TE-VSC seminar

Present status of HIE-ISOLDE RF cavities coating

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Outlook

1. Introduction: about RF cavities and coatings
2. Preparation for the coating
3. Sputtering process
4. Next goals
5. Current status

Introduction

- Use of Ultra High Vacuum (UHV) systems to coat HIE-ISOLDE (**H**igh **I**ntensity and **E**nergy) (**I**sotope **S**eparator **O**n **L**ine **DE**tector) copper (Cu) RF cavities with niobium (Nb) thin films
- Coatings are done using sputtering technique
- These cavities will be installed in HIE-ISOLDE SC linac
- Our facilities are located in B252

Introduction: What is an RF cavity

- Device in charge of accelerate the beam inside a particle accelerator using an RF electric field
- There are a big variety of shapes and geometry depending on the specification of the accelerator, frequency, kind of particles…

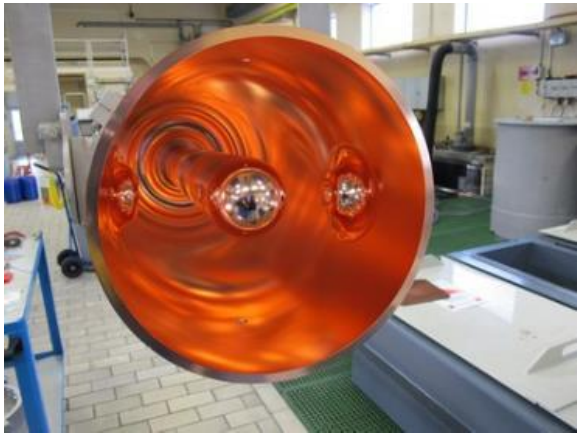
CERN, HIE-ISOLDE 101MHz

CERN, LEP cavity 352MHz

DESY, tesla cavity 1.3GHz

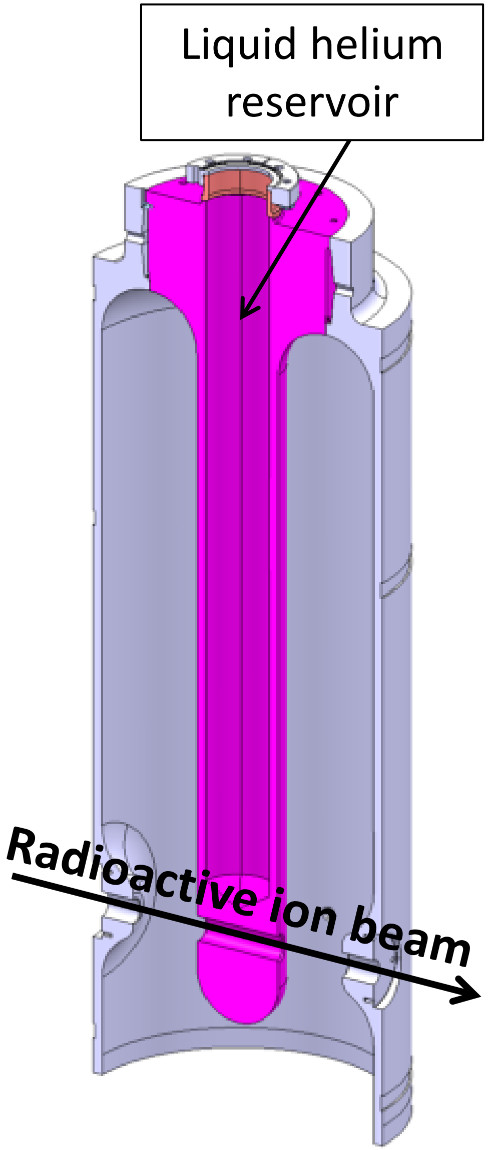
Introduction: coating a surface

- Deposit a layer of a certain material on a substrate
- Even a very thin film (in the order of nanometers to micrometers) can change the properties of the surface in a significant way
- This allows to have advantages of both materials in one piece



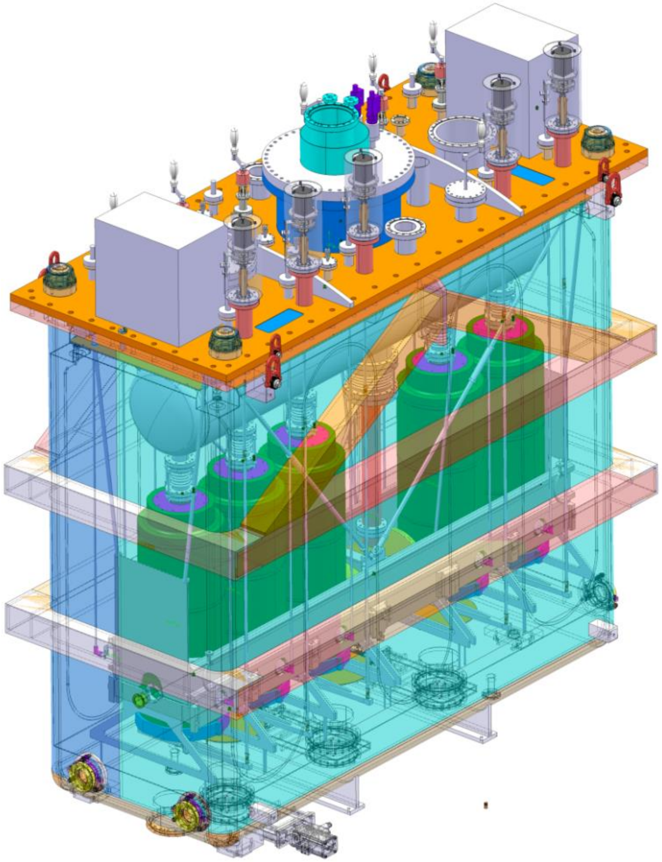
Bulk copper RF cavity without coating

RF cavity coated with Niobium



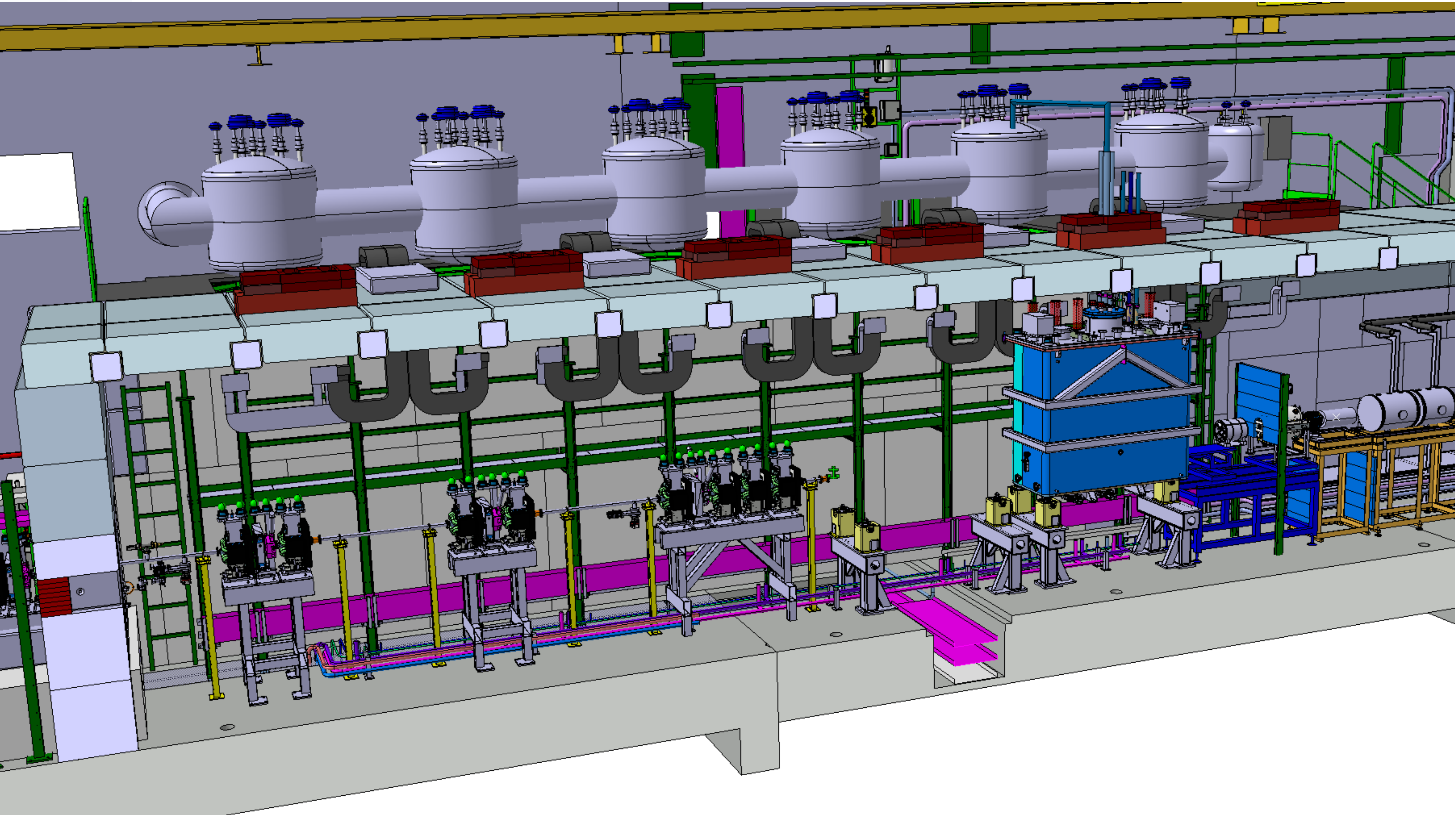
Introduction: cavities in HIE-ISOLDE

- Installing these cavities is one of the upgrades to transform **ISOLDE** into **HIE-ISOLDE** to achieve higher energy
- It will become a super conducting linac instead of a warm linac as it was before
- A superconducting accelerator needs liquid Helium to cool down the cavities to reach working temperature (4.2K)
- Copper thermal conductivity allows to cool the cavity down from the antenna reservoir to achieve working temperature
- These cavities will reduce energy losses due to low surface resistance
- Goal 2014 is 5 cavities

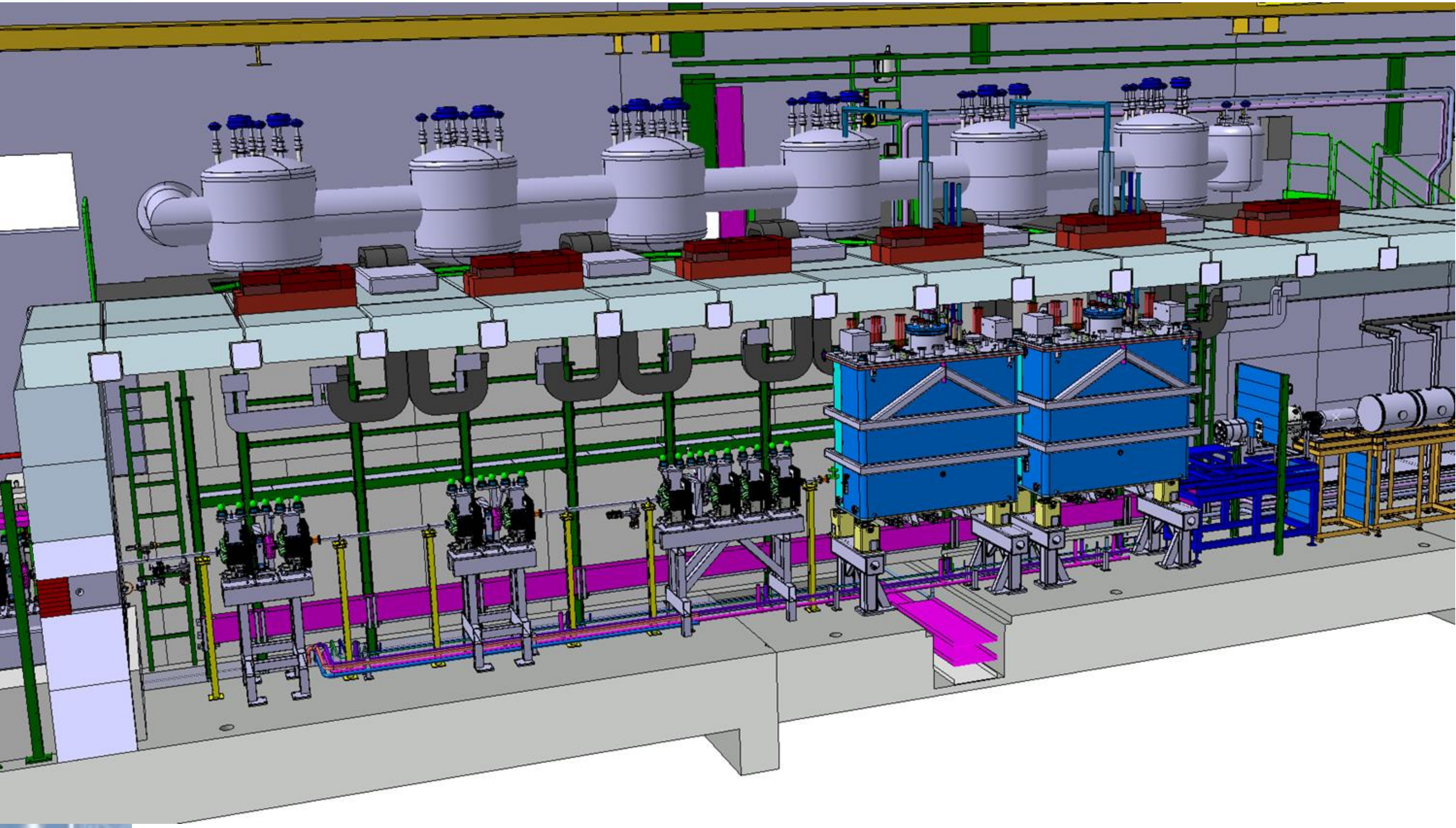


Cryomodule with 5 cavities

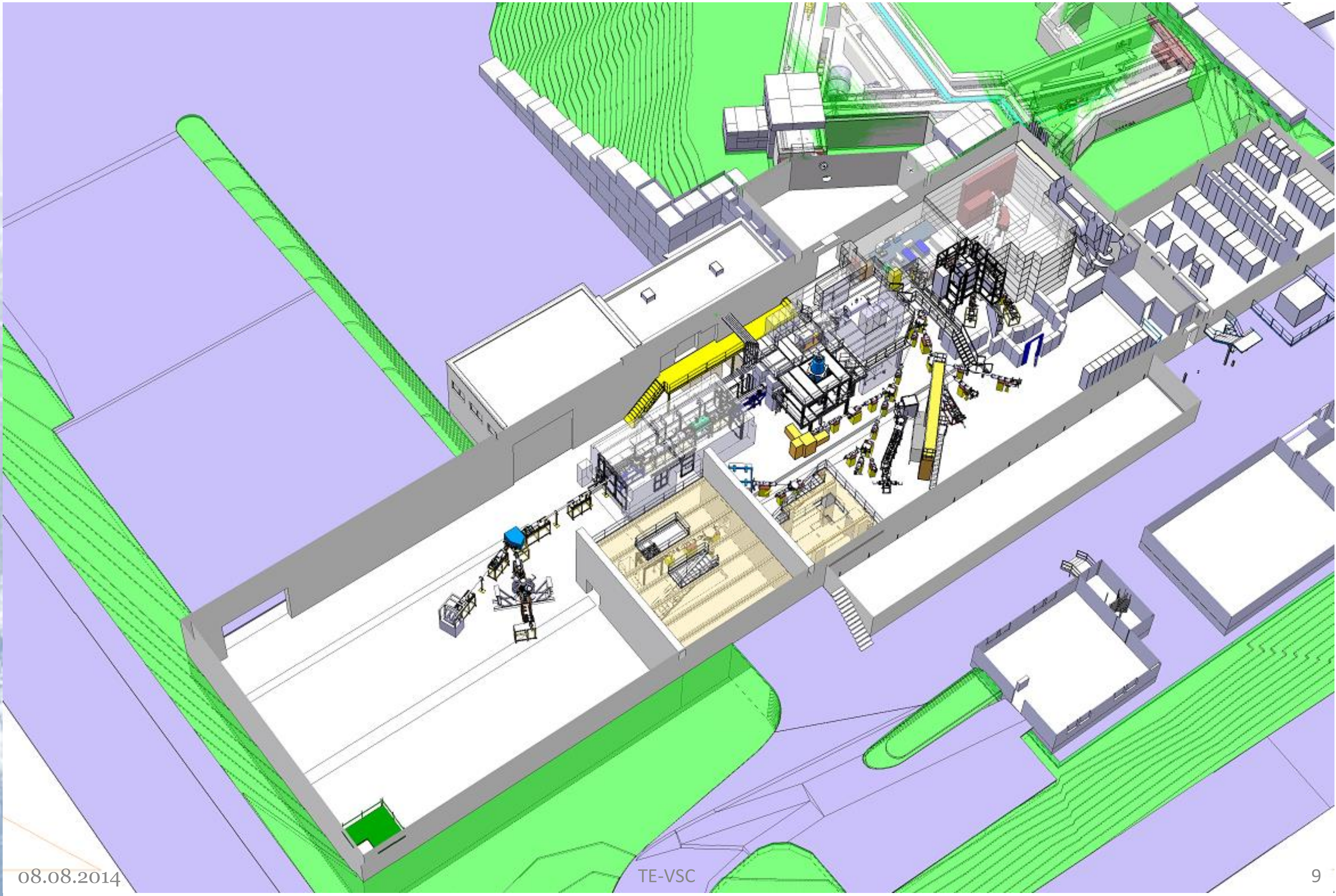
Cryomodules in the accelerator



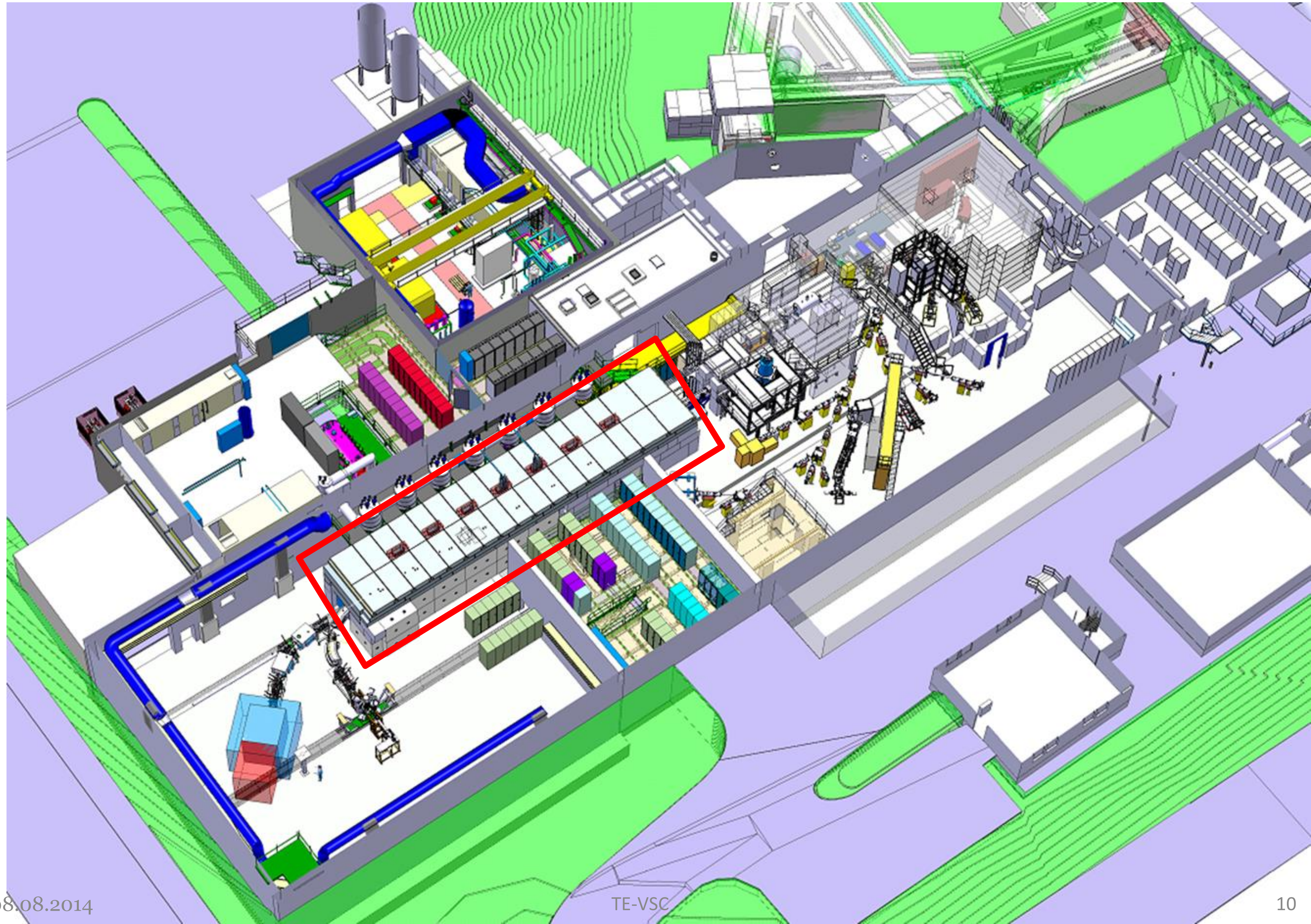
Cryomodules in the accelerator



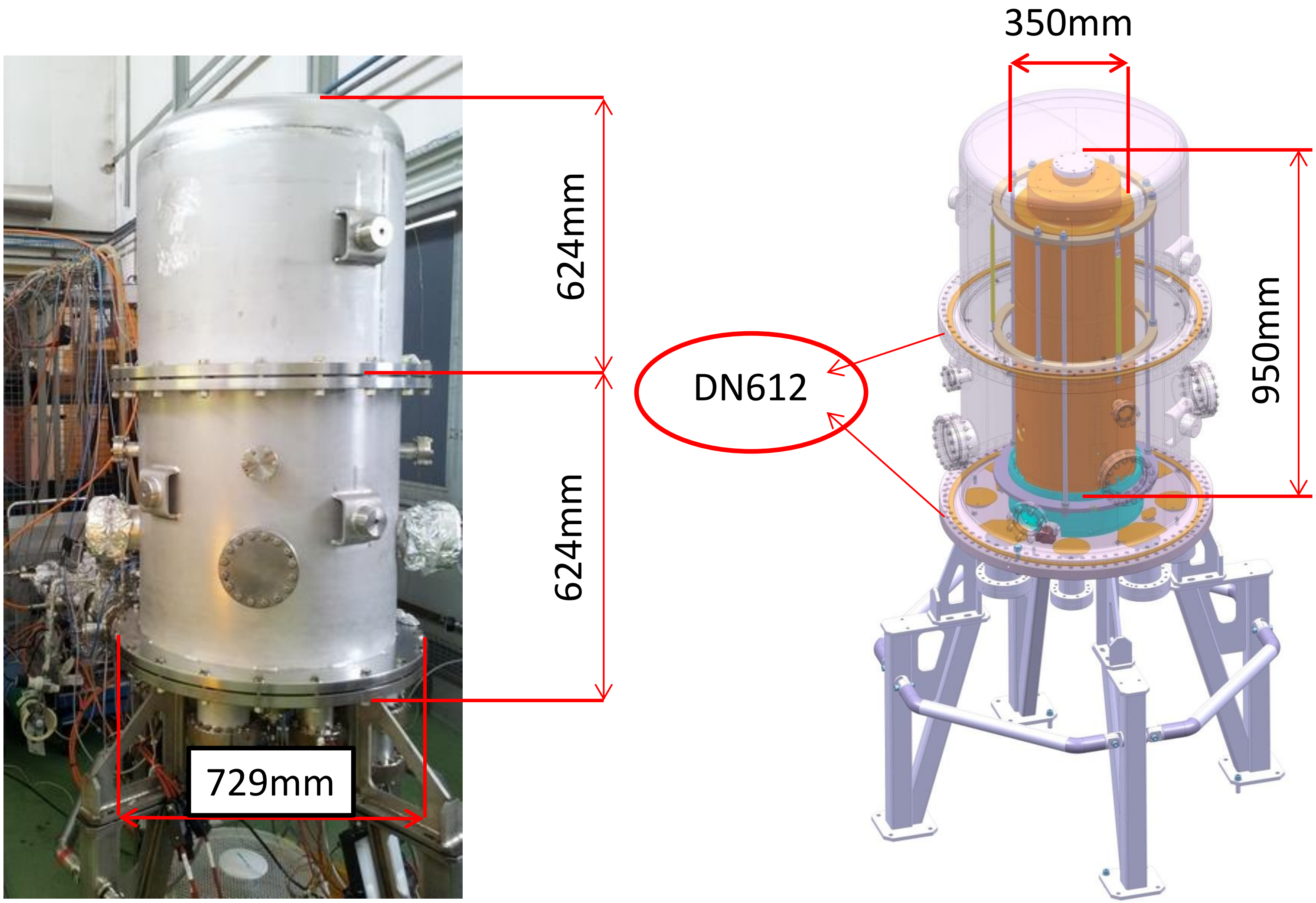
ISOLDE layout



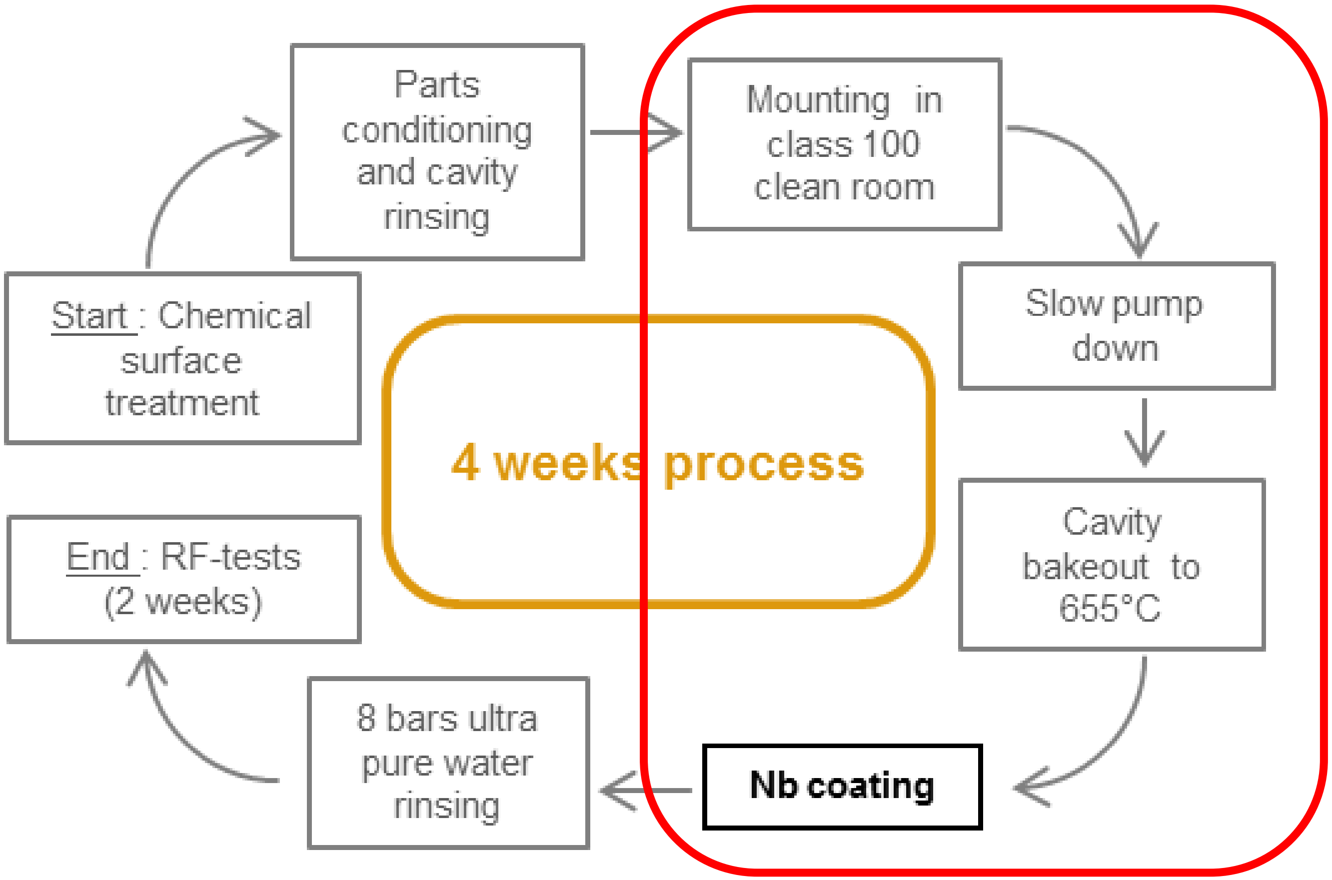
HIE-ISOLDE



Introduction to coating system



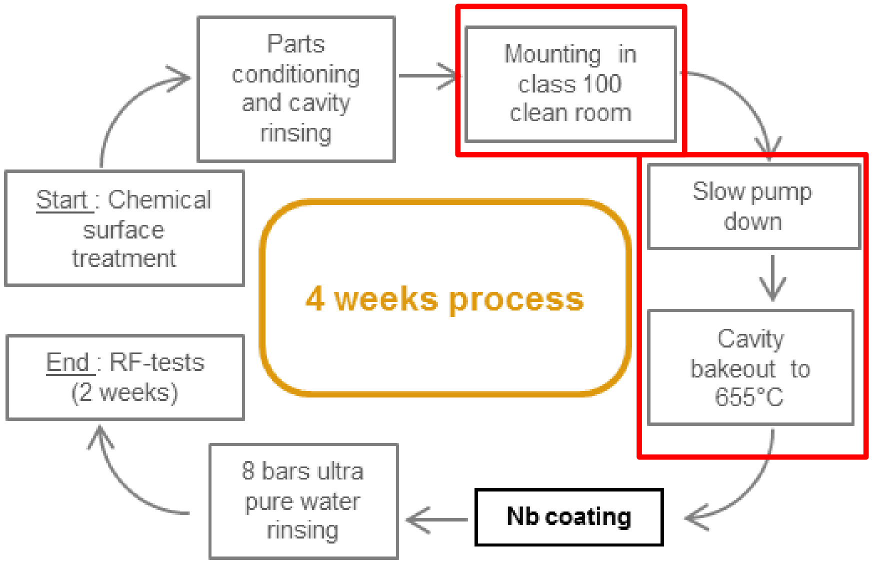
Timeline



Development stage is done. Production phase

Preparation for the coating

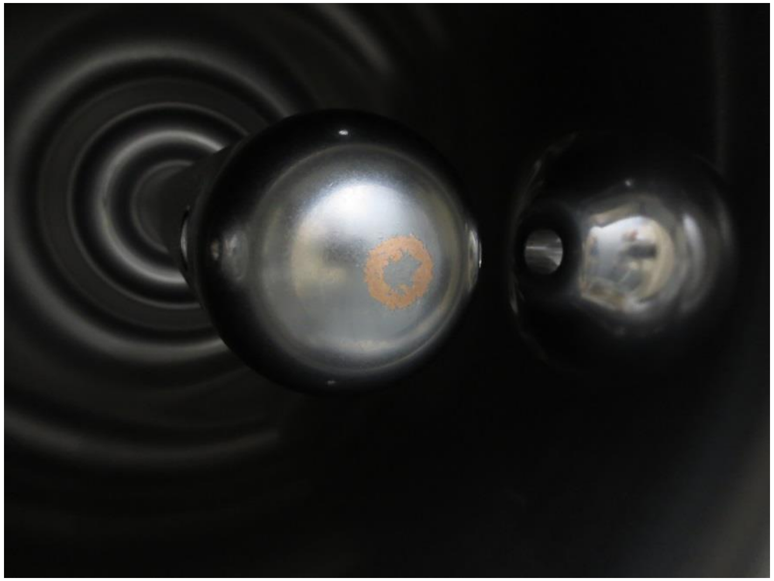
1. Cavity's surface treatment (cleaning and chemical polishing) in the surface treatment workshop
2. Conditioning of the parts and mounting of the vacuum system in cleanroom
3. Pumpdown and high temperature bakeout
4. NEG pump activation



Preparation for the coating: cleanroom

- Mounted inside to prevent airborne particles contamination in our surface
- This would create peel-off and hot spots during the operation in the cryomodule, due to higher electrical resistivity
- Exceeding the cooling capacity of the cryomodule would result in a drop of cavity's performance

Cleanroom assembly



Peel-off

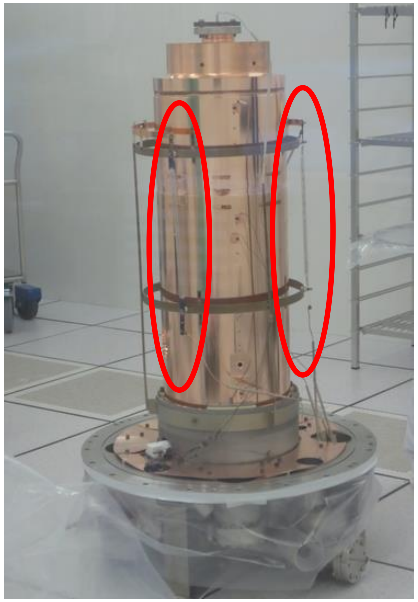
Preparation for the coating: Special Bakeout of the cavity and NEG

- <u>Classical bake out:</u> heating between 120 and 200°C all the surfaces of our vacuum system, depending on the sensitivity of our devices
- One limitation of our system are Viton seals (can't stand more than 140°C) in the big flanges (612mm) of the vacuum chamber

- <u>Special bake out:</u> the **cavity** is heated up to 650°C using IR to release the gas trapped in the substrate (H_2 and O_2)
- To reduce thermal losses during bakeout, we shield our chambers with copper screens

- <u>Activation of NEG pump</u> after bakeout to pump H_2 with higher efficiency + compensate Viton permeation.

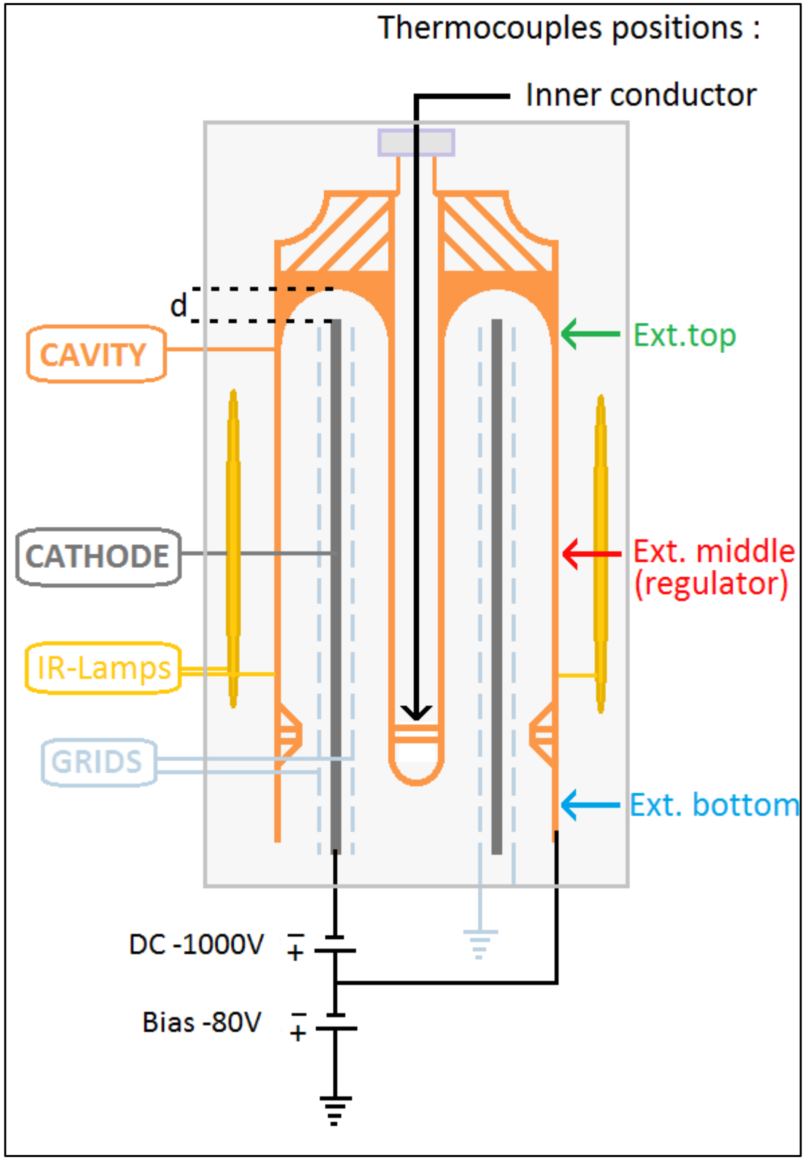
Copper shields



IR lamps

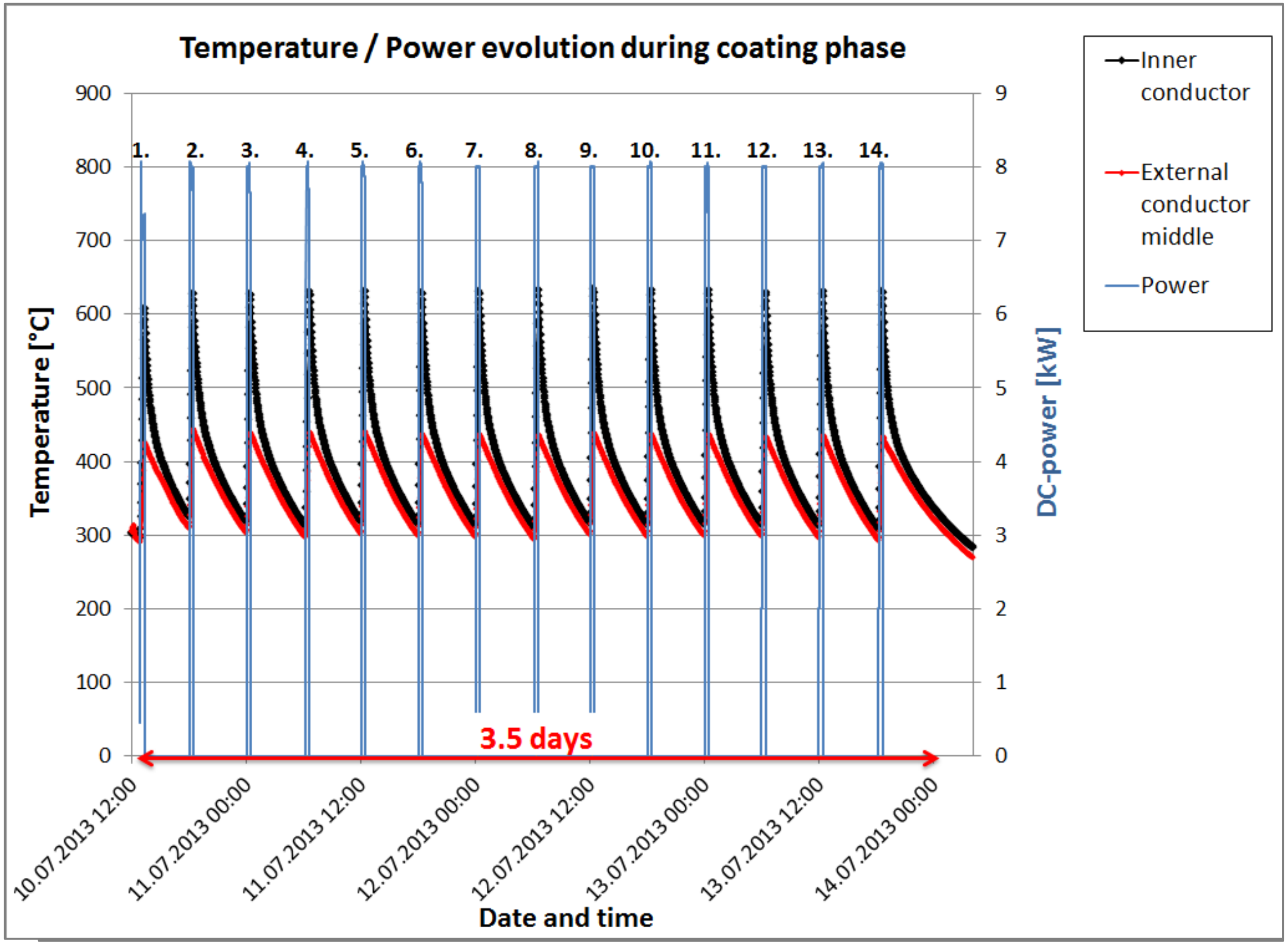
Diode Sputtering process Schematic

- After bakeout and NEG activation, ultimate vacuum is reached (P<1x10E-7 mbar) at 300°C
- We inject a noble gas (Ar) in the chamber up to a process pressure (0,2 mbar) and create a plasma. →Coating
- High temperature : better film properties (from 300°C to 620°C)
- High power (8kW): better RF performance
- Recording all pressures and temperatures.

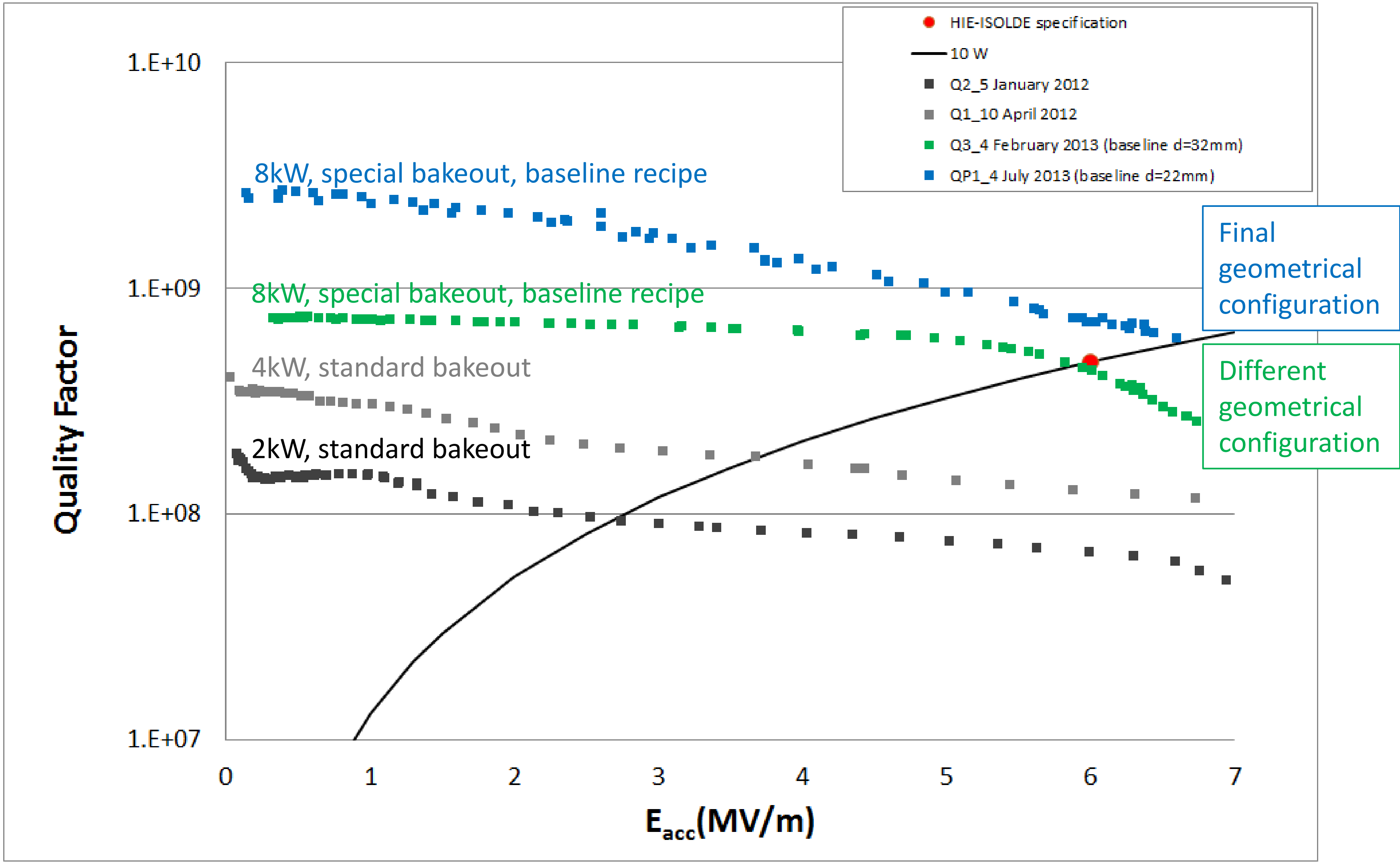


Cycles of the Sputtering process: temperature evolution

- Total energy: 43kWh
- Around 25min per run + 5h30 cooling
- We need 14 runs to complete a coating
- Total effective coating time: 6 hours



RF results

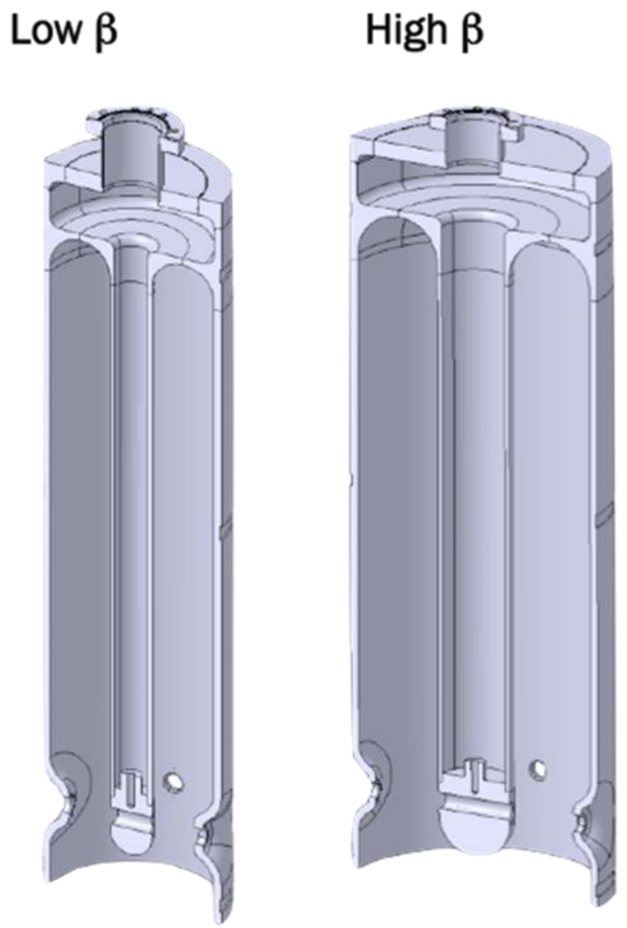


HIE-ISOLDE specification
10 W
Q2_5 January 2012
Q1_10 April 2012
Q3_4 February 2013 (baseline d=32mm)
QP1_4 July 2013 (baseline d=22mm)
8kW, special bakeout, baseline recipe
8kW, special bakeout, baseline recipe
4kW, standard bakeout
2kW, standard bakeout
Final geometrical configuration
Different geometrical configuration
Quality Factor
1.E+10
1.E+09
1.E+08
1.E+07
0
1
2
3
4
5
6
7
E_{acc}(MV/m)

Next goals

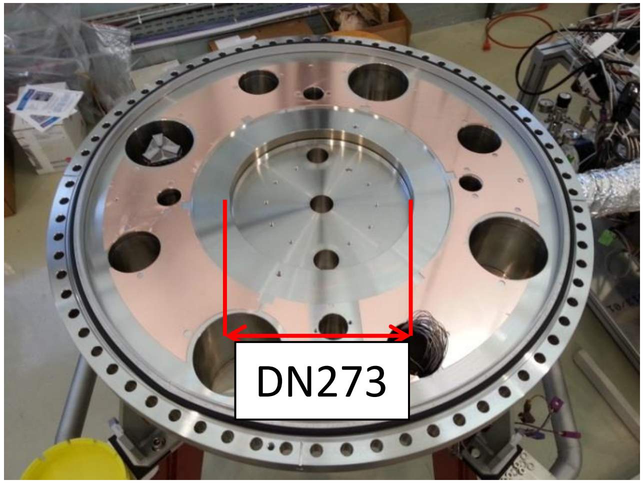
- Backup in case of failure of 1st coating system
- Focus on development with different techniques (magnetron, double cathode, other cavities…)
- Start development of Low beta cavities

→ Second coating system



Flexibility in configuration

- Built entirely in stainless steel 316L
  - Stands better chemical treatments for cleaning
  - Less interaction with magnetic field for magnetron
- Geometry of bottom flange
  - Allows to adapt different cavities (High and low Beta)
  - Develop a double cathode coating system for layer thickness uniformity in complex geometries
- More viewports located in specific zones to implement:
  - Visual control
  - Optical plasma diagnosis and monitoring system

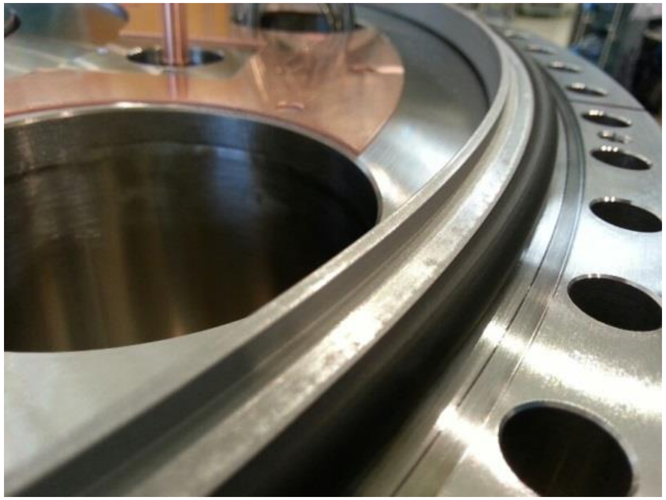


Top view

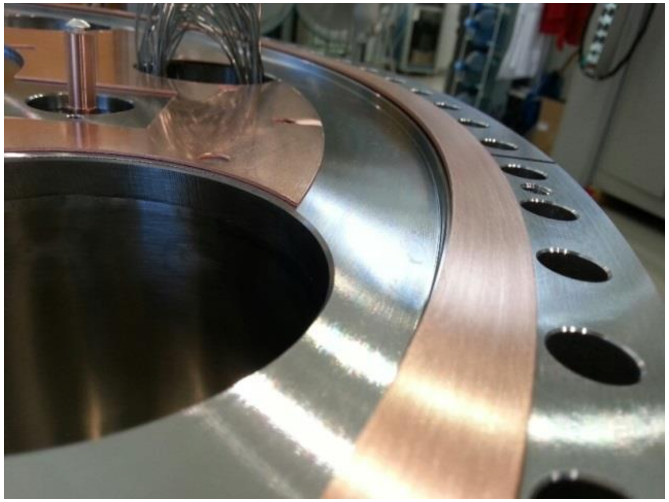

Bottom view

Flexibility in performance

- Special 612mm Flanges: chamber sealed either by copper gaskets or Viton O-rings
  - Copper gaskets (612mm) allow to have a wider temperature range during bakeout and coating
  - Better leak tightness with copper gaskets
  - Viton can still be installed instead of copper (cheaper and faster)

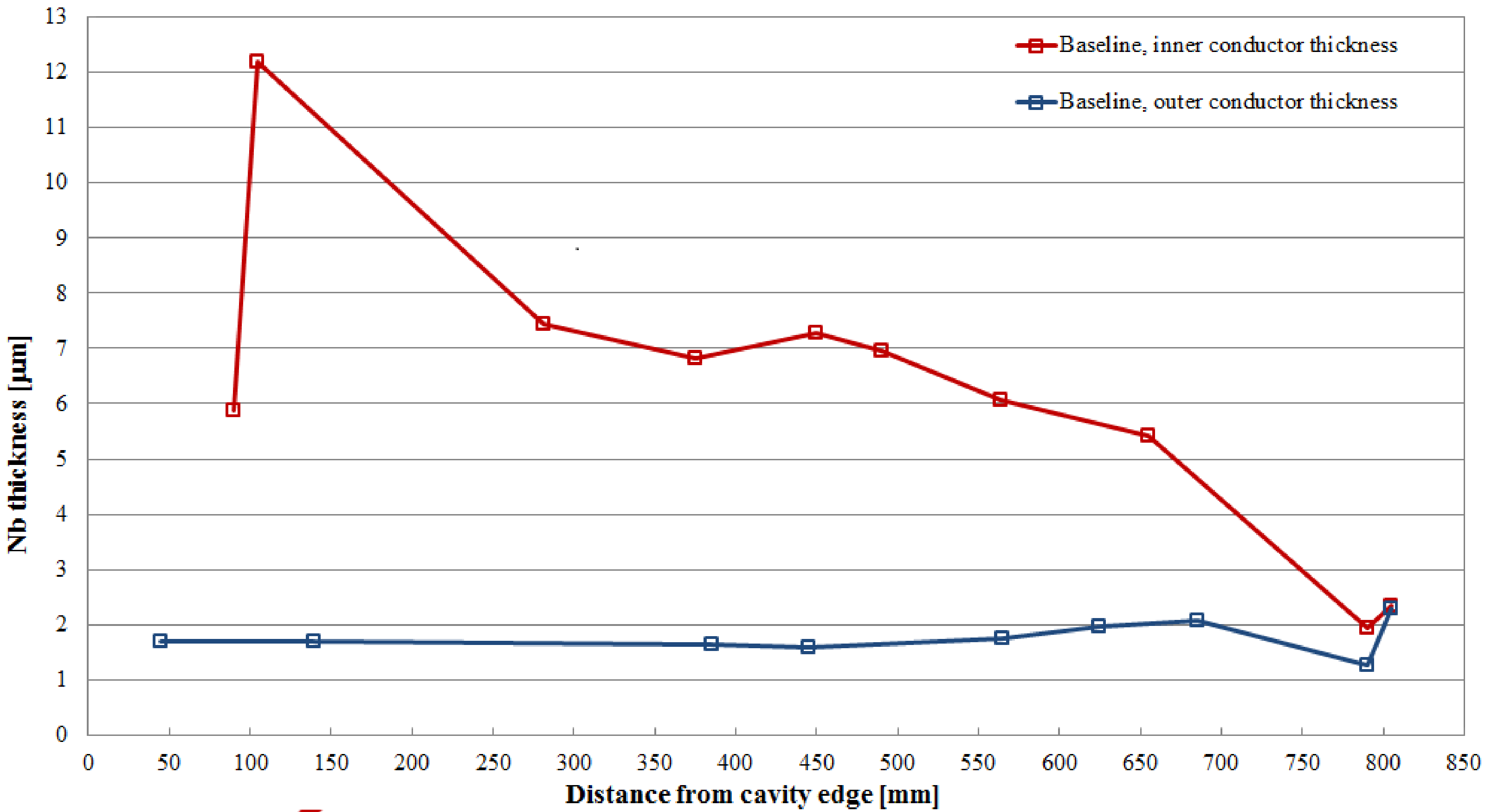


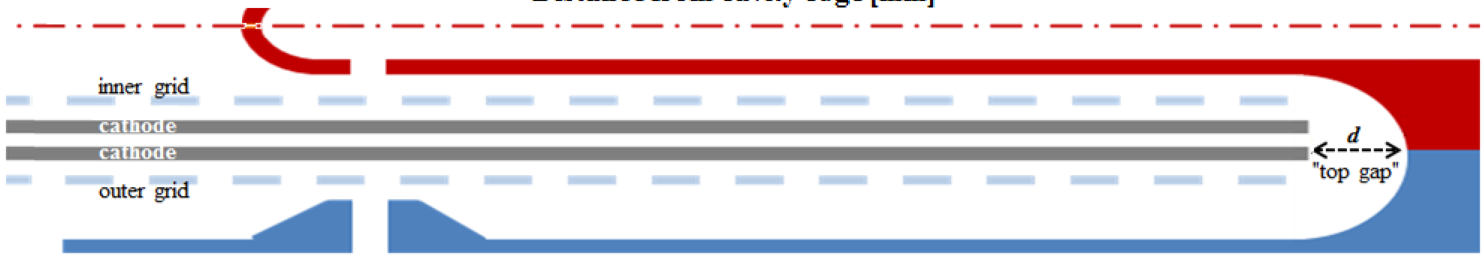
Viton O-Ring



Copper gasket

Thickness profile





Current status

- Second system status :
  - Pieces cleaned in the chemistry
  - Checking assembly of all the pieces
  - Installation of external devices (gauges, valves, NEG pump) and integration in the vacuum system
  - Leaktight
  - Will be fully qualified when one cavity is coated with the standard recipe and tested afterwards in RF facilities reaching specs.

- Cavities status :
  - 3 series cavities already coated and measured
  - 1 series cavity coated → waiting for measurement
  - 1 more series cavity is needed → arrival at CERN next week

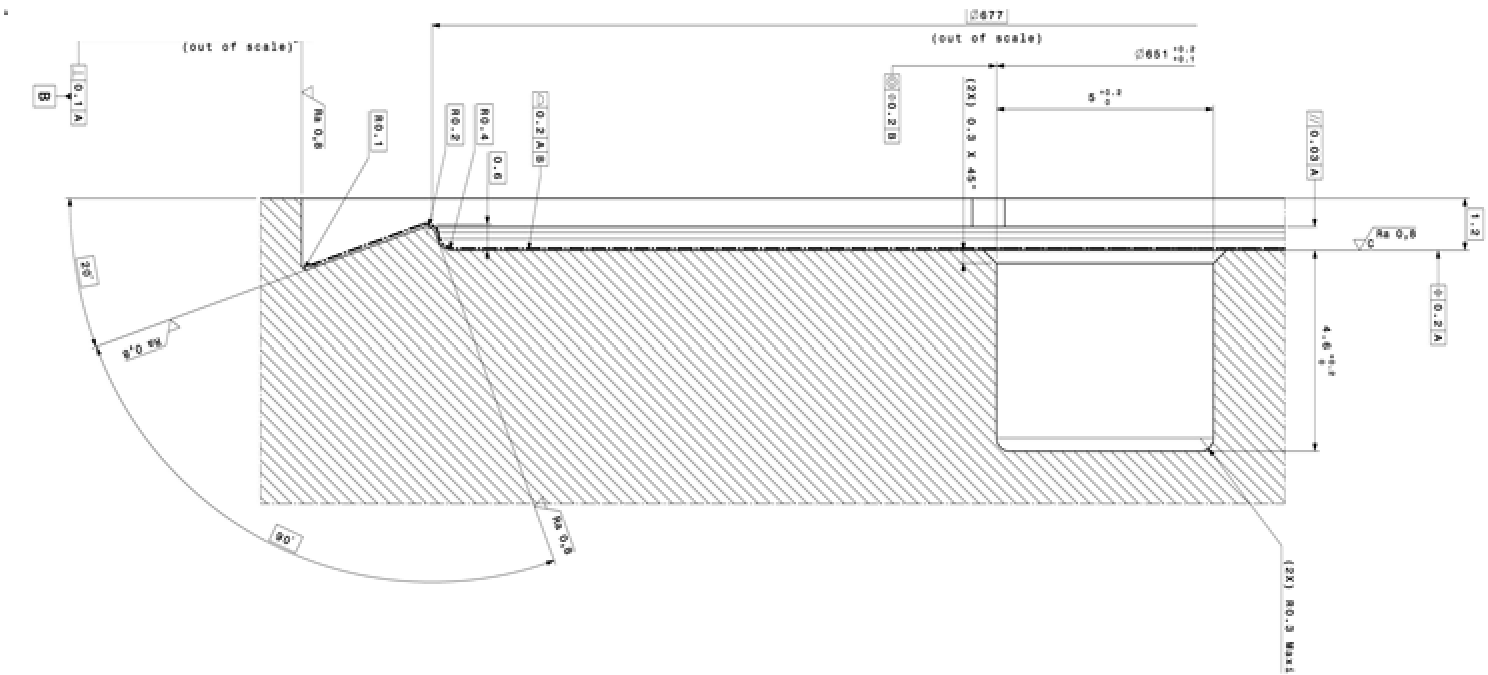
Acknowledgements

- Thin films group, specially Noemie, Alban and Mauro
- Giovanna Vandoni

Thank you very much for your attention

Questions?

Bottom flange



Manufacturing

- Manufactured by Trinos Vacuum Projects Spain, raw material provided by CERN
  - Vacuum chambers
  - Copper shields
  - Support for the structure
  - Cavity support
  - Grids
  - Ceramic isolation pieces