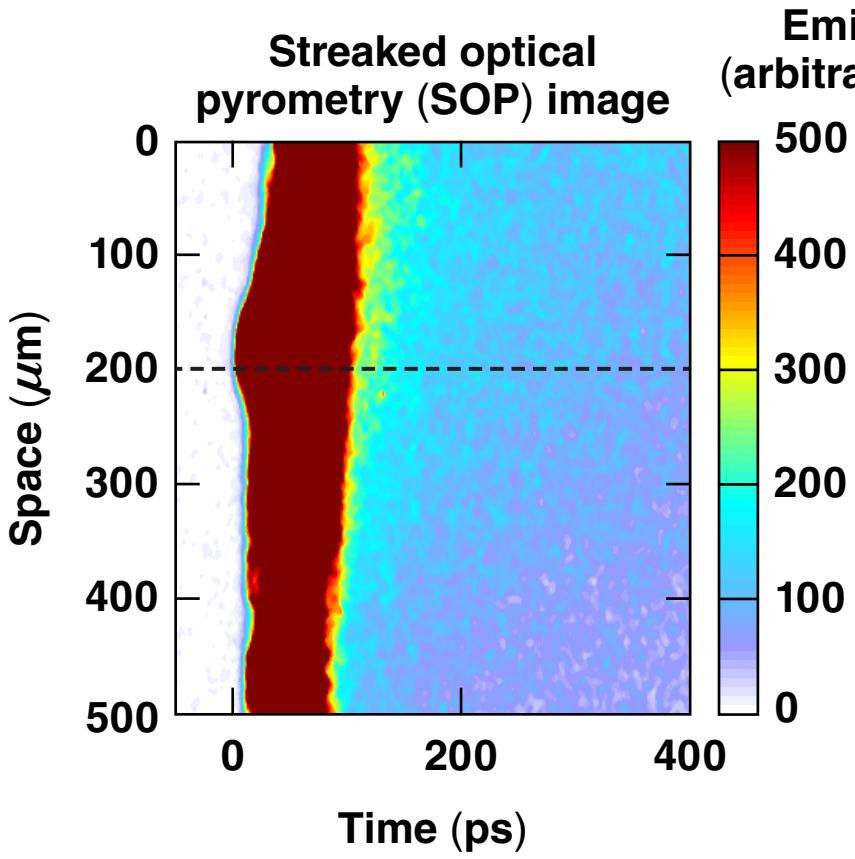
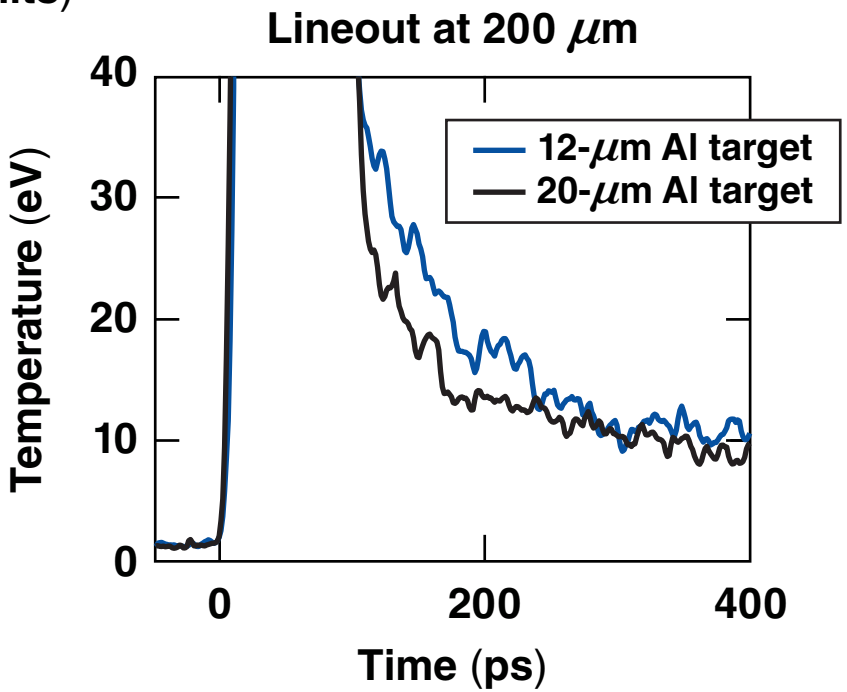
Studying the Equation of State of Isochorically Heated Al Using Streaked Optical Pyrometry





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Summary

Thin aluminum strips were isochorically heated to temperatures of tens of eV using refluxing hot electrons generated by a picosecond laser

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- An experiment was performed using the 10-ps OMEGA EP laser to generate a population of hot electrons refluxing through a 12- and 20-μm-thick aluminum strip
- Streaked optical pyrometry (SOP) measured the thermal emission that showed a bright flash over the first 50 to 100 ps followed by an exponential decay from tens of eV
- Future experiments are designed to study laser-driven proton heating to uncover early heating dynamics

Collaborators

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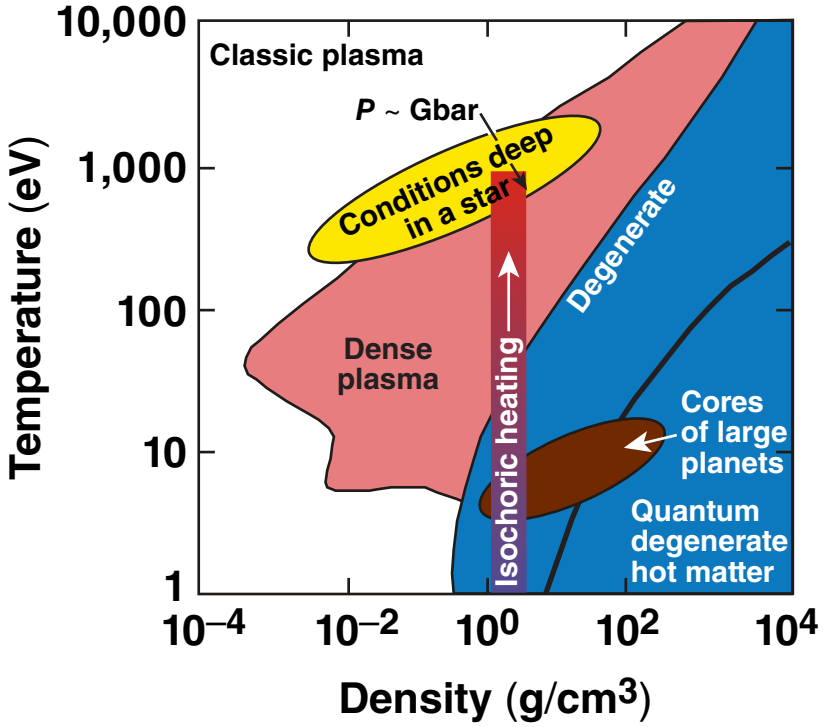
Isochoric heating can access the warm-dense-matter regime where theoretical modeling is difficult and quantitative equation-of-state (EOS) data is sparse



Isochroic heating of solids requires a picosecond impulse, which is shorter than the time scale of hydrodynamic movement.

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A powerful picosecond laser pulse provides the impulse heating for EOS studies

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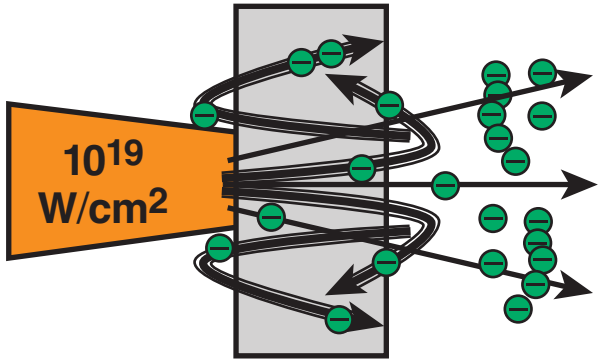
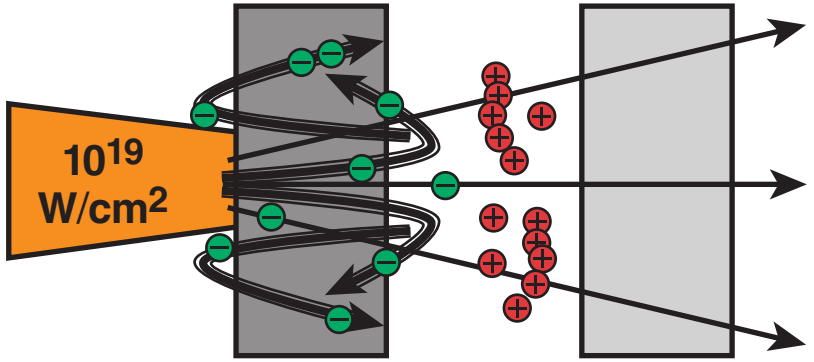
- Direct laser absorption
  - limited penetration depth
  - local heating
- Laser-driven hot electrons
  - large mean free path
  - volumetric heating
- Laser-accelerated ion beams
  - reduced energy deposition
  - the Bragg peak absorption profile preferentially heats the front side





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Experiments were designed on OMEGA EP to compare EOS studies using laser-driven electron and proton heating of aluminum foils

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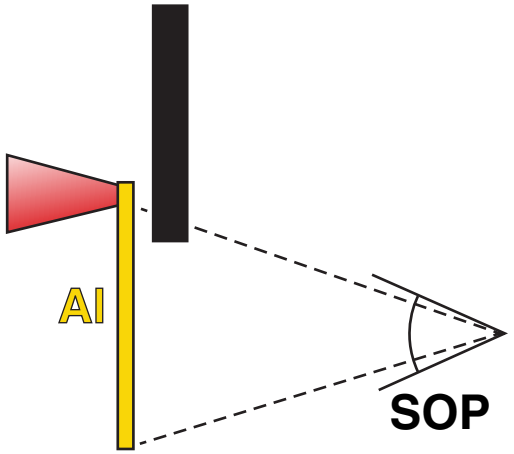
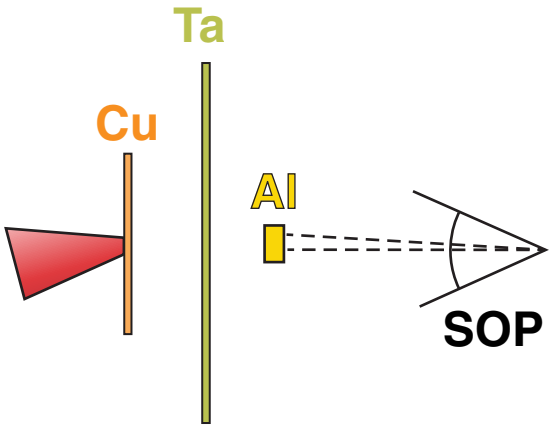
Electron heating



Proton heating



OMEGA EP

10 ps, 250 J

2×10^{18} W/cm^2

Al ribbon targets

$12 \times 100 \times 1000$ μm

$20 \times 100 \times 1000$ μm

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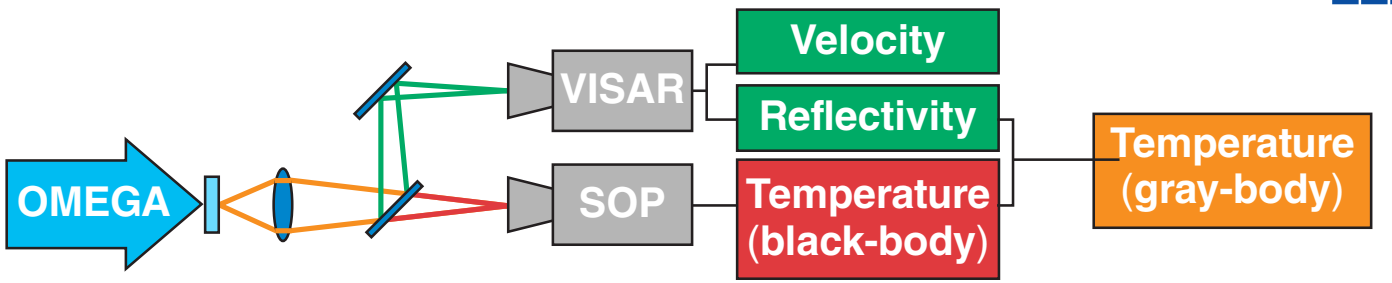
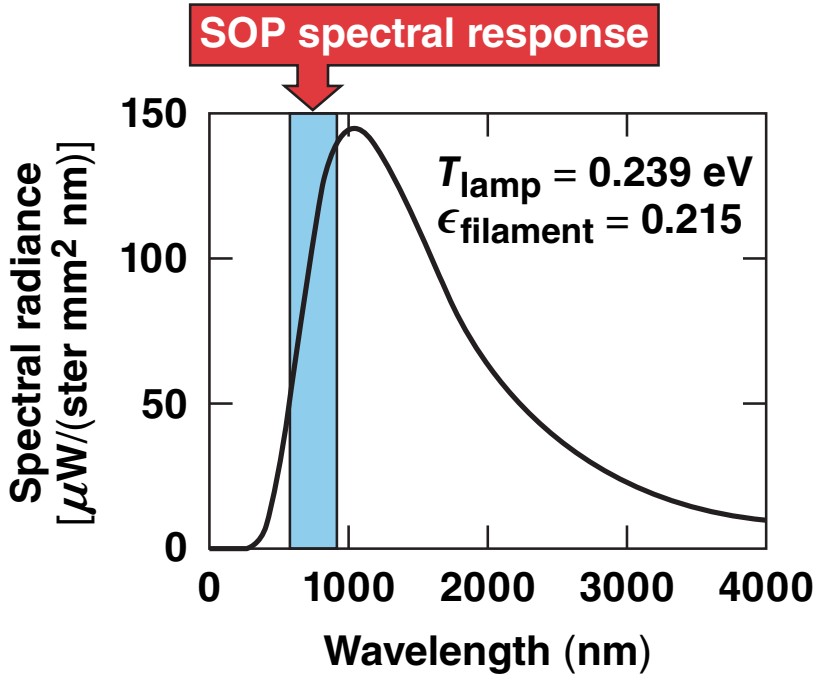
The temperature of the heated material is measured with the absolutely calibrated SOP together with velocity interferometer system for any reflector (VISAR)

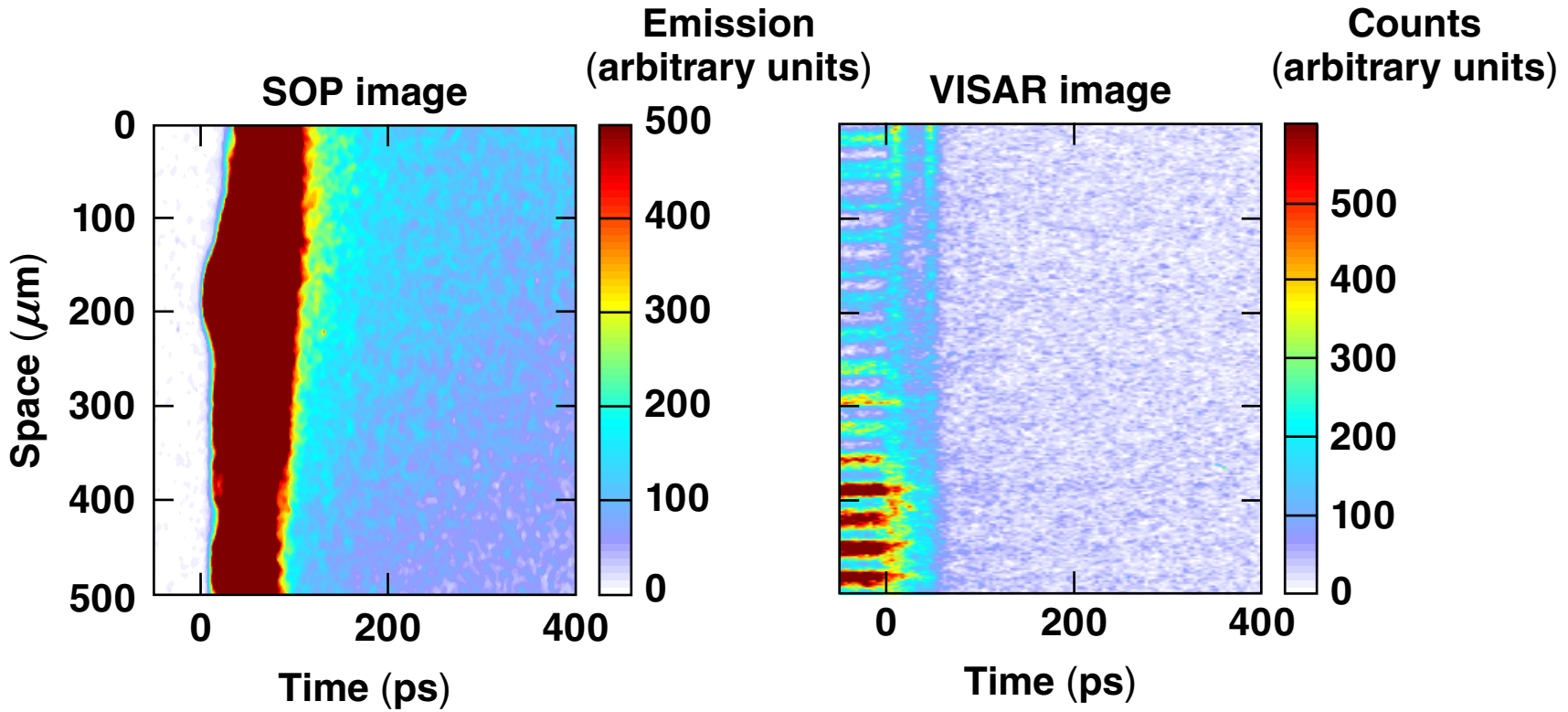


Absolute calibration was performed from 600 μm to 900 μm with a NIST-traceable tungsten-filament lamp.



Courtesy of M. C. Gregor

The SOP data show an initial bright flash followed by decaying thermal emission



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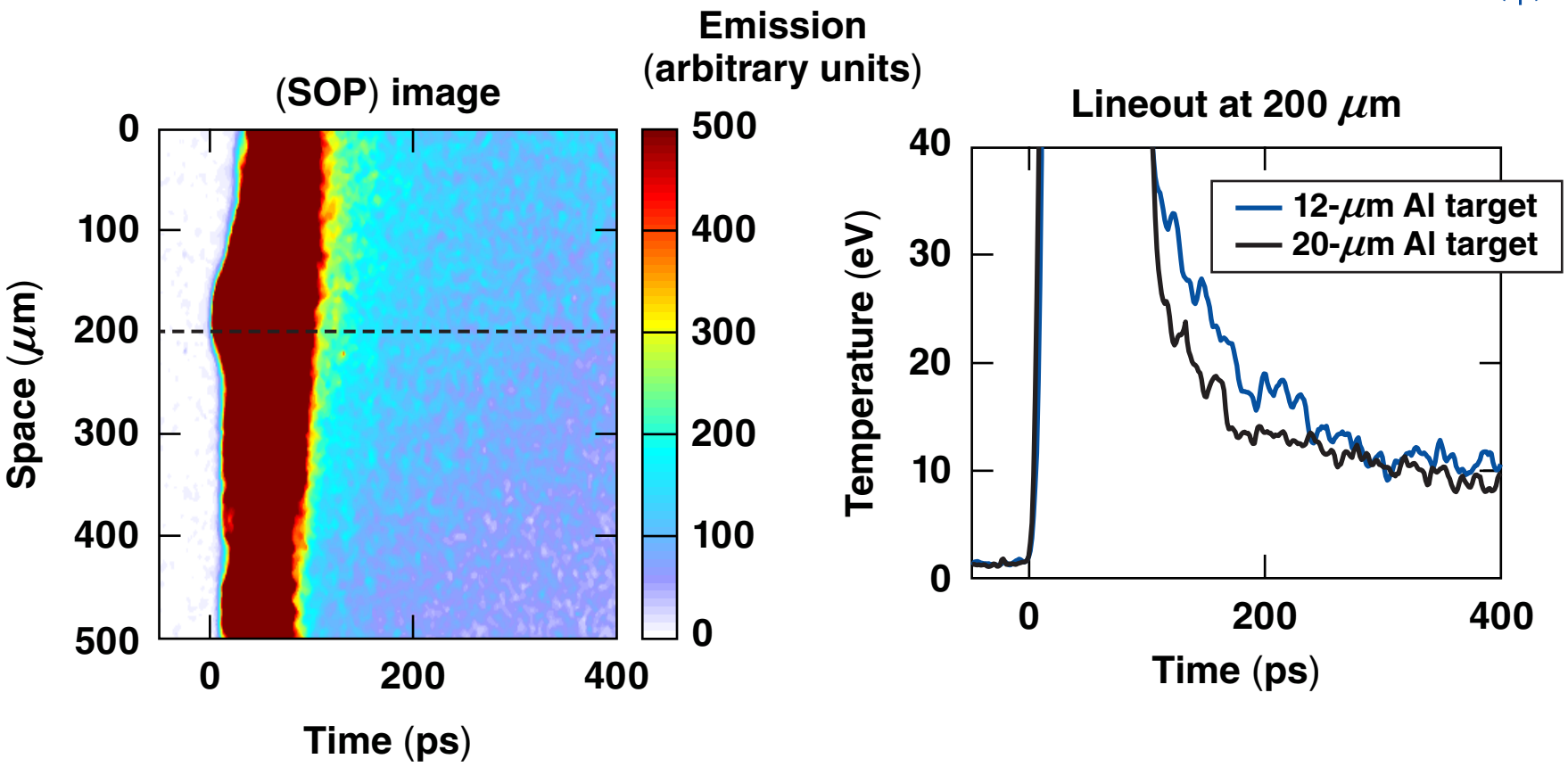
The volumetric heating process of refluxing hot electrons is shown in a comparison of 12- and 20-μm- thick Al targets



The bright flash obscures measurements of the intial temperature, which is needed for EOS studies.

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Summary/Conclusions

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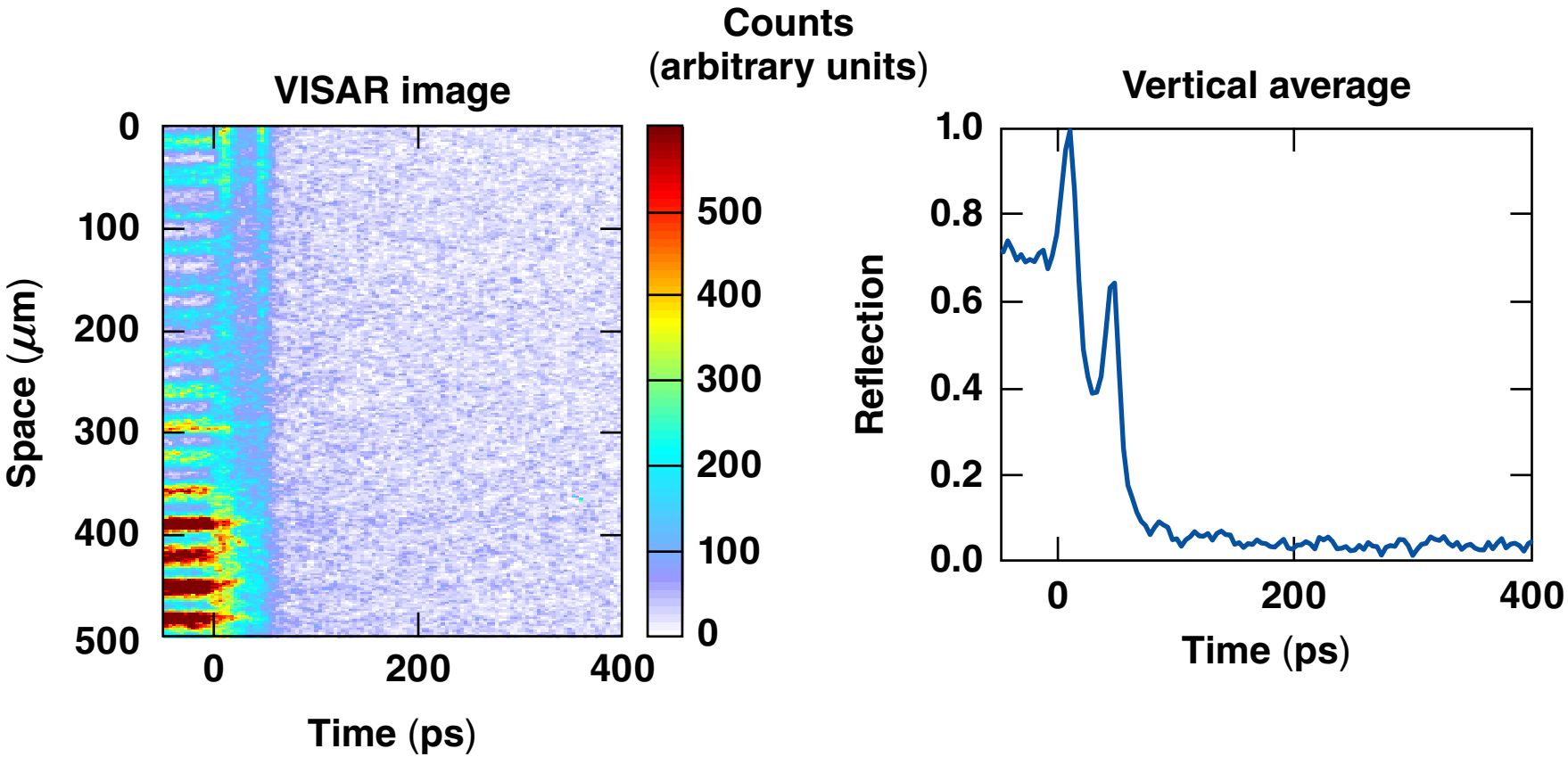
The VISAR images show the reflectivity goes to zero within 50 ps of the OMEGA EP laser hitting the target



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