Persistent hot-spot mix in cryogenic direct drive fusion experiments

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We demonstrate that an x-ray emission signature associated with acceleration-phase mass injection [1,2] shows strong correlations with implosion design (adiabat and target mass) and performance (yield and hot-spot size) as expected for mix. The emission signature increased for a target with elevated levels of ablator particulate with stagnation parameters behaving consistently. Furthermore, we show that this anomalous x-ray emission correlates with increased hot-spot size at low x-ray energies, indicative of a peripheral hot-spot modification, also consistent with mix. The signal persists over a range of implosions designed to be stable to imprint, whereas 3D modeling with features designed to induce mass jetting is shown to provide a plausible explanation for all of these signatures. We estimate a typical high-performance implosion may have up to 2× increase of hot-spot mass at the start of deceleration as compared to a 1D calculation. Such mix may explain why high-performance implosions are unresponsive to beam smoothing[3] as well as recent work suggesting a better than purely hydrodynamic scaling of these implosions[4].

This material is based upon work supported by the Department of Energy [National Nuclear Security Administration] University of Rochester "National Inertial Confinement Fusion Program" under Award Number DE-NA0004144.

[1]R. C. Shah *et al.*, "Persistent hot-spot mix in cryogenic direct drive fusion experiments," submitted to Physical Review Letters.

[2]R. C. Shah *et al.,* Phys. Rev. E **103,** 023201 (2021).

[3] D. Patel *et al.* Phys. Rev. Lett. **131**, 105101 (2023).

[4] C. Thomas *et al.*, "Hydroscaling of Laser Direct-Drive DT Cryogenic Target Implosions," submitted to Physical Review Letters.