UNDERSTANDING SIGNATURES OF RADIATION DRIVE CAPSULE ASYMMETRY IN NEUTRON SPECTRA PREDICTED BY 3D RADIATION HYDRODYNAMICS SIMULATIONS OF INDIRECT DRIVE IMPLOSIONS.

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Non-uniformity in the radiation intensity reaching the surface of an indirect drive fusion capsule can result in strong variations in the areal density and velocity of the dense fuel layer converging on the axis. Such asymmetries can mean that not all of the momentum of the dense fuel is extinguished at stagnation and thus there is a reduction in the efficiency with which the kinetic energy is thermalized and hence a reduction in the pressure of the hotspot material. In cases where the perturbation to the drive is not periodic, but is either incoherent or one-sided, a significant residual bulk velocity of both the dense fuel layer and the hot spot can result. Residual bulk motion of the dense fuel layer provides a non-uniform inertia to the surface of the hotspot and reduces the effective confinement. If the residual motion of the hotspot material has a coherent center of mass velocity this results in a measureable Doppler shift of the thermonuclear neutrons that are emitted. Where this motion is not coherent, the variance of the fluid velocity broadens the Doppler width of the neutron pulse, giving a false signature of high ion temperatures.

In this work, we seek to evaluate whether signatures of bulk residual motion are embedded within the neutron spectra. We make use of the CHIMERA 3D radiation hydrodynamics code developed at Imperial College. A high resolution 1D simulation of a layered capsule implosion driven by the high-foot radiation pulse on the National Ignition Facility is undertaken with a multi-group radiation diffusion model based on CRE tabulated opacities calculated from the SpK model. The radiation pulse is adjusted to provide a ‘tuned’ implosion with effective shock coalescence and minimal fuel adiabat. The code is then rerun for a range of variations in radiation intensity and the results used to construct approximate perturbed initial conditions for a large scale 3D calculation of the stagnation phase.

The velocity distributions are analyzed for P1, P2, P3 and P4 spherically symmetric perturbations along with perturbations based on view factor code calculations of laser and capsule design tolerances, as well as those due to Rayleigh-Taylor instability modes.

These results are then post-processed using a new semi-deterministic model for creating primary and scattered neutron images and spectra. The results indicate that strong asymmetric low mode perturbations such as a P1 have clearly measureable Doppler shifts in the primary spectrum as well as an opposing asymmetry in the scattered neutron images. The P2 has a clear change in variance and thus neutron spectra width between the polar and equatorial observation directions. In more symmetric perturbations such as the P4 it is harder to see anisotropy in the velocity variance, however the temperature distribution of the hotspot is strongly peaked at the center and effectively reduces the size of primary neutron image compared to the overall size of the hotspot. More realistic perturbation scenarios with multiple departures from symmetry produce combined effects which would be challenging to infer from experimental neutron spectra data.