Application of thin film coatings on complex geometries

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Application of thin film coatings on complex geometries

- Introduction
- Examples for planar coating configuration
- Examples for cylindrical coating configuration
- Example of combination of configurations
- Superconducting Nb coatings on Cavities
- Carbon coatings in beam-pipes

Introduction

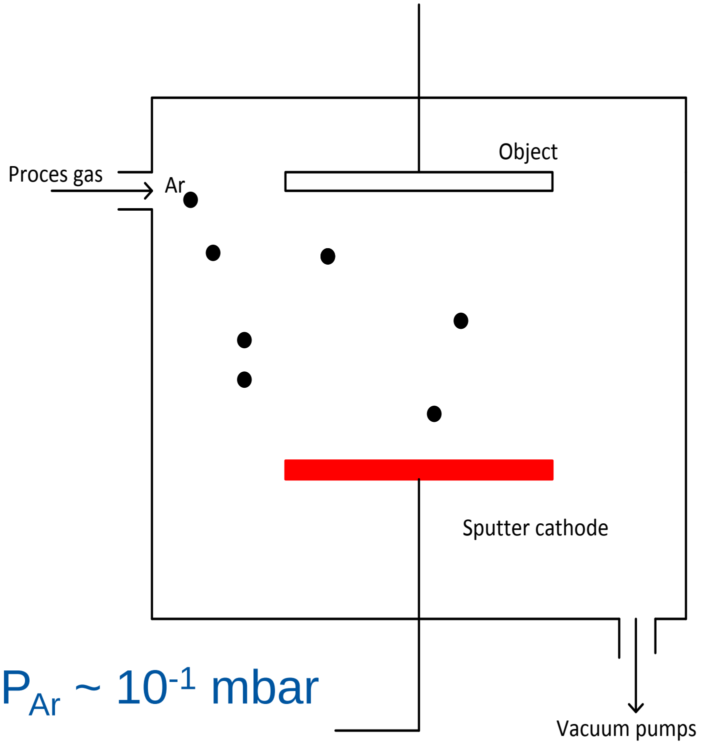
Presentation by Sergio Calatroni this morning

Showed several examples of parts of the accelerator with thin film applications.

Let’s go in detail: **well established techniques** are used for special geometries needed for CERN applications.

Planar DC configuration

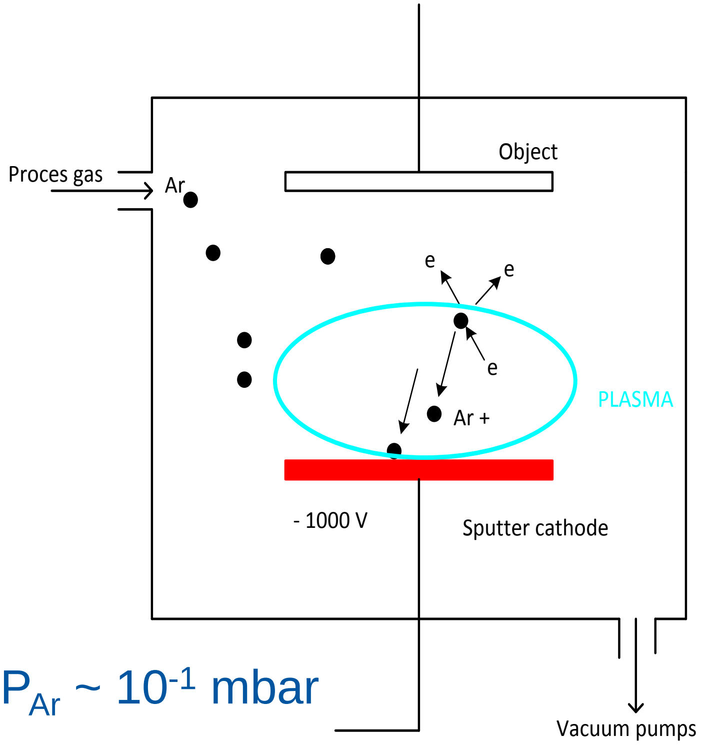
-> DC sputter deposition (sputtering)



$P_{Ar} \sim 10^{-1}$ mbar

Planar DC configuration

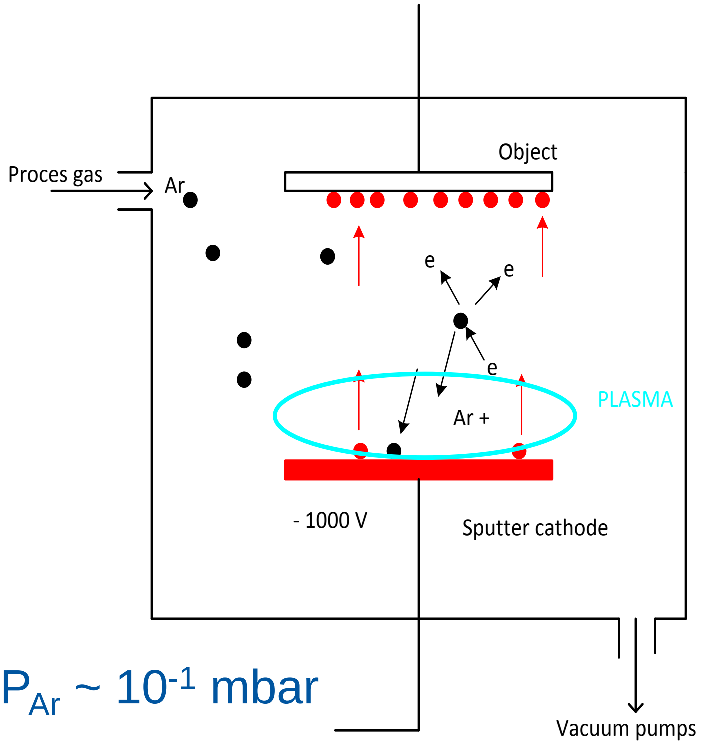
-> DC sputter deposition



P_{Ar} ~ 10^{-1} mbar

Planar DC configuration

-> DC sputter deposition



$P_{Ar} \sim 10^{-1}$ mbar

Advantages:

- uniform erosion
- "easy" up-scaling

Dis-advantages:

- very low deposition rate
- morphology / adherence

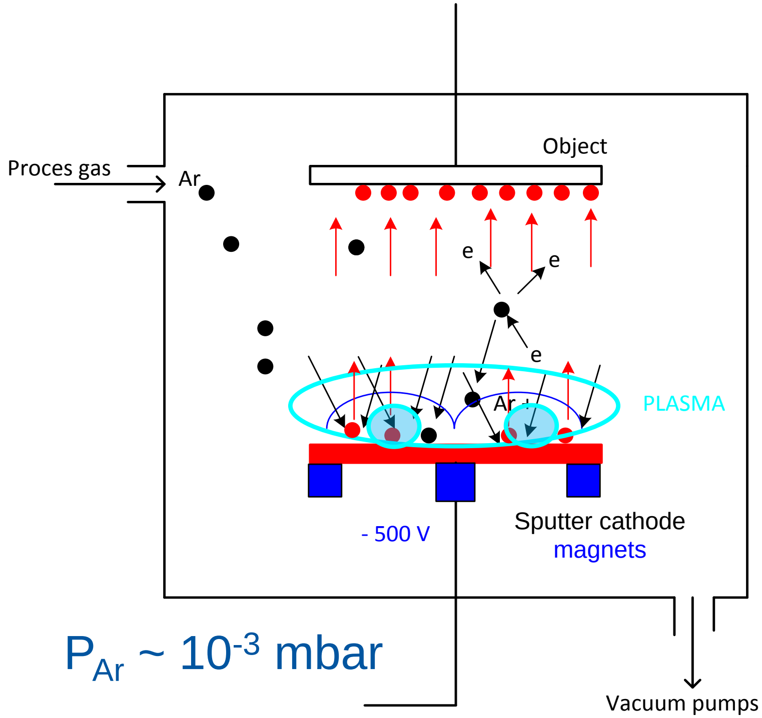
To much interaction of ● with ●
= Mean free path is to low

⬇

DECREASE PRESSURE

Planar Magnetron configuration

-> DC Magnetron sputter deposition:
add magnetic field to sustain plasma



$P_{Ar} \sim 10^{-3}$ mbar

Advantages:

- More ● arrive: higher deposition rates
- ● arrive with higher energy: better adherence / morphology

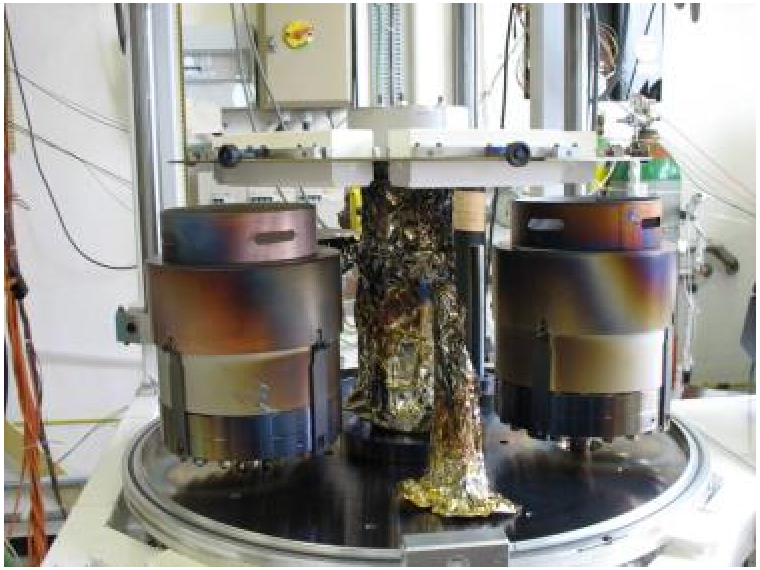
Dis-advantages:

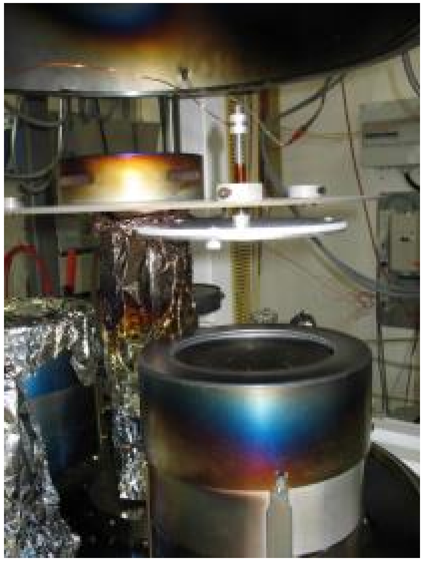
Non uniform erosion of cathodes

Planar DC magnetron configuration

Equipment in our labs for coating small objects up to Ø 150 mm

Sputter cathode: Ø 150 mm



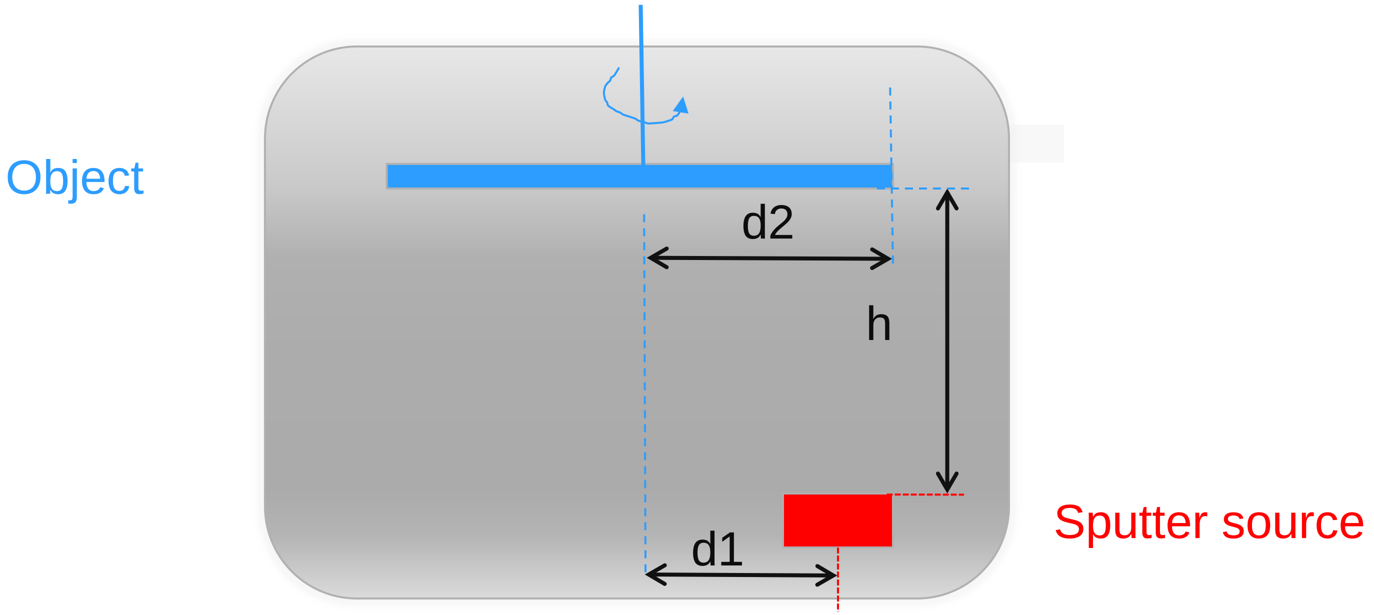


2 magnetrons: multi-layers

Planar DC magnetron configuration

On samples of BIG dimensions

Sputter cathode: Ø 150 mm

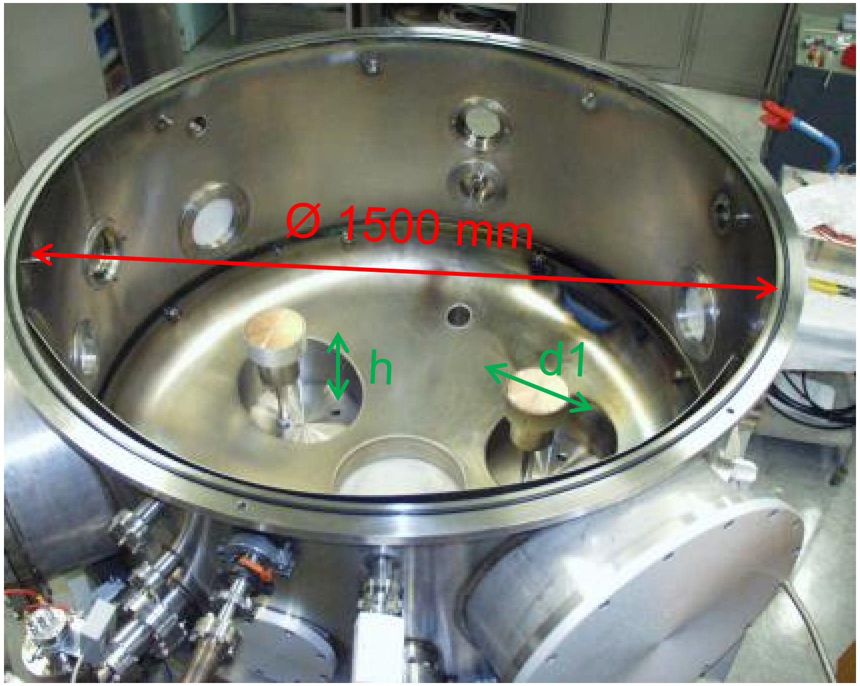


Uniformity = f(d1,d2,h)

But absolute deposition rate v= f($d1^{-1}$,$d2^{-1}$,h^{-1})

Planar DC magnetron configuration

On samples of big dimensions



Planar DC magnetron configuration

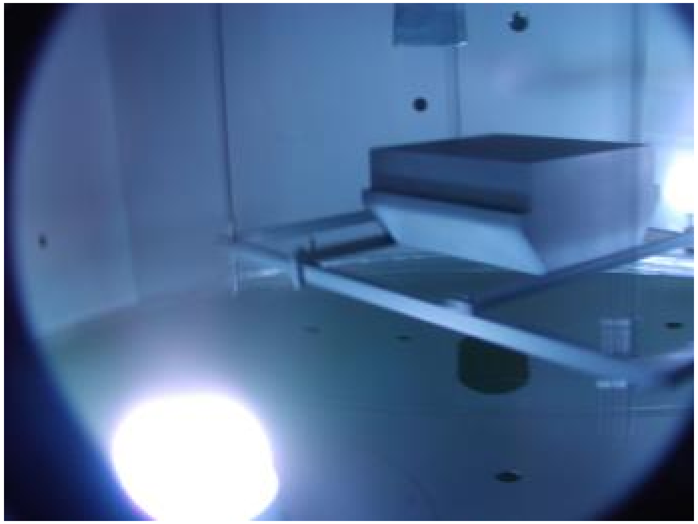
On samples of big dimensions

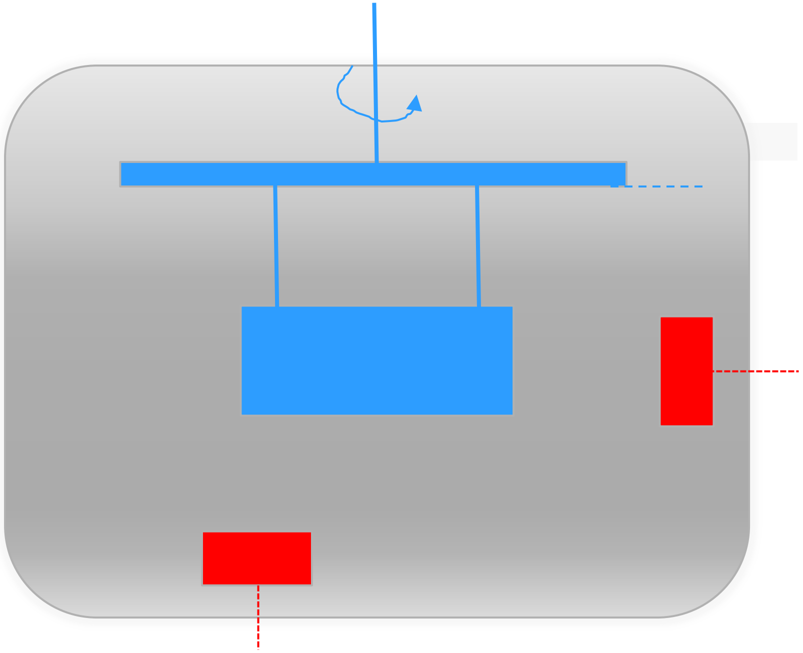
Ø 400 mm ceramic disc
Ti coating ~ 20 nm [10 MΩ]

+/- 10 % uniformity

Planar DC magnetron configuration

On samples of "3" dimensions

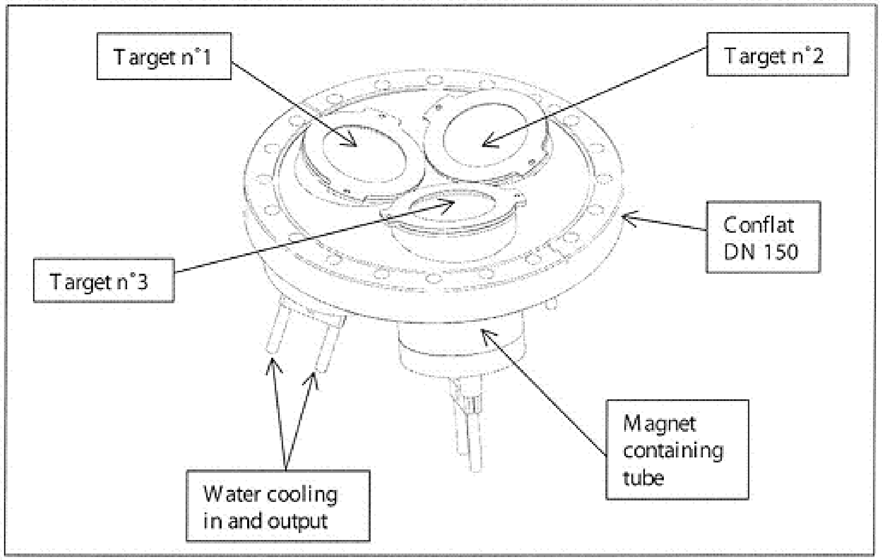


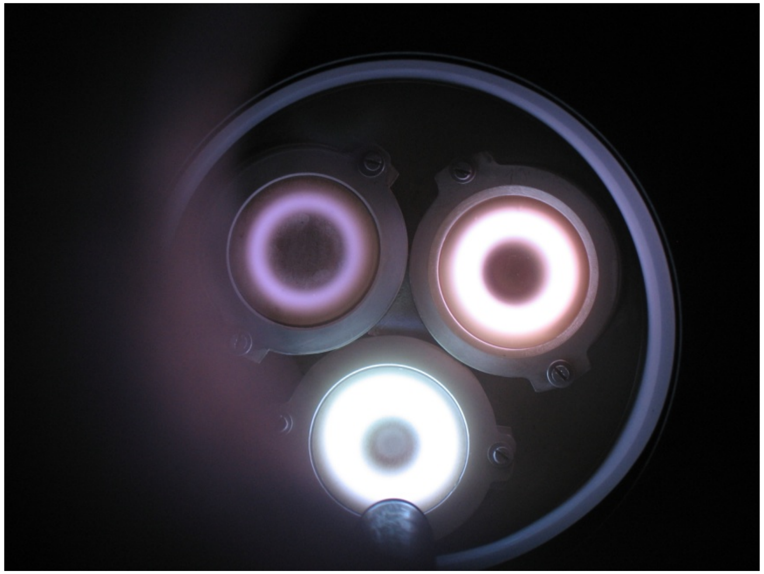


500*210*110 mm
2 µm Ti coating
+/- 40 % uniformity

Planar DC magnetron configuration

- Coating of alloys: e.g. NEG

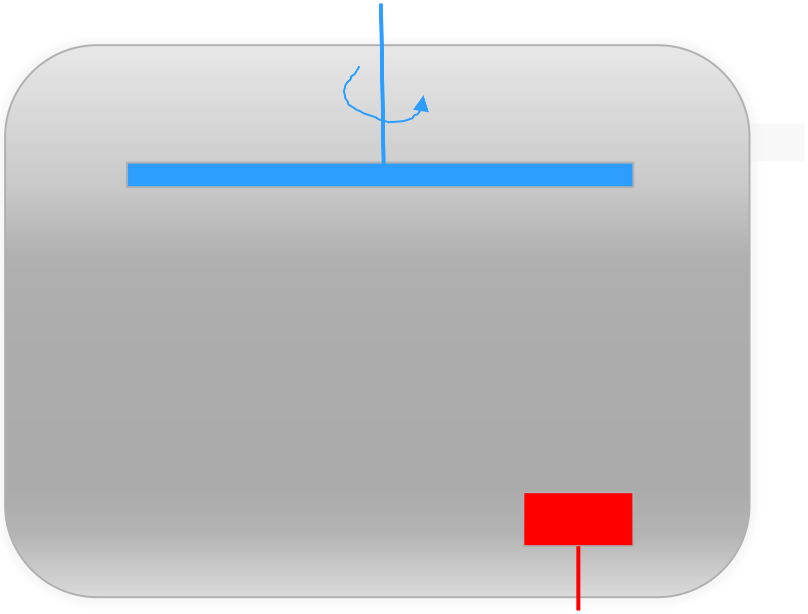




3* Ø 50 mm targets
For R&D purpose:
Small samples !!

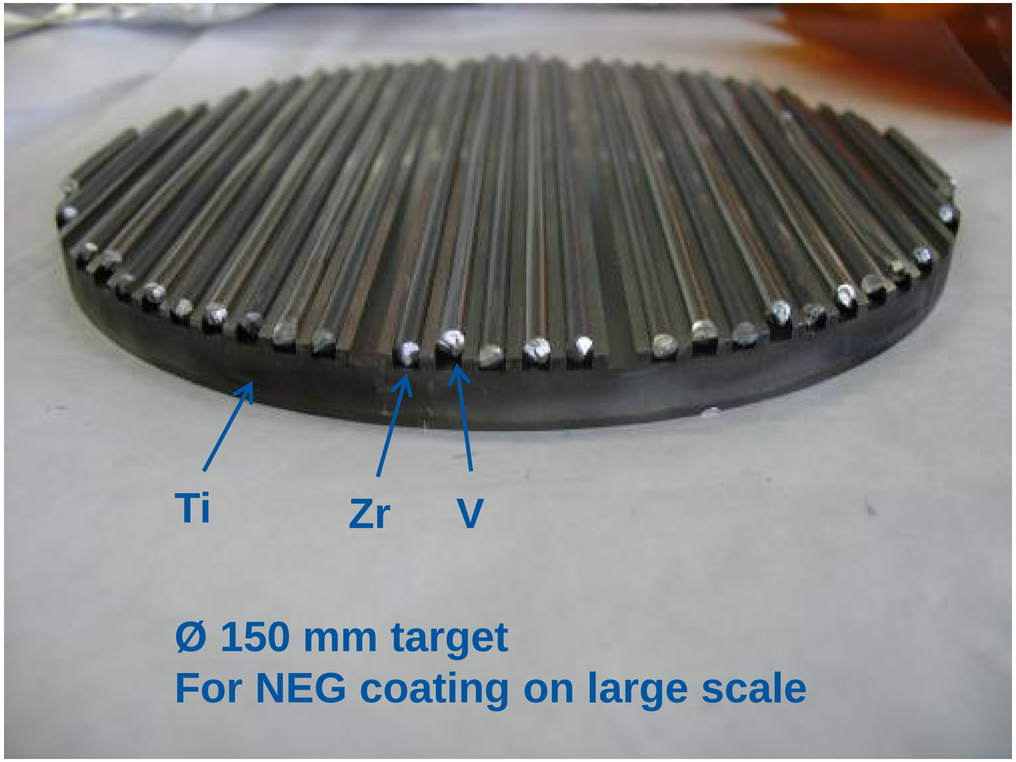
Planar DC magnetron configuration

NEG COATINGS ON BIG PLANAR OBJECTS



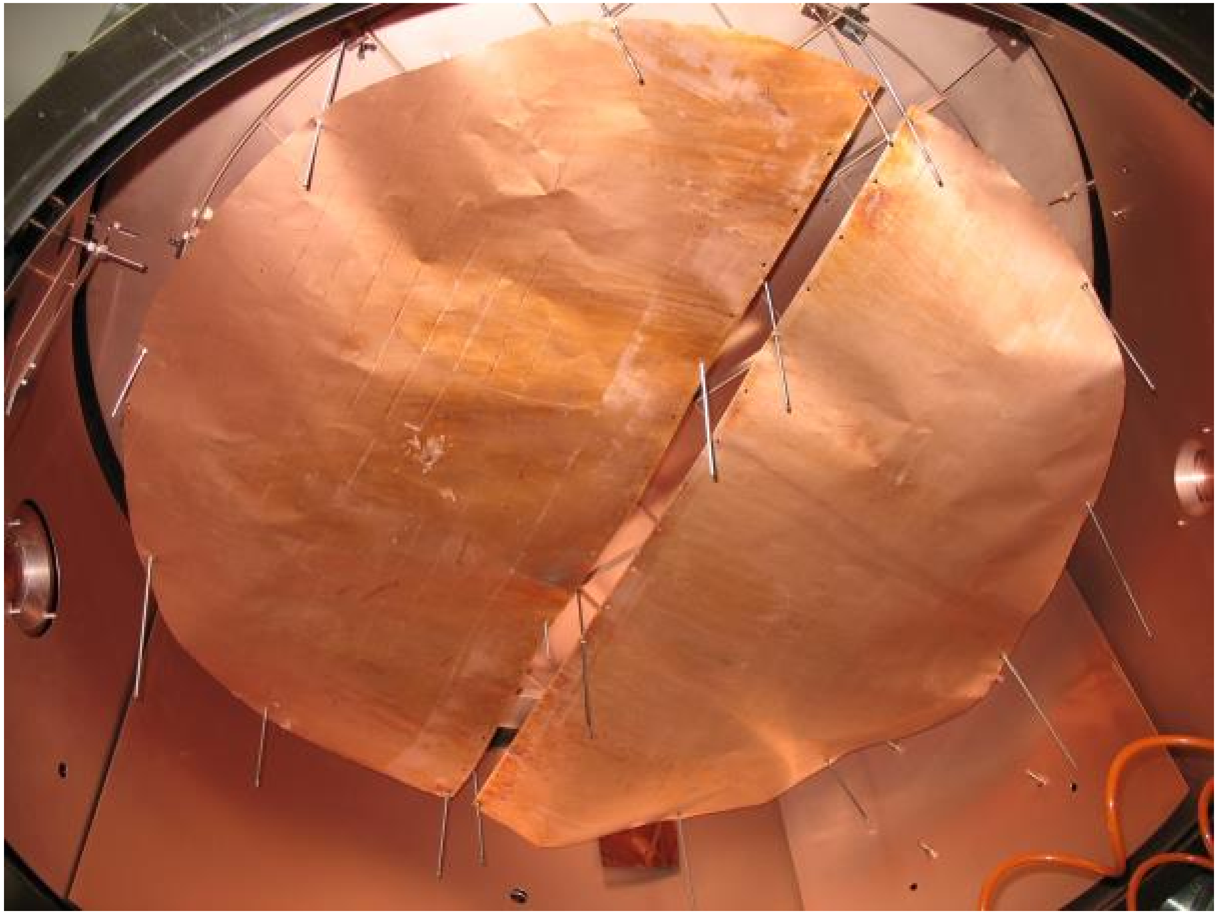
Planar DC magnetron configuration

- Alloyed cathode



Planar DC magnetron configuration

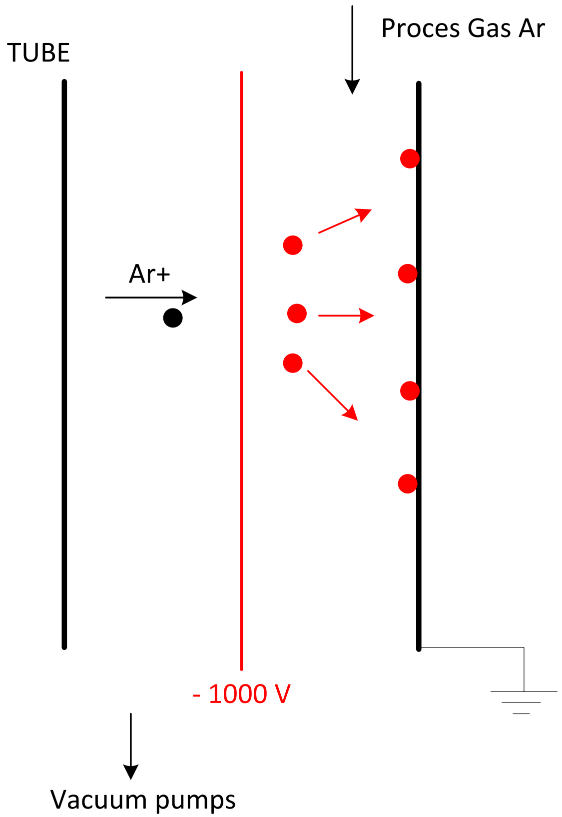
<u>On samples of big dimensions</u>



Ø 1250 mm
1 µm NEG coating
+/- 20 % uniformity

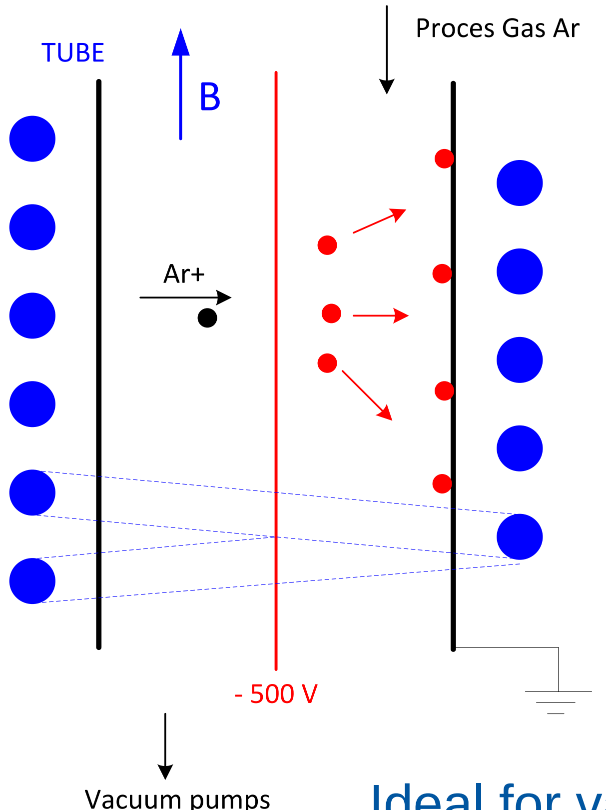
Cylindrical configuration

- General

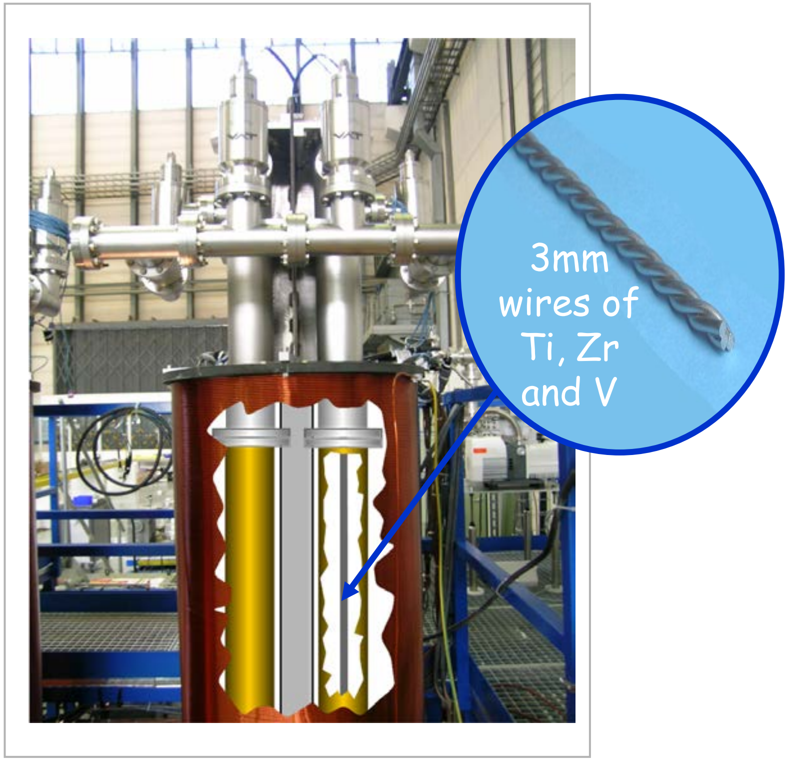


Cylindrical Magnetron configuration

- General



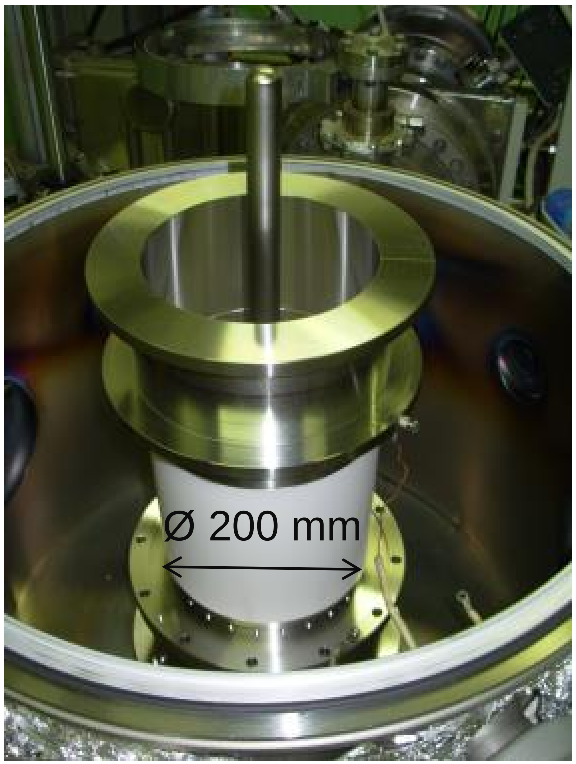
- NEG



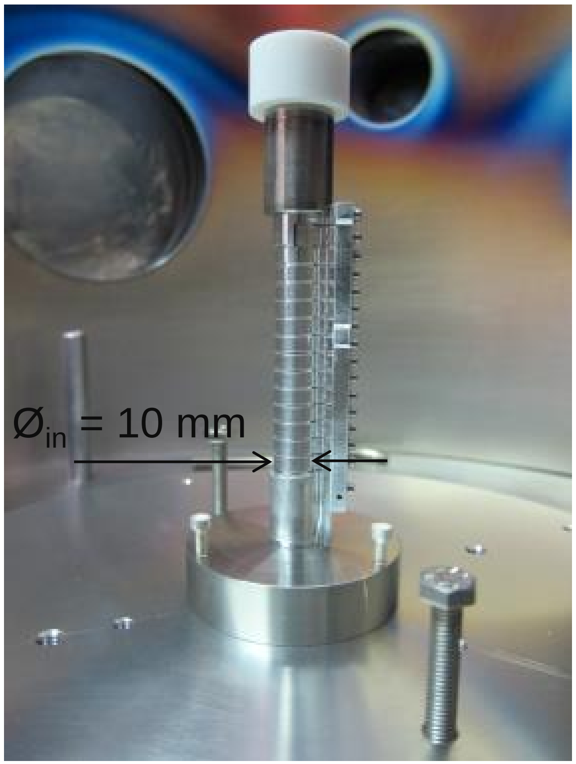
Ideal for vacuum chamber that needs a coating

Cylindrical configuration

Internal coating of object without flanges: in vacuum chamber



PS-booster pick-up

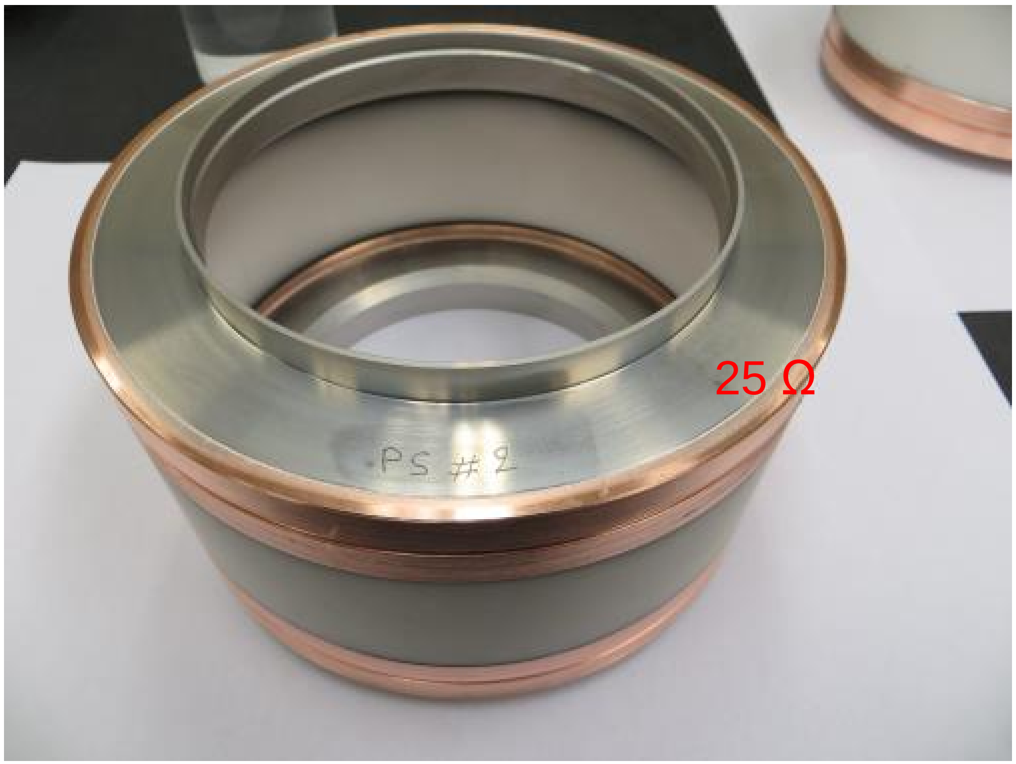


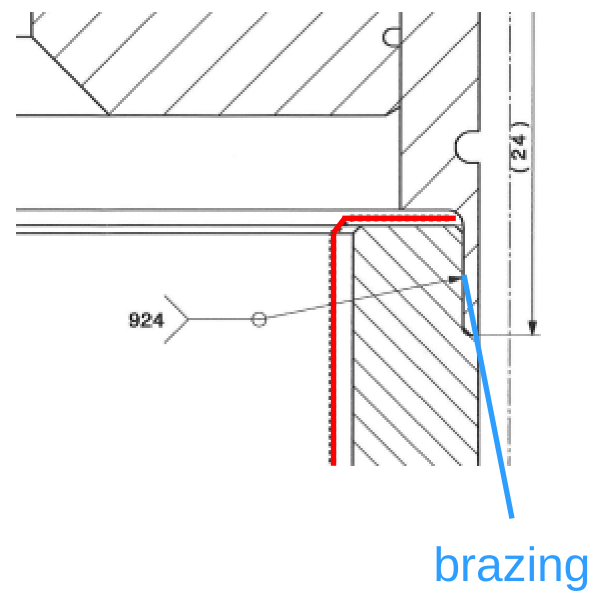
Aegis H-bar cooling trap

Combination of planar + cylindrical

Inductive coupled BPM (particle + medical accelerators)

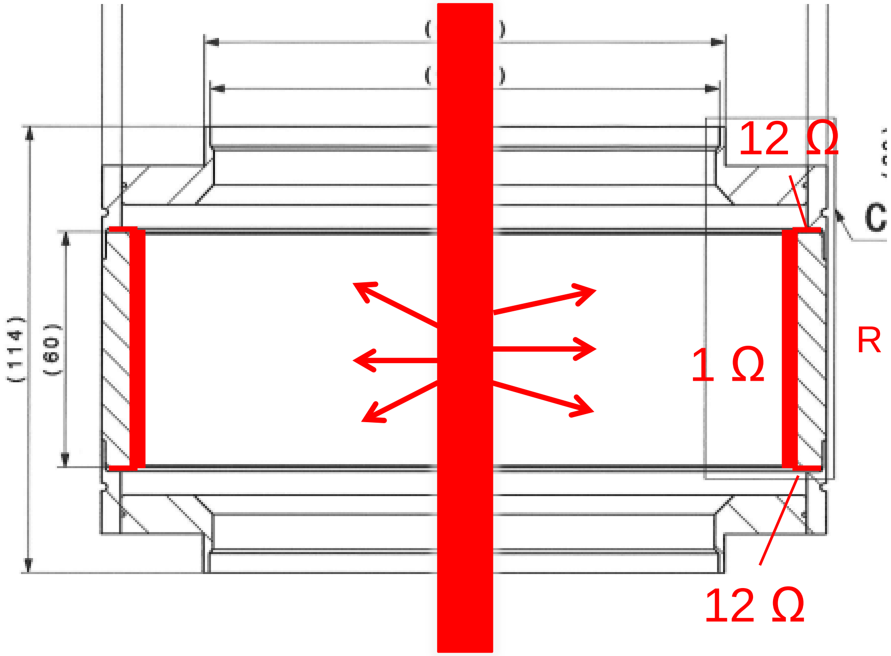
25 Ohm Ti resistive coating over ceramic ring



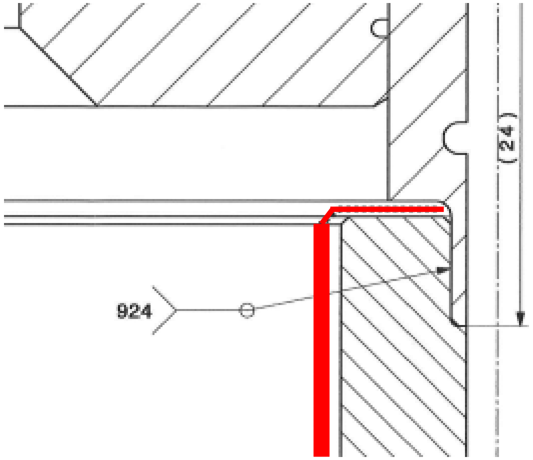


Combination of planar + cylindrical

- 25 Ohm Ti resistive coating over ceramic ring



R = 25 Ohm

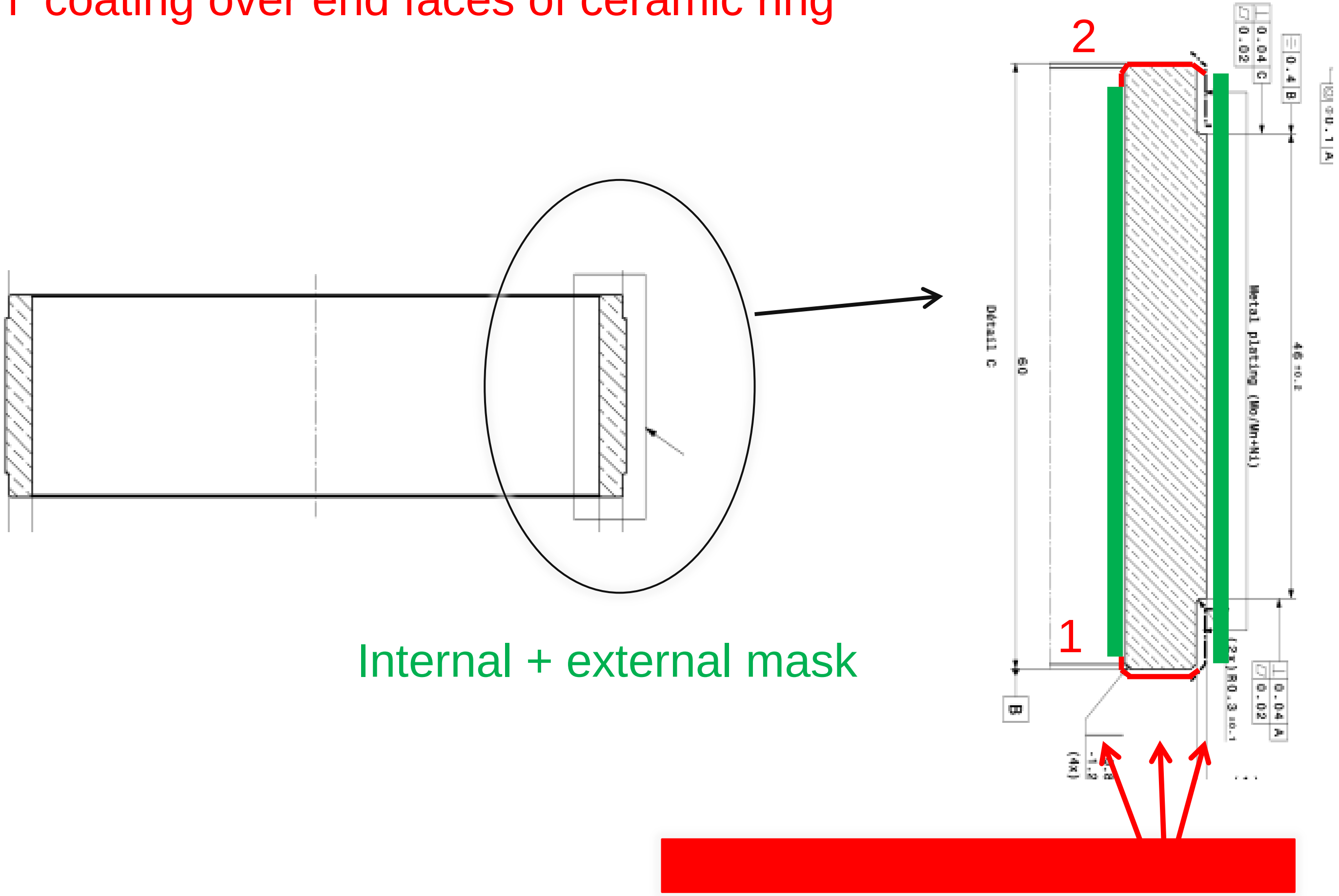


- ~~Cylindrical configuration~~ → combination

Combination of **planar** + cylindrical

25 Ohm Ti resistive coating over ceramic ring

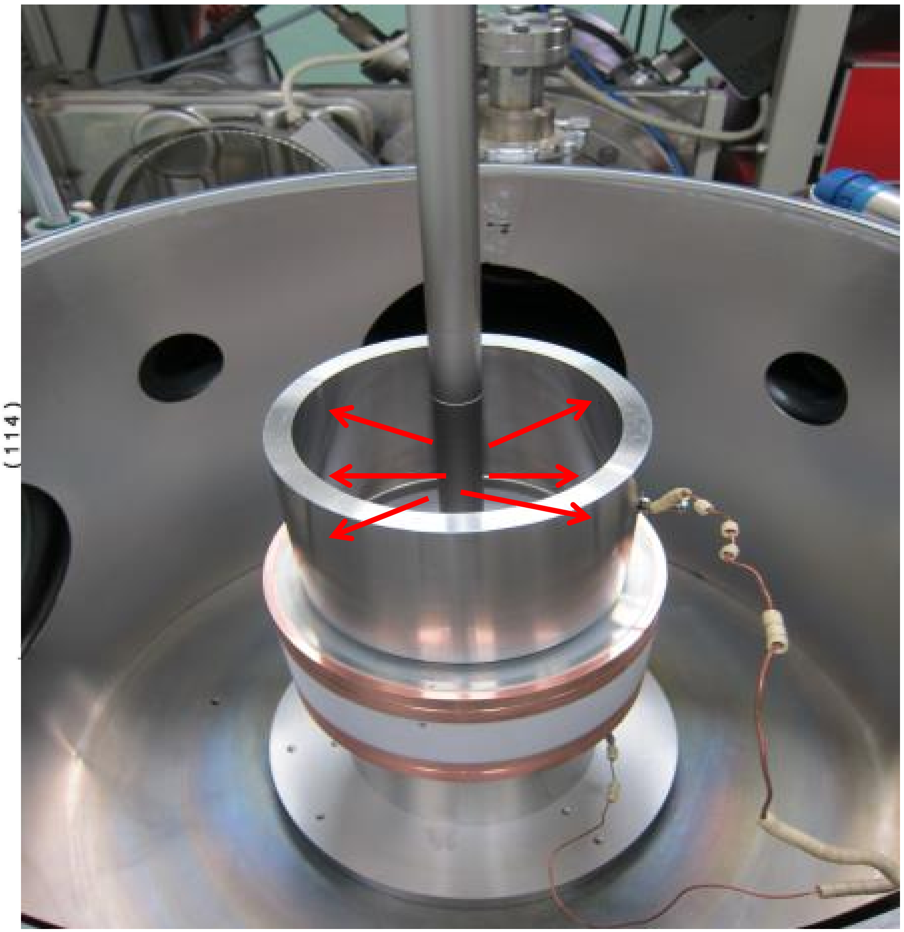
1 Ohm Ti coating over end faces of ceramic ring



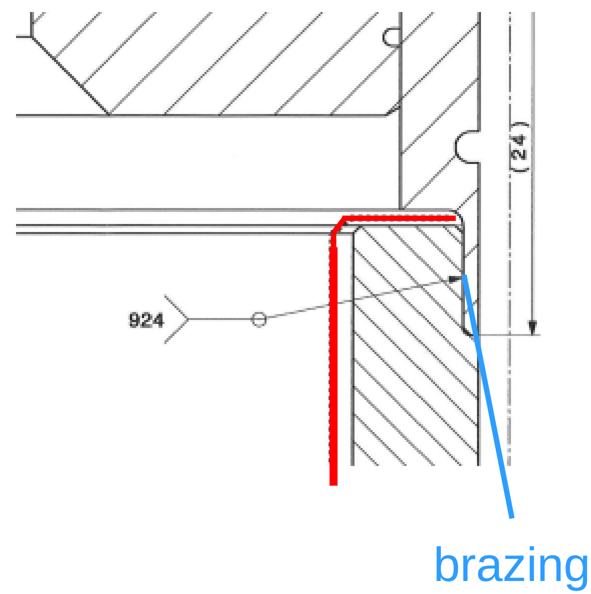
Internal + external mask

Combination of planar + **cylindrical**

- 25 Ohm Ti resistive coating over ceramic ring

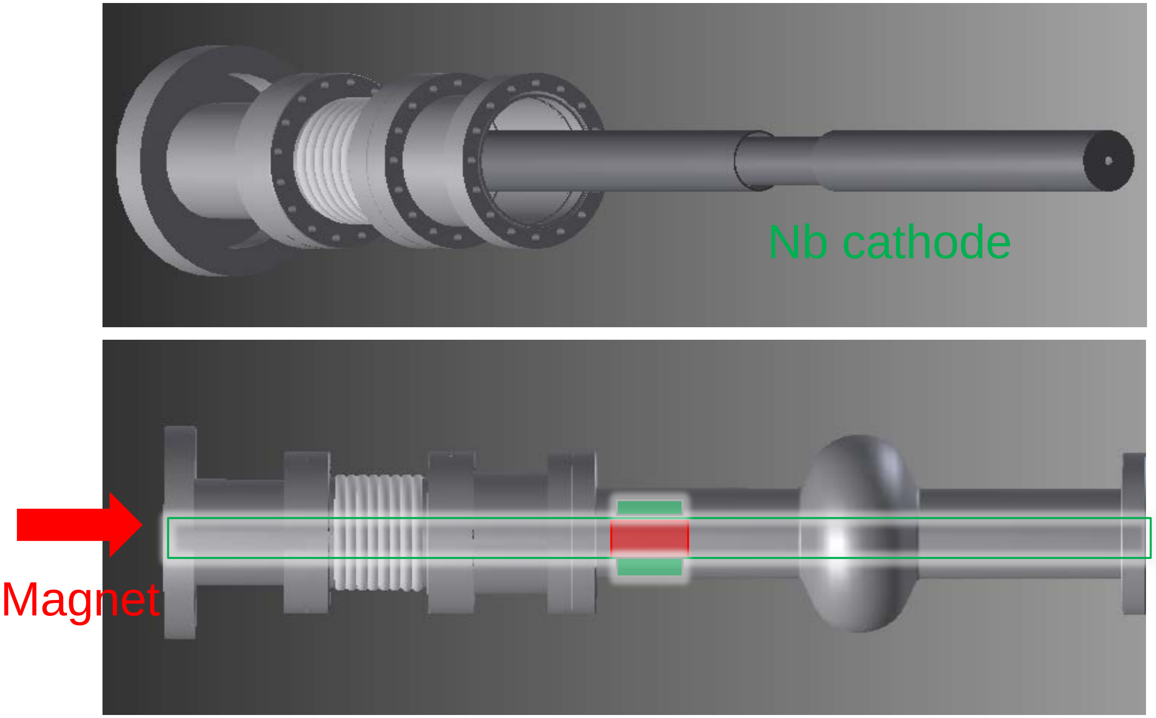


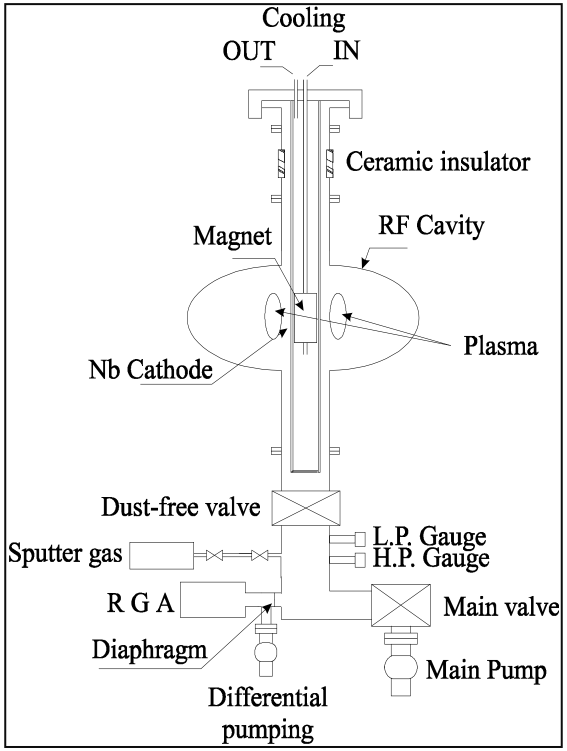
R = 25 Ohm



Cylindrical configuration

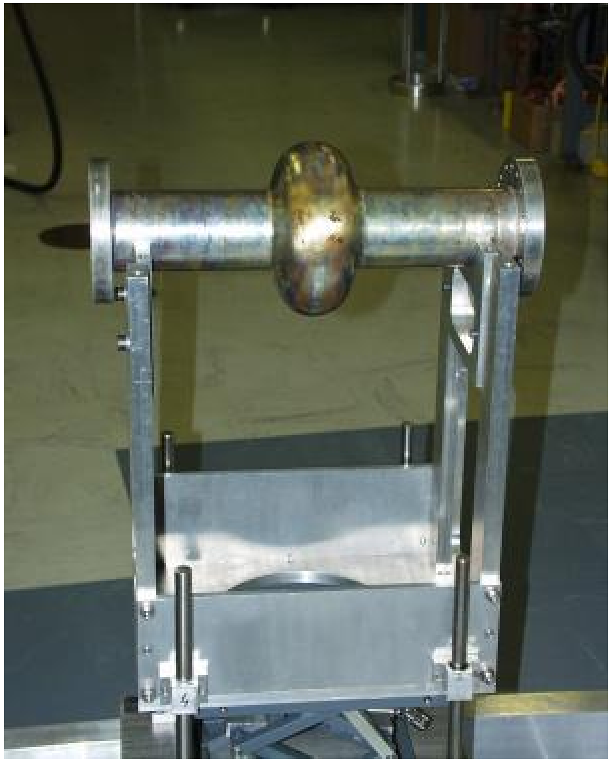
For complex shapes: Superconducting Nb coatings for Cavities





Cylindrical configuration

For complex shapes: Superconducting Nb coatings for Cavities



1.5 GHz
for R&D

Coating set-up DC Magnetron

Cylindrical configuration

For complex shapes: Superconducting Nb coatings for Cavities

LEP 350 MHz

> 250 pieces:
Industrial collaboration

LHC 400 MHz
30 pieces
Industrial collaboration

Cylindrical configuration

For complex shapes: Superconducting Nb coatings for Cavities

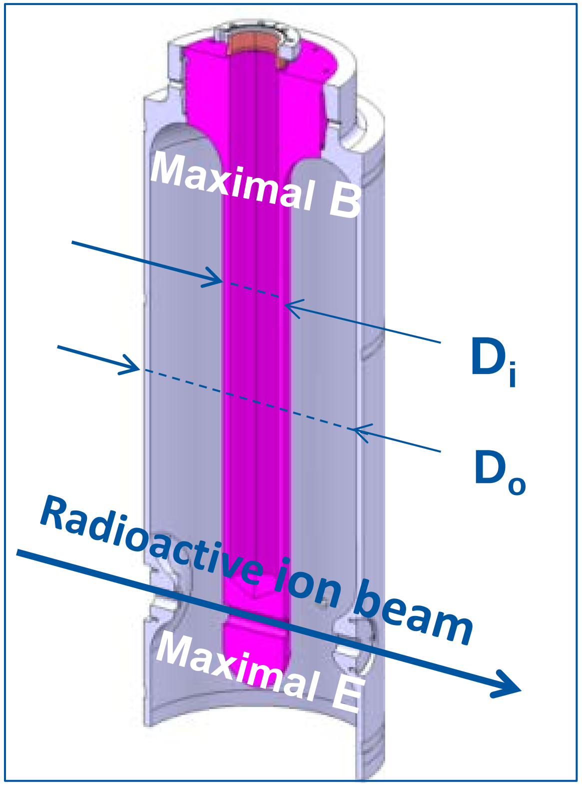
Scientific collaboration

200 MHz

Nb coating on HIE-ISOLDE cavities

→ HIE-ISOLDE facility: upgrade

100MHz High beta **Nb coated** superconductive cavities

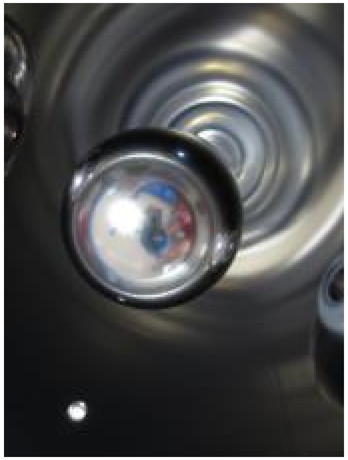


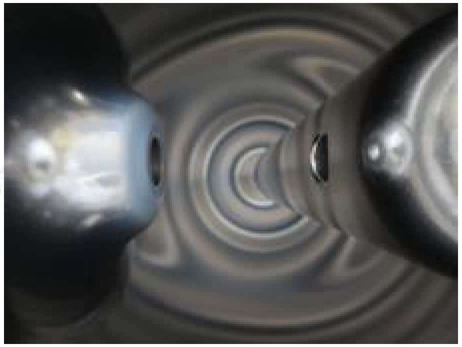
At the end of the project, it is needed to provide :

- **20 High-β cavities**
- 12 Low-β cavities

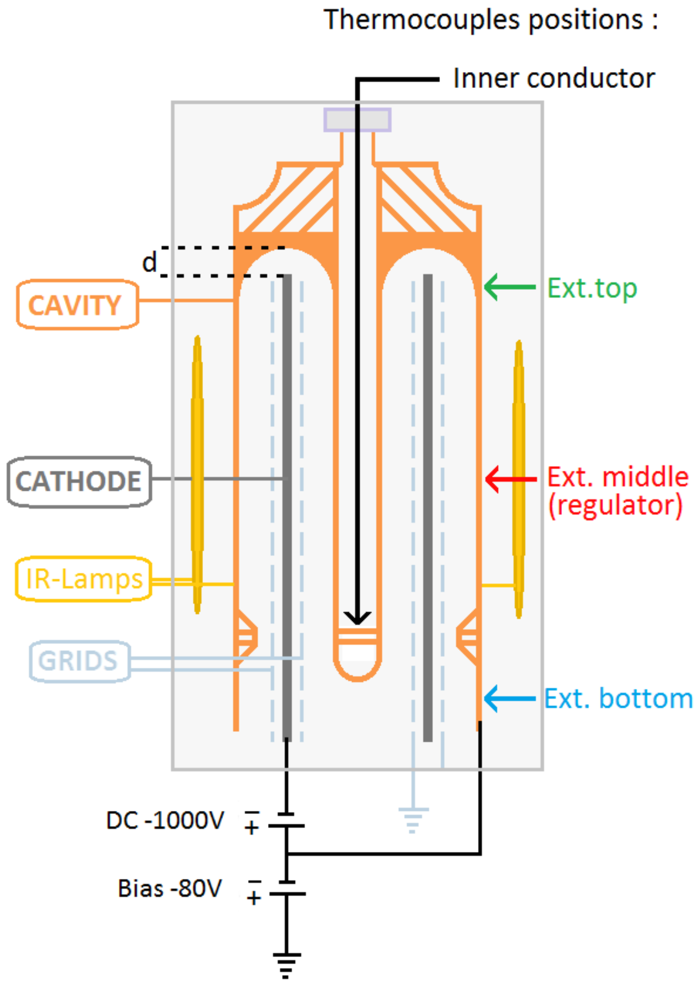
Nb coating on cavities

- → HIE-ISOLDE RF cavities
- before → after Nb coating





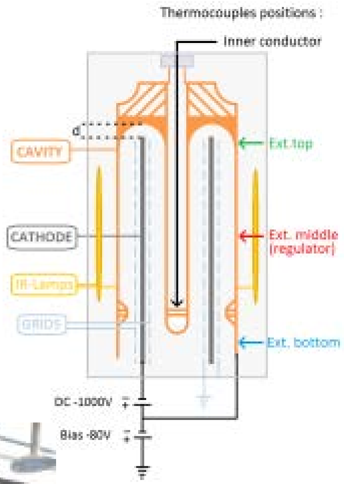
Nb coating on HIE-ISOLDE cavities

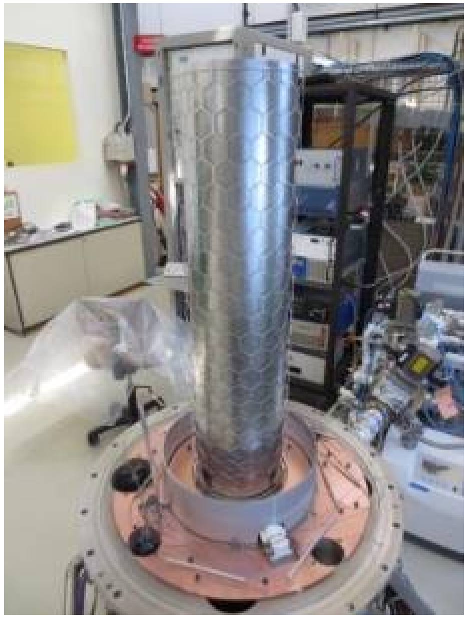


•DC-sputtering in biased diode mode :
- Nb cathode at -1000V
- Grids grounded for plasma polarization
- Cavity **biased** at -80V (to **densify & smooth** Nb layer)

Nb coating on cavities

Assembly in coating system and setup





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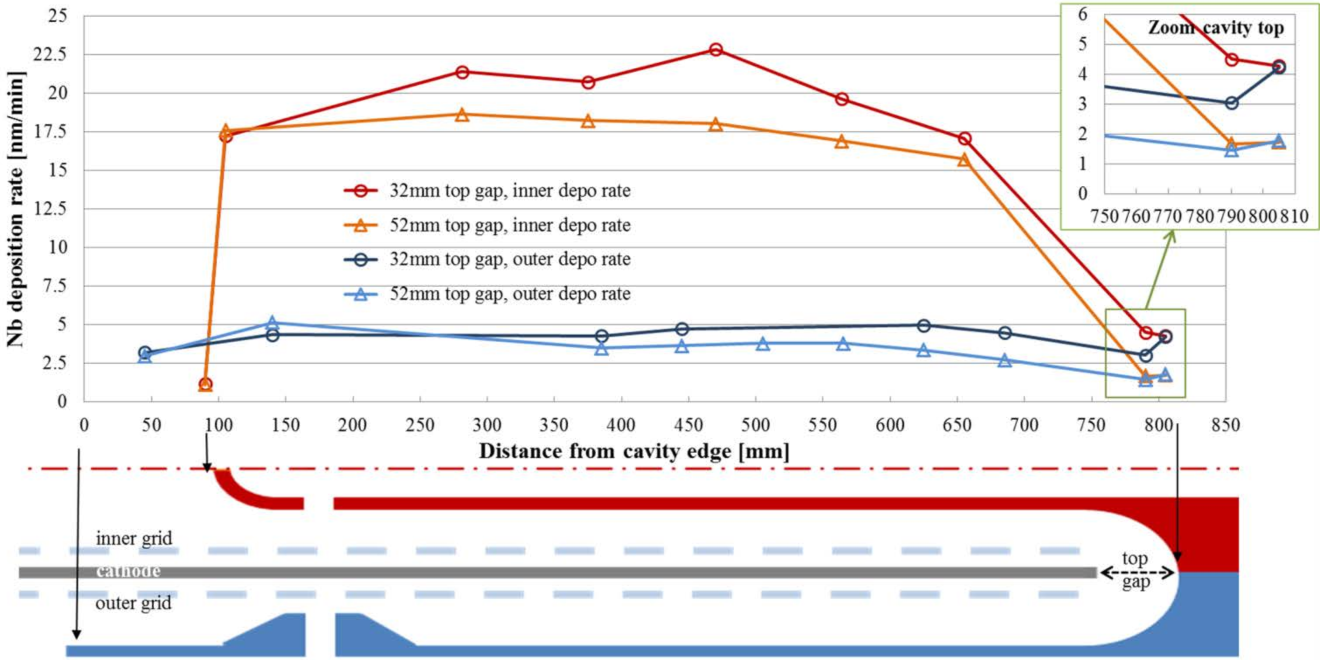
Clean room mounting

Nb coating on cavities

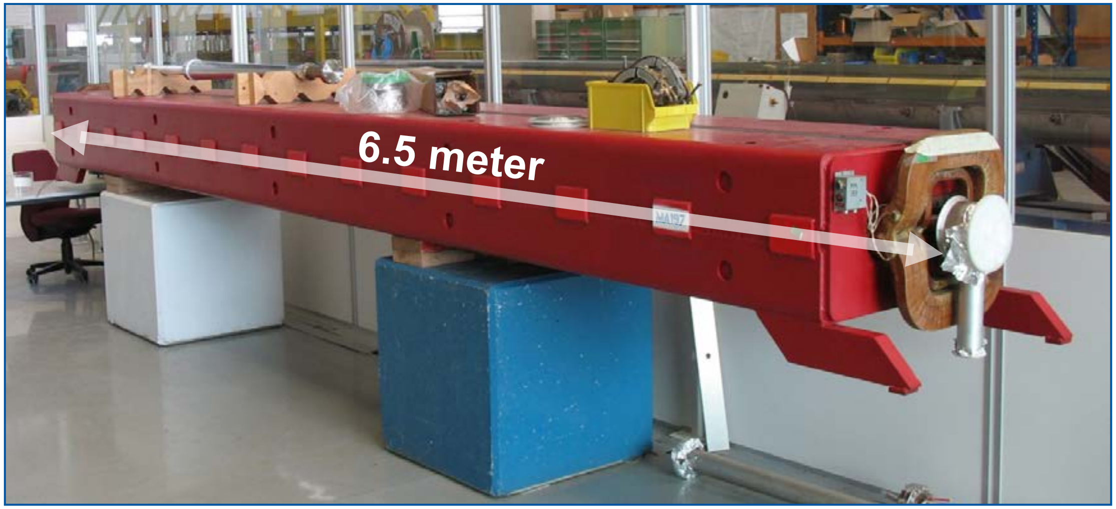
Deposition rate profile along cavity

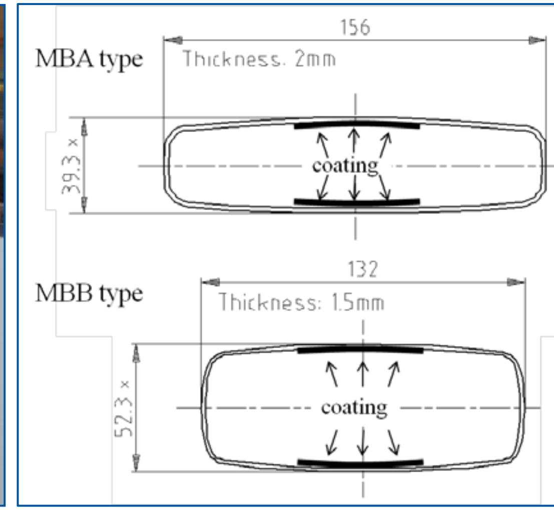


- the smaller the top gap the higher the deposition rate at the top
- x2 deposition rate at the top by reducing the top gap of 20mm
- small difference along the rest of the cavity profile (max 50% higher rate)
- leading to higher quality factor **and better RF performances**

Almost 5 km of the SPS are filled with MBB and MBA type dipoles (>700).

The length of each dipole is 6.5 m and weights ~18 tons.





The beam pipes are embedded in the yoke.

coat new beampipes, open the dipole, insert beampipe, close the dipole.

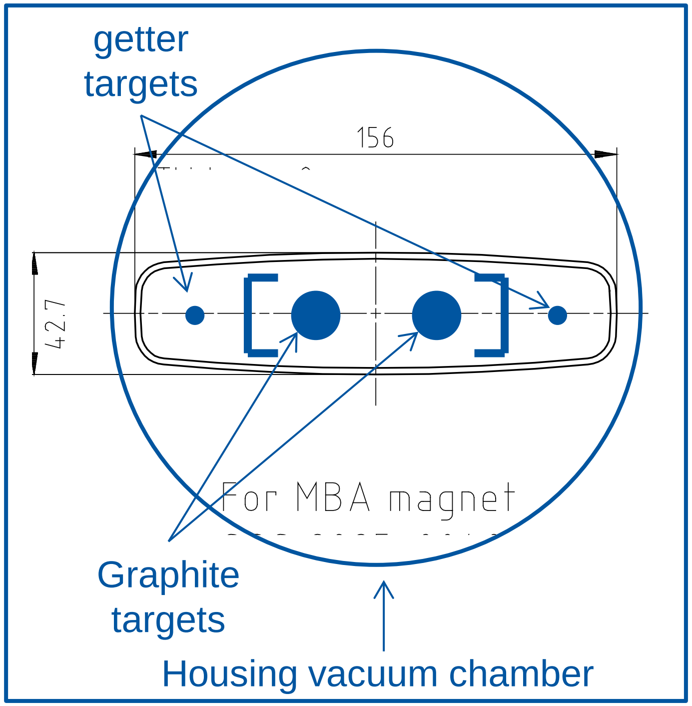
DC Cylindrical Magnetron Sputtering (DCCMS)

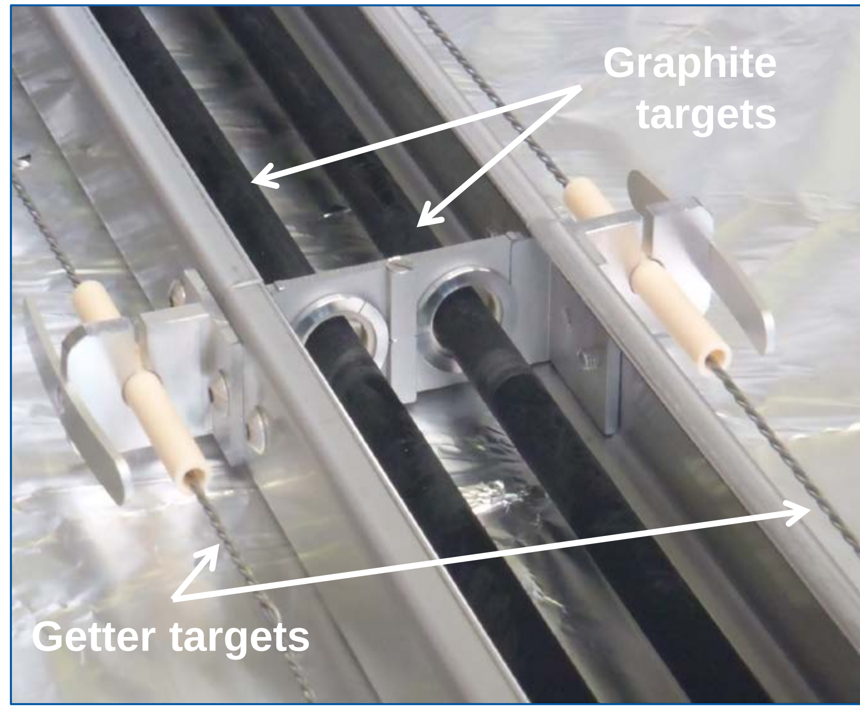
coat the actual beampipes directly in the dipole

DC Hollow Cathode Sputtering (DCHCS)

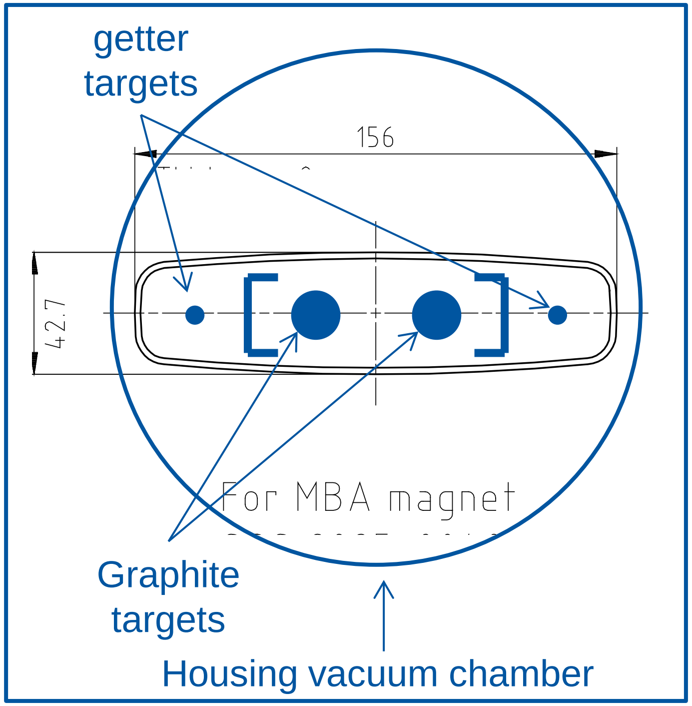
ALREADY SHOWED THIS MORNING BY SERGIO CALATRONI

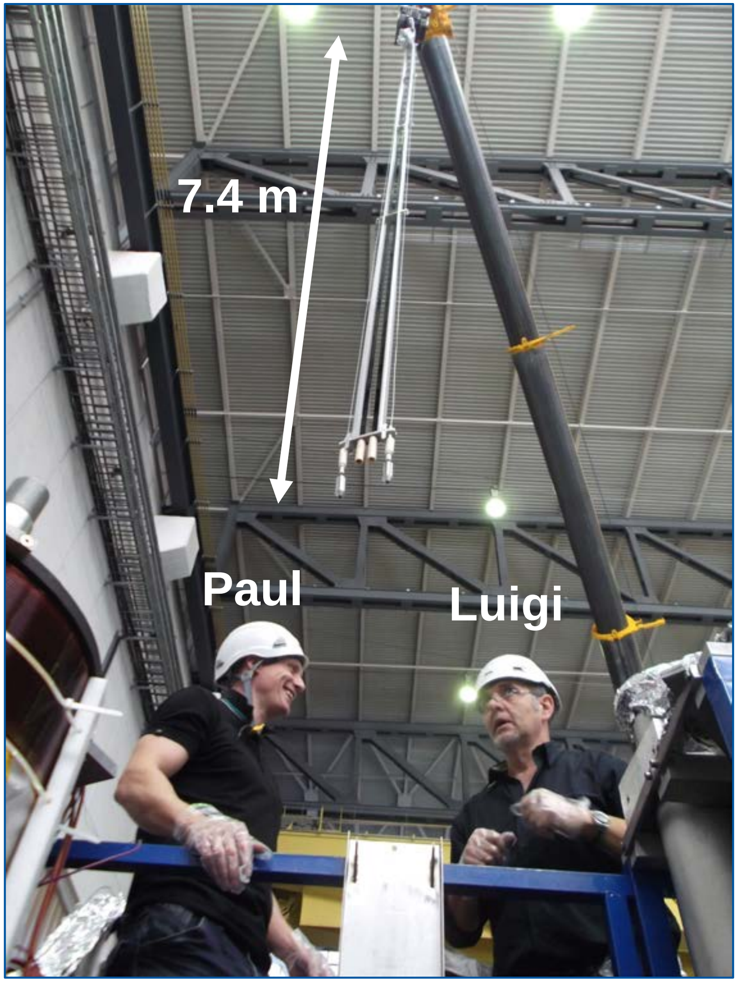
Coat new beampipes by DC Cylindrical Magnetron Sputtering (DCCMS)



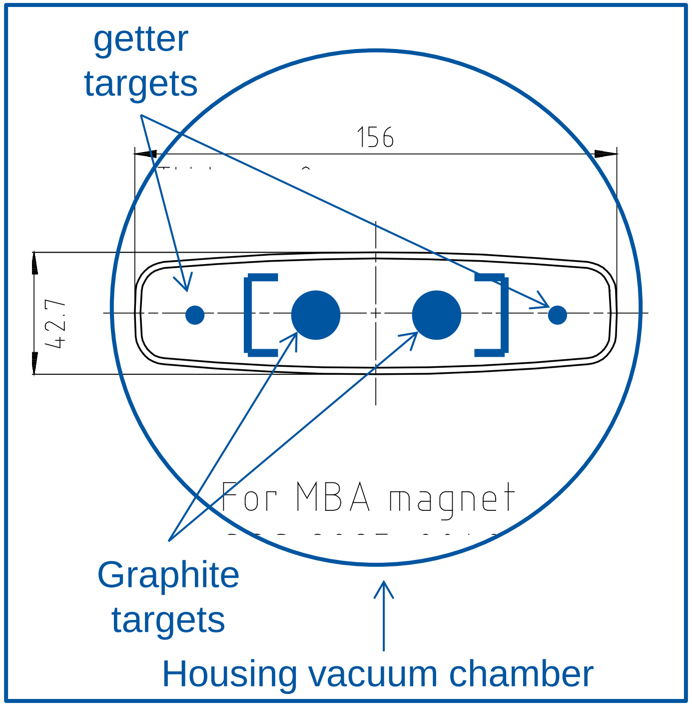


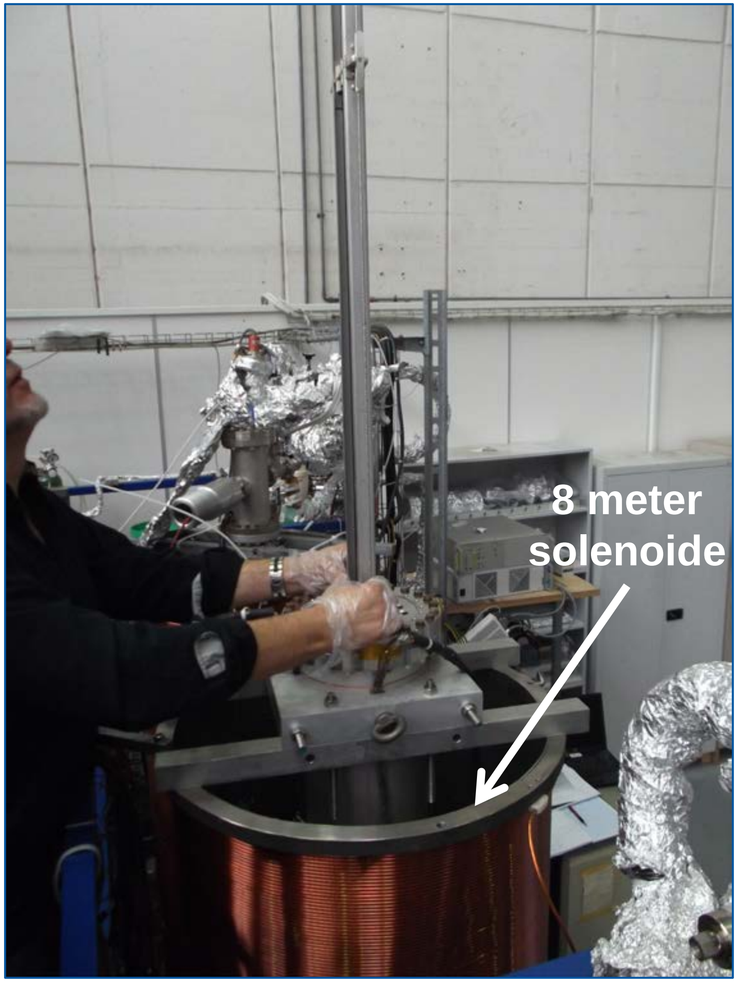
Coat new beampipes by DC Cylindrical Magnetron Sputtering (DCCMS)



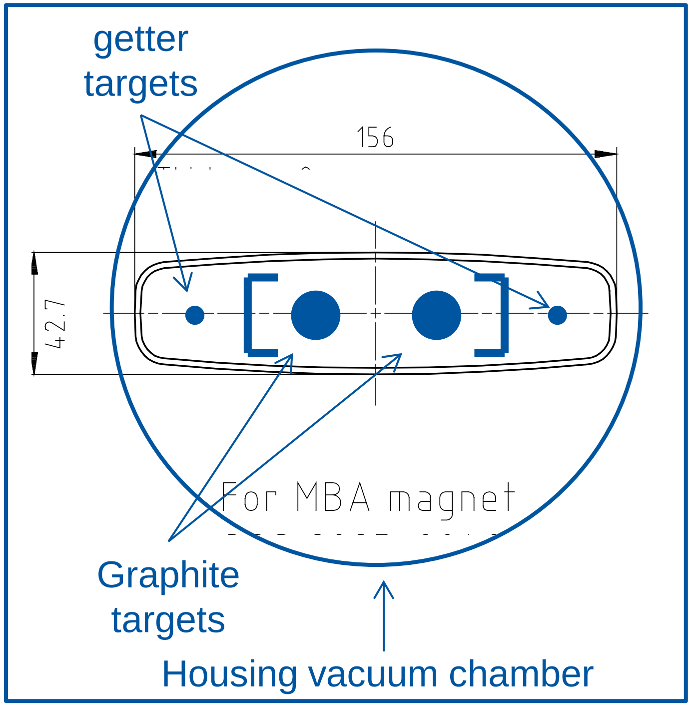


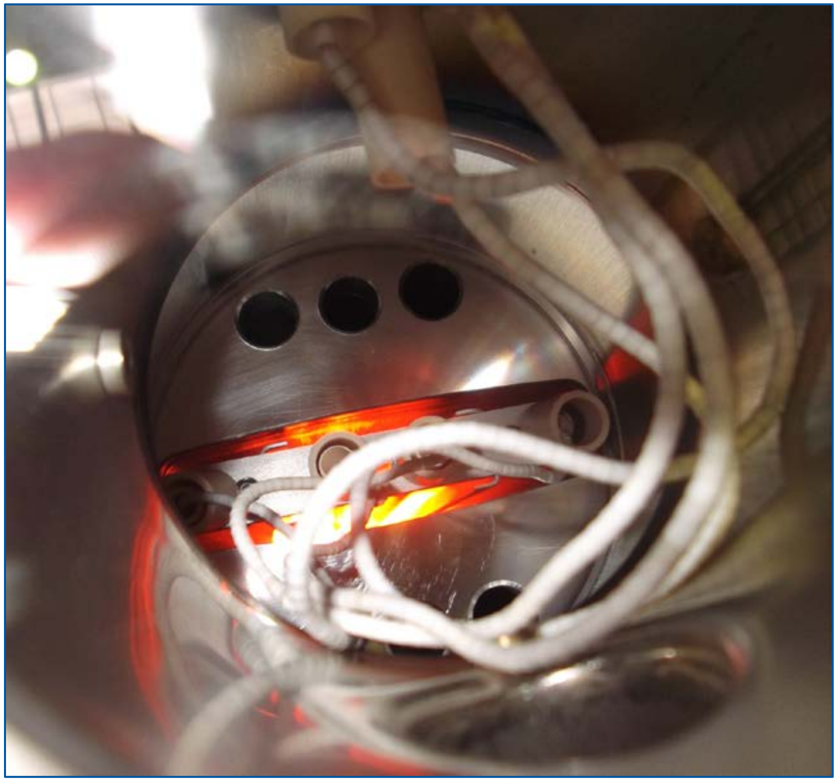
Coat new beampipes by DC Cylindrical Magnetron Sputtering (DCCMS)





Coat new beampipes by DC Cylindrical Magnetron Sputtering (DCCMS)





Pressure: 1.2x10^{-1} mbar (Ne)
Power: 1.8 kW (3A @ 600 V)
B: 180 Gauss

→ ***0.5 μm in 8 hours***

4 magnets coated, installed in SPS; Good Results

Thanks to all colleagues of TE-VSC-SCC

Thanks for your Attention

CERN