FY09 Laser Facility Report

During FY09 the Omega Laser Facility conducted 1153 target shots on OMEGA and 349 target shots on OMEGA EP for a total of 1502 combined target shots (see Table 120.VIII). OMEGA conducted 24 DT and 24 D_2 low-adiabat spherical cryogenic target implosions. Triple-picket pulse-shaping developments highlighted the ongoing development of direct-drive cryogenic implosion capability. A planar cryogenic platform to measure spherical shock timing was validated and used extensively to support spherical cryogenic experiments. A total of 31 planar cryo target shots were taken. The OMEGA Availability and Experimental Effectiveness averages for FY09 were 93% and 96%, respectively.

Table 120.VIII: OMEGA Facility target shot summary for FY09.

OMEGA Target Shot Summary					
Laboratory	Planned Number of Target Shots	Actual Number of Target Shots	NIC	Shots in Support of NIC	Non-NIC
LLE	476	488	68	420	0
LLNL	200	230	125	0	105
NLUF	145	165	0	0	165
LANL	85	93	3	0	90
LBS	70	73	0	0	73
CEA	45	51	0	0	51
AWE	30	35	0	0	35
U. Mich.	10	11	0	0	11
SNL	5	7	7	0	0
Total	1066	1153	203	420	530
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	215	212	0	212	0
LLNL	40	42	16	0	26
NLUF	40	43	0	0	43
LBS	45	36	0	0	36
LANL	10	11	0	0	11
CEA/AWE	5	5	0	0	5
Total	355	349	16	212	121

OMEGA EP was operated extensively in FY09 for a variety of internal and external users. A total of 298 short-pulse IR target shots were conducted. Of these, 212 target shots were taken on the OMEGA EP target chamber and 86 joint target shots were taken on the OMEGA target chamber. Beams 1 and 2 were activated to target in the UV, and the first four-beam UV target shots were conducted. A total of 76 OMEGA EP target shots included UV beams. OMEGA EP averaged 4.7 target shots per day with Availability and Experimental Effectiveness averages for FY09 of 90% and 97%, respectively. Highlights of other achievements for FY09 are shown in Table 120.VIII.

OMEGA pulse-shaping capability continues to evolve to meet the demands of producing triple-picket–shaped pulses for cryogenic experiments (see Fig. 120.51). New environmental hardware and controls upgrades to the Driver Electronics Room have improved temperature and humidity stability. The thermal stability improvements resulted in better stability for the temporal pulse shape. As a result, triple-picket pulse shapes that meet increasingly demanding specifications are now routinely achieved. Pulse-shape measurement diagnostics and analysis software continue to become more sophisticated to accurately predict picket energies and UV pulse shapes.

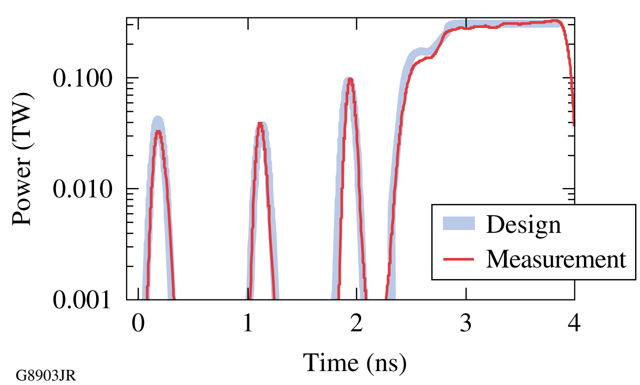

Figure 120.51
OMEGA average pulse shape from a cryogenic target implosion (shot 55723) using pulse shape HE330201T. This shot produced 300-mg/cm^2 ρR, the highest-recorded ρR to date.

The Omega Laser Facility added a planar Moving Cryogenic Transfer Cart (MCTC) to the existing inventory of five MCTC's, bringing the active total to two planar target MCTC's and four spherical target MCTC's. It is an important addition since the planar MCTC's can be interleaved to increase the number of planar experiments that can be carried out in a single shot day. Up to five planar target shots were taken in a single shot day in FY09, and with some minor adjustments to MCTC operations in FY10, the total will be increased further. Planar cryogenic target shots have been particularly instrumental in combination with shock-timing diagnostics to optimize the performance of cryogenic implosions.

A significant change was made in FY09 to the mounting system used for cryogenic implosions. The previous "C-mount" that used four spider-silk supports to suspend the target was replaced by a single-stalk-mount design that has proven to be an operationally robust component. The high-pressure fill, transfer to MCTC, and deployment attrition rates were reduced to negligible levels while maintaining and improving target performance metrics. Operationally, the key metrics are laser pulse shape, layer quality, and target offset (displacement from target chamber center at shot time). The fraction of targets with high-quality layers has increased to ~85%, and the target offset performance has improved to ~50%. Offset remains a difficult challenge and is being addressed through improved use of the tools built into the Target Viewing System and a re-engineered MCTC for spherical targets.

The Target Viewing System (TVS) upgrade in FY08 resulted in new tools becoming available for cryogenic target operations. The primary tool that has been used to make significant improvements in the cryogenic target offset is a pair of 2000-frame-per-second fast cameras. These cameras were used in FY09 to characterize the dynamic performance of the four spherical target MCTC's. There are sources of mechanical instability that occur as a result of the rapid removal of the cryogenic shroud system that occasionally perturb the target beyond acceptable levels; however, a significant fraction of targets are now within the desired 20 μm or less of displacement from target chamber center. This was achieved by three main improvements: use of the fast cameras for characterizing the target alignment carefully with shrouds in place and removed, optimizing the retraction trajectories, and cold-head-pump–induced vibration management.

A Grating Inspection System (GIS) was installed and activated on both OMEGA EP compressors. The GIS is an illumination and imaging scanning system that measures scattered light from the fourth grating of the compressor to detect optical damage. The system can identify grating damage site growth that is 500 μm or larger. The GIS is a key facility diagnostic that is routinely operated after each laser shot to ensure that maximum energy is available to short-pulse users, without risking damage to the gratings.

OMEGA EP was routinely operated at ≥1 kJ in a 10-ps pulse. An exploratory energy-ramp campaign was conducted with energies up to 2.1 kJ on target at ~10 ps to characterize short-pulse optic damage growth rates.

Determining the fraction of laser energy transferred into energetic electrons in intense laser–matter interactions is a vital parameter in high-fluence backlighter development and advanced ignition experiments, including fast ignition. Foil targets were irradiated in OMEGA EP experiments at laser intensities of $I > 10 \times 10^{18}$ W/cm^2 with up to 2.1 kJ of laser energy and pulse durations between 10 to 12 ps. These are the highest-energy, short-pulse laser–matter interaction experiments ever conducted. These experiments demonstrate that powerful electron sources can be generated with high-power, short-pulse lasers in the multikilojoule regime.

The temporal contrast of the two short-pulse OMEGA EP beamlines has been measured up to 0.5 ns before the main pulse. The diagnostic operated for more than 60 high-energy shots, demonstrating very good reliability and reproducibility. No evidence of short prepulse was found prior to main pulse, and an incoherent pedestal generated by the optical parametric chirped-pulse–amplifier's front-end was precisely characterized. The pedestal extends a few nanoseconds before the main pulse and has an intensity of less than 10^{-6} of the peak intensity for a 10-ps pulse. Approximately 10^{-4} of the laser energy is contained in this. Since the pedestal's energy contrast ratio is independent of the compressed pulse width, the intensity contrast would be an order of magnitude larger for a 1-ps pulse (i.e., $>10^7$). Contrast improvements based on LLE-demonstrated technologies are planned for the future to increase the intensity contrast.

There is considerable demand for high-pressure experiments on OMEGA EP. The velocity interferometry system for any reflector (VISAR) is the primary instrument for these experiments. A VISAR diagnostic based on the OMEGA system was installed in June 2009. This system worked as designed on the first shot and is now available for the high-pressure experiments scheduled on OMEGA EP in FY10.