

# 21st ESLS-RF Workshop

## PETRA III RF

### Easy disconnecting a faulty cavity from the transfer line

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**21st ESLS-RF Workshop**

Kraków, Nov.15-16.2017

- > Overview of PETRA- III & RF- system
- > Motivation of “shunting a cavity”
- > First strike: Insert stubs into the hybrid
- > Second strike: Shorten the hybrid to make it transparent
- > Proof of principle



# PETRA- III Overview

**PETRA:** 2304 m, 6 GeV, 100 mA TopUp, 14 undulators (30 beamlines)

Emittance (hor):  $\varepsilon = 1$  nmrاد ! User operation since 2009

Different fill patterns : 40, 60, 240, 320, 480, (960) bunches



**FLASH**

**DESY**

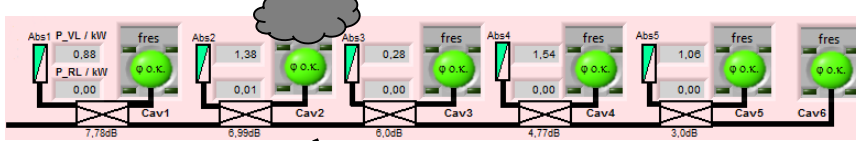
**XFEL**

20 MV,  
12 cavities (7 cell),  
ca. 1600 kW required,  
4 klystrons,  
max. 3200 kW

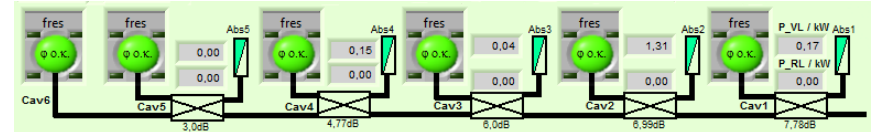
**rf section**

# The RF system

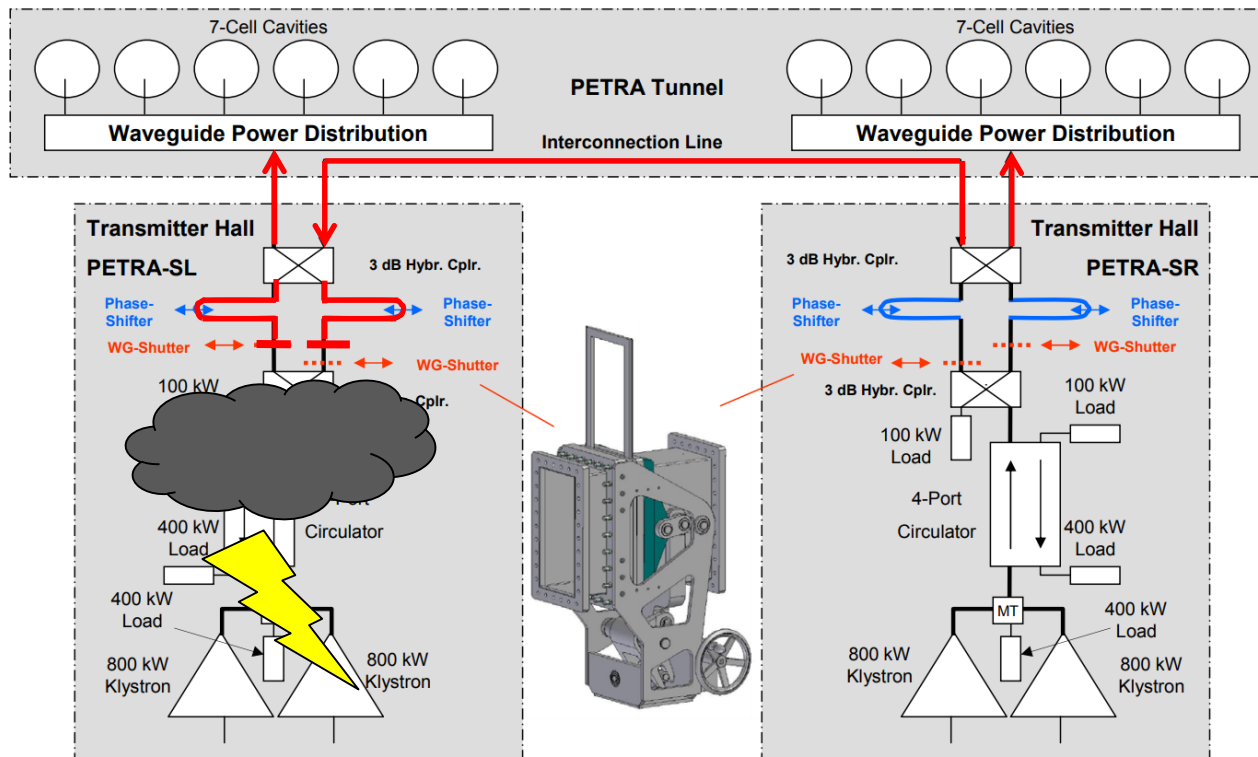
## Cavity line PETRA-SL



## Cavity line PETRA-SR



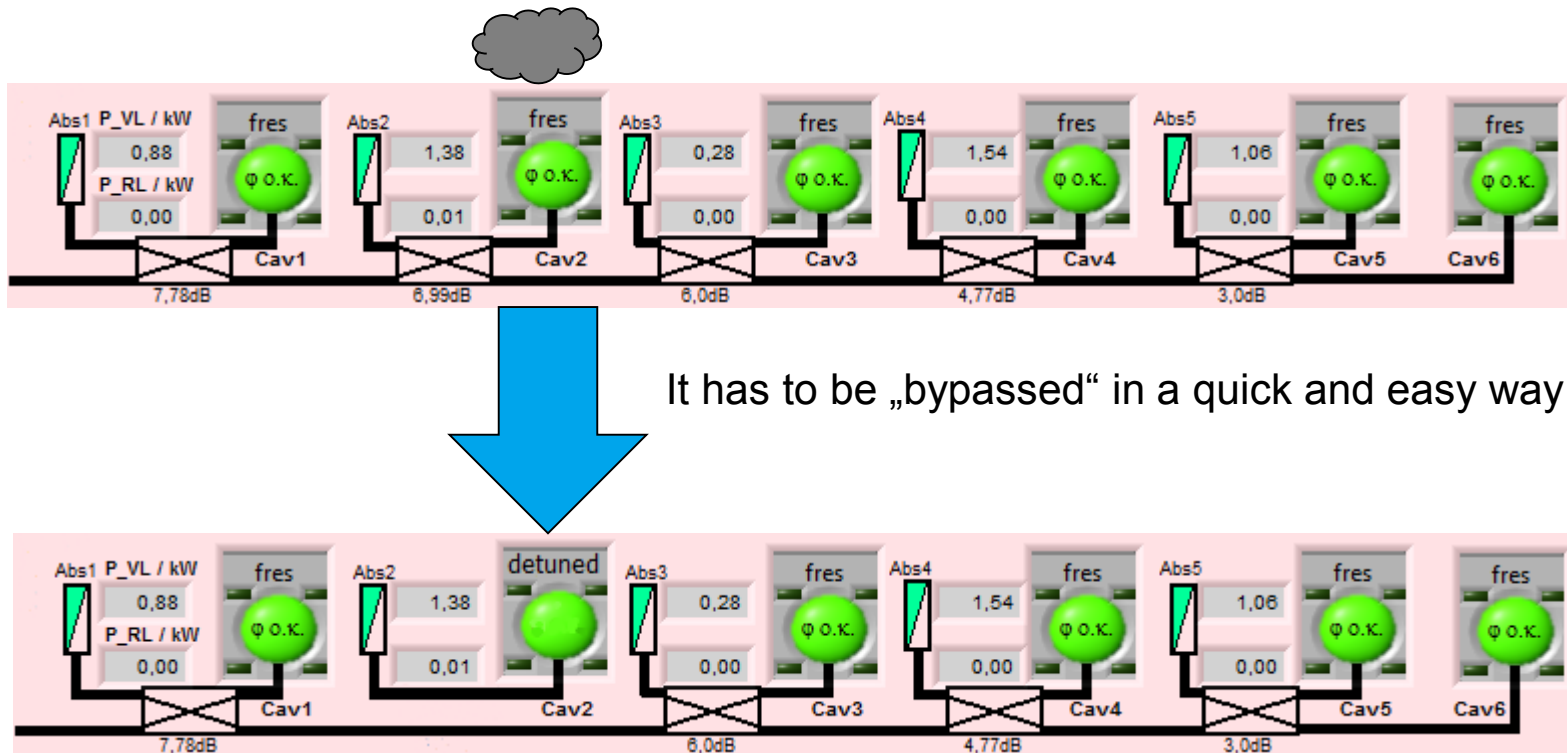
## Transmitter Interconnection



# How to get a malfunctioning Cavity powerless ?

If a Cavity has a problem due to power, e.g.

- arcing
- multipacting
- cooling
- tuning



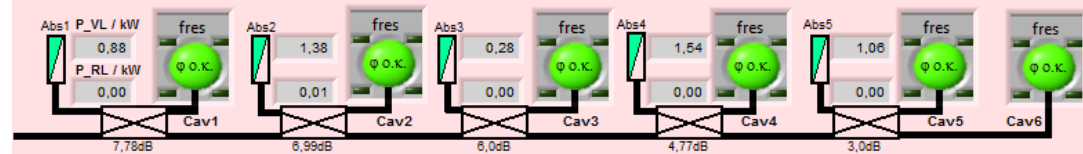
# Photo of PETRA- III Cavity- line

- Transfer- Line is 20 cm below the ceiling
- Hybrids are above the cavities
- Assembling / disassembling not nice



**A quick and easy method of bypassing a cavity is needed**

# Local situation (i.e. PE\_SL\_Cy4)



Cavity load

Hybrid for PE\_SL\_Cy4

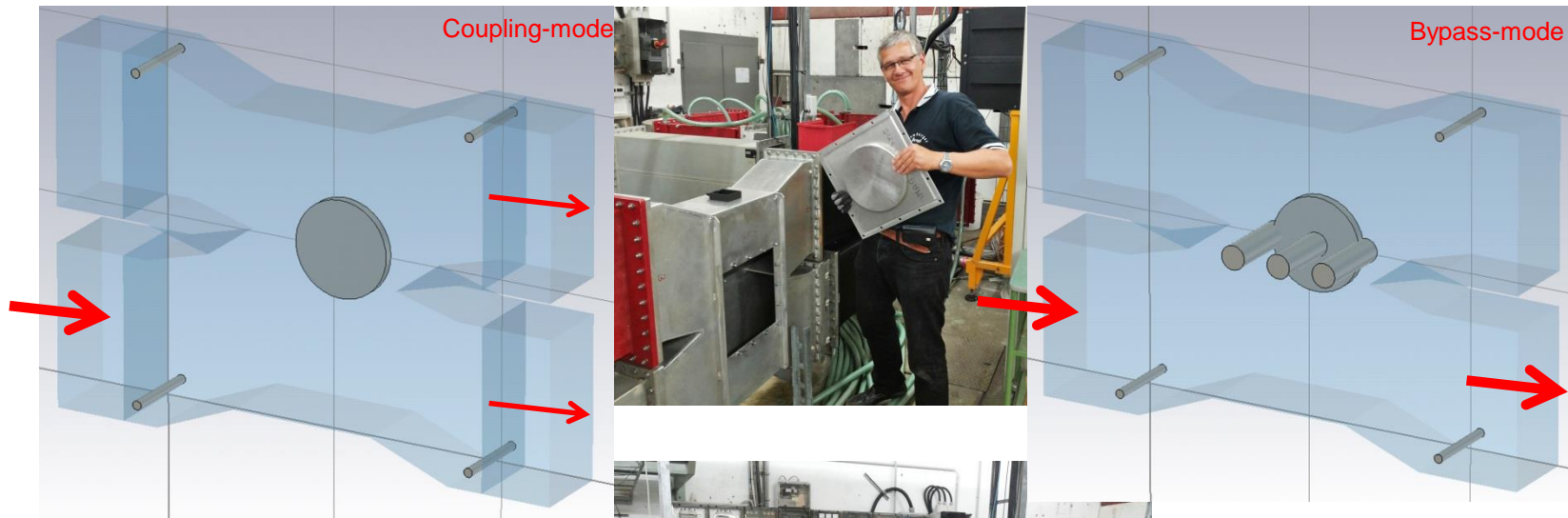
Transmission line, to the other cavities

Cavity branch of PE\_SL\_Cy4

Transmission line, at the outside of the tunnel

# First idea: Hybrids with “insertion devices”

Changing the coupling of a hybrid with different „insertion devices“



Mechanical:  
RF tightness should  
be manageable

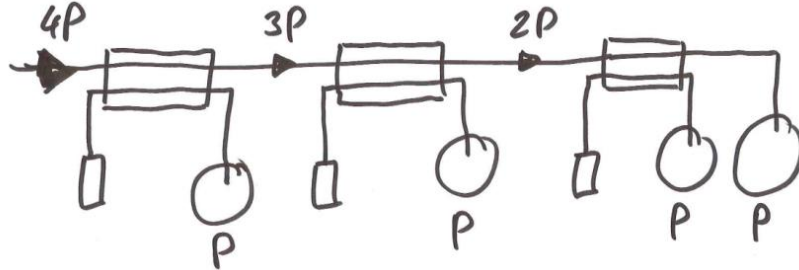
Electrical:  
Difference between  
coupling mode and  
bypass mode  
=> Show stopper



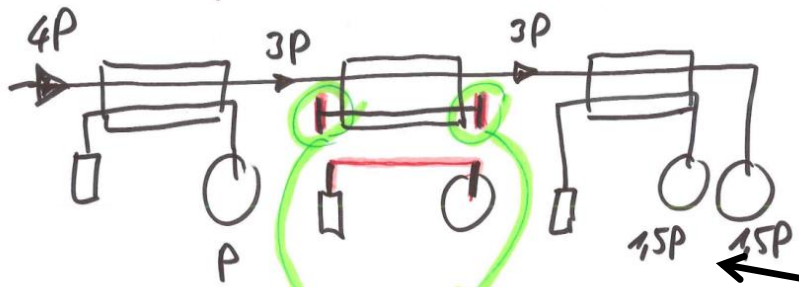


# Second idea: Shorten the Hybrid

## CAVITY HERAUSBRÜCKEN



**Cavity line, original**



**Cavity line, with one cavity shunted**

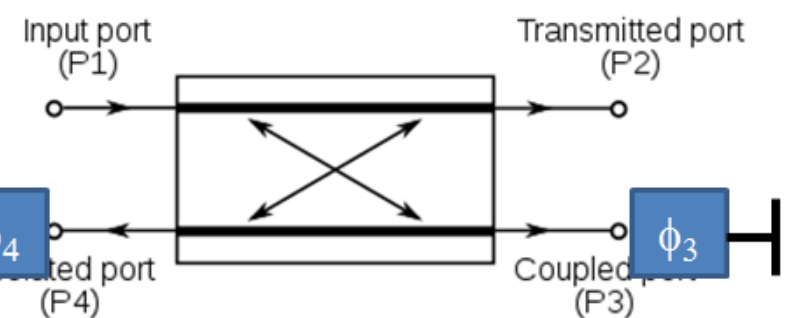
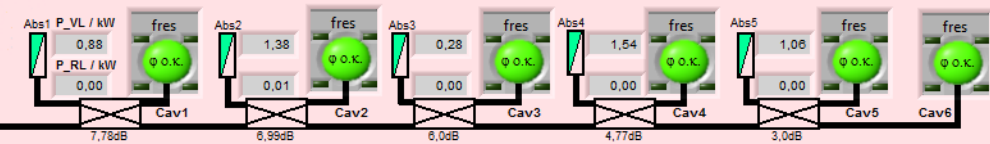
*WS-Ebenen kann man so wählen, dass der Koppler „durchsichtig“ wird*



The power of the „shunted Cavity“ is distributed to the following Cavities

Depending of the coupler, more or less „transparency“ can be achieved, But less power (voltage) is lost, compared to using a load instead of the cavity.

# Shorten the Hybrid (EXCEL- Simulation)



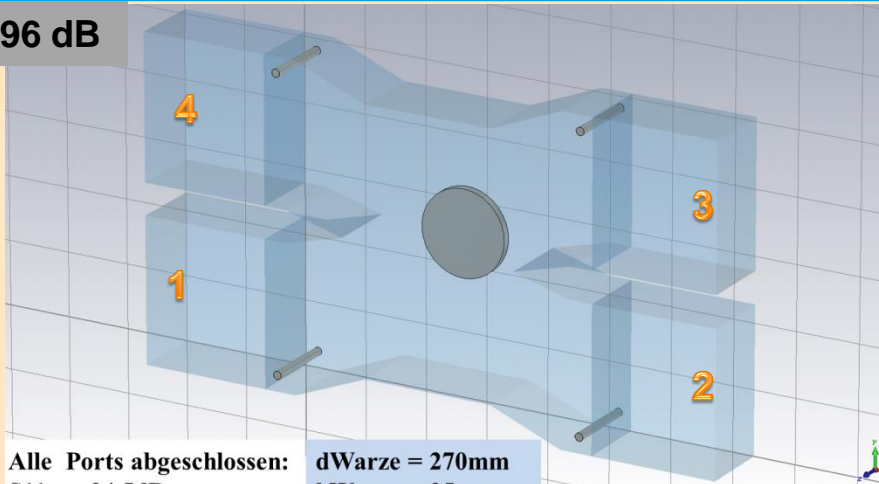
$$r = \frac{A_R}{A_V} \cdot k^2 \cdot \sum_{1}^n [(1 - k^2)^{(n-1)} \cdot e^{j2n\phi_s}]$$

k <sup>2</sup>	k	Phi [°]									
1/2	0,70710678	90									
n Rflx	r <sub>n</sub>	phi <sub>n</sub>	Re{r <sub>n</sub> }	Im{r <sub>n</sub> }	k <sup>2</sup>	k [1]	ak [dB]	Phi [°]	r  [1]	ar [dB]	
1	0,500	180	-0,500	0,000	1/2	0,707	3,010	89,9999995	0,333	9,545 ✓	
2	0,250	360	0,250	0,000	7/15	0,683	3,310	89,9999995	0,30418663	10,337	
3	0,125	540	-0,125	0,000	4/9	0,667	3,522	89,9999995	0,28546731	10,889	
4	0,063	720	0,063	0,000	2/5	0,632	3,979	89,9999995	0,2494558	12,060	
5	0,031	900	-0,031	0,000	1/3	0,577	4,771	89,9999995	0,19845853	14,047 ✓	
6	0,016	1080	0,016	0,000	1/4	0,500	6,021	89,9999995	0,13833195	17,182 ✓	
7	0,008	1260	-0,008	0,000	1/5	0,447	6,990	89,9999995	0,10347561	19,703 ✓	
8	0,004	1440	0,004	0,000	1/6	0,408	7,782	89,9999995	0,08071303	21,861 ✓	
9	0,002	1620	-0,002	0,000	1/7	0,378	8,451	89,9999995	0,06482559	23,765	
10	0,001	1800	0,001	0,000	1/8	0,354	9,031	89,9999995	0,05323885	25,475	
11	0,000	1980	0,000	0,000	1/9	0,333	9,542	89,9999995	0,04451085	27,031	
12	0,000	2160	0,000	0,000	1/10	0,316	10,000	89,9999995	0,03776687	28,458	
					1/20	0,224	13,010	89,9999952	0,01178564	38,573	
			r	0,333251953							
			ar	9,544545932							



# Shorten the Hybrid (CST- Simulation)

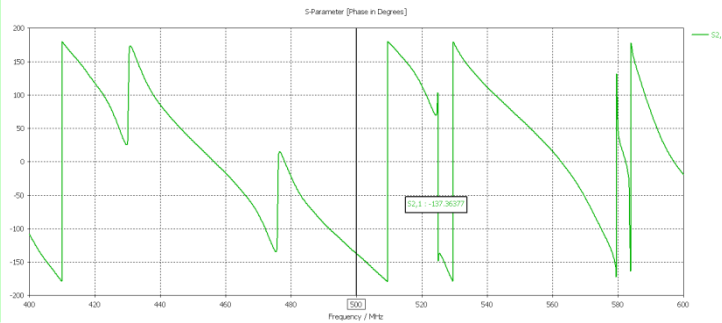
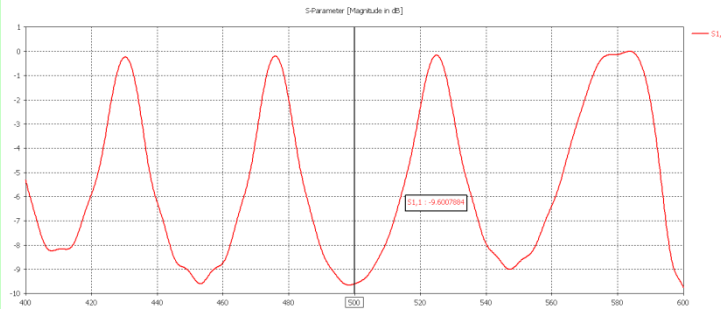
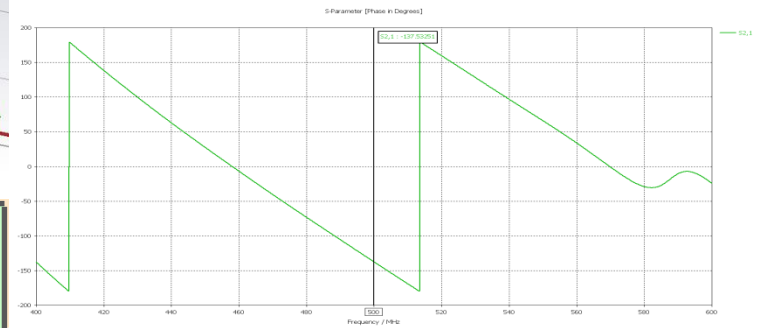
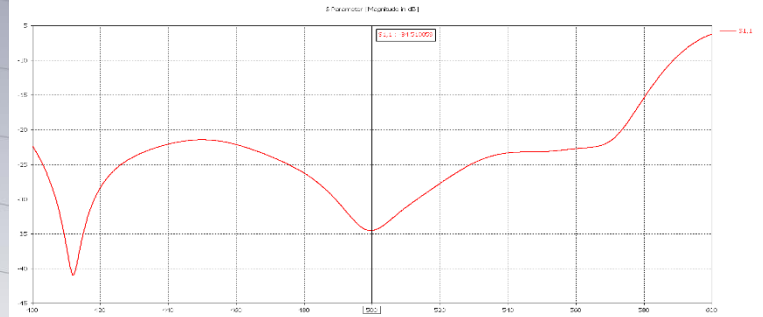
**S21 = -2,96 dB**



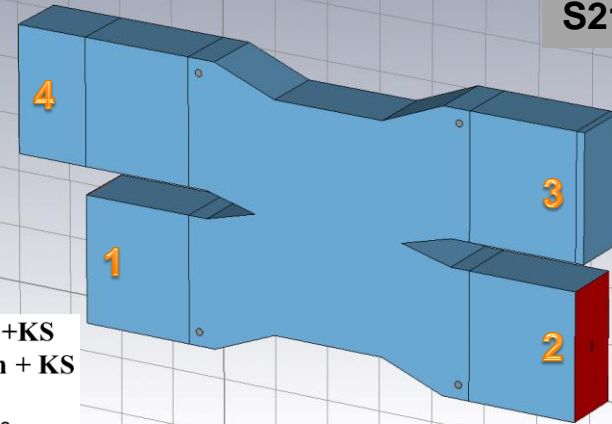
Alle Ports abgeschlossen:  
 S11 = -34,5dB  
 Phi12 = -137,5°

dWarze = 270mm  
 hWarze = 25mm  
 dStab = 25,5mm

a = 50mm, b = 27,25mm



**S21 = -0,55 dB**



Port 3: 30mm +KS  
 Port 4: 260mm +KS  
 S11 = -9,6dB  
 Phi12 = -137,4°

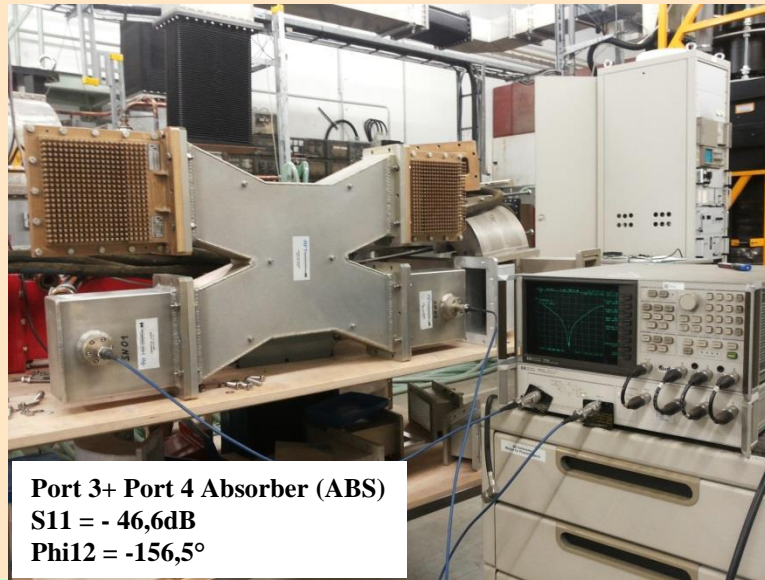


# Shorten the Hybrid (Measurement)

Done with:  
9 dB- coupler @ 1,3 GHz  
(more handy ;-))

Absorber

from Transmitter



**Port 3+ Port 4 Absorber (ABS)**  
**S11 = - 46,6dB**  
**Phi12 = -156,5°**

to cavity

Transmission line

Short

from Transmitter



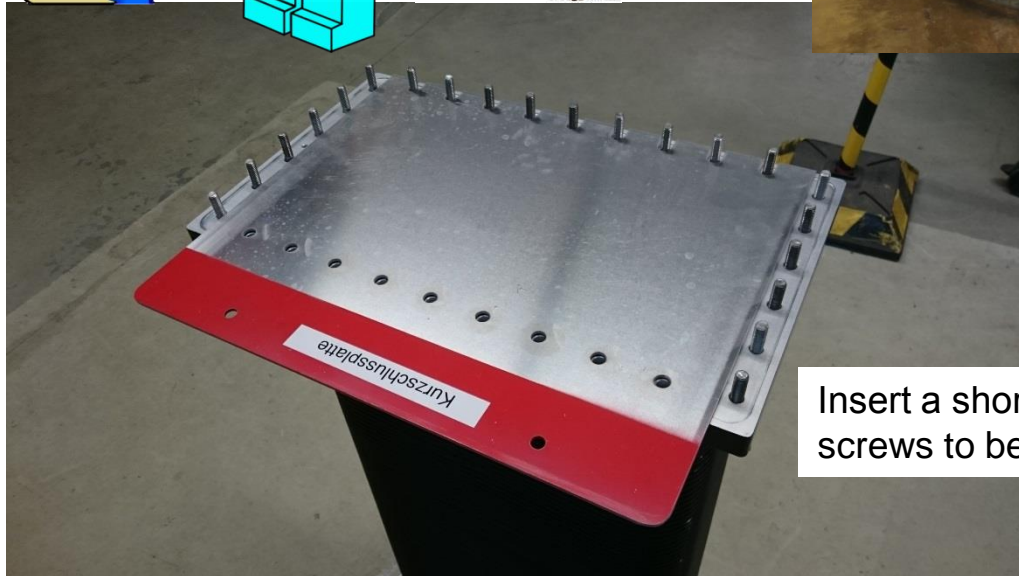
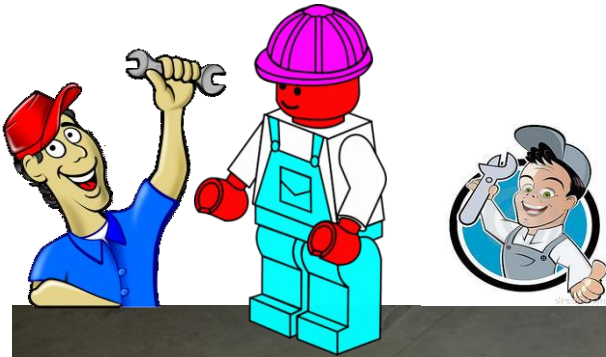
**Port 3: 320mm + KS**  
**Port 4: 100 mm + KS**  
**S11 = - 23,7dB**  
**Phi12 = -157,8 °**

Short

Transmission line

# Making life easier

All, that is needed

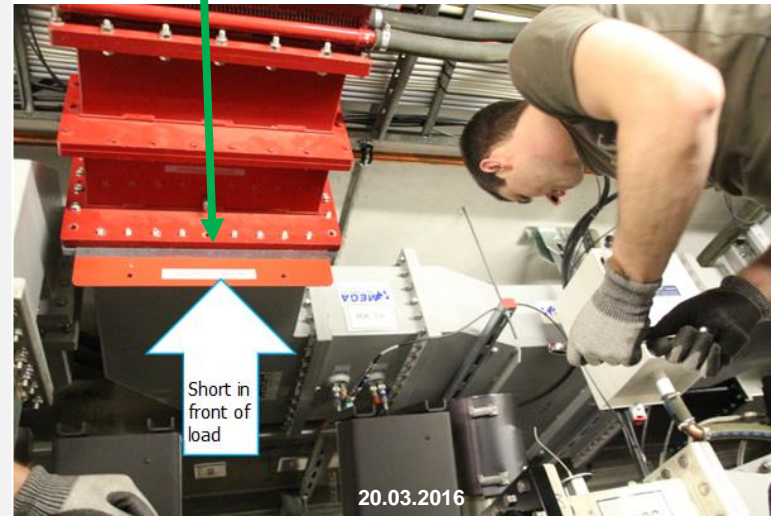
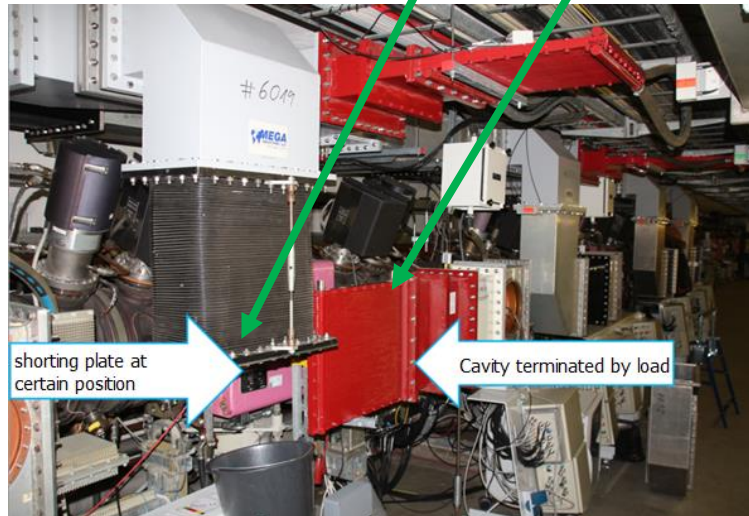
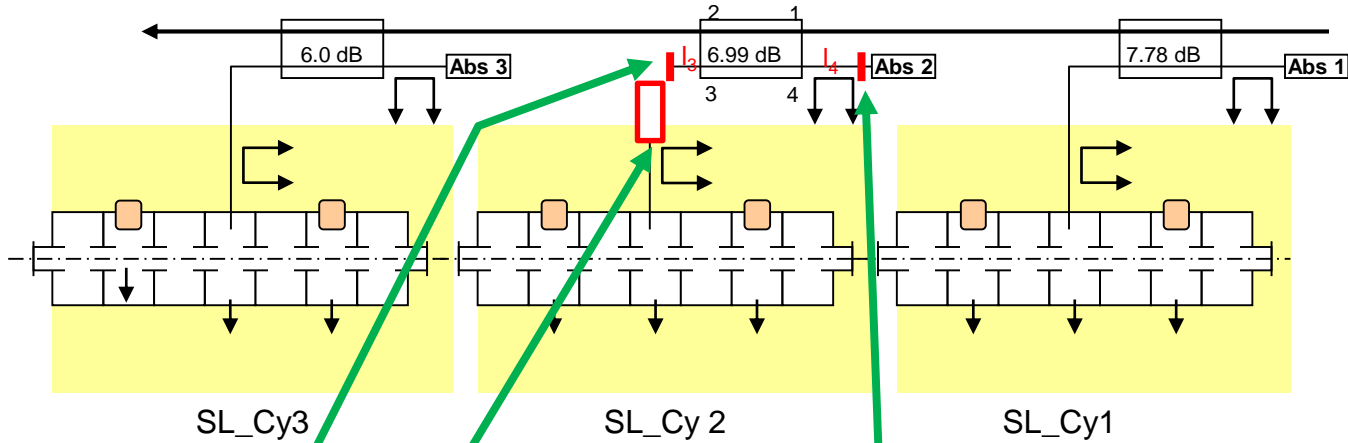


Insert a shorting plate with „only“ 9 screws to be removed

# Vacuum gets bad under power at PETRA-SL

2016/03/20: SL\_Cy2 is disconnected until next shutdown

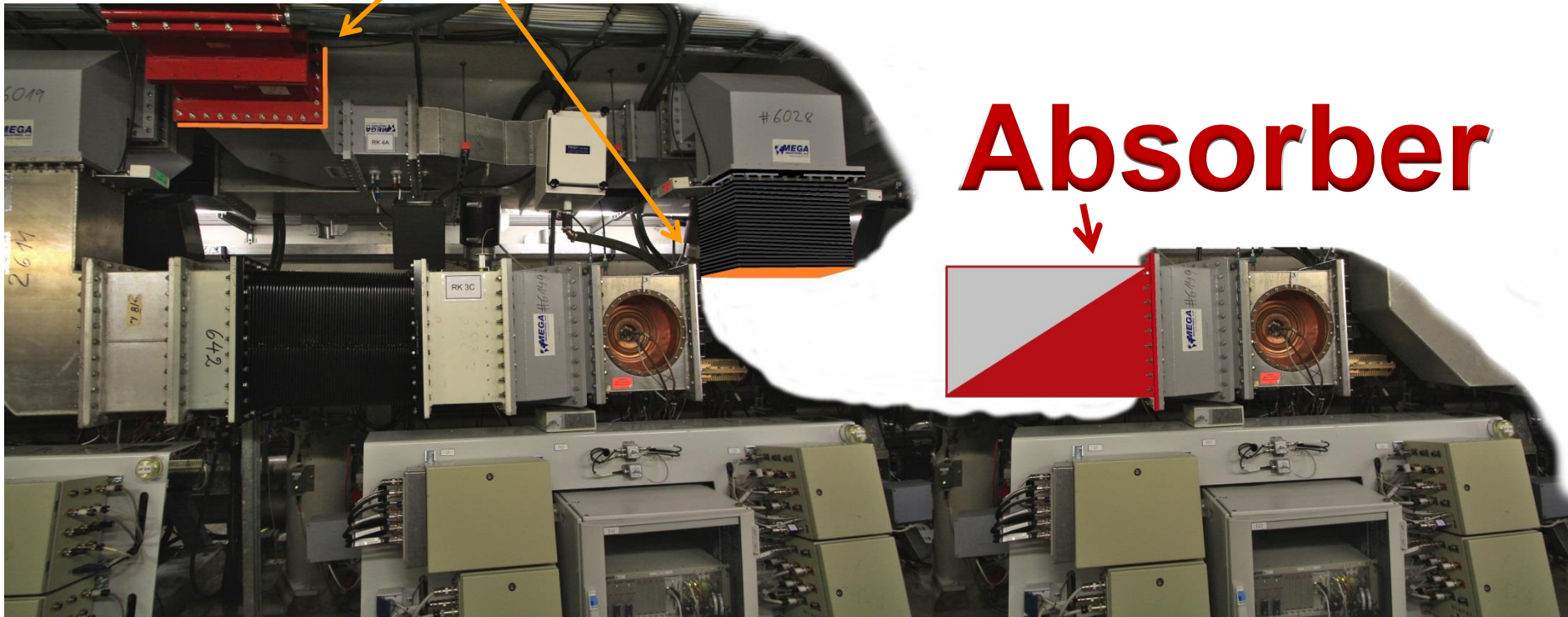
2017/02/08: SL\_Cy1 is disconnected until next shutdown



## Short



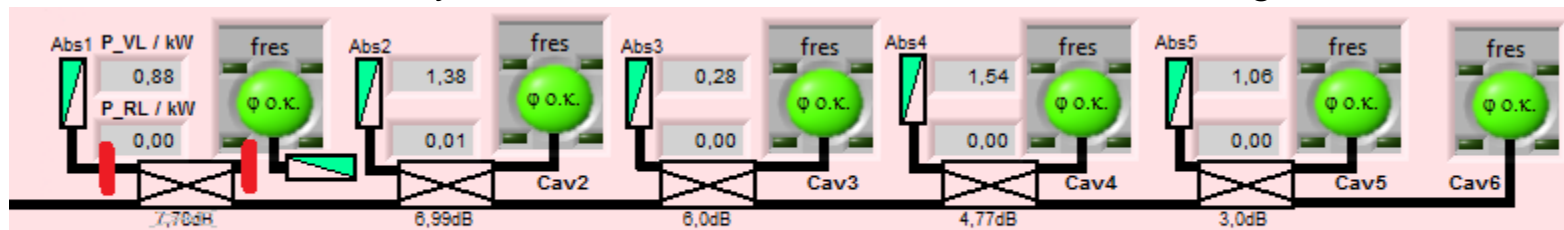
## Absorber



# Proof of principle

## How to check the transparency of the Hybrid (in situ)?

- Check if power of “shunted Cavity” is distributed to following cavities ✓
- Check the coupling between the cavities ✓
  - Detune a cavity and observe the influence to the remaining cavities



↑  
discontinuity?

