Three-Dimensional Evaluation of Laser Imprint in National Ignition Facility
Multi-FM Smoothing by Spectral Dispersion Experiments

HYDRA simulations

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Summary

Multi-FM smoothing by spectral dispersion (SSD) was validated at the National Ignition Facility (NIF)

- One-quad multi-FM planar-imprint experiments confirmed expected ~1.6× higher effectiveness of multi-FM compared to the NIF’s 45-GHz SSD (with LLE’s diffraction grating) in imprint reduction
- Three-dimensional HYDRA simulations resolve all single-beam imprint modes and are in reasonable agreement with the experimental data
- X-ray imaging-system resolution of ~10 μm is required to image imprint-seeded areal-density modulations in the NIF flat-foil imprint experiments
Collaborators

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Single-beam smoothing is required for high-performance direct-drive implosions on the NIF

Inner-cone (23.5°) beam intensity with different levels of smoothing

1-D Multi-FM SSD* has been implemented in a single quad (Q24B) on the NIF.

\[ \sigma_{\text{rms}} = 1 \quad \sigma_{\text{rms}} = 0.16 \quad \sigma_{\text{rms}} = 0.11 \]

rms: root mean square

One-quad multi-FM planar-imprint experiments were performed to validate Multi-FM SSD on the NIF.

- Shot N160204 used multi-FM SSD (3-GHz + multi-FM modulators; 130-GHz total bandwidth)
- Shot N160205 used 45-GHz SSD (3-GHz + 17-GHz modulators; 75-GHz total bandwidth)
- Both shots used the Laboratory for Laser Energetics (LLE’s) 1700-l/mm diffraction grating (compared to the NIF’s standard 1050 l/mm)
Calculated* instantaneous far-field spots are used to model the effects of speckle and SSD

Three-dimensional HYDRA* is used to simulate the 3-D impact of SSD

- Simulations use HYDRA’s spherical laser deposition model (no refractive smoothing)
- Simulations resolve the speckle size (~6 μm)
- Surface corrugation was not simulated

HYDRA simulations predict high-amplitude surface nonuniformities at the time of the earliest radiograph.
Simulations reproduce imprint features seen in the experimental radiographs.

45-GHz SSD, 1.36 ns

Multi-FM, 1.38 ns

λ = 100-μm corrugation
Simulated imprint-seeded broadband modulations of the areal density are within error bars of the experimental data above the noise level.
X-ray imaging-system resolution of $\sim 10 \, \mu m$ is required for imaging the imprint-seeded areal-density modulations.

![Graph showing resolution vs. time and resolution vs. noise for different SSD types.](image-url)
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