

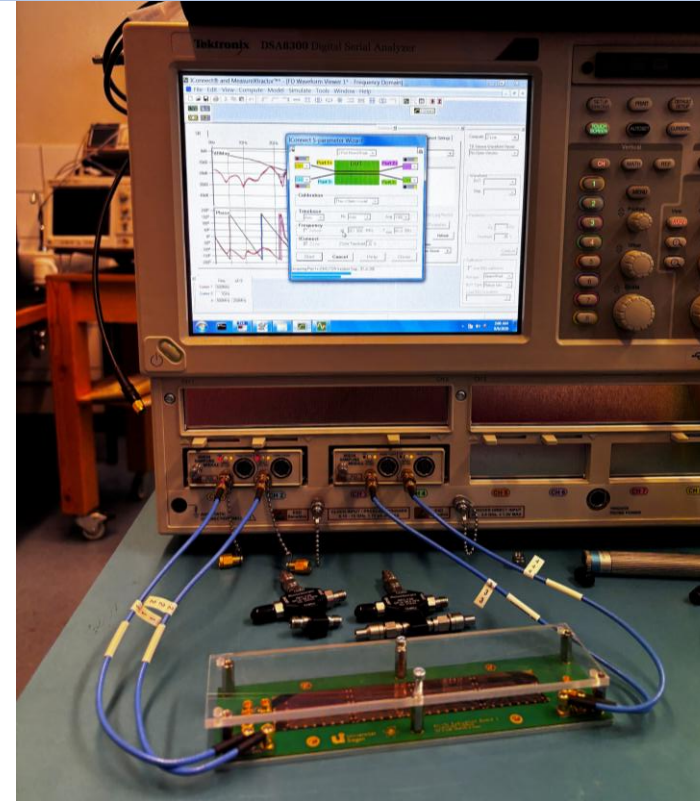
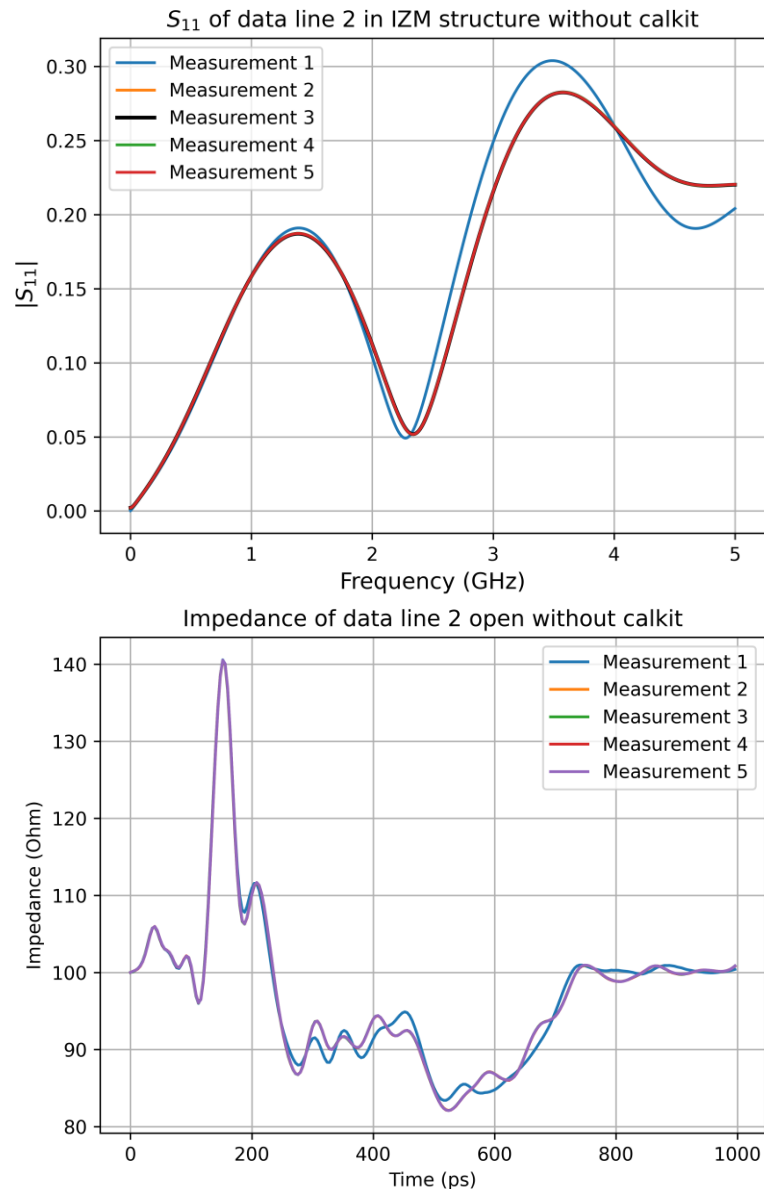
All-silicon meeting

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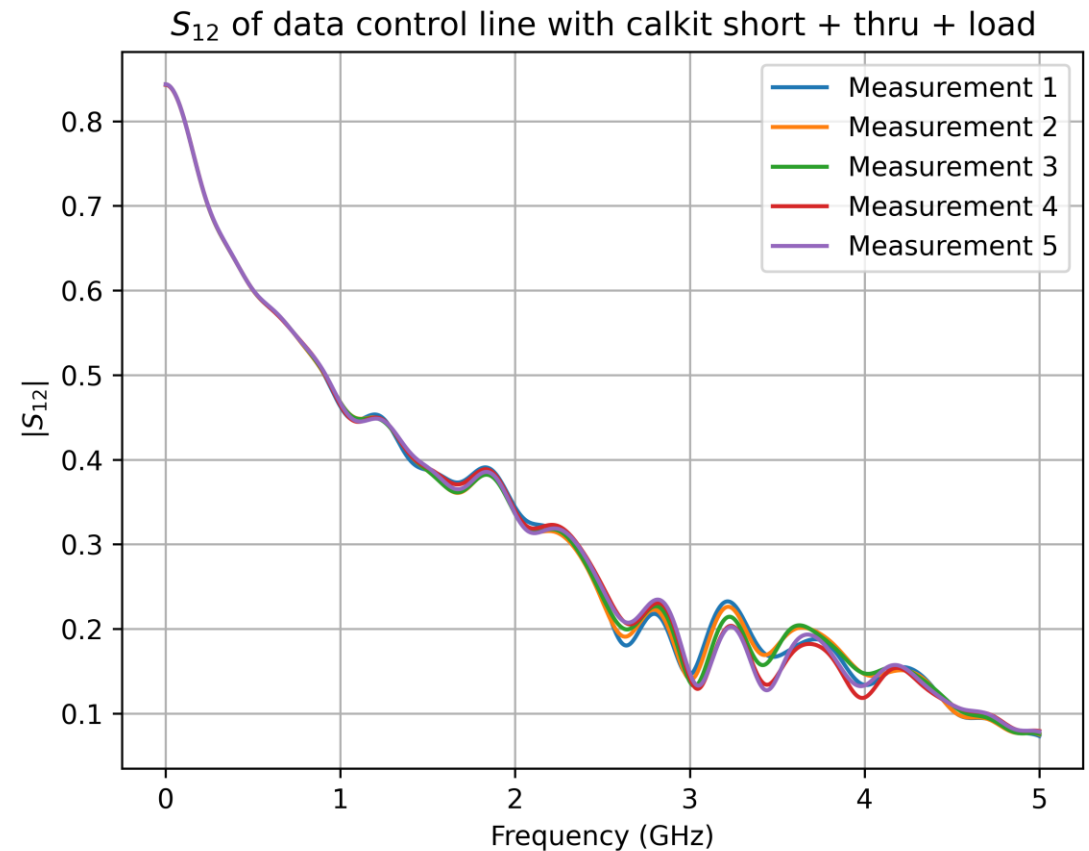
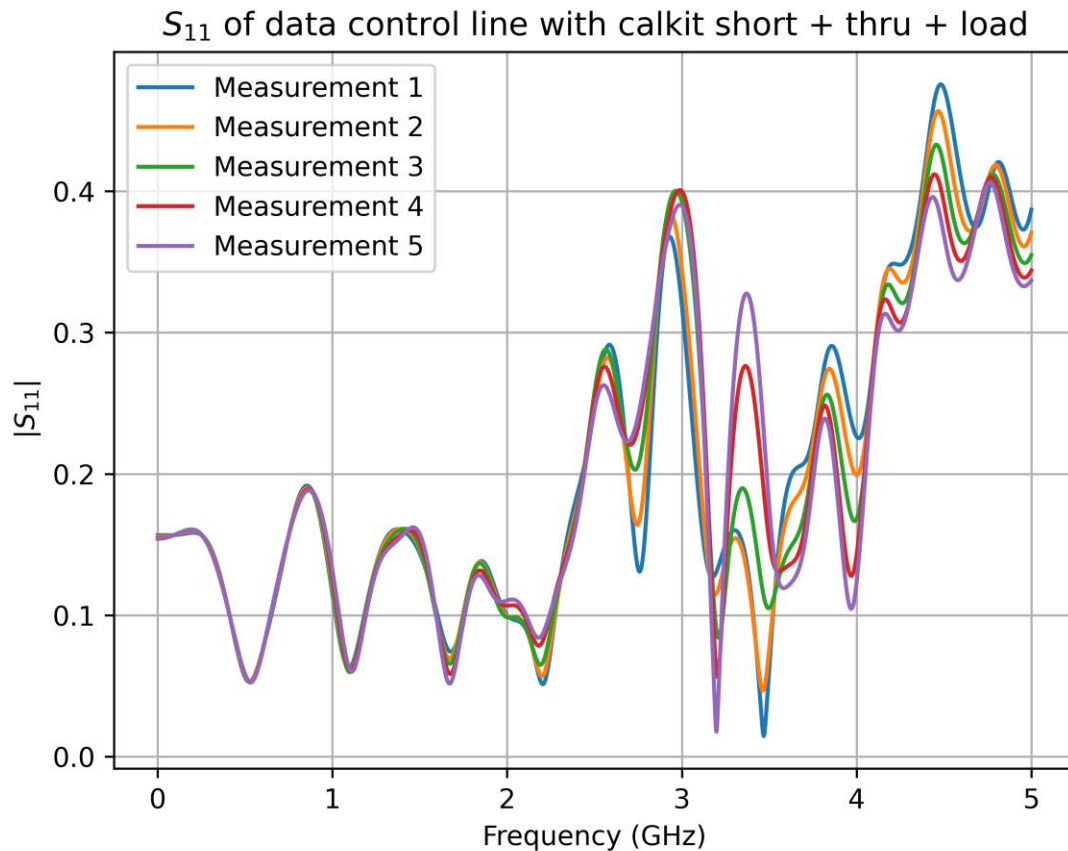
In collaboration with

TDR measurements



- After measurement 1, cables from the readout PCB were unplugged and plugged in again, and then other measurements were taken
- If we repeat measurements without unplugging and plugging in cables, the results remain the same
- Does this suggest that systematic uncertainty comes from cable orientation??

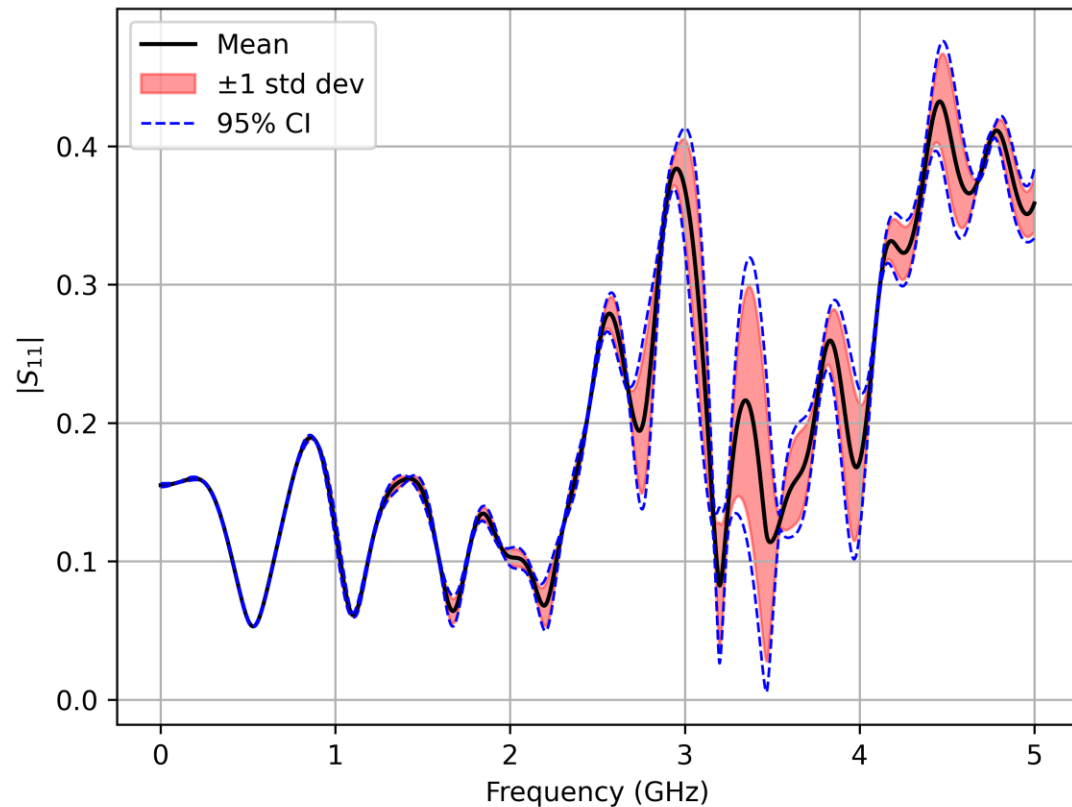
TDR measurements



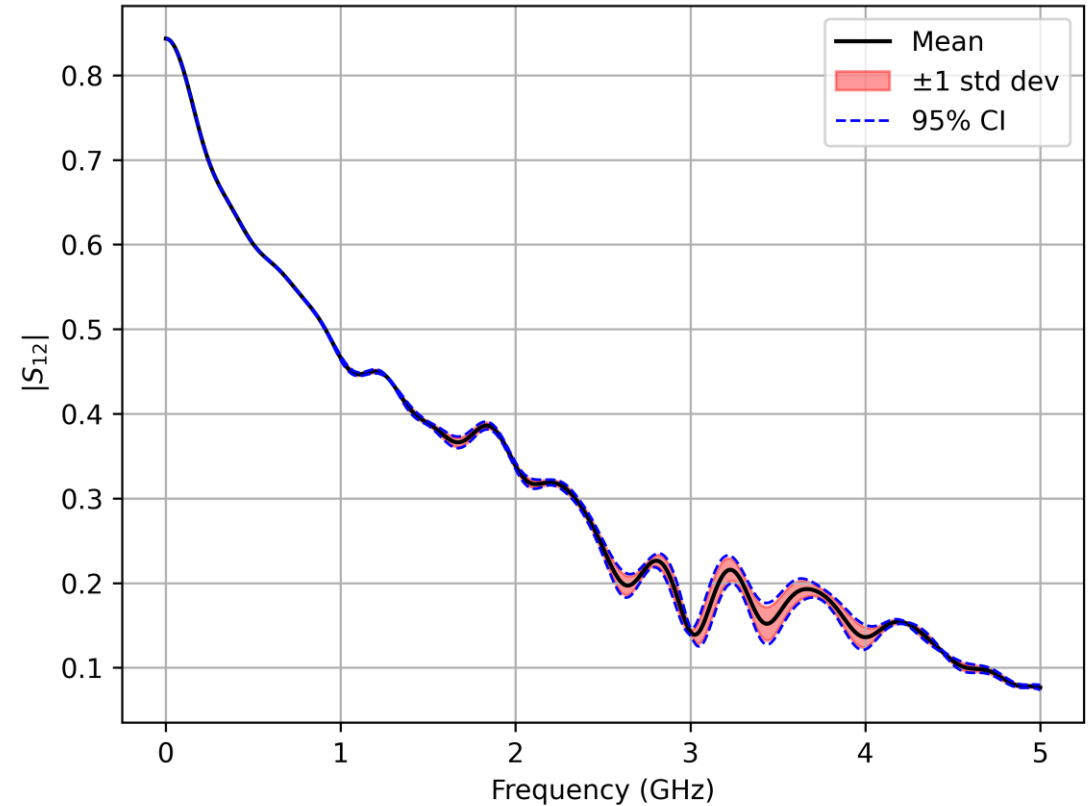
- After each measurement, cables from the readout PCB were unplugged and plugged in again, and then the next measurements were taken
- Doing so result changes from measurement to measurement
- This suggests that systematic uncertainty comes from cable orientation!!

TDR measurements of the data control line

S_{11} statistics of data control line with calkit short + thru + load

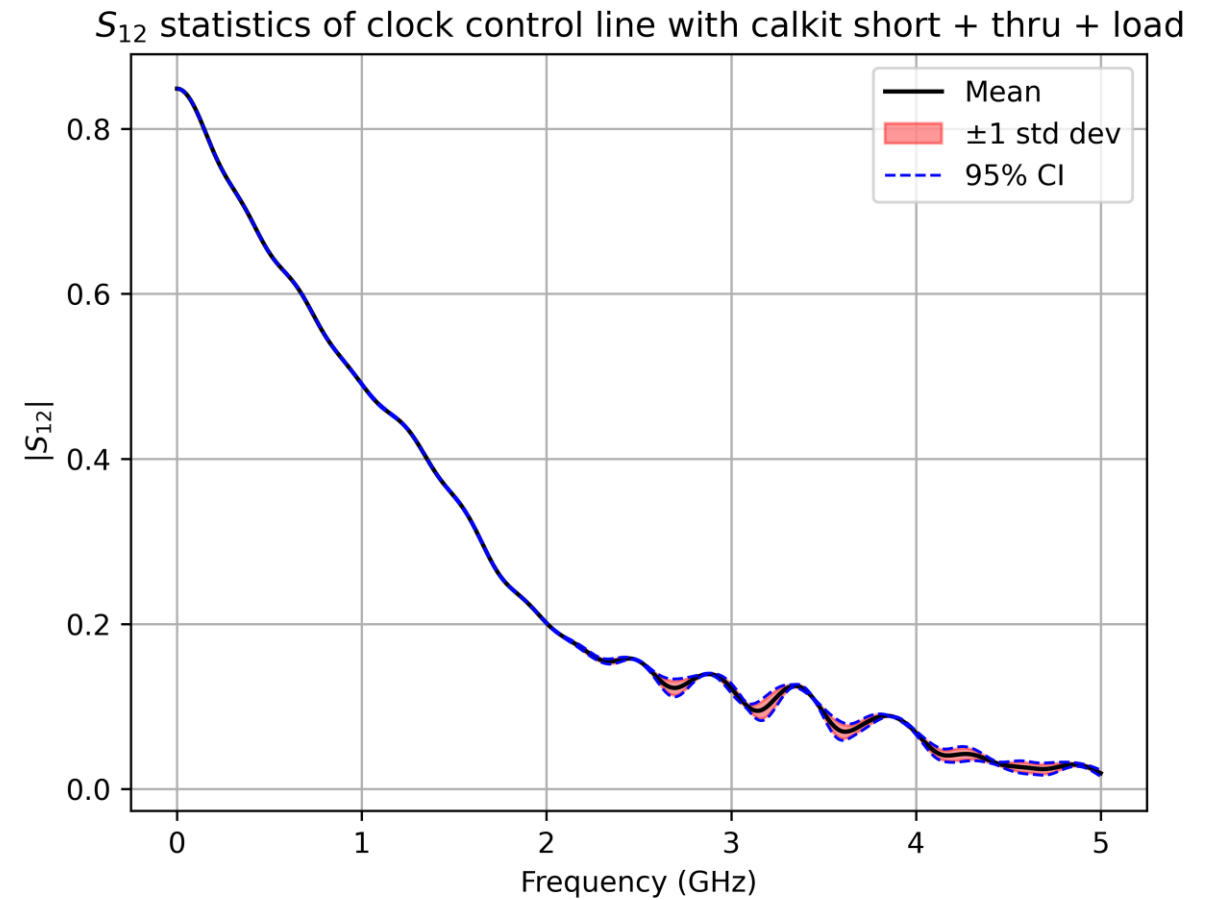
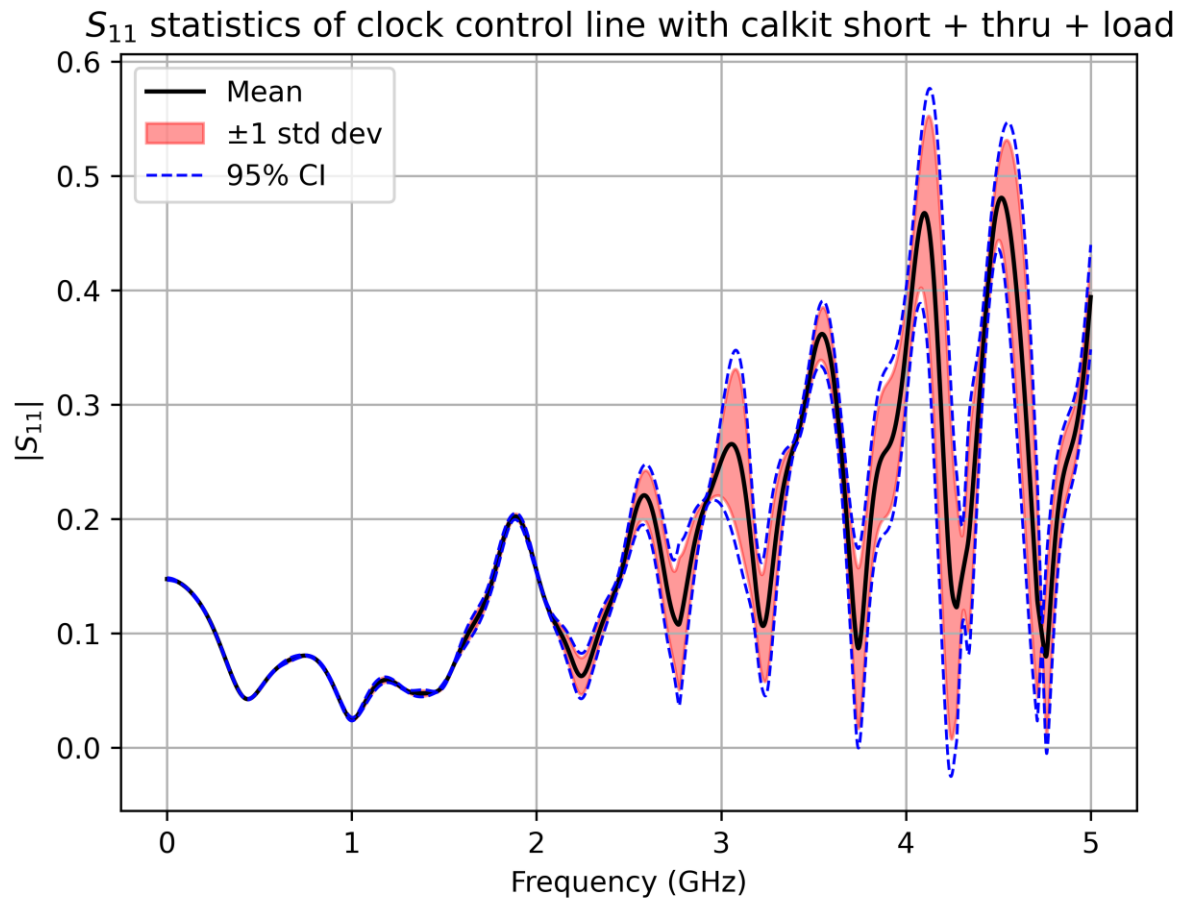


S_{12} statistics of data control line with calkit short + thru + load

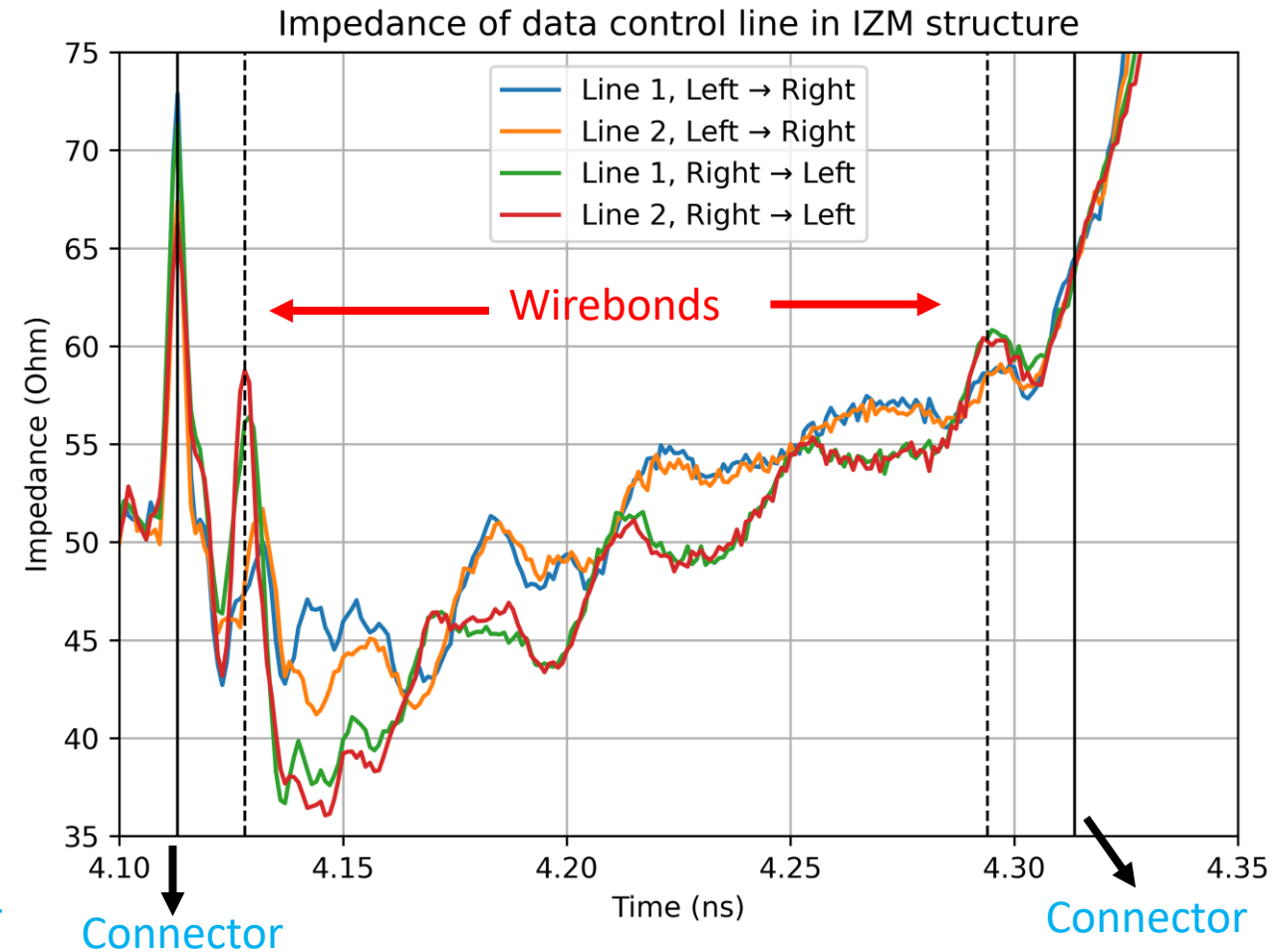
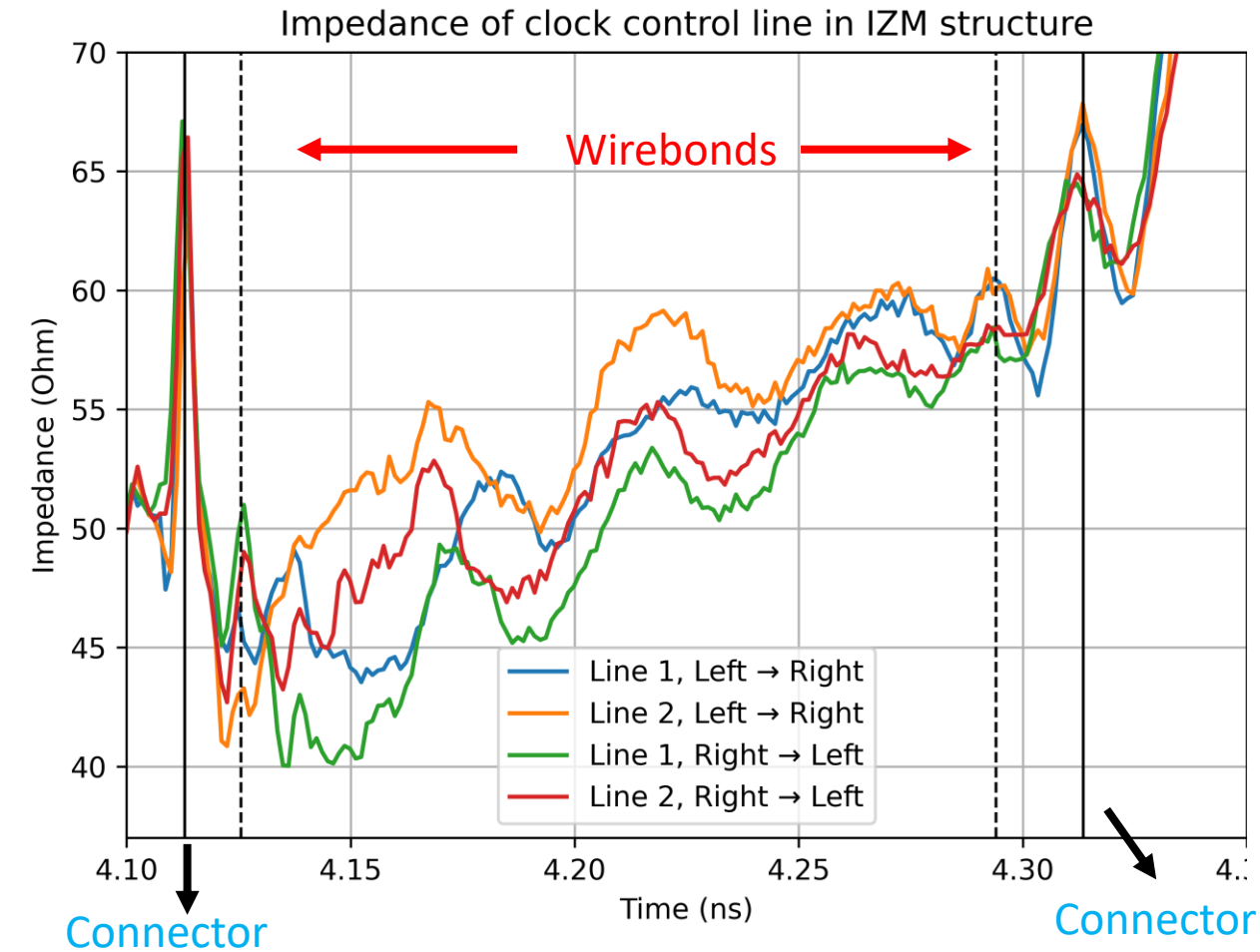


- This suggests that systematic uncertainty comes from cable orientation!!
- Above 2.5 GHz, $|S_{11}|$ rises and becomes much less consistent — especially the deep, widespread dip near 3.3–3.5 GHz, pointing to resonance-like mismatch behavior in that band along with higher measurement uncertainty, which could stem from cable/connector repeatability or an actual structural resonance in the DUT.

TDR measurements of the clock control line

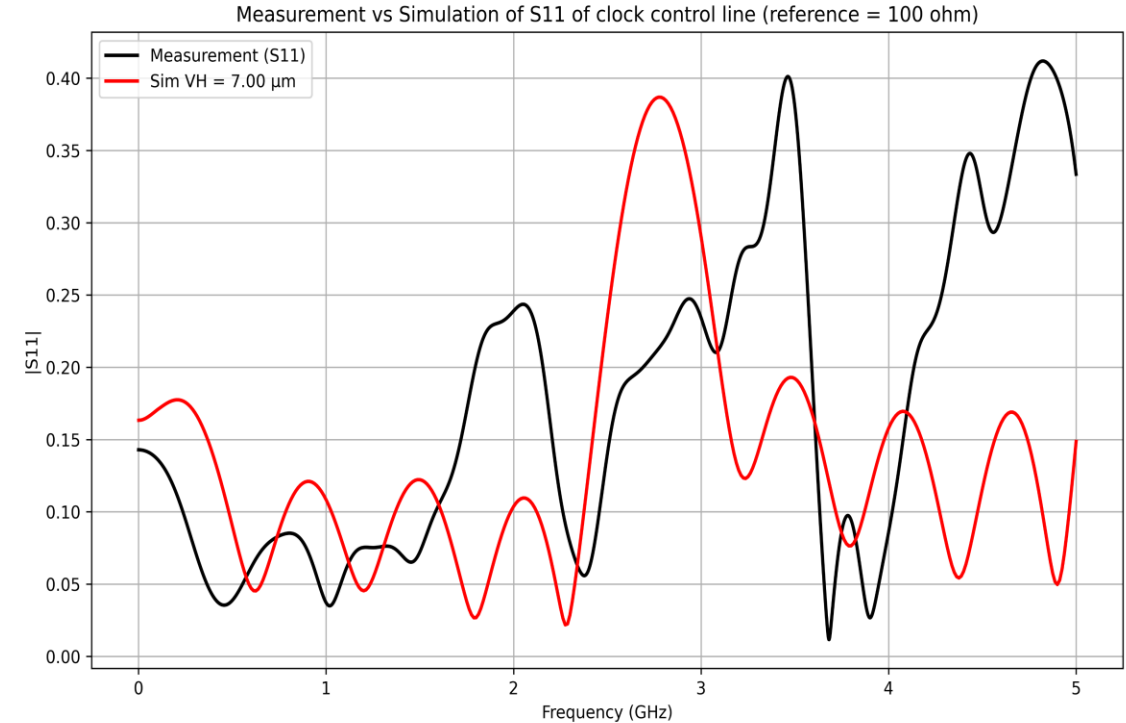
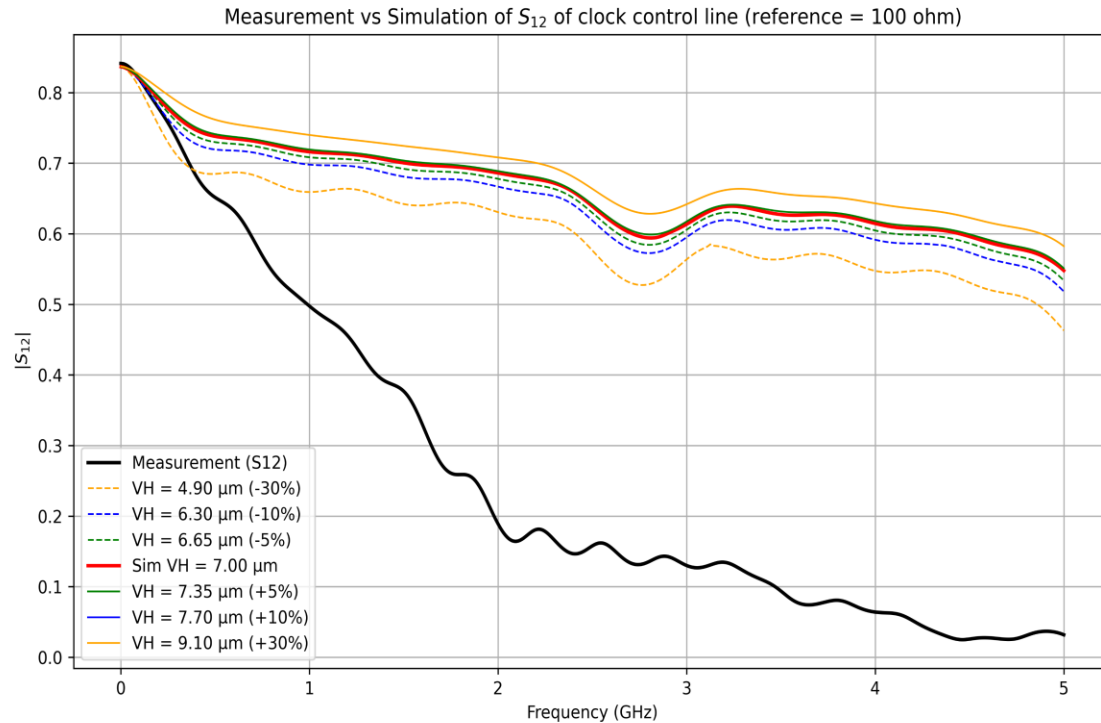


Impedance measurements of the clock and data control line



Comparison of simulations and measurements

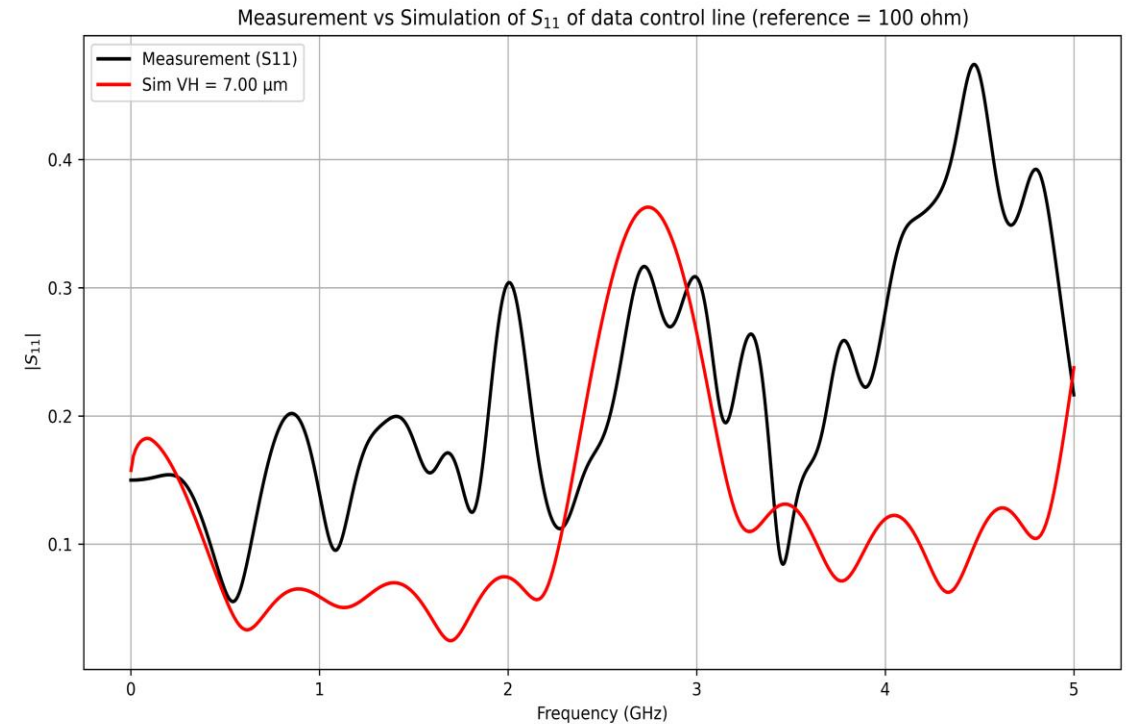
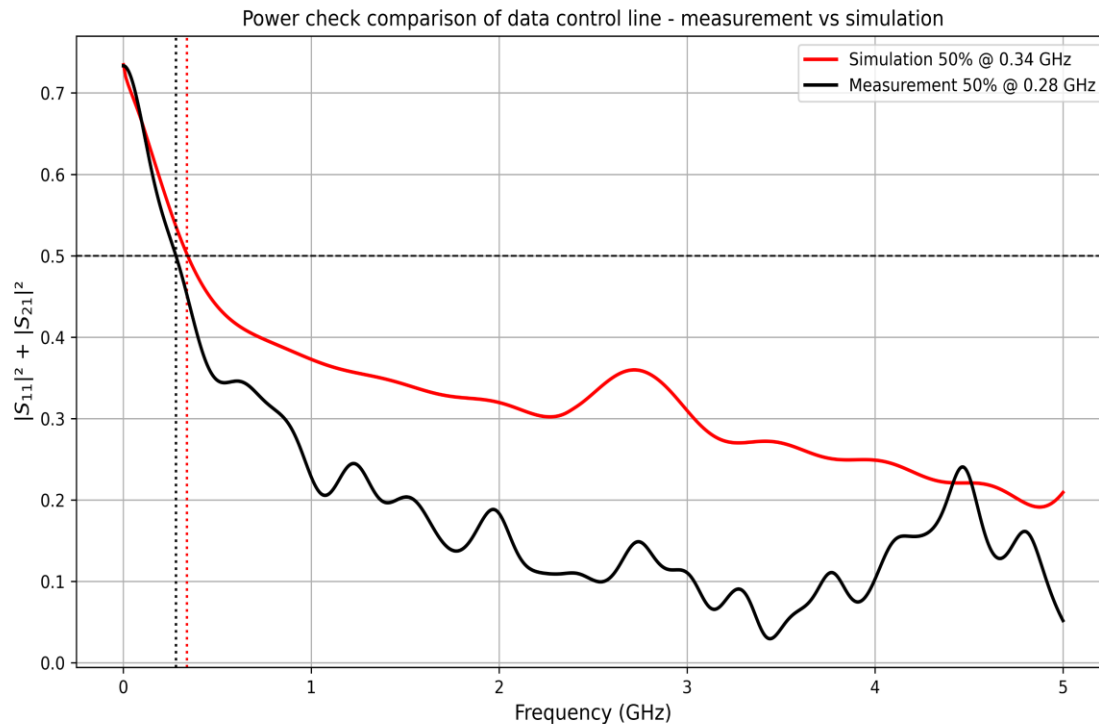
Ideal simulations (without frequency dependence and smooth surface)



- Simulations have a higher transmission magnitude than that of the simulations, suggesting higher power loss in the current structure
- Whereas the reflection magnitude is in a comparable range, by improving the simulation model, it may also be improved
- Both simulations and measurements have the same reference impedance of 100 Ω

Comparison of simulations and measurements

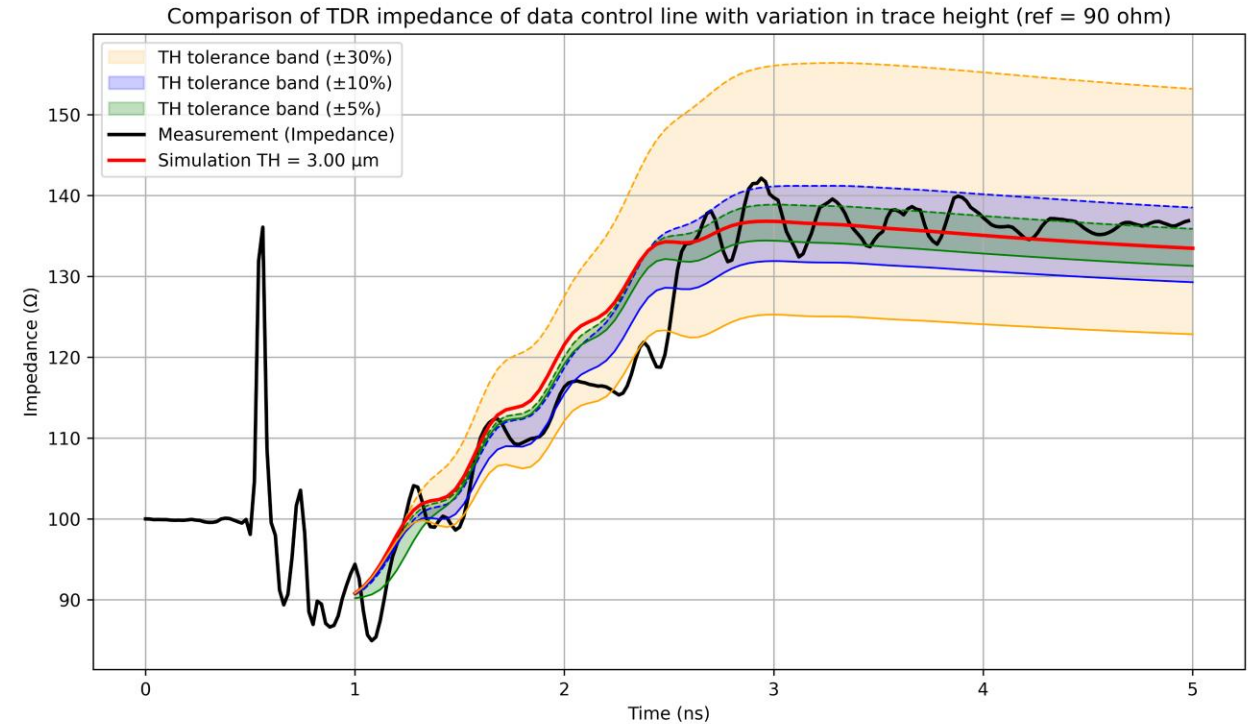
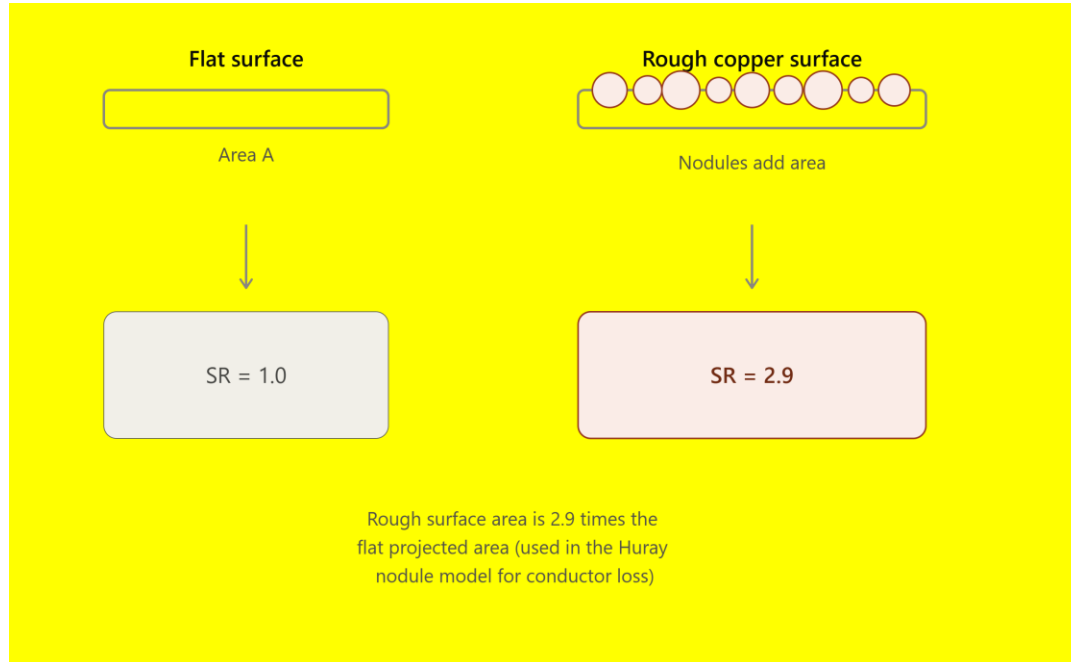
Improved simulations (with frequency-dependent dielectric and rough trace surface)



- For this simulation, a frequency-dependent dielectric material (polyimide) is used.
- Where $\epsilon_r = 3.19782 + \frac{0.302184}{1 + 5.49473 \times 10^{-18} \text{ Freq}^2}$ and $G = 5.84143 \times 10^{-7} + \frac{3.9407 \times 10^{-20} \text{ Freq}^2}{1 + 5.49473 \times 10^{-18} \text{ Freq}^2}$
- Surface roughness condition is applied to copper trace with Nodule radius = 0.5 μm , and hall-hurray surface ratio (SR) = 2.9
- Both simulations and measurements have the same reference impedance of 100 Ω

Comparison of simulations and measurements

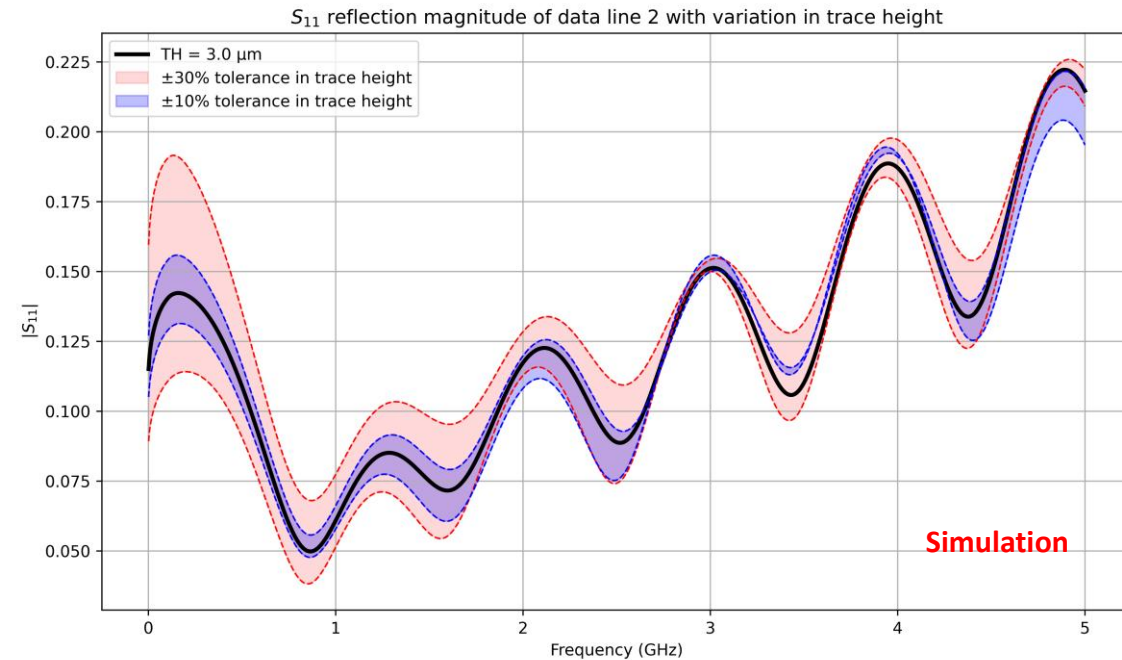
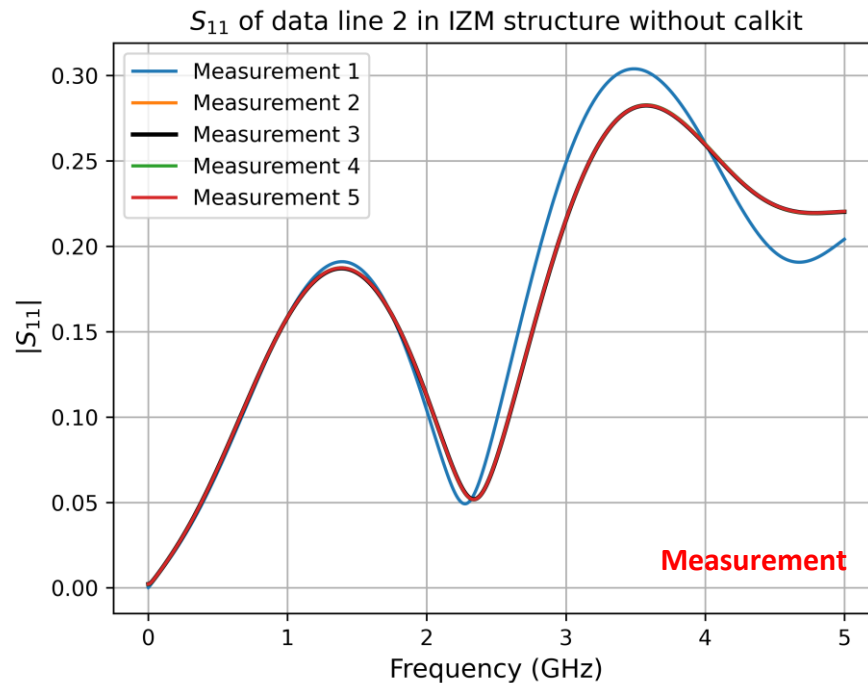
Improved simulations (with frequency-dependent dielectric and rough trace surface)



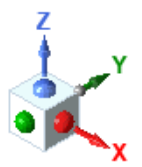
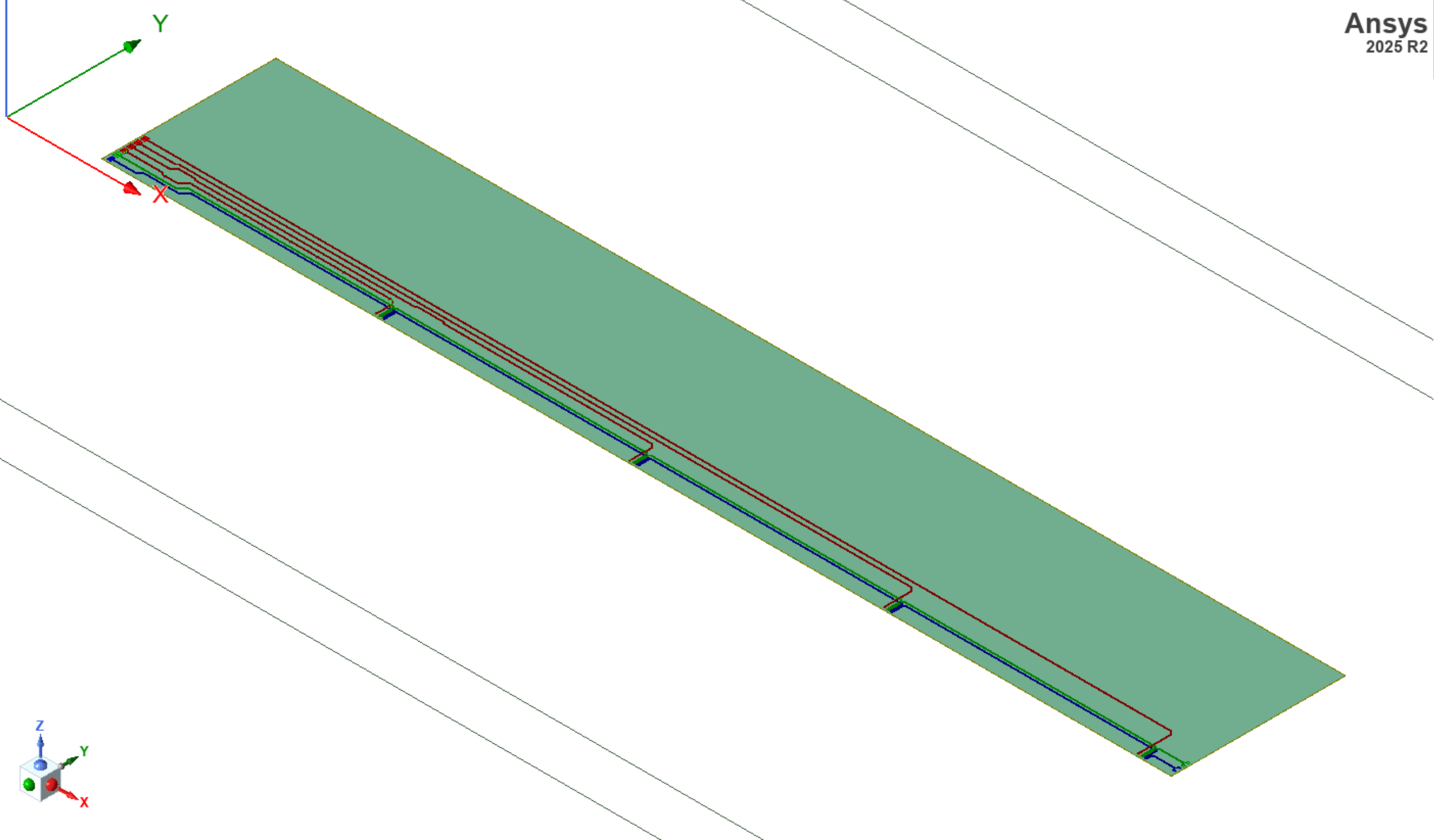
- Can not improve simulation regarding frequency-dependent dielectric and rough trace surface, because further changes of dielectric constant and loss tangent will lead to unphysical parameters
- The impedance mismatch region in a uniform transmission line can be used to improve the simulation model further

Comparison of simulations and measurements

Improved simulations (with frequency-dependent dielectric and rough trace surface)

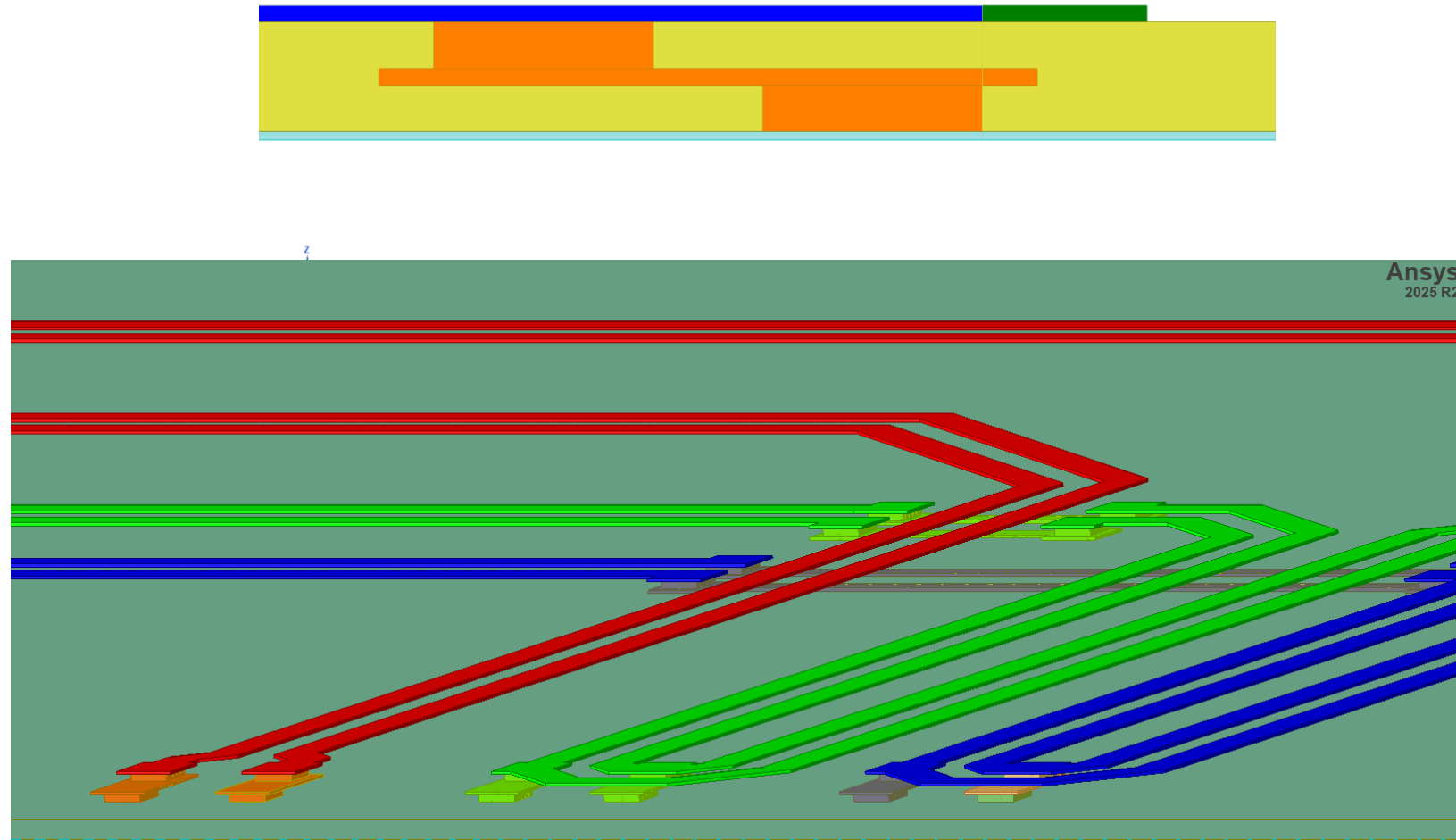
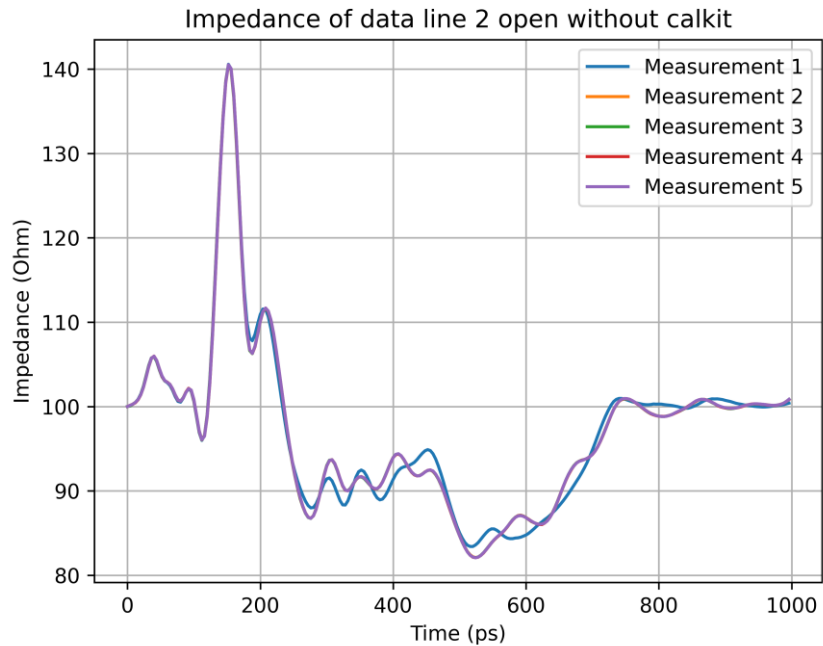


- Reflection pattern in simulation suggests that reflections are occurring at a length of ~ 95 mm (from the via at the end of the line), but in measurement, it is at a length of ~ 43 mm (Impedance mismatch in line).
- This is tricky to realize in simulations because of mesh-creating issues
- Currently working on this issue



Comparison of simulations and measurements

Improved simulations (with frequency-dependent dielectric and rough trace surface)



Next steps :

- Improved simulations of the IZM structure with tolerance in trace height and via height are in progress for all transmission lines

