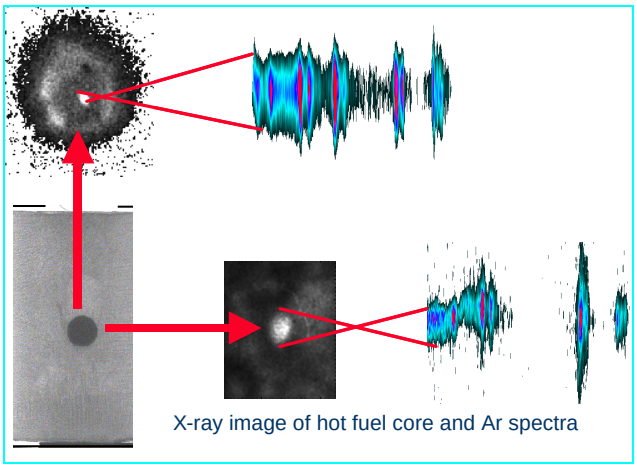
SEPTEMBER 2002 HIGHLIGHTS OF THE PULSED POWER INERTIAL CONFINEMENT FUSION PROGRAM

Experiments on Z Produce the First Clearly Measured Neutrons and Core Symmetry Measurements from Z-Pinch-Driven ICF Capsule Implosions



X-ray image of hot fuel core and Ar spectra

We have used x-rays from a z-pinch to implode inertial confinement fusion (ICF) capsules on Z and produce ~3×10^{10} neutrons. Since the measured neutron yields are consistent with one-dimensional radiation-hydrodynamics simulations and deuterium-deuterium (DD) fusion reactivity at the measured fuel density and temperature, we believe the neutrons are probably generated by thermonuclear fusion in the hot, compressed core of the capsules. However, because the neutron detectors measured signals with sharp rise times at 102°, but not at 0° (with respect to the z-pinch axis), the neutrons could have been produced by beam-generated fusion processes. Therefore, we are designing "null" experiments to quantify the contribution to the yield from these beam-target interaction processes, and we will continue to improve the suite of neutron diagnostics to clarify the neutron production mechanism.

This August, in eleven ICF capsule experiments utilizing the dynamic hohlraum x-ray source on Z, we obtained strong neutron signals from all six deuterium-filled capsules and saw weak, if any, signals from five CD_4–filled capsules, in reasonable agreement with our preshot simulations. The neutron-producing capsules had 2.0-mm-diameter CH shells with 40-50 micron wall thickness and were filled with 12-24 atm of deuterium. These indirect-drive capsules were calculated to absorb ~24 kJ of x-ray energy, the most ever for an indirect drive ICF capsule in the laboratory. As a point of reference, this is about one-sixth the energy absorbed by the point design NIF (National Ignition Facility) capsule. The CD_4–filled capsules had 1.6-mm-diameter CH shells with 50 micron wall thickness and are calculated to absorb ~14 kJ of x-ray energy. The gas for both the D-filled and CD_4-filled capsules was doped with 0.085 atm argon; the resultant Ar K-shell emission was used to diagnose the fuel conditions and provide a bright x-ray source at ~3 keV. High-quality Ar spectra and core images were obtained from an axial diagnostic package containing detectors that have improved resolution (see top right figure). Excellent Ar spectra and core images were observed through the pinch plasma with new side-on spectrometers as well as x-ray framing cameras. Preliminary analysis of these orthogonal images suggests that the imploded core was reasonably symmetric, with an estimated axial-to-radial elongation ratio of ~1.5. Developing the capability to measure the polar symmetry of an imploded fuel core is a crucial enabling step for the dynamic hohlraum ICF concept. Additional information on the capsule performance will be obtained by analyzing the bang time measurement obtained from Ross-filtered photoconducting device (PCD) diodes that observed the argon K-shell emission at peak compression.

Two time-dependent scintillation detectors, at 102° relative to the z-pinch axis, recorded strong neutron signals with the appropriate time-of-flight (TOF) for 2.5-MeV neutrons, characteristic of a DD fusion reaction. In addition, three different neutron activation detectors (indium, Be-probe and Pb-probe) had measurable signals. The average yield for the four shots with a nominal 12 atm deuterium fill was 1.6×10^{10} while the average yield for the two shots at ~24 atm was 4.2×10^{10}. Clear 2.5-MeV neutron TOF signals were not obtained on the paired detectors in the basement of Z at 0°. We are investigating reasons for these observations, including neutron production by beam-target interactions.

The goals for the next dynamic hohlraum shot series, scheduled for Q2FY03, will be to improve the neutron diagnostics and capsule fabrication techniques, study ICF capsule symmetry as we move toward increasingly ablative drives, and study predicted improved radiation-matter coupling with doped foams.

For more information on this article contact: Tom Mehlhorn, tamehlh@sandia.gov; or SNL ICF Manager: Keith Matzen, mkmatze@sandia.gov.
SNL Highlights and other information can be found at our website: http://www.sandia.gov/pulspowr/hedicf/hedicf.html.

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