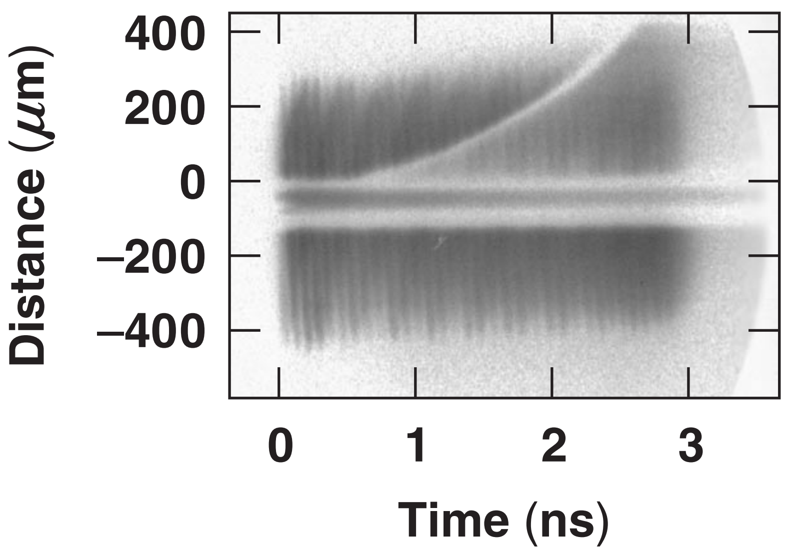
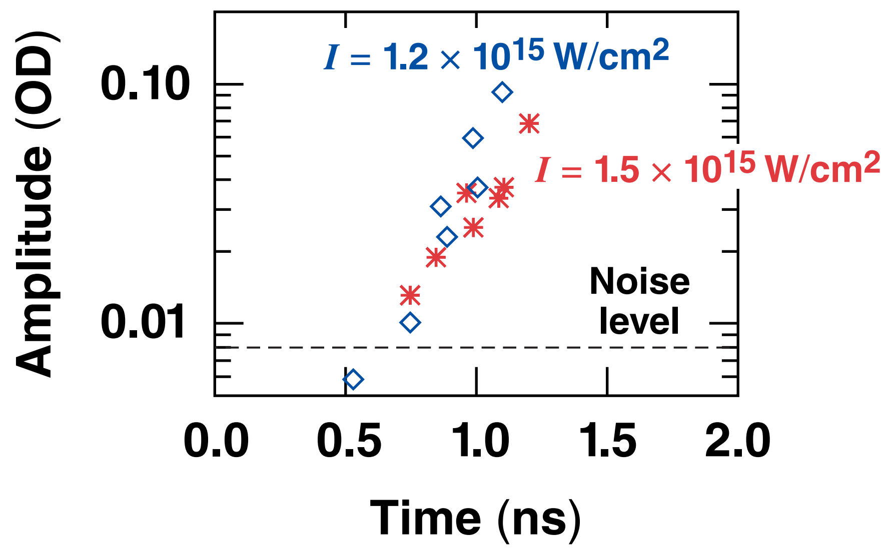
Effects of Electron Preheat in Direct-Drive Experiments on OMEGA

Measured target trajectory



Rayleigh–Taylor growth at wavelength 60 μm



V. A. Smalyuk
University of Rochester
Laboratory for Laser Energetics

37th Annual Anomalous Absorption Conference
Maui, HI
27–31 August 2007

Summary

Hot-electron preheating is critical in compression of planar plastic and spherical cryogenic targets

- Planar plastic targets
  - at low laser intensities, ~2×10^{14} W/cm^2, 2-D simulations agree with acceleration and compression experiments for a constant flux limiter of 0.06
  - for high intensities up to ~10^{15} W/cm^2, time-dependendent flux limiters better explain acceleration experiments
  - hot-electron preheat of the order of ~40 J explains compression experiments at high intensities
  - Rayleigh–Taylor growth reduction correlates with higher hot-electron signals
- In spherical cryogenic implosions
  - peak-burn compression degradation correlates with hot-electron signals
  - thicker plastic ablators reduce hot-electron signals and produce 1-D compression

Contributors

D. Shvarts, R. Betti, J. A. Delettrez, D. H. Edgell, V. Yu. Glebov, V. N. Goncharov, S. X. Hu, F. J. Marshall, R. L. McCrory, P. W. McKenty, D. D. Meyerhofer, P. B. Radha, T. C. Sangster, W. Seka, S. Skupsky, C. Stoeckl, and B. Yaakobi

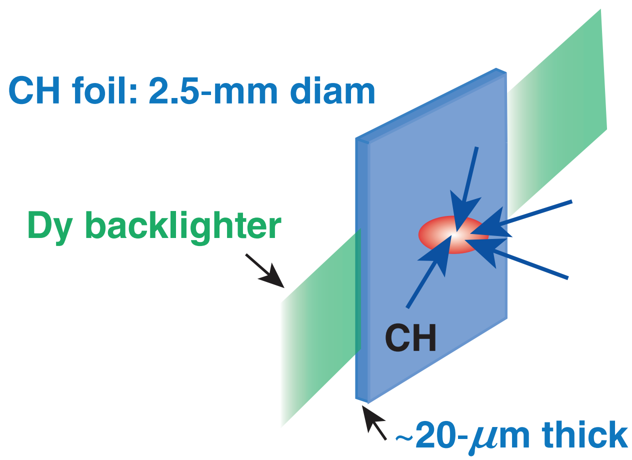
Laboratory for Laser Energetics
University of Rochester

J. A. Frenje, C. K. Li, R. D. Petrasso, and F. H. Séguin

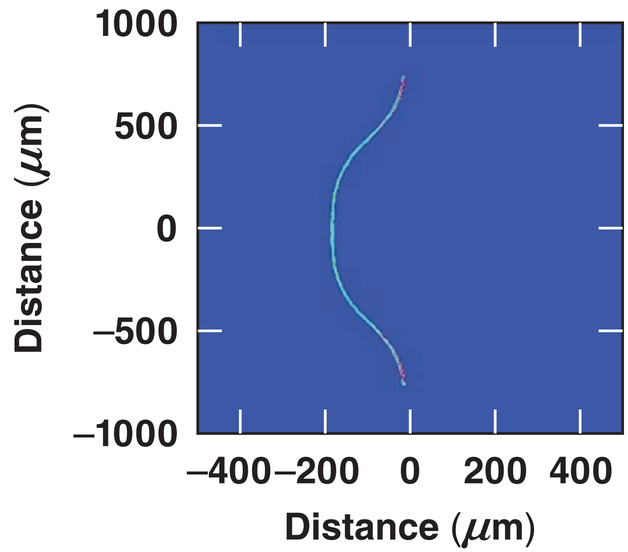
Massachusetts Institute of Technology

Laser coupling was studied using the acceleration of planar, 20-μm-thick plastic targets

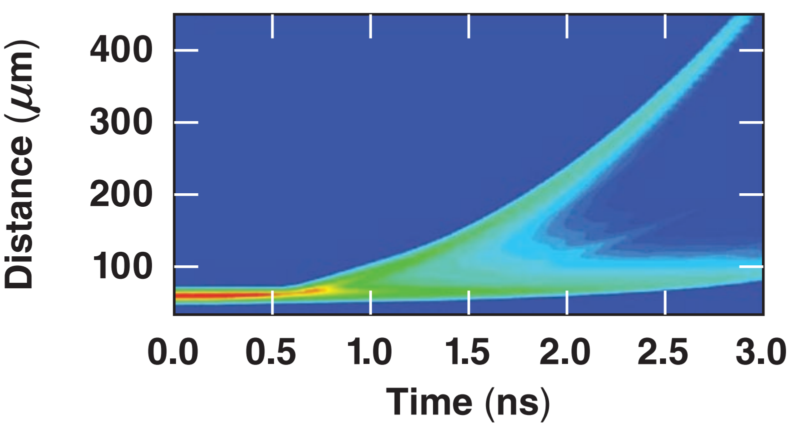
Experimental setup



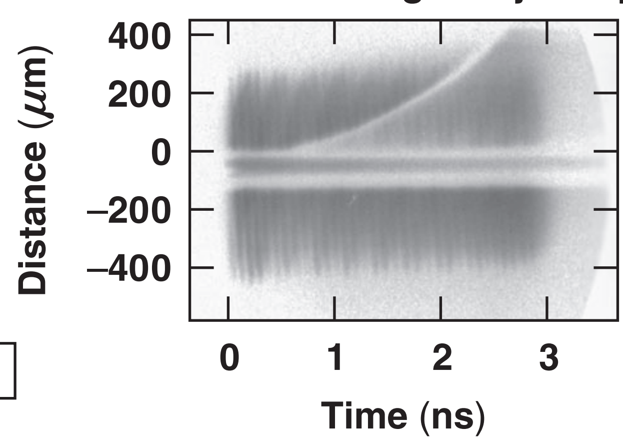
DRACO-simulated target image, shot 46370



Post-processed target trajectory



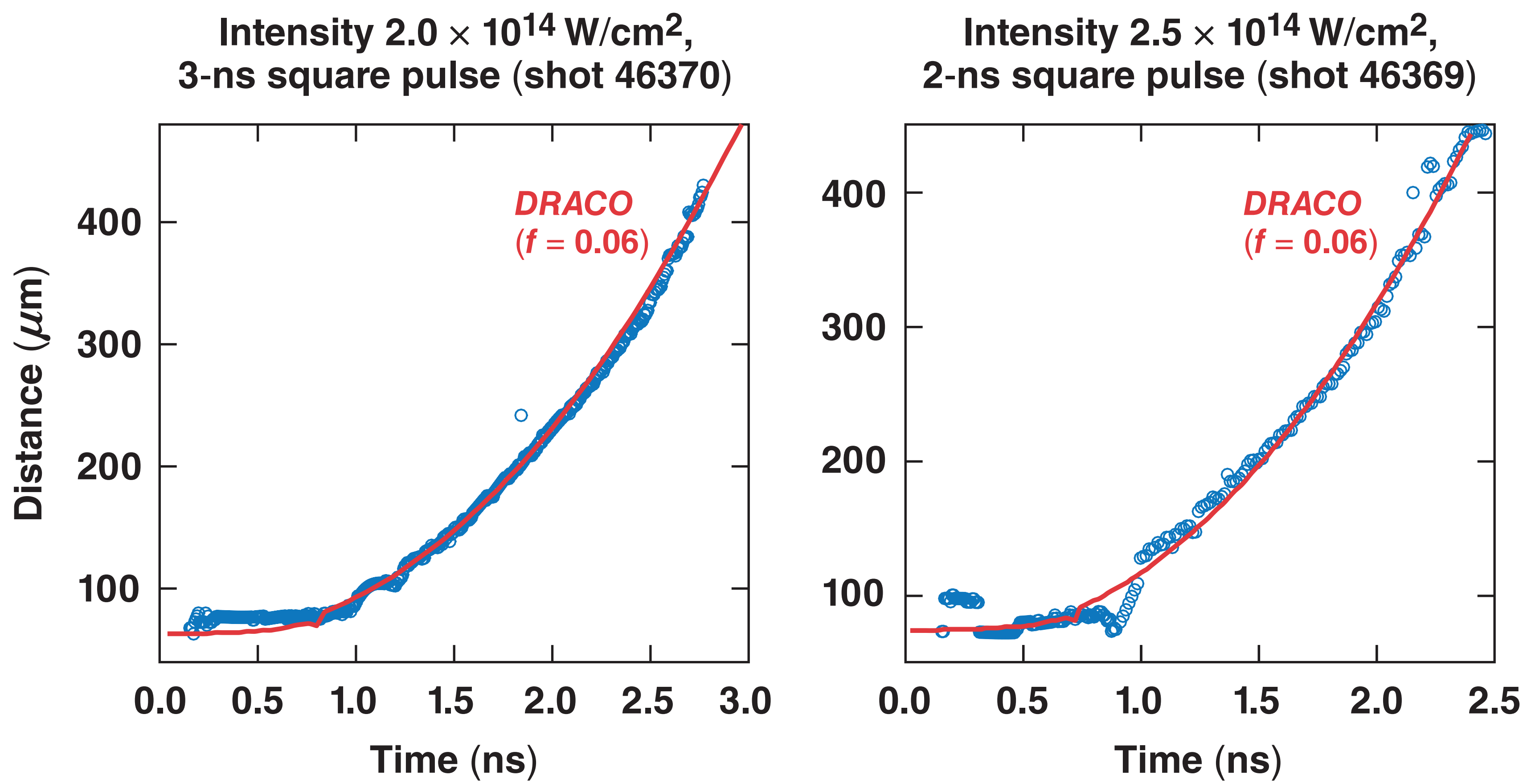
Measured target trajectory



- 3-ns square drive at intensity of 2.5×10^{14} W/cm^2

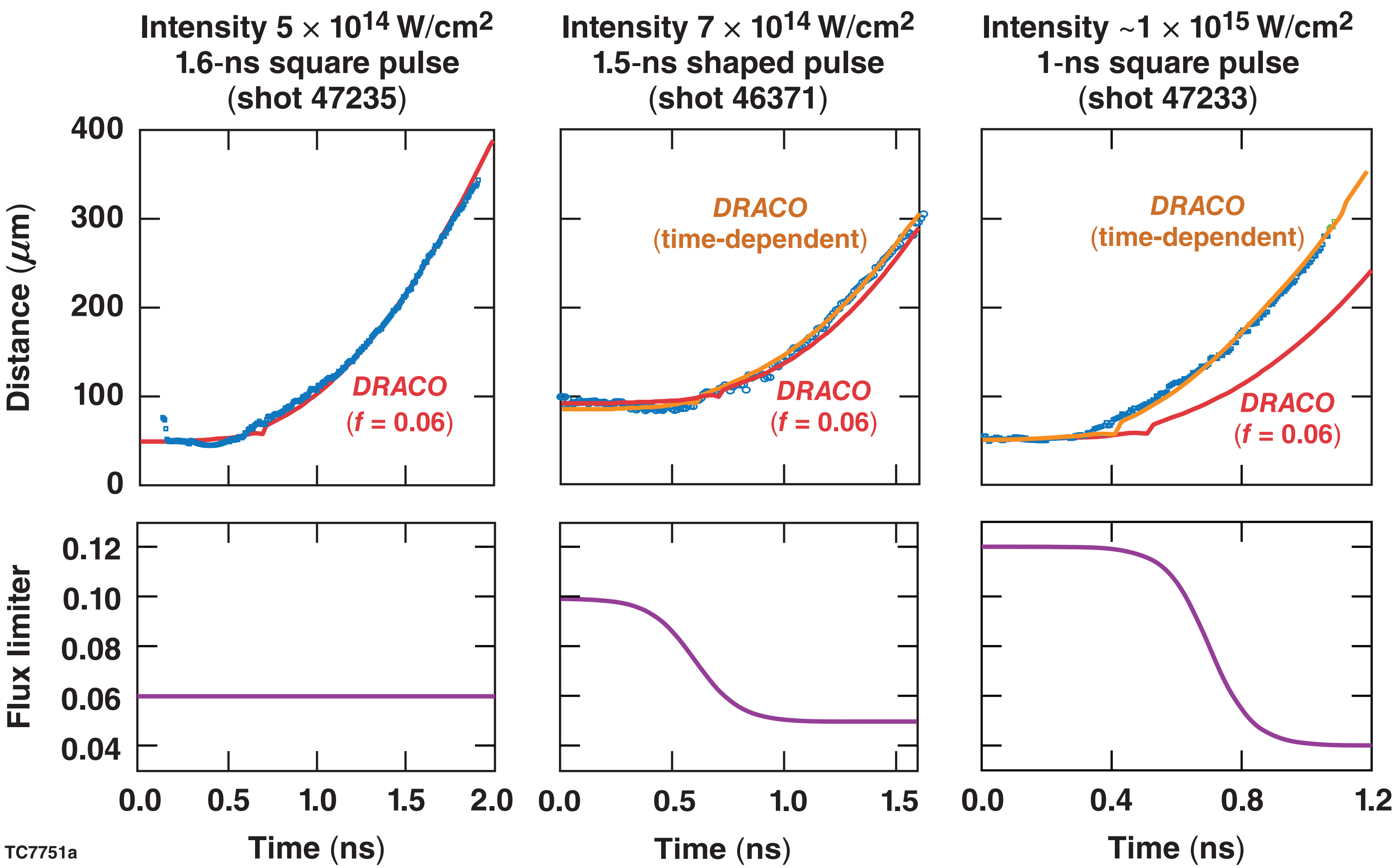
TC7746a

At low intensities (~2 to 2.5 × 10^{14} W/cm^2), we obtained good agreement between experiments and simulations with a constant flux limiter of f = 0.06



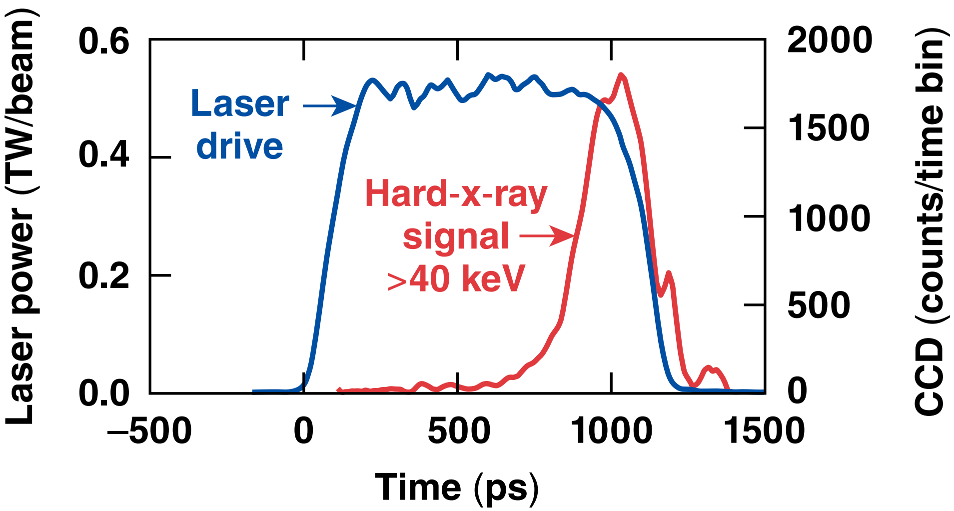
TC7747a

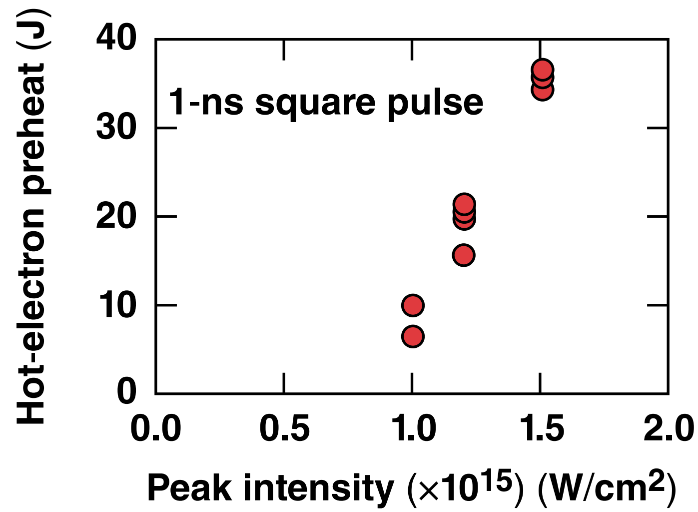
At high intensities, ~10^{15} W/cm^2, simulations with time-dependent flux limiters agree better with experiments than with a constant flux limiter of f = 0.06



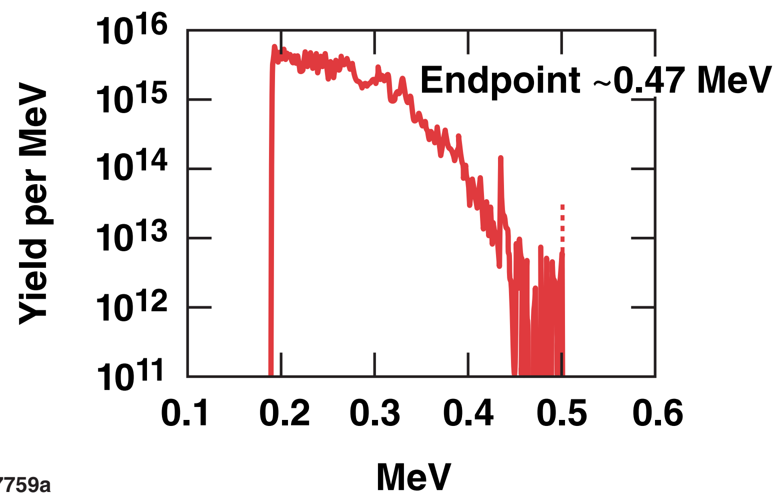
TC7751a

In planar, plastic targets, hot electrons are produced in the last ~400 ps of a 1-ns drive





Proton ablator spectrum CPS1, shot 45930

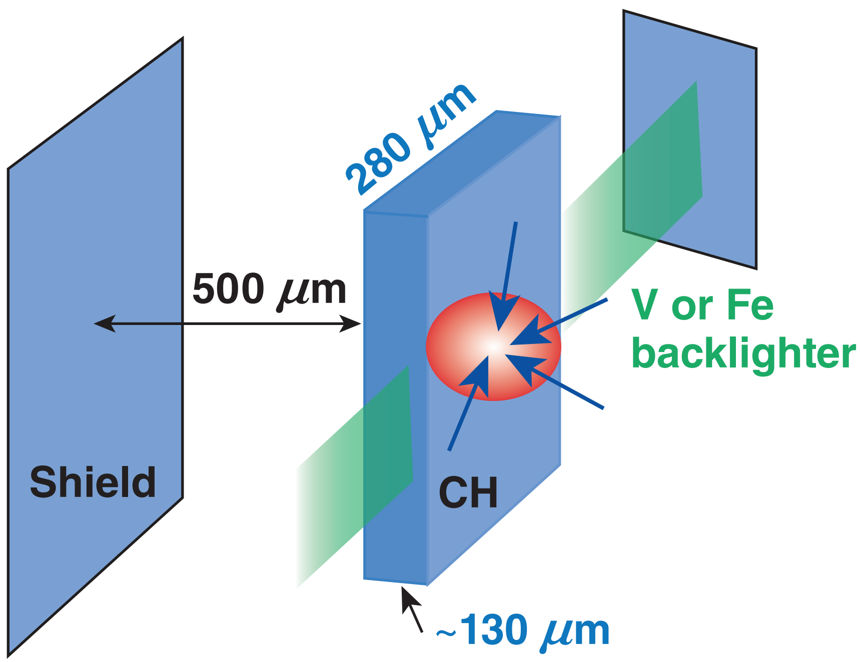


- Hot-electron temperature was measured to be in the range of ~50 to 60 keV.
- Preheat was inferred using the prescription from B. Yaakobi *et al.*, Phys. Plasmas 12, 062703 (2005).
- Endpoint of ~0.47 MeV corresponds to a hot-electron temperature of ~55 keV.

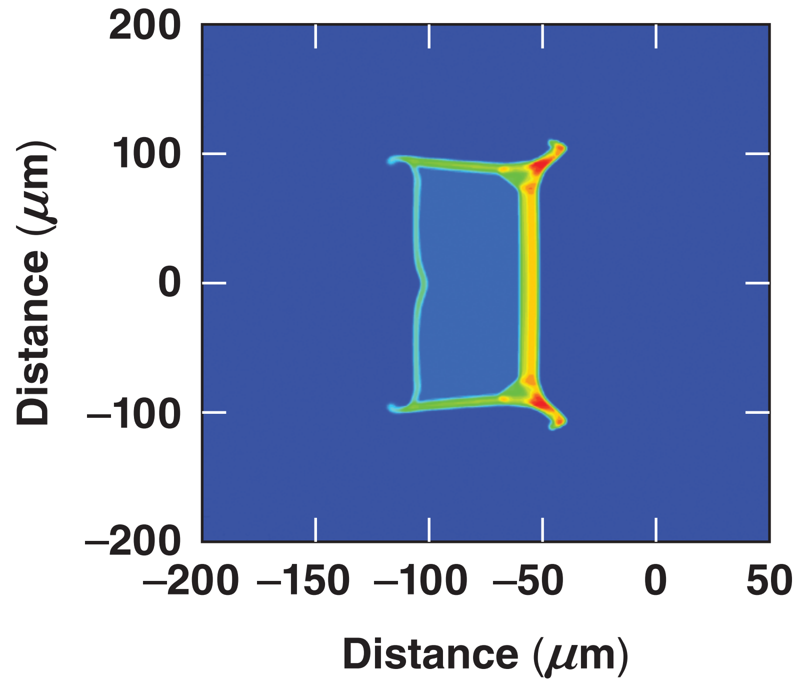
TC7759a

Shock compression was measured with side-on radiography using planar, 130-μm-thick plastic targets

Experimental set-up



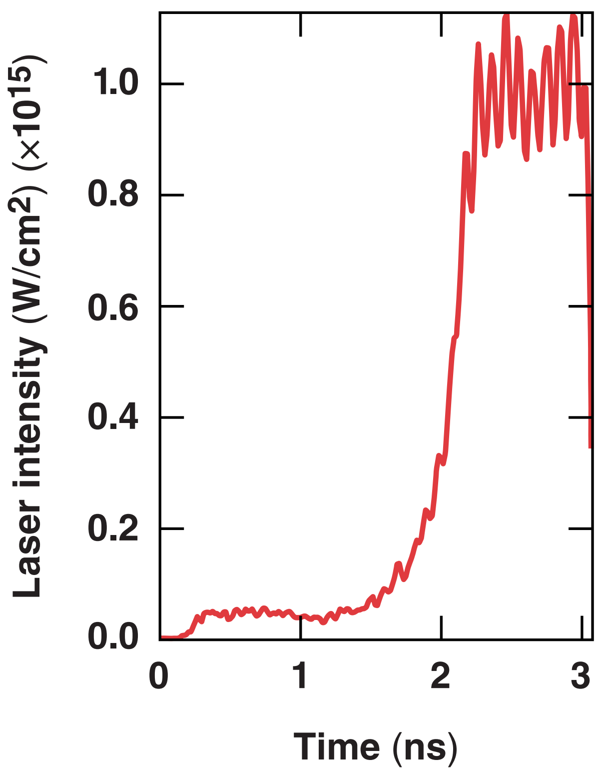
DRACO simulation

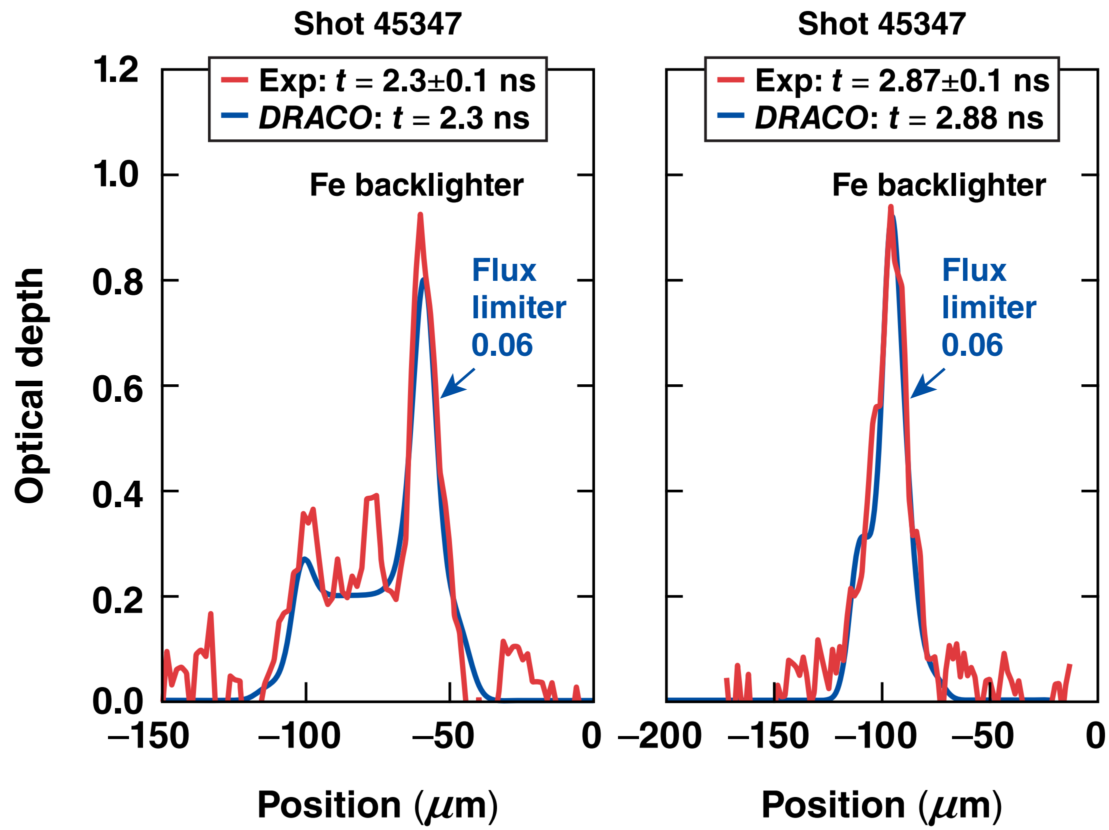


- Shock compression was measured with a framing camera using 1-ns square and 3-ns shaped pulses.
- Experimental spatial resolution was 10 μm, temporal resolution 40 ps.

TC7753a

DRACO simulations are in good agreement with experiments for shaped pulses

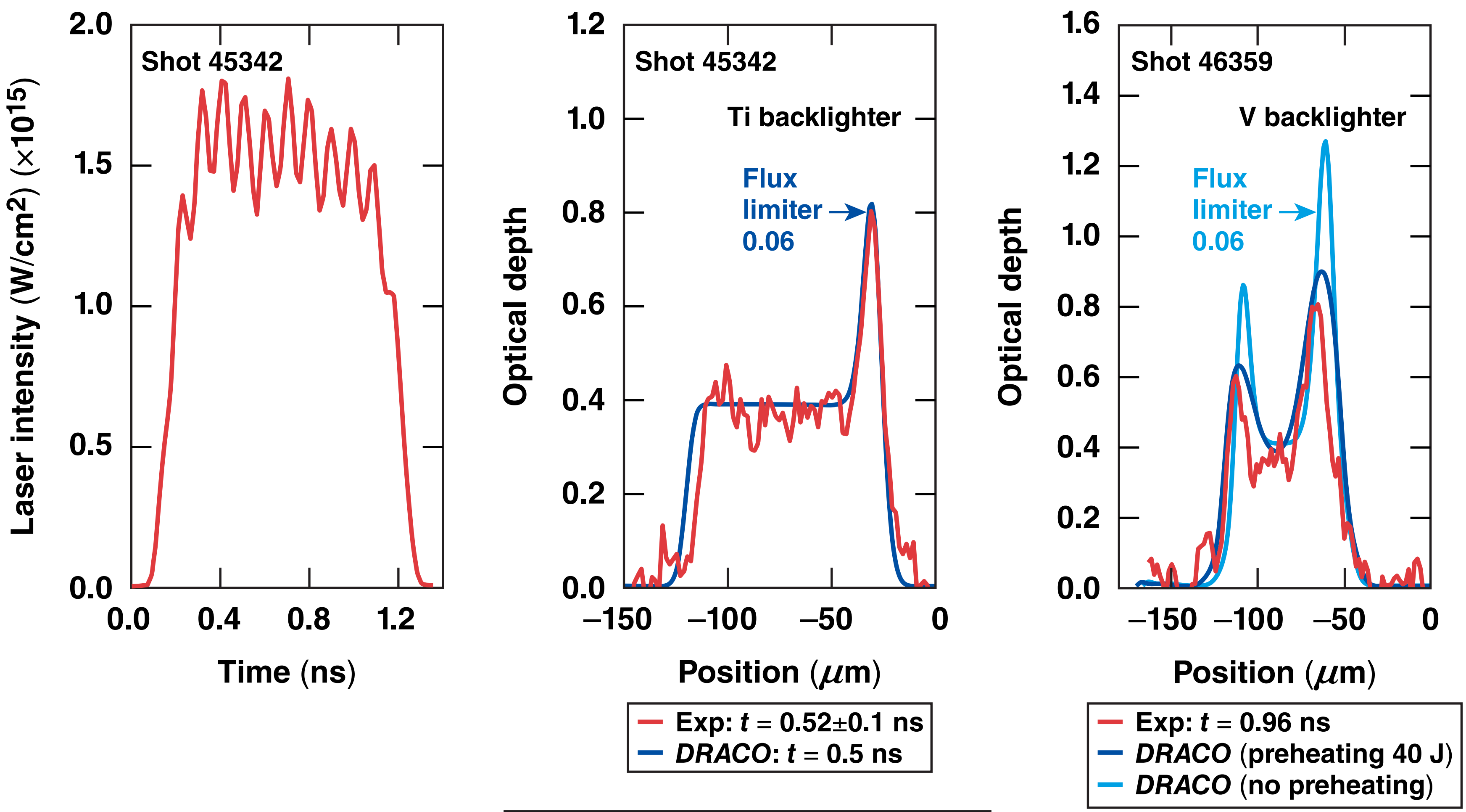




Measured preheat ~ 10 J

TC7755a

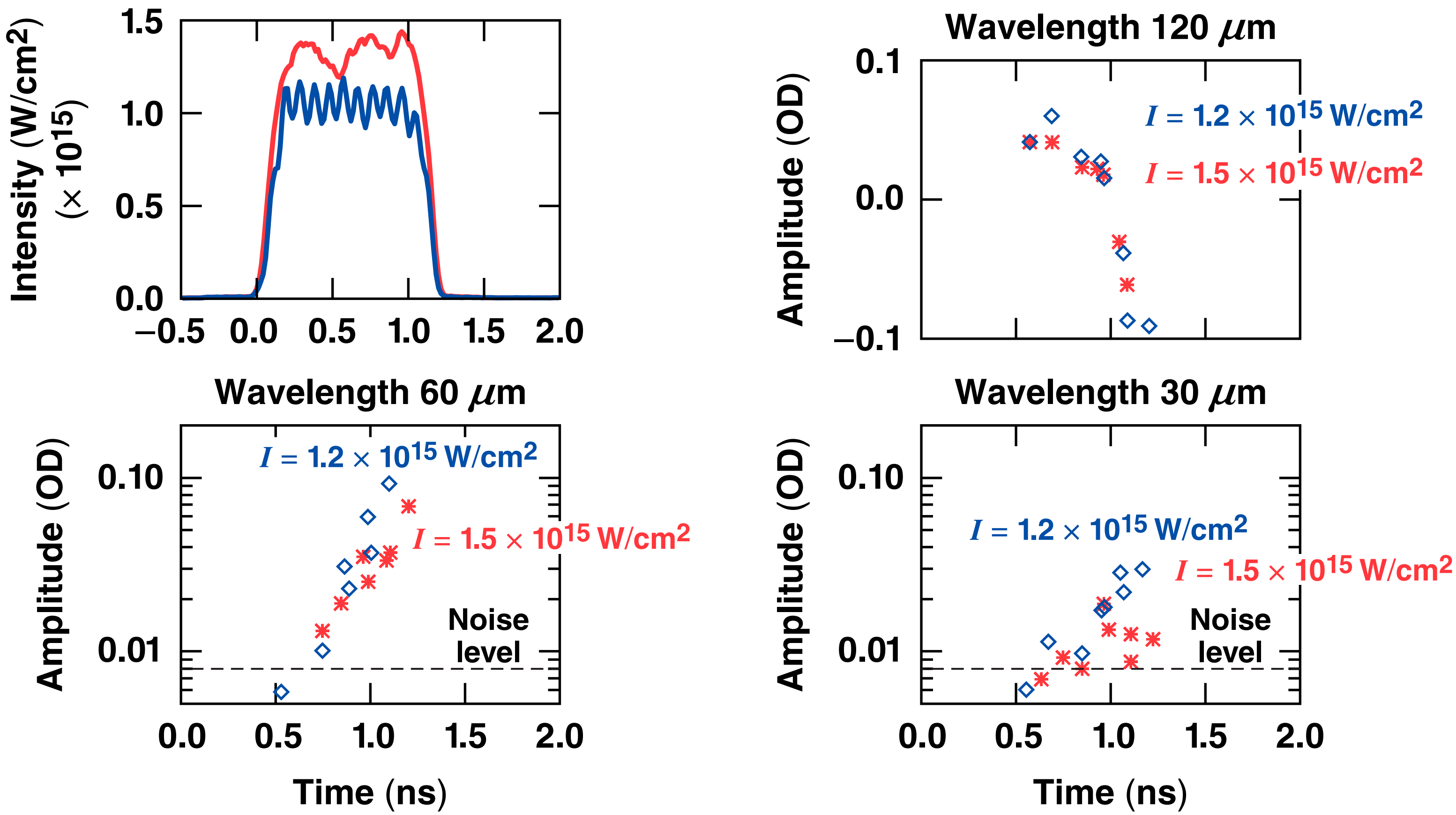
For high-intensity square pulses, experiments show later-time decompression



Measured preheat ~ 40 J

TC7756a

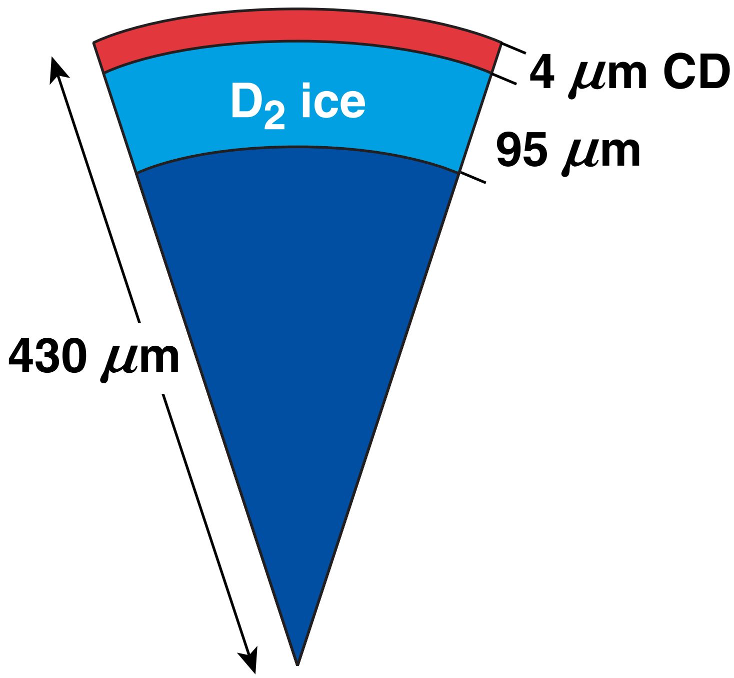
Reduction of RT growth at shorter wavelengths is consistent with increased preheat at higher drive intensities

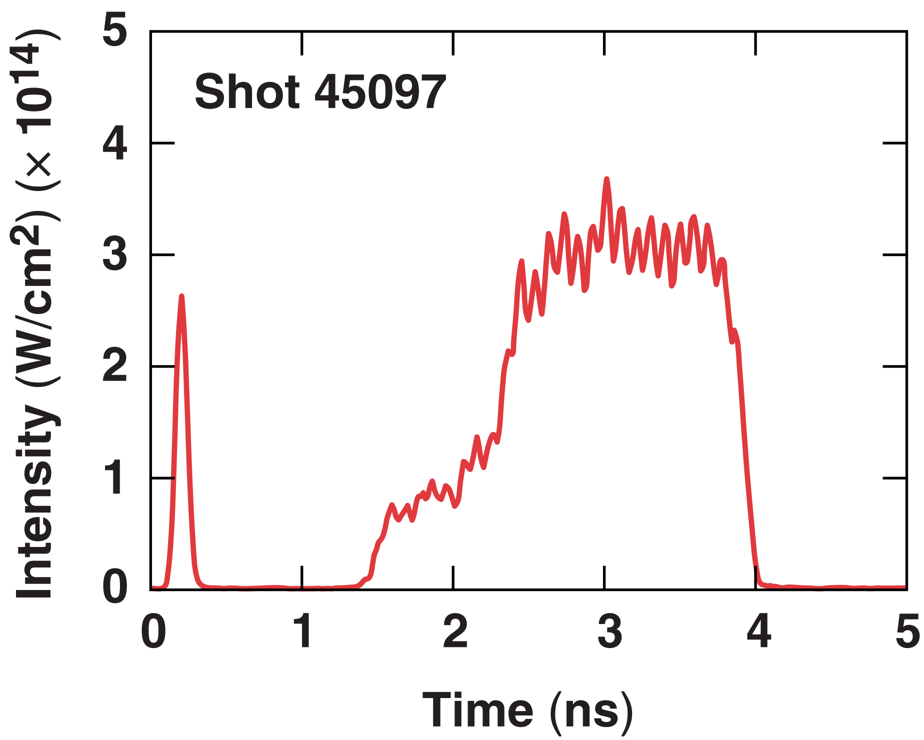


- Betti–Goncharov growth rate $\gamma \simeq \sqrt{\frac{kg}{1+kL_m}} - 1.5\,kv_a$
- Preheat increases v_a by ~4×, stabilizing the shorter wavelength more than the longer wavelength.

E15961

Compression of spherical cryogenic D_2 targets was studied by varying the drive intensity from ~2×10^{14} W/cm^2 to 1.5×10^{15} W/cm^2



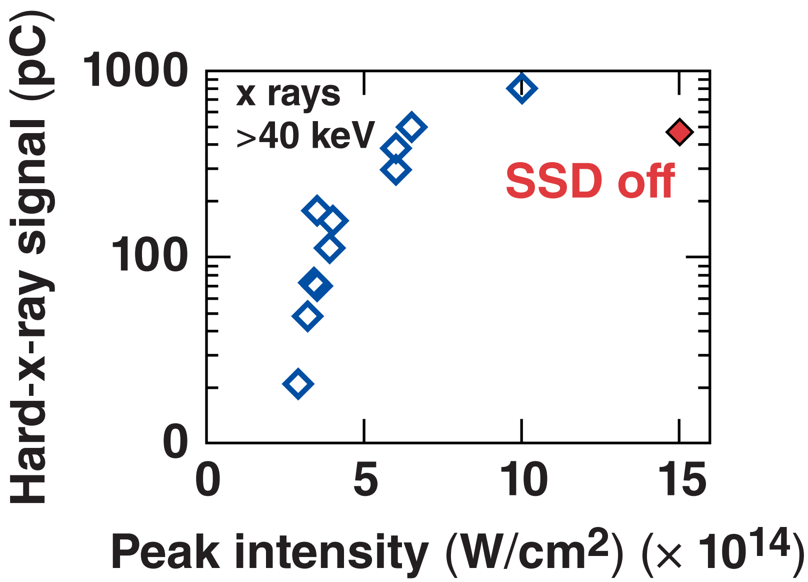


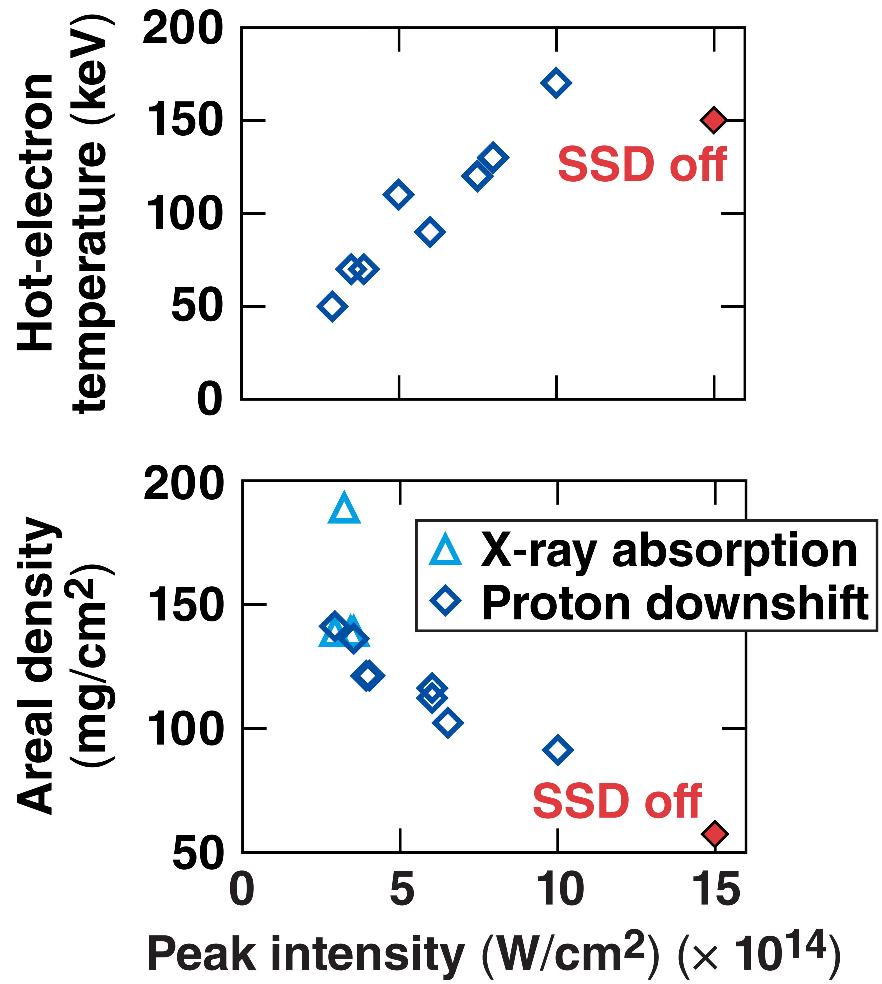
- Peak-burn areal density was measured using a downshift of secondary 14.7-MeV protons and x-ray absorption.

E15820

The hard-x-ray signal and temperature increase with drive intensity while peak-burn areal density decreases

- The adiabats of the implosions were in the range from $\alpha \simeq$ 1.3 to ~3.

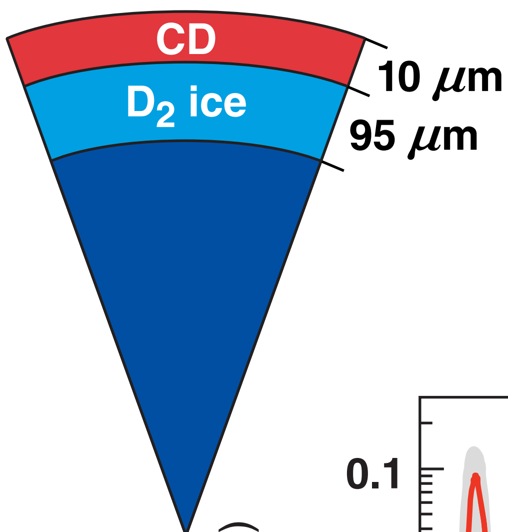


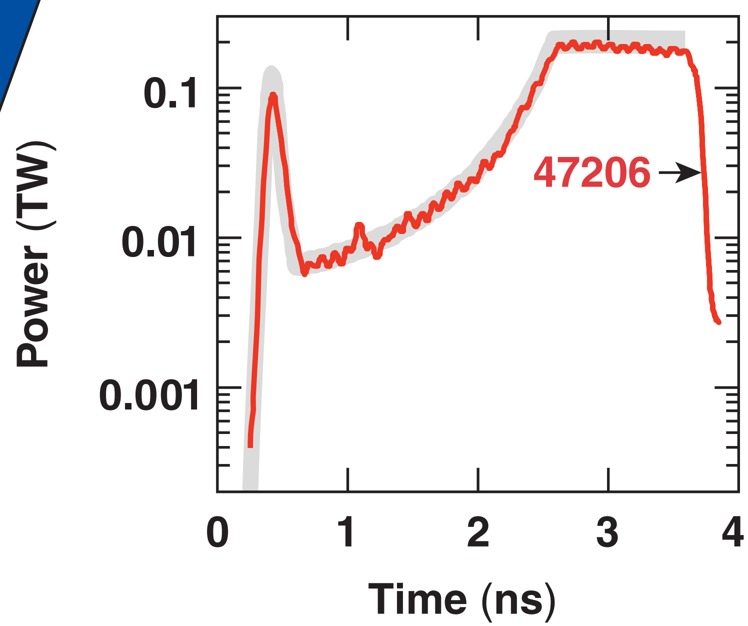


- The hard-x-ray signals in cryo implosions are up to ~10× higher than in equivelent plastic implosions.

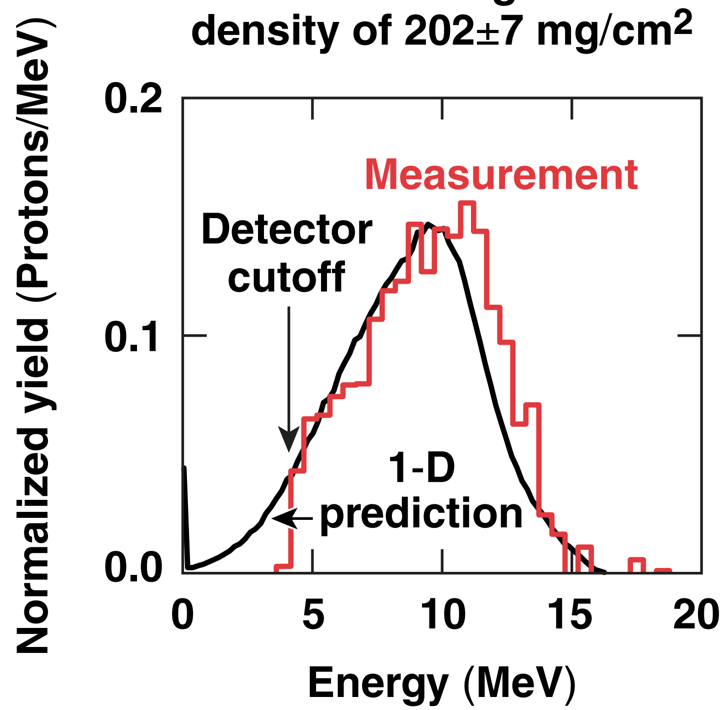
E15821

Thicker, 10-μm plastic ablators dramatically reduce hard-x-ray signals in cryo implosions, producing 1-D ρR's in low-adiabat shots





Neutron-averaged areal density of 202±7 mg/cm^2



E15962

Summary/Conclusions

Hot-electron preheating is critical in compression of planar plastic and spherical cryogenic targets

UR LLE

- Planar plastic targets
  - at low laser intensities, ~2×10^{14} W/cm^2, 2-D simulations agree with acceleration and compression experiments for a constant flux limiter of 0.06
  - for high intensities up to ~10^{15} W/cm^2, time-dependendent flux limiters better explain acceleration experiments
  - hot-electron preheat of the order of ~40 J explains compression experiments at high intensities
  - Rayleigh–Taylor growth reduction correlates with higher hot-electron signals
- In spherical cryogenic implosions
  - peak-burn compression degradation correlates with hot-electron signals
  - thicker plastic ablators reduce hot-electron signals and produce 1-D compression