May 2004 Progress Report on the Laboratory for Laser Energetics
Inertial Confinement Fusion Program Activities

Fast-Ignition, Cone-Target, Fuel-Assembly Experiments: A collaborative experimental program involving LLE, GA, LLNL, and ILE is underway on OMEGA to investigate the fuel assembly in fast-ignition (FI),[1] direct-drive cone targets. Cone targets are an interesting option for FI, allowing the FI laser beam to propagate as close as possible to the compressed core and minimizing the transport distance for the hot electrons. Early experiments on the GEKKO XII laser showed very encouraging results,[2] but the question remains of whether this concept scales to ignition. Ablation of the cone due to x rays from the hot imploding shell is one of the major issues.[3] This might fill the cone with plasma, preventing the FI laser from propagating close to the core, or lead to the mixing of high-*Z* material into the compressed core, preventing it from reaching ignition temperatures due to radiative cooling. Another area of concern is the hydrodynamic efficiency in this nonspherical system and whether enough areal density can be assembled in a dense core for ignition. Finally, it remains to be proven that a dense core can be assembled sufficiently close to the cone tip to allow for an efficient coupling of the electrons.

Gas-tight targets (Fig. 1) were developed to be able to fill the targets with D_2 or D^3He and allow the use of nuclear diagnostics. The first results are very encouraging. Figure 2 shows a backlit radiograph from a directly driven FI cone target at stagnation. CH cone-in-shell targets with 870-μm outer diameter and 24-μm wall thickness filled with up to 10 atm of gas were imploded with 35 beams from OMEGA using a 1-ns square pulse at 12-kJ total energy. The Au cone had a 70° cone angle. Up to 15 beams at 6 kJ were used for backlighting. The image shows a round core ~100 μm from the cone tip, with lower-density plasma in between. Ablation from the cone is visible, and the ablated Au atmosphere around the cone tip has been pushed away to reveal the original cone tip. From the size of the core (~120-μm diameter), an assembled areal density of ~60 mg/cm^2 at peak compression can be inferred—more than 50% of what a 1-D simulation predicts for an equivalent full sphere. In separate experiments, the downshift of the primary D^3He protons was used to determine the assembled areal density independently.[4] To obtain higher yields and better signal-to-noise ratio, the D^3He-filled targets were irradiated using 55 beams at 21 kJ with a 1-ns square pulse. At the time of peak neutron production an assembled areal density of ~60 mg/cm^2 was inferred from the nuclear diagnostics, which is again more than 50% of what a 1-D simulation predicts for an equivalent full sphere target.

Figure 1. Image of a gas-tight cone in shell FI target.

The bright region between the cone and the core is consistent with less mixing between the ablated Au and the compressed core than is observed in comparable indirect-drive experiments.[3] Future experiments will further optimize the cone-in-shell target geometry for integrated cryogenic capsule experiments using OMEGA EP.

OMEGA Operations Summary: During May, OMEGA supported a total of 136 target shots, including 54 shots for a variety of LLE programs (cryogenic target implosions, integrated spherical experiments, Rayleigh–Taylor instability studies, diagnostic development, and SSP); 32 shots for several LLNL campaigns; 13 shots for experiments fielded by CEA; 5 shots for SNL; and 32 shots for four NLUF teams led by scientists from MIT, UC-Davis, UC-Berkeley, and UC-San Diego, respectively.

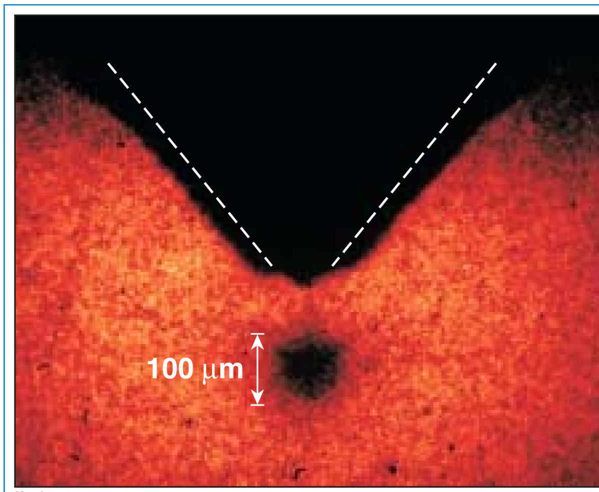

Figure 2. Backlit radiograph of the core from a cone-in-shell target implosion on OMEGA at stagnation. The dashed white lines show the original location of the Au cone inside the capsule.

1. M. Tabak *et al.*, Phys. Plasmas **1**, 1626 (1994).
2. R. Kodama, Nature **418**, 933 (2002).
3. R. B. Stephens *et al.*, Phys. Rev. Lett. **91**, 185001 (2003).
4. F. H. Séguin *et al.*, Phys. Plasmas **9**, 3558 (2002).

Contact: Wolf Seka (585) 275-3815; fax: (585) 275-5960; e-mail: seka@lle.rochester.edu
John M. Soures (585) 275-3866; fax: (585) 256-2586; e-mail: jsou@lle.rochester.edu