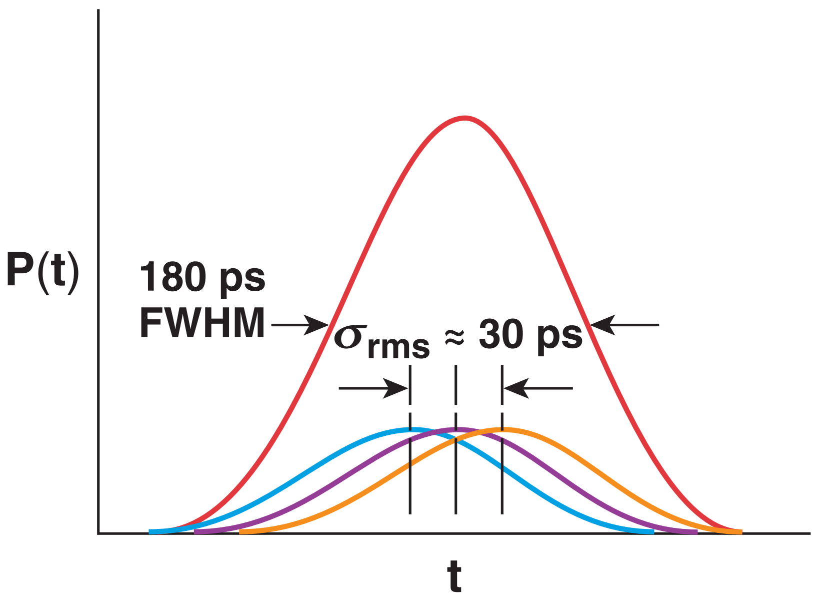
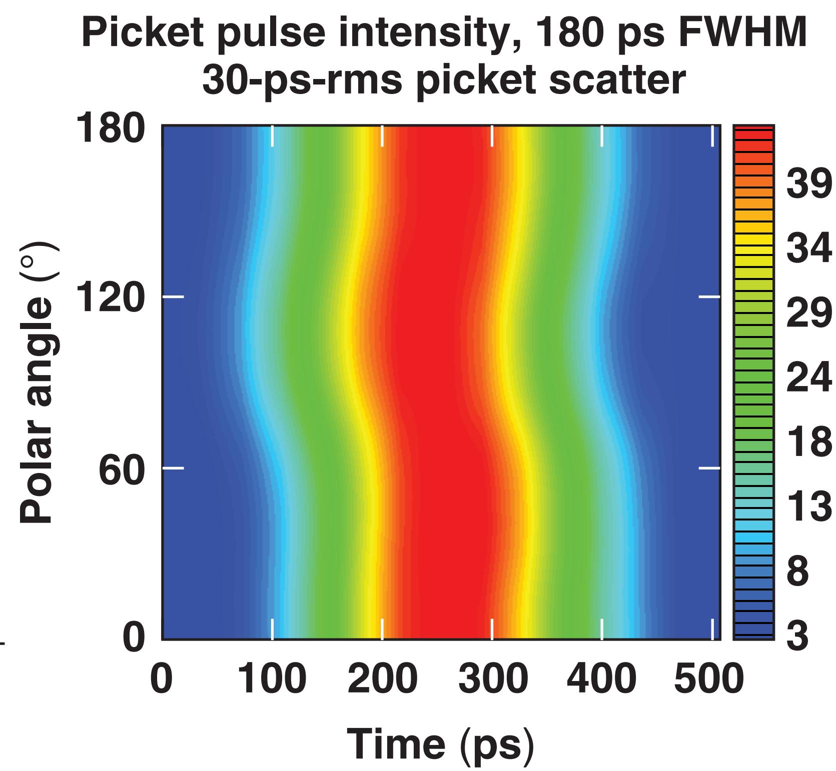
Effects of Perturbed Picket Pulses in Adiabat-Shaped Direct-Drive Implosion Experiments





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Summary

Beam-to-beam picket mistiming within NIF specifications does not compromise performance in adiabat-shaped implosions

- Beam-to-beam picket mistiming appears as nonuniform picket broadening and power imbalance.
- NIF picket mistiming does not affect adiabat shaping within the fuel.
- Power-imbalance-imposed picket mistiming does not contribute significantly to the overall uniformity budget.

Collaborators

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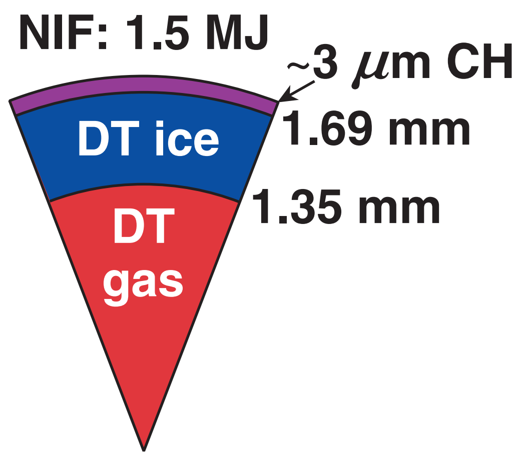
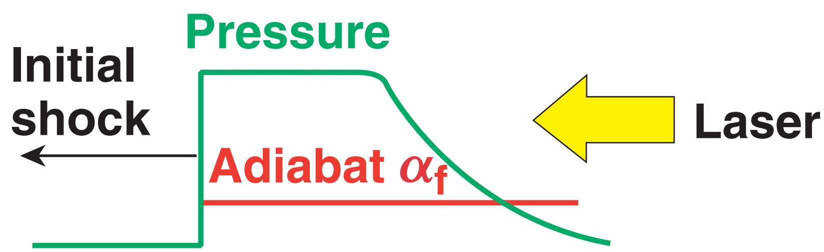
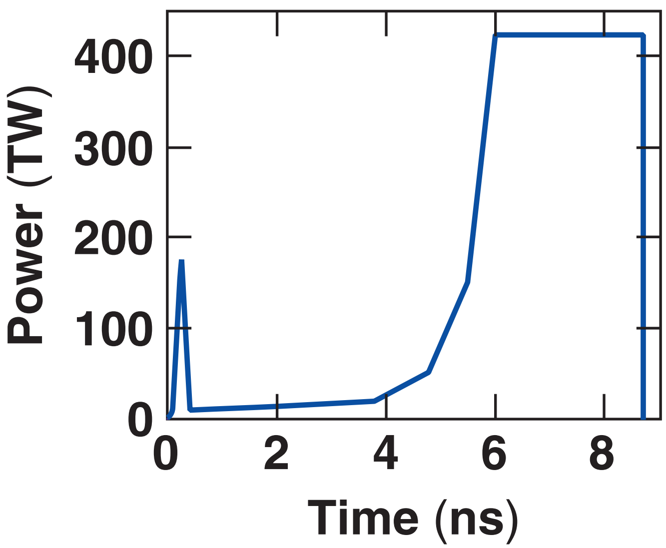
The NIF direct-drive target design employs adiabat shaping* to enhance hydrodynamic stability

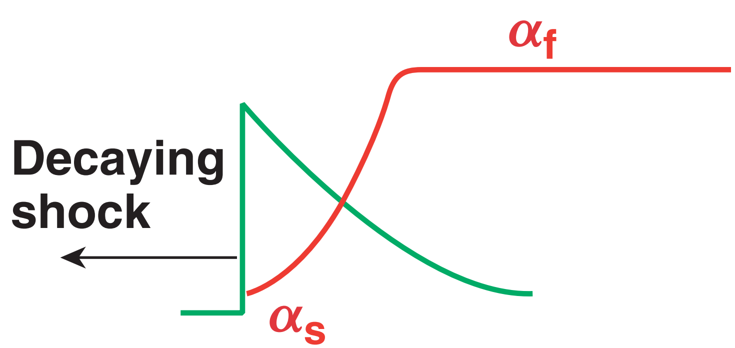


- t = 0 Picket creates a strong shock
- $t = t_p$ Rarefaction wave (RW) launched





- $t = t_{RW}$ RW meets the shock
- $t > t_{RW}$ Shock weakens in time



TC7113

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

Picket-timing scatter produces low-order intensity nonuniformity on target

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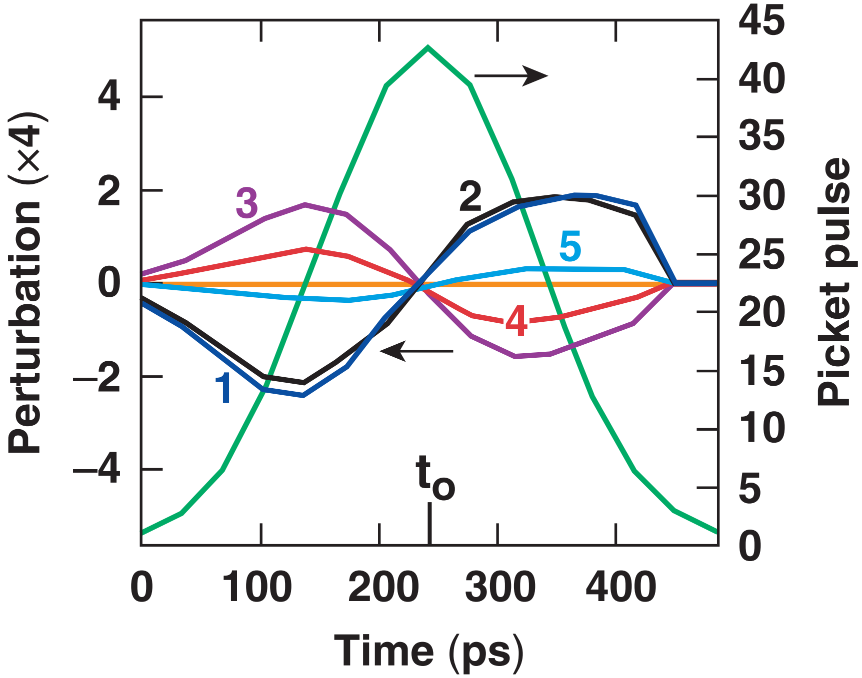
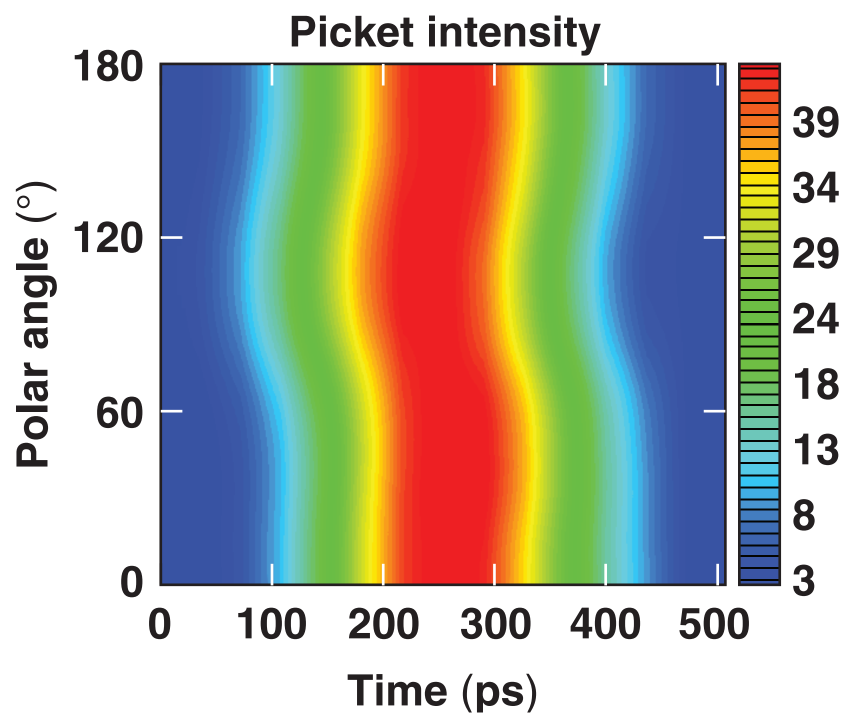
Harmonic amplitudes
- shown for $\cos(\ell\theta)$
- terms of orders $\ell = 1–12$

- Picket pulse,180-ps FWHM
- 48 quads, σ_{rms} = 30-ps* scatter
- $\delta t_o \approx \dfrac{\sigma_{rms}}{\sqrt{n_{beam}/5}} \approx 10\text{ps}$

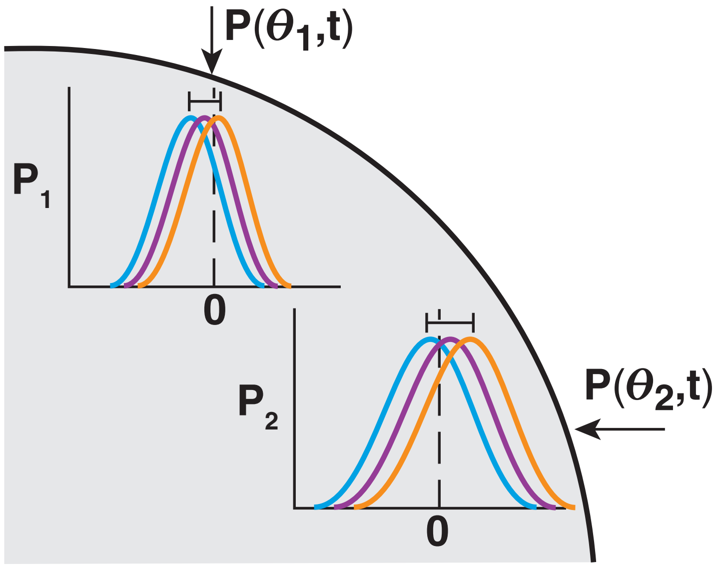


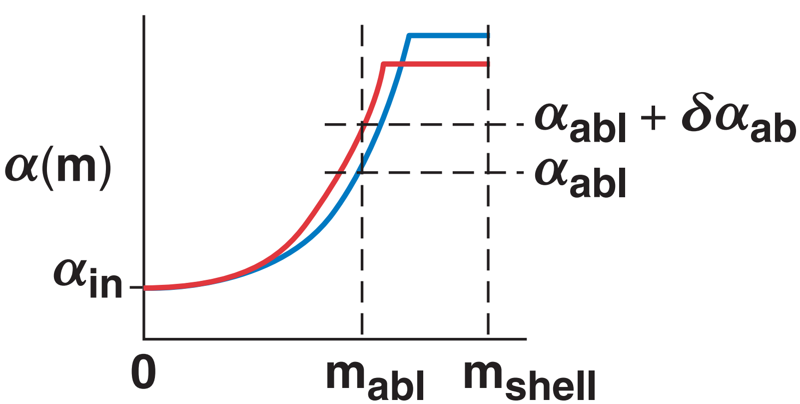


TC7108

*O. S. Jones *et al.*, SPIE, 3492 49 (1998).

Shell adiabat perturbations due to beam mistiming are expected to be small





- The picket width t_p varies over the target surface by δt_p.

$$t_p \approx \left(t_{p0}^2 + \sigma_{rms}^2\right)^{1/2} \pm \delta t_p$$

$$\frac{\delta t_p}{t_p} \approx \frac{1}{2\left(n_{beam}/5\right)}\left(\frac{\sigma_{rms}}{t_p}\right)^2 \approx \frac{0.8\,\text{ps}}{t_p} \approx 0.009$$

- A decaying-shock model* describes the resulting adiabat variations.

$$\frac{\delta\alpha_{abl}}{\alpha_{abl}} \approx \frac{2}{7}\frac{\delta t_p}{t_p} \approx 0.0025$$

$$\frac{\delta V_a}{V_a} \approx \frac{5}{21}\frac{\delta t_p}{t_p} \approx 0.0021$$

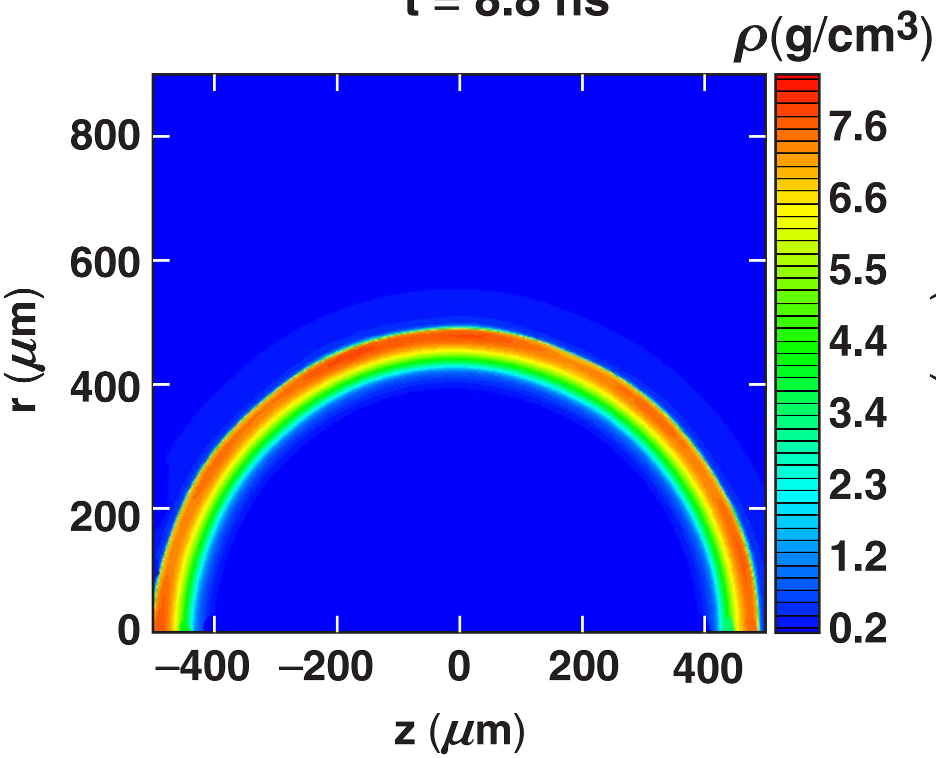
$$\frac{\delta\alpha_{in}}{\alpha_{in}} \approx 0.007\frac{\delta t_p}{t_p} \approx 0$$

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

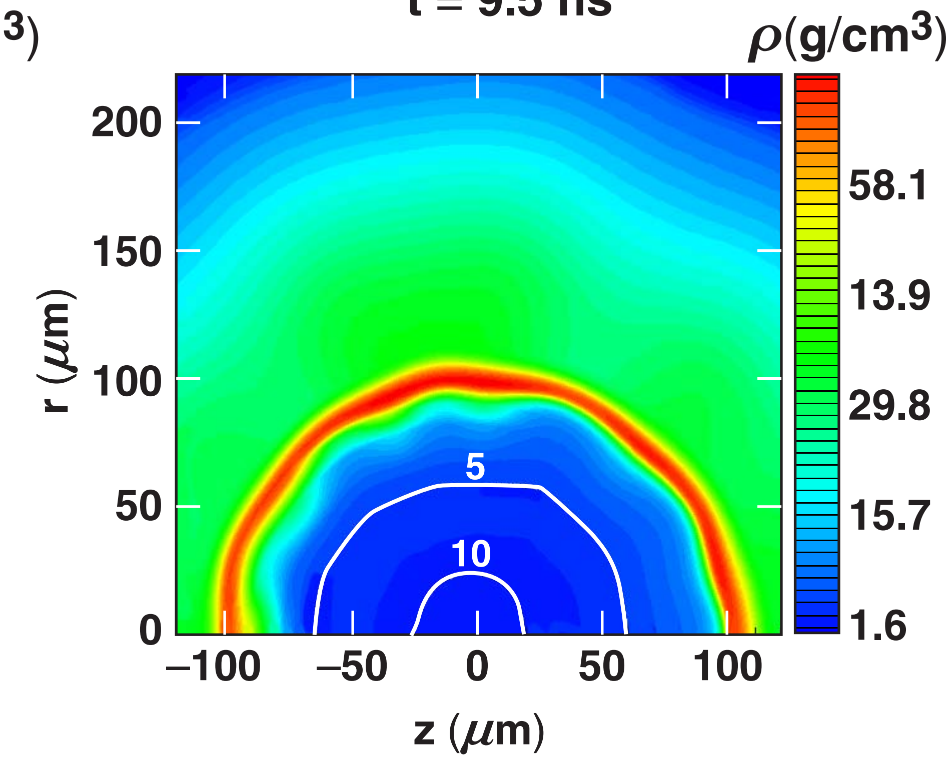
TC7110

Ignition conditions are attained in simulated direct drive with NIF-spec 30-ps-rms* picket scatter

End of the acceleration phase
t = 8.8 ns



Onset of ignition
t = 9.5 ns



T_i contours in keV

TC7112

*O. S. Jones *et al.*, SPIE, 3492 49 (1998).

Scaling gain with $\overline{\sigma}$ allows the formation of a global nonuniformity budget for the direct-drive point design*

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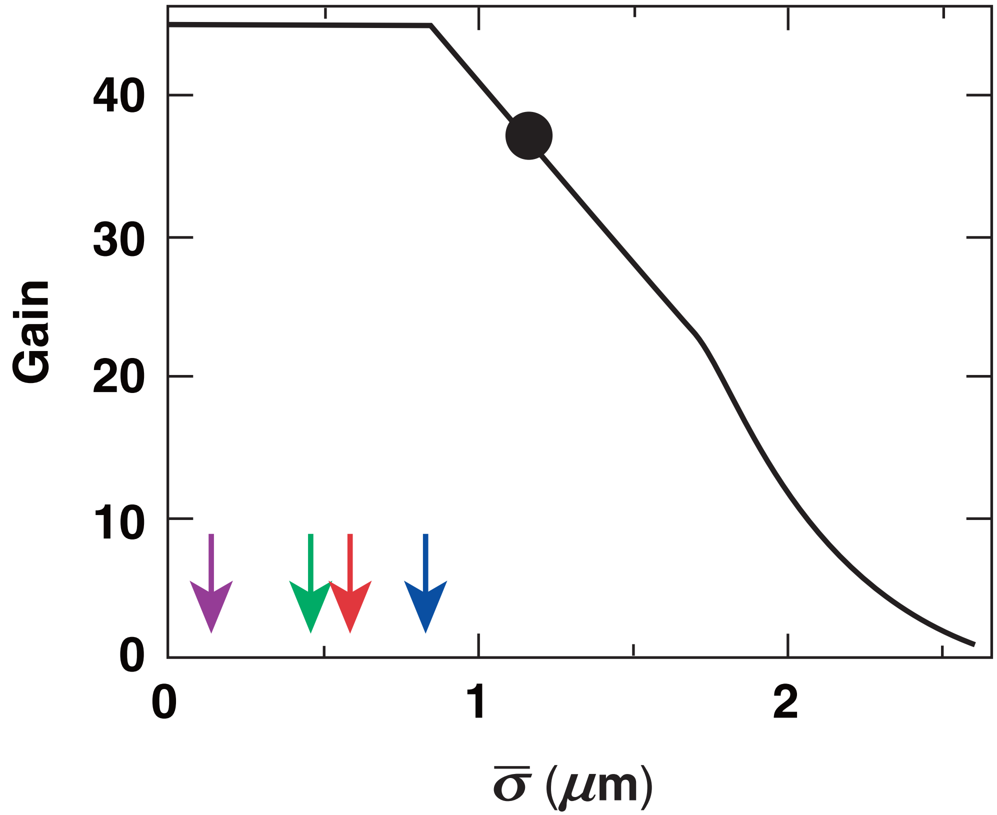
Current specifications

- On-target power imbalance (2% rms): $\overline{\sigma}$ = 0.85 μm
- Inner-surface roughness (1-μm rms): $\overline{\sigma}$ = 0.61 μm
- Applied SSD bandwidth (2 color cycle × 1THz): $\overline{\sigma}$ = 0.50 μm
- Outer-surface roughness (80 nm): $\overline{\sigma}$ = 0.15 μm

$$\overline{\sigma}^2 = 0.06\ \sigma^2_{\ell \le 10} + \sigma^2_{\ell > 10}$$

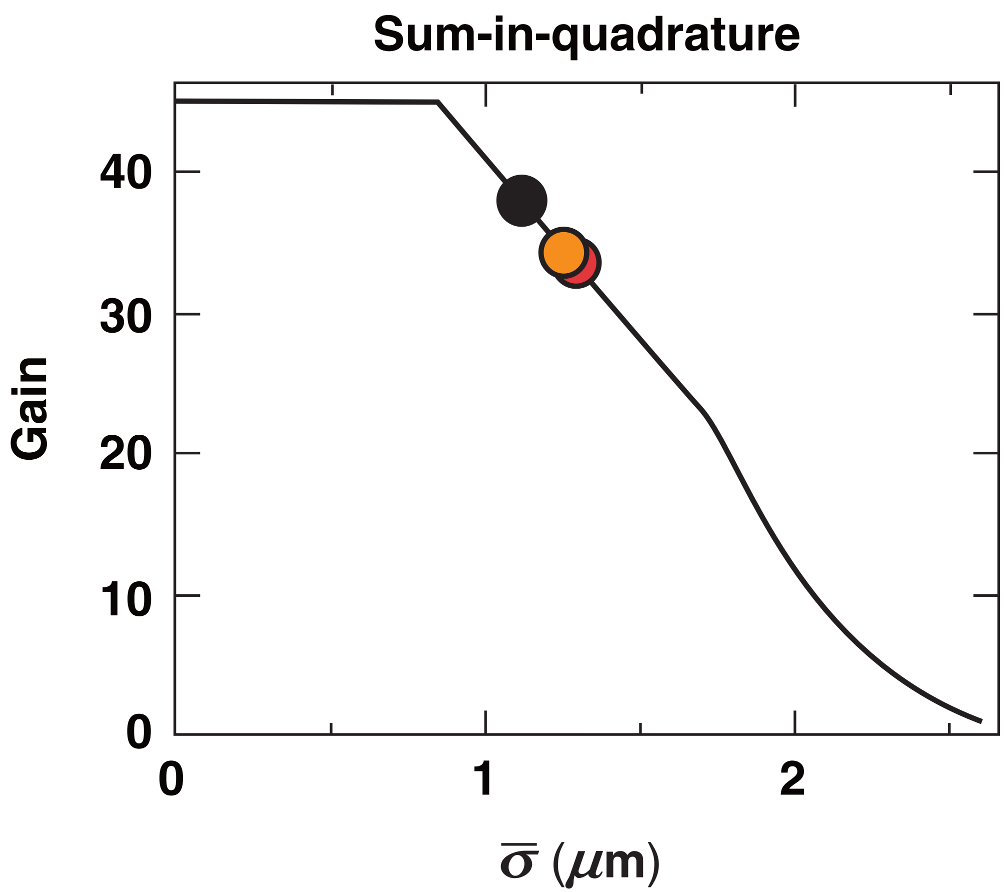
Sum-in-quadrature



TC7252

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

Power imbalance due to picket mistiming does not contribute significantly to the overall uniformity budget



	Picket scatter rms (ps)	$\overline{\sigma}$ (μm)	$\frac{\delta\overline{\sigma}}{\overline{\sigma}}$	Scaled gain
● (black)	0	0	0	38
● (orange)	30*	0.43	6.6%	34
● (red)	45	0.48	8.2%	33

*NIF standard specification

O. S. Jones *et al.*, SPIE, 3492 49 (1998).

Summary/Conclusions

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