BEAM MEASUREMENTS AT LCLS*

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Abstract

The LCLS accelerator is presently in a commissioning phase[1] and produces a 14GeV beam with normalized emittances on the order of one mm-mr, and peak current exceeding 3000 Amps. The design of the beam measurement system relies heavily on optical transition radiation profile monitors, in conjunction with transverse RF cavities, and conventional energy spectrometers. It has been found that the high peak currents and small longitudinal phase space of the beam generate strong coherent optical emission that limits the quantitative use of OTR and other prompt optical diagnostics, requiring the use of wire scanners or fluorescent screen based measurements. We present the results of beam measurements, measurements of the coherent optical effects, and future plans for the diagnostics.

LCLS ACCELERATOR

The Linac Coherent Light Source is a SASE Free Electron Laser, designed to produce X-rays with wavelengths down to 1.5 Angstroms, using electron beam energies up to 13.6 GeV.

Table 1: Accelerator Design Specifications

Energy	4.3 to 13.6 GeV
Bunch Charge	200 pC to 1 nC
Design emittance	~ 1.2 mm-mr slice
Peak current	~ 3.4 KA.
Repetition rate	120Hz, single pulse

An accelerator layout with beam parameters is given in figure 1.

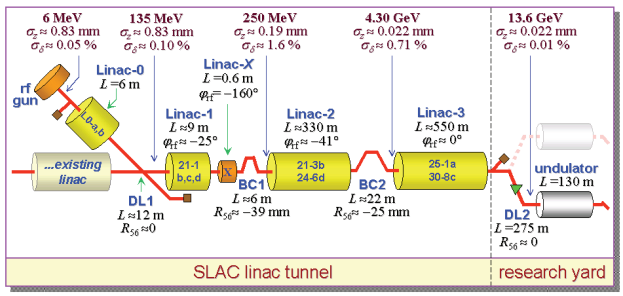

Figure 1: Accelerator layout.

Linac-2 and Linac-3 are only slightly modified from their configuration for the SLC [2]. The remainder of the machine is new, though it makes use of some old SLAC accelerator structures and magnets. As of April 2008, the beam is accelerated to the end of Linac-3 with nominal parameters, except that the repetition rate is presently limited to 30 Hz during commissioning.

BEAM DIAGNOSTICS AND MEASUREMENTS

The LCLS design relies heavily on beam-based control and feedback, necessitating the use of a variety of beam measurement devices:

- Position: Stripline BPMs
- Charge: BPMs, Toroids, Faraday Cups
- Beam Loss: Ion chambers and PMTs
- Profile: Wire Scanners, Optical Transition Radiation monitors, and fluorescent screens
- Emittance: Multiple profile monitors, or Quadrupole magnet gradient scans on a single profile monitor.
- Longitudinal Measurements: Spectrometers, Millimeter wave bunch length monitors, Transverse RF deflection cavities.

Beam Position Monitors

The LCLS injector, and a few locations along the Linac use self-calibrating strip-line BPMS based on digital down conversion: figure 2.

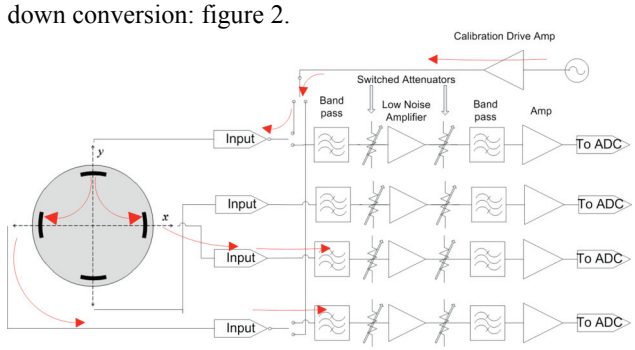

Figure 2: BPM Electronics

The BPMS operate at a center frequency of 140MHz, with a 7 MHz bandwidth. On every pulse, a tone burst is injected onto one strip, and the coupling to the perpendicular strips is measured. This corrects for gain changes in the readout channels and cables. [3]

The BPM noise is measured by performing a linear regression between the BPM under test, and the other BPMS in the accelerator, with the residual indicating the position noise, figure 3.

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