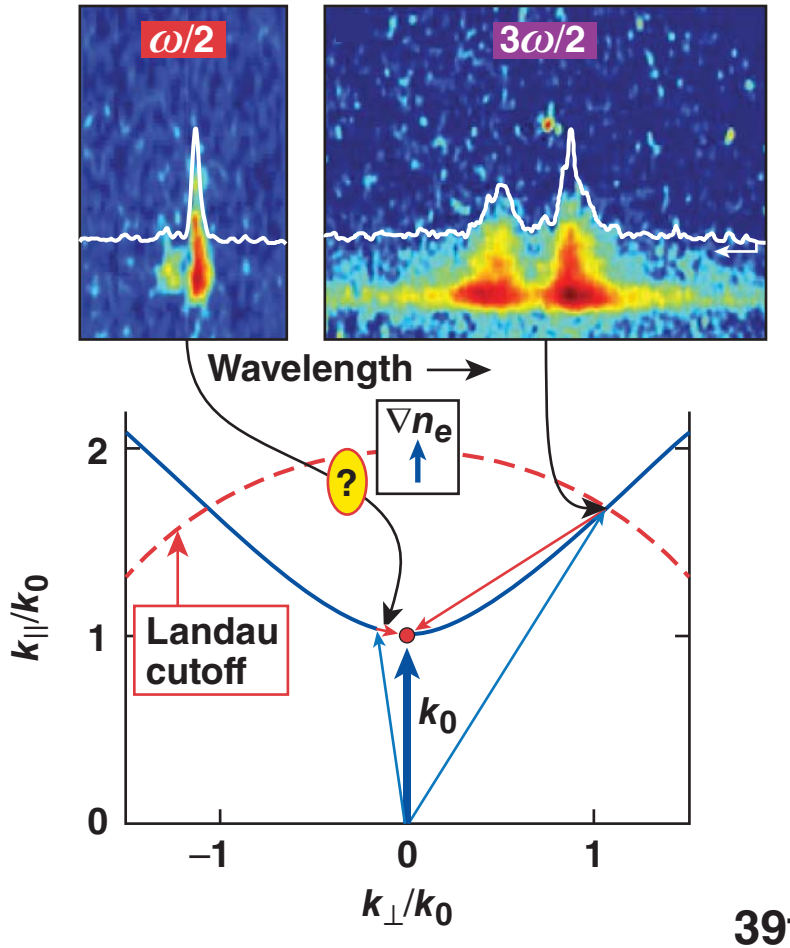
Two-Plasmon-Decay Instability Relevant to Direct-Drive Experiments



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Summary

The TPD thresholds are close to those predicted by Simon *et al.*,[1] but all other observations are deep in the saturated regime

UR LLE

- $3\omega/2$, $\omega/2$, and hard x-ray emission are the standard diagnostics for TPD
- Nonlocality of plasma waves renders TPD instability insensitive to speckle → samples entire intensity distribution → threshold
- The temporal coincidence of $3\omega/2$, $\omega/2$, and x-ray emission are indicative of the highly nonlinear stage of TPD
- The $3\omega/2$ emission (Thomson up-scattering) results from the deeply nonlinear stage of TPD near $k\lambda_{De} \sim 0.25$
- The $\omega/2$ emission has been interpreted as indicative of small-*k* plasmons
  - new theory (DuBois) and Zakharov simulations point to alternative interpretation: *nonlinear conversion from IAW density fluctuations* near the Landau cutoff

E18002

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

Collaborators

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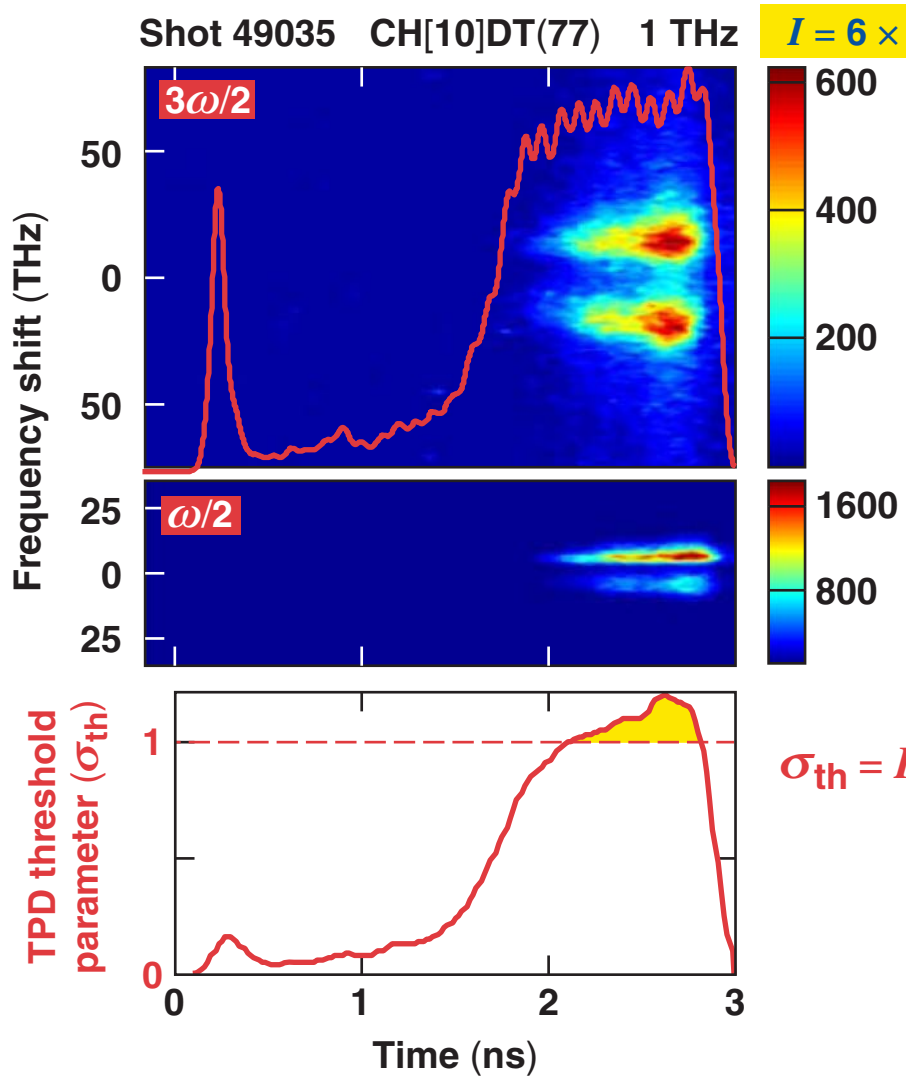
University of California–Davis

Direct-drive-implosion data generally agree well with predicted linear thresholds



$\sigma_{th} = I_{14} L_{n,\mu m}/(230\ T_e, \text{keV})$

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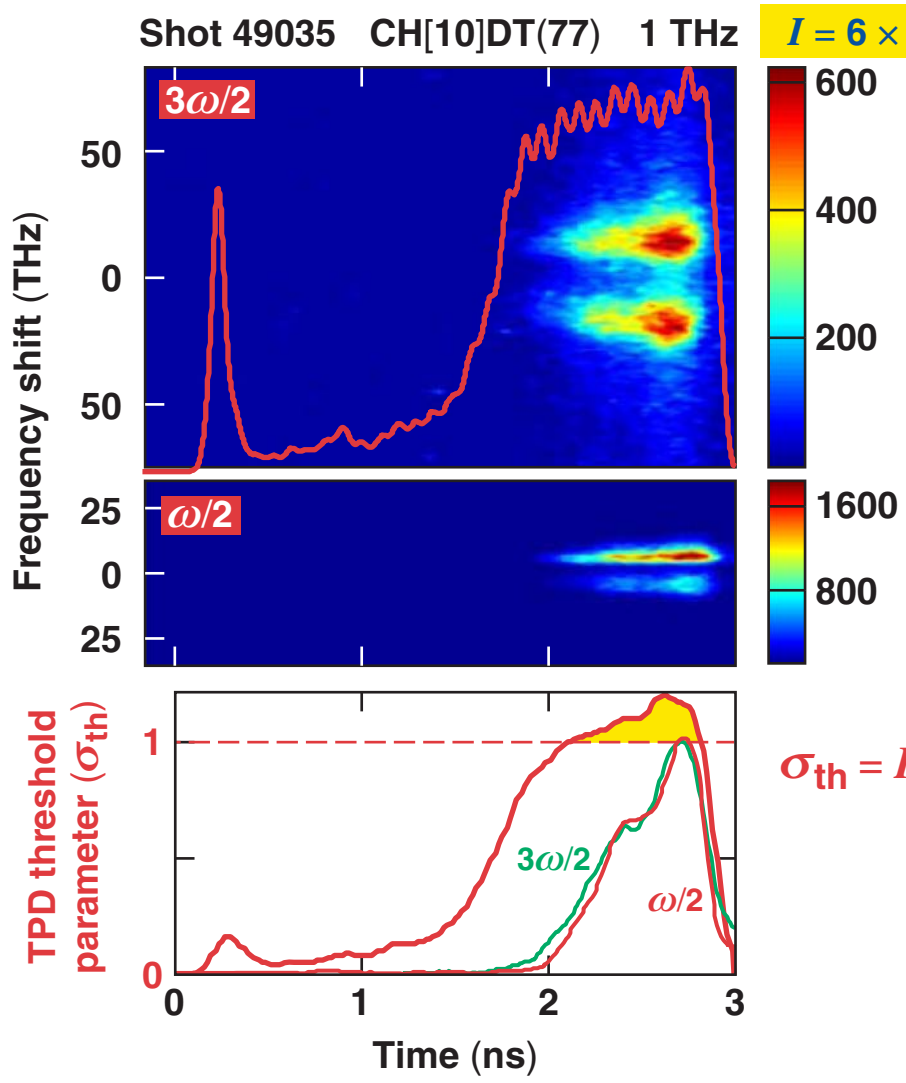
E18003

Direct-drive-implosion data generally agree well with predicted linear thresholds



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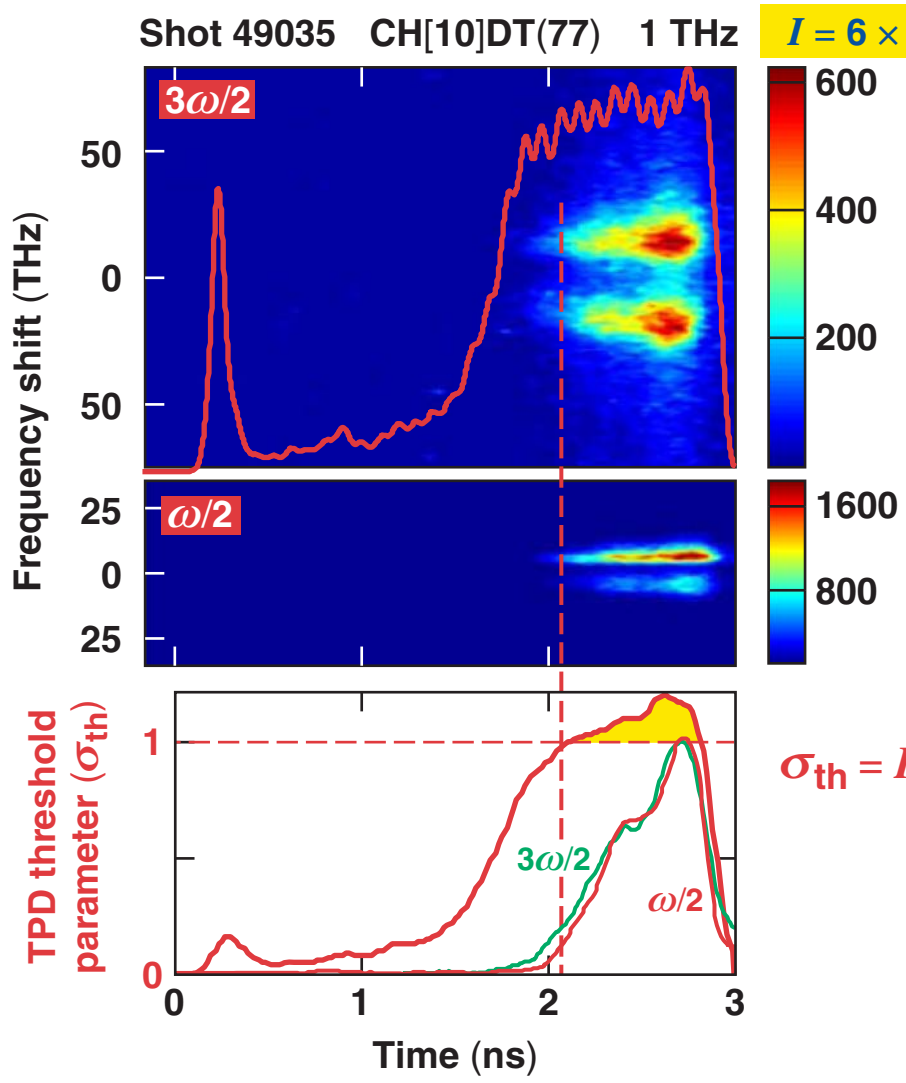

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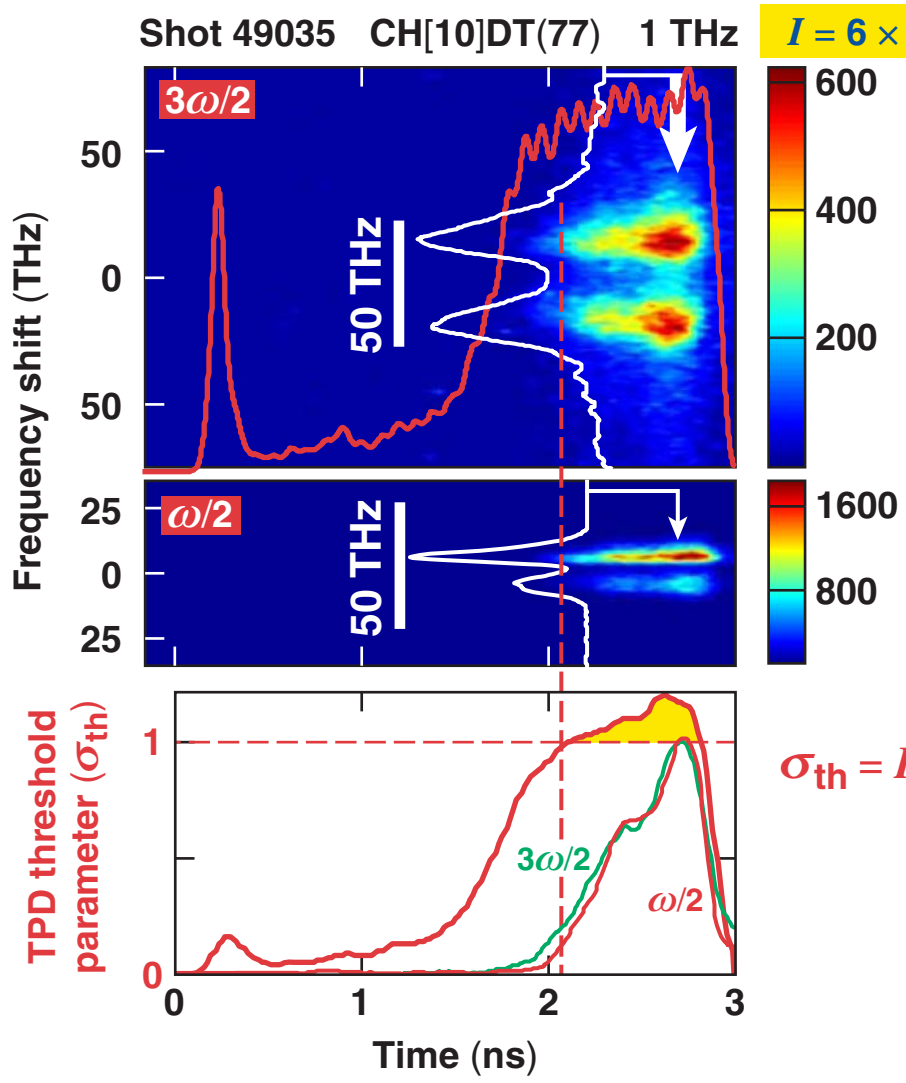

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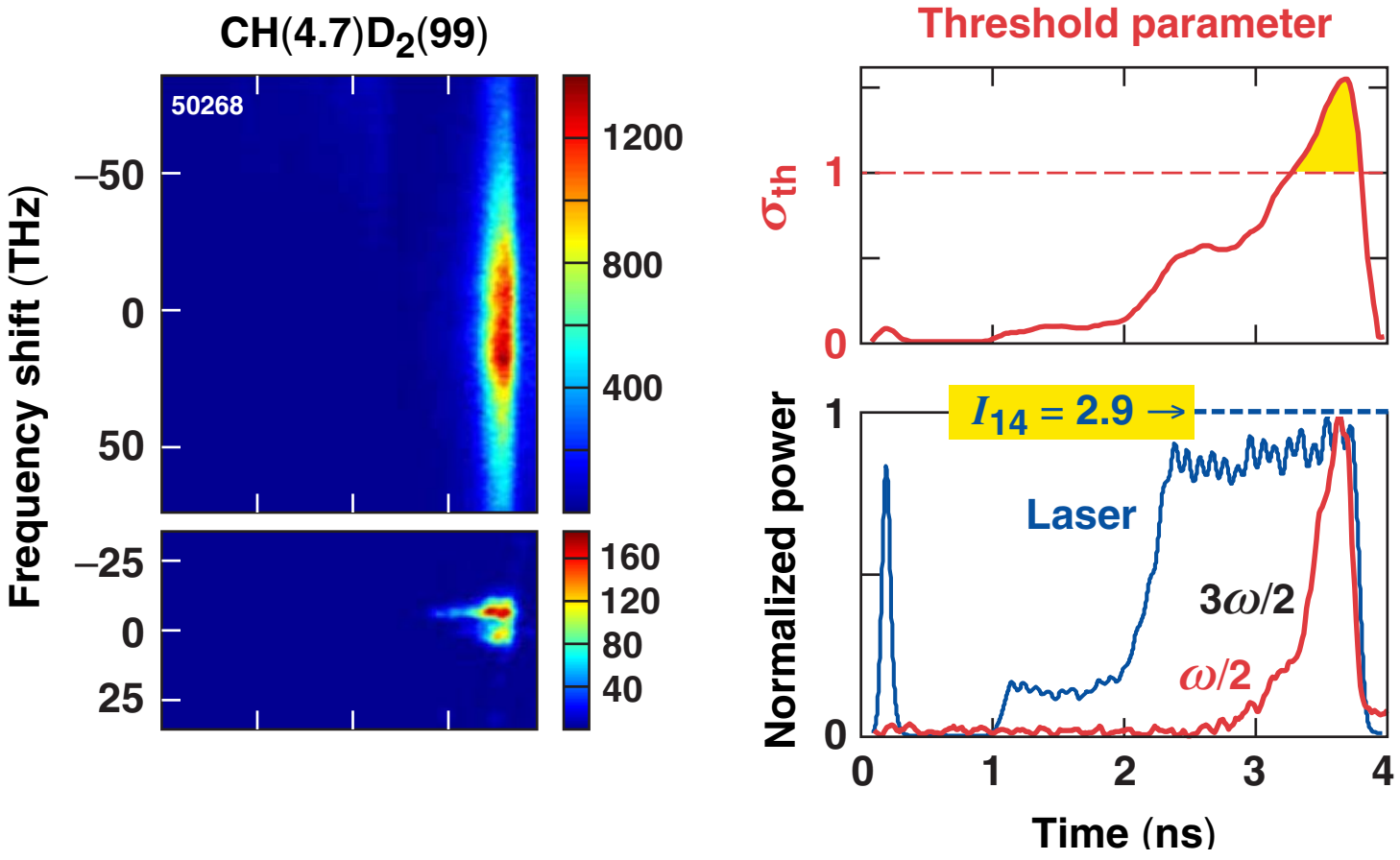
E18003

If $\omega/2$ and $3\omega/2$ emissions originate at ~0.245 n_c and 0.2 n_c one might expect different temporal signatures, but they are basically identical



E18004

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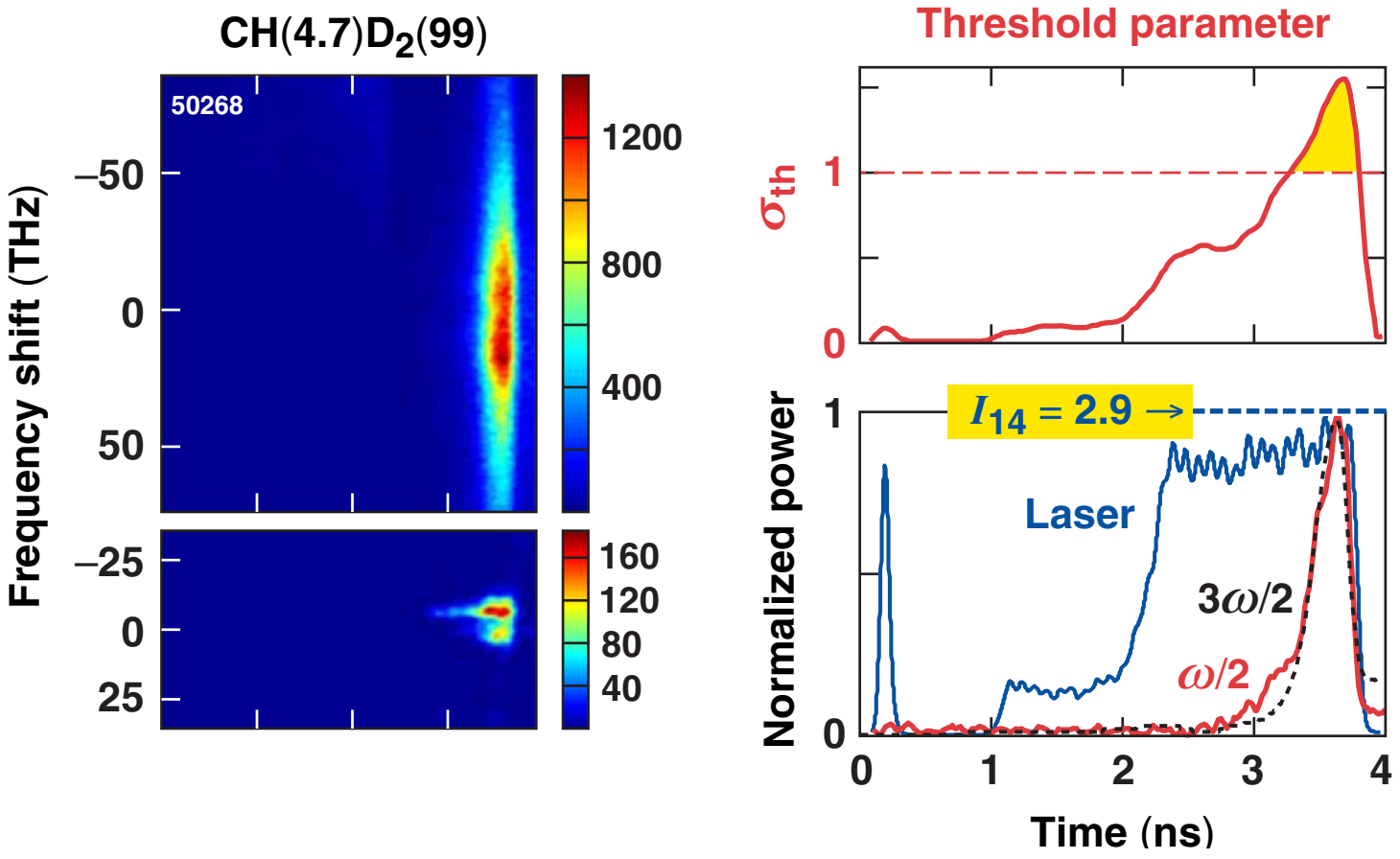

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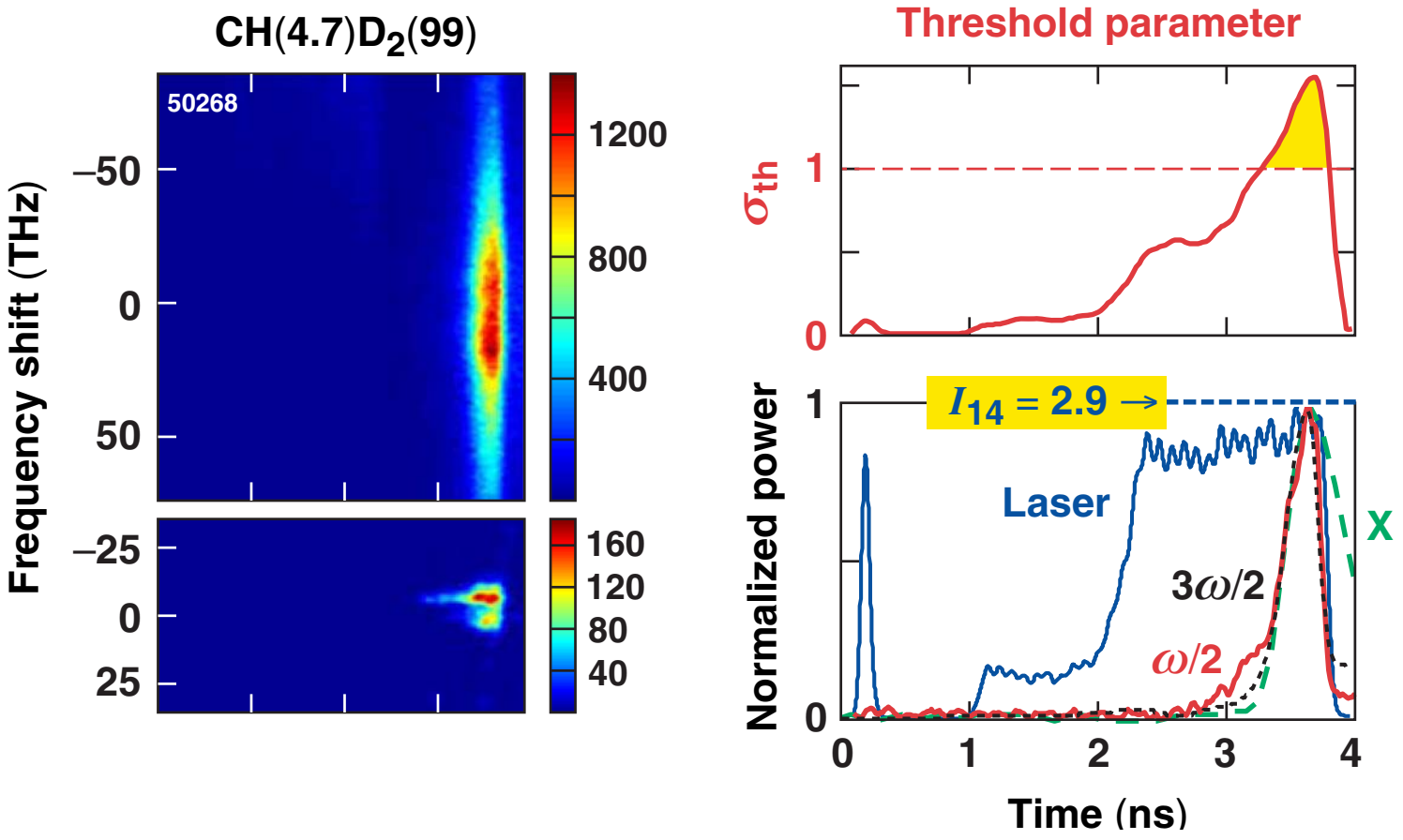

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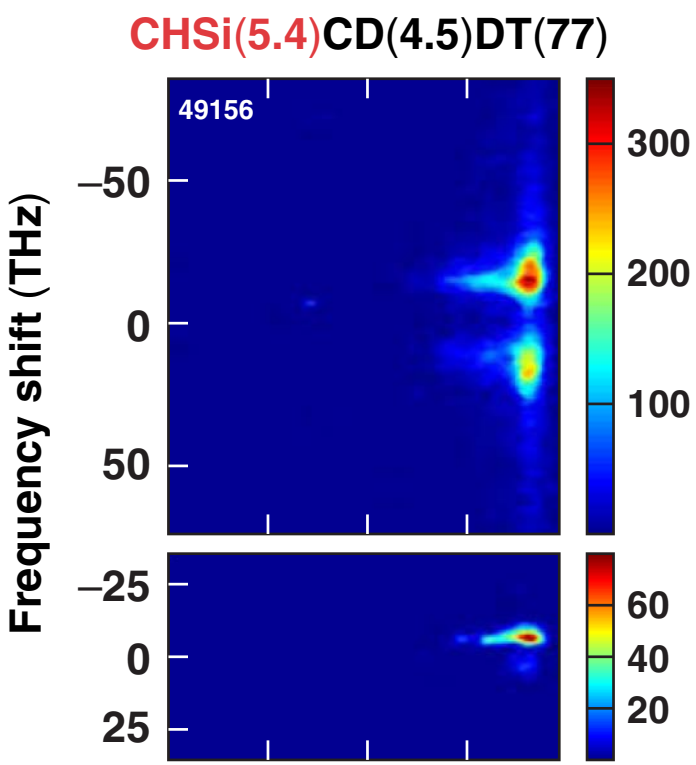

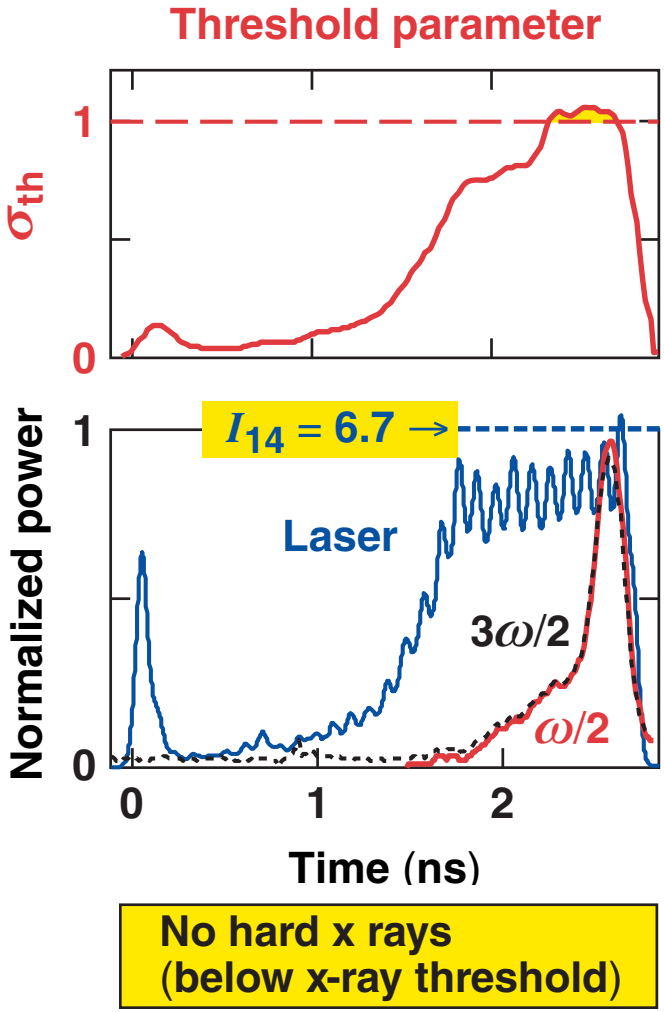

No hard x rays
(below x-ray threshold)

E18005

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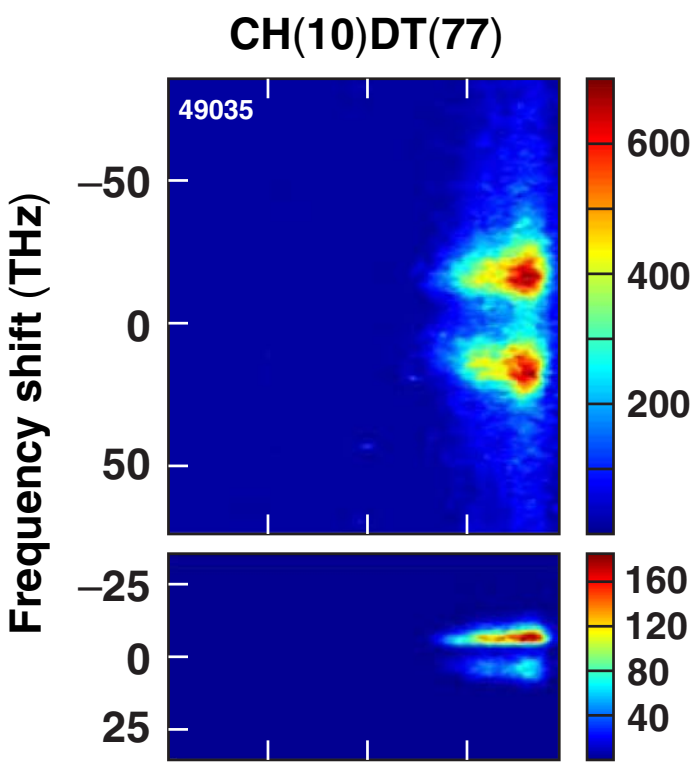

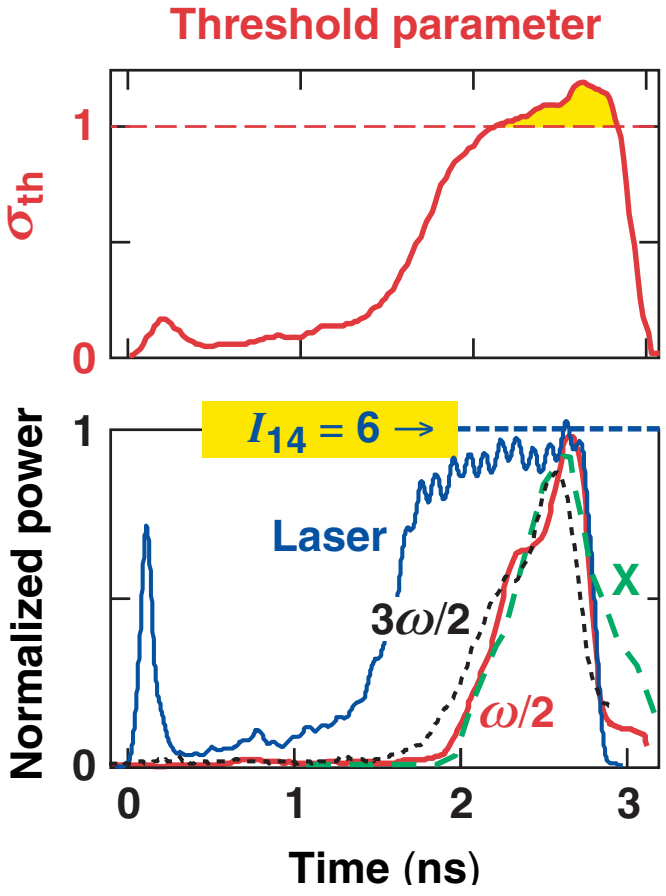

E18006

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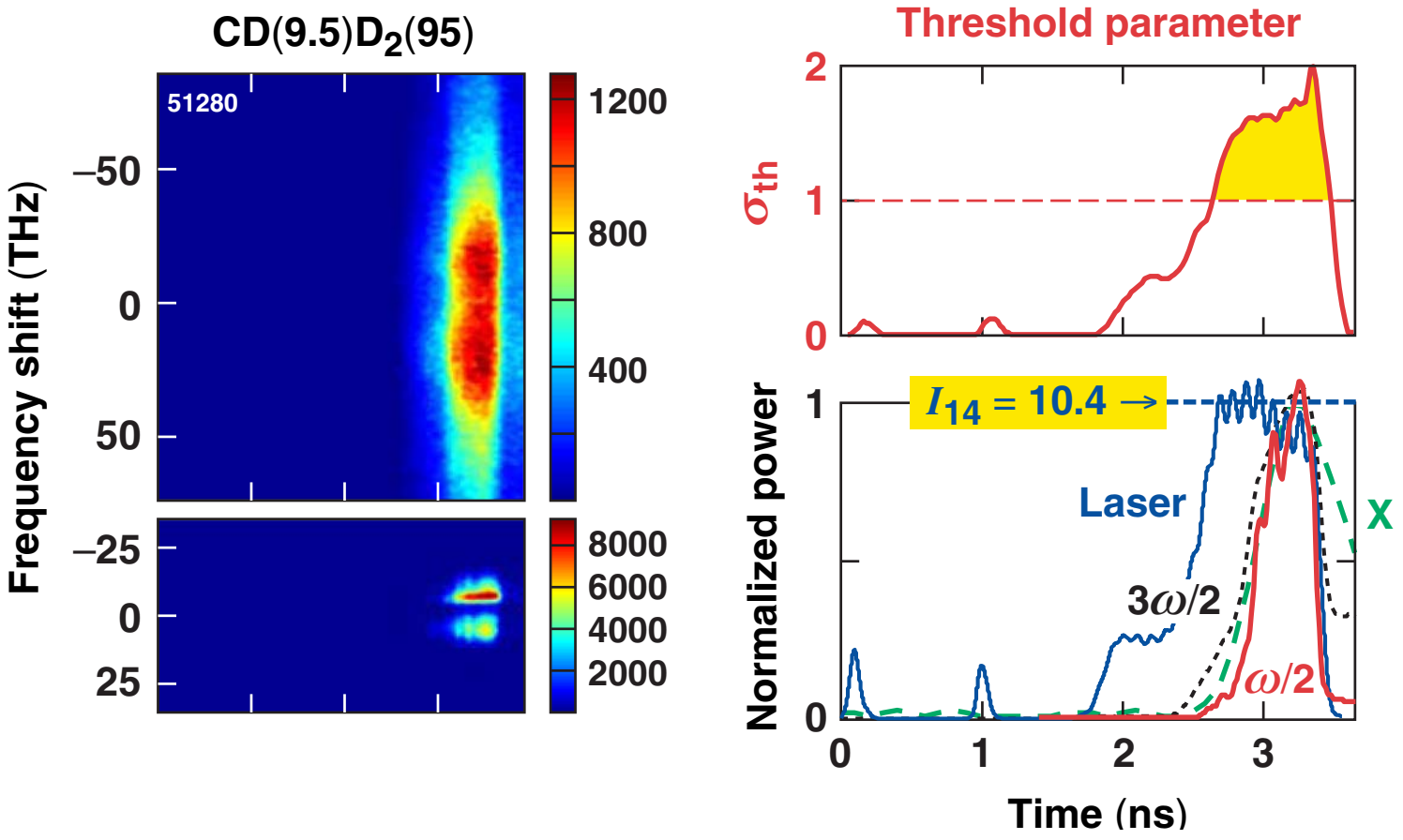
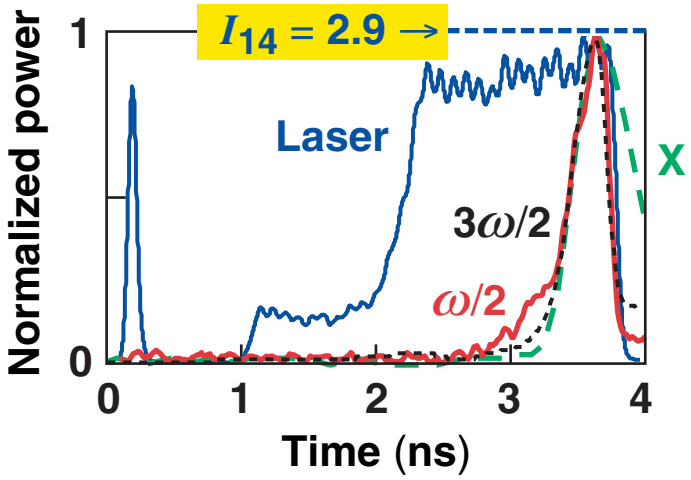


E18007

The coincidence of emission history for $\omega/2$, $3\omega/2$, and x rays strongly hints at a common origin

- If $\omega/2$ were emitted near $n_c/4$ and $3\omega/2$ near 0.20 n_c, it would be difficult to see how the temporal behavior could be so close.
- This is particularly striking when comparing the behavior close to threshold and well beyond.
- The coincidence of the x rays with the half-integer harmonic emission is seen only for thick (≥5-μm) CH shells.
- Don DuBois suggested an alternate interpretation of $\omega/2$ emission in terms of *inverse parametric decay instability*.



E18008

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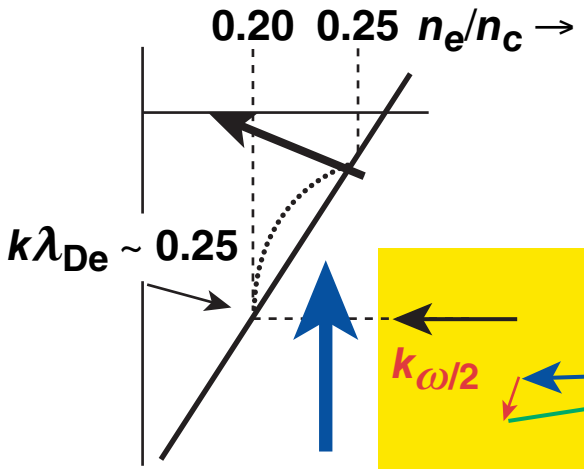
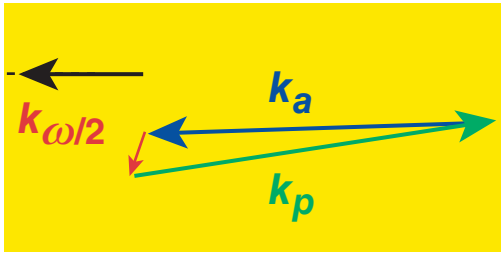
- This is particularly striking when comparing the behavior close to threshold and well beyond.
- The coincidence of the x rays with the half-integer harmonic emission is seen only for thick (≥5-μm) CH shells.
- Don DuBois suggested an alternate interpretation of $\omega/2$ emission in terms of nonlinear conversion from IAW density fluctuations.





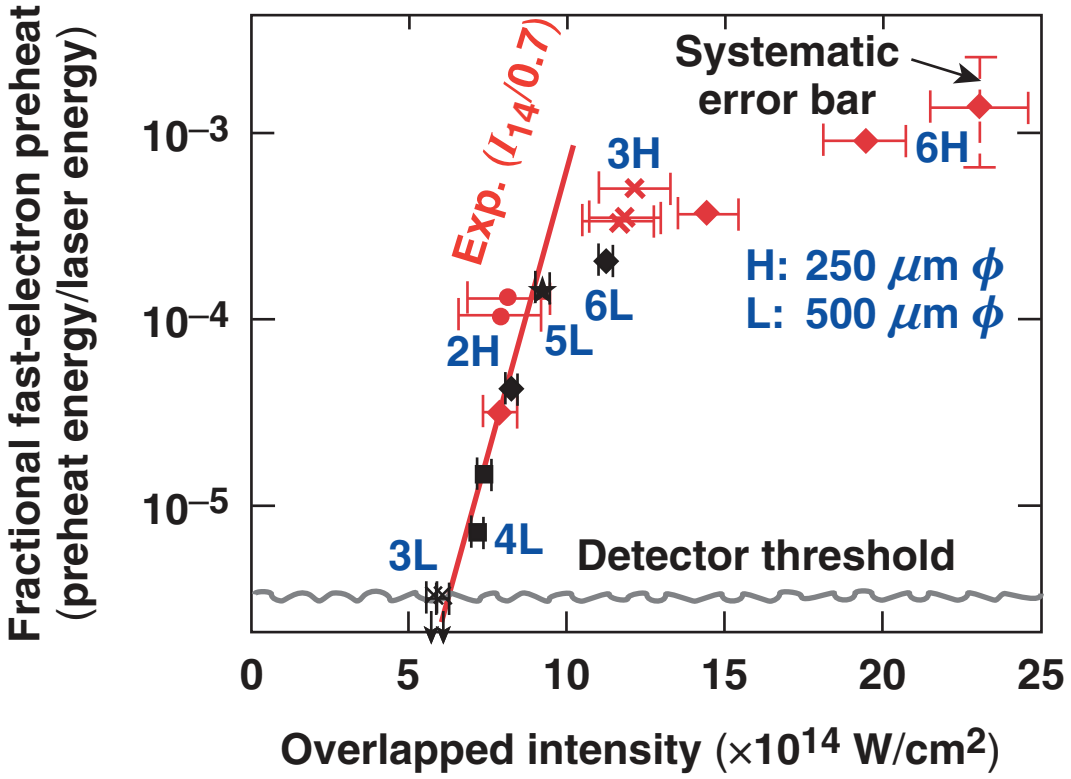
Nonlinear conversion from IAW density fluctuations can efficiently generate $\omega/2$ light at 0.20 n_c, making use of large k's of plasma waves and ion waves near the Landau cutoff

E18009

Past experiments at LLE have shown that the TPD instability is insensitive to speckles and responds only to overlapped intensity

UR LLE

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



E12304c

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

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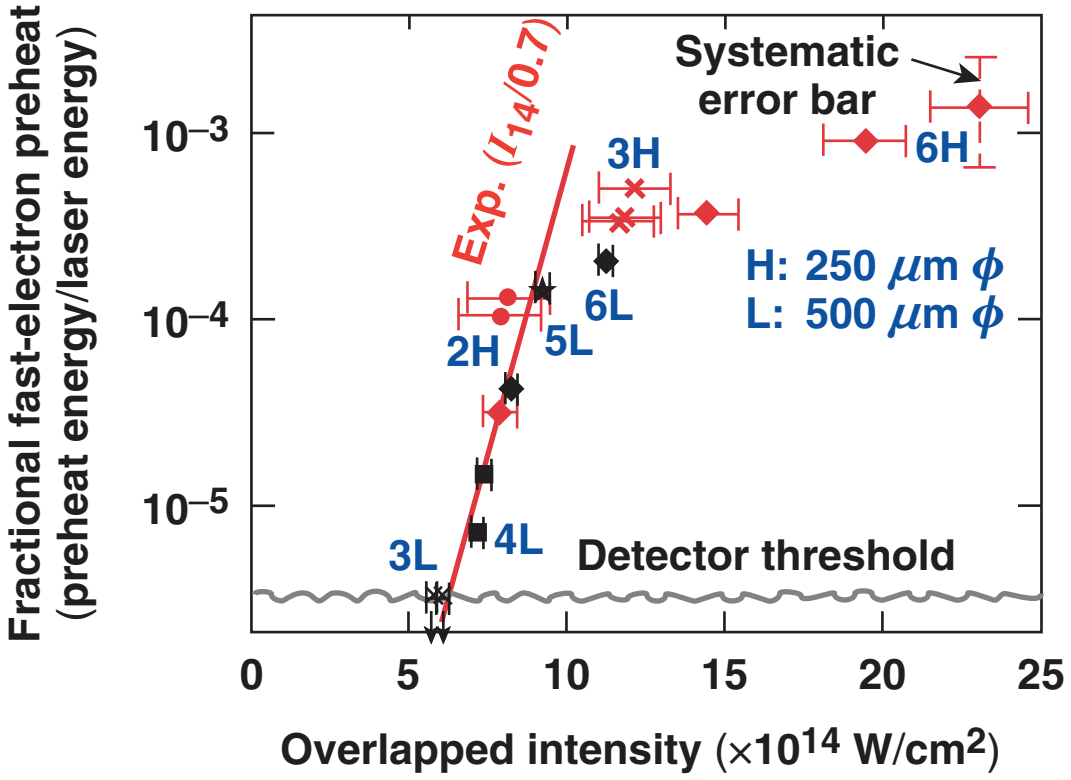

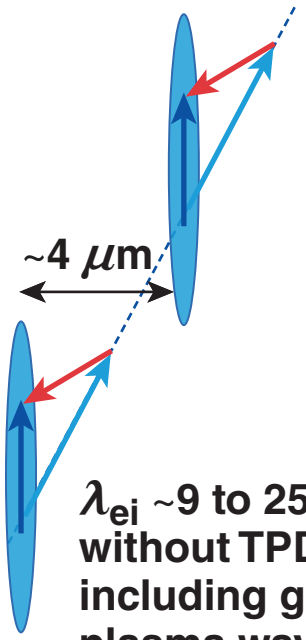

λ_{ei} ~9 to 25 μm without TPD gain; including gain, the plasma waves can sample the entire intensity distribution

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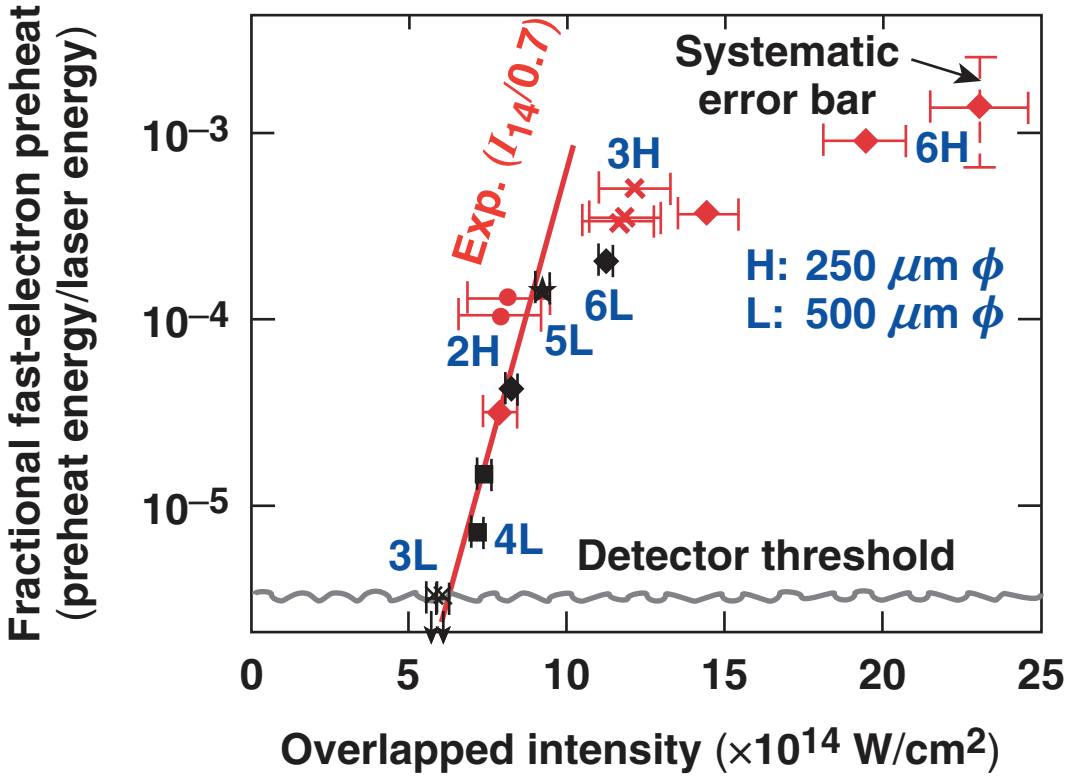
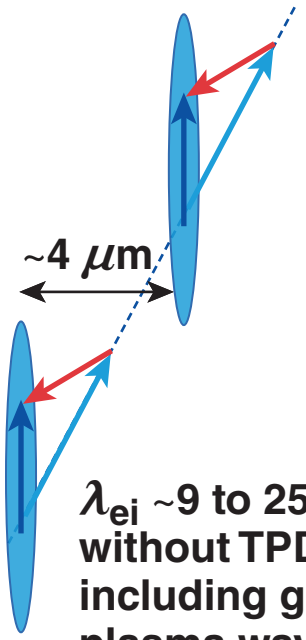




λ_{ei} ~9 to 25 μm without TPD gain; including gain, the plasma waves can sample the entire intensity distribution

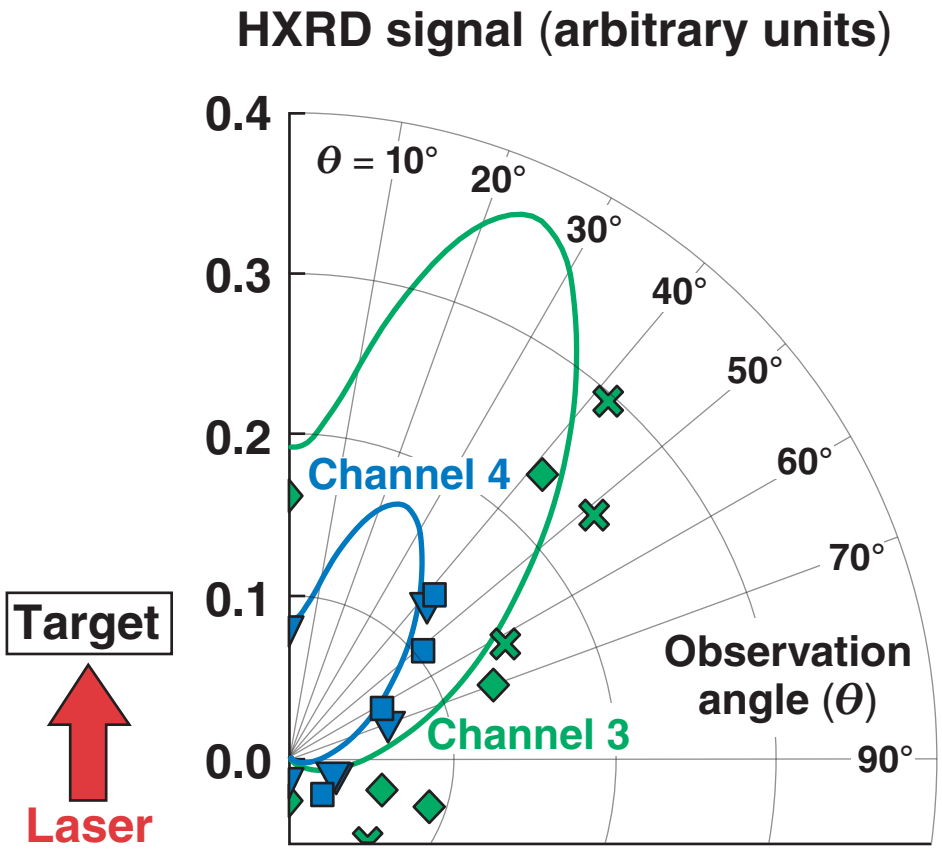
This may also explain why Simon's threshold formula is so successful.

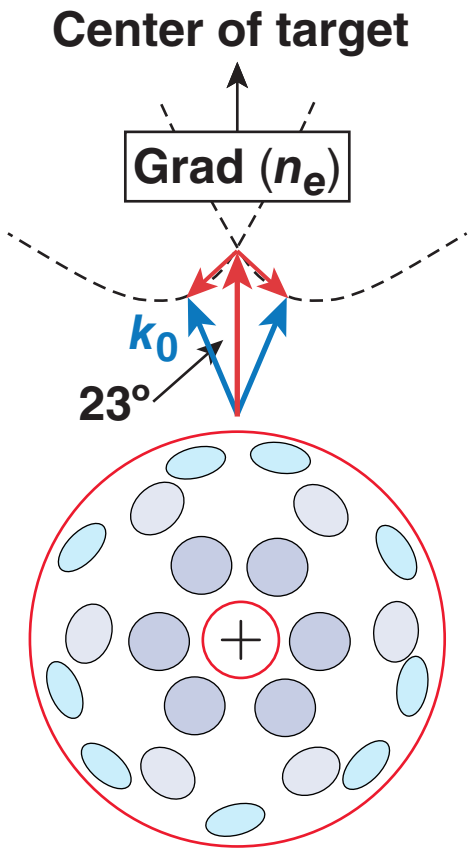
E12304c

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

The effect of overlapped beams has been seen in the hard x rays from planar targets irradiated with multiple beams

UR LLE

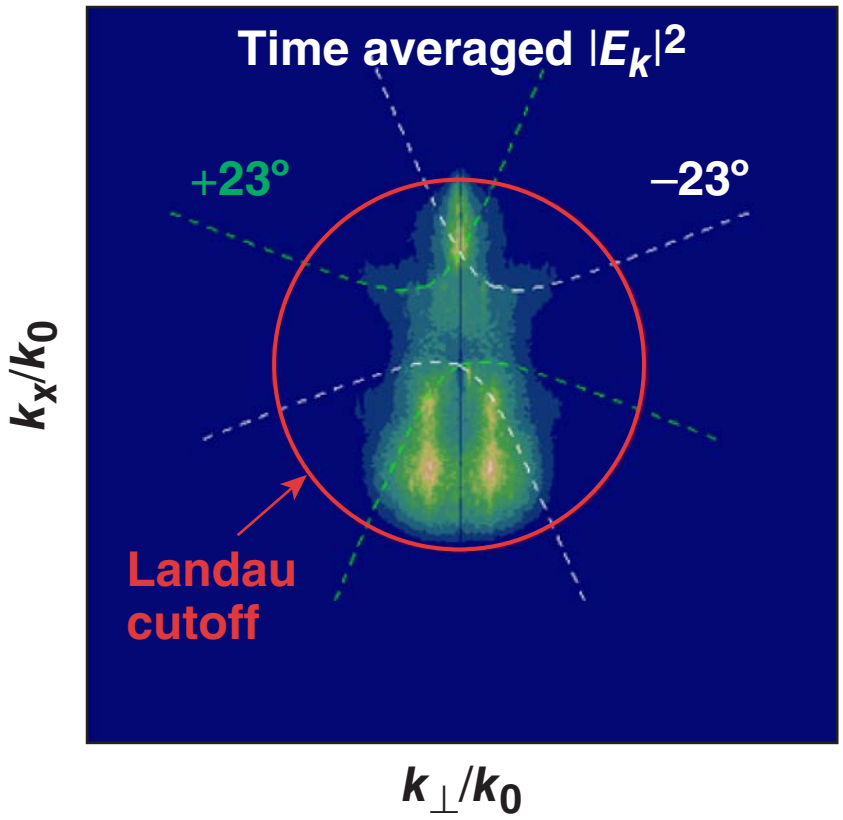


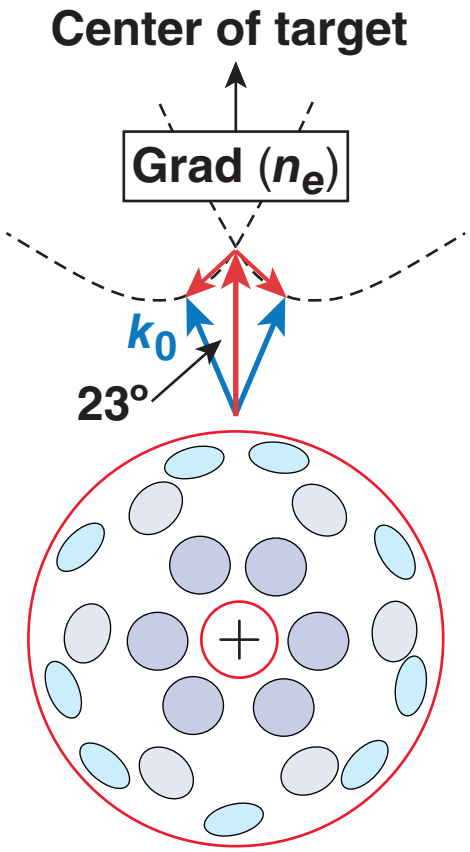


Symmetrically driven plasma waves propagate into target and preferentially drive electrons into target.

E18010

Zakharov simulations have reproduced the directed plasma waves and shown that they are driven toward the Landau cutoff





E18011

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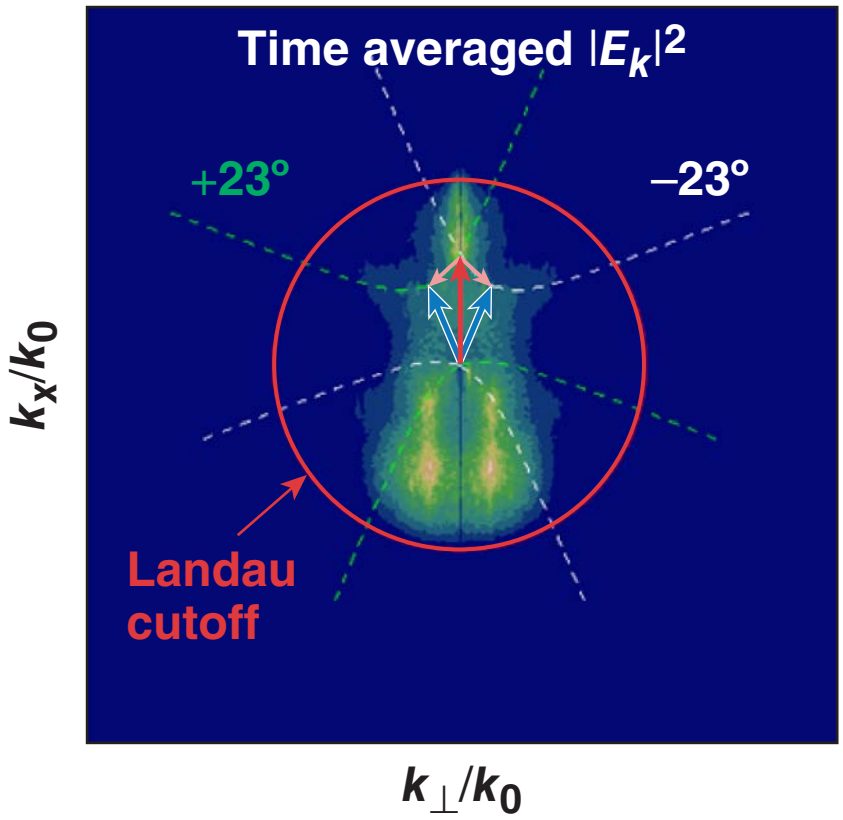
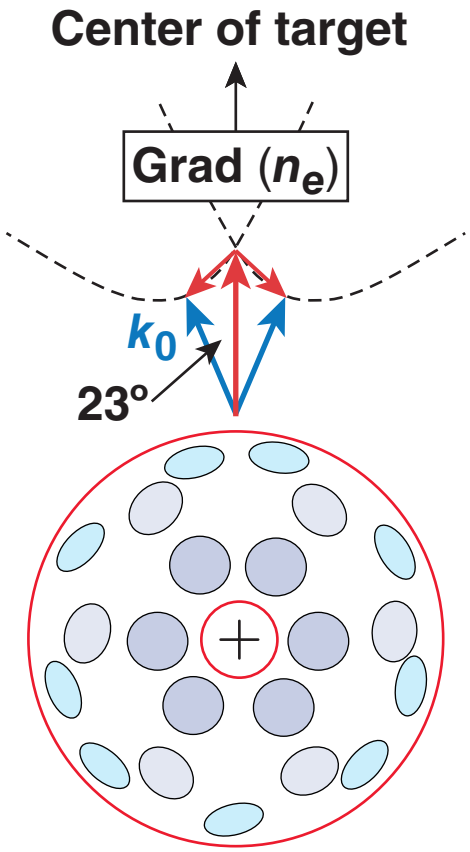
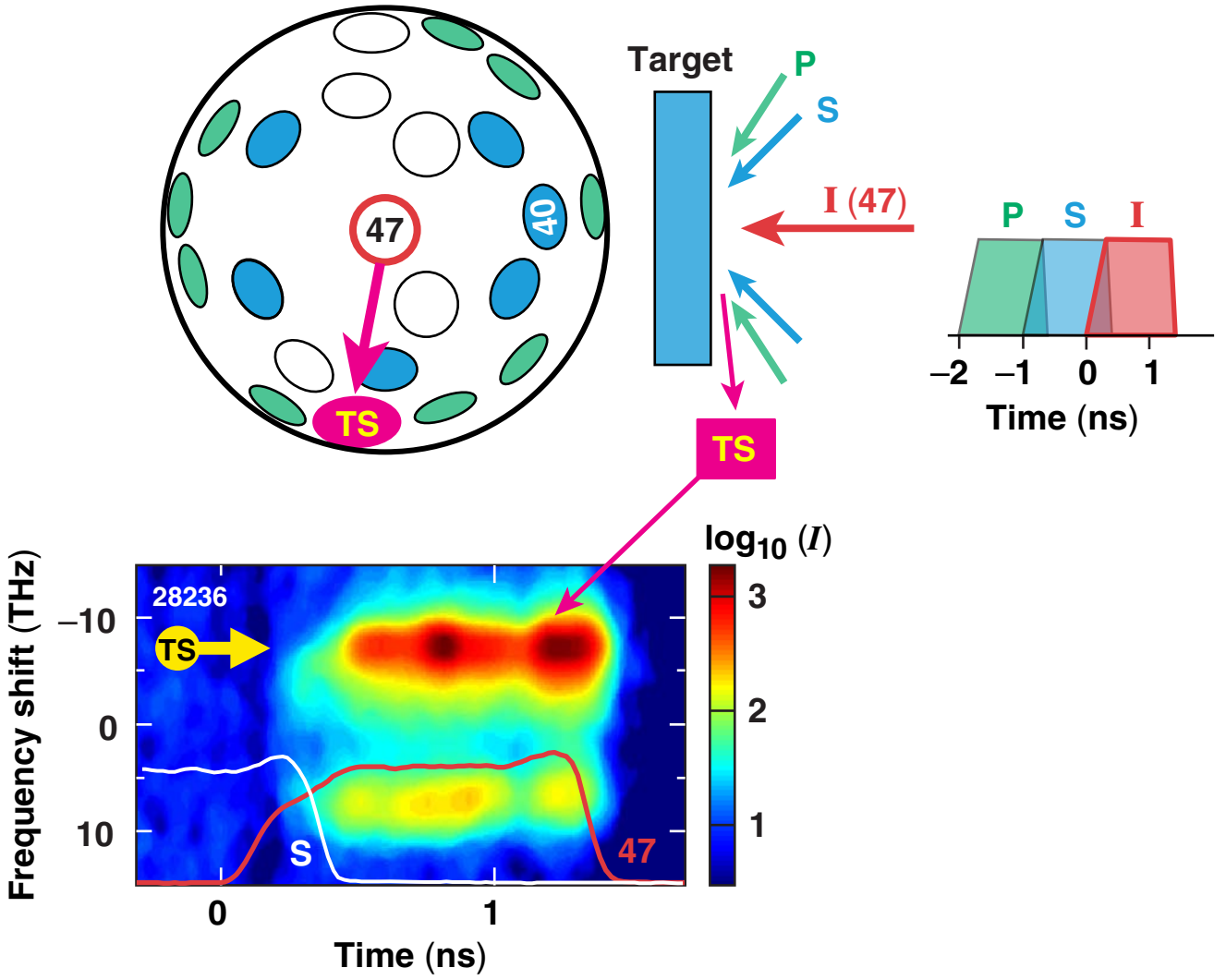




E18011

Thomson scattering in flat target experiments clearly established the Landau cutoff limit, $k\lambda_{De} \sim 0.25$, for TPD plasmons



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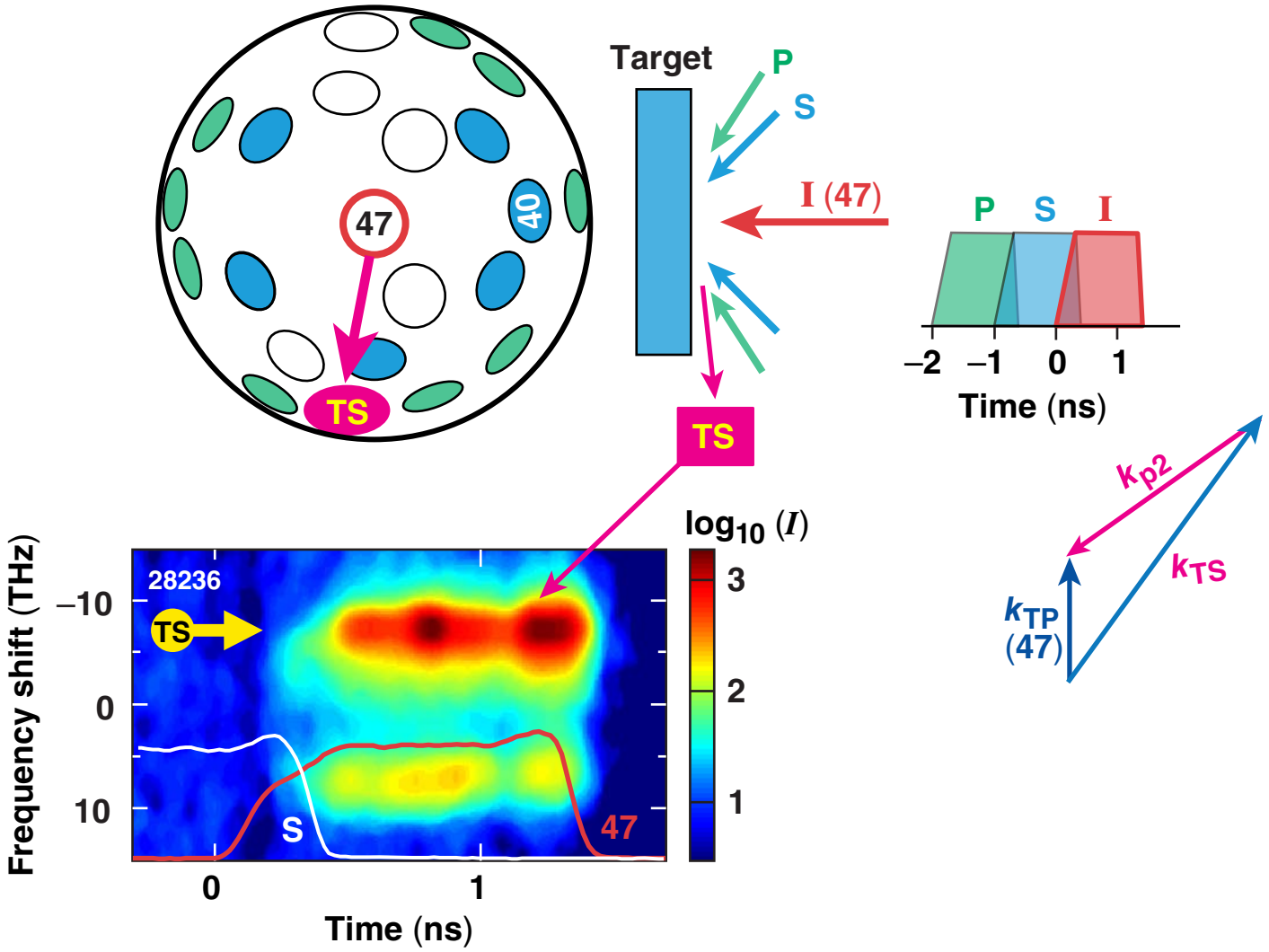

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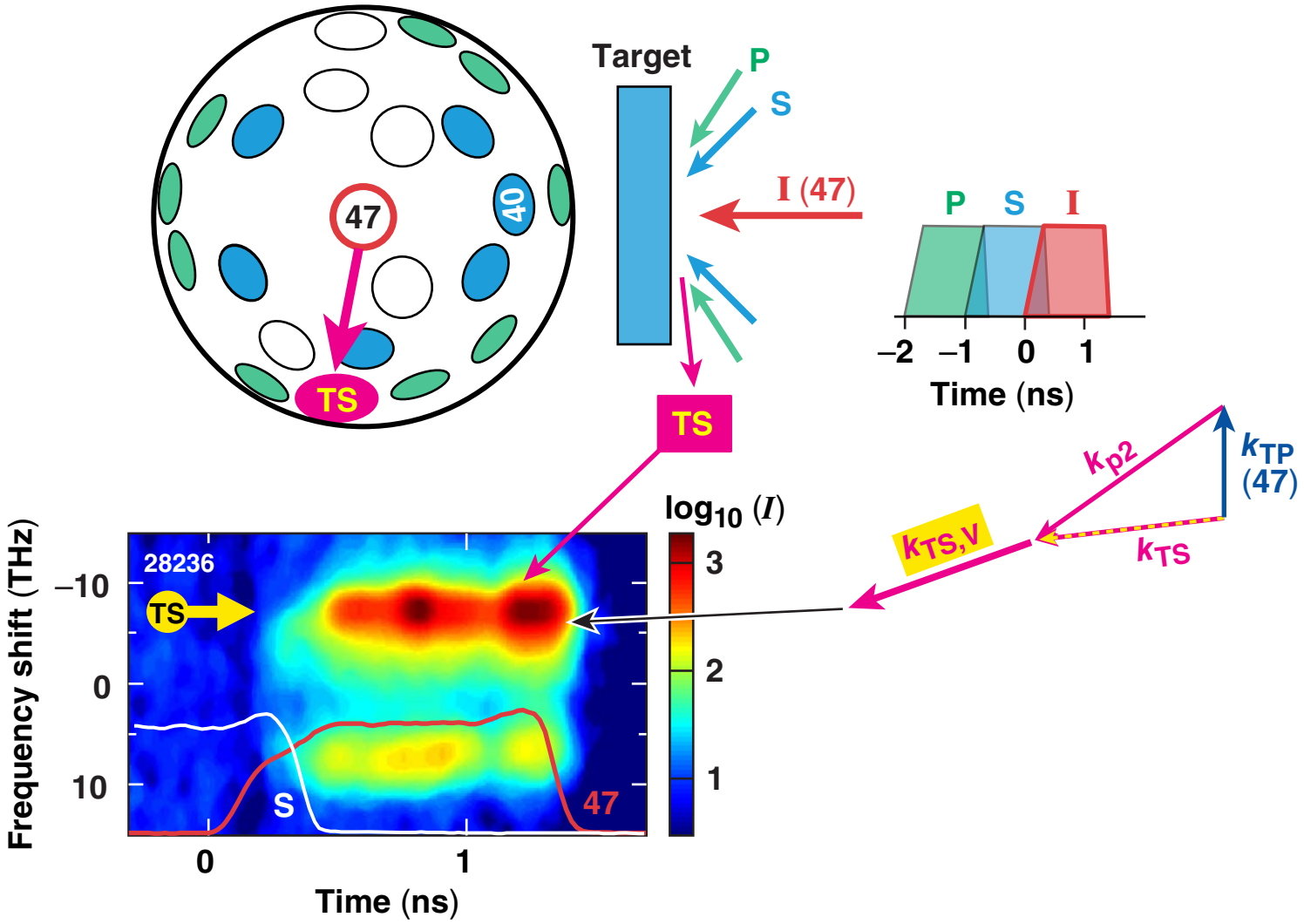

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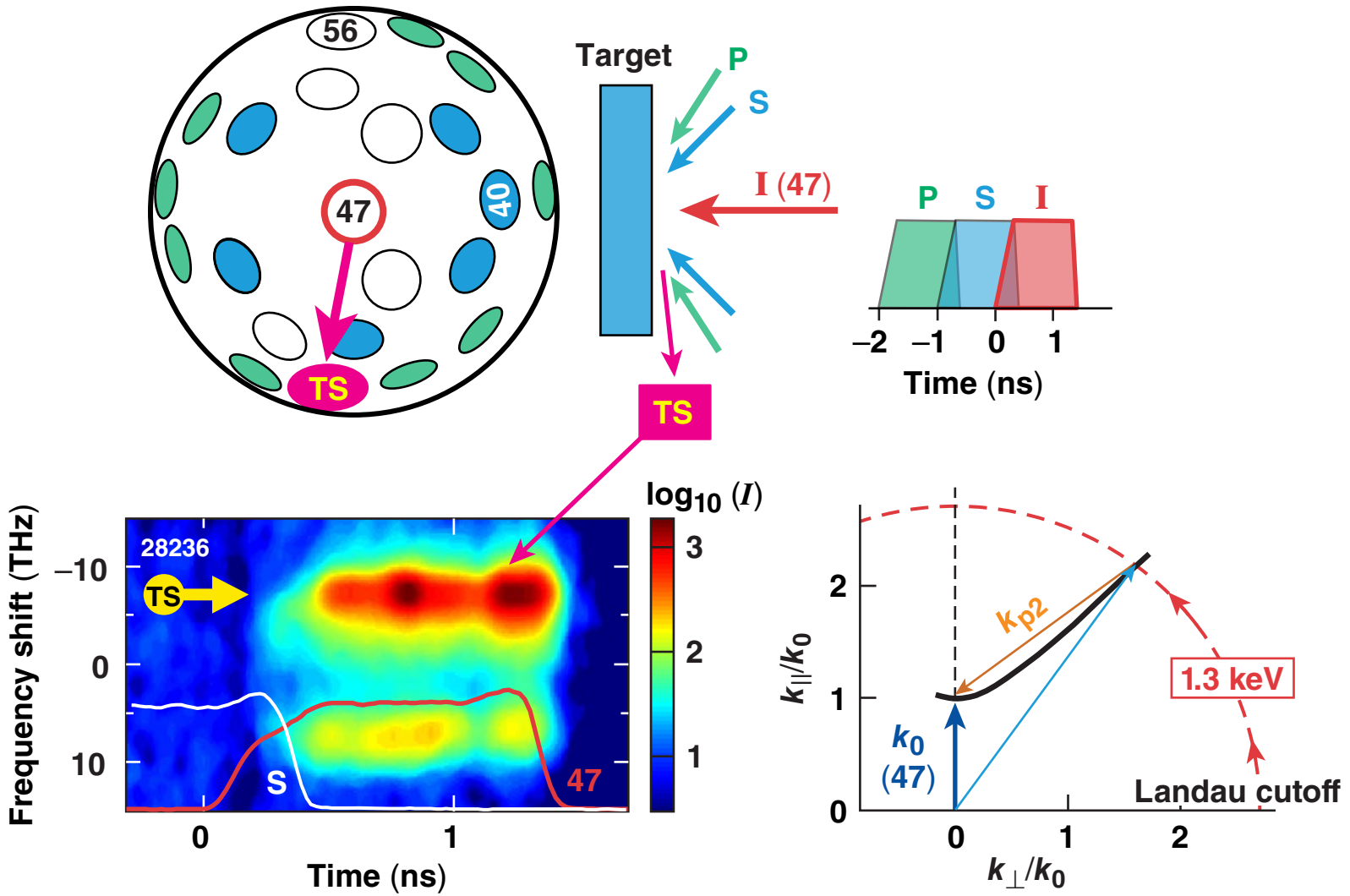
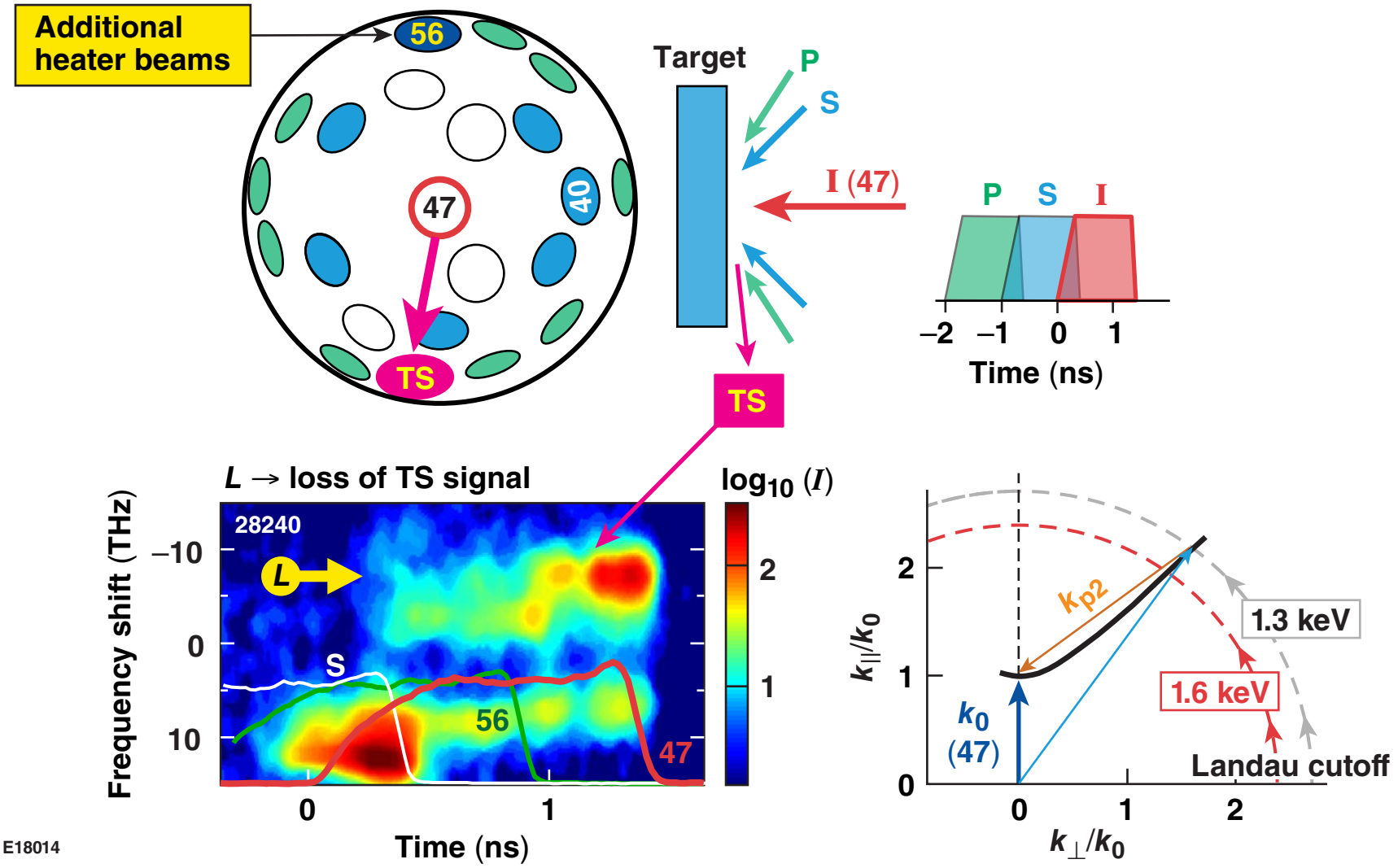


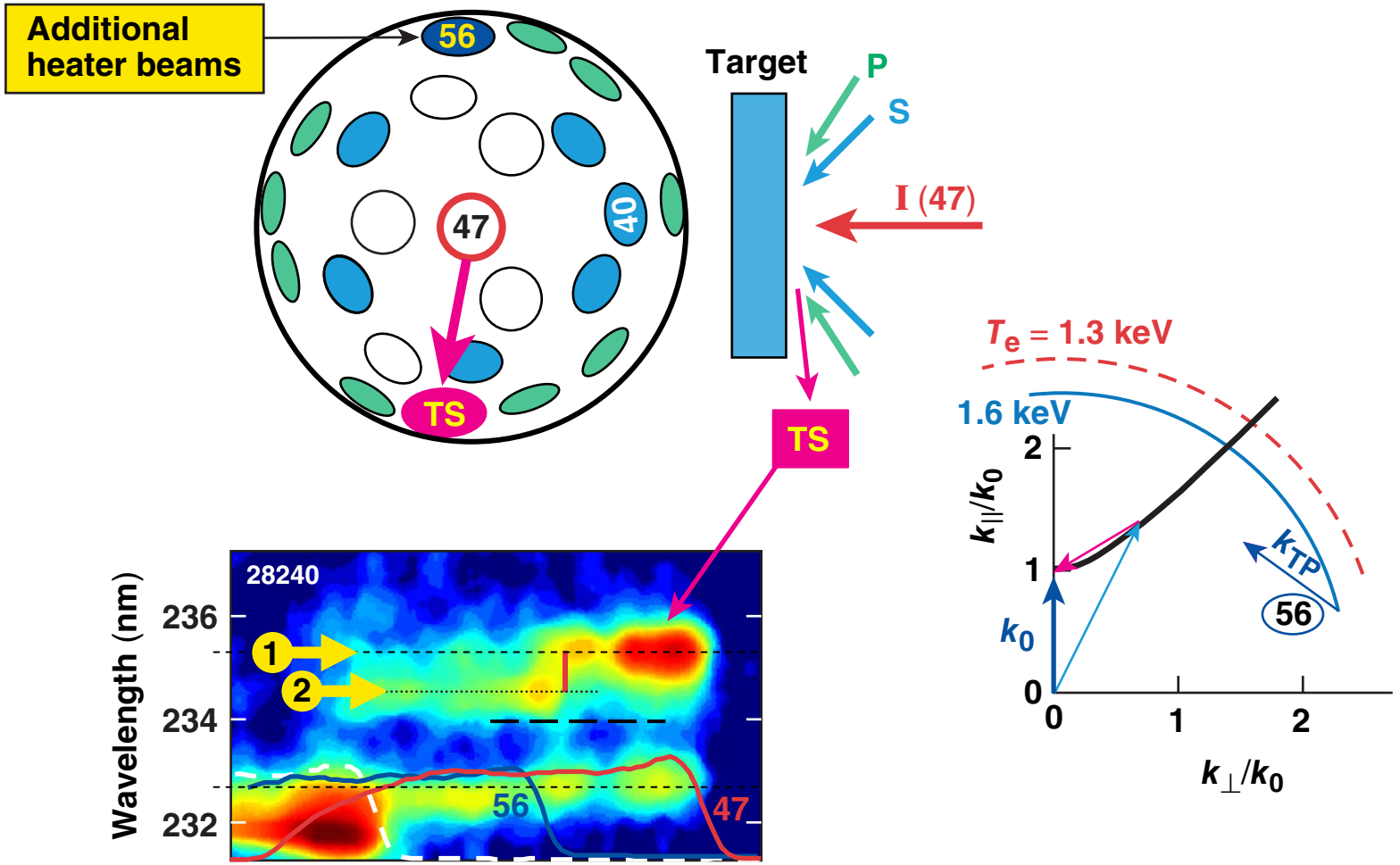
E18013

Thomson scattering probing plasma waves *above* the Landau cutoff results in loss of signal while the signal reappears after the plasma cools off



E18014

The Thomson *k*-matching conditions are consistent with the observed shift; the weakness of the feature is a likely indicator of the plasma-wave amplitude



E18015

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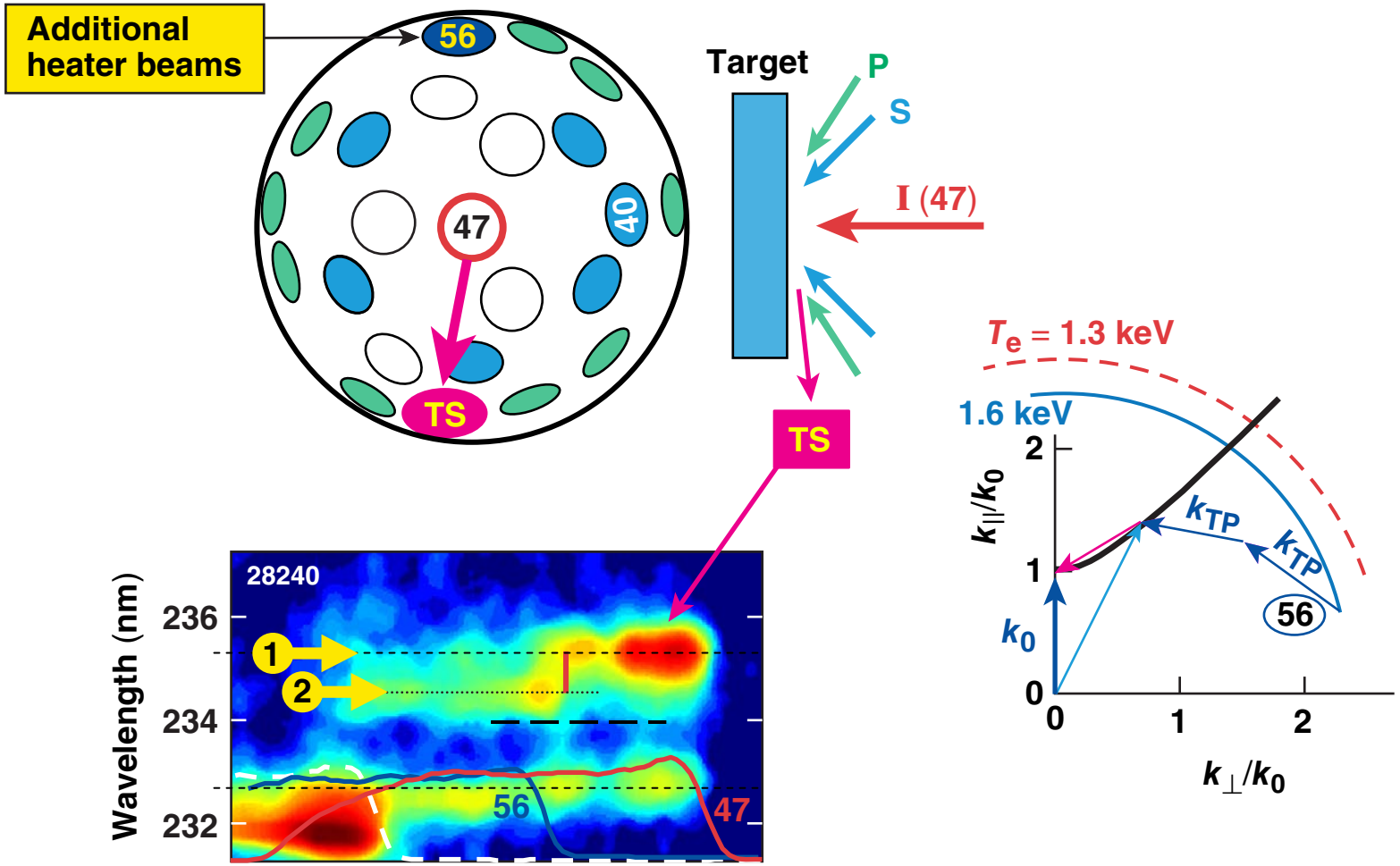

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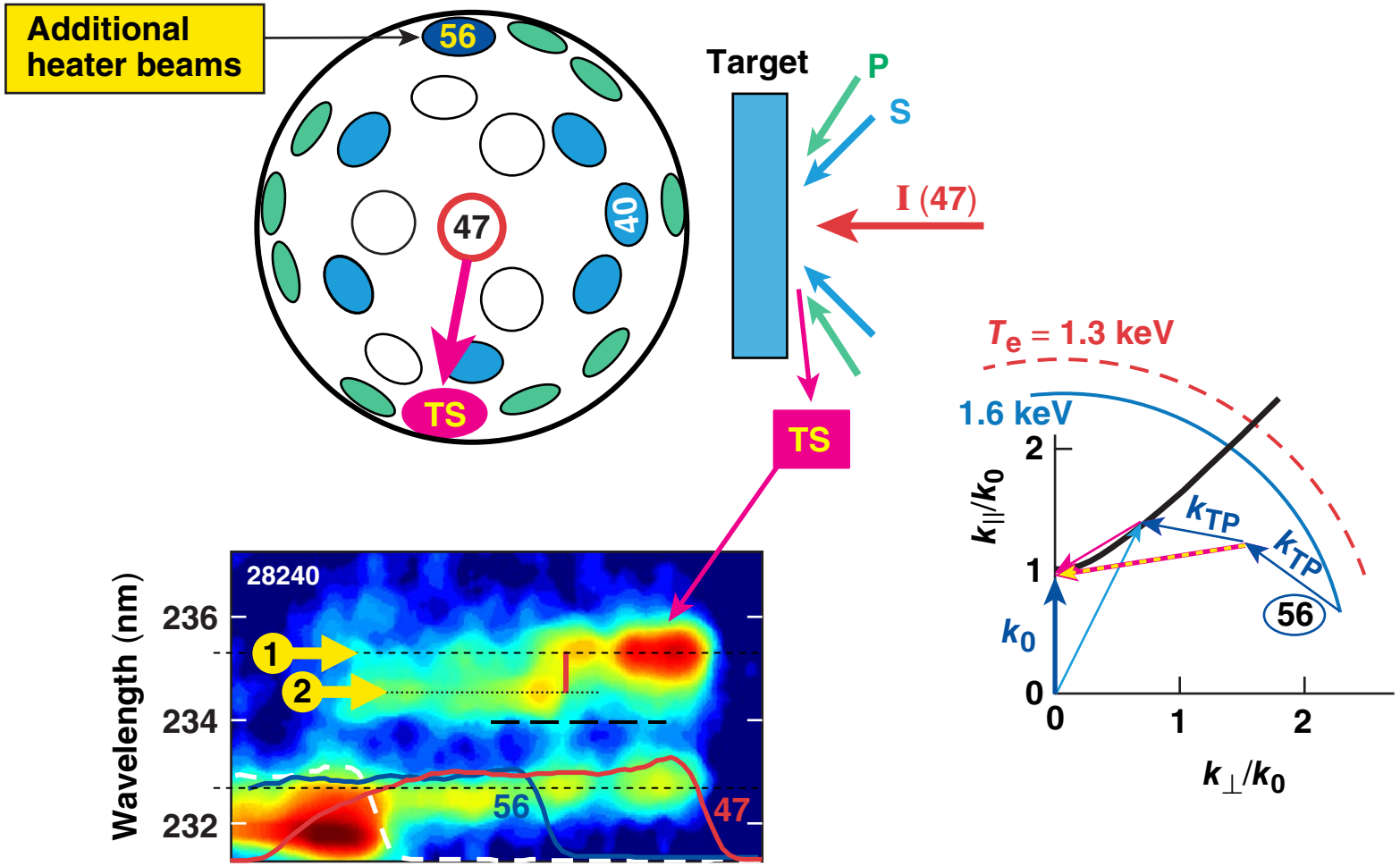

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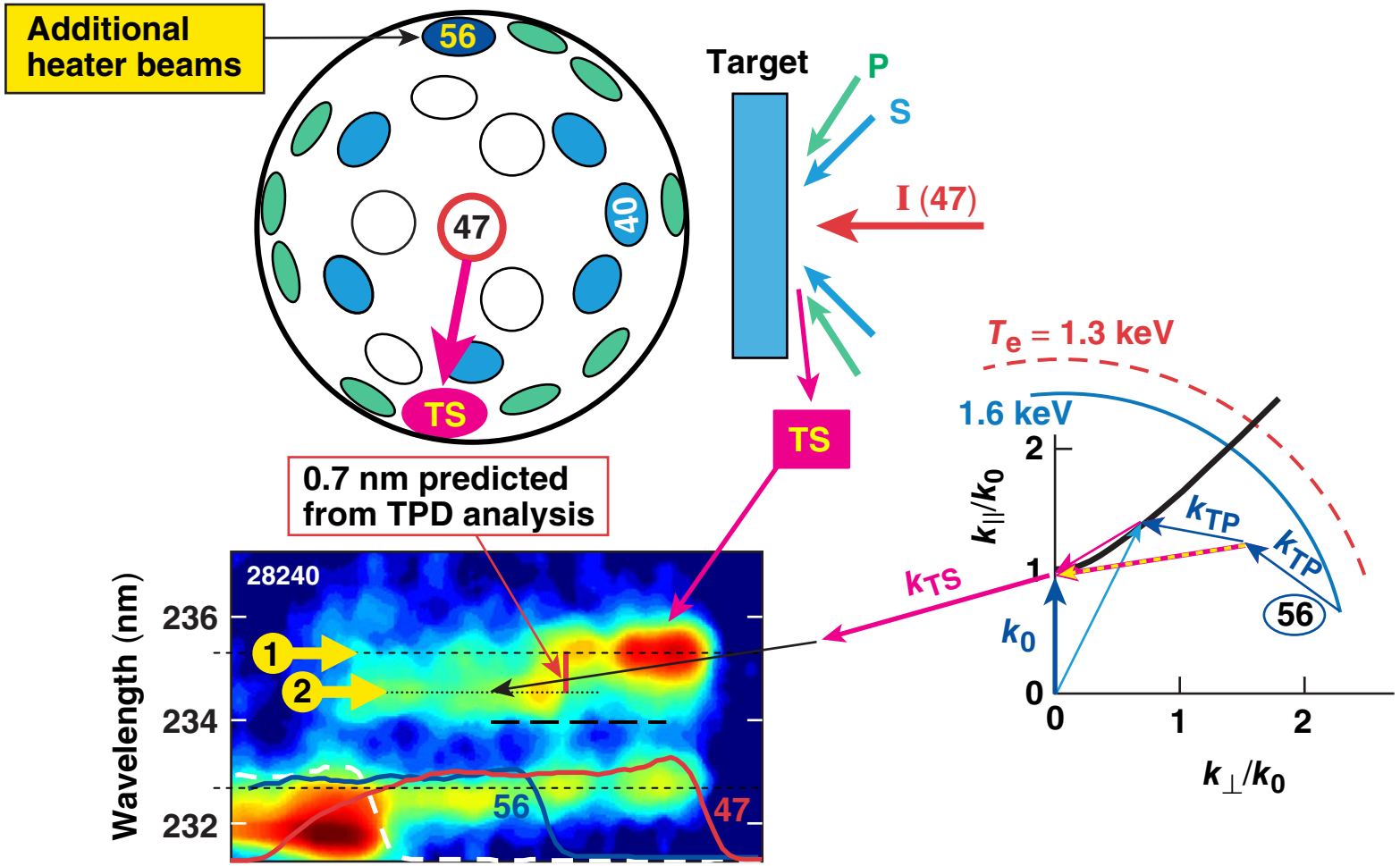
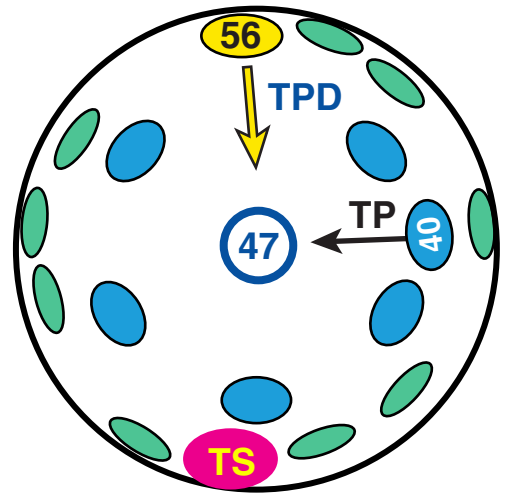
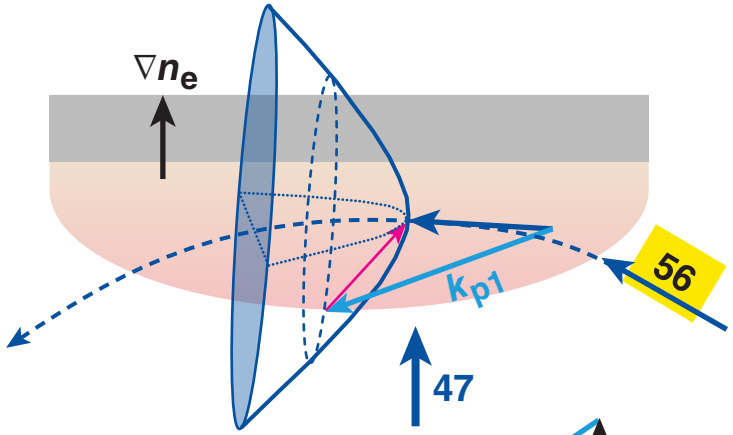
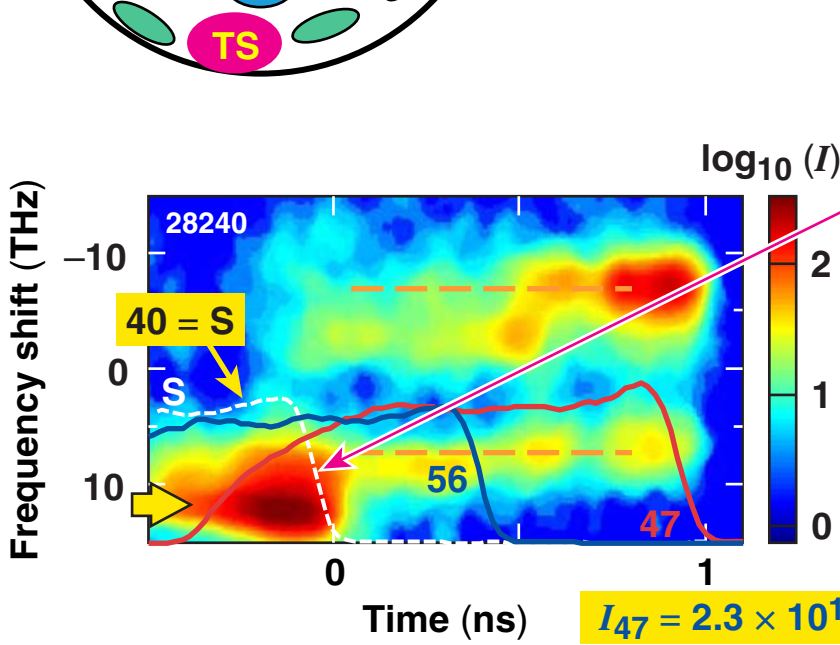


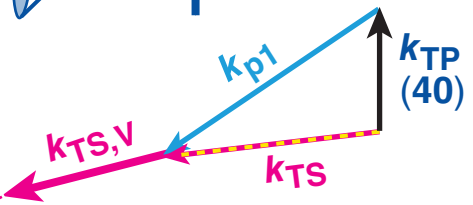
E18015

A strong blue-shifted Thomson-scattered signal is produced when beam 56 TPD plasmons scatter beam 40 (Thomson probe)









Seen from above

This is a truly 3-D problem and the Zakharov model may be able to treat this.

$I_{47} = 2.3 \times 10^{14}$ W/cm^2

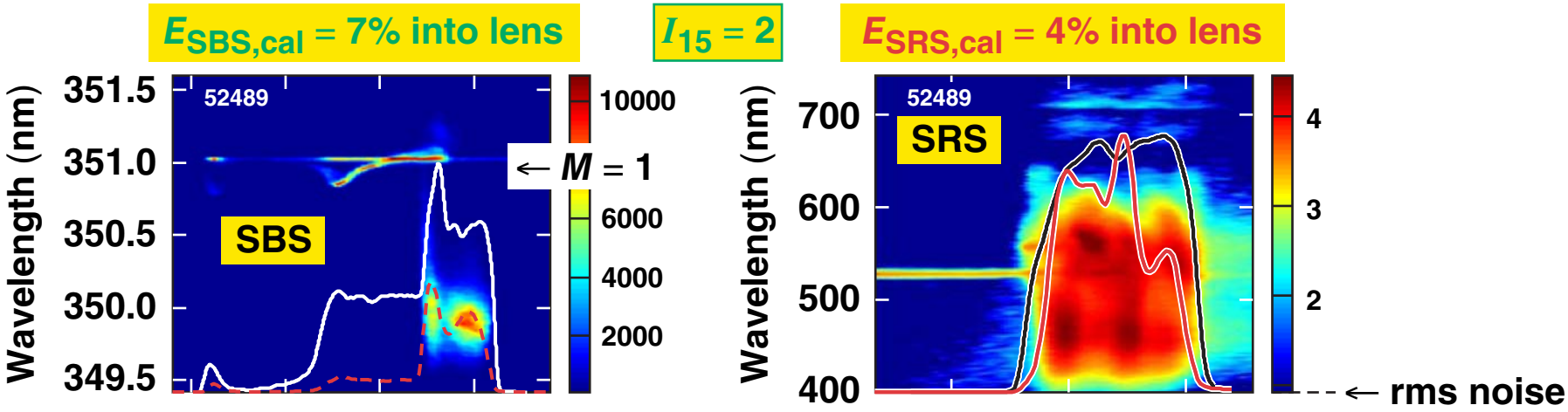
E17432

Recent experiments at LLE indicate suppression of TPD high above TPD threshold

UR LLE

- Experiments at 351 nm on OMEGA and 1054 nm on OMEGA EP have found minimal hard x rays caused by TPD at >10× above threshold in long-scale-length plasmas.
- Caveats: Interaction beams without phase plates and no SSD bandwidth.
- Likely side effects: lots of SRS, SBS, and filamentation (all of them were definitely present in 351-nm experiments on OMEGA).
- Behavior is unknown in the presence of phase plates with or without SSD bandwidth.

No phase plates and no SSD and high intensities suppress the TPD instability through the excitation of filamentation, SBS, and SRS in the low-density corona



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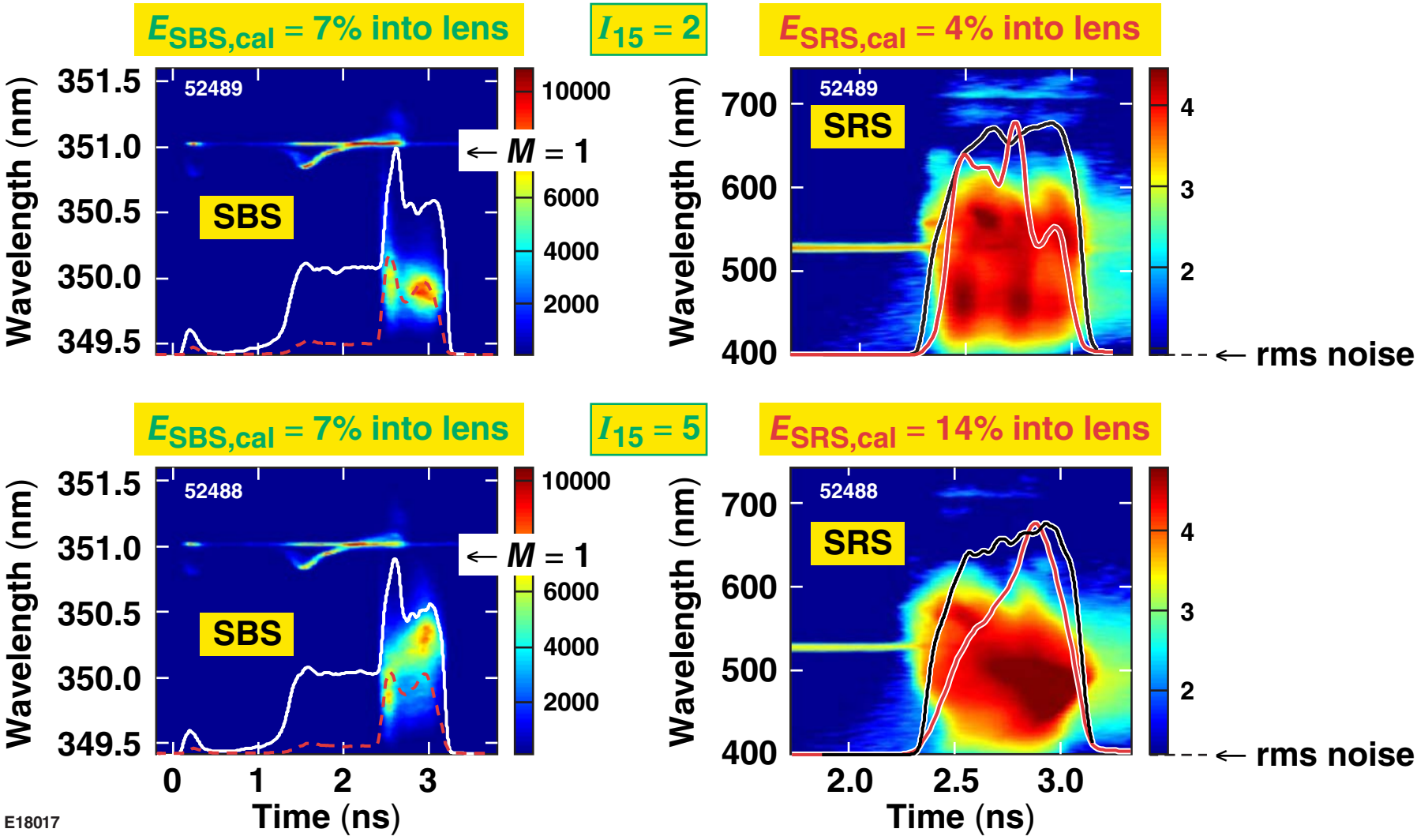

Summary/Conclusions

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- Nonlocality of plasma waves renders TPD instability insensitive to speckle → samples entire intensity distribution → threshold
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