PETRA III Cavity HOM- story

Rüdiger Onken

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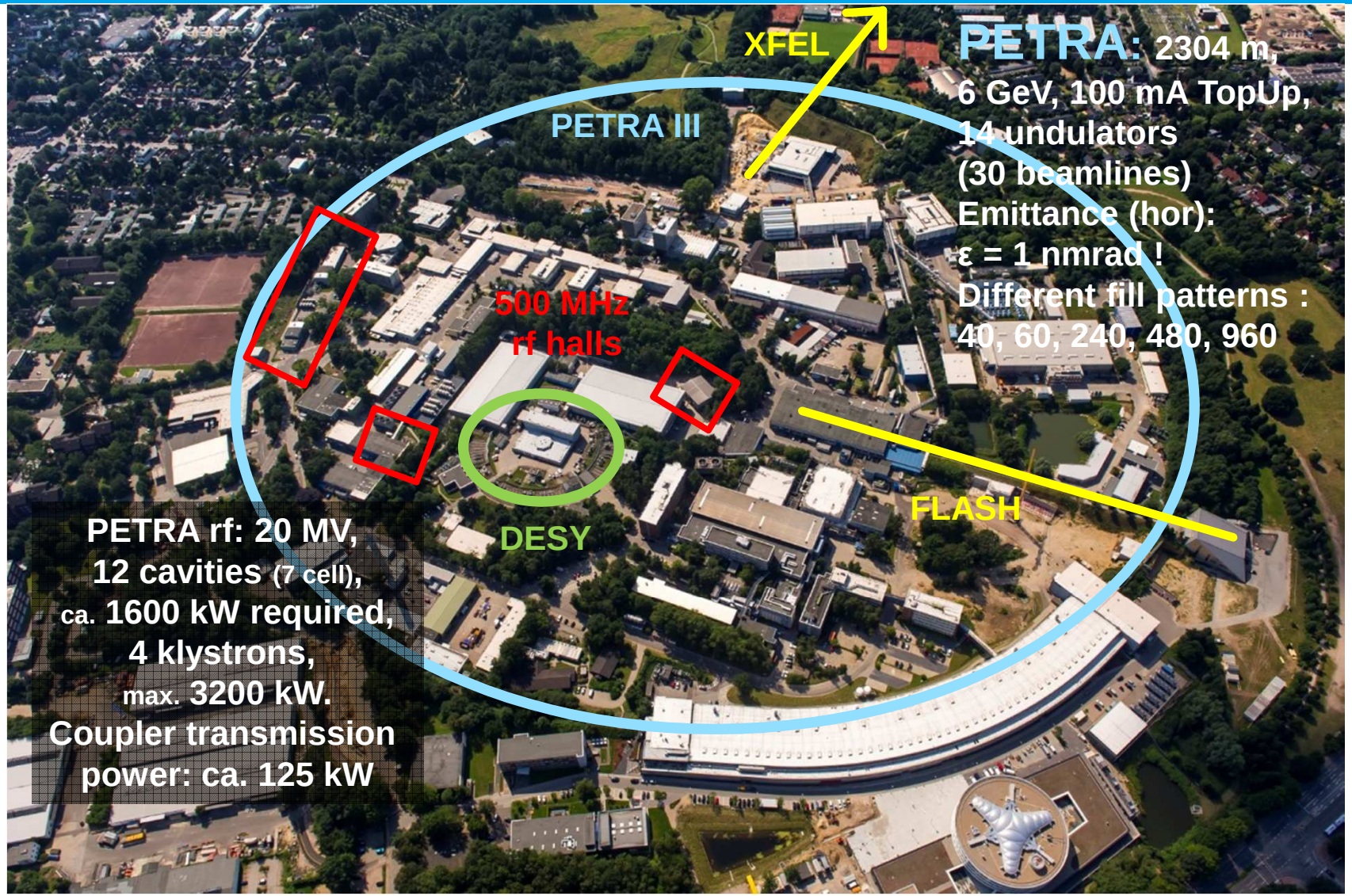
HELMHOLTZ ASSOCIATION

DESY

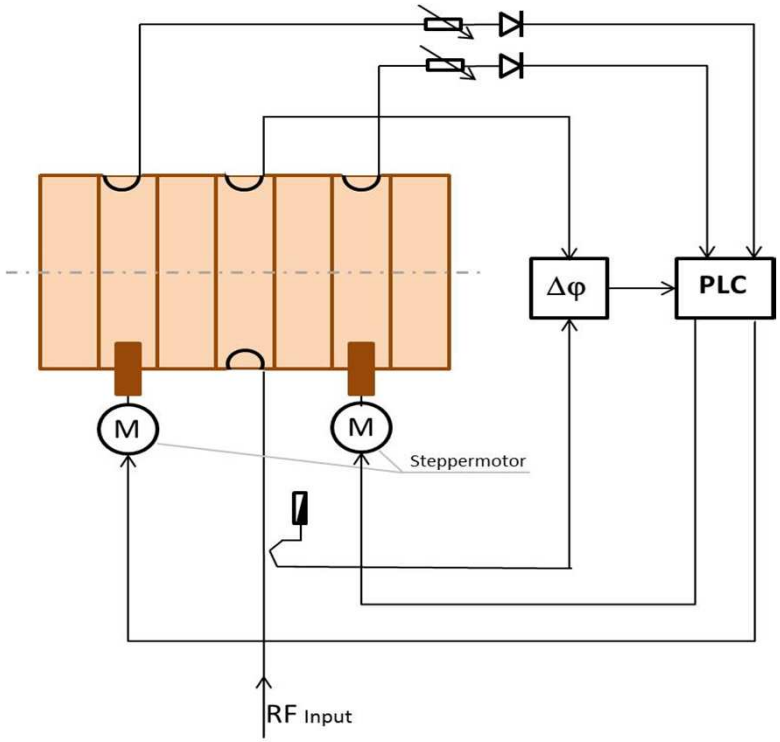
Accelerators at DESY and 500 MHz rf systems

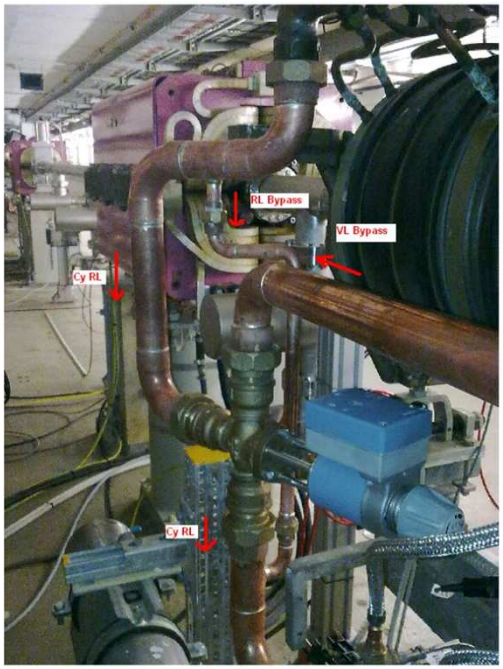


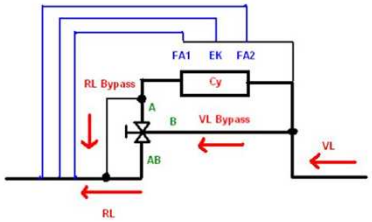
Outline

- HOM‘s in PETRA III Cavities
  - Principle of cavity tuning
  - Fishing for HOM‘s
  - Tuning wallpaper
- Glowing IPC‘s (input coupler)
  - Camera for coupler inspection
- Breaking the window
  - Strange obsevations in 40 Bunch mode
  - Breaking a window
  - Protection of the window

HOM‘s in PETRA III Cavities / Principle of cavity tuning







Hydraulic scheme of temperature tuning

Tuning the Cavity by:
- keeping the difference of Phase constant
- keeping equal field distribution

Playing with attenuation of cell- signal changes field distribution in the cavity.
Can be done by software during operation.

Tuning the temperature of the Cavity by:
keeping mean of cell temperatures constant
=> Bypass water
- Small temperature range
- Average precision ±0.1℃

HOM‘s in PETRA III Cavities / Fishing for HOM‘s

Some devices to suppress HOM’s

16 HOM- antennas with absorbers in the feeding waveguide

Absorbed power = 80 W / system

(not coupling to fundamental mode)

Each doorknob has HOM- absorber

(not coupling to fundamental mode)

HOM‘s in PETRA III Cavities / Tuning wallpaper

Nevertheless we had several trips due to vacuum events or IPC- sparks

Invention of “tuning wallpaper”

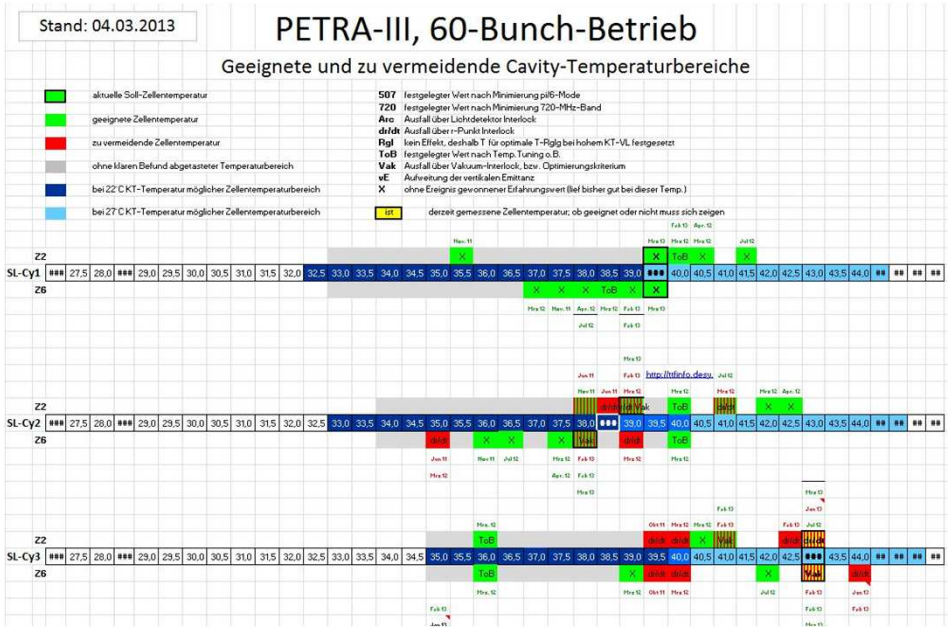
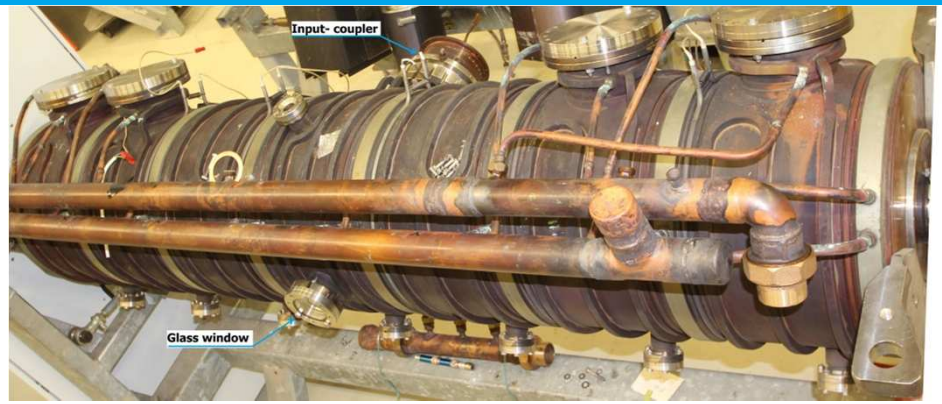


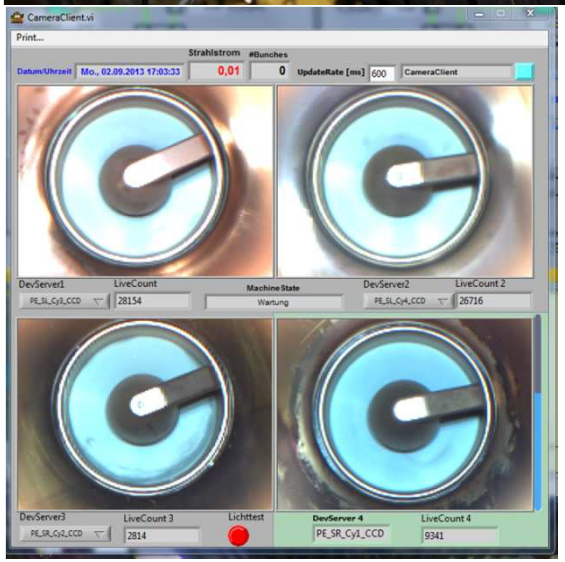
Diagram for each Cavity and bunch pattern
Red= combination of cell-temperatures, where event happened
Green= good tuning value (x= actual tuning values)
Grey= not yet tested

Within month operation got more stable
After a trip one knows, where not to tune

We are still not able to destroy all the HOM’s, but living with them as good as possible.

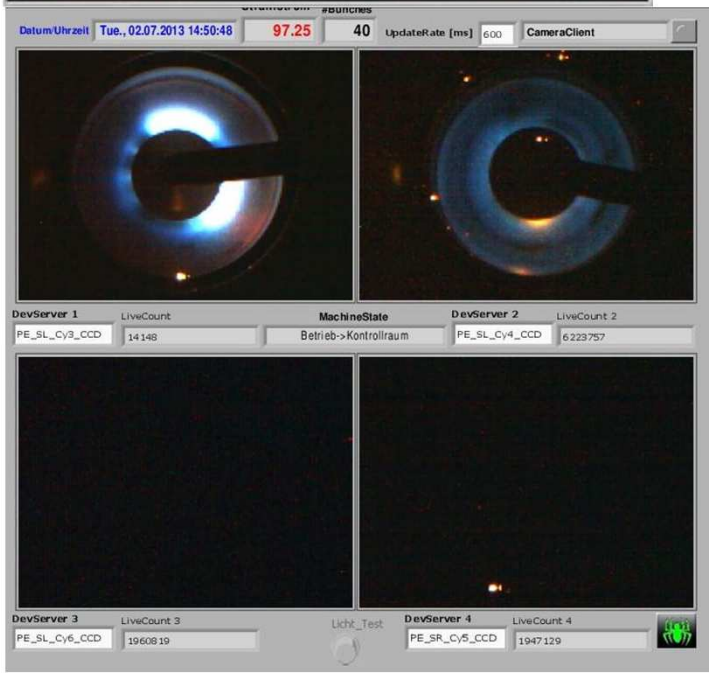
Glowing IPS‘s / Camera for coupler inspection





- Glass window for IPC- spark detector
- Coupler inspection through this window
- Camera to have always same conditions

Glowing IPS‘s / Camera for coupler inspection



During operation it turned out, that 2 of 12 IPS’s are glowing or shining.

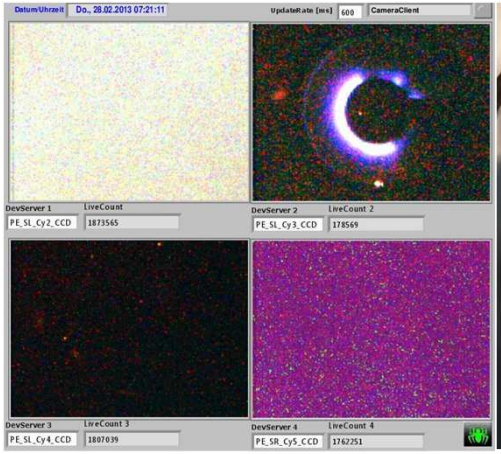
Intensity varies with pressure, tuning and ???

Magnetic fields changes the behavior but does not stop the glowing.

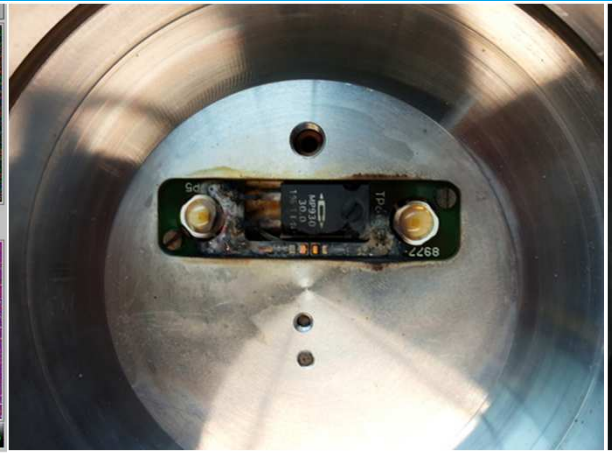
Spark detectors do not see this wavelength, although we had some spark interlock- events

We are living with this 2 IPC’s since 2009.
Will be replaced in next shutdown.

Breaking the window / Strange obsevations in 40 Bunch mode



Noisy TV picture



Melted electronic in camera cup

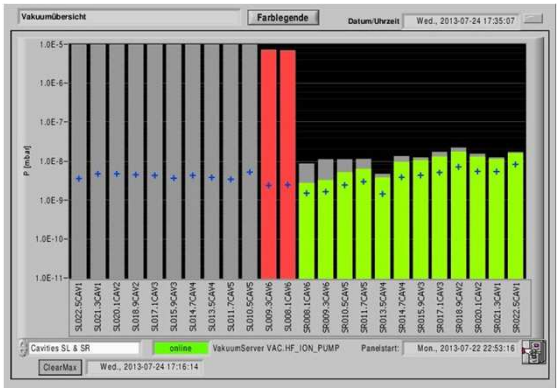
High window temperature

Especially in 40 or 60 bunch- mode a high temperature was observed at the glass window

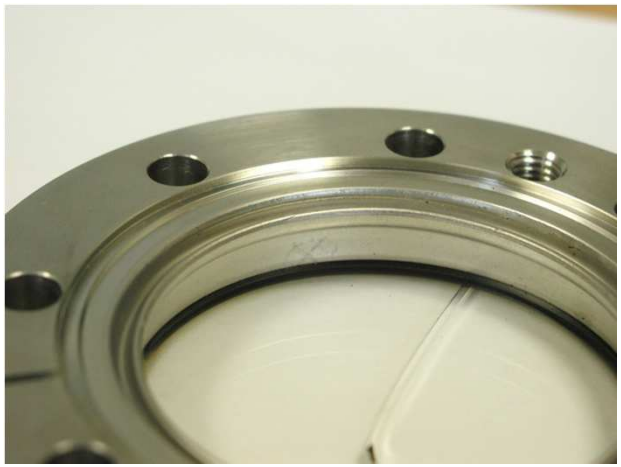
Temperature strips showed T > 160 ℃

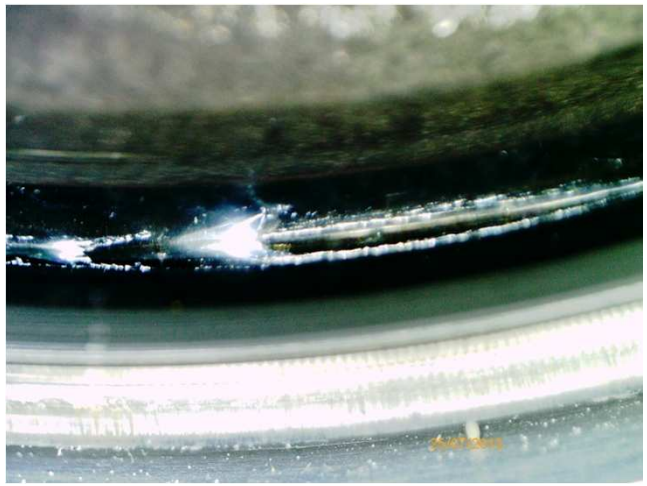
=>

Vacuum crash on a service day during investigation of influence of bunch pattern to the temperature



Breaking the window





Due to heating the window by HOM's:

- One window broke (didn't we had such an event some years ago? Oh yes, in 40 bunch mode ;-))
- Lots of them had crackles in the glass
- Parts where replaced and IR- thermometer was installed

After recovery : Test- run 80 mA in 40 bunches for investigations

- 210℃ at the window (estimate 300℃ with 100 mA in 40 bunches)
- Temperature gradient, at beam dump starts with 30° / min (200℃ => 170℃ in 1 minute)
- Higher Bunch numbers are less critical

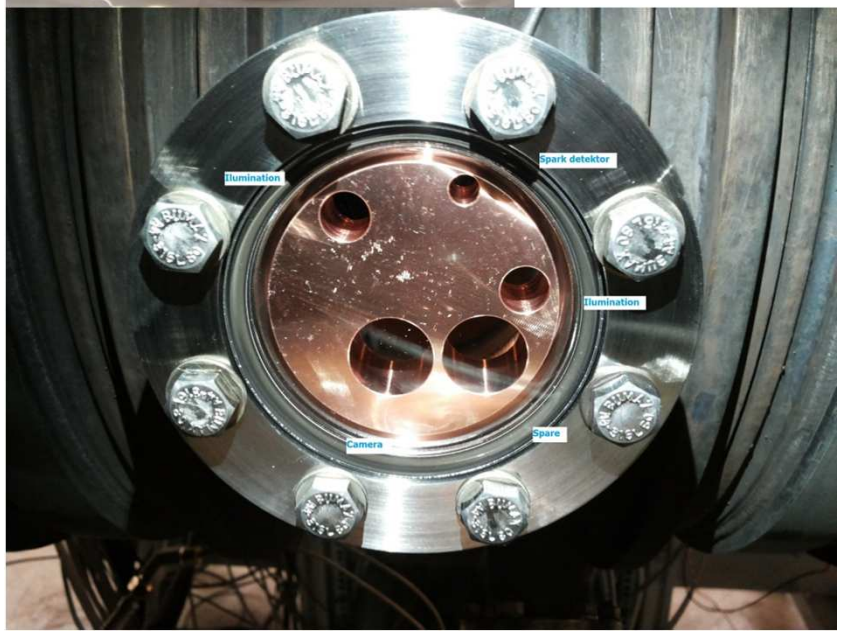
Consequences:

- Limitations in current at certain bunch patterns
- Develop device to protect the window

Breaking the window / Protection of the window

RF- filter and vacuum seal
With holes for

- Camera
- Light
- Spark detector



2 week ago, installed at all PIII- cavities

Last week:
Test run with 100 mA/40 Bunches no glass heating anymore

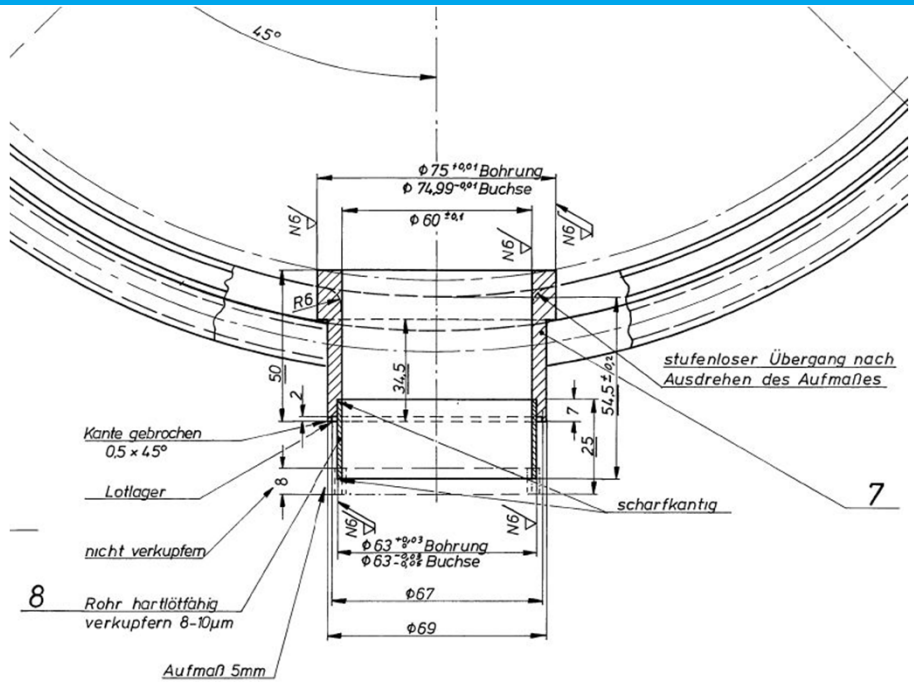
Thanks for Your attention

HOM to go

Glass- window flange as round waveguide:
d: 60 mm
l: 55 mm

Critical frequency: 2,93 **GHz** (H11)
Wavelength @ 3 **GHz**: 463 mm

Frequency [MHz]	Damping (H11)[dB]
2500	15,6
2000	21,9
1500	25,7
1000	28,1
500	29,5



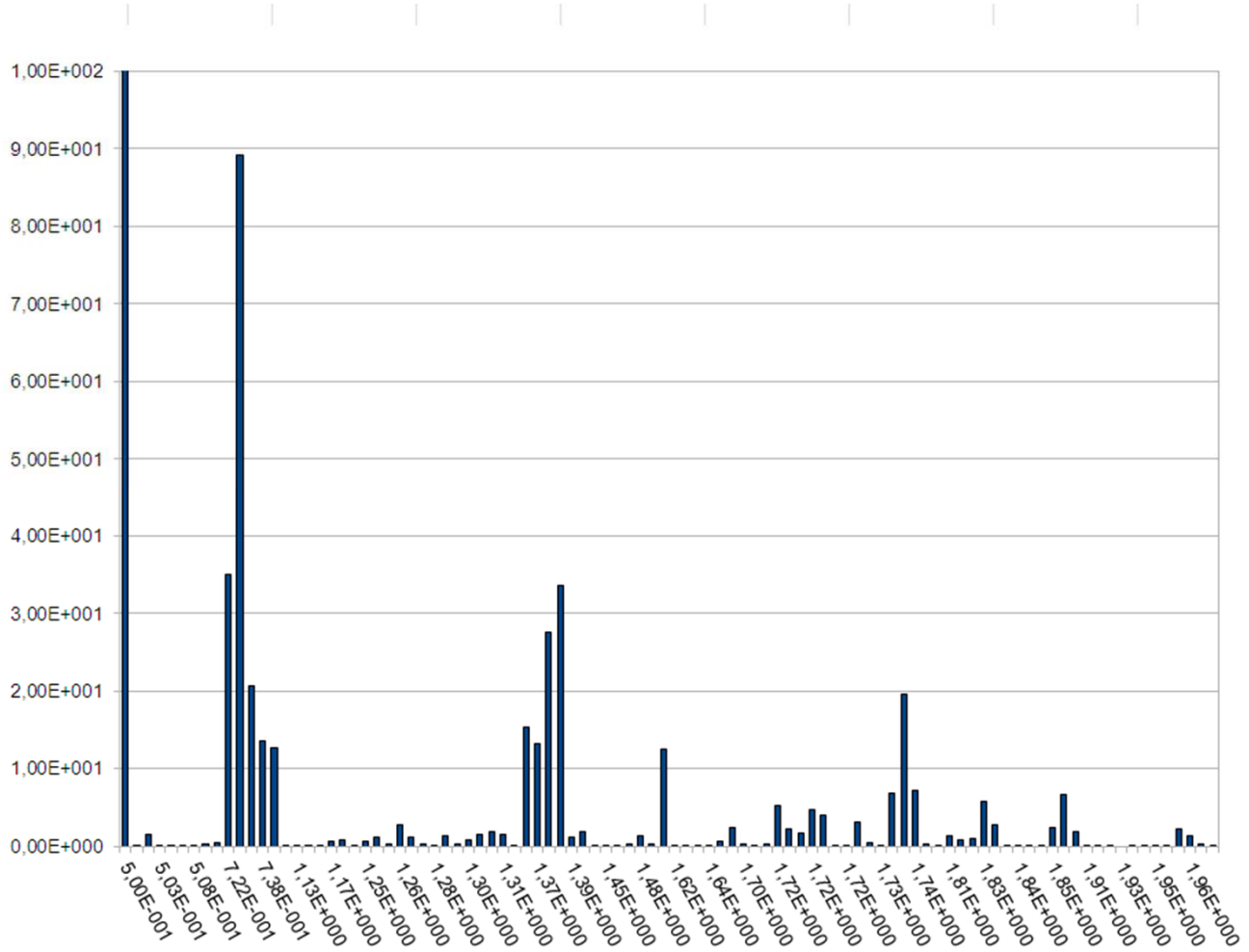
Estimate:

- Diameter of window pipe = 1/20 of cavity circumference
- Coupling: 1/20 of wall current goes over window pipe

➢ $(1/20)^2$ of power is coupled to this 60 mm hole = 50 kW/7/400 = 18 W

Appendix

R/Q for PETRA 7- cell cavity [in GHz]



Appendix

Harmonics of revolution frequency stimulate disturbing cavity- modes (not HOM's)

fu [MHz]:	0,130121
h:	3840

Cavity-Mode [Pi]	1	5/6	2/3	1/2	1/3	1/6	0
PhiDiff zwischen Zellen [°]	180	150	120	90	60	30	0
f [MHz]	499,6646	500,09	501,34	503,28	505,19	507,21	508,57

Nb	h*fu+Nb*fu	optimale & gefährliche Bunchzahlen						
3	500,055003	0,39	-0,03	-1,28	-3,22	-5,13	-7,15	-8,51
8	500,705608	1,04	0,62	-0,63	-2,57	-4,48	-6,50	-7,86
13	501,356213	1,69	1,27	0,02	-1,92	-3,83	-5,85	-7,21
20	502,26706	2,60	2,18	0,93	-1,01	-2,92	-4,94	-6,30
28	503,308028	3,64	3,22	1,97	0,03	-1,88	-3,90	-5,26
35	504,218875	4,55	4,13	2,88	0,94	-0,97	-2,99	-4,35
42	505,129722	5,47	5,04	3,79	1,85	-0,06	-2,08	-3,44
50	506,17069	6,51	6,08	4,83	2,89	0,98	-1,04	-2,40
58	507,211658	7,55	7,12	5,87	3,93	2,02	0,00	-1,36
63	507,862263	8,20	7,77	6,52	4,58	2,67	0,65	-0,71
68	508,512868	8,85	8,42	7,17	5,23	3,32	1,30	-0,06
		Differenz Umlaufharmonische - Cavity-Mode [MHz]						