X-Ray Backlighting of Cryogenic Capsule Implosions: X-ray backlighting is a powerful technique used to image cold dense material in many high-energy-density plasma experiments. Direct-drive cryogenic DT implosions[1] are a challenging backlighting configuration because the optical thickness of the DT shell is low, the shell velocity is high (up to 400 μm/ns), the size of the stagnated shell is small (~30-μm inner radius), and the self-emission of the hot spot at stagnation is bright compared to the backlighter signal. A narrowband crystal-imaging system with a Si backlighter driven by 20-ps pulses from OMEGA EP was set up to radiograph OMEGA cryogenic implosions[2] as shown in Fig. 1. It uses a quartz crystal with a Bragg angle of 83.9° for the Si He$_\alpha$ line at ~1.865 keV. The crystal is mounted on an aspherically shaped glass substrate to correct for the optical aberrations, especially astigmatism at the relatively large angle of incidence of 6.1°. A single-strip x-ray framing camera (XRFC) with an exposure time of ~200 ps was used as a detector for a first set of cryo backlighting experiments.[2] In the radiographs of cryogenic implosions recorded with 200-ps exposure times, the signal from the self-emission of the hot core was 5× stronger than the backlighter. The development of an ultrastable triggering system, with a jitter of 1.5 ps driven by the OMEGA fiducial, enabled the use of a shorter exposure time (40-ps) framing camera in recent experiments, which led to a significant reduction the background from the self-emission and improved contrast in the measured radiograph. The target used in these experiments had a 60-μm-thick DT ice layer and a 12-μm-thick CH ablator and was imploded with a triple-picket laser pulse of 25-kJ UV laser energy. The calculated adiabat was 3. Figure 2 shows a radiograph of a cryogenic implosion recorded with the 40-ps exposure time at a convergence ratio of CR ~ 7 approximately 200 ps before the time of peak neutron production. The regions of core emission, compressed DT, compressed CH, and backlighter spot are highlighted. Although the top portion of the radiograph was clipped by the detector, low-mode distortion of the compressed shell can be observed. The background signal from the hot core is reduced by a factor of ~5 compared to the experiments with the 200-ps framing camera and the absorption of the cold dense shell can be measured with a spatial resolution of 15 μm. The experimental data will be further processed and corrected for the backlighter shape and spatial resolution of the imager and will be compared to 2-D and 3-D simulations.

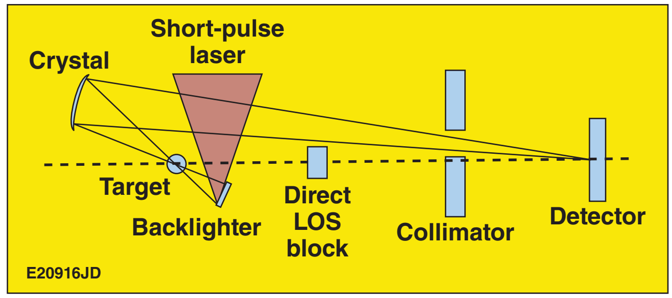

Figure 1. Schematic of the spherical crystal imager backlighting setup (not to scale). The short-pulse laser illuminates a backlighter foil behind the primary target, which is illuminated by 60 beams from the OMEGA laser (not shown). A direct line-of-sight (LOS) block and a collimator protect the detector from background x rays emitted by the backlighter and primary targets.

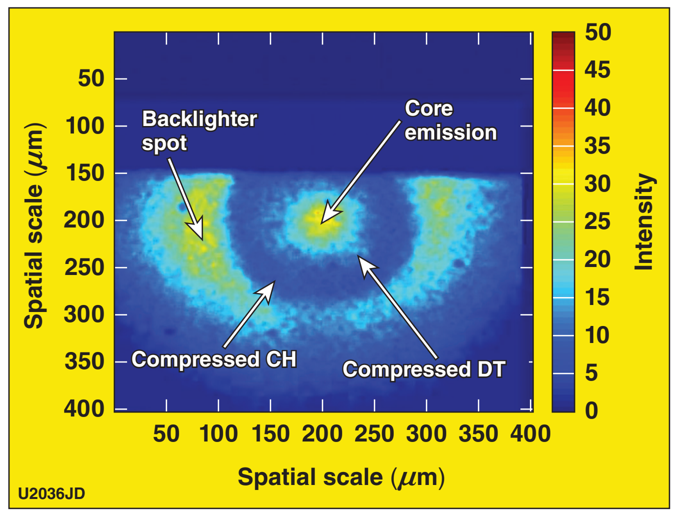

Figure 2. Radiograph of a cryogenic implosion recorded with the aberration-corrected narrowband crystal imager on a 40-ps exposure time framing camera at a convergence ratio CR ~ 7. The Si backlighter target was driven by a 20-ps, 1.5-kJ pulse from OMEGA EP. The image is rendered on a linear intensity scale.

Omega Facility Operations Summary: The Omega Laser Facility conducted 208 target shots during May with an average experimental efficiency (EE) of 97.1% (138 on OMEGA with EE of 98.6% and 70 on OMEGA EP with EE of 94.3%). The ICF program accounted for 45 target shots for experiments led by LLE while the HED program carried out 80 shots for experiments led by LANL, LLNL, and LLE. The NLUF program had 34 shots for three experiments led by the University of Michigan, the University of California, Berkeley, and the University of California, San Diego. Five LBS experiments led by LLE and LLNL accounted for 49 target shots.

1. T. C. Sangster *et al.*, Phys. Plasmas **17**, 056312 (2010).
2. C. Stoeckl *et al.*, Rev. Sci. Instrum. **85**, 11E501 (2014).