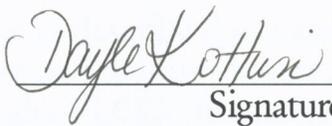
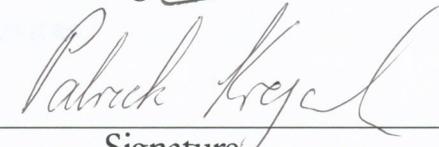
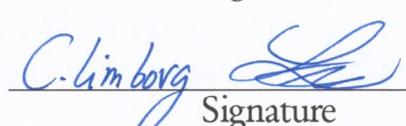
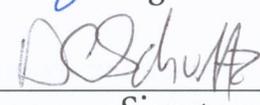
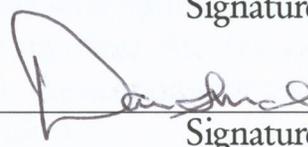


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Injector Controls				
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Brief Summary: The injector controls system will operate at 120 Hz and will consist of a secured network of real-time clients which interface to the hardware and to the servers which provide control panels, archiving and alarm handling to the user. The clients and servers will use EPICS, a toolkit of controls utilities and communications protocols. This document describes specifications required for the control systems unique to the injector: the drive laser and the laser heater. The rest of the control systems are in the global controls specification.

Keywords: Real-time controls, EPICS, drive laser controls, laser heater controls

Key WBS# 's: 1.2.2.1-1.2.2.10, 2.2.2.1-2.2.2.10

Injector Control Subsystems

Many of the injector control subsystems are global across LCLS. Examples are the e-beam diagnostics, timing, low-level RF, and vacuum control subsystems. These systems are specified in *1.1-303 LCLS Control System Requirements*.

The scope of this document is to describe the controls subsystems unique to the injector, namely the drive laser and the laser heater controls systems. Where components are common to all of LCLS (for example, “2-D fine position motor control”), they will also be found in the *1.1-303* document.

LCLS controls systems will implement EPICS and speak the Channel Access (CA) protocol across Ethernet to other devices.

Drive Laser

The drive laser will operate at 120 Hz via gated signals to pre- and final amplifiers. It must shut off within one pulse after receipt of signal from Machine Protection System (MPS).

A schematic for the drive laser is shown in Figure 1. The decision has been made to contract out the part of the drive laser system (shown as area inside dotted rectangle on Figure 1) which contains the stabilizer, the TiS oscillator system, the pulse stretcher, the pulse shaper, the amplifiers, the compressor and possibly the UV converter (depending on the selected vendor).

The following is a list of the SLAC controls requirements for the drive laser, given the vendor-delivered system. They are listed in order, from the beginning to the end of the drive laser:

1. **oscillator:** monitor/archive output power, timing, cooling water temperature, pump internal temperature, pump output power, pump diode current
2. **before stretcher and shaper:** monitor/archive average power, profile, spectrum (drives a shutter), photodiode signal used to trigger, pulse duration (scanning autocorrelator)
3. **stretcher, shaper:** monitor/archive average power, profile, spectrum, photodiode signal, pulse duration
4. **oscillator based measurements:** monitor/archive timing stability (locked to 119 MHz), steering stability

5. **preamplifier:** monitor/archive pump output power, pump diode current, cooling water temperature, internal preamp temperature, internal pump temperature
6. **preamplifier diagnostics:** monitor/archive average power, profile, spectrum (from FROG), pulse duration (from FROG), photodiode signal
7. **low power compressor:** monitor/archive alignment position and camera image
8. **amplifier pulse selection KHz & 120 Hz:** monitor what is driving the Pockels cell (external timing signal with delay)
9. **preamplifier spatial filter:** monitor/archive vacuum gauge readout measured by the spatial filter to detect loss of vacuum.
10. **preamplifier based measurements:** monitor/archive timing stability (from FROG and photodiode signals)
11. **preamplifier (Regen) control:** send 2 gated, 120 Hz signals via TTL (shown on Figure 1) for Pockels cells
12. **light pump for preamplifier control:** send gated, 120 Hz signal via TTL (shown on Figure 1) for Q-switch
13. **low power compressor control:** grating spacing (adjust based on camera image), steering mirror (adjust based on camera image)
14. **final amplifiers #1 & #2:** monitor/archive output power, pump output power, pump diode current, cooling water temperature, internal amplifier temperature, internal pump temperature
15. **final amplifiers #1 and #2 diagnostics:** monitor/archive energy, profile, spectrum, photodiode signal, pump output power, pump diode current
16. **high power compressor:** monitor/archive alignment position and camera image
17. **high power spatial filter:** monitor/archive vacuum gauge
18. **high power compressor control:** grating spacing (adjust based on camera image), steering mirror (adjust based on camera image)
19. **final amplifiers #1 and #2 based measurements:** monitor/archive timing stability (from FROG and photodiode signals), steering stability, pulse energy stability, “Fast Forward Feedback Stabilization” (from 2 photodiodes each amplifier and from 3 Pockels cells each amplifier)
20. **UV conversion:** monitor/archive temperature
21. **UV diagnostics:** monitor/archive energy, profile, spectrum, pulse duration (Streak camera Hamamatsu C6138) and photodiode signal
22. **UV measurements:** monitor/archive timing stability (from FROG and photodiode signals), pulse energy stability (from photodiode and Joulemeter signals)
23. **UV optical transport:** monitor/archive steering stability (energy, profile, photodiode, tube pressure)
24. **Visible transport:** monitor/archive energy before and after tube, profile, photodiode
25. **Visible transport control:** steering motor

26. **IR transport:** monitor/archive energy before and after tube, photodiode
27. **IR transport:** control steering motor
28. **UV conditioning spatial filter:** monitor/archive vacuum gauge readout
29. **UV pulse energy control:** adjust waveplate based on e-beam charge level

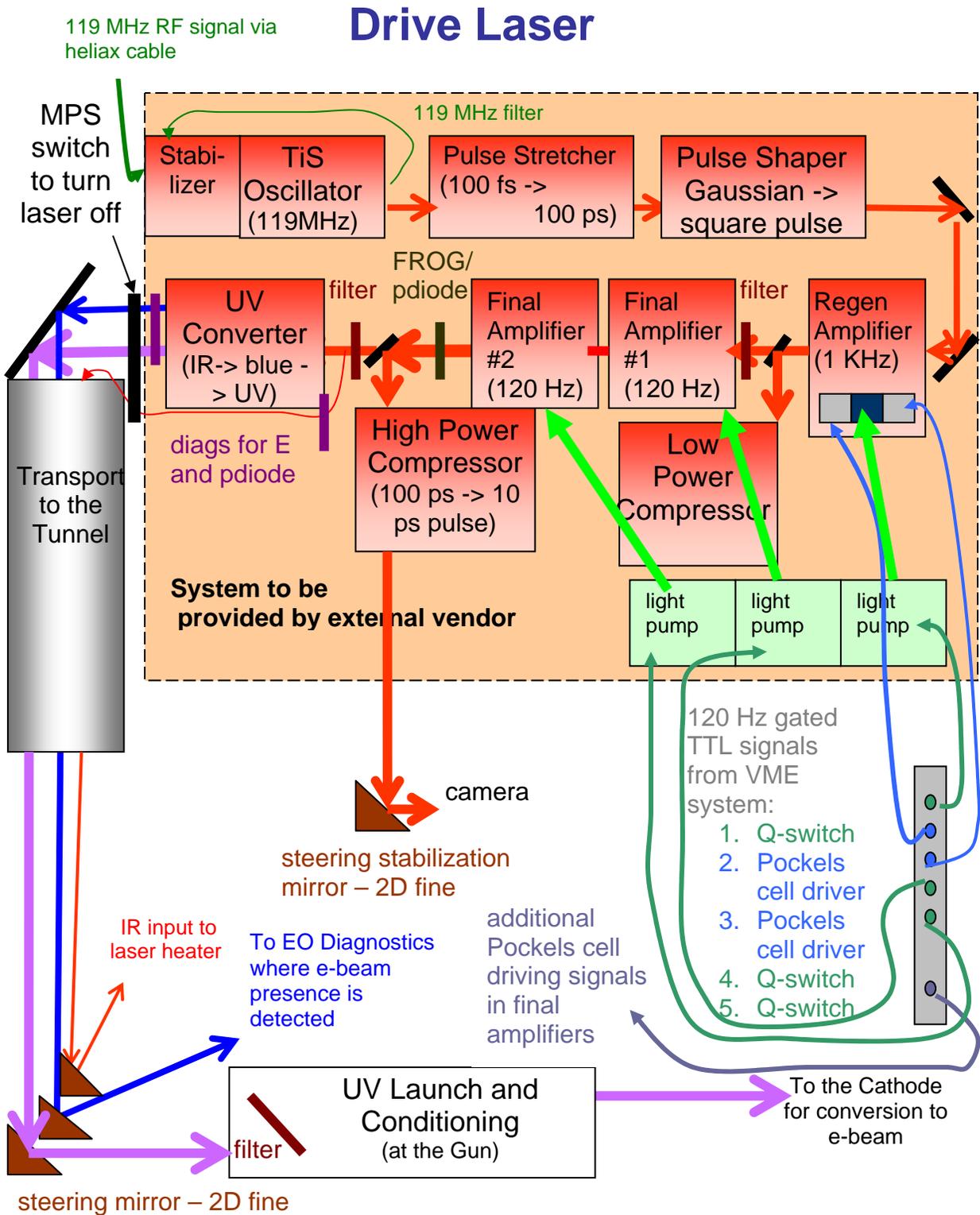


Figure 1 Drive Laser Schematic

Laser Heater

A schematic for the laser heater is shown in Figure 3. The laser heater controls will consist of these components, listed in order, from the beginning to the end of the laser heater:

1. **Pulse stretcher:** 2-D fine position motor control will be used for grating adjuster mirror to position the IR beam.
2. **Path length adjuster:** 1-D fine position motor control will be used for path length adjuster.
3. **Beam stop shutter:** 1 in/out shutter will use coarse position control to stop the beam and will be linked to PPS.
4. **IR beam transport:** 4 2-D steering mirrors will use fine position control to get IR beam through tunnel and onto launch table.
5. **Waist profile camera diagnostic:** 1 in/out flipper will use coarse position control to divert IR beam to waist profile camera.
6. **Beam stop shutter:** 1 in/out shutter will use coarse position control to block the beam and will be linked to PPS.
7. **Steering mirror control:** 1 2-D steering mirror will use fine position control.
8. **Photodiode timing system closed loop:** 2 Optical Transition Radiation (OTR) screens will be used to transversely align the IR beam to the electron beam pulse. Their insertion/extraction from the beam path will be via 1-D coarse position control. A digital camera and a photodiode signal will also be used in this alignment. The loop will have 100 ps resolution (the equivalent of a 10 GHz digitizer), see Figure 2, and using the input signals from both OTRs and the IR laser signal, the optical path will be adjusted by moving the path length adjuster in 2 such that the IR signal overlaps the OTR signal.
9. **Chicane power supply controls:** Controls for the 4 chicanes are needed to perform a 2% trim. The current will be scanned and will be adjustable over the energy range from 135 – 200 MeV.
10. **Chicane temperature controls:** 4 Klaxons (to shut-off system when max temperature exceeded) or thermocouples (to monitor temperature).
11. **Final laser diagnostics:** 1-D flipper to direct IR beam to desired diagnostic: camera with controls to monitor beam profile, timing photodiode and Joulemeter to monitor power.
12. **Laser PPS controls:** to allow normal access when laser is off and controlled access when laser is on (i.e. glasses worn). Shutters will be interlocked to PPS so that state of laser (on/off) is known. PPS will shut down laser unless special access permission is used to override the control.
13. **Undulator controls:**
 - 1-D motor will use fine position control to drive the gap

- linear encoder readout will measure the gap
- software will drive the undulator to desired location, incorporating soft limits on the range of travel
- readouts of 2 limit switches specifying the hard limits on the gap size will be monitored

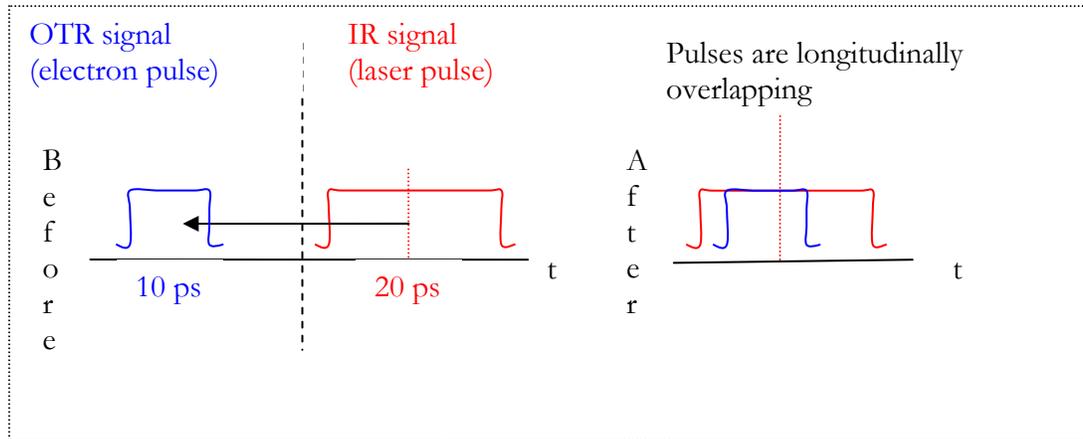


Figure 2 Path length adjuster photodiode timing system

Laser Heater

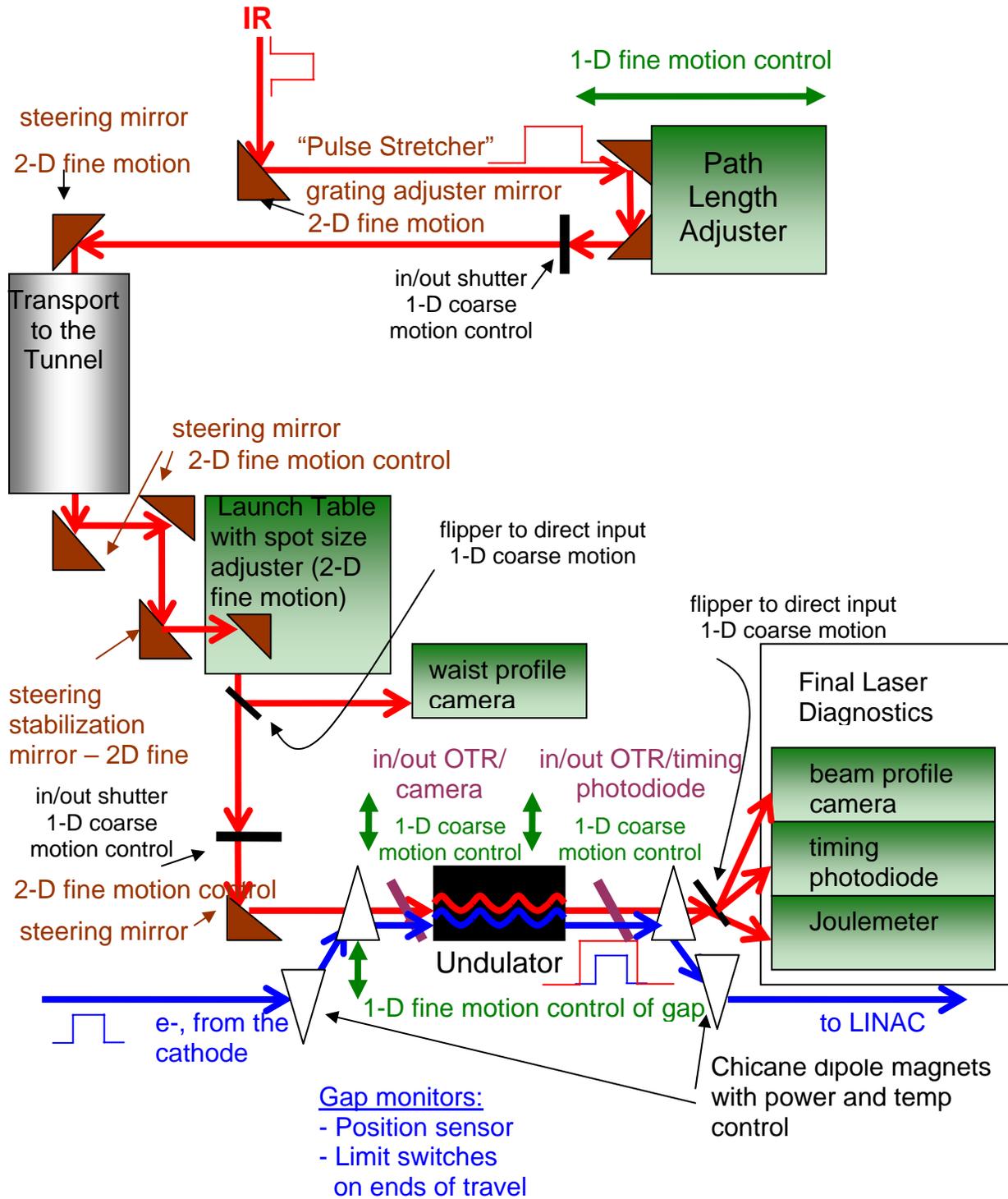


Figure 3 Laser Heater Schematic