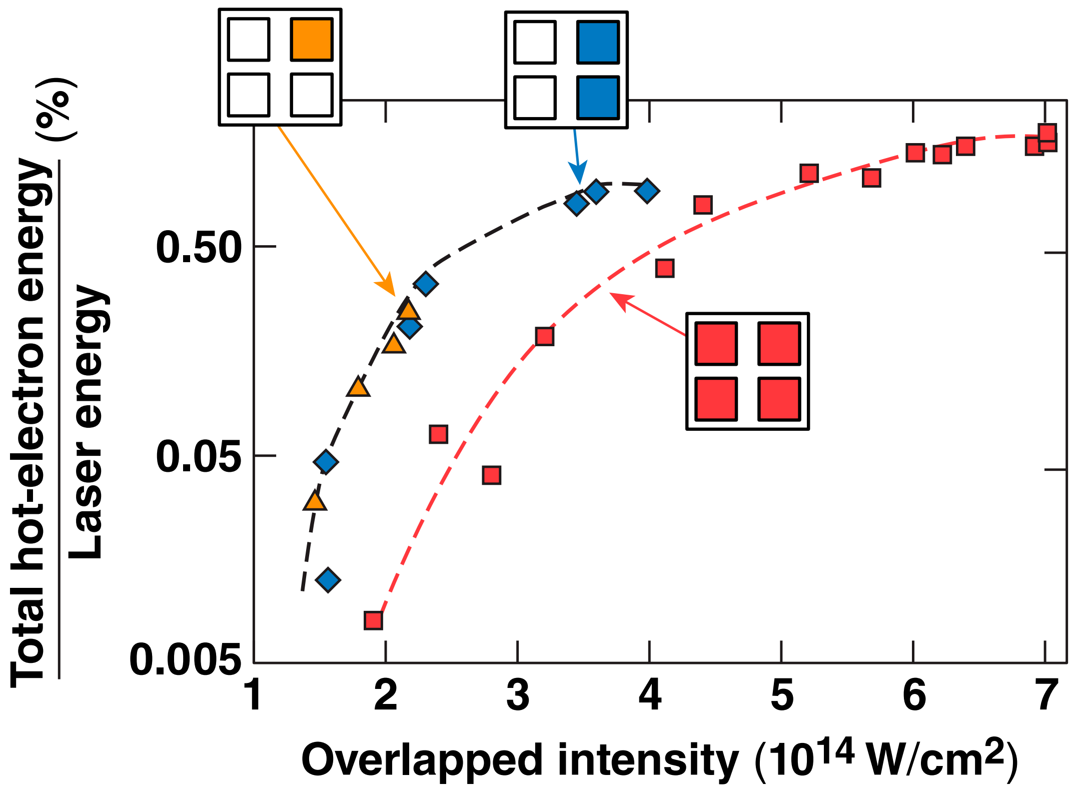
Measurements of Hot Electrons Produced by Two-Plasmon Decay in Near Direct-Drive–Ignition Plasma Conditions

UR LLE



D. T. Michel
Plasma and Ultrafast Physics Group
University of Rochester
Laboratory for Laser Energetics

53rd Annual Meeting of the
American Physical Society
Division of Plasma Physics
Salt Lake City, UT
14–18 November 2011

Summary

Two-plasmon decay (TPD) depends on the laser-beam geometry and the overlapped laser-beam intensity

UR LLE

- OMEGA EP provides a platform to study TPD in NIF conditions ($L_n \sim 400\ \mu m$, $T_e \sim 2.5$ keV)
- For high laser intensity, TPD is saturated and the hot-electron temperature goes up rapidly; this result is consistent with nonlinear Zakharov modeling
- Beam polarization determines the coupling to the common electron–plasma waves (EPW)
- For a given overlapped intensity, the more beams, the lower the hot-electron generation

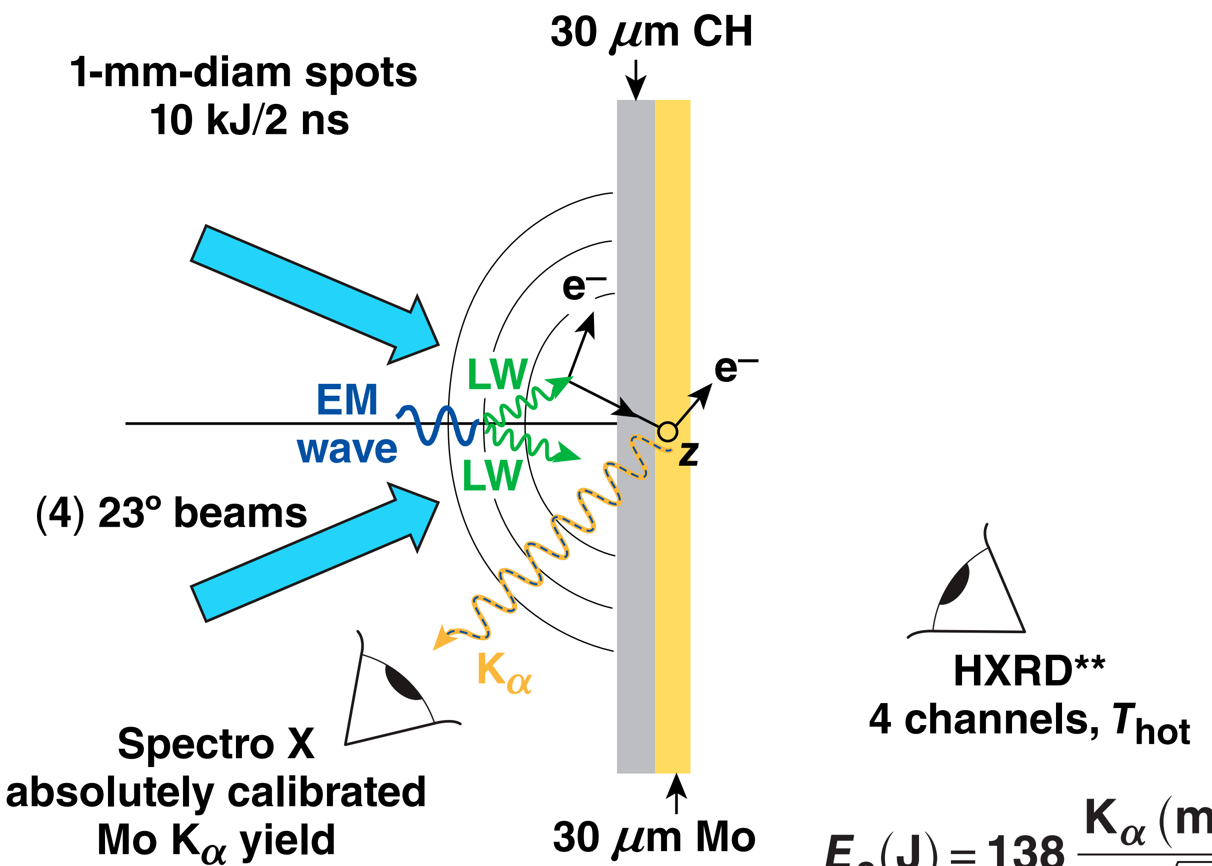
Collaborators

B. Yaakobi, S. X. Hu, R. W. Short,* J. F. Myatt, C. Stoeckl, D. H. Edgell**
W. Seka, V. N. Goncharov, and D. H. Froula

Laboratory for Laser Energetics
University of Rochester

* R. W. Short, UO6.00012, this conference
** J. F. Myatt, UO6.00008, this conference

OMEGA EP provides a planar-target platform to study two-plasmon decay in near-ignition coronal plasma conditions*



$$E_e(\mathrm{J}) = 138\,\frac{K_\alpha\,(\mathrm{mJ/sr})}{\sqrt{T_{hot}}}$$

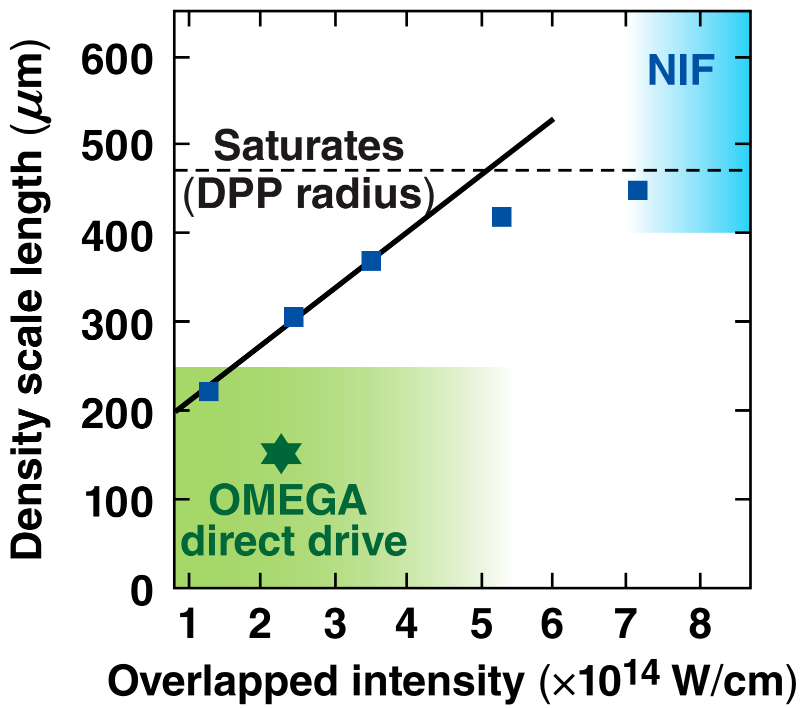
These planar experiments collect ALL hot electrons generated by two-plasmon decay; energy deposited in the fuel will be significantly less.

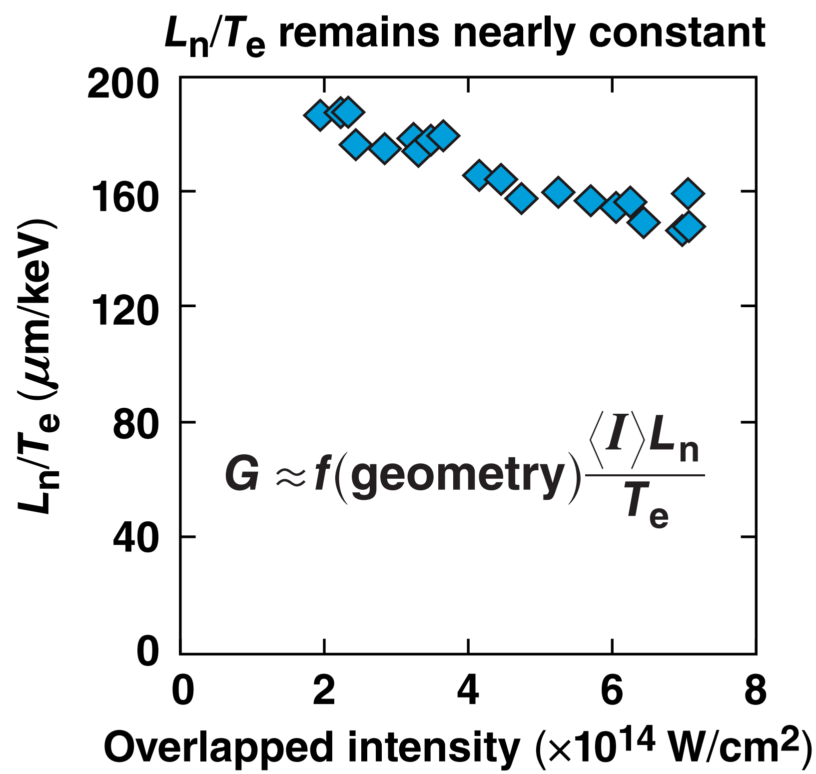
* B. Yaakobi *et al.*, "Fast-Electron Generation in Long-Scale-Length Plasmas," submitted to Phys. Plasmas.

E19967b

** C. Stoeckl *et al.*, Rev. Sci Instrum. 72, 1197 (2001).

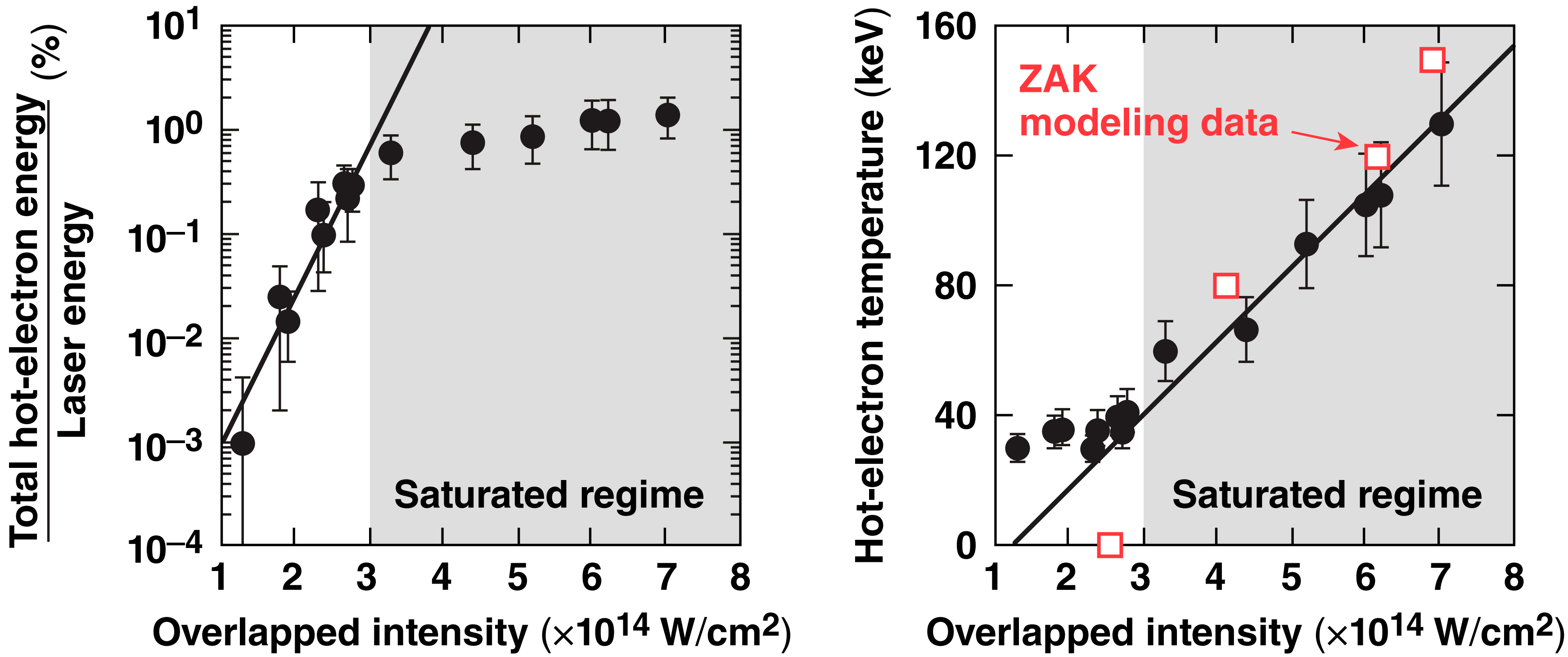
The high laser powers over large laser spots produce long-scale-length plasmas





400-μm density scale lengths and 2.5-keV plasmas approach direct-drive ignition coronal plasma conditions.

The measured hot-electron temperature rises rapidly when the TPD instability reaches saturation



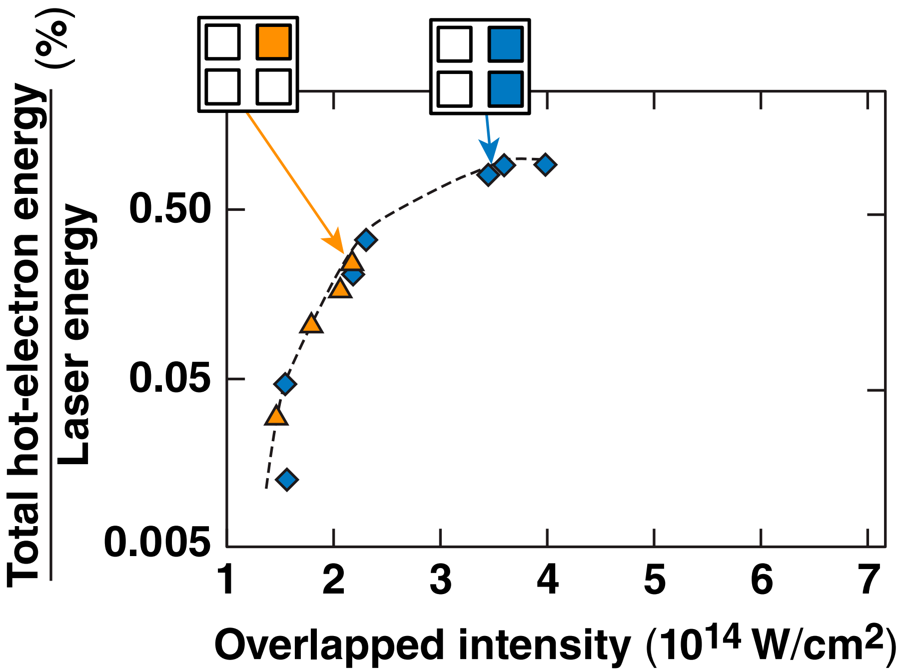
Nonlinear Zakharov modeling* shows very good agreement with the hot-electron temperature measurements.

*D. A Russell and D. F. DuBois, Phys. Rev. Lett. 86, 428 (2001).

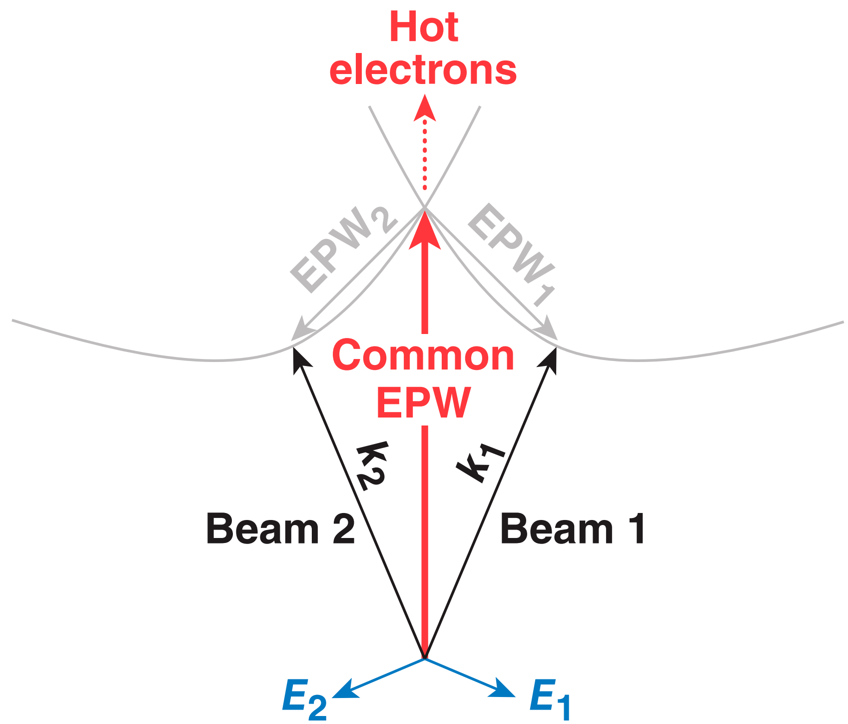
J. F. Myatt *et al*., "The Dynamics of Hot-Electron Heating in Direct-Drive-Implosion Experiments Due to the Two-Plasmon-Decay Instability," submitted to Phys. Plasmas.

E20141a

Measurements demonstrate that TPD is a multibeam effect



TPD is limited to the plane given by *k*, *E*

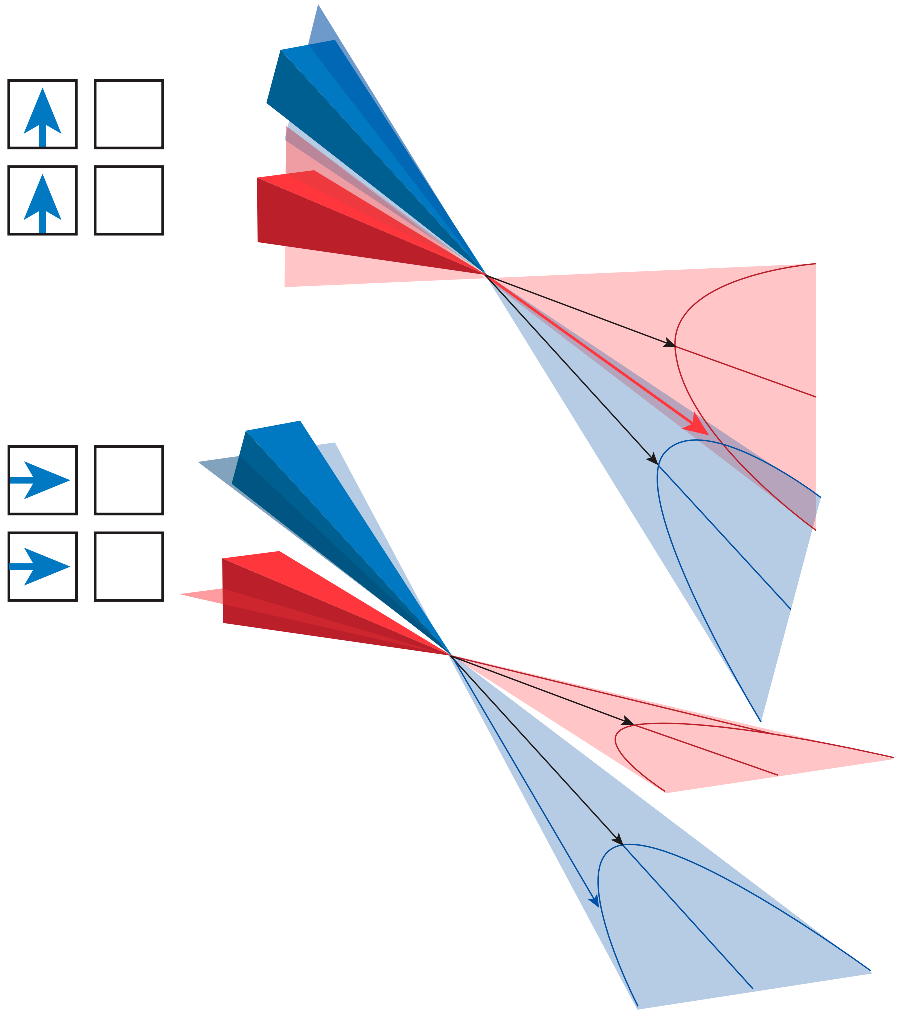


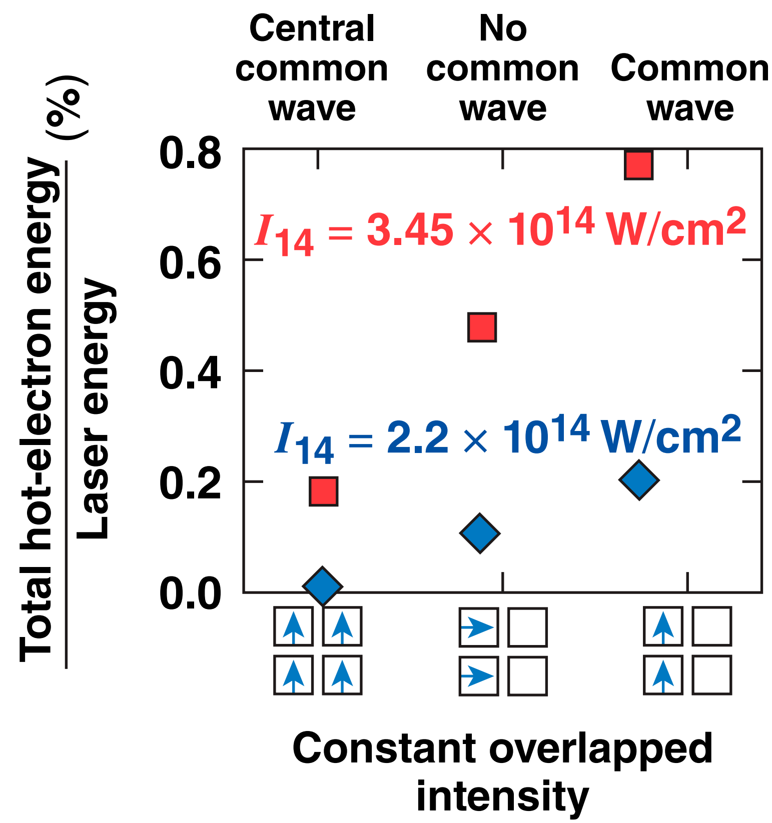
$$G \approx f(\text{geometry})\,\frac{\langle I \rangle L_n}{T_e}$$

TPD results depend on the overlapped laser-beam intensity, which is explained by a common wave process.

E20401

The polarization of the beams determines the coupling to the common plasma waves

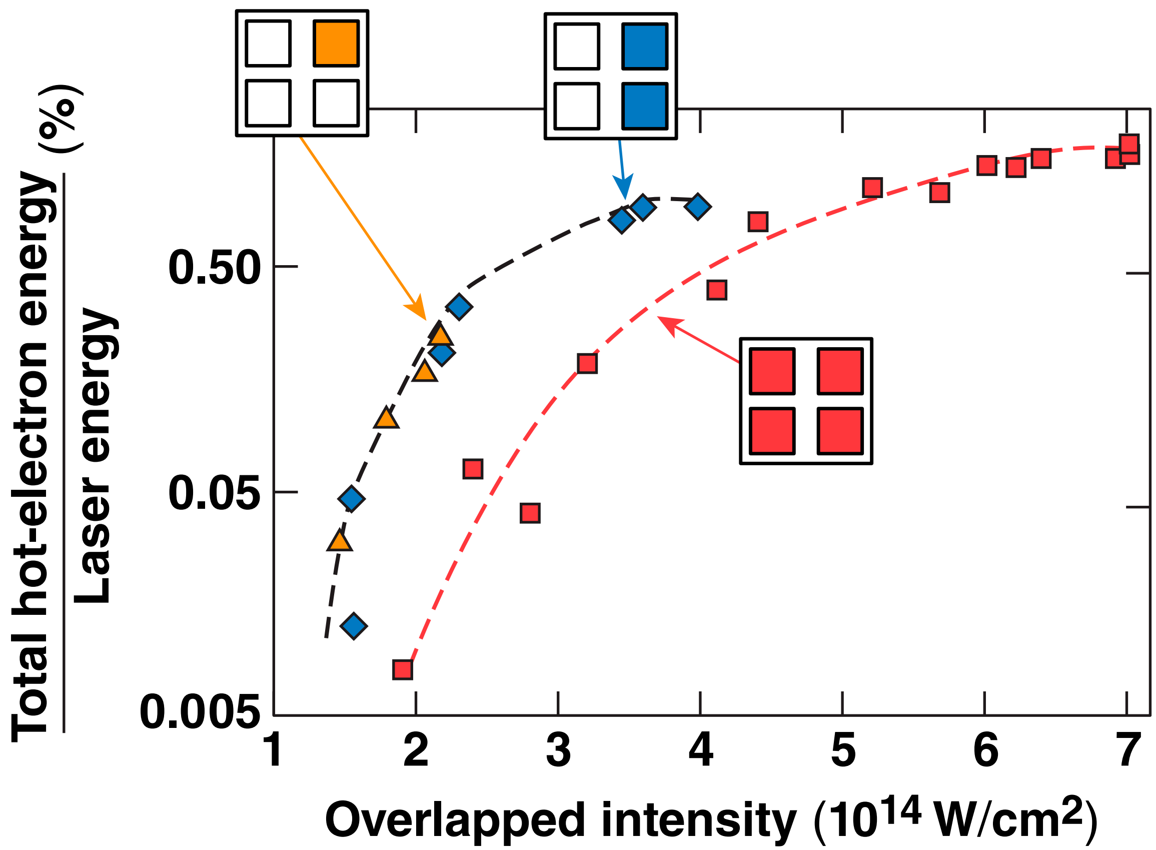




Not all laser beams can drive a common EPW which can significantly reduce the TPD instability in ignition designs.

E20402

The total energy in hot electrons generated by four beams is reduced by an order of magnitude



Multibeam two-plasmon decay seems to be restricted to two beams.

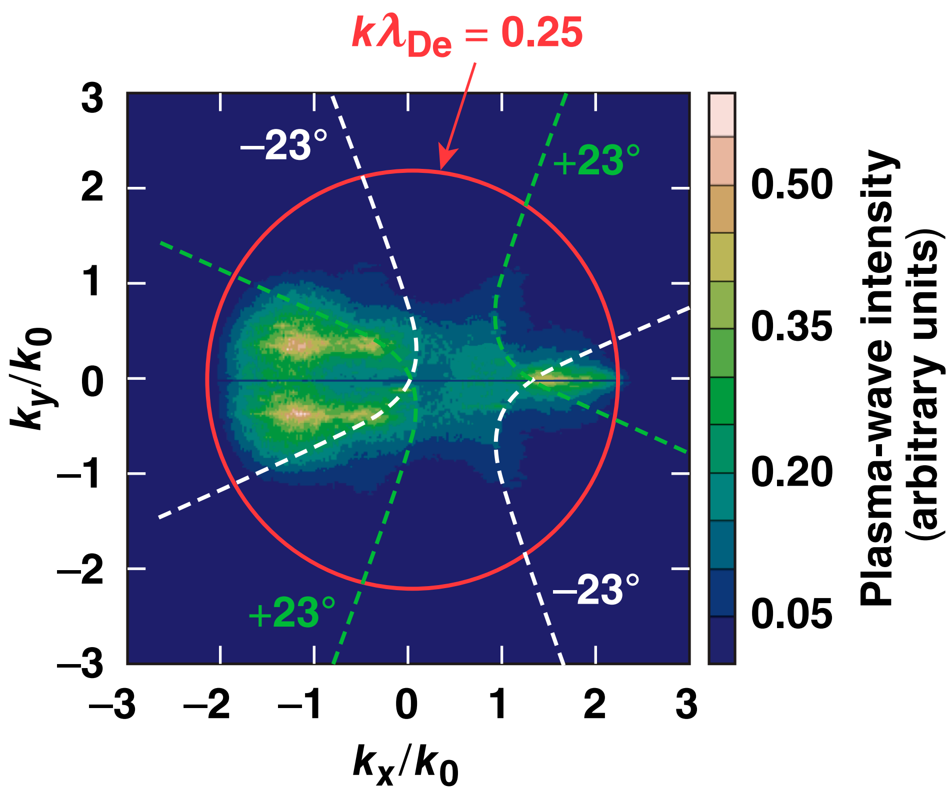
Summary/Conclusions

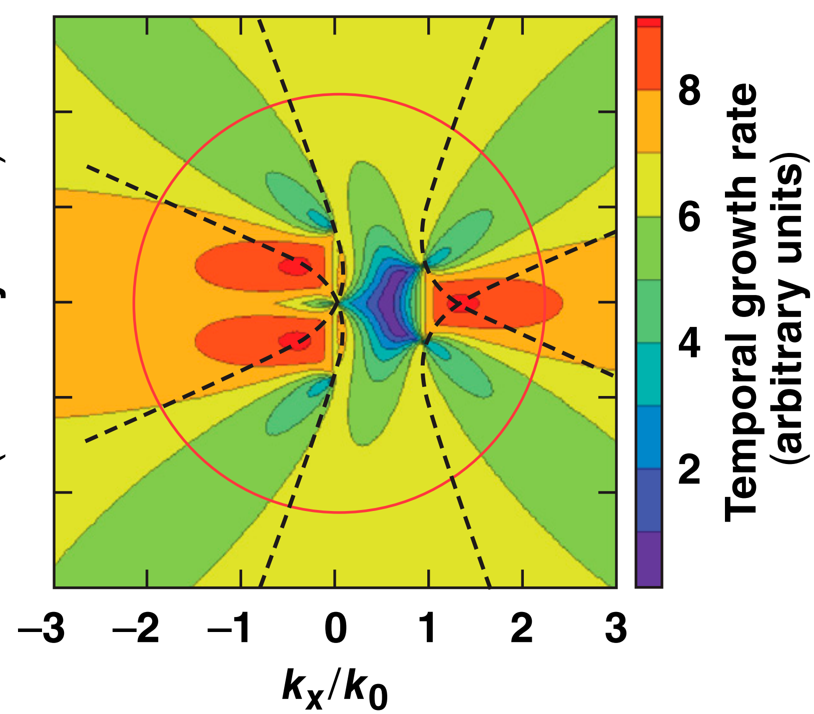
Two-plasmon decay (TPD) depends on the laser-beam geometry and the overlapped laser-beam intensity

UR LLE

- OMEGA EP provides a platform to study TPD in NIF conditions (L_n ~ 400 μm, T_e ~ 2.5 keV)
- For high laser intensity, TPD is saturated and the hot-electron temperature goes up rapidly; this result is consistent with nonlinear Zakharov modeling
- Beam polarization determines the coupling to the common electron–plasma waves (EPW)
- For a given overlapped intensity, the more beams, the lower the hot-electron generation

Zakharov simulations confirm linear theory—a common wave is driven at the intersection of the hyperbolas





TC8462a