Polar-Drive Ignition Experimental Plan on the NIF

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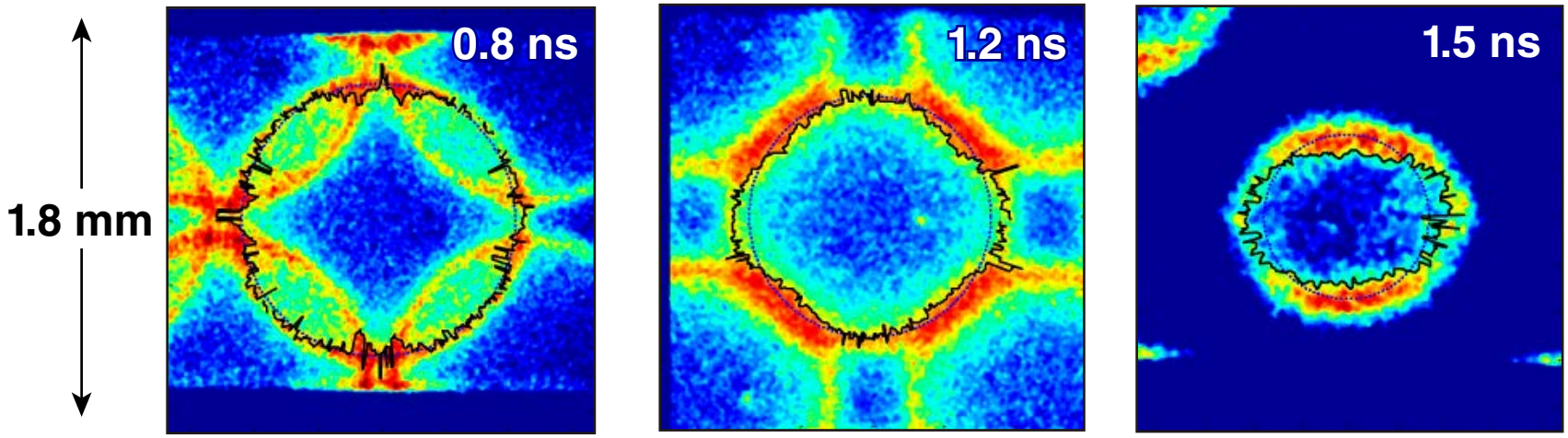
Self-emission images of a NIF polar-drive exploding-pusher implosion



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Summary

The path to polar-drive ignition on the NIF includes Omega and NIF experiments

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- Polar drive (PD) provides a viable alternative to indirect-drive ignition on the NIF
  - uses indirect-drive beam layout to minimize reconfiguration costs
  - is predicted to couple 7 to 9× more energy to the DT fuel for a fixed laser energy
- The plan to develop PD ignition on the NIF includes
  - ongoing development of the physics basis through cryogenic target implosions on OMEGA
  - initial NIF experiments with indirect-drive (IDI) beam smoothing
  - technology development for the NIF

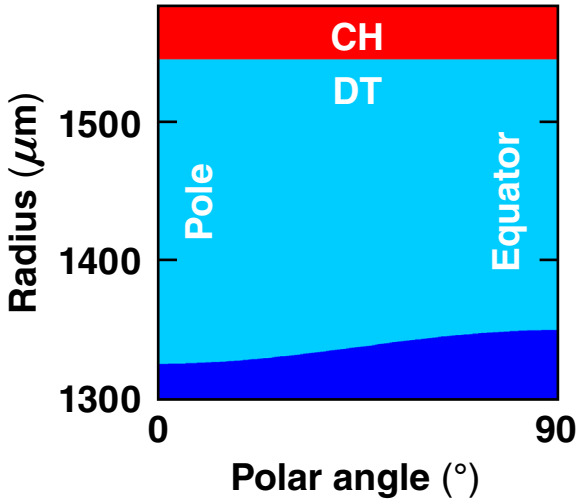
Collaborators

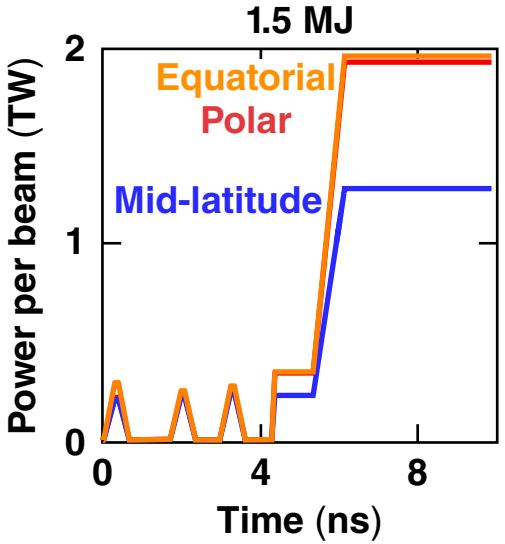
R. S. Craxton, D. H. Froula, V. N. Goncharov, I. V. Igumenshchev,
M. Hohenberger, S. J. Loucks, P. W. McKenty, R. L. McCrory,
D. T. Michel, P. B. Radha, and T. C. Sangster

Laboratory for Laser Energetics
University of Rochester

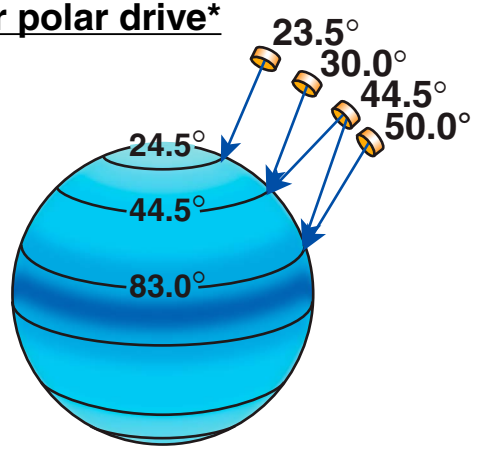
Direct-drive ICF is a viable ignition alternative for the NIF

- Direct drive is predicted to couple 7 to 9× more energy to the compressed core than indirect drive
- 2-D simulations predict PD gains of ~70 on the NIF with illumination geometry only*
- Cryogenic target implosions are studied on OMEGA at ~1/4 of the NIF target scale
  - $R \sim (E_L)^{1/3}$
- LLE is developing polar drive to allow for direct-drive–ignition experiments while the NIF is configured for x-ray drive





Repointing for polar drive*

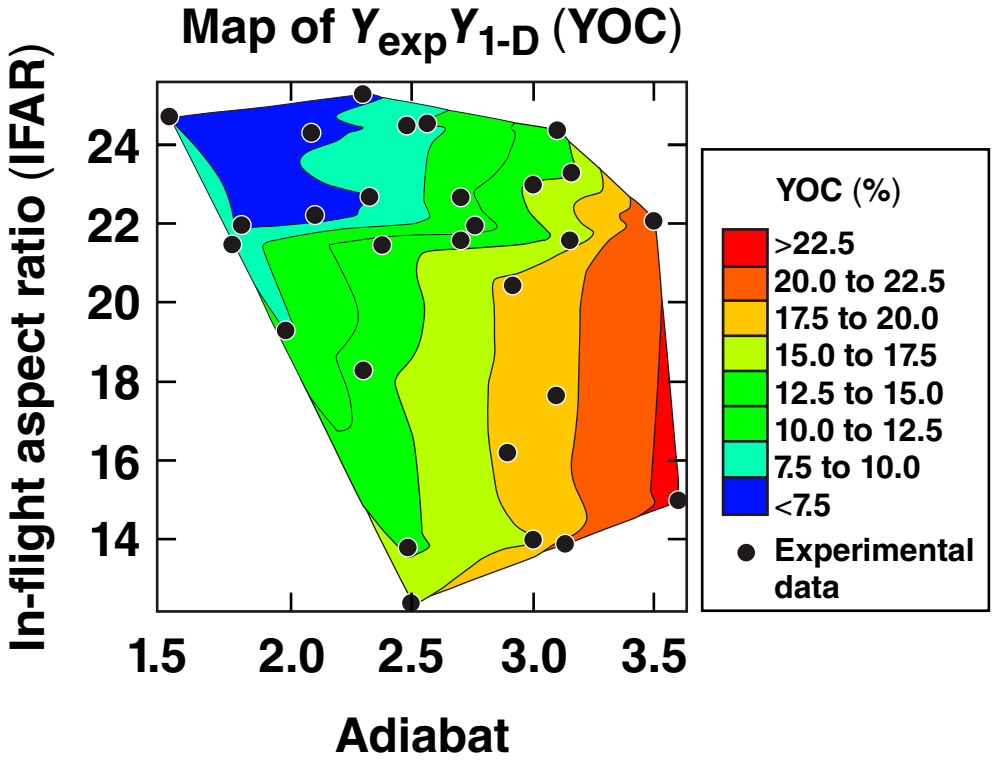


2-D simulations predict polar-drive ignition on the NIF when appropriate beam smoothing has been added.

E18400m

*T. J. B. Collins, JO4.00010, this conference.

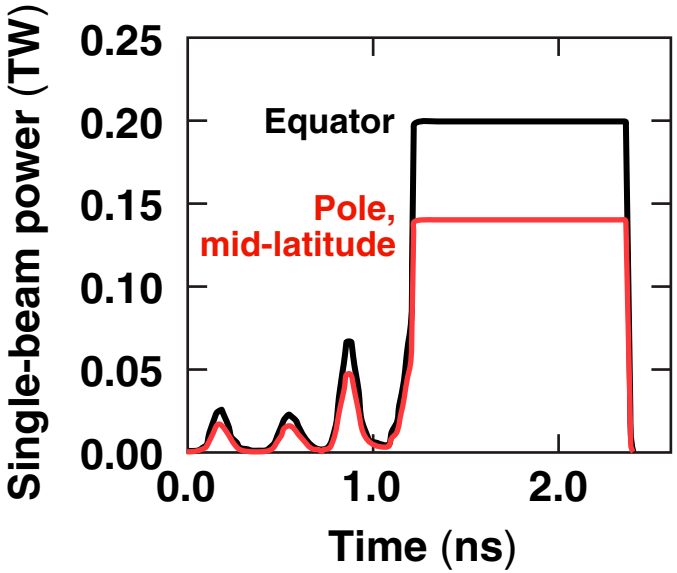
Omega's flexibility allows a wide parameter range to be explored in symmetric cryogenic implosions

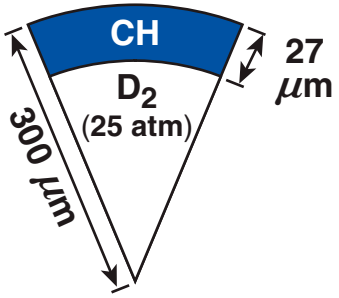


The 1-D simulations include all of the known physics with no adjustable "knobs."

T. C. Sangster, NI2.00002, this conference; and V. N. Goncharov, JO4.00001, this conference.

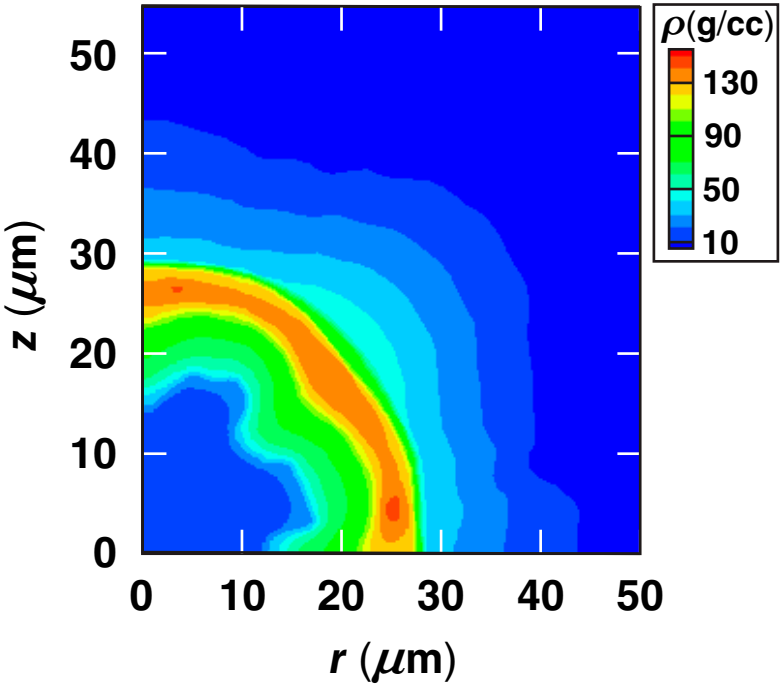
Cryogenic polar-drive implosion experiments will begin on OMEGA in 2013—new phase plates are almost completed



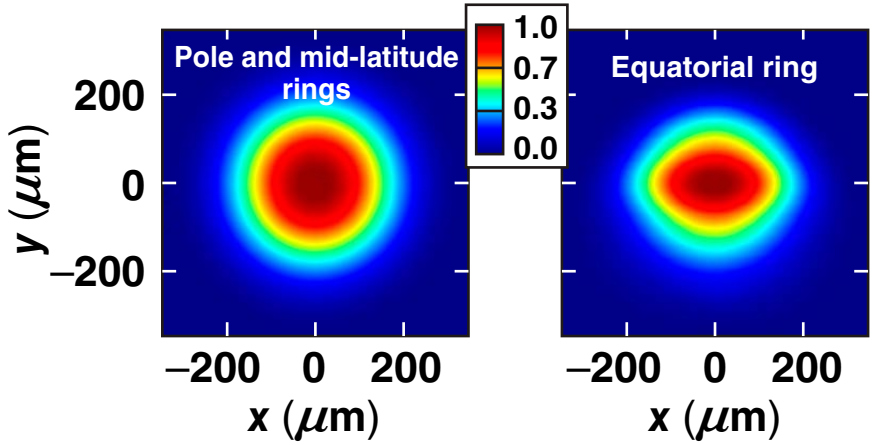


Density contours at peak neutron production

Ring 1, 15 μm, Ring 2, 10 μm, Ring 3 120 μm



OMEGA far-field spot shapes



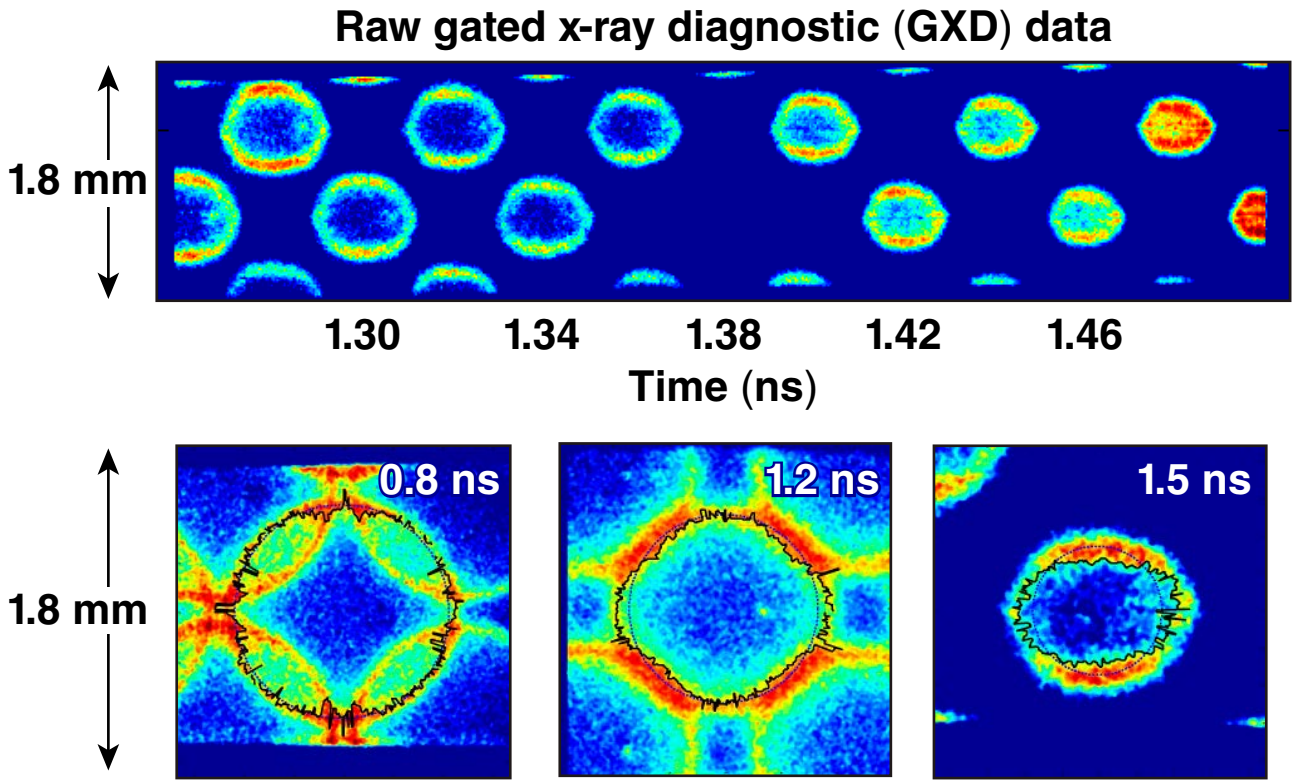
Yield ratio (PD/symmetric) = 65%

BT (symmetric) – BT (PD) = –20 ps

P. B. Radha, NI2.00006, this conference.

TC9654e

LLE is using NIF polar-drive diagnostic commissioning shots and LANL defect-induced mix experiments (DIME) shots to tune the symmetry*



*R. S. Craxton, JO4.00012; P. W. McKenty, JO4.00011; and M. J. Schmitt, Y12.00005 this conference.

Implementing PD requires five changes on the NIF for an ignition demonstration

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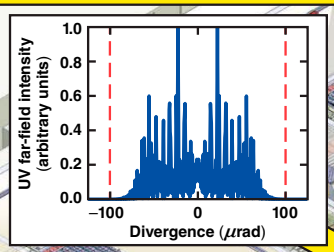
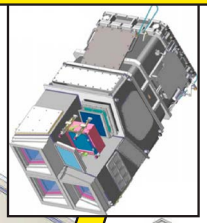
1 Add Multi-FM fiber front end and combine with existing system

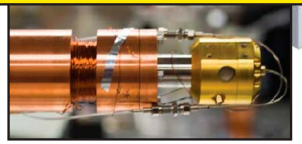


3 4 New PD phase plates (2ω) and polarization plates (3ω) in final optics assembly



2 Add new SSD grating to 48 preamplifier modules (PAM's)

5 New PD ignition target insertion cryostat (PD-ITIC)



Laser technology required for polar-drive ignition on the NIF is being demonstrated using a NIF PAM on OMEGA EP.

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Multi-FM smoothing by spectral dispersion (SSD) has been activated in a NIF PAM on an OMEGA EP beamline*

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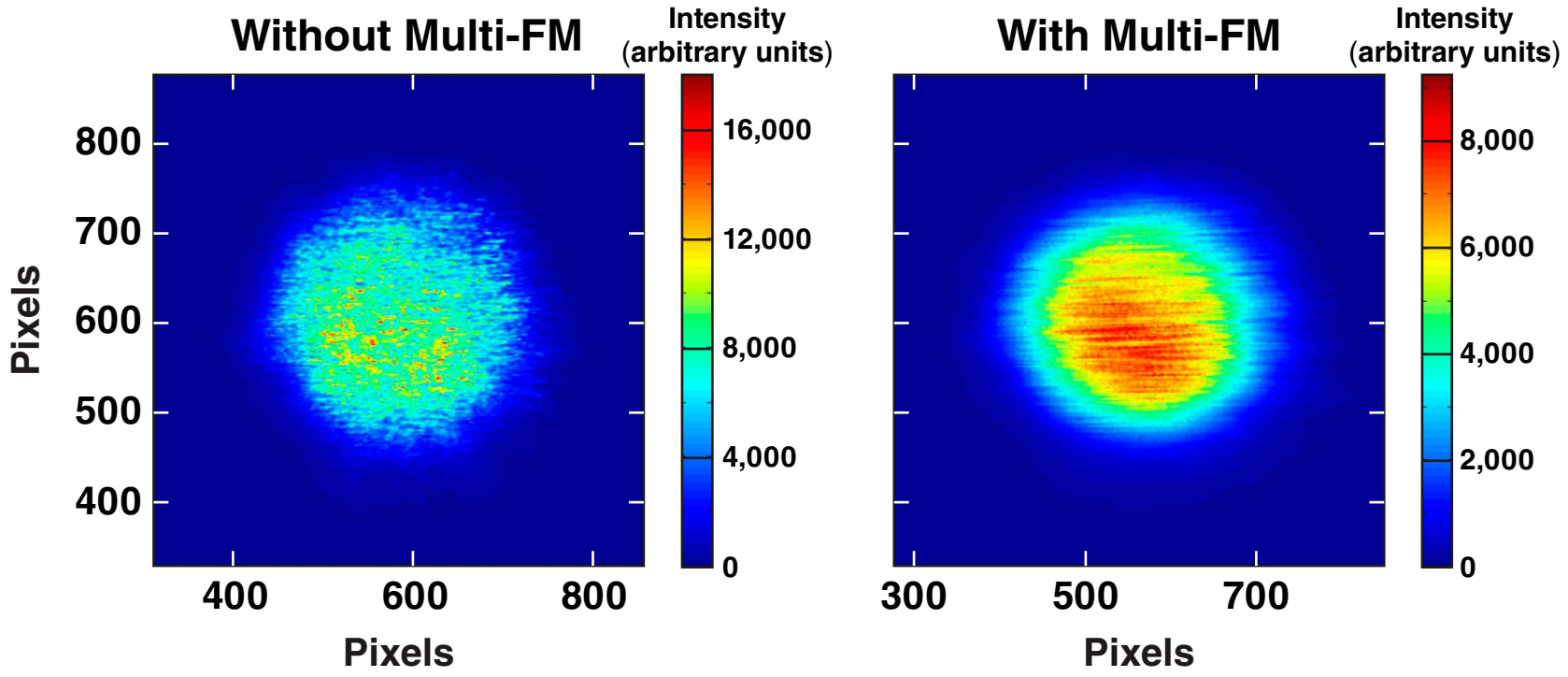
- Equivalent-target-plane images, without and with Multi-FM SSD, show expected smoothing
  - 100-ps laser pulse
  - spatial magnification being measured, ~1-mm-diam spot
- Imprint measurements are in progress



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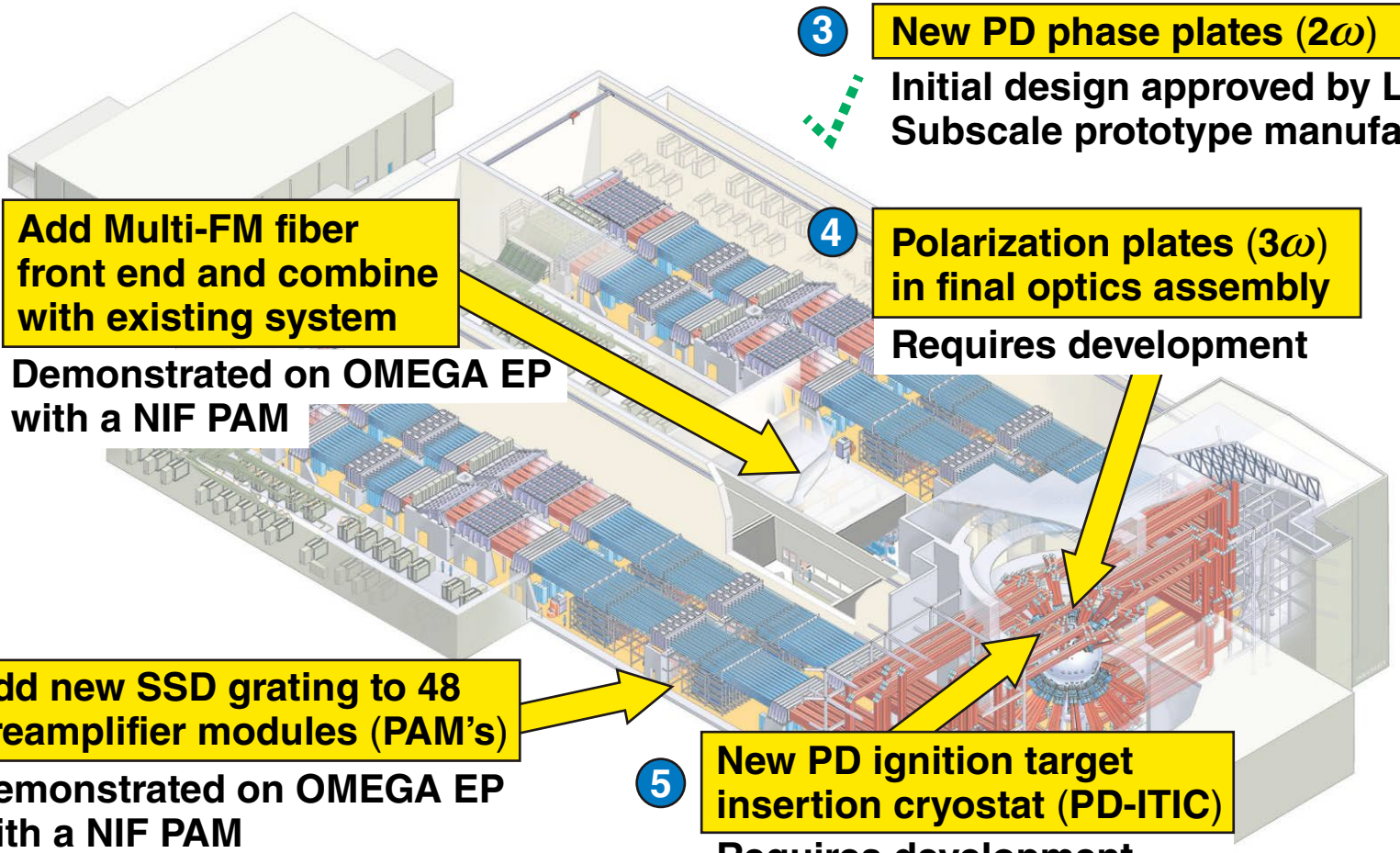
*A. Shvydky, JO4.00009, this conference.

Implementing PD requires five changes on the NIF for an ignition demonstration



3 **New PD phase plates (2ω)**

Initial design approved by LLNL
Subscale prototype manufactured

1 **Add Multi-FM fiber front end and combine with existing system**

Demonstrated on OMEGA EP with a NIF PAM

4 **Polarization plates (3ω) in final optics assembly**

Requires development

2 **Add new SSD grating to 48 preamplifier modules (PAM's)**

Demonstrated on OMEGA EP with a NIF PAM

5 **New PD ignition target insertion cryostat (PD-ITIC)**

Requires development and engineering

The technology path forward is clear.

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Ignition-relevant PD experiments can begin in the NIF's current configuration

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- The PD NIF shot plan is staged to take advantage of facility upgrades for polar drive

IDI smoothing

- Energy coupling and laser–plasma interactions (LPI)
- Initial symmetry studies

Partial PD smoothing (phase plates)

- Shock timing
- Energy coupling and LPI
- Improved symmetry

Full PD smoothing

- High-quality implosions with warm targets
- Cryogenic ignition experiments

Initial PD ICF experiments are planned for FY13.

Summary/Conclusions

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