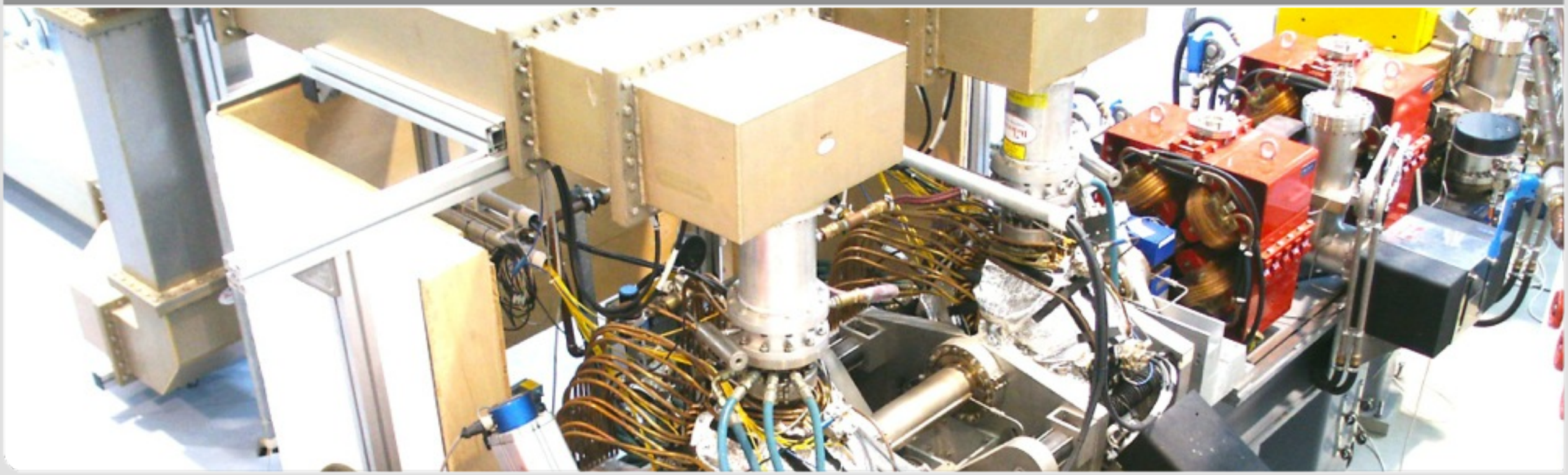
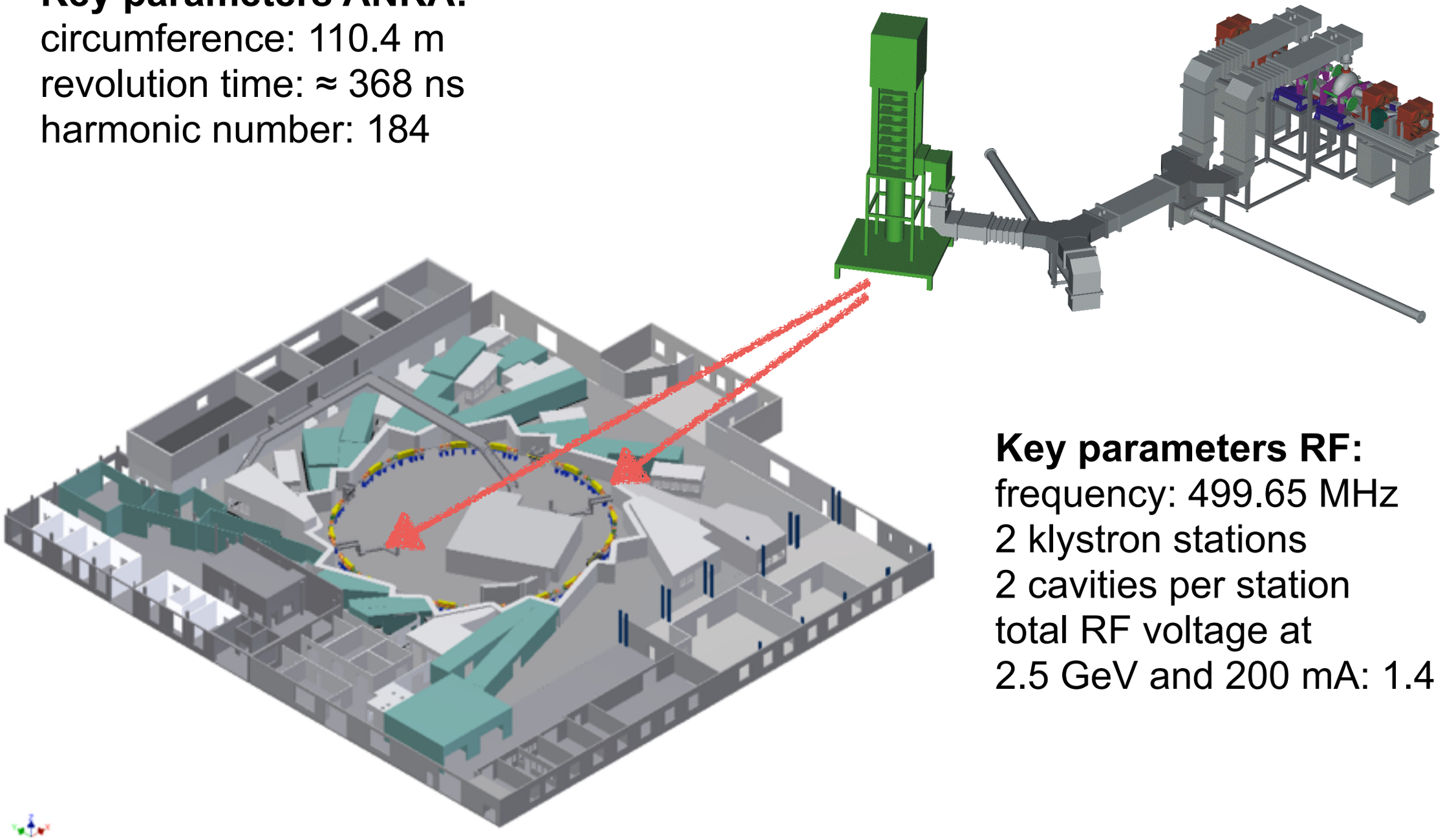
ANKA RF System - Upgrade Strategies

Vitali Judin



ANKA Storage Ring at KIT

Key parameters ANKA:
circumference: 110.4 m
revolution time: ≈ 368 ns
harmonic number: 184



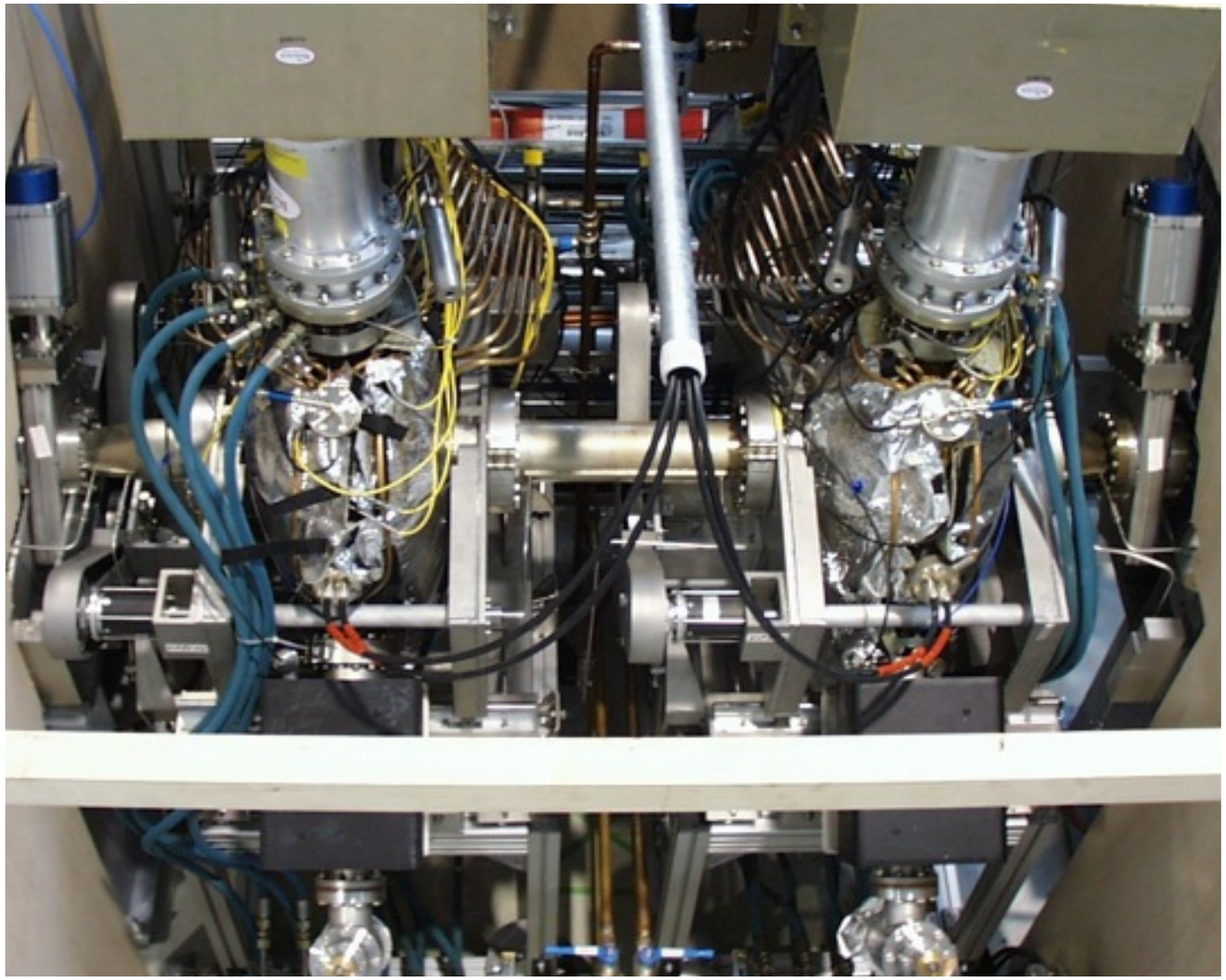
Key parameters RF:
frequency: 499.65 MHz
2 klystron stations
2 cavities per station
total RF voltage at
2.5 GeV and 200 mA: 1.4 MV

Schematic taken from ‘Proceedings of the 1999 Particle Accelerator Conference, New York, 1999’

Elettra type cavities

- Shunt impedance: ~3.3 MOhm
- designed max voltage: 650 kV
- max. ramping 5 kV/s
- Power loss in cavity: <64 kW
- Tuning: via deformation, DC motor
- Water cooled cavity and coupler
- Air cooled coupler window

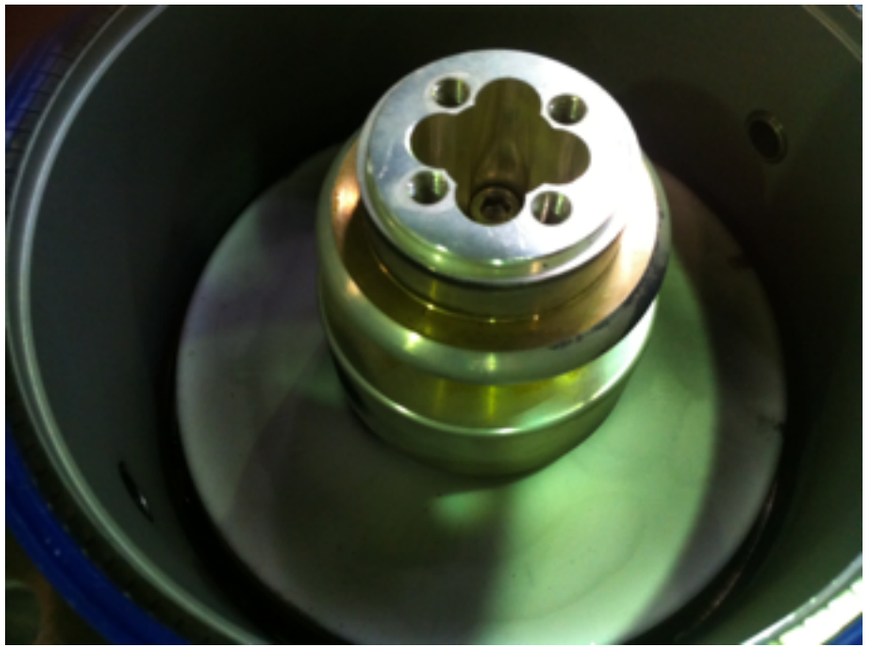
STATUS:
no mayor RF failures since 2012



Recent
RF Activities
at ANKA

Coupler window cleaning

- occasionally interlocks on outlet air temperature due to the high gap voltage in SUO studies
- Air-outlet: S2 26˚C S4 29˚C, Interlock: 35˚C
- Assumption: deposition on ceramic window
- Exchange of experience with SLS:
  - ➡ mechanical cleaning of ceramic surface using the industrial 3M Scotch Brite
- Cleaning in January’ 14: 1-2h per Cavity



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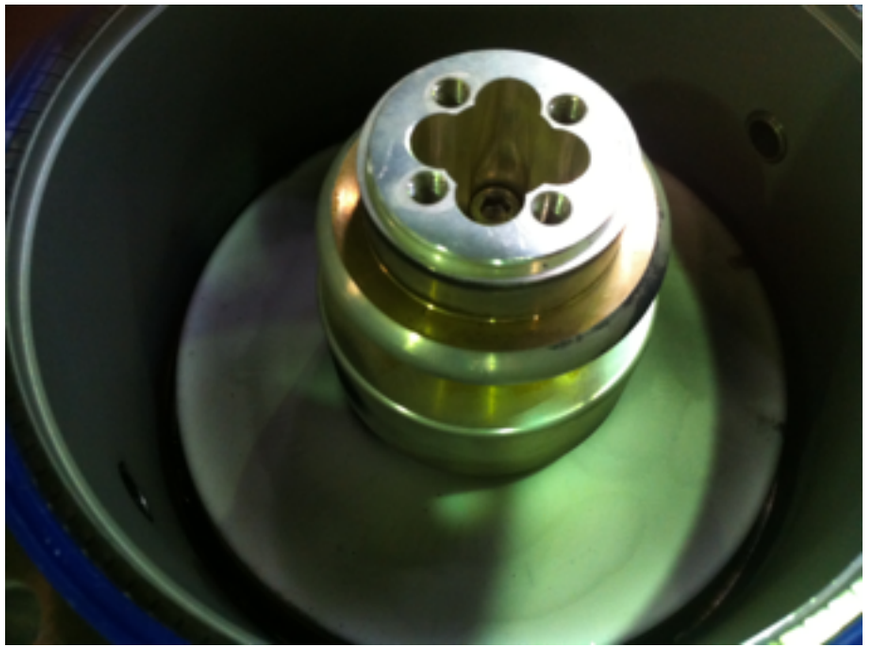
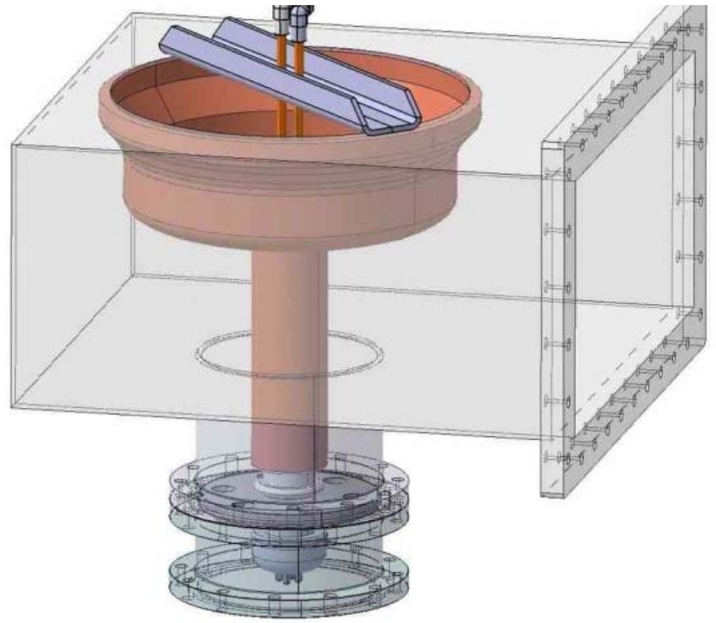


Coupler window cleaning result

- Very high refl. power on one cavity
  - ➡ few hours of “waveguide Tetris” until the source was found
  - ➡ wrong tuning behaviour of the LLRF -> wrong signal level on feedback loop
  - ➡ mechanical pressure on the frequency loop pick-up coax connector
- Consequence:
  - ➡ we could observe spark imprints on copper surface of the waveguide-to-coax connector ➡ not critical.
  - ➡ we have nice clean ceramic windows
  - ➡ stocktaking of waveguide parts
  - ➡ good margin to interlock value
- Future tendency: higher synchrotron radiation due to damping insertion devices at ANKA
  - ➡ higher forward power needed

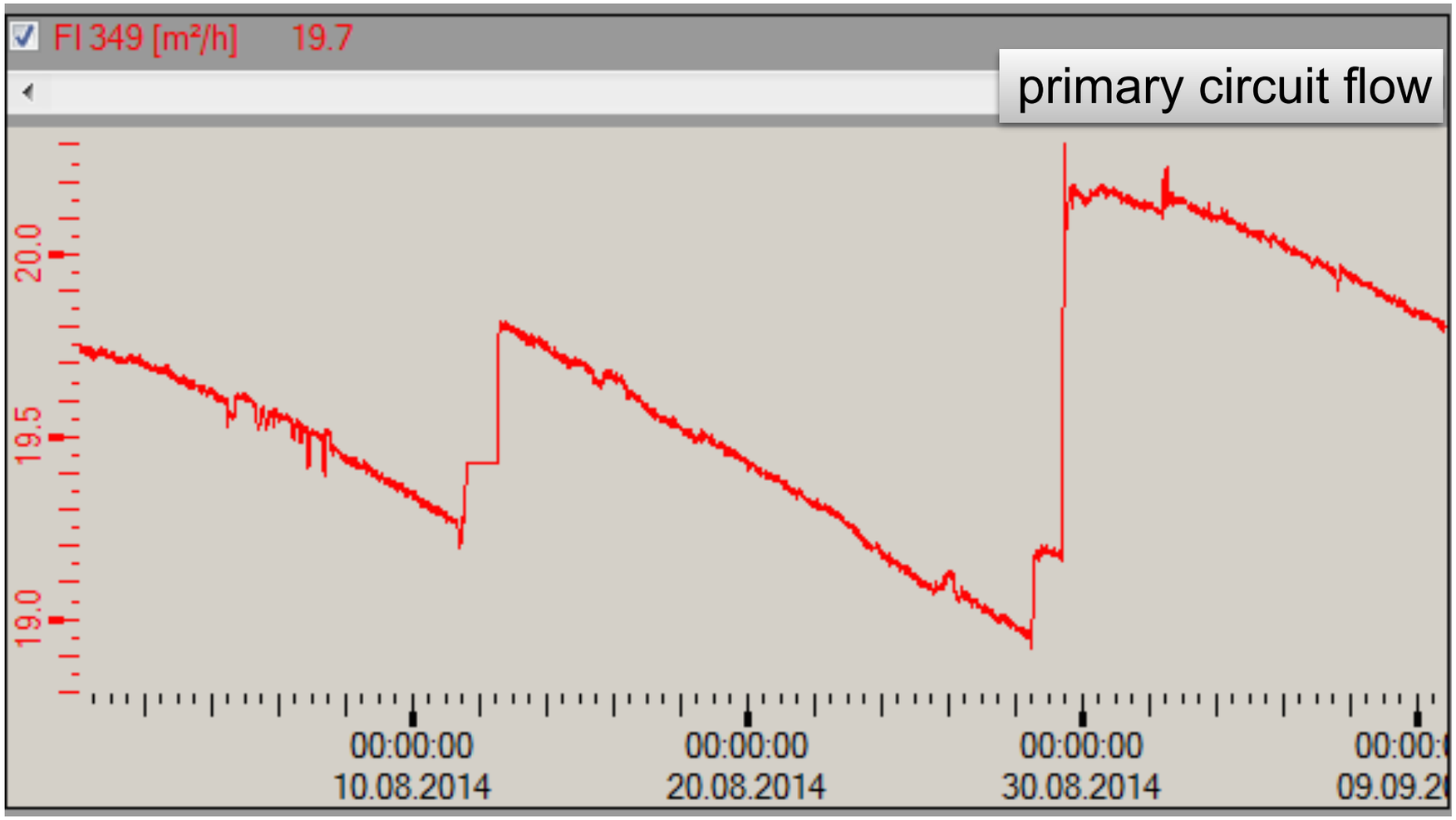
possible long term solution?



A. Fabris et al., WEPMN016, PAC07

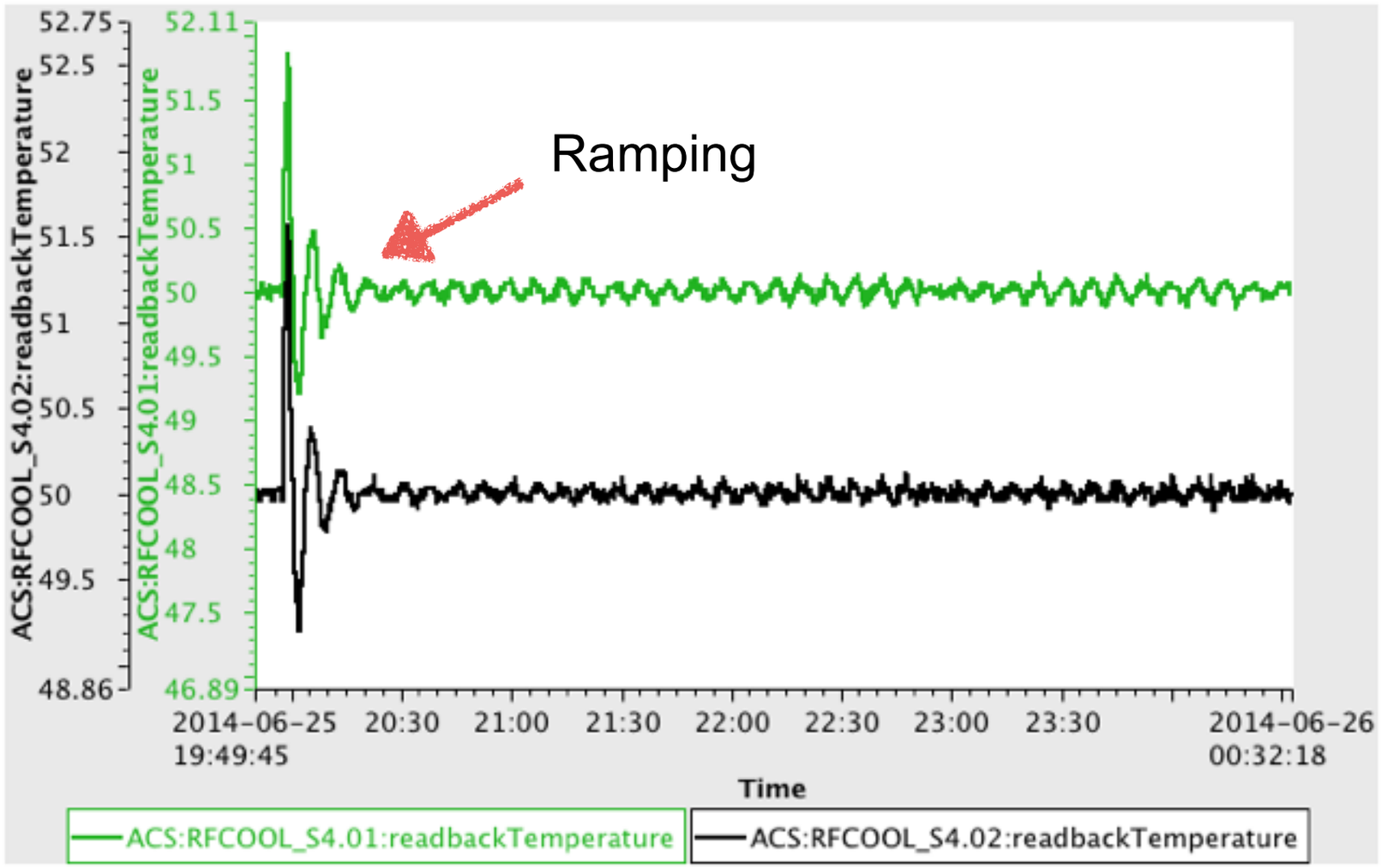
Cooling Rack - Water Flow Rate

- Flow rate of primary cooling circuit is decreasing slowly in time
  - ➡ change of PID behaviour
  - ➡ temperature oscillations also in secondary circuit
  - ➡ reduction of acceptable ramping rate (kV/s)
  - ➡ crossing HOM e.g. during ramping



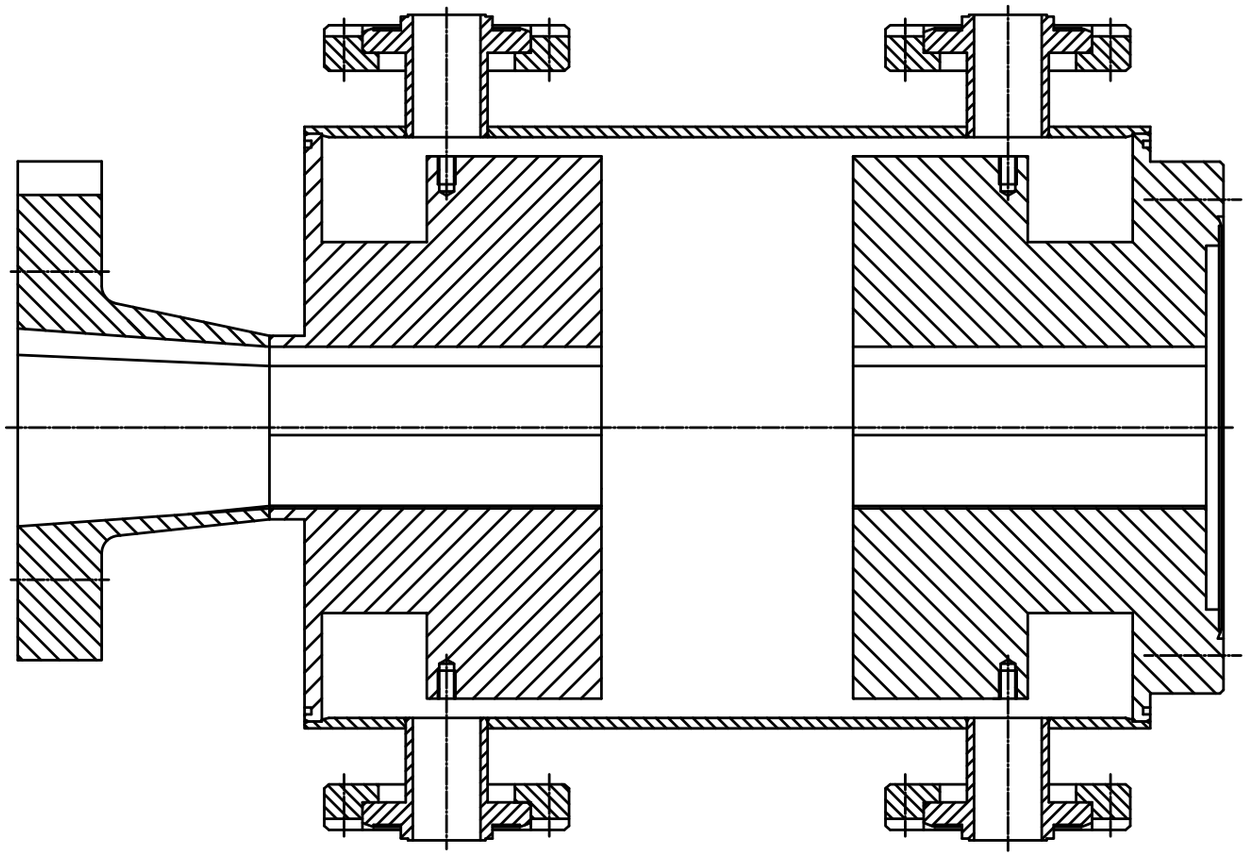
Cooling Rack - Water Flow Rate

- Disturbed PID regulator due to energy ramping oscillates
- critical for special user operation in low alpha mode -> change of peak voltage
  -> change of bunch length -> change of THz radiation/bursting behaviour



BBB Longitudinal Kicker

- Initial BESSY/DELTA design
- tapers to ANKA beam pipe profile
- additional copper absorber
- suitable broad band amplifier:
  - ➡ ~200W 1.0-2.0 GHz
  - ➡ e.g. MILMEGA AS0102



installation planned for
the end of the year

Klystron Service

- Sudden beam losses occured
- RF drive reflected power increased:
  - ➡ maintenance of klystron
    was performed
  - ➡ replacement of RF cable
    inside of lead cover was done
  - ➡ last replacement 2011: wrong material

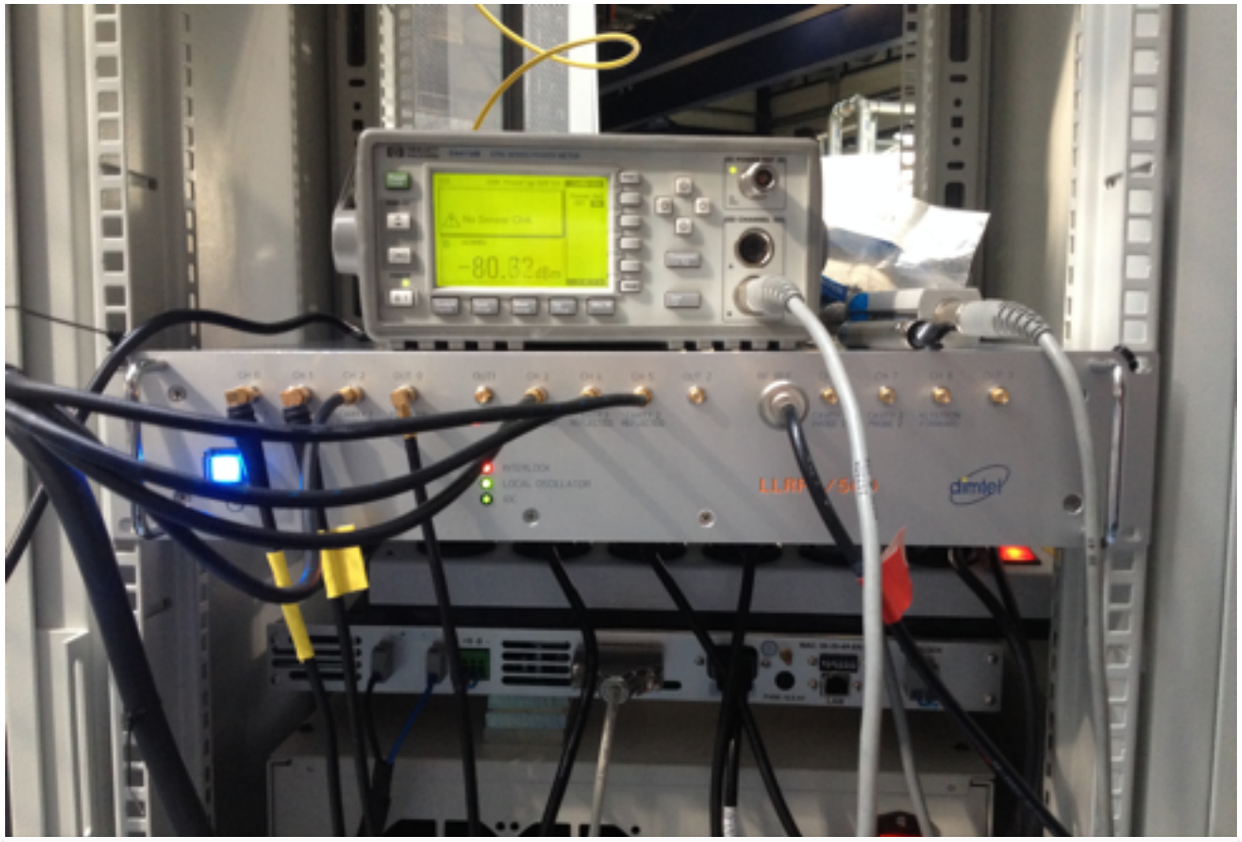
radiation hardness of dielectric material is important issue

Spare Klystron

- life time of klystrons is long but not endless
- spare klystron for ANKA is on stock, but:
  - ➡ is it operable? what is the on-stock lifetime?
  - ➡ vacuum is maintained, but not the heater
- 500 MHz klystron refurbishment could be issue in the next future

DIMTEL LLRF Test at ANKA

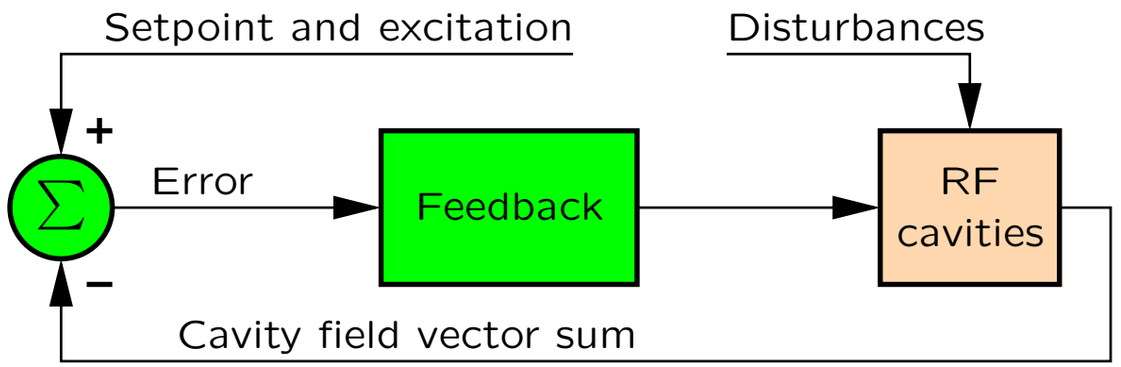
- 1st experience exchange with ELSA
- station S4 was chosen for the test
- constrain:
  - ➡ 1 day MP scheduled
  - ➡ minimal invasive setup
- full installation within 2 hours
- tuner controllability was realised by workaround via EPICS2ACS
- Test passed:
  - ➡ general functionality
  - ➡ open loop / closed loop
  - ➡ rf ramp up/down
  - ➡ soft interlocks + diagnostics
  - ➡ 100mA beam + ramping to 2.5 GeV only 6h after installation **(!)**

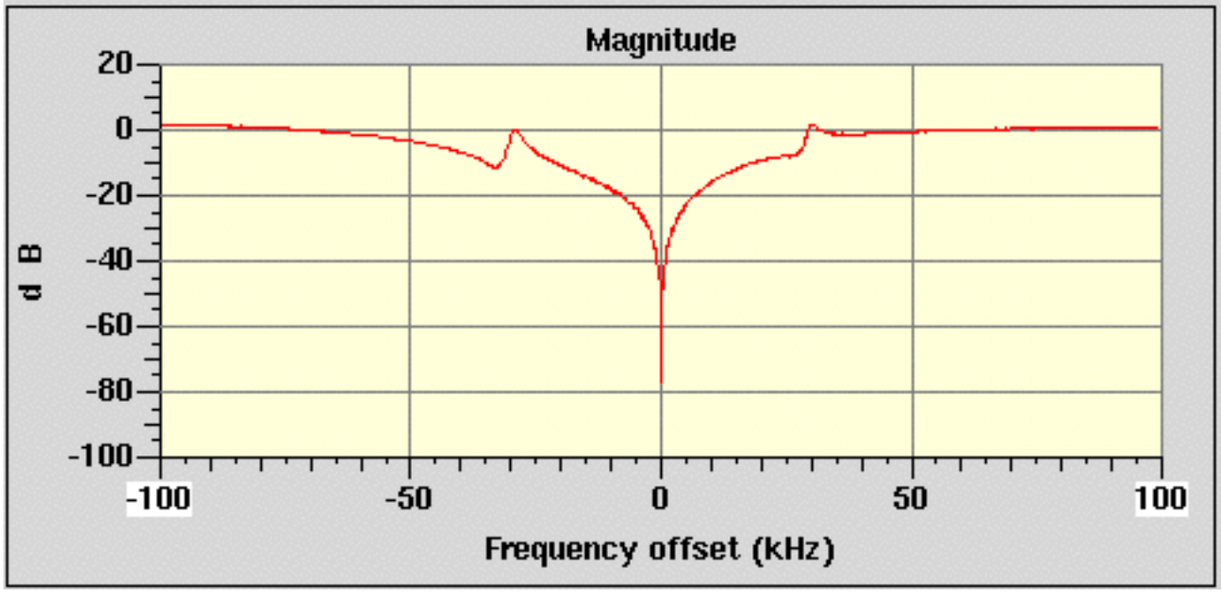


2x CavFWD, 2x CavREF, 2x CavPick-Up
interlock daisy chain (TTL), 1x Drive out
3 inputs and 3 outputs leaved free,

DIMTEL LLRF Test at ANKA - Results

- Closed loop transfer function
  - ➡ Measured from set point to error signal
  - ➡ quantify disturbance rejection
- proportional and integrator loops produce high rejection at low frequencies
- closed-loop disturbance rejection
  - ➡ beam response at 30 kHz
  - ➡ -70 dB rejection at ~30 Hz
  - ➡ -15 dB rejection at 10 kHz





courtesy of D. Teytelman (priv. comm.)
http://www.dimtel.com/products/llrf9

DIMTEL LLRF Test at ANKA - Results

- post-mortem analysis
- manually detuned cavity 2 to reach reflected power interlock (20kW)
- RF drive switched of within 100ns
- Reflected power rise up shortly
- Field decay transients can be used for calculating of Q and detuning:

Parameter	Cav. 1	Cav. 2
Detuning, kHz	-3.8	-29.4
Loaded *Q*	11375	10630

courtesy of D. Teytelman (priv. comm.)
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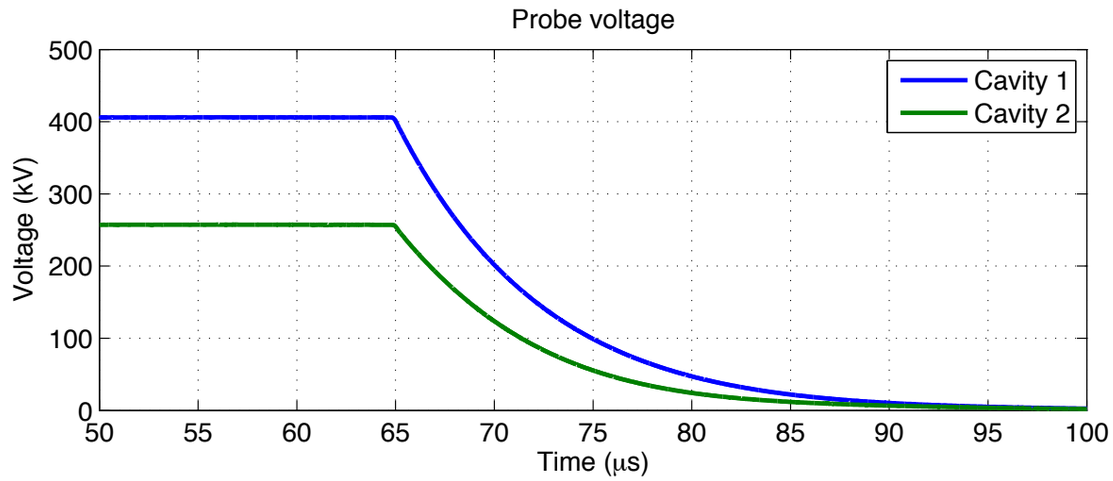
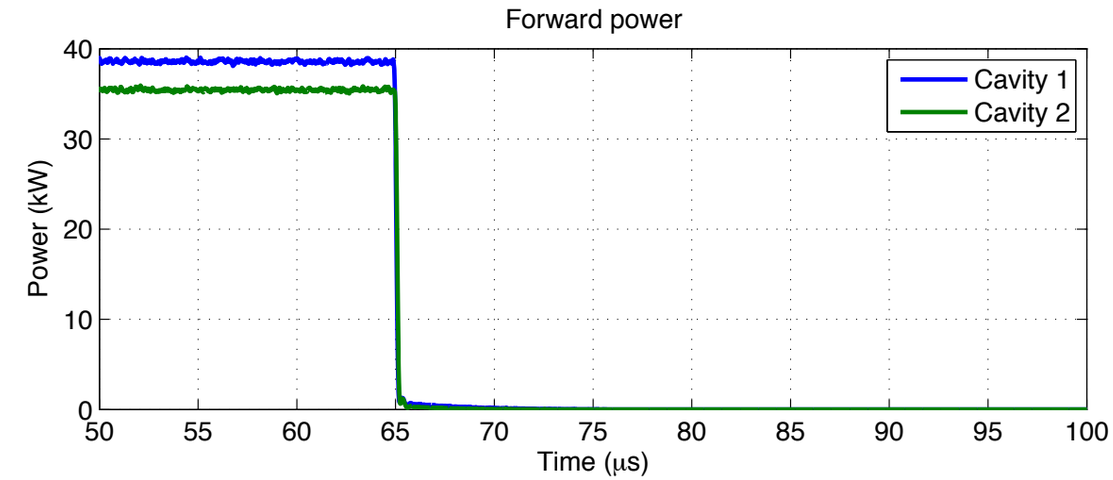
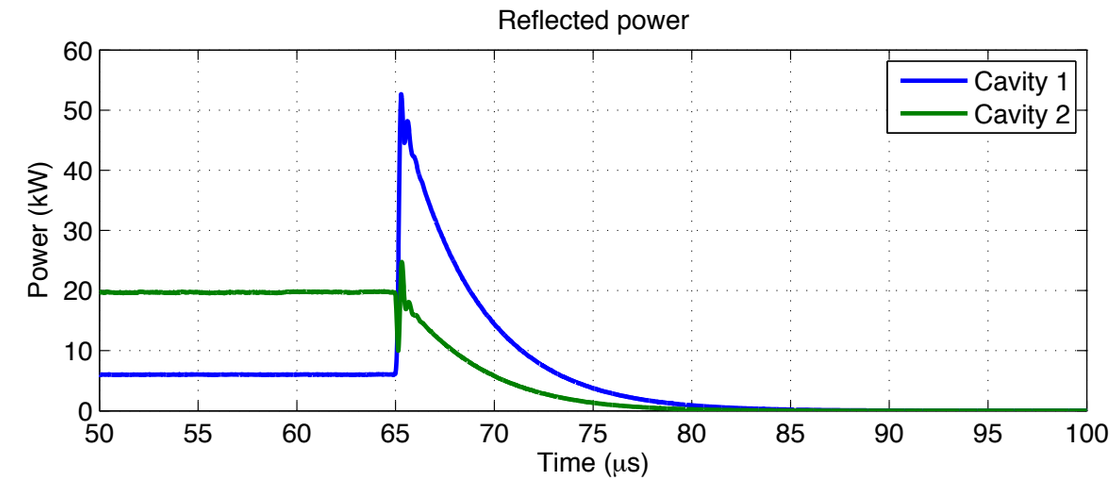
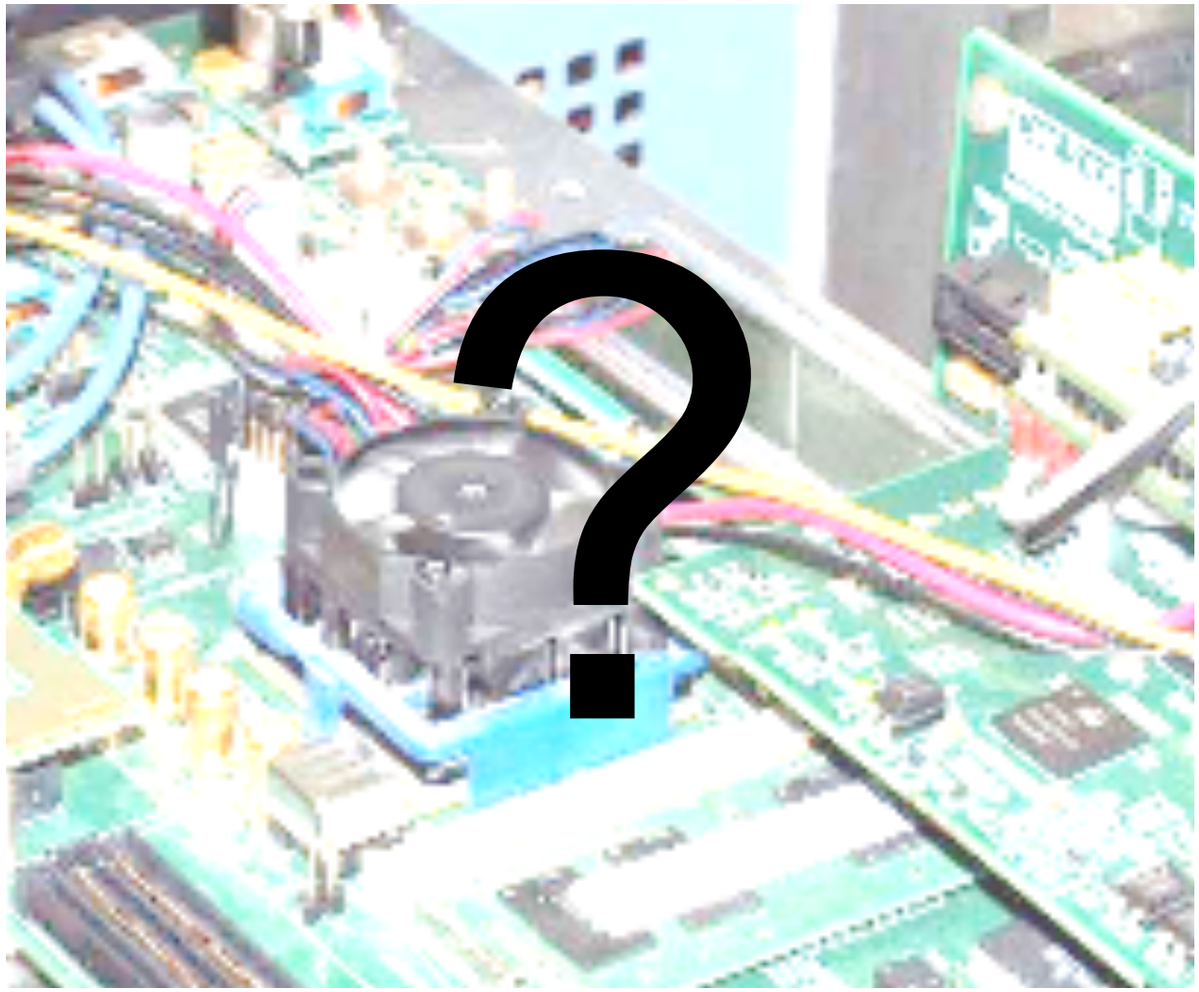






Decision: LLRF Upgrade

- analog LLRF becomes outdated
  - ➡ limited diagnostics
  - ➡ no post-mortem analysis
  - ➡ control system migration
  - ➡ fixed beam phase
  - ➡ new fast-interlock needed
- future oriented strategy
  - ➡ DLLRF with EPICS integration
  - ➡ old racks should be removed
    - ➡ free place for SSA
- tuner modifications needed:
  - ➡ new digital motor controller
  - ➡ new optical encoder



tender is in preparation

Summary

- The upgrade policy over the last few years has provided more reliability of the ANKA RF system in general.
- New DLLRF with full EPICS integration should allow the continuous monitoring of a number of important RF parameters and furthermore perform the post-mortem analysis.
- Longitudinal BBB should give additional freedom in cavity temperature working point and improve injection rate.
- As intermediate step to SSA: the health of the spare klystron should be guaranteed.

Thank you!