Tests with the Fast Frequency Tuners in the Saclay-I design

Lutz Lilje
DESY

Acknowledgements

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Motivation

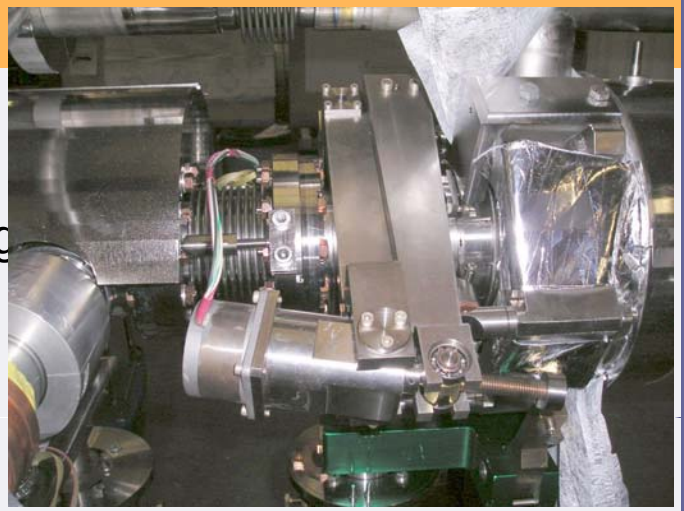
- It is clear that the current version of this tuner does not fit mechanically.
- Nonetheless, the tuner tests ILC concepts
  - Standard TESLA cavity design (and short ILC design)
    - Stiffening concept
  - Motor
    - Cold location
  - Piezo
    - Cold location

Overview

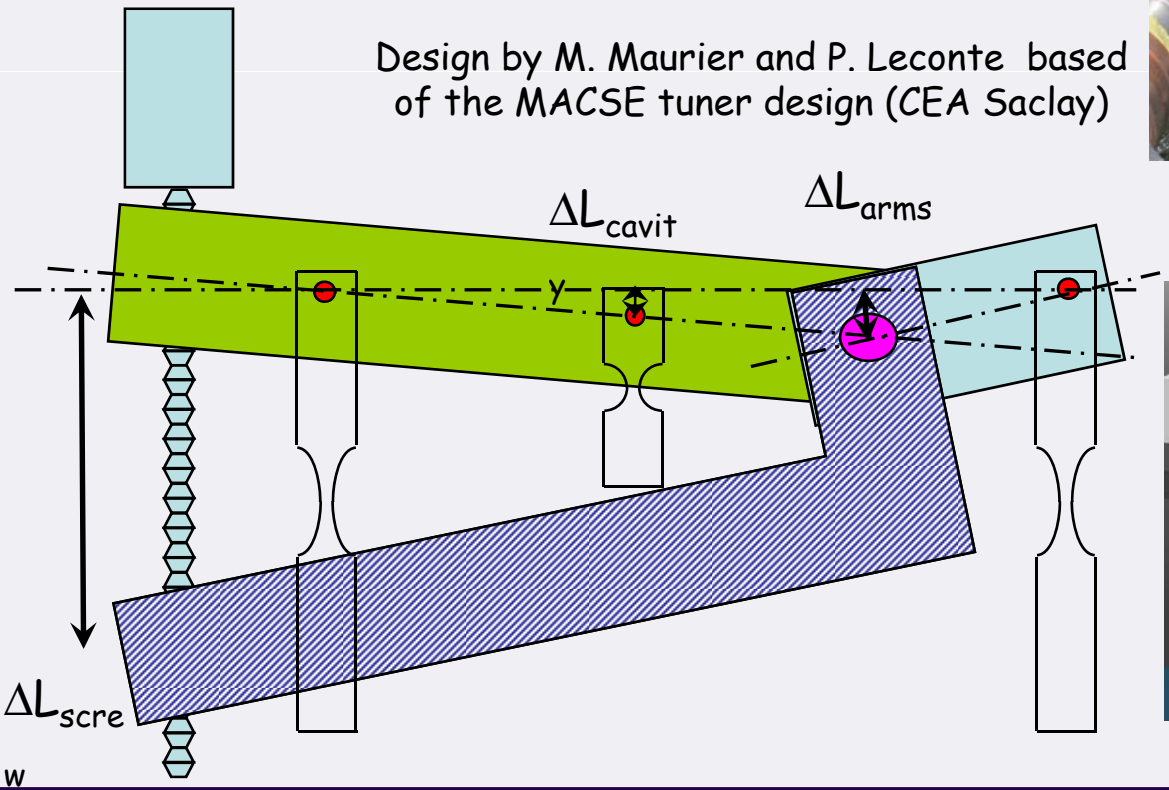
- Tuner system
  - Saclay design with added piezo tuner
- Measurements on Modules
  - Classical Pretuning of the cavity
    - Cavity pushes back on the tuner
      - » Difficult to adjust pre-load on the cavity
  - Double-Piezo fixture
    - M6, (M8)
  - Single-Piezo fixture
    - M5, M7
- CHECHIA Measurements
  - Reversed Pretuning of the cavities
    - Cavity pulls on tuner

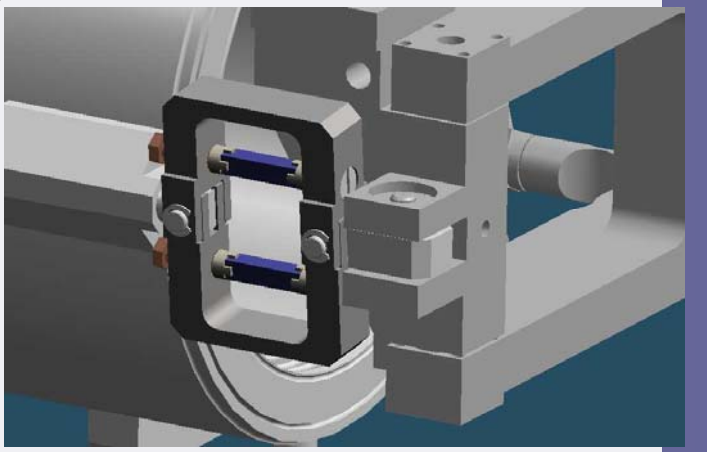
Tuner Setup

– Current design in use at FLASH
  - Design by CEA
  - Fast piezo detuning introduced not from beginning
  - Is the solution for XFEL so far



Design by M. Maurier and P. Leconte based of the MACSE tuner design (CEA Saclay)





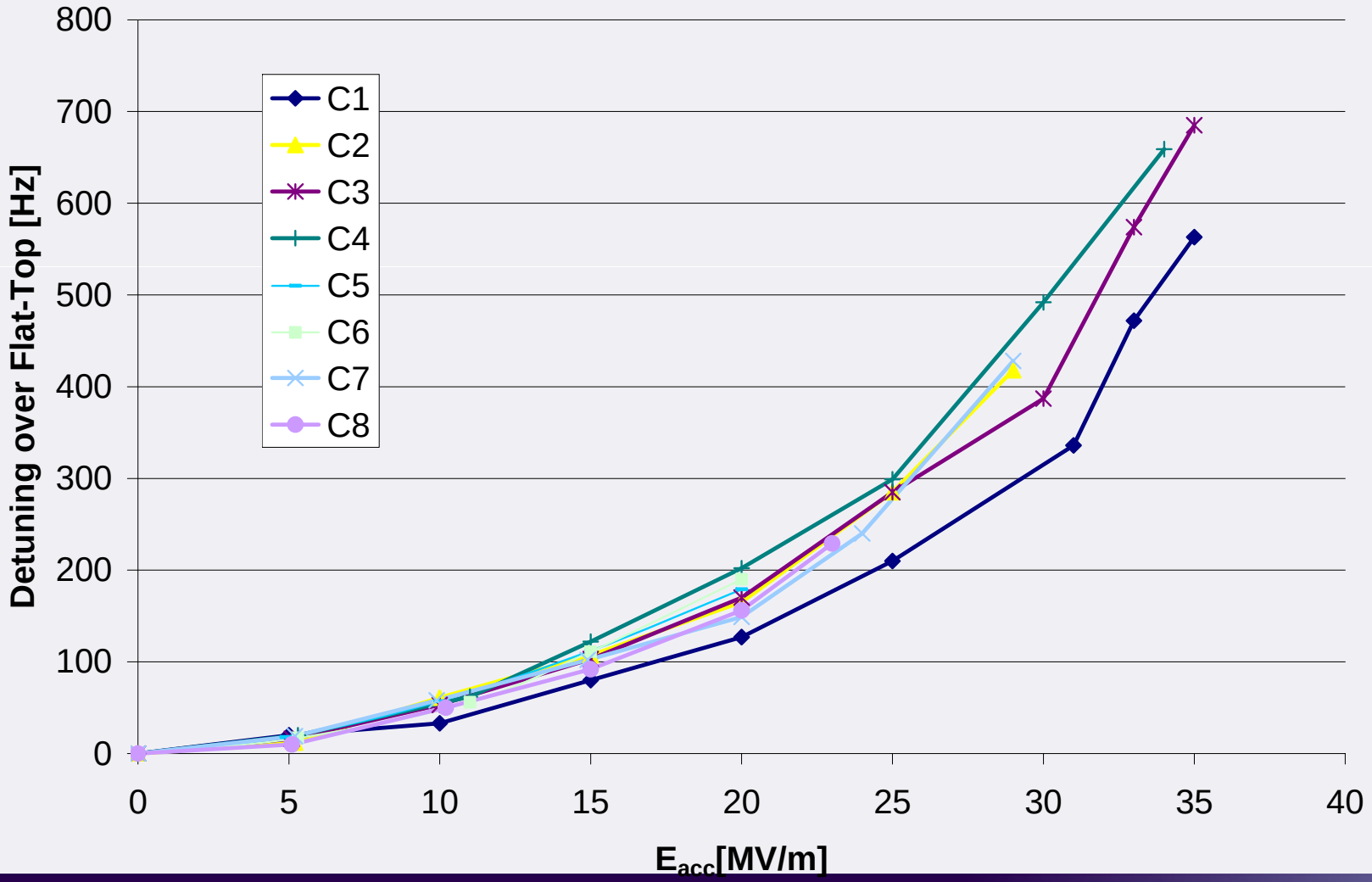
Tuner System Features

- Well-known
- Piezo integration not straight-forward
  - Piezo fixture stiff enough for pre-detuning of roughly +300 KHz
    - Beyond this piezo operation cannot be guaranteed
- Therefore reverse pre-tuning (-200 kHz) of cavities has ben tried in CHECHIA tests
  - Successful
- M8 is fully equipped with this type of piezos
  - Test this year

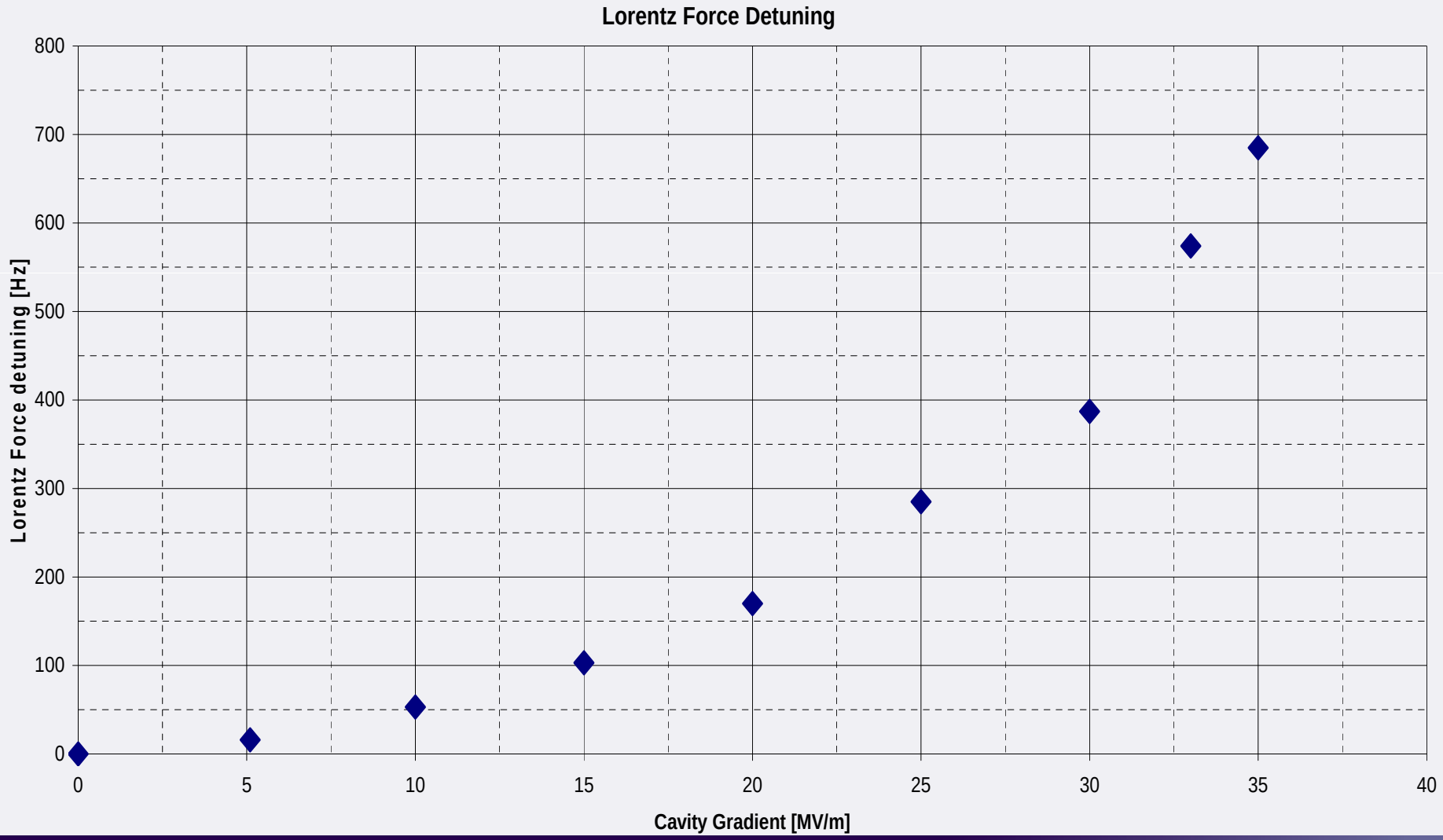
Module 6 Double-Piezo Tests

- Initial demonstration for each cavity
  - Measure detuning
  - Compensate detuning individually, one after the other
    - Classical compensation
    - ´Second oscillation´ compensation
    - No RF feedback
  - In addition
    - Work on piezo diagnostics: Impedance measurement
    - Measure transfer functions from one piezo to another
- Demonstrate compensation on full module for all cavities simultaneously
  - With RF feedback

Lorentz Force Detunings in Module 6

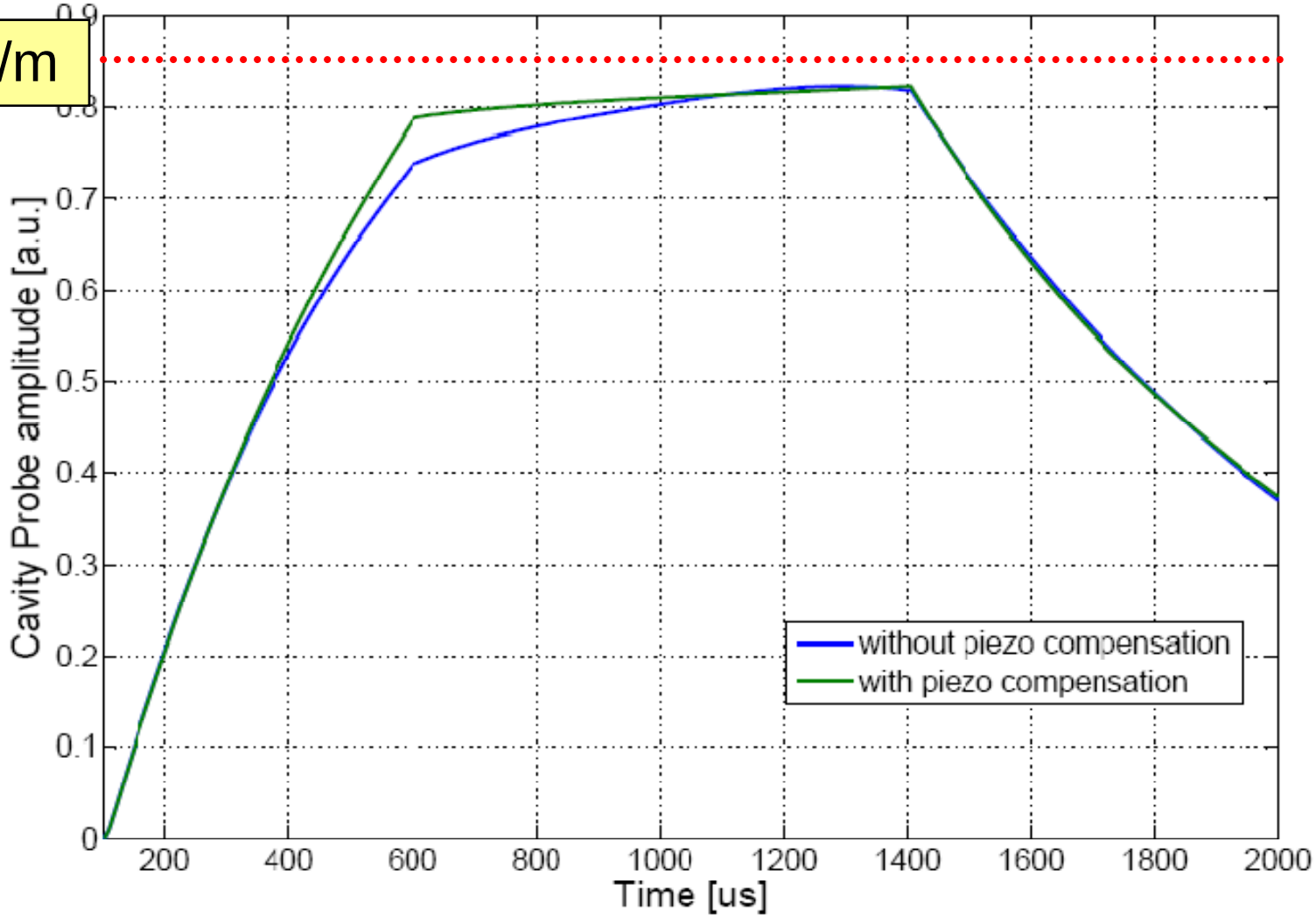


Example: Cavity 3

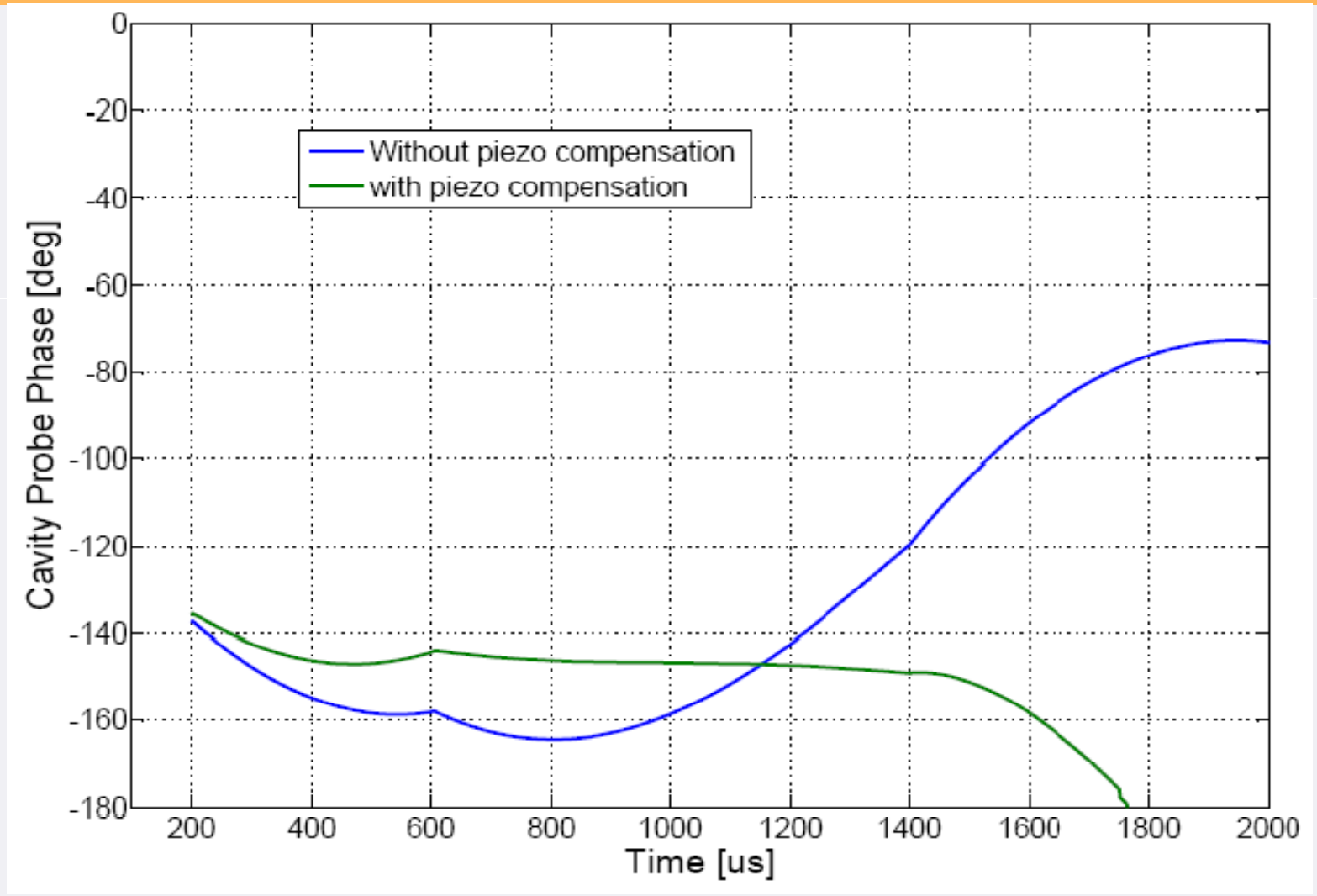


Cavity 3: Gradient

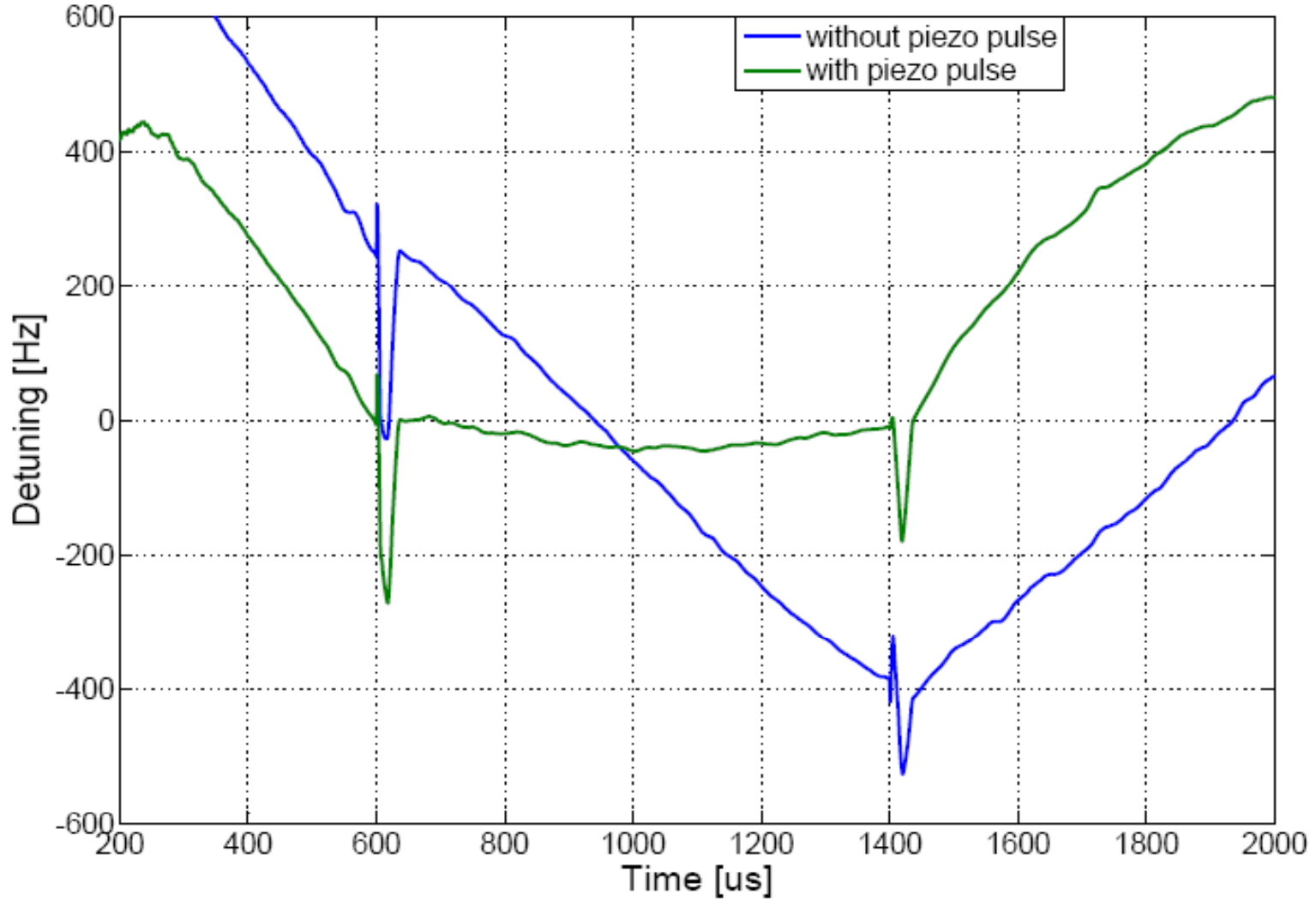
35 MV/m



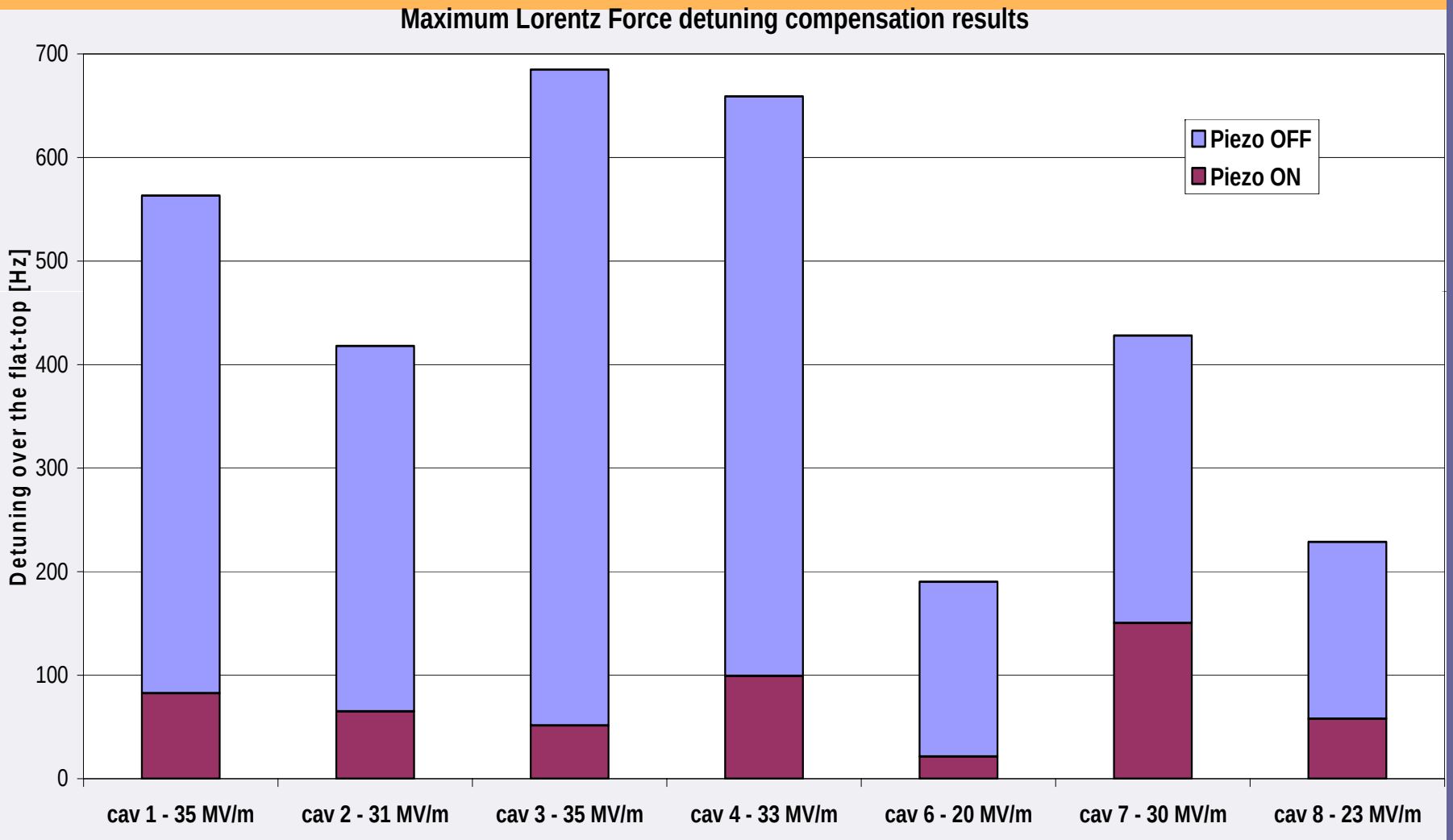
Cavity 3: Phase



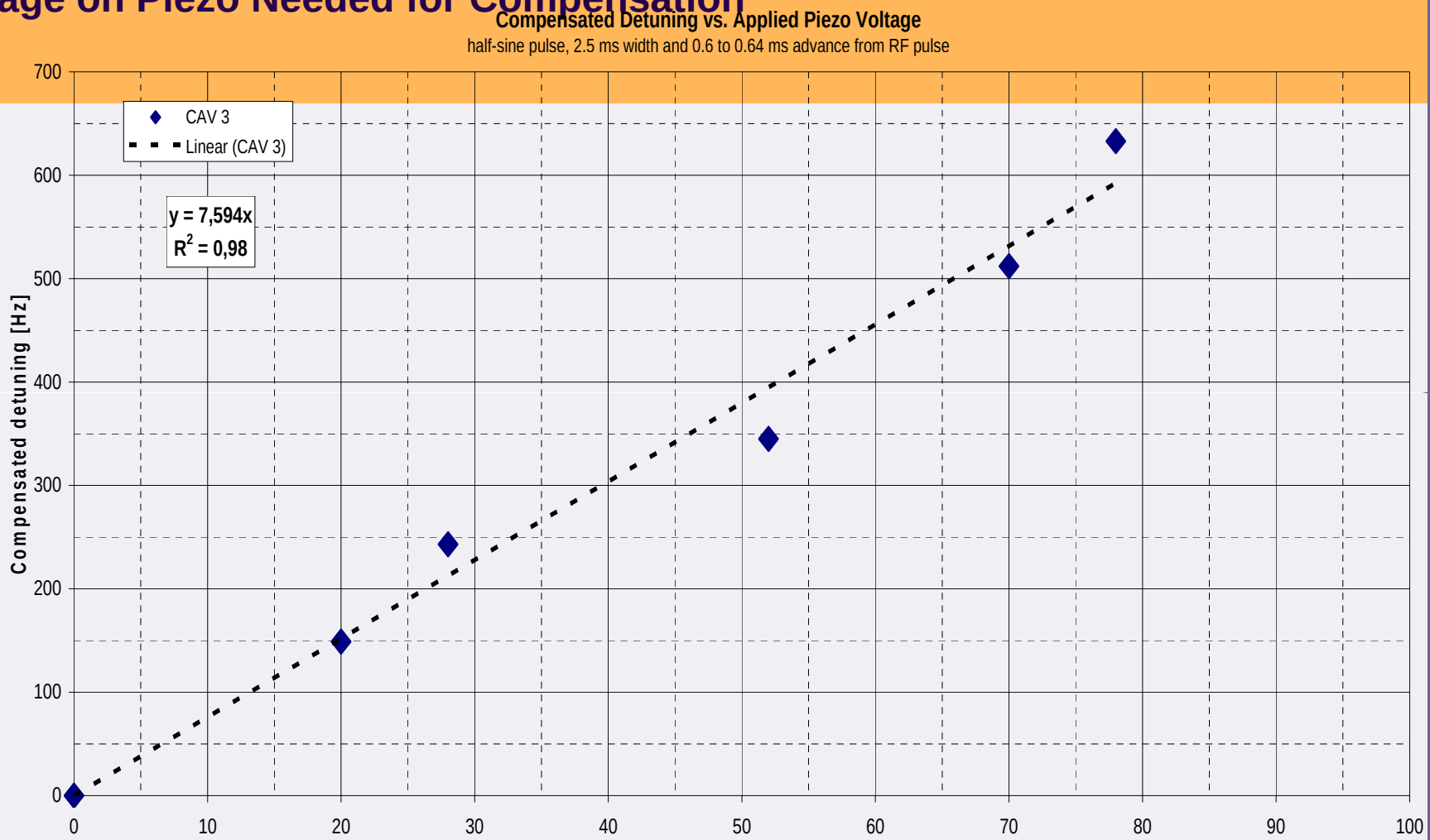
Cavity 3: Detuning



Compensated Detuning per Cavity

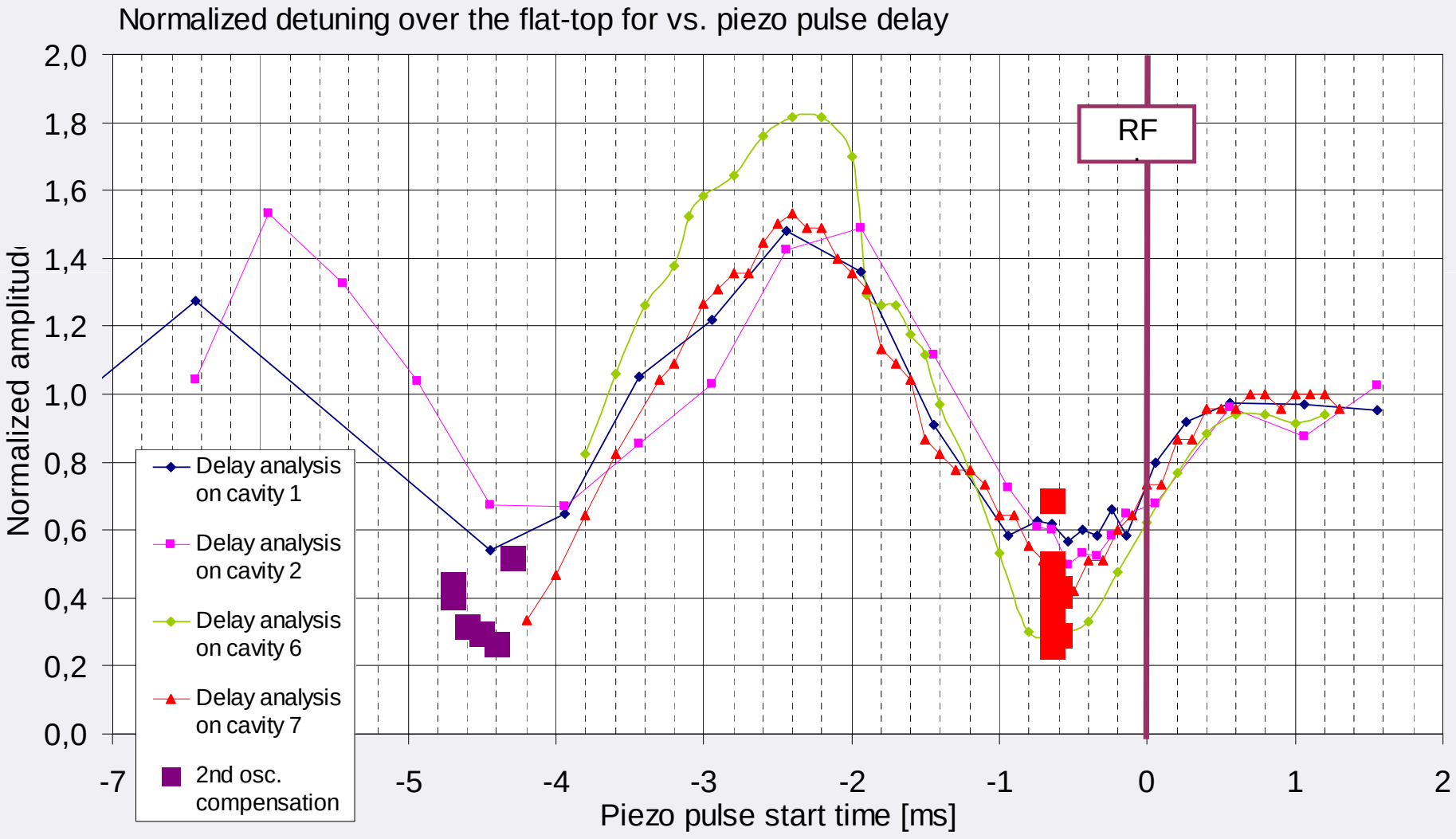


Voltage on Piezo Needed for Compensation

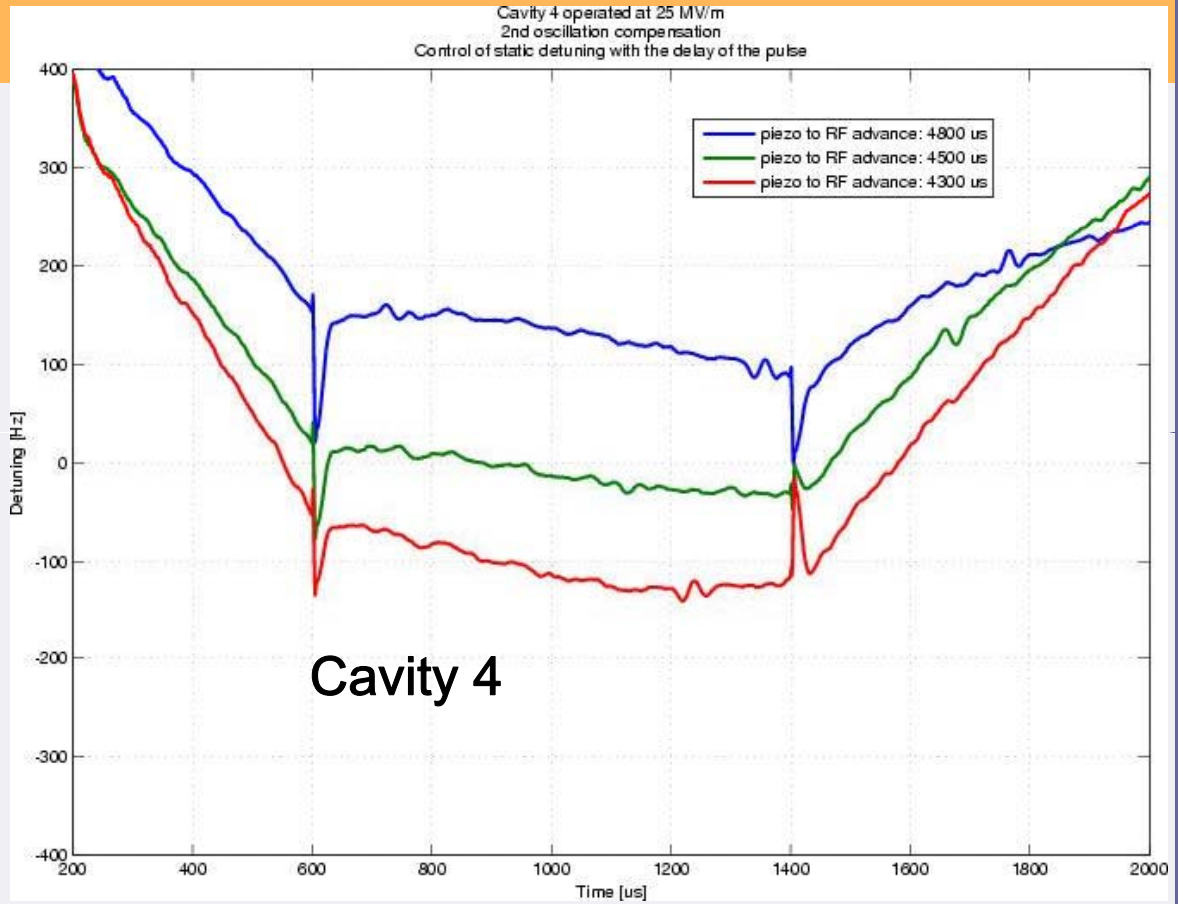


- Piezo Voltages within margin
  - maximum PI piezo voltage of 120 V at room temperature
  - Could also use bipolar operation, but not needed

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



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



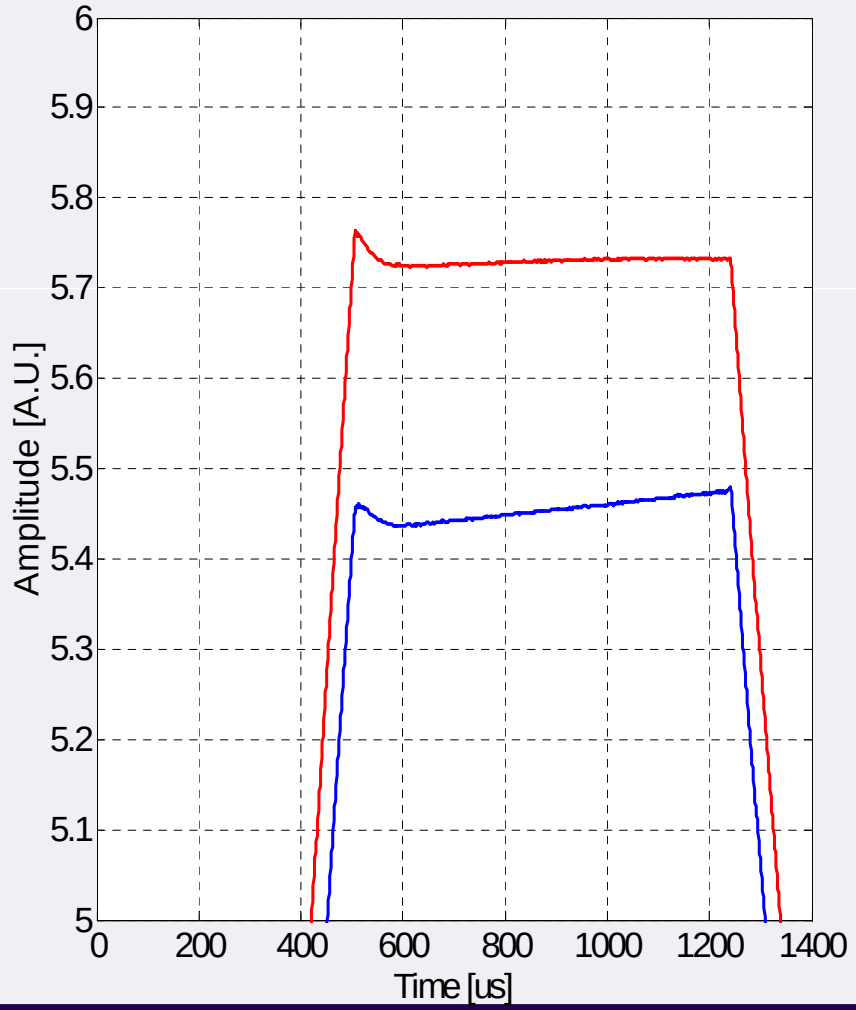
- Can change the cavity pre-detuning of the cavity by changing the Piezo delay to use the ‘second oscillation‘ in the order of 200Hz
  - Less motor usage, increase lifetime
  - Correponds to He drifts of a few mbar

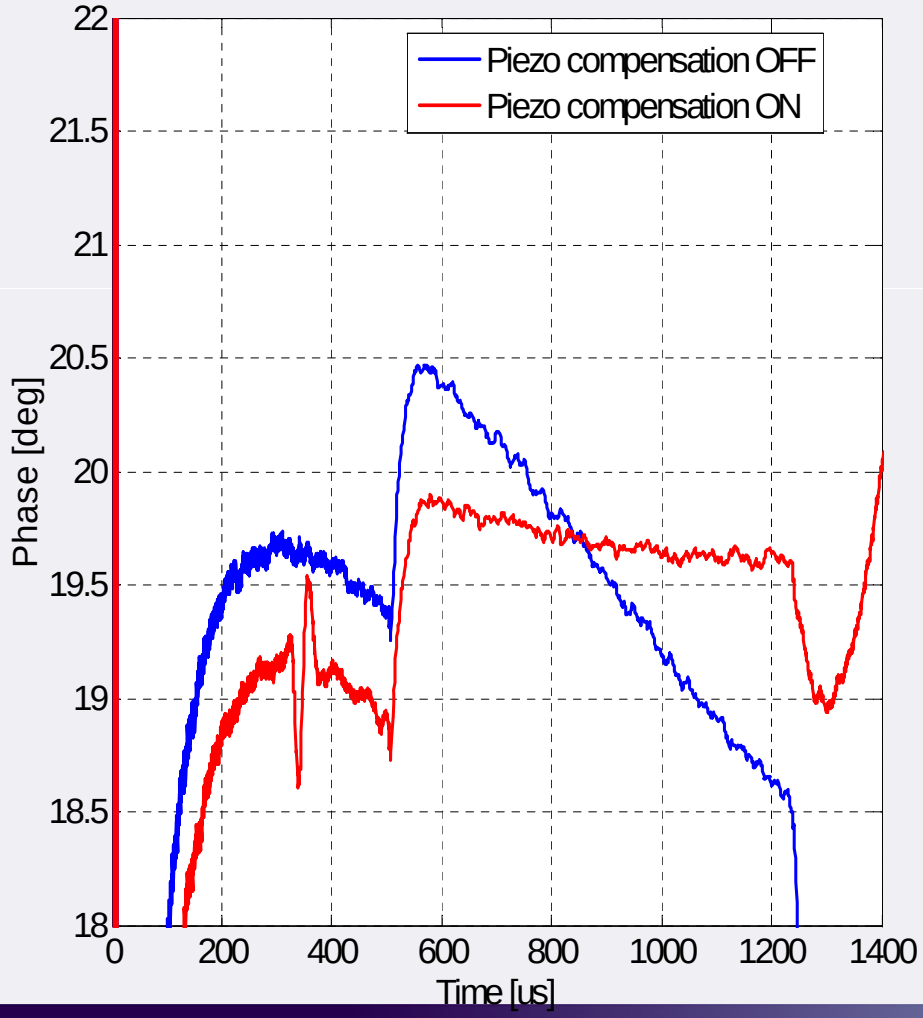
Full Module Tests

- Three modules tested with piezos
  - M5, M6, M7
- At least one module will be done this year
  - M8
  - M3 repair (after crash test) to be decided
- Simultaneous operation of several piezos with the same drive signal possible
  - Only 2 function generators (FG) available
  - E.g. 4 cavities on one FG with amplifier and 2 cavities on the other FG with second amplifier for M6

Operation of Full module – Vector-Sum

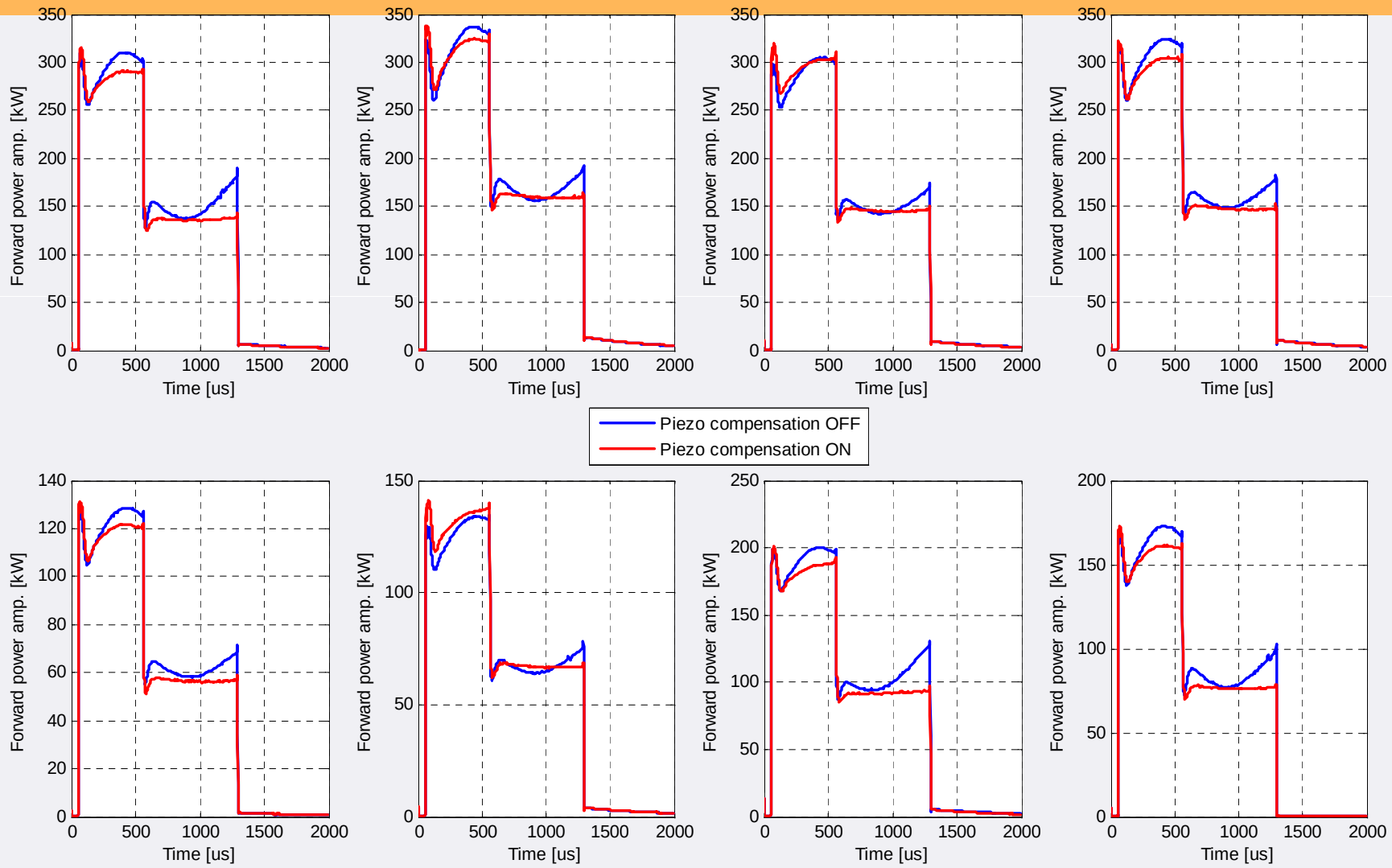
Vector Sum of Module 6 with and without piezo active compensation
RF feedback ON, same control-loop-gain setting





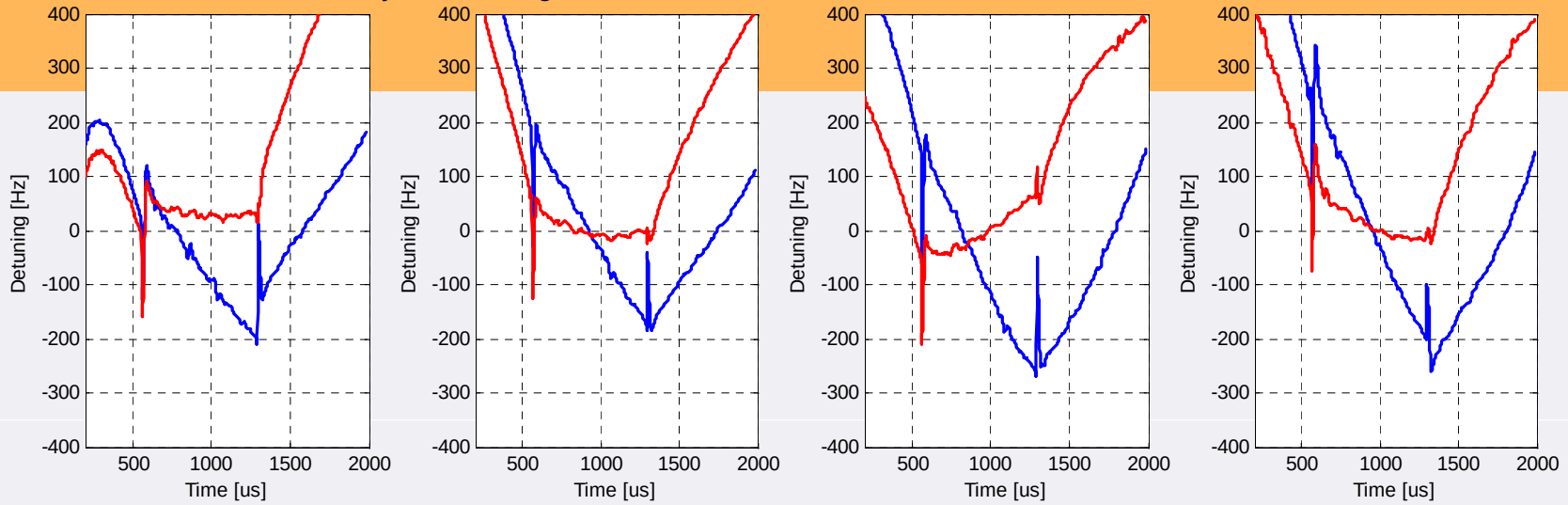
Operation of Full Module – Forward Power

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



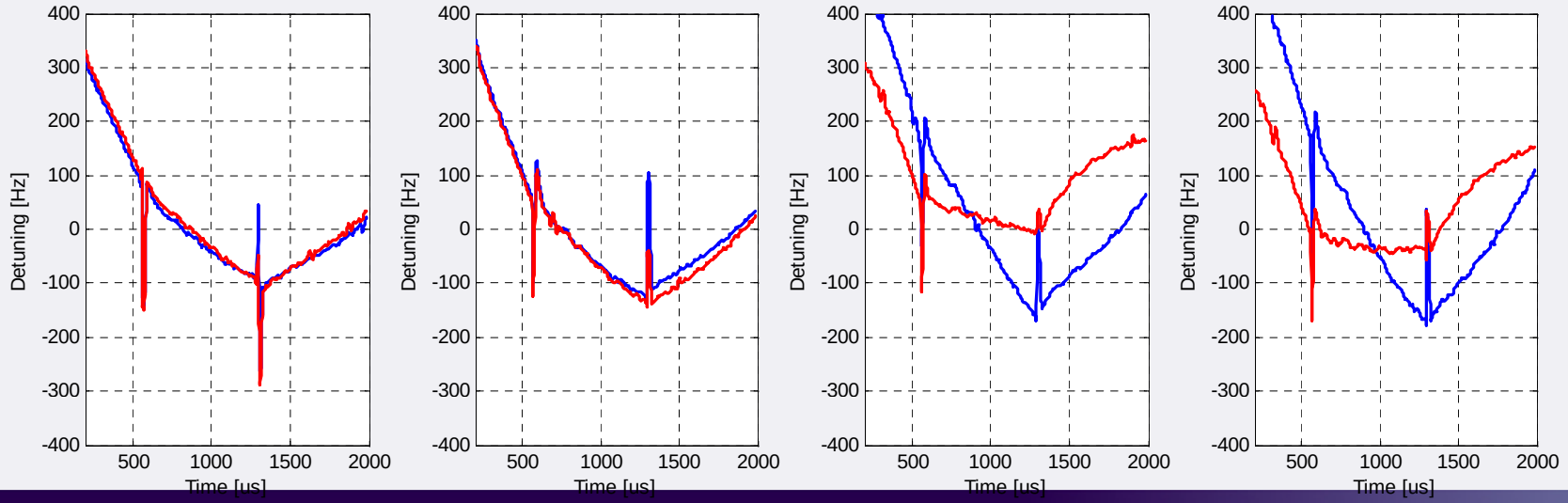
Detuning of all cavities of Module 6 with and without piezo active compensation

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

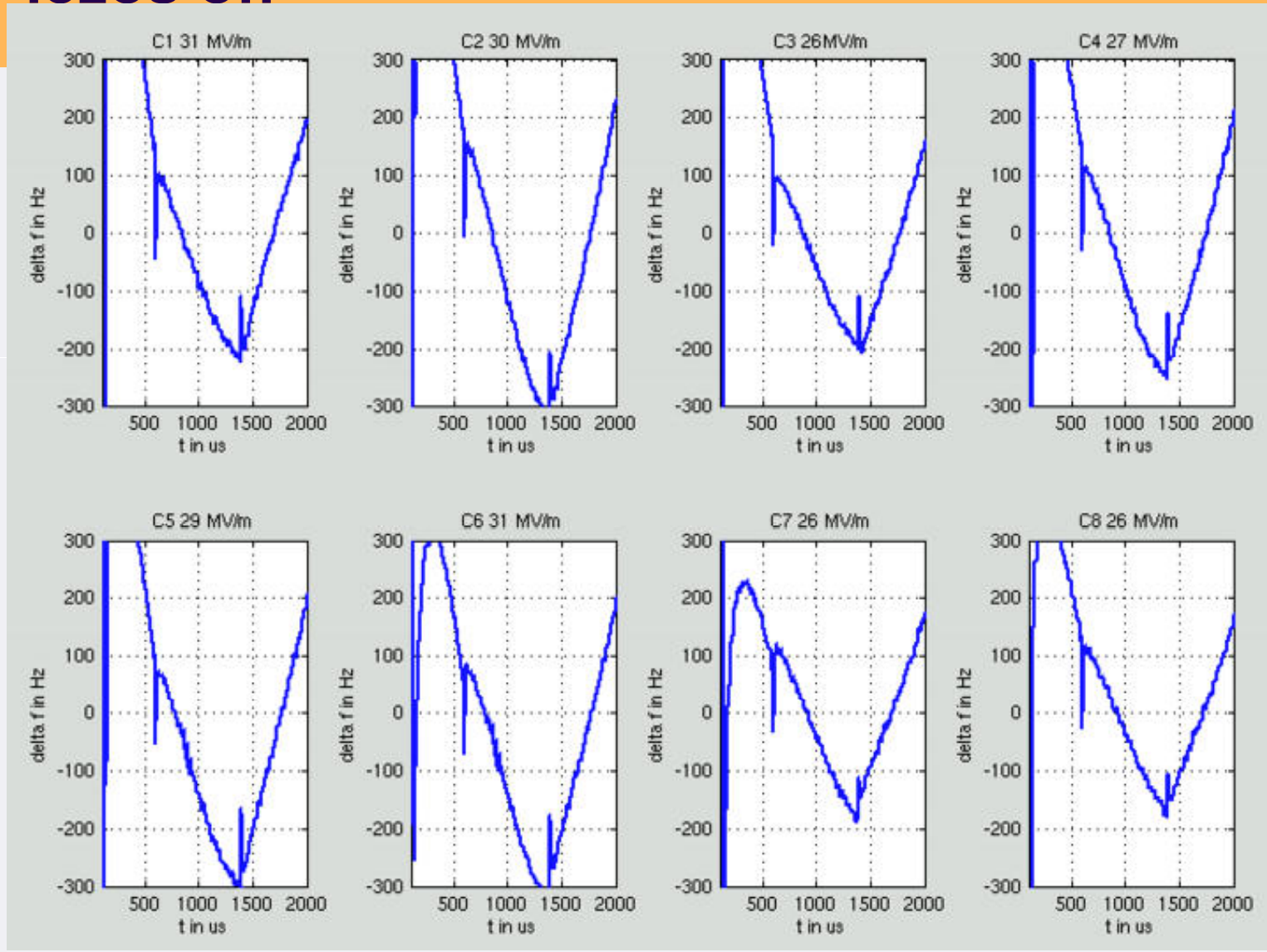


Cavity 5,6 : no signal - no active compensation

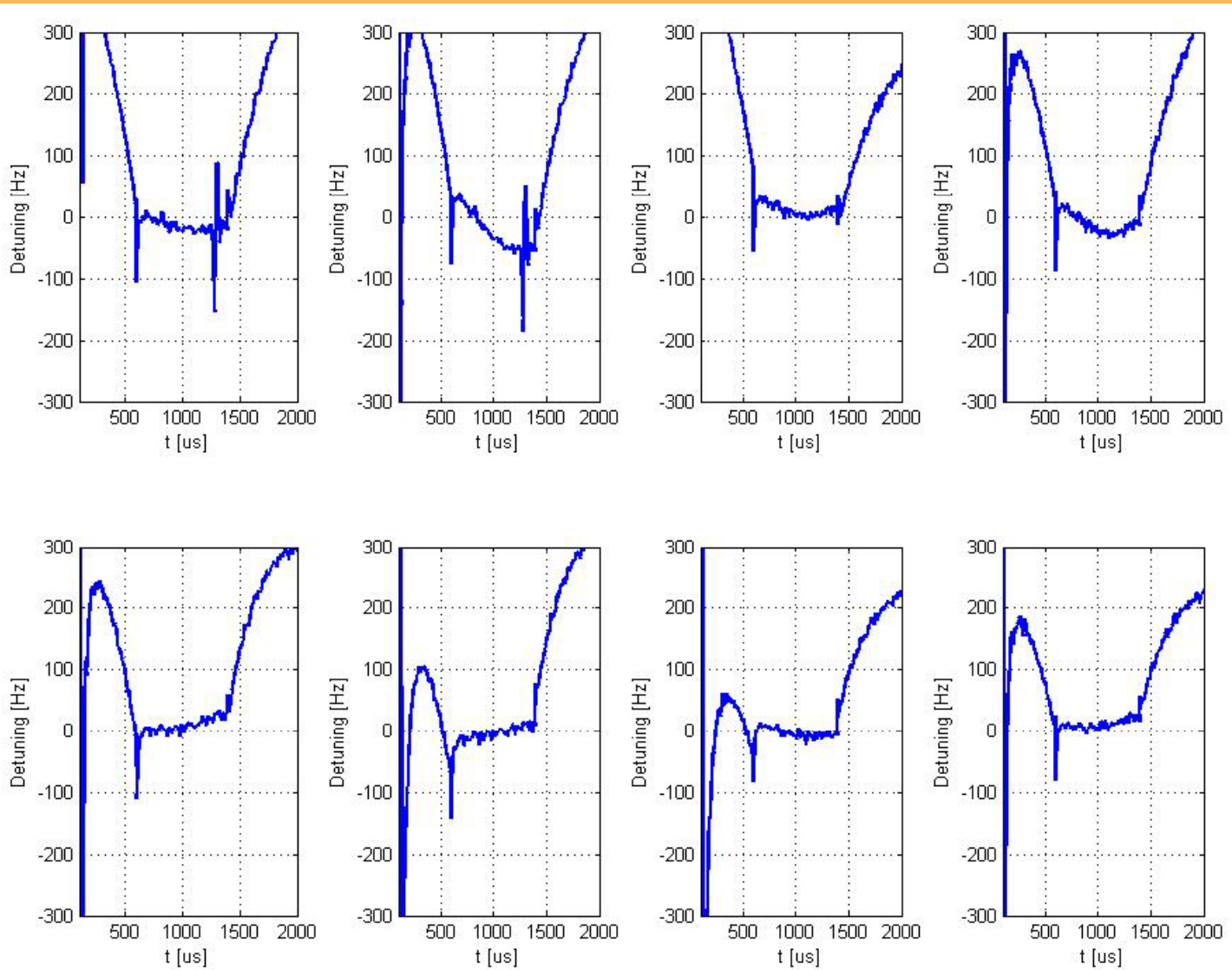
Cavity 7,8 : signal 2 - half sin 2.5 ms width, 64 V, 640 us advance



M5: Piezos off

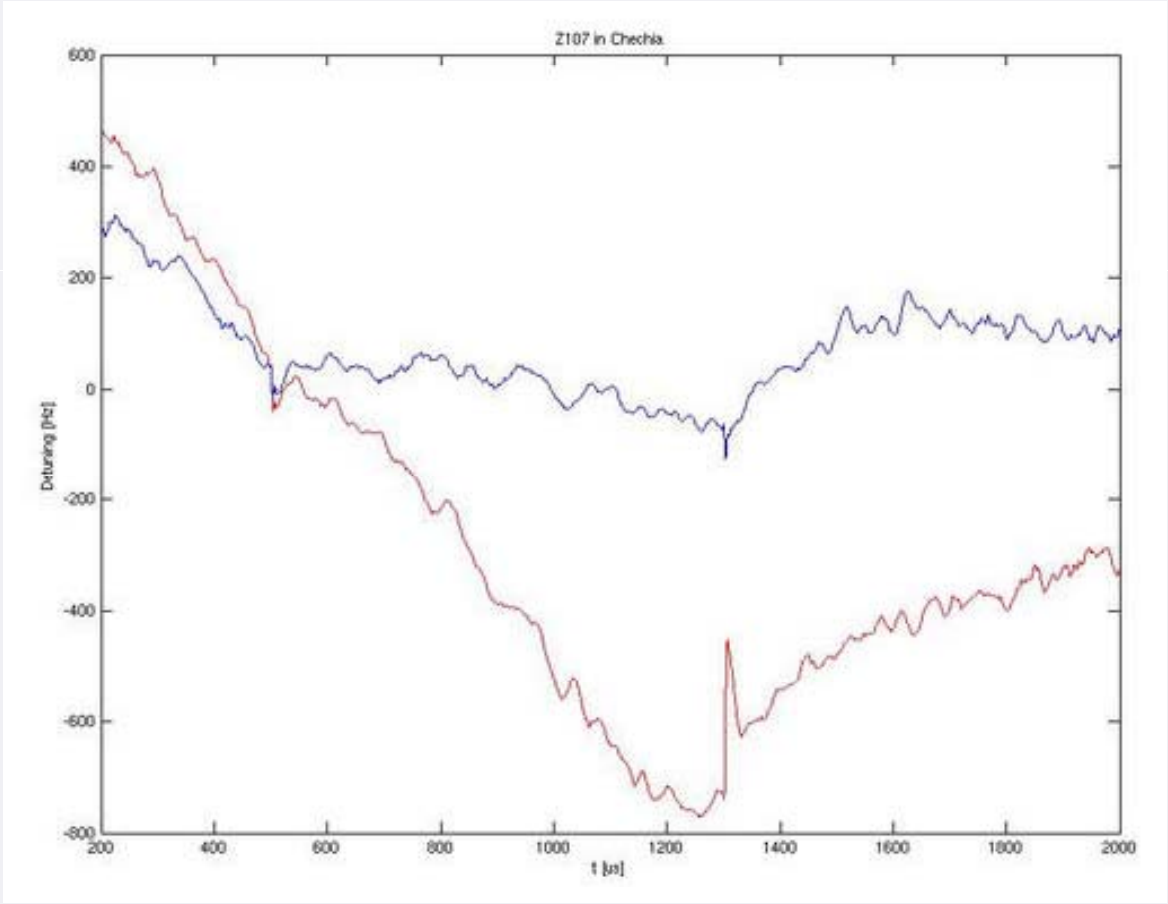


M5: Piezos on



Tests with New Pre-tuning

- E.g. Z107 at 35 MV/m
- Piezo settings
  - Simple pulse
  - Frequency: 400 Hz
  - Voltage: 2.4 V (roughly 100 V)
  - Offset: -0.4
  - Advance to RF signal:0.8511 ms



Next for this type of tuner

- Industrialisation for XFEL
  - Drive units
    - Full-drive units from Industry
    - This year
  - Mechanics
    - Involvement of Mass-production companies
    - This year
- Series production in 2009

Conclusion and Outlook

- Several aspects of relevance for ILC
  - Concept
  - Choice of active elements
  - Industrialization
- Piezo as actuators
  - Endurance operation in TTF will start this year
    - Endurance tests in test stands have been done already
- Successful compensation of detuning on full modules simultaneously
  - TESLA cavities are stiff enough
- ´Second oscillation´ compensation could reduce number of steps on the motors as delay of Piezo could be used to compensate for small frequency drifts
  - Relaxes reliability requirements on motors
- Industrialization of the full tuner system is on the way for XFEL