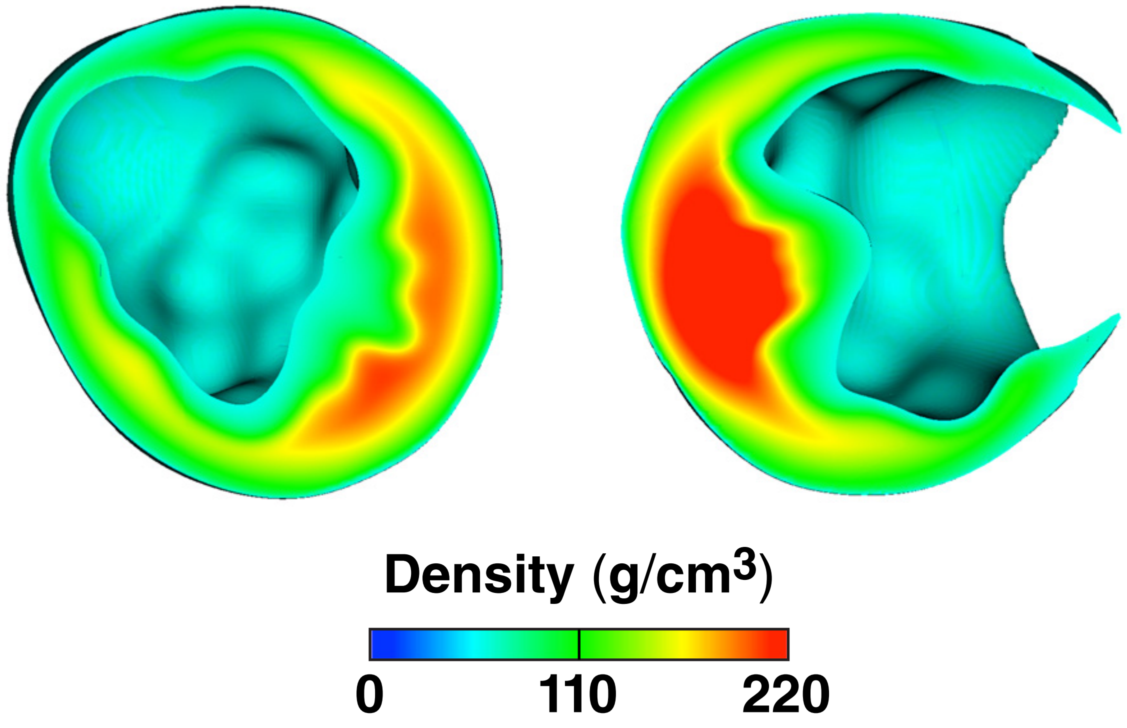
Three-Dimensional Modeling of Low-Mode Asymmetries in OMEGA Cryogenic Implosions

Illumination σ_{rms} = 1.82%
Yield = 8.1 $\times$ 10^{13}



Illumination σ_{rms} = 3.33%
Yield = 4.5 $\times$ 10^{13}

Both have the same target offset, power imbalance, and beam mispointing

K. S. Anderson
University of Rochester
Laboratory for Laser Energetics

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Summary

Large variations in illumination nonuniformity (and yield) can occur with nominally the same perturbation sources

- **Target offset, power imbalance, and beam mispointing all induce predominantly $\ell = 1$ modes in the illumination nonuniformity spectrum**
- **Different random realizations of power imbalance and beam mispointing with the same target offset at nominal OMEGA levels can result in $>2\times$ variation in illumination nonuniformity**
- **Low-mode, 3-D *HYDRA** simulations show a high correlation of yield to total illumination nonuniformity**

*M. M. Marinak *et al.*, Phys. Plasmas 8, 2275 (2001).

Collaborators

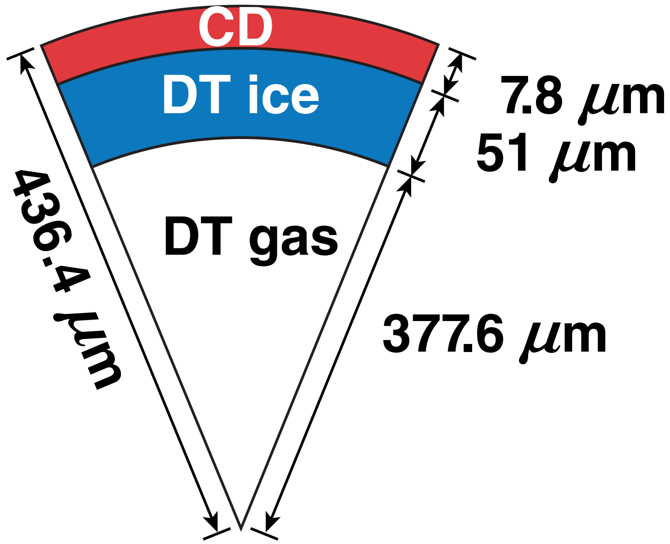
P. W. McKenty, A. Shvydky, T. J. B. Collins, C. J. Forrest, J. P. Knauer, P. B. Radha, F. J. Marshall, and A. B. Sefkow

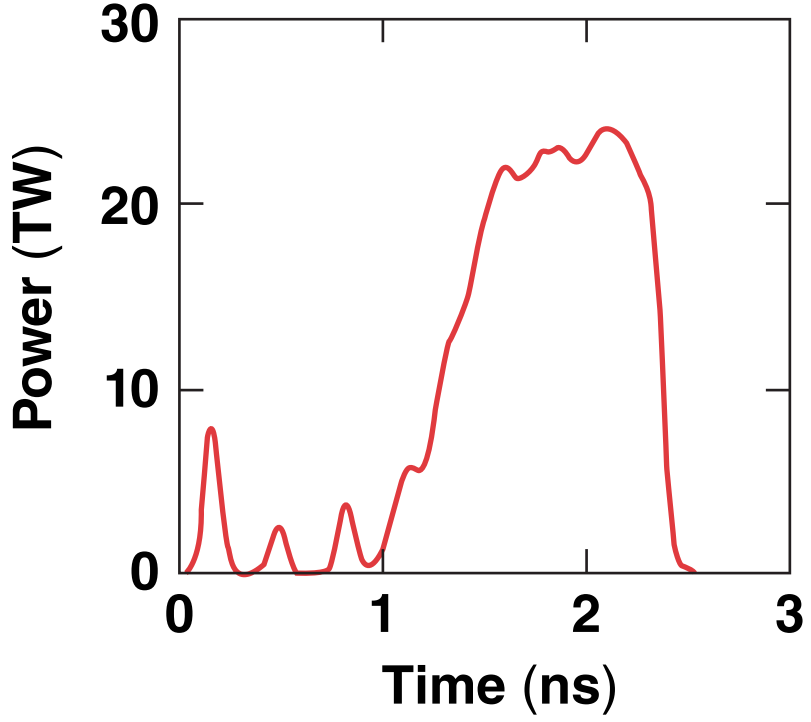
University of Rochester
Laboratory for Laser Energetics

M. M. Marinak

Lawrence Livermore National Laboratory

Three-dimensional *HYDRA* studies were performed for OMEGA shot 78416





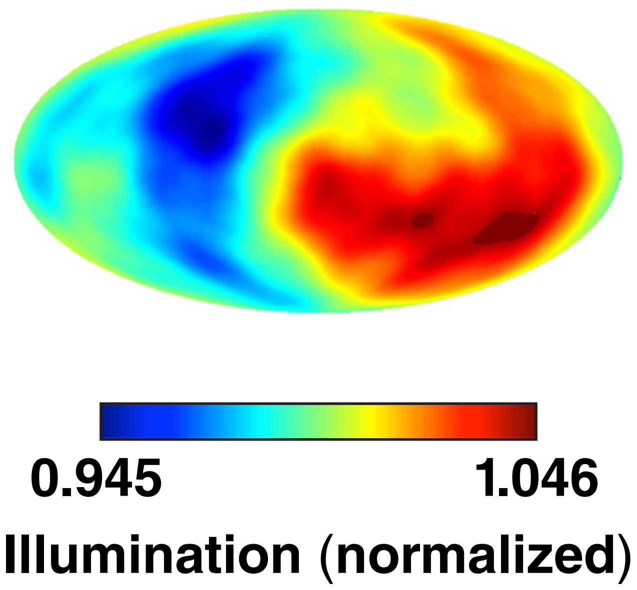
E_L	26 kJ
Adiabat	3.0
V_{imp} (cm/s)	3.5×10^7
CR = R_0/R_{hs}	22
Target offset (μm)	7.5
Power imbalance (%)	3.2
Beam mispointing (μm)	7.4

CR = convergence ratio

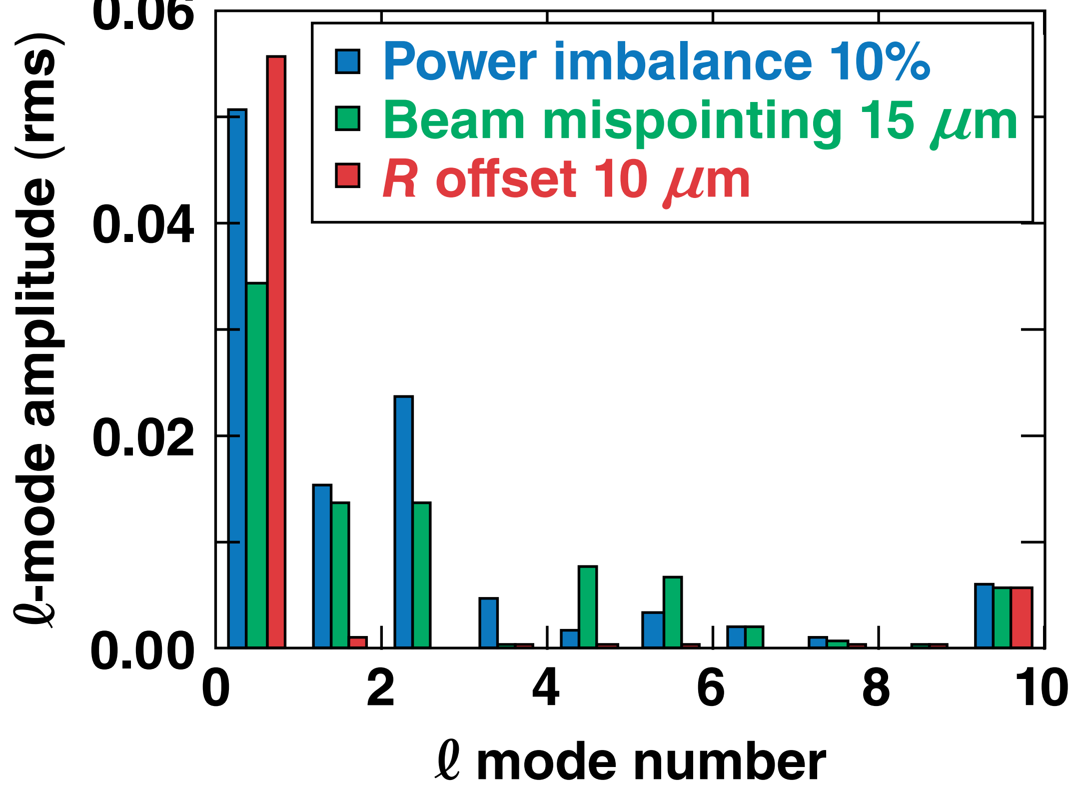
TC13858

The illumination mode spectra indicate target offset, power imbalance, and beam mispointing all lead to a dominant mode 1

Characteristic on-target illumination



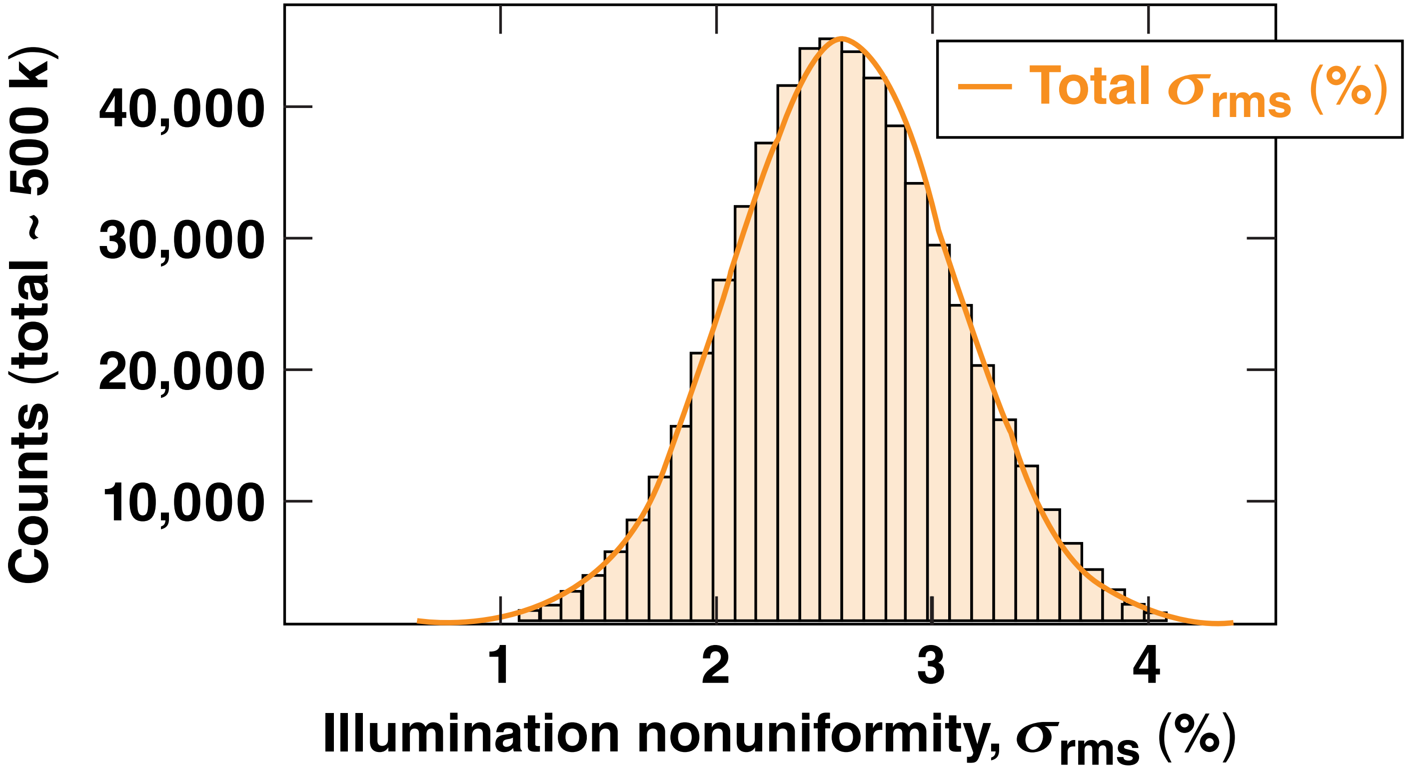
Perturbation spectra on target



TC13859

Different random realizations of the same nominal conditions can have total illumination nonuniformities vary by a factor of >2

R_{offset} = 10 μm, $\sigma_{\text{rms, power imbalance}}$ = 10%, $\sigma_{\text{rms, beam mispointing}}$ = 15 μm



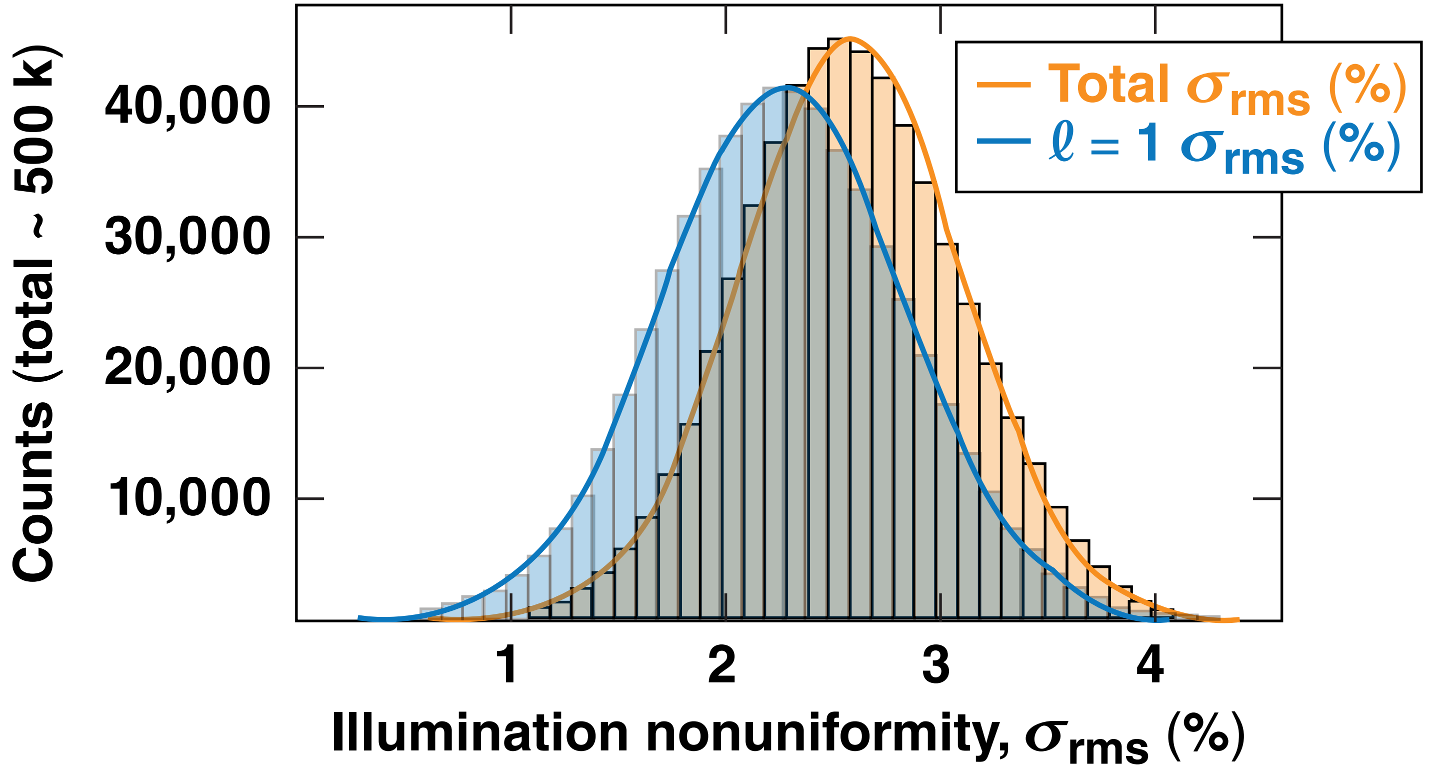
$\sigma_{\text{rms, illumination}}$ = 2.6±1.0%*

TC13860

*95% confidence interval

Different random realizations of the same nominal conditions can have total illumination nonuniformities vary by a factor of >2

$R_{\text{offset}} = 10\ \mu\text{m}$, $\sigma_{\text{rms, power imbalance}} = 10\%$, $\sigma_{\text{rms, beam mispointing}} = 15\ \mu\text{m}$



$\sigma_{\text{rms, illumination}} = 2.6 \pm 1.0\%$*

Most of the variation in $\sigma_{\text{rms, illumination}}$ comes from $\ell = 1$

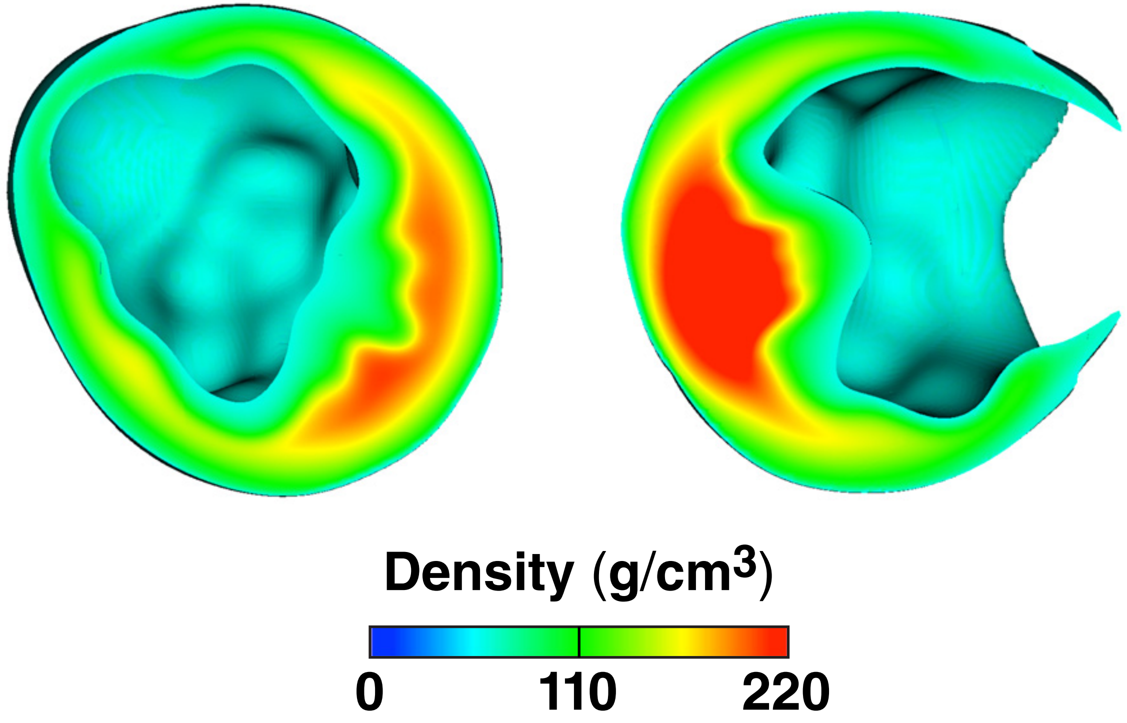
Different relative angles between the perturbation sources' $\ell = 1$ modes change the total σ_{rms}

*95% confidence interval

Three-dimensional *HYDRA* simulations with the same nominal perturbation inputs show very different perturbations and yield

Offset = 10 μm; power imbalance = 5% rms; beam mispointing = 10 μm rms

Illumination σ_{rms} = 1.82%
Yield = 8.1 $\times$ 10^{13}



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Yield = 4.5 $\times$ 10^{13}

A better metric is needed to characterize low-mode laser asymmetries.

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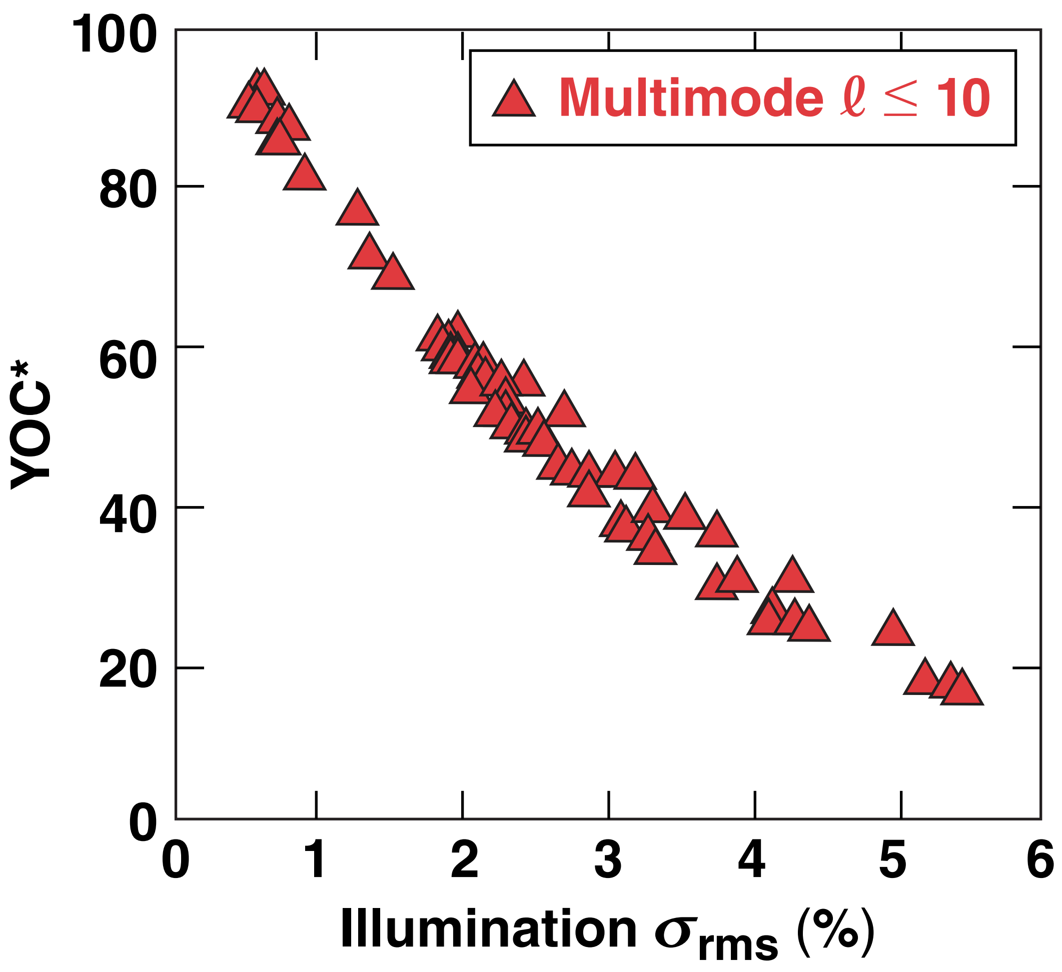
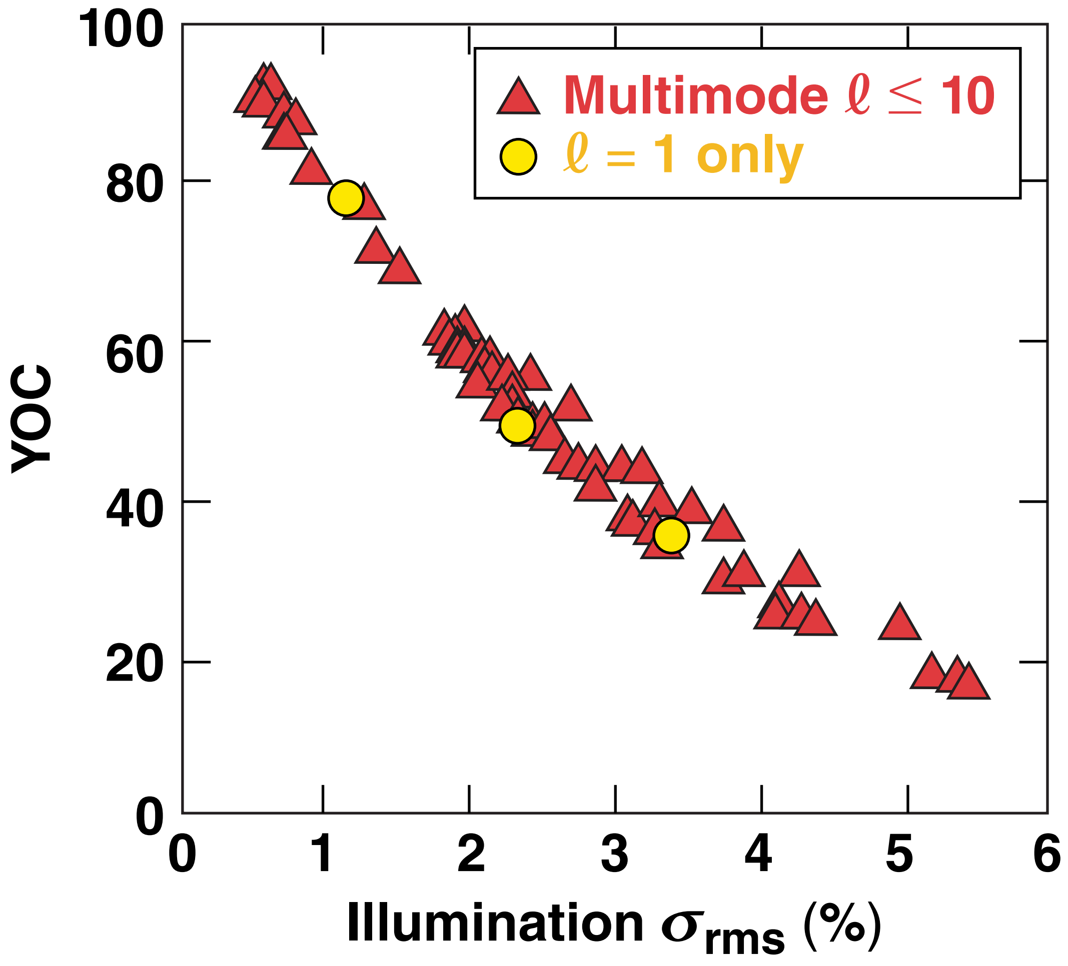
Low-mode, 3-D *HYDRA* simulations show a high correlation of yield to total illumination nonuniformity



TC13863

*YOC: yield-over-clean

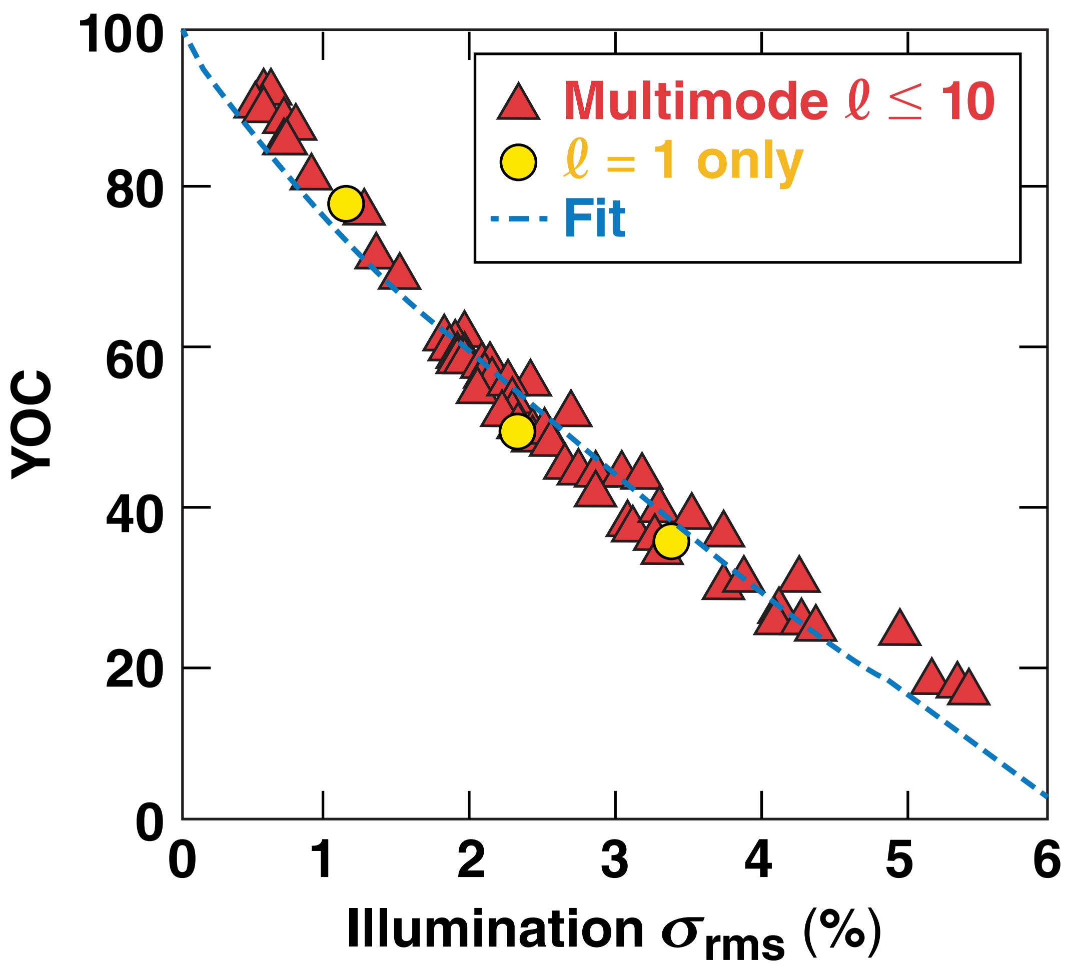
Low-mode, 3-D *HYDRA* simulations show a high correlation of yield to total illumination nonuniformity



- All simulations here are dominated by $\ell = 1$

TC13864

Low-mode, 3-D *HYDRA* simulations show a high correlation of yield to total illumination nonuniformity



- All simulations here are dominated by $\ell = 1$
- Yield can be predicted by a simple formula

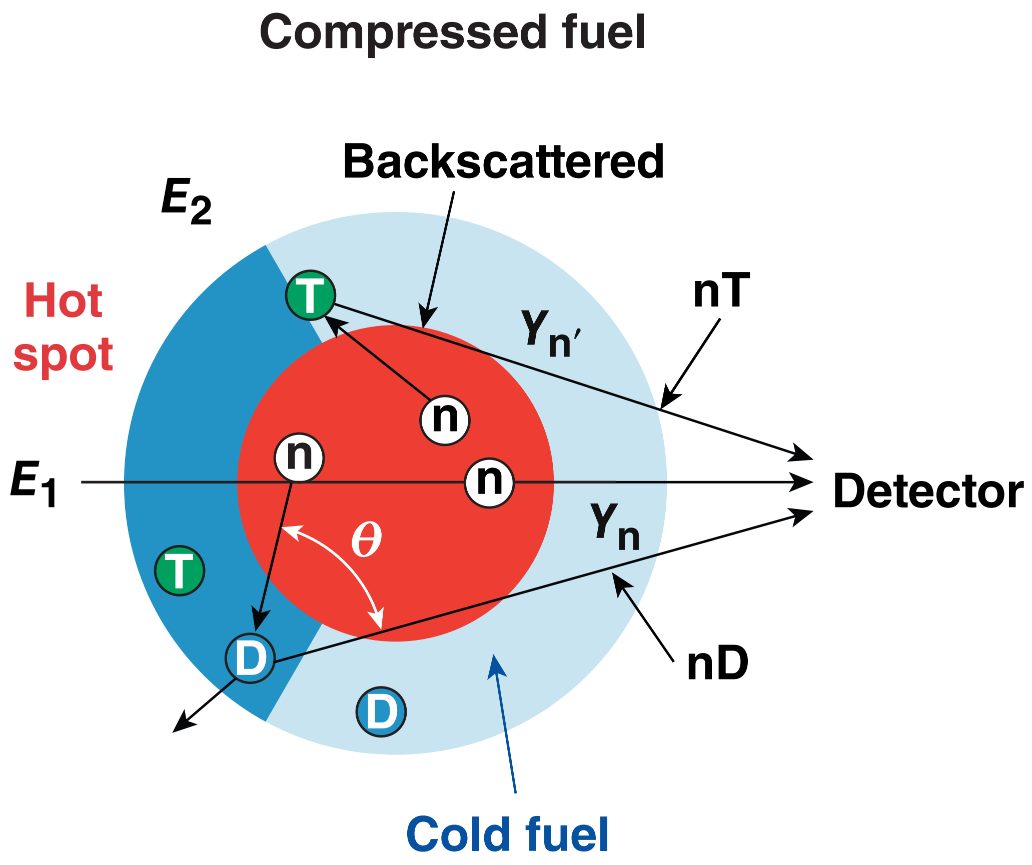
$$\text{YOC}(\sigma_{I,\text{rms}}) = 100\left(1 - 0.24\,\sigma_{I,\text{rms}}^{0.78}\right)$$

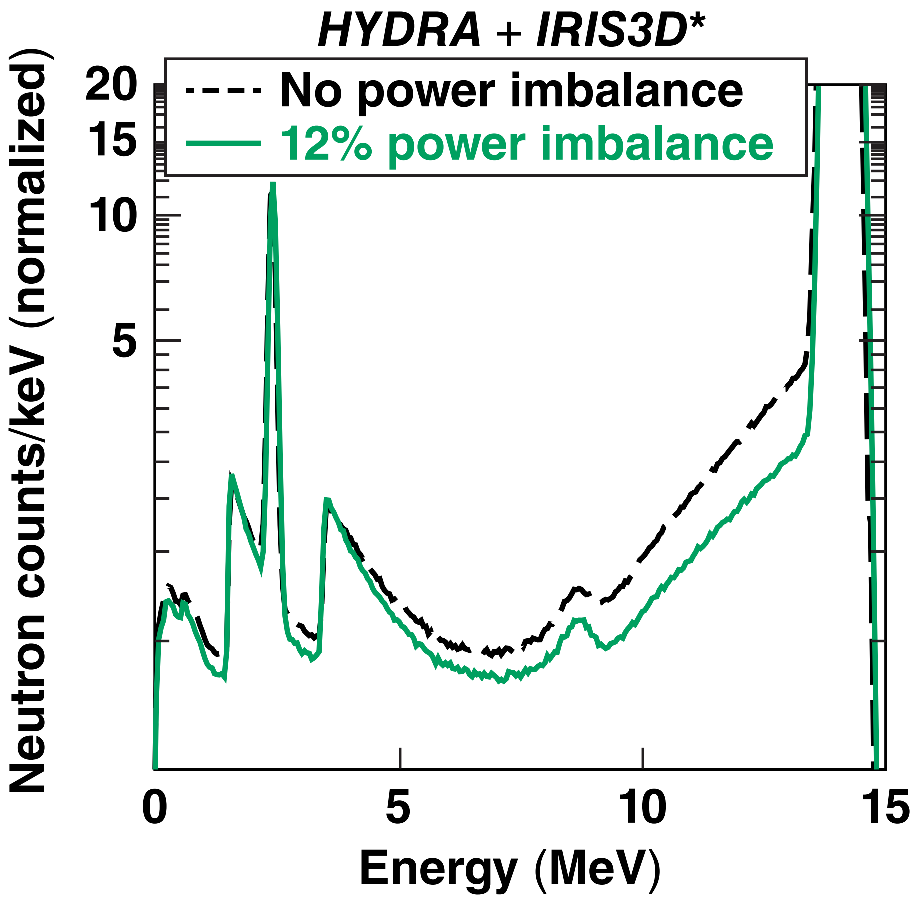
To keep YOC > 80%, the low-mode illumination nonuniformity should be <1%

Target nonuniformity must also be included; these may not be dominated by $\ell = 1$

TC13865

Post-processed neutron spectra from *HYDRA* output are being used to infer areal density at various angles relative to the detector's is line of sight





Scattered neutron energies correlate with scattering angle

*F. Weilacher, P. B. Radha, and C. J. Forrest, "Three-Dimensional Modeling of Neutron-Based Diagnostics to Infer Plasma Conditions in Cryogenic Inertial Confinement Fusion Implosions," submitted to Nuclear Fusion.

TC13866

See also C. J. Forrest *et al.*, UO7.00002, this conference.

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