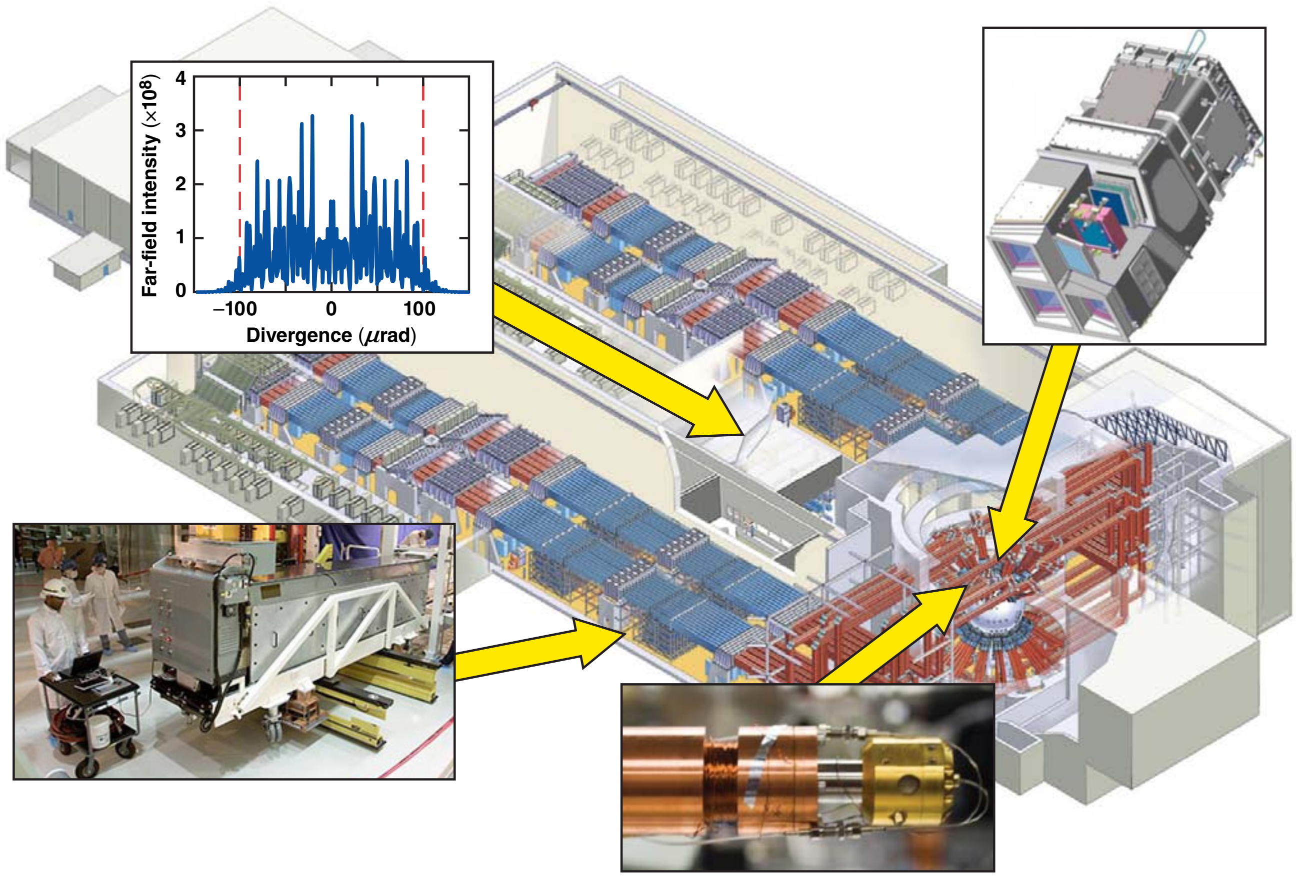
Technology for Polar-Drive Ignition on the NIF



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NAS/NAE Committee on the
Prospects for IFE Systems
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Summary

Polar-drive ignition could be tested on the NIF with a few modest modifications to the facility

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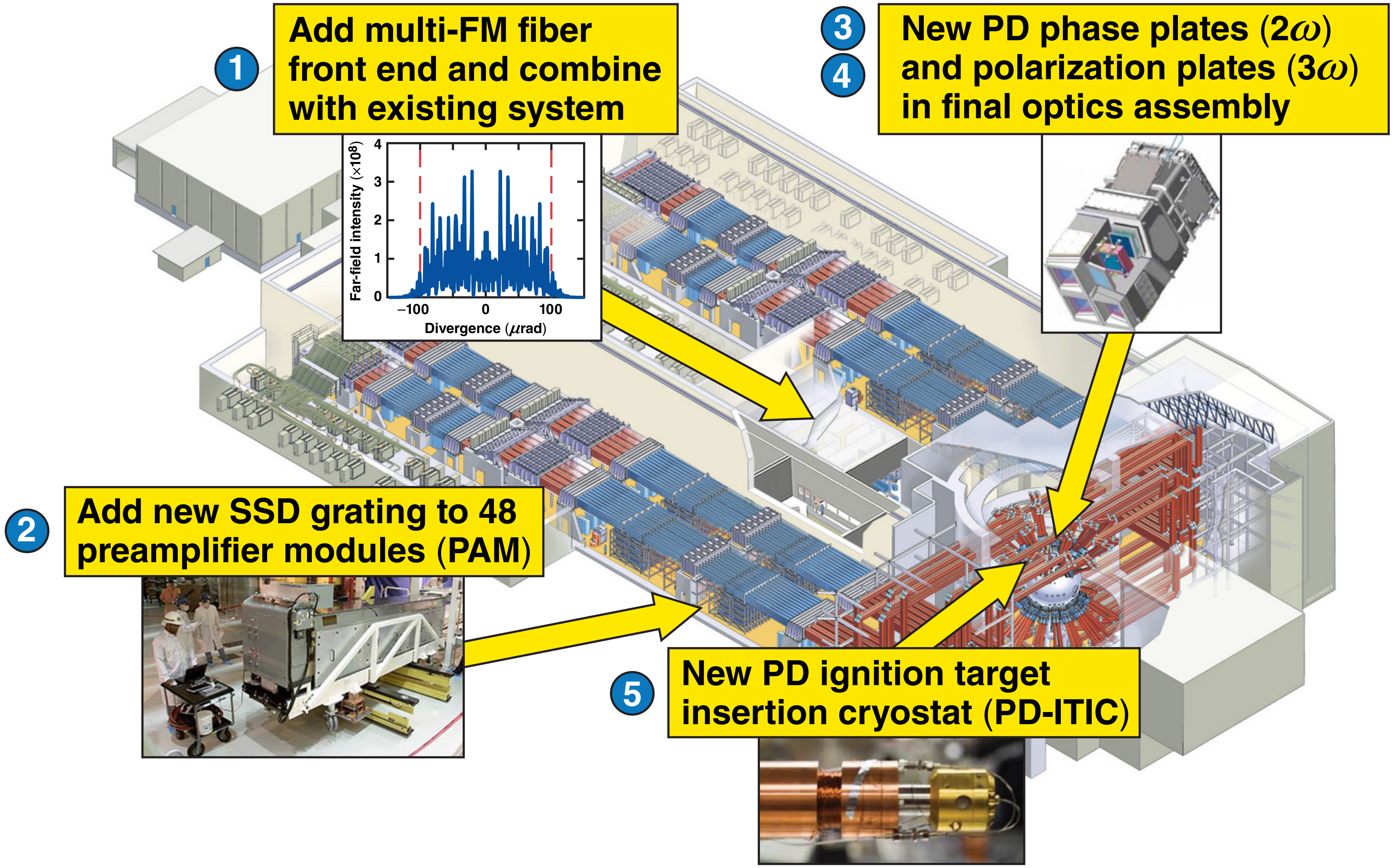
- **Beam-smoothing improvements:**
  - Multi-FM 1-D smoothing for spectral dispersion (SSD) provides the required beam smoothing with simple modifications to the NIF facility
  - Beam smoothing is only required at the beginning of the laser pulse, which minimizes stress on the laser
  - Polar-drive phase plate and polarization-smoothing designs are underway
  - A NIF PD beam-smoothing demonstration on OMEGA EP is planned in FY12

- **Direct-drive target technology:**
  - NIF-scale fill-tube targets have been demonstrated and are being optimized
  - Concepts for a polar-drive ignition target insertion cryostat (PD-ITIC) are being developed

Implementing polar drive (PD) requires five changes on the NIF for an ignition demonstration



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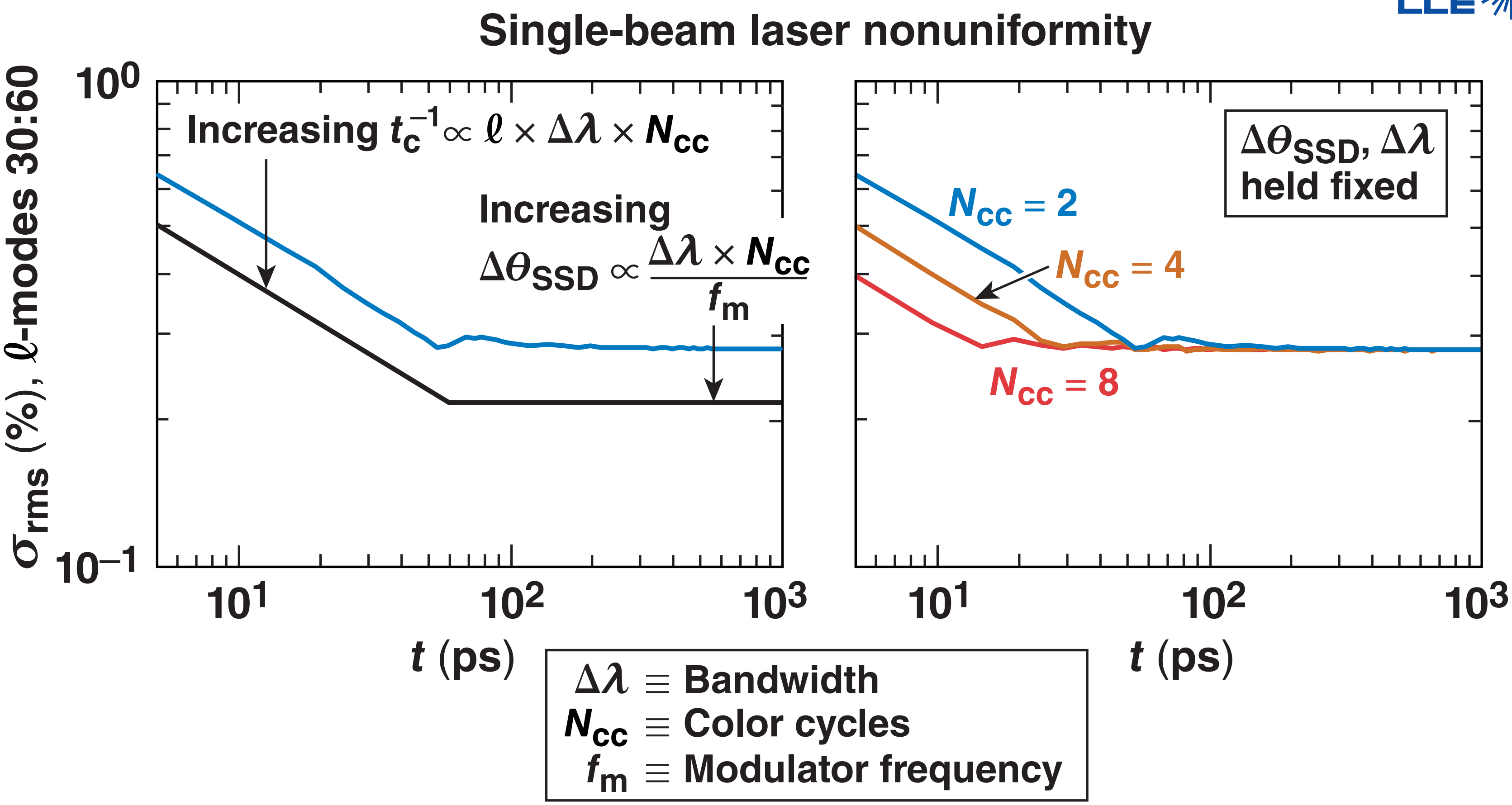
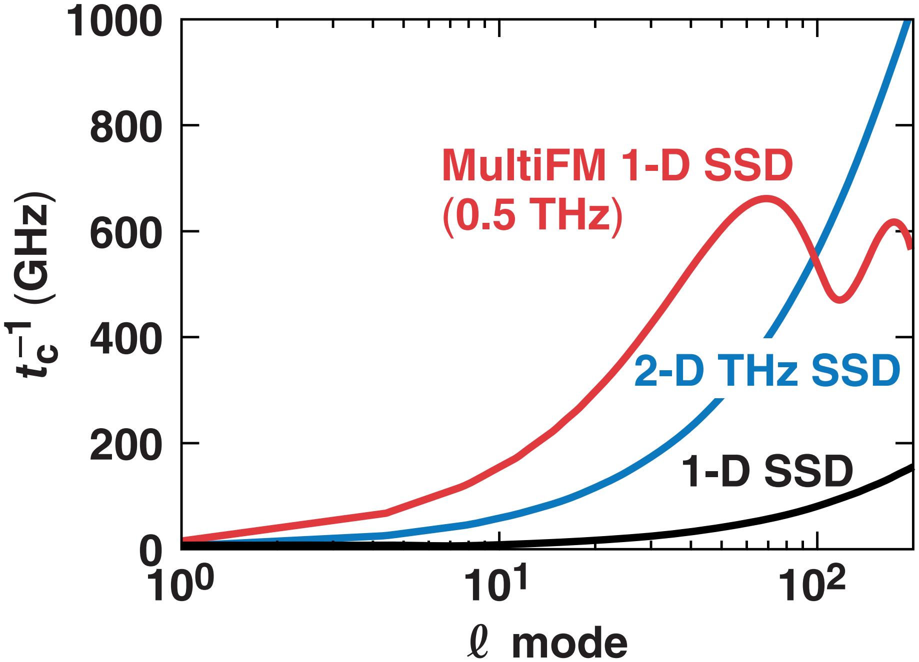
Laser nonuniformity imprint is minimized by optimizing smoothing by spectral dispersion (SSD)



- SSD divergence ($\Delta\theta_{SSD}$) determines the asymptotic uniformity
- Increasing the inverse coherence time (t_c^{-1}) allows the target to experience a smoother spot for a longer period

MultiFM 1-D SSD provides required beam smoothing performance with minimal impact on the facility

Inverse coherence time versus far-field spatial frequency



- Traditional SSD systems using single-frequency phase modulation have low smoothing rates for many important spatial modes ($\ell < 150$)
- MultiFM 1-D SSD is a new approach that
  – provides better smoothing rates with lower total bandwidth (esp. for PD pulse shapes with picket prepulses)
  – can be implemented on NIF with simple modifications

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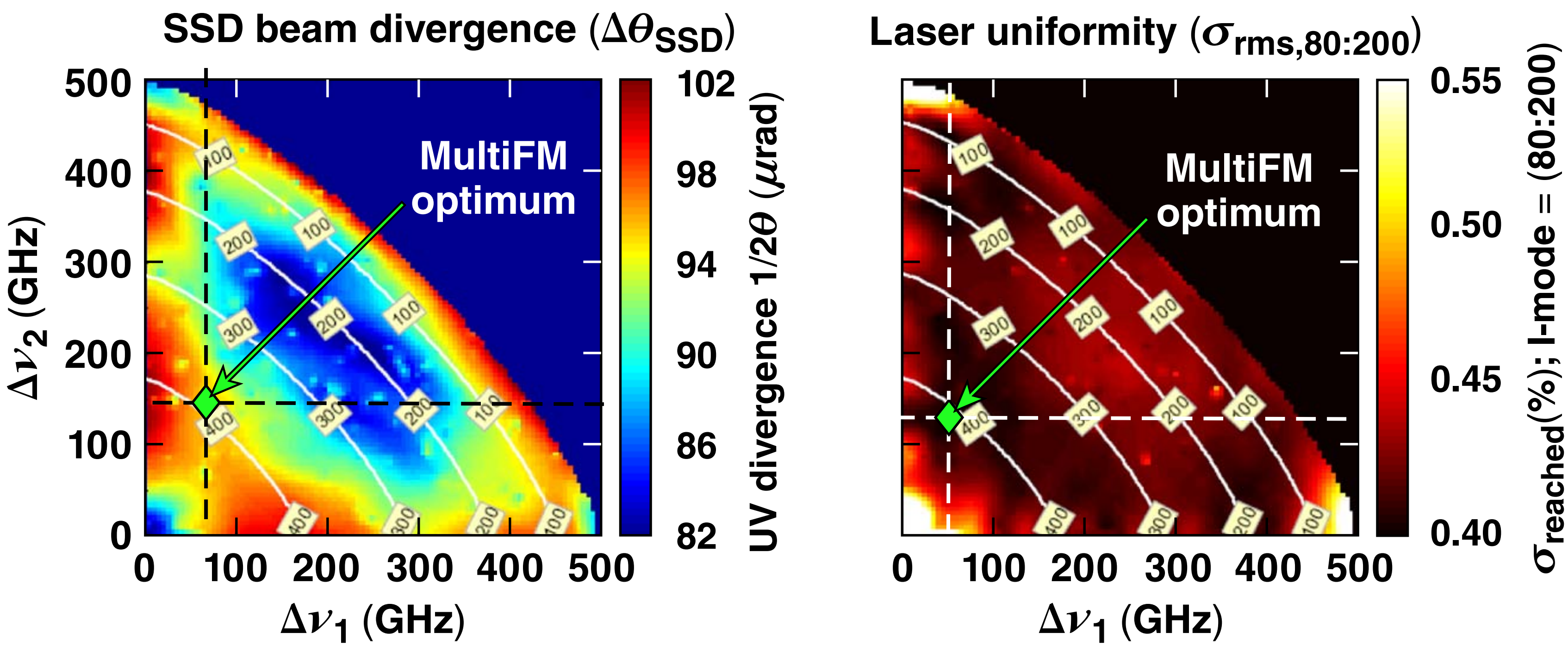
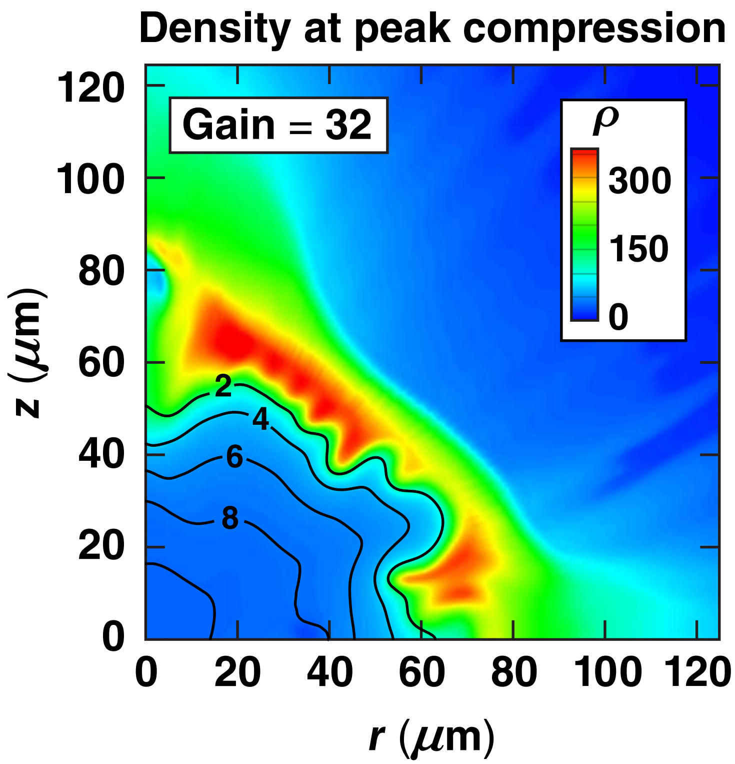
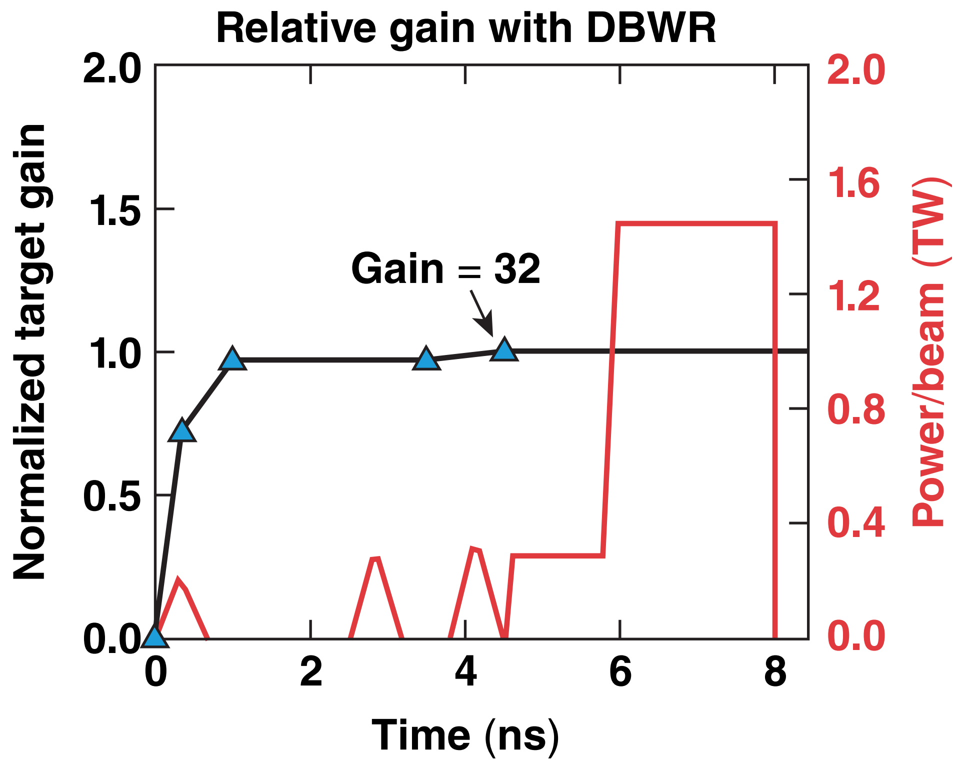
An optimized MultiFM configuration that achieves high gain in polar drive simulations has been identified



- MultiFM 1-D SSD employs technology developed for the telecommunications industry
  - 40-GHz phase modulators and drive electronics
  - UV bandwidth: Δf_{total} = 500 GHz (effective bandwidth)
  - SSD divergence: $\Delta\theta_{SSD}$ = 100 μrad (half angle at full beam)
- *DRACO* 2-D simulations with all nonuniformity sources: Gain = 32

Dynamic Bandwidth Reduction (DBWR) minimizes stress on the laser with little affect on target gain





MultiFM 1-D SSD beam smoothing only needs to be applied to pickets in the polar-drive point design pulse shape.

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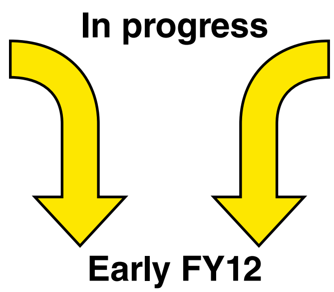
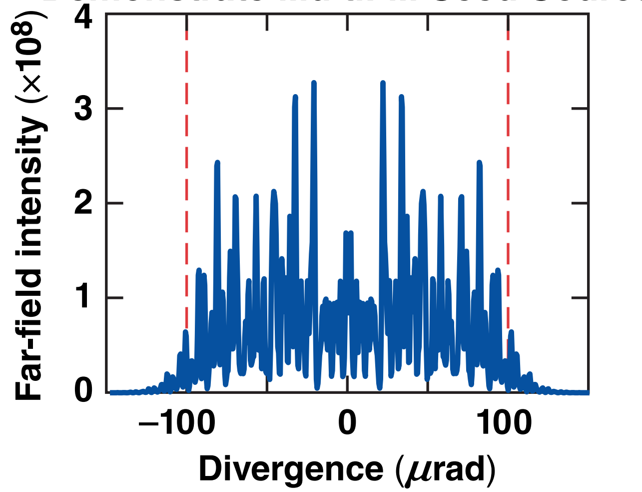
A MultiFM 1-D SSD beam-smoothing demonstration on OMEGA EP will validate laser imprint performance

Integrate NIF PAM into OMEGA EP

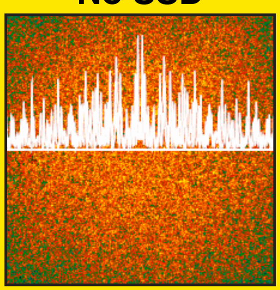


Demonstrate MultiFM Seed Source

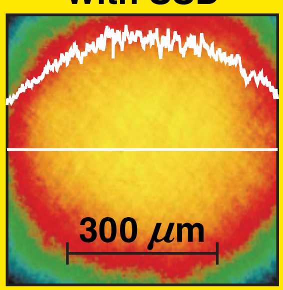


Verify smoothing with equivalent target plane measurements*

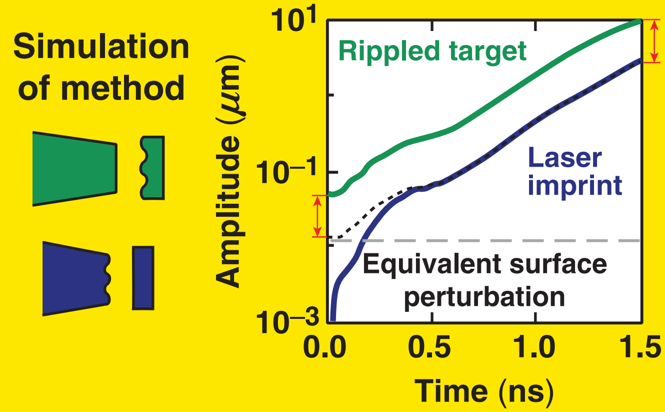
No SSD



With SSD



Verify laser imprint with foil-target experiments on OMEGA EP**



*S. P. Regan *et al.*, J. Opt. Soc. Am. B 17, 1483 (2000).

**T. R. Boehly *et al.*, Laser Part. Beams 18, 11 (2000).

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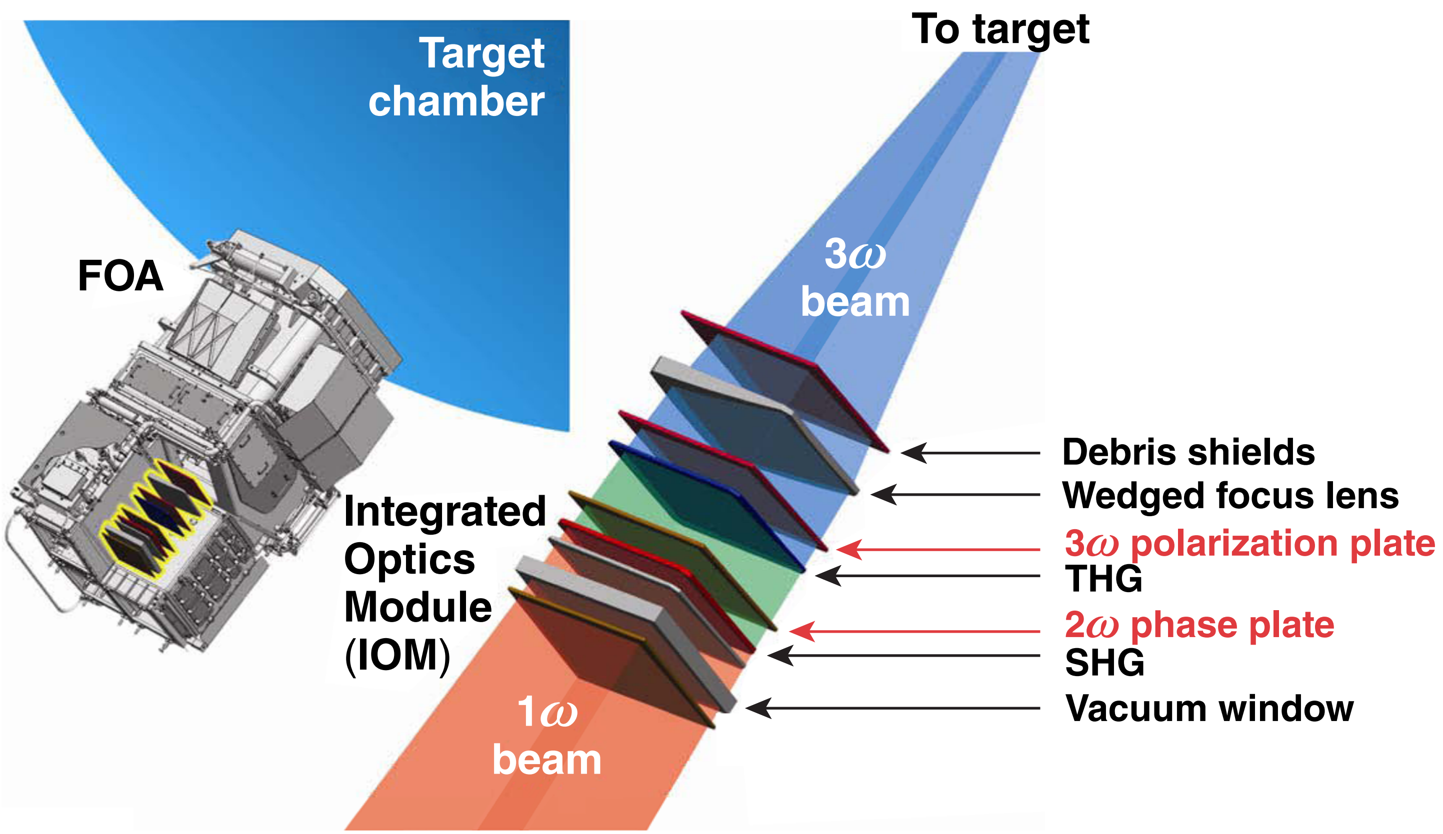
The focal-spot conditioning strategy for polar-drive ignition includes phase and polarization plates



The NIF final optics assembly (FOA) will include:

- Phase plate between the frequency conversion crystals (2ω)
- Polarization plate (3ω)

Phase plates and polarization smoothing are being designed to efficiently and uniformly couple energy to polar-drive targets

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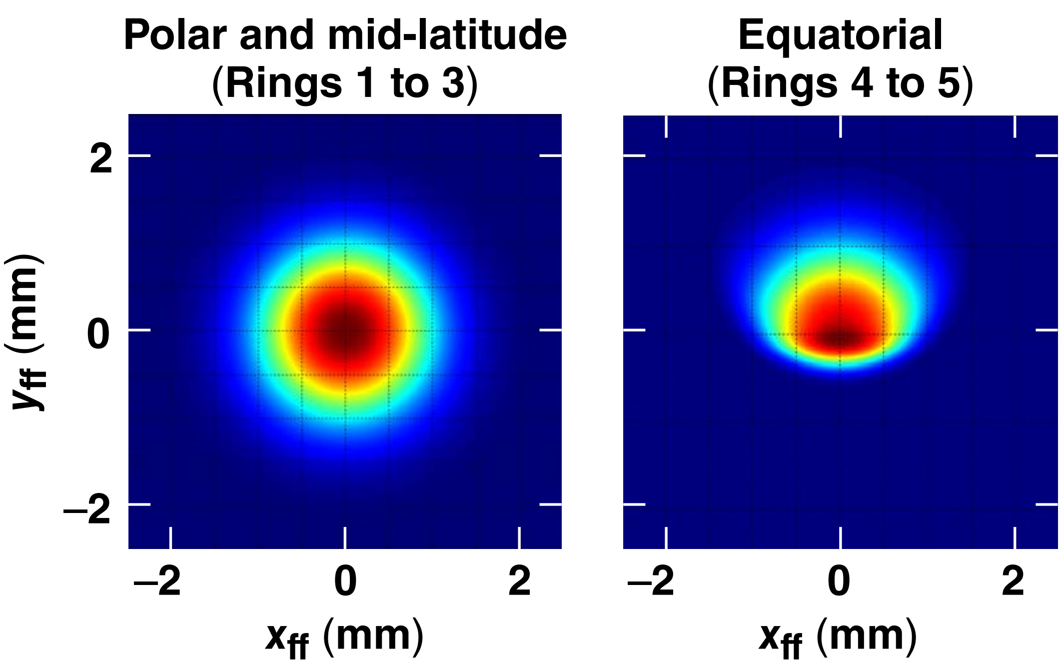
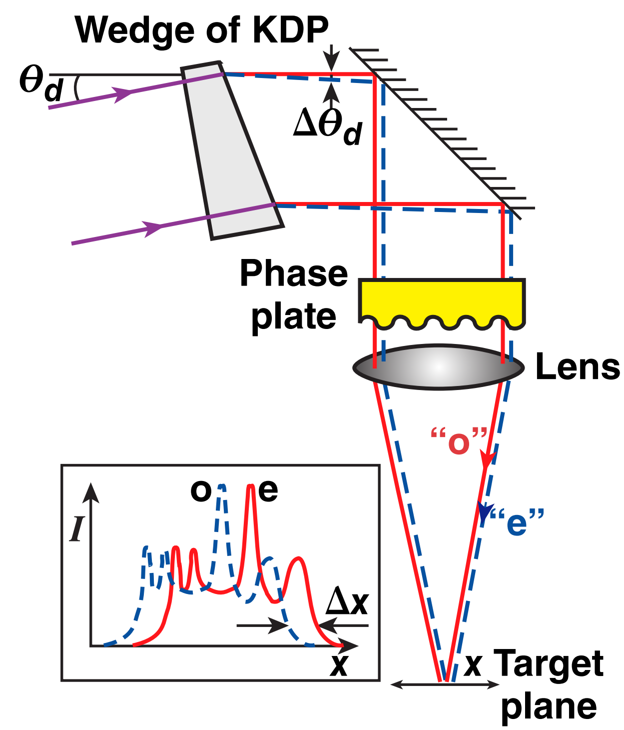
Focal spots for polar-drive beams



Polarization smoothing



- Phase plates efficiently deliver laser energy with a desired focal pattern to achieve required irradiation uniformity.
- Polarization smoothing instantaneously improves targeted modes of focal-spot irradiance modulation.

A NIF fill-tube target has been demonstrated that will be optimized to meet polar-drive ice layer specifications

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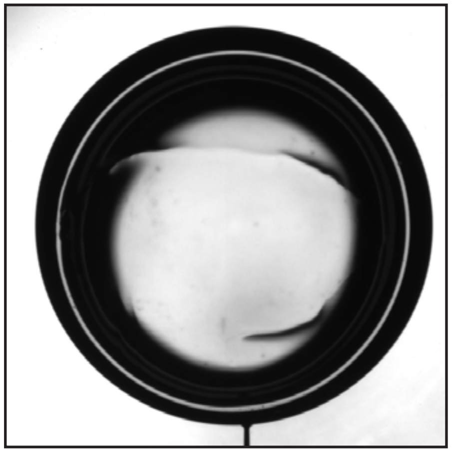
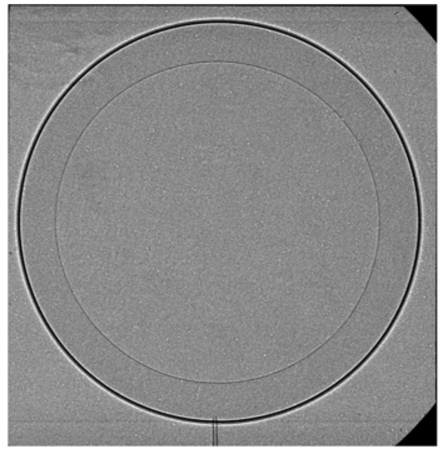
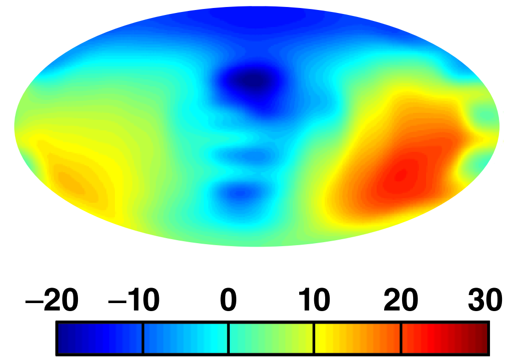
Shadowgraph



X-ray phase contrast

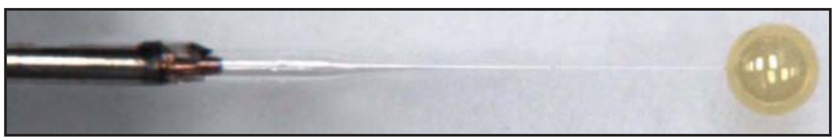


Inner ice layer surface

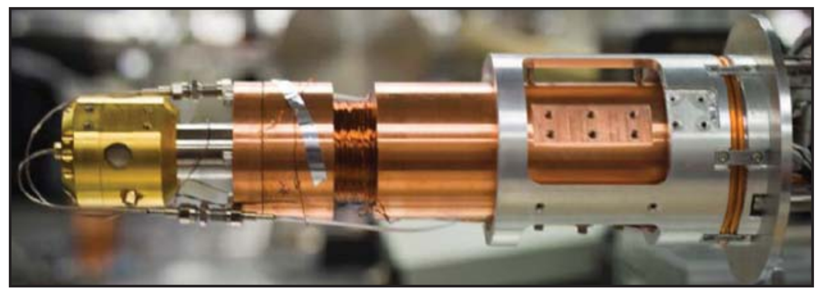


Deviations from sphericity in μm

D_2 layer (297 μm) with mid-IR laser layering



Target: 2.95-mm OD, 20-μm wall
Fill tube: 30-μm OD at shell wall



Cryogenic layering sphere

Facility renovations and equipment upgrades are underway at LLE to demonstrate NIF PD cryogenic layering with DT targets.

A polar-drive ignition target insertion cryostat (PD-ITIC) will minimize the impact on the NIF facility

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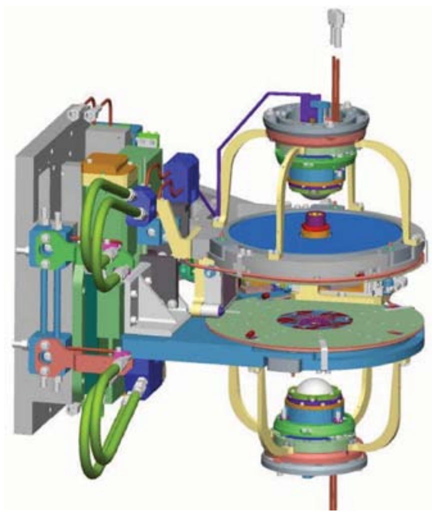
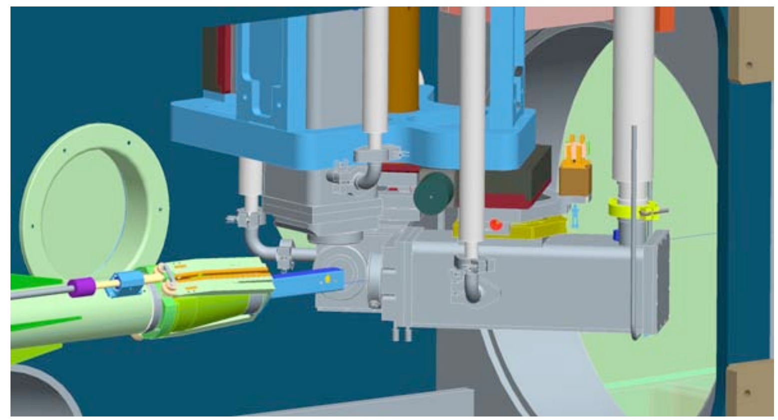
Target Alignment System (TAS)



Load, Layer, and Characterization Station (LLCS)



- A polar-drive target that survives >3-s exposure to the target chamber is required to use existing "clam-shell" shroud design
- Use existing NIF space envelope and cryogenic support systems (TAS, LLCS, TARPOS)

Existing TAS and LLCS place challenging constraints on a PD-ITIC design that will limit size of the cryogenic shroud.

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