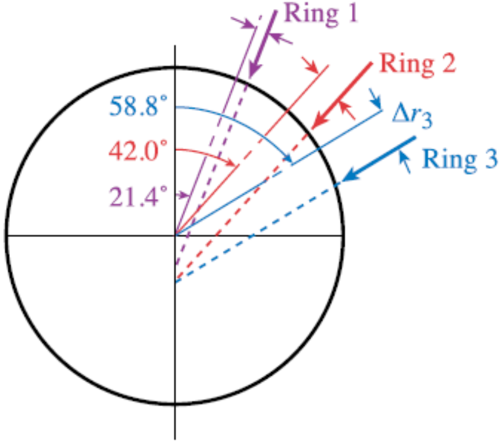
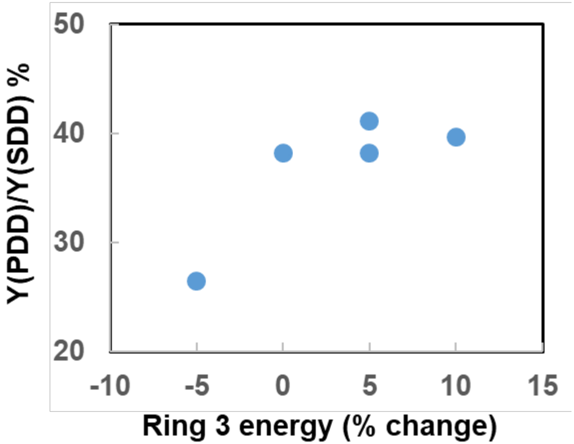
Understanding the Performance of Polar Drive Cryogenic Implosions on OMEGA

OMEGA PDD configuration



OMEGA cryogenic implosions

E_{laser} = 13 kJ



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Meeting of the Division of Plasma Physics
American Physical Society
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The first set of Polar Direct Drive (PDD) cryogenic implosions on OMEGA indicate that laser energy coupling is not significantly compromised in PDD geometry

- Cryogenic targets were irradiated with ignition relevant intensities in both Polar Direct Drive (PDD) and Spherical Direct Drive (SDD) configurations.
- Yield in PDD experiments was ~40% of SDD implosions; a comparable reduction is calculated in 2D simulations.
- Neutron rate histories indicate that this reduction is not due to reduced coupling in PDD geometry relative to SDD geometry.
- Designs, more stable to the Rayleigh-Taylor instability will be investigated.

Collaborators

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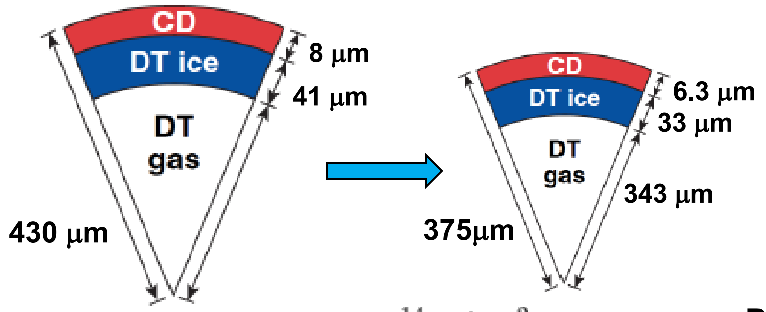
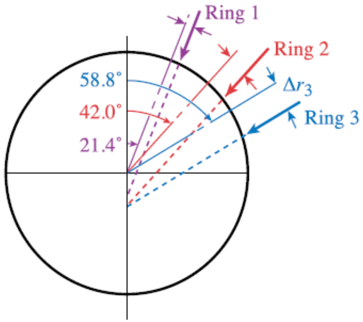
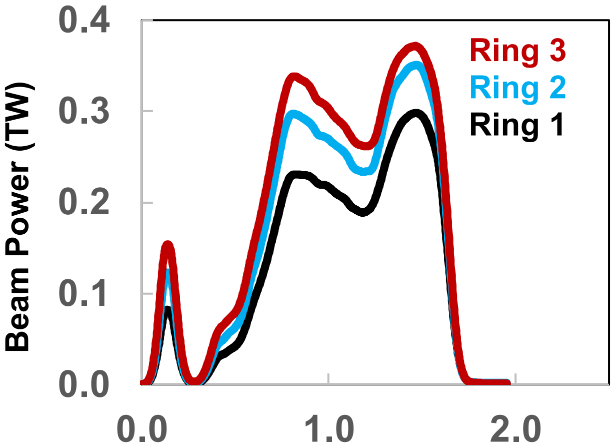
Cryogenic implosions are being investigated on OMEGA in Polar Drive geometry at ignition relevant intensity; the goal is to optimize performance

SG5-860 phase plates E~27 kJ	SG5-650 phase plates E~13 kJ



$$I = 7.5 \times 10^{14} W/cm^2$$





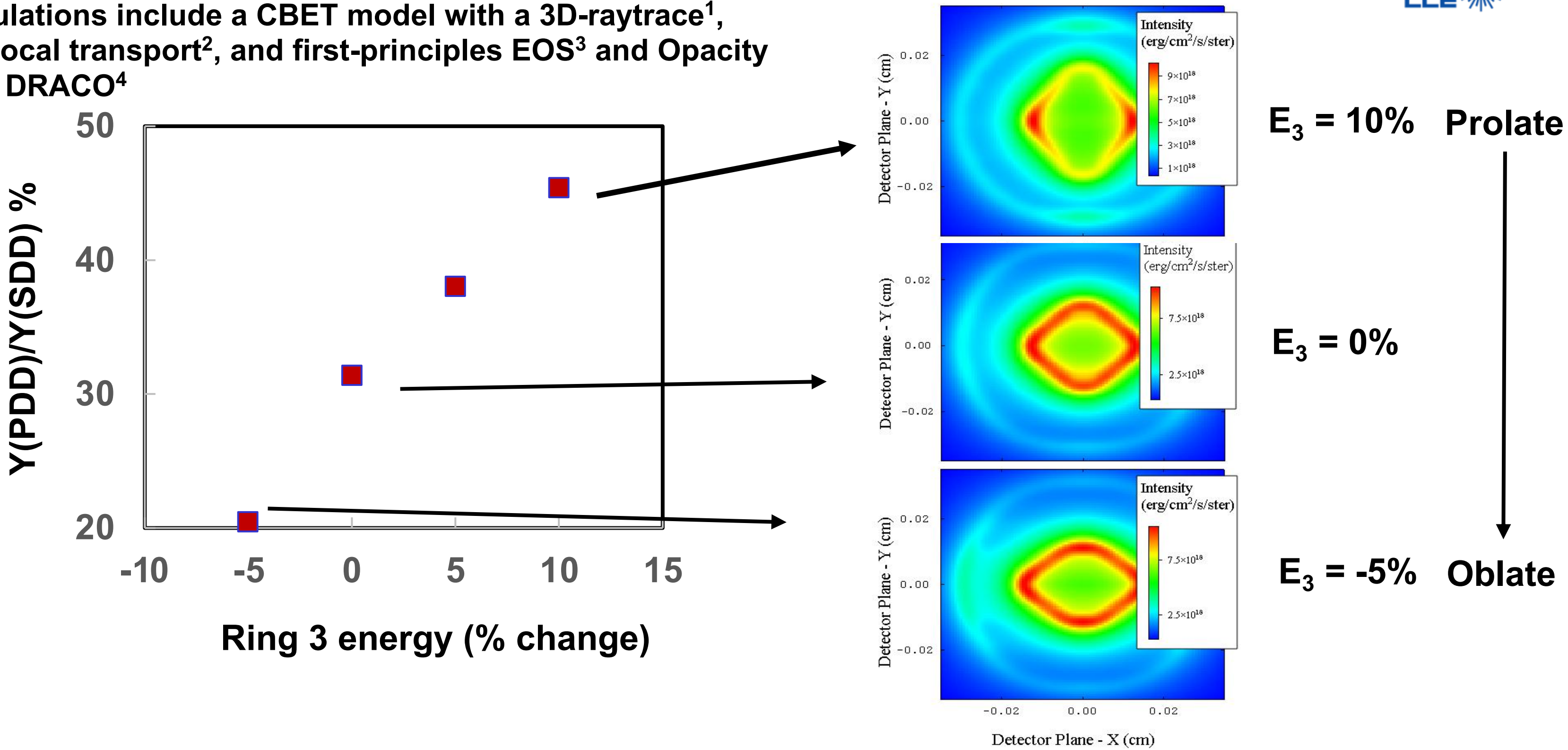
- Pointing scaled from the best performing PDD room-temperature implosion at the larger scale[1]

ρR = 135 mg/cm^2 α = 4.5 V_{imp} = 450 μm/ns   *IFAR* = 26.5

Theobald: BO09.00012; Thomas: BO09.00010; Betti: BO09.00011; [1] P. B. Radha, PoP (2015).

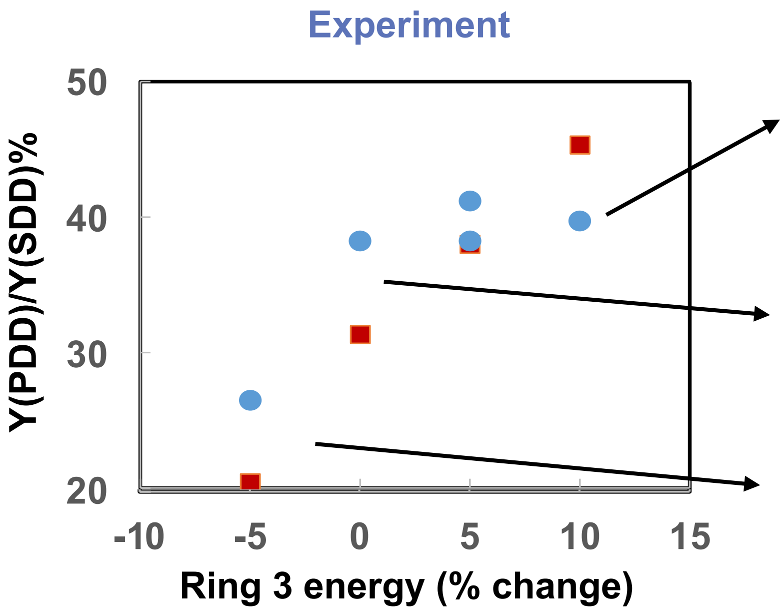
Neutron yield depends on shape in simulations

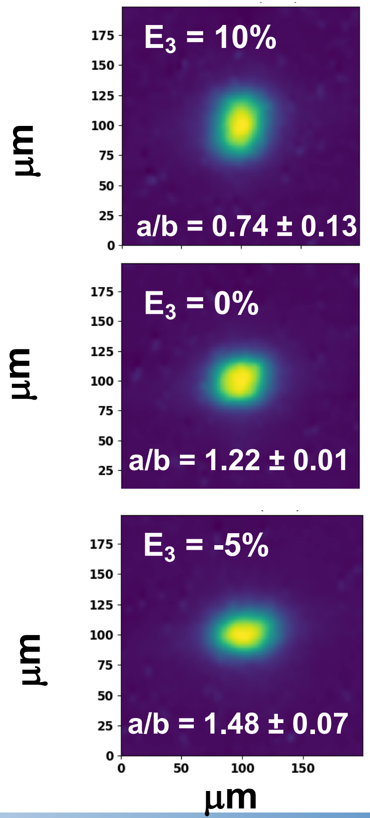
Simulations include a CBET model with a 3D-raytrace[1], nonlocal transport[2], and first-principles EOS[3] and Opacity with DRACO[4]



1 J. Marozas et al., Phys. Plasmas (2017); 2. D. Cao et al., Phys. Plasmas (2015);
3. S. Xx. HU et al., Phys. Plasmas (2017); 4. P. B. Radha et al., Phys. Plasmas (2005).

Experimental yield ratios are similar to those in simulations, though show a different dependence on Ring 3 energy





Time-integrated hotspot x-ray images

Prolate

Oblate

UR LLE
UNIVERSITY of ROCHESTER

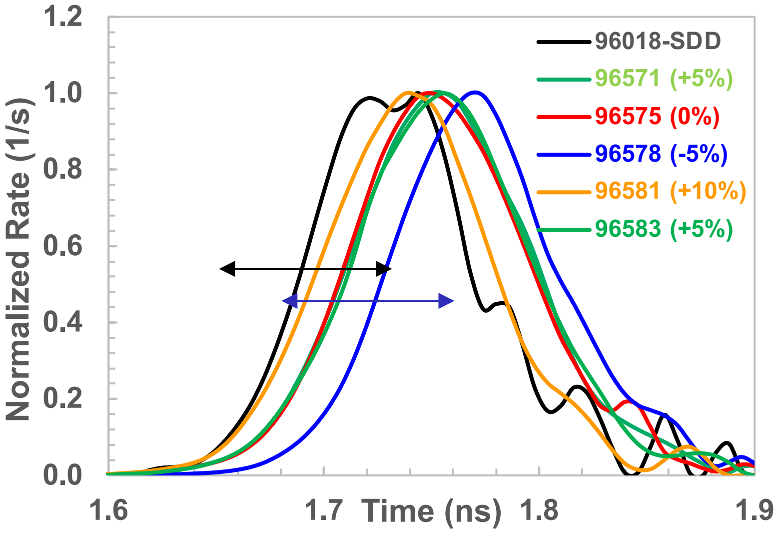
Laser drive in OMEGA PDD cryogenic implosions is close to that in SDD cryogenic implosions

1D Yield: $Y \sim V_{imp}^{6}\ \alpha^{0.88}$ (1)

$\rho R \sim \alpha^{-0.56}$ (2)

$Y \sim V_{imp}^{6}\ \rho R^{1.6}$

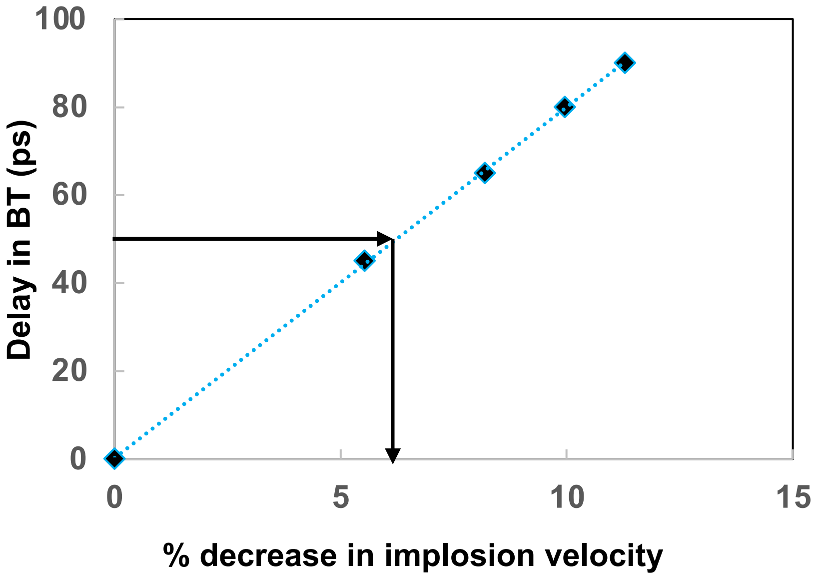
Cryogenic implosion experiments
NTD measurements

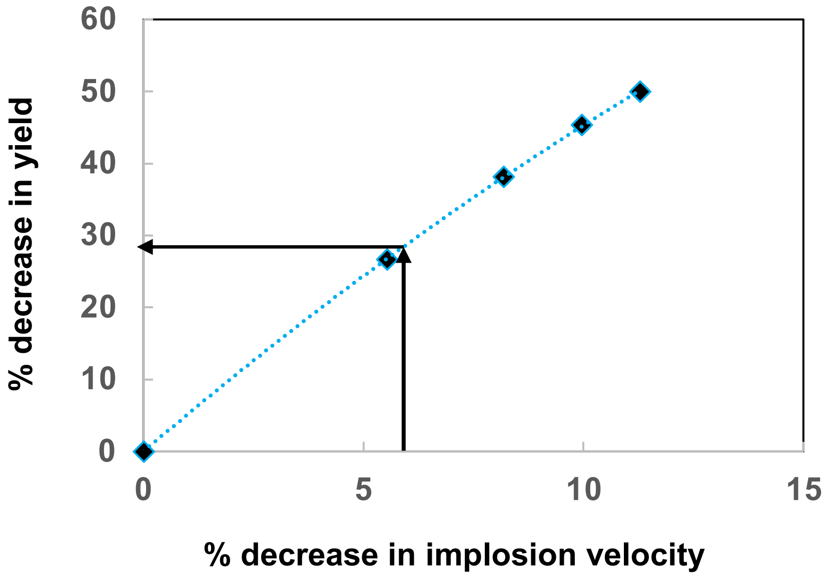


- **Neutrons in PDD cryo implosions are produced later than in SDD implosions but within the 50 ps variation of instrument from day-to-day**

1. V. N. Goncharov et al., Phys. Plasmas (2014); 2. C.D. Zhou and R. Betti, Phys. Plasmas (2007).

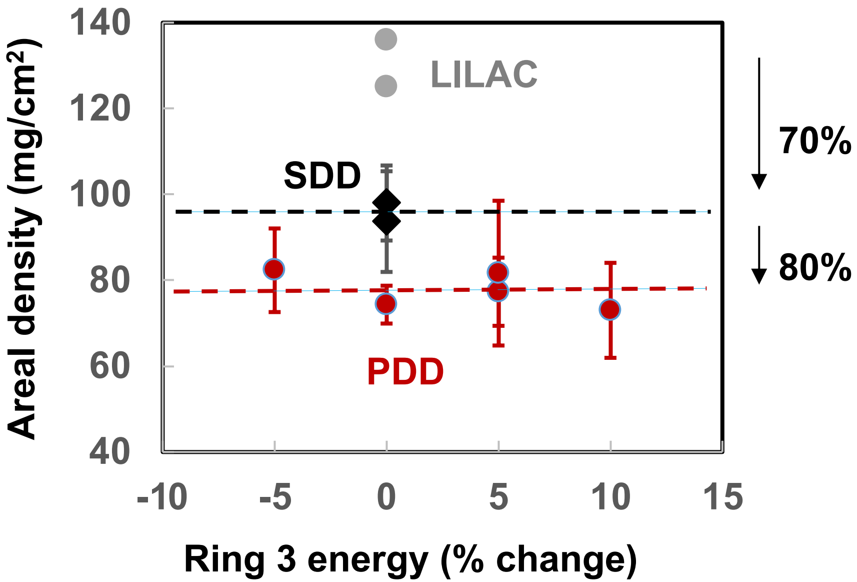
Simulations indicate that decreased drive only marginally influences yield





~6% reduction in implosion velocity, delays bang-time by ~ 50 ps and reduces yield by only ~30%

Areal density is reduced by ~80% in PDD relative to SDD, insufficient to explain the observed yield reduction



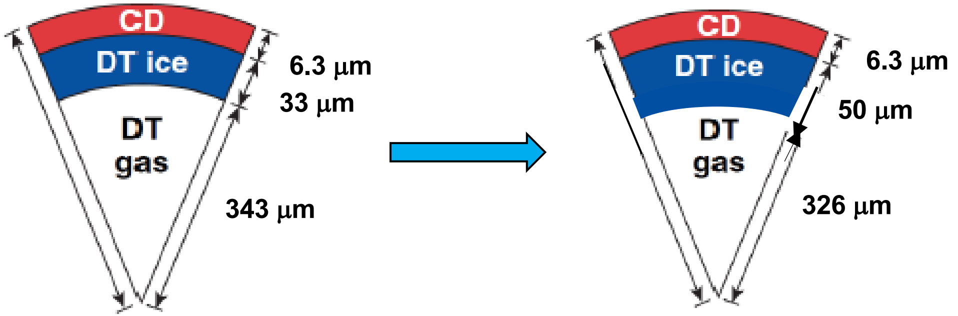
$$Y \sim V_{imp}^{6}\, \rho R^{1.6-2}$$

- 80% of areal density reduces yield by ~ 30-36%

Shape, velocity, or areal density do not dominate experimental yield.

Thicker cryogenic shells and more stable cryogenic implosions will be investigated on OMEGA at the lower scale

- The effect of shorter wavelengths will be investigated next.



	33 μm	50 μm
V_{imp} (μm/ns)	450	380
IFAR	26.5	20
ρR(mg/cm^2)	135	131
α	4.5	4.6

Other options are being considered: Target solutions[1]
Different phase plates[2]

1. F. Marshall et al., Phys. Plasmas (2015); 2. P. B. Radha et al., Phys. Plasmas (2012);
2. F. Weilacher et al., Phys. Plasmas (2015).

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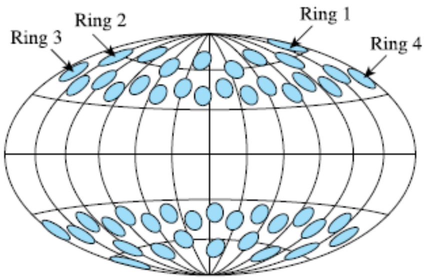
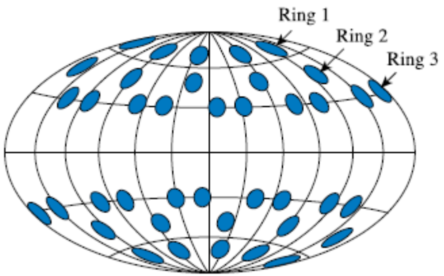
Extra slides

Polar Direct Drive (PDD) is currently the only route to high-yield direct-drive implosions on the National Ignition Facility

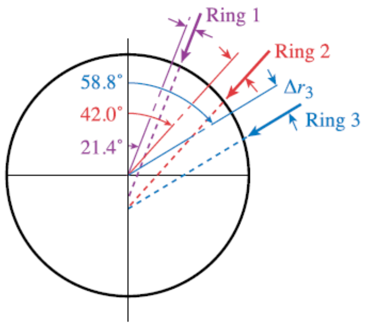
NIF beam configuration



OMEGA 40-beam configuration



OMEGA beam displacement schematic



- **Beam displacement, ring-dependent pulse shapes, and custom spot shapes are used to improve symmetry**

* **Marozas: JT02.00001; Kemp: GO09.00005**