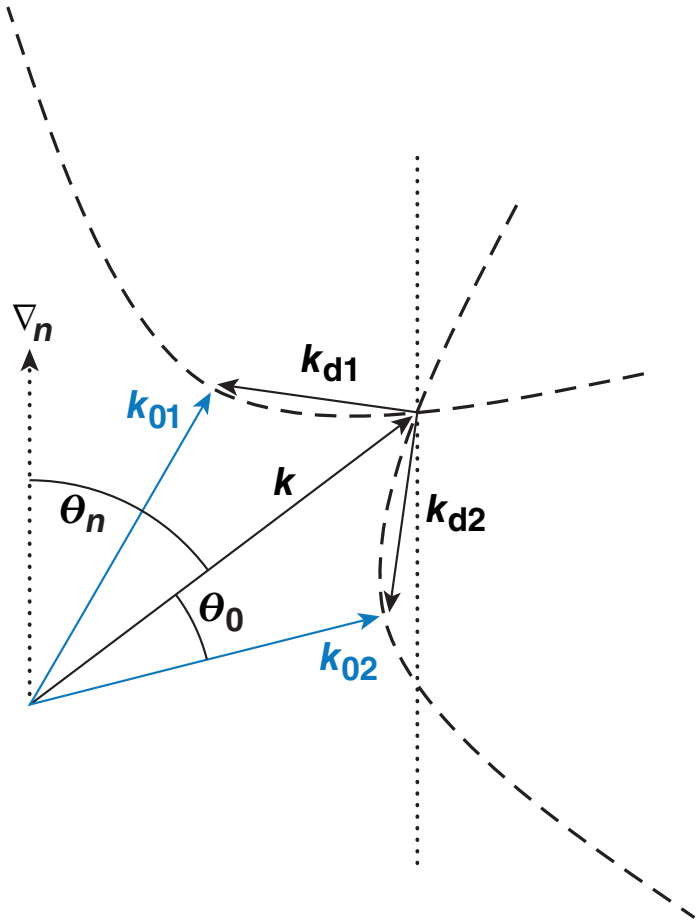
Convective Multibeam Two-Plasmon Decay for Spherical and Planar Irradiation Geometrics



R. W. Short and J. F. Myatt
University of Rochester
Laboratory for Laser Energetics

41st Annual Anomalous
Absorption Conference
San Diego, CA
19–24 June 2011

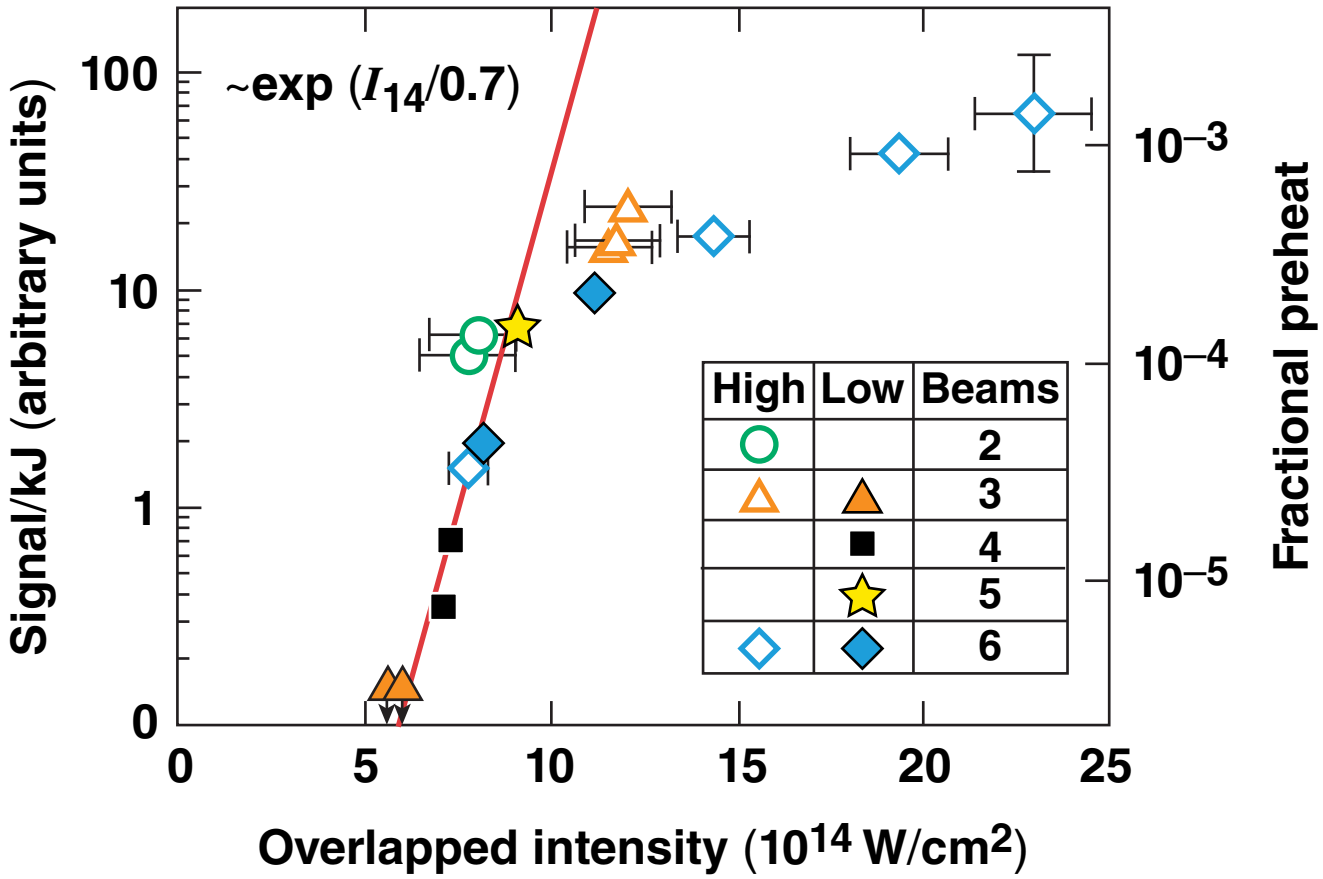
Summary

TPD appears to be collective near normal incidence, less so at high incidence angles

UR LLE

- Experiments on OMEGA have shown that TPD appears to be driven by the collective intensity of several overlapping laser beams.
- A group of beams can drive a common central plasma wave, which is expected to produce most of the hot electrons.
- The angular distribution of this wave will determine the anisotropy of the hot electrons produced, and thus their preheating efficiency.
- At small angles to the density gradient the common wave is driven by the collective intensity.
- At larger angles the most oblique beam predominates and integrated TPD gain increases.

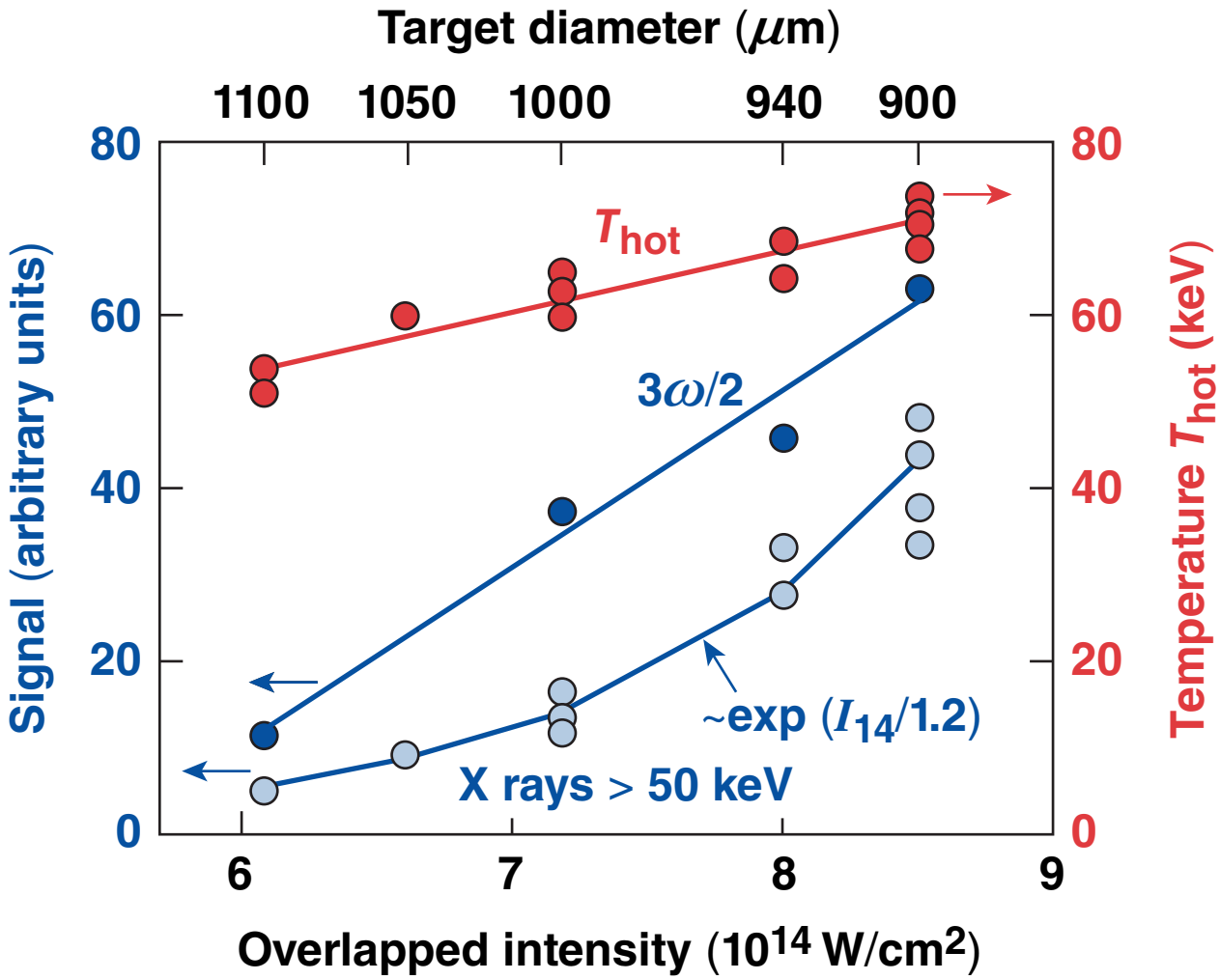
TPD appears to depend on the overlapped intensity for multiple-beam experiments (1)



TC8117b

Planar experiments [C. Stoeckl *et al.*, Phys. Rev. Lett. 90, 235002 (2003).]

TPD appears to depend on the overlapped intensity for multiple-beam experiments (2)

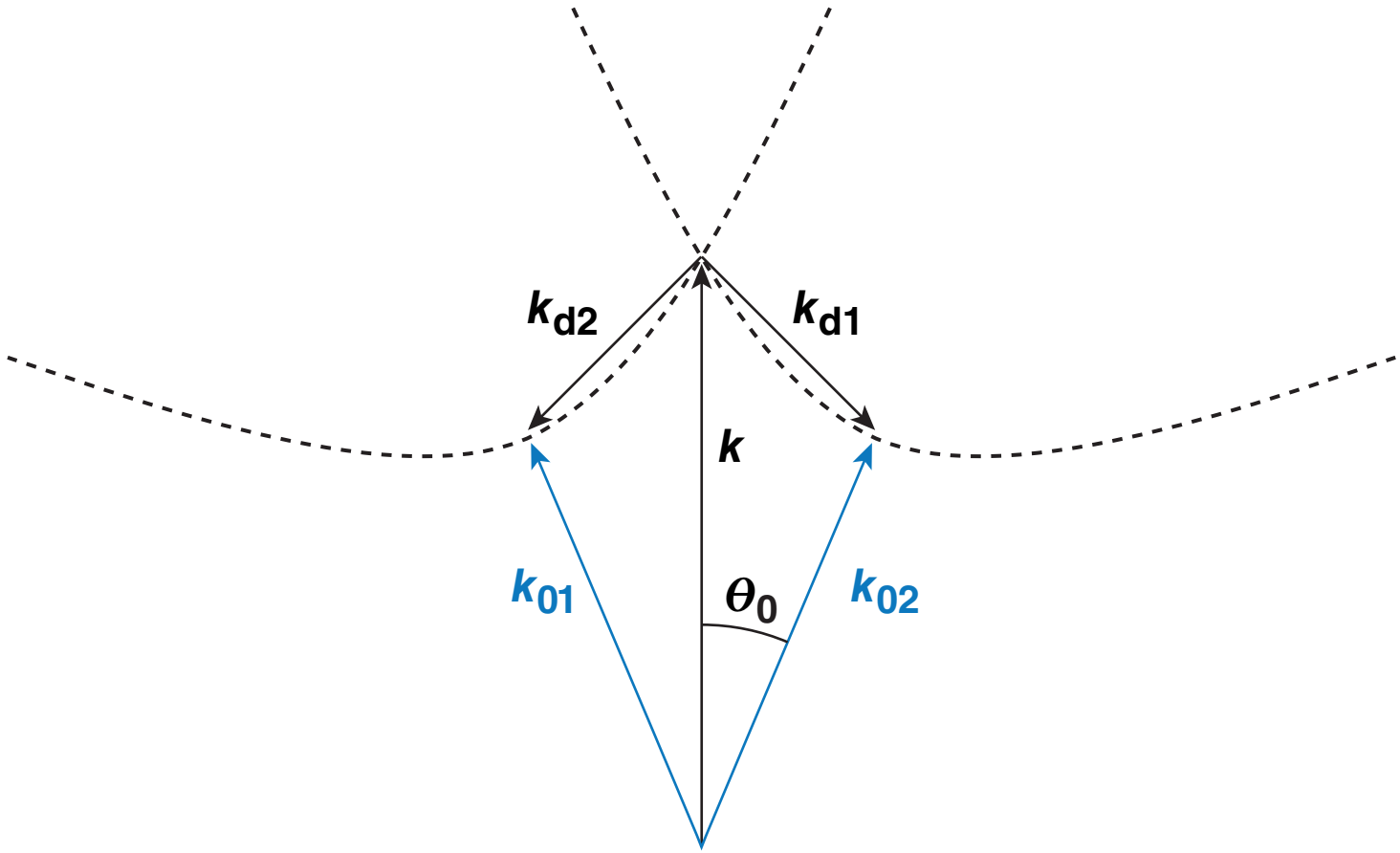


TC9432

Spherical experiments [C. Stoeckl *et al.*, Phys. Rev. Lett. 90, 235002 (2003).]

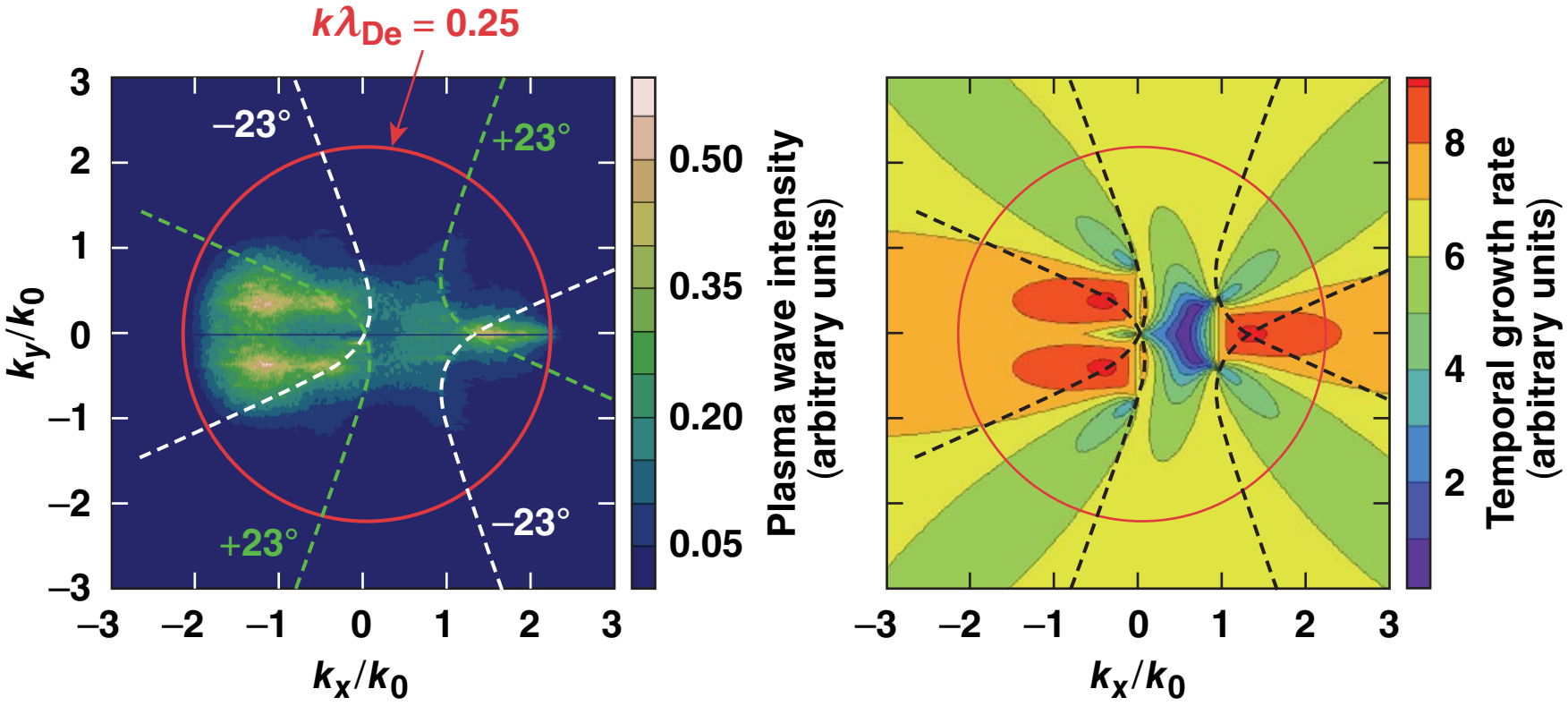
The anisotropy of multibeam TPD interaction can be studied using two beams

- Each pump wave drives a common plasma wave and a satellite—the common wave is of greatest interest.



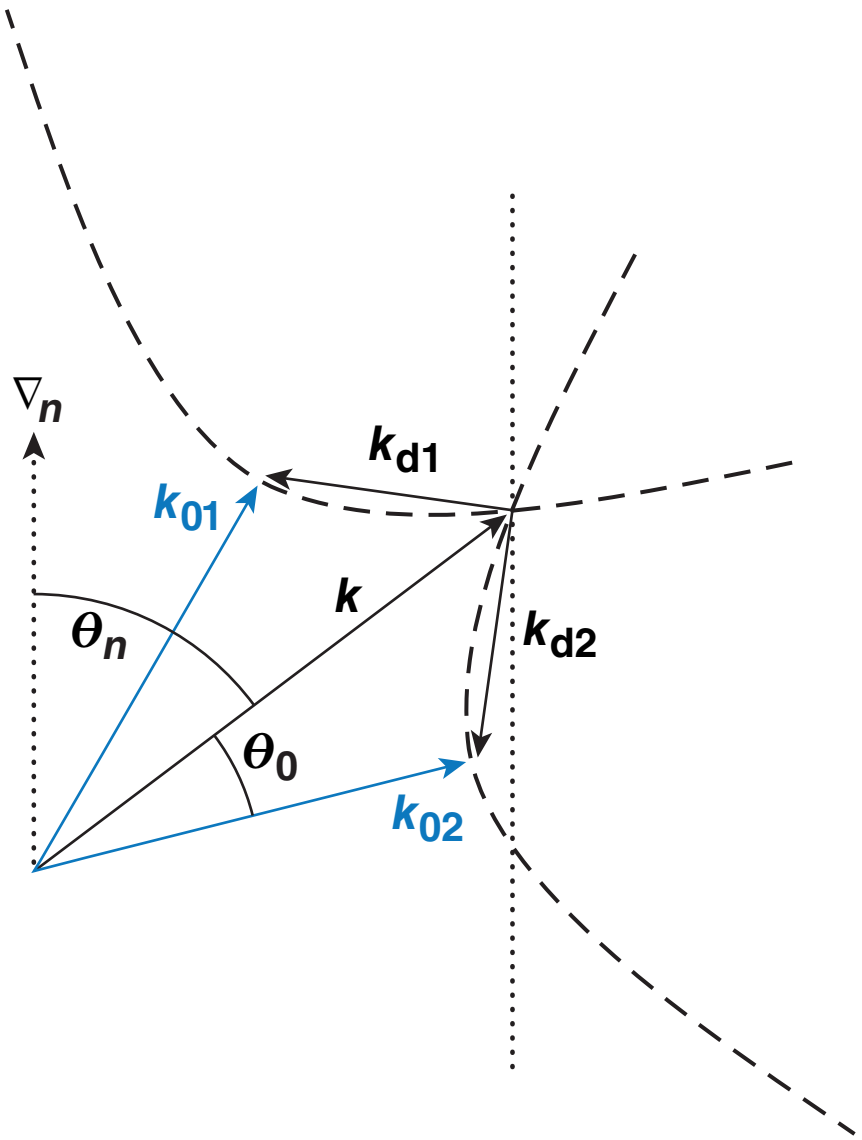
TC9433

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



TC8462a

The centroid of the beams can tilt from the density gradient in (θ_n) or out (ϕ_n) of the plane of the two beams



TC9434

Fourier analysis of the time-dependent TPD equations results in a set of first-order linear equations that can be integrated numerically

$$\frac{du}{dk_x} = \frac{1}{2} e^{i\alpha\beta^{1/2} k_{01x}(k_x - k_{xr})^2} \left(\frac{k^2 - k_{d1}^2}{k k_{d1}} \right) \alpha_1 (\hat{\varepsilon}_1 \cdot k) u_{d1}$$

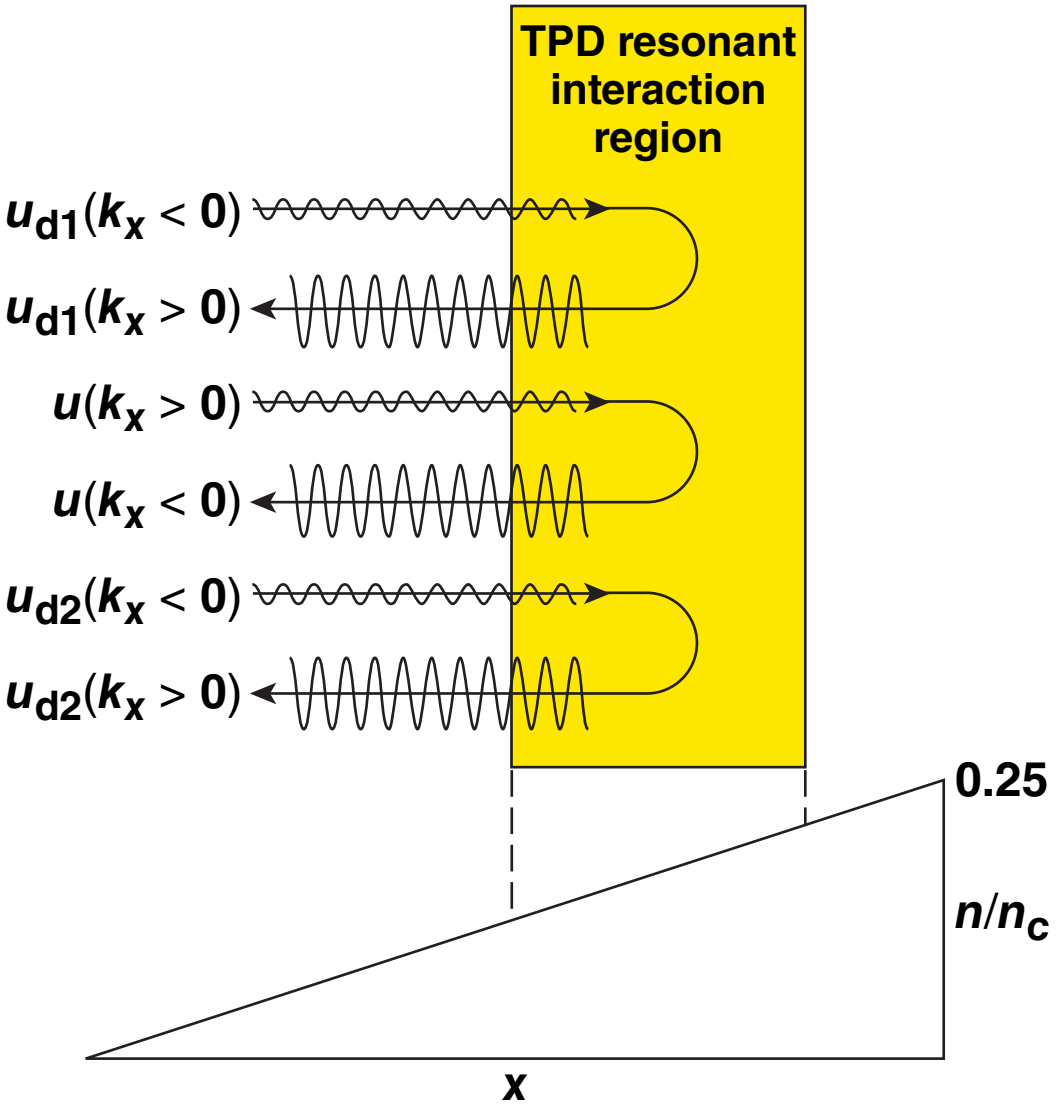
$$+ \frac{1}{2} e^{i\alpha\beta^{1/2} k_{02x}(k_x - k_{xr})^2} \left(\frac{k^2 - k_{d2}^2}{k k_{d2}} \right) \alpha_2 (\hat{\varepsilon}_2 \cdot k) u_{d2}$$

$$\frac{du_{d1}}{dk_x} = -\frac{1}{2} e^{-i\alpha\beta^{1/2} k_{01x}(k_x - k_{xr})^2} \left(\frac{k^2 - k_{d1}^2}{k k_{d1}} \right) \alpha_1 (\hat{\varepsilon}_1 \cdot k) u$$

$$\frac{du_{d2}}{dk_x} = -\frac{1}{2} e^{-i\alpha\beta^{1/2} k_{02x}(k_x - k_{xr})^2} \left(\frac{k^2 - k_{d2}^2}{k k_{d2}} \right) \alpha_2 (\hat{\varepsilon}_2 \cdot k) u$$

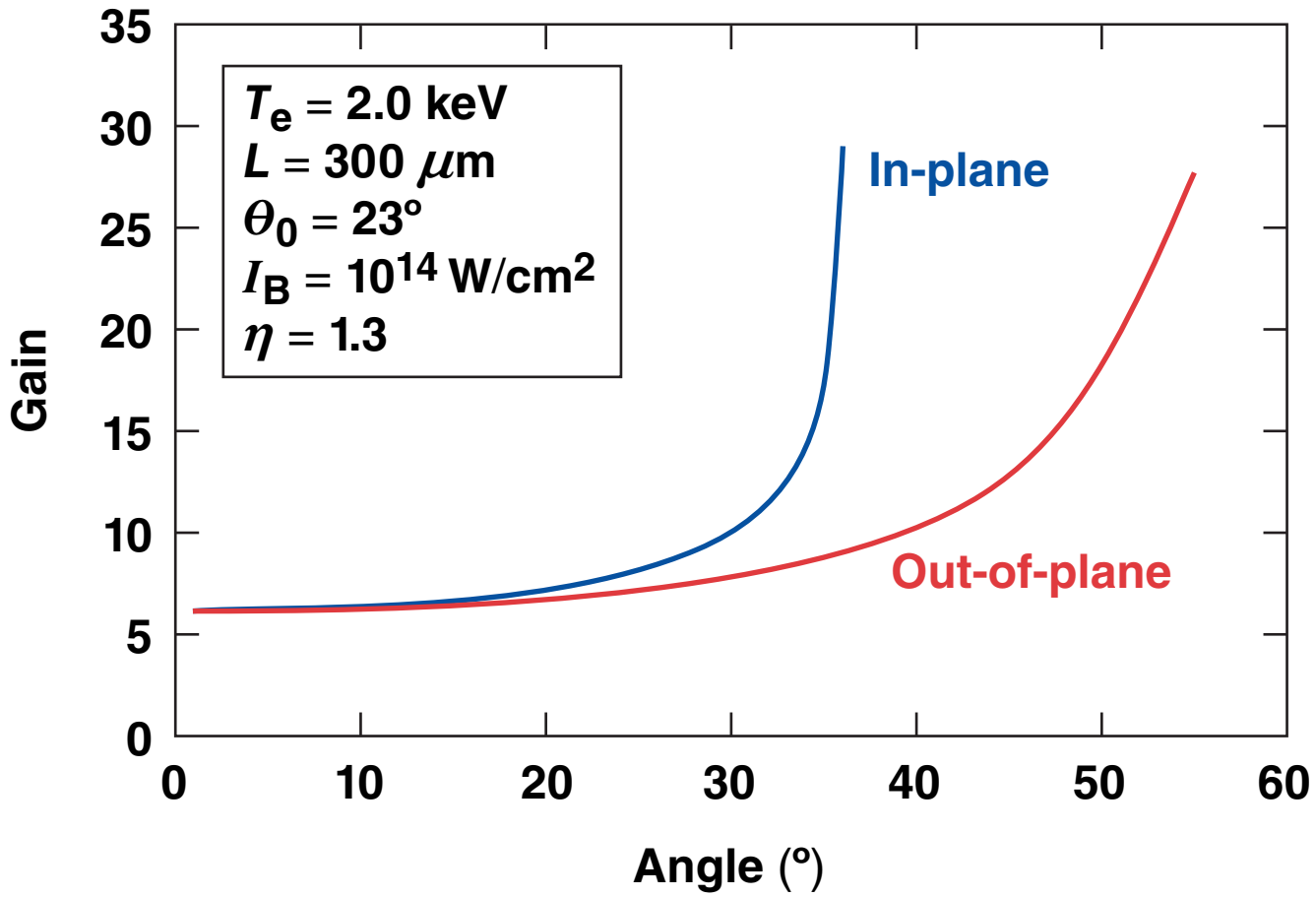
where $\alpha_1 = \dfrac{4k_0 \left| \upsilon_{0i} \right|}{\omega_0} k_0 L$ and $\beta_i = \dfrac{9\upsilon_e^4 k_0^2}{\left| \upsilon_{0i} \right|^2 \omega_0^2}$

Spatial growth can be obtained by numerical integration of the Fourier-transformed equations



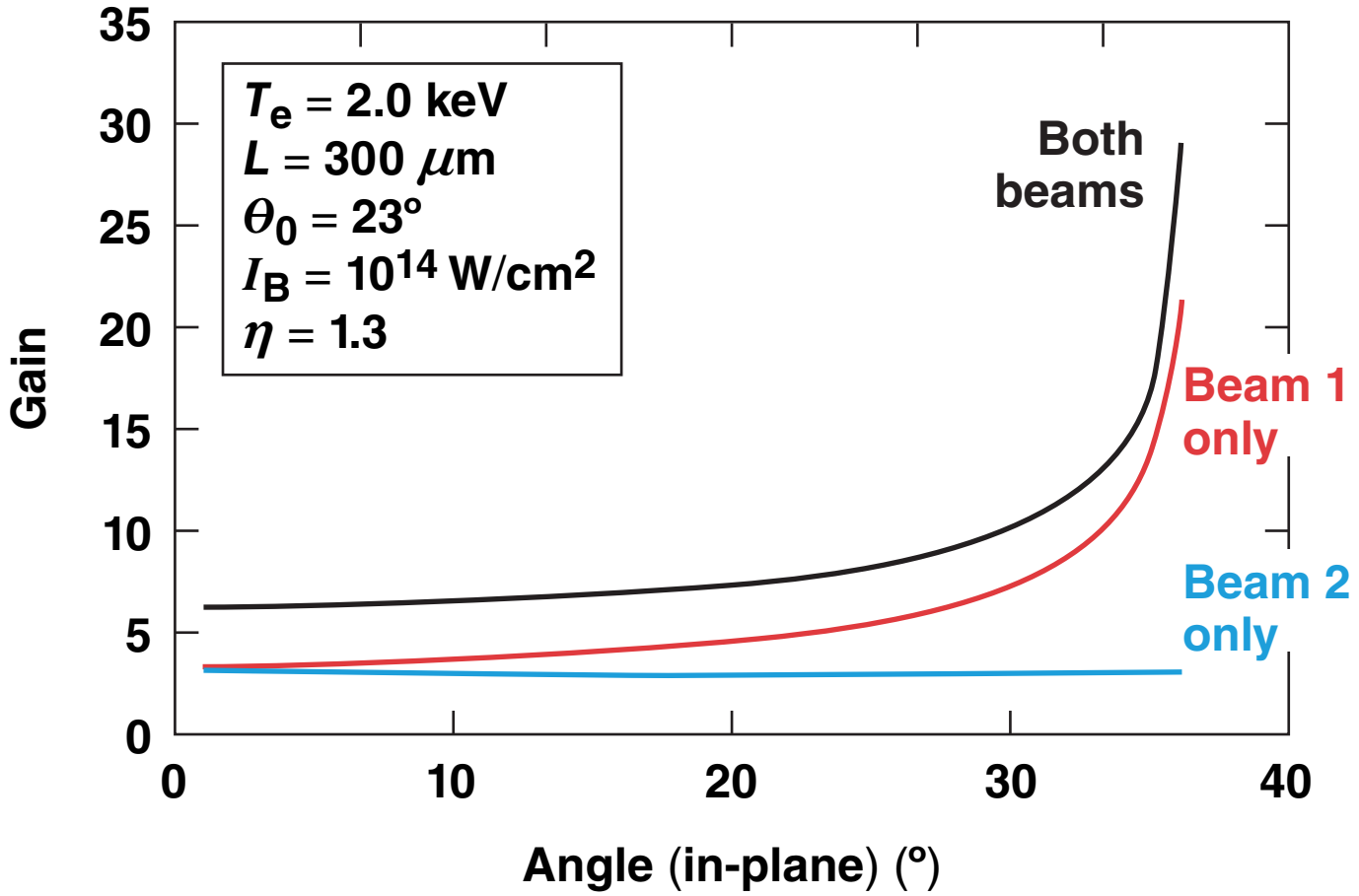
TC8470b

The integrated gain increases with tilt, more rapidly in the beam plane than out



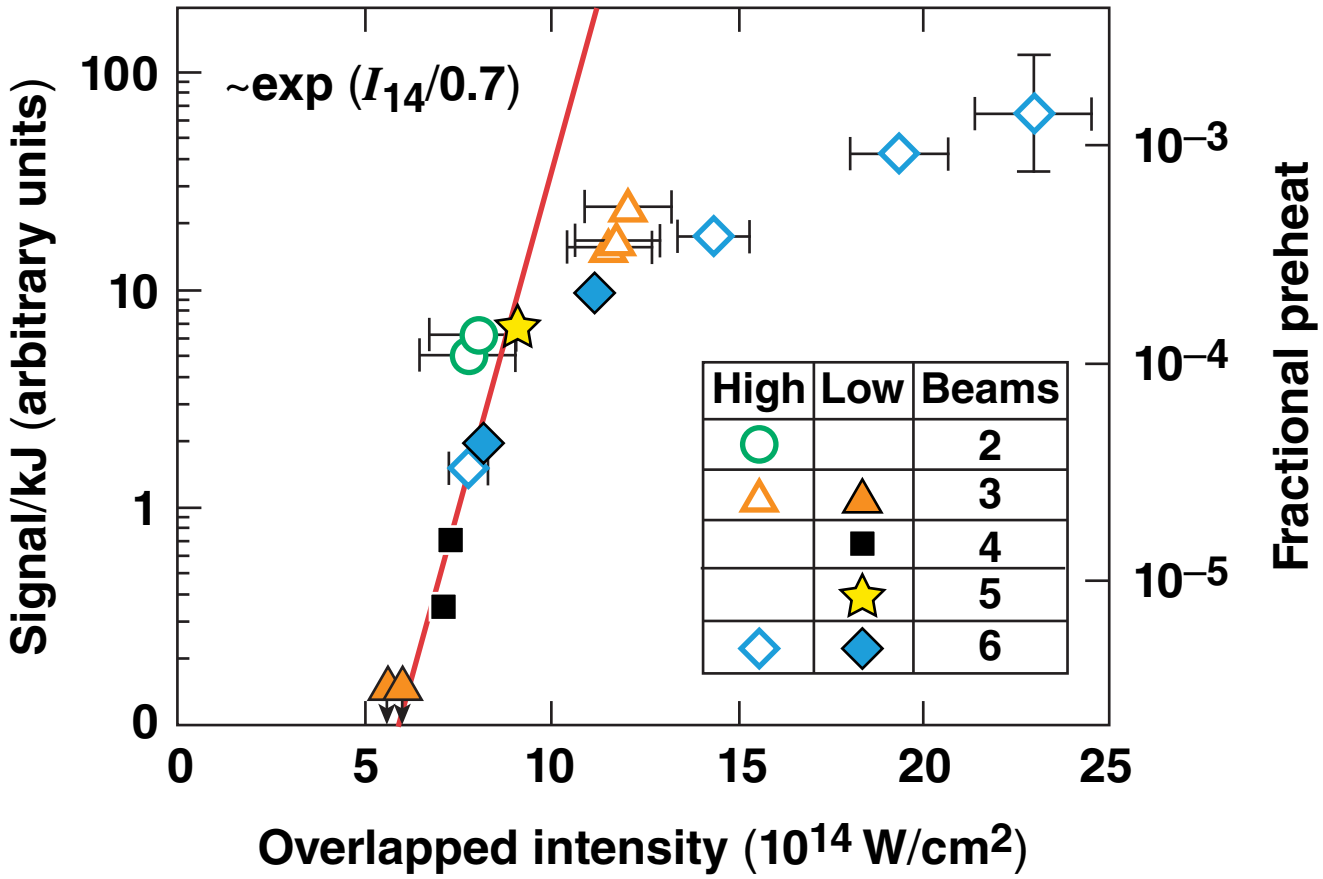
TC9435

At large angles the most oblique beam provides most of the gain



TC9436

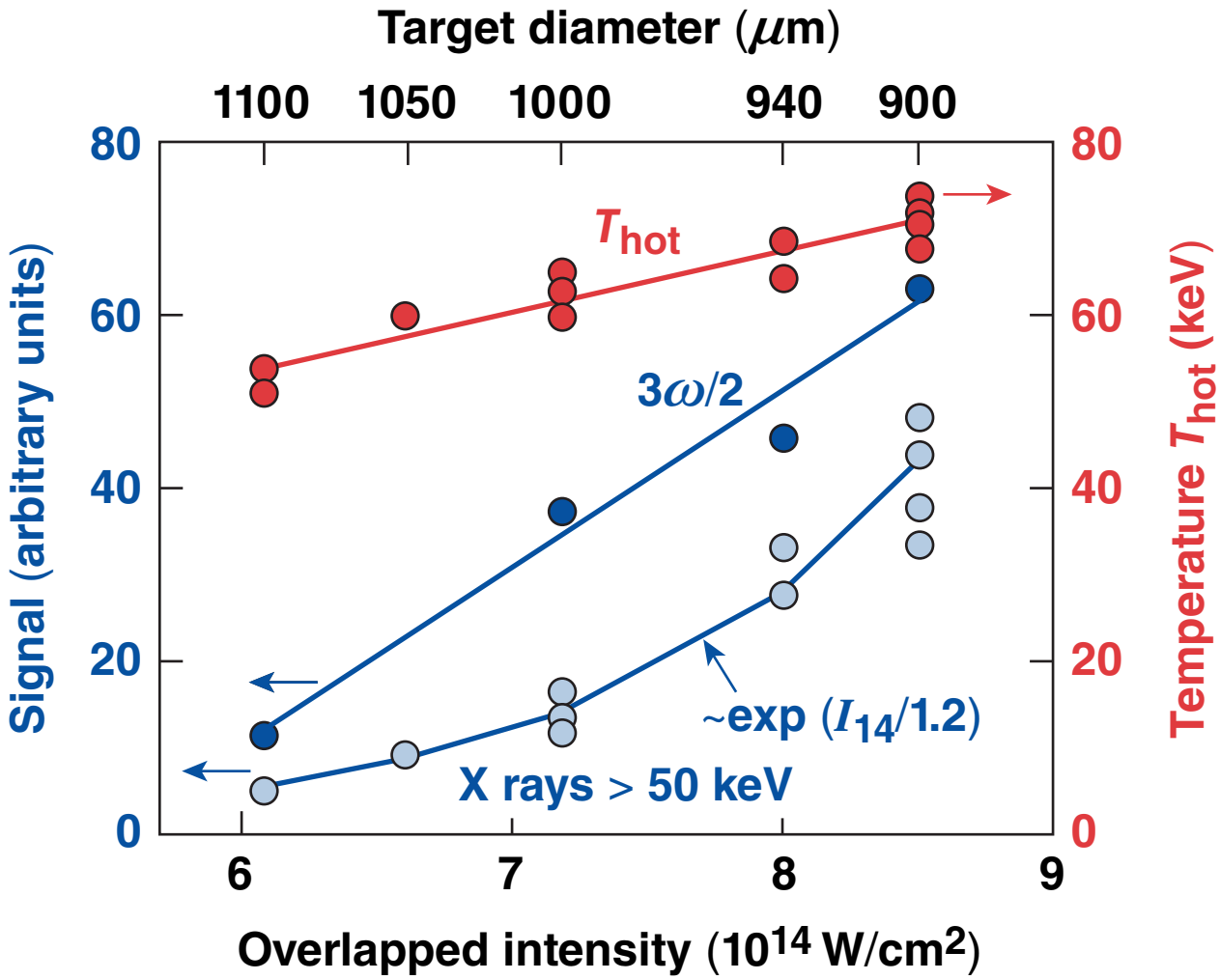
TPD appears to depend on the overlapped intensity for multiple-beam experiments (1)



TC8117b

Planar experiments [C. Stoeckl *et al.*, Phys. Rev. Lett. 90, 235002 (2003).]

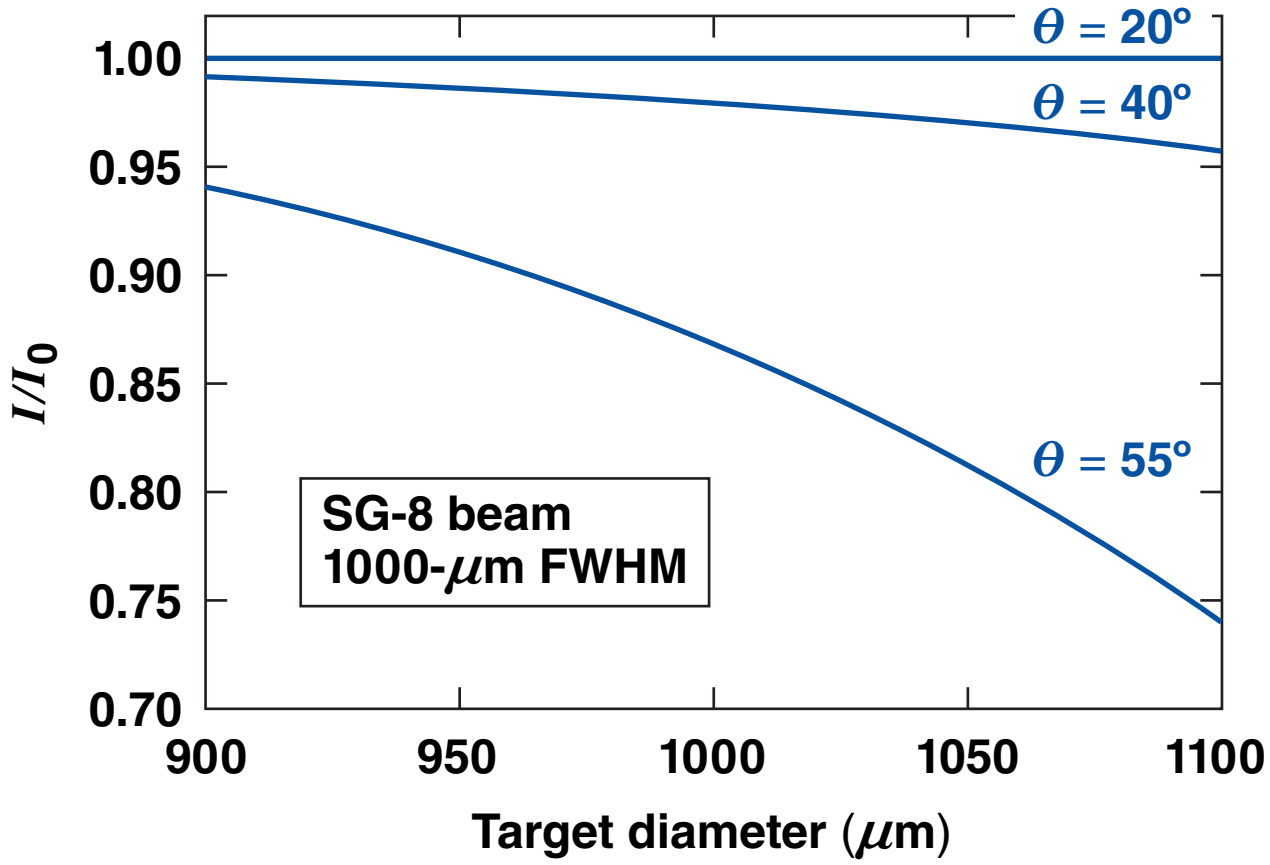
TPD appears to depend on the overlapped intensity for multiple-beam experiments (2)



TC9432

Spherical experiments [C. Stoeckl *et al.*, Phys. Rev. Lett. 90, 235002 (2003).]

For spherical targets, the single-beam intensity at large incidence angles decreases as the diameter increases



- The decline in the TPD signal with increasing target diameter is consistent with domination of TPD by the most oblique rays in each beam.

TC9499

The linear theory is consistent with experimental observations to date

UR LLE

- Further experiments using multibeam irradiation of tilted flat targets are planned to investigate the effects of oblique incidence on TPD levels.
- Simulations using Jason Myatt's Zakharov code will be used to carry the theory into the nonlinear regime.
- The theory breaks down when the incidence angles are large enough that the pump beams have turning points near the quarter-critical surface. Extending the theory to this regime is difficult; experiments should tell us if it is worth pursuing.

The polar-drive campaign heightens the importance of understanding oblique incidence TPD

UR LLE

- Polar drive involves high intensities incident at large angles near the equatorial region of the target.
- Linear theory of oblique multibeam irradiation predicts increased TPD activity; but also that hot electrons generated along the direction of the common plasma wave are less likely to intersect the core and cause preheat.
- Hot electrons that miss the core may heat the coronal plasma and contribute to drive.
- Integrated experiments measuring the K_α emission of a small Mo core surrounded by a larger CH shell are planned to investigate these effects.

Summary/Conclusions

TPD appears to be collective near normal incidence, less so at high incidence angles

UR LLE

- Experiments on OMEGA have shown that TPD appears to be driven by the collective intensity of several overlapping laser beams.
- A group of beams can drive a common central plasma wave which is expected to produce most of the hot electrons.
- The angular distribution of this wave will determine the anisotropy of the hot electrons produced, and thus their preheating efficiency.
- At small angles to the density gradient the common wave is driven by the collective intensity.
- At larger angles the most oblique beam predominates and integrated TPD gain increases.