Statistically Informed Physics Understanding and Design Optimization of Direct-Drive Inertial Confinement Fusion Experiments

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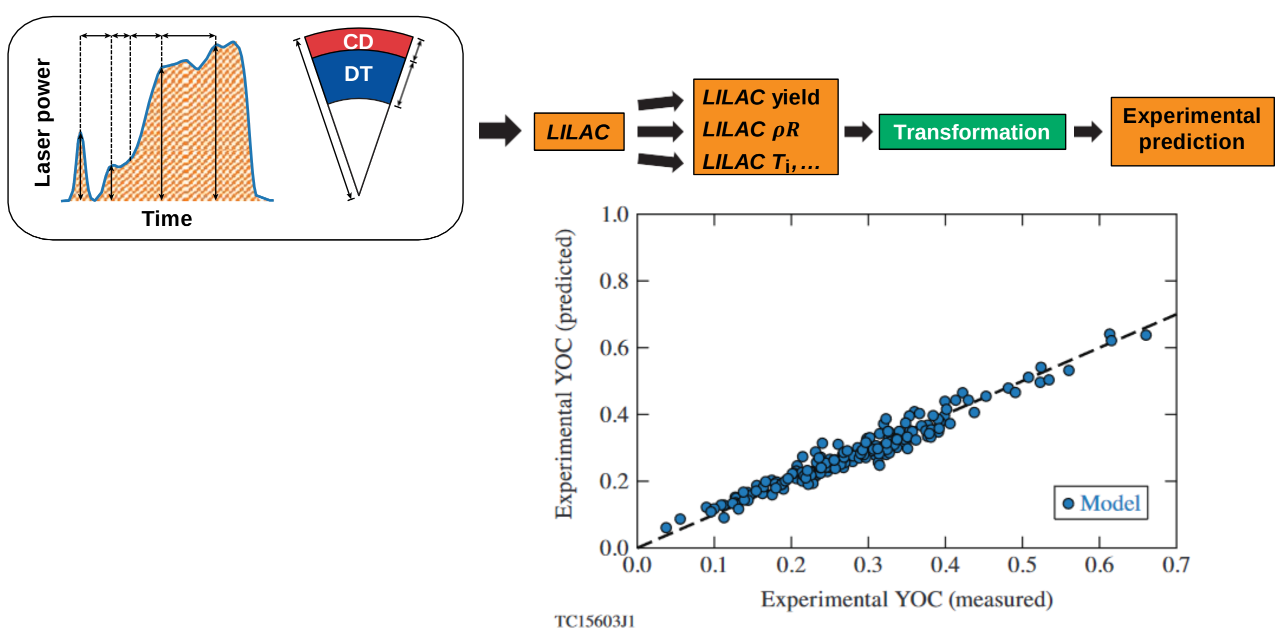
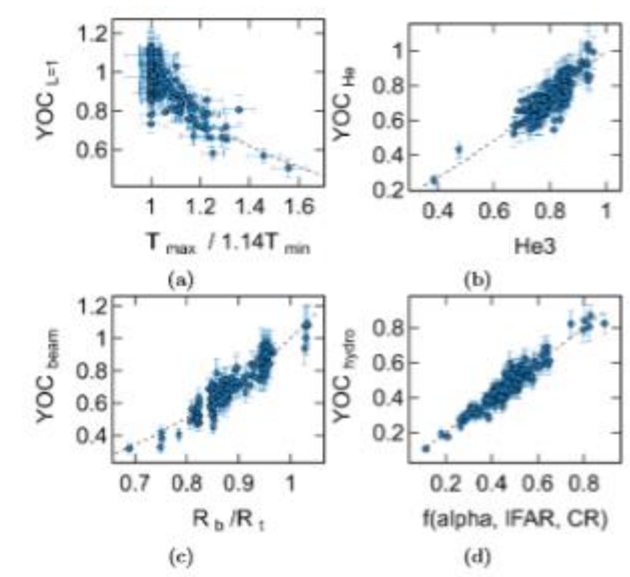
The effective design of ICF implosions requires accurate predictive capabilities*



* V Gopalaswamy et al. Nature,565 (2019) ICF: inertial confinement fusion YOC: Yield Over Clean (i.e. with respect to simulations)

Each term in the model is interpreted and quantified as a physical effect*

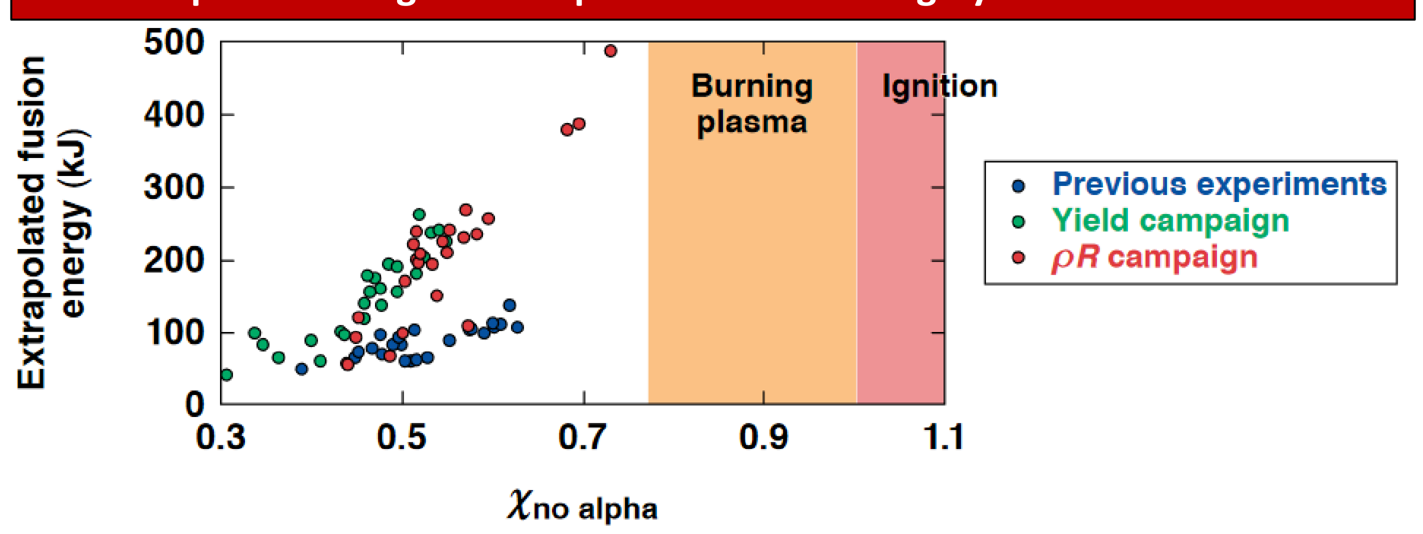


- $YOC_{\ell=1}$ → Low modes
- $\frac{T_{max}}{T_{min}}$ ~ Bulk motion of hotspot
- f_{He3} → He3 from tritium decay of fuel increases initial pressure, decreasing convergence
- $\alpha, IFAR, CR$ → Implosion Stability
- $\frac{R_b}{R_t}$ → Laser – plasma interaction

* A, Lees et al, to be submitted to Phys. Rev. Lett. FAR: in-flight aspect ratio CR: Convergence Ratio Alpha: Shell Entropy R_b: Laser Beam spot size at early times R_T: Target Outer Radius

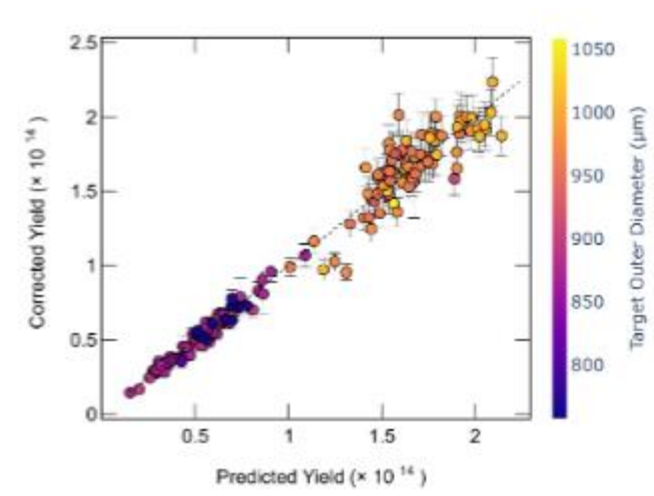
Use of this statistically guided design led to significant increases in yield and areal density*

These improved designs are expected to lead to high yields at the NIF scale**



* V Gopalaswamy et al. Nature,565 (2019) ** Nora, R. et al. *Phys. Plasmas* **21**, 056316 (2014). $\chi_{no-\alpha}$:Normalized Lawson Parameter NIF: National Ignition Facility

OMEGA Yields above 2e14 are accessible if controllable degradations are minimized*



- Low modes on OMEGA ($YOC_{\ell=1}$) are due to random mis-pointing
- Helium-3 fraction due to tritium decay due to time from target fill to shot
- These contributions can be controlled and minimized

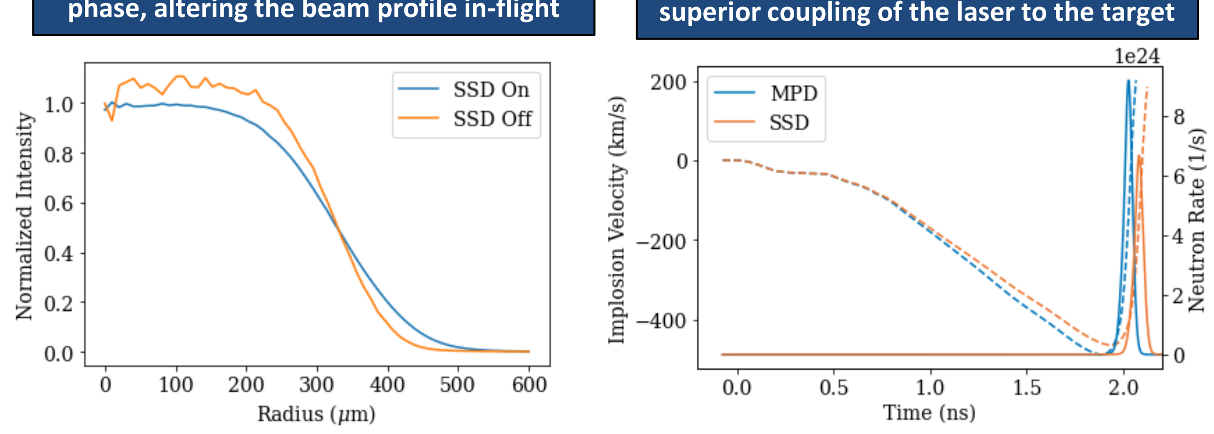
* A, Lees et al, to be submitted to Phys. Rev. Lett.

The beam-target radius degradation suggests that drive-phase zooming could lead to high performance implosions

Best performing implosions are degraded by ~ 40% by R_b/R_t

The MPD* can toggle SSD during the drive phase, altering the beam profile in-flight

LILAC Simulations show the MPD achieves superior coupling of the laser to the target



The model predicts 25% increase in yield for MPD designs (Experiments in June 2021)

* T.Z. Kosc, High Power Lasers For Fusion Research (2015) MPD: Multi-pulse Driver SSD: Smoothing by Spectral Dispersion

The possibility of megajoule yields at the NIF scale exists if moderate increases in neutron yield and areal density are achieved

Extrapolation at 1.9 MJ of symmetric illumination