August 2001 Progress Report on the Laboratory for Laser Energetics Inertial Confinement Fusion Program Activities

Cryogenic Target Implosions: With the completion of the improvements to the OMEGA Cryogenic Target Handling System (CTHS), cryogenic target implosions were restarted. Five target shots were successfully performed using layered and characterized thin-wall targets. The capsules, which consisted of ~930-μm-diameter, ~3-μm-thick shells of high-strength CH, were filled with ~1000 atm of D_2. Infrared laser heating was used to obtain either 80-μm- or 100-μm-thick ice layers on the inside of the CH shells. Layer characterization using the technique described in last month's report showed an inner-ice-surface roughness of 10 to 15 μm rms, mostly in the lowest-order modes ($\ell \leq 4$). The targets were imploded using a 1-ns square pulse with ~24-kJ laser energy, the best single-beam smoothing available [distributed phase plates (DPP), polarization smoothing (PS), and 1-THz smoothing by spectral dispersion (SSD)], and optimized beam-to-beam energy balance (<3% rms). This resulted in a calculated target irradiation uniformity of ~2% rms. Neutron yields up to 3.1×10^{10} were produced, up to 30% of the yield predicted by 1-D clean hydrodynamic simulations (YOC). There was a correlation of YOC with the layer quality. These capsules are predicted to have a convergence ratio of ~20, a compressed fuel density of 8 g/cm^3, and an implosion adiabat α~25. Measurements of the capsule areal density (~25 mg/cm^2) were made by secondary proton spectroscopy in collaboration with the MIT Plasma Science and Fusion Center. X-ray imaging was used to assess the symmetry of the implosions (Fig. 1).

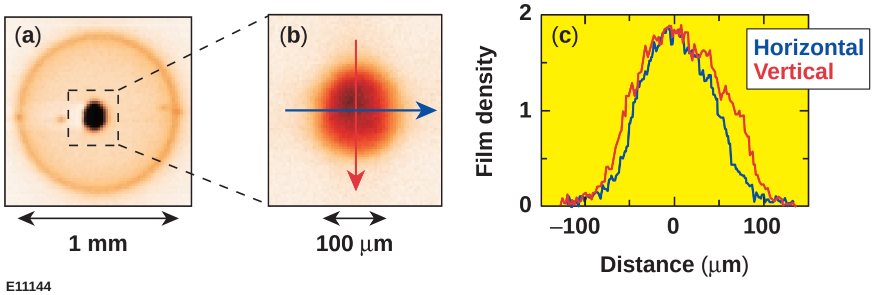

Figure 1. (a) Static pinhole camera image of shot 24096 in the 2- to 5-keV energy band showing the emission from the thin plastic shell enclosing the cryogenic D_2 layer and the formation of a nearly round core in the center of the image. (b) Static x-ray image of core taken with a KB microscope in the energy band of 2 to 6 keV. (c) Lineouts of film density of the core along two orthogonal directions. In this energy band for DEF film, the film density is nearly linearly related to x-ray intensity. The neutron yield on this shot was 3.1×10^{10} (30% of clean 1-D), and the capsule areal density was 25 mg/cm^2 (67% of clean 1-D).

Summer High School Student Research Program: A total of 130 students from local high schools have participated in the LLE Summer High School Research Program since its inception in 1989. Entry to the program, available to students between their junior and senior years, is highly competitive and is based on essays, teacher recommendations, school transcripts, and individual interviews. The students work full time for eight weeks on projects supervised by senior members of the Laboratory and attend weekly seminars on technical topics associated with LLE's research. This summer, 13 students from 10 high schools carried out a broad range of research activities ranging from laser modeling and characterization (see Fig. 2) to studies of the permeability of plastic shells under cryogenic conditions.

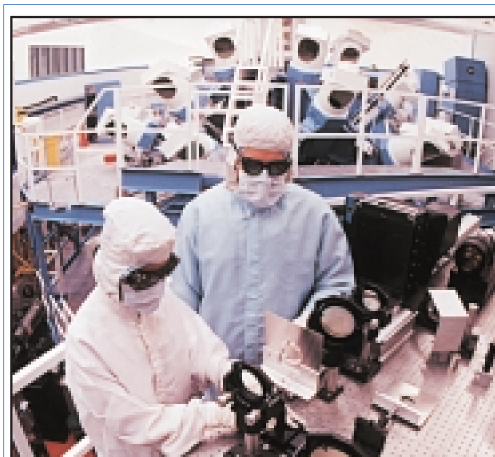

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Figure 2. Summer Intern Uyen Tran (in white), now a senior at the Wilson Magnet High School of Rochester, and her LLE research supervisor, Dr. Sean Regan, are shown aligning the apparatus that was used to record the far-field laser beam pattern of one of the OMEGA beams. Uyen's summer project was to investigate the OMEGA far-field energy distribution with an annular aperture placed in the near field of the beam. The OMEGA target area is in the background.

OMEGA Operations Summary: In August, a total of 151 target shots were taken on OMEGA. This is the highest number of target shots taken during a single month on OMEGA and reflects the ever-continuing improvements in operational availability. External NLUF campaigns included 5 shots by C. Hooper (U. of Florida) and D. Haynes (U. of Wisconsin); 14 shots by B. Afeyan (Polymath Sciences); and 7 shots by H. Baldis (U.C.-Davis) and D. Kalantar (LLNL). In addition, LLNL teams carried out a variety of experiments totaling 41 shots, and the NWET program had 10 shots. LLE experiments totaled 72 shots this month for a variety of campaigns including integrated spherical implosions (32), Stockpile Stewardship Program (8), long-scale-length plasma physics (26), and Rayleigh–Taylor instability (6).

Contact: Wolf Seka (716) 275-3815; fax: (716) 275-5960; e-mail: seka@lle.rochester.edu
John M. Soures (716) 275-3866; fax: (716) 256-2586; e-mail: jsou@lle.rochester.edu