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Machine Learning Enabled Quantitative Prediction of the First-Ever Igniting Inertial Confinement Fusion Experiment

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On December 5, 2022, scientists at the Lawrence Livermore National Laboratory carried out the first-ever Inertial Confinement Fusion experiment that met all criteria for ignition. This 2.05-megajoule laser shot at the National Ignition Facility compressed a millimeter-size capsule containing hydrogen fuel, leading to fusion reactions, and generating 3.15 megajoules of energy, a gain of 1.5. The outcome of this historic experiment did not come as a big surprise; a pre-shot analysis predicted a much higher chance of ignition for this new design relative to previous designs. In this talk, we describe a new method developed to make this prediction. The method combines a very sparse dataset of previous experiments with a large ensemble of simulations, Bayesian inference to incorporate uncertainties, machine learning to make the technique computationally feasible, and is built on several years of experience with the analysis of inertial confinement experiments. During the months that followed the ignition shot, we have adapted and applied this method to predict subsequent experiments, which begin to form a validation set for our predictive model. The predictive modeling is expected to play an increasing role in evaluating new designs and facility upgrades, or determining driver requirements for inertial fusion energy needs. LLNL-ABS- 850875. Prepared by LLNL under Contract DE-AC52-07NA27344.

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