FACET Experimental Laser(s)

FACET-II

Facility for Advanced Accelerator Experimental Tests

FACET-II PAC Meeting 2022

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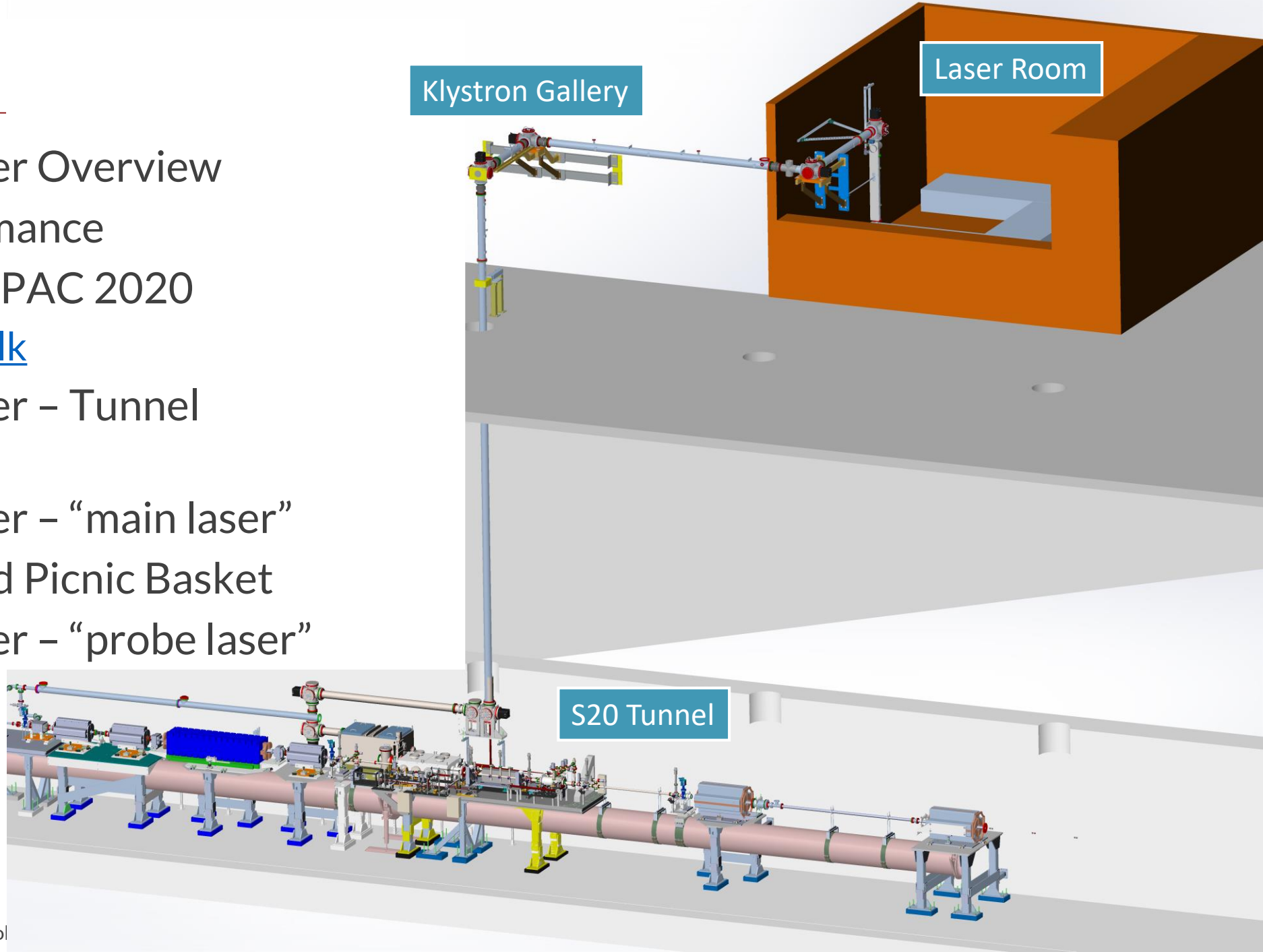
SLAC NATIONAL ACCELERATOR LABORATORY

Stanford University | U.S. DEPARTMENT OF ENERGY

Outline

- Experimental Laser Overview
  - Present performance
  - Upgrades since PAC 2020
    - Link to 2020 talk
- Experimental Laser – Tunnel Overview
- Experimental Laser – “main laser”
  - Compressor and Picnic Basket
- Experimental Laser – “probe laser”
  - EOS
  - Shadowgraphy
  - Ionizer

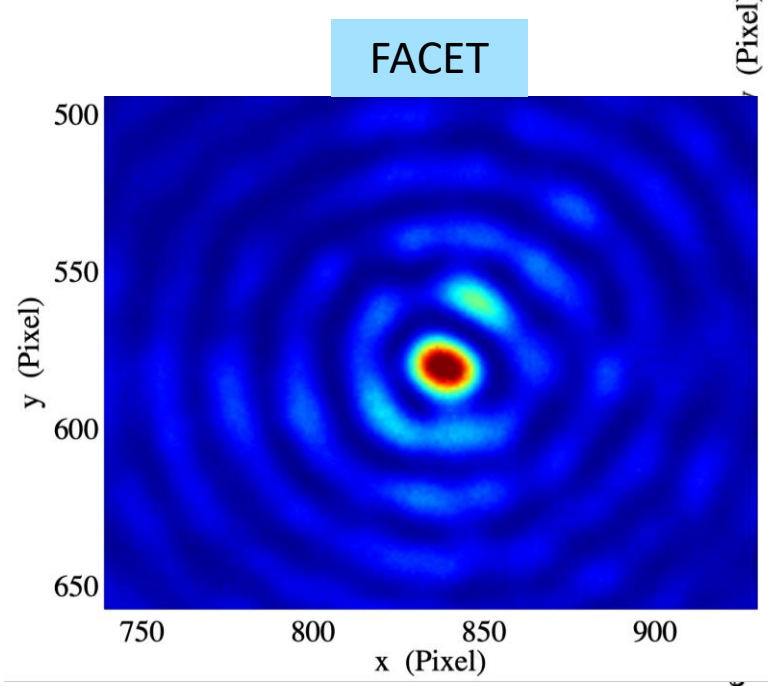


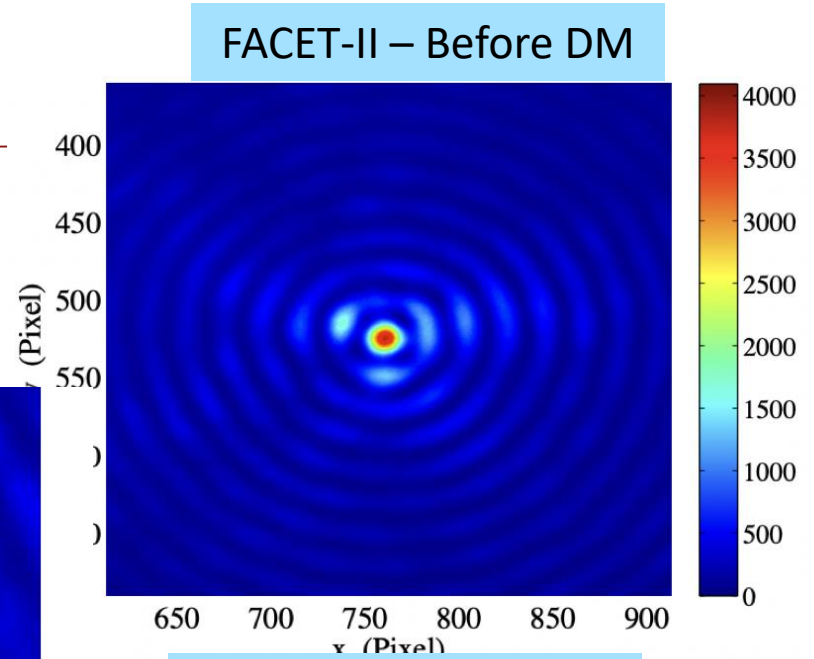
Present and optimal performance

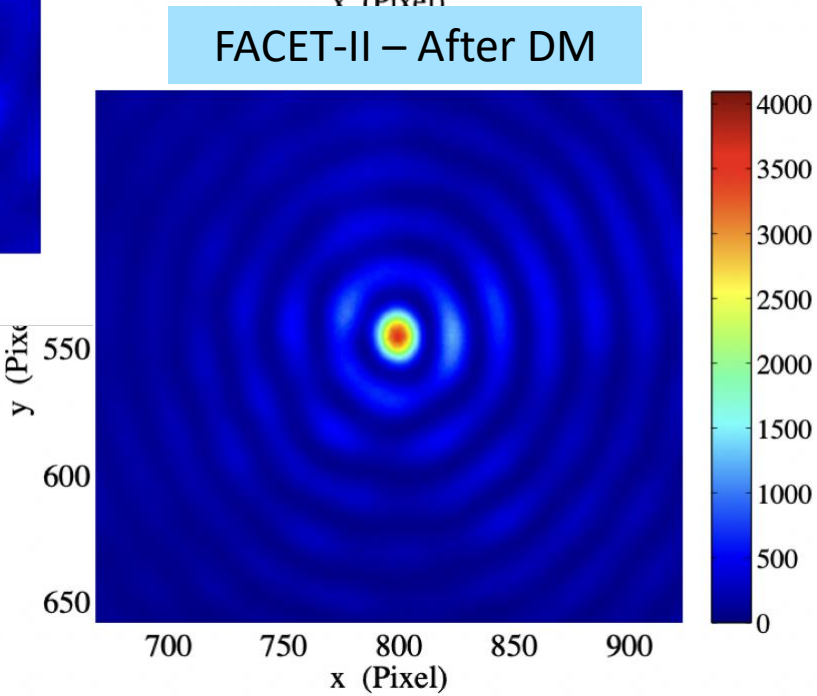
Function	Present	No Major Upgrades	How do we do better?
Power-amp Pump [J]	*2.2*	*2.6*	*Can turn up lamps, but not tested*
Power-amp Output [J]	*0.7*	*0.8*	
Beam Transport Input [J]	*0.7*	*0.7*	
Compressor Input [J](beam transport output)	*0.6*	*0.6*	
Minimum Beam Size @ Compressor [radius, cm]	*2.0*	*1.7*	
Pulse Length Before Compression [ps] [FWHM]	*150.0*	*150.0*	
Compressor Output [J]	*0.36*	*0.44*	
Pulse Duration after compression (fwhm) [fs]	*55.0*	*40.0*	*Spectrum says we should be good. Need to build compressor in laser room*
Peak Power [TW]	*6.6*	*11.1*	
Intensity [10^{18} W/cm^2]*	*44.1*	*73.5*	
*a0**	*4.5*	*5.8*	

Upgrades since PAC 2020

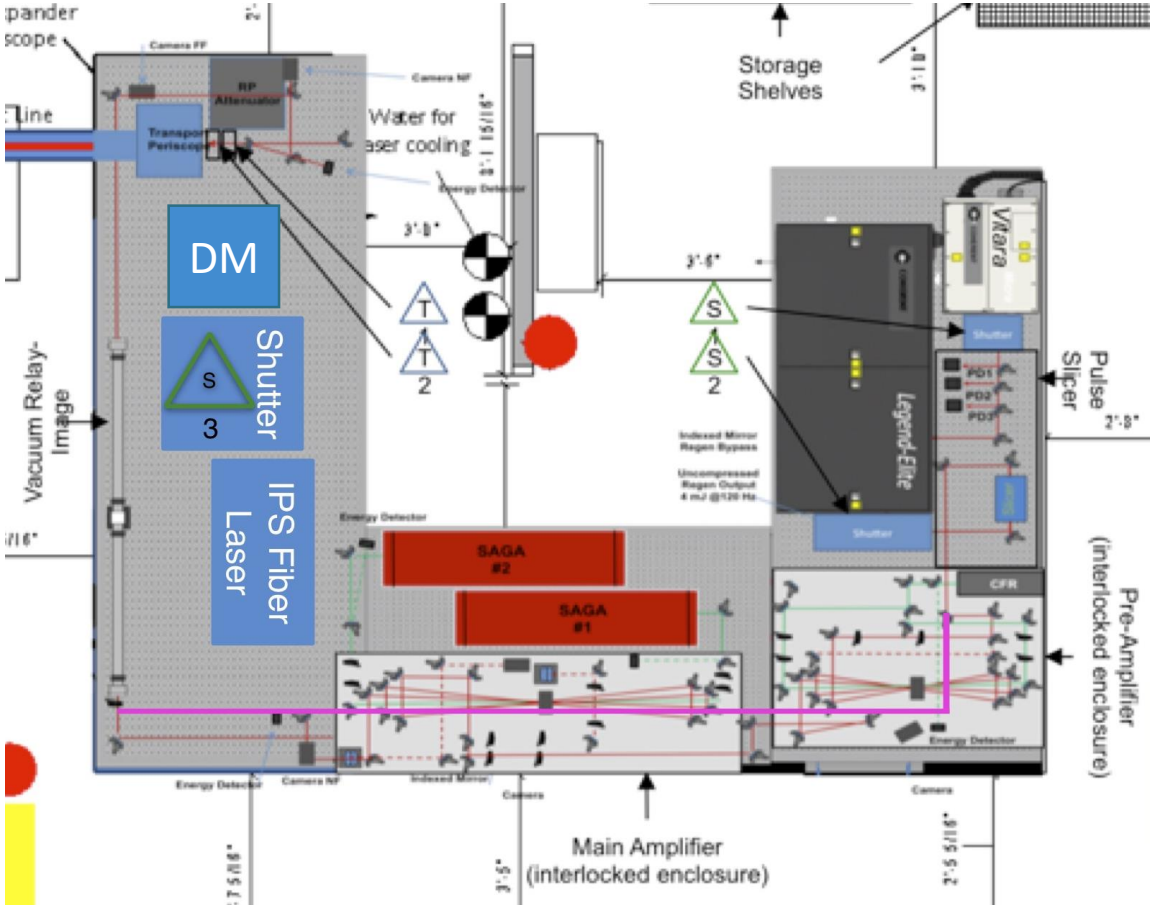
- Removed all but two windows
  - Previous source of astigmatism
  - Replaced all lenses with high quality optics
- Rebuilt safety attenuator
  - Previous provided different wavefronts for building vs running experiments
- Active alignment system (17 cameras)
  - Reduces sensitivity to temperature/humidity changes
- Improved SAGA flashlamp lifetimes
- Installed deformable mirror





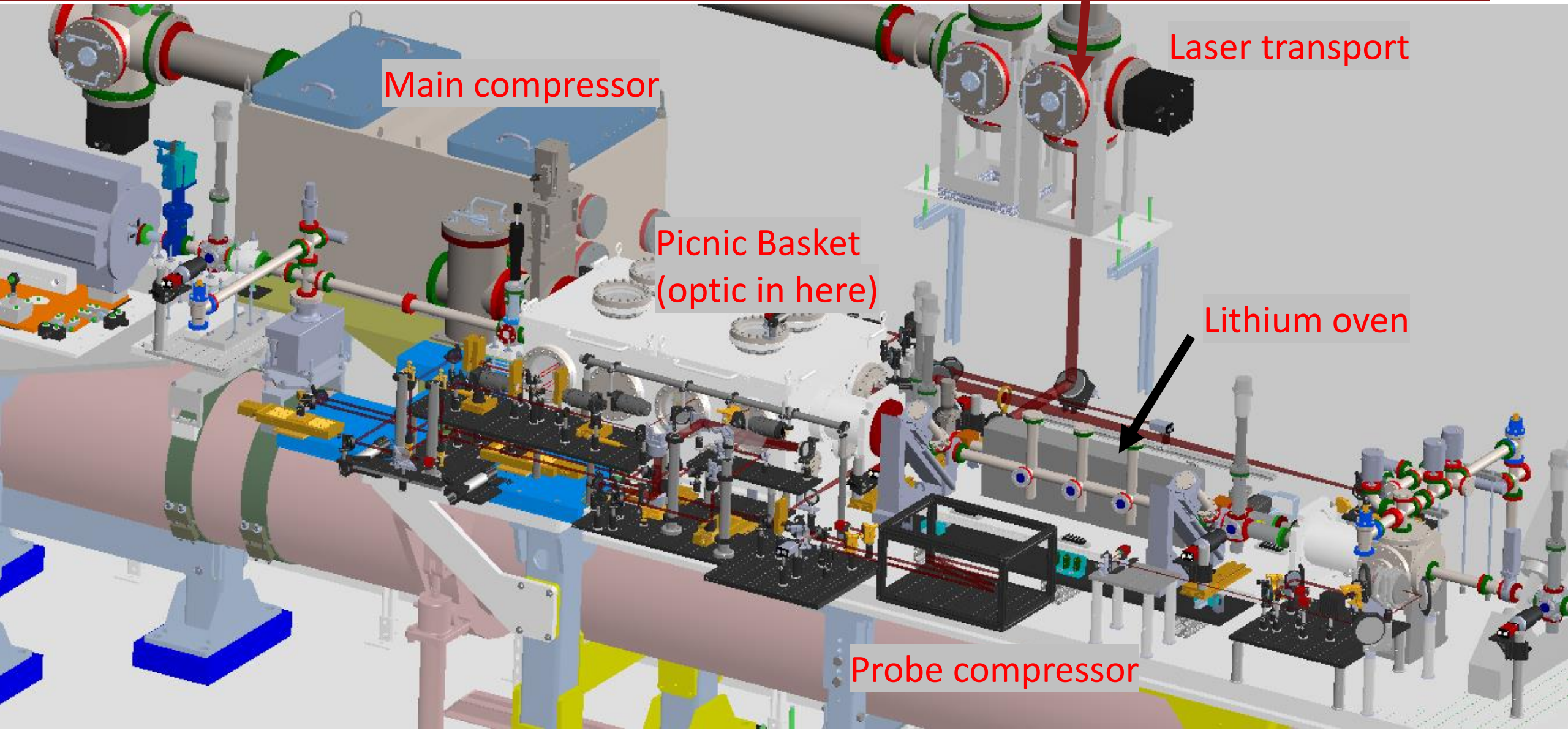


There is still work to do

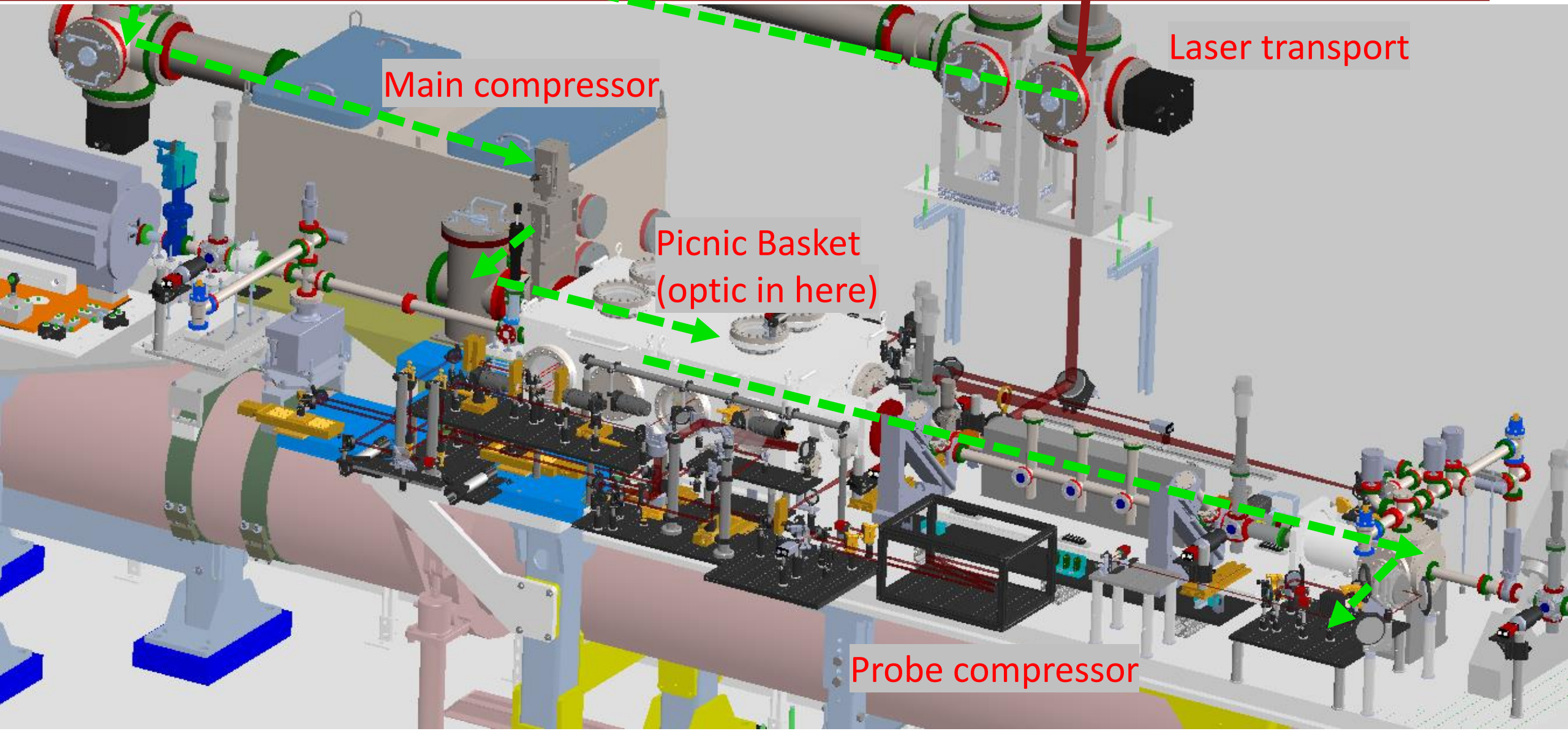


- Laser Room Compressor
  - Want to optimize/test in the laser room, much easier than the tunnel
- Spatial Filter
- Image SAGA pump lasers to the crystal in the MPA
- Develop method for pulse dropping
  - Automate on/off shots for backgrounds/controls
- Make windows thinner for probe
- All total, work list is about a year long

Experimental Laser – Tunnel Overview

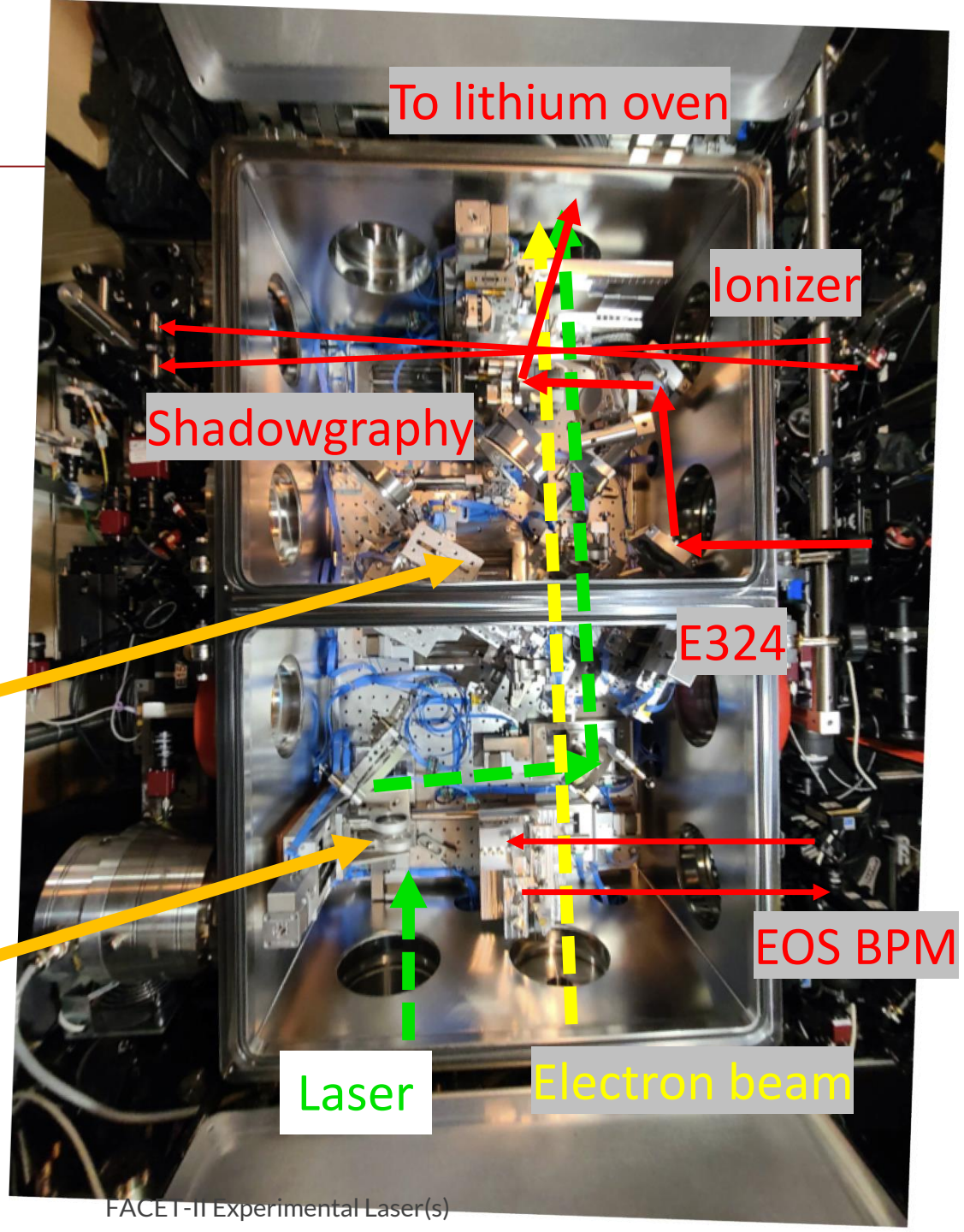


Experimental Laser – Main Laser



Experimental Laser – probe laser

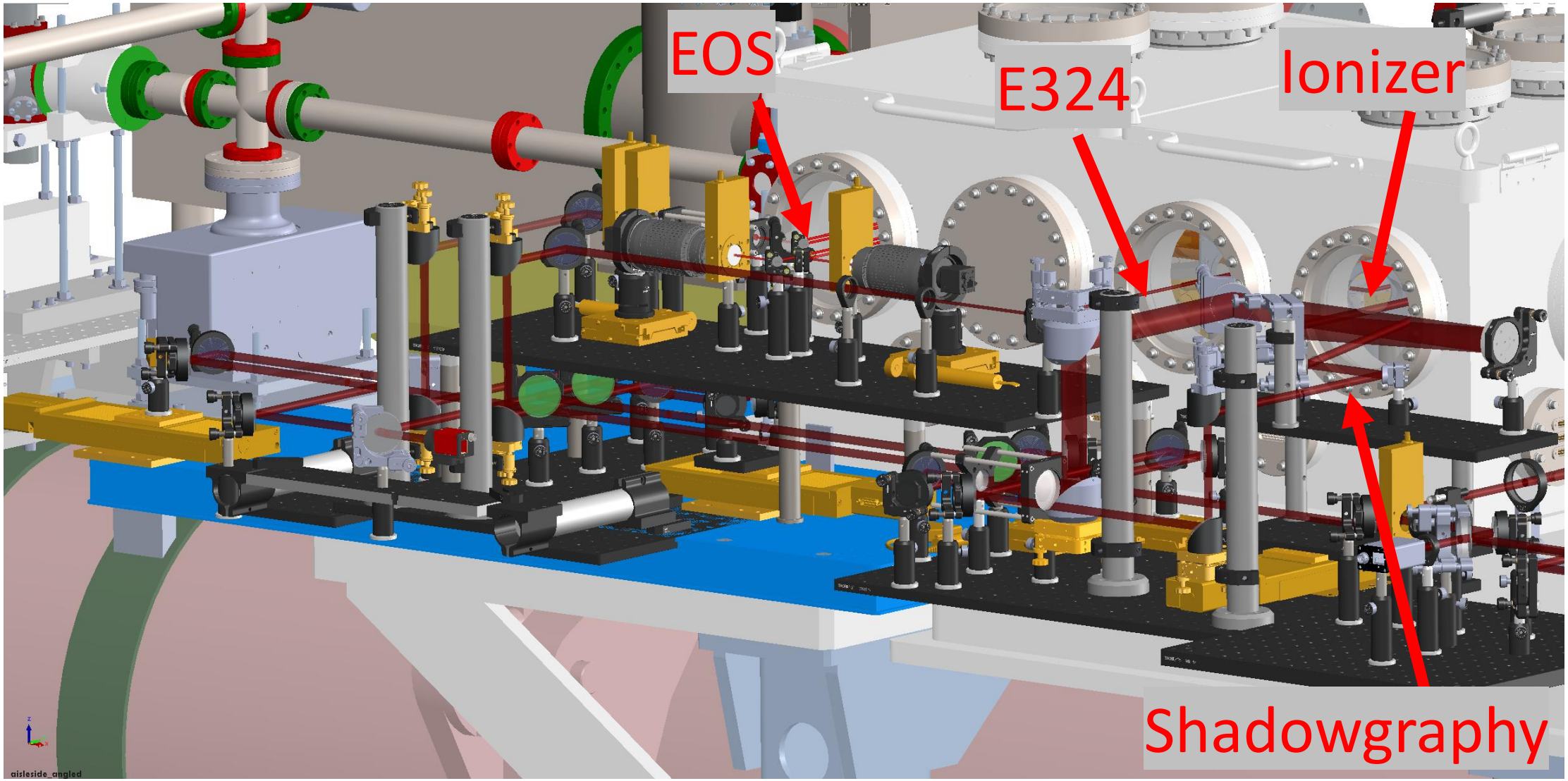
- **EOS BPM:** Laser and e-beam timing and e-beam positioning
- **Shadowgraphy:** Gas-jet shadowgraphy probe
- **Ionizer:** Transverse laser beam ionizing the gas jet
- **E324:** Lithium oven probe



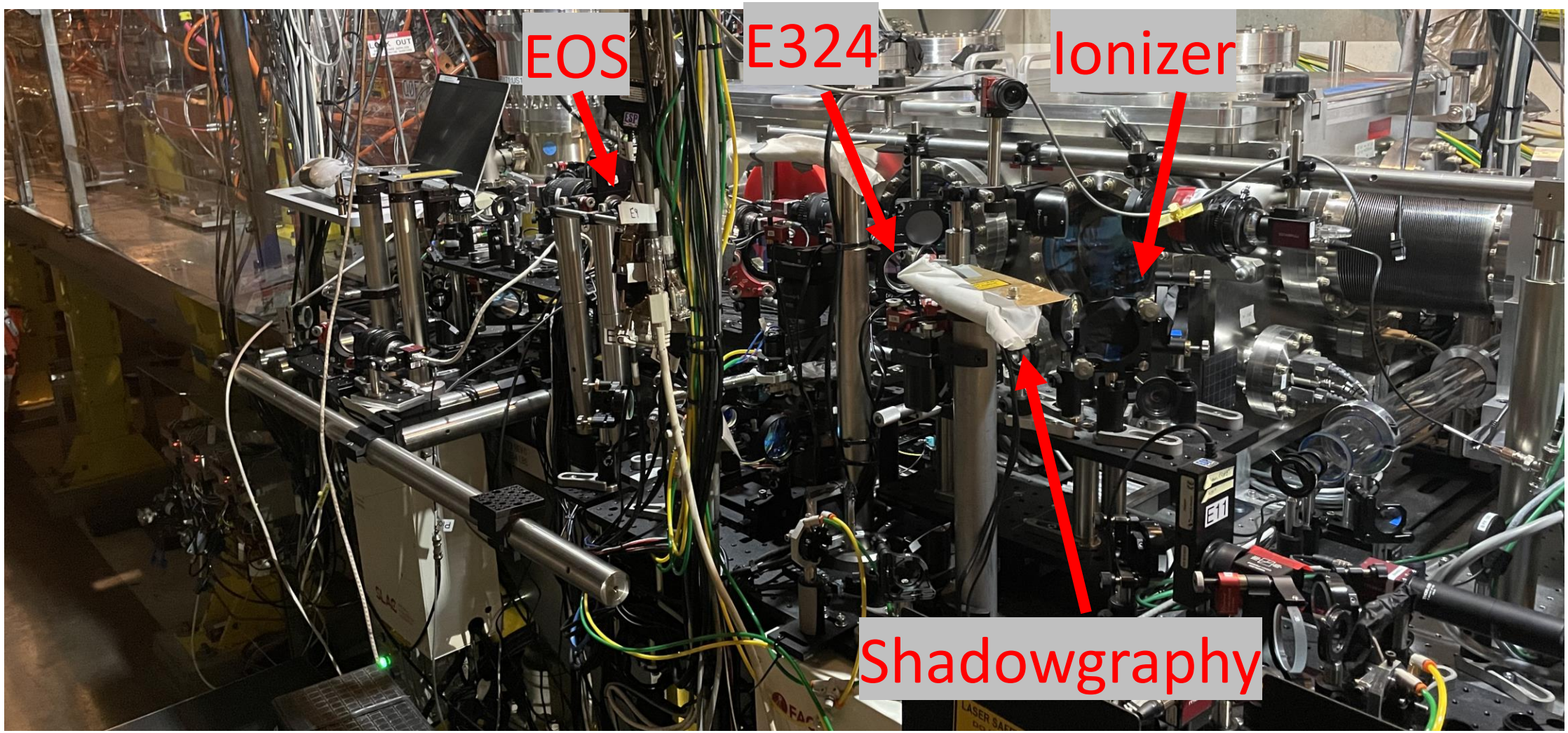
- OAPs (E320)

- Axicon (E300)
- Axilens (E305)
- Tandem Optic (E301)

Probe Laser

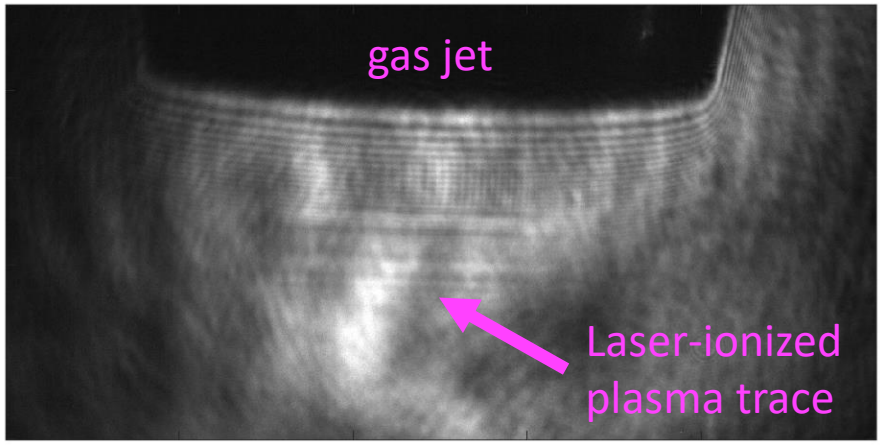


Probe Laser



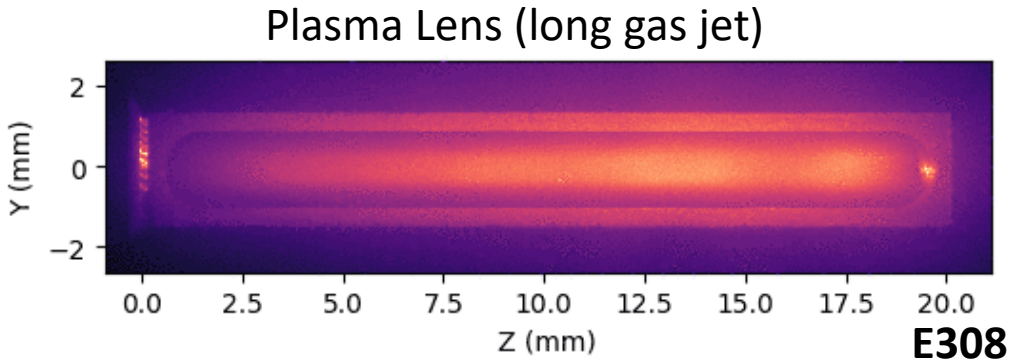
EOS + Shadowgraphy + Ionizer

- Low and high resolution Shadowgraphy are working
- Fourier plane is a future upgrade

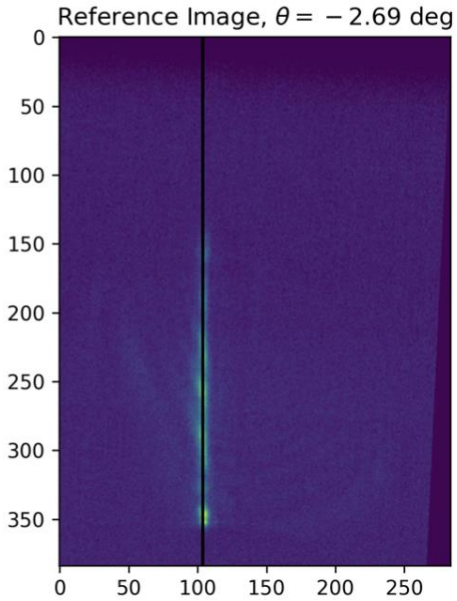


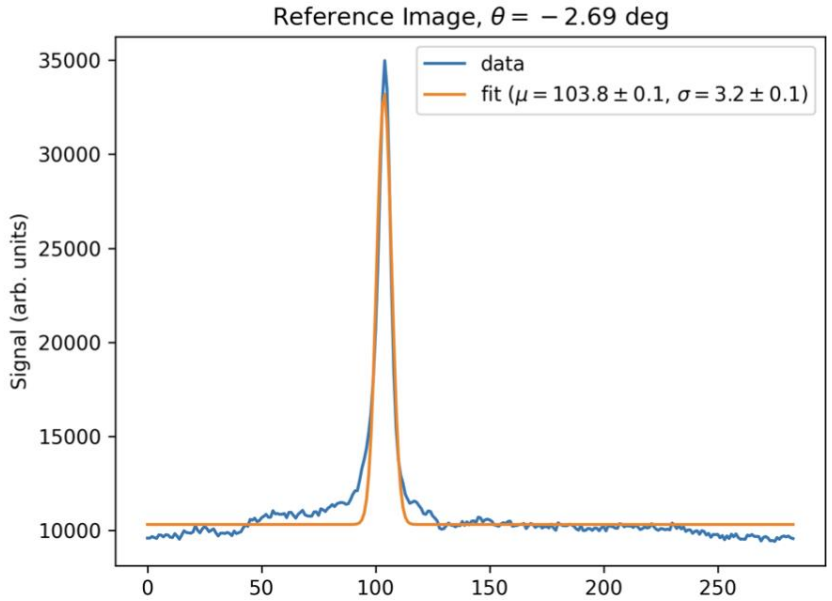
E305

- Axilens ionized gas jet lensing the electron beam



E308





- EOS working – everyone uses it
- 18 fs/pixel calibration
  - 52 fs shot-to-shot jitter
- Next step is to add a second crystal and try to measure beam position.

C. Hansel

Summary

- One laser, five laser lines
  - Main laser can run three experiments, one at a time, remotely switching between them
  - Probe laser runs 4 systems simultaneously

- Rebuilt all the capacity of FACET and:
  - Improved repeatability
  - Improved reliability
  - Pushing to peak performance

- Working on pulse length, laser room space to test optics, spatial filter, pump laser imaging – and much more
  - Over a year of work
  - Science goals drive how this work is prioritized