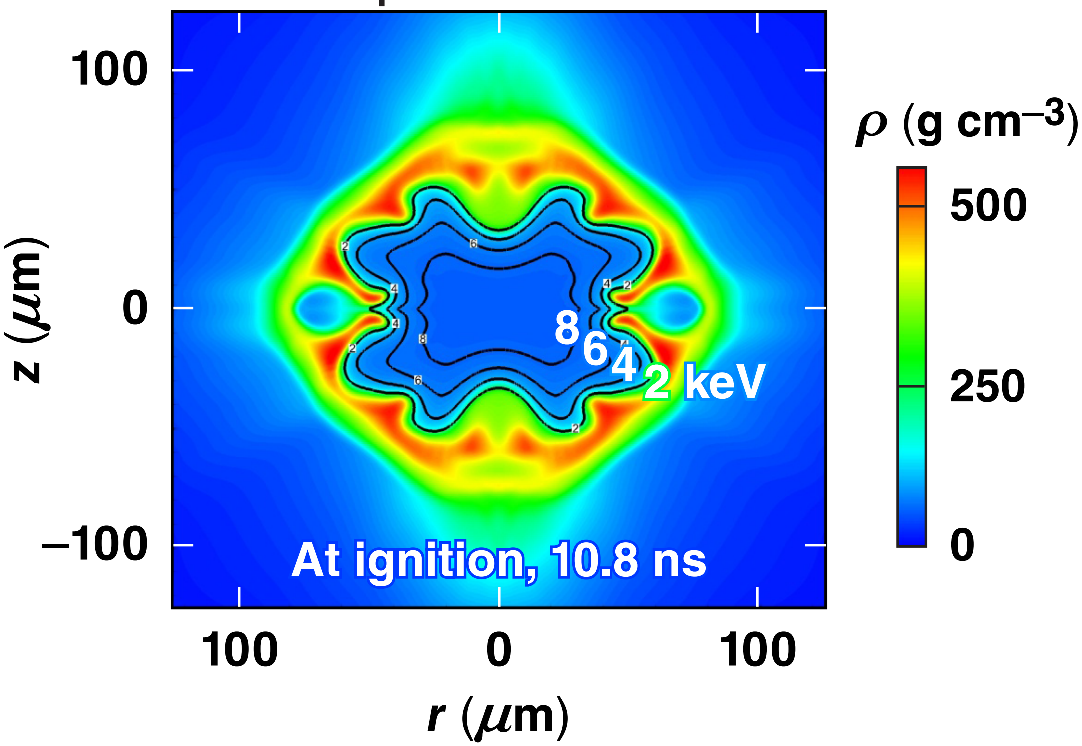
Optimization of NIF Polar-Drive Point Designs

Gain = 76 with beam geometry
V_{imp} = 370 μm/ns



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Summary

The NIF Polar-Drive point design has been retuned to improve hydrodynamic stability

- **The target implosion speed for the Polar Drive ignition design has been reduced, leading to a lower in-flight aspect ratio (IFAR) and less acceleration-phase instability**
- **Designs at a range of implosion speeds show the trade-off between target margin and IFAR**
- **The retuned ring pointing angles and energies have been further optimized in 2-D using *Telios***

Collaborators

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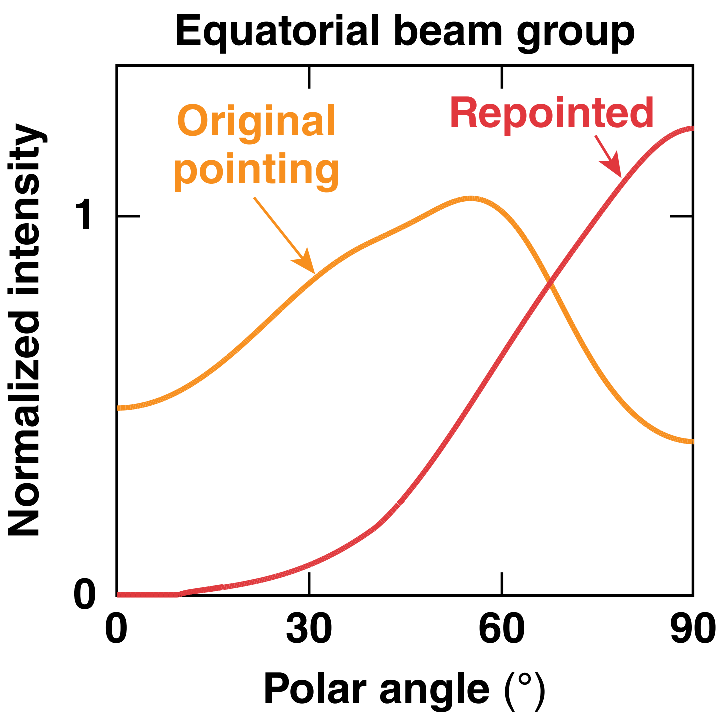
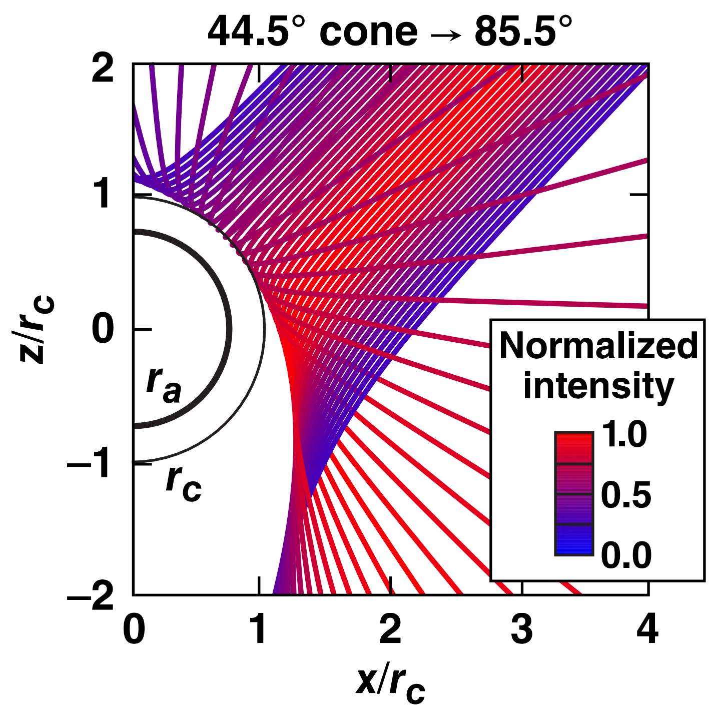
Polar-drive irradiation near the equator is at lower densities than at the pole, reducing laser coupling

- The laser beams in Polar Drive are repointed toward the equator to increase implosion uniformity
- Repointing beams leads to greater ray-path lengths, at a greater distance from the target, through lower densities ($n = n_{crit} \times \cos^2\theta_{inc}$)





Repointing equatorial beams moves energy to the equator

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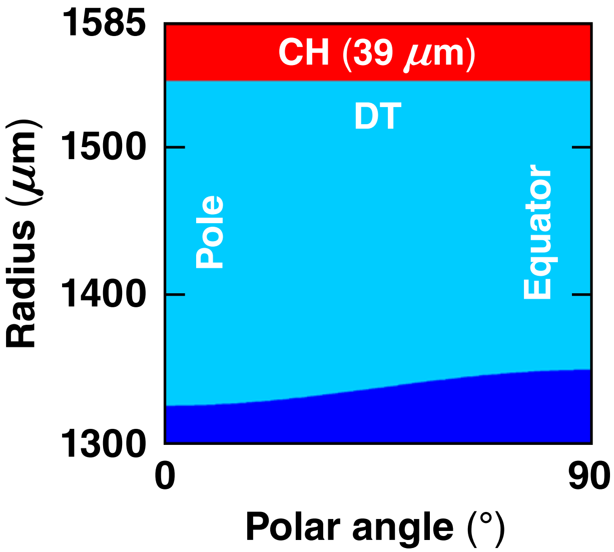
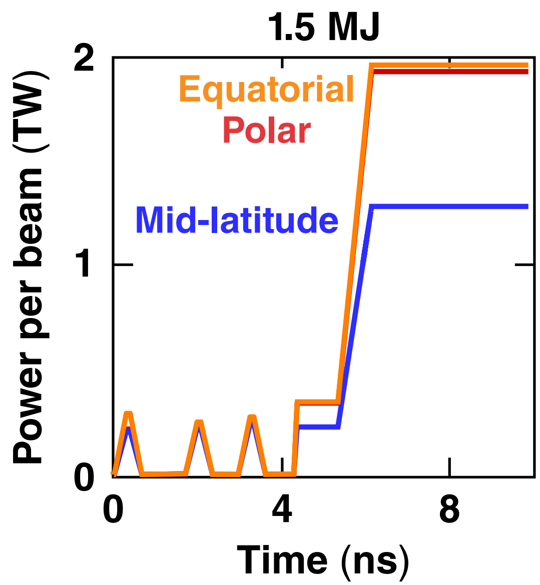
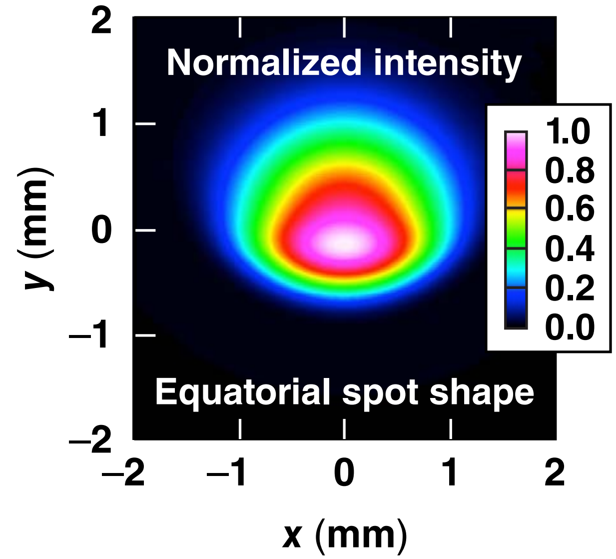
Reduced coupling is mitigated by ice-layer shimming, tailored ring energies and polar-drive phase plates







- This design employs a 12-μm ice-layer shim to reduce the mass at the equator, offsetting the reduced laser coupling
- The PD equatorial phase plates direct energy toward the equator
- Multi-FM SSD beam smoothing and polarization smoothing will be used to reduce single-beam nonuniformities*

*J. A. Marozas, J. D. Zuegel, and T. J. B. Collins, Bull. Am. Phys. Soc. 55, 294 (2010).

A new suite of polar-drive ignition designs has lower implosion speeds and less acceleration-phase instability

UR LLE

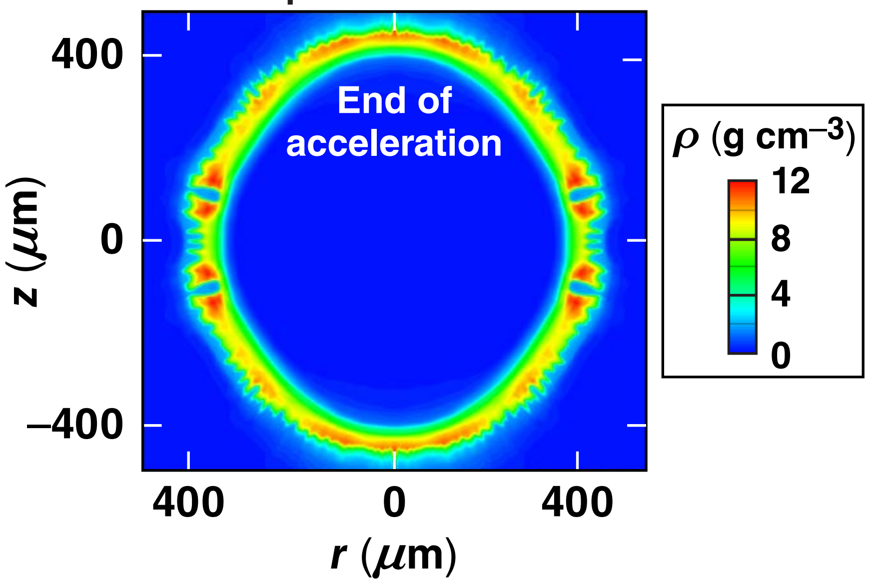
- The implosion speed has been reduced by increasing the shell thickness
- The adiabat has also been reduced to preserve ignition margin
- The IFAR, which is scales as $V_{imp}^2/\langle\alpha\rangle^{3/5}$*, is reduced to 30, giving a less unstable implosion than previous polar-drive ignition designs**

1.5 MJ, IFAR = 30

DT thickness (μm)	192	208	218	235
V_{imp} (μm/ns)	380	370	360	350
Minimum inflight α	1.68	1.55	1.47	1.40

Shot on OMEGA*** (218 and 235 columns)

V_{imp} = 370 μm/ns

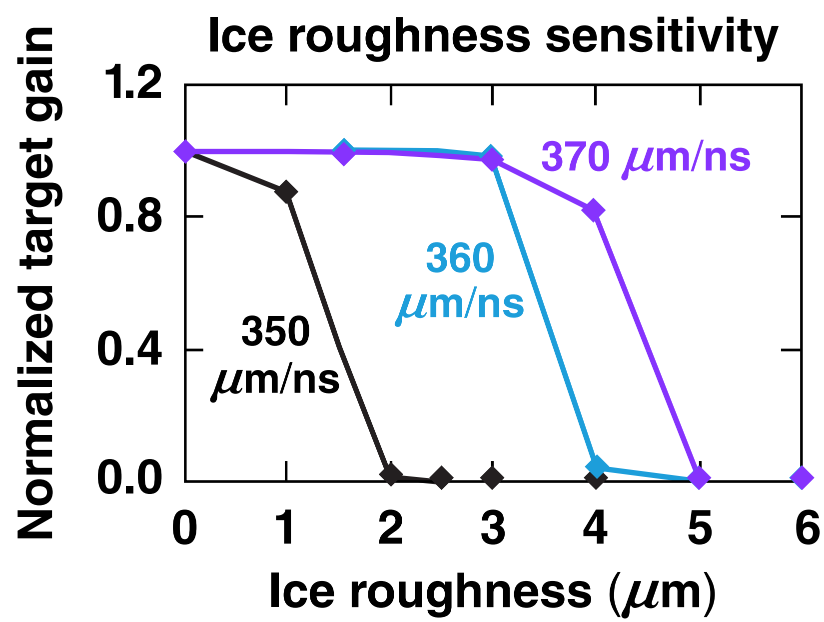


*J. D. Lindl, *Inertial Confinement Fusion: The Quest for Ignition and Energy Gain Using Indirect Drive* (Springer-Verlag, New York, 1998).
**T. J. B. Collins *et al.*, Phys. Plasmas 19, 056308 (2012).
***V. N. Goncharov, JO4.00001, this conference.

TC10224

The decrease in implosion speed comes with a decrease in margin

- Margin $\approx (E_{kin} / E_{min}^{ign}) - 1$, where E_{min} is the minimum energy needed for ignition
- $E_{min} \sim \alpha^{1.88} V_{imp}^{-5.89} P^{-0.77}$ *
- Decreasing the implosion speed from 380 to 350 μm/ns raises E_{min}^{ign} by ~40%
- The reduced margin is reflected in a greater sensitivity to ice roughness



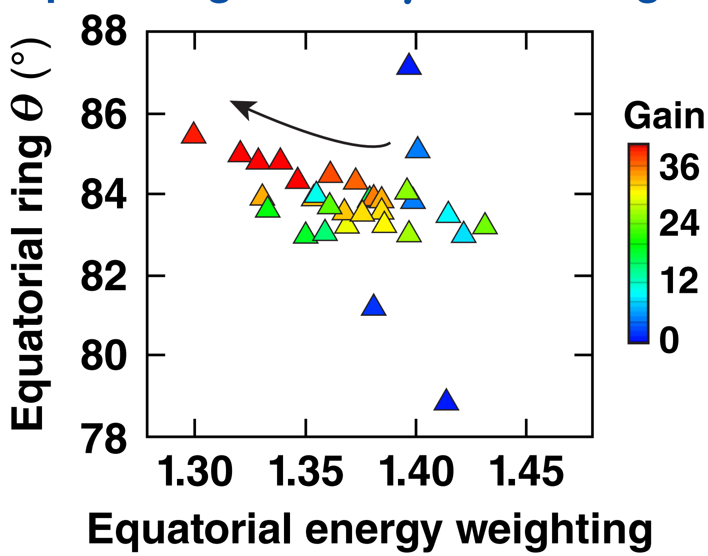
TC10225a

*M. C. Herrmann, M. Tabak, and J. D. Lindl, Nucl. Fusion 41, 99 (2001).

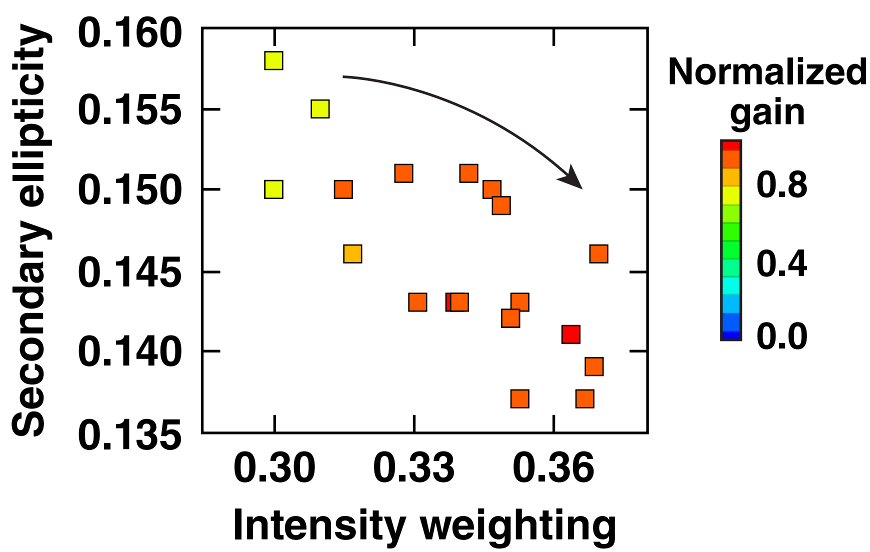
Telios is being used to optimize 2-D PD designs in multidimensional parameter space

- *Telios* is a C++ implementation of a Downhill Simplex method used to optimize target designs in 1-D and 2-D with respect to any function of the target properties, including gain, adiabat, IFAR, etc.
- The ring energies and pointing angles for V_{imp} = 400 μm/ns design were optimized, increasing the gain without nonuniformities from 11 to 42:

Optimizing the 400 μm/ns design



Optimizing the equatorial spot shape



- A separate optimization obtained a 40% increase in gain when the equatorial spot shape was varied to increase the energy in the secondary ellipse

TC10226

Optimization with *Telios* indicates the robustness of the 370 μm/ns design

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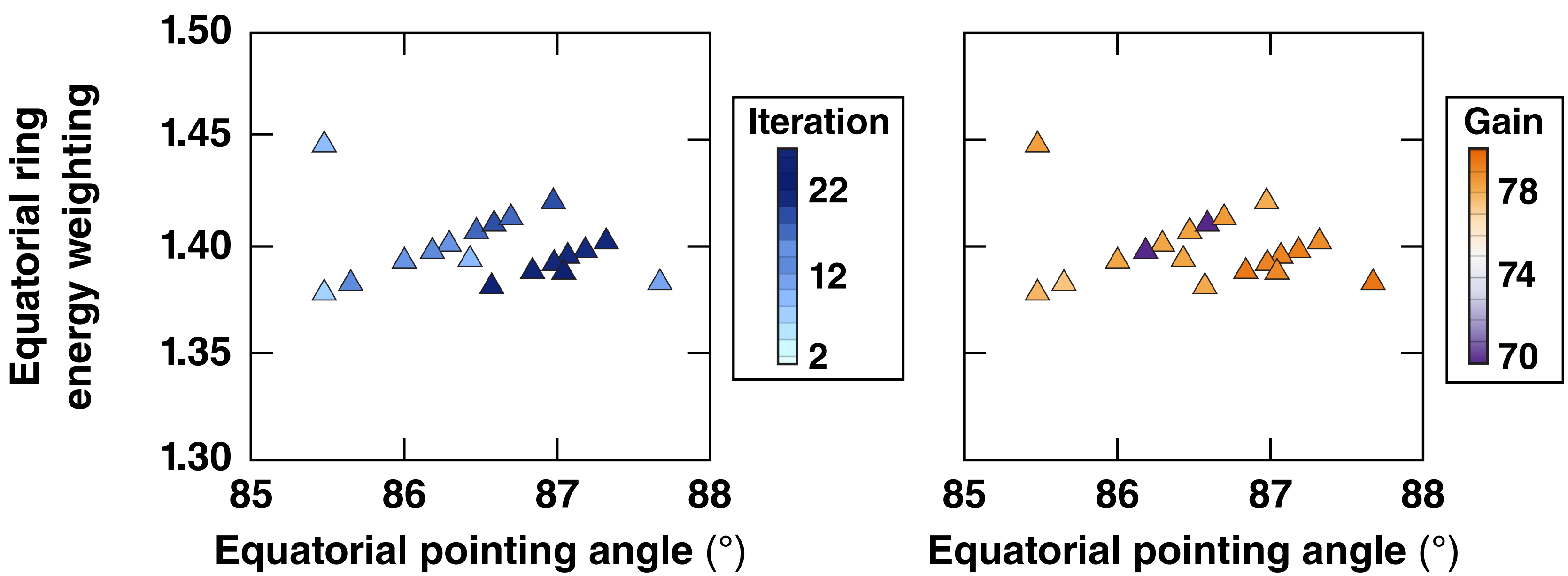
- *Telios* was used to maximize the target gain for the 370 μm/ns design while
  - holding the adiabat, pulse energy and IFAR constant
  - varying the beam pointing angles and relative pulse energies
- Little variation in target gain was found, indicating a stability plateau with respect to the polar pointing angles and ring energies:



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These designs will be re-optimized with non-local thermal transport and crossed-beam energy transfer

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- A nonlocal thermal transport package using a modified Schurtz[1] algorithm has been implemented in *DRACO* and is being tested on the 370 μm/ns design[2]
- Mitigation strategies, including multiple drive frequencies, are being explored using a new crossed-beam energy transfer model[3]
- NIF experiments will investigate direct-drive laser coupling and implosion symmetry using existing NIF optics and beam smoothing and warm targets early in FY13[4]

[1] G. P. Schurtz, Ph. D. Nicolaï, and M. Busquet, Phys. Plasmas 7, 4238 (2000).
[2] J. Delettrez, JO4.00013; D. Cao *et al.*, CP8.00079, this conference.
[3] J. Marozas, UO5.00003, this conference.
[4] P. R. Radha, NI2.00006, this conference.

Summary/Conclusions

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