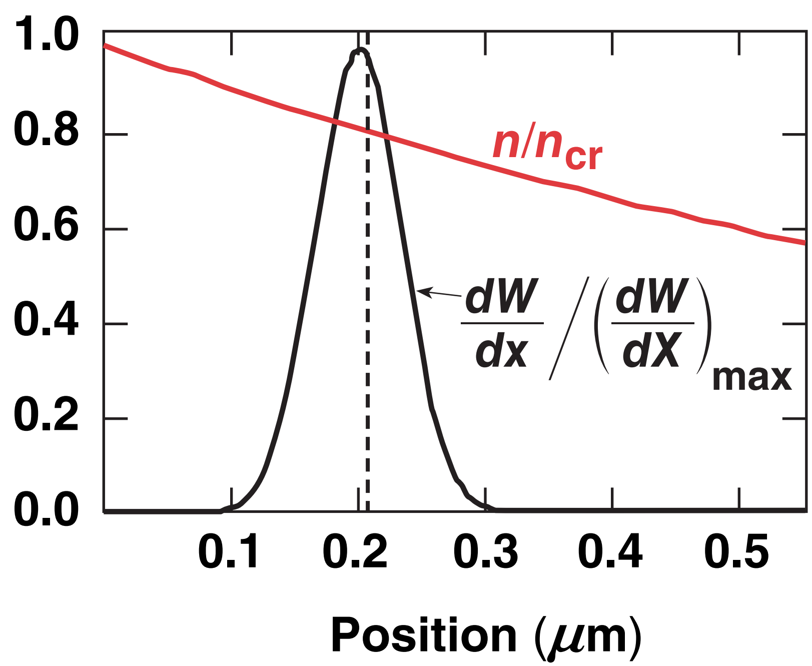
Thermal Transport Modeling in ICF Direct-Drive Experiments: Resonance Absorption



W: energy coupled to fast electrons

V. N. Goncharov
University of Rochester
Laboratory for Laser Energetics

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Summary

Current modeling shows that hot electrons generated by resonance absorption do not affect the implosion adiabat in direct-drive ICF experiments with $\lambda_L = 0.35\ \mu m$

- A newly developed nonlocal transport model* has been applied to study resonance absorption mechanisms in directly driven ICF targets.
- The hot electrons are generated mainly by the wave–particle interaction (Landau damping of plasma waves).
- When applied to ICF direct-drive targets, the nonlocal model predicts an increase in adiabat and temperature due to the resonance absorption electrons less than 5%.

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

Collaborators

**I. V. Igumenshchev, V. A. Smalyuk, W. Seka, T. R. Boehly,
R. L. McCrory, and J. A. Delettrez**

**University of Rochester
Laboratory for Laser Energetics**

D. Shvarts

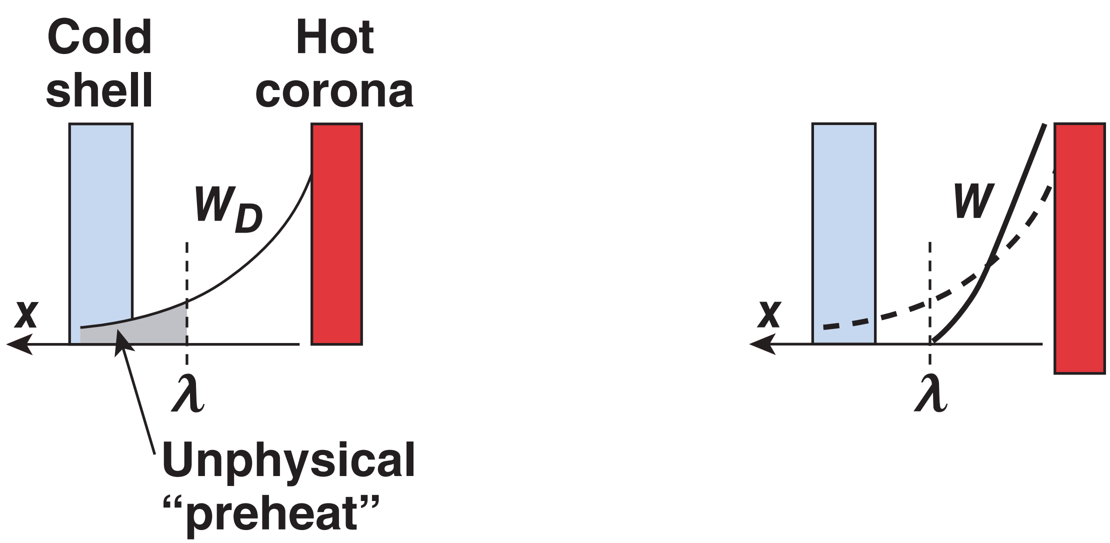
**Nuclear Research Center
Negev, Israel**

W. Manheimer and D. Colombant

Naval Research Laboratory

A new nonlocal transport model* has been used to simulate direct-drive ICF experiments

- The model solves the Boltzmann equation with Krook's collision operator (diffusion-type solution).
- To limit the delocalization length, the diffusion kernel $W_D = e^{-x/\lambda}$ is replaced by the solution of the electron–energy deposition equation $W = \sqrt{1 - x/\lambda}$.



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Absorption of *s*- and *p*-polarizations is calculated using linear Maxwell equations

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- Electron–ion collisions are corrected for effects of laser field.

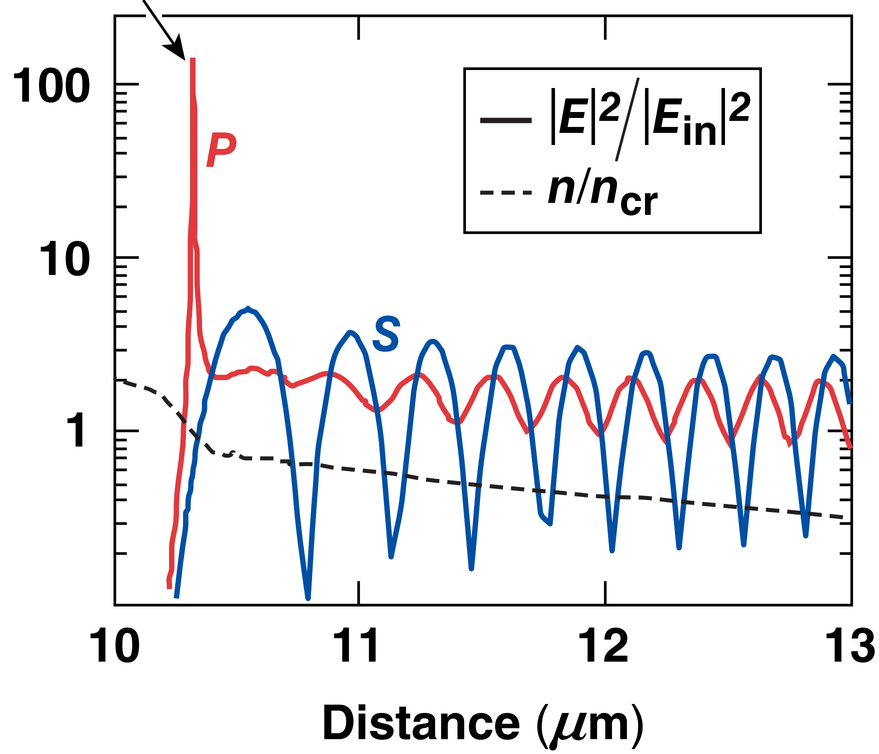
$$\nu_{ei} = \nu_{ei}^{M} \frac{f_0(0)\left(\sqrt{2\pi}\, v_T\right)^3}{n_e}$$

$$1 - \frac{0.6}{1 + \left(0.3/\alpha_L\right)^{0.75}}$$

$$\alpha_L = Z\nu_E^2 \Big/ \nu_T^2 \sim |E|^2$$

- $I = 10^{15}$ W/cm^2, $\lambda_L = 0.351$ μm

Peak is determined by wave convection*



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*I. V. Igumenshchev, next talk

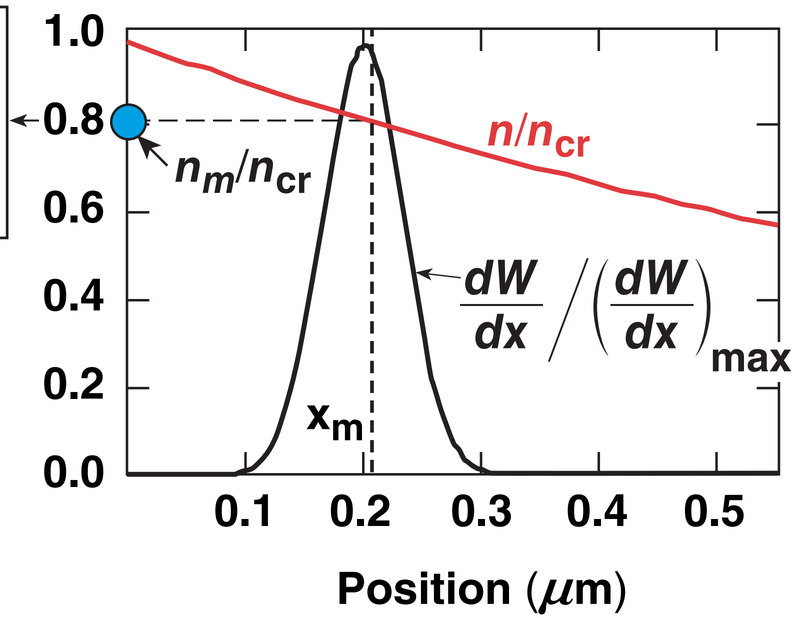
Fast electrons are created by wave–particle interaction

- **Landau damping** $\frac{\gamma}{\omega_p} = 0.7\left(xe^{-x}\right)^{3/2}, \quad x = \left(\frac{n_{cr}}{n} - 1\right)^{-1}$

- **Density scale length** $(L_n \sim 1\ \mu m) \gg$ **Debye length** $(\lambda_D \sim 10^{-3}\ \mu m)$

- **Energy loss to hot electrons** W

$$\frac{n_m}{n_{cr}} \approx 1 - \frac{1.5}{\ln\left(0.6\frac{L_n}{\lambda_D}\right)}$$



$$T_h = \frac{T(x_m)}{1 - \frac{n}{n_{cr}}}$$

$$T_h \approx \left(1 + \frac{2}{3}\ln 0.6\frac{L_n}{\lambda_D}\right)T(x_m)$$

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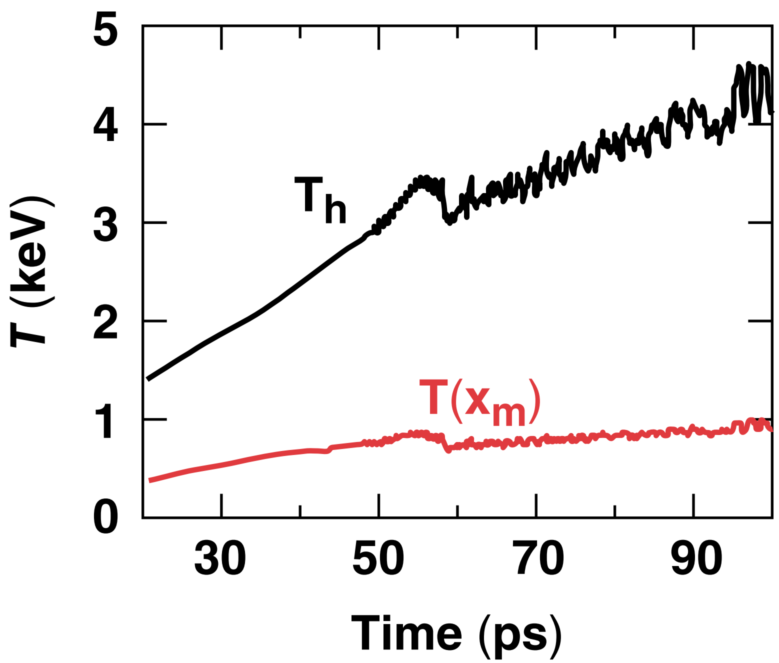
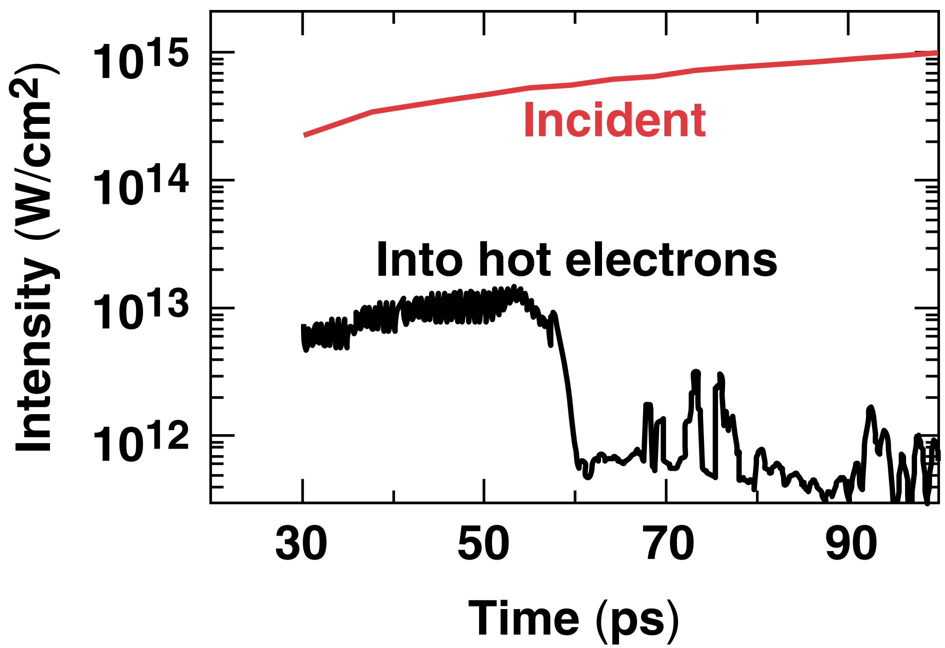
Hot electrons are generated early in the pulse

- 10-μm CH foil is driven by 10^{15} W/cm^2 laser pulse with 100 ps rise time
- 50% *s*- and 50% *p*- polarization





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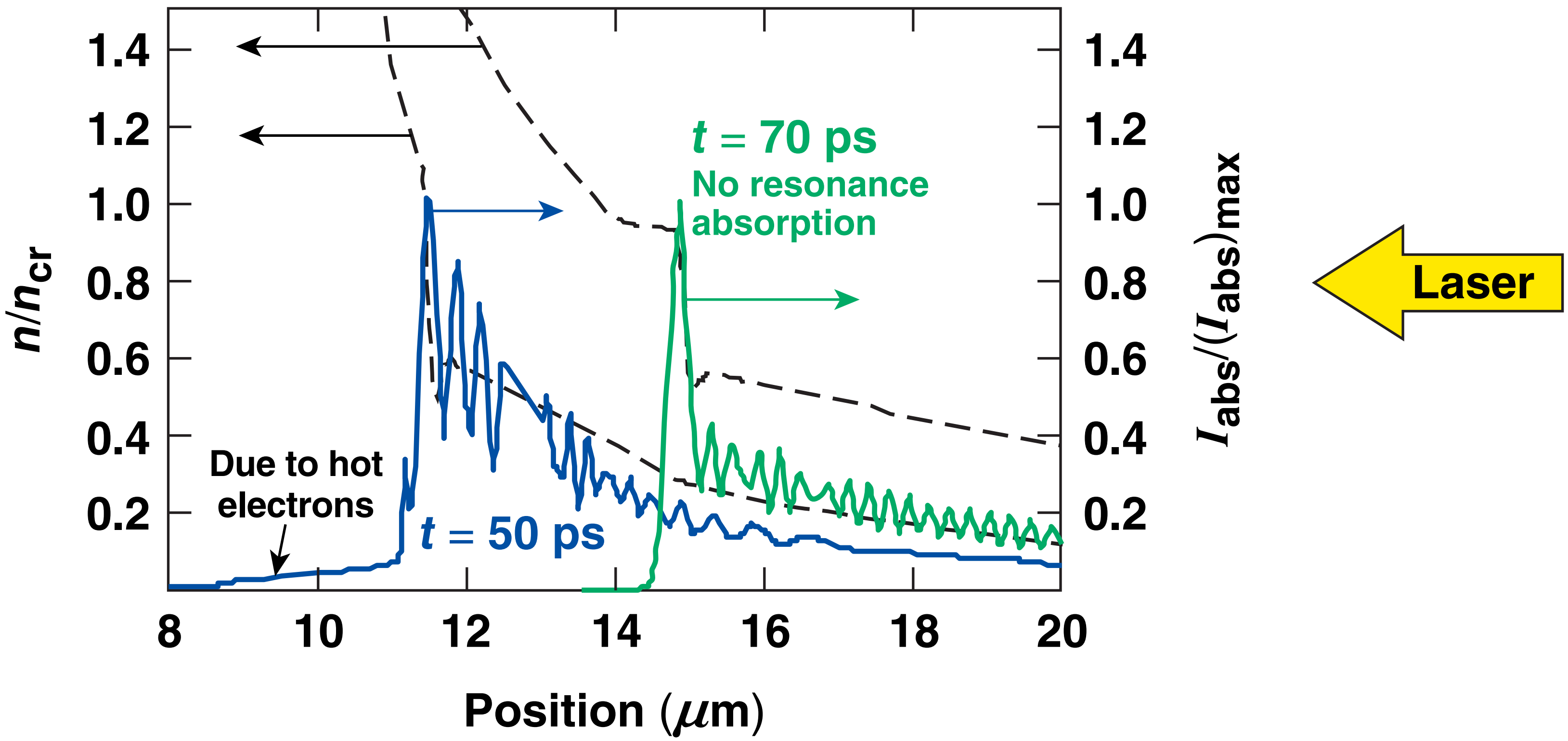
Resonance absorption is significantly reduced as the region with sharp density variation moves below the critical surface



The duration of hot-electron production depends on the thermal conduction model.

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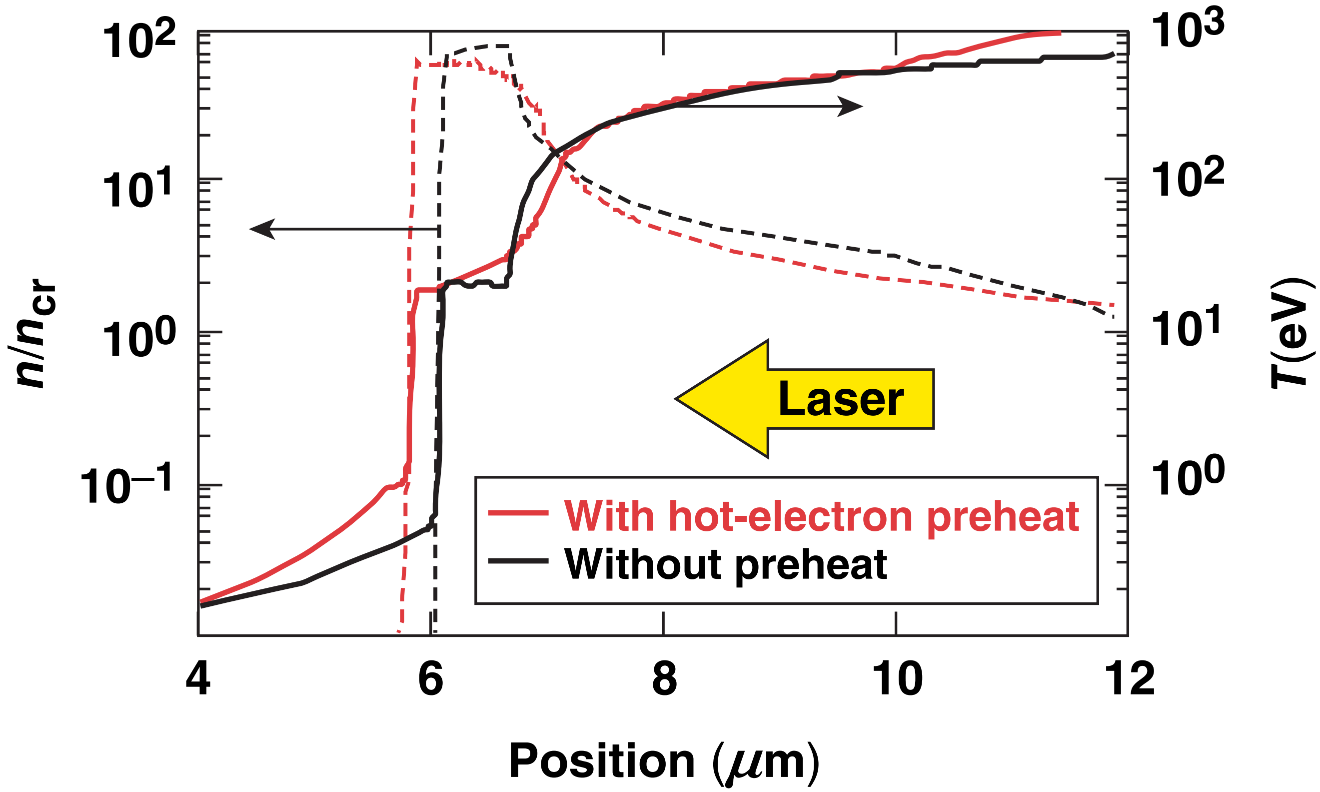
Hot electrons from the resonance absorption do not significantly modify cold-shell temperatures



Summary/Conclusions

Hot electrons generated by resonance absorption do not affect the implosion adiabat in direct-drive ICF experiments

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- A newly developed nonlocal transport model* has been applied to study resonance absorption mechanism in directly driven ICF targets.
- The hot electrons are generated mainly by the Landau damping of plasma waves.
- When applied to ICF direct-drive targets, the nonlocal model predicts an increase in adiabat and temperature due to the resonance absorption electrons less than 5%.

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