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Achieving Record Hot Spot Energies with the Largest HDC Implosions on NIF in HYBRID-E

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The performance of Inertial Confinement Fusion (ICF) implosions is governed by four key parameters implosion velocity, adiabat, inflight ablation pressure, and capsule size [1]. Experiments on the NIF have roughly bracketed the limits of these terms for current systems [2-4]. While optimizing these terms has previously enabled experiments at the NIF to achieve record hot spot energies and fusion yield, experiments to explore cliffs in performance indicate that these terms may have reached their near optimum for these platforms [5]. The goal of HYBRID campaigns is to increase energy delivered to the hot spot by increasing capsule scale and to determine the largest capsule size that can be fielded symmetrically within the current experimental limits at NIF. Here, we report on HYBRID-E experiments that have fielded the largest diamond capsule implosions driven symmetrically on the National Ignition Facility (NIF) (inner radius of $\sim$1100μm) to high velocities of up to 400 km/s. This was enabled by using a modest amount of cross beam transfer (CBET) and choosing hohlraum parameters in a semi-empirical way [6] to control symmetry at small case-to-capsule ratio (CCR). These experiments build on the work of previous campaigns, including HYBRID-B [7-9] which symmetrically fielded a $\sim$1050μm inner radius capsule implosion, without CBET, at a larger CCR and slower implosion velocity. We report record fuel kinetic energies and hot spot energies of ˜15kJ by driving a 65μm thick DT layer to ˜360 km/s in a 1100μm inner radius HDC capsule. This configuration currently holds the record for the highest neutron yield on NIF and gave several times higher yield than a direct comparison experiment using a 10μm thinner DT ice layer which showed more meteors, or glowing bright spots, that cool the implosion via ablator mix into the hot spot. This strong sensitivity to ice thickness could be due to instabilities seeded by defects in the capsules that contain thousands of voids. Experiments to increase hohlraum temperature using a smaller laser entrance hole (LEH) resulted in higher implosion velocities up to 400km/s. However, preliminary experiments at higher velocities again showed meteors. While the origin and mitigation of these meteors is still being investigated, ongoing work is being done to test better quality capsules, reduce ablation front growth factors, and further increase ice thickness at high implosion velocity. In the coming months we also plan to scan capsule scale (1050μm-1100μm inner radius) to determine the optimal capsule scale for the current laser capability of NIF with hot spot pressure being a primary metric.

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