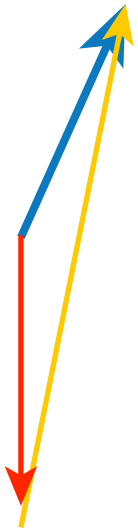
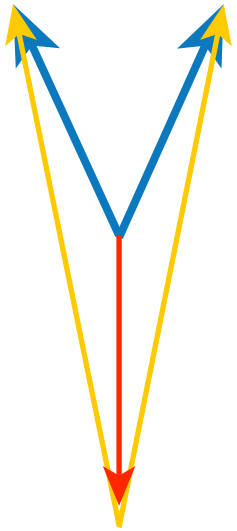
Multibeam Laser–Plasma Interactions Lead to Localized Interaction Regions



Single-beam interactions



Multibeam interactions sharing a common daughter wave

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Division of Plasma Physics
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Summary

There is ample experimental evidence for nonuniform energy deposition into various three-wave interaction processes

UR LLE

- Stimulated Brillouin scattering (SBS)
  - SBS backscatter is inherently nonuniform
  - low-gain SBS sidescatter [cross-beam energy transfer (CBET)] significantly affects drive uniformity
- Stimulated Raman scattering (SRS) is filamentation-mediated in backscattering at high intensities
- Two-plasmon decay (TPD) is predominantly a multibeam process responding to overlapped intensity nonuniformities

All three-wave interaction processes have the potential to lead to drive nonuniformity over the surface of inertial confinement fusion (ICF) targets.

E23628

Collaborators

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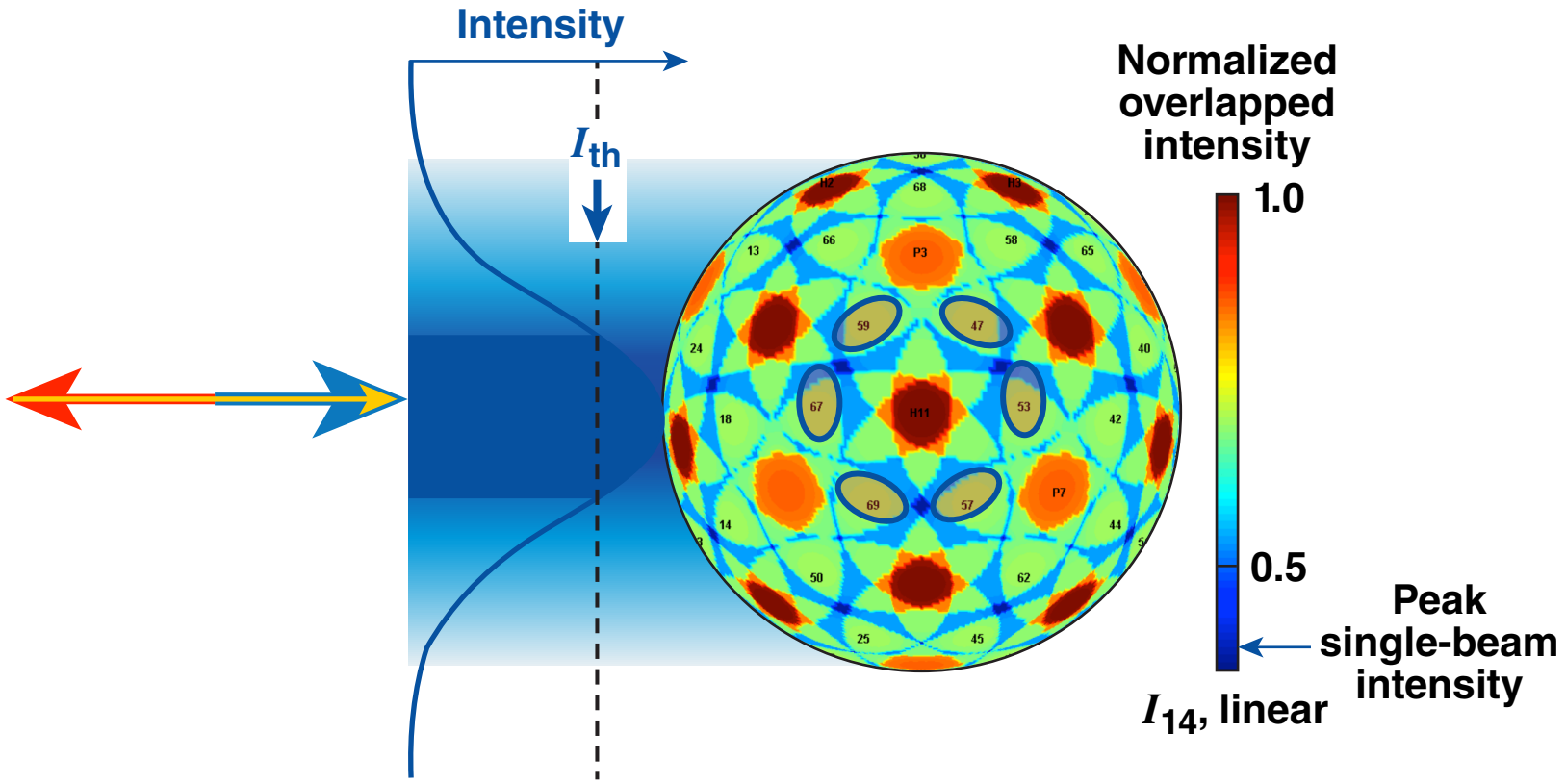
SBS

The gain of three-wave interactions is intensity dependent, inherently causing nonuniform energy deposition



- The effect is obvious for a backscattering instability (e.g., SBS)
- It applies to all laser–plasma instabilities (LPI's), back- or sidescattering and multibeam instabilities (polarization!)

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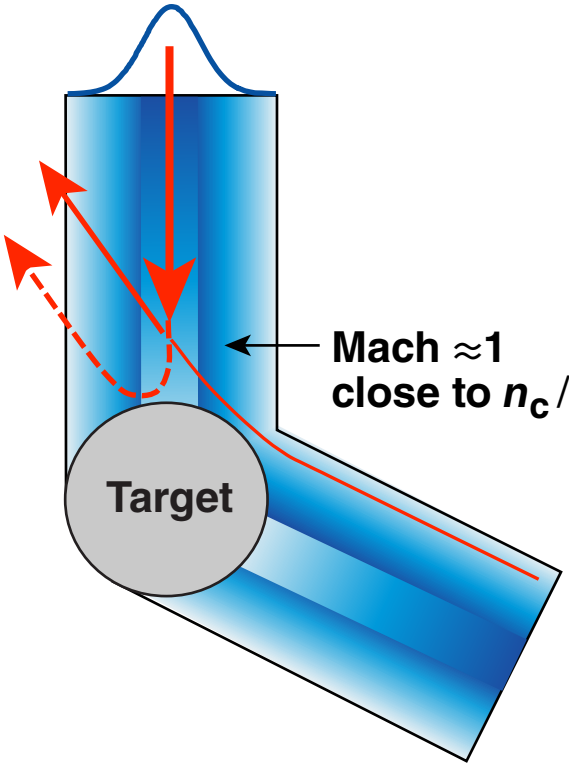
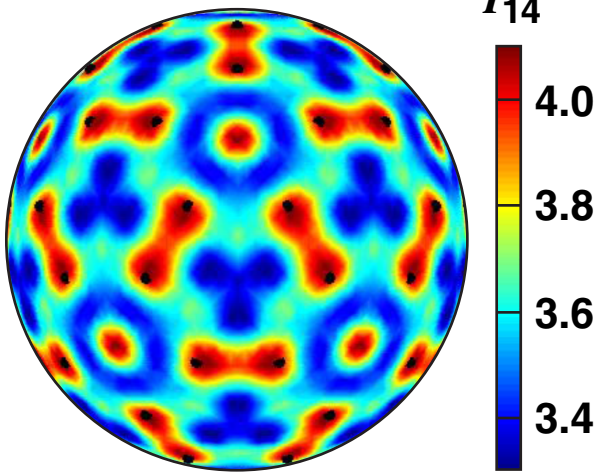
SBS

Low-gain SBS (CBET) leads to nonuniform laser drive for direct-drive ICF

- CBET was identified via scattered-light spectroscopy*
- CBET reduces absorption by ~10% to 20%
- Reduces hydrodynamic efficiency**
- **Causes localized reduction in drive – low-order-mode perturbations**
- Mitigation strategies are being investigated***



Intensity at n_c/4



$\sigma_{rms} \cong 6\%$
Peak-to-valley: ~24%
OMEGA cyro implosion

*D. H. Edgell *et al.*, Bull. Am. Phys. Soc. 52, 195 (2007).
**I. V. Igumenshchev *et al.*, Phys. Plasmas 17, 122708 (2010).
***D. H. Froula *et al.*, NO4.00013, this conference.

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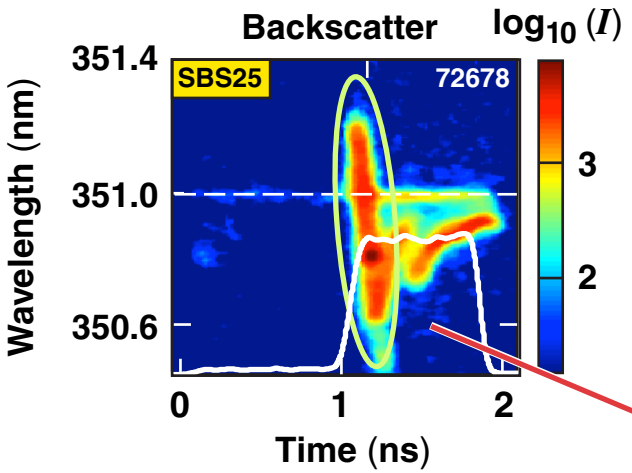
SBS

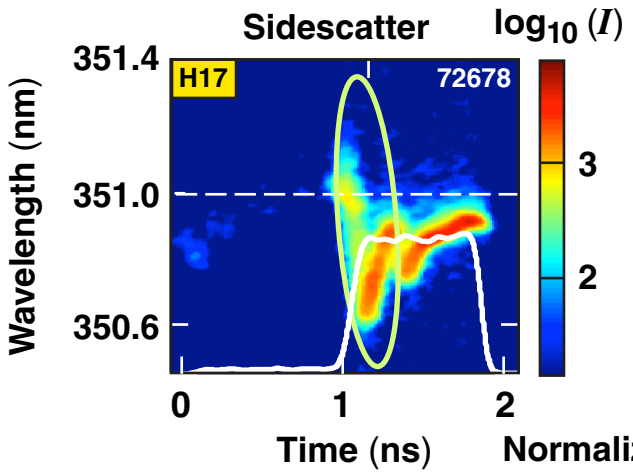
SBS is exacerbated by speckles and fast-rising laser pulses

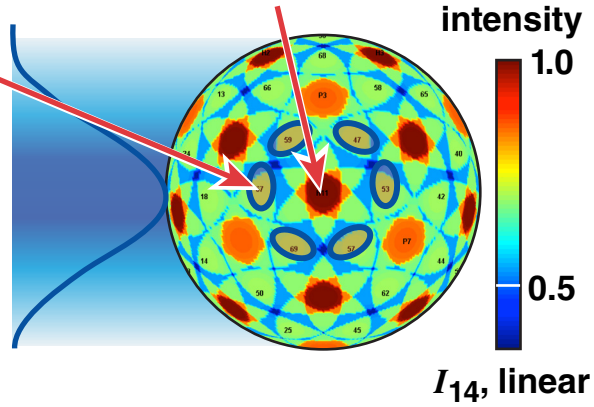
UR LLE

Single beam I_{14} = 8, no SSD*

Overlapped: I_{14} = 45







- Fast-rising pulses
  - rapidly changing ablation rate
  - velocity plateau descends ∇n

- ~15% instantaneous SBS backscatter (~6% time integrated)
- ~40% locally because of intensity distribution
- SBS tends to be hot-spot driven
- SBS is sensitive to rapid changes in ablation rate

*Smoothing by spectral dispersion

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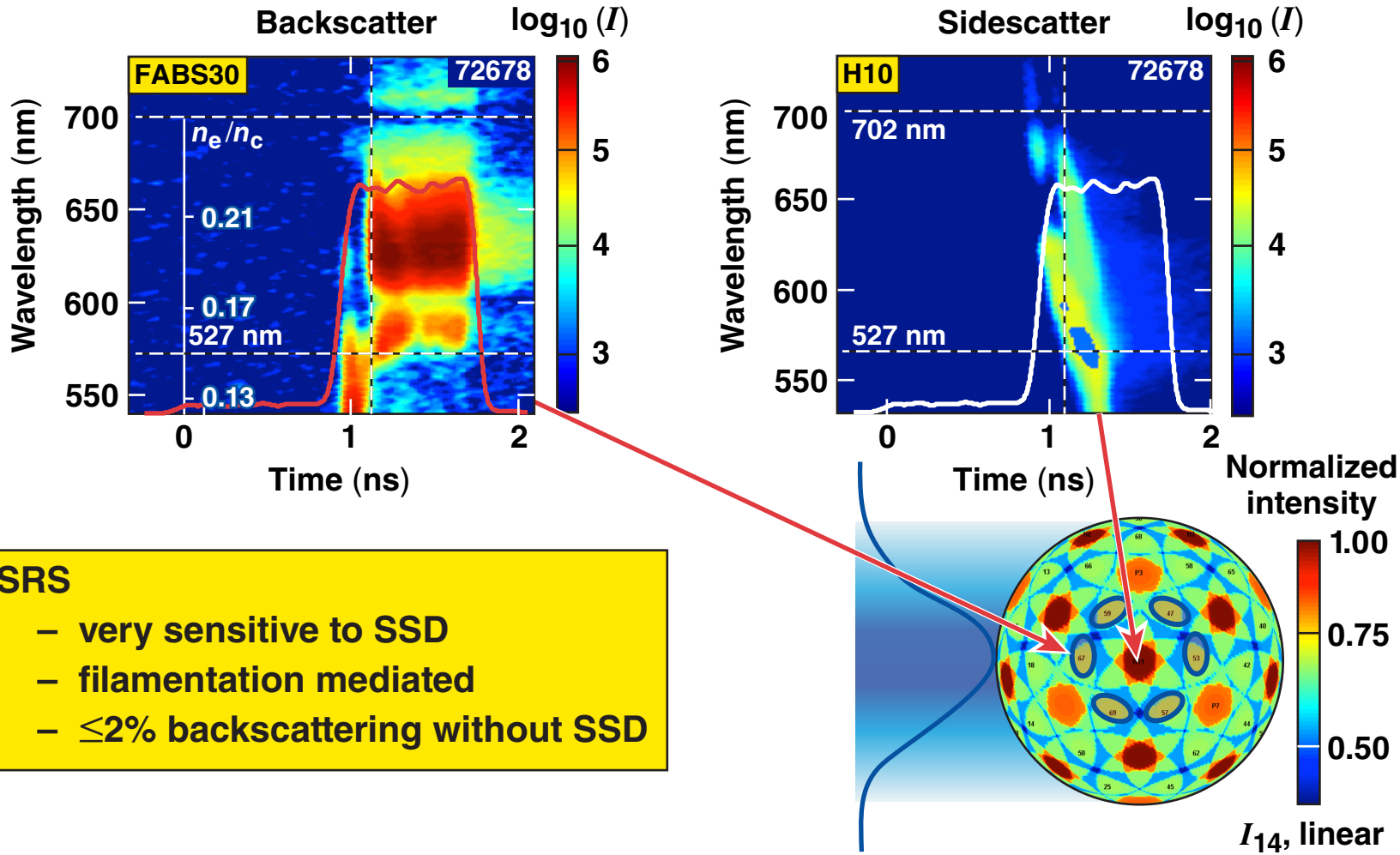
SRS

High-intensity spherical shock experiments are also prone to SRS backscattering

Single beam I_{14} = 8, no SSD

Overlapped: I_{14} = 45



- SRS
  - very sensitive to SSD
  - filamentation mediated
  - ≤2% backscattering without SSD

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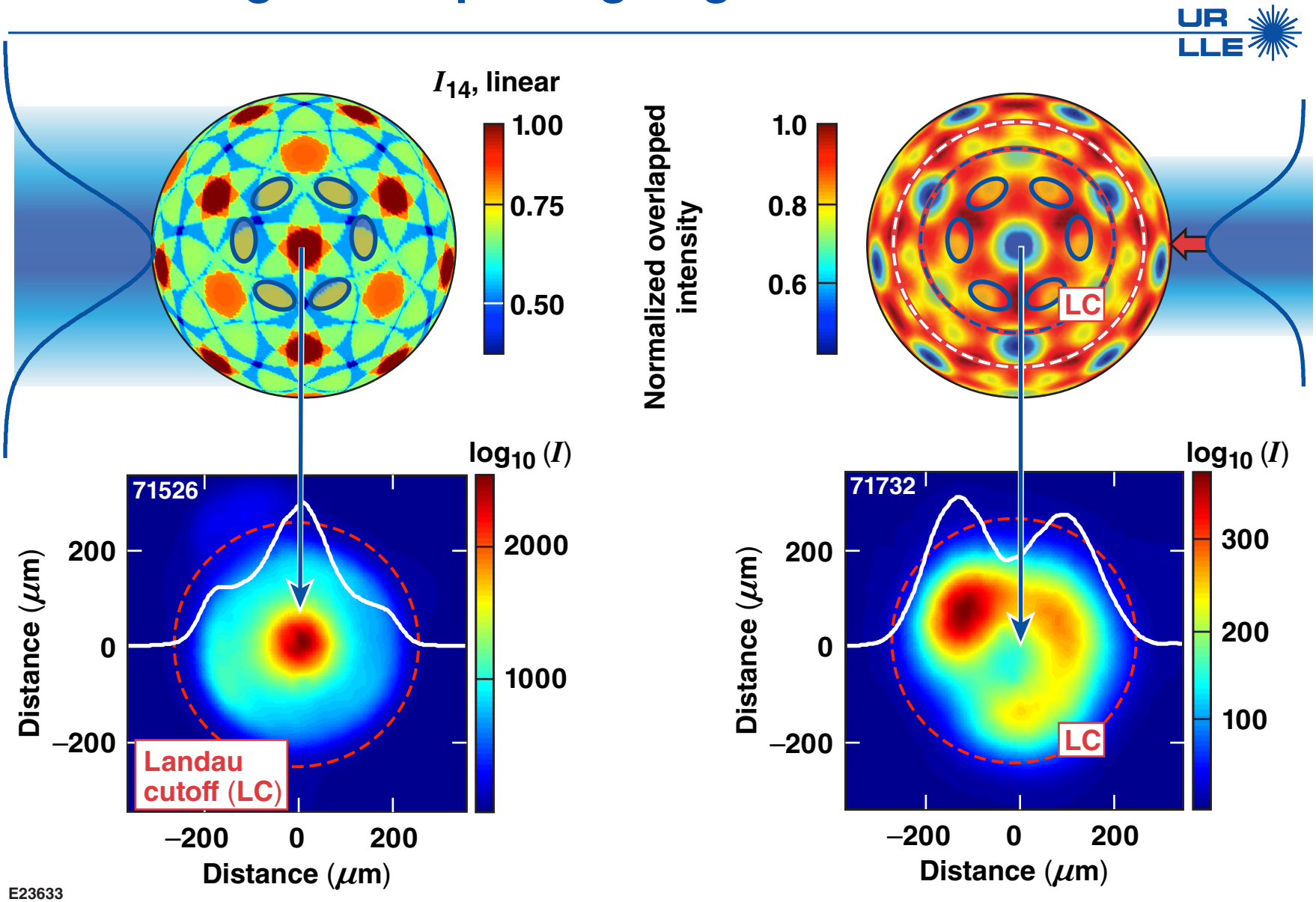
TPD

Nonuniform energy deposition into TPD is visible in $\omega/2$ images of imploding targets



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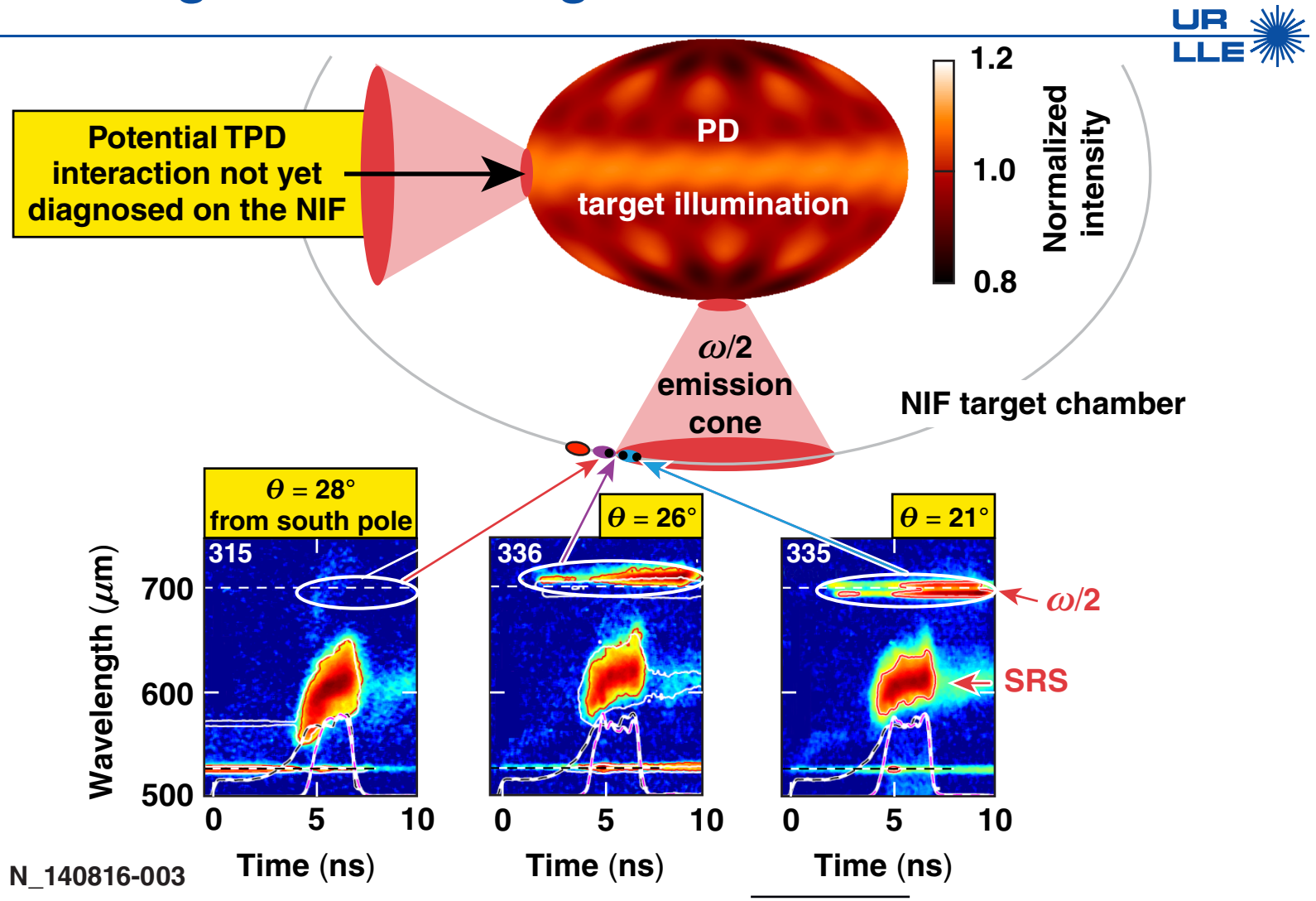
TPD

TPD in current National Ignition Facility (NIF) polar-drive (PD) implosions* occurs in clearly delimited regions of the target



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*M. Hohenberger, CI1.00001, this conference.

Summary/Conclusions

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