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Gamma measured ablator areal density observations, trends and time shifts on the National Ignition Facility[1]

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In inertial confinement fusion, few diagnostics are able to look at the final state of the ablator in integrated, cyro-layered implosions. The Gamma Reaction History diagnostic measures fusion gammas as well as the neutron induced 4.4 MeV carbon ablator. Recently, a new analysis routine was developed to isolate this carbon gamma line from other neutron induced background, giving the areal density (ρR) of the ablator as well as the time shift between the carbon gammas and the DT fusion. Now carbon ρR values have been generated for a database across many National Ignition Facility (NIF) shots. The values can be compared and contrasted across the NIF campaigns. They reveal that the ablator is surprisingly not set by velocity, DT cold fuel radius or picket intensity, as one might expect. But instead is sensitive to the coast time, mass remaining and dopants. This verifies that coast time is a vital metric that continues to apply pressure onto the capsule late time, improving performance, as well as the effectiveness of dopants to reduce mix and preheat and increase compression. The data is also suggestive that fill tube jets increase the effective carbon ρR but the signal is within the uncertainty level. Future improvements could use carbon ρR in combination with x-ray diagnostics to constrain the mass and density of all mixed material – cold or hot. The carbon gammas are observed to systematically arrive ˜15ps later than the DT fusion peak, implying the ablator areal density is increasing across the burnwidth of the reaction. This shift allows estimation of the amount of kinetic energy and velocity in the ablator at bangtime and may reflect a slower final ablator speed than what is predicted by simulations, consistent with a slower implosion and observed longer burnwidth. Simulations predict that an igniting capsule has the carbon gamma signal arrive before the DT fusion peak, suggesting the carbon gamma timing could be a metric that could be used to quantify future ignition.

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