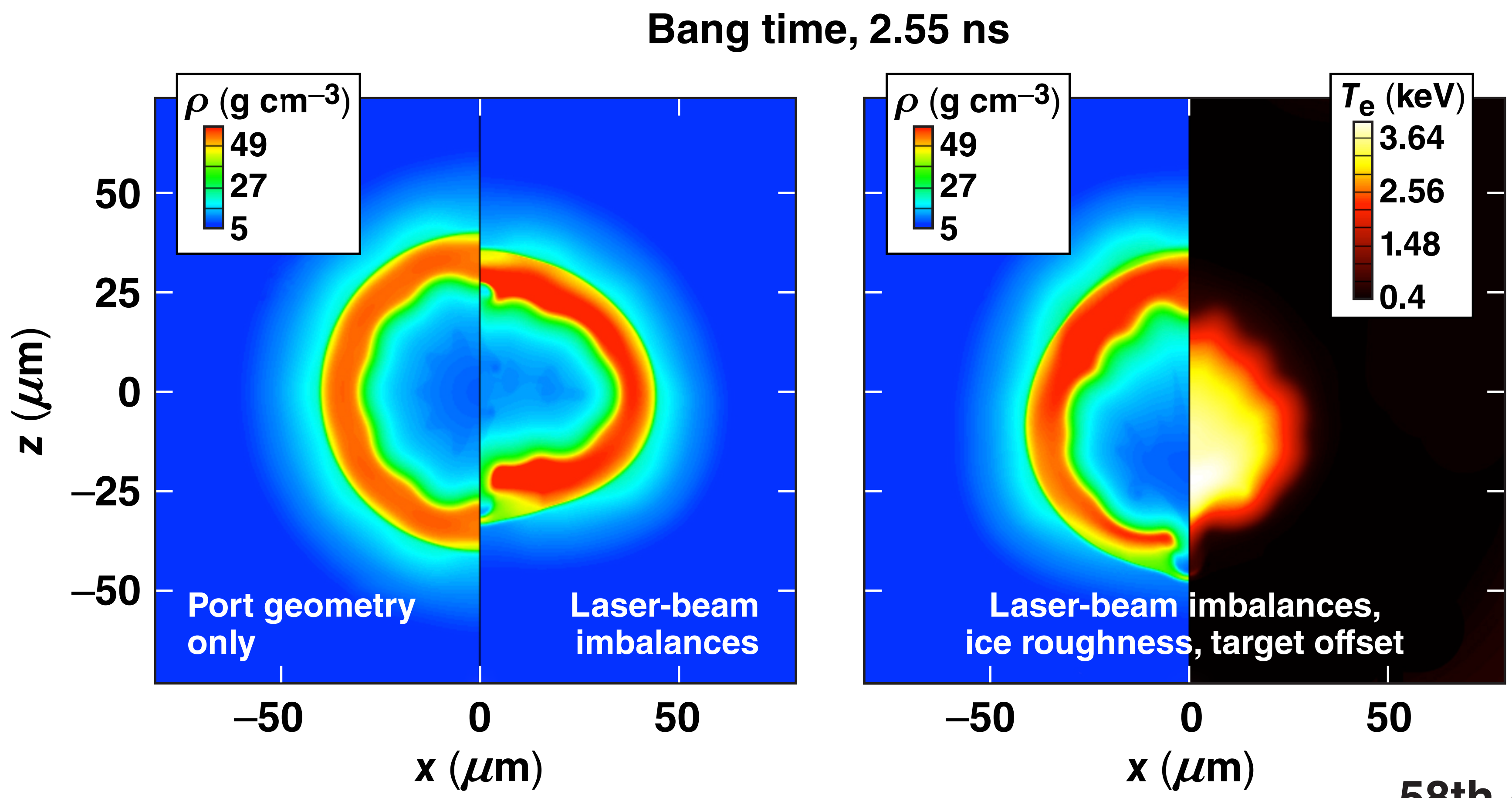
Multidimensional Study of High-Adiabat OMEGA Cryogenic Implosions



Offset = 10.5 μm
σ_{ice} = 0.65 μm
5.3% power imbalance
8-μm mispointing
5-ps mistiming

T. J. B. Collins
University of Rochester
Laboratory for Laser Energetics

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Summary

Simulations indicate that high-adiabat cryogenic implosion performance on OMEGA is dominated by target offset and ice roughness

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- Cryogenic targets were imploded with a minimum shell adiabat of $\alpha \sim 7$, with smoothing by spectral dispersion (SSD) on and off, and with moderate- and high-intensity pulses
- 2-D simulations indicate that the primary loss of yield is a result of a reduction in the hot-spot volume caused by ice roughness and target offset
- High-adiabat experiments and simulations confirm that the shell remains integral despite laser imprint

TC13175

Collaborators

R. Betti, A. Bose, A. R. Christopherson, V. N. Goncharov, J. P. Knauer, J. A. Marozas, F. J. Marshall, A. V. Maximov, D. T. Michel, A. Mora, P. B. Radha, S. P. Regan, W. Shang, A. Shvydky, C. Stoeckl, K. M. Woo, and G. Varchas

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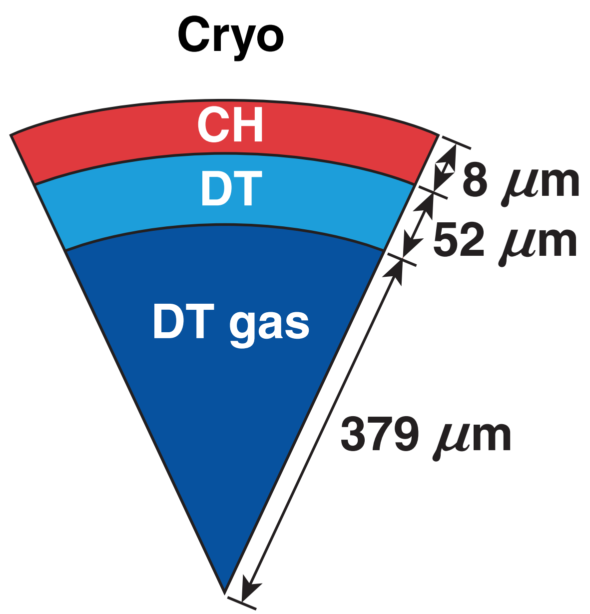
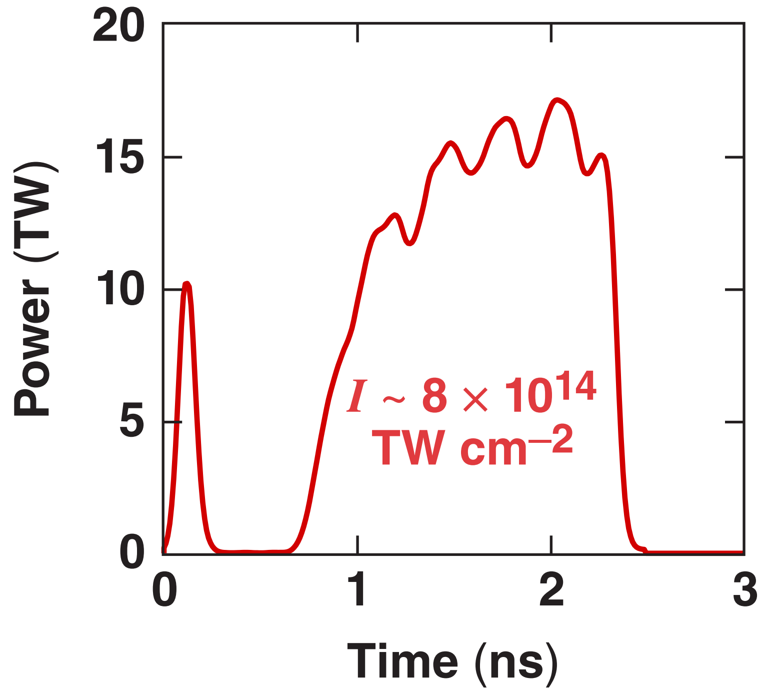
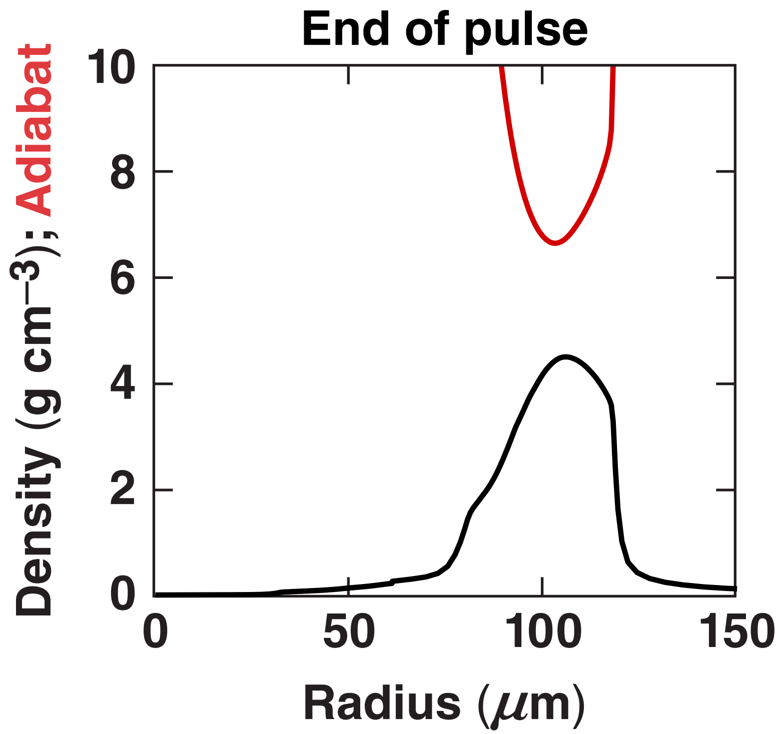
Laboratory for Laser Energetics

Cryogenic targets were imploded on a high adiabat to prevent shell breakup as a result of imprint and to explore a "1-D" regime*

- The predicted minimum adiabat is ~7, much higher than that of designs that scale to ignition
- These implosions use a single ~10-TW picket for low-mode growth with a convergence ratio (CR) of 13 and an in-flight aspect ratio (IFAR) of 15
- A comparison with high-intensity shots ($I \sim 10^{15}$ TW cm^{-2}) shows minor indications of intensity-dependent effects, such as ~10% increase in hot-spot size and ~6% reduction in ρR





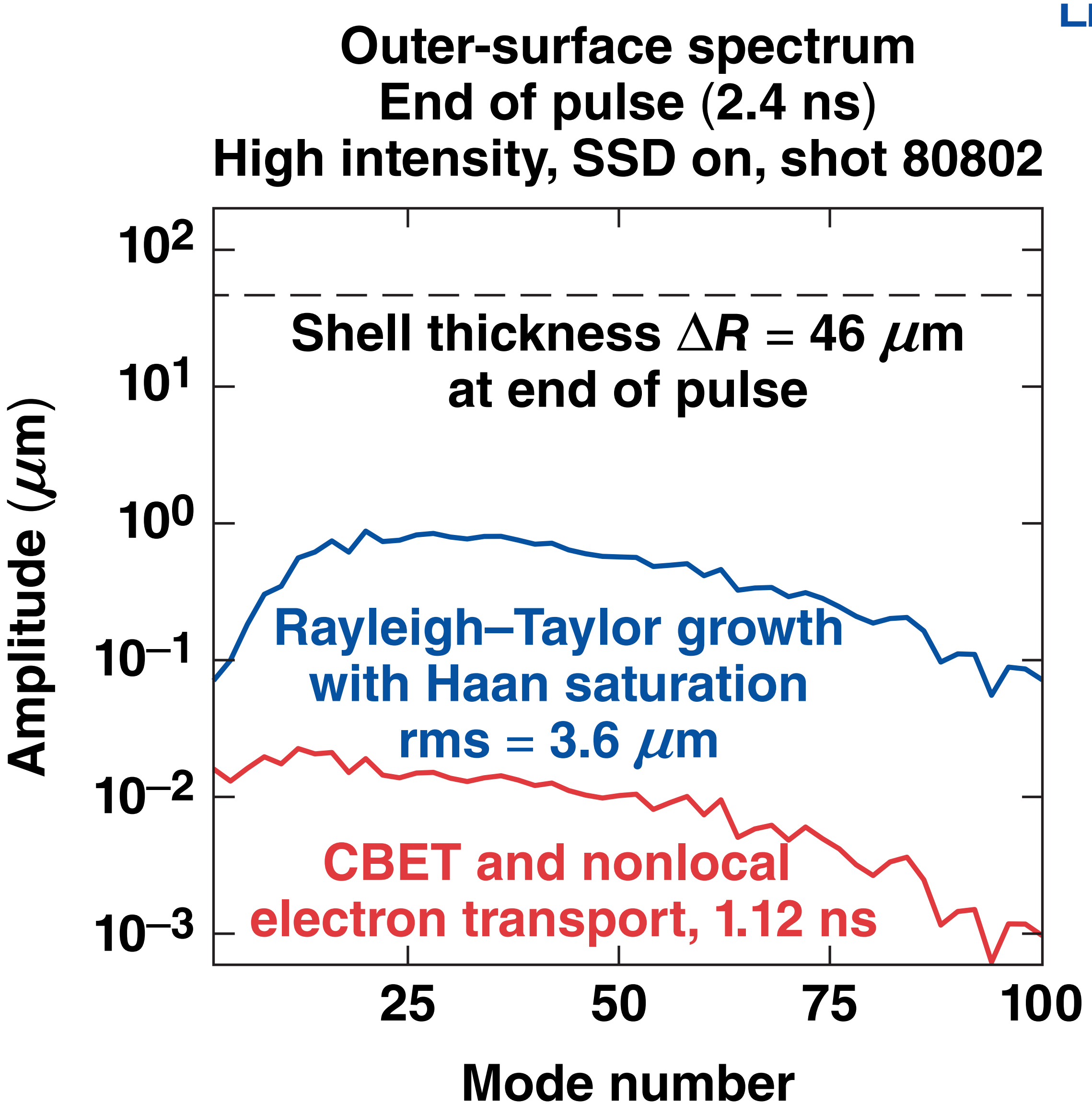


*R. Betti *et al.*, PO5.00008, this conference.

TC13176

Imprint as a result of single-beam nonuniformities is expected to have a small effect on target performance

- Turning off SSD in warm-target implosions reduces the bang time and lengthens the burn*
- Shots based on the same pulse were performed with and without SSD
- Small changes in the pulse energy and spot size account for the majority of the 55-ps difference in bang times
- The burn duration [full width at half maximum (FWHM)] in both experiment and simulation is nearly identical when SSD is turned off

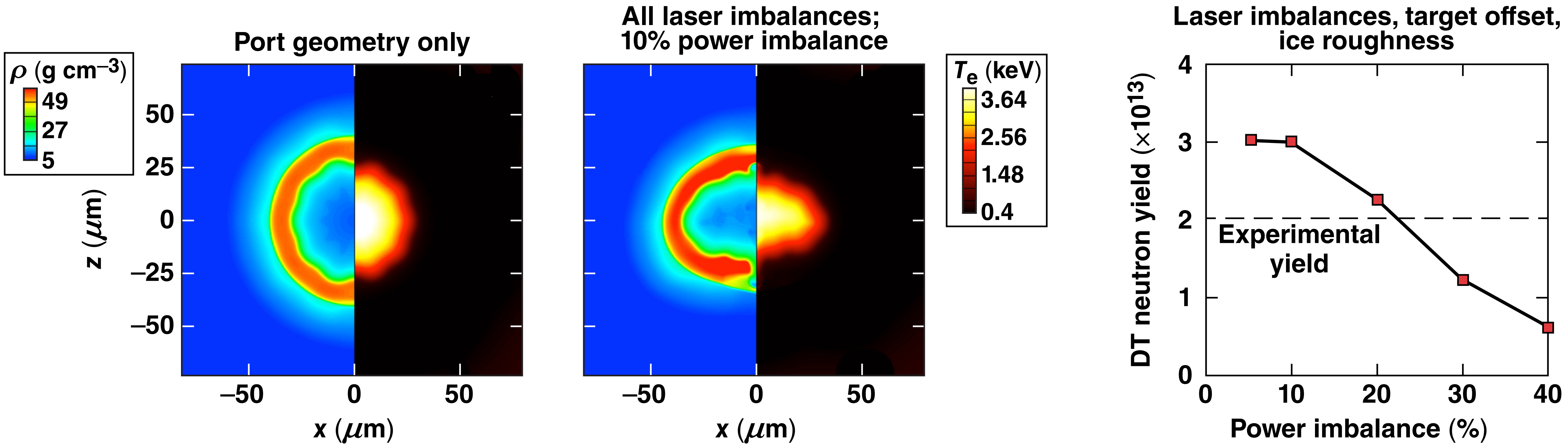


*S. X. Hu *et al.*, Physics of Plasmas 23, 102701 (2016).

TC13177

Drive nonuniformities have a modest impact on target yield in 2-D simulations

- A 5-ps beam mistiming, 8-μm mispointing, and 5.3% power imbalance were estimated experimentally
- When these are simulated, the yield is degraded 8% relative to a "clean" simulation
- The yield is degraded 12% when the power from modes with $m \neq 0$ is added in quadrature to the $m = 0$ modes to account, in part, for 3-D mode growth
- High-adiabat, low-convergence implosions are expected to have little sensitivity to drive perturbations

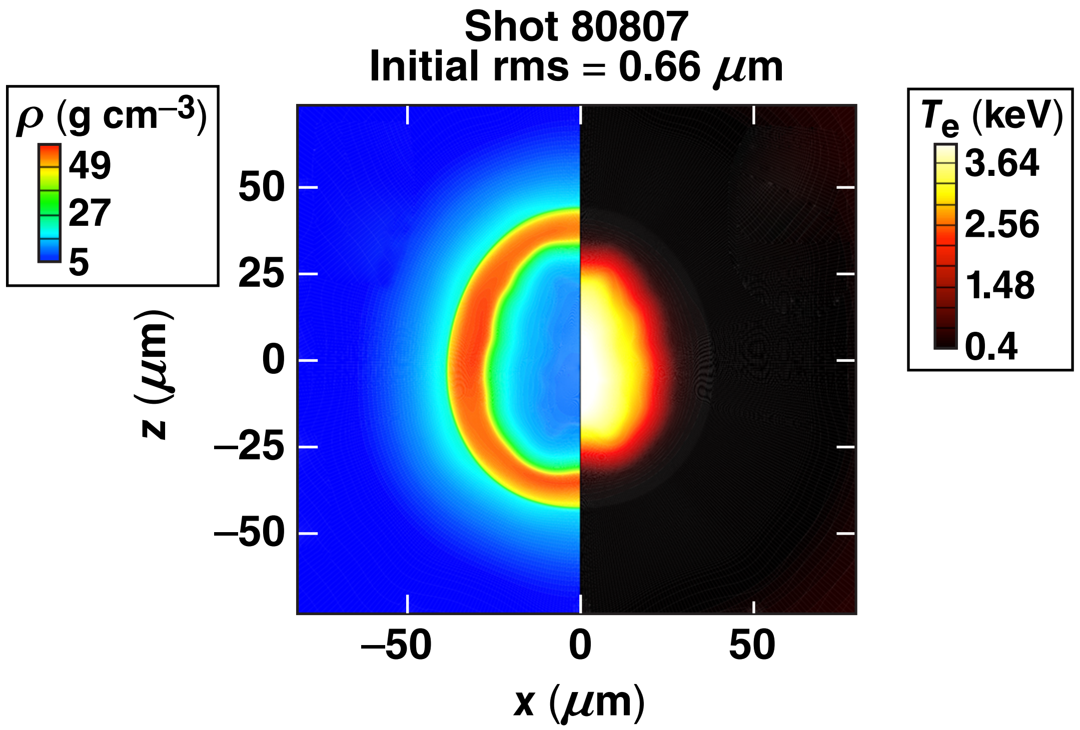


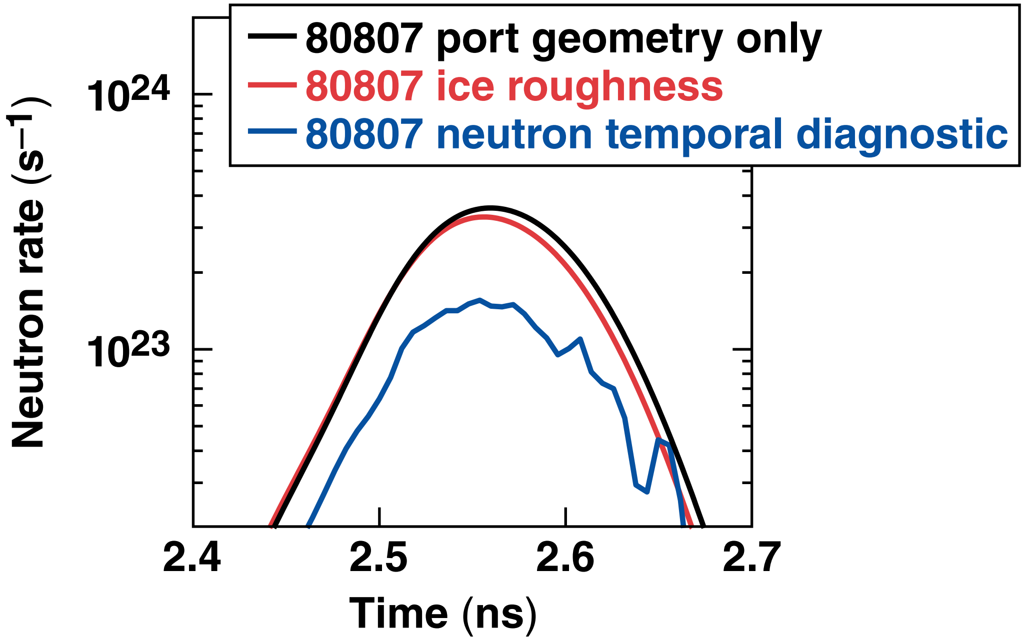
The power imbalance must be increased to over 20% to reproduce the experimental yield.

TC13178

Ice roughness has a small impact on target performance for $\alpha \sim 7$ implosions

- Despite the large $\ell = 2$, the hot-spot volume is largely unchanged, leading to almost no reduction in yield
- The yield reduction relative to clean is 6%

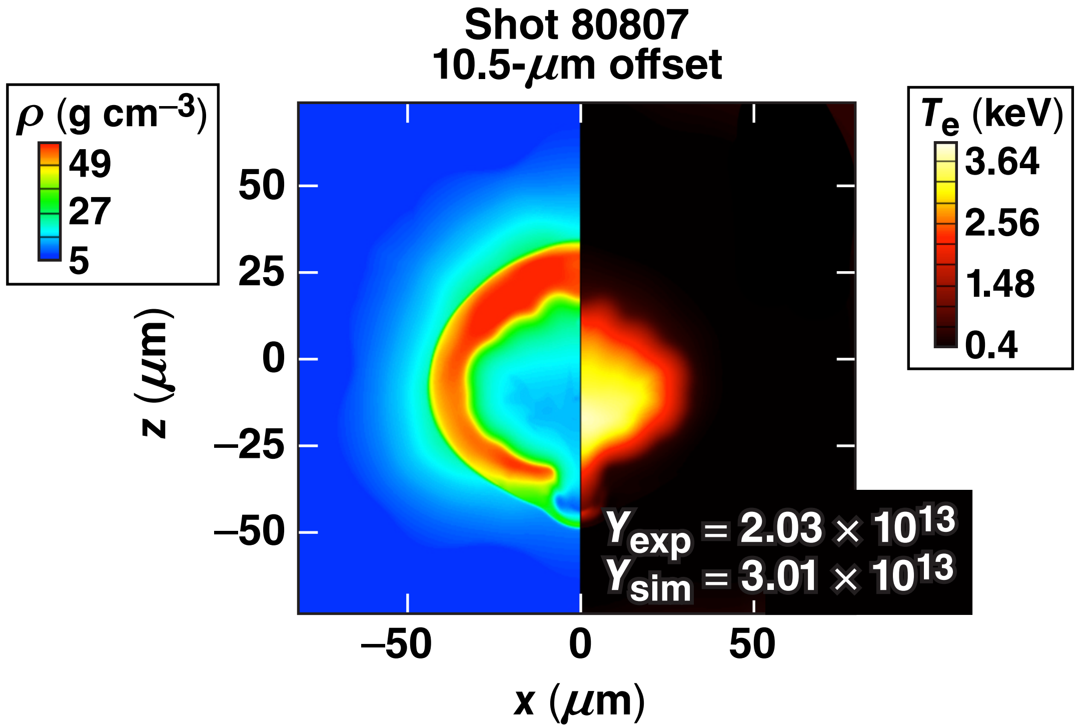




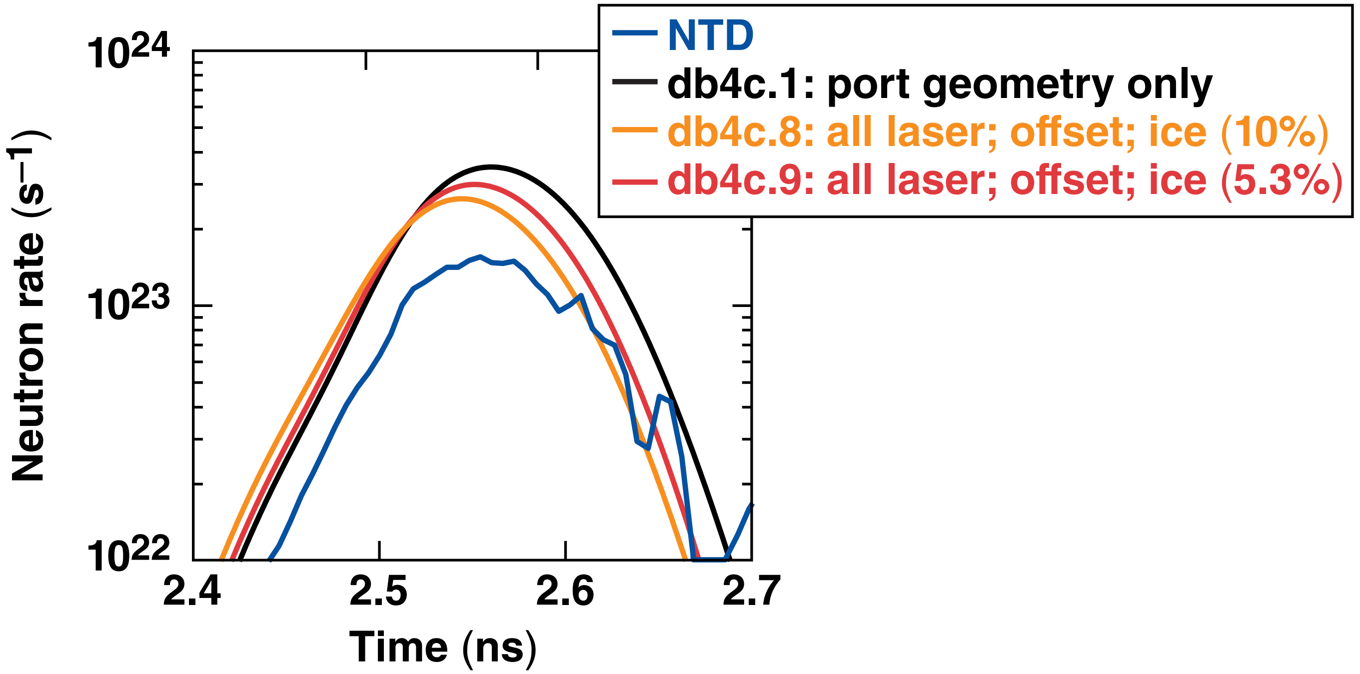
TC13179

Target offset is predicted to be the leading cause of target-performance degradation

- A simulation with target offset has a 12% degradation of yield relative to a "clean" simulation, approximately the same as all laser imbalances put together, with 10% power imbalance
- Simulations including beam mistiming, mispointing, and 5.3% power imbalance, with measured ice roughness and target offset, show a reduction in yield of 17% from the clean yield
- Even when the power imbalance is doubled to 10%, the yield degradation is just 26%



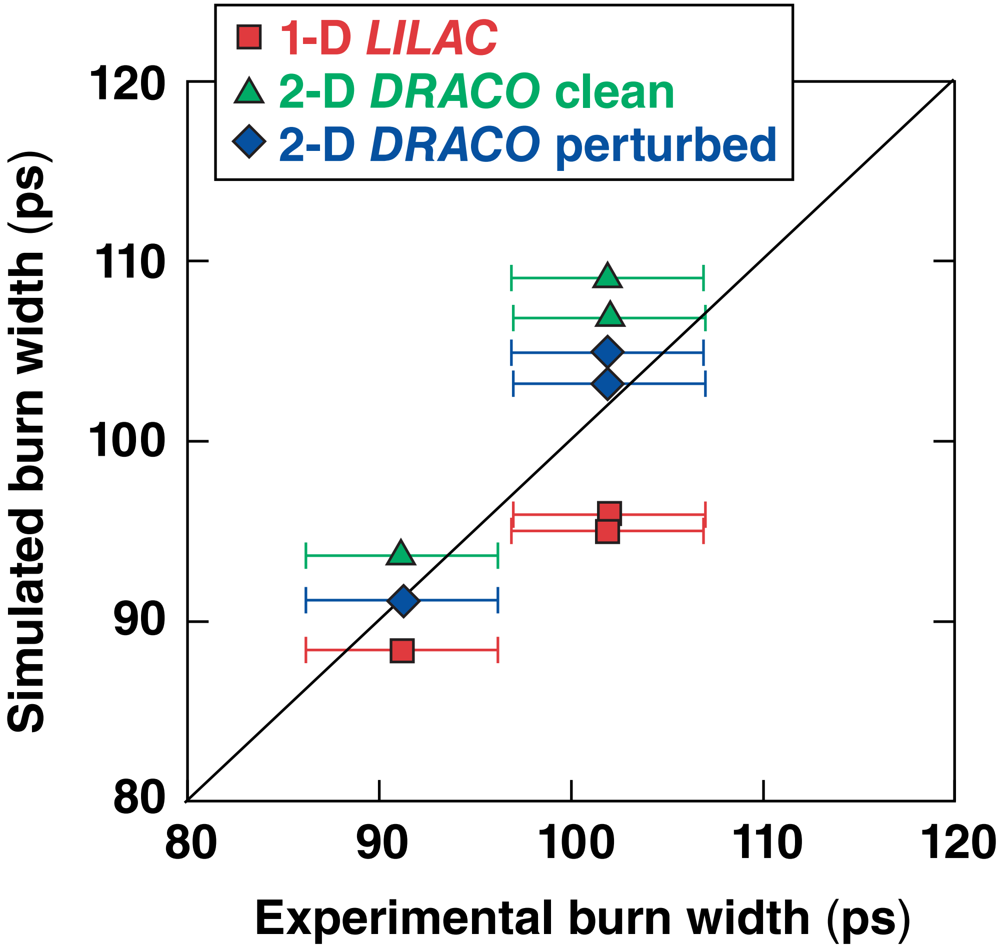
Laser imbalances (10%), offset, ice roughness



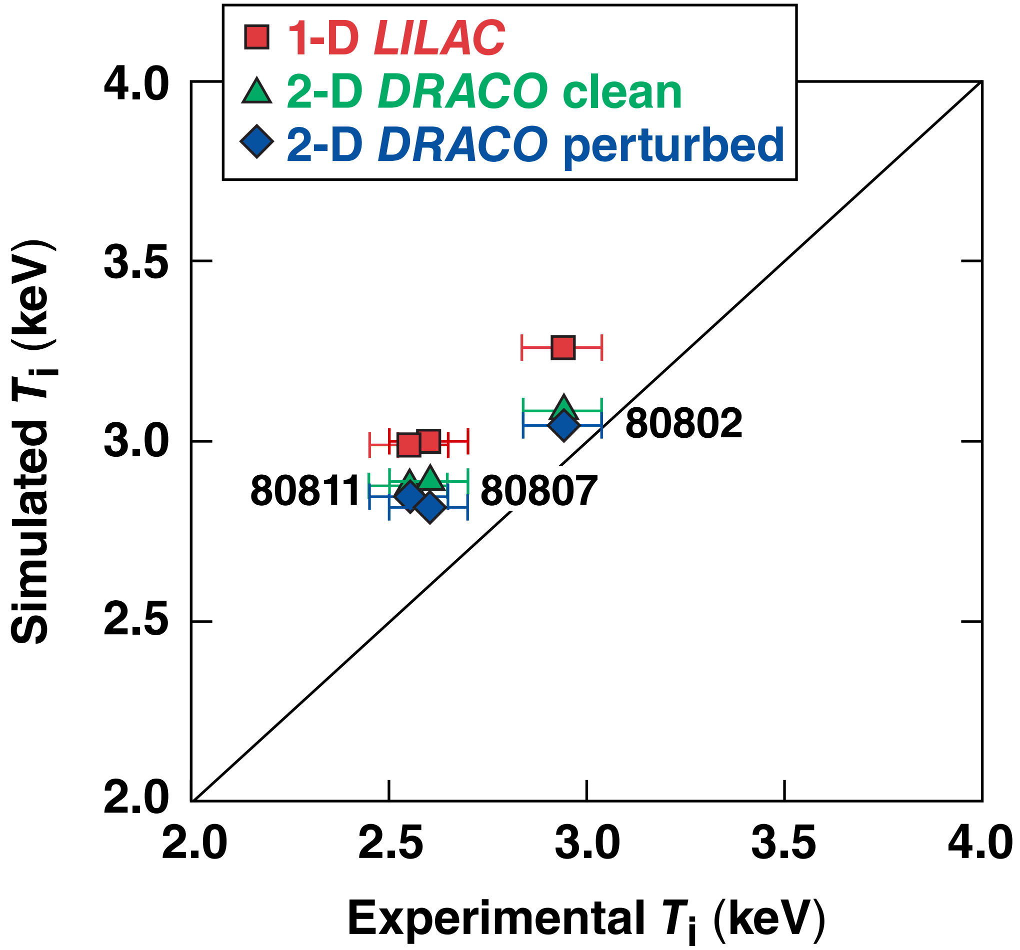
TC13180

Burn widths are well reproduced by simulation

- Long-wavelength perturbations lead to a small amount of burn truncation
- 2-D ion temperatures are closer to experimental values



Time and spatial-neutron-weighted hot-spot ion temperatures

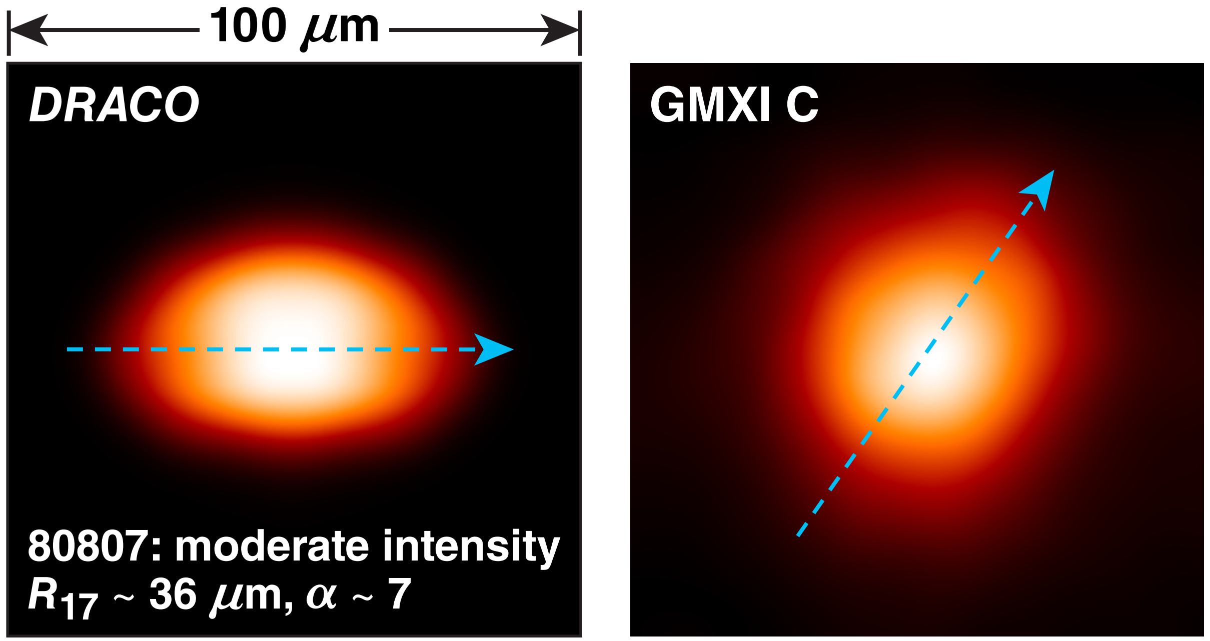


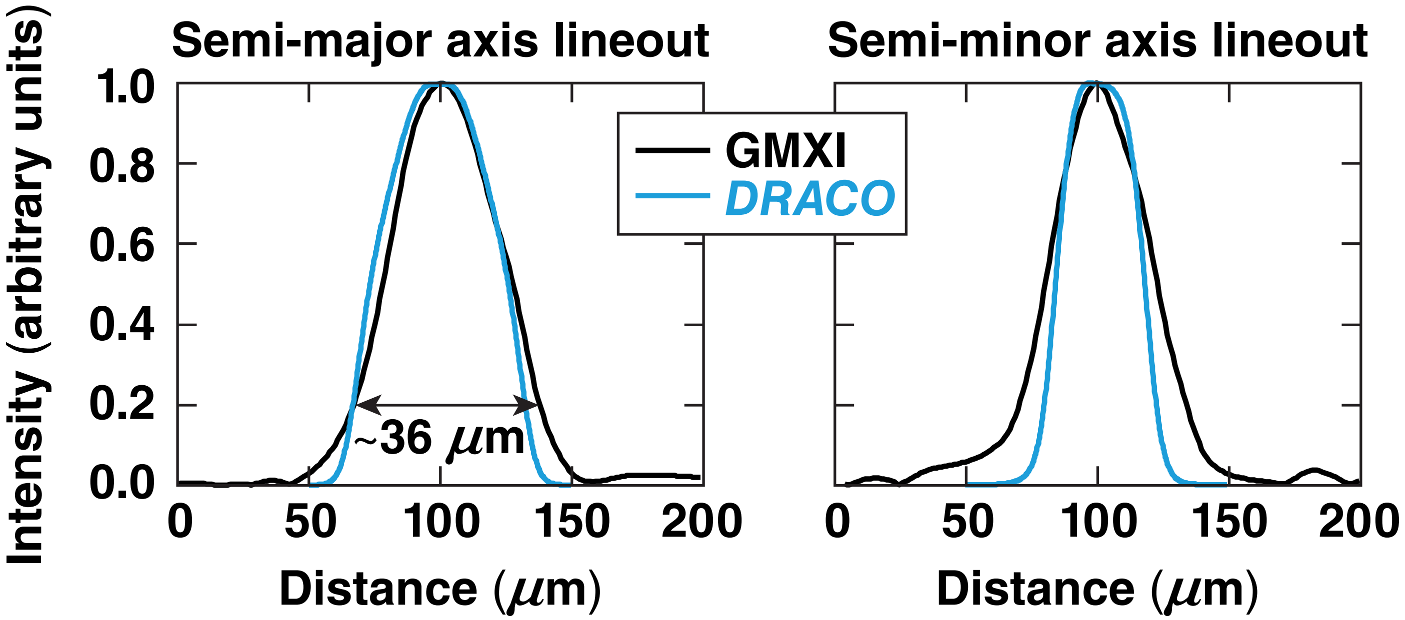
Data are shown for high intensity (80802), low intensity (80807), and low intensity without SSD (80811)

TC13181

DRACO simulations show hot-spot sizes comparable to those determined by integrated x-ray images

- The gated monochromatic x-ray imager (GMXI) was used to observe 4.5- to 6-keV x rays
- The hot-spot size is affected by the amount of mass ablated into the hot spot disruption
- The simulated hot-spot shape is more oblate than the GMXI image





TC13182

High-adiabat implosions are being used to identify physical processes that must be better modeled or added to simulation

- Simulations reproduce expected trends but over-predict target yield
- 1-D modeling of the cryogenic implosion using the preheat inferred from the plastic-target implosions indicates an ~10%* reduction of areal density and a 5% reduction of yield
- The power imbalance must be increased by 4× over the measured level to account for the observed yield degradation
- Other sources of performance degradation include
  - 3-D effects, notably asymmetric hot-spot fluid flow**
  - perturbations caused by the target mounting stalk, including possible ice-surface perturbations†
  - shell disruption caused by surface target debris
  - uncertainties in physics modeling
- Simulations will be performed modeling the first two of these, and efforts are underway to improve target characterization to the submicron level

* J. A. Delettrez *et al.*, UO9.00015; A. R. Christopherson *et al.*, NO5.00007, this conference.
** K. S. Anderson *et al.*, NO5.00011, this conference.
† D. Cao *et al.*, TO5.00012, this conference.

TC13183

Simulations indicate that high-adiabat cryogenic implosion performance on OMEGA is dominated by target offset and ice roughness

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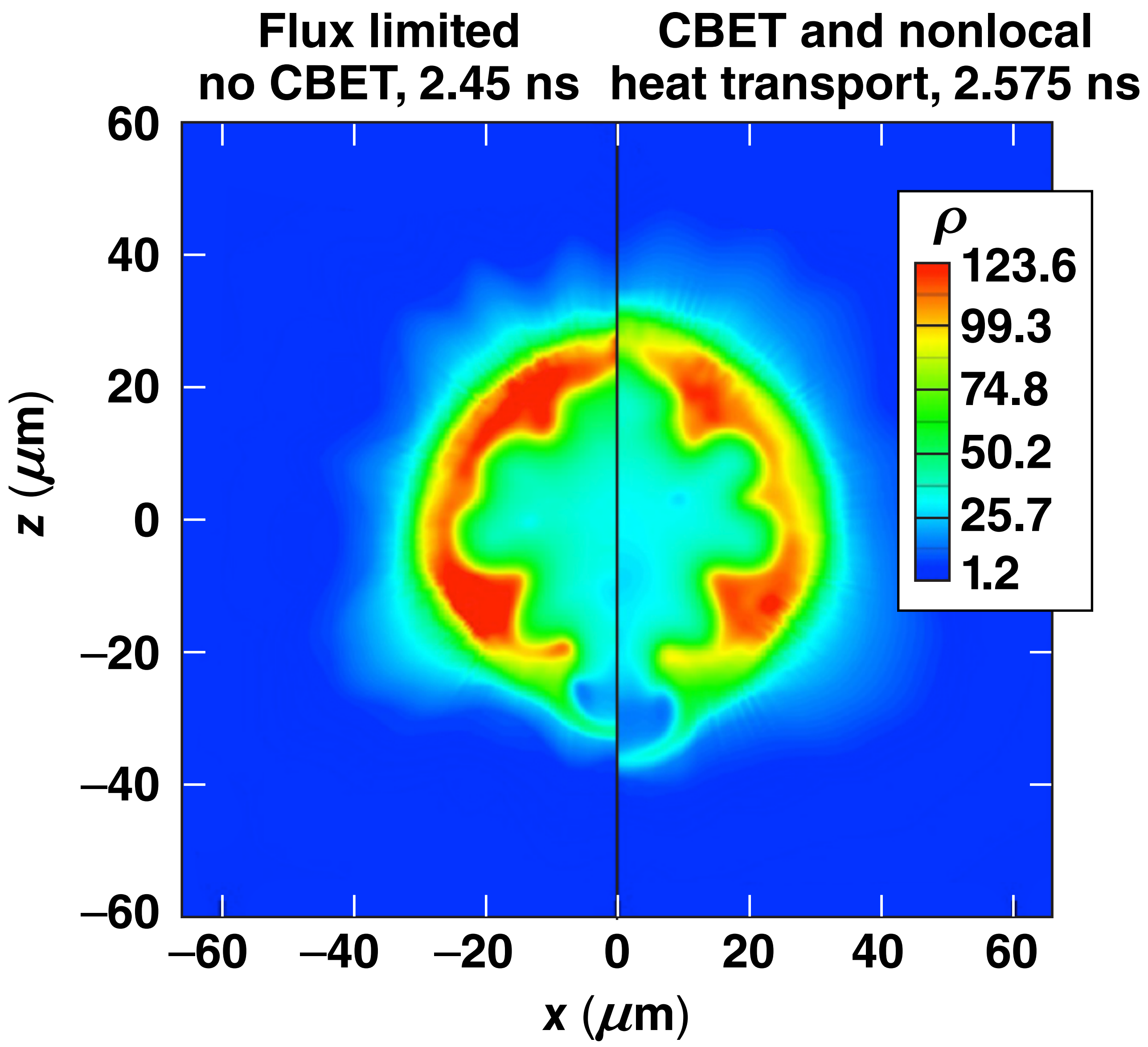
CBET has a modest effect on the spectrum of drive nonuniformities

- In CBET, an ion-acoustic wave couples incoming and outgoing laser beams, removing energy from incoming rays, and reducing the overall laser drive by as much as 40%
- CBET occurs nearly uniformly around the target
- CBET increases the deposition-weighted radius, resulting in a larger smoothing volume for drive perturbations



TC13184