Integrated Simulations of Electron Transport and Ignition for Fast-Ignition Targets: The design and analysis of future integrated fast-ignition experiments combining compression and heating of high-density thermonuclear fuel requires hybrid (fluid + particle) simulations of the implosion and ignition process. The two-dimensional (2-D) axisymmetric hydrocode *DRACO*[1] and the 2-D/3-D hybrid-PIC code *LSP*[2] have been integrated to simulate the implosion and heating of direct-drive, fast-ignition fusion targets. *DRACO* includes the physics to simulate compression, ignition, and burn of fast-ignition targets. *LSP* simulates the transport of hot electrons to the dense fuel core. Integrated simulations of spherically symmetric DT, high-gain, fast-ignition targets for the NIF have been performed.[3] The target is a 488-μm-thick, 994-μm-outer-radius, DT wetted-foam shell imploded by 300 kJ of UV light. The minimum ignition energy is found to be 43 kJ for hot electrons with a realistic angular spread and Maxwellian energy-distribution function. The simulations show an extraordinarily beneficial effect of the self-generated magnetic fields driven by the resistive electric field that supports the return current. The self-generated resistive magnetic field grows to levels of tens of megagauss, collimating the hot-electron beam, increasing the coupling efficiency of the hot electrons to the target, and reducing the minimum ignition energy. For an initial divergence of 20° (half-angle), a mean electron energy of 2 MeV, and a distance from the cone tip to the center of the target of 125 μm, the minimum hot-electron energy for ignition is found to be ~43 kJ. The integrated simulations show that the ignition energy increases to 92 kJ when the self-generated magnetic field is artificially suppressed. Simulations of cone-in-shell plastic targets designed for fast-ignition experiments on OMEGA EP are also performed using the integrated codes (see Fig. 1). The OMEGA target consists of a 35-μm-thick CD shell with a re-entrant gold cone with a 50° opening angle. Previous implosion experiments with these targets without the short pulse have produced neutron yields from D–D fusion reactions in the range of 2 to 3×10^7. The shell implosion is simulated up to peak compression with the hydrocode *DRACO*. The integrated simulation with *DRACO* + *LSP* is used to determine the coupling efficiency of the hot electrons to the dense core as a function of the mean electron energy and initial divergence. The hot electrons from the 2.6-kJ, 10-ps IR OMEGA EP pulse are predicted to raise the dense core temperature by about 1 keV. Consequently, the neutron yield is estimated to increase to mid-10^9, a two-order-of-magnitude increase with respect to the implosion yield.

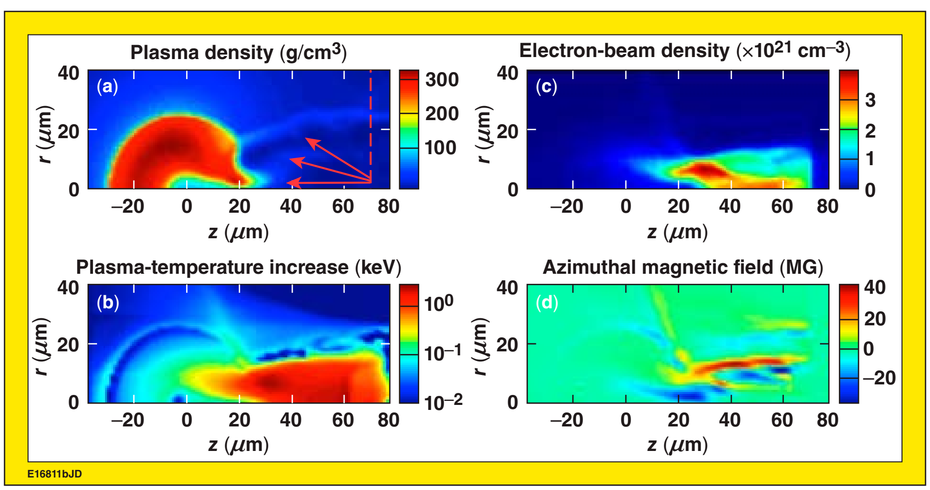

Figure 1. (a) Plasma density, (b) plasma-temperature increase, (c) snapshots of the electron-beam density, and (d) magnetic field at a time near peak compression in the integrated simulation of an OMEGA fast-ignition experiment. The hot-electron beam is injected at the position of the cone tip, 70 μm from the center of the target, with energy of 780 J (30% energy-conversion efficiency from a 2.6-kJ OMEGA EP pulse), mean energy of 2-MeV, angular divergence of 40° (full angle), spot diameter of 20 μm, and duration of 10 ps. The hot-electron beam is collimated by the resistive magnetic field and raises the target temperature by about 1 keV.

OMEGA Operations Summary: The OMEGA facility produced a total of 143 target shots in October, including 13 on OMEGA EP and 130 target shots on OMEGA (including 13 joint shots with OMEGA EP). The OMEGA shots included 99 NIC shots by teams from LLNL and LLE; and 31 HED, LBS, and NLUF shots by teams from LLNL, the University of Michigan, and LLE. Eleven OMEGA EP shots were taken for the NIC program and two for the LBS program. The experimental effectiveness was 95.4% for OMEGA and 92.3% for OMEGA EP.

1. P. B. Radha *et al*., Phys. Plasmas **12**, 056307 (2005).
2. D. R. Welch *et al*., Phys. Plasmas **13**, 063105 (2006).
3. A. A. Solodov *et al*., Phys. Plasmas **15**, 112702 (2008).