Planning of RF measurements and prototype II usage

The conclusion after measurements done is that the carbon wire burns out due to excessive heating (coupling to cavity resonances).

Therefore we need to attenuate resonances and to perform NEW simulations.

The following step is to modify the actual system and to perform new measurements.
The idea is to install 3 new feedthroughs (with 120° symmetry if mechanical restrictions allow) and to use together with the all-mode-coupler.
Feedthroughs will be used to have the desired resistance over the gap but to place the resistors outside vacuum.

Planning proposal:
01.07-13.08: mechanical modification
14.08-28.08: measurements

E.Piselli – L.Timeo

Additional slides…

Update on SPS Wire Scanner Prototype Measurements

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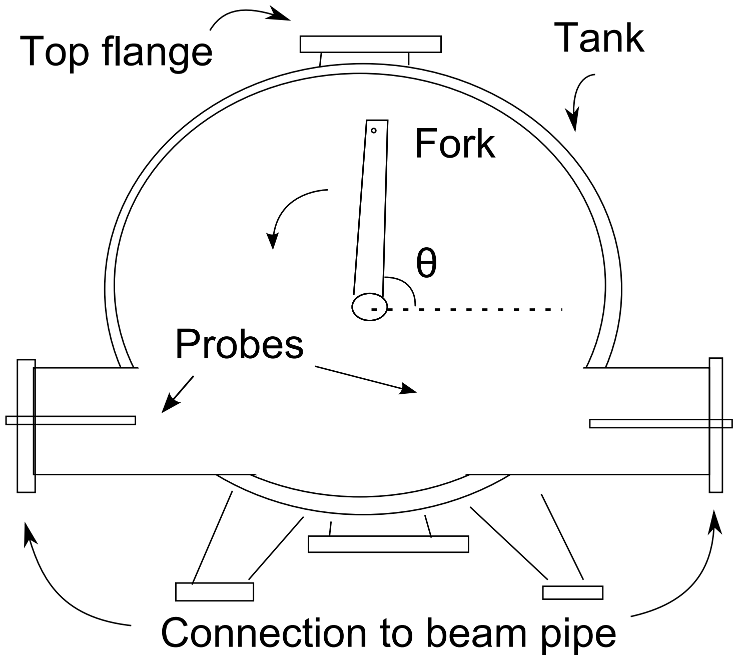
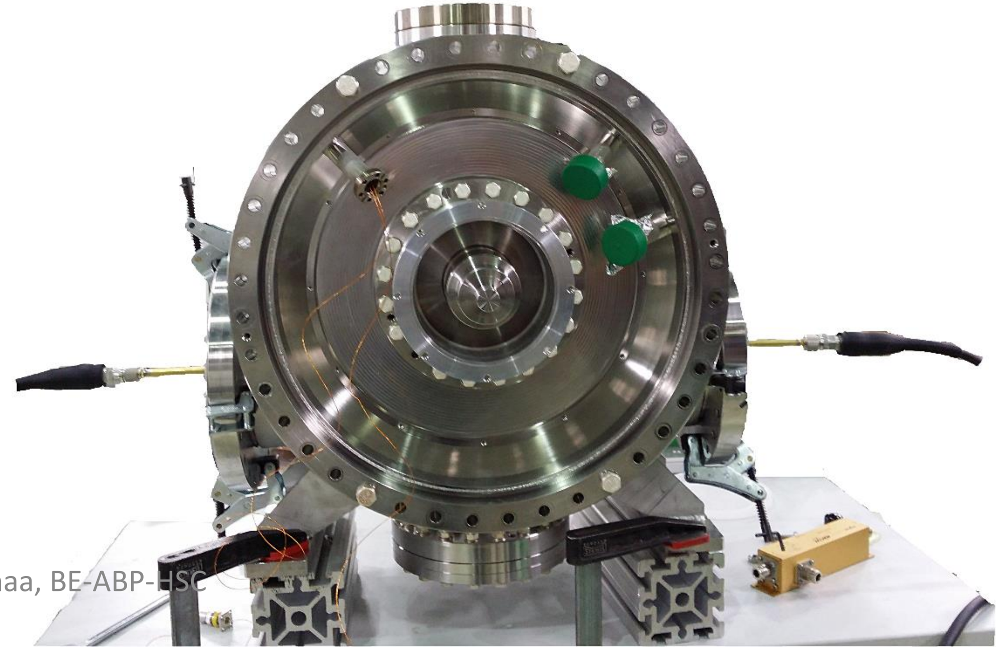
Outline

- Introduction
- Measurement Setup
- Methods/Tools/Approach
- Analysis/Results
- Final Words

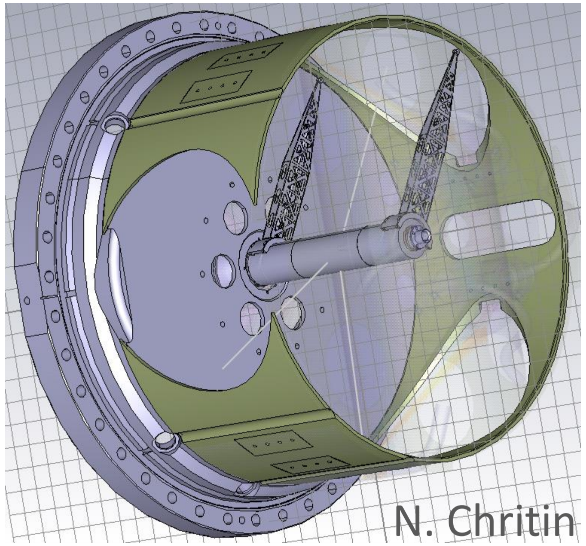
SPS Wire Scanner Structure

- Side flanges: Connect the tank to the beam pipe.
- Top, bottom, back flanges: Mode coupling, vacuum pumping.
- The fork: Rotates around the centre of the tank.
- The tank: Vacuum container.



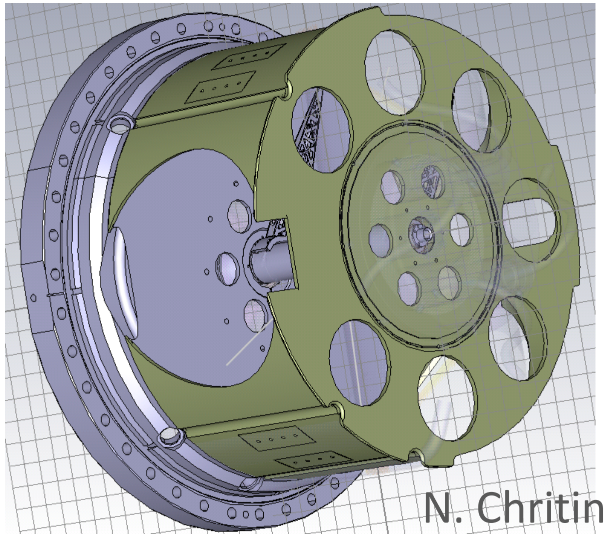


SPS Wire Scanner Drum

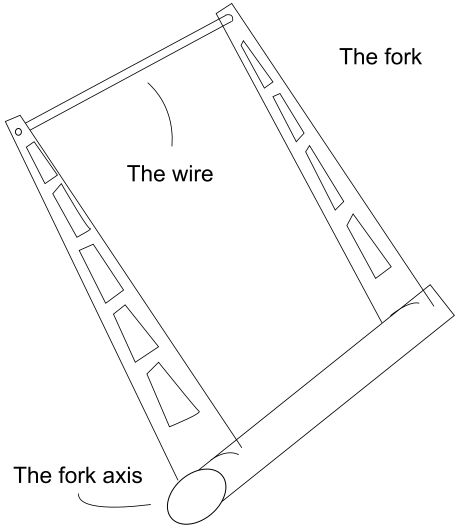


- The drum is the support for the scanning mechanism.
- It allows easy removal of the wire scanner system in case of e.g. wire breakage
- There is a gap between the drum and the tank

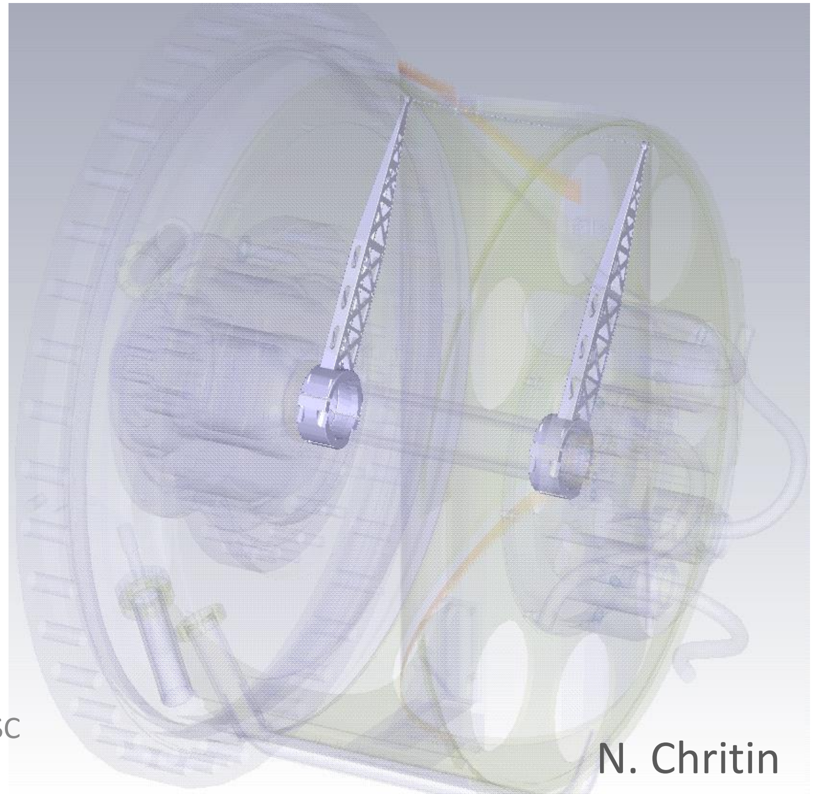
⟹The outer cavity and the inserted drum build a re-entrant-type cavity



SPS Wire Scanner Fork



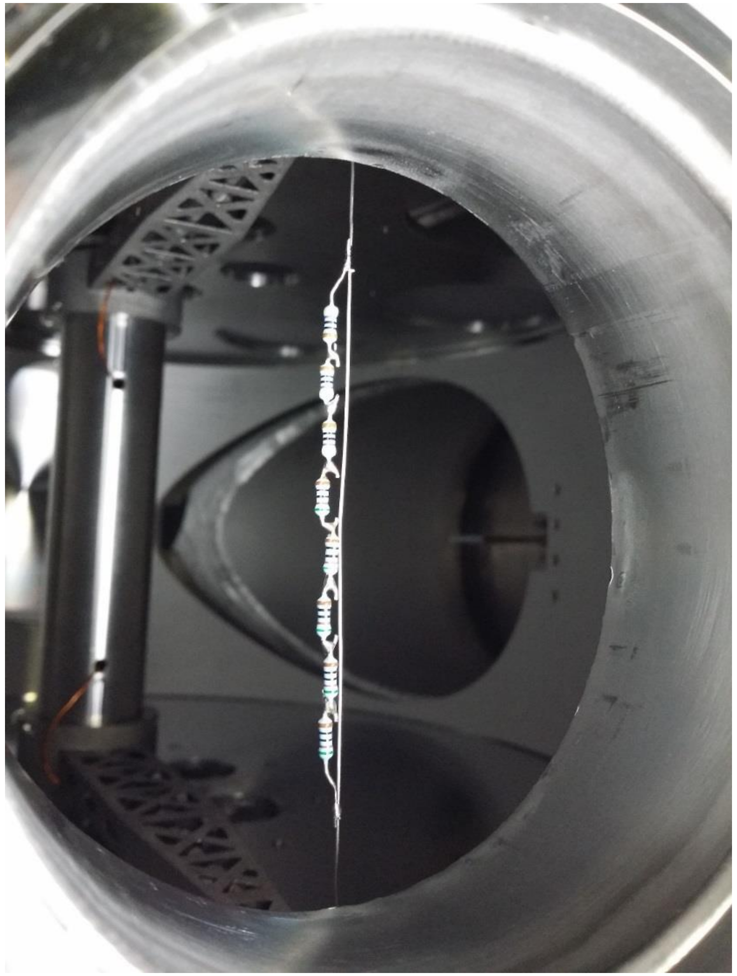
- The scanner consists of a fork and a wire.
- The wire is insulated from the fork.
- It couples electromagnetically to cavity resonances.
- For mechanical reasons we don’t use carbon wire *for measurements*.
- PROBLEM: Copper wire has very different electrical properties.



Carbon-Like Wire

- PICTURE : View from the top flange.
- PICTURE: New wire during assembly. Original wire is *cut* away after the assembly phase.
- SOLUTION: Replace the copper wire with a series of resistors summing up to 4 kOhm

$\Longrightarrow$ mimic the electrical properties of carbon wire

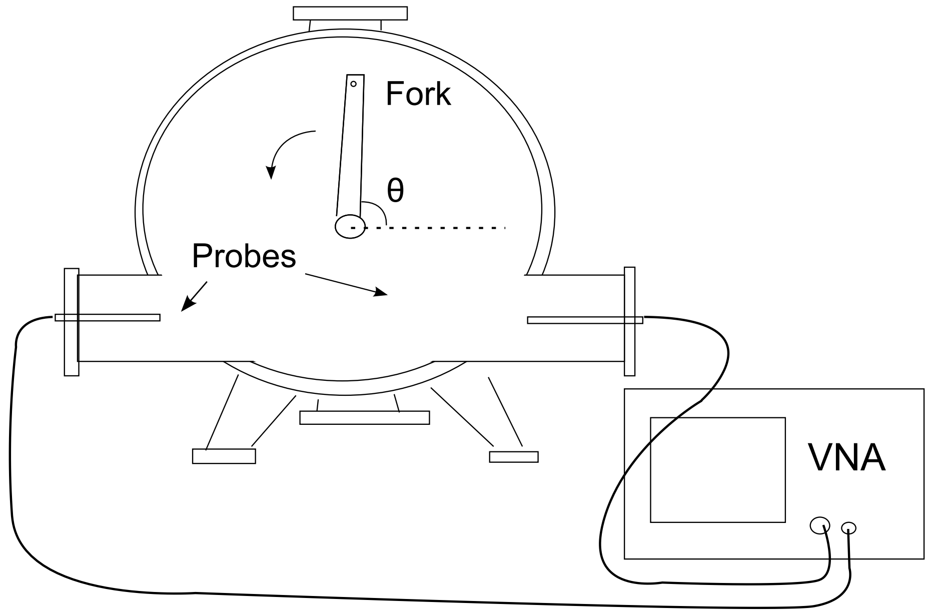


Motivation

- PROBLEM 1: The carbon wire of the fork of SPS wire scanner burns out due to excessive power dissipation on it.
- PROBLEM 2: Structure possibly creates an impedance problem.
- The structure of the wire scanner allows beam to excite resonances that couple to the wire $\Longrightarrow$ attenuate resonances
- It is critical to find out which of the beam induced cavity resonances are harmful to the wire and find a solution to dampen them.

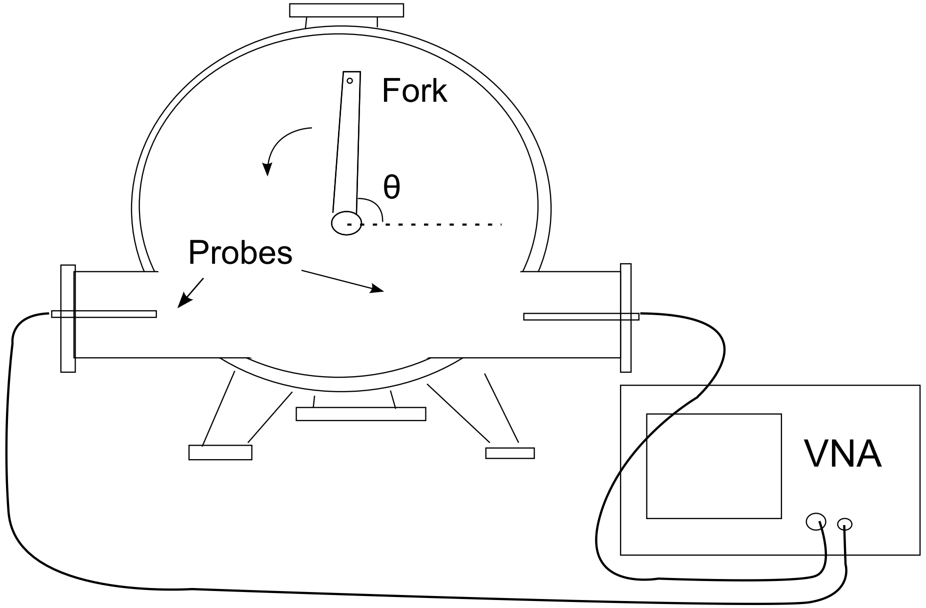
Measurement Setup - 2-Port Measurement

- 2-Port S-parameter measurement:
- Port 1: Left probe
- Port 2: Right probe
- The probes are set along the beam line
- Transmission (or S_12, S_21): Cavity modes excited and seen from the probes.
- Reflection (S_11 or S_22) : Coupling strength between the cavity and the probe



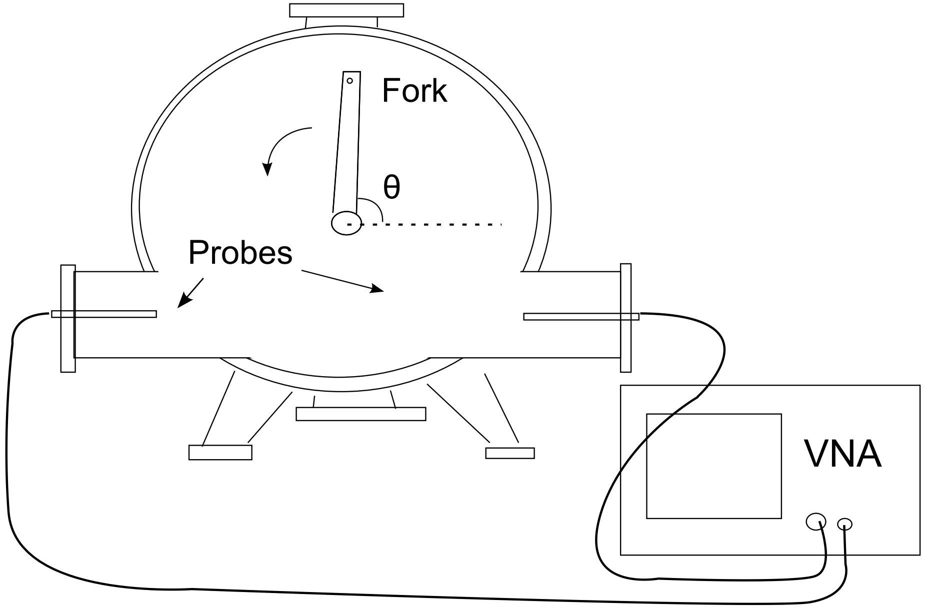
Measurement Setup - 4-Port Measurement With Hybrid

- 4-Port S-parameter measurement:
- Port 1: Left probe
- Port 2: Right probe
- Port 3: Delta-signal (from the hybrid connected to the wire)
- Port 4: Sum-signal
- Delta: Coupling of the fork to electric fields
- Sum: Coupling of the fork to magnetic fields



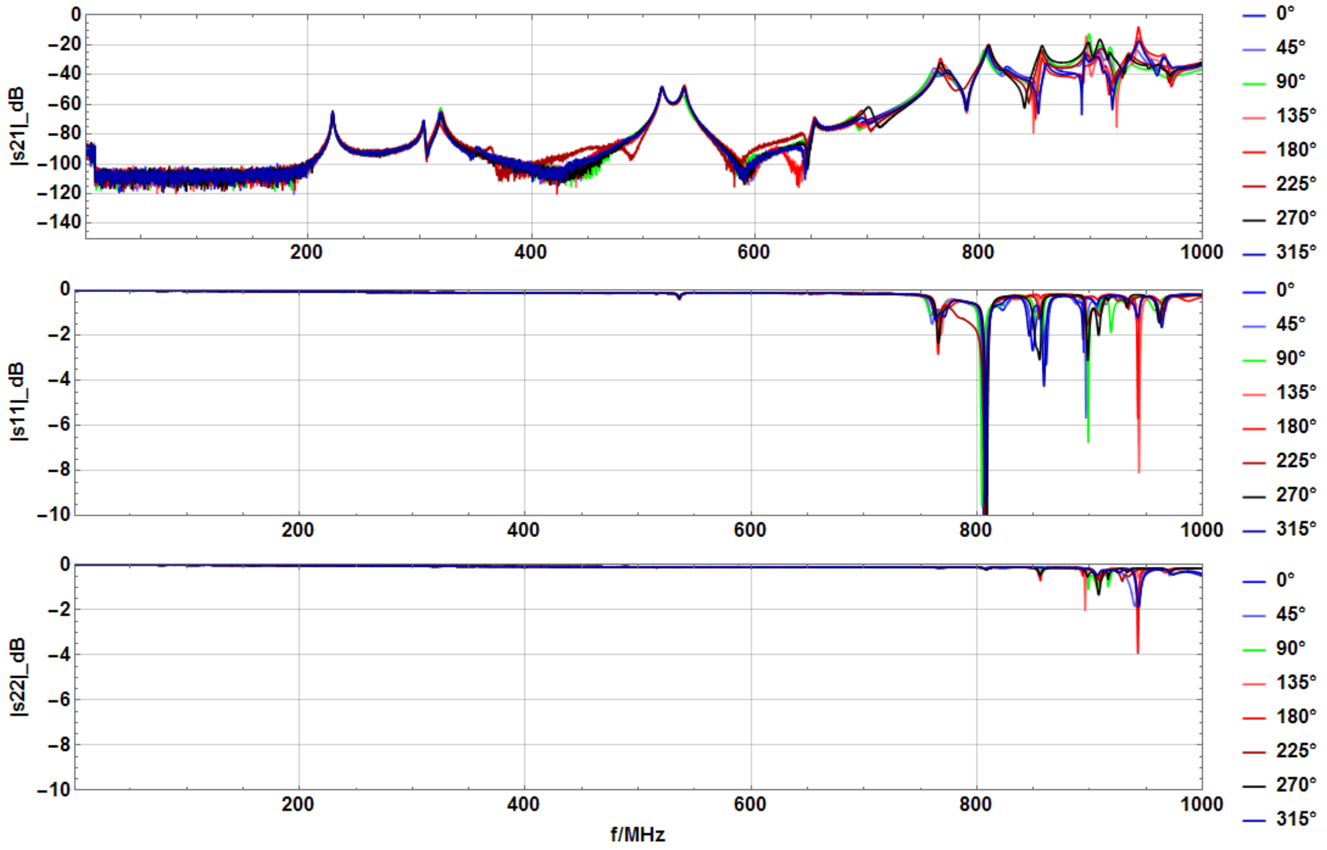
Measurement Setup

- Aim to perturb the system as little as possible (S_11 and S_22).
- Following measurements:
- Functional measurement: Rotate the fork to see which resonances couple with the fork and how much (2-port meas.).



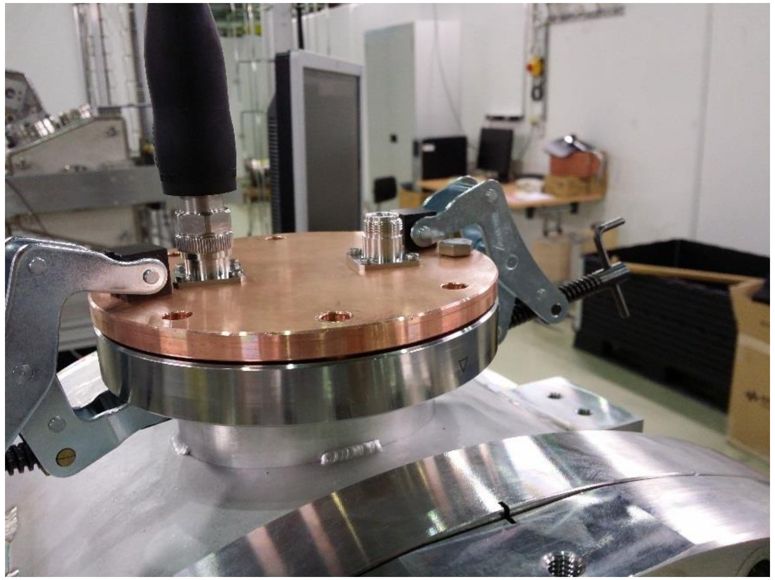
Fork Angle Dependency

- Transmission measurement on plain structure in function of the fork position
- First resonances unaffected by the fork position
- The fork seems to strongly couple at high frequencies
- At high frequencies the probes are too strongly coupled on resonances -> modify couplers



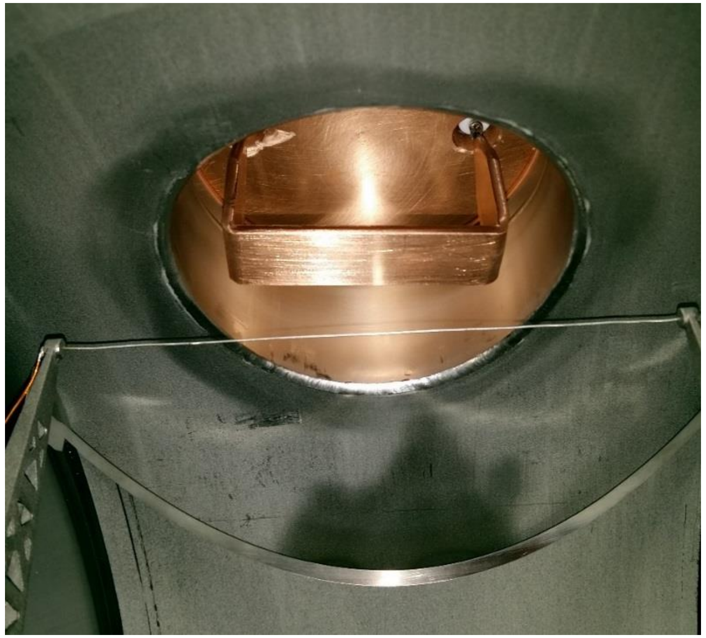
Mode Damping – Top Flange

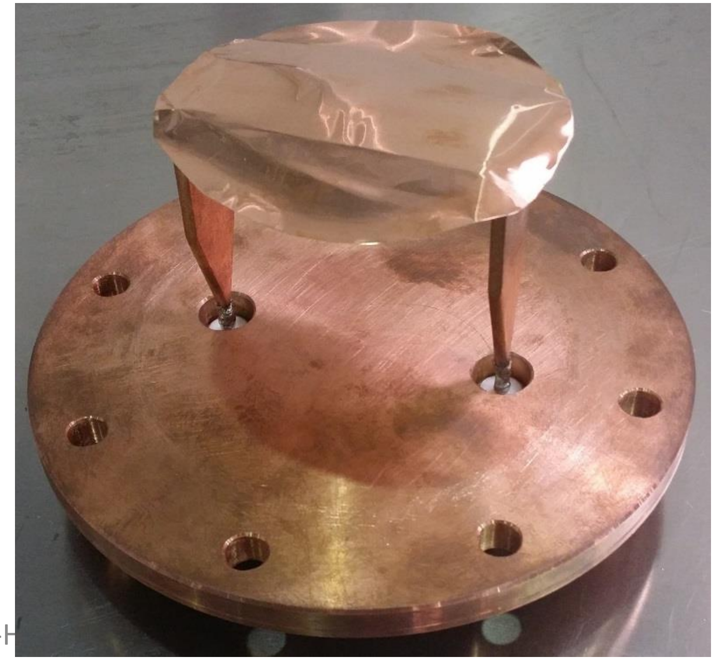
- PICTURE: Top flange and the coupler.
- We insert an *all-mode-coupler* from the top flange in order to attenuate oscillations inside the cavity.
- The coupler acts on both electric and magnetic fields (thus an all-mode-coupler).
- Coupling ability limited by the depth we can penetrate into the cavity (not too close to the wire).



Mode Damping – Top Flange

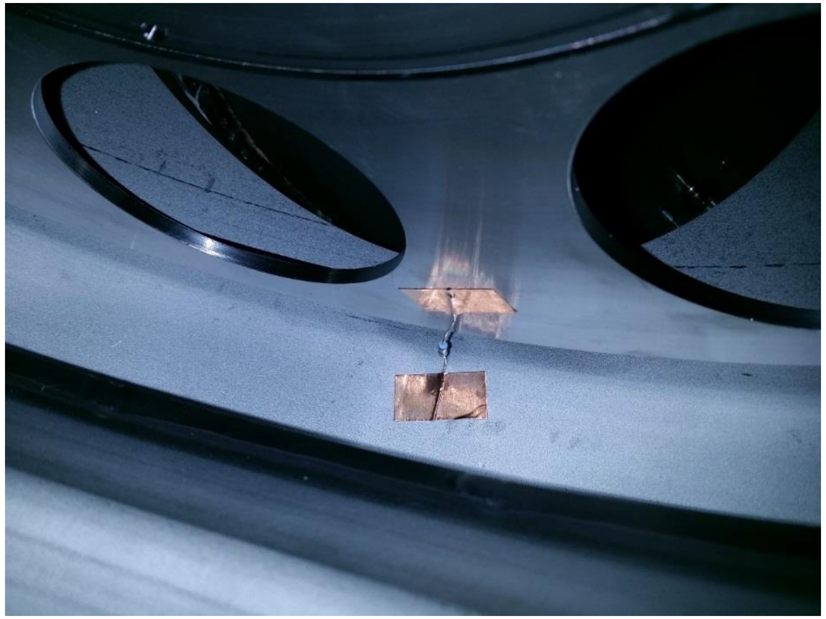
- PICTURE 1: The fork, the wire and the coupler seen from the beam axis.
- NOTE: Wire limits the penetration depth of the coupler.
- PICTURE 2: Coupling to electric fields was further enhanced by increasing the surface area with a copper foil
- Some modes still unaltered -> insufficient alone





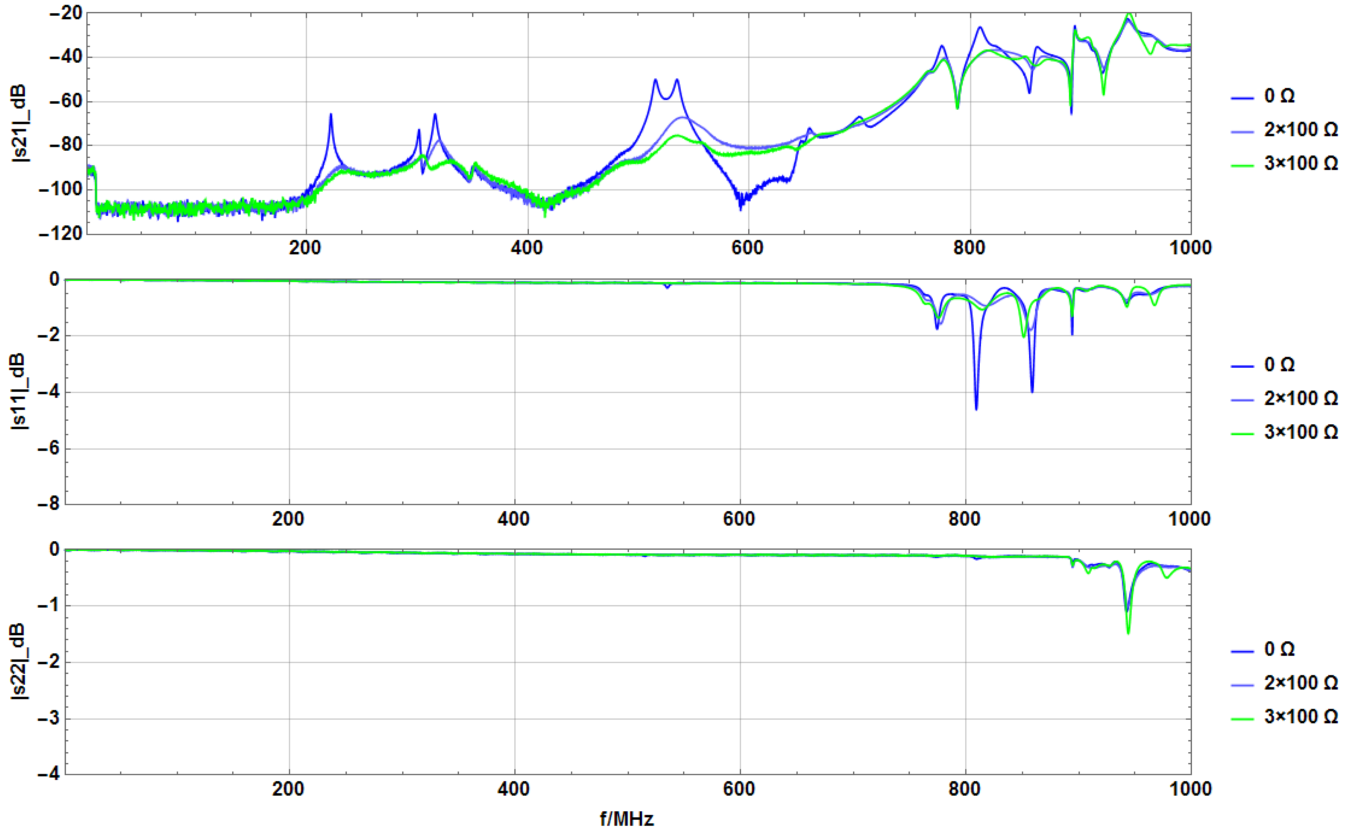
Lossy contact over the gap

- PICTURE: Resistor inserted to bridge the gap between the tank and the drum (attached with copper tape).
- Test of a possible solution by inserting a number of resistors of 10, 50 and 100 Ohm over the gap.
- The results were promising independent of the resistance within 10-100 Ohm.



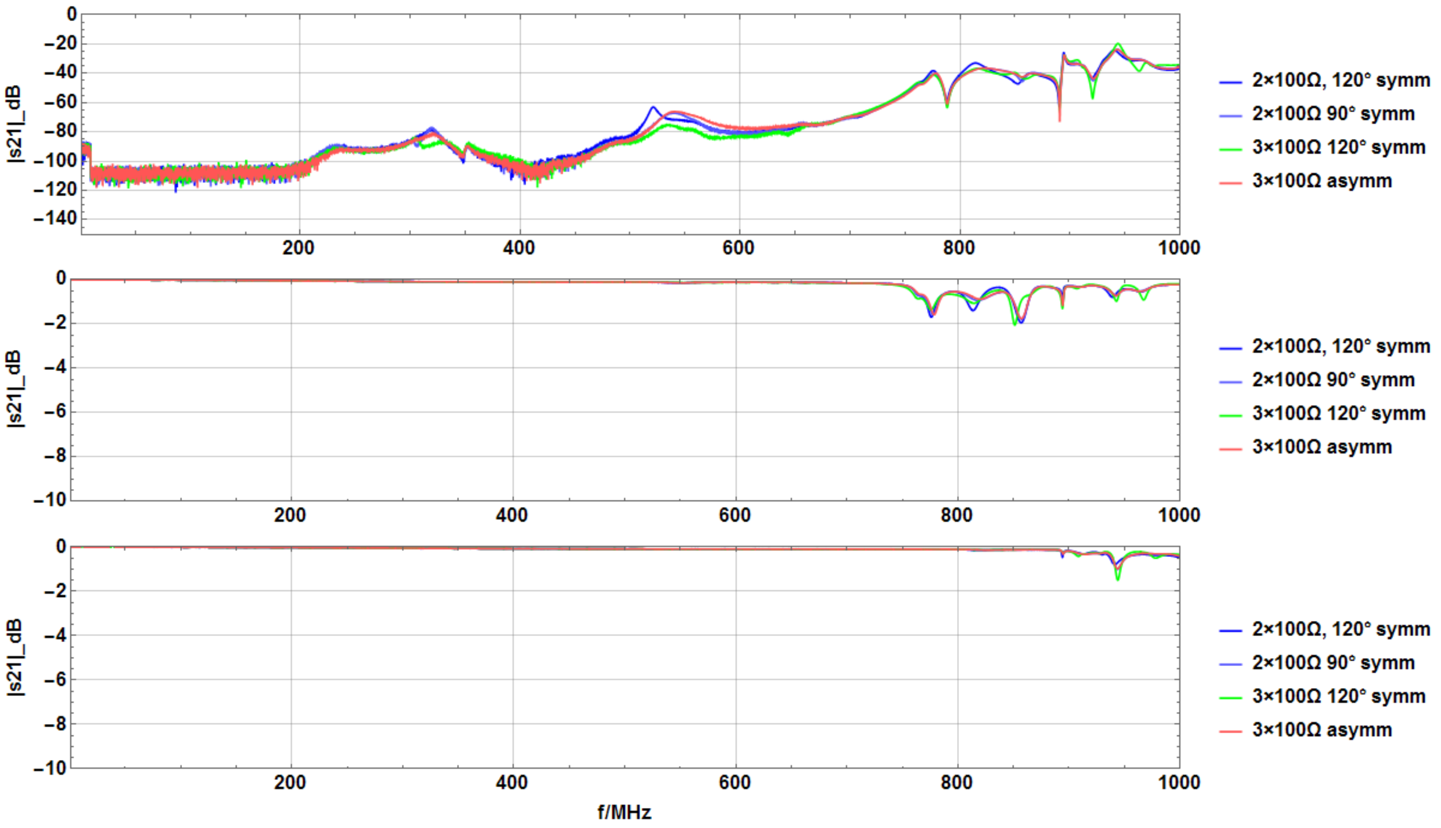
Resistor Number Dependency

- Good damping is achieved with already two resistors.
- Three resistors really perform well up to 700 MHz



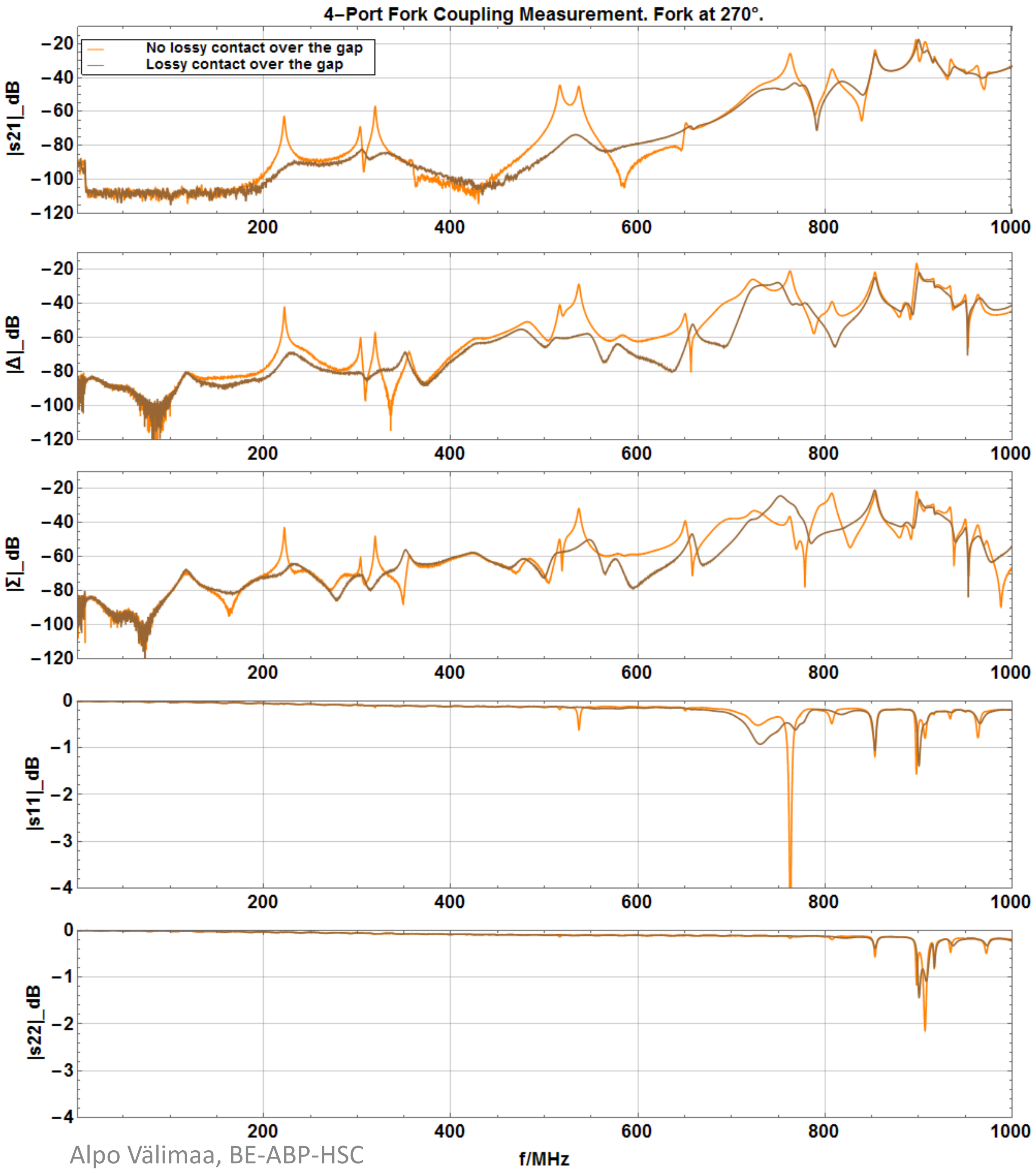
Resistor Position Dependency

- Resistor positioning has some visible effect.
- Better damping is achieved with symmetric positioning.



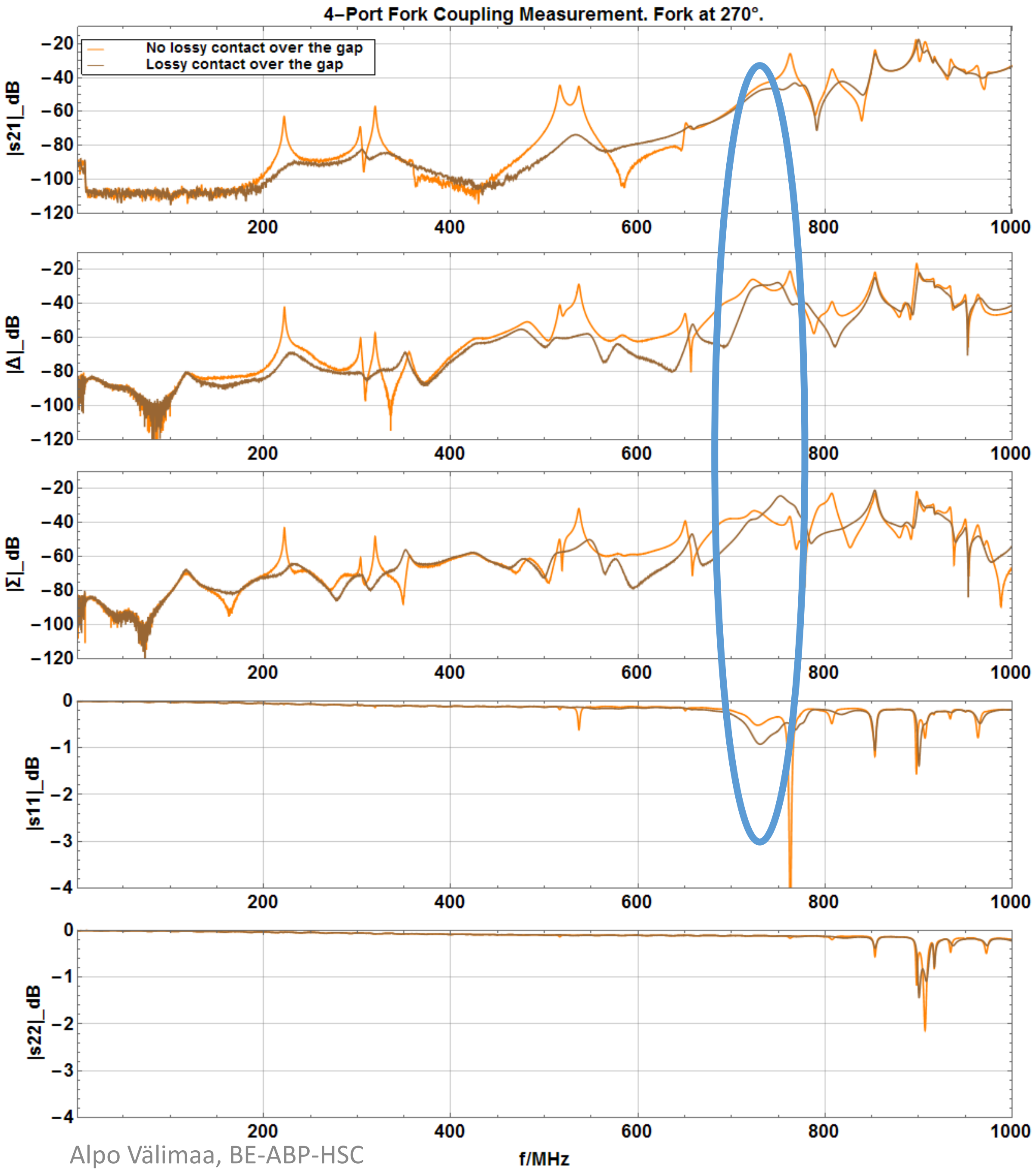
Lossy Contact Over The Gap – 3x100 Ohm At 270°

- S_13 (Delta) and S_14 (Sum): Magnetic and electrical coupling of the fork to resonances excited by the probe 1.



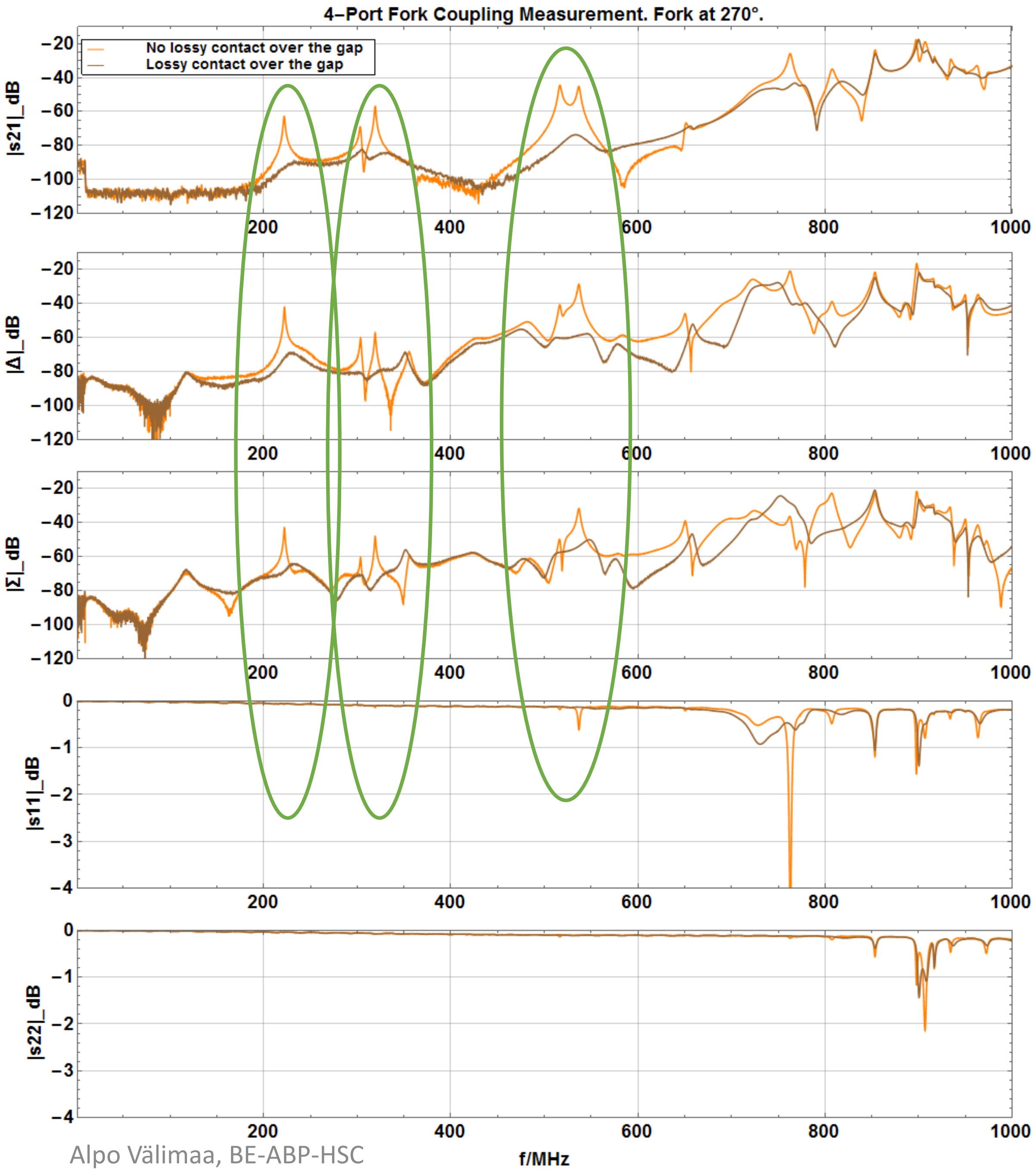
Lossy Contact Over The Gap – 3x100 Ohm At 270°

- S_13 (Delta) and S_14 (Sum): Magnetic and electrical coupling of the fork to resonances excited by the probe 1.
- Strong coupling of the probe 1 near 700 MHz disturbs the measurement; Elsewhere good data.



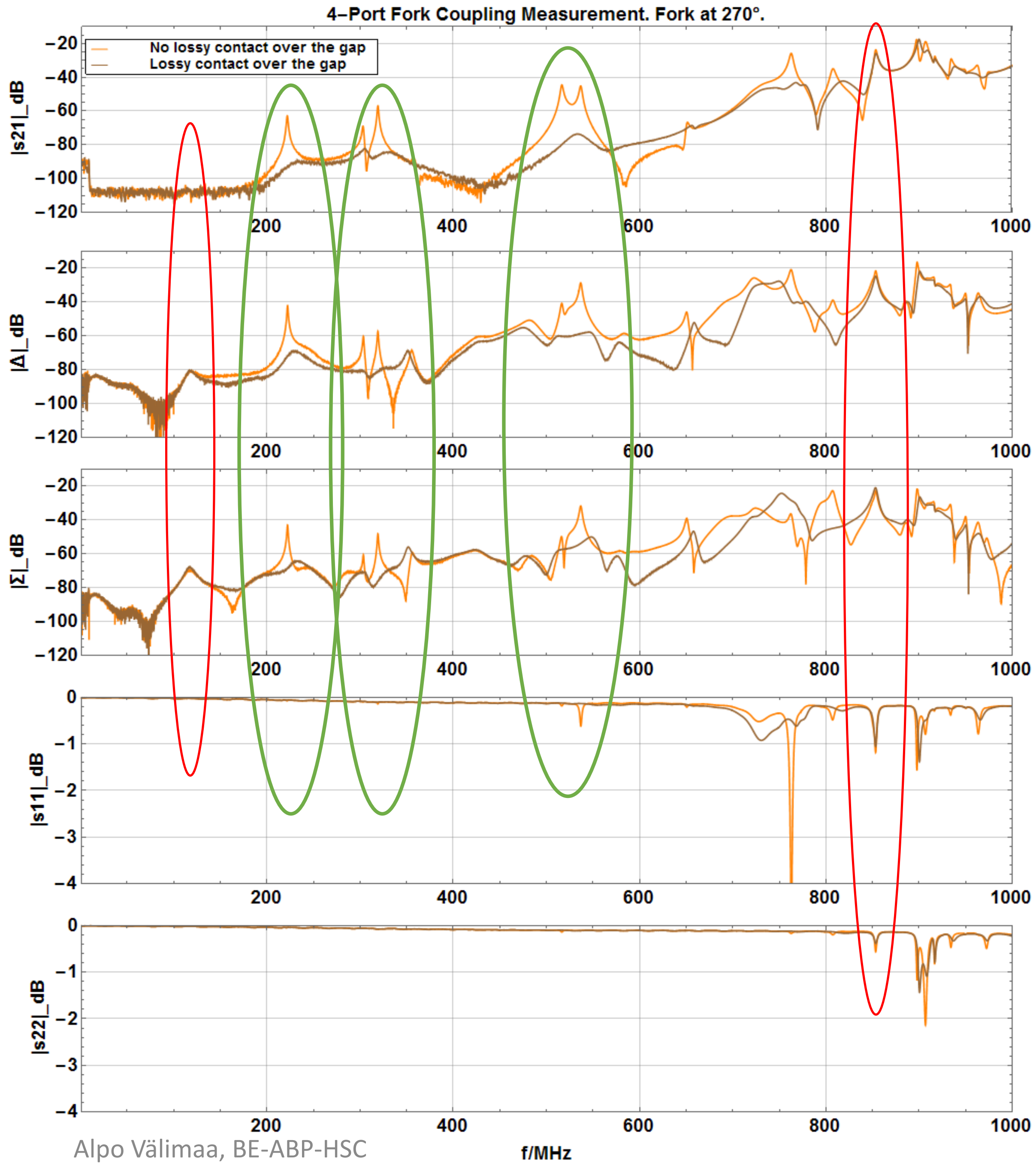
Lossy Contact Over The Gap – 3x100 Ohm At 270°

- Green: Lossy contact performs well



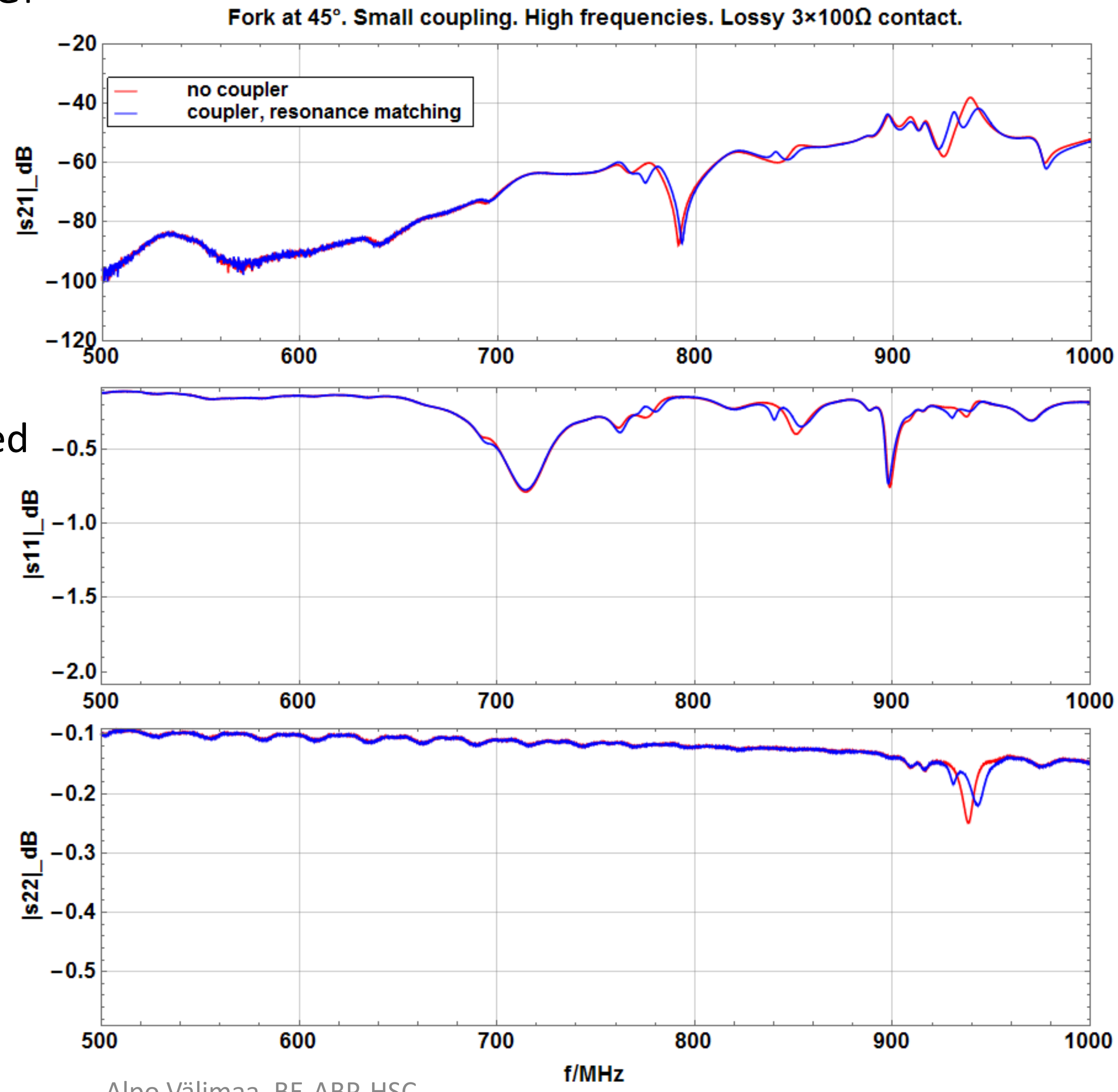
Lossy Contact Over The Gap – 3x100 Ohm At 270°

- Green: Lossy contact performs well
- Red: Little or no visible effect



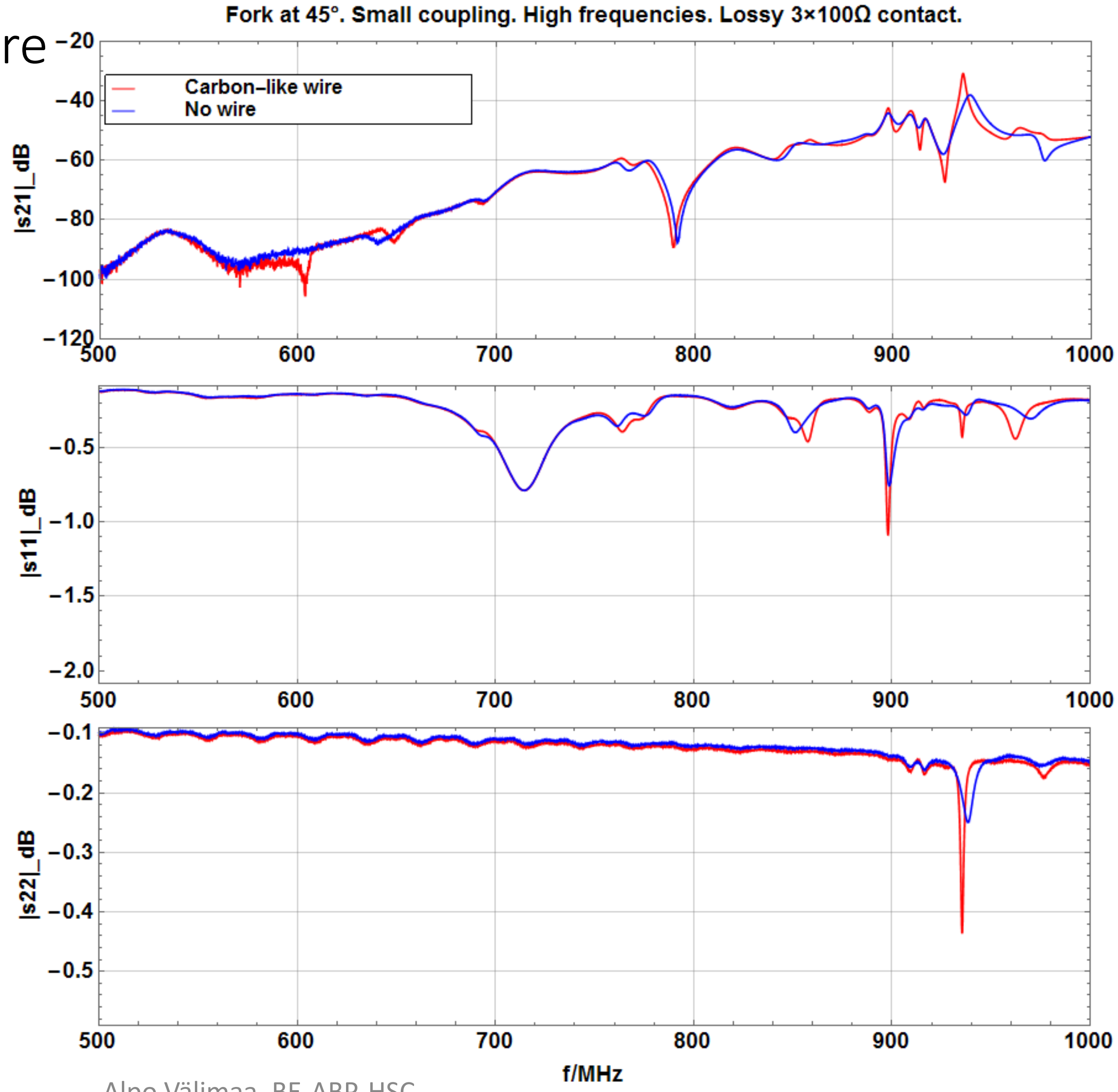
The All-Mode-Coupler – Performance Example

- PICTURE: Example of matching the coupler on a targeted resonance
- More information needed to know what is sufficient!



The Effect Of The Wire

- PICTURE: With and without wire.



Proposed Solution In The Low Frequency Range - Wire Heating & Impedance Problem

- Add feedthroughs to have the desired resistance over the gap but to place the resistors outside vacuum
- Place them with 120 degree symmetry – if mechanical restrictions allow – to avoid azimuthal modes of lowest order
- Details are to be optimized in simulations

Proposed (Partial) Solution In The High Frequency Range - Wire Heating (& Impedance Problem?)

- Find the resonances which to dampen with the all-mode-coupler.

Conclusions/Following Steps

- The carbon wire burns out due to excessive heating (coupling to cavity resonances)

⟹ attenuate resonances

⟹ proposed solution: feedthroughs & the all-mode-coupler

⟹ simulations to be done

- Impedance problem can be quantified when simulations match measurements