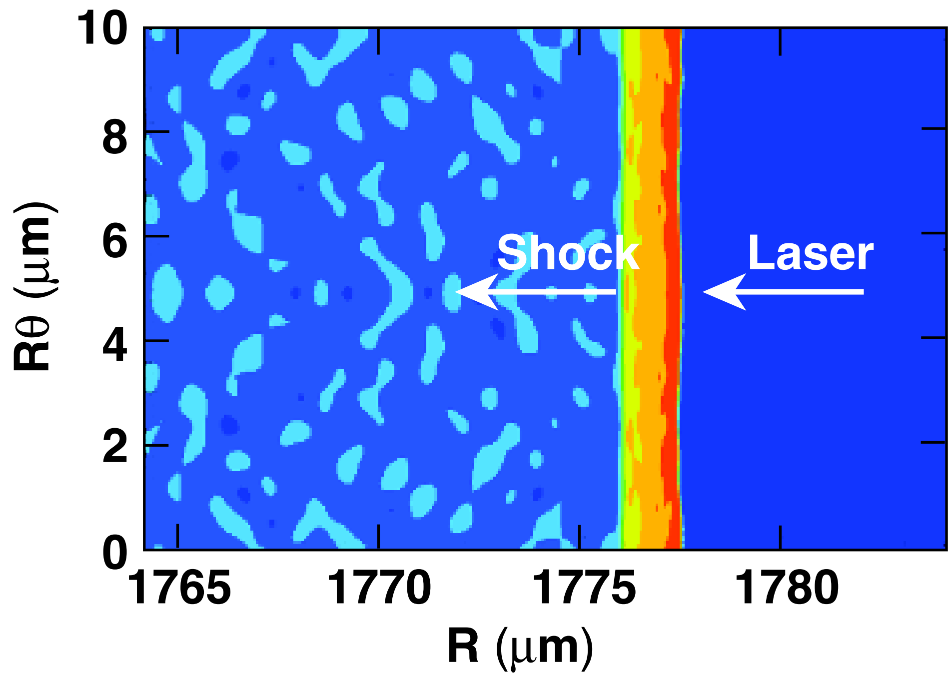
High-Gain NIF Target Designs for Direct Drive Using Wetted Foam



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Summary

The high-gain wetted-foam design has almost double the gain, and similar stability as of the "all-DT" design

- The foam increases absorption and reduces radiative preheat.
- The density fluctuations in the foam result in surface nonuniformities.
- Simulations of bare-DT targets show surface amplitudes $\sim$ 10 nm for wavelengths $\leq$ 10 μm.

TC5786

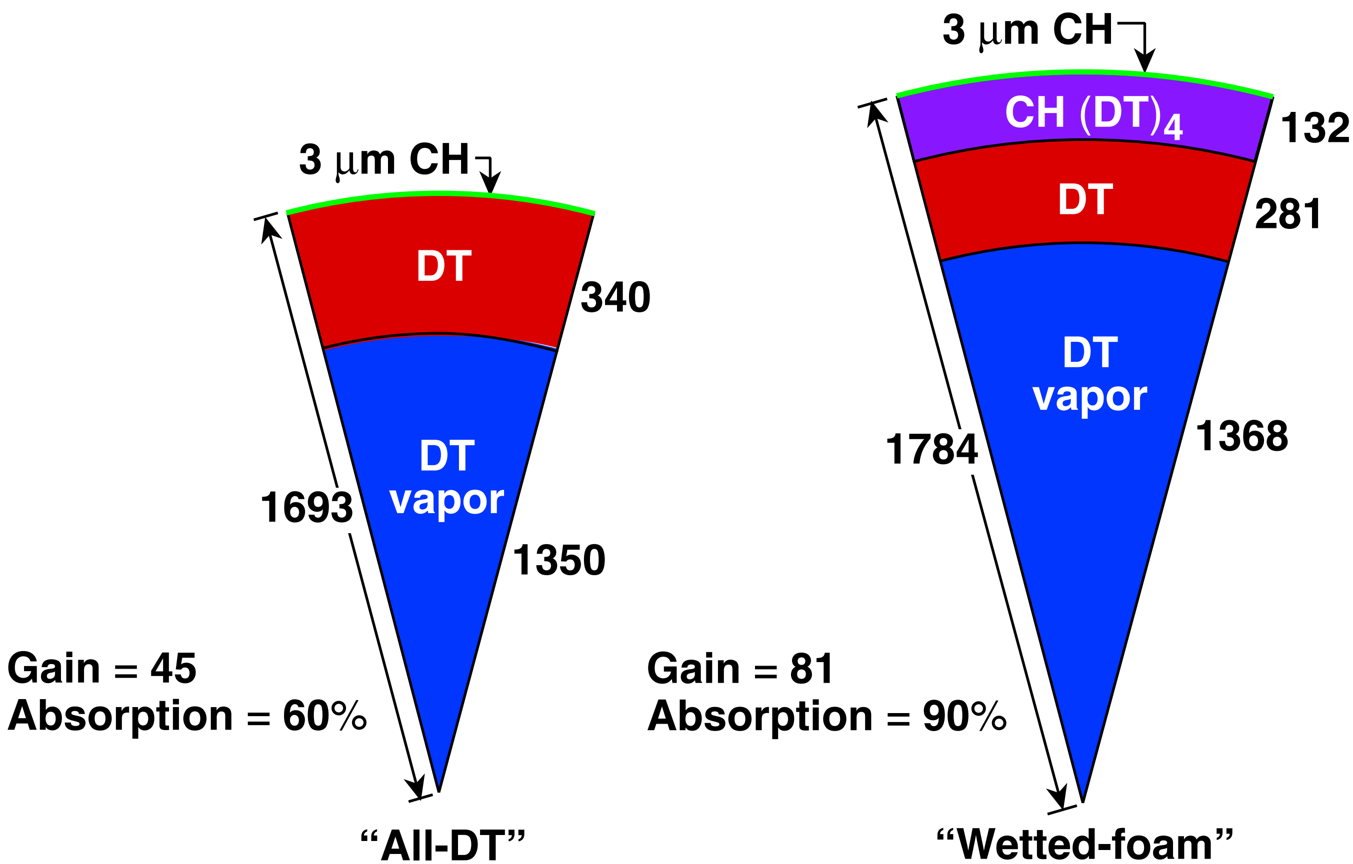
Outline

High-gain wetted-foam design

- Reasons the increased gain
- Effects of foam-density inhomogeneities

Wetted-foam targets have higher laser absorption and more fuel, resulting in higher target gain

- Foams have been used previously to selectively radiatively preheat the ablator.[1]



- If the foam is replaced by DT and the absorption is increased, the gain remains 81.
- The foams also protects the fuel from preheat due to radiation from the CH.

[1] D.G. Colobant et al., Phys. of Plasmas 7, 2046 (2000).

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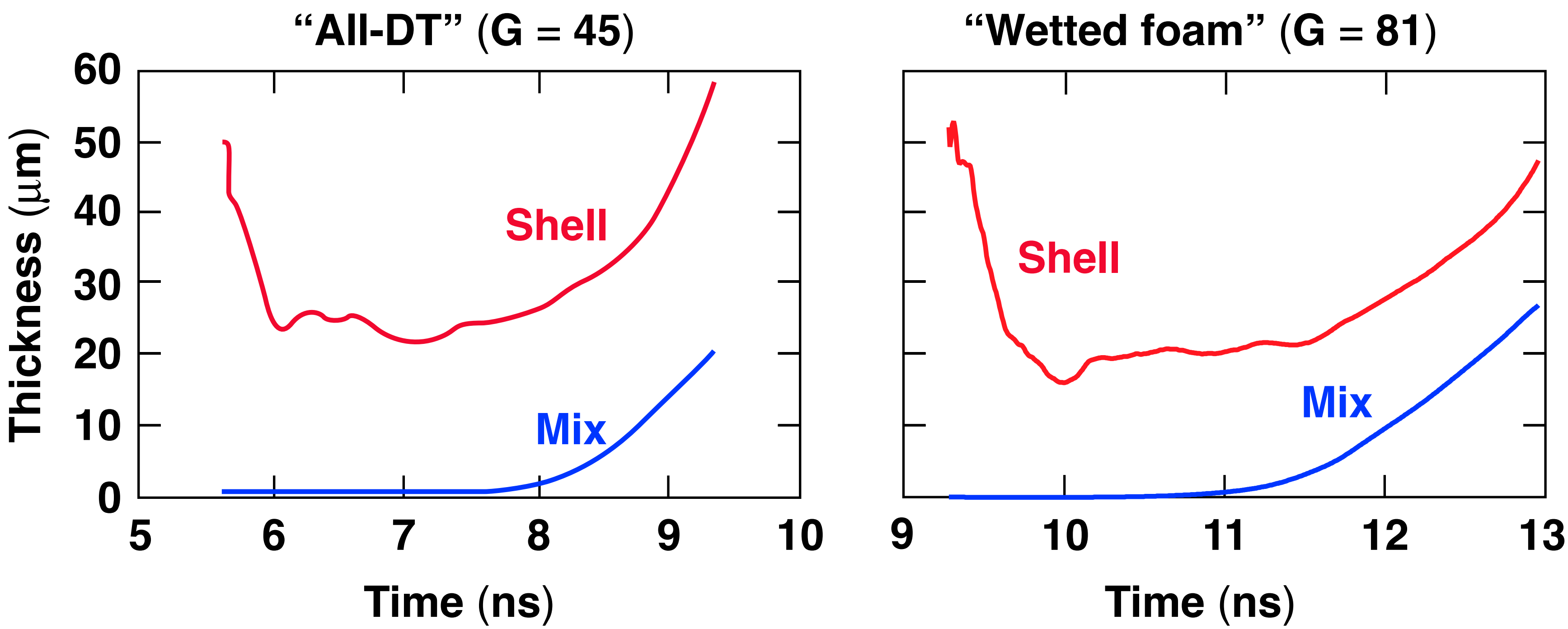
A preliminary analysis shows similar hydrodynamic stability during acceleration for the “wetted foam” and “all-DT” designs (1.5 MJ)



Assumptions:

- “Wetted foam” has the same laser imprint as the “all-DT” design (1 THz).
- “Wetted foam” is treated as a homogeneous mixture.
- Inner-surface roughness = 1 μm.

V. N. Goncharov et al., Phys. Plasmas 7, 5118 (2000).

Different wetted-foam designs are being examined for NIF

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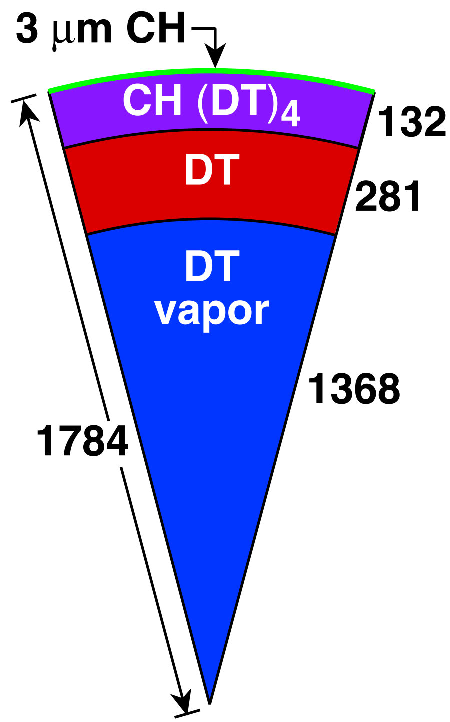
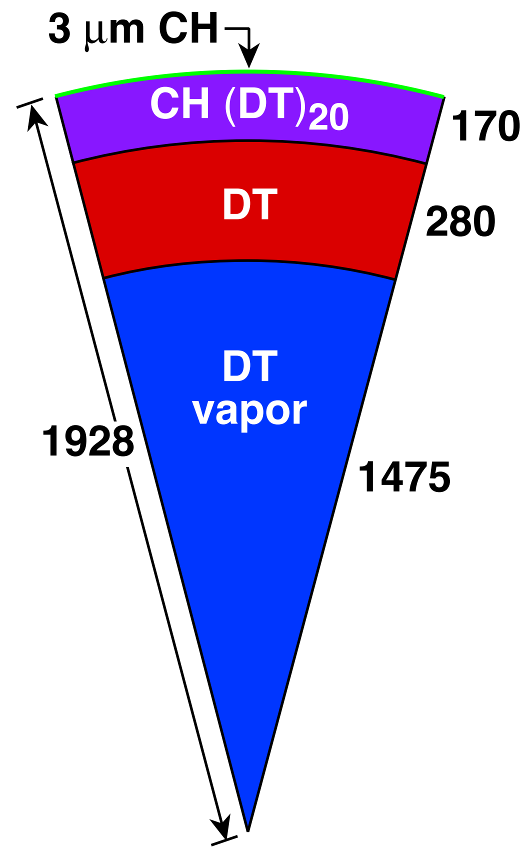
1.5-MJ Wetted-Foam Designs		
	1	2
Foam (mg/cm^3)	140	30
Gain	81	120
Absorption (%)	90	85
ρR (g/cm^2)	1.4	1.7
Adiabat	2.5	2.0
Margin	48	32
Velocity (cm/s)	4.0×10^7	3.2×10^7





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The foam also protects the fuel from radiative preheat

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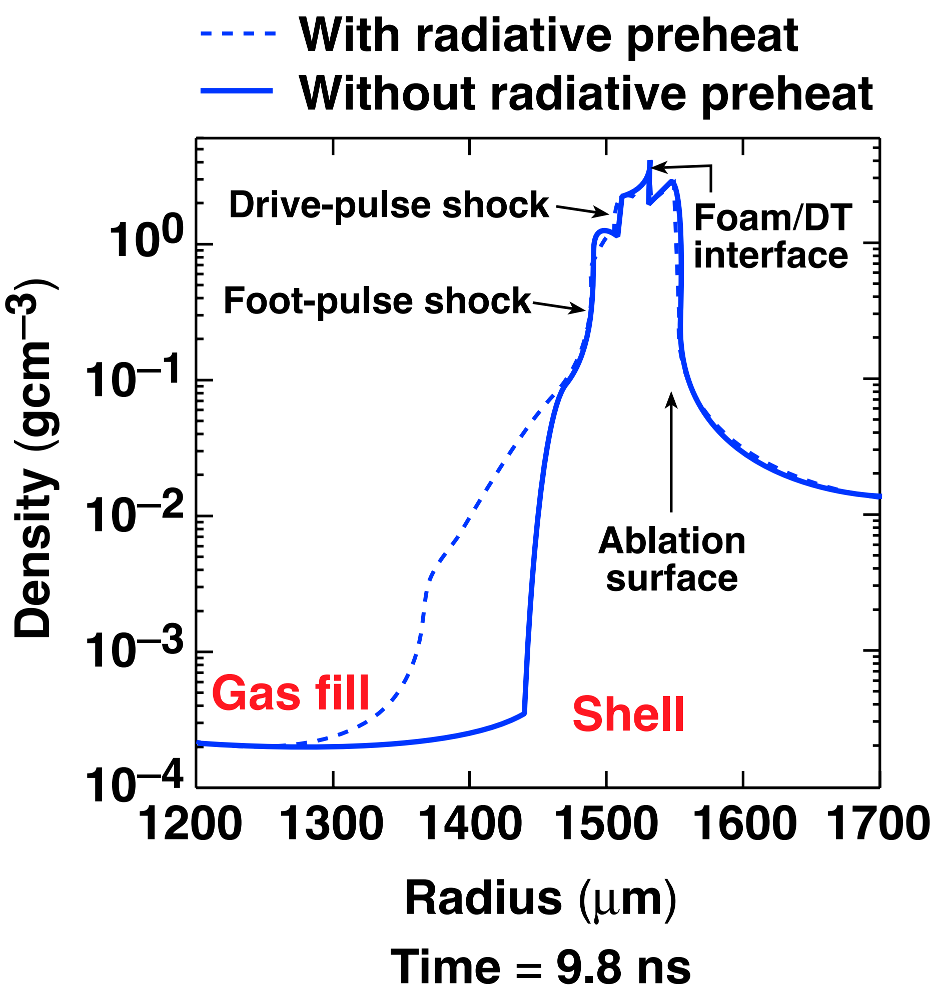
- The inner edge of the shell expands into the fill in the absence of foam protection from radiative preheat.
- When the main shock passes down this density gradient, it is strengthened and moves faster.
- The thicker shell of the higher-gain design requires shielding from radiative preheat for successful shock/shell timing.



TC5782

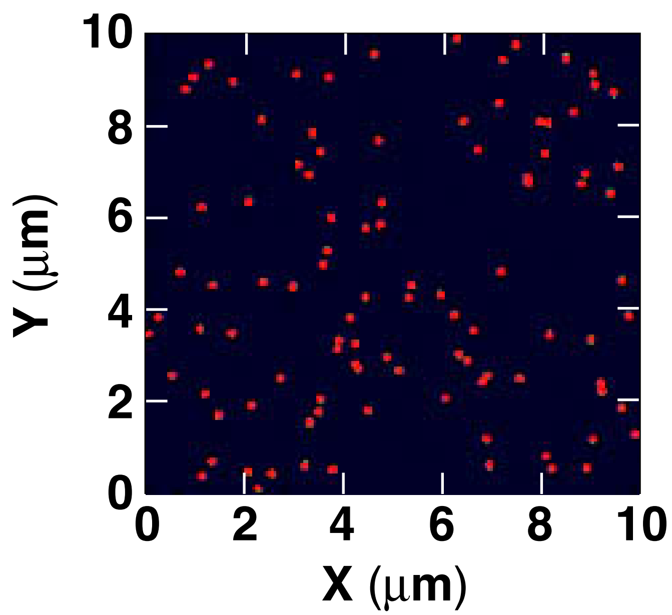
Shocks passing through foam result in turbulence, and short-term under-compression

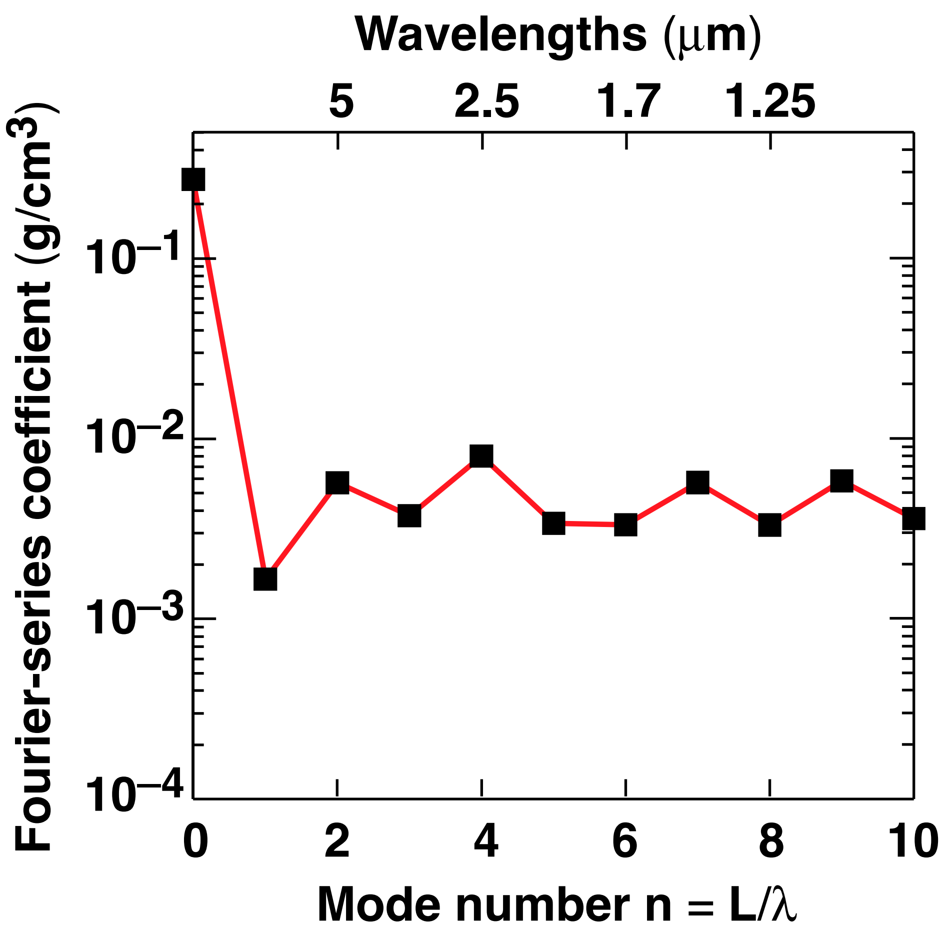
- A shock in foam causes fluctuations in velocity, pressure, etc., and a modified shock speed[1].
- These fluctuations weaken the shock, reducing the post-shock average pressure and density.
- The fluctuations decrease in time << shock propagation time.

[1] G. Hazak et al., Phys. Plasmas 5, 4357 (1998).

The spectrum of density fluctuations for fibrous foams wetted with DT

- The 2-D Fourier transorm of a wetted foam was calculated (for a box size of L = 10 μm).
- The spectrum is relatively flat for low mode numbers.





Foam properties:
- Fiber spacing ~ 1 μm
- Fiber radius ~ 0.1 μm

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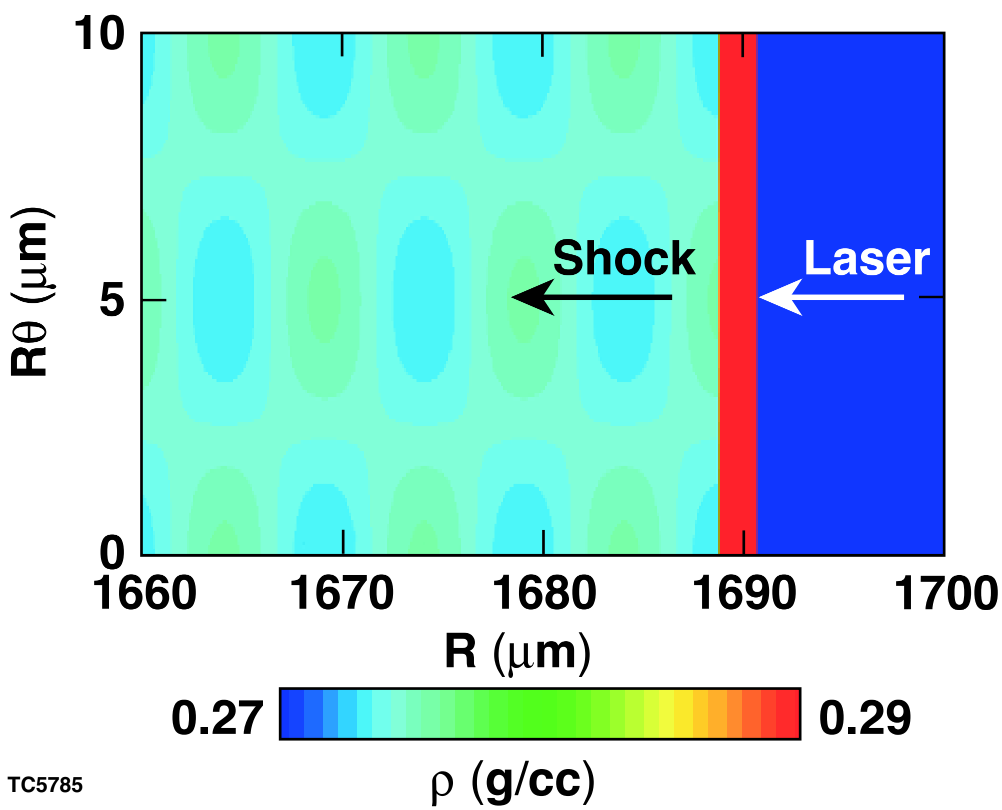
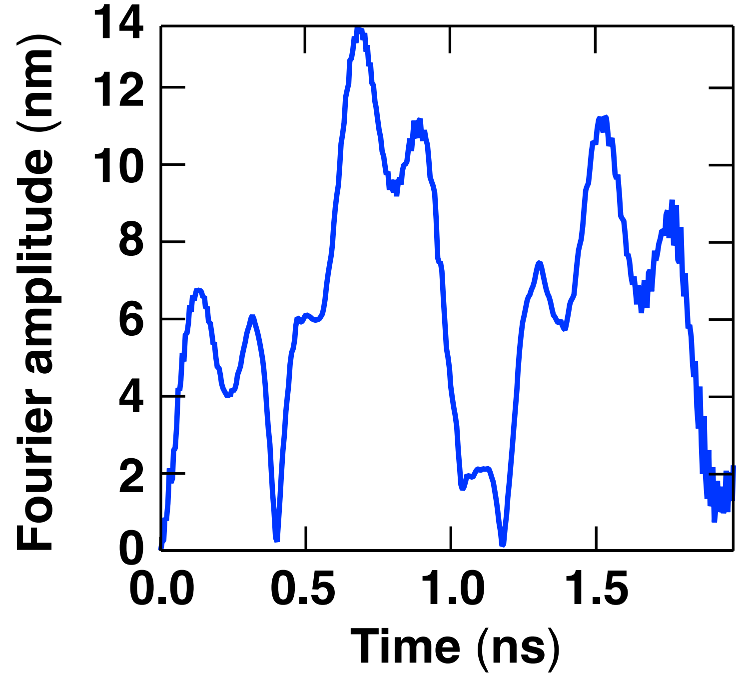
Foam inhomogeneities produce surface nonuniformities

- A single mode with λ = 10 μm (NIF: $\ell \sim$ 1120; OMEGA: $\ell \sim$ 370) of the foam density fluctuations was imposed on a foam target.
- The surface nonuniformity during shock transit has an amplitude ~ 10 nm.
- The ablative stabilization cutoff for DT is 10 μm.
- The growth remains linear, not spreading to longer wavelengths.





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Fiber-resolved simulations are needed

- Previous studies[1] have modeled the hydrodynamics of shock propagation in a wetted foam.
- Simulations underway with fiber-scale resolution of wetted foams will determine the resulting surface nonuniformities.

[1] G. Hazak et al., Phys. Plasmas 5, 4357 (1998).

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