Module Issues

XFEL Linac Review

26.3.2007

R. Lange/L. Lilje

- Ongoing Tests
- Module Designs
- Future tests

Acknowledgements

- Many people have contributed to the overall design and test effort
- Thanks for transperencies to A. Bertolini, D. Kostin, A. Bosotti, R. Paparella, K. Jensch

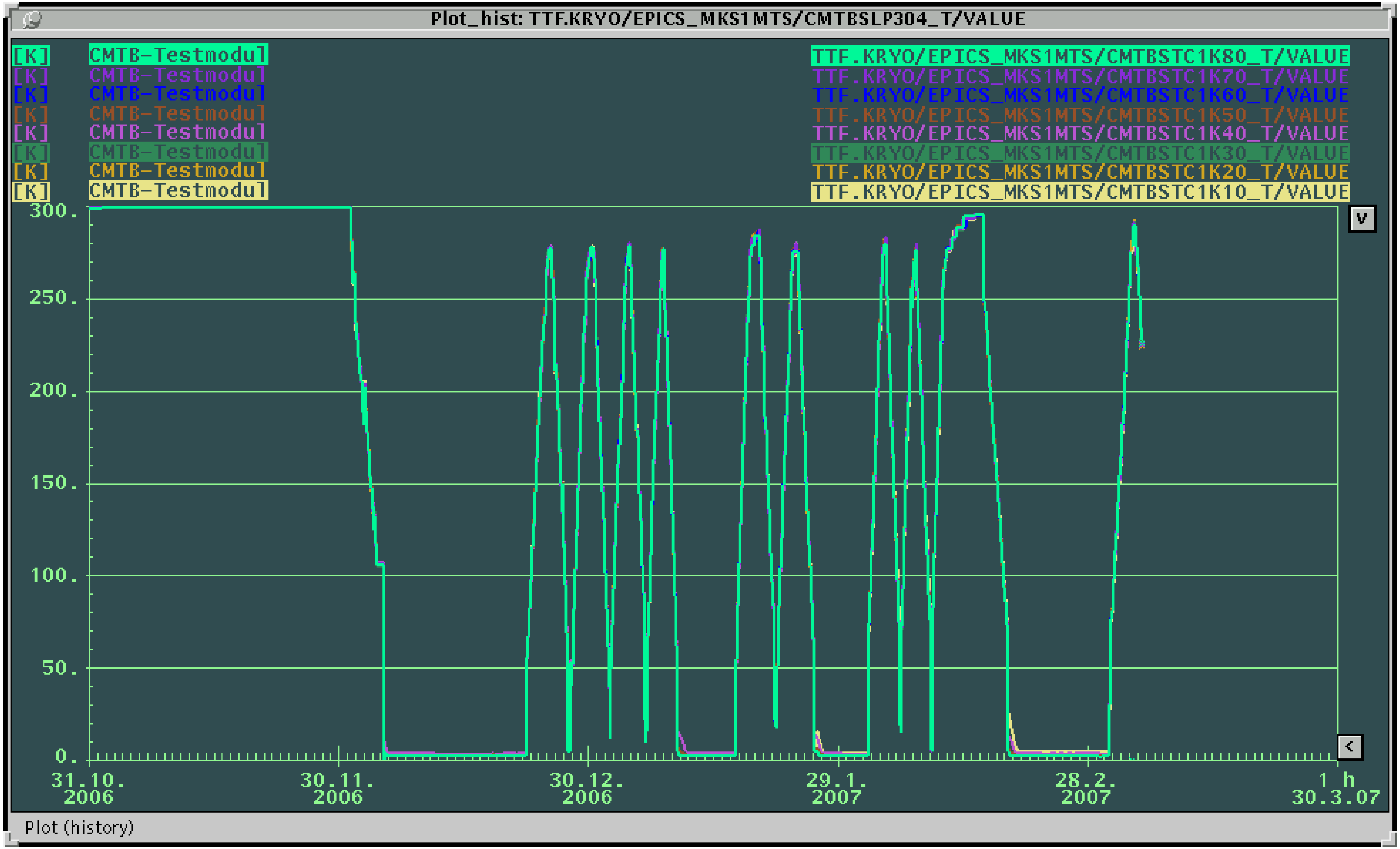
Tests

- M6 on CMTB
  - TTF type 3 module
  - Heat load static (expected value)
    - 40 /80 K: 80 Watt +/- 5 (75 Watt)
    - 4 K: 13 Watt +/- 2 (13 Watt)
    - 2 K: 3.5 Watt +/-1.5 (2.8 Watt)
    - Note: 2 Endcaps lead to higher loss!
  - No leaks occurred in 11 thermal cycles
  - RF performance
    - Coupler processing very smooth
    - 2 cavities degraded
  - Piezo tests
  - Alignment over thermal cycles
  - Vibration measurements
    - More data will be in the talk by H. Brueck
  - (LLRF tests)

CMTB Module 6 during 11th cool down

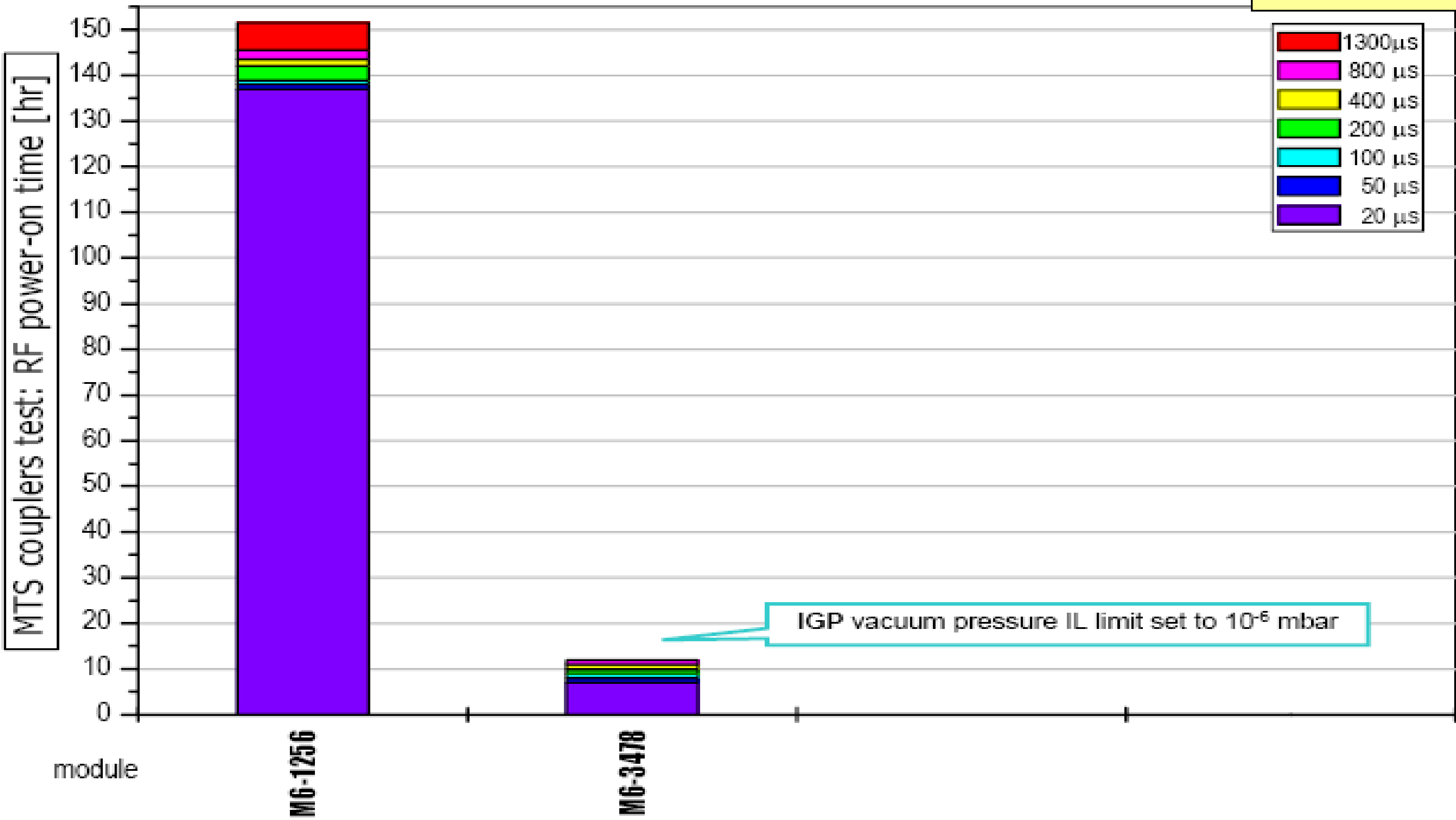
Status:06-March-07

R. Lange



RF power rising time for different pulse lengths during the couplers conditioning:

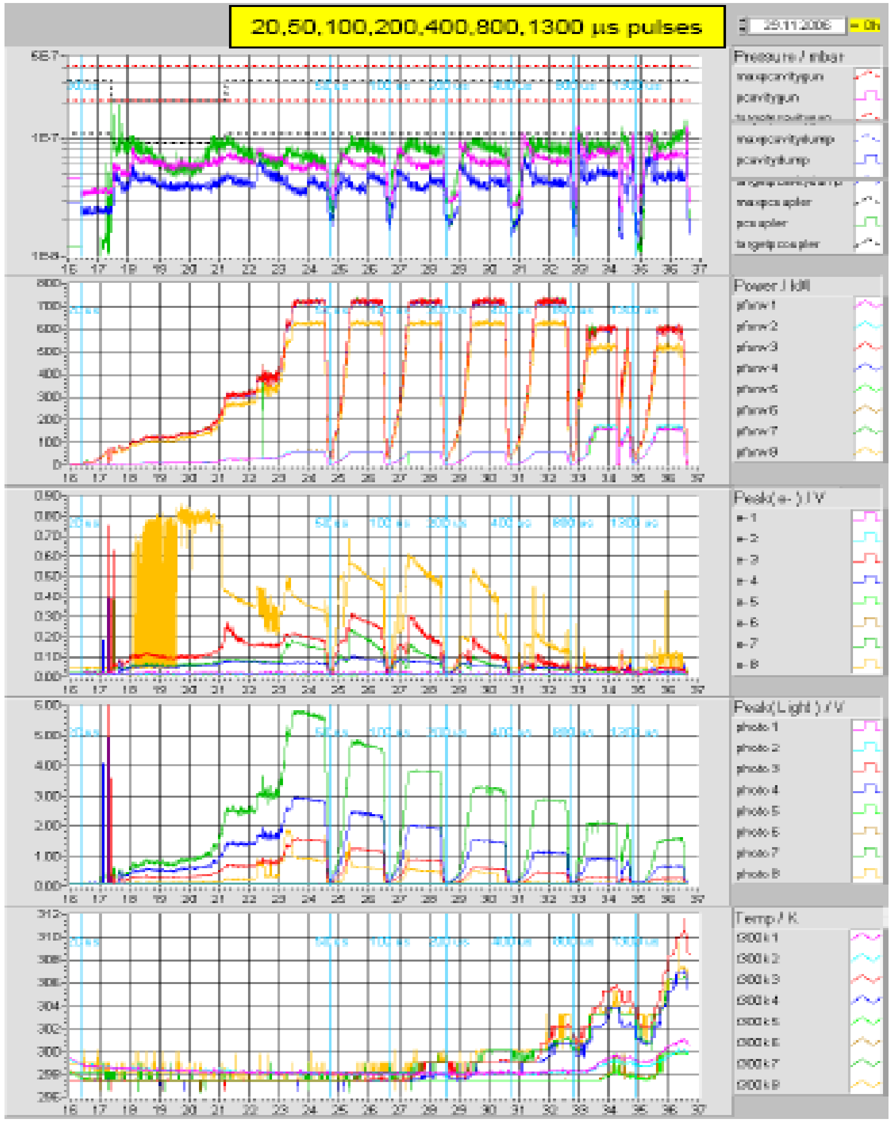
D. Kostin



- First set of couplers were processed with very tight interlock thresholts
- For the second set interlock thresholts were relaxed
- Their conditioning times comparable to recent CHECHIA experiences

D. Kostin

Second Set of Couplers



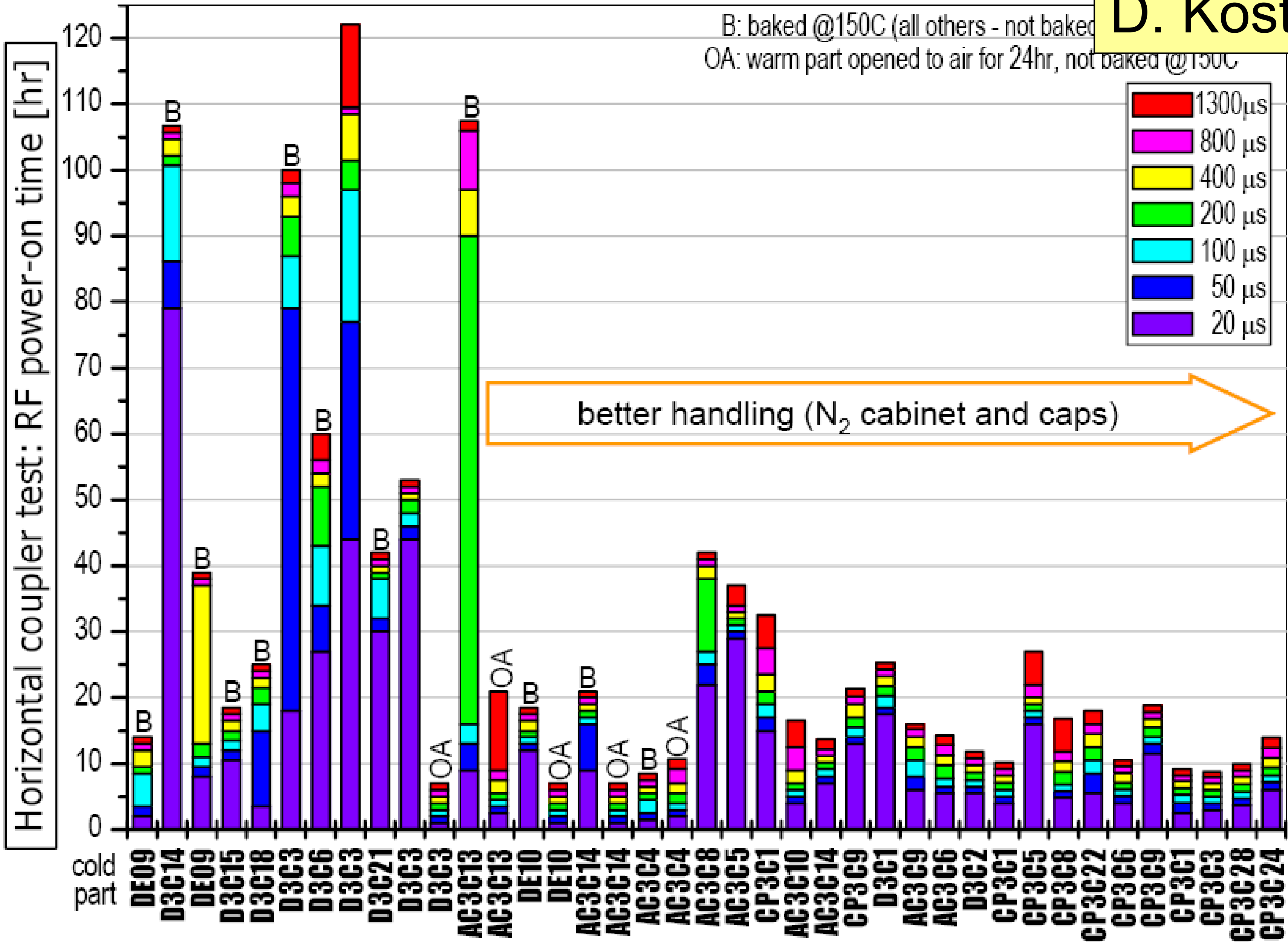
Input RF couplers 3,4,7,8 warm conditioning

Setting of the higher IGP (pumping speed 60 l/s) vacuum pressure interlock limit (7V: 10^{-6}mbar) as well as conditioning the couplers at higher pressure (like at horizontal cavity cryostat test stand: 1..3x10^{-7} mbar) allows for shorter couplers conditioning time.

The IGP IL limit was initially set to 5V: 7x10^{-8} mbar, at Horizontal test stand it is set to 7.5V: 2x10^{-6} mbar.

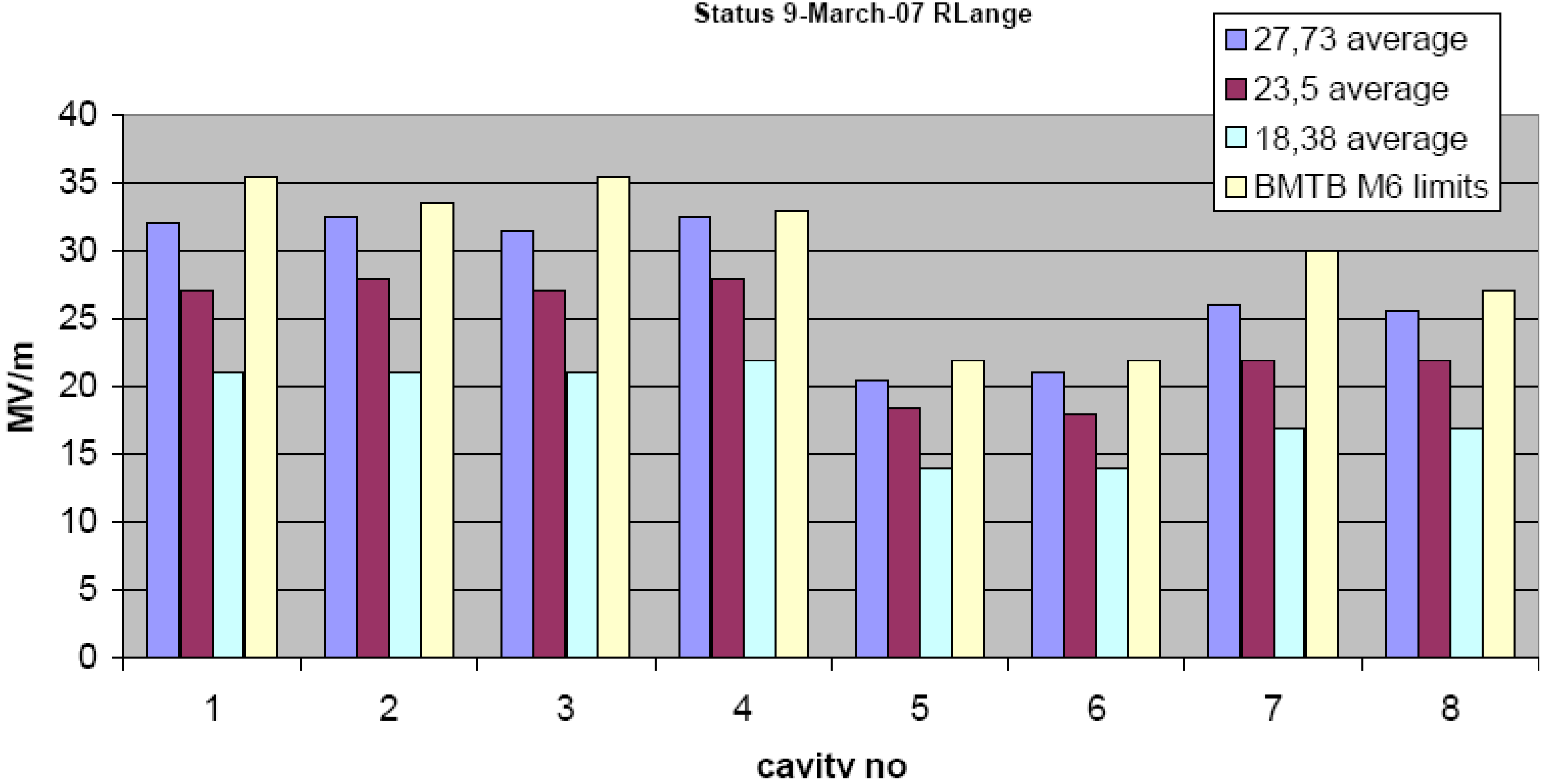
Horizontal test stand conditioning:

D. Kostin

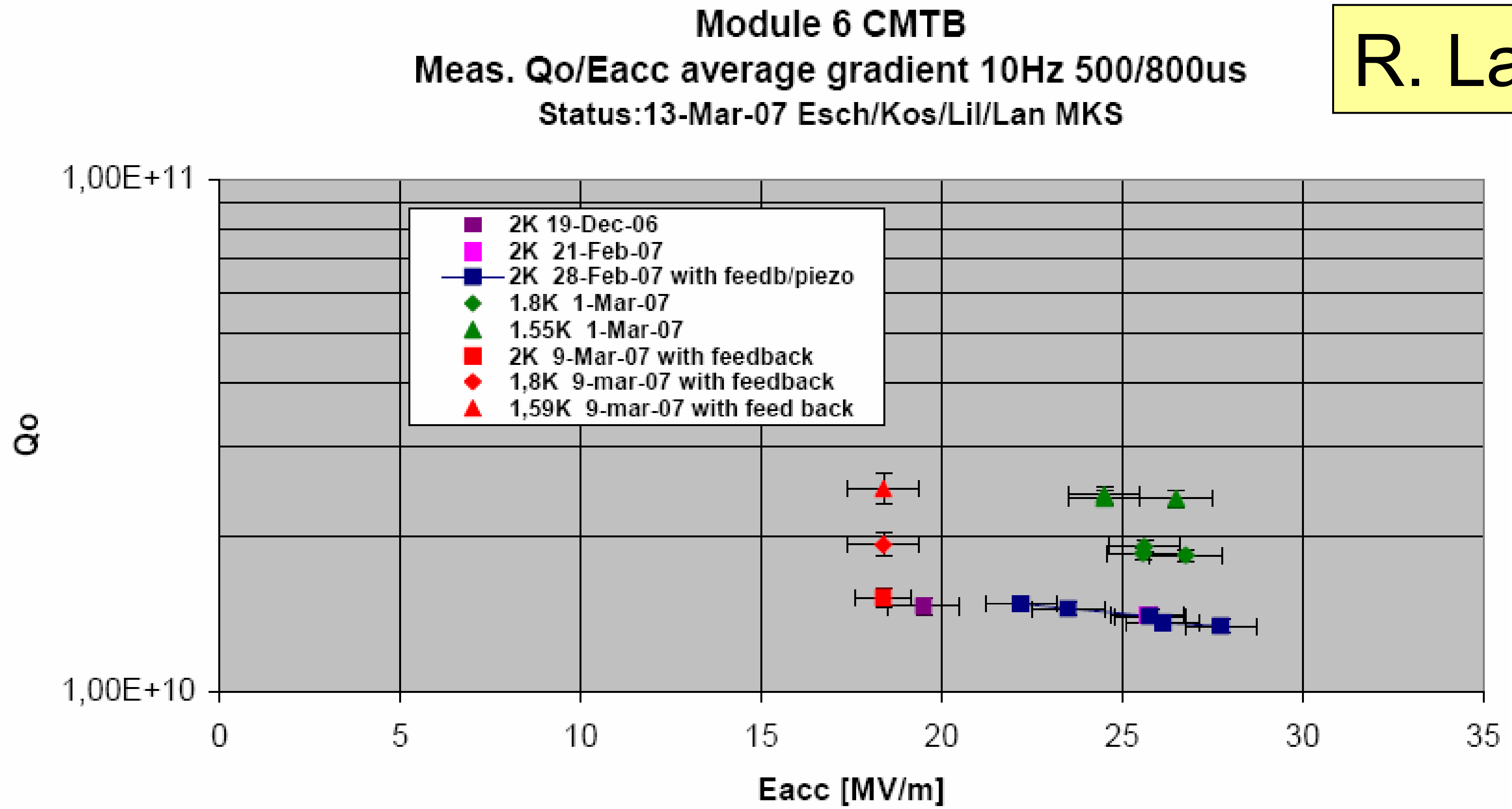


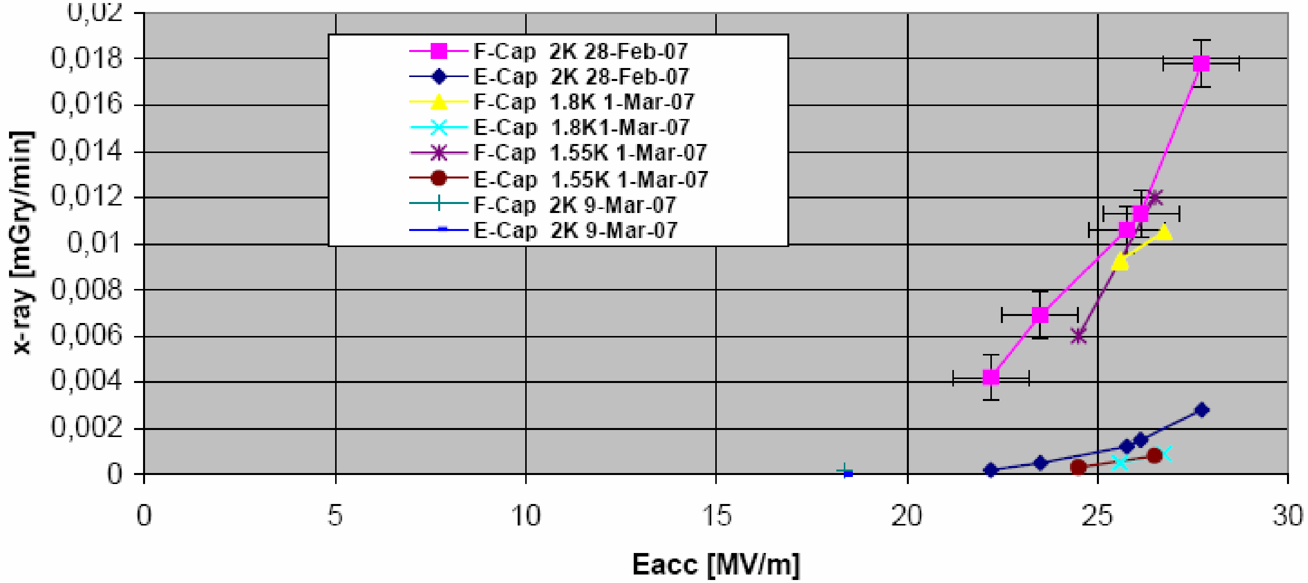
R. Lange

CMTB M6
rf operation with spec. power distribution
Status 9-March-07 RLange



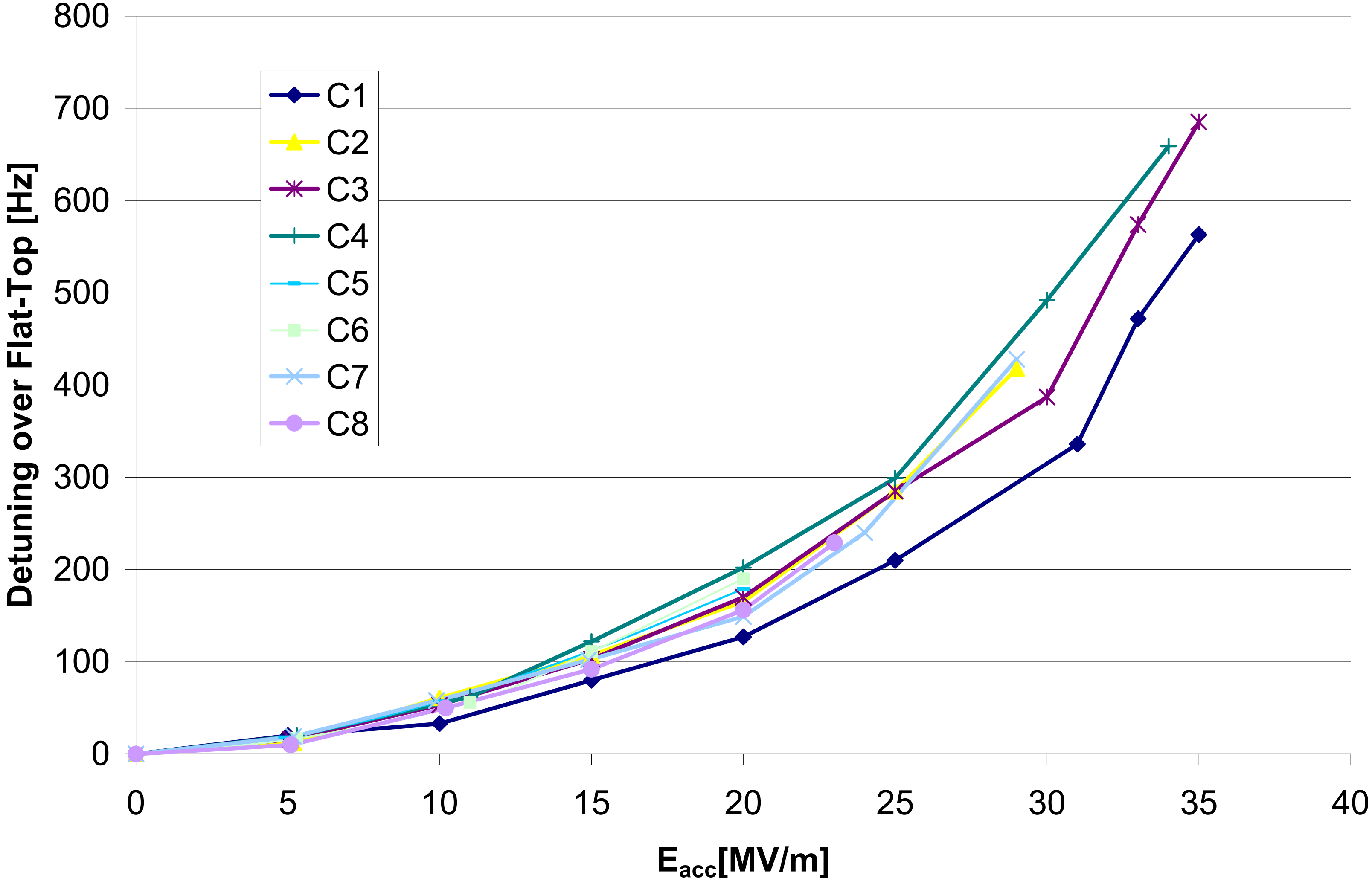
R. Lange



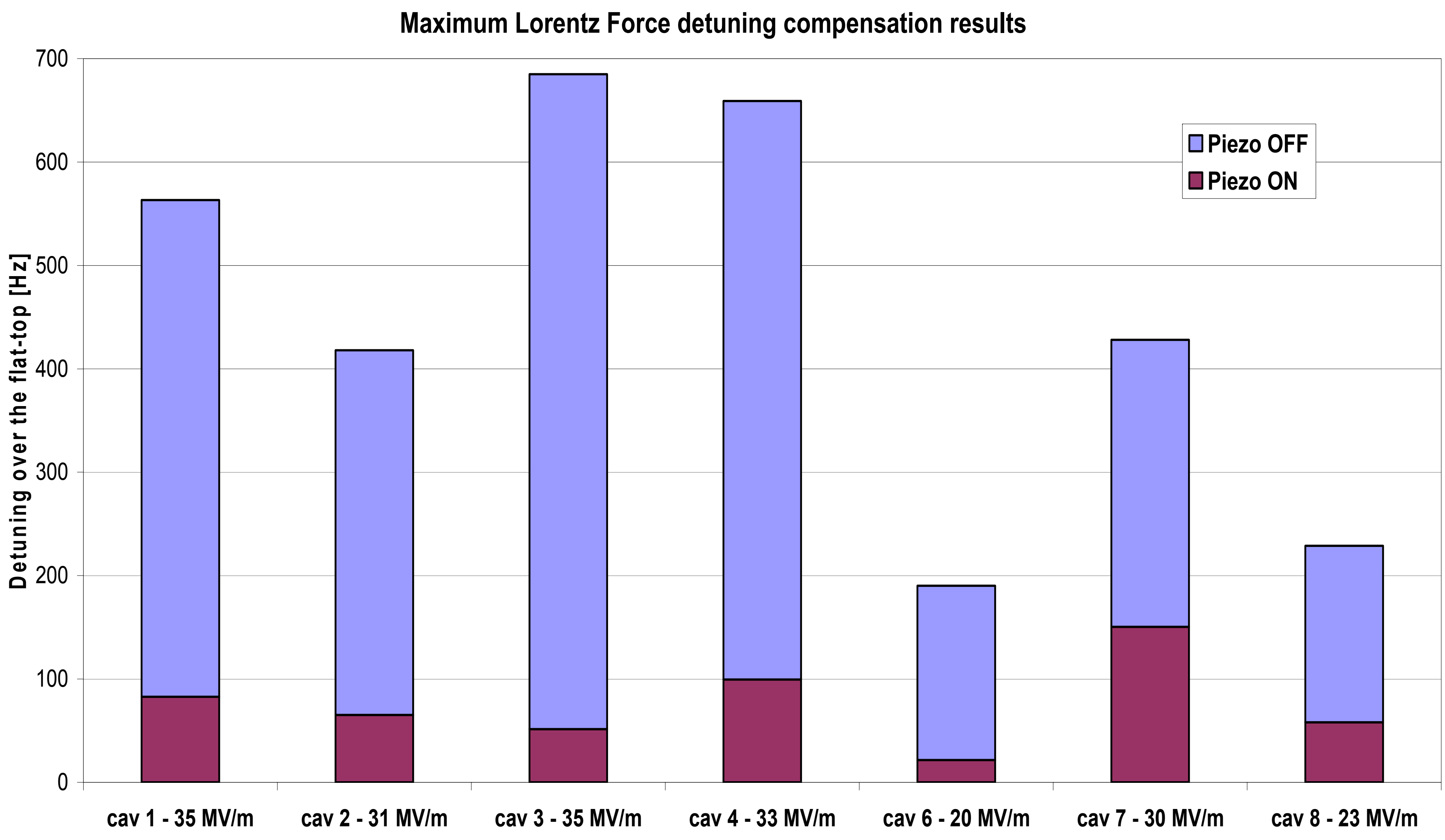


3.2007

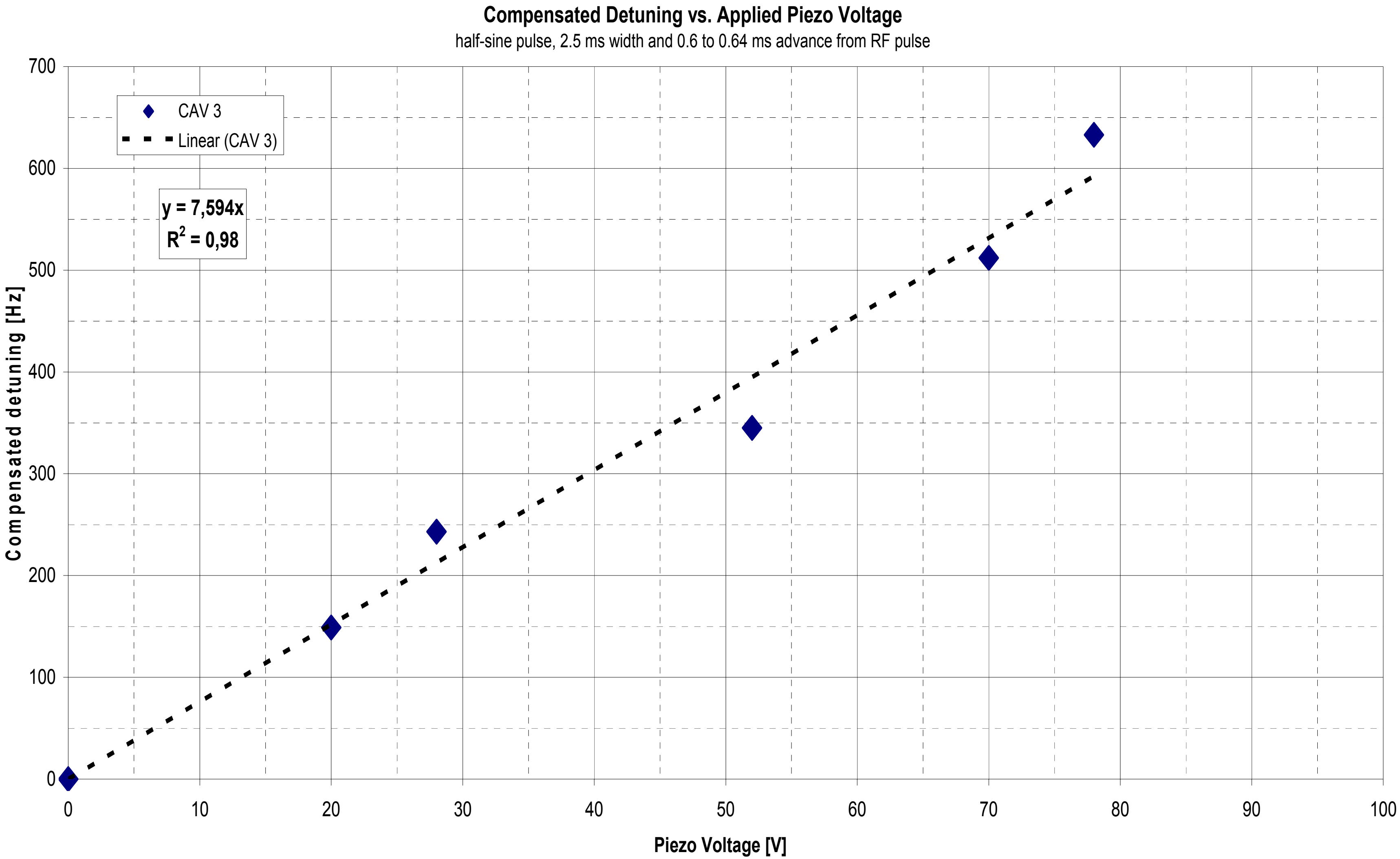
Lorentz Force Detunings in Module 6



Compensated Detuning per Cavity

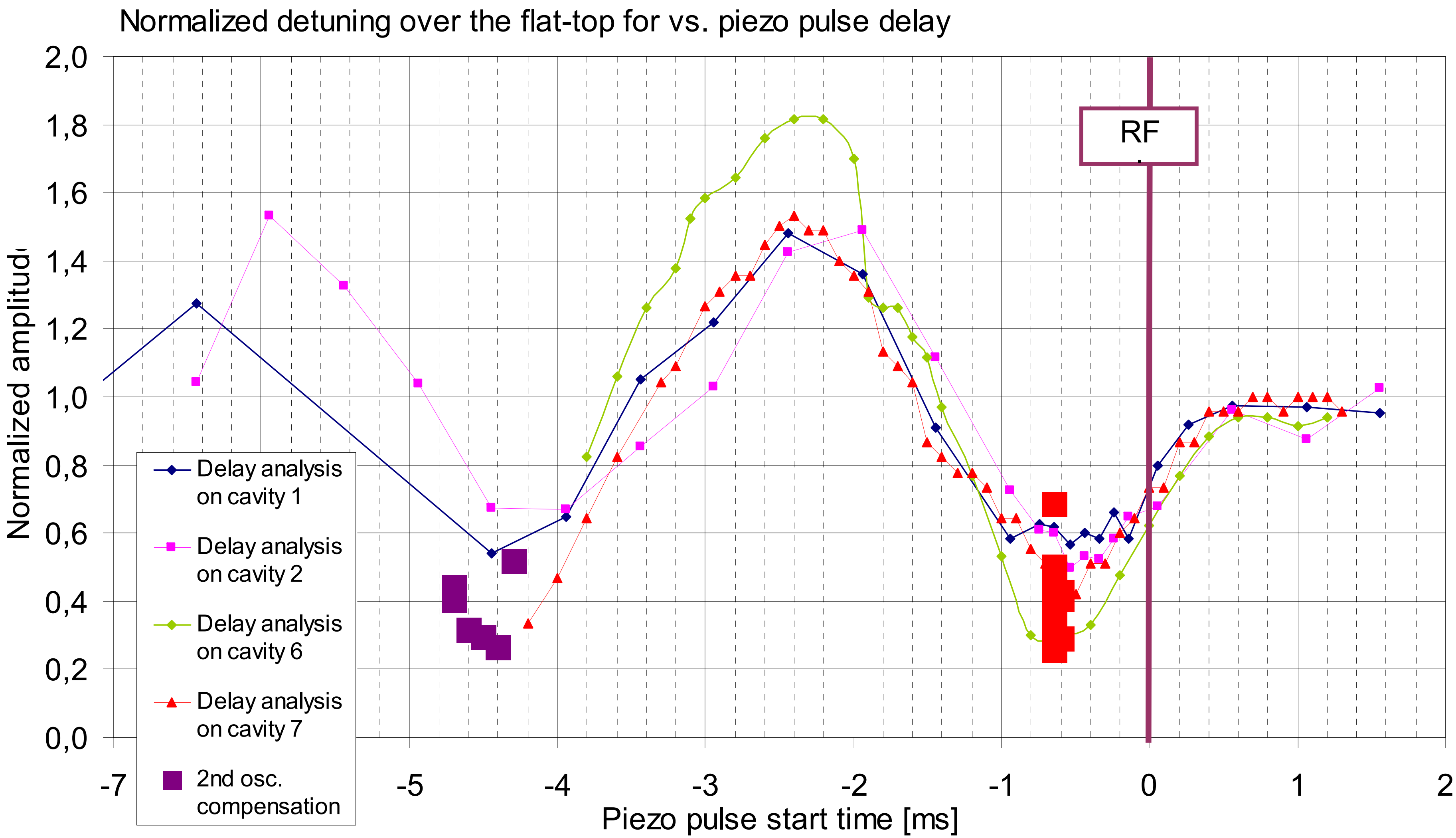


Voltage on Piezo Needed for Compensation

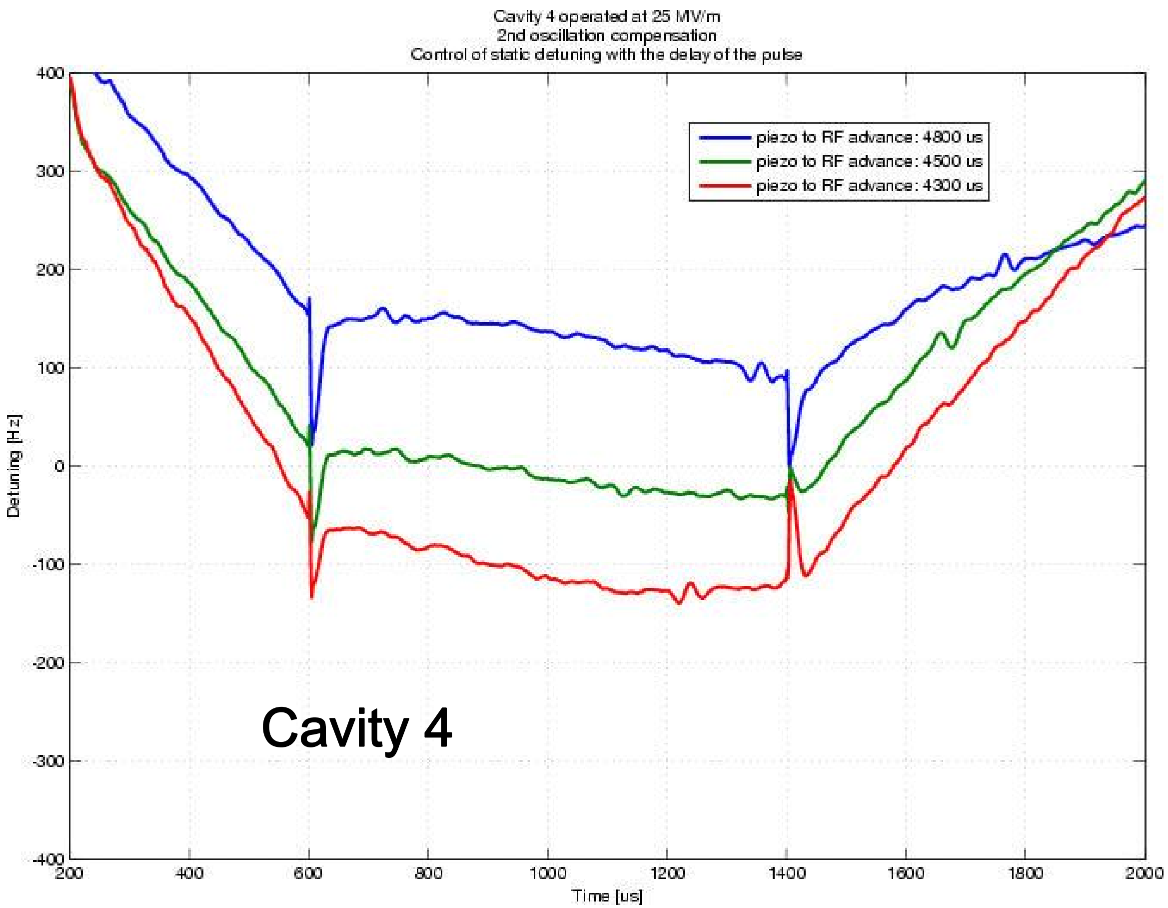


- Piezo Voltages within margin
  - maximum PI piezo voltage of 120 V at room temperature
  - Could also use bipolar operation, but not needed

Compensated Detuning vs. Delay to RF@25 MV/m

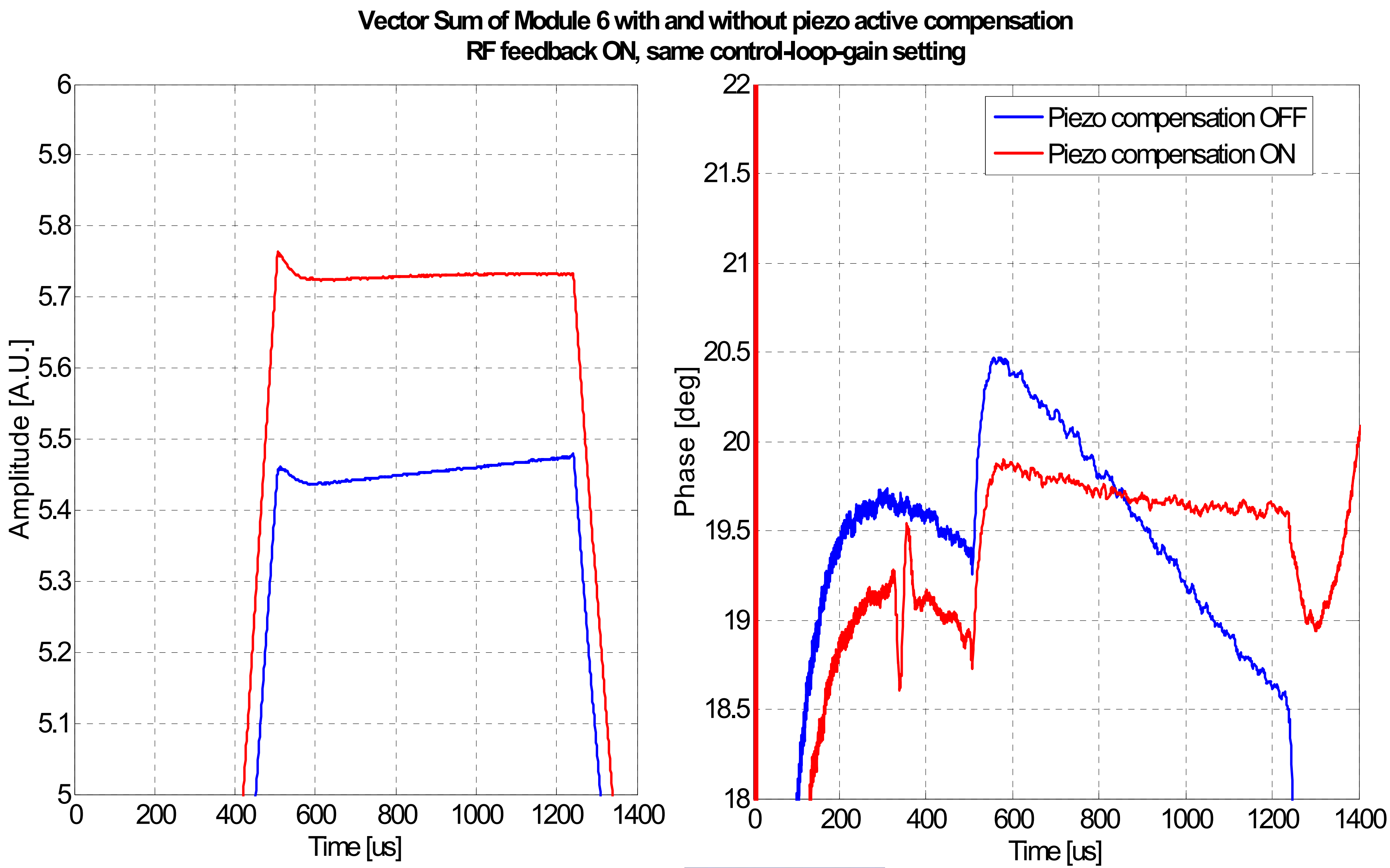


Pre-Detuning Change Due to Piezo Pulse Delay when using the ‚second oscillation‘



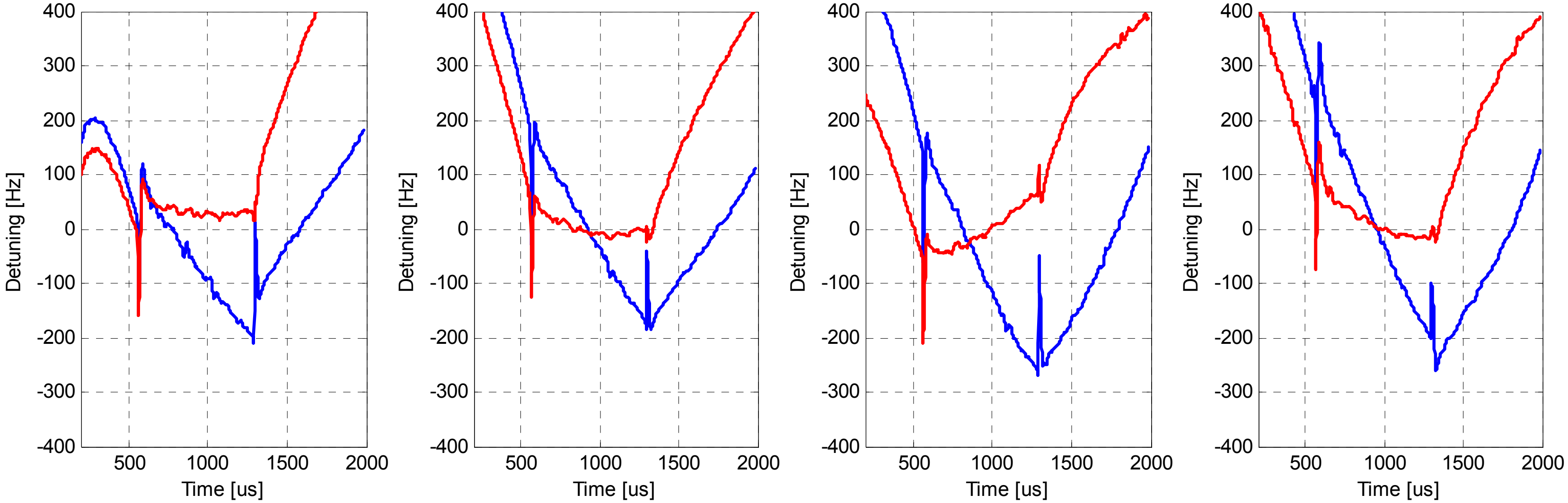
– Can change the cavity pre-detuning of the cavity by changing the Piezo delay to use the ‘second oscillation‘ in the order of 200Hz
  - Less motor usage, increase lifetime
  - Correponds to He drifts of a few mbar

Operation of Full module – Vector-Sum

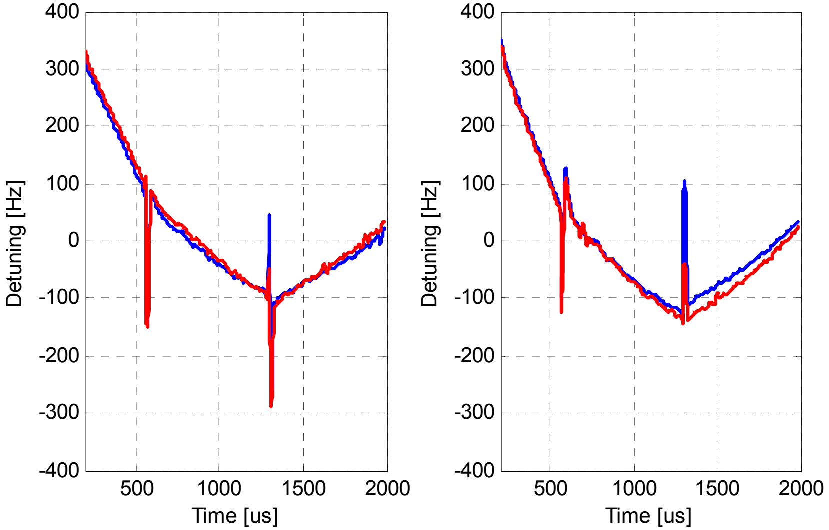


Detuning of all cavities of Module 6 with and without piezo active compensation

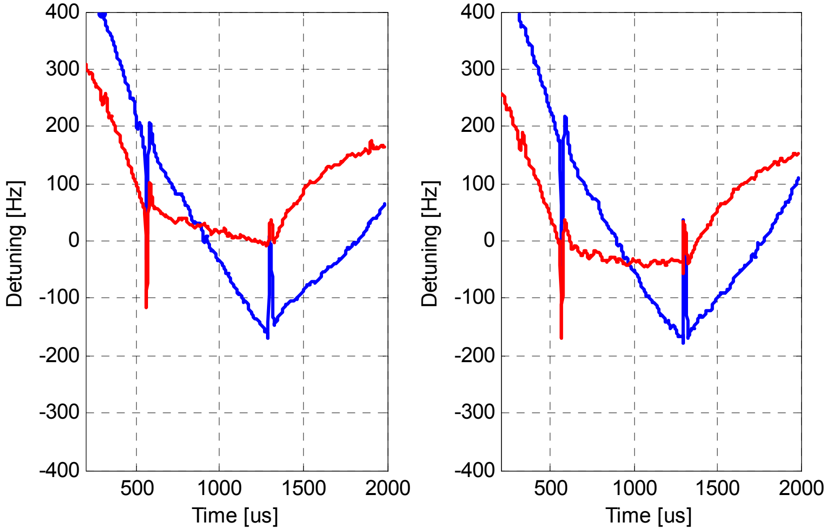
Cavity 1,2,3,4 : signal 1 - half sin 2.5 ms width, 60 V, 640 us advance



Cavity 5,6 : no signal - no active compensation



Cavity 7,8 : signal 2 - half sin 2.5 ms width, 64 V, 640 us advance

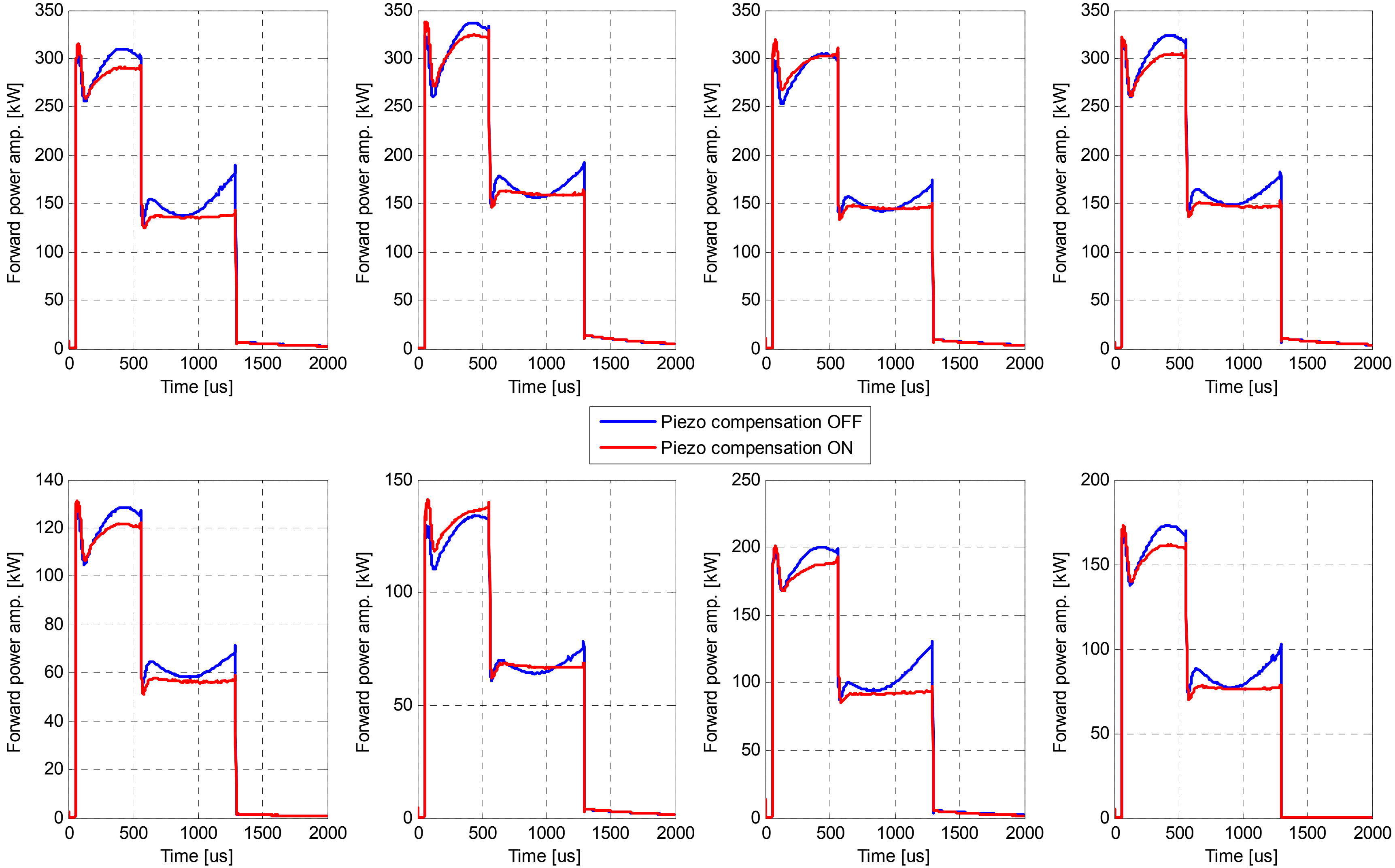


Lutz Lilje DESY -MPY-

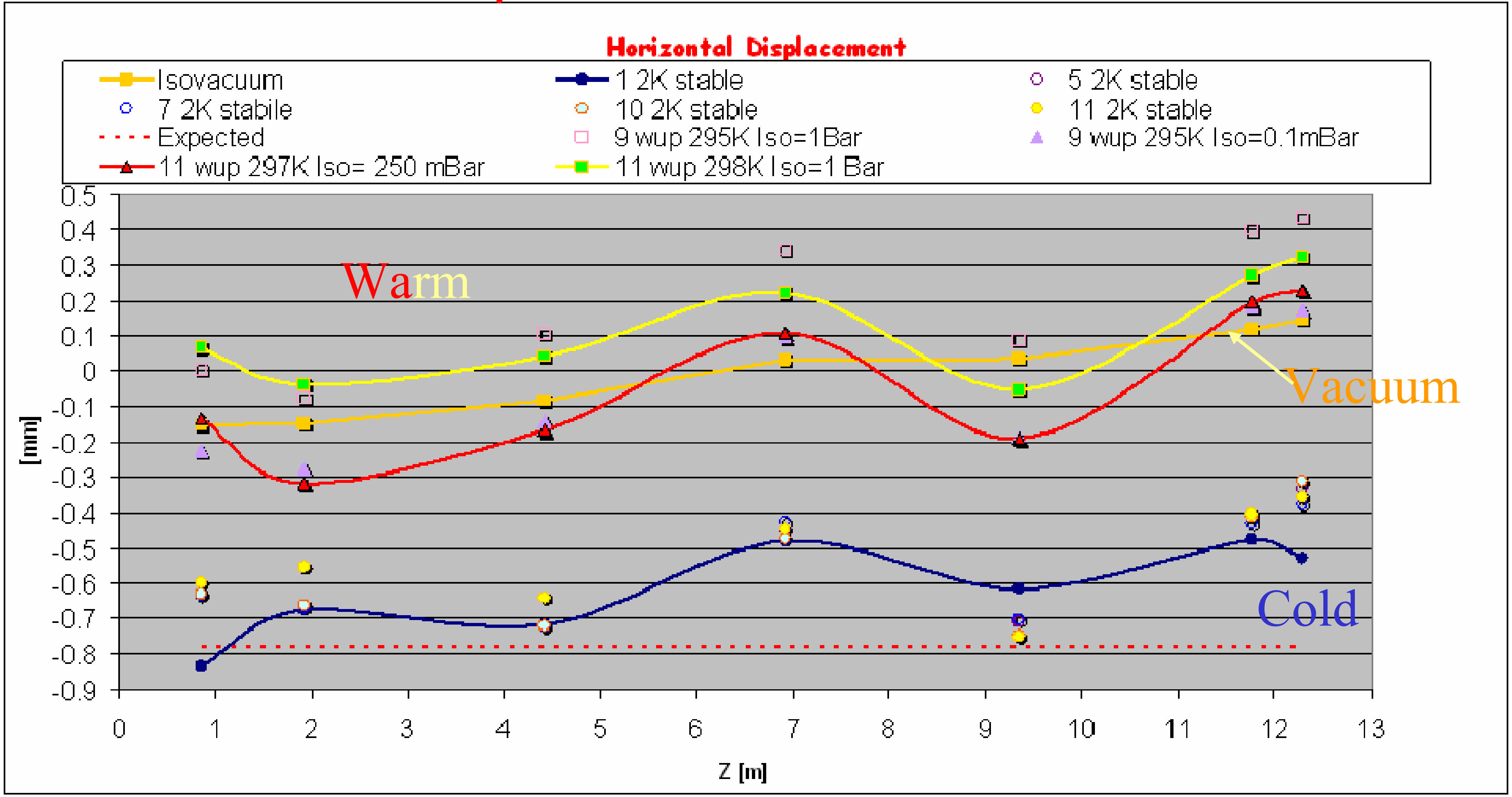
28.03.2007

Operation of Full Module – Forward Power

RF feedback switched ON on module 6 in CMTB. Collection of all amplitude of forward power signals with and without piezo active compensation

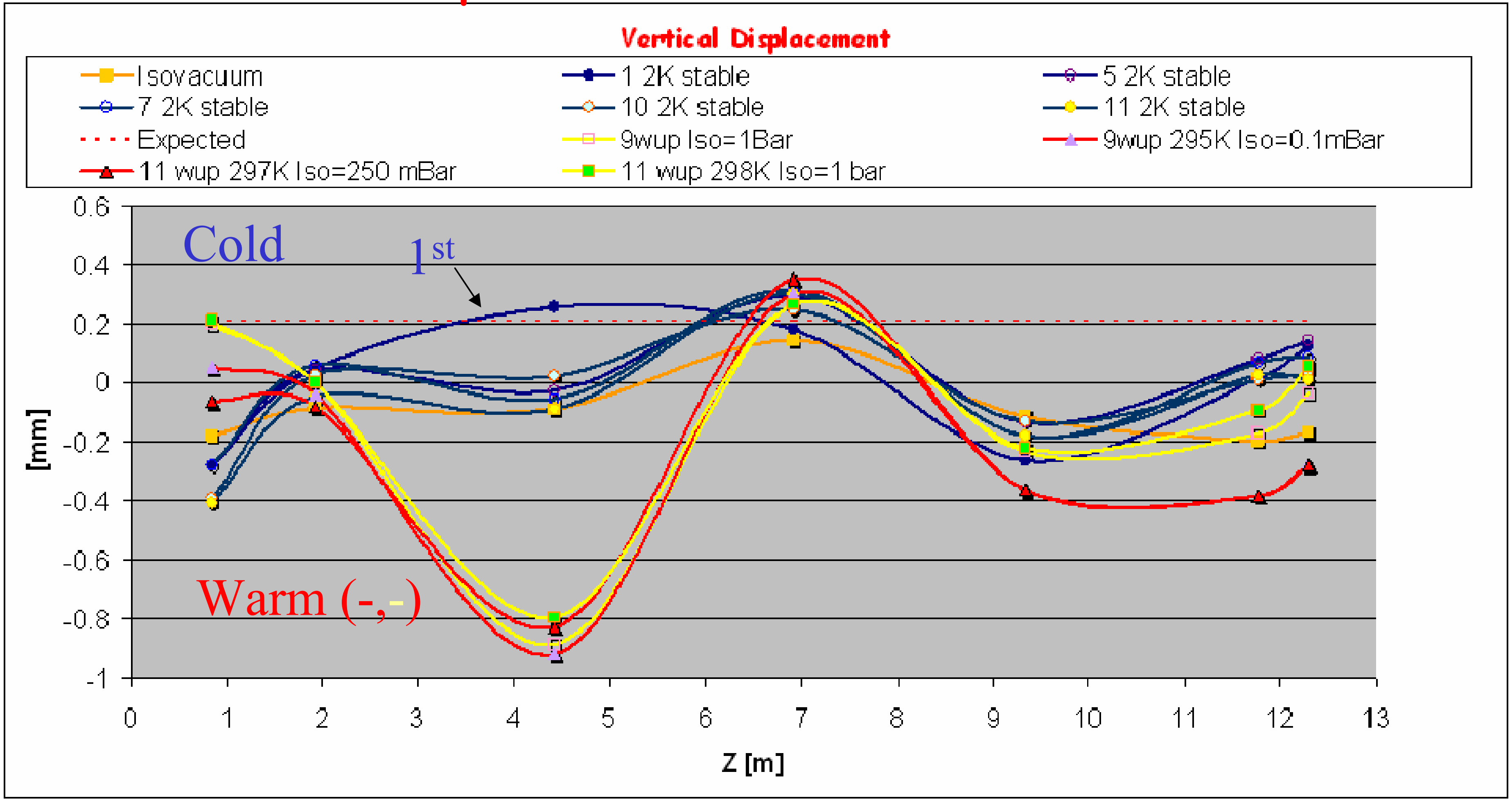


Cooldown and Warmup data for different cycles: Horizontal Displacements (only stable T points considered)



A. Bosotti

Cooldown and Warmup data for different cycles: Vertical Displacements (only stable T points considered)

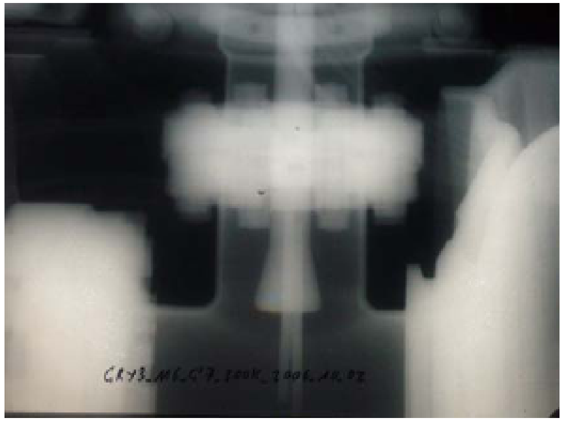


A. Bosotti

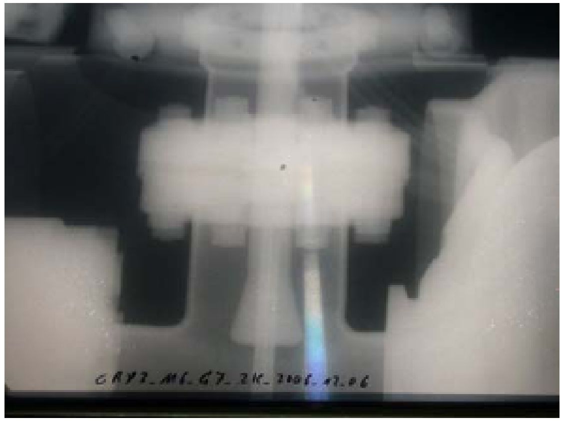
Longitudinal Position: Xray of Coupler Antenna (C7)

(Ansicht Y-Achse)

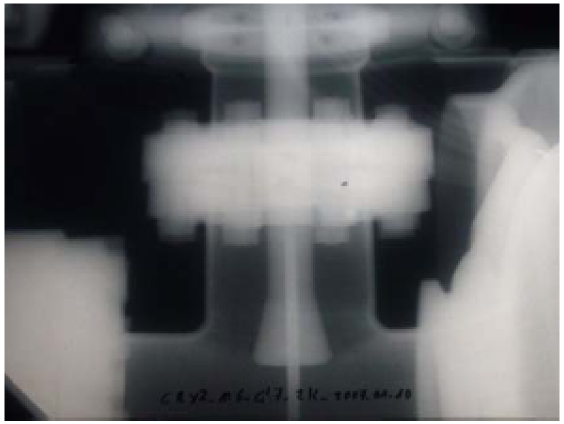
300 K vor
1 therm.
Zyklus



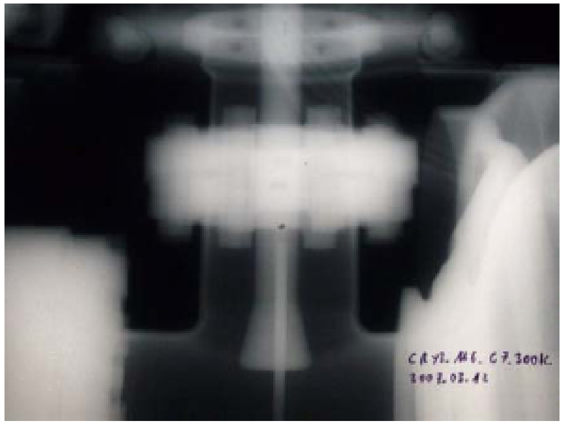
2 K nach
1 therm.
Zyklus



2 K nach
5 therm.
Zyklus



300 K nach
11 therm.
Zyklus



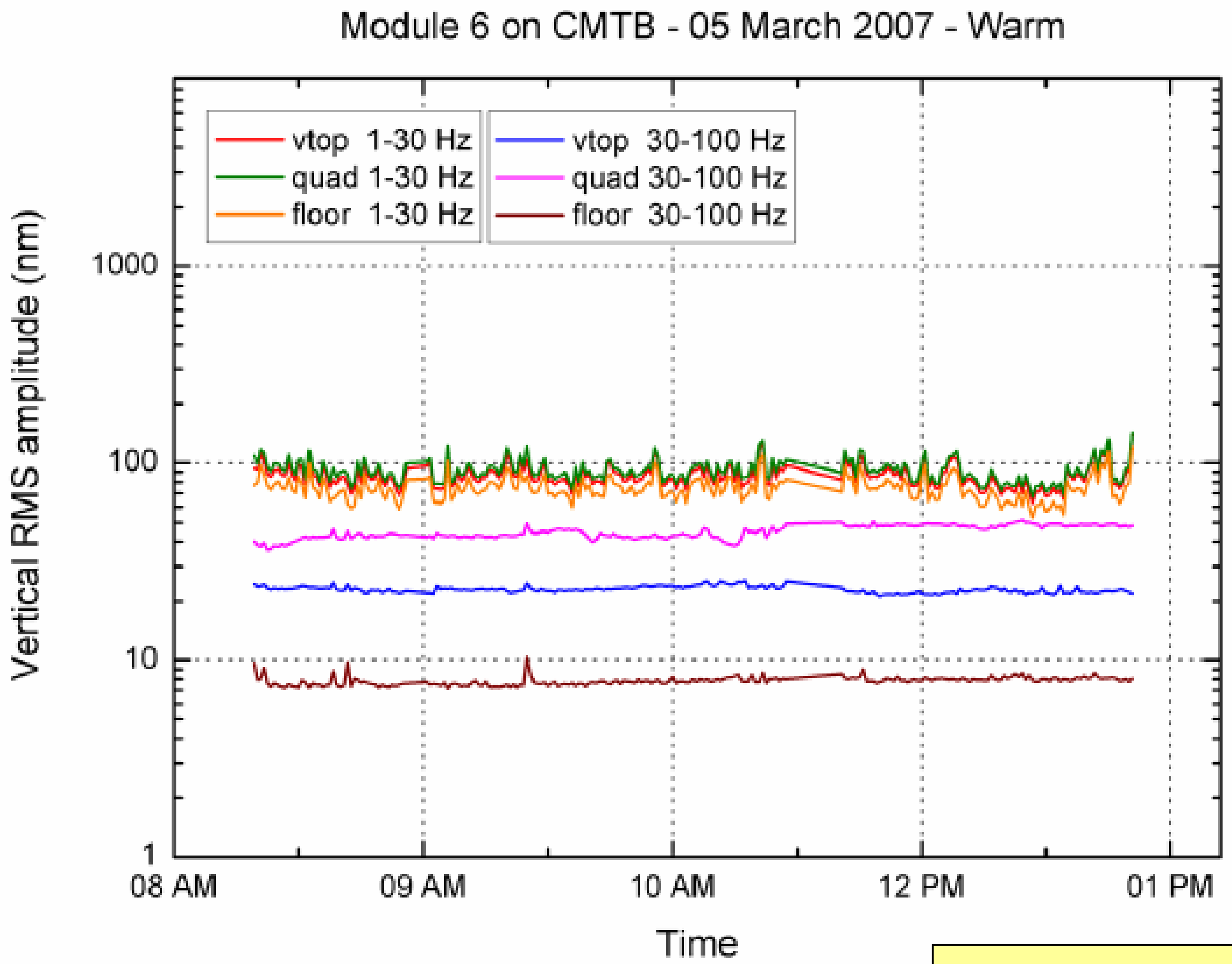
← Beam direction

K. Jensch

Quadrupole vibrations – Cryomodule warm III

RMS analysis

In the low frequency band the quadrupole motion tracks the ground vibration level. Slight amplitude differences are related mainly to the mechanical transfer function of the module on its support system. Non perfect equalization of the sensor response can also affect the accuracy. Quad RMS overestimated because of the low resonant frequency (4.14 Hz) of this geophone at room temperature.

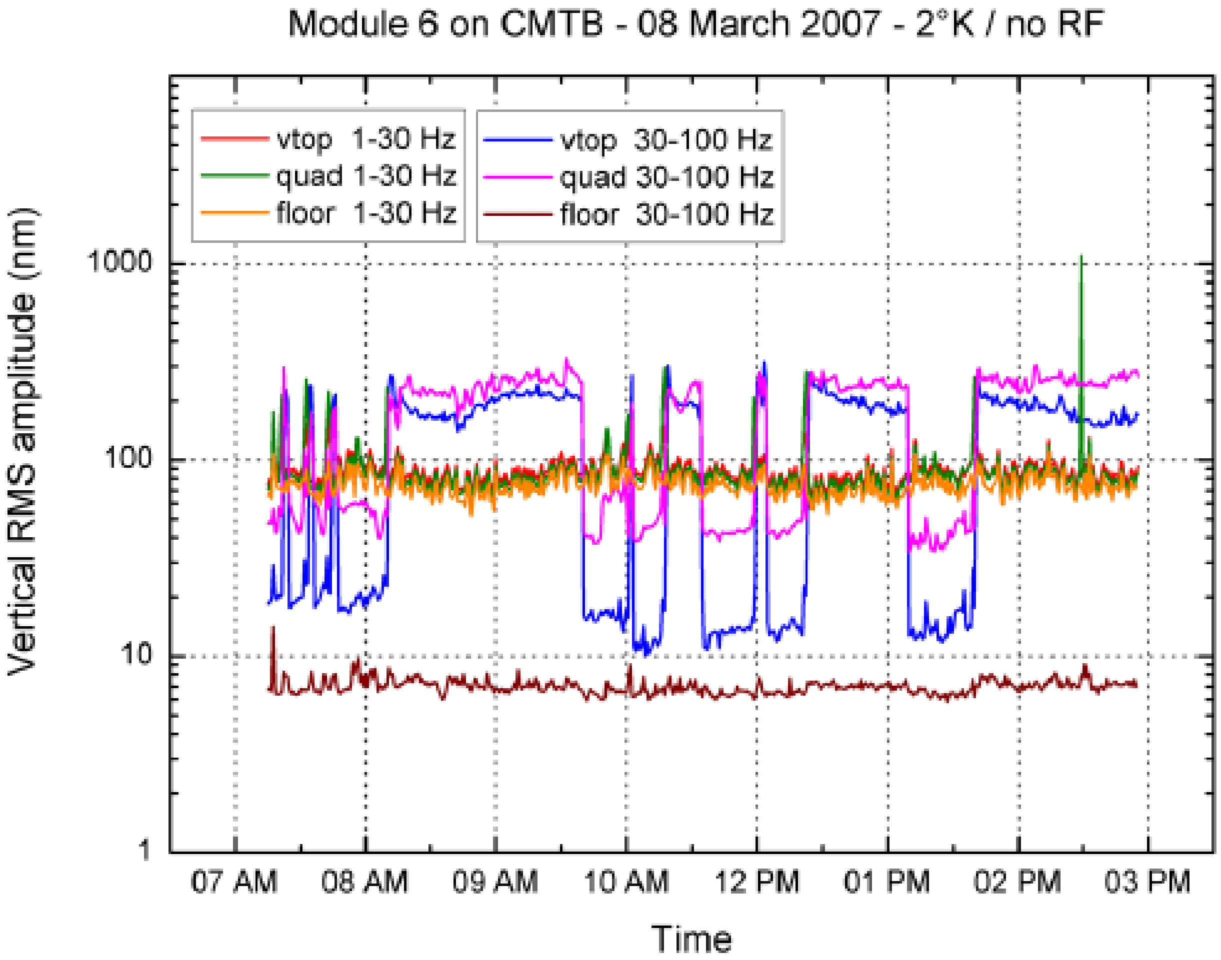


A. Bertolini

Quadrupole vibrations – Cold steady state – no RF

RMS analysis

Ground motion tracking confirmed at low frequencies, with ~10% quad/gnd and top/gnd rms ratios.
Large vibration amplitude at high frequency from the CMTB cryogenic plant.
The refrigeration system doesn't affect the quadrupole stability at low frequency (f<30 Hz).
High frequency noise to be checked after the solution of CMTB cryoplant problems.



A. Bertolini

A. Bertolini

Geophone test at 4K

- classic 4.5 Hz industrial geophone can operate at 4K without any loss of sensitivity
- in-situ high accuracy calibration procedure demonstrated
- a new tool for low frequency vibration investigations at cryogenic temperatures

Quadrupole vibration measurements at 4 K

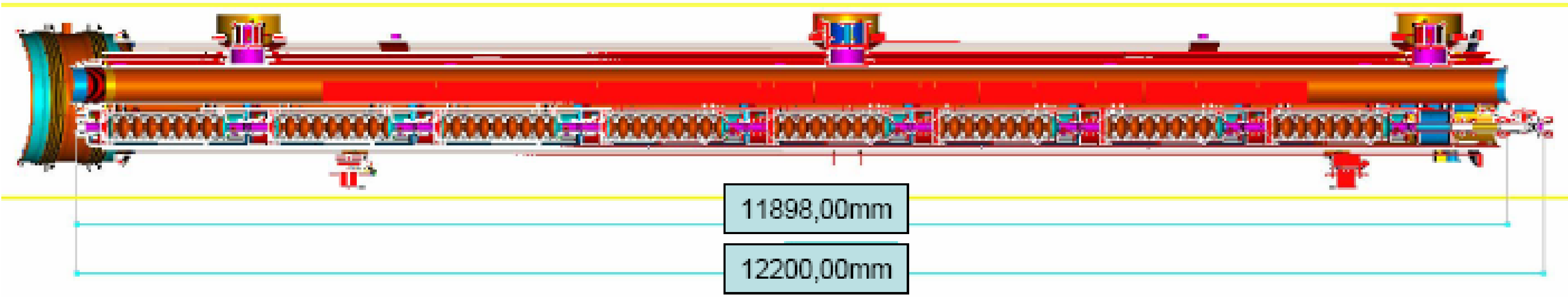
- low frequency (1-100 Hz) quadrupole vertical stability is not affected by high gradient RF operation
- quadrupole vertical stability is not affected by the refrigeration system at frequencies up to 30 Hz; results not conclusive at higher frequency because of the present limitations of the CMTB cryo plant.
- needed comparison with operation in the FLASH linac. Can we keep the geophones aboard Module 6?
- the results will be cross-checked with laser interferometry on Module 8 at the end of the year.

Design

- TTF type III+ design and manufacturing done (M8 and M9)
  - Mechanical design is based on TTF Type III modules (M4,M5, M6)
    - Minor differences
      - Quad longitudinal fixation
        - » Like cavities
      - Other Quad/BPM type differences
        - » 2K
        - » E.g. other current leads
      - Correct lambda distance between cavities
      - allows to put HOM absorber between modules
  - Most of XFEL prototype features will be tested
  - Active industrial participation in module assembly
- XFEL Prototype status
  - As above, but…
    - Shorter overall cryostat ~200 mm
    - Shield tubing enlarged
    - 2-Phase line under investigation,
      - max. 89mm outer diameter possible without major design changes
  - Cryostat order will be placed now
    - Qualification of cryostat vendors

Module TypeIII+

(overview)



3D-JT-File complete cryo module under EDMS*750581

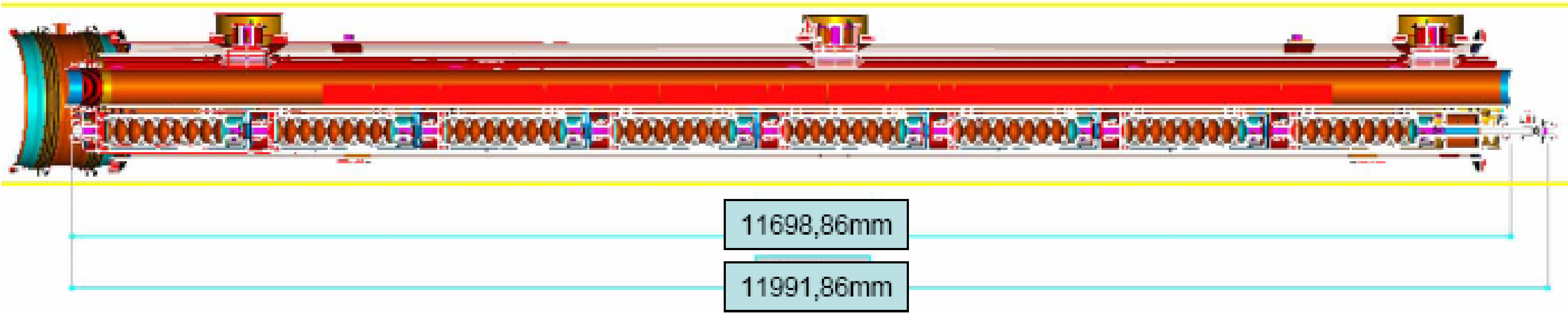
02-Nov-2006

XFEL X-Ray Free-Electron Laser

K. Jensch

XFEL-Cryomodule

(overview)



3D-JT-File cavity string under EDMS**752701

02-Nov-2006

XFEL
X-Ray Free-Electron Laser

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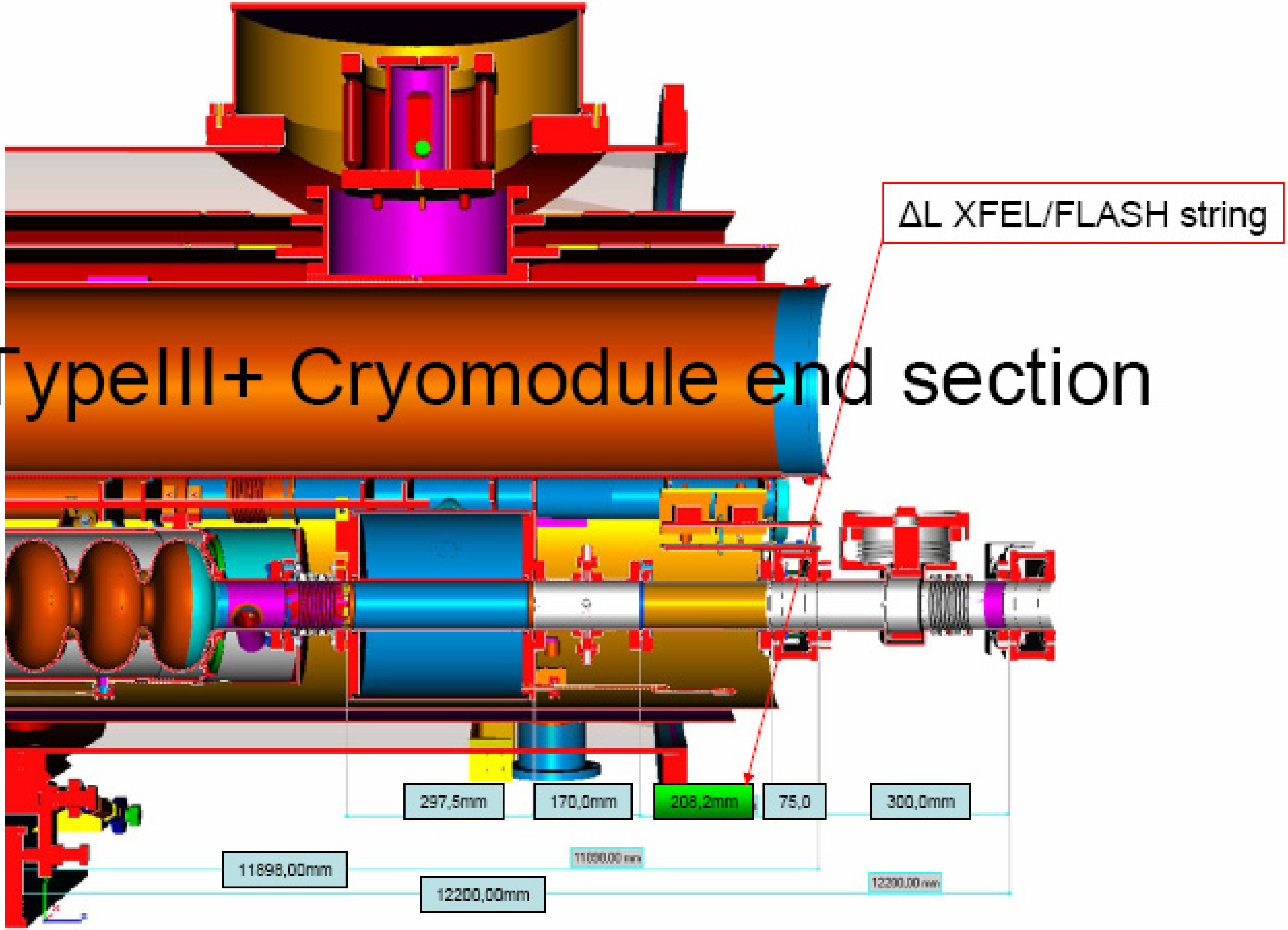
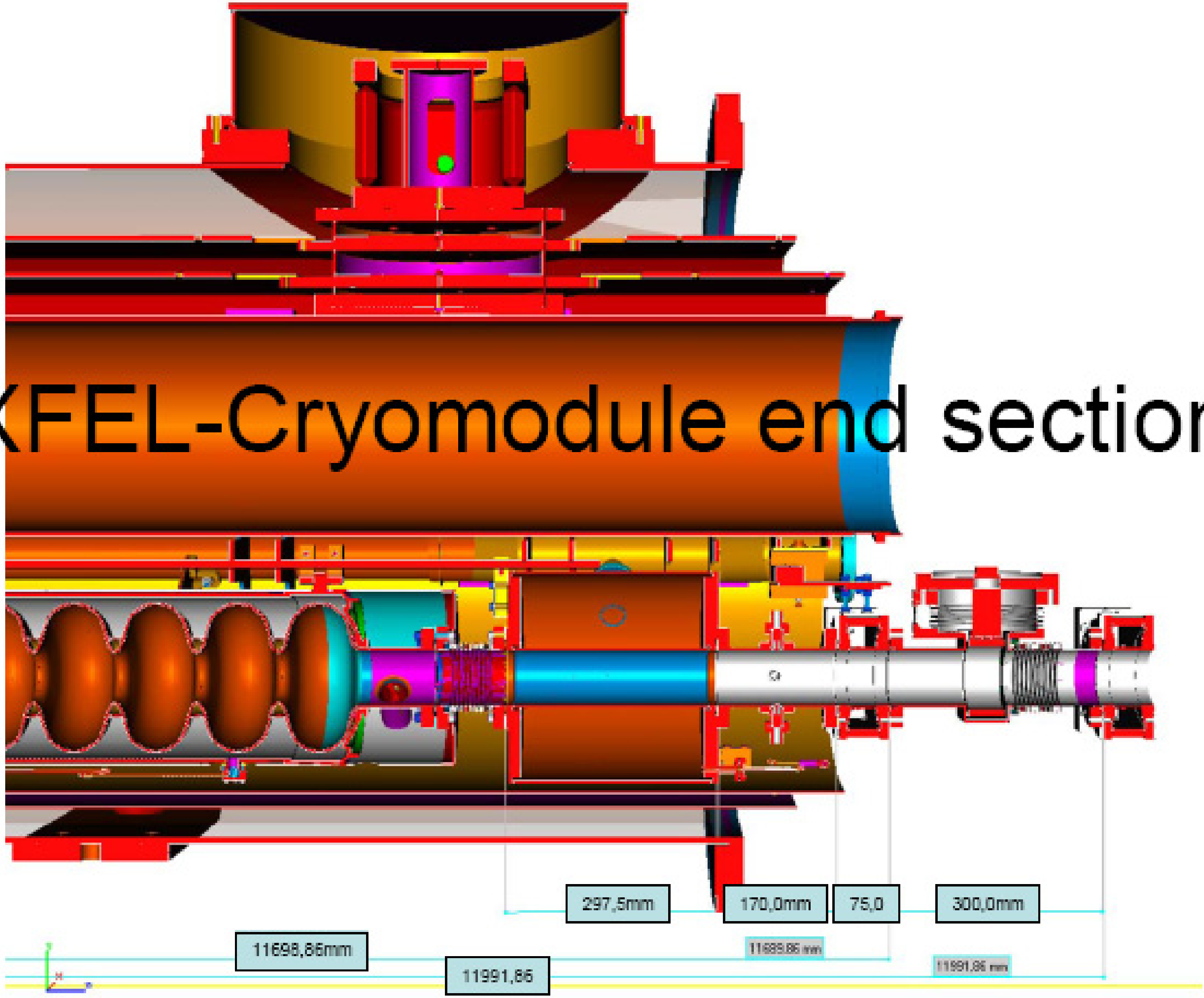
TypeIII+ Cryomodule end section



XFEL-Cryomodule end section



K. Jensch

Future Tests

- Destructive test on M3*
- More vibration measurements
  - M7
    - Parallel accelerometer and geophone measurements
    - Continuous measurements
  - M8
    - Laser interferometry on quad
  - FLASH
    - Accelerometers (all modules) and geophones (in M6/ACC6) will be monitored continuously
- Test on longitudinal positioning of Quad/BPM package
  - On M8/(M9)
- More detailed tests on piezo tuning system
  - Reversed cavity pre-tuning needs full demonstration
- Further LLRF tests

Conclusion

- CMTB has proven to be essential tool for thorough linac-independent tests of modules
- M6 has passed several important tests
  - Coupler processing
  - Alignment over several thermal cycles
  - Piezo compensation
- Nonetheless some issues remain
  - Cavity performance degradation
  - Vibration needs more understanding (~30 Hz peak)
- Minor evolutions in design will be tested on M8
  - Important step toward a XFEL prototype test