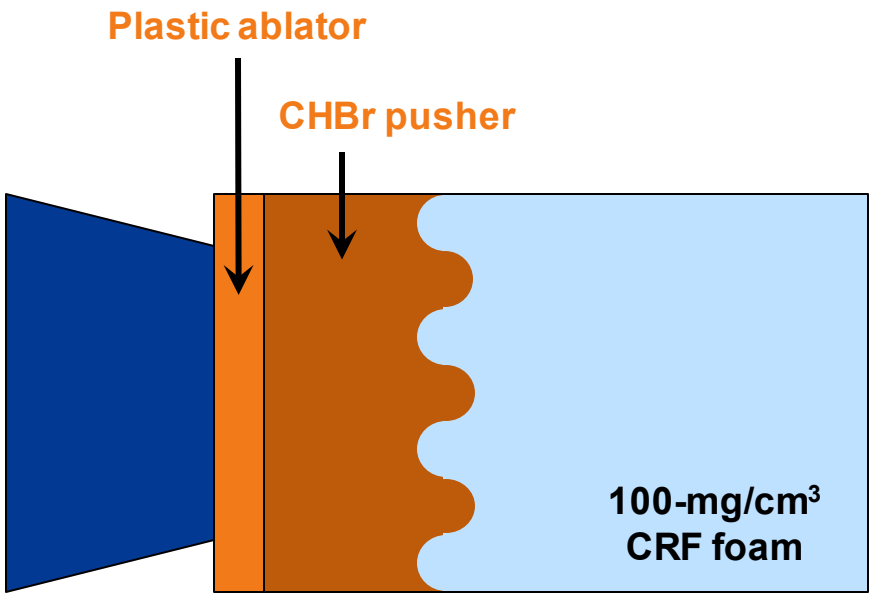
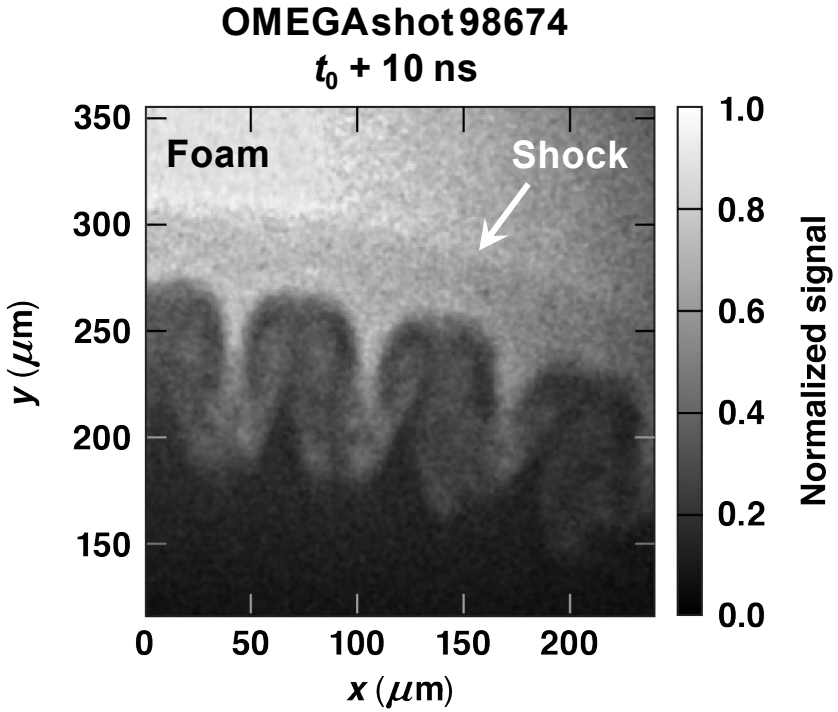
High-Resolution X-Ray Imaging of Shock-Driven Interface Dynamics





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Summary

X-ray radiography of highly nonlinear perturbation growth at a planar, shock-driven interface is significantly improved using a Fresnel zone plate

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- Resolution tests using a zone plate and a 4.75-keV Ti He-like resonance line have achieved 1-μm static spatial resolution using direct x-ray detection with a CCD
- Radiographs are obtained of single-mode perturbation evolution at a shock-driven interface between a plastic pusher and a low-density foam
- With few-micron dynamic resolution, the data show clear bubble and spike growth, the spike-tip morphology during roll-up, secondary instabilities, and spike breakup

CCD: charge-coupled device

Collaborators

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*Retired

Experiments were carried out using single-mode perturbation evolution at an embedded interface following the passage of an unsupported shock wave

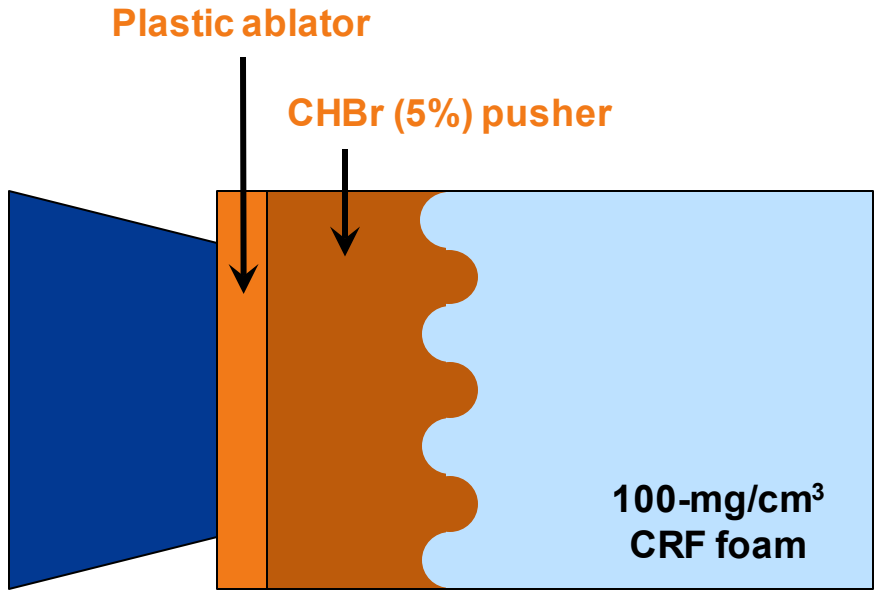
OMEGA laser drive

- 2.25-kJ, 1-ns pulse
- 7×10^{14} W/cm^2

or

OMEGA EP laser drive

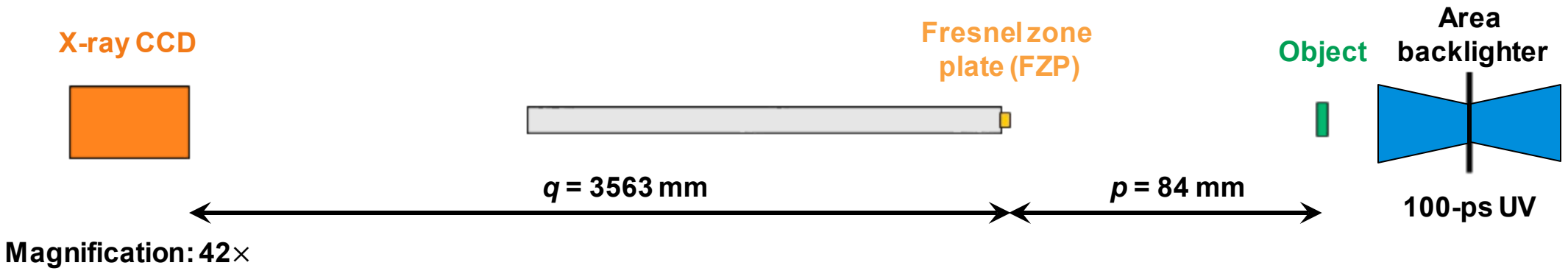
- 2.20-kJ, 2.5-ns pulse
- 2×10^{14} W/cm^2



- Initial modulation wavelength: 50 or 100 μm
- Peak-to-valley amplitude: 10 or 20 μm

CRF: carbonized resorcinol formaldyhyde

The OMEGA radiography platform couples a laser-driven area backlighter to a high-magnification zone plate optic and an x-ray CCD



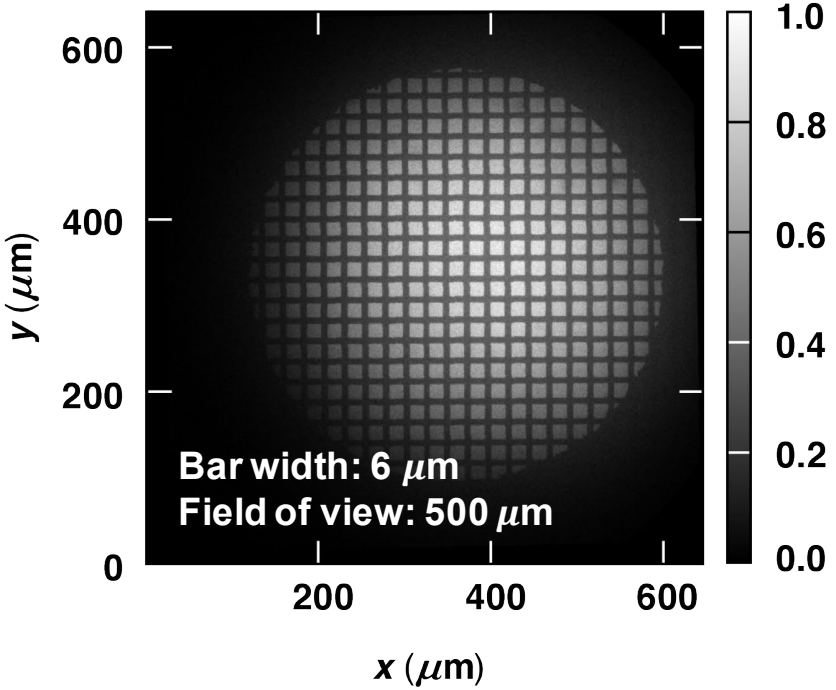
- Fresnel zone plate (FZP) focus equation: $\frac{1}{f} = \frac{1}{p} + \frac{1}{q}$
- For an FZP, the focus is given by: $f_{\mathrm{FZP}} = \frac{4N(\Delta r)^2}{\lambda}$

p = object to optic distance
q = optic to image distance
N = number of zones
Δr = width of outermost zone of FZP
λ = wavelength of x rays

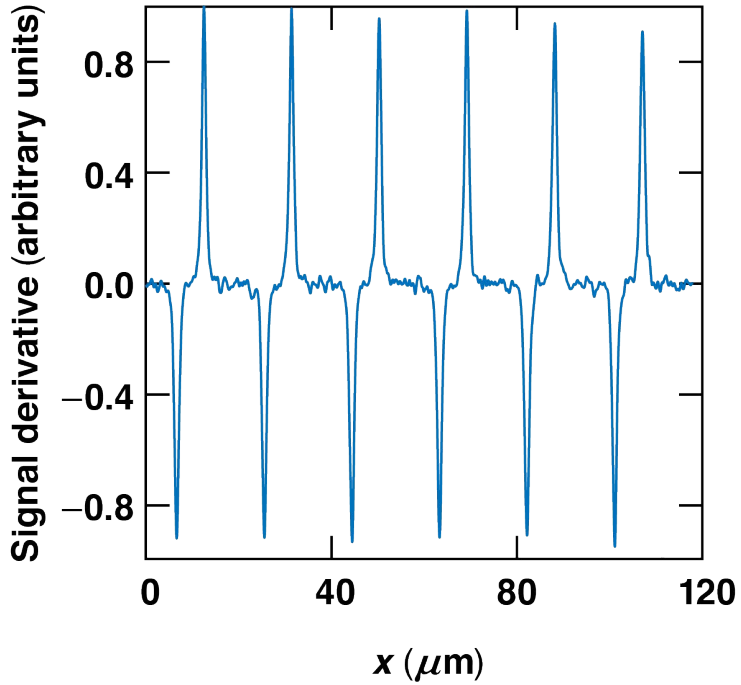
The zone plate deployment is set by the x-ray energy, the zone plate characteristics, and the focus equation.

At 42× magnification, a star resolution pattern shows 1-μm spatial resolution

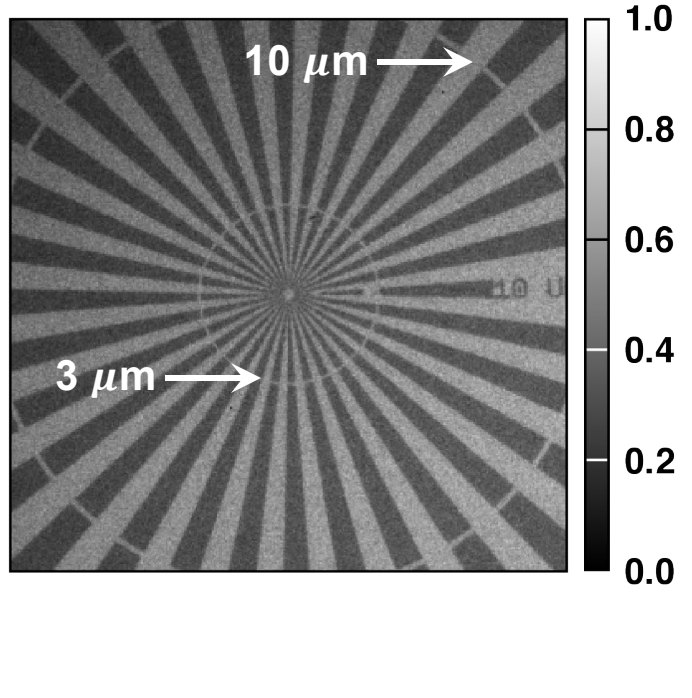
OMEGA shot 98669
Ti He$_\alpha$ source: 4.75 keV, 100 ps



Line spread function

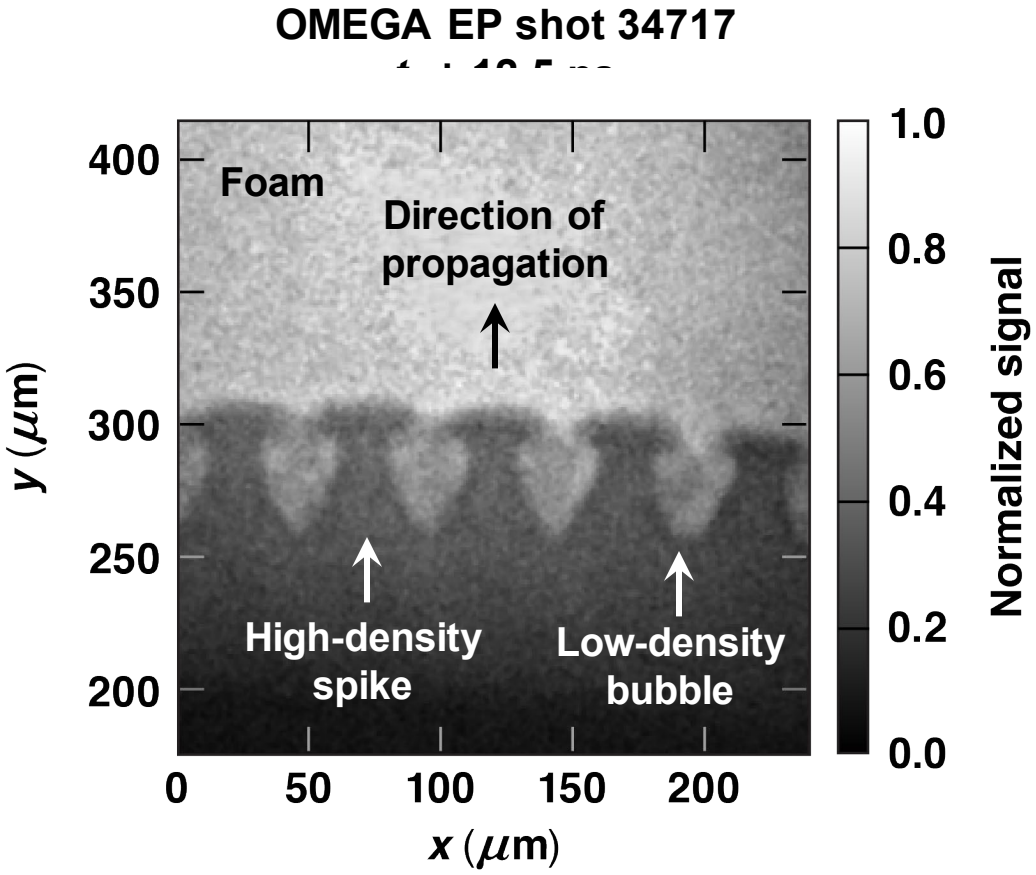


OMEGA shot 98670
Custom star pattern



Static spatial resolution: (1.0±0.1) μm.

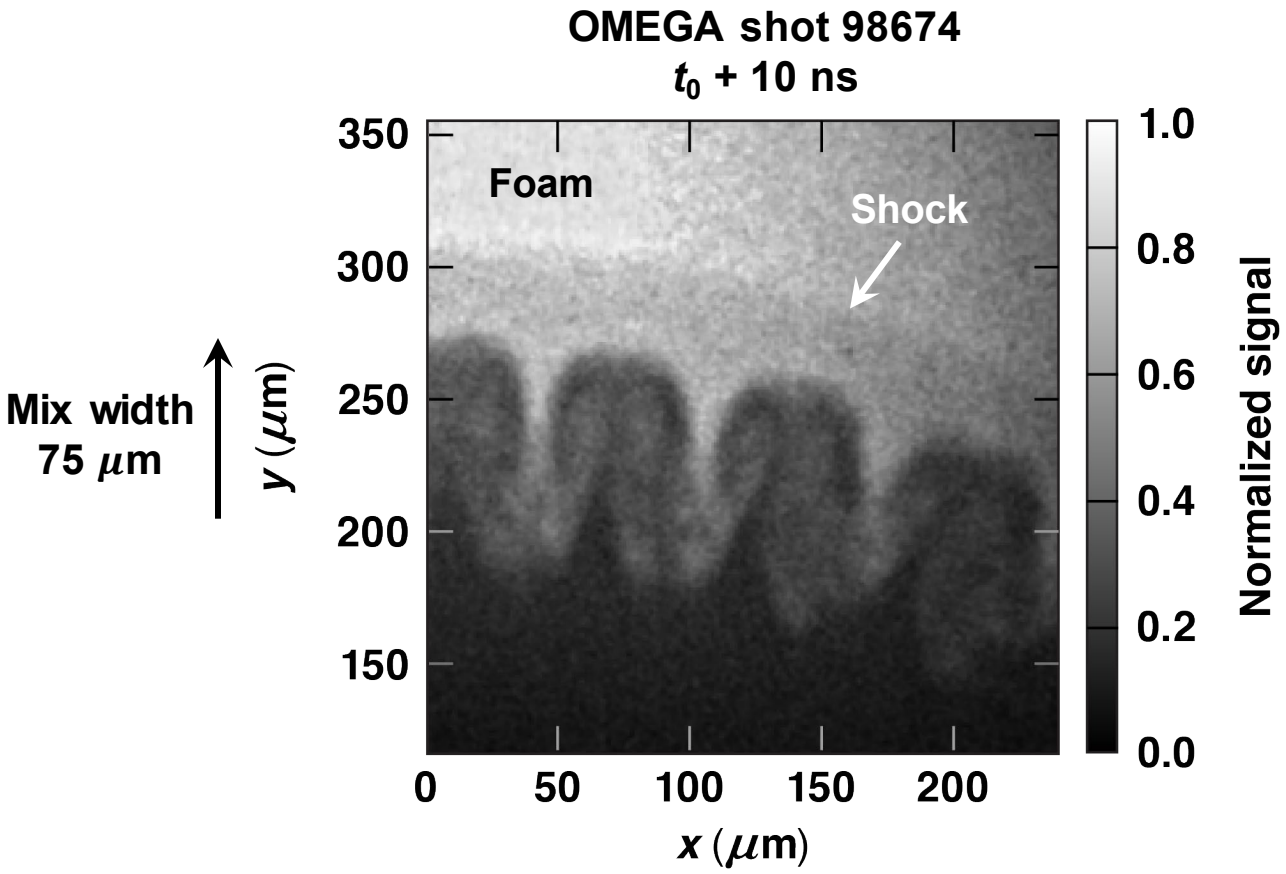
Bubble and spike growth is observed, followed by spike-tip broadening



Target
- ablator: 25 μm
- pusher: 120 μm

Interface
- initial modulation wavelength: 50 μm
- peak-to-valley amplitude: 20 μm

The spike morphologies show the effects of vorticity generation, asymmetric shear, and late-stage rollup

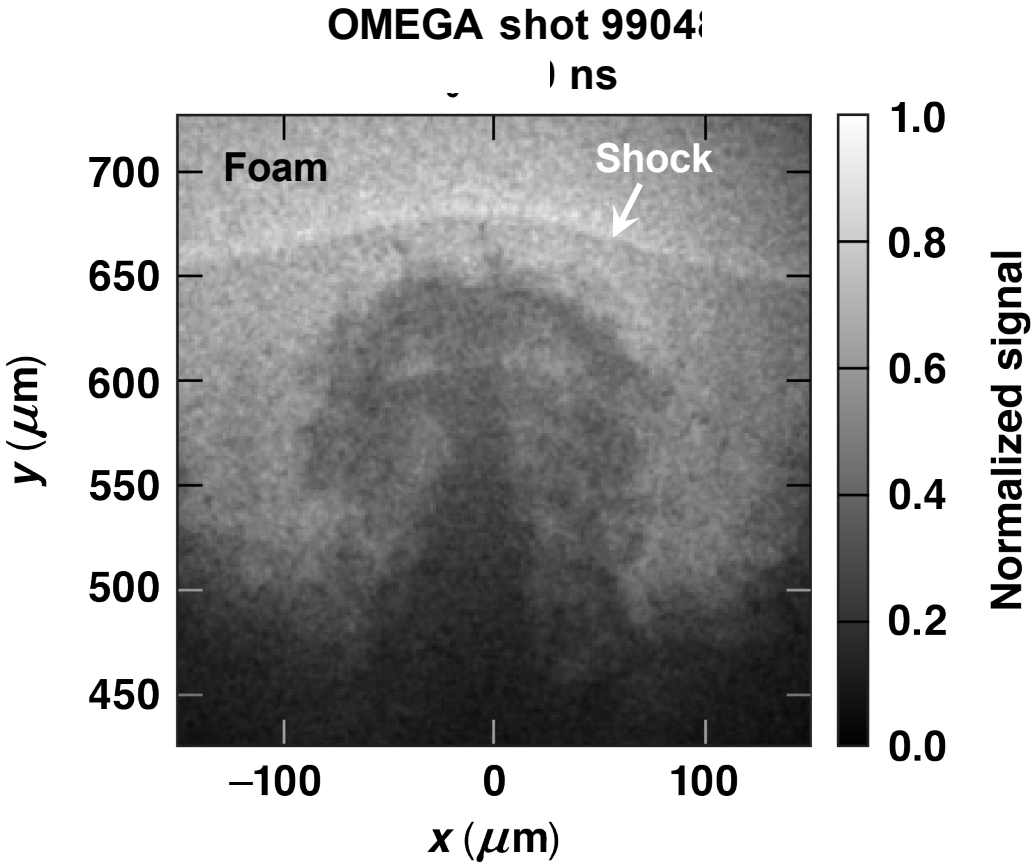


OMEGA laser drive

- **2.25-kJ, 1-ns pulse**
- **7×10^{14} W/cm^2**

The shock wave is tracked ahead of the mixing region.

Late-time development shows shock-wave catch-up and interaction, secondary instability growth, and fine-scale disruption of the spike



Target
- ablator: 125 μm
- pusher: 150 μm

Interface
- initial modulation wavelength: 100 μm
- peak-to-valley amplitude: 10 μm

T. J. B. Collins JO04.00012*

Future experiments with tracer layers will help isolate the observed flow features.

*T. J. B. Collins *et al.*, JO04.00012, this conference.

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Application to ICF-relevant perturbation sources is the next step.

ICF: inertial confinement fusion