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Time-dependent nuclear measurements of fuel-shell mix in ICF implosions at OMEGA[1]

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Fuel-shell mix remains a pivotal concern in inertial confinement fusion (ICF), as it can preclude ignition. Mix is the result of saturation of Rayleigh-Taylor (RT) instability growth at a density interface that leads to small-scale, turbulent eddies and atomic-level mixing of cool, high-density fuel in the shell with hot, low-density fuel in the core. If sufficient mixing occurs, it will disrupt the formation of the "hot-spot" required for ignition. To sensitively probe the evolution and extent of mix in spherical implosions, the time dependence of the D^3He nuclear reaction rate was measured from implosions of capsules filled with pure ^3He. The capsule shell was comprised of a 1-μm layer of CD inside a 19-μm layer of CH. Nuclear burn will only occur in such capsules if there is sufficient mixing of D from the shell with hot ^3He in the core. By utilizing novel D^3He reaction-rate and proton spectrometers, all sensitive to the 14.7 MeV D^3He protons, a comprehensive, time dependent picture of mix was constructed. Important qualitative features were immediately evident: first, the shock burn of D^3He, always present for gas fills of D^3He, was absent, enabling a strong limit to be set on the amount and extent of D penetration into the ^3He. Second, the time necessary for RT instabilities to induce mix and to be heated by the hot core resulted in a 90 ps delay in the D^3He bang time as compared to bang time for implosions with D^3He fills. And third, when the gas pressure of ^3He was reduced from 20 to 4 atm, the extent of mix was enhanced by about a factor of 5.

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