Proton Radiography Measurements of Target Charging: Containment of energetic electrons by sheath-field formation in high-intensity laser–solid interactions is critical to the performance of bright, high-energy x-ray sources.[1,2] Proton radiography experiments were performed at the Omega EP Laser Facility to investigate the target-charging dynamics in high-intensity laser interaction with thin-foil targets. Figure 1 shows a schematic of the experimental setup. The OMEGA EP backlighter produced ~1 kJ in a 10-ps pulse that irradiated a 20-μm-thick Cu target. A second OMEGA EP high-intensity laser pulse (≤0.5 kJ, 10 ps) delayed from the primary interaction irradiated a secondary target foil, generating a high-current, divergent source of protons. The protons derive from hydrocarbon contaminants on the rear surface of the foil and are accelerated by target-normal sheath fields. A series of time-resolved radiographs were obtained on each shot due to time-of-flight effects of the broadband, sub-relativistic–proton source (extending to proton energies of $E_p < 60$ MeV) and by employing a stack of filtered radiochromic film (RCF) as a dosimetric detector. Figure 2 shows two proton radiographs of the main interaction. Electromagnetic field deflections and collisional stopping and scattering give rise to variations in the spatial distribution of proton-energy deposition on each film layer. At $t = t_0 \pm 5$ ps, where t_0 is the onset of intense laser irradiation, a collimated jet of relativistic electrons exit the target rear surface. The fastest electrons penetrate the foil and escape its rear surface, setting up a space-charge field that accelerates protons in the target normal direction, while reflecting the majority of electrons back into the target. Sheath fields form over the entire target surface, preventing most of the electrons from escaping the target potential. As the target charges, protons and ions from target-surface contaminants are accelerated by target-normal sheath fields to MeV energies [see Fig. 2(b)]. The energetic electrons recirculate (reflux) within the target, making multiple transits of the foil as they transfer their energy to the target bulk material.[3,4] These results will be used to compare against target-charging models of these experiments.

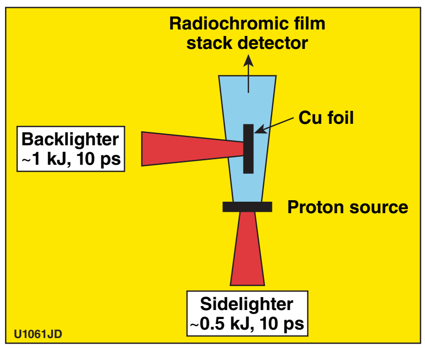

Figure 1. Schematic of the OMEGA EP experimental setup.

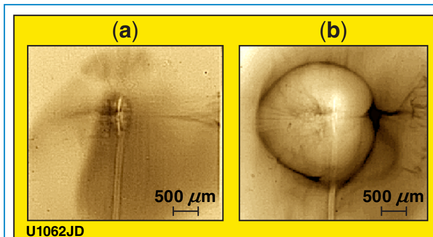

Figure 2. Proton radiographs of a copper foil irradiated by an intense, high-energy laser pulse on the OMEGA EP Laser System. The images were taken at (a) $t = t_0$ and (b) $t = t_0 + 7$ ps, where t_0 is the onset of laser irradiation. The laser irradiates the target from the left.

NIF Magnetic Recoil Spectrometer: The magnetic recoil spectrometer (MRS) was developed in a collaboration between the MIT Plasma Science and Fusion Center (PSFC) and LLE to measure the fusion neutron spectrum in the range of 6 to 32 MeV. The MRS is being used on OMEGA to infer the areal density of DT-filled cryogenic targets.[5] In November 2008 a joint effort was undertaken by LLE, MIT, and LLNL to design, build, and integrate a version of the MRS for the NIF that will be used as one of the primary diagnostics for the National Ignition Campaign (NIC). In February 2010, LLE completed the fabrication and integration of the diagnostic and it was shipped to LLNL. Once received at LLNL it will be integrated on the NIF target chamber and deployed for upcoming NIC experiments.

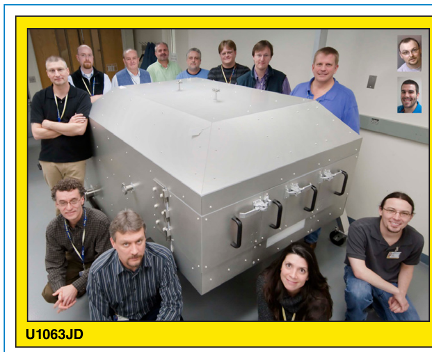

Figure 3. The NIF MRS and the LLE–MIT team responsible for its design and construction.

OMEGA Operations Summary: The Omega Laser Facility conducted 178 target shots in February (123 on OMEGA and 55 on OMEGA EP, including 24 joint shots) with an overall average experimental effectiveness of 93.2%. Of the total, 103 shots were for the NIC program led by teams from LLE, LLNL, and LANL; 39 shots were conducted for the HEDSE program by LLNL and LANL scientists; 14 shots were taken for AWE (UK); 16 shots for the Laboratory Basic Sciences program were carried out by LLE; and 6 shots were taken for an NLUF experiment by a Rice University led team.

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