Test simulations of TT2-111R lossy dispersive material properties

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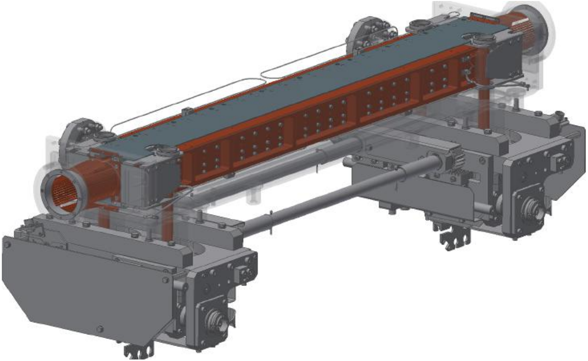
General outline

- Why we do need TT2-111R dispersive properties simulations: the new BPM collimator design for HiLumi-LHC
- TT2-111R dispersive permeability implementation in GdfidL: test simulations
- Results comparison between S-parameters analytical prediction, GdfidL and HFSS results
- TT2-111R effects on new collimator design impedance estimation
- Conclusions and future perspectives

The new BPM-button HiLumi-LHC collimator design



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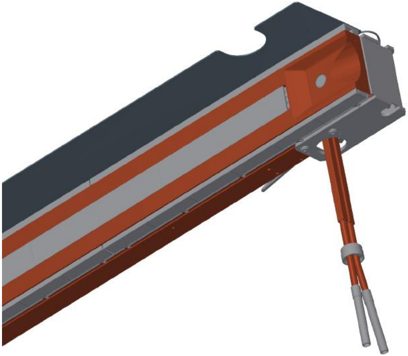
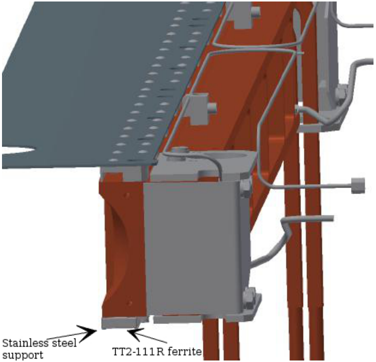
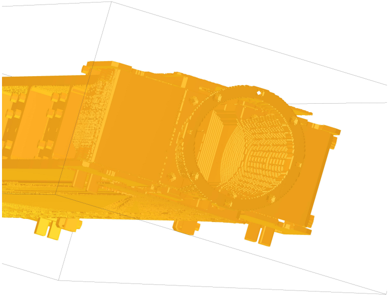
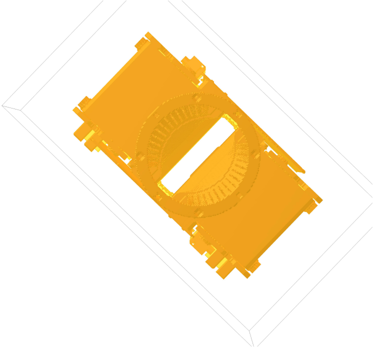




RF fingers are removed and their HOM damping functions are supposed to be supplied by TT2-111R ferrite blocks

New collimator design GdfidL model





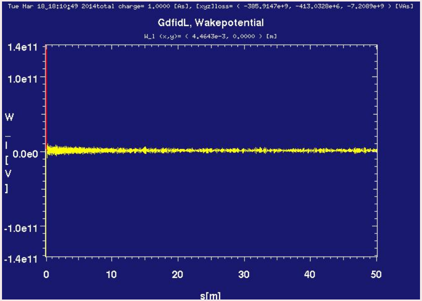
No more symmetry planes are applicable

$\Downarrow$

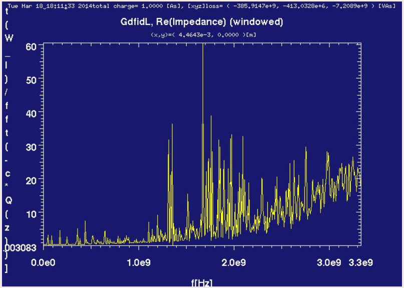
whole structure has to be simulated $\Rightarrow$ more simulation time needed?

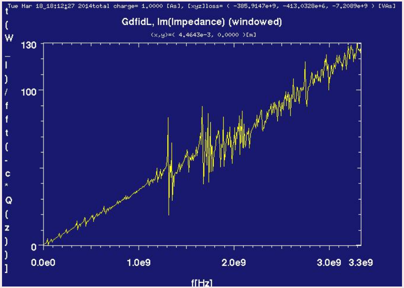
New collimator design, no RF fingers, no ferrite, GdfidL simulations $\|$

$W_{\|}$



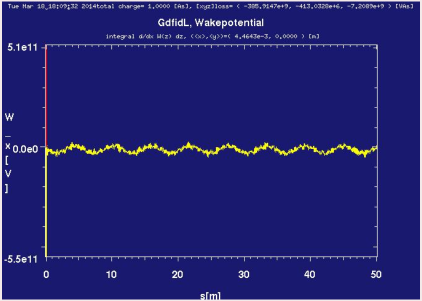
$Z_{\|}$



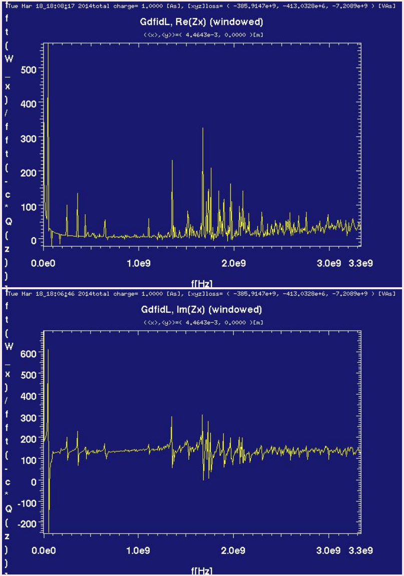


New collimator design, no RF fingers, no ferrite, GdfidL simulations $\perp$

$W_\perp$

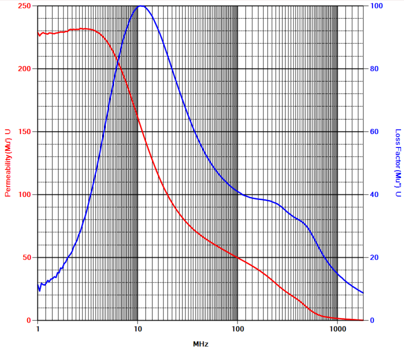


$Z_\perp$

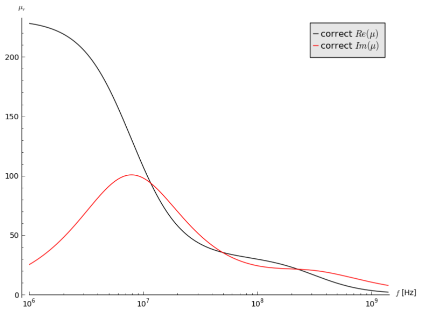


TT2-111R dispersive properties

Experimental data (Courtesy of B. Salvant)



Lorentz function fit



Lorentz function

$$\mu_{r_{TT2-111R}}(\omega) = \mu_\infty + \mu_\infty^2 \sum_{n=1}^{2} \frac{A_n \omega_n^2}{\omega_n^2 + j\omega\gamma_n - \omega^2}$$

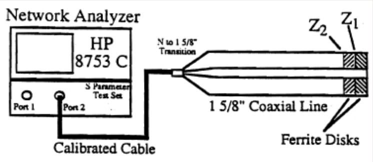
Fit parameters

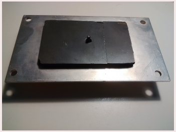
$$\begin{cases} \omega = 2\pi f(Hz) & ;\mu_\infty = 1.36 \\ A_1 = \dfrac{200}{\mu_\infty^2} & ;\omega_1 = 2\pi \cdot 10^9 \quad ;\gamma_1 = 800 \cdot 10^9 \\ A_2 = \dfrac{30}{\mu_\infty^2} & ;\omega_2 = 4\pi \cdot 10^9 \quad ;\gamma_2 = 80 \cdot 10^9 \end{cases}$$

How to test correct code μ implementation?

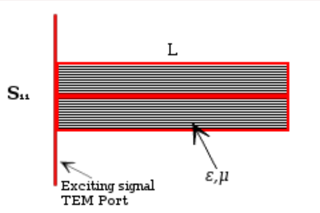
In our opinion it's a very useful method to arrange simple coaxial probe measurement simulations, in order to check for the numerically computed S-parameters to be fully in agreement with theoretical prediction.

Measurement layout (From R. Boni *et al.*, LNF-93/014)





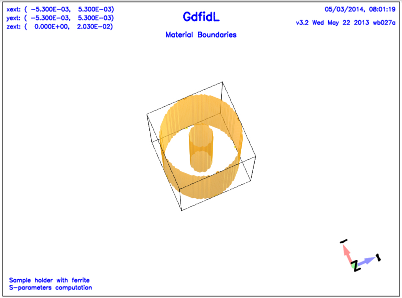
Simulated measurement



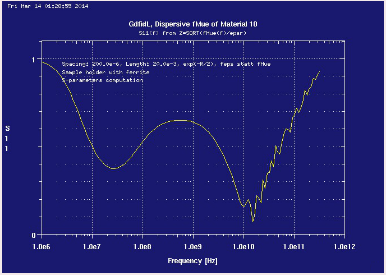
Analytical formulas

$$S_{11} = \frac{\Delta \cdot \tanh(\gamma L) - 1}{\Delta \cdot \tanh(\gamma L) + 1}; \qquad \gamma = j\omega\sqrt{\varepsilon\mu}; \qquad \Delta = \sqrt{\frac{\mu_r}{\varepsilon_r}}$$

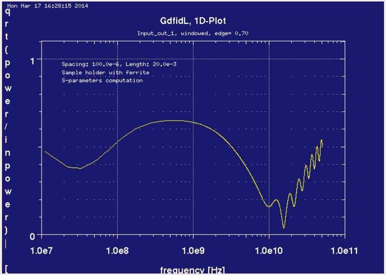
GdfidL DUT model



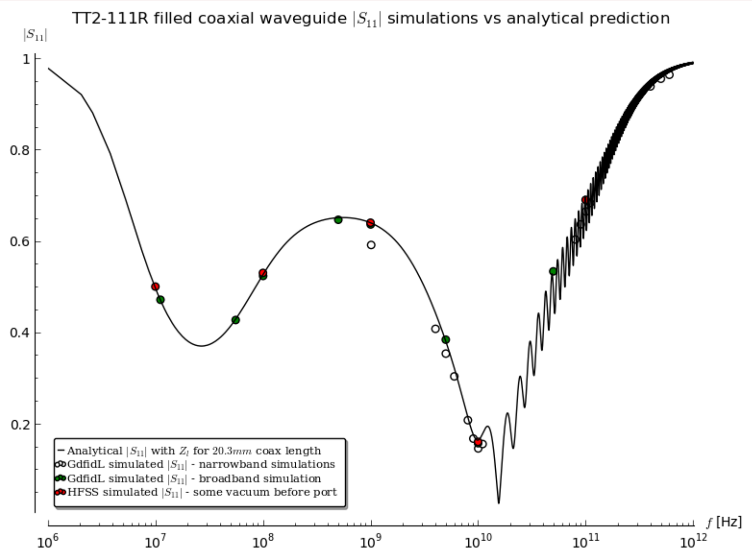
GdfidL analytical S_{11}



GdfidL computed S_{11}

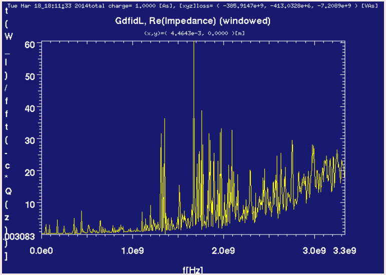


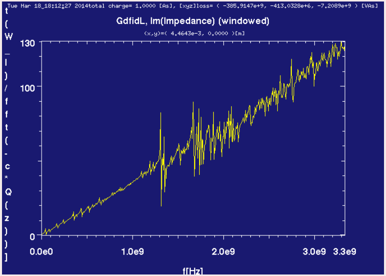
S_{11} results comparison



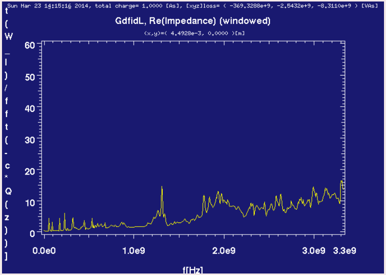
TT2-111R effects on new collimator design: $Z_{\parallel}$

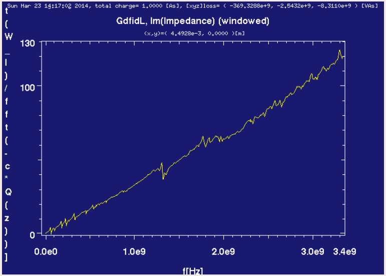
Without TT2-111R





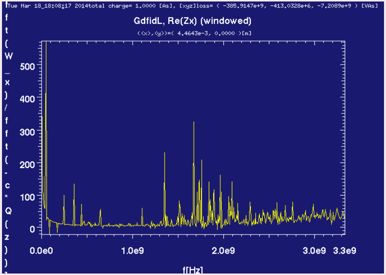
With TT2-111R

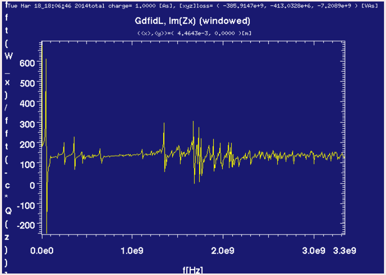




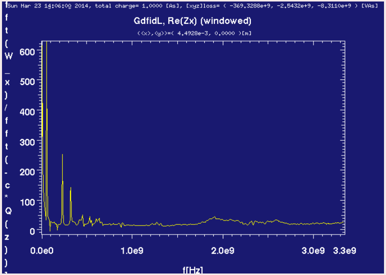
TT2-111R effects on new collimator design: $Z_\perp$

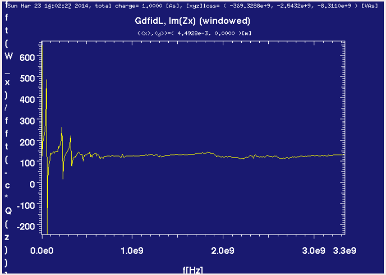
Without TT2-111R





With TT2-111R





Conclusions I

- New LHC secondary collimator design with BPM is thought to replace RF fingers with TT2-111R ferrite blocks;
- In order to accurately estimate the impedance of new collimators, dispersive properties of the ferrite have to be correctly managed by FDTD electromagnetic codes;
- We implemented TT2-111R measured magnetic permeability into GdfidL code, by means of a two-resonances Lorentz function fit;
- In order to check for the code to correctly simulate the dispersive properties, we performed a simple coaxial cable measurement simulation, so to compare the computed S-parameters to the well established analytical formulas, available from transmission lines theory;
- We also performed the same type of test with a FD code, HFSS, for benchmarking purposes;

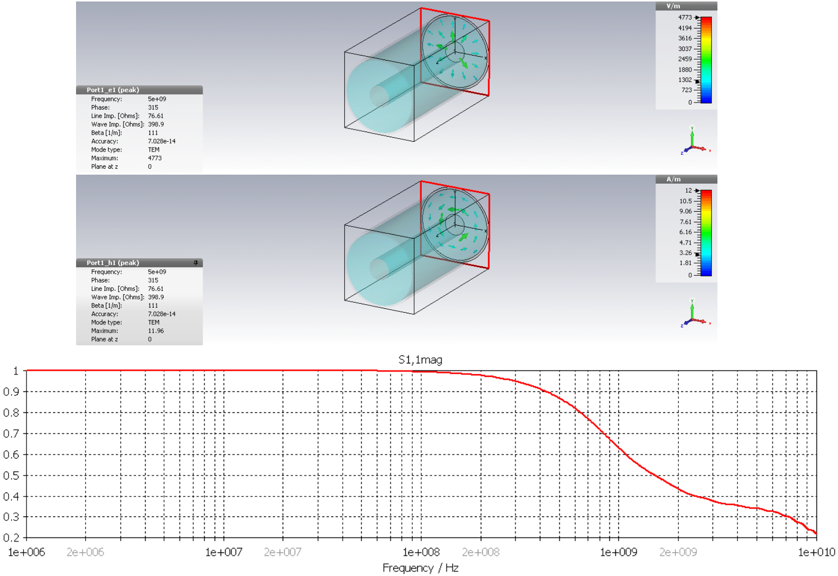
Conclusions II

- Owing to the perfect agreement between the simulated S_{11} and the theoretical prediction, we calculated the ferrite-filled secondary collimator wakes and impedances;
- Comparing the obtained results with those for the new collimator design, but without any RF finger or ferrite, it was clearly shown that TT2-111R determines a quite strong damping of HF modes, while some modes still lie in the LF range (up to $\sim 100\ MHz$);
- A full understanding of LF damping(?) properties of ferrite cannot be reached without a proper definition of the whole material dispersive properties, i.e. μ AND ε;
- In future steps a complete $\varepsilon_{r_{TT2-111R}}$ implementation is expected; from this point of view some experimental data feedback would be very well accepted from CERN collegues.

Thanks for your kind attention

What comes from CST - points for discussion?

No vacuum before port computation



What comes from CST - points for discussion?

Some vacuum before port computation