STATUS OF BELLOWS AND FLANGES IMPEDANCE STUDIES

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FUTURE CIRCULAR COLLIDER

FCC Week 2021: FCC-ee impedance & collective effects

CERN

STVDIVM VRBIS

OVERVIEW

- Introduction
- Wakefield and impedance from simulations
- Qualitative study
- Conclusions and future steps

MOTIVATION

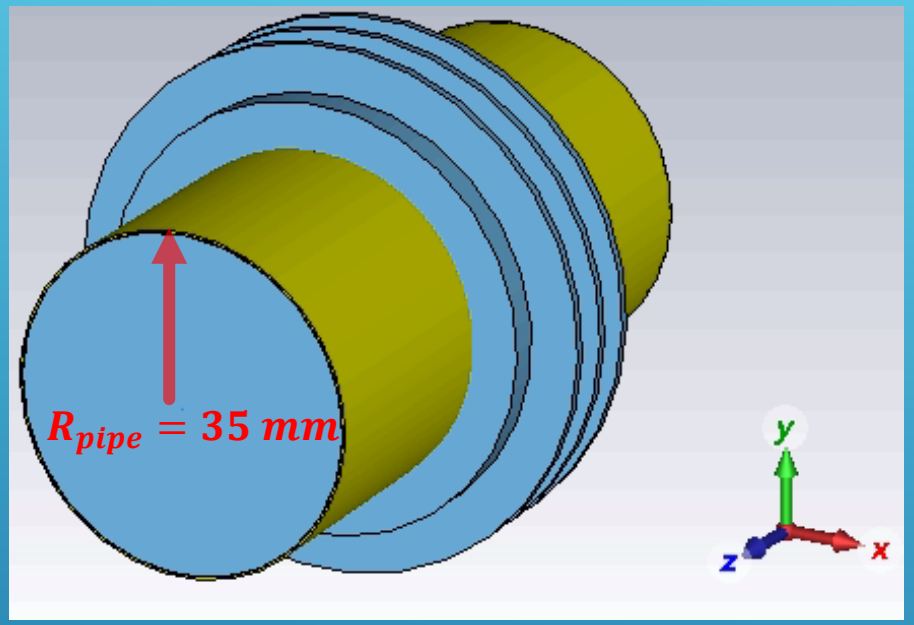
- The bellows are one of the major impedance sources among the accelerator machine → An accurate evaluation is needed.

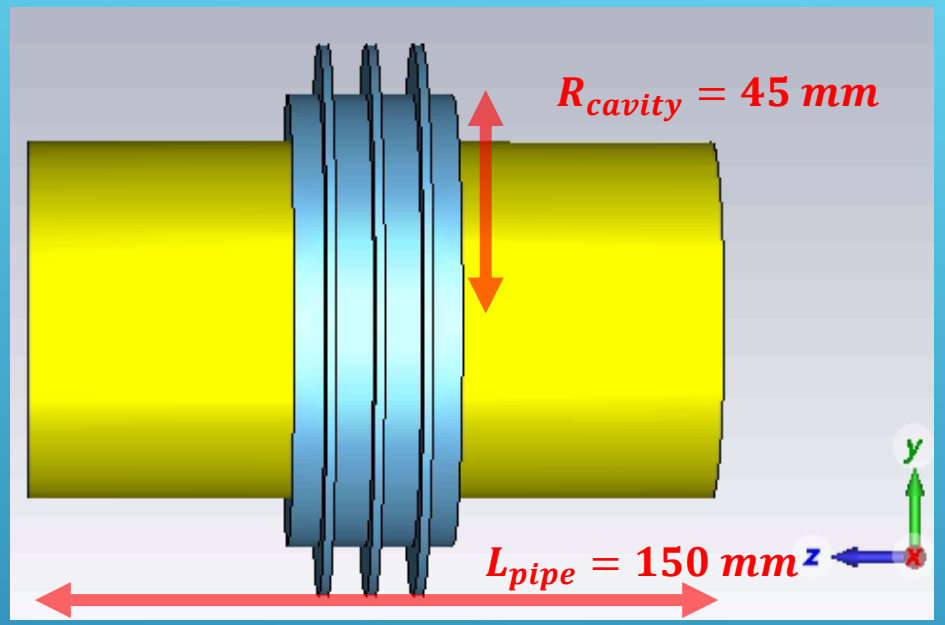
- The inclusion of vacuum flanges is another important contribution to consider in the framework of an impedance budget.

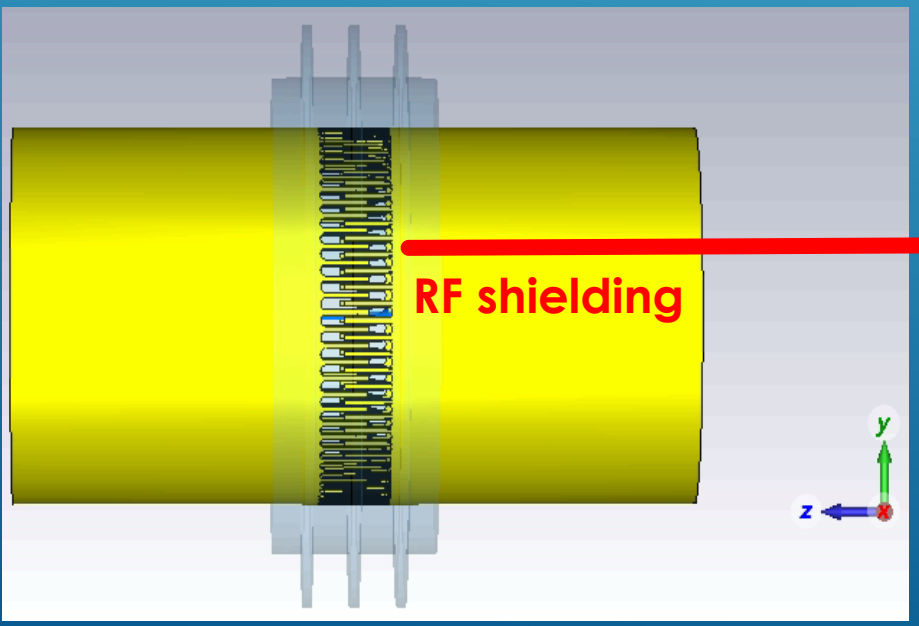
STEP BY STEP APPROACH

Simple bellow model with circular vacuum chamber → Bellow model with a realistic vacuum chamber → Bellow model with vacuum flanges

3D SIMPLE BELLOW MODEL







Similar to those of the SuperKEKB!

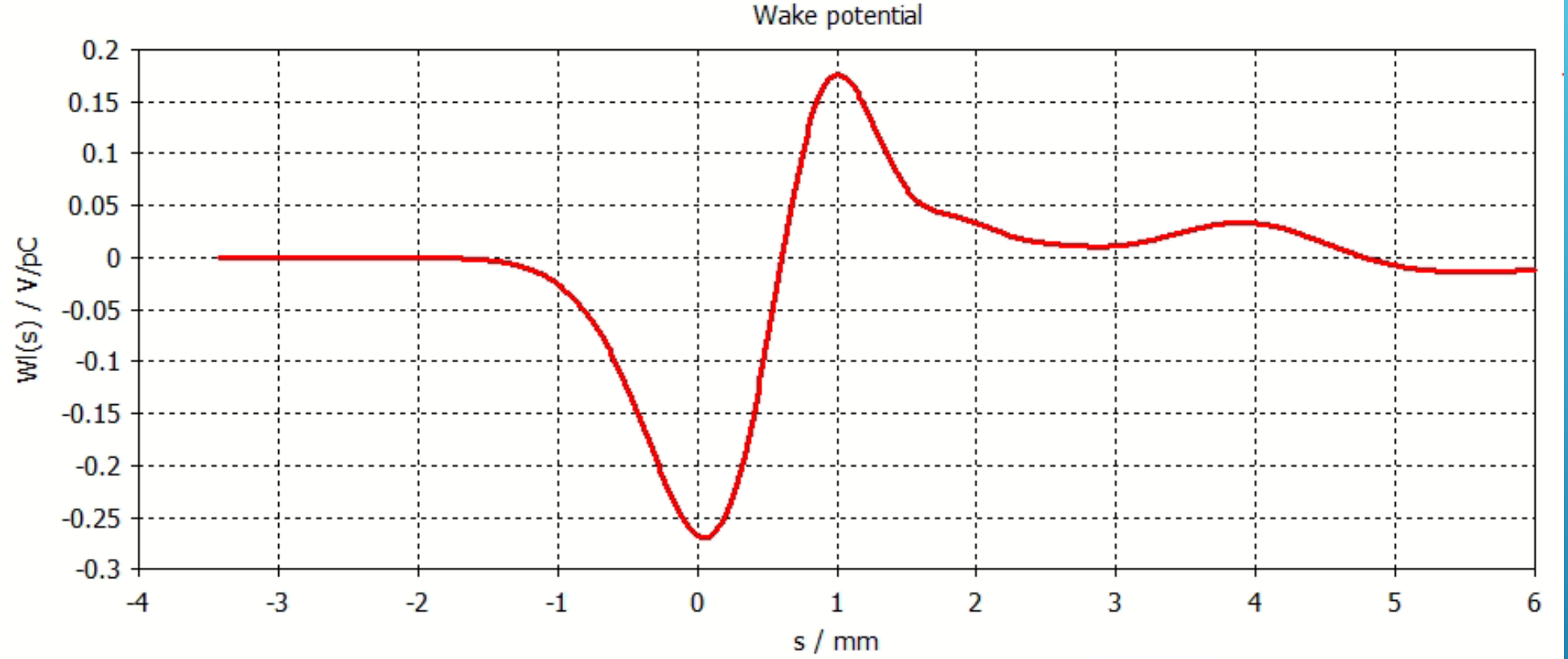
Teeth length: $L = 10\ mm$

Teeth width: W= $1\ mm$

Radial thickness: R = $0.5\ mm$

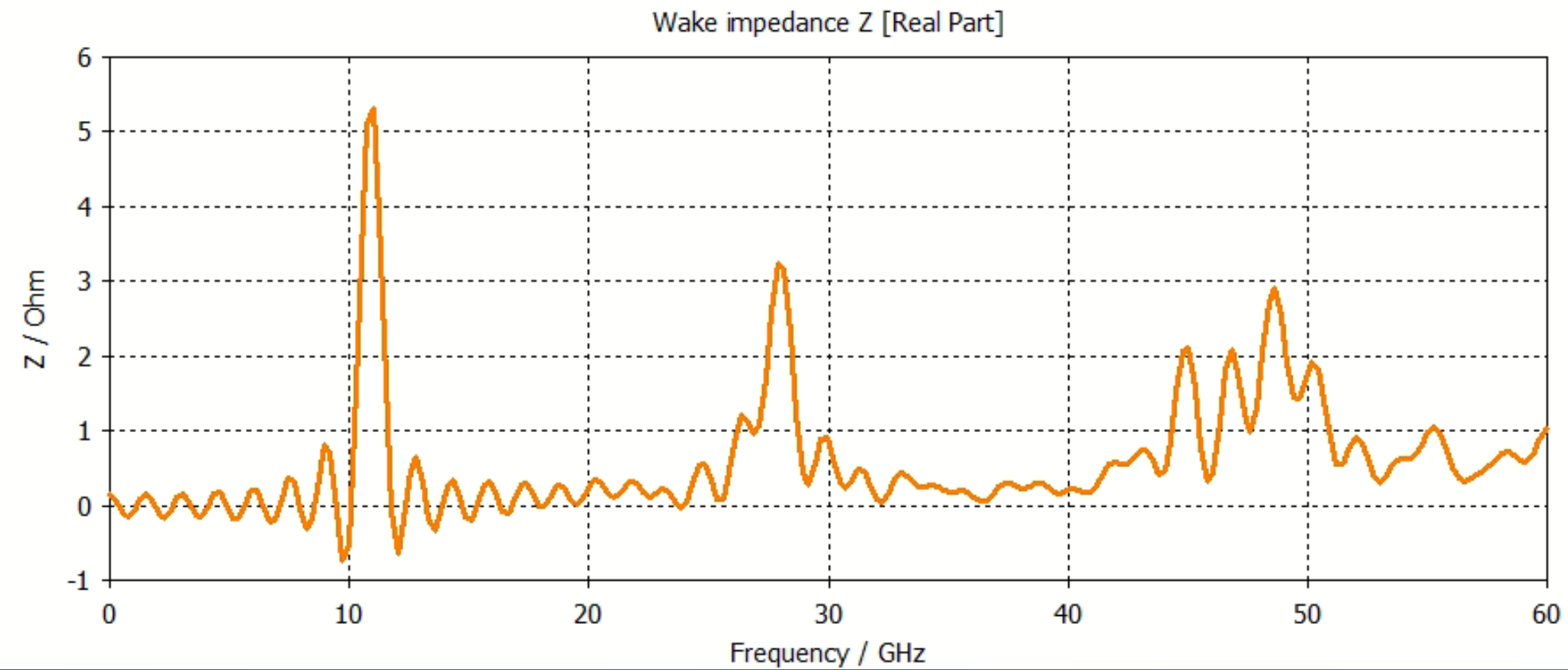
PRELIMINARY RESULTS OF WAKE AND IMPEDANCE FROM SIMULATIONS

LONGITUDINAL WAKE POTENTIAL FROM CST SIMULATION



- **Bunch length :** $\sigma_z = 0.4\,mm$
- **Wake length:** $WL = 200\,mm$

LONGITUDINAL IMPEDANCE FROM CST SIMULATION



- **Bunch length :** $\sigma_z = 0.4\,mm$
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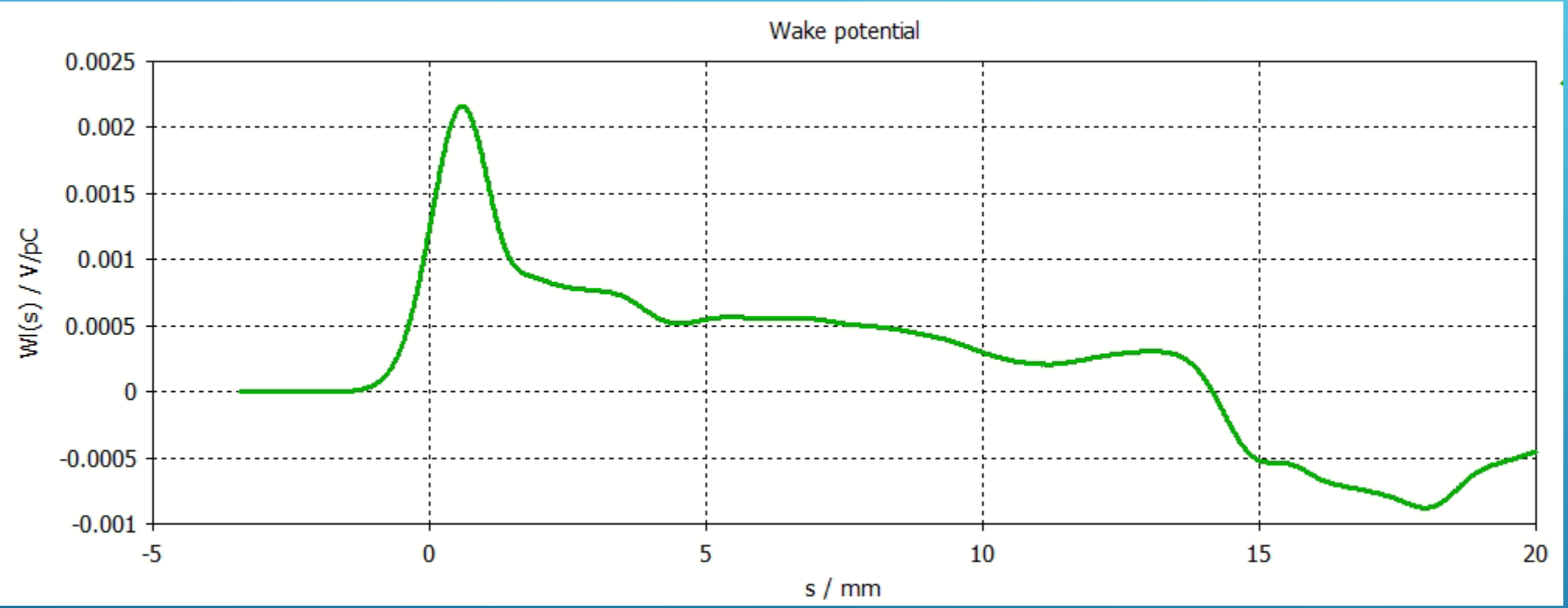
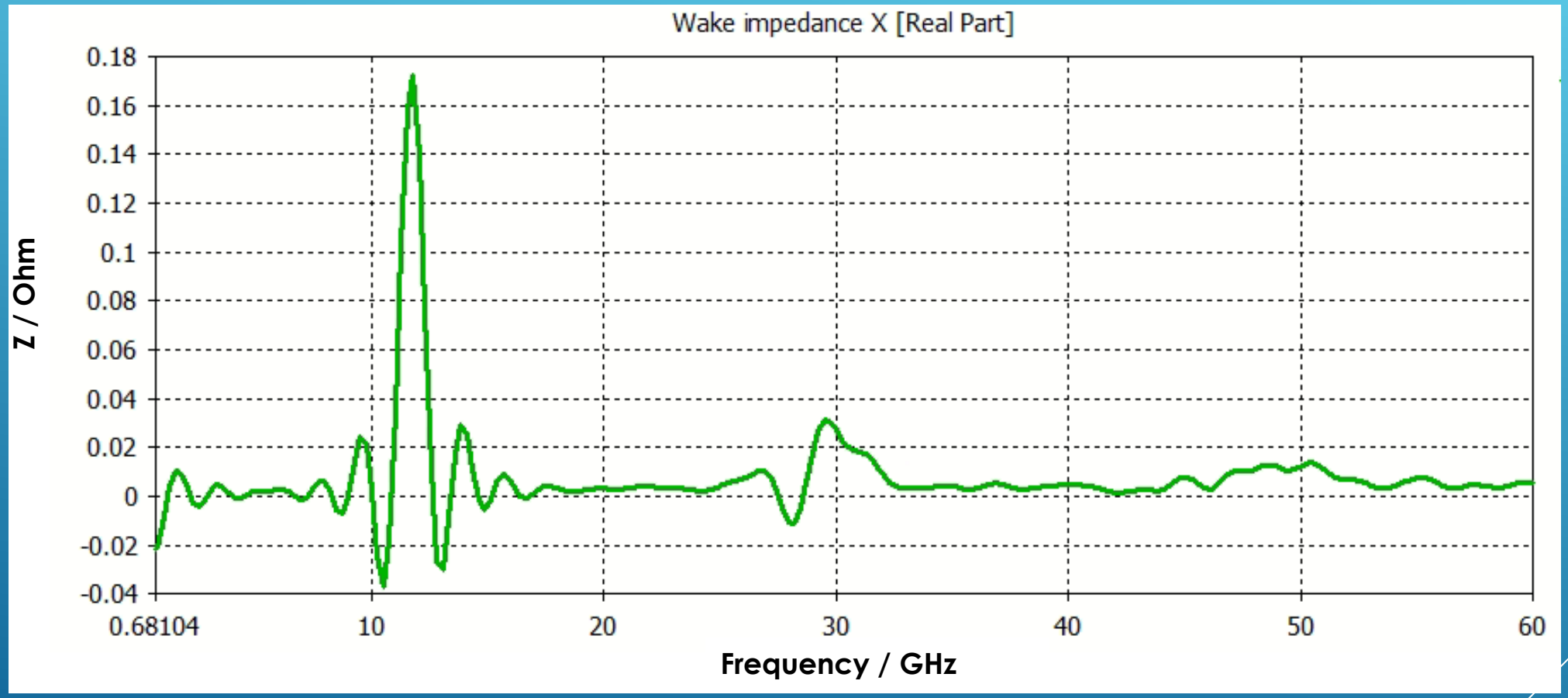
TRANSVERSE WAKE POTENTIAL FROM CST SIMULATION



- **Bunch length :** $\sigma_z = 0.4\ mm$
- **Wake length:** $WL = 200\ mm$
- **X offset:** $5\ mm$

- The transverse kick is obtained by displacing only the beam transverse location because the detuning term is zero.

TRANSVERSE IMPEDANCE FROM CST SIMULATION

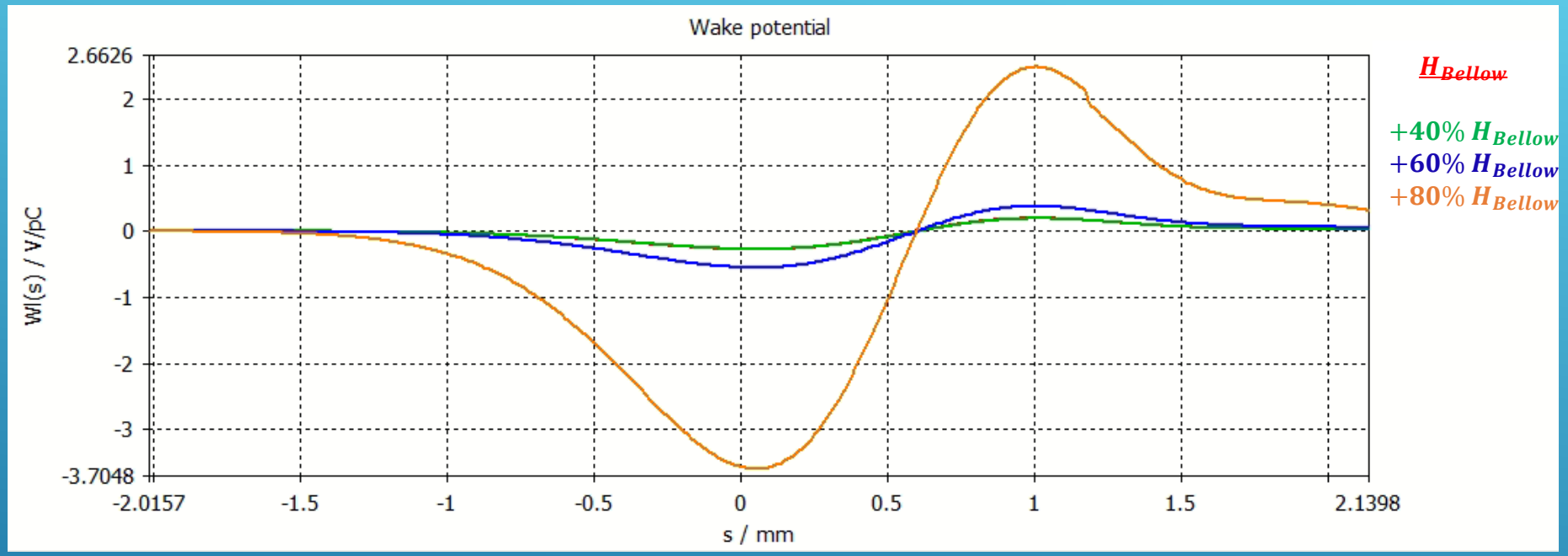


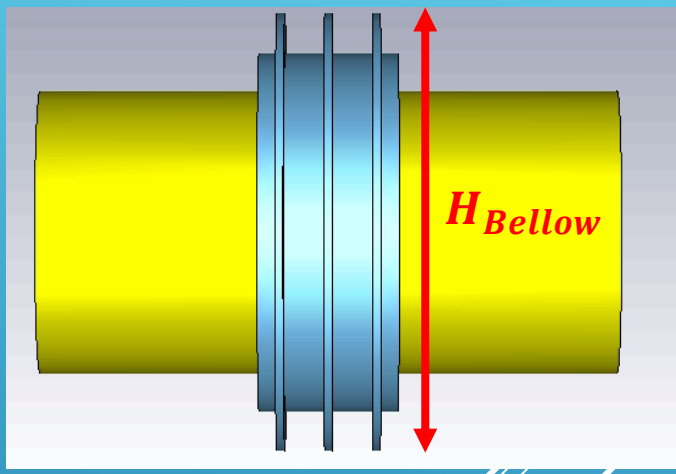
- **Bunch length :** $\sigma_z = 0.4\ mm$
- **Wake length:** $WL = 200\ mm$
- **X offset:** $5\ mm$

- For an axisymmetric structure there is no difference between the horizontal and vertical plane.

TESTS ON LONGITUDINAL WAKE

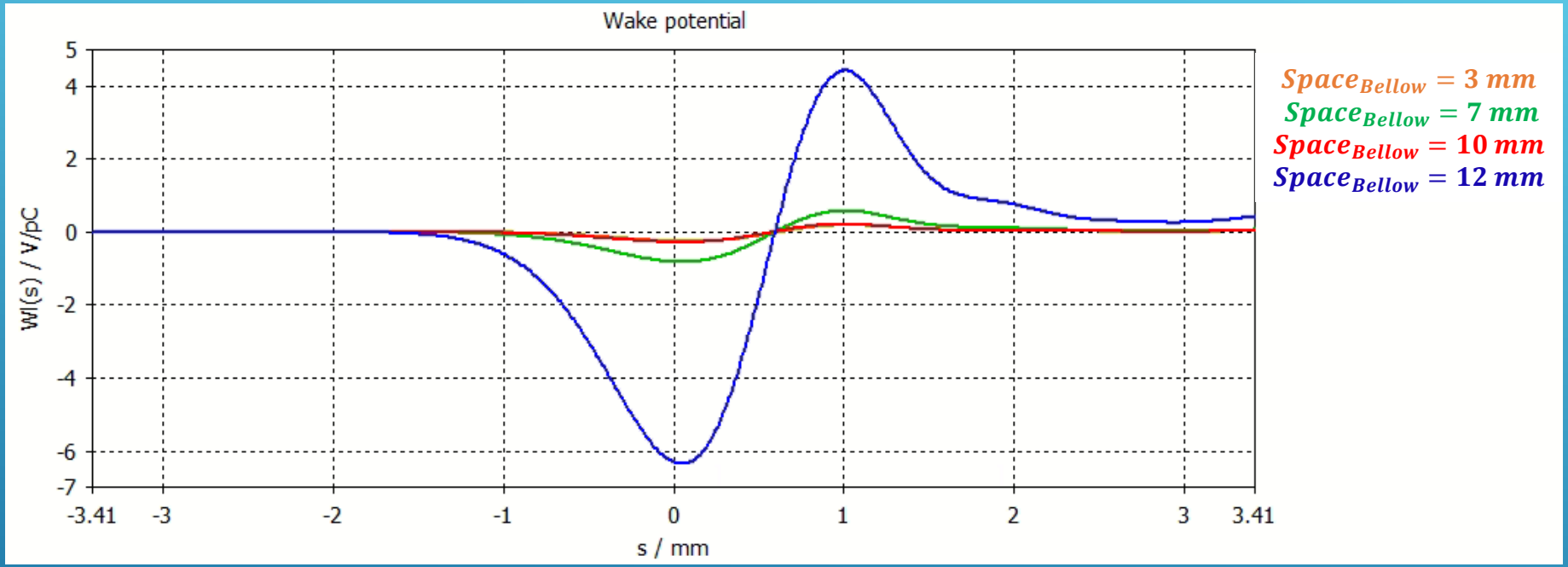
LONGITUDINAL WAKE POTENTIAL FOR DIFFERENT H_{Bellow}

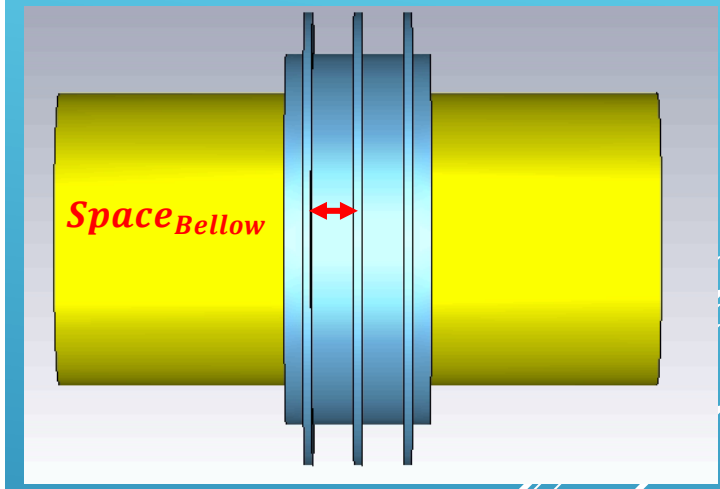




- The short range wake potential is affected by the height of the bellow

WAKE POTENTIAL FOR DIFFERENT $Space_{Bellow}$

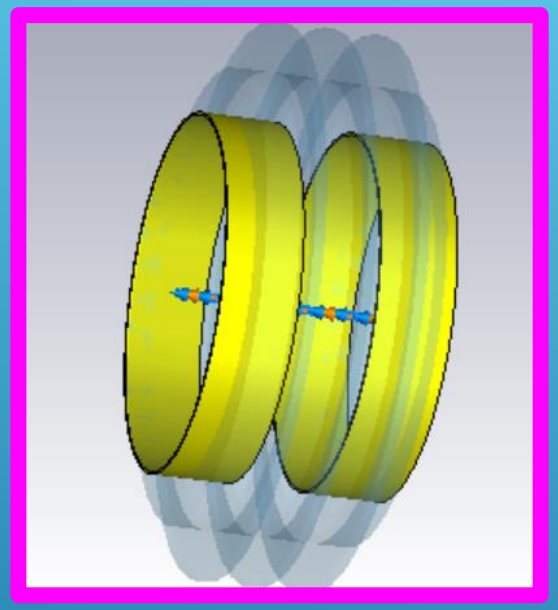


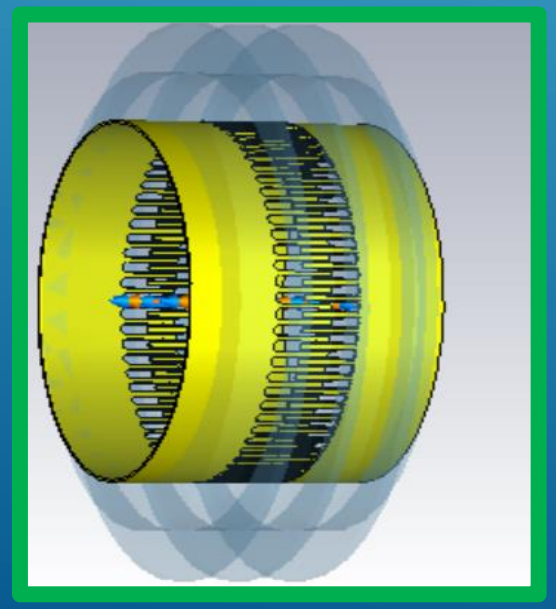


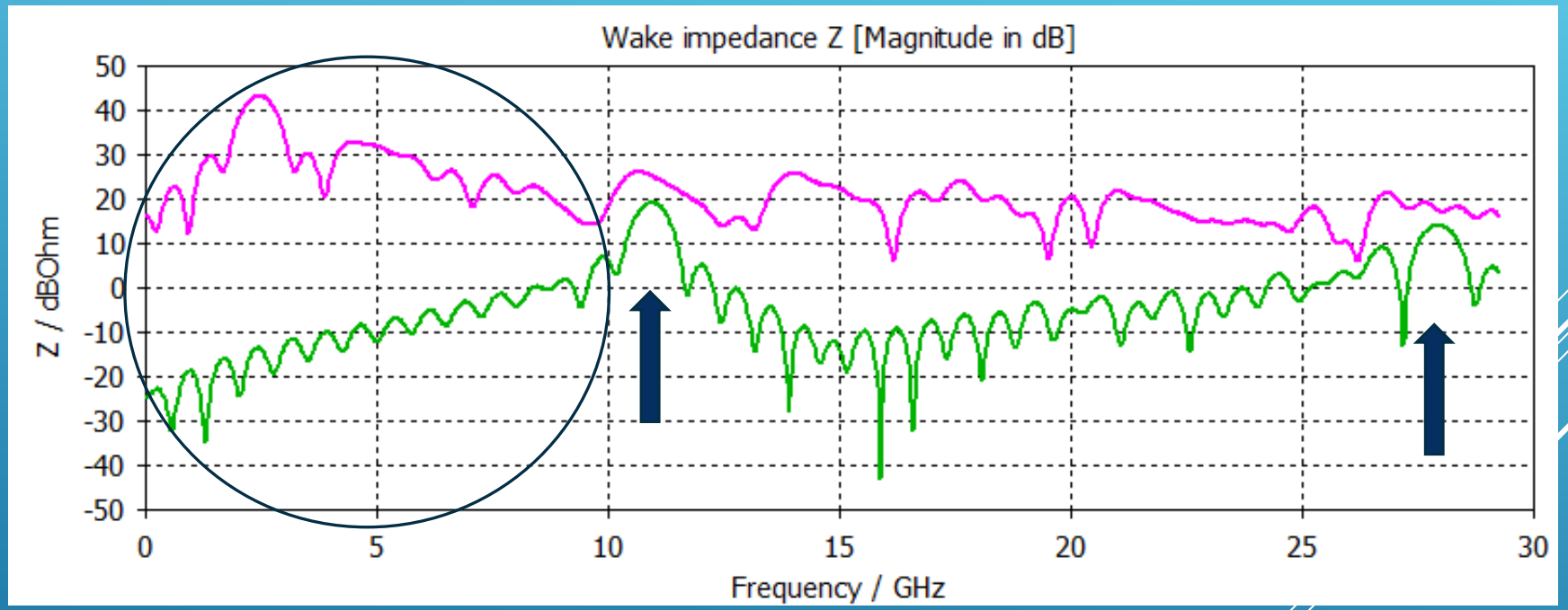
- The short range Wake Potential is affected by the space between the convolutions.

QUALITATIVE STUDY

QUALITATIVE STUDY: EFFECTS OF THE SHIELDING

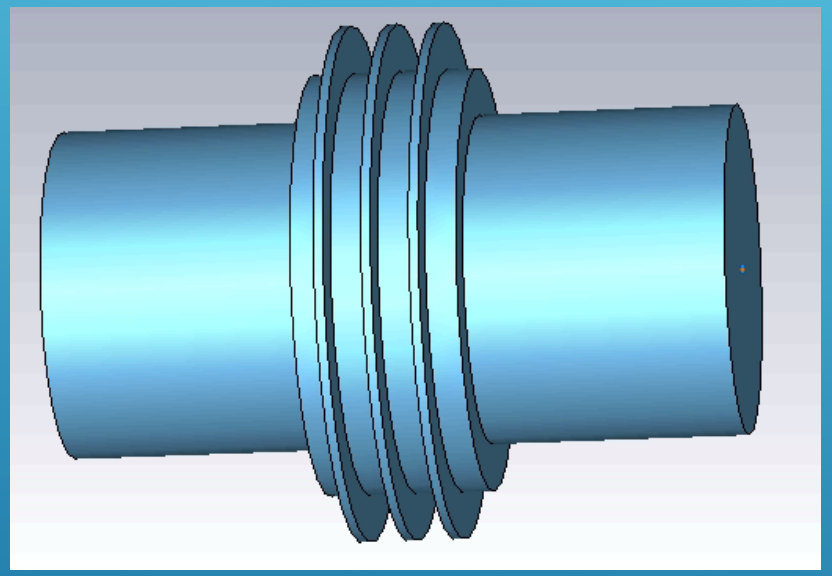






- The low frequency resonances due to the bellows are attenuated by the shileding
- The resonances in the impedace behaviour are probably related to the coupling between the pipe and the cavity

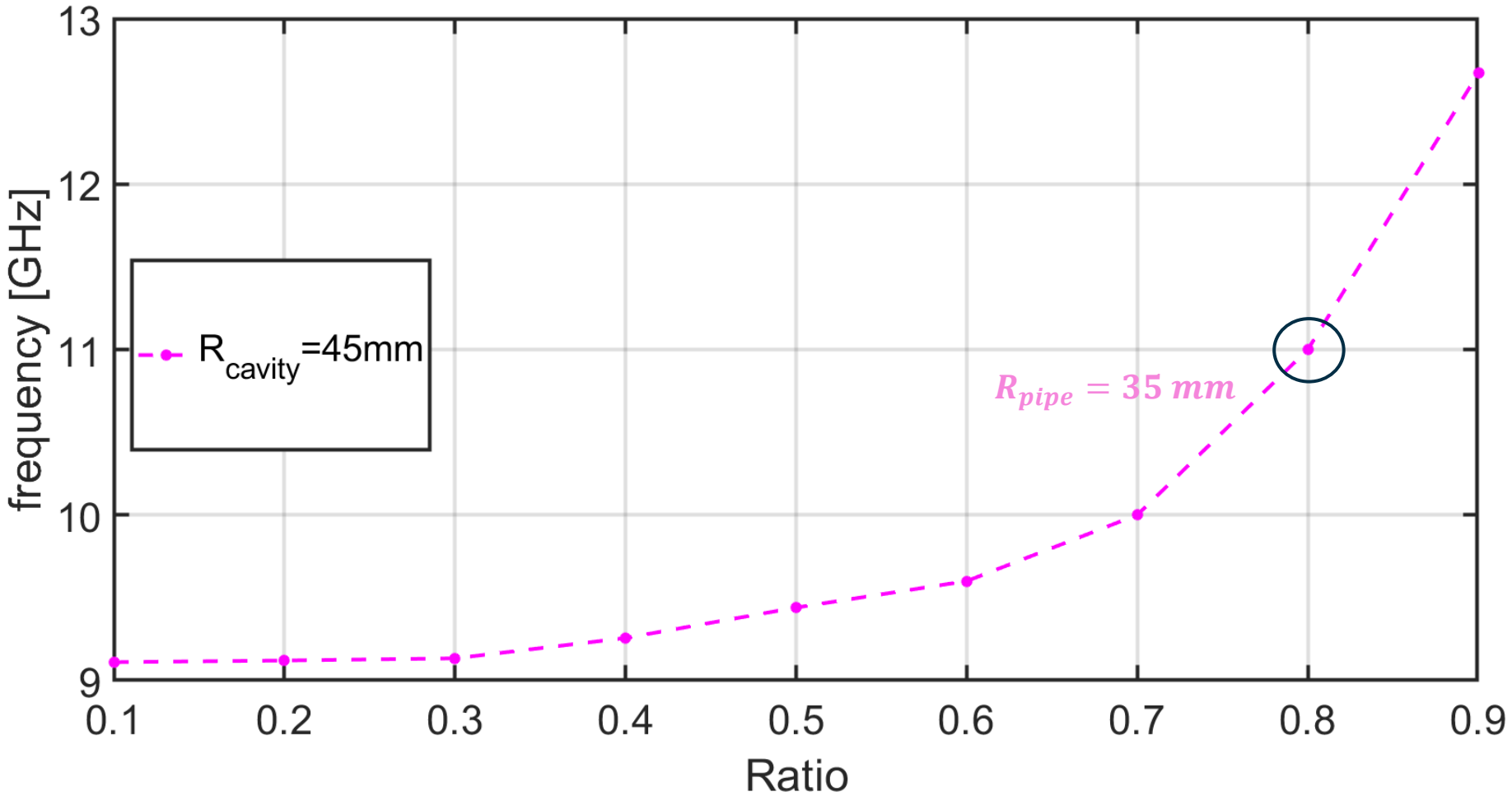
QUALITATIVE STUDY: A SIMPLIFIED MODEL



- Several tests have been carried out on the main geometric parameters of the model to understand the source of the resonances
- The most significant shift in frequency of the resonances occurs when the $Ratio = \frac{R_{pipe}}{R_{Cavity}}$ varies.

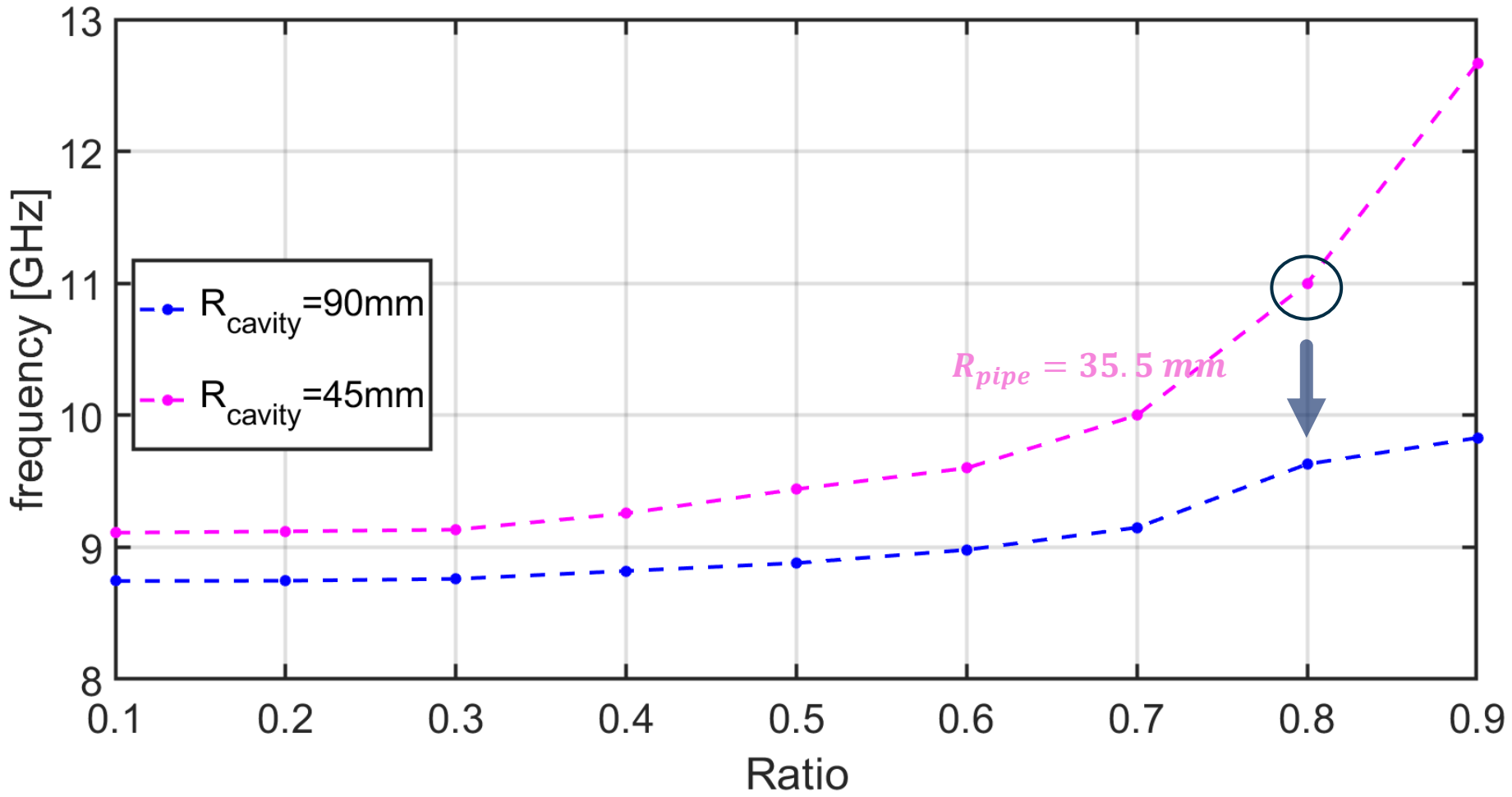
FREQUENCY SHIFT OF THE FIRST MODE AS A FUNCTION OF RATIO

$$Ratio = \frac{R_{pipe}}{R_{Cavity}}$$



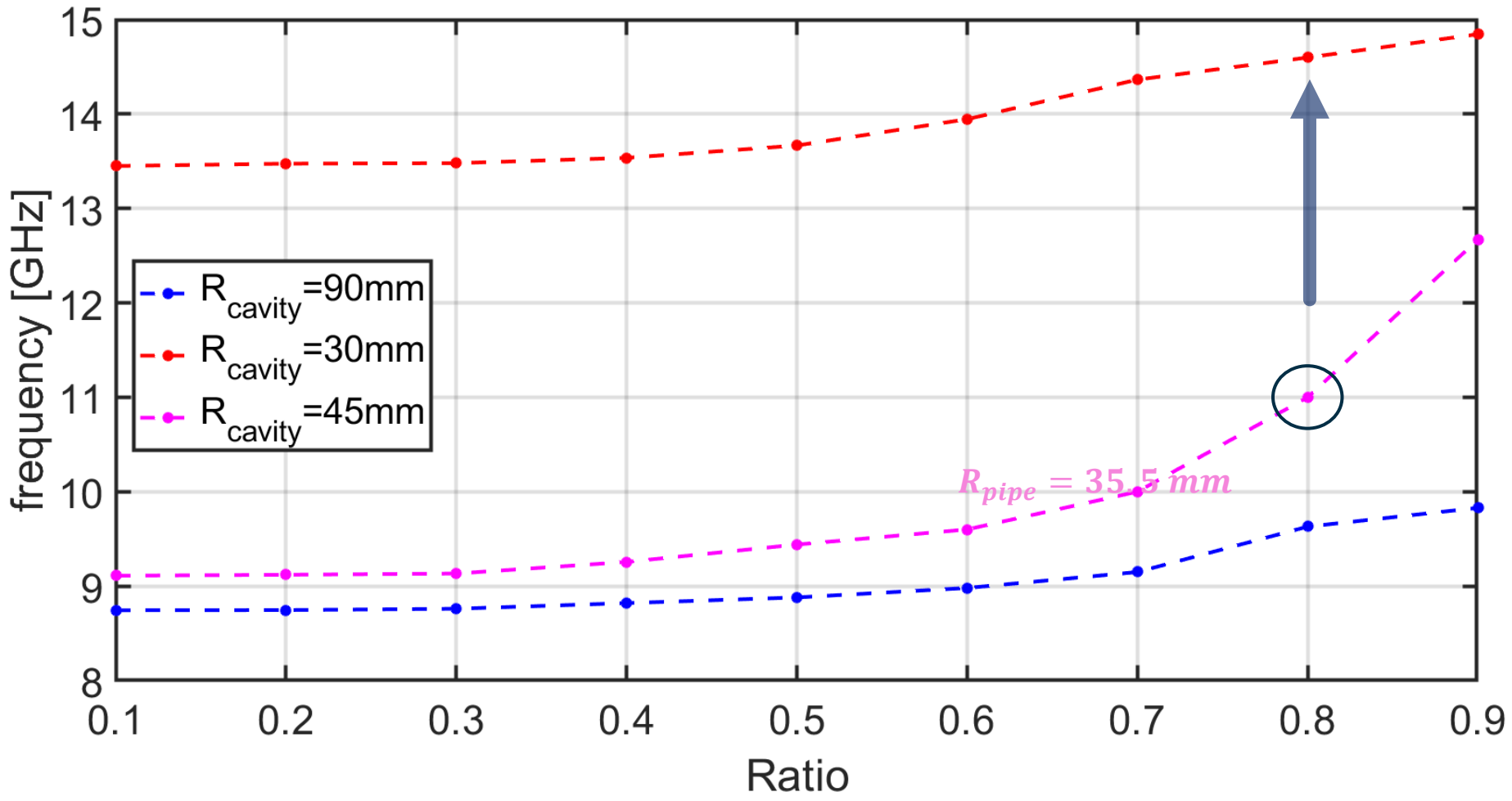
- When Ratio=1 the mode vanishes

FREQUENCY SHIFT AS A FUNCTION OF RATIO



$$Ratio = \frac{R_{pipe}}{R_{Cavity}}$$

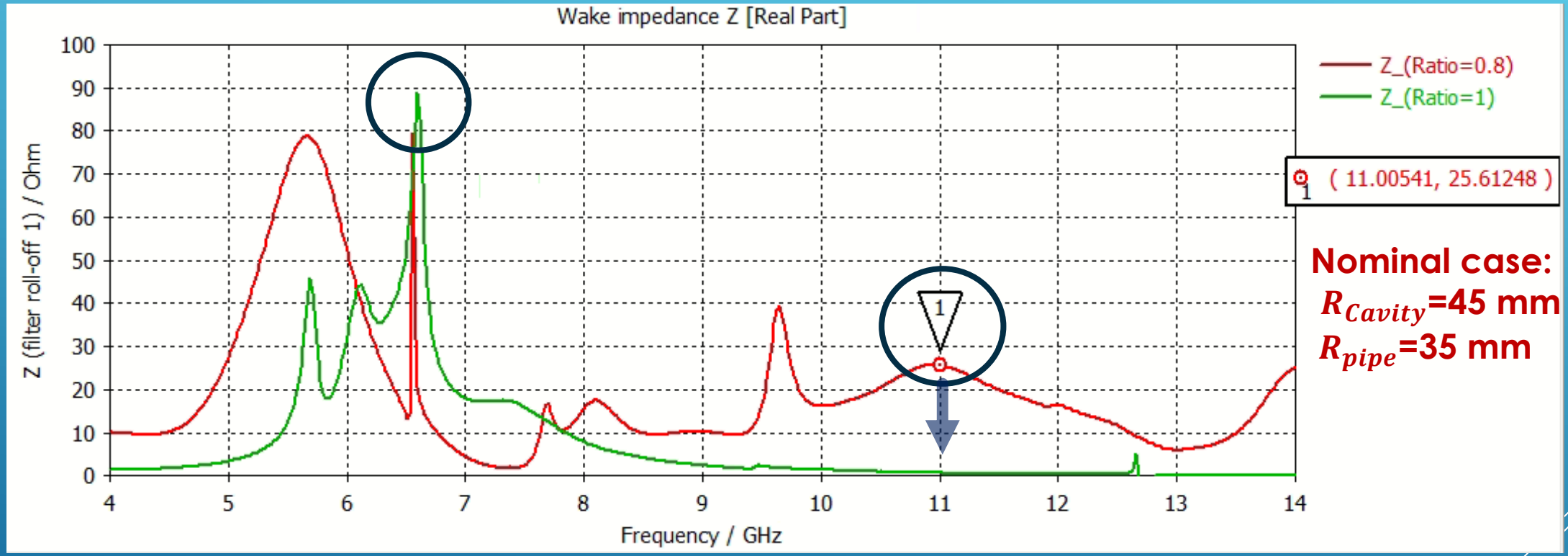
FREQUENCY SHIFT AS A FUNCTION OF RATIO



$$Ratio = \frac{R_{pipe}}{R_{Cavity}}$$

IMPEDANCE RESULTS: R_{Cavity}= 45 MM

$$Ratio = \frac{R_{pipe}}{R_{Cavity}}$$



Nominal case:
R_{Cavity}=45 mm
R_{pipe}=35 mm

CONCLUSIONS

- The numerical convergence of the results has been preliminary studied and the simulations required important computational resources.
- The longitudinal and transverse Wake Potential and Impedance have been computed.
- The longitudinal Wake Potential is affected by the height of the bellows as well as the space between the convolutions of the bellows.
- A qualitative study in order to understand the intrinsic behaviour of the impedance has been performed.

FUTURE STEPS

- Still work on the ongoing qualitative study to verify the results obtained so far (e.g. the frequency shifts of the mode) in the real complex model.
- Study the model with the realistic chamber and the vacuum flanges.

THANK YOU !