Effects of a Fill Tube on the Performance of OMEGA Direct-Drive DT Cryogenic Implosions: The effects of a fill tube on the performance of direct-drive DT cryogenic implosions on the OMEGA laser were investigated in anticipation of the fill-tube target that will be deployed in 2020 for the 100-Gbar Campaign. A fill-tube target is required to fill nonpermeable ablator materials that are designed to mitigate laser–plasma instabilities.[1] The current DT cryogenic targets are filled using a high-pressure permeation fill station.[2] These targets are supported using a SiC stalk having a 17-μm diameter. For this experiment, a 10-μm-diam, ~1-mm-long fill tube extending outward from the capsule surface was added to the target. The fill tube was filled with glue except for the 100-μm portion in contact with the plastic ablator. The fill tube penetrated the inner wall of the plastic ablator by ~10 μm. The orientation of the fill tube was along the H5 axis in the OMEGA target chamber. The mechanical perturbation from the fill tube and the stalk can seed hydrodynamic instabilities and mix material from the ablation surface into the hot spot.[3] The shadow cast by the fill tube can cause a nonuniform laser drive, seeding hydrodynamic instabilities as well. Understanding the degradation in implosion performance caused by the fill tube is important for direct-drive inertial confinement fusion research.

Gated x-ray images were recorded during the acceleration and early stagnation phases at photon energies down to ~1 keV using a technique developed by Michel *et al*.[4] Images recorded around the time of early stagnation do not show any evidence of fill-tube material jetting into the hot-spot region. Time-integrated, spatially resolved x-ray spectra recorded in the photon-energy range of the Si K-shell emission do not show any hot-spot mix mass from the glass fill tube or the SiC stalk.

Three DT cryogenic implosions were performed with the added fill tube, while one control target was imploded without a fill tube. The implosion target has an 8-μm-thick, 860-μm-outer-diam plastic ablator surrounding a 50-μm-thick cryogenic DT layer. The triple-picket laser drive delivered 26 kJ to the target. The calculated adiabat, convergence ratio, and in-flight aspect ratio quantities were ~4, ~17, and ~23, respectively. As shown in Fig. 1, changes to the measured neutron yield, areal density, and ion temperature caused by the fill tube were found to be small compared to the implosion performance without the fill tube. The fill tube reduced the neutron yield by ~10%. Post-shot, 1-D simulations performed with the *LILAC* hydrodynamics code show that the ratio of the measured yield to the simulated yield was ~35% for all of the shots under consideration. The measured areal density and the ion temperature inferred from the neutron time-of-flight (nToF) are slightly lower with the fill tube, but the difference is within the error bar. These results are encouraging news for the future fill-tube targets on OMEGA. Future experiments will explore the effects of the fill tube on lower-adiabat, higher-convergence DT cryogenic implosions.

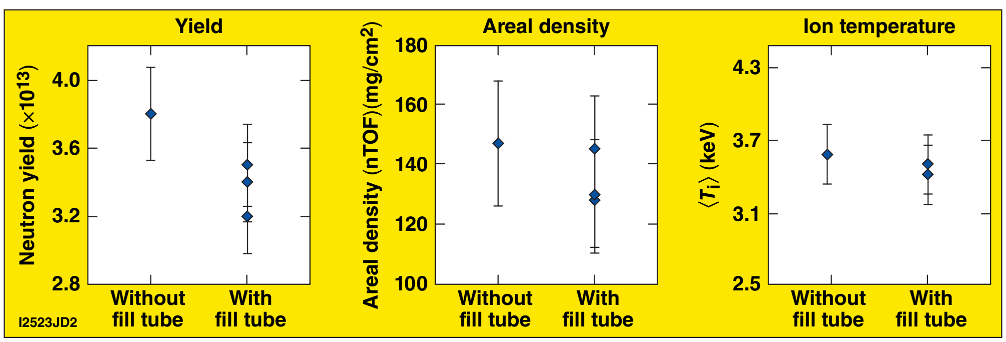

Figure 1. Summary of the measured neutron yield, areal density, and neutron-averaged ion temperature results with and without a fill tube added to the stalk-mounted DT cryogenic implosion target.

Omega Facility Operations Summary: During May 2017, 225 target shots were taken at the Omega Laser Facility with an average experimental effectiveness (EE) of 96.6% (the OMEGA laser had 151 shots with an EE of 91.1% and OMEGA EP had 74 shots with EE of 96.6%). ICF experiments led by LLE accounted for 71 target shots, and HED experiments by LLNL, LANL, and LLE accounted for 81 target shots. Four NLUF experiments led by principal investigators from Princeton University, MIT, and the University of Michigan carried out 43 shots and 22 target shots were provided for two LBS experiments led by LLNL. The facility also provided eight target shots for experiments led by CEA (France).

1. V. N. Goncharov *et al*., Phys. Plasmas **21**, 056315 (2014). 2. Harding *et al*., Phys. Plasmas **13**, 056316; LLE Review Quarterly Report **81**, 1 (1999). 3. I. V. Igumenshchev *et al*., Phys. Plasmas **16**, 082701 (2009). 4. D. T. Michel *et al*., Rev. Sci. Instrum. **83**, 10E530 (2012).