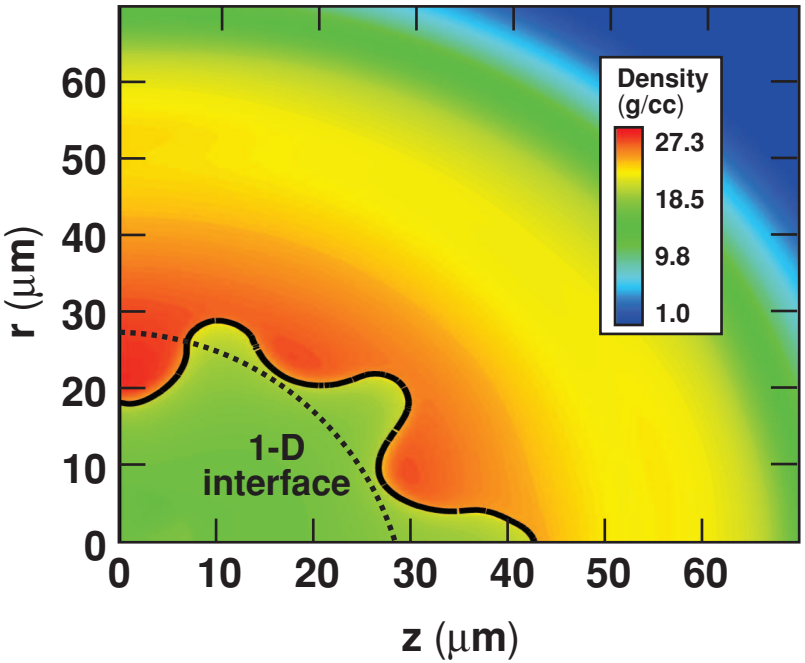
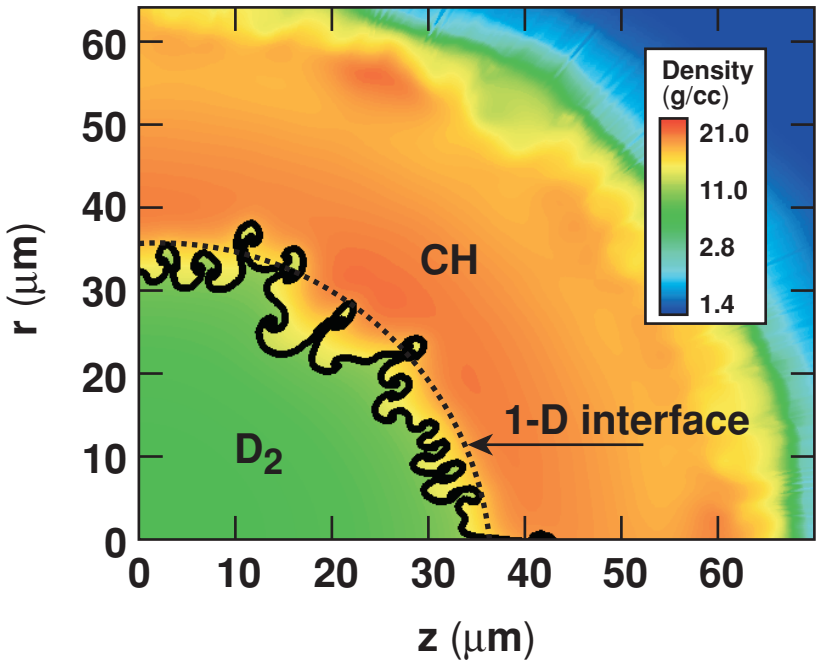
The Effect of Laser Nonuniformities on Plastic Shell Direct-Drive Implosions on OMEGA

UR LLE

Beam-beam imbalances
ℓ = 2–12



Single-beam nonuniformity
ℓ = 2–80



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Collaborators

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Summary

The effects of beam-beam imbalances and single-beam nonuniformity have been simulated in 2-D

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- **Beam-beam imbalances manifest primarily in low-order modes that do not affect target yields; however, significant areal density variations are calculated.**
- **Single-beam nonuniformity significantly affects shell stability during the acceleration phase.**
- **The highly evolved nonuniformities at the fuel–shell interface are suggestive of small-scale mixing.**

Outline

The effect of laser nonuniformities on plastic-shell direct-drive implosions on OMEGA

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- Targets, pulse shapes
- Beam-beam imbalances (BB): modeling, results
- Laser imprint (single-beam nonuniformity): modeling, results

The effect of laser nonuniformities on the performance of plastic-shell targets has been studied

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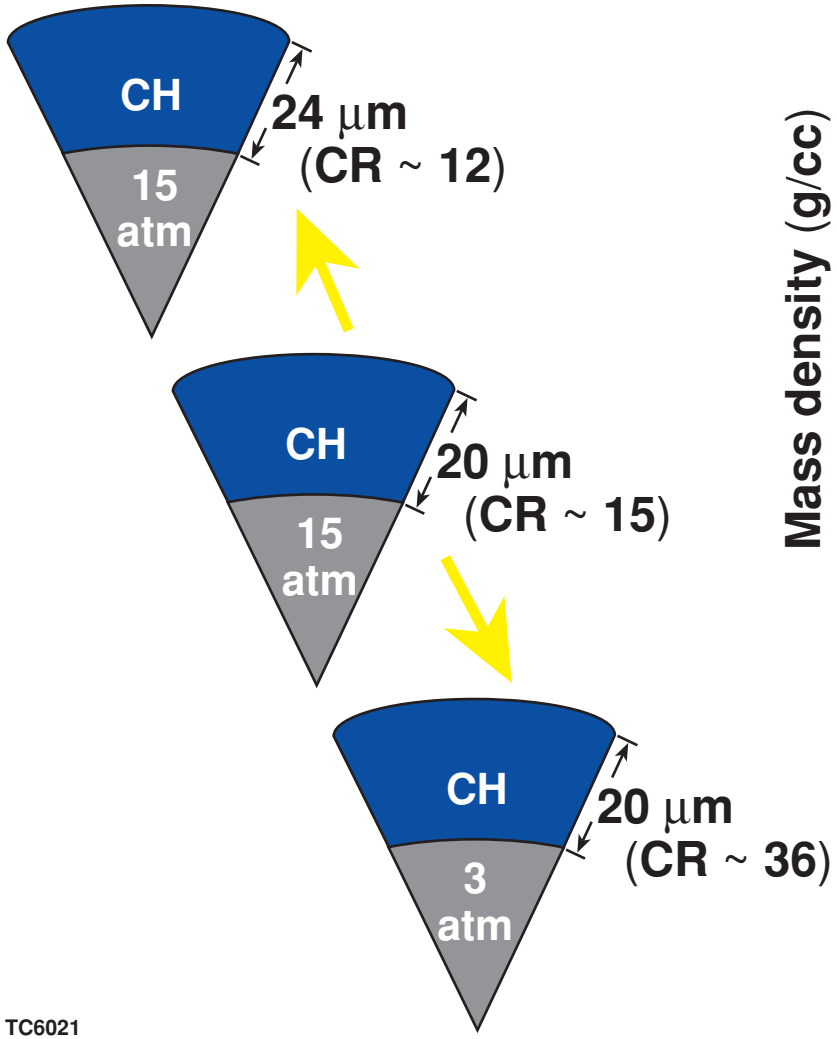
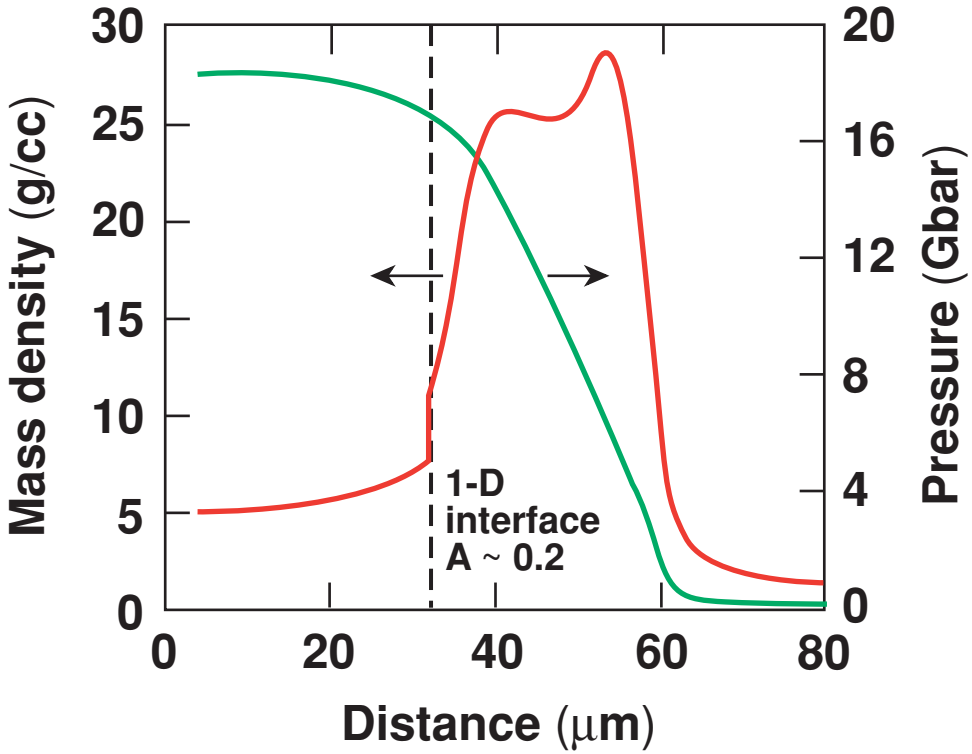
D_2-filled CH shell;
1-ns square pulse
full-beam smoothing



1-D profiles at peak
neutron production
(CR ~ 15)



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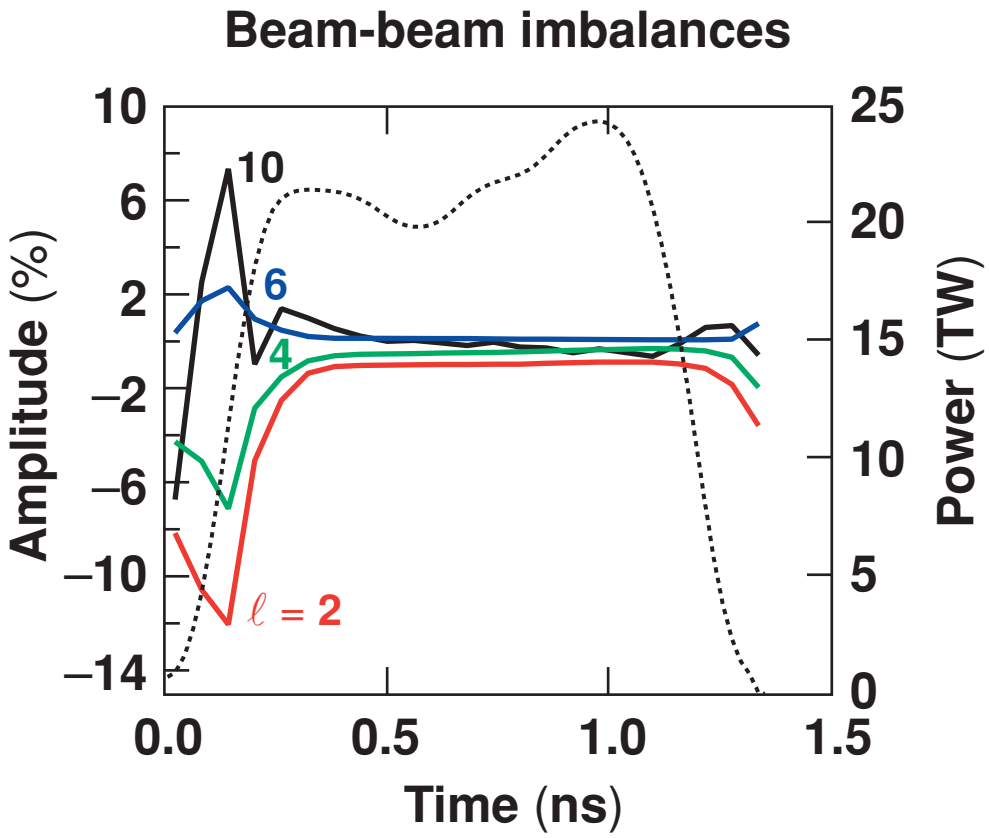
Beam-beam imbalances manifest primarily in low-order modes



- Included are effects of
  - timing imbalance (~20 ps)
  - energy imbalance (~1.7% rms)
- Phase of mode is chosen to be that of the m = 0 spherical harmonic.

Beam-beam imbalances

Shocks primarily determine the nonuniformity seeds at the fuel-shell interface

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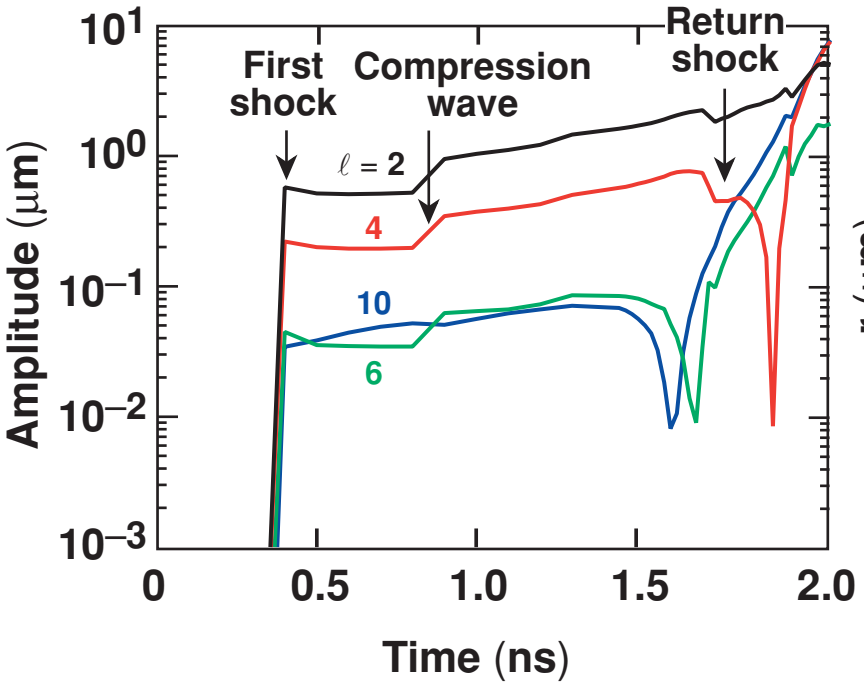
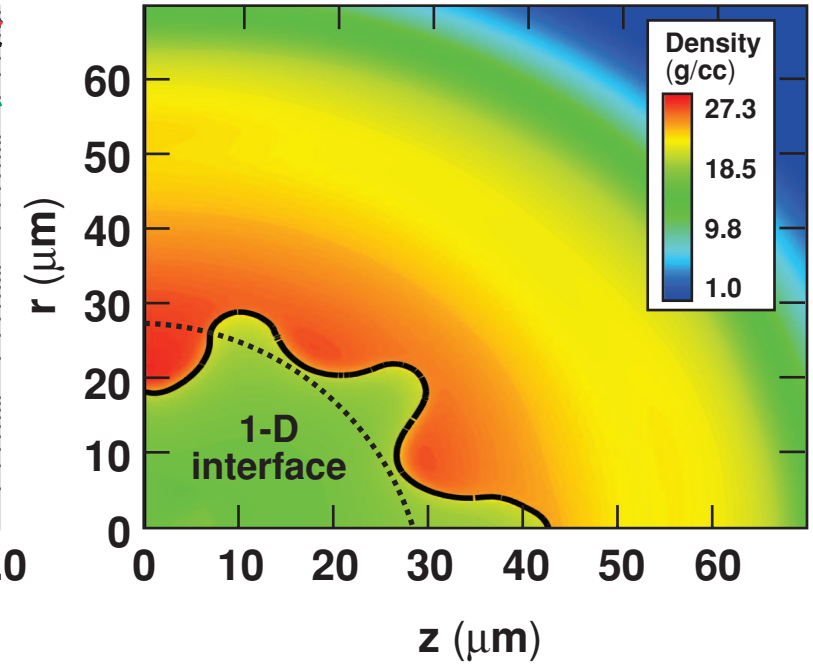
20-μm-CH shell amplitude at fuel–shell interface

ℓ = 2–12



Density contours at peak compression

$\rho R = 113 \, ^{+20}_{-18}$ mg/cm^2



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Other measures of target performance are marginally affected by beam-beam imbalances

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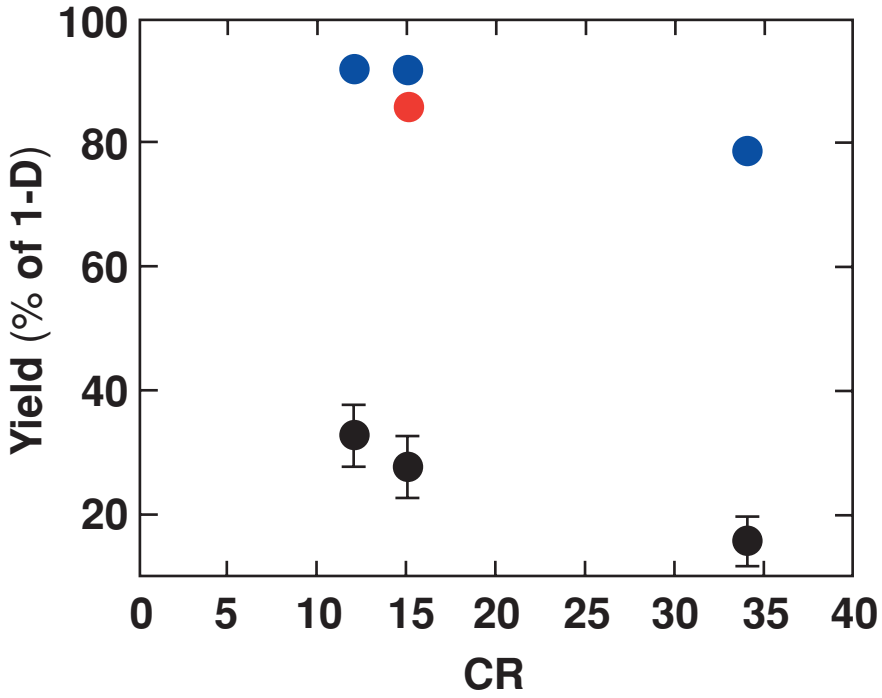
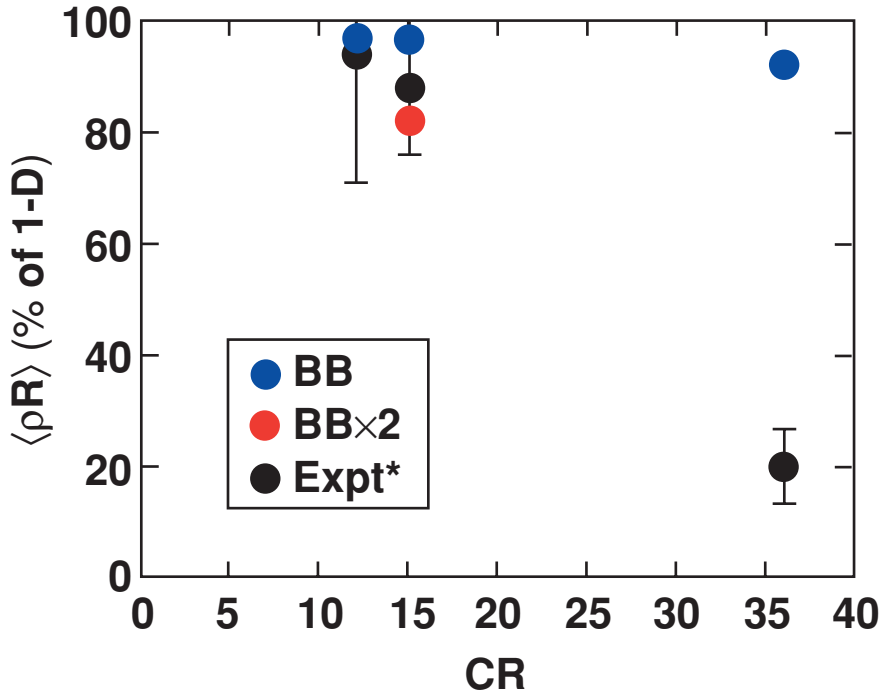
Yield (normalized to 1-D)



Neutron-averaged fuel areal density (normalized to 1-D)



Target performance is being compromised due to high-order modes.

*C. Li *et al.*, Phys. Plasmas 8, 4902 (2001).
**F. Marshall *et al.*, LLE Rev. 91, 116 (2002).

TC6024

Single beam nonuniformity primarily manifests in high order modes

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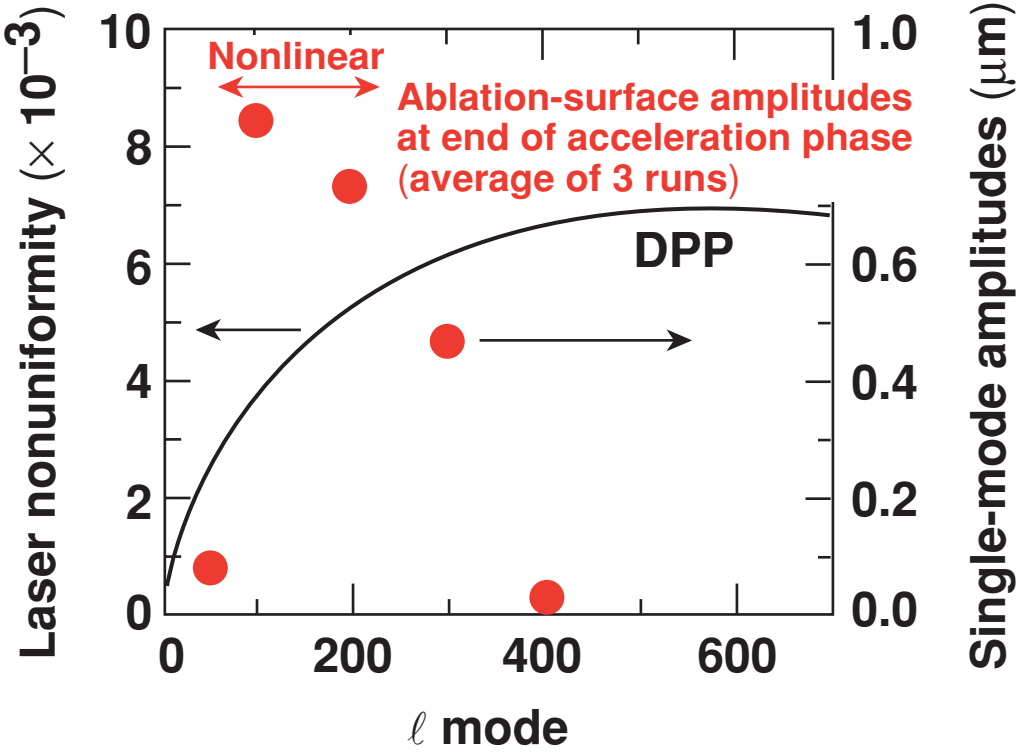
Nonuniformity due to Distributed Phase Plate (DPP) speckle*



- **Laser smoothing is modeled nondeterministically.**

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*R. Epstein, J. Appl. Phys. 82, 2123 (1997).

Single-beam nonuniformity

Laser imprint significantly influences shell stability during the acceleration phase

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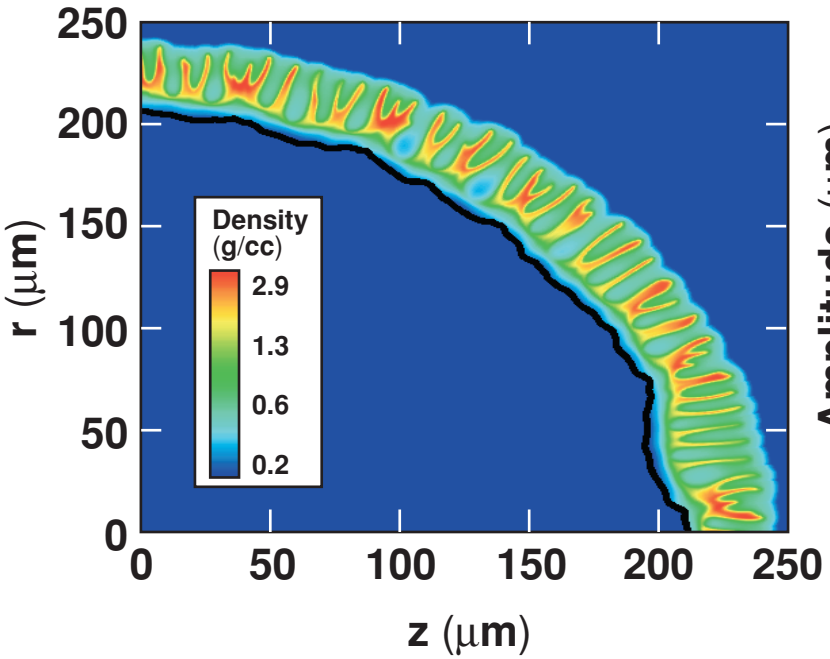
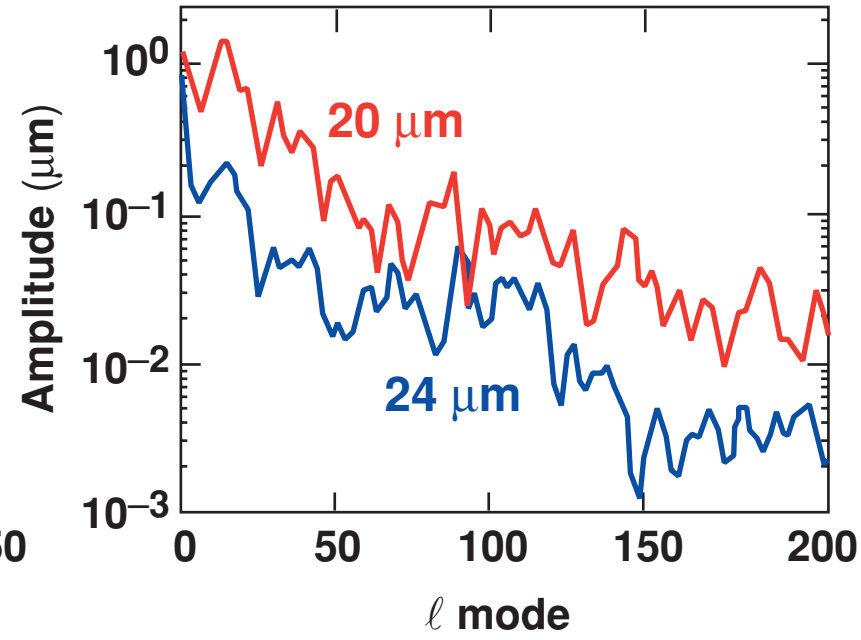
20-μm-CH shell with 15 atm fill
BB + laser imprint (2–200)
at end of acceleration
$\rho R = 5 \, {}^{+2}_{-1}$ mg/cm^2



Amplitude at fuel–shell interface at end of acceleration phase



- Non-uniformity seeds at fuel–shell interface are also determined by shell deformation.

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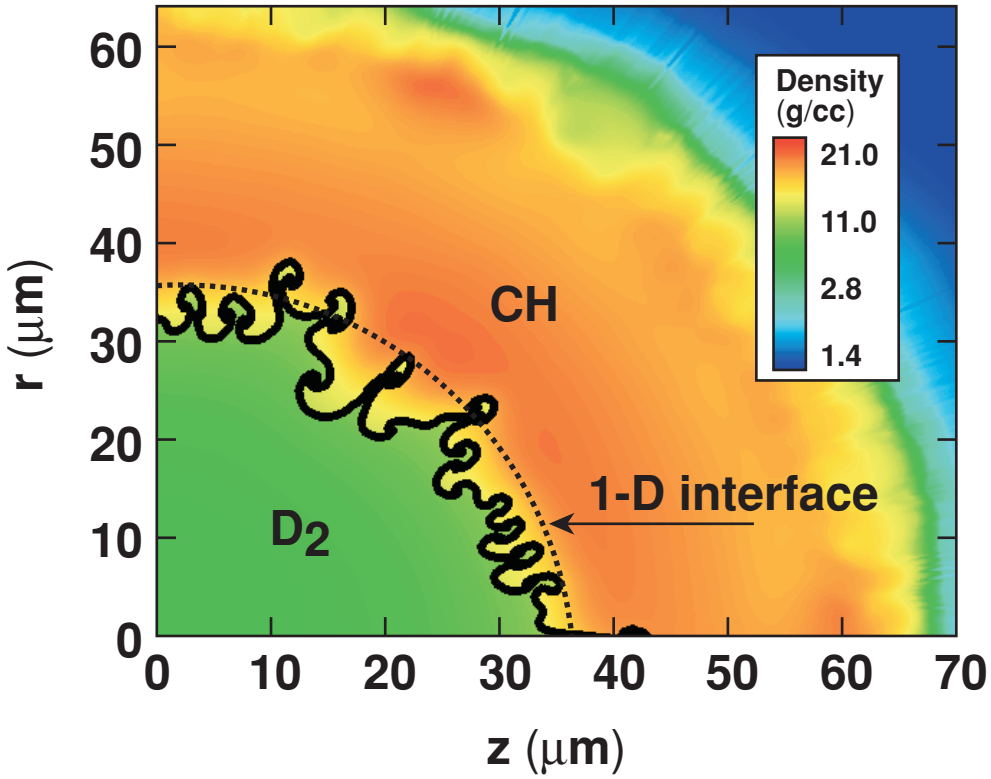
The highly evolved nonuniformities at the fuel-shell interface are suggestive of small-scale mixing

20 μm CH shell; 15 atm fill
laser imprint at peak neutron production
ℓ = 2–80



Yield (% of 1D)	
Imprint only (2–80)	80
BB (2–12)	92
BB×2 (2–12)	88
Experiment	(28±4)

P. B. Radha *et al.*, Phys. Plasmas 9, 2208 (2002).
C. K. Li *et al.*, Phys. Rev. Lett. 89, 165002-1 (2002).
S. P. Regan *et al.*, BO2.002
J. A. Frenje *et al.*, BO2.003

Summary/Conclusions

The effects of beam-beam imbalances and single-beam nonuniformity have been simulated in 2-D

UR LLE

- Beam-beam imbalances manifest primarily in low-order modes that do not affect target yields; however, significant areal density variations are calculated.
- Single-beam nonuniformity significantly affects shell stability during the acceleration phase.
- The highly evolved nonuniformities at the fuel–shell interface are suggestive of small-scale mixing.
- Large-scale simulations to assess the effect of laser imprint on target performance are ongoing.