January 1999 Progress Report on the Laboratory for Laser Energetics Inertial Confinement Fusion Program Activities

Integrated Spherical Experiments (ISE): Spherical targets are driven on the 60-beam OMEGA laser system with high-contrast shaped pulses. Recent monthly reports have described the pulse-shaping system. We have carried out a series of experiments that show that the measured shell trajectories are well modeled by the 1-D hydrocode *LILAC*. The primary experimental diagnostic is the imaging x-ray streak camera (IXRSC). The IXRSC has a fixed pointing toward target chamber center and a spatial resolution of ~20 μm. Its absolute timing is established using a fiducial laser pulse, which has been calibrated using 0.1-ns laser pulses. Figure 1 shows an IXRSC image of the trajectory of a 20-μm-thick CH shell for a "foot-ramp," 21-kJ drive pulse. This pulse shape is optimized for spherical burnthrough experiments and has an intensity contrast of 20:1. The pulse has an ~0.5-ns foot, followed by a 2-ns ramp to a peak intensity of 5×10^{14} W/cm^2. The predicted *LILAC* x-ray emission from the shell trajectory is overlaid, showing good agreement. The zero of the temporal axis is defined to be the 2% intensity point on the laser pulse.

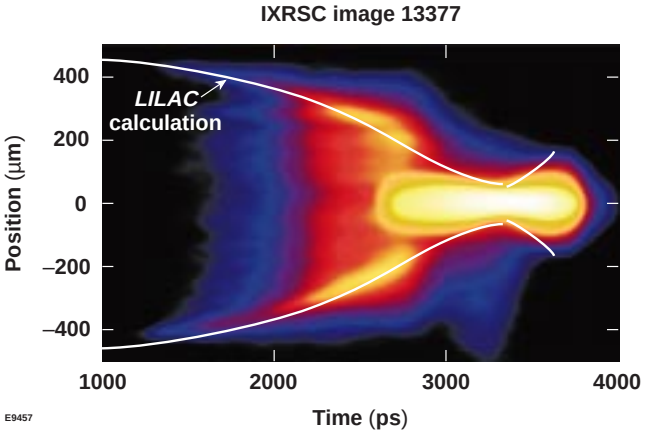

Fig. 1

Implosions of D-^{3}He–Filled Capsules: One application of the charged-particle spectrometers (CPS-1 and CPS-2) on OMEGA is to carry out measurements of fuel temperature and capsule areal density on D-^{3}He–filled capsules. The fusion of deuterium and helium results in an energetic (14.7-MeV) proton that has a large range in CH (typically 500 mg/cm^2 in a several-keV plasma). The slowing down of the energetic proton can be used to measure the capsule areal density for high-density capsules. In addition, the ratio of D-D fusion reactions to D-^{3}He fusion reactions can be used to measure the ion temperature of the burning fuel. In recent OMEGA experiments, the charged-particle spectrometers jointly developed by MIT, LLE, and LLNL have been used to make such measurements. Figure 2 shows the 14.7-MeV proton spectrum measured by CPS-2 for the implosion of a 938-μm-diam,18.4-μm-thick CH capsule filled with 2.8 atm of D_2 and 4.9 atm of ^{3}He. This target was irradiated with 28.3 kJ of UV light with 2-D SSD smoothing and a 1-ns square-top pulse shape. Pre-shot, no-mix, 1-D calculations of the capsule implosion predicted a fuel convergence ratio of nearly 30, a fuel temperature of 3.6 keV, and shell and fuel areal densities of 120 mg/cm^2 and 34 mg/cm^2, respectively. The near-2-MeV slowing down observed in the proton spectrum implies a proton-averaged shell areal density of 60 mg/cm^2 (50% of the predicted one). Simultaneous measurements of the secondary-reaction-product yield made with the single-hit neutron detector array (MEDUSA) indicate a neutron-averaged fuel areal density approximately 45% of that predicted. The fuel-ion temperature as measured by the ratio of D-D to D-^{3}He reactions was nearly equal to the predicted temperature, and the measured neutron and proton yields were approximately 40% of the clean, 1-D computer simulation of the capsule implosion. Measurements such as these are key to developing a comprehensive understanding of the dynamics of high-convergence capsule implosions.

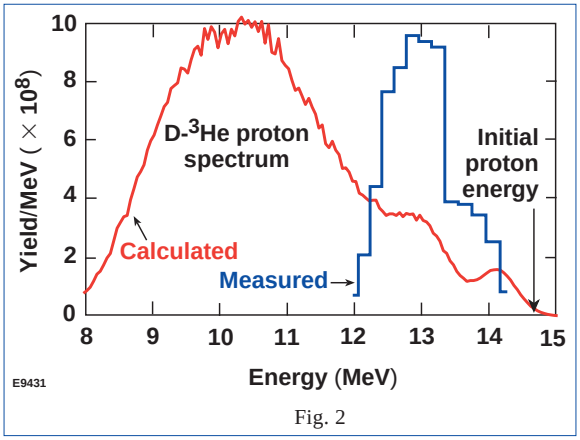

Fig. 2

OMEGA Operations Summary: Diagnostic systems were calibrated and configured during the first week of January. Five separate experiments shared the 31 shots dedicated to this diagnostic checkout week. The second week was split between LLE long-scale-length plasmas (LSP, 19 shots) and NLUF (similar configuration, 12 shots). During the last two weeks of the month, 60-beam spherical implosions were carried out for LLE campaigns for thermonuclear burn characterization and core mix studies; these two campaigns received 35 and 34 shots, respectively. On-target shots for January totaled 131, reflecting OMEGA's high shot rate potential.

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