LLRF Activities at SLAC

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LLRF 2017

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SLAC NATIONAL ACCELERATOR LABORATORY

U.S. DEPARTMENT OF ENERGY
Office of Science

Overview

From Modernizing the existing complex

LCLS-I, SPEAR3

P52 (van Winkle)

To Building the new

LCLS-II

O-11 (Benwell), O16 (Doolittle),

P26, P27, P28 (Benwell), P71 (Huang), P79 (Doolittle),

P93 (Bachimanchi), P94 (Einstein-Curtis), P98 (Xu)

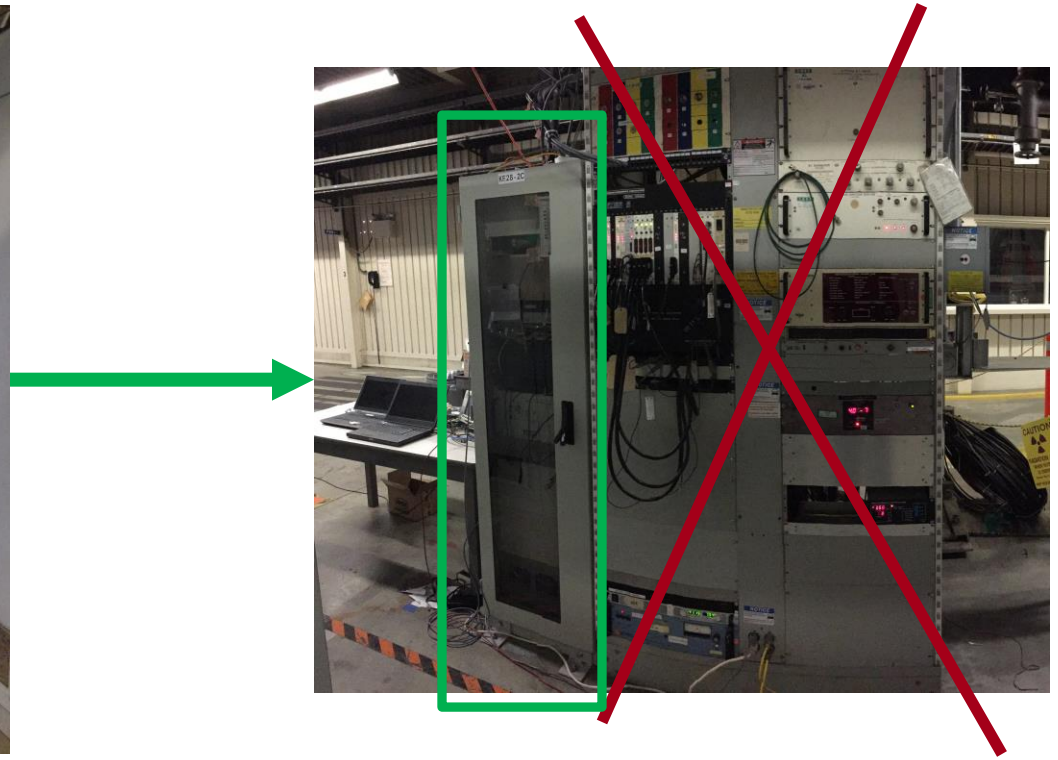
Also part of:

Tutorials: Wed (Doolittle), Thu (Einstein-Curtis)

LCLS-I LLRF Upgrade

SLAC are upgrading the 50 year old infrastructure at each of the 80 RF stations in the SLAC linac

- 10 Sectors with 8 Stations each – 80RF stations
- 2856 MHz Pulsed at 120 Hz.

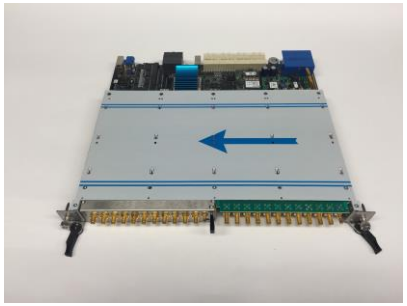


LCLS-I LLRF Upgrade (2)

SLAC Using High Performance Architecture (ATCA Based) – Developed for LCLS-II systems

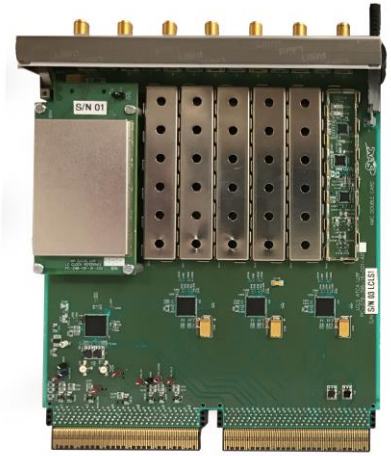
Each Stations contains:

- 1 Precision Card
  - LO/Clock generation
  - 6 2856 MHz down-converters
  - 3 ADC chips each containing 2 ADCs
- 1 Up-converter card
  - Up-converter
  - 16 Bit Parallel DAC
  - 3 ADC chips each containing 2 ADCs
  - 4 2856 MHz down-converters
  - 2 DC ADC connections



ATCA Carrier Card

LCLS-I Station Configuration



Precision Card

Up-converter

P52

Other Applications leveraging ATCA LLRF platform

SLAC

Several other applications around the lab are leveraging the LCLS-I Mission readiness LLRF cards (with slight modifications for differing input frequencies)

- SPEAR Booster (Input Frequency 358.54 MHz)
- SPEAR Ring LLRF (Input Frequency 476 MHz)
- LCLS-II Laser Locker (experiments and Gun) (Input frequency 2600 MHz)
- LCLS-II Experiment RF reference over fiber project (Input frequency 2600 MHz)

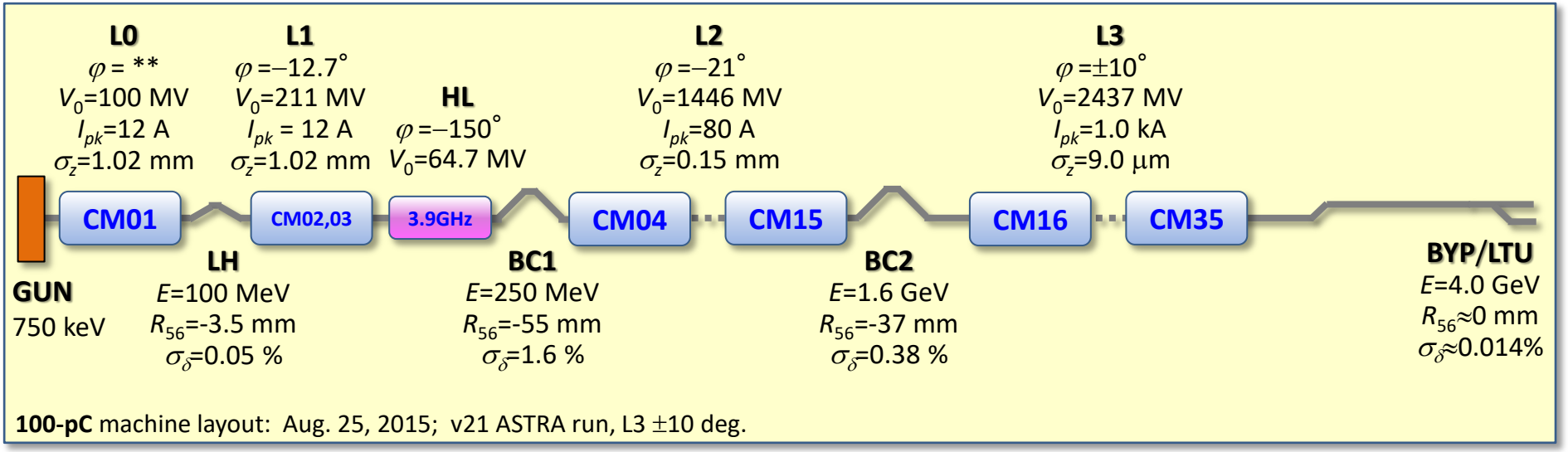
Advantages:

- Firmware is highly leverageable
- Firmware built using system generator for easy algorithm development using Simulink
- System generator has allowed us to develop a significant DSP library allowing non-VHDL/Verilog experts to develop complex algorithms

See P52 Poster

LCLS-II LINAC RF Requirements

Required Field Control is derived from the linac energy spread and beam jitter tolerances at the undulator.



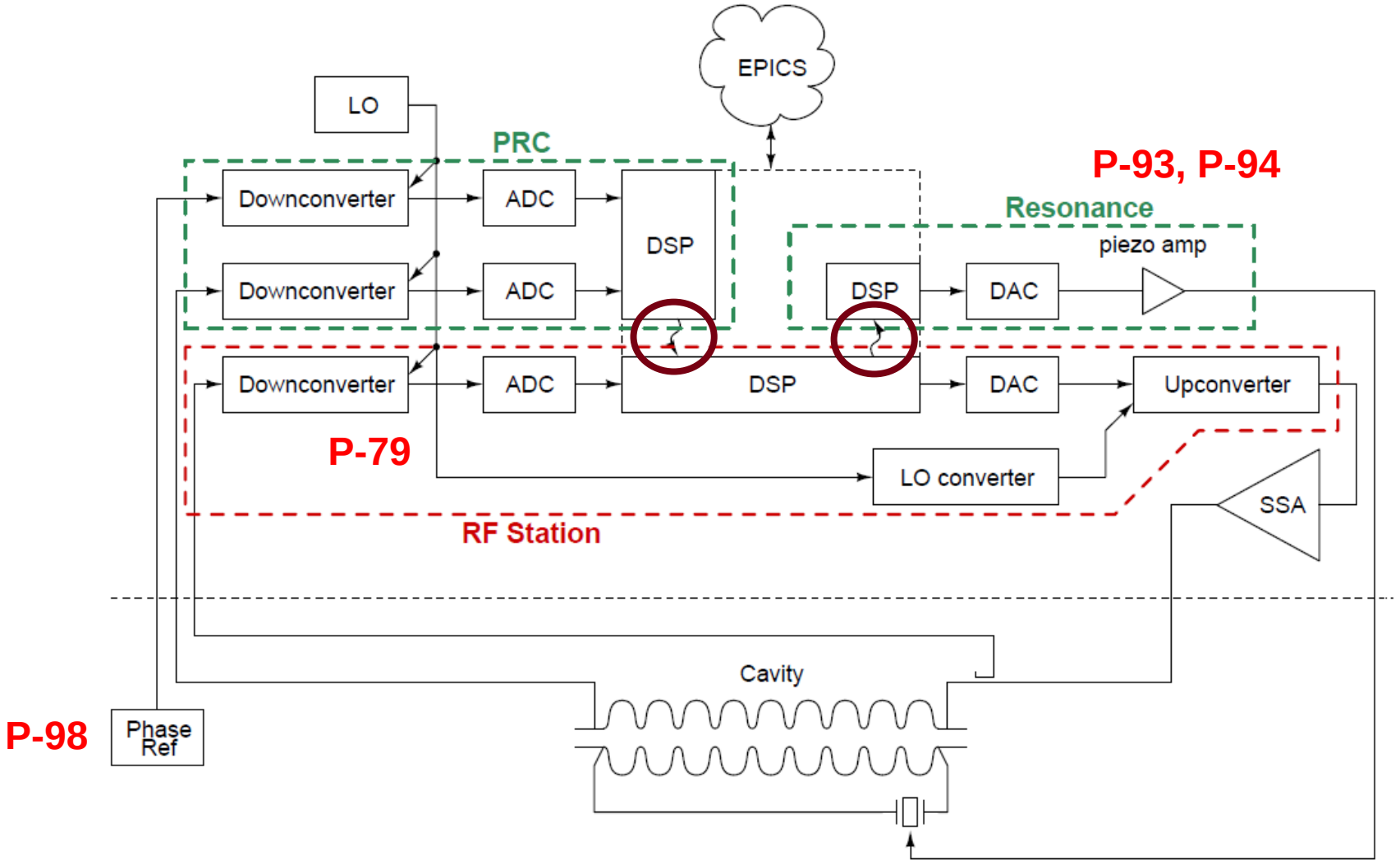
LCLS-II LINAC

O-11, O-16

Cavity Field Control Design Specification

- For the time period > 1 Hz : 0.01% and 0.01°
- For the time period < 1Hz: 5.0% and 5.0°
  - The LLRF system will be supported by EPICS BBF (commissioning) and eventually a dedicated BBF system.
  - LLRF System is designed to be BBF ready

Simplified Hardware Architecture



LLRF Testing on Cryomodules

- LLRF installed at the FNAL CMTS
  - Presently capable of four cavity operation
  - Second rack for full cryomodule is installed, cables being run.
- JLAB soon to repurpose Low Energy Recirculating Facility (LERF) for LCLS 2 cryomodule testing
  - 4 full LLRF racks (2 cryomodules) scheduled for installation in February 2018

Power Supply

Resonance Chassis

RF Station 1

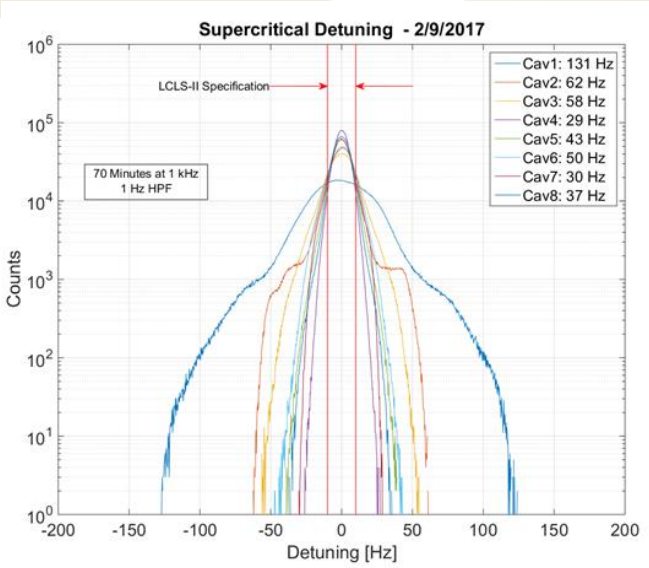
RF Station 2

Precision Receiver Chassis

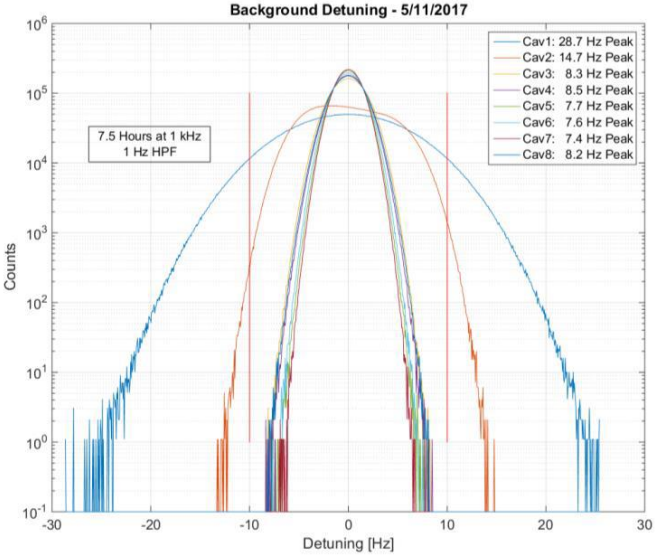
P-26, P-27, P-28

Active Microphonic Compensation

- During pCM tests Thermal Acoustic Oscillations (TAO) were discovered in the cryogenic piping.
- Microphonic detuning in the 30 to 50 Hz peak range. The specification is 10 Hz peak.
- Mitigation made by combination of:
  - **Mechanical design changes in CM cryogenics piping**
  - **Development of active resonance controls**



pCM



After Improvements F1.3-02

LLRF + FNAL Microphonics Mitigation group
- Warren Schappert
- Yuriy Pischanikov
- Jeremiah Holzbauer

Questions?