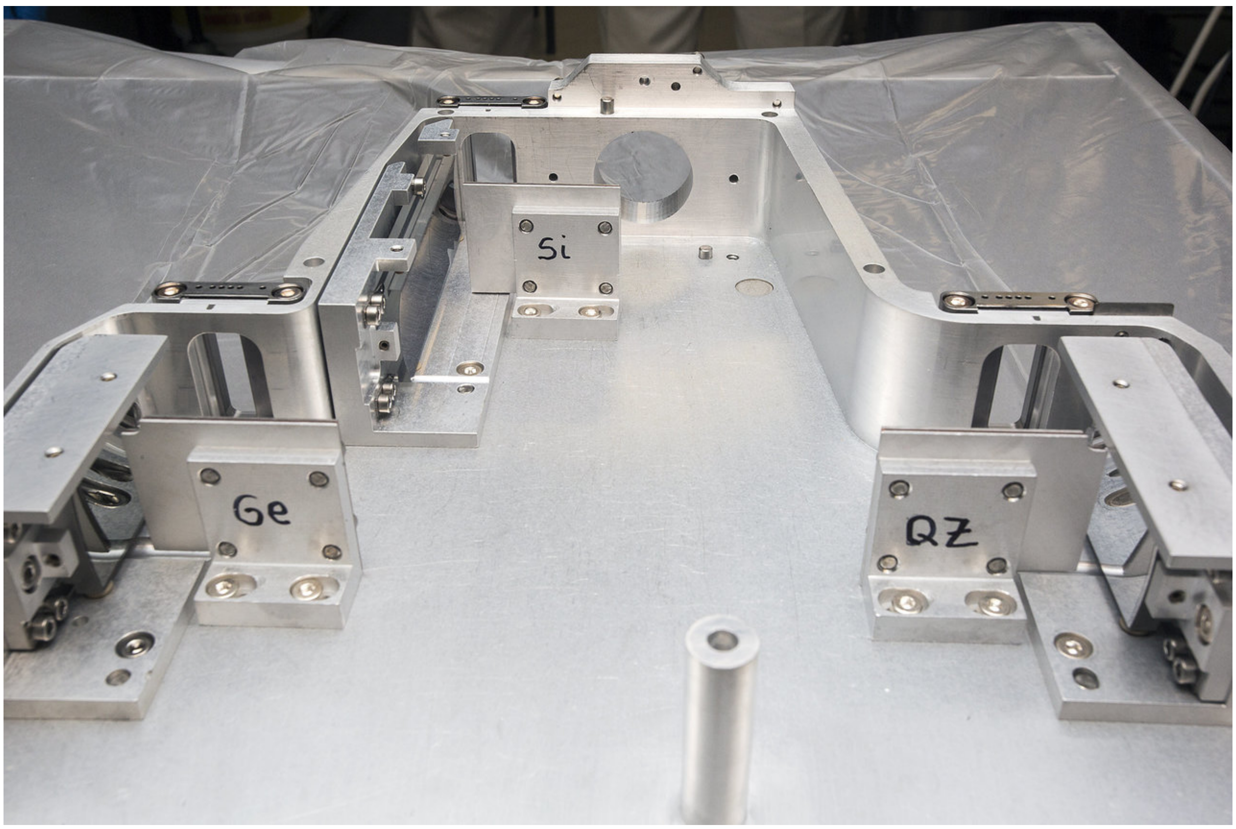
PPPL scientists deliver new high-resolution diagnostic to national laser facility

November 21 2017, by Raphael Rosen



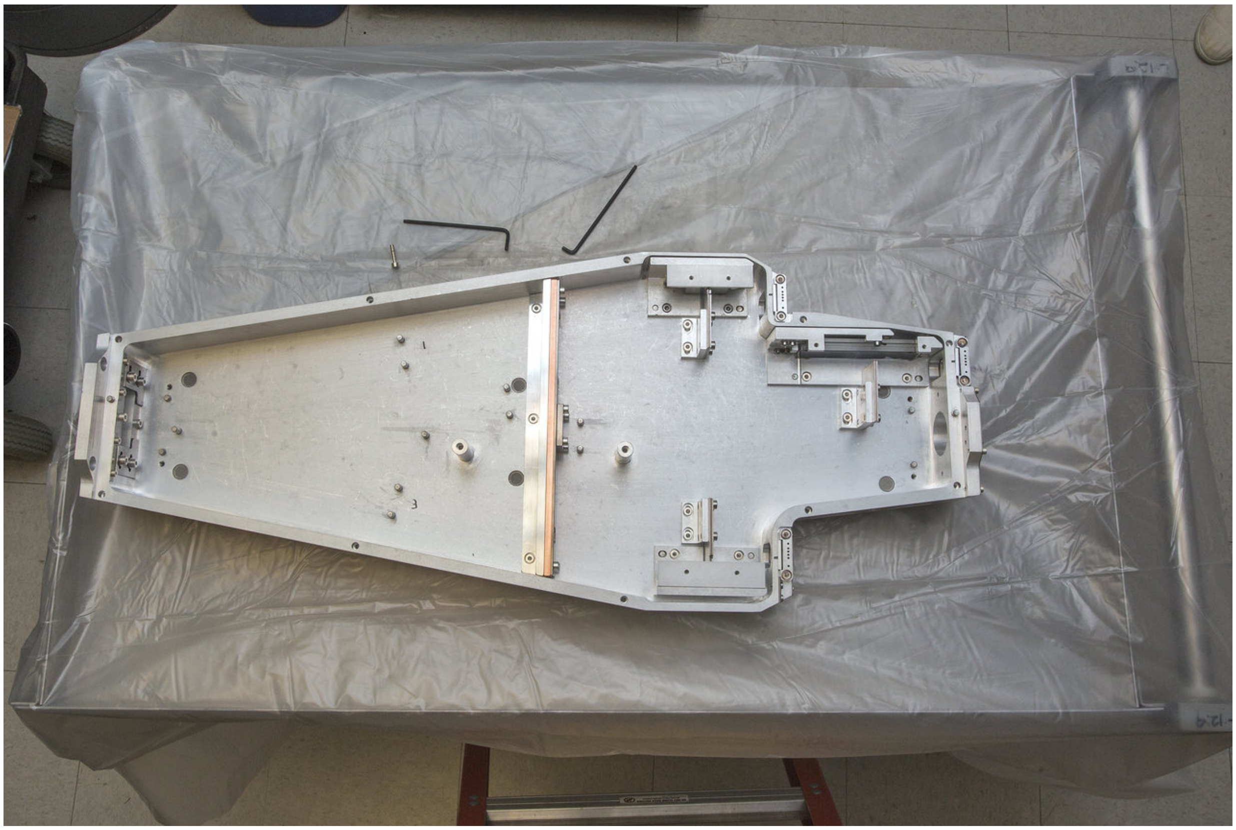
The three spectrometer channels inside the instrument. Credit: Elle Starkman

Scientists from the U.S. Department of Energy's (DOE) Princeton Plasma Physics Laboratory (PPPL) have built and delivered a high-resolution X-ray spectrometer for the largest and most powerful laser facility in the world. The diagnostic, installed on the National Ignition Facility (NIF) at the DOE's Lawrence Livermore National Laboratory, will analyze and record data from high-energy density experiments created by firing NIF's 192 lasers at tiny pellets of fuel. Such experiments are relevant to projects that include the U.S. Stockpile Stewardship Program, which maintains the U.S. nuclear deterrent without full-scale testing, and to inertial confinement fusion, an alternative to the magnetic confinement fusion that PPPL studies.

PPPL has used spectrometers for decades to analyze the electromagnetic spectrum of plasma, the hot fourth state of matter in which electrons have separated from atomic nuclei, inside doughnut-shaped fusion devices known as tokamaks. These devices heat the particles and confine them in magnetic fields, causing the nuclei to fuse and produce fusion energy. By contrast, NIF's high-powered lasers cause fusion by heating the exterior of the fuel pellet. As the exterior vaporizes, pressure extends inward towards the pellet's core, crushing hydrogen atoms together until they fuse and release their energy.

NIF tested and confirmed that the spectrometer was operating as expected on September 28. During the experiment, the device accurately measured the electron temperature and density of a fuel capsule during the fusion process. "Measuring these conditions is key to achieving ignition of a self-sustaining fusion process on NIF," said PPPL physicist Lan Gao, who helped design and build the device. "Everything worked out very nicely. The signal level we got was just like what we predicted."

The spectrometer will focus on a small capsule of simulated fuel that includes the element krypton to measure how the density and temperature of the hot electrons in the plasma change over time. "The fusion yield is very sensitive to temperature," said Marilyn Schneider, leader of NIF's Radiation Physics and Spectroscopic Diagnostics Group. "The spectrometer will provide the most sensitive temperature measurements to date. The device's ability to plot temperature against time will also be very helpful."



A cross section of the instrument showing three crystal spectrometers. Credit: Elle Starkman

Provided by Princeton Plasma Physics Laboratory

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