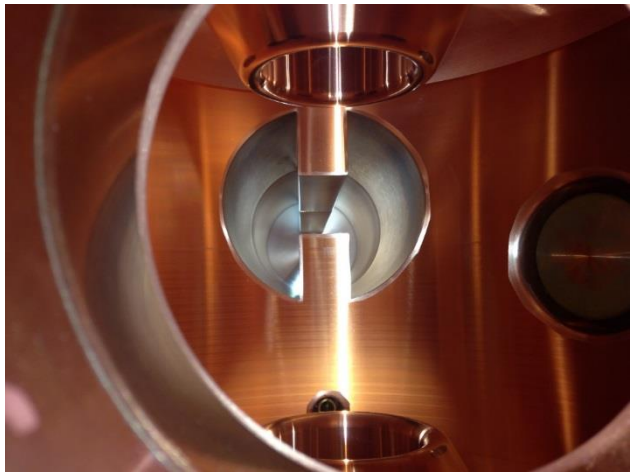
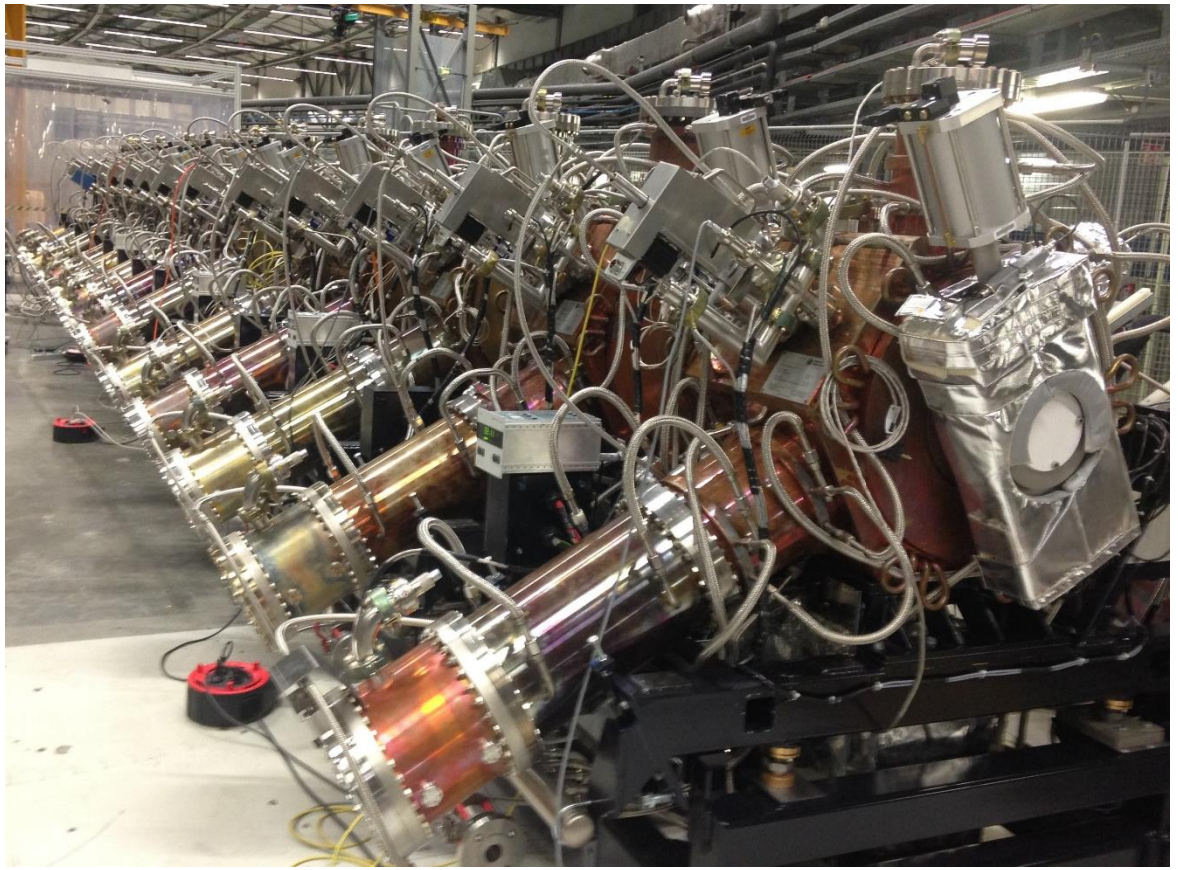
22ND – ESLS RF MEETING - SOLEIL





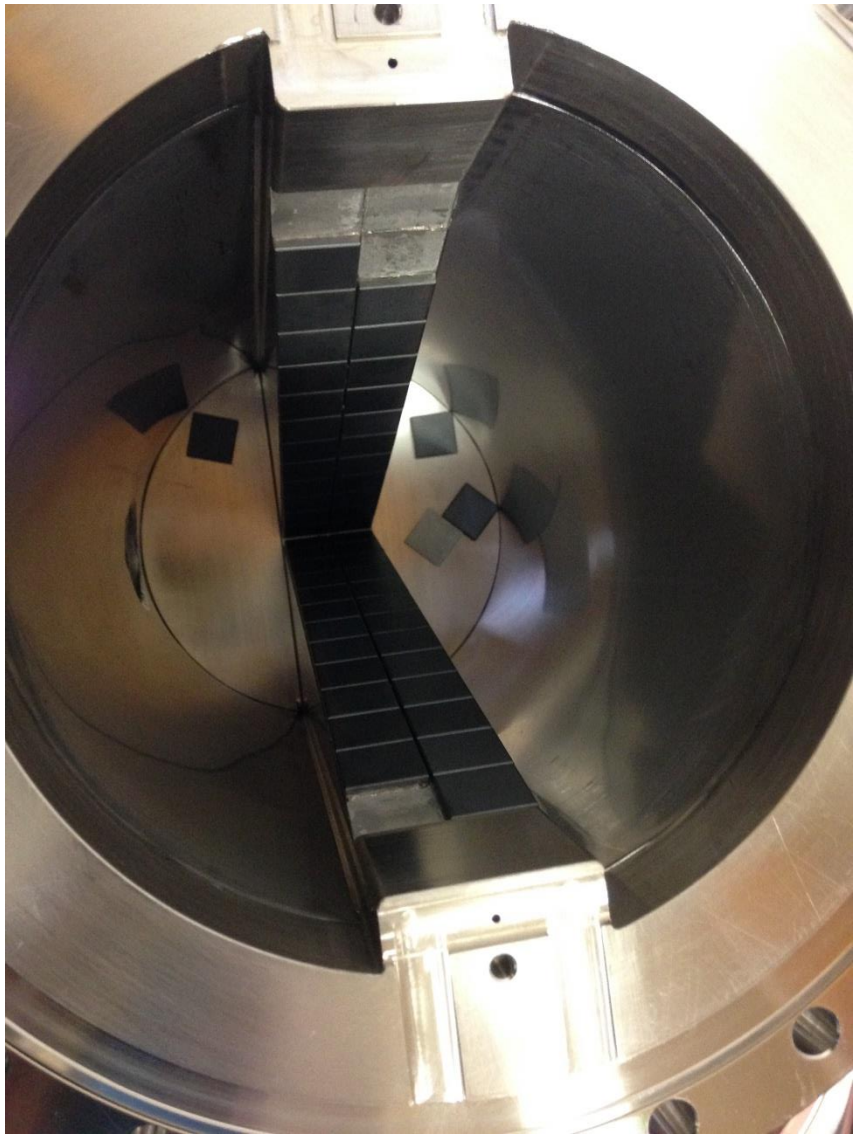
Impedance Characterization of the HOM Damped Cavities for the ESRF-EBS

Alessandro D'Elia – ESRF – ASD/RF Group

CONTENTS

- **Motivations**
- **Longitudinal impedance:**
  - All dampers installed: GdfidL simulations and presentation of a reconstruction technique using HFSS to cross check the results;
  - Removal of the small damper;
  - Effect of the ancillaries: ion pump and tuner;
- **Transverse impedance:**
  - With and without small damper
  - Effect of the ancillaries: tuner.

MOTIVATIONS



Despite of a fully satisfactory prototype phase, during the production of the HOM Absorbers, severe issues have been encountered in brazing the ferrite tiles on their metallic wedges.

This forced us to revise our strategy and to move to a different design of the HOM Absorbers. This implied to resume the impedance studies in order to:

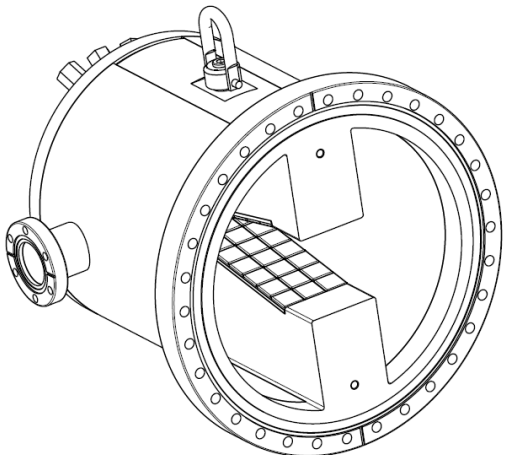
1. Verify that the new design was as good as the original one;

2. Verify the “damping performances” of each damper (in particular the small one on the top of the cavity) to run properly the ESRF-EBS machine in case of “emergency”.

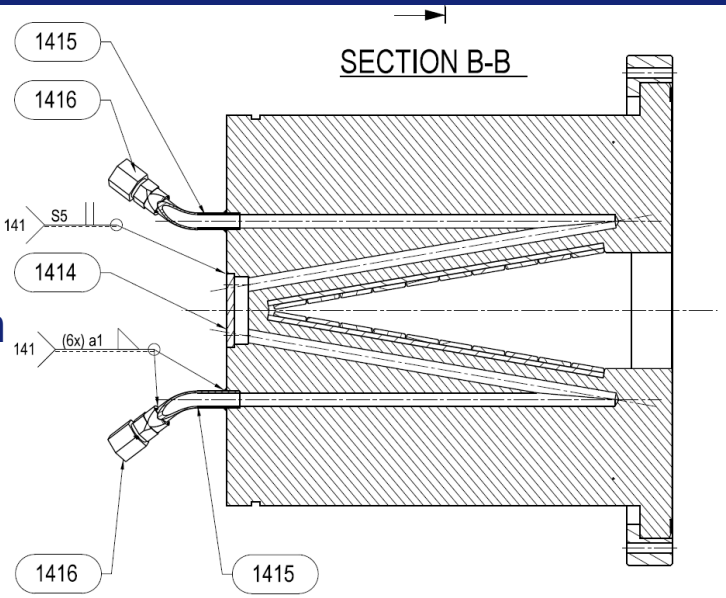
POSSIBLE CONSEQUENCES OF FALLING TILES

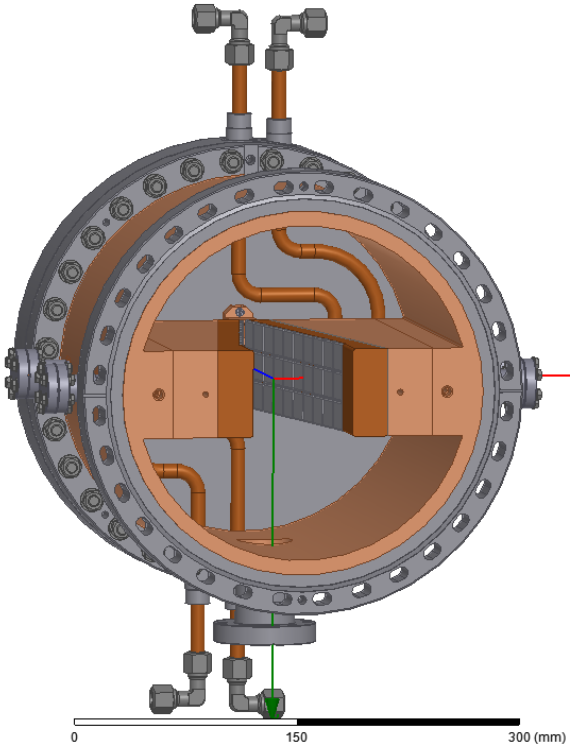
La journée des Tuiles par Alexandre Debelle

HOM ABSORBERS – THE NEW DESIGN

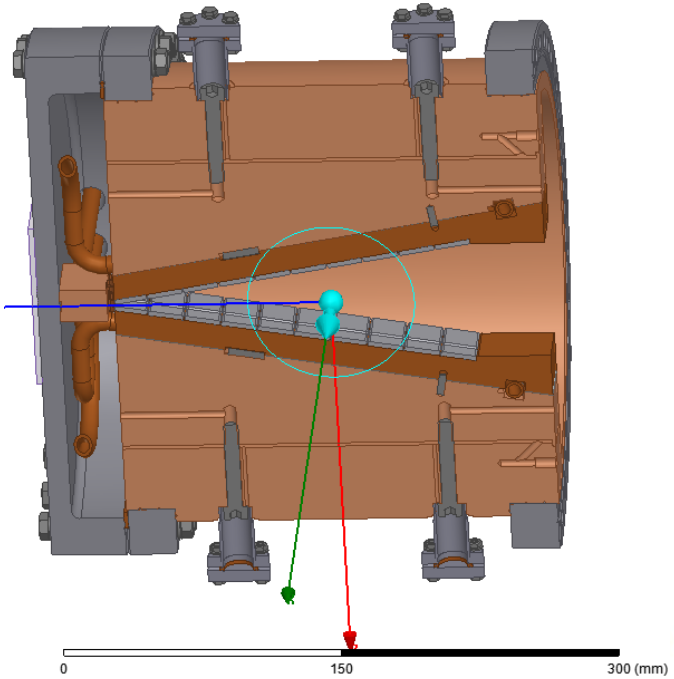


Original Design





New RI Design



ESRF

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- **Transverse impedance:**
  - With and without small damper
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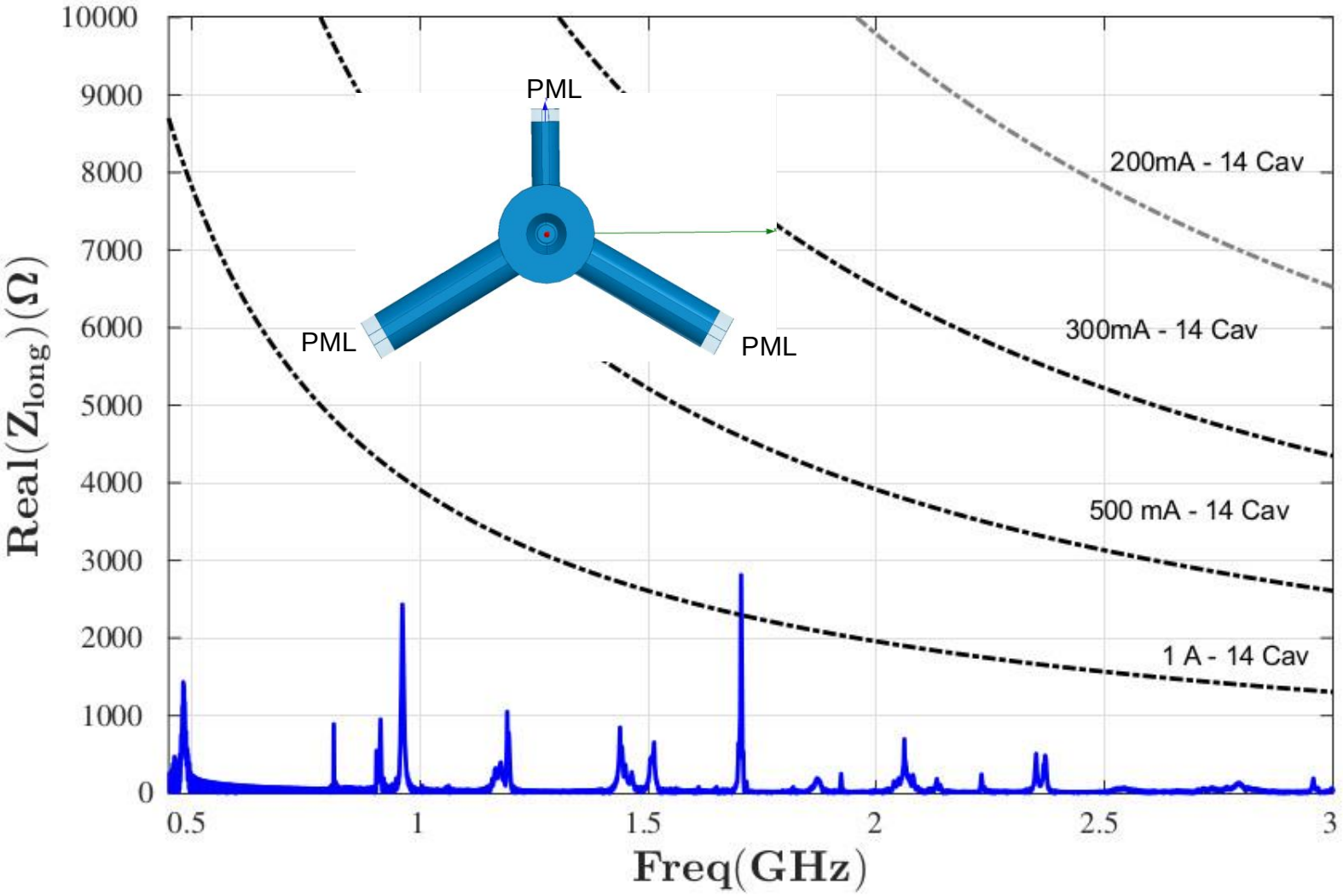
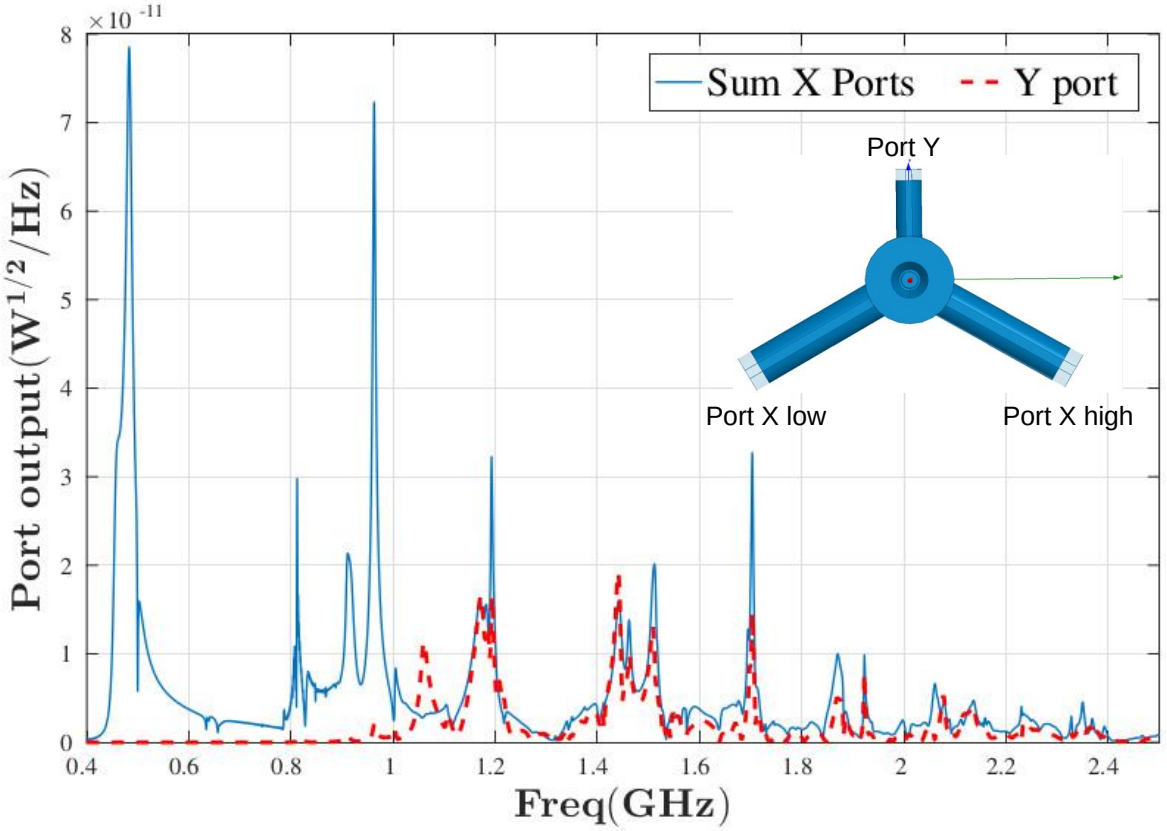
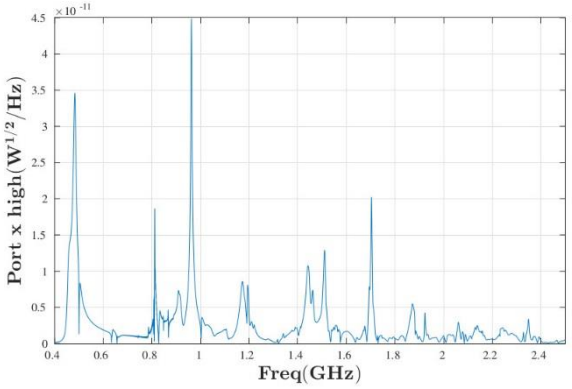
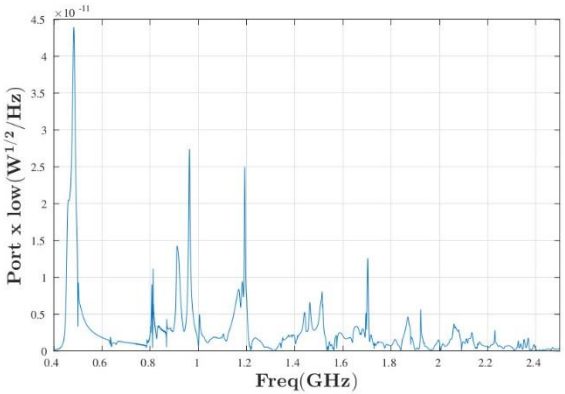
LONGITUDINAL IMPEDANCE: IDEAL STRUCTURE WITH PML, GDFIDL



POWER FLOW THROUGH THE COUPLING SECTIONS: GDFIDL







POWER FLOW THROUGH THE COUPLING SECTIONS: MEASUREMENTS VS GDFIDL

In May 2016, a measurement of the power flow, through the HOM dampers on the cavity 23-2, has been planned and performed during a run in 16 bunches.

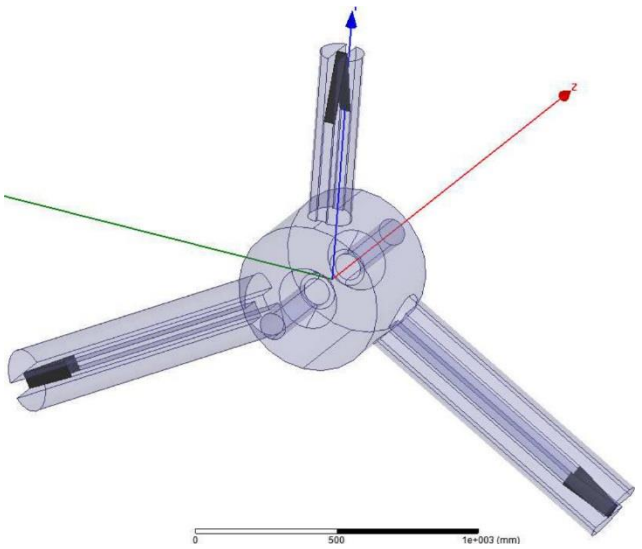
Port/Damper	Simulation	Meas. (Passive)	Meas. (Active)
X Low (W)	313	279	313
X High (W)	301	244	279
Y (W)	188	139	139

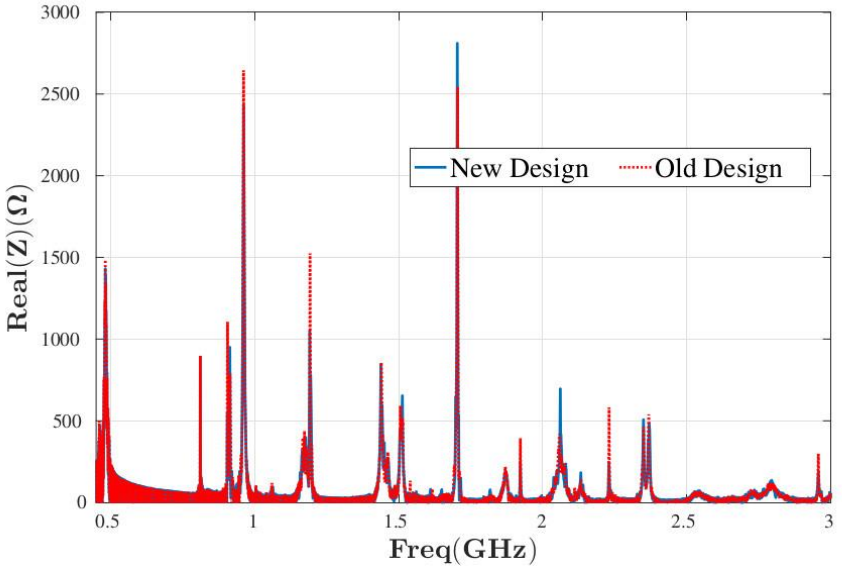
Some remarks:

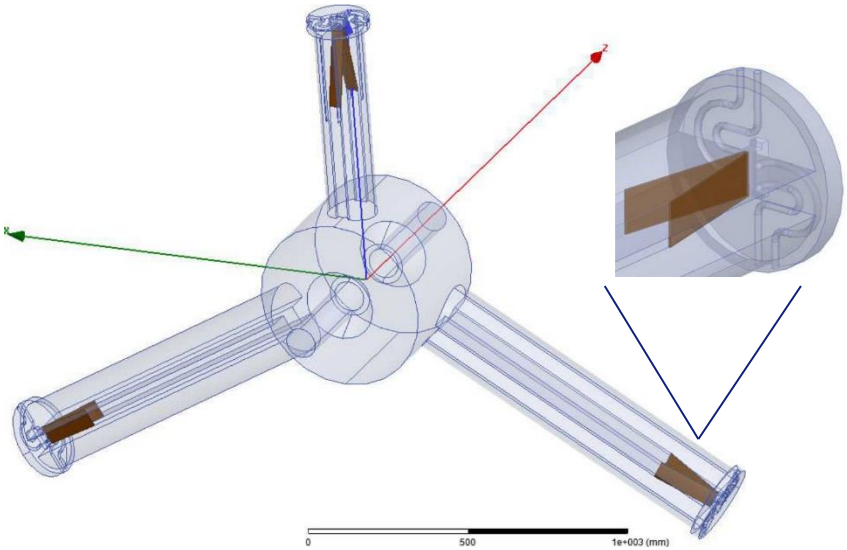
The power in GdfidL is a power per bunch per cavity, this means that, to compare the results, also the measured beam power must be scaled per bunch and per cavity. Scaling the power per bunch is trivial, scaling the power per cavity is less trivial as the storage ring install 5 X 5-cell cavities and 2 Monocell cavities. For the sake of the simplicity, each 5-cell cavity has been considered equivalent to 5 Monocell cavities.

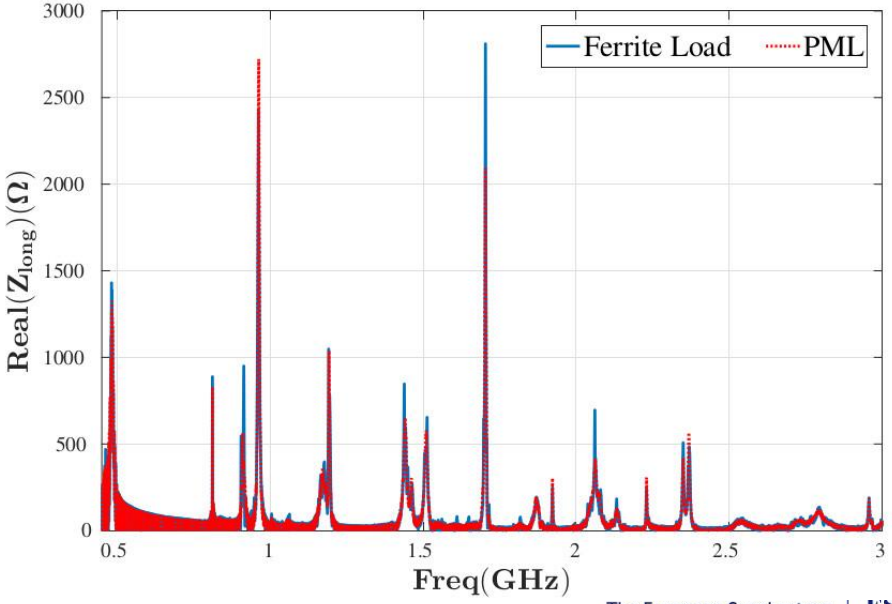
Furthermore the water flow rate must be strongly reduced to measure decent temperature variations from input to output (<1degC); dealing with these small quantities induces an uncertainty in the measurements, estimated to be around 10%.

FULL STRUCTURE SIMULATIONS







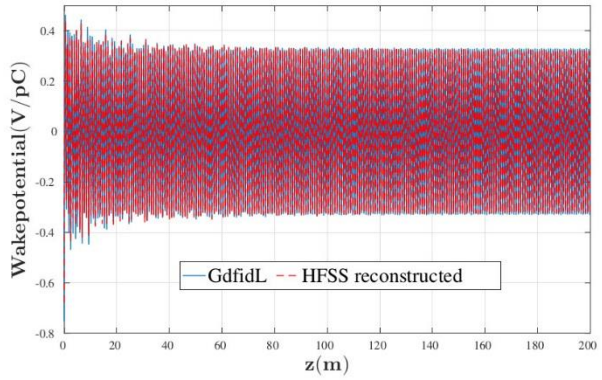


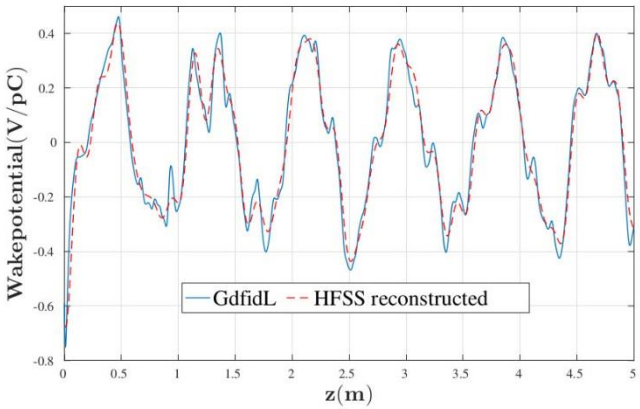
RECONSTRUCTED WAKEPOTENTIAL USING HFSS

In parallel with GdfidL, we can reconstruct the wakepotential behavior using HFSS by means of *

$$W(z) = 2\sum_n k_n \cos\left(\frac{\omega_n z}{c}\right) \mathrm{Exp}\left[-\frac{\omega_n}{2Q_n^{ext}}\frac{z}{c}\right]; \qquad k_n = \frac{|V_n|^2}{4U_n} \equiv \text{loss factor}$$

n being the index of the mode



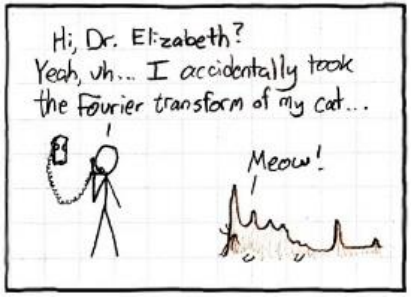


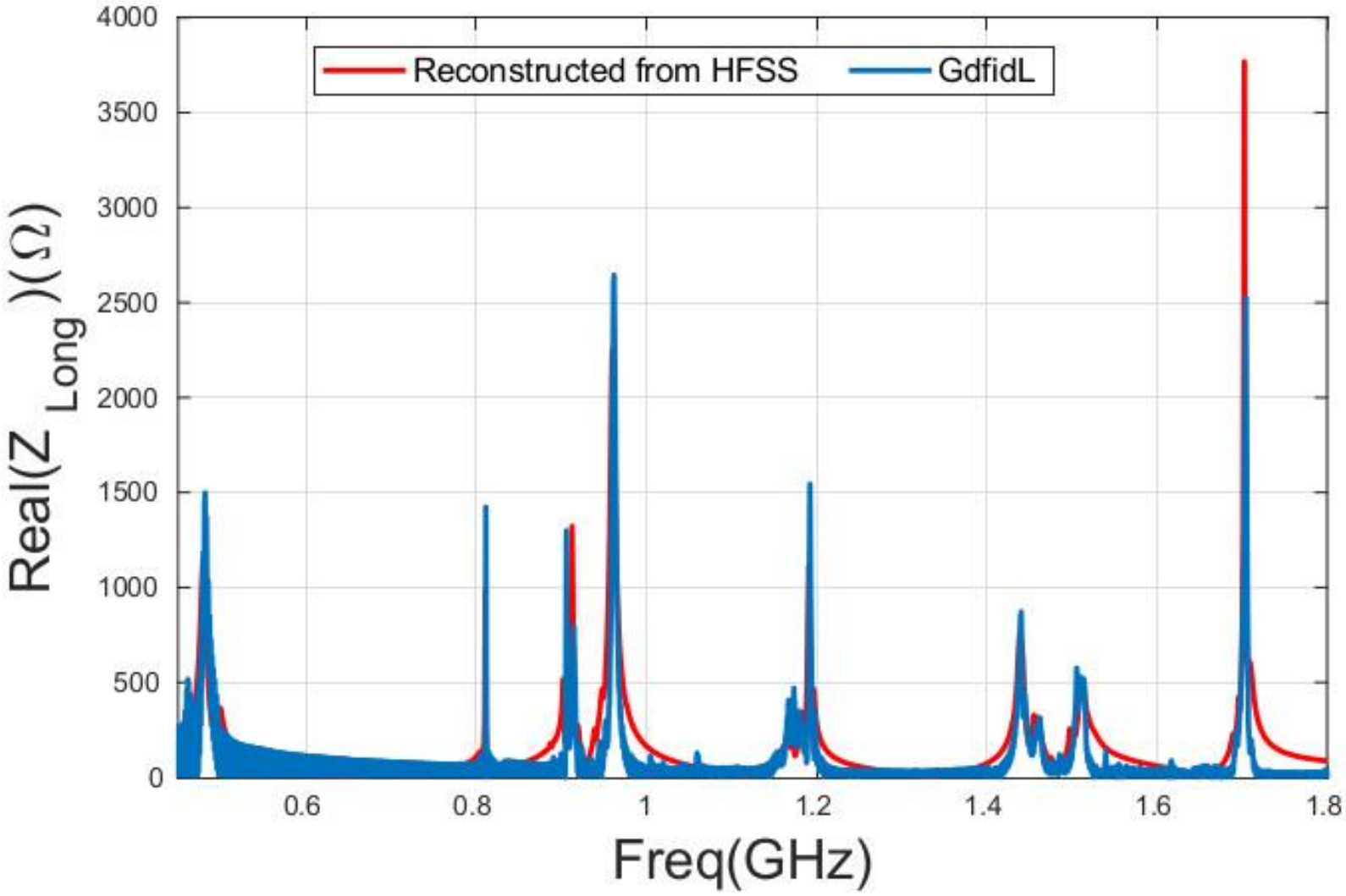
This technique is particularly interesting to cross check our results basically because HFSS is a frequency domain solver and therefore:

1. External Q's are directly calculated → particularly important to study cavities without dampers;
2. Ferrite can be easily modeled as a frequency dependent material (as it is in reality).

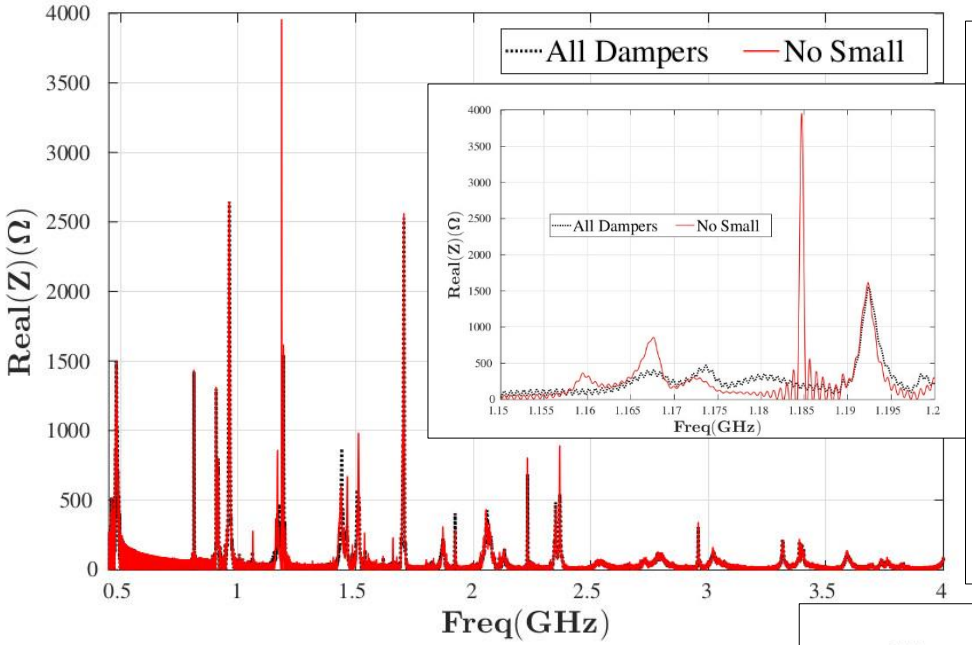
* Bane, Wilson and Weiland, "Wake Fields and Wake Field Acceleration", SLAC-PUB-3528

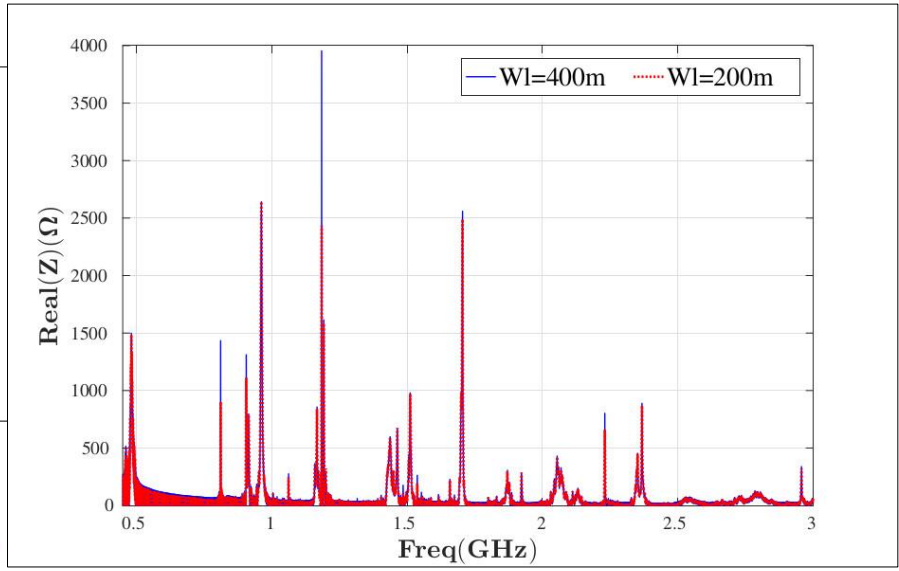
FFT: RECONSTRUCTED IMPEDANCE USING HFSS

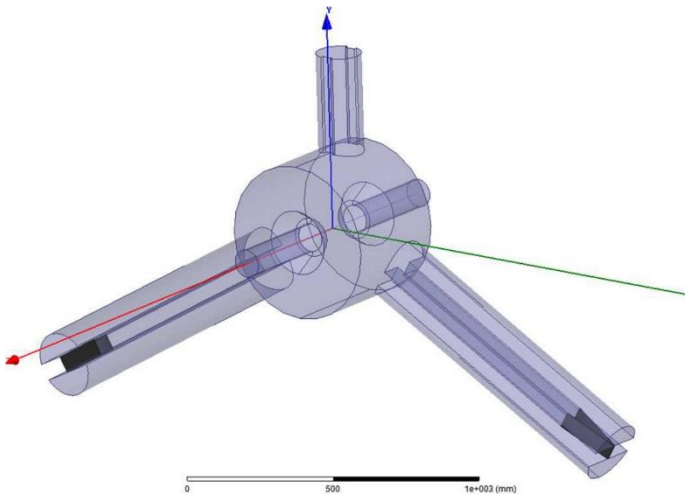


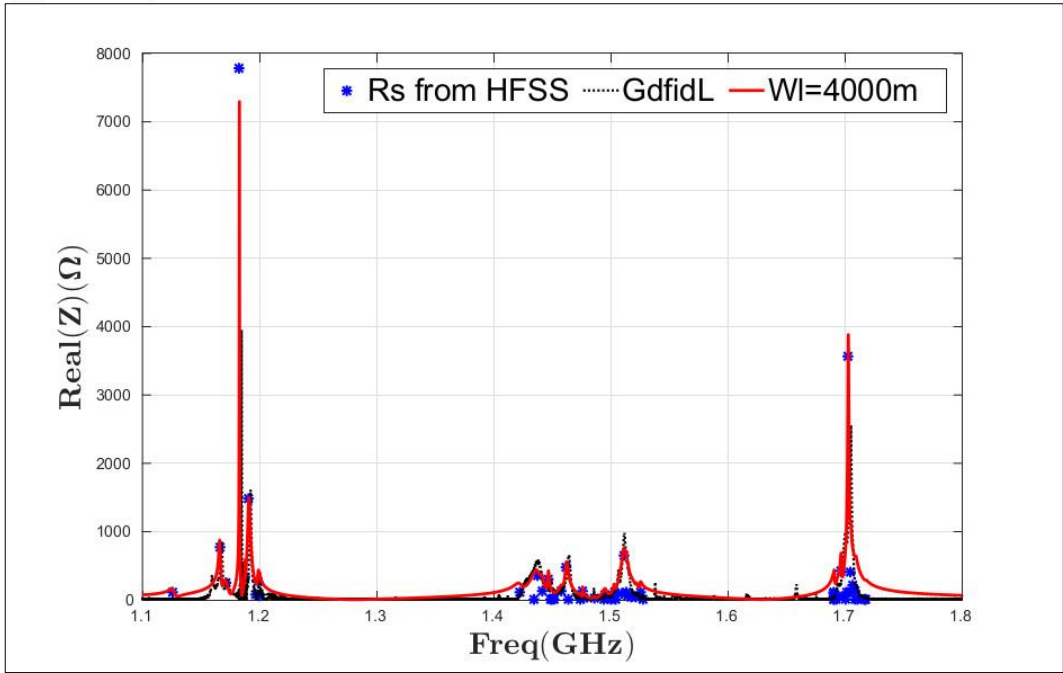


REMOVAL OF THE SMALL DAMPER

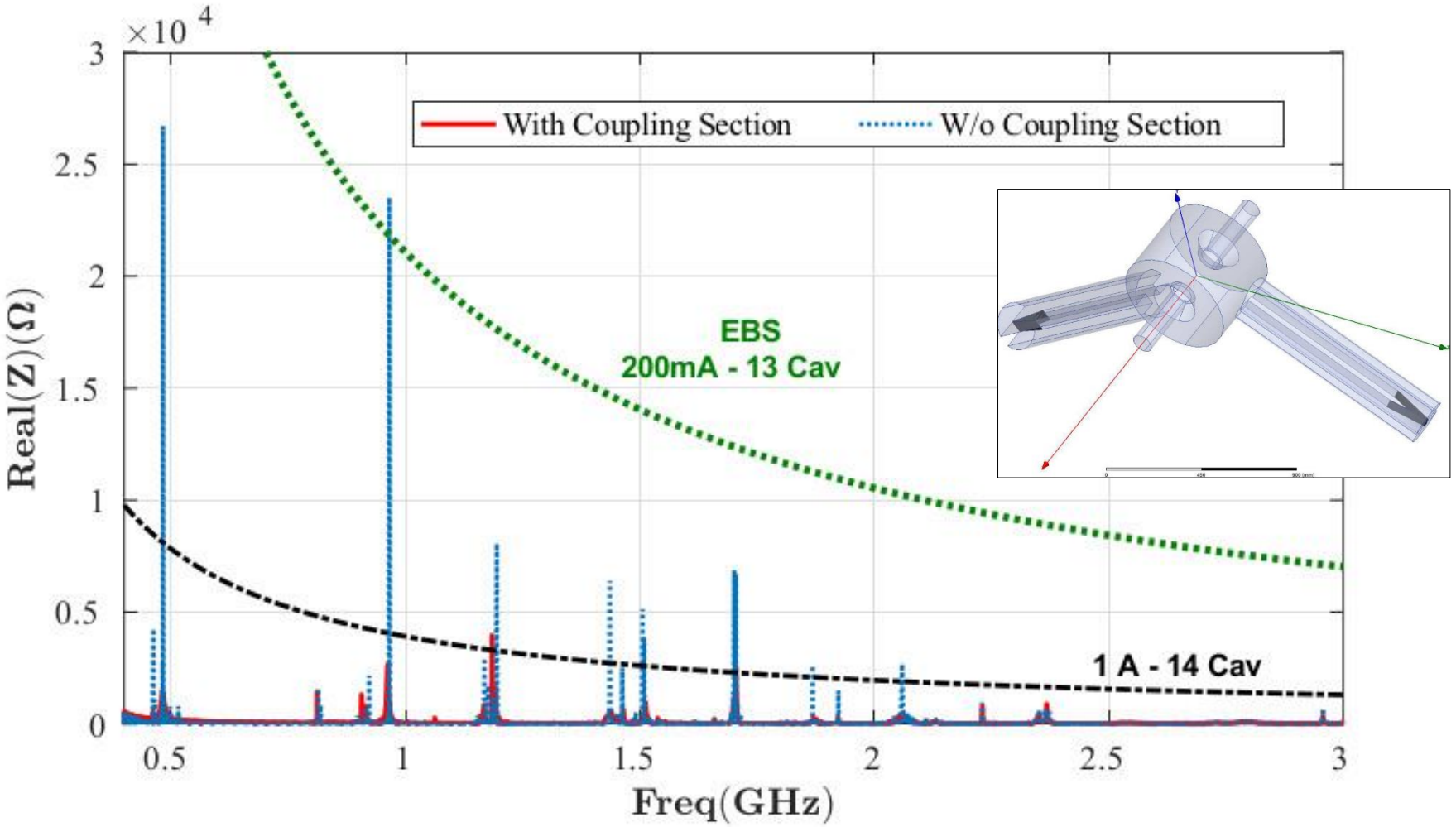




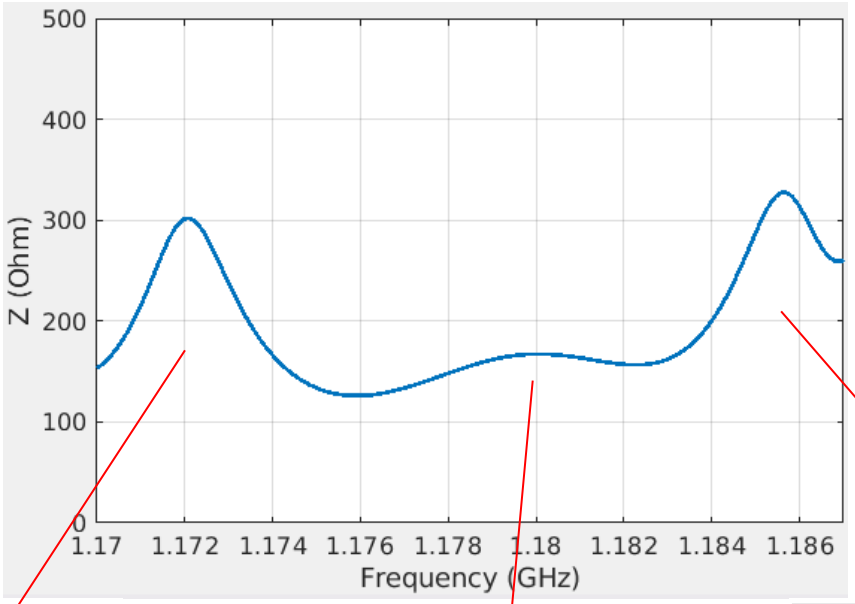


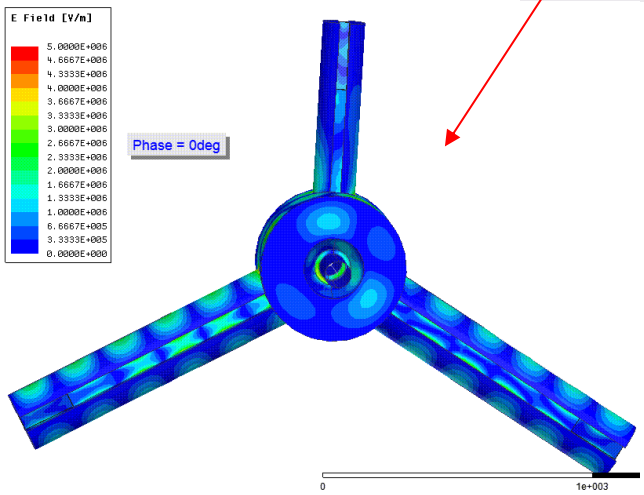


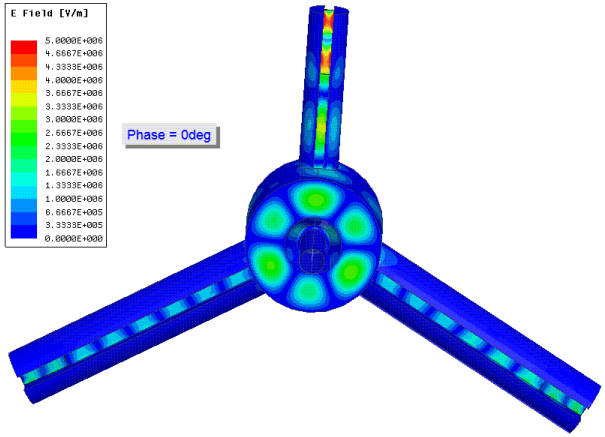
REMOVAL OF THE SMALL DAMPER: NO COUPLING SECTIONS

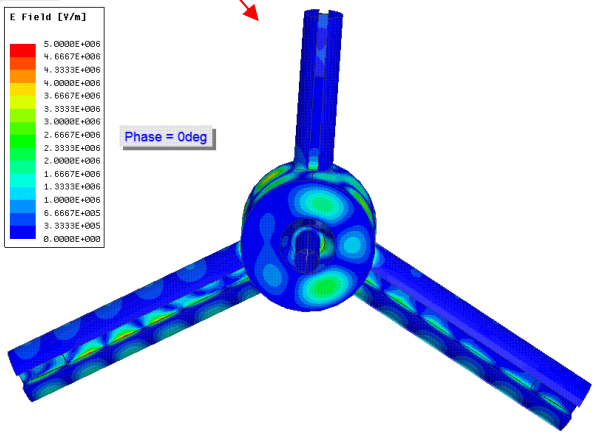


LOOKING AT THE FIELDS: ALL DAMPERS

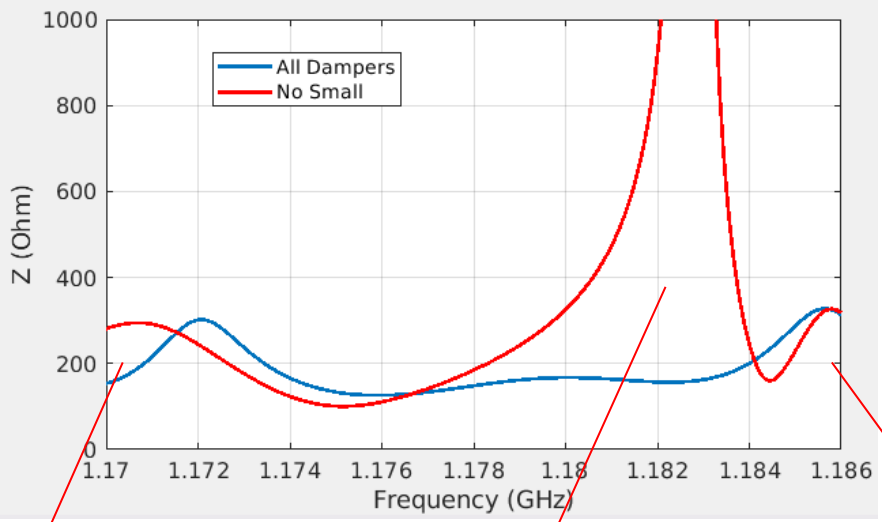


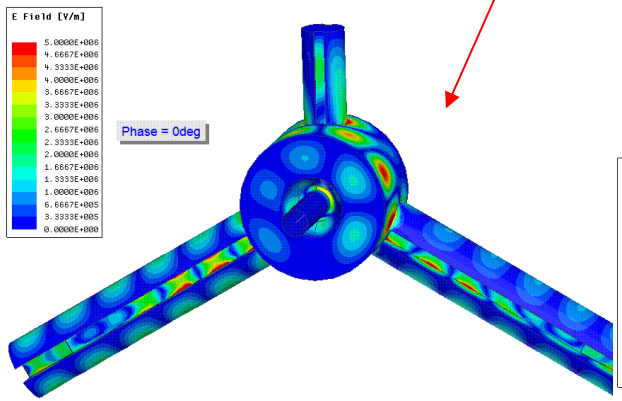


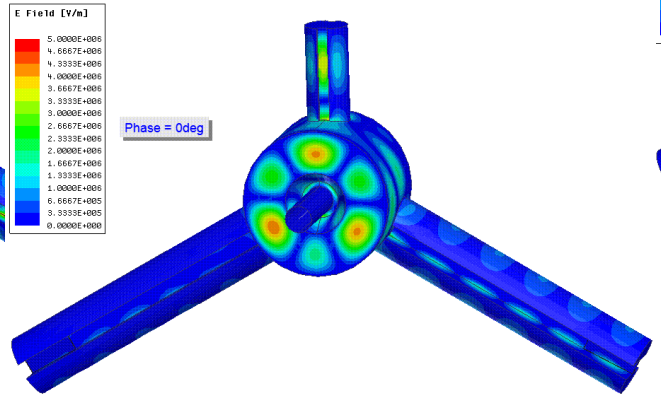


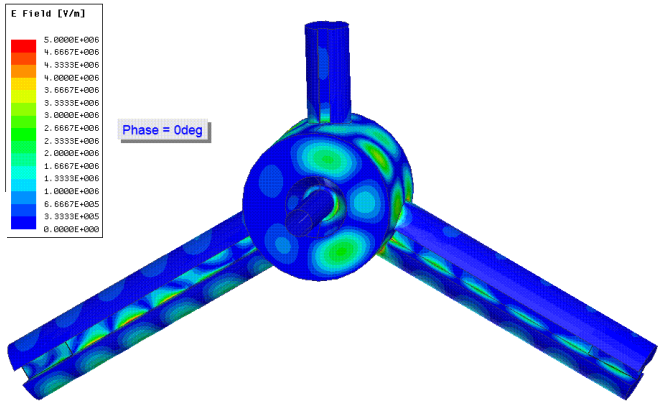


LOOKING AT THE FIELDS: NO SMALL DAMPER

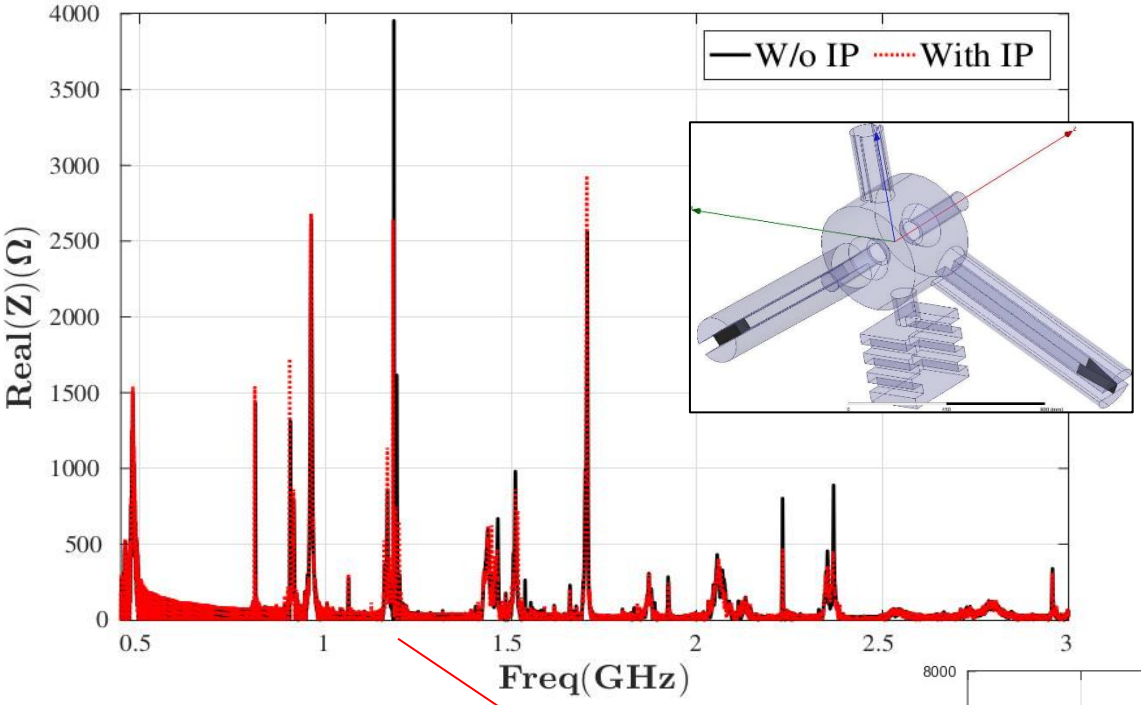


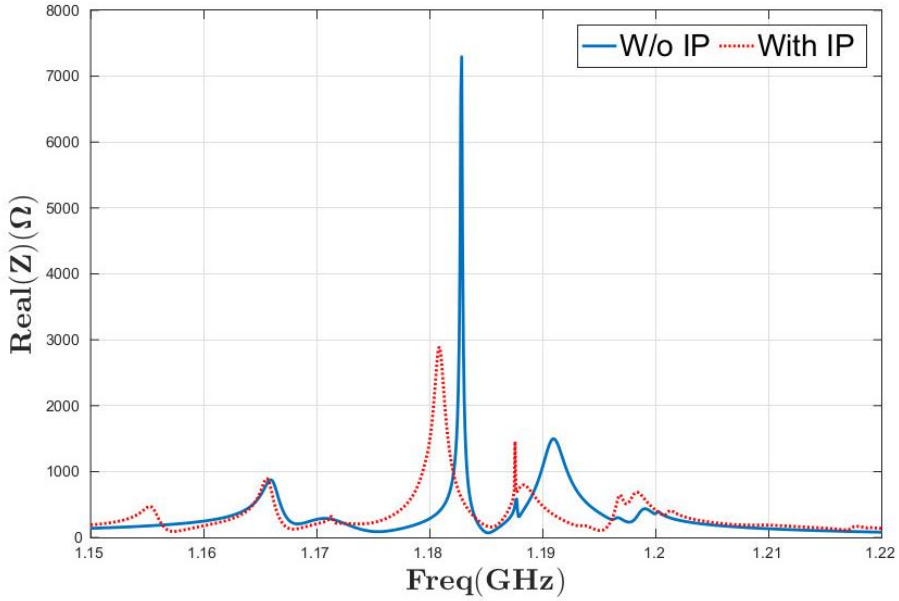




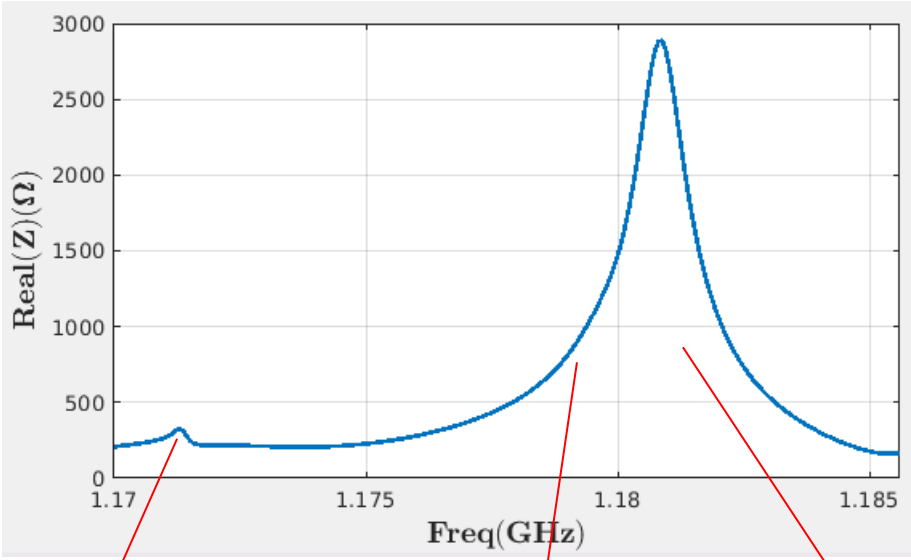


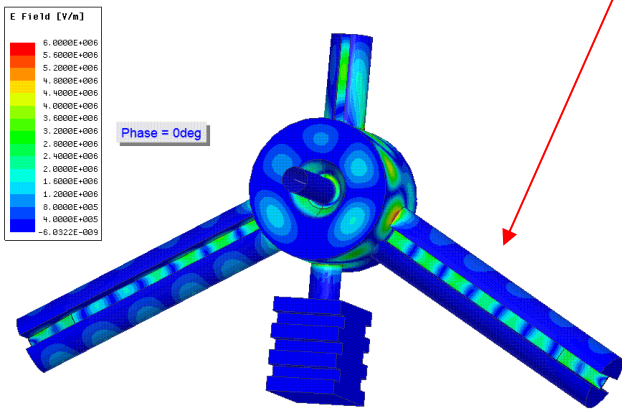
REMOVAL OF THE SMALL DAMPER: ION PUMP

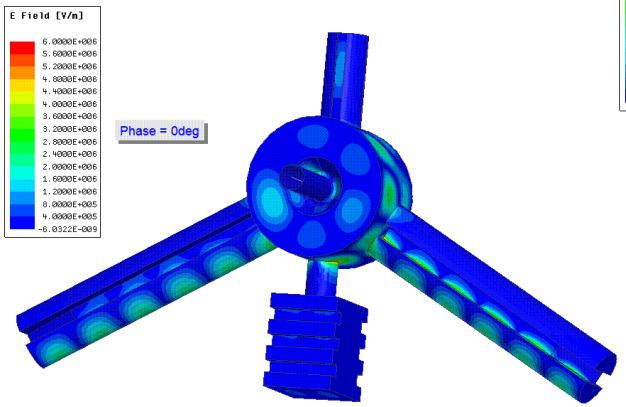


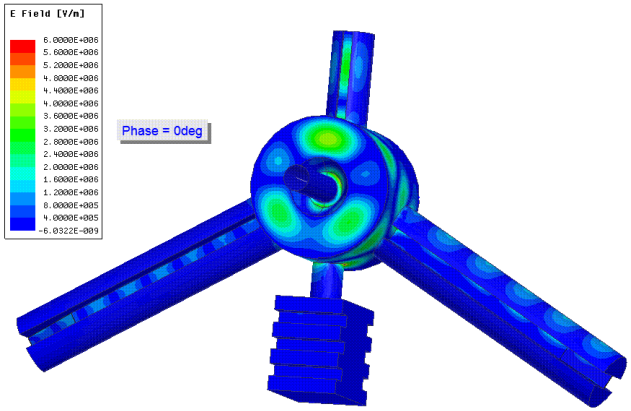


AGAIN THE FIELDS: WITH AND WITHOUT THE ION PUMP

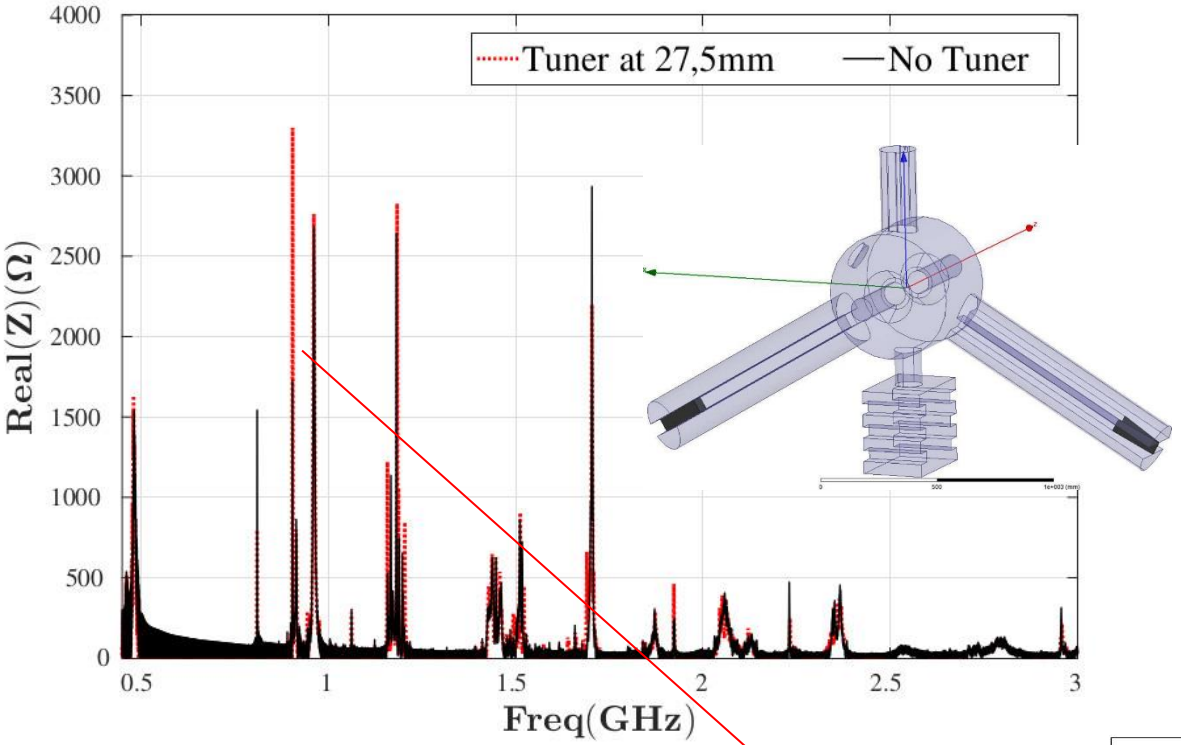


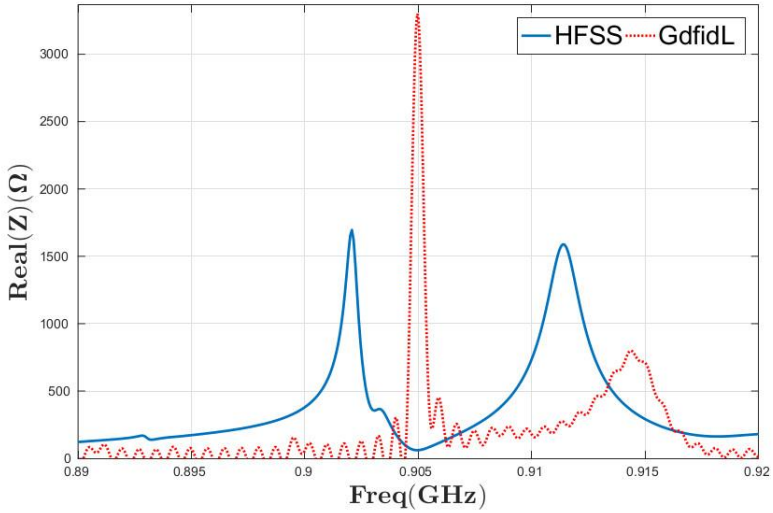






REMOVAL OF THE SMALL DAMPER: ION PUMP + TUNER





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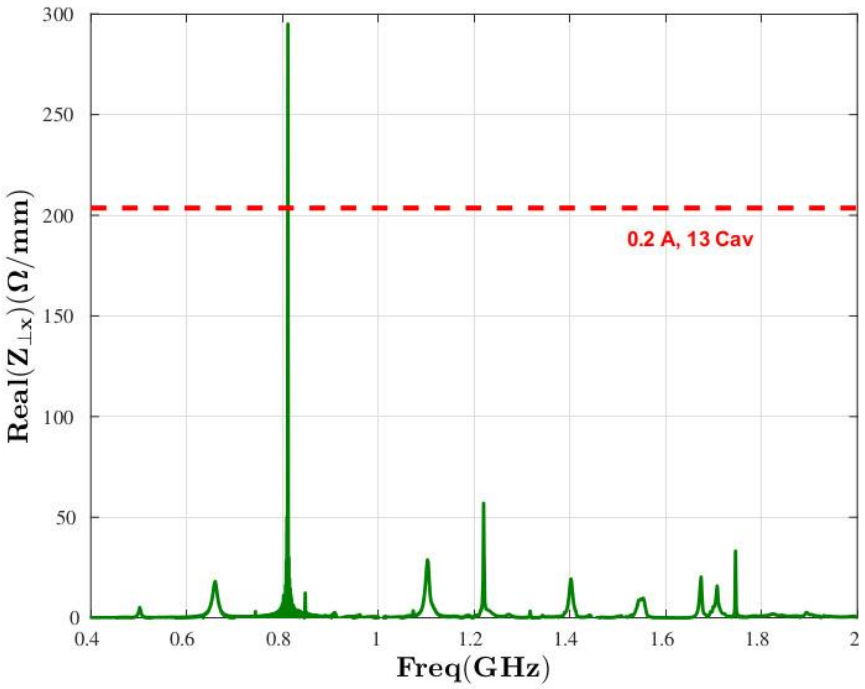
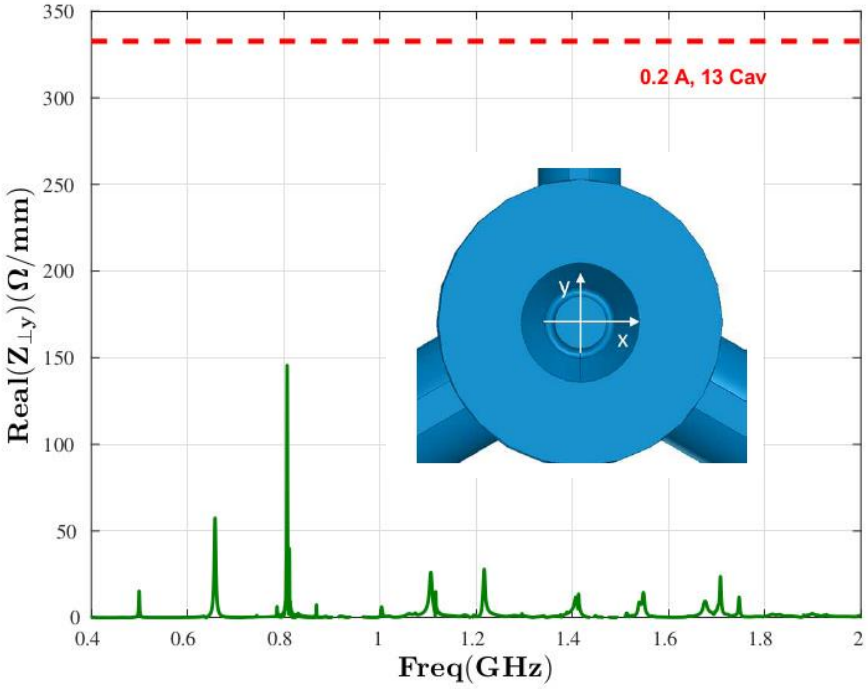
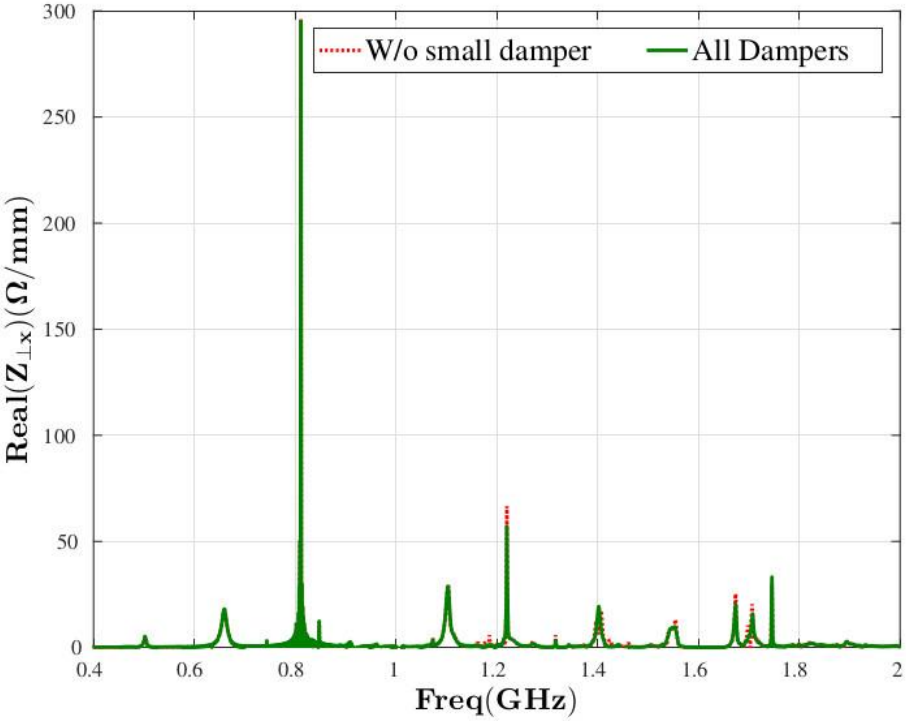
TRANSVERSE PLANE: ALL DAMPERS

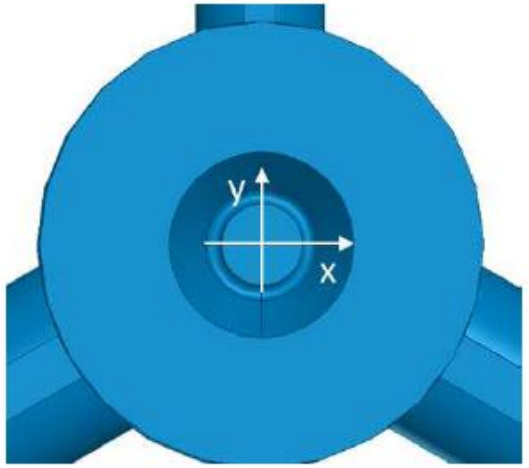
The EBS machine as well as the present one, will be a high chromaticity machine. Moreover a transverse feedback system is efficiently in use and will also be available for the new machine.
Since its commissioning, the present SR (which installs 5-cell cavities, LEP type) has never suffered of coupled bunch transverse instabilities. Nevertheless a characterization of the transverse plane is anyhow welcomed also in view of further, future upgrades.

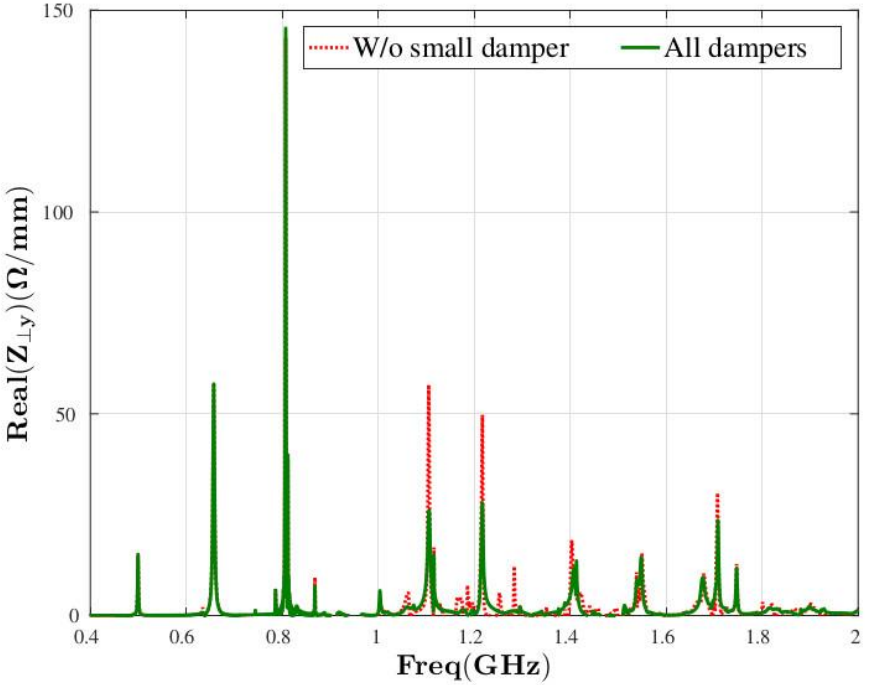




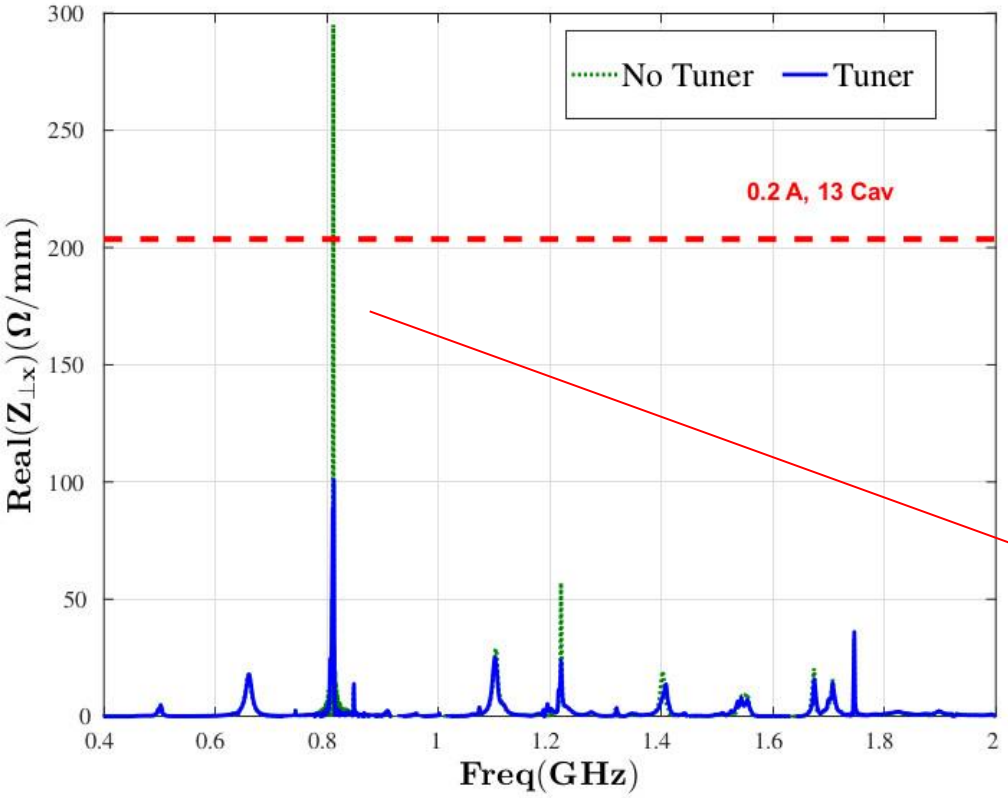
TRANSVERSE PLANE: NO SMALL DAMPER

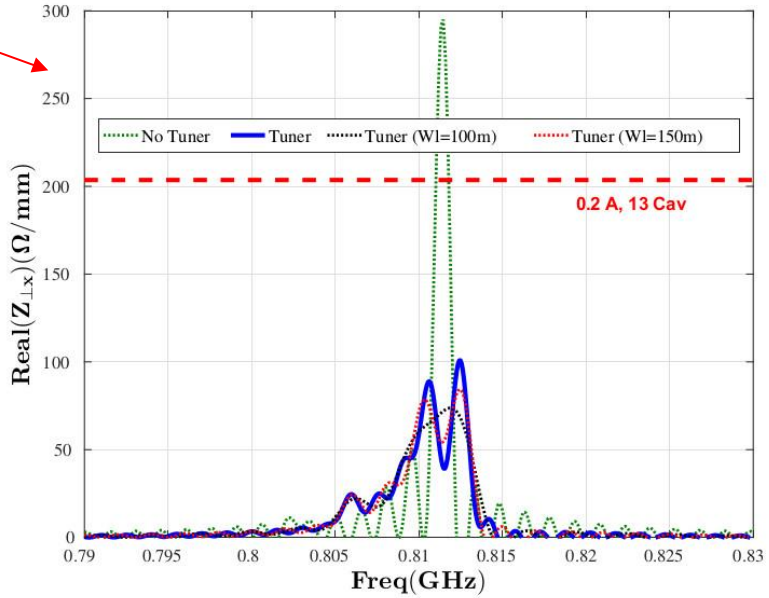




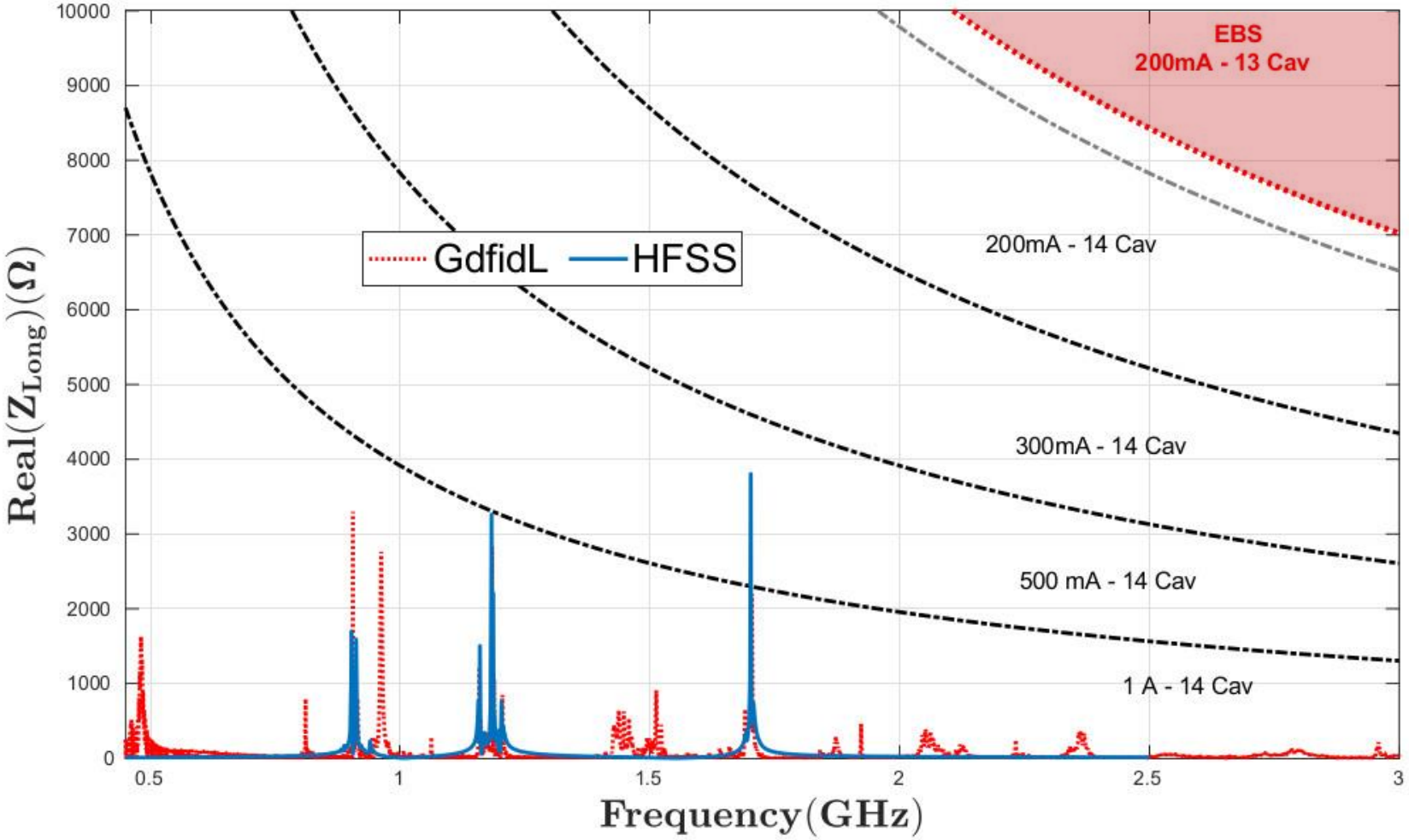


TRANSVERSE PLANE: NO SMALL DAMPER + TUNER





CONCLUSION: THE SMALL DAMPER WILL NOT BE INSTALLED



No small damper with Ion Pump

THANKS FOR YOUR ATTENTION!!!

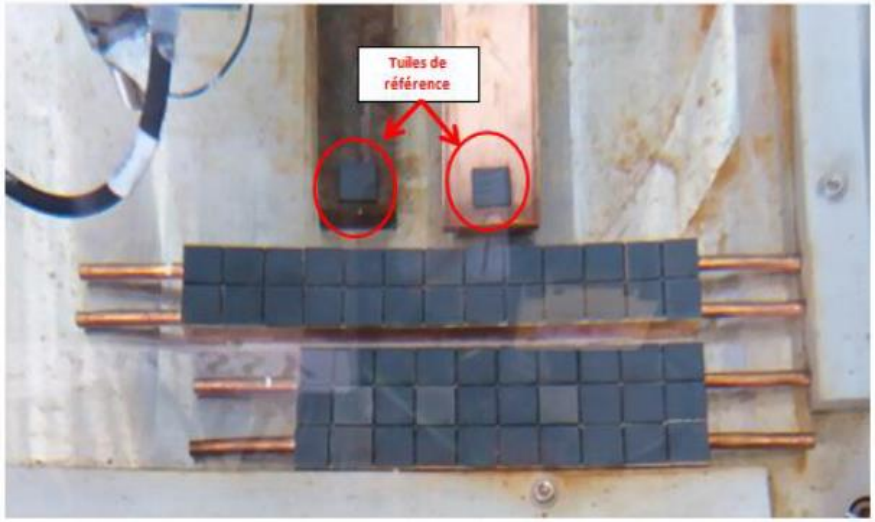
Tool to remove the small damper

Modified from https://www.fritzcartoons.com/product/646-guillotine-guy/

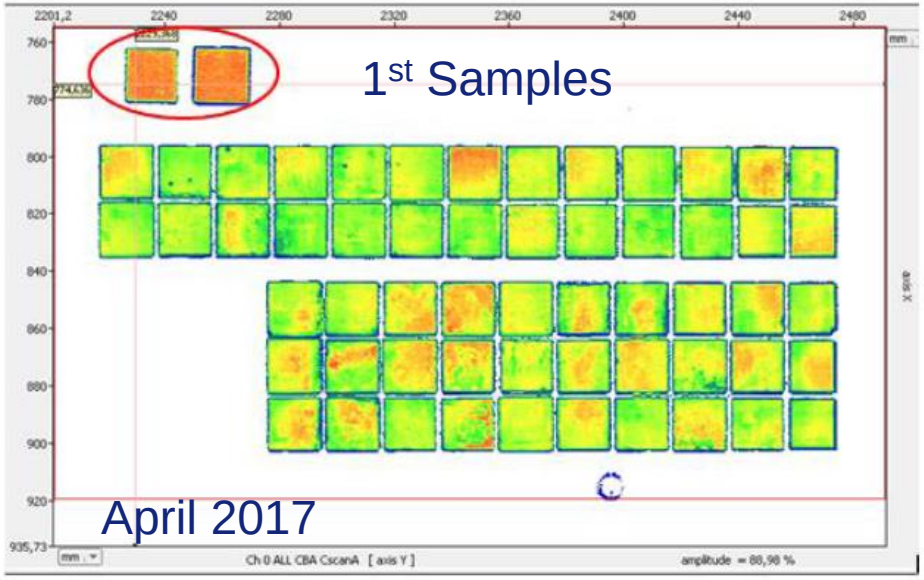
ADDITIONAL SLIDES

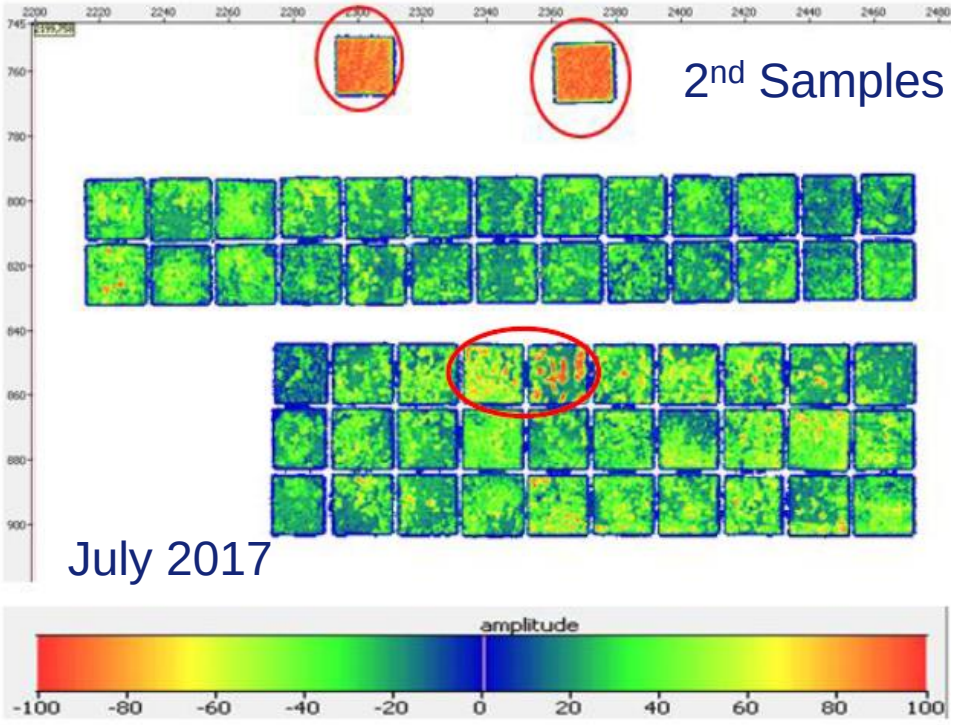
HOM ABSORBERS – ULTRASONIC TESTS OF FERRITE BRAZING AT THE "INSTITUT DE SOUDURE" (IS)

Brazing Samples

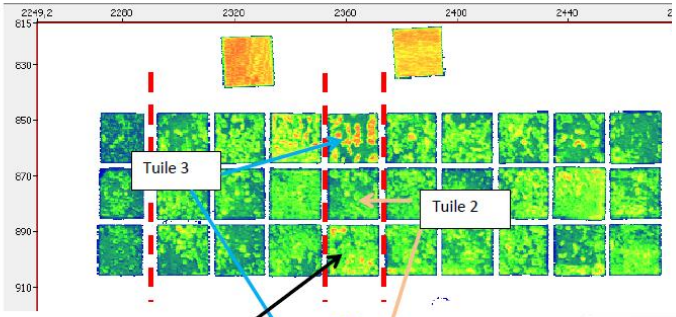


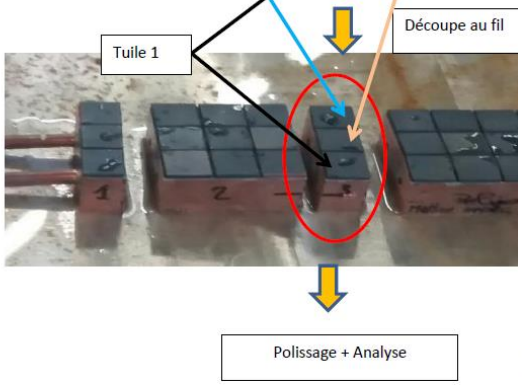
Brazing definitely improved, to be confirmed by a microscopic cut analysis



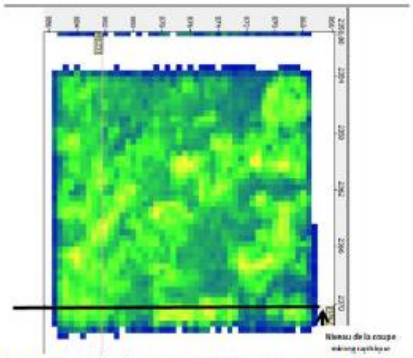


HOM ABSORBERS – MICROSCOPIC CUT ANALYSIS AT THE IS

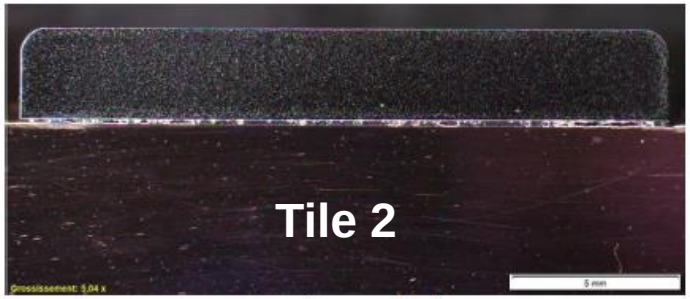




All these defects make the brazed interface more fragile and in principle there is no guarantee of a good adhesion of the ferrite tiles **in time**.



Localisation de la coupe micrographique sur le résultat du contrôle UT

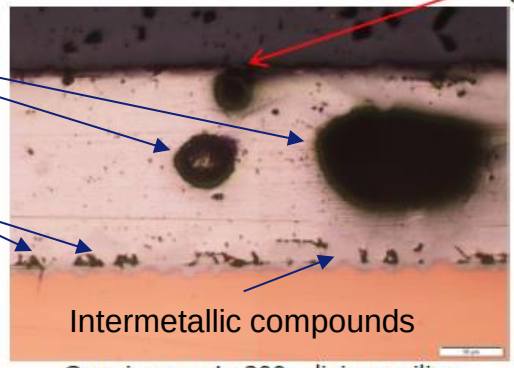


Grossissement x8

Grossissement x50

Micro-porosities due to trapped gas during brazing

Cavities

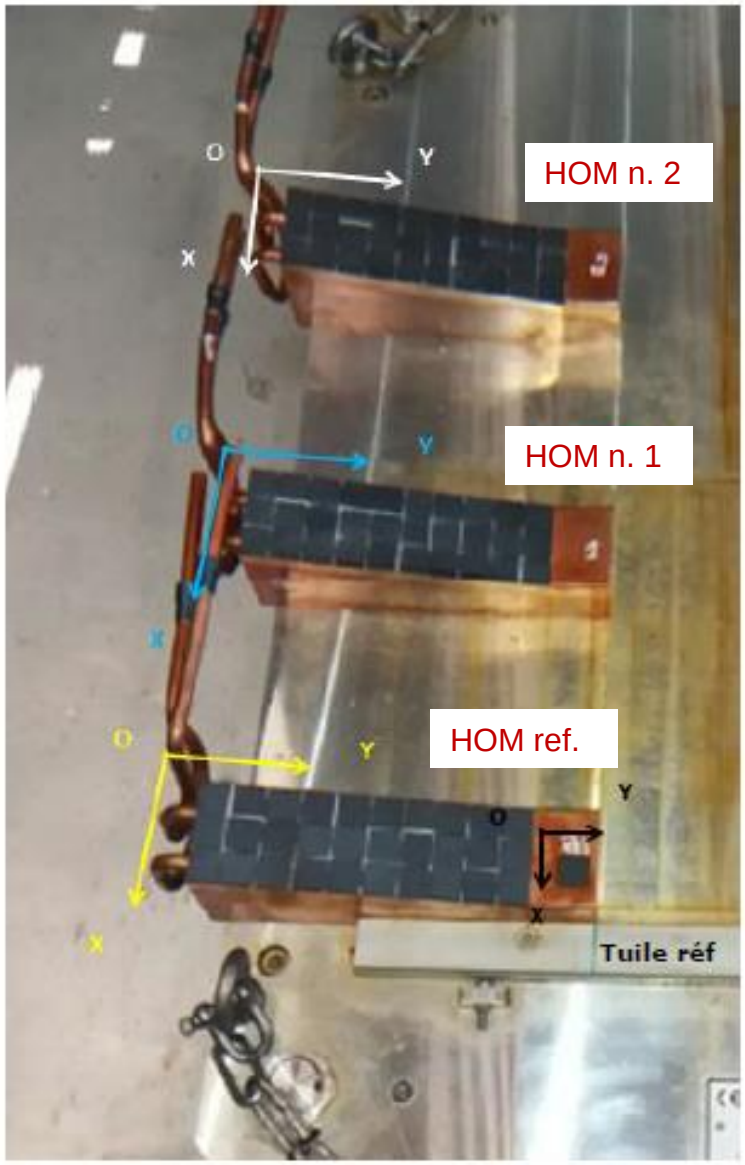


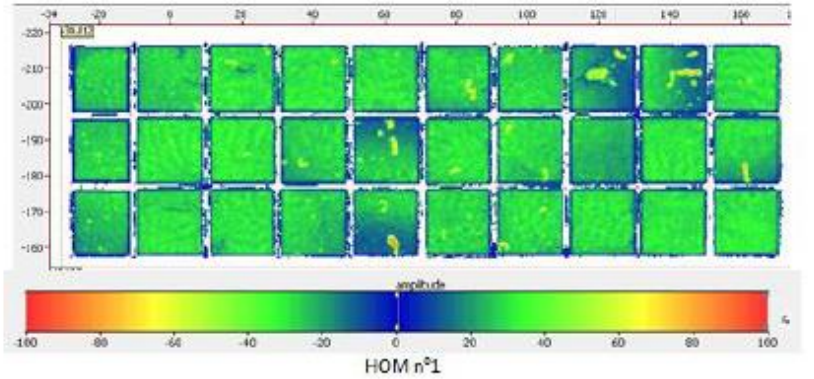
Grossissement x200 – liaison milieu

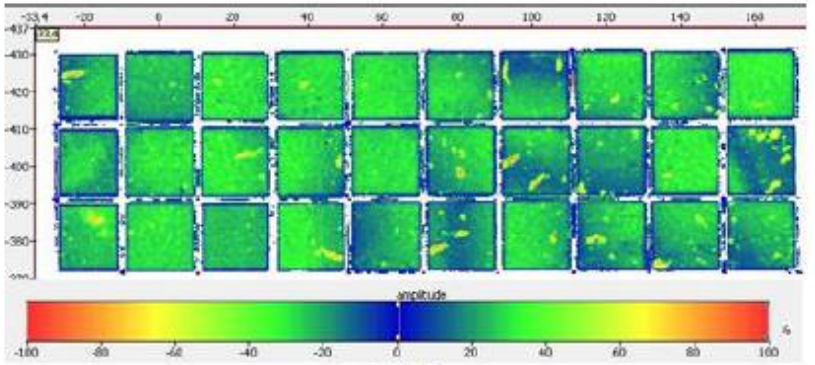
Grossissement x500 - Interface ferrite

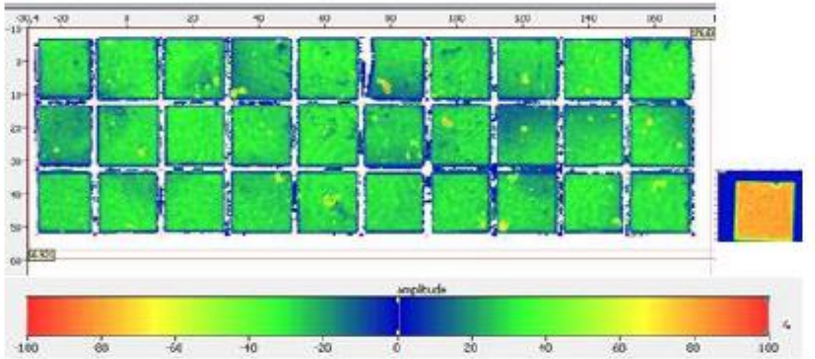
AGEING TESTS

-
-
-
-



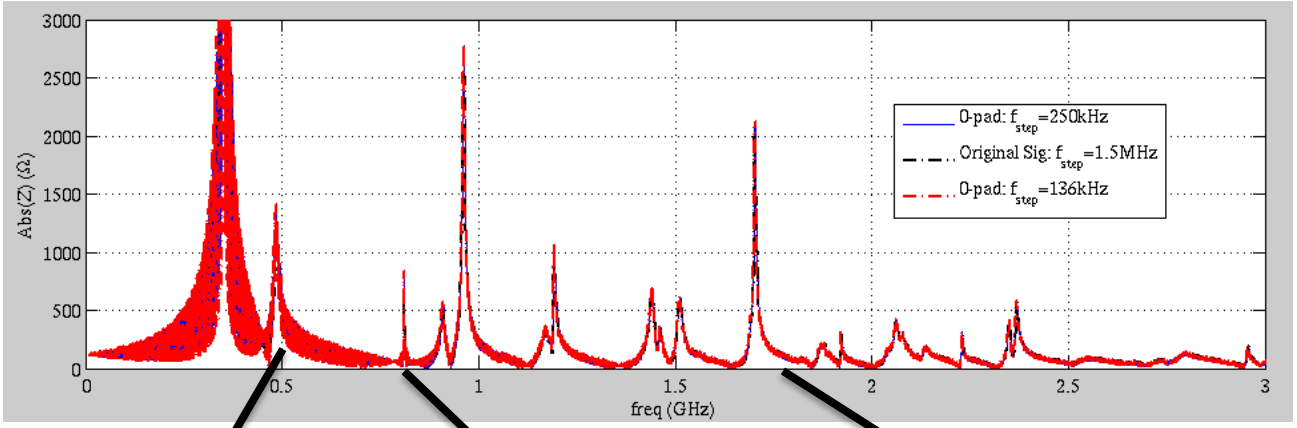


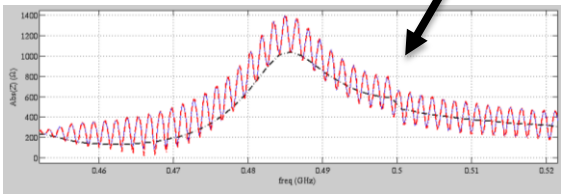




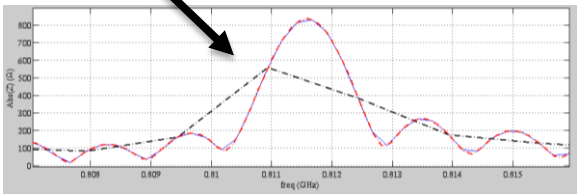
DEEPER ANALYSIS: 0-PADDING

Just a reminder: 0-padding means that we are just adding zeros, in general, to the extremities of the signal interval, in this case only on the right side. The effect is to artificially reduce the frequency step in the frequency domain giving better resolution. Of course that does not add any more information to the measured/simulated signal. Finally also the noise will be “better resolved”.

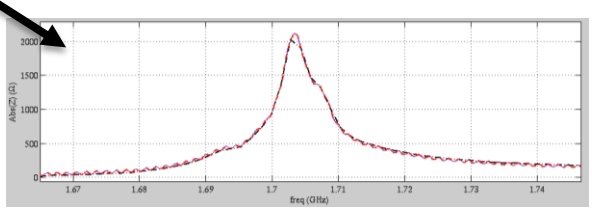




Noisy but the original is well shaped: I do not expect big surprises



Interesting: it looks having a very high Q (see next slide)



The rest is well shaped and 0-padding confirms that all the frequencies above 900MHz are well resolved for a wake 200m long (we remind that the final purpose hereby is to study the effect of the small damper)