The HIE-ISOLDE Faraday Cup

BI Day
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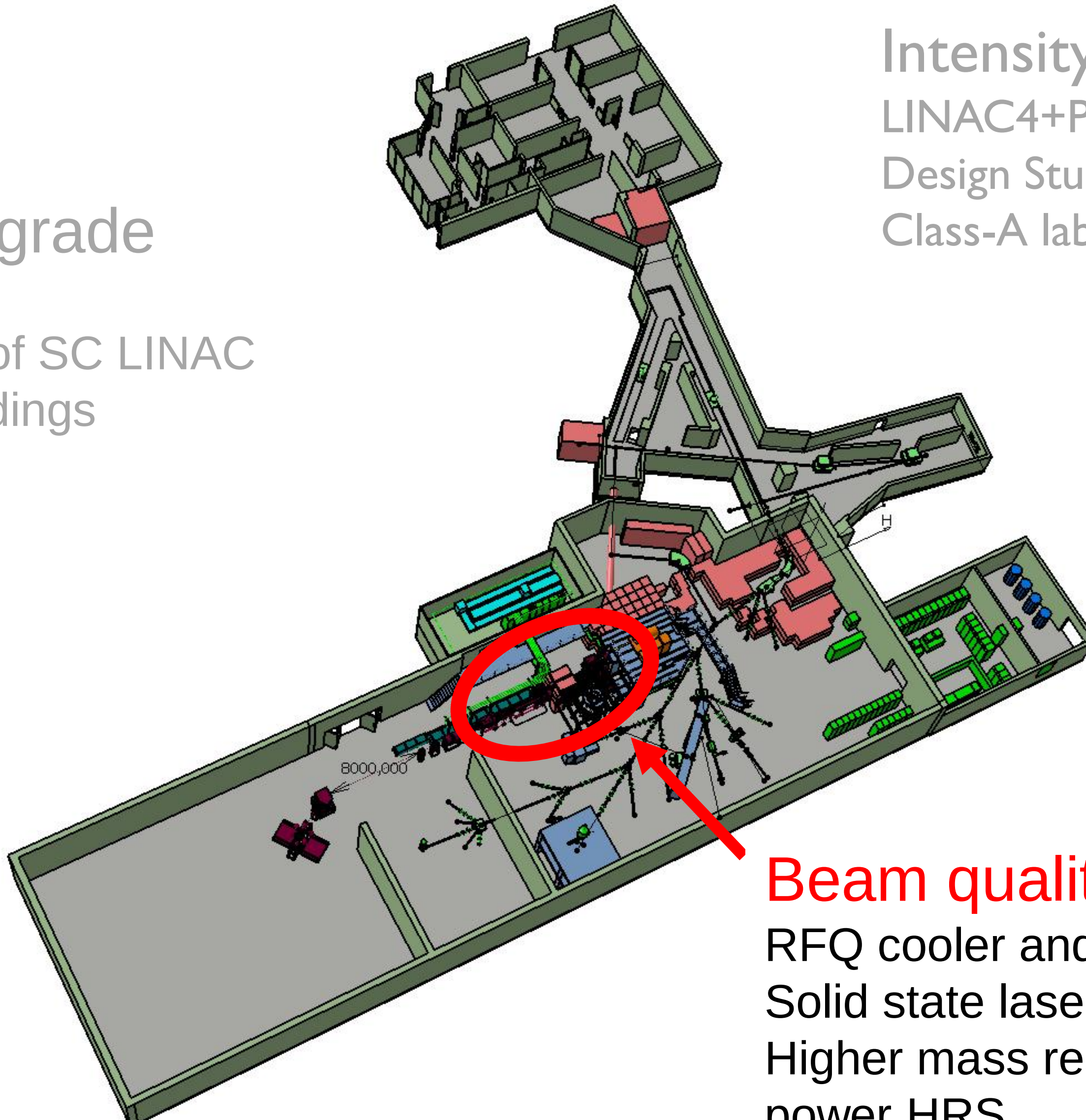
Energy upgrade
10 MeV/u
Construction of SC LINAC
+ service buildings

Intensity upgrade
LINAC4+PSB
Design Study of target area,
Class-A lab and beam lines



Beam quality upgrade
RFQ cooler and buncher
Solid state lasers for RILIS
Higher mass resolving
power HRS

1. Introduction to HIE-ISOLDE

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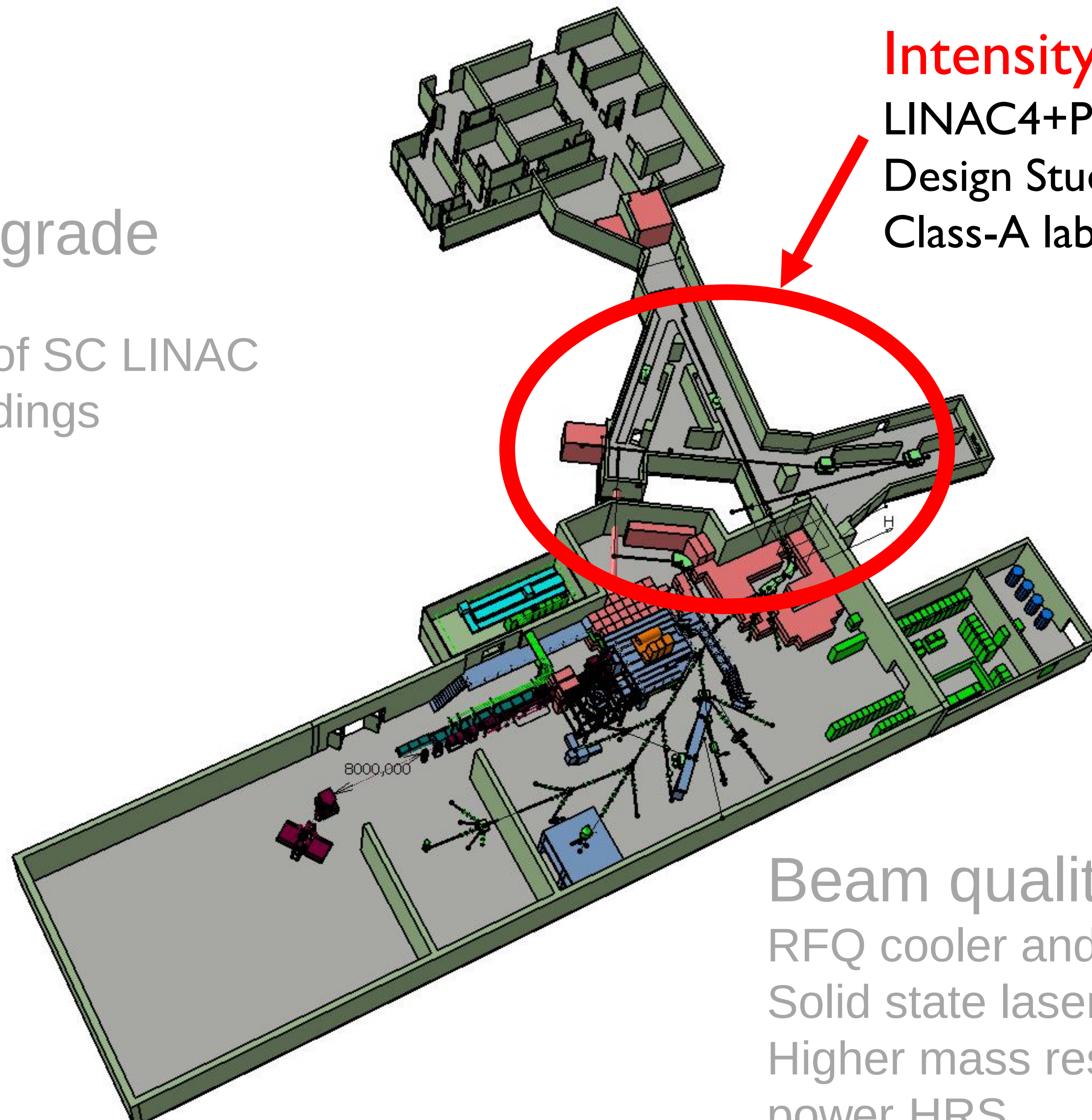

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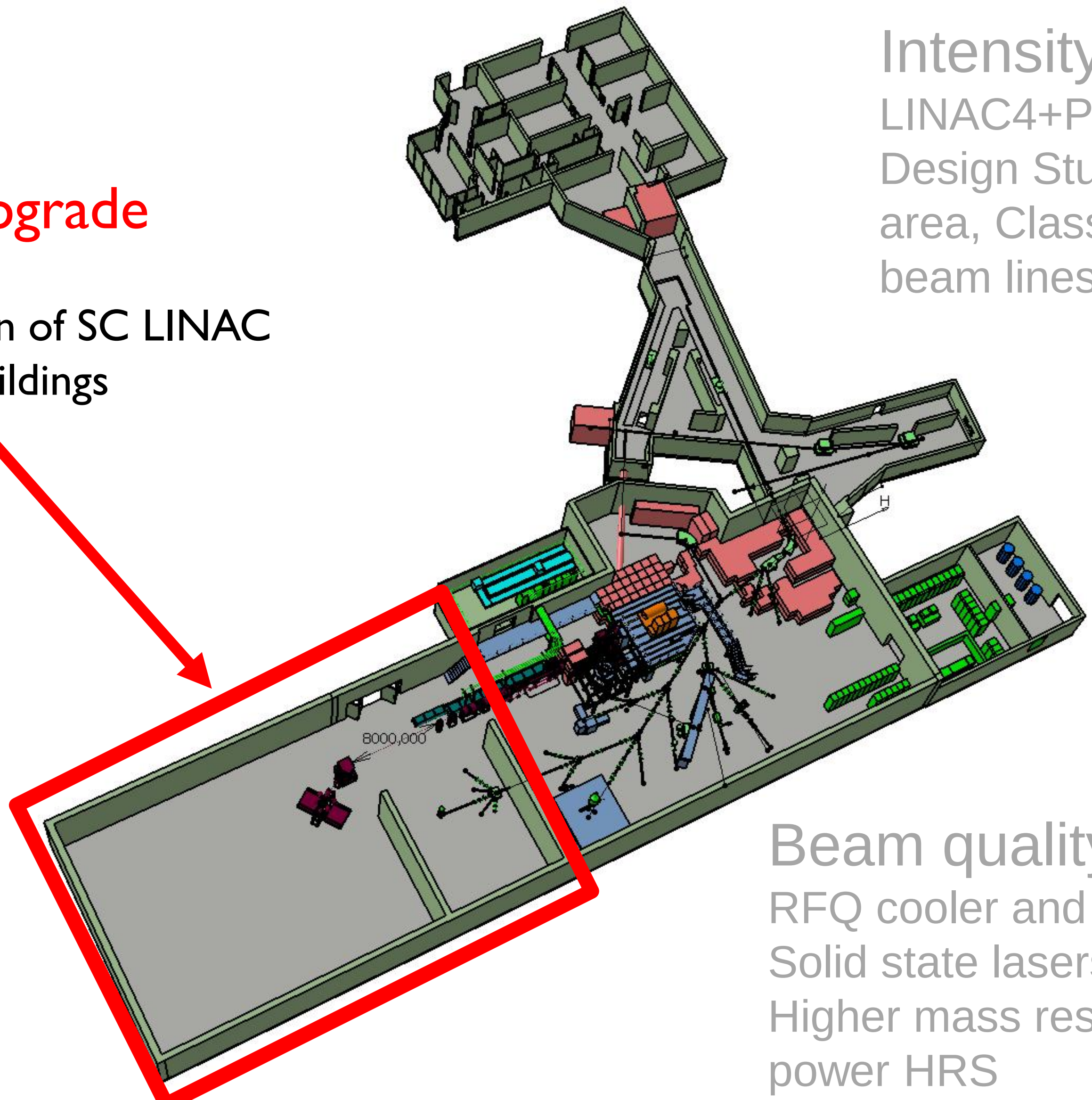

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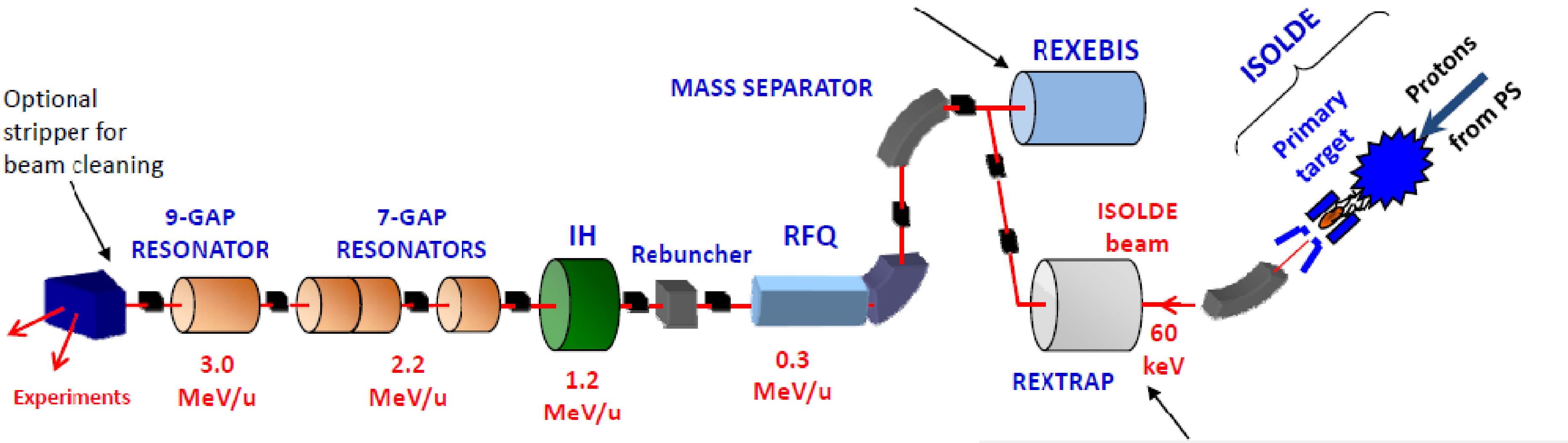
REX-ISOLDE layout

* Energy from 60 kV to few MeV/u
* Operational since Oct 2001
* Until now:
  >30 elements
  close to 100 isotopes

Electron beam ion source

* 1+ ions to n+
* Super conducting solenoid, 2 T
* Electron beam <0.4 A, 3-6 keV
* Breeding time 3 to >200 ms



Linac

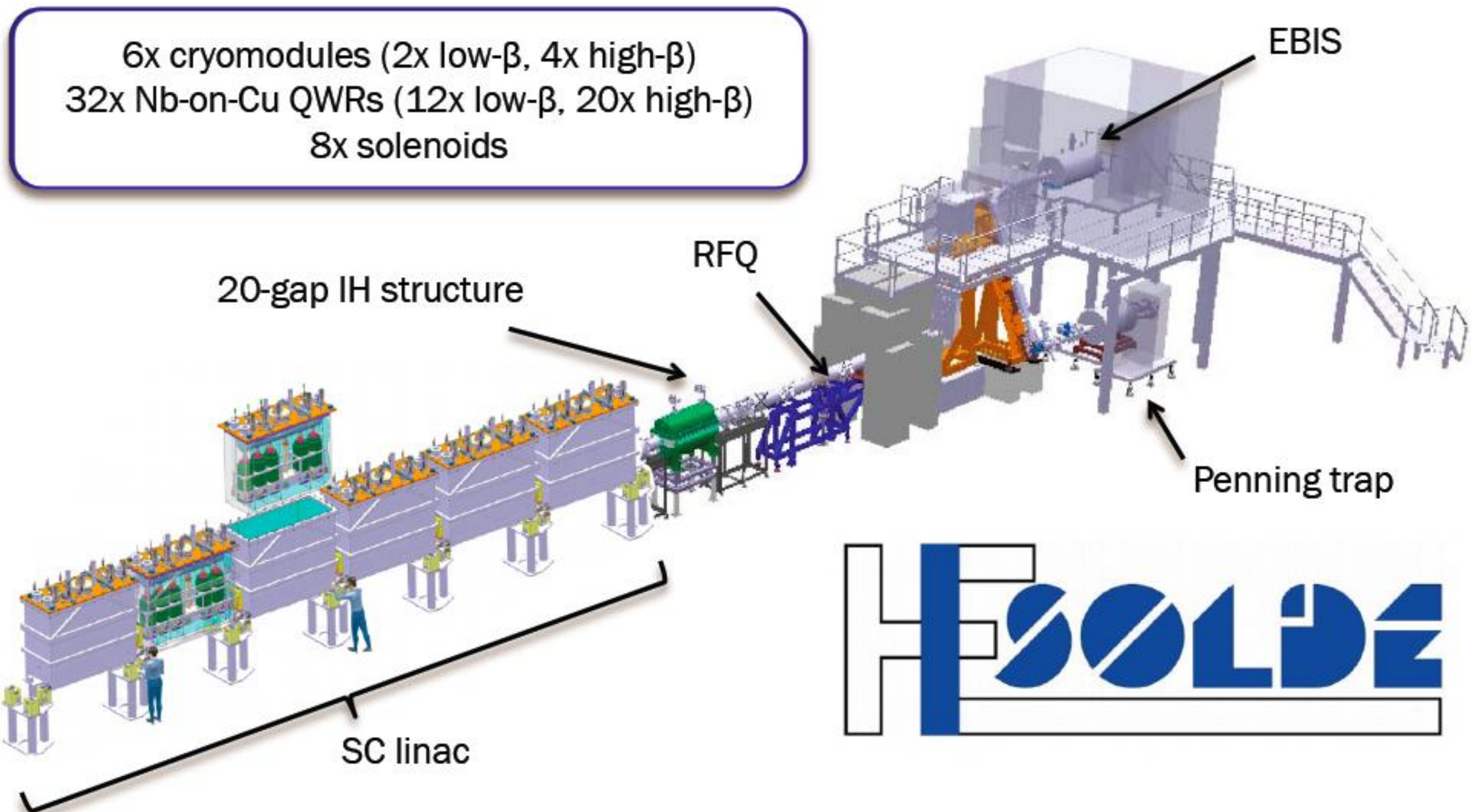
Type	normal conducting 6 accelerating cavities
Length	11 m
Freq.	101 MHz (202 MHz for the 9GP)
Duty cycle	1 ms 100Hz
Energy	300 keV/u, 1.2-3 MeV/u (variable)
A/q max.	4.5

Penning trap

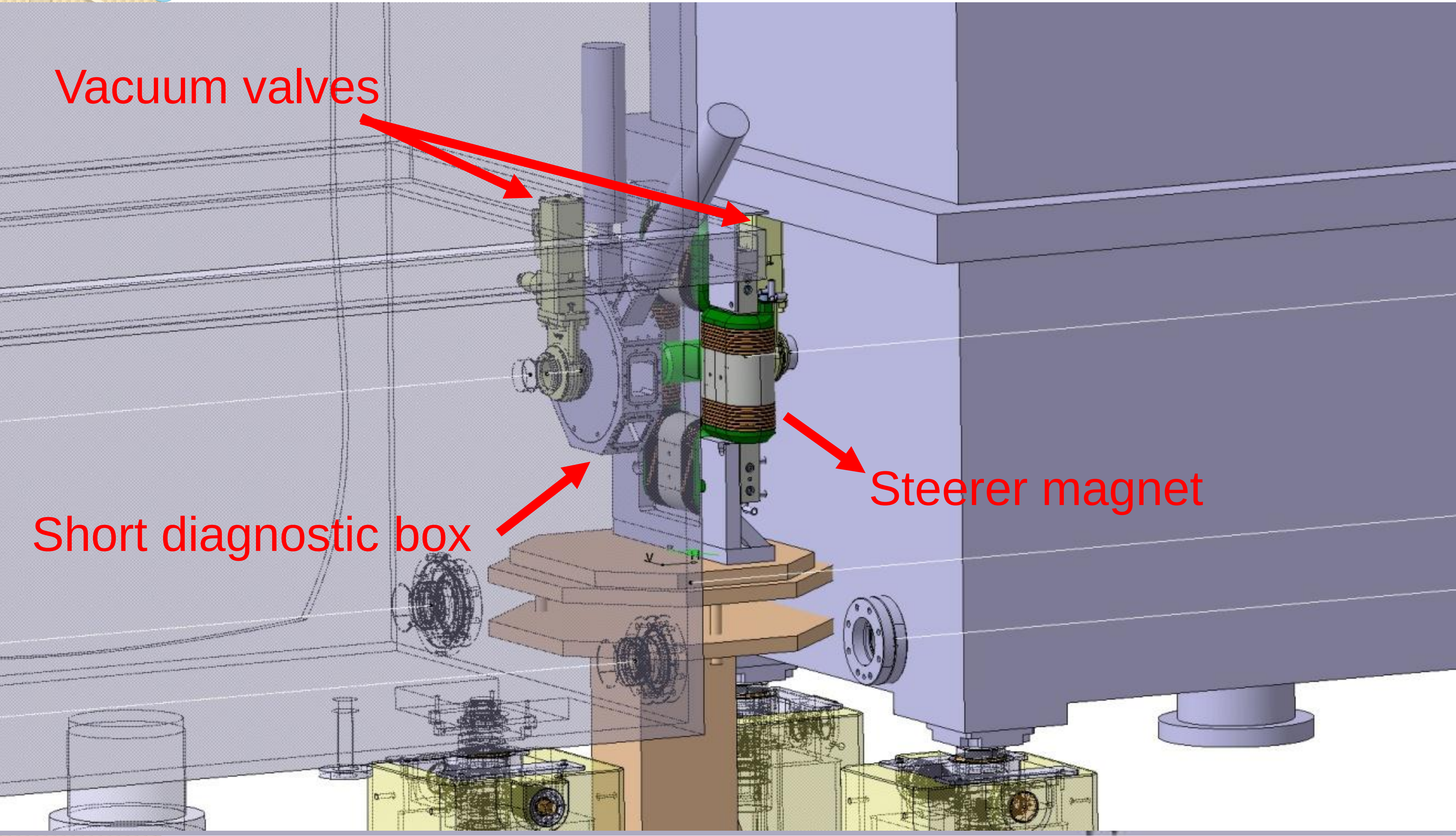
* Longitudinal accumulation and bunching
* Transverse phase space cooling
* 3 T solenoid field
  + quadratic electrostatic potential
  + RF cooling
* Buffer gas filled (5E-4 mbar)
* Cooling time ~20 ms

Courtesy F. Wenander

2. The short diagnostic boxes

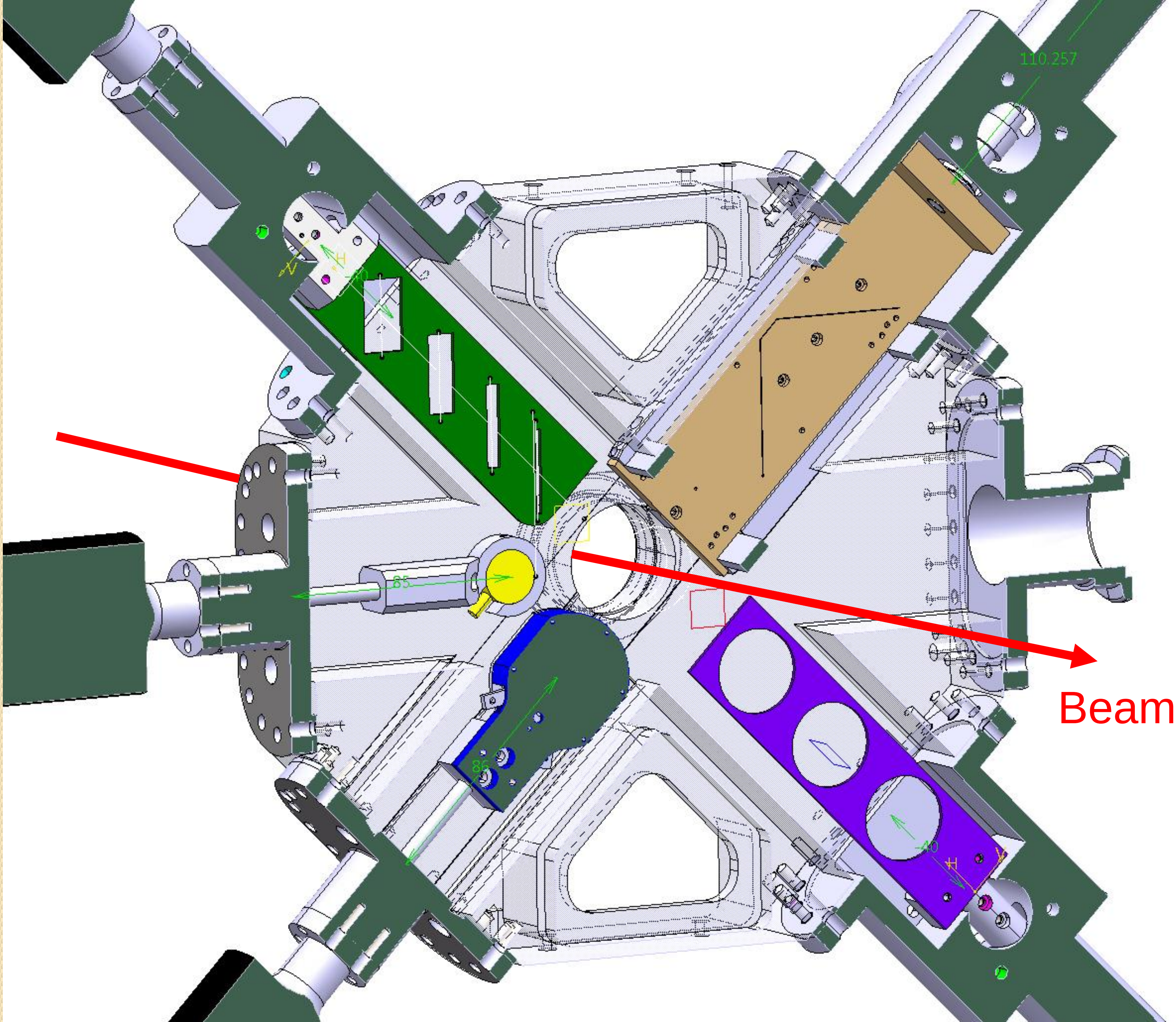


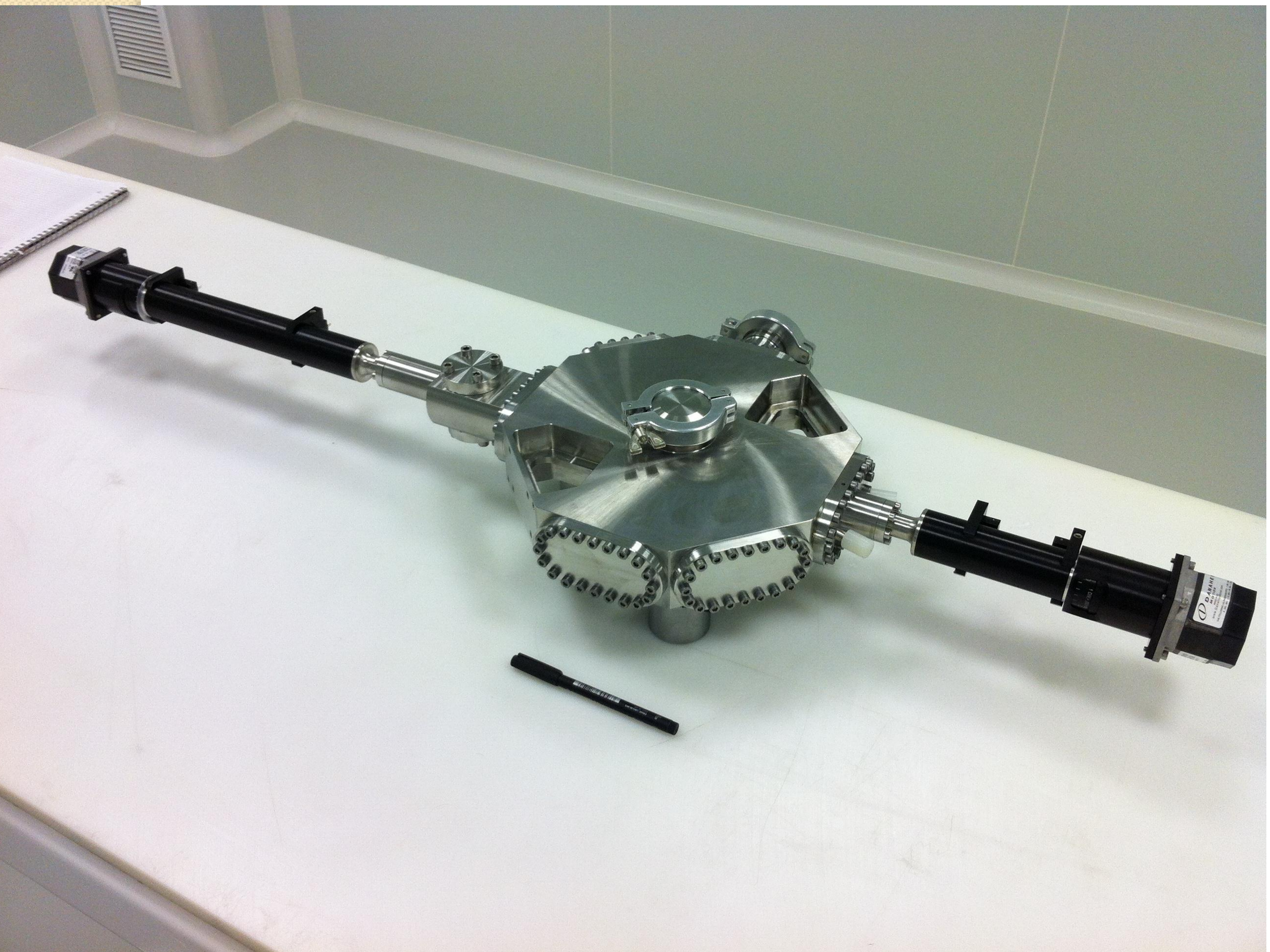
2. The short diagnostic boxes

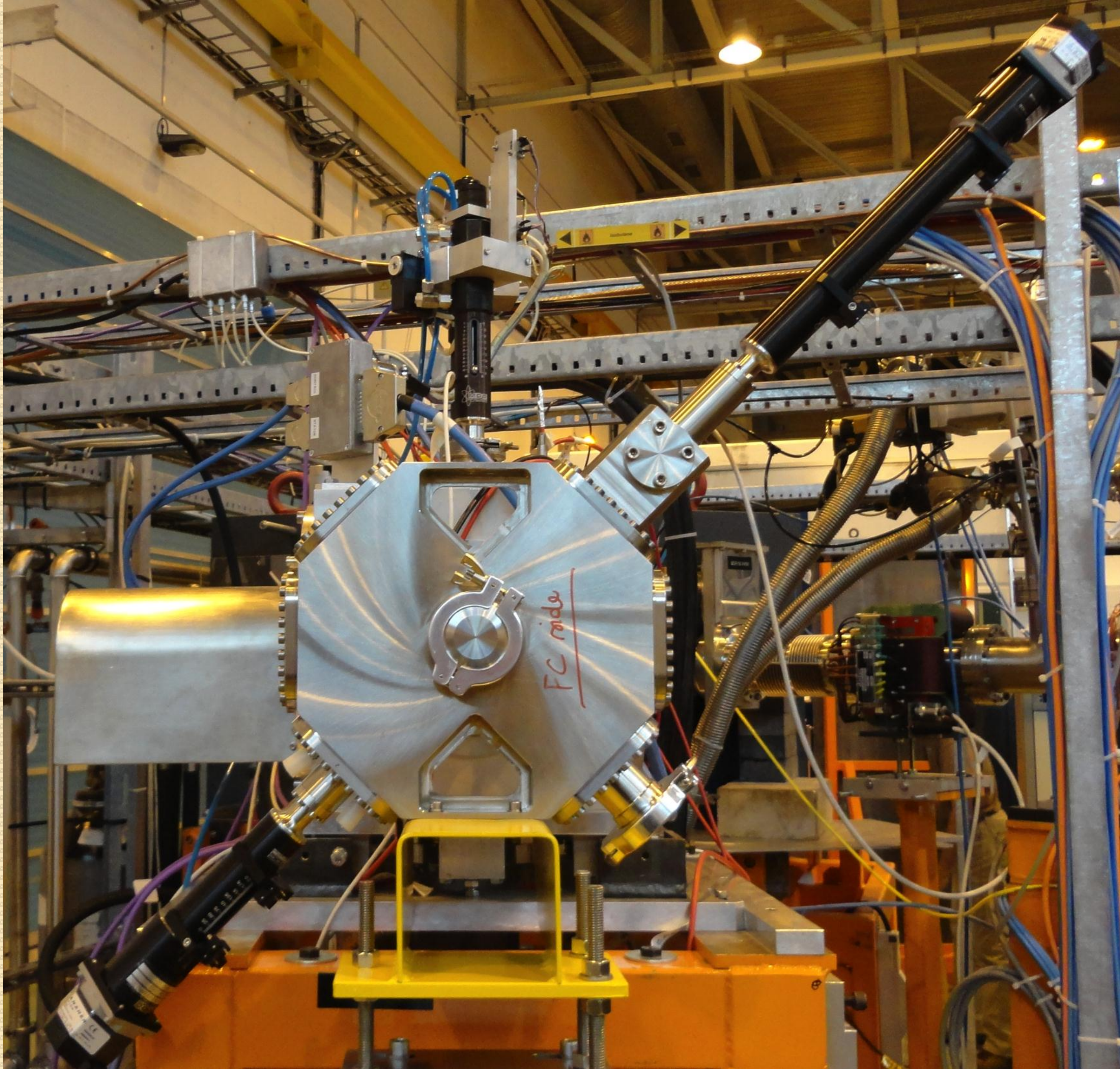


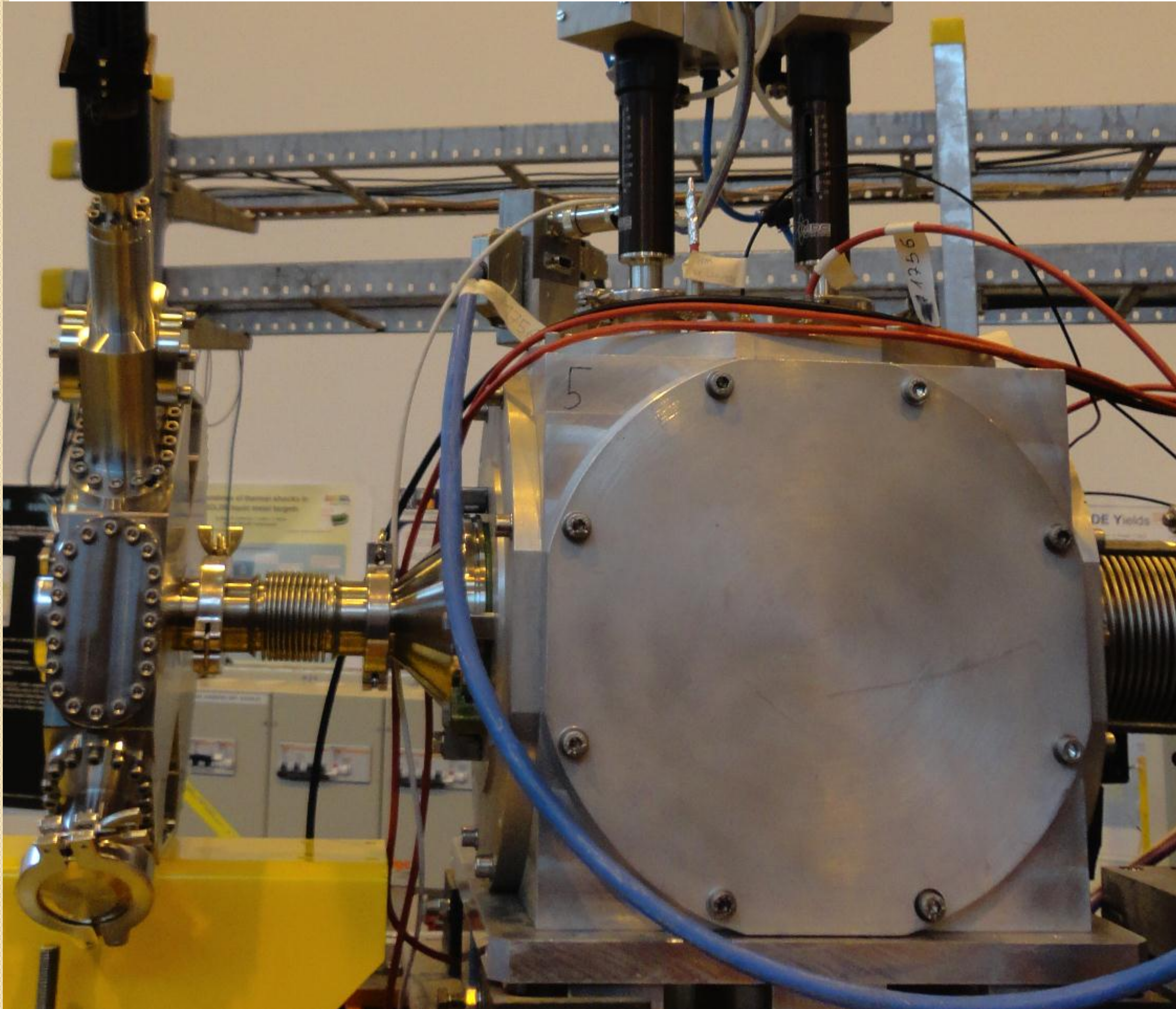
2. The short diagnostic boxes

- Currently being developed by CERN and Added Value Solutions (AVS) with the support of the Spanish government (CDTI)
- The device fits in the 90 mm long space available and contains
  - A 45 degree scanning blade with 2 slits (H,V)
  - HIE-ISOLDE Faraday cup
  - Solid-state detector (Absolute energy, ToF)
  - Collimators blade
  - Attenuating and stripping foils

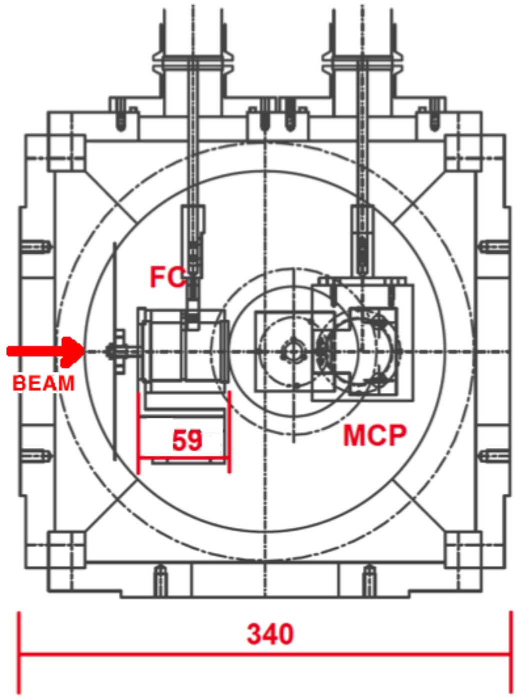

110.257
85
86
40
Beam




FC side

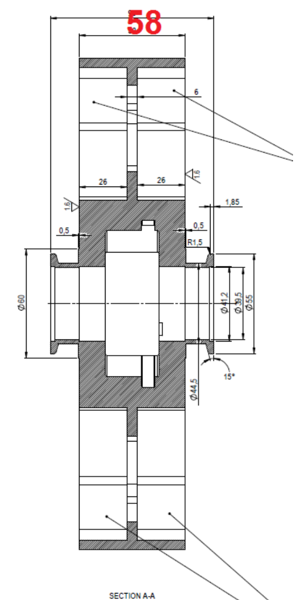

5
DE Yields

REX vs HIE - DBs



REX DB

- REX - Faraday cup (length: 59 mm)
- MCP (beam profile - image) or Si detector (energy and TOF)
- Collimators wheel (attenuating and stripping foils as well)

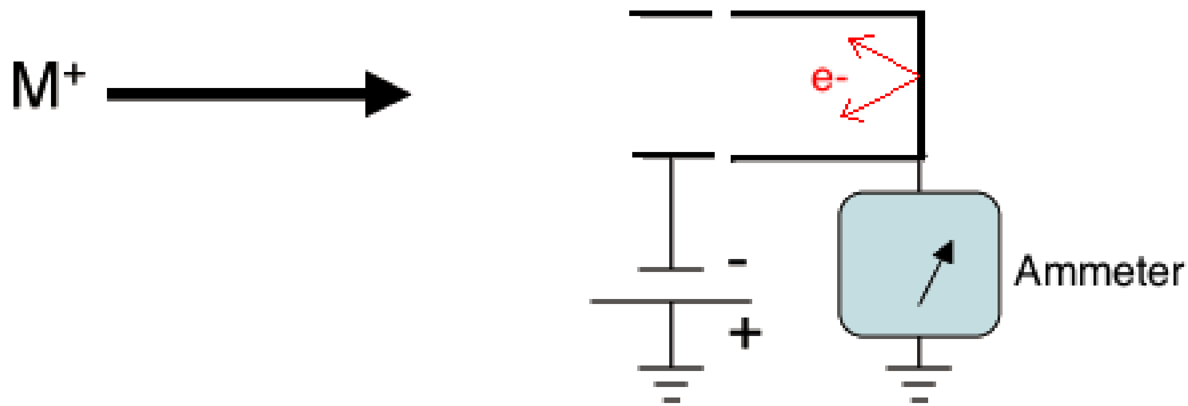


HIE DB

- HIE - Faraday cup (14 mm)
- Scanning slits (beam profile)
- Collimators (optics)
- Stripping foils in some cases
- Solid-state detector in a few boxes (absolute energy, TOF)

The most important device that needs to be tested is the FC

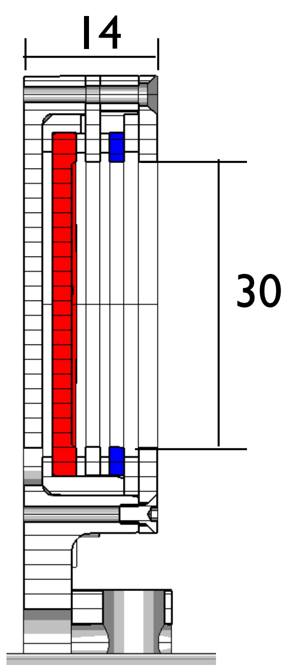
3. Review of Faraday cups



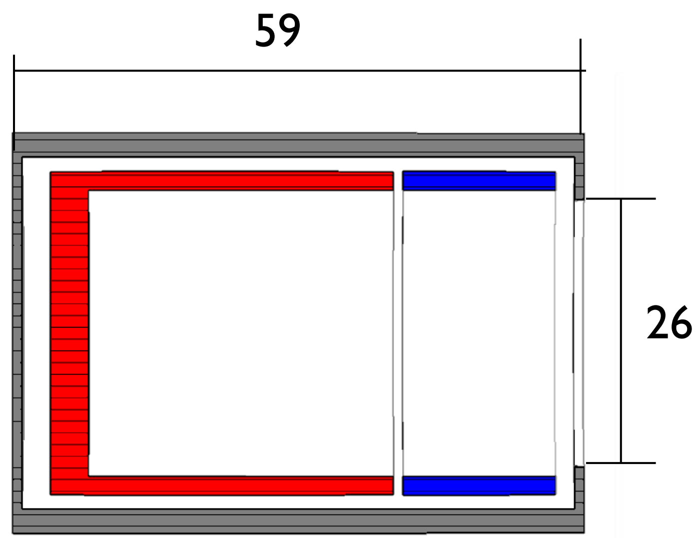
- Destructive measurement
- Measures absolute beam current
- The escape of electrons increases the value read in the picoammeter.
- Ion-induced electron emission:
  - Low energy electrons (E_e < 20 eV)
  - High energy electrons (E_e ~ keV for MeV/u ions)

4. The HIE-ISOLDE Faraday cup

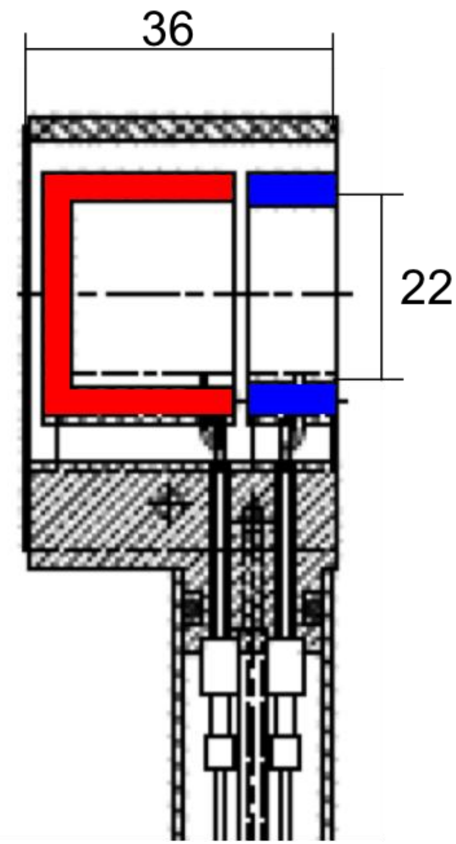
HIE-ISOLDE



REX-ISOLDE

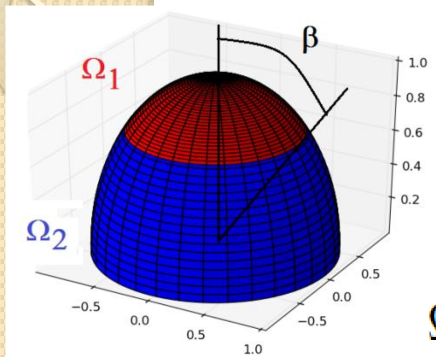


ISAC 2



(Distances in mm)

Electrons captured and retained Intensity: solid angle of the signal plate

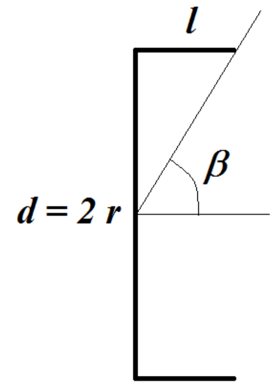


In a simplified model:

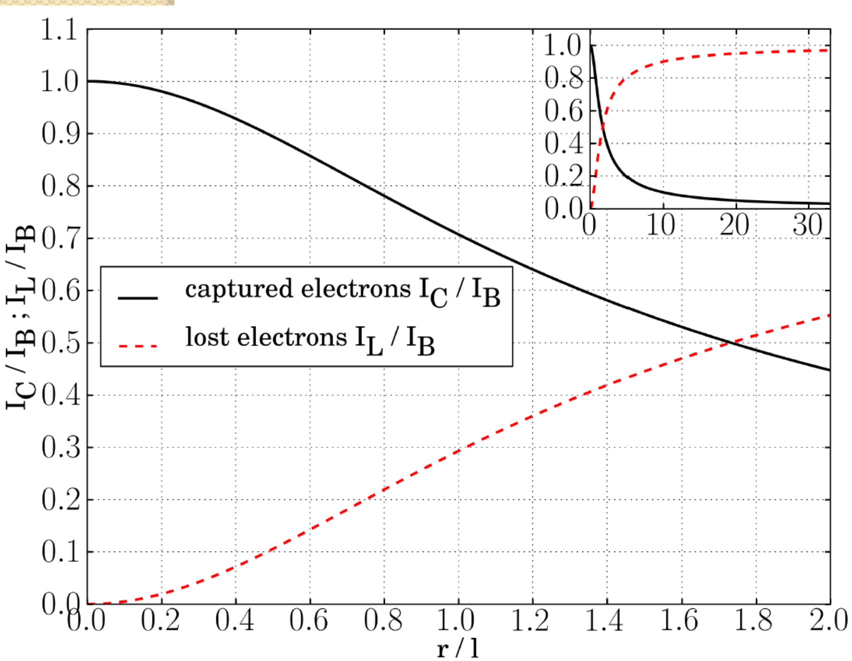
Ω_2 → retained electrons

Ω_1 → lost electrons

$$\Omega_2 \;=\; 2\pi - \Omega_1 = 2\pi \cos \beta.$$



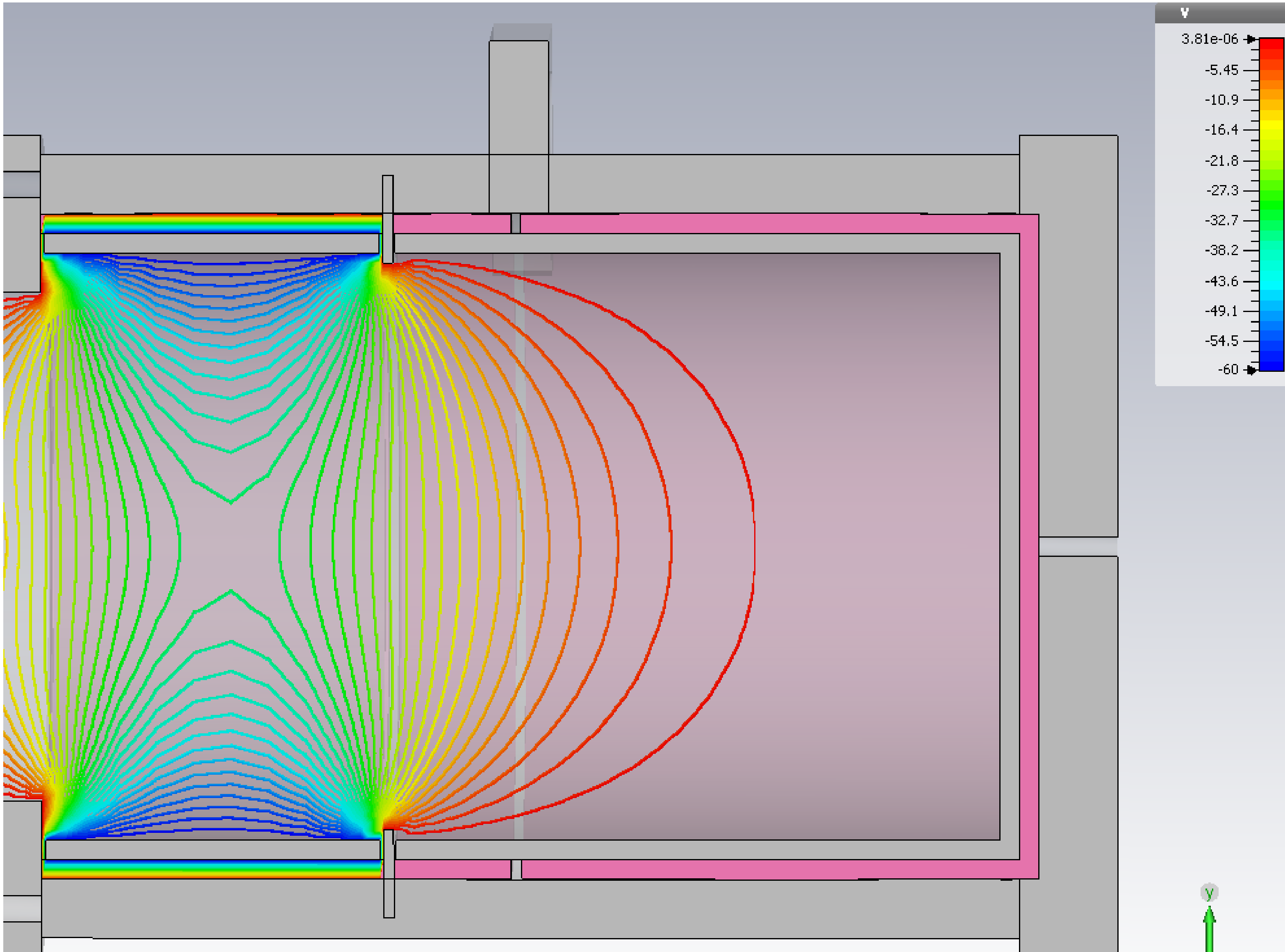
Signal plate geometry



cup	r (mm)	l (mm)	r / l	cos β
REX	14.8	32.0	0.4625	0.907
HIE	15.0	0.5	30	0.033

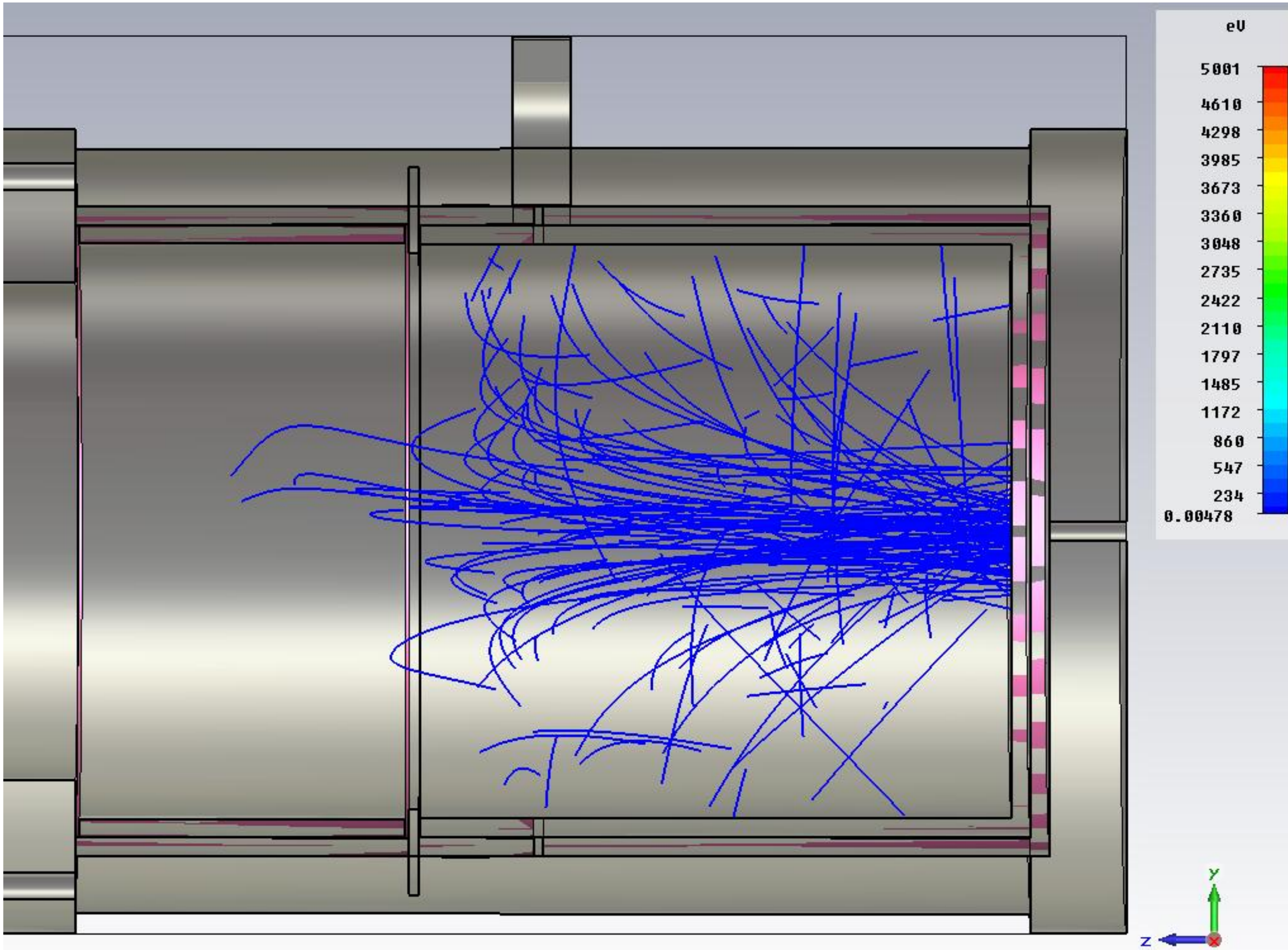
$$\frac{I_C}{I_B} = \frac{\Omega_2}{2\pi} = \frac{1}{\sqrt{1+(r/l)^2}}$$

5. Simulations



REX-ISOLDE Faraday cup potential distribution -60 V

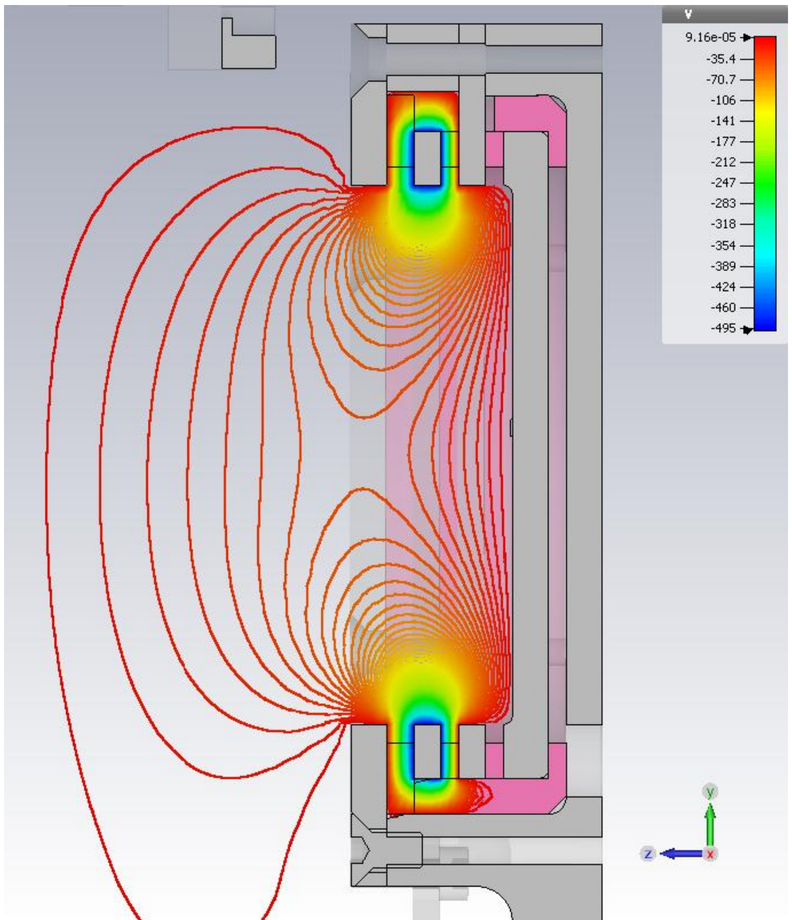
5. Simulations



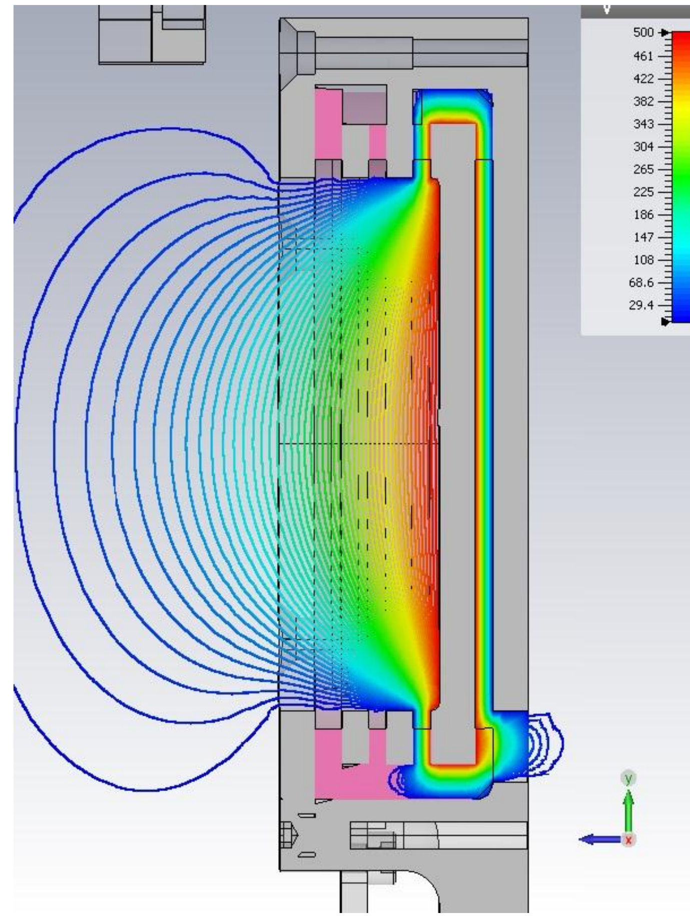
REX-ISOLDE Faraday cup secondary e- tracking

5. Simulations

- More uniform potential distribution
- Enhanced effectiveness

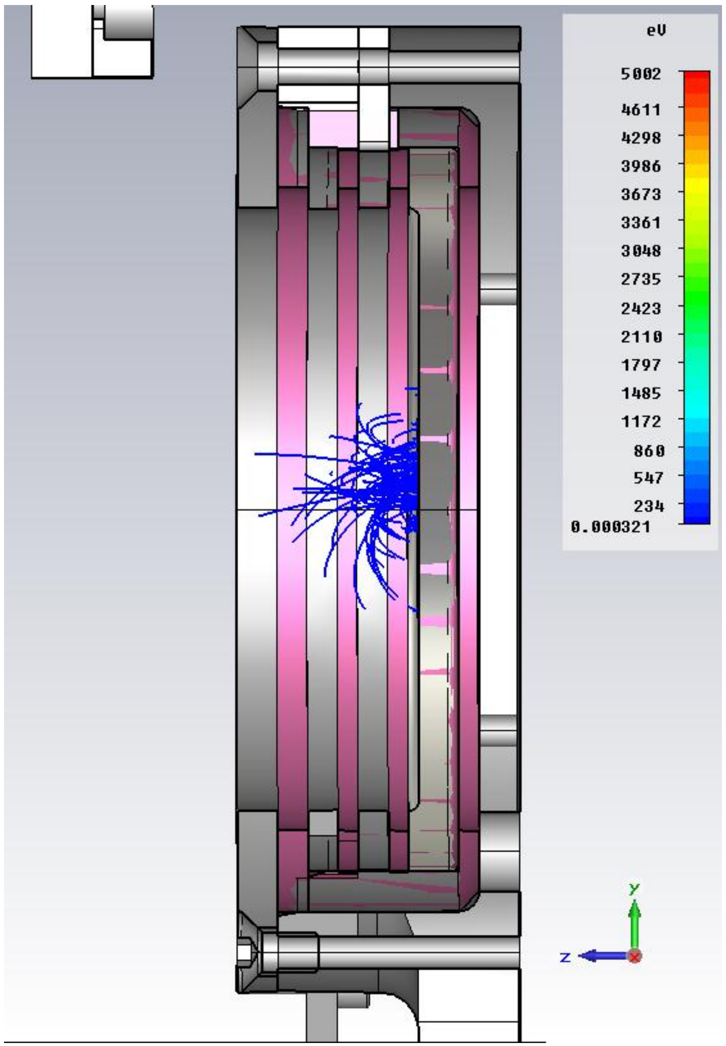


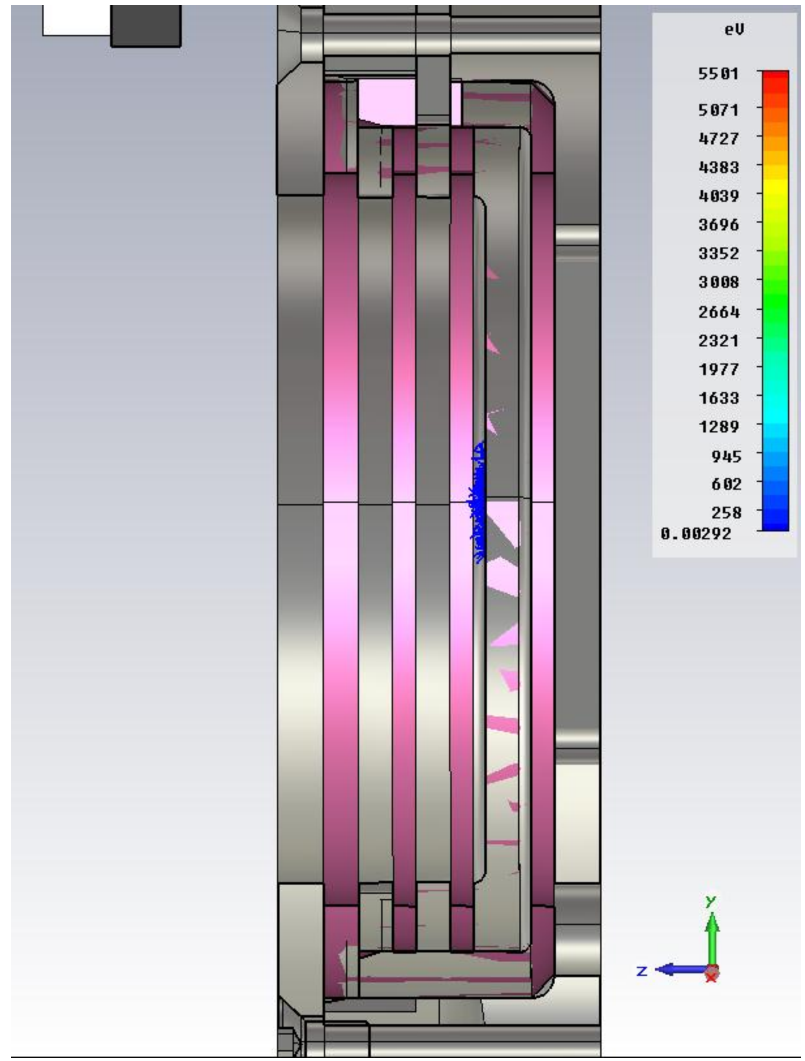
HIE-ISOLDE Faraday cup: -500V



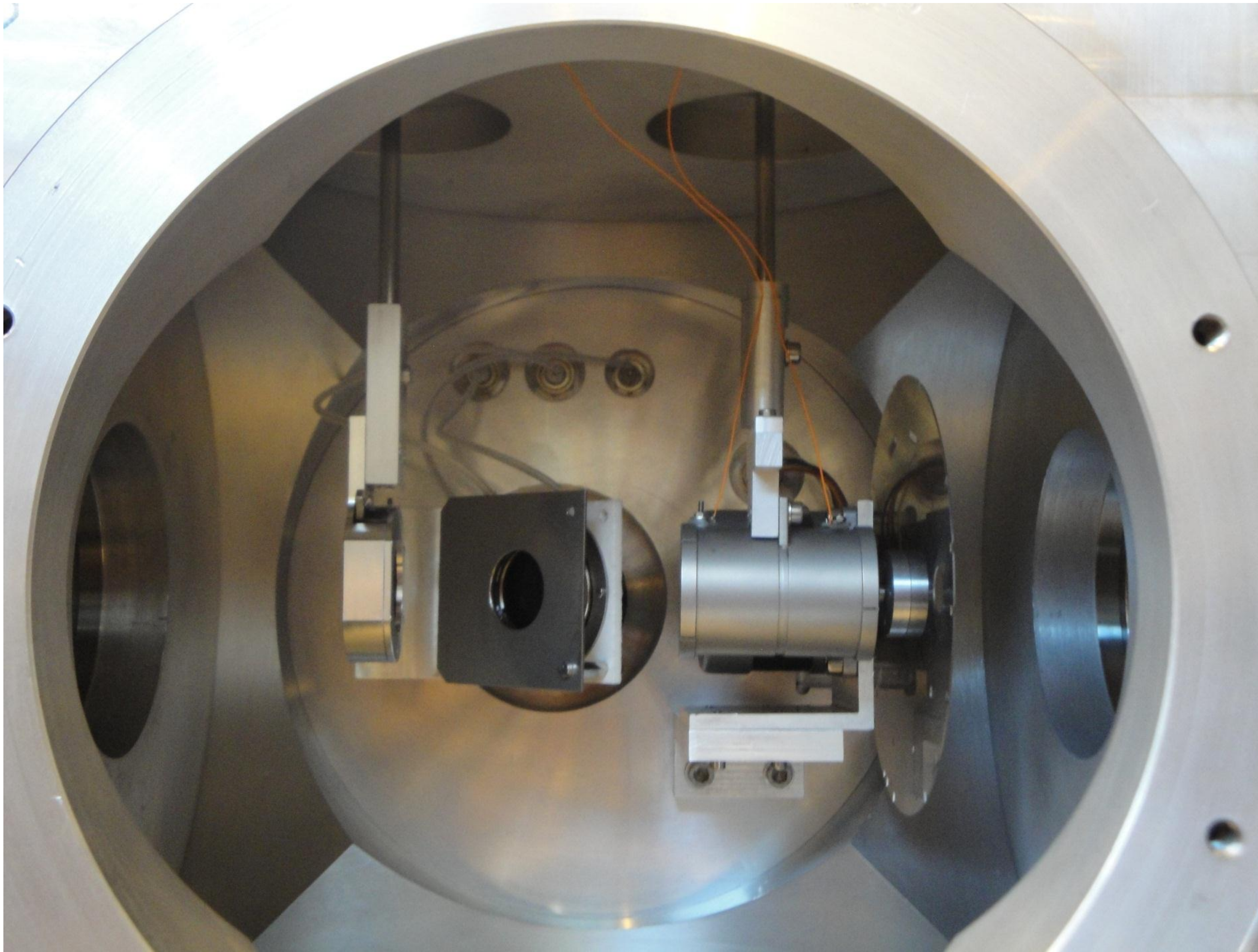
+100V

5. Simulations





6. Experimental tests

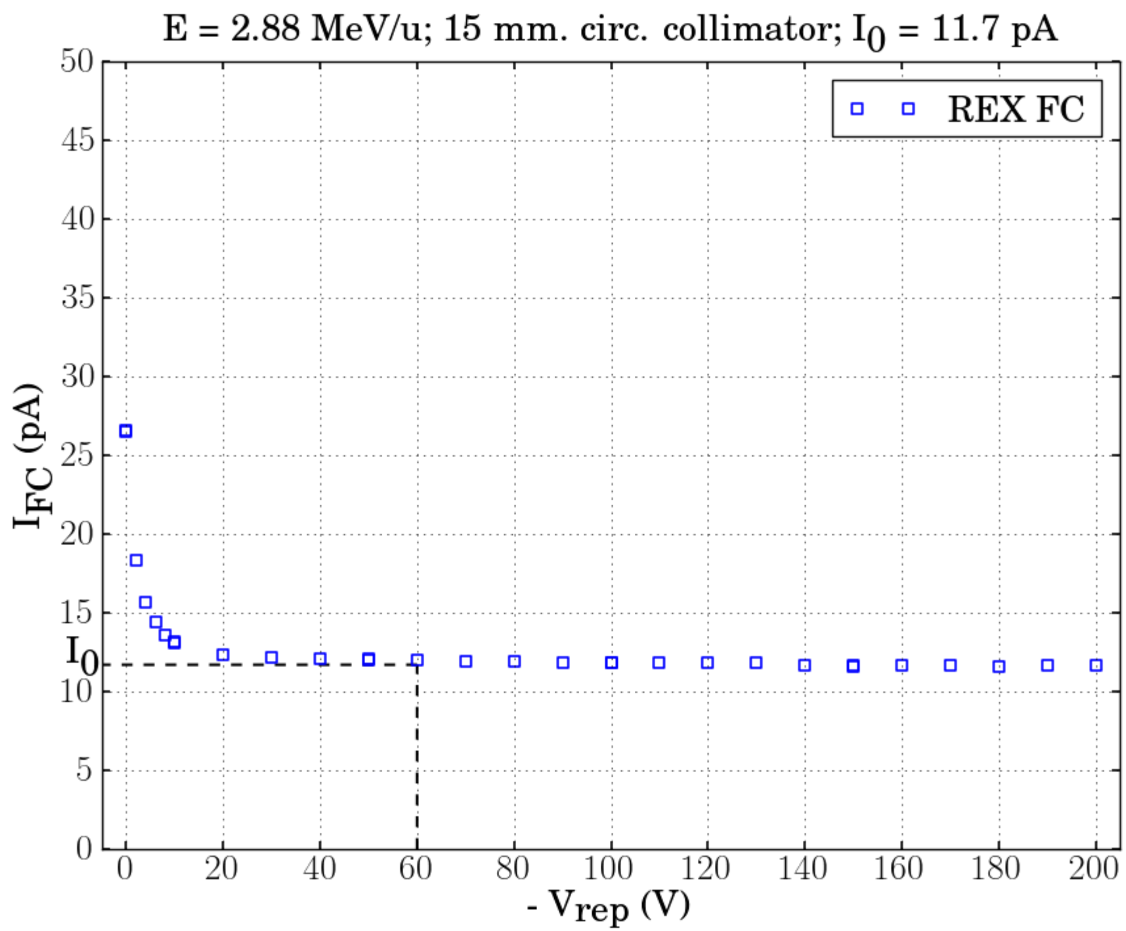


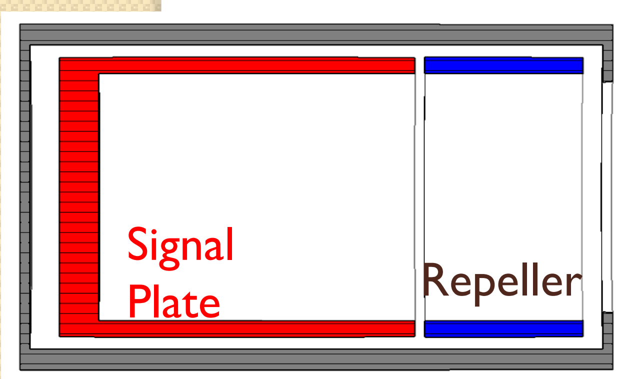
Definition of I_0

stable beam
A/Q =4

$V_{signal\ plate} = 0\,V$

$V_{repeller} < 0\,V$ (variable).



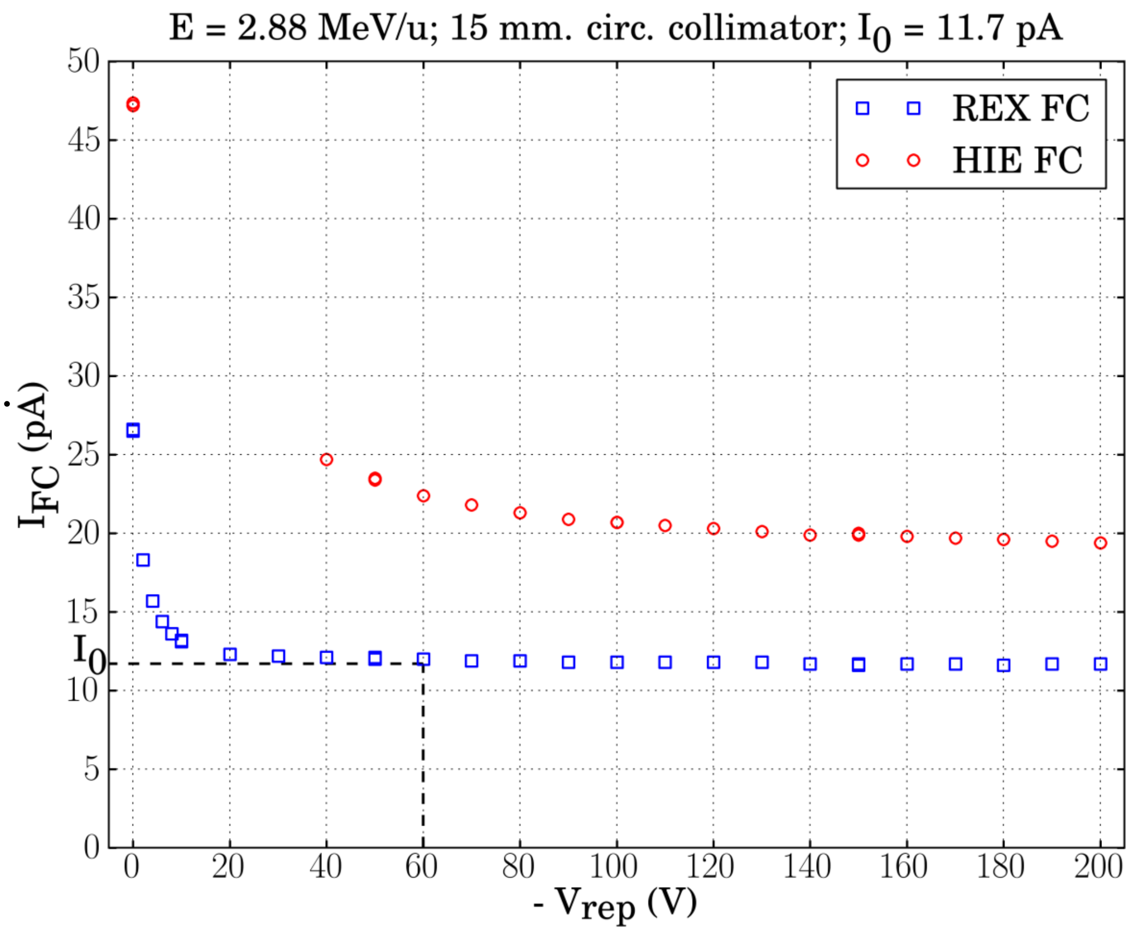


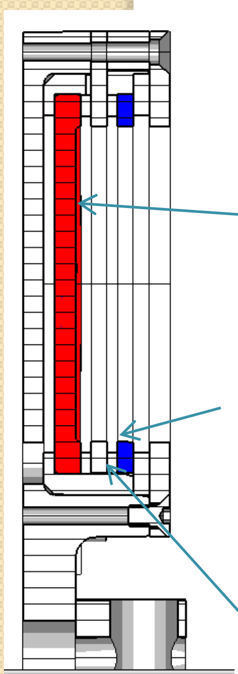
Biasing the repeller ring

stable beam
A/Q =4

$V_{\text{signal plate}} = 0\,\text{V}$

$V_{\text{repeller}} < 0\,\text{V}$ (variable).





Signal Plate

Repeller ring

Ground ring

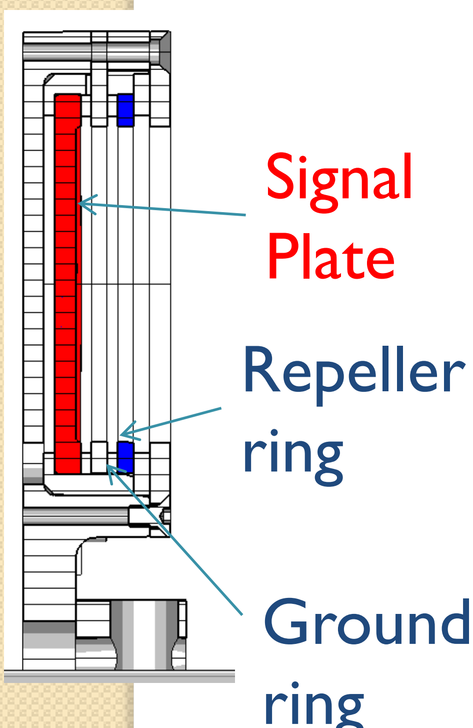
The short cup does not measure the same current value and needs much higher repelling voltage.

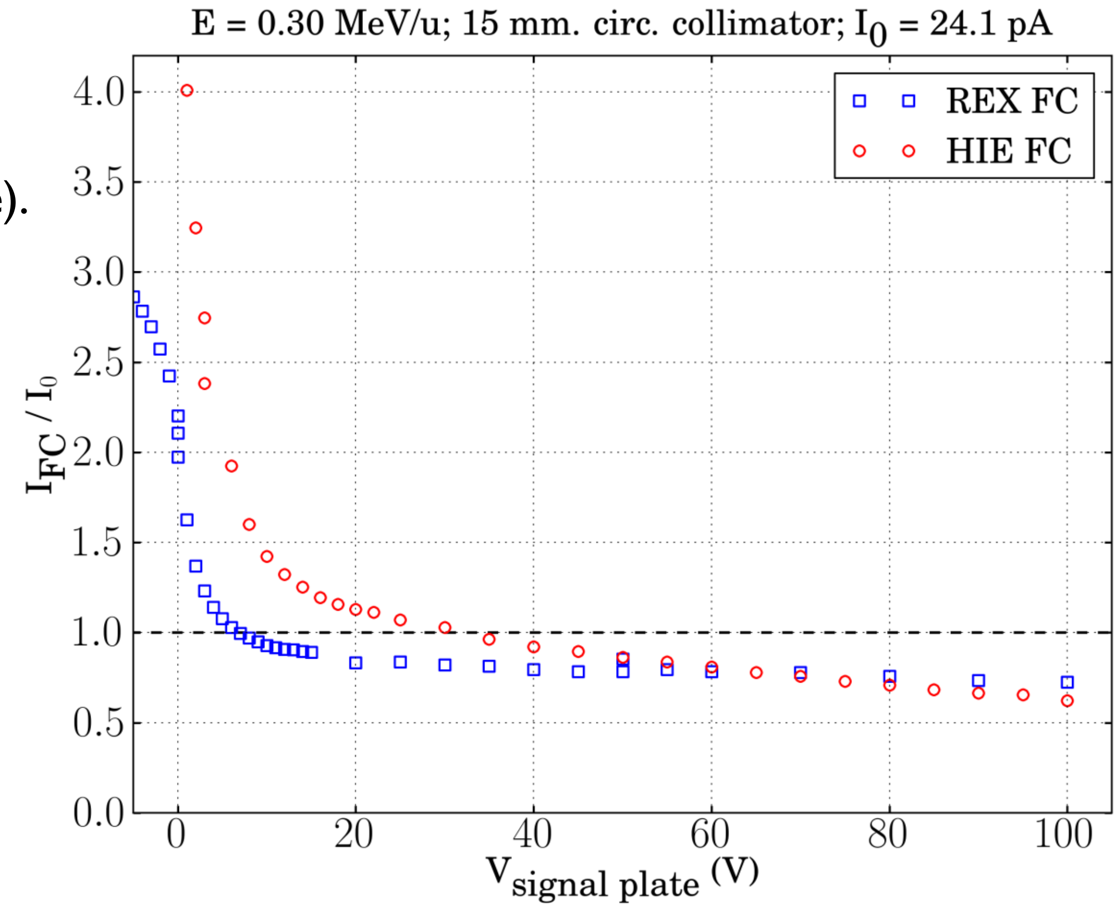
Biasing the signal plate

stable beam
A/Q =4

$V_{signal\ plate}$ > 0V (variable).

$V_{repeller}$ = 0V





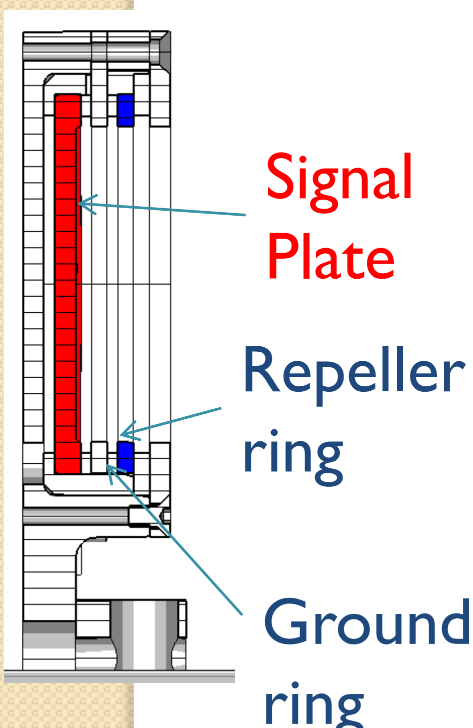
- High leakage current
- Beam current does not reach a current plateau increasing the voltage

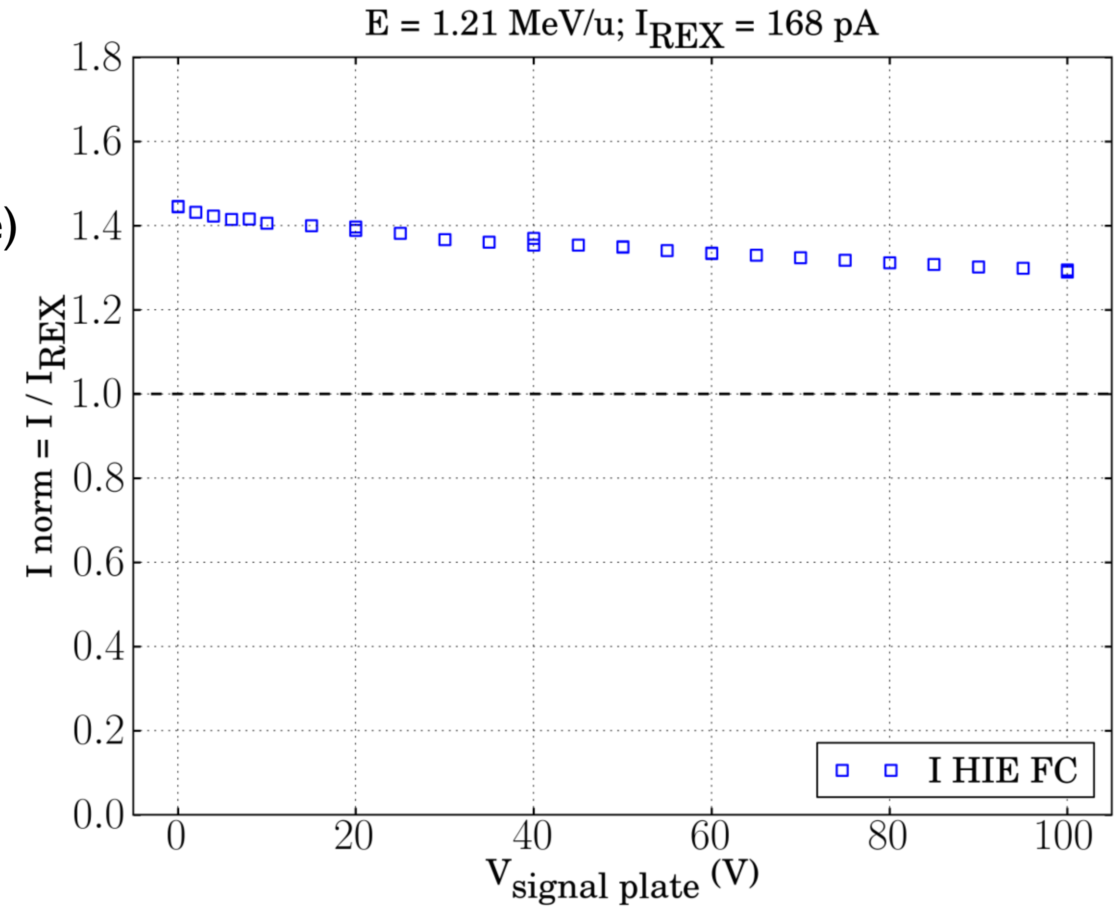
Biasing repeller ring & signal plate

stable beam A/Q =4

$V_{signal\ plate}$ > 0 V (variable)

$V_{repeller}$ = -500 V





7. Conclusions

- Current measurements do not agree with the nominal beam current using the present design
- Further improvements in the design are in progress
- Beam profile measurements are unaffected in principle by a change in the design.

Acknowledgements

- The ISOLDE Collaboration
- The HIE-ISOLDE Project Team and groups within CERN Accelerator and Technology Sector
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