K-Shell Spectroscopy of High-Intensity Laser–Solid Interactions: The study of suprathermal electron generation and transport in relativistic laser–plasma interactions at solid density is of fundamental interest for high brightness and high energy backlighter sources for the radiography of high-energy-density plasmas and fast-ignitor studies. A detailed K-shell spectroscopy study of ultrahigh intensity laser–solid interactions is currently under way at the LLE multitertawatt (MTW) high-intensity-laser facility to understand the conversion efficiency of laser energy into suprathermal electrons and the subsequent line emission characteristics over a wide range of laser pulse durations, focused laser intensities, and target compositions. MTW is a chirped-pulse–amplification (CPA) laser system that combines optical parametric amplification with Nd-doped laser glass amplification and currently delivers 1- to 10-J, 1- to 10-ps duration laser pulses in a focal spot of 4- to 5-μm FWHM.

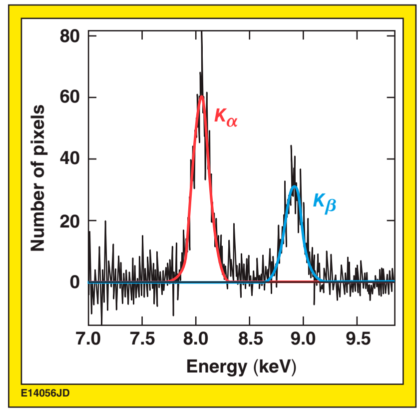

Figure 1. Copper K-shell spectrum for a laser intensity of 1×10^{19} W/cm^{-2}. The experimental data is compared to Gaussian fits; K_α emission line (red curve) and K_β emission line (blue curve).

Copper foil targets ($500 \times 500 \times 20$ μm) have been irradiated by the MTW laser at an angle of 20° to the target normal with 1-ps duration pulses and intensities of 10^{17} to 10^{19} W/cm^{-2}. The plasma K-shell line emission was measured approximately normal to the target surface with an x-ray CCD operating in the single-photon–counting mode[1] (Fig. 1). Good signal-to-noise was achieved with a combination of lead collimators and a 150-μm-thick copper K-edge filter. Figure 2 shows the ratio of the total energy in K_α photons to the laser energy as a function of the laser intensity. While the K_α yield is insensitive to the details of the suprathermal electron spectrum, the absolute K_α yield is dependent upon the suprathermal electron conversion efficiency.[2] The MTW experimental data (red squares) is in agreement with a theoretical refluxing model (solid curves show suprathermal-electron conversion efficiencies of 1%, 10%, and 40%). This model describes the confinement of suprathermal electrons within the target by the sheath fields that are set up at the front and rear surfaces of the target. Without refluxing, the model underestimates the measured K_α signal by more than an order of magnitude at intensities above 10^{19} W/cm^2 (dashed curves show suprathermal-electron conversion efficiencies of 1% and 40%). The MTW data is in good agreement with data previously taken at the Rutherford Appleton Laboratory using the Vulcan petawatt (PW) (blue triangles) to within experimental error. Both data sets show conversion efficiencies of laser energy into suprathermal electrons in the 10% to 30% range.[2]

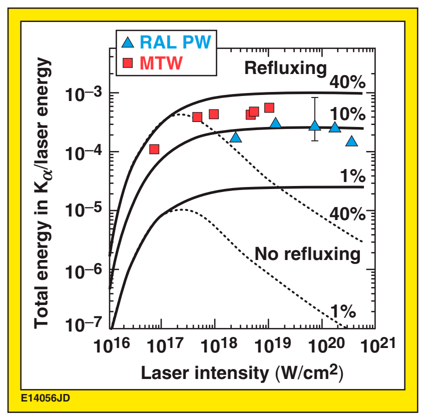

Figure 2. The ratio of the total energy in K_α photons to the laser energy plotted as a function of laser intensity. The solid and dashed curves correspond to theoretical suprathermal electron refluxing and nonrefluxing models, respectively, for conversion efficiencies in the 1% to 40% range. Experimental data from MTW and PW are in good agreement with the refluxing model.

OMEGA Operations Summary: OMEGA conducted 109 target shots during December 2006. The shot breakdown by laboratory was LLE (35), LANL (29), LLNL (24), CEA (11), and NLUF (10). A total of 65 NIC shots were taken in December (35 for IDI and 30 for DDI). The NLUF shots were taken for laboratory astrophysics experiments carried out by a team led by the University of Michigan. The last week in December was dedicated to system maintenance and highlighted by OMEGA EP short-pulse beam-tube-integration activities. To support integration of the new off-axis parabola inserter, TIM-2 was removed from port H7 and re-installed on port H3, the target chamber access platform was modified, and port H7 was enlarged. The integration of the OMEGA EP short-pulse beam tube onto port H9 continued. Additionally, optical fibers were installed to support activation of a new harmonic energy diagnostic (HED). The new HED system replaces the existing system that can no longer be supported.

1. C. Stoeckl *et al*., Rev. Sci. Instrum. **75**, 3702 (2004).
2. W. Theobald *et al*., Phys. Plasmas **13**, 043102 (2006).