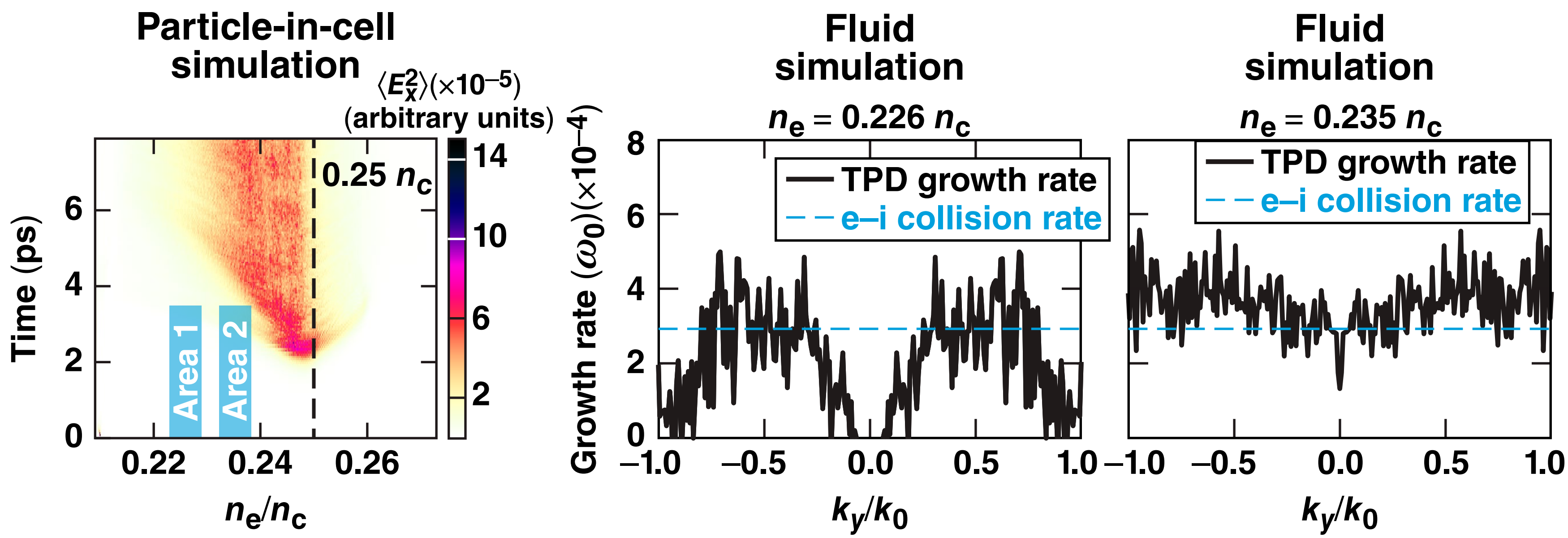
Collisional Effects on Hot-Electron Generation in the Two-Plasmon–Decay Instability in Inertial Confinement Fusion



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Summary

Electron–ion collisions can reduce hot-electron generation in two-plasmon–decay (TPD) instablility*

- Particle-in-cell (PIC) simulations reveal a staged-acceleration mechanism for hot-electron generation in TPD*
- PIC and fluid simulations found that this reduction is partially caused by collisional suppression of the nonlinear TPD modes away from the quarter-critical surface
  - these modes form the first stage of hot-electron acceleration

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

Collaborators

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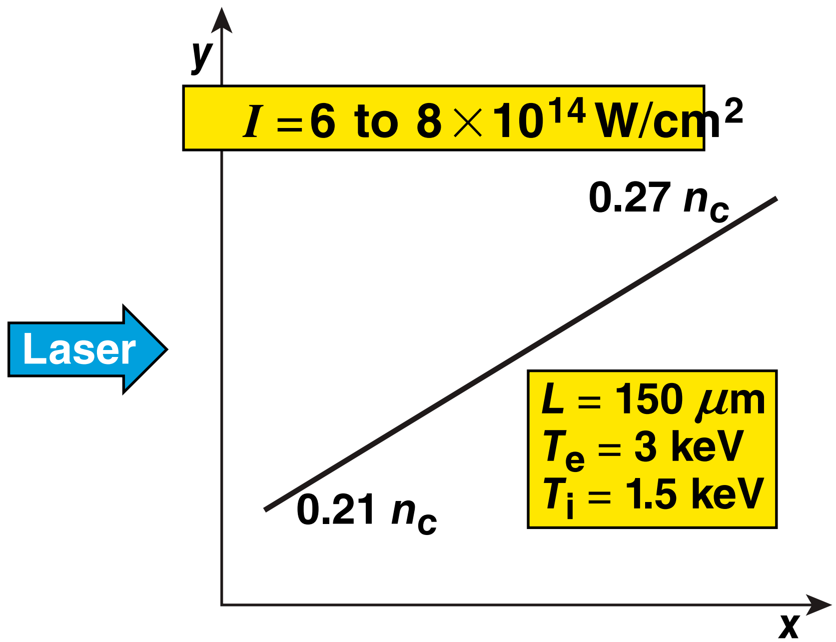
TPD hot-electron generation has been studied with PIC simulations with parameters relevant to OMEGA experiments



Two ion species (CH) are used

- Hot electrons generated in TPD can preheat a target in inertial confinement fusion (ICF)
- PIC simulation is a useful tool to study TPD hot-electron generation
- Numerical collisions in *OSIRIS** are lower than physical collisions
  - for $n = 0.25\ n_c$ and $T_e = 3$ keV, $\nu_{ei}^{numerical} \approx 0.1 \nu_{ei}^{physical}$
- The effects of physical collisions are studied by turning on/off the collisional package in *OSIRIS*

TC10205

*R. A. Fonseca *et al.*, Lect. Notes Comput. Sci. 2331, 342 (2002).

The electron–ion collision package from *OSIRIS* is benchmarked by measuring the plasma-wave damping rates

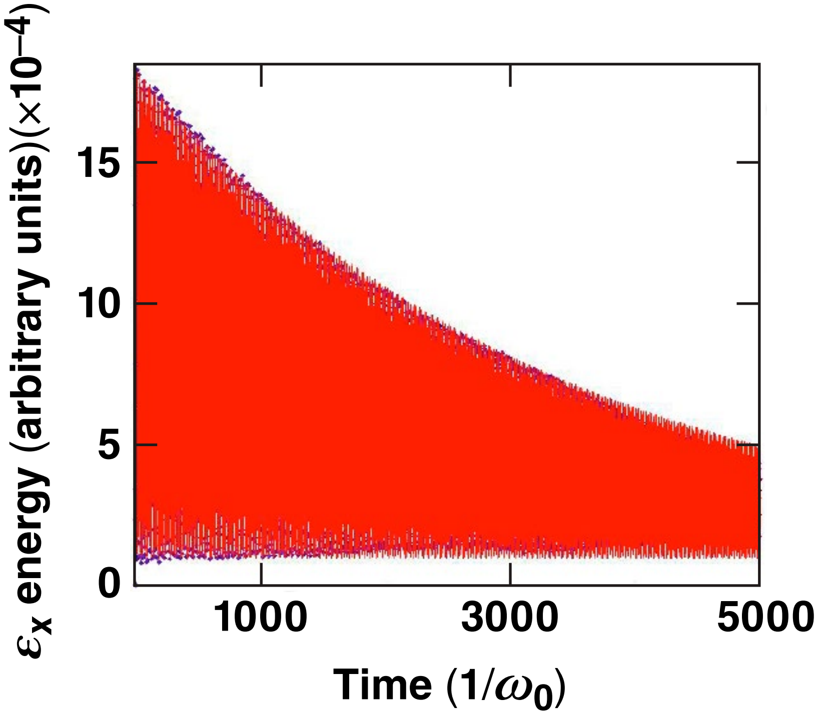
- **Simulation parameters**

  $n_e = 0.25\ n_c$ CH plasma

  $T_e = 3$ keV 100 particles/cell

- **The energy of a plasma wave should evolve like**

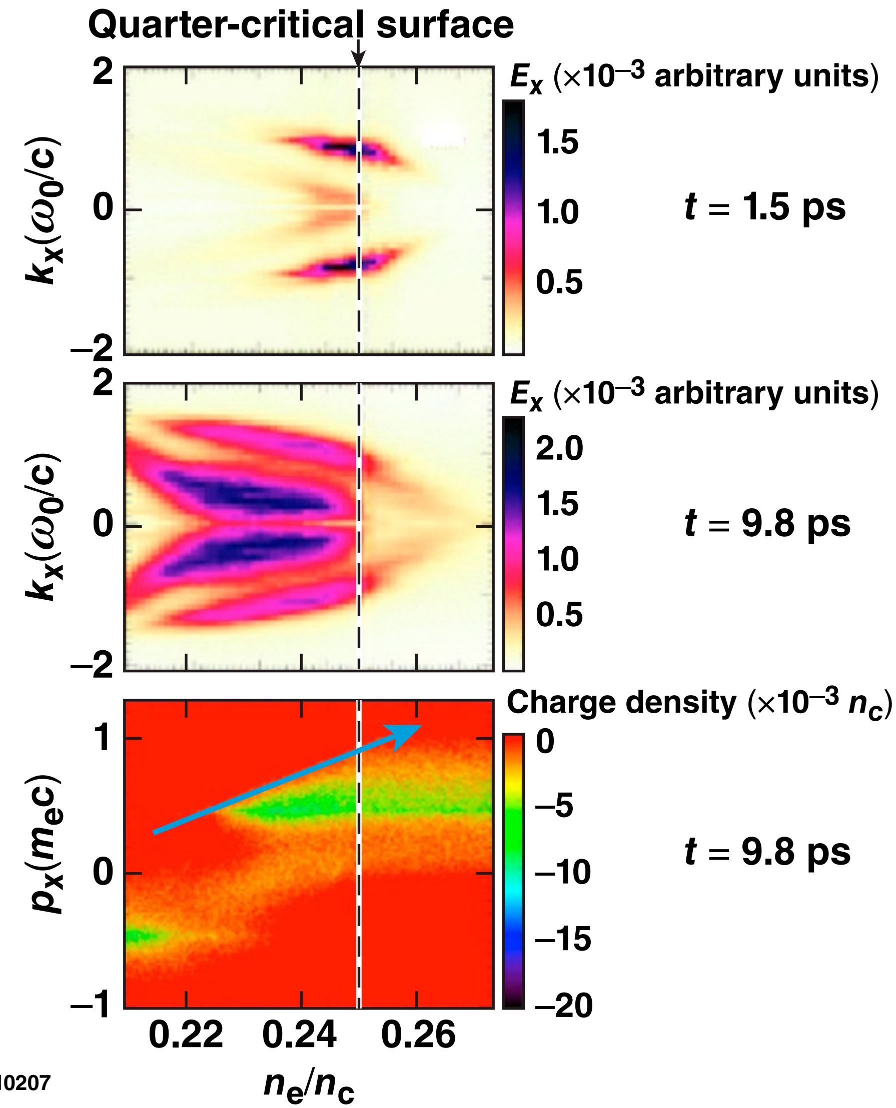
  $$\varepsilon_x = a e^{-\nu_{ei} t} \sin^2(\omega_p t) + c$$



Fitted results: $\nu_{ei}^{package} = 2.94 \times 10^{-4}\ \omega_0 = 98\%\ \nu_{ei}$

TC10206

The high-k modes of electron plasma waves away from the quarter-critical surface are important for the first stage of acceleration*

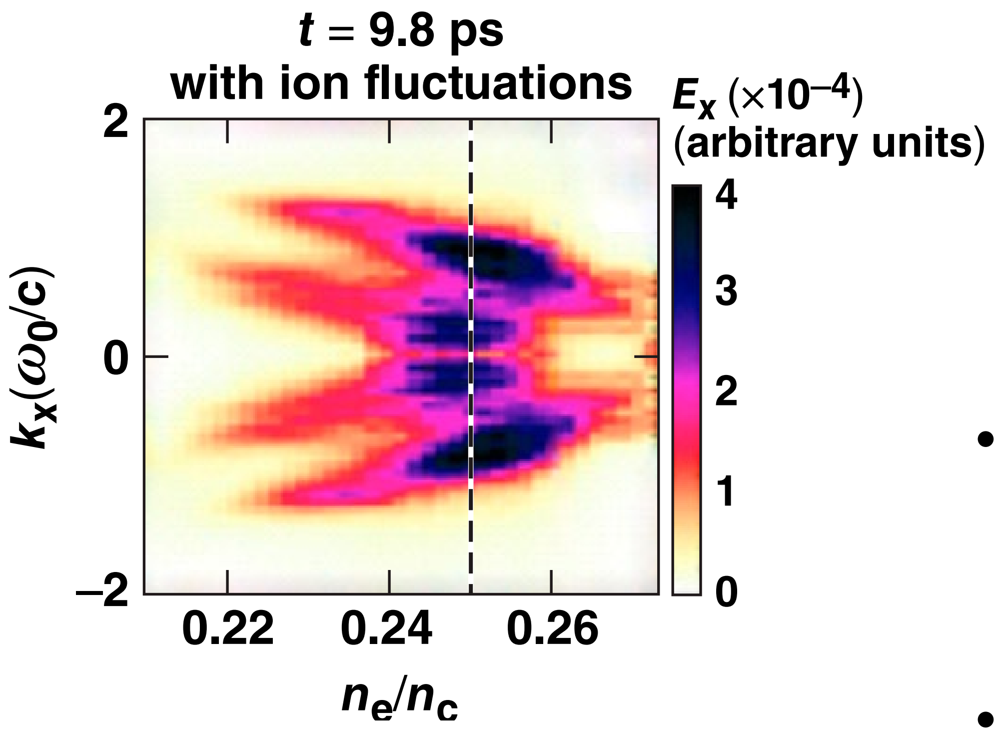


TC10207

- New modes away from the quarter-critcal surface appear in the nonlinear stage and form the first stage of electron acceleration
- Hot electrons are stage accelerated from left to right
- It is important to know the nature and phase velocities of the high-k modes

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

Fluid* simulations show that the high-*k* modes are TPD modes under ion-density fluctuations**



- *LTS** is a fluid code solving the full linear PDE's of TPD

$$\frac{\partial \psi}{\partial t} = \phi - 3v_e^2 \frac{n_p}{n_0} - v_0 \cdot \nabla \psi$$

$$\frac{\partial n_p}{\partial t} = -\nabla \cdot (n_0 \nabla \psi) - v_0 \cdot \nabla n_p$$

$$\nabla^2 \phi = n_p$$

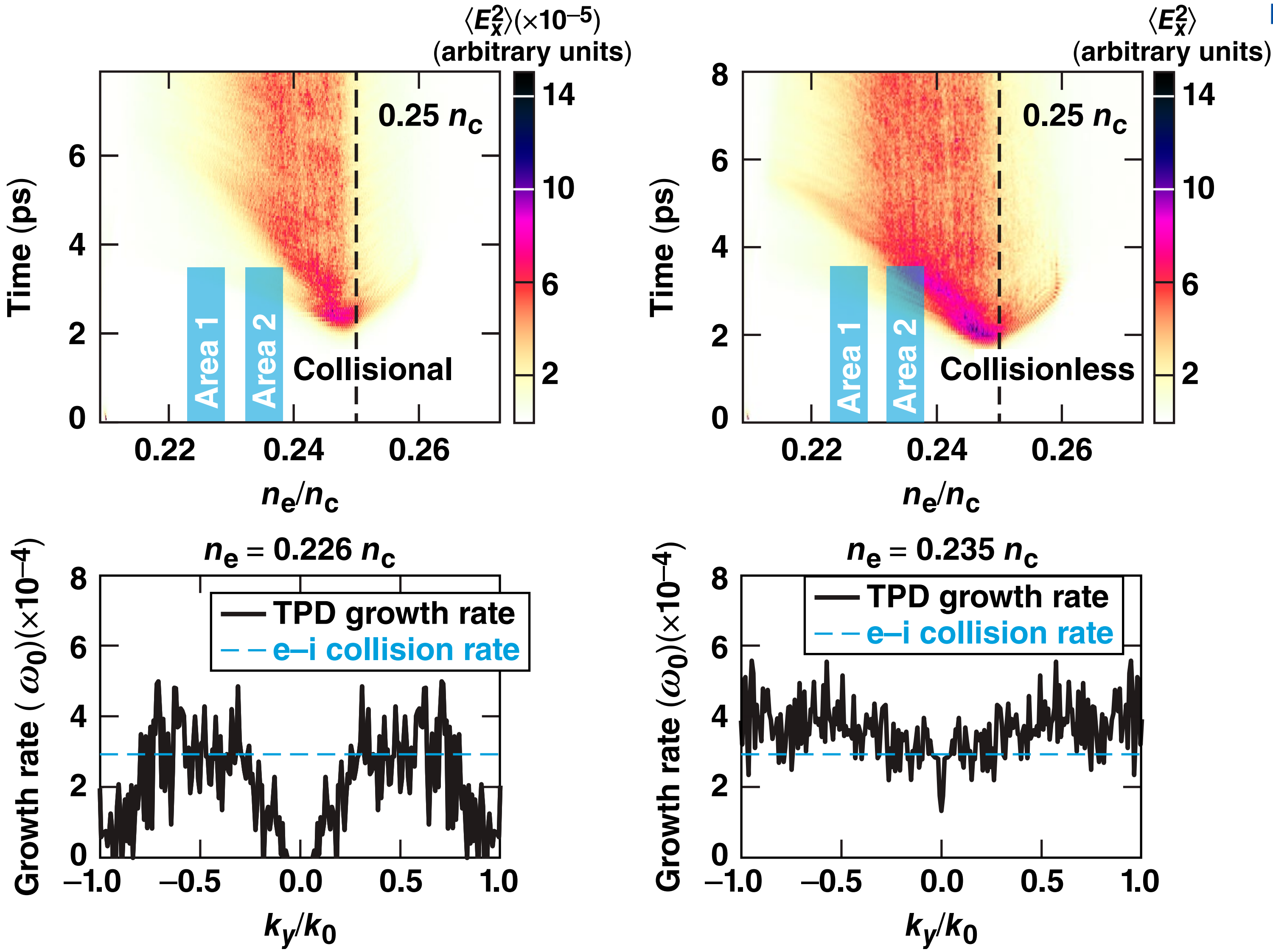
- Static background ion-density fluctuations taken from *OSIRIS* can be added to *LTS*

$$n_0 \rightarrow n_0 + \delta n$$

- The high-*k* modes have significant growth in *LTS* only when ion-density fluctuations are introduced

* R. Yan, A. V. Maximov, and C. Ren, Phys. Plasmas 17, 052701 (2010).
** R. Yan *et al*., Phys. Rev. Lett. 108, 175002 (2012).

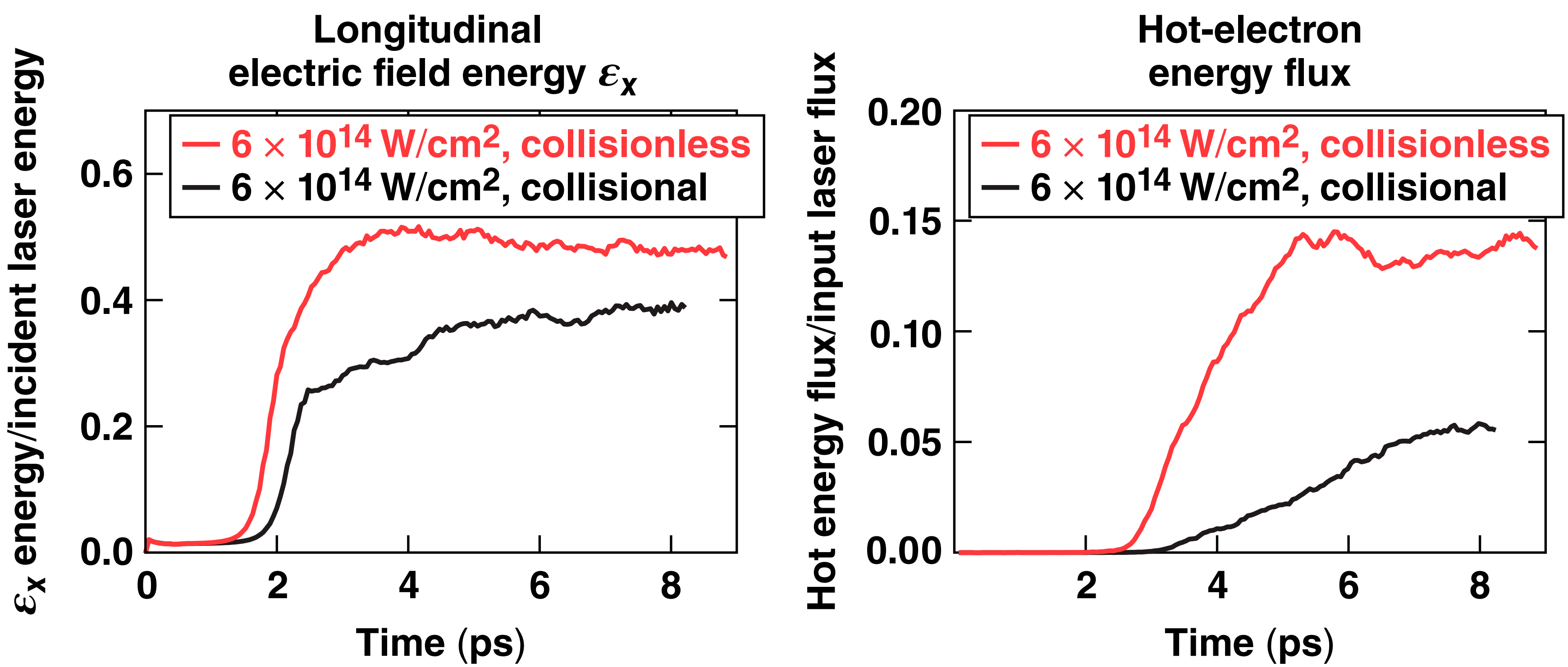
Collisions can reduce the strength of the high-k modes



The TPD modes in the low density region can develop wherever the growth rate is higher than the local e-i collision rate.

TC10209

The longitudinal electrostatic field energy and hot-electron generation are reduced by collisions



- Collisions reduce the efficacy of the staged-acceleration mechanism
  - increase the phase velocity of the first-stage plasma wave
  - reduce the amplitude of all plasma waves

TC10210

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