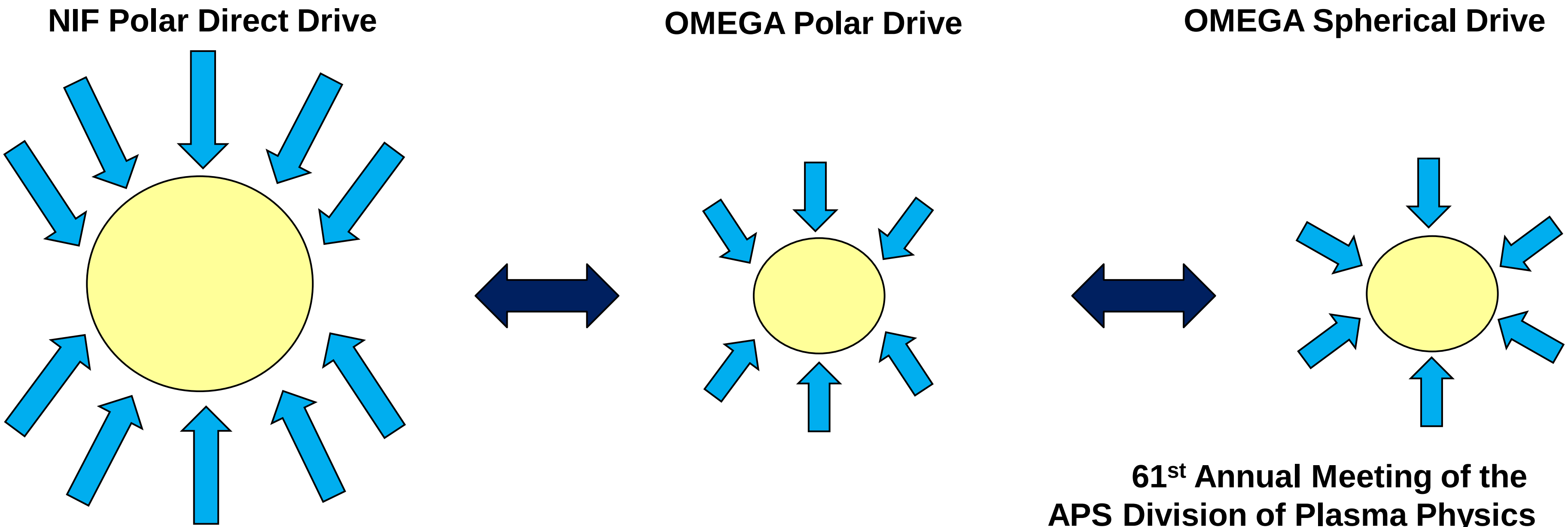
Validating direct-drive implosion energetics based on OMEGA and NIF experiments

high-adiabat implosions/solid spheres



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Summary

Polar-direct-drive experiments on the NIF and scaled experiments on OMEGA are crucial to validating implosion energetics

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- **Simulations of previous PDD NIF implosions model several observables well although not all is understood – differences can be attributed to a) errors in coupling models; b) imprint; c) fast-electron preheat**
- **NIF high yield implosions less sensitive to imprint, can potentially be scaled to OMEGA with several caveats including the increased role of kinetic effects in the hotspot on OMEGA**
- **Solid sphere experiments, robust to imprint and kinetic effects, are being explored to study laser-energy coupling through shock radiography.**

Collaborators

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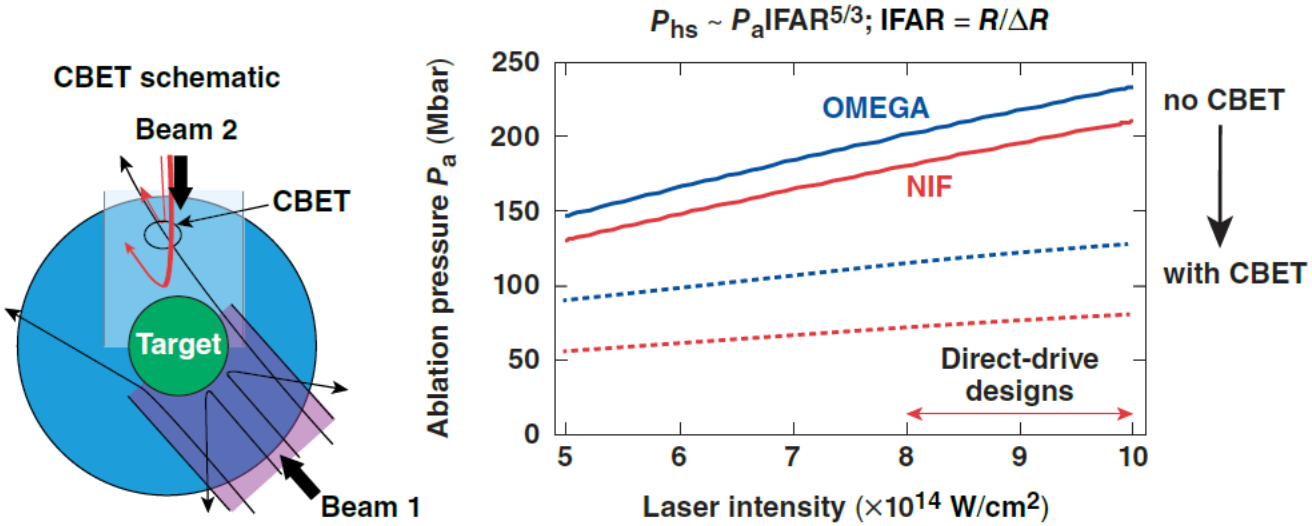
Reduced laser-energy coupling is modeled at the MJ-scale (NIF) relative to kJ-scale (OMEGA)

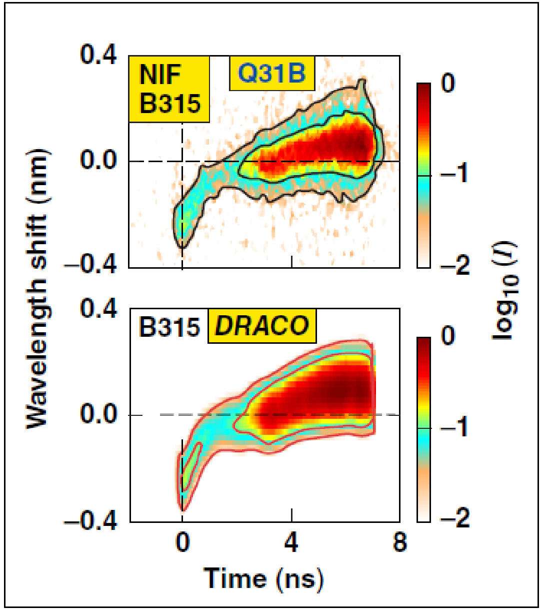


- Ignition designs* take this difference into account but how accurate are these models?

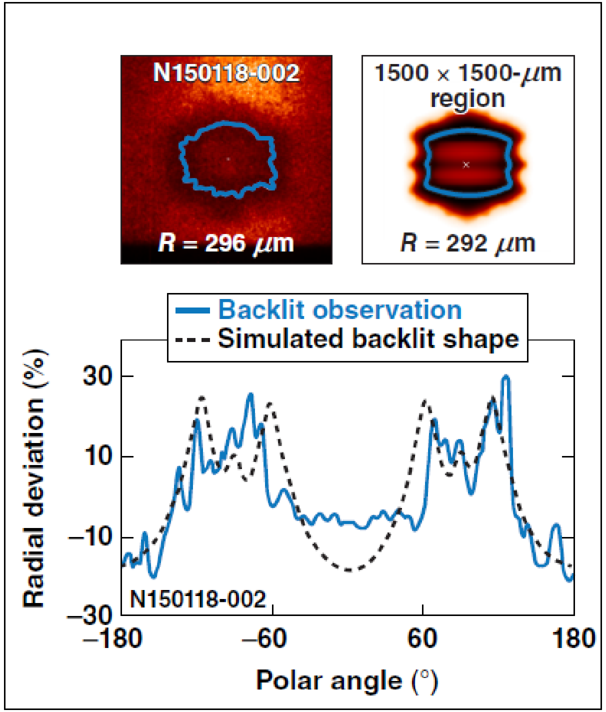
*T. J. B. Collins et al., Phys. Plasmas (2018)

Simulations of initial NIF PDD* experiments to study coupling model several observables well

Scattered-light spectra

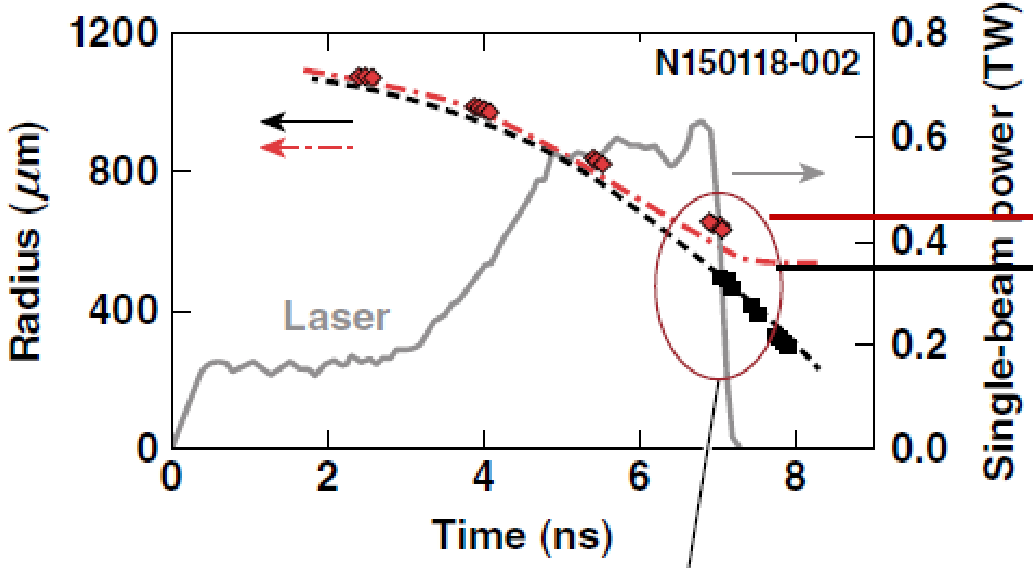


Shapes (Fe backlighter)



*P. B. Radha *et al.*, Phys. Plasmas 23, 056305 (2016).

Simulations of initial NIF PDD* experiments to study coupling model several observables well, although not all is understood



$$\frac{\Delta v_{imp}}{v_{imp}} \sim -25\%$$

- Shell decompression has been attributed to errors in coupling models* , imprint*, consistent with OMEGA experiments** and/or fast-electron preheat*

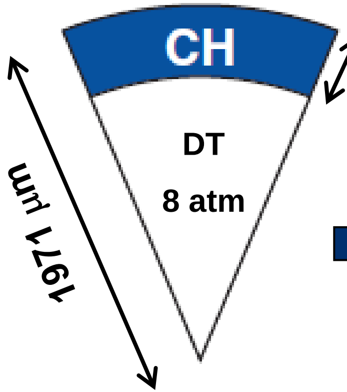
*P. B. Radha *et al.*, Phys. Plasmas 23, 056305 (2016).

**D. T. Michel *et al.*, Phys. Rev. E 95, 051202(R) (2017).
S. X. Hu *et al.*, Phys. Plasmas 23, 102701 (2016).

*** Christopherson, UI20001
Solodov, O5.00011

PDD implosions, less sensitive to laser-imprint, can be scaled to OMEGA for an empirical test of laser-energy coupling

NIF shot: N190227-001*



P (peak) = 390 TW

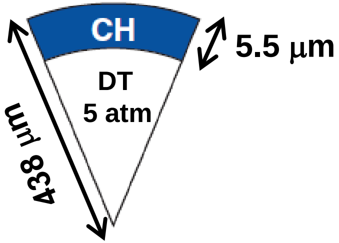
E_{laser} = 1100 kJ

$P \sim R^2$

$E \sim R^3$

$T \sim R$

OMEGA PDD/SDD design



P (peak) = 19 TW

E_{laser} = 12 kJ

Yield energy scaling:

$$Y = n^2 < \sigma V > Vt_{burn} = n^2 T^2 Vt_{burn} \sim P^2 Vt_{burn} \sim E^{1/3} E \sim E^{4/3}$$

	Yield	Knudsen # (λ_{mfp}/R_{hs})
NIF (PDD)	1.1×10^{16}	0.07
OMEGA (PDD)	3.6×10^{13} Scaled: 2.7×10^{13}	1.5
OMEGA (SDD)	5.1×10^{13}	1.6

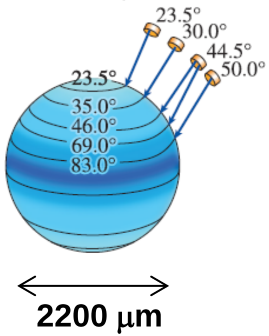
- Kinetic effects are significant for thin shell implosions on OMEGA**

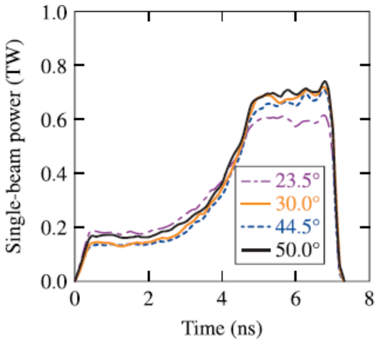
*Yeamans, Blue, Craxton, Garcia et al.; Marozas YO5.00010; McKenty YO6.00006

** Rinderknecht et al., Phys. Plasmas 21, 056311 (2014).

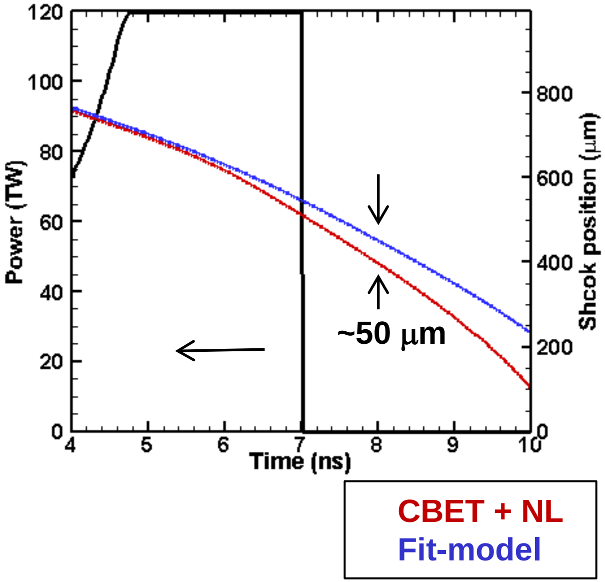
Solid spheres offer another platform for quantifying laser energy coupling without the challenges of addressing imprint or hot-spot kinetic effects

Solid sphere design (same as N150018-002)





Shock position



- **Shock radiography* will be used to diagnose coupling**

* T. Doeppner et al., Phys. Rev. Lett., 121, 025001 (2018).

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- Simulations of previous PDD NIF implosions model several observables well though not all is understood – differences can be attributed to a) errors in coupling models; b) imprint; c) fast-electron preheat
- NIF high yield implosions less sensitive to imprint, can potentially be scaled to OMEGA with several caveats including the increased role of kinetic effects in the hotspot on OMEGA.
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Coordinated NIF and OMEGA experiments are needed to pin down laser-energy coupling across different coronal density scale-lengths