European Coordination for Accelerator Research and Development

PUBLICATION

Piezo Control for LFD compensation

Grecki, M (DESY Hamburg) *et al*

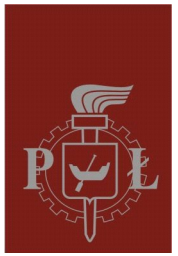
13 April 2010

The research leading to these results has received funding from the European Commission under the FP7 Research Infrastructures project EuCARD, grant agreement no. 227579.

This work is part of EuCARD Work Package **4: AccNet: Accelerator Science Networks**.

The electronic version of this EuCARD Publication is available via the EuCARD web site <http://cern.ch/eucard> or on the CERN Document Server at the following URL : <http://cdsweb.cern.ch/record/1259235

Piezo Control for LFD compensation

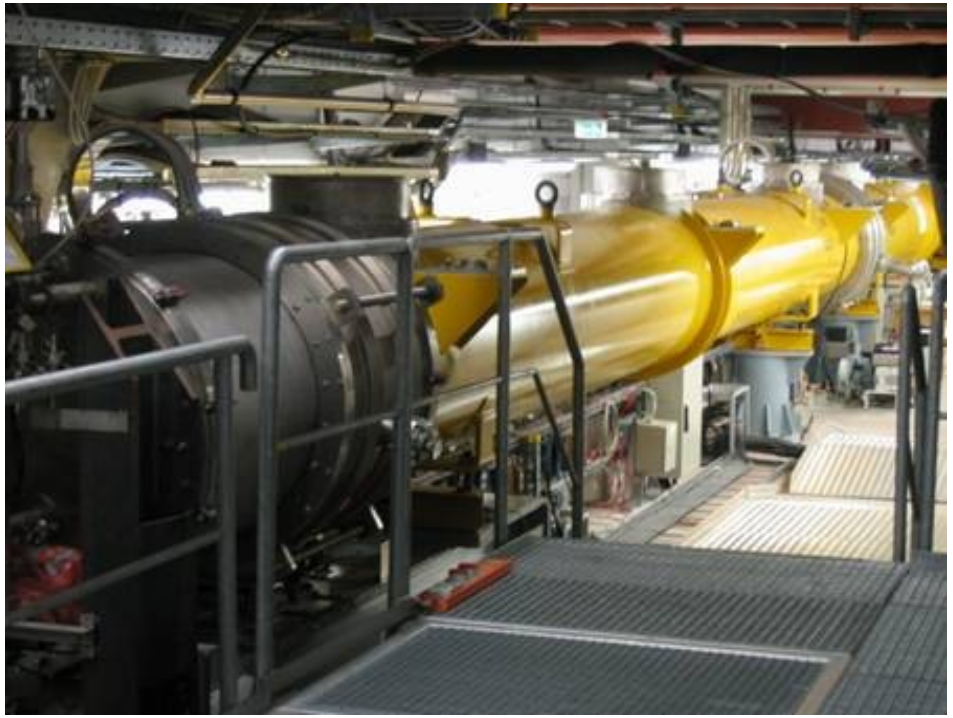


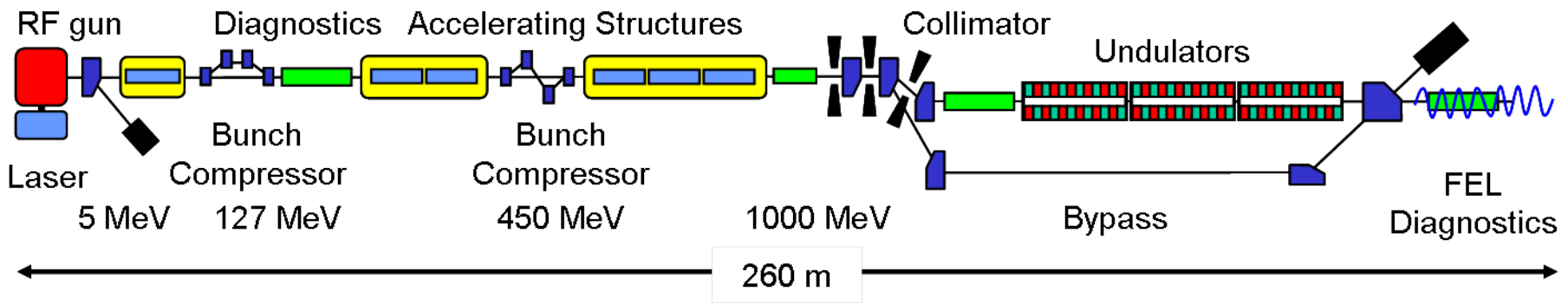
M.Grecki, DESY, Hamburg

K.Przygoda, T.Pozniak,
Technical University of Lodz,
Lodz, Poland

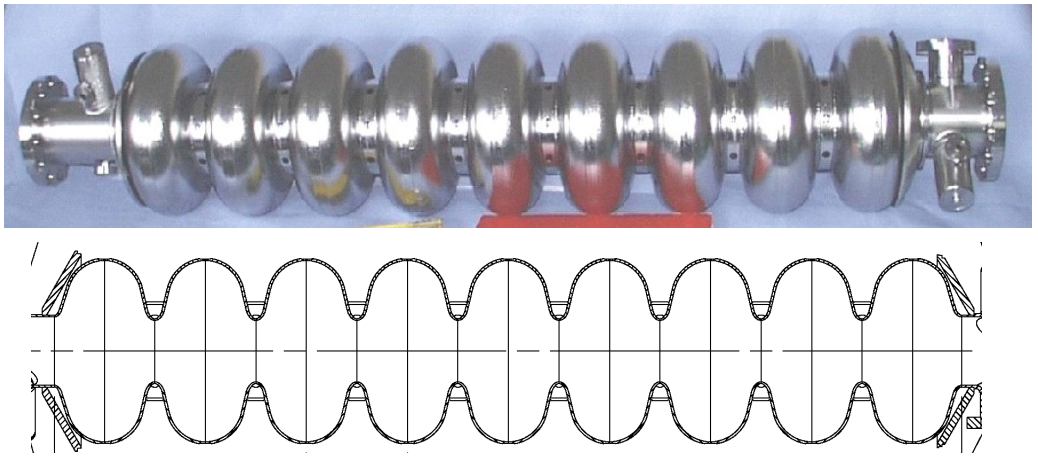
LLRF09 KEK, 18-21.10.2009

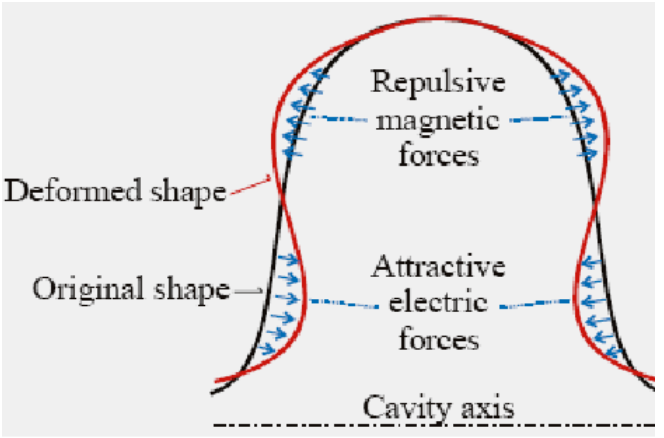
FLASH

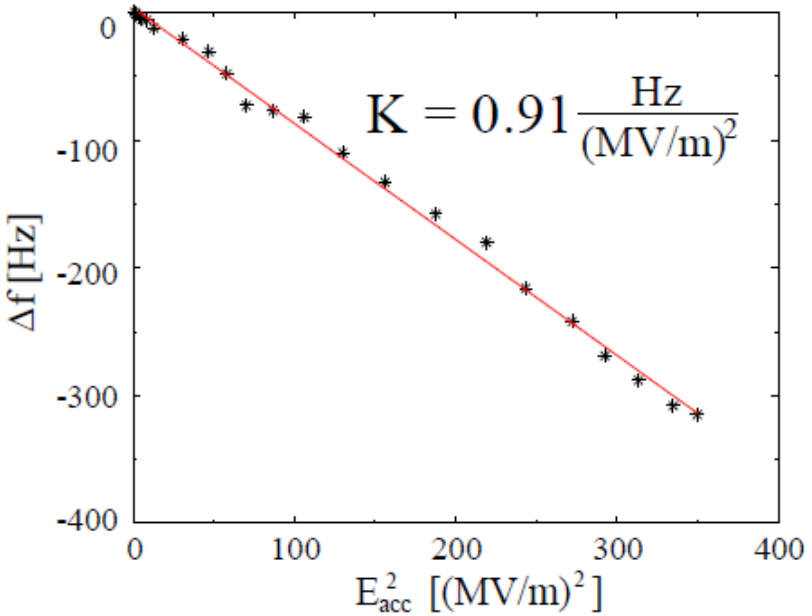


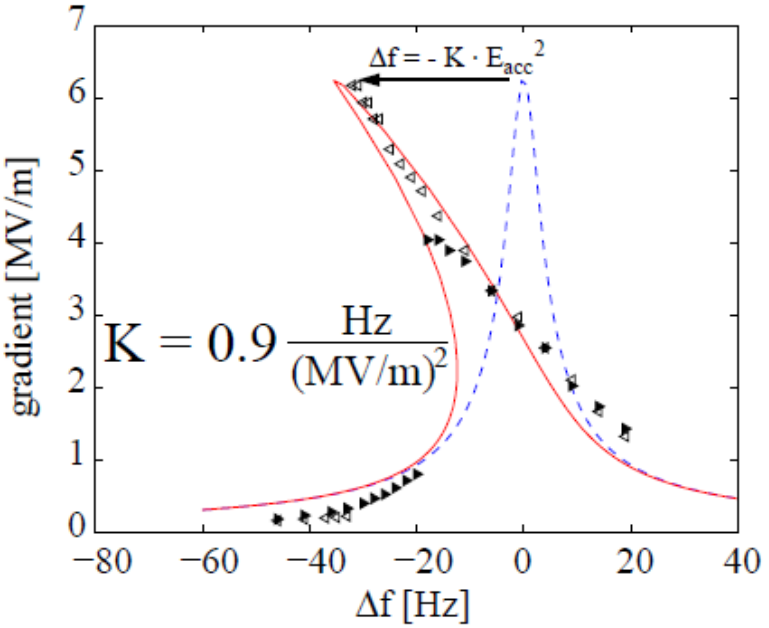

RF gun
Diagnostics
Accelerating Structures
Collimator
Undulators
Laser
Bunch Compressor
Bunch Compressor
FEL Diagnostics
5 MeV
127 MeV
450 MeV
1000 MeV
Bypass
260 m

Lorentz Force Detuning (LFD)

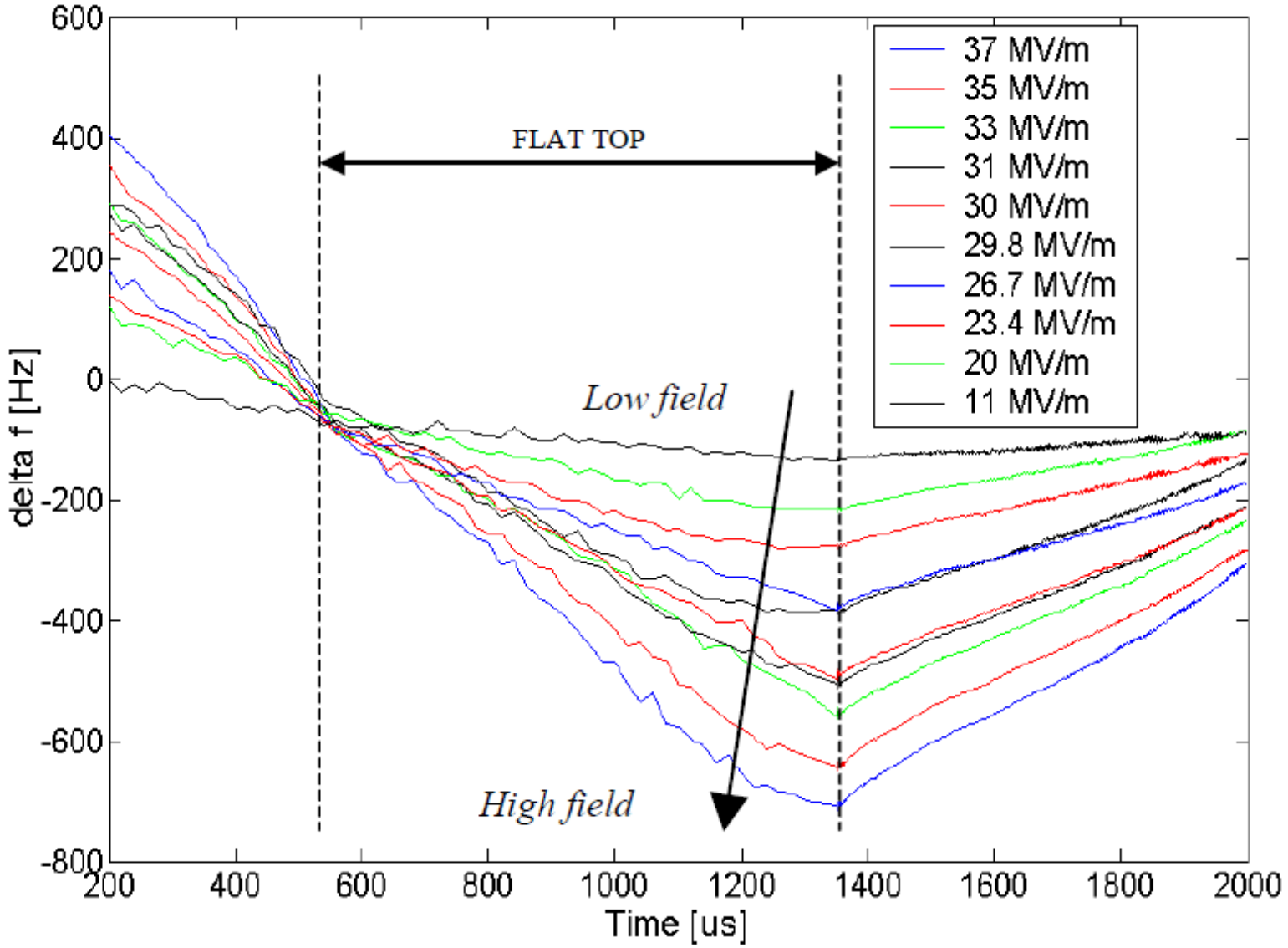






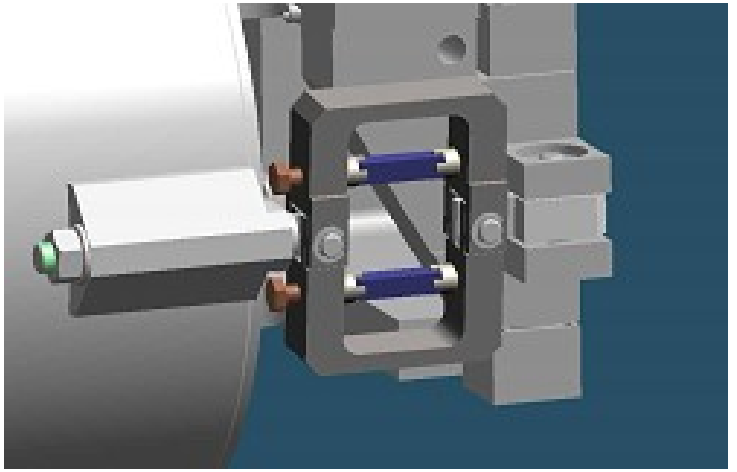


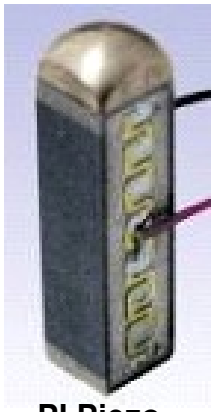
LFD vs gradient



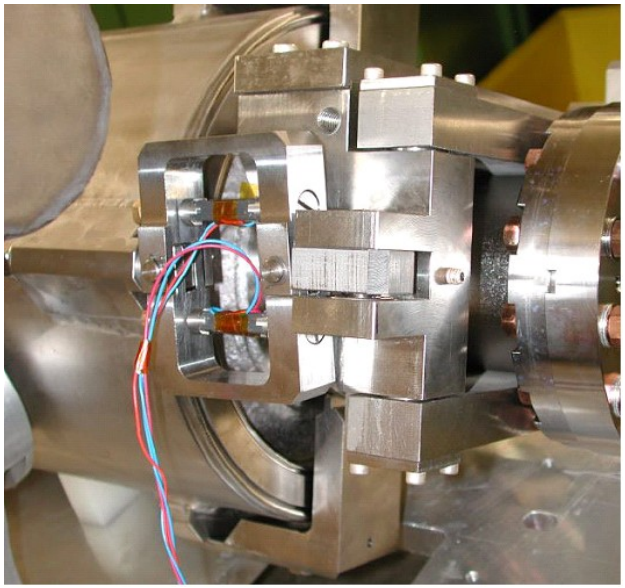
Goals of Piezo Control System

- Drive the piezoelements assembled in fast tuners frames to minimize the Lorentz Force Detuning
- On-line frequency detuning calculation
- Microphonics measurement and compensation





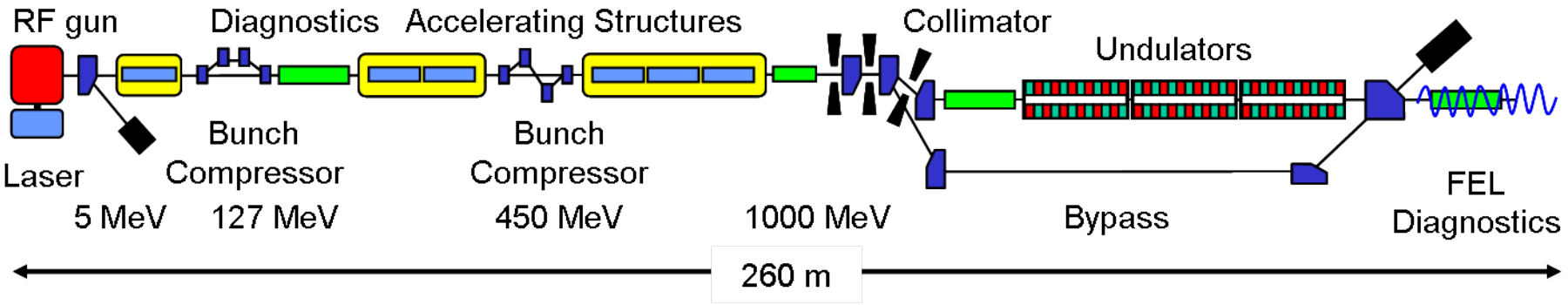
PI Piezo

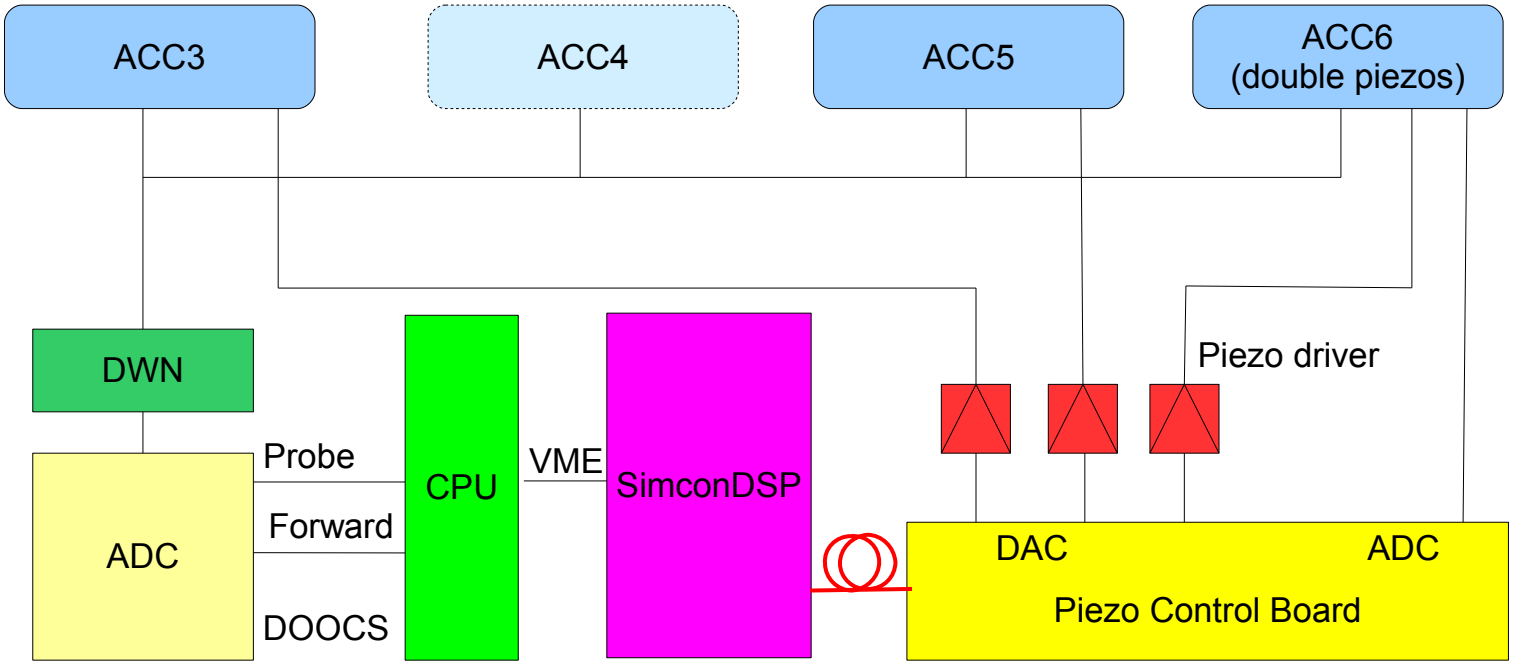


General Requirements of Piezo Control System for FLASH

- Dynamic Lorentz force detuning (LFD) during flat-top $\Delta\omega$< 10 Hz for field up to 30 MV/m (compensation up to 600 Hz with single puls, up to 1kHz with resonant excitation) providing constant offset of $\Delta\omega$ during flat top
- Piezo control must allow to tune/detune cavities in limited range instead of using step motor tuners
- Active attenuation of mechanical vibrations
- Maximum repetition rate of RF (LFD compensation) pulse 10 Hz
- Piezo control must assure piezo lifetime at least 10^{10} pulses (~20 years of operation), piezo must be protected and monitored (it is fragile to over current and over voltage; in particular caused by resonance in the cables)
- Possible microphonics compensation between the RF pulses (sensor/actuator mode)

Piezo tuners at FLASH





Piezos installed in ACC3,5,6

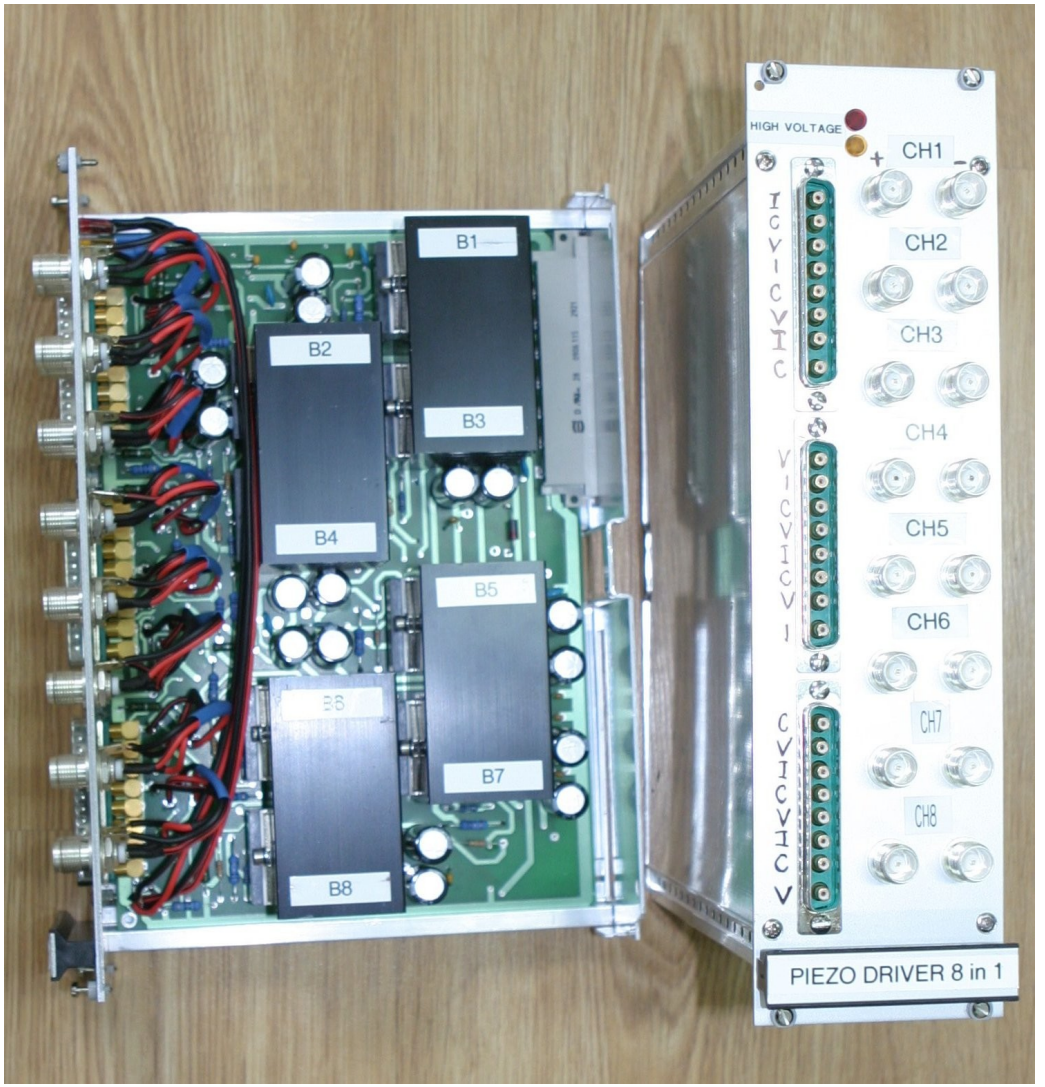
Producent ratings	Noliac	PI ceramic
Model:	SCMAS/S1/A/10/10/30/200/42/6000	P-888.90
Cells:	8	8
Voltage:	< 200 V	< 120 V
Blocking force:	6 kN	3 kN
Size:	10 mm x10 mm x 30 mm	10 mm x10 mm x 35 mm
Capacitance:	6 μF	12 μF

Piezos Capacitance at ACC3,5,6

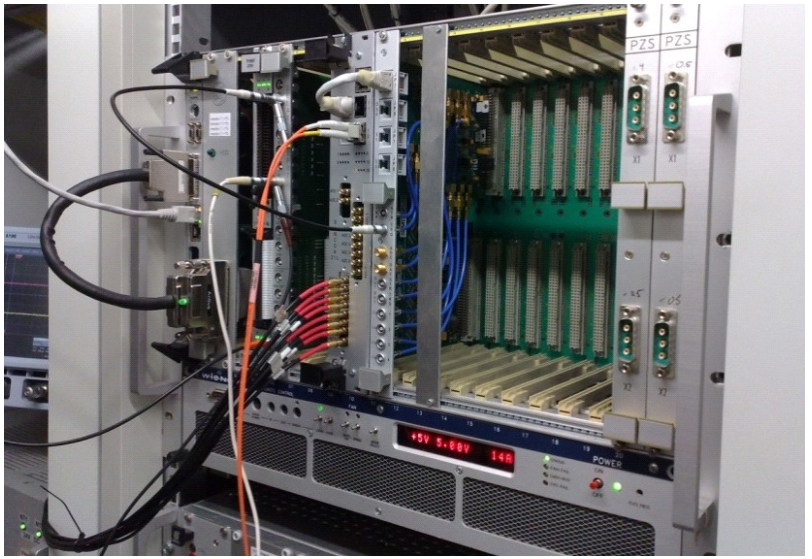
cavity	piezo	model	ACC3/M7	model	ACC5/M5	model	ACC6/M6
1	1	PI	4,93uF	Noliac	2,1uF	PI	4,13uF
	2	-	Unavailable	-	Unavailable	PI	4,45uF
2	1	PI	4,61uF	Noliac	2,22uF	PI	4,4uF
	2	-	Unavailable	-	Unavailable	PI	4,2uF
3	1	PI	4,91uF	Noliac	2,28uF	PI	4,21uF
	2	-	Unavailable	-	Unavailable	PI	4,1uF
4	1	PI	4,6uF	Noliac	3,12uF	PI	3,86uF
	2	-	Unavailable	-	Unavailable	PI	4,2uF
5	1	Noliac	2,6uF	Noliac	2,2uF	PI	4,22uF
	2	-	Unavailable	-	Unavailable	PI	4,28uF
6	1	Noliac	2,13uF	Noliac	2,13uF	PI	3,73uF
	2	-	Unavailable	-	Unavailable	PI	4,41uF
7	1	Noliac	2,22uF	Noliac	2,19uF	PI	4,69uF
	2	-	Unavailable	-	Unavailable	PI	4,41uF
8	1	Noliac	2,21uF	Noliac	2,17uF	PI	4,31uF
	2	-	Unavailable	-	Unavailable	PI	4,2uF

Piezodriver

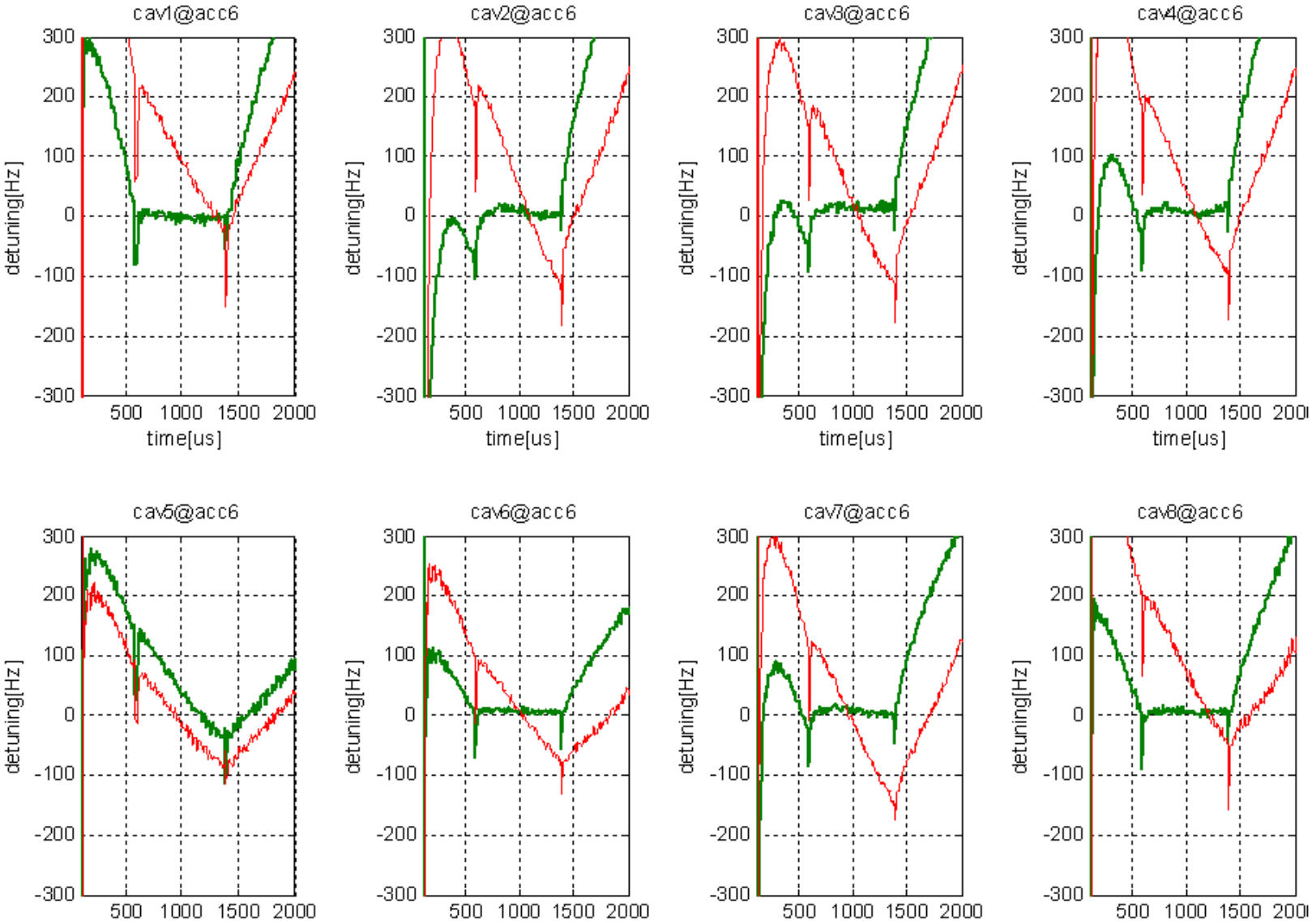
- Suitable for both types of piezostacks up to 5µF:
  - Physik Instrumente (P-888.90 PIC255)
    C_{2K} = 4,4 µF
  - NOLIAC (SCMAS/S1/A/10/10/20 /200/42/6000)
    C_{2K} = 2,4 µF
- Maximal supply voltage up to ± 150 V (nominal operating voltage ±80V)
- Input voltage ± 1 V
- Amplifier gain Gu= 100V/V,
- Operational temperature Tc < 75°C (Tj <125 °C)
- Pass-band frequency up to 5 kHz (for load 5µF)
- Monitoring of output voltage and current
- Single channel PZD with Apex PB51
- 8 channels on single board (Eurocard form factor)
- Up to 4 periods of sinus wave 80V, 200 Hz in 5µF load, 10 Hz repetition rate (thermal limit)



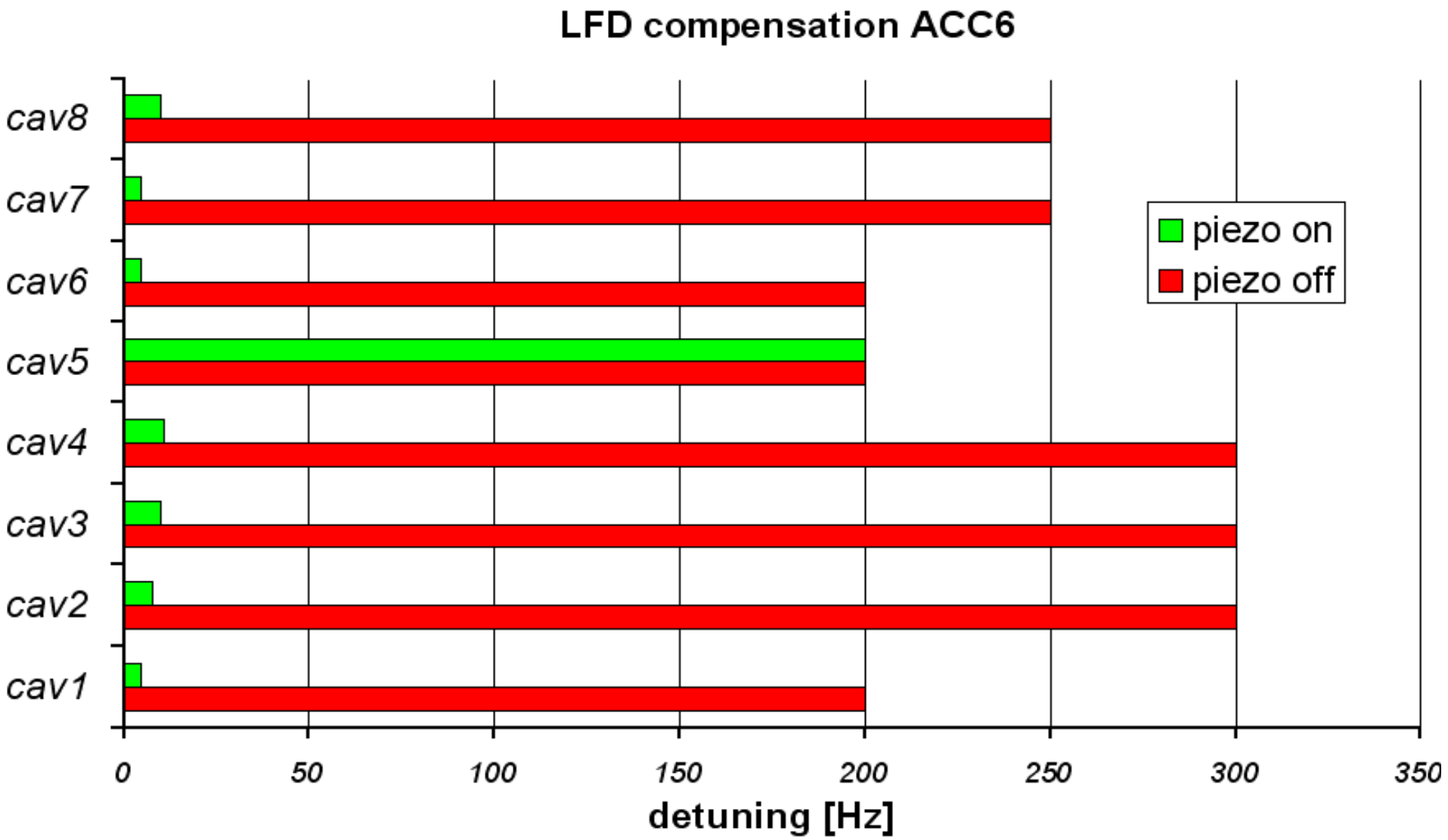
Piezo Control System at FLASH



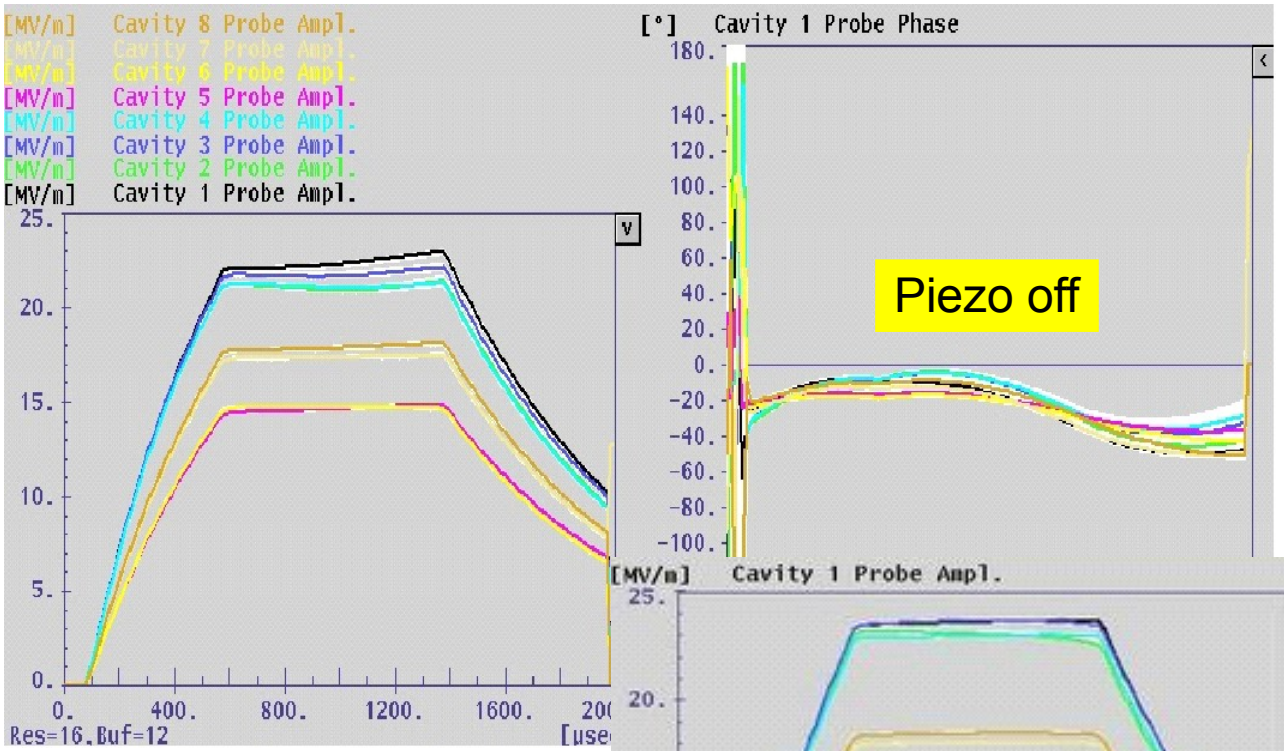
ACC6 (SP = 20 MV/m, rep = 5 Hz)

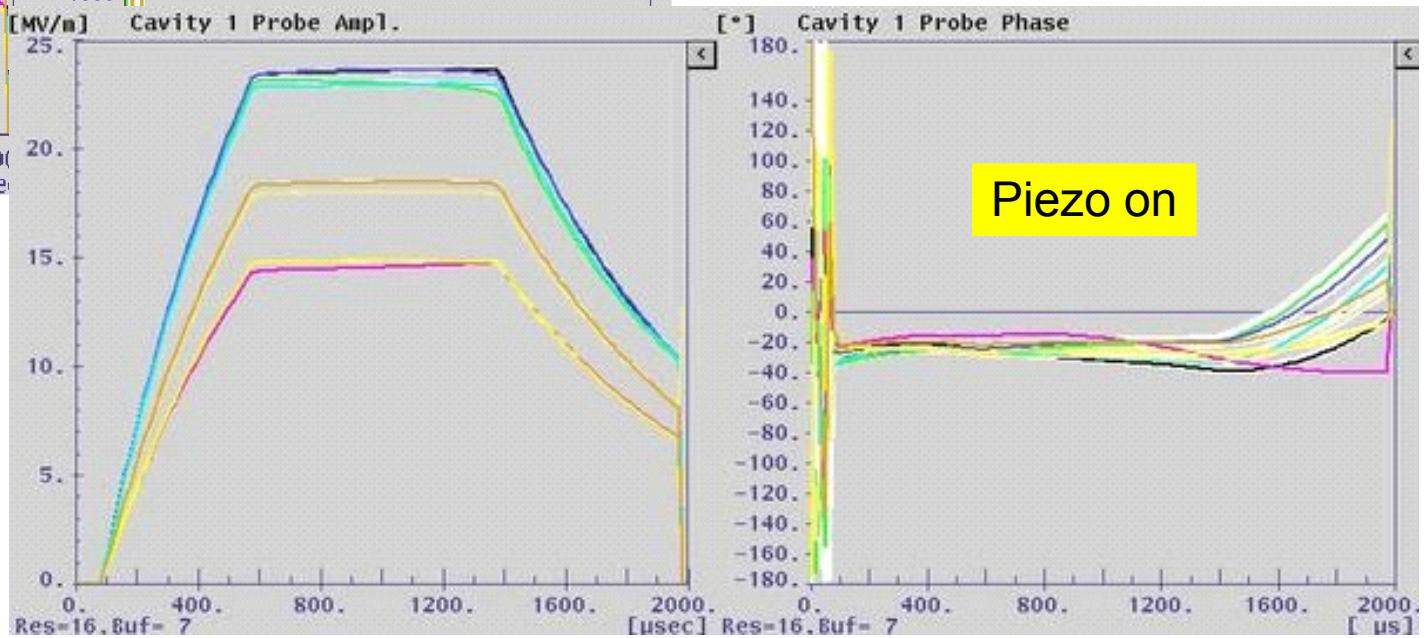


ACC6 (SP = 20 MV/m, rep = 5 Hz)

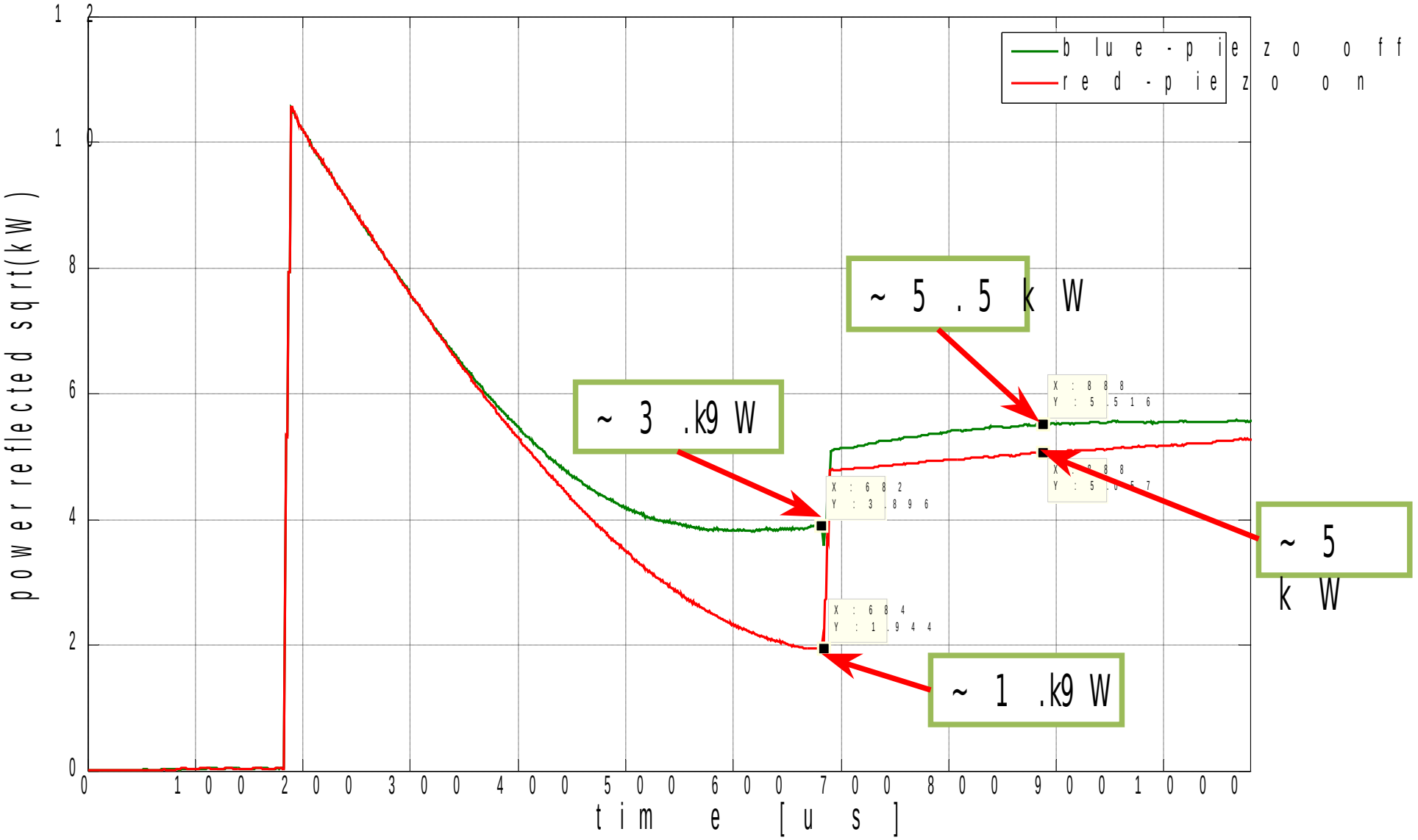


ACC6 (SP = 20 MV/m, rep = 5 Hz)

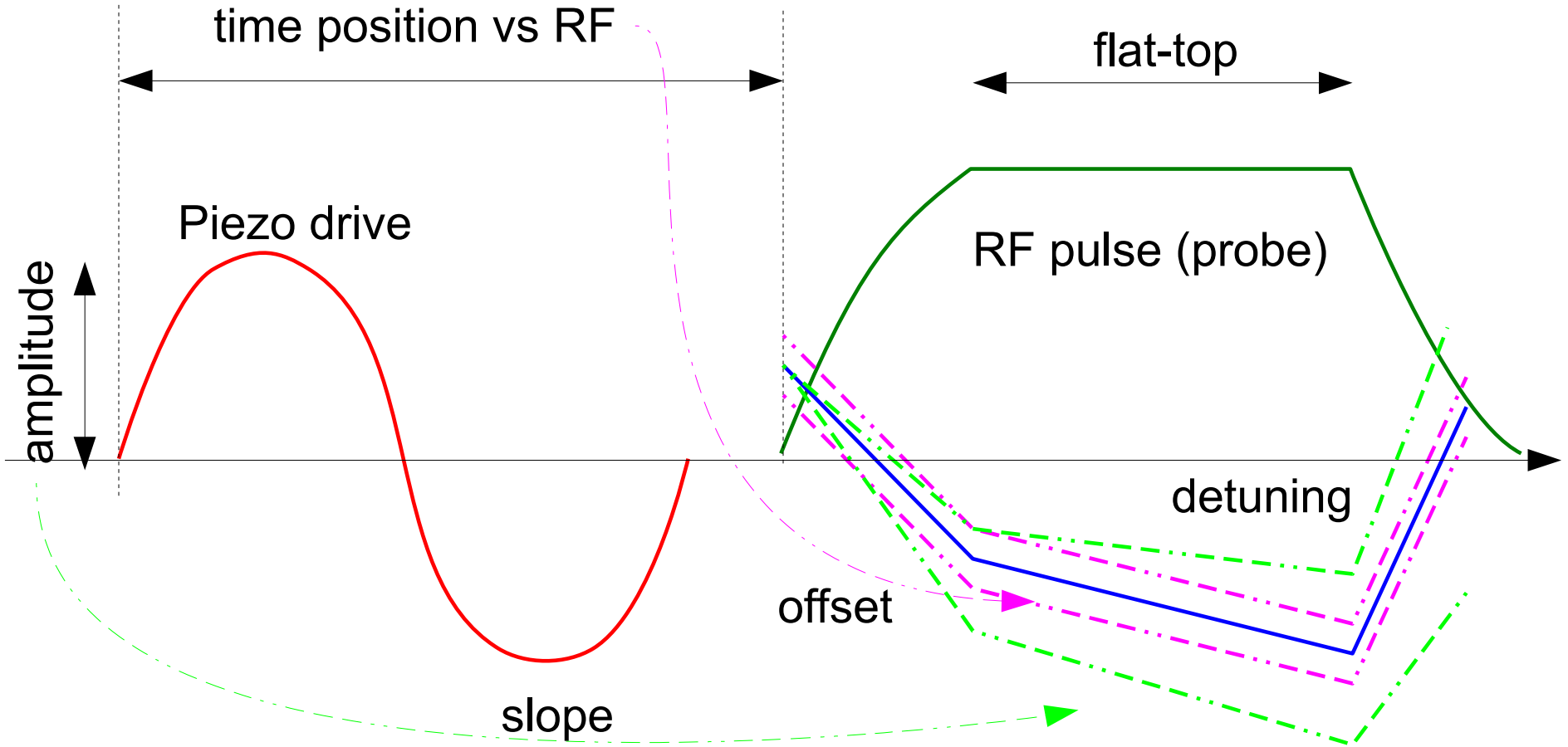




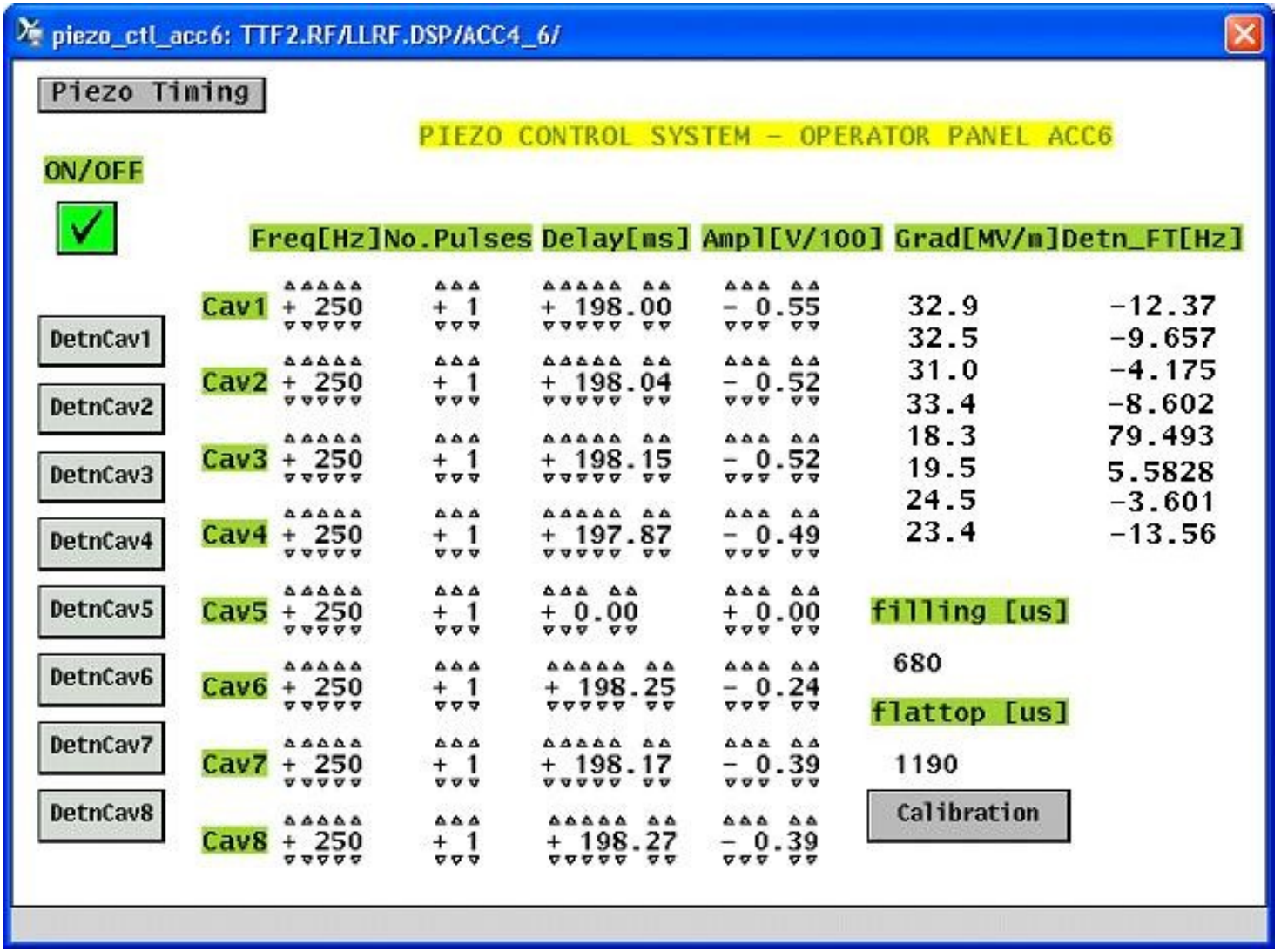
Reduction of reflected power



Piezo Driving Pulse

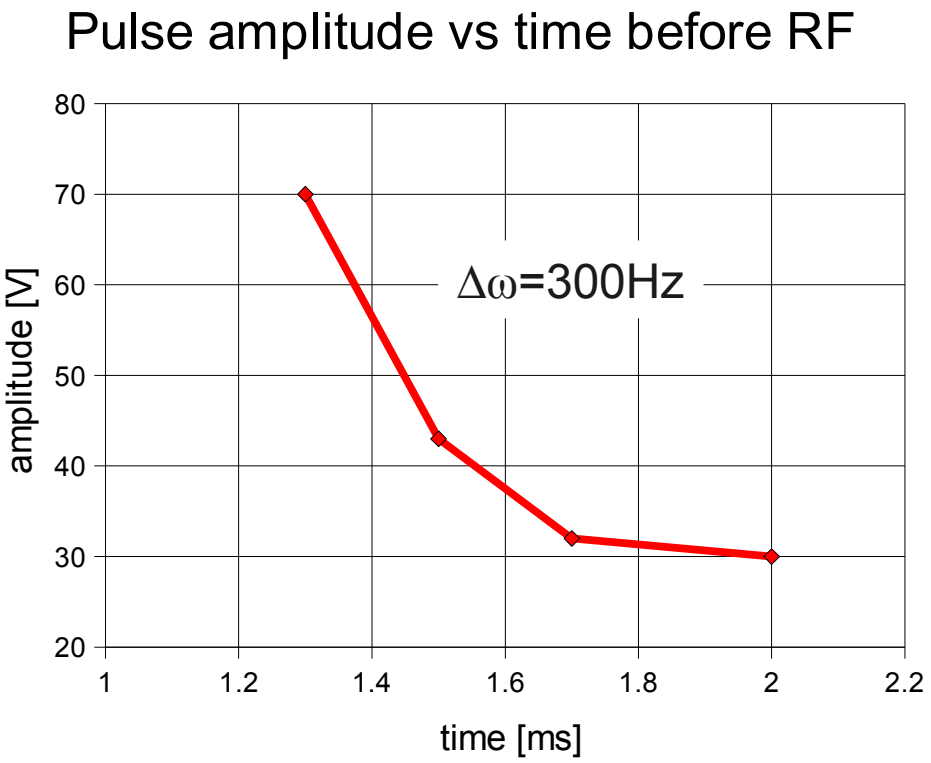


Piezo Control Panel

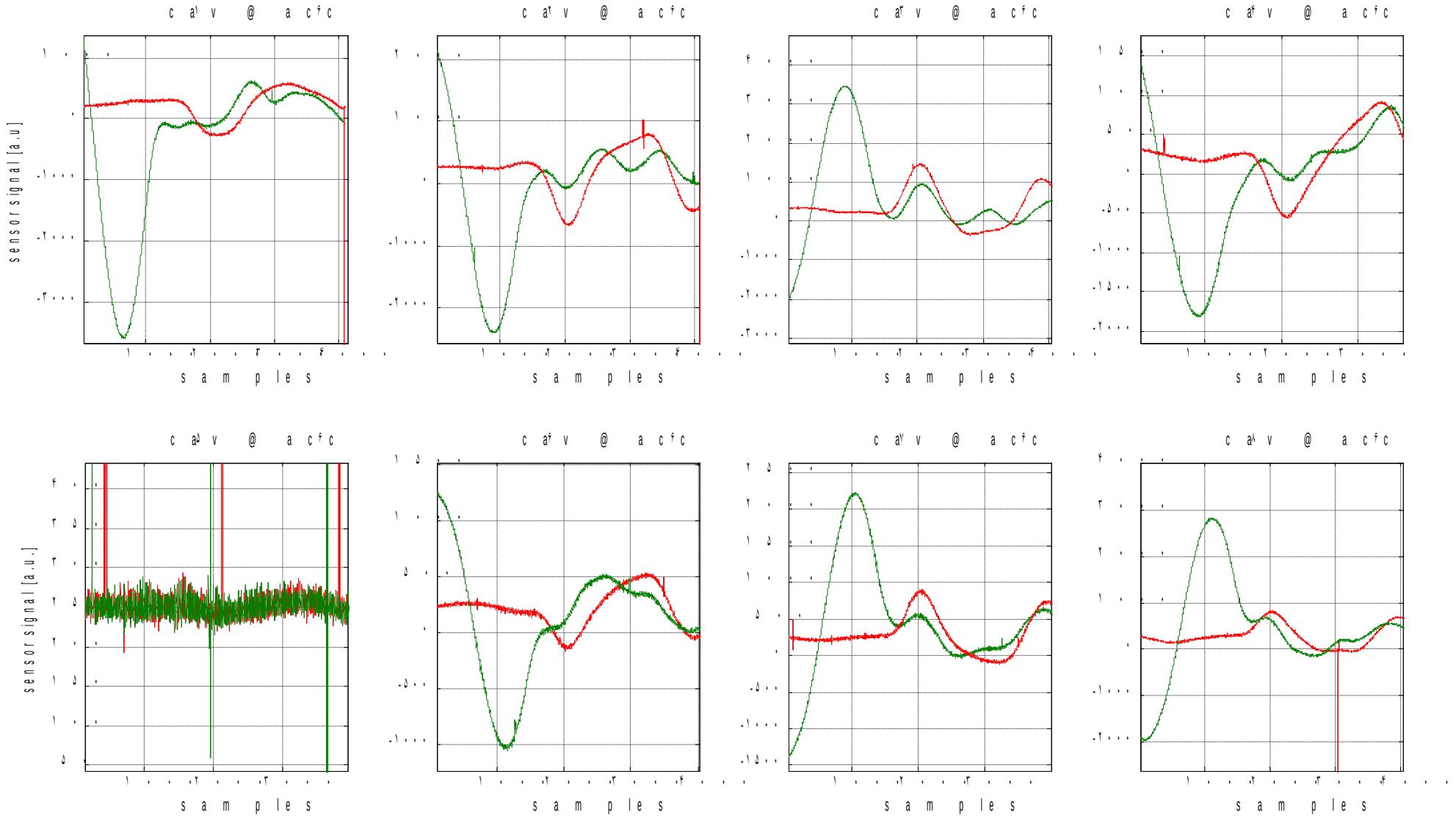


Microphonics

- Due to limited speed of acoustic wave propagation through the cavity it is not possible to react within the RF pulse for variable microphonics
- Microphonics must be measured in advance (before RF pulse - either second piezo used as a sensor of some RF must be present before the pulse) and compensated as soon as possible



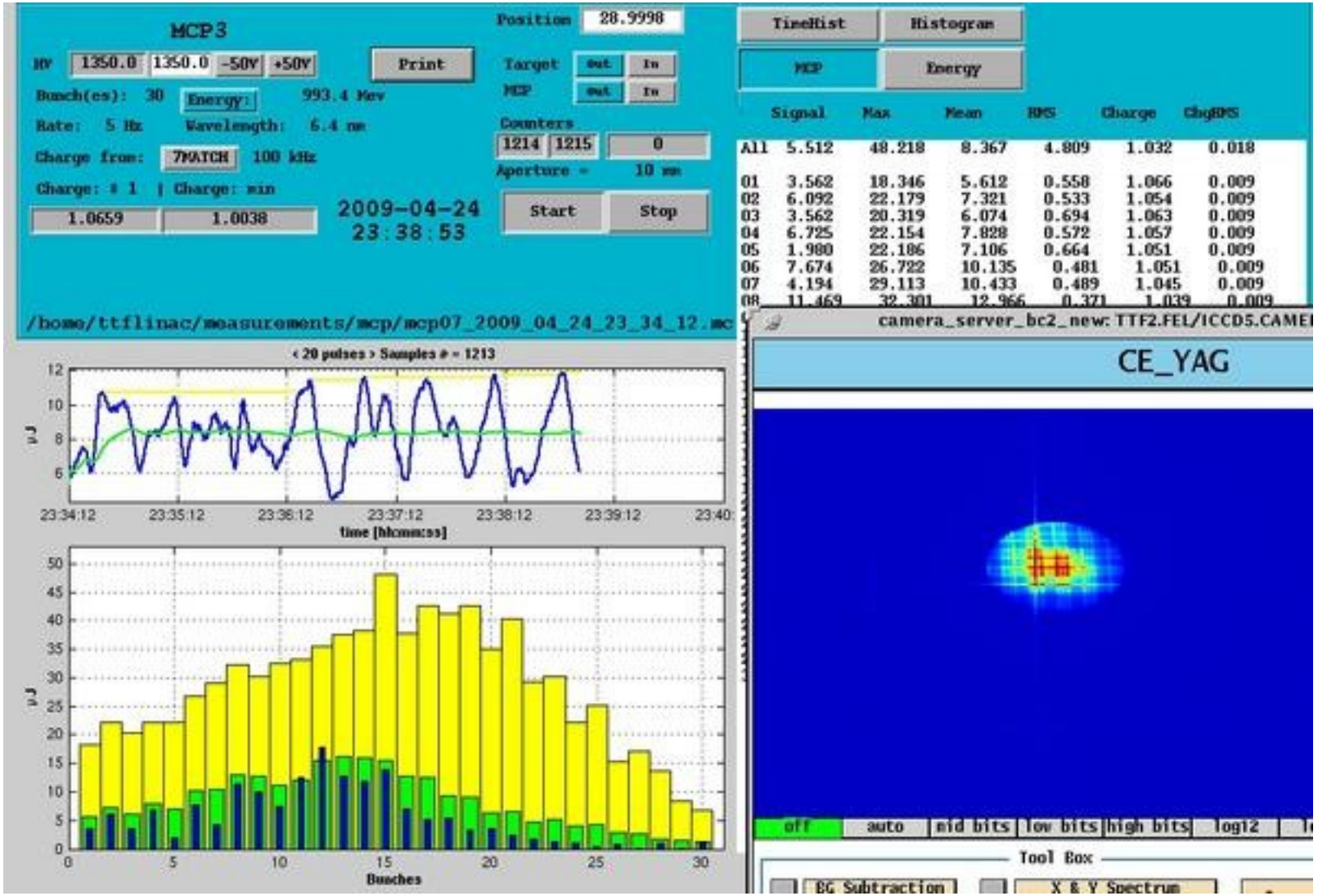
Piezo sensors in ACC6



Without piezo drive

With piezo drive

Piezo operation influence on SASE level



ATCA integration

- Advantages:
  - No need for separate piezo crate (place, crate, power supply etc.)
  - The control link through the backplane
- Bigger form factor than Eurocard (2.5 more space) allows to integrate in the single board 16 channel piezo driver together with DACs and ADCs, probably it is also possible to put DC/DC converter (48V -> ±100V) in the board
- Special care for piezo connectors (high voltage, backside connection through customized RTM)

Conclusion

- Fast tuners with piezos are installed at FLASH and are operable.
- Piezo control system was developed and implemented. It is able to control piezos in 4 modules (32 cavities) simultaneously
- Commisioning of the piezo control system is in progress and will be continued after shutdown.
- The integration of piezo control in ATCA looks possible and promising.

Thank you for your attention