FY16 Laser Facility Report

During FY16, the Omega Facility conducted 1414 target shots on OMEGA and 779 target shots on OMEGA EP for a total of 2193 target shots (Tables 148.IX and 148.X). OMEGA averaged 11.7 target shots per operating day with Availability and Experimental Effectiveness averages for FY16 of 95.6% and 96.6%, respectively.

OMEGA EP was operated extensively in FY16 for a variety of internal and external users. A total of 718 target shots were taken into the OMEGA EP target chamber and 61 joint target shots were taken into the OMEGA target chamber. OMEGA EP averaged 7.9 target shots per operating day with Availability and Experimental Effectiveness averages for FY16 of 96.9% and 95.8%, respectively.

Table 148.IX: OMEGA Laser System target shot summary for FY16.

Laboratory/ Program	Planned Number of Target Shots	Actual Number of Target Shots	ICF	Shots in Support of ICF	Non-ICF
CEA	44	55	—	—	55
HED	423.5	491	—	—	491
LANL	44	52	52	—	—
LBS	115.5	136	—	—	136
LLE	352	327	—	327	—
LLNL	77	75	75	—	—
NLUF	198	232	—	—	232
SNL	22	22	22	—	—
Calibration	0	24	—	24	—
Total	1276	1414	149	351	914

Table 148.X: OMEGA EP Laser System target shot summary for FY16.

Laboratory/ Program	Planned Number of Target Shots	Actual Number of Target Shots	ICF	Shots in Support of ICF	Non-ICF
HED	180	292	—	—	292
LBS	54	82	—	—	82
LLE	120	161	—	161	—
LLNL	12	14	14	—	—
NLUF	90	110	—	—	110
NRL	18	25	25	—	—
SNL	24	37	37	—	—
Calibration	0	58	—	58	—
Total	498	779	76	219	484

Highlights of Achievements in FY16

Spherical implosions on the OMEGA Laser System benefit from symmetric laser drive and uniform beam focal spots. As we continue to seek higher implosion pressures, we have embarked upon a system-wide campaign for improvements in subsystems to achieve improved power balance and uniformity.

In FY16, efforts have focused on temporally balancing the energy over 100-ps intervals of the pulse shape. To achieve this, each stage of beam splitters, spatial filters, and amplifiers must have the passive transmission losses and active gain balanced. An observed visible scatter (haze) has developed on several amplifier disks over 21 years of service, prompting investigation of transmission *in situ*. The haze is a scattering source for IR light and is a primary loss mechanism in the OMEGA system. Efforts in FY16 led to the discovery that this haze can be cleaned and the disks restored to pristine transmission characteristics. Since each amplifier exhibits a unique amount of haze, we will utilize system time in FY17 to systematically address the losses. Additionally, the spatial-filter transmission is affected by damage sites in the lenses. A tighter threshold for replacement was adopted in FY16 to minimize contributions to imbalance. We also completed development of a characterization tool to ensure quantitative measurement of the lens-damage site area within the beam aperture.

The OMEGA equivalent-target-plane diagnostic is a precision far-field laser instrument for characterizing the on-target beam uniformity. It has existed since FY01 and had been used to sample Beam 46 for 15 years. During FY16 it was changed from Beam 46 to Beam 56 to allow a second sample of the laser system. This capability will be used in FY17 to further study the on-target focal spot compared to x-ray images of the same beam recorded on an x-ray charge-coupled–device (CCD) diagnostic.

The relative phase of OMEGA smoothing by spectral dispersion (SSD) modulators gives an effective pointing shift to the on-target focal spot when SSD is used on picket pulses. This phenomenon led LLE to synchronize the modulators to the pulse shape. Previously, the co-timing has been set at the beginning of the day using target shots in an operationally costly manner. This year, a pulse shape was created that has a temporal profile matching the modulation period so that the majority of setup can be achieved before target shots and verified during the standard setup shots such as the pointing shot. Additionally, a streaked spectrometer at the output of the system has been fabricated and dedicated to SSD phase measurement, ensuring that drift does not limit this key aspect of focal-spot position during the campaign.

Several efforts have also been pursued to improve laser capabilities on OMEGA. The beam-to-beam timing system has been optimized to reduce the mean arrival time of the pulse to <3-ps root mean square (rms).[1] This method was demonstrated in FY15 and refined to enable quarterly calibration runs during FY16. The UV spectrometer focus was improved and spectrally calibrated using an in-house laser source matched to the primary wavelength. The OMEGA users identified a need for additional beam blocks to prevent blowthrough on the target chamber. Nine additional units were acquired, increasing the total available to 15.

LLE has supported laser-driven MagLIF (magnetized liner inertial fusion) experiments on OMEGA, including experiments where preheating the gas within a magnetized cylindrical target during compression is required. MagLIF on OMEGA utilizes 40 laser beams to compress a cylindrical target, one beam to preheat the fuel, and the magneto inertial fusion electrical discharge system (MIFEDS) to provide an axial magnetic field. A project was implemented in FY16 to improve the symmetry by properly orienting a single laser beam with respect to the compression beams. This symmetry is not readily available with the spherical symmetry of beams on OMEGA. The Beamline 35 pulse is redirected with the use of multiple mirrors to Port P9 and focused onto the cylindrical target using a newly acquired focus lens for the third-harmonic (351-nm) light. The energetics of Beam 35 are controlled by detuning frequency-conversion efficiency to achieve ~200 J in a 2-ns pulse.

The OMEGA EP short-pulse laser presents a number of challenges to operation because of the high fluence of the beam. Early in FY16, the lower-compressor diagnostic beam path was augmented with a large-aperture, neutral-density (ND) filter to reduce the accumulated B-integral distortions and enable the ability to diagnose the temporal and spectral characteristics of the signal path beam at higher energies. Significant improvements in the available uniformity of filter glass made it possible to calibrate the spatial transmission of this optic. This action ensured the safe operation of the laser at energies much closer to the upper-compressor capabilities.

Numerous improvements have been made to the OMEGA EP Laser System including an overhaul of the SBSS (stimulated Brillouin scattering suppression) system. This system ensures that acoustic waves are not generated during propagation of laser pulses by giving the beam a small amount of bandwidth to avoid the nonlinear Brillouin scattering effect. This effort reduced the amount of lost shot time from >600 min to <40 min per quarter. The short-pulse diagnostic package scanning autocorrelator was upgraded with an improved CCD detector replacing a photodiode, and the ultrafast temporal diagnostics (UTD) upgrade continued to explore the capabilities of pulse lengths between best compression (~700 fs) and 10 ps. The UTD scopes were ordered and will be installed in early FY17.

Additional diagnostic capabilities added in FY16 include a low-yield neutron time-of-flight diagnostic on the H15 port of OMEGA, covering a new range of neutron energies. The proton temporal diagnostic received a 3-cm nose cone, enabling one to more precisely measure DD and D^3He reaction history.

LLE has taken important steps in the development of future target diagnostics, one of which is the OMEGA EP subaperture backscatter system—an initial capability established in FY16. This hardware will measure the stimulated Brillouin and stimulated Raman scattering bands on a UV beam from the target. Measurements began in the fourth quarter and will be used to define the final system architecture.

Important time-integrated measurements of the high-resolution spectrometer diagnostic were completed in FY16. The shots collected data on scientific cameras (future use will include a streak camera for time-resolved measurements) using the two crystal options and paved the way for final design of the system.

The Experimental Operations and support groups have integrated several new key features to improve operational efficiency. The OMEGA Target Bay structure has been augmented with 600 ft^2 of additional decking space to make storage of the increasing ten-inch–manipulator diagnostic inventory more readily available. Additionally, the darkrooms have been outfitted with digital scanners to rapidly provide a moderate resolution image of film-based data to the Principal Investigator and aid in experimental direction during the campaign.

REFERENCES

1. W. R. Donaldson, J. Katz, R. Huff, E. M. Hill, J. H. Kelly, J. Kwiatkowski, R. B. Brannon, and R. Boni, Rev. Sci. Instrum. **87**, 053511 (2016).