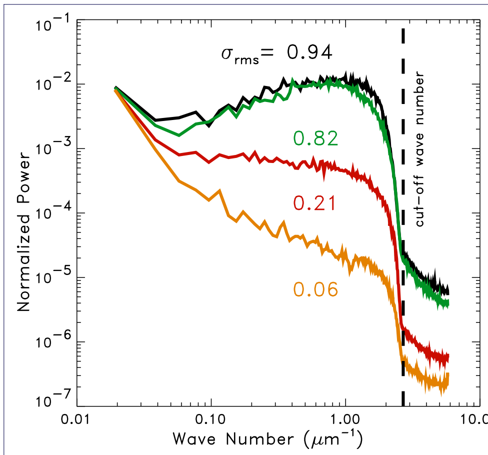
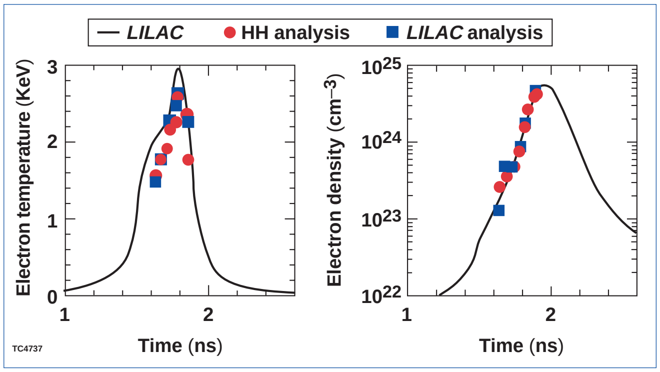
June 1998 Progress Report on the Laboratory for Laser Energetics' Inertial Confinement Fusion Program Activities

Laser Imprinting: The temporal dependence of beam smoothing produced by SSD on OMEGA was investigated by recording ultraviolet equivalent-target-plane (ETP) images of 100-ps and 3-ns square laser pulses. A new ETP setup recorded the images with a charge-coupled-device (CCD) camera instead of film. An ETP image of a laser pulse with zero accumulated B-integral ($\Sigma B < 0.5$) was also recorded to quantify the amount of beam smoothing due to the beam self-phase modulation at high laser powers. The low noise level of the CCD camera is fully exploited in this experiment to extract power spectra with negligible noise levels. Power spectra calculated from the measured ETP images for various laser pulses are shown in the figure. The power spectrum is the azimuthal sum at each frequency of the square of the Fourier amplitudes, and the cutoff wave number is given by the smallest laser speckle. The power spectra are normalized to the dc component, and the σ_{rms} is defined as the square root of the ratio of the power in the high frequencies to the power in the low frequencies (e.g., $k < 0.04$ mm^{-1}). The power spectrum for $\Sigma B = 0$ and no FM bandwidth (black curve) has the highest $\sigma_{rms} = 0.94$ (designed value: $\sigma_{rms} = 0.99$). The green curve is the power spectrum of a 100-ps pulse without SSD and $\Sigma B = 5.0$ radians resulting in $\sigma_{rms} = 0.82$. The same pulse with SSD (0.25 THz, red curve) reduces σ_{rms} to 0.21. A 3-ns square pulse with SSD (0.25 THz, orange curve) yields $\sigma_{rms} = 0.06$. It should be noted that a smoothing time of 3 ns is unrealistically long, but that smoothing times of 100 ps to 300 ps are more likely for direct-drive ICF experiments.



Power spectra calculated from the measured ETP images for various laser pulses of the SSD smoothing time experiment.

X-ray Spectroscopy: Analysis of the x-ray spectral features from rare gases (such as Ar) diffused into some of the targets shot on OMEGA are used to characterize the temperature and density during the capsule's implosion. Temperature and density estimates have been obtained from our experimental spectra by Charles Hooper and Donald Haynes of the University of Florida. Recently, they similarly interpreted a simulated time-resolved argon spectrum calculated by our 1-D hydrodynamics code *LILAC* and our atomic-physics radiation-transport post-processor. The solid curves in the two plots shown here represent the average core temperature and electron density around peak compression. The red dots are the results of the analysis of this synthetic spectrum by Hooper and Haynes. Their temperature and density estimates agree well with the *LILAC* averages, inspiring confidence in our spectrum simulation model. This also bodes well for analyzing real time-resolved spectra in terms of meaningful average temperature and density histories of an imploded core. More recently, the atomic-physics radiation-transport model used to generate the synthetic spectrum was used to calculate spectra representing single temperature-density points. These were implemented into a spectrum-fitting code to obtain temperature and density estimates of our own, which are shown in the plots as blue squares. These results agree well with the results from the more detailed and complete model of Hooper and Haynes. This agreement gives added confidence in the *LILAC* spectrum simulations and in our new spectral analysis capability.



OMEGA Operations Summary: The month of June was the first full month of extended shift operations. There were three shot weeks and one quarterly maintenance week during the reporting period. Rayleigh–Taylor and Imprinting in Non-Spherical Geometry (RTI) and Integrated Spherical Experiments (ISE) programs were supported during this month, as was the laser Beam Uniformity (BU) campaign; 49 target shots and 42 high power laser shots were distributed between the campaigns as follows: RTI 22, ISE 27, BU 42. June results reinforce the validity of the OMEGA extended-shift operations strategy, i.e., 12-hour shot days, three days per week.

Contact: Wolf Seka (716) 275-3815; fax: (716) 275-5960; e-mail: seka@lle.rochester.edu
John M. Soures (716) 275-3866; fax: (716) 256-2586; e-mail: jsou@lle.rochester.edu