Adaptive Lorentz Force Detuning Compensation in FERMILAB Cryomodule 1.

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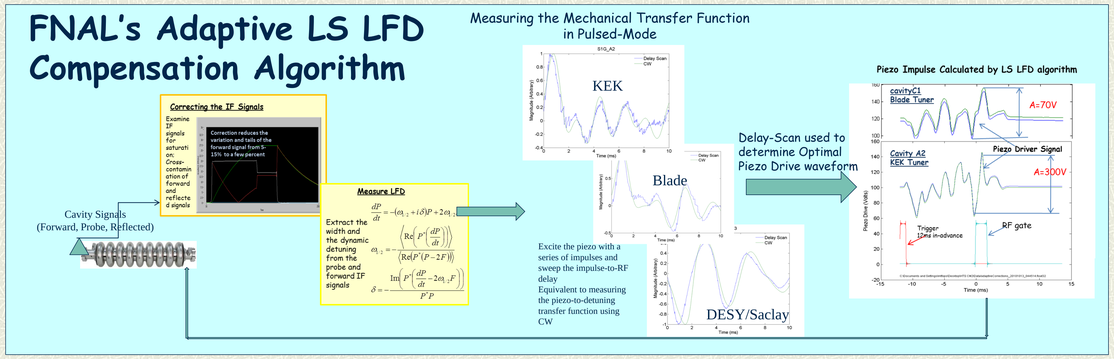
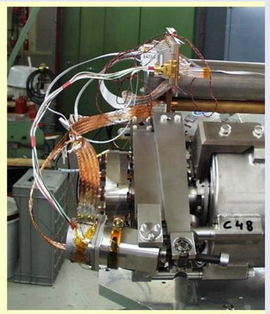
Abstract

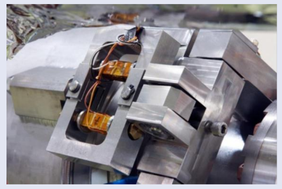
Cryomodule 1 of the Fermilab SRF Accelerator Test Facility has recently been commissioned. First results are presented from the simultaneous compensation of Lorentz force detuning in eight the 1.3 GHz Tesla style superconducting cavities.

FNAL's Adaptive LS LFD Compensation Algorithm



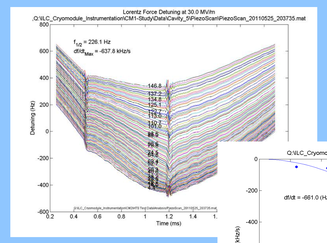


DESY/Saclay Style Piezo Tuner

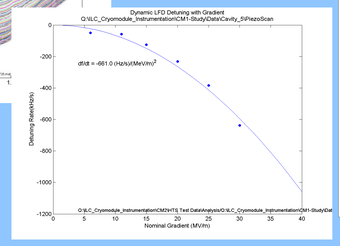


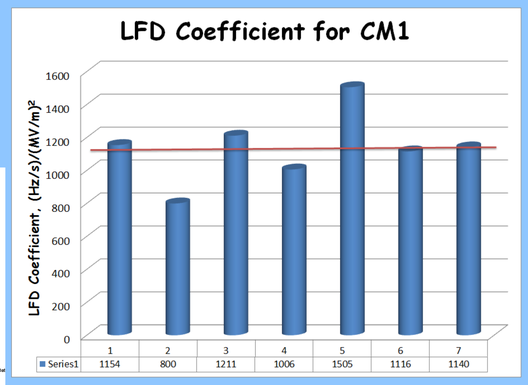
CM1 Cavity Characterization

- ✓ Cavity run at Eacc =5, 10, 15, 20… MV/m.
- ✓ Cavity detuned from resonance aprox +/-400Hz by changing DC voltage on the piezo to +/-100V.
- ✓ Cavity RF waveforms (forward, probe, reflected) used to calculate cavity detuning during RF pulse.
- ✓ Piezo tuning sensitivity and Dynamic LFD coefficient measured for each Eacc.



Piezo-to-Cavity Tuning sensitivity ~ 4Hz/V (800Hz tuning range)





Summary

Piezo Control System (with FNALS's Adaptive LS LFDC algorithm) has been successfully deployed for CM1 at NML.

LFDC and cavity's characterization techniques developed during FNAL's SRF R&D program have been used for CM1 related studies.

Residual LFD (after compensation) was not more that 50Hz for all 8 cavities (during compensation of "Fill+Flat-Top" part of RF pulse)

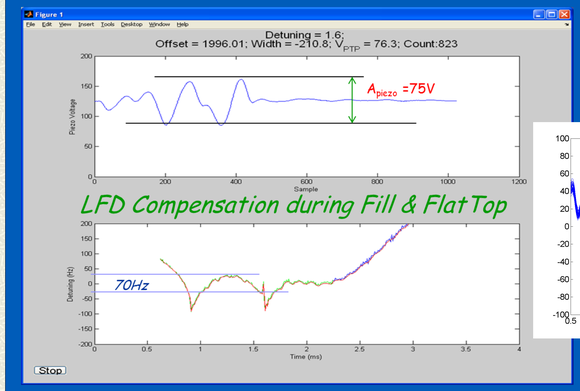
CM1 is creating unique opportunities to extend FNAL's SRF Cavity Resonance Control R&D program to the new level

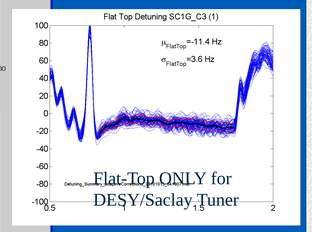
- LFD & microphonics compensation for entire cryomodule – not just one cavity;
- Step from R&D piezo control system to robust/industrial style system incorporated inside LLRF system.

CM1 LFD Compensation (cavity#5 at Eacc=30MV/m)

Without LFD Compensation

$\Delta F_{FlatTop=700us}$=500Hz + $\Delta F_{Fill=500us}$=600Hz == **1100Hz**

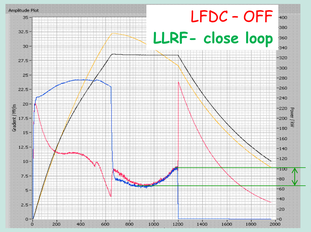




Flat-Top ONLY for DESY/Saclay Tuner

RF waveform:
Forward, Probe, Reflected

LFD Compensation for cavity#4 (CM1) (Eacc=23MV/m) ΔF_{LFD}=450Hz



65% extra power