THREE DIMENSIONAL IMAGING OF THE NEUTRON EMISSION OF IMPLOSION EXPERIMENTS AT NIF

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An existing neutron imaging system at the National Ignition Facility (NIF) [1] is used to provide data on the size and shape of the fusion hotspot and the surrounding cold fuel for ICF experiments. This imaging system views the implosions from an equatorial view and is composed of two basic pieces: a pinhole aperture array that is used to form the neutron images and a scintillator-based detector system that is used to measure the neutron flux passing through the aperture array. A scintillating fiber bundle is viewed with two fast-gated image collection systems, which allows the collection of two independently timed images along the same line of sight. Because the detector array is positioned 28 meters from the neutron source, the neutron arrival time at the detector is correlated to the neutron energies, allowing measurements of the neutron source distributions from two energy ranges by gating the detectors at the two different times. Typically, one detector is gated to view the 14 MeV neutrons that are generated from DT fusion processes and provides information on the size and shape of the hot spot. The second detector is gated to measure the source distribution of lower energy neutrons, typically in the range from 6-12 MeV. These lower energy neutrons are predominantly DT-fusion neutrons that have scattered in the surrounding cold fuel and, therefore, provide information on the distribution of this cold fuel.

Typical neutron emission measurements at NIF show a clear asymmetric hotspot and cold fuel. Because this single-view image is a summation of the neutrons generated along the line of sight of the instrument, it is impossible to determine the three dimensional distribution of the hotspot or cold fuel. This is a significant short coming, as the source of this asymmetry is not fully understood and is very likely an indication of the processes which dominate the stagnation phase of these high convergence implosions.

A conceptual design has been developed for the addition of two new neutron imaging systems at NIF, orthogonal to the existing system, which will provide a measure of the three dimensional structure of the hot spot and cold fuel. Practical considerations in the development of this concept have required the development of techniques to allow measurements along a shorter line of sight (~16 m) and concepts have been developed to allow simultaneous x-ray emission measurements on nearly the same line of sight.

The collection of this multi-dimensional data would enable the study of the effects of three dimensional asymmetries on the stagnation phase physics, providing a measurement of 3D asymmetry and performance to guide the development and validation of 3D models and simulations. The design concept for these measurements will be presented along with results from preliminary measurements collected in the development of short line of sight neutron imaging systems.

[1] F. E. Merrill et al., *"The neutron imaging diagnostic at NIF"*, Rev. Sci. Instrum. 83, 10D317 (2012); doi: 10.1063/1.4739242