FACET·II

Facility for Advanced Accelerator Experimental Tests

Laser Status and Possible Future Upgrades

Brendan O'Shea

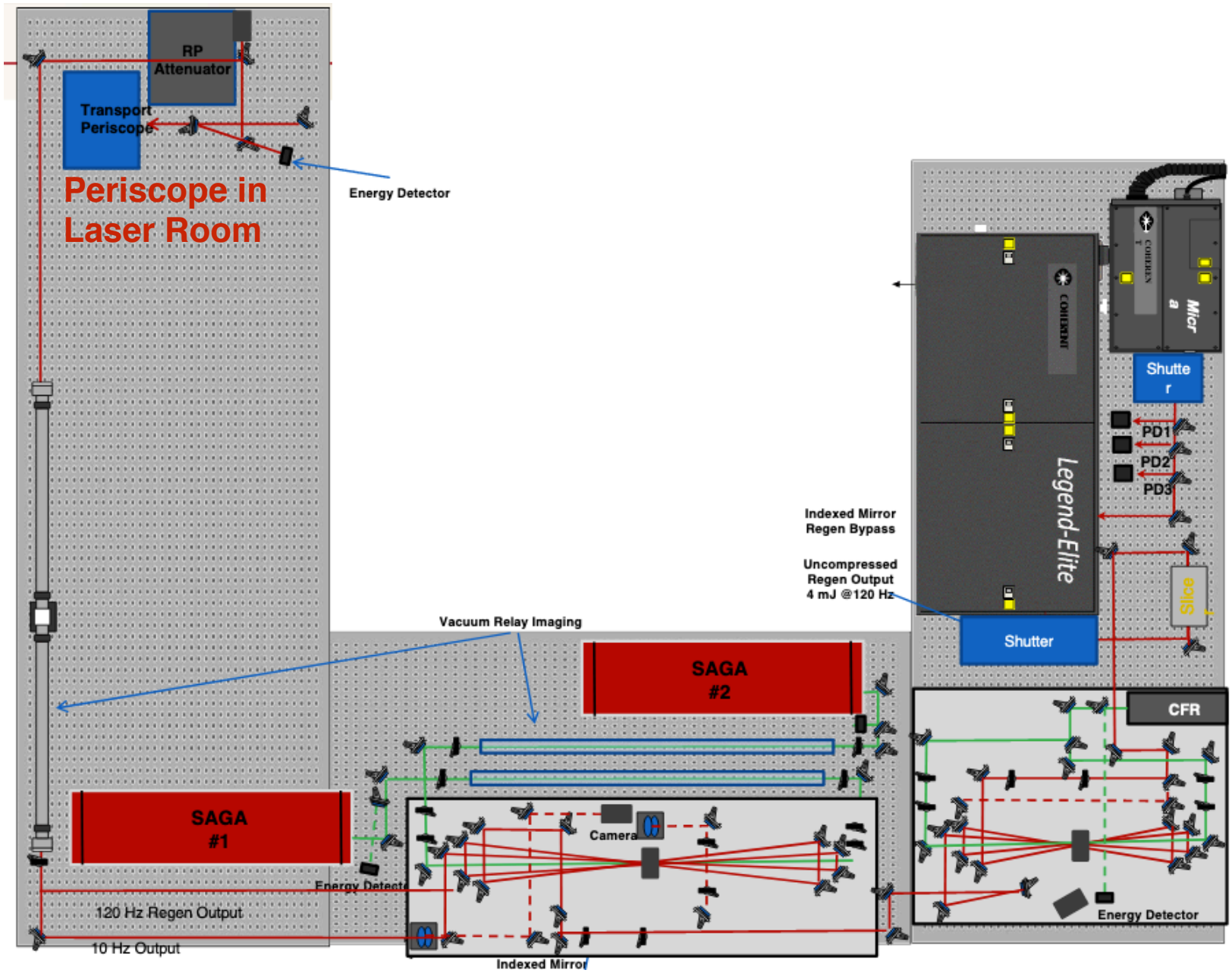
Overview

- Experimental Laser Requirements Overview
- Current Laser Layout
- Performance and Upgrades
- Upgrade Specifics
- Schedule
- Questions?

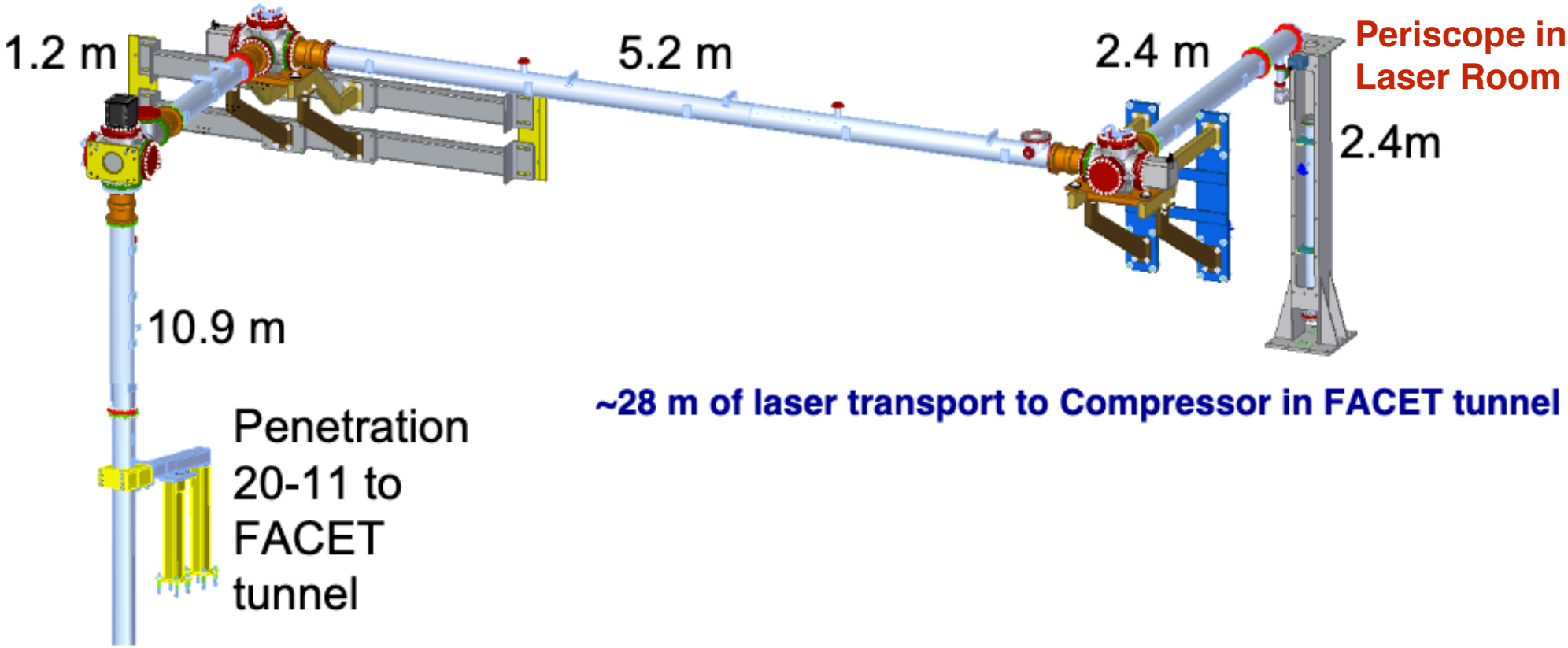
Experimental Requirements

	Energy [mJ]	Pulse Length FWHM [fs]	Wavefront Control	Probe Laser
E300 Energy Doubling	30	70	Yes	No
E301 Hydrogen PWFA	500	70	Yes	No
E302 Transverse Wakefields in PWFA	30	70	Yes	Yes
E303 Positron Generation & Acceleration	30	70	Yes	No
E305 Filamentation & Gamma Bursts	150	70	Yes	No
E310 Trojan Horse II	30/500	35	Yes	Yes
E320 Strong Field QED	>600	35	Yes	No
E324 Plasma Imaging	N/A	35	Yes	Yes

Laser Description Pt 1 - Laser Room

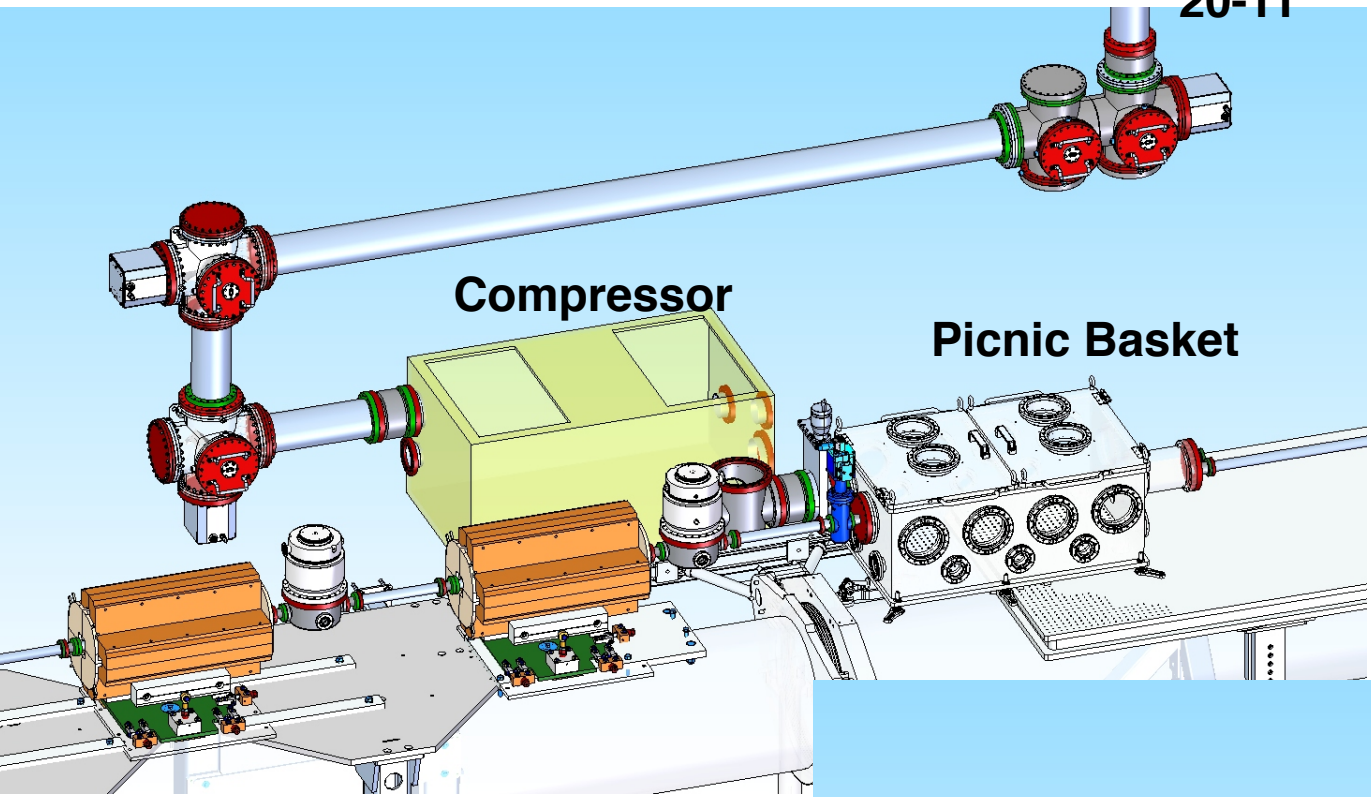


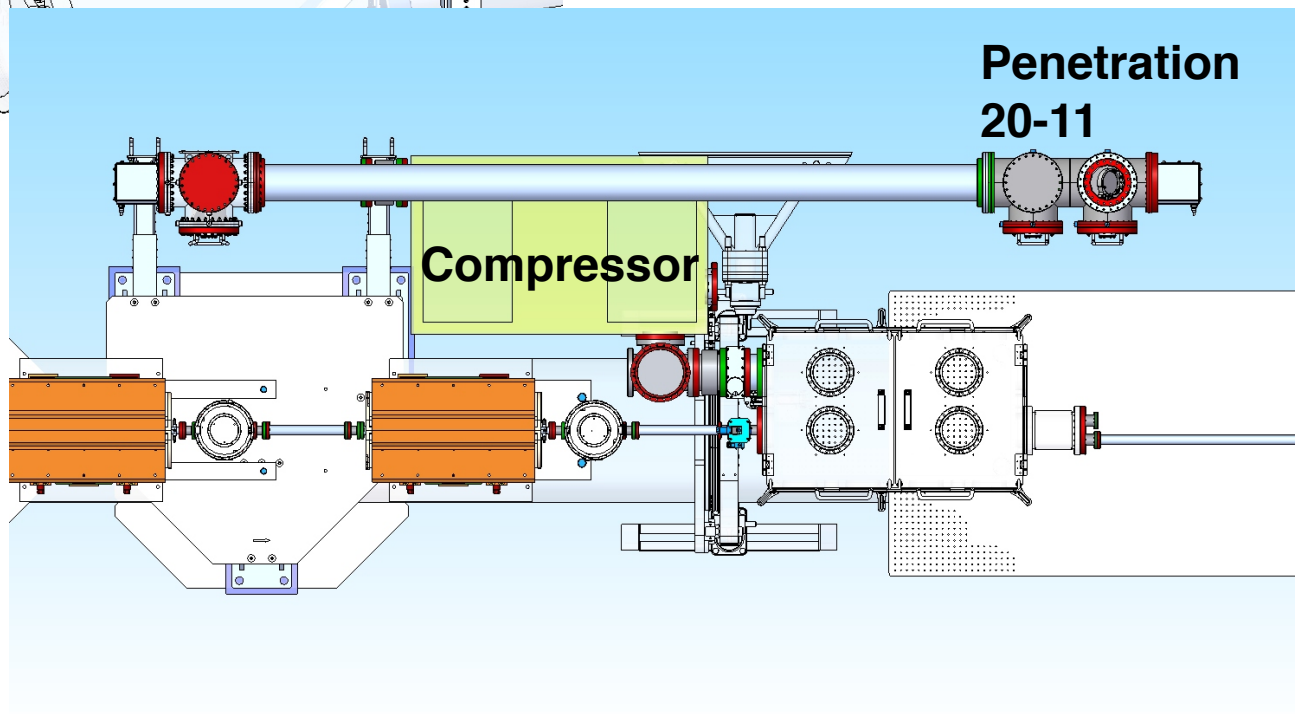
Laser Description pt 2 - Transport



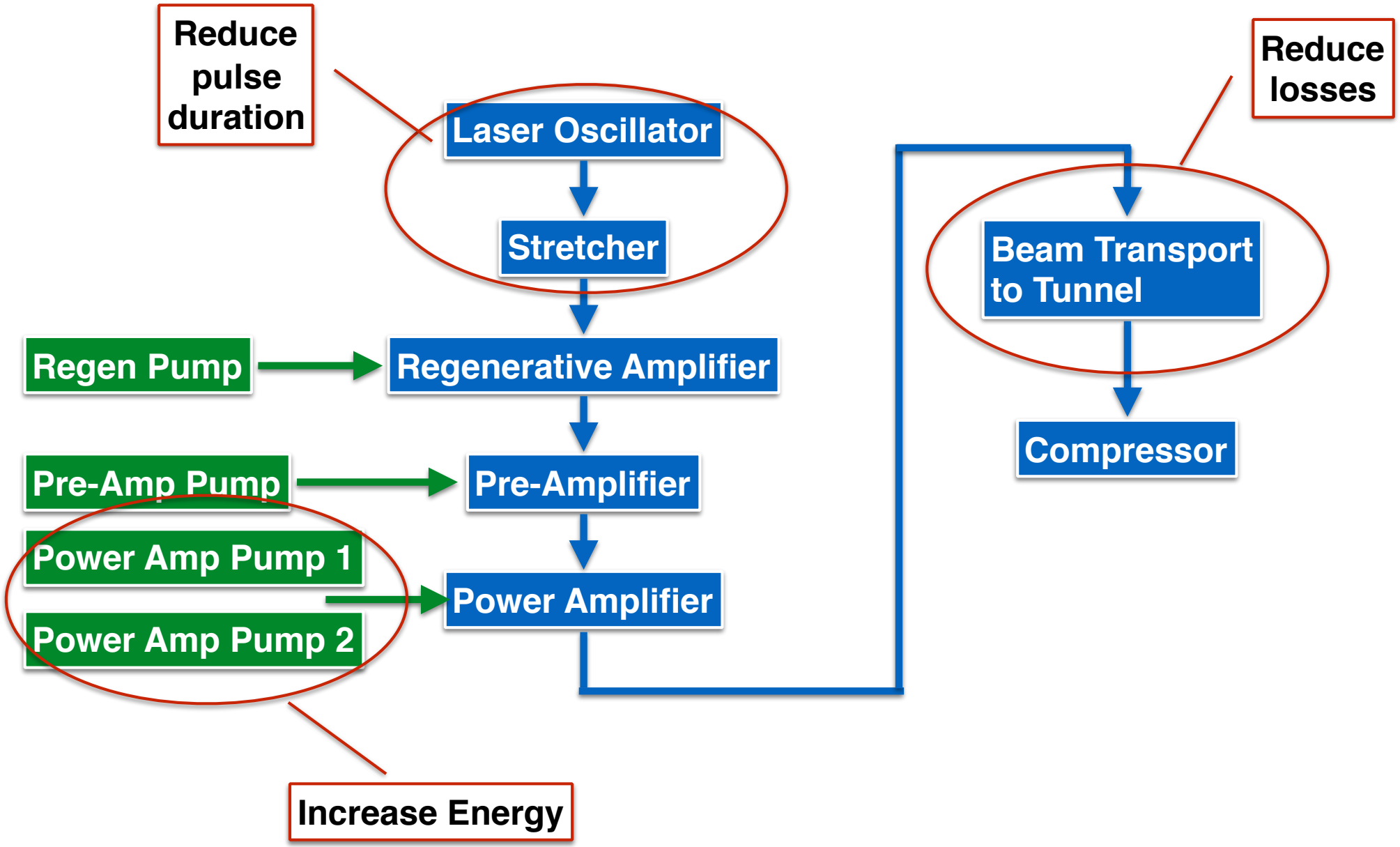
~28 m of laser transport to Compressor in FACET tunnel

Laser Description pt 3 - Tunnel

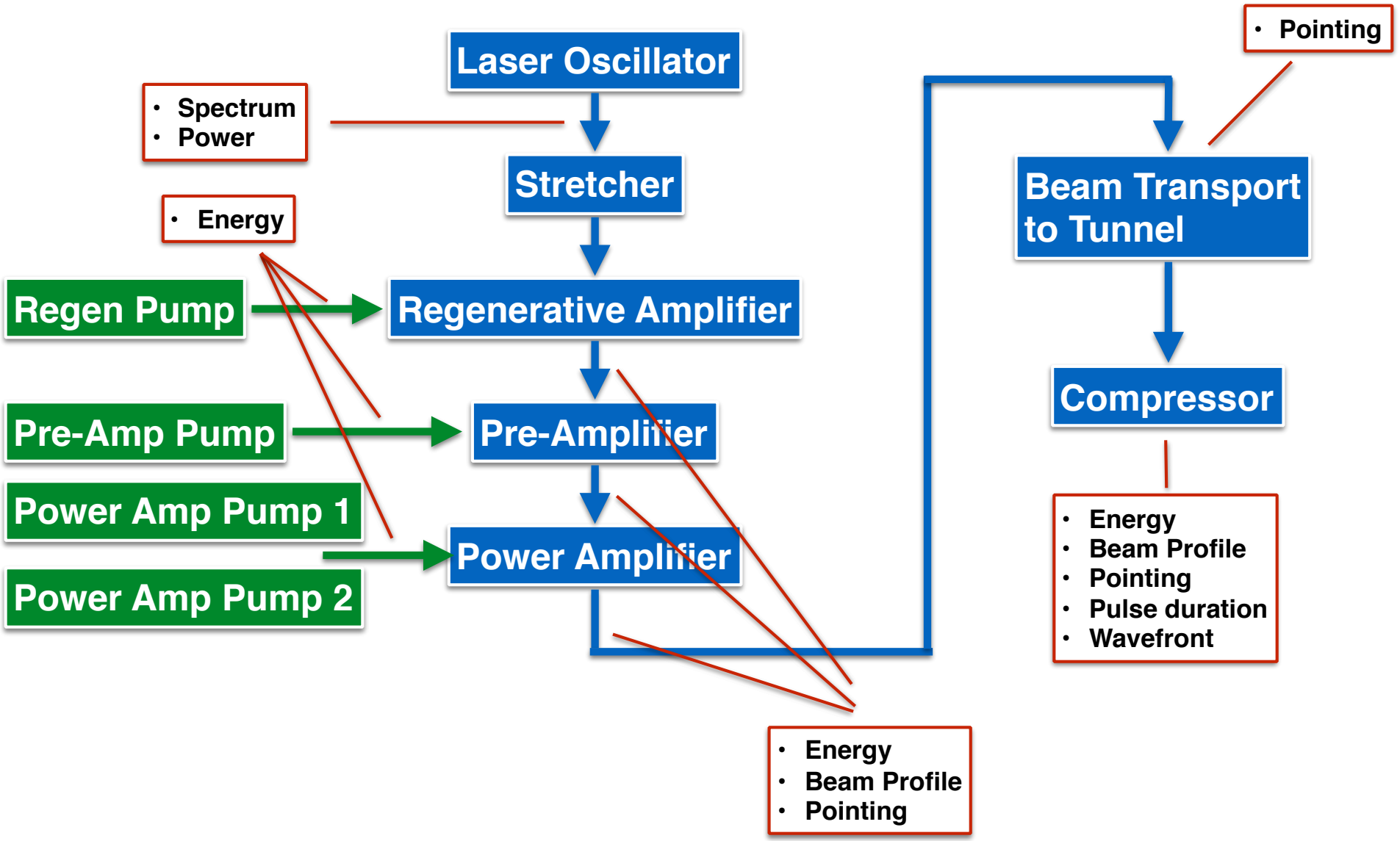




Laser System Block Diagram: Upgrades



Laser System Block Diagram: Diagnostics Upgrades



Laser Upgrades

	Energy Upgrade	Pulse Length Management	Wavefront Control
	Pump Laser Upgrade	Spectral Phase Control (Dazzler)	Deformable Mirror
E300 Energy Doubling			
E301 Hydrogen PWFA			
E302 Transverse Wakefields in PWFA			
E303 Positron Generation & Acceleration			
E305 Filamentation & Gamma Bursts			
E310 Trojan Horse II			
E320 Strong Field QED			
E324 Plasma Imaging			

Laser Performance Previous and Goals

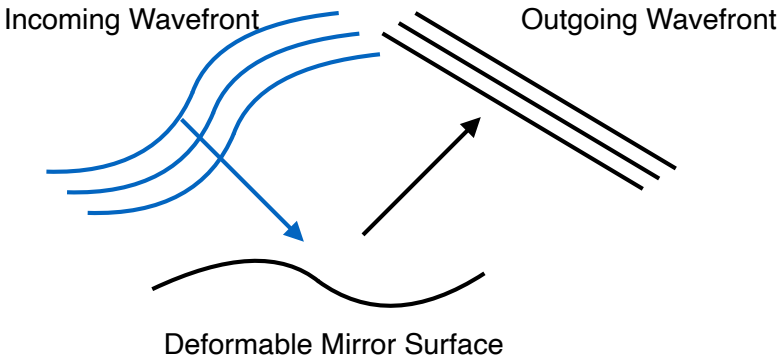
Function	Past Performance	Optimal Performance	40 TW (Stretch Goal)	Present Performance
Upgrades		Dazzler/Wizzler Deformable Mirror Transport	Optimal Present + GAIA 8" gratings	
Power-amp Pump [J]	2.8	3.6	7.5	3.2
Power-amp Output [J]	0.6	1.1	2.3	1.0
Beam Transport Input [J]	?	1.0	2.0	0.9
Compressor Input [J](beam transport output)	0.4	0.9	1.8	0.8
Minimum Beam Size @ Compressor [radius, cm]	2.0	2.1	3.0	1.9
Pulse Length Before Compression [ps] [FWHM]	150.0	150.0	150.0	150.0
Compressor Output [J]	0.25	0.61	1.28	0.54
Pulse Duration after compression (fwhm) [fs]	70.0	35.0	35.0	35.0
Peak Power [TW]	3.6	17.5	36.5	15.6
Intensity* [10^{18} W/cm^2]	23.7	116.3	242.4	103.4
a0*	3.3	7.3	10.6	6.9

Upgrade Plans

Upgrade	Purpose	Status	Next Milestone
Deformable Mirror	Flat Phase Front	Coating being applied by manufacturer	Shipped to SLAC in early November
Spectral Phase Control	Shorter laser pulses, 35 fs fwhm	Dazzler + Wizzler Order to be placed	Order to be placed
Single Window Laser Transport	Reduce astigmatism - better phase front	Design in hand	Order parts
Laser chain monitoring system	Reduce laser drift, find issues before they become problems	Cameras installed between all amplifiers and in laser transport	Laser monitoring after full energy achieved

Deformable Mirror

What is it:



- Corrects Wavefront errors

- Optimized for 60 mm, can operate at 40 mm
- Up to 5th order Zernike polynomial correction - 37 actuators
- Dominant wavefront error at FACET was astigmatism
  - Expect zero resulting astigmatism
- Learning what we can from Berkeley
  - Trivial: What computer should we buy?
  - Life saving: Fiber laser to provide phase reference

Example Performance:

ILAO Star Optimized for 65 mm

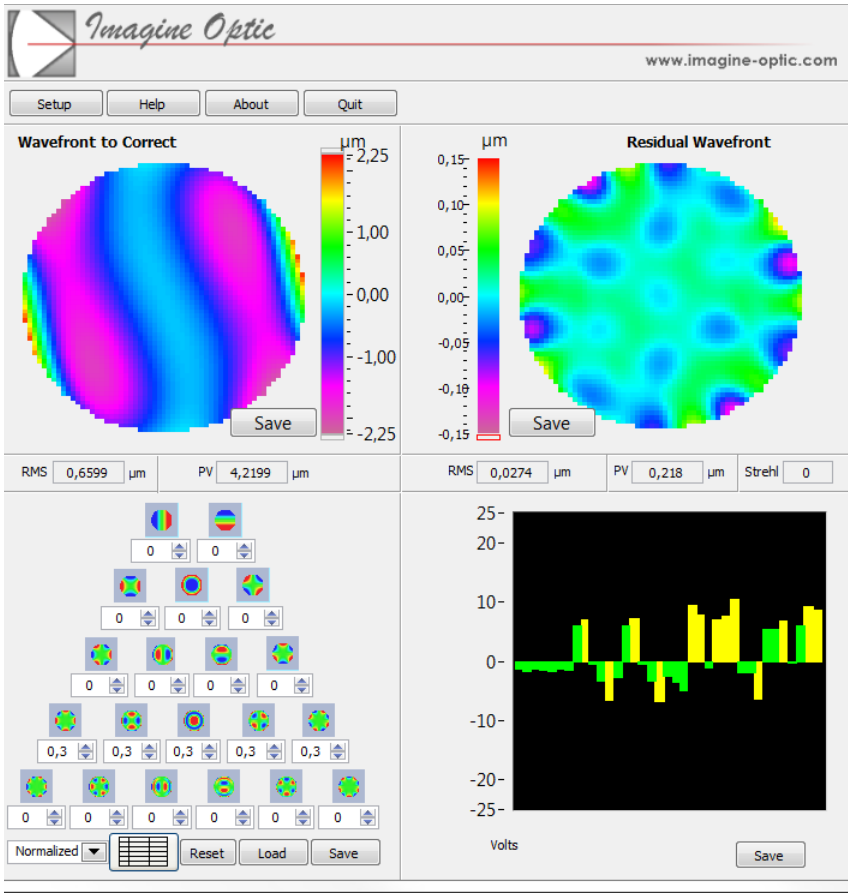
37 actuators

Correction diameter : 65 mm

Correction : 4th order with 0,66 µm rms

Residual after correction : **27 nm rms**

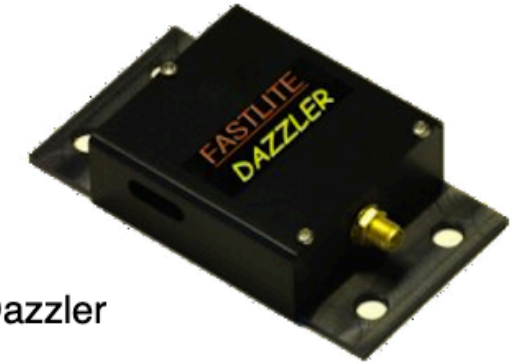
Dynamic used : **40%**



Spectral Phase Control

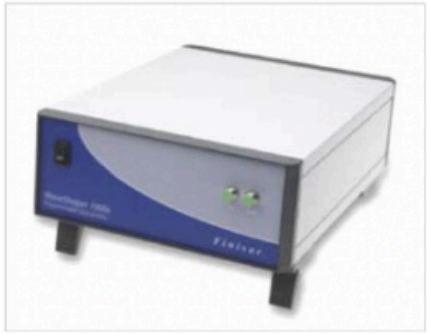
- FACET had a measured pulse length of 50 fs FWHM, minimum
- Uncorrected spectral dispersion can be a measured (FROG, SPIDER, Wizzler) and controlled (Dazzler, SLM) with commercial devices
- Reduction in windows + deformable mirror can help here too
- Anticipate routine operation at 35 fs FWHM

SPIDER

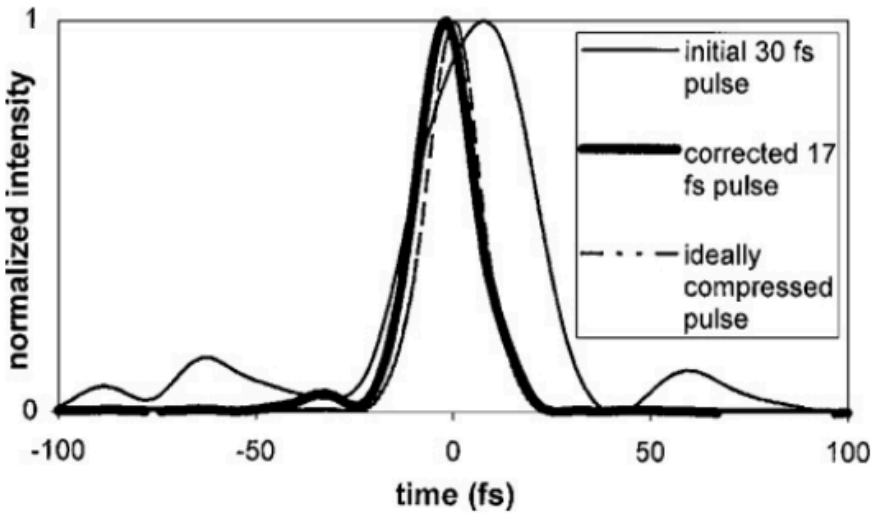


Dazzler

FROG

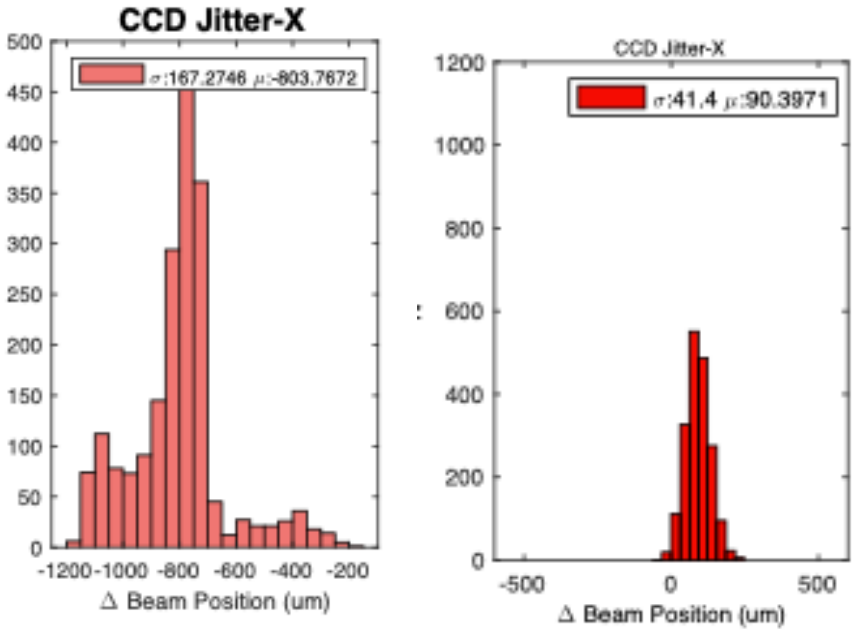


Wave shaper

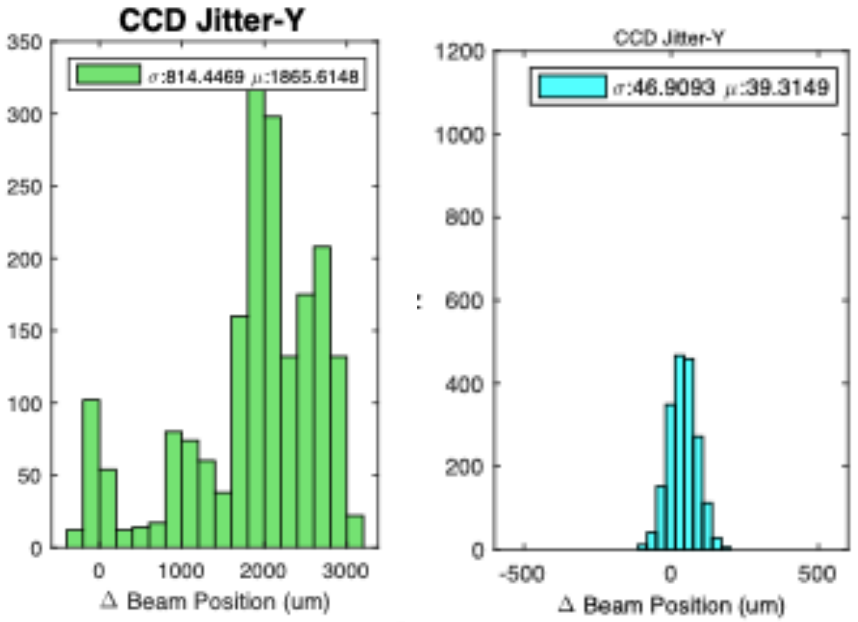


Single Window Transport / Laser Monitoring

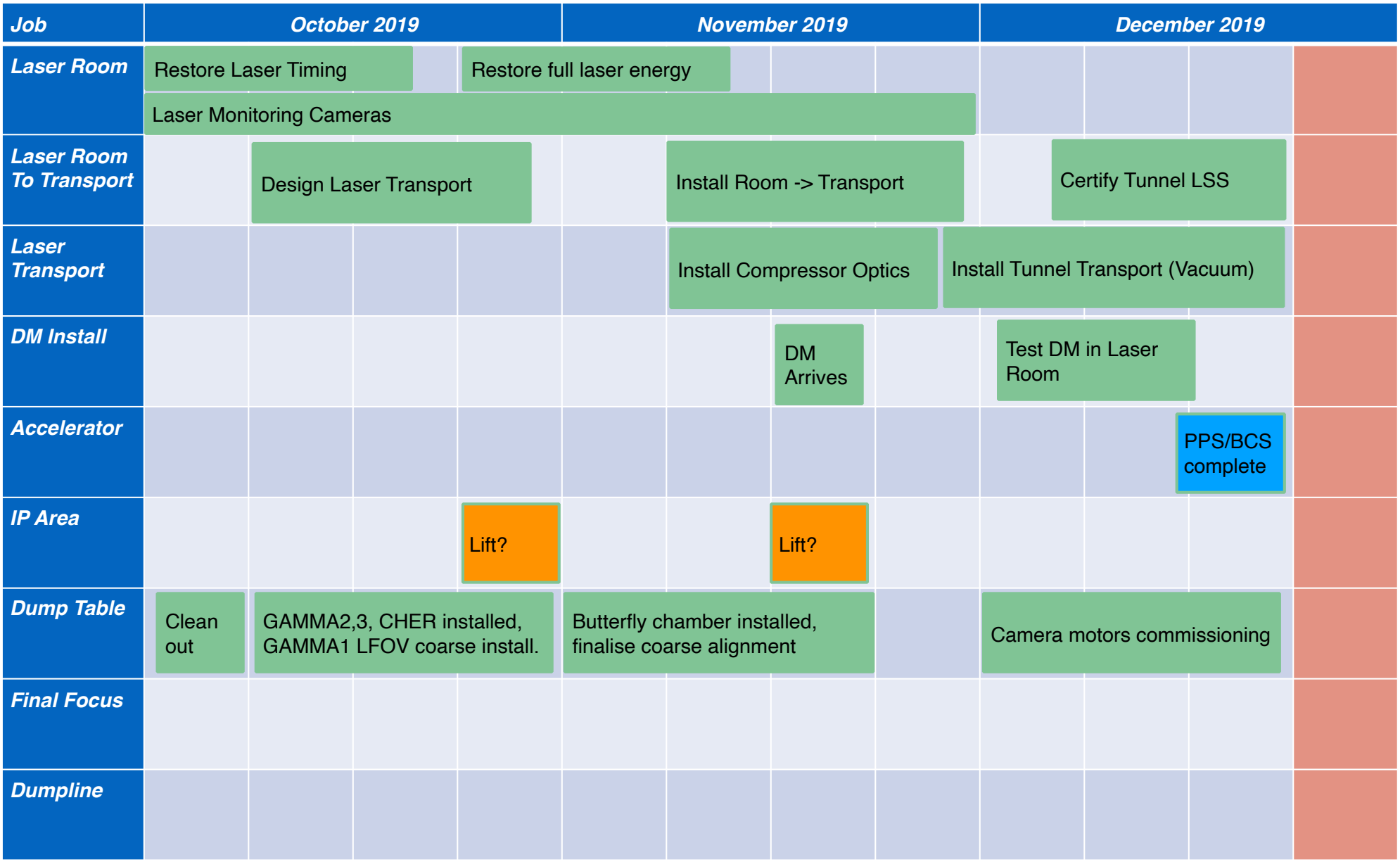
- FACET had seven windows in the laser transport system (along with 4 lenses)
- Laser transport inhabits three temperature zones (laser room, gallery and tunnel)
- Windows were found to contribute to astigmatism, energy loss
- Temperature changes in gallery drove laser drift, realignment required ~hour



- FACET-II has only one, better characterized window
- Mirrors in the transport are dual coated to propagate a HeNe with the 800 high energy laser
- HeNe used to monitor and correct temperature drift
- Reduced long term drift 20-fold (<40 um)



FACET-II


Job
October 2019
November 2019
December 2019
Laser Room
Restore Laser Timing
Restore full laser energy
Laser Monitoring Cameras
Laser Room To Transport
Design Laser Transport
Install Room -> Transport
Certify Tunnel LSS
Laser Transport
Install Compressor Optics
Install Tunnel Transport (Vacuum)
DM Install
DM Arrives
Test DM in Laser Room
Accelerator
PPS/BCS complete
IP Area
Lift?
Lift?
Dump Table
Clean out
GAMMA2,3, CHER installed, GAMMA1 LFOV coarse install.
Butterfly chamber installed, finalise coarse alignment
Camera motors commissioning
Final Focus
Dumpline

Questions?