The 1D Cryogenic Implosion Campaign on the OMEGA Laser System

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The 1D-campaign on OMEGA is aimed at validating a novel approach to design cryogenic implosion experiments and provide valuable data to improve the accuracy of 1D physics models. This new design methodology is being tested first on low-convergence high-adiabat (α~6-7) implosions and will subsequently be applied to implosions with increasing convergence up to the level required for a hydro-equivalent demonstration of ignition. This design procedure assumes that the hydrodynamic codes used in implosion designs lack the necessary physics and that measurements of implosion properties are imperfect. It also assumes that while the measurements may have significant systematic errors, the shot-to-shot variations are small and that cryogenic implosion data are reproducible as observed on OMEGA. To explain how this new design technique works, consider a simple 1D example where the experiment is perfectly 1D and the 1D code used to design it is lacking some essential physics and therefore cannot be used solely as a tool to guide the design. The input to the 1D code consists of the measured pulse shape and the target specifications. Note that the outcome of the experiment also depends on the same input, i.e. the laser pulse shape and the target specs. Since the outcome of the experiment and the output of the 1D code both depend on the same input, then they must be related even though the 1D code is incorrect and the code output does not match the experimental outcomes at stagnation. One of the goals of the 1D campaign is to find this correlation and use it to design future implosions. In the 1D-campaign, this predictive methodology was used to design four implosions using a simple two-shock pulse design and leading to pre-shot predictions of yields within 5% and ion temperatures within 3% of the experimental values. These implosions have also produced the highest neutron yield (7.7×10^{13}) in OMEGA cryogenic implosion experiments with an areal density ~ 110 mg/cm^2. With every shot day, the accuracy of the predictive model improves due to the increased size of the database. The validity of this approach is constrained within a limited range of extrapolations implying that the predictive capability is only reliable if the next target design is not too different from a past one. How big of a step one can take from one design to another is still an unanswered question and will need to be assessed through experiments. This material is based upon work supported by the Department of Energy National Nuclear Security Administration under Award Number DE-NA0001944, Lawrence Livermore National Laboratory under Contract DE-AC52-07NA27344, the University of Rochester, and the New York State Energy Research and Development Authority. The support of DOE does not constitute an endorsement by DOE of the views expressed in the article.