THE HIE-ISOLDE SUPERCONDUCTING CAVITIES

Task 10.4 Thin Films

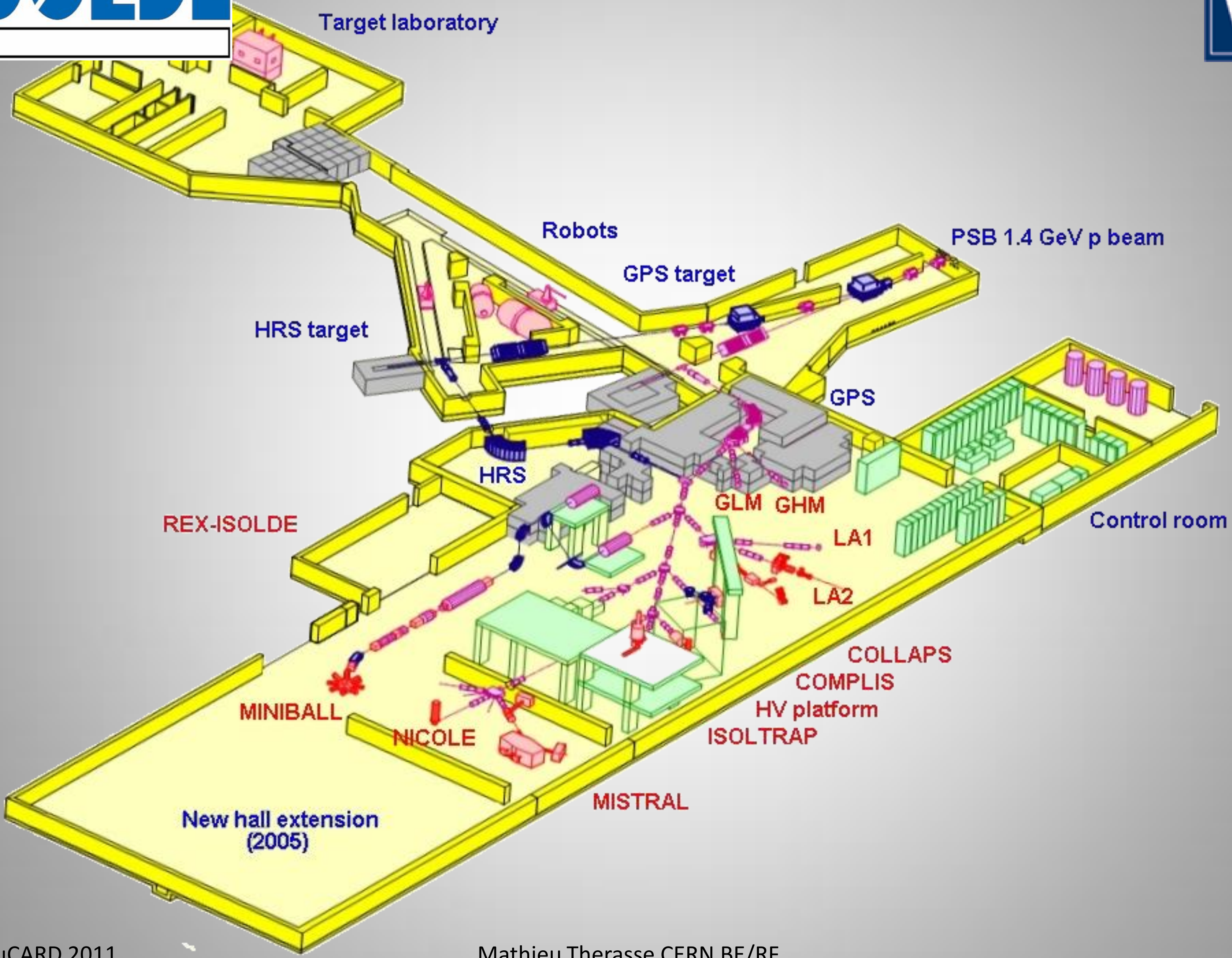
Sub-task 1

New and improved techniques for the production of Nb sputtered Quarter Wave (QW) cavities.

QW cavities are highly suitable for heavy ion superconducting linacs, which today are used (or widely proposed to be used) for applications such as accelerators for radioactive ions beams, for low energy injectors and other ion beam applications. The work, led by CERN in collaboration with INFN-LNL, will focus on **magnetron sputtering**, **high peak power magnetron sputtering** and better shaping (techniques) of the cavities.

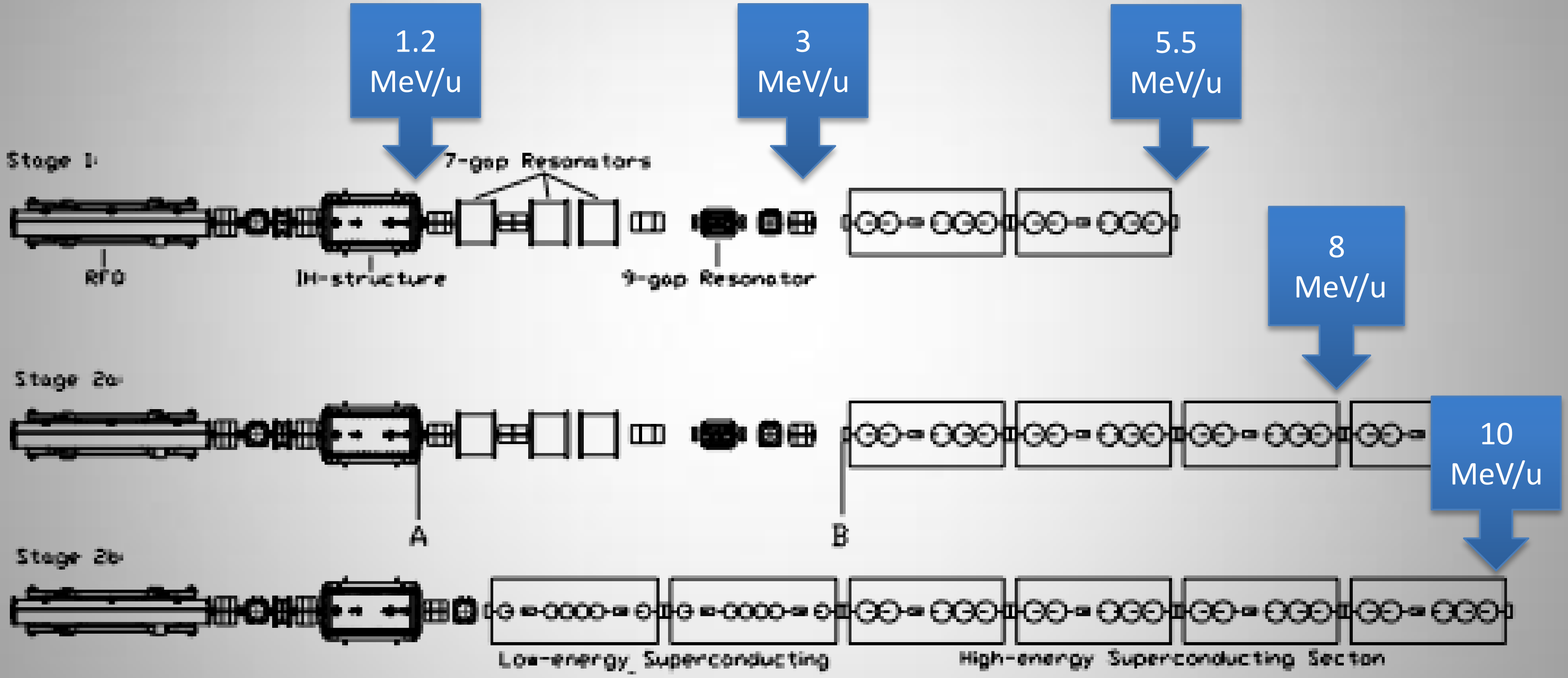
The target value is to reach accelerating field of **6 MV/m** with a

Q-value of at least 5×10^8.


Target laboratory
Robots
PSB 1.4 GeV p beam
GPS target
HRS target
GPS
HRS
GLM
GHM
REX-ISOLDE
LA1
Control room
LA2
COLLAPS
COMPLIS
HV platform
MINIBALL
NICOLE
ISOLTRAP
MISTRAL
New hall extension
(2005)

HIE linac staged installation

3 stages installation


1.2 MeV/u

3 MeV/u

5.5 MeV/u

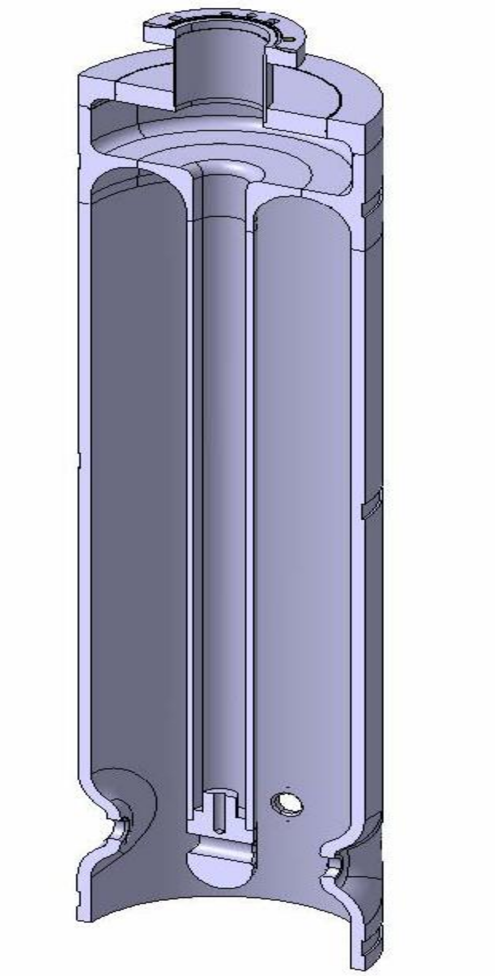
8 MeV/u

10 MeV/u

Quarter Wave Resonators (QWRs)

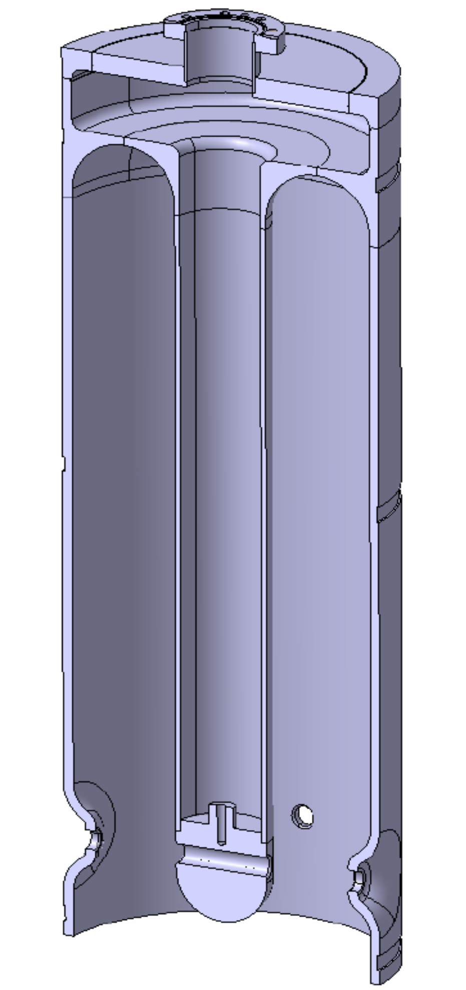
12 Low-β cavity

20 High-β cavity



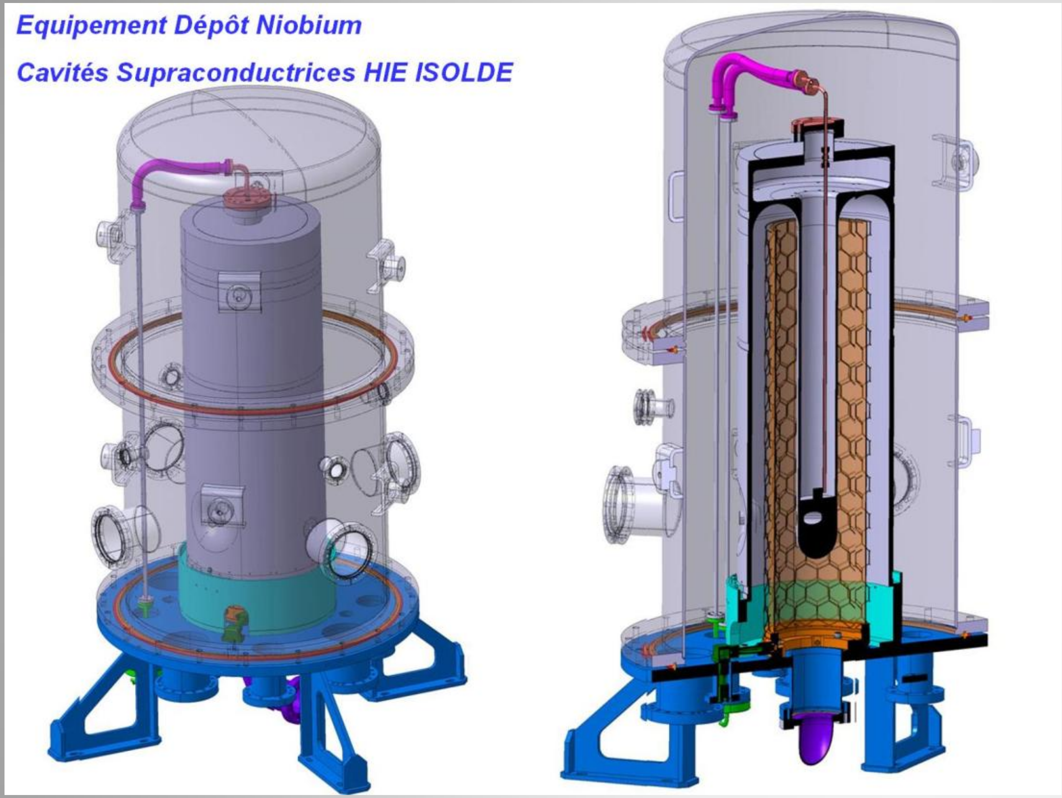
101.28	**f (MHz)**	101.28
50	**Inner Cond. Diam (mm)**	90
195	**Outer Cond Diam (mm)**	300
6	**Designed Gradient (MV/m)**	6
3.2×10^8	**Q_0 for 6MV/m at 7W**	5×10^8
5.4	**Epk/Eacc**	5.6
80	**Hpk/Eacc (Oe/MV/m)**	96

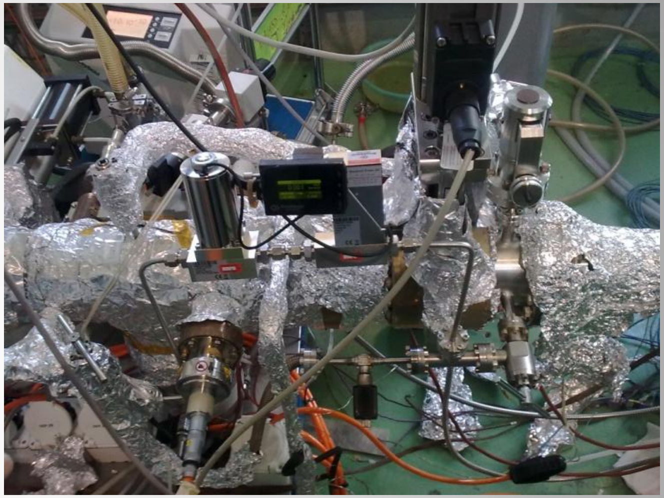
Nb\Cu technology



Facility for QWR coating

Design of sputter coating system

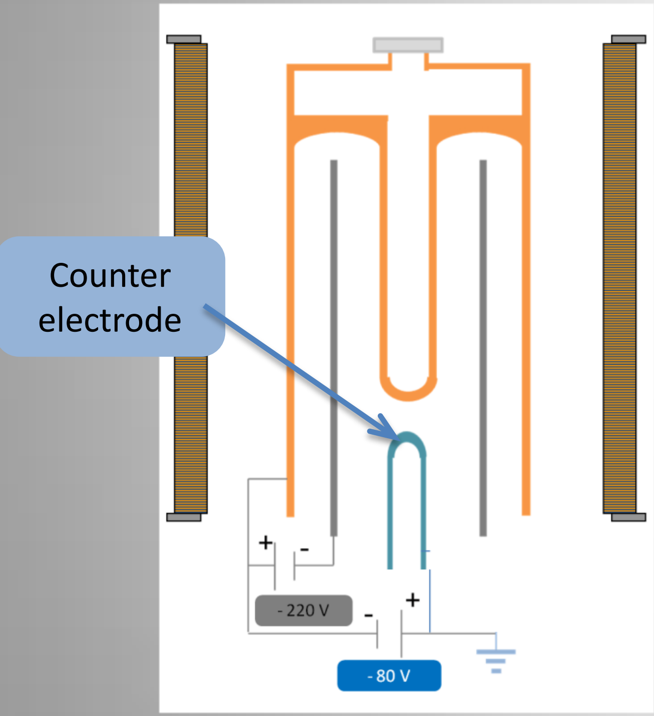




- A new flow controller with electronic valve to regulate the pumping speed and avoid turbulences inside the coating system

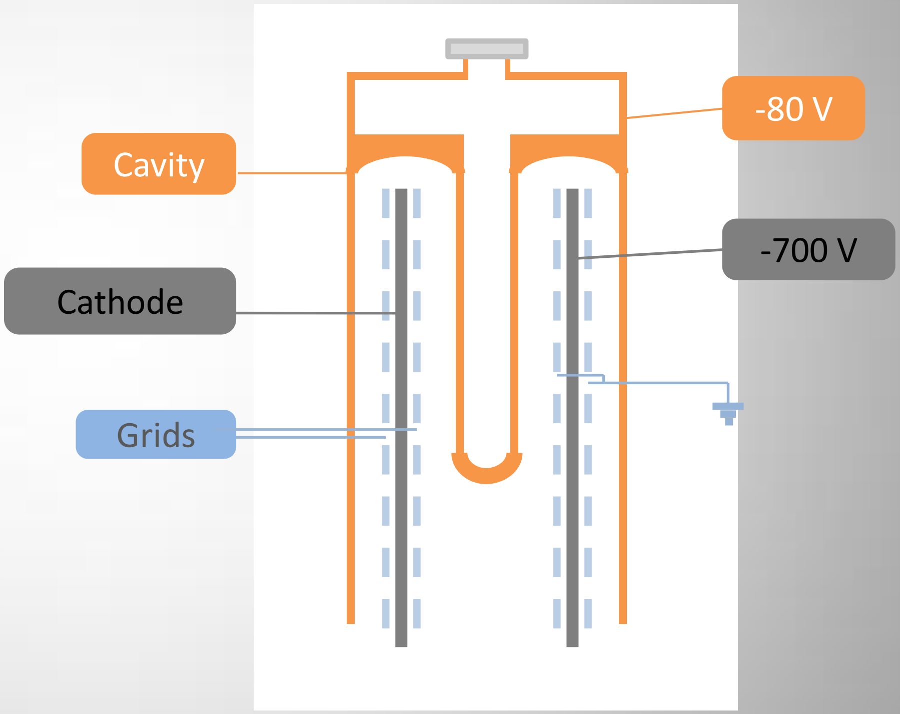
Coating

Bias Magnetron Sputtering



Coil: I=40 A; B= 100G

Bias Diode Sputtering



Cavity preparation for the coating

Surface Treatments

Chemical polishing (SUBU) and passivation

Sulfamic acid (H_3NO_3S) 5 g/L,

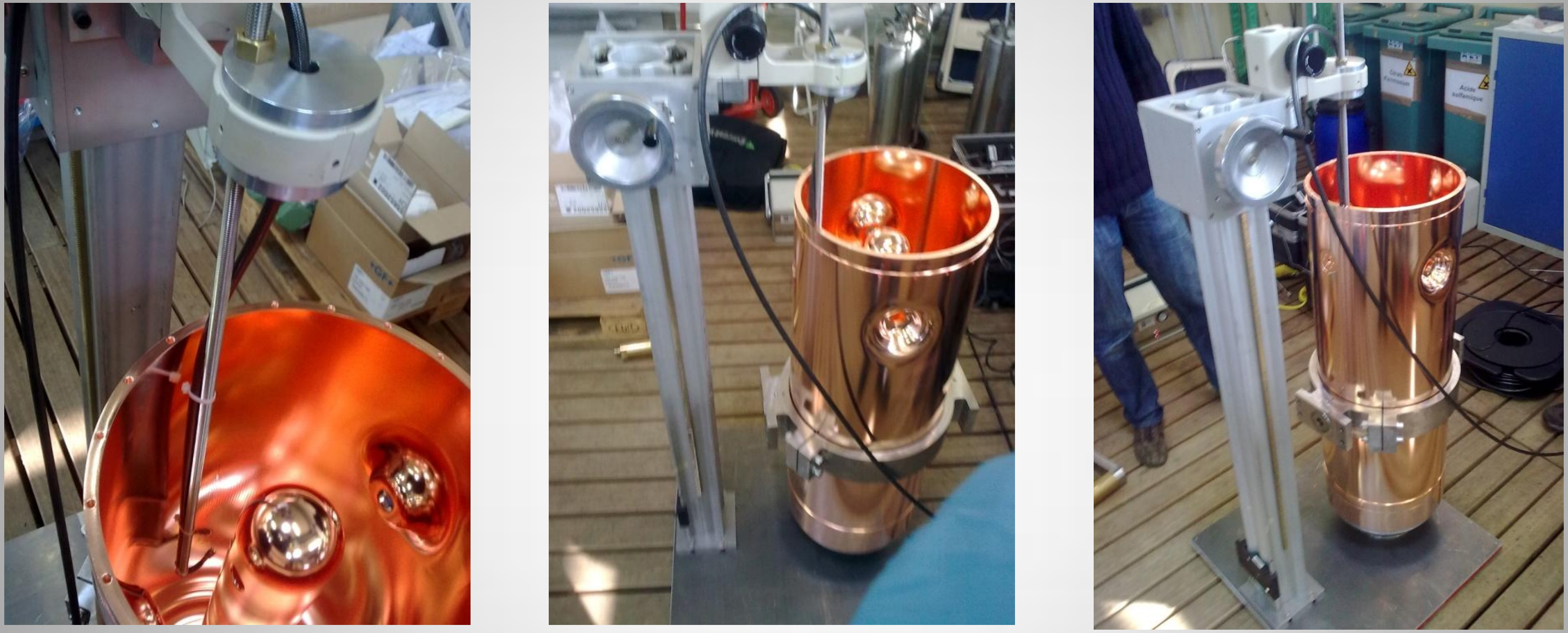
H_2O_2 5% vol,

n-butanol $C_4H_{10}O$ 5% vol,

di-ammonium citrate ($C_6H_{14}N_2O_2$) 1 g/L

Chemical polishing is carried out at 72 C and is preceded and followed by washing with a diluite solution of sulfamic acid

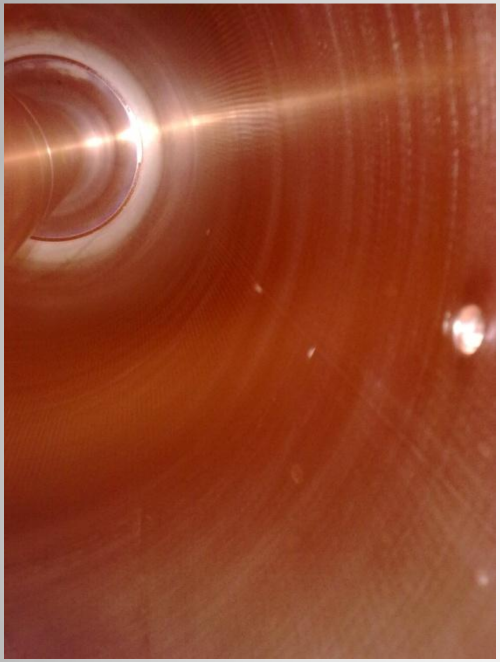
Visual inspection system



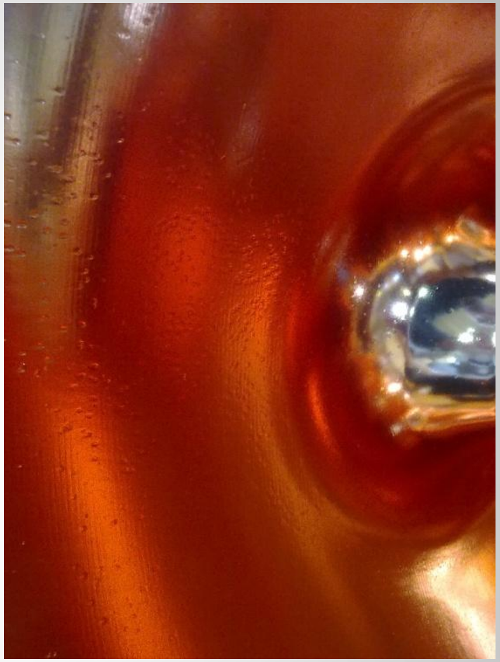
We use an endoscope
This enable us to do the inspection in all parts (welding) of the cavity and avoiding scratch during the inspection

Second copper cavity Q2

Before chemical etch



After chemical etch 90 µm



Q2: Unsatisfactory copper surface observed after first “subu” etching:

- Presence of pinholes
- Pinholes may have been formed during the etching process by bubbles trapped by surface imperfections (after machining?)
- The cavity was declared good for service after 5 “subus” (90 um removed)

Rinsing before coating

- In the hood (Baldaquin class 100, ISO 5)
- Ultrapure (18 MΩ.cm) water : 3 runs
- Pressure = 6 Bars
- Final rinsing with pure alcohol
- Drying during one night in the Hood (baldaquin)
- The cavity is covered with a plastic bag under N2 atmosphere

Mounting of the coating system

- Before entering in the clean room (class 100) all parts of the coating system are conditioned in the Hood (Baldaquin Class 100)
- Conditioning : Remove dust with Alcohol cleaning+ blown with N2 + in a plastic bag with N2 atmospher

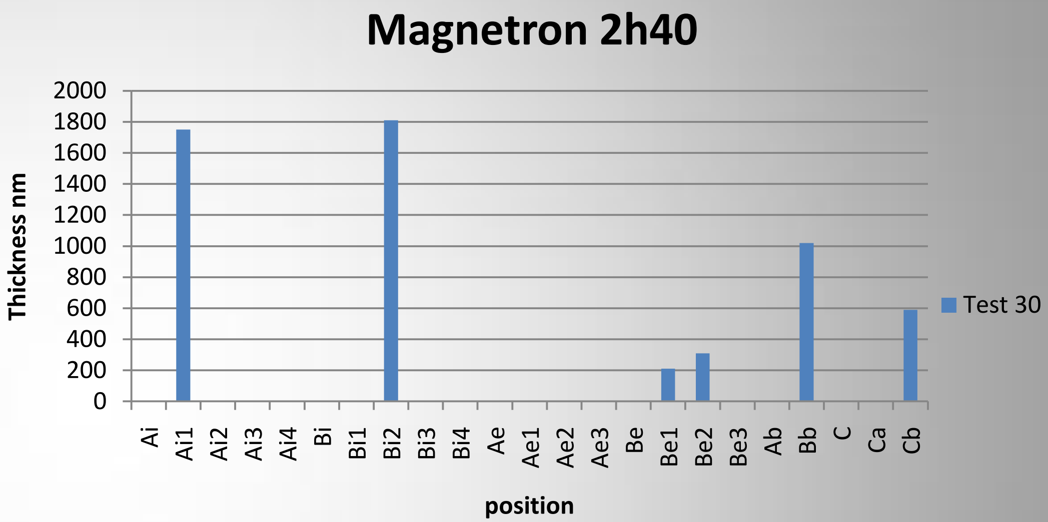
Results for coating

Last test for magnetron sputtering

Magnetron sputtering at low pressure in order to improve the coating rate on the tip

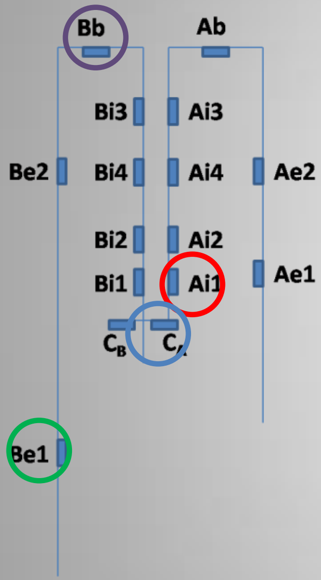
Ion etching
During 10 min
P=0.36x10^{-2} mbar
Cavity U=540V; I=0.76 A
Coil I=30A; U=34V

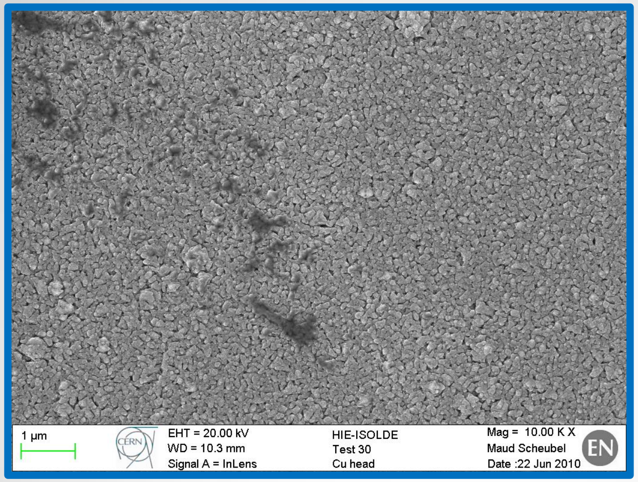
Magnetron sputtering
Time coating= 2h40
P=0.8x10^{-2} mbar
Cathode I= 2.7A; U=340V
Cavity I=3.1A; U=80V
Coil I=30A; U=36V
T$_{cavity}$= 150 C

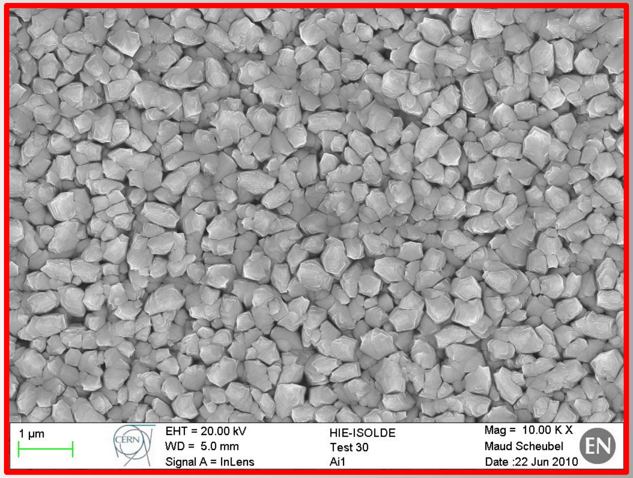


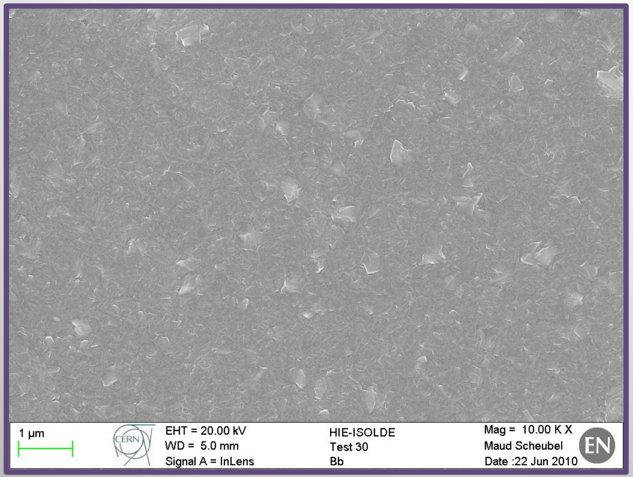
- **Stable plasma**
- **Coating rate:** inner part = 11 nm/min
  outer part = 2 nm/min
  on the tip = 3.7nm/min
  on the bottom = 6 nm/min
- **Increase of coating rate on the tip** (1.4nm/min at 1.5x10^{-2} mbar to 3.7nm/min at 0.8x10^{-2} mbar)
- **Ratio** $\approx$5 between the inner and the outer part

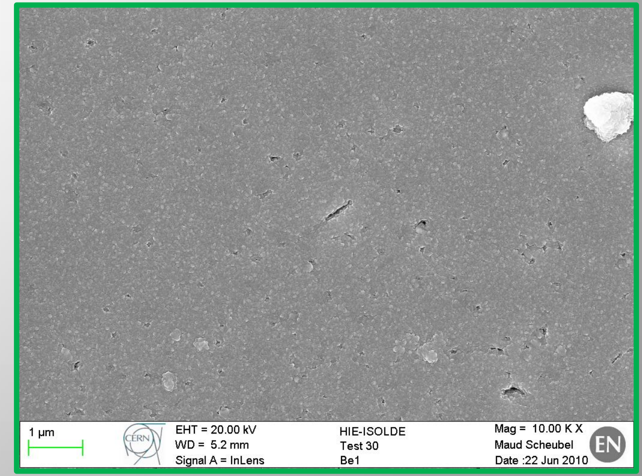
SEM Analysis









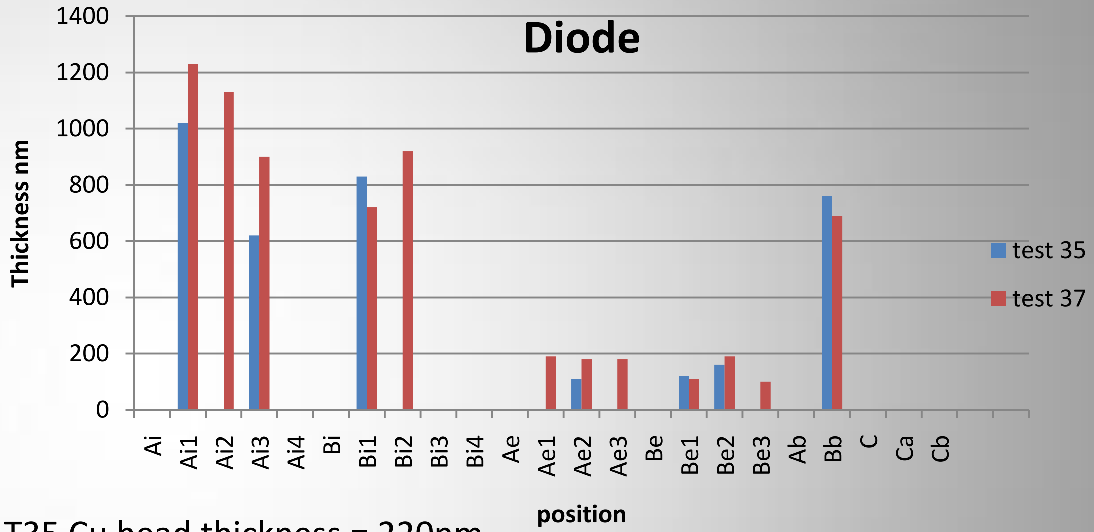


Bias Diode sputtering

Diode coating on samples

Ion etching
During 10 min
P=0.36x10^{-2} mbar
Cavity U=540V; I=0.76 A
Coil I=30A; U=34V

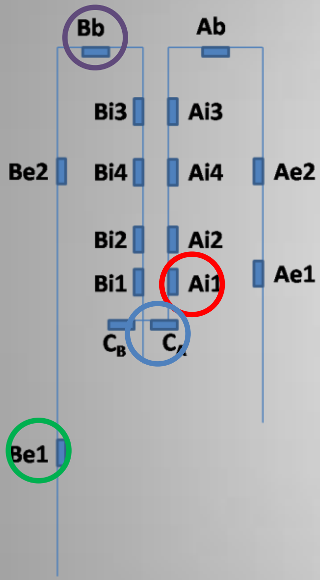
Diode sputtering
Time coating= 7h
P=1.5x10^{-1} mbar
T_{cavity}=150 C
Test 35
Cathode I= 2A; U=580V
Cavity I=3A; U=80V
Test 37
Cathode I= 2.5A; U=580V
Cavity I=3A; U=80V

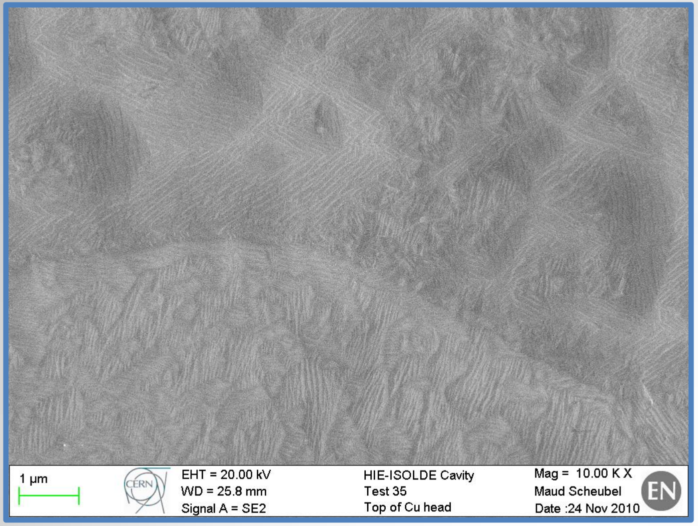


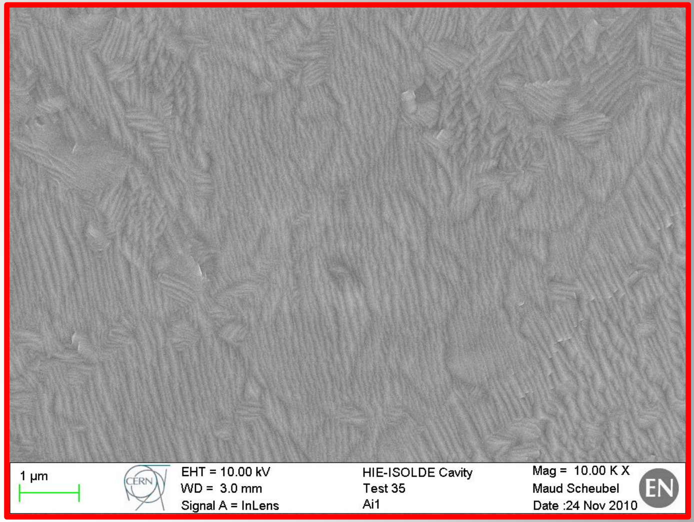
T35 Cu head thickness = 220nm
T37 Cu head thickness = 110 nm

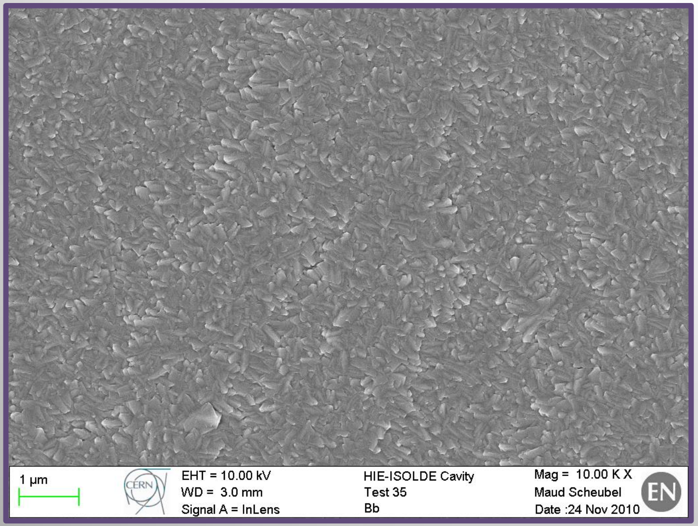
- **Stable plasma**
- **Low coating rate**: inner part = 1nm/min
  outer part = 0.23nm/min
  on the tip = 0.5nm/min
- **Ratio** ≈5 between the inner and the outer part

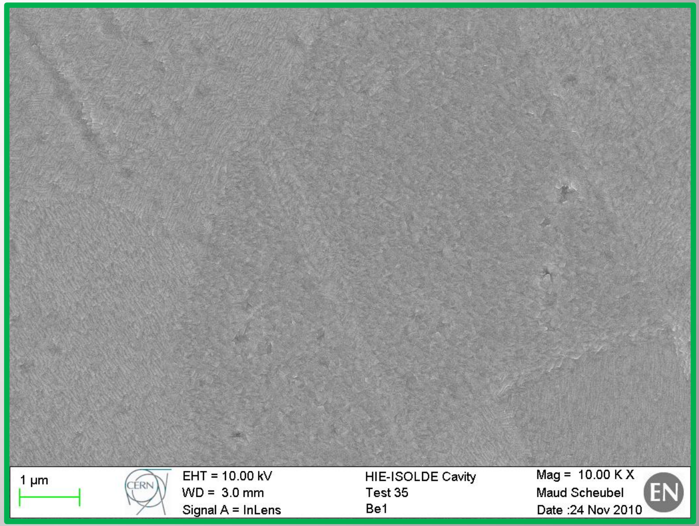
SEM Analysis











Improvement of the thickness homogeneity

Due to geometrical factors the ratio between the film thickness on the external wall and on the inner conductor cannot be lower than 4

One solution could be a **combination of Diode and Magnetron coating**

System configuration:
Coating system with inner grid and without the outer grid

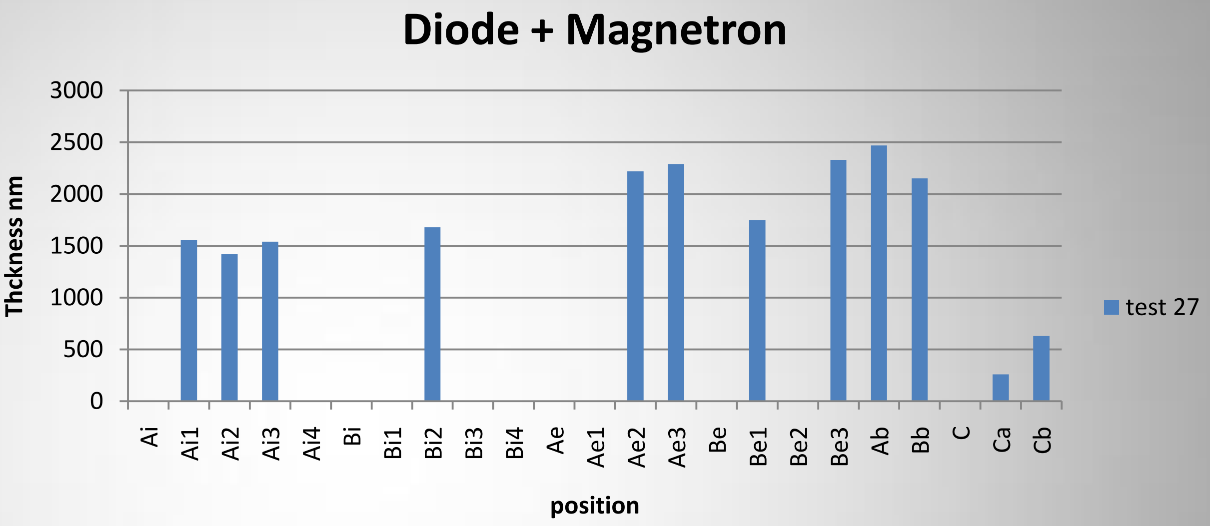
→
- No plasma or low plasma outside the cathode during the diode coating
- The grid cuts down the plasma completely inside the cathode during the magnetron sputtering

Diode + Magnetron

Ion etching
During 10 min
P=0.36*10-2 mbar
Cavity U=540V; I=0.76 A
Coil I=30A; U=34V

Diode sputtering
Time coating= 5h50
P=1.5*10-1 mbar
Cathode I= 2A; U=780V
Cavity I=3.6A; U=80V

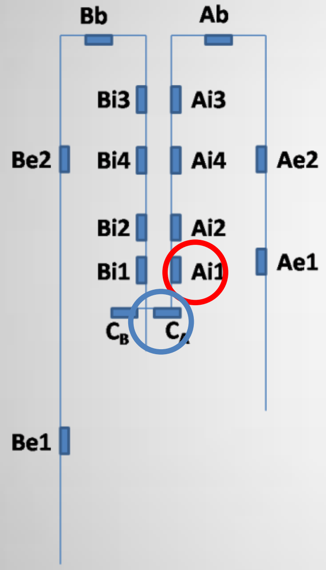
Magnetron sputtering
Time coating= 2h25
P=1.5*10-2 mbar
Cathode I= 3A; U=360V
Cavity I=3.7A; U=80V
Coil I=40A; U=32V

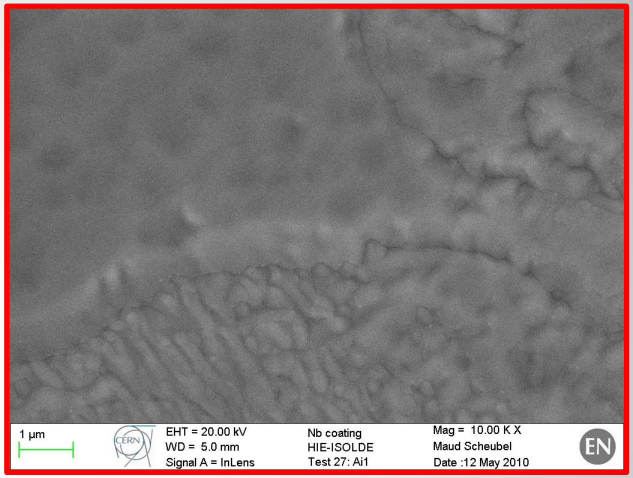


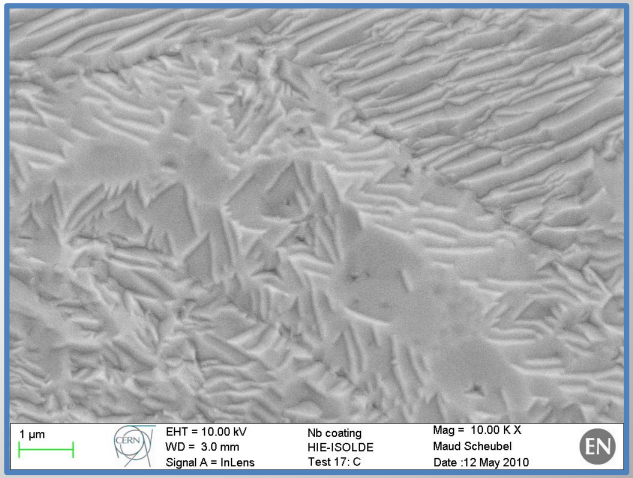
- We reduced the **ratio** between inner and outer part to **1.5** instead of minimum 4

→ Decrease of the coating time and risk of peel off

SEM Analysis







Coating on Cu cavity

Q1 Magnetron coating
30/06/2010

Ion etching
During 10 min
P=0.36*10-2 mbar
Cavity U=572V; I=0.76 A
Coil I=30A; U=34V

Magnetron sputtering
Coating time= 8h20
P=1.5*10-2 mbar
Cathode I= 3A; U=244V
Cavity I=3.24A; U=80V
Coil I=40A; U=50V
T_{cavity}=150 C

Q2 Magnetron coating
29/03/2011

Ion etching
During 10 min
P=0.36*10-2 mbar
Cavity U=540V; I=0.76 A
Coil I=30A; U=34V

Magnetron sputtering
Coating time= 8h
P=0.8*10-2 mbar
Cathode I= 2.5A; U=360V
Cavity I=3.9A; U=80.4V
Coil I=30A; U=36V
T_{cavity}=150 C

Q1 Diode coating
29/03/2011

Ion etching
During 10 min
P=0.36*10-2 mbar
Cavity U=540V; I=0.76 A
Coil I=30A; U=34V

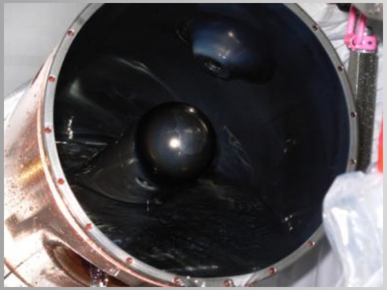
Diode sputtering
Coating time= 38h
P=1.5*10-1 mbar
Cathode I= 1.65A; U=450V
Cavity I=3A; U=80V
T_{cavity}=150 C

RF test at CERN

Preparation and mounting of the cavity

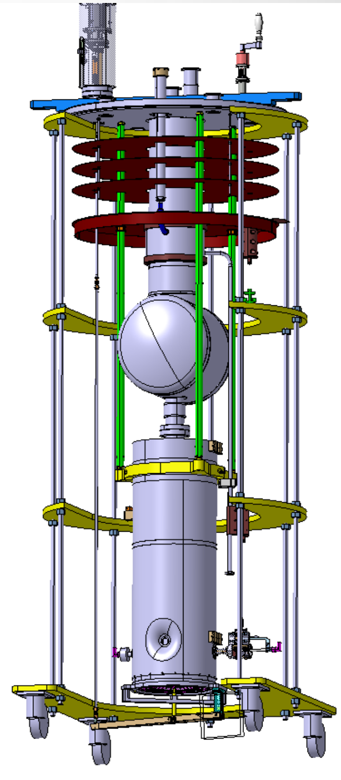
Rinsing after coating

- Pressure 6 bars
- Pure Alcohol
- Drying during one night in the Hood (baldaquin)
- In a plastic bag with N2 atmospher



Mounting

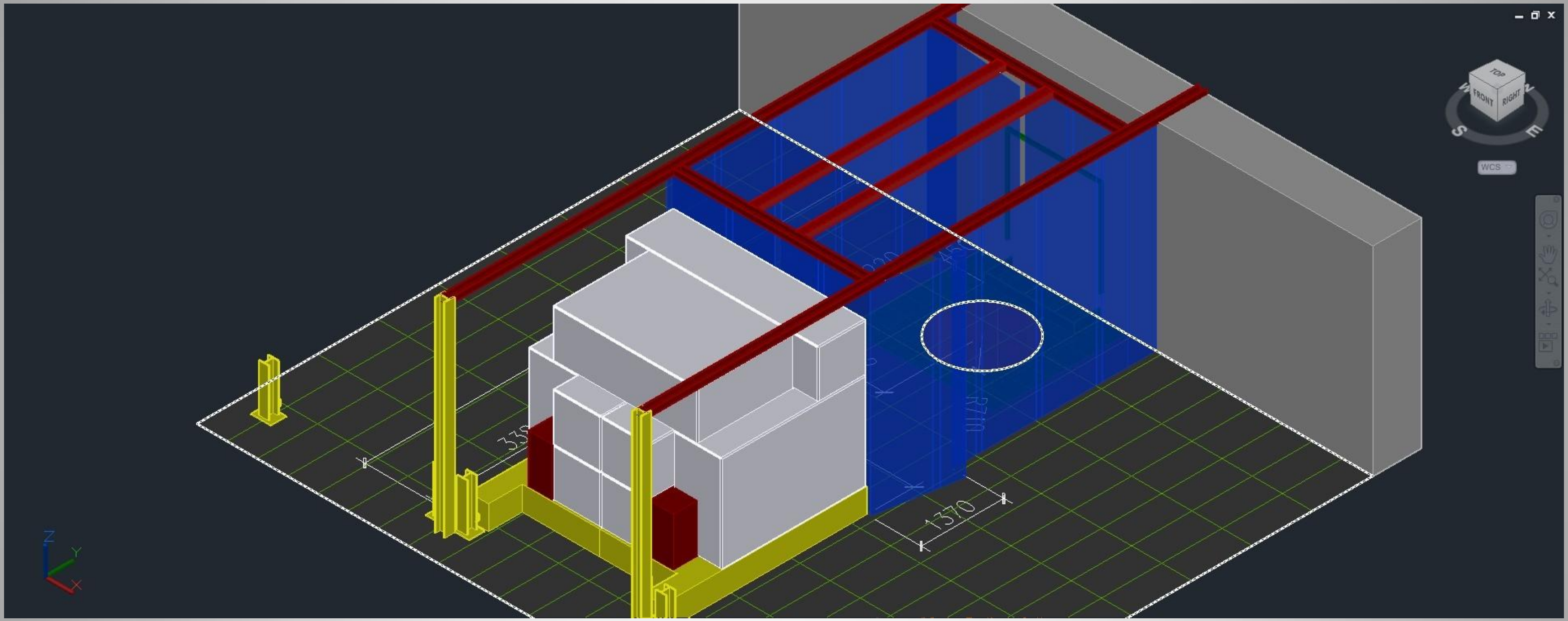
- Clean room (Class 100, ISO 5)
- Particle counting
- The cavity and the stand are protected by a plastic bag



Installation of the cavity in the Cryostat

- Cleaning of the area (alcohol and blowing with N2)
- Laminar flow to avoid dust
- Use of equipment for clean area

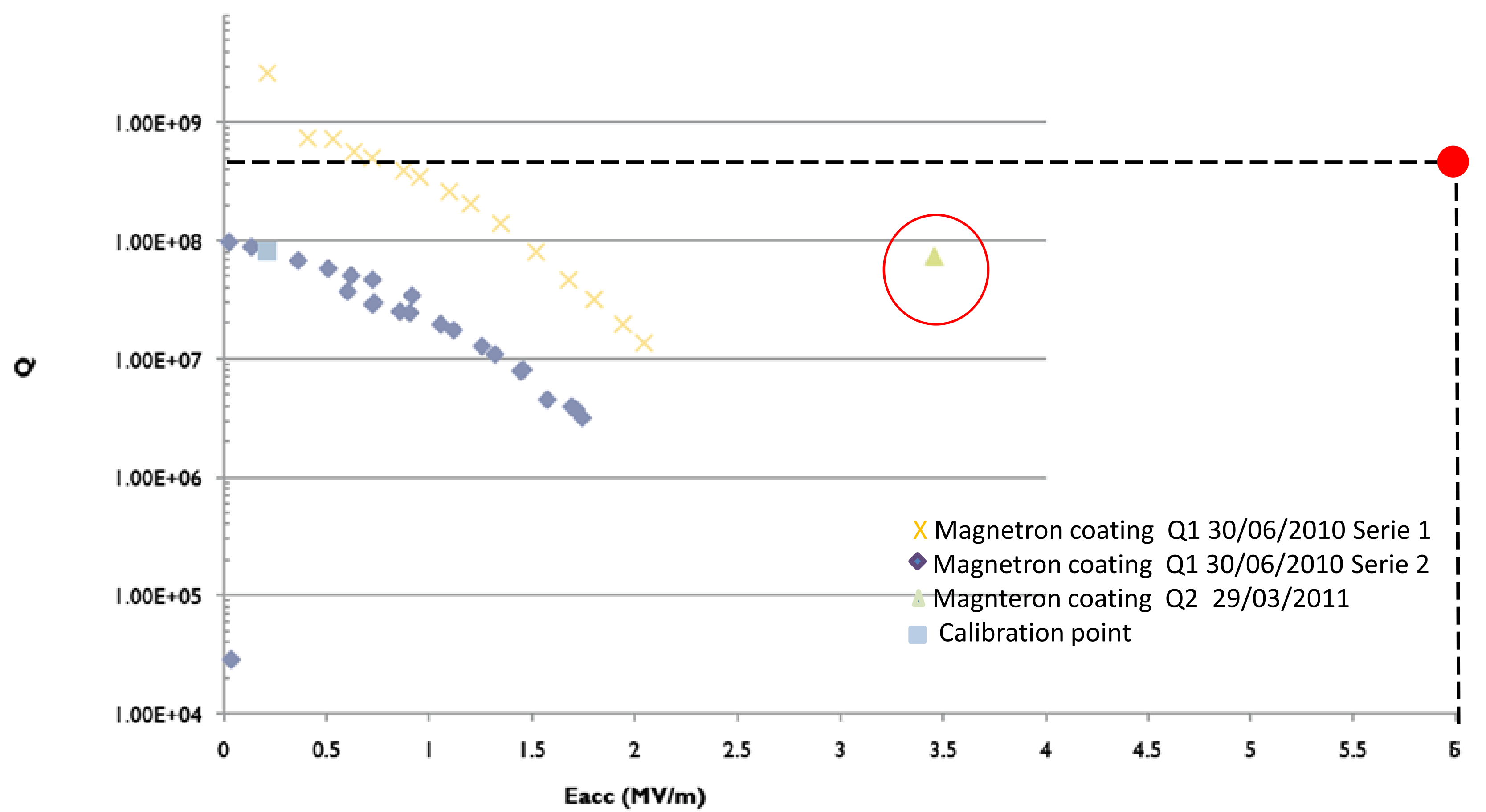
Building of a Clean area



- Structure with soft wall
- Laminar flow

→ We hope to have a clean area of ISO 7 (class 10 000) or better in 1 month

RF tests results



- ● Expected value : Q = 5.10^8 at 6 MV/m

Next Steps

Coating

- Test of combination of magnetron and diode coating on copper cavity to have more homogeneous distribution of the thickness between the external wall and the internal conductor

RF tests

- RF measurements for the last magnetron and diode coating on copper cavities
- After RF tests, test of the high pressure rinsing effect on cavities' performances

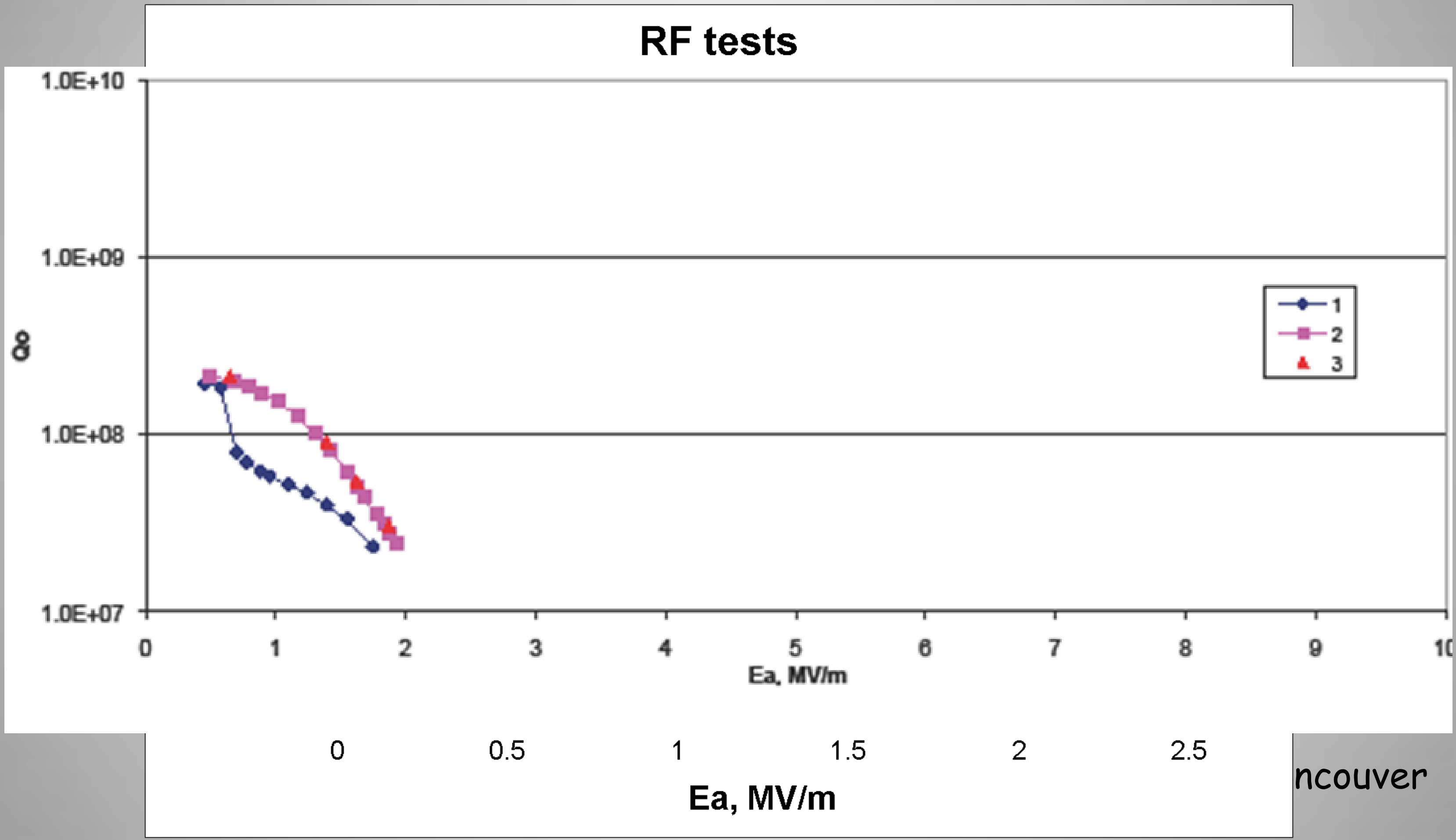
➡ The main goal is to finalize the coating parameters

Facilities improvement

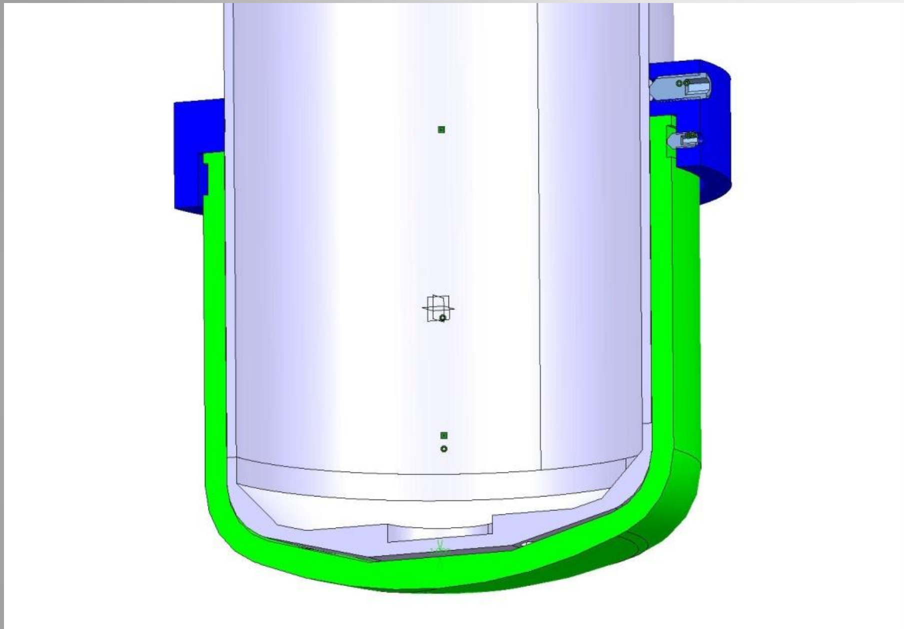
- Installation of the clean area for the RF test area
- Achievement of high pressure rinsing system for QWR cavities

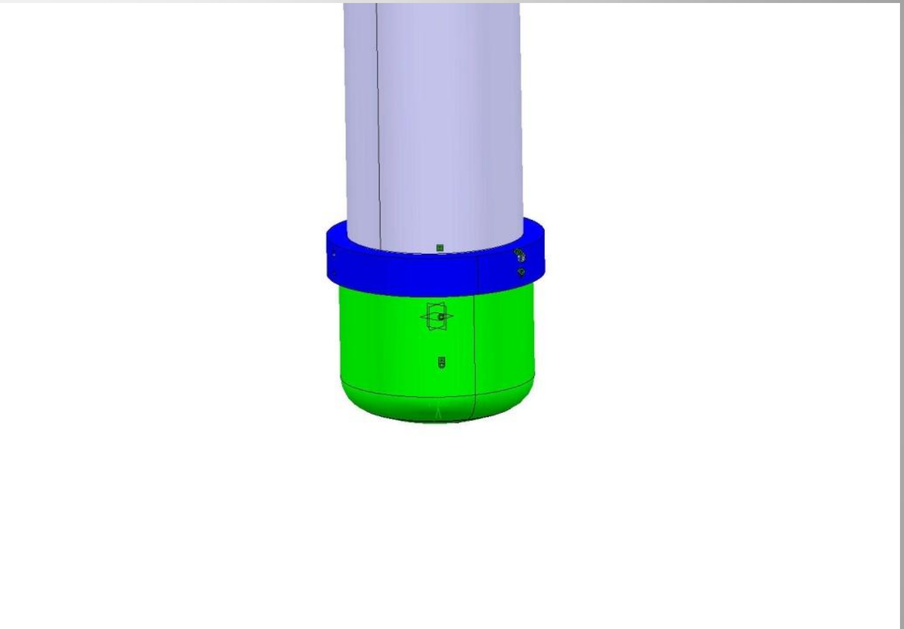
Thanks for your attention

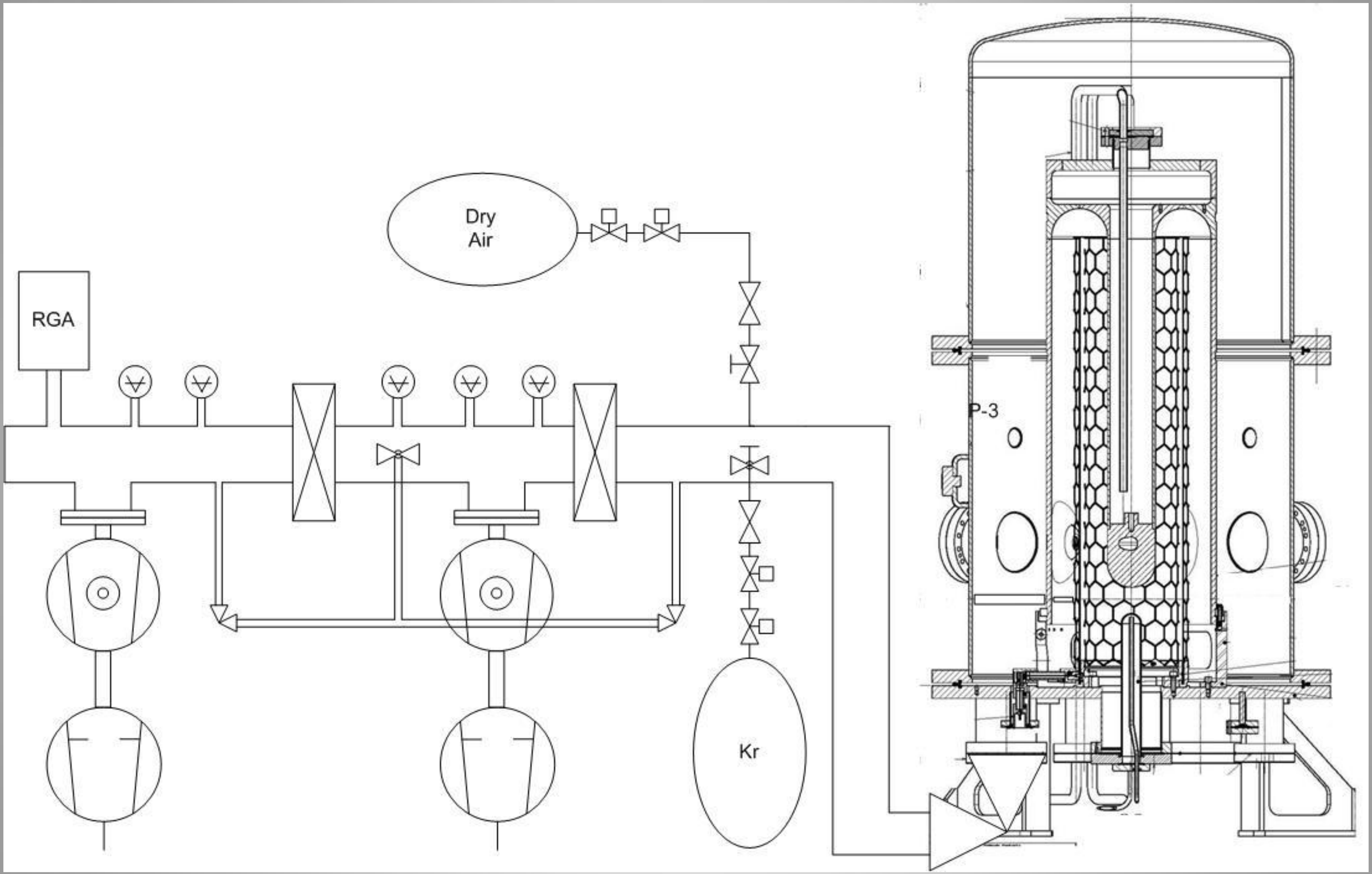
RF Measurement



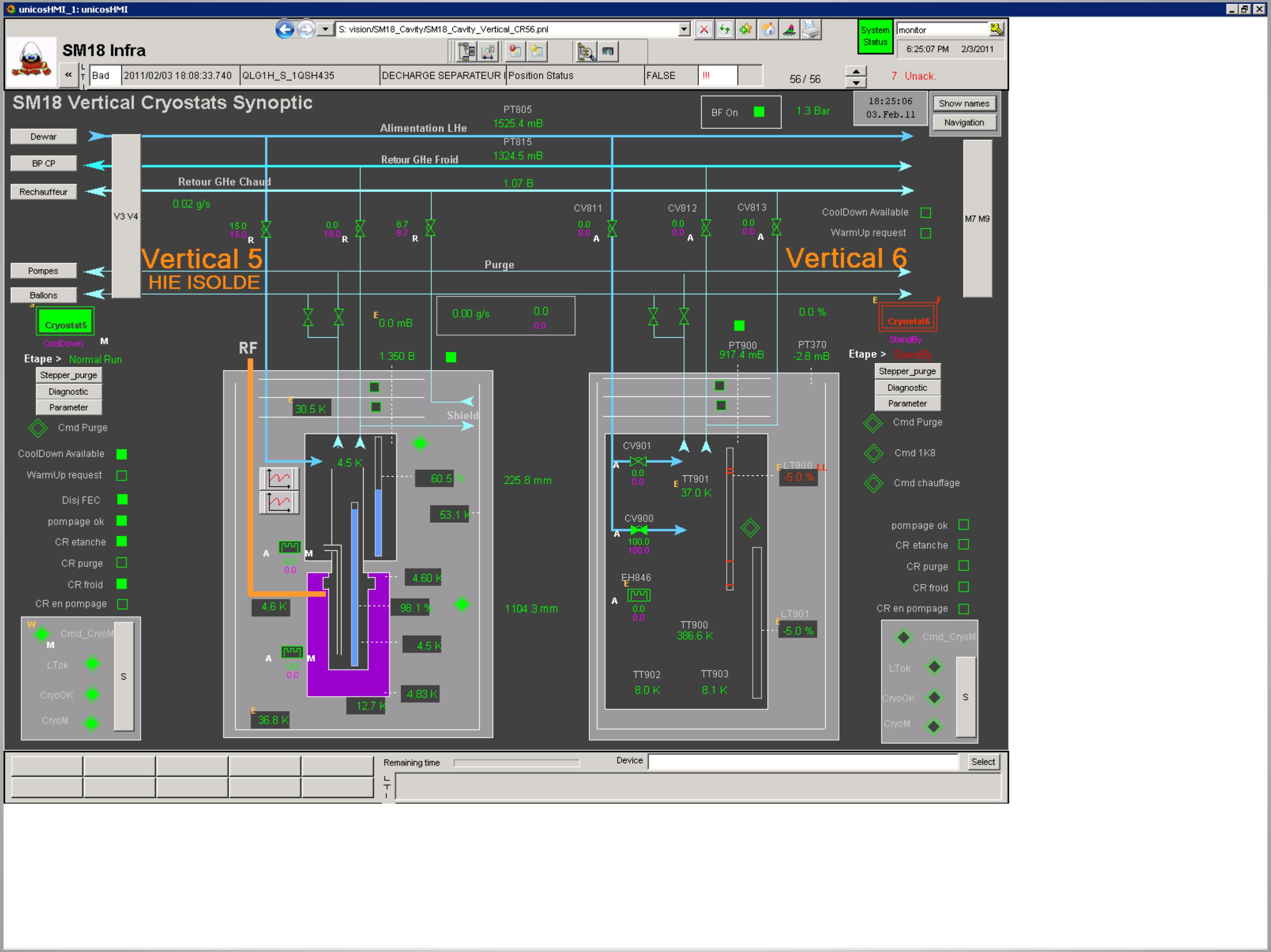
ncouver






Dry Air
RGA
Kr
P-3


TRT-540
E.-170-00A



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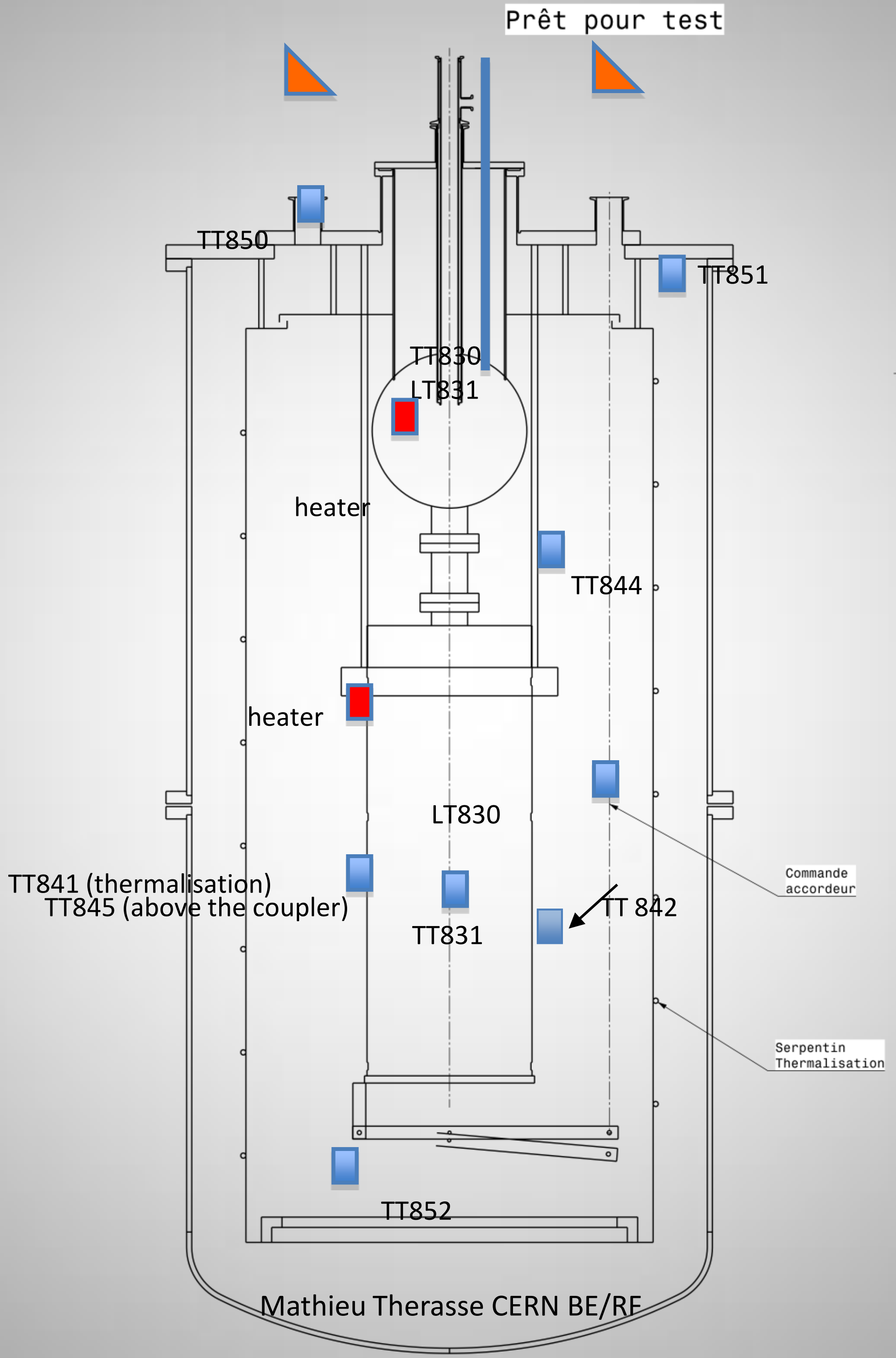


TT850

TT851

TT830

LT831

heater

TT844

heater

LT830

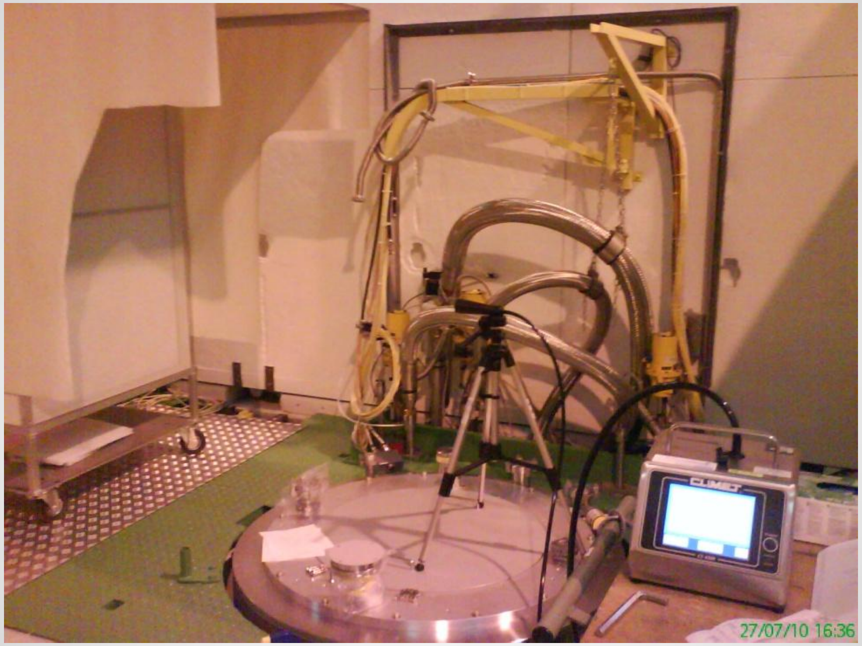
TT841 (thermalisation)

TT845 (above the coupler)

TT831

TT 842

TT852


CLIMET
27/07/10 16:36


PALSUN
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