

Challenges of LCLS-II

Larry Doolittle, LBNL, 2015-10-08

Two ways to look at LCLS-II:

- a) **A challenging, high-precision, high-reliability machine**, since the undulator will find every defect in the electron beam, and photon-physics experimentalists are used to the mature environment of a synchrotron light source
- b) **Not worse than the XFEL**, kind of strange metric since there's little evidence that XFEL will actually deliver a useful beam

LCLS-II will be the second large-scale SRF installation in the U.S., after CEBAF (construction 1987-1994).

Fun Fact: CEBAF was built to turn groundbreaking nuclear-physics research from SLAC's nuclear physics era (1966-1983) into a high-data-rate, precision experimental tool. LCLS-II is designed to turn groundbreaking X-ray laser research from SLAC's LCLS-I era (2009-present) into a high-data-rate, precision experimental tool.

The CEBAF SRF cavities were prototyped at Cornell, and tested on a 500 mA (?) CW storage ring. The cryomodule design was developed at Jefferson Lab from 1987-1990, for use with a design current of up to 1 mA.

The LCLS-II cavities and cryomodule are derived from the ILC design, optimized for 9 mA 0.1% duty factor and production quantity 16000, but repurposed and minimally reengineered for 0.3 mA CW and production quantity 280.

Some LCLS-II LLRF Challenges:

“Why don’t you follow the XFEL design?”

Finding the resonance: 20 Hz wide, at least in the initial turn-on it could be anywhere in a 200 kHz band.

Resonance shifts by many bandwidths when you run the gradient up to its design value.

Unknown microphonic spectrum, vs. tight requirements (0.01° and 0.01%) on cavity field stability. 82 dBA measured in gallery (with LCLS-I modulators turned off). A bridge carries I280 over the linac.

Scale to 280 cavities: strung along 700 m of linac. Need to include a drift-compensating Phase Reference Line.

Interact with other SLAC subsystems and mandates, some of which are moving targets, culture clash between software and gateway paradigms, ...

Software Project Management/Estimation, our parochial component of an industry-wide problem. Usual estimates are that 50% to 80% of large projects fail.

LCLS-2 LLRF Hardware Architecture Concept

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- L-band (1300 MHz RF, 1320 MHz LO)
- L-band ϕ ref, 100m to 200m runs
- - - low-latency digital link, optical fiber

Centralized LO with local distribution amp

Four cavities (one penetration) shown
Timing, Interlocks, etc. not shown
"Not to scale"



