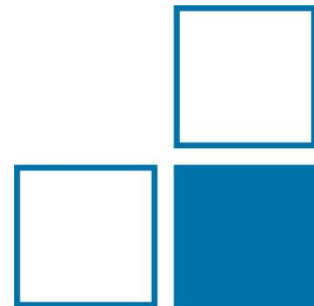
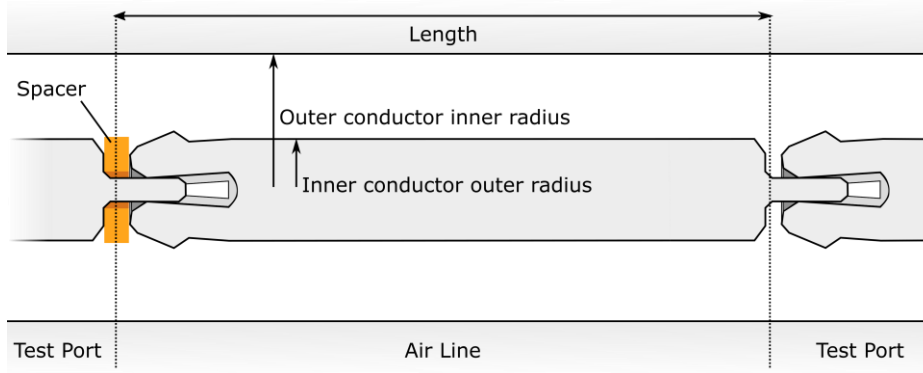


Geometrical Characterization of Air Lines

Frauke Gellersen, 2.22



Coaxial Air Lines

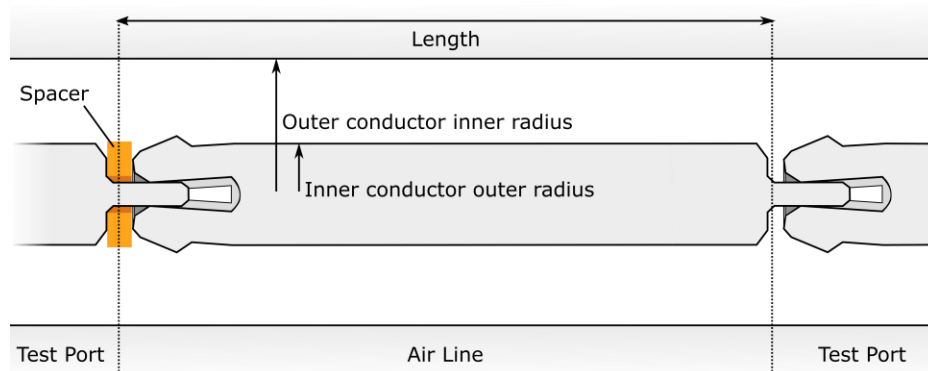


- Outer conductor inner radius b
- Inner conductor outer radius a
- Length of inner and outer conductor
- Effective conductivity
- Similar for offset shorts



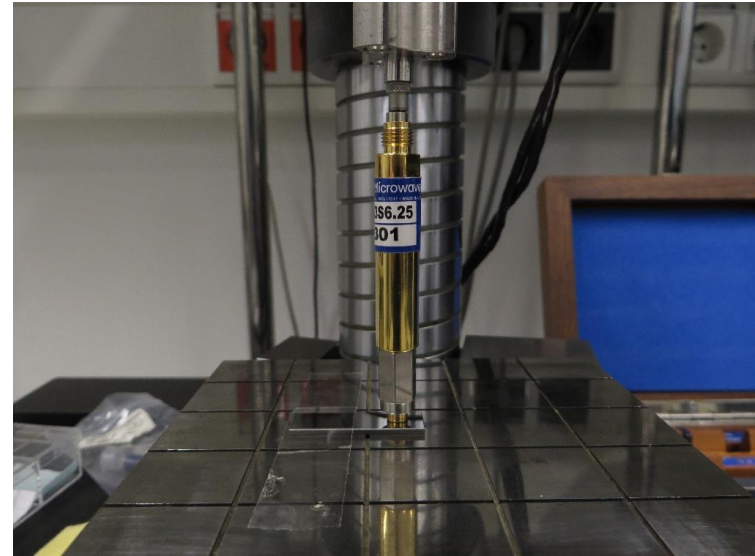
Outline

- Length measurement
- Inner conductor outer diameter
- Outer conductor inner diameter
- Coaxial connectors
- Effective conductivity
- Impedance and propagation constant
- S-parameters



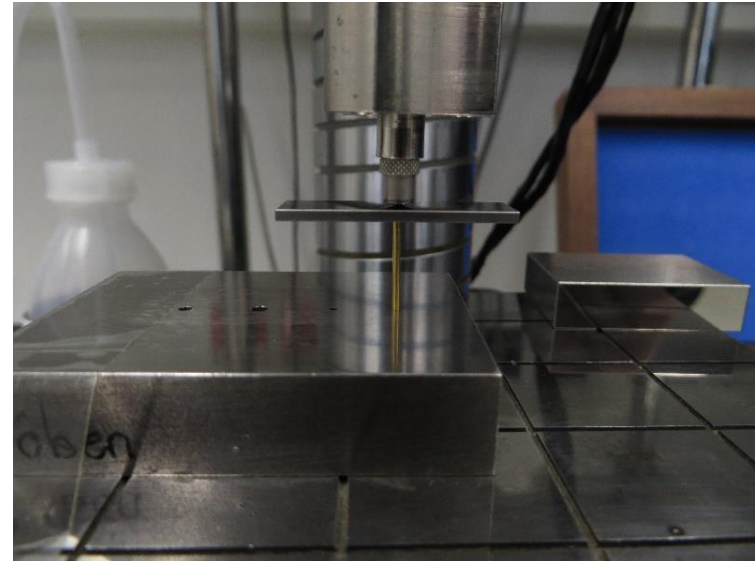
Length measurement

- Tactile measurement
- Gauge blocks for calibration
- Outer conductors difficult to probe
- Cylinders used in the measurement
- Inner conductor very fragile
- No pin inserted during the measurement



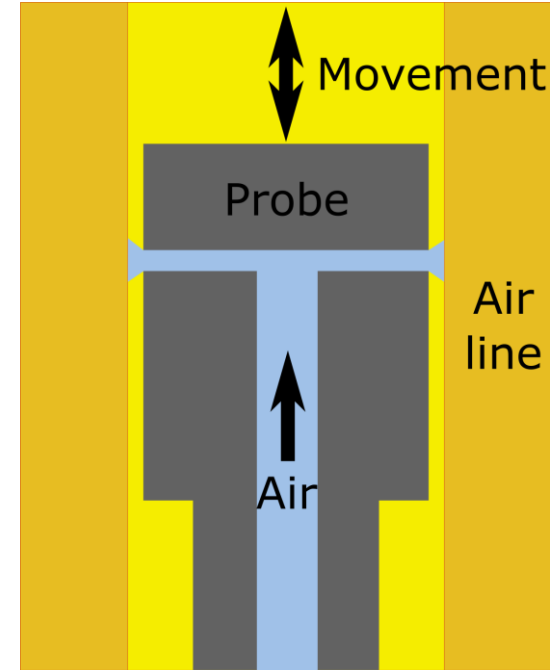
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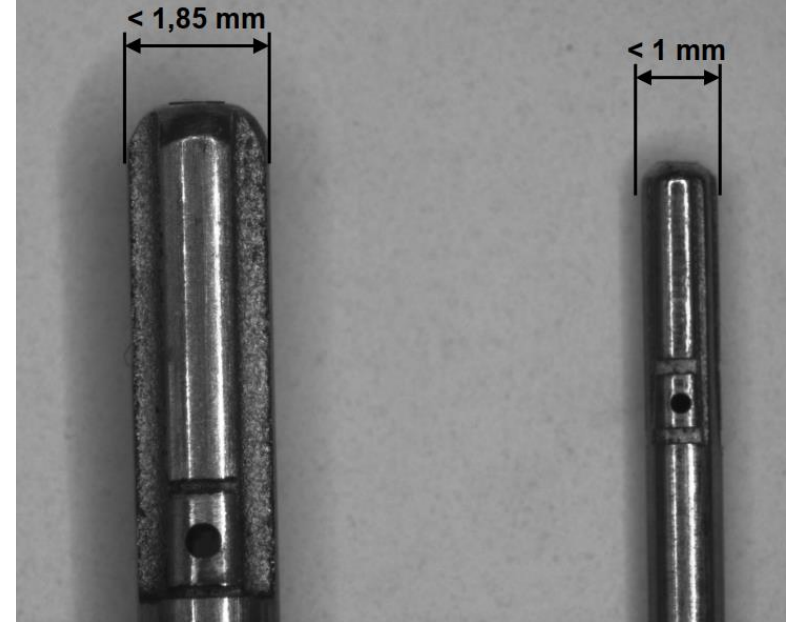
Outer conductor diameter

- Air-gauge
- Gauge rings for calibration
- Limited measurement range
- Measurement for several angles
- Beginning and end of the line
- Averaging



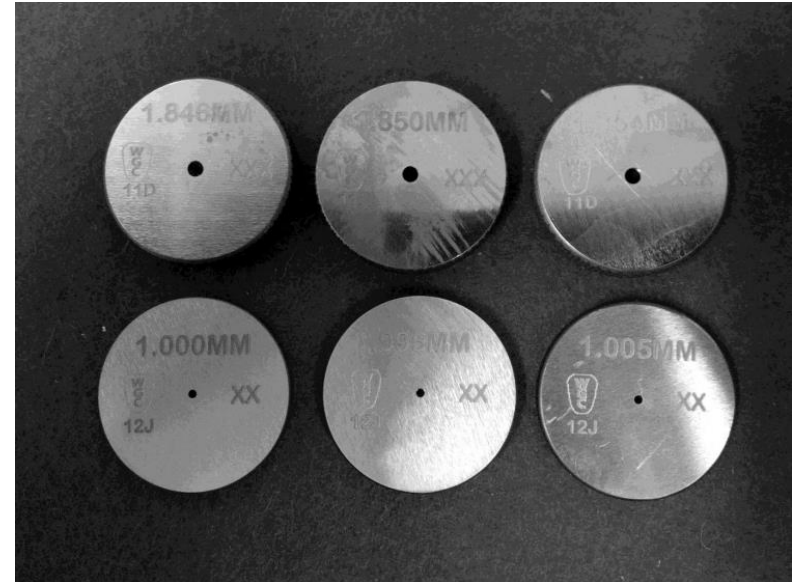
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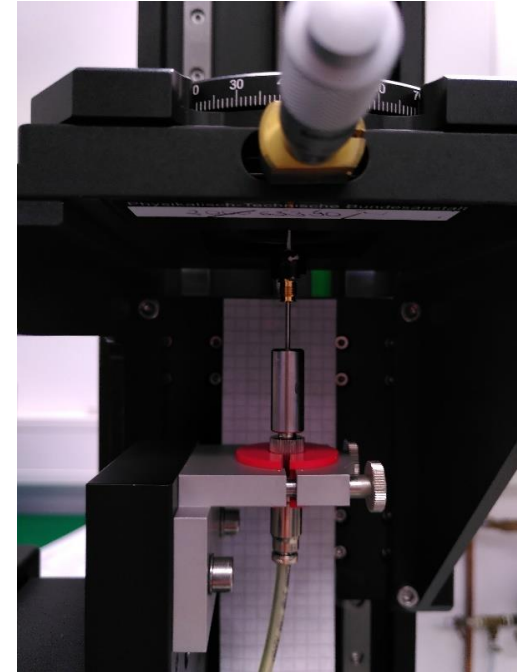
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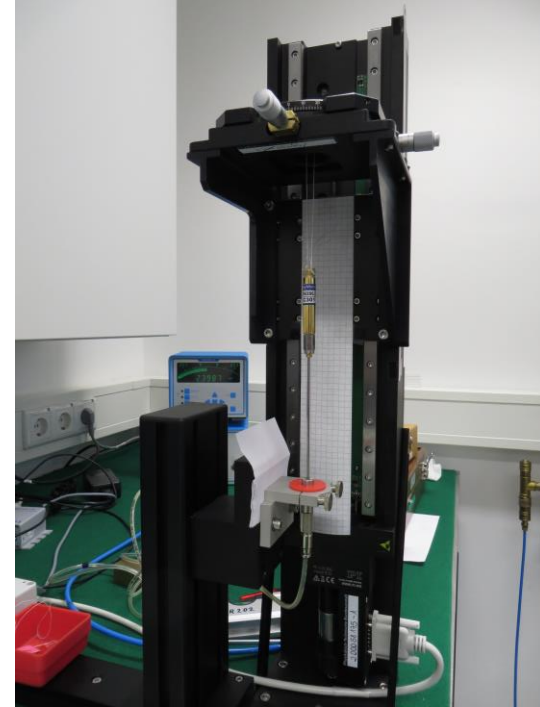
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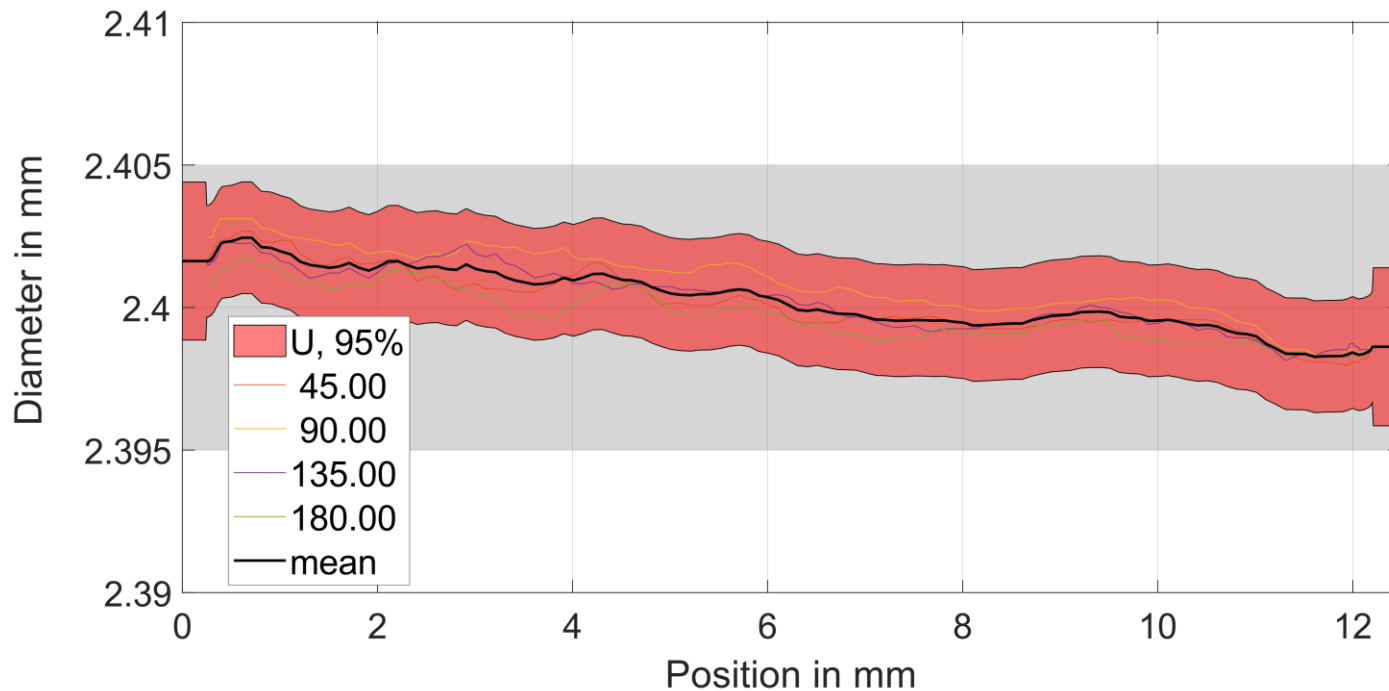


Outer conductor diameter

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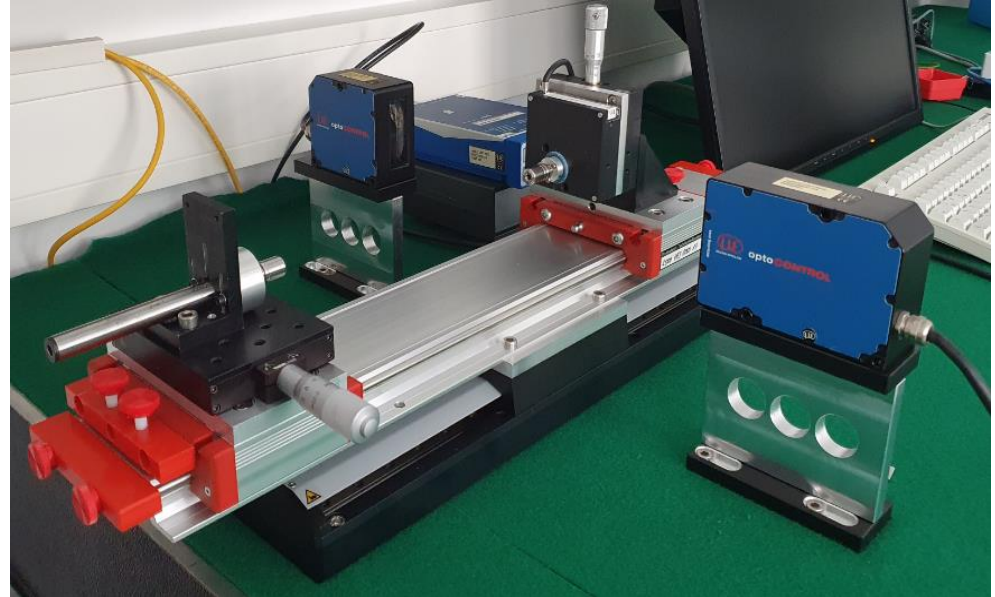


Air gauge diameter result



Inner conductor diameter

- LED micro meter
- Gauge plugs for calibration
- Starting angle must be chosen
- Edges are problematic
- Pin in jack influences the result



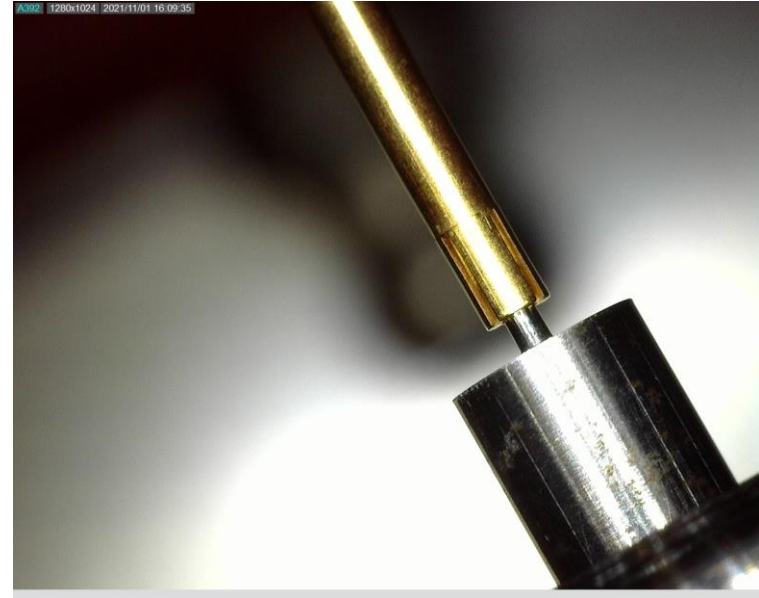
Inner conductor diameter

- LED micro meter
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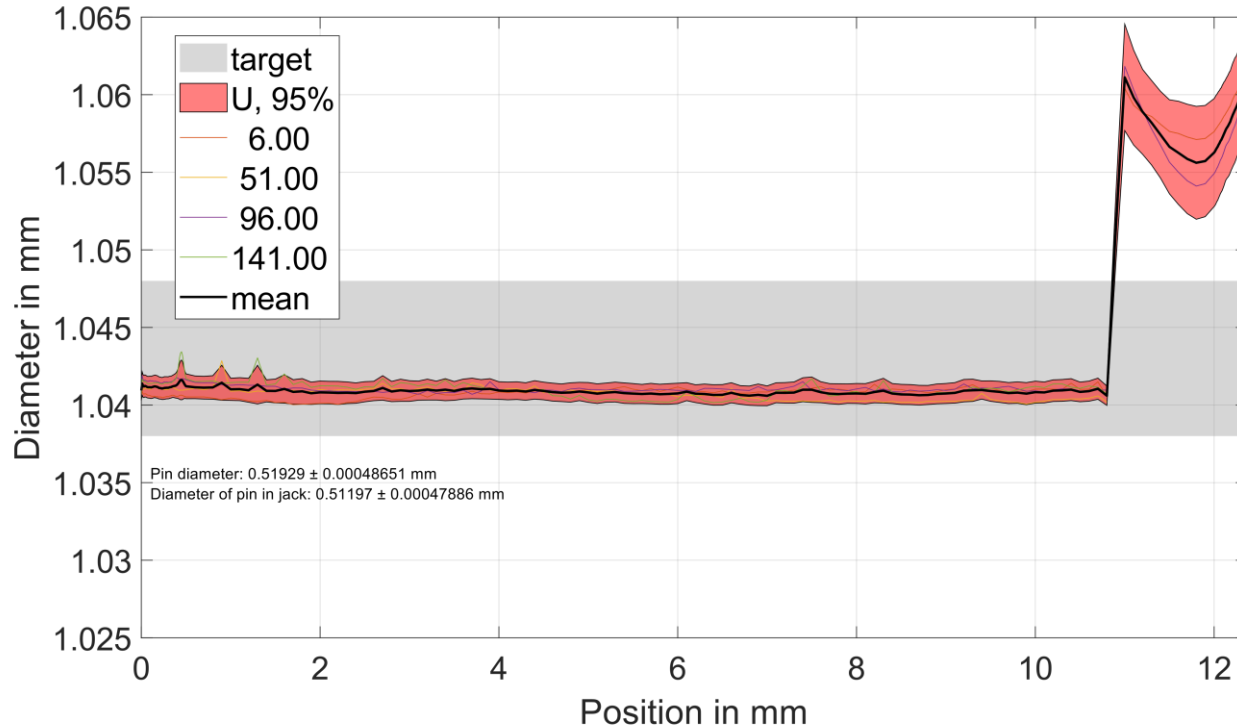


Inner conductor diameter

- LED micro meter
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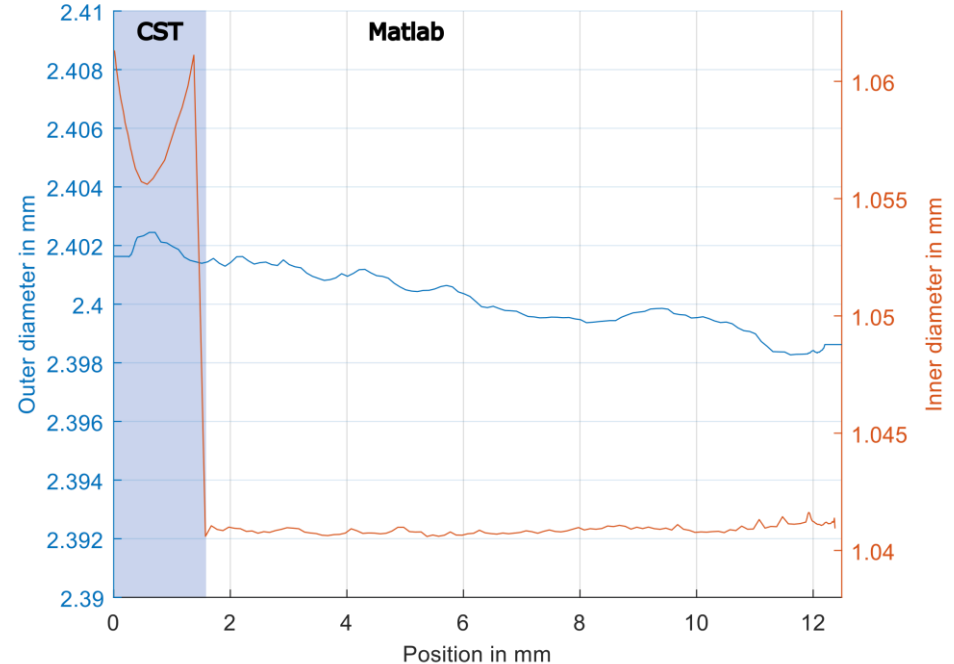
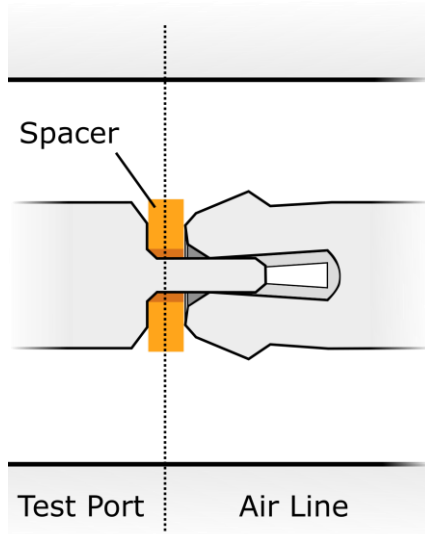


Inner conductor diameter result



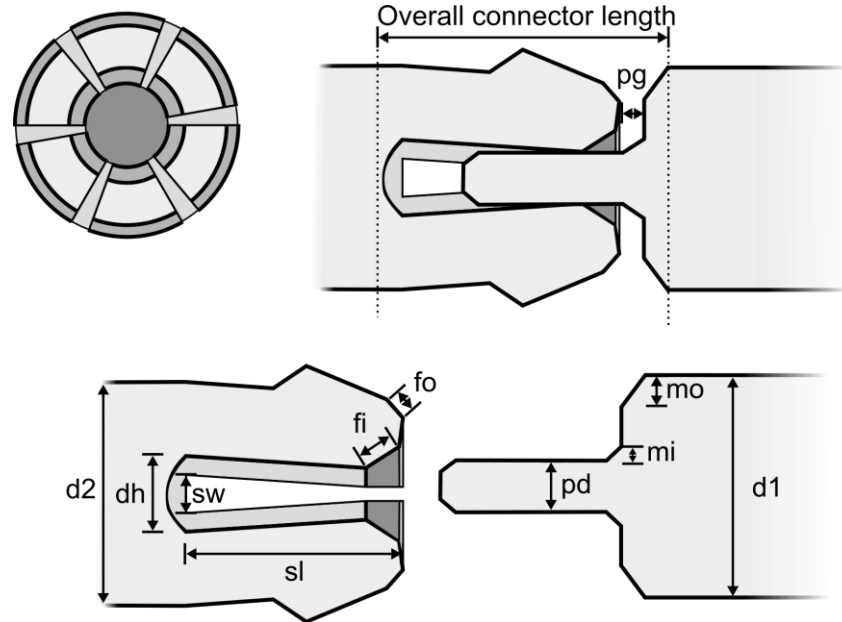
Combination of the results

- Pin depth of measurement port
- Kapton ring to control pin depth
- Important for combination



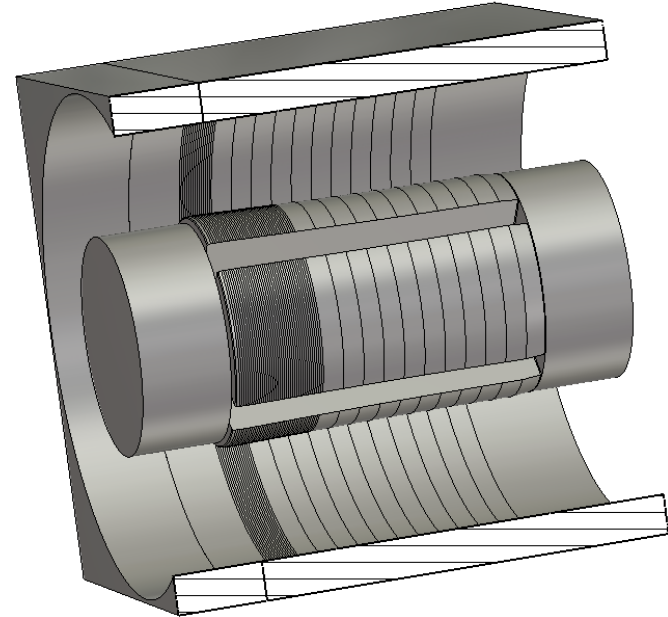
Connector Simulation

- Symmetric
- Measured diameters
- Adjust diameter for nominal pin
- Geometries from CT and microscope



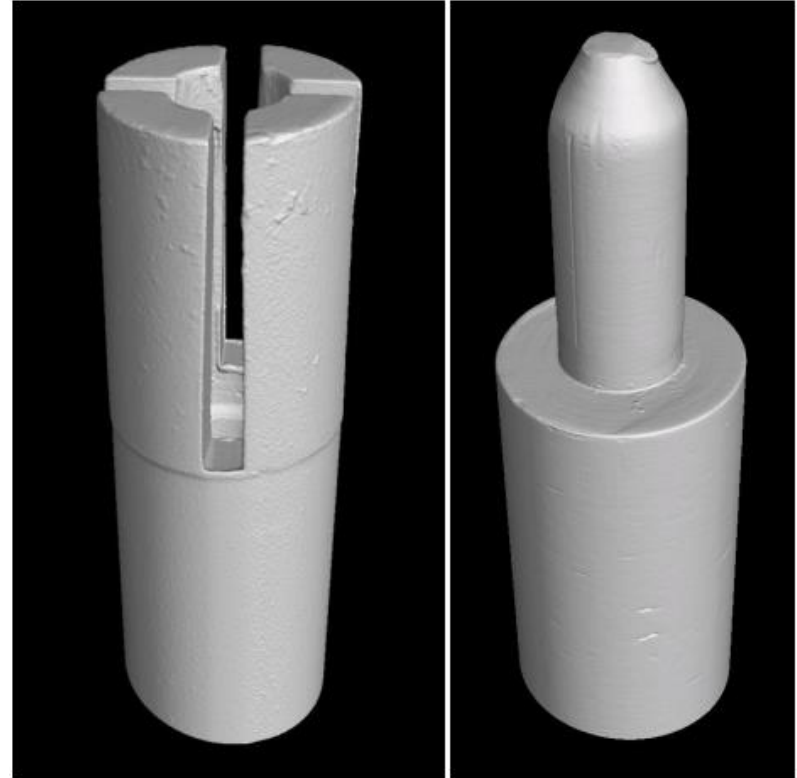
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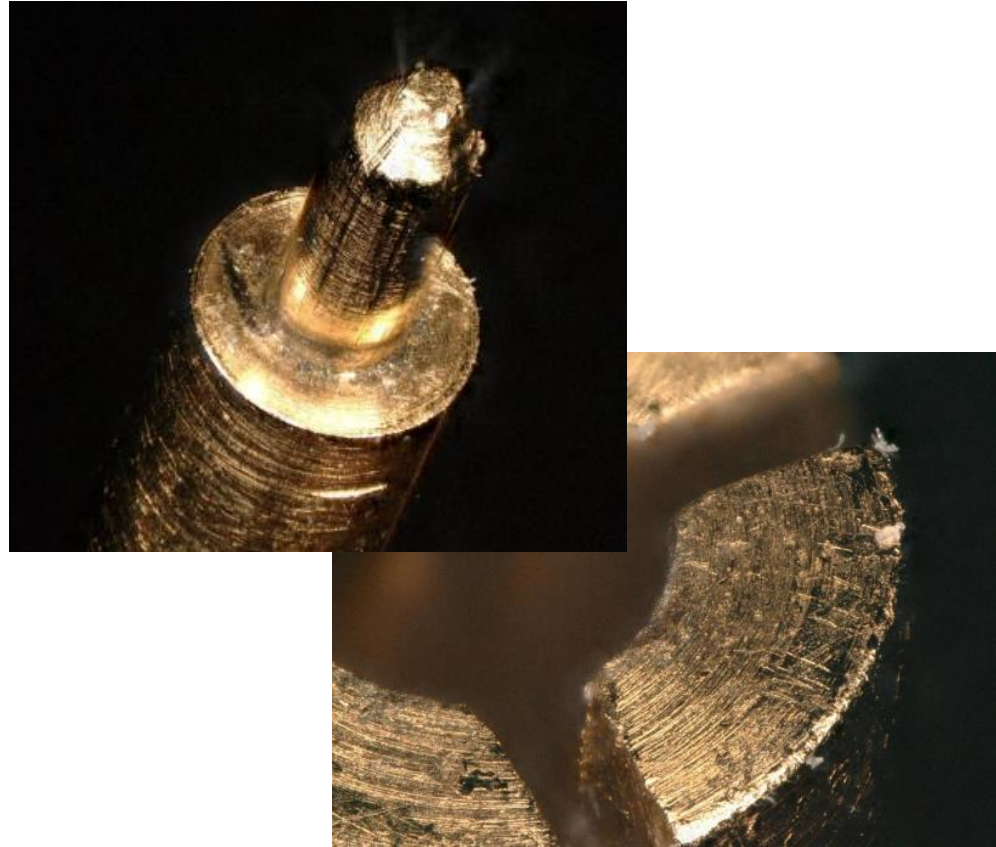
Connector characterization

- Computed tomography
- Microscope images
- No traceability
- Measurements difficult
- No symmetry



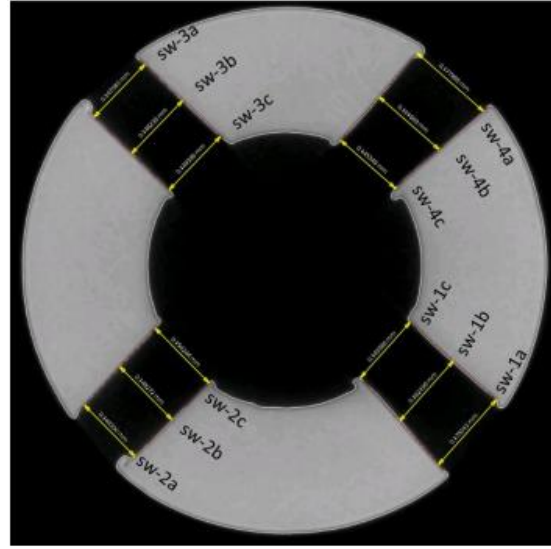
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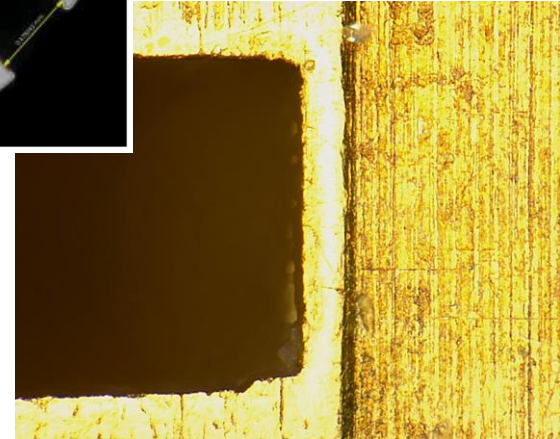


Connector characterization

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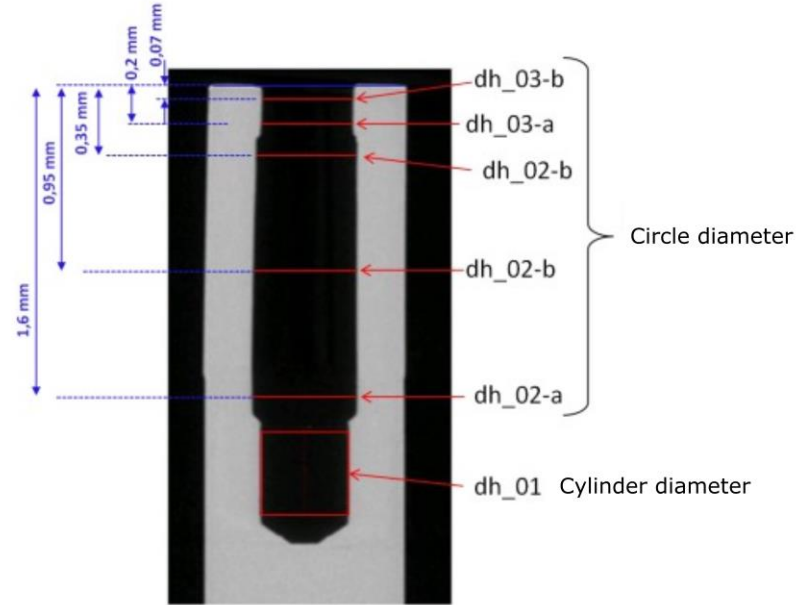


Sw1a = 175 μm
Sw2a = 144 μm
Sw3a = 147 μm
Sw4a = 178 μm



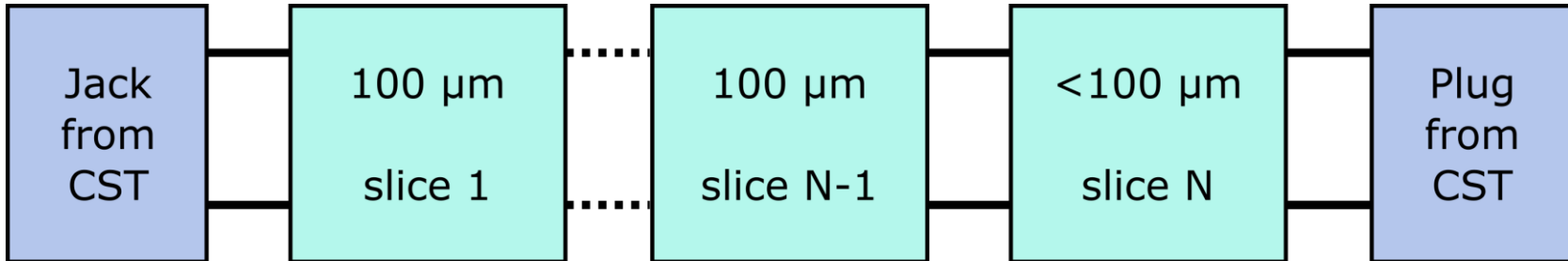
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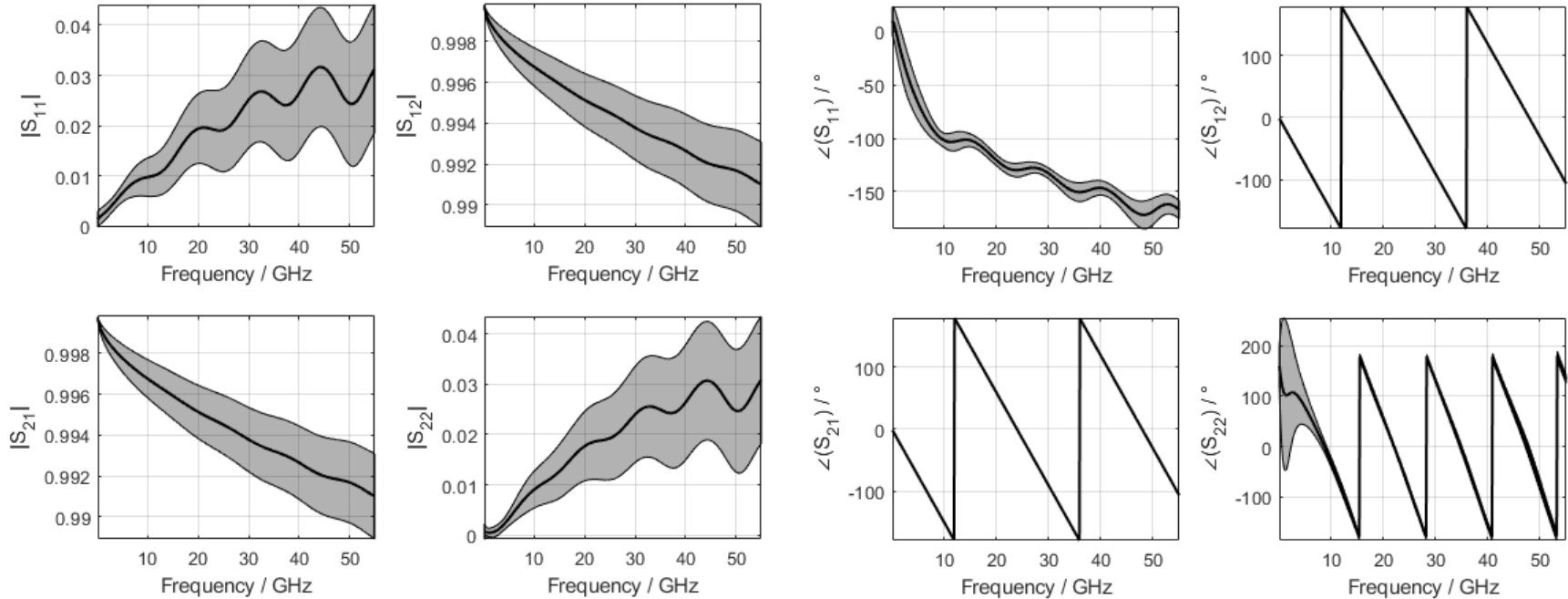
Calculate impedance and cascade

- Use diameters to calculate impedances
- Calculate S-Parameters of line section
- Cascade with simulation results for connectors

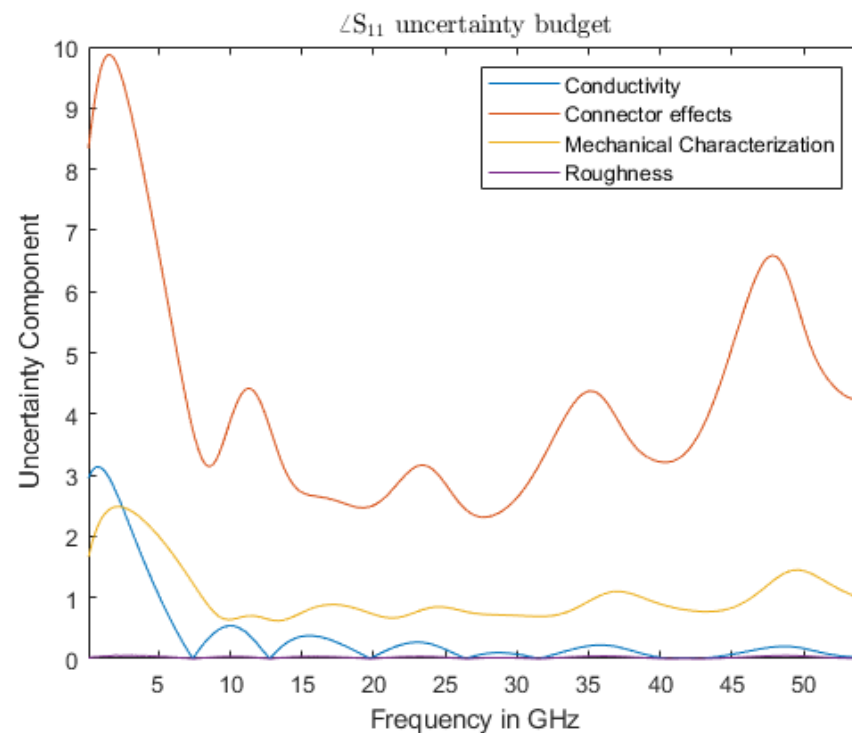
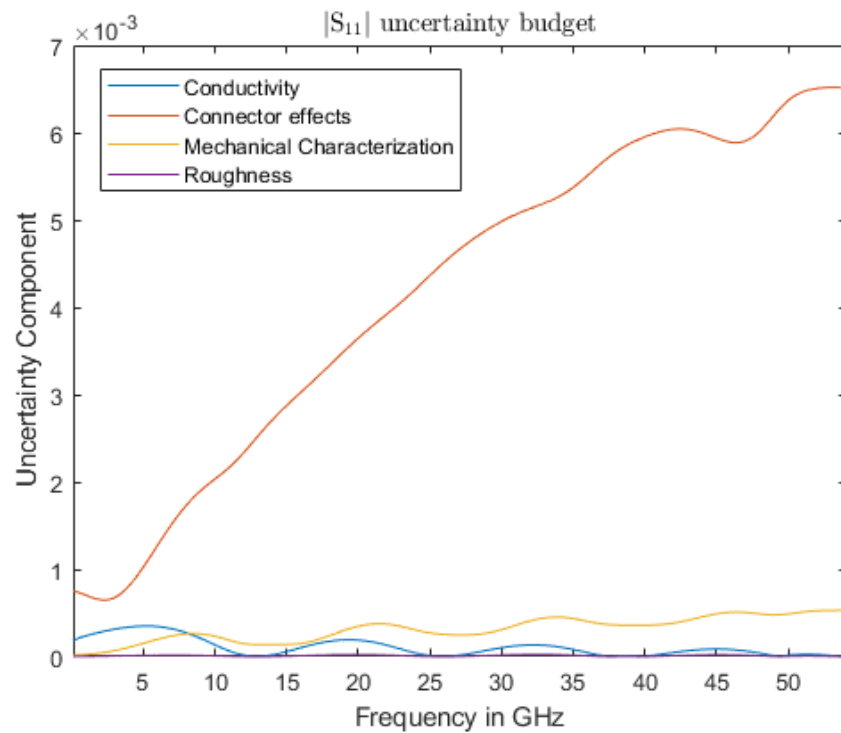


Calculated S-Parameters

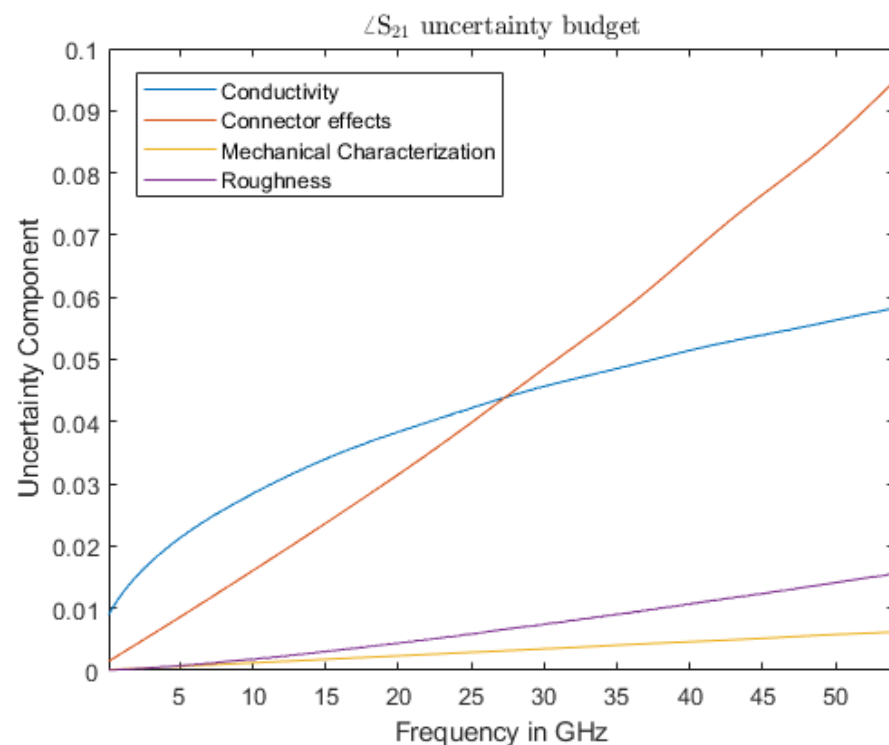
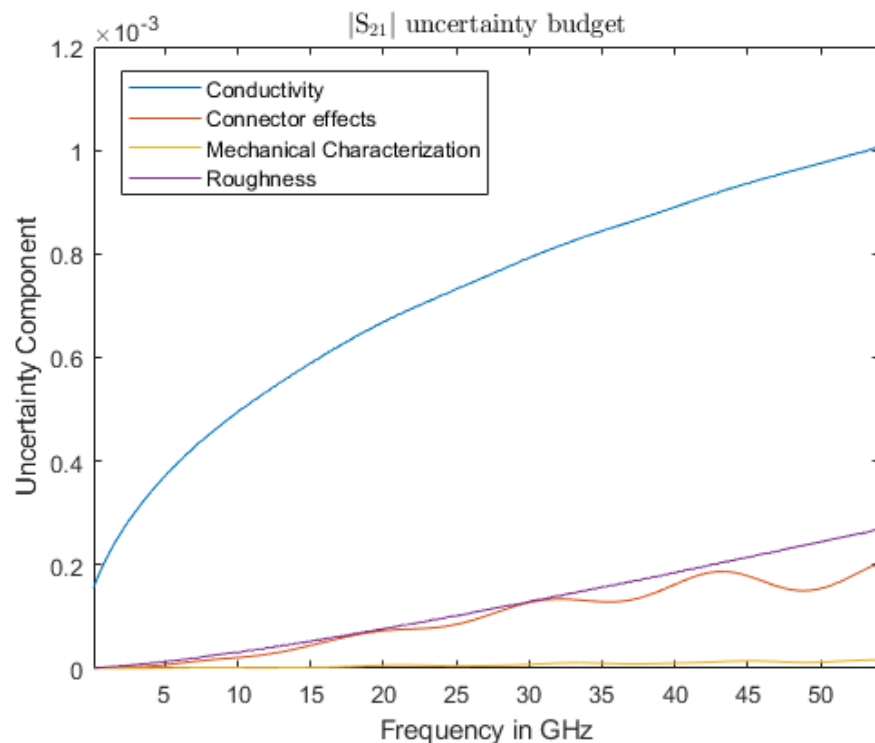
PC 2.4mm Air Line 12.5mm



Uncertainty of Reflection S_{11}

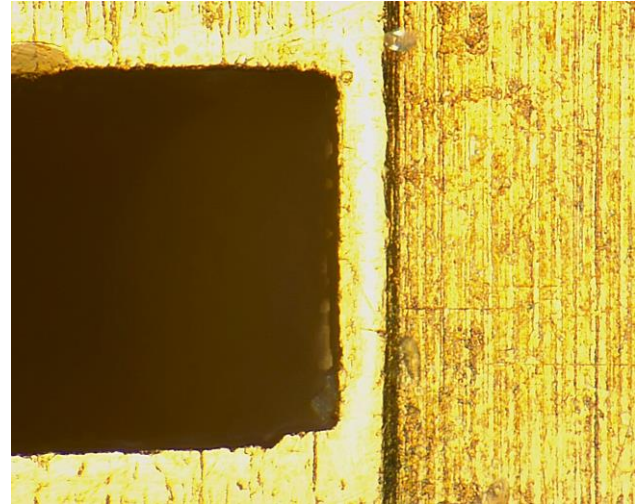


Uncertainty of Transmission S_{21}



Effective conductivity and roughness

- Overdetermined calibration
- Optimize conductivity and roughness
 - One value pair for inner and outer conductor
- Input of impedance calculation
- Minimize residuals after calibration



Conclusion and outlook

- Various dimensional measurements needed
- Connectors are challenging to measure and model
- Material parameters need to be optimized after the s-parameter measurement
- In the future coaxial connectors will get smaller



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