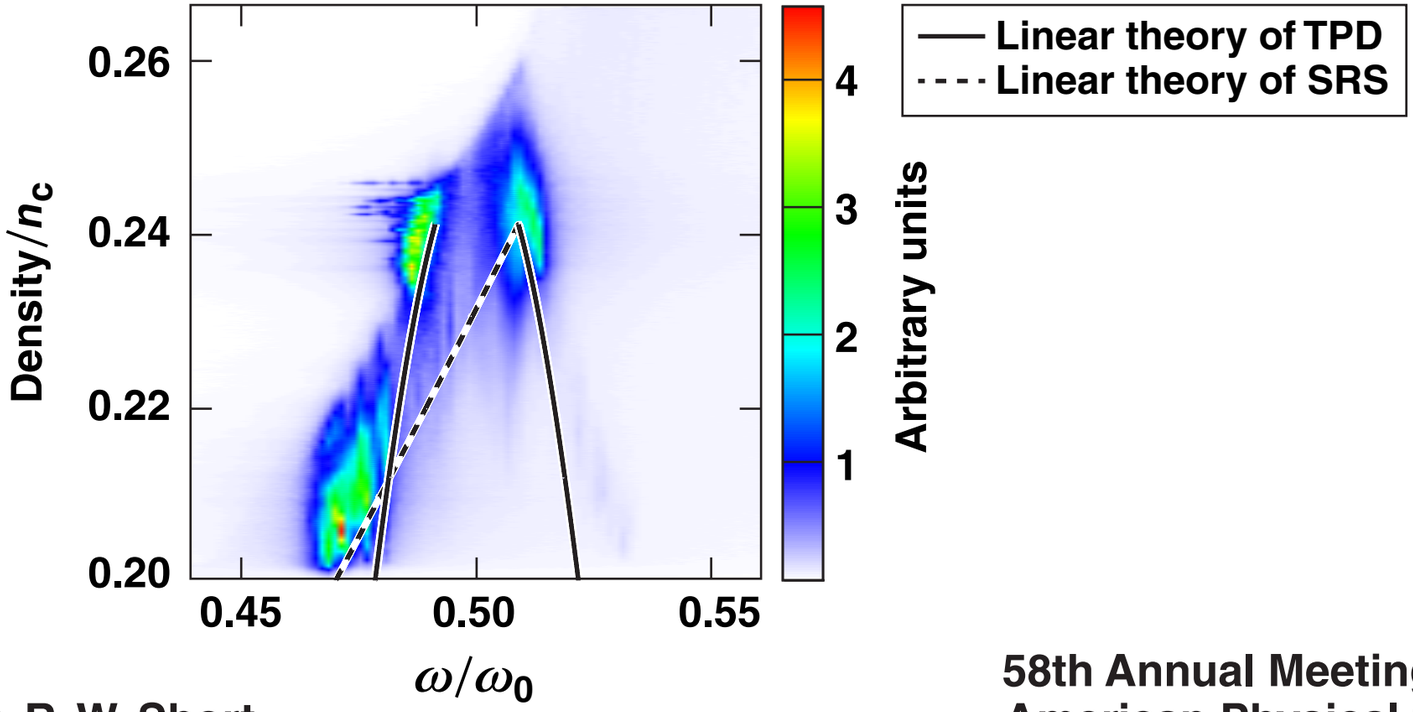
Laser-Plasma Interaction Near the Quarter-Critical Density in Direct-Drive Inertial Confinement Fusion

UR LLE

Langmuir wave intensity, pol = 45°, saturation stage



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Summary

The interplay between different instabilities was studied near the quarter-critical density for National Ignition Facility (NIF)-relevant parameters

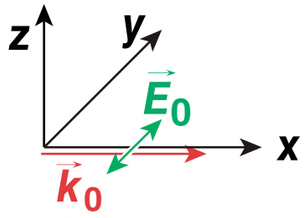
- A series of two-dimensional simulations has been performed with the particle-in-cell (PIC) code *OSIRIS**
- Spectral analysis of the fields confirms the signatures of two-plasmon decay (TPD) and stimulated Raman scattering (SRS)
- SRS determines the broad feature in the frequency spectra, consistent with the NIF experimental results**
- The fast-electron generation in the simulations including both TPD and SRS is significantly lower than in TPD-only simulations

*R. A. Fonseca *et al.*, Lect. Notes Comput. Sci. 2331, 342 (2002).
**W. Seka *et al.*, UO9.00003, this conference.

Recent experiments on the NIF [planar laser–plasma interaction (LPI) platform*] motivate a study of LPI near quarter-critical density at large density scale lengths and high T_e

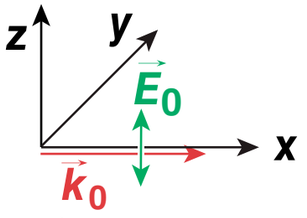
- Three types of simulations in 2-D have been performed with varying polarizations
- Parameters
  - incident laser intensity $I = 8 \times 10^{14}$ W/cm^2 (plane wave)
  - density range from 0.20 to 0.27 n_c (with density scale length $L_n = 300$ μm)
  - temperatures $T_e = 4$ keV, $T_i = 2$ keV
  - simulation box size: 112 × 20 μm (laser propagates along the *x* axis)

(1) 2-D in-plane (TPD)



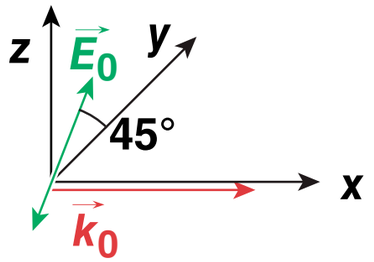
$\vec{E}_0 = E_0 \cdot \vec{e}_y$

(2) 2-D out-of-plane (SRS)



$\vec{E}_0 = E_0 \cdot \vec{e}_z$

(3) Combination of 1 and 2



*M. J. Rosenberg *et al.*, NO5.00010, this conference.

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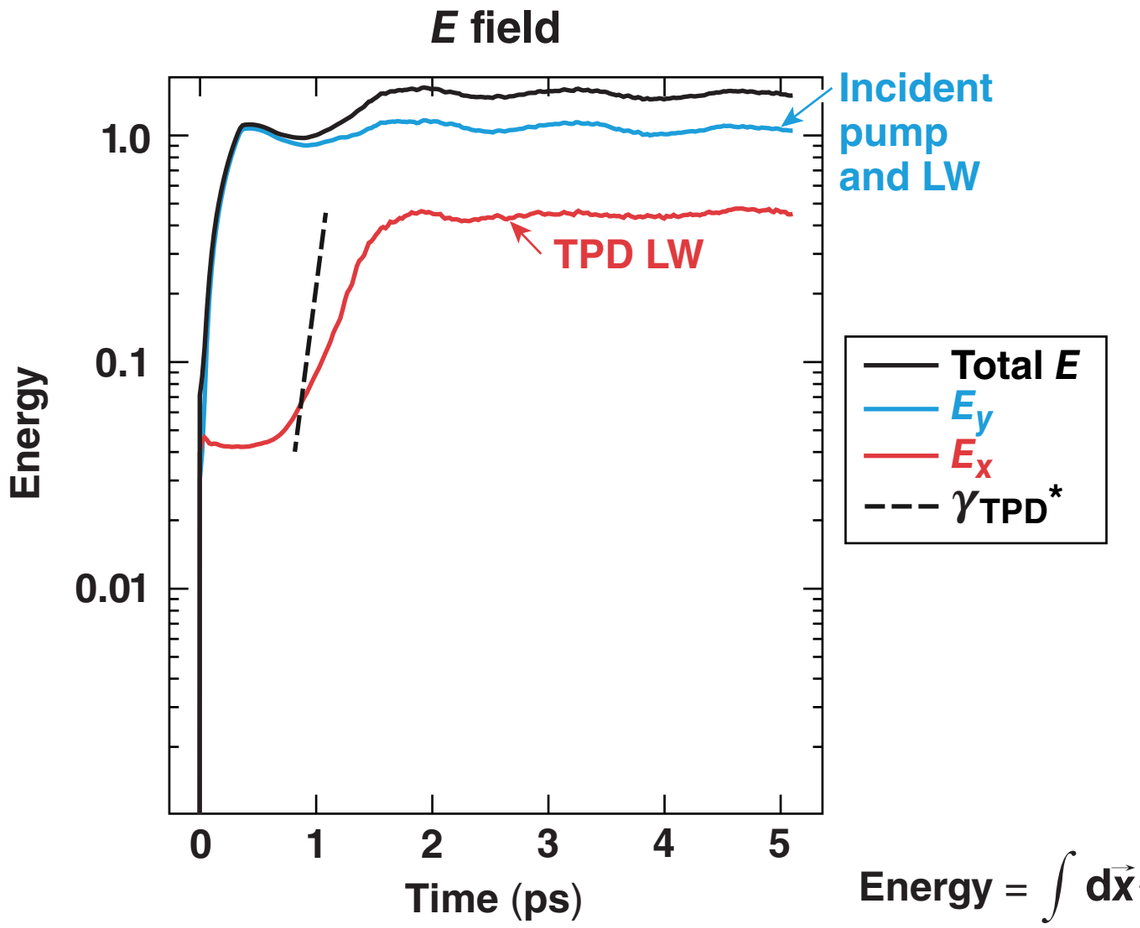
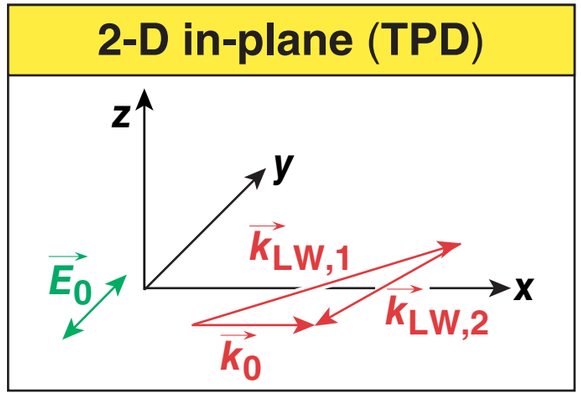
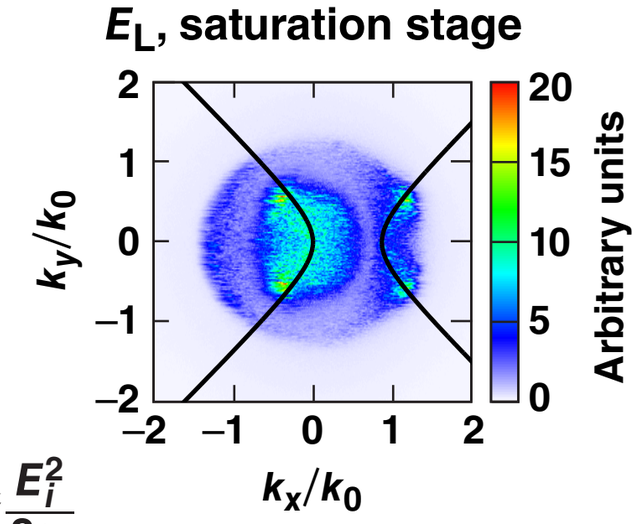
Quasi-stationary nonlinear saturation is reached after a few picoseconds







— Linear theory of TPD

$$\text{Energy} = \int d\vec{x} \frac{E_i^2}{8\pi}$$

* A. Simon *et al.*, Phys. Fluids 26, 3107 (1983).
** C. S. Liu, M. N. Rosenbluth, and R. B. White, Phys. Fluids 17, 1211 (1974).

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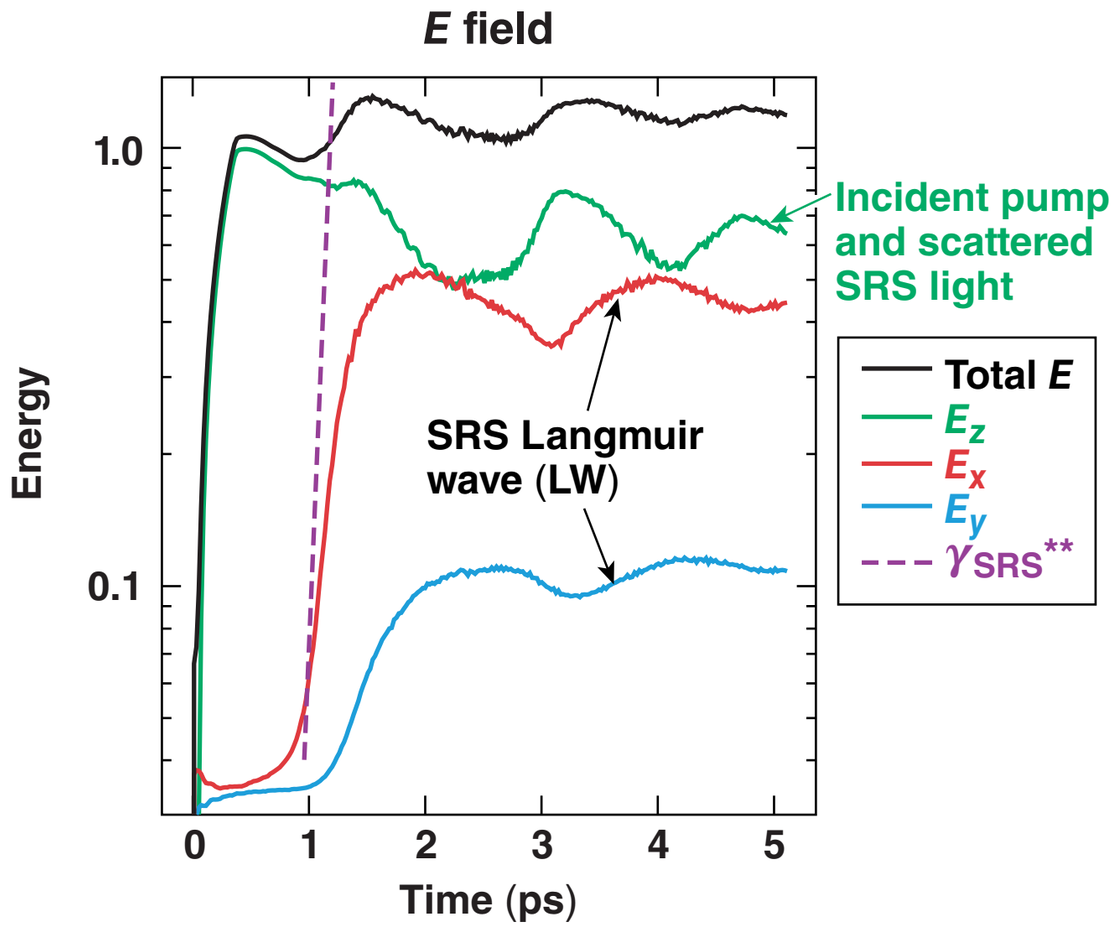
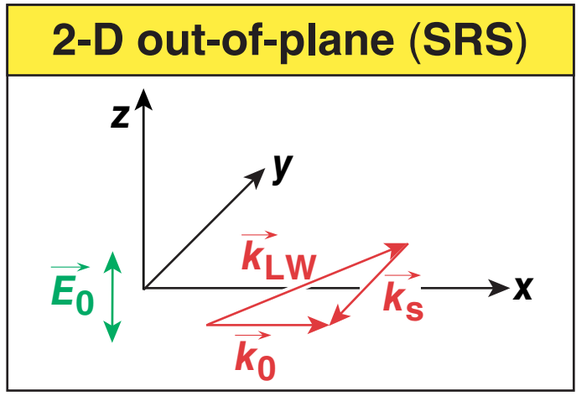
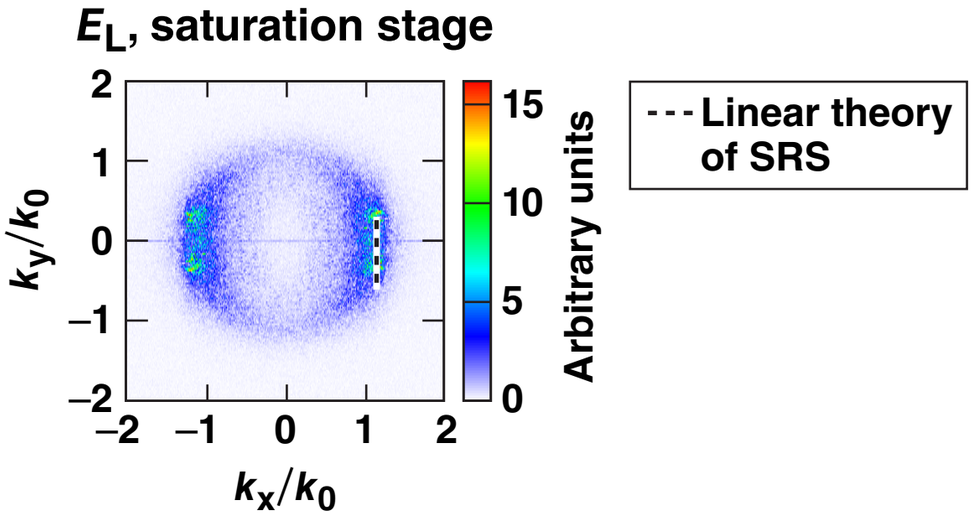
In out-of-plane simulations, the field spectra are consistent with the signatures of SRS







* A. Simon *et al.*, Phys. Fluids 26, 3107 (1983).
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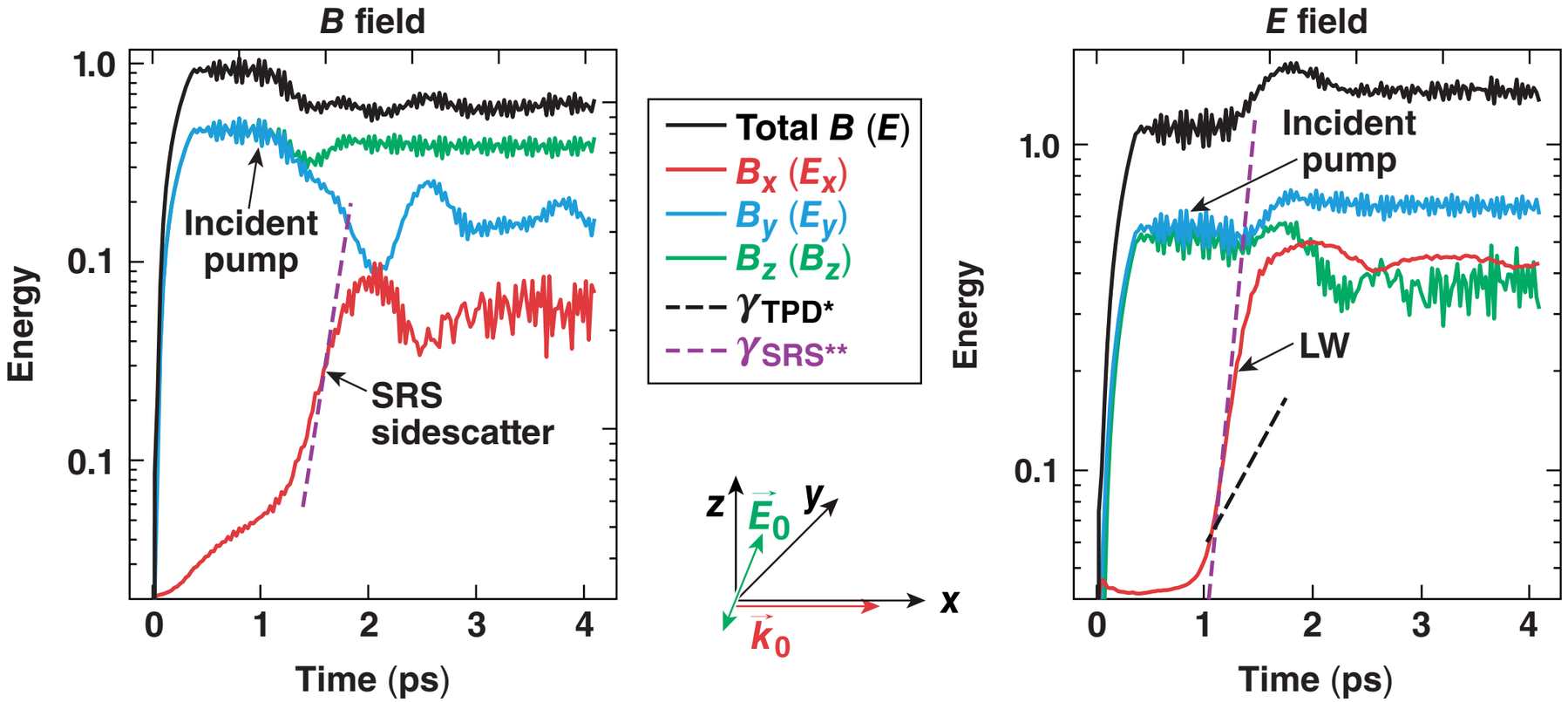
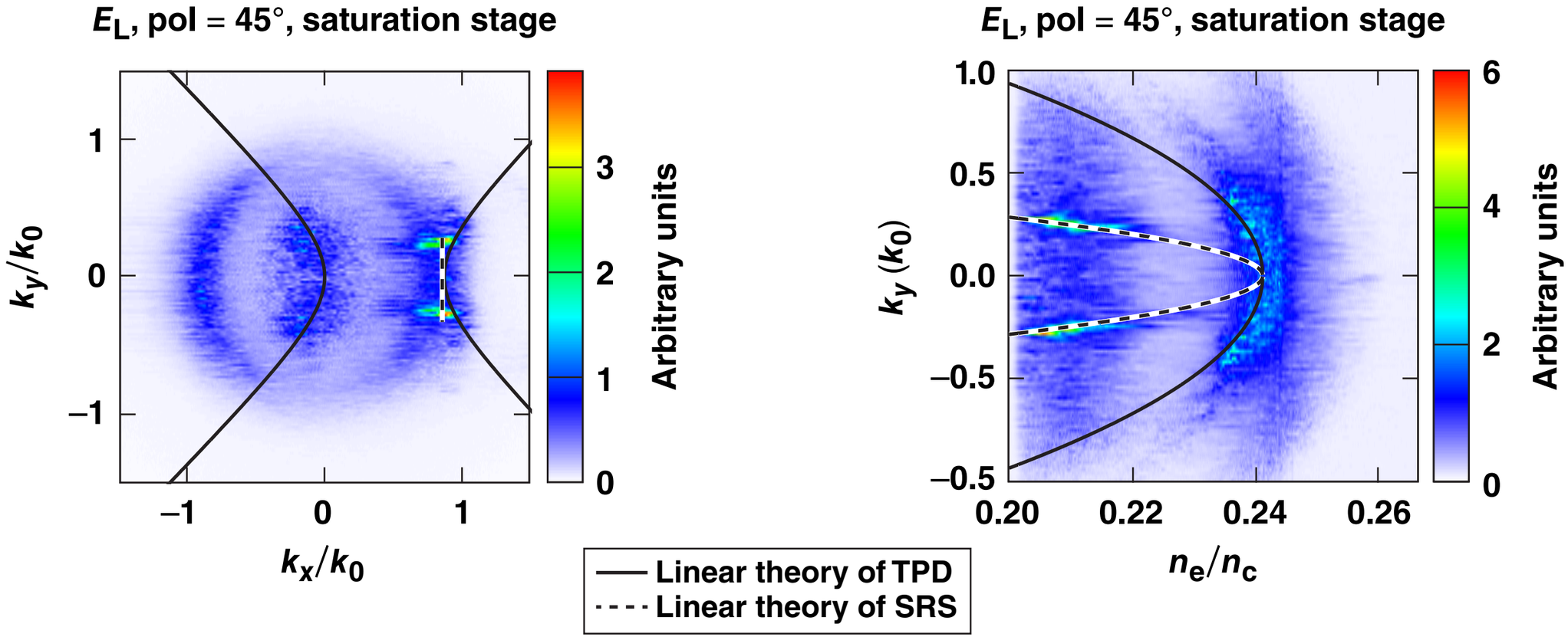
With the laser polarization at 45° to the simulation plane, there is an interplay between TPD and SRS



Growth rates of TPD* and SRS are calculated for intensities of the projections of the laser field (0.5 I_0).**

* A. Simon *et al.*, Phys. Fluids 26, 3107 (1983).
** C. S. Liu, M. N. Rosenbluth, and R. B. White, Phys. Fluids 17, 1211 (1974).

The range of densities over which the instabilities are active has been identified



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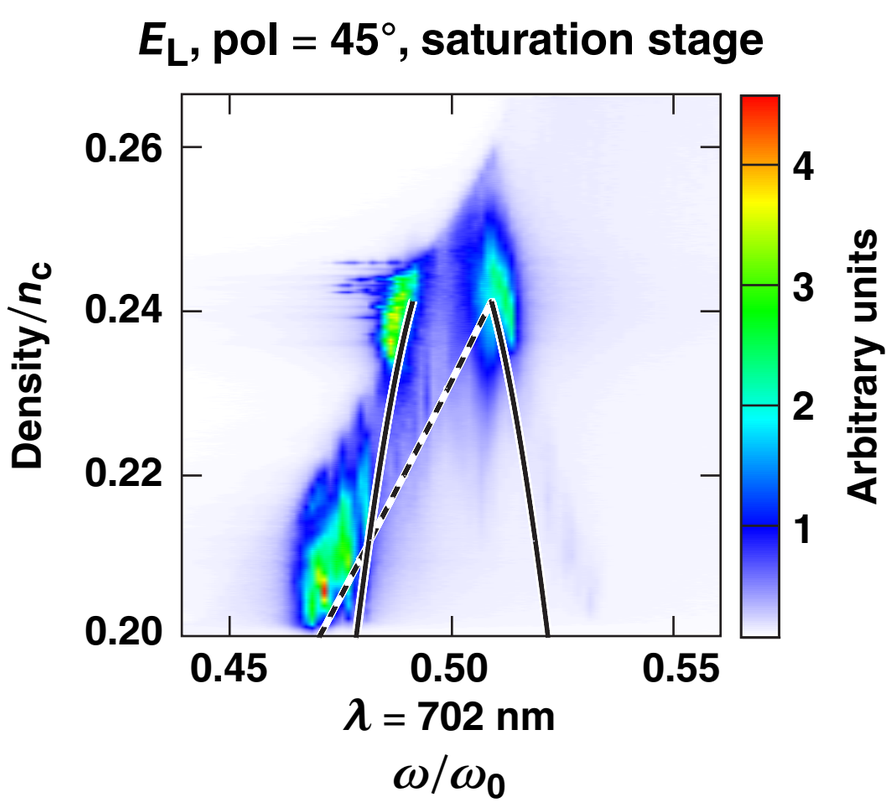
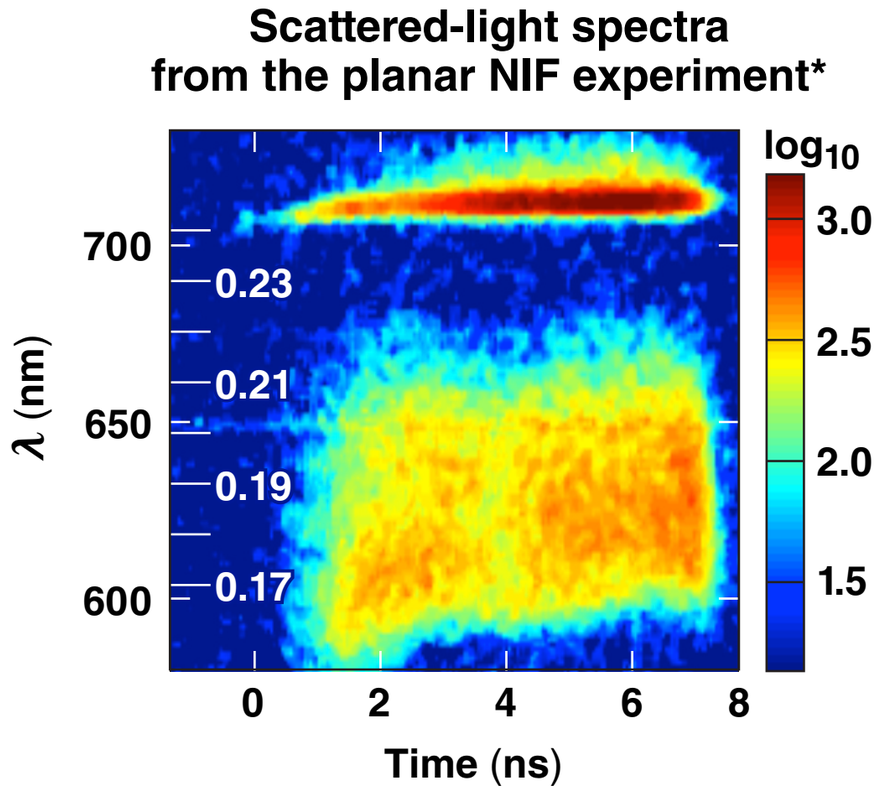
The frequency spectra in simulations are consistent with the SRS developing at densities below the quarter-critical density

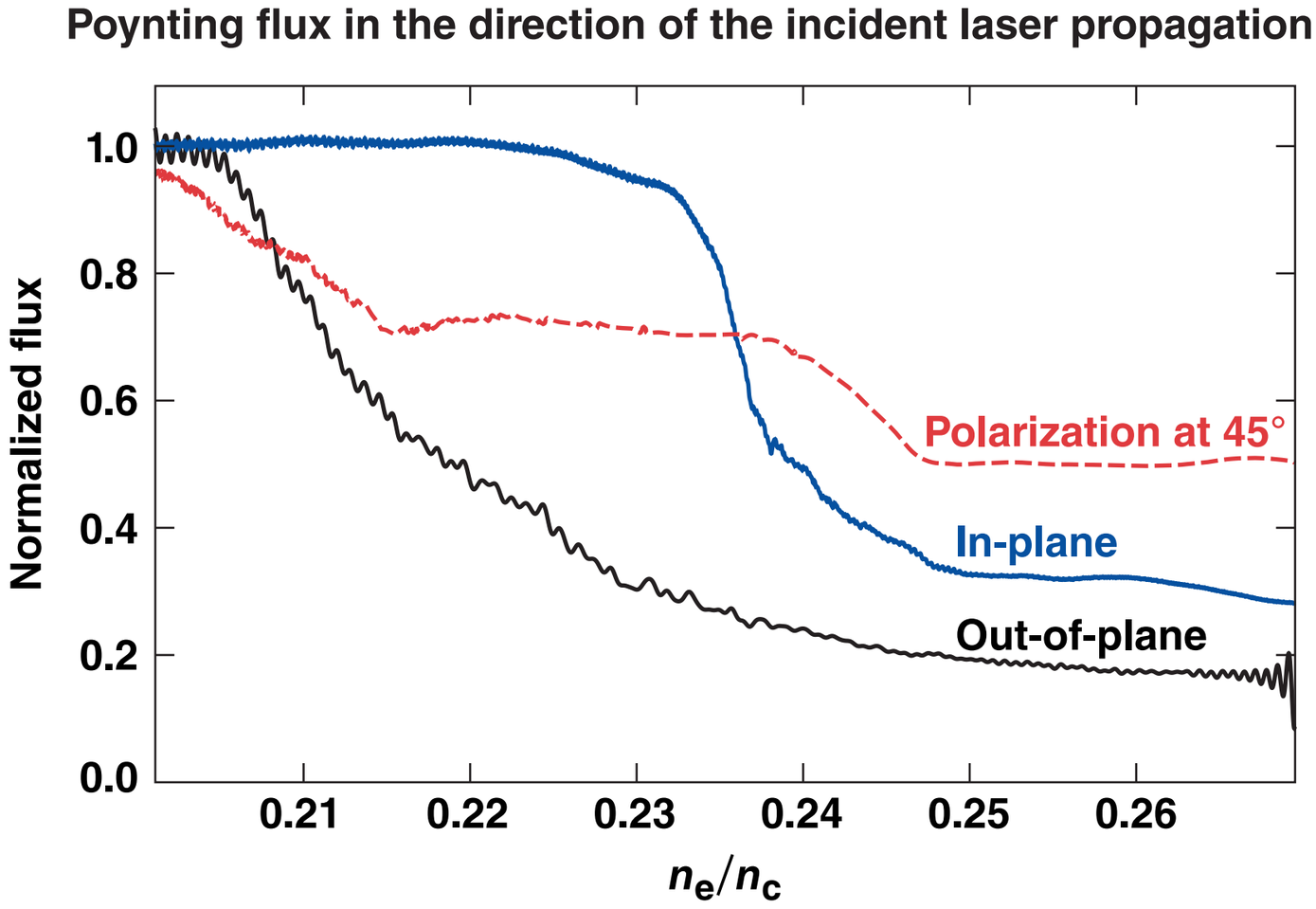




The broad feature in the frequency spectra is caused by SRS.

*W. Seka *et al.*, UO9.00003, this conference.

The Poynting flux analysis shows the density range where the instability develops for different polarization orientations



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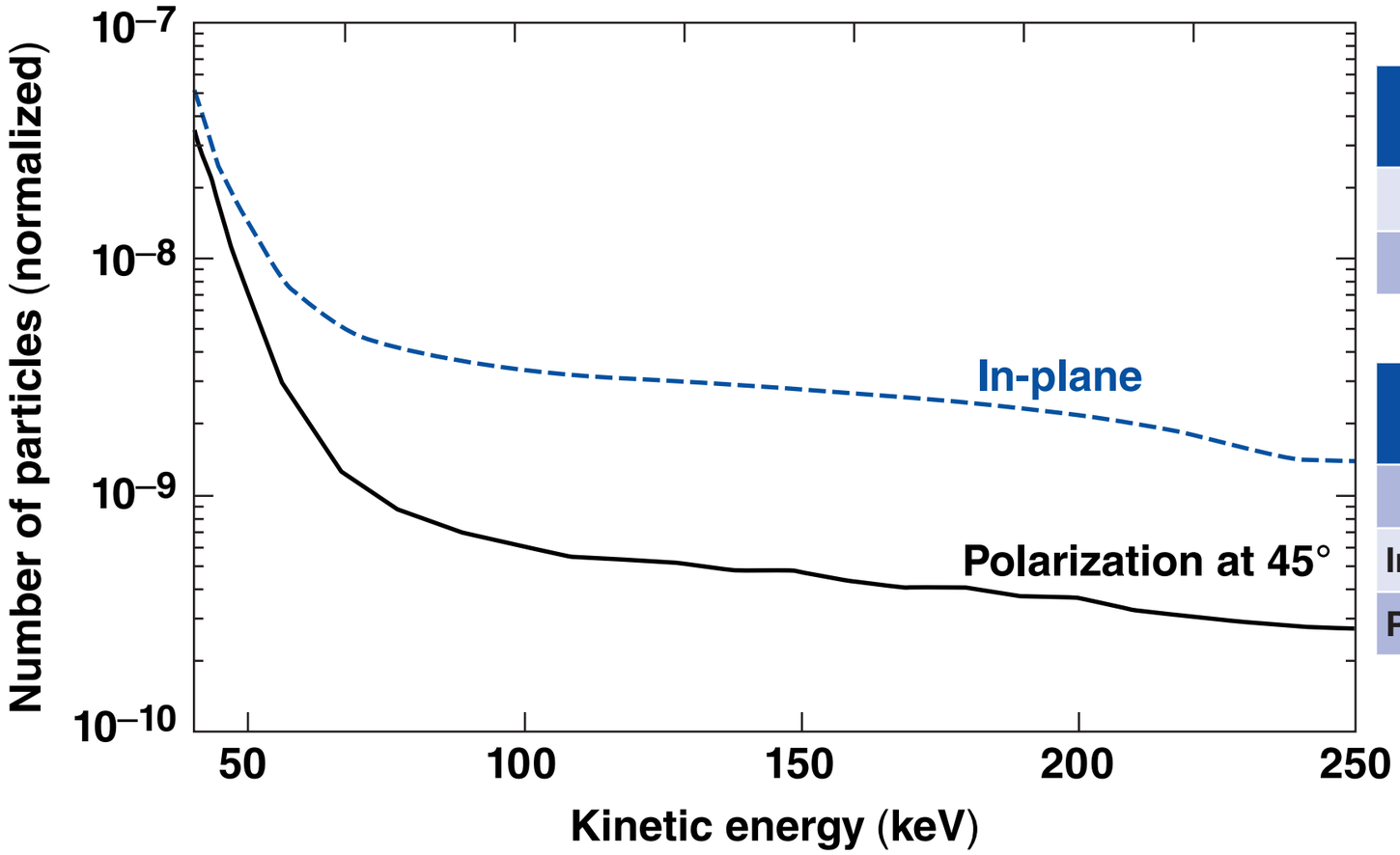
The distribution of fast electrons generated by the instability depends strongly on the orientation of the incident laser field

The flux of fast electrons (E > 45 keV) in the direction of the incident laser propagation



The temperature (fitted between 50 and 150 keV)	
T_e = 62 keV	In-plane
T_e = 35 keV	Polarization 45°

The flux of fast electrons (in percentage of incident laser)		
	E > 50 keV	100 keV > E > 50 keV
In-plane	26.0%	7.9%
Polarization 45°	7.5%	4.2%

TC13034

Summary/Conclusions

The interplay between different instabilities was studied near the quarter-critical density for National Ignition Facility (NIF)-relevant parameters

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