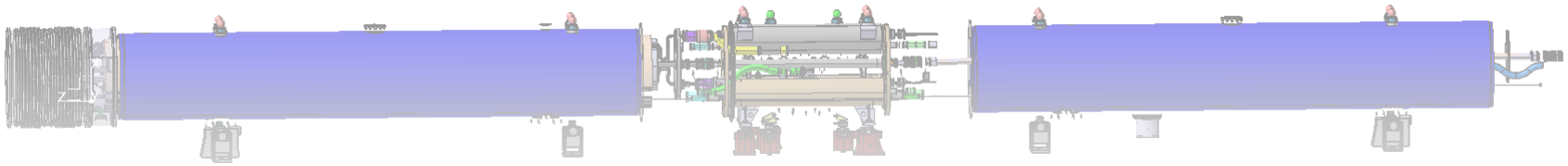

Impedance Analysis on The TCLD and the 11T dipoles

Inigo Lamas, Benoit Salvant, Lorenzo Teofili

31/07/2018 WP11

CERN

EN ENGINEERING DEPARTMENT

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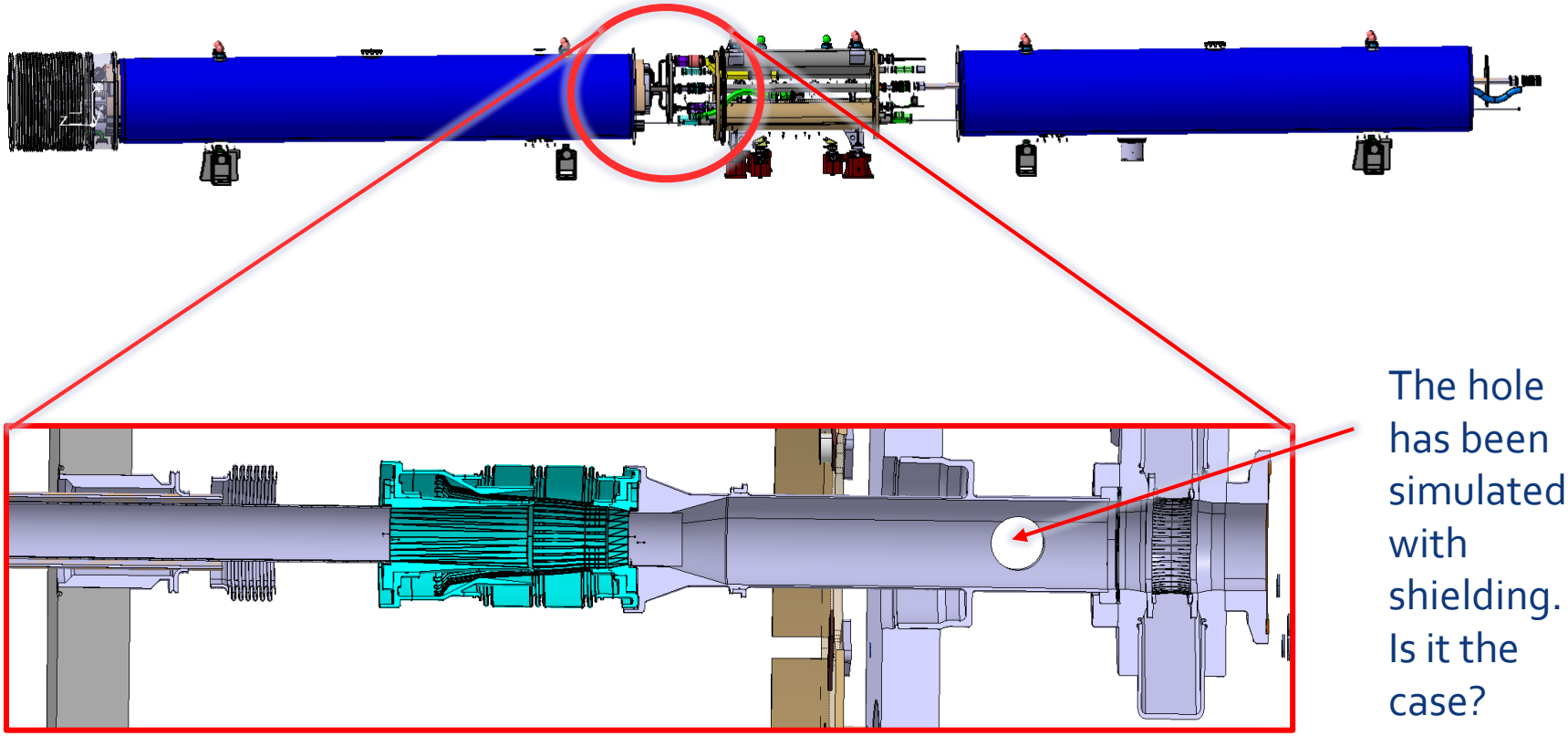
INFN Istituto Nazionale di Fisica Nucleare

Scope Of the Presentation

- Introduce the model geometry and the Possible issues for the Impedance
- CST model
- Simulation Results
- Conclusion

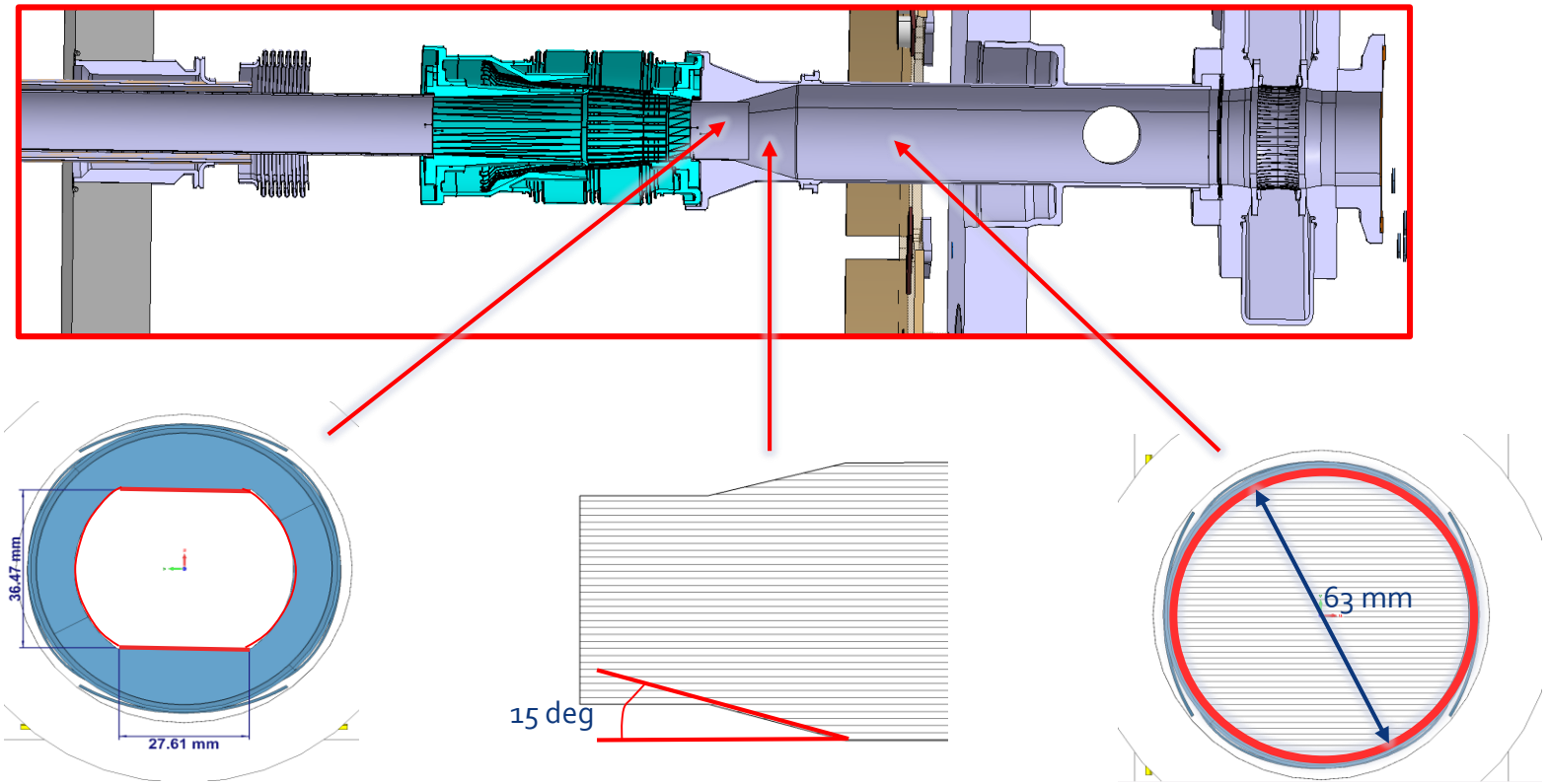
Geometry



The hole has been simulated with shielding. Is it the case?

Analyzing the structure, the most critical part for the impedance is represented by the pipe that is connecting the collimator TCLD with the dipole.

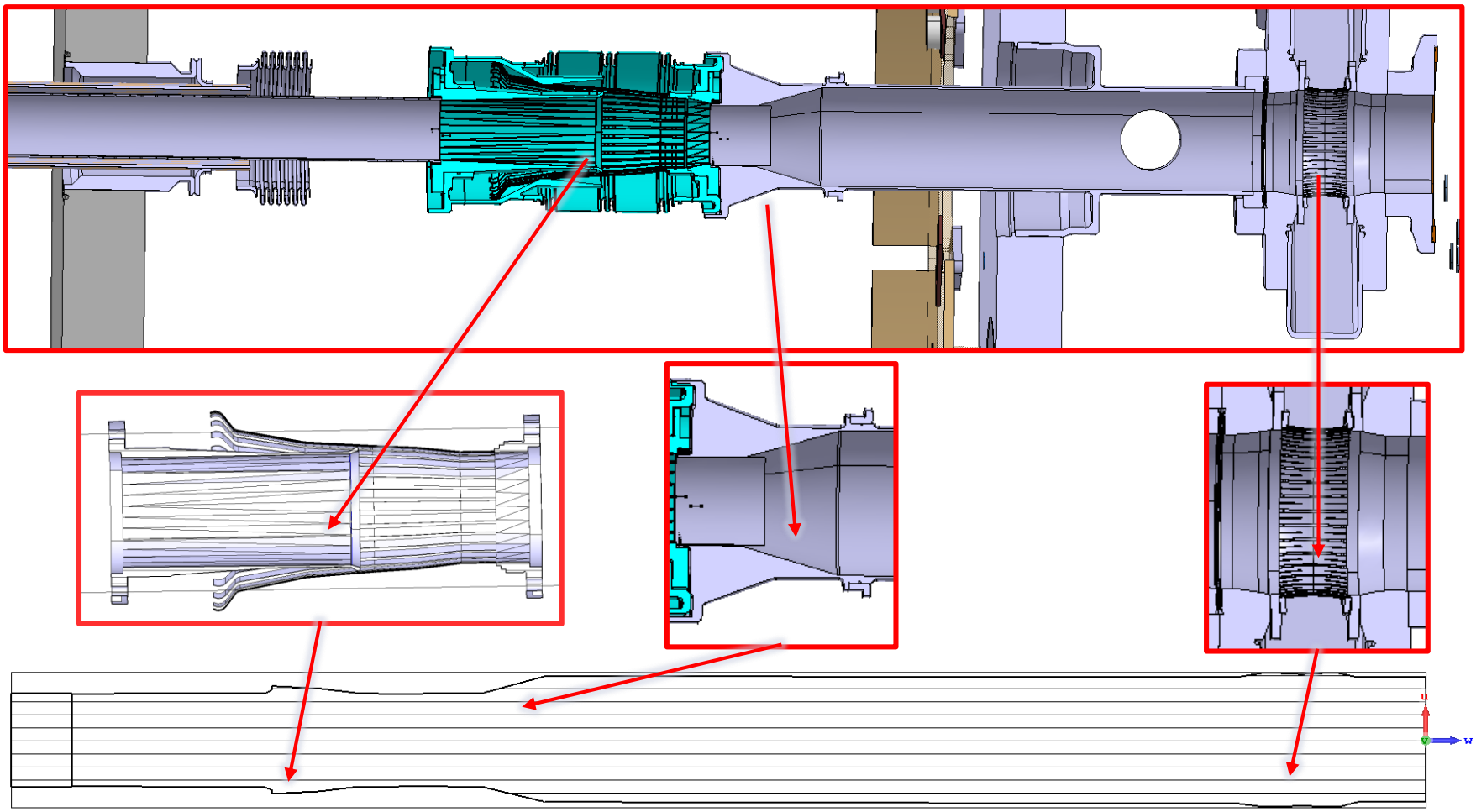
Geometry



Impedance is particularly sensitive to change of sections, however, given the necessity of the change of section all the impedance mitigation measurements seems to be respected.

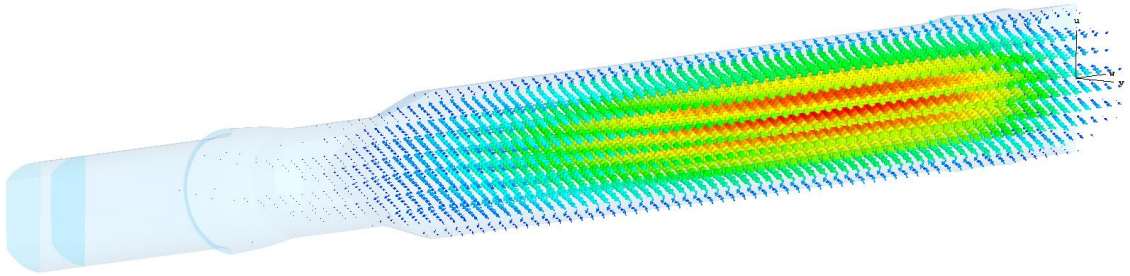
CST Representation

The Critical Parts have been represented in CST.

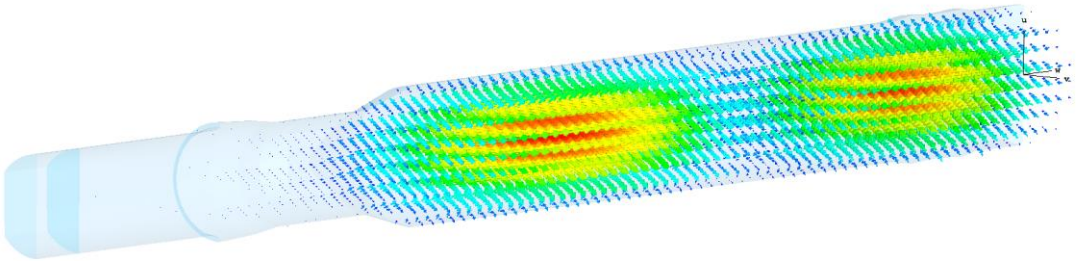


Simulation Results: Eigenmode

Modes Frequencies
2.800248 GHz
2.800269 GHz
2.846947 GHz
2.847081 GHz
2.933964 GHz
2.934371 GHz
3.055854 GHz
3.056826 GHz
3.204595 GHz
3.206745 GHz



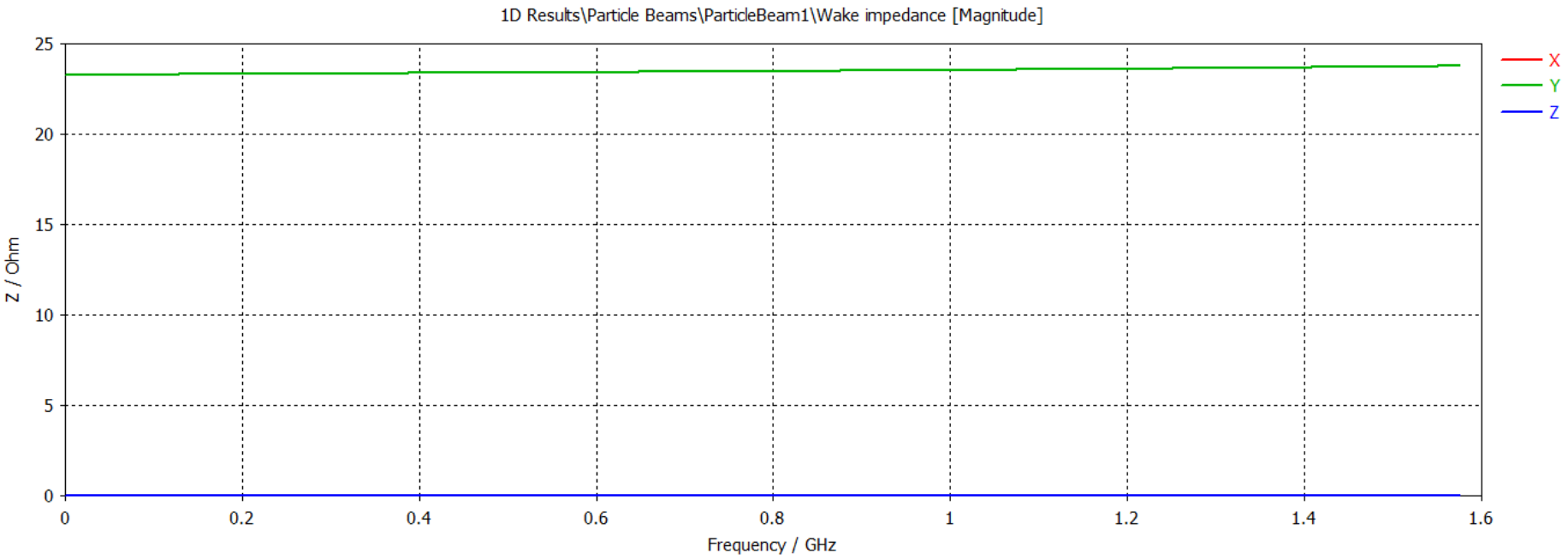
Electric Field mode 1



Electric Field mode 3

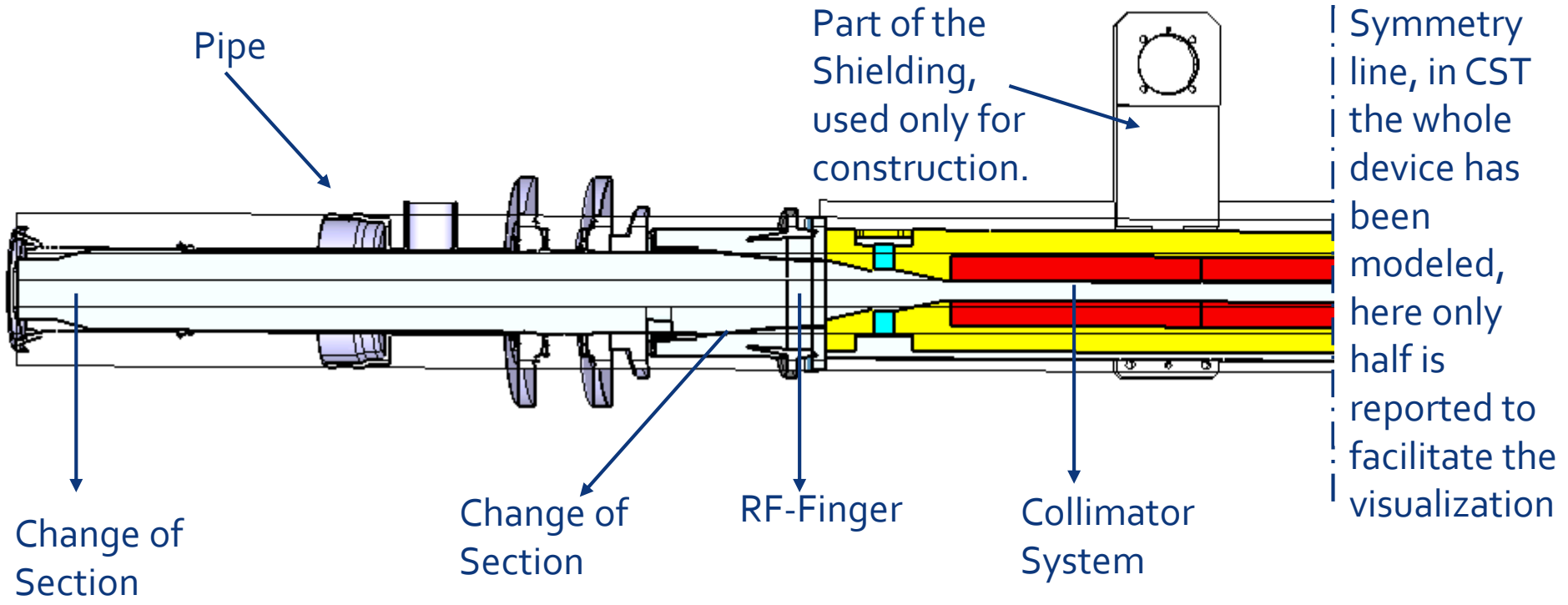
The modes in the structure are at high frequencies if compared with the HL-LHC beam frequency content. The beam will not couple with them.

Simulation Results: Wakefield



Wakefield results agrees with the eigenmode ones, no High order modes are found for frequency up to 1.6 GHz.

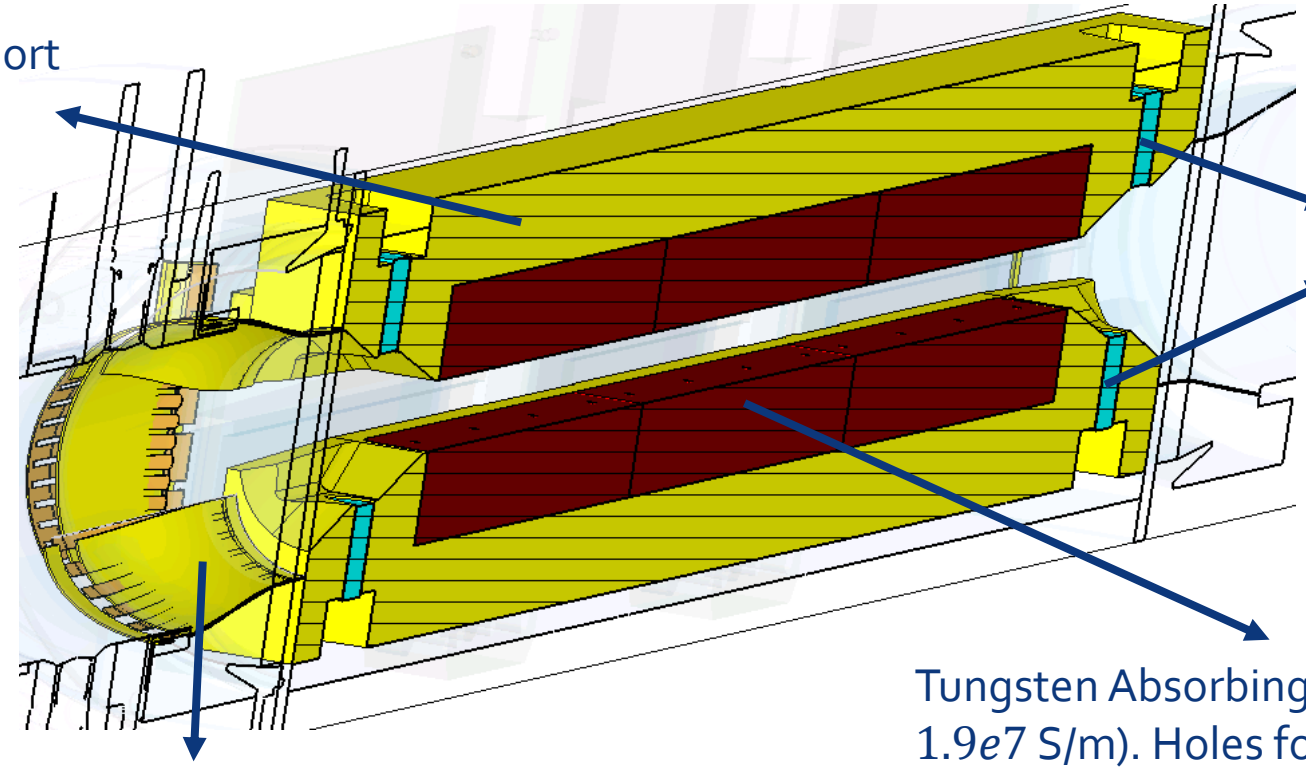
Device Geometry: yx section[1]



1 Another analysis on a more complex geometry was performed. The collimator was included, so it was possible to study modes on the interface between the collimator and the inner pipe.

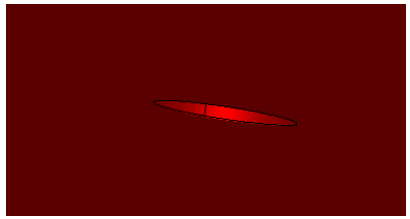
Device Geometry: yx section[1] 2

Copper Support



BPM: Stainless Steel ($\sigma = 1.5e6$ S/m)

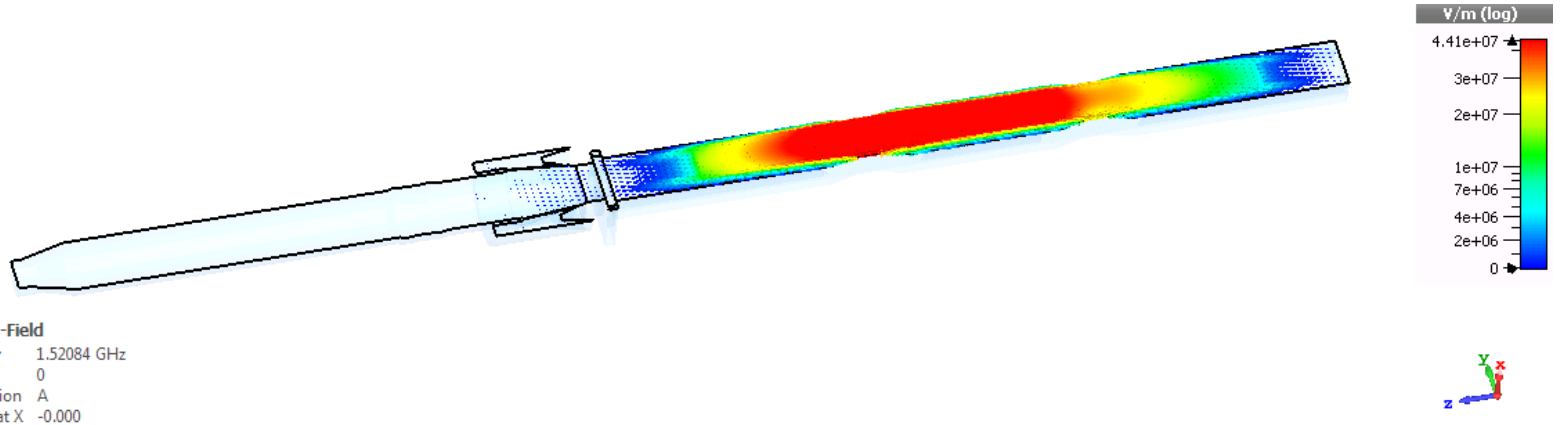
Tungsten Absorbing Blocks ($\sigma = 1.9e7$ S/m). Holes for outgassing have been simulated on the surface.



RF-finger in CST and in CATIA. In CST they have been represented as a continuous panel of copper ($\sigma = 5.96e7$ S/m). Here you see the panel superimposed to the real fingers (non simulated.)

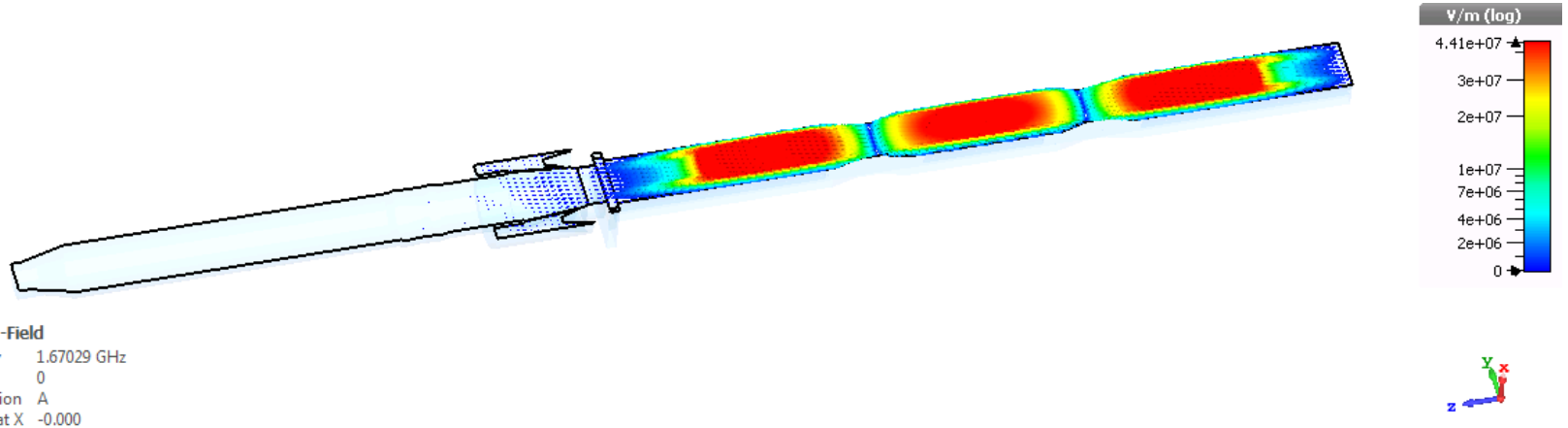
1 Refer to slide 3

Eigenmode Results



Mode 4 E-Field

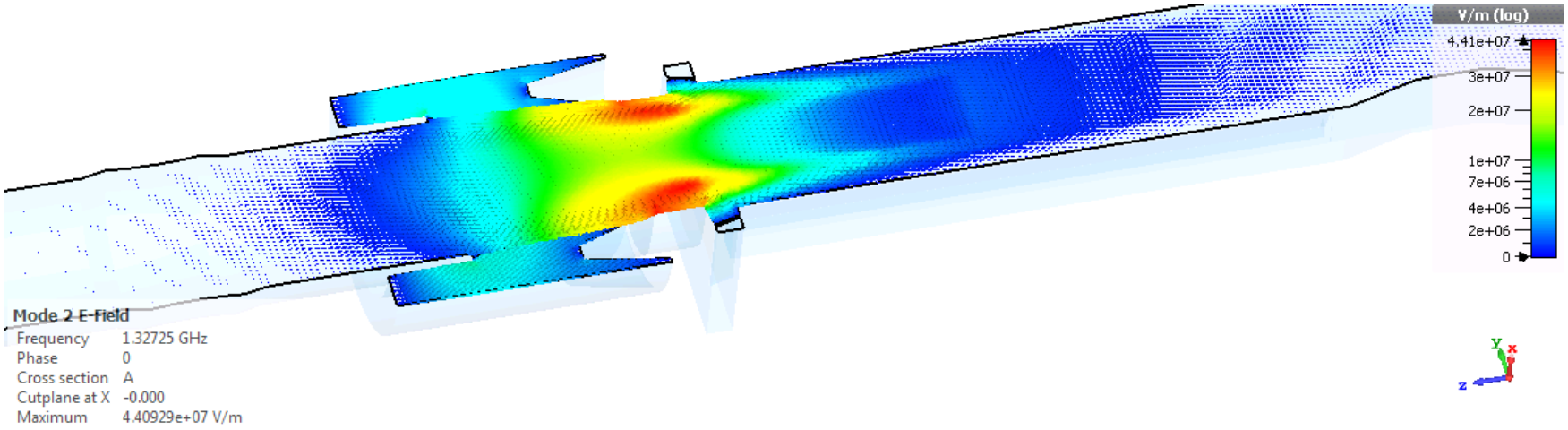
Frequency	1.52084 GHz
Phase	0
Cross section	A
Cutplane at X	-0.000
Maximum	8.33814e+07 V/m



Mode 6 E-Field

Frequency	1.67029 GHz
Phase	0
Cross section	A
Cutplane at X	-0.000
Maximum	7.14138e+07 V/m

Eigenmode Results



In case the geometry with the collimator is considered High Order modes have been found at lower frequencies, however, they are in the collimator region and not in the connection 11T dipoles – Collimator.

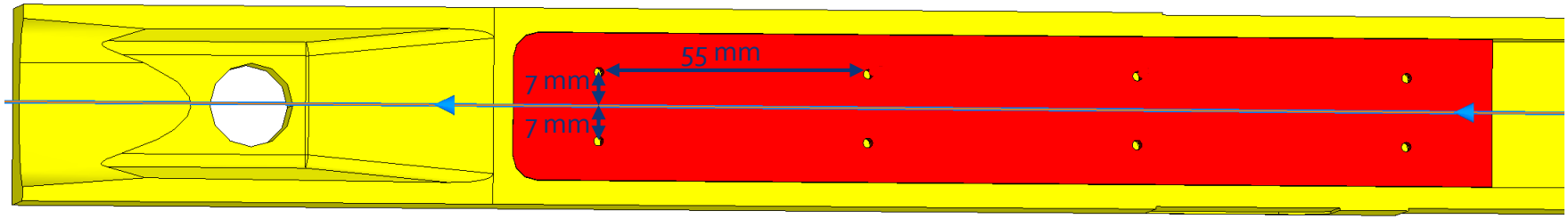
Conclusion

- CST Simulations have been performed on the most critical area of the 11T dipoles assembly
- Good agreement between the eigenmode and the wakefield solver
- Several modes have been found, they are at high frequencies (if compared with the beam frequency spectrum), thus, they will not couple with the beam
- A more complete analysis, that includes the collimator has been performed, modes at lower frequencies has been found but they are in the collimator fingers or in the collimator itself. They are currently under investigation (refer to the talk in WP2 for more info https://indico.cern.ch/event/743627/contributions/3071935/attachments/1692450/2723322/20180724_WP2TCLD_ok.pdf)
- According to the simulation results, the proposed design of the connection pipe between the 11T dipoles and the TCLD is ok from an impedance point of view.

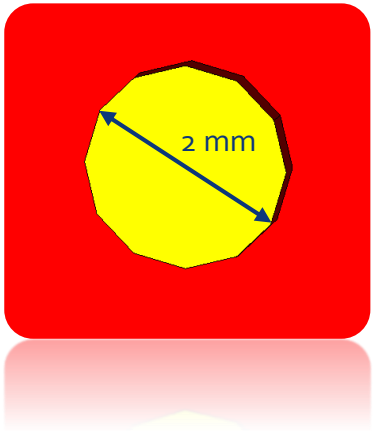
Thank You For Your Attention

Backup Slides

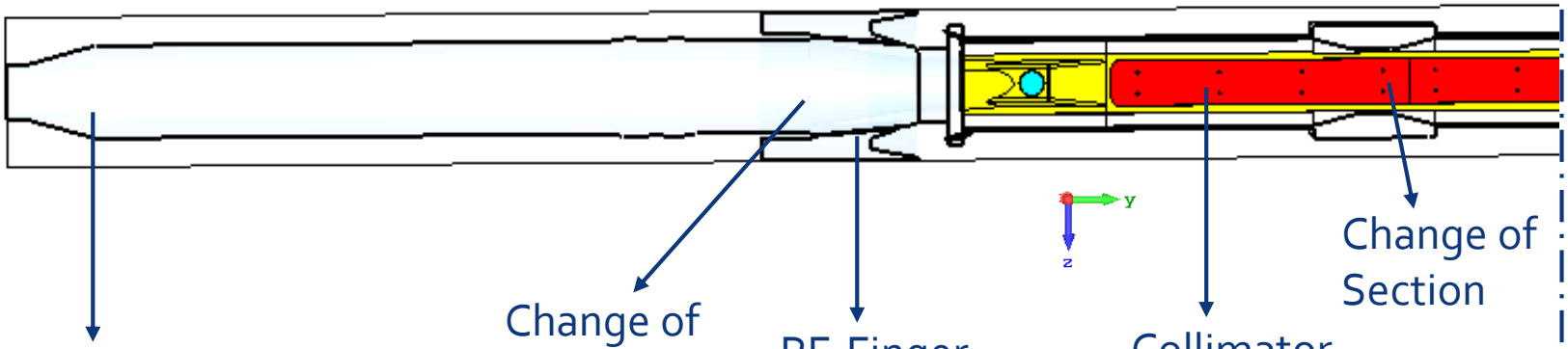
Device Geometry: Holes In the Tungsten Block

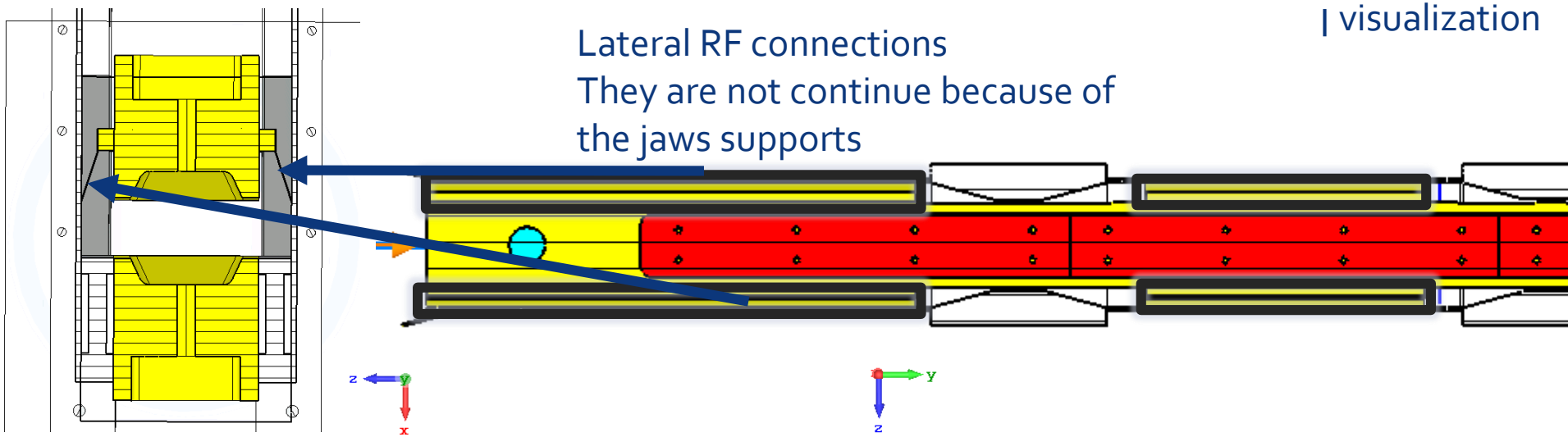


The holes have 1 mm radius.
They are for outgassing.
Their distance from the golden orbit is 7 mm.
This device has not the 5th axis functionality, thus nominally the golden orbit will remain at 7 mm from the holes.



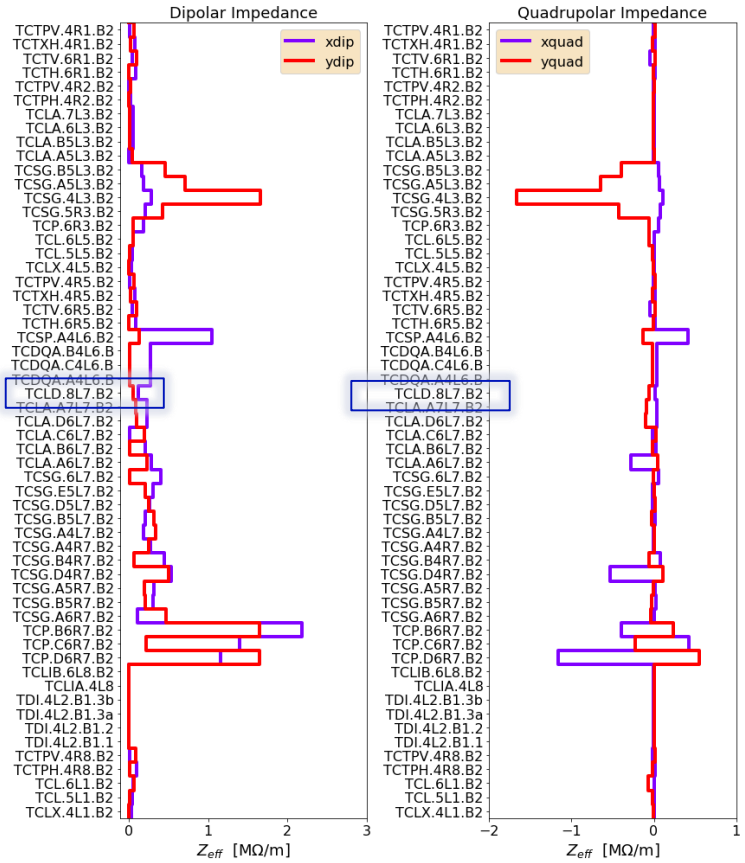
Device Geometry: yx and xz section





Effective impedance of the TCLD collimator

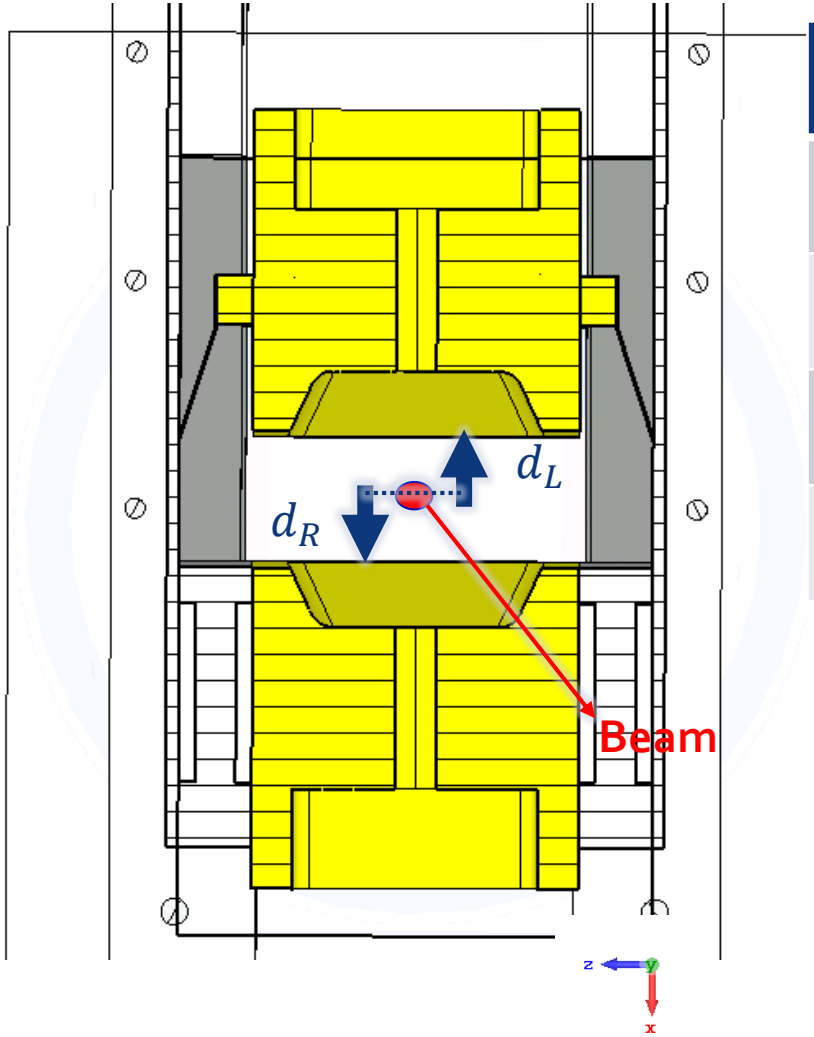
David Amorim,
Sergey Antipov



According to HL-LHC impedance model, the effective impedance of the TCLD collimator (E = 7 TeV, Q' = 0) is 0.12 MOhm/m in the horizontal and 0.06 MOhm/m in the vertical plane respectively. It amounts to less than 1% of the total effective impedance.

The plot depicts the real part of the effective impedance for every collimator in HL-LHC.

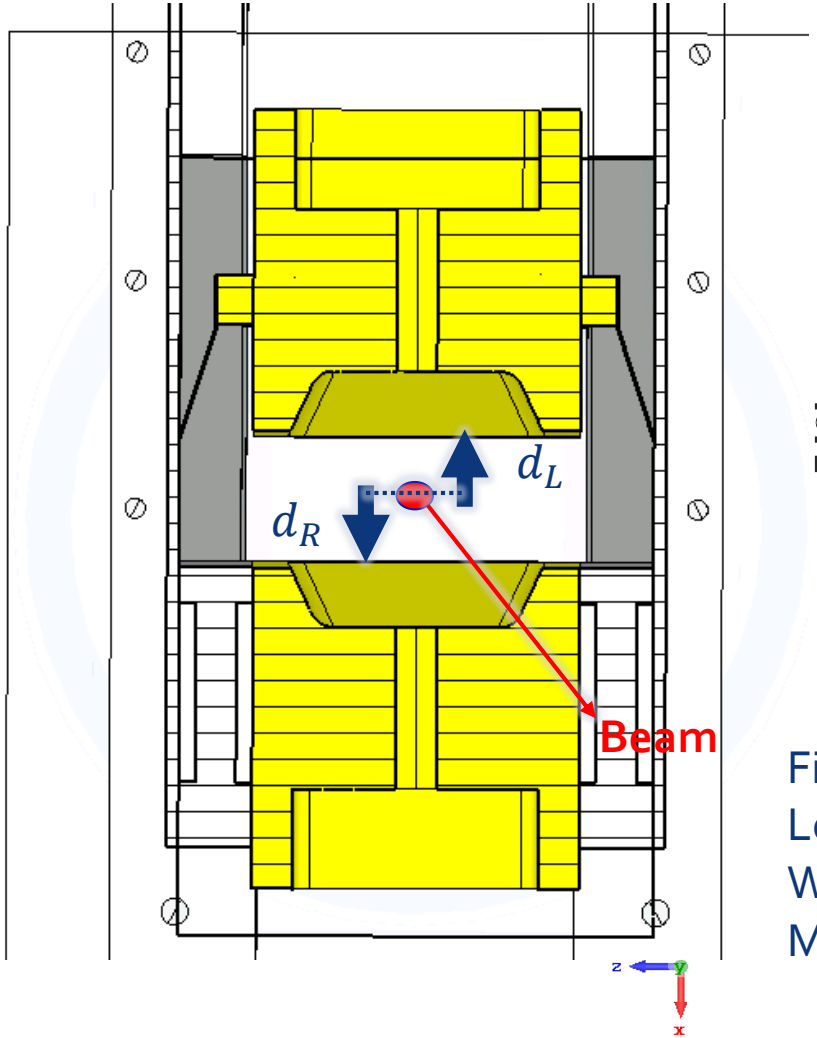
Different Operational Scenarios



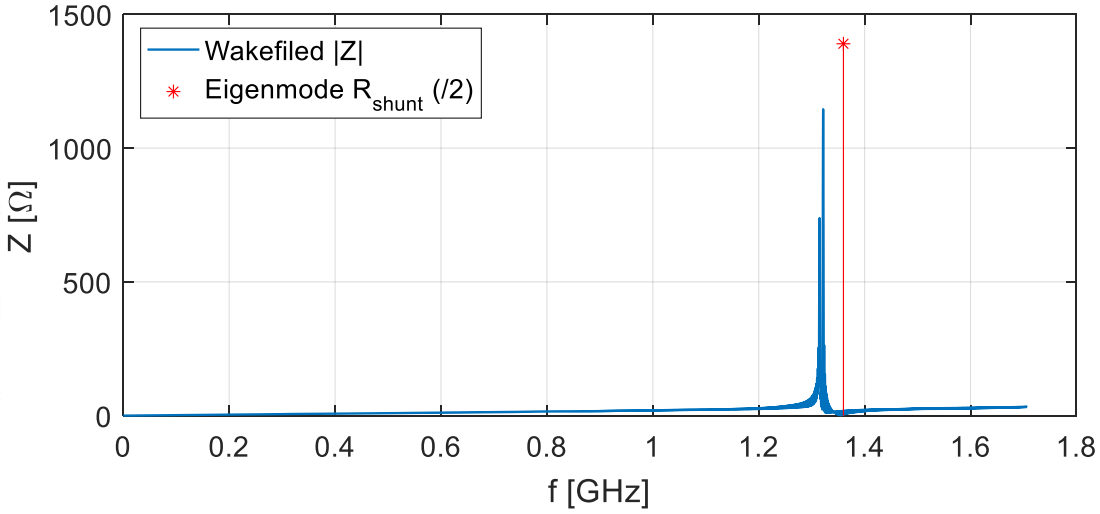
Location	Collimator	d_R	d_L
P 7	1	1.66 mm	1.66 mm
	2	1.79 mm	1.79 mm
P 2	1	10.53 mm	4.65 mm
	2	10.53 mm	4.65 mm

Since the collimators have always the same structure, only the case P 7-1 and P 2-1 were simulated being the most conservative.

P 7 Wakefield Simulations 1

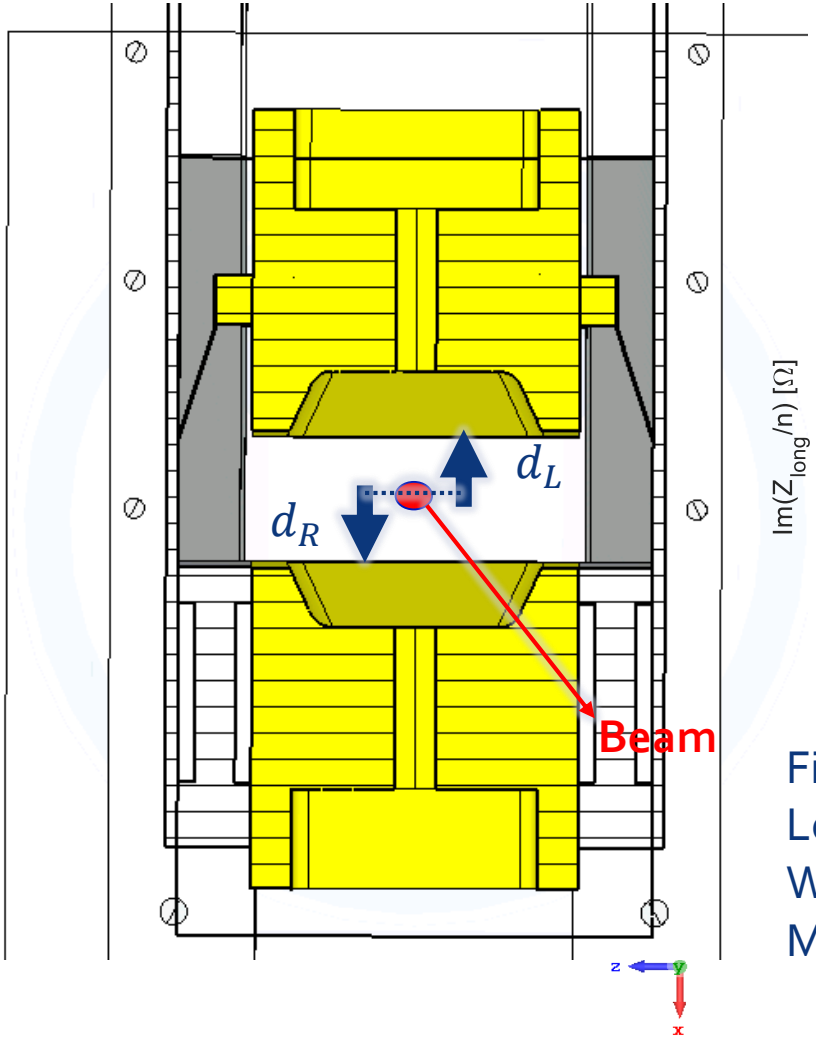


Location	Collimator	d_R	d_L
P 7	1	1.66 mm	1.66 mm

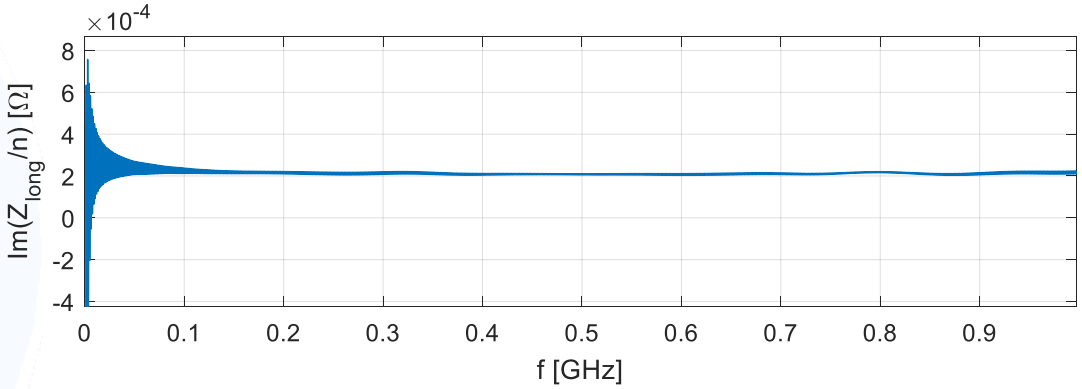


First simulations
Longitudinal Impedance.
Wakefield and Eigenmode results. Only one resonant Mode observed for a frequency of 1.3 GHz.

P 7 Wakefield Simulations 1



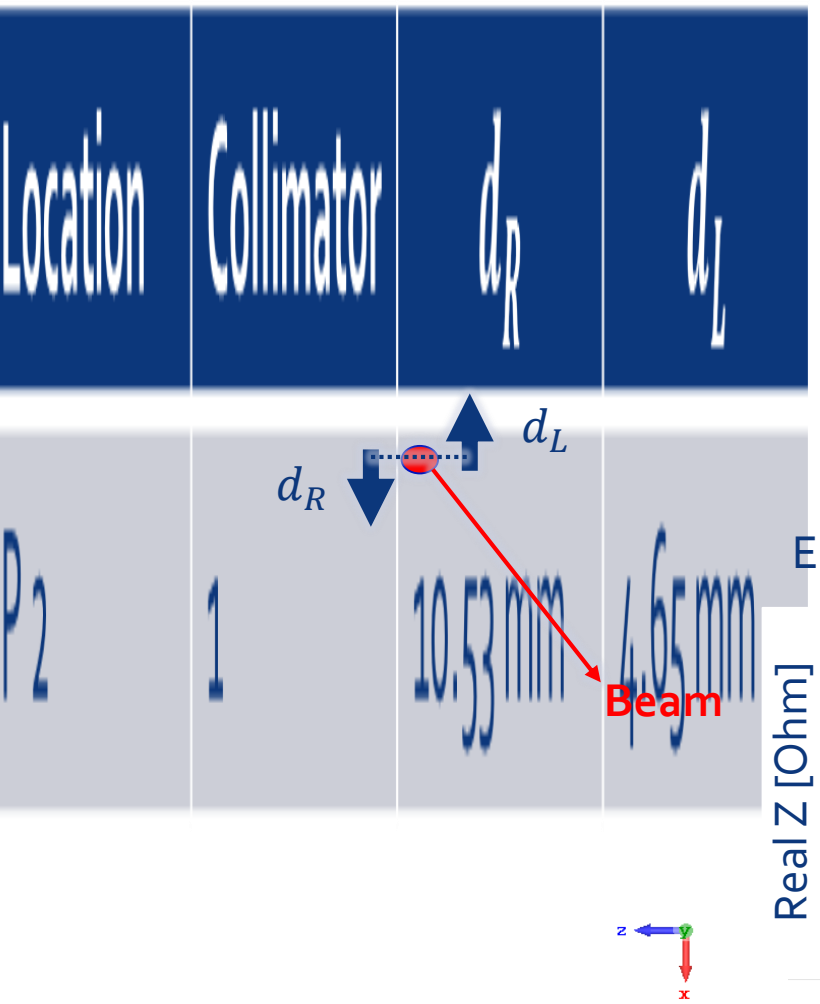
Location	Collimator	d_R	d_L
P 7	1	1.66 mm	1.66 mm

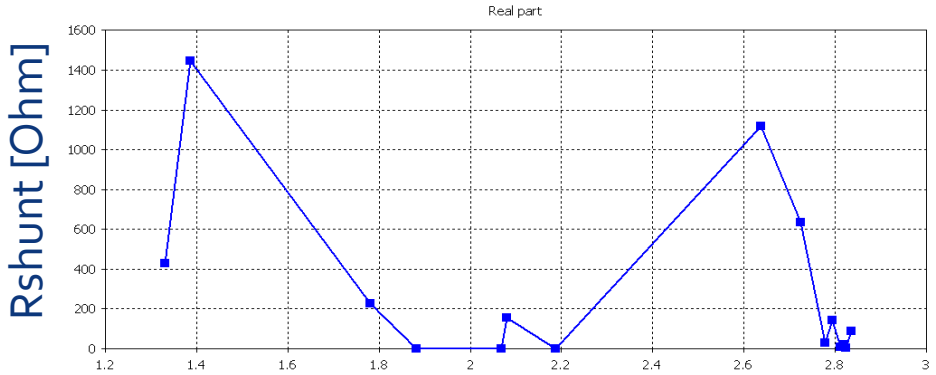


First simulations
Longitudinal Impedance.
Wakefield and Eigenmode results. Only one resonant Mode observed for a frequency of 1.3 GHz.

P 2 Wakefield Simulations 1

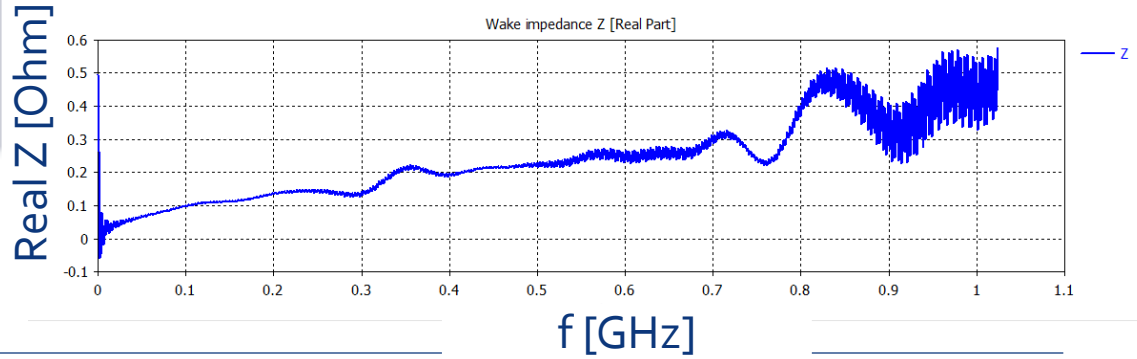
Location	Collimator	d_R	d_L
P 2	1	10.53 mm	4.65 mm



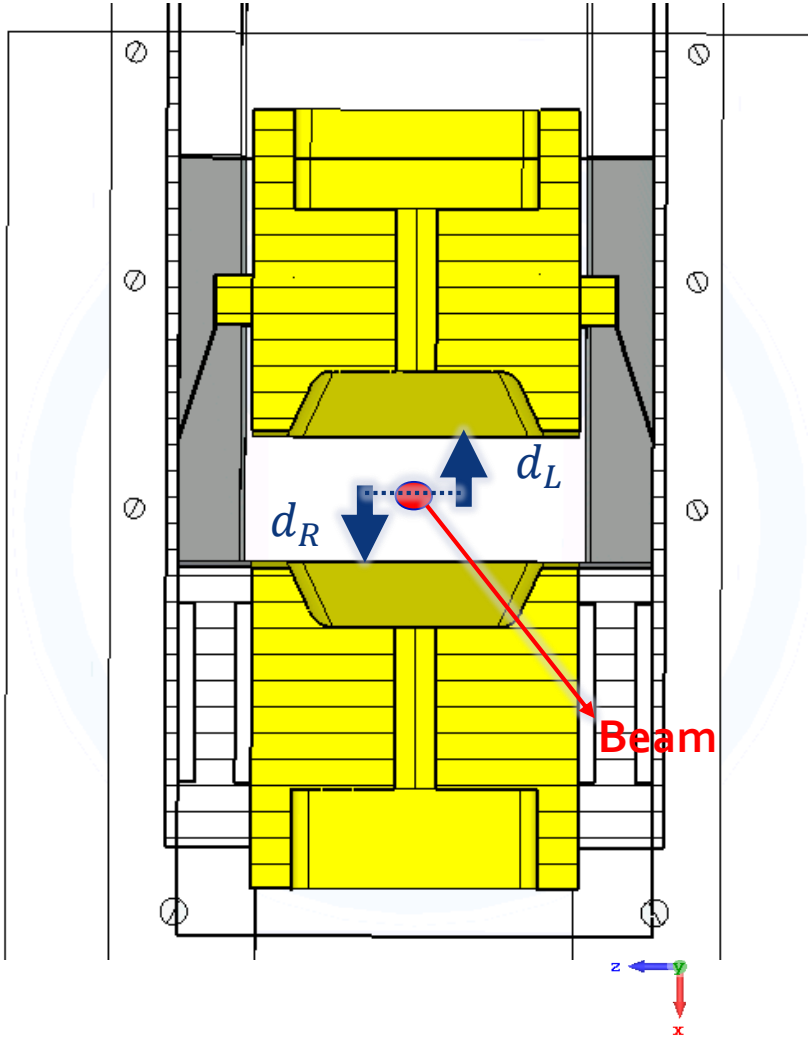


Eigenmode results. f [GHz]

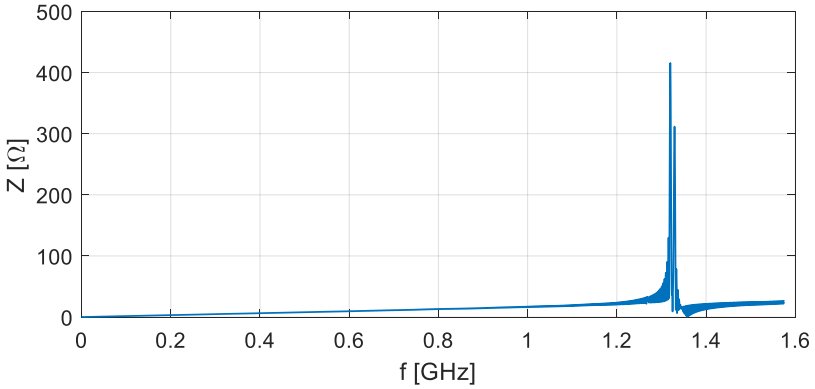
Wakefield preliminary results.

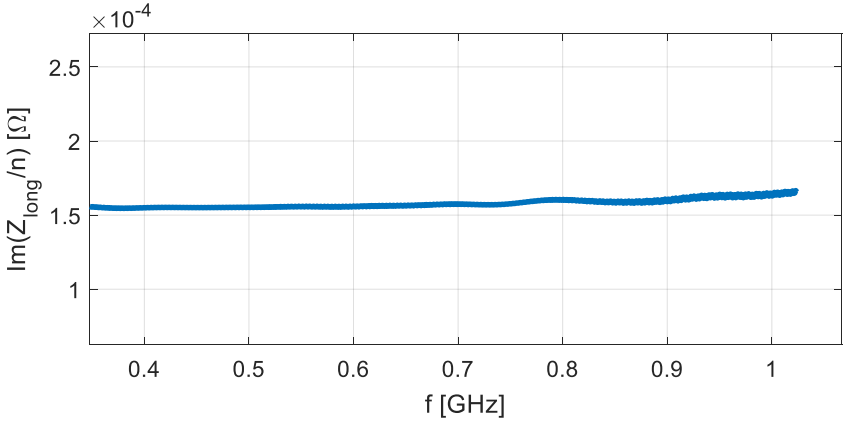


P 2 Wakefield Simulations 1

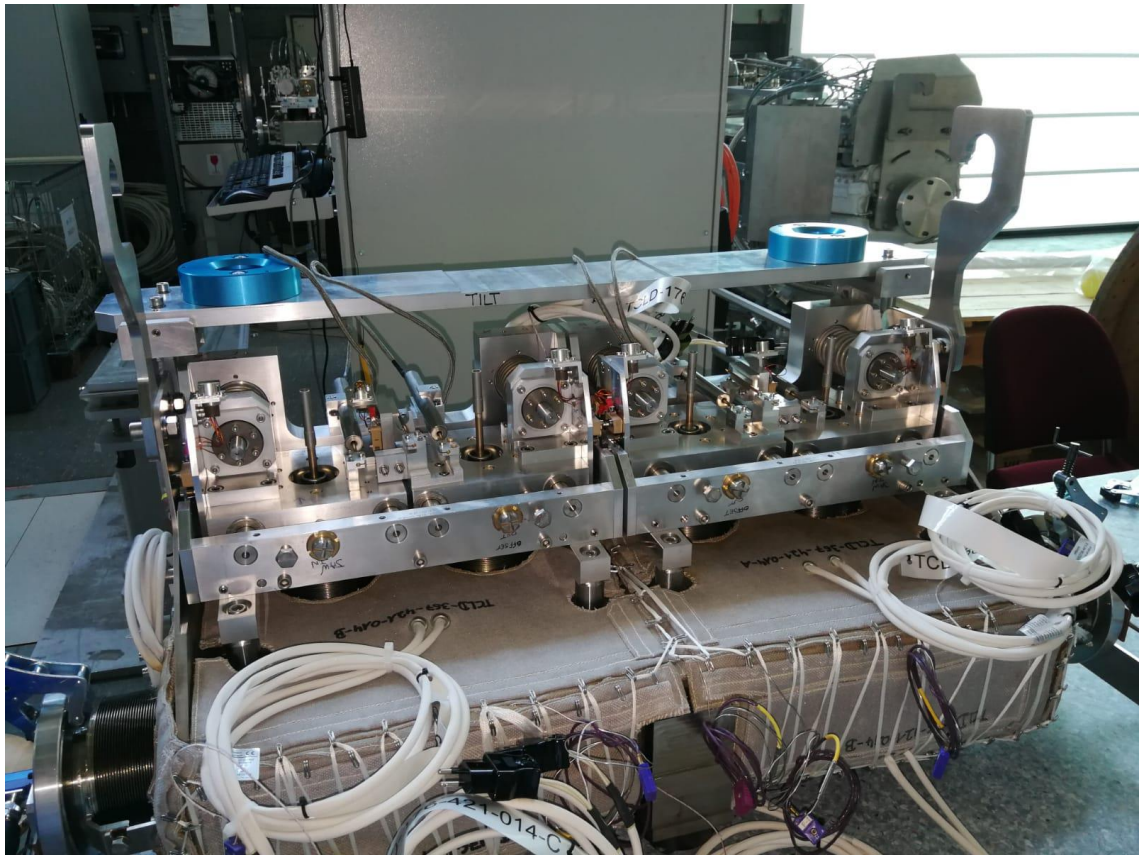


Location	Collimator	d_{UP}	d_{DO}
P 2	1	10.53 mm	4.65 mm

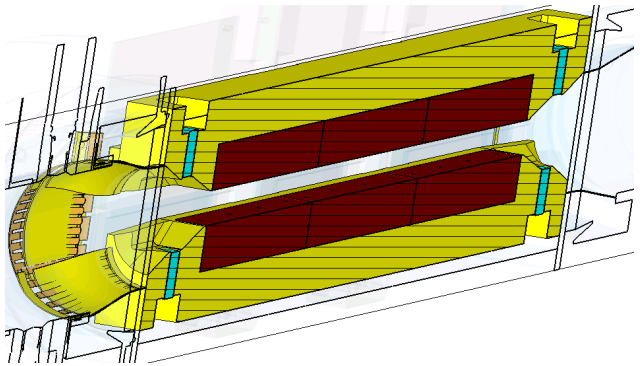




Probe Measurements Results

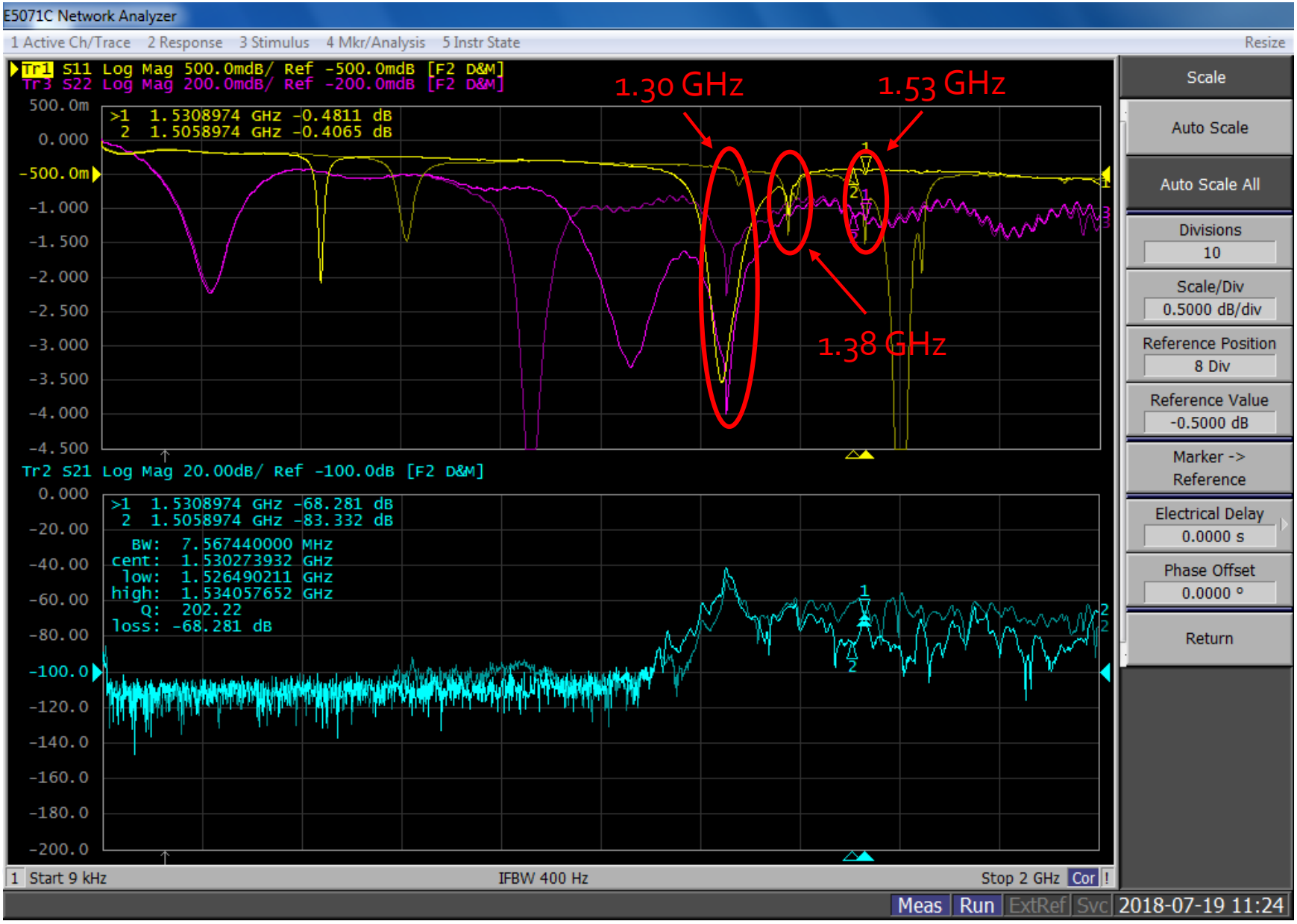


A measurement campaign is currently on going on the collimator.



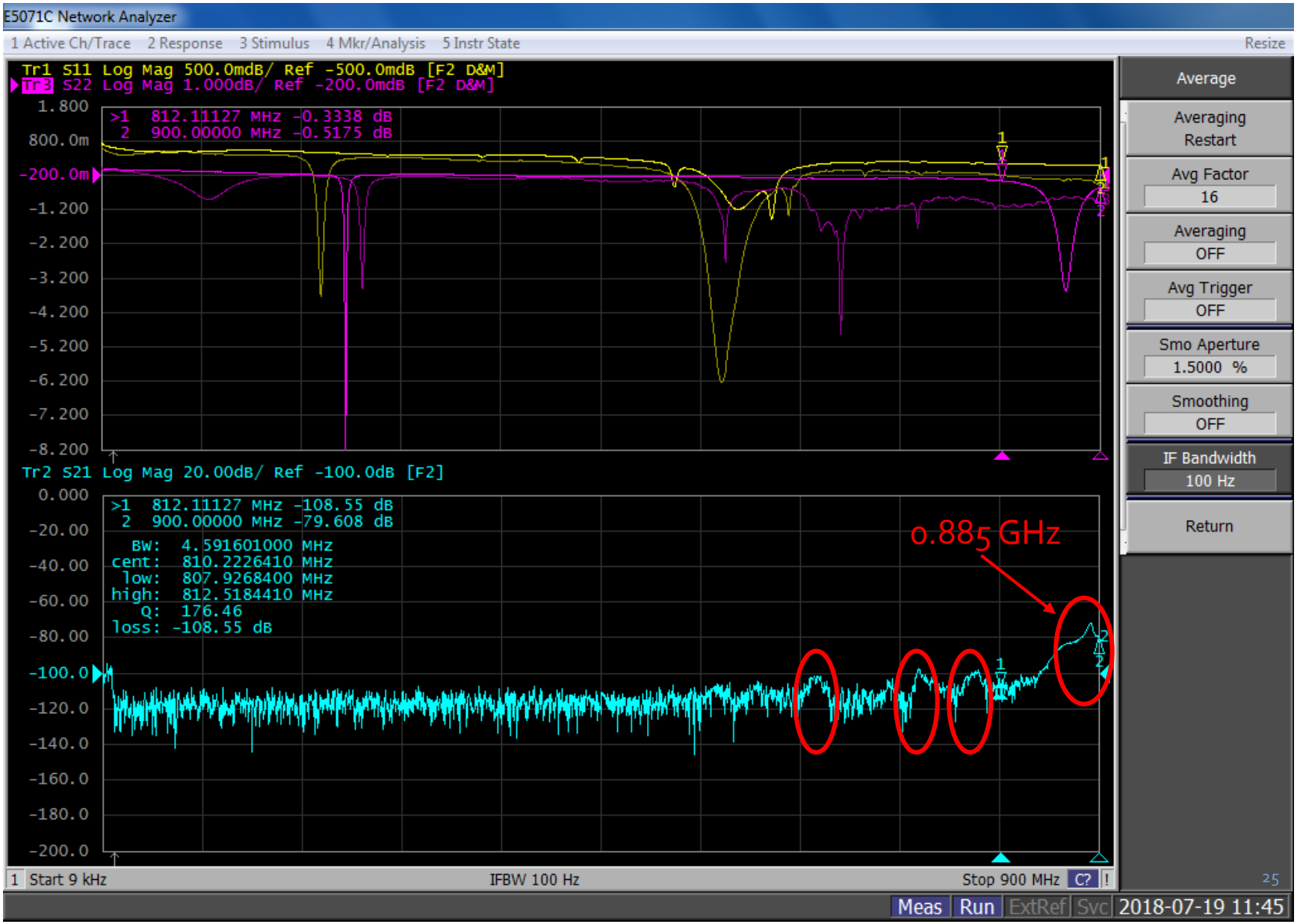
P 7 Probe Mesurements

Nicolo' Biancacci, Francesco Giordano, Lorenzo Teofili



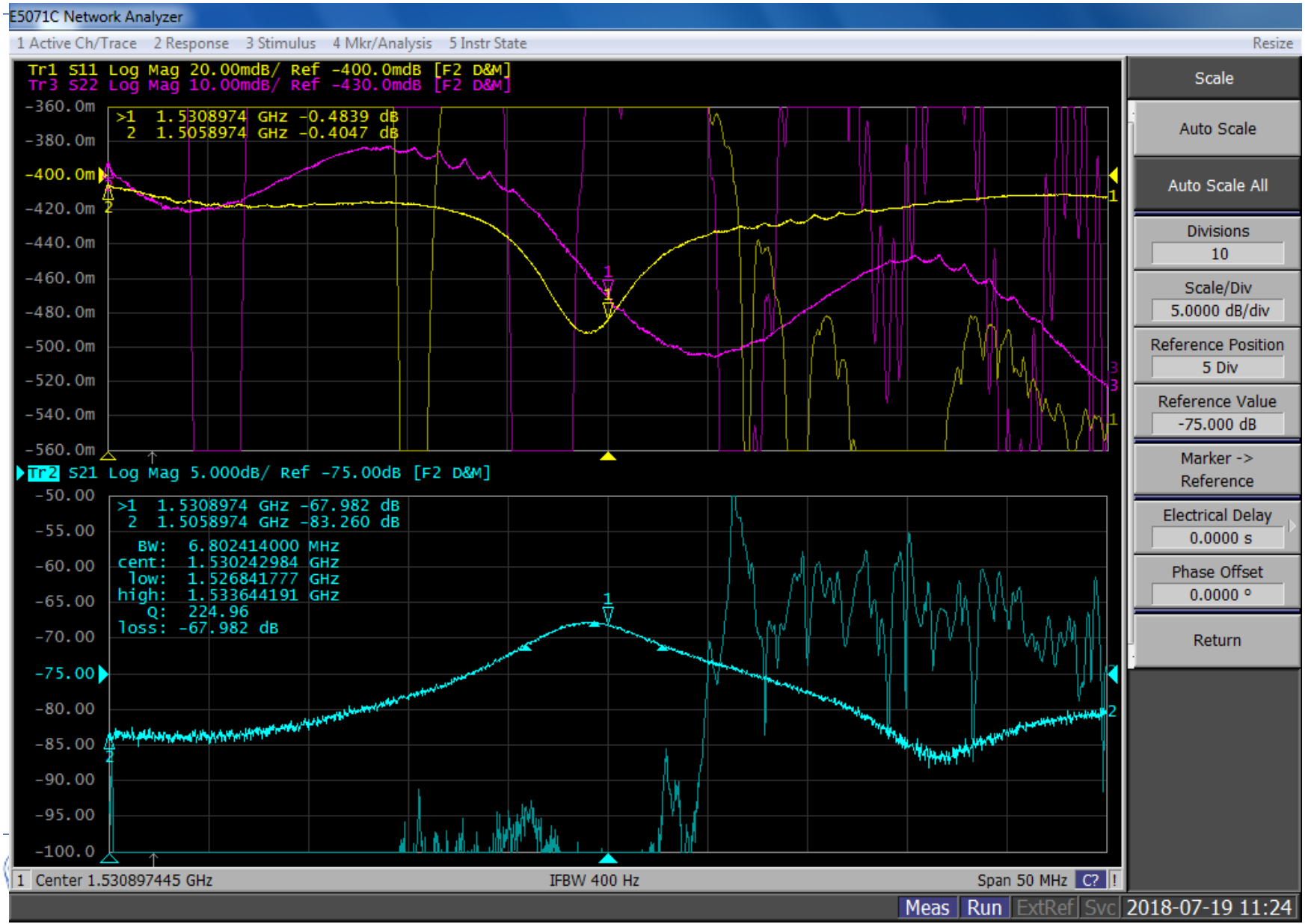
P 7 Probe Mesurements

Nicolo' Biancacci, Francesco Giordano, Lorenzo Teofili



P 7 Probe Mesurements

Nicolo' Biancacci, Francesco Giordano, Lorenzo Teofili



P 7 Probe Mode Table

Nicolo' Biancacci, Francesco Giordano, Lorenzo Teofili

probe depth (l,r) [cm]	fr [GHz]	Q	jaw setup [mm]	probe type	Comments
15.2	0.885	166	11.5	straigth	
14.22	1.11	170?	11.5	loop	
20.5	1.28	137	11.5	straigth	probably 2 modes
23.5	1.53	247	11.5	straigth	
5.5	1.63	254	11.5	straigth	several modes
14.22	1.03		11.5	loop	
14.22	0.944	?	11.5	loop	
14.22	1.81		11.5	loop	
14.22	1.78		11.5	loop	
14.22	1.74		11.5	loop	
	1.28		2.2	loop	
	1.37		2.2	loop	
28.28	1.82		2.2	loop	
	1.92		2.2	loop	
	1.78		2.2	loop	
	1.75		2.2	loop	
	1.70		2.2	loop	
21.9	1.53	262	2.2	loop	
28.28	0.433		2.2	loop	
28.28	0.519		2.2	loop	
28.28	0.602		2.2	loop	
28.28	0.771		2.2	loop	
28.28	0.892		2.2	loop	
28.28	1.03		2.2	loop	
28.28	1.29		2.2	loop	
28.28	1.48		2.2	loop	
28.28	0.717	134	7.7	bended	
14.3	0.746		7.7	bended	
14.3	0.798		7.7	bended	
	0.650		full open	bended	
	0.665		full open	bended	
	0.738		full open	bended	
	0.754		full open	bended	
	0.822		full open	bended	
	0.872		full open	bended	
	0.895		full open	bended	
	1.12		full open	bended	

The Simulations were able to get only few of the observed modes, thus, new simulations were run with a modified geometrical model.

P 7 Wakefield Simulations VS Measurements

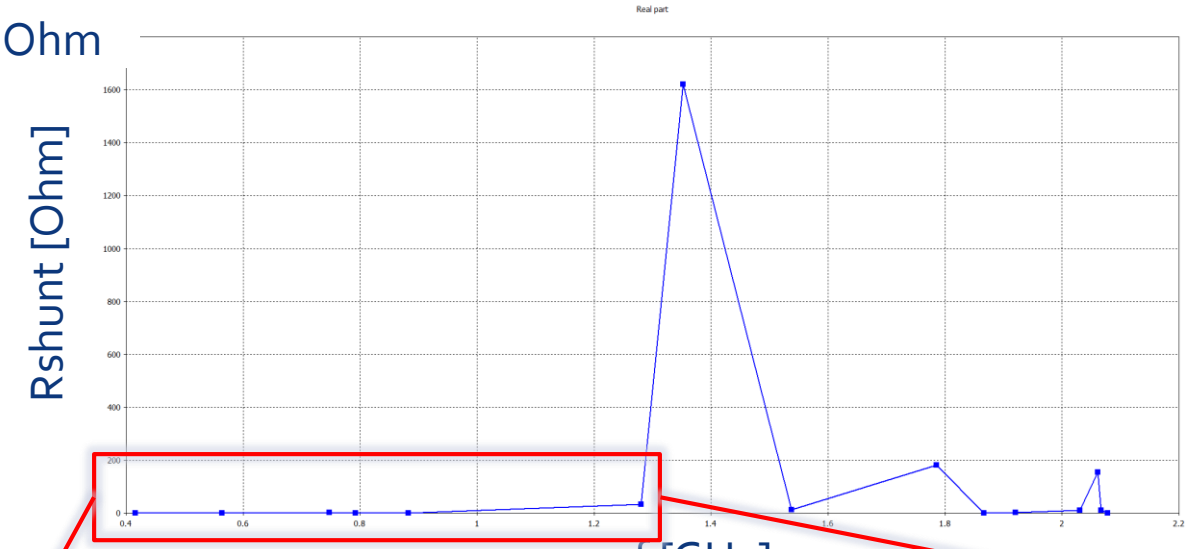
CST Eig. P2	Measurements	CST Eig. P7	Measurements
0.41 GHz	Not Observed Yet	Not Observed	0.433,0.519,0.602,0.771, 0.892, 1.03 GHz
0.56 GHz	Not Observed Yet	1.17 GHz	1.28, 1.25 GHz ?
0.75 GHz	Not Observed Yet	1.32 GHz	1.28, 1.25 GHz ?
0.79 GHz	Not Observed Yet	1.37 GHz	1.37 GHz
0.88 GHz	0.885 GHz	Not Observed	1.48 GHz
Not Observed	1.03, 1.11 GHz	1.52 GHz	1.53 GHz
1.28 GHz	1.28 GHz	1.57 GHz	1.53 GHz?
1.35 GHz	Not Observed Yet	1.67 GHz	1.70 GHz?
1.53 GHz	1.53 GHz	1.73 GHz	1.75 GHz
1.78 GHz	1.78 GHz	1.78 GHz	1.78 GHz

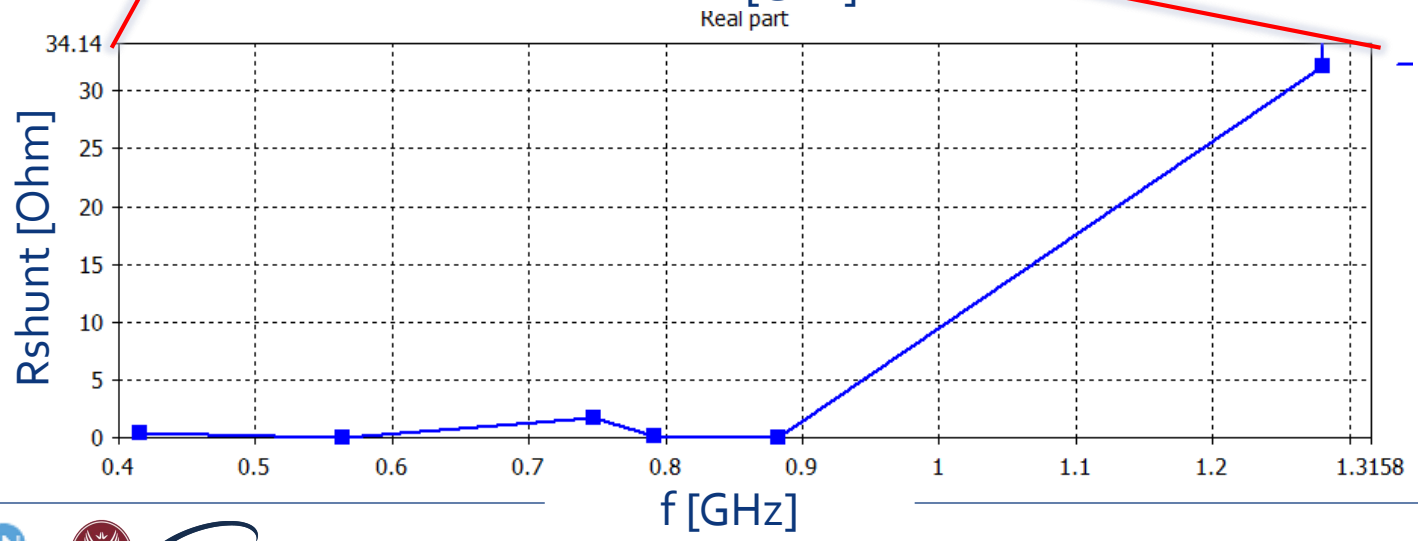
Due to the disagreement between the measurements and the first round of simulation a second round of simulations was performed. Good agreement for both the configuration only at high frequencies. Low frequency modes presents in the P2 config. simulations are seen in the P7 meas

Modes Shunt Impedance (P7 config)

1600 Ohm

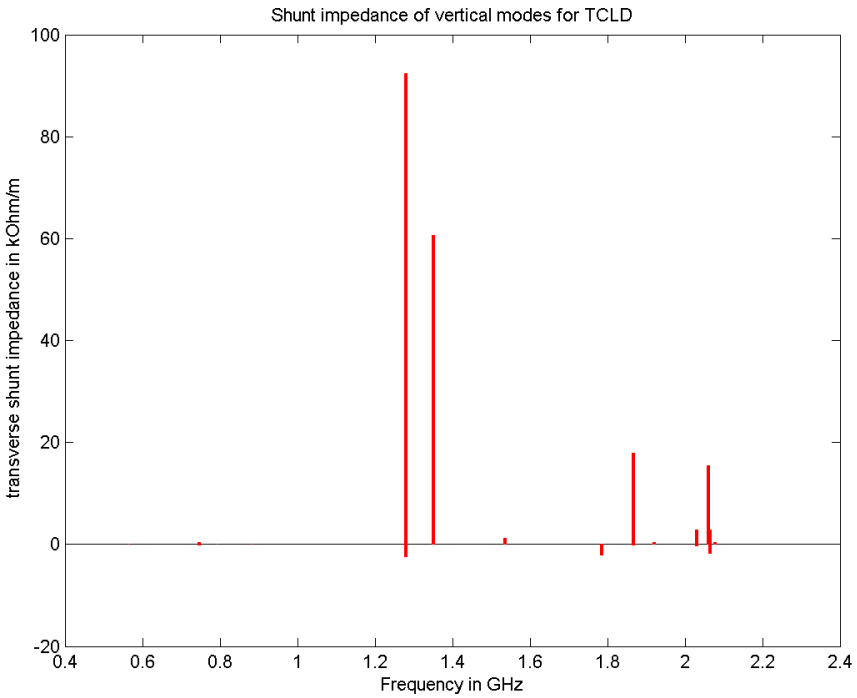
Small Shunt Impedance, Possible reason why they were not not visible in the wakefield Solver.

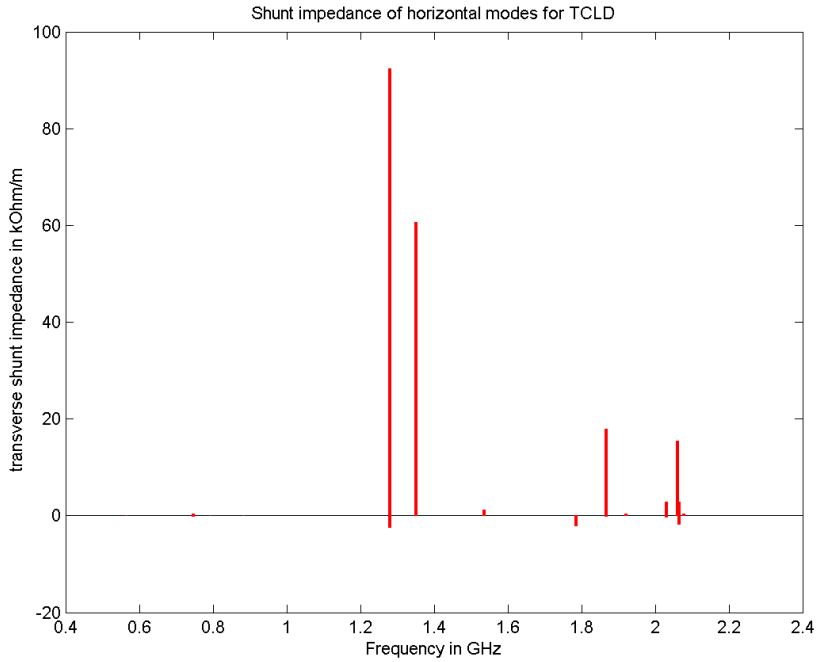




Investigation on the Transverse Mode

Benoit Salvant





R shunt remains at or below 100 kOhm/m.
No problem from transverse modes are forseen.