Nuclear Diagnostic Advancements for the National Ignition Facility

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Los Alamos National Laboratory (LANL) leads the effort on two transformative diagnostics for the National Ignition Facility (NIF), namely the Neutron Imaging System (NIS) and Time-resolved Gamma-ray Spectroscopy. Both are undergoing a multi-phase, multi-year effort to dramatically improve measurement fidelity. NIS is headed toward three dimensional imaging of hot spot (based on primary neutrons), cold fuel (down-scattered neutrons) and remaining ablator (^{12}C(n,n')gammas). The first phase consisted of installing a 2nd imager capable of imaging the hot spot from the north pole. A third imager is in development to be located on the equator nearly orthogonal to the other two. All 3 imagers will be upgraded to be capable of imaging all 3 components in the coming years. Three dimensional visualization of the nested shells of material will significantly improve our understanding of implosion performance. Time-resolved Gamma-ray Spectroscopy is being driven by new requirements to improve reaction history and ablator areal density measurements at the NIF, necessitating diagnostic capability improvements in sensitivity, temporal and spectral response relative to the existing Gamma Reaction History diagnostic (GRH-6m) located 6 meters from target chamber center (TCC). Relative to GRH-6m, a new "Super" Gas Cherenkov Detector (GCD) will ultimately provide ~200x more sensitivity to DT fusion gamma rays, reduce the effective temporal resolution from ~100 to ~10 ps and lower the energy threshold from 2.9 to 1.8 MeV to further investigate neutron-induced gammas from ablator materials. As a first step, the existing GCD-3 has been installed into a reentrant well using a new Diagnostic Insertion Manipulator (WellDIM-3.9m), putting it within 4 meters of TCC. It will enable use of a revolutionary new pulse-dilation photomultiplier tube (PD-PMT) technology currently under development which has the potential to improve the effective measurement bandwidth by >10x relative to current PMT technology. Reaction History features such as onset of alpha heating, shock reverberations and burn truncation due to dynamically evolving failure modes will help elucidate implosion performance. In addition, time-resolved mix measurements will become feasible for the first time.