March 2000 Progress Report on the Laboratory for Laser Energetics Inertial Confinement Fusion Program Activities

1-THz SSD Bandwidth Measurements: Recently LLE installed two new 2-D SSD configurations on the OMEGA laser system. One configuration produces three color cycles with a nominal bandwidth of 0.35 THz and can be frequency converted with a single tripler configuration. The second, single-color-cycle system produces a nominal bandwidth of 1 THz and requires dual triplers for frequency conversion. The on-target bandwidth for these two configurations was measured using the OMEGA wavefront sensor, which directs a portion of the ultraviolet (UV) laser light to a spectrometer that records a time-integrated spectrum. The effective UV bandwidth, defined in Fig. 1, is calculated from the measured spectral data for each shot. The measured, on-target, SSD bandwidth on OMEGA is shown in the figure for a compilation of laser shots that were configured with either three-color-cycle SSD (blue dots) or 1-THz SSD (red dots). The excellent reproducibility of the laser beam smoothing is indicated by the small standard deviation (dotted horizontal lines) from the average measured bandwidths (solid horizontal lines). Presently, 1-THz SSD can be propagated in 13 beams, with all 60 beams expected to be available this summer.

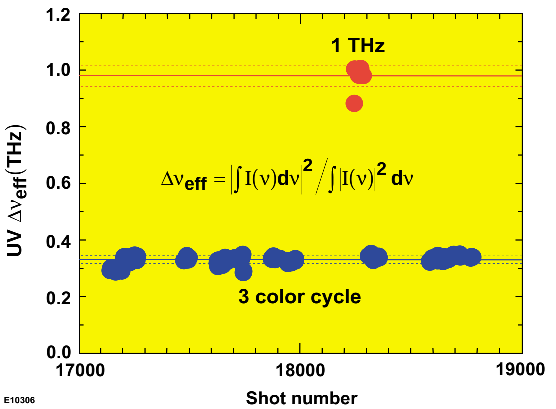

Figure 1. Measured 2-D SSD bandwidth for 1-Thz and three-color-cycle SSD systems for a series of OMEGA shots.

Density Diagnostic for Cryogenic Target Implosions: In a collaboration with a team from MIT, we demonstrated a density diagnostic that will be used on OMEGA cryogenic fuel layer targets. OMEGA cryogenic targets are expected to achieve total capsule area density (ρR) of a few hundred mg/cm^2. To characterize the capsule conditions for deuterium-burning capsules, we developed a diagnostic technique that is based on measuring the spectral shape of secondary protons generated in deuterium fusion. The secondary protons are born with an energy spectrum that is nearly flat between 12.5 and 17.4 MeV. As they escape the capsule, the protons slow down in the compressed plasma. Using a two-region ice-block model to simulate conditions typical of OMEGA cryogenic targets, we showed that the mean energy of the escaping protons is nearly linearly dependent on the fuel's areal density (Fig. 2). We tested this approach using the OMEGA charged-particle spectrometer (CPS) on implosions of warm deuterium-filled polymer shells. To achieve a high-quality spectrum with a gas-filled shell we integrated the spectra of four nearly identical capsule implosions achieving an average primary yield of 1×10^{11} neutrons and a secondary yield of 5×10^7 secondary protons per shot. Figure 3 shows the measured four-shot spectrum. The measured downshift in proton mean energy of approximately 2 MeV is consistent with a capsule areal density of approximately 50 mg/cm^2. This approach shows promise of being useful on cryogenic implosions where the primary and secondary yields are expected to be higher than we obtained in these warm capsule implosions.

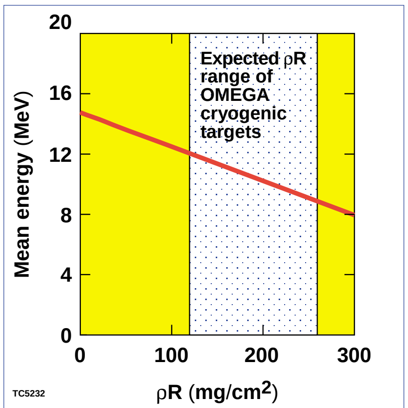

Figure 2. Calculated mean energy of secondary protons (red line) as a function of total areal density of OMEGA cryogenic capsule.

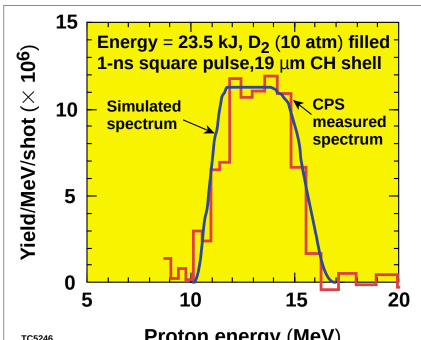

Figure 3. Secondary proton spectra from OMEGA shots 17663, 17664, 17665, and 17669 combined (red line). The blue line is the simulated spectrum for a capsule areal density of ~50/mg^2 and the CPS setup parameters.

OMEGA Operations Summary: The March 2000 OMEGA shots were divided among the LLE RTI campaign (47 shots), various LLNL campaigns (44 shots), and one week of LANL-led shots (29 shots), for a total of 120 shots for the month. The most noteworthy modification to the system was the switchover from the 1996 SBS pulse-shaping system to the recently installed aperture-coupled-stripline (ACSL) shaping system. Operations teams continued to install and activate two reworked frequency-conversion assemblies per week; as of the end of March a total of 31 of the 60 crystals have been replaced.

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