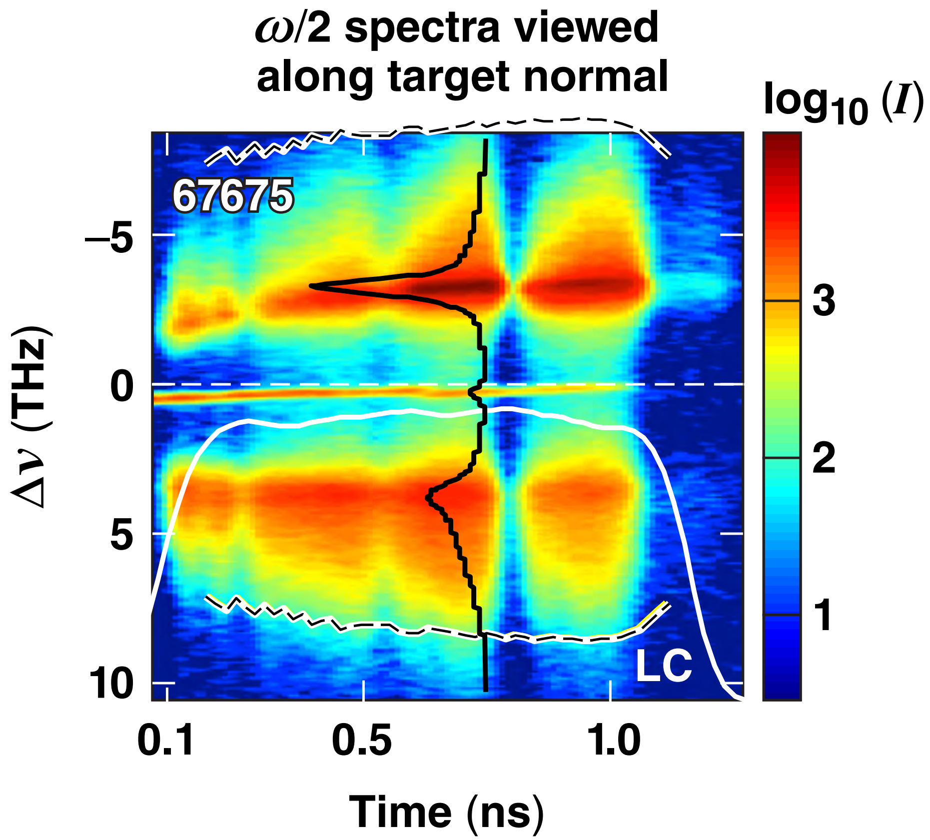
Nonlinearity of the Two-Plasmon–Decay Instability in Imploding Direct-Drive Targets



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Summary

Experiments show that the two-plasmon–decay (TPD) instability progresses rapidly from the threshold to the nonlinear regime

- $\omega/2$ emission from close to $n_c/4$ (absolute instability) dominates close to the threshold
- $\omega/2$ emission emanating from $0.25 \le n_e/n_c \le 0.2$ [Landau cutoff (LC)] evolves extremely rapidly past the threshold
- There is no observable linear regime in the evolution of TPD
- Multibeam TPD has been firmly established for both the absolute threshold and the convective region

Collaborators

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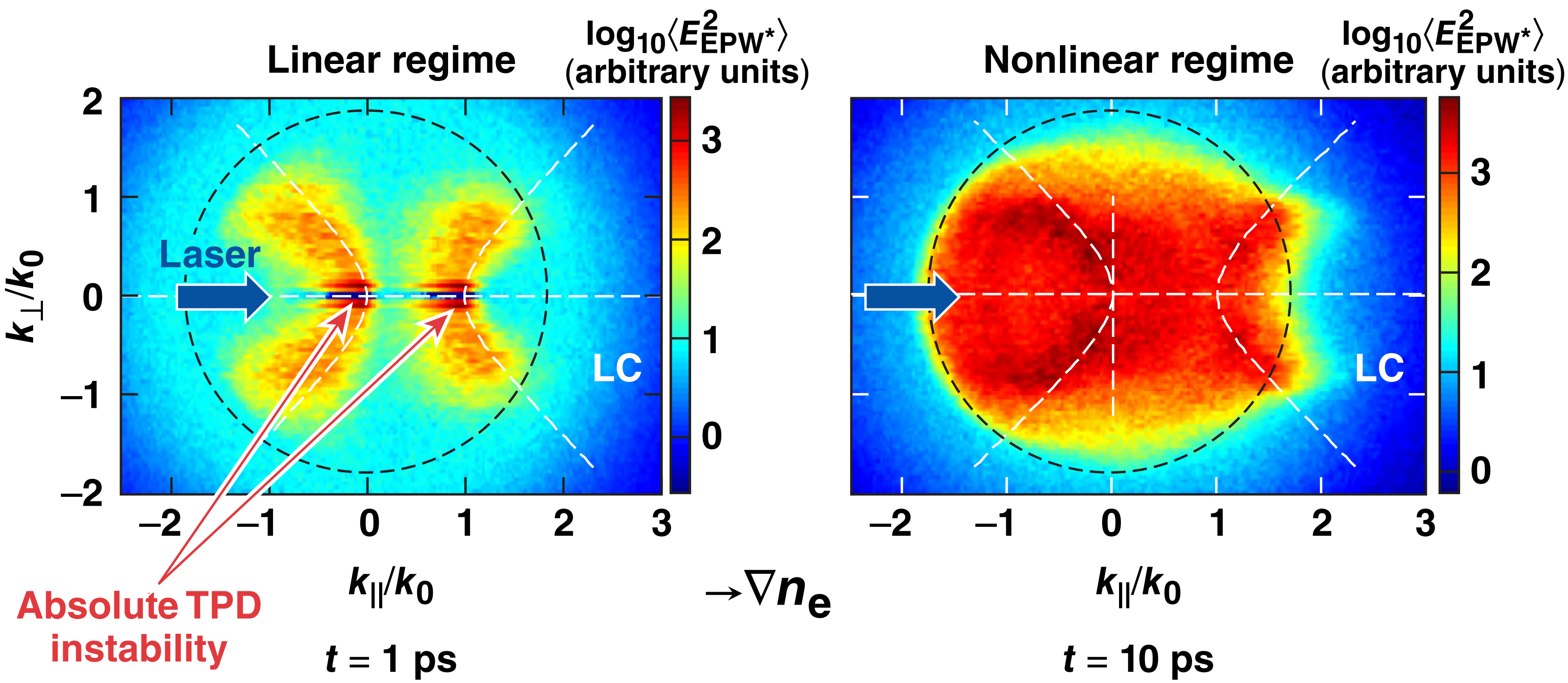
Zakharov TPD simulations demonstrate transition from the linear to nonlinear stage

Single beam, 1.3× above absolute TPD threshold, L_n = 150 μm, T_e = 3 keV, CH plasma



Rapid evolution to a broad plasma wave spectrum leads to equally rapid evolution to a broad ω/2 spectrum.

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

*EPW: electron plasma wave

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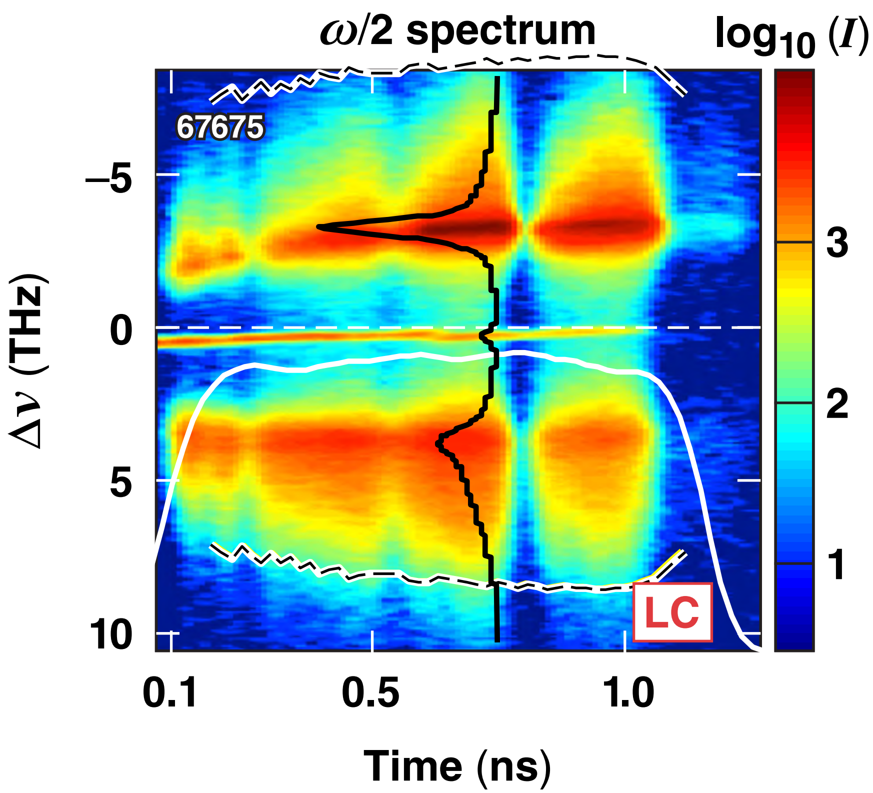
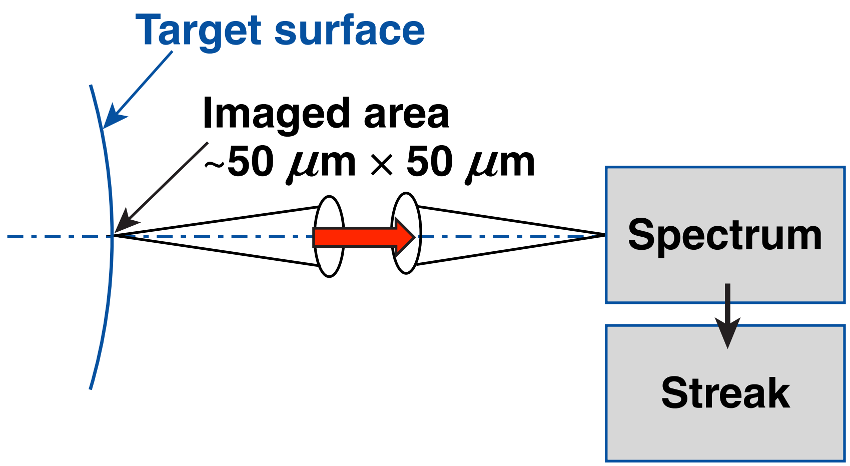
Evidence for the absolute TPD instability is seen in $\omega/2$ spectra





$I_{14} = 5.6$

The extent of the TPD instability from ~n_c/4 to ~n_c/5 (Landau cutoff) is clearly evident in ω/2 spectra

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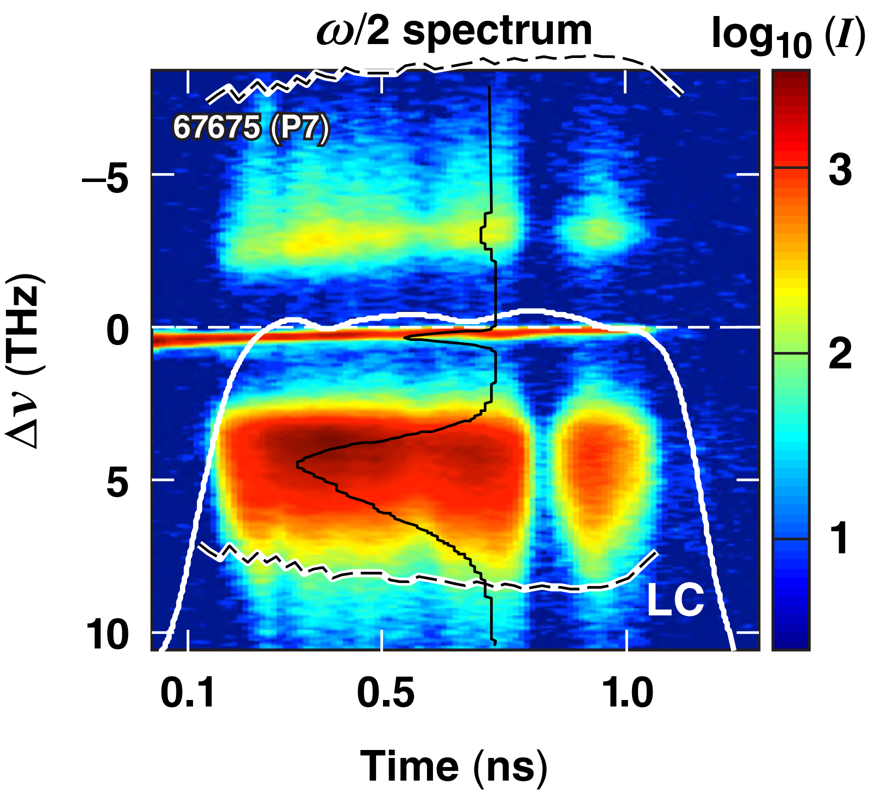
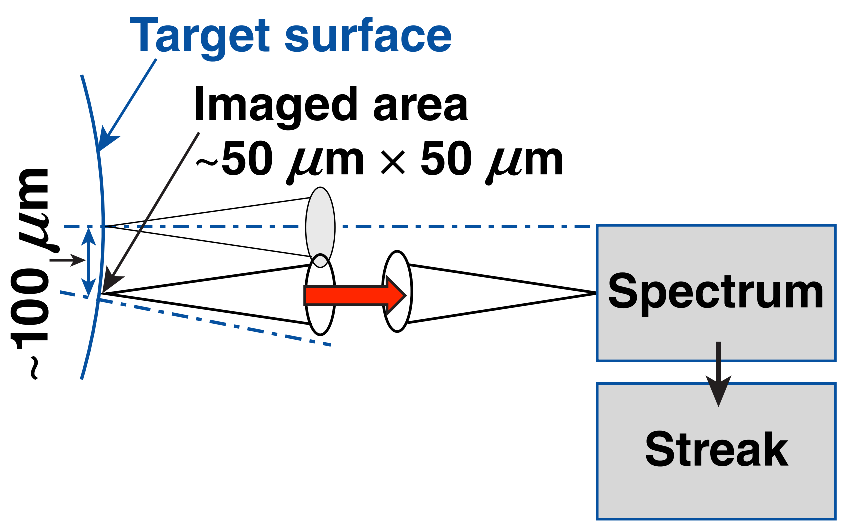


I_{14} = 5.8



The nonlinear evolution of the TPD instability is seen in time-resolved $\omega/2$ spectra

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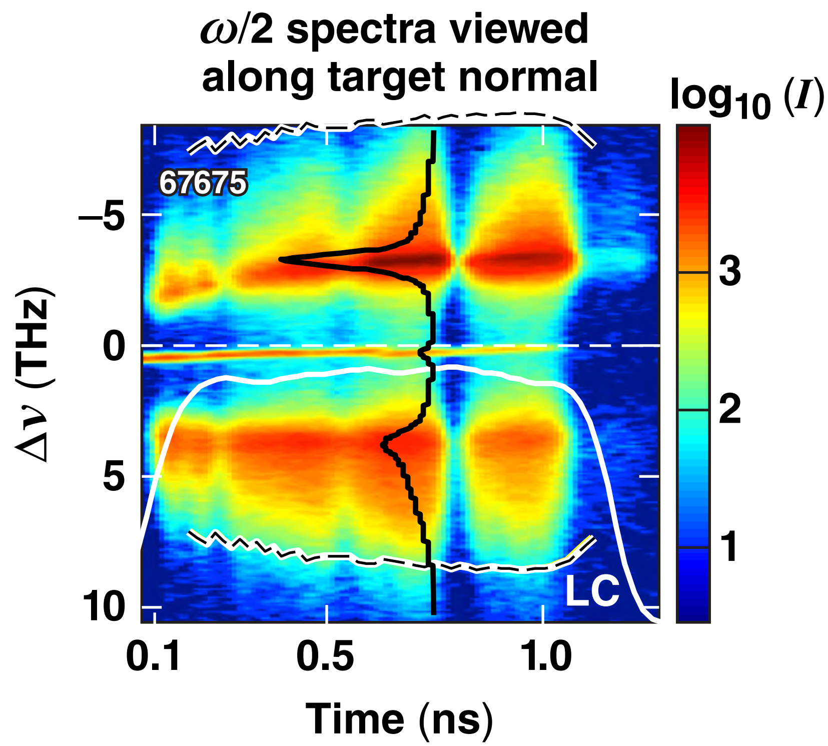
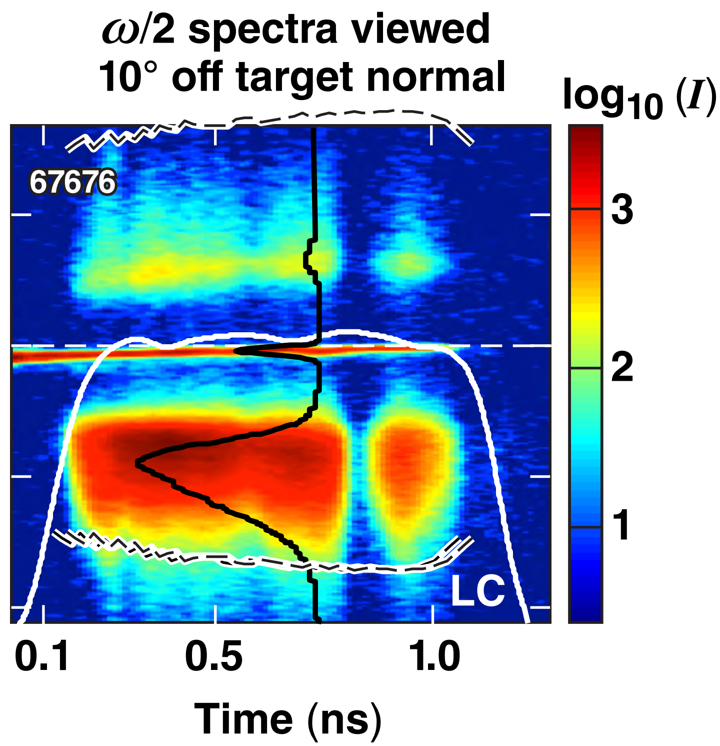


$I_{14} = 5.6$



$I_{14} = 5.8$

- Broad $\omega/2$ spectra are an indication of nonlinearity of the TPD instability.
- The quasi-instantaneous onset of broad spectral emission demonstrates the rapidity of the nonlinear evolution.

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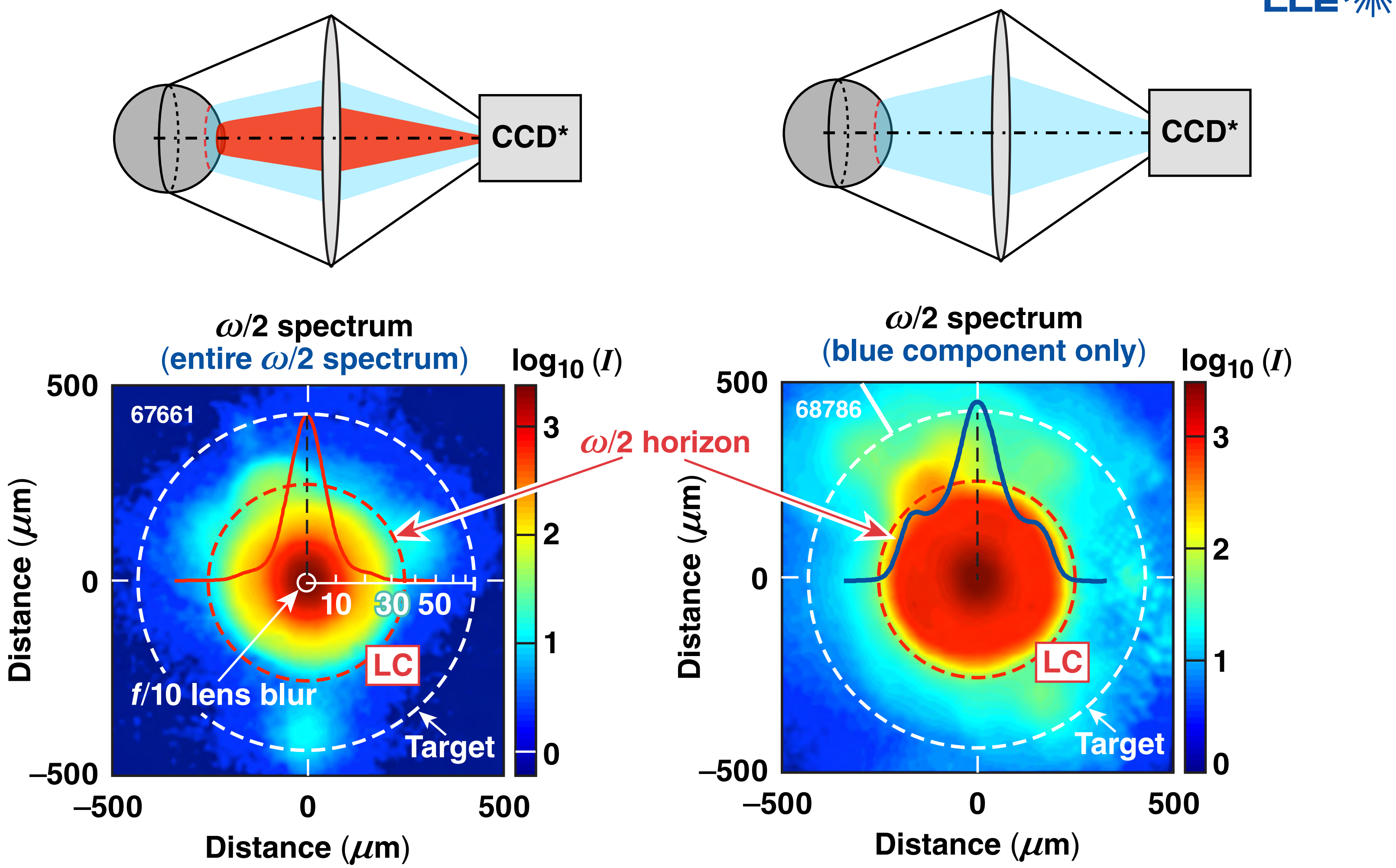
The multibeam nature of the TPD instability is best seen in $\omega/2$ images of imploding targets



$I_{14} = 8.6$

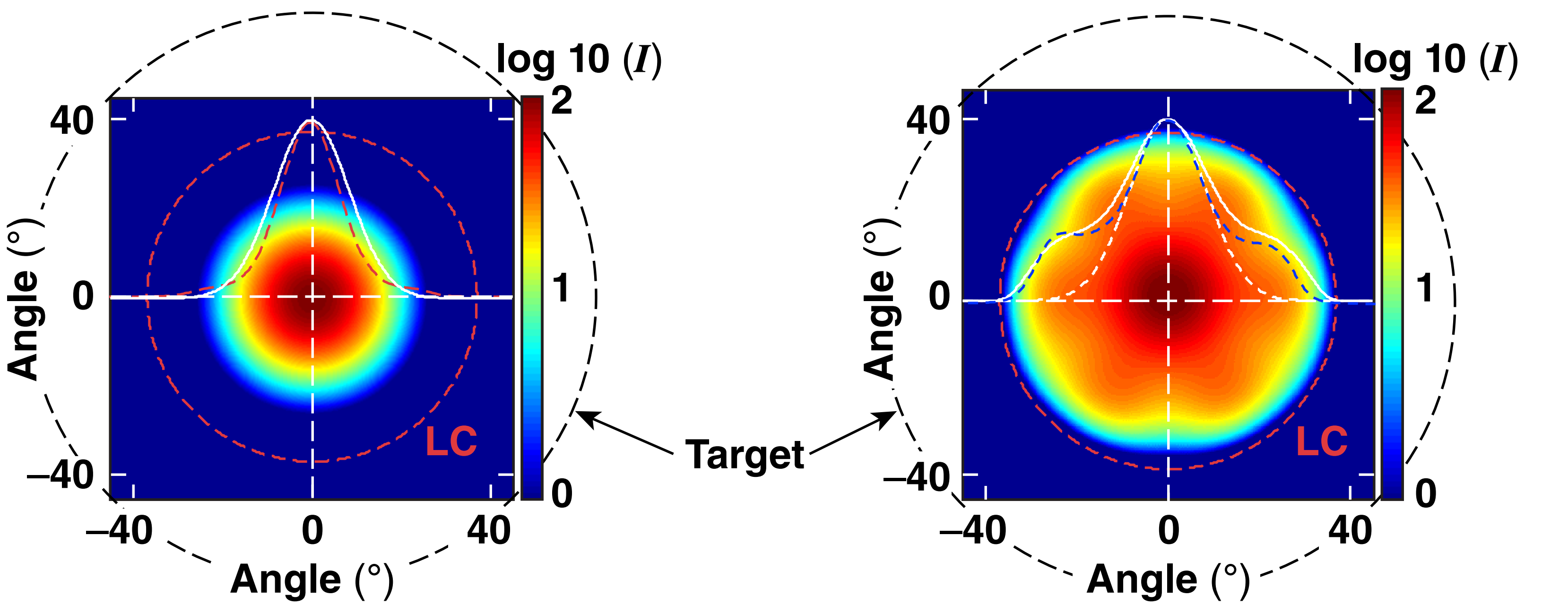
$I_{14} = 9.4$

*CCD: charge-coupled device

Superposing Gaussians with surrounding Landau cutoff super-Gaussians illustrates the multibeam nature of TPD

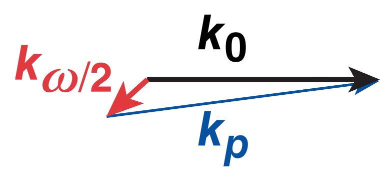
"Simulated" $\omega/2$ image
(10° half-cone angle
around HEX port)

"Simulated" $\omega/2$ image including
contributions from HEX port,
six beams at 23°,
two PENT ports at 37° and LC at 37°



Thomson scattering is severely restricted because of the disparity of TPD k_p's, $k_{\omega/2}$ and k_0

- For ~2-keV plasma: $1 < k_{p1}/k_0 < 2.4$ and $0.1 < k_{p2}/k_0 < 1.5$
- In the TPD interaction region: $0.1 \lesssim k_{\omega/2}/k_0 \lesssim 0.2$



- Thomson scattering can generate
  - broad red-shifted spectral component only within
    $0.24 < n_e/n_c < 0.25 \longrightarrow 1.0 < \Delta\omega/\omega_{min} \lesssim 1.1$
  - broad blue-shifted spectral component within
    $0.215 < n_e/n_c < 0.23 \longrightarrow 1.5 < \Delta\omega/\omega_{min} \lesssim 2$
- Collisional absorption limits plasma wave propagation to ~5 μm changing k_p's by <2%

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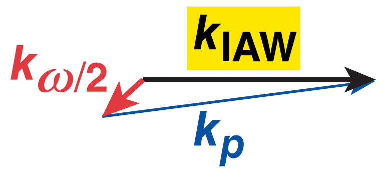
Inverse parametric decay can generate $\omega/2$ light wherever appropriate plasma and ion waves are present

- For ~2-keV plasma: $1 < k_{p1}/k_0 < 2.4$ and $0.1 < k_{p2}/k_0 < 1.5$
- In the TPD interaction region: $0.1 \lesssim k_{\omega/2}/k_0 \lesssim 0.2$



- Inverse parametric decay
  - beating of EPW with IAW of roughly equal k vectors
- No restrictions in k_p's or observed frequency shifts provided roughly matching IAW's are available
- Zakharov simulations indicate that ion turbulence is prevalent in the nonlinear regime

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Summary/Conclusions

Experiments show that the two-plasmon–decay (TPD) instability progresses rapidly from the threshold to the nonlinear regime

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