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Swedish Contributions to the HESR Electron Cooling

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CM 25, GSI 9th December

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- Divisions Poland /Sweden
- Decision from VR about the electron cooler
- Contributions from Uppsala
- Test set-up gun and collector
- Recent development of magnet system in the bends

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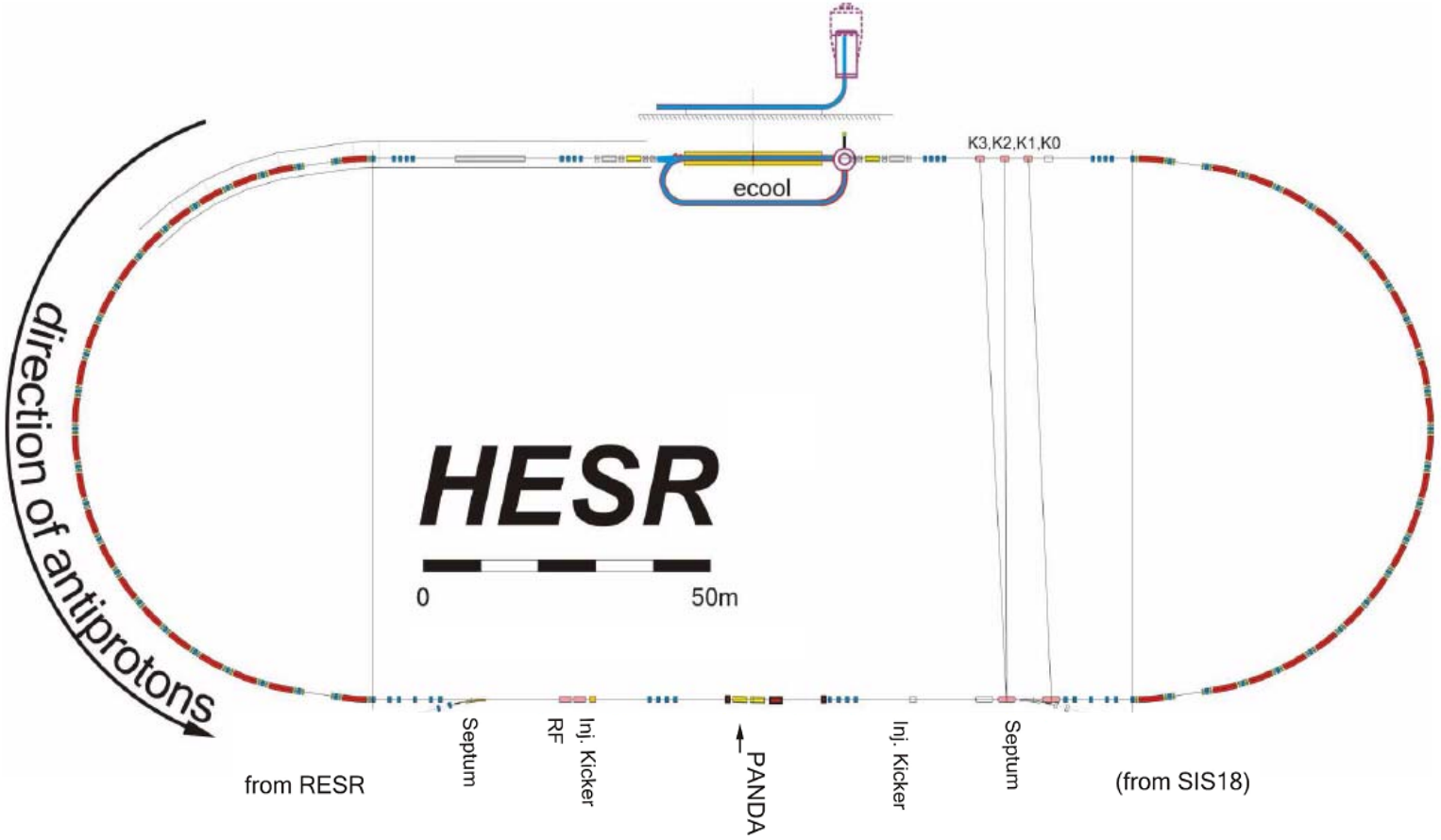
High Energy Storage Ring



- Antiproton energy, 0.8 –14 GeV (1.5 – 15 GeV/c)
- Electron cooling up to 8.0 GeV (4.5 MeV electron energy)
- Stochastic cooling above 3.0 GeV

straights of 132 m
circumference 574 m
up to 10^{11} pbar

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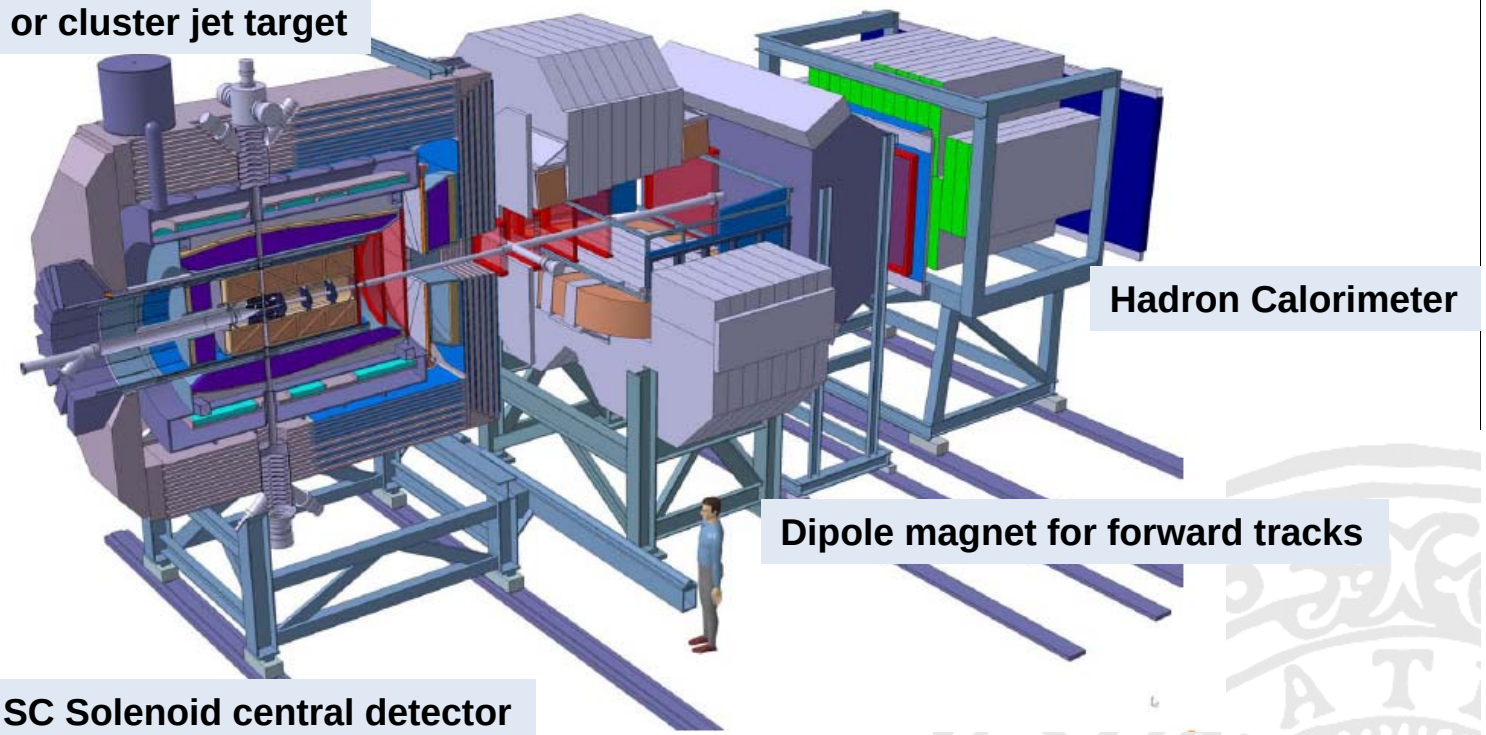
PANDA

(AntiProton Annihilations at Darmstadt)



- PANDA requires luminosity of $2 \cdot 10^{31}$ - $2 \cdot 10^{32}$ cm^{-2} s^{-1} with 10^{10} -10^{11} stored antiprotons
- Internal (hydrogen pellet) target of $4 \cdot 10^{15}$ cm^{-2}
- Target effects will be compensated by electron cooling and stochastic cooling

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Why electron cooling at HESR?

- PANDA want resolution of near ~ $\Delta p/p = 10^{-5}$.
  This cannot be achieved with stochastic cooling alone.
- Possibility for absolute calibration of antiproton energy by means of H^--beam and $^7Li(p,n)$-reaction:
  $E_{threshold} = 1880.3558 \pm 0.0812$ kV
- Beam cooling below 3 GeV will be provided by Electron Cooling **only** (at present). (Stochastic cooling for lower energies studied.)
- PANDA would like to start at lower energies to compare with LEAR data. The cooler needs to be there from the **start** to get beam cooling at lower energies. (or modified stochastic cooling system)
- Recent initiative for an e-p collider as an upgrade for HESR. Electron cooler at 14 GeV (8 MeV) needed to reach luminosity.

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Challenges

- Severe demands of straightness of the magnetic field, 10^{-5} rad rms to achieve good cooling.

- Low high-voltage ripple and high stability, Requirements of the experiments in the order of 10^{-5}.

- Collector with high efficiency. 99.999% collection of the recirculating electrons.(Limited charging capability; and important to avoid high voltage breakdowns.)

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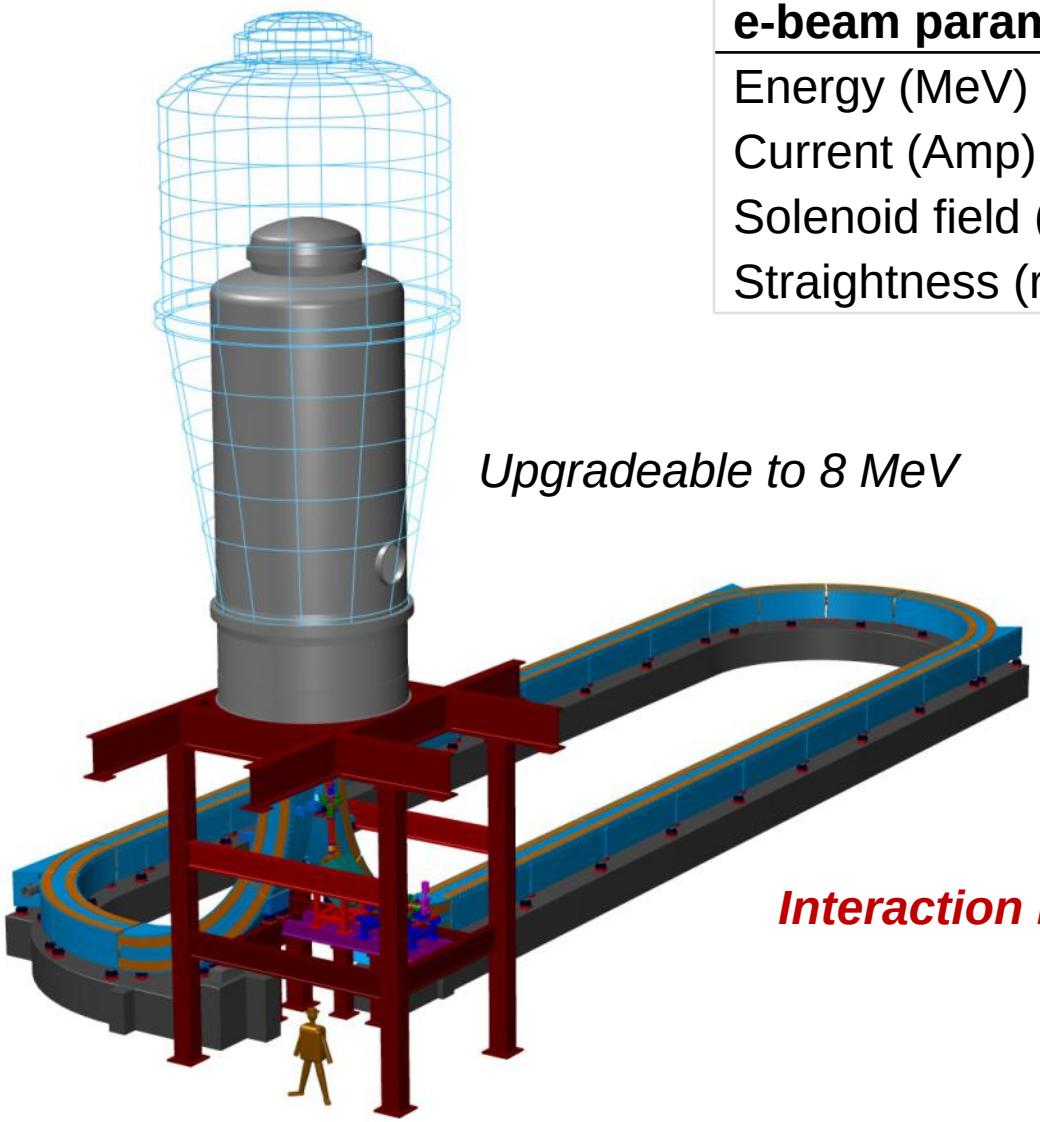
HESR Electron Cooler

e-beam parameters:	***HESR***
Energy (MeV)	0.45 - 4.5
Current (Amp)	1
Solenoid field (T)	0.07 -0.2
Straightness (rad rms)	$1 \cdot 10^{-5}$



Upgradeable to 8 MeV

Interaction length 24 m

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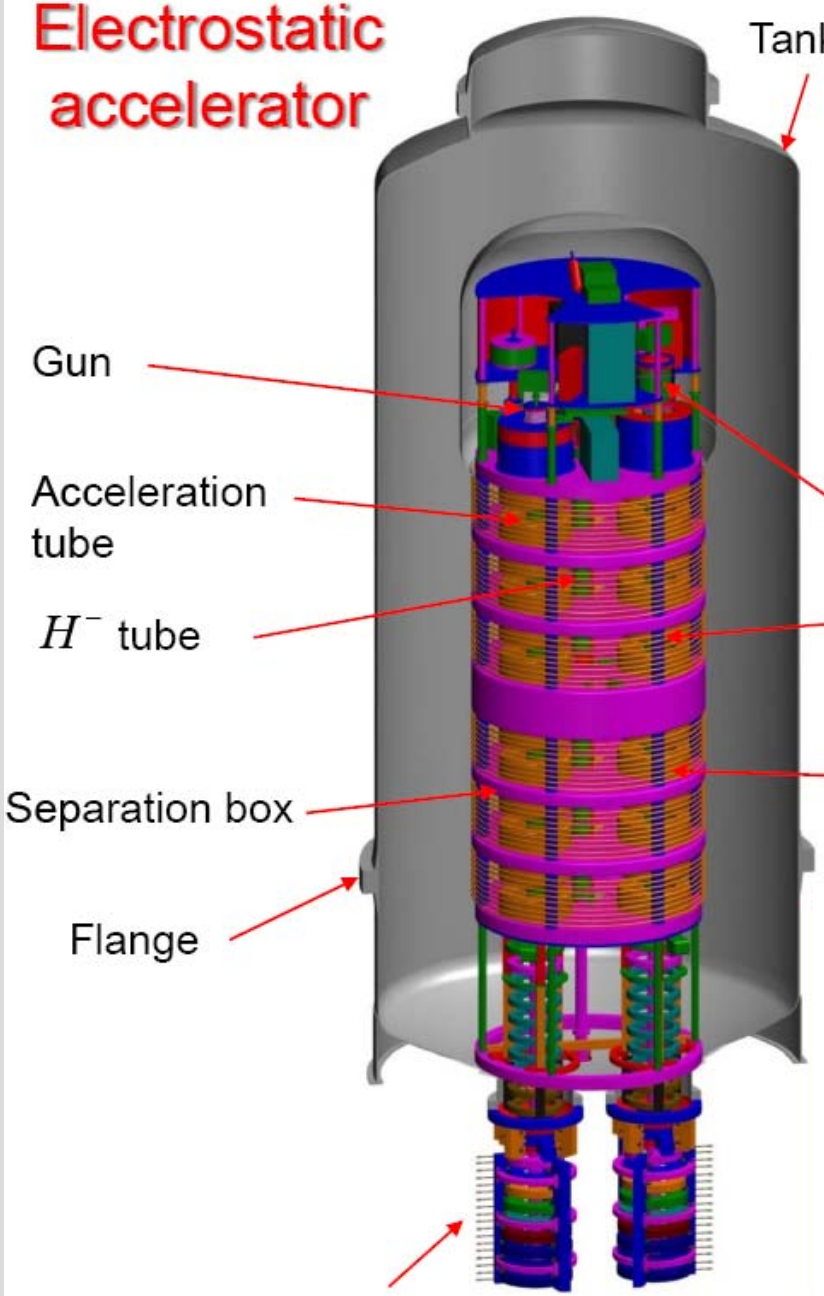
Electrostatic accelerator



Requirements:

- range 0.45 – 4.5 MV
- beam current 1 A
- stability (< 1 Hz) $\Delta U/U < 1 \cdot 10^{-5}$ rms
- ripple (> 1 Hz) $\Delta U/U < 2 - 3 \cdot 10^{-5}$ rms
- magnetic flux $\Phi = B \cdot \pi \cdot R_{beam}^2$ = 16 μWb
- upgrade to 8 MV possible

- Pelletron
- 3 beam tubes
- B = 0.07 T

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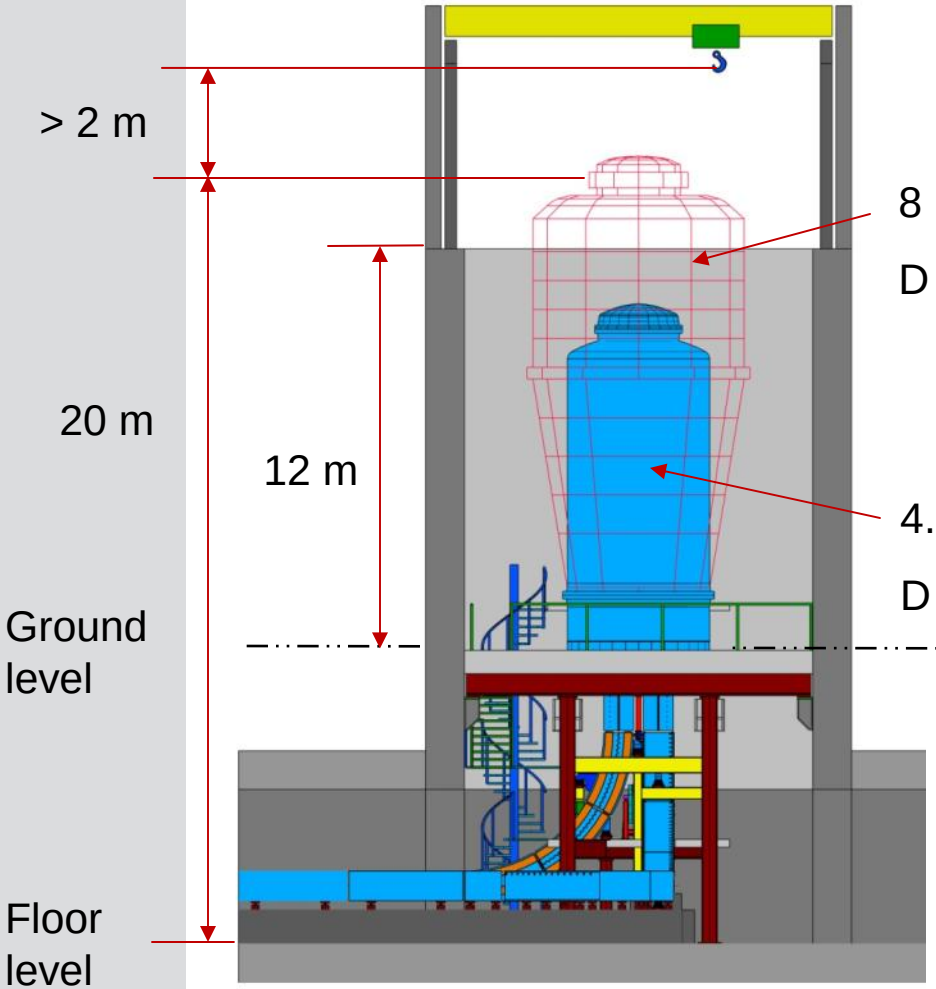
Accelerator building



The design shall not exclude a future upgrade to 8 MeV

- Size min. 9 x 12 m (inside)
- Concrete walls t = 1 m (8 MeV, 20 μA)
  h =12 m above ground
- Roof crane 22 m above floor

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In-kind contribution

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In-kind contribution

- In September, preliminary division between Sołtan Institute, Poland and Uppsala University, Sweden.
- Sołtan Institute 8 M€
- Uppsala University 3.25 M€
- Recent decision from VR (Science Research Council) to give 1.5 M€ (out of 10 M€) as in-kind contribution
- Condition that Uppsala University provides funding for personnel (Discussions have started)

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In-kind contribution, Sweden

- Division of Swedish contribution 10 M€

Cash	~3 M€
CRYRING as LSR / FLAIR	2 M€
Experiments	3.5 M€
Electron Cooler	1.5 M€

My own interpretation! Not confirmed

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Swedish contributions to HESR Electron Cooler

Preliminary

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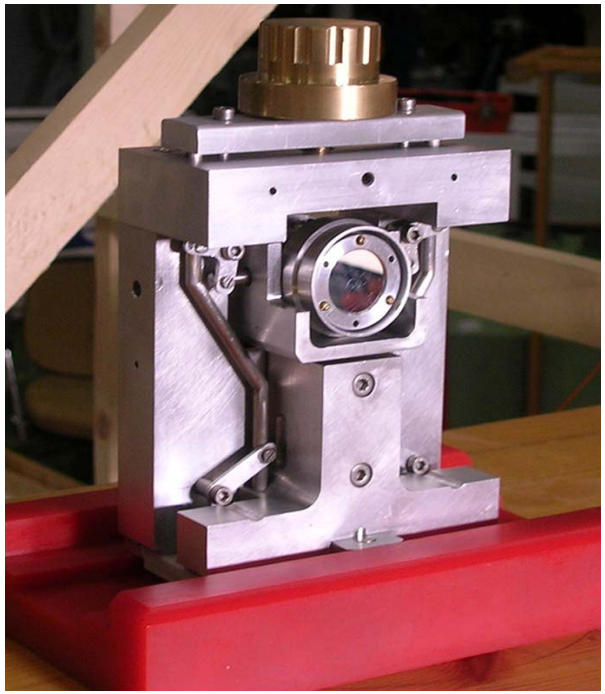
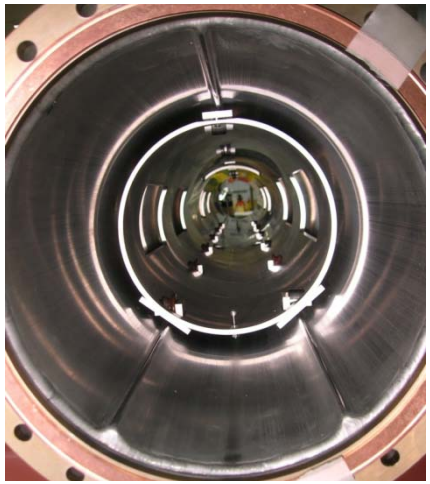
Magnetic field straightness measurement system

Test set-up with a sensor in a carriage moving on rails



Sensor in specially designed holder



Carriage in vacuum tube

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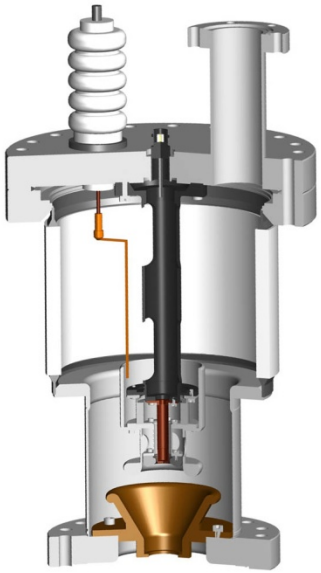
Gun and Collector

Prototype tests 2008



- Anode voltage 26 kV
- Beam current 1 A
- Cathode diameter 10 mm
- Cathode field 0.2 T

- Pulsed beam
- Fast closing of the gun
- Produce pencil beam

- Collector voltage 3.5 kV
- Efficiency < 99.999%
- Secondary electrons are suppressed by a bent magnetic field

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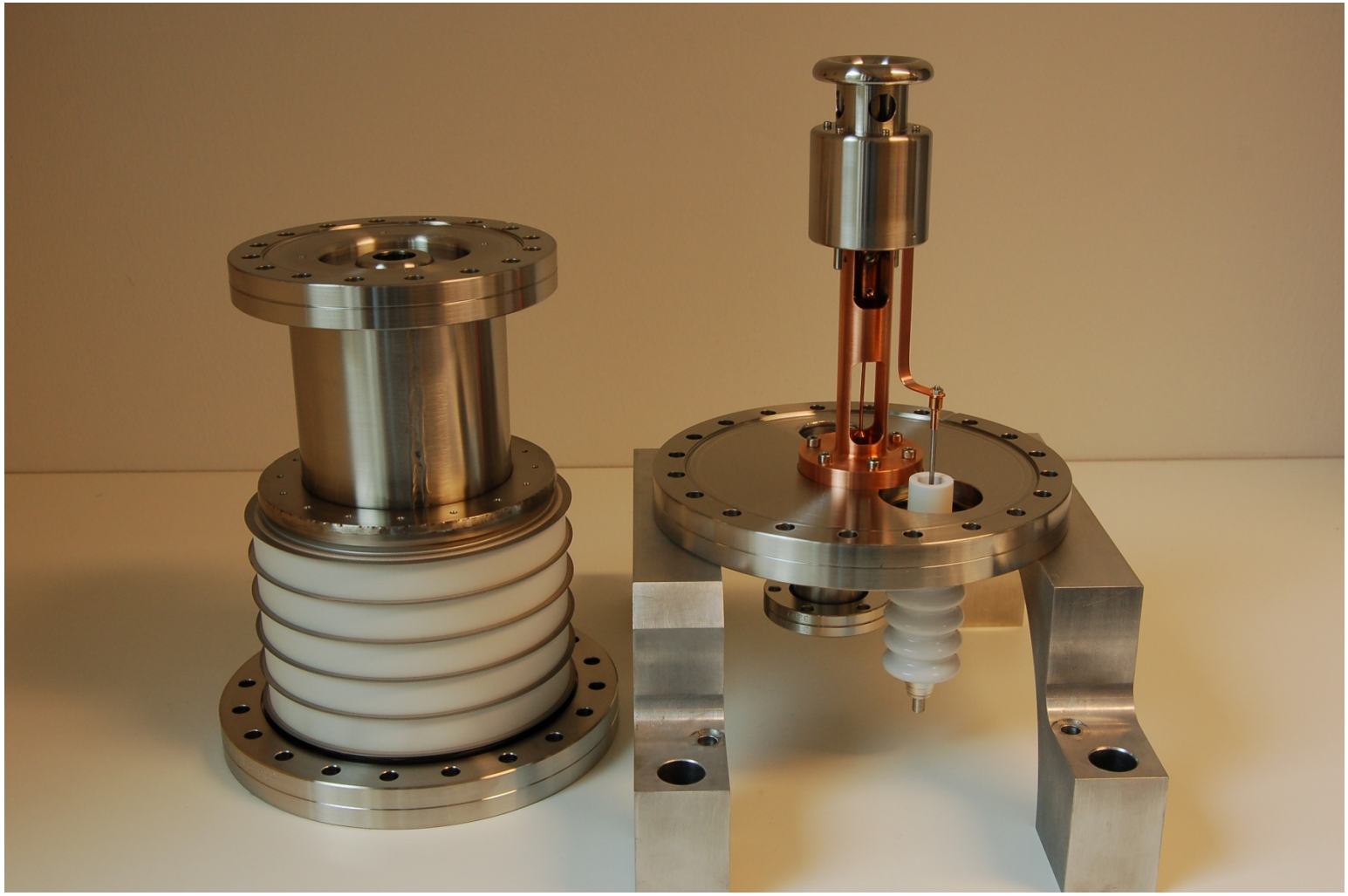
Electron gun



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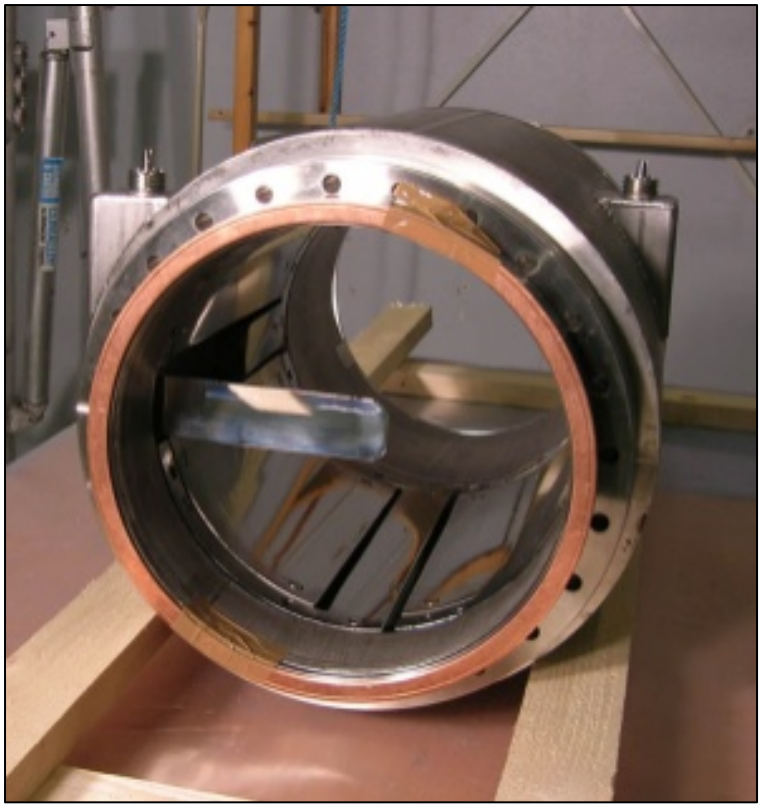
Electron Beam Diagnostics



Combined Scraper and Pick-up

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Prototype Tests

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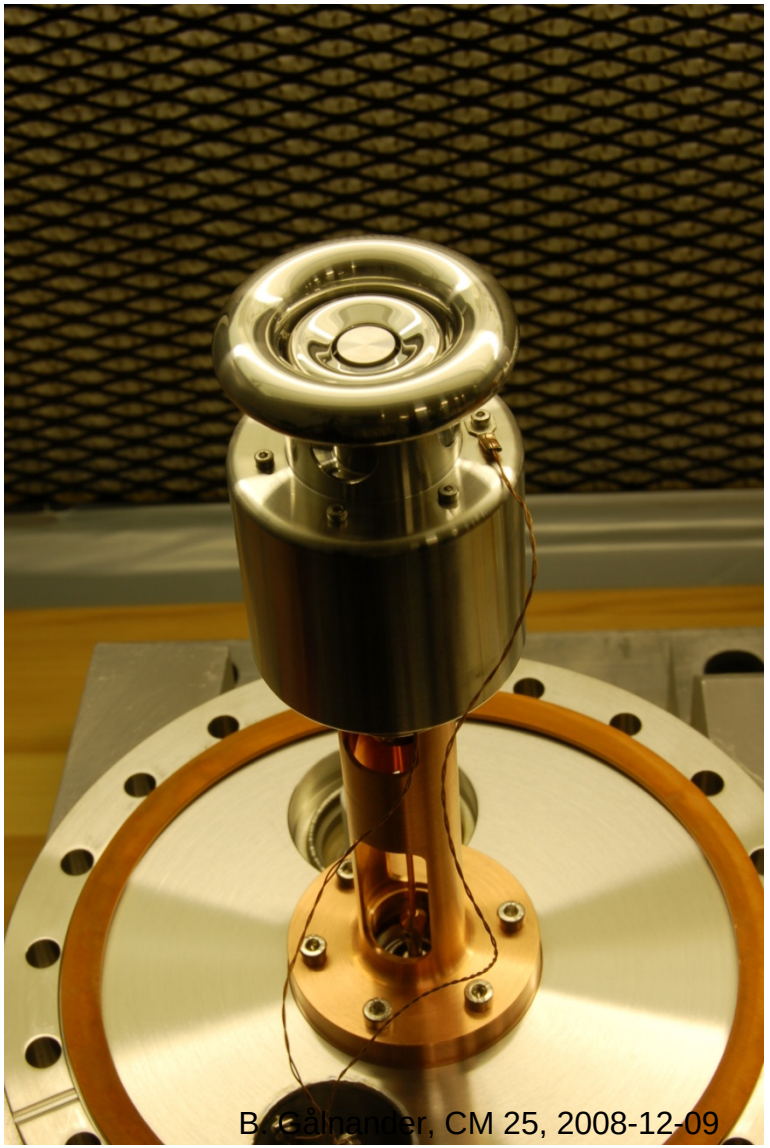
Electron gun

Temperature measurement of insulator



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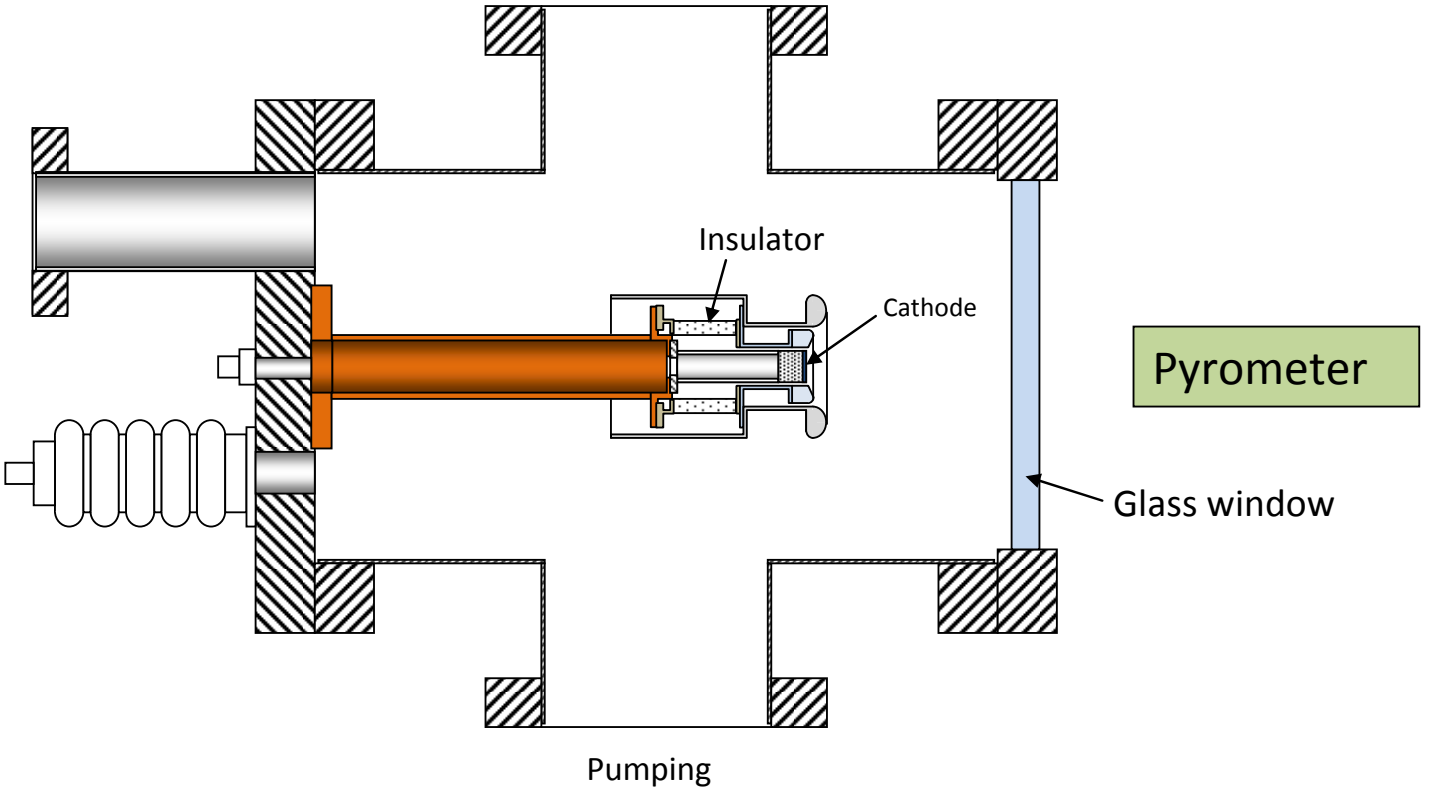
Electron gun

Measurement of cathode temperature



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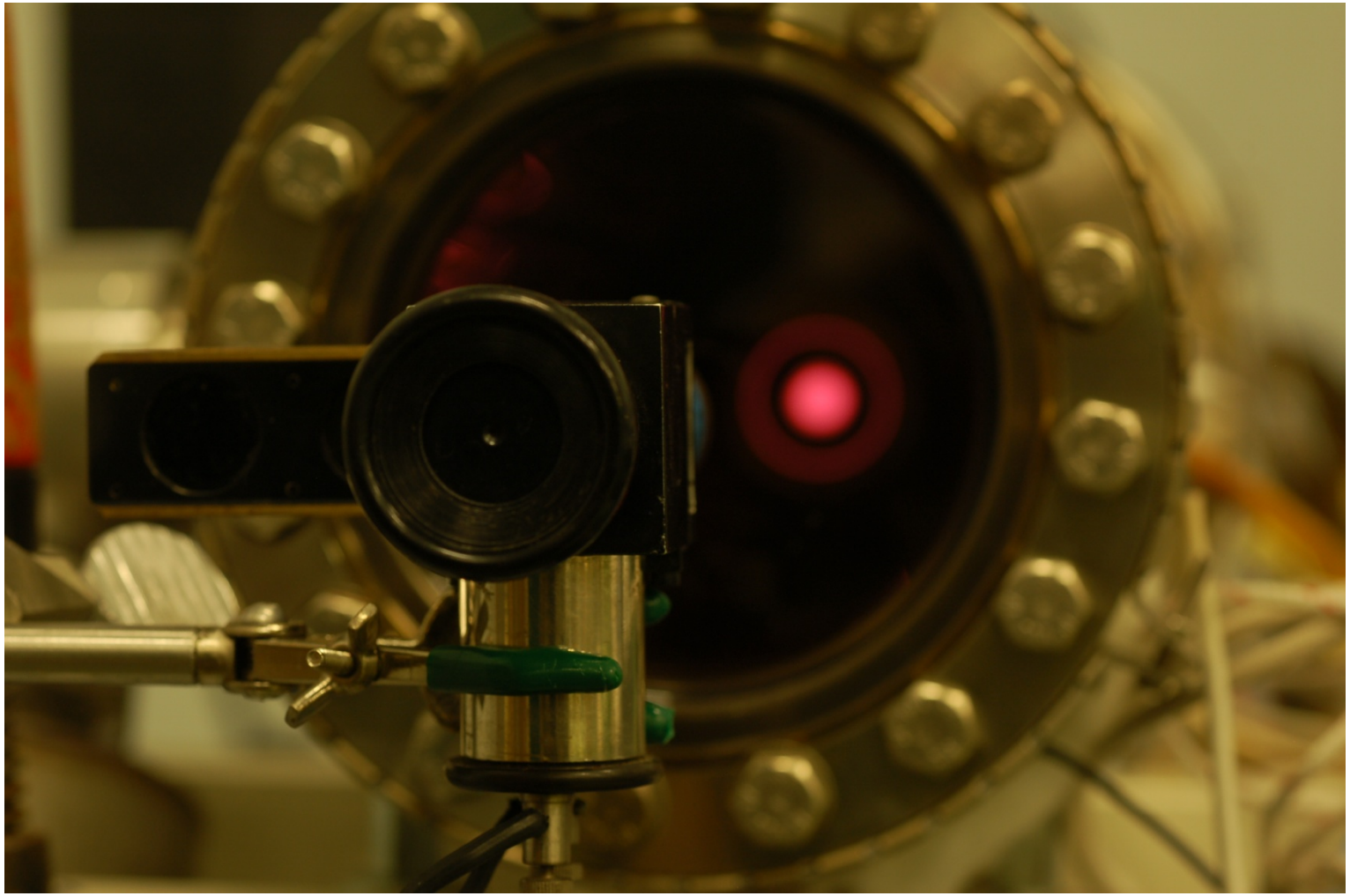
Electron gun

Measurement of cathode temperature



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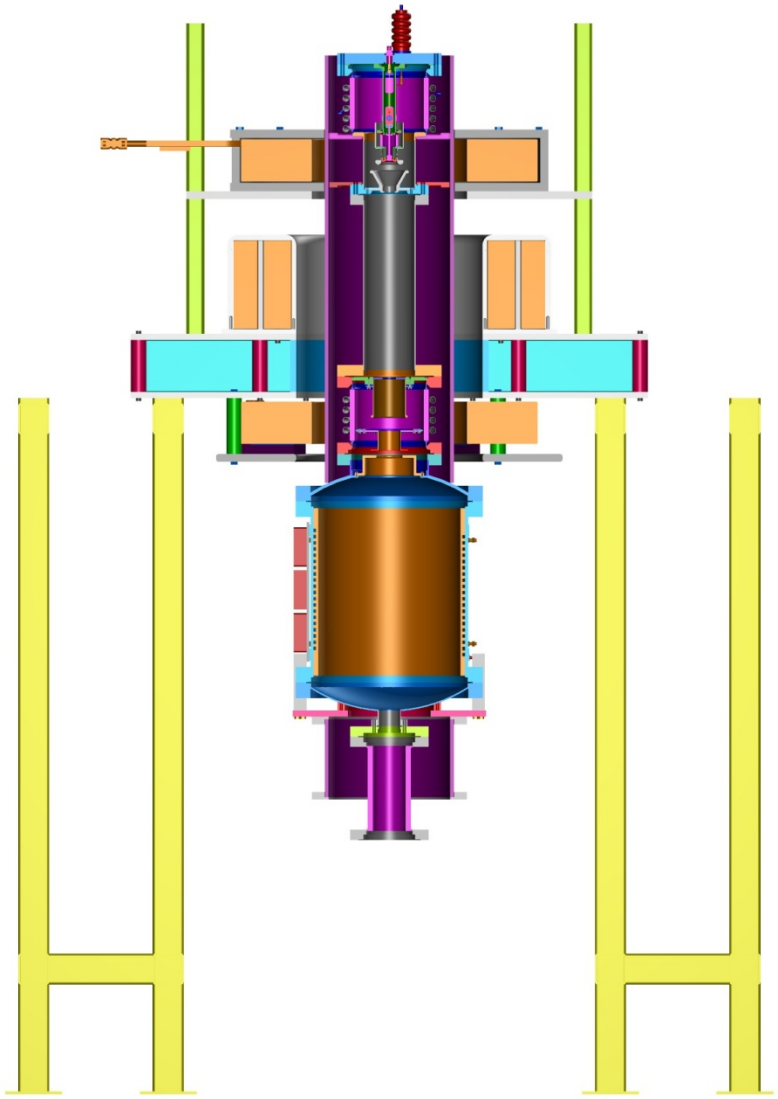
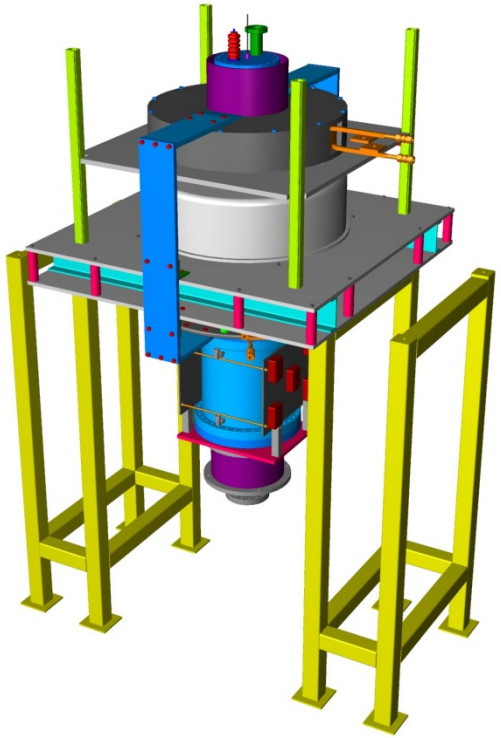
Gun and Collector test bench





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Magnet System Design of Bends

Recent Developments

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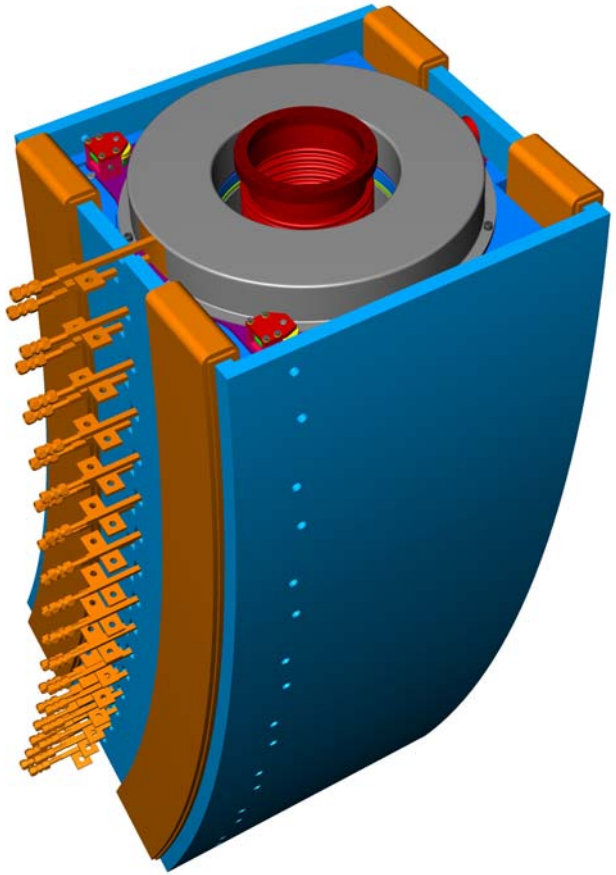
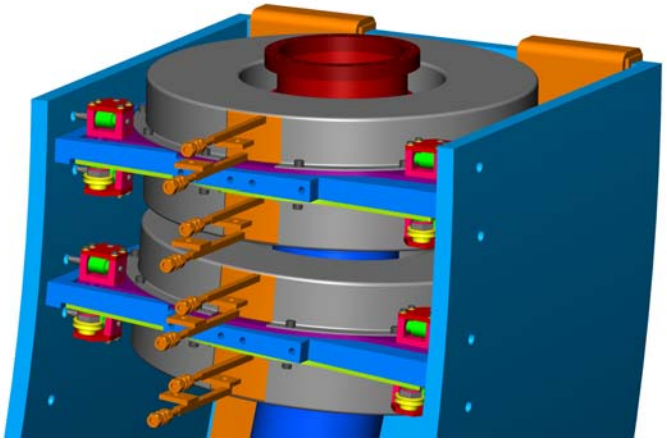
Bent magnet boxes





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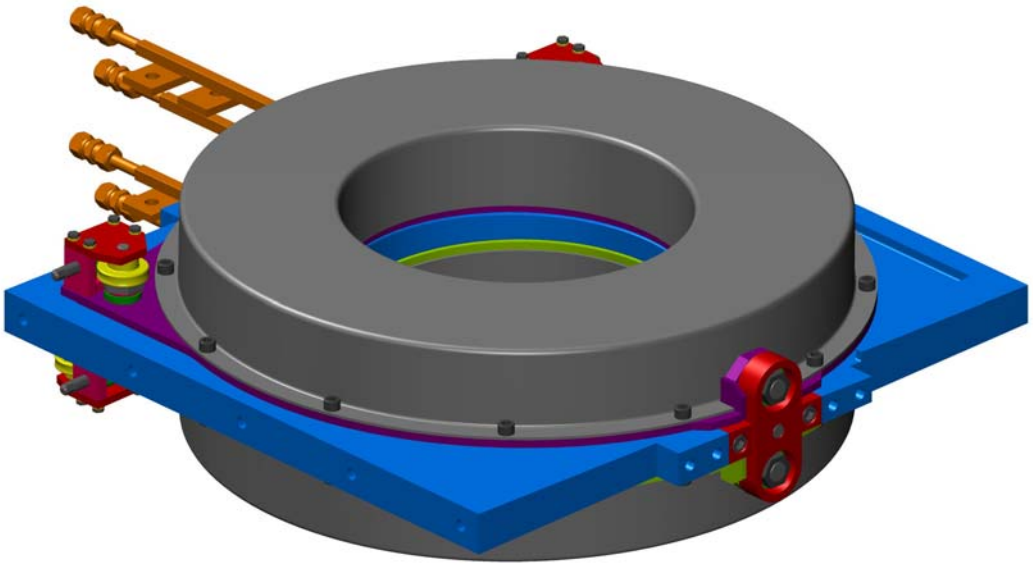

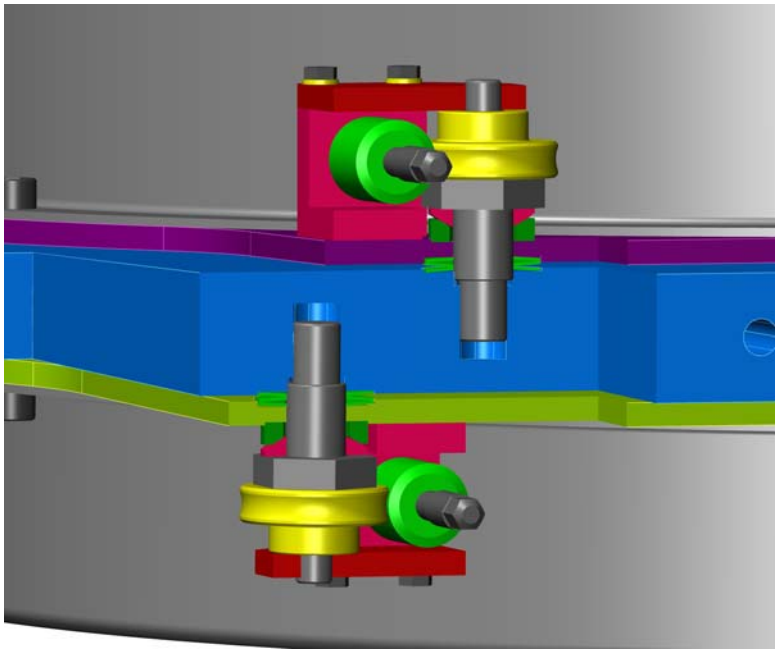

Mechanism for correction of coils

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