Experimental Investigation of the Two-Plasmon Decay Instability at Oblique Incidence

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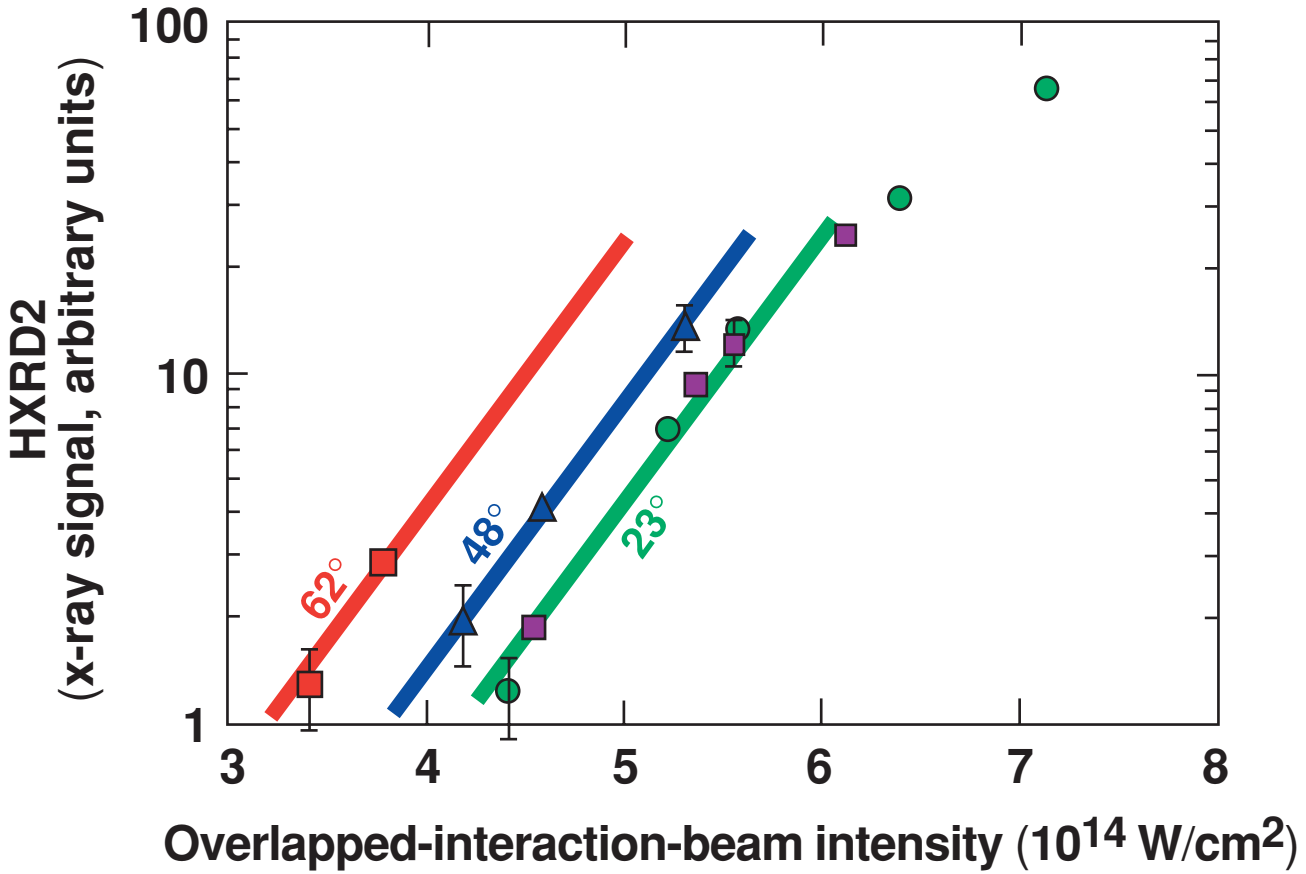

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Summary

The two-plasmon decay (TPD) instability exhibits weak angular dependence as evidenced by hot-electron preheat

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- Angular dependence of TPD is of interest to polar-direct-drive-ignition experiments.
- Hard x-ray signals measure hot-electron preheat.
- Experiments involved six interaction beams incident on performed plasmas.
- TPD threshold appears lower at higher angles of incidence.
- Preheat efficiency (preheat energy/laser energy) is independent of angle.

Outline

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- Motivation
- Experimental arrangement
- Hard-x-ray data
- Conclusions

Motivation

Recent experiments have shown consistent fast-electron generation and sensitivity to overlapped-beam intensities

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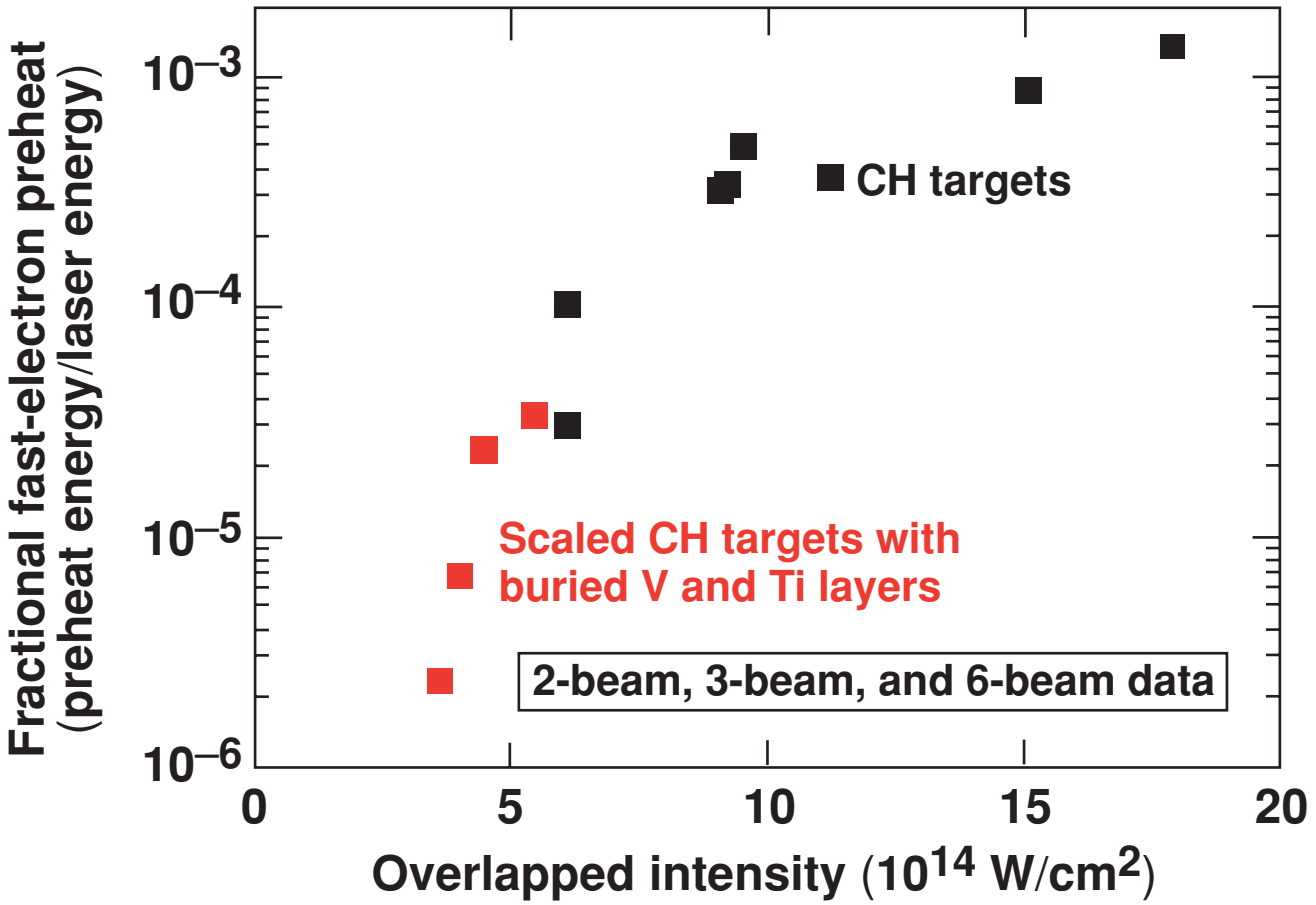

2 to 6 beams (23°), long-scale-length plasmas

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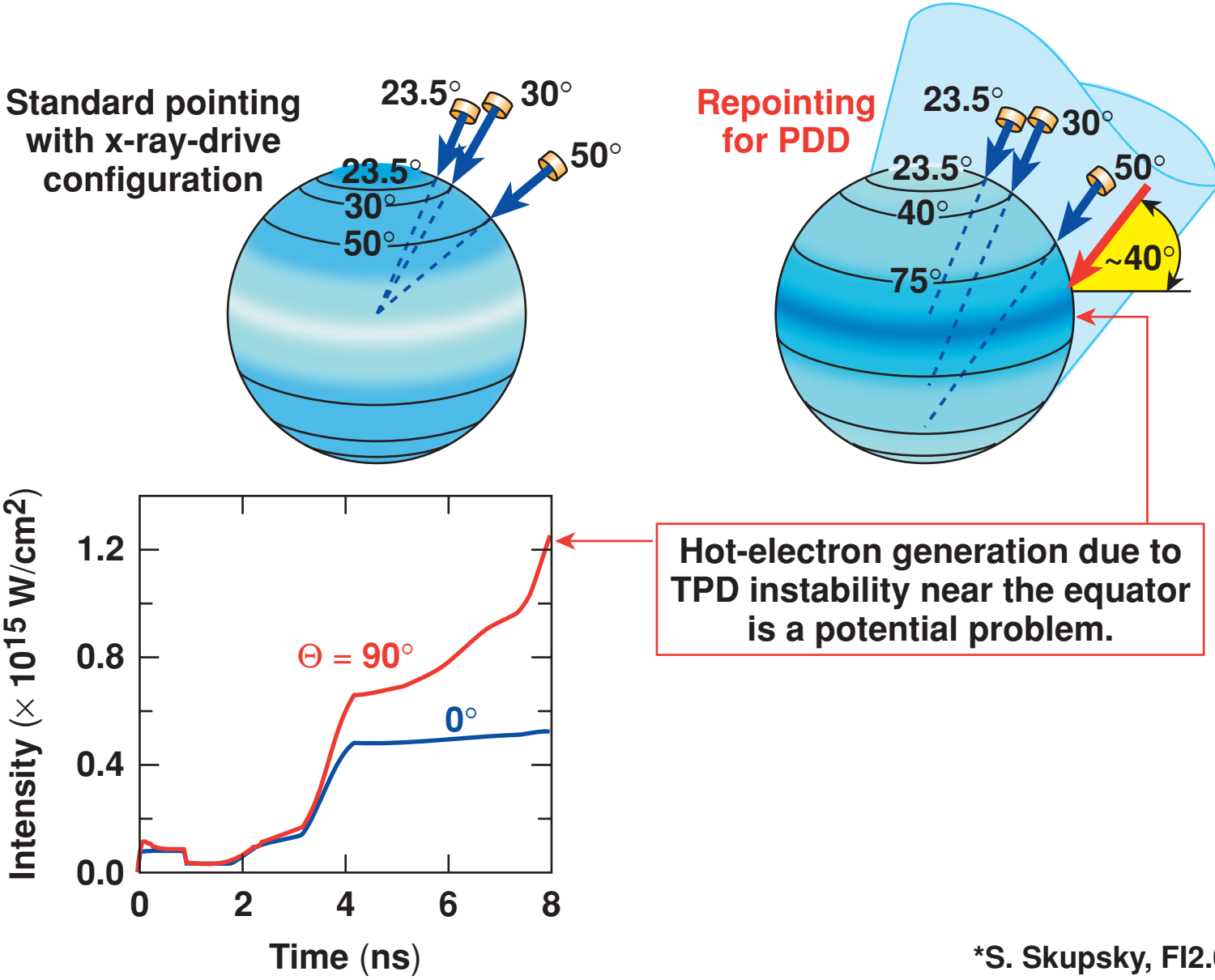
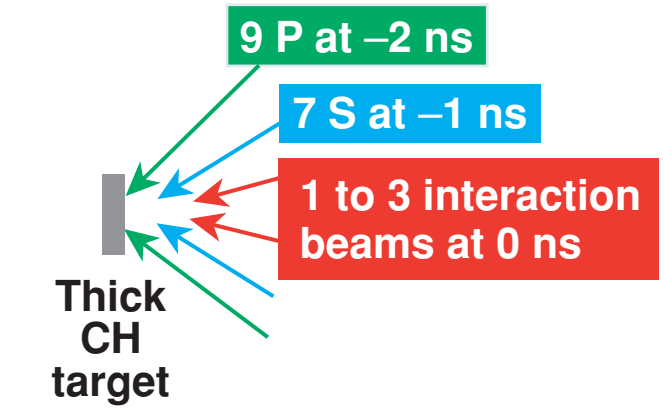
Polar direct drive* (PDD) allows directly driven implosions on the NIF with indirect-drive beam geometry

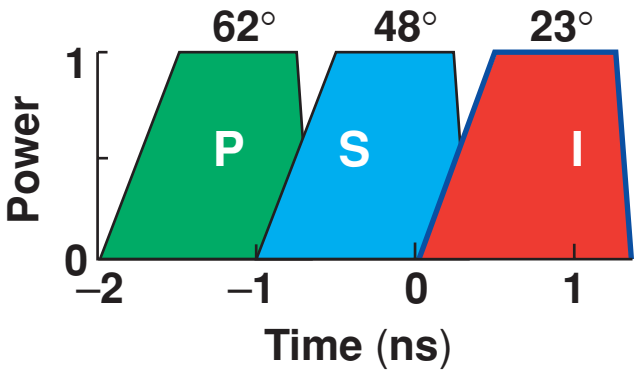


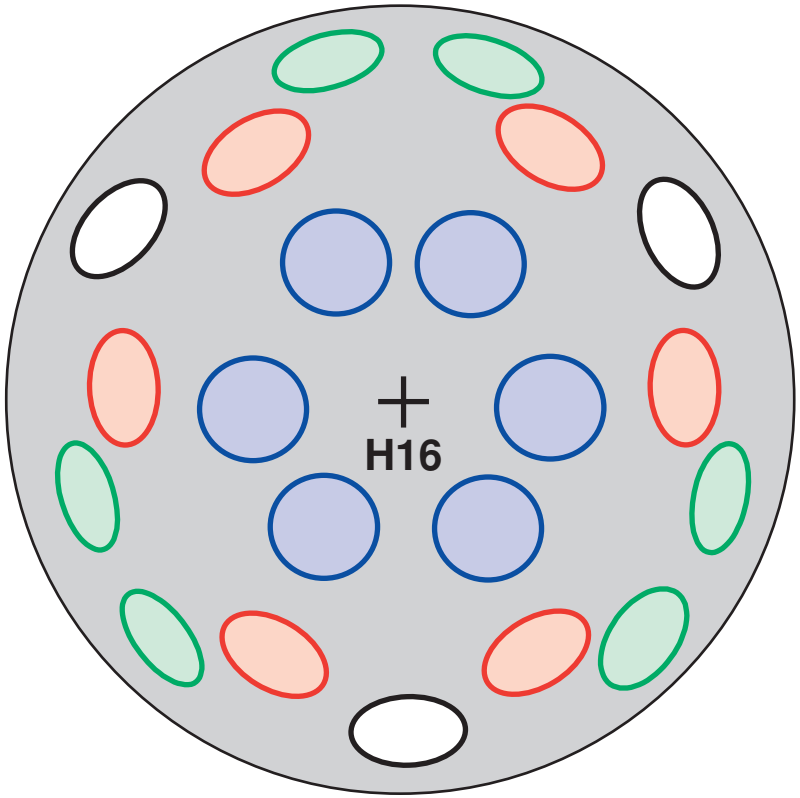
I1423a

*S. Skupsky, FI2.003

Preformed plasmas are irradiated with six beams at various angles of incidence







- Beam angles and overlapped intensities:
  - 23° (6×10^{14}), 48° (4.2×10^{14}), 62° (3×10^{14} W/cm^2)
  - All other beams defocused ($I_{beam} < 3 \times 10^{13}$ W/cm^2)

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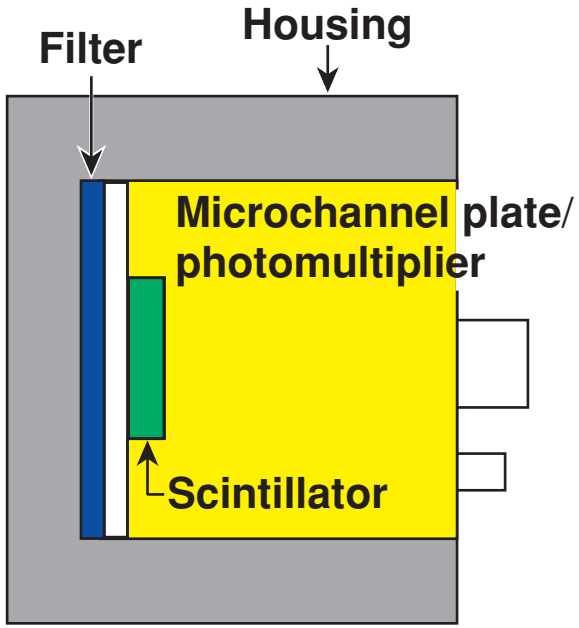
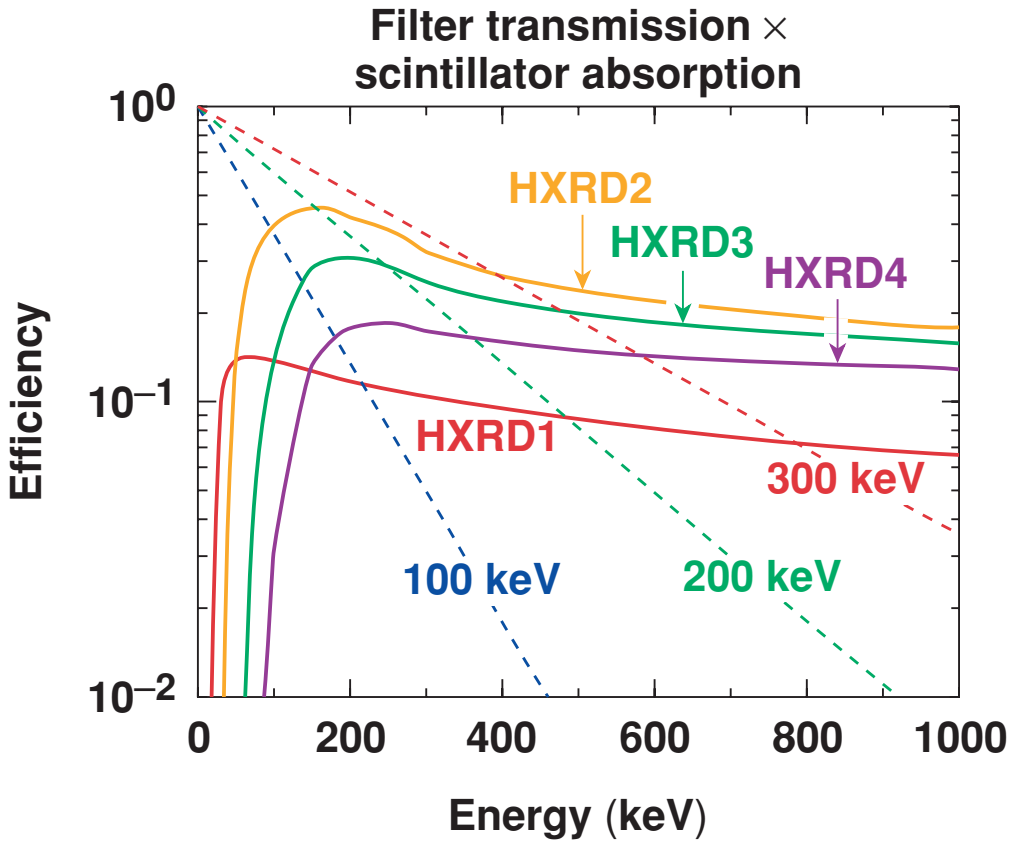
Hard-x-ray detector (>50 keV) has been shown to yield reliable relative preheat measurement

- Four edge-filtered photomultipliers sample E_x > 50 to 200 keV with time resolution.
- Cross-calibrating with absolute K_α measurements has demonstrated that absolute preheat levels can be determined.





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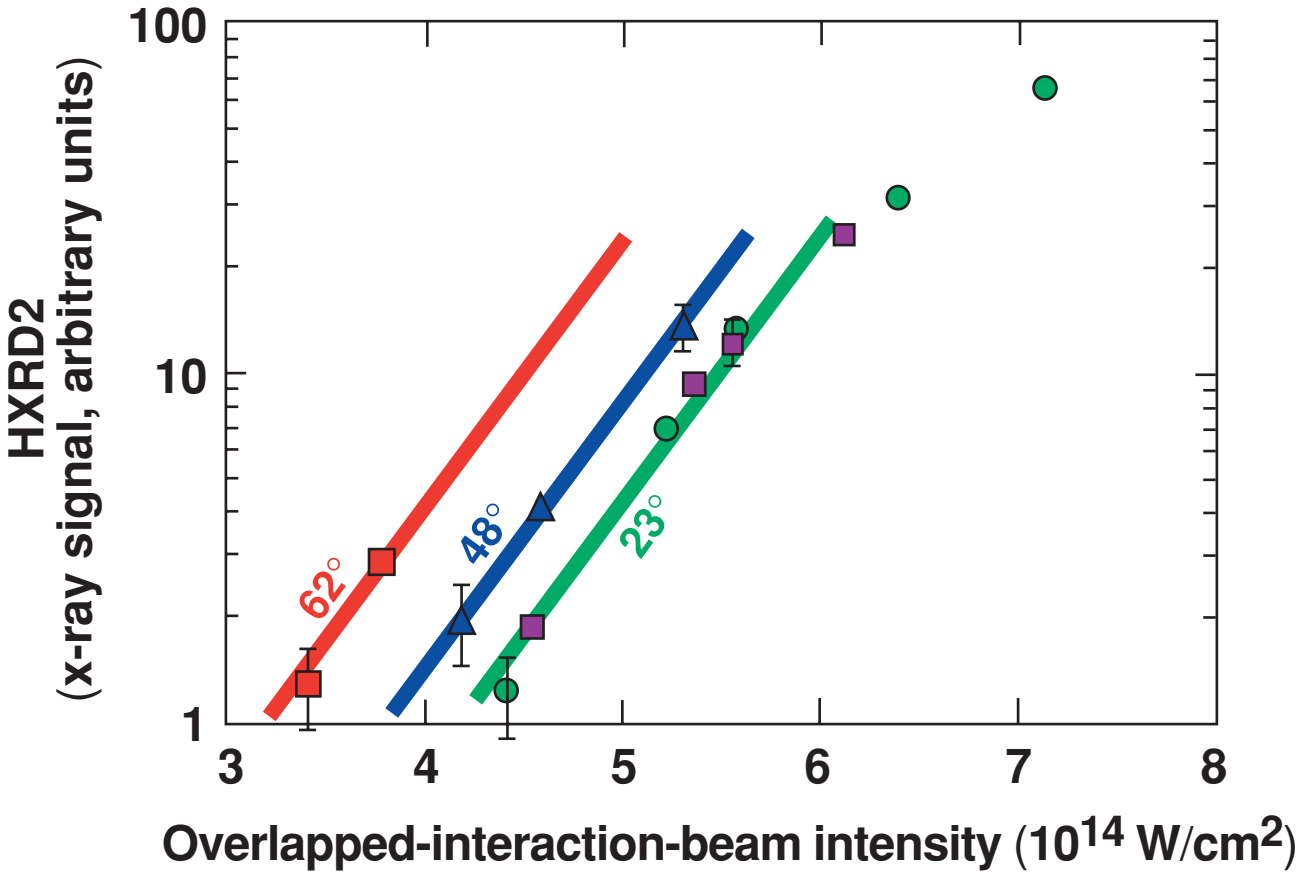
The two-plasmon-decay instability appears to have a lower threshold for higher angles of incidence



- Beam conditioning: phase plates, polarization smoothing, no bandwidth.

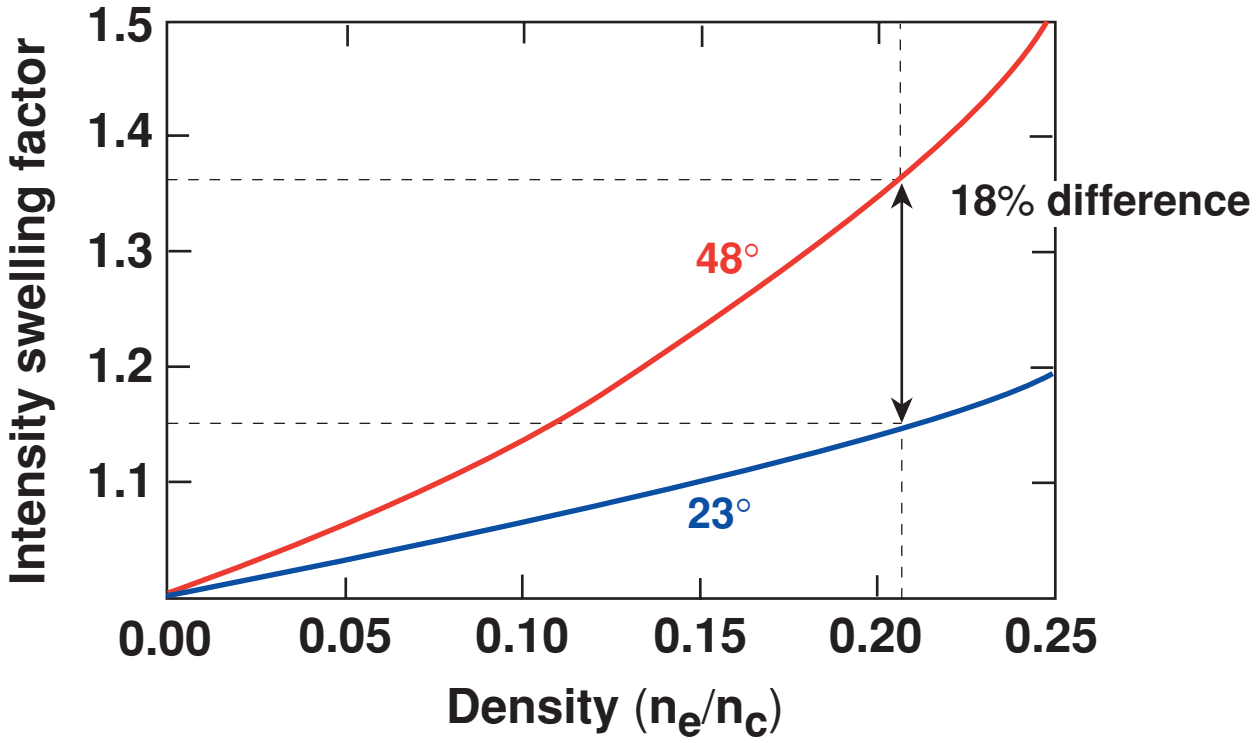
E12662

Stoeckl *et al.*, Phys. Rev. Lett. 90, 235002-1 (2003).

The observed angular dependence of the hot-electron production may have several causes

- Effective density gradient at oblique incidence
- Electric field swelling near turning point
  - Appears to overestimate observed angular dependence
- Other?

$$dE^2/E^2 = \cos(\theta)/\sqrt{\cos^2(\theta) - n_e/n_c}$$



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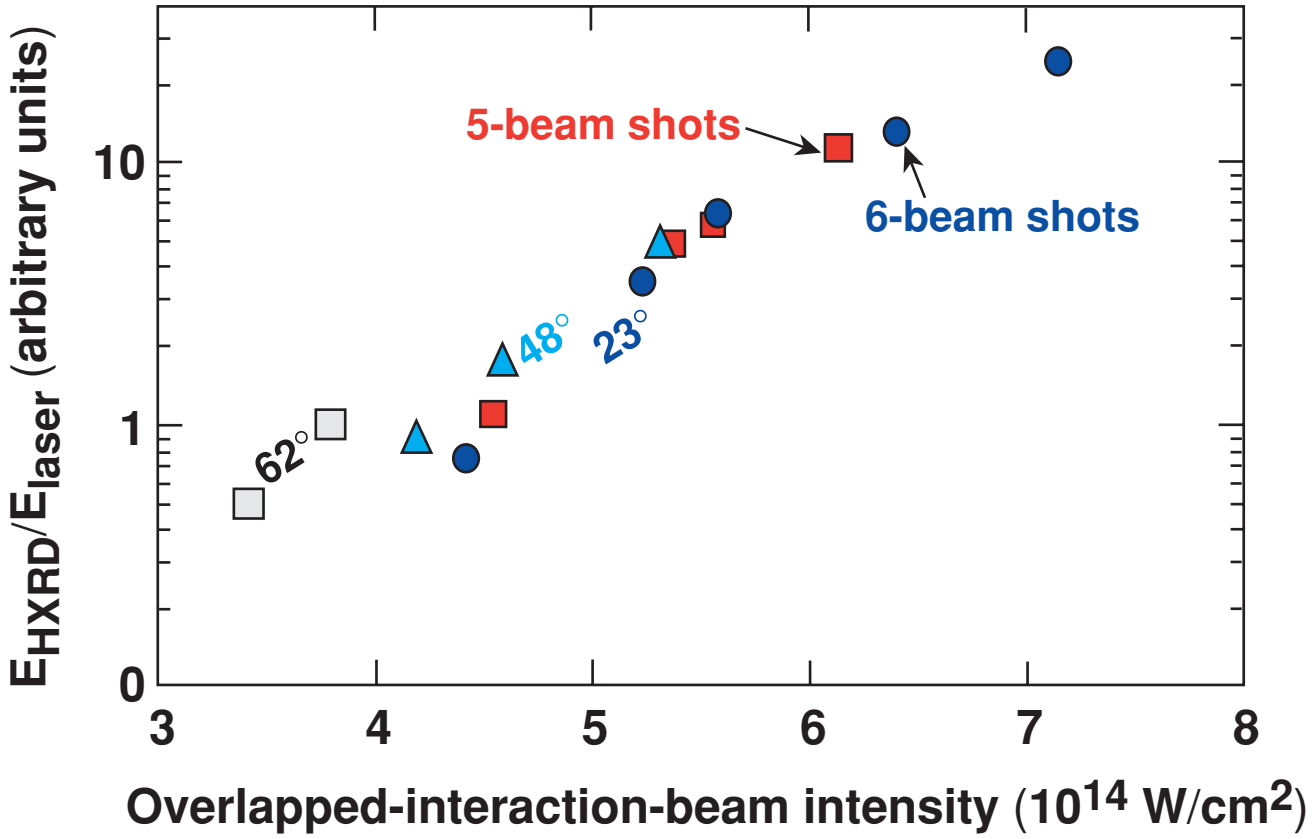
The preheat efficiency shows no discernible angular dependence between 23° and 48°



$$I = \frac{E_L}{A\tau_L}, \text{ A = beam area on target}$$

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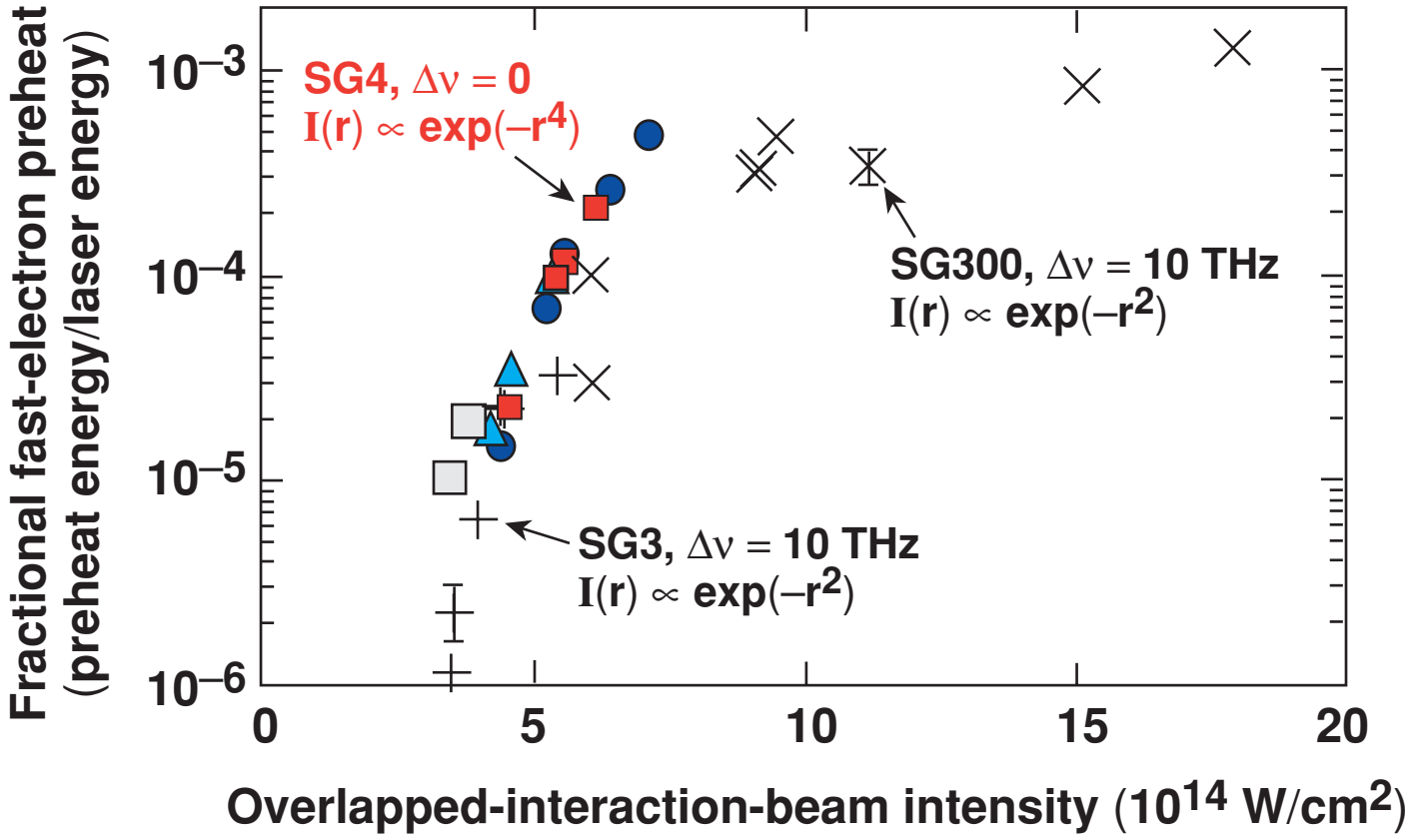
Fast-electron-preheat efficiencies depend weakly on different on-target intensity distributions (phase plates) and bandwidths



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The significantly different intensity distributions can explain different levels of electron preheat from the TPD instability

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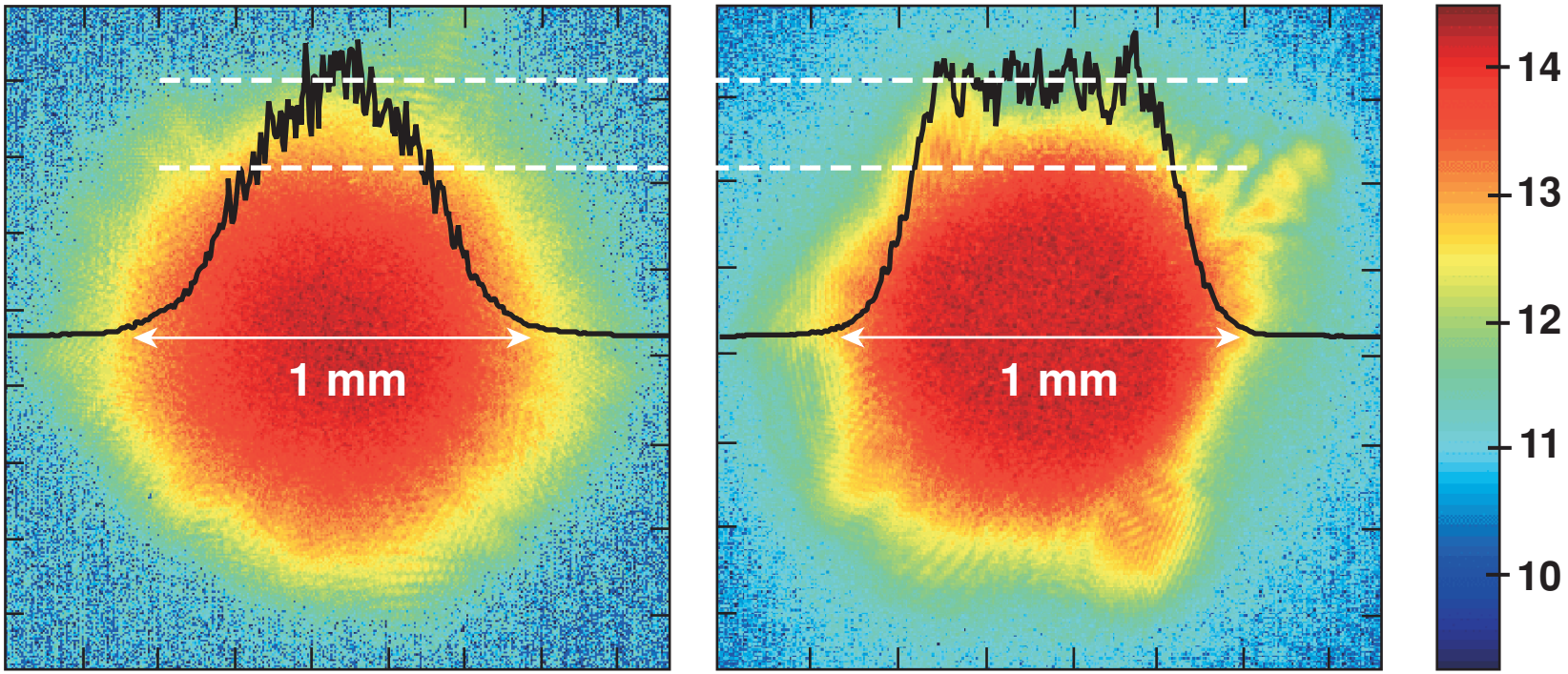
SG3 with 1-THz bandwidth

SG4 without bandwidth



For a given $I_{int} \rightarrow E^{SG4}_{\geqslant I_{int}} > E^{SG3}_{\geqslant I_{int}}$

E12666

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