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Measurements of Thermonuclear Burn Dynamics from Nuclear Reaction History

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The recent achievement of ignition at the National Ignition Facility (NIF) has enabled the physics of ignition and burn propagation to be studied in a laboratory setting for the first time. The primary diagnostic for studying the dynamics of thermonuclear burn for an ICF implosion is nuclear reaction history, which is measured by the Gamma Reaction History diagnostic (GRH) at the NIF. The GRH is a gas cherenkov detector that measures the 16.7 MeV DT fusion gamma ray with a temporal resolution < 10 ps [1]. This enables the diagnostic to measure the fast changes in the nuclear reaction rate and the relative derivative of the reaction rate, or "α-curve". The shape of measured α-curves indicates that burn propagation is occuring due to an ablation front at the inner surface of the ice layer which tamps the seeding of the thermal instability driven by fusion until the ice is ablated into the hot-spot.[2][3] While data shows ignition and propagating burn are occuring, the magnitude of the maximum of the α-curve are within 20% of the value predicted by analytic theory and radiation hydrodynamic simulations of the condition indicative of thermal ruanway and robust ignition ($\alpha_{max} > 50/ns$). This implies the implosions are still marginally igniting and a thermal instability has not yet been seeded in the implosions and simulations predict increase of 2-4x in yield is still achievable for the current NIF target designs.

References

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