High-Energy Electron-Conversion Efficiency Measurement with High-Energy (2.1 kJ), Short Pulse (10 to 12 ps): Determining the fraction of laser energy transferred into energetic electrons in intense laser–matter interactions is a vital parameter in high-fluence backlighter development and advanced ignition experiments, including fast ignition. Foil targets were irradiated in OMEGA EP experiments at laser intensities of $I > 10^{18}$ W/cm^2 with up to 2.1 kJ of laser energy and pulse durations between 10 to 12 ps. **These are the highest energy short-pulse laser–matter interaction experiments ever conducted.** A K-photon emission-suppression technique (described in the *July 2007 Progress Report*) is used to contain electrons accelerated by OMEGA EP within a copper foil target. Efficient containment is achieved by rapid target charging during laser irradiation. Line radiation generated as the electrons interact with the target is used to infer the laser-to-high-energy, electron-energy-conversion efficiency (see Fig. 1). The data are consistent with a conversion efficiency of ~20%, independent of laser energy and pulse duration. This is an important observation, showing powerful electron sources can be generated with high-power, short-pulse lasers in the multikilojoule regime.

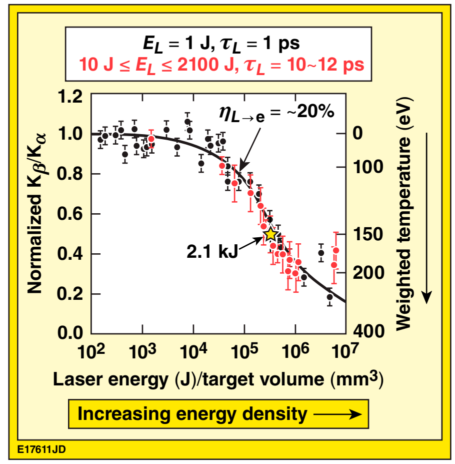

Figure 1. Measured K-photon emission ratio (K_β/K_α), normalized to the cold material value, as a function of increasing energy density (laser energy/target volume). The black points are measurements obtained on the MTW laser at a laser energy E_L ~ 1 J and a pulse width of ~1 ps; the red points are OMEGA EP measurements with 10 J ≤ E_L ≤ J and a pulse width of 10 to 12 ps. The black curve represents theoretical predictions for the K_β/K_α ratio, assuming electron refluxing and a laser-to-electron energy-conversion efficiency of 20%.

OMEGA EP Temporal Contrast Measurement: The temporal contrast of the two short-pulse OMEGA EP beamlines has been measured up to 0.5 ns before the main pulse using a high-bandwidth photodiode and oscilloscope. The diagnostic operated during more than 60 high-energy shots, demonstrating very good reproducibility. No short prepulse was found before the main pulse, and an incoherent pedestal generated by the optical parametric chirped-pulse amplifier front-end was precisely characterized. The pedestal extends a few nanoseconds before the main pulse and its intensity is less than 10^{-6} of the peak intensity for a 10-ps pulse (Fig. 2). Approximately 10^{-4} of the laser energy is contained in this pedestal and this fraction is constant up to a maximum short-pulse energy of 2.1 kJ. Since the pedestal's energy contrast ratio is independent of the compressed pulse width, the intensity contrast would be an order of magnitude larger for a 1-ps pulse (i.e., $>10^7$). Front-end improvements based on technologies demonstrated at LLE will be implemented in the future to increase the intensity contrast.

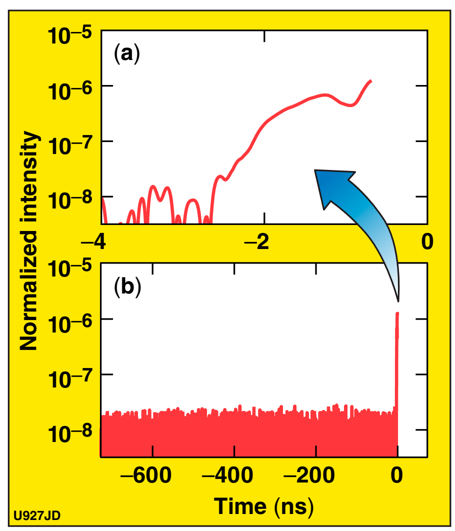

Figure 2. Temporal contrast for OMEGA EP Beamline 2 (shot 5833, 10 ps, 1 kJ) in (a) a 4-ns and (b) a 700-ns window before the main pulse. The intensity is normalized to the peak of the pulse at $t = 0$.

OMEGA Operations Summary: The OMEGA and OMEGA EP Laser Systems conducted 81 and 21 target shots in September with average experimental efficiencies of 99.4% and 97.6%, respectively. A total of 45 shots were taken for the National Ignition Campaign by teams from LLNL and LLE. Twenty-one target shots were taken for HED experiments by LLNL and LANL teams; 12 shots were conducted by AWE; and three experimental teams led by the University of California–Berkeley, Rice University, and the University of California–San Diego conducted 24 NLUF experiments. During the electron-conversion-efficiency experimental campaign, the OMEGA EP Laser System output energy was ramped from 1.0 kJ to 2.1 kJ on target. The 2.1-kJ shot represents the highest short-pulse energy produced to date by an OMEGA EP beamline. Damage sites were observed on the final grating of the compressor and two additional optical components following the gratings. All optics, including the final grating, were replaced during the scheduled maintenance period. As a result of this campaign, specific improvements are being made to the OMEGA EP beam quality to ensure safe operation in the future. OMEGA EP's Beam 2 (UV) was activated to target, and scheduled maintenance was conducted on both OMEGA and OMEGA EP during the last week of September.