Panel 3: Implosion hydrodynamics

A challenge that the NIF ignition experiments are facing right now is low hot –spot pressure at stagnation and low neutron yield. This can result from a combination of 1D (fuel adiabat) and 3D effects (asymmetry, mix).

The hot-spot pressure scales with ablation pressure p_q, implosion velocity V_{imp} , and fuel adiabat α as $p_m \sim p_a^{\frac{1}{3}} V_{imp}^3 \alpha^{-1}$.

The fuel adiabat is set by properly timing four shocks at the beginning of an implosion. Matching the shock timing data with direct numerical simulations, however, requires using either time-dependent reduction factors on the laser energy or a "switch" between LTE and non-LTE models in gold which is set to 75 eV to match velocities of the shocks launched by the second and third pickets. Only LTE tables are used to simulate velocity of the first shock. This threshold, however, might be dependent on resolution of the region where the laser interacts with the hohlraum wall. A self-consistent model explaining drive pressure evolution consistent with shock velocity data is desirable since it's not clear that the adjustment factors predict correct hydro profiles and drive pressure evolution during the main drive.

The strength of the 4^{th} shock is much weaker than in simulations, and the final implosion velocity is 5-10% lower than predicted (corresponding to ~ 10-20% effective reduction in the drive the capsule experiences). The observed strength of the fourth shock can be matched in these standard simulations only if the incident laser power is reduced substantially during the rising edge of the 4^{th} pulse so that the predicted X-ray drive on the capsule rises more slowly than predicted. Currently, no model can explain entirely these observations.

Additional degradation of the shell adiabat could come from extra steepening in the adjustment compression wave, which is generated at the beginning of shell acceleration after all four shocks break out of the shell. Such a compression wave does not turn into a strong shock in an optimized design. In a scenario when the fourth shock is weak, the adjustment wave might be traveling through more relaxed density and pressure gradients and turn into a stronger 5^{th} shock.

Loss in drive pressure leads to shell decompression and a reduction in the stagnation pressure, as suggested by the scaling shown in (1). The experimentally measured timing of x ray emission at peak compression is always late compared to predictions. This suggests that the drive is reduced. At present time, there is no clear explanation for such a reduction. Possible scenarios include LEH dynamics, change in plasma opacity due to mix of shell blowoff with wall blowoff, and sidescaterring due to LPI.

Low neutron yield and stagnation pressure can also be explained by an increase in the volume of the vapor region due to multi-dimensional effects (low-l mode hot spot distortion and mix). Current calculations of the hot-spot distortion growth do not include effects of magnetic fields which become important for highly distorted implosions. Including these fields is important step in understanding the hot-spot formation.

This group will focus on what the dominant physics issues appear to be, how we might unravel the importance of each through analysis of existing data, new experiments or measurements, and how to better model them.