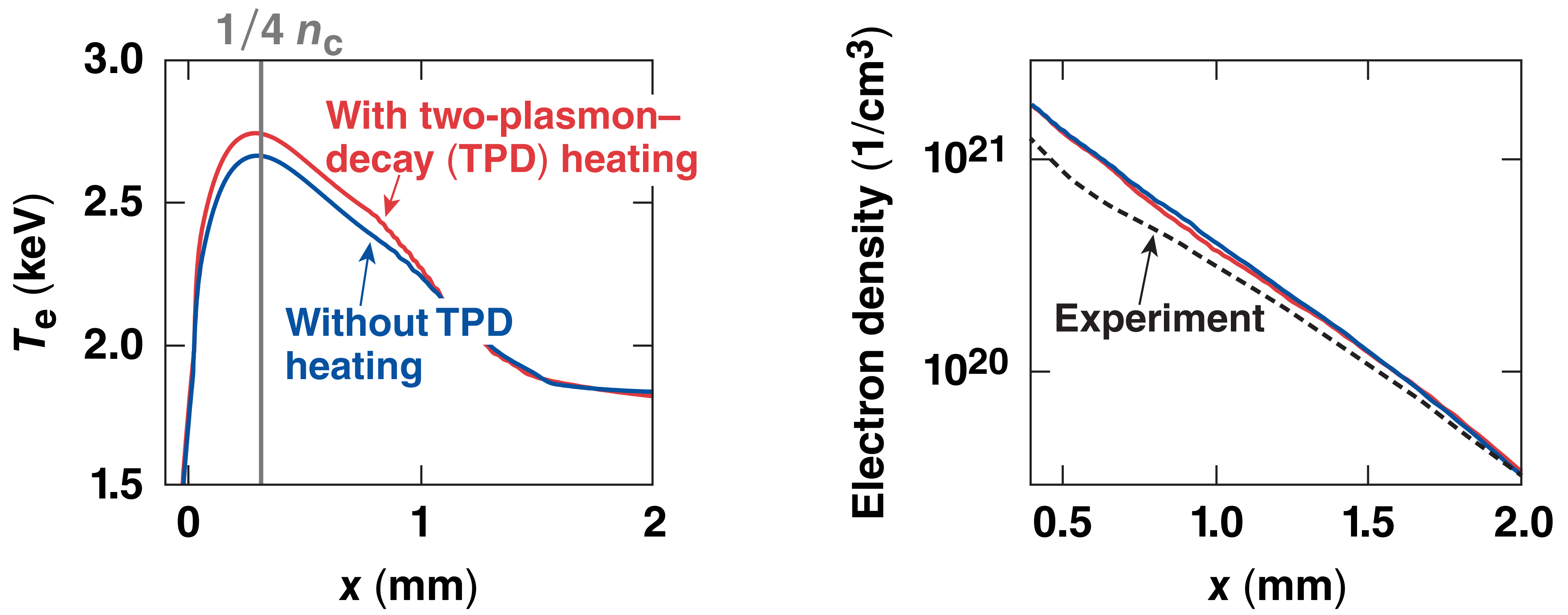
The Effects of Laser–Plasma Instabilities on Hydro Evolution in Direct-Drive Inertial Confinement Fusion



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57th Annual Meeting of the
American Physical Society
Division of Plasma Physics
Savannah, GA
16–20 November 2015

Summary

OSIRIS particle-in-cell (PIC) simulations were performed to obtain a total laser absorption near the $n_c/4$ surface that can be input into the *DRACO* fluid simulation*

- Laser absorption caused by laser–plasma instability (LPI) is simulated by *OSIRIS* and then is input to *DRACO*
- The *DRACO* simulations show that LPI-induced laser absorption can increase the electron temperature but only slightly changes the density scale length in the corona

*S. X. Hu *et al*., Phys. Plasmas 20, 032704, (2013).

Collaborators

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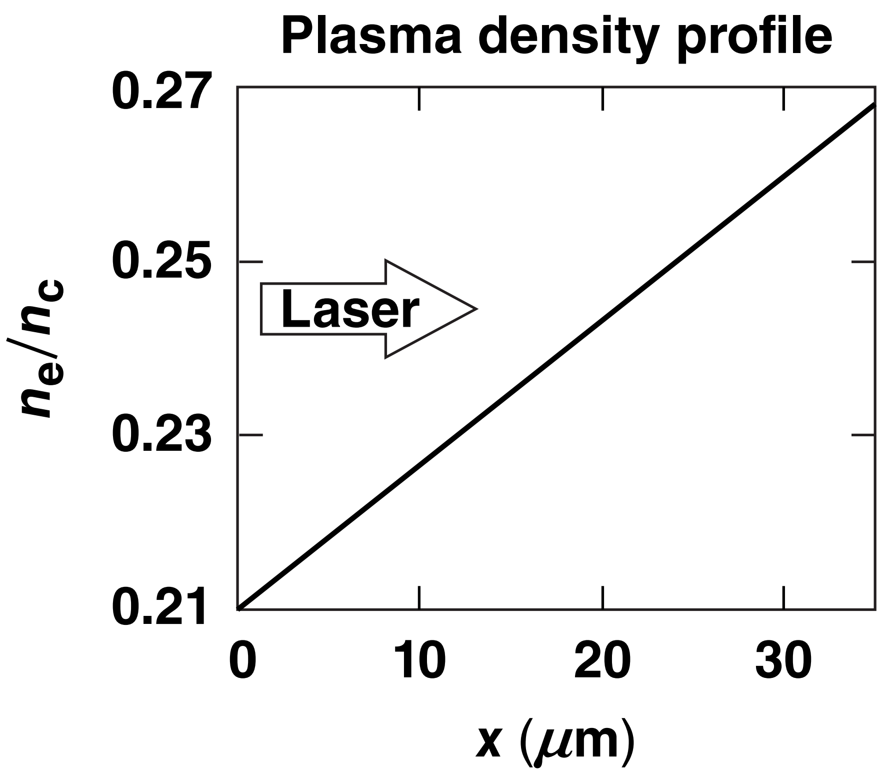
Motivation

Recent PIC simulations* showed an LPI–induced laser absorption of ~15% near the $n_c/4$ surface in typical OMEGA spherical implosions

- It is not known how the 15% absorption of the laser energy near the $n_c/4$ region would change the hydro behavior
- PIC and hydro simulations are coupled together to study this effect



$L = 150\ \mu m$
$T_e = 3$ keV
$I = 6 \times 10^{14}$ W/cm^2

*R. Yan *et al*., Phys. Rev. Lett. 108, 175002 (2012).

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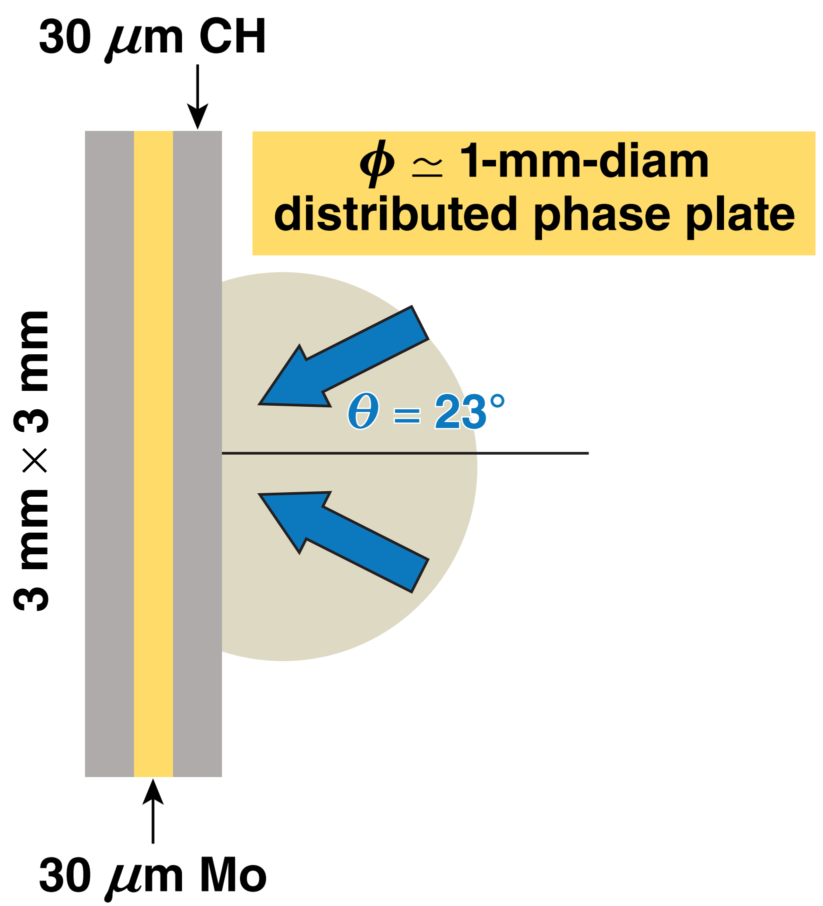
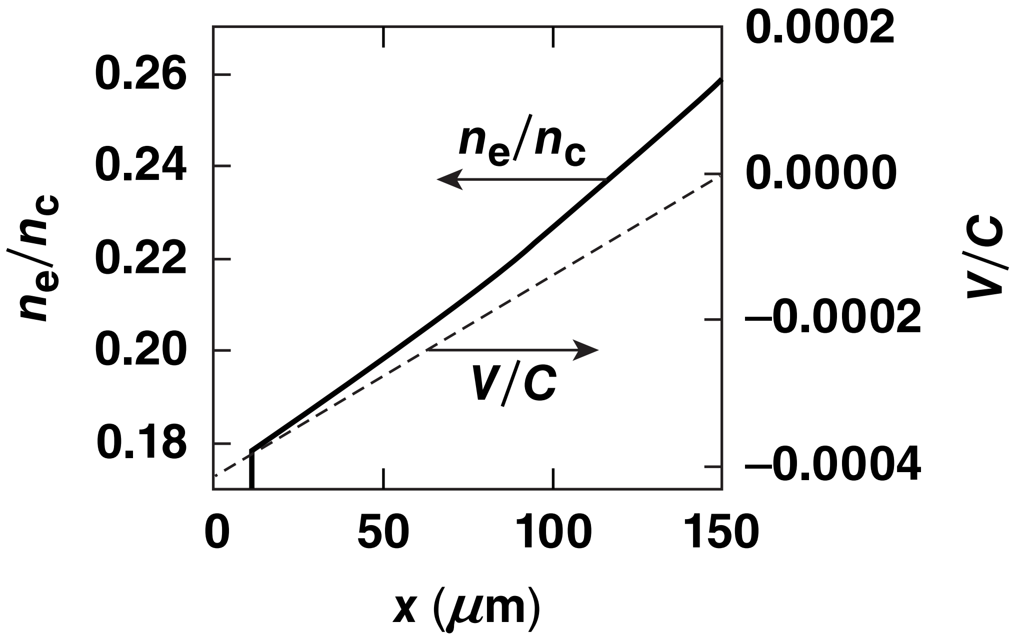
An *OSIRIS** PIC simulation was used to study the laser absorption near the $n_c/4$ region for an OMEGA EP long-scale-length experiment





- Plasma and laser conditions near the $n_c/4$ surface from *DRACO***

$$L = 375\ \mu m$$
$$I = 5.5 \times 10^{14}\ W/cm^2$$
$$T_e = 2.5\ keV$$
$$T_i = 1.5\ keV$$
$$\eta = \frac{L_\mu \lambda_\mu I_{14}}{81.86\ T_{keV}}\ ***$$

*R. A. Fonseca *et al*., Lect. Notes Comput. Sci. 2331, 342 (2002).
**S. X. Hu *et al*., Phys. Plasmas 20, 032704, (2013); D. T. Michel *et al*., Phys. Plasmas 20, 055703 (2013).
***A. Simon *et al*., Phys. Fluids 26, 3107 (1983).

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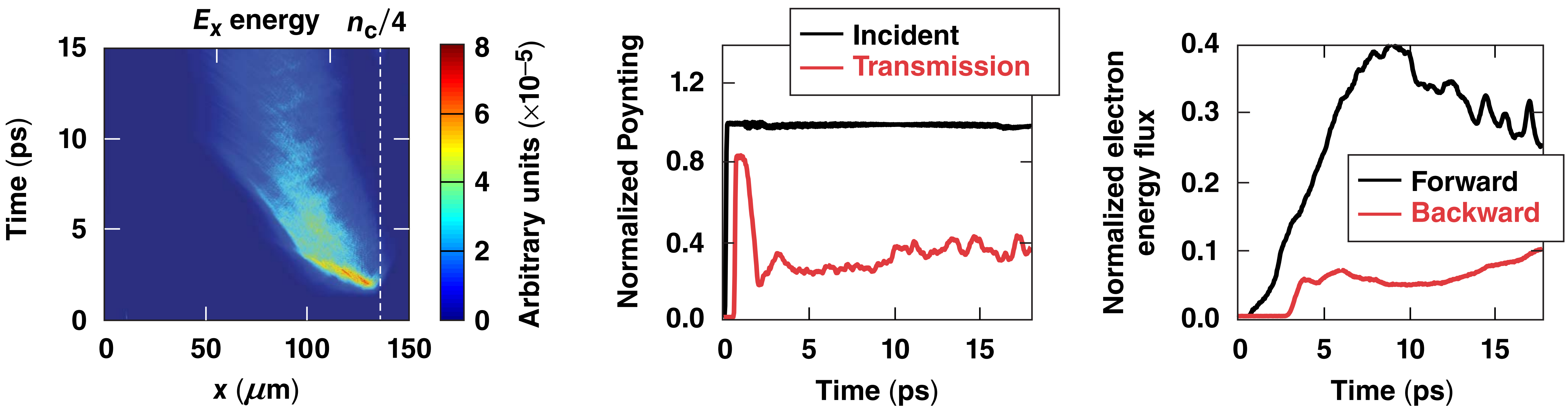
Strong pump depletion and a significant amount of forward- and backward-going hot electrons were observed



- The laser energy is depleted by 68% in the simulation box
- The absorbed energy goes to plasma heating (33%) and electrons leaving the box (25% forward and 5% backward)

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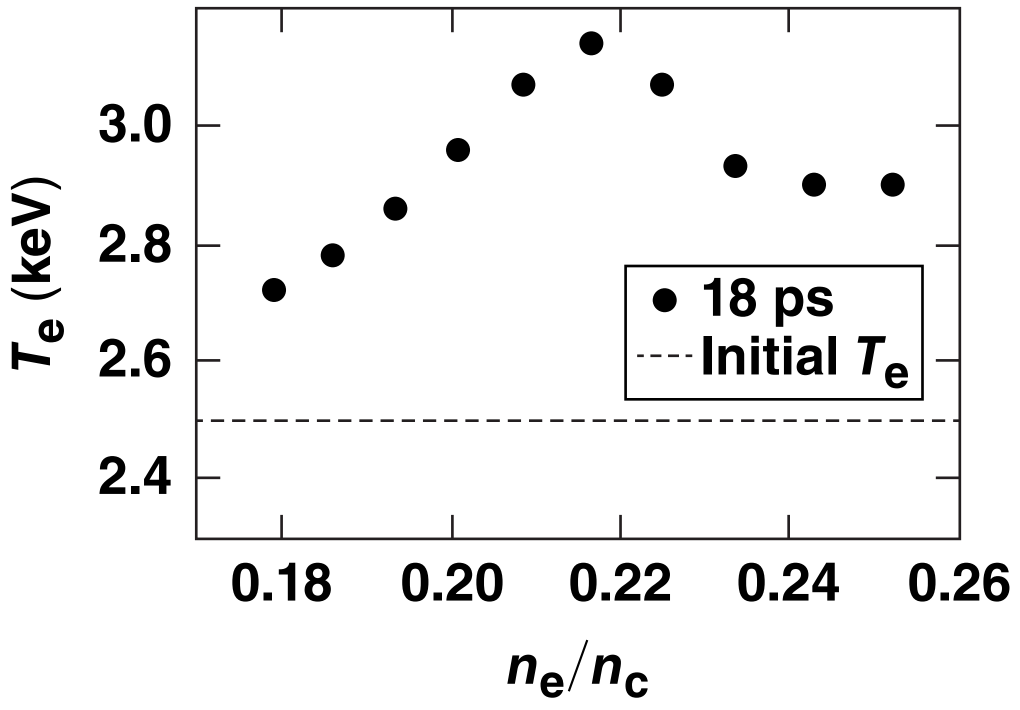
The energy-balance information is coupled back to *DRACO*

- The collisional damping of the two-plamon–decay (TPD) plasma waves absorbs 30% of the laser energy between 0.17 n_c and 0.25 n_c
- Hot-electron energy is deposited in the regions with densities above 0.25 n_c and below 0.17 n_c according to their stopping range
- Hot-electron energy is calculated as follows,* with f_c determined by the PIC simulation ($G_c = 8.7$)

$$G_c = 3 \times 10^{-2} \frac{I_{qc} L_n \lambda_0}{T_e}$$

$$f_{hot} = \begin{cases} f_c \left(G_c/4\right)^6, & G_c \le 4 \\ f_c \left(G_c/4\right)^{1.2}, & G_c > 4 \end{cases}$$



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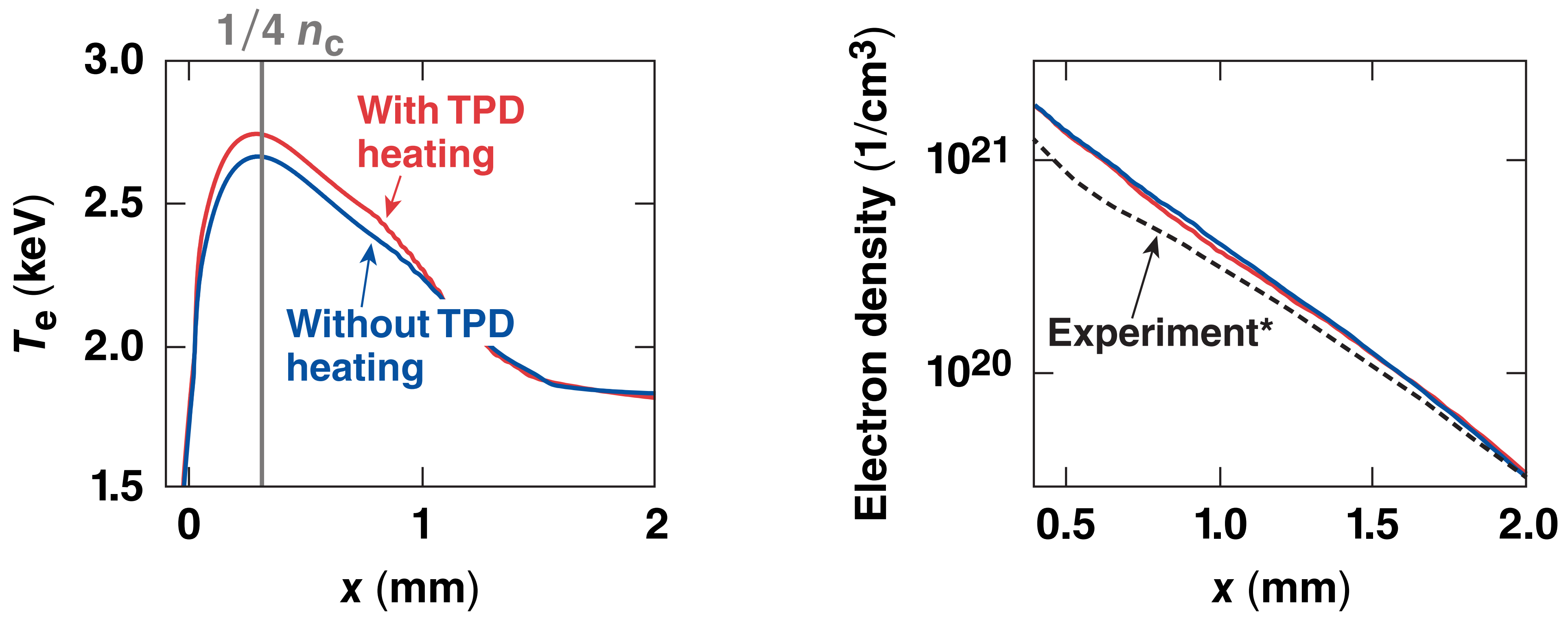
*S. X. Hu *et al*., Phys. Plasmas 20, 032704 (2013).

The LPI-induced laser absorption increases the electron temperature by 100 eV, but only slightly changes the density scale length in the corona



- The new *DRACO* simulation raised the electron temperature near the $n_c/4$ surface by 100 eV

*D. Haberberger *et al*., Phys. Plasmas 21, 056304 (2014).

E12526

The temperature and density profiles are not sensitive to the hot-electron energy

- The simulation results show that the hot-electron energy fraction above 25 keV is ~11% of the incident laser energy, more than the ~2% obtained from the experiment
- The hot-electron temperature of ~50 keV in the PIC simulation agrees with the experiment
- The hydro profiles are not sensitive to whether the energy is carried by the hot electrons or the laser

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