A New Wavelength-Tunable Beam for Laser–Plasma Interaction Experiments: Laser–plasma instabilities constrain the operable design space for each approach to inertial confinement fusion (ICF) by impacting laser drive, implosion symmetry, hot-electron preheat, etc. The need to validate modeling of cross-beam energy transfer (CBET) motivated the development of the tunable OMEGA P9 (TOP9) beam—an upgrade to the OMEGA EP laser that leverages the existing optical parametric amplification system in the short-pulse front end of Beamline 1 for spectrally broad amplification of a new, tunable, narrowband fiber front end. After amplification and frequency tripling, a new transport system image relays the beam to the P9 port of the OMEGA target chamber for joint operations with the OMEGA 60-beam laser (see Fig. 1). The beamline can deliver up to 0.5 TW in 1-ns-duration pulses with a wavelength that is tunable from 350.2 to 353.4 nm. Combined with the new gas-jet platform, TOP9 enables CBET experiments in large, uniform, quasi-stationary plasmas with open access to Thomson scattering for robust plasma characterization.

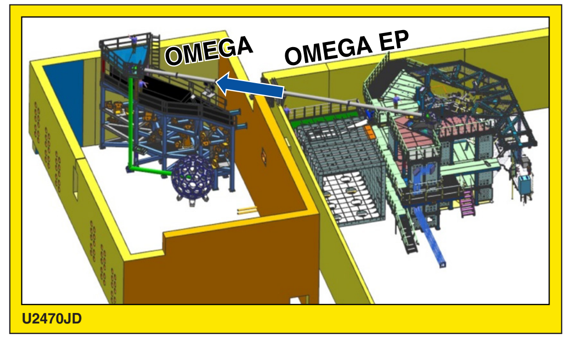

Figure 1. OMEGA EP Beamline 1, with a new wavelength-tunable front end, is transported to the P9 port of the OMEGA target chamber for joint operations.

Early experiments have tested the hypothesis that accounts for the so-called "Langdon effect" required for CBET modeling, particularly for indirect-drive ICF. The idea that laser-plasma heating can distort the electron distribution function (EDF) away from the usual thermal Maxwellian (i.e., Gaussian) distribution and toward a higher-order super-Gaussian has been around for decades; however, no experimental validation existed in ICF-relevant conditions. Recent OMEGA experiments have found that when plasmas are heated in a manner that is similar to a hohlraum laser entrance hole, simultaneous electron- and ion-feature Thomson probing provides clear evidence for the presence of a super-Gaussian EDF of the order of $m = 3$ (see Fig. 2). In such plasmas, the ion-acoustic waves that mediate CBET oscillate at higher frequencies than they would in a Maxwellian plasma with equivalent thermal energy, which directly affects the coupled laser interactions. Preliminary TOP9 experiments have verified the impact of the non-Maxwellian distribution function on CBET. The expectation is that accounting for the Langdon effect will improve CBET modeling in both direct- and indirect-drive ICF, and that evidence of non-Maxwellian EDF's in ICF-relevant plasmas will spark interest in other potentially affected areas such as laser absorption and heat transport.

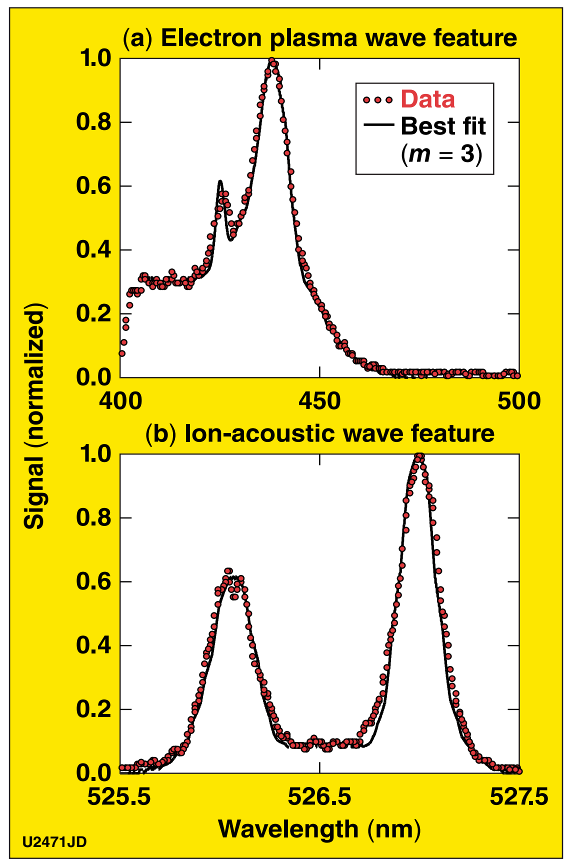

Figure 2. Fitting electron and ion-plasma wave features simultaneously requires a super-Gaussian electron distribution function of the order of $m = 3$, providing clear evidence of the Langdon effect.

Omega Facility Operations Summary: During September 2018, the Omega Laser Facility conducted 180 target shots with an average experimental effectiveness (EE) of 97%. Of these shots, 122 were taken on the OMEGA laser, including 6 shots jointly with OMEGA EP with an EE of 98.8%. Sixty-four shots were taken using the OMEGA EP laser with an EE of 93.8%. The ICF Program carried out 52 target shots for experiments led by LLE, while the HED Program accounted for 71 target shots led by LLNL, LANL, and LLE. Two NLUF experiments led by the University Michigan and the Univeristy of California, Berkeley had 17 target shots, and one LBS experiment led by LLNL had 13 target shots. Finally, CEA carried out three experiments with 27 target shots.