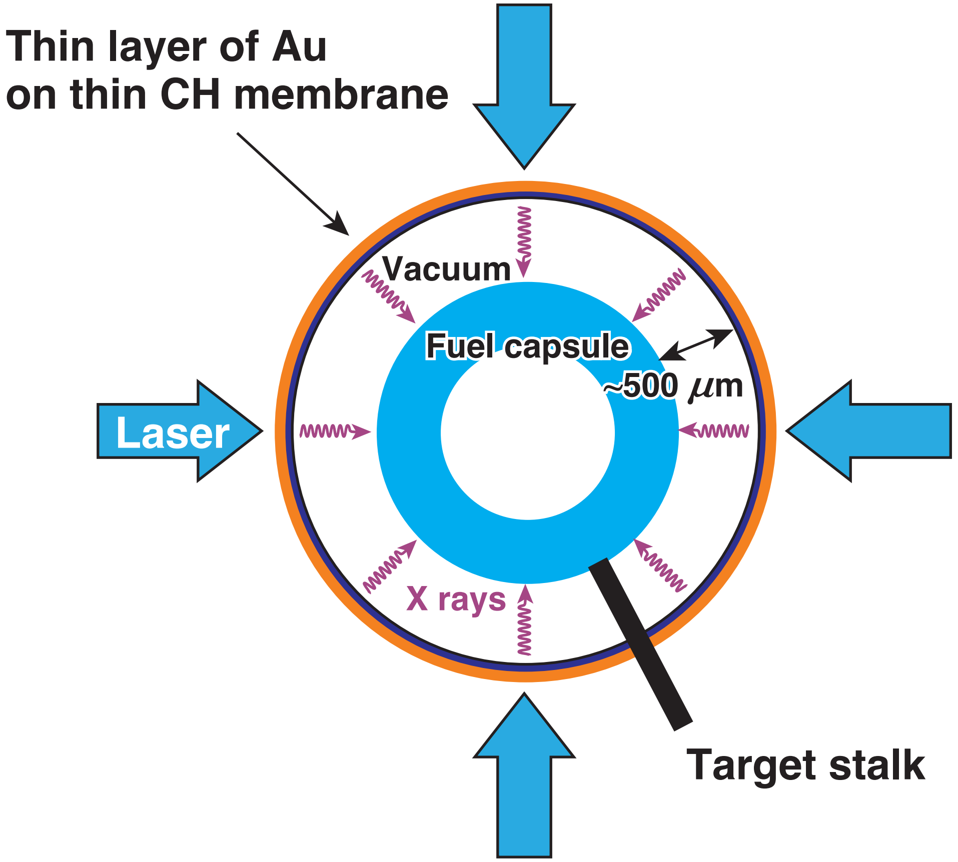
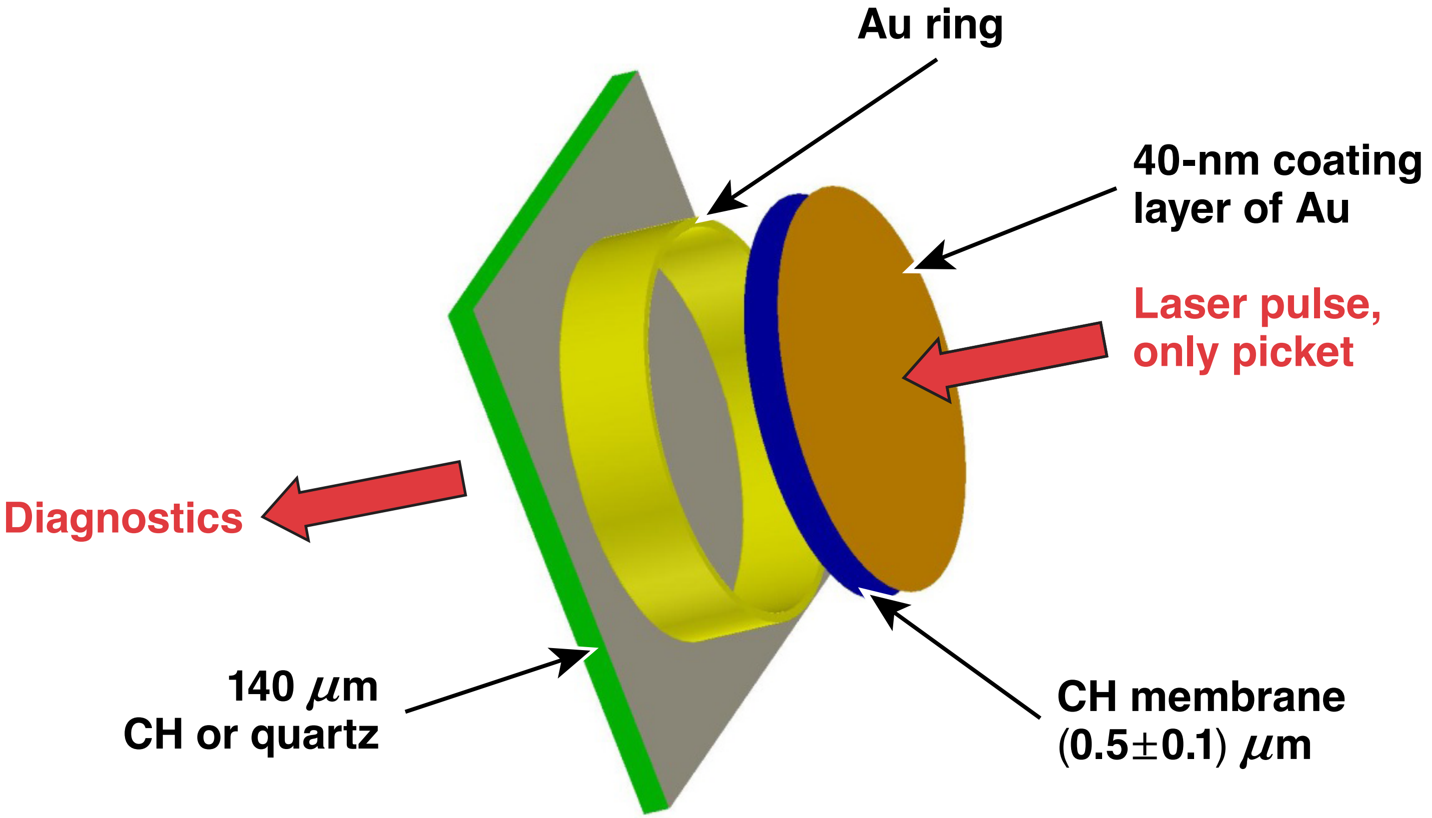
The Hybrid Target Approach: A Promising Path Forward to Mitigate Laser Imprint in Direct-Drive Inertial Confinement Fusion





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Summary

Experiments in planar geometry testing the hybrid concept demonstrate a significant reduction in modulation growth

- In phase I, x-ray–driven picket-pulse shocks from a thin high-*Z* layer were detected with VISAR/SOP
- Shock pressures of several Mbar were inferred from VISAR/SOP measurements
- In phase II, face-on x-ray radiography with 6-ns-long UV pulses measured the modulation growth in planar CH foils and two hybrid targets
- The modulation growth is largest in the CH target and lower in the hybrid targets potentially caused by a reduction in imprint

VISAR: velocity interferometer system for any reflector
SOP: streaked optical pyrometer

Collaborators

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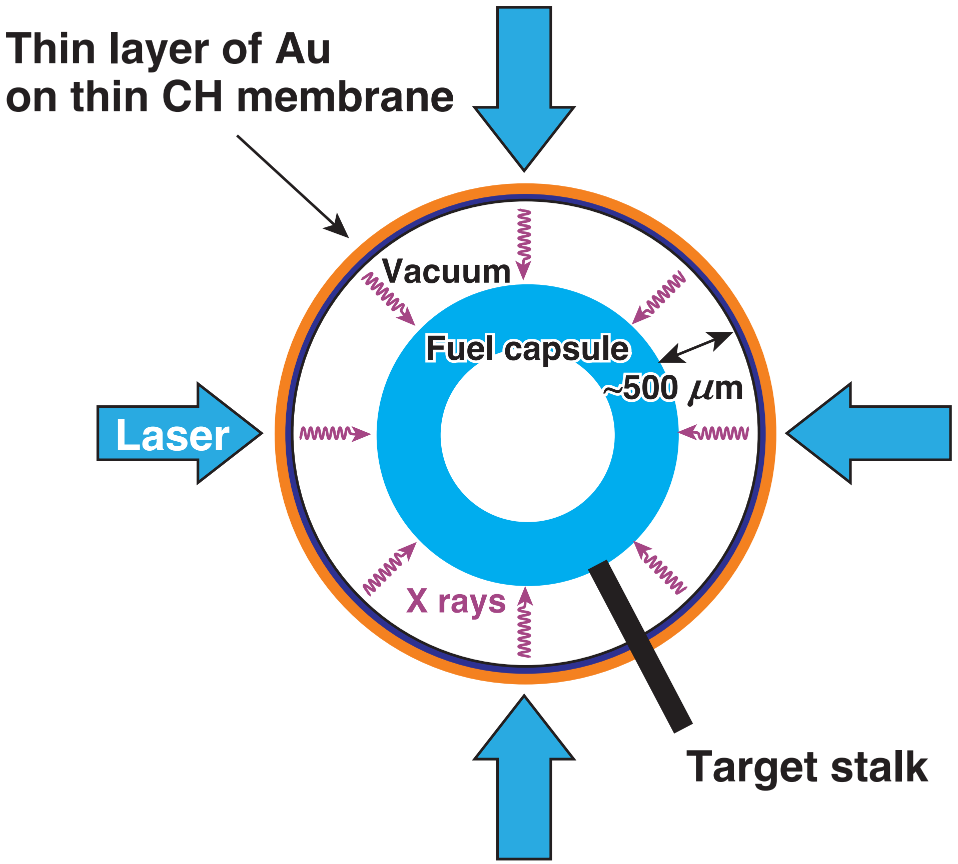
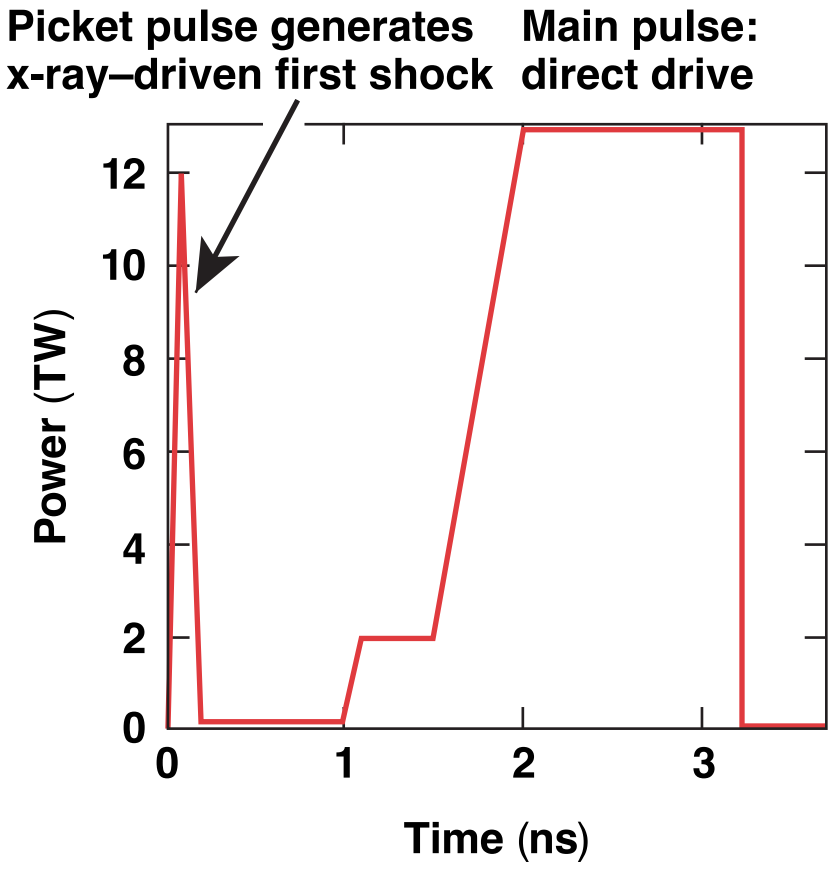
The hybrid target approach might reduce imprint, which helps to increase the target design parameter





X rays from a high-*Z* layer generate the initial shock while the main drive ablates through the thin shell and implodes the capsule.

S. Eliezer, J. J. Honrubia, and G. Velarde, Phys. Lett. A 166, 249 (1992);
R. G. Watt *et al.*, Phys. Rev. Lett. 81, 4644 (1998);
M. Karasik *et al.*, Phys. Rev. Lett. 114, 085001 (2015);
S. X. Hu *et al.*, Phys. Plasma 25, 082710 (2018).

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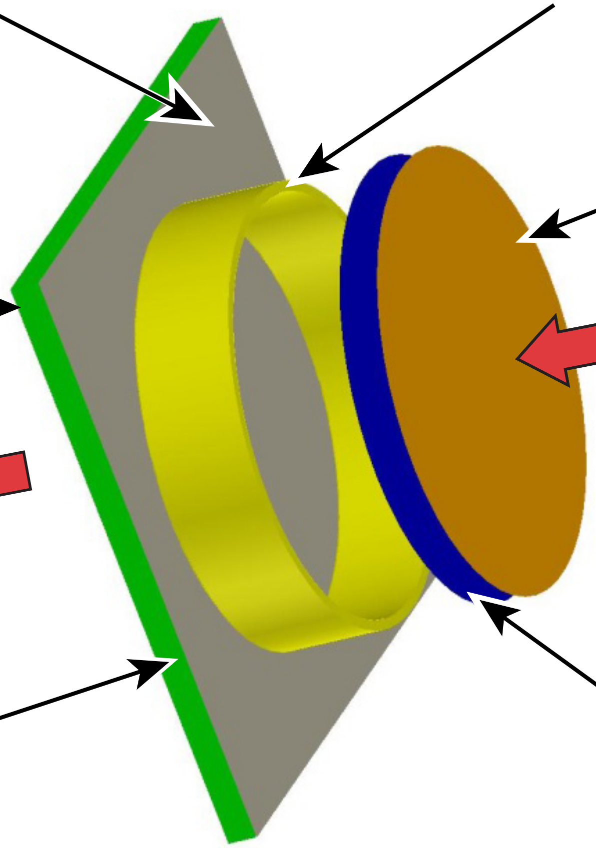
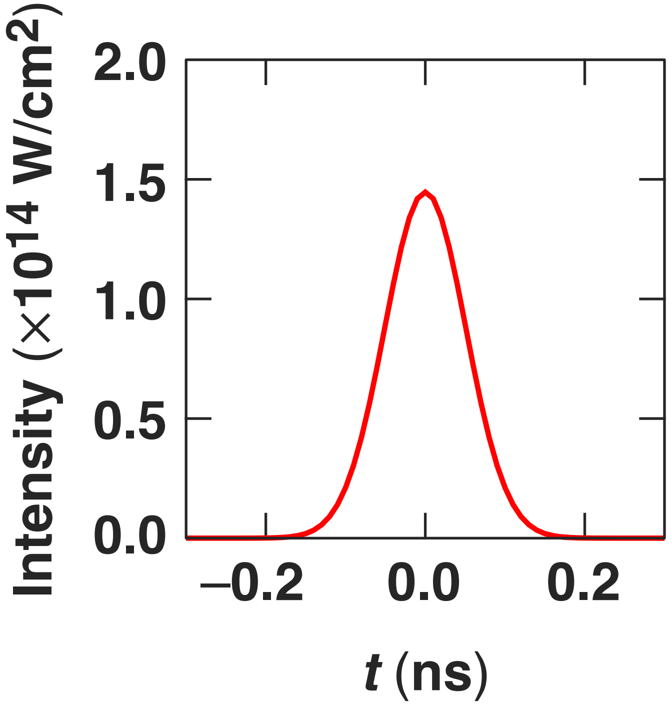
In phase I, a proof-of-principle experiment was performed in planar geometry to measure the shock pressure from the x-ray pulse





AR: antireflective

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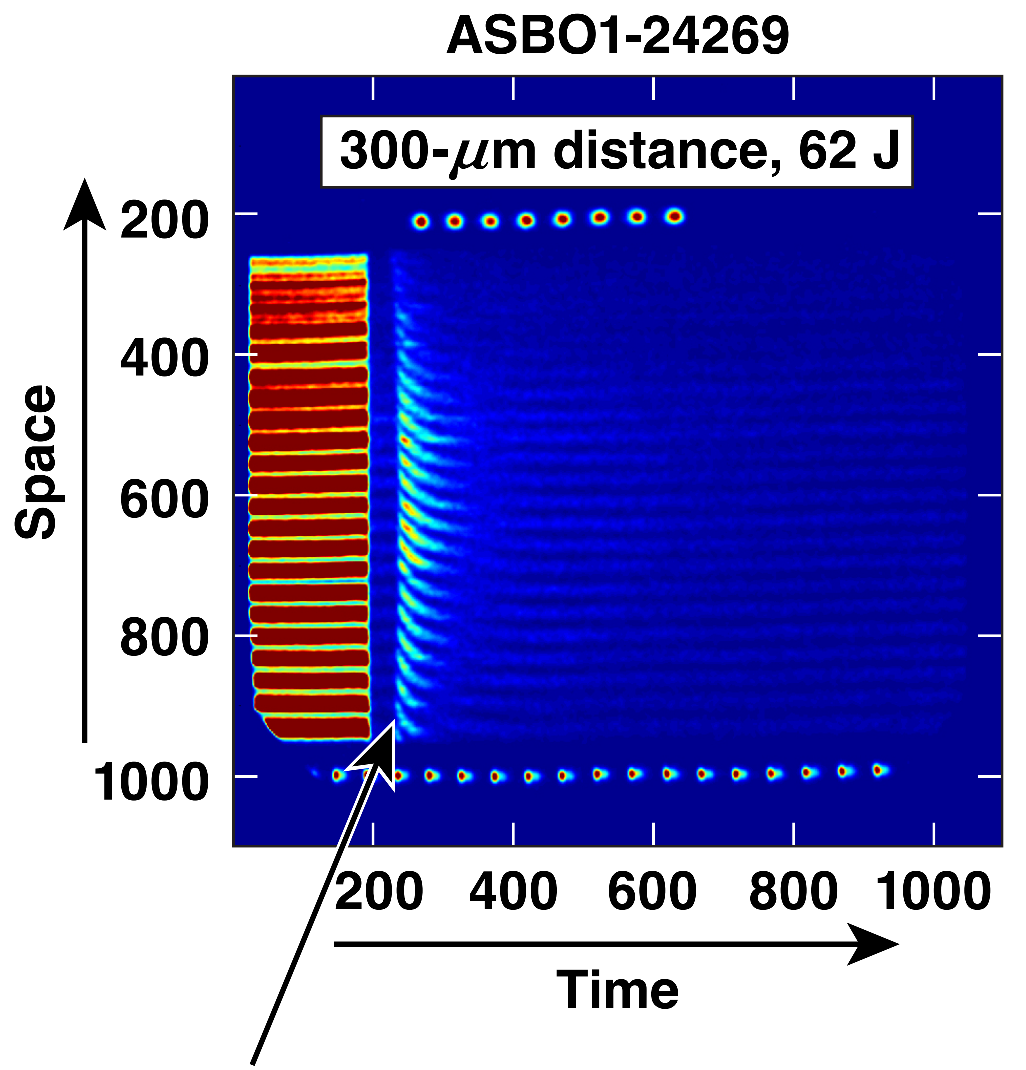
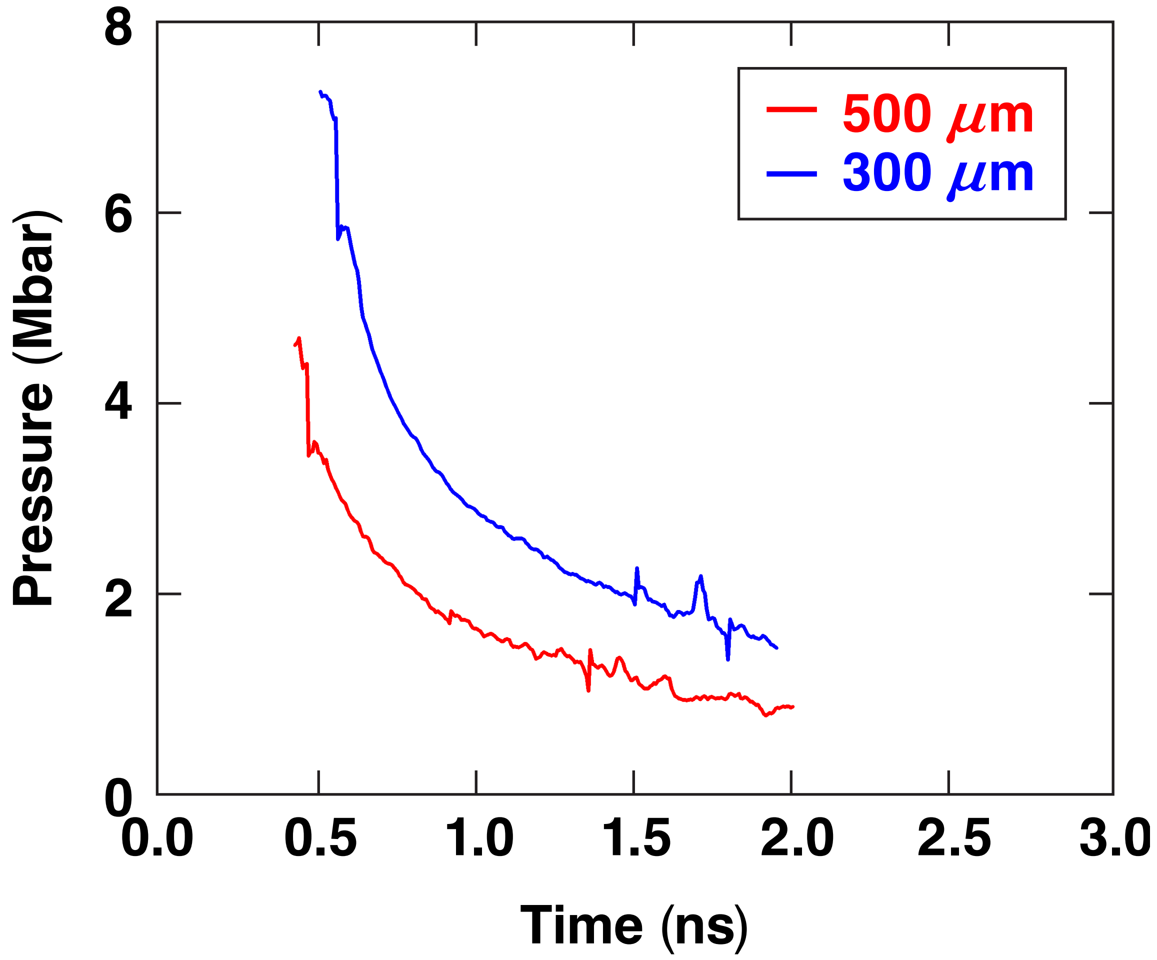
Shock pressures of several Mbar were inferred from VISAR/SOP measurements

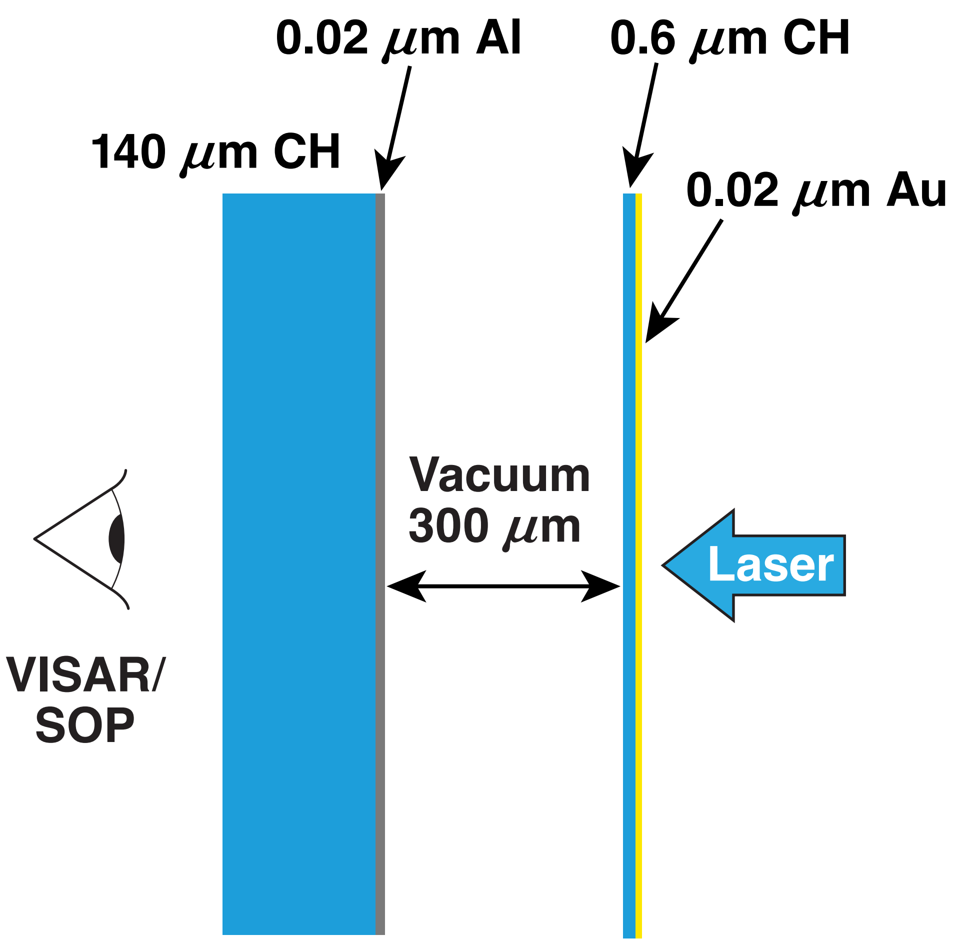


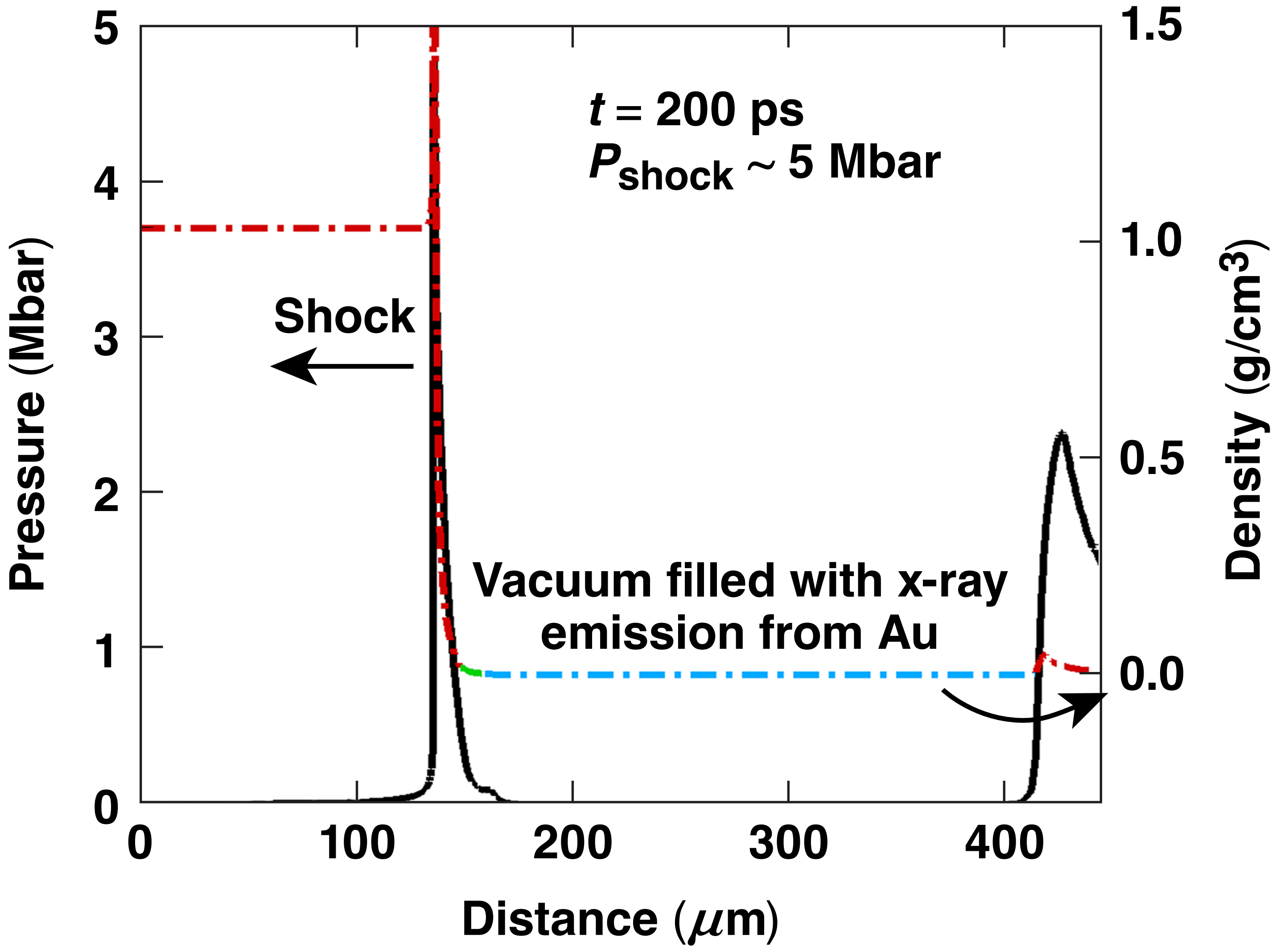


Blanking caused by free-charge carrier production in quartz layer

ASBO: active shock breakout

One-dimensional hydrodynamic simulations were performed with *LILAC* that show an x-ray–driven shock





The demonstration of x-ray–driven shocks concluded phase I.

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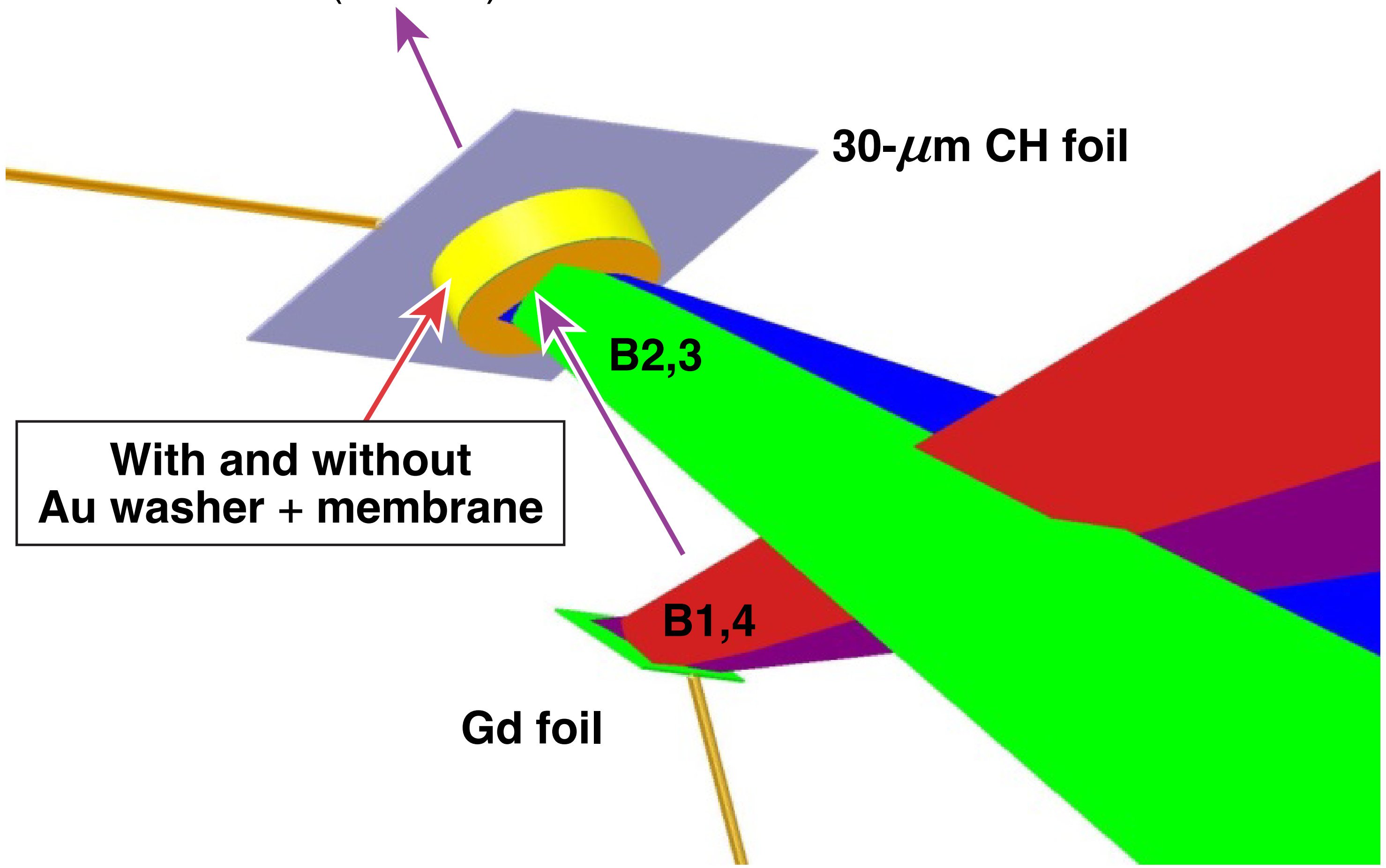
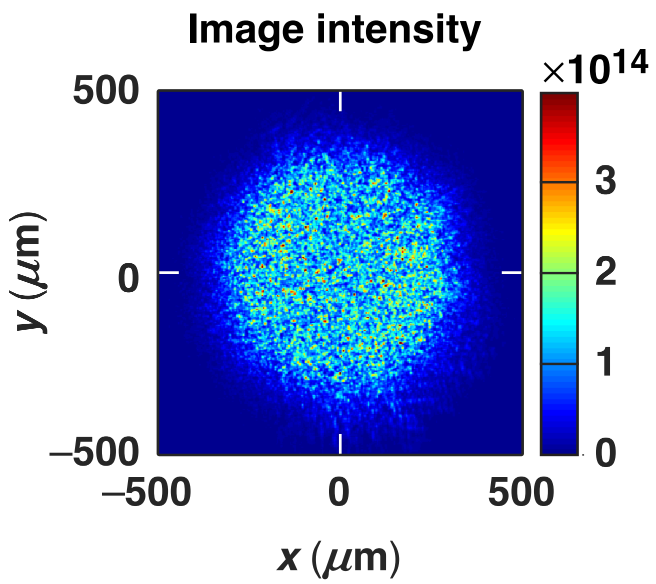
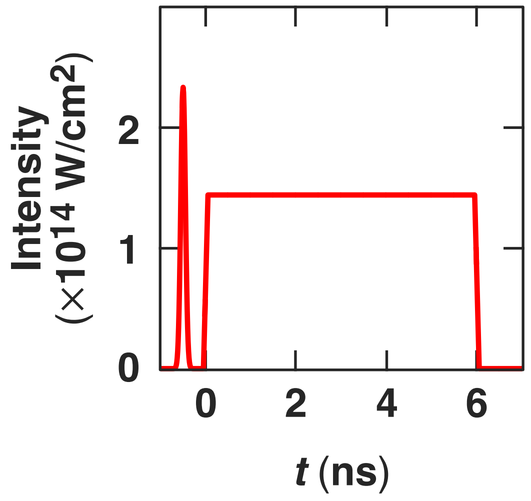
In phase II, the effect of imprint was studied on OMEGA EP with an SG8-0750 distributed phase plate and no SSD



Measured speckle pattern



$\langle I \rangle = 1.4 \times 10^{14}$ W/cm^2



SSD: smoothing by spectral dispersion
TIM: ten-inch manipulator
XRFC: x-ray framing camera

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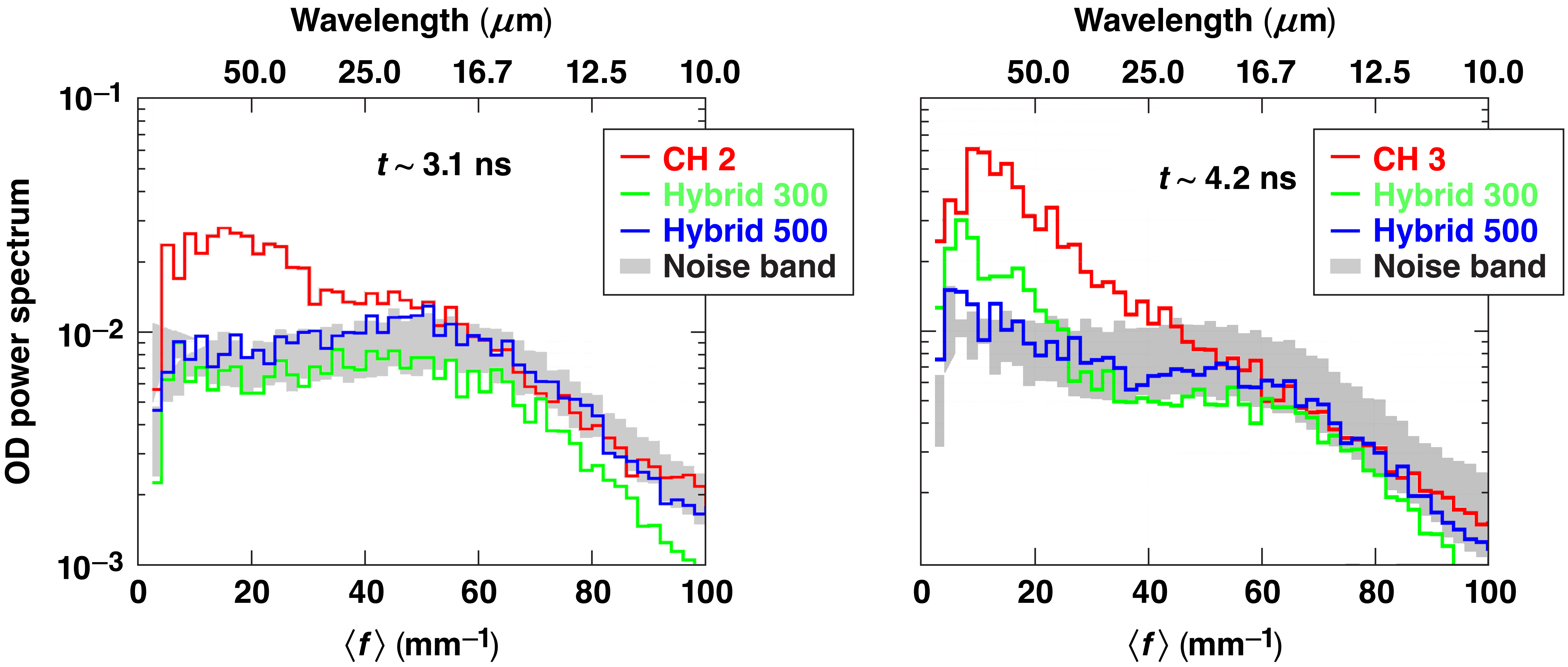
A Fourier analysis of the optical depth shows less modulation growth in the hybrid targets



OD: optical depth

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Experiments in planar geometry testing the hybrid concept demonstrate a significant reduction in modulation growth

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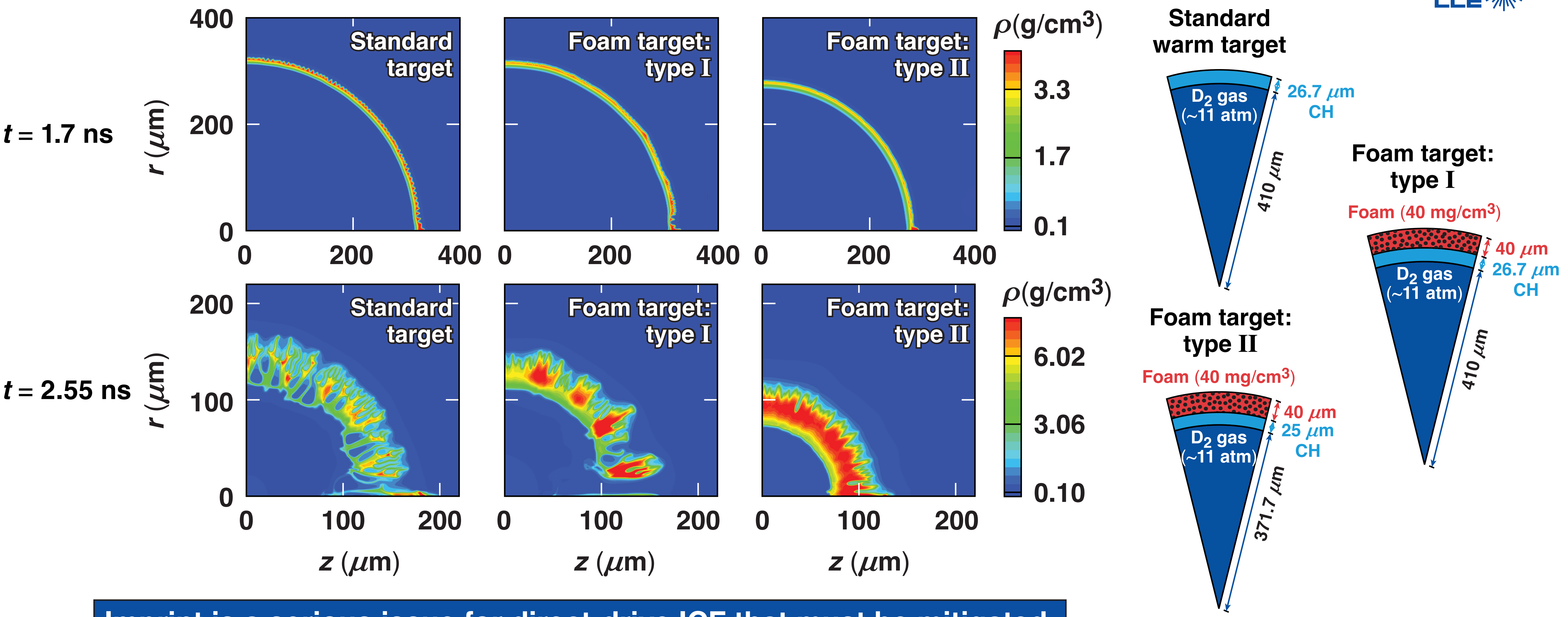
SOP: streaked optical pyrometer

Nonuniformities in the drive laser can imprint mass perturbations that seed hydrodynamic instabilities



Imprint is a serious issue for direct-drive ICF that must be mitigated.

S. X. Hu *et al.*, Phys. Plasmas 25, 082710 (2018).
ICF: inertial confinement fusion

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The modulation growth was observed in a time range of up to ~5.5 ns