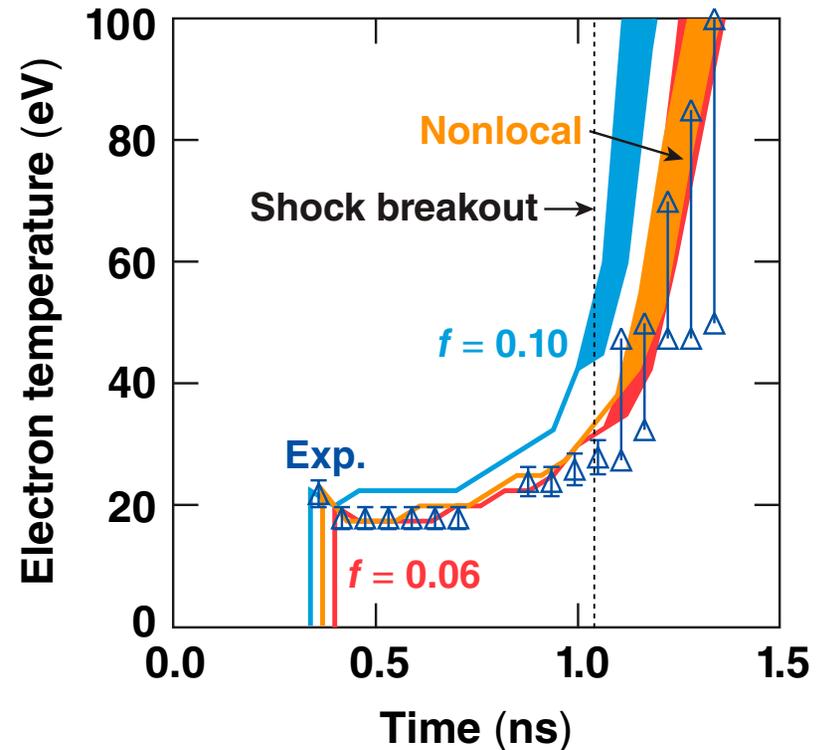
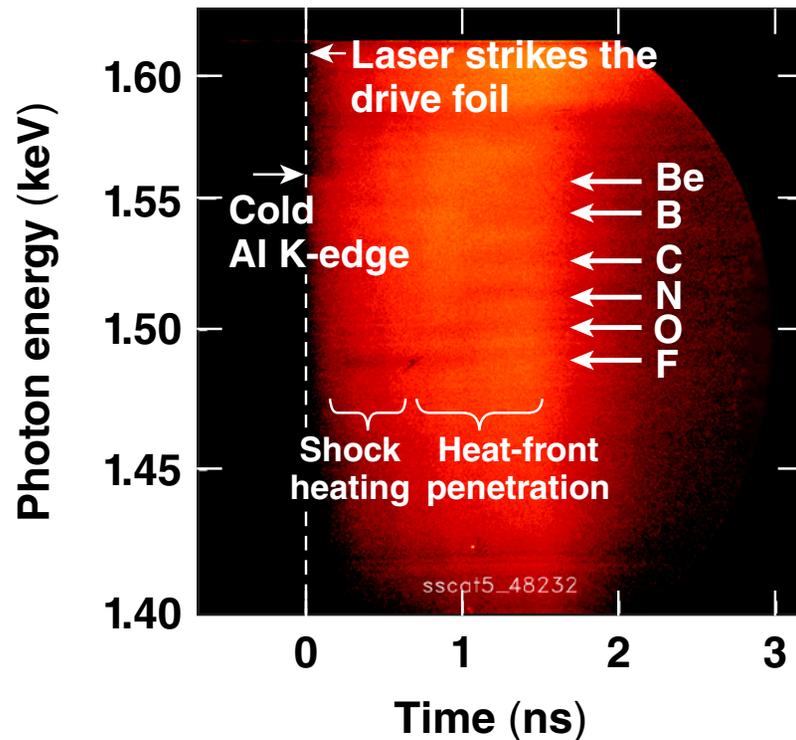


Experimental Investigation of Thermal-Transport Models in Direct-Drive Targets Using X-Ray Absorption Spectroscopy



Shot 48232, Peak intensity: 8×10^{14} W/cm², CH[10]Al[1]CH[40]



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50th Annual Meeting of the
American Physical Society
Division of Plasma Physics
Dallas, TX
17–21 November 2008

Summary

Nonlocal* and flux-limited ($f = 0.06$) thermal transport models accurately predict measurements while the shock transits the foil



- A CH foil with a buried Al tracer layer was directly irradiated with a square or shaped pulse drive with peak intensities of 5×10^{13} to 1×10^{15} W/cm².
- Shock-wave heating and heat-front penetration were measured using time-resolved Al 1s–2p absorption spectroscopy to test thermal-transport models with the 1-D hydrodynamics code *LILAC*.
- The measured absorption spectra were modeled with *PrismSPECT*** to infer T_e and ρ , assuming uniform conditions in the Al layer ($T_e \sim 10$ to 40 eV and $\rho \sim 3$ to 11 g/cm³).
- Lower T_e than predicted at late times of the drive was attributed to reduced radiative heating caused by lateral heat flow in the corona.

* V. N. Goncharov *et al.*, Phys. Plasmas **13**, 012702 (2006).

** Prism Computational Sciences, Inc. Madison, WI 5371 .

Collaborators



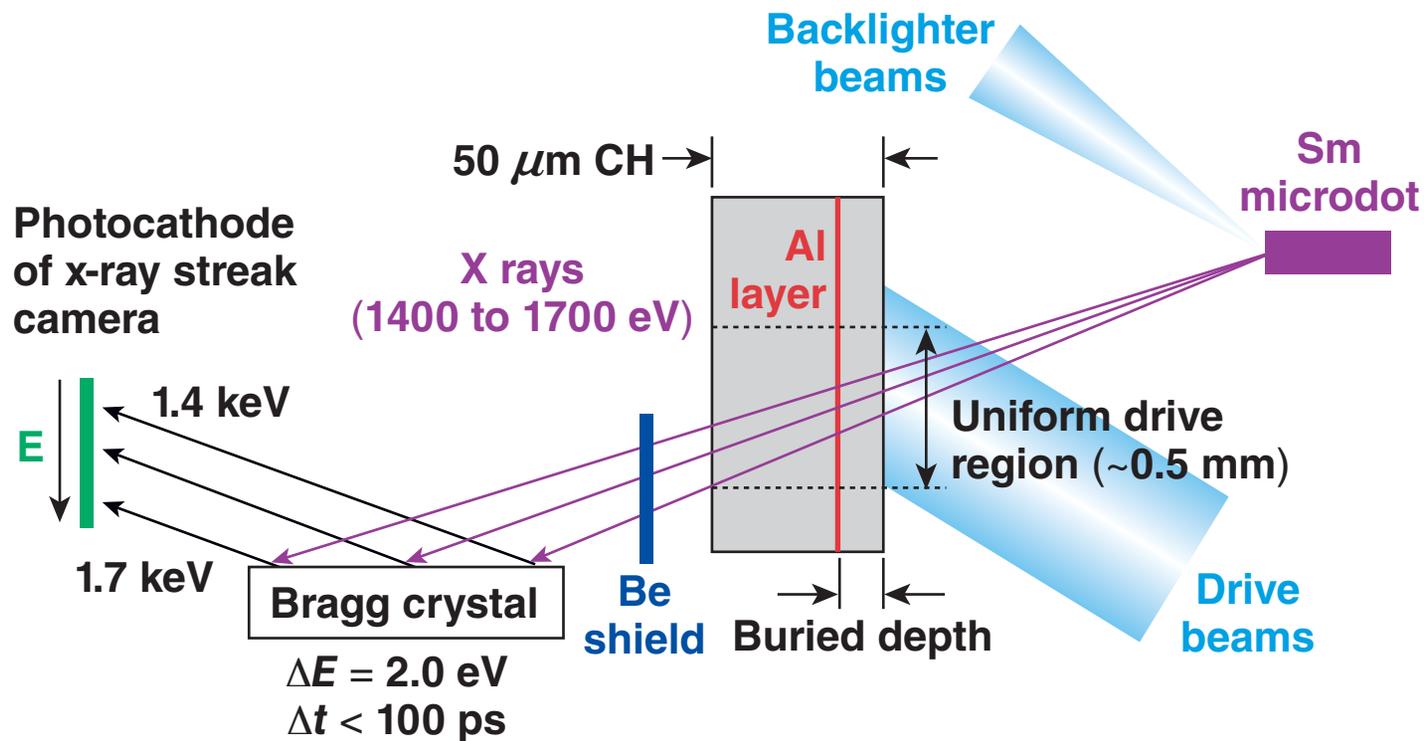
**S. P. Regan, P. B. Radha, R. Epstein, D. Li, V. N. Goncharov, S. X. Hu,
D. D. Meyerhofer, J. A. Delettrez, P. A. Jaanimagi, V. A. Smalyuk,
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R. C. Mancini

University of Nevada–Reno

X-ray absorption spectroscopy of a CH planar target with an Al tracer layer was used to test thermal-transport models

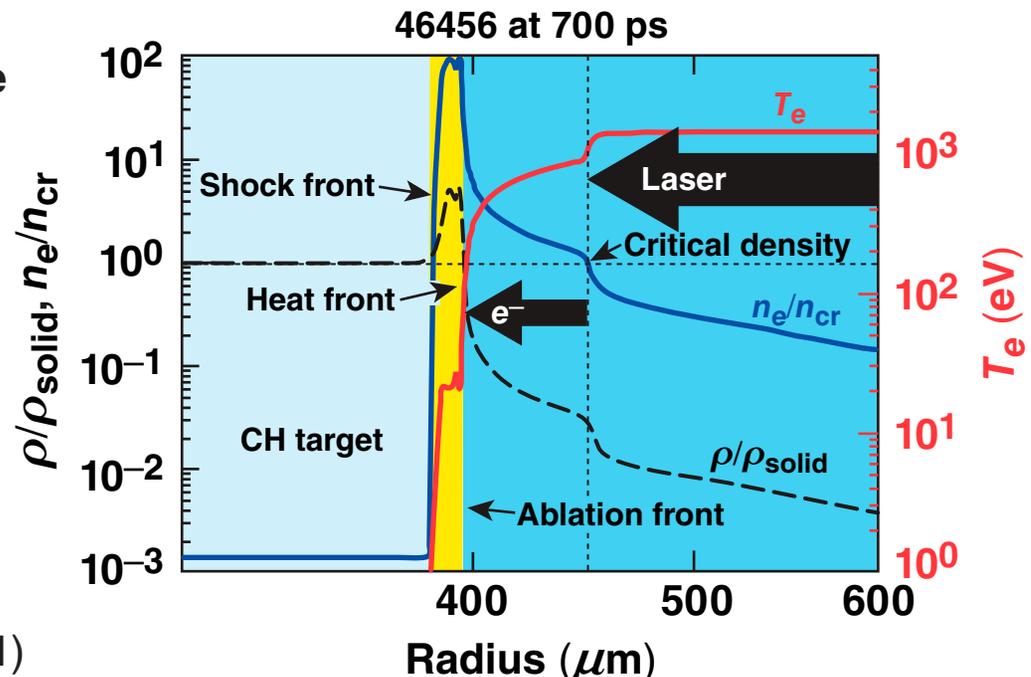


An *in-situ* calibration of the x-ray streak camera was performed to eliminate background light from the measured signals.

Heat flux in *LILAC* is calculated using a flux-limited or a nonlocal thermal-transport model

LILAC (1-D hydrodynamics code)¹

- Laser absorption with ray trace
- Radiation transport
- Equation of state (*SESAME*)
- Thermal transport
 - flux-limited model,
 $q_{\text{eff}} = \min(q_{\text{SH}}, f \times q_{\text{FS}})$
 - classical Spitzer flux:²
 $q_{\text{SH}} = -k \nabla T$
 - free streaming flux:
 $q_{\text{FS}} = n T v_T$
 - flux limiter³ f ($0.04 < f < 0.1$)
 (q_{SH} is invalid in plasmas with strong T_e gradient)
- Nonlocal model⁴ (no flux limiter) acts like a time-dependent flux limiter



The strength of the shock wave depends on thermal-transport models.

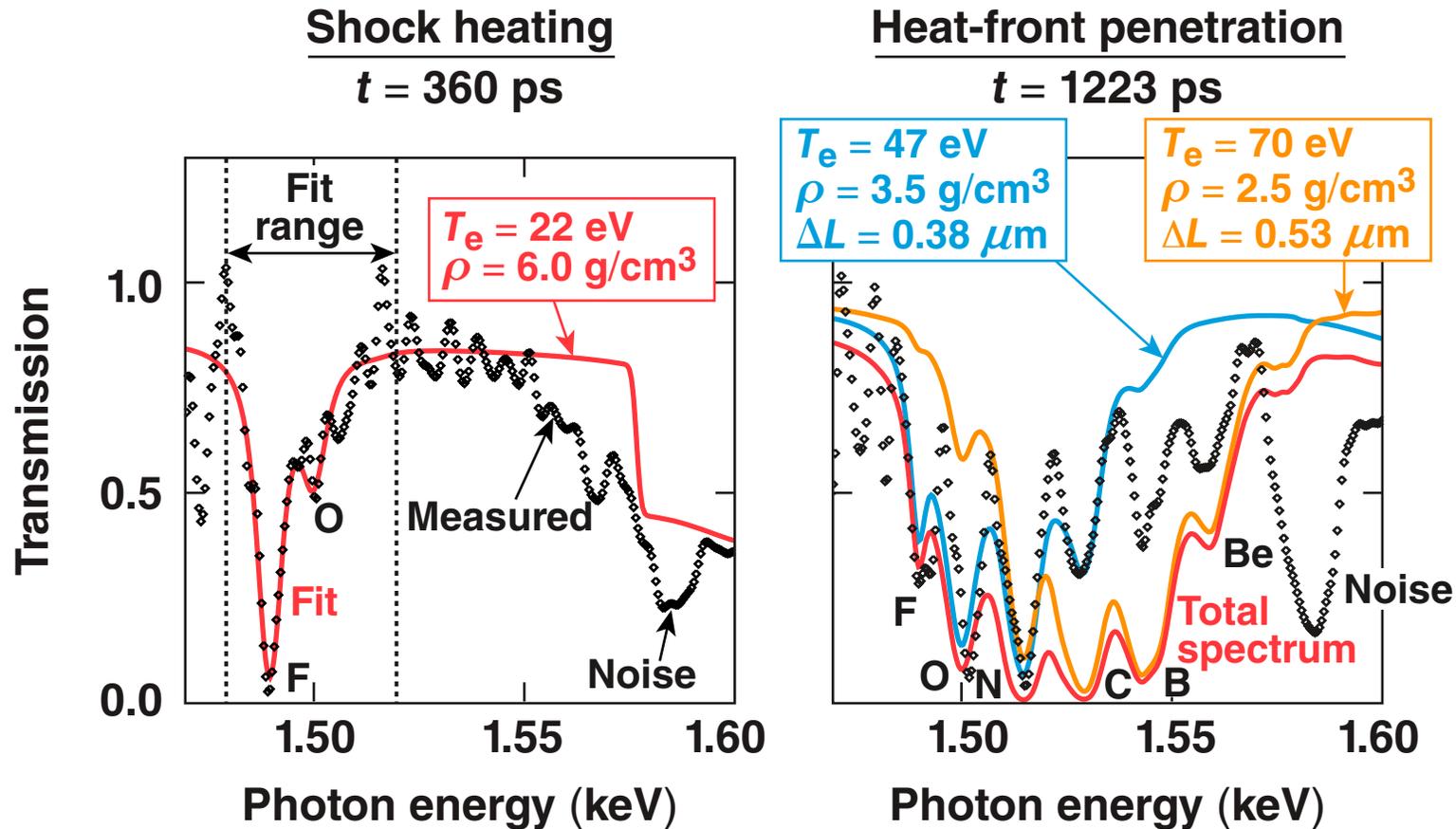
¹J. Delettrez *et al.*, Phys. Rev. A **36**, 3926 (1987).

²R. C. Malone, R. L. McCrory, and R. L. Morse, Phys. Rev. Lett. **34**, 721 (1975).

³J. Delettrez, Can. J. Phys. **64**, 932 (1986).

⁴V. N. Goncharov *et al.*, Phys. Plasmas **13**, 012702 (2006).

The measured spectra were fit with *PrismSPECT* to infer T_e and ρ assuming uniform conditions in the Al layer

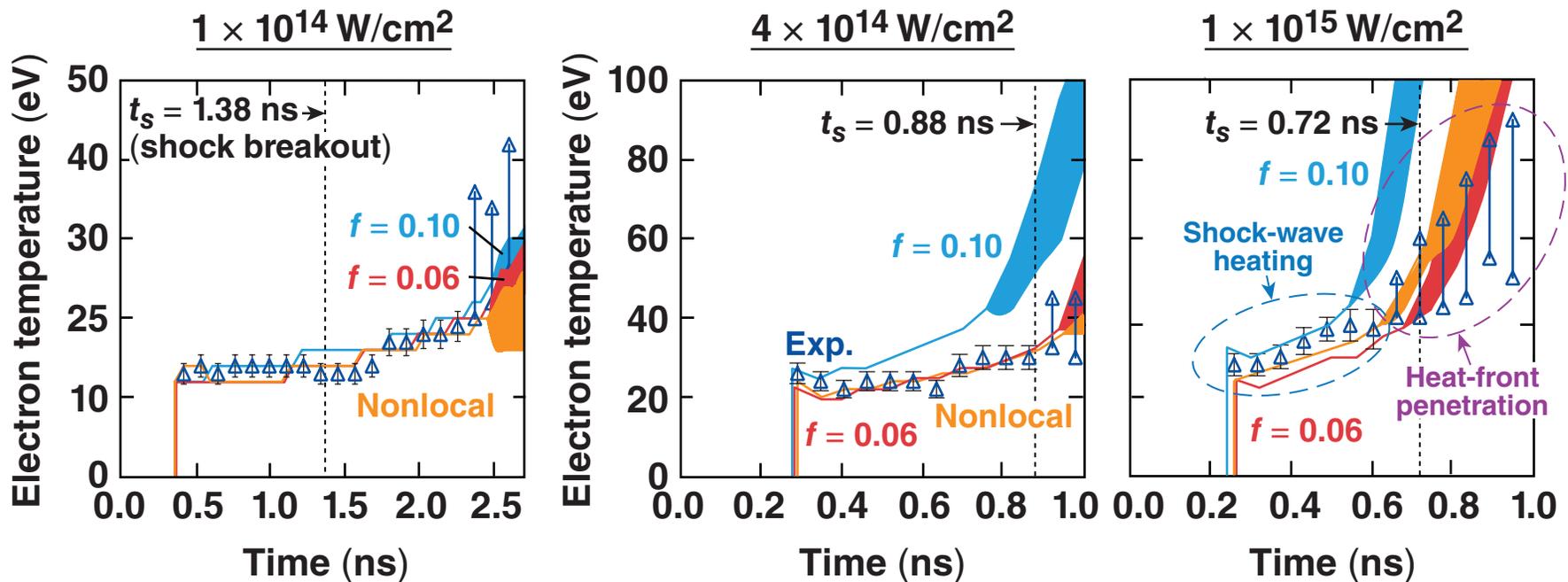


The measured spectra created by the heat front were qualitatively compared with the modeled spectra to determine the range of T_e in the Al layer.

The *LILAC* simulations using $f = 0.06$ and the nonlocal model agree with the experimental results for the square laser-pulse drive

Square laser pulse

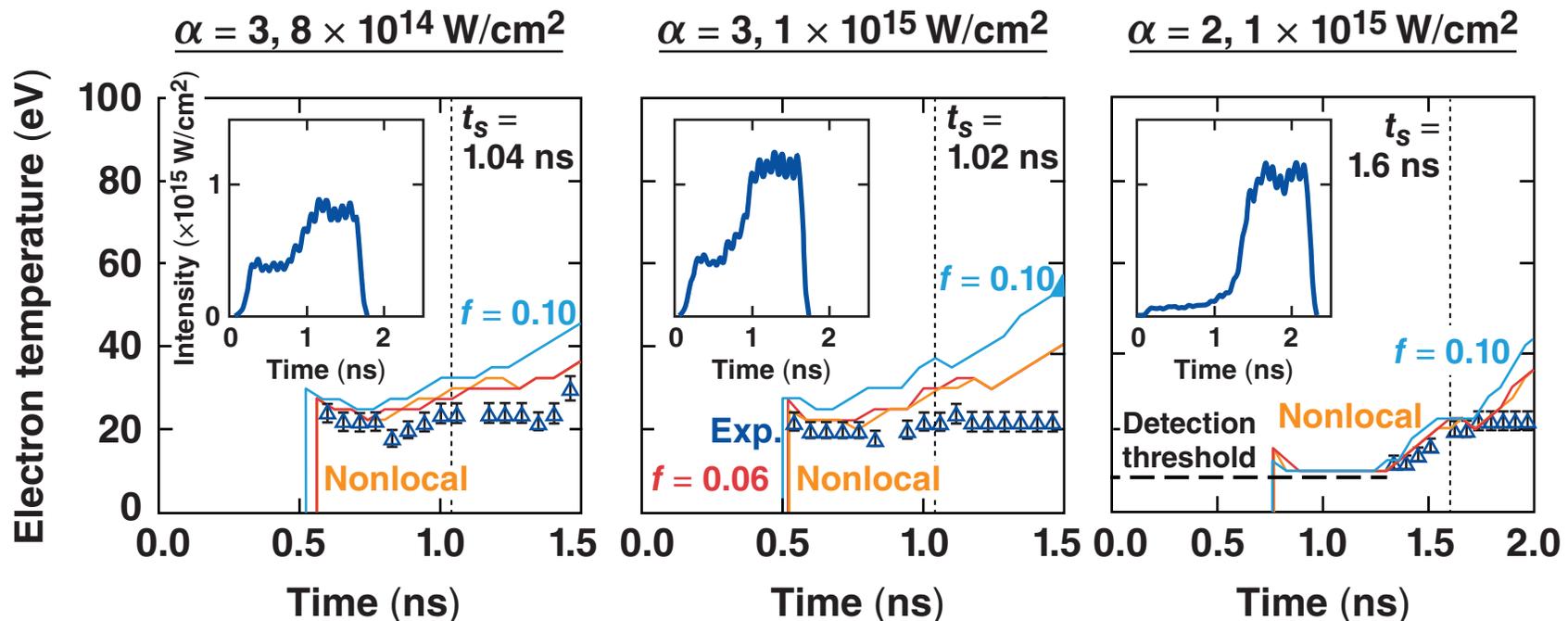
10- μm buried depth



The initial shock-wave heating predicted by *LILAC* using $f = 0.06$ or the nonlocal model agrees with the measurements for the shaped laser pulse drive

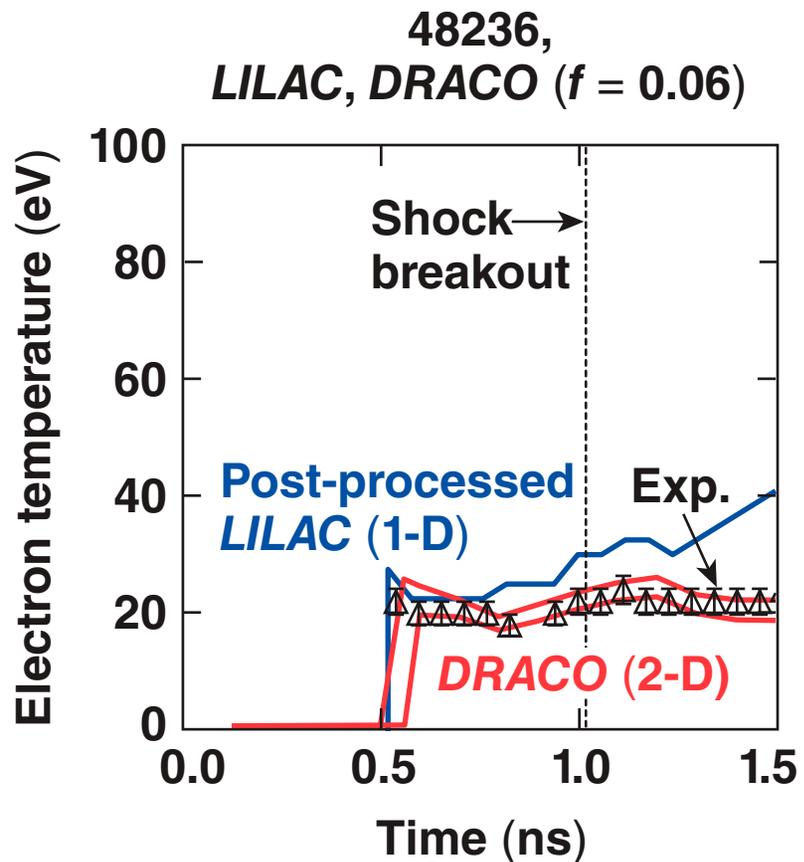
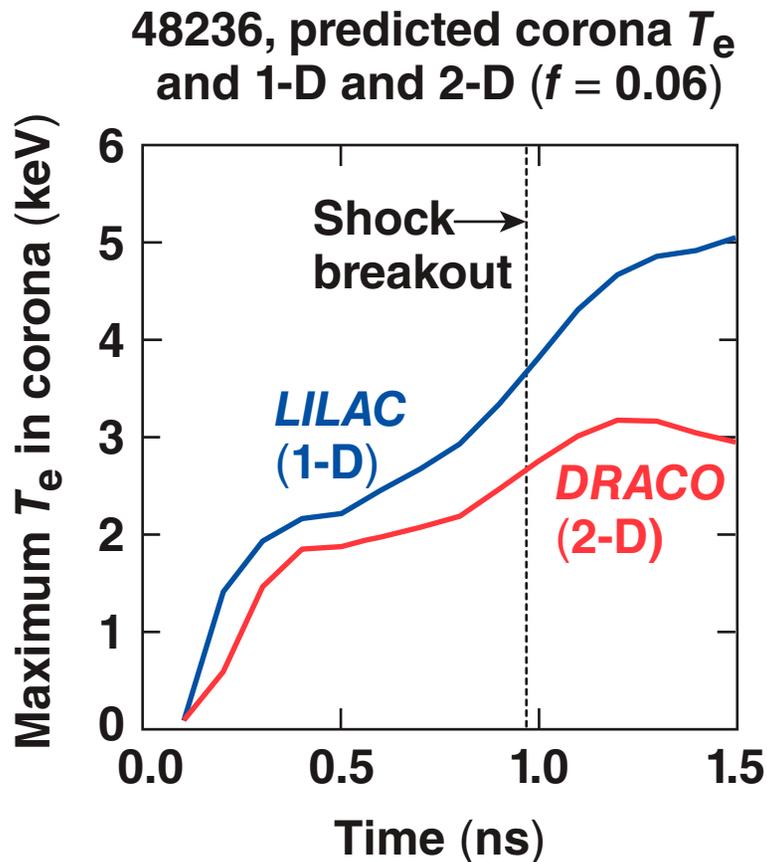
Shaped laser pulse

20- μm buried depth



The discrepancies between the measured and predicted T_e are observed at late times of the drive.

Predicted T_e from a 2-D simulation is closer to the measurements than the 1-D prediction at late time



The lateral heat flow in a 2-D geometry results in a lower radiative heating of the Al than in 1-D geometry.

Summary/Conclusions

Nonlocal* and flux-limited ($f = 0.06$) thermal transport models accurately predict measurements while the shock transits the foil



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