SIGNATURES OF NON-THERMAL FUEL MOTION IN THE DT-NEUTRON SPECTRUM MEASURED AT THE NATIONAL IGNITION FACILITY

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Efficient conversion of shell kinetic energy to hot-spot thermal energy is an essential requirement to achieving ignition at the National Ignition Facility (NIF). Ensuring efficient conversion requires a fundamental understanding of fuel assembly and hot spot formation, which is obtained, in part, through measurements using neutron spectrometers [1,2] and neutron activation detectors [3], which provide accurate, directional measurements of DT and DD ion temperatures and yields from layered deuterium-tritium implosions. The measured difference between DT and DD ion temperatures is consistently higher than expected based on density and temperature profiles and the different temperature-dependence of the DT and DD reactivities. In addition, the observed DD/DT yield ratio is consistently higher than predicted when correcting for the different attenuation of the two through the surrounding dense fuel layer. In this paper, we develop a 1D, self-consistent picture to explain these results based on refs [4-6]. The difference in measured DD and DT ion temperatures suggests that significant energy is lost to radial [4] or turbulent [5] kinetic fuel motion at peak burn.[1] However, explaining the full observed temperature difference with fuel motion only leads to thermal temperatures too low to explain the observed neutron yields and unrealistically high fuel velocities at peak burn. One possible way to reconcile these observations is to also consider different spatial profiles of the deuterium and tritium fuel ions in the burning region of the implosion, so-called species separation [6-8]. However, this conjecture needs to be thoroughly scrutinized before any conclusions can be drawn.

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[1] No significant line-of-sight variations are observed in the ion temperature measurements, indicating that fuel flows are on average uniform in all spatial direction.