Innovative crab cavity design for FCC_hh

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On behalf of the WOWCC development team

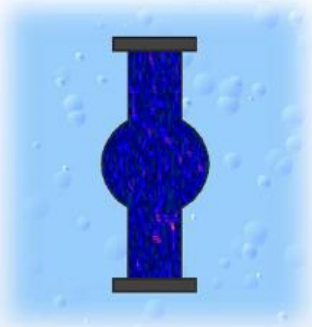
10/04/2018

FCC week 2018, Amsterdam

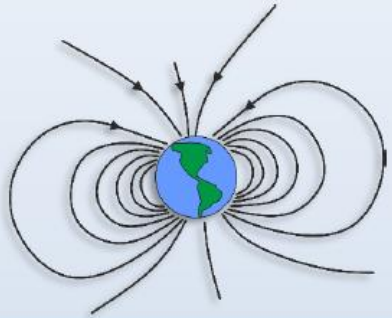
Motivation

S. Aull, SRF2015

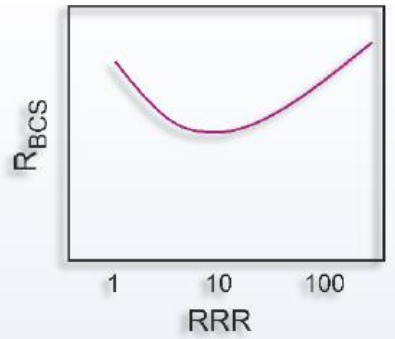
Can we apply the state of the art Nb coating technique to 400 MHz crab cavity?



No thermal runaway



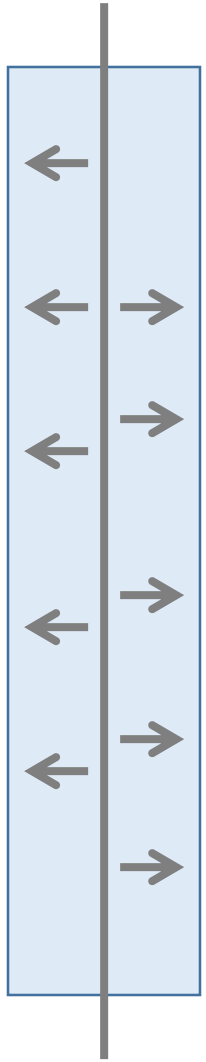
No magnetic shielding



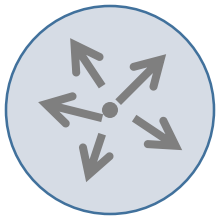
Minimize BCS losses

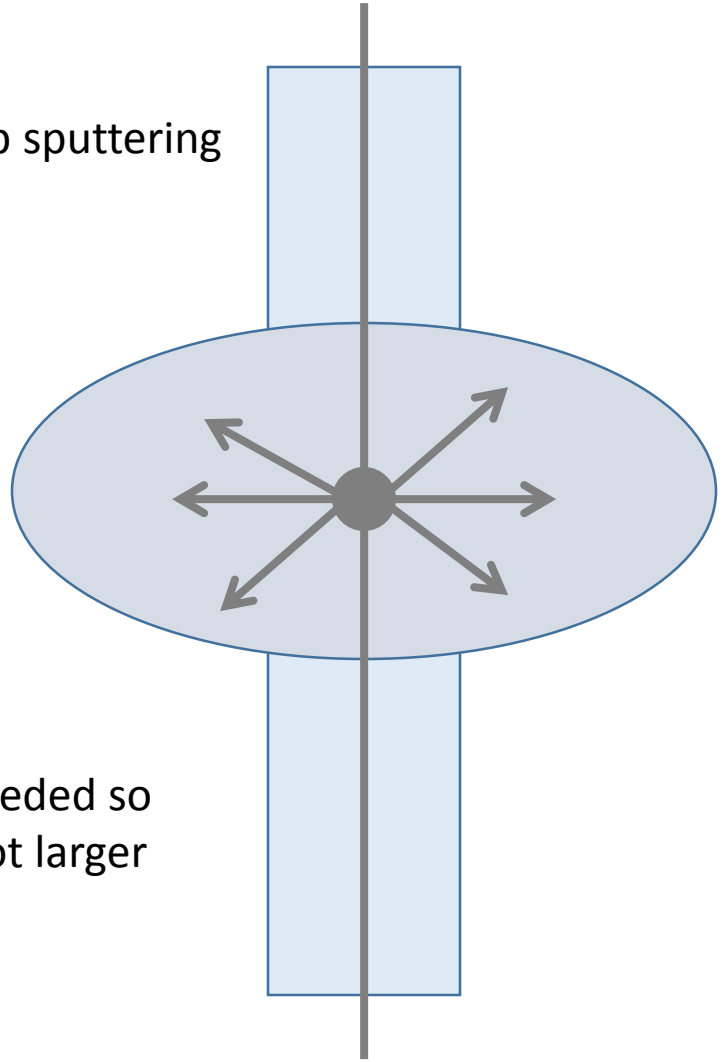
Save on raw material

Nb on Cu coating



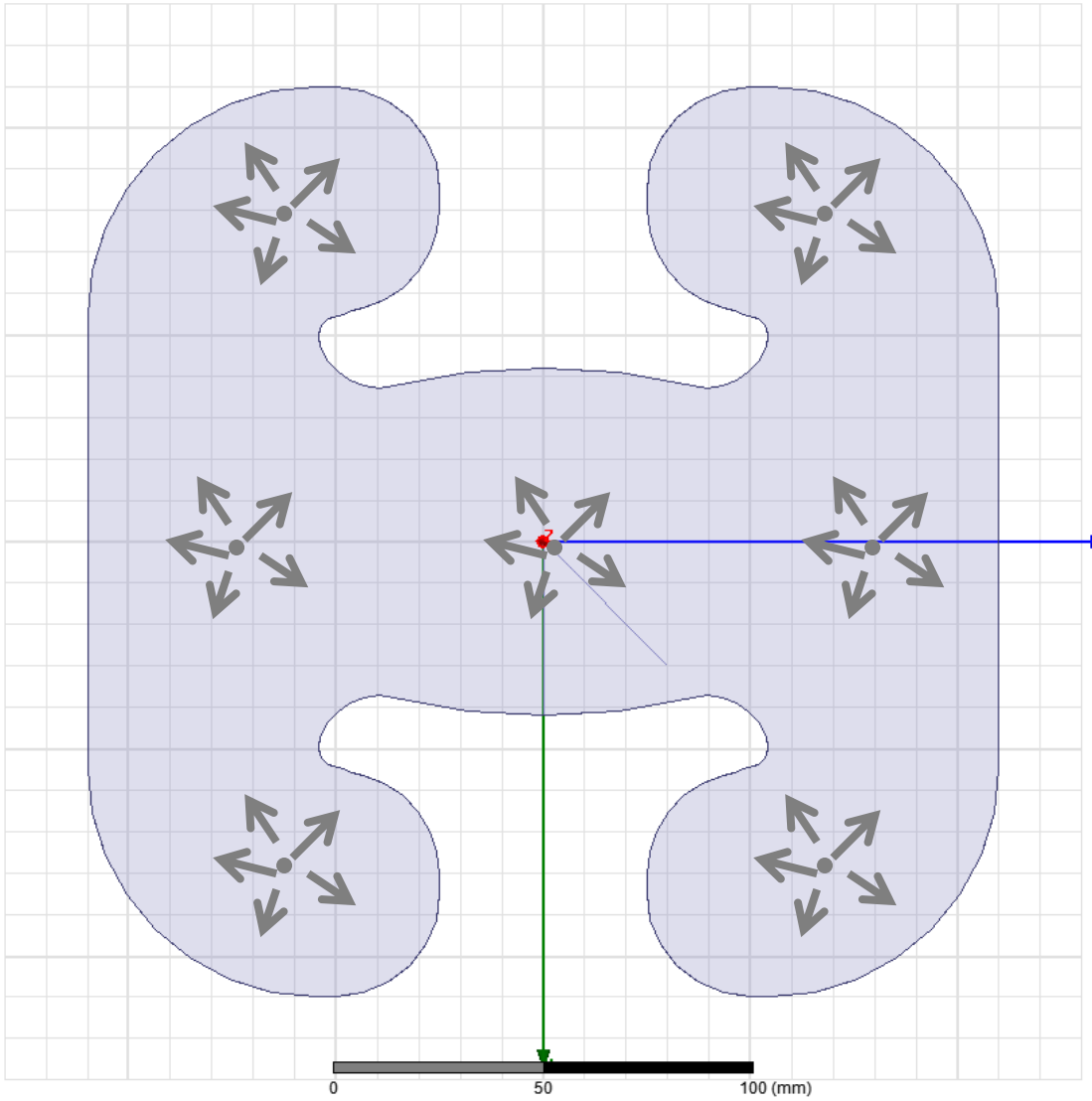
Some standard shapes for Nb sputtering



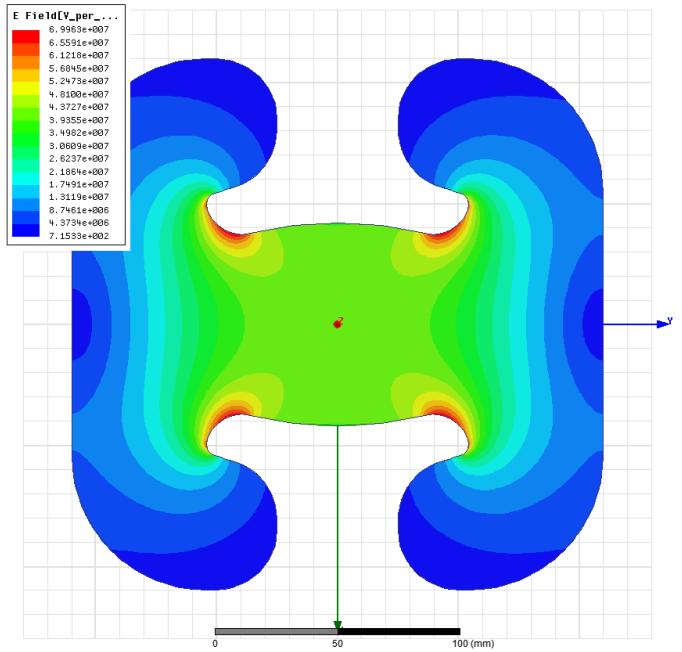


Access to the surface is needed so that the impact angle is not larger than 45 degree

2D cross-section of a compact crab cavity

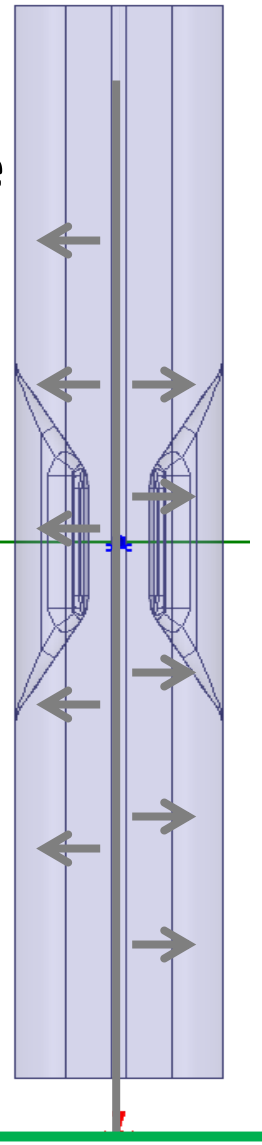


- 2D cross-section of crab cavity requires several sputtering cathodes in order to cover the whole cross section **homogeneously**
- Large aperture beam pipes are needed

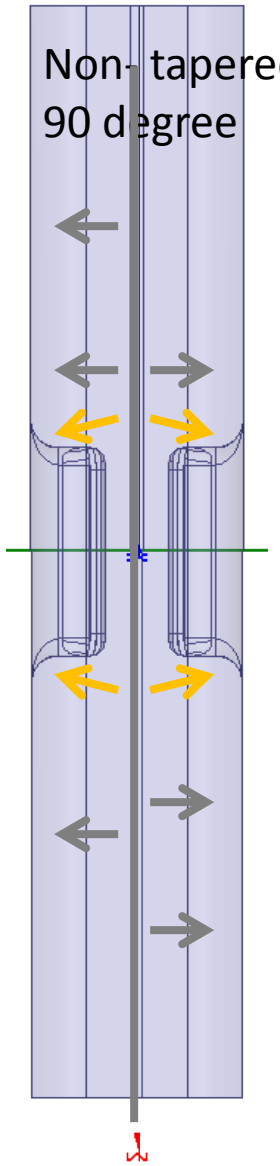


Concept of Wide Open Waveguide (WOW) crab cavity

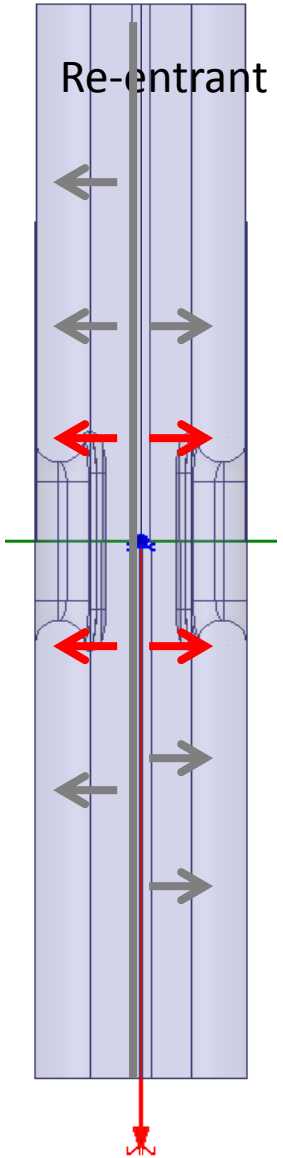
Tapered:
30 degree



Non- tapered:
90 degree

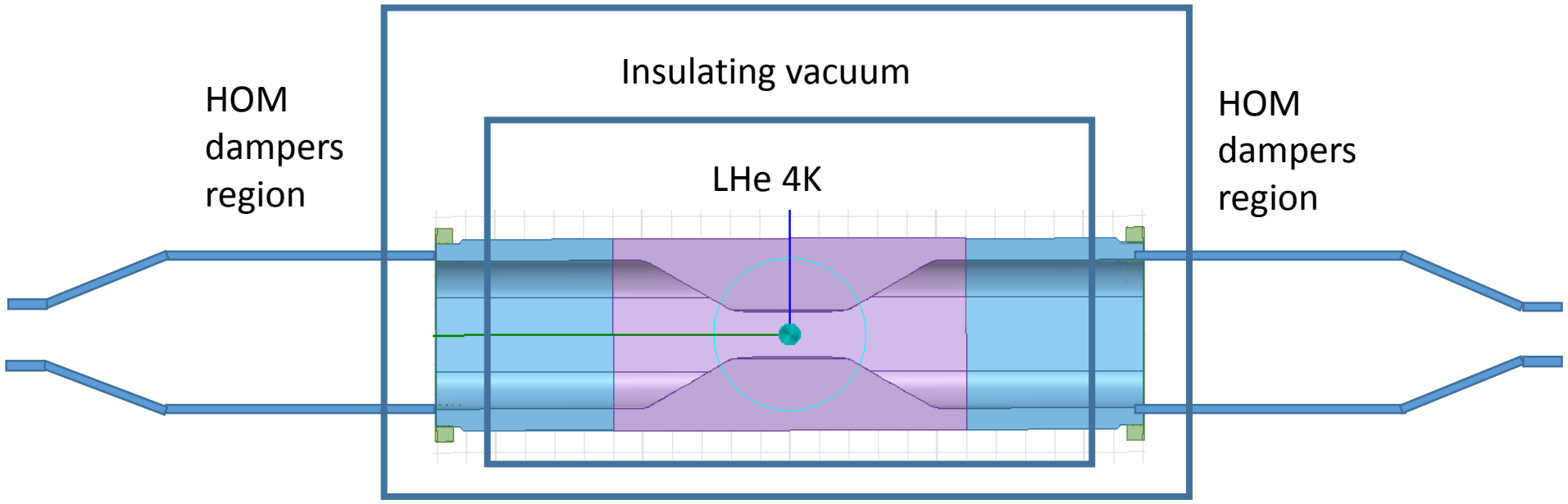


Re-entrant



- Tapered shape is easy to coat. Limit of tapering angle: ~70 deg
- Non-tapered or re-entrant shapes will require more sophisticated coating scheme.

WOW CC layout concept



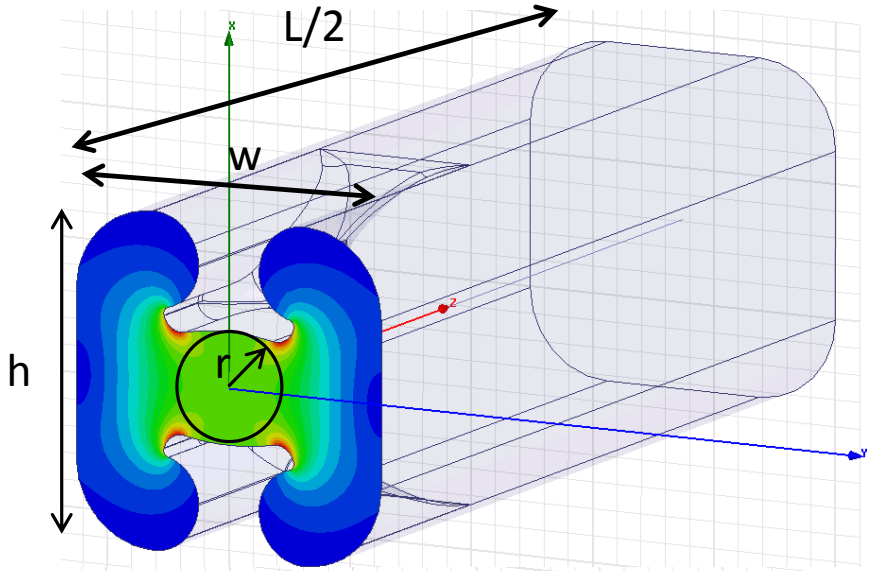
- Big aperture beam pipes carry the HOMs outside of the cryostat
- HOM dampers are located at room temperature outside of the cryostat
- Tapers from big aperture to the standard aperture beam pipe attached at the ends

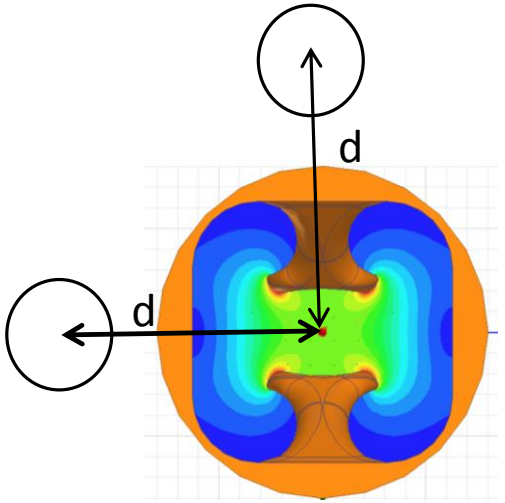
Main Parameter of the WOWCC

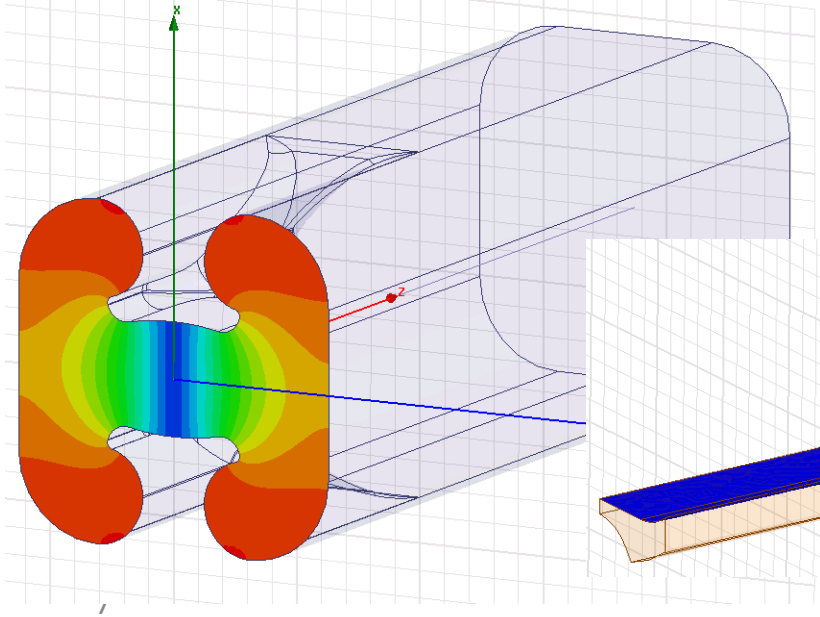
w [mm]	251.70
h [mm]	251.70
r [mm]	42.00
L [mm]	1400.00
d [mm]	192.00

Table 1: Main parameters of the WOWCC

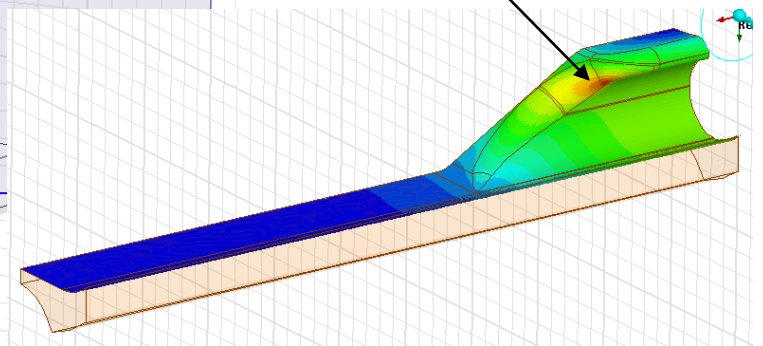
Parameter	Unit	Value
dimensions (W×H×L)	[mm]	250×250×1400
smallest aperture	[mm]	42
frequency	[MHz]	400
geometry factor G	[Ω]	108.9
deflecting voltage V_{x0}	[MV]	3.0
R_x/Q	[Ω]	343.5
E_{pk} at V_{x0}	[MV/m]	45.3
B_{pk} at V_{x0}	[mT]	78.3
Q_0 at V_{x0}		4.0×10^8



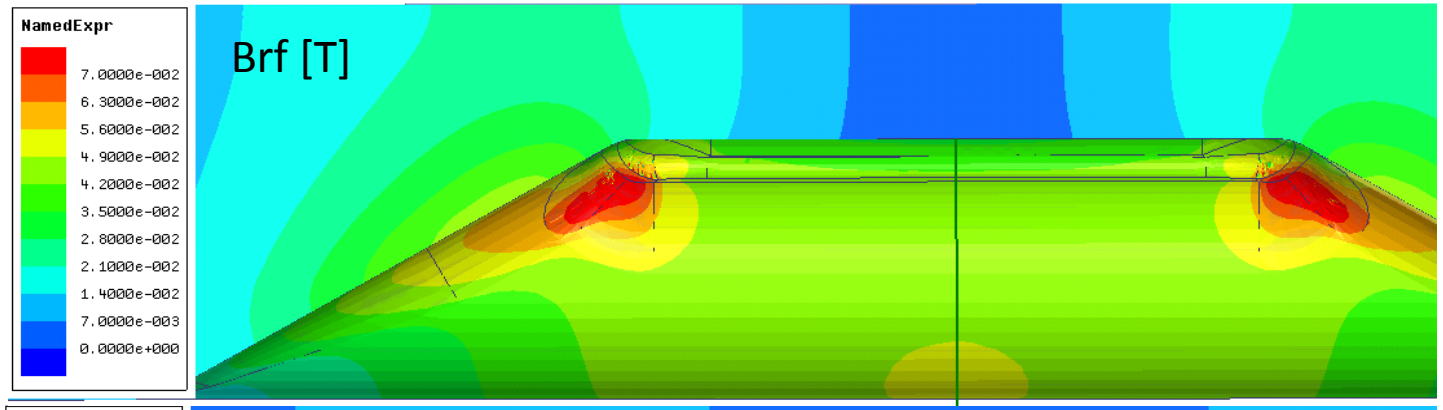


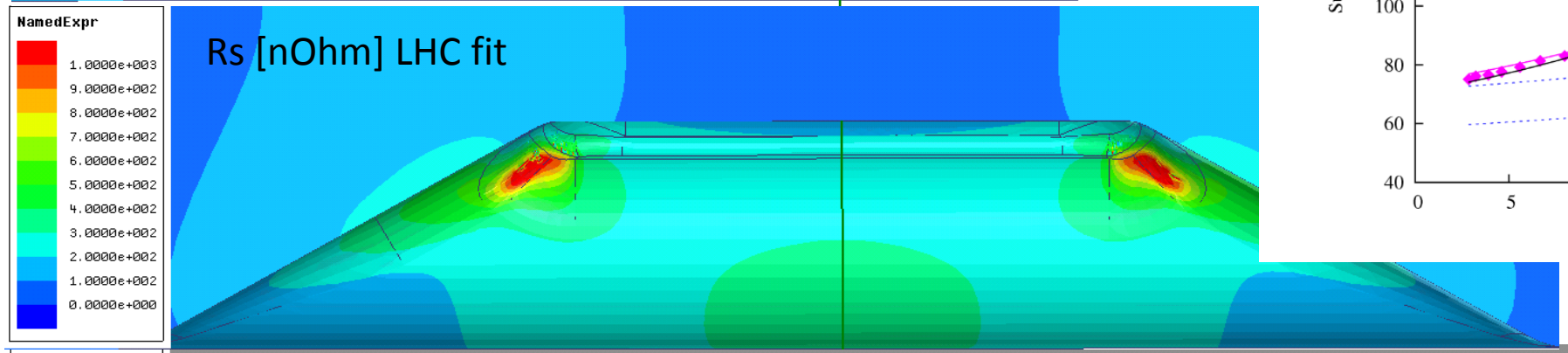


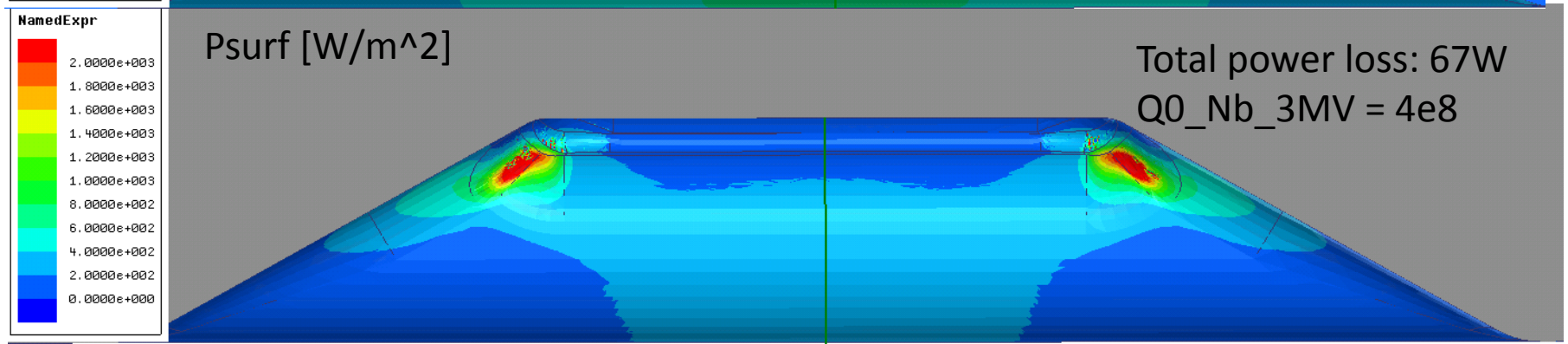
B_{peak} = 70 … 80 mT

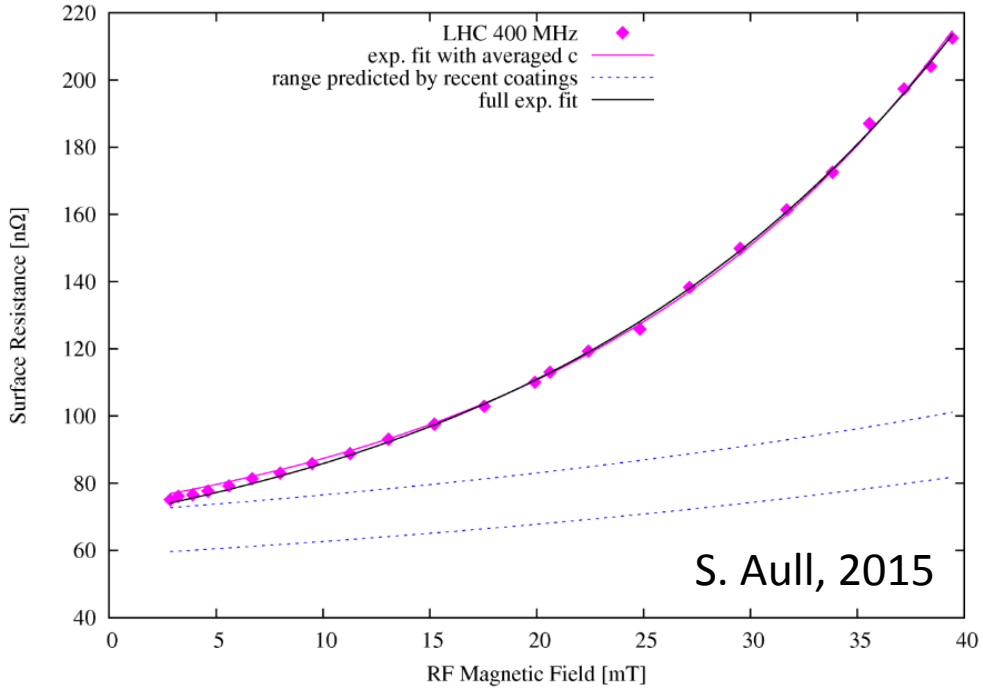


Power loss distribution on the surface at 3 MV









Though LHC data has been taken for Q factor calculation,
there is a big potential in the new coatings.

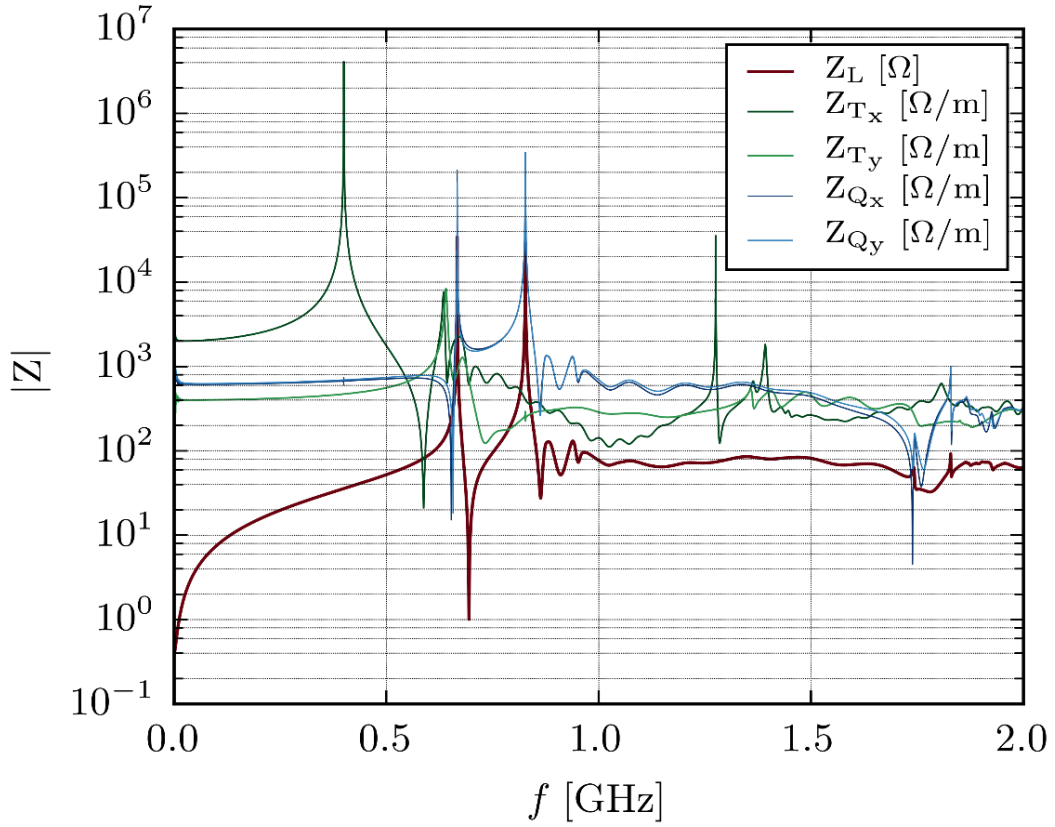
Wake Field and Impedance Calculation

Monopole

Loss factor [V/pC]	0.012
$(Z_L/N)_{eff}$ [mΩ]	**0.974**

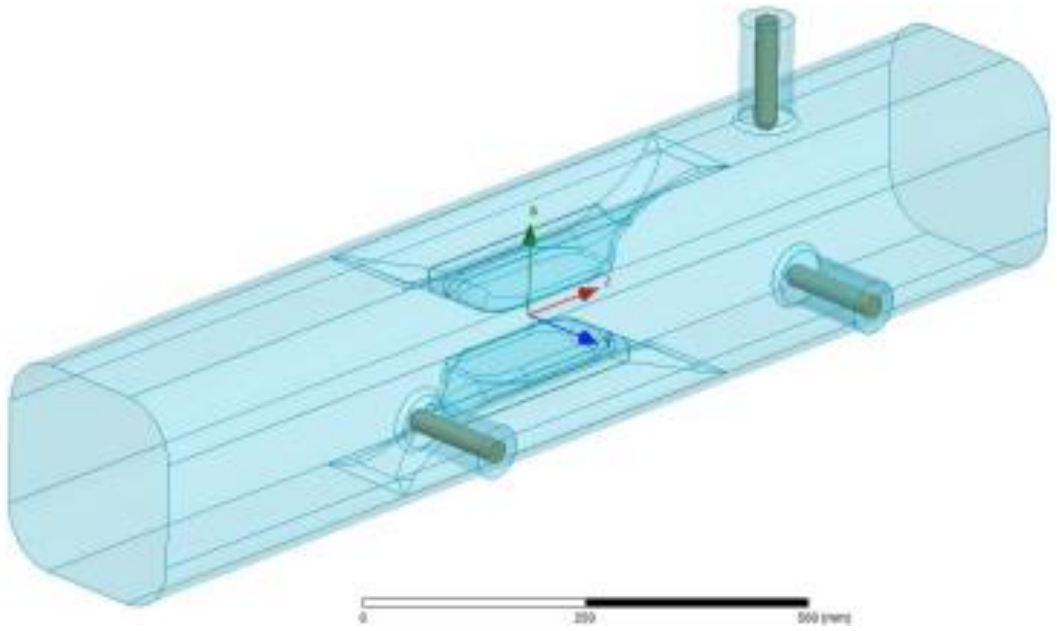
Dipole

Kick factor x [V/pC/m]	1.673
Kick factor y [V/pC/m]	0.460
$(Z_T)_{eff}$ x [Ω/m]	**1562.8**
$(Z_T)_{eff}$ y [Ω/m]	437.6



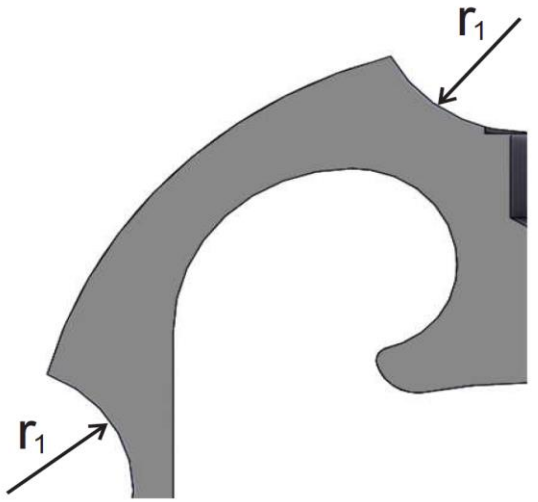
HOMs of the WOWCC

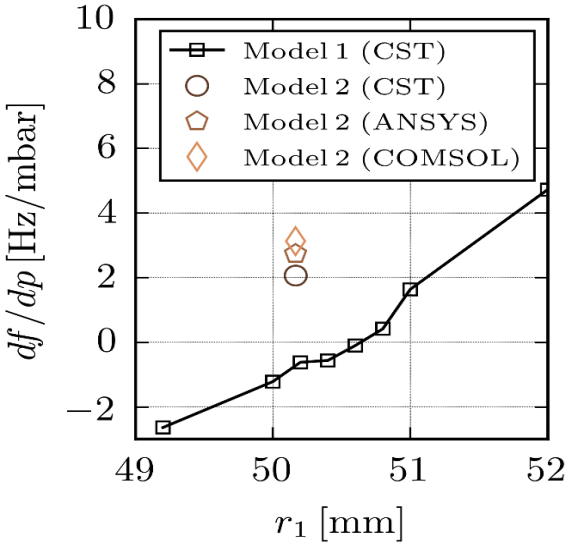
Cavity mode[a]	f [MHz]	R/Q [Ω][b]	Beam pipe mode[a]	Cut-off [MHz]	Q_{ext}[c]
TE_{111}	400.0	342.7	TE_{11}	624.9	1.0×10^6
TE_{112}	638.3	15.7	TE_{11}	624.9	< 35
TE_{111}	643.8	0.08	TE_{11}	624.9	< 40
TE_{012}	667.0	13.9	TM_{01}	847.6	4.8×10^4
TM_{011}	827.2	25.1	TM_{01}	847.6	4.8×10^3
TE_{211}	1276	0.30	TE_{21}	1180	2.3×10^4



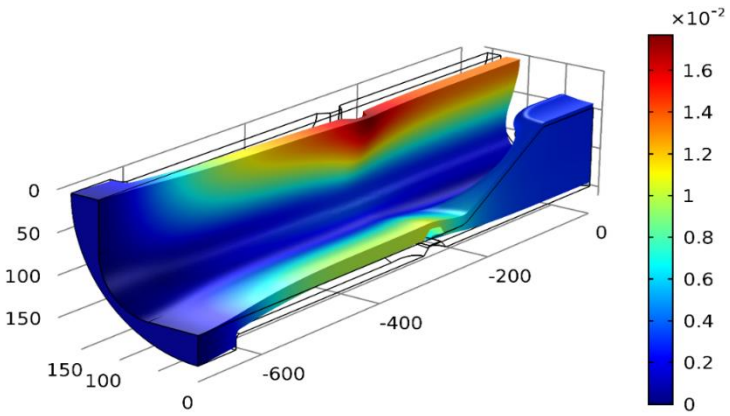
RF frequency sensitivity to Pressure

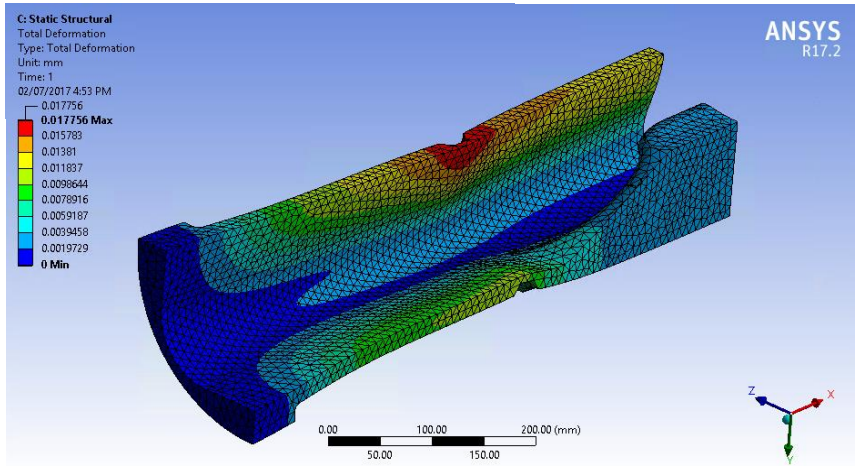
- Outer cavity shape is optimized such that the deformation of pressure fluctuation affects the fundamental mode frequency as less as possible
- External shape is parametric in r1 (groove radius)
- Three codes compared: CST, ANSYS, and COMSOL





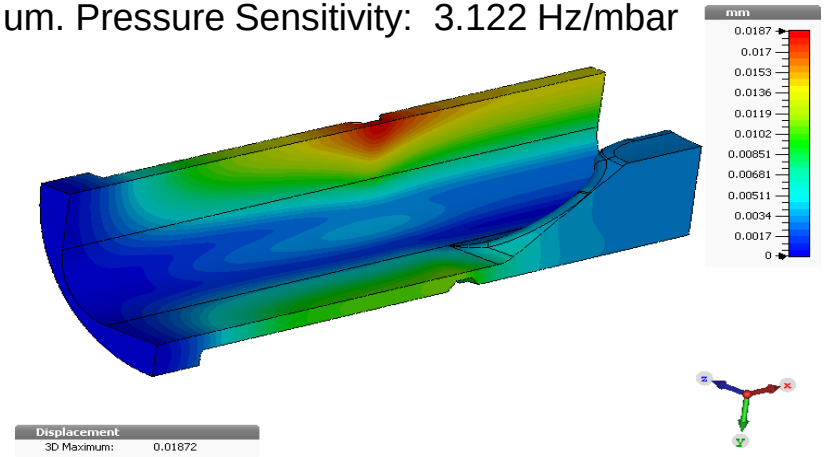
CST Simulation. Max. deformation: 18.7 um. Pressure Sensitivity: 2.068 Hz/mbar



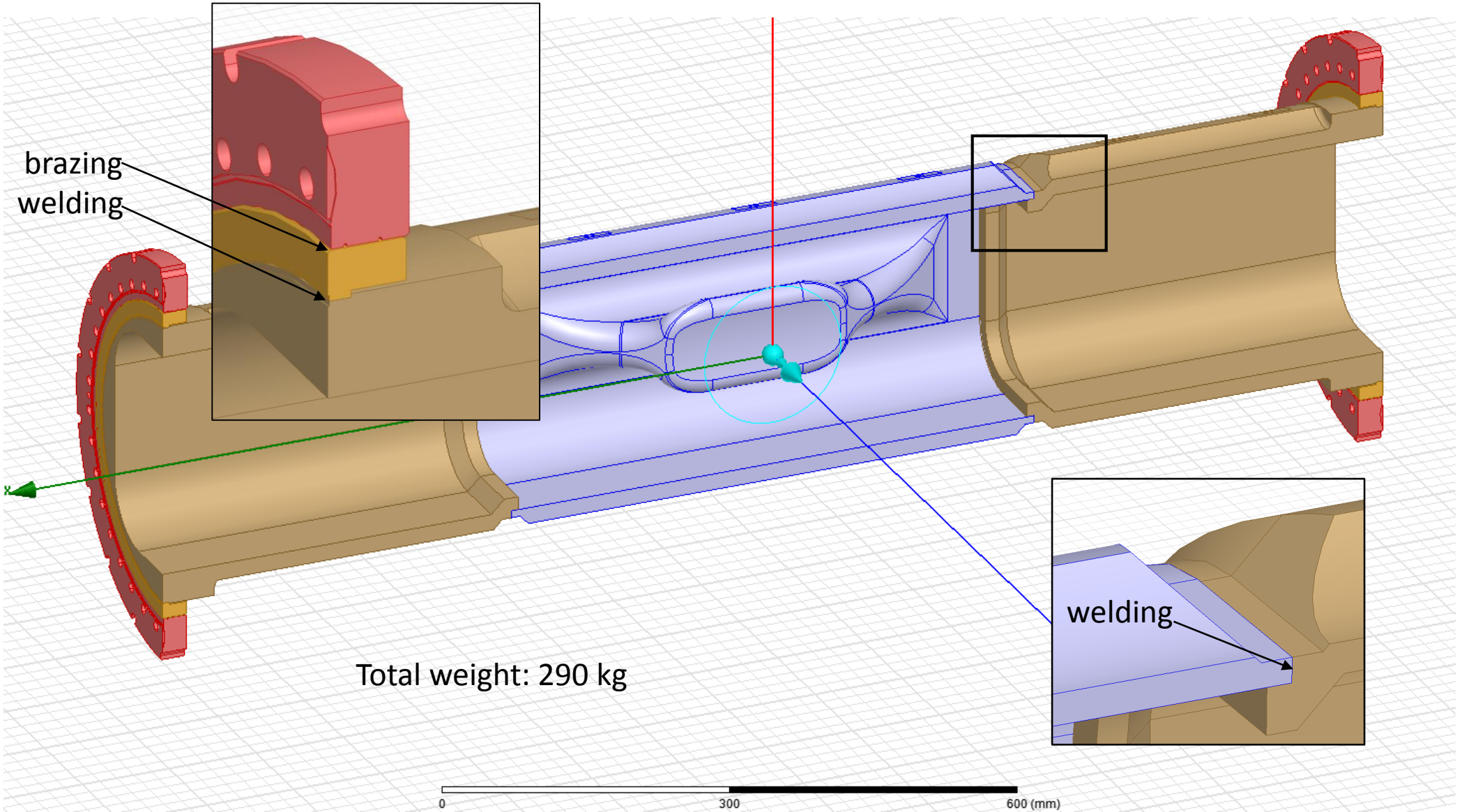


ANSYS-HFSS Simulation. Max. deformation: 17.7 um. Pressure Sensitivity: 2.732 Hz/mbar

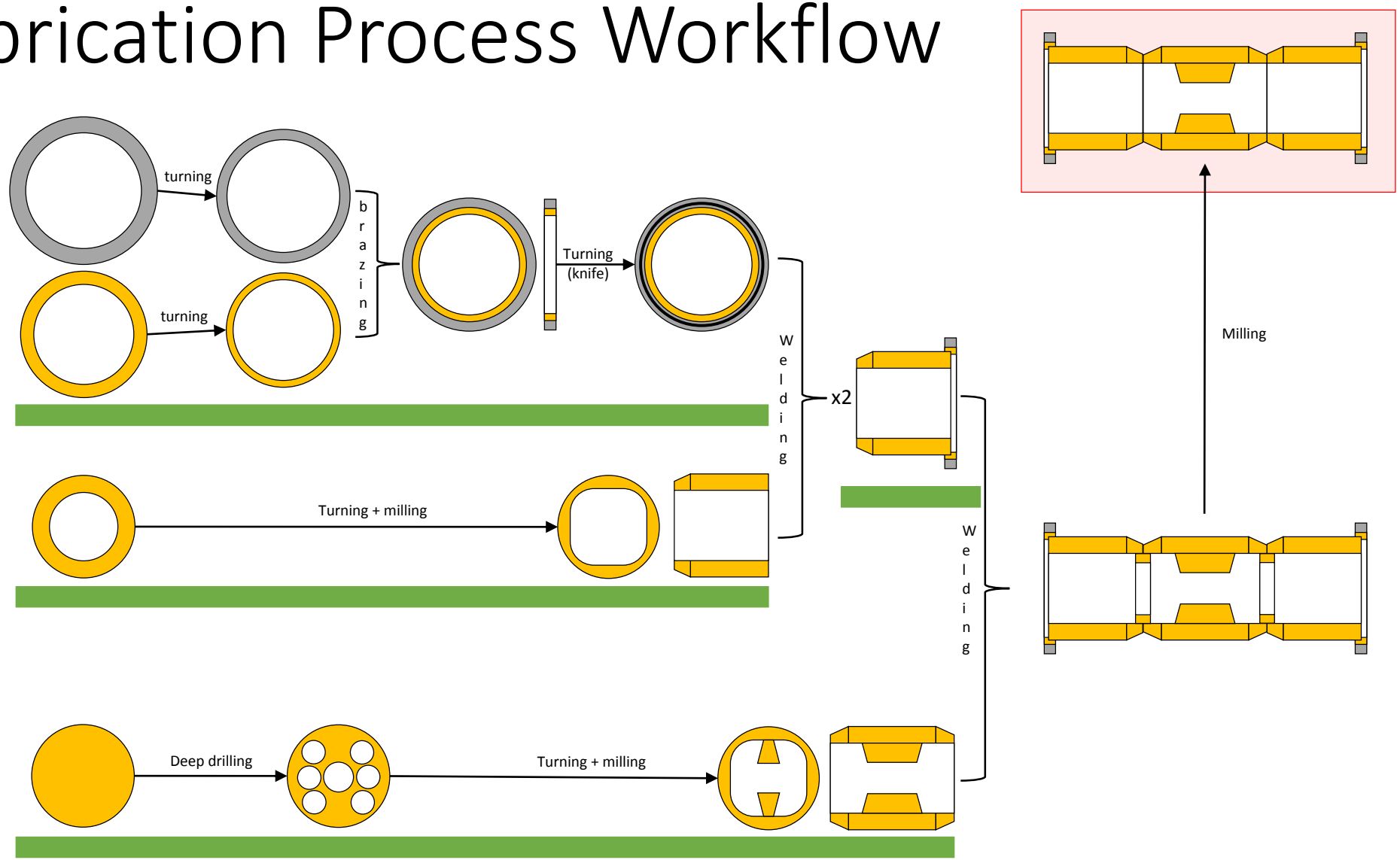
COMSOL Simulation. Max. deformation: 17.7 um. Pressure Sensitivity: 3.122 Hz/mbar



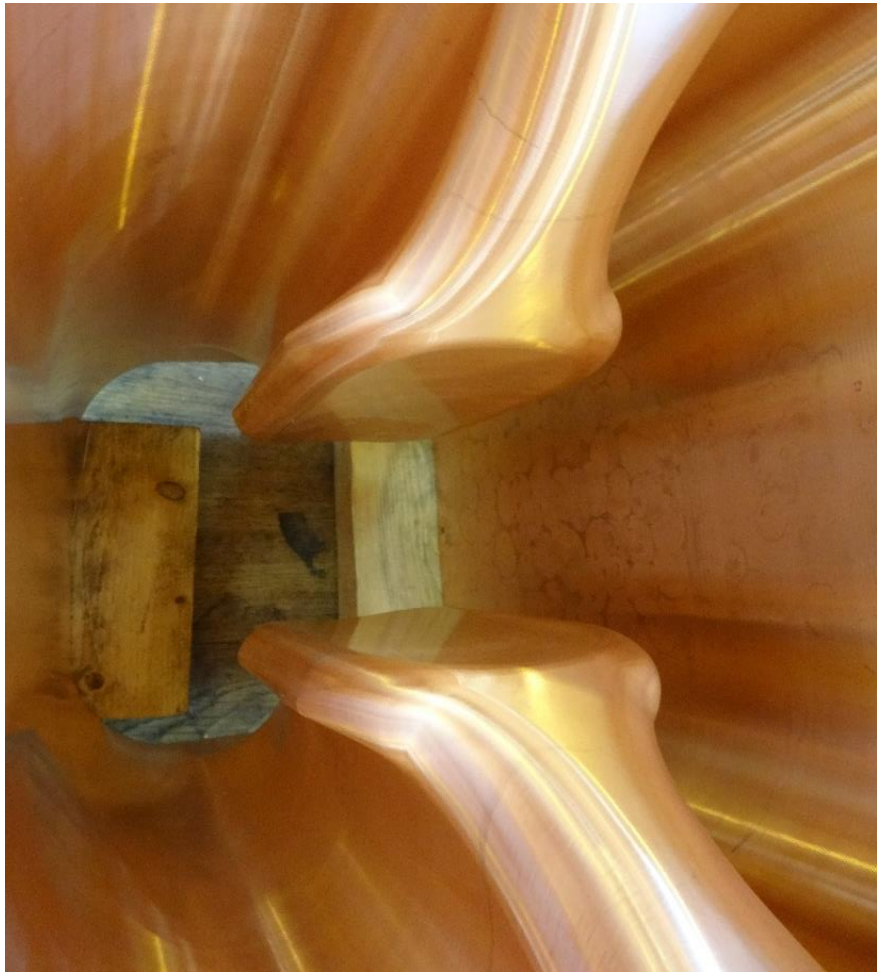
Assembly concept of the WOWCC copper substrate



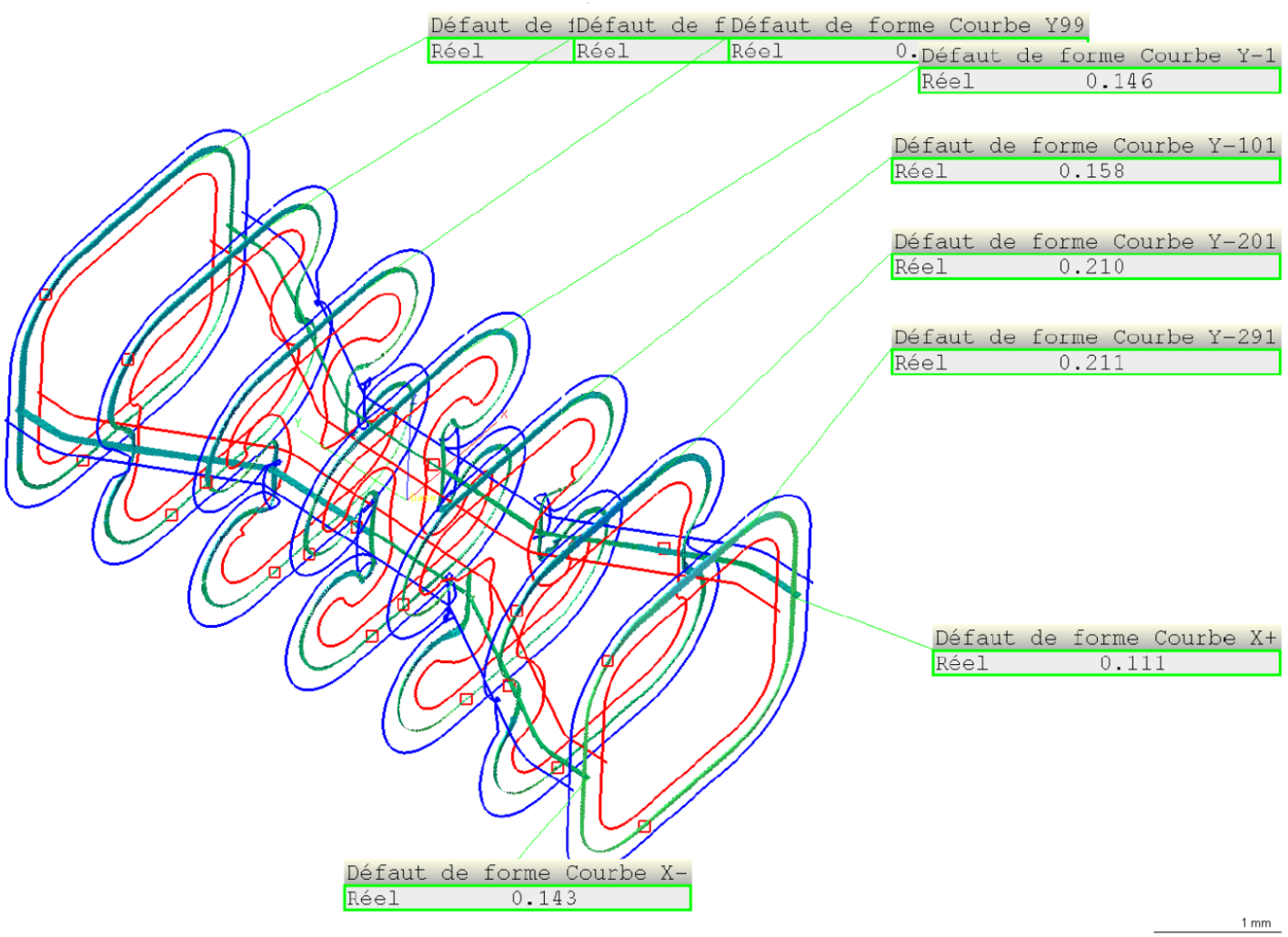
Fabrication Process Workflow



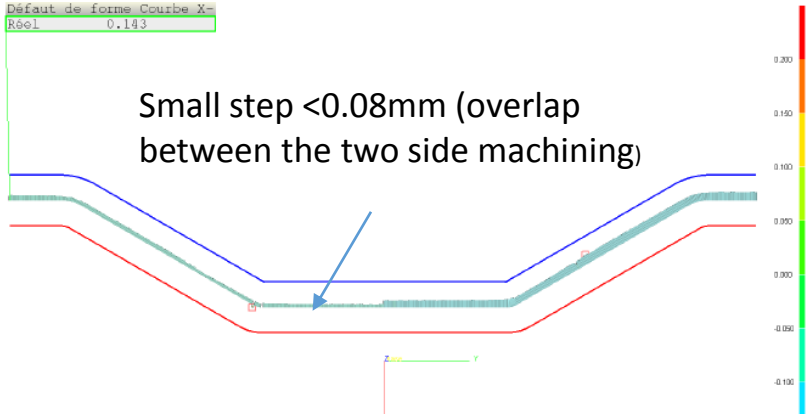
Fabrication: Central part milling



Fabrication: central part metrology

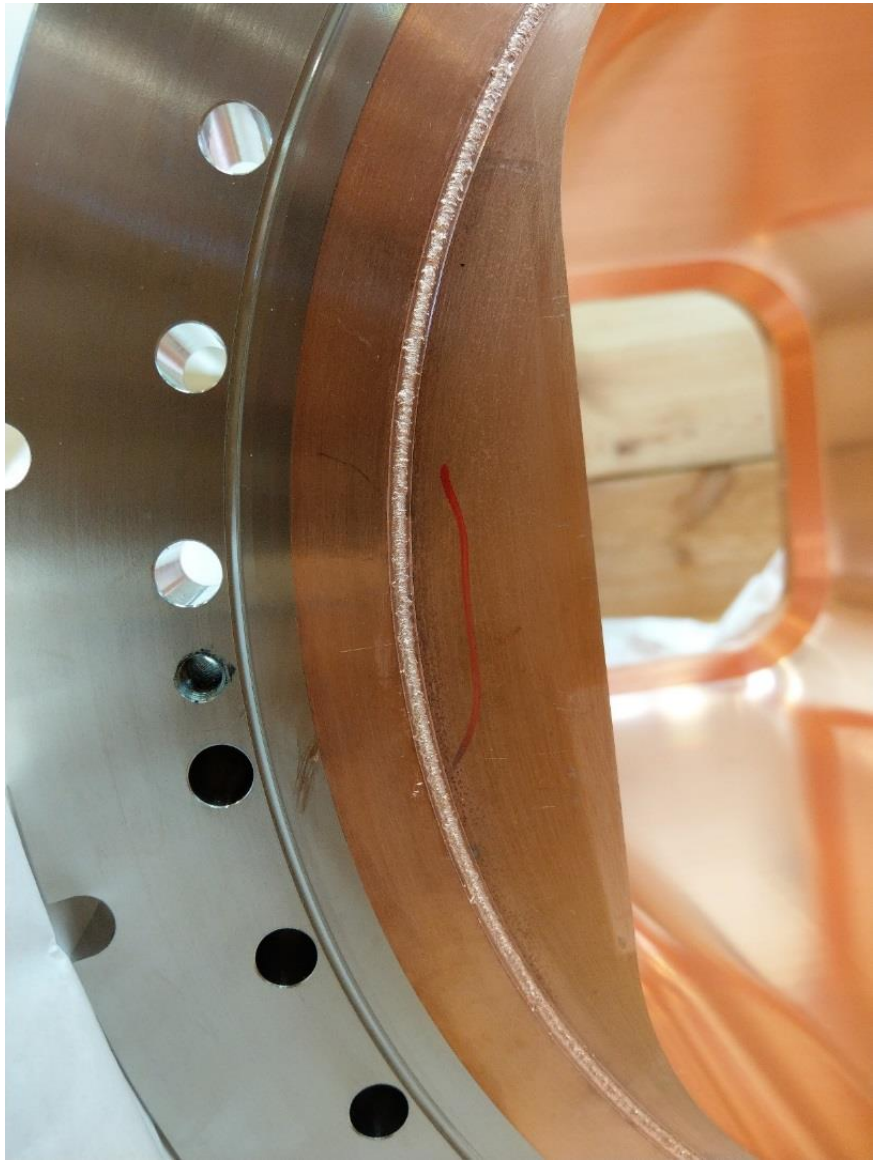


- **Internal shape accuracy is within specs.**
- Except for small defects
  - Length is +0.1 mm probably due to thermal effects
  - There is a step of 0.08 mm in the cavity center due milling from two sides, see below



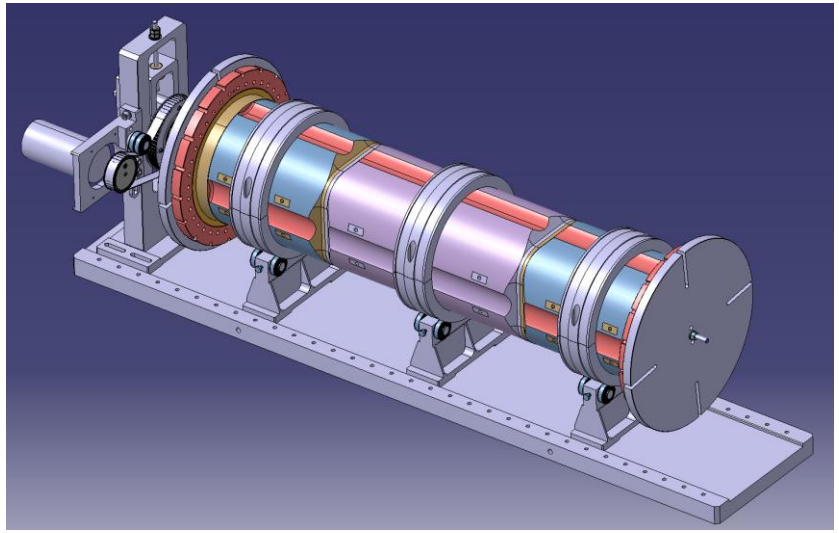
Fabrication: extremity parts

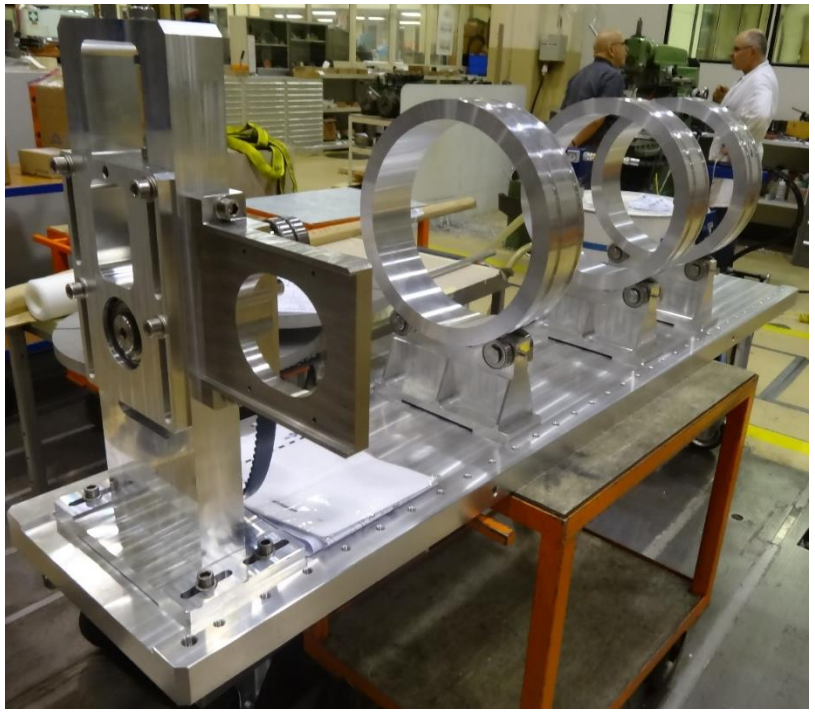
- Welding of extremities



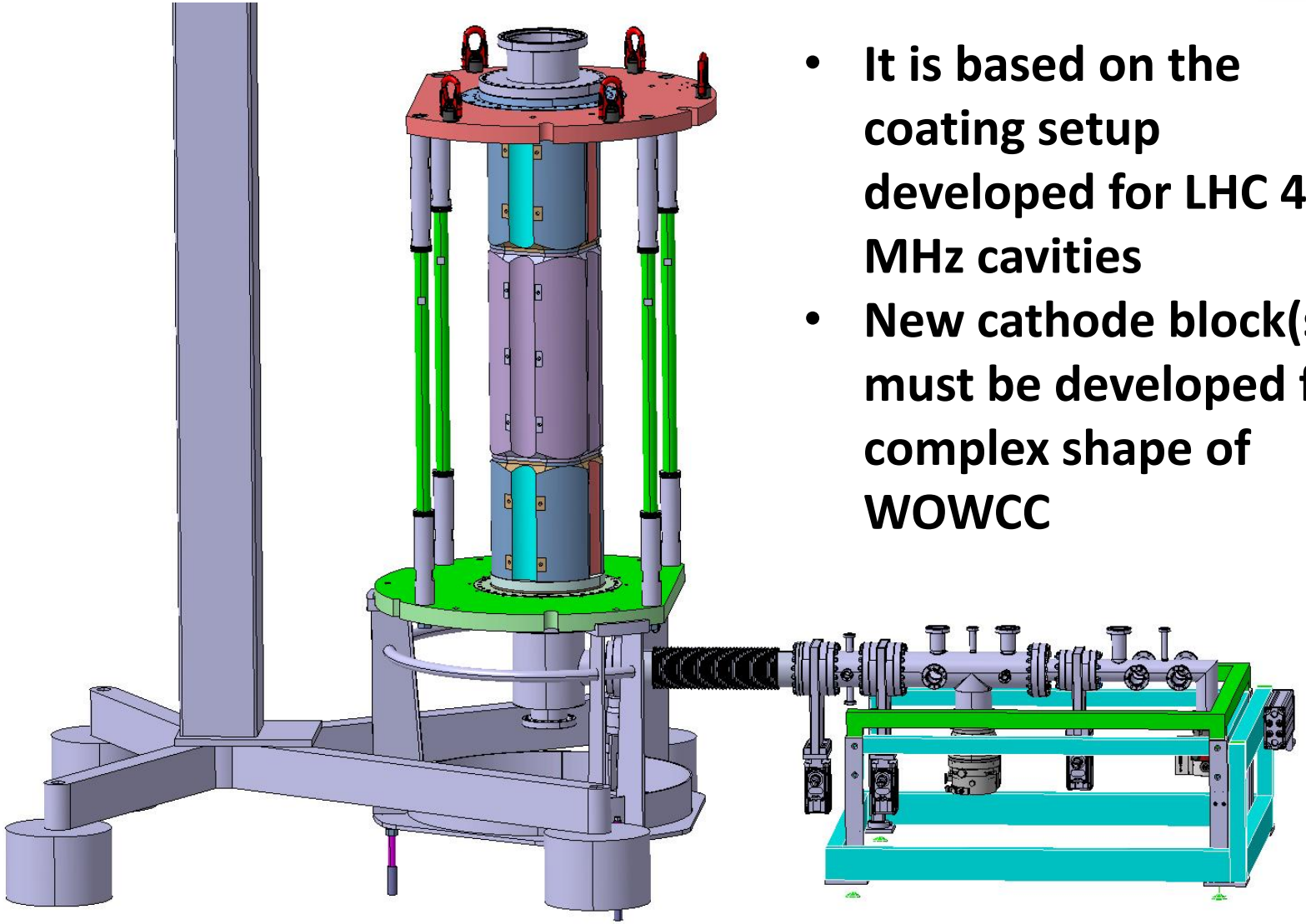
Welding of the full cavity is planned this week

- Tooling is finished and assembled

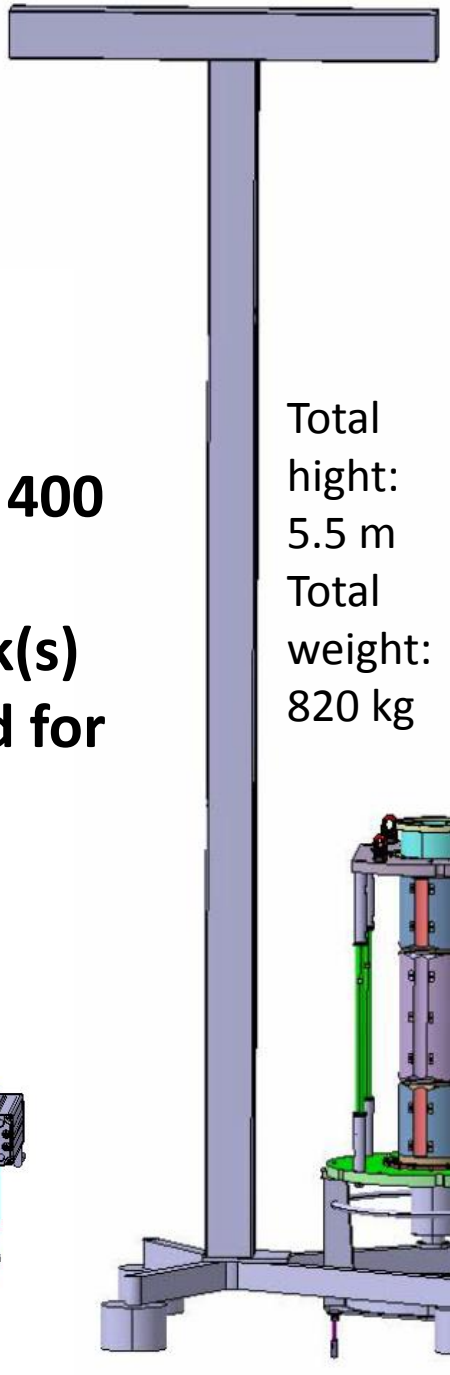




Coating of WOWCC

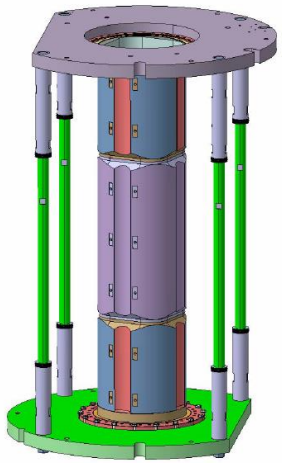


- **It is based on the coating setup developed for LHC 400 MHz cavities**
- **New cathode block(s) must be developed for complex shape of WOWCC**

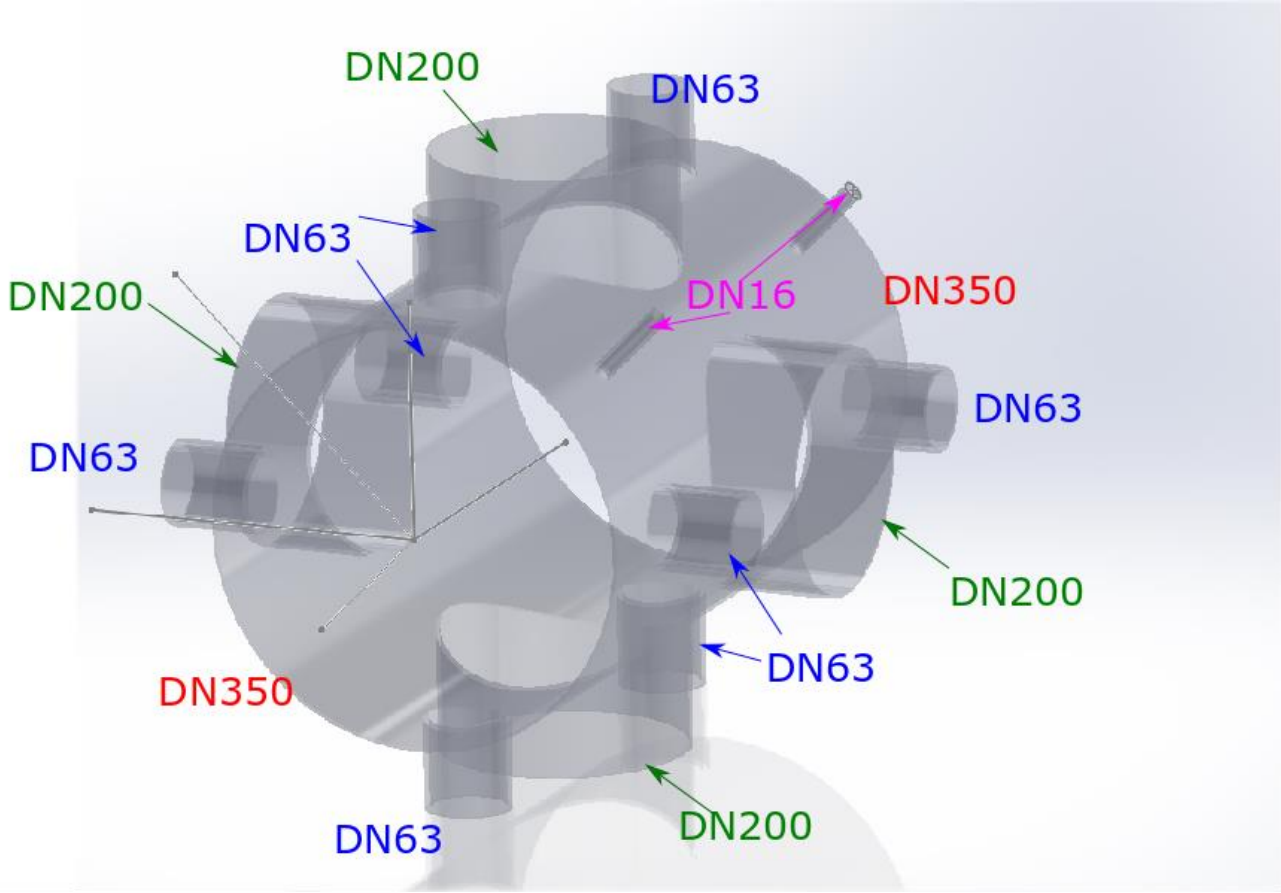


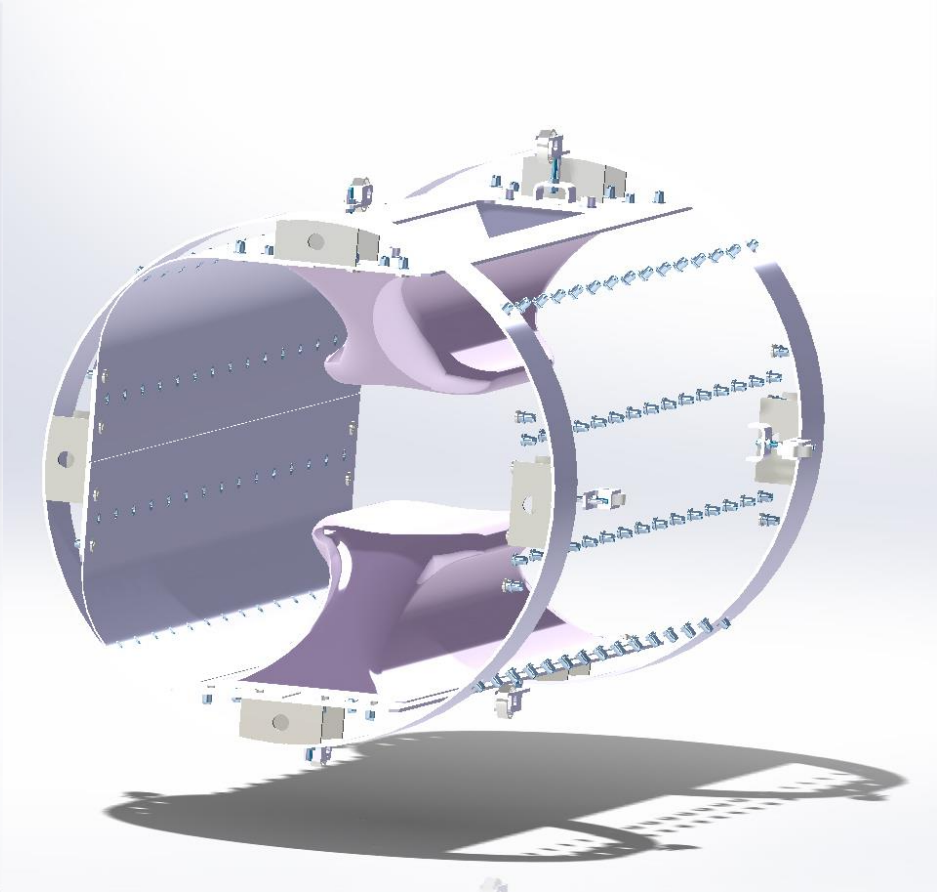
Total hight: 5.5 m
Total weight: 820 kg

WOWCC + frame weight: 517 kg



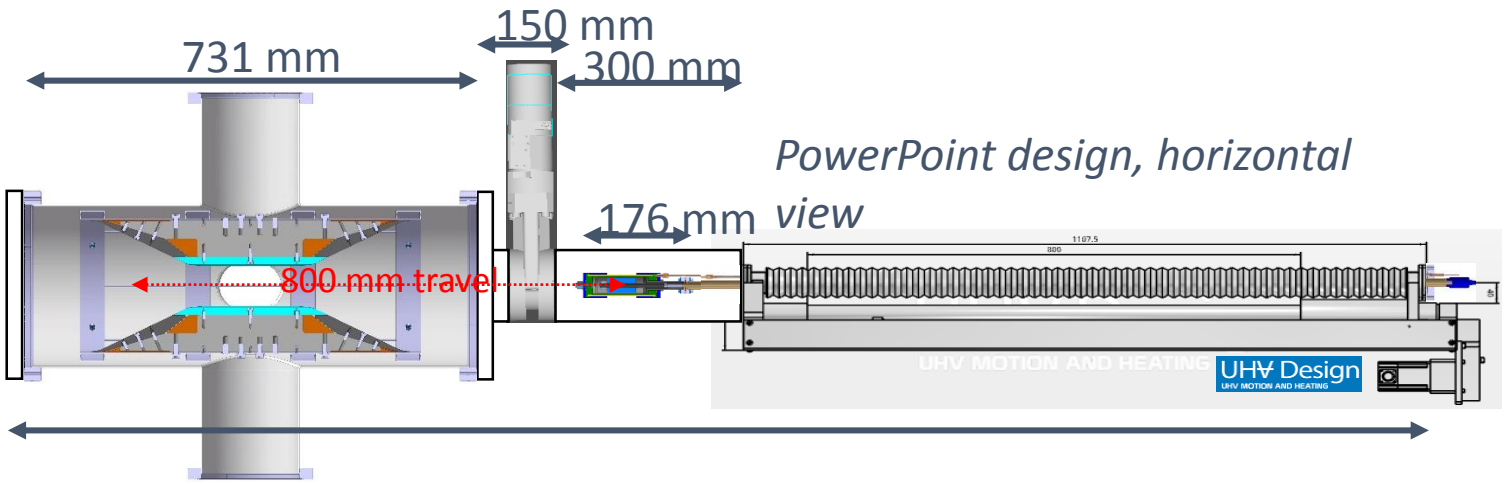
Mockup setup for coating developments : vacuum chamber and the insert



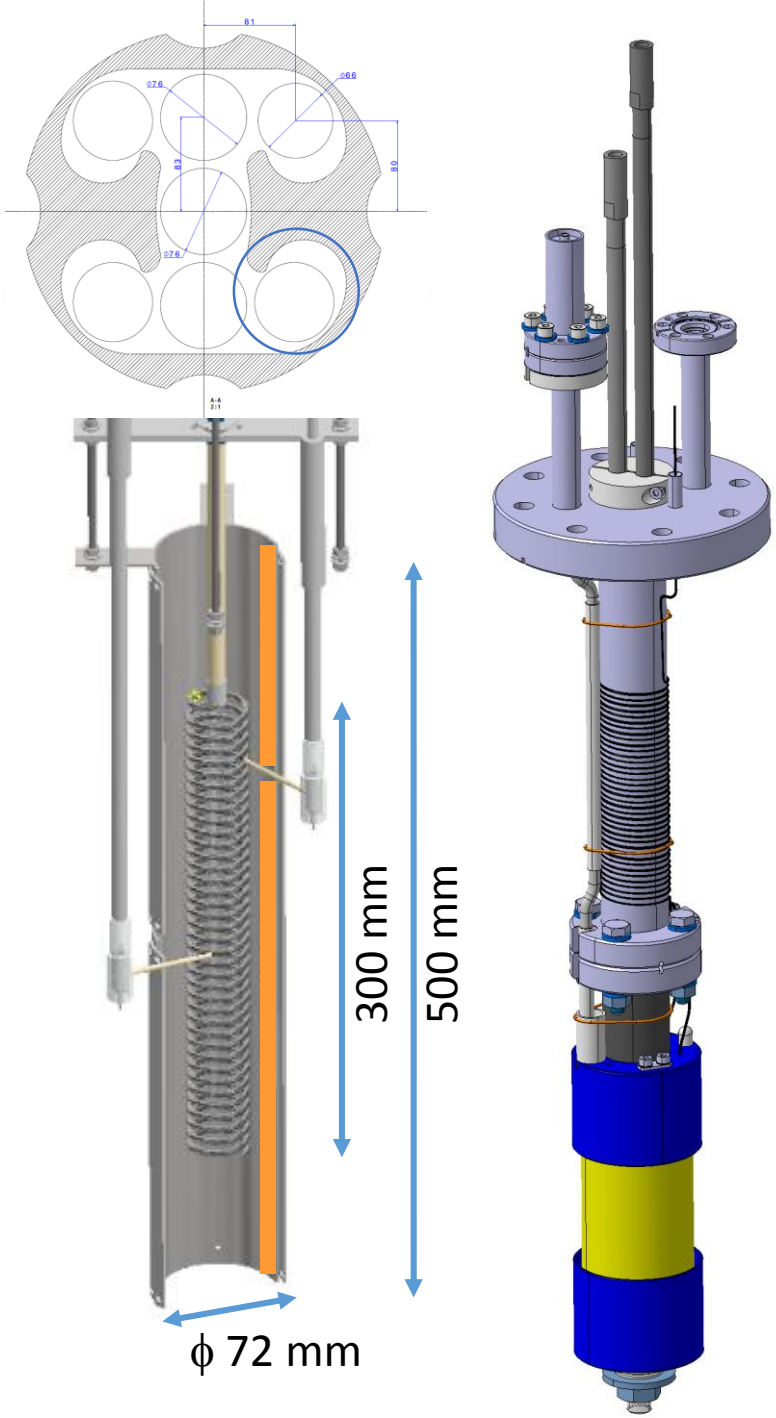


Development of new sputtering source

- Phase 1 prototyps are under delopement. They will be used for R&D in the mockup setup
- Phase 2 prototype will follow to be used in the “scale 1” coating setup for WOWCC



PowerPoint design, horizontal view



Thank you very much !