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Near-vacuum hohlraums for driving fusion implosions with high density carbon ablators[1]

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Achieving ignition requires reaching fast implosion velocities, which highlights the need for a highly efficient hohlraum to drive indirect-drive inertial confinement fusion implosions. Gas-filled hohlraums are typically utilized due to the pulse length (15-20 ns) needed to drive plastic (CH) capsules. With the recent use of 3x denser high-density carbon (HDC) capsules, ignition pulses can be less than 10 ns in duration, providing the opportunity to utilize near-vacuum hohlraums (NVH) to drive ignition-relevant implosions on the National Ignition Facility (NIF) with minimal laser-plasma instabilities which complicate standard gas-filled hohlraums. Initial NVH implosions on the NIF have demonstrated coupling efficiency significantly higher than observed in gas-filled hohlraums – backscatter losses less than 2% and virtually no suprathermal electron generation. A major design challenge for the NVH is symmetry control. Without tamping gas, the hohlraum wall quickly expands filling the volume with gold plasma. However, results to-date indicate that the inner-cone beams propagate freely to the hohlraum wall for at least 6.5 ns. With minimal predicted cross-beam power transfer, this propagation enables symmetry control via dynamic beam phasing – time-dependent direct adjustment of the inner- and outer-cone laser pulses. A series of experiments with an HDC ablator and NVH culminated in a 6 ns, 1.2 MJ cryogenic DT layered implosion yielding 1.8 x 10^{15} neutrons—significantly higher yield than any CH implosion at comparable energy. This implosion reached an ignition-relevant velocity – 350 km/s – with no observed ablator mix in the hot spot. Recent experiments have explored two-shock designs in a larger, 6.72 mm hohlraum, and upcoming experiments will incrementally extend the pulse duration toward a 9 ns long, three-shock ignition design.

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