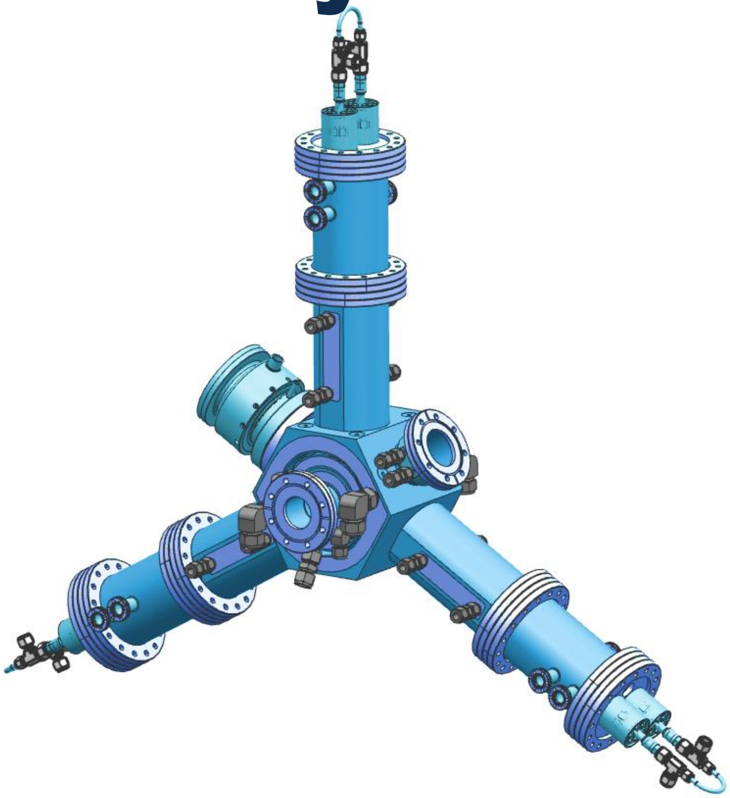
1.5 GHz Cavity design for the Clic Damping Ring and as Active Third Harmonic cavity for ALBA.



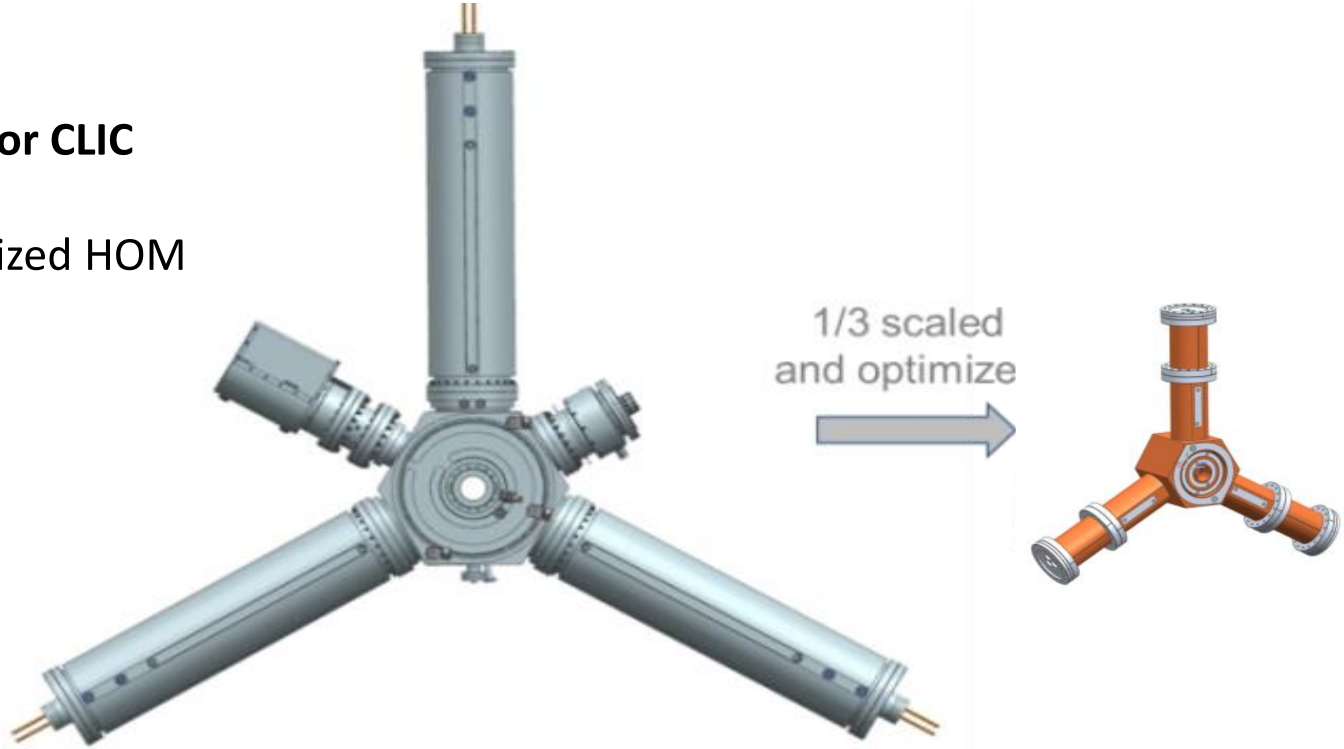
Beatriz Bravo

Overview

1. Introduction
2. Active operation
3. Electromagnetic design
4. Mechanical design

Introduction

Proposal for
Main RF system for CLIC
3HC for ALBA:
Scaled and optimized HOM damped cavity



500 MHz HOM damped normal conducting cavity

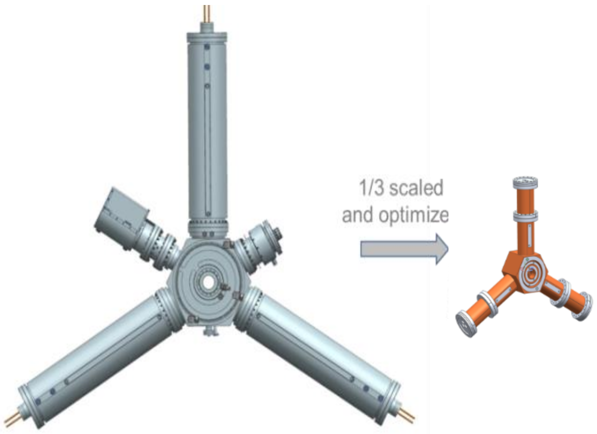
1500 MHz ACTIVE HOM damped NC cavity

Introduction

Active cavity Proposal

Scaled and optimized HOM damped cavity

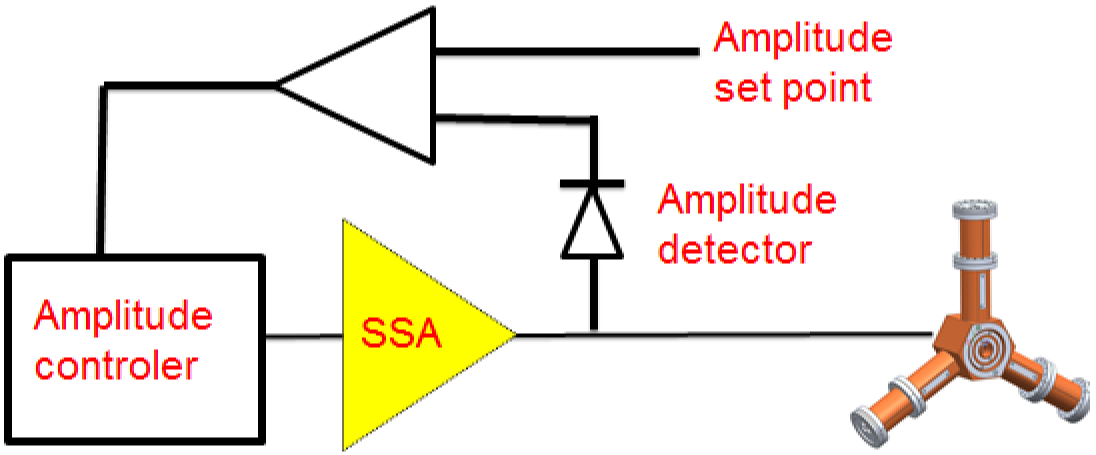
REQUIREMENTS	
Total VOLTAGE	1 MV
ϕoptimum	2.8 degrees
FREQUENCY	1,5 GHz
Beam power	0 kW
Nominal ⁄ maximum power dissipated per cavity	16⁄20 kW
Number of cavities	4 or 5?



Active Operation

OPERATION

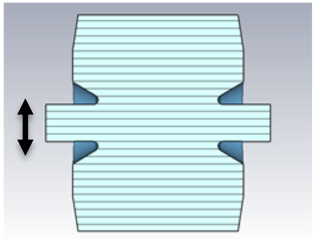
- Phase of the cavity set to ϕ=0
- Amplitude loop. Same forward power with beam and not beam.



φ	Pforw/cav (i=0 mA)	Pforw/cav (I=0,2A)	Pbeam/cav	Bunch length
-2,8	16kW	8 kW	-8 kW	3,3 σ
0	16kW	16kW	0 kW	3,7 σ

It was considered 4 cavities that provide 1.1 MV and shunt impedance, Rs=2.4MΩ.

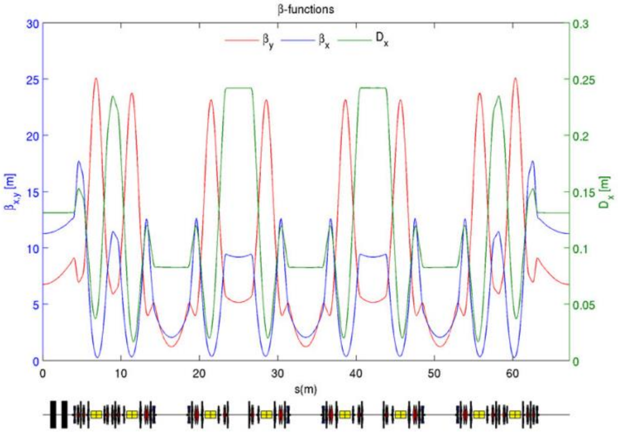
Cavity design: Beam aperture



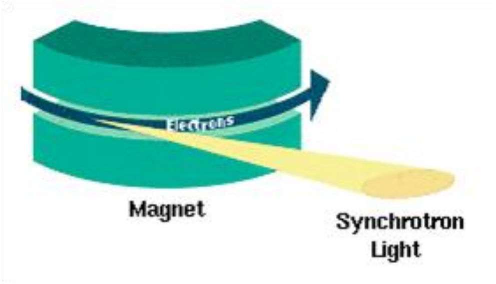
<u>Rs dependence strongly on the beam pipe dimensions</u>.

Constrains beam pipe diameter:

1. Electron beam aperture. Lattice

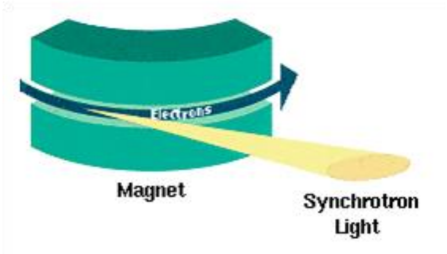


2. Synchrotron radiation.

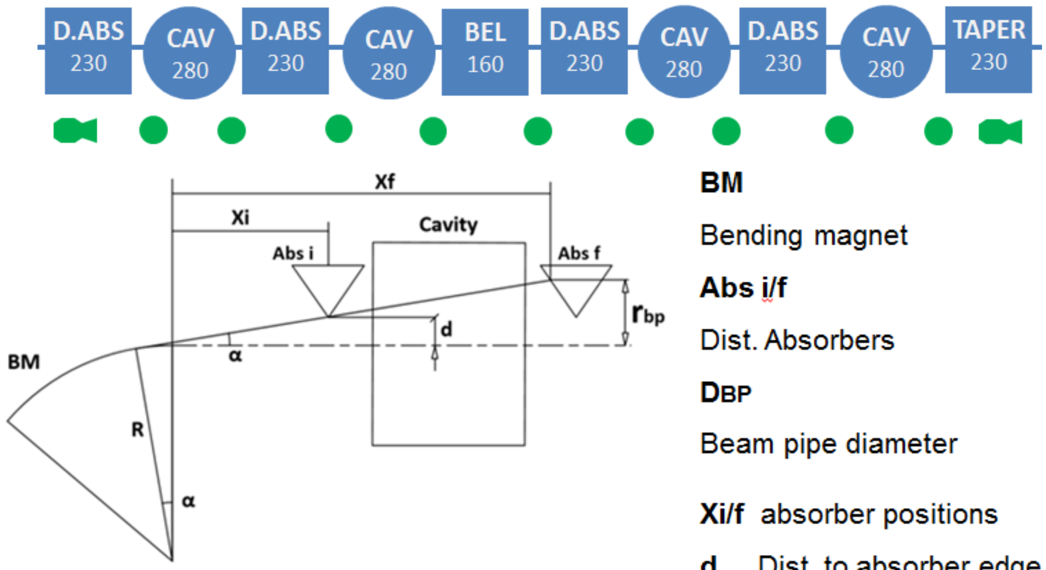


Cavity design: Beam aperture

2. Synchrotron radiation



Ray Tracing



BM
Bending magnet

Abs i/f
Dist. Absorbers

DBP
Beam pipe diameter

Xi/f absorber positions

d Dist. to absorber edge

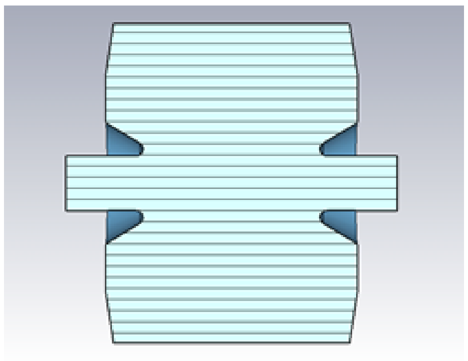
γ safety margin
(2 mm)

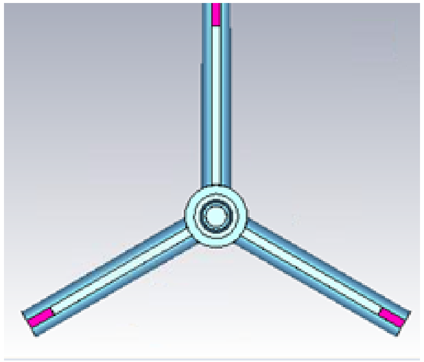
where: $D_{BP} = 2 \cdot [d + (X_f - X_i) \cdot \tan\alpha + \gamma]$

After the analysis the Beam pipe diameter was fixed to 46 mm

Cavity design: Electromagnetic designed

Body optimization



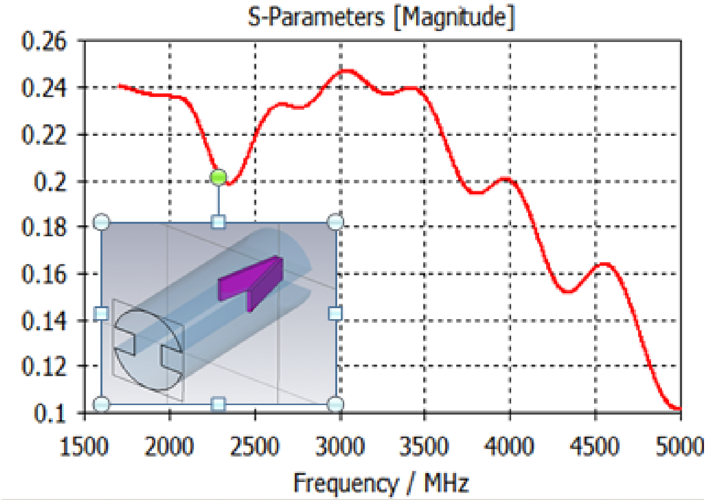


For high Rs and Q of the fundamental mode.

Final parameters:

Rs=1,5 MΩ, Q=17000, V=215kV.

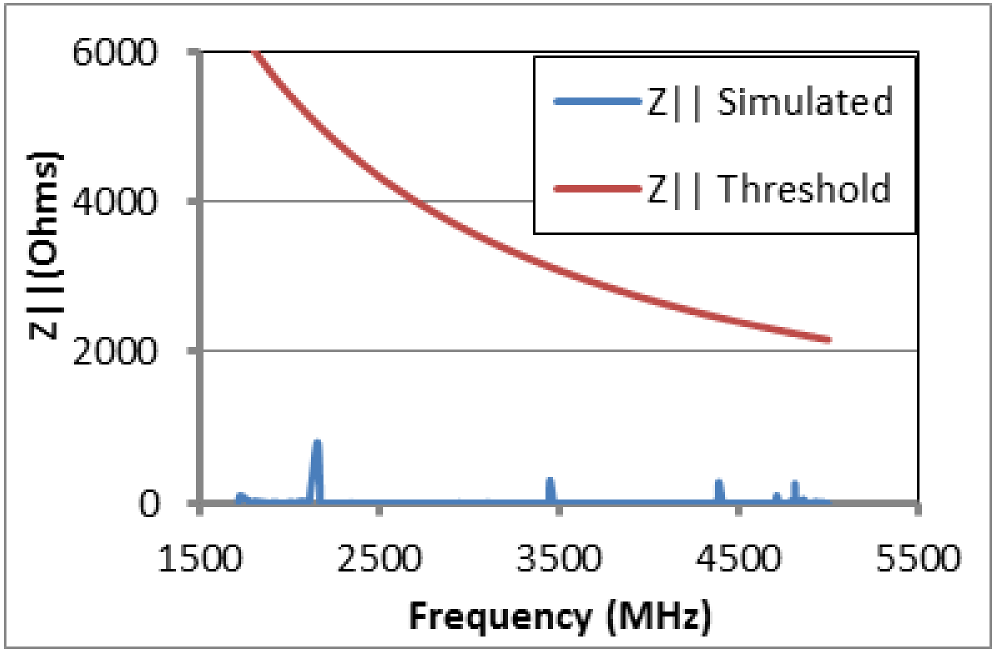
Damper optimization



- Do not couple the fundamental mode.
- Maintain a low reflection response |S11|<0.3.

Cavity design: Electromagnetic designed

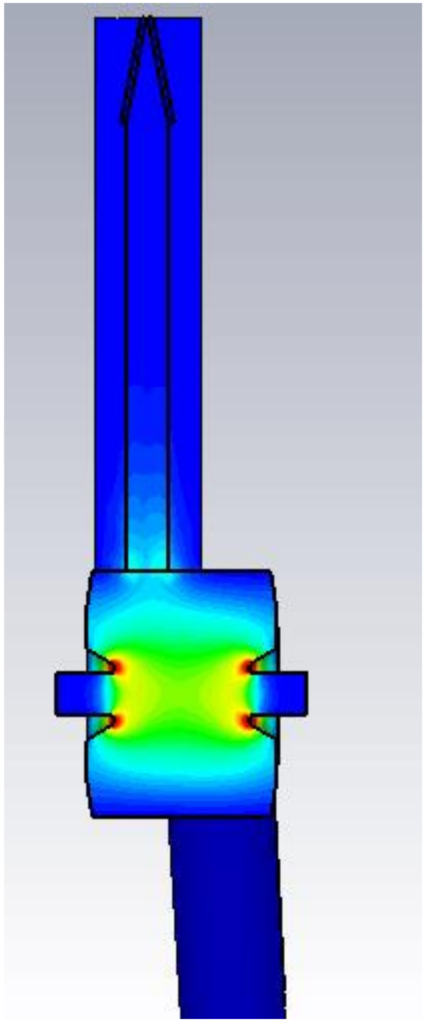
HOM analysis



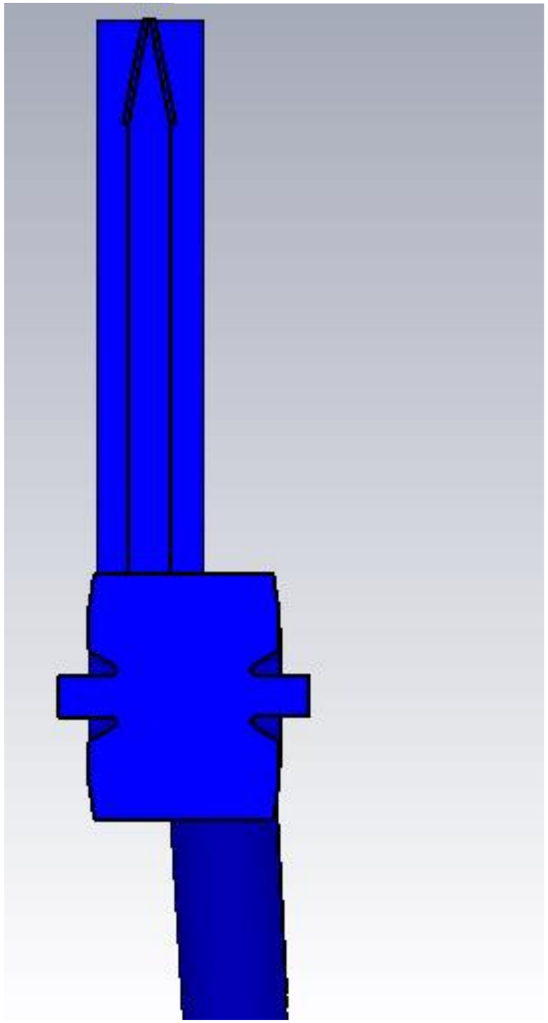
- Maximum power dissipated in the ferrites of each damper will be 115W
- Ferrite C48 is not in the CST material library
    - Electric and magnetic properties data till 3GHz.
    - From 3GHz till 5 GHz we made a fit.

Cavity design: Electromagnetic design

Fundamental mode (1,5 GHz)

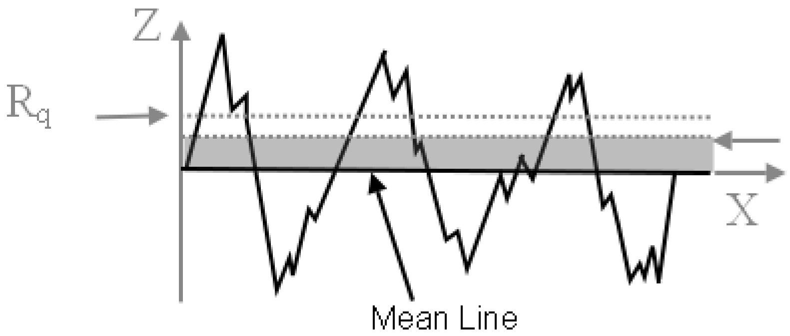


HOM (1,86 GHz)



Cavity design: Electromagnetic designed

Surface roughness



- Hammerstad and Jensen (H&J) model.
- It assumes a triangular corrugated surface.

$$\alpha_{cond,rough} = \alpha_{cond,smooth} K_{sr}$$

$$K_{sr} = 1 + \frac{2}{\pi} \arctan\left(1.4\left(\frac{\Delta_{rms}}{\delta_s}\right)^2\right)$$

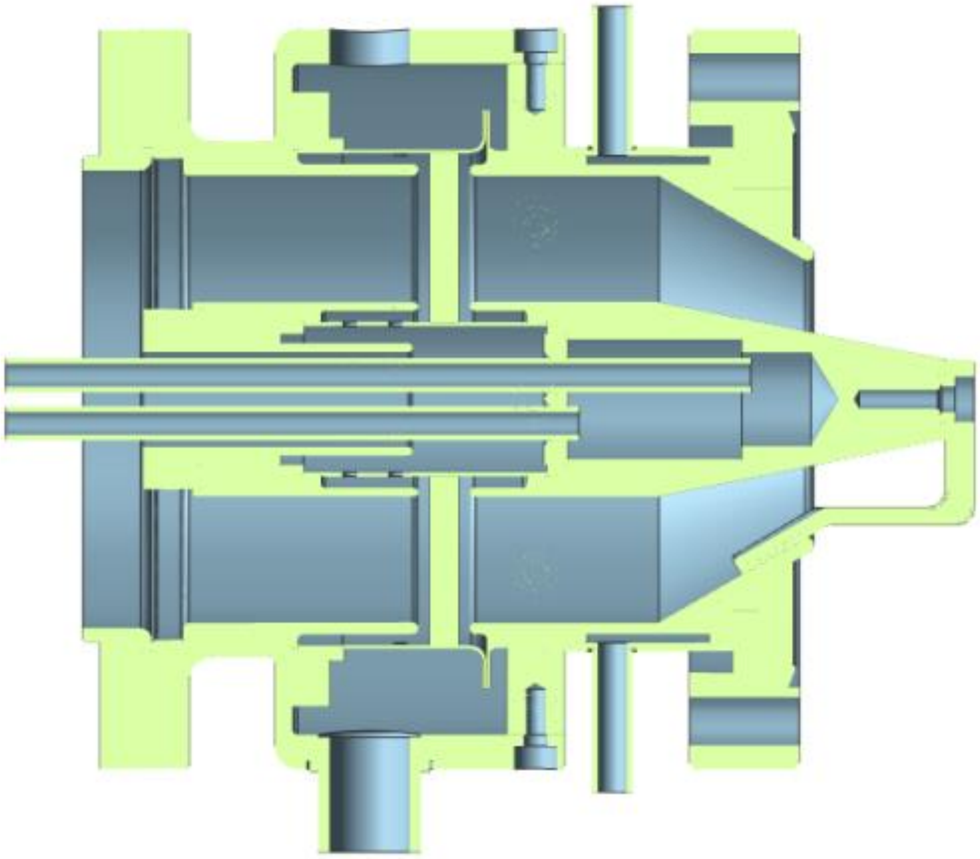
$$\frac{R_{cond,rough}}{R_{cond,smooth}} = \frac{Q_{cond,rough}}{Q_{cond,smooth}} = \frac{1}{K_{sr}}.$$

Δ_{rms}(μm)	K_{sr} (f=1.5GHz)	R/Q	R(MΩ)	Q	Vacc(kV) P_d=16kW	Vacc(kV) P_d=20kW
0	1	80.7	1.4	17337	211	236
0.6	1.11	80.7	1.26	15618	200	224
0.8	1.19	80.7	1.17	14569	193	216
1	2	80.7	0.7	8668	149	167

the surface roughness degrades the Rs and Q

Cavity design: Electromagnetic designed

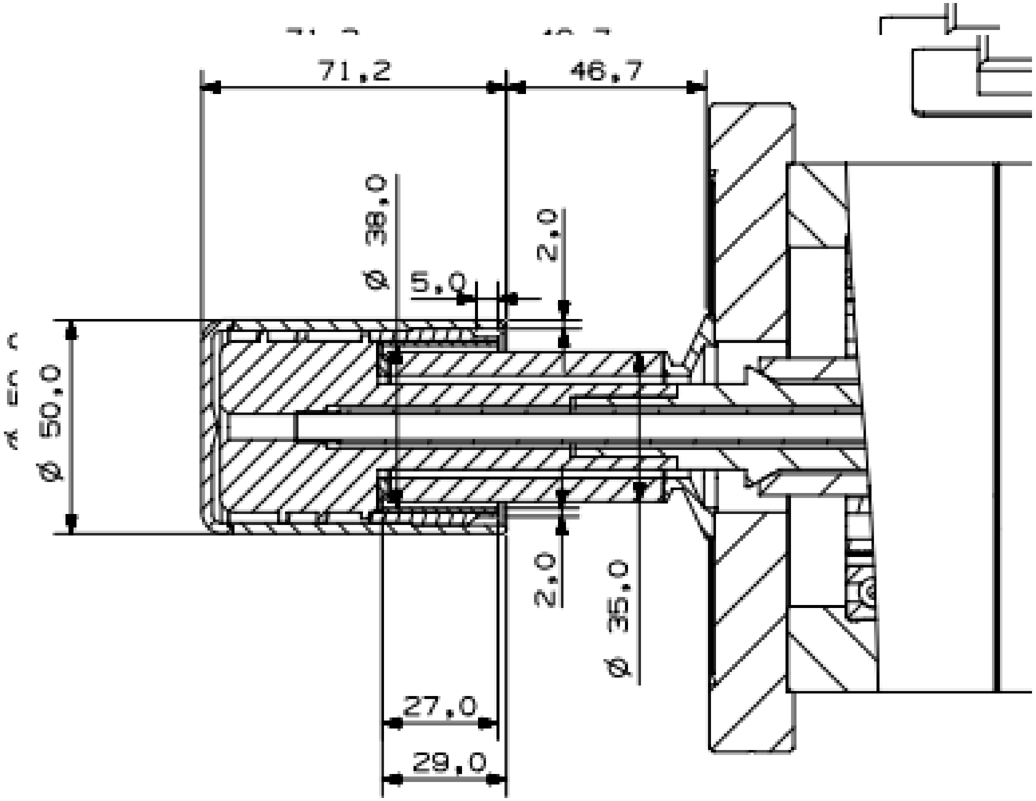
INPUT COUPLER



- Power handling 32kW.
- Inductive coaxial loop.
- Distance between the aluminas, the width and the shape of the aluminas highly affects the matching.

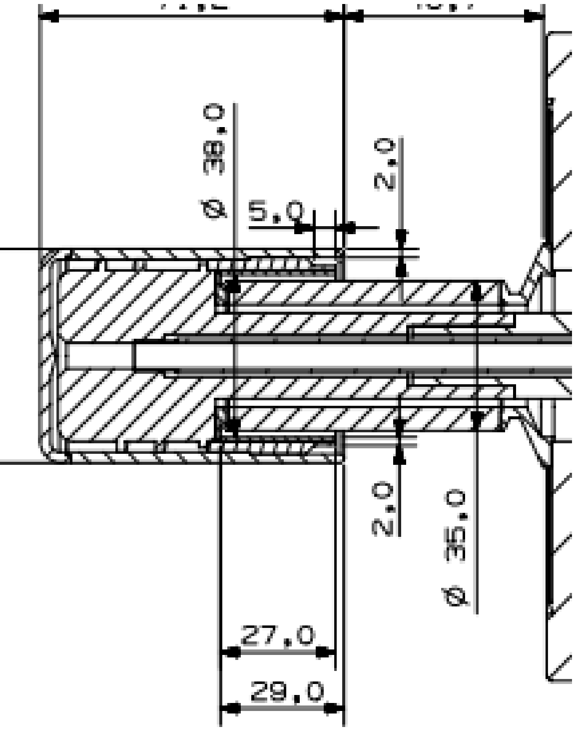
Cavity design: Electromagnetic designed

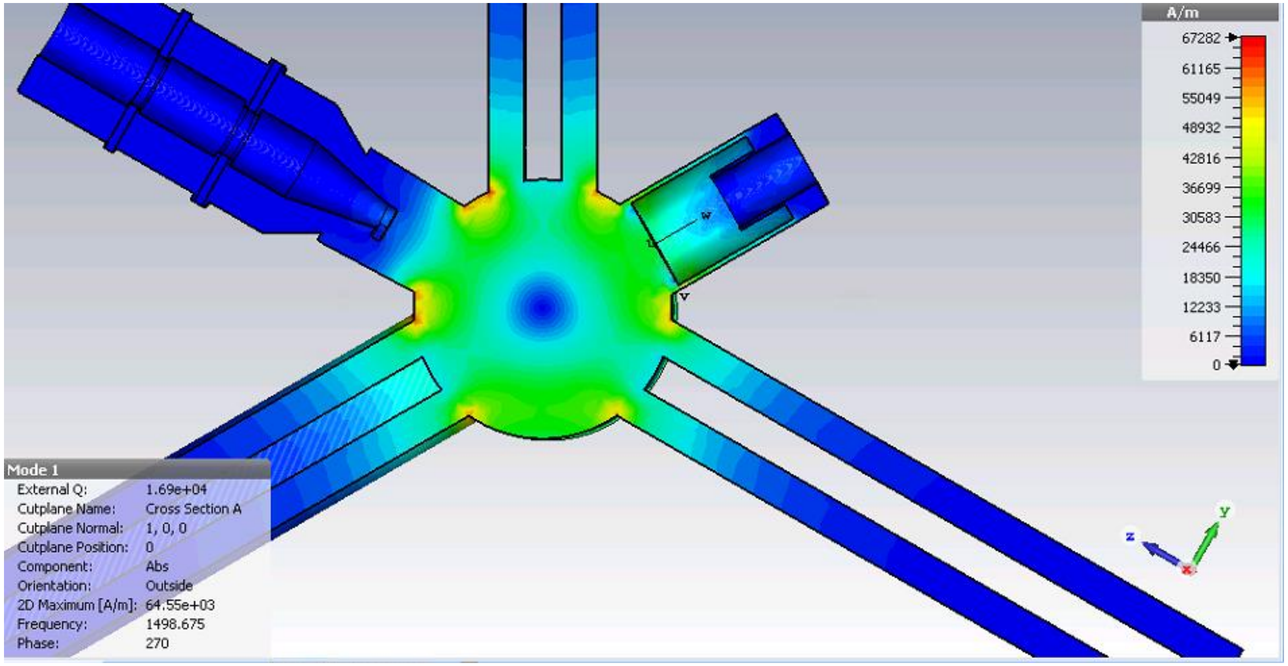
PLUNGER



Cavity design: Electromagnetic designed

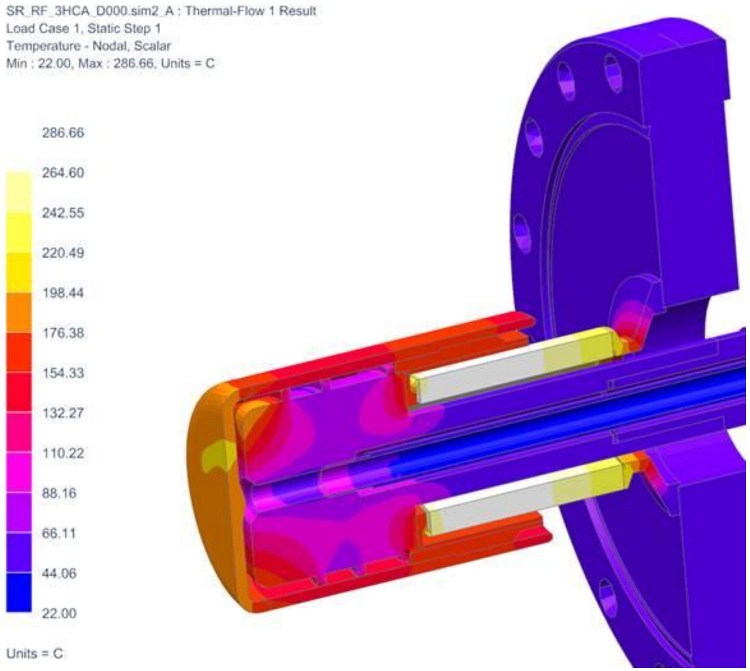
PLUNGER

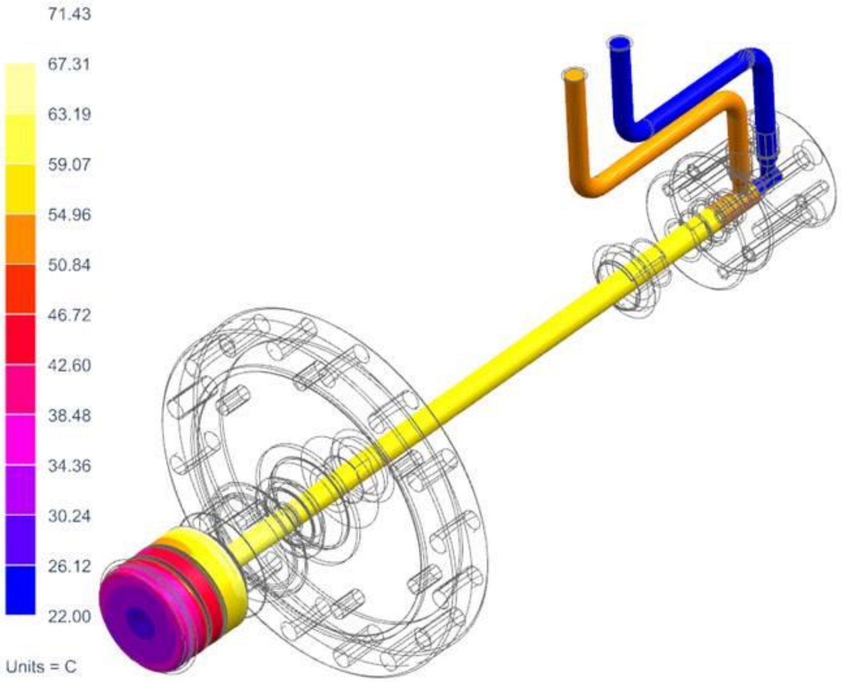




Cavity design: Electromagnetic designed

PLUNGER

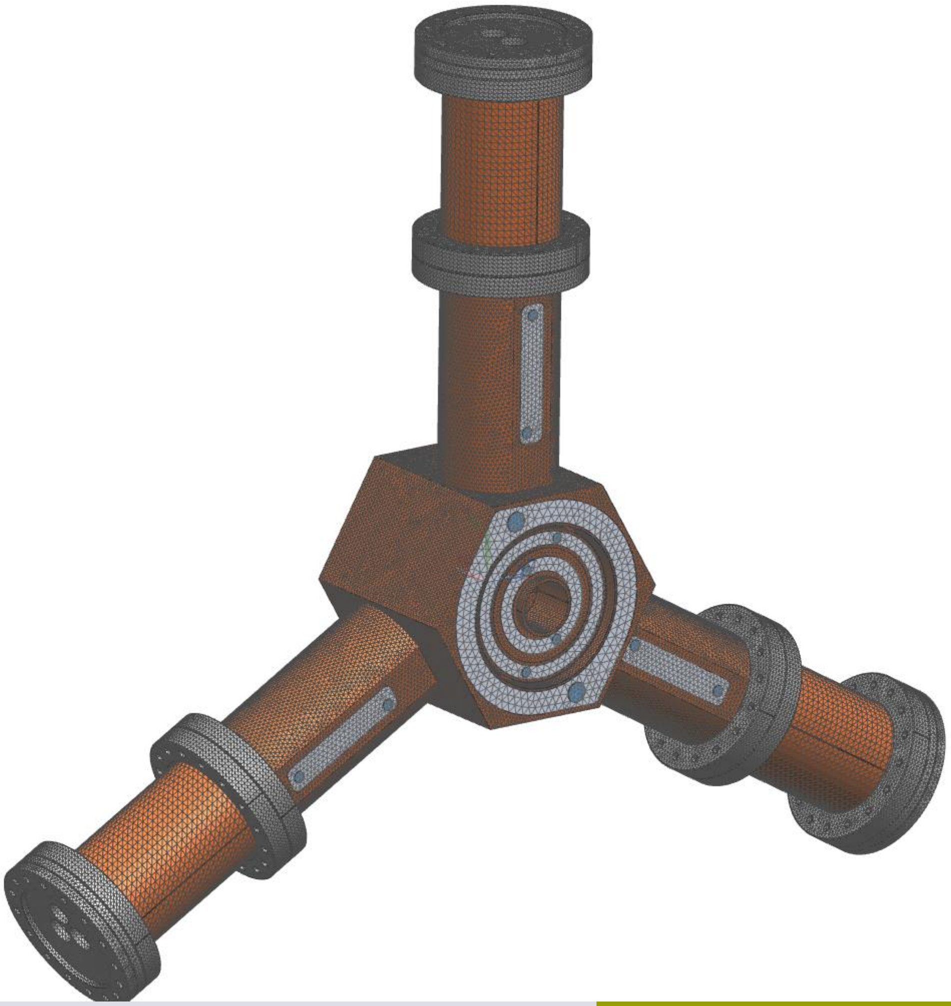




Cavity design: Electromagnetic designed

PLUNGER

- New design based on the Bessy 3HC plunger design in under development.
- The plunger degrades the quality factor and the Rs.
- Taking into account all the elements
  - Quality factor 14000
  - Shunt impedance 1.2 Mohms
- Number of cavities necessary 5, but we will install 4



FEM thermo-fluid simulations

Solver **NX** thermal flow

Materials:

- OFHC Cooper, Stainless steel and water.

Boundary conditions

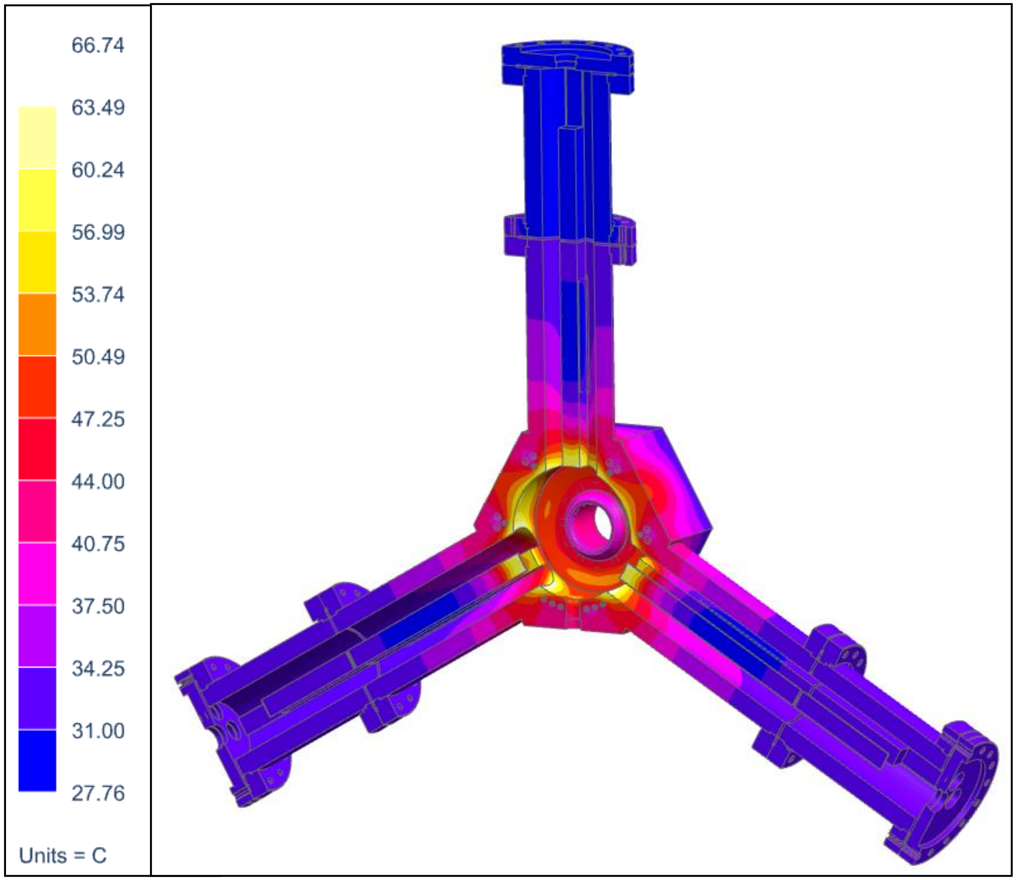
- Total power dissipated in the body of the cavity is 20 kW.
- Perfect thermal contact between welded components
- **Cooling**: Water 30 l/min (Main body), 10 l/min (Front and Rear Lid). Inlet Temp 23 ºC.
- Radiation and convection to environment

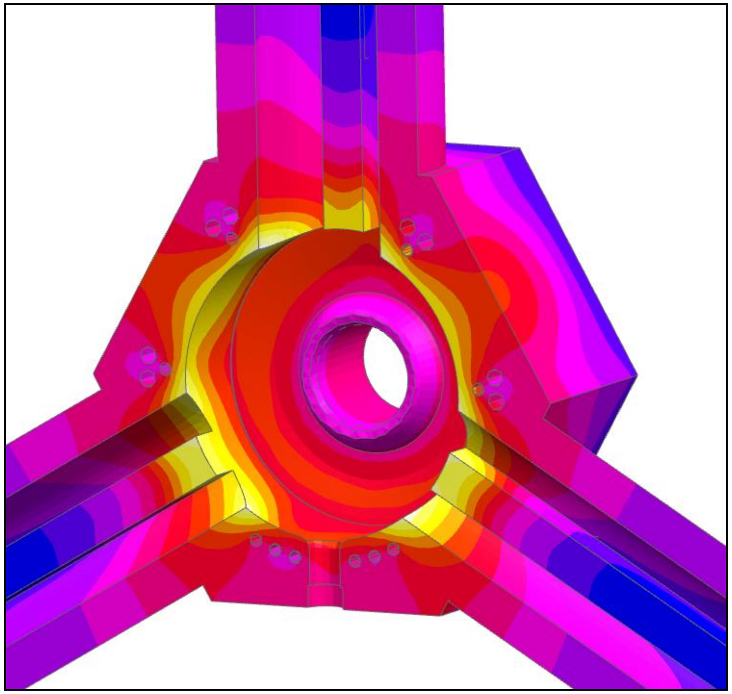
Constraints

- Max water velocity 2 m/s.

Thermo/Fluid Simulations

Temperature (^{o}C)



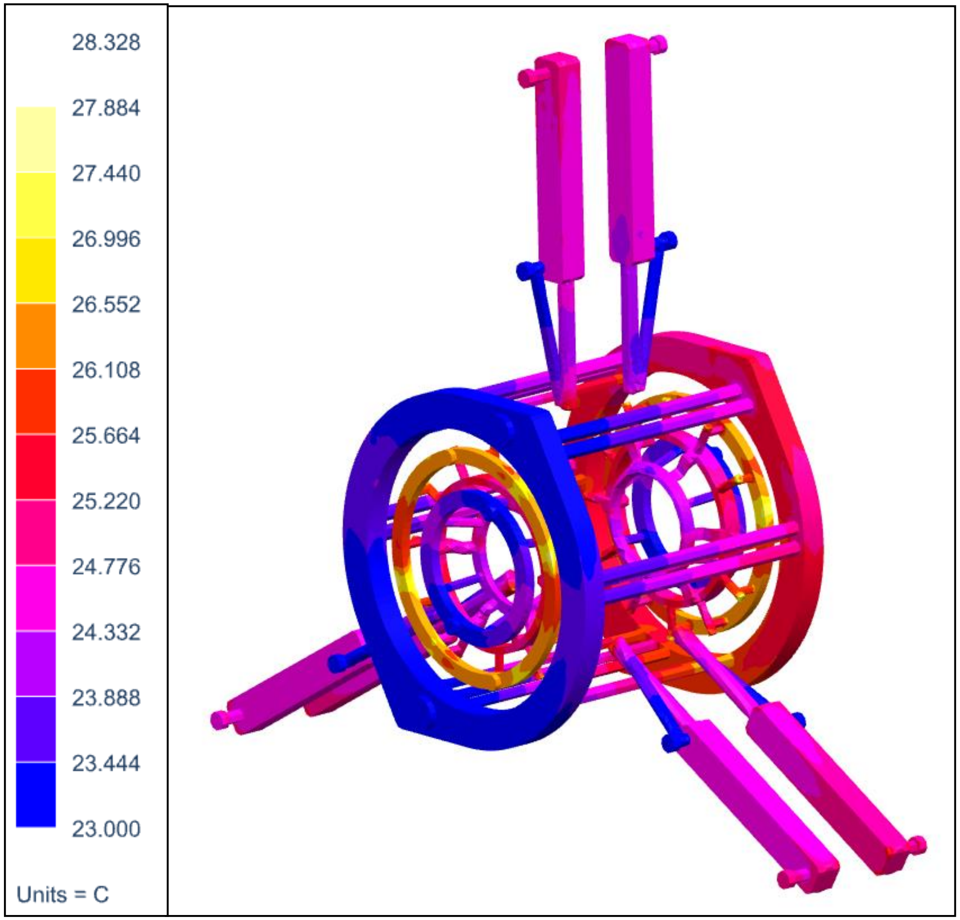


Steady state simulation
Max. Copper Temp.
66.74 ºC

- After several design/simulation iterations, the simulation results shows a maximum temperature of 67 ºC that is reached in the ridges edges located in the inner face of the cavity.

Thermo/Fluid Simulations

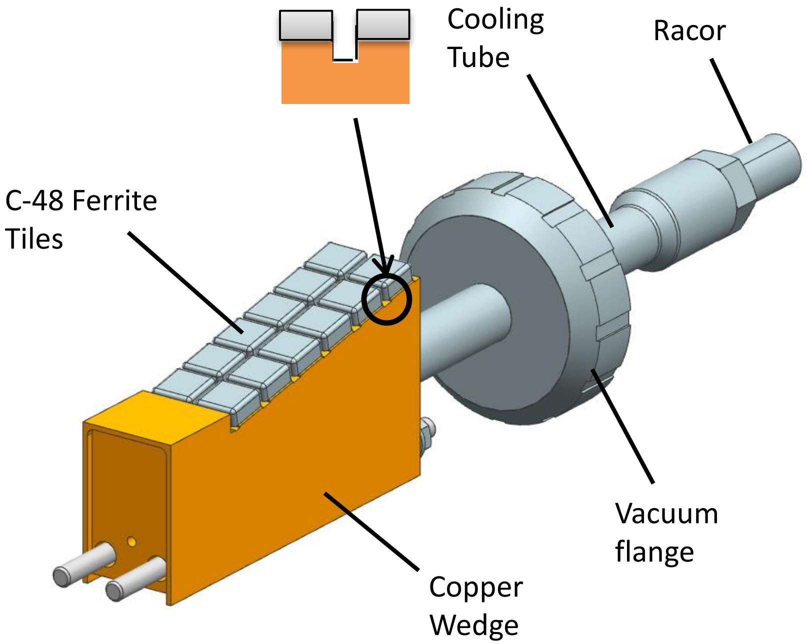
Water temperature (^{o}C)



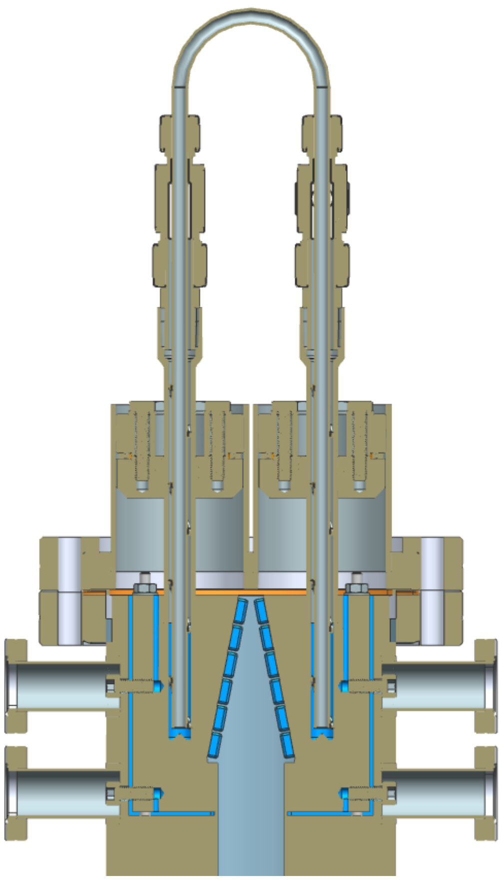
Steady state simulation
Max. Water Temp.
28.33 ºC

Mechanical Design

Ferrite wedge assembly and cooling



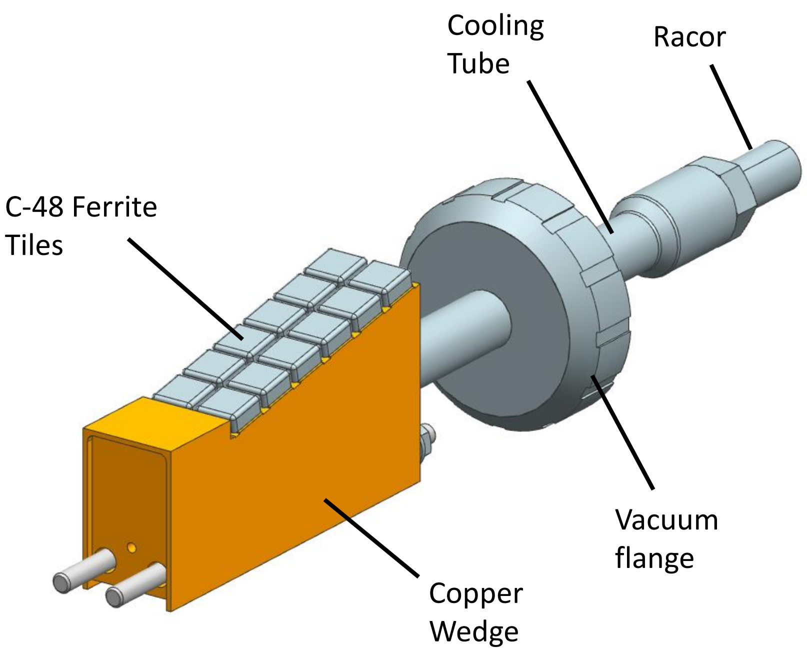
Detailed design of ferrite wedge



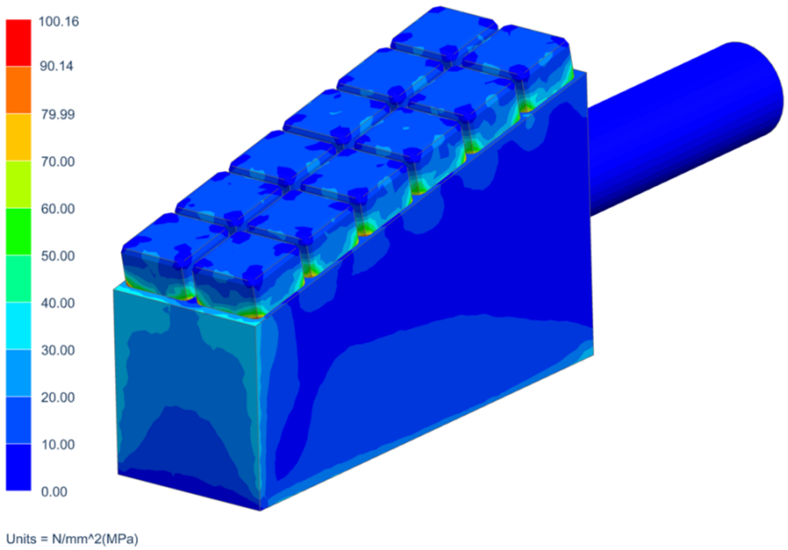
Implementation of ferrite wedge in Cavity Damper

Mechanical Design

Ferrite wedge assembly and cooling



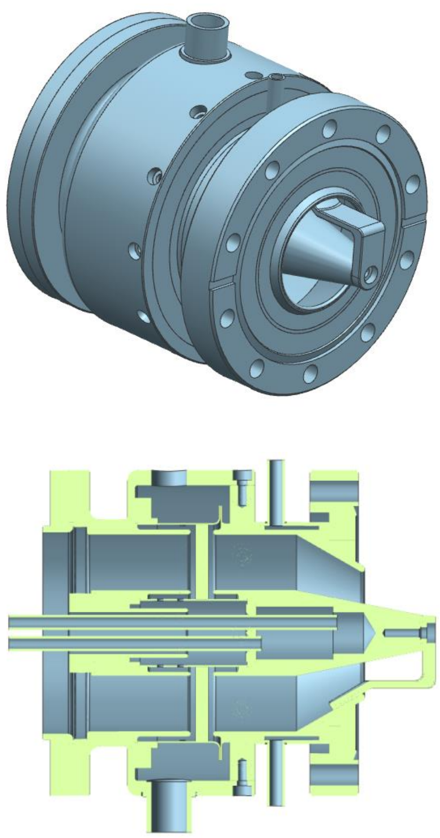
Detailed design of ferrite wedge



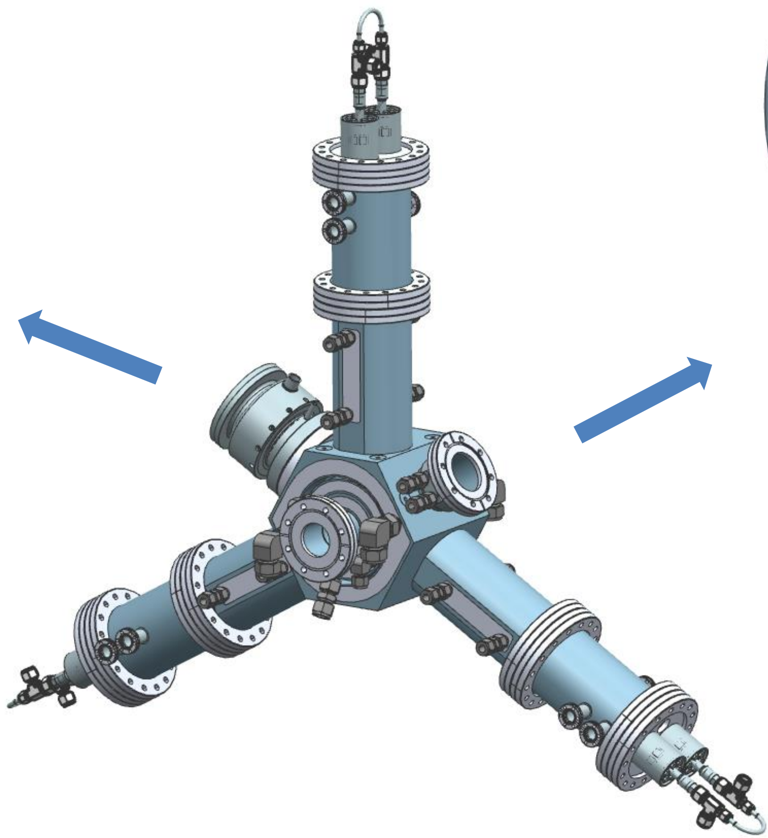
Max traction stress of 21.2 MPa at the top of tiles
Max compression stress of 98 MPa at bottom corner

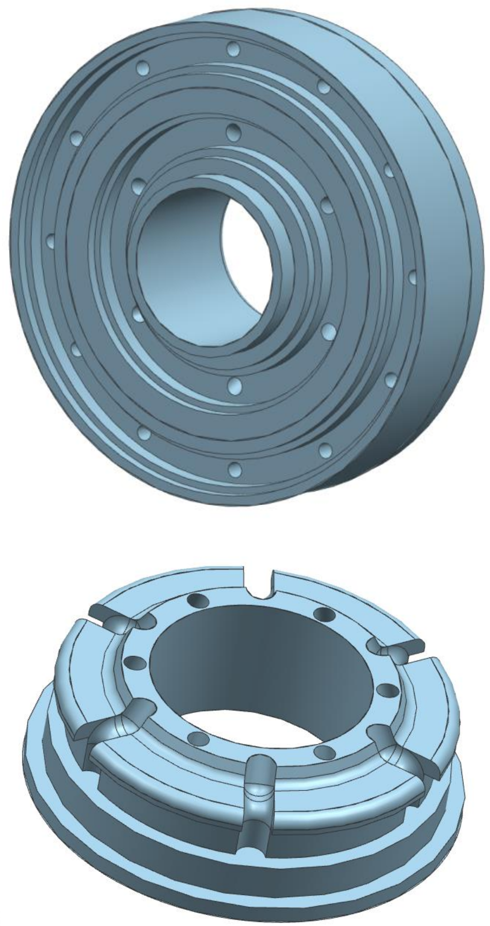
Mechanical Design

Other details of the design



RF Coupler (3D, section)





Cooled Cavity Body Lids

Conclusions

- The 1.5 GHz normal conducting cavity project should yield a substantial improvement in beam lifetime for the and as an effective accelerating cavity for the CLIC project.
- The plunger has to be re designed due to overheating problem.
- The adaptation of technology from the 500MHz HOM damped cavity construction project has allowed the development of a robust, efficient, 1.5 GHz cavity design.
- We would like to publish the call for tender for the prototype at the end of the year.

THANKS FOR YOUR ATTENTION