February 2005 Progress Report on the Laboratory for Laser Energetics
Inertial Confinement Fusion Program Activities

Progress on Polar Direct Drive: Compared with the NIF baseline indirect-drive ignition capsule design, direct-drive capsule designs have a major advantage in laser energy coupling to the capsule. For example, the baseline indirect-drive design couples ~150 kJ to the capsule, whereas the baseline direct-drive design can result in over 1 MJ of absorbed energy. The baseline NIF indirect-drive beam configuration, however, is not well suited for driving direct-drive capsules, and the required modifications to achieve symmetric 192-beam drive are not presently in the NIF facility plan. Confidence in the demonstration of ignition and high gain using direct drive on the NIF continues to increase as a result of progress in OMEGA direct-drive implosion experiments and LLE's work on direct-drive-ignition capsule designs. The polar-direct-drive (PDD) concept was devised[1,2] to provide an early direct-drive-ignition capability for the NIF. This concept uses the NIF "indirect-drive" beam configuration with the beams re-pointed toward the target's equator.

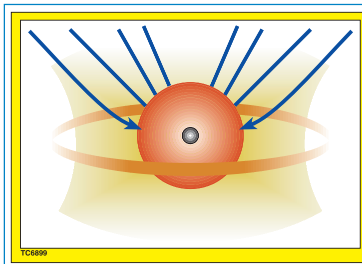

Figure 1. The Saturn target design for polar direct drive on the NIF uses the indirect-drive NIF ports with the beams re-pointed toward the equator and with a plastic ring placed around the target.

The primary limitation of PDD, when compared with the baseline symmetric direct-drive approach, is that extra laser power needs to be placed near the equator to compensate for the oblique angle of incidence there. Time-dependent nonuniformity occurs because the radius of the critical surface (near which most absorption occurs) decreases significantly during the laser pulse. To mitigate this problem, recent OMEGA experiments have explored a new "Saturn" PDD configuration [see Figs. 1 and 2(a)]. The Saturn target[3] uses a plastic ring placed around the capsule. The ring is partially ablated during the implosion and forms a low-density plasma that refracts some of the incoming laser beam energy toward the capsule's equator. Spider silk strands attached to the ring support the capsule. Recent OMEGA experiments have validated the initial theoretical expectations of the Saturn concept [see Figs. 2(b) and 3]. In these experiments, 40 of the OMEGA beams (no equatorial beams) were used, and the beam pointing was systematically and predictably varied to demonstrate that the capsule implosion symmetry can be controlled using this concept. The results shown in Fig. 3 demonstrate that nearly symmetric direct-drive implosions are currently possible using this approach with minimal (~2×) reduction in performance compared to fully symmetric, normal-incidence beam irradiation. The lessons learned from these OMEGA experiments will be applied to future direct-drive-ignition designs for the NIF.

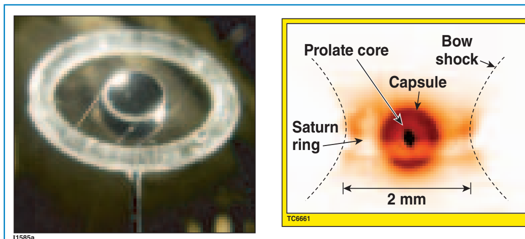

Figure 2. (a) A Saturn target shot on OMEGA. A standard OMEGA capsule of 865-μm diameter is supported using spider silk on a plastic ring of 1100-μm major radius and 150-μm minor radius. (b) Time-integrated pinhole-camera image of a Saturn target implosion viewed from 10.8° above the equator, showing self-emission from the capsule, the shadow of the ring, the bow shock where the capsule plasma and the ring plasma collide, and an imploded core that was prolate for this shot.

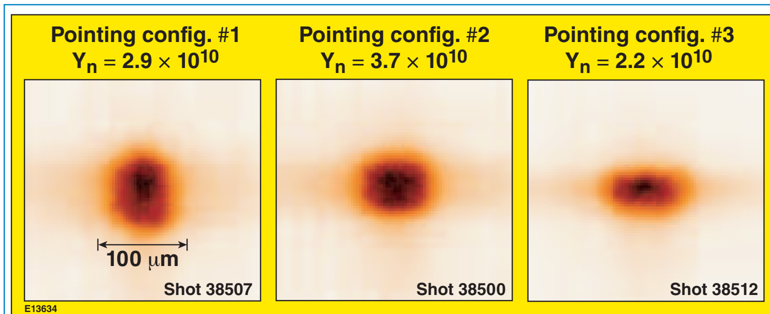

Figure 3. X-ray framing camera images of three Saturn targets irradiated with different beam-pointing configurations. Configuration #2 (center image), predicted to give optimum uniformity, produced the most symmetric core and the greatest neutron yield. The other configurations gave prolate and oblate cores, respectively, relative to the vertical axis and lower yields.

OMEGA Operations Summary: During February 2005, OMEGA conducted 153 target shots for several user groups as follows: LLE (55 shots for ISE, SSP, RTI, and DD campaigns); LLNL (43 shots); NLUF (31 shots for the University of California at Davis, the University of Washington, the University of Michigan, and the University of California–Berkeley campaigns); NRL (12 shots); and SNL (12 shots).

1. S. Skupsky *et al*., Phys. Plasma **11**, 2763 (2004).
2. R. S. Craxton *et al*., to be published in Physics of Plasmas (2005).
3. R. S. Craxton and D. W. Jacobs-Perkins, to be published in Physical Review Letters (2005).

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