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IFE/1-1: Diagnosing Implosion Performance at the National Ignition Facility (NIF) by Means of Advanced Neutron-Spectrometry and Neutron-Imaging Techniques

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Proper assembly of capsule mass, as manifested through the evolution of fuel areal density, is essential for achieving hot-spot ignition planned at the National Ignition Facility (NIF). Experimental information about areal density and areal-density asymmetries, hot-spot ion temperature (Ti) and yield (Yn) are therefore critical for understanding the assembly of the fuel. To obtain this information, a suite of neutron Time-of-Flight (nTOF) spectrometers and a Magnetic Recoil Spectrometer (MRS) has been commissioned and extensively used on the NIF for measurements of the neutron spectrum in the energy range from 1.5 to 20 MeV. This range covers all essential details of the neutron spectrum, allowing for the determination of areal density, Yn, and Ti. The spectrometers are fielded at different locations around the implosion for directional measurements of the neutron spectrum, also allowing for determination of areal-density asymmetries and possible kinetic effects. The data obtained from these diagnostics have been essential to the progress of the National Ignition Campaign (NIC), indicating that the implosion performance, characterized by the Experimental Ignition Threshold Factor (ITFx), has improved about two orders of magnitude since the first cryogenic shot taken in September 2010. Areal-density values greater than 1 g/cm2 are now readily achieved. By combining the areal-density data with information about the spatial extent of the high-density region obtained from Neutron Imaging System (NIS), it has been demonstrated that densities above 500 g/cc and pressure-time (Ptau) products in excess of 10atm s have been achieved, which are according to HYDRA simulations about a factor of three from ignition conditions.

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