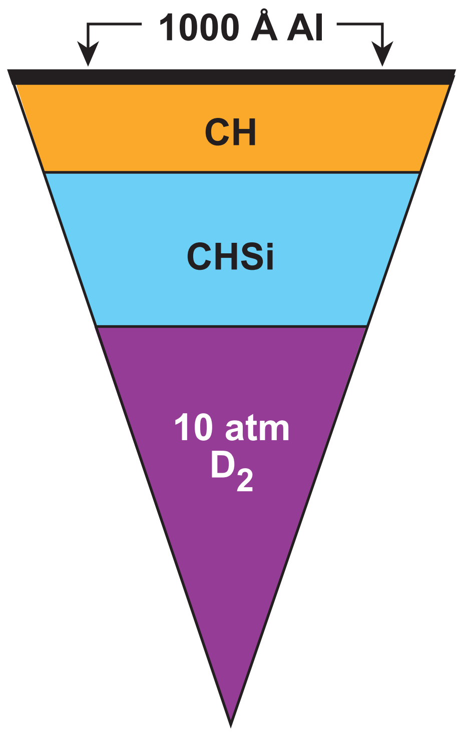
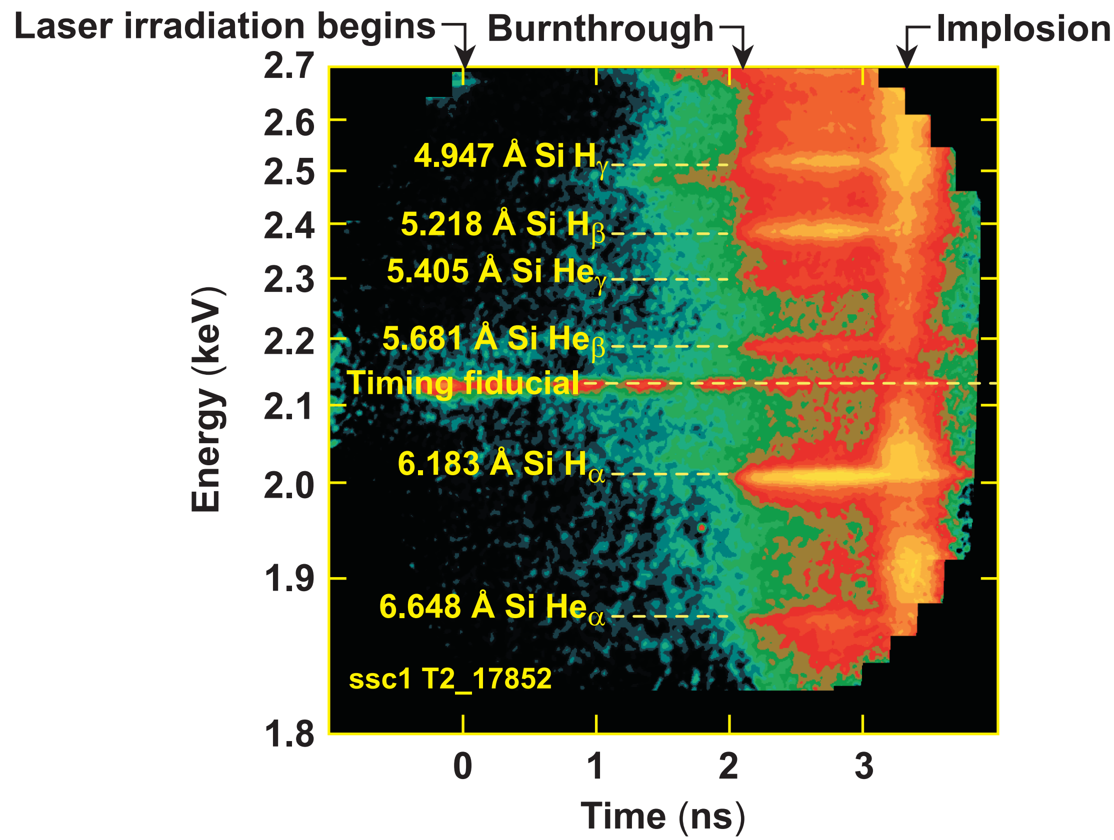
Laser-Driven Burnthrough Experiments on OMEGA with 1-THz SSD and Polarization Smoothing





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Laser-Driven Burnthrough Experiments on OMEGA with 1-THz SSD

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Burnthrough (BT) experiments are conducted on laser-driven plastic targets containing a buried Si-doped signature layer to study the ablative Rayleigh–Taylor instability (RTI). Both accelerated planar foils and spherically imploding capsules are utilized. Nonuniformities in the laser irradiation lead to target mass perturbations that seed the RTI, which causes Si to penetrate the heat front earlier than predicted by 1-D simulations. The onset of the Si *K*-shell emission occurs earlier for higher levels of laser imprint. Targets were irradiated by the 60-beam OMEGA laser system with peak intensities up to 6×10^{14} W/cm^2. BT measurements with 1-THz SSD are compared with previous experiments that had less SSD bandwidth and therefore higher levels of laser imprint. BT times from a 1-D postprocessor that includes the measured BT T_e and laser imprint spectra obtained from a 2-D hydrocode are compared with the experimental results. This work was supported by the U.S. Department of Energy Office of Inertial Confinement Fusion under Cooperative Agreement No. DE-FC03-92SF19460.

Collaborators

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Summary

Burnthrough experiments were performed with 1-THz SSD and polarization smoothing (PS)

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- Burnthrough (BT) experiments are conducted on laser-driven plastic targets containing a buried Si-doped signature layer to study the ablative Rayleigh–Taylor instability (RTI).
- RTI causes Si to penetrate the heat front earlier than predicted by 1-D simulations.
- Spherically imploding capsules were irradiated by the 60-beam OMEGA laser system with shaped pulses having peak intensities up to 6×10^{14} W/cm^2, and BT times were measured.
- Laser beams were smoothed with 1-THz SSD and PS.
- BT times are obtained from a 1-D postprocessor that includes the measured BT electron temperature and calculated laser-imprint spectra.

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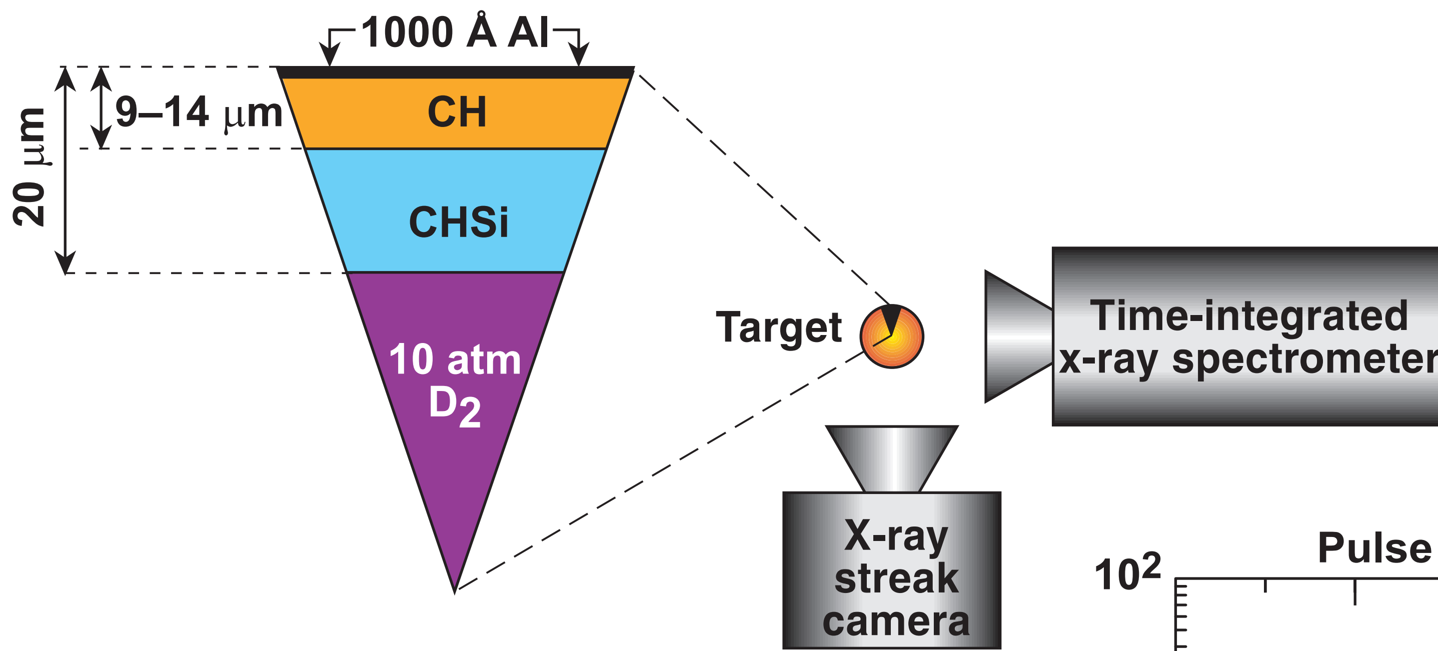
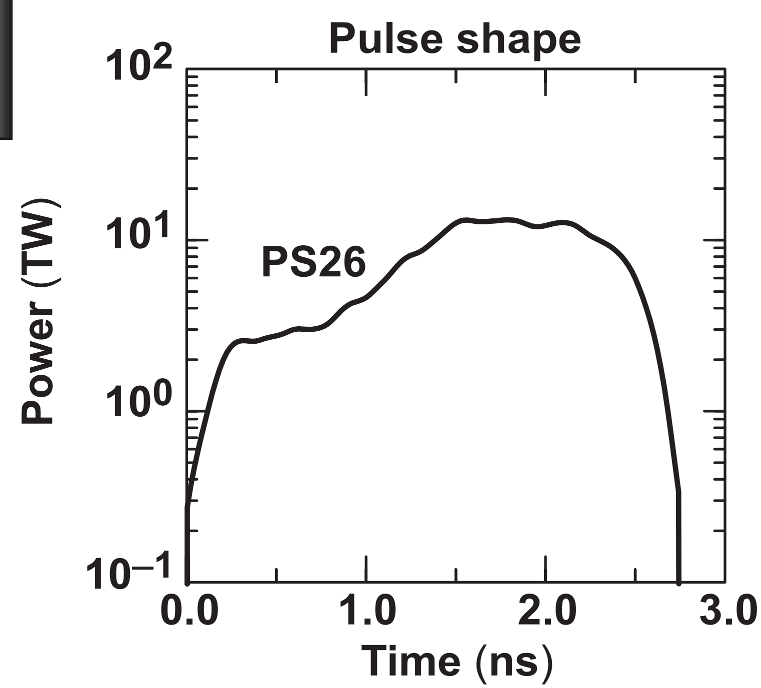
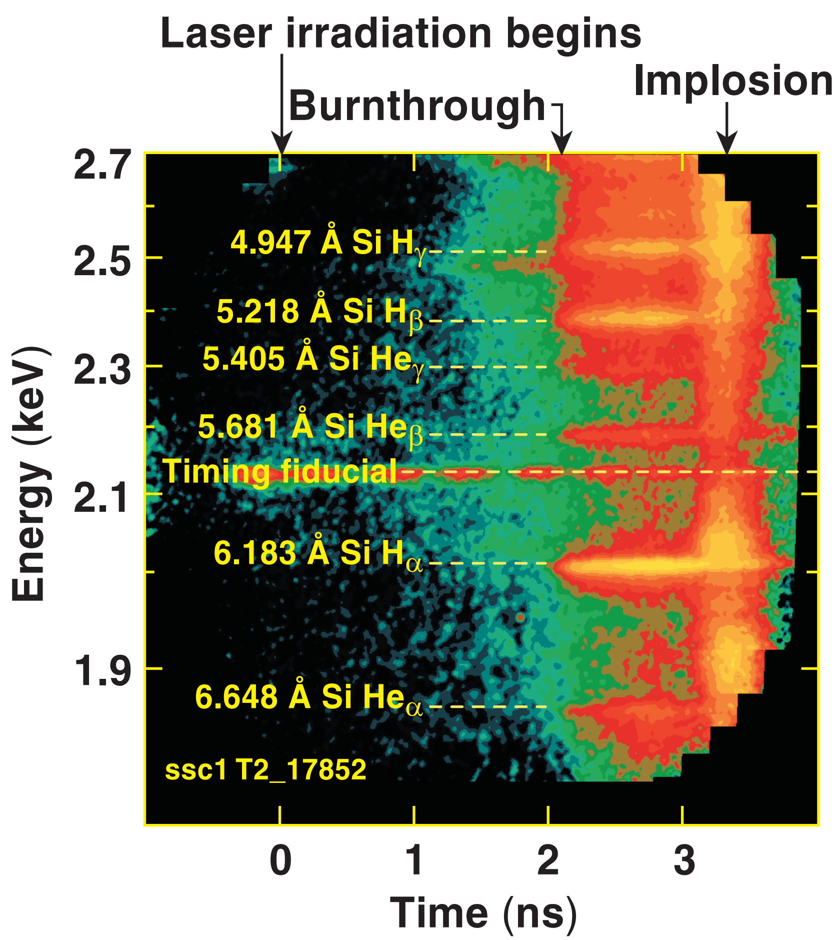
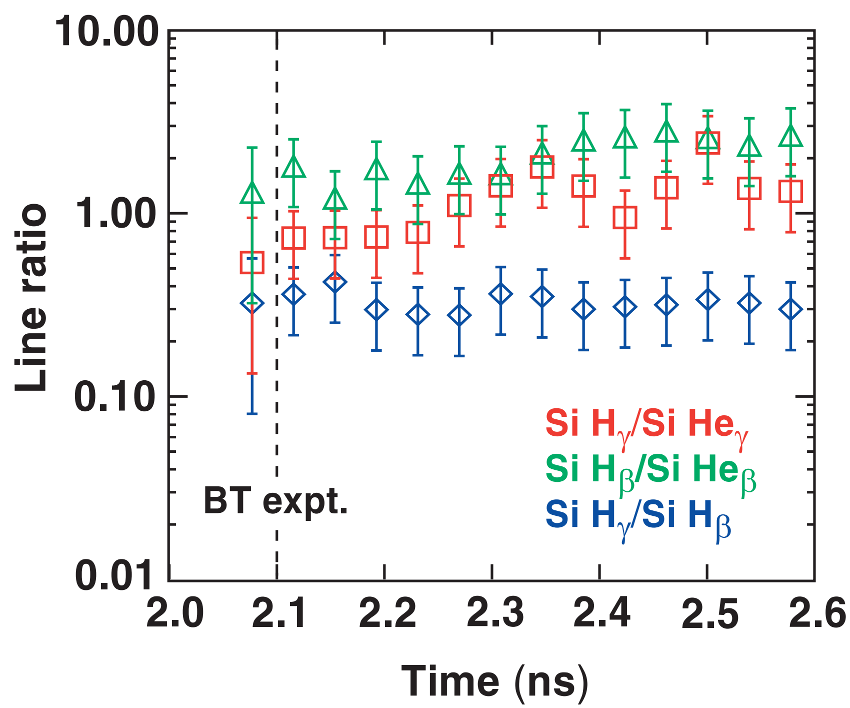
Si K-shell emission from a buried signature layer is monitored to measure burnthrough





Time-resolved x-ray spectroscopy is used to determine burnthrough time and the burnthrough electron temperature





- Burnthrough T_e ~ 750 eV is inferred from measured line ratios.

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Mixing is calculated using a multimode postprocessor to a 1-D hydrocode

- Laser imprint is calculated with the 2-D hydrocode *ORCHID*.
- Single-mode amplitudes grow using rates calculated from the Betti formula:*

$$A_k = A_{0k} e^{\gamma t}, \text{ where } \gamma = 0.98 \sqrt{\frac{kg}{1 + kL_m}} - 1.7\, kV_a.$$

- Saturation is included using Haan's model.**
- Mix thickness is obtained from rms amplitude summed over all modes ($\ell \leqslant 300$).

γ = instability growth rate
k = wave number of the mode
g = target acceleration
L_m = minimum-density-gradient scale length
V_a = ablation velocity

* R. Betti *et al.*, Phys. Plasma 5, 1446 (1998).

** S. W. Haan, Phys. Rev. A 39, 5812 (1989).

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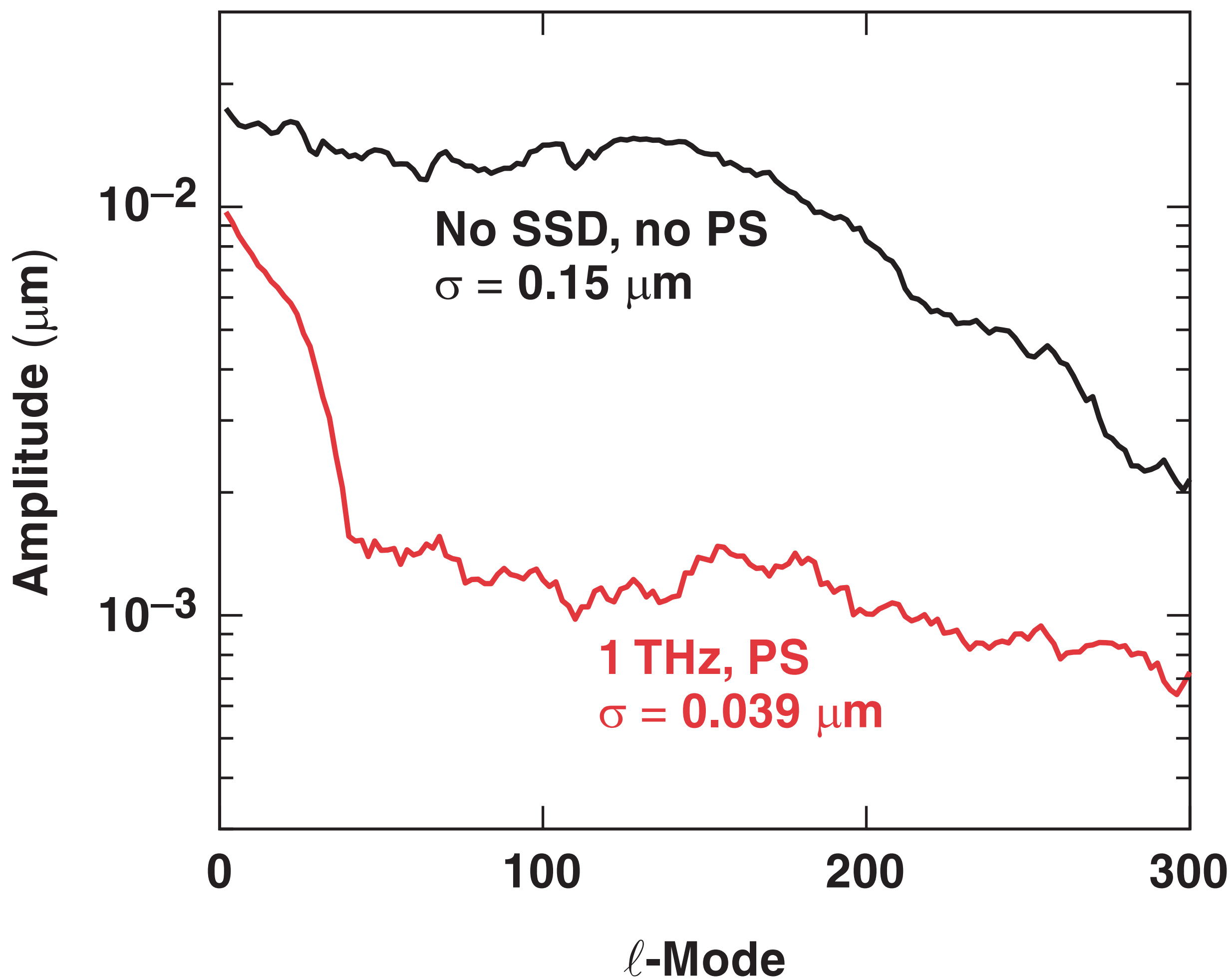
Imprint calculated by *ORCHID* for PS26 is substantially reduced with 1-THz SSD and PS



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Three times are defined in the burnthrough model

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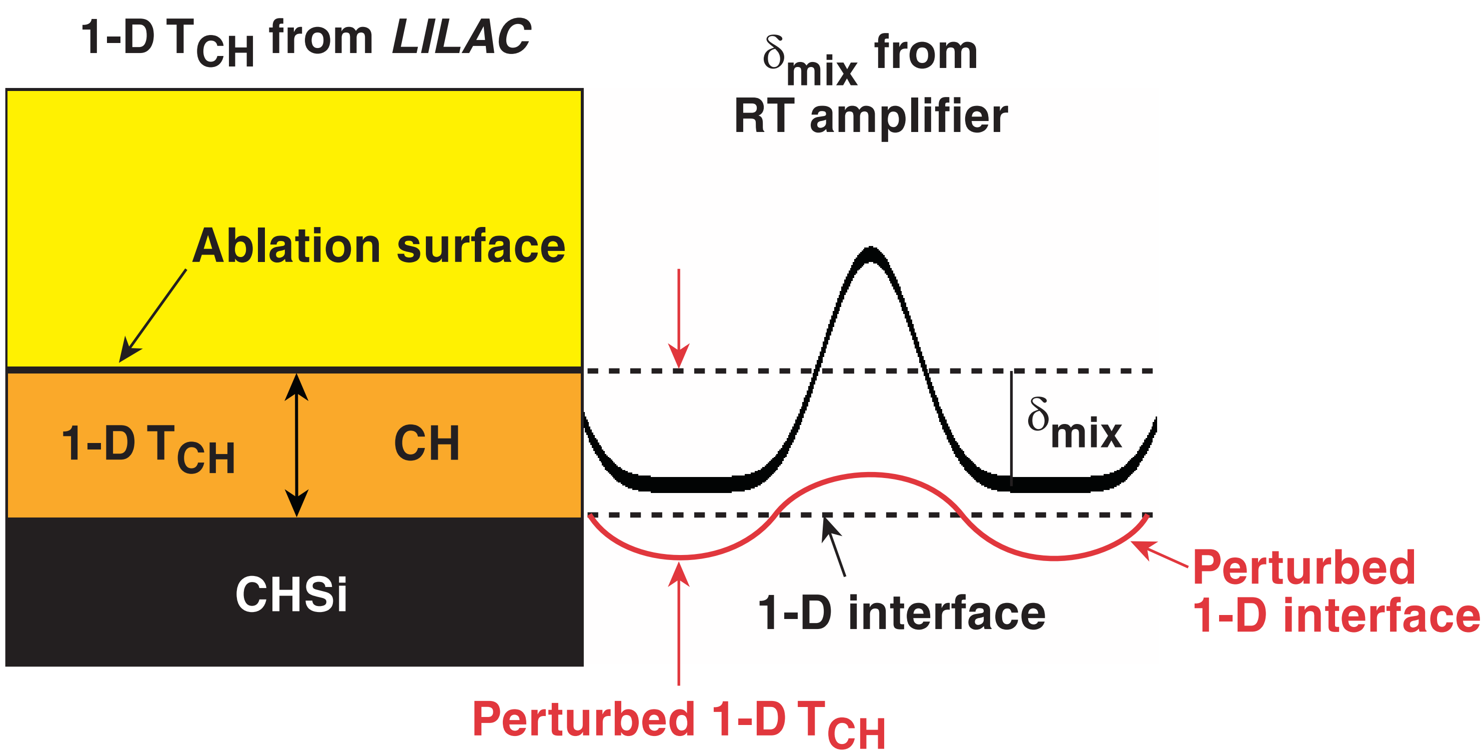
- t1: time for bubble to reach perturbed 1-D interface
- t2: time for Si to reach the tip of the spike
- t3: time to ablate Si to the 750-eV isotherm

Time t1 is defined to be when δ_{mix} equals the perturbed 1-D CH ablator thickness



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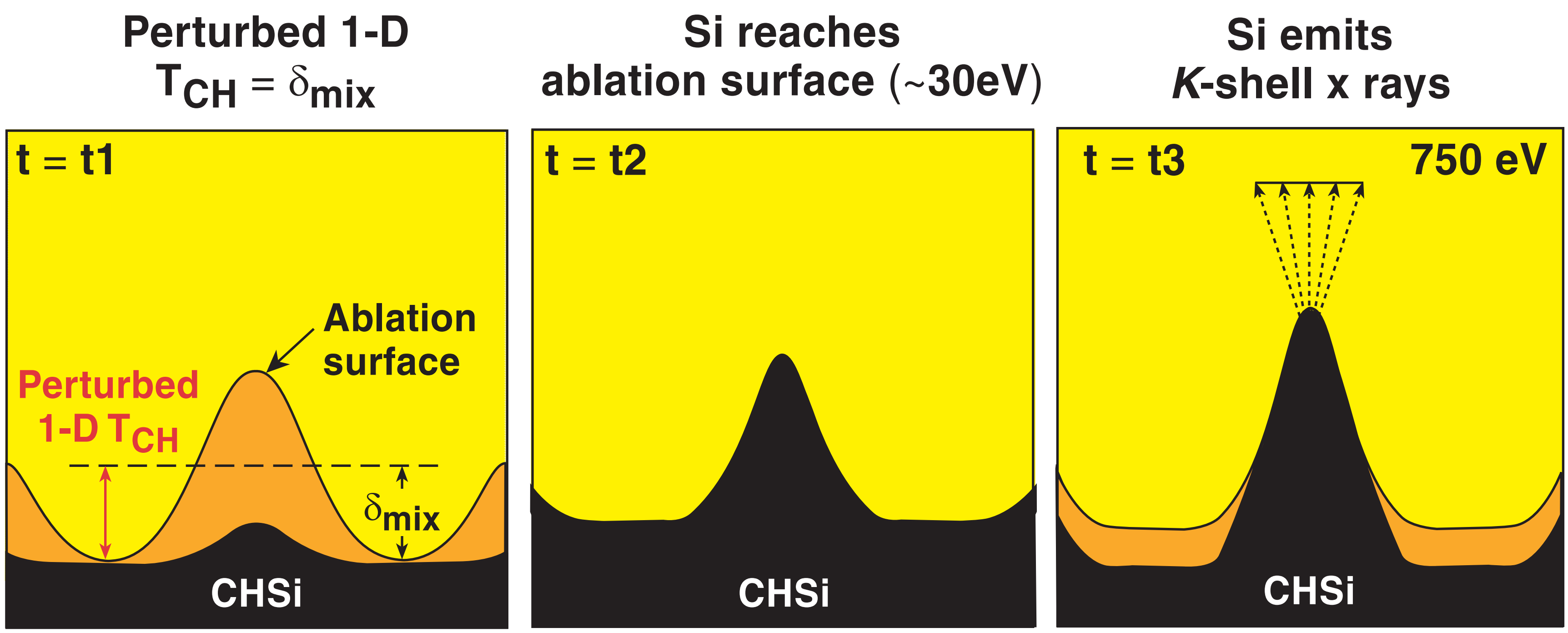
RT instability growth of accelerating shell causes early ablation at ~30-eV isotherm of Si from buried signature layer



Postprocessor does not model time from t1 to t2.

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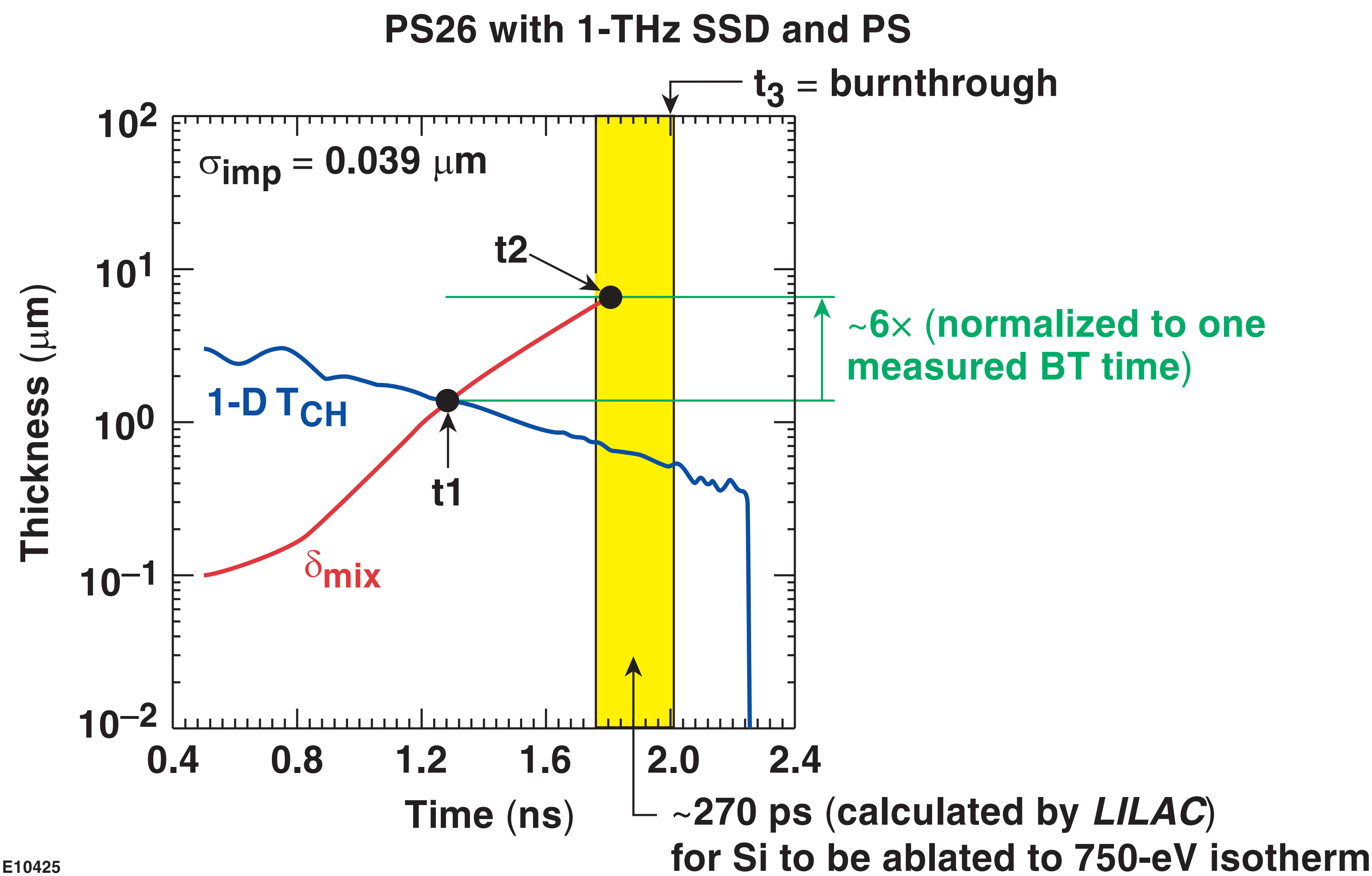
To predict burnthrough time δ_{mix} is allowed to grow by a factor of 6 from t1 to t2



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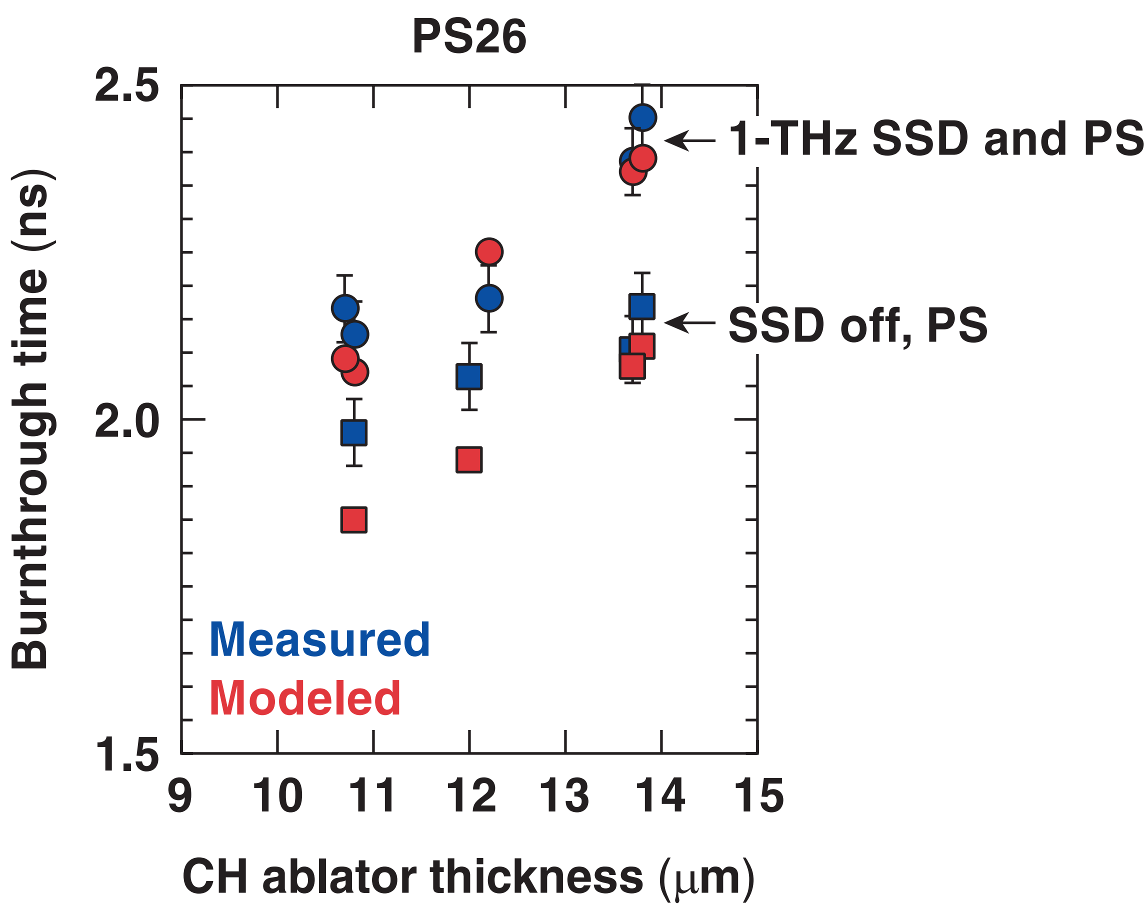
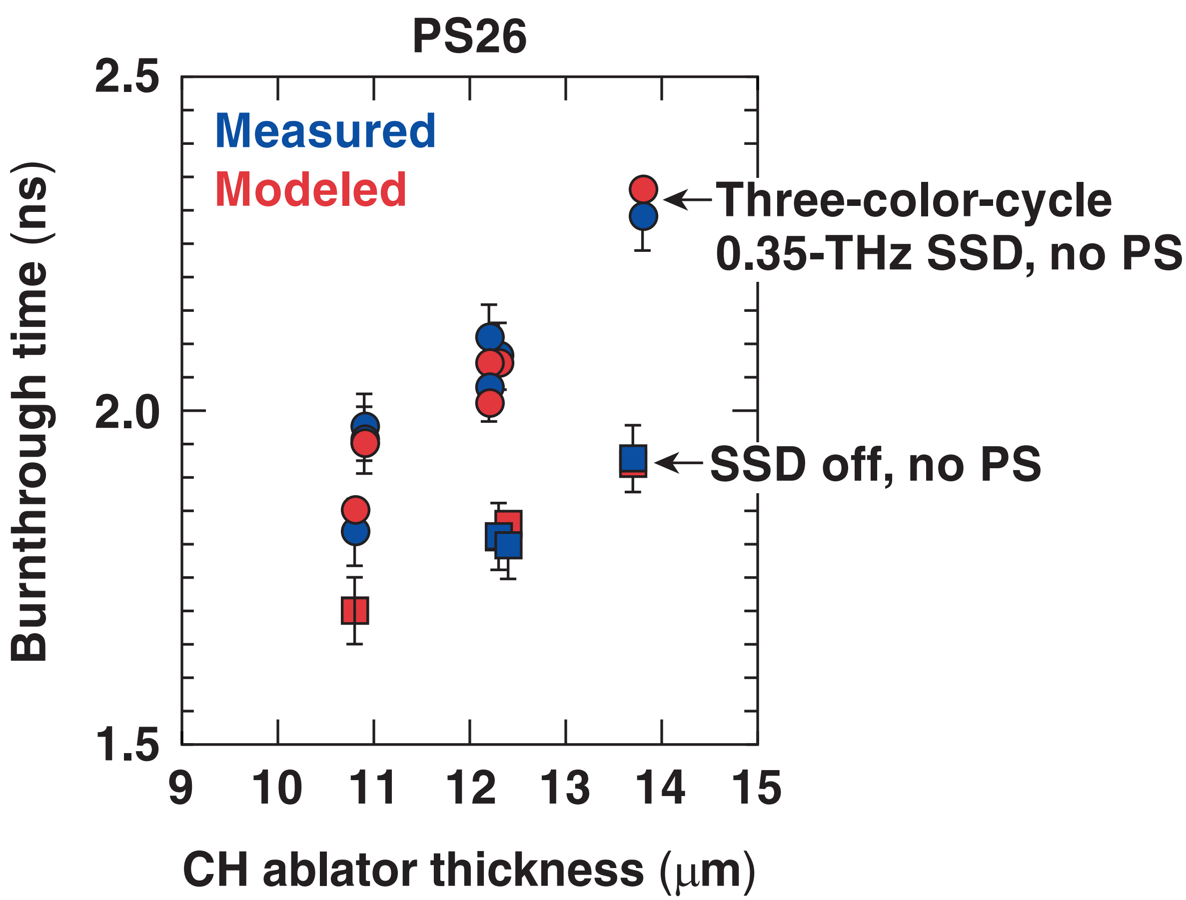
Burnthrough occurs later when laser beams are smoothed with 1-THz SSD and PS



E10661

A normalization factor of 3 is required to fit measurements with 0.35-THz SSD and with no SSD bandwidth



Summary/Conclusions

Burnthrough experiments were performed with 1-THz SSD and polarization smoothing (PS)

- Spherically imploding burnthrough capsules were irradiated by the 60-beam OMEGA laser system with shaped pulses having peak intensities up to 6×10^{14} W/cm^2.
- Four types of laser-beam smoothing with phase plates were studied:
  - no-SSD bandwidth
  - 0.35-THz, three-color-cycle SSD
  - PS with no SSD bandwidth
  - PS with 1-THz SSD
- BT times are obtained from a 1-D postprocessor that includes the measured BT electron temperature and calculated laser-imprint spectra.
- BT with PS requires a larger normalization factor.

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Imprint calculated by *ORCHID* for PS26 is substantially reduced with 1-THz SSD and PS

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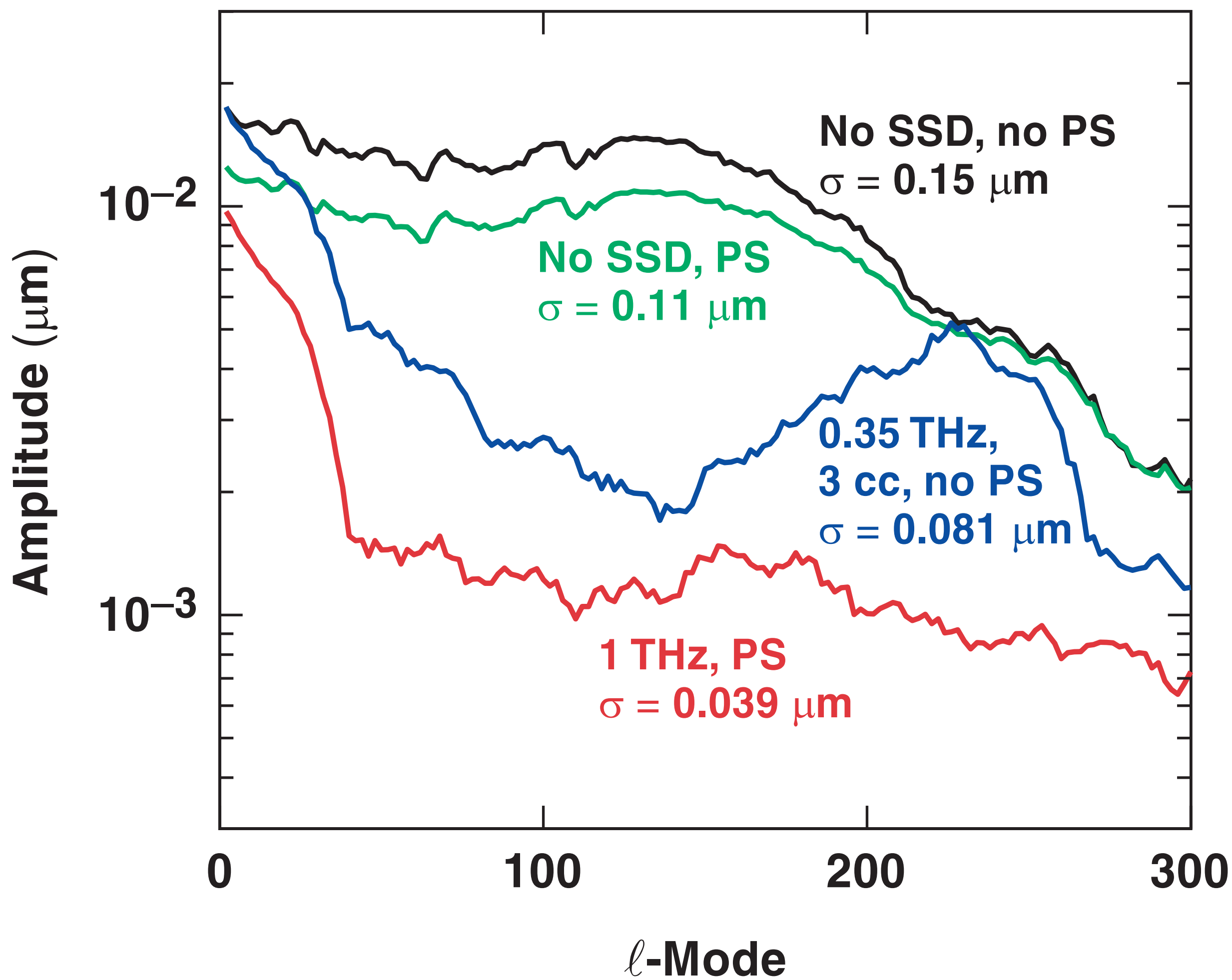

E10702