FY10 Laser Facility Report

During FY10 the Omega Facility conducted 1343 target shots on OMEGA and 480 target shots on OMEGA EP for a record total of 1823 combined target shots (see Tables 124.III and 124.IV).

Many changes were made to the laser system to improve low-adiabat, direct-drive cryogenic implosion performance. OMEGA conducted 38 DT spherical implosions and 40 planar cryogenic target experiments in support of shock timing. Triple-picket operational improvements highlighted the ongoing development of direct-drive cryogenic implosion capability. The OMEGA Availability and Experimental Effectiveness averages for FY10 were 93% and 94%, respectively.

Table 124.III: Omega Facility target shot summary for FY10.

OMEGA Target Shot Summary					
Laboratory	Planned Number of Target Shots	Actual Number of Target Shots	NIC	Shots in Support of NIC	Non-NIC
LLE	352	361	0	339	22
LLNL	320	376	212	0	164
NLUF	135	150	0	0	150
LANL	130	135	55	0	80
LBS	155	190	0	0	190
CEA	45	55	0	0	55
AWE	30	37	0	0	37
U. Mich.	15	19	0	0	19
FSC	20	20	0	0	20
Total	1202	1343	267	339	737

Table 124.IV: Omega EP Facility target shot summary for FY10.

OMEGA EP Target Shot Summary					
Laboratory	Planned Number of Target Shots	Actual Number of Target Shots	NIC	Shots in Support of NIC	Non-NIC
LLE	200	206	0	193	13
LLNL	95	107	31	5	71
LBS	75	89	0	0	89
NLUF	40	47	0	0	47
LANL	20	24	0	0	24
CEA	5	7	0	0	7
Total	435	480	31	198	251

OMEGA EP was operated extensively in FY10 for a variety of internal and external users. A total of 308 short-pulse IR target shots were conducted. Of these, 232 target shots were taken into the OMEGA EP target chamber and 76 joint target shots were taken into the OMEGA target chamber. A total of 117 OMEGA EP target shots included UV beams. OMEGA EP averaged 4.9 target shots per operating day with Availability and Experimental Effectiveness averages for FY10 of 86% and 94%, respectively.

Highlights of achievements in FY10 include the following:

OMEGA Three-Color-Cycle (3CC) Beam Smoothing

Three-color-cycle (3CC) smoothing by spectral dispersion (SSD) is shown to improve picket-pointing performance in simulations. In April, the OMEGA laser was returned to a 3CC-SSD configuration. For the last decade, OMEGA had operated in the 0.8-color-cycle (or terahertz) SSD configuration. The principal motivation for this action is that the three-color-cycle, 1/3-THz SSD system provides a readily available reduction in the dynamic SSD mispointing error (SSD mpe). SSD mpe became an important parameter when the drive pulse shapes for high-performance cryogenic implosions were converted from continuous foot pulses to discrete picket pulses for adiabat control. Since the ~100-ps pickets sample only a fraction of the full bandwidth, they are susceptible to a pointing deviation from the time-integrated far field. The 3CC-SSD system reduced the SSD mpe from ~40 nm to ~5 nm in the direction of the 10.4-GHz modulator. The system provides smoothing equivalent to the 1-THz, 2-D SSD system for ℓ modes < 200. The 3CC-SSD system uses less bandwidth and has the benefit of frequency converting more efficiently, providing improved power balance and greater available on-target energy.

OMEGA Pulse Shaping

OMEGA pulse-shaping capability continues to evolve to meet the demands of producing triple-picket–shaped pulses for cryogenic experiments. Additional improvements to the Driver Electronics Room's temperature and humidity stability were implemented, significantly improving temporal pulse-shape stability. As a result, triple-picket pulse shapes now routinely achieve precision picket-pulse–shape requirements. Pulse-shape measurement diagnostics and analysis software continue to become more sophisticated to accurately predict picket energies and UV pulse shapes.

Efforts to facilitate on-target picket power balance resulted in significantly improved target-irradiation uniformity for cryogenic implosions. The P510 streak cameras were upgraded with new electronics to further improve pulse-shape measurement capability. Stage-F amplifier gain adjustments were routinely implemented for experiments to balance picket energies as measured by the enhanced P510 streak cameras. Prior to this effort, beam-to-beam picket-pulse energy performance was greater than 10%. Beam-to-beam picket-pulse energy performance of 5% or less is now routinely achieved.

To improve picket energy and pointing performance, the phase of the SSD modulators was synchronized to the system's radio frequency. Simulations indicate that this work will improve cryogenic pulse-shape performance and repeatability on target.

OMEGA Pulse-Shape Measurement Diagnostic

A new short-pulse timing diagnostic was deployed and calibrated on OMEGA EP. The pulse-shape measurement (PSM) diagnostic uses high-bandwidth oscilloscopes and photodiodes to measure short-pulse timing at the output of the grating compressor chamber (GCC). The PSM diagnostic is calibrated using target implosions on both OMEGA and OMEGA EP and is the primary diagnostic for routinely achieving short-pulse beam timings to within 50 ps on the first shot of the day. This diagnostic is also being employed to measure the drift sources of the OMEGA EP Laser System to understand and account for sources of error.

OMEGA Multilayer Dielectric Gratings

A full complement of 12 multilayer dielectric gratings was acquired from a commercial vendor to improve short-pulse energy performance on one of the OMEGA EP beamlines. These gratings followed a development effort and qualification testing of appropriate sub-aperture samples. Notable improvements were made to the production grating cleaning and vacuum-damage test protocols. The 12 compressor gratings were inserted into the GCC upper compressor in two batches: six in June in the first and second tiled-grating assemblies, and the remaining six in the chamber vent at the end of the fiscal year. It is expected that the operational energy envelope of this compressor will be increased by ~50% to >1.5 kJ at 10 ps in the coming year.

Knowledge of the damage limits of currently available large-area diffraction gratings is being improved. A dedicated vacuum short-pulse damage facility has been developed and is being used to study multilayer dielectric gratings under use conditions to guide safe operational limits as well as improve grating-fabrication processes. Furthermore, an *in situ* grating-damage observation system (see **Grating Inspection System for Large-Scale Multilayer Dielectric Gratings for High-Energy Laser Systems**, p. 165) makes it possible to detect damage on the final gratings during operations.

OMEGA EP Focal-Spot Diagnostic

The accuracy of target-plane, on-shot focal-spot predictions using the OMEGA EP focal-spot diagnostic (FSD) has been improved. The FSD uses a wavefront measurement in the short-pulse diagnostics package to predict the target-plane fluence distribution. Phase-retrieval techniques have been implemented that produce a more reliably accurate wavefront measurement that in turn yields significantly more accurate focal-spot predictions (see **Improved On-Shot Focal-Spot Measurement on OMEGA EP Using Phase-Retrieval–Enhanced Wavefront Measurements**, p. 192). As a result, on-shot target-plane focal-spot fluence data are now provided post-shot for short-pulse shots on OMEGA EP (see Fig. 124.76). The improved FSD will

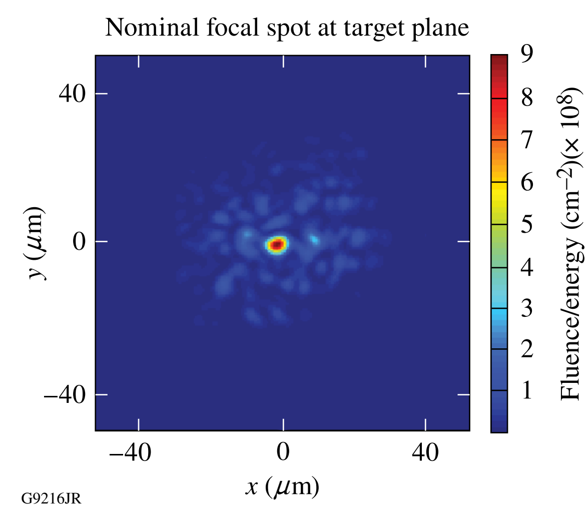

Figure 124.76
An example of an on-shot target-plane fluence measurement provided by the OMEGA EP focal-spot diagnostic on a short-pulse target shot.

play a central role in efforts to improve focal-spot repeatability and focusability.

OMEGA EP Contrast Diagnostic

Temporal contrast is now being measured in the short-pulse OMEGA EP beamlines using the high-contrast diagnostic suite (see Fig. 124.77). The on-shot contrast of short-pulse beams has been characterized using a set of calibrated fast photodiodes. This diagnostic is now operating on all high-energy shots, and nanosecond-contrast data are provided to the users. The nanosecond contrast is dominated by the parametric fluorescence from the front end that extends over a few nanoseconds, and the power of the associated pedestal is typically $10^6\times$ lower than the peak power. The contrast of the optical parametric chirped-pulse amplifier (OPCPA) front end propagating through the entire laser system has been measured using a high-resolution scanning nonlinear cross-correlator in a temporal window starting 700 ps before the main pulse. No significant discrete prepulse has been observed. These diagnostics have been used to study the contrast of OMEGA EP and support contrast-improvement campaigns. Contrast improvements have been realized by optimizing the wavelength of the seed source for the OPCPA pump, the timing between the pump and signal in the OPCPA, and the nonlinear crystal configuration in the OPCPA front end. The contrast data are combined with data from the FSD to predict the on-shot intensity contrast of the pulse and the intensity of the nanosecond pedestal.

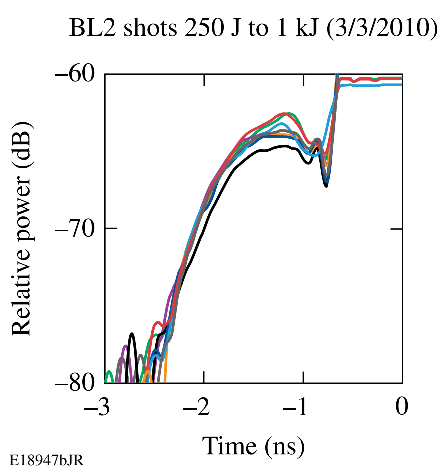

Figure 124.77
Nanosecond contrast data of shots taken on 3 March 2010. On-target contrast improvements have been measured with the high-contrast diagnostic suite.

OMEGA EP Distributed Phase Plates

The first two distributed phase plates were deployed on OMEGA EP in November 2009. These UV phase plates produce 750-μm-diam focal spots and have been used extensively for experiments.

OMEGA EP Parabola Vacuum Antechambers

Vacuum antechambers for the backlighter and sidelighter off-axis parabolas (OAP's) were deployed on the OMEGA EP target chamber. These antechambers facilitate storage of the parabolas behind a protective gate valve when not in use. Access to the parabola for work such as optics replacements, installation/removal of the disposable debris shield in front of an OAP, and other maintenance no longer requires the OMEGA EP target chamber to be vented.

Experimental Diagnostics

Two new ten-inch manipulators were installed on the OMEGA EP target chamber, increasing our non-fixed diagnostic fielding capacity by 40%. A number of facility tools to better support the scientific user were implemented; for example, online availability of diagnostic documentation packages and diagnostic calibration data is now accessible by the user community.

Experimental capability evolved with the addition of 22 new diagnostics for use on OMEGA and 17 for OMEGA EP. Much of this activity involved other laboratories (e.g., LLNL, LANL, NRL, CEA, AWE), and included diagnostics such as the spherical crystal x-ray imager, electron–positron–proton spectrometers, neutron-detector test platforms for NIF diagnostics, and numerous x-ray spectrometers. Upgrades to existing diagnostic subsystems, such as the proton film pack, OMEGA high-resolution velocimeter, 4ω Thomson-scattering spectrometer, gamma reaction history diagnostic, and the DANTE x-ray diode array were also completed.