June 2002 Progress Report on the Laboratory for Laser Energetics Inertial Confinement Fusion Program Activities

High-Performance, Direct-Drive Target Designs: Continuing development of the "wetted-foam" direct-drive target design[1] has resulted in a substantial increase in target gain and an extension of the designs to the higher laser energies that might be of interest for fusion energy production. A new feature of these designs is adiabatic shaping to place the ablation surface on the high adiabat required for hydrodynamic stability, while leaving the main part of the fuel on a low adiabat required for high compression. This is accomplished by means of a decaying shock launched by an intensity spike at the foot of the pulse.[2] (The intensity spike also serves a second function of reducing laser imprint.[3]) The results for 1-D target gains are shown in Fig. 1 for different implosion velocities at laser energies of 1.5 MJ and 5 MJ. Predicted target gains approach 300 at 5-MJ incident laser. These designs were examined using a detailed stability postprocessor.[2] For the target at 5 MJ with an implosion velocity of 2.4×10^7 cm/s and a gain of 270, the mix region during acceleration was calculated to be only 5% of the shell thickness, and the hot-spot distortion was estimated to be only 20%. Full 2-D simulations of these designs are underway. The key features of these designs can be examined on the OMEGA laser using scaled-down versions of these targets. Adiabat shaping, by means of an intensity picket, is already being tested in OMEGA experiments for CH-shell experiments and will be applied to cryogenic experiments shortly. A program to start fabricating these shells for OMEGA experiments has been initiated at General Atomics.

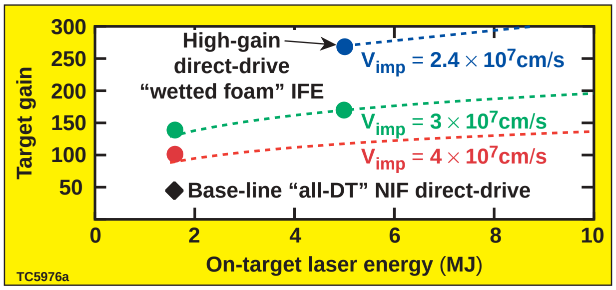

Figure 1. Plot of calculated target gain (thermonuclear energy out/laser energy on target) as a function of the laser energy in MJ for several "wetted-foam" direct-drive capsule designs with different implosion velocity compared to the base-line "all-DT" NIF direct-drive capsule design. The dashed lines are the results of a simple scaling model while the symbols represent 1-D hydrocode simulations.

Controlled Target Irradiation: The OMEGA laser is designed to provide a high degree of uniformity and flexibility in target illumination. The ability to impose a controlled (non-symmetric) on-target irradiation pattern is useful for benchmarking multidimensional hydrodynamic simulations and assessing diagnostic performance. Recently, irradiation patterns with 15%–30% reduced intensity on the poles of a spherical target were requested to generate prolate shaped cores in direct-drive implosions. Using an algorithm developed by LLE engineers, the UV output energy of the individual beamlines was varied by adjusting the amplifier bank voltages to produce the requested asymmetry in illumination. Figure 2 shows plots of the requested and actual intensity distribution on target for a shot (27515) with a nominal 30% reduced polar intensity. The average deviation of the actual energy of each beam from the requested energy is ~4% rms. As expected, this shot (taken for an LLNL campaign) did result in a prolate core as evidenced by x-ray imaging.

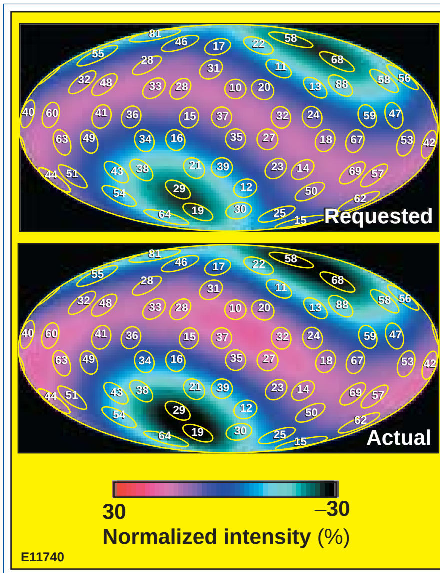

Figure 2. Aitoff projections showing the requested and actual (as measured by HED system) intensity patterns for shot 27515.

OMEGA Operations Summary: During June 2002 a total of 93 target shots were taken on OMEGA for Lawrence Livermore National Laboratory (LLNL), Sandia National Laboratory (SNL), National Laser Users' Facility (NLUF), and LLE experiments. During a week of scheduled maintenance, a second-harmonic (2ω) beamline and associated diagnostics were activated in collaboration with LLNL. The 29 LLNL shots included indirect-drive implosions, 2ω beam activation, long-scale-length plasma interaction, hohlraum albedo, and NWET x-ray conversion measurements. Eleven SNL experiments were conducted for the WBS3 ablator burnthrough and shock-breakout campaigns. The 22 NLUF shots included laboratory astrophysics experiments led by the University of Michigan; neutron imaging experiments; and proton imaging and implosion symmetry experiments led by the MIT Plasma Science and Fusion Center. A total of 31 LLE shots were used for neutron diagnostics development and cryogenic target experiments.

1. S. Skupsky *et al.*, Laboratory for Laser Energetics LLE Review **88**, 183, NTIS document No. DOE/SF/19460-404 (2001).
2. V. N. Goncharov *et al.*, Bull. Am. Phys. Soc. **46**, 142 (2001); V. N. Goncharov *et al.*, Phys. Plasmas **7**, 5118 (2000).
3. T. J. B. Collins and S. Skupsky, Phys. Plasmas **9**, 275 (2002).

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