STATUS OF THE ESRF SINGLE CELL HOM DAMPED CAVITY R&D*

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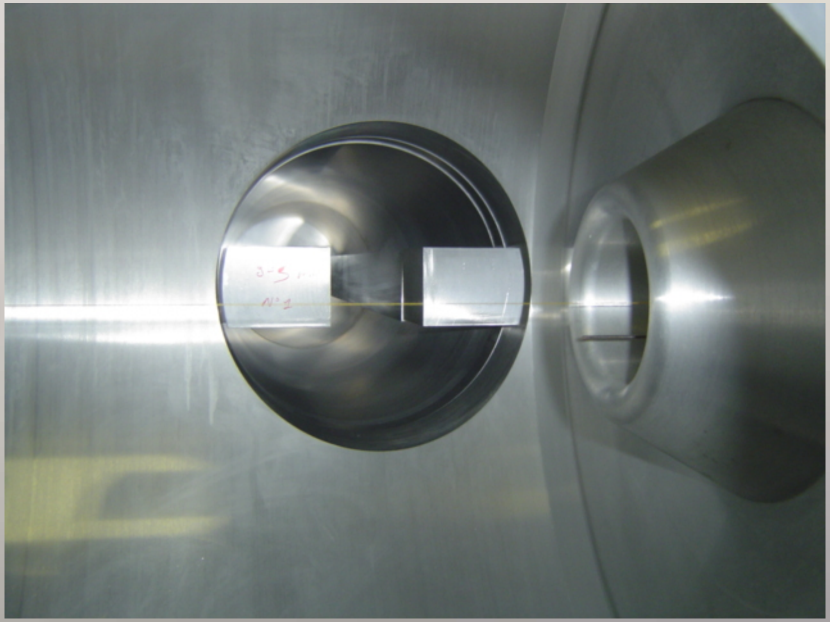
INTRODUCTION (1/2)

The development of the new 352 MHz cavity for the ESRF is based on the 500 MHz European HOM damped normal conducting cavity with three circular double ridge waveguide HOM dampers loaded by UHV compatible absorbing NiZn ferrite material (C48/Countis industries).

The first units built for the MLS near BESSY and for ALBA have shown that an inevitable gap between the cavity ports and the ridges of the connected HOM dampers can lead to a significant impedance of the TM011 mode and to an overheating of the vacuum flanges by local surface currents.

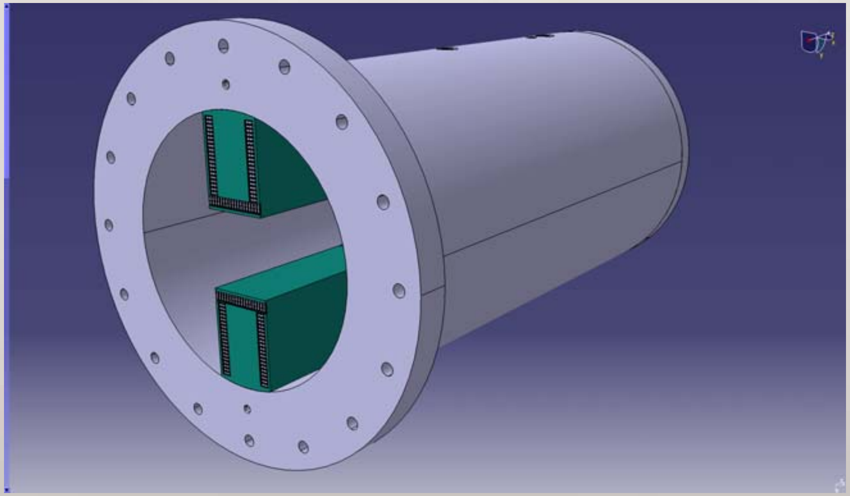


INTRODUCTION (2/2)

We propose a solution to avoid the gap by splitting the HOM dampers in two parts:

Coupling section e-beam welded to the cavity body

HOM damper terminated by a ferrite load, with RF fingers for head on connection to the coupling section



To achieve 300 mA safely, design margins have been taken:

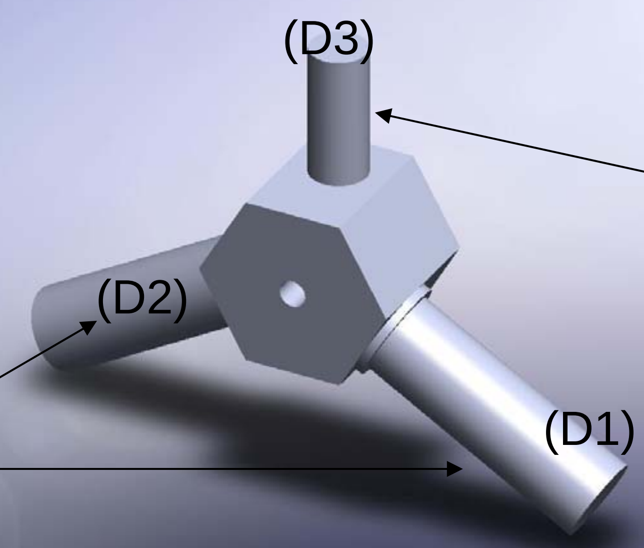
- ✓ 500 mA of stored beam in terms of power (2.5 MW of beam power)
- ✓ 1 A in terms of HOM damping

HOM DAMPING

• The use of standard Conflat flanges CF250 imposes a maximum inner diameter of 230 mm for the HOM dampers.

• For mechanical reasons the damper axes are positioned at least at 150 mm from the inner walls of the end discs.

Single cell cavity with optimised HOM dampers



Third smaller damper needed to damp the few remaining HOM

GdfidL simulations have shown that only 2 dampers are required to damp the lowest HOM

HOM DAMPERS

✓ **2 dampers** with $\mathbf{f_c}$ **= 452 MHz**:

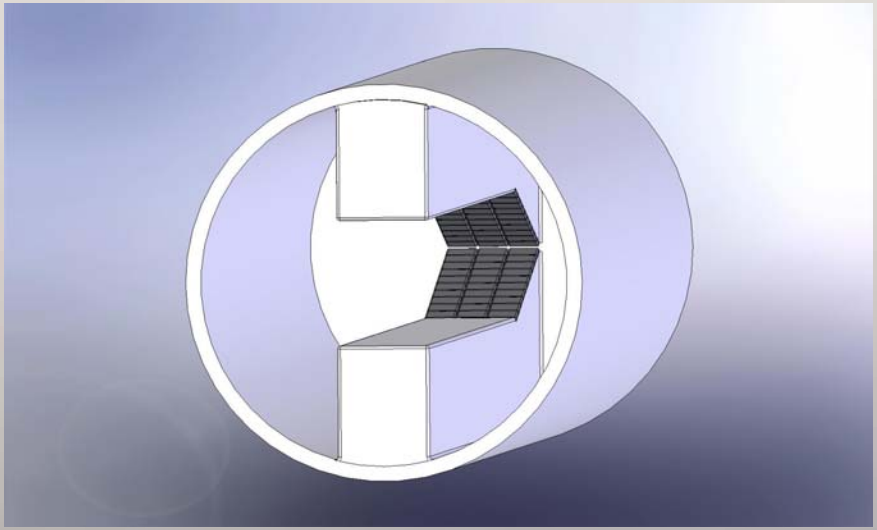
- inner diameter: 230 mm
- gap between ridges: 69 mm
- ridge width: 60 mm
- 1 damper at 150 mm from the front disc
- 1 damper at 150 mm from the back plane

✓ **1 damper** with $\mathbf{f_c}$ **= 1.56 GHz**:

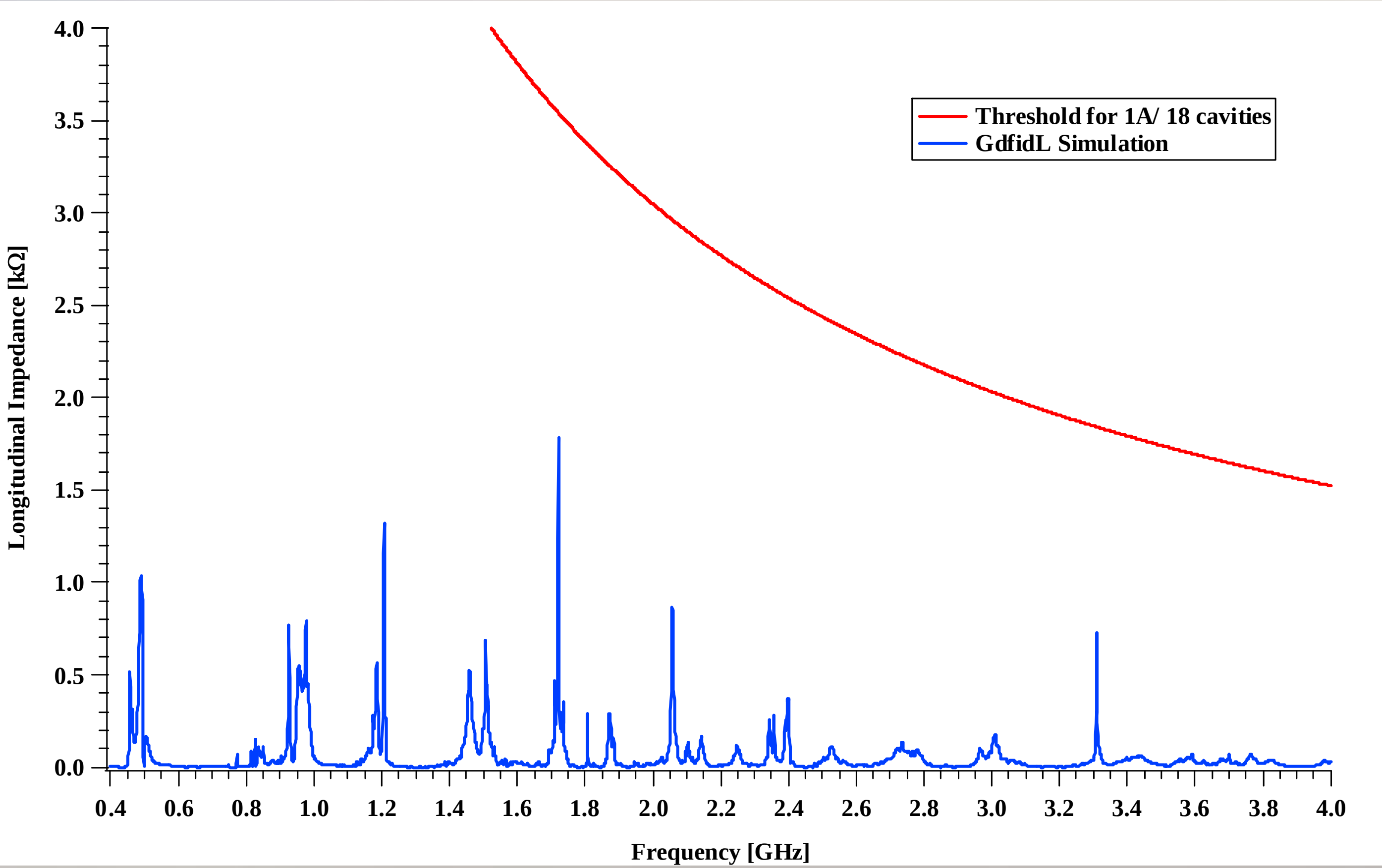
- inner diameter: 160 mm
- gap between ridges: 130 mm
- ridge width: 60 mm
- at 63.1 mm from the cavity equator

✓ The ferrite model used in these computations is based on the high power prototype designed at BESSY and consists of an assembly of small ferrite tiles of 2.7 mm thickness over a length of:

- 200 mm for dampers with fc = 452 MHz
- 250 mm for dampers with fc = 1.56 GHz



Longitudinal HOM spectrum



Longitudinal HOM spectrum well below threshold level
at 1 A for 18 cavities

Longitudinal HOM spectrum for various tuner positions

Simulations has been performed including:

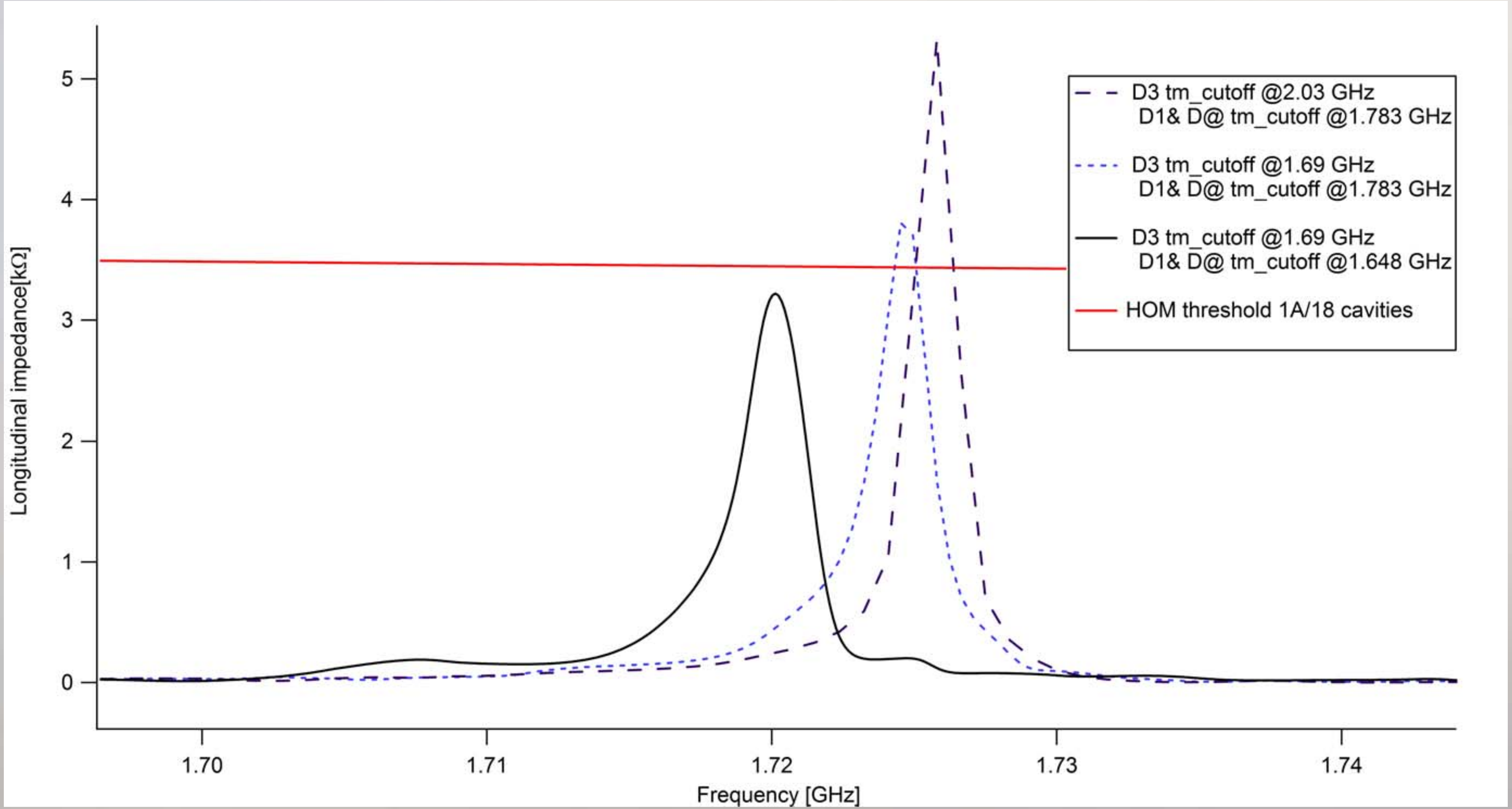
- pumping port in the bottom of the cavity
- coupler port
- various tuner positions: from -20 mm to 40 mm / inner cavity radius

All the HOM still remain below the threshold for 1A & 18 cavities except the HOM @ 1.7 GHz

Extensives simulations shown that this HOM couples strongly with the TM modes of the HOM dampers

To damp this HOM, the TM cutoff frequencies of both D3 & D1,D2 should below 1.7 GHz

TM cutoff tuning to damp the HOM @ 1.7 GHz



Tuner @ -20mm: worst case

GdfidL Simulations & Measurements

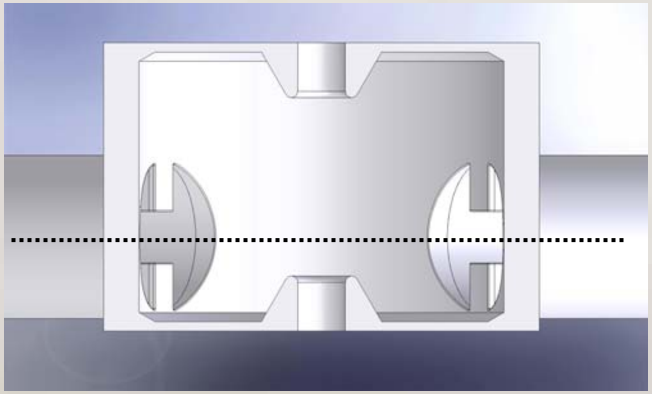
Measurements done on a first aluminium prototype with two dampers only.

Large discrepancy for the HOM @ 758 MHz

- Two dampers in the same plane:

Q_{simu} = 1780 $Q_{measurement}$ = 9200

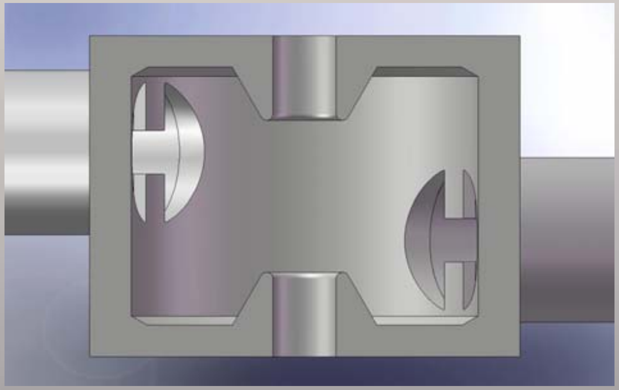
R_{simu} = 970 Ω $R_{measurement}$ = 11 kΩ



- One damper in the front plane and one in the back plane:

Q_{simu} =1200 $Q_{measurement}$ = 1300

R_{simu} = 840 Ω $R_{measurement}$ = not measurable

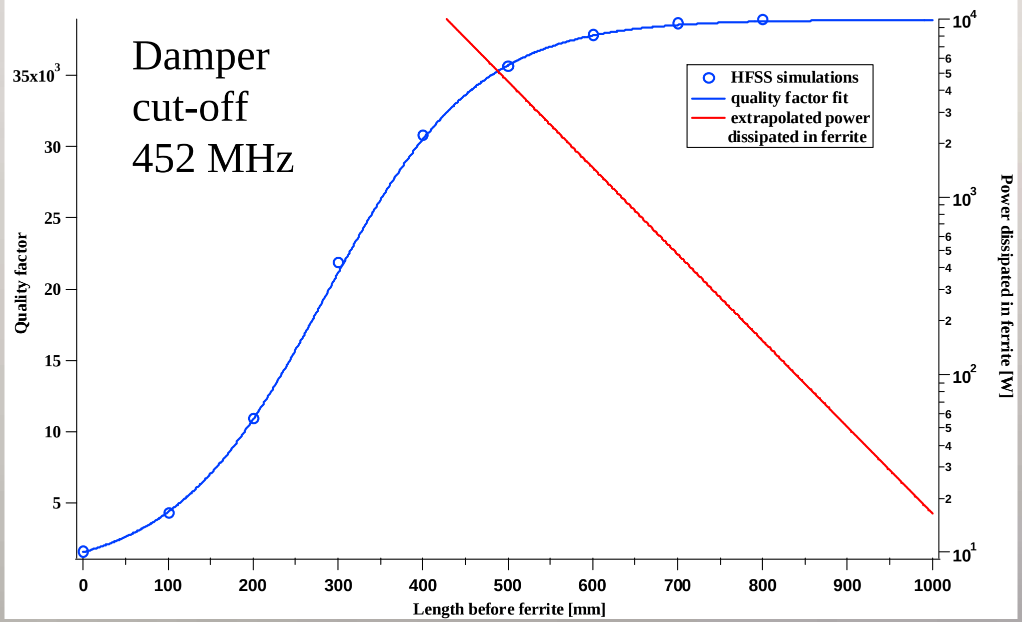


FUNDAMENTAL MODE

• The beam pipe diameter has been kept at 100 mm as on the existing five-cell cavities to remain compatible with the existing X-ray absorbers and to ease the installation

single cell cavity without HOM dampers optimized to obtain a maximum shunt impedance of 6.1 MW: R/Q = 148.5 W & Q_o = 41100

• Quality factor and accelerating mode power dissipated in the ferrites for the worst case of a degraded operation at 9 MV with 12 cavities:

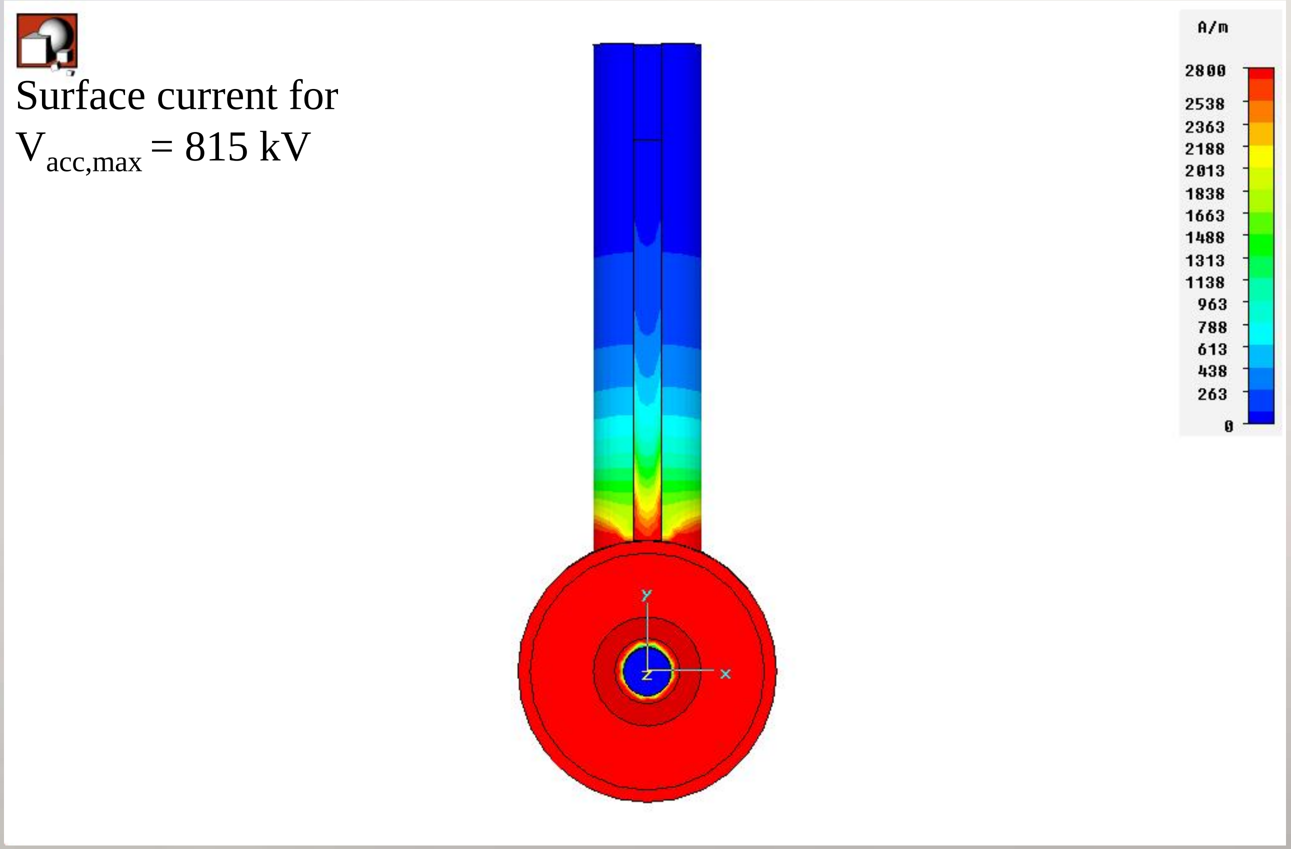


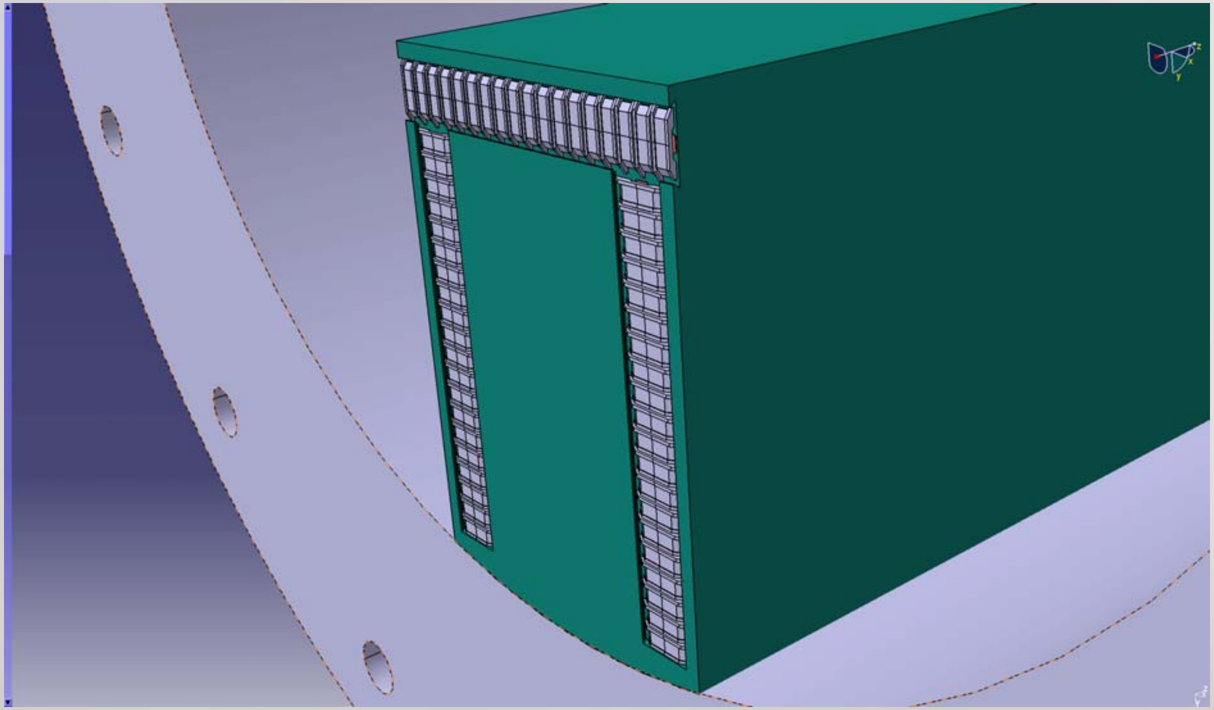
Requiring less than 100 W dissipation in the ferrites

840 mm before ferrites for HOM damper with fc = 452 MHz

- Numerical computations of the complete structure with eigenmode solvers (HFFS & MWS) need a large amount of memory
- To determine the impedance and quality factor of the fundamental mode, computations are done with only one damper per simulation
- The fundamental mode parameters were then extrapolated for the complete structure and are estimated to R/Q = 145 W, Q_o = 35000

RF POWER TESTS OF RF FINGERS FOR THE HEAD ON CONNECTION OF RIDGE WAVEGUIDES

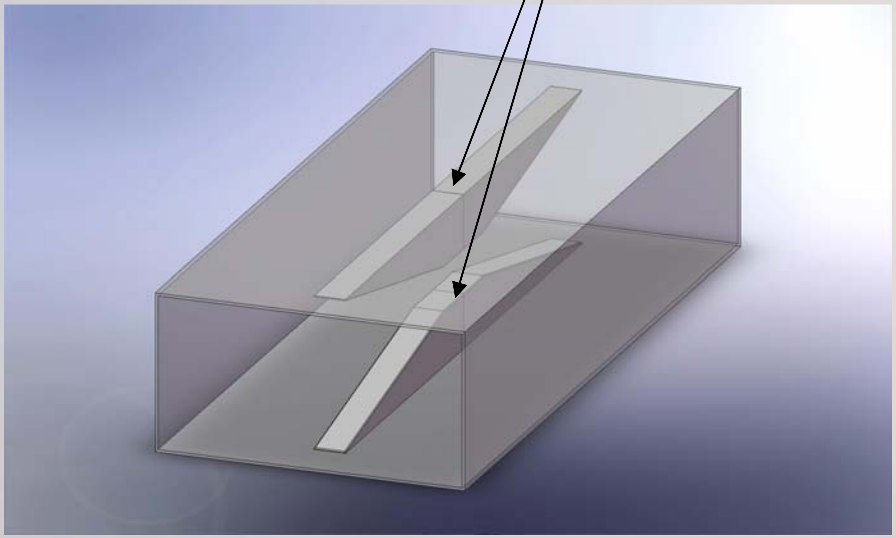




In the flange that will connect the ferrite loaded damper to the coupling section:

- the copper gasket will guarantee the electrical continuity on the outer cylinder.
- In the ridge zones, the electrical continuity will be established by means of RF fingers.

Tapered double ridge WR2300 waveguide with head on connected ridges, for power tests of RF fingers



• Reflection: -28 dB.

• RF power 1 MW => 600 A/m on flat top of ridges.

Test setup:

- the power tests were carried out on the RF system of the ESRF booster.
- The device was placed after the circulator between an H-bend and the dummy load.
- An already installed arc detector was placed on the H-bend to interlock the RF power in case of RF finger arcing.
- Thermal sensors (PT100) were inserted in the top ridges to follow up their temperature.

Results:

- ✓ the RF power was increased slowly up to 1.05 MW without arcing of the RF fingers.
- ✓ After 3 hours of test the device heated up to 80º C on the flat top of the ridges, compared to a 40º C heating of the waveguide network around the device.
- ✓ After the first test, the device was dismounted and no trace of over-heating or arcing was observed.
- ✓ No problem was observed after three further tests.

Minimum length of the coupling section: 280 mm

OUTLOOK

- Tests with different types of RF fingers are planned in order to further optimize the mechanical and electrical interface.
- Studies of the vacuum system configuration and the thermal behavior are under way.
- Validation of the model on aluminium prototype with various dampers.
- The goal is to launch the fabrication of a high power copper prototype beginning of next year.