Measuring Multiple Spherically Converging Shocks in Liquid-Deuterium Targets: Inertial confinement fusion (ICF) target designs use a sequence of shocks to compress the shell and fuel. By optimizing the strength and timing of these shocks, an isentropic implosion can be approximated, minimizing the required energy for compression. Realization of this quasi-isentropic compression requires the shocks to merge precisely at a specified time and position in the fuel. In collaboration with LLNL, LLE has developed techniques for making precise shock timing and velocity measurements.[1] For the first time, four spherically converging shocks were observed and timed in cryogenic spherical target experiments on OMEGA. A velocity interferometry system for any reflector (VISAR) and a streaked optical pyrometer (SOP) were used to detect shock waves in deuterium-filled cone-in-shell targets (see Fig. 1) irradiated with a uniform multishock pulse. Figure 2 shows the VISAR data from a four-shock experiment where the laser pulse was similar to those planned for an ignition target—i.e., three short pulses followed by the main drive pulse. The first three shocks and their decays are observed at 0.3, 1.6, and 2.3 ns. At 3.1 ns, the fourth shock (from the main pulse) overtakes those shocks. Shortly after, x rays from the main pulse cause the blanking (loss of transparency) of the VISAR window and the data abruptly cease. Figure 3 shows the shock velocities inferred from the Fig. 2 data. Velocities of 42, 64, 83, and 135 km/s are deduced for the four shocks. Simulations of the shock velocities and coalescence are also shown in Fig. 3. The theoretical simulation agrees with the data within the requirements for a properly tuned ignition pulse. The first three shocks of the ignition targets used for the NIC will have velocities of ~20, 40, and 70 km/s, respectively. These results demonstrate that shocks with the strengths required for ignition targets can be readily observed and timed using this technique.

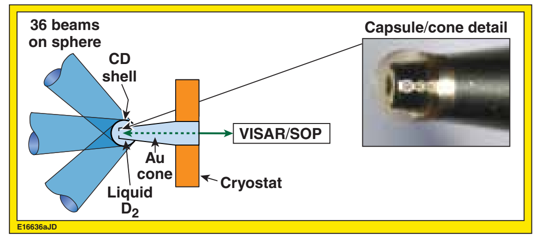

Figure 1. Schematic (left) and photograph of cone-in-shell target used to conduct multiple shock-timing tests on the OMEGA laser.

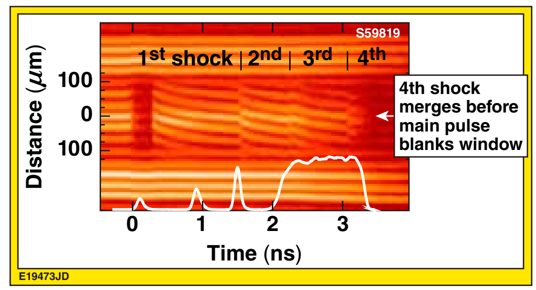

Figure 2. VISAR shock data for an experiment where the driving laser pulse (shown on the bottom of the figure) consisted of three short pulses followed by a high-energy long pulse. This pulse configuration generates four shocks that merge at ~3.1 ns.

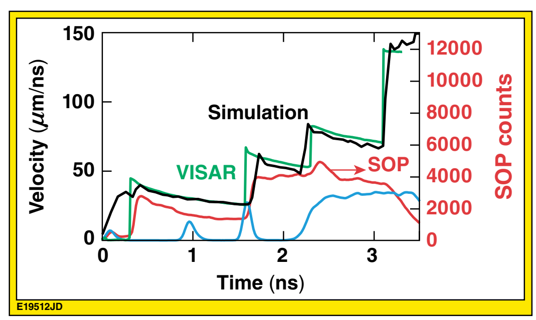

Figure 3. Green curve: shock velocities inferred from streak camera data of Fig. 3; red curve: SOP signal (arbitrary units) and blue curve: laser pulse time history (arbitrary units); black curve, theoretical simulation.

Omega Operations Summary: The OMEGA 60-beam UV laser conducted 101 target shots in October with an average experimental effectiveness of 95.5%. Seventy-three shots were taken for the National Ignition Campaign led by teams from LLNL and LLE. An NLUF experiment led by Princeton University conducted 6 target shots; LLE carried out 9 shots for an LBS experiment, and an LLNL-led HED experiment accounted for 13 target shots. Significant facility time was provided for testing an upgraded moving cryostat transfer cart (Cart 7). Several other projects were carried out including:

- The OMEGA SSD modulator synchronization hardware was installed and measurements were conducted to facilitate phase tuning.
- Omega EP Facility enhancements are progressing on schedule, highlighted by the completion of Phase 1 IRAT/injection upgrade on Beam 2.
- The grating compressor chamber (GCC) optics were replaced on schedule, including new gratings for two upper compressor gratings.
- The GCC was pumped down to operating vacuum and preparation began for joint shot operations in November.

1. T. R. Boehly *et al*., Phys. Plasmas **16**, 056302 (2009).