
Keck II Next Generation Laser System
November 16, 2014
Ethan Tweedie Photography

Project Background

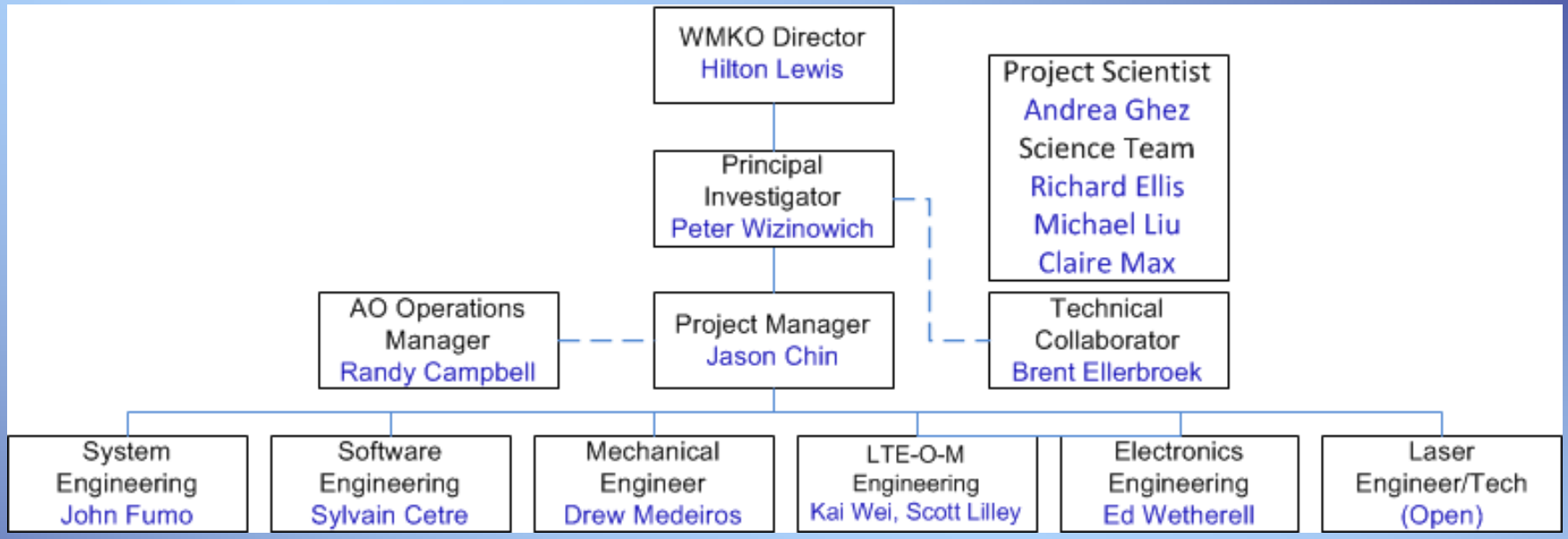
- 2012: completion of the Free Space Transport in Keck I with the LMCT laser
- 2013-2014: Center Launch System (CLS) for Keck II (dye laser)
- Next Generation Laser (NGL) system
  - Funded by GBMF and WMKF
  - Replacement of the dye laser with the TOPTICA laser
  - TOPTICA laser developed with consortium (ESO, WMKO, TMT)
  - Integration with the completed CLS
  - Preparation for future Next Generation Adaptive Optics System (NGAO) with three lasers

Schedule

Milestone	Date
System Design Review	April 26, 2013
Preliminary Design Review	March 25, 2014
Detailed Design Review	November 03, 2014
Decision date to decommission dye laser	February 01, 2015
Integration of subsystems on the summit	February – September 2015
Decommissioning of dye laser	September 2015
Installation and commissioning of new laser	September 2015 – Jan 2016
NGL system science	February 2016

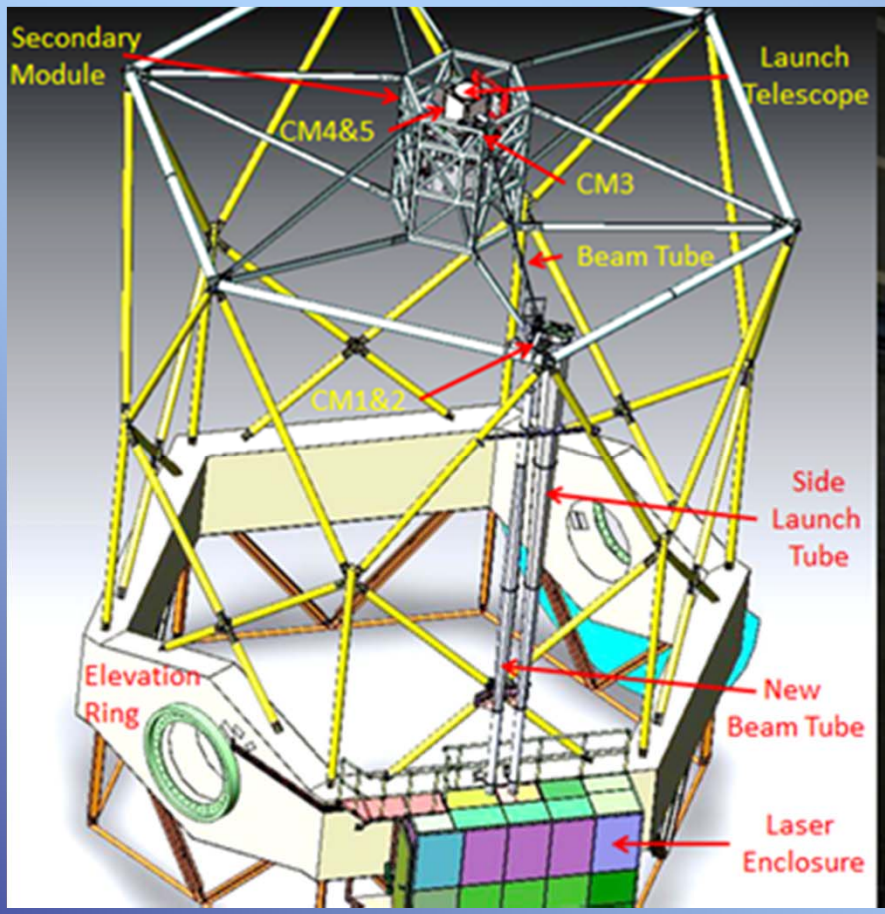
- Full Scale Development Phase (Nov 2014 – Apr 2015)

Project Team

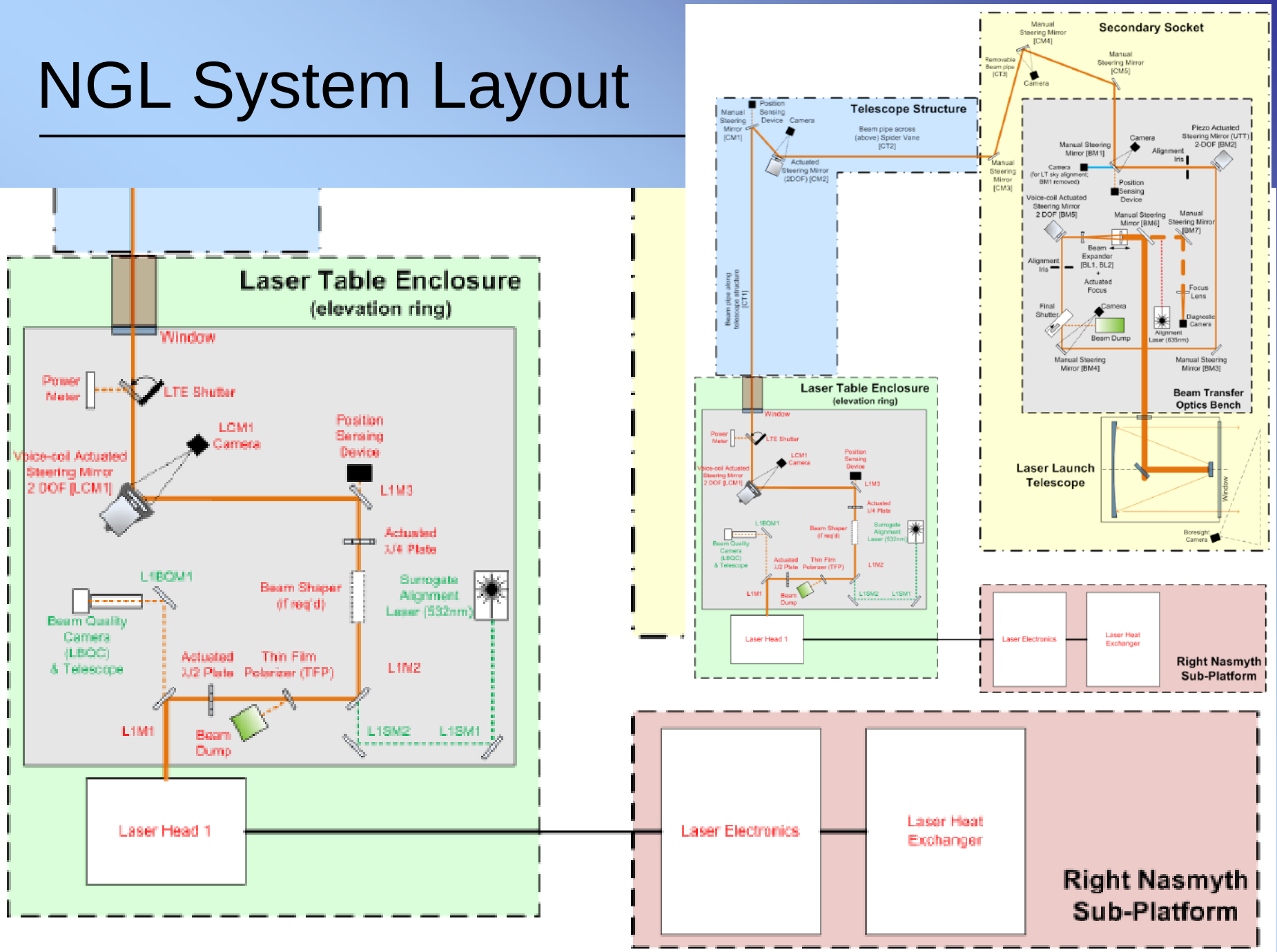



System Overview

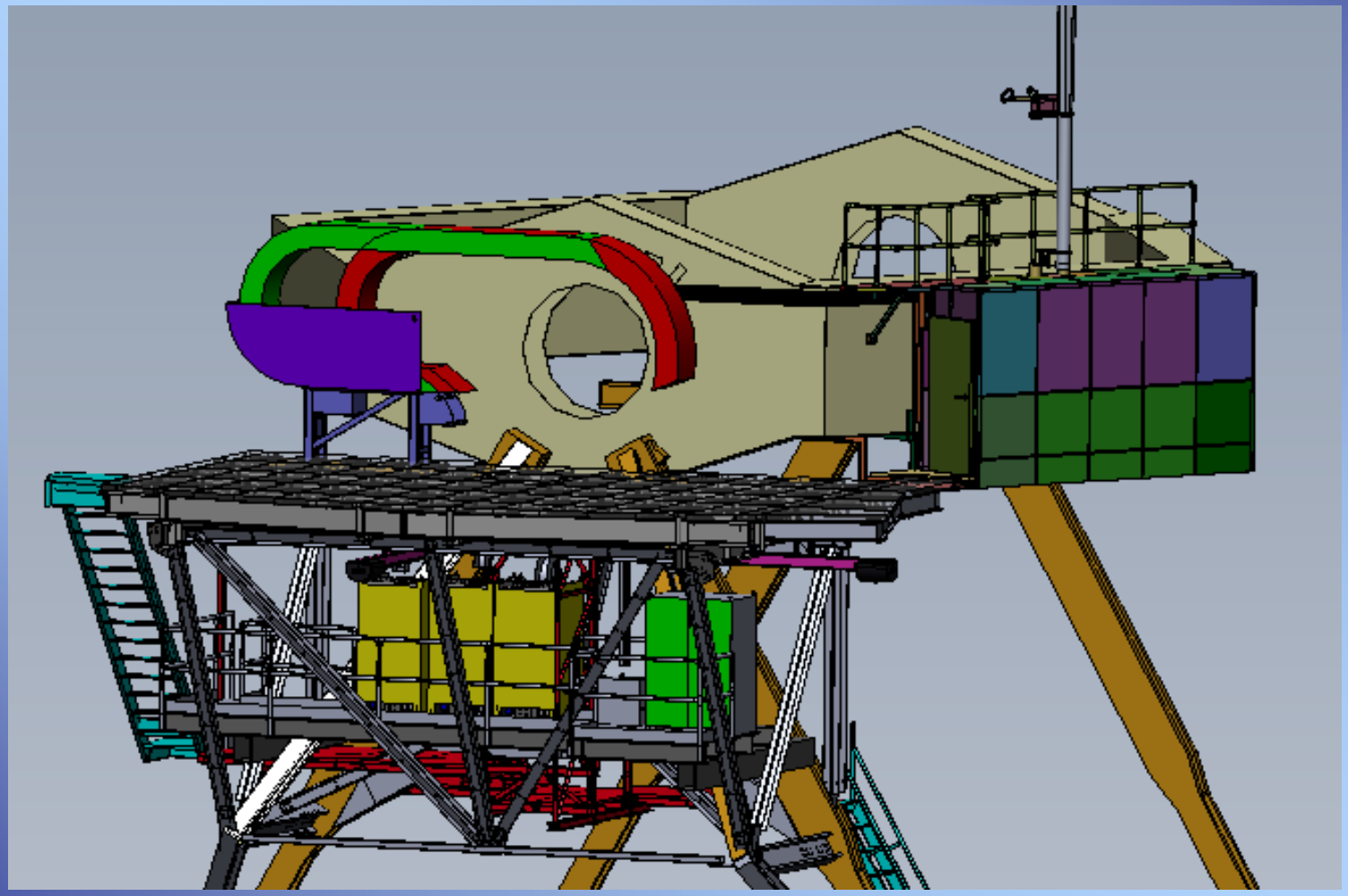
Center Launch System



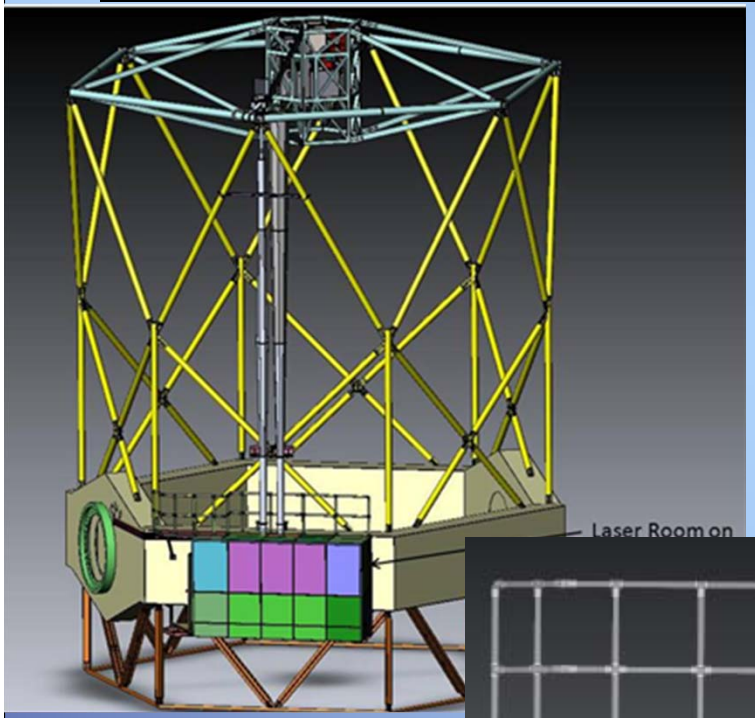
NGL System Layout



Laser Platform



Laser Table Enclosure

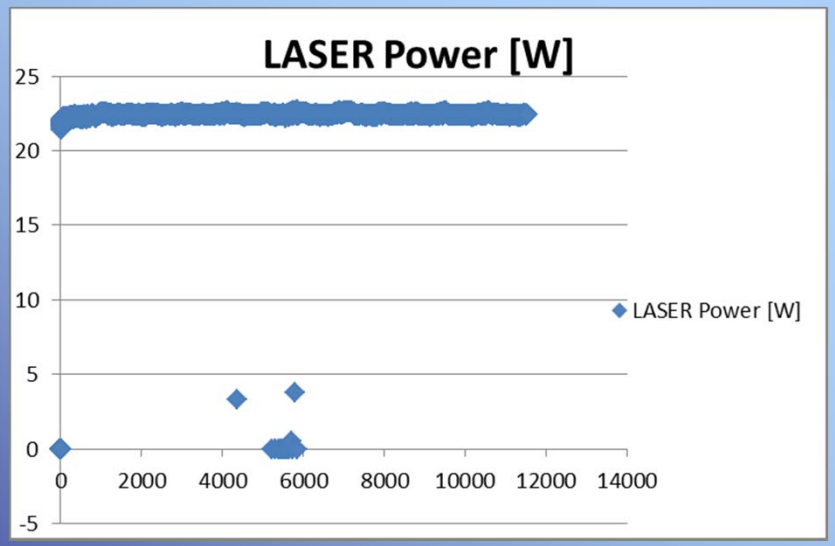


Toptica Laser System

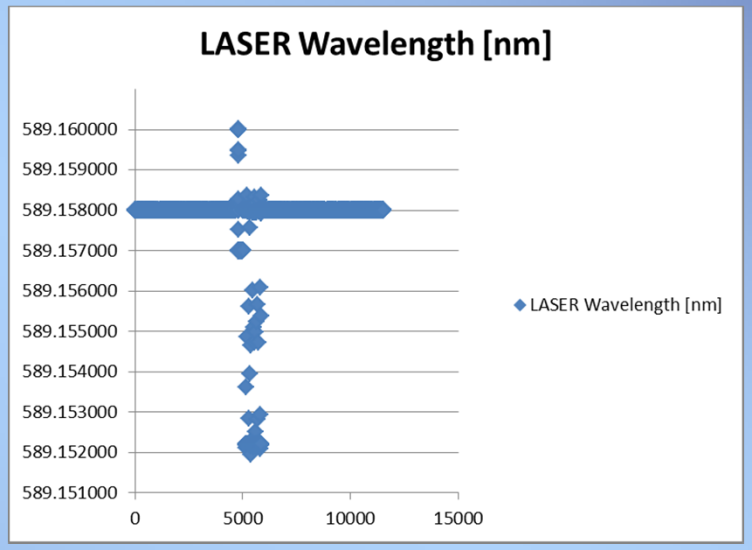
- Continuous wave (CW); 20W with optical repumping of D2b.
- Diode pump fiber laser with second harmonic generation
- Ability to detune off wavelength
- Fast startup (<40 minutes with calibration)
- Continuous and manual health checks to monitor performance
- Efficiency; low power usage compared to existing laser systems
- Remote pumping (WMKO) vs. local pumping (ESO)
  - Requires slightly 8% more power from diodes

Toptica Laser System Performance

- Power and wavelength extremely stable
- <2% change in power due to elevation changes



Fluctuations during detuning



Fluctuations due to manual wavelength changes

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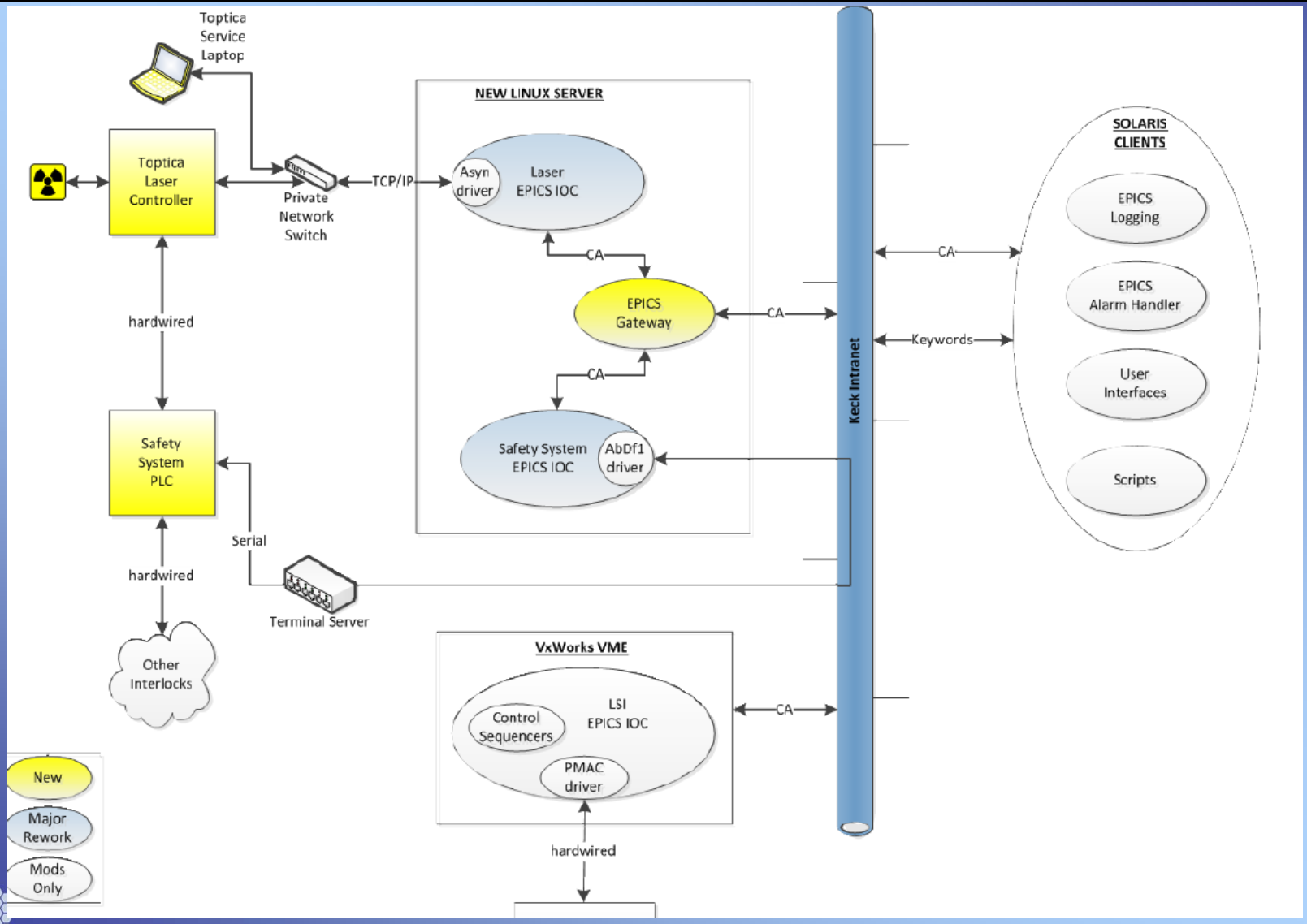
Toptica Laser System Status

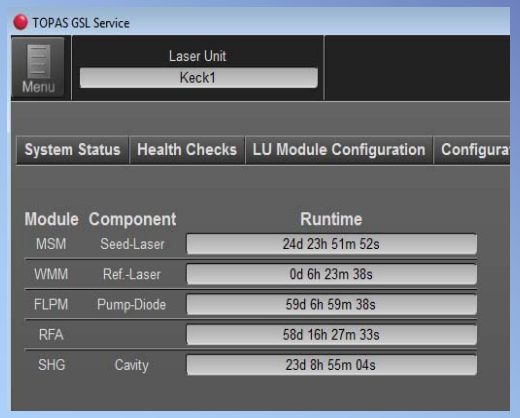
- Factory Acceptance Testing completed in 09/2014
  - Sufficient redundancy in system; power supply and diodes
  - Failed diodes did not impact performance
- Laser delivered to WMKO in 10/2014
- Headquarters Acceptance Testing
  - Initial setup and tests completed 11/14/2014 (TOPTICA/MPBC personnel)
  - Performance tests; Nov 2014 to Jan 2015
  - Environmental testing; 0°C glycol and <10°C room
  - Put time on system and diodes
  - Simulate night time observing

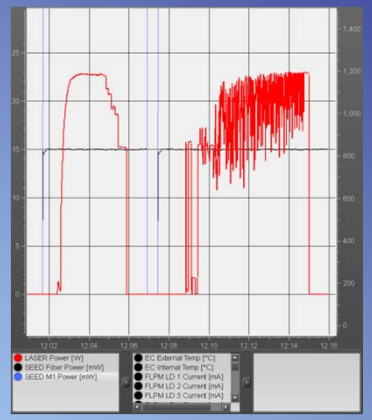
Laser System Control

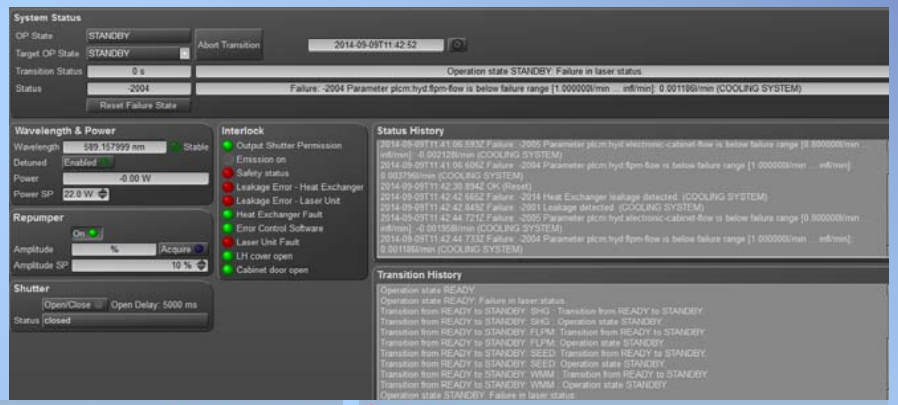


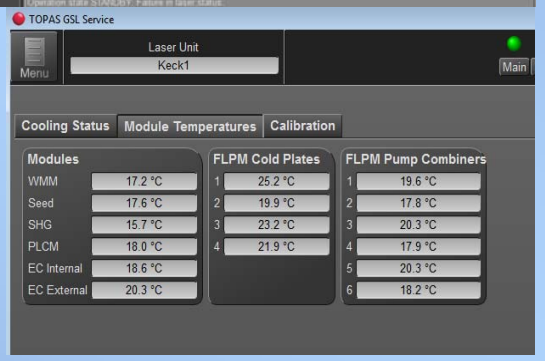
Laser Service Laptop

- Ability to control laser
- Plot performance
- Trigger health checks
- Load new firmware
- Log data
- Troubleshooting
- Communicates with internal subsystems
- Internal diagnostics, reference laser, wavemeter, FPI
- Interlocks viewing
- Thresholds
- Run time
- Version control

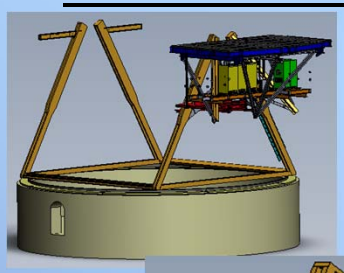


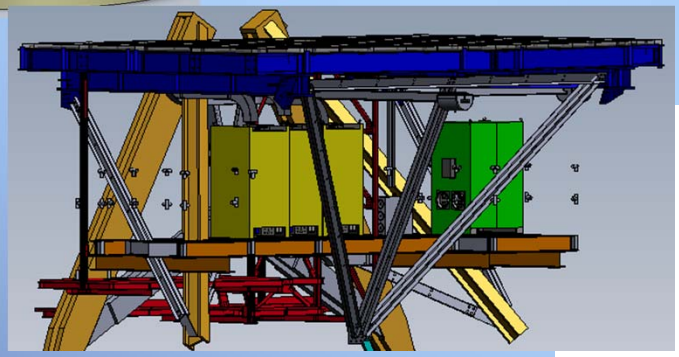


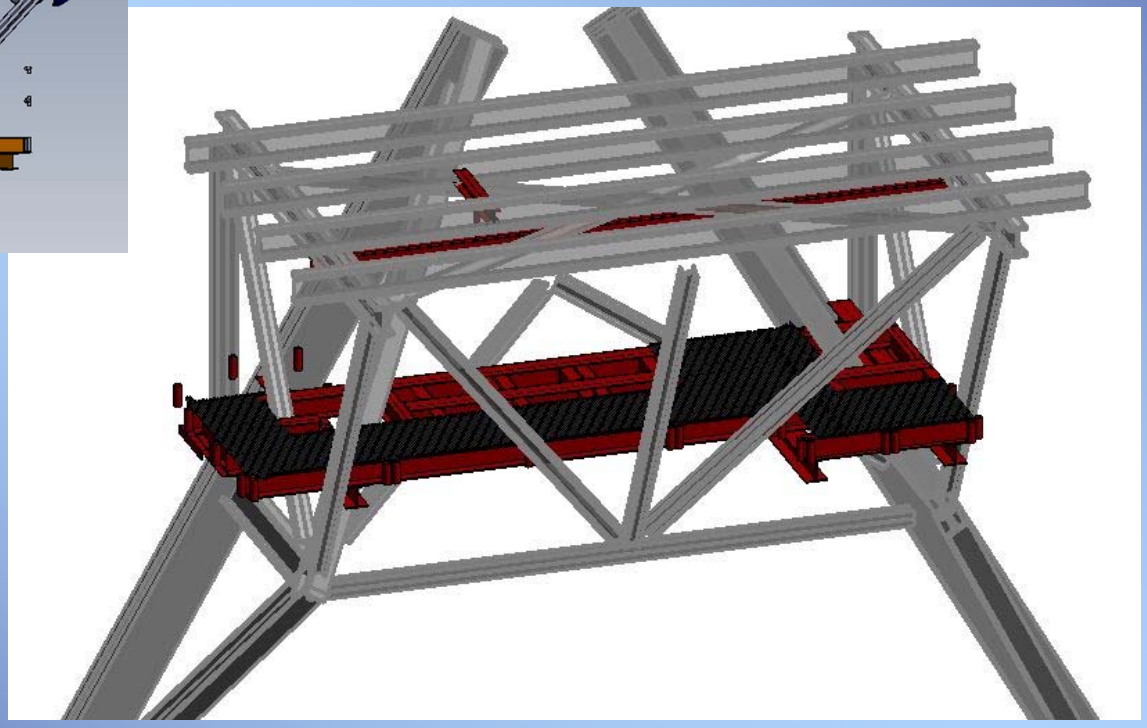




Platform Layout







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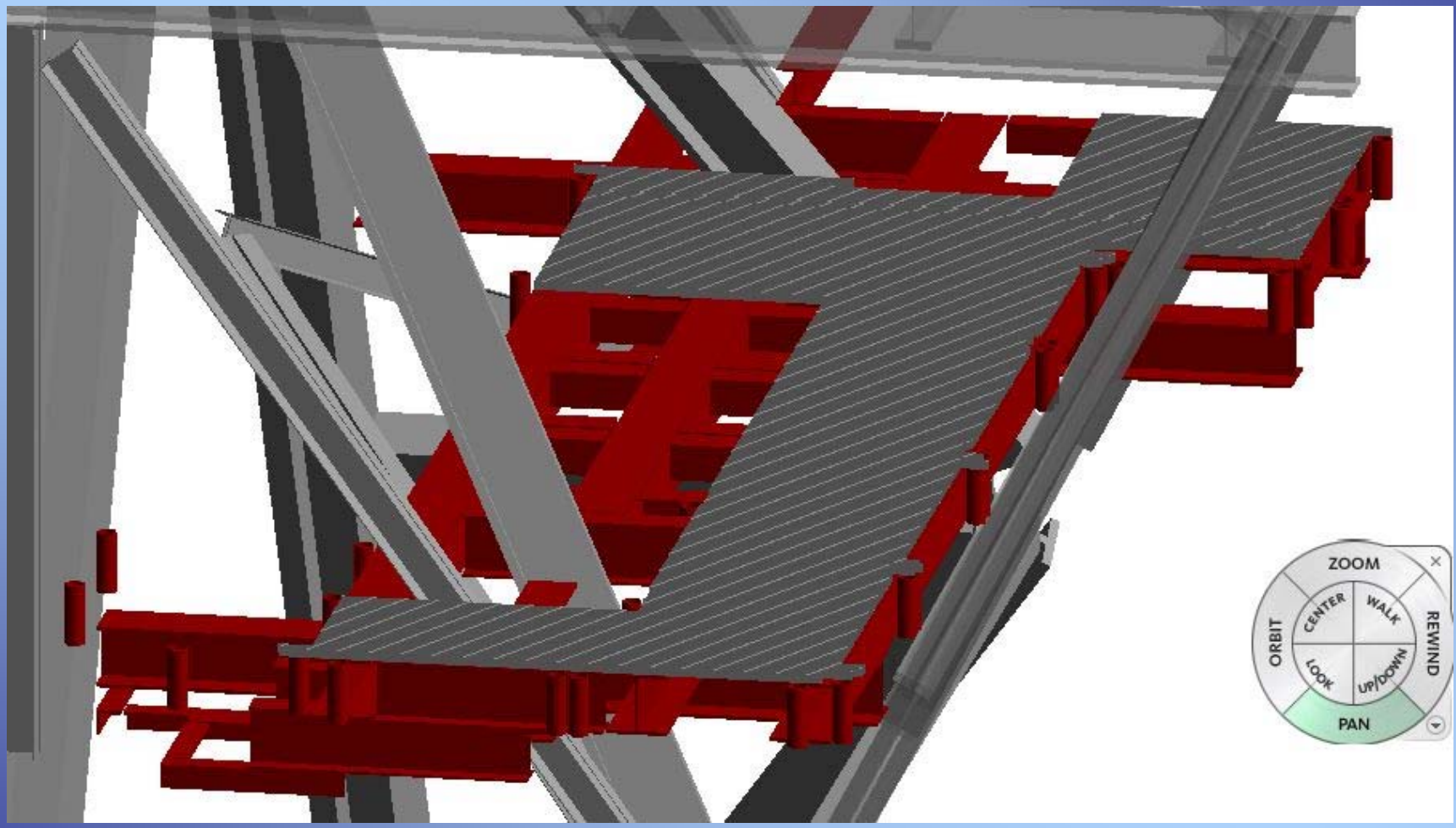

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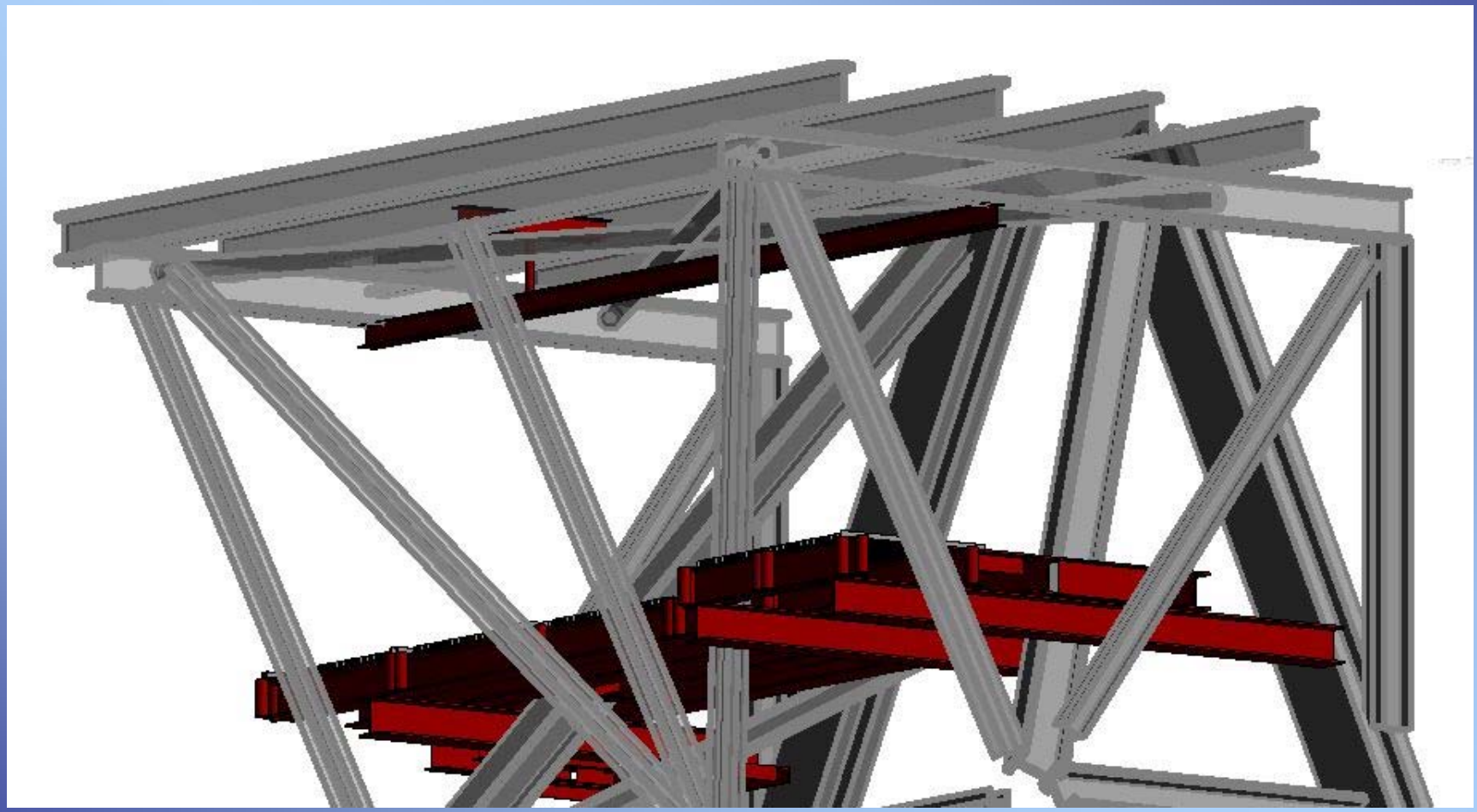
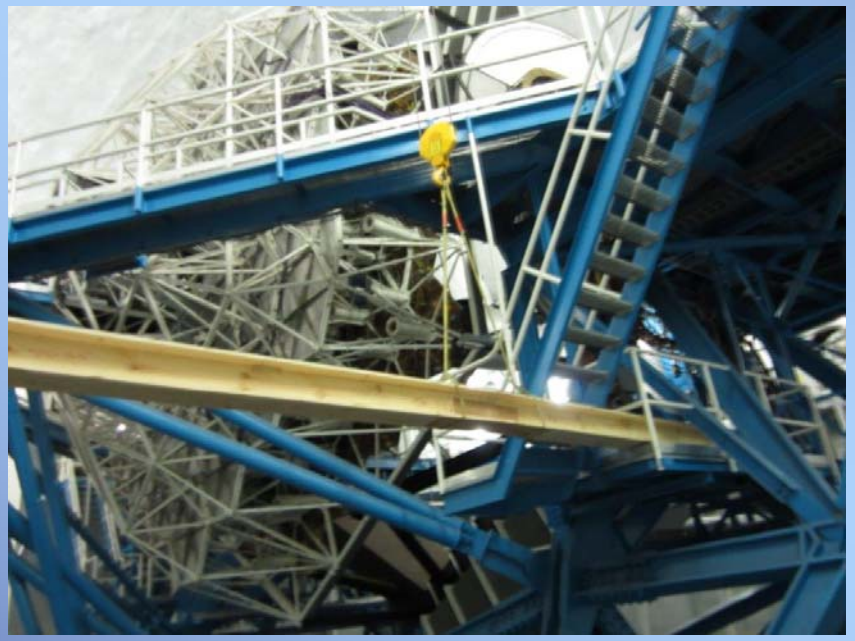
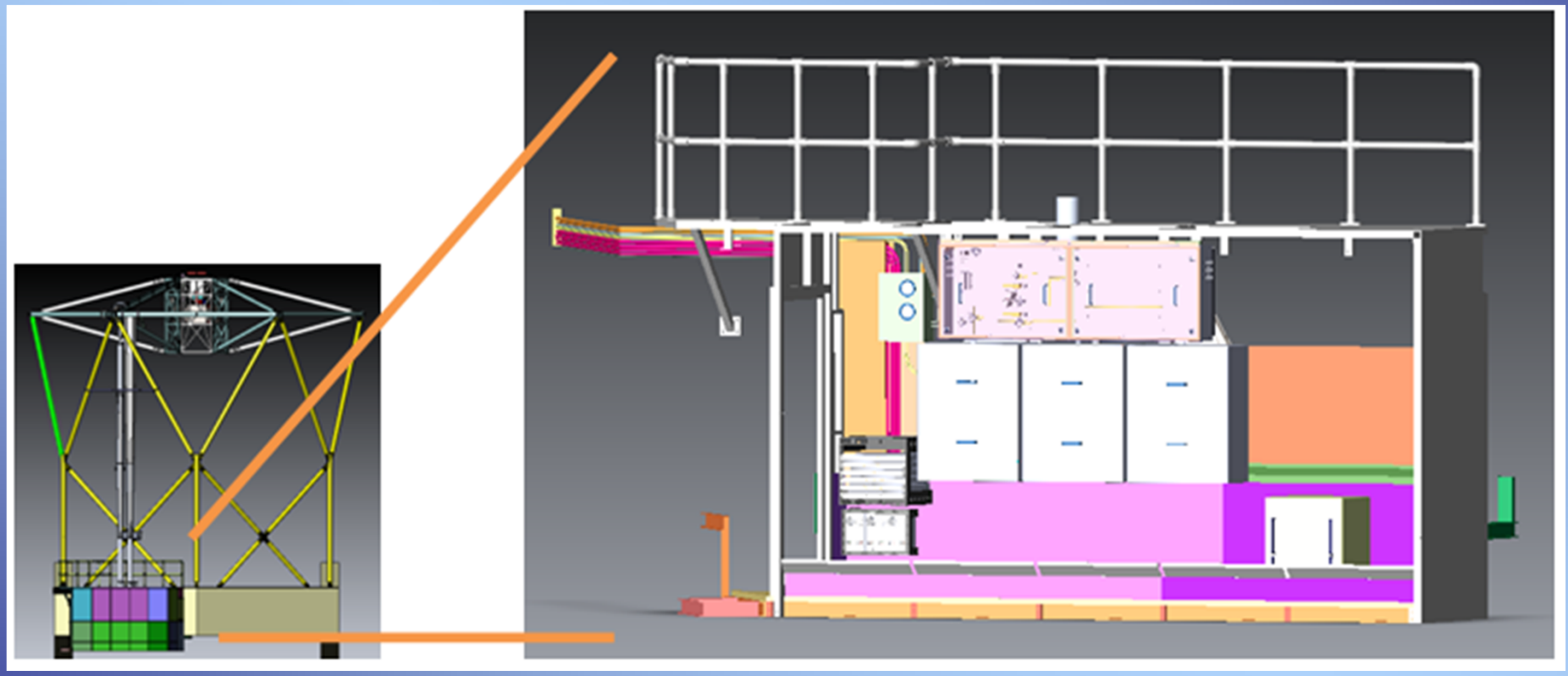


Platform next steps

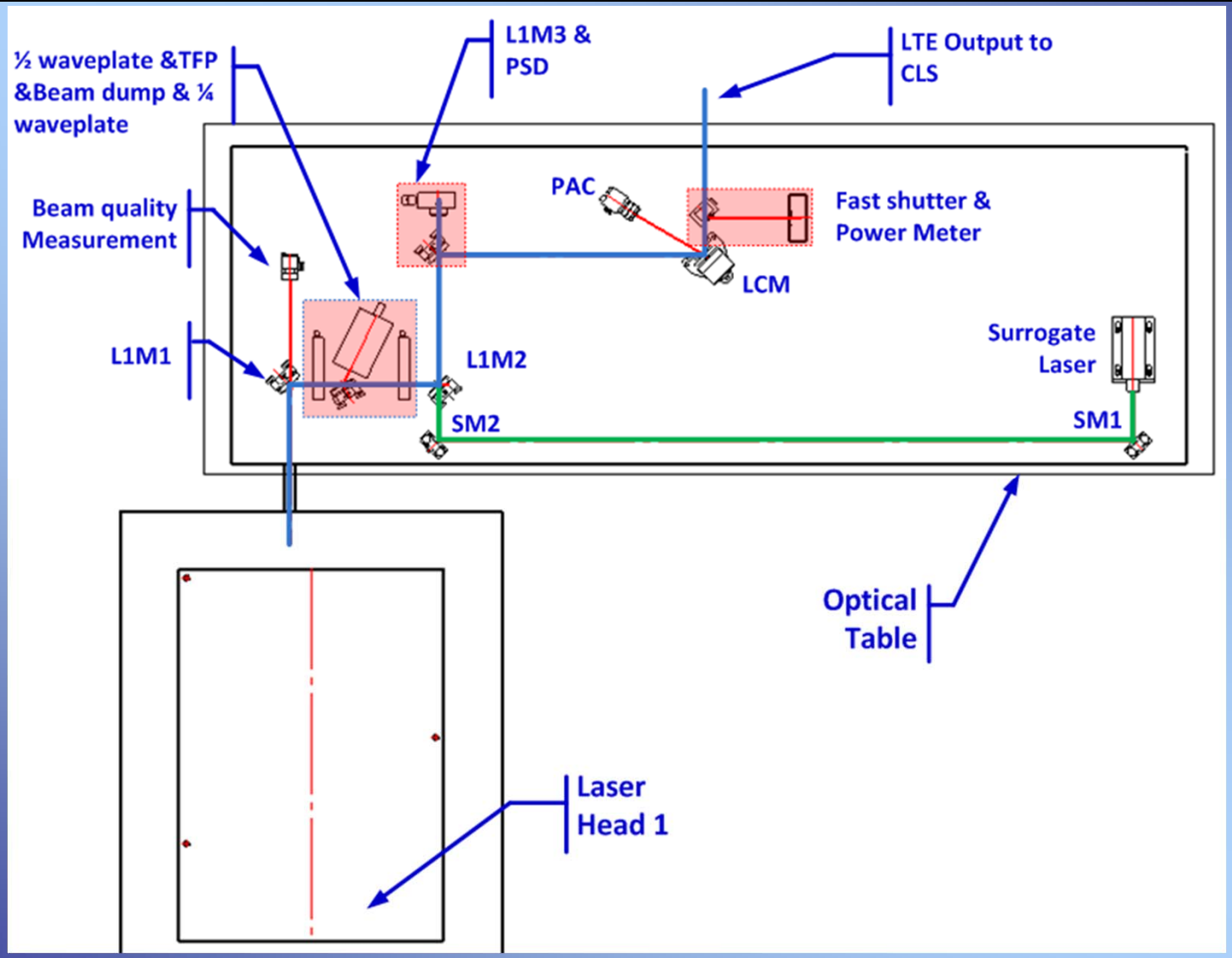
- Platform current being fabricated; completion in Jan 2015
- Installation Jan-Mar 2015
- I&T challenge; to install platform without any observing down time



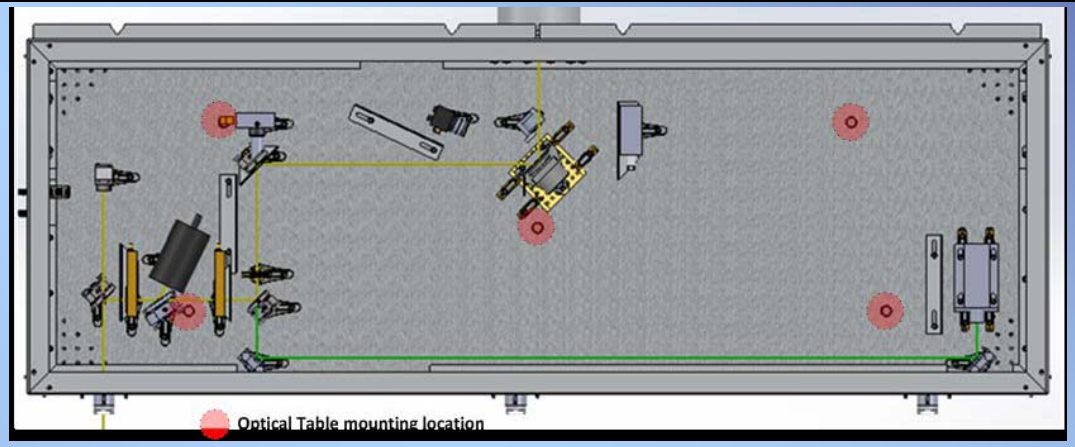
Laser Room on Elevation Ring

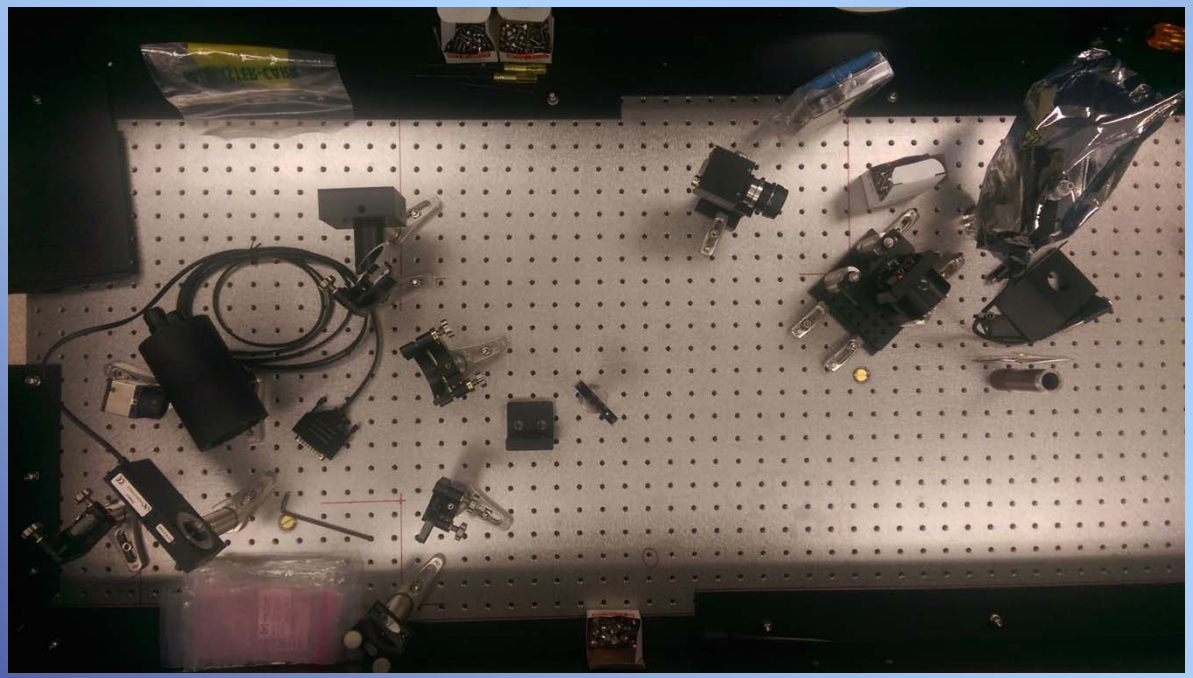


LTE Layout for NGL

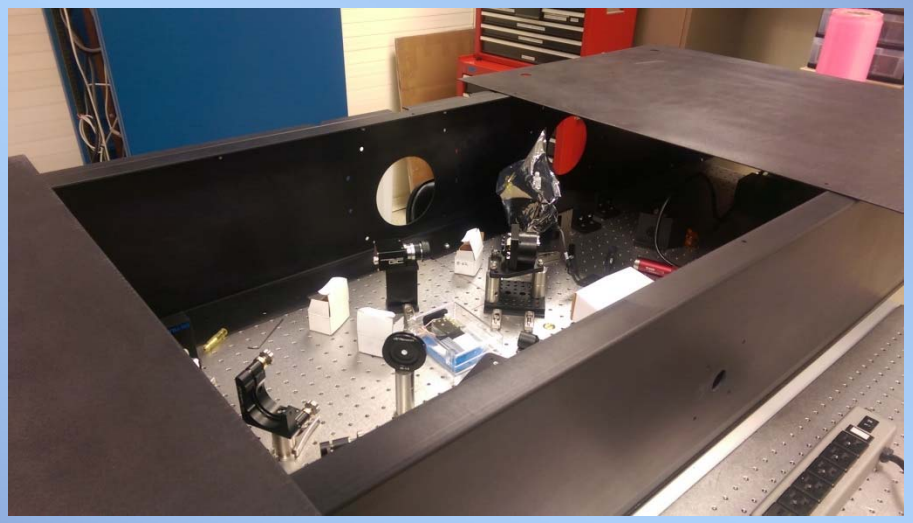


LTE Optical Bench





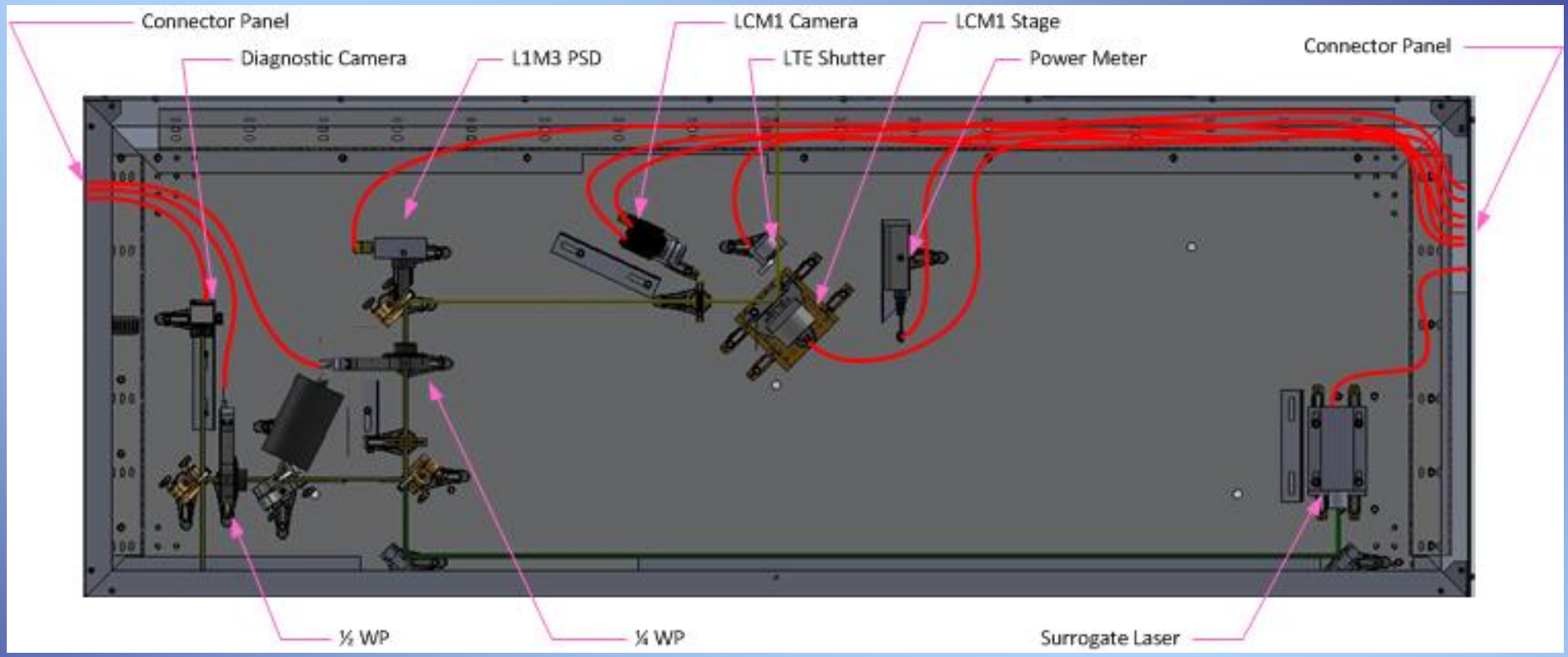
LTE Optical Bench Enclosure



HQ LTE Testing

- Align LTE with TOPTICA laser
- Integrate LTE components with electronics and safety system
- Verify all LTE functionality
- Use LTE components to verify laser performance (WFS, power heads, PSD)
- Integrate LTE with mounting frame
- Characterize LTE performance

LTE Devices/Cabling

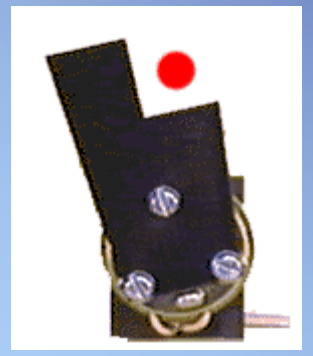


LTE Devices

- Shack-Hartmann Diagnostic Camera (Thorlabs WFS 150)
- WP1 and WP2 (control power and polarization)
  - Newport PR50CC
- Position Sensing Diodes
  - On-Trak OT-301
  - Position and power
- LCM1
  - OIM-101 voice coil stage
  - Account for telescope flexure and vibration
  - Stage driven ¼ span → 0.2 urad/bit or 4.8um/bit 12 meters away

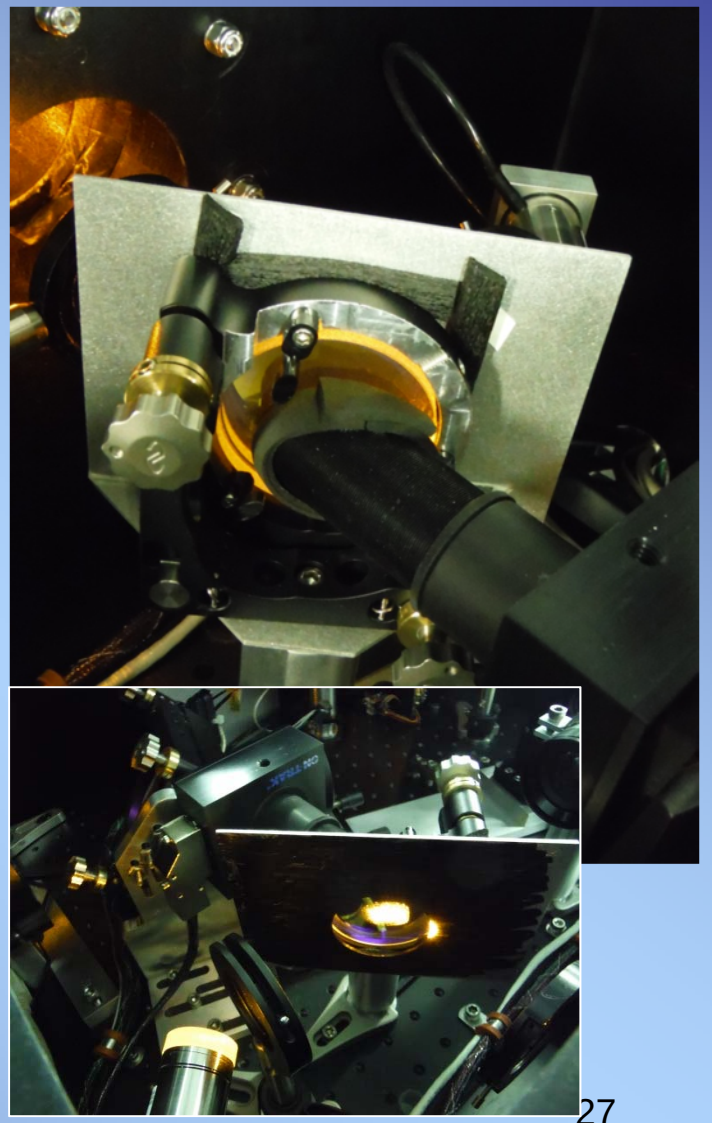
LTE Devices

- LCM1 Camera
  - AVT GC-1290
  - GigE interface, SW configurable gain/exposure
  - 48px/mm plate scale; ~150 illuminated px w/ 3mm laser beam
- LTE shutter
  - Custom built EOPC shutter with position feedback
- Power Measurement
  - Coherent PowerMax series thermopile
  - Liquid cooled with remote measurement
- Surrogate green laser
  - Lasermate compact laser modules (adjustable power)



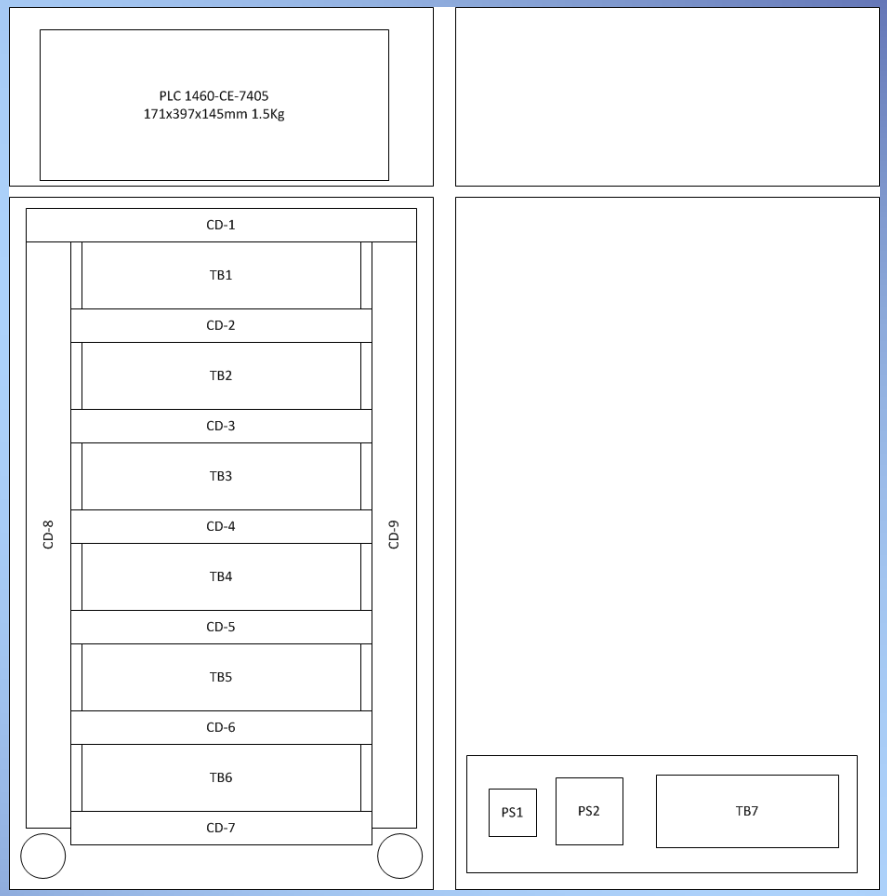
Challenges

- PSD stray light
  - Working with leakage signal through highly reflective optic
  - Implement Shrouds and blacked areas of uncoated optic
  - Leakage dependent on polarization (10x change S vs P)
  - 532nm (surrogate) leakage quite different than 589nm



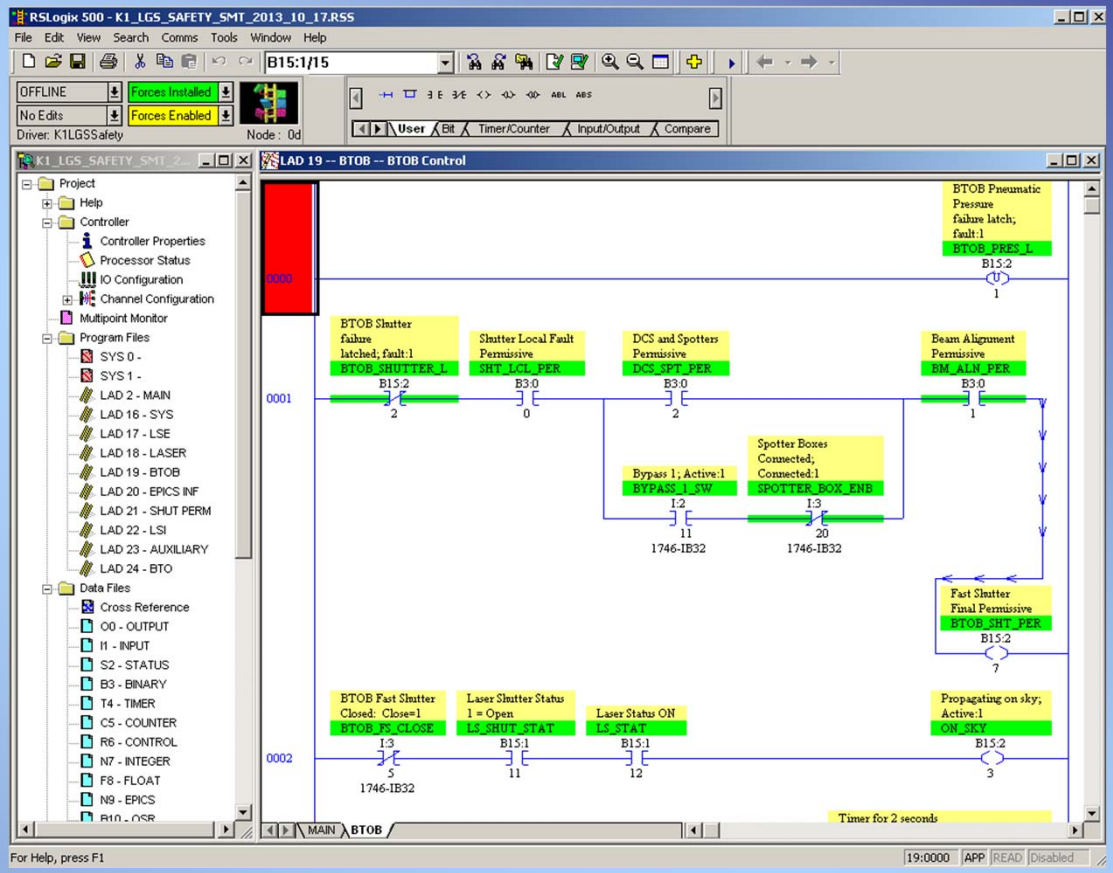
Safety System Controller

- Allen Bradley SLC500 series PLC
- Used on the Keck I Safety System



PLC Programming

- RSLogix 500 Programming Environment
- Similar to Keck I for launch system
- Main differences are laser related

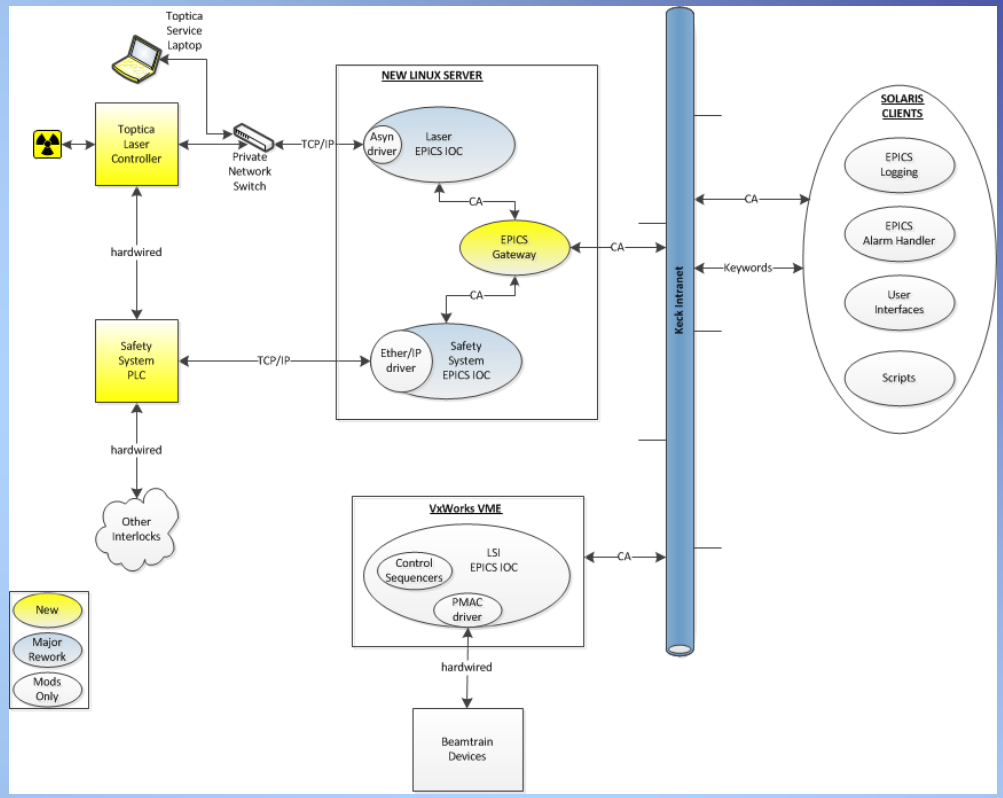


Safety System Indicators and Key Switches

- Existing indicator panels
- Keyswitch panels to tag out system as well as for maintenance
  - Disable shutters
  - In dome propagation

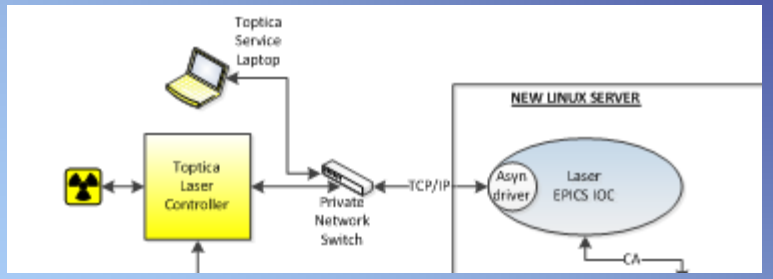
Software Architecture

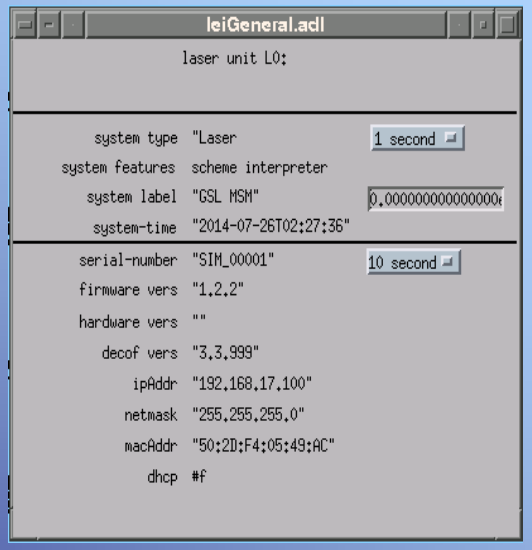
- EPICS based; Experimental Physics Industrial Control System
- Laser Controller (Linux Server)
- Laser Safety System (Linux IOC via server)
- Laser Steering Interface for motion control (PMAC with VxWorks)

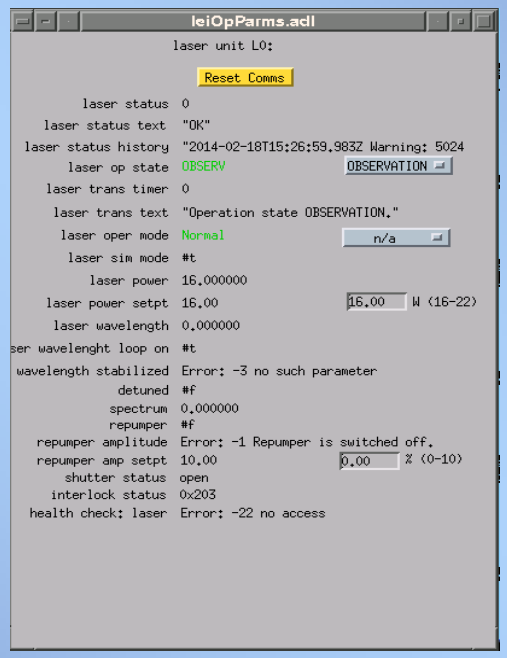


Laser Controller Interface

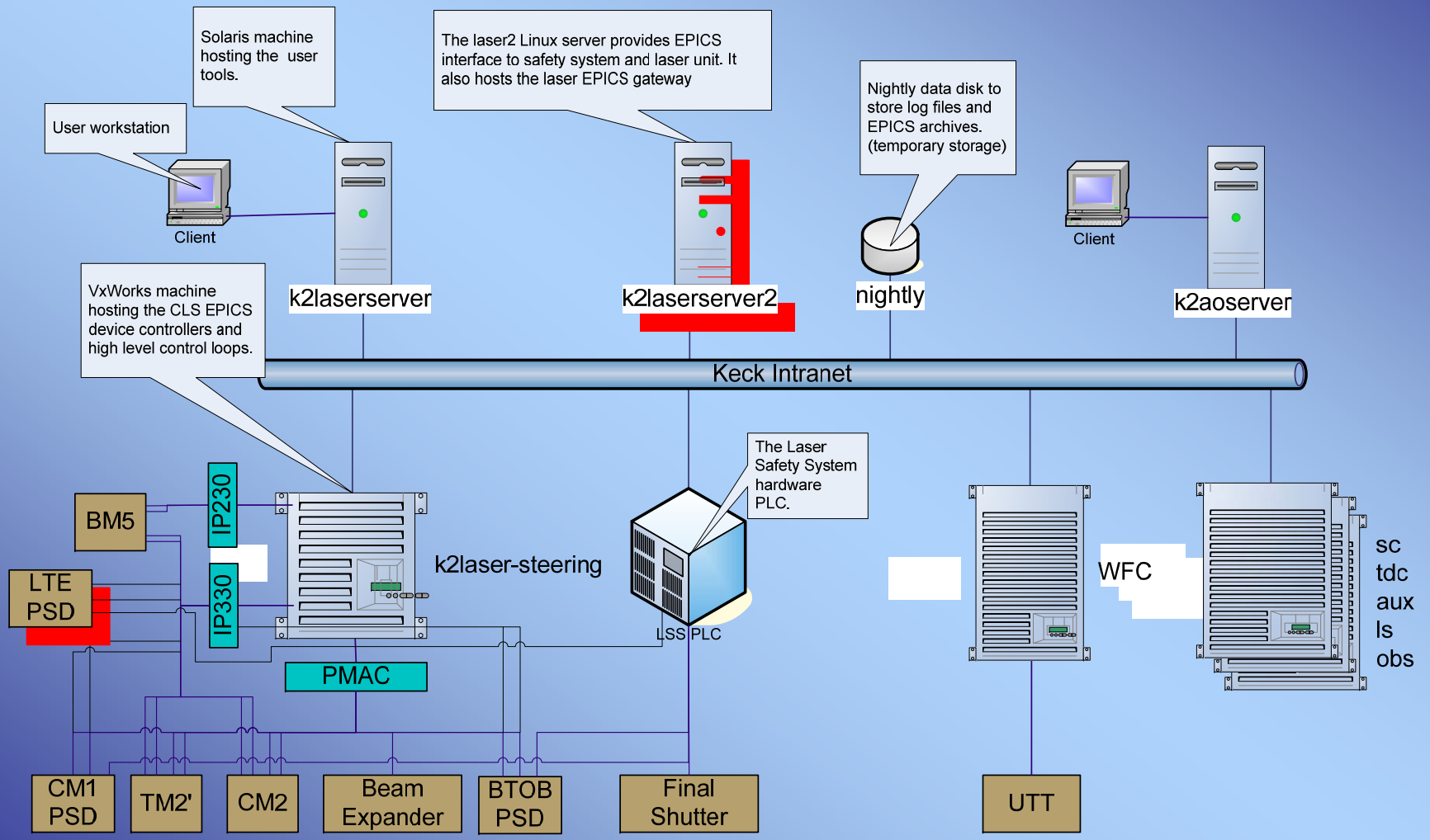
- Laser Controller Interface
  - Laser Epics Interface (lei)
    - Ethernet based, EPICS asyn eth interface and stream device
    - Solution validated using TOPTICA Simulator



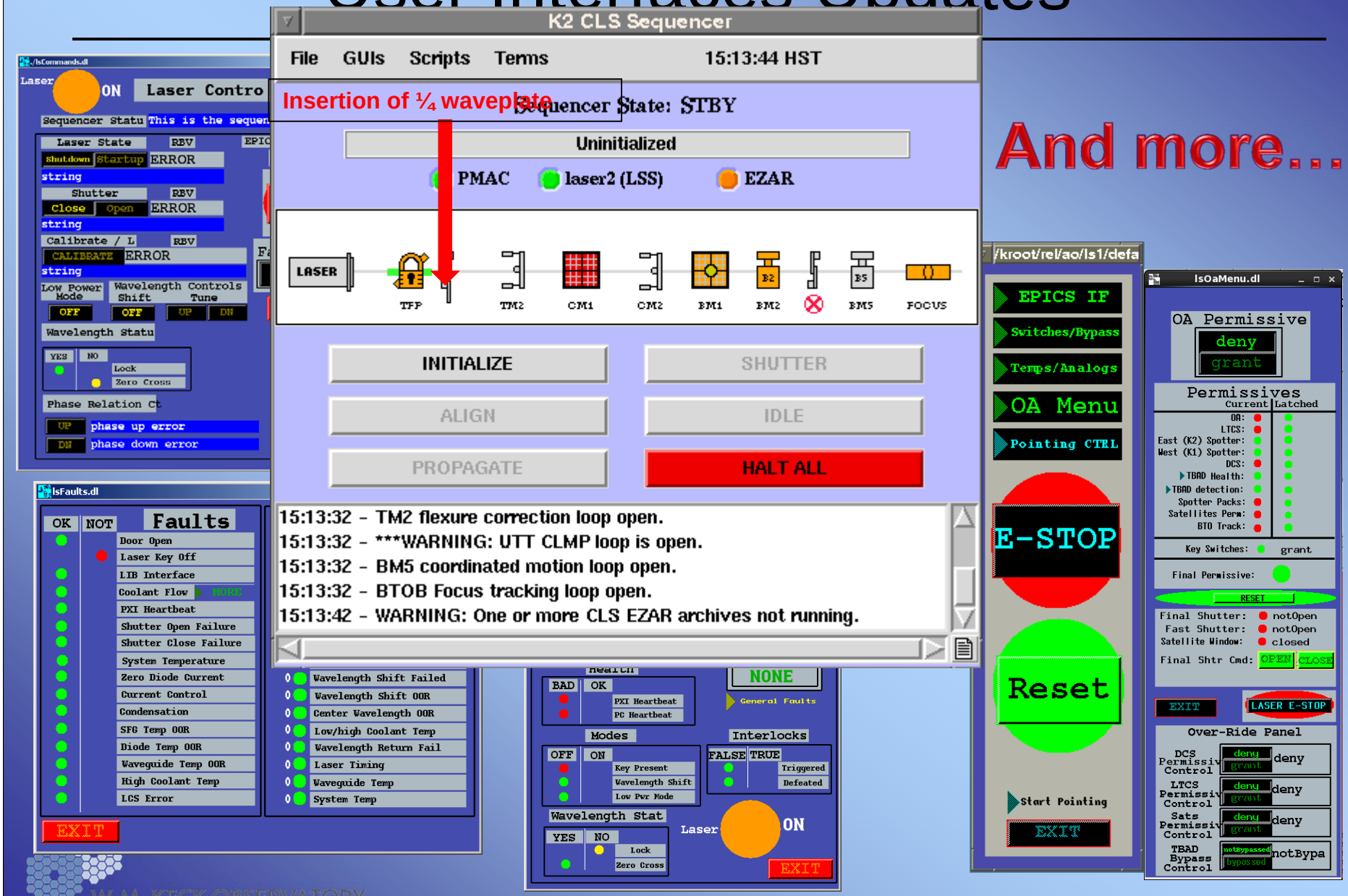




Control System Network



User Interfaces Updates



And more...

W. M. KECK OBSERVATORY

Startup/Shutdown Procedure

- Pre-req: LEI IOC on, LSS IOC on, EPICS gateway on, LSI-Crate on, Power on. In case it is not on, run the red lines
  - From k2laserserver2 (Linux IOC)
    1. Start LEI IOC (2 sec)
    2. Start LSS IOC (2 sec)
    3. Start EPICS gateway (2 sec)
    4. Start LEI GUI (2 sec)
    5. Go to OBS mode with the following sequence (99 sec , source KAON 1051)
       1. STANDBY -> READY (6 sec)
       2. READY -> ON (85 sec)
       3. ON -> (OBS 8sec)
  - From k2laserserver or k2laserver2
    1. Boot LSI crate (240 sec)
    2. Power On CLS device (~30 sec, see CLS TWIKI page)
    3. Start k2clsSequencer.py GUI (5 sec)
    4. From menu, run Start Of Night script (10 sec)
    5. Push INITIALIZE button (worth case, after a reboot of the crate: 180 sec, normal operation, less than 60 sec)
- Shutdown:
  1. GO to STANDBY with LEI GUI (70 sec , source KAON 1051)
     1. OBS -> ON (4 sec)
     2. ON -> READY (62 sec)
     3. READY -> STBY (4 sec)
  2. From k2clsSequencer.py menu, run End Of Night script (10 sec)

176 sec < STARTUP TIME < 572 sec

SHUTDOWN TIME = 80 sec

Telemetry

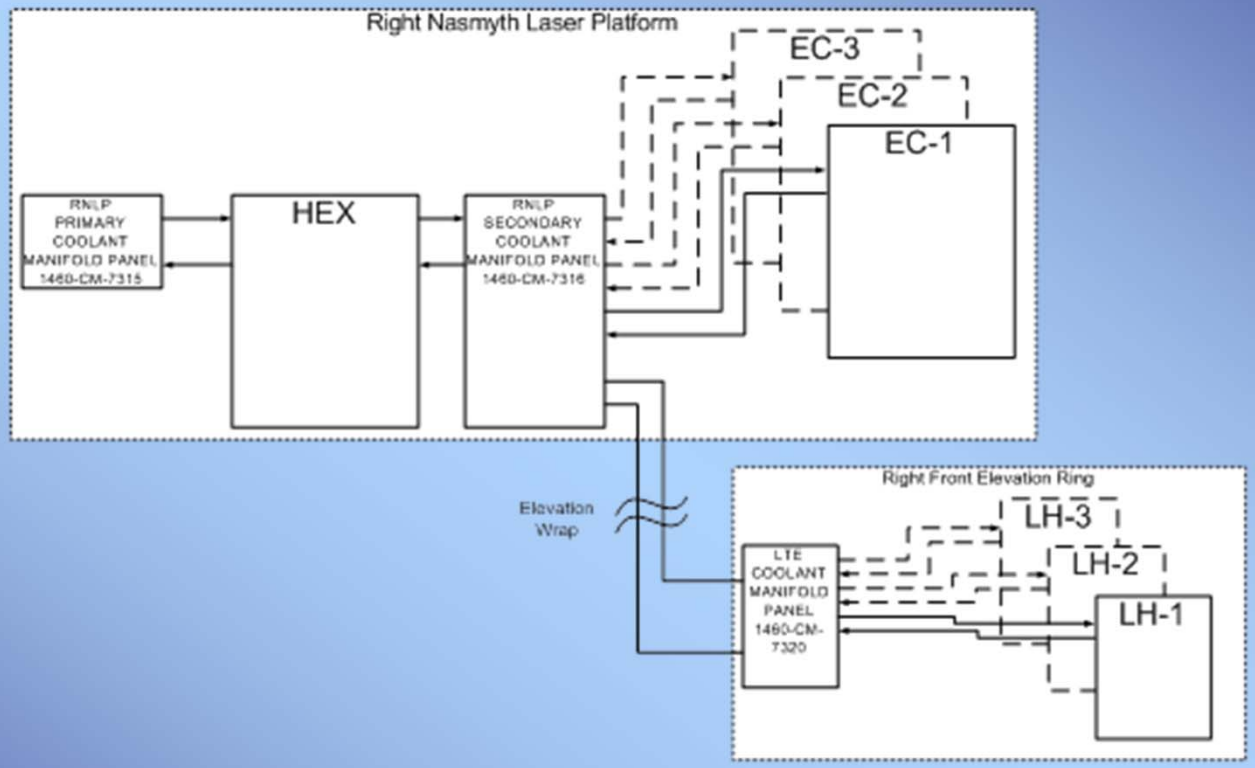
- (EPICS logging) ezar files
  - lsPointingDiag.ezar, lsTemps.ezar, lsFlexDiag.ezar, laserDiag.ezar will be updated by adding new TOPTICA channels and removing obsolete old laser channels
- TOPTICA independent data logging by laser
- TOPTICA independent data logging by service software laptop

Laser Power Requirements

#	Location	Clean Power Usage (W)		Commercial Power Usage (W)	
		Single Laser	Three Laser	Single Laser	Three Laser
1	Laser Table	50	50	100	100
2	Right Nasmyth Laser Platform	1400	4200	2500	2500
3	AO Electronics Vault	300	300	0	0
	Net Total	1750	4550	2600	2600

- Scaled up to account for aging of diodes
- Laser system feeds limited to 10A breakers for laser safety
- Compared to existing K2 dye laser system (55kW)

Cooling System Requirements



- Primary loop operating near 0°C
- Secondary loop operating at 15°C
  - Lines must be insulated to prevent heat from going into the dome

LGS AO Road Map

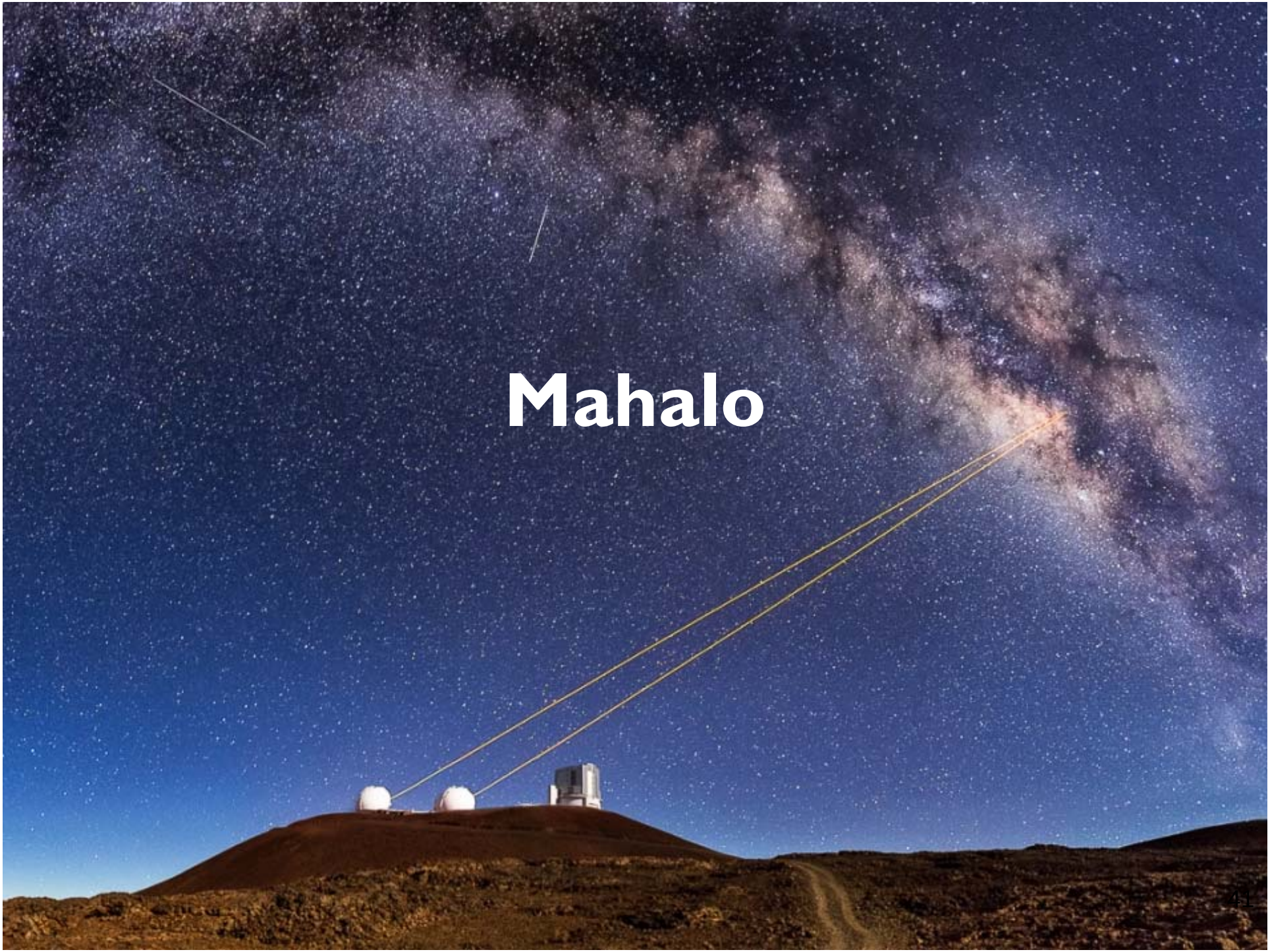
- Current Systems
  - CLS commissioning

KECK 1	KECK 2
LCMT Laser	LLNL Dye Laser
Free Space Transport	Center Launch System
OSIRIS Spectrograph	NIRC2 Imager

LGS AO Road Map

- 2015 and beyond

K1/2	Project	Completion
1	NIR Tip-Tilt Sensor	2015
1/2	On-axis PSF-R Demo	2015
1/2	Off-axis PSF-R Demo	2015
1	OSIRIS IFS Upgrade	2015
1	Enhanced NIR Tip-Tilt Sensor	2015
2	TOPTICA Laser	2016
1	OSIRIS Imager Upgrade	2016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