February 2007 Progress Report on the Laboratory for Laser Energetics
Inertial Confinement Fusion Program Activities

Laser-to-X-Ray Coupling for Direct-Drive ICF: Understanding laser-to-x-ray energy conversion is important for ignition capsule designs. For example, x-ray radiation can be a source of preheat in direct-drive capsules. Scientists at LLE measured the amount of ultraviolet (UV) laser power converted into x rays for a range of laser intensities relevant to direct-drive inertial confinement fusion (i.e., 10^{13} to 10^{15} W/cm^2). Solid, spherical, 0.86-mm-diam plastic targets were symmetrically irradiated with 351-nm laser light from the 60-beam OMEGA Laser System. Laser-irradiation nonuniformity levels of a few percent were achieved with SG4 phase plates, two-dimensional smoothing by spectral dispersion, and polarization smoothing. The intensity on target was varied by increasing the pulse length of the square laser pulse shapes from 1 to 3.7 ns and by reducing the UV laser energy from 23 to 1.8 kJ. Fourteen shots were taken to investigate the laser-to-x-ray conversion efficiency for five laser intensities. The lowest two intensities were achieved by detuning the frequency conversion crystals on OMEGA for the 3.7-ns pulse. The x-ray flux in the 50- to 5500-eV photon energy range was recorded with the Dante diagnostic,[1] which has an absolute radiometric calibration based on synchrotron emission measurements.[2,3] Thirteen energy-resolved channels in the spectral range were monitored with a temporal resolution of 100 ps. X-ray spectra were inferred from the measurements using a least squares fitting routine. The peak conversion efficiencies plotted in Fig. 1 as a function of laser intensity are observed to decrease from 6% to 3% as the laser intensity is increased from 2×10^{13} W/cm^2 to 1×10^{15} W/cm^2. Simulations of the laser-to-x-ray coupling, obtained by post-processing the predictions of the 1-D hydrodynamics code *LILAC* to calculate the radiation transport through the target, are shown to be in good agreement with the measurements. The flux-limited electron-thermal-conduction model of *LILAC* uses a flux limiter of 0.06; however, the predictions for the lowest three intensities show negligible sensitivity to the choice of the flux-limiter value.

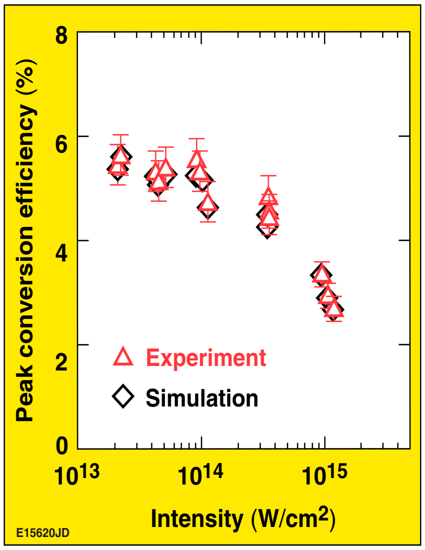

Figure 1. Measured peak conversion efficiencies (red triangles) of 351-nm laser light into x rays for laser intensities in the range of 10^{13} to 10^{15} W/cm^2. Simulations (black diamonds) of the laser-to-x-ray coupling, obtained by post-processing the predictions of the 1-D hydrodynamics code *LILAC* to calculate the radiation transport through the target, are in good agreement with the experimental results.

Cryogenic Target Experiments: Recent experiments have significantly advanced the maximum neutron-averaged areal density $\langle \rho R \rangle_n$ achieved in cryogenic D_2 implosions on OMEGA. Using a relaxation picket drive pulse (shown in Fig. 2; the drive pulse was less than 14-kJ UV on target), the $\langle \rho R \rangle_n$ from shot 46520 was 137±9 mg/cm^2. This result is based on five individual measurements along different lines of sight using the wedged-range-filter spectrometers to measure the energy loss of secondary protons produced in the core (the standard technique employed at LLE). A number of previous implosions using different pulse shapes and drive intensities achieved neutron-averaged areal densities of 100 to 105 mg/cm^2, so this recent result suggests that the relaxation picket at moderate drive intensities should lead to significantly higher $\langle \rho R \rangle_n$ and peak $\langle \rho R \rangle$ in the near future.

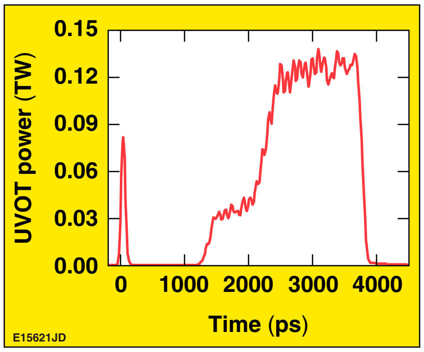

Figure 2. Typical relaxation picket drive pulse used for OMEGA cryogenic implosion campaign.

OMEGA Operations Summary: During February 2007, OMEGA conducted 140 target shots for LLE (85), LLNL (33), SNL (7), and CEA (15) with an overall experimental effectiveness of 97.5%. The NIC accounted for 107 of these shots: IDI (41) and DDI (66). A total of 33 shots were taken for various non-NIC programs.

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1. H. N. Kornblum, R. L. Kauffman, and J. A. Smith, Rev. Sci. Instrum. **57**, 2179 (1986).
2. K. M. Campbell *et al.*, Rev. Sci. Instrum. **75**, 3768 (2004).
3. C. Sorce *et al.*, Rev. Sci. Instrum. **77**, 10E518 (2006).