FY17 Laser Facility Report

During FY17, the Omega Laser Facility conducted 1353 target shots on OMEGA and 785 target shots on OMEGA EP for a total of 2138 target shots (see Tables 152.IV and 152.V). OMEGA averaged 10.7 target shots per operating day with Availability and Experimental Effectiveness averages for FY17 of 95.7% and 94.4%, respectively.

OMEGA EP was operated extensively in FY17 for a variety of internal and external users. A total of 773 target shots were taken into the OMEGA EP target chamber and 12 joint target shots were taken into the OMEGA target chamber. OMEGA EP averaged 8.7 target shots per operating day with Availability

Table 152.IV: OMEGA Laser System target shot summary for FY17.

Laboratory	Planned Number of Target Shots	Actual Number of Target Shots	ICF	Shots in Support of ICF	Non-ICF
CEA	39	47	—	—	47
CELIA	17	18	—	—	18
HED	418	471	—	—	471
LBS	121	132	—	—	132
LLE	396	377	—	377	—
LLNL	77	78	78	—	—
NLUF	154	180	—	—	180
SNL	11	15	15	—	—
ARPA-E	17	10	—	—	10
Calibration	0	25	—	25	—
Total	1250	1353	93	402	858

Table 152.V: OMEGA EP Laser System target shot summary for FY17.

Laboratory	Planned Number of Target Shots	Actual Number of Target Shots	ICF	Shots in Support of ICF	Non-ICF
CEA	7	12	—	—	12
HED	210	296	—	—	296
LBS	49	67	—	—	67
LLE	98	132	—	132	—
LLNL	28	35	35	—	—
NLUF	112	139	—	—	139
NRL	21	24	24	—	—
SNL	21	29	29	—	—
Calibration	0	51	—	51	—
Total	546	785	88	183	514

and Experimental Effectiveness averages for FY17 of 95.8% and 96.6%, respectively.

Highlights of Achievements in FY17

1. 100-Gbar Campaign

The OMEGA Laser System is the preeminent direct-drive laser facility. It capitalizes on the benefits of a spherically symmetric laser configuration and high-uniformity focal spots to conduct implosion and high-energy-density–physics experiments. In FY16, LLE embarked on a campaign to seek higher implosion pressures through improved laser power balance and a cryogenic fill-tube target system. In FY17, significant progress was made in these two areas.

LLE has continued the effort to temporally balance the energy over 100-ps sections of the pulse shape. To achieve this, each of the beamlines of OMEGA must balance passive transmission losses and active gain between each of the 60 beams. During earlier characterization of transmission, amplifier losses were directly linked to observed surface scattering. In FY17, 23 amplifier disks were precision cleaned, resulting in a direct increase in transmission and improved balance of passive transmission in the amplifier stages. After a study of the frequency-conversion process was concluded, the second tripler optics were removed since the current three-color-cycle smoothing by spectral dispersion (SSD) does not require a dual-tripler setup. This removal eliminated a source of loss and imbalance in the system. A set of 15 rover calorimeters has been deployed to expedite System Science measurements of the gain and loss of each stage. With dedicated system time, the power imbalance has been cut in half to 3%. Numerous efforts have begun to expand our capability to characterize the system: LLE is working on a full-beam-in-tank (FBIT) diagnostic to observe the focal spot after UV transport; a modification to the streak-camera diagnostic that will improve signal integrity by eliminating fluorescence in the fiber; stage-F digital alignment cameras (to characterize losses caused by pre-shot optics damage); and a passive IR beam-transmission diagnostic that will not require amplified laser shots.

In FY17 significant strides were made on two additional efforts required to reach our goal of 100-Gbar pressure. Achieving the highest uniformity is dependent on the target placement at the time of the implosion. Vibrations have been a major source of target offsets. The moving cryostat transfer carts were outfitted with a vibration isolation stage that uses eddy current feedback to actively damp vibrations. It is difficult to quantify the effect of just these isolators because other changes were also made but the overall improvement is sufficient to achieve ~60% of all targets positioned to less than 10 μm (see Fig. 152.36).

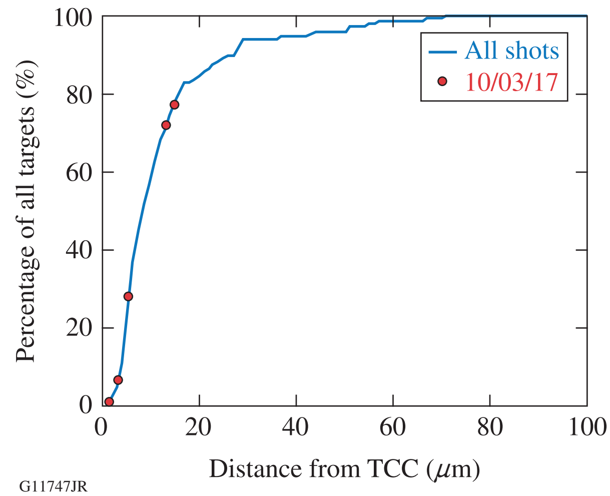

Figure 152.36
Cryogenic DT target positioning accuracy for FY15–FY17, including position data for the five most-recent shots. TCC: target chamber center.

Early theoretical predictions showed that the targets must have nonpermeable capsules to optimize the ablator.[1] A cryogenic fill-tube project is underway to provide for this need on OMEGA and to augment the permeation fill system. In FY17, a DT fill-tube target was successfully layered in the laboratory. By FY20, this system will be able to fill, characterize, and deliver a target to OMEGA.

2. Cross-Beam Energy Transfer Mitigation Study

Longer-term improvements to the laser–plasma interaction physics will require mitigation of cross-beam energy transfer (CBET). This phenomena must be characterized to fully understand how to design a system that minimizes the coupling loss to direct-drive capsules that diverts ~30% of the hydrodynamic drive of implosion capsules. LLE chose to utilize OMEGA EP to produce a tunable UV beam and inject it into the OMEGA target chamber to study CBET. This is an efficient design because it utilizes many of the existing OMEGA EP subsystems with little or no modifications. This effort consists of two main subprojects: (1) The installation and activation of a tunable wavelength source laser injected into the optical parametric amplifier (OPA) system on Beamline 1. The tunable laser was installed in Q3 and is being activated. (2) Transport of the UV beam from the OMEGA EP Bay to port P9 in the OMEGA target chamber. Final design of this project was completed in FY17, and fabrication and installation are underway. Closely tied to this effort, a gas-jet target system has been deployed on OMEGA to produce highly uniform, low-density plasma. This produces the optimum environment to study the interactions of OMEGA beams with the new tunable laser.

3. Improvements to the Laser Systems

The OMEGA EP short-pulse diagnostic package was augmented with a new ultrafast temporal diagnostic able to measure pulse widths between best compression and 100 ps. This feat—achieved with a phase-diversity technique in a fiber pulse stacker[2]—has increased the permissible energy on target for pulses between best compression and 10 ps. This diagnostic is utilized in shot preparations for ensuring proper configuration and also for an on-shot measurement with improved accuracy. Other front-end improvements include the expansion of a time-multiplexed pulse-shaping system to OMEGA EP. Currently deployed on Beamlines 3 and 4, this subsystem allows a single higher-resolution waveform generator to feed the independent OMEGA EP beams and will minimize jitter between pulses. On OMEGA, an improved SSD spectrometer is being used to monitor bandwidth up to the time of shot and to ensure that the phase modulators are operating to specification.

4. Improvements to Target Diagnostics

Diagnostic improvements continue to expand the capabilities of the laser systems. On OMEGA EP, a high-resolution spectrometer has been deployed with the ability to measure time-resolved x-ray spectra over a range that includes the Cu K_α lines. This diagnostic is housed in a 4π lead enclosure to optimize the signal-to-noise ratio (SNR) by preventing scattered x-ray signals from reaching the sensor. The 4ω probe diagnostic has been upgraded with an interferometry arm.

A single-line-of-sight, time-resolved x-ray imager (SLOS-TRXI), developed in conjunction with General Atomics, Lawrence Livermore National Laboratory, Sandia National Laboratories, and Kentech Instruments Ltd., has been deployed on OMEGA to measure hot-spot self-emission with a temporal resolution of 40 ps and spatial resolution of 10 μm. Unique in its ability to take multiple pinhole images along a single axis, this hardware represents the first phase in development with improvements in the areas of throughput and spatial resolution to follow.

LLE continues to design and develop improved diagnostics for characterizing experiments. A neutron time-of-flight diagnostic is being deployed on the H10 port with significant improvement to the SNR. The powder x-ray diffraction diagnostic is being upgraded to acquire time-resolved images.

REFERENCES

1. V. N. Goncharov, T. C. Sangster, R. Betti, T. R. Boehly, M. J. Bonino, T. J. B. Collins, R. S. Craxton, J. A. Delettrez, D. H. Edgell, R. Epstein, R. K. Follet, C. J. Forrest, D. H. Froula, V. Yu. Glebov, D. R. Harding, R. J. Henchen, S. X. Hu, I. V. Igumenshchev, R. Janezic, J. H. Kelly, T. J. Kessler, T. Z. Kosc, S. J. Loucks, J. A. Marozas, F. J. Marshall, A. V. Maximov, R. L. McCrory, P. W. McKenty, D. D. Meyerhofer, D. T. Michel, J. F. Myatt, R. Nora, P. B. Radha, S. P. Regan, W. Seka, W. T. Shmayda, R. W. Short, A. Shvydky, S. Skupsky, C. Stoeckl, B. Yaakobi, J. A. Frenje, M. Gatu-Johnson, R. D. Petrasso, and D. T. Casey, Phys. Plasmas **21**, 056315 (2014).
2. C. Dorrer, L. J. Waxer, A. Kalb, E. M. Hill, and J. Bromage, Opt. Express **23**, 33,116 (2015).