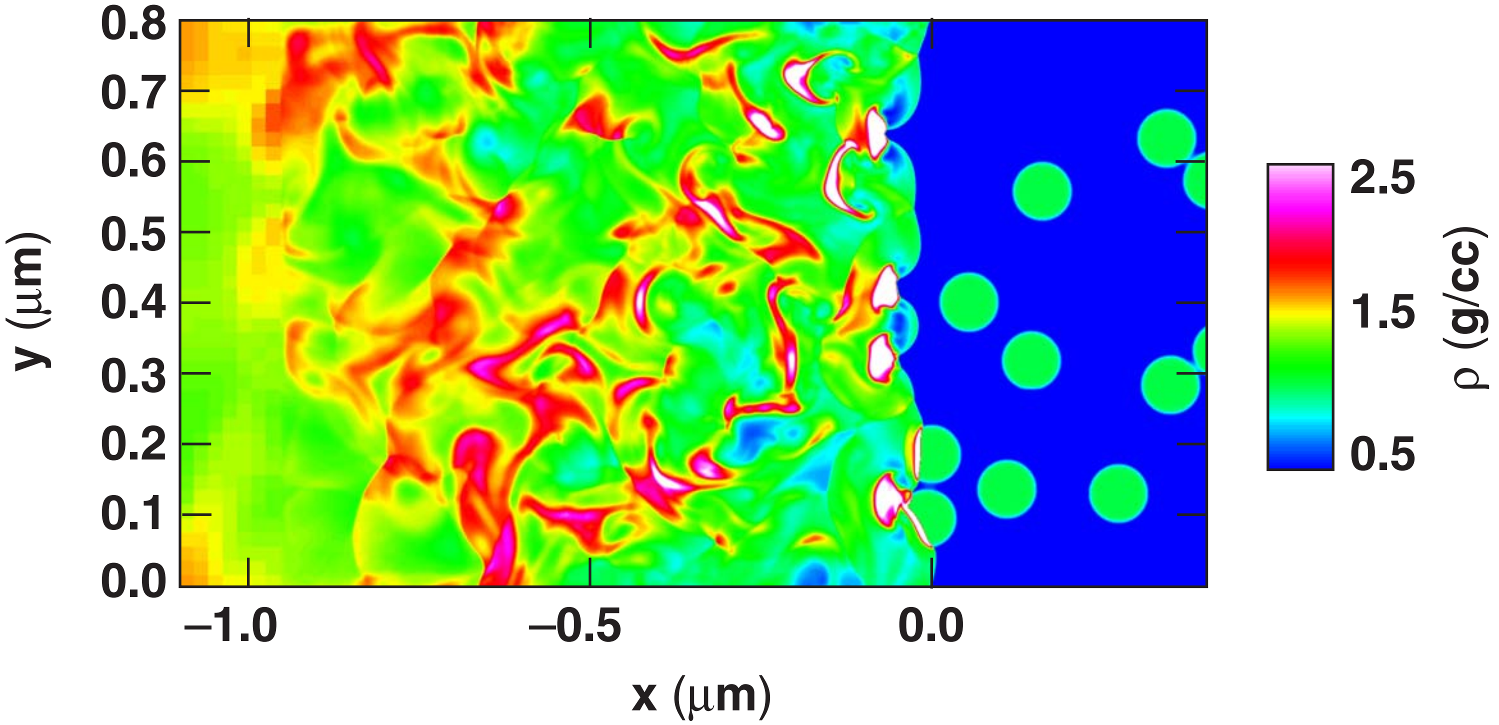
Shock Propagation in Wetted Foam



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Summary

Strong shocks in wetted foam obey the Rankine–Hugoniot jump conditions

- Plastic foam layers saturated with DT in NIF ignition target designs have higher laser absorption and higher gains than “all-DT” designs.
- Shock interaction with the foam microstructure generates a mix region for the CH fibers and the DT fuel.
- The post-shock conditions quickly approach to within a few percent of the Rankine–Hugoniot values, validating the homogeneous approximation.

Collaborators

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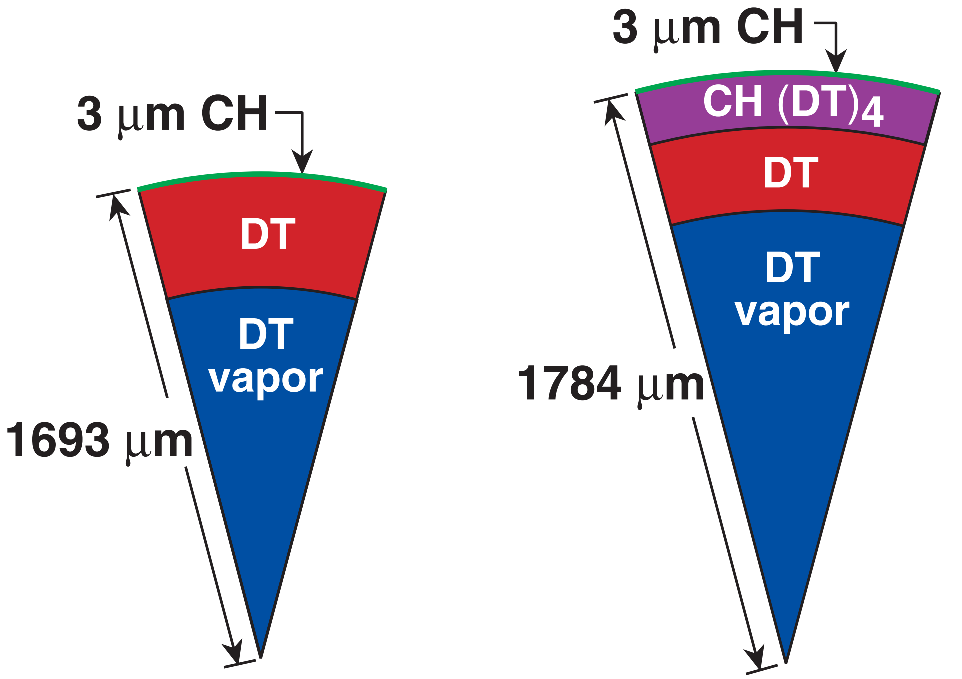
Wetted foams have higher absorption, allowing higher gain for stability comparable to all-DT designs

- A typical foam fiber spacing is 0.2 μm.
- Wetted foam designs are generally simulated using an average mixture of the CH and DT.
- Fiber-resolved simulations are used to gauge effects of microstructure on shock propagation[1].



"All-DT"
1-D gain = 45
Absorption = 60%

"Wetted-foam"
1-D gain = 81
Absorption = 90%

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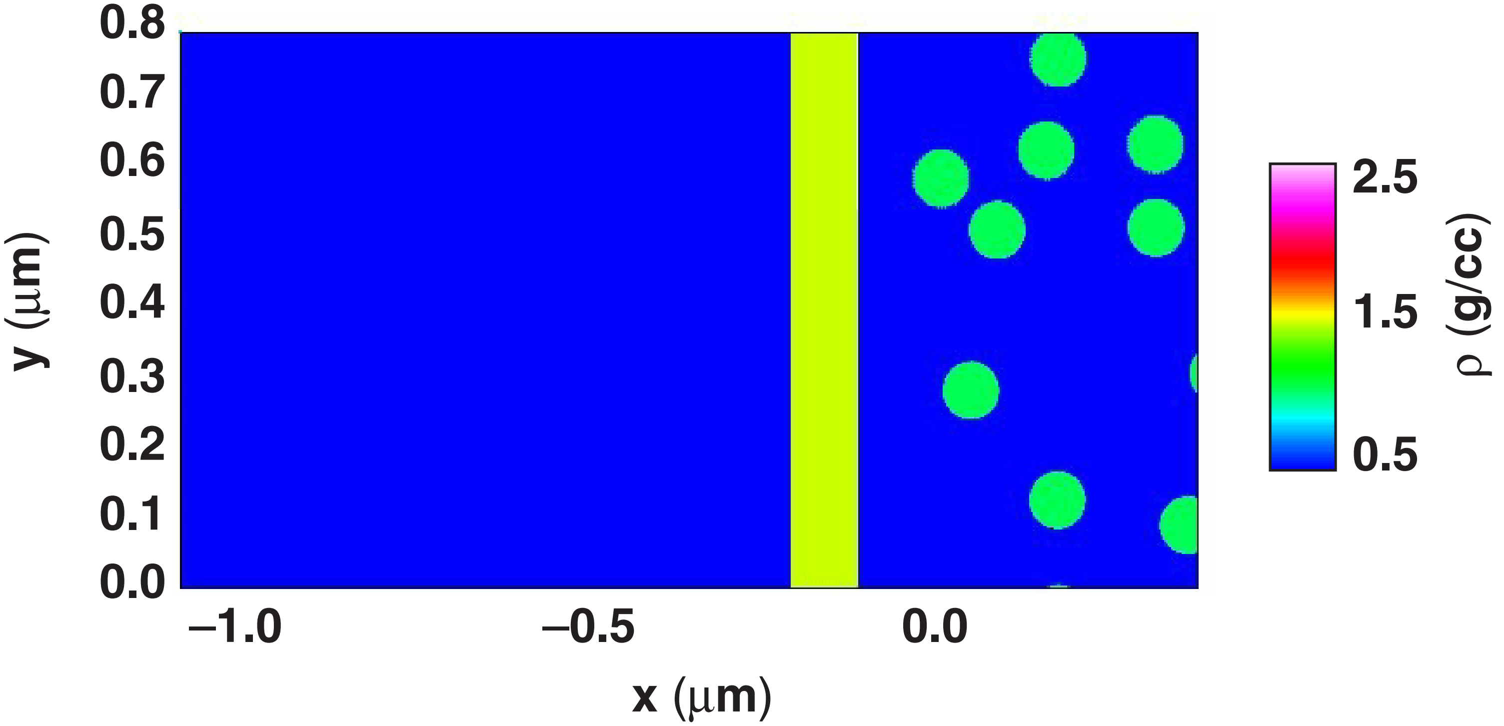
[1] G. Hazak *et al.*, Phys. Plasmas 5, 4357 (1998), A. D. Kotelnikov and D. C. Montgomery, Phys. Fluids 10, 2037 (1998), F. Philippe *et al.*, Laser Part Beams 22, 171 (2004).

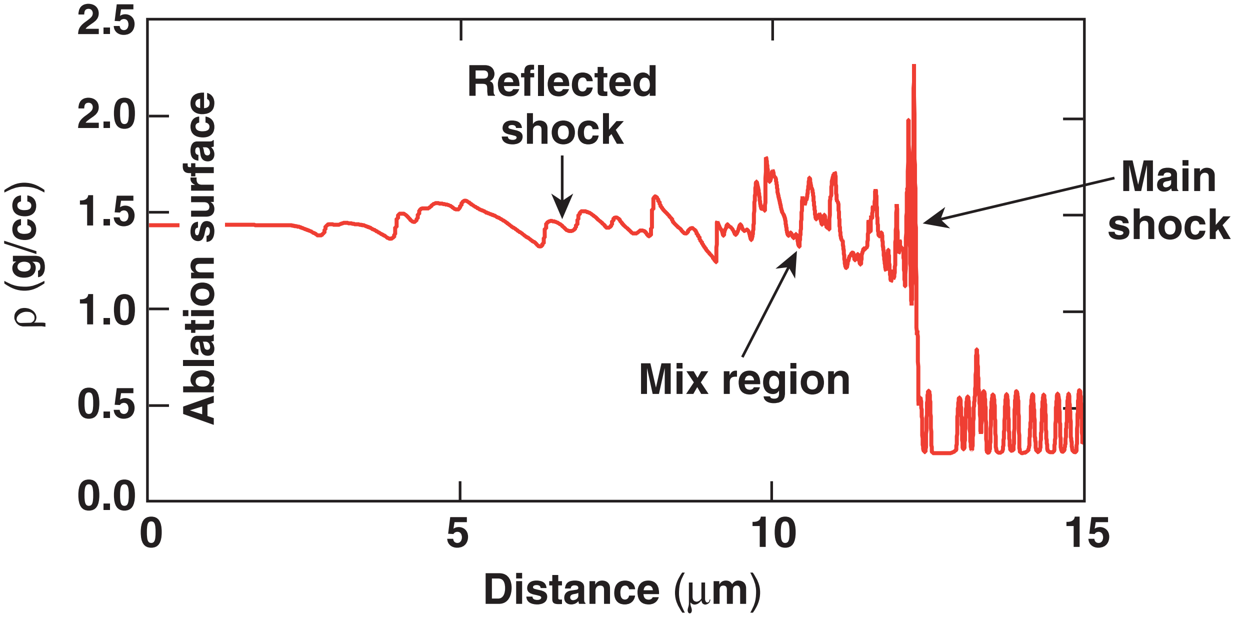
The adaptive-mesh refinement code *AstroBEAR* was used to model the fluid flow in wetted-foam layers

- *AstroBEAR* uses ideal-gas EOS, and has no radiation or heat transfer.
- *AstroBEAR* solves the (inviscid) Euler equations with material tracking.
- The inflow boundary condition models steady-state ablation.



The inflow conditions used model the ablative boundary condition in wetted-foam targets

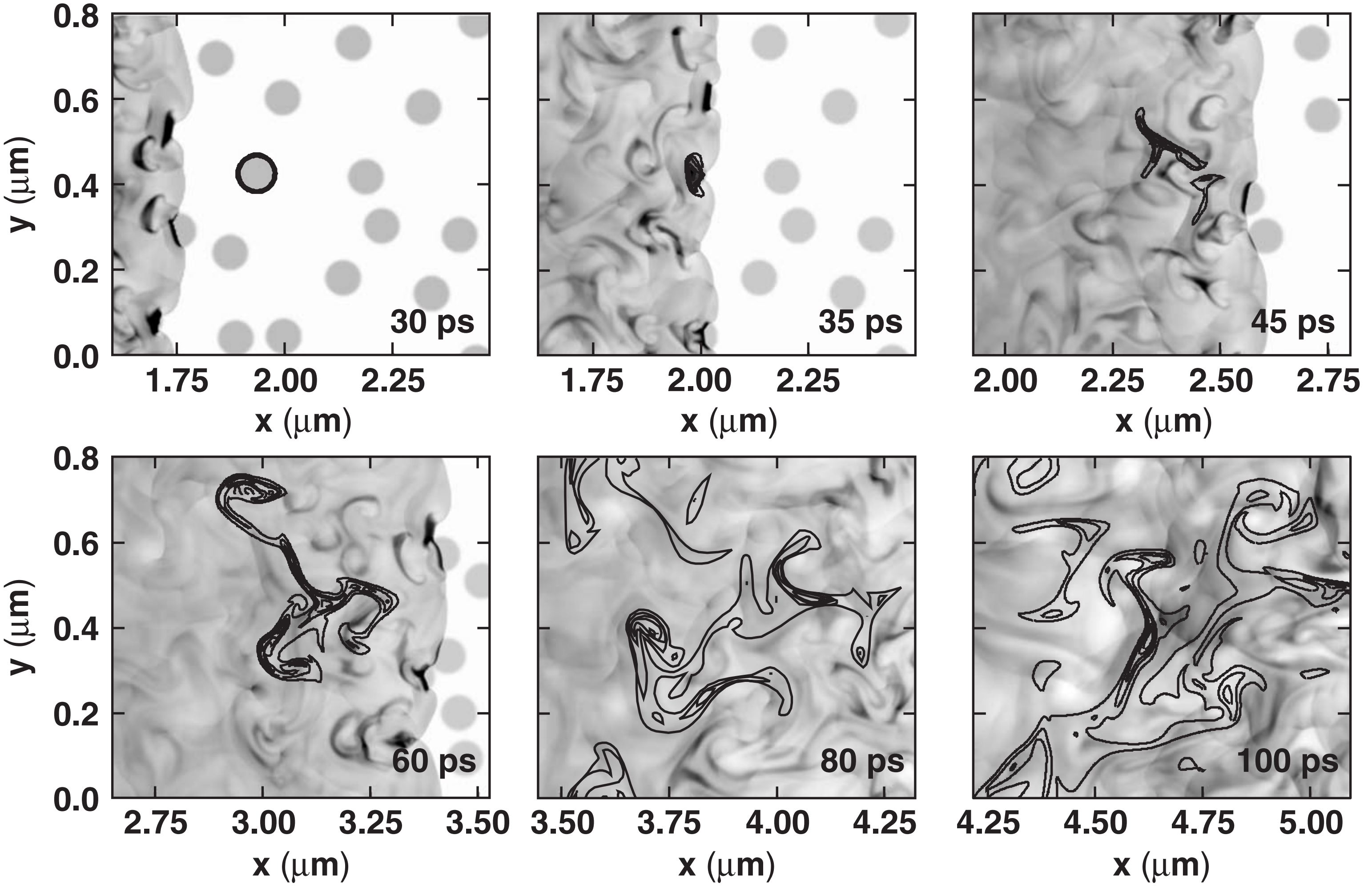
- In an ICF wetted-foam target, the main shock reflects off the fibers, sending shocks toward the ablation surface.



- These raise the post-shock pressure above the ablation pressure.
- When they reach the critical surface, a rarefaction wave is sent into the target correcting this overpressure.
- The corrected pressure is simulated in the AMR simulations using inflow conditions equal to the steady-state post-shock conditions in the wetted foam.

The DT and fiber materials are efficiently mixed by the first shock

- **The level of mixing can be gauged by tracking a single fiber.**



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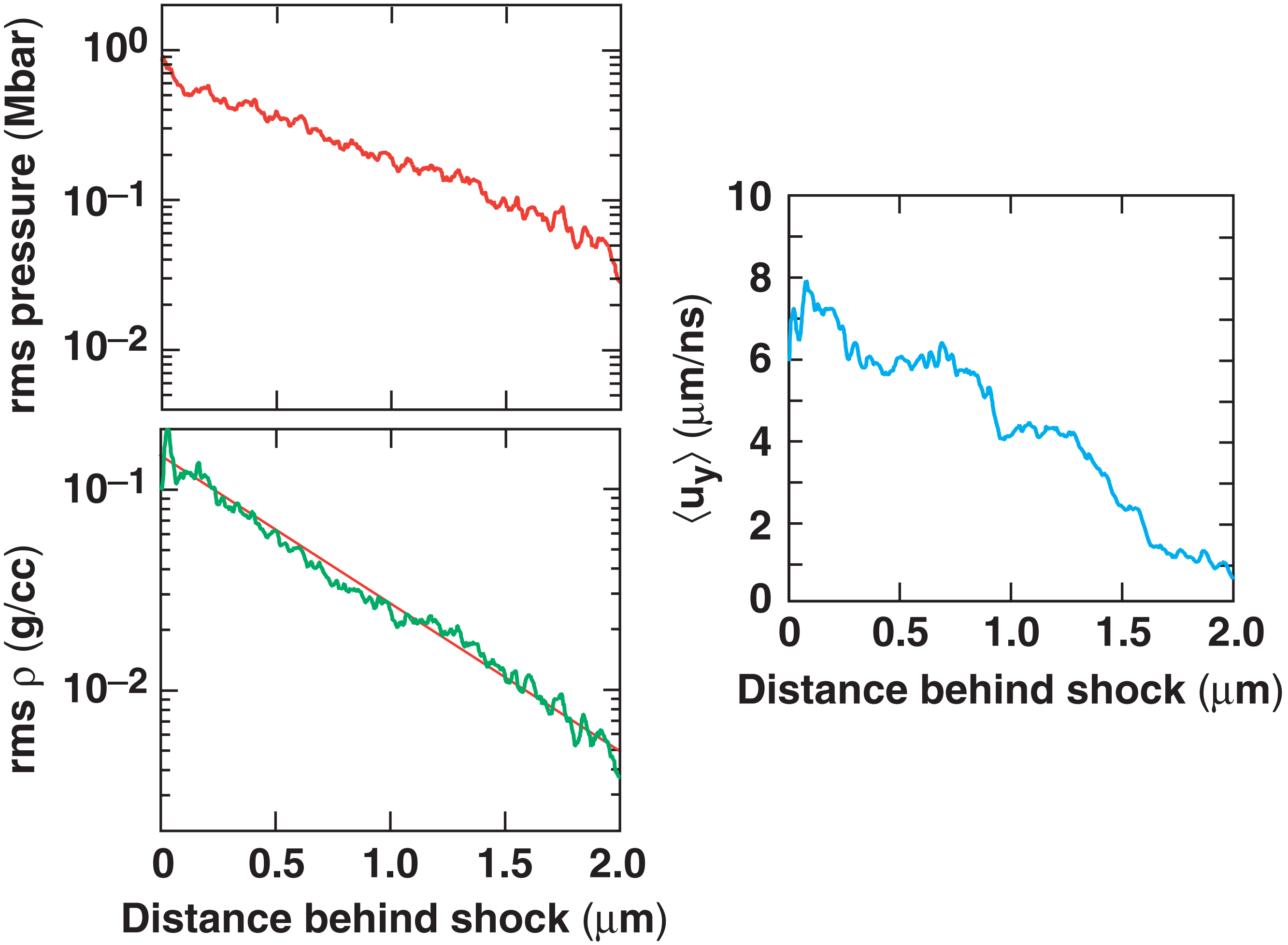
Fluctuations decay quickly behind the shock

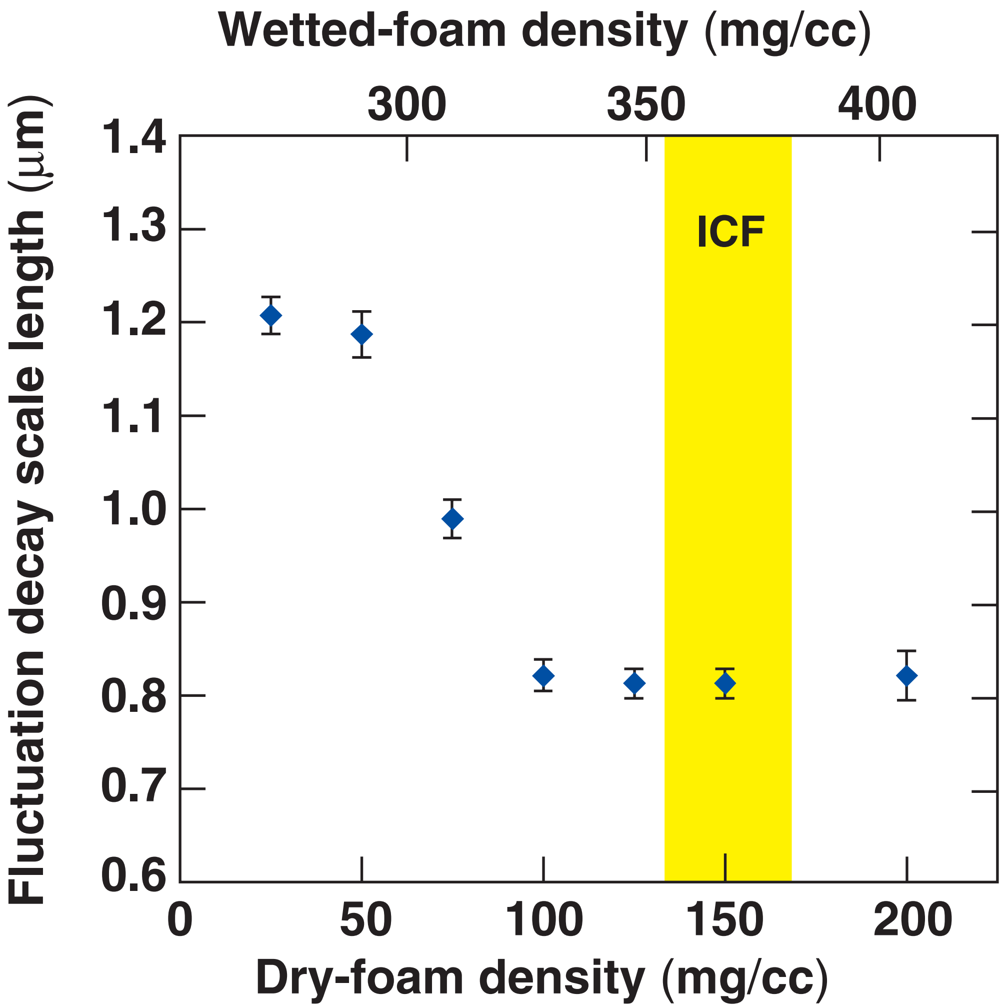
- The decay rate is approximately the same for each mode.
- The decay rate does not change when the resolution is increased.



- Simulation size 8 μm × 0.8 μm.

The fluctuation decay scale length is ≤ 1.2 μm

- The ICF-relevant foam densities are large enough to provide increased absorption, but small enough to minimize radiative preheat of the fuel.



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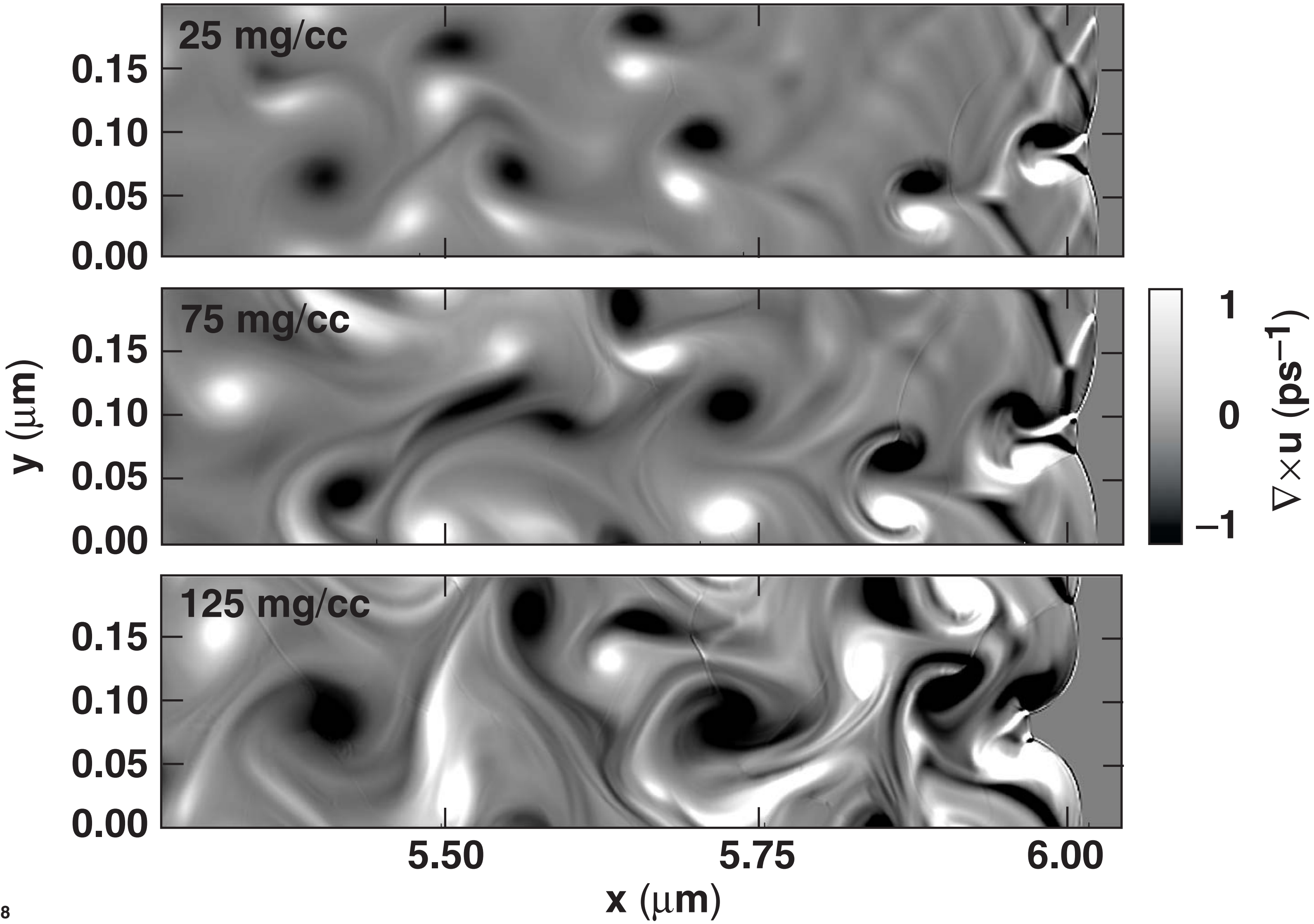
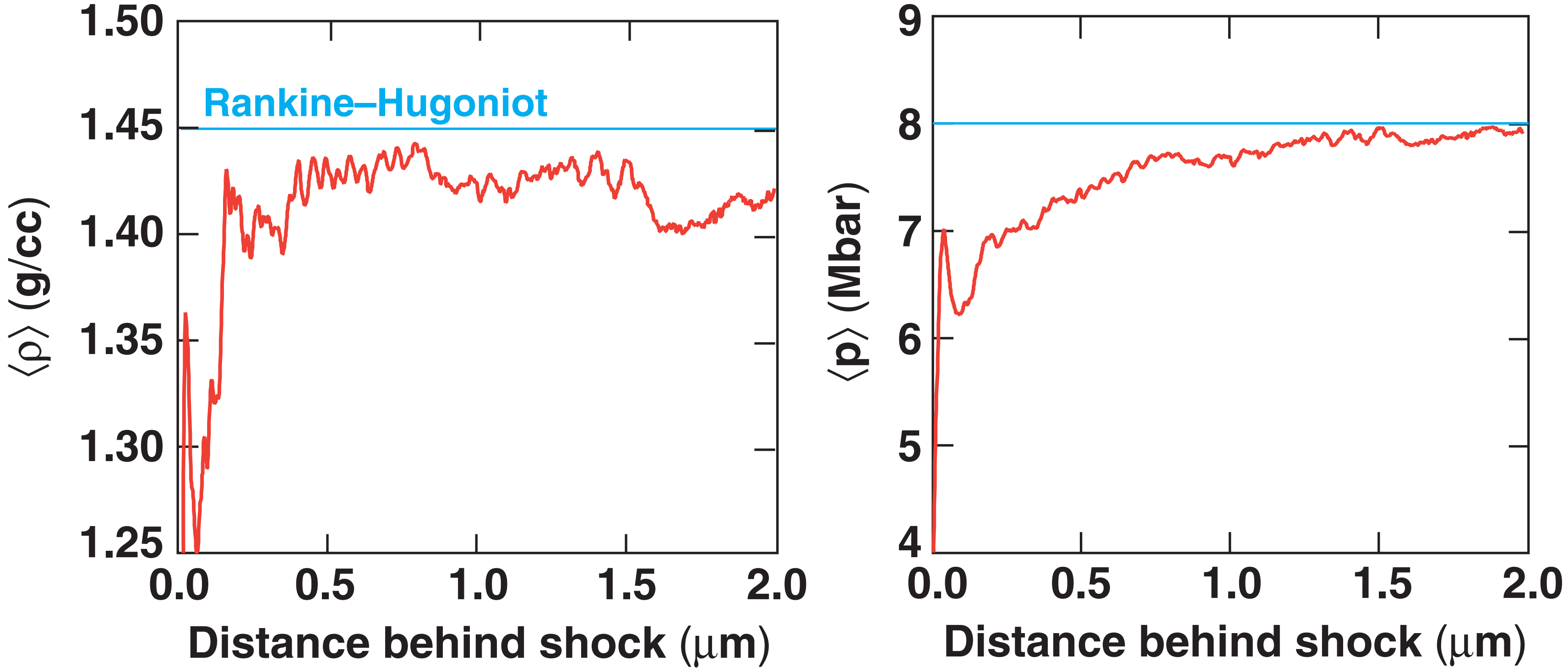
The fiber vortex pair interaction time scale is determined by the foam density



TC6808

The flow variables asymptote to a few percent of the Rankine–Hugoniot values

- From an 0.8 μm × 8 μm simulation:



- The ratio of the kinetic energy to total energy is 52% in the mix region.
- The shock speed is ~0.3% slower than the homogeneous shock speed.

Summary/Conclusions

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