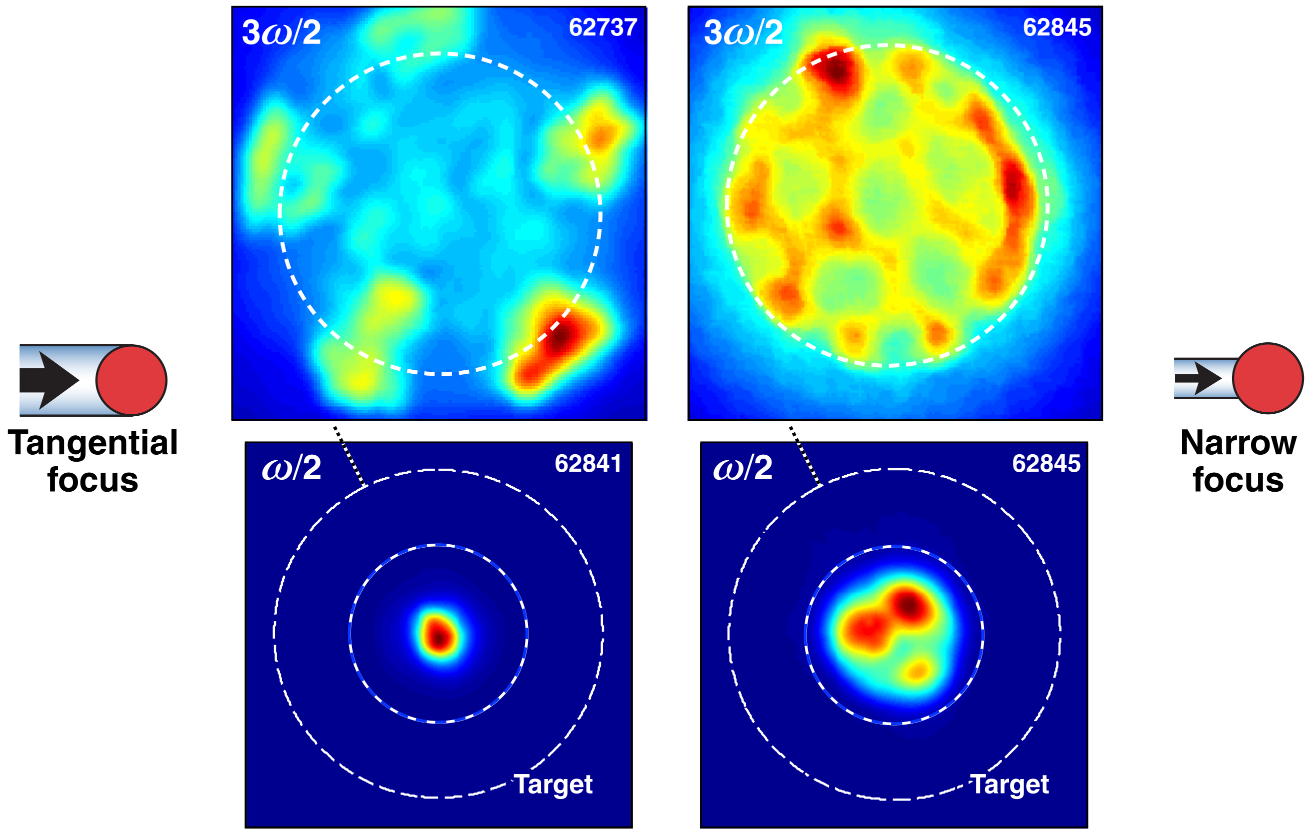
Half-Integer Harmonic Images and Spectra Point Toward Localized, Multibeam Two-Plasmon Decay



W. Seka
University of Rochester
Laboratory for Laser Energetics

42nd Annual Anomalous Absorption Conference
Key West, FL
25–29 June 2012

Summary

Images and spectra of the $3\omega/2$ and $\omega/2$ emission from implosion experiments indicate localized multibeam two-plasmon-decay (TPD) instability

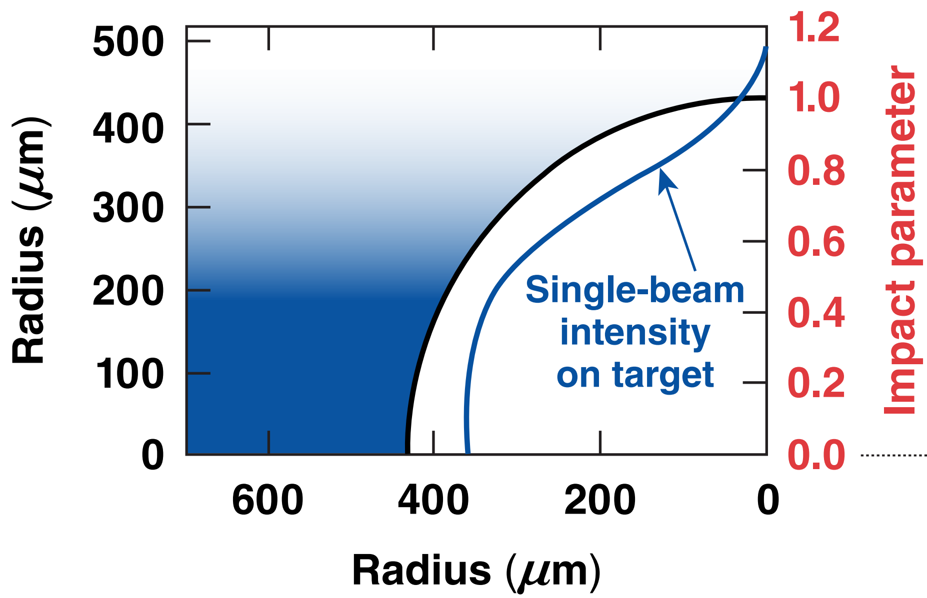
- $3\omega/2$ and $\omega/2$ images are consistent with driving common waves in HEX and PENT ports on OMEGA
- Comparison of on-target laser-light nonuniformity and $3\omega/2$ and $\omega/2$ images allows for inferences on TPD driven in localized areas
- Two distinct TPD instability regions have been identified
- $\omega/2$ spectra point toward multibeam common-wave processes

Collaborators

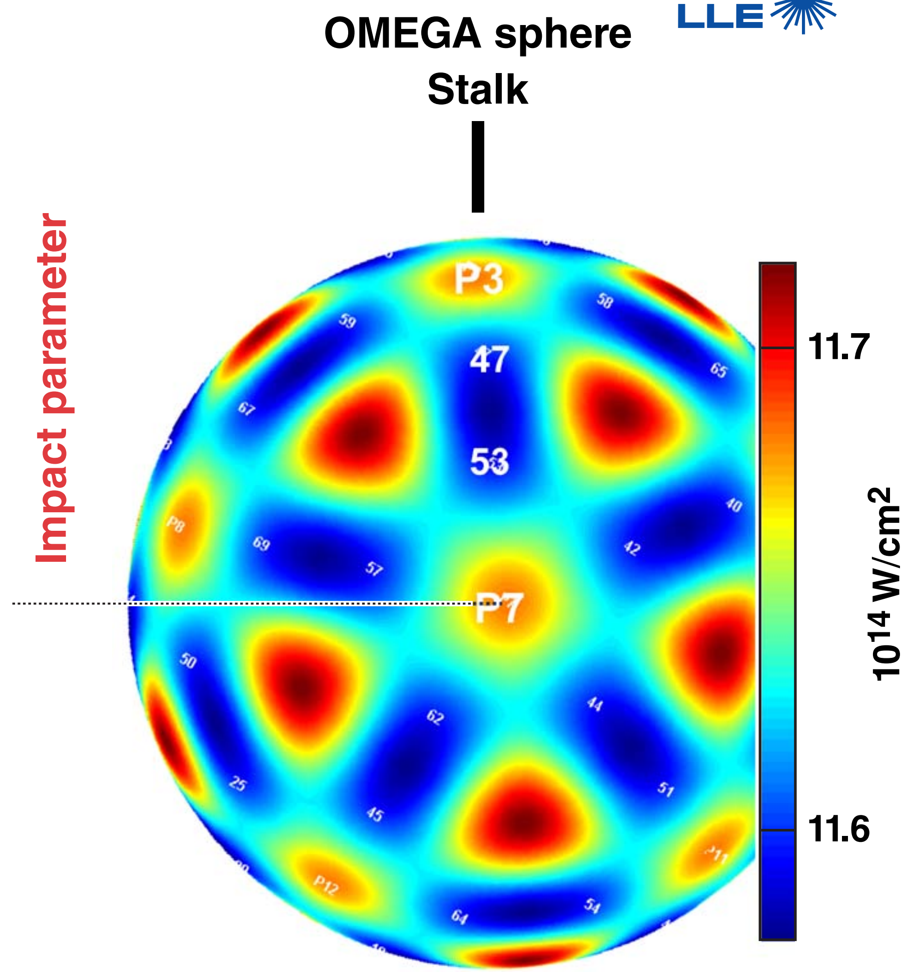
D. H. Edgell, D. H. Froula, J. Katz, J. F. Myatt, J. Zhang, R. W. Short,
D. T. Michel, A. V. Maximov, and V. N. Goncharov

University of Rochester
Laboratory for Laser Energetics

OMEGA implosions are usually carried out with tangential illumination



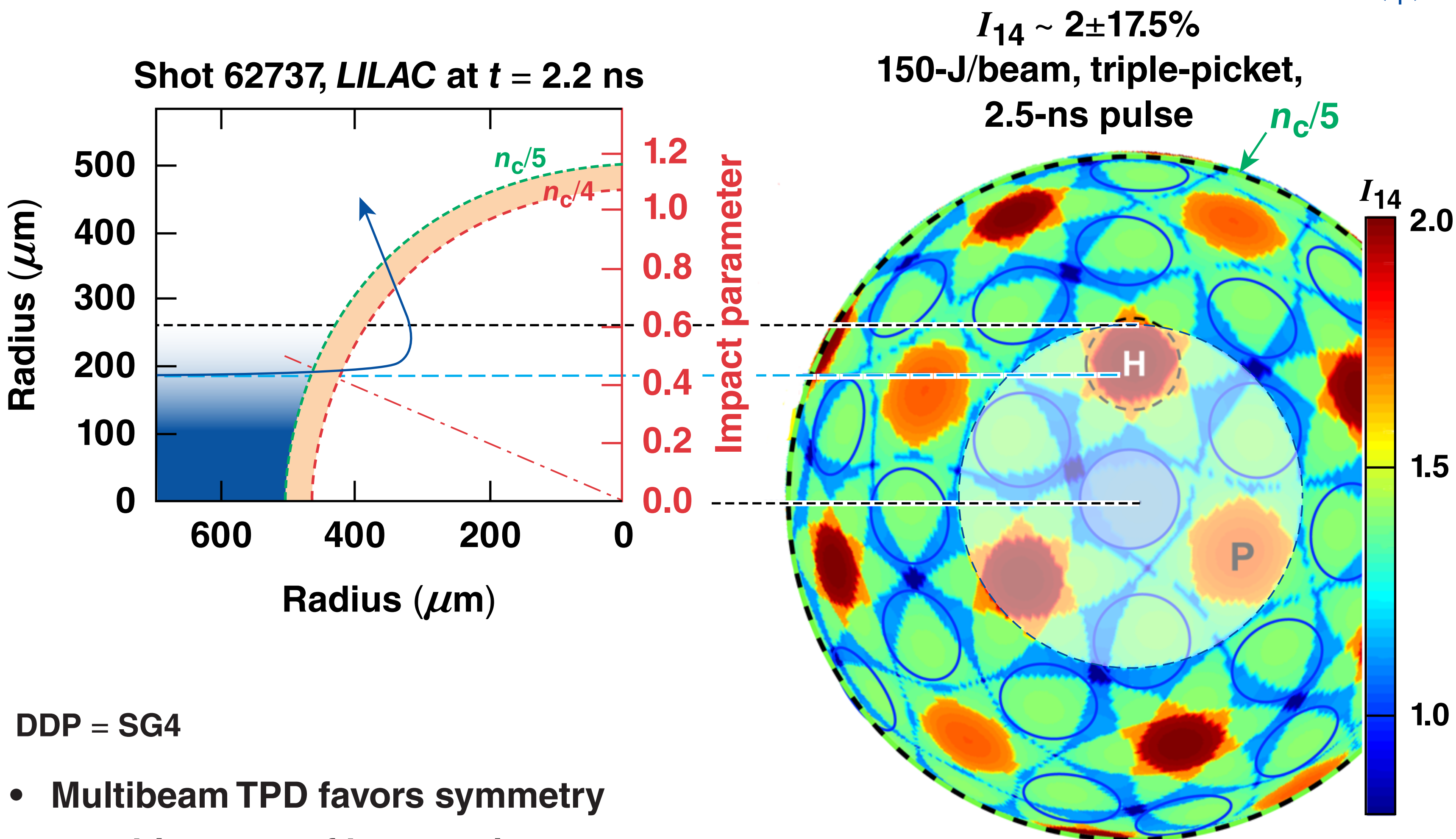
DDP = SG4



For 60 beams with a 1-ns square pulse and 450 J/beam, I ~ 11.6 × 10^{14} W/cm^2±0.3%

E21335

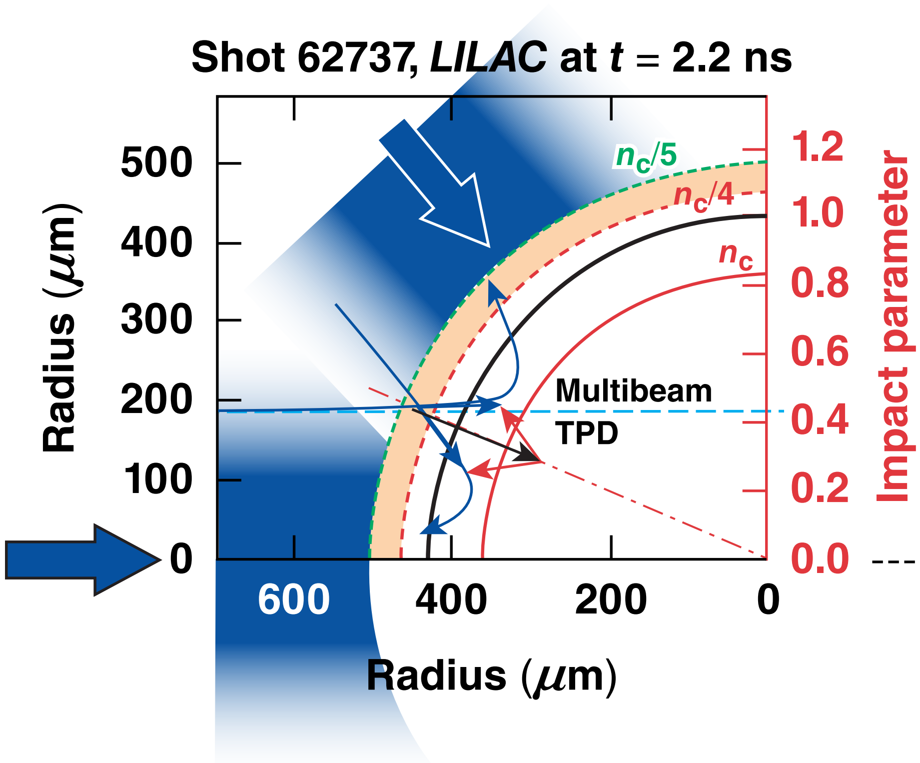
Later in the pulse, the irradiation uniformity relevant for TPD near quarter critical is considerably worse

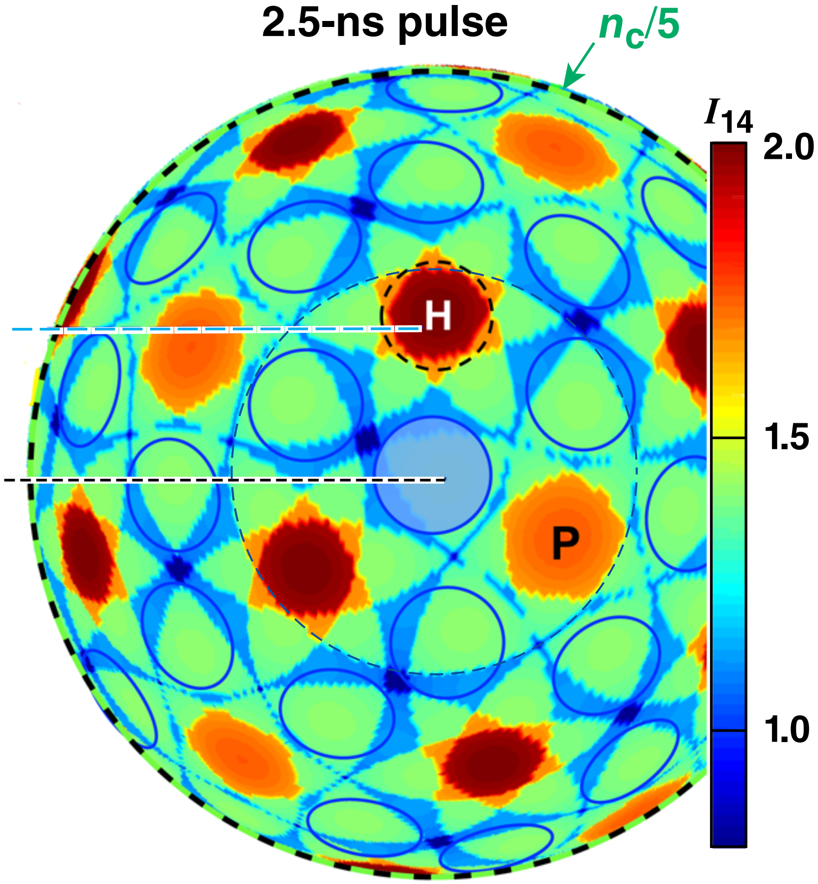


DDP = SG4

- Multibeam TPD favors symmetry
  - bisectors of beam pairs
  - centers of HEX or PENT ports

Later in the pulse, the irradiation uniformity relevant for TPD near quarter critical is considerably worse





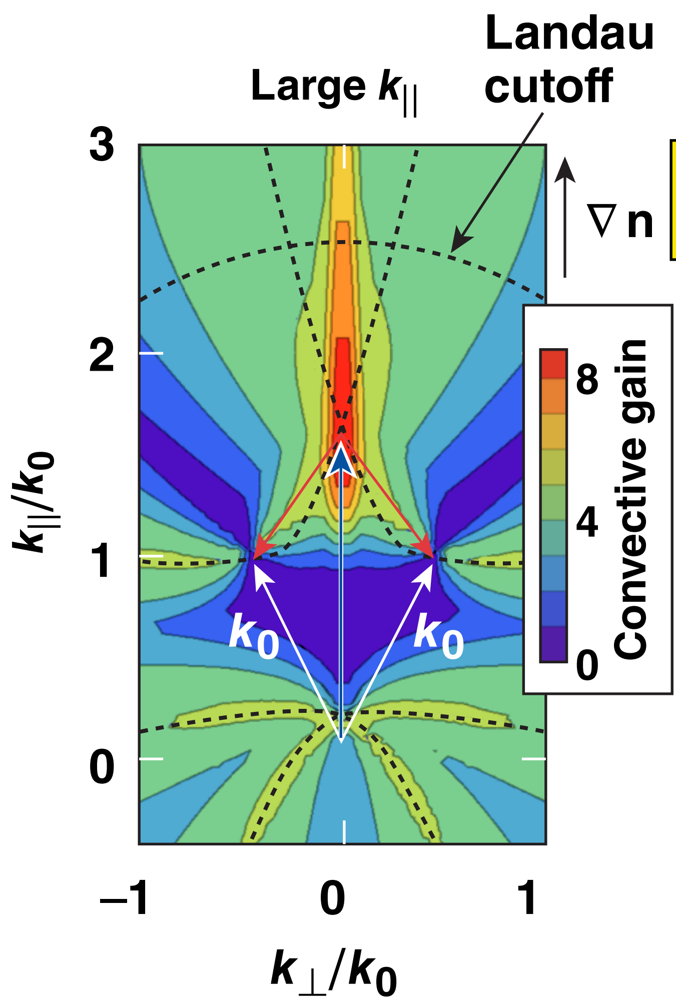
DDP = SG4

- Multibeam TPD favors symmetry
  - bisectors of beam pairs
  - centers of HEX or PENT ports

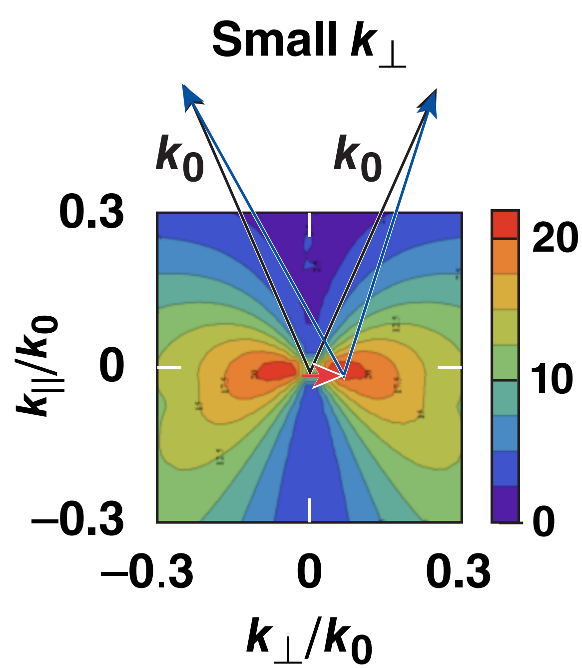
E21347a

There are two distinct multibeam TPD instability regions

Convective gain for two-beam common-mode TPD instability



In-plane polarization

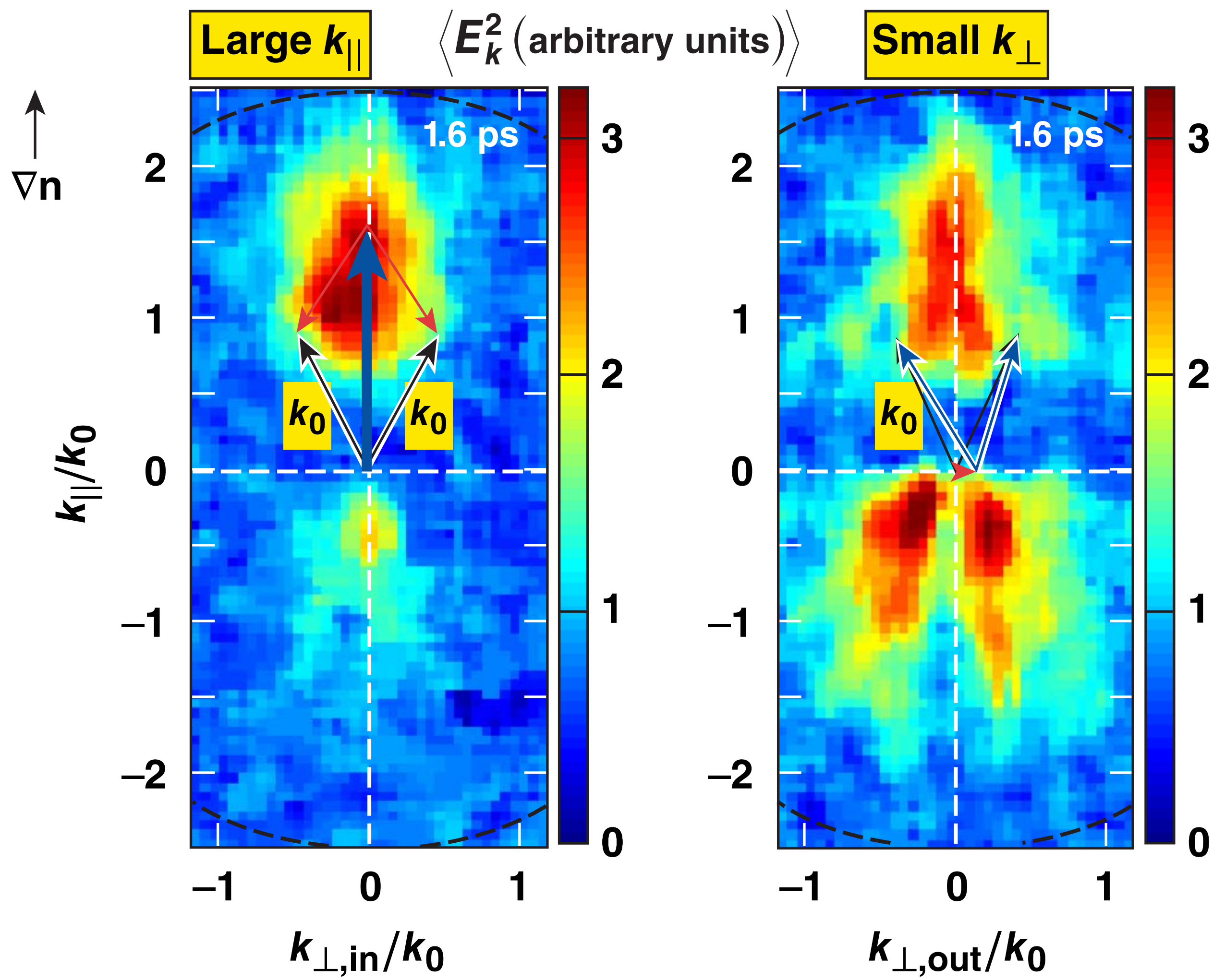


Out-of-plane polarization

- **Six-beam TPD convective-gain calculation indicates absolute instability for small $k_{\perp}$. (Single-beam intensity is below absolute threshold.)**

E21348

Nonlinear 3-D Zhakarov simulations show both interaction regions including propagation and amplification of plasmons



In-plane polarization

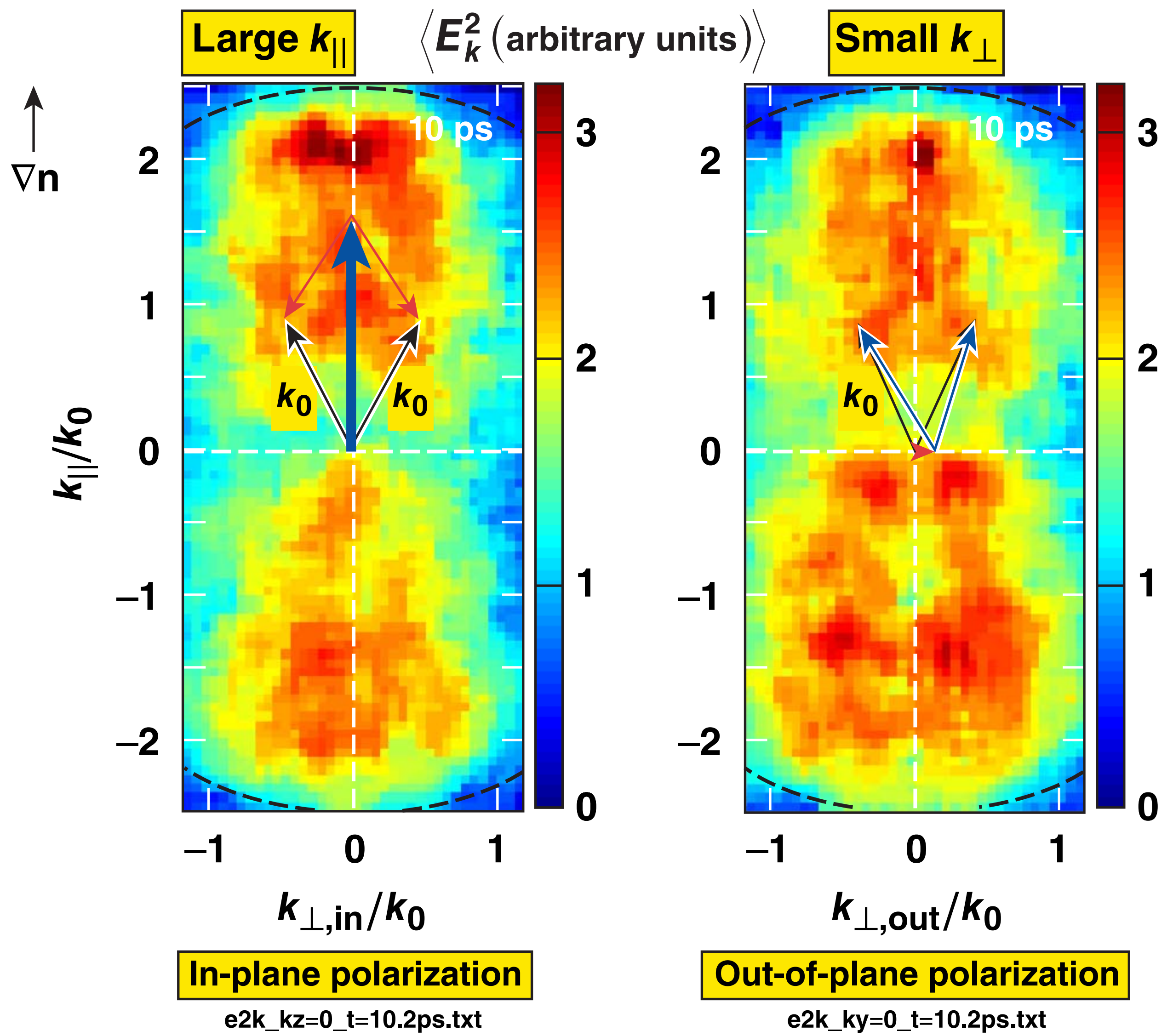
e2k_kz=0_t=1.6ps.txt

Out-of-plane polarization

e2k_ky=0_t=1.6ps.txt

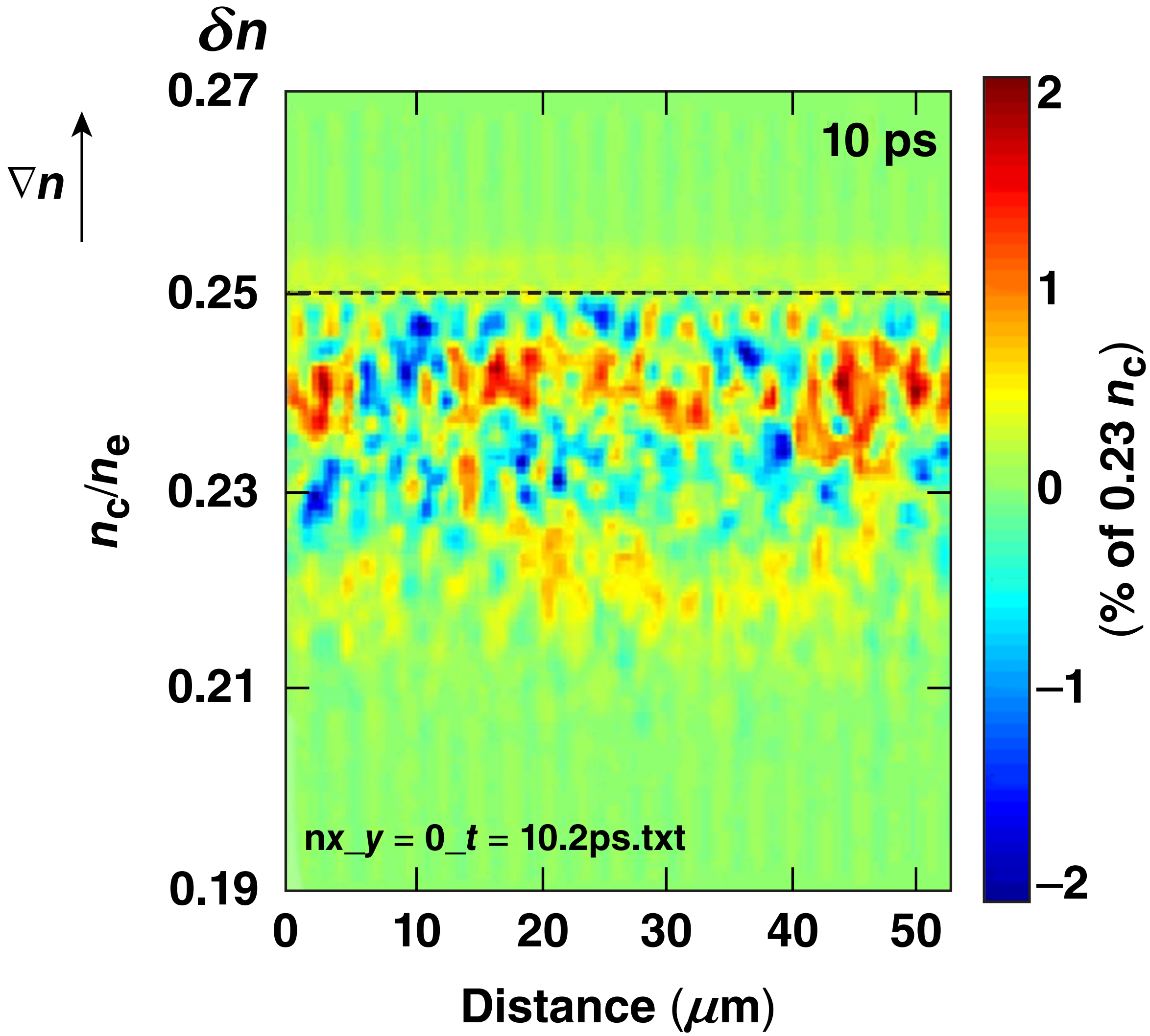
E21364

Nonlinear 3-D Zakharov simulations saturate after a few picoseconds and diverge significantly from nonlinear gain estimates

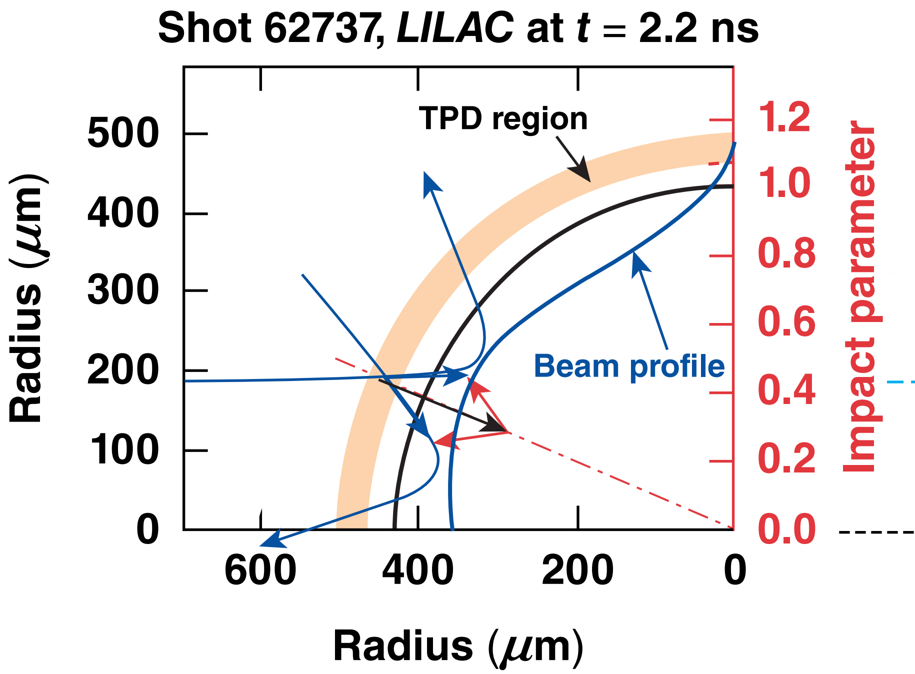


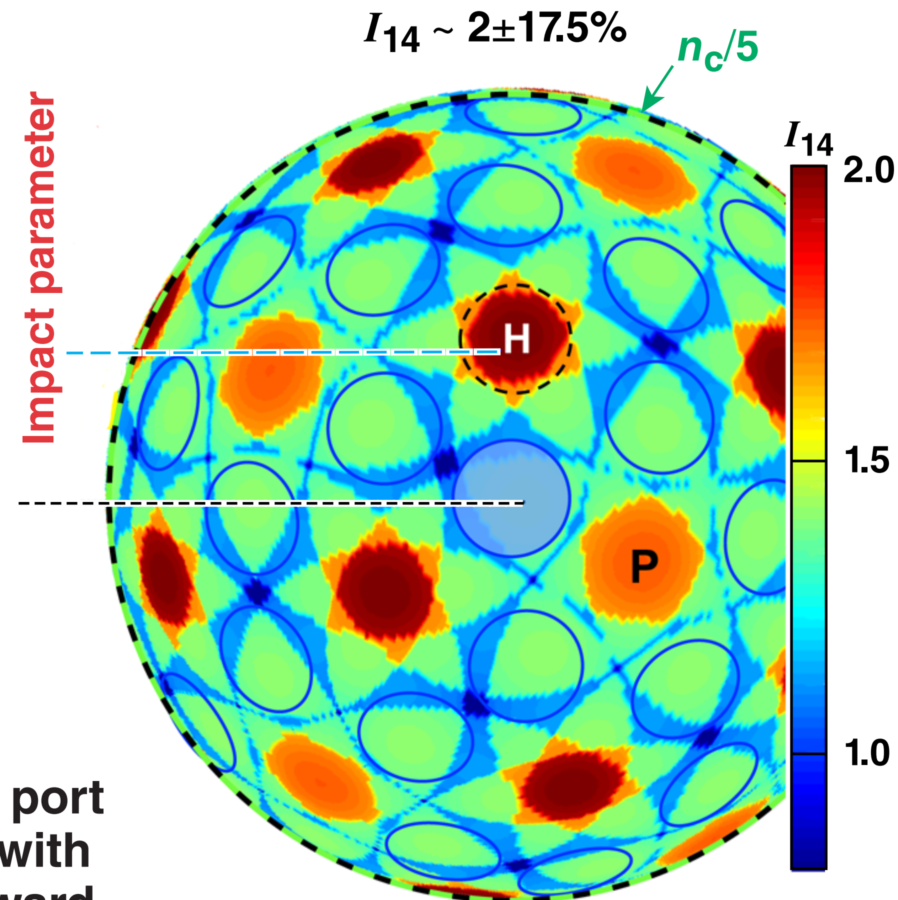
E21365

After 10 ps, very strong density perturbations near $n_c/4$ strongly influence the TPD instability



HEX and PENT locations on OMEGA are naturally favored for multibeam TPD interaction



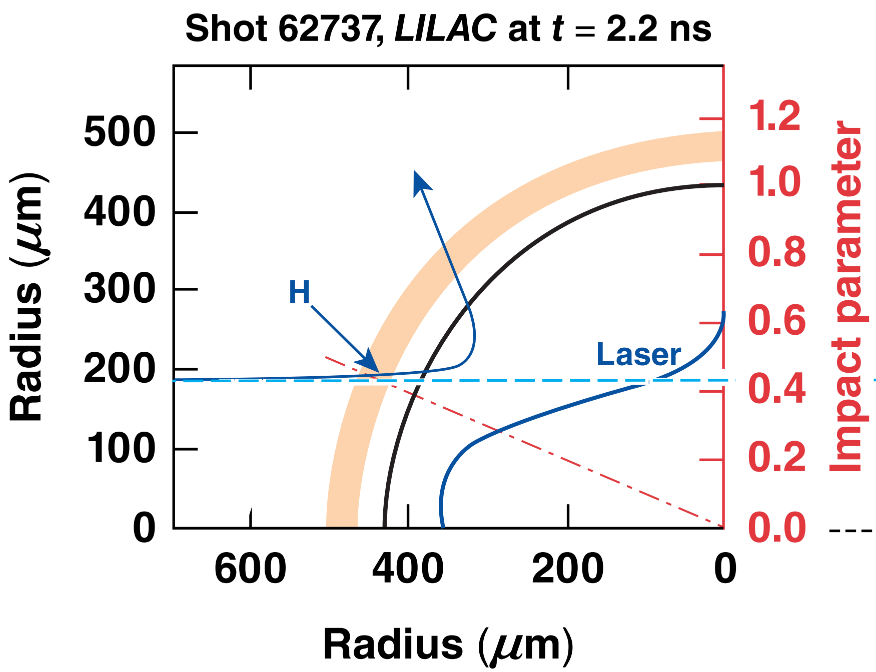


DDP = SG4

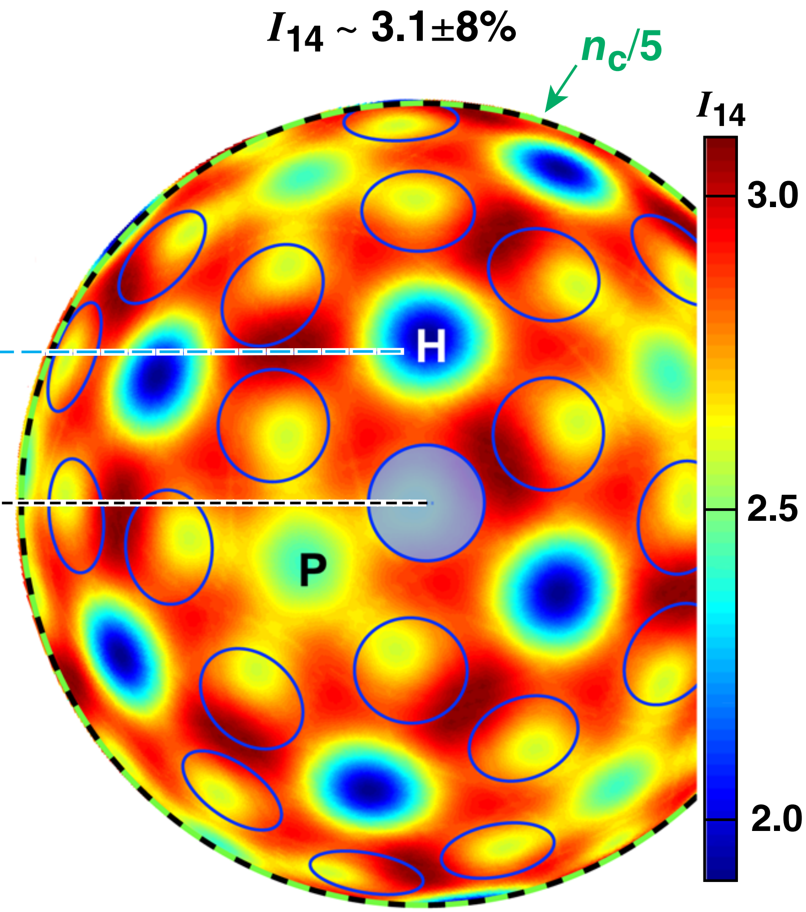
- Only six beams surrounding HEX port can contribute to multibeam TPD with shared plasmon going radially inward

E21350

Changing target illumination can significantly change the location and drive intensity of multibeam TPD



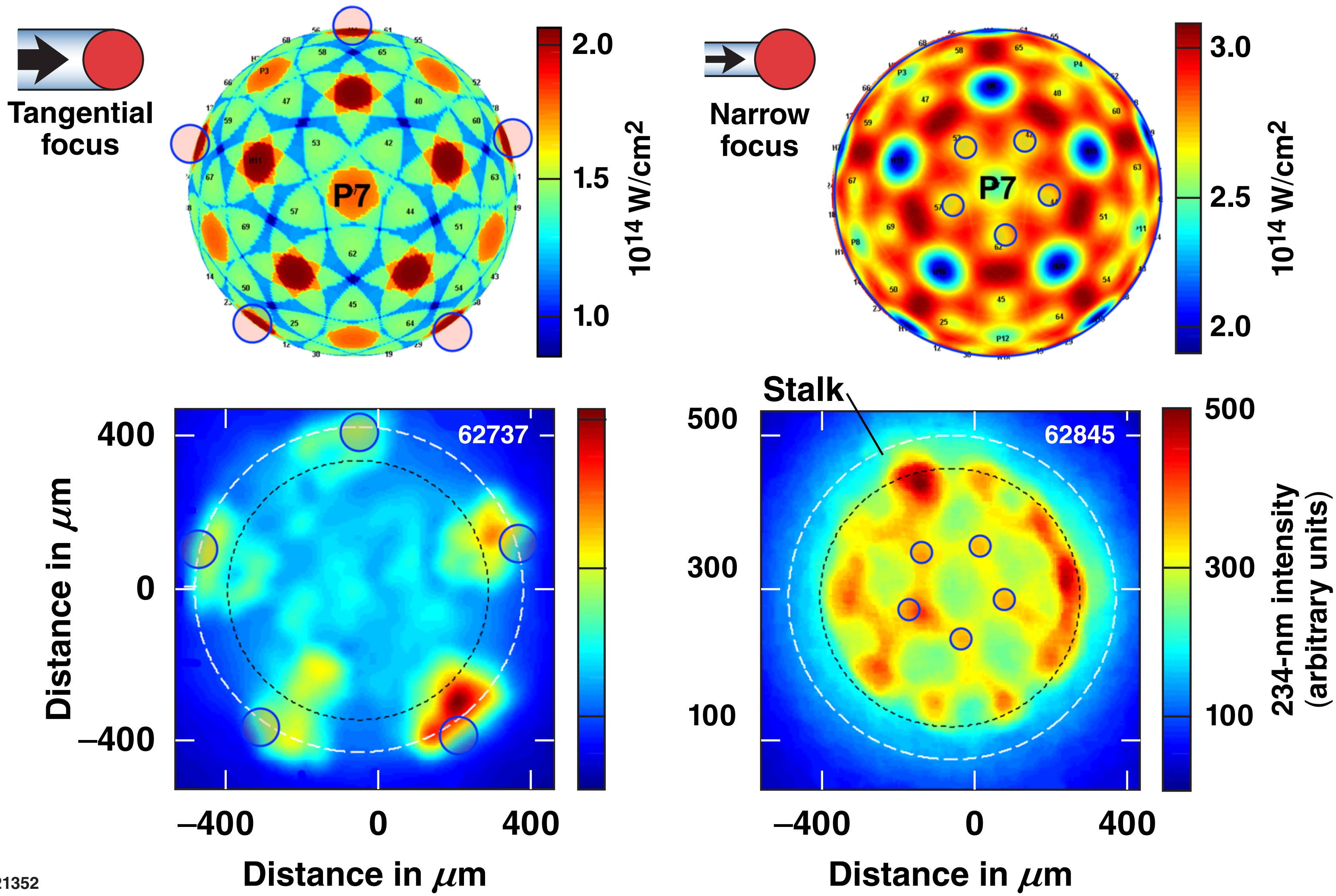
DDP = SG4



- 60-beam drive (illumination) nonuniformity degraded to 10% (from 0.3%)

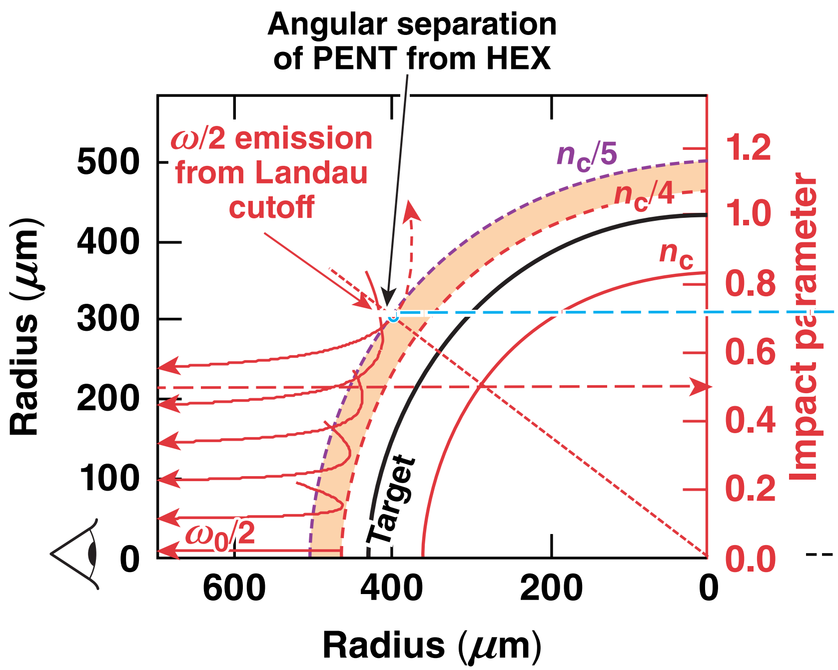
E21351

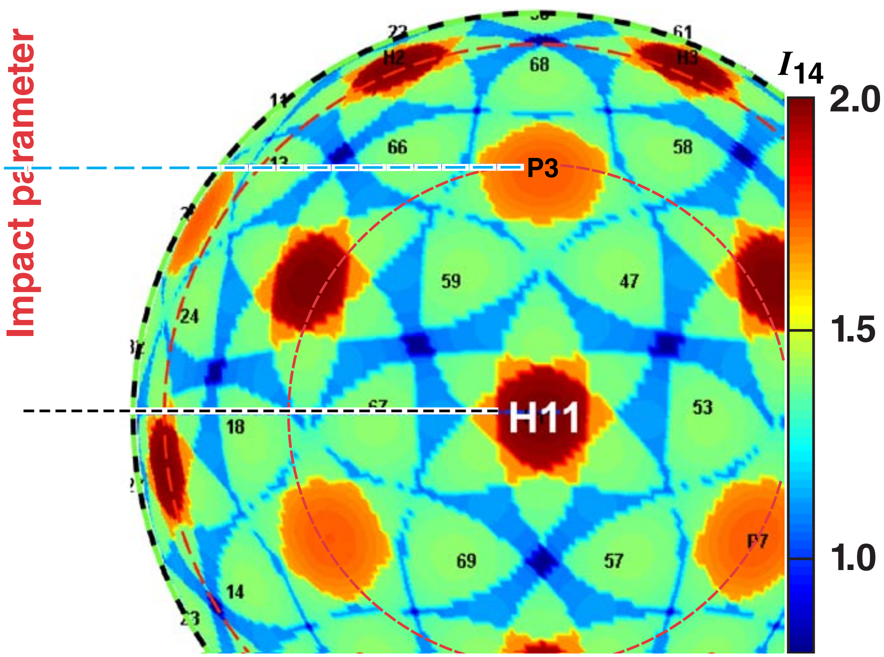
The structure observed in $3\omega/2$ images is consistent with TPD operating in localized regions



E21352

$\omega/2$ images are dominated by refraction and can be understood using ray tracing

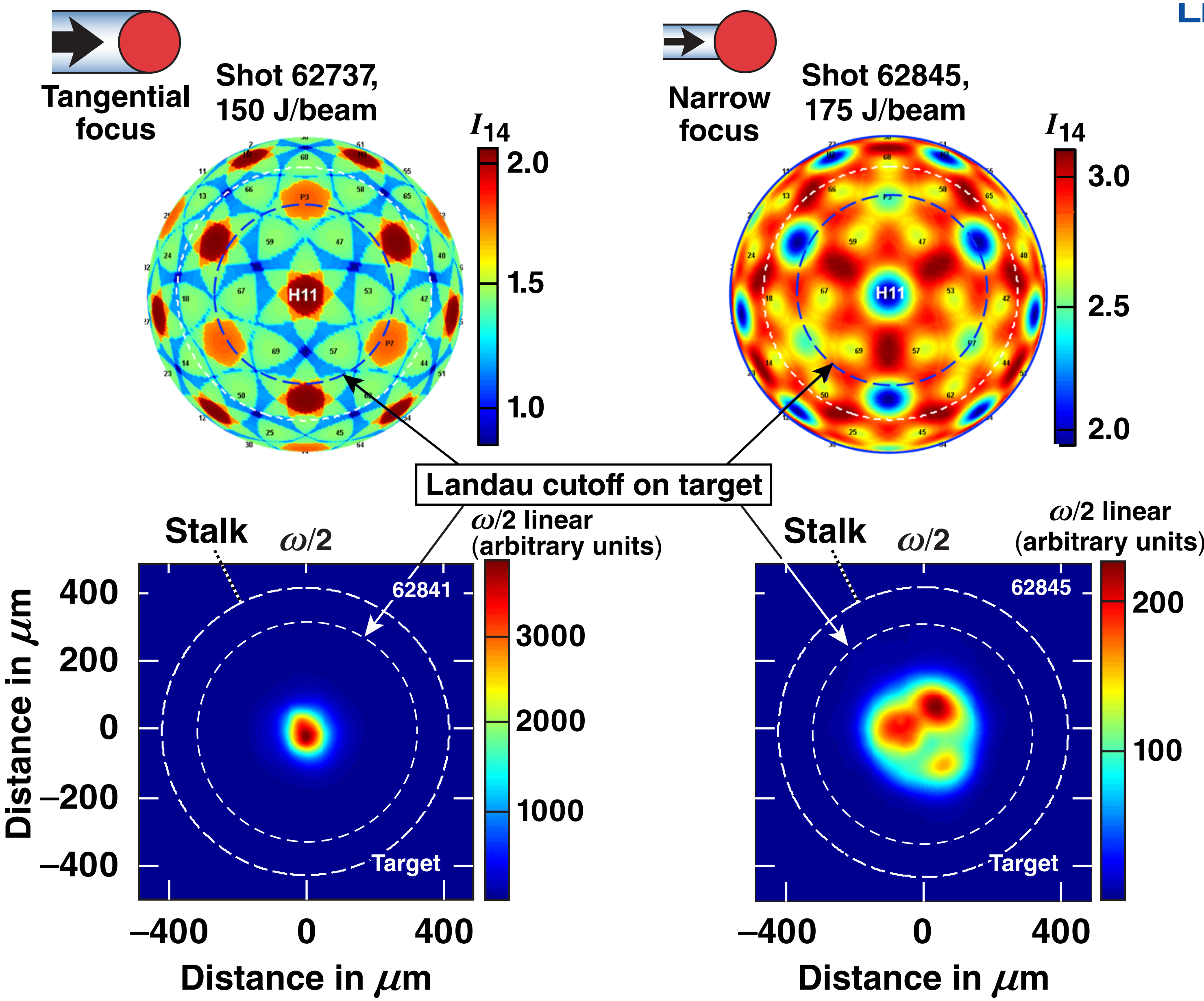




LILAC simulation for shot 62737, 150 J/beam

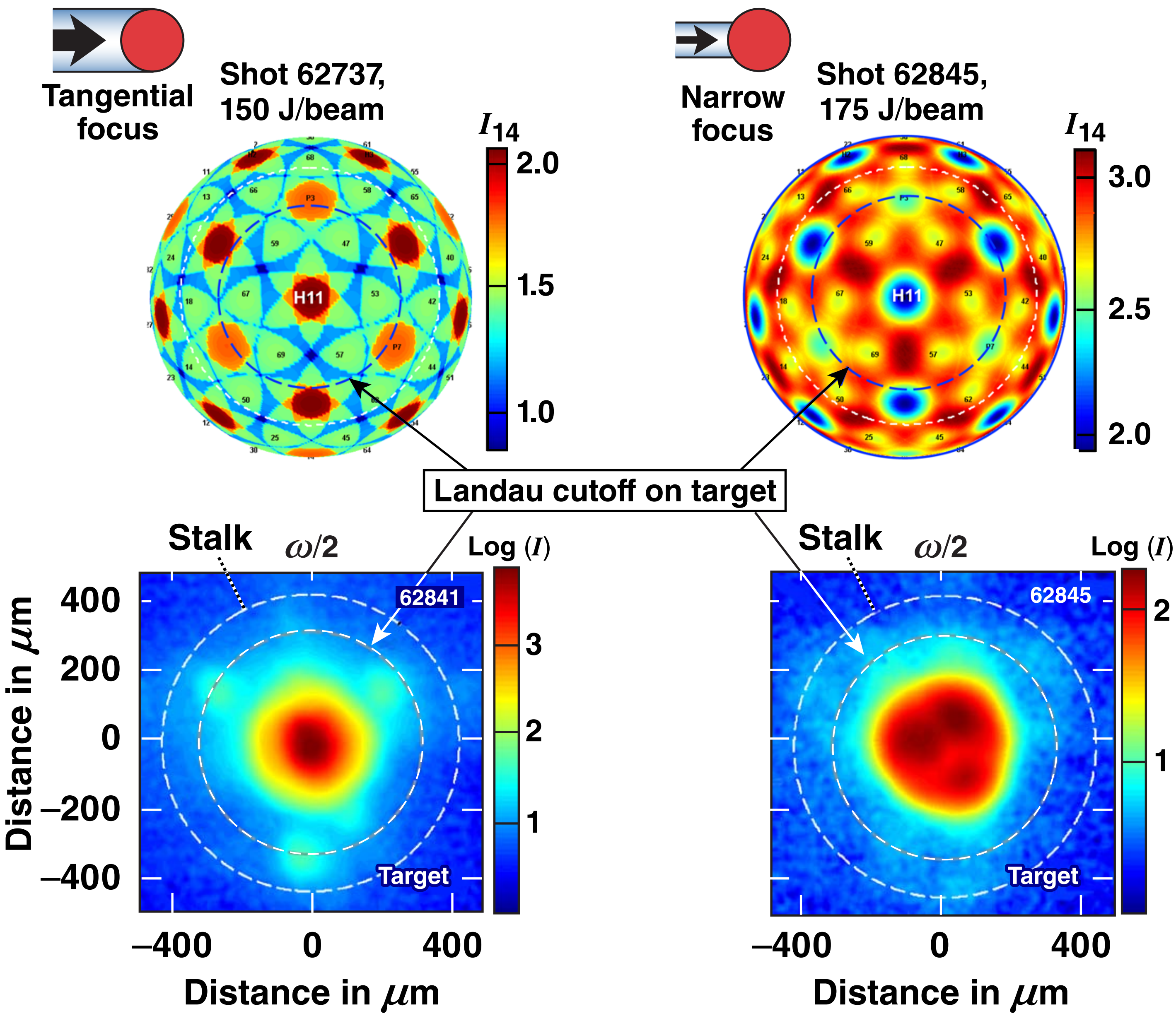
E21353

Different illumination conditions lead to understandable changes in $\omega/2$ images



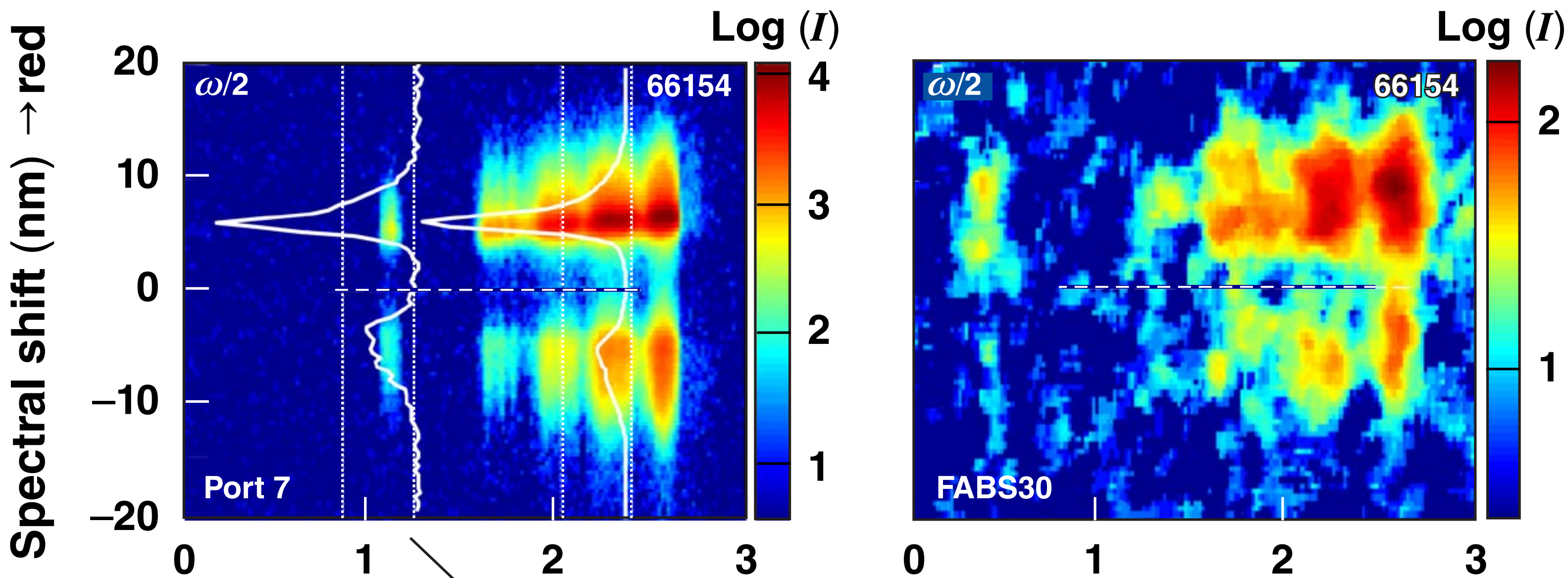
E21354

Different illumination conditions lead to understandable changes in $\omega/2$ images



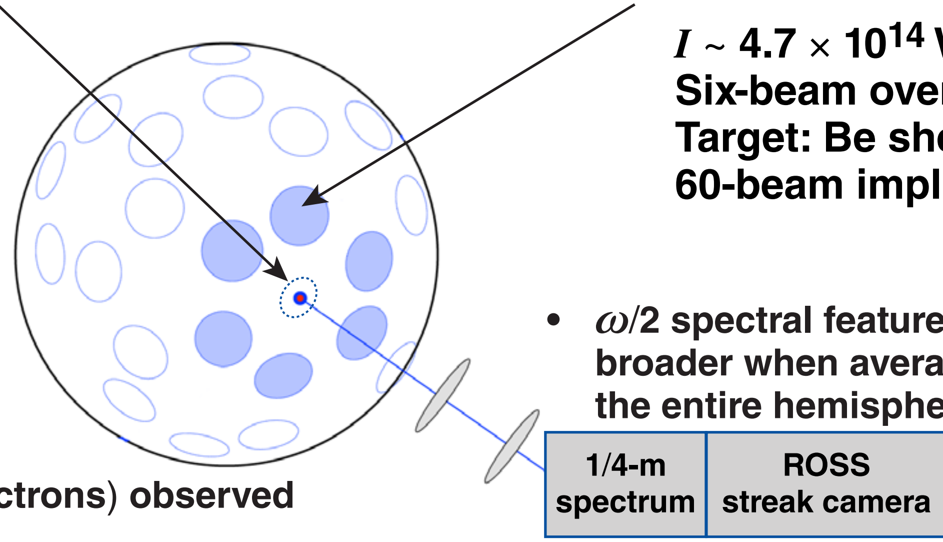
E21355

$\omega/2$ spectra viewed in HEX ports clearly indicate small $k_\perp$ instability



$I \sim 4.7 \times 10^{14}$ W/cm^2
Six-beam overlap: 3.8×10^{14}
Target: Be shell
60-beam implosion

- Single beam absolute TPD threshold is above peak single-beam intensity; six-beam overlapped intensity is above TPD absolute multibeam threshold

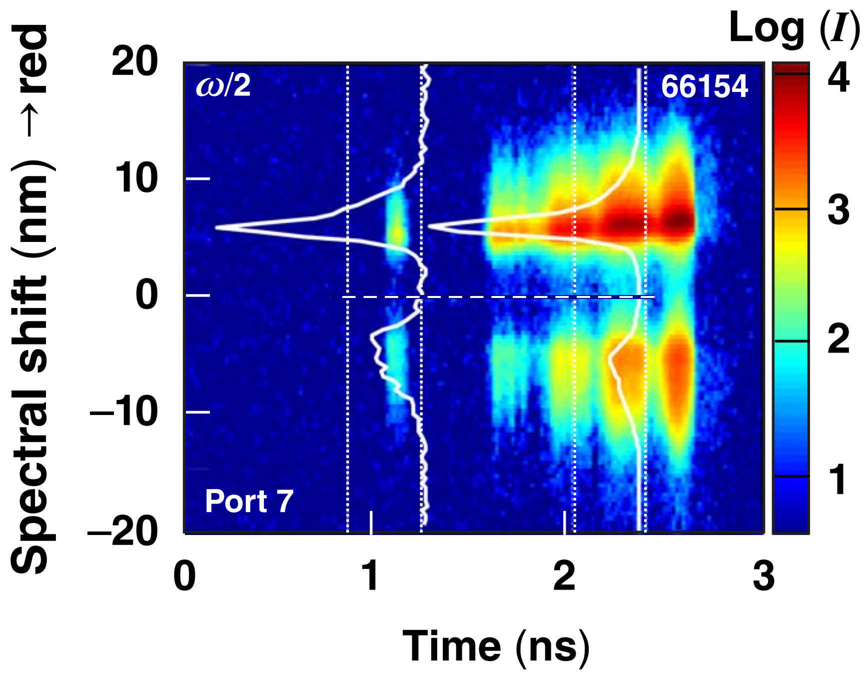


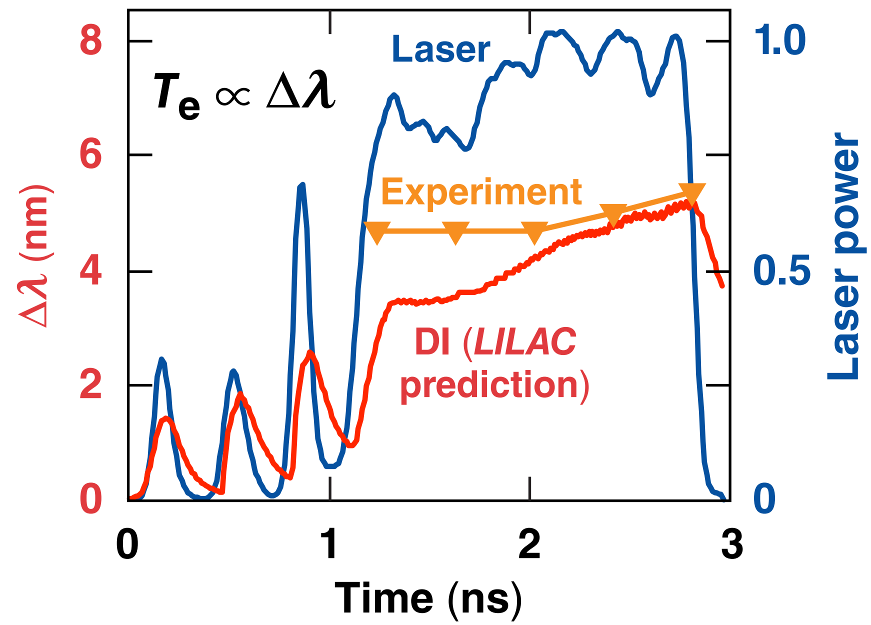
- $\omega/2$ spectral features are broader when averaged over the entire hemisphere

- No hard x rays (fast electrons) observed

E21356

$\omega/2$ spectra viewed in HEX ports clearly indicate small $k_\perp$ instability

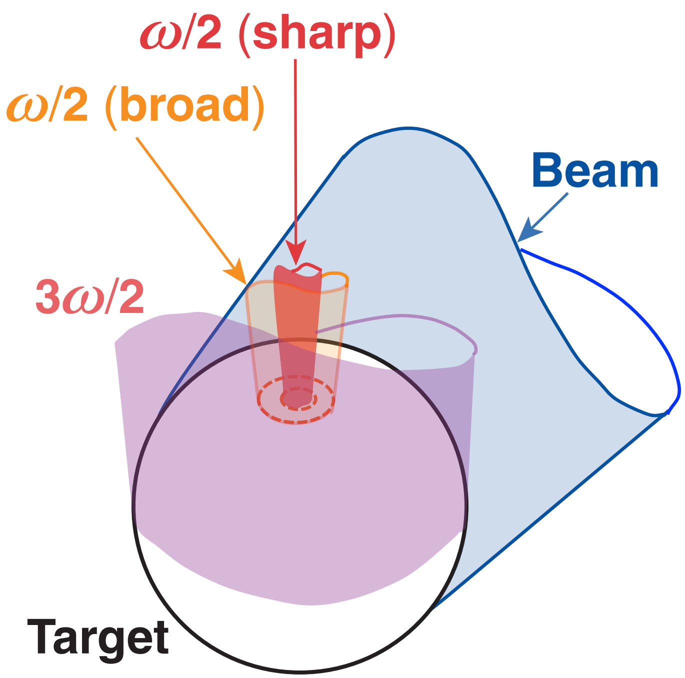


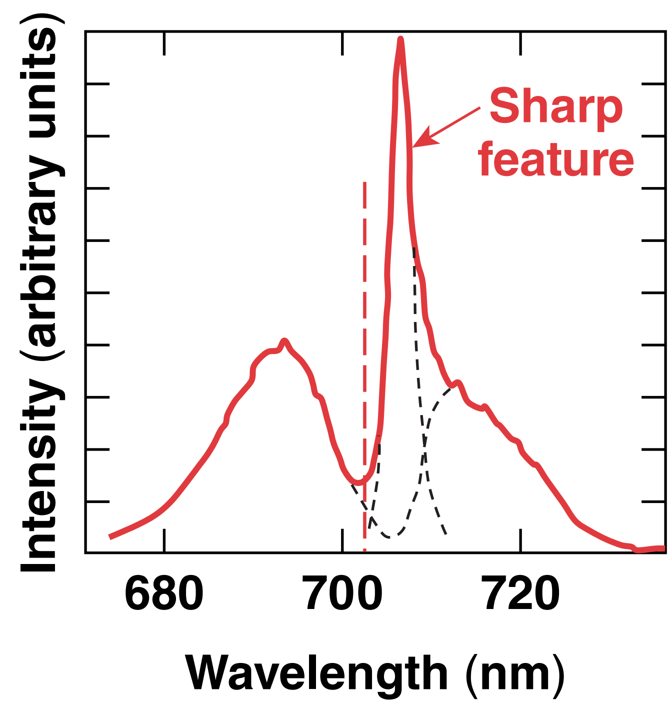


I ~ 4.7×10^{14} W/cm^2
Six-beam overlap: 3.8×10^{14}
Target: Be shell
60-beam implosion

E21357

In 1985* $\omega/2$ spectra were found to contain a valuable T_e measurement feature that has not been seen again until very recently



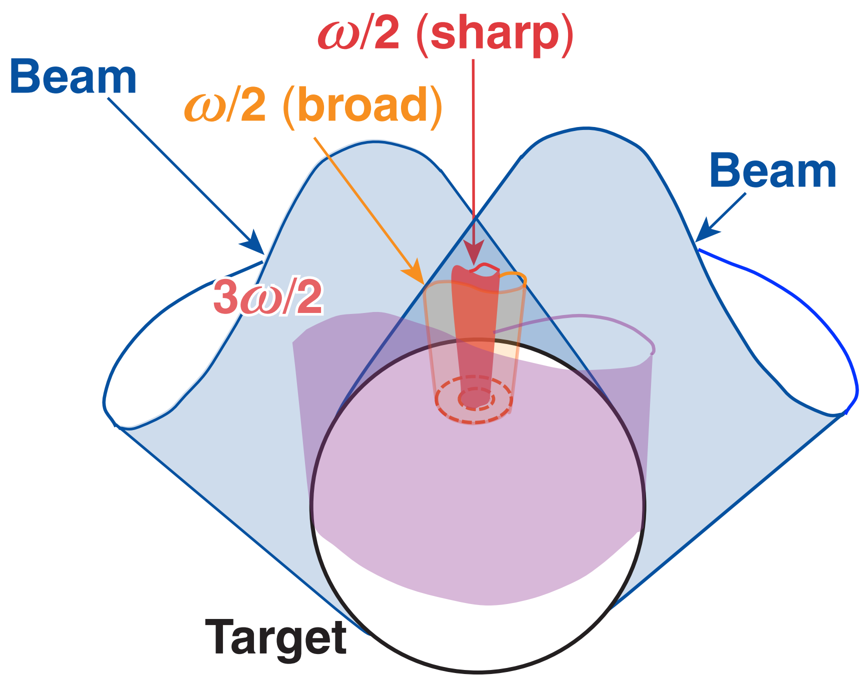


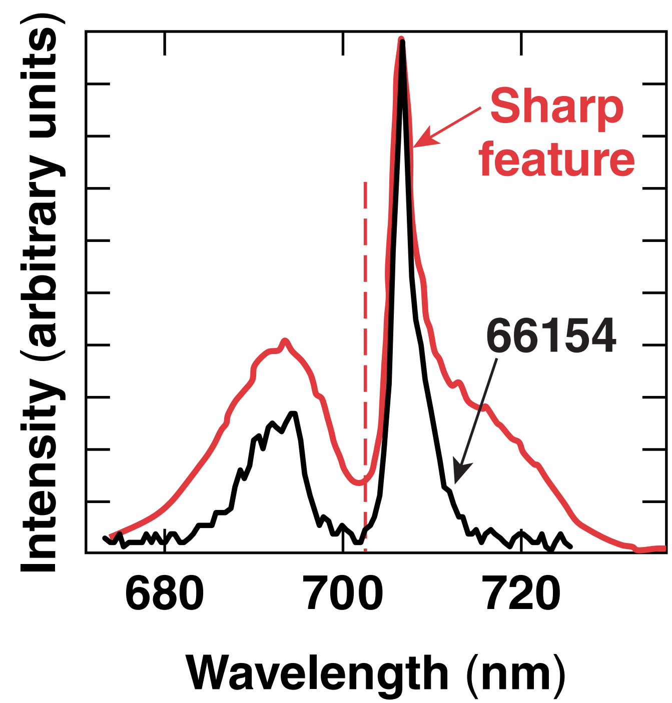
- No through-focusing lens measurements or time-resolved measurements existed at that time

E21363

*W. Seka *et al.*, Phys. Fluids 28, 2570 (1985).

The new interpretation involves multibeam TPD and is consistent with previous observations





E21363a

W. Seka *et al.*, Phys. Fluids 28, 2570 (1985).

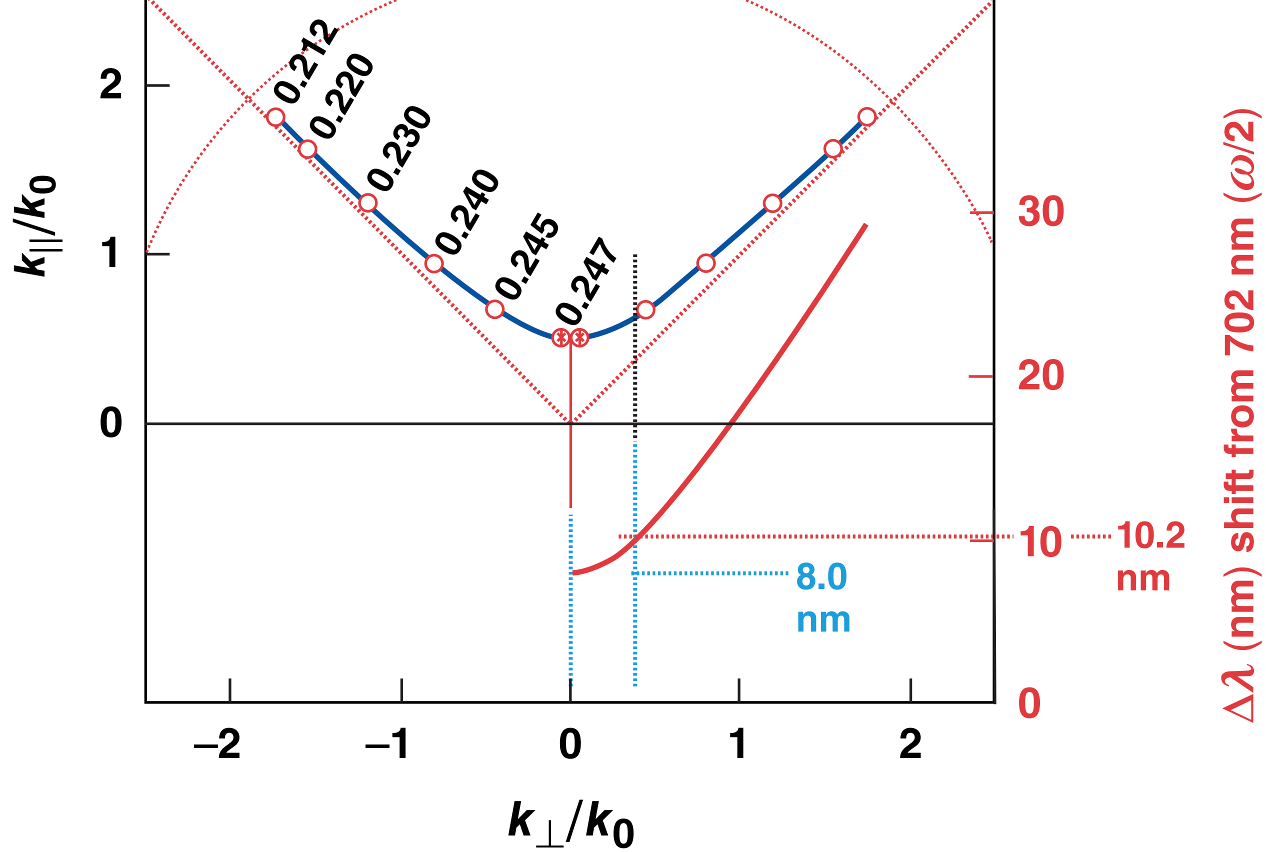
Summary/Conclusions

Images and spectra of the $3\omega/2$ and $\omega/2$ emission from implosion experiments indicate localized multibeam two-plasmon-decay (TPD) instability

- $3\omega/2$ and $\omega/2$ images are consistent with driving common waves in HEX and PENT ports on OMEGA
- Comparison of on-target laser-light nonuniformity and $3\omega/2$ and $\omega/2$ images allows for inferences on TPD driven in localized areas
- Two distinct TPD instability regions have been identified
- $\omega/2$ spectra point toward multibeam common-wave processes

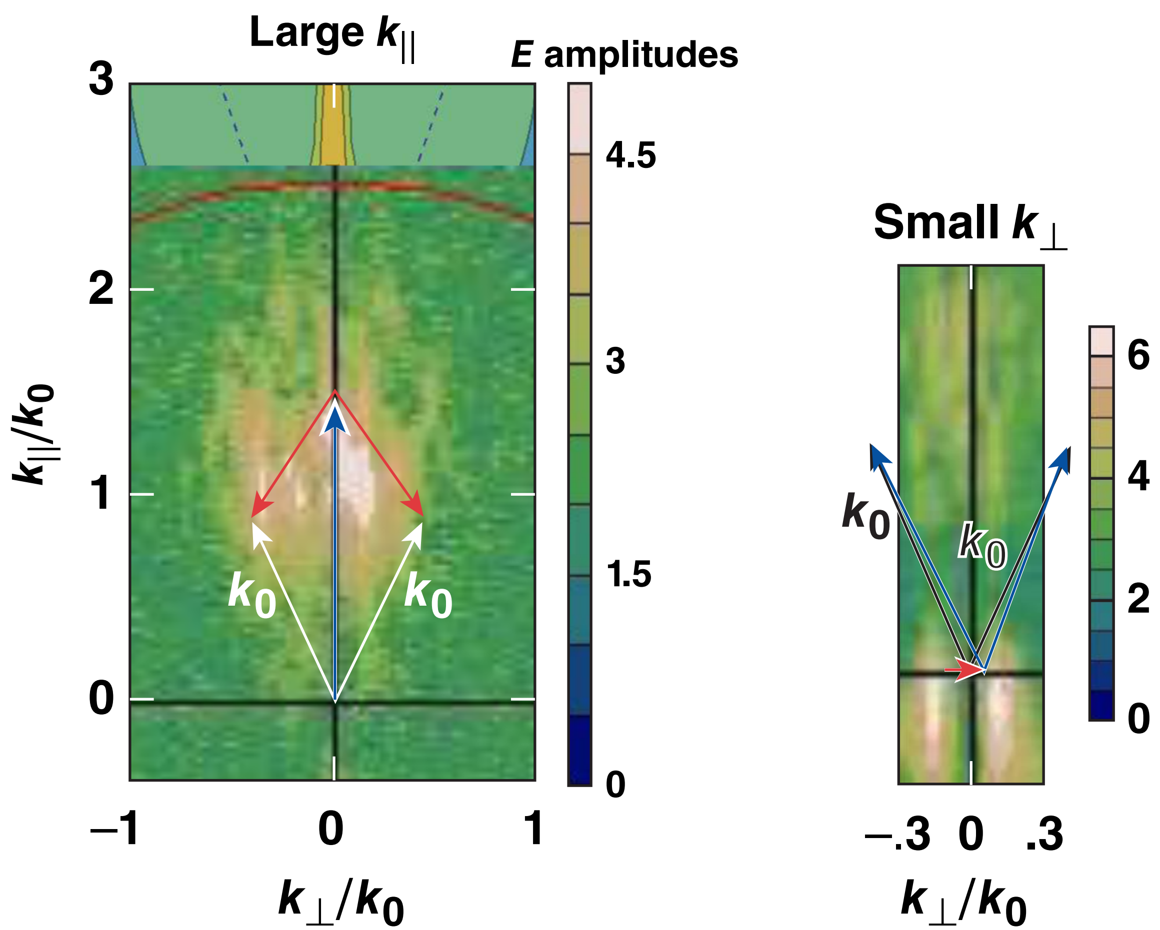
For $k_\perp/k_0 < 0.2$ the 702-nm wavelength shift varies little

Maximum density: 0.247 at $T_e = 1.3$ keV



E21358

Linear 3-D Zhakarov simulations show both interaction regions including propagation and amplification



In-plane polarization

Out-of-plane polarization

- Multibeam simulations indicate common-mode instability over a wide range of $k_{||}$ extending to the Landau cutoff
- Absolute instability including propagation and amplification of small plasmons

E21349