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

Neutron Diagnostics Development: During May 2005, scientists from AWE, CEA, LANL, LLE, and LLNL used high neutron-yield implosions on OMEGA to test 15 neutron diagnostic systems that are under development for the NIF. These diagnostics included a neutron imaging system (NIS), three neutron diagnostics based on a light pipe, two gas-filled Cherenkov light detectors, a high-yield neutron bang time detector, four CVD diamond detectors, two new neutron time-of-flight detectors based on vacuum photodiodes, and copper and carbon activation detectors.

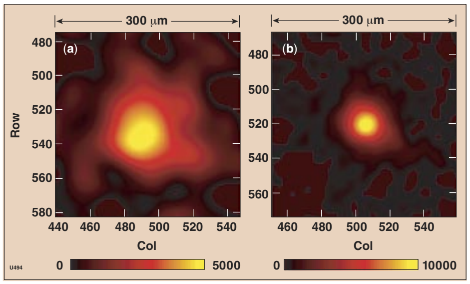

Figure 1. (a) The NIS image of shot 39826 (D_2 filled). (b) Neutron image of shot 39814 (DT filled).

For the first time ever, CEA scientists recorded neutron images from a D_2 cryogenic capsule implosion. The image was recorded using a penumbral aperture and a million-pixel neutron detector. The NIS image of shot 39826 (D_2 filled, cryogenic) with a neutron yield of 4.1×10^{11} is shown in Fig. 1(a). The image has a source resolution of 58 μm and a signal-to-noise ratio (SNR) of 16. For the higher-yield DT implosions, the much higher SNR produced with a ring aperture led to a source resolution of 10 μm. Figure 1(b) shows a neutron image of shot 39814 where an imploded plastic capsule with a shell thickness of 15 μm and filled with 15 atm of DT produced a neutron yield 3.2×10^{13}. The source resolution of this image is 10 μm and the SNR is 28.

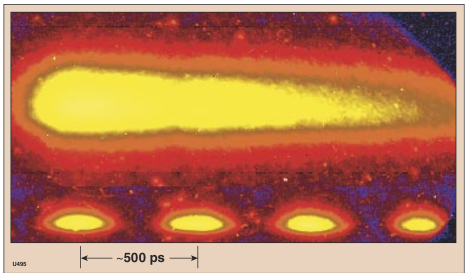

Figure 2. Streak camera image from neutron scintillator "light pipe" on shot 39819.

One of the difficulties associated with time-resolved measurements in high-yield implosions is that neutron-induced noise limits the use of streak cameras in such systems. To mitigate this issue, light generated by a neutron scintillator placed near the capsule was transported outside of the Target Bay area by a polished stainless pipe (light pipe) to a streak camera ~8 m from the target. Figure 2 shows the streak camera signal from this diagnostic for shot 39819 with a neutron yield of 3.0×10^{13}. The strong optical signal obtained on this test demonstrates the feasibility of a high-yield neutron temporal diagnostic for OMEGA and the possible implementation of the light-pipe technique on the NIF. Finally, Fig. 3 shows the signal from a fast scintillator coupled to a vacuum photodiode and located 5.4 m from the target. This detector shows promise for neutron time-of-flight measurements at very high yields. The subnanosecond response vacuum photodiodes are insensitive to x-ray backgrounds, and have a very large dynamic range. CVD diamond and vacuum photodiode based detectors calibrated on OMEGA will measure neutron yield and ion temperature during the "ignition" campaign on the NIF.

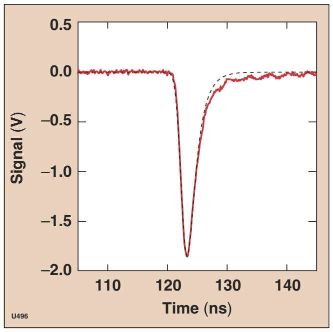

Figure 3. The signal from a fast scintillator coupled to a vacuum photodiode and located at 5.4 m from TCC (shot 39814).

OMEGA Operations Summary: During the month of May 2005, OMEGA conducted a total of 121 experiments for LLE (54 shots), NLUF (17 shots), and LLNL (50 shots). The NLUF target shots were provided for teams led by the University of Michigan and Rice University. In addition, the first integrated front-end source (IFES) was installed and activated on the main driver during the month of May (see Fig. 4). The IFES replaces the existing OMEGA master oscillators (OMO's) and two pulse-shaping amplitude modulators. The IFES architecture consists of a single-frequency cw fiber laser, a dual amplitude modulator for pulse shaping, and a cw-pumped fiber amplifier that boosts the energy injected into OMEGA's diode-pumped regenerative amplifier. The IFES system requires significantly less maintenance, is easier to operate, requires no optical alignment, has improved pulse-shaping stability, and is much more reliable than the OMO system. The "backlighter," SSD, and "fiducial" sources will be converted to the IFES architecture during the months of June and July.

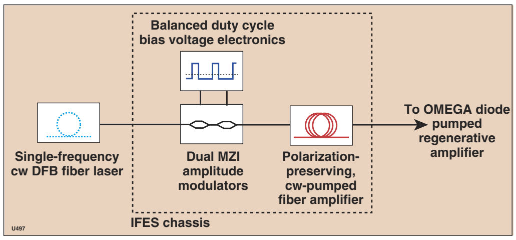

Figure 4. Schematic of IFES architecture.

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