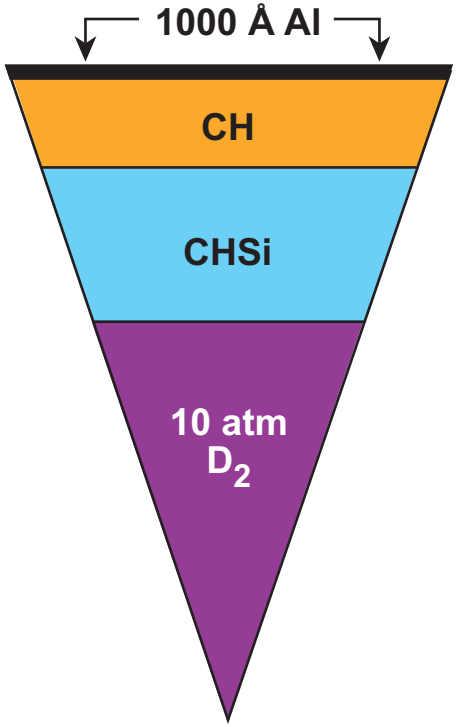
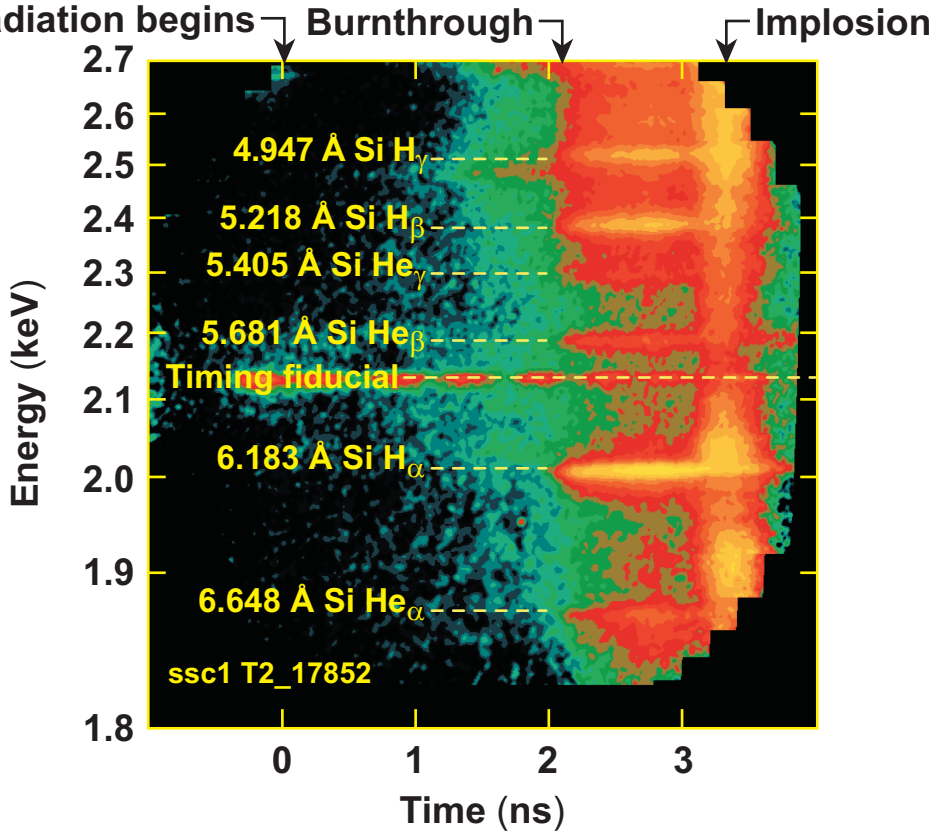
Laser-Driven Burnthrough Experiments on OMEGA





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30th Annual Anomalous
Absorption Conference
Ocean City, MD
21–26 May 2000

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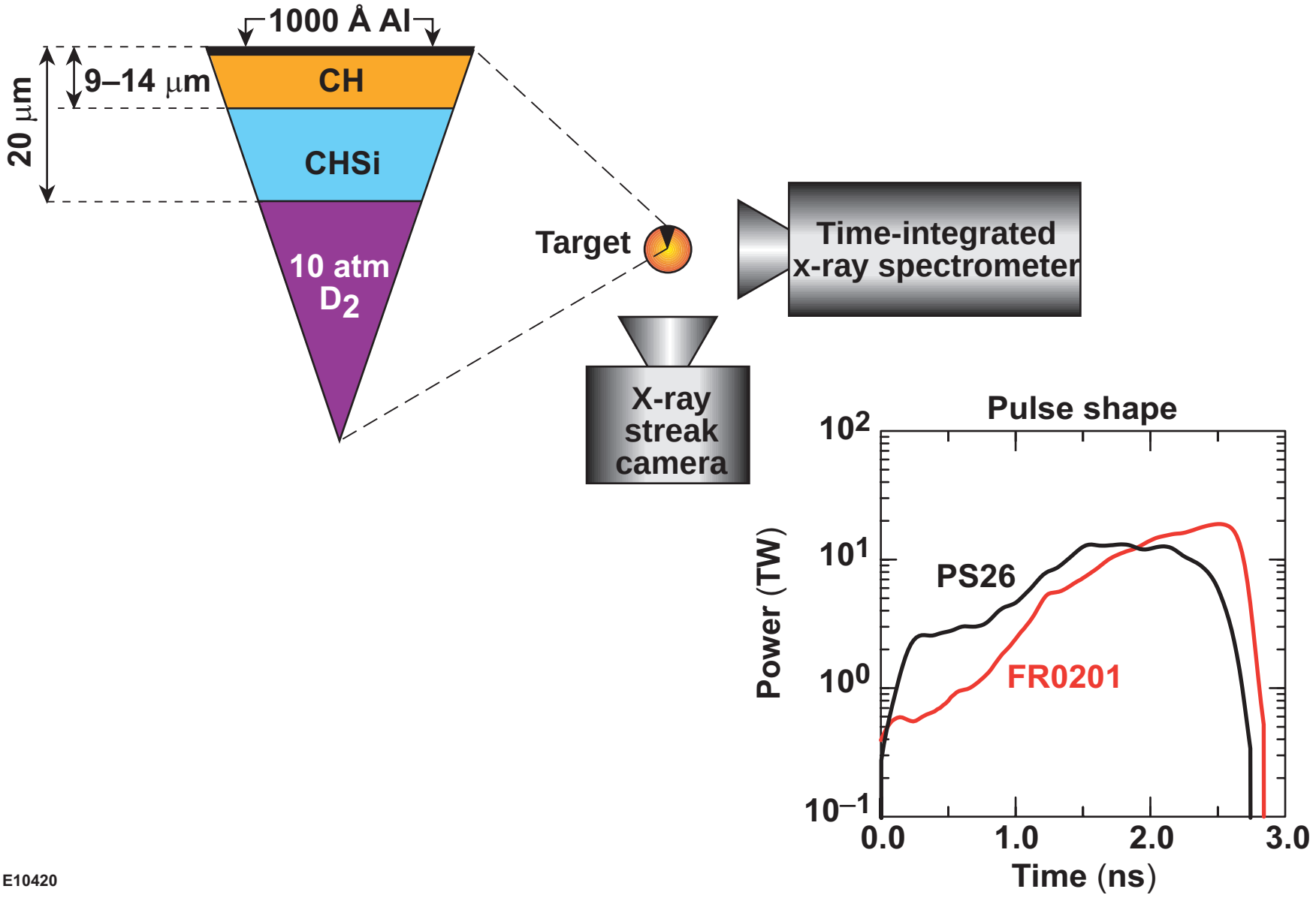
Summary

Experimental measurements of burnthrough have been made and compared with a new theoretical model

UR LLE

- The measured burnthrough electron temperature is ~750 eV.
- The experiment has been modeled using an *ORCHID*-calculated imprint and a multimode *LILAC* postprocessor.
- Experimental results show late burnthrough with 3 color cycle, 0.35 THz SSD, consistent with the smaller calculated imprint level.

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



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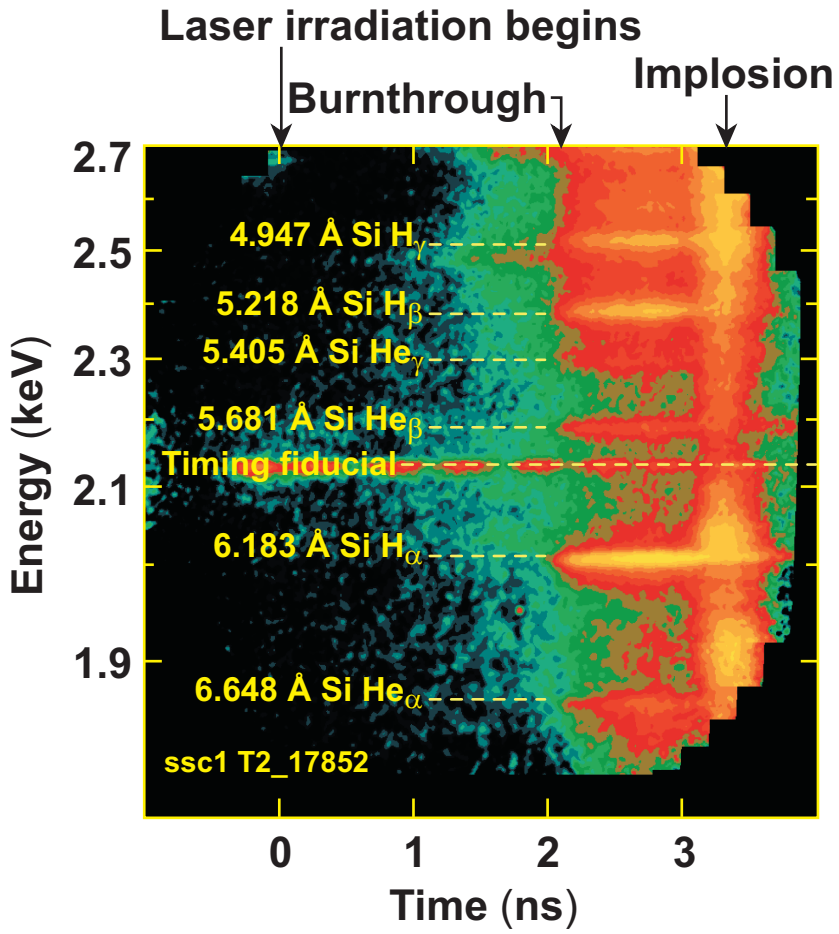
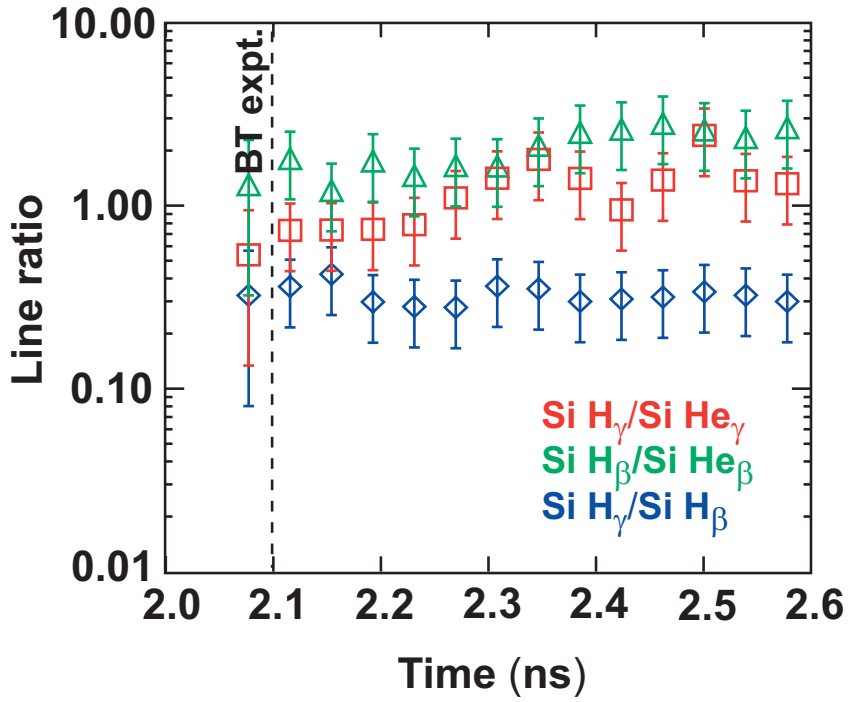
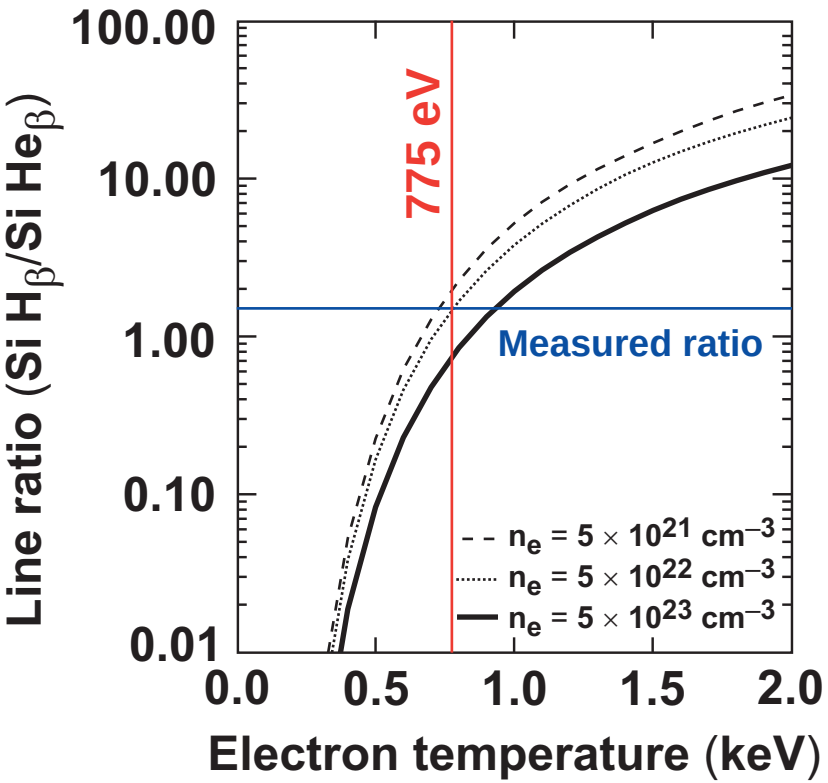
Time-resolved x-ray spectroscopy is used to determine burnthrough time and the burnthrough electron temperature

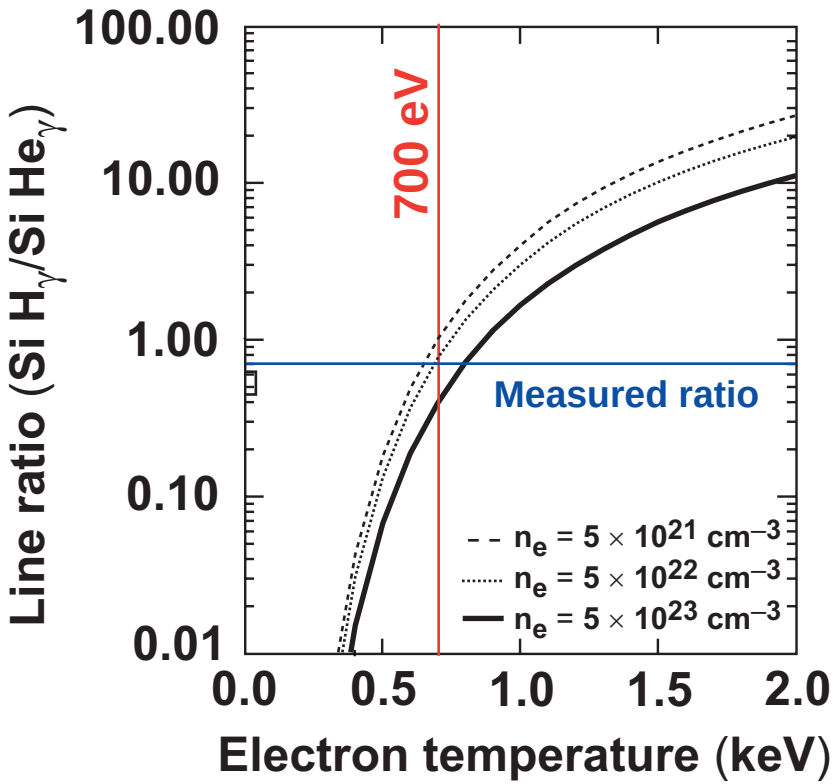




- Measured line ratios show little variation in time.

Burnthrough occurs when Si is ablated to the ~750-eV isotherm





- Line ratios are relatively insensitive to variations in electron density.

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

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

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

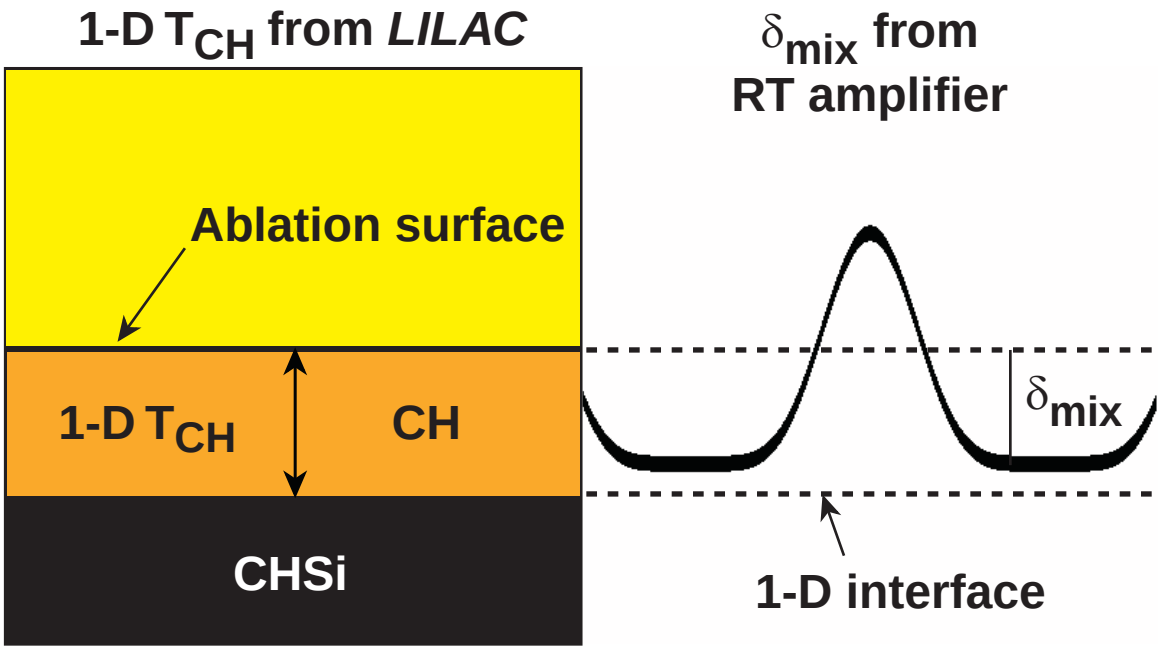
- Saturation is included using Haan's model.**
- Mix thickness is obtained from rms amplitude summed over all modes ($\ell \leqslant 300$).

γ = instability growth rate
$k = \frac{\ell}{r}$ is wave number of the mode
g = target acceleration
L_m = minimum density-gradient scale length
V_a = ablation velocity

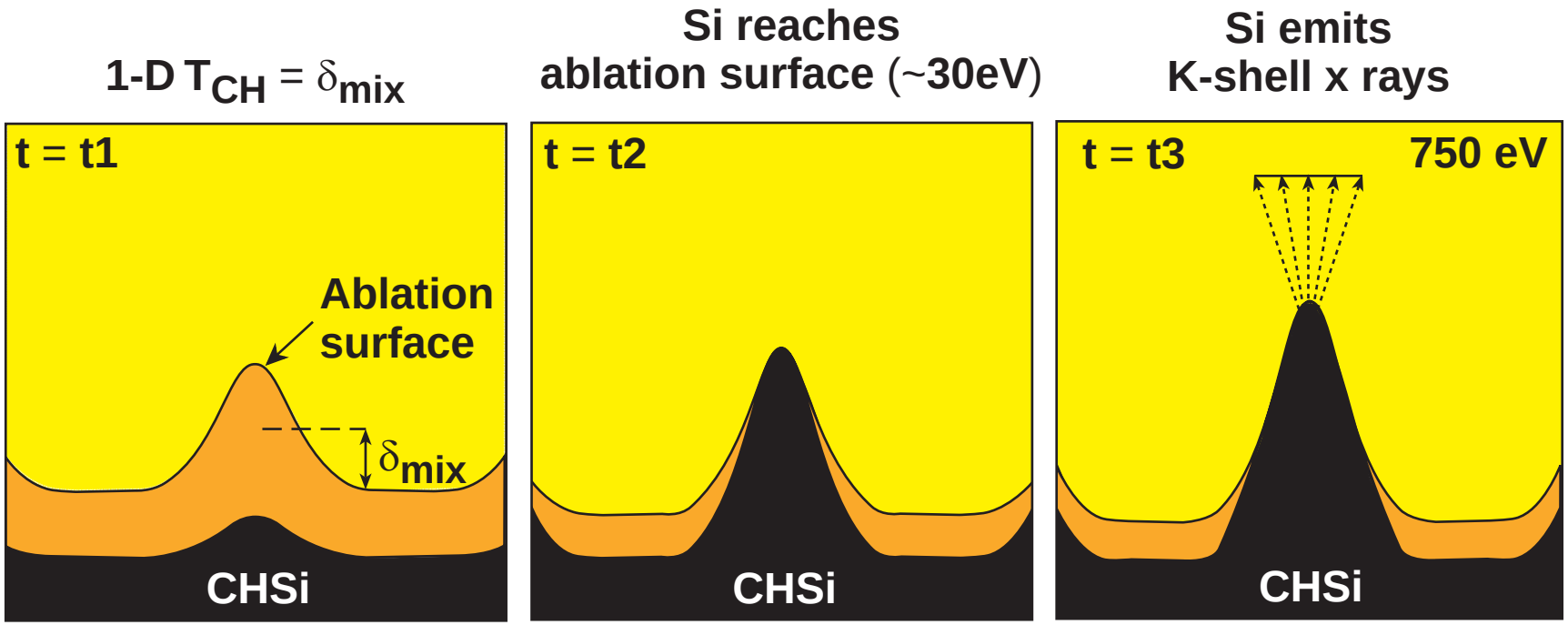
* R. Betti *et al.*, Phys. Plasma 5, 1446 (1998).

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

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

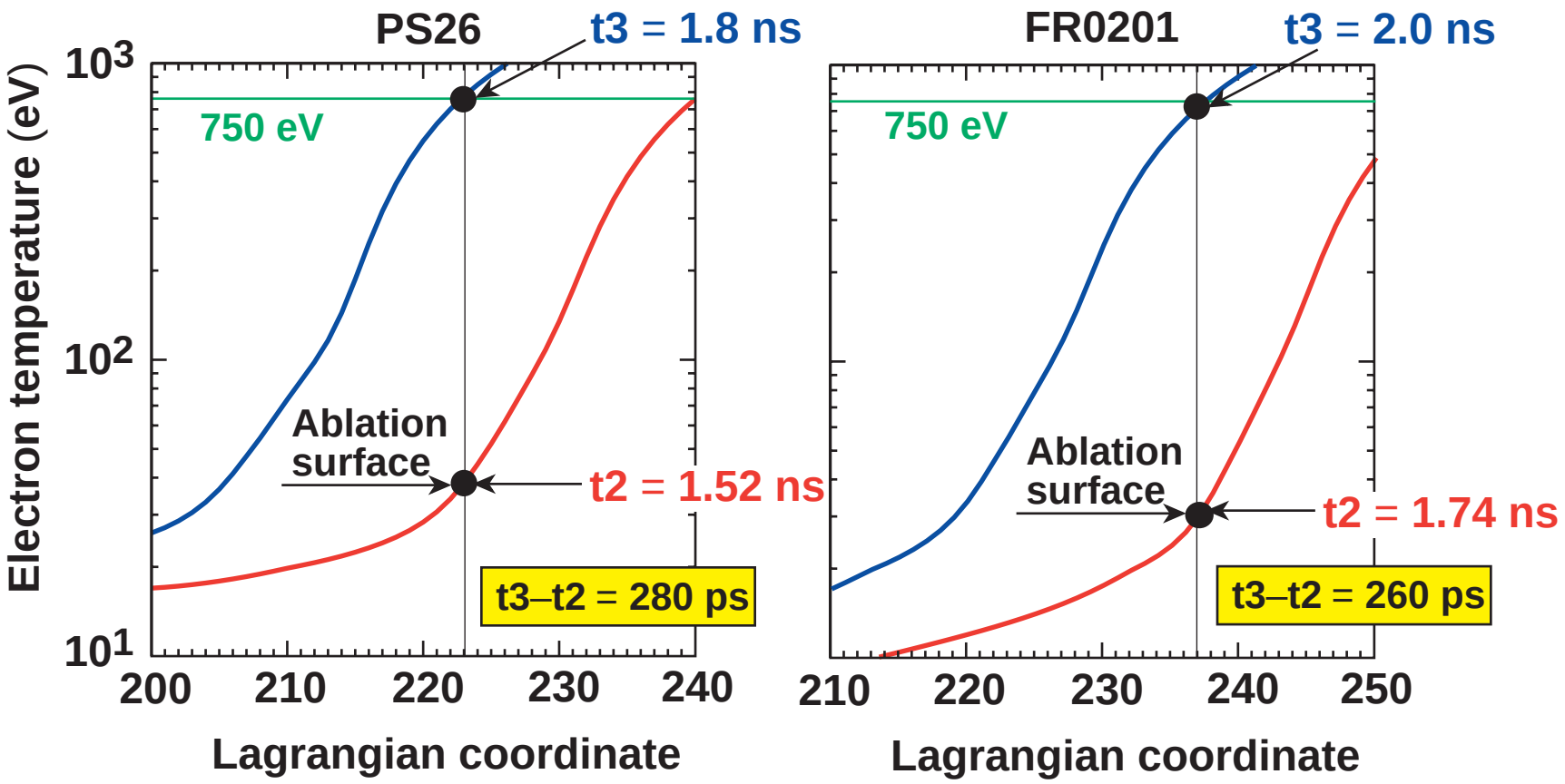


RT instability growth of accelerating shell causes early ablation at ~30-eV isotherm of Si from buried signature layer



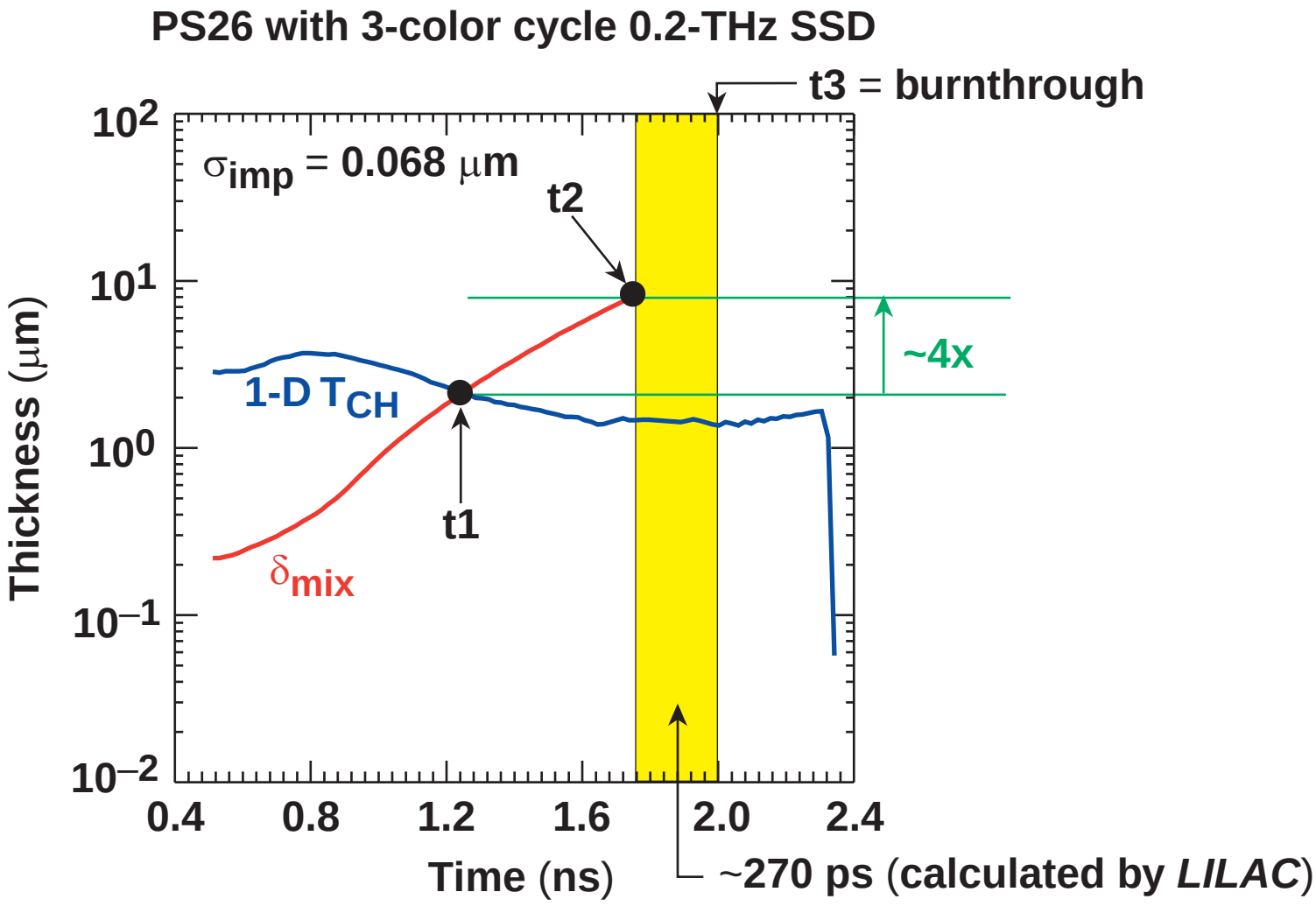
Postprocessor does not model time from t1 to t2.

LILAC simulations indicate that a fluid element takes ~270 ps to move from the ablation surface to the 750-eV isotherm

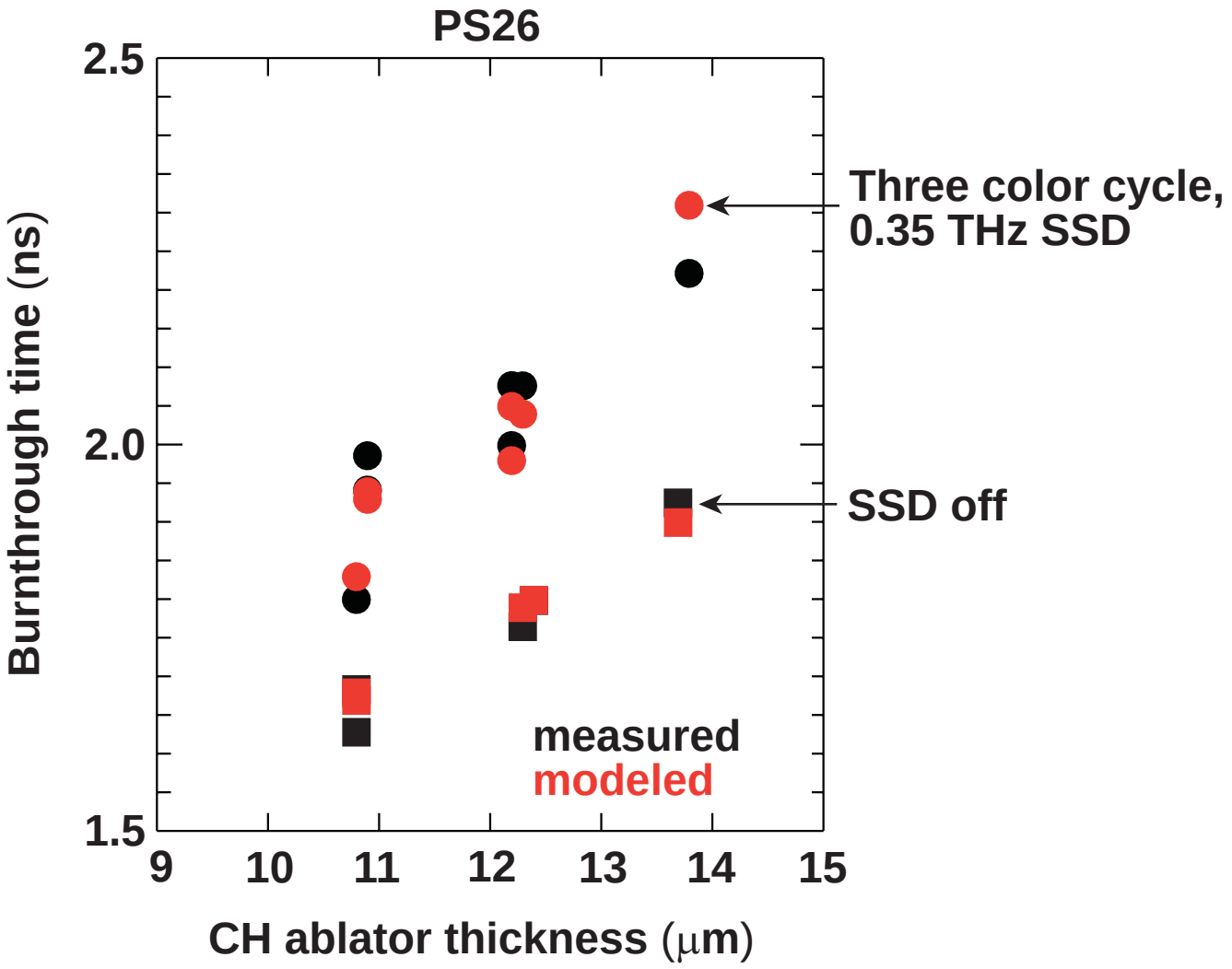


Shown are Te profiles at times when a fluid element is at the ablation surface (t2) and when it reaches the 750-eV isotherm (t3) .

To predict burnthrough time δ_{mix} is allowed to grow by a factor of 4 from t1 to t2



Burnthrough occurs later when laser beams are smoothed with SSD



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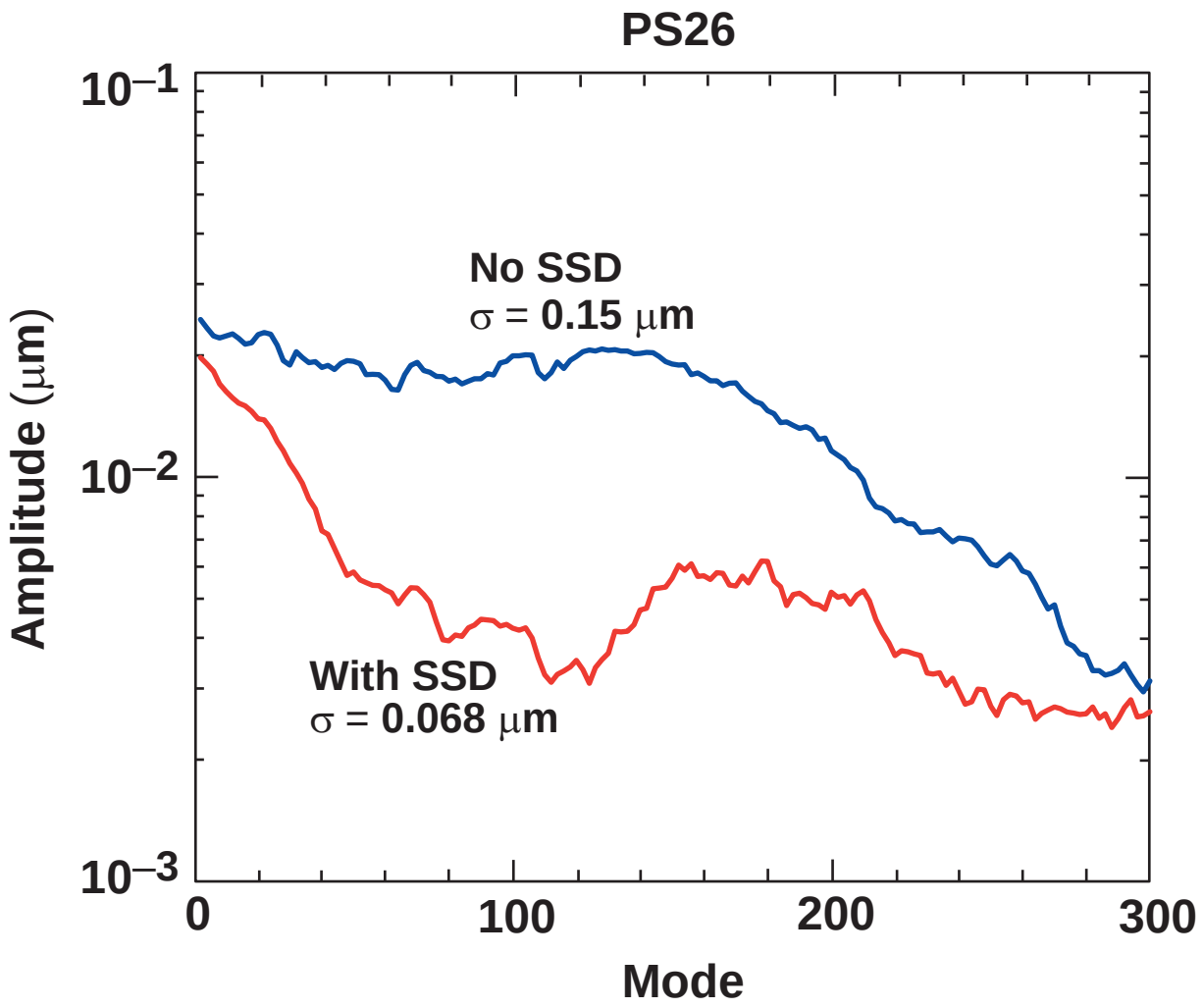
ORCHID calculation predicts that three color cycle SSD reduces laser imprint by a factor of 2.2 for PS26



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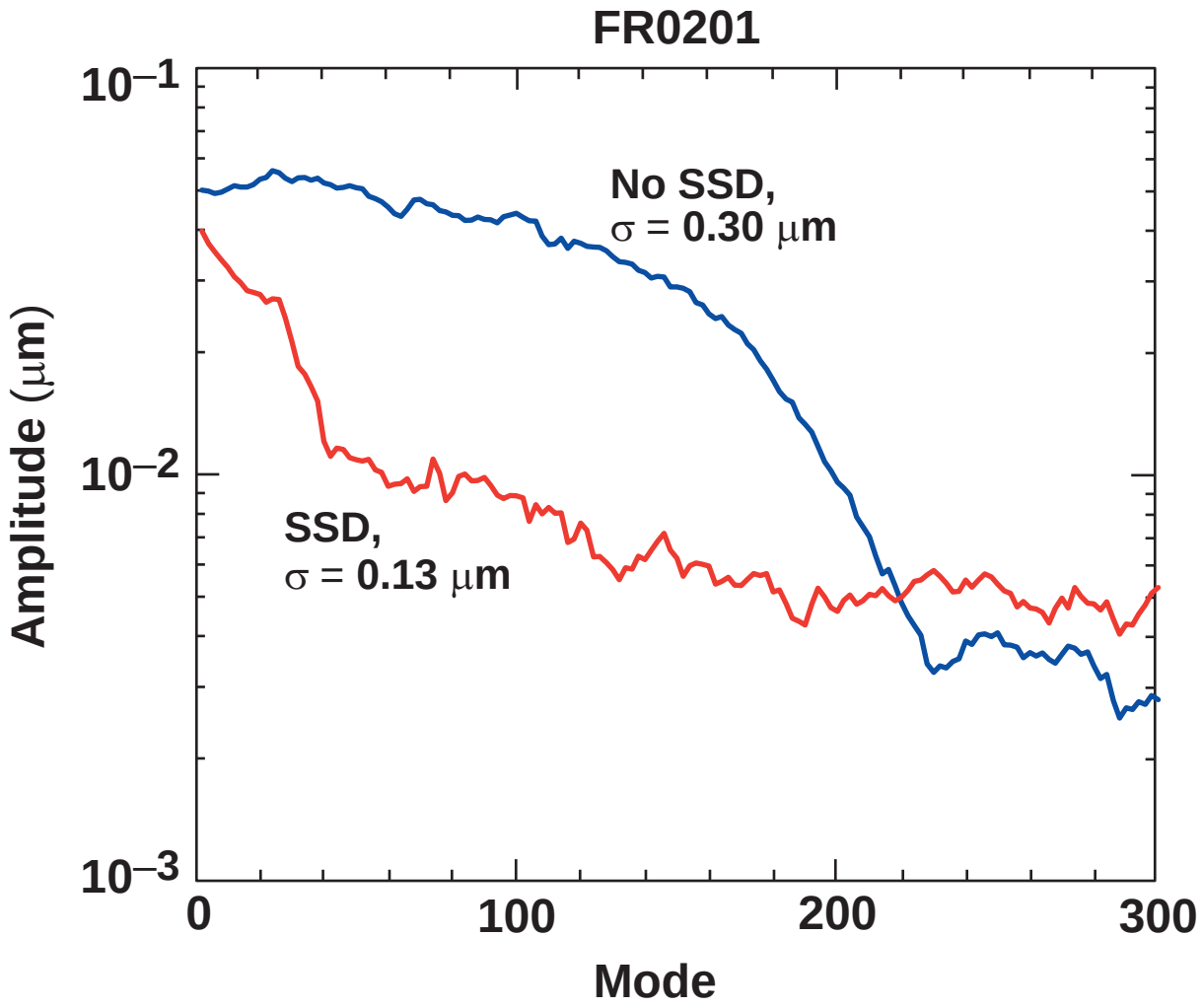
ORCHID calculation predicts a similar reduction in laser imprint for pulse shape FR0201



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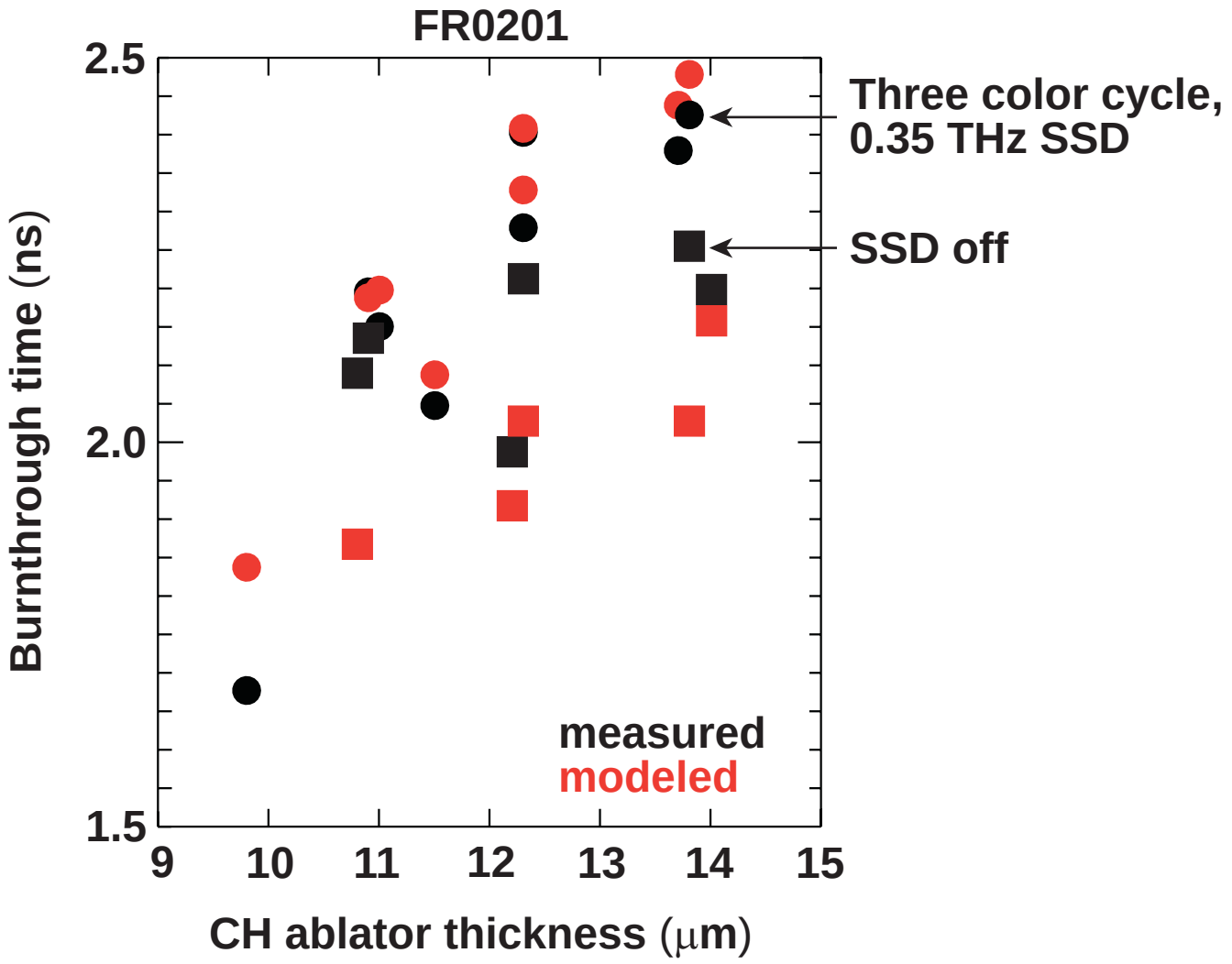
A factor of 5 in the growth of δ_{mix} is needed from t1 to t2 to predict burnthrough time for FR0201



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Summary/Conclusion

Experimental measurements of burnthrough have been made and compared with a new theoretical model

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- The measured burnthrough electron temperature is ~750 eV.
- The experiment has been modeled using an *ORCHID*-calculated imprint and a multimode *LILAC* postprocessor.
- Experimental results show late burnthrough with 3 color cycle, 0.35 THz SSD, consistent with the smaller calculated imprint level.
- Further 2-D simulations with particle tracking are needed to understand the mass flow within the spike.