Spherical Strong-Shock Generation for Shock-Ignition Inertial Fusion: The generation of ablation pressures of up to ~400 Mbar was demonstrated in spherical strong shock (SSS) experiments on the OMEGA laser by using 1.8-ns shaped pulses of various laser energies.[1] A 1-ns, low-intensity foot is followed by a 0.8-ns, high-intensity square pulse. The low-intensity foot creates a plasma atmosphere around the target with which the high-intensity portion of the pulse interacts—situation that resembles the conditions of a shock-ignition target, where first a low-intensity pulse assembles the fuel and then at the end of the pulse, an intensity spike launches the ignitor shock wave into the shell. The SSS experiments used ~430-μm-diam solid plastic spherical targets, about half the size of a standard OMEGA target, and small-spot phase plates on all 60 OMEGA beams to reach shock-ignition–relevant laser intensities. The shocks reach several ~Gbar pressures upon convergence in the center of the solid target. The results are relevant to the validation of the shock-ignition (SI) scheme and to the development of an OMEGA experimental platform to study material properties at Gbar pressures. The SSS experiments investigate the strength of the ablation pressure and the hot-electron production at overlapping beam laser intensities of ~3 to 6 $\times$ 10^{15} W/cm^2. The demonstration of ablation pressures exceeding 300 Mbar is crucial to validate the SI concept. The timing of the x-ray flash from shock convergence in the center of the solid plastic target is used to infer the shock velocity and pressure.

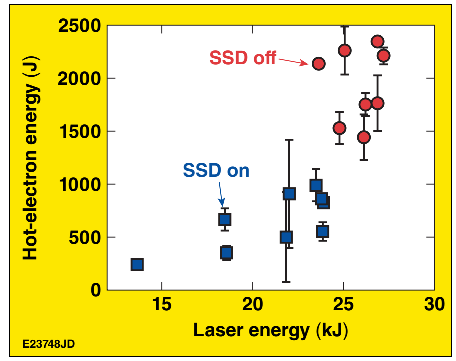

Figure 1. Total energy converted into hot electrons versus laser energy. Up to ~9% of the total laser energy was converted into hot electrons at moderate temperatures (50 to 100 keV). About a factor of 2 more hot electrons were generated when smoothing by spectral dispersion (SSD) was turned off.

Hot electrons are generated by laser–plasma instabilities including the two-plasmon decay (TPD) and stimulated Raman scattering (SRS) during the rise of the high-intensity square pulse. The hot-electron temperature was moderate (<100 keV) and the conversion efficiencies of laser energy into hot electrons reached up to ~9% (Fig. 1).

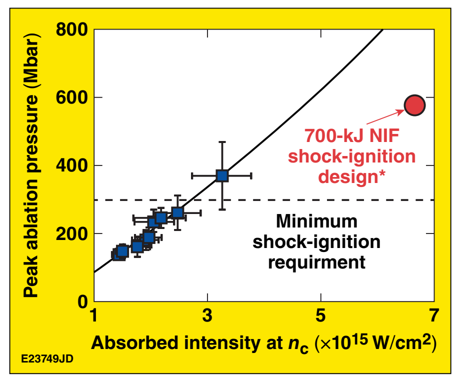

Figure 2. Scaling of the inferred maximum ablation pressure versus the maximum laser intensity that is absorbed at the critical surface. The ablation pressures (solid squares) were inferred from simulations that match all the experimental observables. The solid line shows the extrapolation to higher intensities based on the OMEGA experiments, which is favorable for SI. The red solid point shows the requirement for the 700-kJ NIF SI design.[2]

The shock and ablation pressures are inferred by constraining radiation–hydrodynamic simulations to the experimental observables: the temporal occurrence of the x-ray emission, the hot-electron energy and temperature distribution, and the temporal evolution of the hard x-ray emission. Figure 2 shows the scaling of the maximum ablation pressure versus the laser intensity absorbed at the critical surface. Hot electrons significantly contribute to the shock formation and increase the ablation pressure by ~30%. At the highest intensity, the minimum required ablation pressure of 300 Mbar for SI designs is clearly surpassed. Based on this extrapolation, ablation pressures exceeding 800 Mbar are expected at absorbed intensities of 6 $\times$ 10^{15} W/cm^2, which would exceed the required 600 Mbar of the point design by ~30%. However, the current OMEGA experiments were done at shorter density scale length than required for the 700-kJ NIF SI design.[2] Further experiments on the NIF are required to study the ablation pressure scaling for longer density scale length.

Omega Facility Operations Summary: The Omega Facility conducted 139 target shots in September with an average experimental effectiveness of 90.6%. OMEGA and OMEGA EP accounted for 83 and 56 targets shots in September (with experimental effectiveness of 88% and 96.4%, respectively. The ICF program had 31 target shots for five campaigns led by LLE and LLNL scientists. HED accounted for 36 target shots for five campaigns led by LLNL, LANL, and LLE scientists. The LBS program had 36 target shots for experiments led by LLNL and LLE and the NLUF program carried out 7 target shots for an experiment led by the University of California, Berkeley. Nineteen target shots were taken for CEA-led experiments.

1. W. Theobald *et al.*, Bull. Am. Phys. Soc. **59**, 61 (2014).
2. K. S. Anderson *et al.*, Phys. Plasmas **20**, 056312 (2013).