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Indirect drive fusion with the NIF laser*

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The challenges and progress in uniformly and efficiently compressing ICF capsules to reach ignition at the 2 MJ NIF laser facility using laser-produced hohlraum x-rays will be described in the context of ongoing hohlraum and capsule performance optimization and cryogenic implosion experiments. Currently, imaging and spectroscopy of the X-ray and neutrons emitted from the compressed core show that we have reached ion temperatures of 4.8 keV and peak pressures of 300 Gbar producing alpha-heated dominated neutron yields of up to 2e16 [1]. The higher yields have been achieved by reducing ablation-front hydroinstability perturbation seeds [2], growth rates [3] and implosion convergence ratios while increasing peak implosion velocities.

The yield and fuel compression sensitivity to various drive parameters for the >75 low mix NIF indirect-drive cryogenic DT implosions performed to date is empirically examined across all ablators (CH, C and Be) and in-flight adiabats. Yields normalized by fuel mass increase with the expected high power of velocity as shown in Fig. 1, and increase with fuel compression after normalizing out velocity, but only up to a point. Mass and velocity normalized yields and compressions drop by factors 1.5-3x in the cases of large mode 1 and 2 drive asymmetries. The trends follow analytic expressions [5,6].

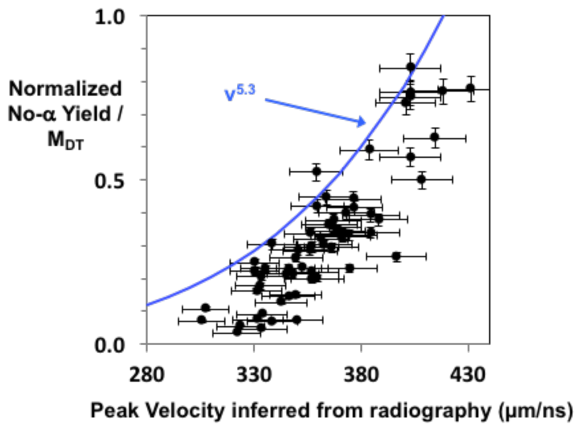

Figure 1. DT Yield dividing out alpha heating component and normalized to DT mass vs peak implosion velocity.

Even for the higher adiabat C designs, compression for low coast implosions [4] is improved as shock merge depths approach the DT fuel-gas interface as shown in Fig. 2. However, it appears that compression and performance can also be increased by reducing the number of shocks crossing the ablator-DT fuel interface from 3 to 2 [7] as shown by the green points. This may point to increased sensitivity to the RM hydroinstability or Atwood # acting as a seed for subsequent ablator-DT mix.

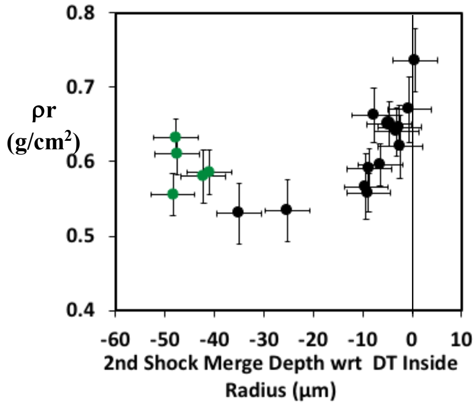

Figure 2. Measured fuel areal density at bangtime vs inferred 2nd shock merge depth for C implosions.

To enable further progress at existing NIF energies, the final DT fuel areal density which provides confinement will be increased back to ≥1 g/cm^2 levels by using larger capsules and/or thicker DT ice layers that require longer drives and hence reoptimized hohlraums. In parallel, new in-flight and stagnation x-ray radiography techniques (Compton [8] and refraction-enhanced [9]) to study fuel uniformity, mix and preheat are being implemented. The highlights of such more recent hohlraum and capsule experiments will also be presented.

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