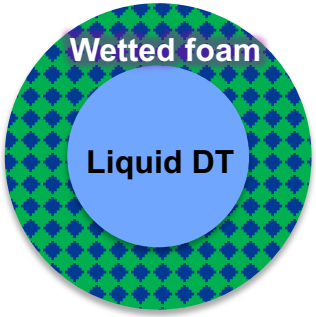
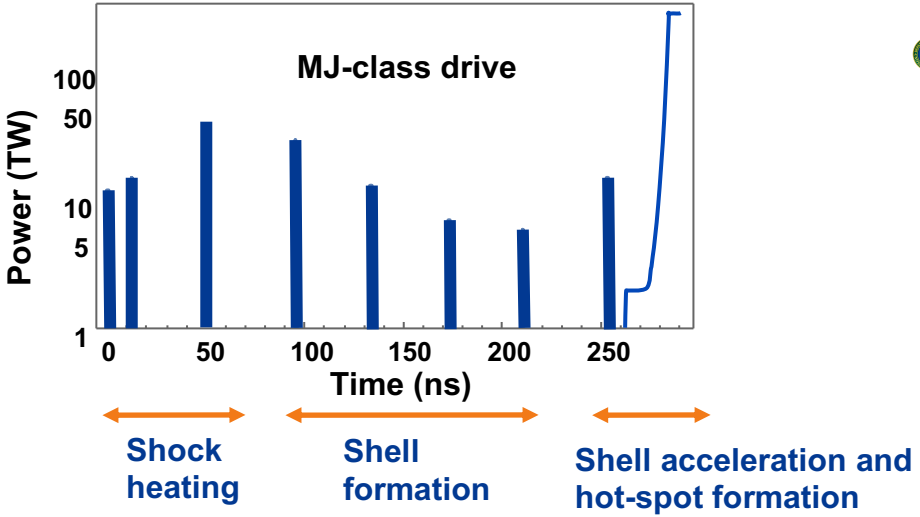
Novel Hot-Spot–Ignition Designs for Inertial Confinement Fusion with Liquid Deuterium–Tritium Spheres





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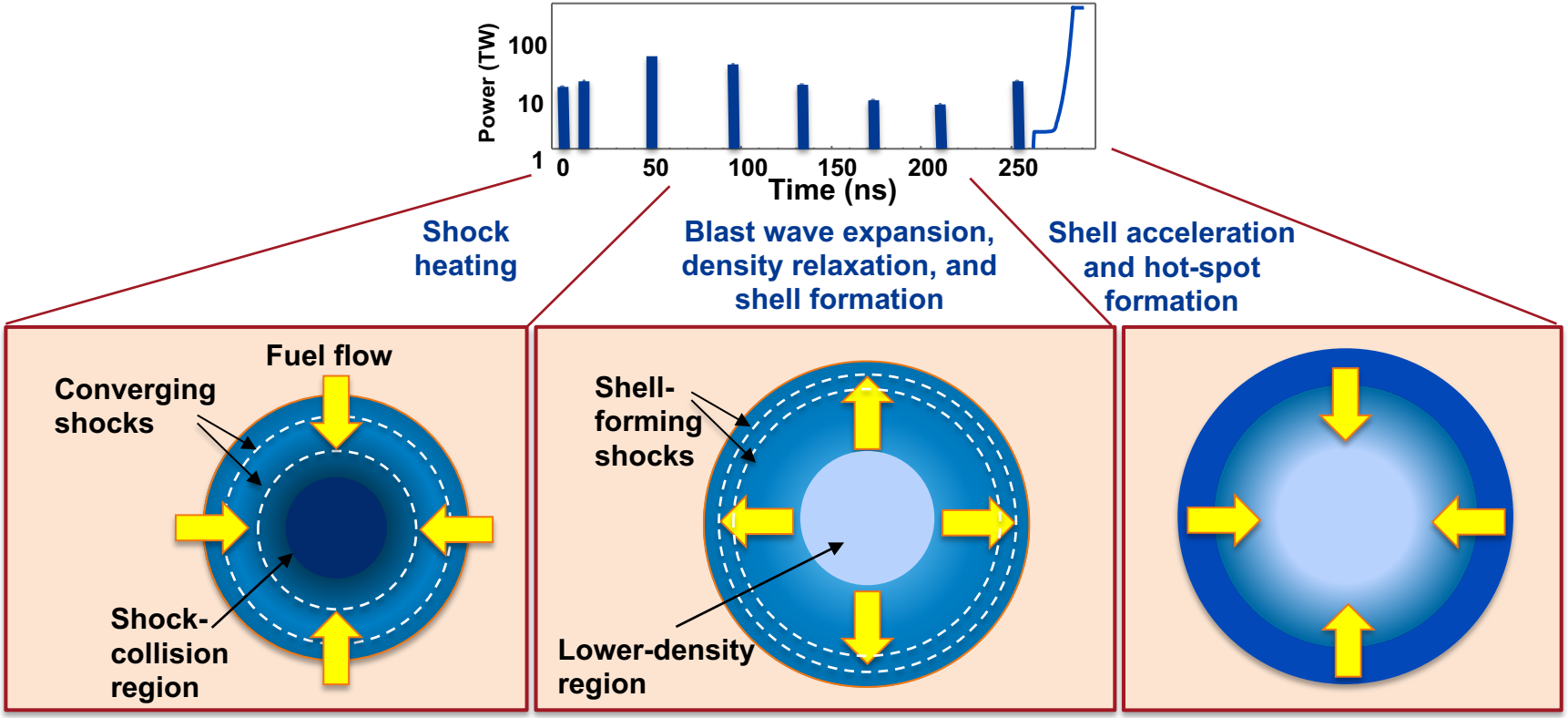
Summary

The dynamic shell formation concept* expands the parameter space for MJ-yield and high-gain ignition designs

- A liquid DT sphere inside a wetted foam shell is used as a target in the new design; the lower-density central region and higher-density shell are created dynamically by appropriately shaping the laser pulse
- Changing the strength of outward mass flow enables the design to control density in the central region and target convergence ratio
- Accurate multidimensional modeling of the new designs are underway to assess their stability properties

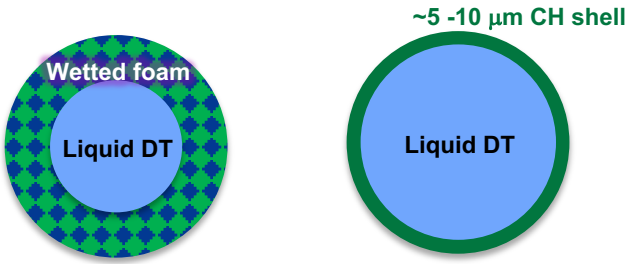
*V. Goncharov *et al.*, Phys. Rev. Lett. 125, 065001 (2020)

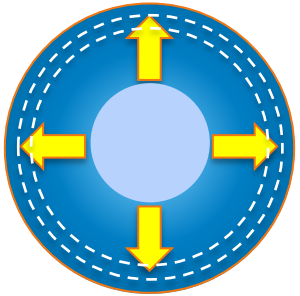
The dynamic shell design evolves through three stages



The dynamic shell design offers several advantages over a conventional layered target design

- Target simplicity
- Fuel uniformity
- Control of density in central region
- Control of shell velocity and ablated mass with pulse shaping





The stronger blast wave leads to lower central density

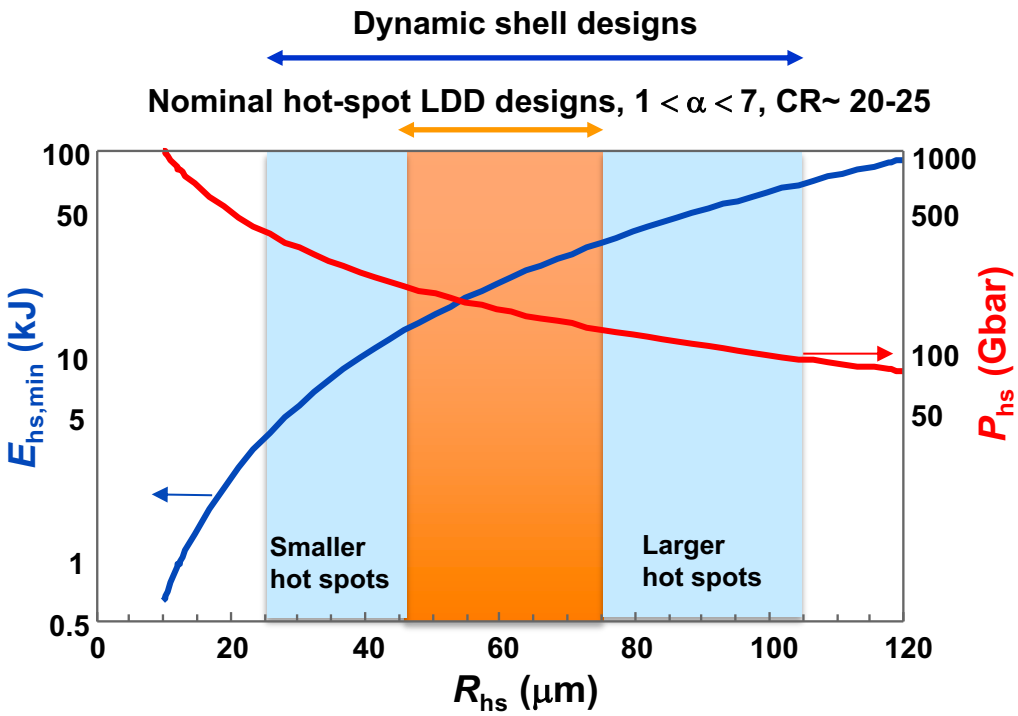
The shell and hot-spot convergence ratio can be controlled by varying central density.

The dynamic shell formation designs expand the ignition parameter space

Ignition/Lawson criterion $\frac{\text{Power gain}}{\text{Power loss}} > 1$

$$P_{hs} R_{hs} > 1 \text{ Gbar} \times \text{cm}; \quad T_i > 4 \text{ keV}$$

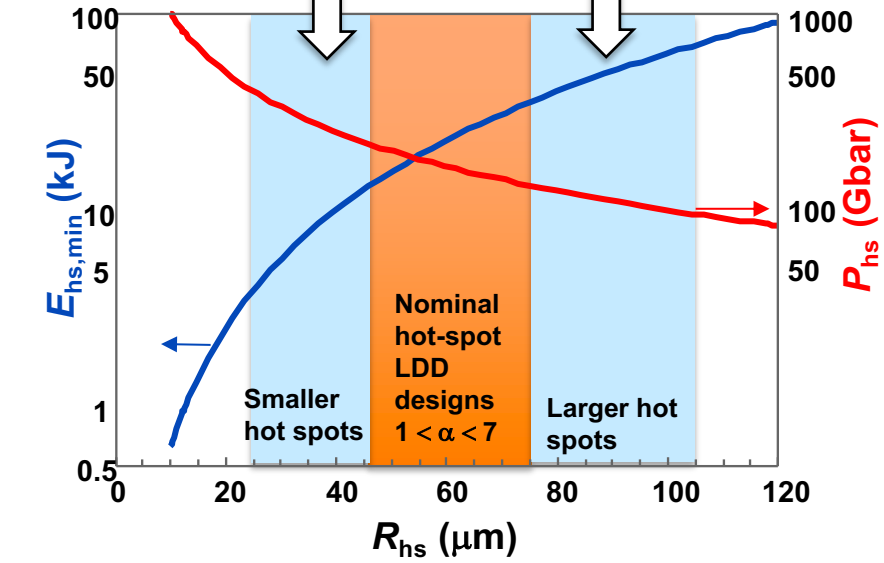
$$E_{hs} > 16 \text{ kJ} \left(\frac{R_{hs}}{50\ \mu\text{m}}\right)^2$$



The dynamic shell formation designs expand the ignition parameter space

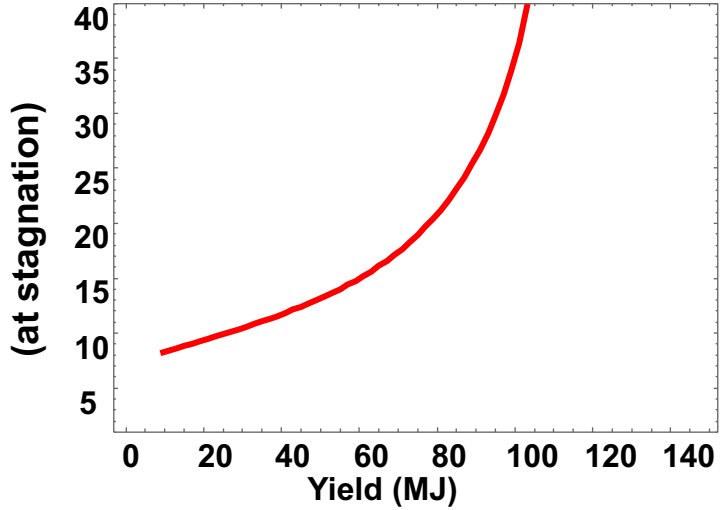
High convergence, CR > 30
Low required hot-spot energy
High fuel mass, low V_{imp}
$Y_n \sim 100$ MJ

Low convergence, CR < 15
High required hot-spot energy
Low fuel mass, high V_{imp}
$Y_n \sim 1$ MJ



Including hydroefficiency

Incident $E_{laser} = 1$ MJ



Improved laser coupling is required to access low-CR design space

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Low required hot-spot energy
High fuel mass, low V_{imp}
$Y_n \sim 100$ MJ

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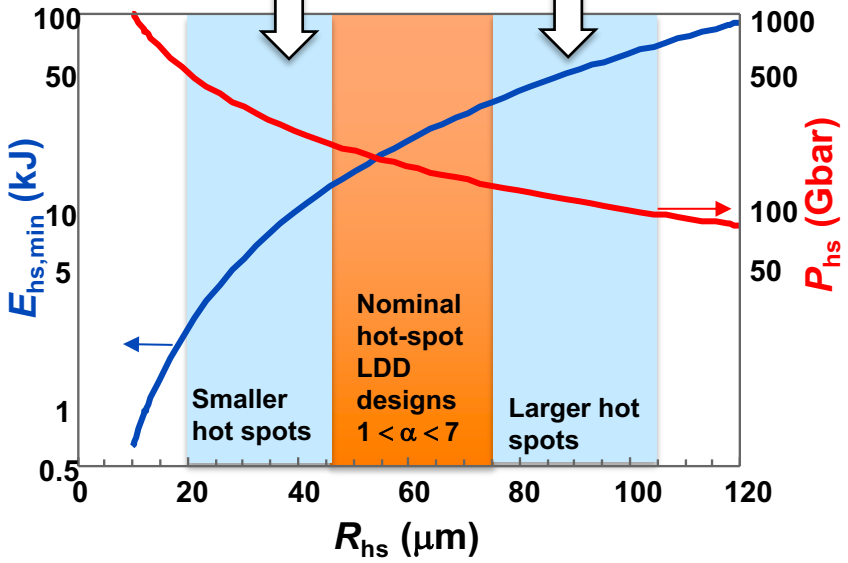
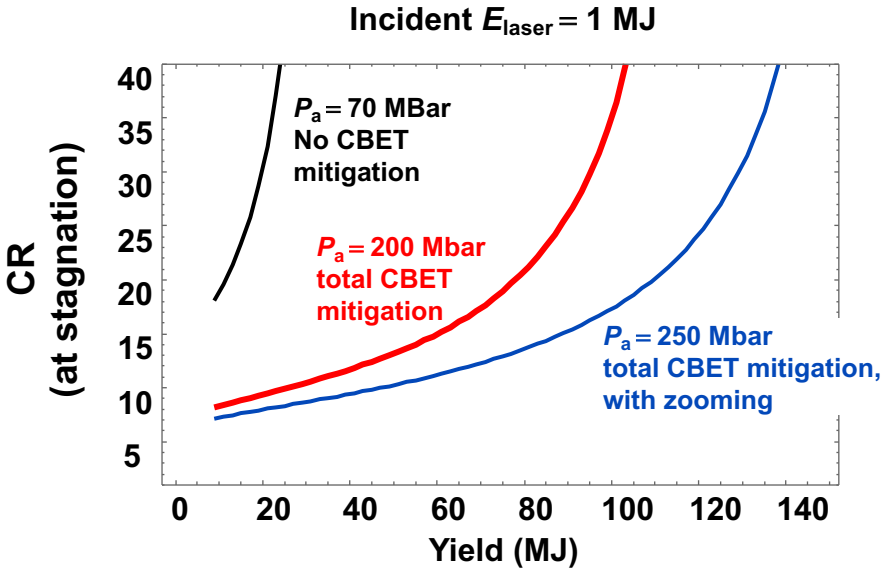
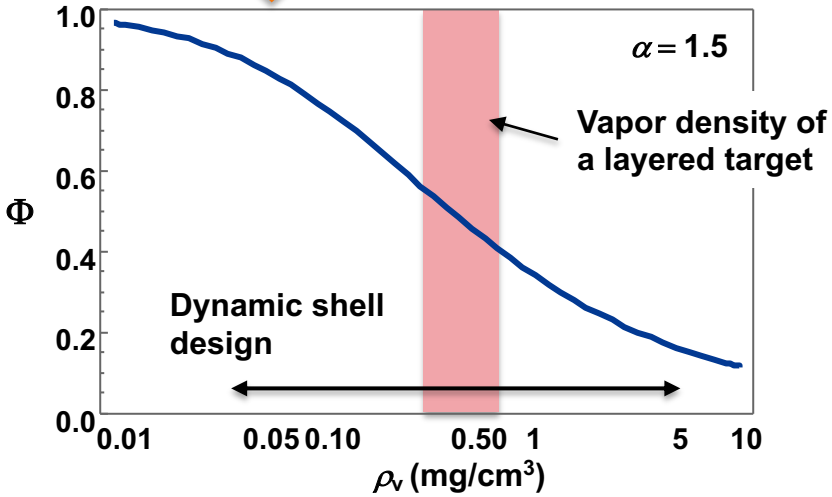


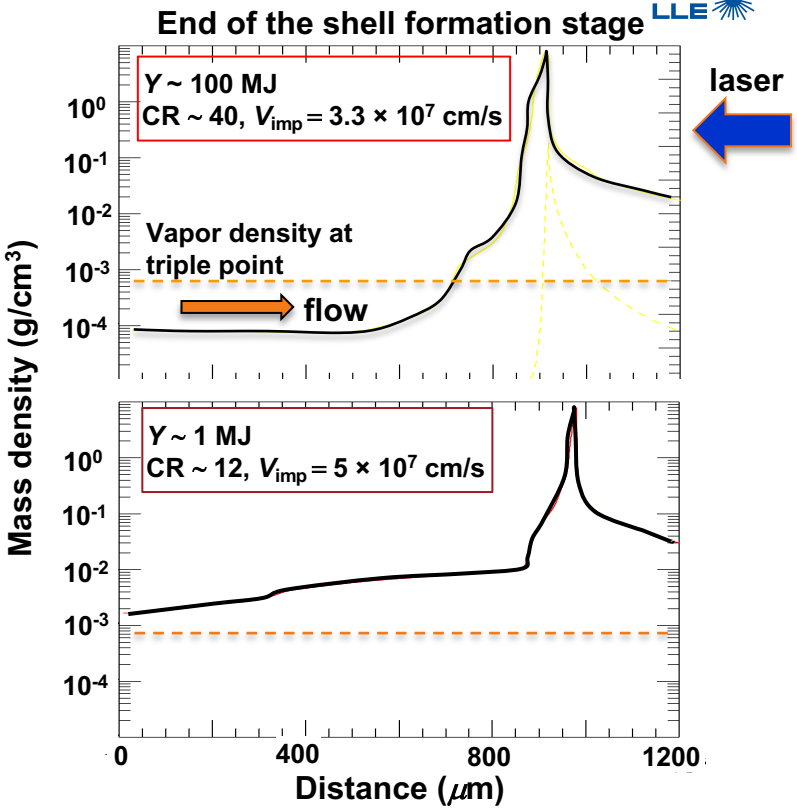


The high and low CR's are achieved in the dynamic shell designs by controlling density in the central (void) region

Shell CR is controlled by
- Shell adiabat α,
- Implosion velocity V_{imp}
- Void density ρ_v

$$\mathrm{CR} \sim \Phi(\rho_v)\frac{V_{imp}^{0.7}}{\alpha^{0.3}}$$





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