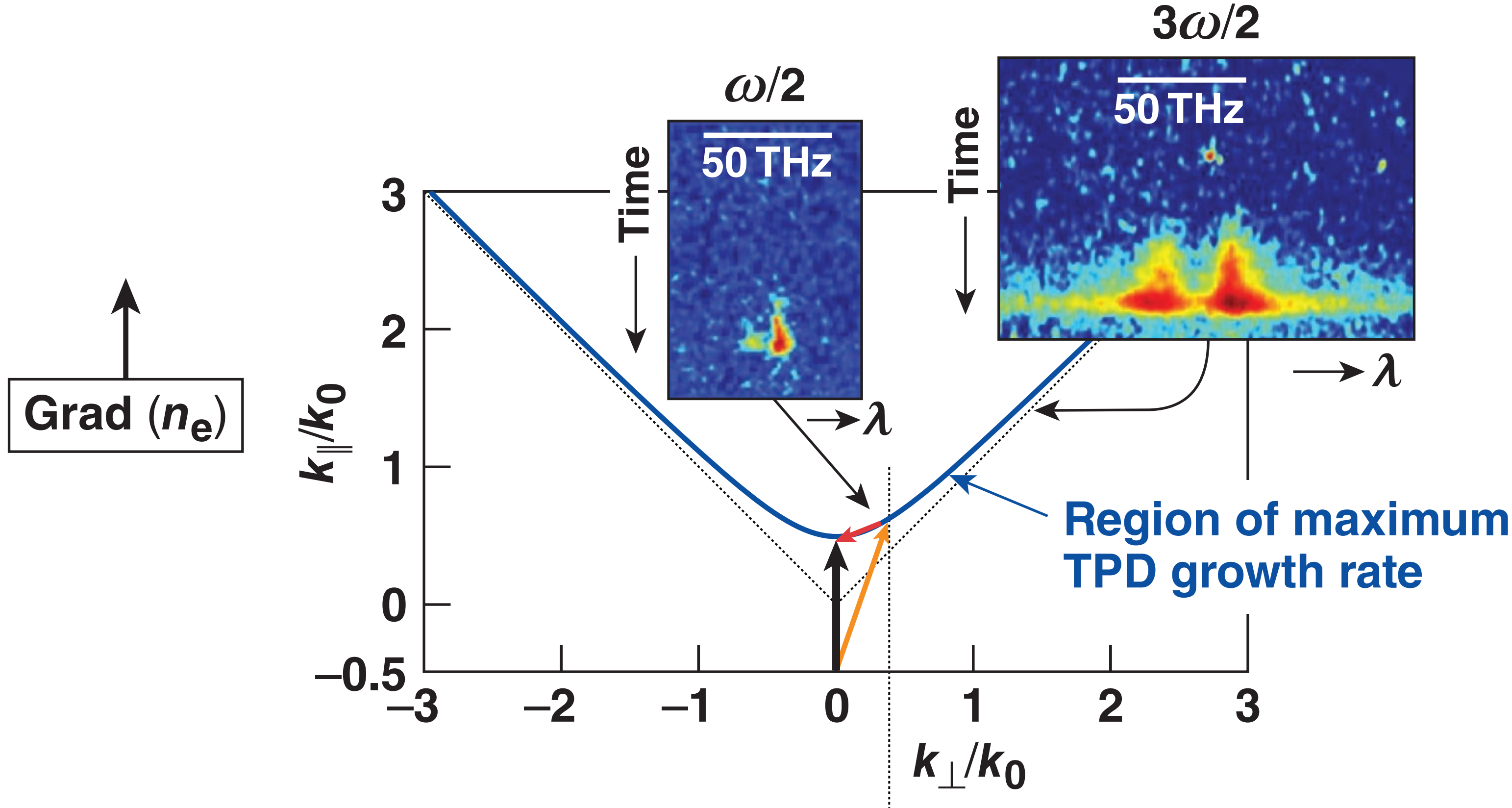
Two-Plasmon-Decay Instability in Direct-Drive Implosion Experiments



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Summary

Shared plasma waves appear to be responsible for fast-electron generation caused by the TPD instability in direct-drive-implosion experiments

- The TPD instability is seen via $3\omega/2$, $\omega/2$, and hard x-ray emission in most direct-drive-implosion experiments.
- TPD plasmons are identified between $0.2 \le k_\perp/k_0 \le 2.5$ corresponding to $k\lambda_{De} \sim 0.3$.
- Absolute TPD instability $k_\perp/k_0 \le 0.2 \rightarrow$ appears to be absent.
- Hard x-ray emission is anisotropic
  - consistent with shared plasma waves in the HEX beam configuration on OMEGA
  - consistent with overlapped intensity dependence of TPD preheat measurements of the past

Collaborators

D. H. Edgell
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The TPD instability occurs near $n_c/4$ and has a low threshold intensity

UR LLE

Experimentally verified characteristics of TPD instability:

- $I_{th} \sim 2 \times 10^{14}$ W/cm^2 for OMEGA direct-drive implosions
- Characteristic emission of $\omega/2$ and $3\omega/2$ and hard x rays
- Hard x-ray emission depends on overlapped intensity (NOT single-beam intensity)
- Landau cutoff determines TPD decays with longest plasma *k* vectors

Recent data:

- TPD plasmons: $0.2 < k_\perp/k_0 < 2.5$ corresponding to $k\lambda_{De} \sim 0.3$
- Hard x-ray emission is anisotropic → anisotropic fast electrons*
- T_{hot} of fast electron up to 120 keV
- Fast electrons appear directed along density gradient
- Temporal dependence of $3\omega/2$, $\omega/2$, and hard x-ray emission is roughly equal

*J. Myatt, this conference

OMEGA implosion experiments have yielded excellent $\omega/2$, $3\omega/2$, and hard x-ray spectra

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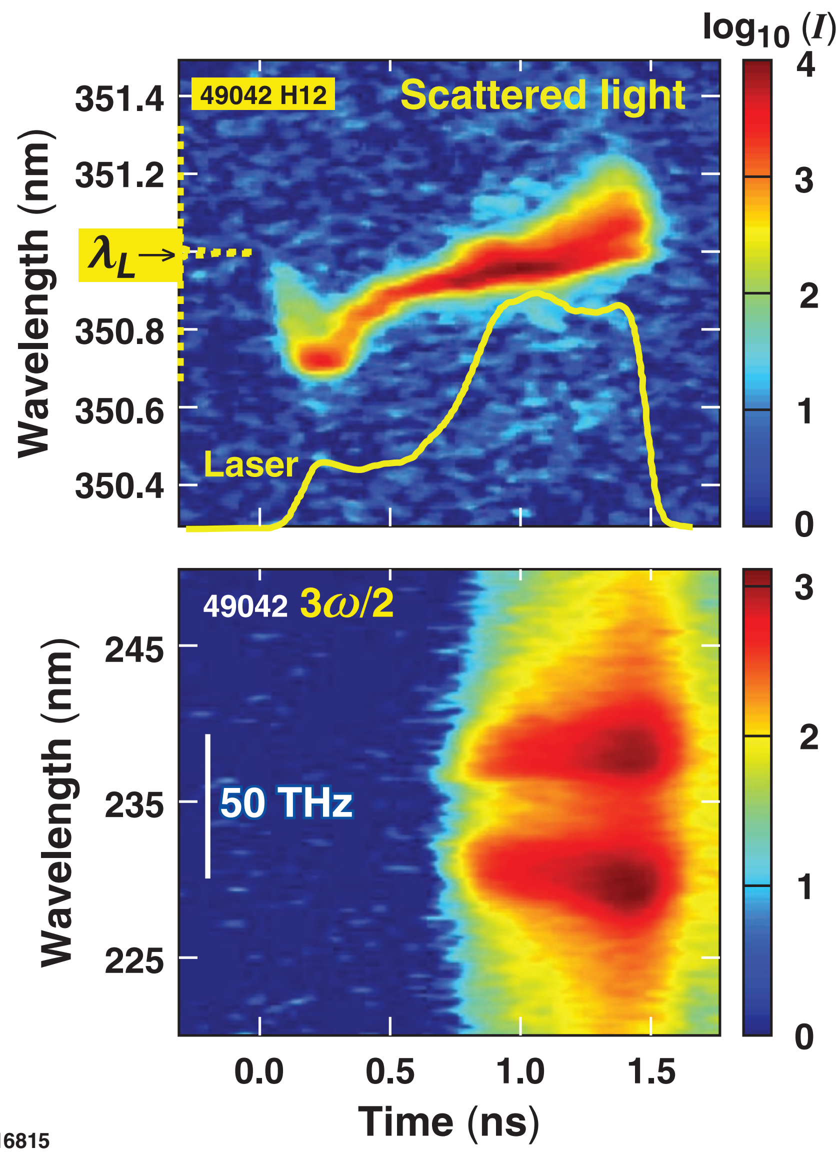

10-μm Si(6%)CH + 14-μm CD shell, 848-μm diam, warm; 60 beams, no SSD

E16815

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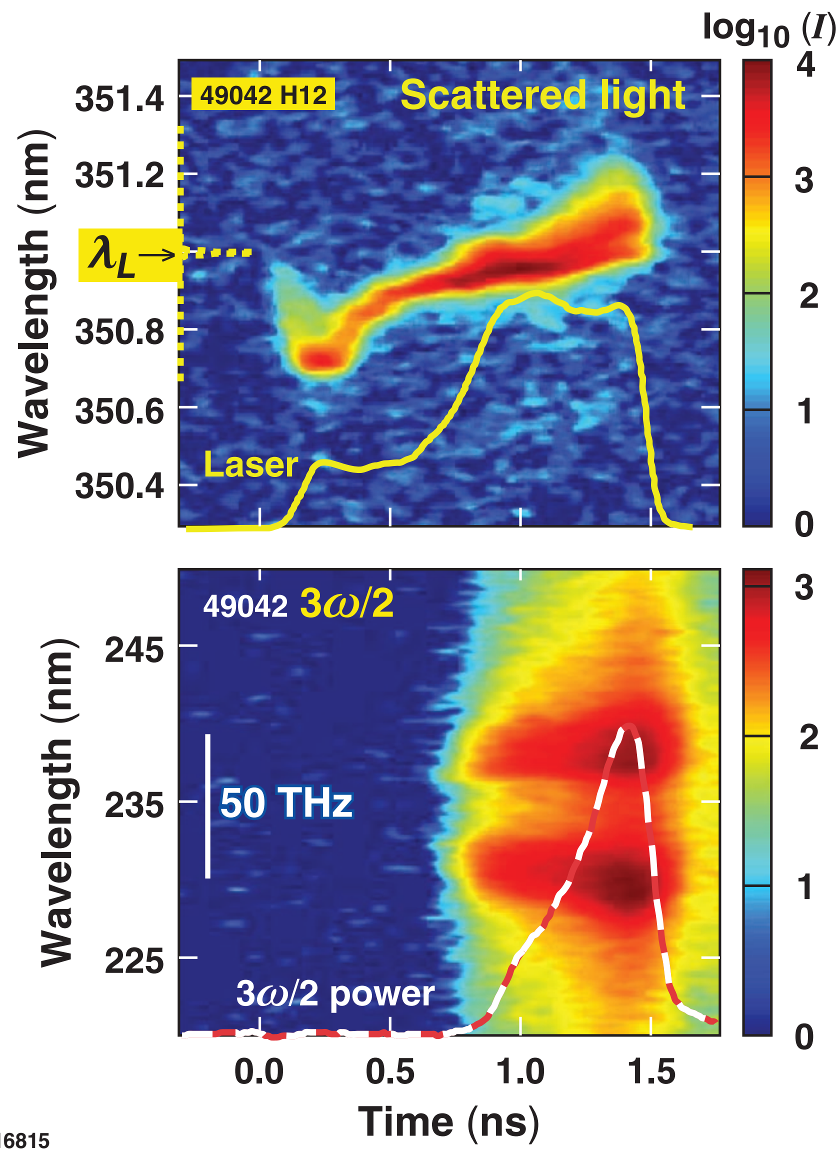

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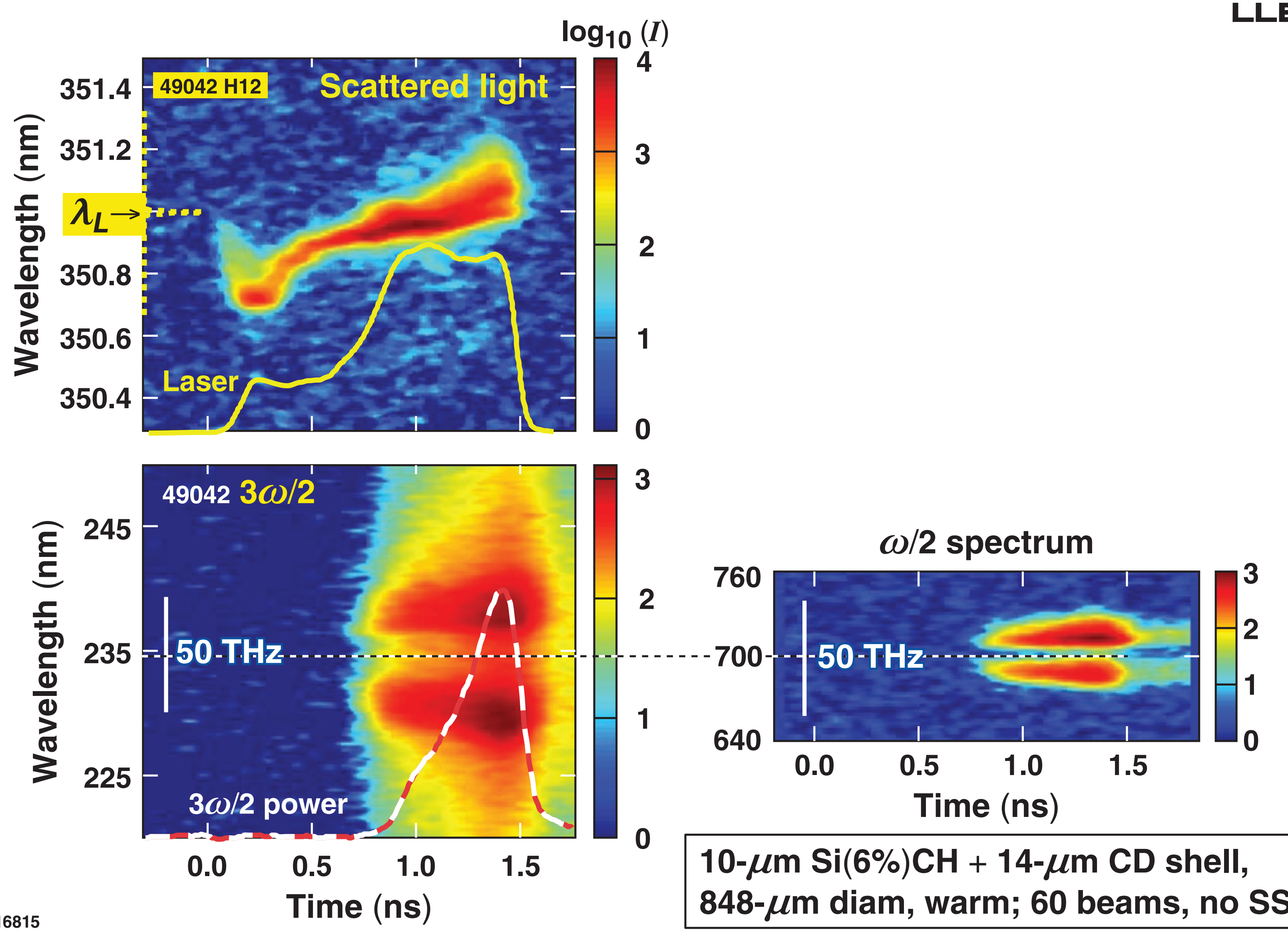

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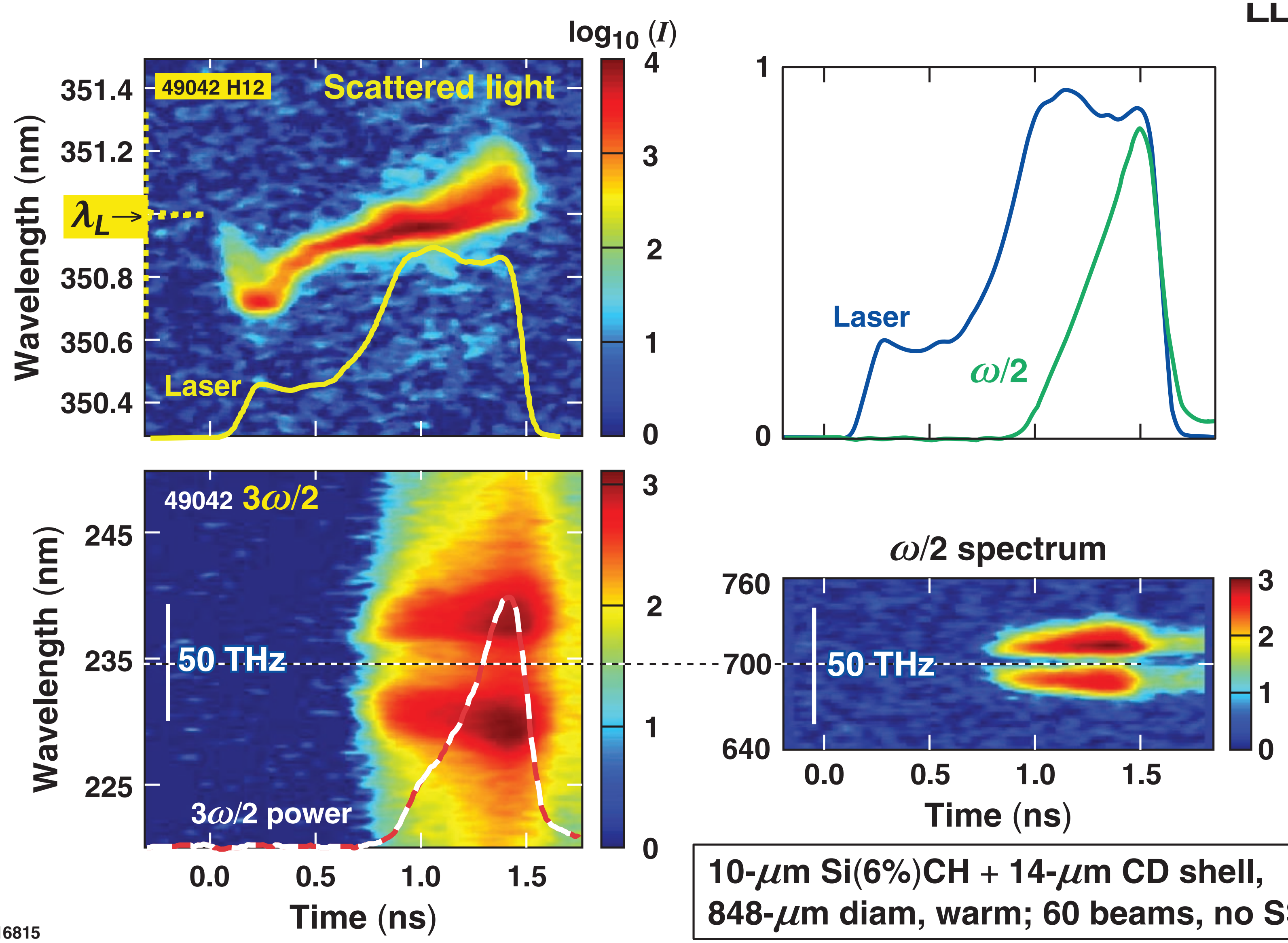

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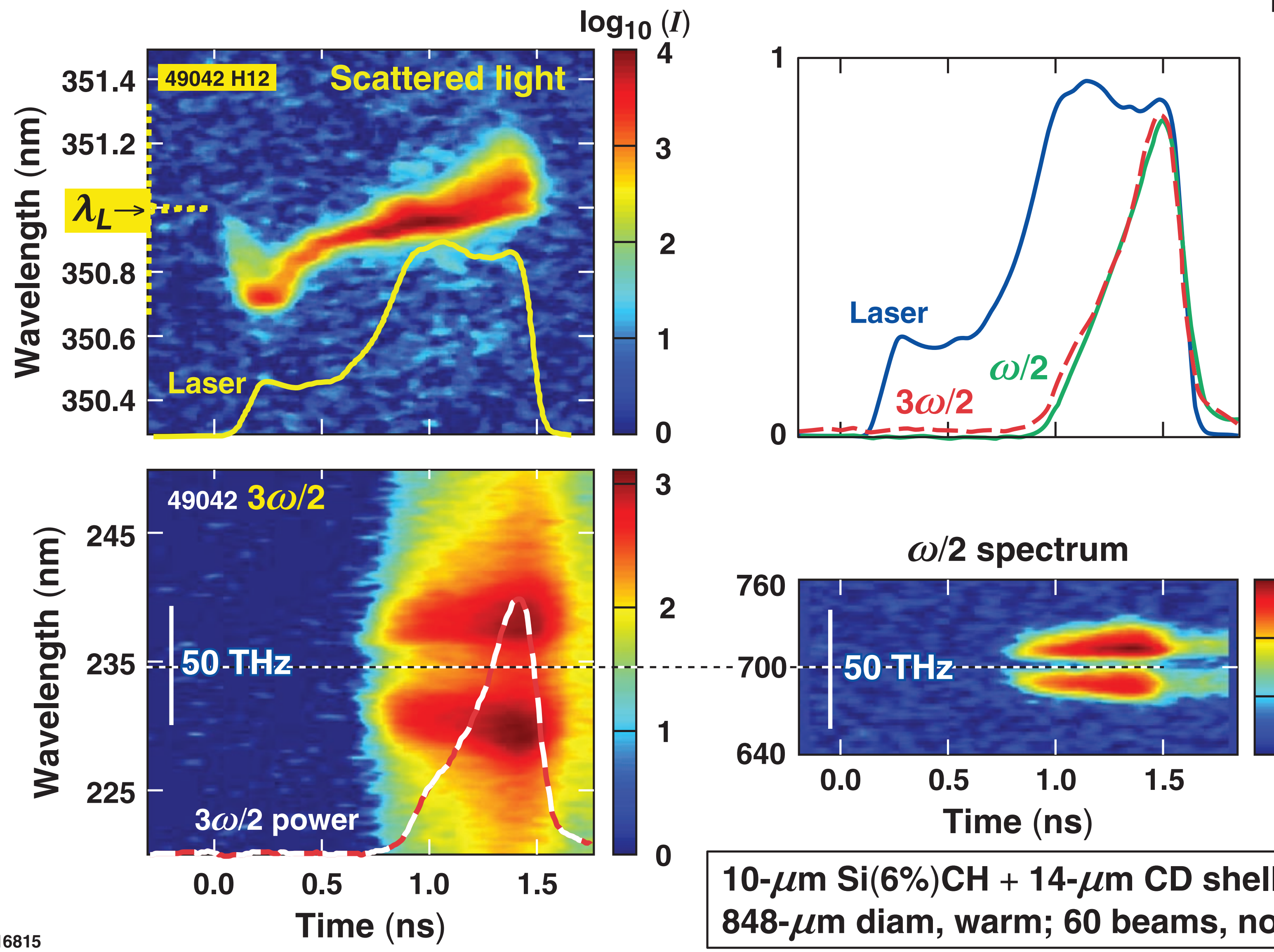

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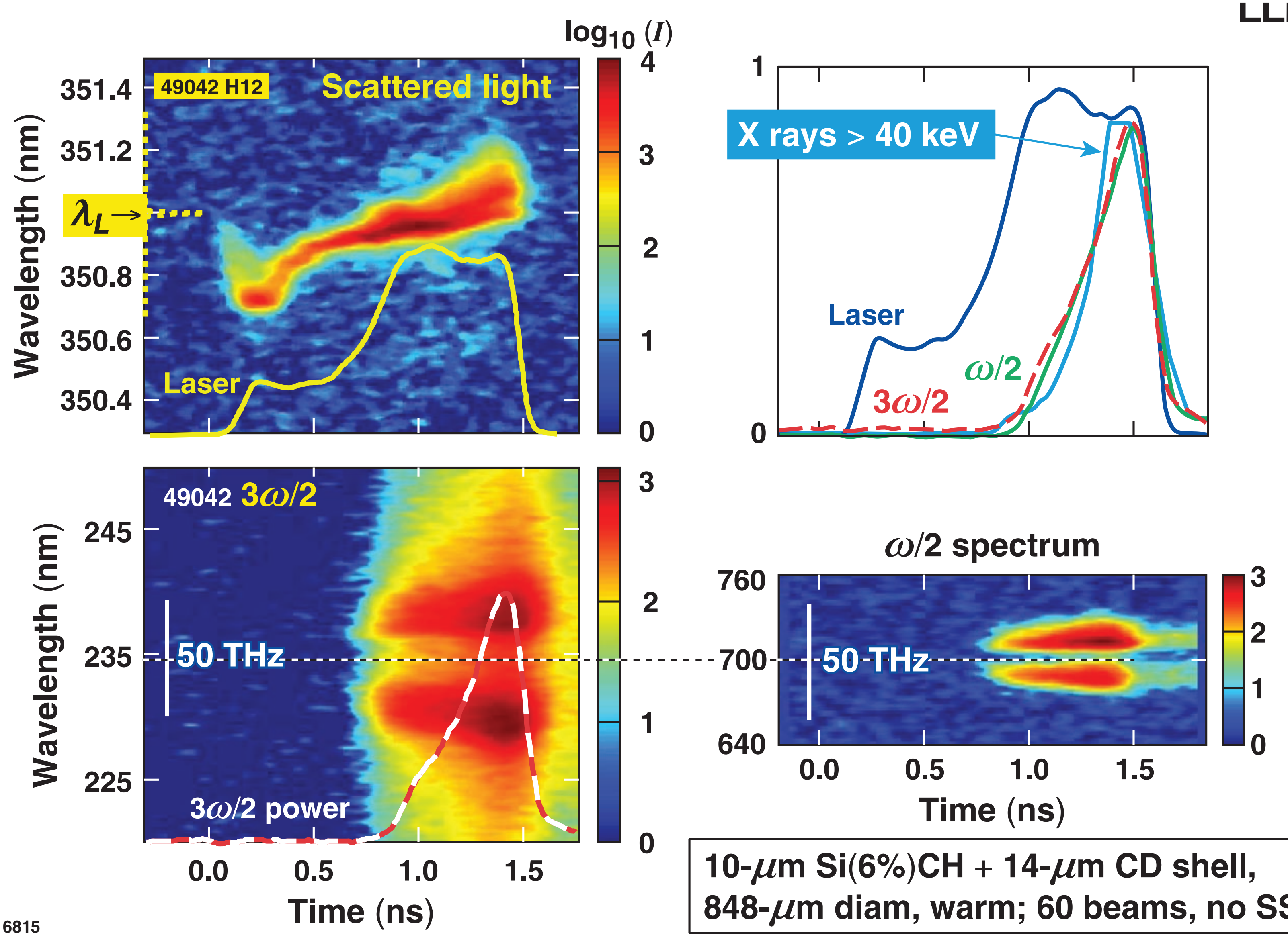

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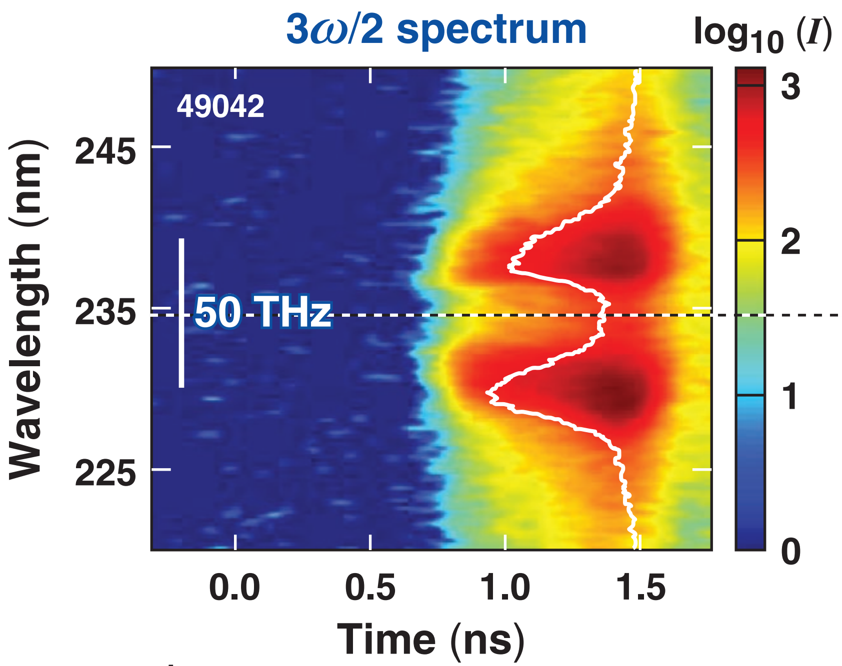
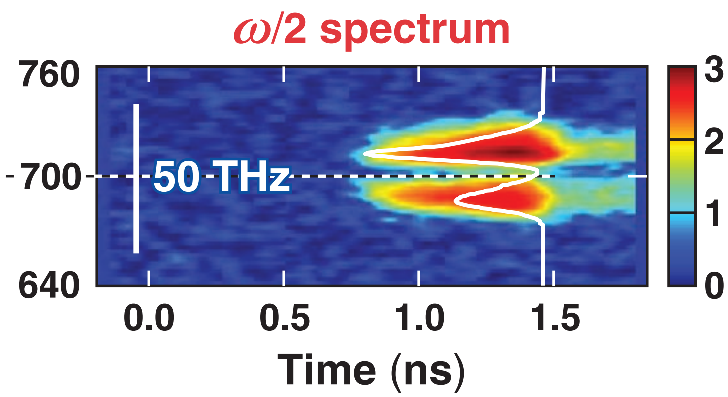
$3\omega/2$ and $\omega/2$ spectra indicate the presence of TPD plasma waves of small and large $k_\perp$





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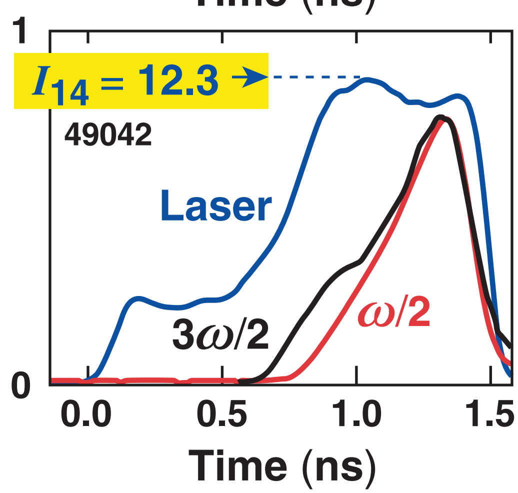

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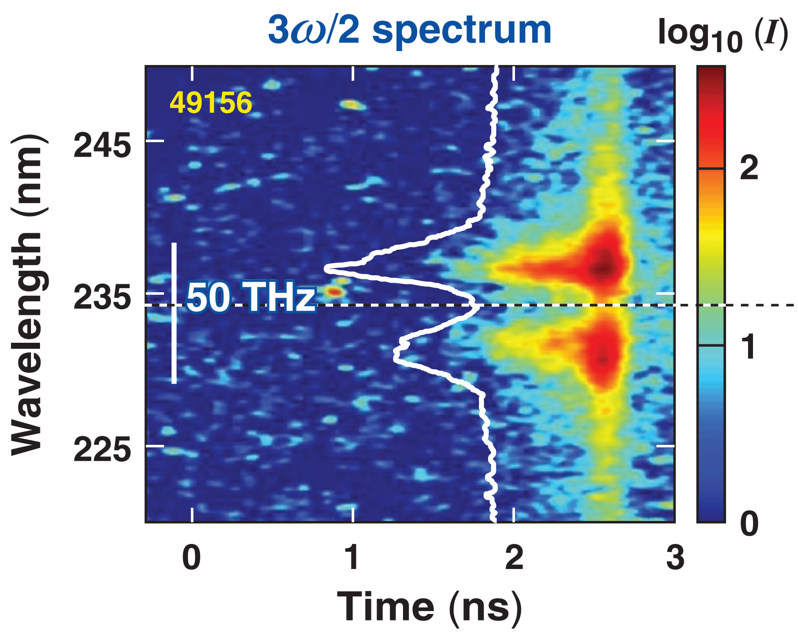
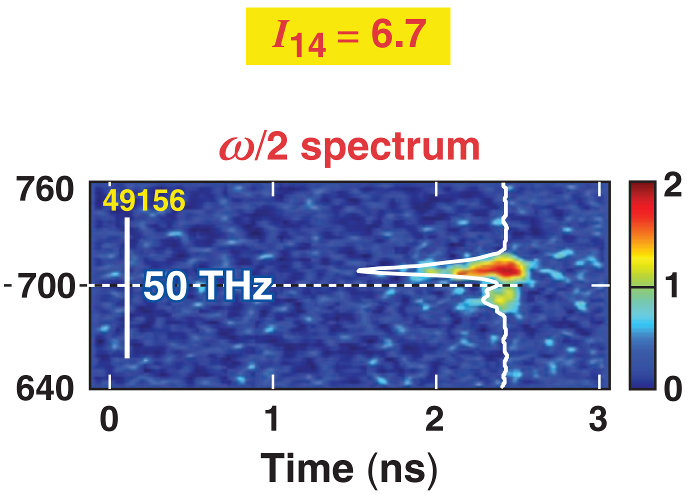
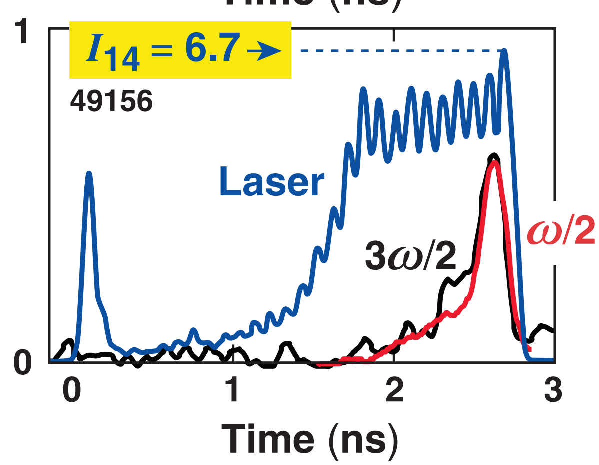
Close to the TPD threshold, the $\omega/2$ spectrum has a very strong, narrow red component suggestive of direct plasmon-to-photon conversion





Cryo shot
CHSi(5pc)[5.4]CD[4.5]DT(77)
1 THz, HE28291P



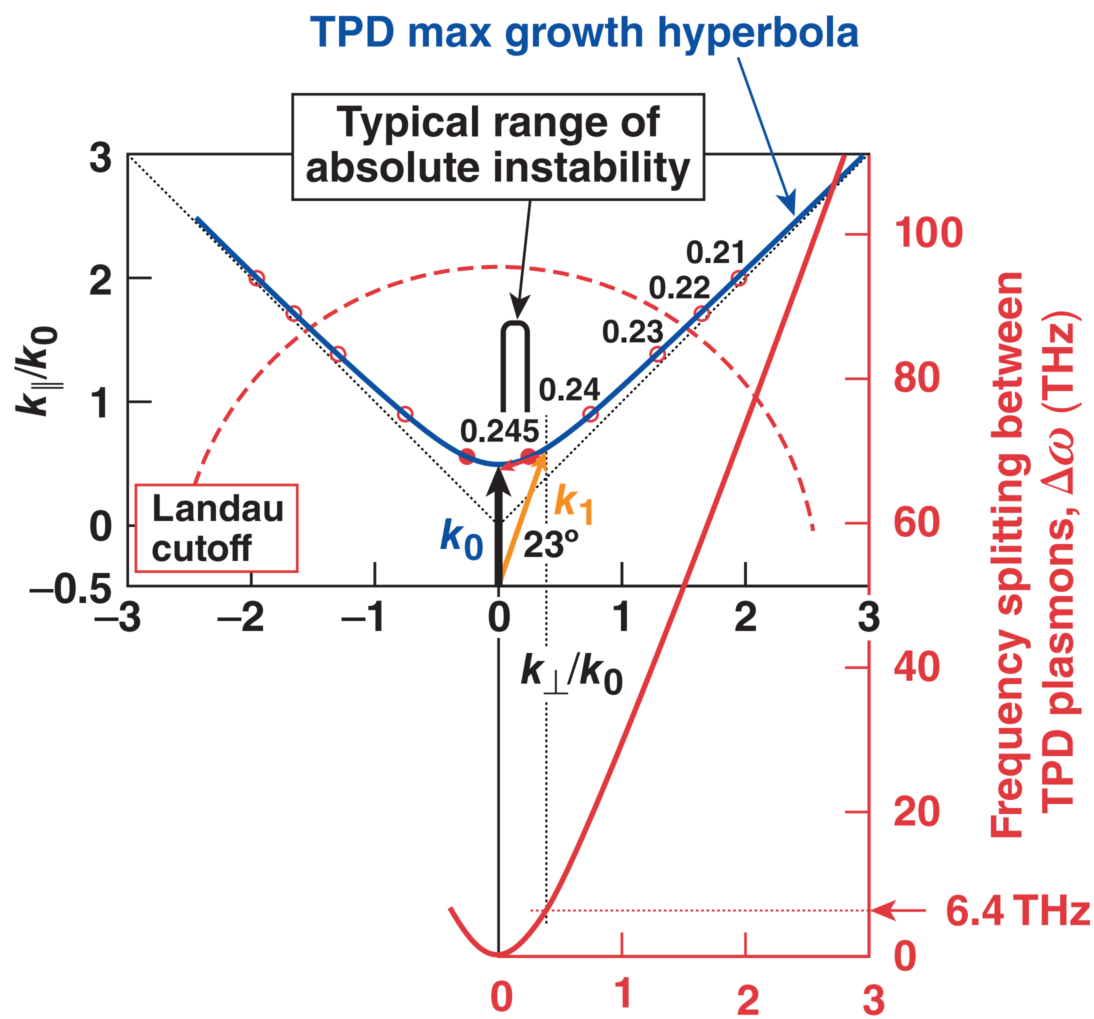
E16817

The light at $\omega/2$ can only be observed very close to the direction of the density gradient and its frequency range is restricted by $k_{\perp,\,\omega/2} \le k_{0,\,\omega/2}$

UR LLE

$$\Delta\omega = \omega_0 \frac{9}{4} \frac{T_e}{511} \kappa$$

$$\kappa = k_{1,\parallel}/k_0 - 1/2$$



E16818

The light at $\omega/2$ can only be observed very close to the direction of the density gradient and its frequency range is restricted by $k_{\perp,\,\omega/2} \leq k_{0,\,\omega/2}$

UR LLE

$$\Delta\omega = \omega_0 \frac{9}{4}\frac{T_e}{511}\kappa$$

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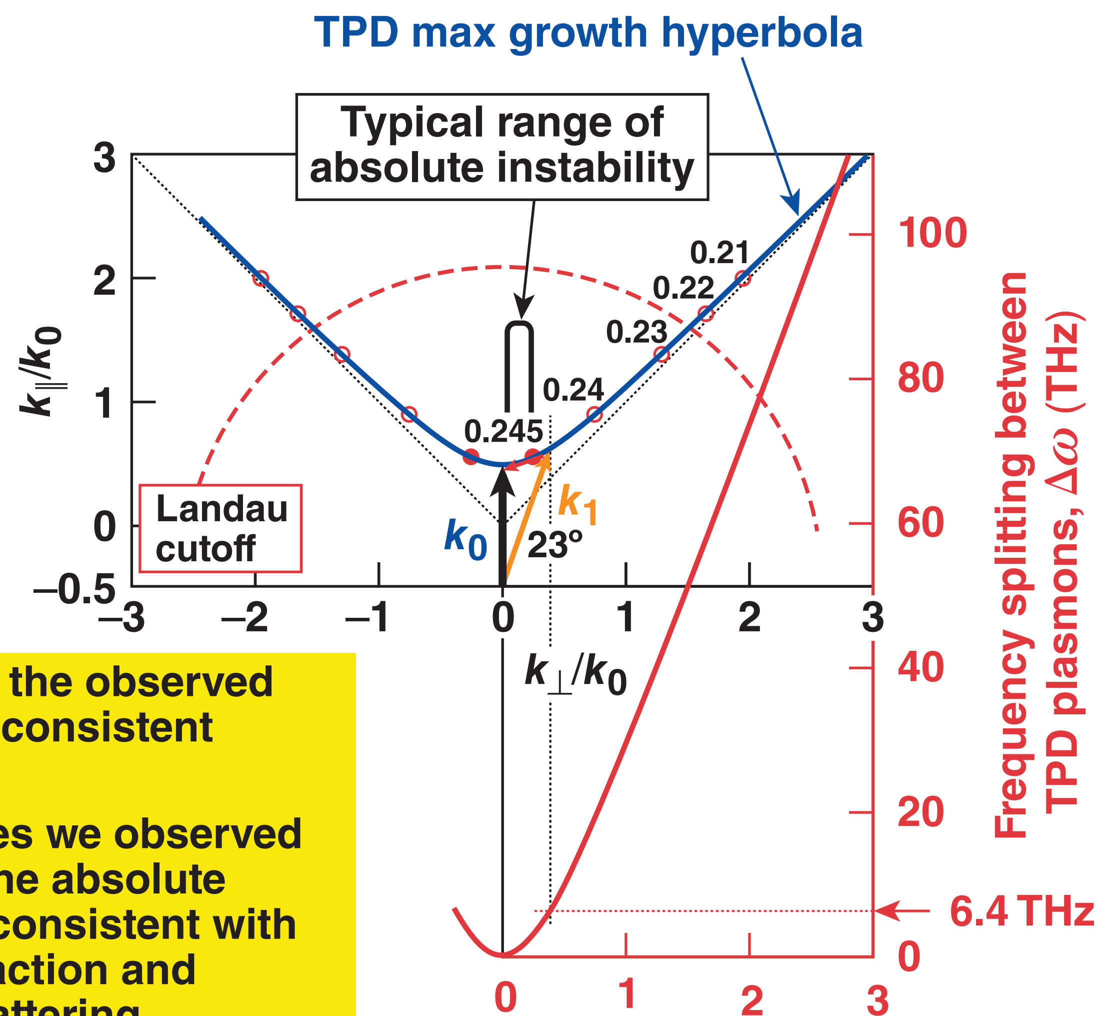
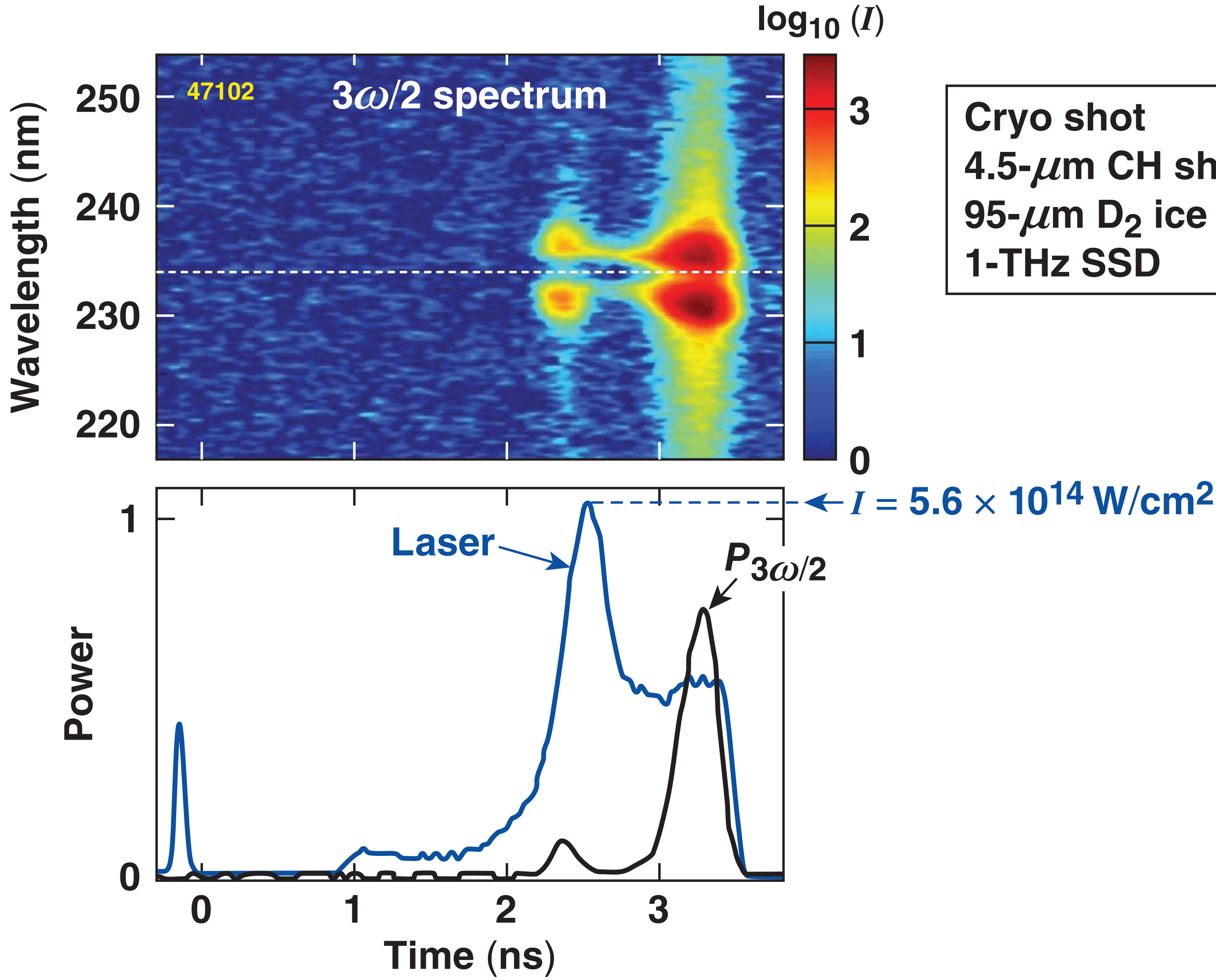


- Close to threshold the observed $\omega/2$ light could be consistent with absolute TPD.
- At higher intensities we observed $\omega/2$ light beyond the absolute instability region, consistent with 23° HEX TPD interaction and Thomson downscattering.

E16818

The 3/2 harmonic emission depends on intensity, density scale length, and electron temperature (suggests IL_n/T_e dependence)

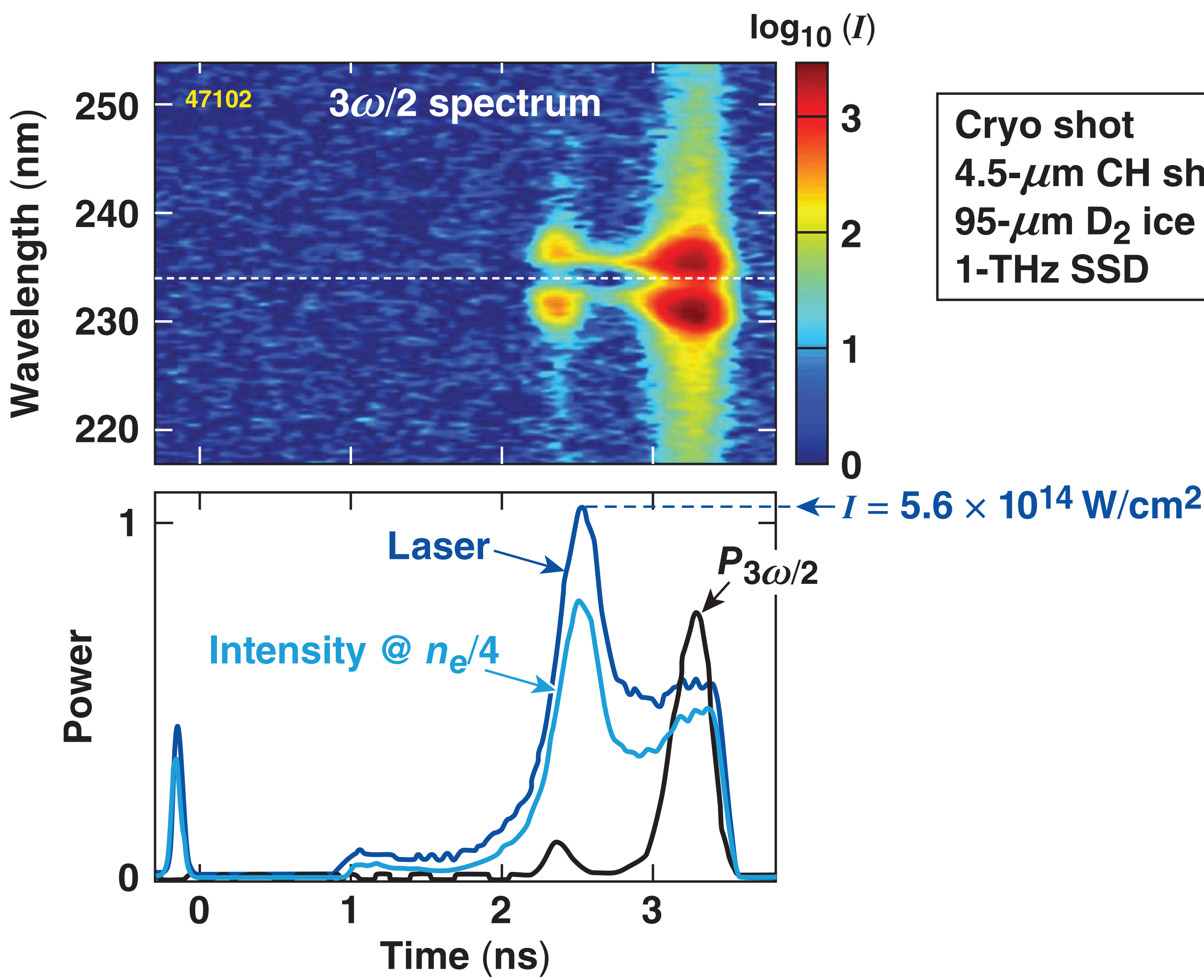
UR LLE



Cryo shot
4.5-μm CH shell
95-μm D_2 ice
1-THz SSD

E16819

The 3/2 harmonic emission depends on intensity, density scale length, and electron temperature (suggests IL_n/T_e dependence)



Cryo shot
4.5-μm CH shell
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E16819

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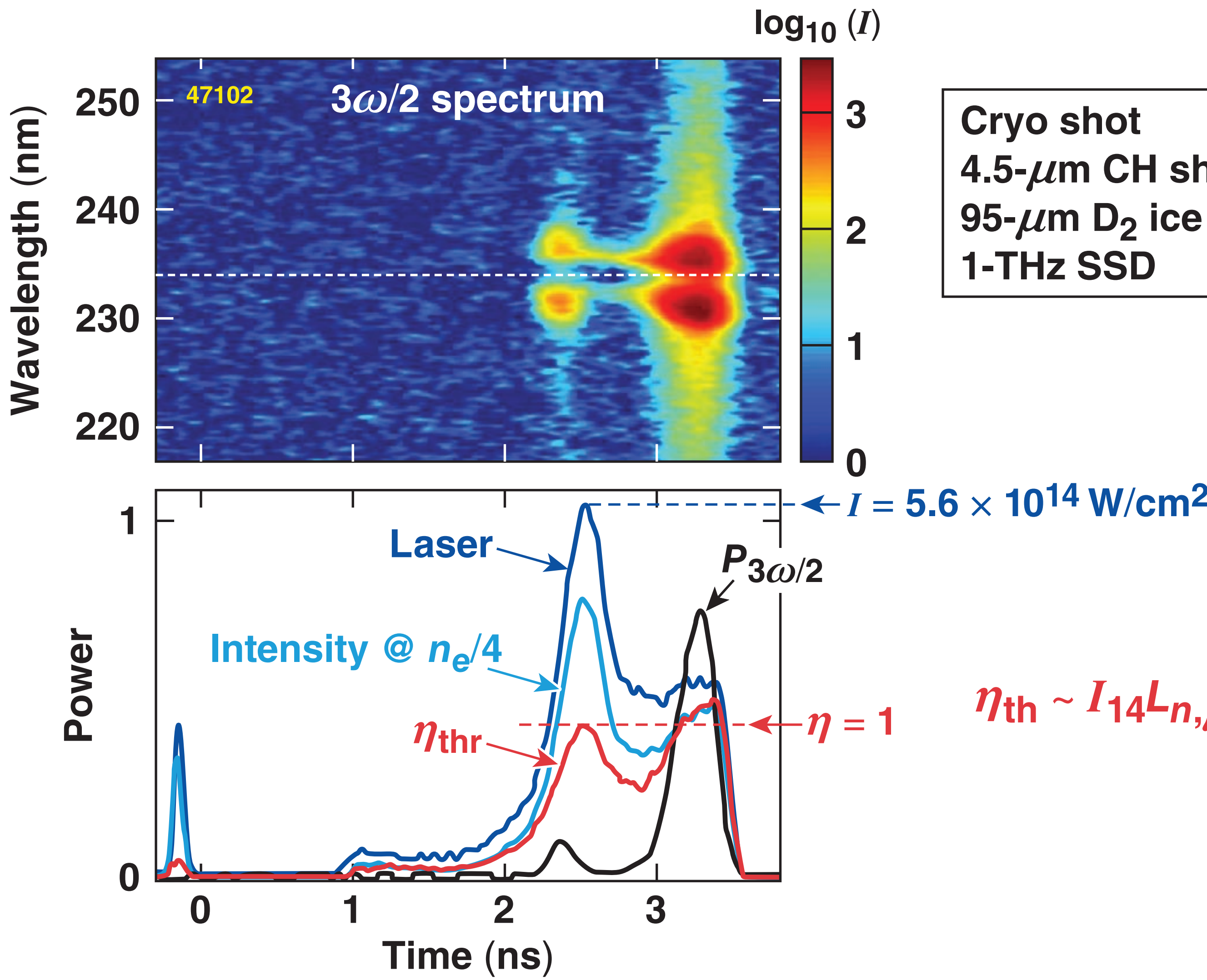

Cryo shot
4.5-μm CH shell
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$\eta_{th} \sim I_{14} L_{n,\mu m}/230\ T_{e,keV}$

E16819

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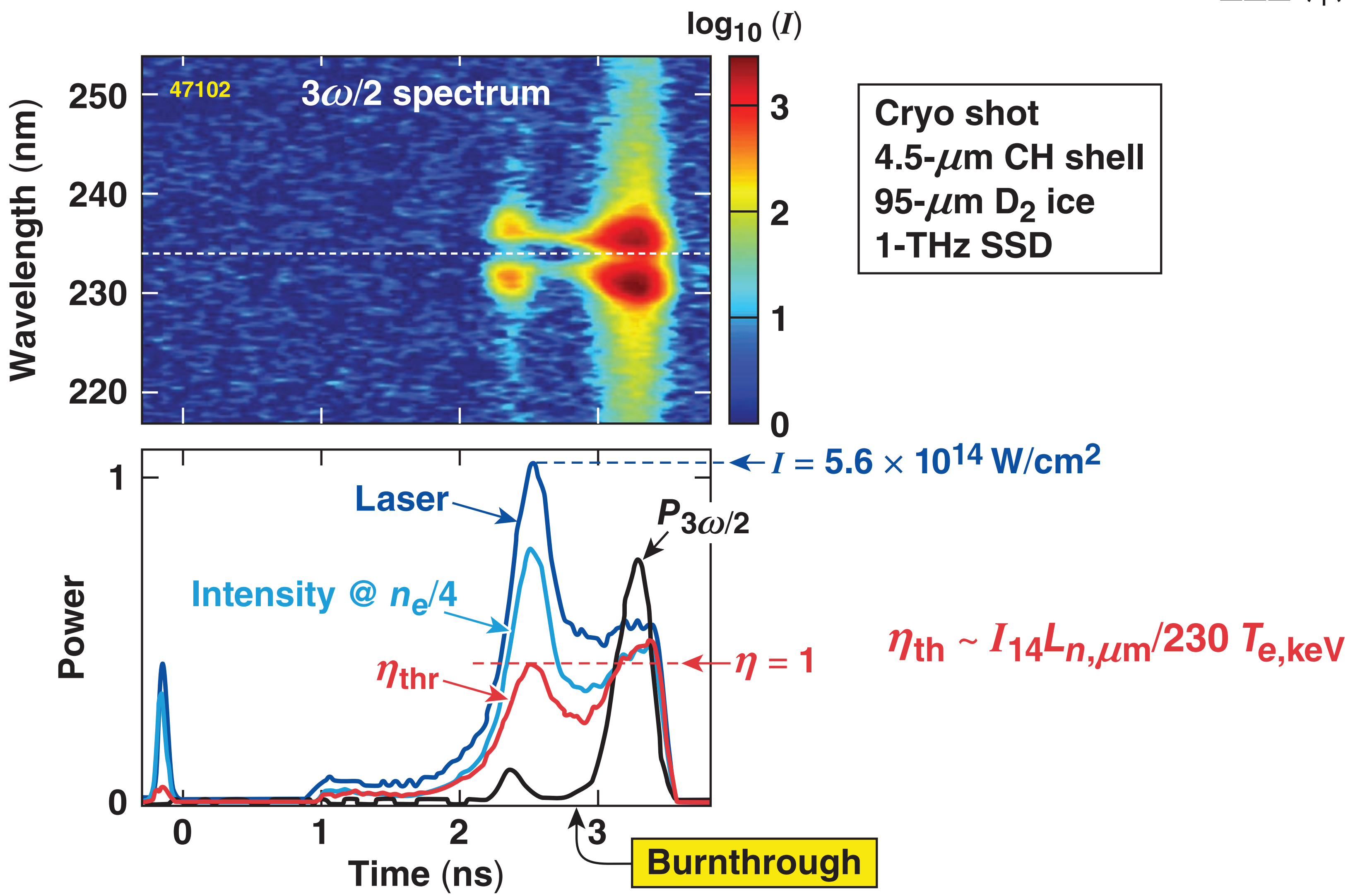
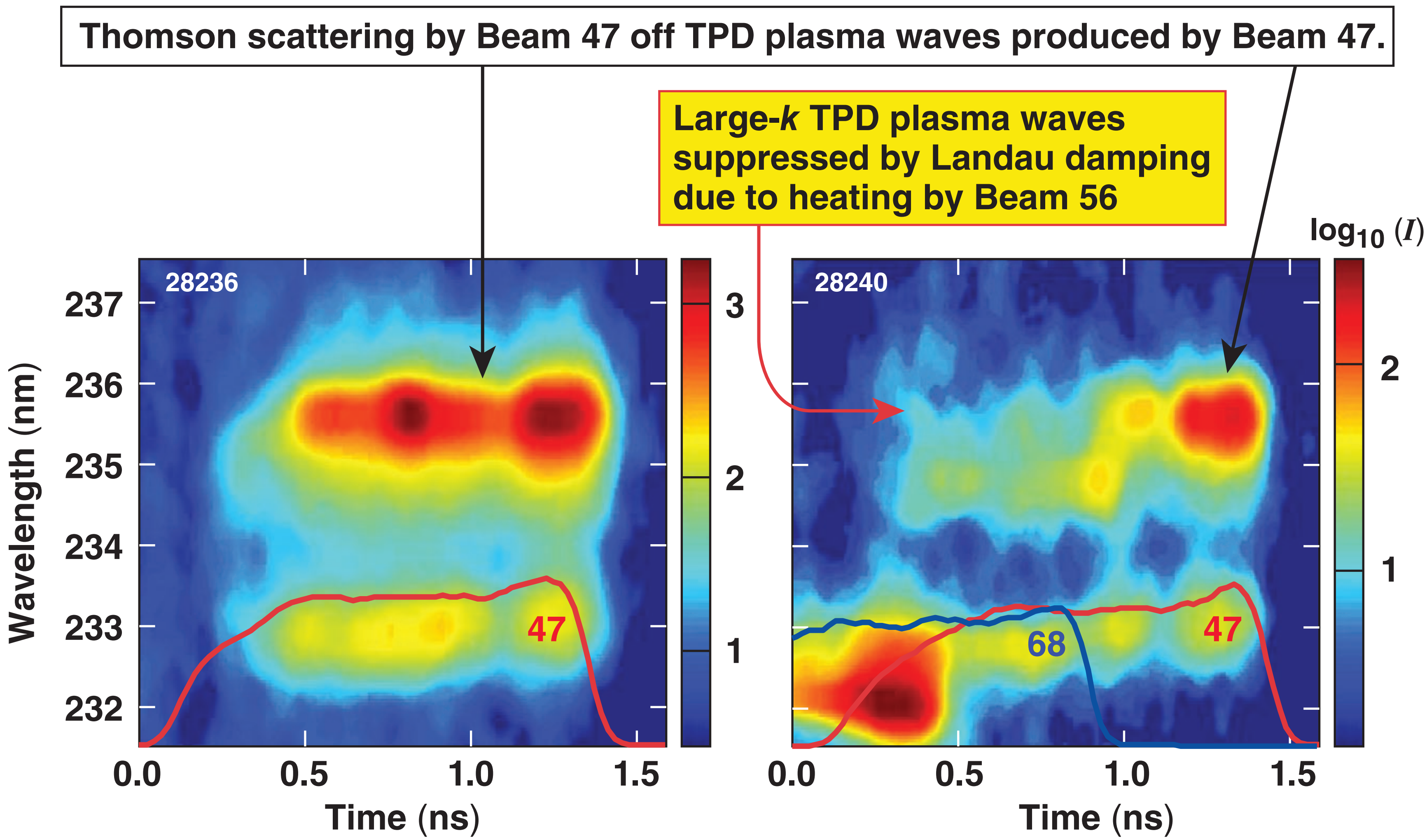


E16819

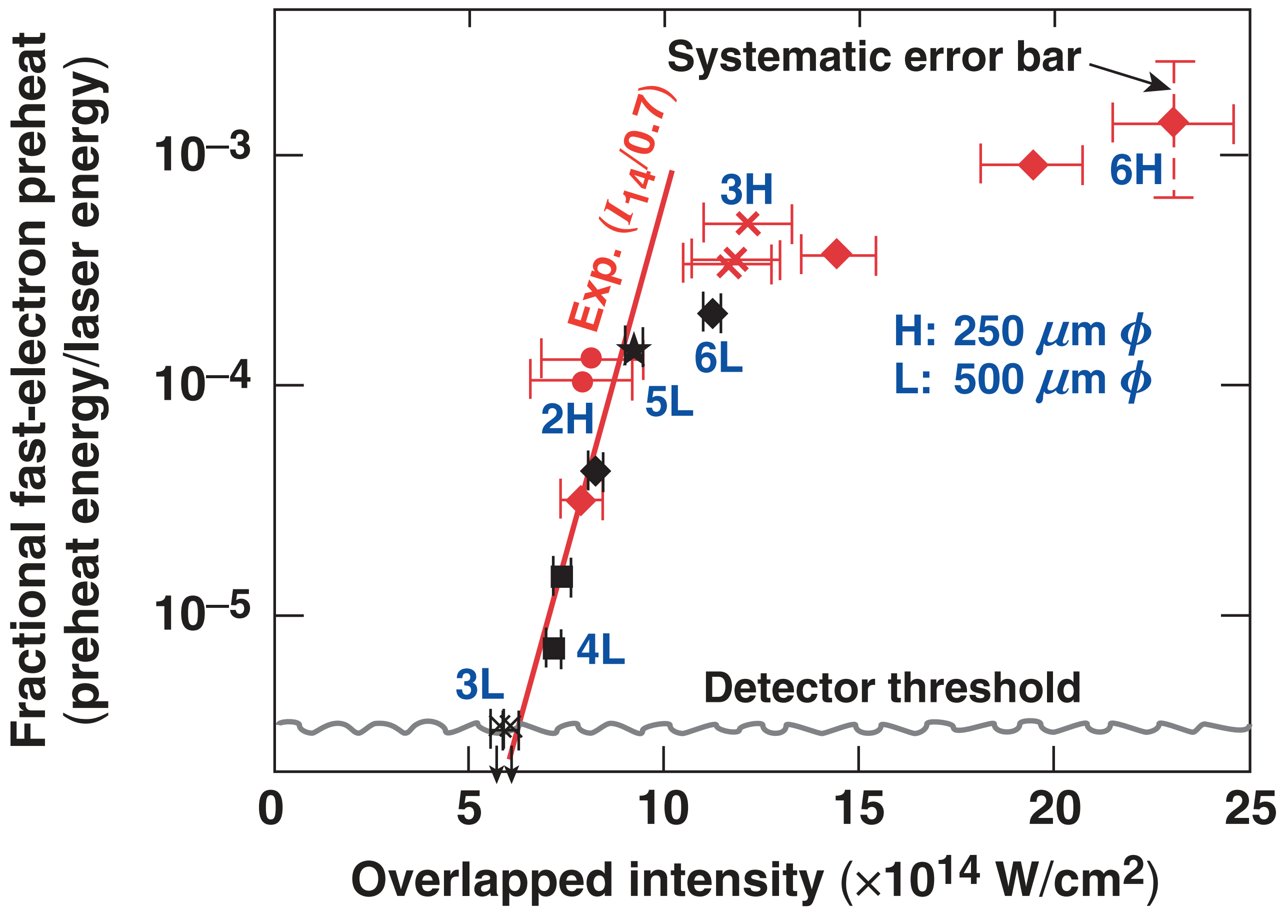
Thomson scattering off TPD plasma waves close to the Landau cutoff demonstrates temperature sensitivity



E16820

In planar experiments TPD scales with overlapped intensity and saturates above 10^{15} W/cm^2

- Planar CH targets, 100-μm thick, multiple-overlapping beams



E12304b

C. Stoeckl *et al*., Phys. Rev. Lett. 90, 235002 (2003).

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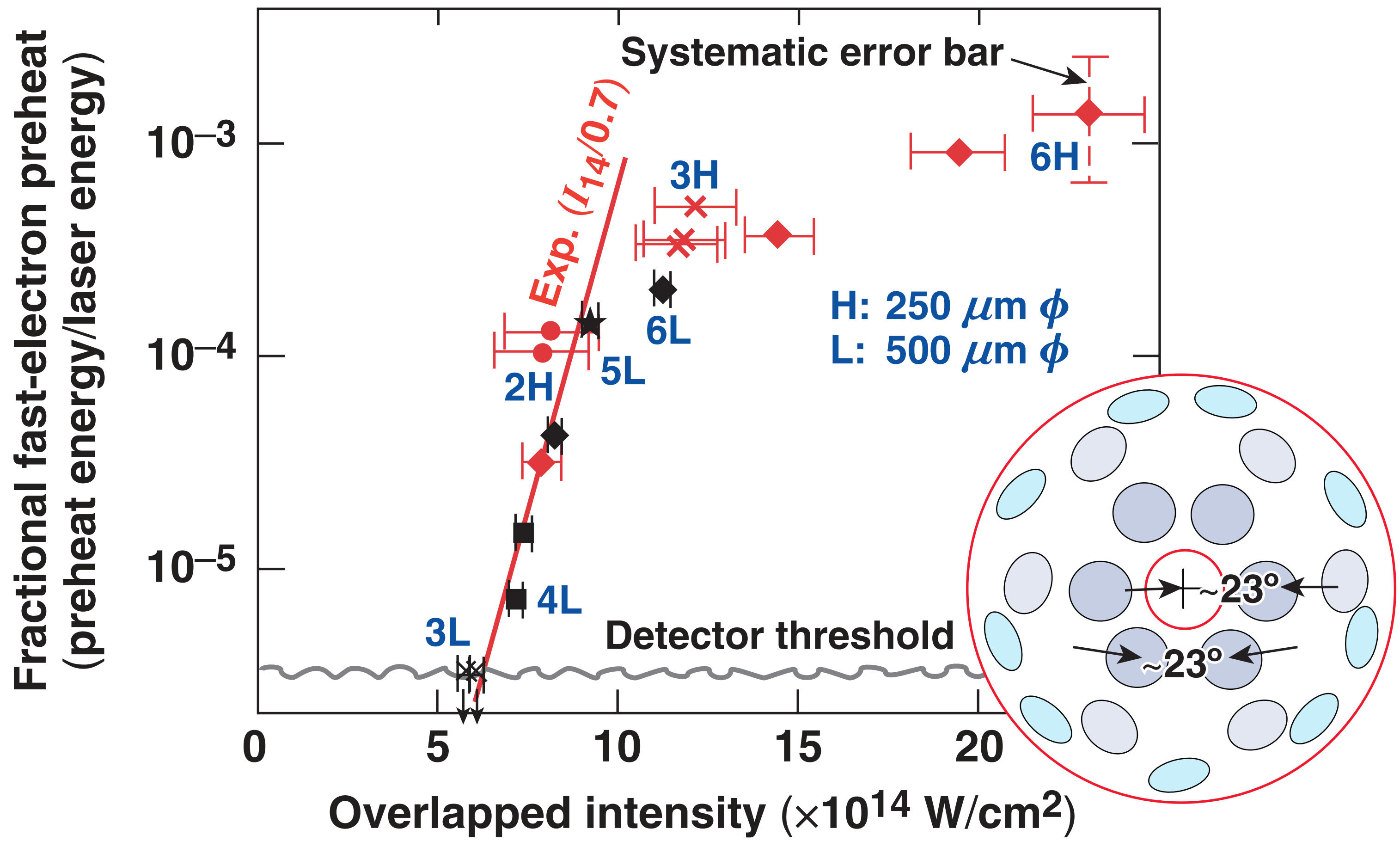
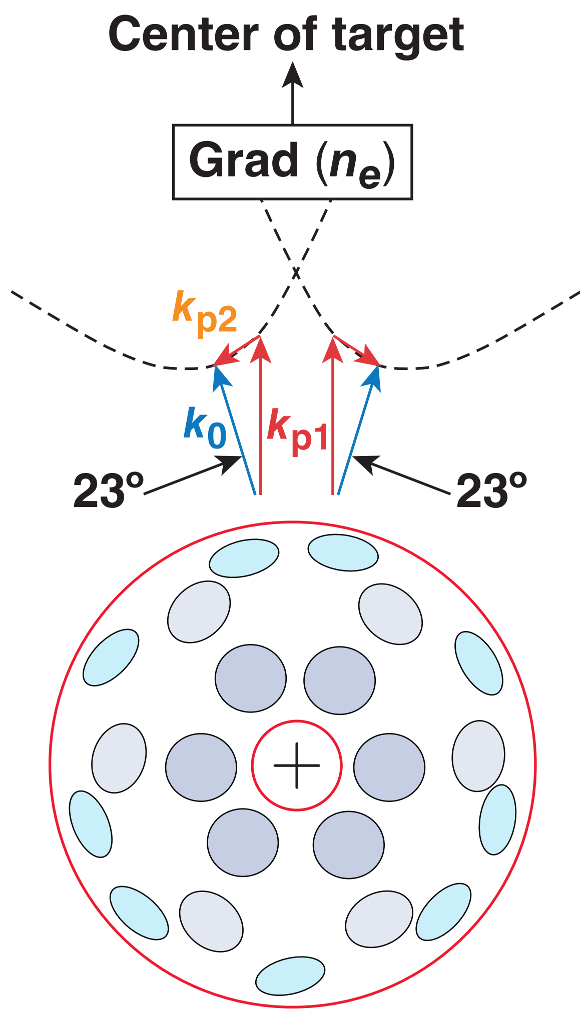


E12304b

C. Stoeckl *et al*., Phys. Rev. Lett. 90, 235002 (2003).

Overlapped beams can share plasma waves propagating towards the center of the target



On OMEGA hexagonal and pentagonal arrangements of beams are ideally suited for multibeam TPD effects.

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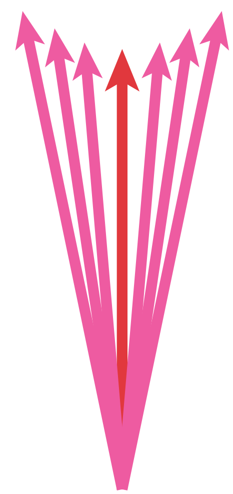

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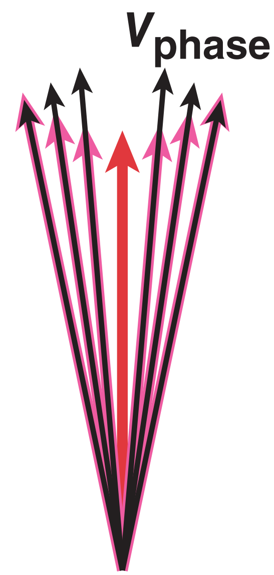

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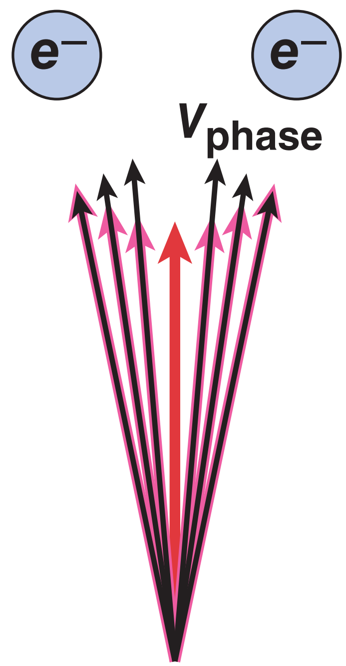

→ **Directional energetic-electron production would be expected from this process.**

We have found striking evidence for anisotropic distribution of energetic electrons due to TPD instability*

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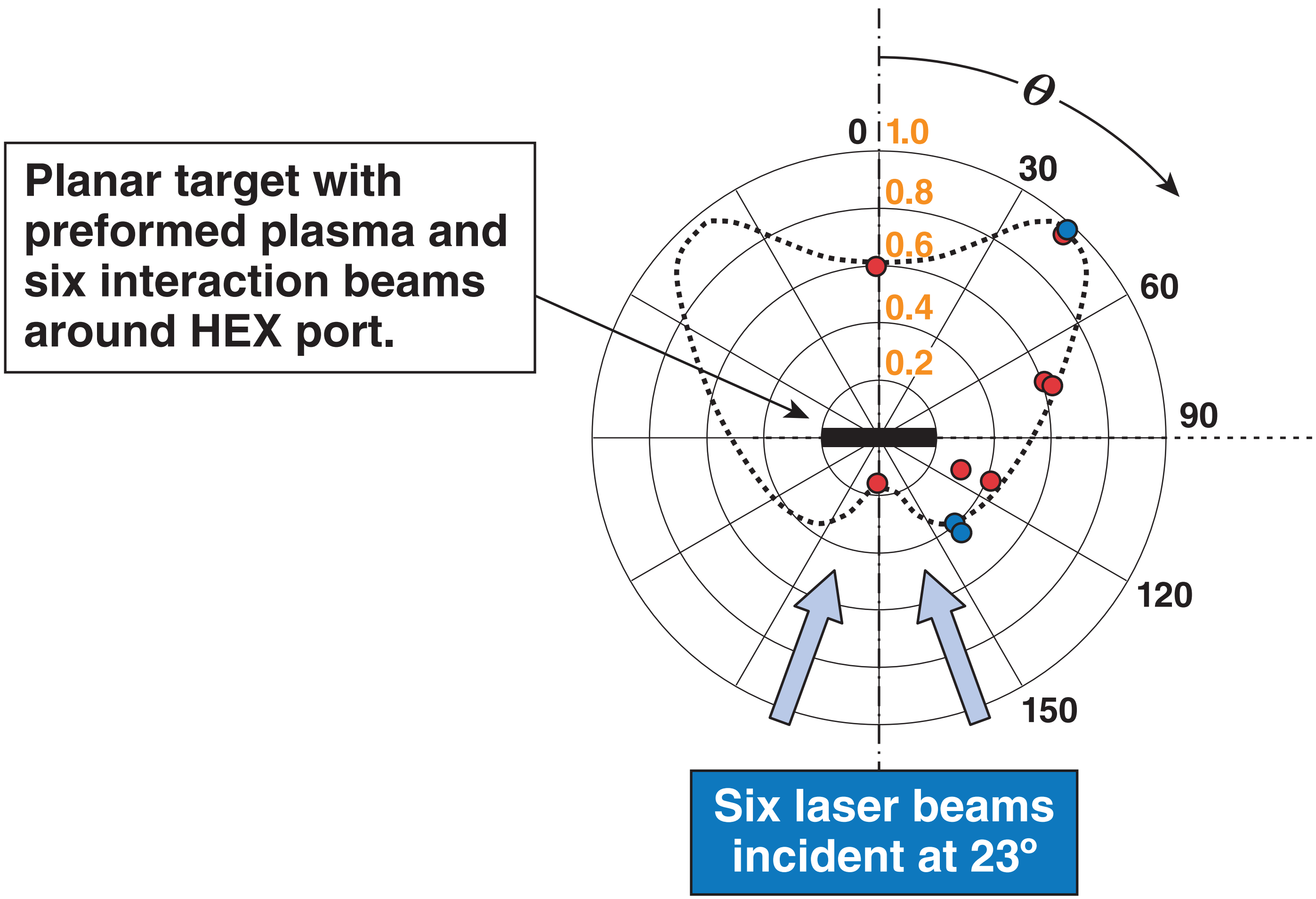
Polar plot of measured hard x-ray emission ($h\nu_x > 40$ keV)



E16824

*J. Myatt, this conference.

Summary/Conclusions

Shared plasma waves appear to be responsible for fast-electron generation caused by the TPD instability in direct-drive-implosion experiments

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E16812