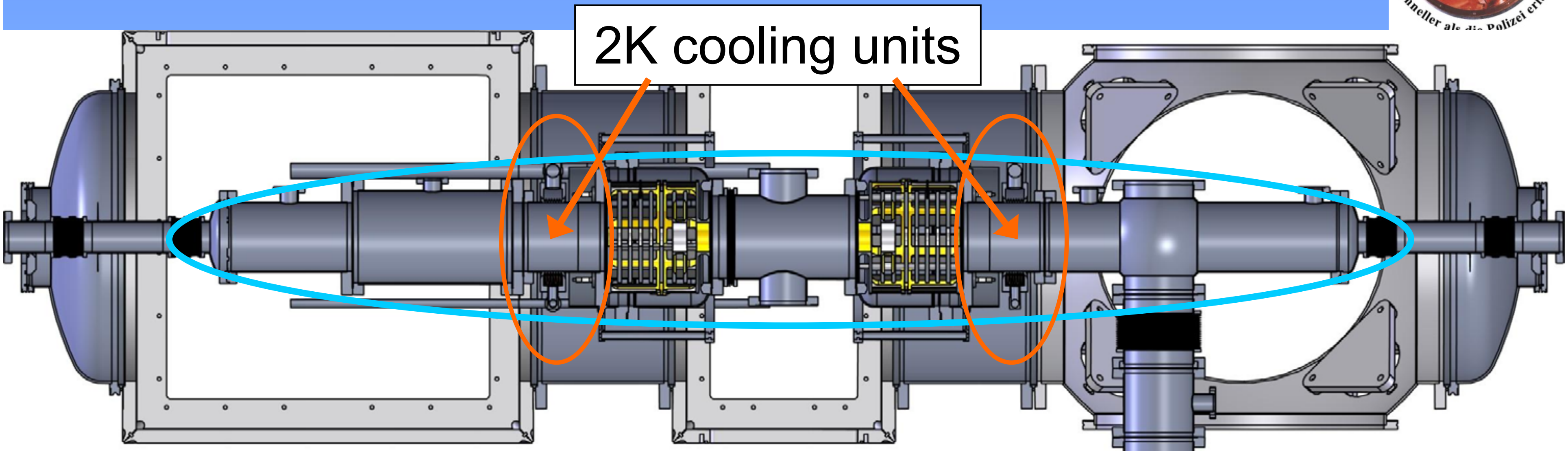
2-10

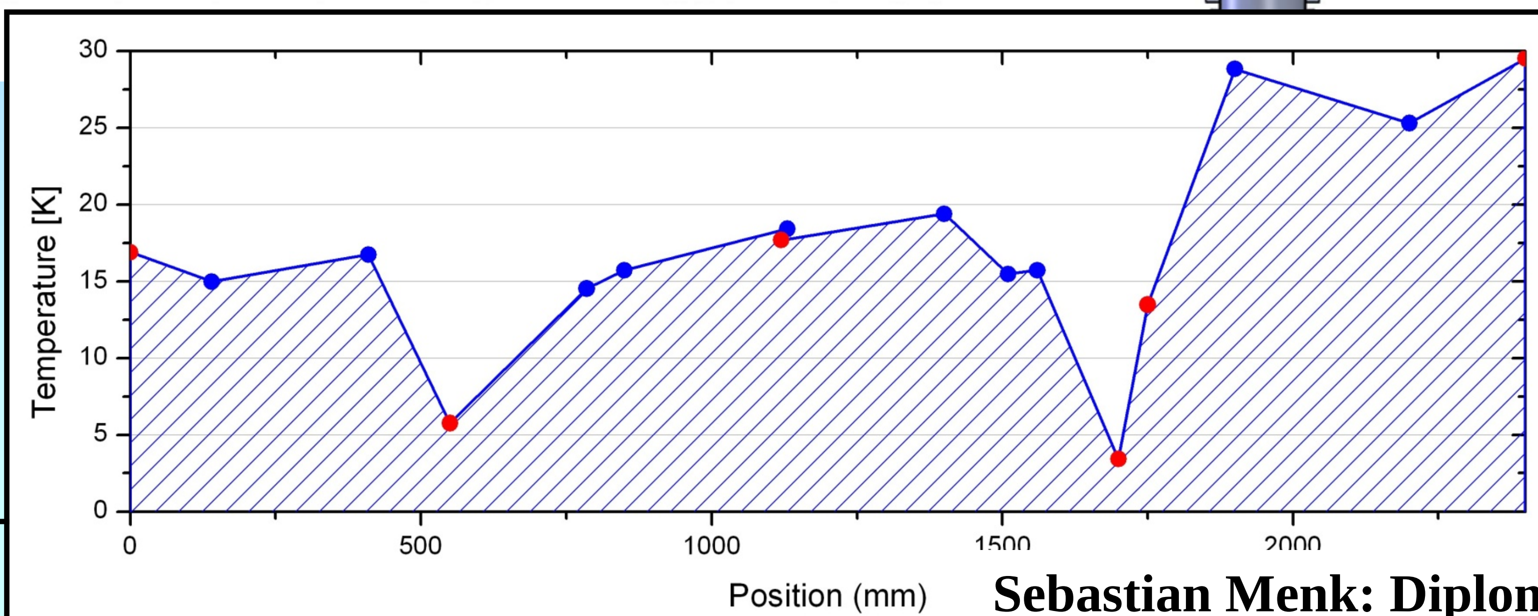
old cha





Measured cryogenic temperatures at cool downs





Sebastian Menk: Diploma Thesis

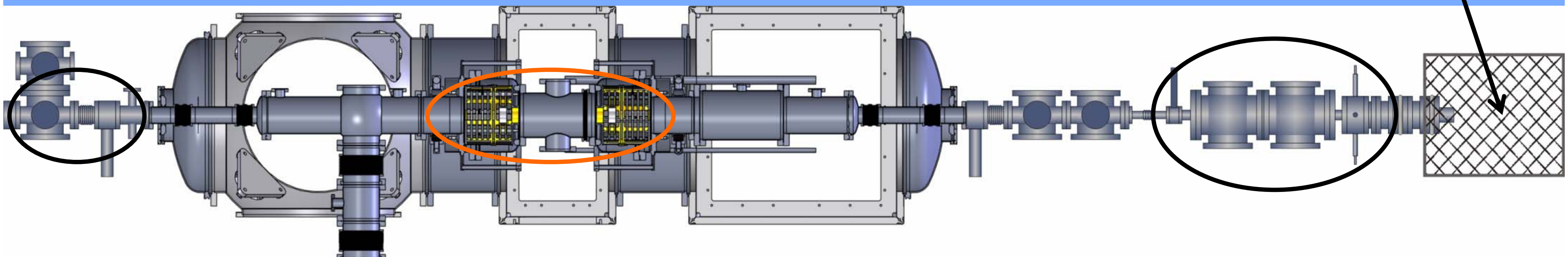
Ion Trapping & Detection

Ion source

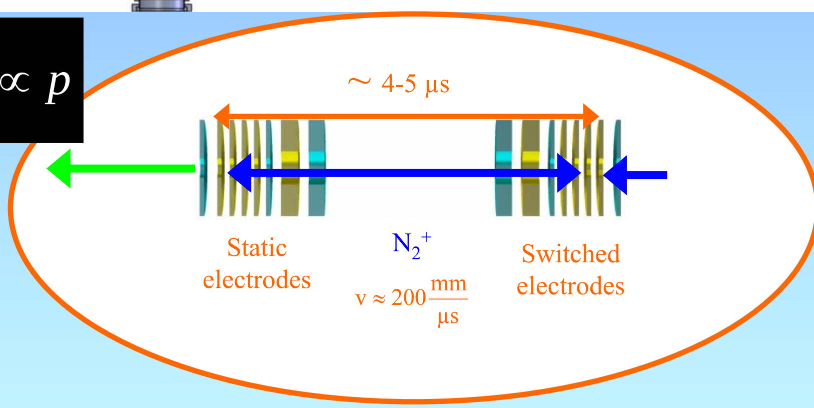
Produces N_2^+ ions with energies of 2-10 keV

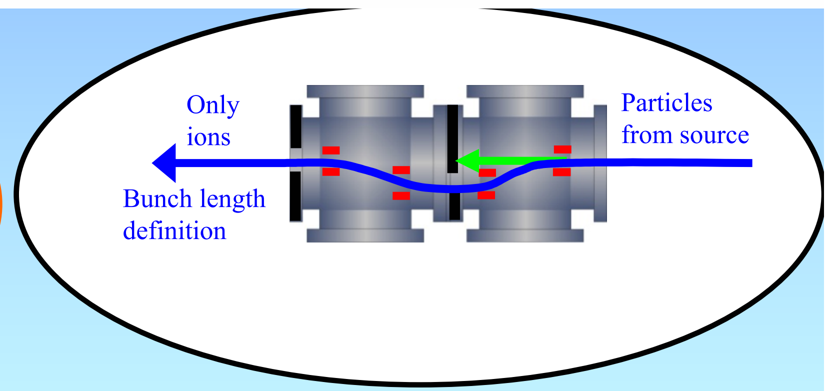
Counting of neutral fragments on a chevron MCP

Detection **Cryogenic ion trap** **Beam cleaner**



$$\frac{1}{\tau} = n \cdot \sigma \cdot < v > \propto p$$





- Trapping of N_2^+ ions by switching the electrodes
- After ~400 ns electrode voltage at 95%
- Neutralisation by electron capture of the restgas (mainly H_2 at 2K)

Sebastian Menk: Diploma Thesis

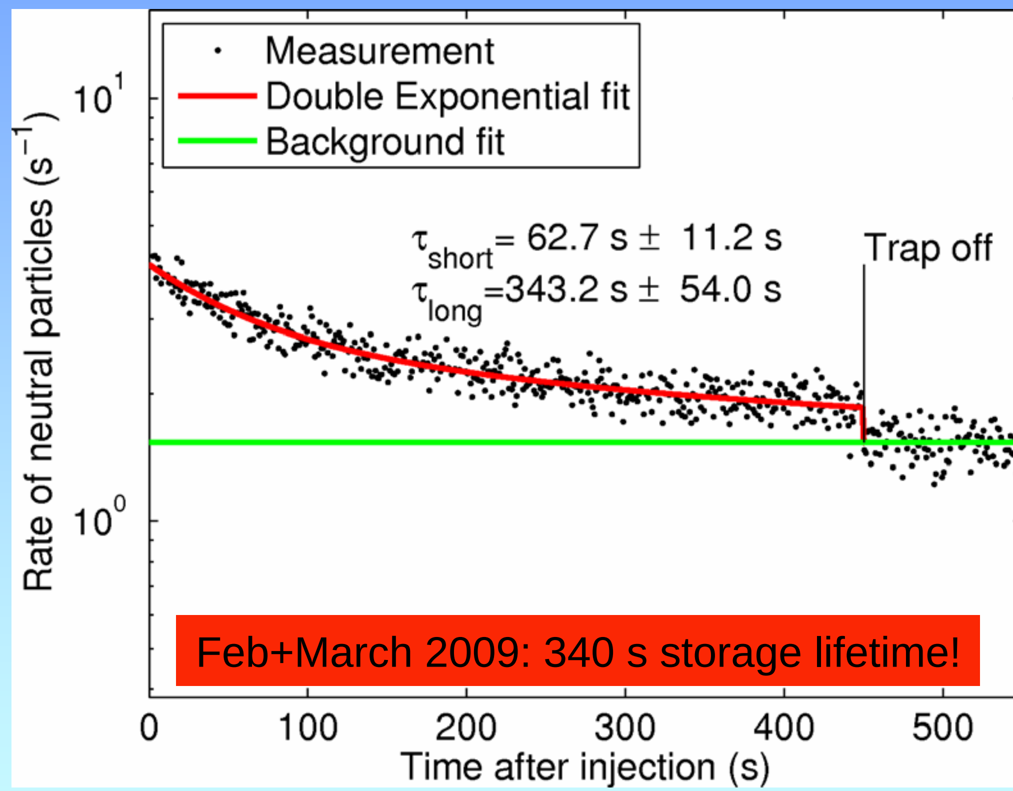
Storage Lifetime

2008: First storage of ions in CTF under cryogenic conditions

However: lifetime limited to 24 s – much shorter than expected

Improvements in 2009:

- Reduced ripple on trap voltages (fast HV switches)
- Cryogenic chamber baked for better vacuum at RT
- Improved differential pumping after ion source
- Improved shielding against infrared radiation at trap entrance+exit



With collision cross-sections from the literature, the new lifetime would translate to a residual gas density of 44000 cm^{-3} or $1.6*10^{-12}$ mbar (at Room Temperature).

Trap Vacuum

CTF pressure: $8*10^{-14}$ mbar

Cryogenic pumping of hydrogen at 1.8 K: Expect vacuum of few 10^{-13} mbar (RT equiv.)

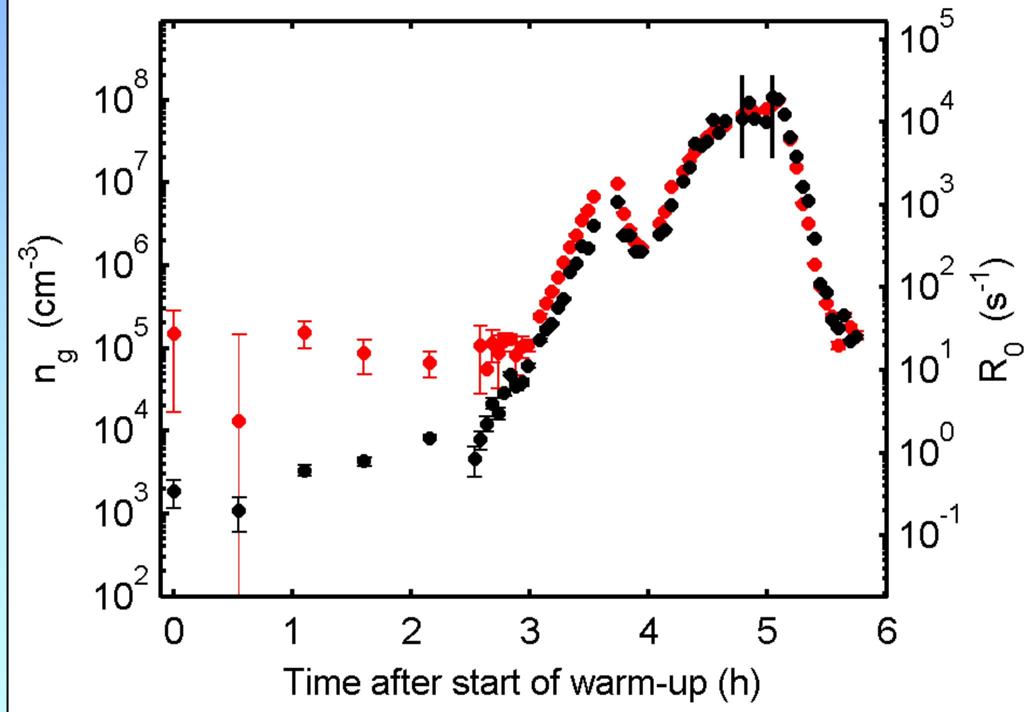
Most likely particle loss from trap not dominated by residual gas collisions

- Model: 2 loss mechanisms:
  - residual gas collisions (proportional to pressure)
  - ion evaporation from trap acceptance volume (constant)
- Total rate from particle loss:

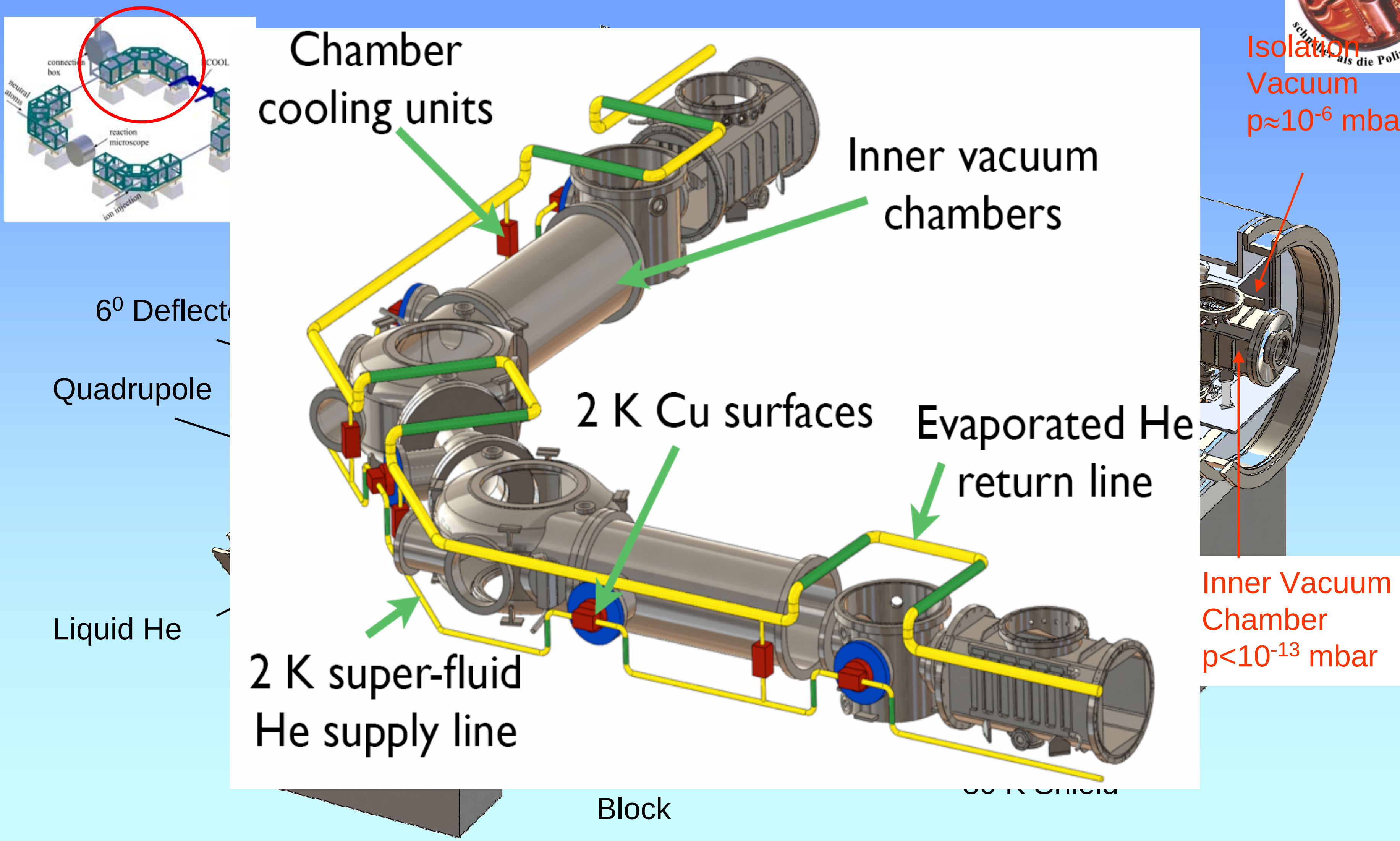
$$dN/dt = k\,N(t)$$
$$k = k_c + k_s + k_{ev}$$

- Neutral particle rate:

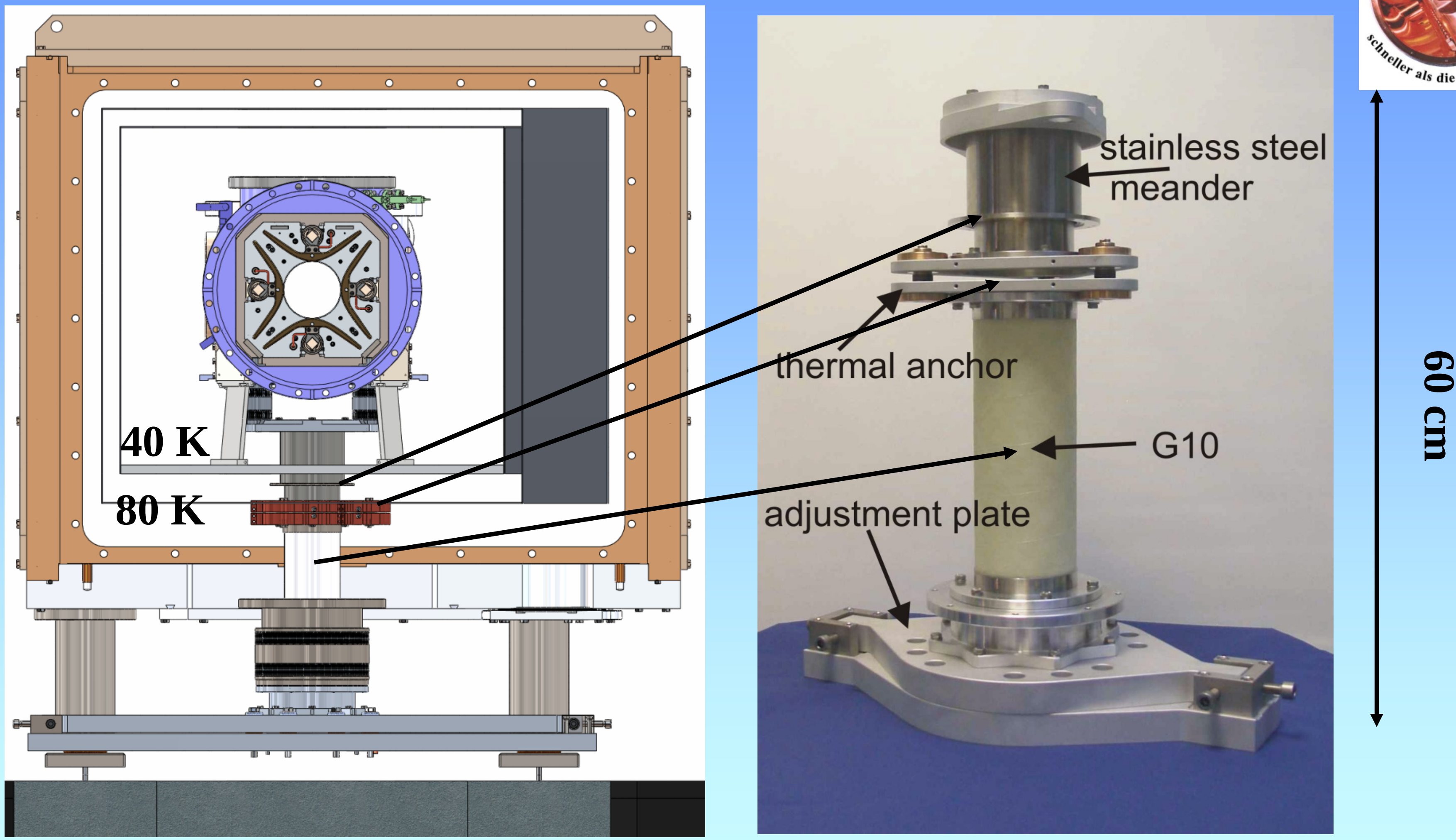
$$R_o = \tfrac{1}{2}\,\alpha\varepsilon n N_o$$



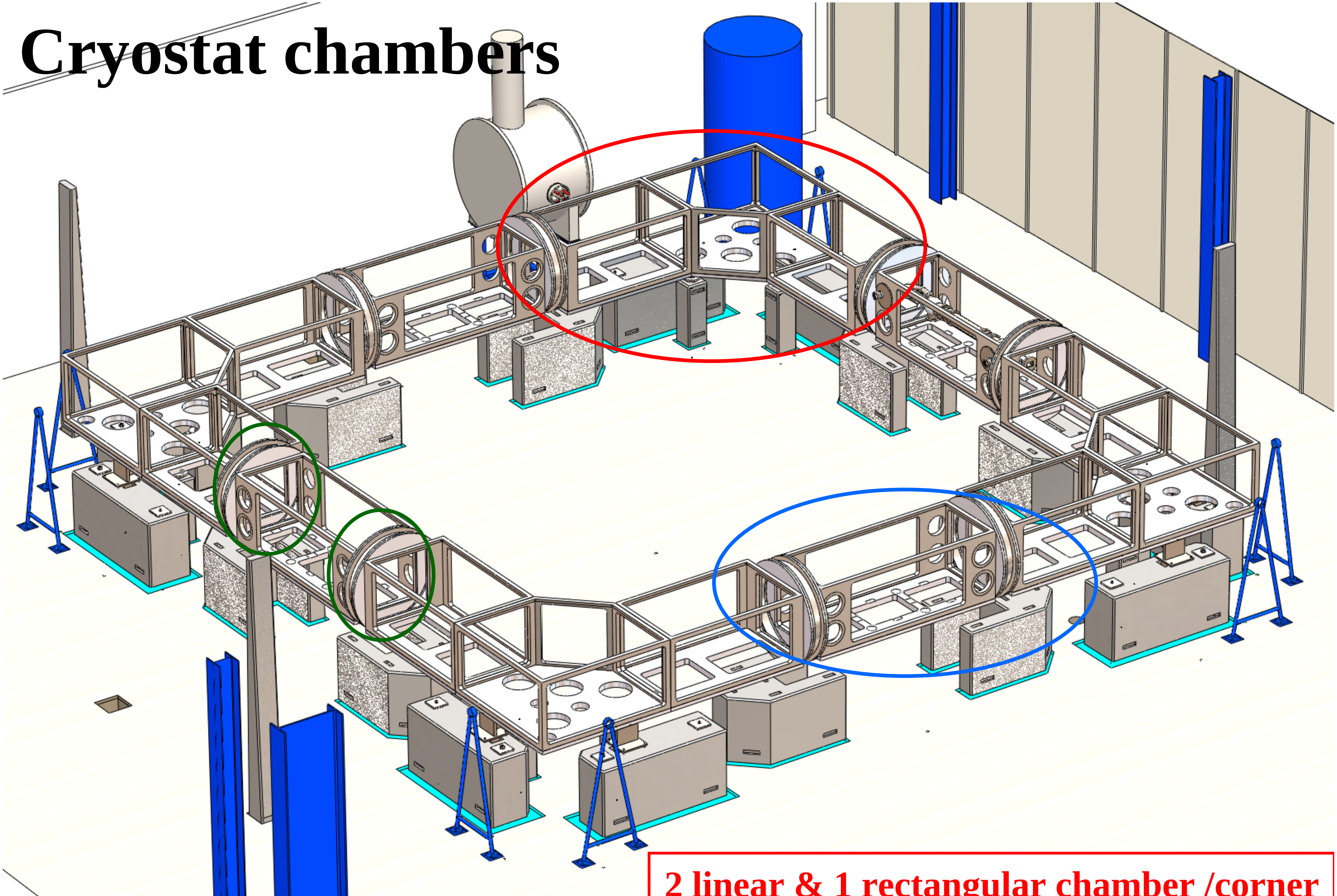
CSR Mechanical Layout



Support Concept

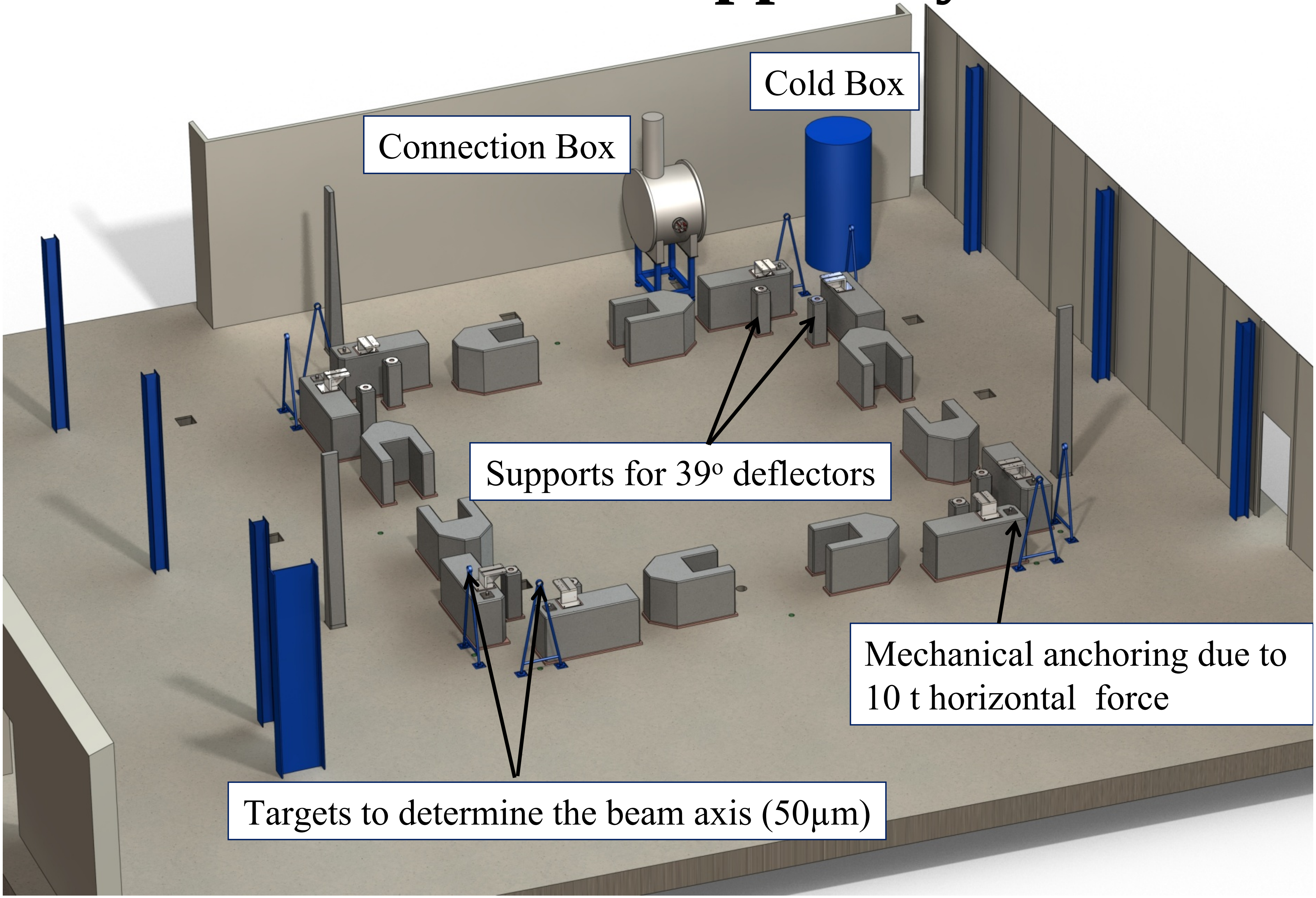


Cryostat chambers



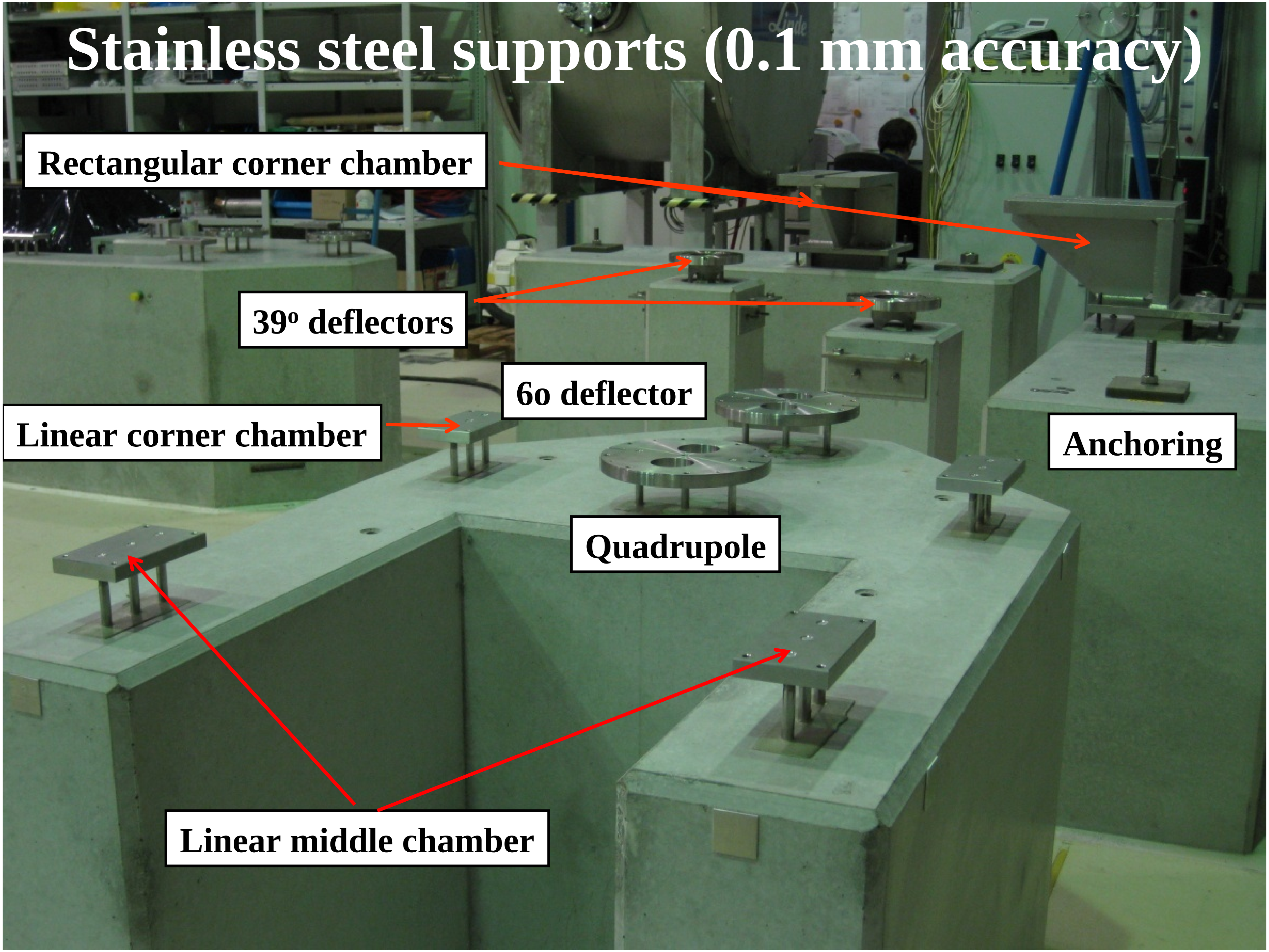
2 linear & 1 rectangular chamber /corner
4 middle section chambers
2 bellows/linear section

Schema of the support system



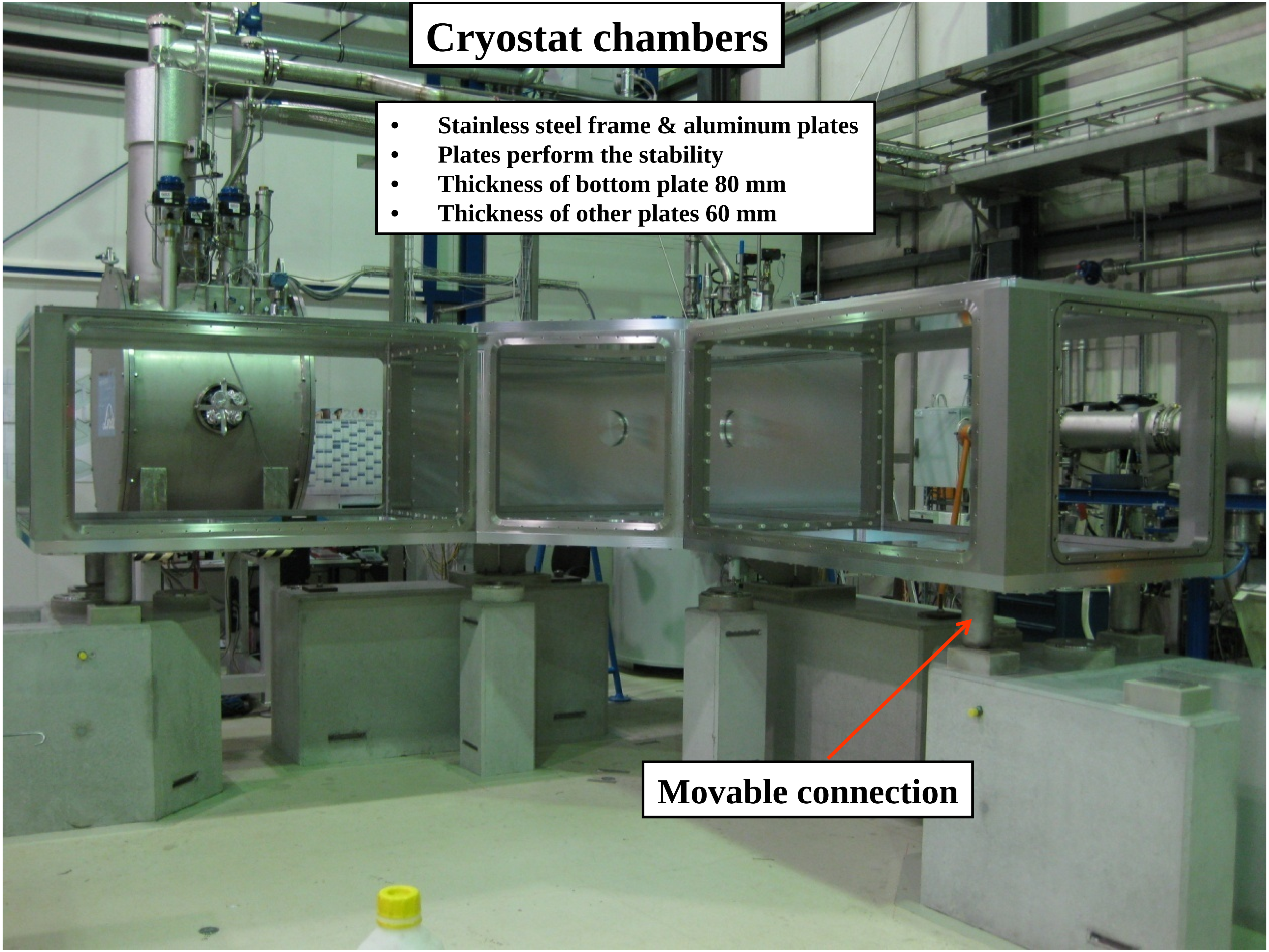
Support concrete blocks

Stainless steel supports (0.1 mm accuracy)

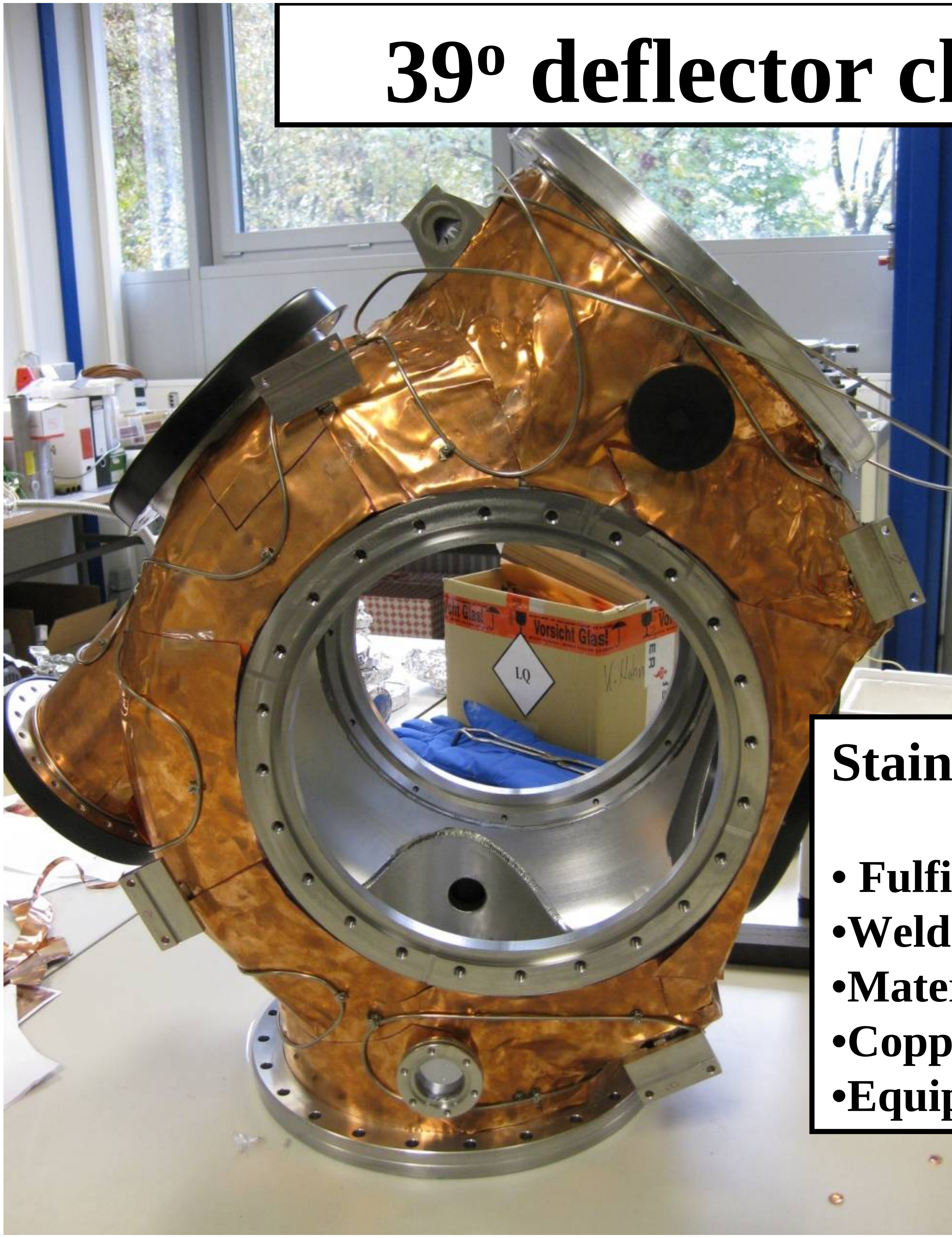


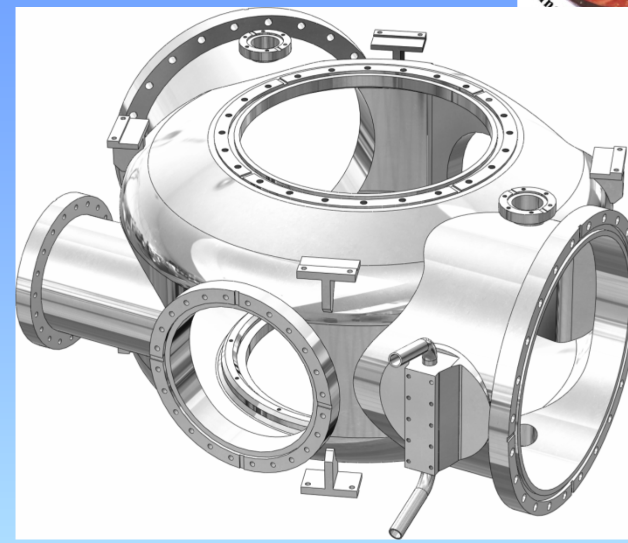
Cryostat chambers

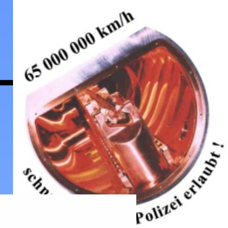
- Stainless steel frame & aluminum plates
- Plates perform the stability
- Thickness of bottom plate 80 mm
- Thickness of other plates 60 mm



39° deflector chamber





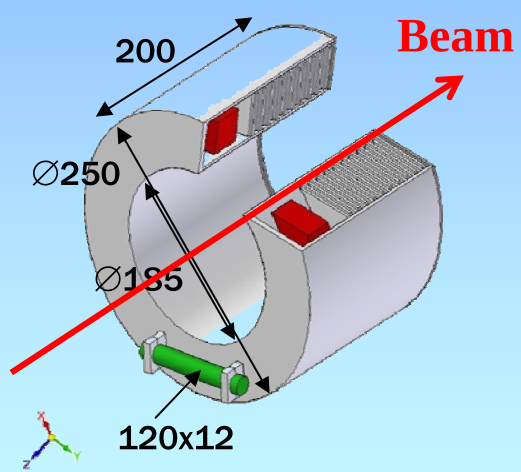


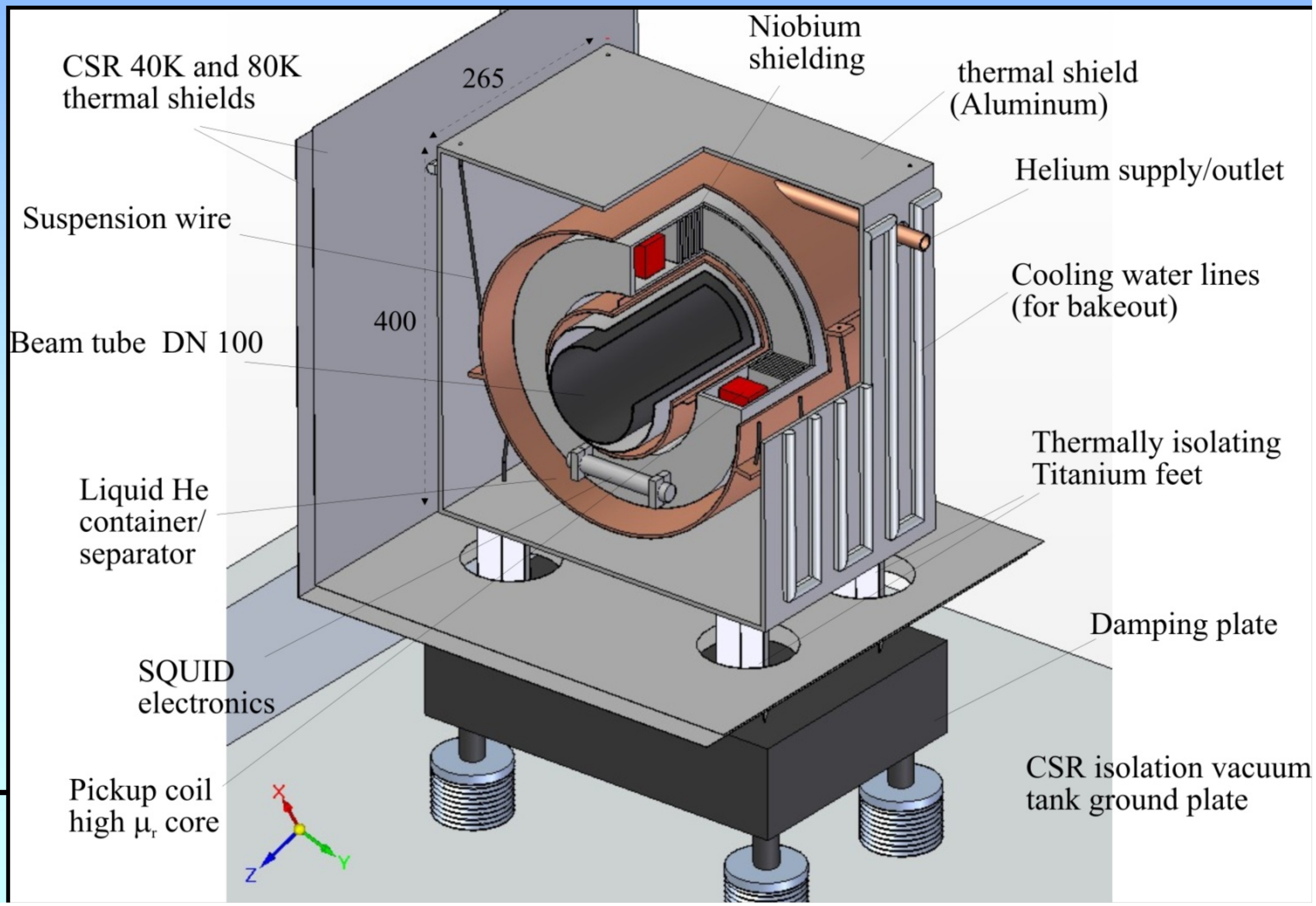
Stainless steel chamber

- Fulfilles pressure directive
- Welded with filler
- Material 316L
- Copper layer for temperature levelling
- Equiped with nonmagnetic heater wires

CCC installation in CSR

Collaboration to develope a Squid based cryogenic current comparator CCC to determine currents down to around 10 nA pulsed and DC between Uni Jena, GSI and MPI





Conclusions and Outlook

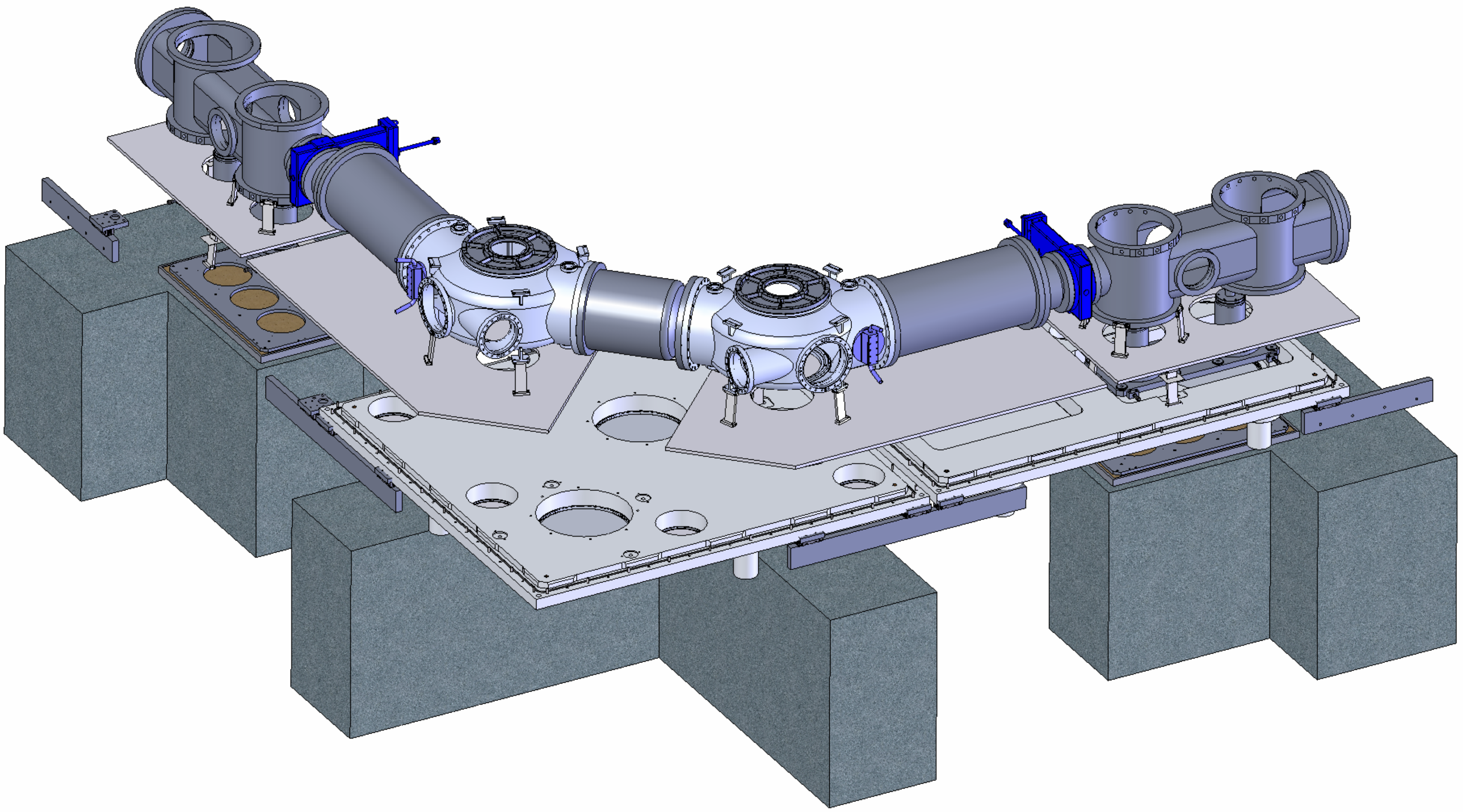
- First successful operation of the ***cryogenic ion beam trap***
- Achieved ***low temperatures*** of down to 2 Kelvin
- Observed ***linear pressure dependence of the storage life time*** during cool-down
- Determined ***dominant loss processes*** for different pressure conditions
- Pressure tests indicated a limiting ***pressure independent lifetime***
- Modified high-voltage switches with reduced fluctuations
- Determined pressure to ***$8*10^{-14}$ mbar***

- Moved trap for further experiments
- Proceeded with ordering and started assembly of CSR

CTF/CSR Team

R. Bastert, K. Blaum, F. Fellenberger, M. Froese, M. Grieser, M. Lange, F. Laux, S. Menk, D. Orlov, R. Repnow, A. Shornikov, T. Sieber, R. v. Hahn, A. Wolf

Thank you for your attention!



Robert von Hahn for the CSR-Team