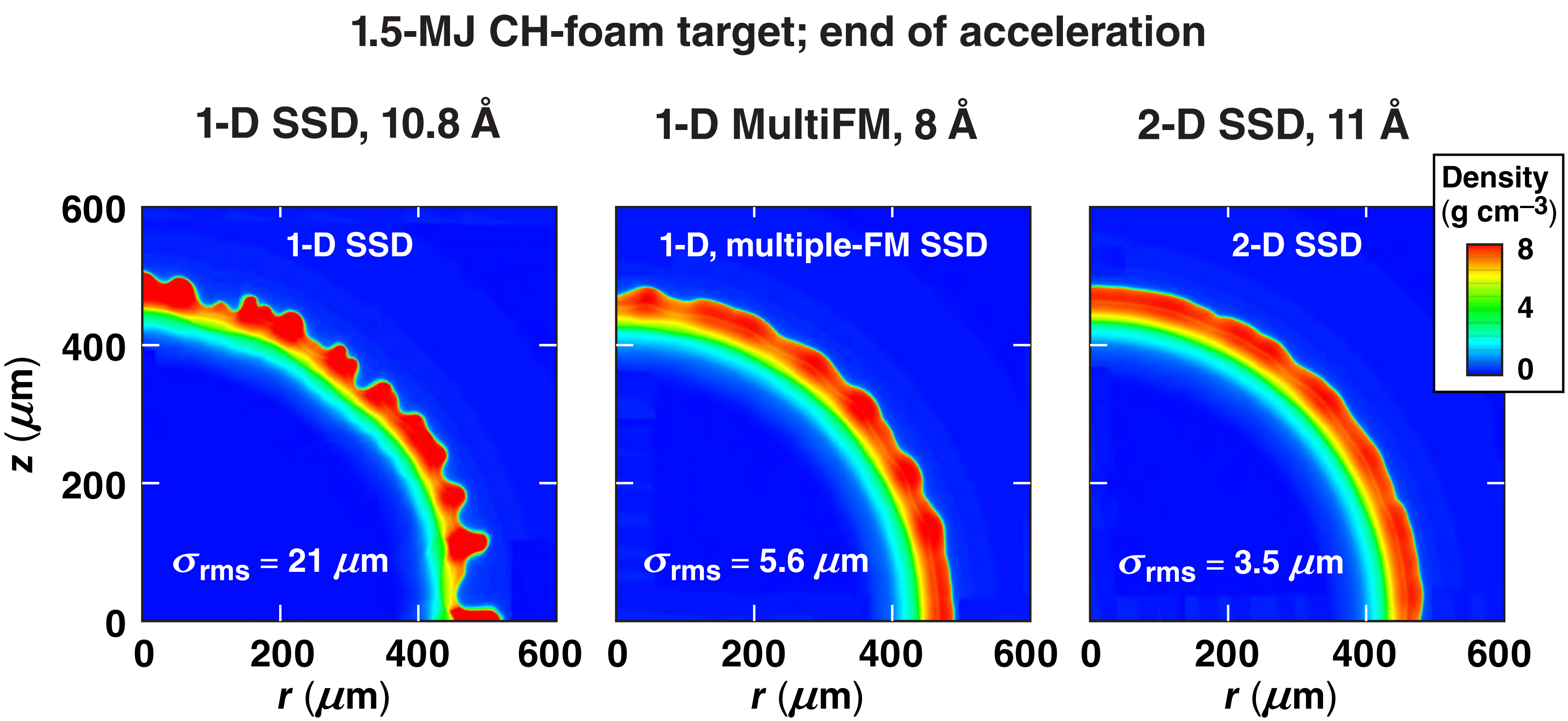
An Alternative Laser-Speckle-Smoothing Scheme for the NIF



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49th Annual Meeting of the
American Physical Society
Division of Plasma Physics
Orlando, FL
12–16 November 2007

Summary

Multiple FM modulators in 1-D reduces imprint to 2-D SSD levels

UR LLE

- Multiple FM modulators in 1-D (1-D MultiFM SSD*)
  - reduced complexity, i.e., no second dimension
  - applied in a fiber within a rack-mounted unit, so layout impact is minimal because bulk optics are not needed
  - takes advantage of multiple color cycles without the disadvantage of coherence maxima in the spectrum
  - simulations show that imprint levels are comparable to 2-D SSD in direct drive and should apply to polar direct drive

TC7998

*J. E. Rothenberg, J. Opt. Soc. Am. B 14, 1664 (1997).

Collaborators

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Implementing 2-D SSD on the NIF will be expensive and technically challenging

UR LLE

- 2-D SSD is required for igniting 1-MJ and 1.5-MJ direct-drive designs*
- This result assumed single FM modulators
- Bulk optics modulators are required for the second SSD dimension
  - space constraints in the NIF PAM's
- 1 THz (12 Å) of 2-D SSD requires dual-frequency triplers
- Simulations show that imprint from multiple FM SSD modulators in 1-D is comparable to 2-D SSD
- Less bandwidth is used; 650 GHz (8 Å)
- Potentially can get to 0.5 THz (6 Å) with a single-frequency-conversion crystal using multiple FM modulators in 1-D

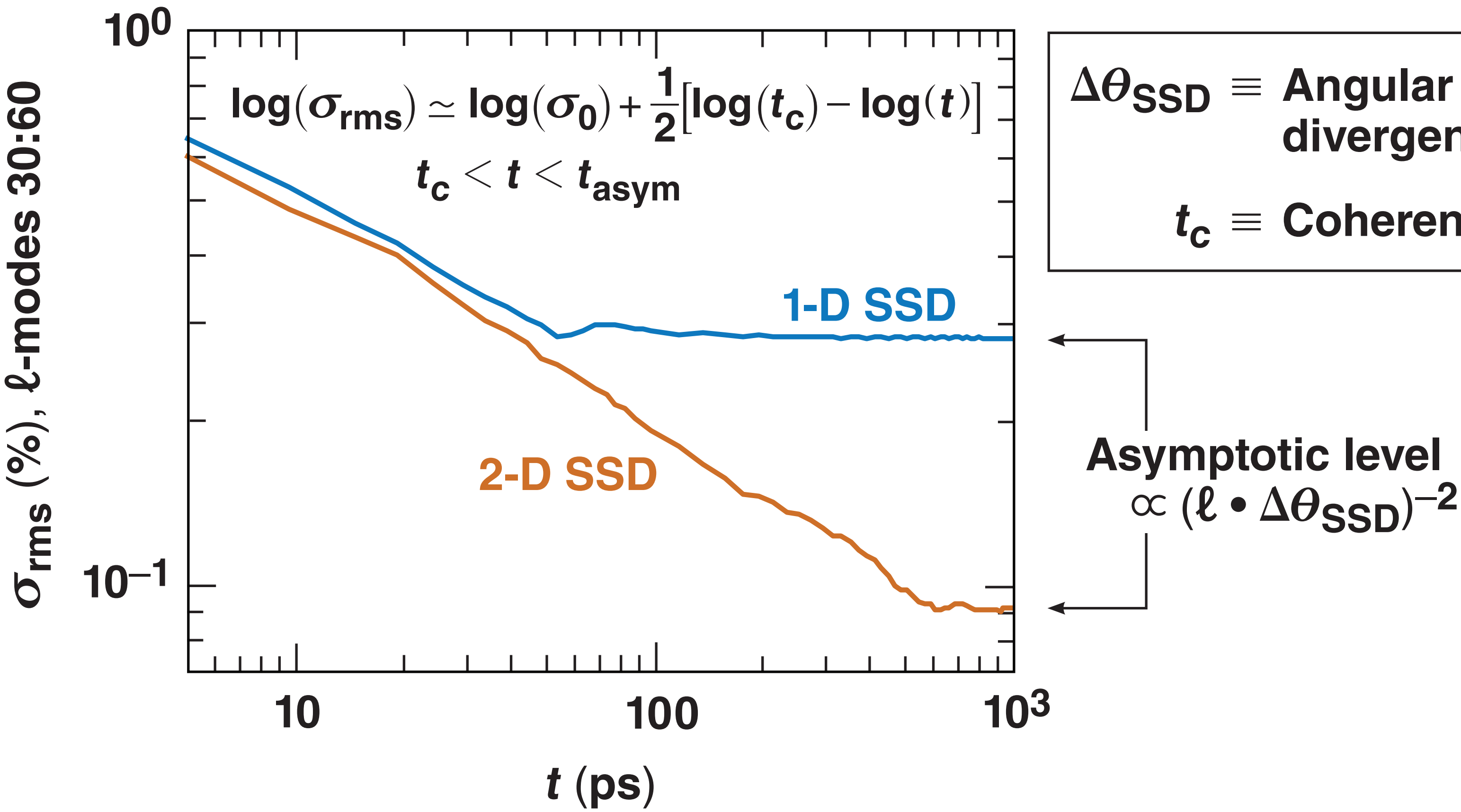
Testable on OMEGA EP

*T. J. B. Collins, Phys. Plasmas 14, 056308 (2007).

TC8005

Laser-speckle smoothing is characterized by the coherence time and the angular divergence

UR LLE



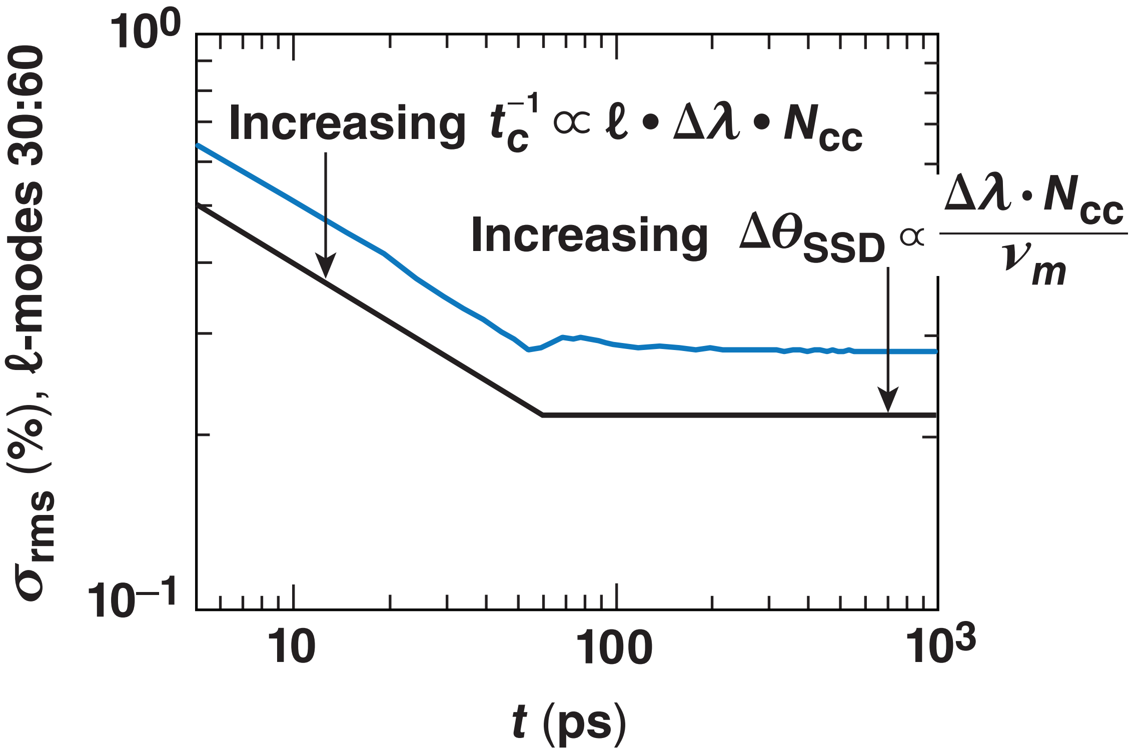
$\Delta\theta_{SSD} \equiv$ Angular divergence

$t_c \equiv$ Coherence time

- Both the coherence time and asymptotic level are functions of ℓ-mode

TC7999

SSD smoothing can be improved by increasing the divergence and/or the inverse coherence time



1-D SSD

$\Delta\lambda$ ≡ Bandwidth

N_{cc} ≡ Color cycles

ν_m ≡ Modulator frequency

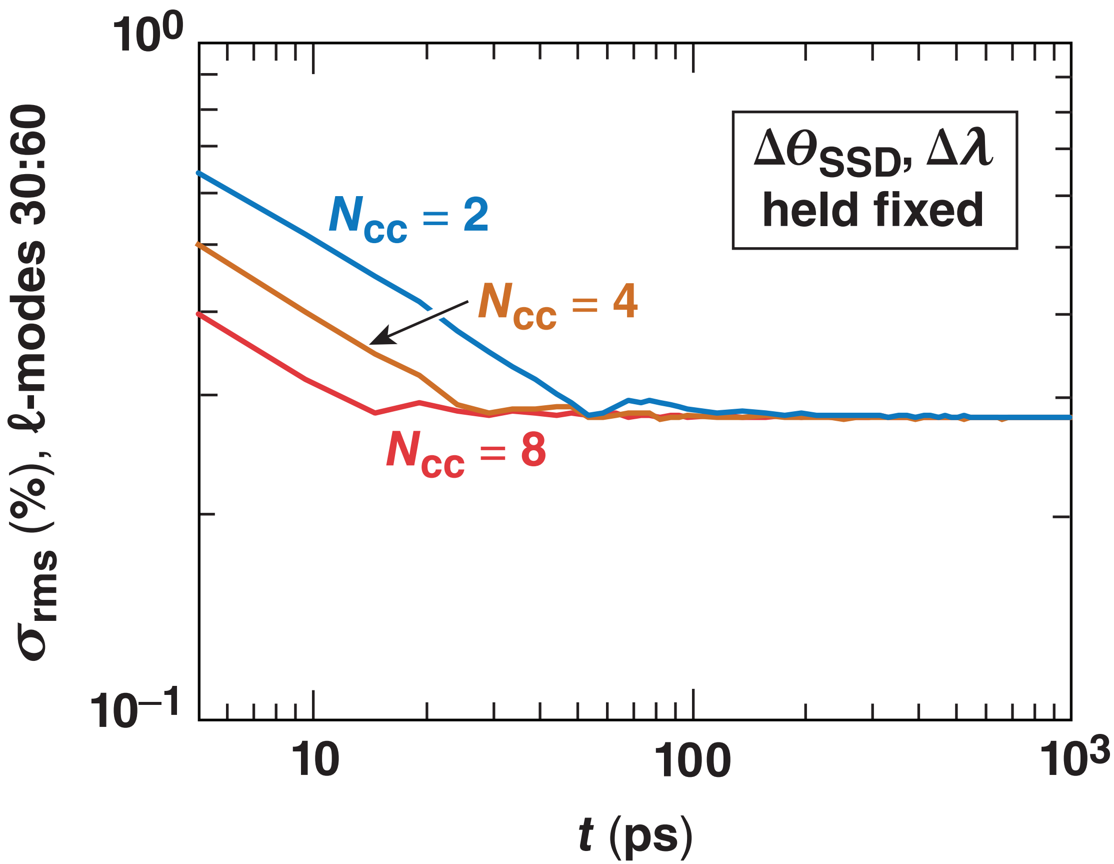
- Increasing divergence
  - allowing divergence to be closer to the existing pinhole $\Delta\theta_{SSD}$ = 100 μrad, $\Delta\theta_{pinhole}$ = 300 μrad
  - dynamic bandwidth reduction* can make this possible without risk of pinhole closure
- Increasing the inverse coherence time
- Increasing N_{cc} and/or $\Delta\lambda$ does both

*P. W. McKenty *et al.*, Bull. Am. Phys. Soc. 51, 295 (2006).

TC8000

Increasing the inverse coherence time, t_c^{-1}, allows the target to experience a smoother spot for a longer period

UR LLE



1-D SSD

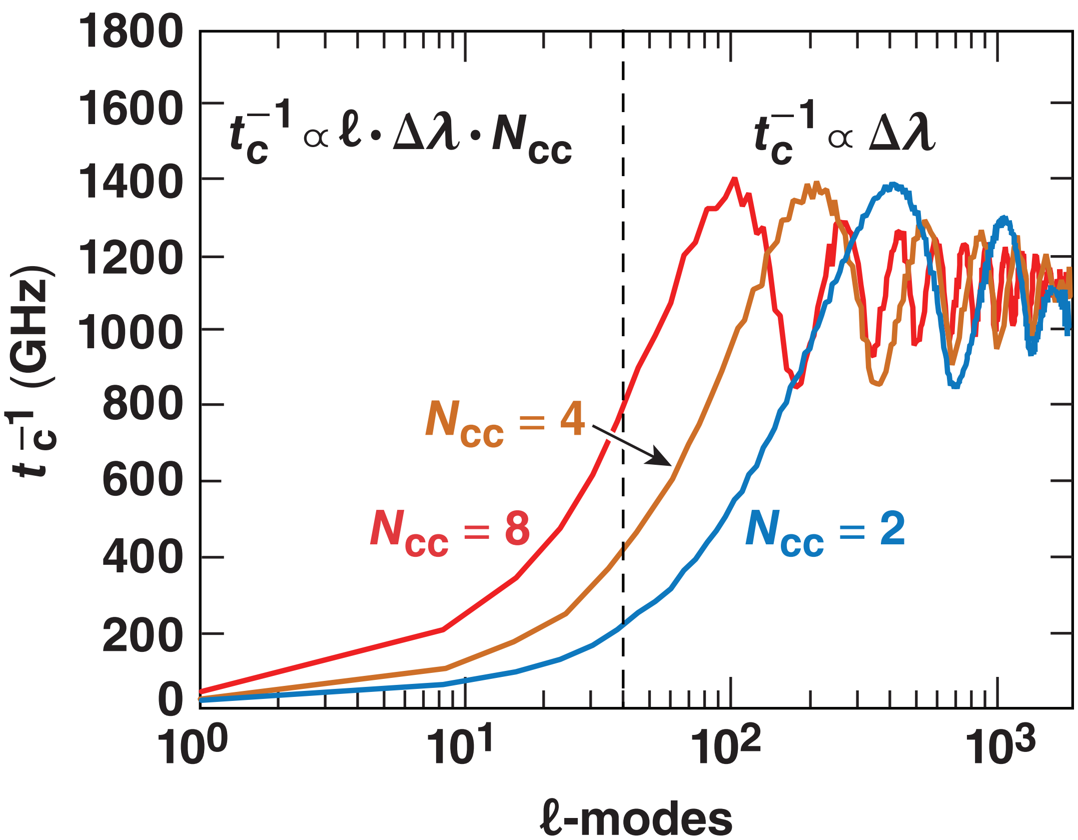
$$t_c^{-1} \propto \ell \bullet \Delta\lambda \bullet N_{cc}$$

$$\Delta\theta_{SSD} \propto \frac{\Delta\lambda \cdot N_{cc}}{\nu_m}$$

- Implies ν_m increases as N_{cc} increases

TC8001

Increasing the color cycles increases t_c^{-1} for the lower ℓ-modes and produces resonances for the higher ℓ-modes

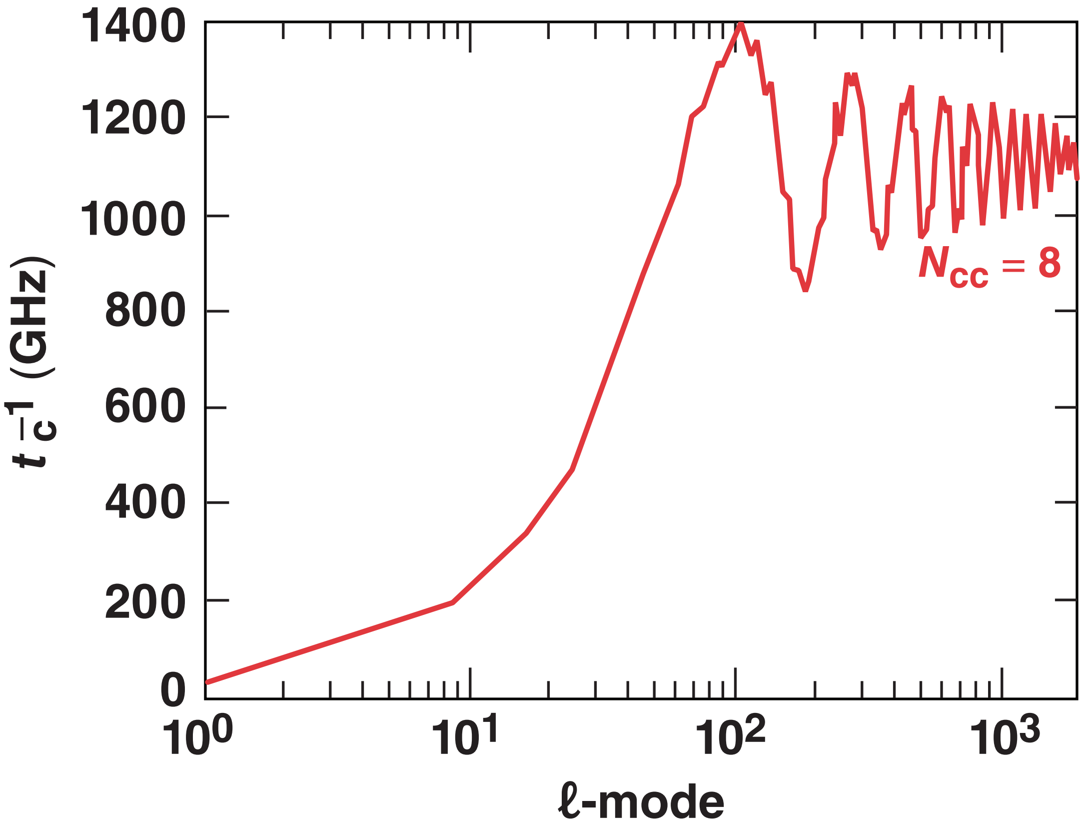


1-D SSD

- Improved smoothing in the lower ℓ-modes occurs at the expense of higher ℓ-mode uniformity

TC8002

Employing multiple FM modulators in 1-D reduces the peak-to-peak variations in the inverse coherence time



1-D SSD, N_{cc} = 8

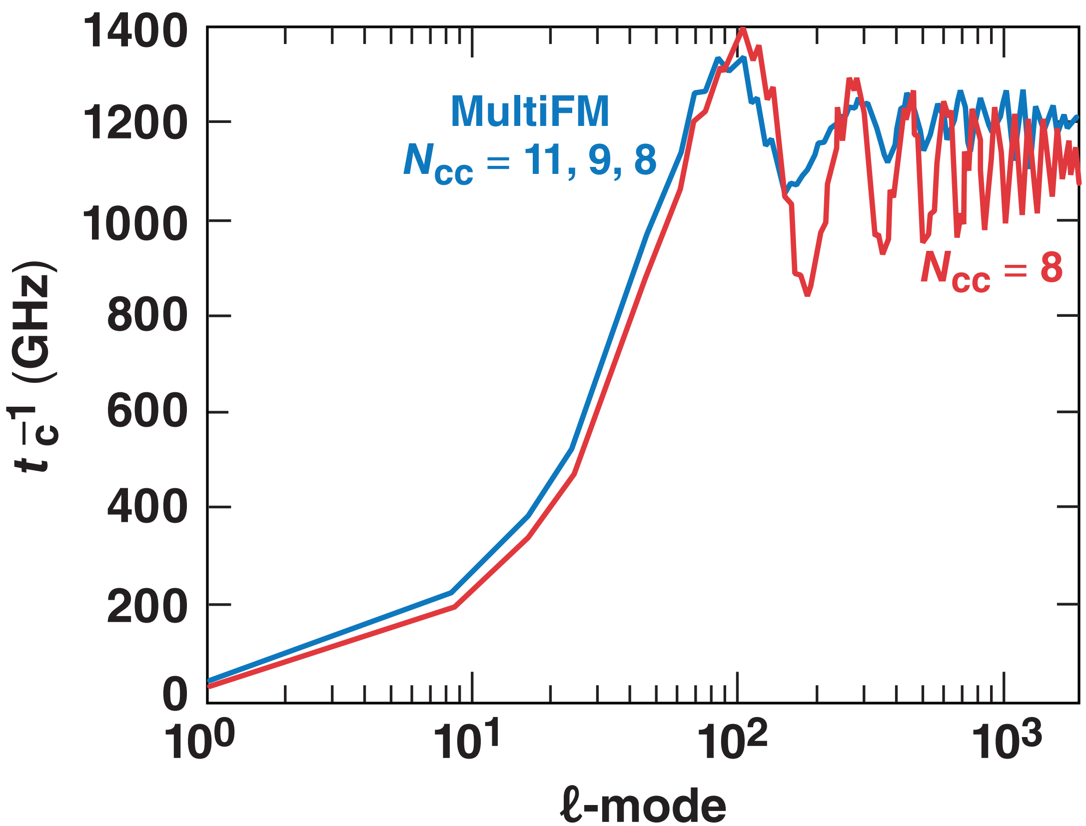
$\Delta\theta_{SSD}$ fixed

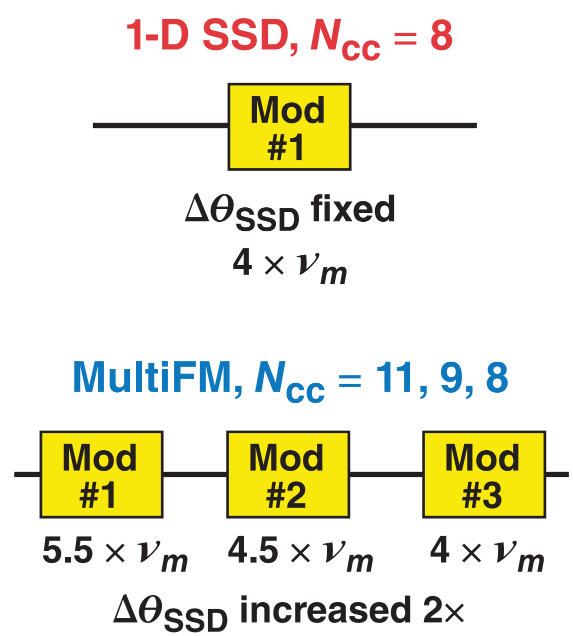
$4 \times \nu_m$

$$\Delta\theta_{SSD} \propto \frac{\Delta\lambda \cdot N_{cc}}{\nu_m}$$

TC8003

Employing multiple FM modulators in 1-D reduces the peak-to-peak variations in the inverse coherence time

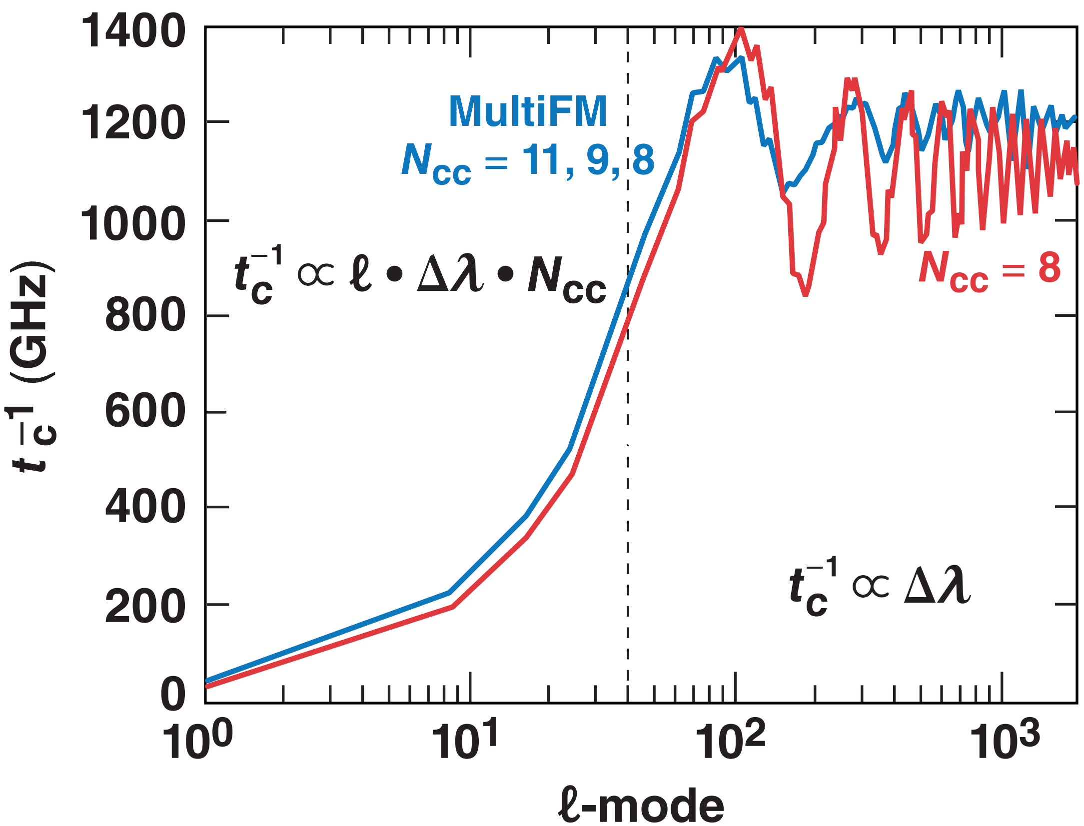


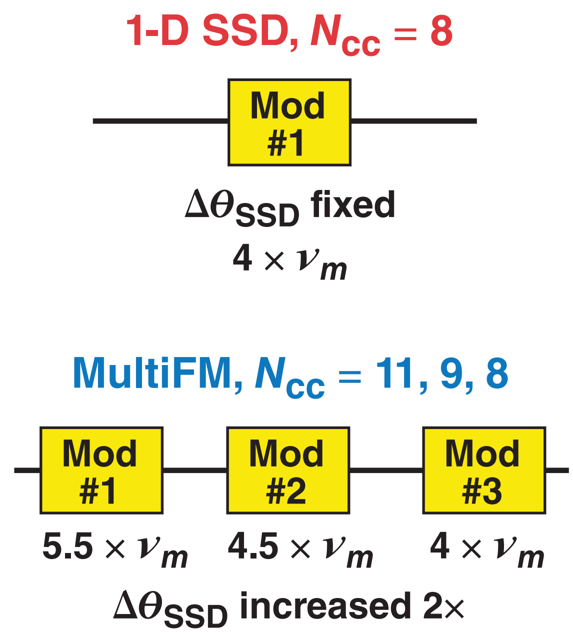


$$\Delta\theta_{SSD} \propto \frac{\Delta\lambda \cdot N_{cc}}{\nu_m}$$

- t_c^{-1} decreased by 4×, and $\Delta\theta_{SSD}$ increased by 2× relative to 1-D SSD

Employing multiple FM modulators in 1-D reduces the peak-to-peak variations in the inverse coherence time





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TC8003

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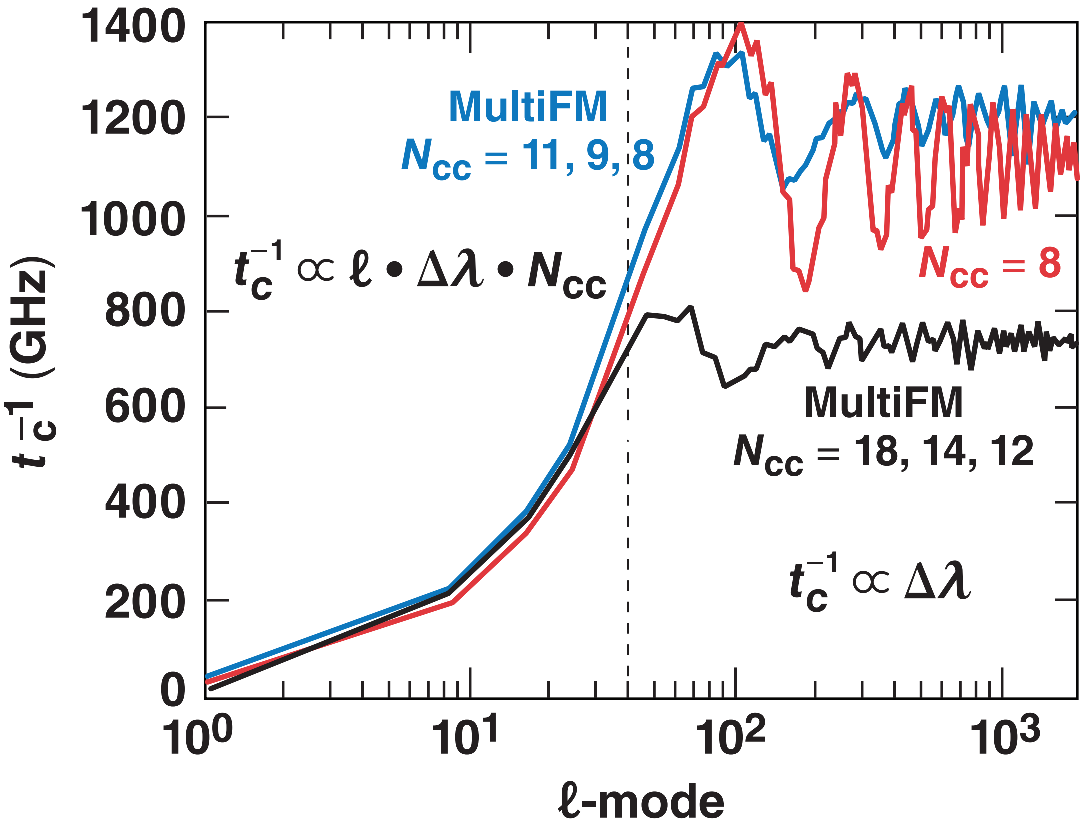
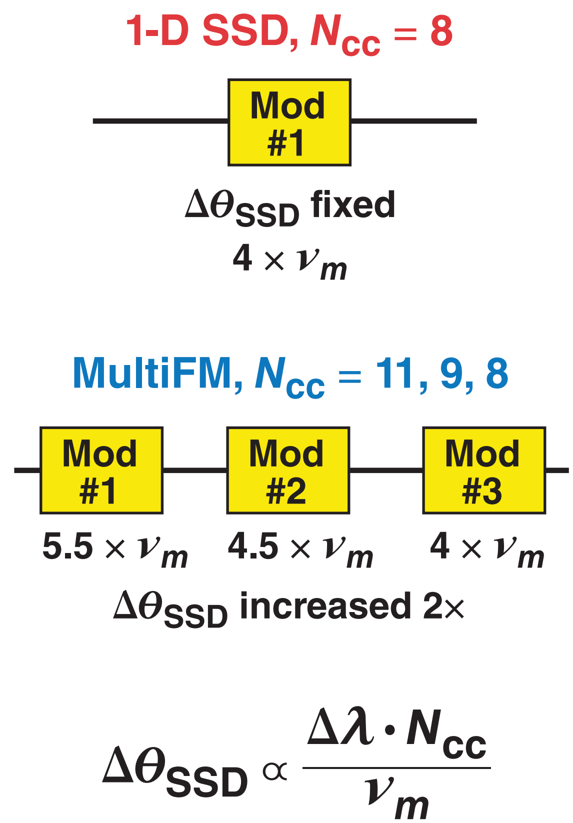
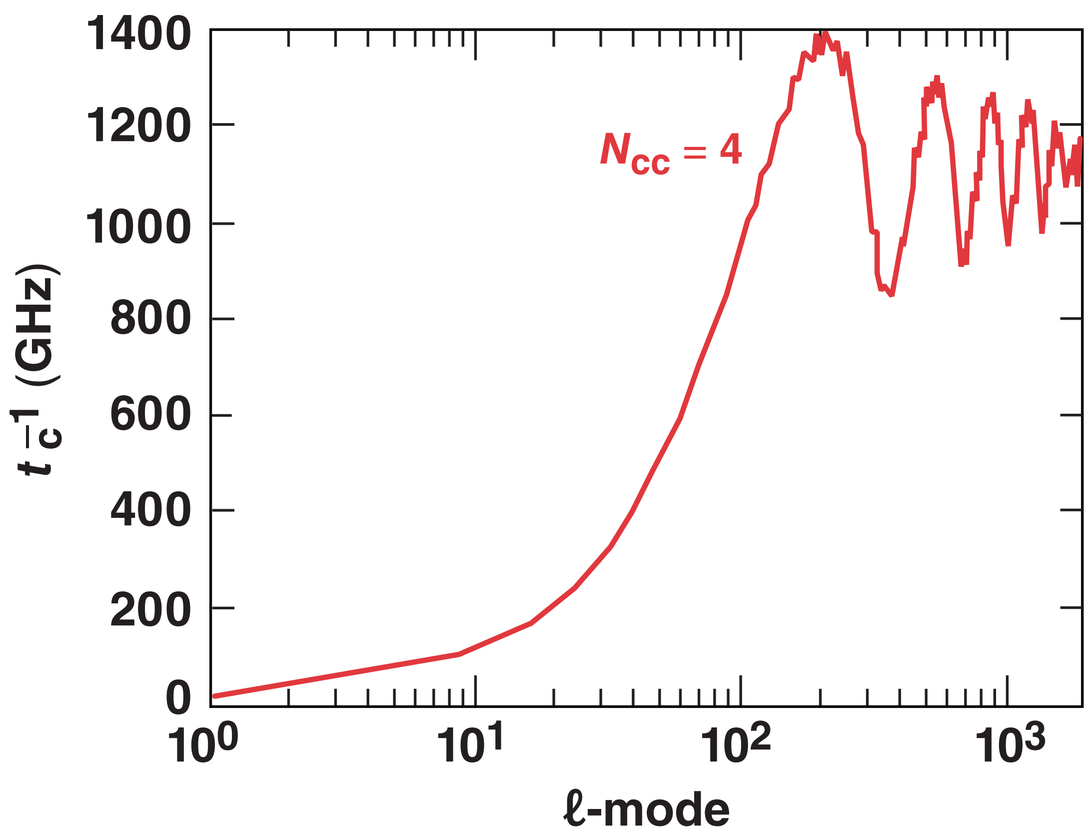




- t_c^{-1} decreased by 4×, and $\Delta\theta_{SSD}$ increased by 2× relative to 1-D SSD
- Lower ℓ-mode performance can be kept constant by keeping the product $\Delta\lambda \bullet N_{cc}$ and $\Delta\theta_{SSD}$ constant
- Targets with low IFAR are more stable to higher ℓ-mode feedthrough

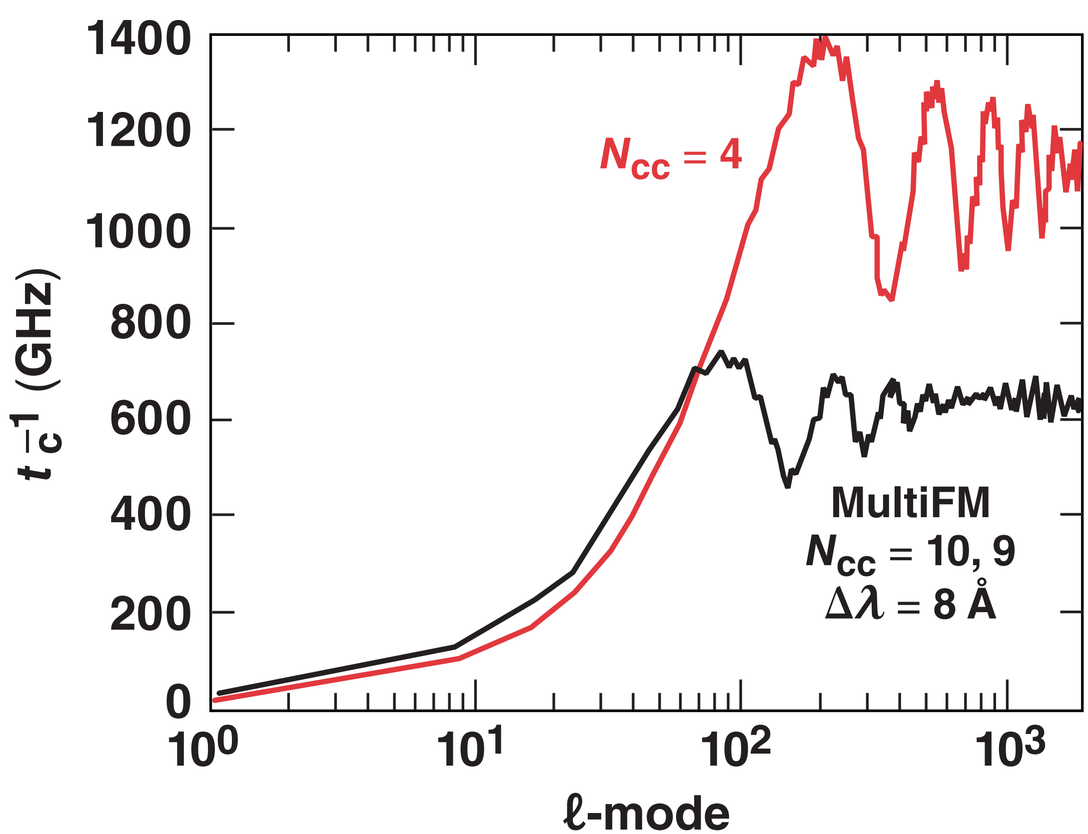
TC8003

Modulator frequencies required to match the 4 color-cycle 1-D SSD are lower



TC8004

Modulator frequencies required to match the 4 color-cycle 1-D SSD are lower

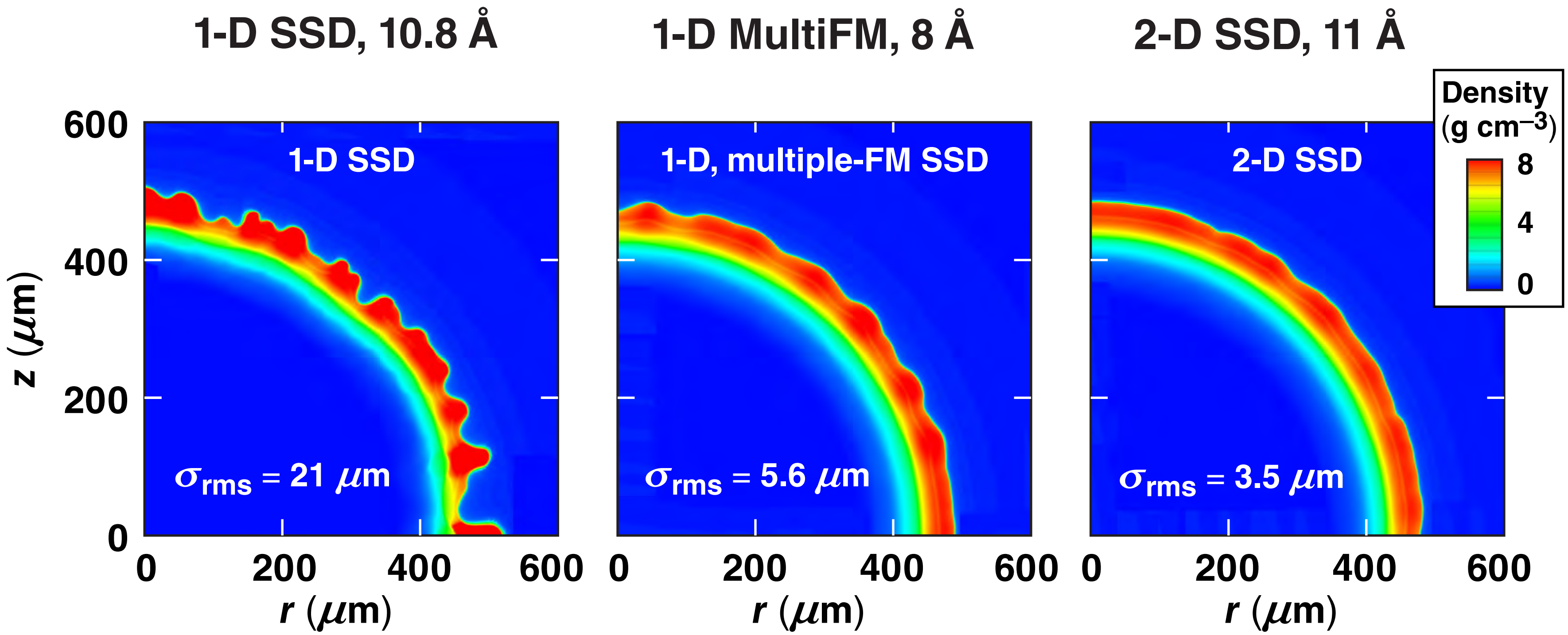


- The bandwidth is reduced to 8 Å (650 GHz), the divergence is reduced to 100 μrad, and the modulator frequencies are reduced to ~50 GHz.

TC8004

Simulations show that multiple FM modulators in 1-D reduces imprint to 2-D SSD levels

1.5-MJ CH-foam target; end of acceleration



- Simulations are in progress to confirm gain

TC7944a

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