Proton Core Imaging Spectroscopy (PCIS): The MIT Plasma Science and Fusion Center and LLE collaborated to develop penumbral proton imaging to study the spatial distributions of DD and D^3He reactions in imploded D^3He-filled capsules on OMEGA.[1,2] The imaging is performed with a pinhole camera in which the recorder consists of stacked sheets of CR-39 nuclear track detector separated by ranging filters that result in efficient detection of 14.7-MeV D^3He protons on one sheet [see Fig. 1(a)] and 3-MeV DD protons on another. When target capsules have thin shells (e.g., 1.8 μm SiO_2), allowing both types of protons to escape at burn time, the images on separate sheets of CR-39 can be used to simultaneously reconstruct radial profiles of the DD and D^3He burn. These profiles are used to determine the ion temperature [$T_i(r)$], as shown in Fig. 1(b). Thick-shell capsules (e.g., 20 μm CH) can attain such high shell areal density (ρR) that only the higher-energy protons can escape at bang time, and their profile reflects the effects of compression and mix. For thick shells, DD protons escape during first shock coalescence, when ρR is far below its peak value, and thus the shock-induced DD burn profile can be studied. Since fuel–shell mix has been experimentally shown to be inconsequential at this early time, comparisons of 1-D simulations with experiments are in progress.

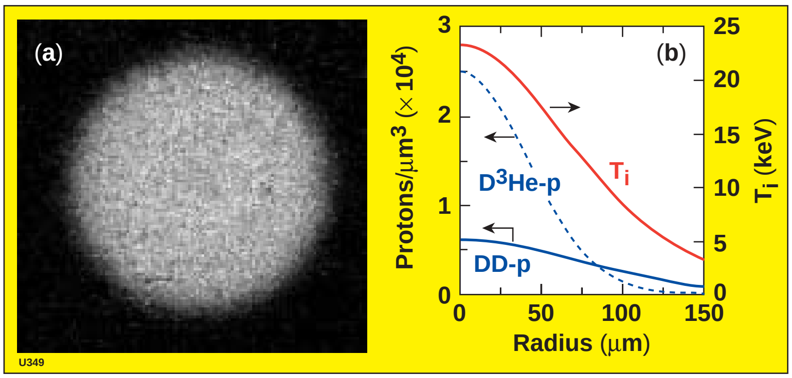

Figure 1. PCIS data from OMEGA shot 27456, in which the capsule consisted of 18 atm of D^3He in a 1.8-μm-SiO_2 shell. (a) An image of D^3He protons made behind a 600-μm-diam pinhole. Since the pinhole is much larger than the compressed capsule, all structural information is contained in the penumbra. (b) Radial profiles of proton emissivity and ion temperature (T_i) in the imploded capsule. The profiles were inferred from five pinhole images of D^3He protons and five pinhole images of DD protons.

Proton Temporal Diagnostic (PTD): A new TIM-based proton temporal diagnostic (PTD) was developed on OMEGA to record the fusion-reaction-rate history of protons generated from the thermonuclear burn of D^3He-fueled capsules. The diagnostic is based on a fast scintillator (BC-422) that acts as a proton-to-light converter protected by a thin (~100-μm) tantalum foil against x-ray and direct laser illumination. A sophisticated optical system transfers the scintillator light to a high-speed optical streak camera for recording. A simultaneously recorded optical fiducial provides a reference for accurate timing with respect to the incident laser pulse. The instrumental temporal resolution of 25 ps is sufficient for simultaneous measurements of the shock coalescence and compression peaks of D^3He implosions. Figure 2 shows laser pulse, shock, and compression proton peaks recorded by a PTD from an OMEGA implosion of a 24-μm-thick plastic shell filled with 18 atm of D^3He.

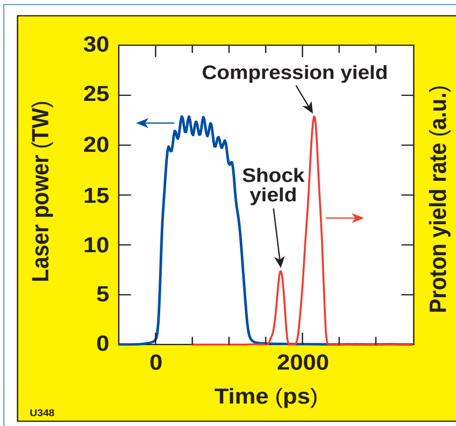

Figure 2. PTD record (red) obtained on an OMEGA implosion of a D^3He-filled target displayed along with the laser pulse history (blue).

OMEGA Operations Summary: A total of 120 target shots taken on OMEGA during April included the following: 38 target shots for LLNL experiments, 46 for LLE [including the integrated spherical experiments, Stockpile Stewardship Program, laboratory astrophysics, cryogenic target, and Rayleigh–Taylor instability campaigns], 16 for LANL experiments, 6 for CEA programs, and 14 for NLUF campaigns for three teams of investigators led by the University of Illinois, the University of Michigan, and the University of California, Berkeley.

1. R. D. Petrasso, J. A. Frenje, F. H. Séguin, C. K. Li, B. E. Schwartz, C. Stoeckl, P. B. Radha, J. A. Delettrez, D. D. Meyerhofer, S. Roberts, T. C. Sangster, and J. M. Soures, "Proton and Alpha Core Imaging of OMEGA D^3He Implosions," Bull. Am. Phys. Soc. **47**, 145 (2002).
2. B. E. Schwartz, F. H. Séguin, J. A. Frenje, R. D. Petrasso, C. K. Li, P. B. Radha, D. D. Meyerhofer, S. Roberts, T. C. Sangster, J. M. Soures, and C. Culligan, "Proton and Alpha Core Imaging Spectroscopy of Direct-Drive OMEGA Implosions," Bull. Am. Phys. Soc. **47**, 219 (2002).

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