July 2000 Progress Report on the Laboratory for Laser Energetics Inertial Confinement Fusion Program Activities

Cryogenic Target Implosion: The first cryogenic capsule implosion using the new Cryogenic Target Handling System (CTHS) on OMEGA was carried out on 14 July 2000 (see Fig. 1). The primary purpose of this shot was to test the fully integrated CTHS subsystems using a deuterium-filled capsule. The capsule consisted of a 939-μm-diam, 9-μm-thick, CD shell and was filled with deuterium to 1003 atm at 303 K; these conditions result in a 96.1-μm (±0.1 μm) ice layer. To minimize the support structure mass and provide a relatively stiff support, the capsule was suspended by three 0.5-μm-thick spider-silk strands in a "C"-shaped mount (see Fig. 2). The energy on target was 16 kJ in a 1-ns square laser pulse. For this first test shot, less than half (27 beams) of OMEGA's 60 beams were used in order to protect the system from opposing beam damage in the event that the target was not in its prescribed position after shroud retraction. Thickness uniformity of the ice layer was not characterized. A primary DD neutron yield of 3.5±0.3 × 10^8 and an ion temperature of 5.1±1.3 keV were measured on this shot; the secondary neutron yield was 7.9±1.1 × 10^5. This first cryogenic target shot was the culmination of an intensive activation program during the past several months. This program focused on several issues: characterizing and minimizing vibration of the target; testing and refining the target manipulation at cryogenic temperatures; and testing the control software for the retraction of the thermal shroud (around the target) and the timing sequence for firing the laser. Issues that require further study are (1) the target vibration induced by the retracting shroud and (2) the production and characterization of a smooth ice layer in a target. A major source of target vibration is the initial shroud separation. The target has a resonant frequency of 284 Hz at 77 K and vibrates with a maximum amplitude of ~20 μm. During shroud retraction, however, the vibration amplitude can exceed 100 μm. The velocity profile of the shroud retraction was programmed to minimize this vibration (see Fig. 3).

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Figure 1. Photograph of the OMEGA target chamber during the first target shot using the CTHS. At the bottom center of the photograph is the cryogenic target positioner used to place the target at the chamber center.

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Figure 2. Photograph of a target suspended by three spider-silk strands on the specially designed "C" mount.

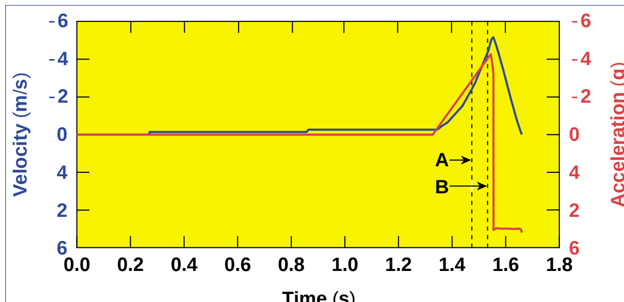

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Figure 3. The acceleration time history of shroud retraction is designed to minimize target vibration. The linear motor (LIM) translating the shroud initially accelerates at constant acceleration (–0.023 g) until all mating surfaces part. The LIM then accelerates to a maximum velocity of 5 m/s followed by deceleration at 5 g until the system comes to rest. The target is exposed at time point A, and the laser fires 54 ms later at point B.

OMEGA Operations: In July the OMEGA facility produced 84 shots for seven different campaigns. In addition to the LLE cryogenic target campaign (1 shot), the following additional campaigns received OMEGA shots: Los Alamos National Laboratory (LANL) (21 shots on target); Lawrence Livermore National Laboratory (LLNL) (7 shots); National Laser Users' Facility (NLUF) (10 shots by Prism Computational Sciences, Inc.); Nuclear Weapons Effects Testing (NWET) (11 shots); the LLE RTI campaign (25 shots); and the LLE Beam Uniformity campaign (9 shots). Significant facility improvement projects concluded during July included the refurbishment of all the frequency-conversion crystal surfaces, the addition of 10^{12}-Hz (1-THz) bandwidth tripling capability, and the installation of refurbished spatial-filter lens coatings.

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