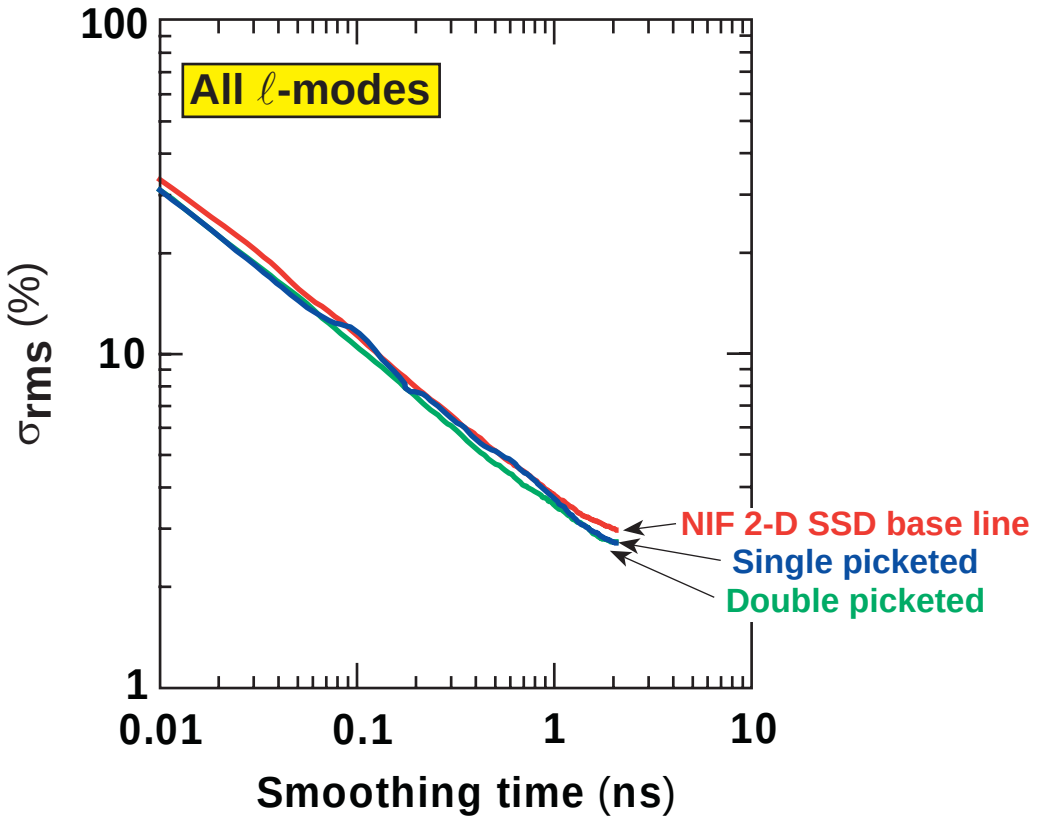
The Smoothing Performance of "Picket-Fence" Schemes on NIF



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The Smoothing Performance of Various Picket-Fence Schemes on NIF

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An ultrafast "picket fence" pulse train (~20 ps) has been proposed for the National Ignition Facility (NIF)[1] to increase both the beam-to-beam power balance and the frequency-conversion efficiency by virtue of a pulse train with high peak power and small duty cycle. The target-plane irradiation nonuniformity is spectrally decomposed and is calculated as a function of time using the beam-smoothing technique SSD (smoothing by spectral dispersion). With a prudent choice of parameters, the uniformity for a picket-fence configuration can be as good as or better than that of a base-line 2-D SSD beam with a similar bandwidth and laser divergence. The picket-fence bandwidth can be tailored to increase the effective bandwidth, reduce pinhole loading, and improve asymptotic uniformity. This work was supported by the U.S. Department of Energy Office of Inertial Confinement Fusion under Cooperative Agreement No. DE-FC03-92SF19460.

1. J. E. Rothenberg, "Ultrafast 'Picket Fence' Pulse Trains to Enhance Frequency Conversion of Shaped Inertial Confinement Fusion Laser Pulses," to be published in *Proc. of CLEO/Europe-IQEC 2000*, Nice, France, 10–15 Sept 2000.

Summary

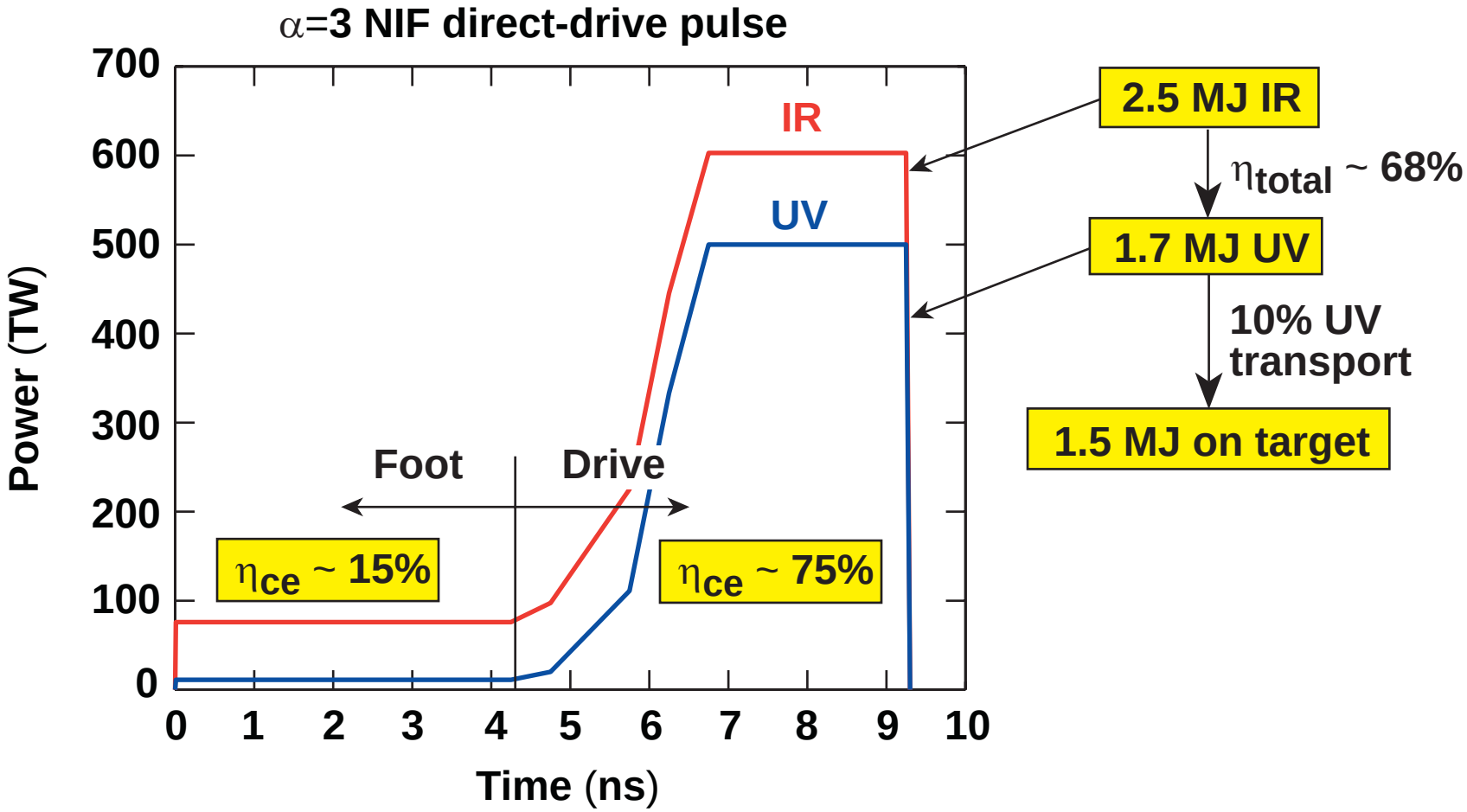
Picket-fence smoothing can meet or exceed the base-line NIF 2-D SSD design

- Smoothing performance depends mainly on total $\Delta\lambda_{SSD}$ and divergence.
- Reduced pinhole loading is possible.

Outline

- **Motivation**
- **Picket-fence characteristics**
- **Advantages**
- **Far-field nonuniformity**

The foot of a NIF direct-drive ICF pulse converts at a low efficiency of 15%



The low IR intensity in the foot degrades the frequency conversion efficiency.

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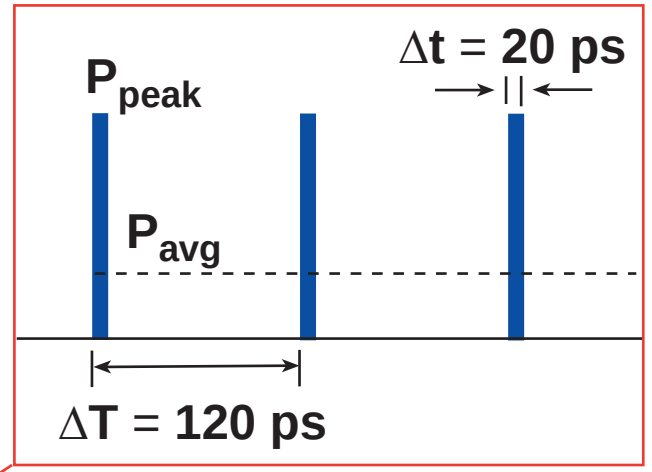
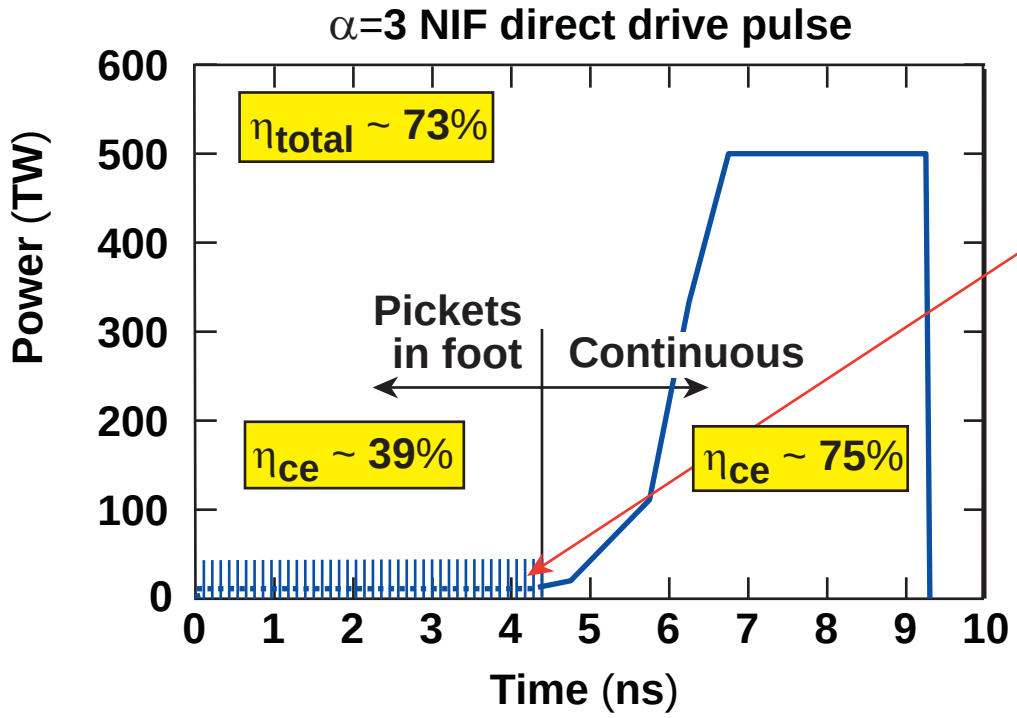
Ultrafast pickets increase the conversion efficiency from 15% to 39% in the foot

- Short pulses increase the peak power in the foot.
- Maintain the desired average power on target.

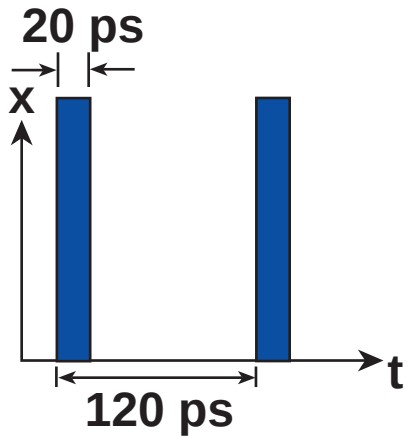


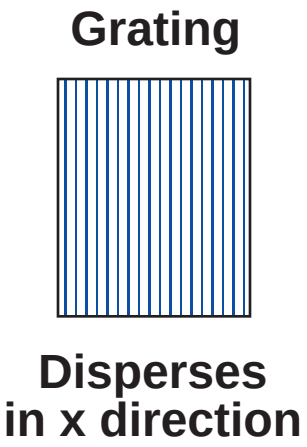


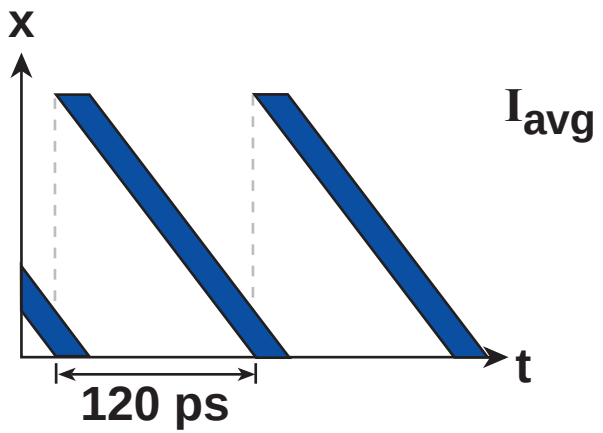
- For NIF indirect-drive pulses the total efficiency can be increased from 50% to 72% by using pickets.

* J. E. Rothenburg, "Ultra-fast 'picket-fence' pulse trains to enhance frequency conversion of shaped inertial confinement fusion laser pulses', CLEO 2000 proceedings

The target is continuously illuminated by using a grating that spatially shears the beam

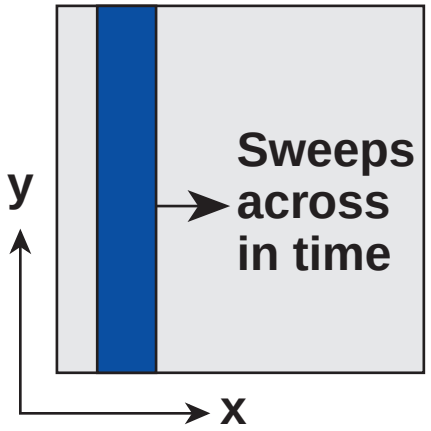






- The picketed beam illuminates a small strip of the whole aperture.
- Speckle size increase in the corresponding direction.

Near-field illumination with a single picket



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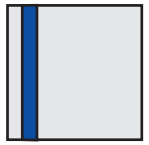
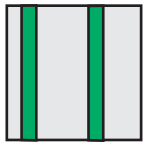
The far-field nonuniformity for a picket-fence scheme must be equivalent to the NIF direct-drive 2-D SSD base-line

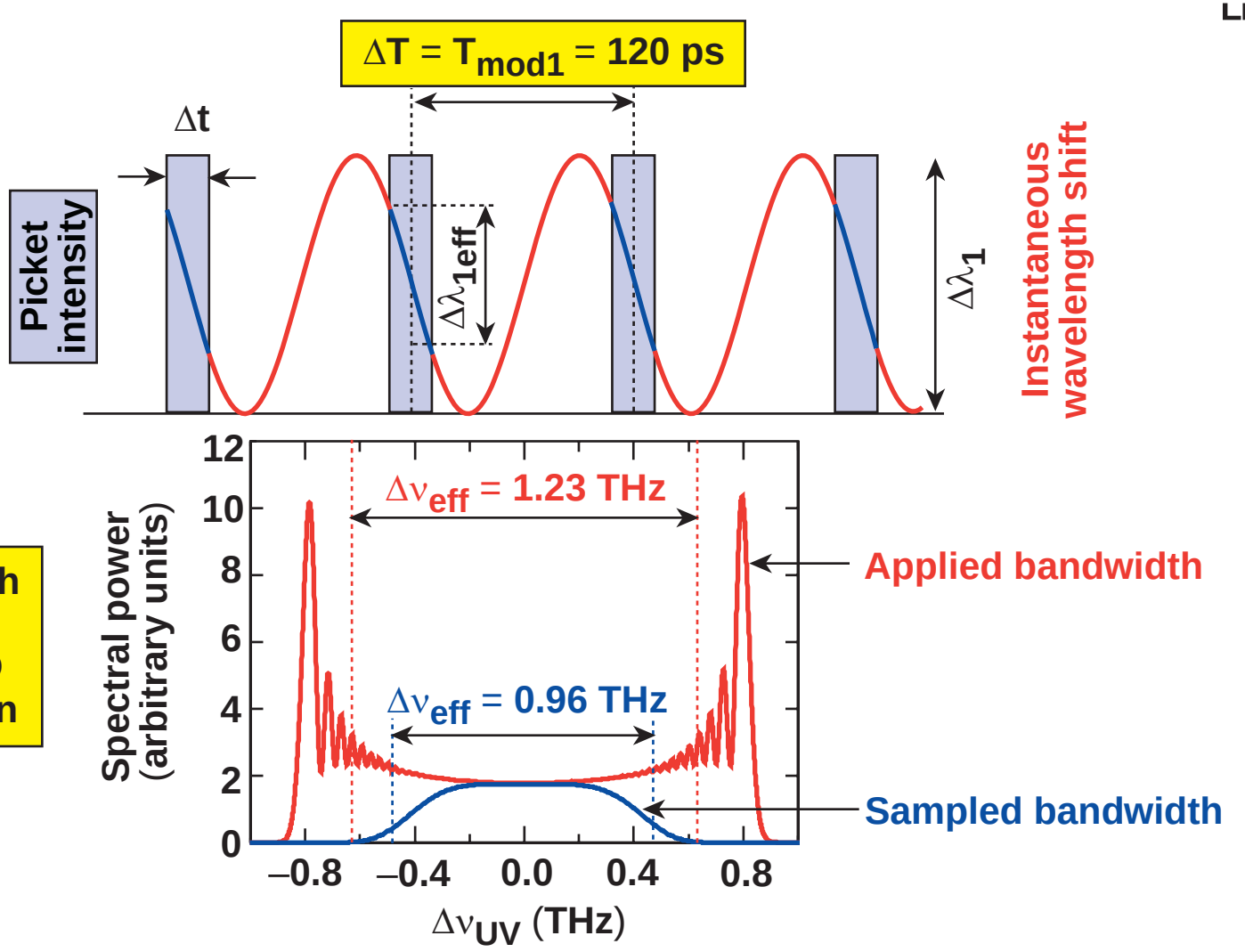
- NIF direct-drive 2-D SSD base line:
  - Bandwidth: 1-THz UV; 10.9 × 1.9-Å IR
  - Divergence: 100 × 50 μrad

  (Results in single-beam nonuniformity: $\sigma_{rms} \leqslant 4\%$ after 1 ns)

- Picket fence:
  - Same 2-D SSD bandwidth and divergence

Scheme	Pulse width (ps)	Pulse period (ps)	Near-field
Single picketed	20	120	
Double picketed	20	60	

Ultrafast pickets "sample" the bandwidth of the first SSD dimension phase modulator



Bandwidth of the first SSD dimension

The sampled spectrum is uniformly distributed about the center.

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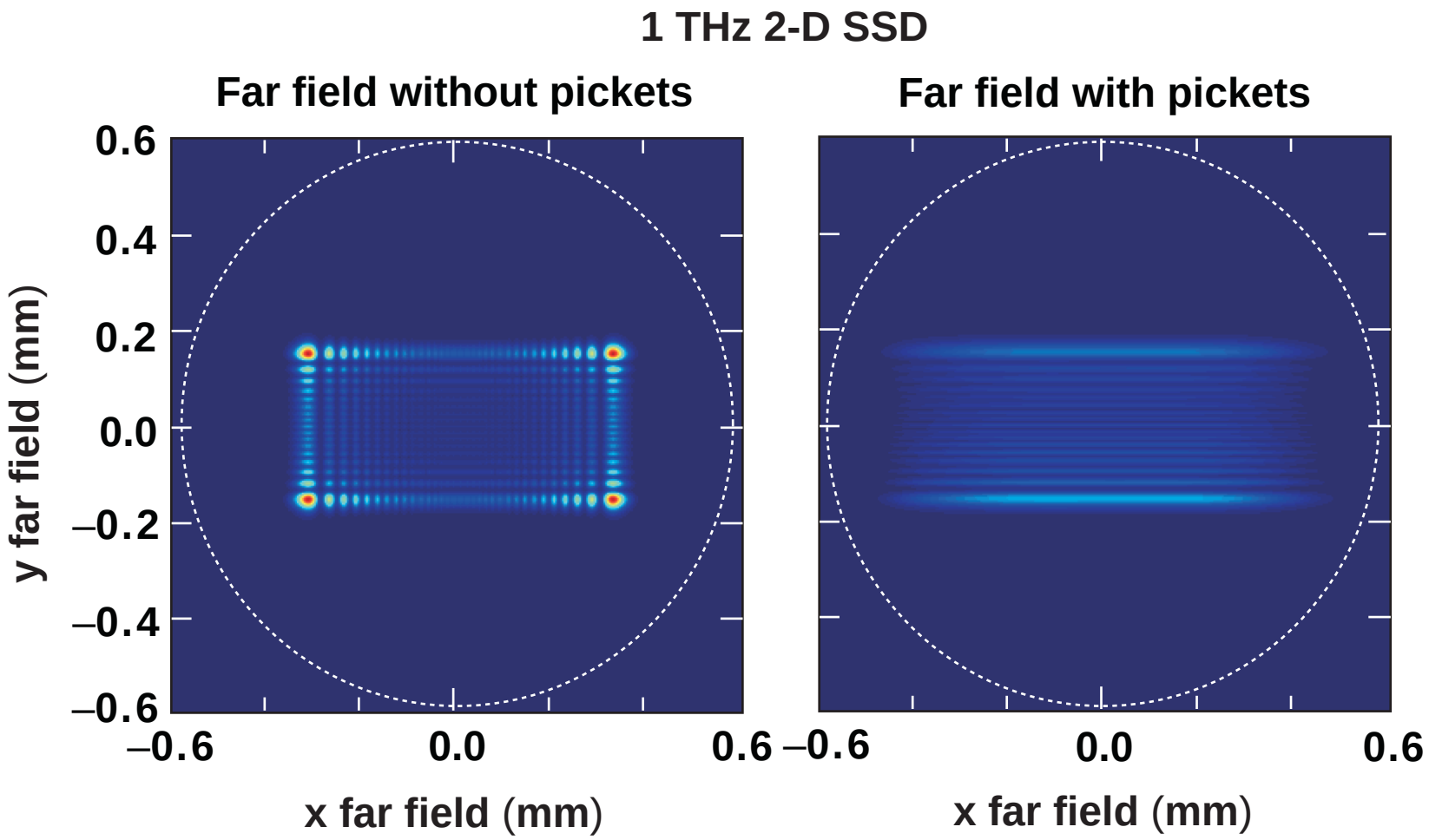
The time-integrated intensity pattern with pickets shows less energy concentrated near edge of pinhole



- Simulated pinhole outlines for illustration purposes only

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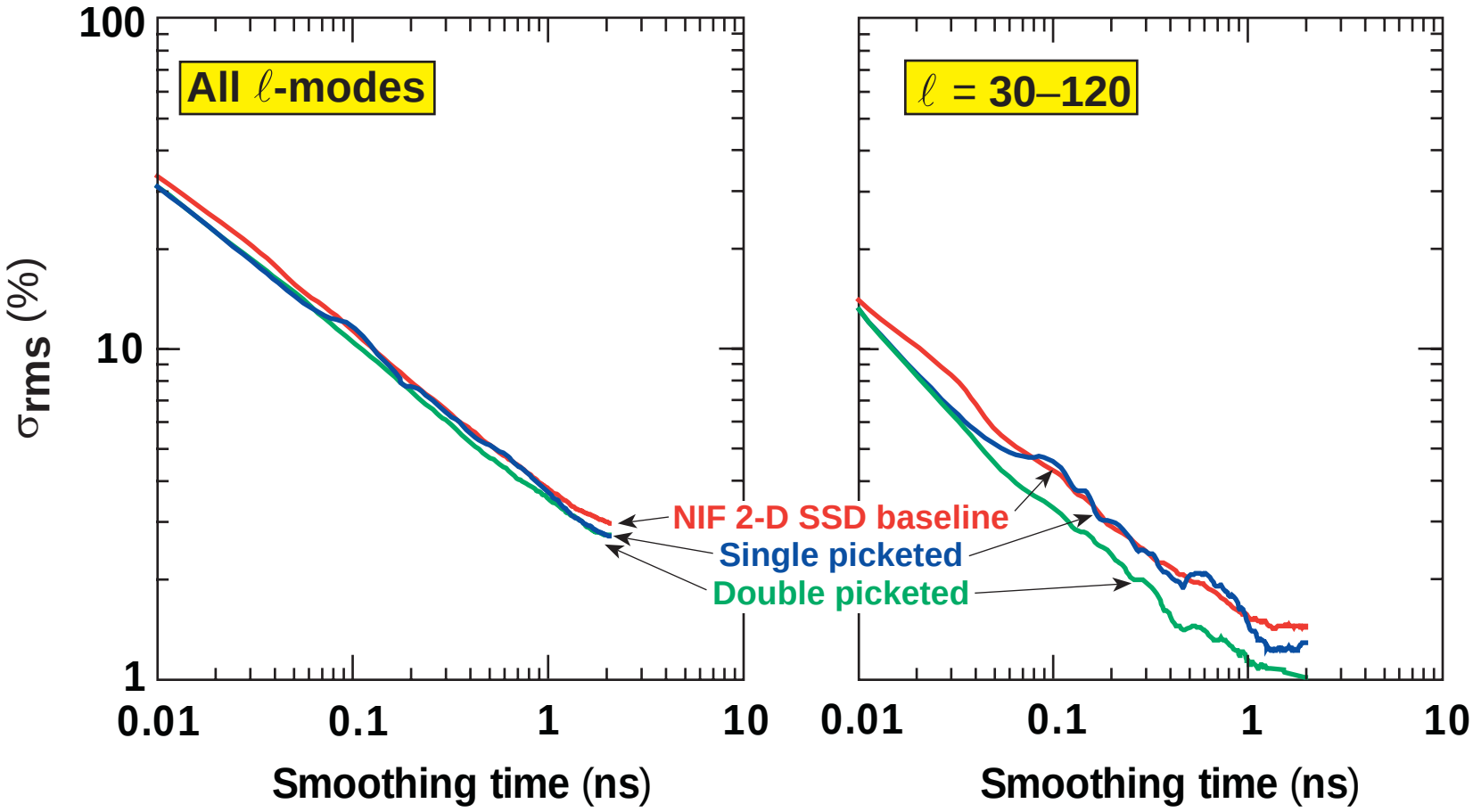
The far-field nonuniformity can meet or exceed the baseline NIF 2-D SSD design

- Both schemes meet requirements.
- Double-picketed beam exceeds the requirement for longer wavelengths.



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Summary/Conclusion

Picket-fence smoothing can meet or exceed the base-line NIF 2-D SSD design

- Smoothing performance depends mainly on total $\Delta\lambda_{SSD}$ and divergence.
- Reduced pinhole loading is possible.