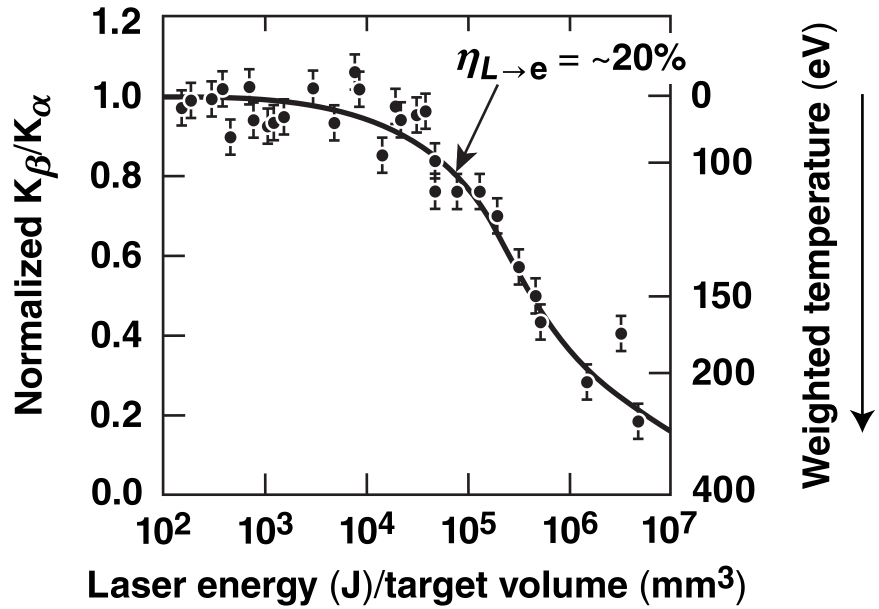
Fast-Electron Generation with Multi-kJ Pulses on OMEGA EP

E_L = 1 J, τ_L = 1 ps



Increasing energy density ⟶

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51st Annual Meeting of the American Physical Society Division of Plasma Physics
Atlanta, GA
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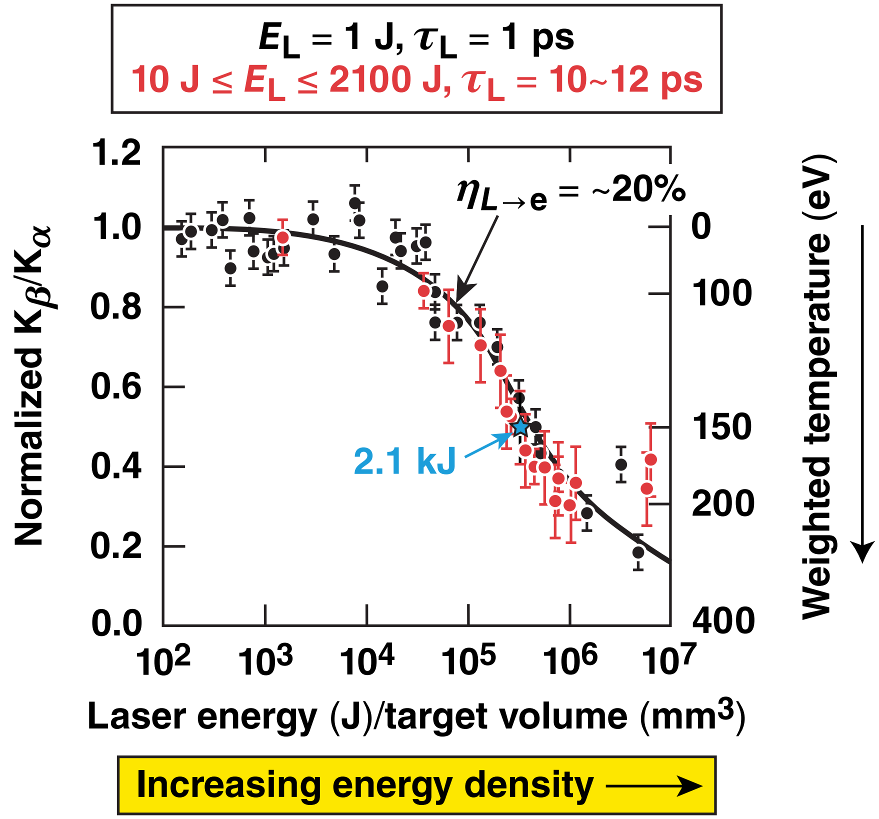

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Summary

OMEGA EP experiments show fast-electron coupling independent of laser energy and pulse duration

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UR LLE OMEGA EP

- High-energy-conversion efficiency into fast electrons is critical for various HEDP applications, e.g., dense-matter probing and fast ignition
- K-photon-emission suppression measurements within copper foil targets indicate $\eta_{L \rightarrow e} \approx 20\%$ over a wide range of target volumes
- Time-resolved x-ray emission measurements suggest energy coupling occurs over the whole duration of the incident drive

E18414

Collaborators

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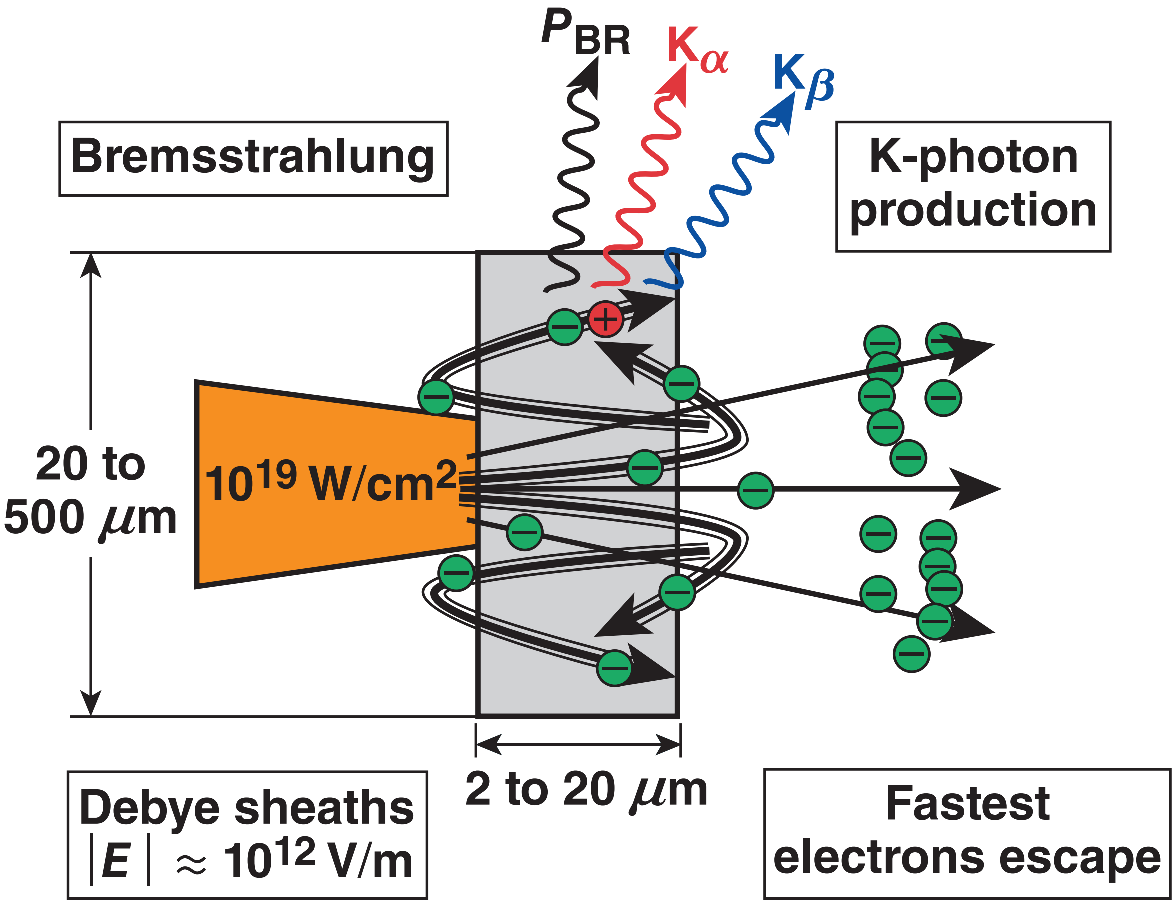
Fast-electron recirculation in mass-limited targets allows access to high-energy-density phenomena



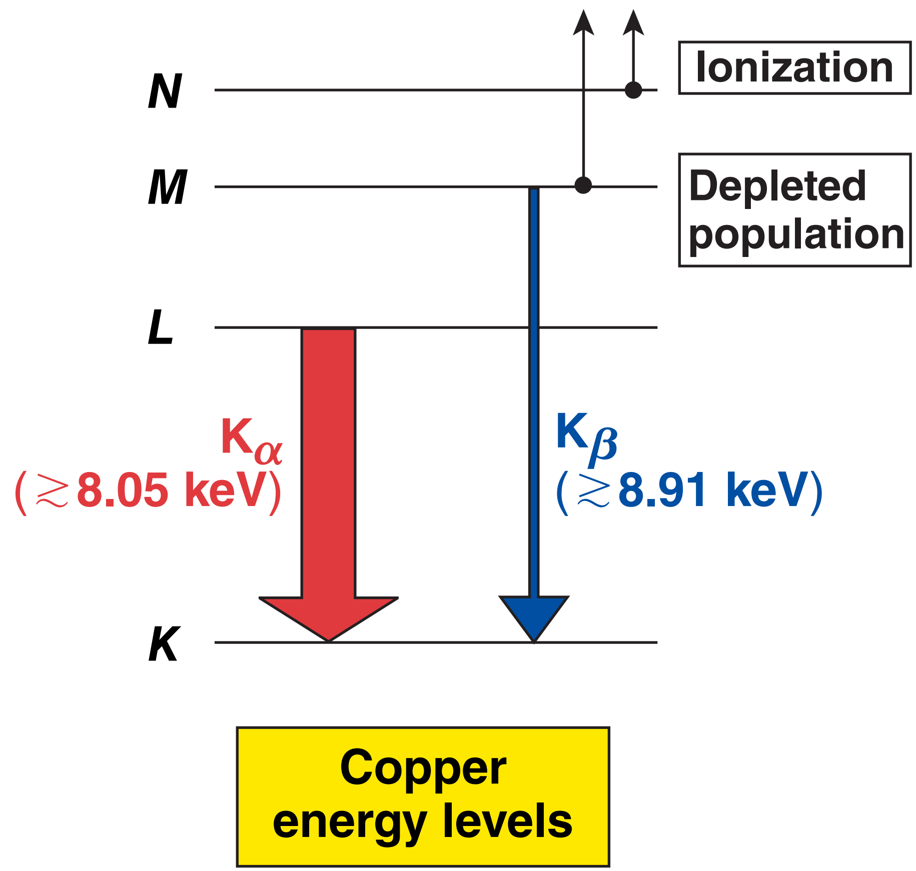
- Refluxing is caused by Debye-sheath field effects[1,2]
- Majority of fast electrons are stopped in the target
- Provides a simple geometry for testing laser-coupling, electron-generation, and target-heating models[3,4]

[1]S. P. Hatchett *et al.*, Phys. Plasmas 7, 2076 (2000).
[2]R. A. Snavely *et al.*, Phys. Rev. Lett. 85, 2945 (2000).
[3]W. Theobald *et al.*, Phys. Plasmas 13, 043102 (2006).
[4]J. Myatt *et al.*, Phys. Plasmas 14, 056301 (2007).

E16142f

Target bulk-heating affects $L \rightarrow K$ and $M \rightarrow K$ electron transitions*

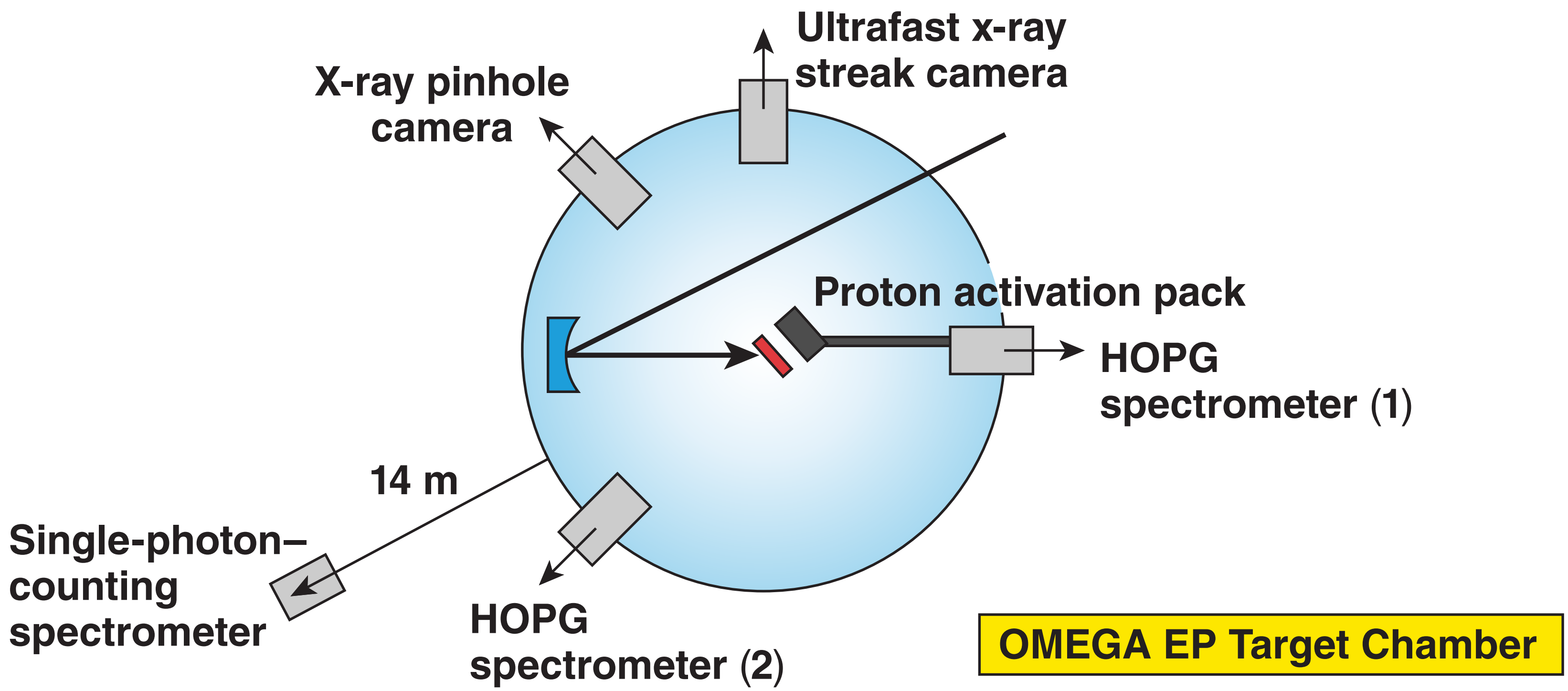
- Inelastic electron–electron collisions heat the target
- Collisional ionization with thermal background plasma occurs
- T_e > 100 eV causes significant M-shell depletion
- Target heating is inferred from K_β/K_α



*P. M. Nilson *et al*., Phys. Rev. E 79, 016406 (2009).
G. Gregori *et al*., Contrib. Plasma Phys. 45, 284 (2005).
J. Myatt *et al*., Phys. Plasmas 14, 056301 (2007).

E16143a

OMEGA EP experiments were performed with up to 2.1-kJ, 10- to 12-ps laser pulses



- Laser intensities $I \sim 5 \times 10^{18}$ W/cm^2
- Copper foil targets
- Target volumes:
  500 × 500 × 50 μm^3 to 75 × 75 × 5 μm^3

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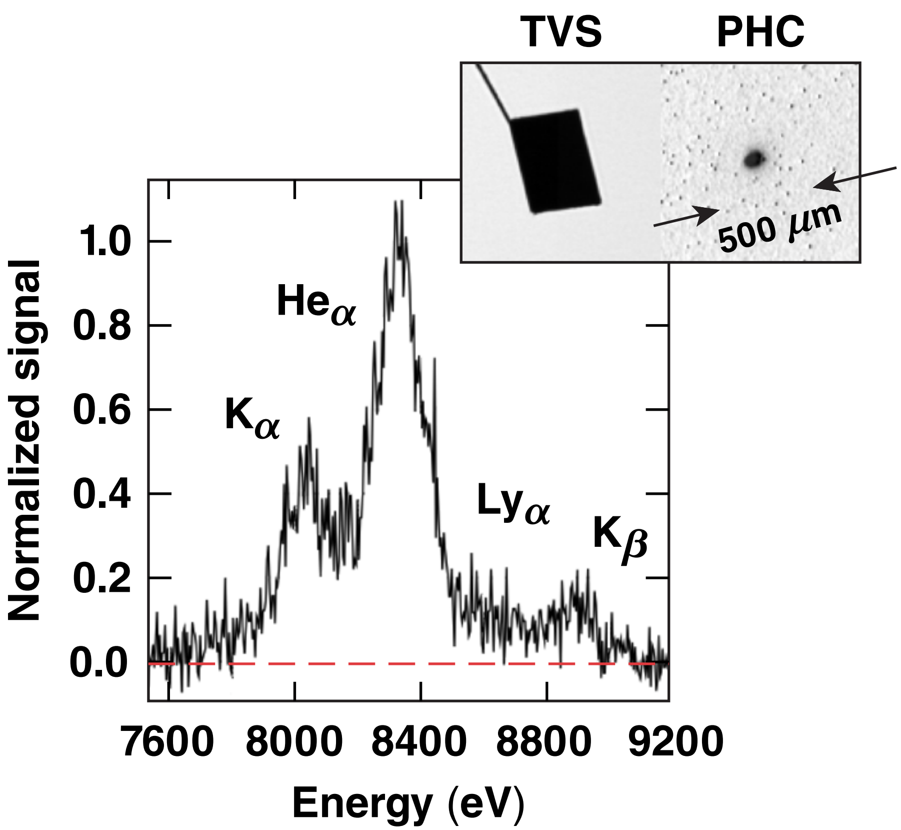
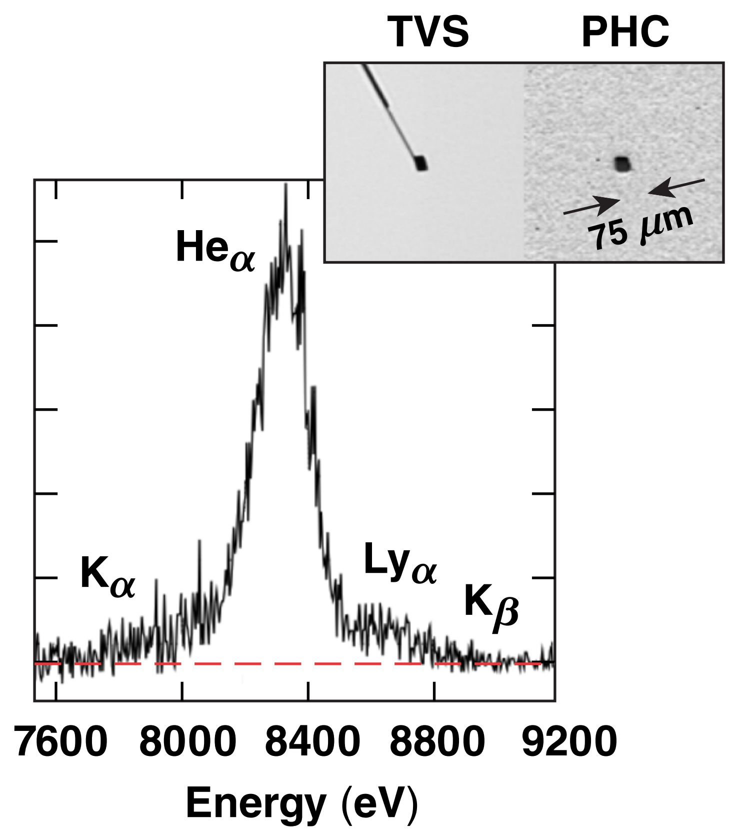
The effect of bulk-target heating on the K-shell-emission spectrum is observed with OMEGA EP



Cu target: 500 × 500 × 20 μm^3
Laser: 950 J, 10 ps

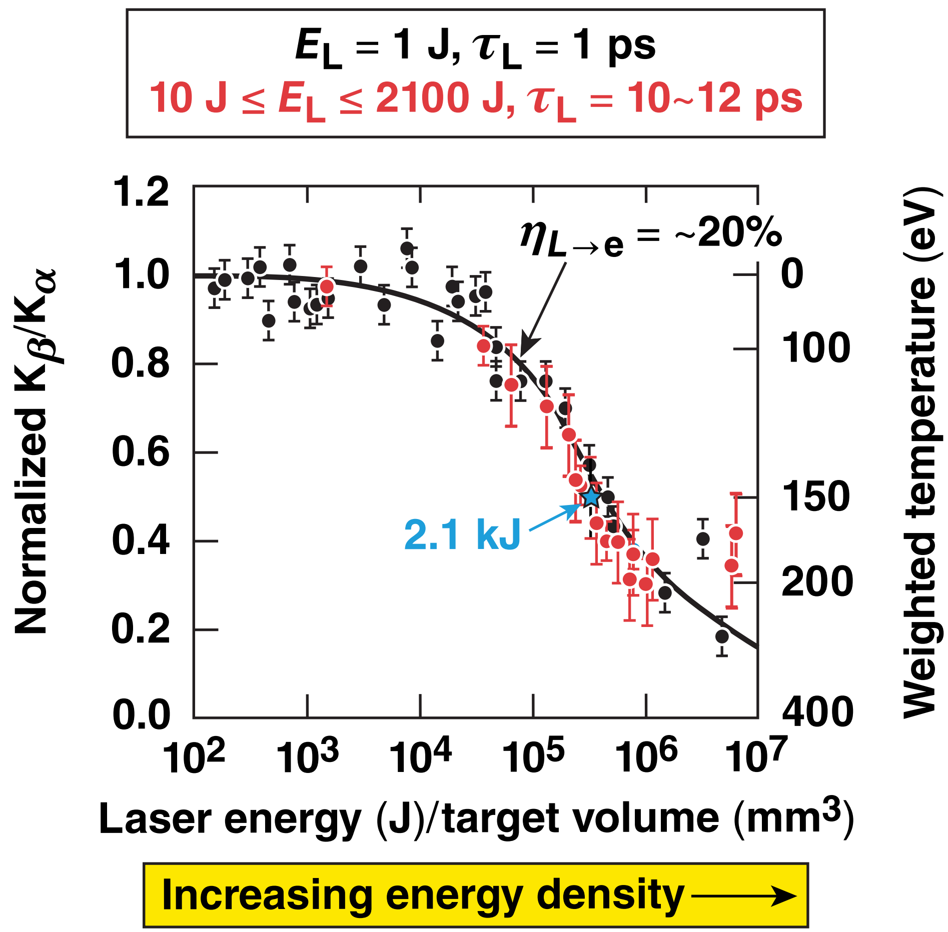


Cu target: 75 × 75 × 5 μm^3
Laser: 1042 J, 10 ps

E18445

Electron-energy coupling efficiency is independent of laser energy and pulse duration*

- $\eta_{L\rightarrow e}$ inferred from K-photon suppression measurements represents a minimum electron-energy conversion efficiency
- Energy-conversion efficiency offset due to high-energy proton acceleration is assumed to be small
- $\eta_{L\rightarrow p}$ ~ 1% with 1-kJ, 10-ps pulses**

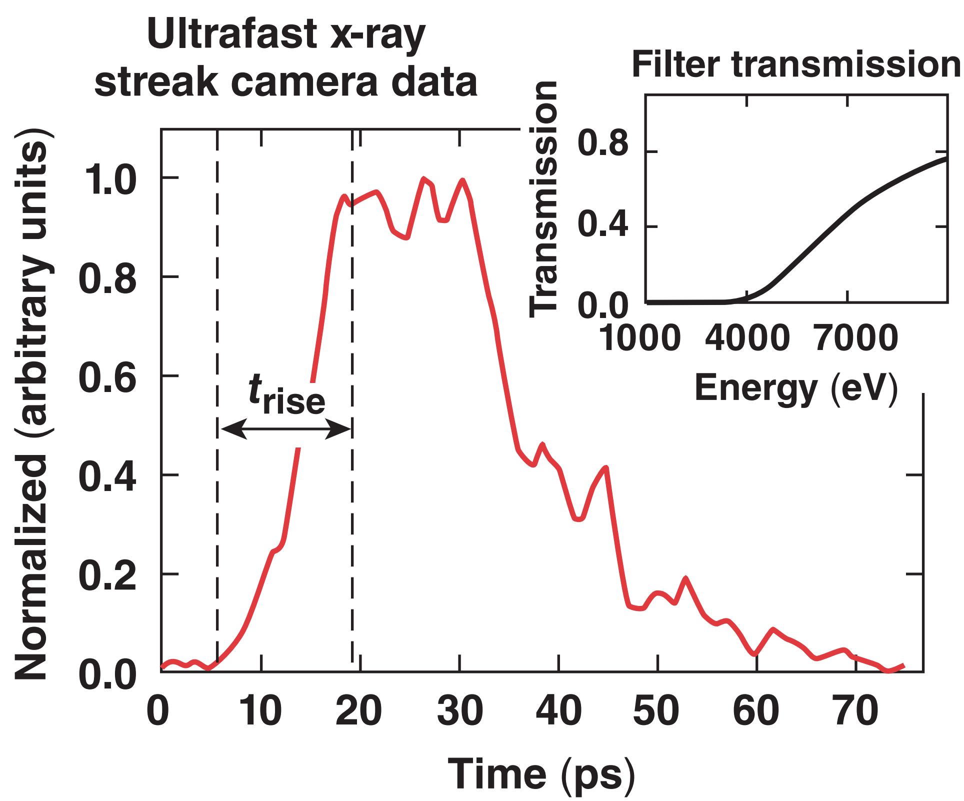


*P. M. Nilson, submitted to Phys. Rev. Lett. (2009).
**Private communication with L. Gao.

E17611f

Time-resolved x-ray emission measurements suggest energy coupling occurs over the whole duration of the incident drive

- Streak camera is sensitive to bremsstrahlung, inner-shell radiation, and thermal ionic-line emission
- OMEGA EP: E_L = 974 J, τ_L = 11 ps
  100 × 100 × 10-μm^3 Cu



X-ray emission rise time correlates to the laser-pulse duration.

E18096

OMEGA EP experiments show fast-electron coupling independent of laser energy and pulse duration

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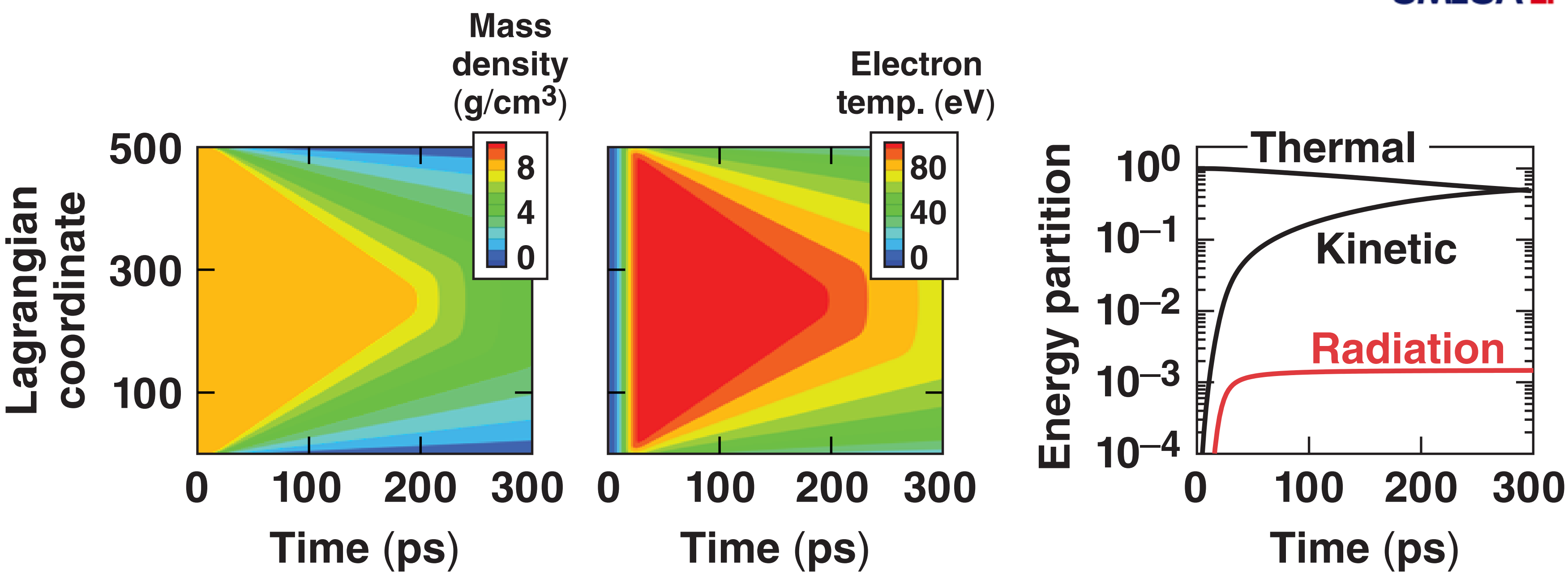
- K-photon-emission suppression measurements within copper foil targets indicate $\eta_{L \rightarrow e} \approx 20\%$ over a wide range of target volumes
- Time-resolved x-ray emission measurements suggest energy coupling occurs over the whole duration of the incident drive

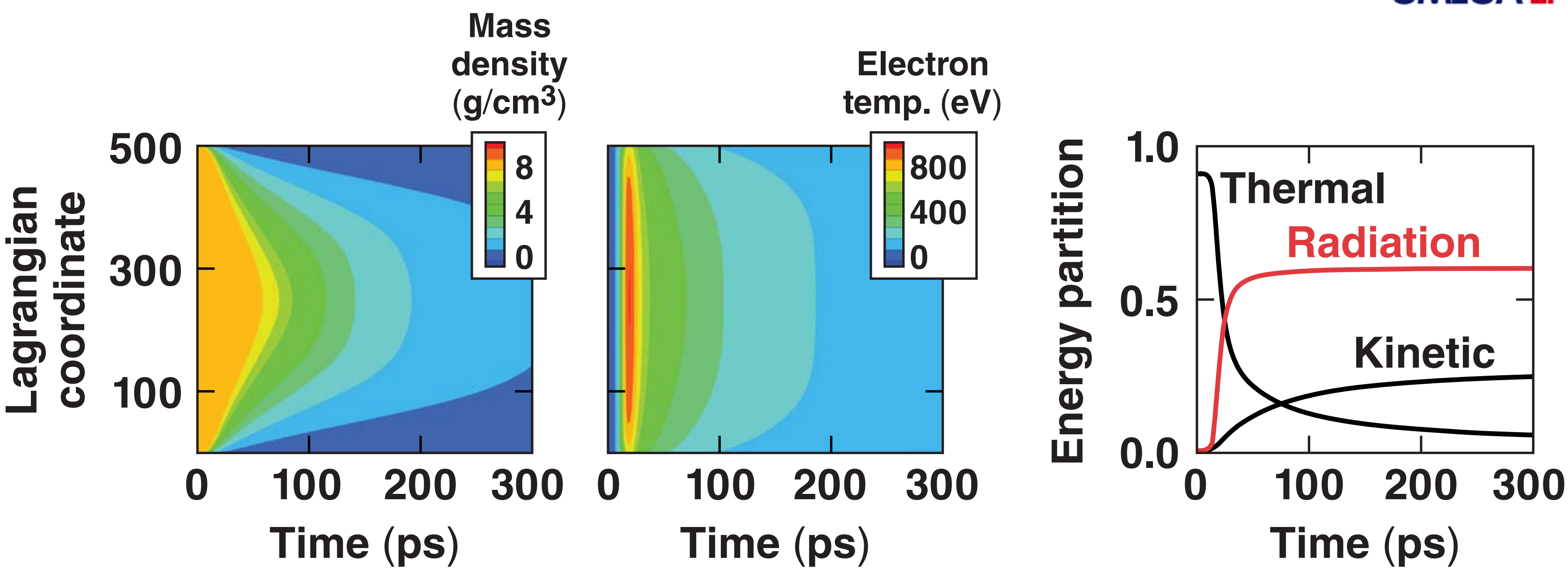
1-D *LILAC* calculations confirm target decompression is minimal over a 10-ps drive time



- 500 × 500 × 20-μm^3 Cu target
- 200 J of electron energy with T_h = 1 MeV
- 10-ps energy-deposition phase (FWHM)

Thermal decompression dominates.

1-D *LILAC* calculations confirm target decompression is minimal over a 10-ps drive time



- $100 \times 100 \times 10$-μm^3 Cu target
- 200 J of electron energy with T_h = 1 MeV
- 10-ps energy-deposition phase (FWHM)

Radiation cooling quenches the HED state in mass-limited targets prior to decompression.

E18095b