# *November 2009 Progress Report on the Laboratory for Laser Energetics*

## *Inertial Confinement Fusion Program Activities*

***Hot-Spot X-Ray Spectrometer for the NIF:*** As part of the National Ignition Campaign, LLE scientists and engineers designed, constructed, and calibrated a new snout for the gated x-ray detector (GXD)—called the hot-spot x-ray spectrometer (HSXRS)—for the National Ignition Facility (NIF). This dual-channel imaging spectrometer records multiple monochromatic x-ray images of the implosion core in the 10- to 13-keV photon energy range with a spatial resolution of 11 $\mu$m and a temporal resolution of 70 ps. The low-energy channel extends from 10 to 11 keV, while the high-energy channel covers the 11.6- to 13-keV range. The spectral window was selected to monitor K-shell emission from the Ge dopant in the plastic-shell ablator. In the absence of hydrodynamic mixing, the Ge dopant would remain in the cold, dense shell and not emit any K-shell x rays. However, hydrodynamic simulations indicate that tens of nanograms of Ge-doped plastic may be mixed into the hot spot, ionizing the Ge and causing it to emit K-shell x rays. Therefore, crucial evidence of ablator material mixing into the hot spot can be recorded with the HSXRS. Each channel of the HSXRS consists of a pinhole array, a pentaerythritol (PET) crystal, a low-energy x-ray filter, and hard x-ray shields. One-dimensional spectral imaging is achieved using slit arrays. The HSXRS has a 12× magnification placing the pinhole array and the GXD 10 cm and 130 cm from the target, respectively. On 17 November 2009, the HSXRS was successfully fielded on the NIF for an ~850-kJ implosion. The spatially integrated spectrum recorded using a slit is shown in Fig. 1(a). The spectral locations of the Ge K-shell emissions are identified. The lower- and higher-energy channels were recorded 300 ps and 200 ps before bang time, respectively. The measured spectrum was dominated by He-like Ge emission and Li-like satellites. In Fig. 1(b) the image of the implosion core in Ge–He$_\alpha$ emission at 10.2 keV taken ~100 ps before bang time shows a bright spot with a full width at half maximum (FWHM) of ~25 $\mu$m, which is smaller than the ~60-$\mu$m core diameter. Further analysis of HSXRS data is required to determine the type of mixing and quantify the level of Ge in the hot spot.

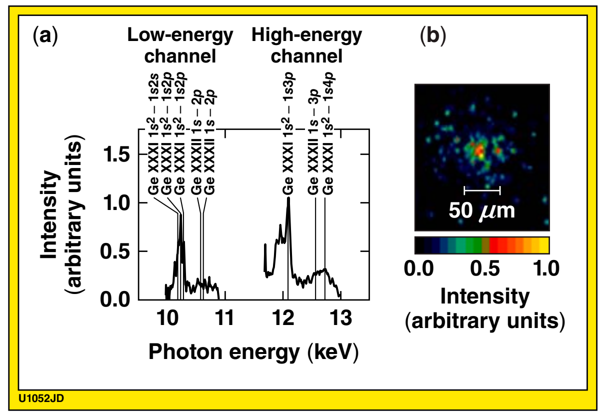


Figure 1. (a) The spatially integrated HSXRS spectrum recorded using a slit is shown with the spectral locations of the Ge K-shell emissions identified. The lower- and higher-energy channels are recorded 300 ps and 200 ps before bang time, respectively. (b) HSXRS image of NIF implosion core in Ge–He$_\alpha$ emission at 10.2 keV recorded ~100 ps before bang time. The bright spot has a FWHM of ~25 $\mu$m, which is smaller than the implosion core diameter of ~60 $\mu$m.

***NIF Polar-Drive Implosions:*** The first two NIF polar-drive experiments, designed to produce high neutron yields with low shell areal densities, were carried out on the NIF laser in the middle of November 2009. Marking the first time that two NIF implosion shots were executed in a single day, the second shot achieved the experimental design goals, producing a neutron yield in excess of $1.0 \times 10^{10}$ with an inferred neutron-averaged ion temperature in excess of 5 keV. These results are consistent with 2-D modeling of the experiments. Figure 2 shows x-ray image data and a corresponding simulated image produced by using the Spect3D[1] package to post-process *DRACO* code output.

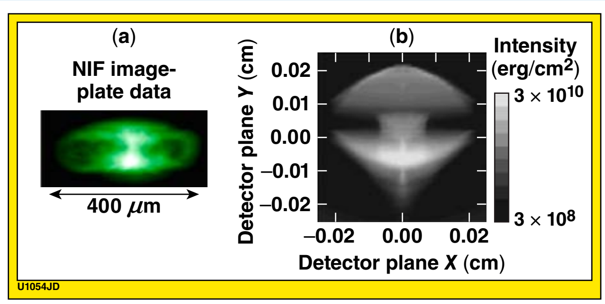


Figure 2. (a) Time-integrated x-ray image of the implosion taken from an image plate. (b) Simulated time-integrated image shows an illuminated oblate imploded shell and a self-emitting prolate core with filtering (~$h\nu$ > 5.5 kV) and GXD response.

***OMEGA Operations Summary:*** The OMEGA Facility conducted a total of 69 target shots during November (56 on OMEGA and 13 on OMEGA EP, respectively). The experimental effectiveness averaged 91.1% on OMEGA and 100% on OMEGA EP. Forty-three shots were taken for the NIC by teams from LANL, LLE, and LLNL and 26 were conducted for HEDSE campaigns by LLNL scientists. Scheduled maintenance was conducted on both facilities during the weeks of 2 November and 23 November. The first two DPP's were deployed on OMEGA EP. The temporal contrast of Beam 2 on OMEGA EP was improved via OPCPA pump-timing optimization.

1. Prism Computational Sciences, Inc., Madison, WI 53711.