

# CERN practical days - RF

09:00

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# Outline

## 1 Forenoon Session

- Band Pass Filter
- Strip-Line BPM
- RF - Cavities

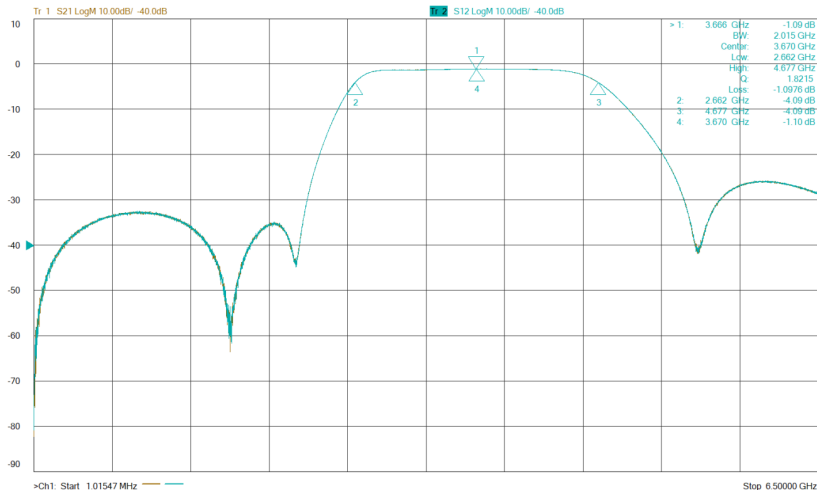
## 2 Afternoon Session

- Useless Repetition
- Coupling of an RF Cavity

## 3 Resume

## 4 Appendix

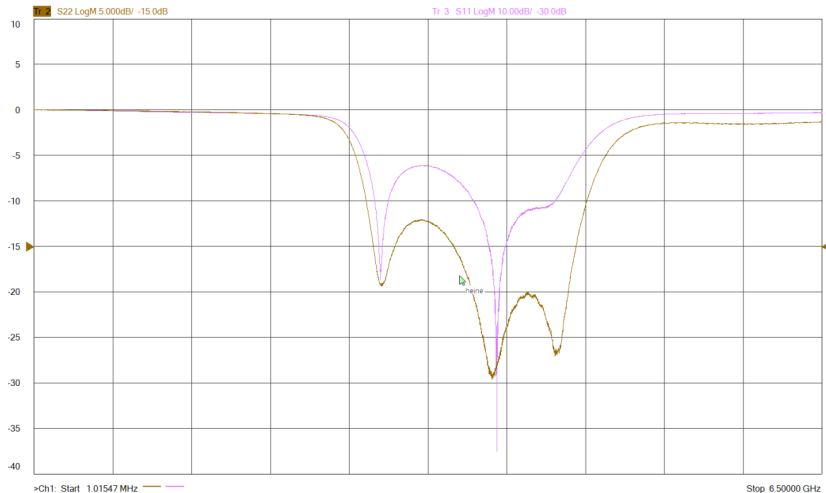
# Band Pass Filter (1) - Transmission $S_{12}$ , $S_{21}$



$$BW = 2.015 \text{ GHz}, \quad f = 2.66 \text{ GHz} \dots 4.67 \text{ GHz}$$

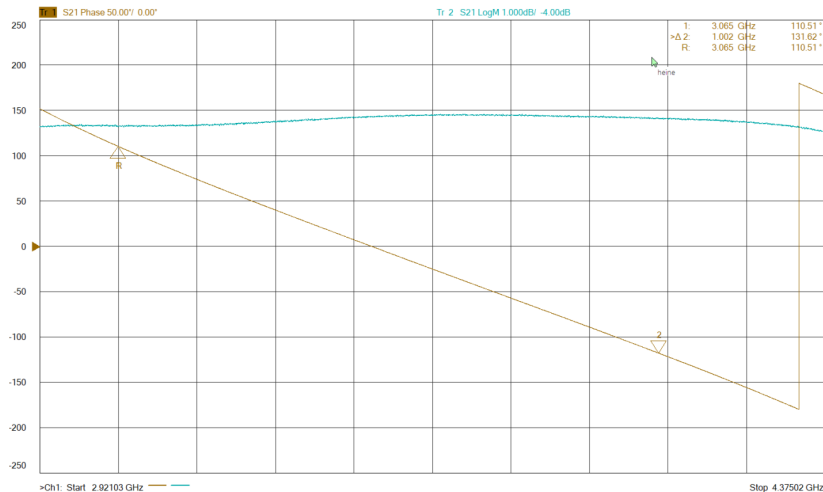
$$S_{21} \approx S_{12} \Rightarrow \text{Reciprocal}$$

# Band Pass Filter (2) - Input/Output Reflection $S_{11}$ , $S_{22}$



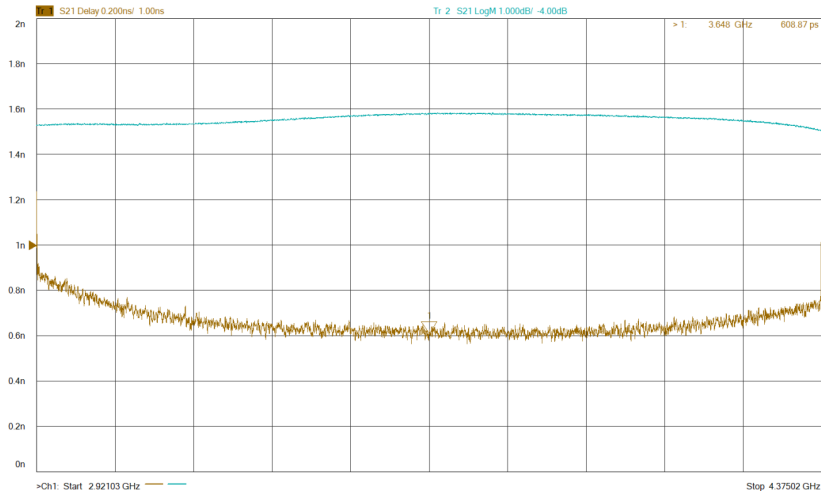
$S_{11} \neq S_{22} \Rightarrow$  Non symmetric

# Band Pass Filter (3) - Phase $\angle S_{12}$



$$t_g = -\frac{d}{d\omega} \angle S_{12} \approx -\frac{\Delta \angle S_{12} [\text{rad}]}{\Delta \omega} = \frac{(360^\circ - 131.62^\circ) \cdot \pi/180}{2\pi \cdot 1.002 \text{ GHz}} = 633 \text{ ps}$$

# Band Pass Filter (4) - Group Delay $t_g$



From group delay plot:  $t_g = 608.87$  ps

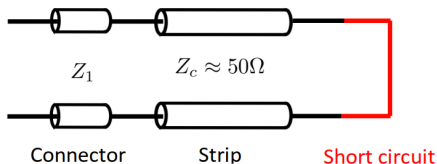
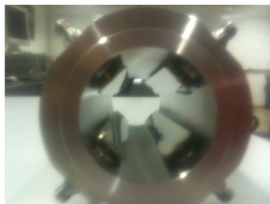
# Strip-Line BPM (1) - Intro

Reflectometry for 500 MHz and  $50\ \Omega$

a Connector

b Strip line

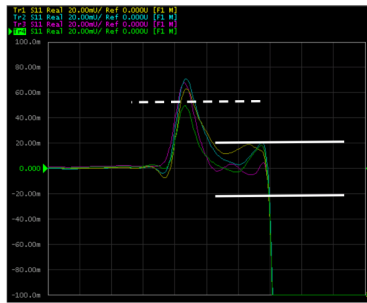
- ▶ Four 14 cm strips
- ▶ Short-circuit termination



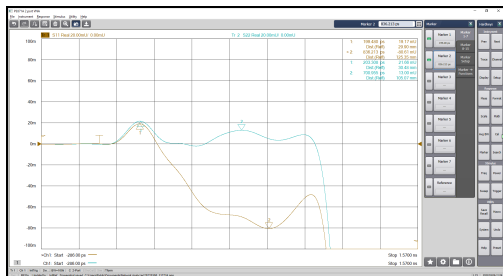
(a) Strip line: image and circuit

# Strip-Line BPM (2) - Time Domain Reflectometry

- Measuring  $S_{11}$  in time domain to check acceptance criteria
  - a Connector: +50 mU
  - b Strip line:  $\pm 20$  mU
- Strip line *blue* in specs, *gold* not in specs



(b) TDR Aim

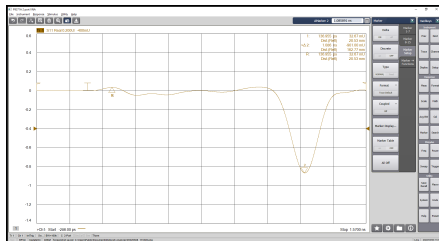


(c) TDR Reproduced

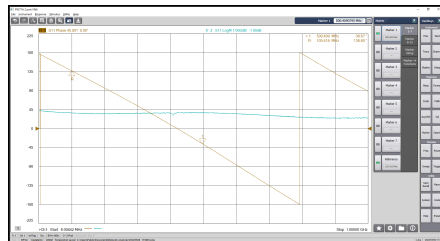


# Strip-Line BPM (3) - Frequency Domain Characterization

- Strip-line length from  $S_{11}$ 
  - ▶ from  $S_{11}$ : 1.086 ns, 162.77 mm
  - ▶ from phase: 1.218 ns, 182.58 mm
  - ▶ from group delay: 1.32 ns, 197.87 mm
- Cross-talk from  $S_{21}$ 
  - ▶ Maximum reflection of  $-25.25$  dB at 797.68 MHz
  - ▶ Reflection of  $-53.06$  dB at operation frequency 500 MHz



(d) Calculation from  $S_{11}$



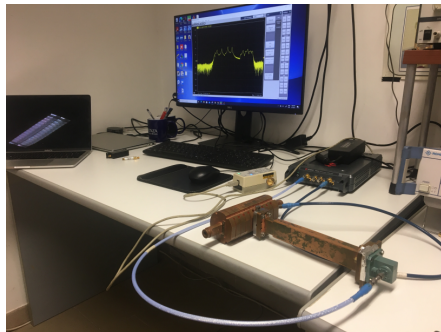
(e) Calculation from phase

# RF - cavities (1) - Intro

- Multi cell cavity in X-band
- Operating mode at 11.424 GHz
- Under coupled antenna



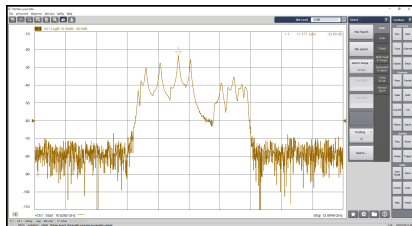
(f) Multi cell cavity



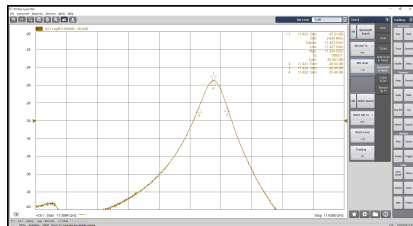
(g) Setup

# RF - cavities (2) - Transmission measurement

- Identify different modes
- Calculated  $Q$  from the 3 dB bandwidth: 3093



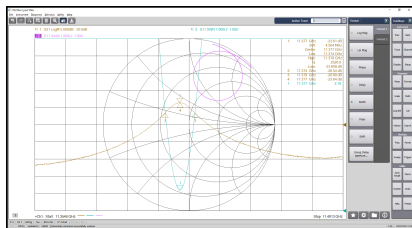
(h) All modes ( $S_{21}$ )



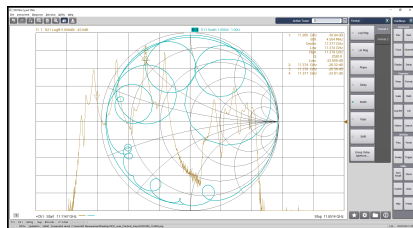
(i)  $Q$  for a certain mode

# RF - cavities (3) - Transmission measurement

- Identify SWR
- Under coupling ( $S_{11}$  in Smith Chart)



(j) Caption a



(k) Caption b

# Useless Repetition (Manfred Wendt)

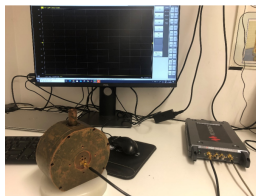
- Stuff
- More Stuff

# RF Cavity, Coupling, Smith Chart (Fritz Caspers)

- Two Antennas in cavity
  - ▶ Longitudinal field antenna
  - ▶ Coupling loop
- Under-, over- and critical coupling

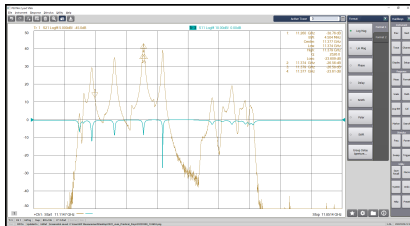
# Resume

- Network Analyser
  - ▶ Time and Frequency Domain
  - ▶ Scattering parameter, Impedance, SWR, phase
  - ▶ Calculation of Q, reflexion coefficient
- Spectrum Analyser (Modulation)
- Cavities
- Coupling
  - ▶ Under, over and critical coupling
  - ▶ Smith chart

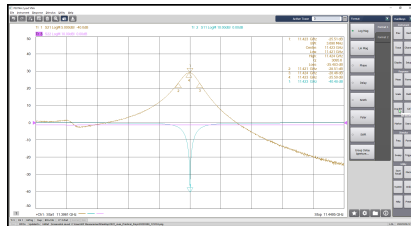


(1) Cavity setup

# Appendix (1) - Multi mode cavity



(m)



(n)