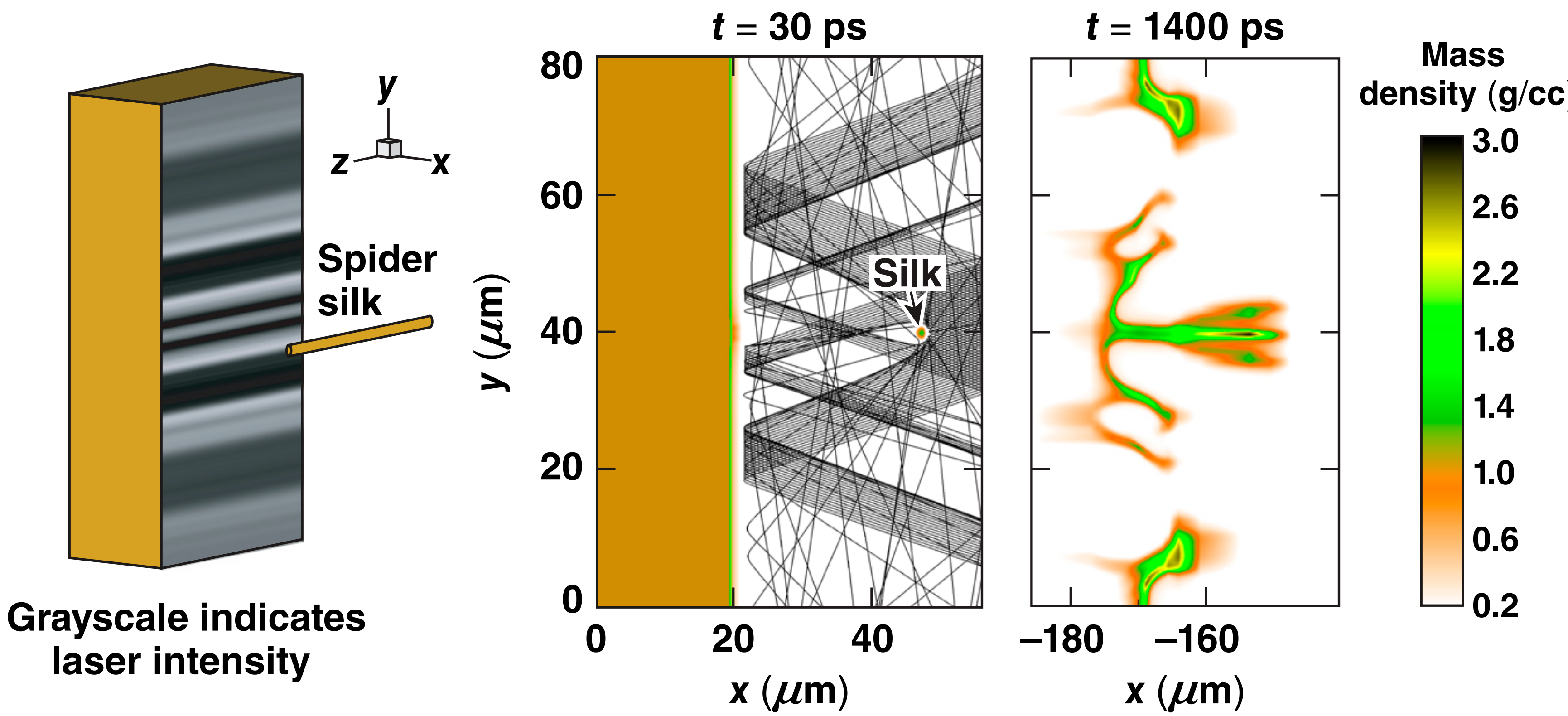
Planar Modeling of Target-Mount Perturbation Experiments on OMEGA using 3-D Ray Trace



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Summary

Shadowing and refraction of laser illumination by the ablating silk causes perturbations with length scales of up to 60 μm

- OMEGA cryo targets are suspended using up to four spider silks.
- Experiments placed silks on or above laser-driven planar targets to determine their effect on illumination uniformity.
- These experiments were simulated in planar geometry, modeling the finite-beam effects of the twelve laser port locations.
- Both simulation and experiment demonstrate that silks imprint large-scale perturbations.

Collaborators

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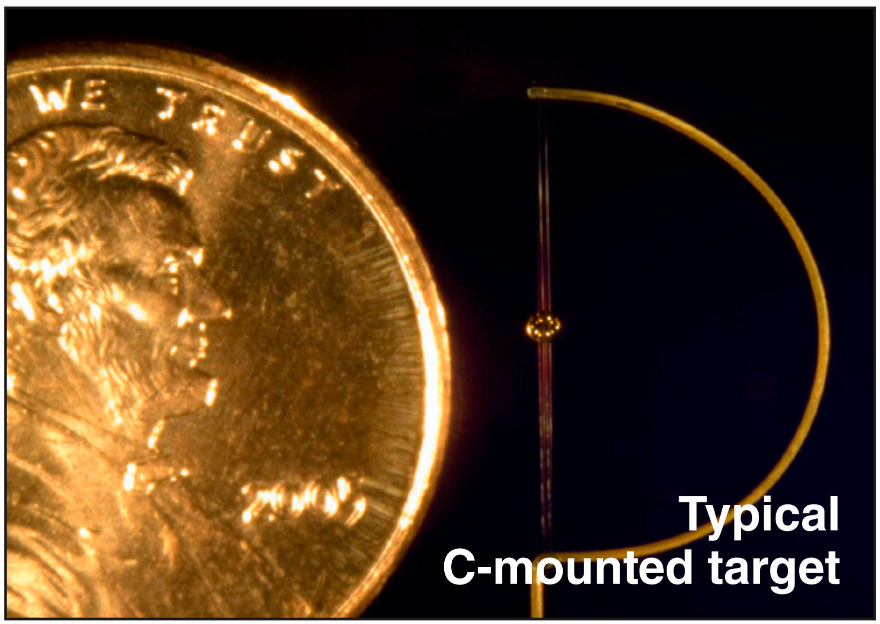
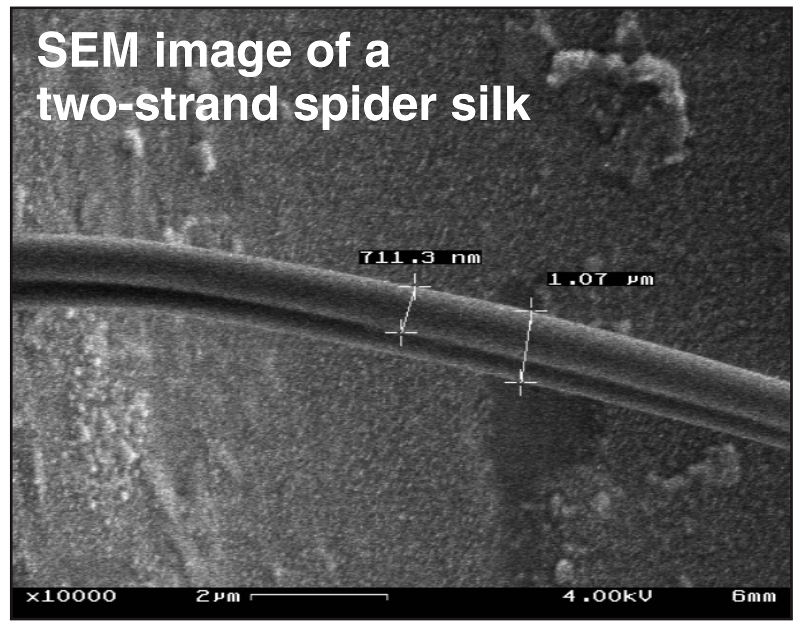
OMEGA cryogenic targets are suspended in the target chamber using four spider silks attached to a C-shaped mount

- Silk-mounted targets have an ~140-μm region where the silk is adjacent to the target surface, with composition $CH_9N_2O_{41}$ and $\langle Z \rangle = 6.7$.

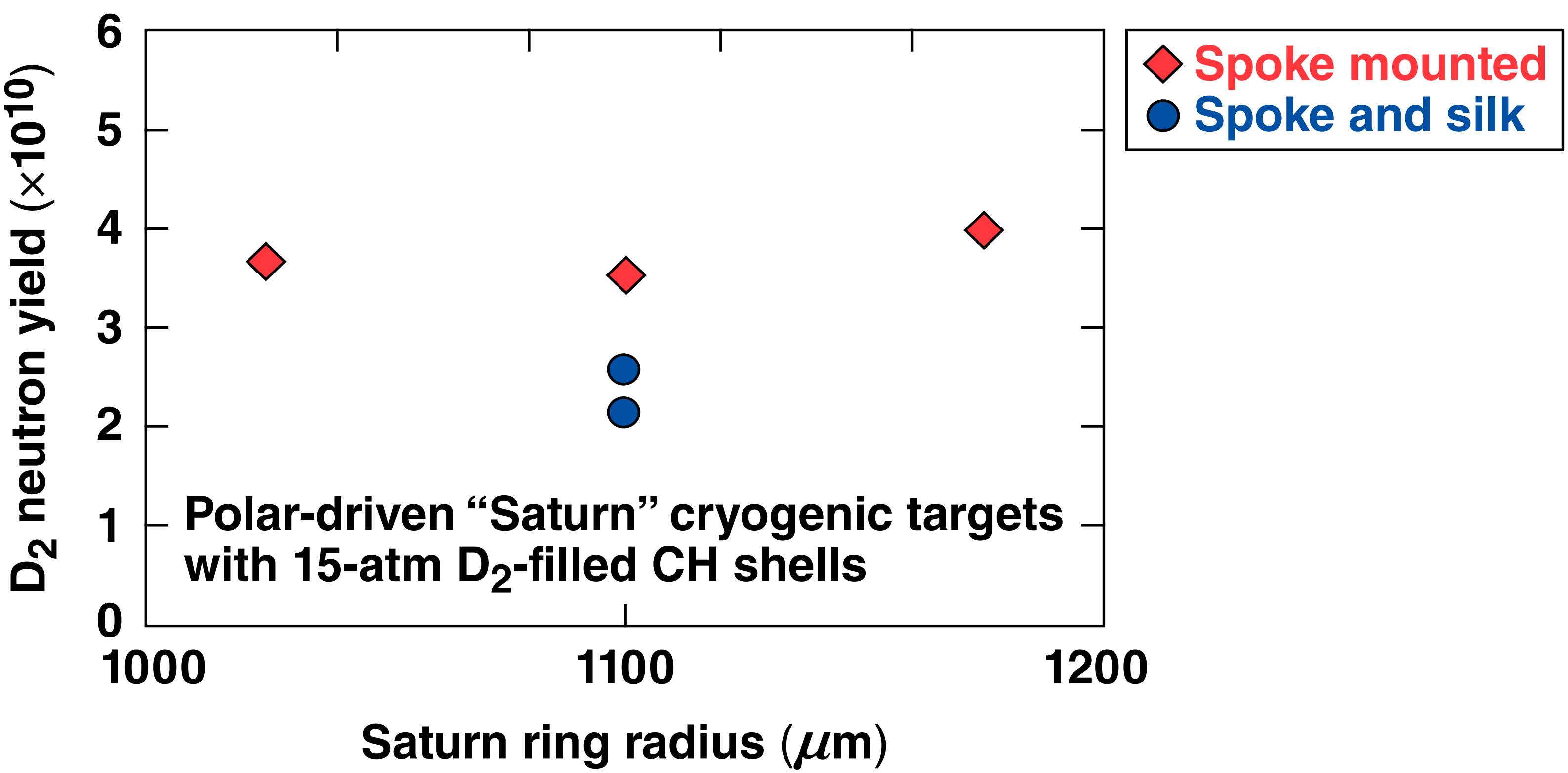




- Spider silks are typically composed of two entwined protein strands ~1 μm in diameter.

Target silks have been found to affect target performance in some experiments*

- Saturn**-target neutron yields are reduced when silks are added to the existing spoke target mounts.

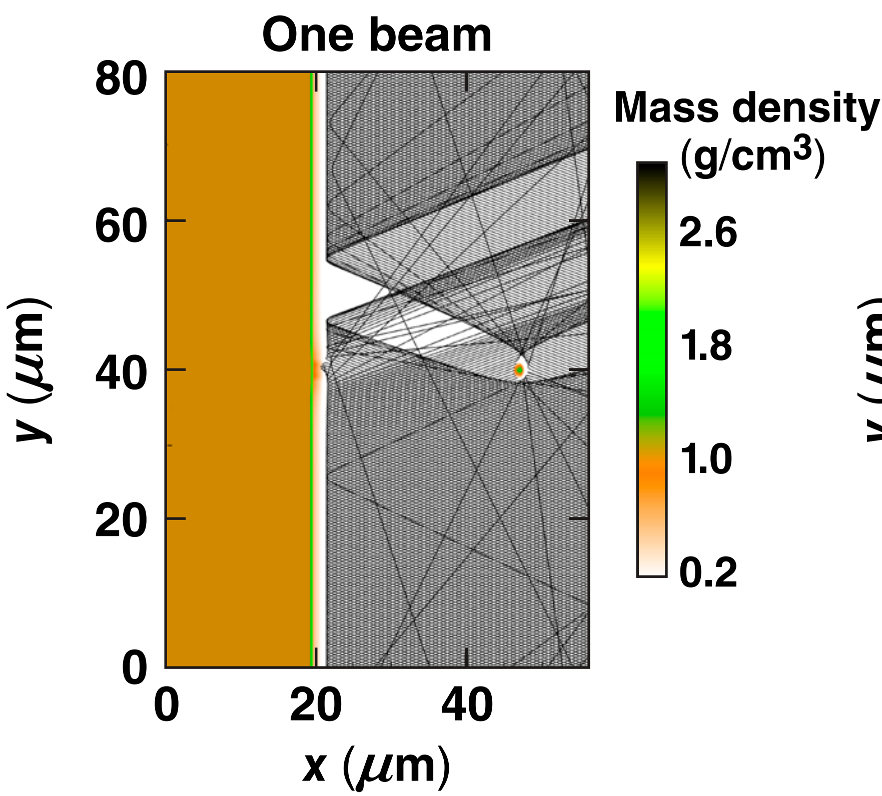


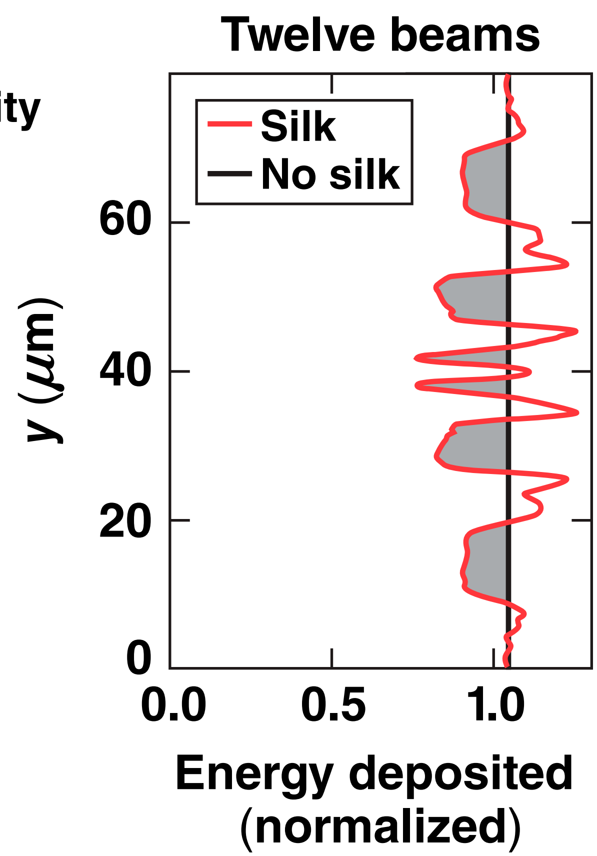
*F. J. Marshall *et al*., J. Phys. IV France 133, 153 (2006).
**R. S. Craxton and D. W. Jacobs-Perkins, Phys. Rev. Lett. 94, 095002 (2005).

TC8259

Spider silk shadowing and refraction reduce illumination uniformity

- As the silk ablates it generates a plasma that refracts laser light, casting shadows that imprint on the target



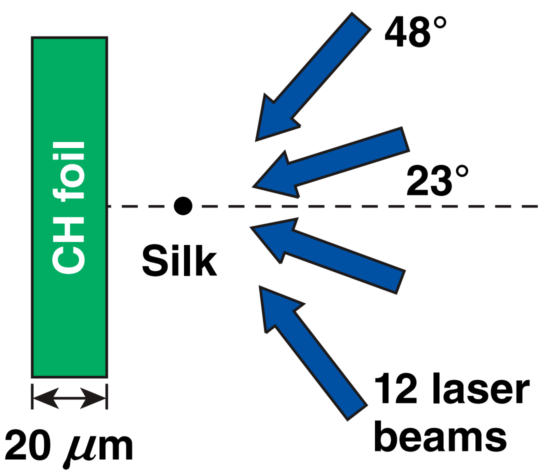


- Silk suspended 27 μm over the target surface

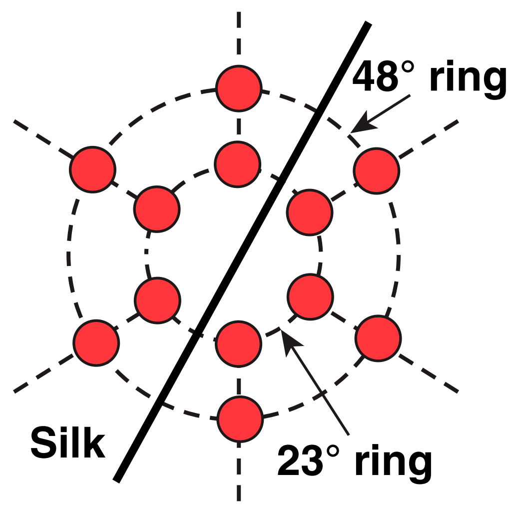
Planar experiments have been performed to measure the silks' effect on target illumination

- The target was driven with a 2-ns square ~400-TW/cm^2 pulse
- Silks were suspended at 27 and 42 μm above the foil
- For comparison, one silk was placed on the target surface

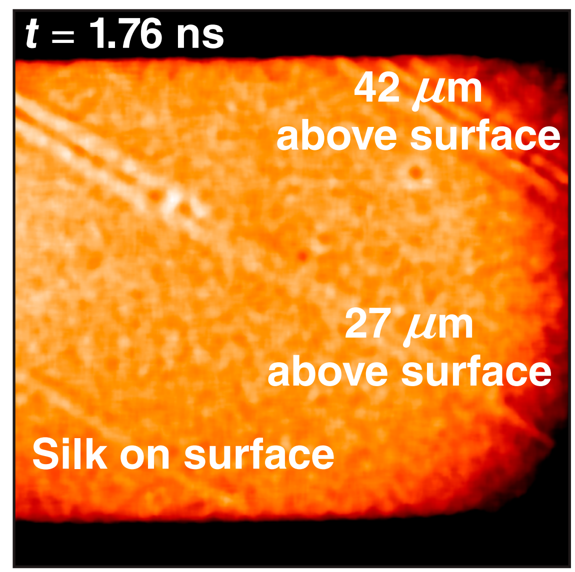
Experimental setup



Beam ports

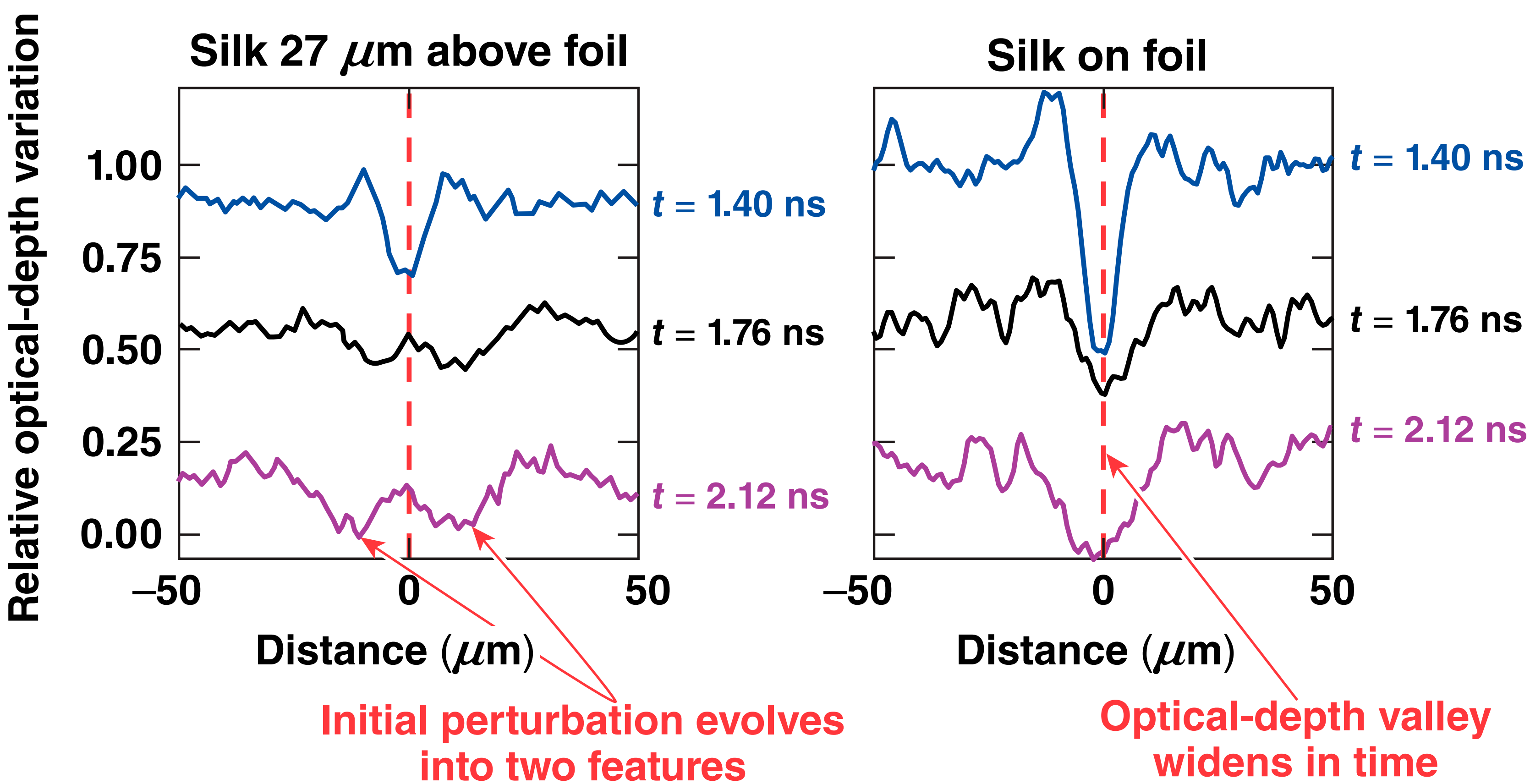


1.3-keV x-ray backlighter image



Experiments show that shadowing induces mass modulations that grow in time

- An optical-depth variation of 1 corresponds to a ~10-μm mass modulation
- Detector resolution is ~20 μm



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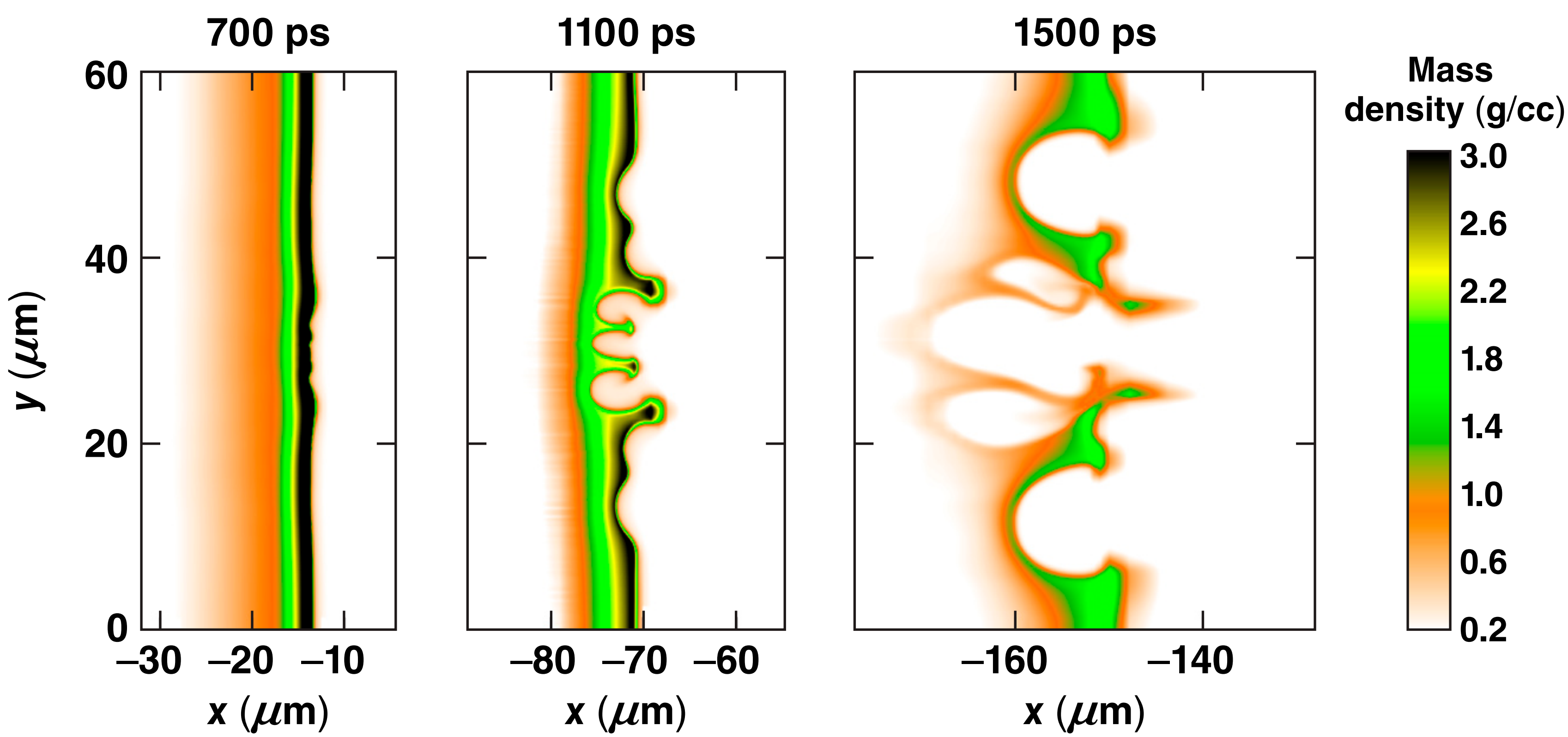
Placing a silk on the foil produces a 50-μm perturbation

- **The silk ablates within 100 ps, creating a high-Z plume, causing an illumination perturbation**
- **This seeds Rayleigh–Taylor growth, which eventually punctures the foil**



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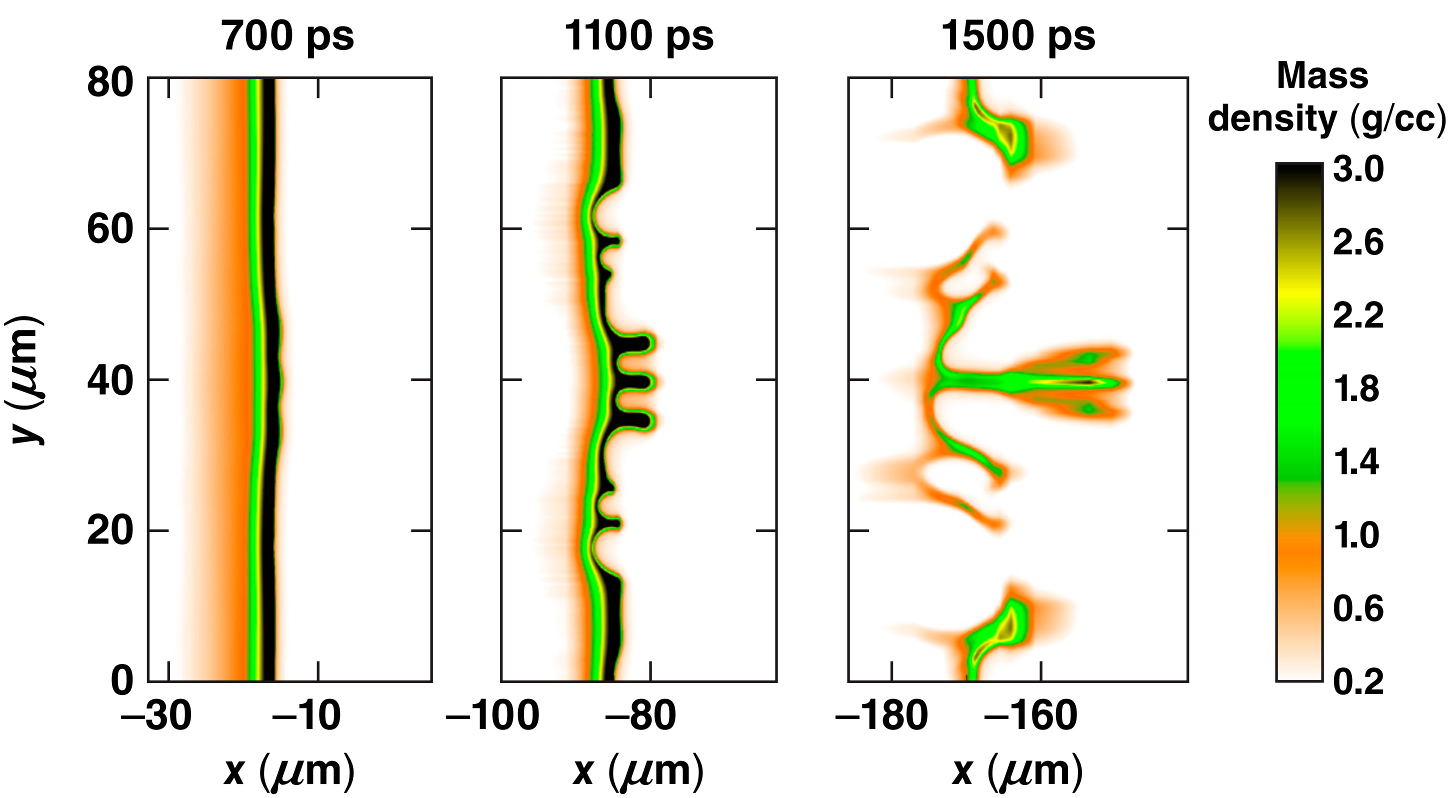
A silk suspended 27 μm above the foil produces a 60-μm perturbation

- Shadows cast by the ablating silk cause the foil to puncture in two lines parallel to the silk

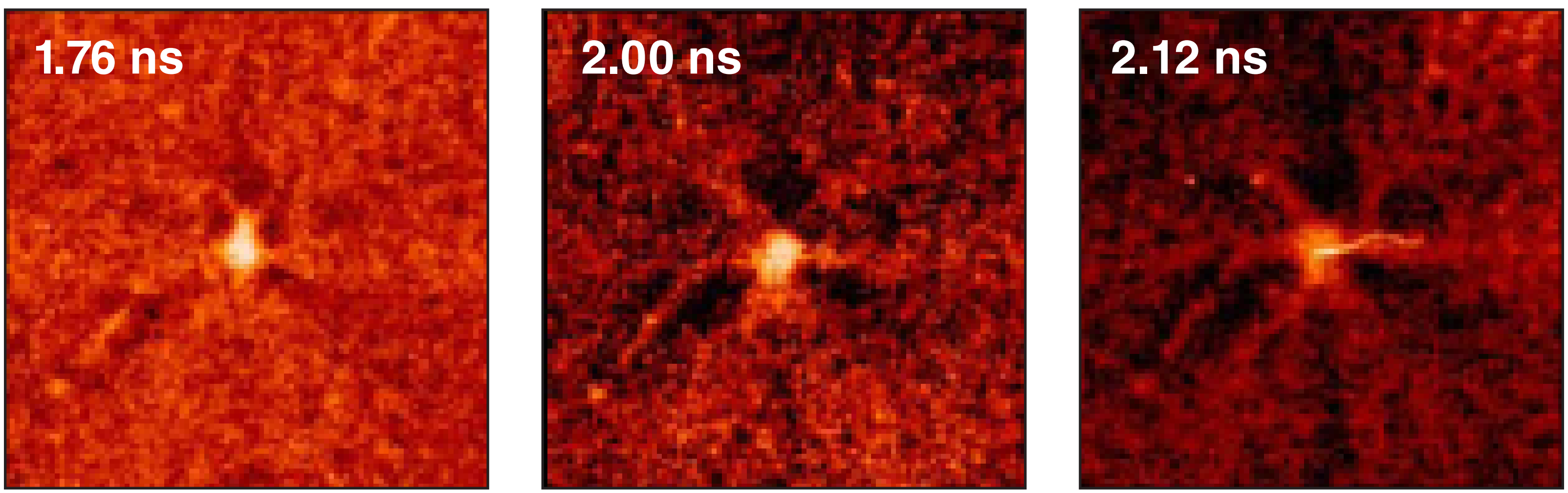


TC8265

Future work

The effects of stalk target mounts will also be investigated

- These experiments also included stalks mounted on planar targets
- X-ray radiographs show hexagonal shadowing matching the beam geometry
- These will be modeled in 3-D planar geometry



Summary/Conclusions

Shadowing and refraction of laser illumination by the ablating silk causes perturbations with length scales of up to 60 μm

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- Experiments placed silks on or above laser-driven planar targets to determine their effect on illumination uniformity.
- These experiments were simulated in planar geometry, modeling the finite-beam effects of the twelve laser port locations.
- Both simulation and experiment demonstrate that silks imprint large-scale perturbations.

The target-silk experiments have been simulated in full 3-D planar geometry

- Hydrodynamic symmetry is enforced parallel to the silk
- Simulations are performed in 3-D ray trace independently modeling each of the 12 OMEGA beams
- The 3-D ray trace uses a version of Kaiser's[1] method, with improved accuracy
  - a high-resolution orthogonal fine-scale mesh is overlaid on simulation
  - sub-zone integration is used to trace rays through the fine-scale mesh

[1] T. B. Kaiser, Phys. Rev. E 61, 895 (2000).