

A NEW BETSI TEST BENCH AT CEA/SACLAY

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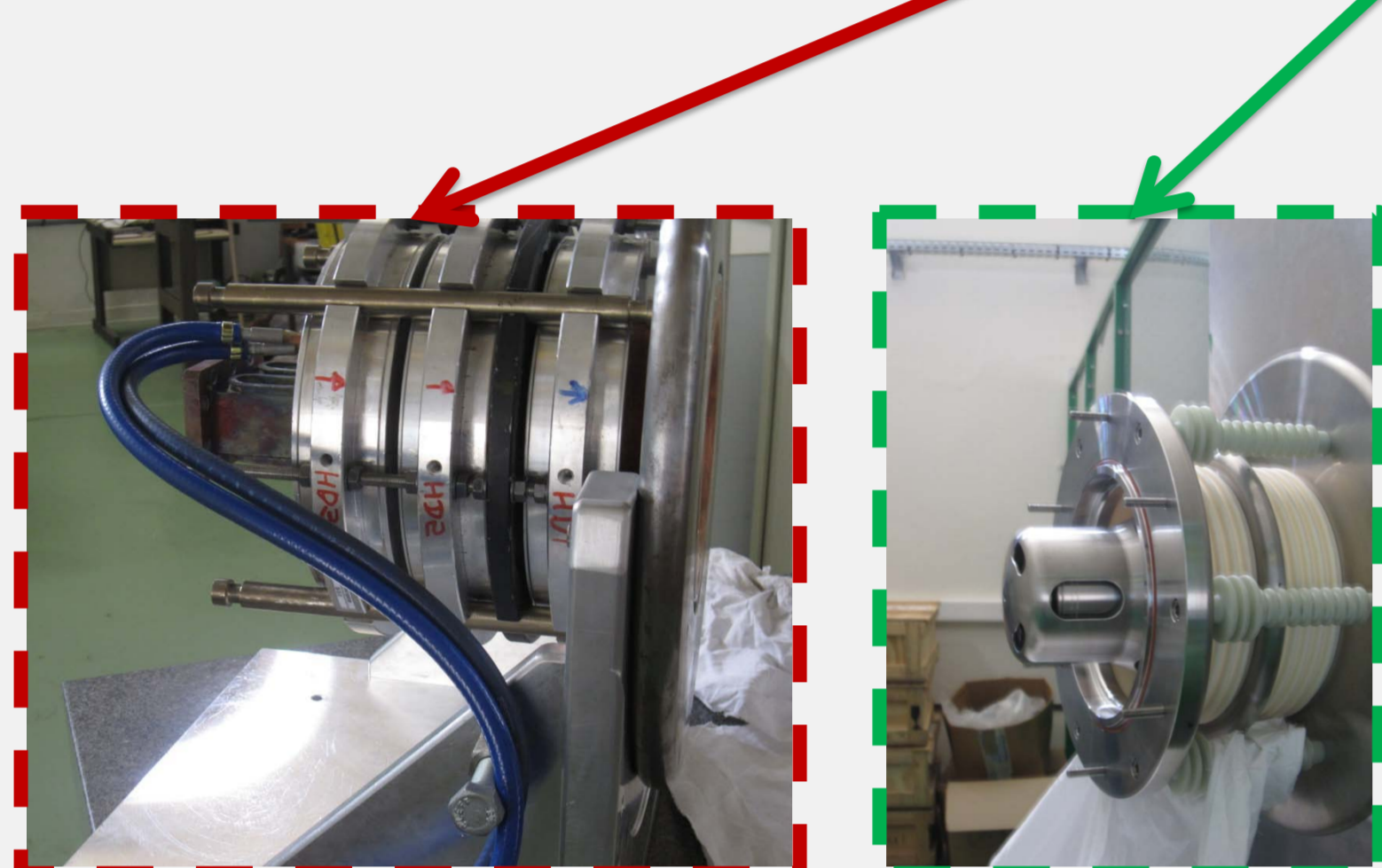
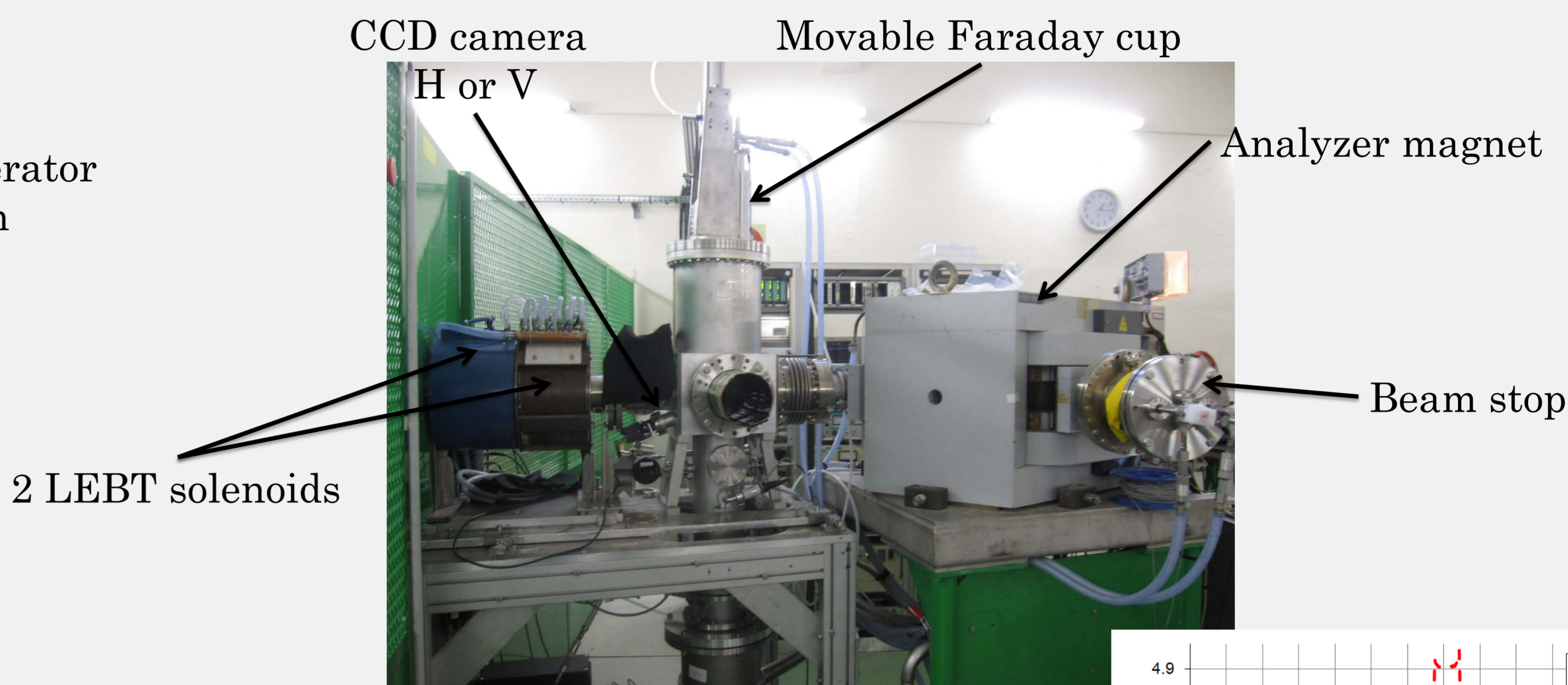
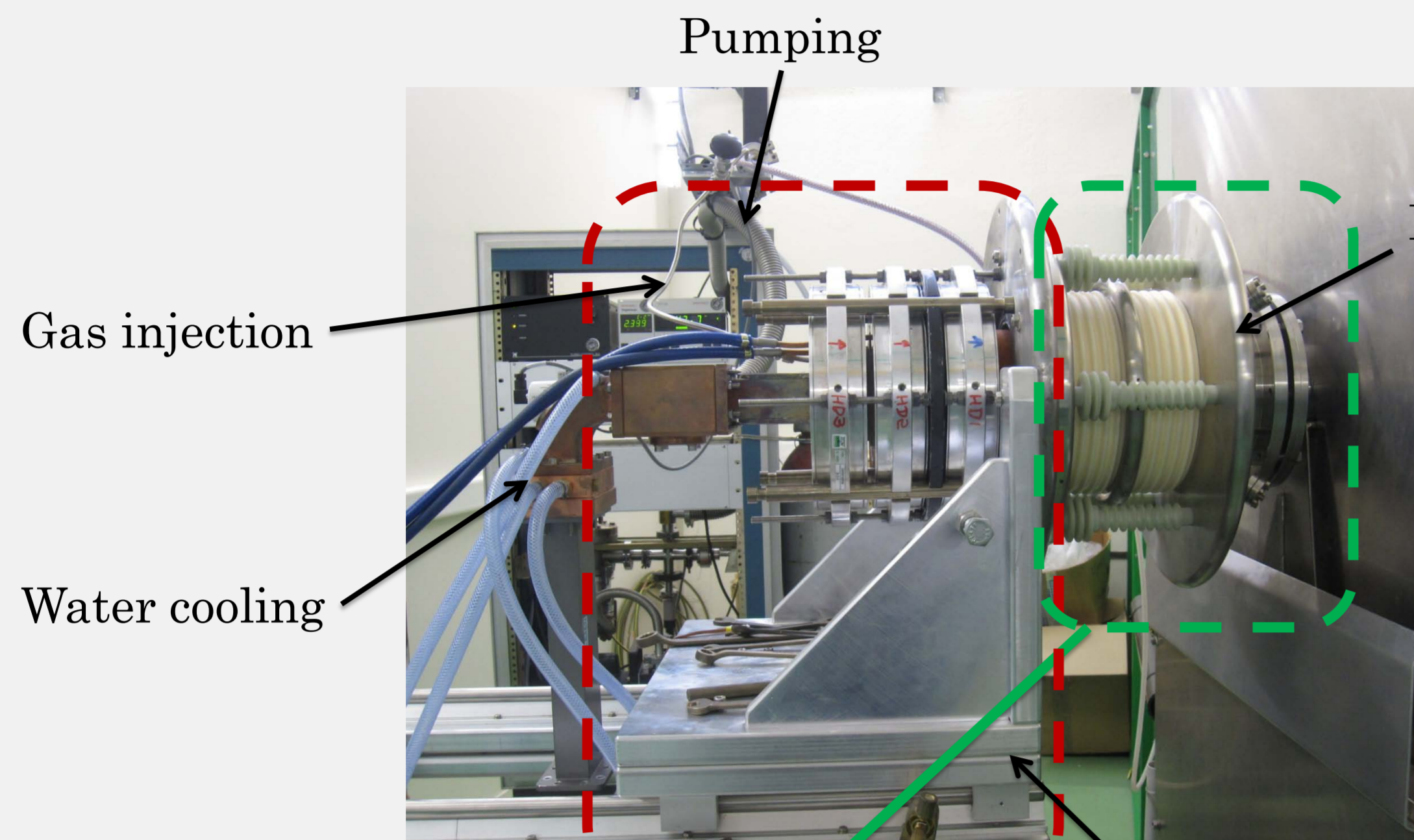
Abstract: By the 90s, CEA has undertaken to develop the production of high intensity light ion beams from plasma generated by electron cyclotron resonance (ECR). Important results were obtained with the SILHI source in pulsed or continuous mode. Presently, CEA/Saclay is now involved in the construction of different injectors dedicated to large infrastructures like IFMIF or SPIRAL2. Other installations are also interested by high intensity ion sources like ESS or FAIR. To improve and test new sources, a new test bench named BETSI (Banc d'Etudes et de Tests des Sources d'Ions) is now operating for several years. Low energy beam line diagnostics consist of a Faraday cup, cameras and a species analyzer. The SILHI emittance scanner can also be installed on the beam line. On this test bench, different permanent magnet source configurations are tested.

The new test bench BETSI (Banc d'Etudes et de Tests des Sources d'Ions)

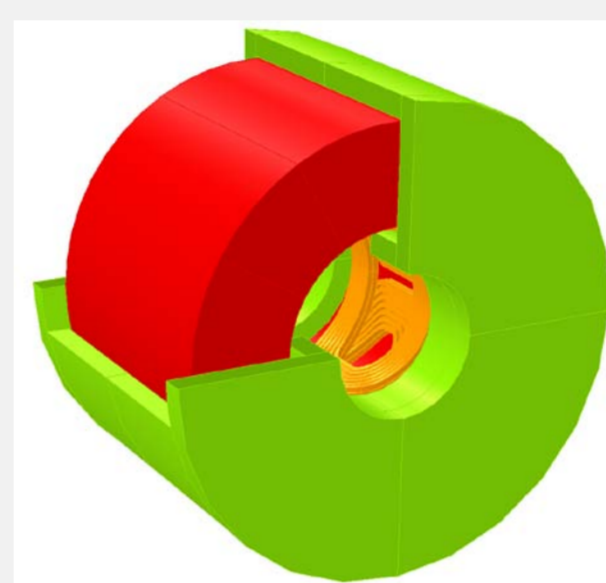
The BETSI test bench is dedicated to study the influence of the source parameters on the beam characteristics. It operates up to 50 kV and ignites continuous or pulsed hydrogen plasma with a 2.45 GHz magnetron.

- Quick and easy connection to the beam line with movable table.
- Plasma chamber and RF windows are water cooled.
- The gas injection system is located on high voltage platform.
- The radio frequency wave injection is produced by a magnetron located at ground potential.
- An additional pumping is installed on the high voltage table.

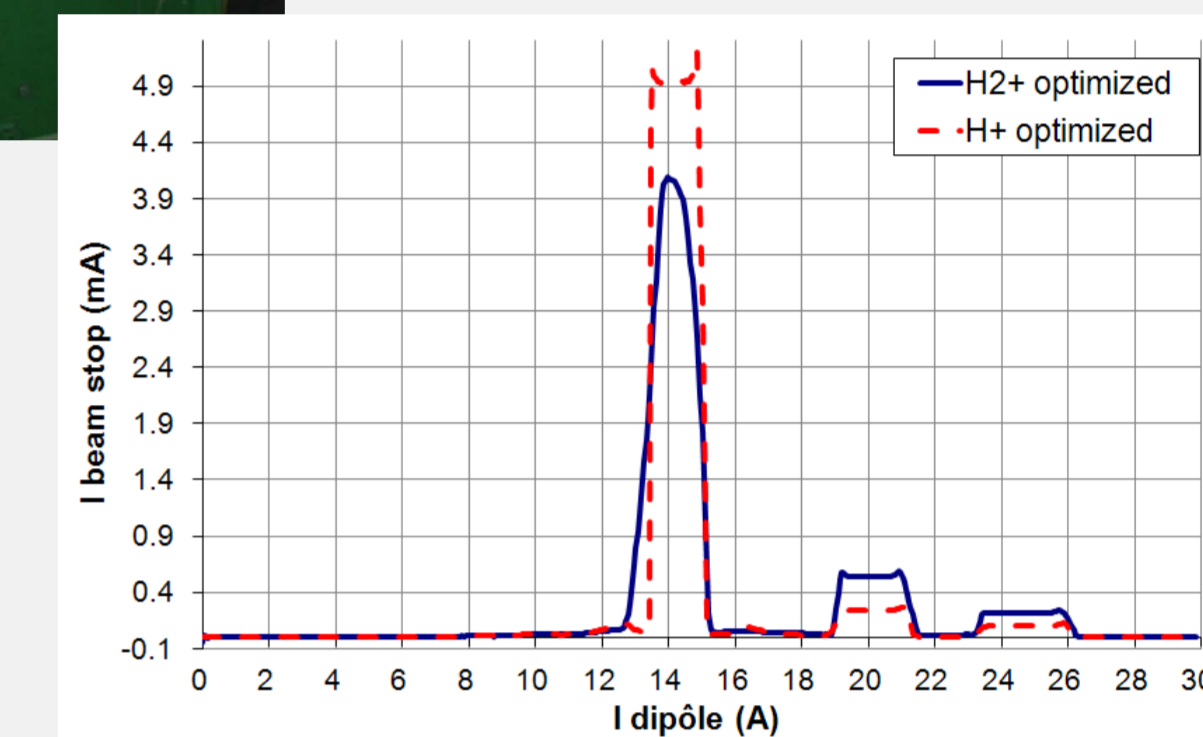
- Pair of solenoids to reduce beam divergence and focalization.
- Pumping and diagnostic box:
 - Vertical and horizontal viewport for CCD camera diagnostics
 - Vertical movable Faraday cup.
- Classical mass analyzer magnet.
- Beam stop with magnetic electron repeller.



- 1 day with 2 people to assemble all circle red part
- Water cooled at 3 bars
- Pressure in the chamber 10^{-3} Pascal
- Pressure regulation with micro leakage
- High voltage extraction limit 50 kV
- Magnetron frequency 2.45 GHz



Future LEPT solenoid with H+V Correctors

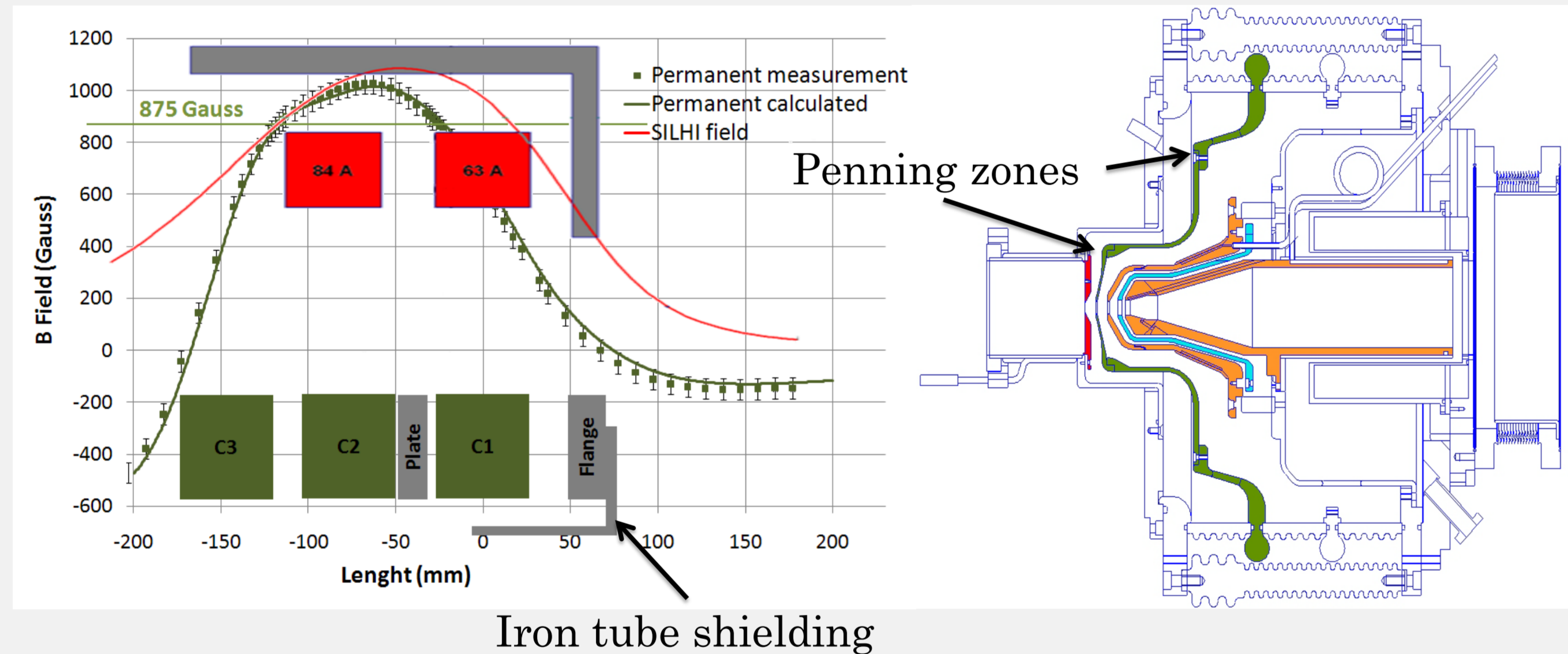


Analyzer magnet → Measurement of H⁺ and H₂⁺ ions rates.

Permanent magnet sources developments

DEVELOPMENTS ON SILHI PLATFORM

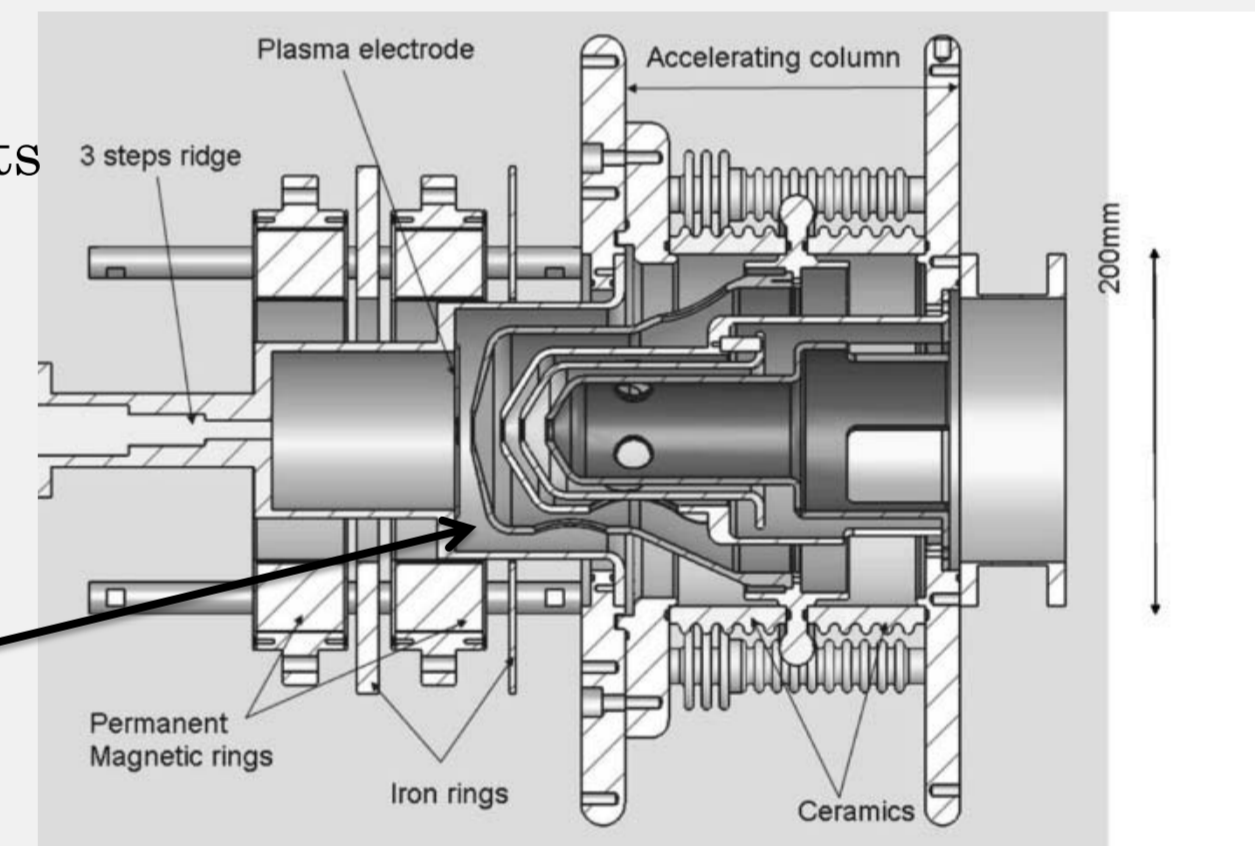
First experiments showed Penning discharges occurred in the extraction system with the SILHI extraction system. It came from the particular permanent magnet configuration built without shielding. To reduce the magnetic field in that accelerator column, an iron shielding was introduced as close as possible to the extraction hole.



NEW ACCELERATING COLUMN ON BETSI

On the BETSI test bench, the accelerating column diameter is reduced from 400 to 200 mm that implies changing the electrode shape and size, which has as consequences to modify electric field distribution in the far axis region. Thus with this new accelerating column, no Penning discharge is occurred for mainly magnetic configurations.

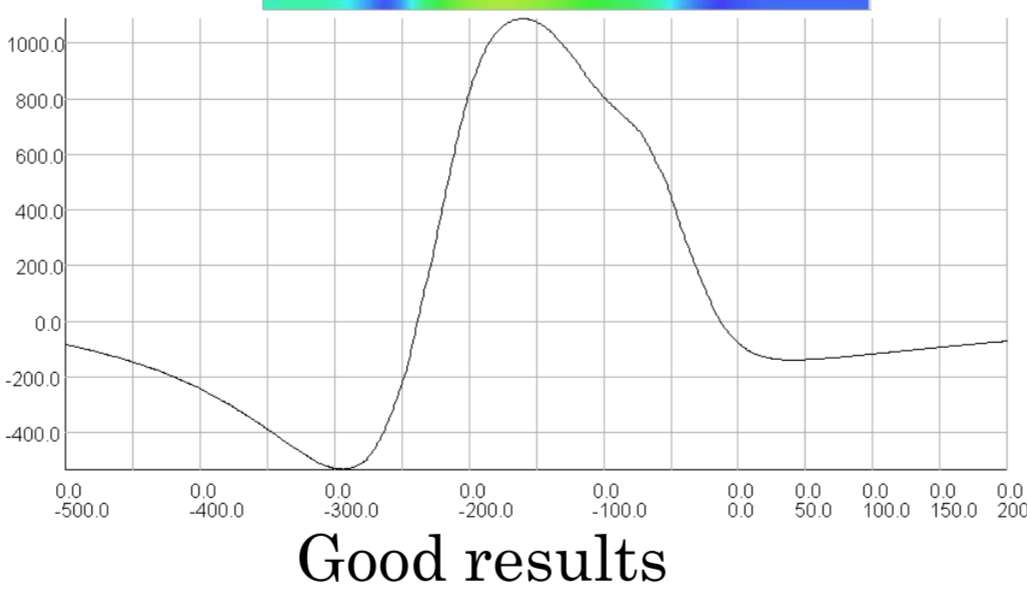
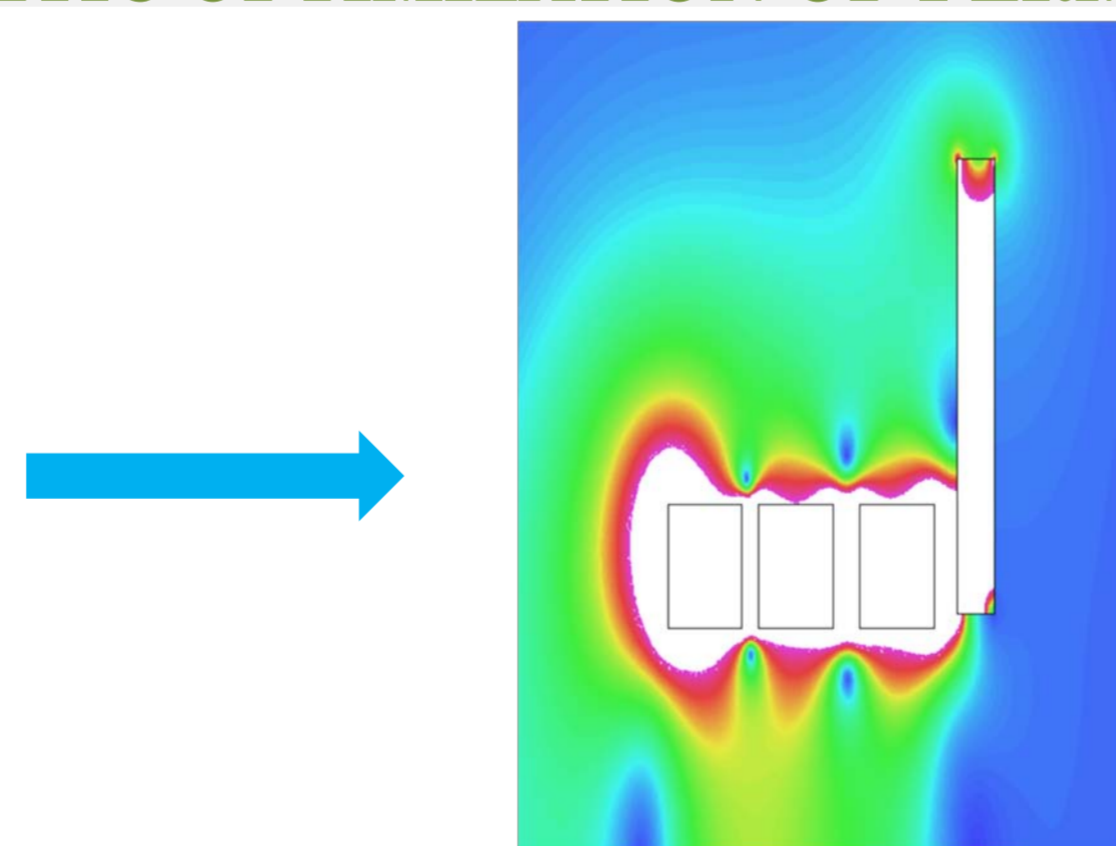
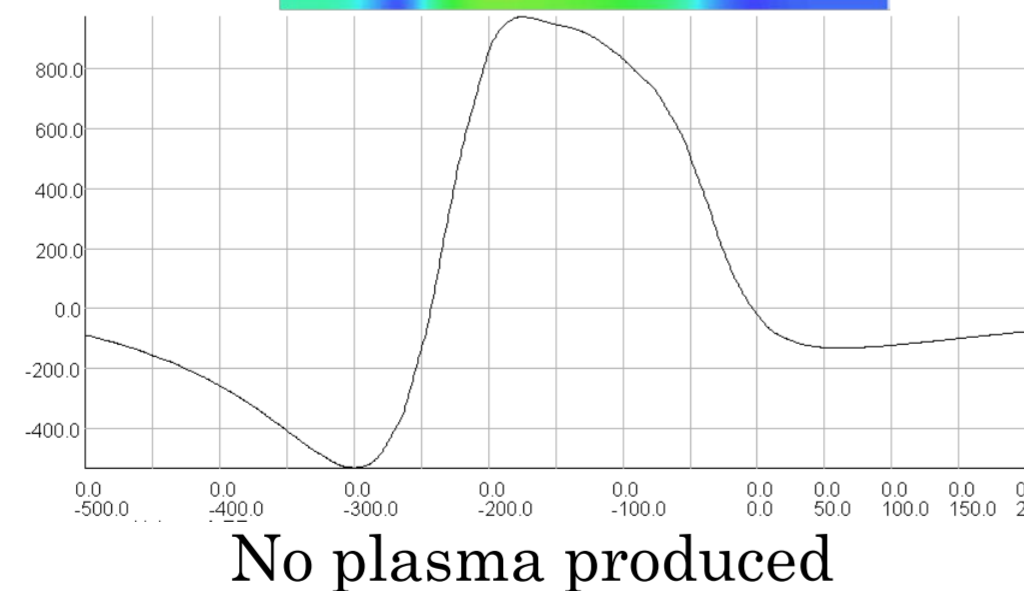
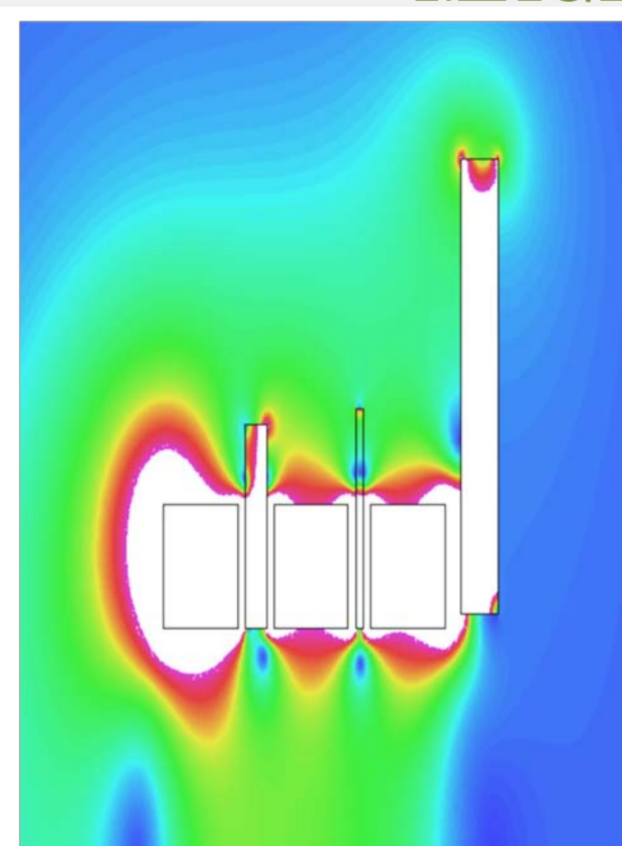
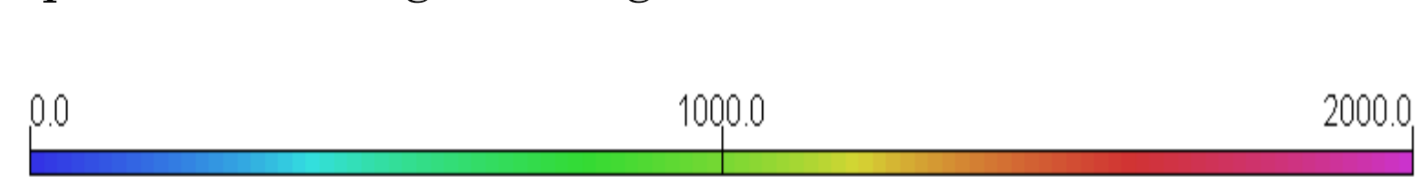
BETSI sources:
 B field → 2 or 3 axial oriented ring-shaped permanent magnets + plates + flange
 Extraction potential → 50 kV
 Accelerating column diameter → 200 mm



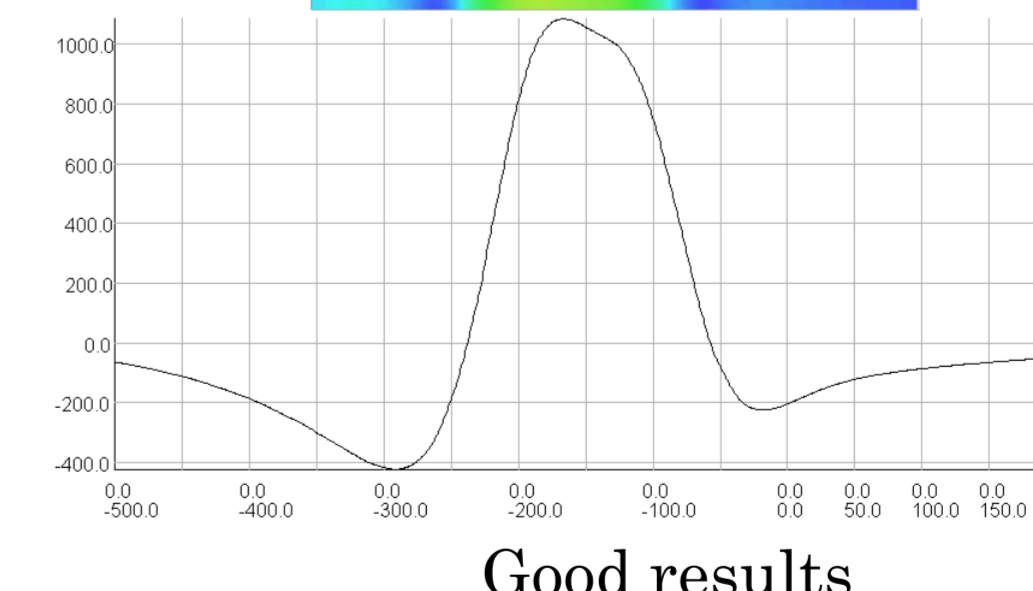
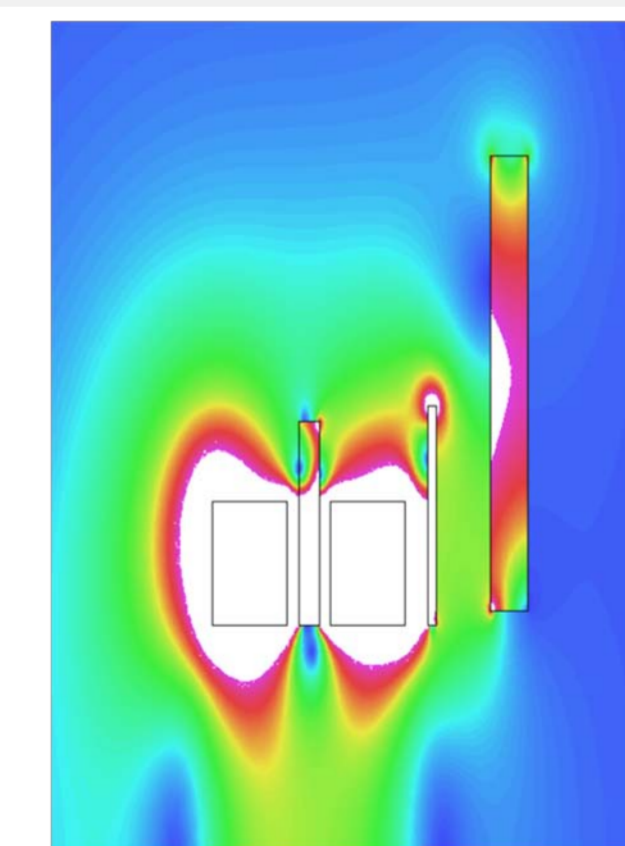
Penning zone for particular magnetic configurations

MAGNETIC OPTIMIZATION OF PERMANENT MAGNETS SOURCE

The developments realized on BETSI test bench are focused on magnetic optimization of permanent magnet sources. In order to simplify the shielding, several magnetic simulations were realized with 2 or 3 permanent magnets rings.

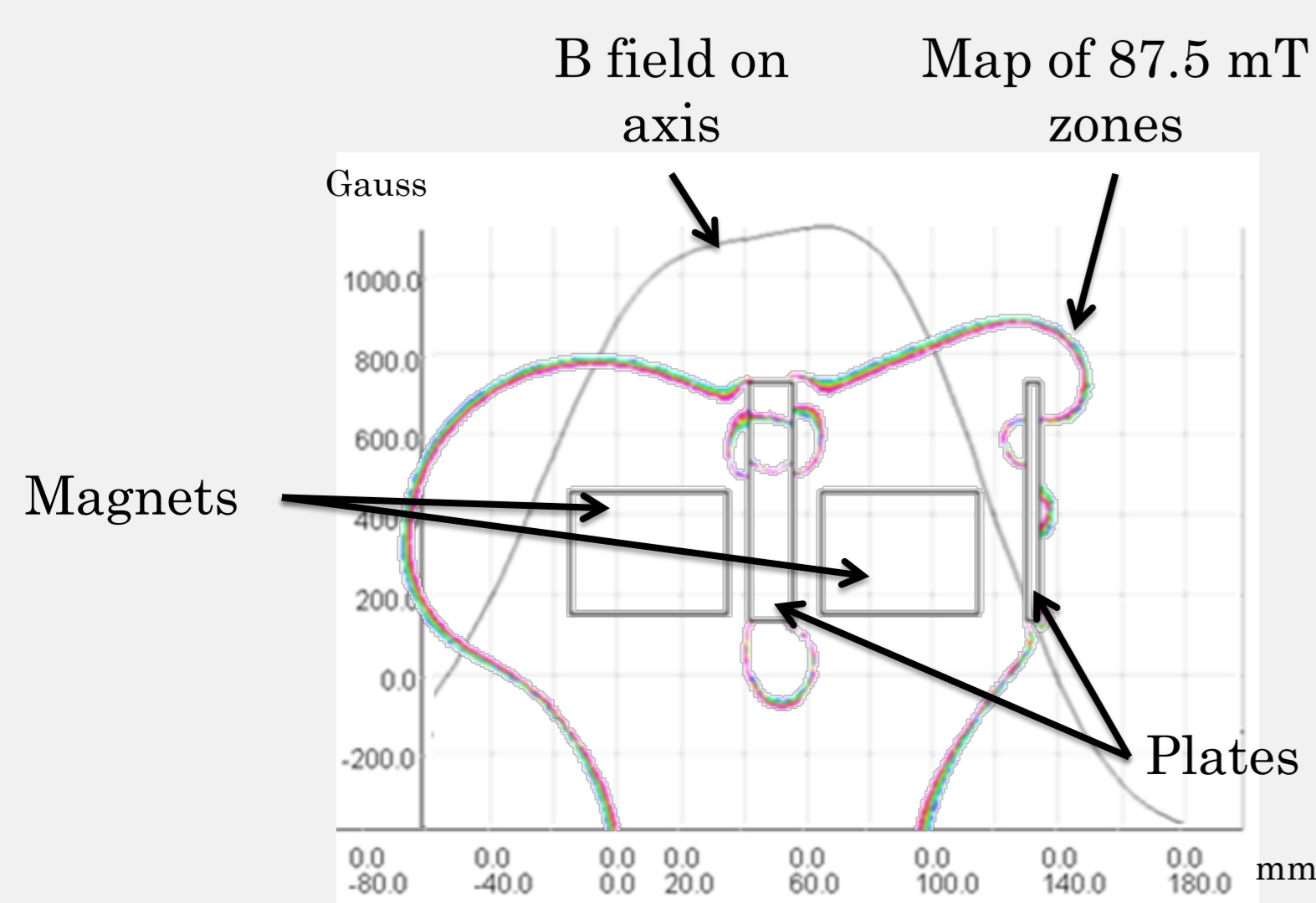


5 mA produced
 Plasma electrode Ø4.8 mm
 RF power 500 W
 Extraction voltage 20 kV



4.5 mA produced
 Plasma electrode Ø3 mm
 RF power 300 W
 Extraction voltage 40 kV

The best results were obtained with 2 permanent magnets and 2 plates (one of 15 mm thick located between the 2 magnets, and the second one of 5 mm on the extraction electrodes side). The two resonant zones of 87.5 mT were respectively located near radio frequency input and near plasma extraction electrode. A 5.7 mA total beam was extracted with 86 % of H⁺.



SOURCE CHARACTERISTICS		BEAM CHARACTERISTICS	
Electrode Ø3mm			
Gas flow	0.95 sccm	Total current	5.75 mA
Pressure	$5.1 \cdot 10^{-6}$ Torr	H ⁺ max current	4.97 mA
e ⁻ Filter	1.5 kV	H ₂ ⁺ max current	0.54 mA
HTEI	20 kV	H ₃ ⁺ max current	0.24 mA
HT	40 kV	H ⁺ /total	86.41 %
PHF	550 W	H ₂ ⁺ /total	9.45 %
Pulsed time	50 ms	H ₃ ⁺ /total	4.14 %

With the SILHI emittance scanner
 Measurement after the solenoids
 normalized emittance: 0.012 π.mm.mrad
 Proton Beam intensity: 2 mA
 Extraction voltage: 20 keV
 Hole diameter: 3 mm
 RF injected power: 800 W

