

# CERN practical days - RF

09:00

Ruben Heine    Marvin Noll

14.03.2022

# Outline

## 1 Forenoon Session

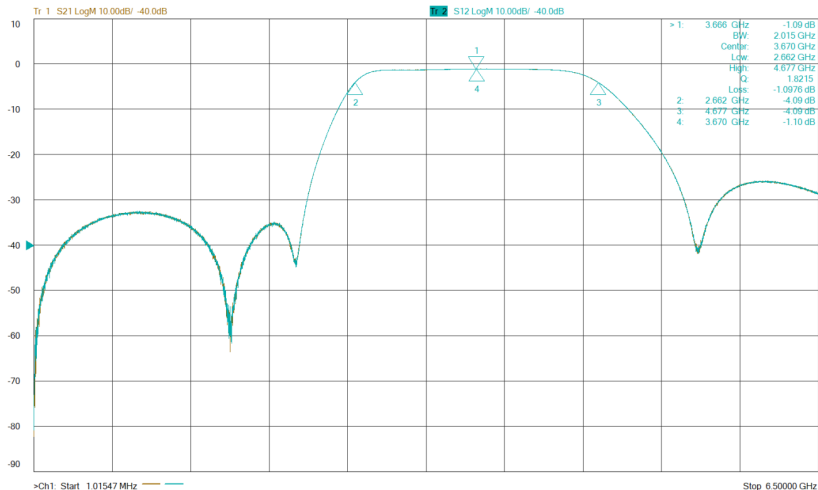
- Band Pass Filter
- Strip-Line BPM
- RF - Cavities

## 2 Afternoon Session

- Useless Repetition
- Coupling of an RF Cavity

## 3 Resume

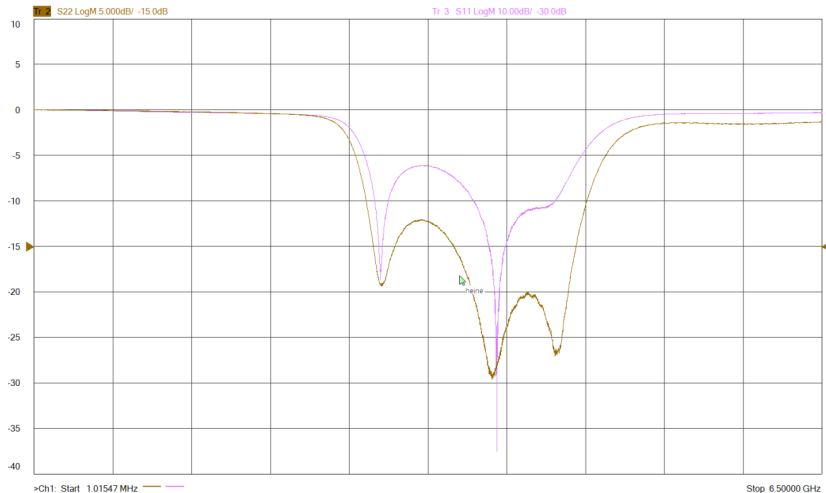
# Band Pass Filter (1) - Transmission $S_{12}$ , $S_{21}$



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

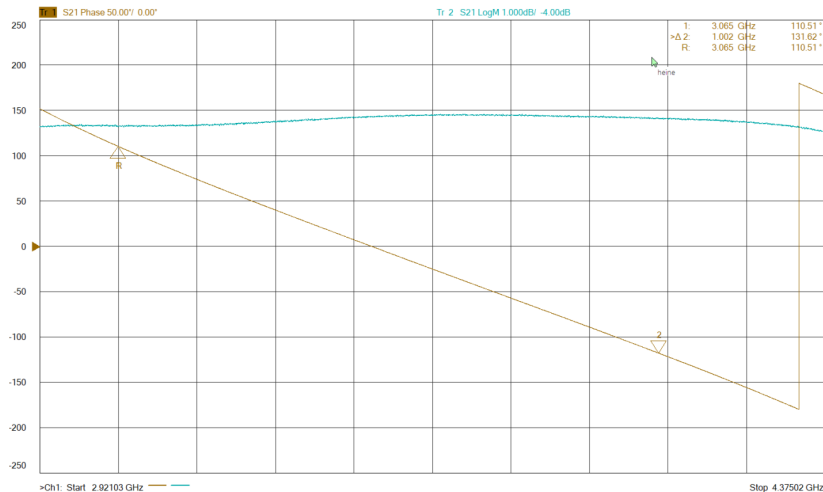
$$S_{21} \approx S_{12} \Rightarrow \text{Reciprocal}$$

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



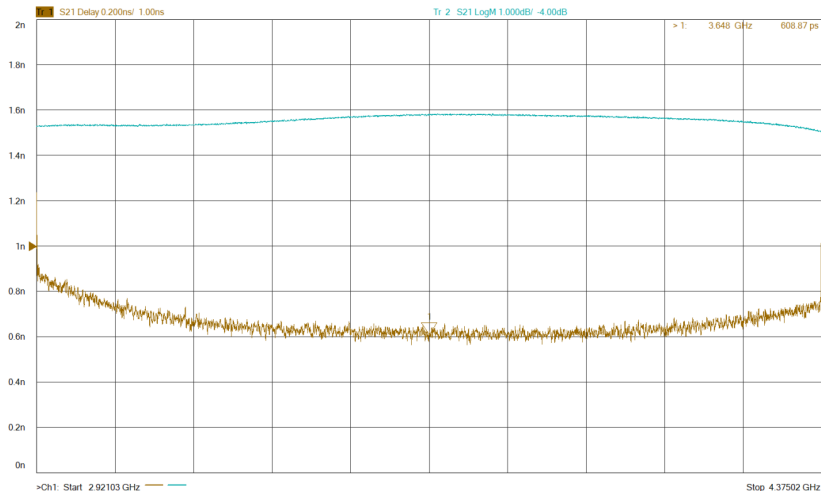
$S_{11} \neq S_{22} \Rightarrow$  Non symmetric

# 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 (3) - Group Delay $t_g$



From group delay plot:  $t_g = 608.87$  ps

# Strip-Line BPM (1) - Intro

Reflectometry for 500 MHz and 50 Ohm

a Connector

b Strip line

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

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

- Measuring S11 in time domain to check acceptance criteria
  - a Connector:  $+ 0.5$
  - b Strip line:  $-/+ 0.2$
- Repeat for all strip lines



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

- Strip-line length from S11
- Comparison with group delay
- Cross-talk from S21
  - ▶ Minimum at Hz

# RF - cavities (1) - Intro

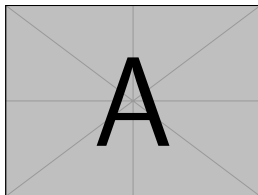
- Multi cell cavity in X-band
- Operating mode at 11.424 GHz
- Under coupled antenna

## RF - cavities (2) - Transmission measurement

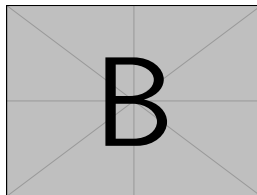
- Identify different modes
- Calculated  $Q$  from the  $3dB$  bandwidth
- Cross-talk from  $S_{21}$ 
  - ▶ Minimum at Hz

# Useless Repetition (Manfred Wendt)

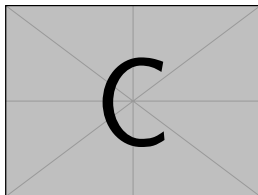
- Stuff
- More Stuff



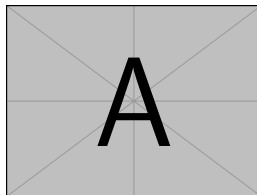
(a) Caption a



(b) Caption b



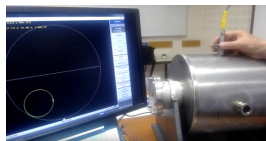
(c) Caption c



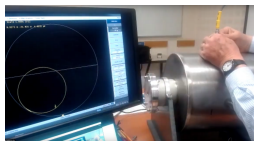
(d) Caption d

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

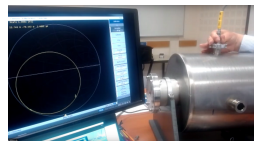
- Two Antennas in cavity
  - ▶ Longitudinal field antenna
  - ▶ Coupling loop
- Under-, over- and critical coupling



(a) Under Coupled



(b) Critically Coupled



(c) Over Coupled

# Resume

- Last session with Michele
- We learned, that...
- Whatever ...