MEASUREMENTS OF STAGNATION CONDITIONS IN NIF IMPLOSIONS: REPRODUCIBILITY AND INTENTIONAL ASYMMETRY*

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At peak compression, the core of an ICF implosion produces signatures of stagnation in both X-rays and neutrons. We use these experimental signatures to measure the extent to which the implosion has produced a nearly spherically symmetric and stationary hot spot surrounded by uniform cold fuel. Our diagnostic teams on NIF thoroughly diagnose the hot spot conditions, measuring the bulk implosion drift velocity, the ion temperature, the residual flow variation in the hot spot, and the evolution of the hot spot shape. We also characterize the distribution of the cold fuel by measurement of both primary neutron yield and downscattered neutron yield as a function of angle.

We report here the results of a 5-shot sequence of cryogenic DT layered implosions designed to measure NIF implosion stagnation, the reproducibility of this stagnation process, and the response of the stagnation phase to intentional perturbation. Three of the 5 shots are nearly identical repeats. We find the key performance metrics are reproducible. The neutron yield, for example, showed a standard deviation of less than 15%. We provide a Bayesian analysis of the repeated shots in the context of the dozens of shots with similar targets and pulse shapes.

Having established the reproducibility of the underlying implosion platform, we examine two implosions with intentional perturbations. The first perturbation was made by increasing the upper hemisphere of driving lasers by 4%, while reducing the lower hemisphere by an equivalent amount. This drive imbalance produces bulk translational flow, jetting and recirculation within the hot spot, and asymmetric cold fuel. The stagnation measurements show clear signs of the damaged stagnation, and these signatures match well our expectations from simulation. The final perturbation will provide an analogous imbalance by off-centering the central gas cavity in the cryogenic DT ice layer. Together, the suite of implosions provides a demonstration of our ability to measure stagnated flow performance, both under nominal conditions and under strong perturbation.

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