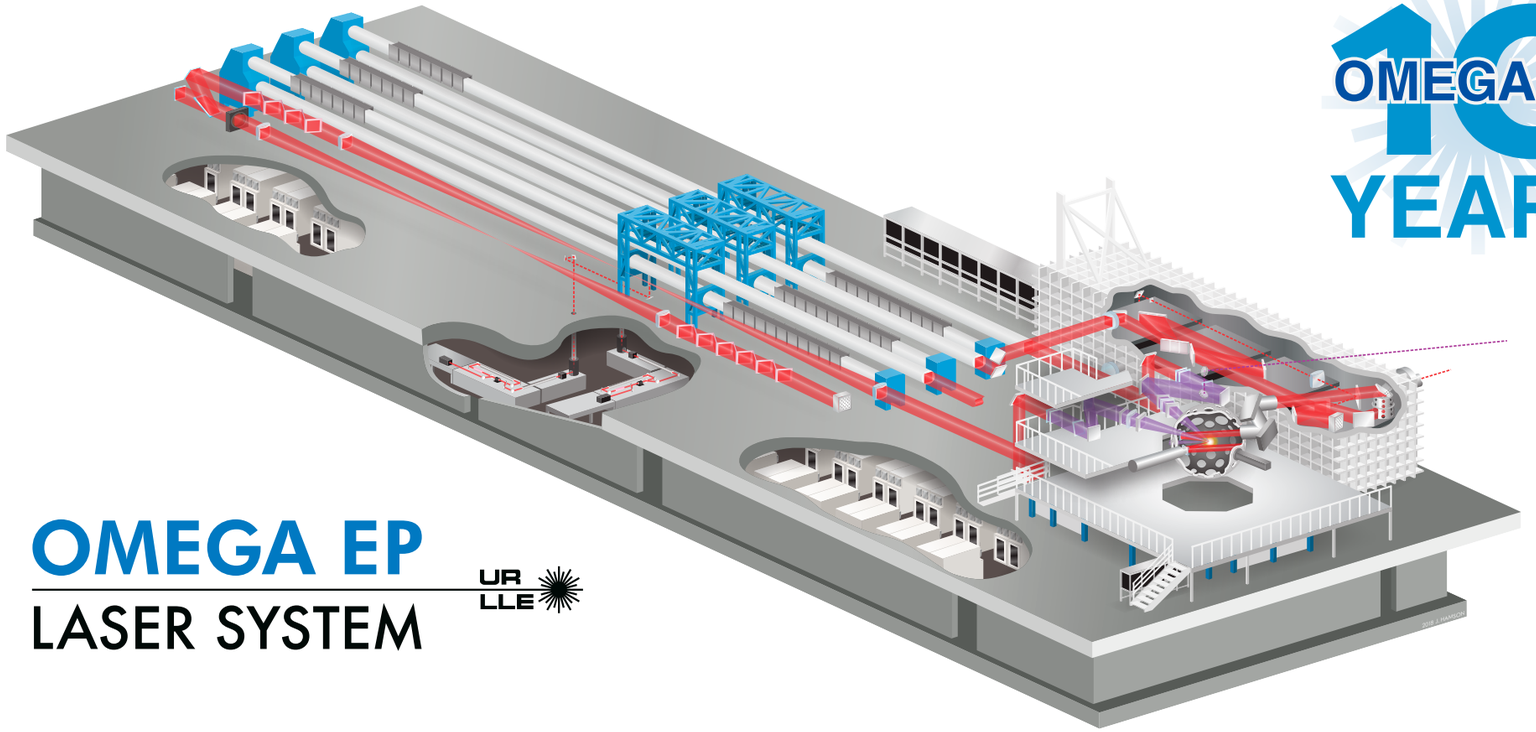
Omega Facility OLUG 2018 Update: Progress on Recommendations and Items of General Interest



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University of Rochester
Laboratory for Laser Energetics

Omega Laser Facility Users Group Workshop
Rochester, NY
25–27 April 2018

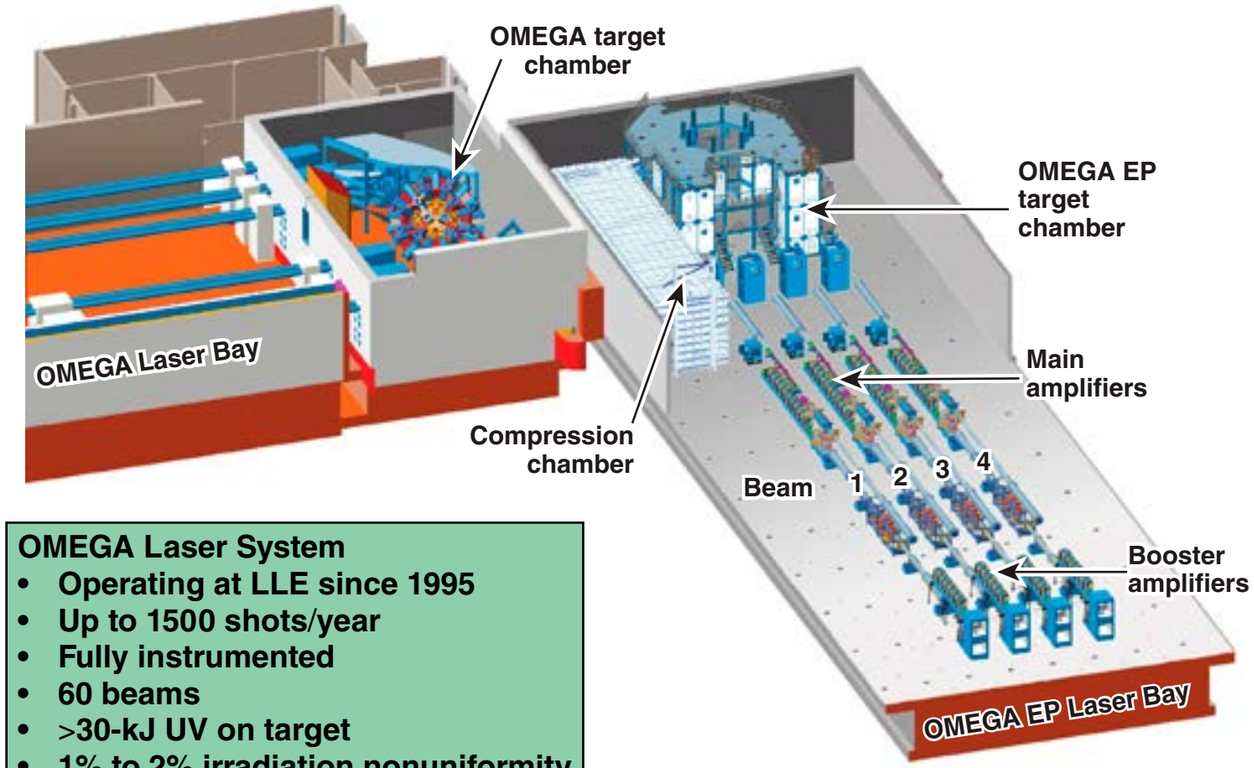
Summary

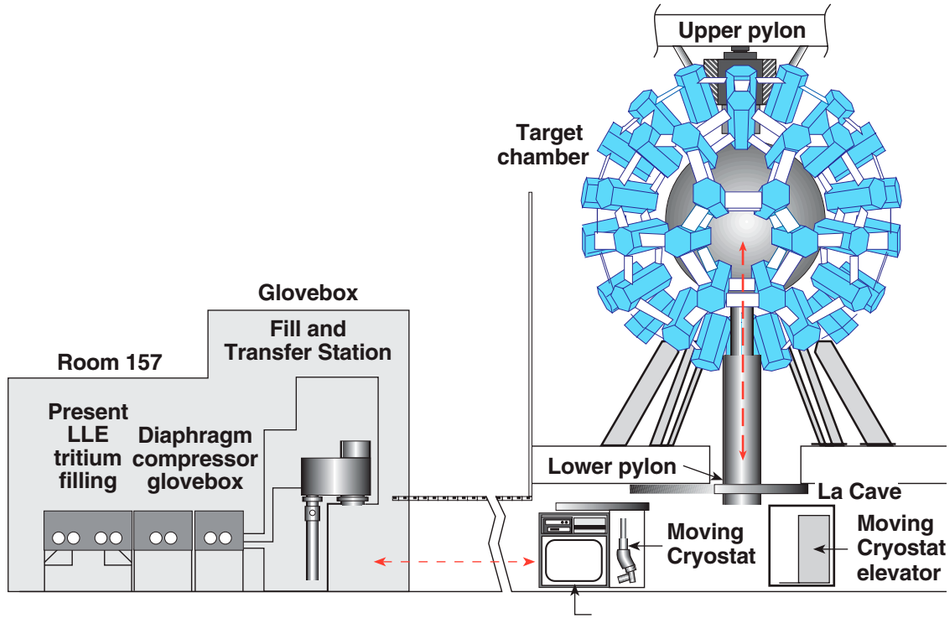
Omega is an effective and efficient facility and evolves to meet the needs of users

- OMEGA and OMEGA EP are National Nuclear Security Administration (NNSA) workhorse facilities
- Operational statistics show continued high performance
- The facility responds to the Omega Laser Facility User Group (OLUG) recommendations
- Significant capability requests were included in the Cooperative Agreement renewal
- Omega supports LLE and user-developed diagnostics

OMEGA EP is exactly ten years post-commissioning this week.

The Omega Laser Facility consists of OMEGA, OMEGA EP, and the Cryogenic and Tritium Facility





OMEGA Laser System
- Operating at LLE since 1995
- Up to 1500 shots/year
- Fully instrumented
- 60 beams
- >30-kJ UV on target
- 1% to 2% irradiation nonuniformity
- Flexible pulse shaping
- Short shot cycle (1 h)

More than half of OMEGA's shots are for external users.

OMEGA EP Laser System
- Construction completed 25 April 2008
- Adds four NIF*-like beamlines; 6.5-kJ UV (10 ns)
- Two beams can be high-energy petawatt
  - 2.6-kJ IR in 10 ps
  - Can propagate to the OMEGA or OMEGA EP target chamber

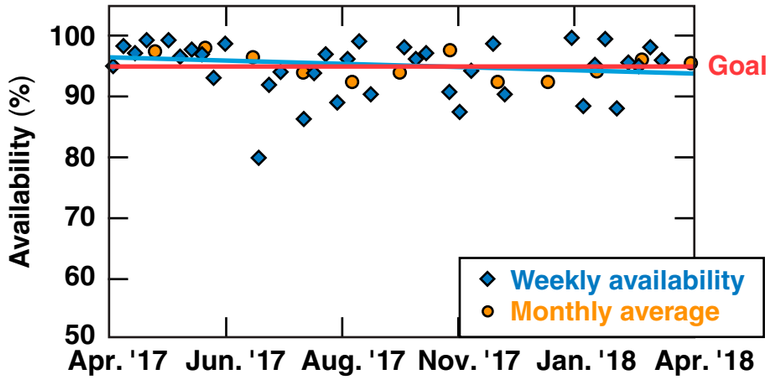
Cryo & Tritium Facility
- Operating since 2000
- Cryo and ambient DT fills
- DT cryo since 2006
- Spherical and planar geometry
- ~50 DT cryo implosions/yr

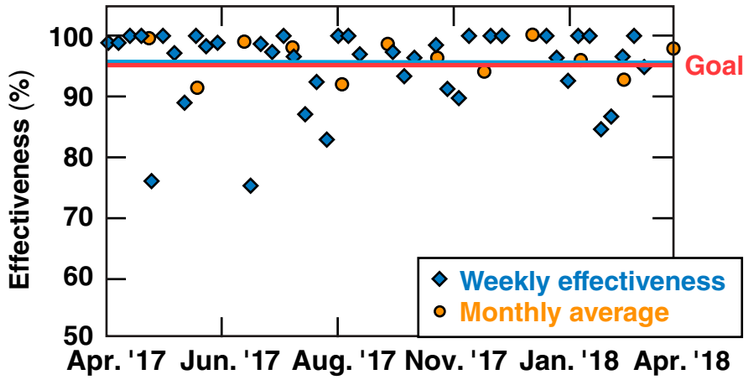
G10425n

*NIF: National Ignition Facility

The Omega Laser Facility tracks and reports availability and effectiveness quantitative metrics

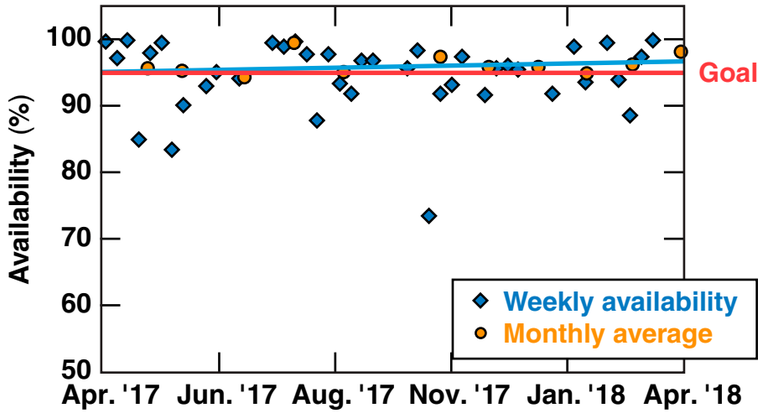
OMEGA

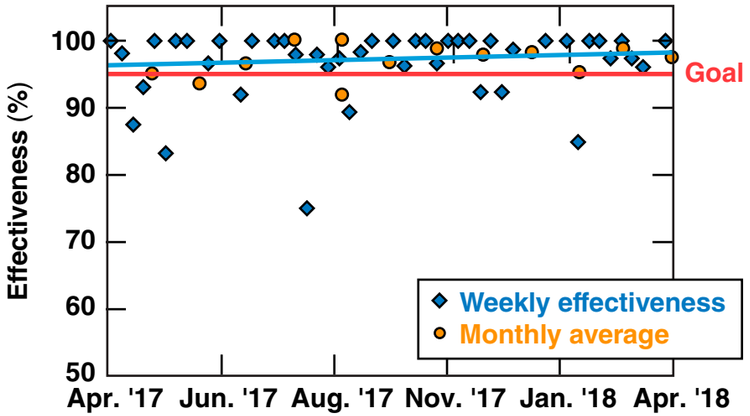




April ’17 to April ’18	OMEGA	OMEGA EP
Target shots	1341	906
Availability	95.2%	96.1%
Effectiveness	95.4%	96.9%

OMEGA EP





Availability and effectiveness continue to indicate high reliability and productivity.

G12032

LLE is making good progress on many of the April 2017 Findings and Recommendations (1 of 4)

1. We recommend increasing the NLUF shot allocation to advance fundamental high-energy-density (HED) science and student/postdoc training
2. We recommend an opposing-beam configuration for OMEGA EP
3. We recommend developing the capability for an absolute measurement of Raman backscattered light
4. We recommend a distributed phase plate (DPP)-smoothed, nanosecond-duration beam with a small focal spot on OMEGA EP
5. We recommend additional heated tritium fill cells for filling glass capsules

Green = complete
Orange = in process
Red = deferred lack of funding
Black = withdrawn

G12033

LLE is making good progress on many of the April 2017 Findings and Recommendations (2 of 4)

6. We recommend a facility-owned TIM-mounted, DMX-type instrument to spectrally characterize x-ray drives in OMEGA EP
7. We recommend more options of spectral range coverage for the high-resolution spectrometers IXTS and HRS2
8. We recommend a Thomson-scattering capability for OMEGA EP
9. We recommend to update/expand the flat-fielding database of x-ray framing cameras
10. We recommend having a Dante radiation temperature analysis and time-history result available during shot day

TIM: ten-inch manipulator
IXTS: imaging x-ray Thomson spectrometer

G12034

LLE is making good progress on many of the April 2017 Findings and Recommendations (3 of 4)

11. We recommend several upgrades and improvements of the ASBO* and SOP** diagnostics
12. We recommend a three-wavelength VISAR† system for OMEGA EP
13. We recommend improving the beam combiner optic lifetime and/or replacement capability, to support year-round interleaved joint OMEGA/OMEGA EP shots
14. We recommend the option of taking photos of OMEGA EP shots
15. We recommend to investigate extending the duration of OMEGA EP UV beams to 15 to 20 ns

*ASBO: active shock breakout
**SOP: streaked optical pyrometer
†VISAR: velocity interferometer system for any reflector

G12035

LLE is making good progress on many of the April 2017 Findings and Recommendations (4 of 4)

16. We recommend investigating the feasibility of splitting one of the OMEGA EP short-pulse beams into two focal spots

17. We recommend that work to improve the PI portal and web-based resources continues with emphasis on data permission access

18. We recommend a web-based system and better microphones for pre-shot briefings so offsite attendees can improve their involvement and participation in the discussions

19. We recommend adding a web-based meeting option to Monday morning's experiment briefings so PI's who want to join the meeting after their experiment can do so

Current status: 7 green, 8 orange, 4 red

F & R #1

The Facility Advisory & Scheduling Committee (FASC) voted to increase Basic Science shot time

1. *We recommend increasing the NLUF shot allocation to advance fundamental HED science and student/postdoc training*
   - The FASC has membership from all National Labs and LLE
   - One action of the committee is to recommend following year allocations
   - With OLUG request in mind, the FASC recommended increasing the fraction of NLUF and LBS facility time
   - The action notionally adds four shot days to basic science, an 8% increase (two NLUF, two LBS)
   - The recommendation from the FASC is subject to NNSA guidance

The preliminary FY19 schedule will be developed at the FASC Annual Meeting 12–13 June.

G12037

F & R #2

Opposing beams on OMEGA EP are a longstanding OLUG request that LLE would like to support

UR LLE

2. *We recommend an opposing beam-configuration for OMEGA EP*

- **Action: This request, pending since 2011, is a significant engineering project; the cost was estimated at ~$2 M**
- **This is on par with the annual allocation for all diagnostics projects at LLE**
- **LLE will continue to advocate for this capability with the NNSA and welcomes support from the user community for advocacy**

G12038

F & R's #3

Item #3 could potentially be facilitated by a user

3. *We recommend developing the capability for an absolute measurement of Raman backscattered light science and student/postdoc training*

- **Raman observed from 450 to 700 nm makes calibration difficult; current calibration is only at 351 nm and there is a discrepancy between Beams 25 and 30 FABS; Raman measurements may be off by 4×**
- **An alternate source needs to be directed to Beams 25 and 30**
- **LLE could support a user-developed system to accomplish this**

F & R #4

UV DPP design and analysis work is underway for OMEGA EP

UR LLE

4. *We recommend a DPP-smoothed, nanosecond-duration beam with a small focal spot on OMEGA EP*

- **OMEGA EP System Science and Theory DPP design staff are evaluating the optimum parameter space for this request**
- **UV beamline wavefront characterization has commenced**
- **Under evaluation:**
  a) 125-μm-radius (1/e) super-Gaussian fifth order
  b) 100-μm-radius (1/e) super-Gaussian fifth order
- **Item (b) has a theoretical 95% encircled energy radius of 111 μm and with 1.25 kJ in a 1-ns pulse would give intensity = 2.85×10^{15} W/cm^2, four beams equipped with these DPP's = 1.1×10^{16} W/cm^2**

G12040

F & R #5

Items 5 requests additional DT target filling flexibility

5. *We recommend additional heated tritium fill cells for filling glass capsules*

- **A second "Hoppe Fill" heated fill system was built and this year it was deployed for a D_2 glass target fill (in the LLE Target Fab)**
- **The deployment of two heated "Hoppe Fill" systems inside the DT glovebox would be operationally cumbersome and undesirable**
- **A more-flexible and robust fill system concept has been developed and will be submitted as a project for FY19**

G12041

F & R #6

Optical diagnostics on OMEGA continue to evolve

6. *We recommend a facility-owned TIM-mounted, DMX-type instrument to spectrally characterize x-ray drives in OMEGA EP*

- **No significant progress**
- **LLE has considered options to accomplish**
- **Significant resources and sustained investment required to make calibrated measurements**
- **A user-developed instrument could be supported**

A strong scientific case does not exist internal to LLE, request OLUG continue to analyze, demand, and justify the cost and effort.

F & R #7

Spectral capabilities of x-ray spectrometers have been increased with the addition of new crystals

UR LLE

7. *We recommend more options of spectral range coverage for the high-resolution spectrometers IXTS and HRS2*

- **LLNL has fabricated crystals for IXTS and additional ranges have been tested on OMEGA EP (February)**
- **HRS2 capability continues to evolve:**
  - **modified existing crystal position**
  - **can now measure the Ni K edge (as of Q1 FY18)**
  - **potentially important to x-ray absorption near edge structure (XANES) investigation**
  - **however; HRS2 is a fixed geometry instrument with limited flexibility**
- **OLUG could consider requesting another survey spectroscopy platform with a full hemisphere of angular coverage in the second leg**

F & R #8

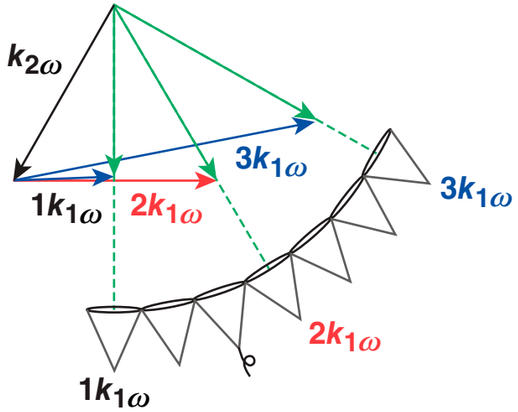
Optical Thomson scattering on OMEGA EP requires construction of the scattering source laser

UR LLE

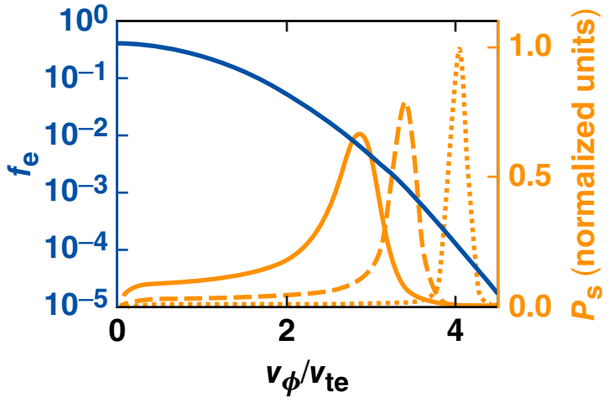
8. *We recommend a Thomson-scattering capability for OMEGA EP*

- **A TIM-based Thomson-scattering device with >90° collection is in development**
- **The fourth-harmonic probe is being modified to be a higher-energy second-harmonic scattering-source laser**

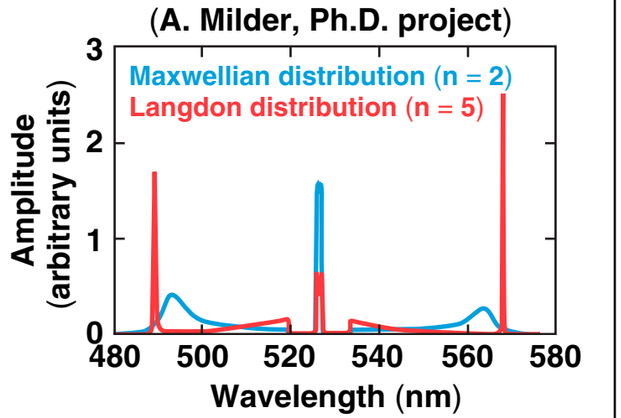
New k-resolved Thomson scattering



Each scatttering angle probes a different part of the distribution function



Multiple scattering angles could measure the Langdon effect



G12044

F & R #9

Flat-field characterization of x-ray framing cameras has been expanded

9. *We recommend to update/expand the flat-fielding database of x-ray framing cameras*

- **Additional data has been acquired for all framing cameras, please see C. Sorce with any requests**
- **More work needs to be done to make the database user accessible**
  - **in the IT/Informatics queue**

G12045

Radiation temperature analysis for DANTE resides at LLNL

10. *We recommend having a DANTE radiation temperature analysis and time-history result available during shot day*

- **LLNL owns the reduction code**
- **A LLNL collaborator (co-PI) can usually expedite analysis**
- **The issue is really “during the shot day”—recommend OLUG take the request to LLNL directly**

G12046

A new telescope will be installed in June on the OMEGA and OMEGA EP ASBO and SOP systems and progress is being made on the other F&R's

11. *We recommend several upgrades and improvements of the ASBO and SOP diagnostics*

Findings and recommendations request	Current status
Suppress the "wiggles" in OMEGA EP ASBO	Wiggles not always present, source unknown, still a problem?
Smaller field of view option (2× higher magnification along the imaging direction) to accommodate smaller targets (DAC's, PXRDIP's, etc.)	Updated telescope still at ~13×, design started for 2× higher magnification
Absolute calibration of SOP in OMEGA EP	Calibration data collected, Experimental Support Group needs help to analyze and create calibration analysis programs
Faster timing combs	2-GHz comb will be replaced by 5 GHz in ~May 2018, 10-GHz comb by end of FY18
A centralized server to archive and make available all necessary calibration details; timing, magnification, and SOP calibration	Server request noted and passed along to Informatics and IT group

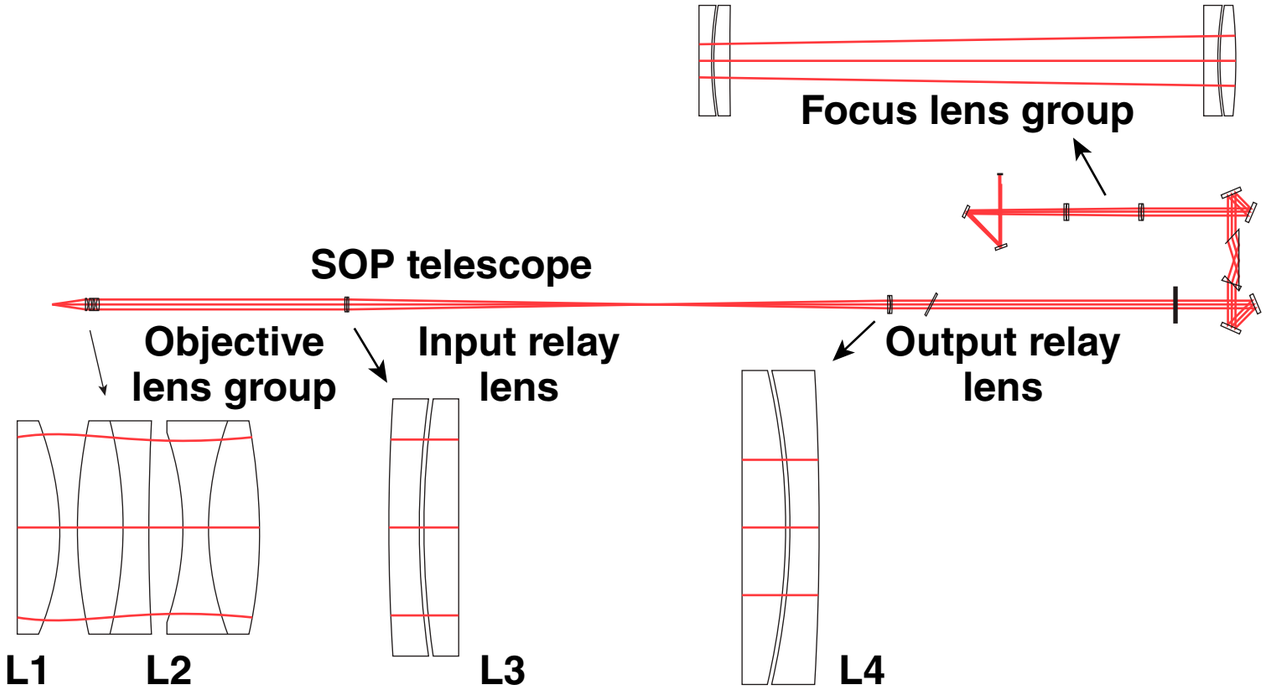
DAC: diamond anvil cell
PXRDIP: powder x-ray diffraction image plate

G12047

Multiwavelength VISAR for OMEGA EP is a major modification to a workhorse diagnostic

12. *We recommend a three-wavelength VISAR system for OMEGA EP*

- The modifications for SOP telescope minimize chromatic aberrations in the collection and relay optics to the VISAR cabinet
- The system will relay 530 to 850 nm with high-quality broadband correction
- An FY19 project will be submitted to add a second wavelength to VISAR on OMEGA EP
- Stay tuned for a broadband reflectivity concept in development! Simultaneity? $1 to 2 million? Is ~800 nm ok?



G12048

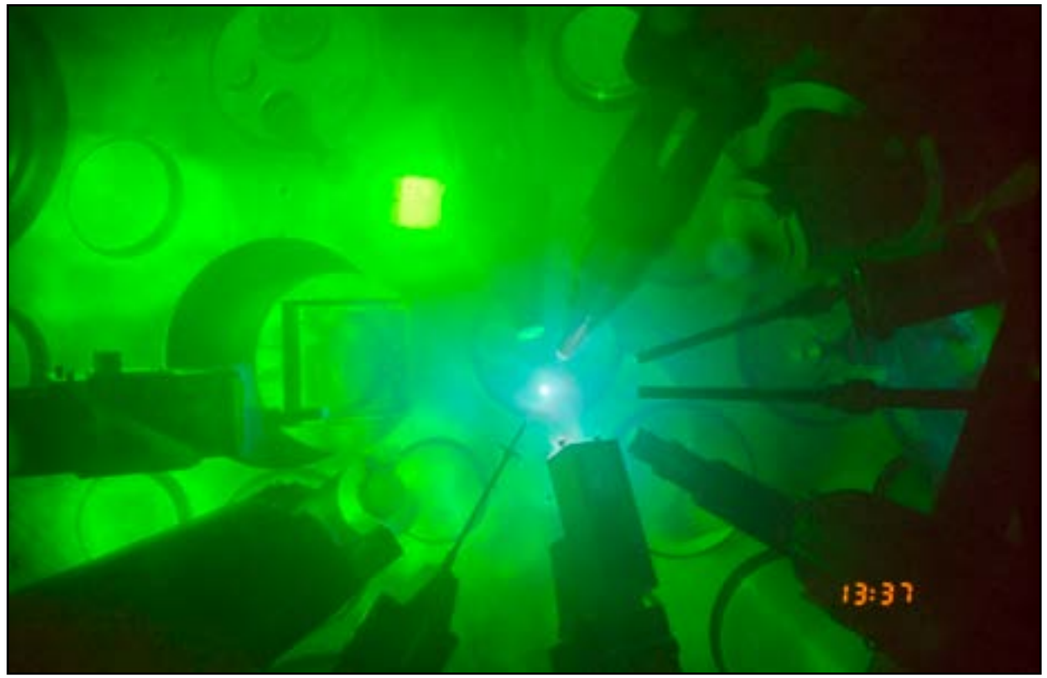
New coating capability in Optical Manufacturing (OMAN) is coming on-line

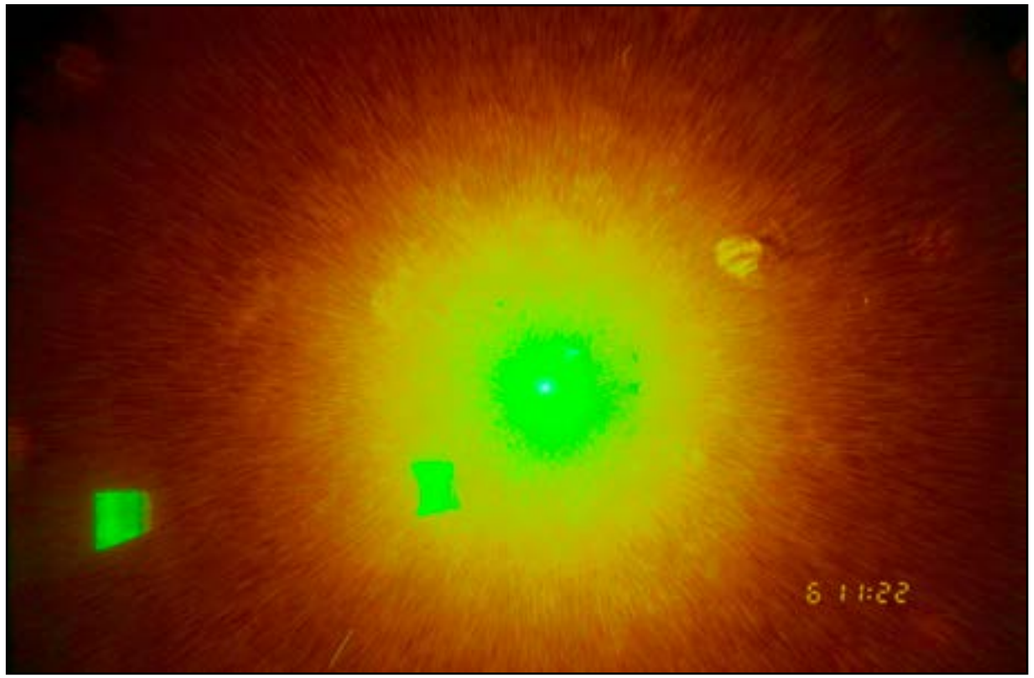
13. *We recommend improving the beam-combiner optic lifetime and/or replacement capability, to support year-round interleaved joint OMEGA/OMEGA EP shots*

- **This is the most challenging optic to produce for OMEGA EP**
- **Stress management is key; standard technology has propensity to craze**
- **OMAN just installed new plasma ion-assisted deposition (PIAD) equipment in the new 74-in. chamber (CEA chamber)**
- **PIAD coating development is secondary to CEA optic production but will occur interleaved with production**
- **Once successful subscale coatings achieve requirements then a full-scale beam combiner will be coated, first attempt anticipated in CY 2019**

A self-emission survey camera has proven to be a useful tool on OMEGA; the OMEGA EP camera is online

14. *We recommend the option of taking photos of OMEGA EP shots*





Shot 27689 3/1/2018

G12050

Longer pulses on OMEGA EP are in development in FY18, schedule to completion still pending

15. *We recommend to investigate extending the duration of OMEGA EP UV beams to 15 to 20 ns*

- **A project was launched after OLUG 2017 to develop a new extra-long pulse regen (ELPR)**
- **ELPR will be a glass regen based on OMEGA and NIF-ARC proven design elements**
- **FY18 goal is to design, build, and characterize the ELPR**
- **Integration on OMEGA EP will require a significant overhaul of OMEGA EP sources, this is a multi-year initiative (recommend retaining on F&R)**

The OMEGA regenerative oscillator (regen) is a key element of system performance and reliability, gain is in excess of 10^6.

G12051

ARC: advanced radiographic capability

Two foci from a single beam is challenging to achieve

16. *We recommend investigating the feasibility of splitting one of the OMEGA EP short-pulse beams into two focal spots*

- Short-pulse near fields have ~2-cm gaps that could be exploited
- Five concepts are in consideration for accomplishing this F&R
  - engineer transport mirror with three independent tiles
  - cut OAP and make one piece adjustable
  - insert a transmission wedge in one beamlet in the beam path
  - split one of the OMEGA EP beams before the compressor
  - use a plasma refocusing mirror
- A refined set of requirements would help in the trade-off of these approaches
- This is a costly and multi-year F&R, requiring sustained importance from OLUG and funding priority

Short-pulse Beam 2
shot #27696, 3/1/18

OAP: off-axis parabola

G12052

IT related items are frequently revealed in the valuable “postdoc” open forum

17. We recommend that work to improve the PI portal and web-based resources continues with emphasis on data permission access
    - Work continues
18. We recommend a web-based system and better microphones for pre-shot briefings so offsite attendees can improve their involvement and participation in the discussions
    - Partially done
19. We recommend adding a web-based meeting option to Monday morning’s experiment briefings so PI’s who want to join the meeting after their experiment can do so
    - Done!

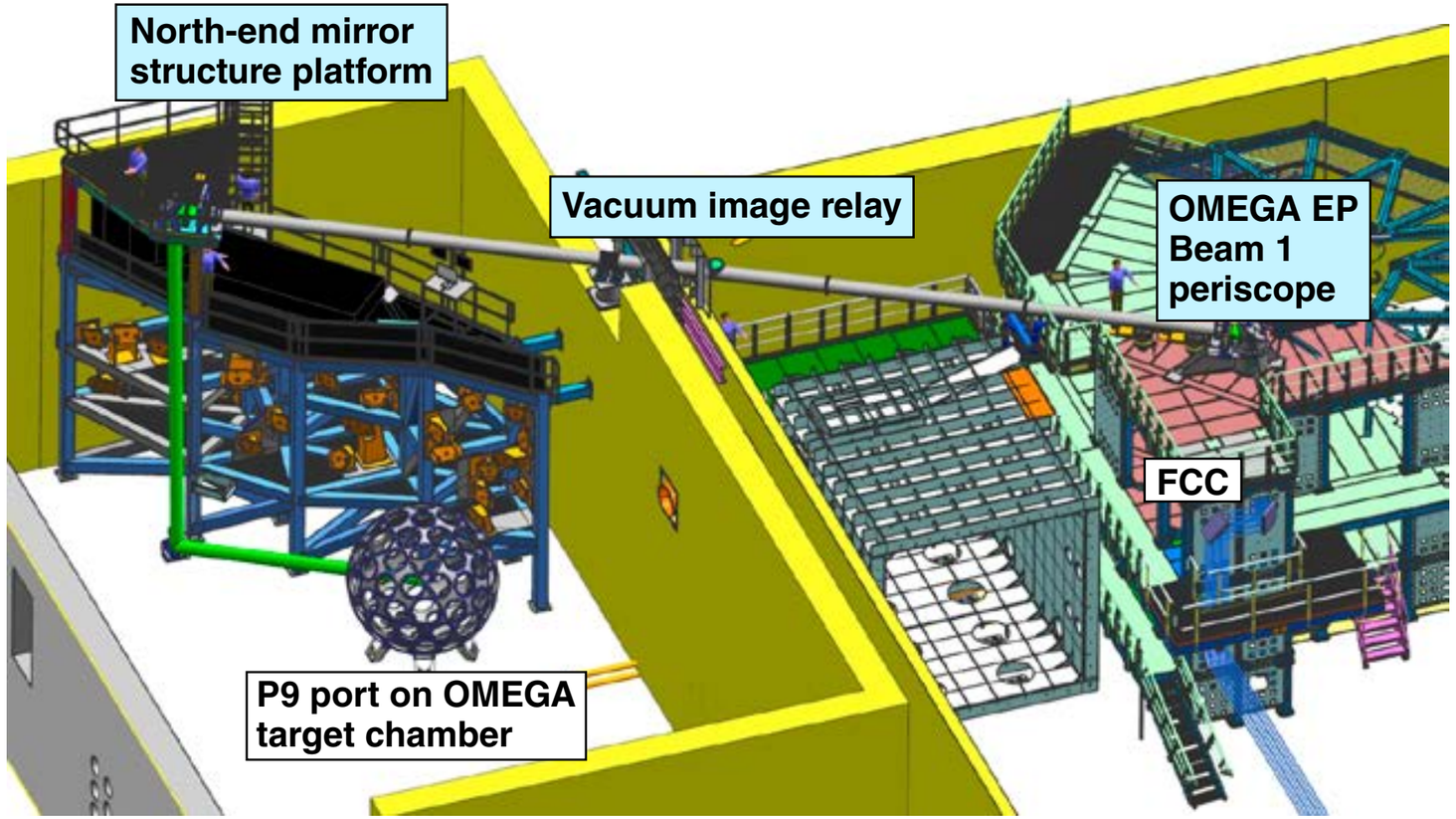
UPDATES on prior year OLUG F&R requests and items of general interest

- LLE continues to improve power balance*
  - P510 signal integrity improved with energy-balanced signals, fluorescence suppression, cross-talk mitigation, etc.
  - beam-splitter balance improved with noise source mitigated
  - optics with higher transmission losses identified, LCP's for example
- The fourth-harmonic probe system has been improved**
- The gas-jet system has been deployed, operational envelope expanding†
- The tunable OPA beam on OMEGA EP is being activated††, ‡
- Target Viewing System software enhancements improve target positioning analysis‡‡
- OMEGA EP spherical crystal imager improvements

*S. Sampat *et al.*, this conference.
L. J. Waxer *et al.*, this conference.
**R. Brown *et al.*, this conference.
†D. Mastrosimone *et al.*, this conference.
††B. E. Kruschwitz *et al.*, this conference.
‡A. Consentino *et al.*, this conference.
‡‡G. Pien *et al.*, this conference.
LCP: liquid crystal polarizer

G12054

A tunable (~ ±1-nm) UV beam is in development for laser–plasma interaction (LPI) from OMEGA EP to OMEGA port P9

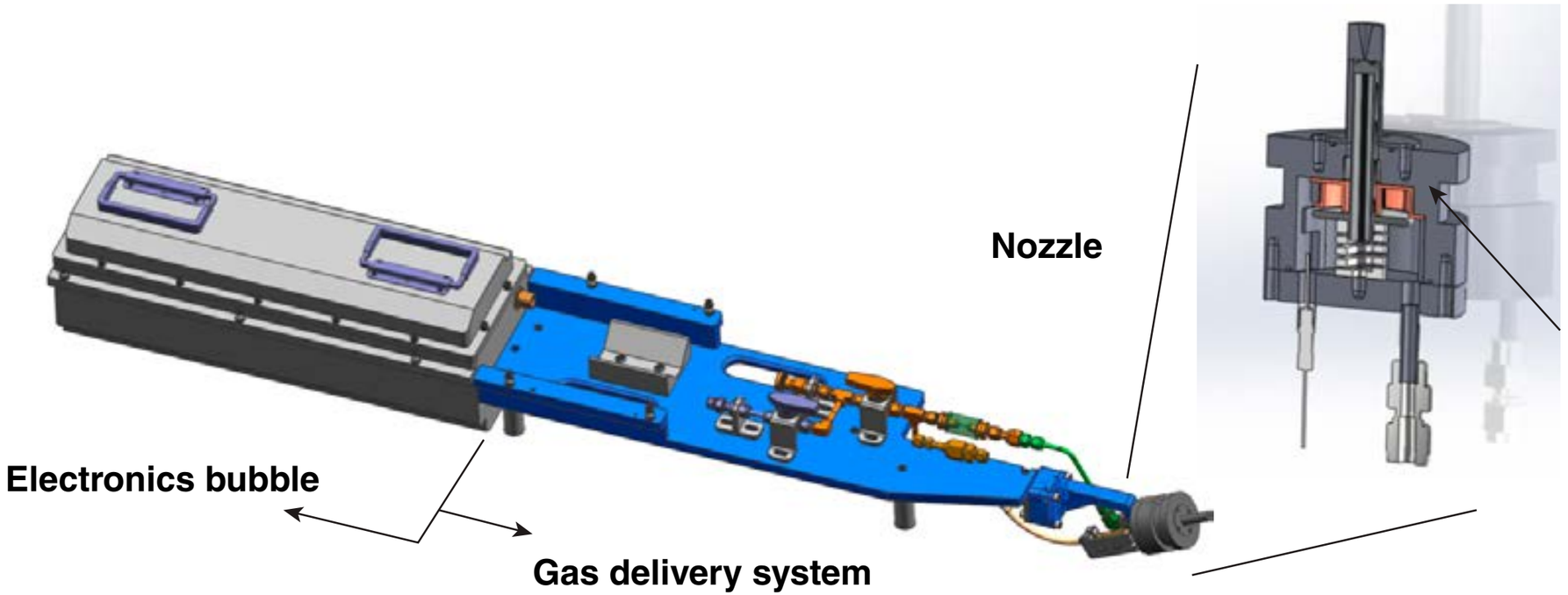


Planned completion in June 2018.

G12055

The LLE gas-jet system has been deployed on OMEGA and OMEGA EP and looks to become a popular system

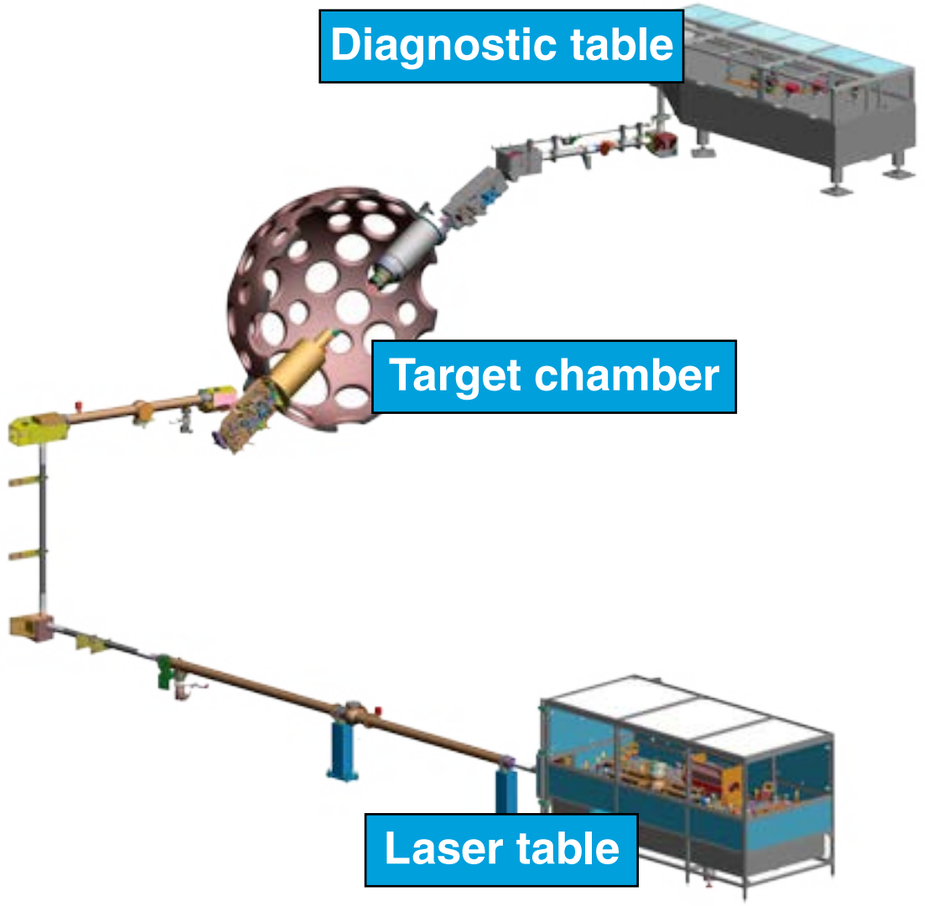
- First used with long-pulse beams in OMEGA in August 2017*
- Fielded in OMEGA EP in November 2017
- Will be fielded in OMEGA EP with short-pulse beams in May 2018



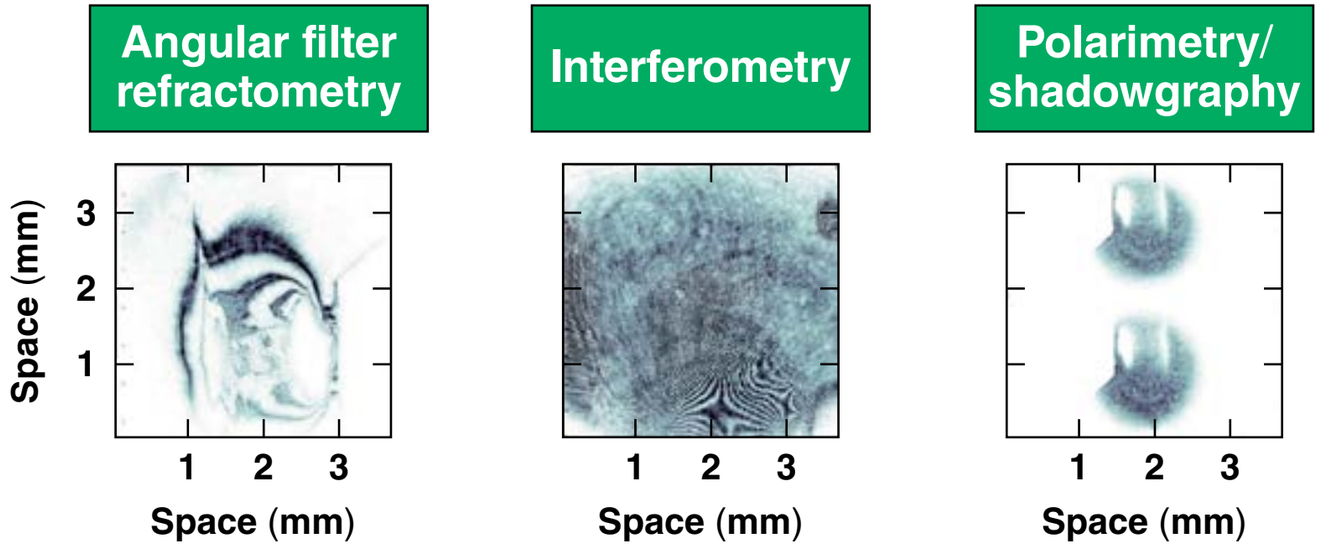
*H. Rinderknecht *et al.*, Phys. Rev. Lett. 120, 095001 (2018).

G12056

The fourth-harmonic probe beam plasma diagnostics are routinely requested for low-density plasma experiments



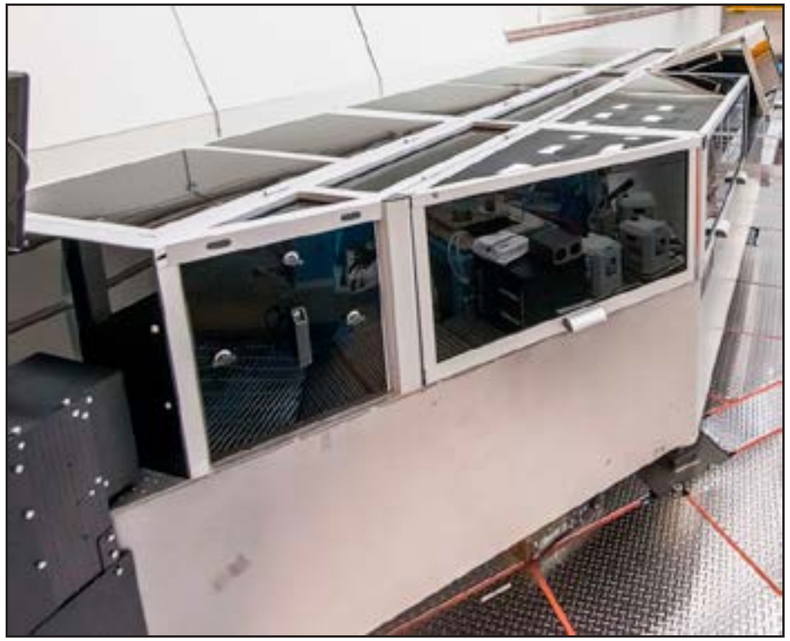
- Activated in November 2012
- The probe beam is 3.3-mm diameter at target chamber center with
  - wavelength = 263 nm; pulse width ≈ 10 ps
- The diagnostic table uses multiple techniques to diagnose plasma at high spatial resolution (5 μm)

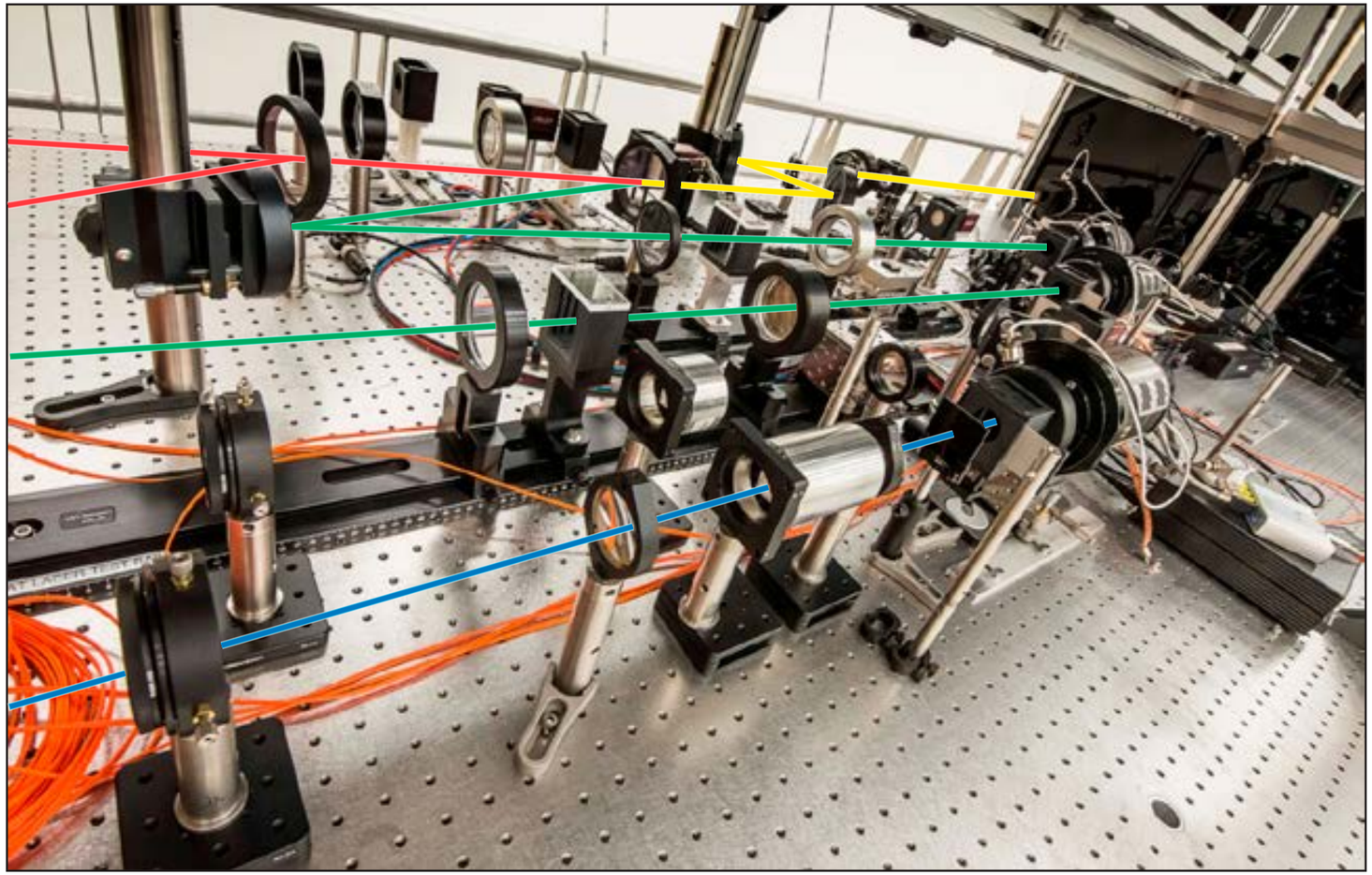


*LLE Review Quarterly Report 137, 50 (2013).

G12057

An interferometry arm was improved in FY18 on the 4ω diagnostic suite on OMEGA EP





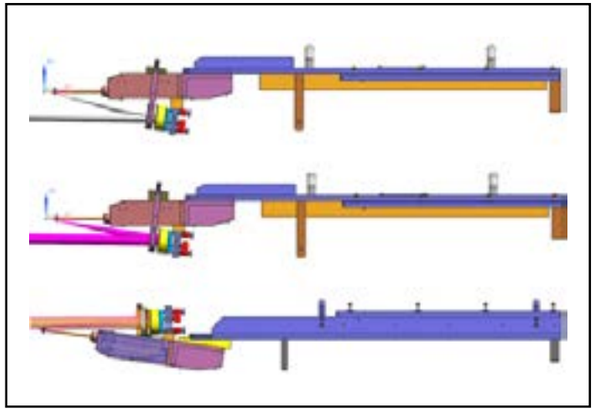
Shared 4ω beamline
Interferometry
Angular filter refractory (×2)
Polarimetry

G12058

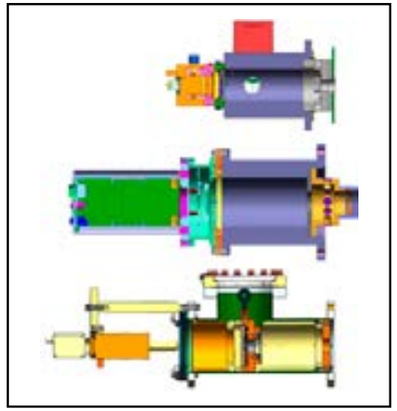
The OMEGA EP spherical crystal imager (SCI) has been improved for capability and flexibility, an OLUG 2016 F&R

- Three crystals:
  - 8.0 keV (Cu) at 1.3°
  - 6.1 keV (Mn) at 5.1°
  - 1.2 keV (Si) at 6.1°
- Three detectors:
  - x-ray charge-coupled device (CCD)
  - image plate
  - framing camera
- Collimator and line-of-sight (LOS) block are on detector side
- Retractable pointer for ease of alignment
- Fiber illuminator for optical alignment

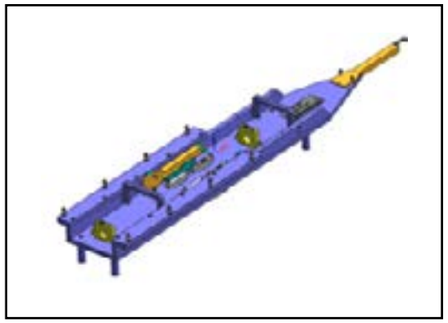
Three crystal assemblies deployed from TIM-10



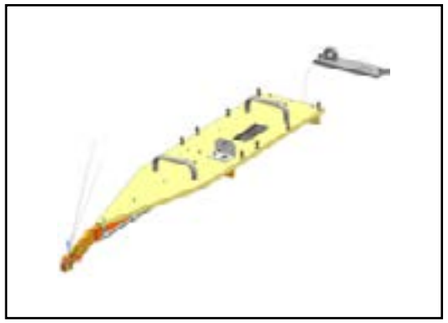
Three detectors mounted behind TIM-13



One collimator and LOS block assembly deployed from TIM-13



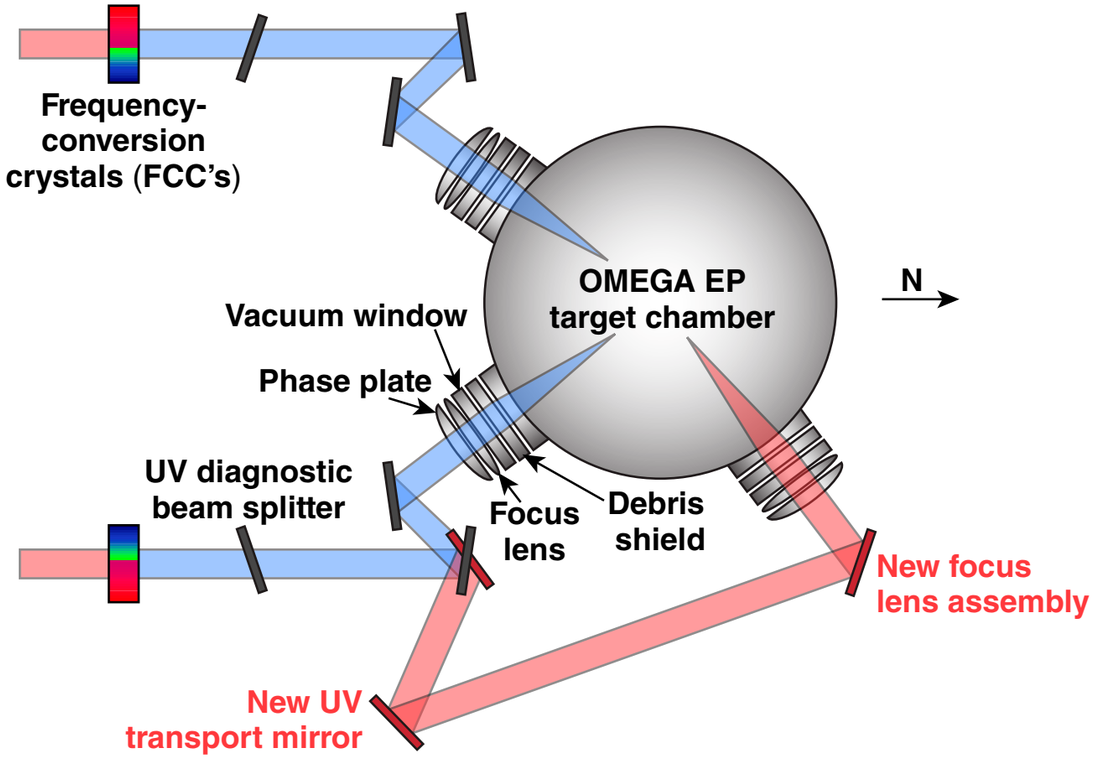
One fiber alignment assembly deployed from TIM-12



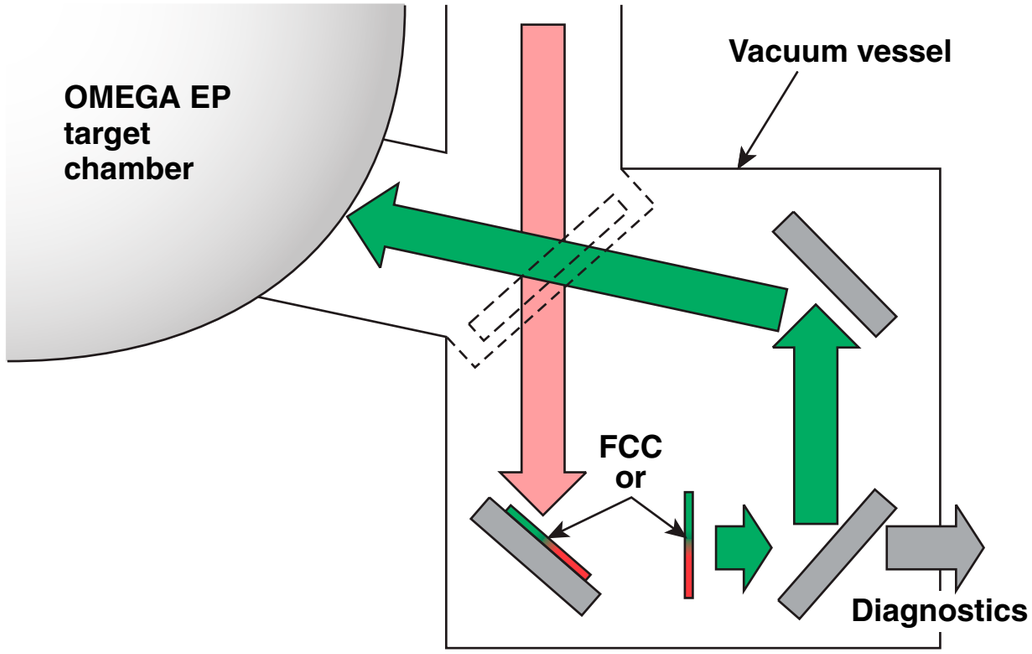
G12092

LLE continues to consider larger OLUG requests for future development

- Opposing-beam configuration

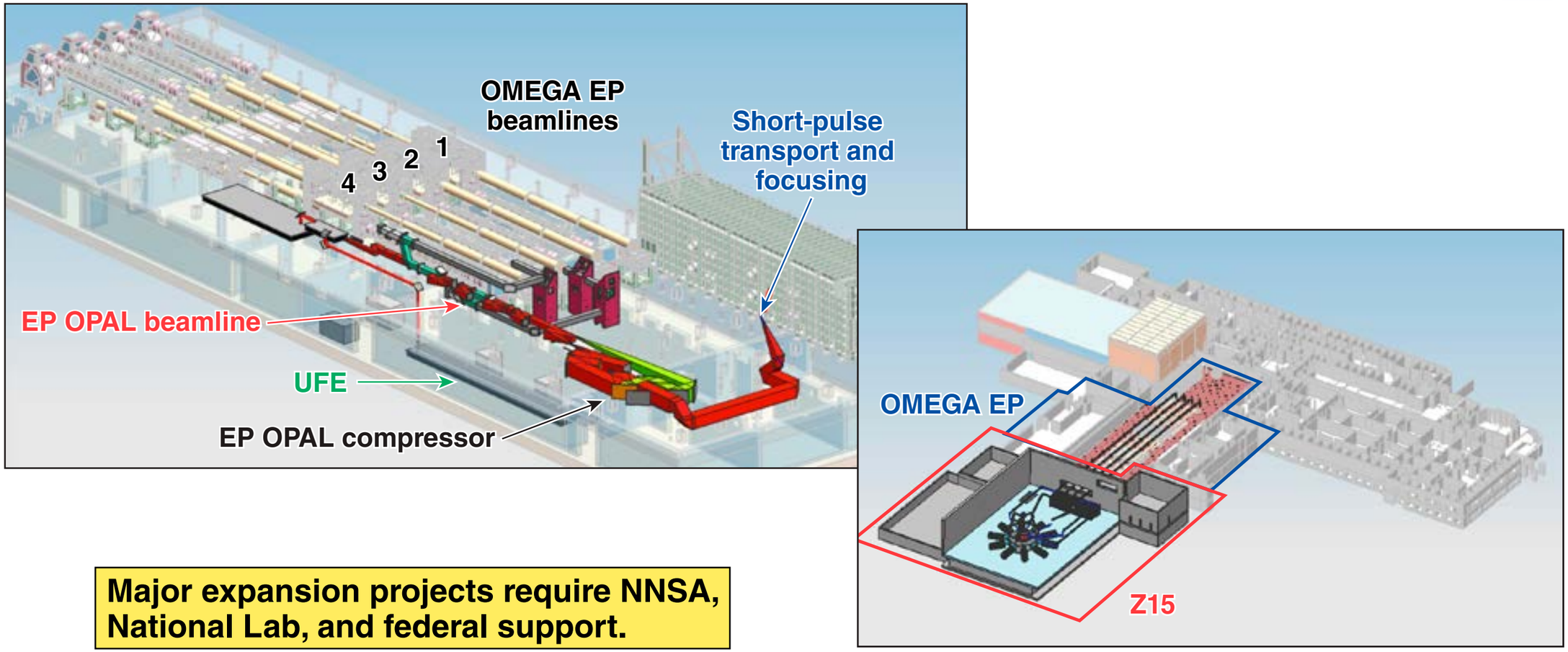


- Short-pulse doubling



G12059

LLE will not be proposing any large-scale projects in the next five-year Cooperative Agreement



Major expansion projects require NNSA, National Lab, and federal support.

OPAL: optical parametric amplifier line
UFE: ultra-broadband front end

G12060

Summary/Conclusions

Omega is an effective and efficient facility and evolves to meet the needs of users

- OMEGA and OMEGA EP are National Nuclear Security Administration (NNSA) workhorse facilities
- Operational statistics show continued high performance
- The facility responds to the Omega Laser Facility User Group (OLUG) recommendations
- Significant capability requests were included in the Cooperative Agreement renewal
- Omega supports LLE and user-developed diagnostics

OMEGA EP is exactly ten years post-commissioning this week.