Demonstrating Polar-Drive Beam Smoothing Technology for NIF on OMEGA EP

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Summary

Polar-drive beam smoothing will be proven on Omega EP to prepare for direct-drive ignition on NIF

- Shock ignition on NIF will use polar direct drive
  - MultiFM 1-D SSD beam smoothing is a viable approach for NIF to provide the required beam smoothing
- Dynamic bandwidth reduction minimizes stress on the laser with little affect on target gain
- Spatio-temporal distortion from the SSD grating limits pulse shaping
  - Pulse shapes must be clearly specified to avoid confusion
- MultiFM technology is being developed and proven in an offline testbed

Efforts to demonstrate MultiFM 1-D SSD beam smoothing on OMEGA EP are well underway
Implementing polar drive (PD) requires five changes on the NIF for an ignition demonstration.

1. Add multi-FM fiber front end and combine with existing system
2. Add new SSD grating to 48 preamplifier modules (PAM)
3. New PD phase plates ($2\omega$) and polarization plates ($3\omega$) in final optics assembly
4. New PD ignition target insertion cryostat (PD-ITIC)

T. Kessler (next talk)

Not addressed in this workshop
A MultiFM 1-D SSD beam-smoothing demonstration on OMEGA EP will validate laser performance

Integrate NIF PAM into OMEGA EP

In progress

Early FY12

Demonstrate MultiFM Seed Source

Far-field intensity ($\times 10^8$)

Divergence (μrad)

Verify smoothing with equivalent target plane measurements*

No SSD

With SSD

300 μm

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

Simulation of method

Ripped target

Laser Imprint

Amplitude (μm)

Equivalent surface perturbation

Time (ns)


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

- Polar-drive ignition on NIF requires MultiFM 1-D SSD beam smoothing only for pickets in the pulse shape.
- DBWR will be tested on Omega EP by optically splicing two pulse shapes with and without MultiFM bandwidth.
Demonstrating PD beam smoothing on Omega EP involves four major stages

1. Activate NIF PAM in OMEGA EP Laser Sources Beamline 4
2. Develop MultiFM 1-D SSD seed source and laser diagnostics
3. Activate MultiFM 1-D SSD in OMEGA EP
4. Verify PD beam smoothing on OMEGA EP

*Fiber amplifiers, SSD compensation & fail-safe systems not shown for clarity

** Fiber front end w/ dynamic bandwidth reduction

** Similar to NIF systems

MPA = Multi-Pass Amplifier
ETP = Equivalent Target Plane
NIF PAM integration in Omega EP is nearly complete and activation will start in Q3FY11

• Temporally shaped pulses have been injected into PAM regenerative amplifier and propagated through PAM to the BL4 injection point

• MPA power conditioning activation and pulse amplification will be accomplished during Q3FY11 maintenance shutdown

• Narrowband BL4 activation should be completed in FY11
A MultiFM testbed has been built to develop and verify system performance before moving into EP

- **Main pulse rack:**
  - Arbitrary waveform generator (using AWG comparable to NIF)
  - SBS suppression with fail-safe system
  - 17-GHz phase modulation

- **Picket pulse rack:**
  - Multiple picket pulse generation (AWG with ~50-ps resolution)
  - MultiFM phase modulation system

- **Surrogate PAM with regenerative amplifier and SSD grating (not shown)**
Spatio-temporal distortion from the SSD grating in the PAM limits pulse shaping

SSD grating puts “skew” on pulse shape

For MultiFM 1-D SSD:
\[ \Delta t_{skew} = 360 \text{ ps} \]

Picket pulse widths (FWHM)*
IR+UV (no skew) / UV (on target)

- 285 ps
- 200 ps
- >400 ps
- 160 ps
- 120 ps
- ~400 ps

Pulse shapes must be clearly specified to avoid confusion!

* from A. Shvydky
Pulse shaping to provide dynamic bandwidth reduction has been demonstrated by optically splicing Picket pulses (w/o MultiFM yet).

Polar-drive pulse shape performance will be tested to characterize suitability for experiments on Omega EP and NIF.
MultiFM 1-D SSD employs technology originally developed for the telecommunications industry

- Custom 40-GHz phase modulators and drive electronics are expected soon
- Phase-locked modulation provides better control of beam smoothing
The only PAM modification required for MultiFM 1-D SSD is a new grating in the multi-pass amplifier.

- For Omega EP, the existing 1-D SSD grating will be replaced
  - Minor mechanical design effort

- For NIF, the existing 1-D SSD grating is needed for indirect drive. Two options will be explored:
  - Engineer new mount that can accommodate all three required optics (mirror, 1-D SSD and MultiFM 1-D SSD gratings)
  - install MultiFM grating at an image plane equivalent to RP4
Efforts to demonstrate MultiFM 1-D SSD beam smoothing on OMEGA EP are well underway

• Activate NIF PAM in OMEGA EP Laser Sources Beamline 4
  – NIF PAM regen and alignment through PAM is complete
  – Operational Readiness Review anticipate by May 2011

• Develop MultiFM 1-D SSD seed source and diagnostics
  – Main pulse shaping with 17-GHz phase modulator activated offline
  – Optical splicing demonstrated offline (w/o MultiFM)
  – Custom phase modulators & MultiFM driver electronics due by May 2011

• Activate MultiFM 1-D SSD in OMEGA EP
  – Dedicated EP system time in Q4FY11 (LS4) and Q1FY12 (BL4)

• Verify PD beam smoothing on OMEGA EP
  – Modifications to UV diagnostic package to facilitate equivalent target plane (ETP) measurements are designed and will be ready early in Q3FY11.
  – ETP experiments are planned in Q4FY11 and Q1FY12 (w/ mFM)
  – Planar foil imprint/RT experiments will demonstrate PD smoothing by Q2FY12
Conclusion

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