Common integrated modeling of the CH, HDC, and Be campaigns

Andrea Kritcher [1], Dan Clark[1], Steve Haan[1], Joe Ralph[1], Austin Yi[2],
Prav Patel[1], Debbie Callahan[1], Omar Hurricane[1], John Edwards [1], & Integrated Experiment teams

1) Lawrence Livermore National Laboratory, USA

2) Los Alamos National Laboratory, USA

A limiting factor in the performance of high gain ICF designs is ability to control low mode asymmetries in the radiation drive throughout the entire duration of the laser pulse while simultaneously achieving adequate fuel velocities [1,2]. The amplitude and mode number of radiation drive asymmetries depend on the capsule and hohlraum radius, hohlraum length, laser beam balance, laser beam pointing, laser pulse shape, laser power and energy, hohlraum gas fill density, size of the laser entrance hole, hohlraum wall material, etc. While several of these design choices are independent of the choice of ablator material, the required picket energy and laser pulse duration, both of which affect late-time wall motion and inner beam propagation, are dependent on ablator material. For example, High Density Carbon (HDC) targets can utilize shorter pulse lengths as compared to CH due to the faster shock transit in C at the same DT adiabat, and should be less susceptible to late time wall motion. However, HDC requires a larger picket energy to avoid incomplete melt of the HDC, leading to increased late time wall movement. These tradeoffs as well as other design choices for currently fielded campaigns (HiFoot, HiFoot672, HDC, Bigfoot, Be) are assessed in this work using the same postshot simulation methodology.

To consistently assess the radiation drive magnitude and symmetry, integrated postshot simulations of the hohlraum and capsule together have been completed for each design platform using the same simulation methodology [3]. Integrated modeling of the hohlraum and capsule using HYDRA [4] includes physics approximations which are modeled using flux limiters and multipliers on the radiation drive. These simulations also require multipliers on the late time impaired inner beam propagation due to wall motion and formation of bubbles on the wall that are thought to attenuate the inner beams. Once a multiplier set is determined from tuning shots, changes in the radiation drive and symmetry, as a result of changes to the laser pulse, can be predicted using the tuned model. A projection of the relative plausible fuel kinetic energy using the full NIF laser, at 1.8 MJ/500 TW Full NIF Equivalent while maintaining adequate symmetry is assessed for each ablator material using this tuned model. The simulation results are compared to experimental data.

References

[1] A. L. Kritcher, D. E. Hinkel, D. A. Callahan, O. A. Hurricane, et al, Physics of Plasmas 23, 052709 (2016);

[2] D. E. Hinkel, L. F. Berzak Hopkins, T. Ma, J. E. Ralph, et al, Phys. Rev. Lett. 117 (22), 225002.

[3] O. S. Jones, C. J. Cerjan, M. M. Marinak, et al., Phys. Plasmas 19, 056315 (2012).

[4] M. M. Marinak, G. D. Kerbel, N. A. Gentile, O. Jones, D. Munro, S. Pollaine, T. R. Dittrich, and S. W. Haan, Phys. Plasmas 8, 2275 (2001).

*This work was performed under the auspices of the U.S. Department of Energy by Lawrence Livermore National Laboratory under contract DE-AC52-07NA273

LLNL-ABS-729538