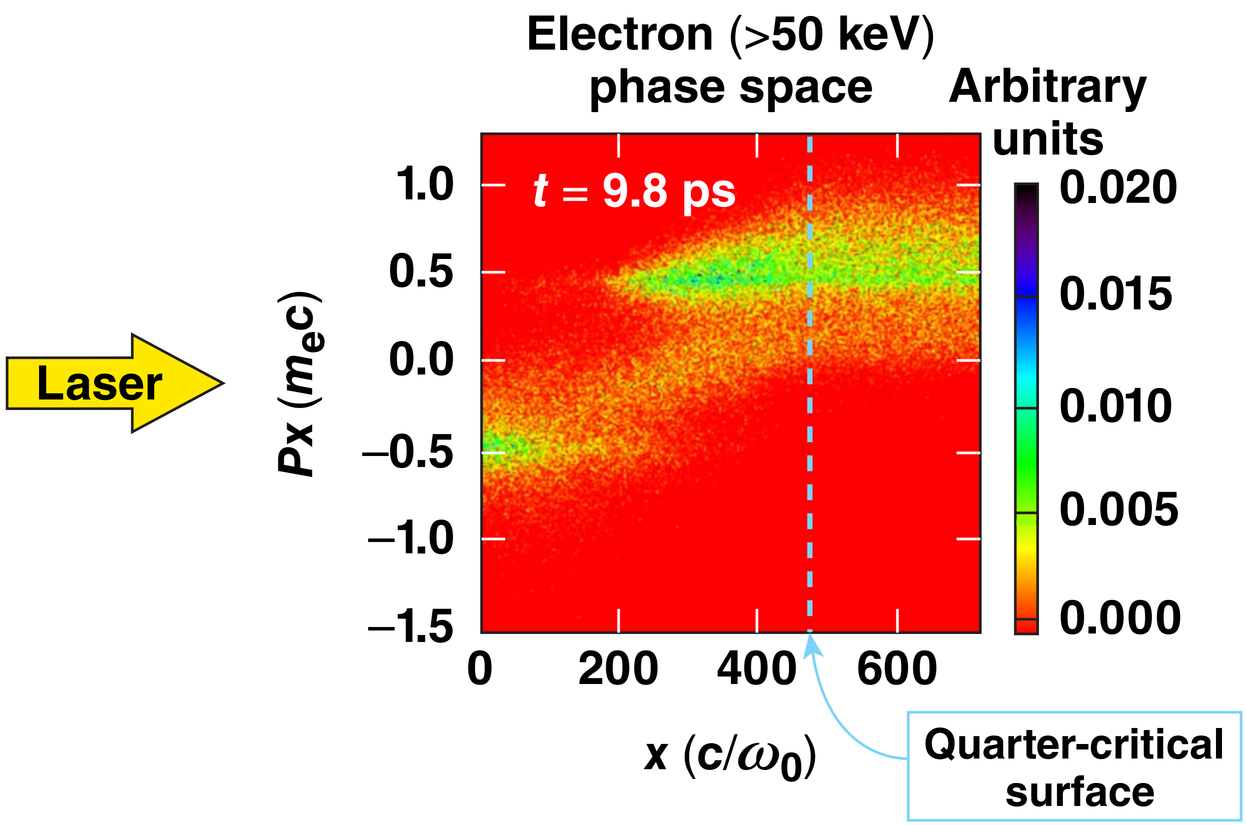
Energetic-Electron Generation in Two-Plasmon-Decay Instabilities in Inertial Confinement Fusion



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Summary

Particle-in-cell (PIC) simulations up to 10 ps for OMEGA parameters show saturation of two-plasmon decay (TPD) and hot-electron generation

- In PIC simulations, significant laser absorption and hot-electron generation occur in the nonlinear stage
- Generation of hot electrons is correlated with new TPD modes in the lower-density region during the nonlinear stage
- Hot electrons are accelerated from the low-density region to the high-density region through a staged process
- The simulation with a single narrow beam shows reduction of hot-electron generation

Collaborators

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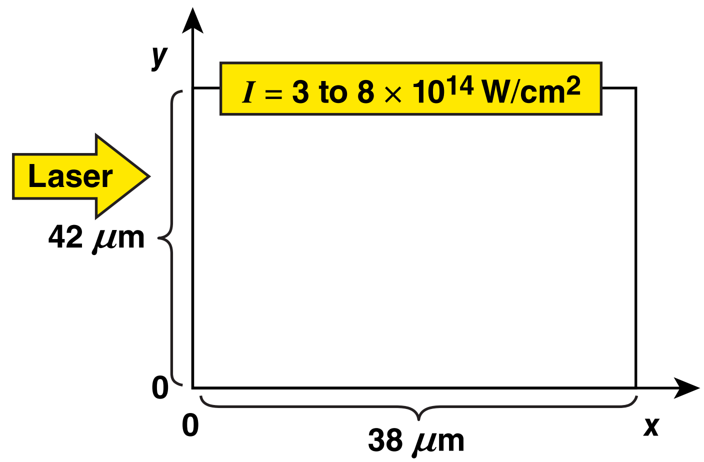
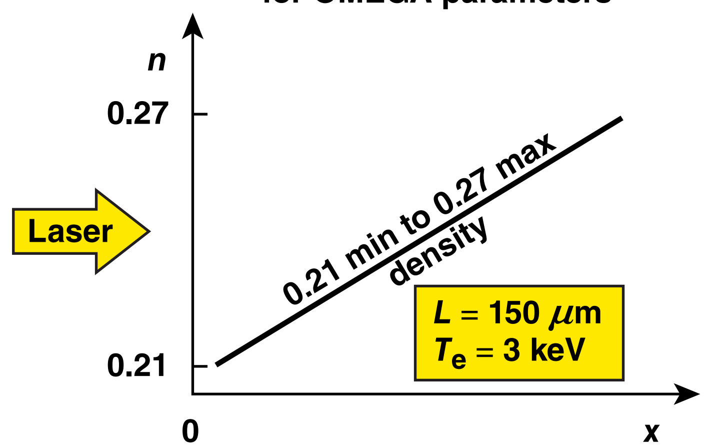
PIC simulations of 10 ps with *OSIRIS** have been conducted for a range of OMEGA parameters

- Plane wave and Gaussian beams are used
- The simulation box is transversely periodic
- The open boundaries are used for fields and the thermal-reflecting boundaries are used for particles in the longitudinal direction
- Boundary diagnostics record the energy distribution of the particles going out of the thermal-reflecting boundaries



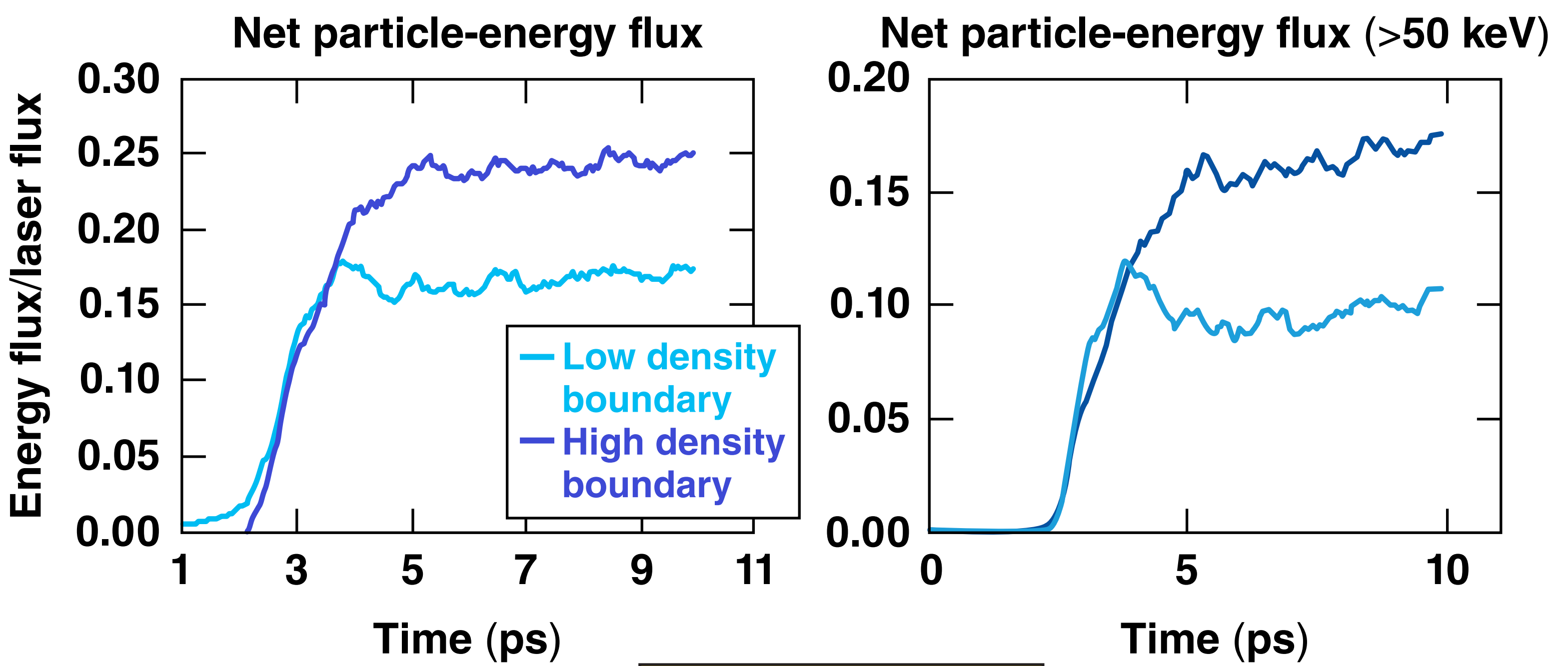
Simulation configuration for OMEGA parameters



TC9412

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

The net particle-energy flux reaches a quasi-steady state after ~5 ps



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

- In the quasi-steady state
  - absorbed laser energy is balanced by the energy flux exiting the box
  - the particle and field energies in the simulation box are essentially constant

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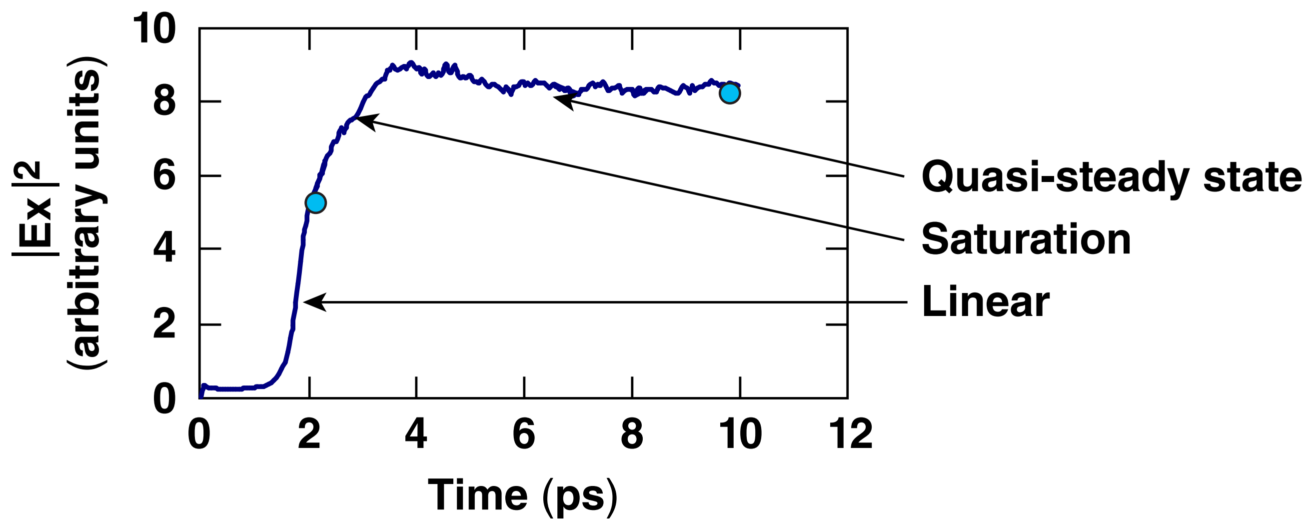
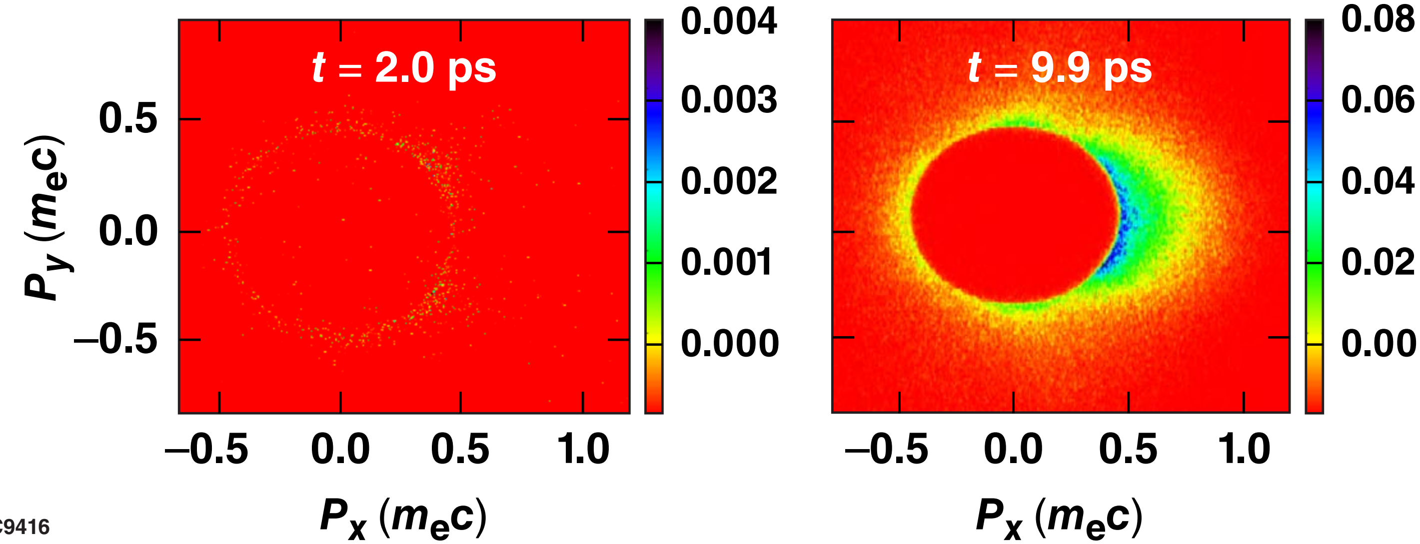
Most hot electrons are produced in the nonlinear stage



Electron >50-keV distribution in P_x–P_y space



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

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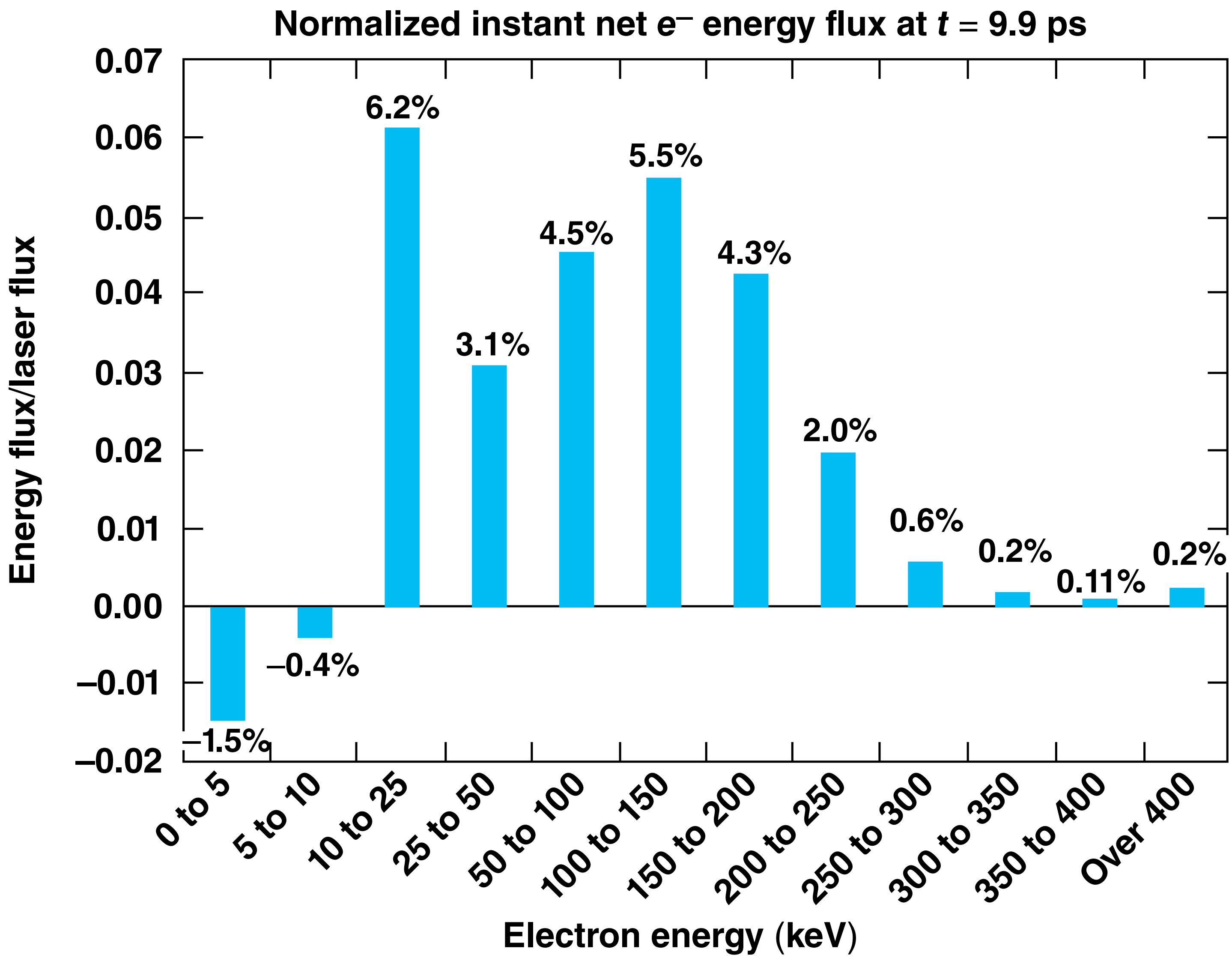
The net energy flux exiting the high-density boundary includes significant contribution from the hot electrons



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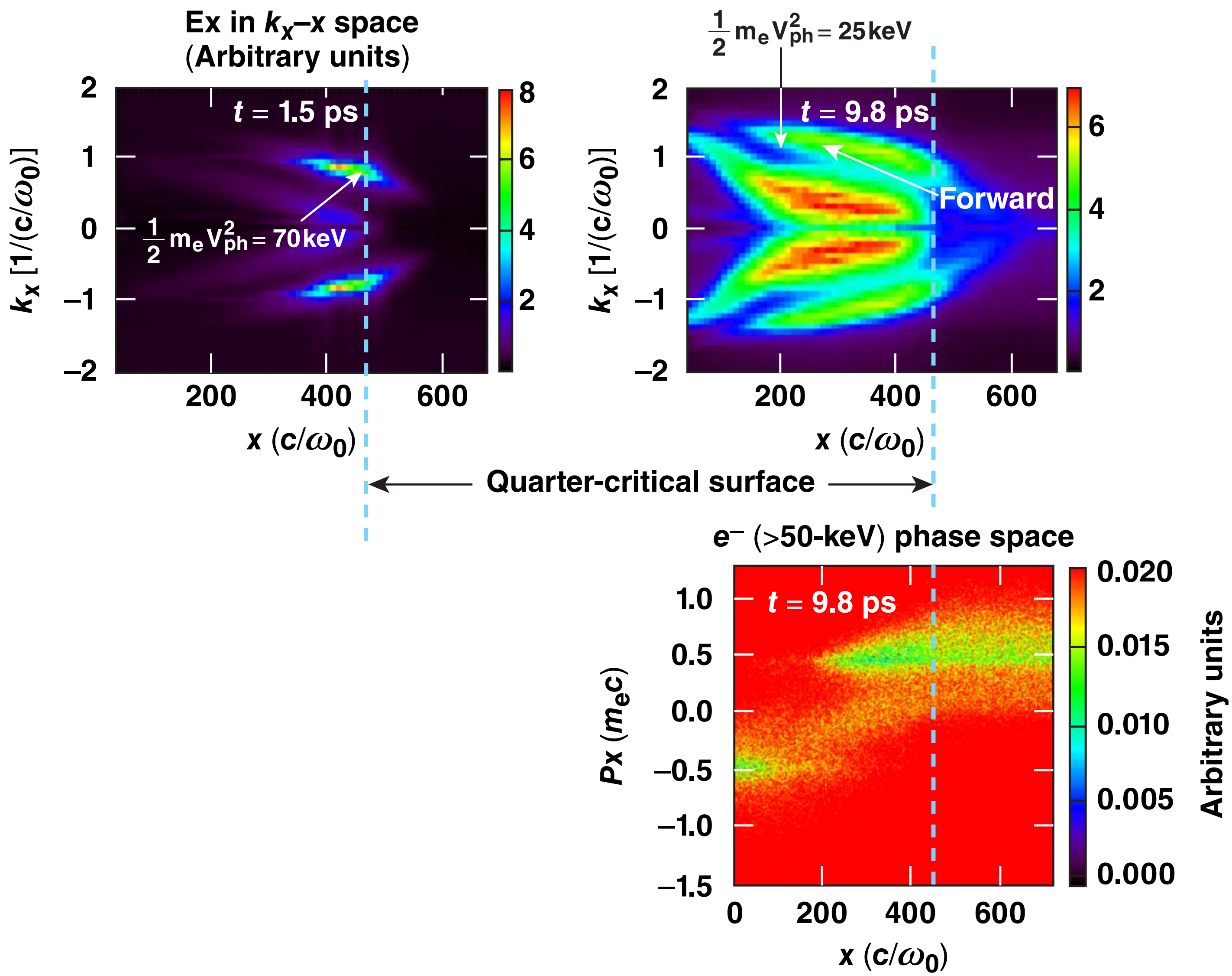
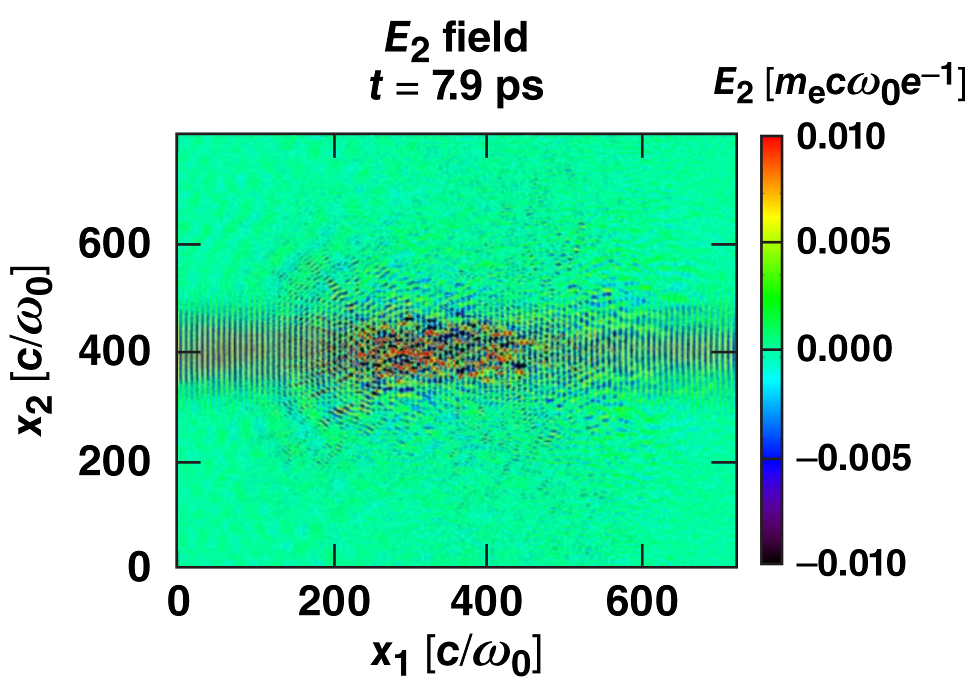
The hot electrons are generated through staged acceleration initiated by new TPD modes with low phase velocity in the nonlinear stage



TC9419a

Important differences exist between the simuations and experiments

- Collision could supress TPD at the marginal unstable laser intensities
- Speckles
  - in experiments, polarization smoothing changes laser polarization even within a single speckle, which needs 3-D modeling
  - simulation with a narrow beam has shown a reduced hot-electron generation



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Simulation with a narrow beam showed a reduced hot-electron generation

	I_{14}max	T (keV)/ T_i (keV)	L	η*	Total absorption	Hot (>50-keV) electrons
Plane wave	3	3/1.5	150	0.6	~0	~0
	6	3/1.5	150	1.2	42%	17%
	8	3/1.5	150	1.4	39%	15%
	8 (d = 4 μm)	3/1.5	150	1.4	22%	5%

TPD threshold

$$\eta = (I_{14}\lambda_{\mu m}L_{\mu m}/T_{keV})/82$$

TC9415a

*A. Simon *et al.*, Phys. Fluids 26, 3107 (1983).

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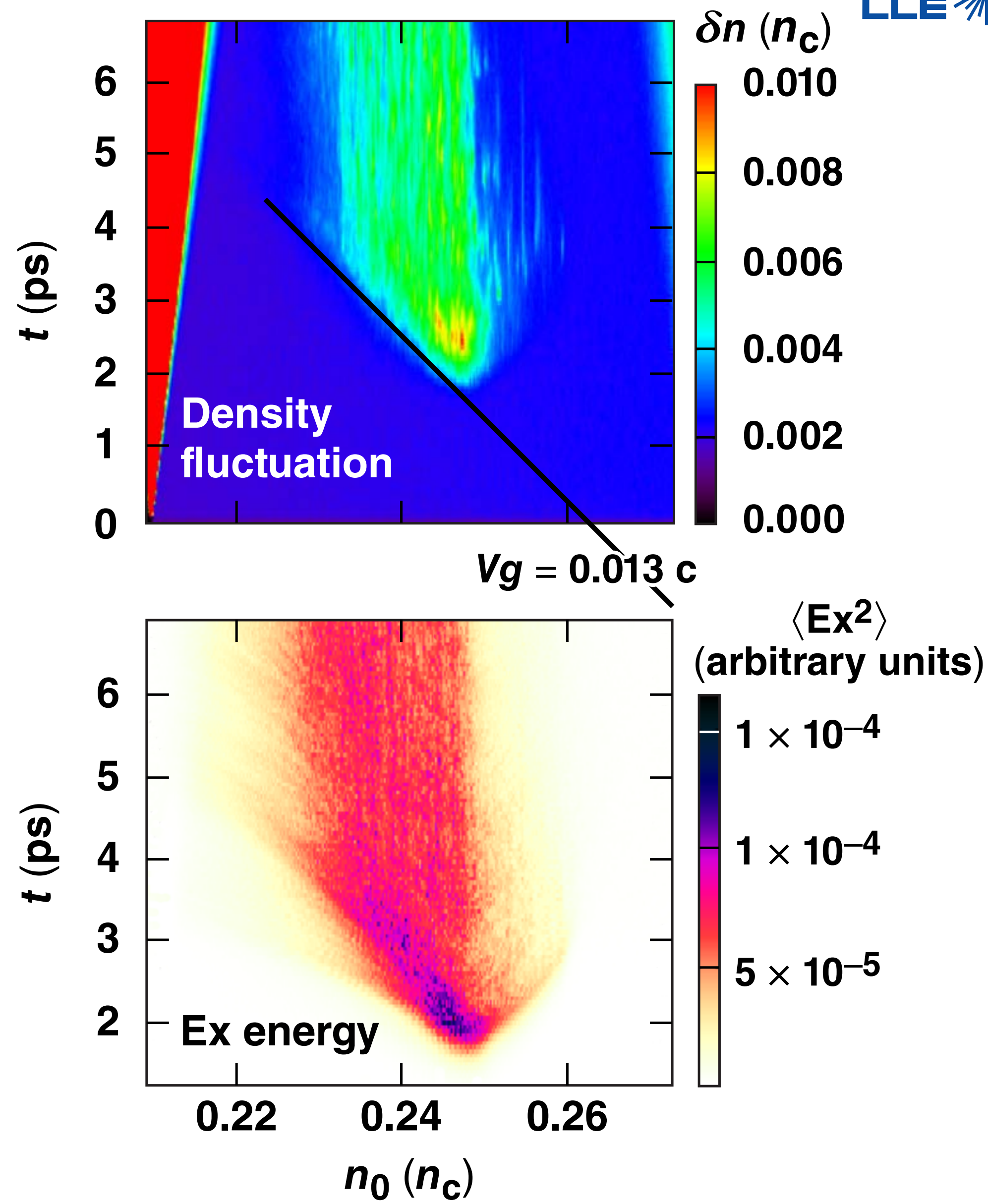
Ion-density fluctuations are driven by plasma waves propagating to lower-density regions

- The region of ion-density fluctuations is spreading at the group velocity of plasma waves with the largest *k*
- Ion fluctuations at the low-density region can induce new TPD modes locally



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