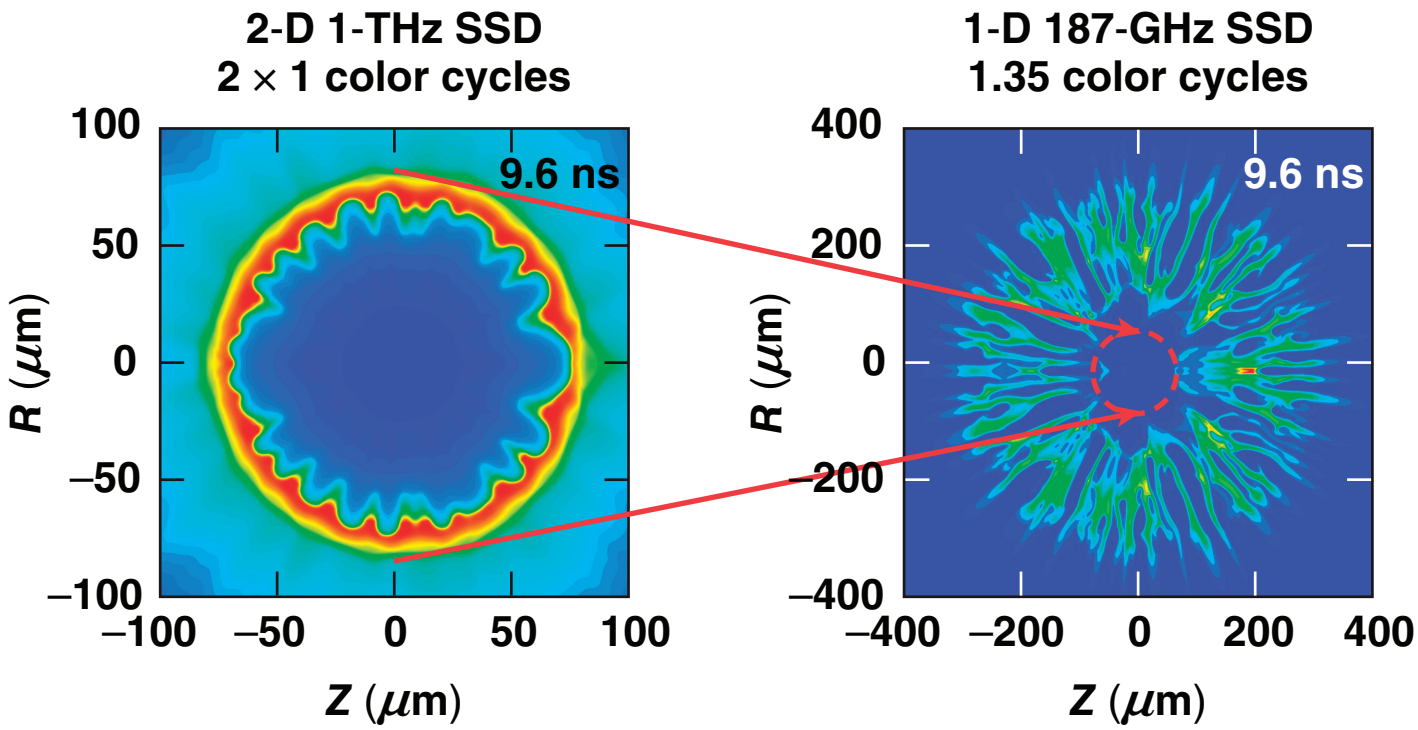
Numerical Investigation of Bandwidth Reduction in NIF Direct-Drive Ignition Designs



P.W. McKenty
University of Rochester
Laboratory for Laser Energetics

48th Annual Meeting of the
American Physical Society
Division of Plasma Physics
Philadelphia, PA
30 October–3 November 2006

Summary

OMEGA and OMEGA EP experiments will determine effective techniques for reducing SSD bandwidth while maintaining adequate laser-beam smoothing

UR LLE

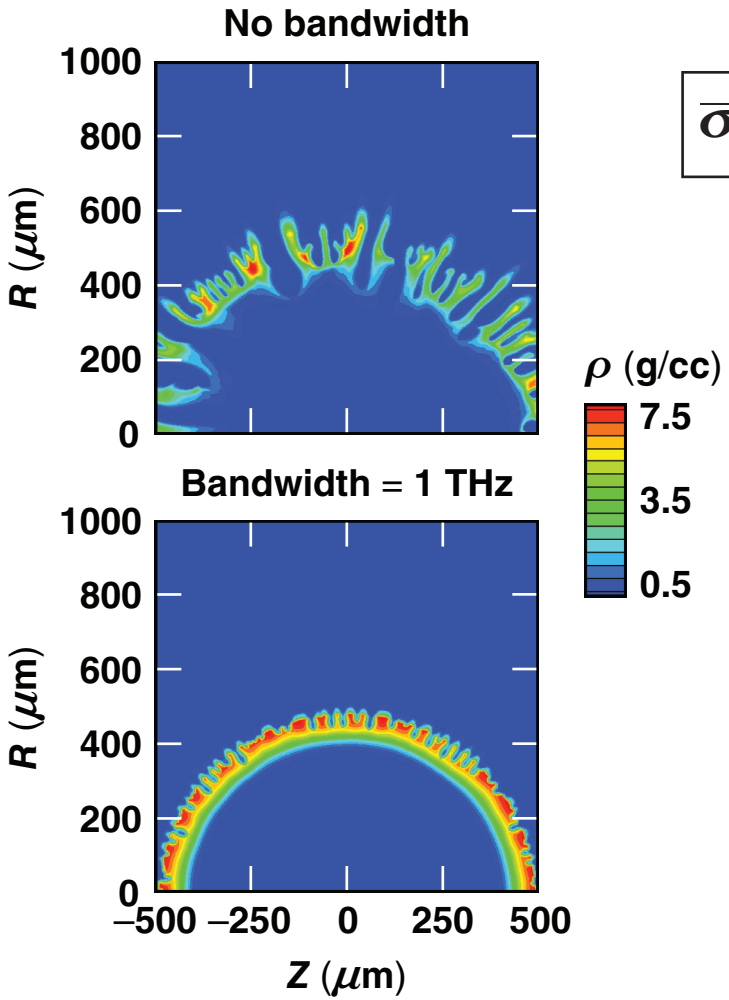
- Current adiabat-shaping techniques cannot sufficiently smooth the laser-imprint nonuniformities initially present on the NIF.
- OMEGA EP experiments with a NIF PAM will examine the effects of beam-smoothing techniques on a NIF-like beam.
- OMEGA implosions will focus on determining the most efficient adiabat-shaping technique and testing our understanding of SSD in cryogenic and warm-foam target implosions.

Collaborators

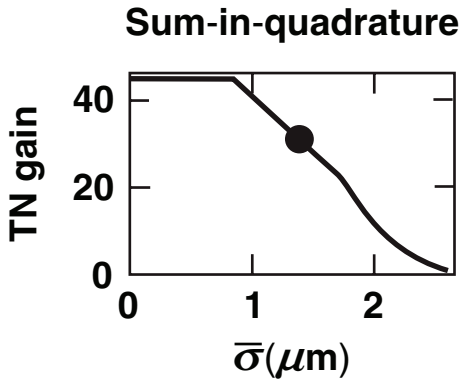
UR LLE

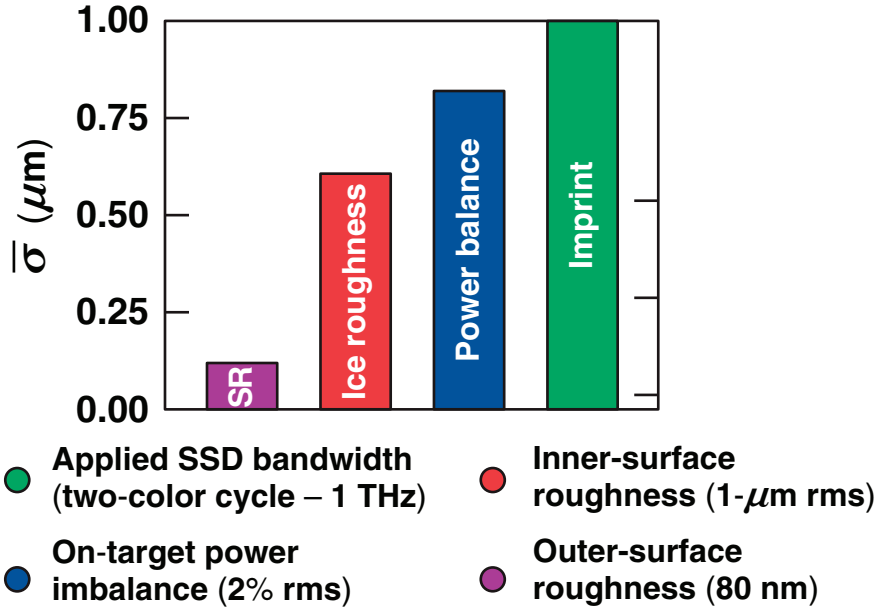
K. Anderson, R. Betti, T. J. B. Collins, V. N. Goncharov, J. P. Knauer, J. A. Marozas, R. L. McCrory, P. B. Radha, S. Skupsky, and J. D. Zuegel

The need for laser-beam smoothing (SSD, ISI…) has been established for some time



$$\overline{\sigma}^2 = 0.06\,\sigma_{1-9}^2 + \sigma_{\geq 10}^2$$

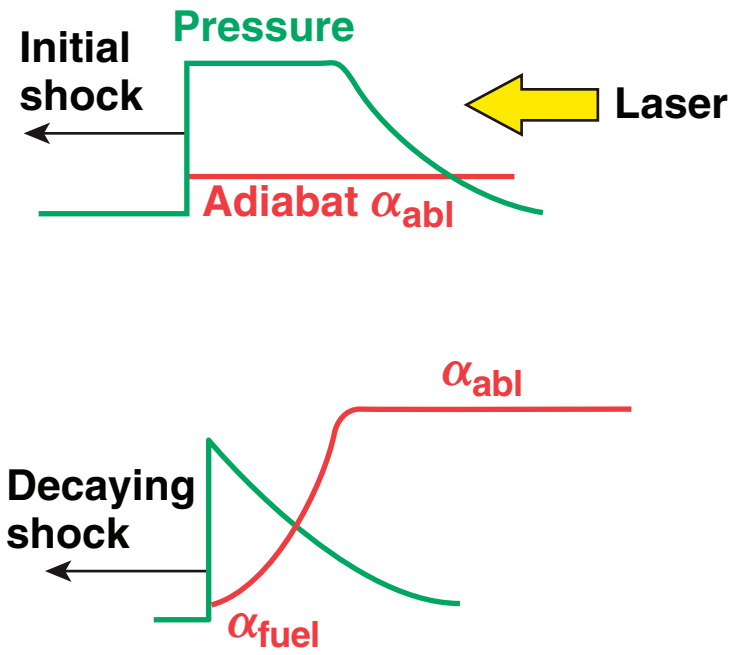


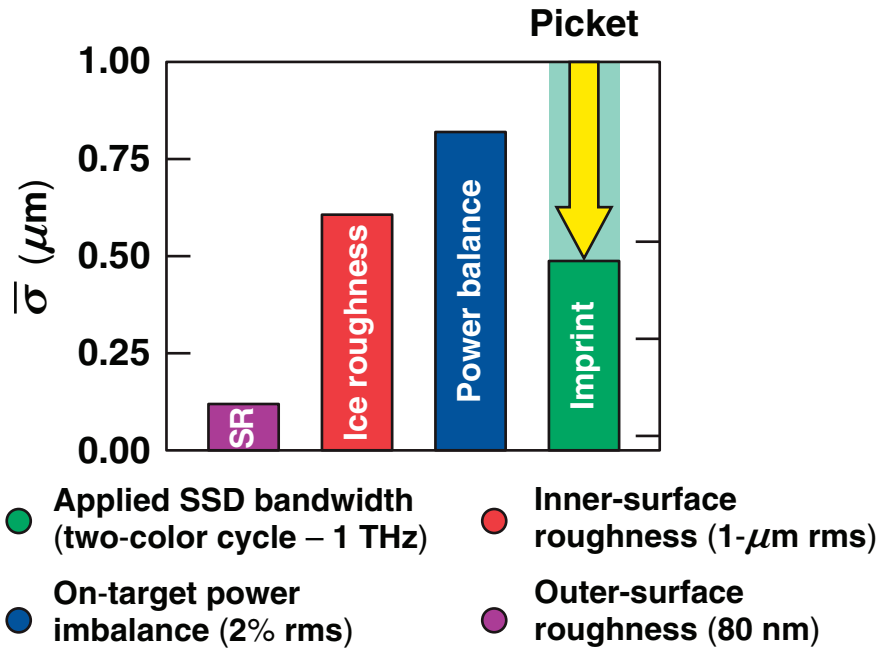


TC7607

P. W. McKenty *et al.*, Phys. Plasmas 8, 2315 (2001).

Adiabat-shaping techniques improve the in-flight stability and increase the overall robustness of the direct-drive point design





V. N. Goncharov *et al.*, Phys. Plasmas 10, 1906 (2003).

Initial beam-smoothing parameters for the NIF are substantially different than those required for DD

UR LLE

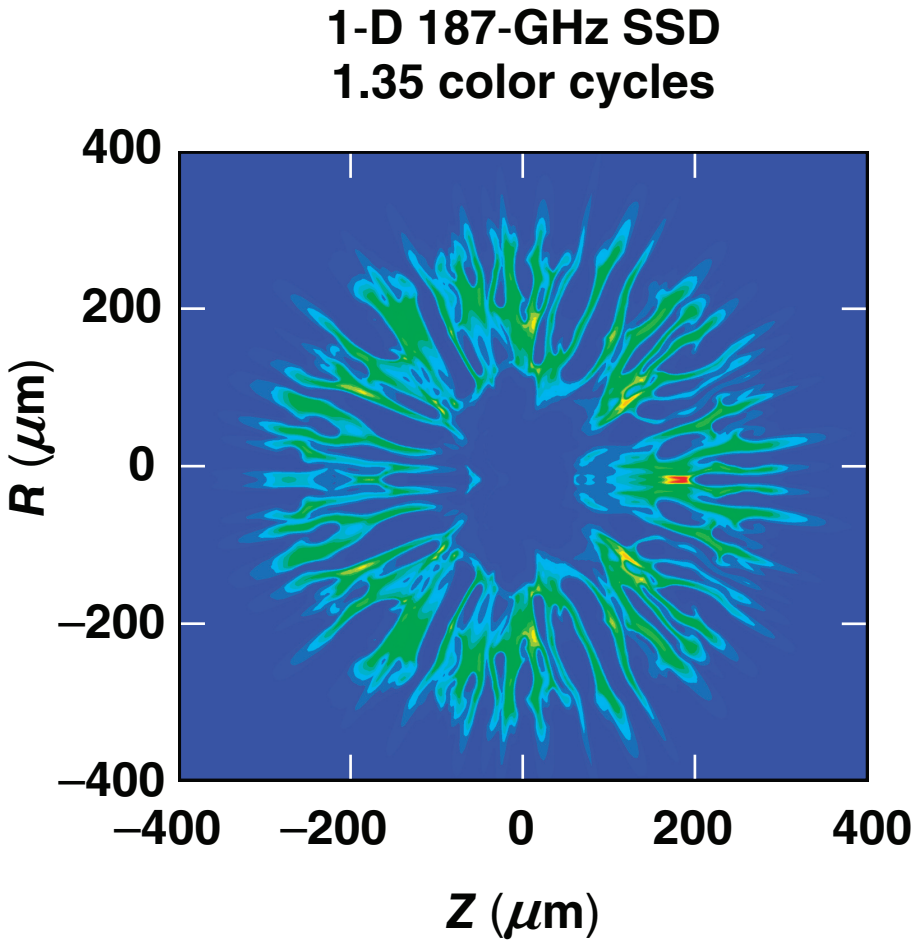
Direct-Drive Requirements	Initial NIF Specifications
2-D SSD	1-D SSD
Modulation frequencies (*X*) 15.4 GHz – (*Y*) 2.45 GHz	Modulation frequency 17.0 GHz
IR Bandwidth (*X*) 10.8 A – (*Y*) 2.0 A	IR Bandwidth 2.3 A
Angular Divergence (*X*) 100 μrad – (*Y*) 50 μrad	Angular Divergence 50 μrad
Color cycles (*X*) 2 – (*Y*) 1	Color cycles 1.35

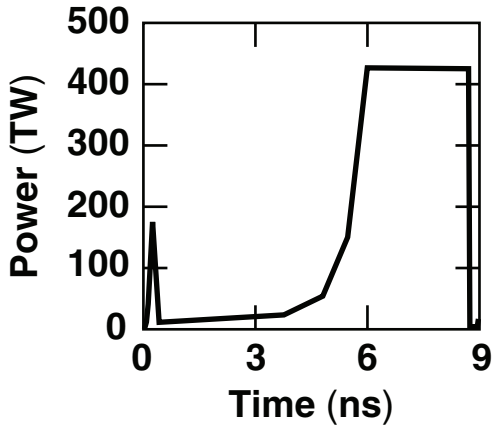
Sustained transport of high levels of bandwidth may lead to unacceptable damage to the laser system.

TC7609

Current adiabat-shaping techniques cannot overcome the initial levels of beam smoothing available on the NIF

UR LLE





SSD (dim)	BW (THz)	CC	Gain
2	1	2 × 1	42
2	1	1 × 1	23
1	1	1	4
1	0.187	1.35	0

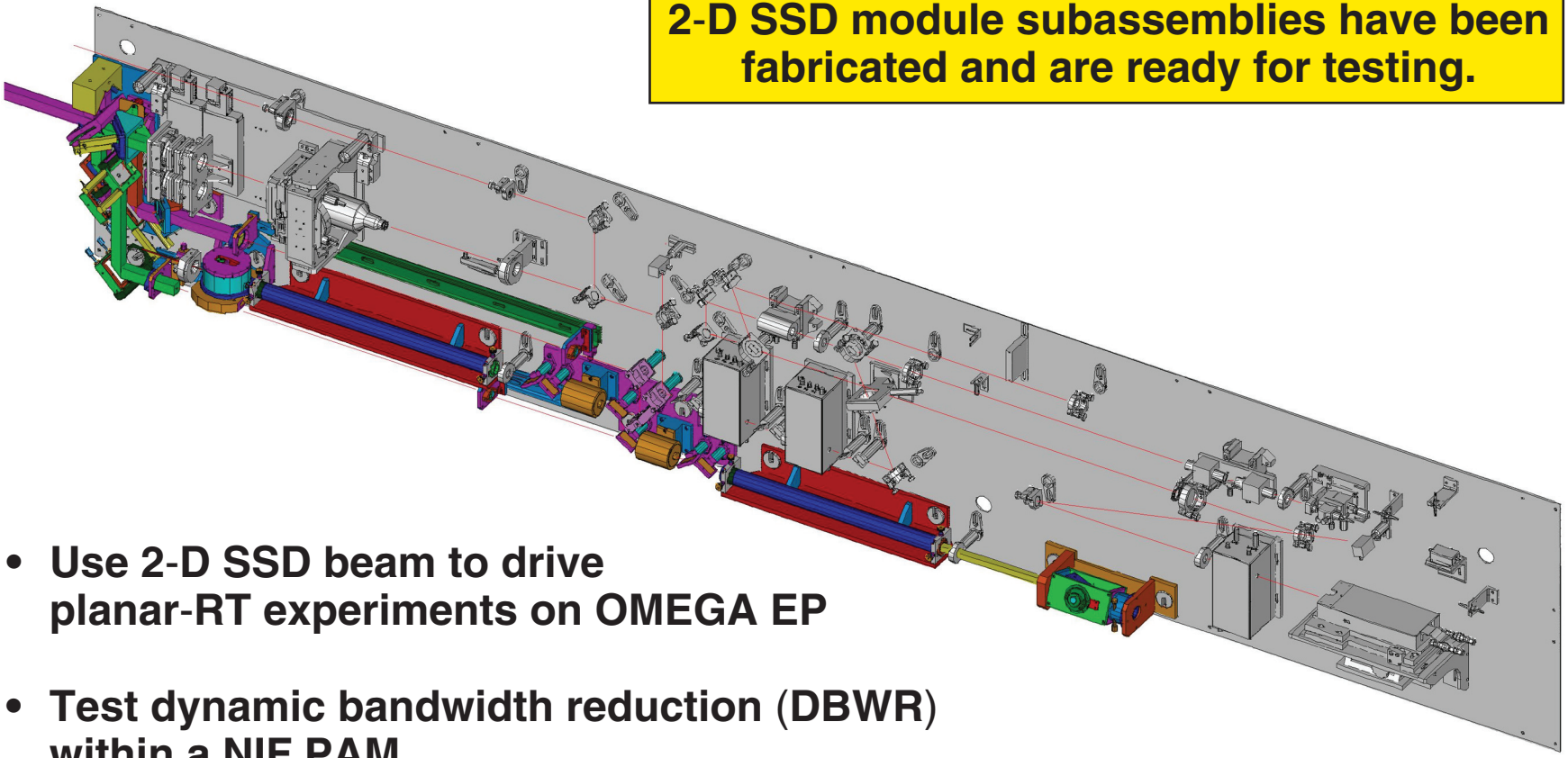
Minimum level of smoothing appears to be 2-D 1-THz SSD with 1 × 1 color cycles

TC7610

OMEGA EP will implement 2-D SSD into a NIF PAM to test levels of laser-amplitude modulation

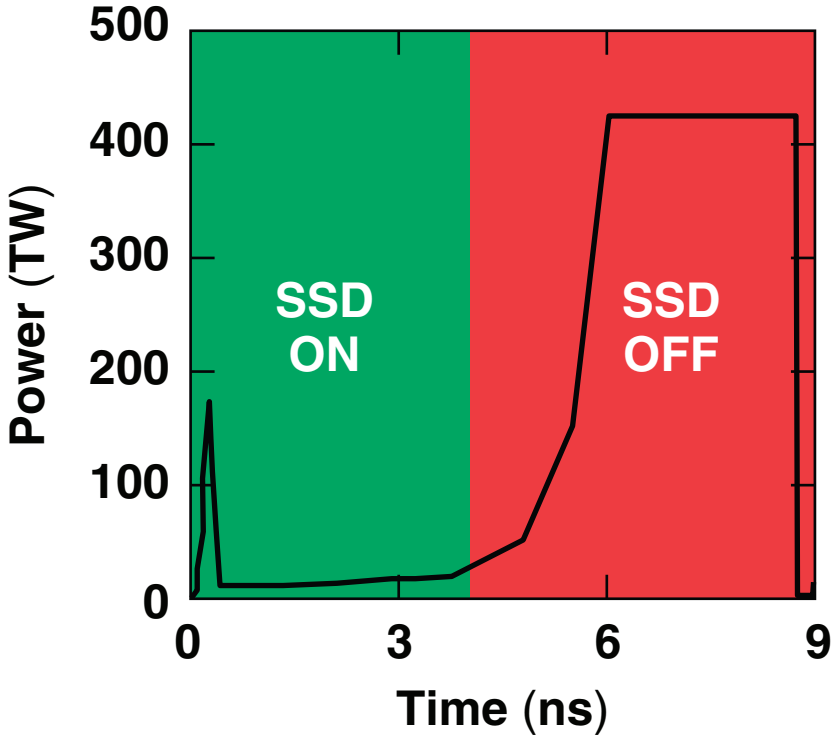
UR LLE

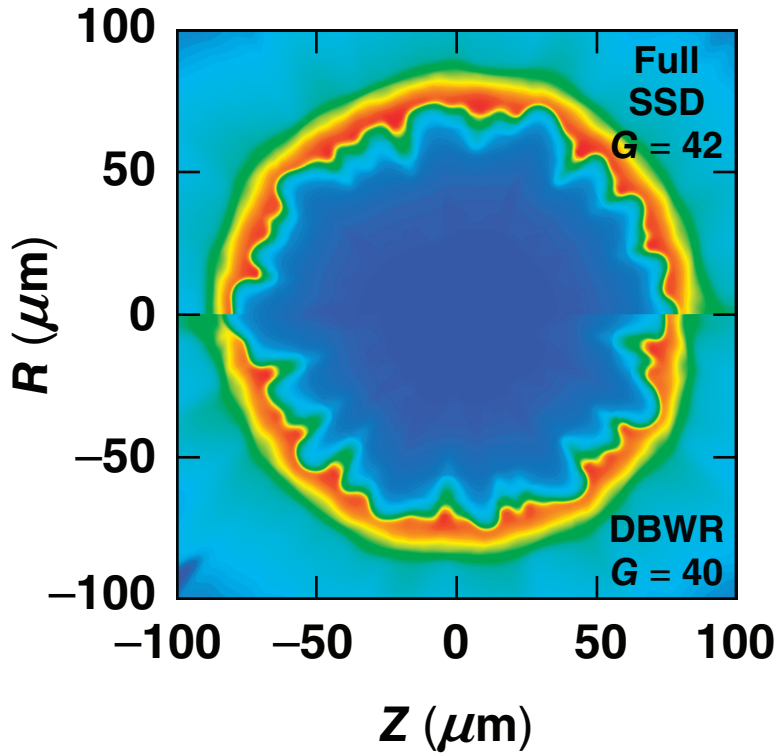
2-D SSD module subassemblies have been fabricated and are ready for testing.



- **Use 2-D SSD beam to drive planar-RT experiments on OMEGA EP**
- **Test dynamic bandwidth reduction (DBWR) within a NIF PAM**
- **Test the propagation of various bandwidth/color-cycle pairs**

Dynamic bandwidth reduction (DBWR) can minimize laser damage without seriously affecting target performance



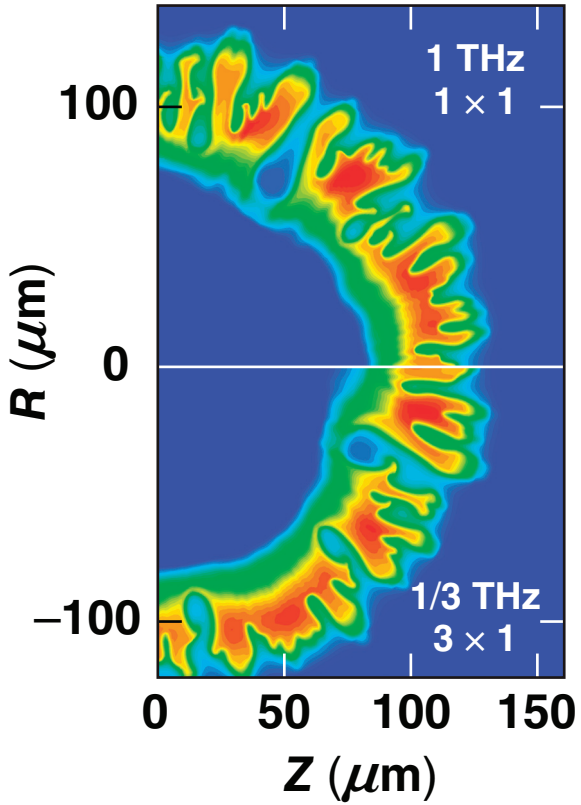


TC7612

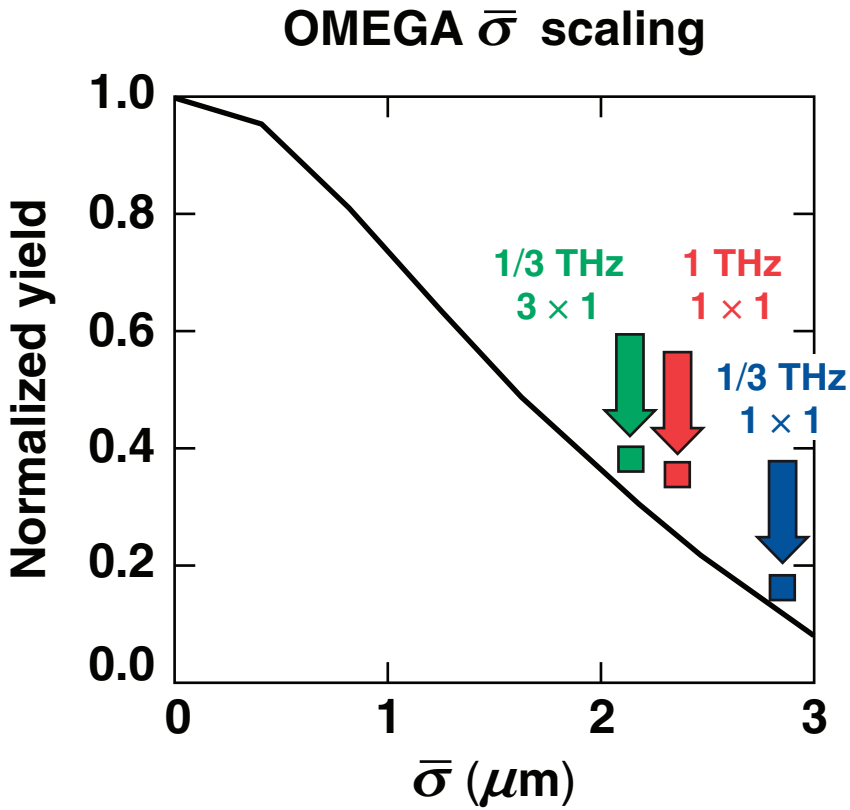
OMEGA will test reduced-bandwidth implosions trading bandwidth for increased color cycles

UR LLE

Imprint simulations
λ = 2 to 200, DPP + PS



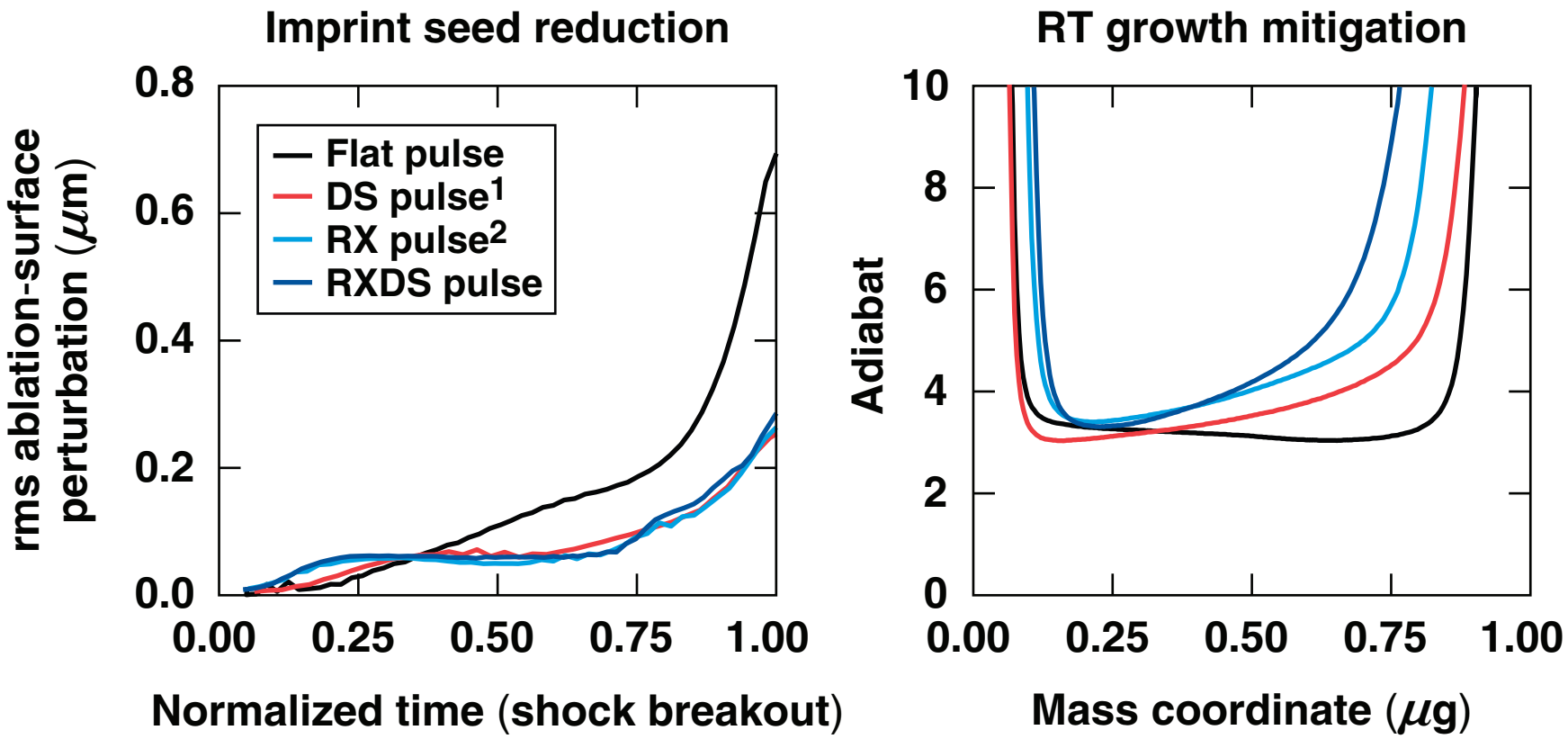
Smoothing time ~ $1/\Delta\theta$
$\Delta\theta\omega = \Delta\lambda N_{cc}$



TC7613

OMEGA cryogenic and warm-foam implosions will examine the advantages of various adiabat-smoothing techniques

UR LLE



see J. Knauer V02.01

[1]V. N. Goncharov *et al.*, Phys. Plasmas 10, 1906 (2003).

[2]K. Anderson *et al.*, Phys. Plasmas 11, 5 (2004).

TC7614

Summary/Conclusions

OMEGA and OMEGA EP experiments will determine effective techniques for reducing SSD bandwidth while maintaining adequate laser-beam smoothing

UR LLE

- Current adiabat-shaping techniques cannot sufficiently smooth the laser-imprint nonuniformities initially present on the NIF.
- OMEGA EP experiments with a NIF PAM will examine the effects of beam-smoothing techniques on a NIF-like beam.
- OMEGA implosions will focus on determining the most efficient adiabat-shaping technique and testing our understanding of SSD in cryogenic and warm-foam target implosions.