

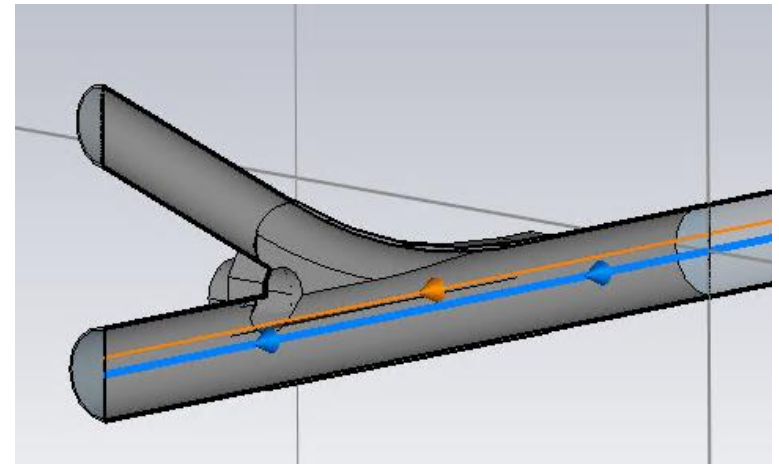
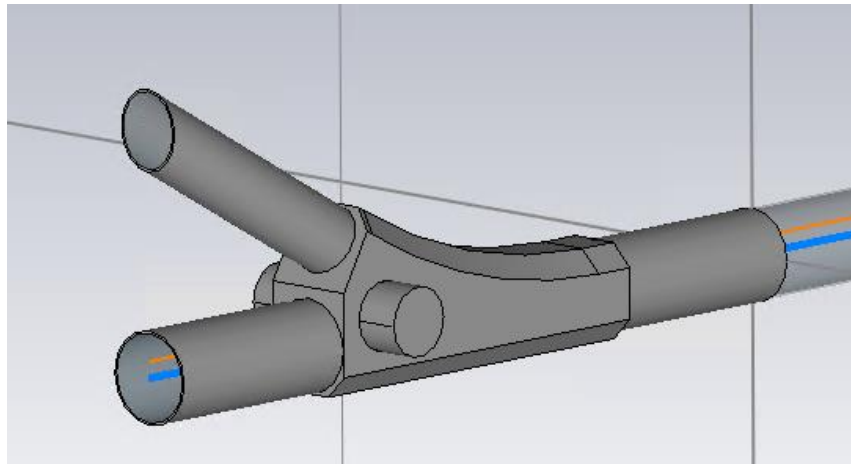
Update on electron lens impedance studies (without electrons)

Carlo and Benoit

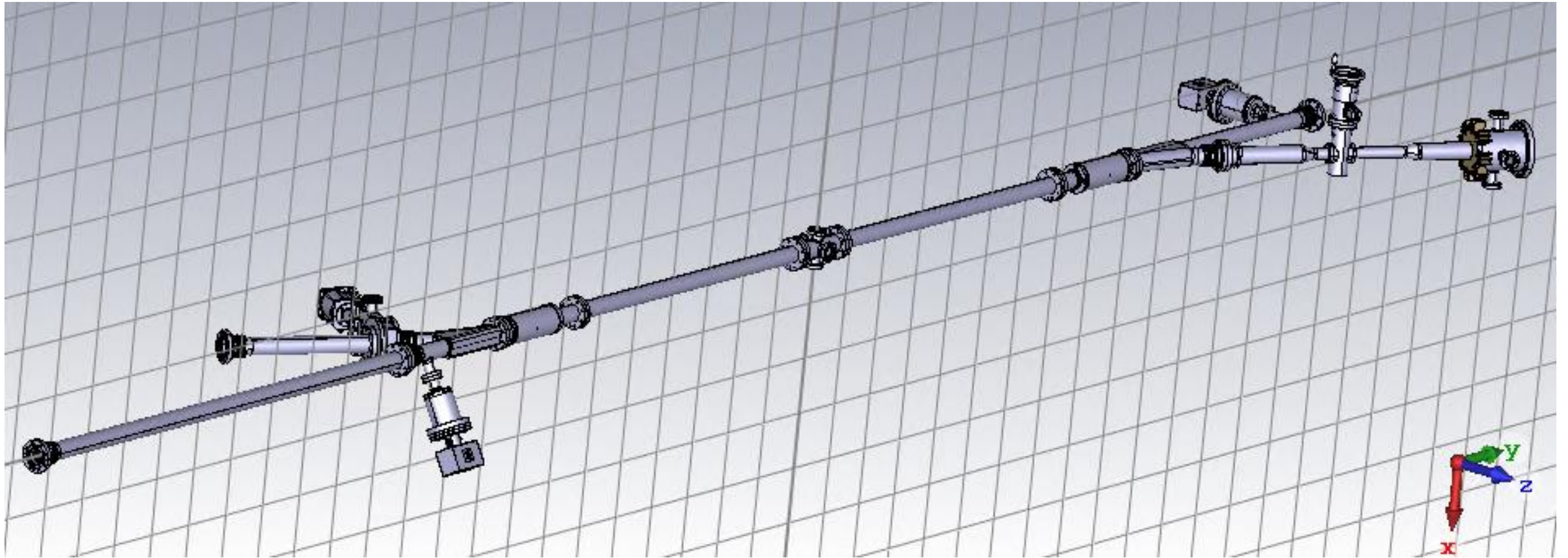
Thanks to Antti Kolehmainen, Diego Perini (EN-MME)
and Riccardo de Maria (BE-ABP)

Context

- Hollow electron lens for halo control for HL-LHC
- Design discussed since a long time with EN-MME
- Work in particular in 2017 by a 2-week HSSIP stagiaire Chloe Rakotoalivony in 2017



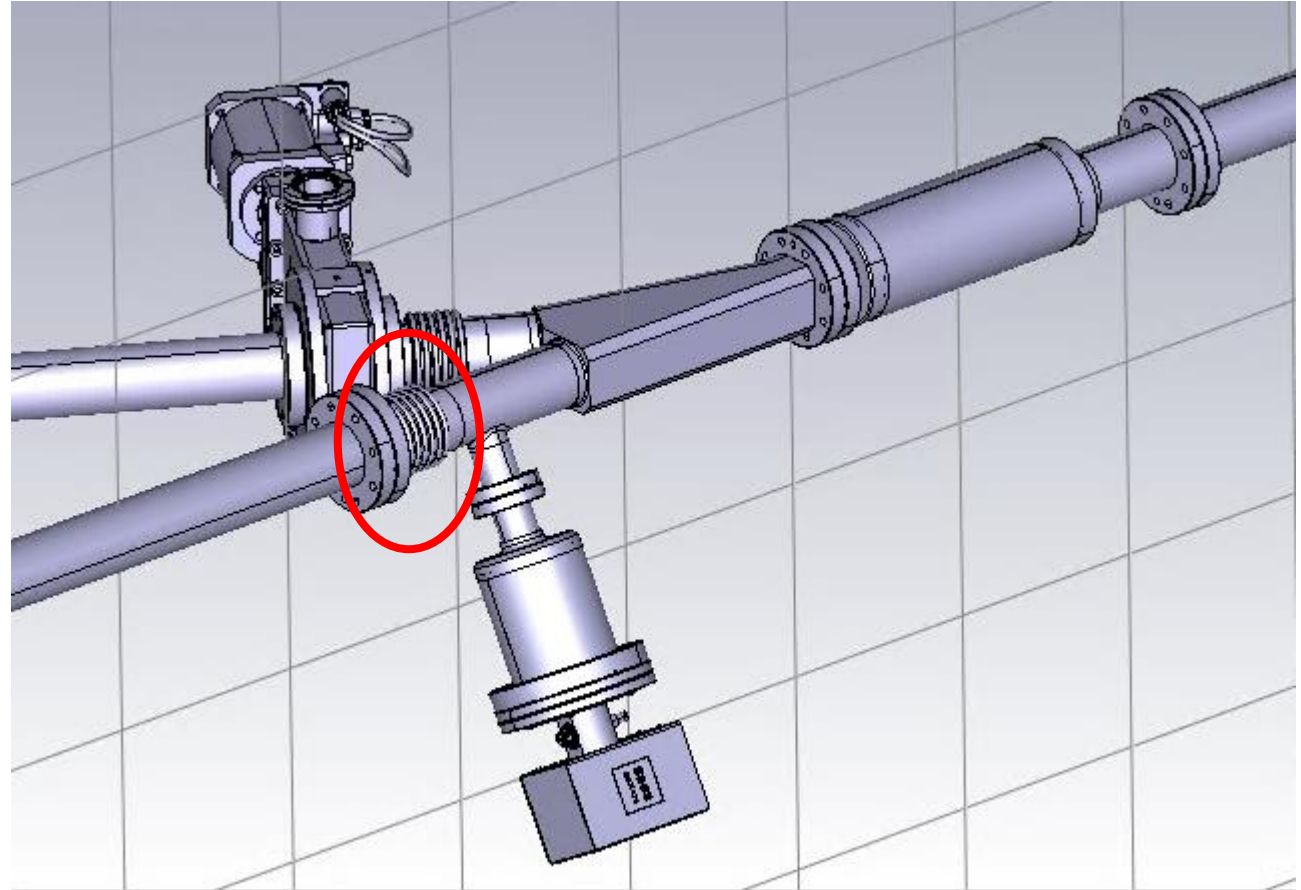
New design (August 2020)



Provided by Antti from EN-MME

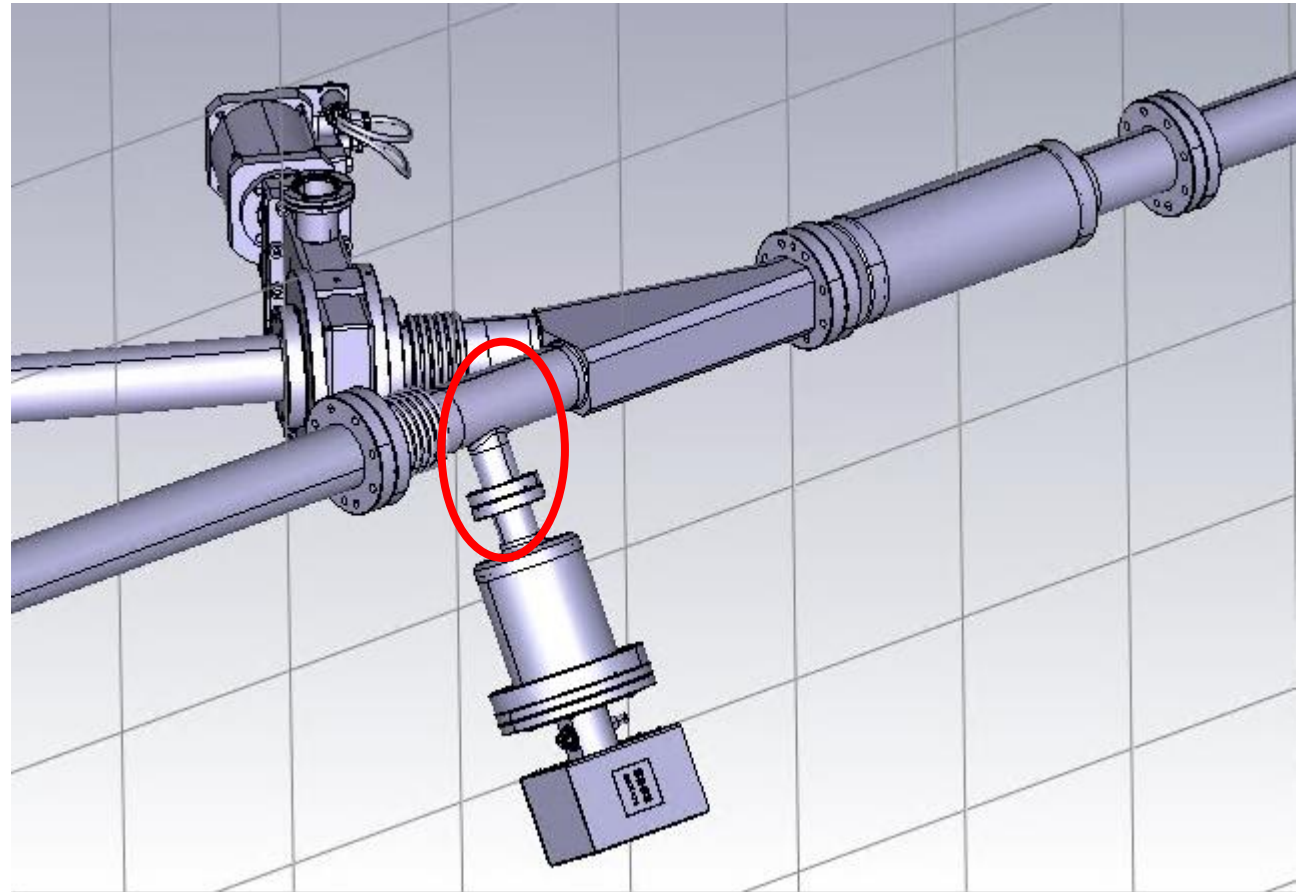
Comments

- Bellow should be shielded



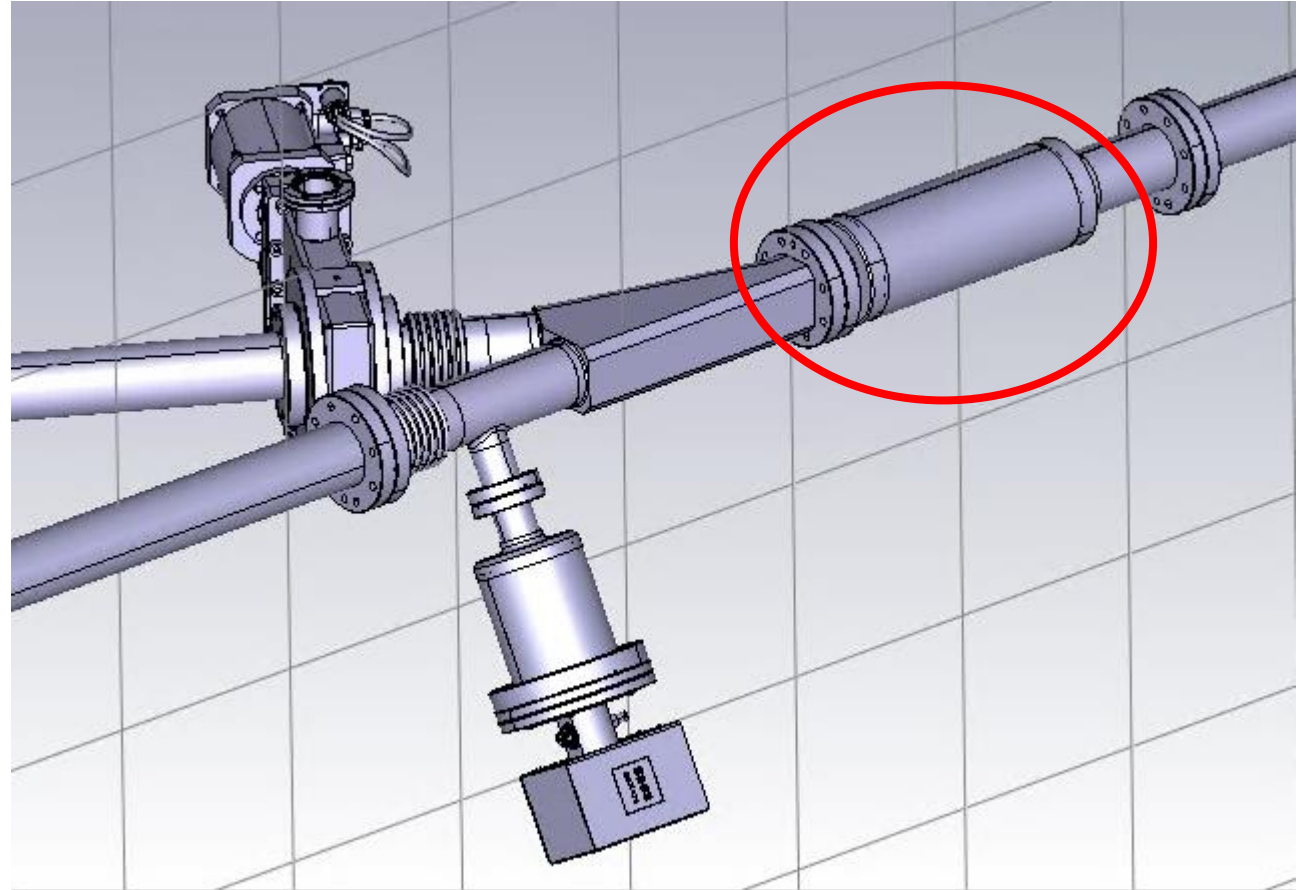
Comments

- Bellow should be shielded
- Pump should be shielded



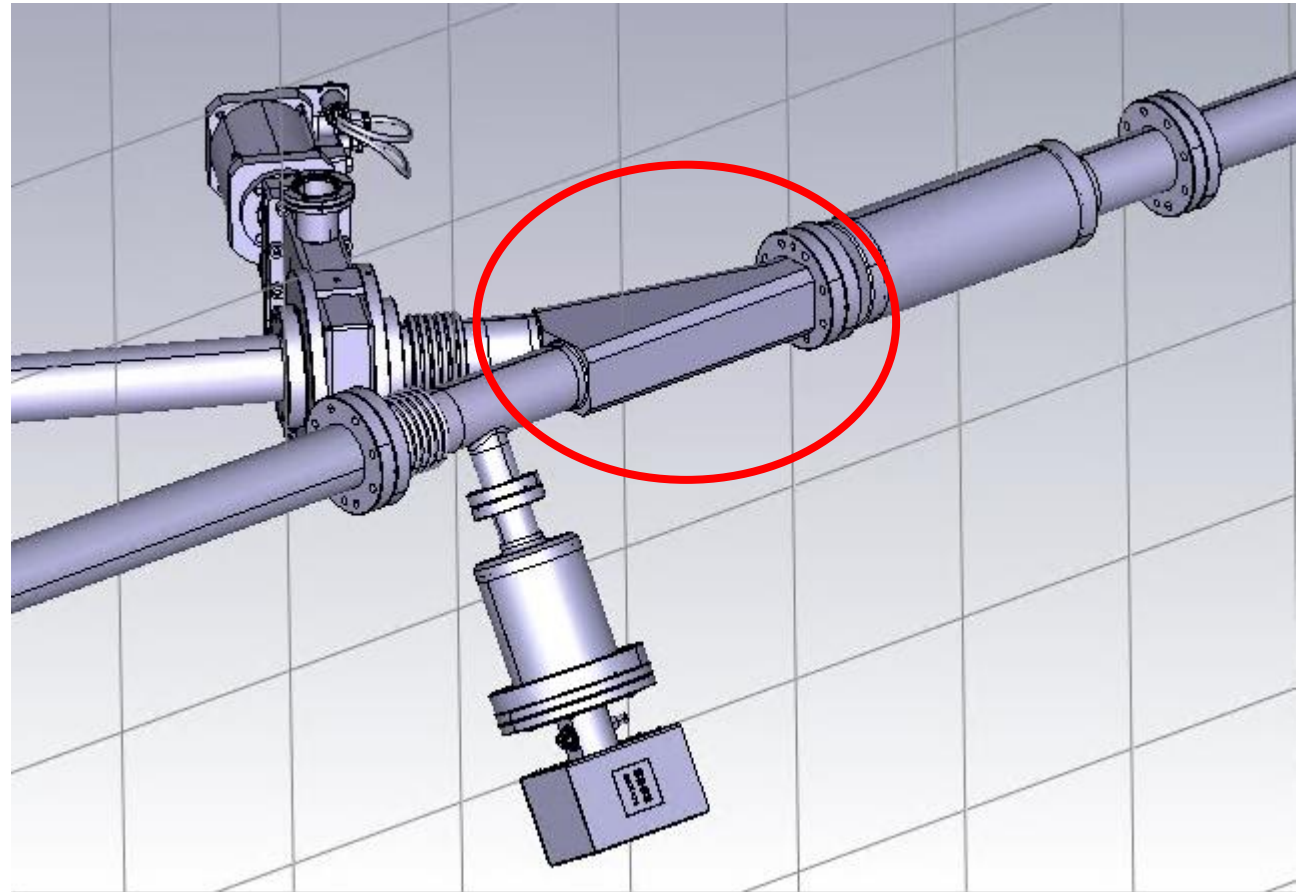
Comments

- Bellow should be shielded
- Pump should be shielded
- Non-standard BPM (studied)



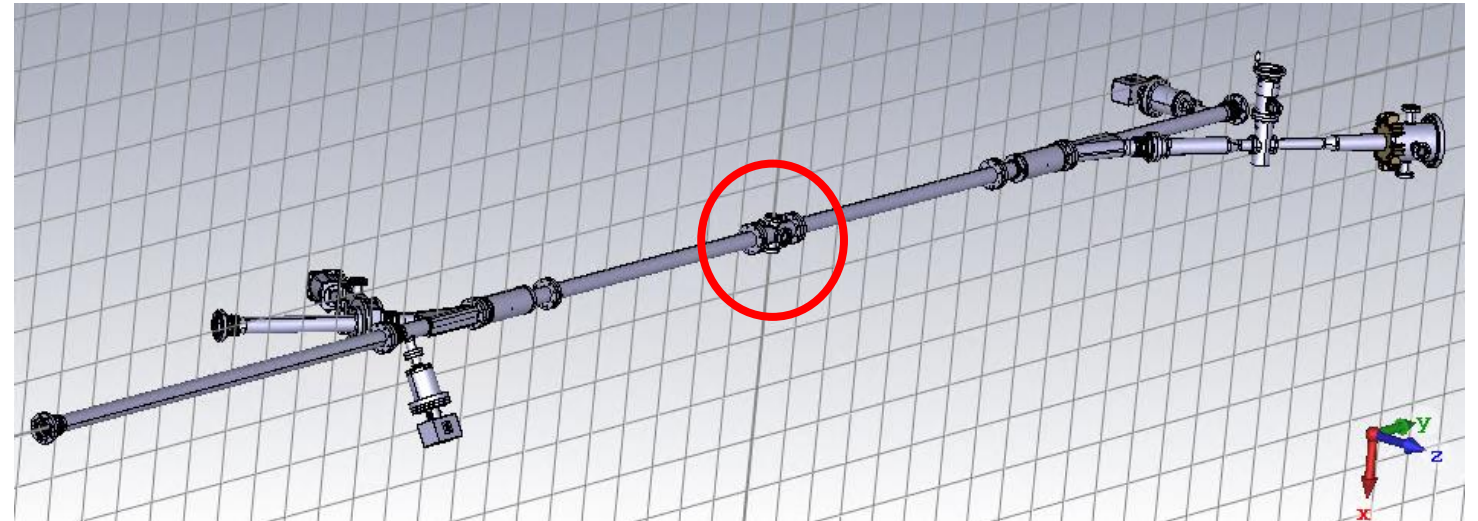
Comments

- Bellow should be shielded
- Pump should be shielded
- Non-standard BPM (studied)
- Y chamber volume could be reduced



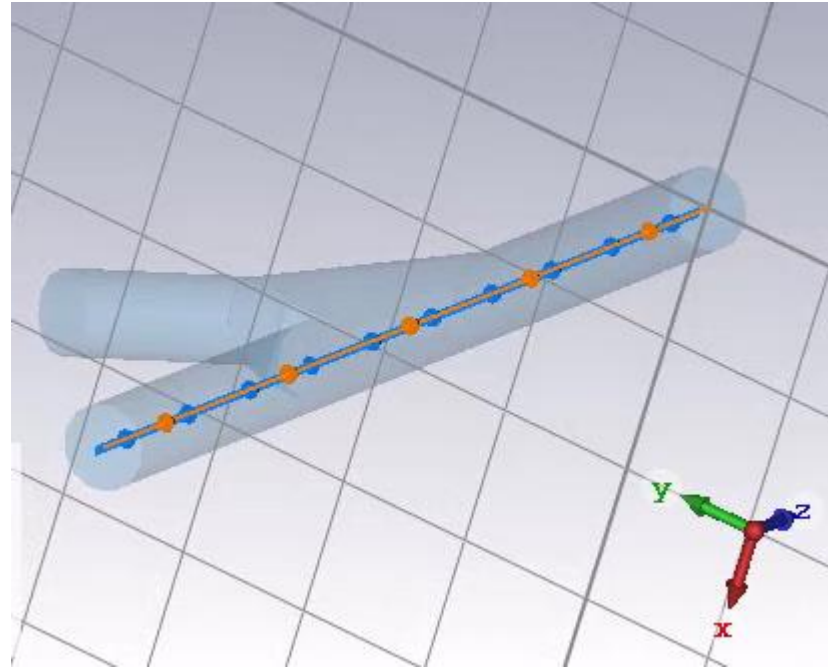
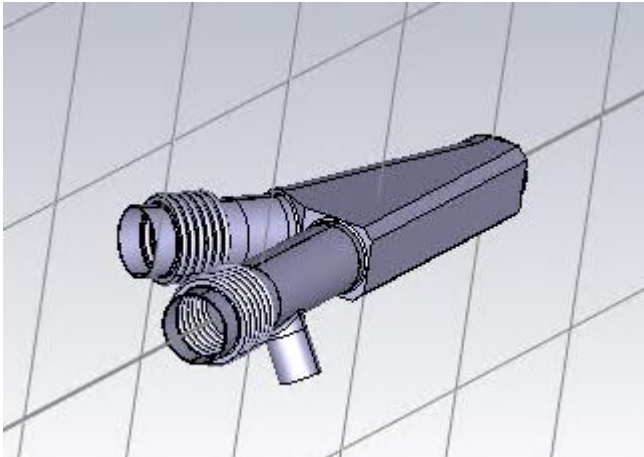
Comments

- Bellow should be shielded
- Pump should be shielded
- Non-standard BPM (studied)
- Y chamber volume could be reduced
- BGC design ongoing and not available
- Coatings? ID60 should impose copper coating



→ Under discussion with EN-MME

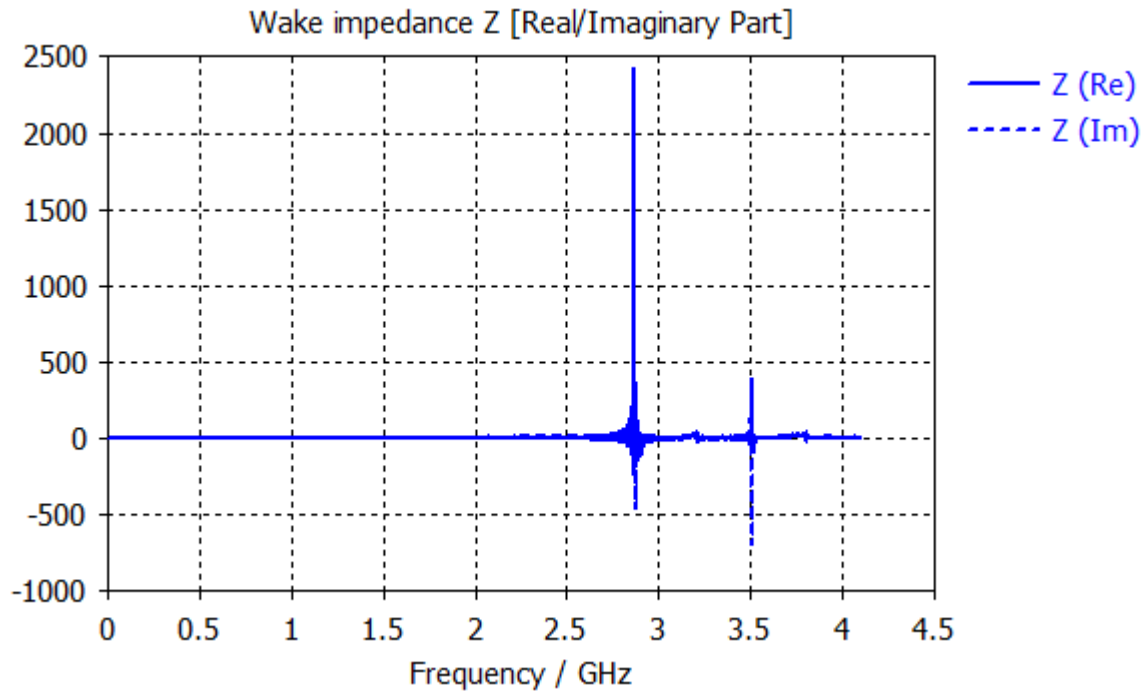
Y chamber



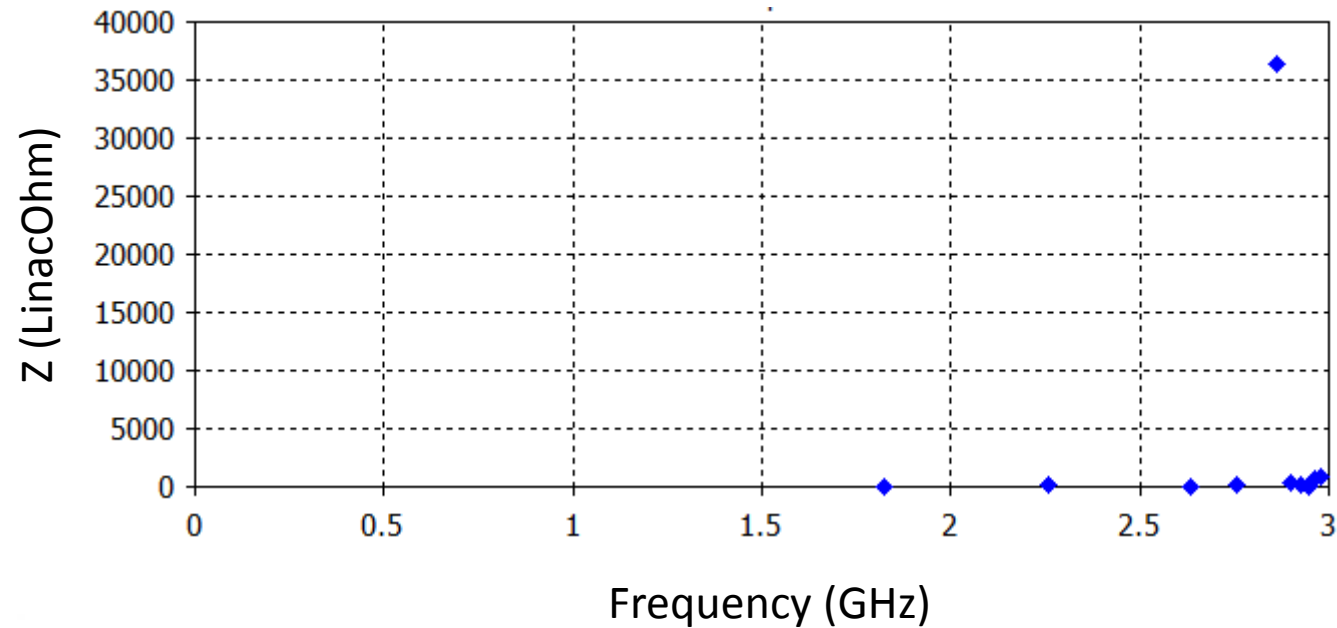
- EN-MME followed the guideline we provided to minimize the volume around the incoming pipes
- We could theoretically do a bit better, by adding a blade as in the other LHC Y chambers.
- Nevertheless, contrary to the other Y chambers, not a simple symmetric merge of two pipes

Longitudinal impedance

CST Wakefield solver

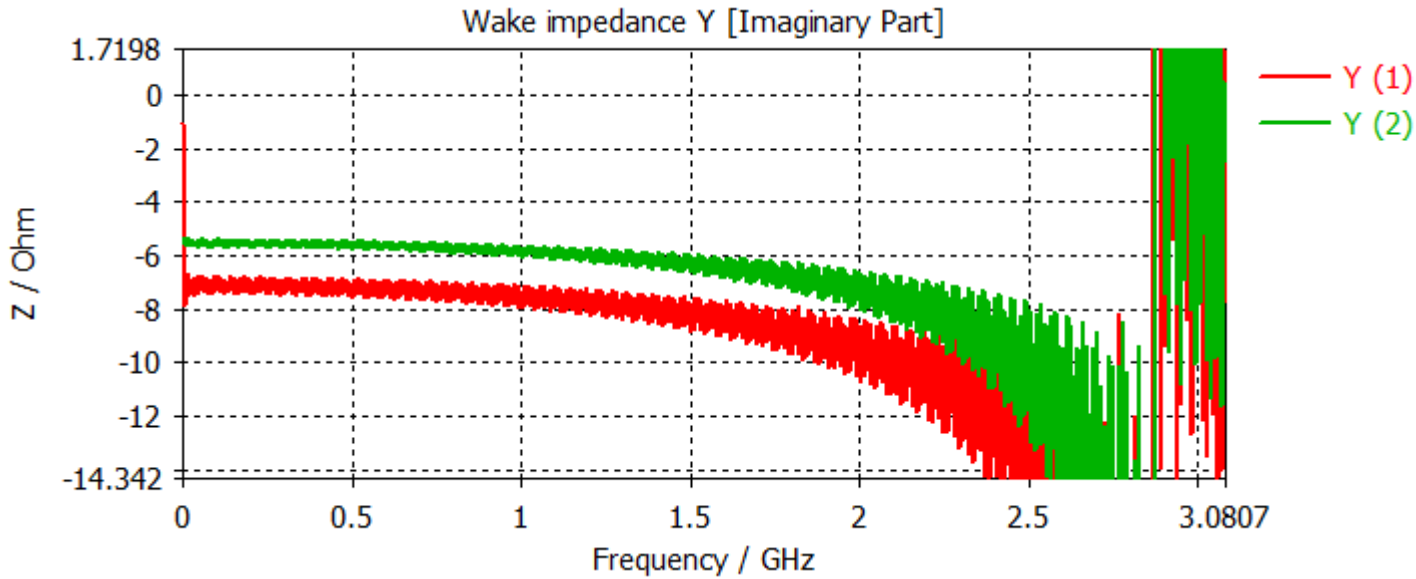


CST Eigenmode solver



- First mode at 2.86 GHz (18 kOhm and $Q=18,000$ if copper coated)
- $\text{Im}(Z/n)^{\text{eff}} \sim 0.02$ mOhm for 1 Y chamber (to be compared to 90 mOhm for full LHC)

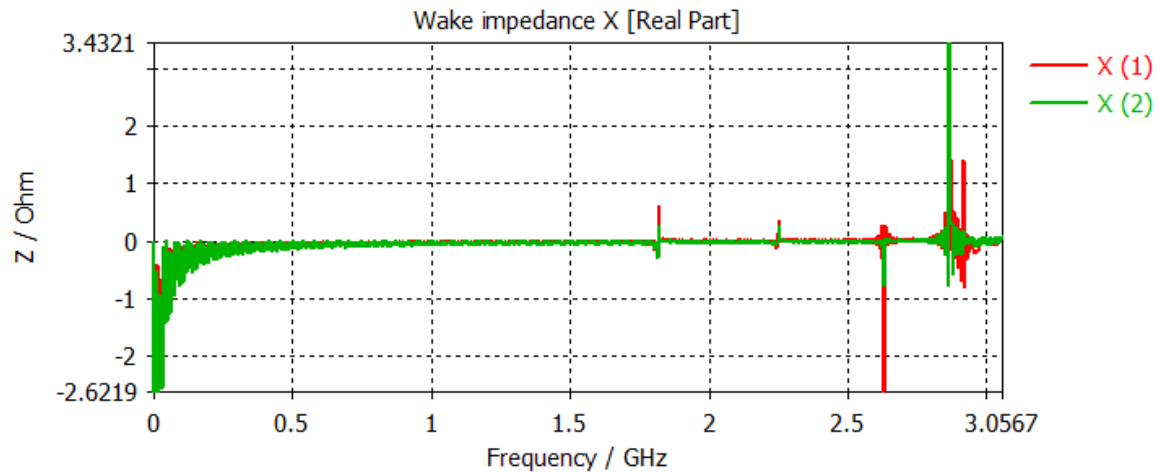
Transverse impedance ($y \rightarrow$ horizontal)



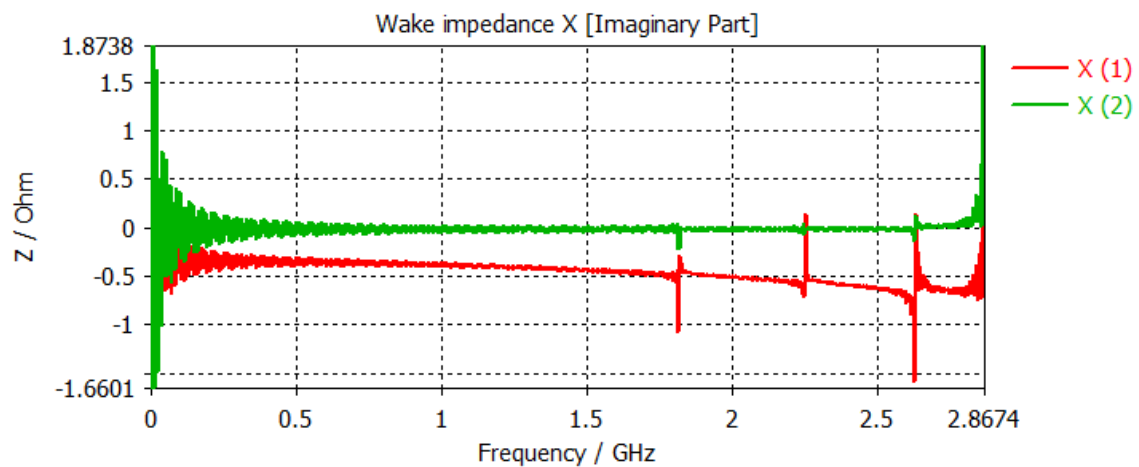
→ Beta \sim 280 m (from Riccardo)

→ $\text{Im}(Z_x) = 1.5 \text{ Ohm per } 5 \text{ mm} = 300 \text{ Ohm/m}$ for 1 Y chamber

Transverse impedance (x → vertical)

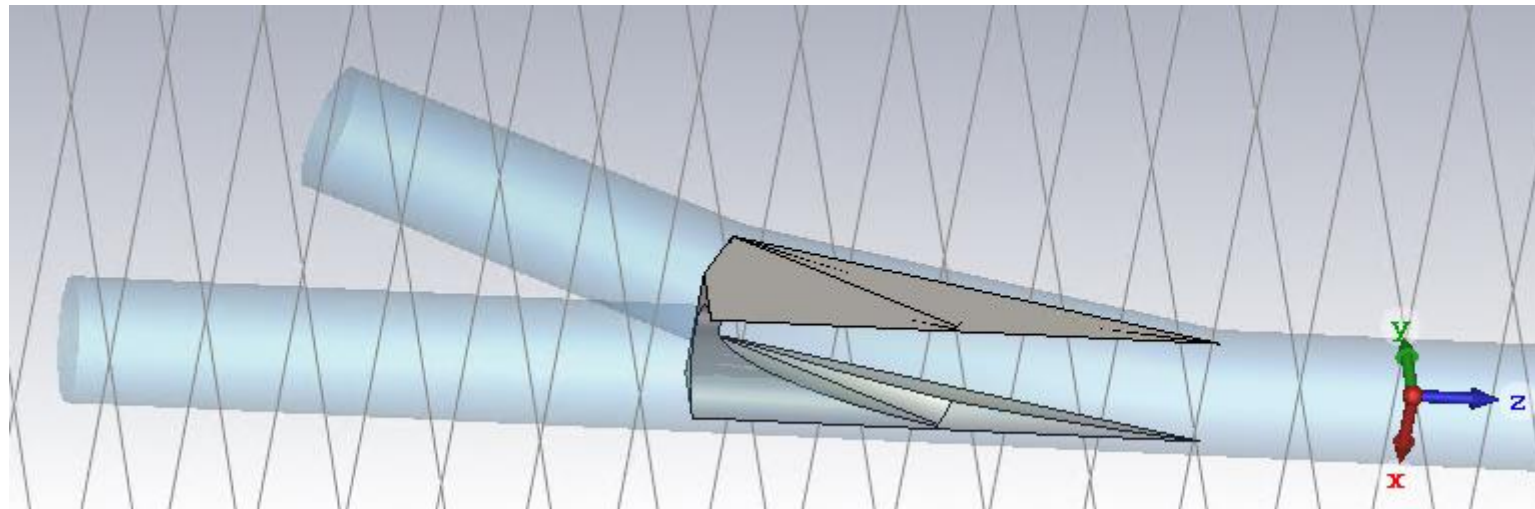


- Beta ~280 m (from Riccardo)
- $\text{Im}(Z_y) = 0.5 \text{ Ohm per } 5 \text{ mm} = 100 \text{ Ohm/m}$ for 1 Y chamber



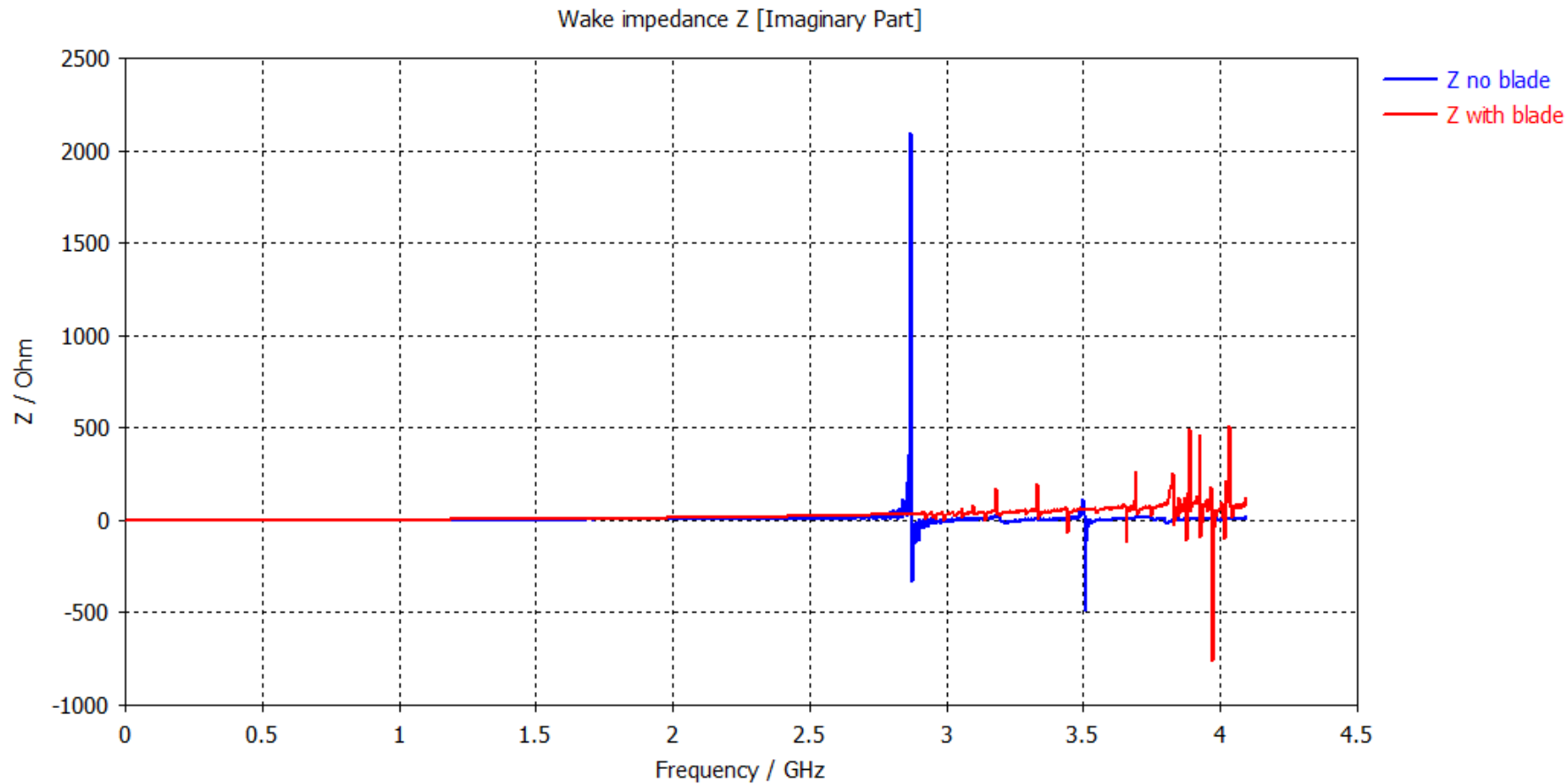
- First mode at 1.82 GHz
- 4 kOhm/m and $Q=19,000$ for copper from eignemode

Adding a shielding blade



→ Not a trivial geometry to manufacture

Impact of shielding blade

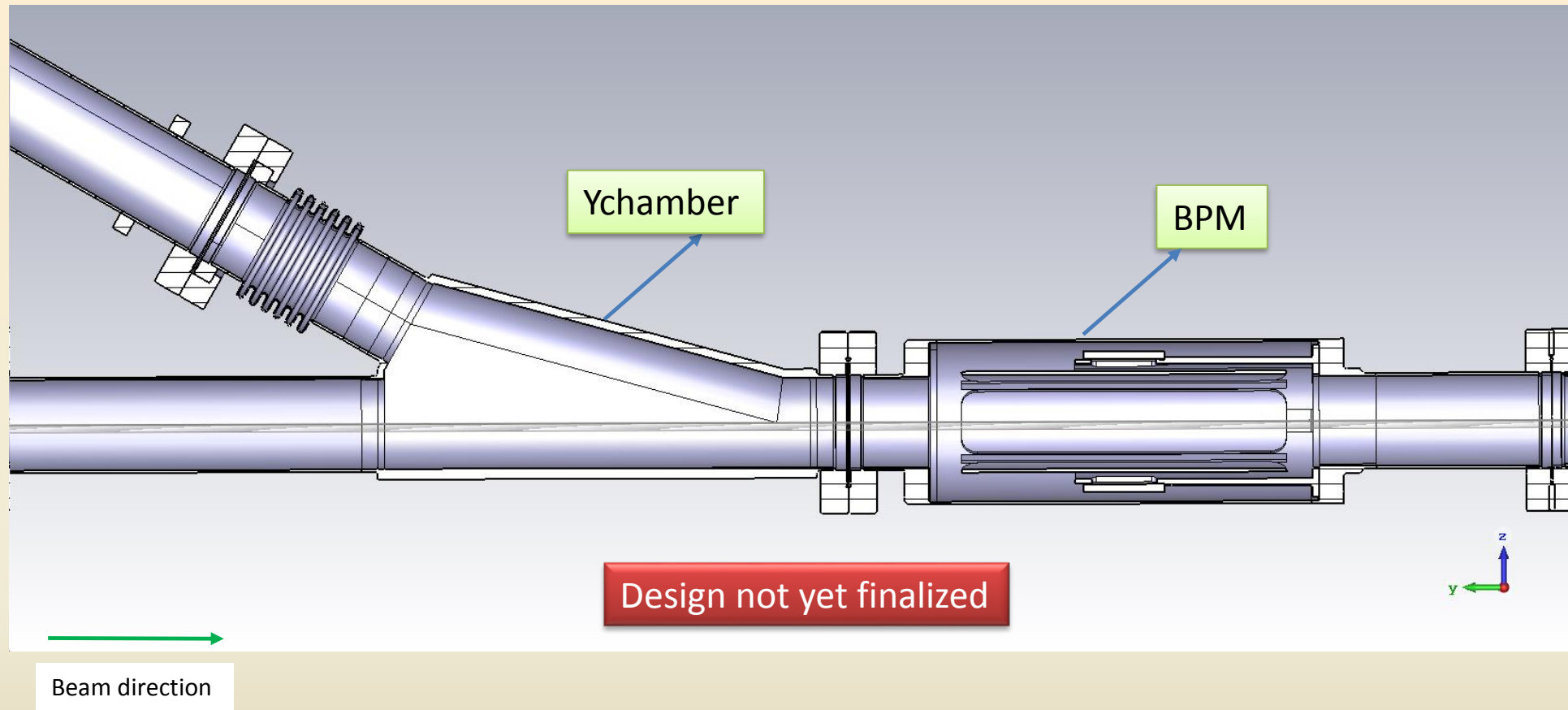


- Mode at 2.86 GHz disappears
- No significant beneficial impact on $\text{Im}(Z/n)$
- Vertical mode gets worse (30 kOhm/m instead of 4 kOhm/m)

Conclusions for Y chamber

- Current model leads to very moderate impedance contribution.
- One could reduce longitudinal impedance if it is an issue by adding a blade, but
 - (1) It is not clear that the shape is feasible
 - (2) The first vertical mode at 1.85 GHz increases from 4 to 30 kOhm/m in simulations.

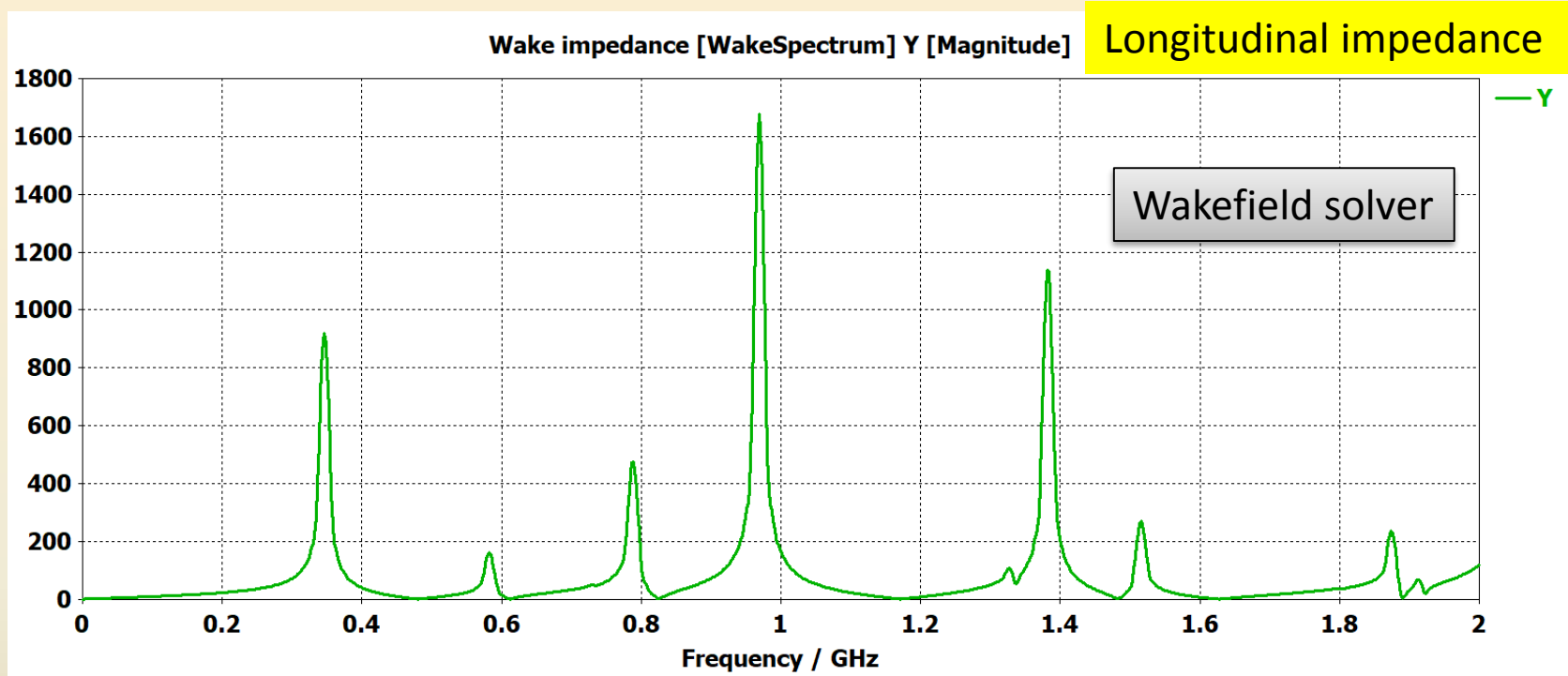
Simulation model



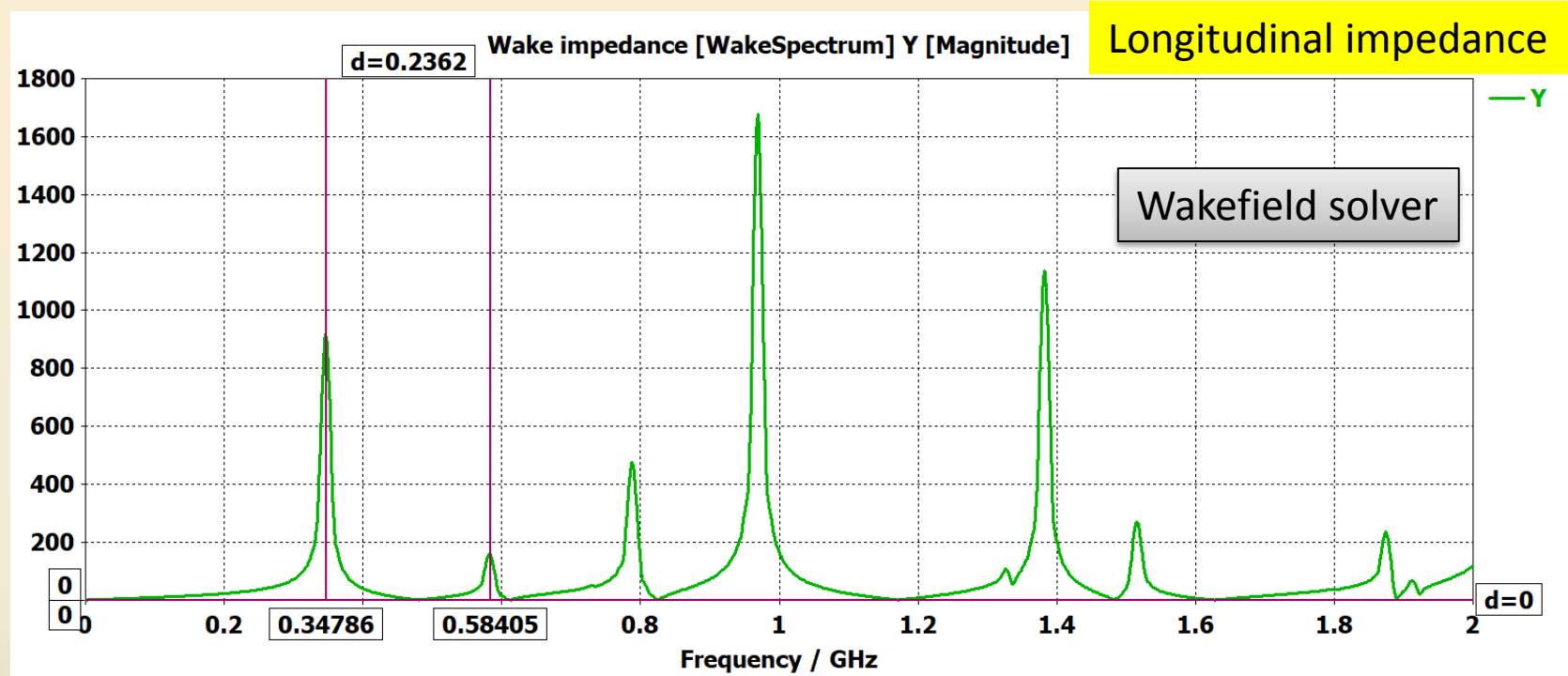
Geometric impedance of the hollow electron lens

$$Z_{G\text{-elens}} \approx 2 * Y_{\text{chamber}} + 2 * \text{BPM} + \text{CBGC}$$

Beam position monitor impedance simulations



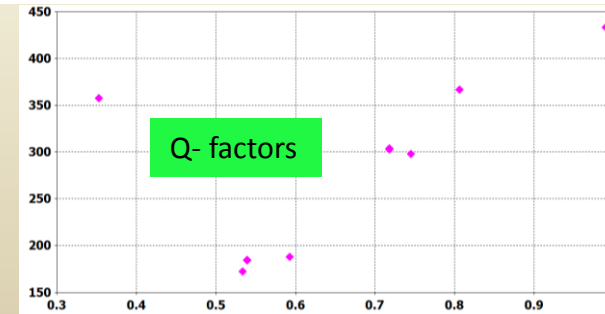
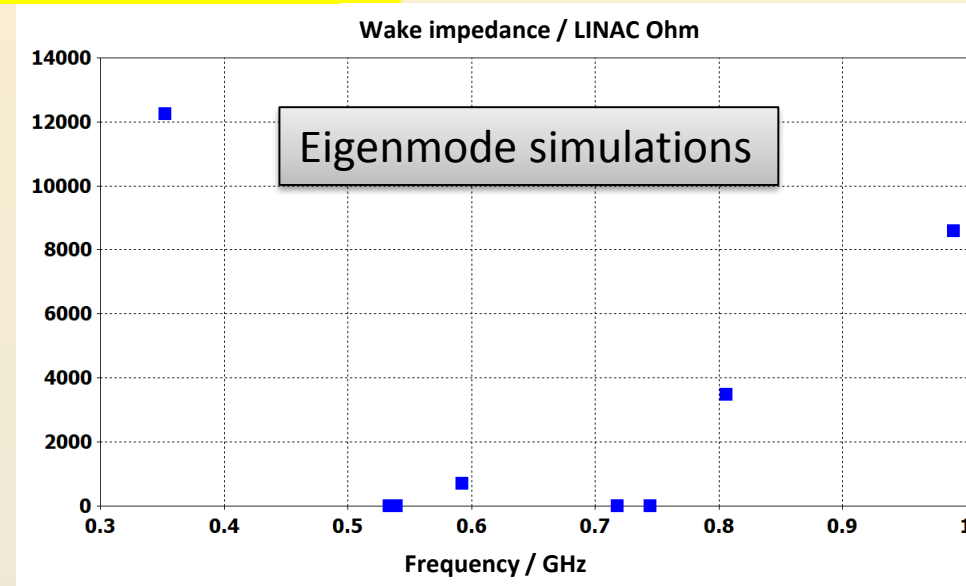
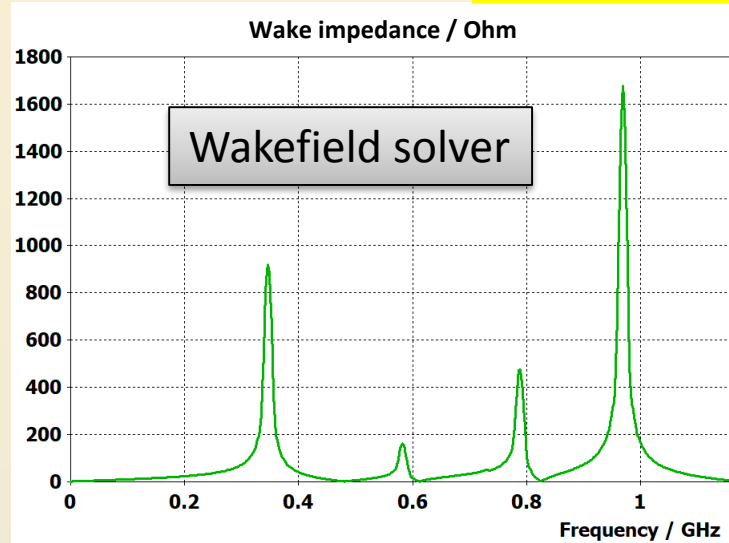
Beam position monitor impedance simulations



Wake is not decayed. Impedance spectrum gives information about the frequency of the impedance resonances. First resonance expected at about 350 MHz. Four significant impedance resonances are expected below 1 GHz

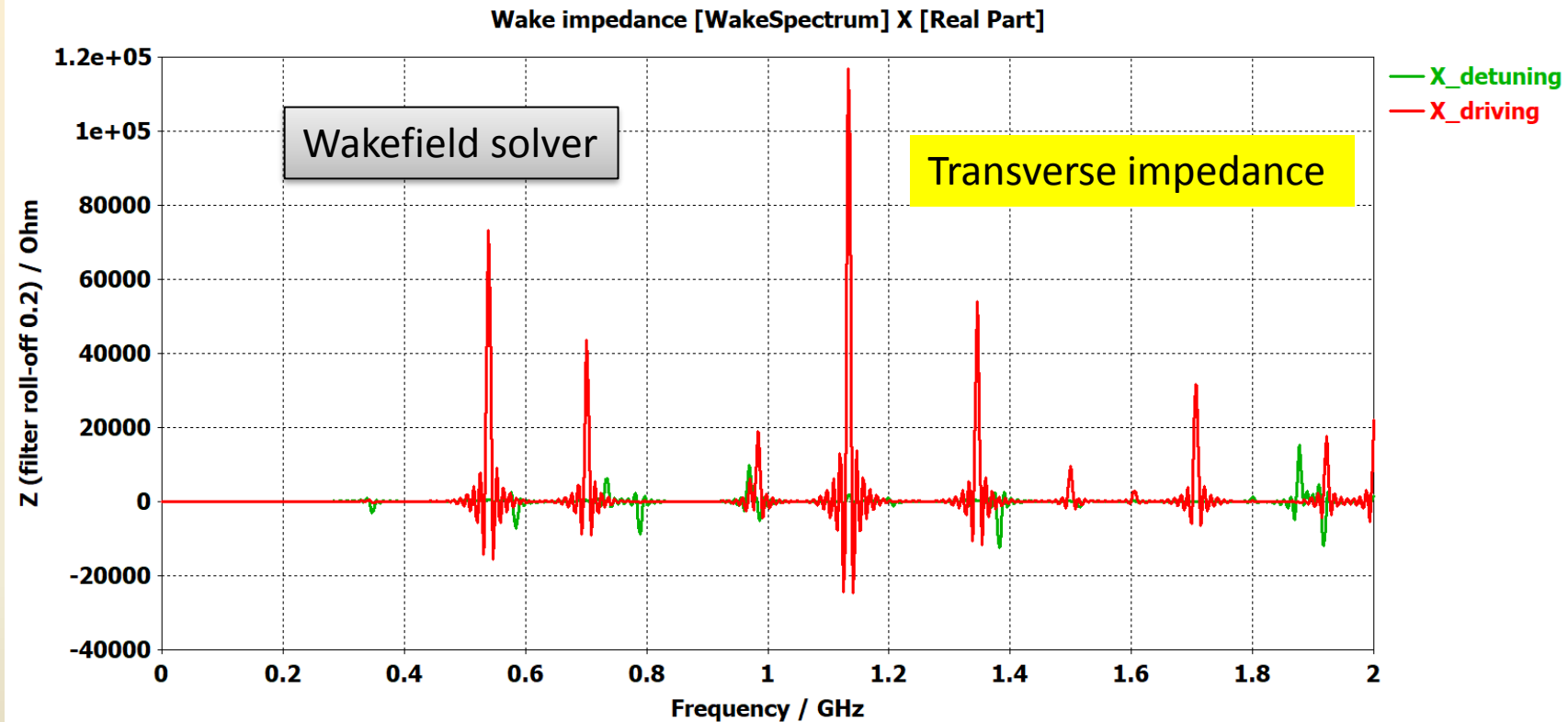
Beam position monitor impedance simulations

Longitudinal impedance magnitude



Very good agreement between eigenmode and wakefield solver for the frequencies of the impedance resonances

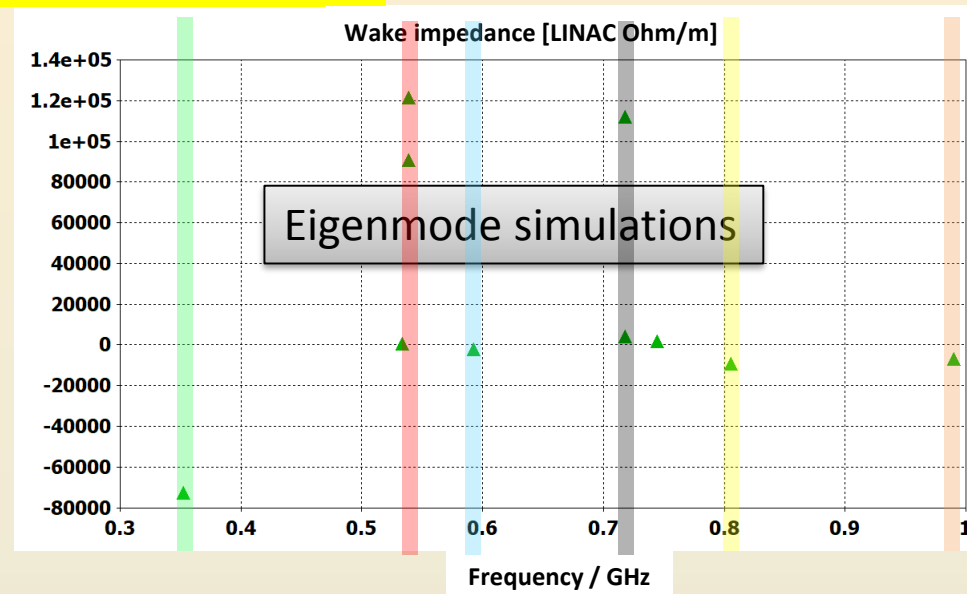
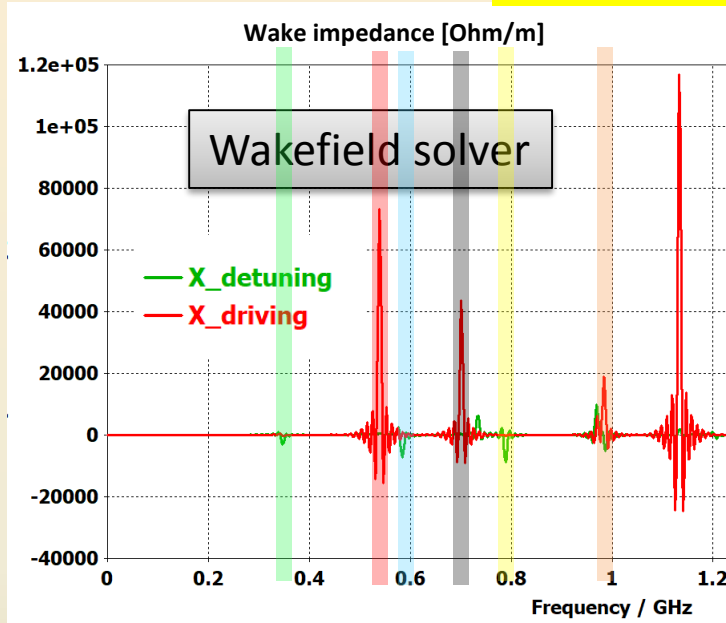
Beam position monitor impedance simulations



Wake is not decayed. Impedance spectrum gives information about the frequency of the impedance resonances. First detuning resonance expected at about 350 MHz.
First driving resonance expected at about 540 MHz.

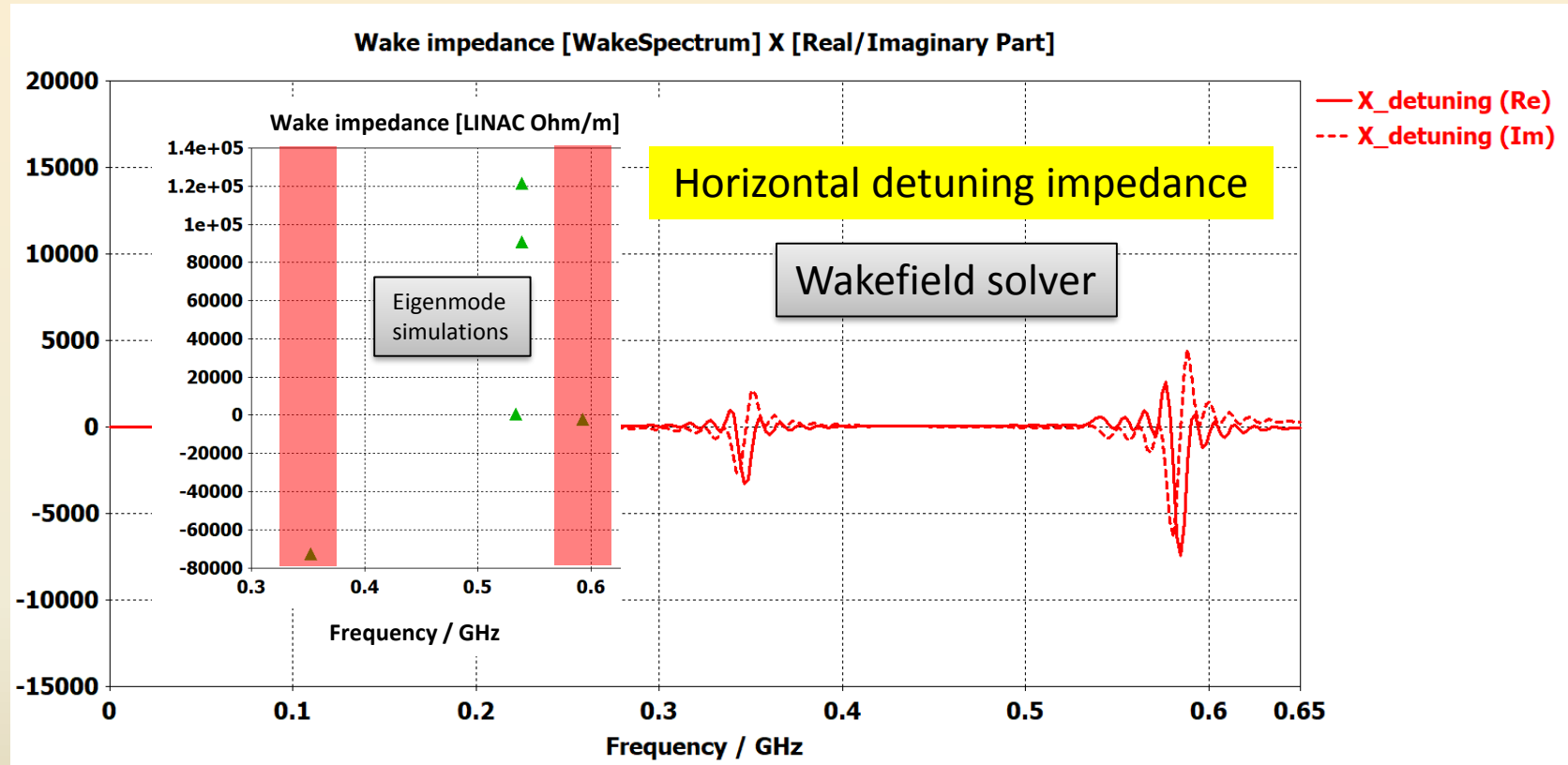
Beam position monitor impedance simulations

Longitudinal impedance magnitude



Very good agreement between eigenmode and wakefield solver for the frequencies of the impedance resonances

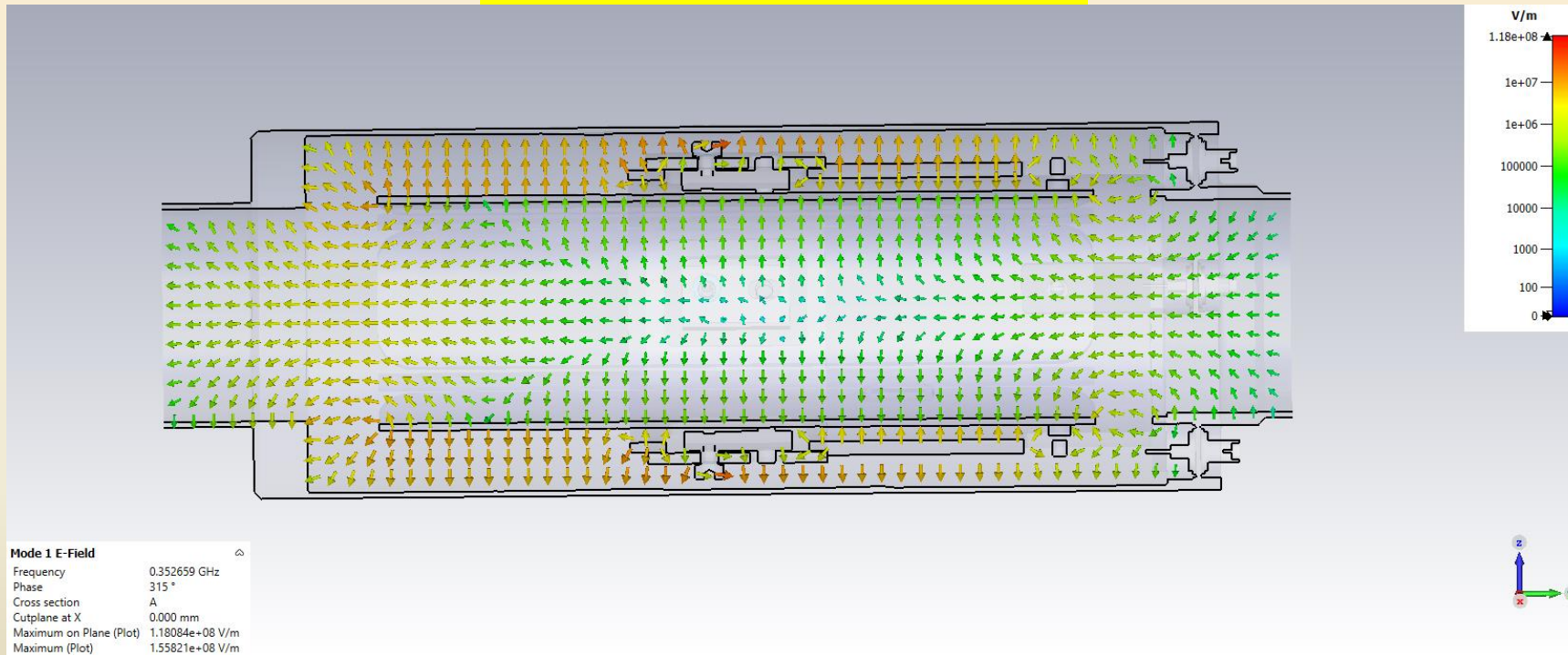
Beam position monitor impedance simulations



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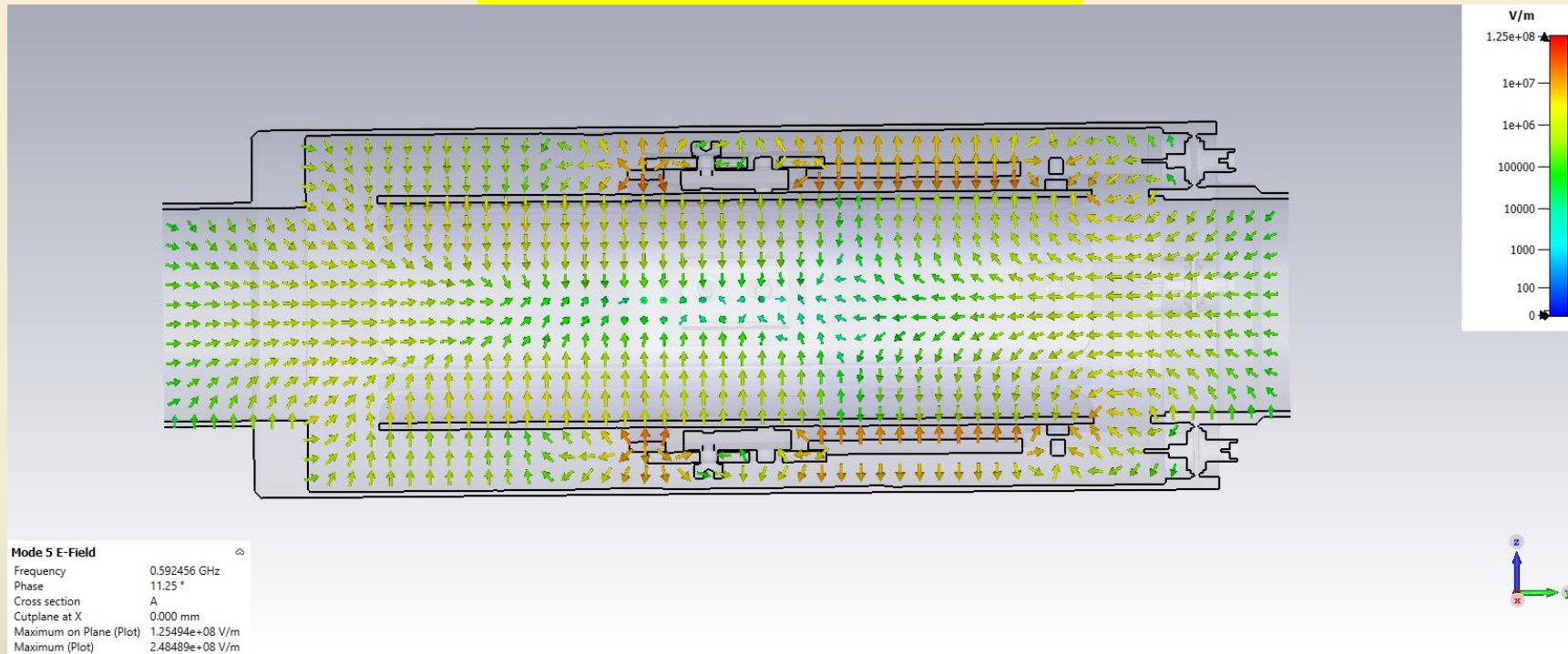
Beam position monitor impedance simulations

First detuning mode

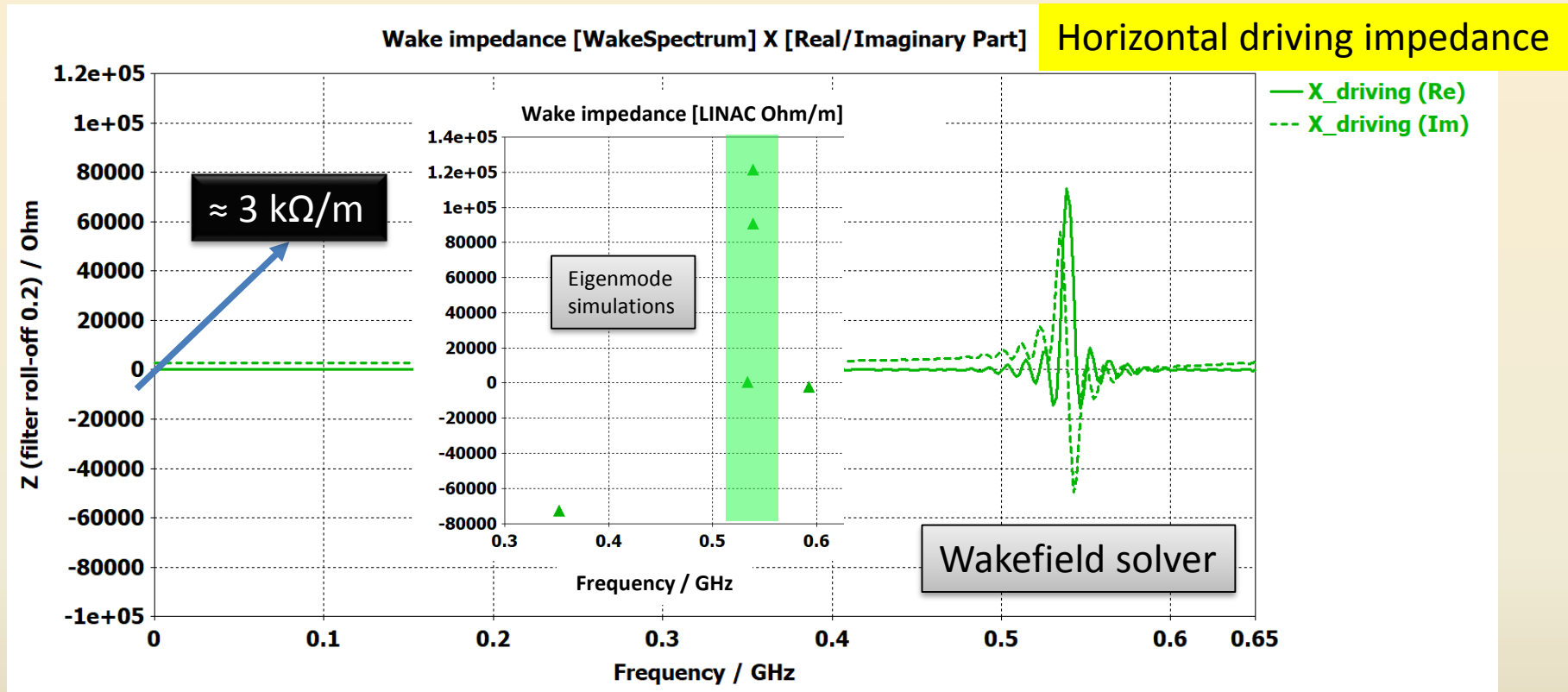


Beam position monitor impedance simulations

Second detuning mode



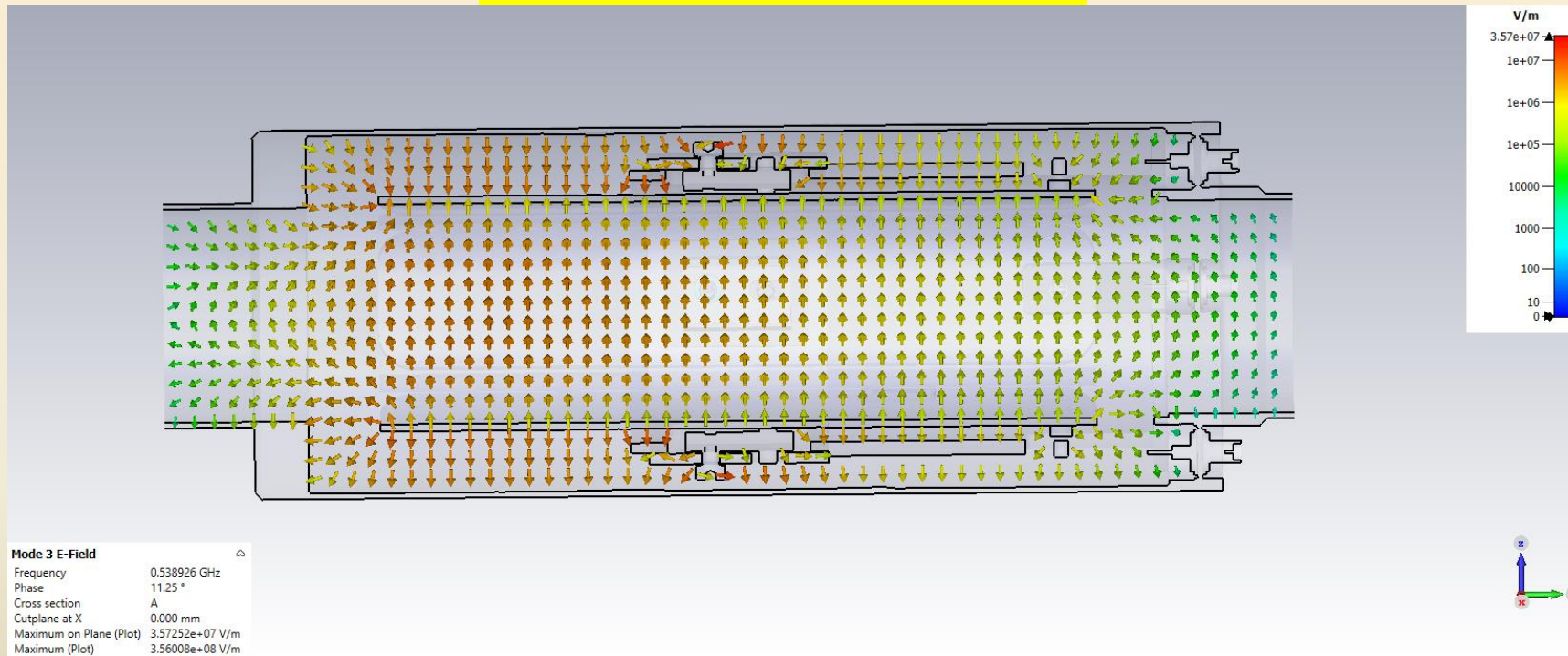
Beam position monitor impedance simulations



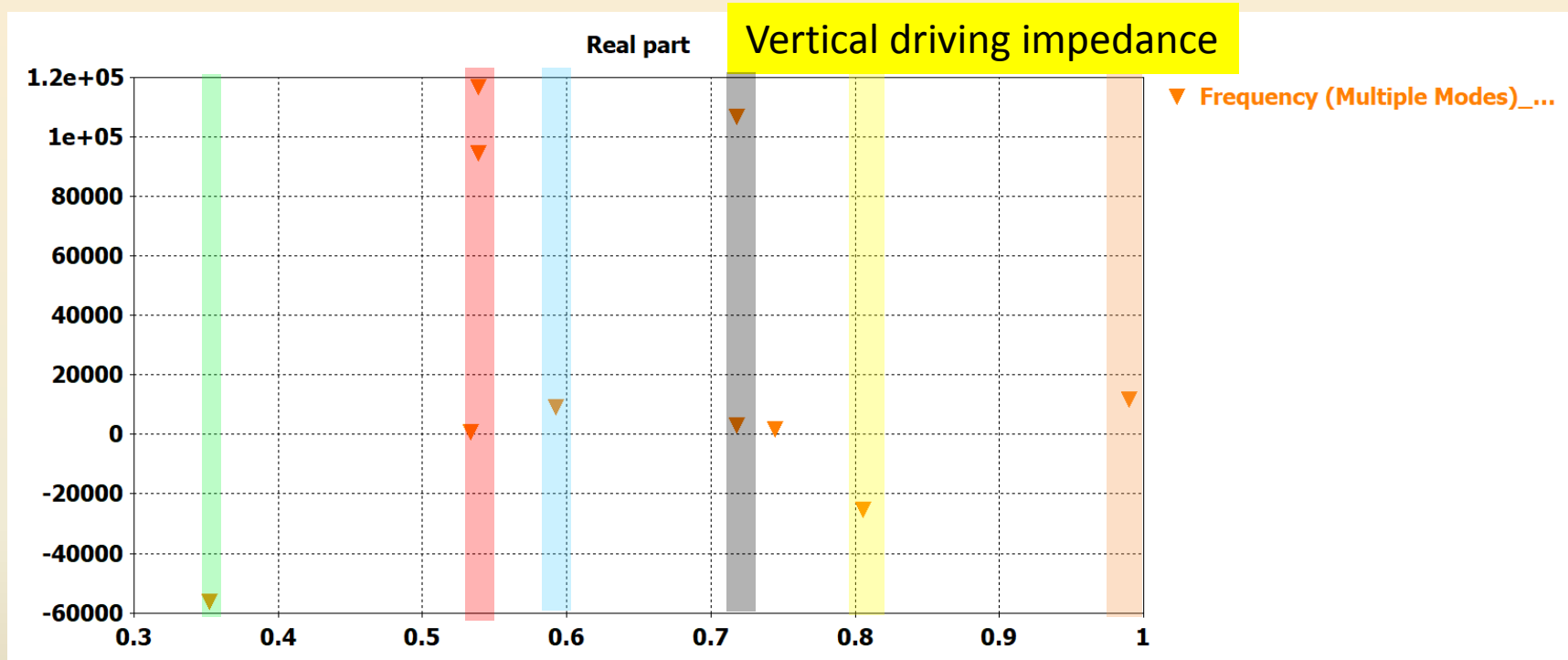
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Beam position monitor impedance simulations

First driving mode



Beam position monitor impedance simulations



Wake is not decayed. Impedance spectrum gives information about the frequency of the impedance resonances. First resonance expected at about 350 MHz. Four significant impedance resonances are expected below 1 GHz

Summary and next steps

- A preliminary beam coupling impedance model of the electron lens including the effect of BPM and Y chamber has been built
- The results are not final
 - Design not yet finalized:
 - missing standard shieldings of bellows and holes
 - BGC not integrated in the CATIA model
 - BPM terminations not integrated in the CATIA model
- Update model accordingly to design development
- Include realistic termination in the BPMs
- Include the realistic connection to BGC