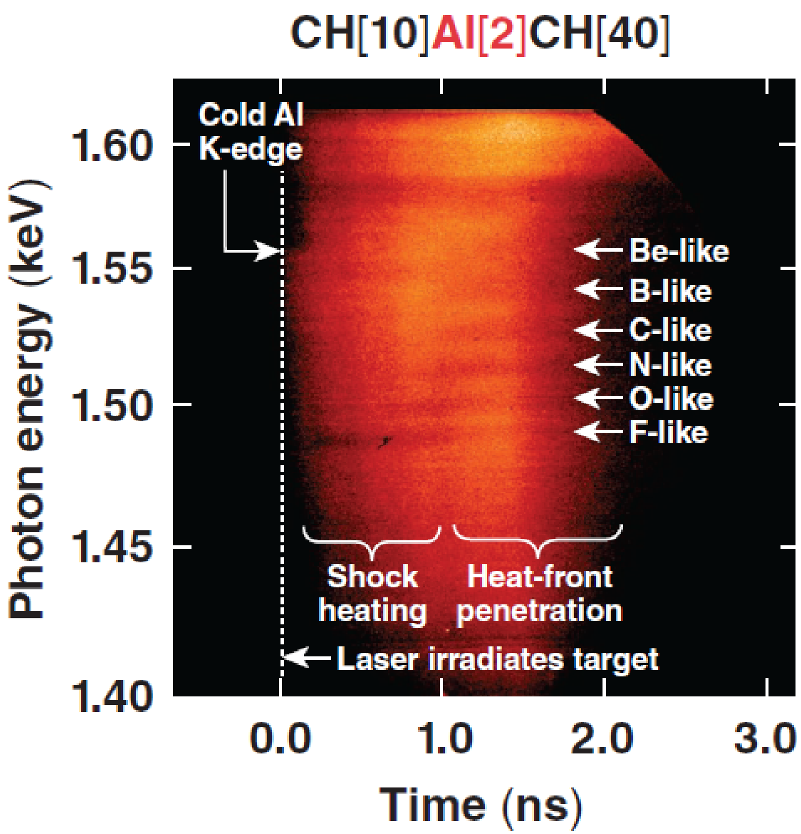
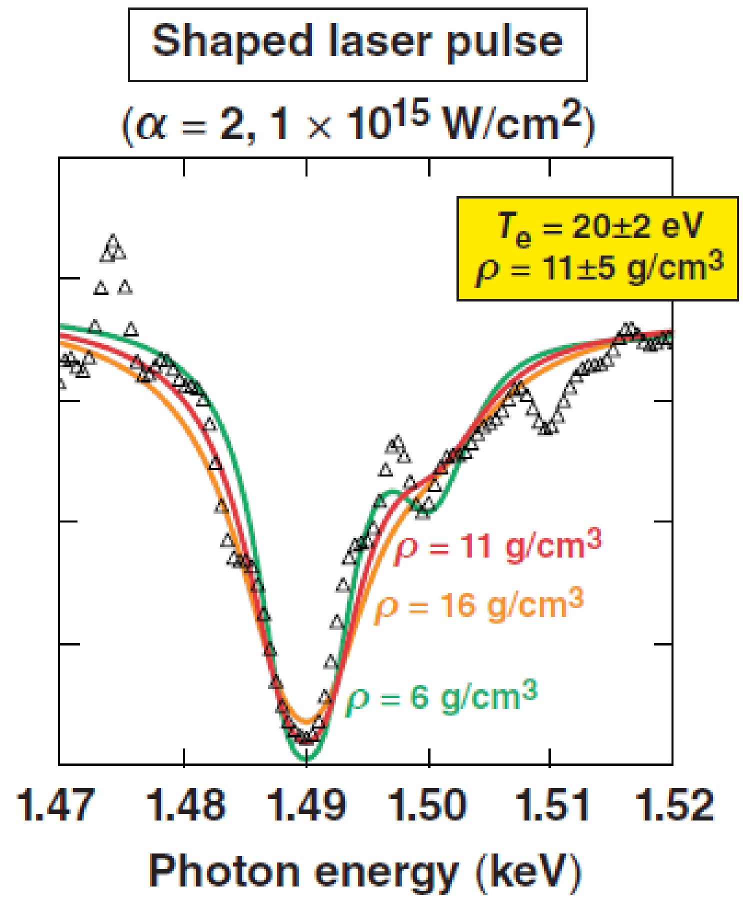
Investigation of shock-wave heating and compression in direct-drive planar targets using absorption spectroscopy on OMEGA





H. Sawada
University of California, San Diego

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Summary

T_e and ρ in the Warm Dense Matter (WDM) regime were measured using Al 1s-2p absorption spectroscopy

UR LLE

- A CH foil with a buried Al tracer layer was directly irradiated with a square and shaped pulse drive with peak intensities of 5×10^{13} to 1×10^{15} W/cm^2.

- The measured spectra were modeled with PrismSPECT to infer T_e and ρ ($10 < T_e < 40$ eV, $3 < \rho < 11$ g/cm^3) assuming uniform conditions in the Al layer

- The level of shock-wave heating and timing of heat-front penetration were compared with the 1-D hydrocode LILAC to test thermal-transport models.

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

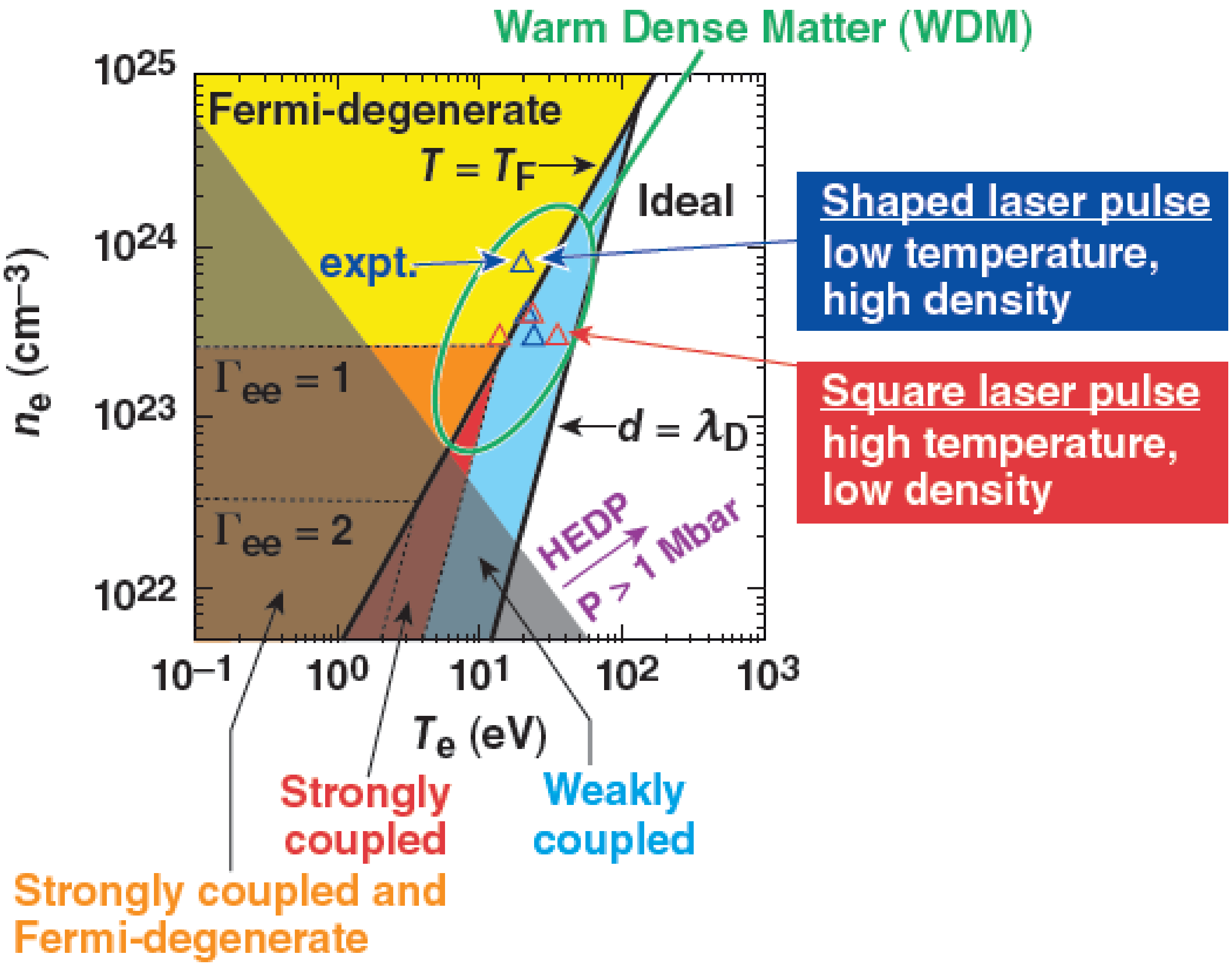
Collaborators

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, T. R. Boehly, T. C. Sangster, and B. Yaakobi

Laboratory for Laser Energetics
University of Rochester

R. C. Mancini
University of Nevada - Reno

The temperature and density of the shock-heated and compressed matter are set by the laser pulse shape

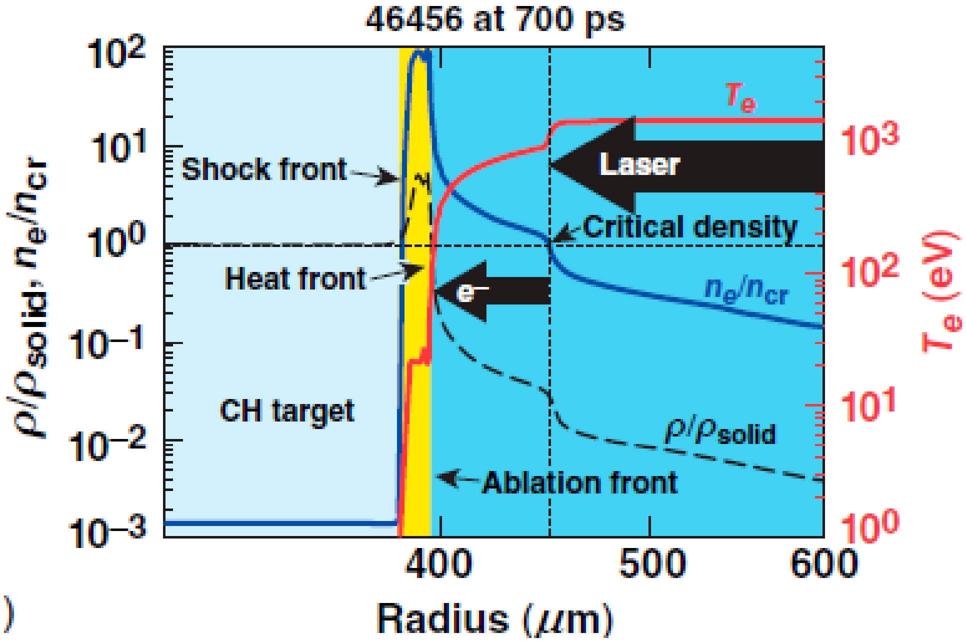


E16639

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, $q_{eff} = \min(q_{SH}, f \times q_{FS})$
  - classical Spitzer flux:[2] $q_{SH} = -\kappa \nabla T$
  - free streaming flux: $q_{FS} = nTv_T$
  - flux limiter[3] f ($0.04 < f < 0.1$) (q_{SH} is invalid in plasmas with strong T_e gradient)
- Nonlocal model[4] (no flux limiter) acts like a time-dependent flux limiter

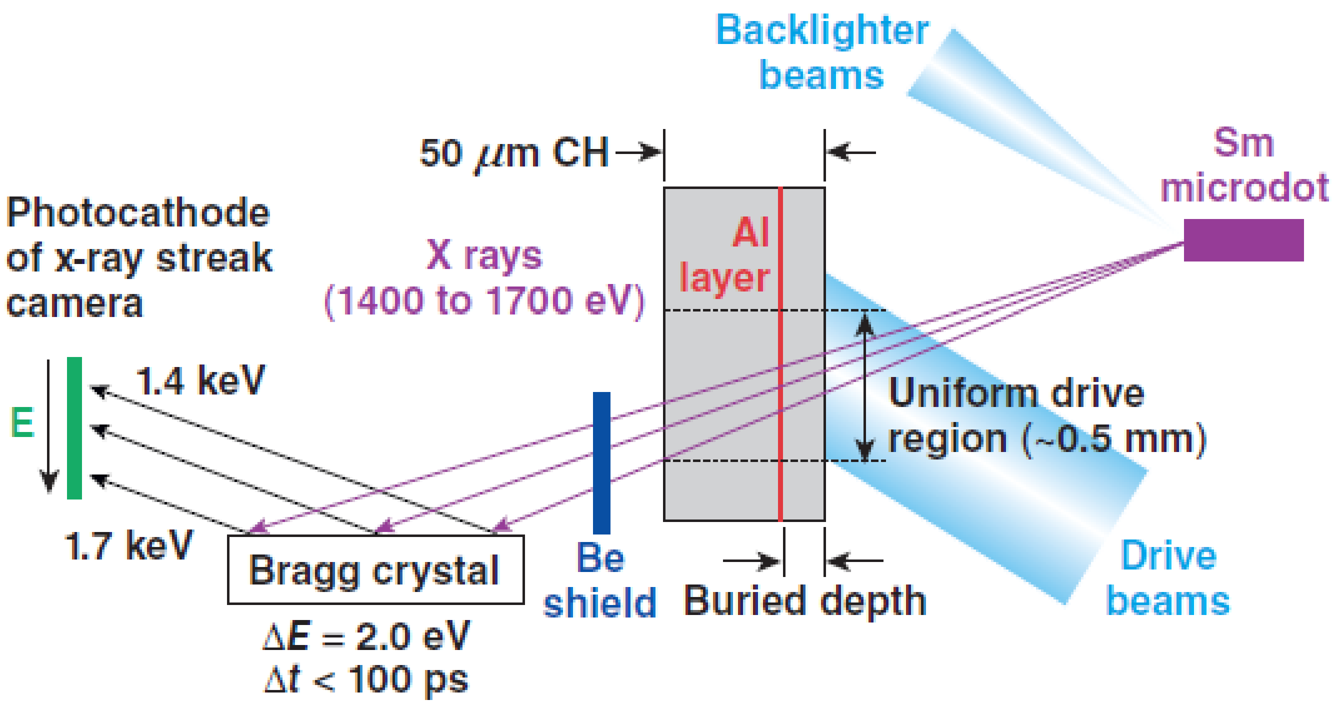


The strength of the shock wave depends on thermal-transport models.

[1] J. Delettrez *et al.*, Phys. Rev. A 36, 3926 (1987).
[2] R. C. Malone, R. L. McCrory, and R. L. Morse, Phys. Rev. Lett. 34, 721 (1975).
[3] J. Delettrez, Can. J. Phys. 64, 932 (1986).
[4] V. N. Goncharov *et al.*, Phys. Plasmas 13, 012702 (2006).

E15064c

Al absorption spectroscopy experiments were performed on OMEGA using continuous Sm spectrum in 1.4 to 1.7 keV



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

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

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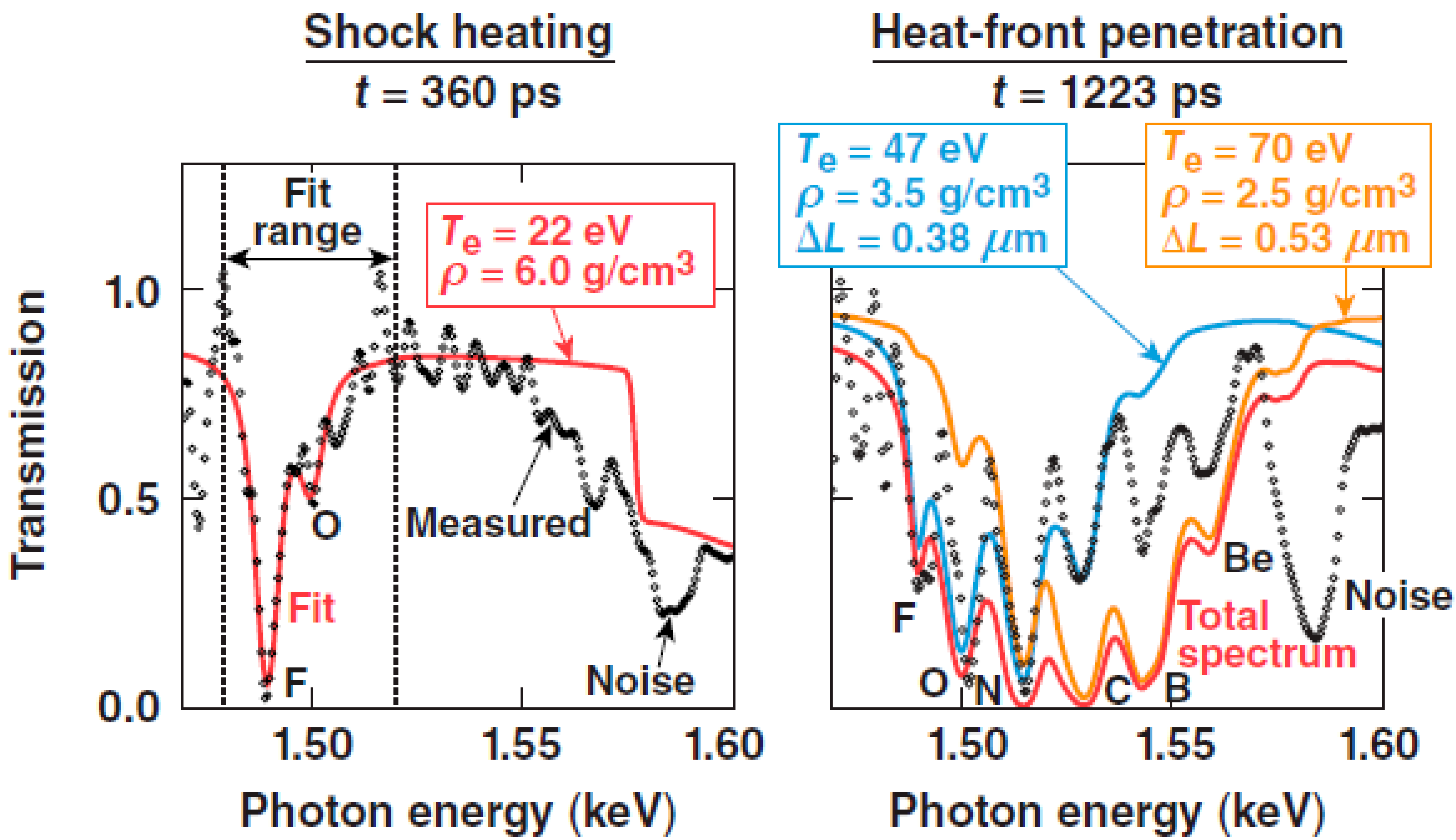
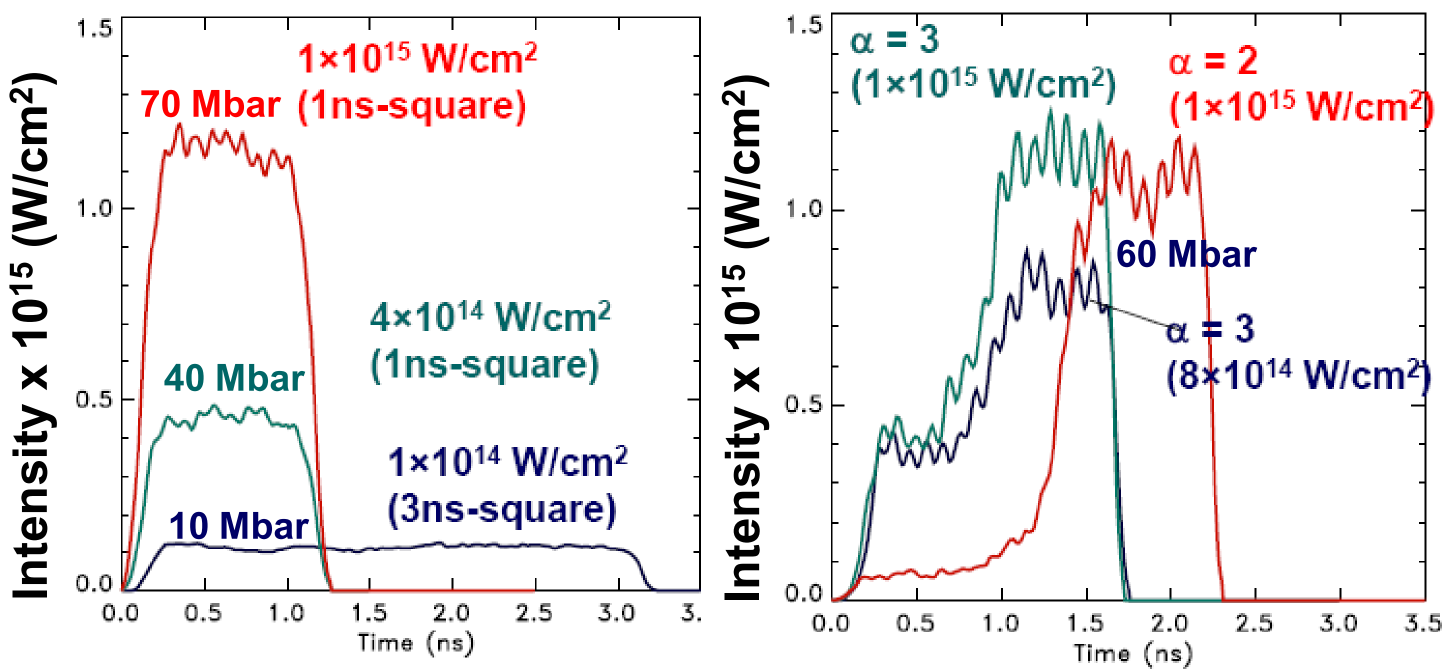


The measured spectra created by the heat front were qualitatively compared with the modeled spectra to determine the range of T_e in the Al layer.

E17056

Strong shock waves and isentropic compression were studied using square and shaped pulse drives

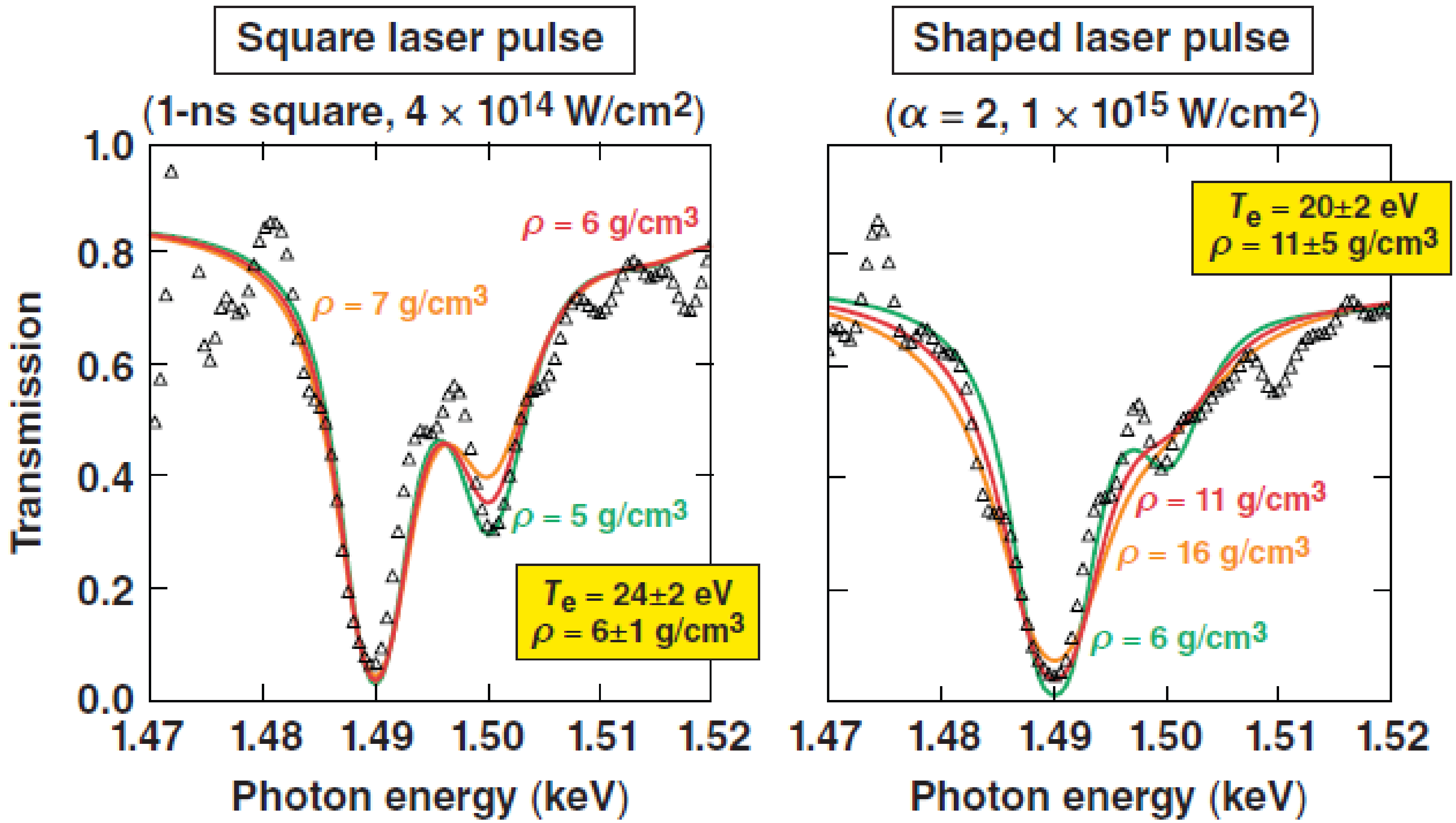
Square laser pulse (single shock wave)	Shaped laser pulse (multiple shock waves)



Shock-wave pressure in the 10-70 Mbar range is generated.

Higher compression is achieved with a shaped laser-pulse drive compared with the square pulse

UR LLE



T_e (*LILAC*) = 22 eV
ρ (*LILAC*) = 7.7 g/cm^3

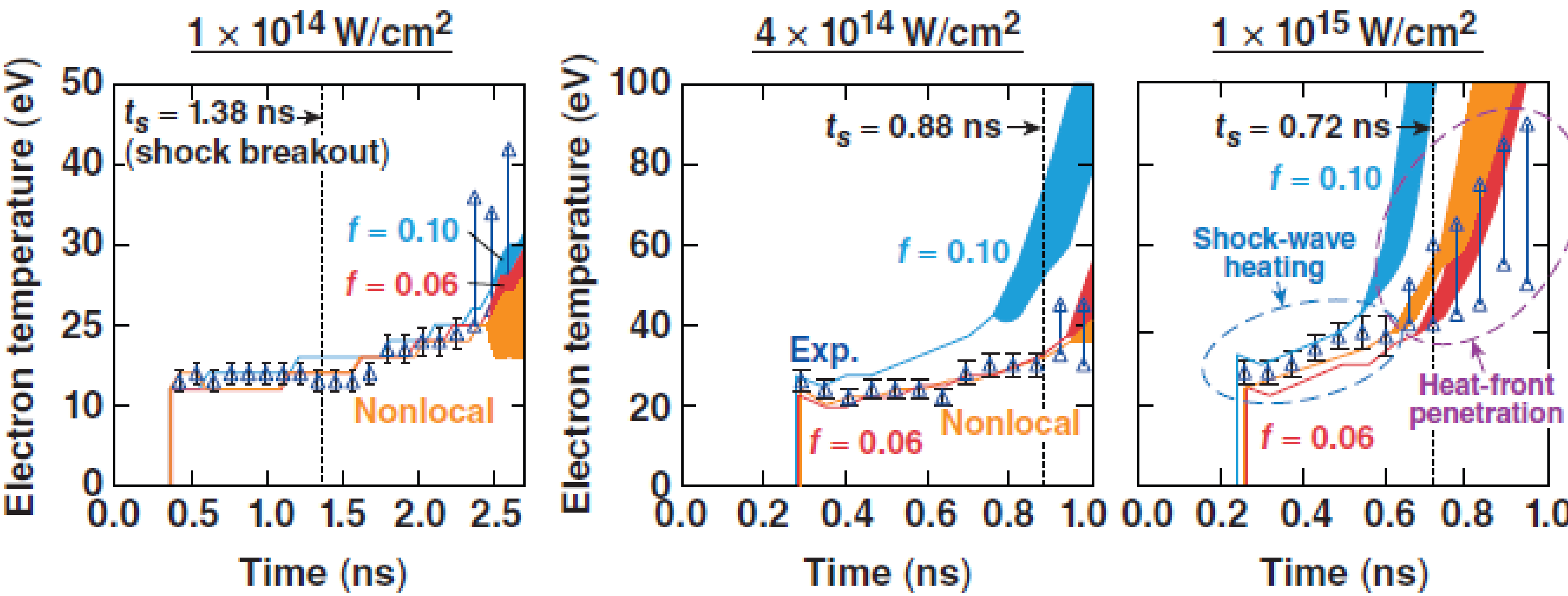
T_e (*LILAC*) = 20 eV
ρ (*LILAC*) = 13.5 g/cm^3

E16535

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

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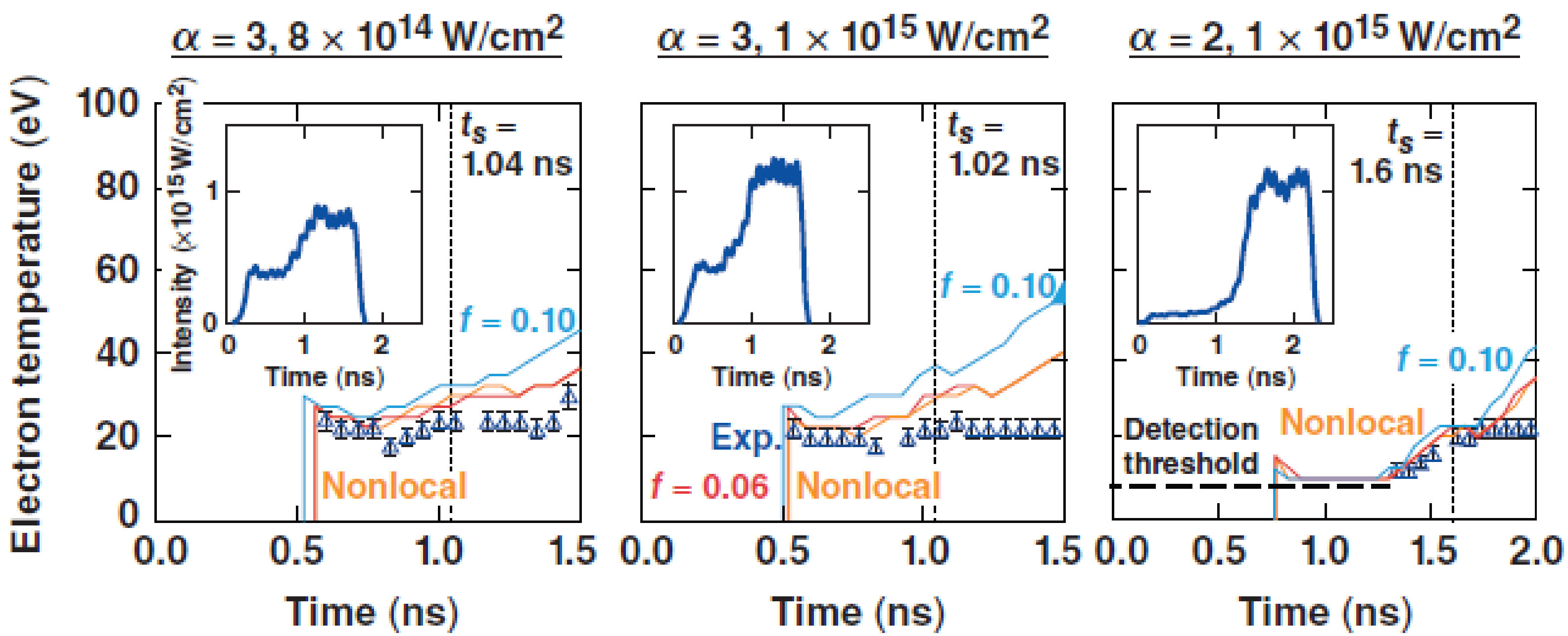
Shaped laser pulse

20-μm buried depth



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

E17422

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

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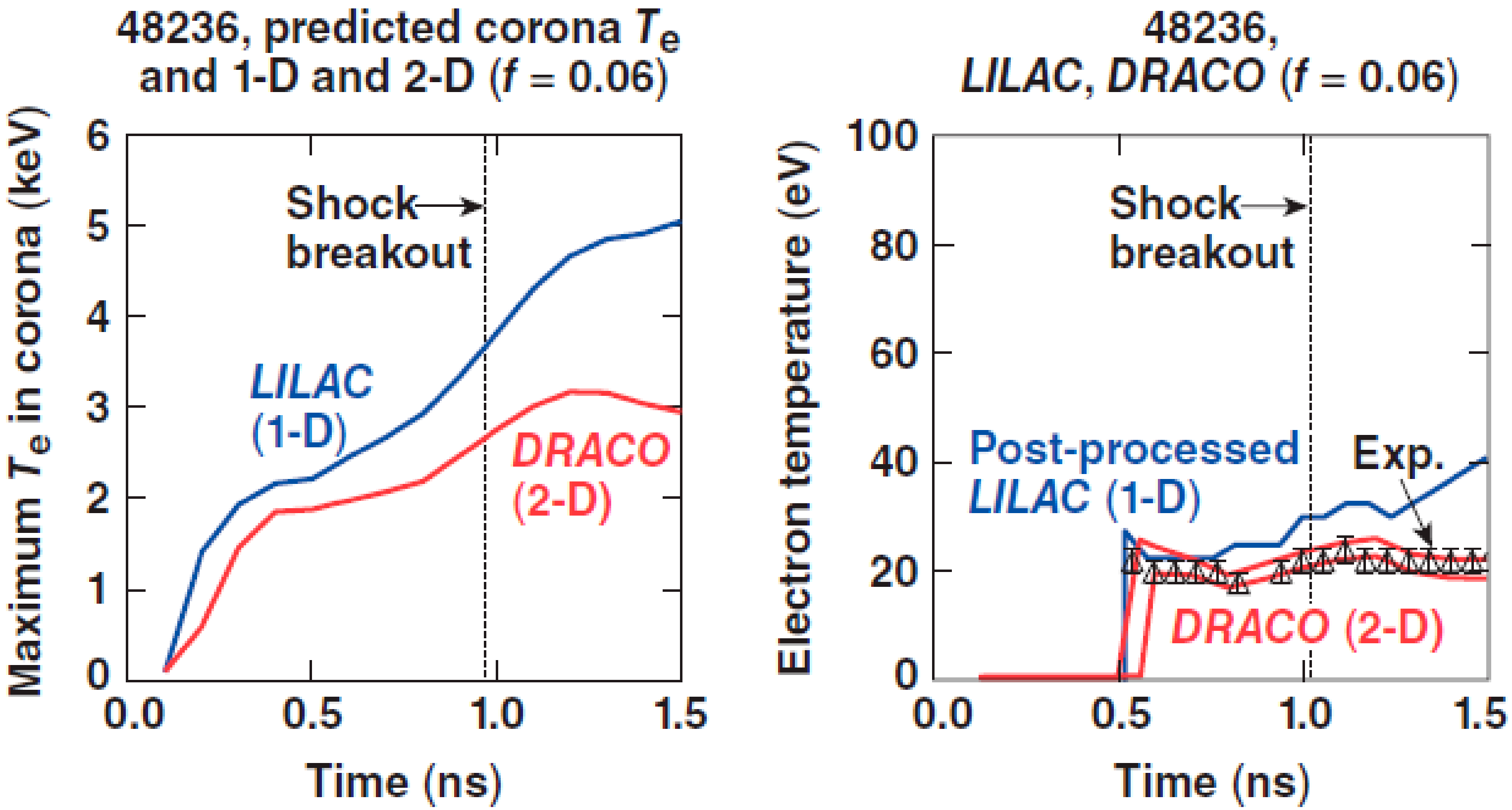

The lateral heat flow in a 2-D geometry results in a lower radiative heating of the Al than in 1-D geometry.

E17063

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