Laser Heater Controls at the Linac Coherent Light Source

Matt Boyes, Sheng Peng

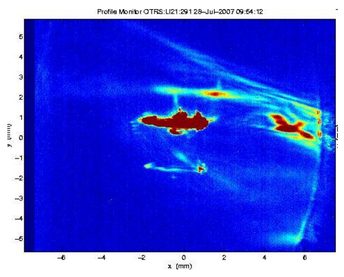
SLAC National Accelerator Laboratory
Menlo Park, CA

Motivation

Coherent Synchrotron Radiation Induced Emittance Growth

Coherent Synchrotron Radiation (CSR) occurs when the bending of a relativistic electron beam allows the synchrotron radiation emitted by the tail of the microbunch to "catch up" with the head electrons. If the arc length of the bend is long enough, this radiation sweeps along the entire length of the microbunch and transfers energy from the tail to the head. Therefore CSR tends to increase the energy of the head while lowering that of the tail.

Ref: Y.S Derbenev et al. DESY TESLA-FEL Technical Note 95-05(1995)



CSR observation on an OTR

The LCLS injector system will incorporate a laser-electron-beam heater system (an inverse free electron laser) in order to generate an uncorrelated energy spread in the electron beam [1]. This produces Laudau damping in the bunch compressor chicanes in order to suppress potential micro-bunching instabilities that may be driven by Coherent Synchrotron Radiation (CSR) in the bunch compressors, and Longitudinal Space Charge (LSC) forces in the linac. The laser-heater system is shown in Fig. 1. The heater system is located just down beam of the L0b accelerator section at 135 MeV in the off-axis LCLS injector housing.

P. Emma- PRD 1.2-004-r2

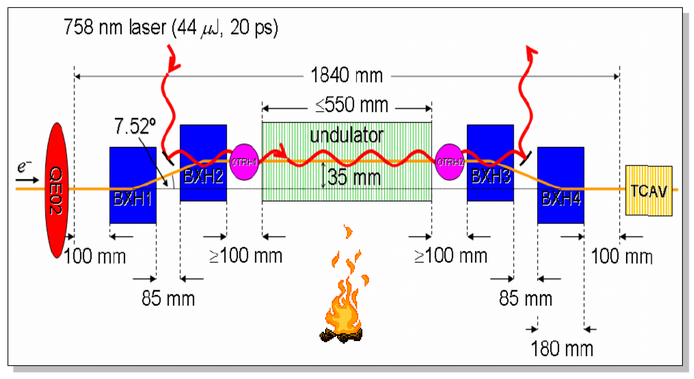


Fig. 1

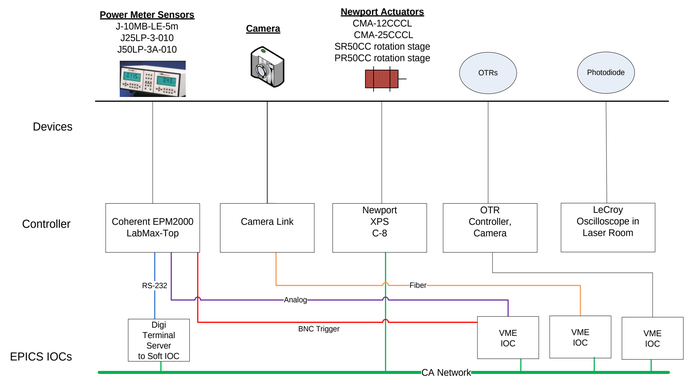
Laser Beam Required Parameters

Parameter	Value	Range	Unit
Wavelength	758	750 - 770	nm
Laser Beam Waist Radius (2σ) (in the center of the undulator)	0.36	0.32 – 0.60	mm
Laser Beam Rayleigh Range	50	42-1600	cm
Laser Pulse Energy	44/200 (nominal/high setting)	0-200	μJ
Laser Pulse Duration (FWHM)	20	10-20	ps
Centroid Position Stability	<35		μm

(ESD 1.2-122)

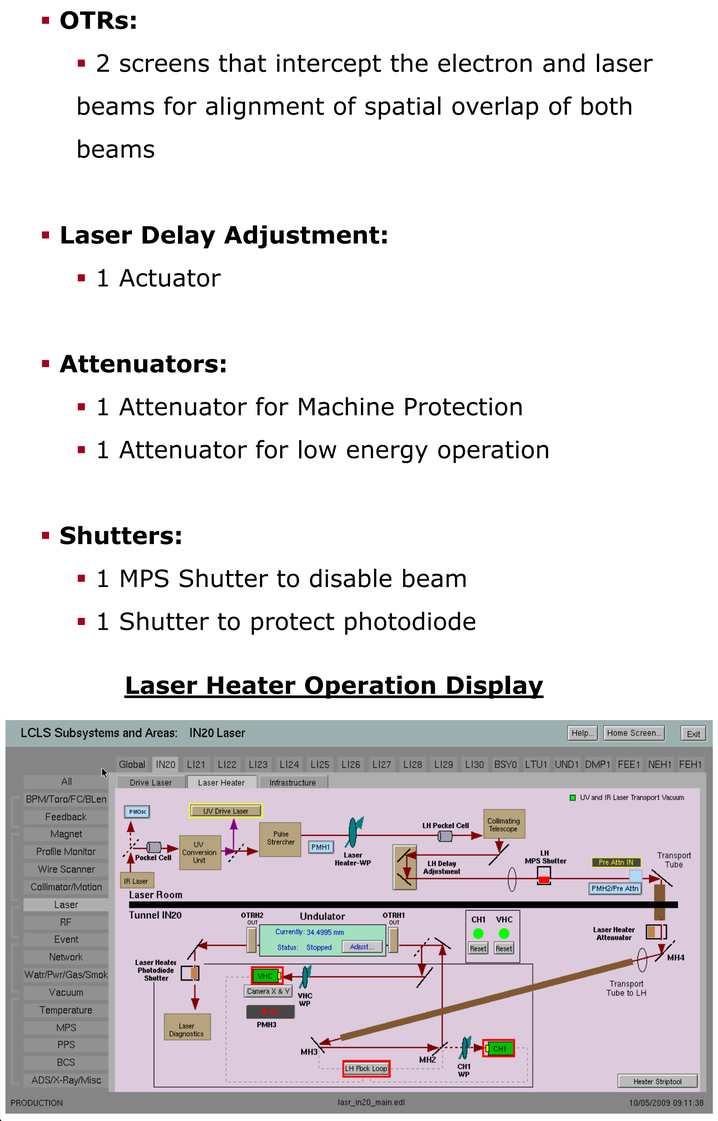
Main Devices

Laser Heater Block Diagram



- **Energy Control:**
  - Waveplate and polarizer
- **Fast Energy Control:**
  - Pockels Cell and polarizer
- **Energy Measurement:**
  - 2 Coherent EPM 2000 Power meters with insertable sensors
  - 1 Coherent LabMax-TOP Power meters with fixed sensor for beam synchronous acquisition
- **Laser Steering Feedback:**
  - 4 Actuators for position and angle correction
  - 2 Cameras for position measurement
  - 2 Waveplates for camera intensity control
- **Time Measurement:**
  - 1 Photodiode
- **Virtual Heater Camera (VHC) adjustment:**
  - 2 Actuators for x and y position adjustment
- **OTRs:**
  - 2 screens that intercept the electron and laser beams for alignment of spatial overlap of both beams
- **Laser Delay Adjustment:**
  - 1 Actuator
- **Attenuators:**
  - 1 Attenuator for Machine Protection
  - 1 Attenuator for low energy operation
- **Shutters:**
  - 1 MPS Shutter to disable beam
  - 1 Shutter to protect photodiode

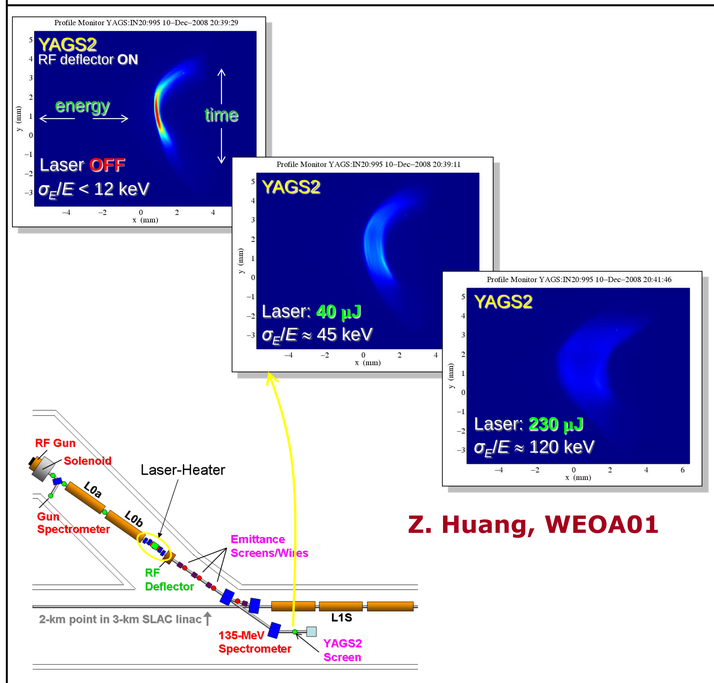
Laser Heater Operation Display



Machine Protection

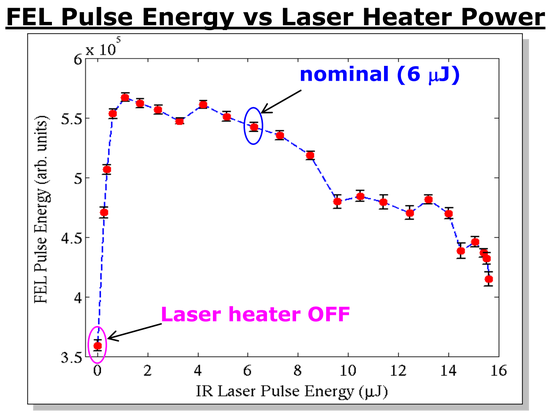
- OTR foil damage was observed when exposed for >3 minutes to laser beams at energies >7μJ
- Machine protection logic requires a laser attenuator to be in if an OTR screen is in or if the photodiode is exposed to the laser

Observations



Z. Huang, WEOA01

FEL Pulse Energy vs Laser Heater Power



D. Ratner, TUOA03

Issues

- **Newport XPS C8:**
  - Power loss recovery requires expert
  - Limits on cable length require controller installation in accelerator tunnel

Acknowledgments

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