low level radio frequency
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DESY
DMCS

Piezo operation experience at FLASH

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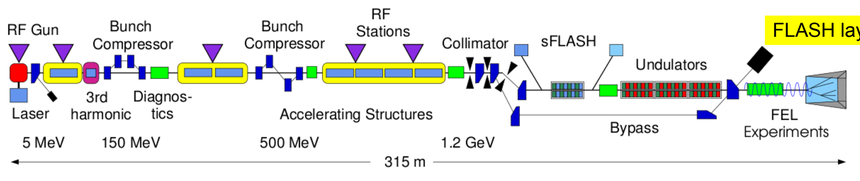
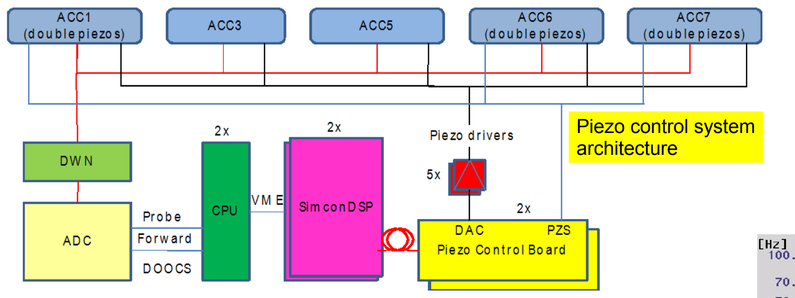
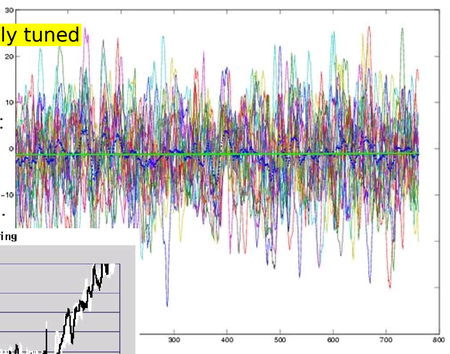
Abstract: Some of the FLASH superconducting accelerating modules are equipped with fast piezo tuners. From the total number of seven modules three of them are equipped with double piezos and two with single piezos. They are used to compensate of the Lorentz Force Detuning (LFD) and to tune cavities in limited range. In the double piezos modules it is possible to probe the piezo sensor signal in order to investigate the cavity vibrations. The operation experience over last run period is presented, including also some results from piezo tests at Chechia horizontal test stand.

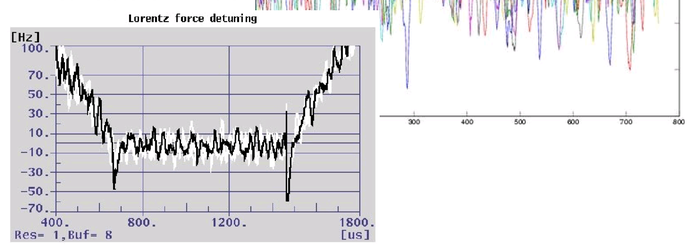


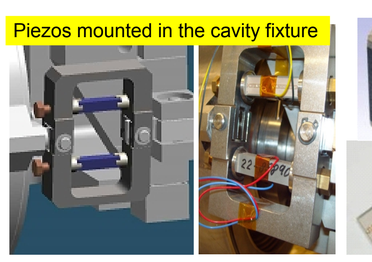
FLASH layout



Piezo control system architecture






Piezos mounted in the cavity fixture

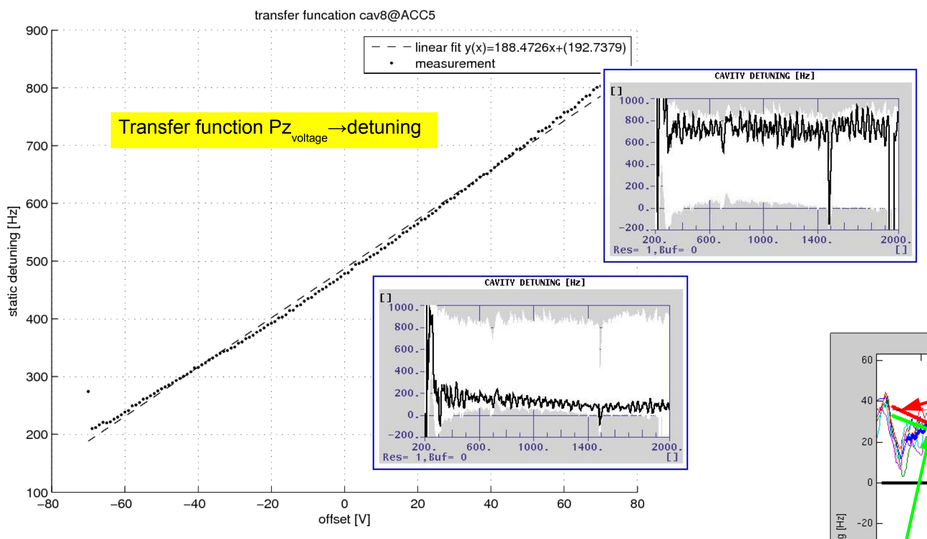
Manufacturer ratings	Noliac	PI Ceramics
Model	SCMAS/S1/A	P-888.90
Cells	8	8
Voltage range [V]	0 ÷ 200	-30 ÷ 130
Blocking Force [kN]	6	3@120V
Size [mm^3]	10 x 10 x 30	10 x 10 x 35
Capacitance [uF]	6	12

Parameters of piezos at FLASH

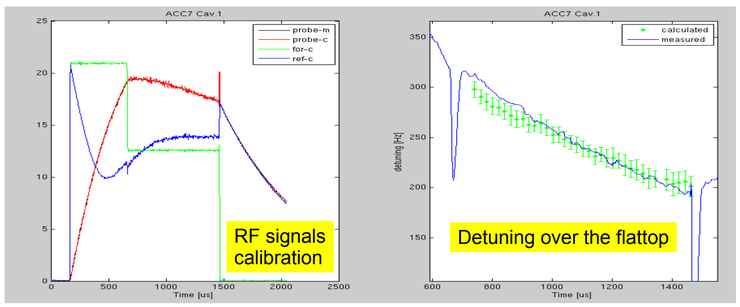
$$\Delta\omega = \frac{d}{dt}\varphi_c + 2\omega_{1/2}\frac{|V_{for}|}{V_c}\sin(\varphi_{for}-\varphi_c)$$

Detuning calculation

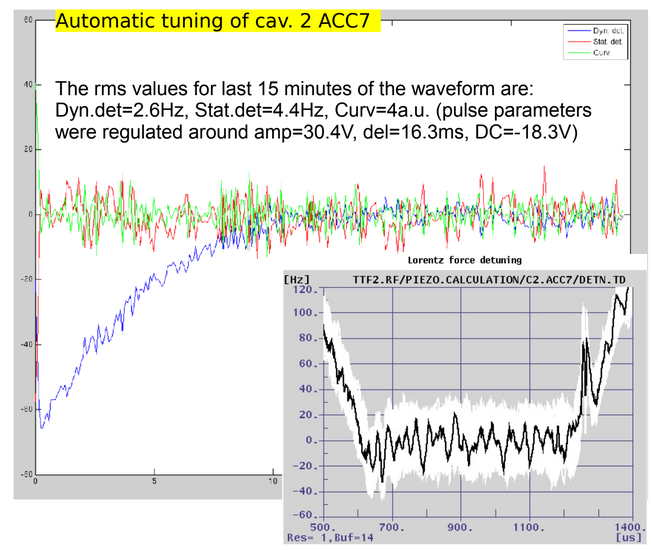
$\Delta\omega$ – *detuning*,
V_c, φ_c – *field amplitude and phase*,
$\omega_{1/2}$ – *cavity bandwidth*
V_{for}, φ_{for} – *forward power amplitude and phase*

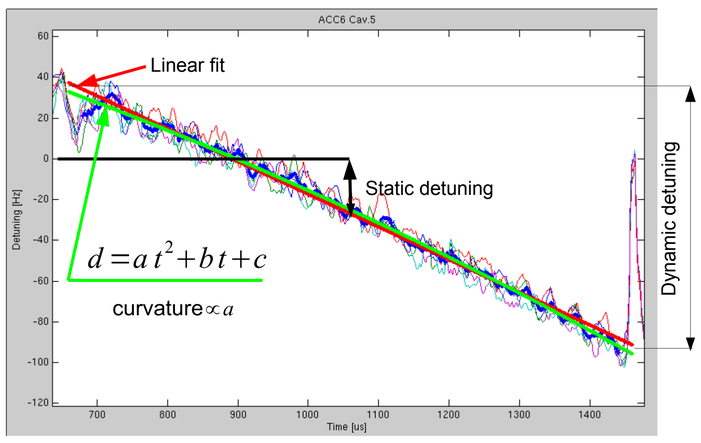


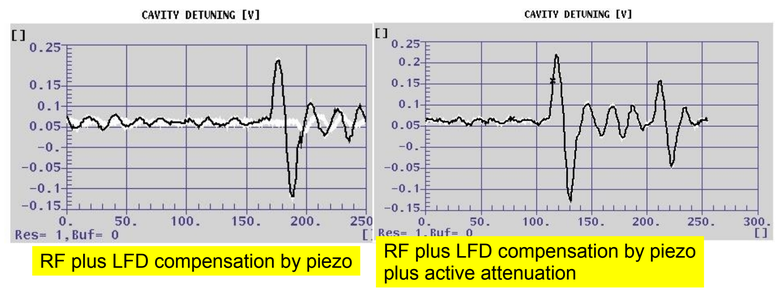
Transfer function $Pz_{voltage}$→detuning



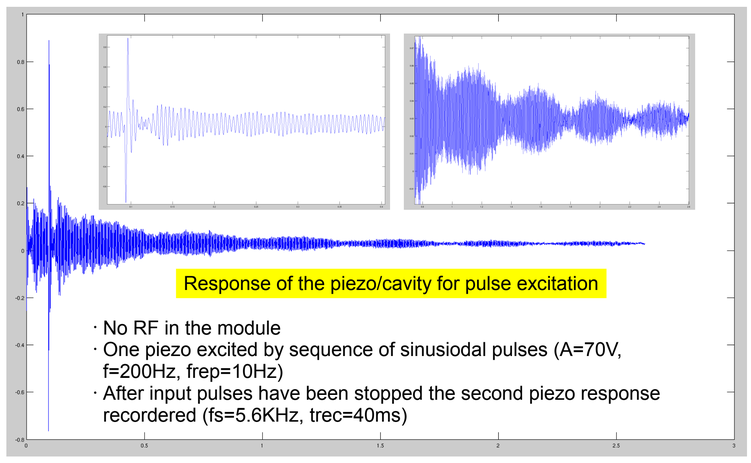
RF signals calibration
Detuning over the flattop

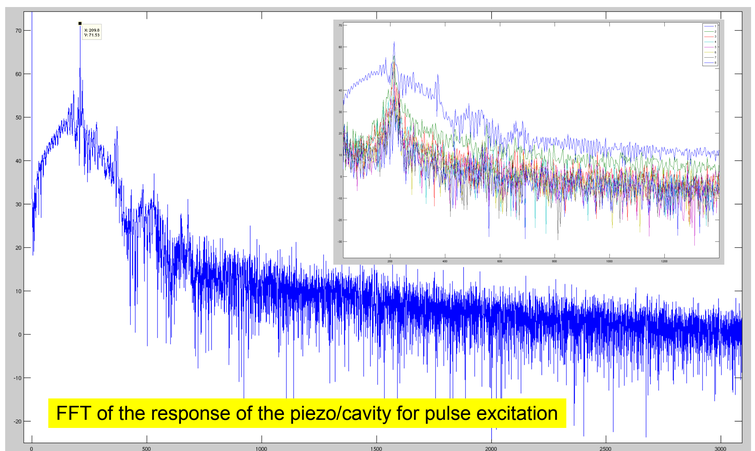


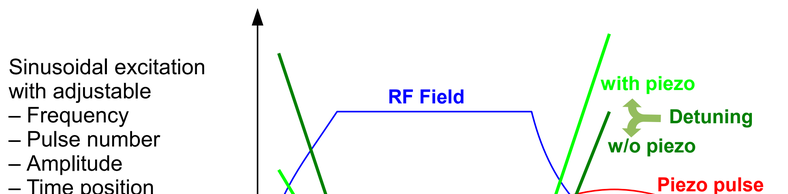


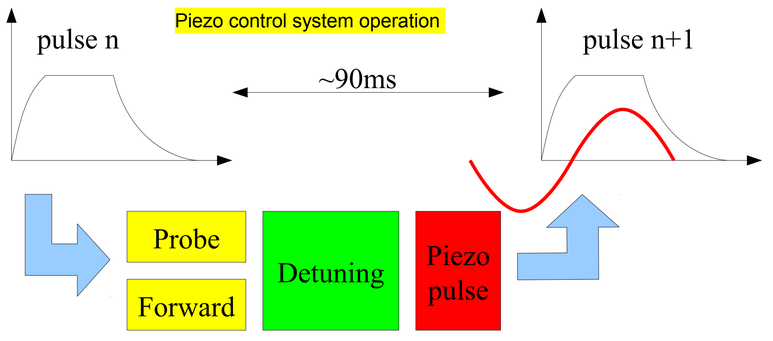


RF plus LFD compensation by piezo
RF plus LFD compensation by piezo plus active attenuation



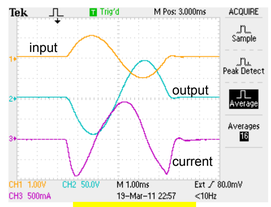




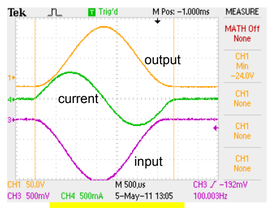


Piezo reliability

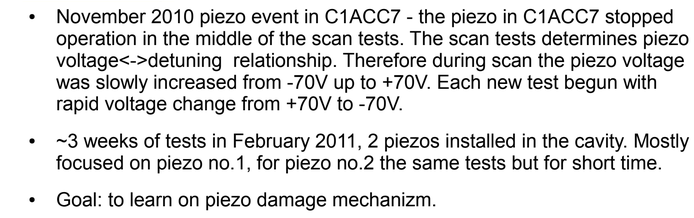
- November 2010 piezo event in C1ACC7 - the piezo in C1ACC7 stopped operation in the middle of the scan tests. The scan tests determines piezo voltage<->detuning relationship. Therefore during scan the piezo voltage was slowly increased from -70V up to +70V. Each new test begun with rapid voltage change from +70V to -70V.
- ~3 weeks of tests in February 2011, 2 piezos installed in the cavity. Mostly focused on piezo no.1, for piezo no.2 the same tests but for short time.
- Goal: to learn on piezo damage mechanizm.
- Bipolar mode 0,±70V, 10/200Hz, single pulse.
- Simulation of scan tests (failure reason?).
- Bipolar mode 0,±120V, 10Hz, rectangular waveform.
- DC ±300V for few minutes.
- **Piezos survived all tests**



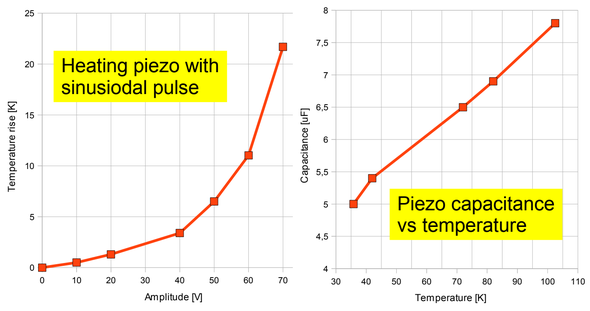
Bipolar drive

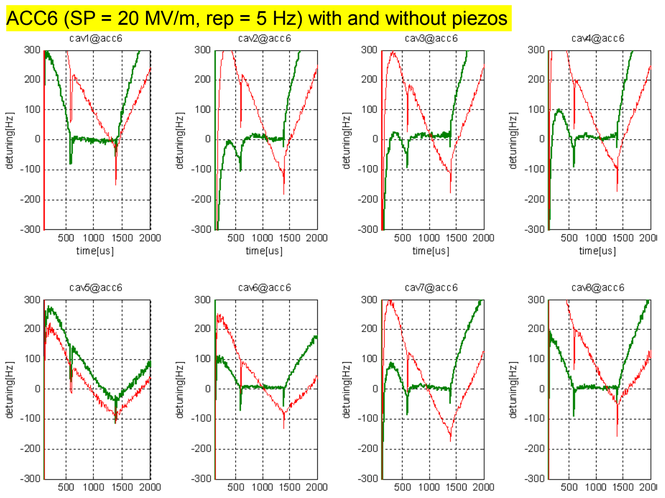


Unipolar drive



Switching up and down (±100V)





Conclusion:

- LFD can be well compensated with fast piezo tuners.
- Fast tuners with piezos are installed at FLASH (ACC1,3,5,6,7) and are operable through piezo control system.
- The failure reason for piezo in C1ACC7 is unknown. Other piezos works without problems.
- After discussions with piezos manufactures it has been decided the piezos will be operated in bipolar mode (in cryo temperatures repolarization happens at voltages much higher than available from piezo driver).

Future plans:

- Detuning calculation also with beam.
- Implementation of automatic cavity tuning / training of the operators to use piezos routinely.
- Investigations of piezo sensor signals for microphonics evaluation.
- Further piezo reliabilty study.
- Development of piezo control system for XFEL.