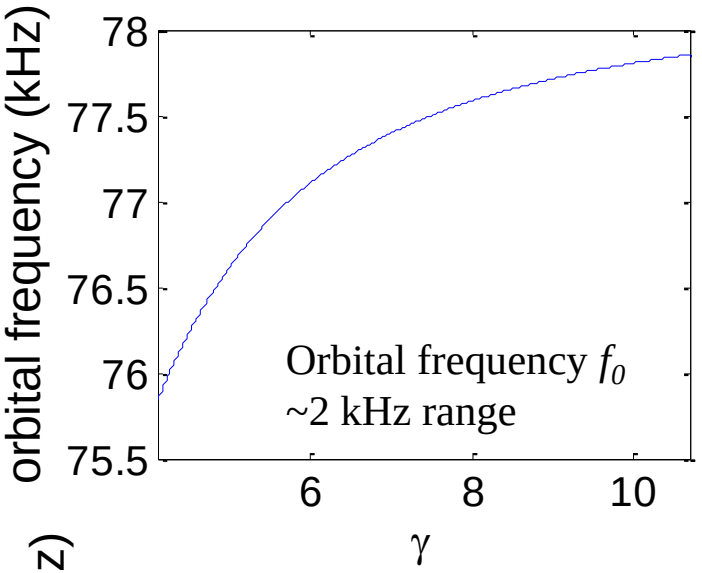
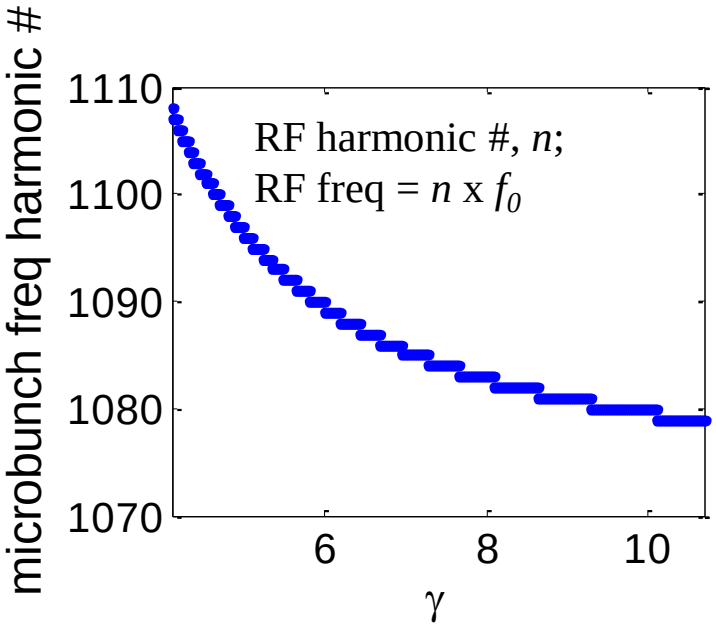
LEReC Laser Controls & RF Requirements

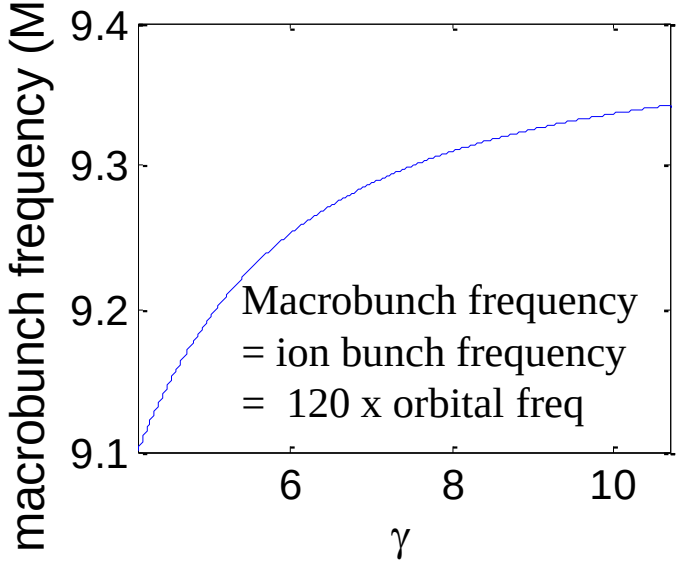
Brian Sheehy 10/31/13

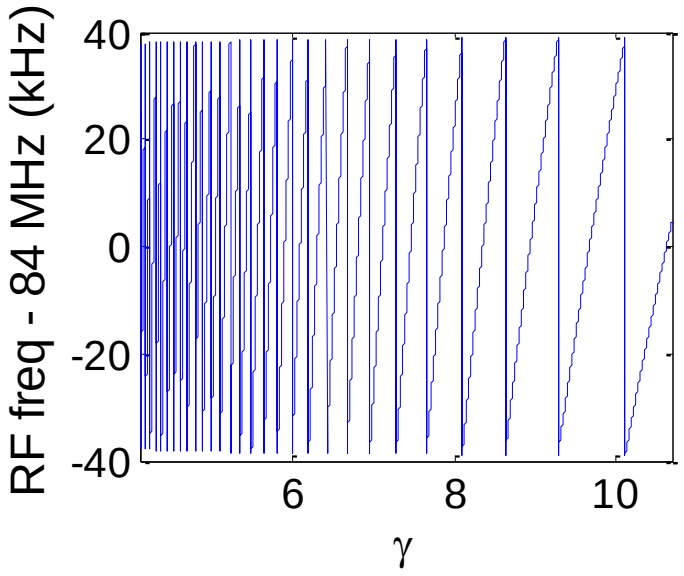
- Laser timing
- Laser design
- RF and Control Needs

Bunch structure and beam energy

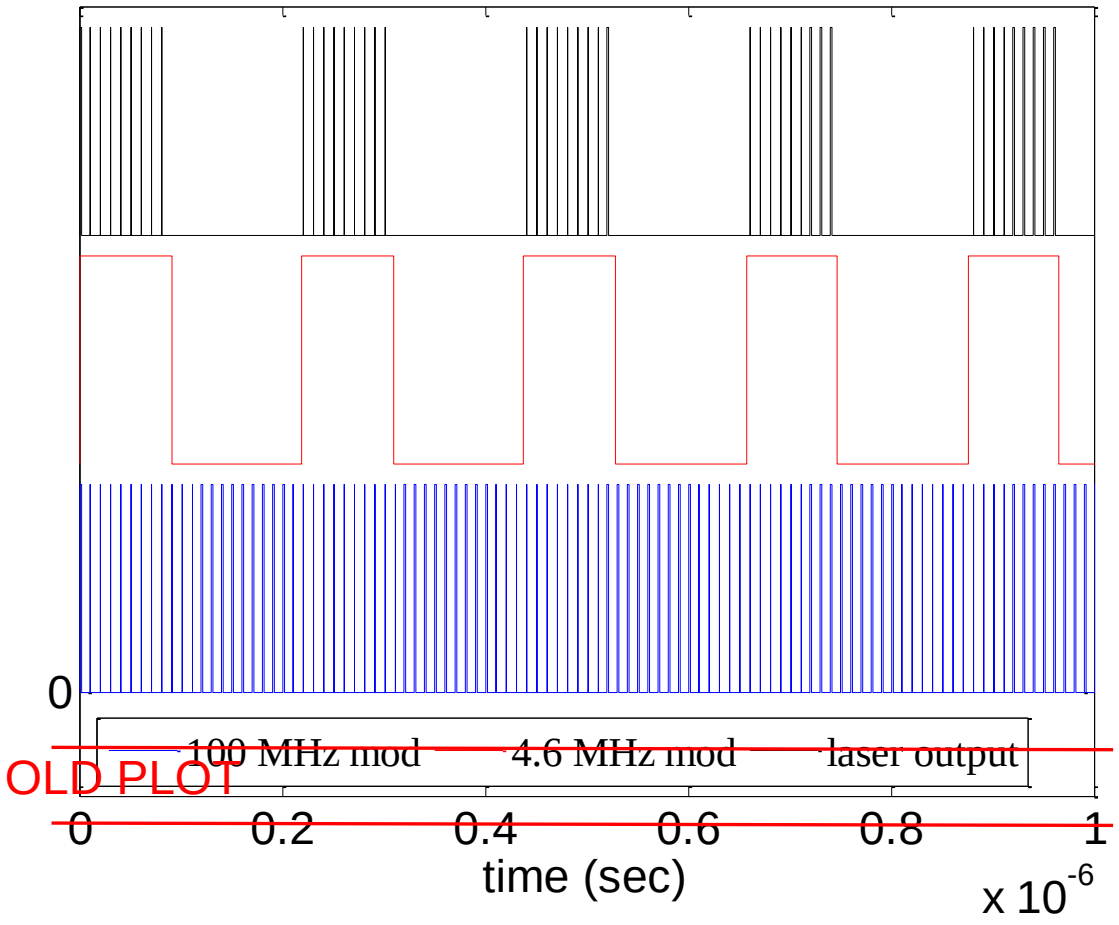








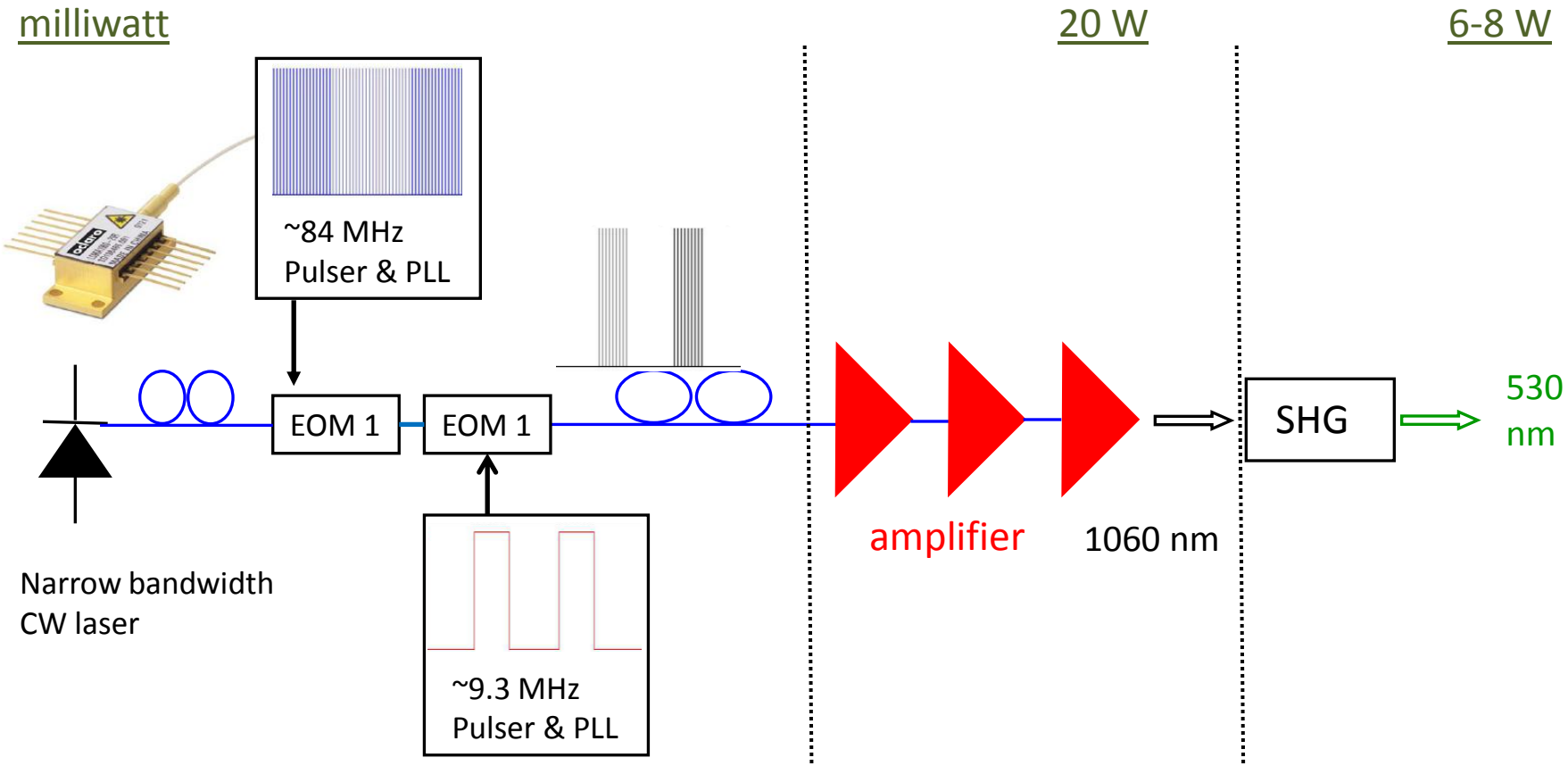
Timing Structure



- Average macrobunch frequency is set at the 60th harmonic of the ring fundamental f_0
  - one macro gate per ion bunch
  - varies with ϒ: 9.10-9.34 MHz
  - 60-gate pattern phase-locked to f_0
- Microbunch frequency is *n*th harmonic of f_0 and equal to gun RF freq
  - *n* varies with ϒ: 1284 - 1319, for f_{rf} = 84 MHz ± 39 kHz
- this assures turn-by-turn stability
  - microbunch comb located differently in each bunch relative to bunch center, but does not shift turn-by-turn
- individual pulses are 750 psec FWHM, <150 psec rise and fall times

As long as the microbunch frequency is phase-locked with f_0, the pattern is stable with respect to the ion bunches. The pattern can be ‘rastered’ by shifting that phase (along with gate pattern)

Laser Scheme



Optical Pulse Generator

Yb-doped Fiber Amplifier

Frequency Doubler (PPKTP or sPPLT)

EOM = Electro-optic modulator

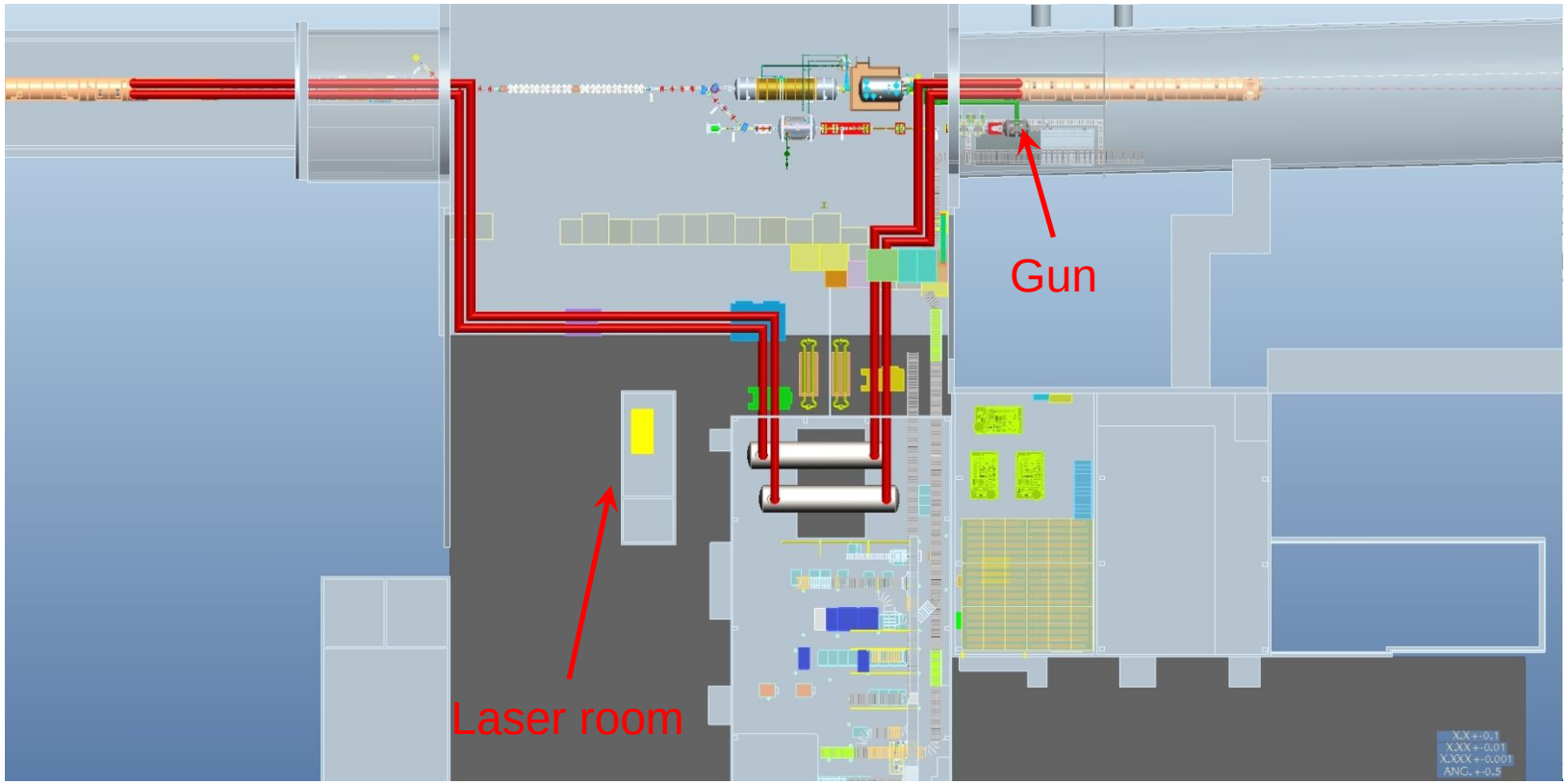
PLL = phase-locked loop

Fiber coupling

Laser Scheme

- Front end is a narrowband CW laser, with 2-stage electro-optic modulation, at 2 harmonics of the ring frequency f_0 , which depends on the beam energy.
  - ~ 9.3 MHz, or $120 f_0$
  - ~84 MHz or $n f_0$, where n varies with beam energy over [1079, 1108]
    - constrained by SRF cavity tunability of ~ 100 kHz
  - 750 psec FWHM pulses <150 psec rise and fall times
- Multistage fiber amplifier to 20 W average power
  - peak power 1.2 kW
- Frequency double to 530 nm in PPKTP or MgO:sPPLT
- Fiber transport ~30 m from laser building to gun in ring enclosure

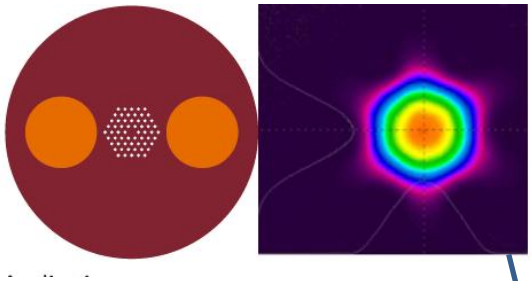
Transport

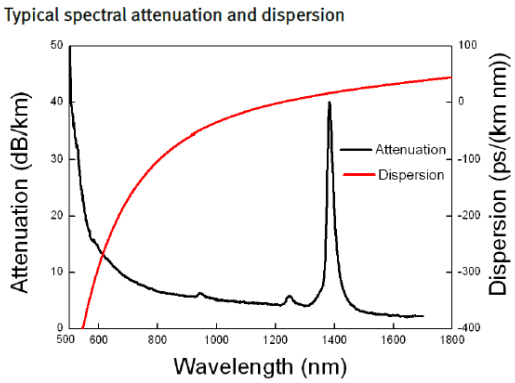


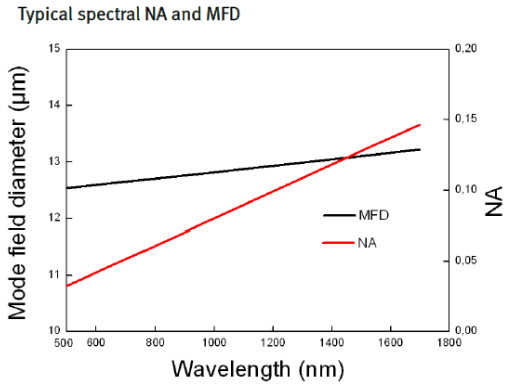
- Laser must be located outside of ring area
  - -will likely use the same modular building being used for Coherent electron cooling experiments
- ~ 30 meter path with multiple bends required. Fiber transport is best option

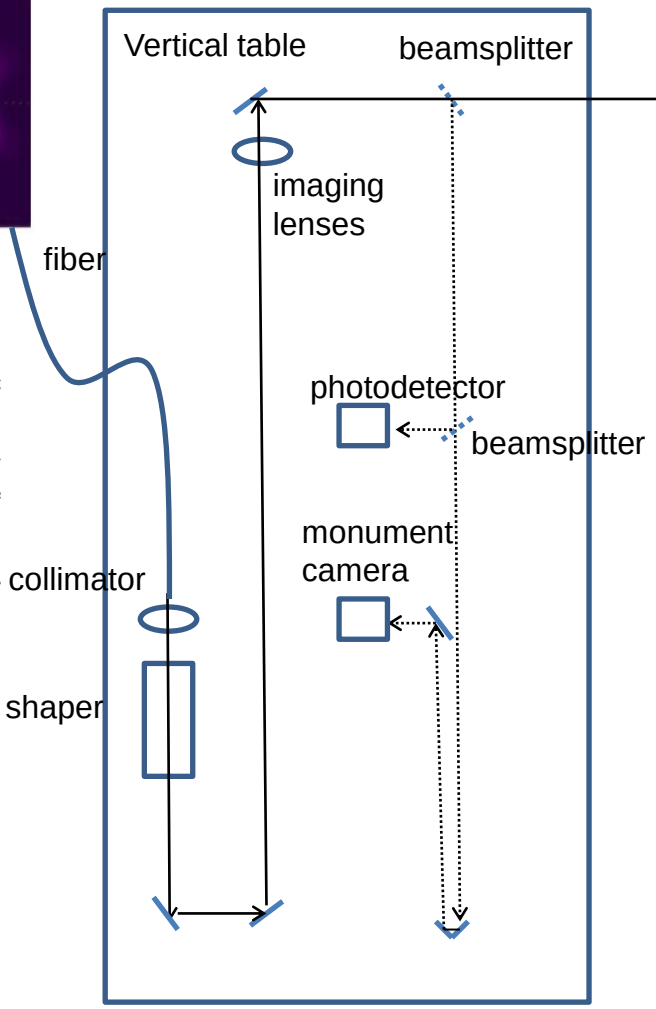
Transport

From Laser room









Laser cross

similar setup at ERL

- losses 25% over 30 m from laser room

Control and RF needs/Timing

- Basic Scheme is a low power source electro-optically modulated and then amplified
  - All of the phase and timing information is in the signal sent to the EO modulator
  - Optical pulse shape is determined by the pulse shape sent to EO modulator.
  - Optical pulse train should be detected downstream and phase extracted to correct for drifts

So for phase locking and basic timing, we need:

1. An 84 MHz pulser with 750 psec flat top, 150 psec rise/fall time pulses
   - pulser could be commercial/custom, but input phase-locked trigger source will have to come from LLRF (subnanosecond ,TTL)
2. To generate a digital pattern of 120 gates phase-locked with orbital frequency
3. digital phase measurement similar to ERL's, with feedback to shift the phases of the 9 MHz and 84 MHz pulsers.
   - May want to do that in 2 locations, laser room & gun location
     - Monitor/control thermal drifts similar to ERL

Control and RF needs/non-Timing

- Laser control
  - Text based commands passed through serial interface
    - On/off, status readbacks, current settings, EOM bias settings
    - Similar to CeCPoP laser software that Peggy Harvey is developing
- Cameras
  - GiGE, similar to ERL, for alignment and spot quality monitors
- Laser Power monitors
  - Can probably port ERL software, use Newport heads
- Steering mirror controls
  - Newport system a bit buggy, would prefer switching to Thorlabs
    - Some issues?