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Studying shock dynamics and in-flight ρR asymmetries in NIF implosions using proton spectroscopy[1]

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Ignition-scale, indirect-drive implosions of CH capsules filled with D^3He gas have been studied with proton spectroscopy at the NIF. Spectral measurements of D^3He protons produced at the shock-bang time provide information about the shock dynamics and in-flight characteristics of these implosions. The observed energy downshift of the D^3He-proton spectra are interpreted with a self-consistent 1-D model to infer ρR, shell R_{cm}, and yield at this time. The observed ρR at shock-bang time is substantially higher for implosions where the laser drive is on until near the compression-bang time ("short-coast") while longer-coasting implosions generate lower ρR at shock-bang time. This is most likely due to a larger temporal difference between the shock- and compression-bang time in the long-coast implosions (~800ps) than in the short-coast implosions (~400ps). These differences are determined from the D^3He proton spectra and in-flight x-ray radiography data, and it is found to contradict radiation-hydrodynamic simulations, which predict a $700 - 800$ps temporal difference independent of coasting time. A large variation in the shock proton yield is also observed in the dataset, which is interpreted with a Guderley shock model and found to correspond to $\sim 2\times$ variation in incipient hot-spot adiabat caused by shock heating. This variation may affect the compressibility of NIF implosions. Finally, data from multiple proton spectrometers placed at the pole and equator reveal large ρR asymmetries, which are interpreted as mode-2 polar or azimuthal asymmetries. At the shock-bang time (CR $\sim 3 - 5$), asymmetry amplitudes $\geq$10% are routinely observed. Compared to compression-bang time x-ray self-emission symmetry, no apparent asymmetry-amplitude growth is observed, which is in contradiction to several growth models. This is attributed to a lack of correspondence between shell and hot-spot symmetry at peak compression, as discussed in recent computational studies [R.H.H. Scott et al., Phys. Rev. Lett. 110, 075001 (2013)].

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