Transverse impedance of crystal goniometer (v2)

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Acknowledgments:

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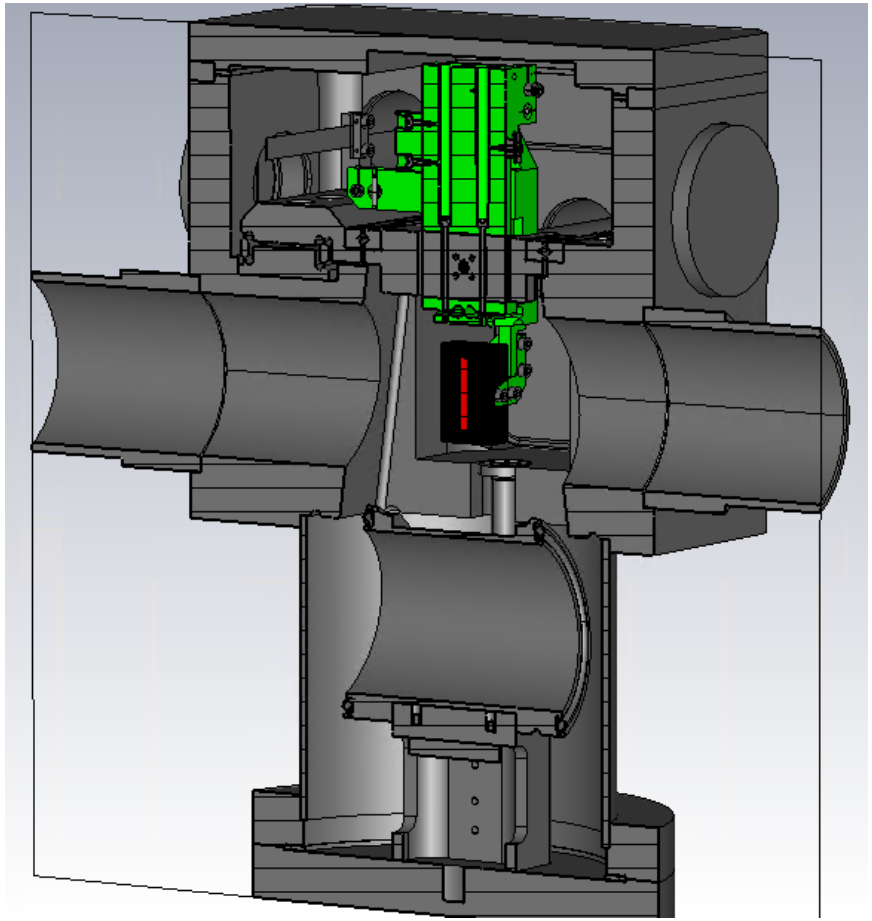
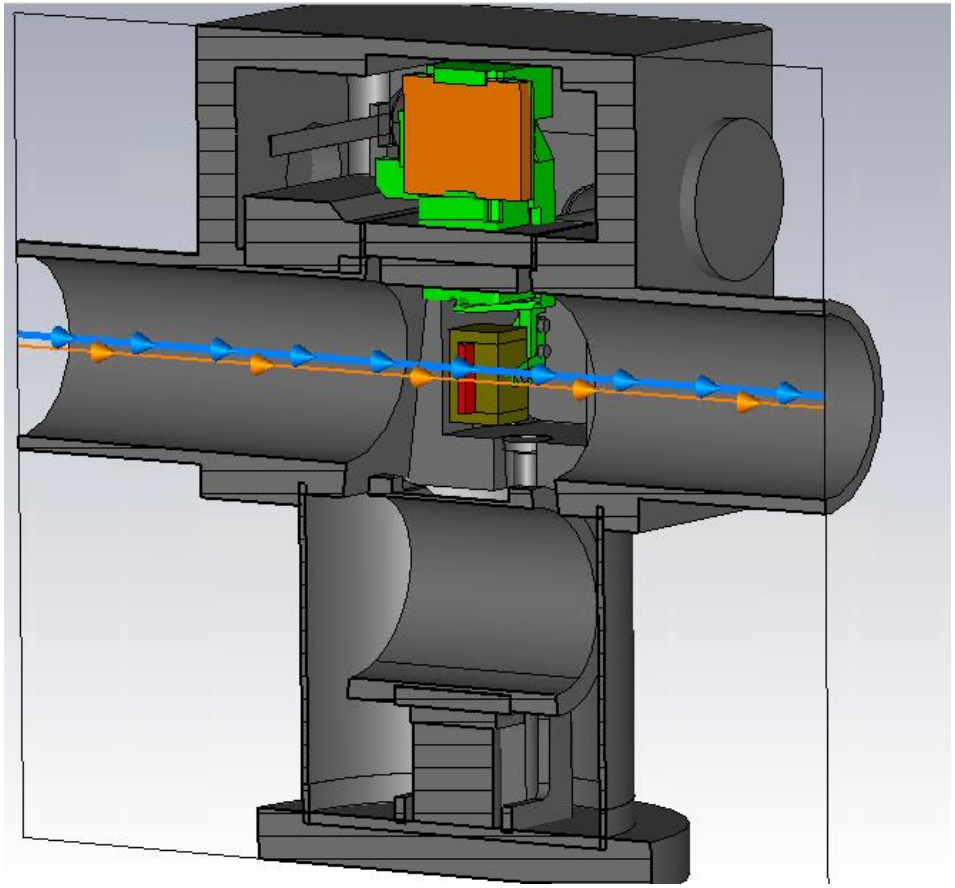
Status



- → Collaboration with University of Sapienza (Rome)
- → Understand and improve the discrepancies between simulations and measurements
- → Danilo performed simulations of longitudinal impedance
- → With the issues of 11T dipoles, crystals are now the baseline of HL-LHC with ions
- → Need a fast approval of the system for Run 3, based on version 2

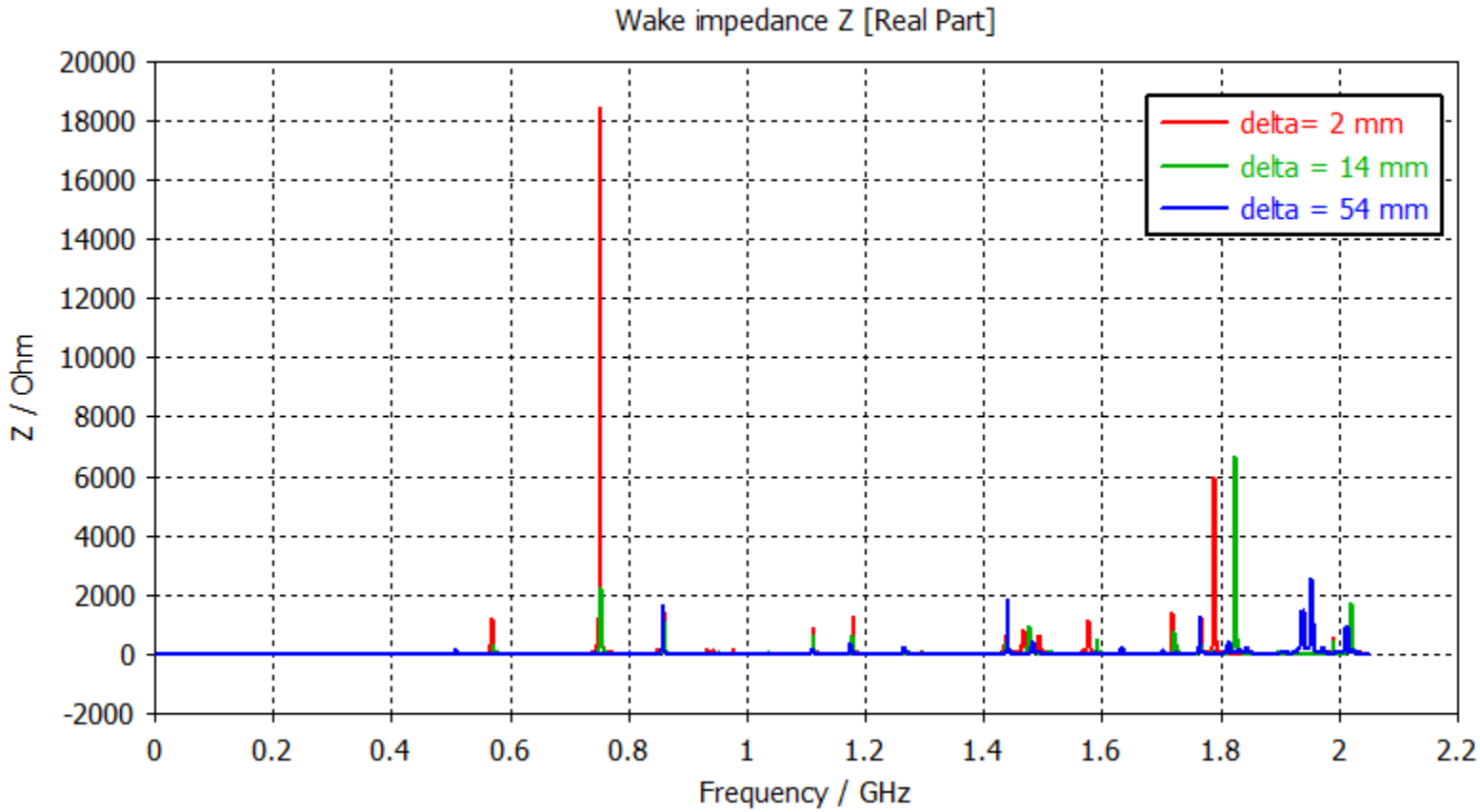
- → Need transverse impedance for ions, and we decided to do it ourselves with high priority

Need to remodel

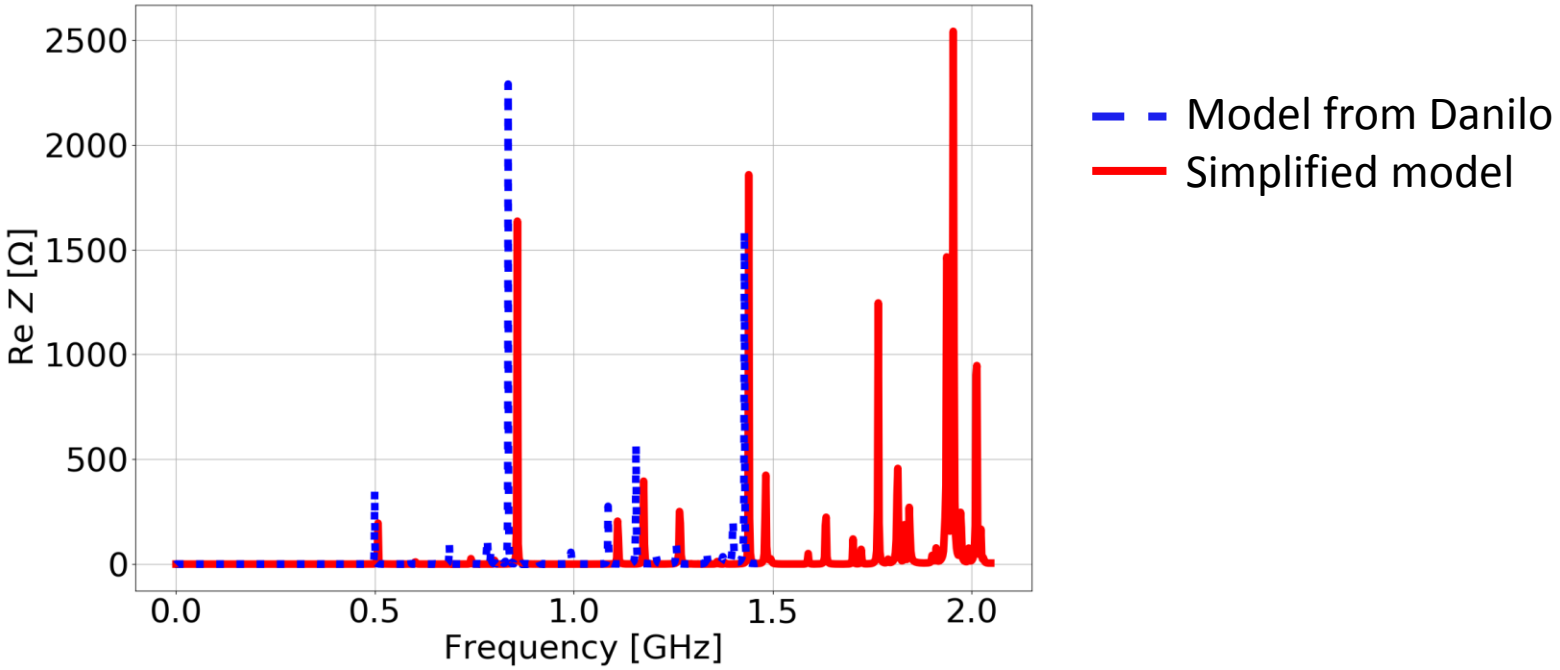


- The model could not be digested correctly by CST
- Required remodeling to remove many unnecessary details and model issues

Longitudinal impedance

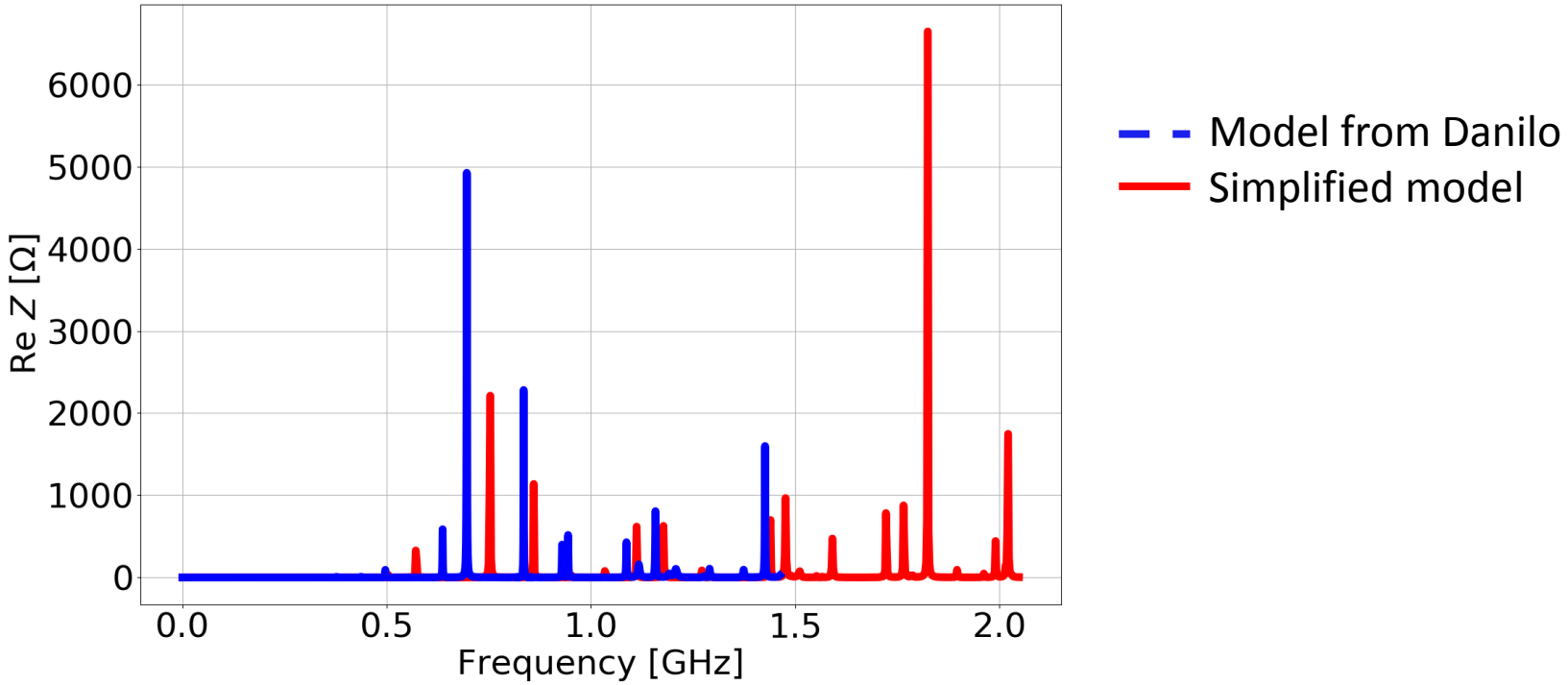


longitudinal impedance (crystal in parking position – 54 mm)



→ Similar impedance spectrum

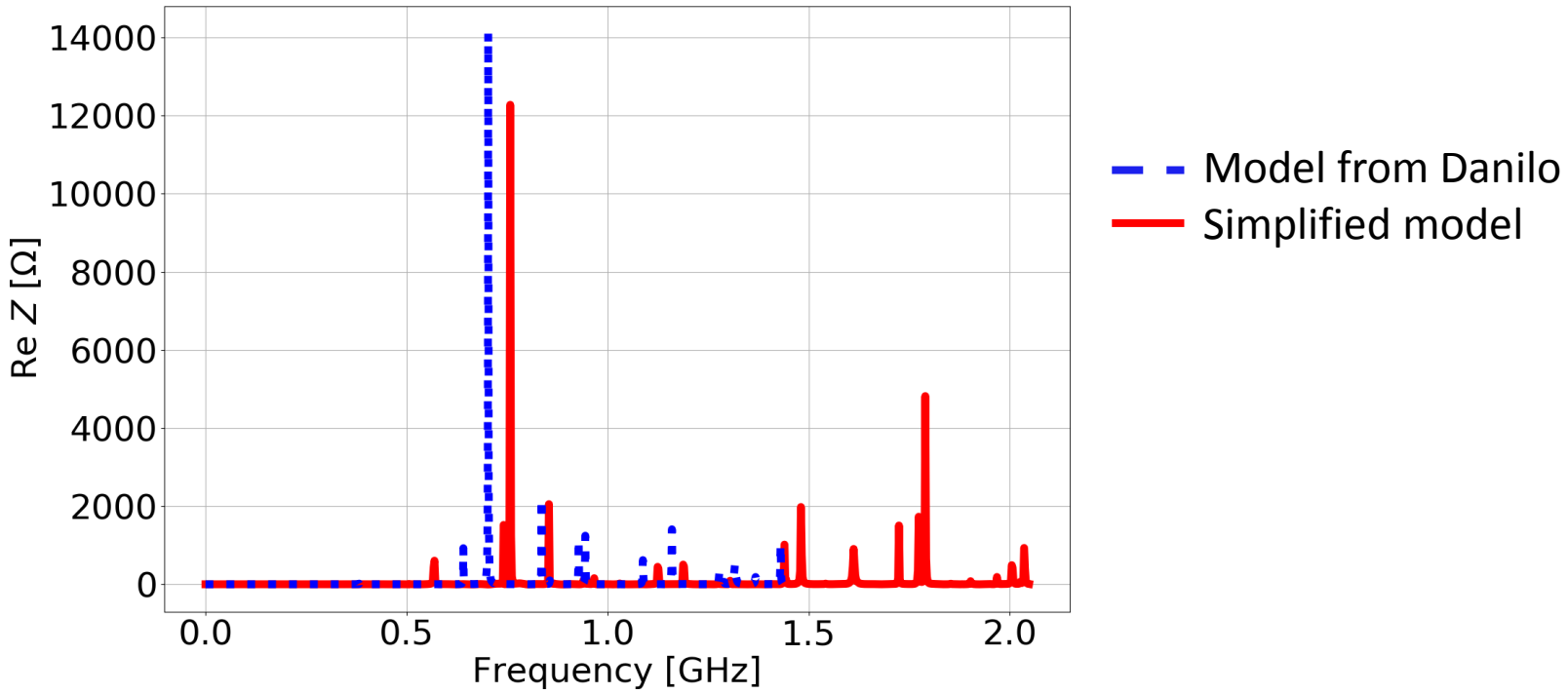
longitudinal impedance (crystal at 14 mm)



→ Impedance spectrum is quite different

→ Same order of magnitude for frequency range and shunt impedance

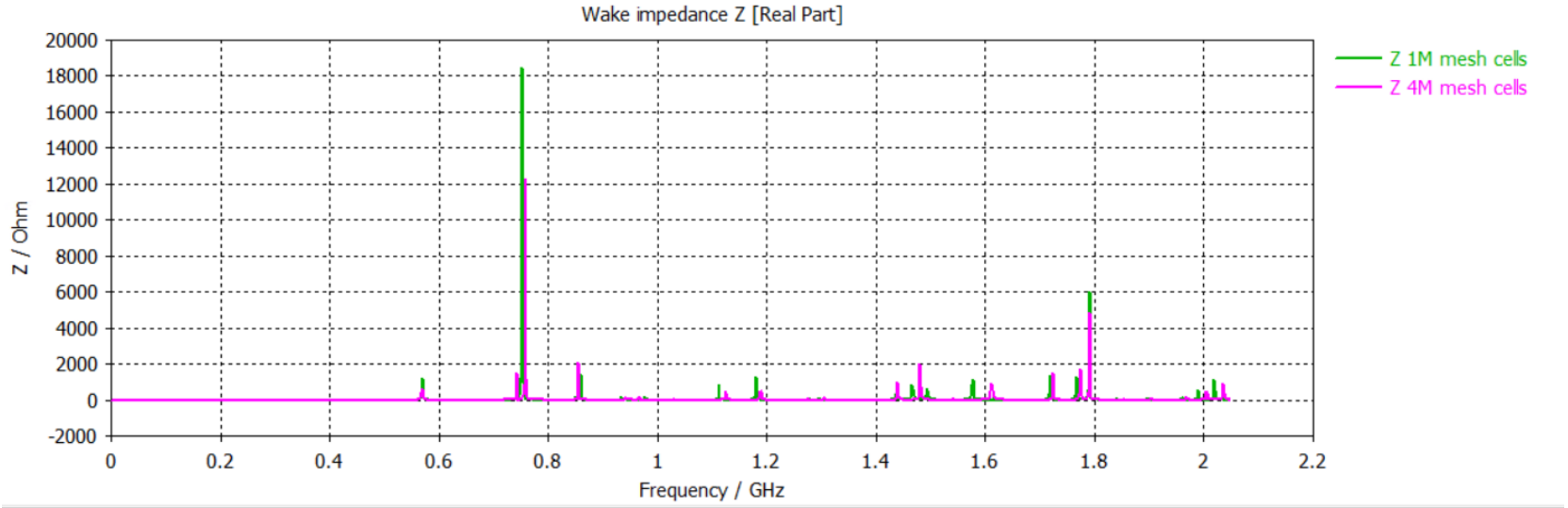
longitudinal impedance (crystal at 2 mm)



→ Impedance spectrum is quite different

→ Same order of magnitude for frequency range and shunt impedance

Increasing mesh cells around the beam



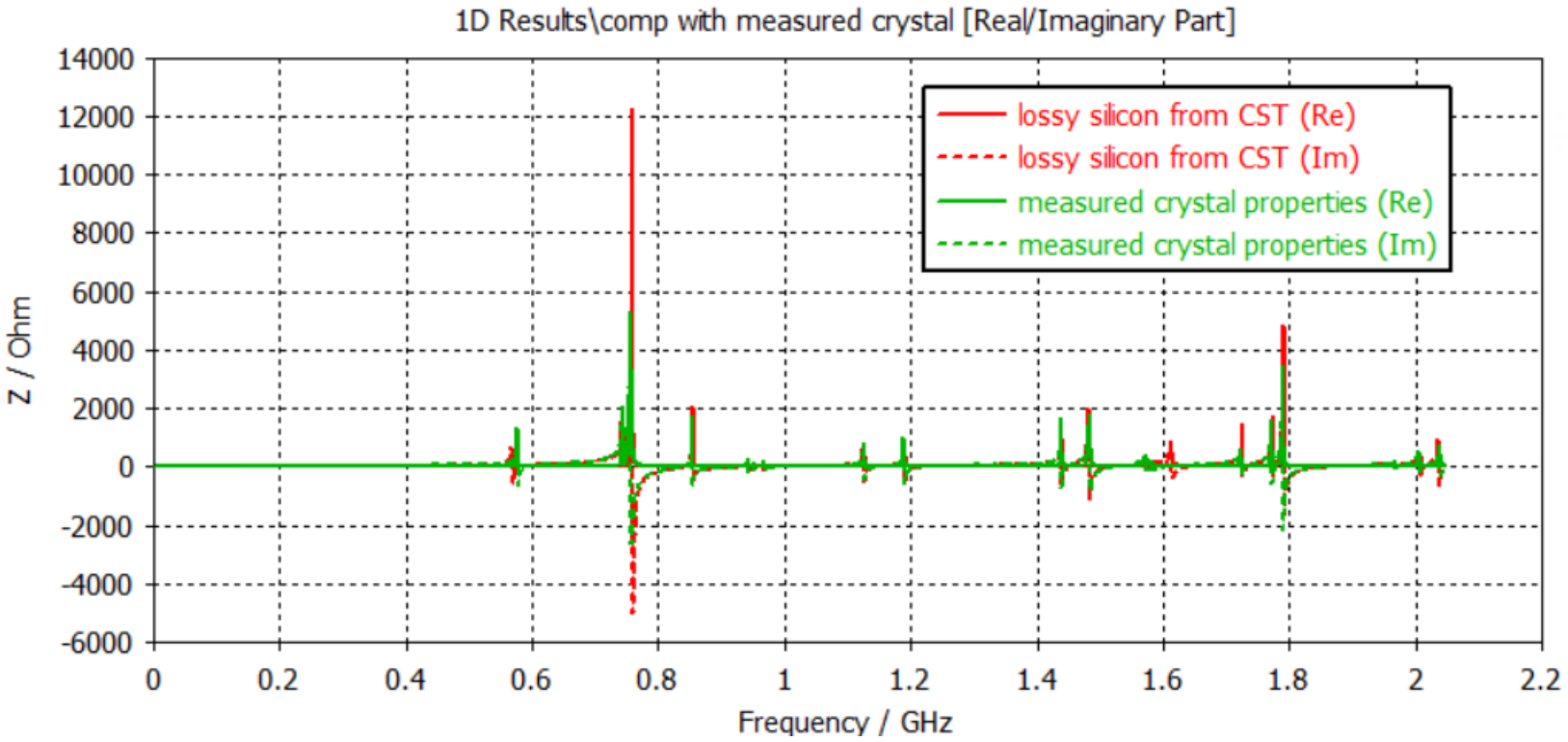
Im(Z/n)~1 mOhm (i.e. ~1% of the total LHC low frequency until 500 MHz) for 1 crystal

→ 1 crystal per plane per beam
→ 2% of total LHC impedance when all crystals fully inserted

Using the crystal properties measured by Danilo and Mauro

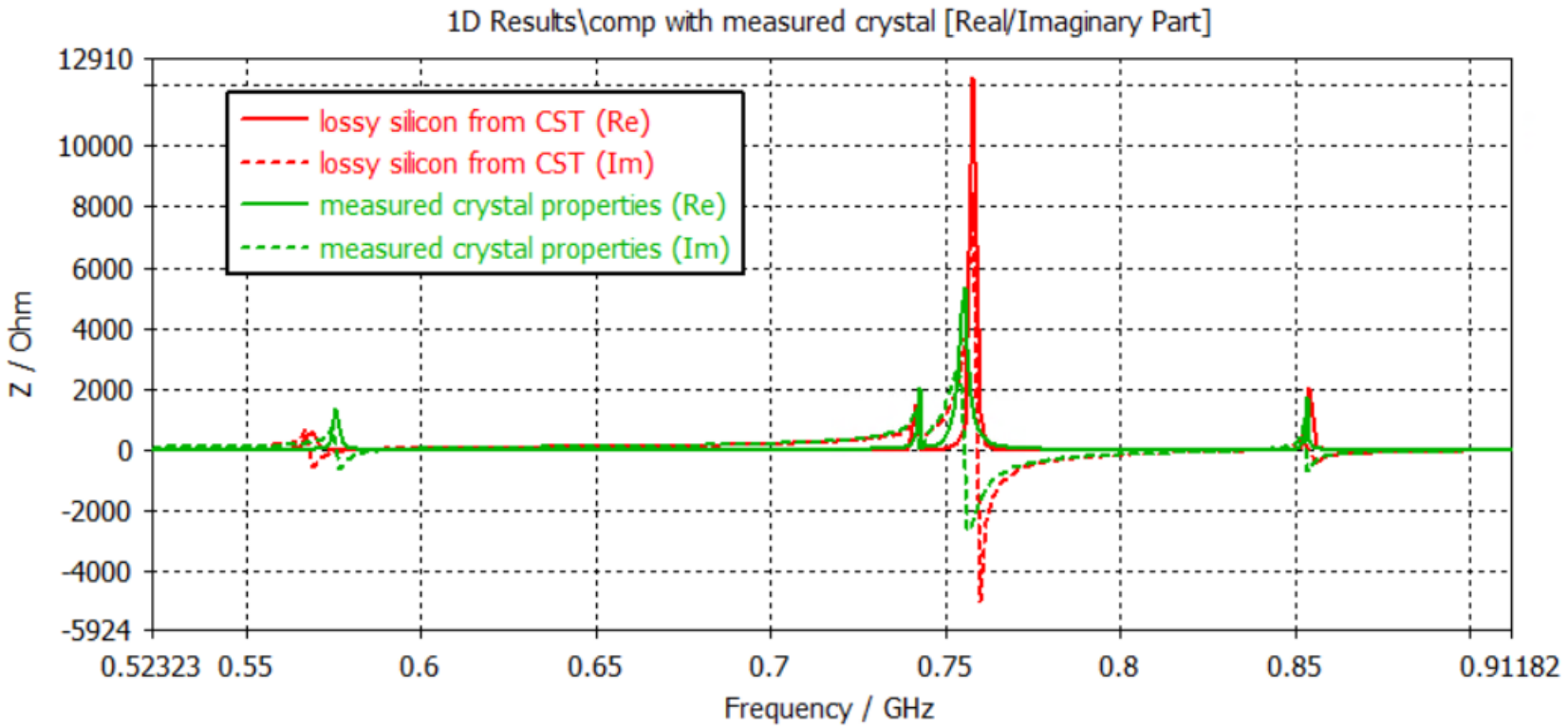
- Measured by cavity perturbation measurements between 2 and 4 GHz
- Significant difference between placing the crystal in one direction or another

Longitudinal imaginary impedance



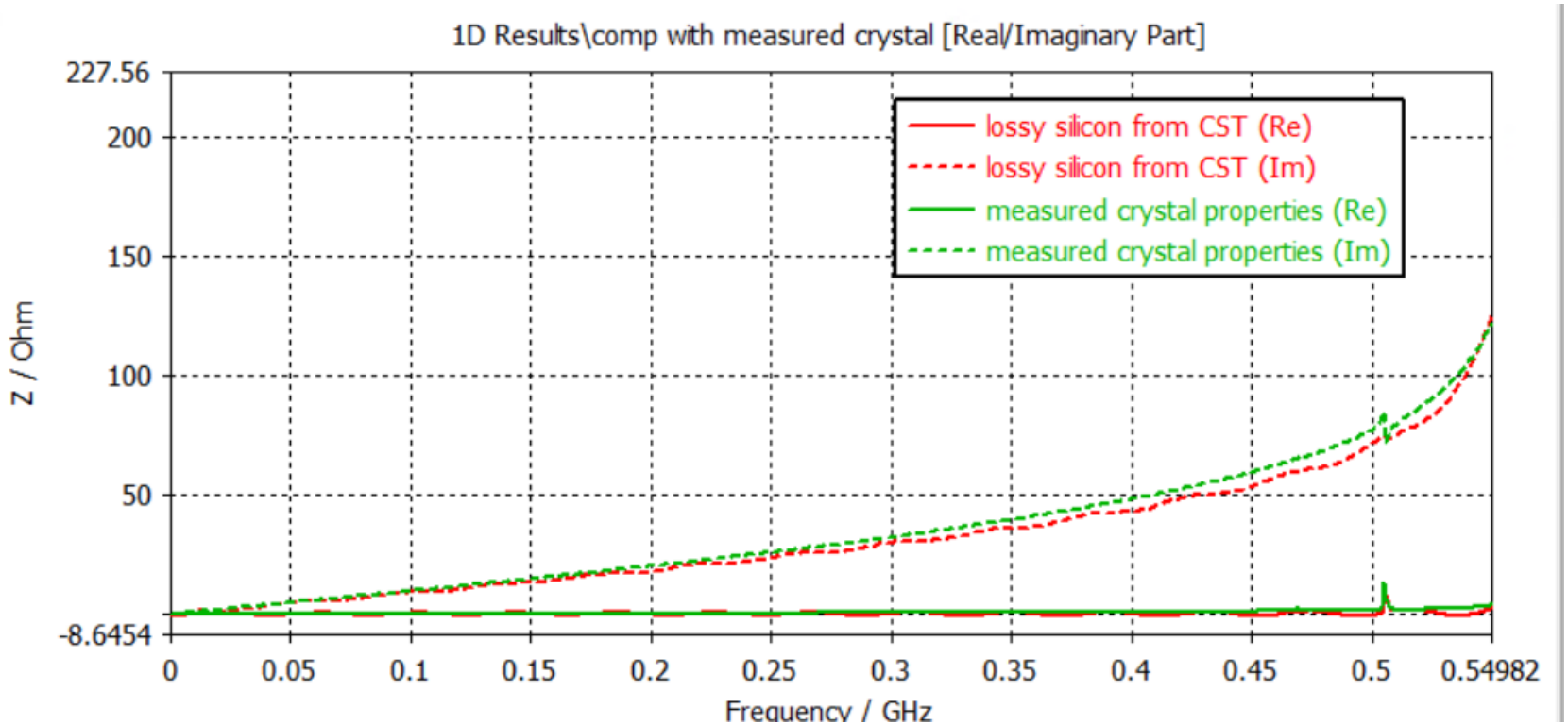
→ More losses on the main crystal mode

Longitudinal imaginary impedance



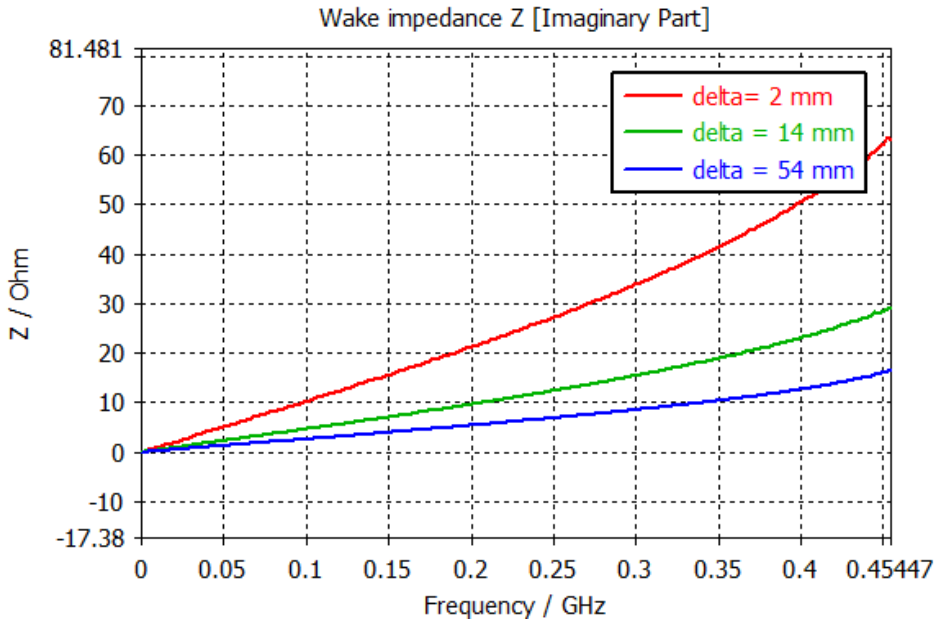
→ Frequency shift of 2.5 MHz and reduction of the crystal mode by a factor 2.4

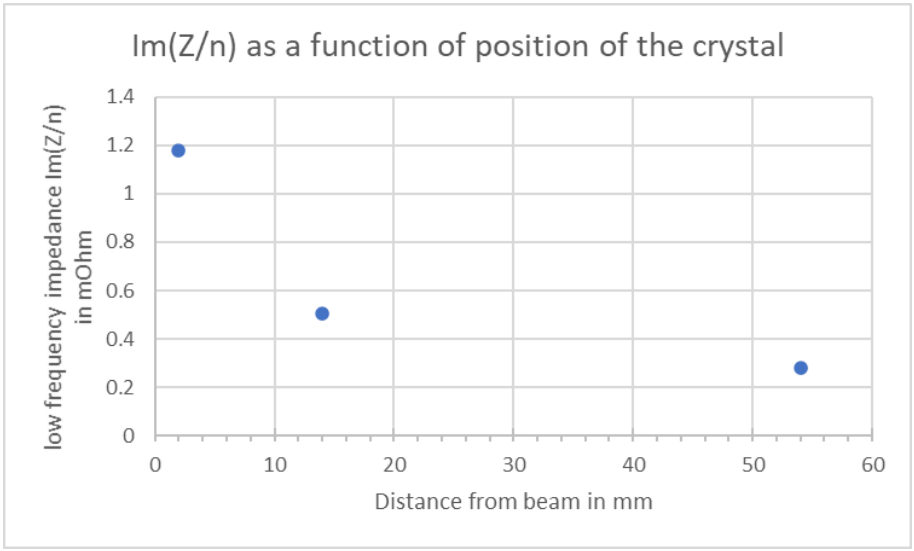
Longitudinal imaginary low frequency impedance



→ No significant change with crystal properties

Longitudinal imaginary low frequency impedance



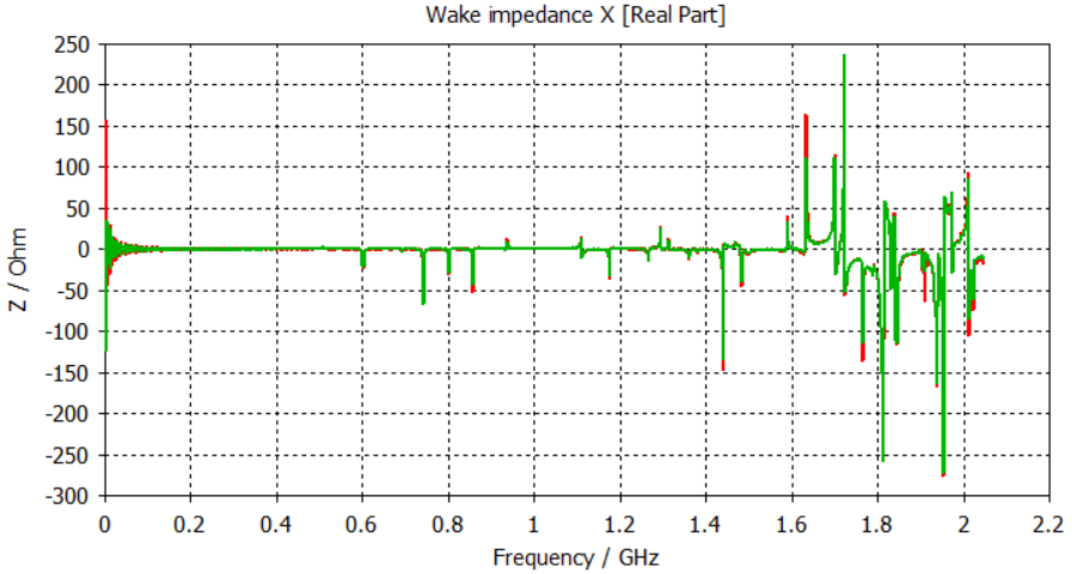


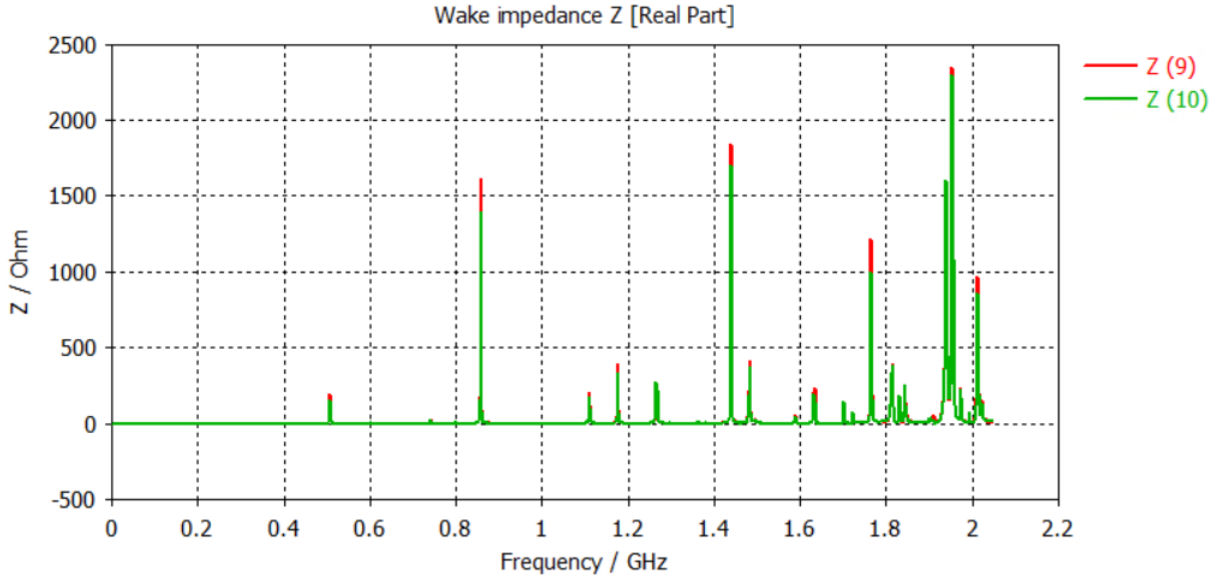
→ Significant contribution of the goniometer to the longitudinal impedance of LHC

→ Contribution divided by 5 when crystal in parking position

Transverse impedance

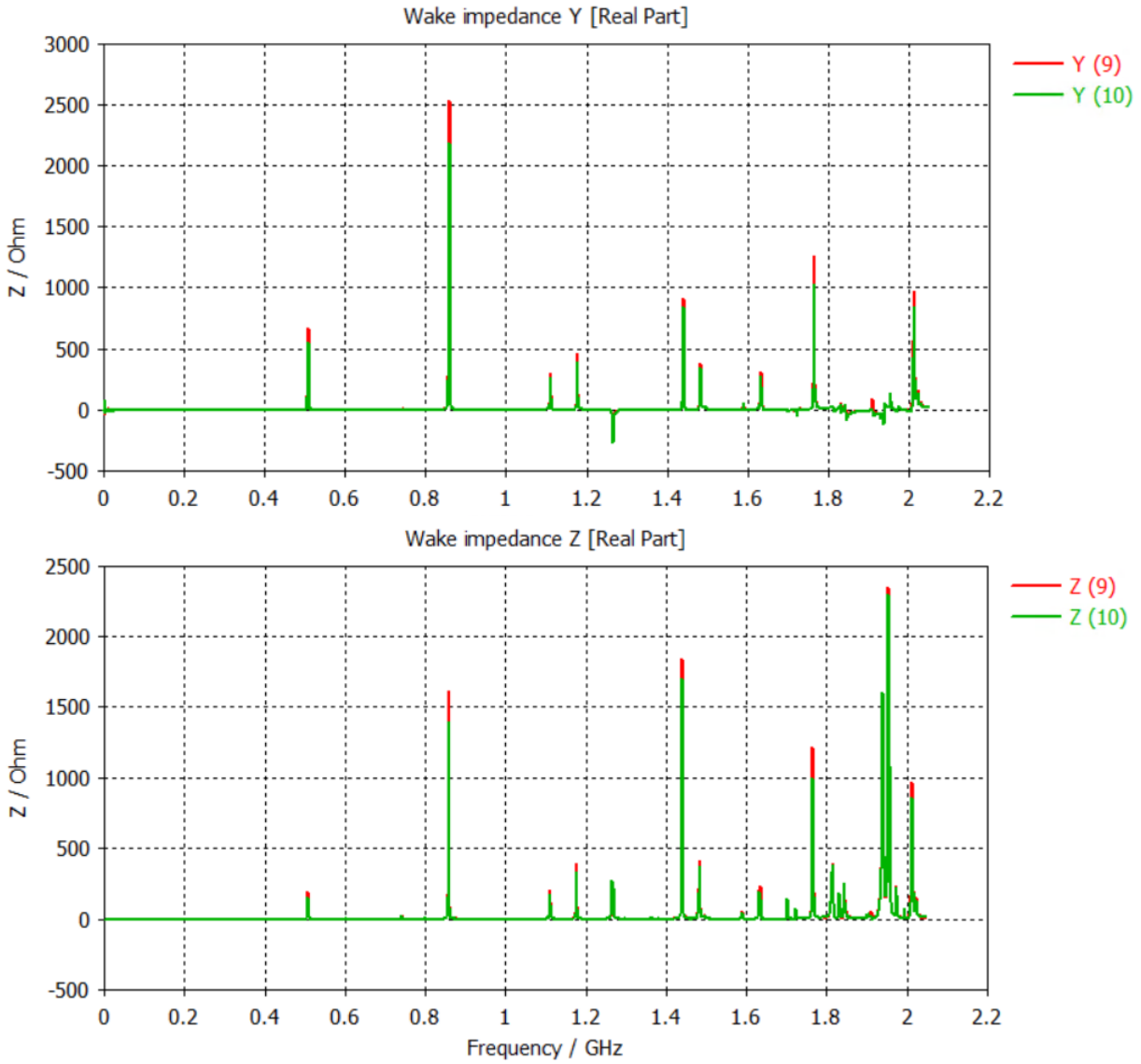
54 mm (parking position): are there transverse modes?





→Several transverse modes below 1 GHz (600 MHz, 800 MHz, 940 MHz), but shunt impedance small compared to large constant term.

Transverse modes?



→ All major vertical modes are already longitudinal modes

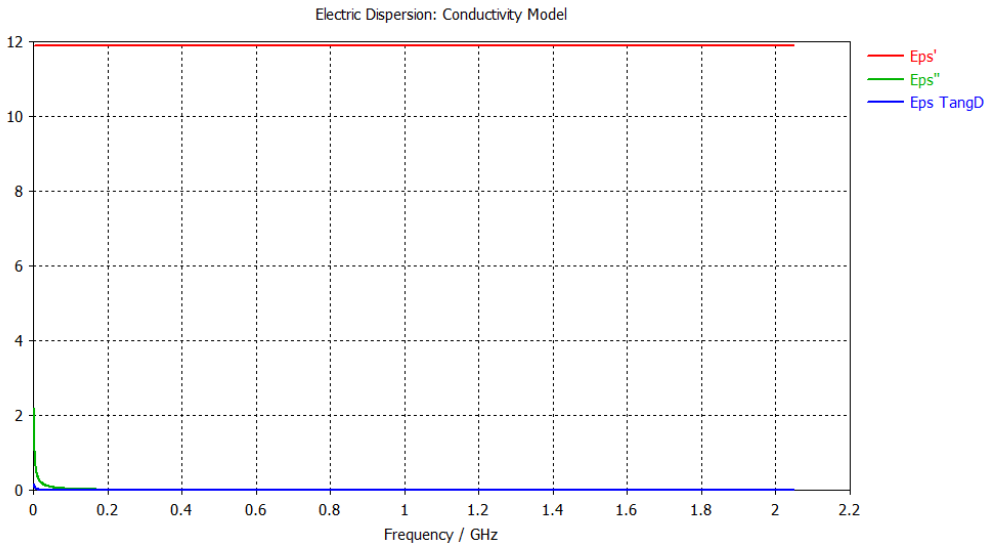
Transverse impedance (very noisy, requires convergence)

- 2 mm
  - → Zx= 15 Ohm/mm = 15 kOhm/m
  - → Zy= 13 Ohm/mm = 13 kOhm/m
- 14 mm
  - → Zx =11 Ohm/5mm= 2 kOhm/m
  - →Zy = 5 Ohm/5mm = 1 kOhm/m
- 54 mm
  - → Zx=5 Ohm/5mm=1 kOhm/mm
  - → Zy= 5 Ohm/5mm=1 kOhm/mm

Next steps

- Longitudinal impedance contribution is significant compared to LHC impedance model (1 mOhm/goniometer)
- Transverse contribution appears less significant for beta functions of IR7, to be confirmed with more simulations
- Parameter sweep ongoing for transverse impedance with measured crystal parameters
- Simulations with Eigenmode solver are now feasible with simplified geometry
- Could we get an assessment of the crystal parameters closer to the frequency range of interest?

Silicon lossy
(CST default model)



Silicon fit from
measured data