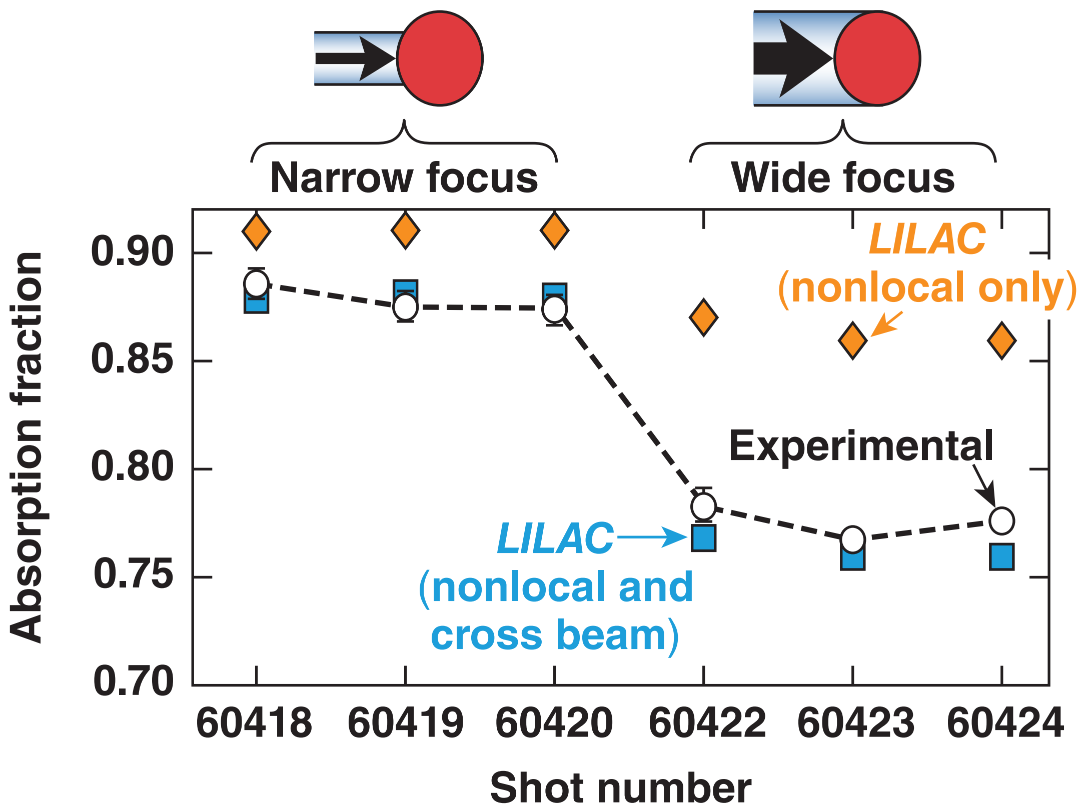
Reducing the Cross-Beam Energy Transfer in Direct-Drive Implosions Through Laser-Irradiation Control



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Summary

The loss of hydrodynamic efficiency in direct-drive implosions caused by cross-beam energy transfer can be reduced by changing the irradiation conditions

UR LLE

- Cross-beam energy transfer (CBET) is due to low-gain SBS sidescattering
- EM-seeding of SBS sidescattering is due to outer parts of one beam crossing the inner parts of another beam
- Beam sizes smaller than the target size reduce CBET, but may increase the illumination nonuniformity
- **Experiments with different illumination geometries and detailed spectral analyses have significantly increased our understanding of CBET**

E19904

Collaborators

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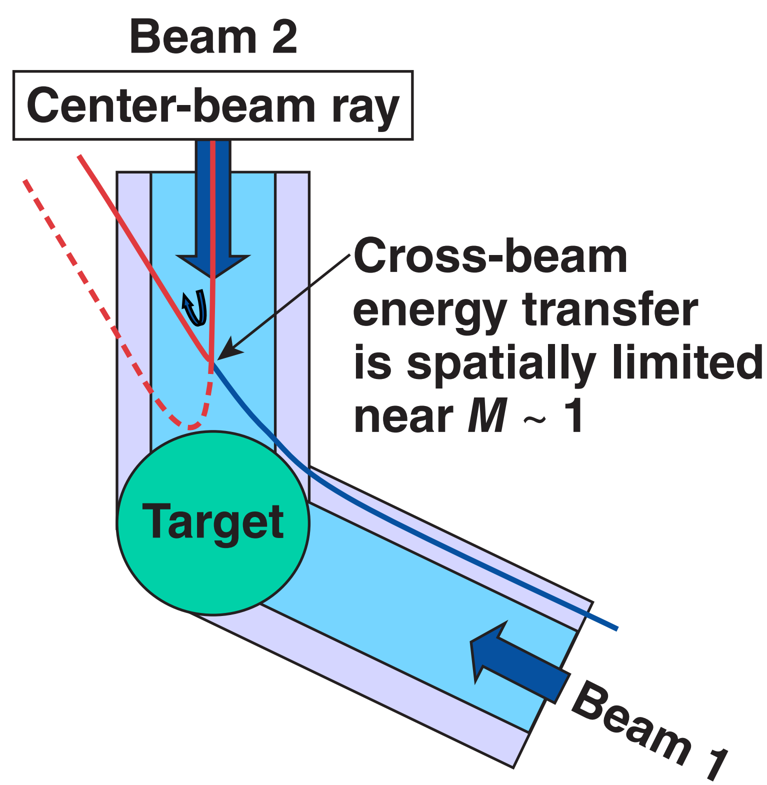
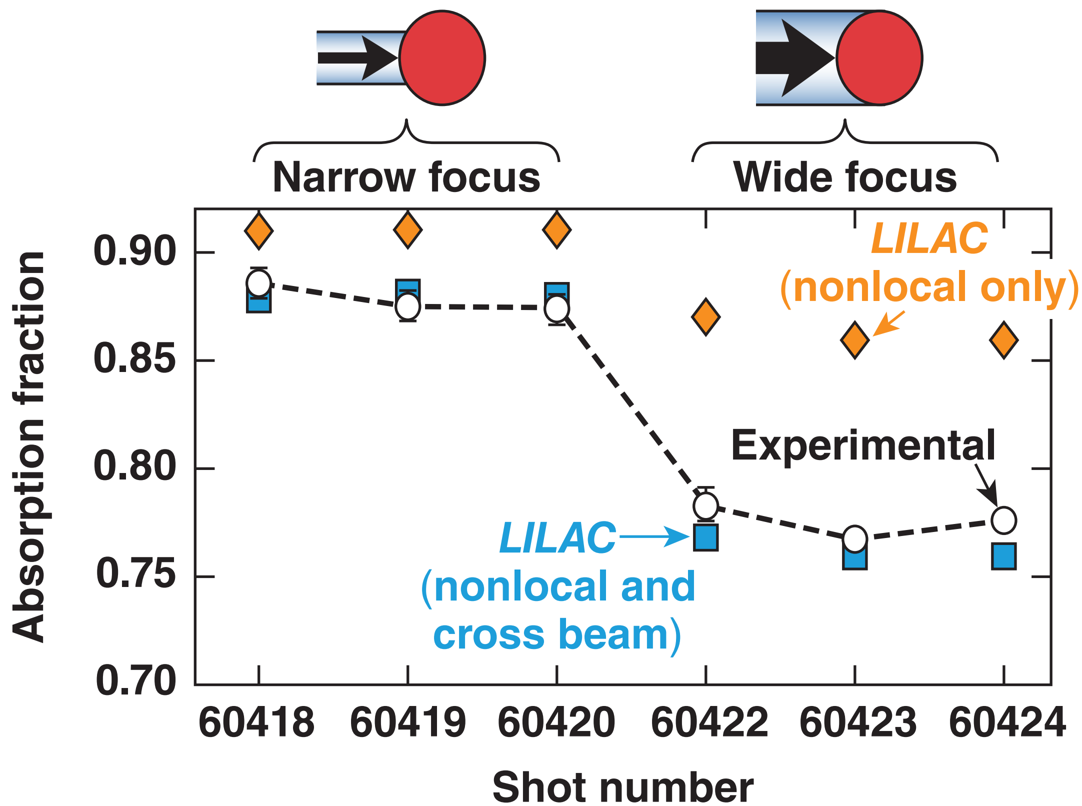
Cross-beam energy transfer involves EM-seeded, low-gain SBS sidescattering



- EM-seed is provided by outer parts of beams
- Inner parts of beams transfer some of their energy to outgoing parts of other beams

- **This process reduces hydrodynamic drive efficiency**
- **Reducing the beam size can reduce cross-beam energy transfer**

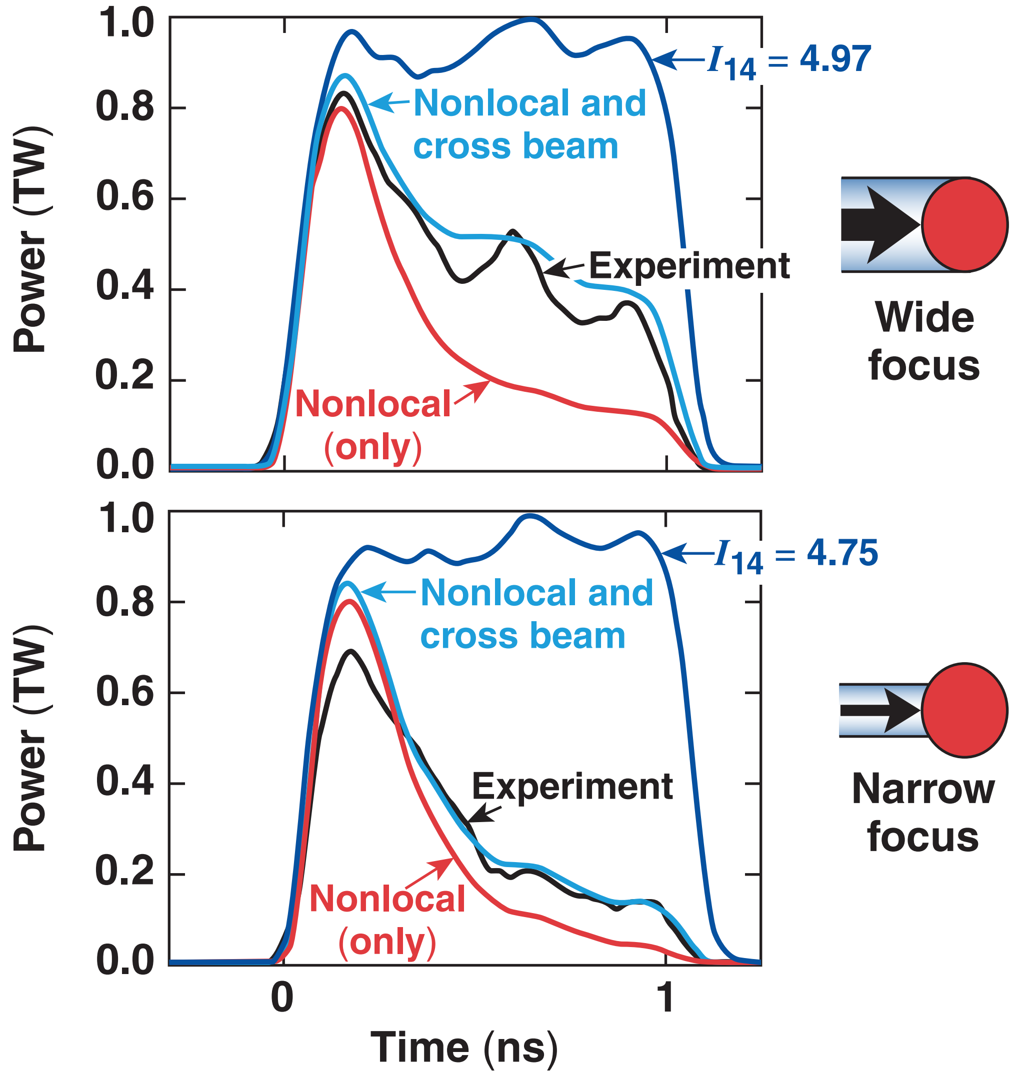
Large-shell, room-temperature implosions demonstrate reduced CBET for narrower beams on target



- Large targets: 1400-μm diam
- Phase plates:
  - SG4 focused (860-μm diam at 5% intensity) → narrow focus
  - SG4 defocused (1400-μm diam at 5% intensity) → wide focus

TC9385

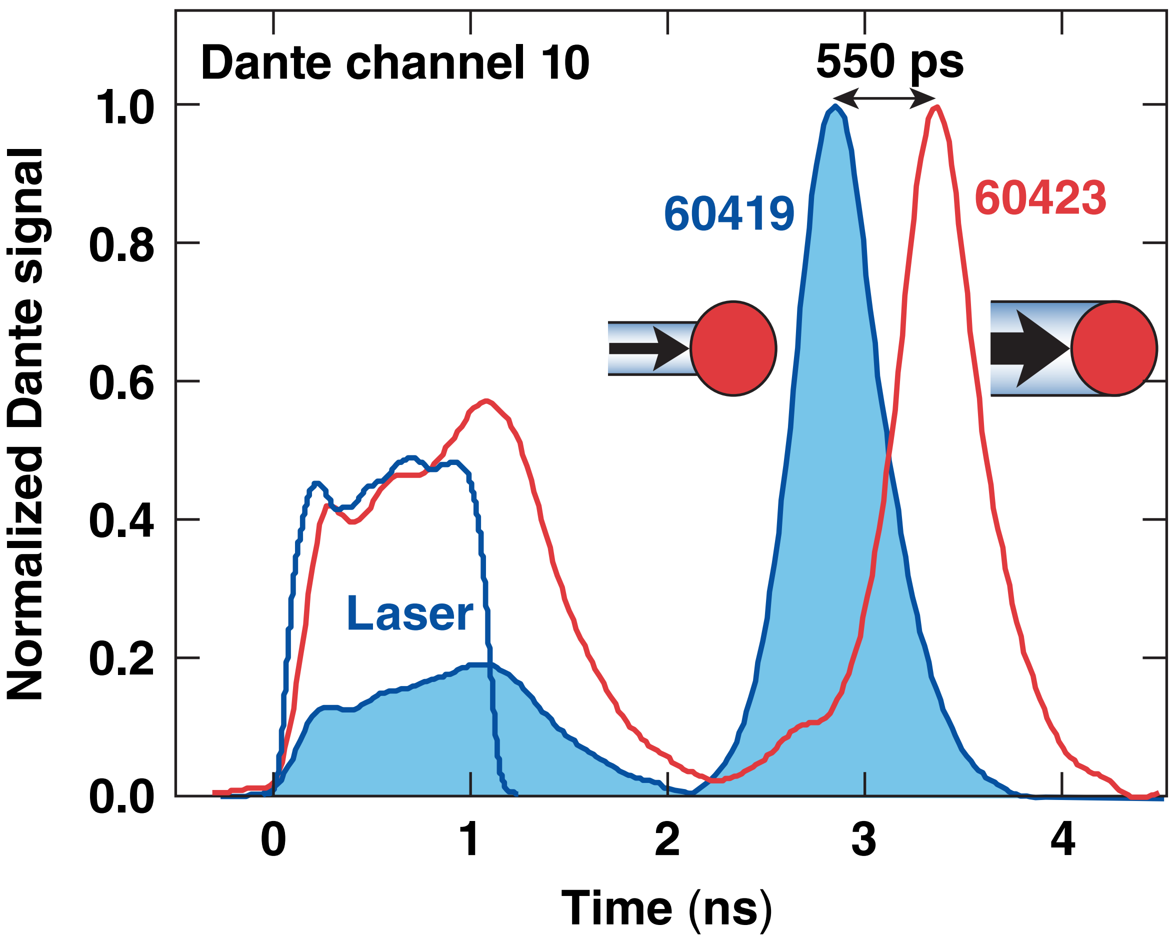
Cross-beam energy transfer significantly affects the time-resolved scattered power



- Near-absence of CBET
  - simulations with and without cross-beam energy transfer are nearly identical

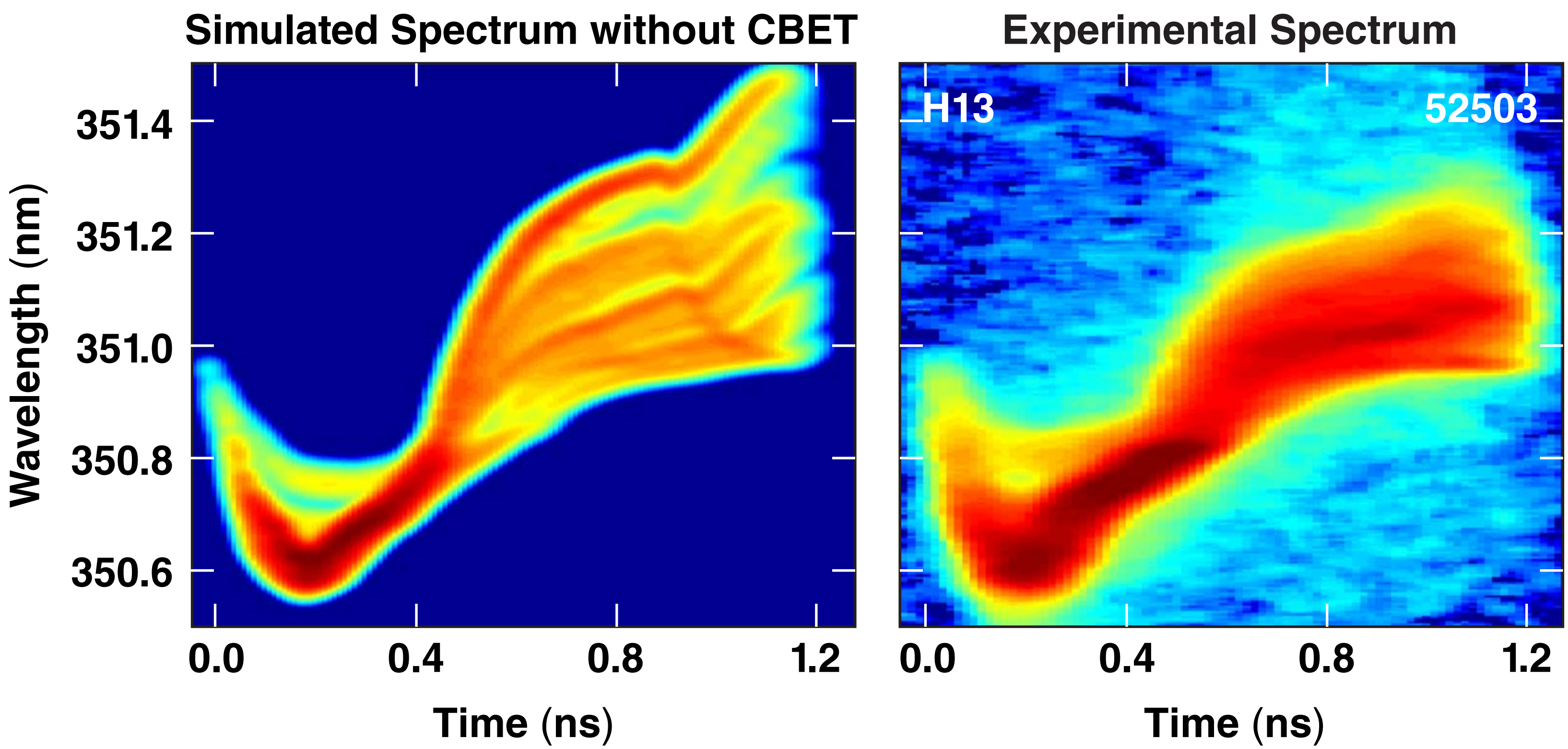
TC9386

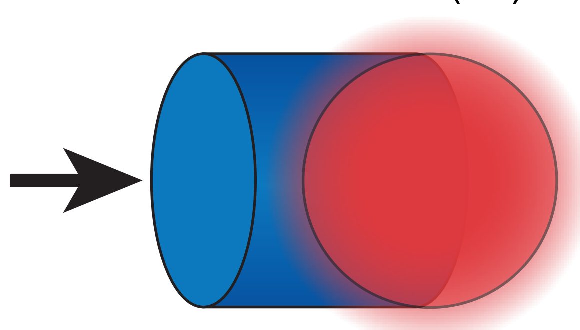
Reducing CBET increases the drive efficiency and causes the x-ray bang time to occur earlier



Constant input laser energy

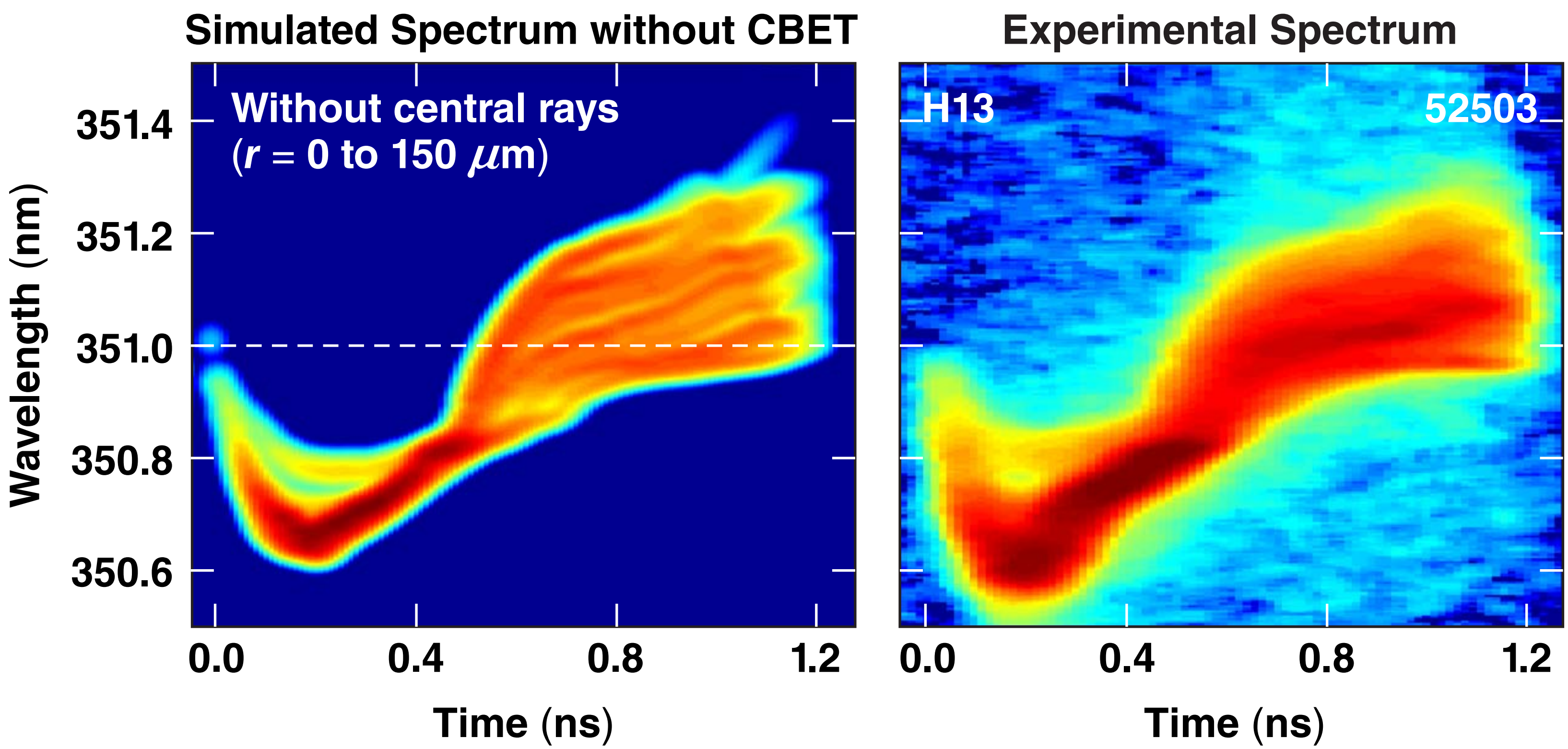
The reduced hydrodynamic drive caused by CBET is evident in experimental scattered light spectra

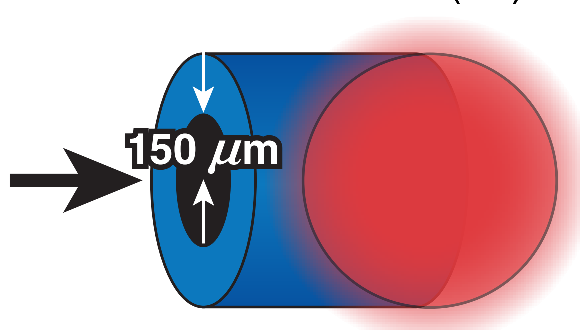




E19907

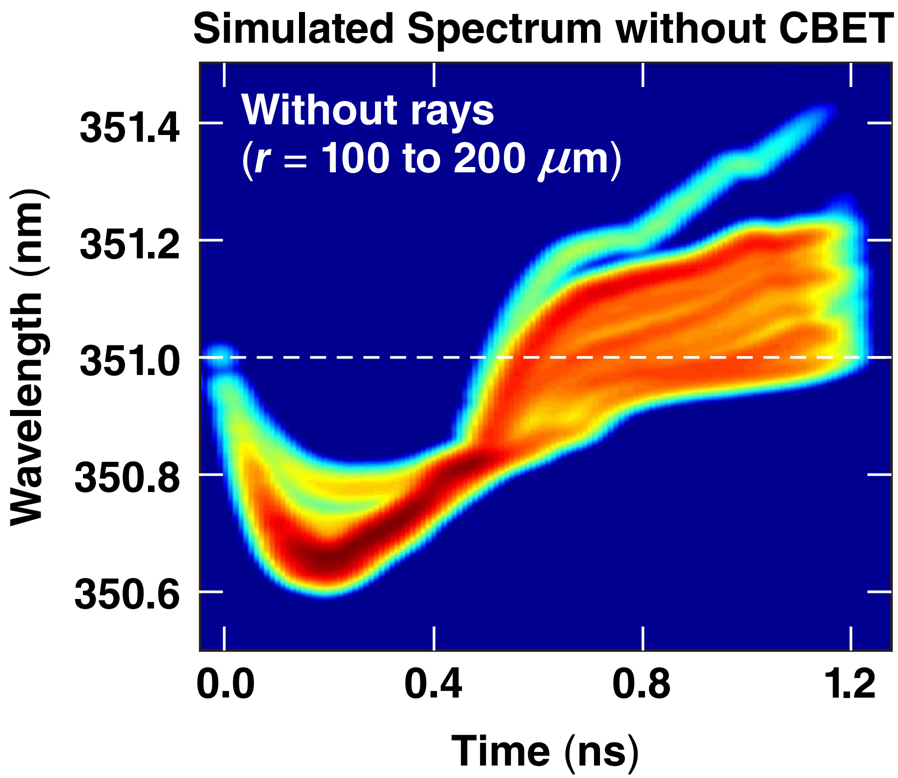
The reduced hydrodynamic drive caused by CBET is also evident in experimental scattered light spectra

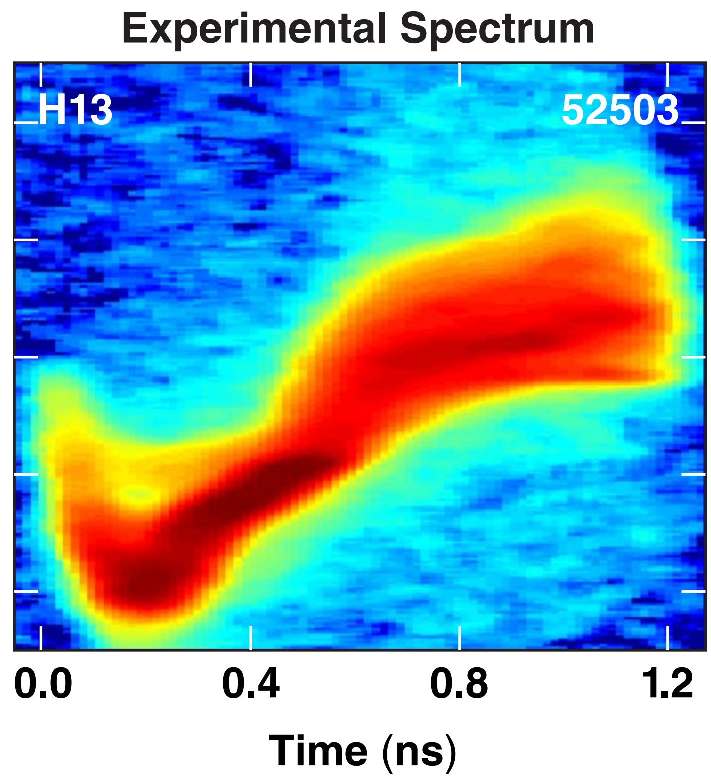


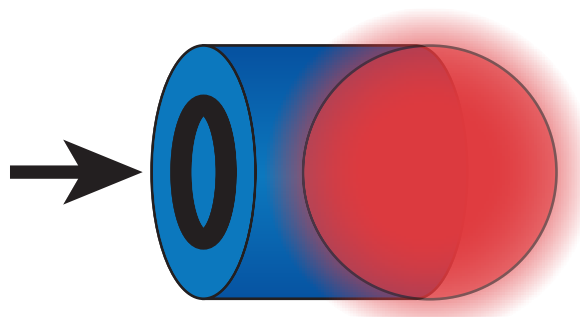


E19908

The reduced hydrodynamic drive caused by CBET is also evident in experimental scattered light spectra

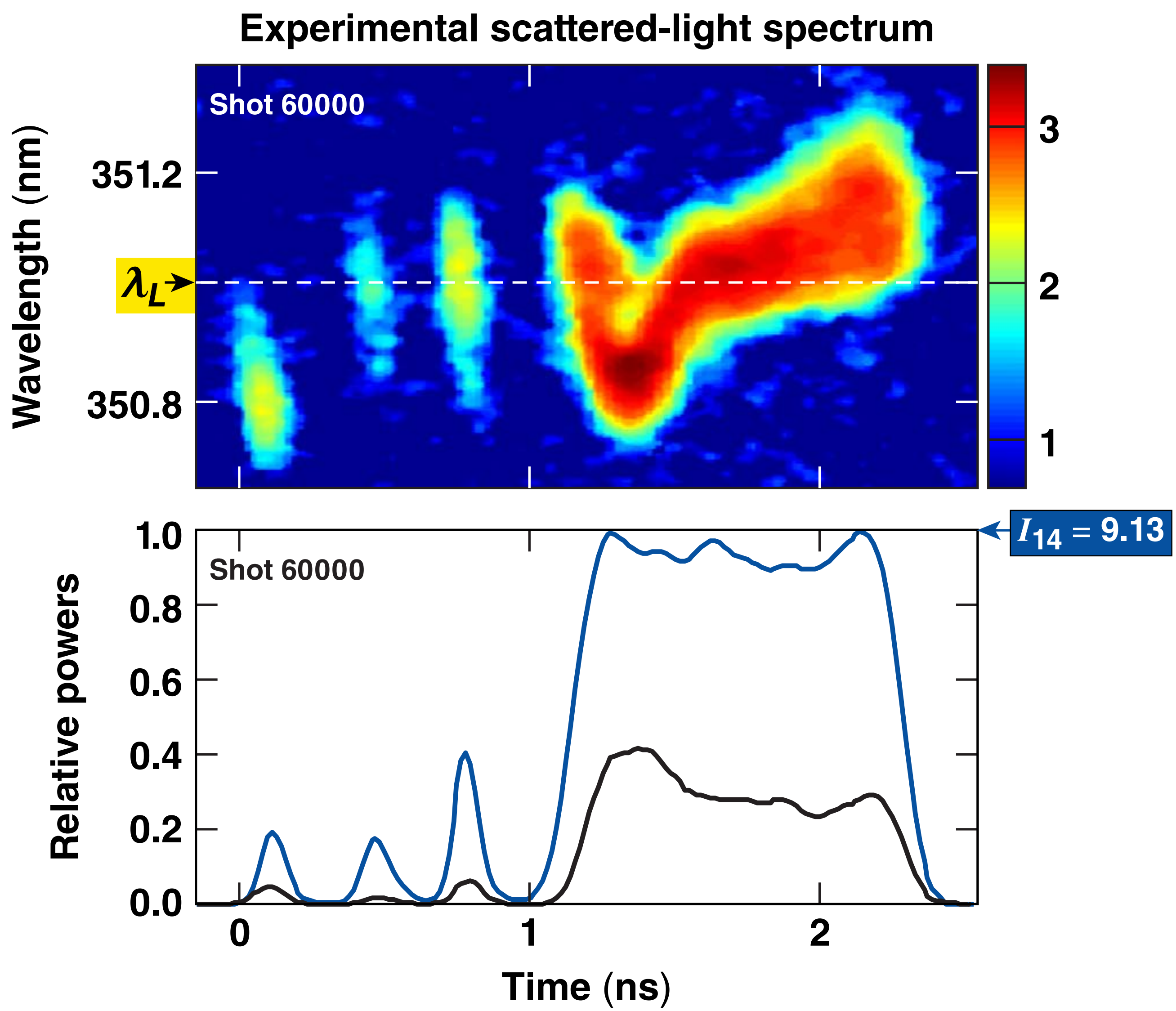






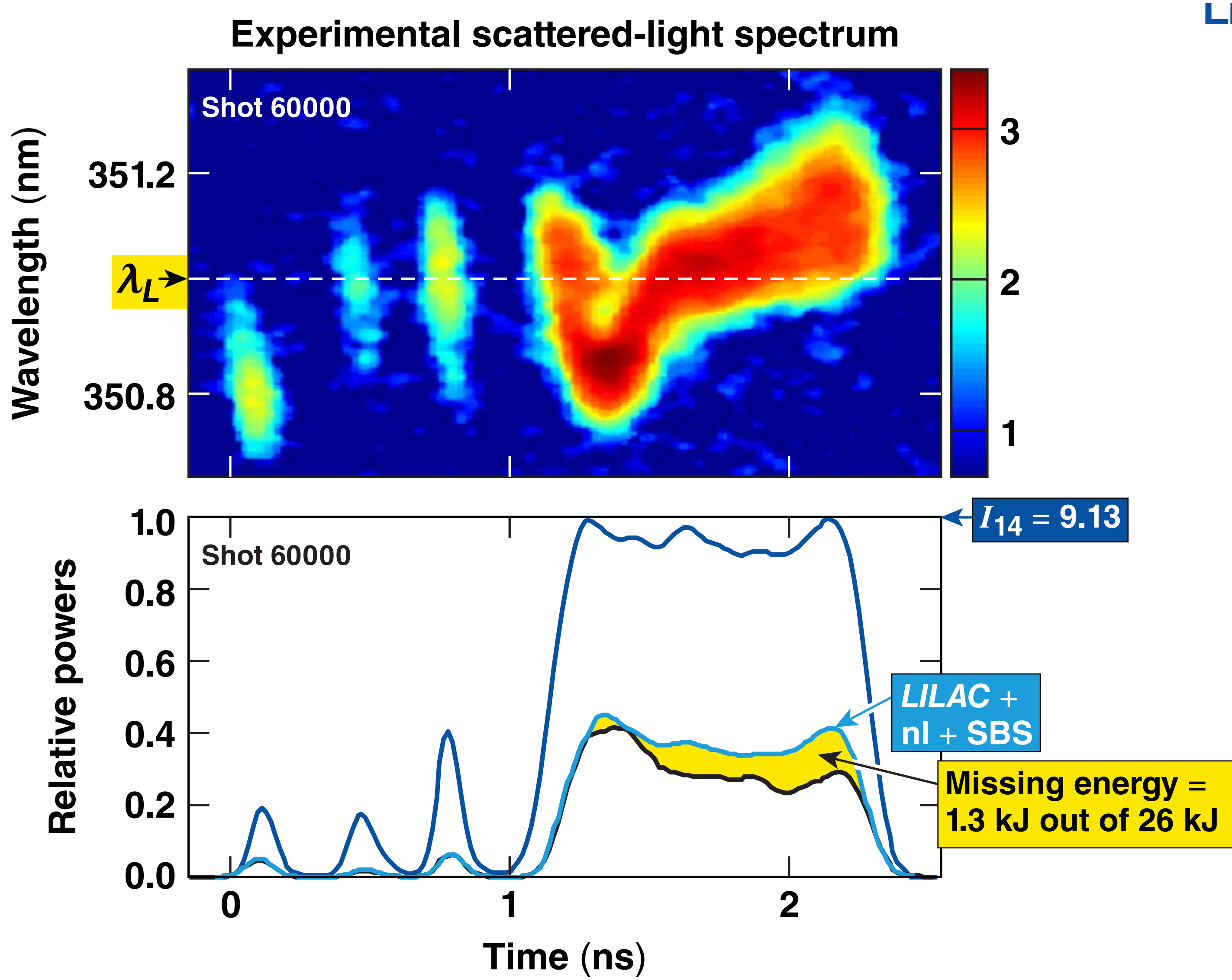
E19909

Scattered-light spectra of high-intensity implosions lie below CBET prediction and suggest TPD absorption



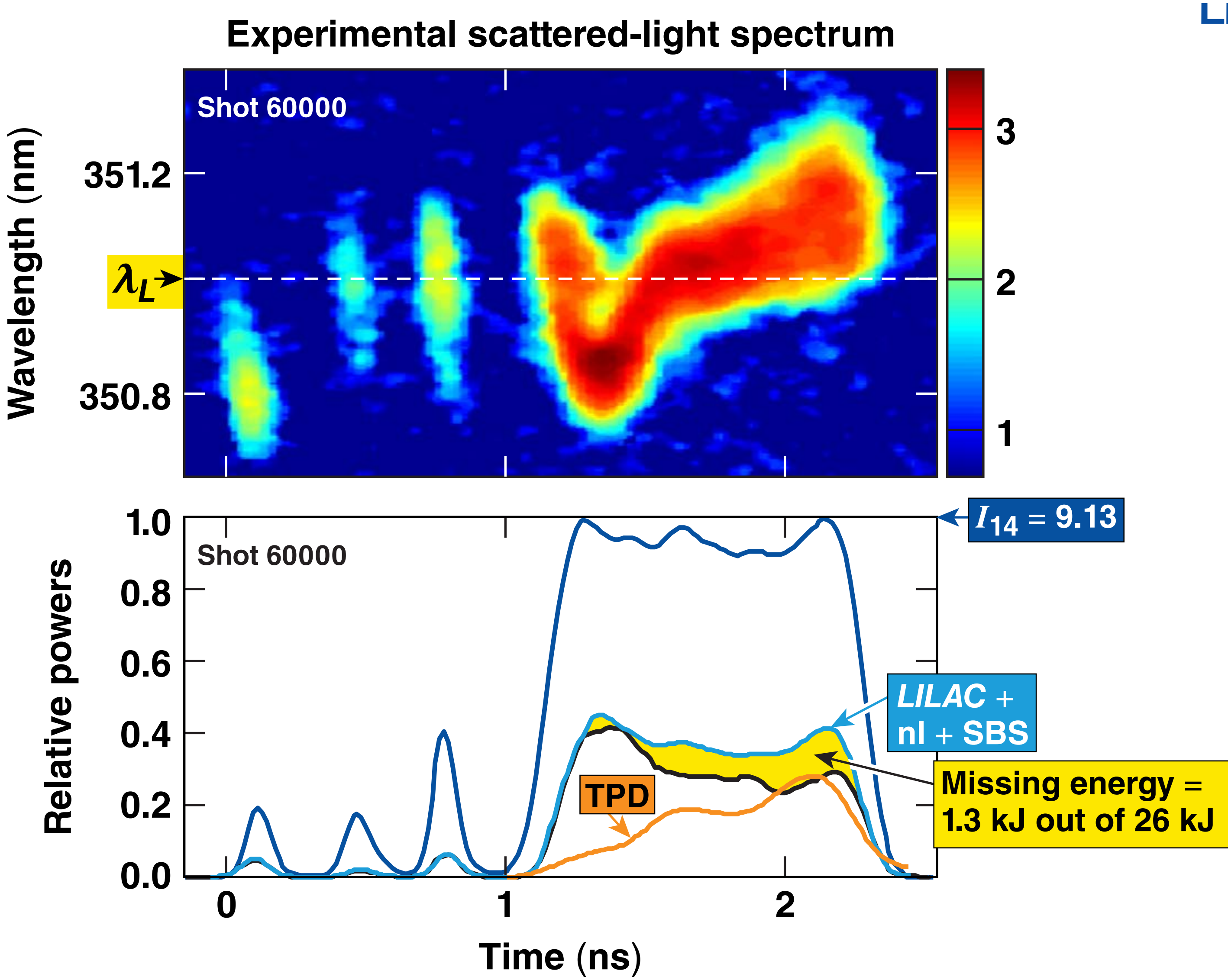
E19910

Scattered-light spectra of high-intensity implosions lie below CBET prediction and suggest TPD absorption



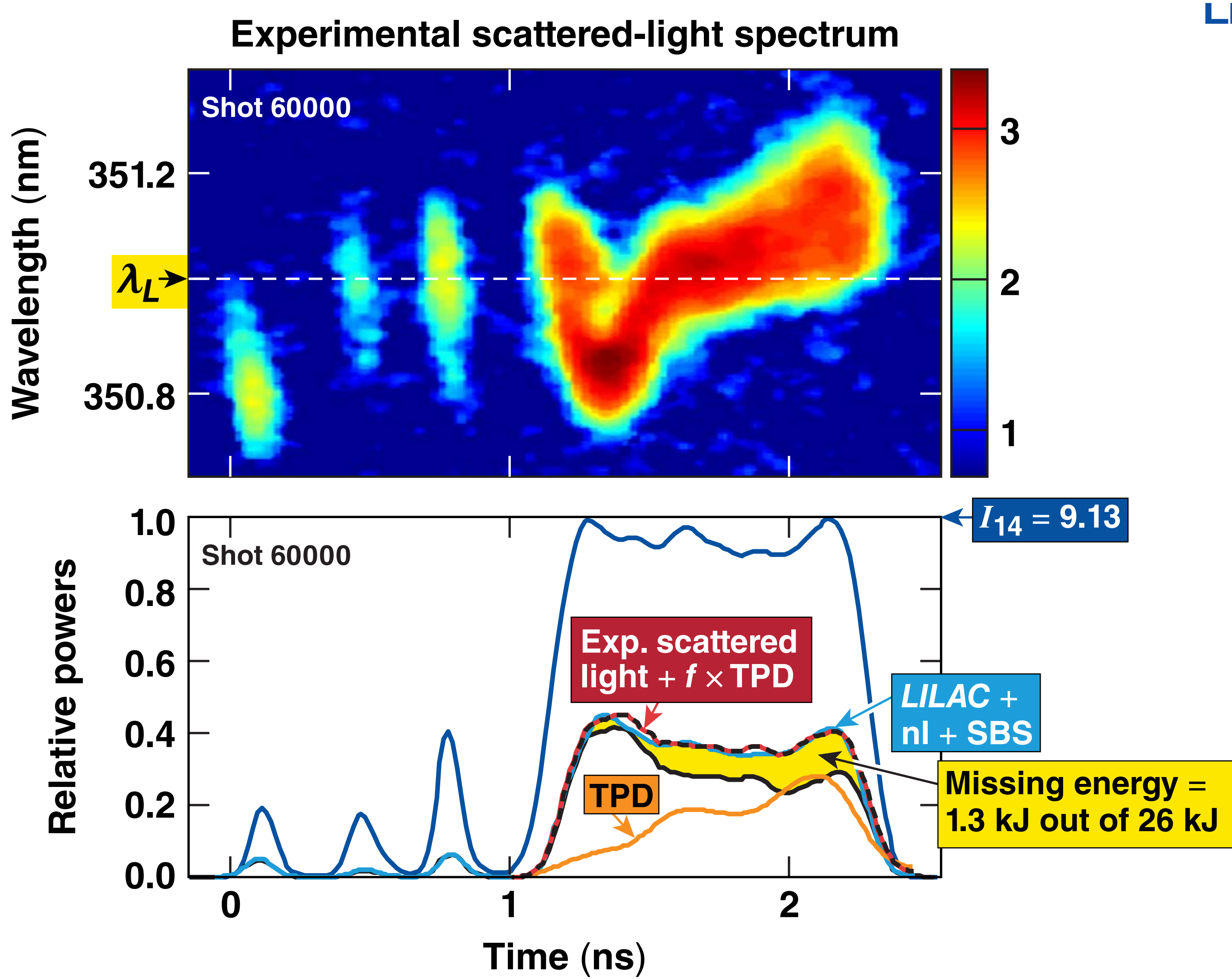
E19910a

Scattered-light spectra of high-intensity implosions lie below CBET prediction and suggest TPD absorption



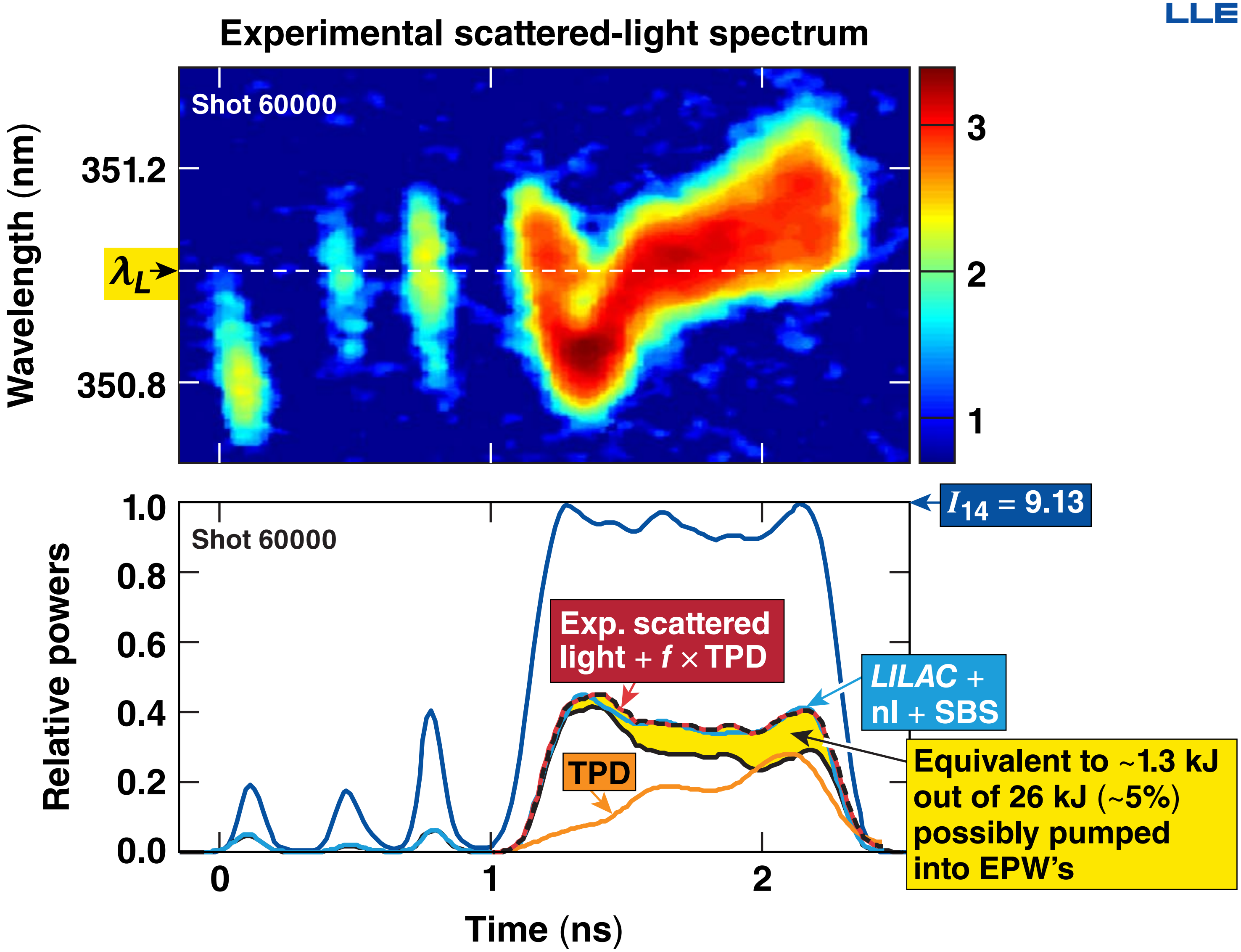
E19910b

Scattered-light spectra of high-intensity implosions lie below CBET prediction and suggest TPD absorption



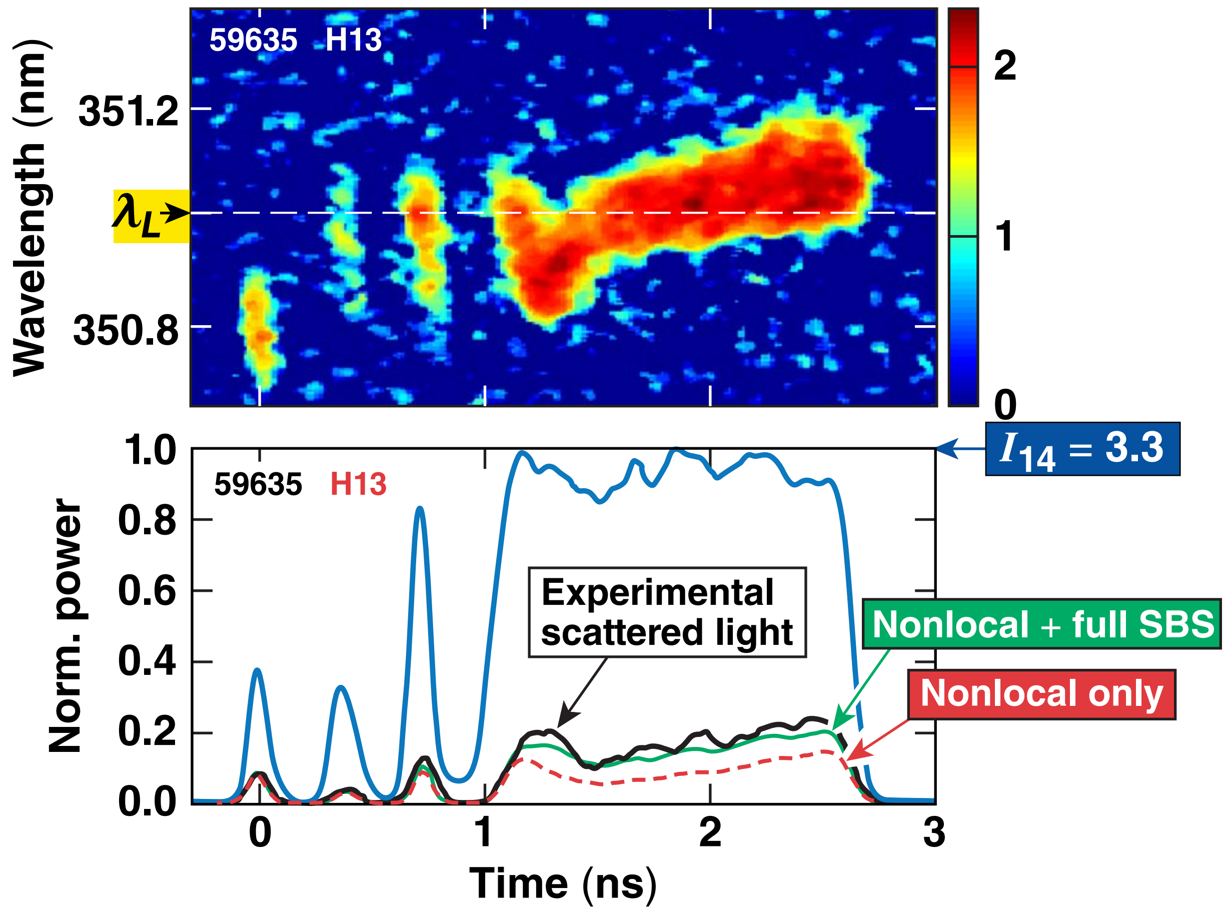
E19910c

Scattered-light spectra of high-intensity implosions lie below CBET prediction and suggest TPD absorption



E19910d

At low intensities (<4 × 10^{14} W/cm^2, overlapped) the *LILAC* predictions with CBET for scattered light are within 2% of time-integrated measurements

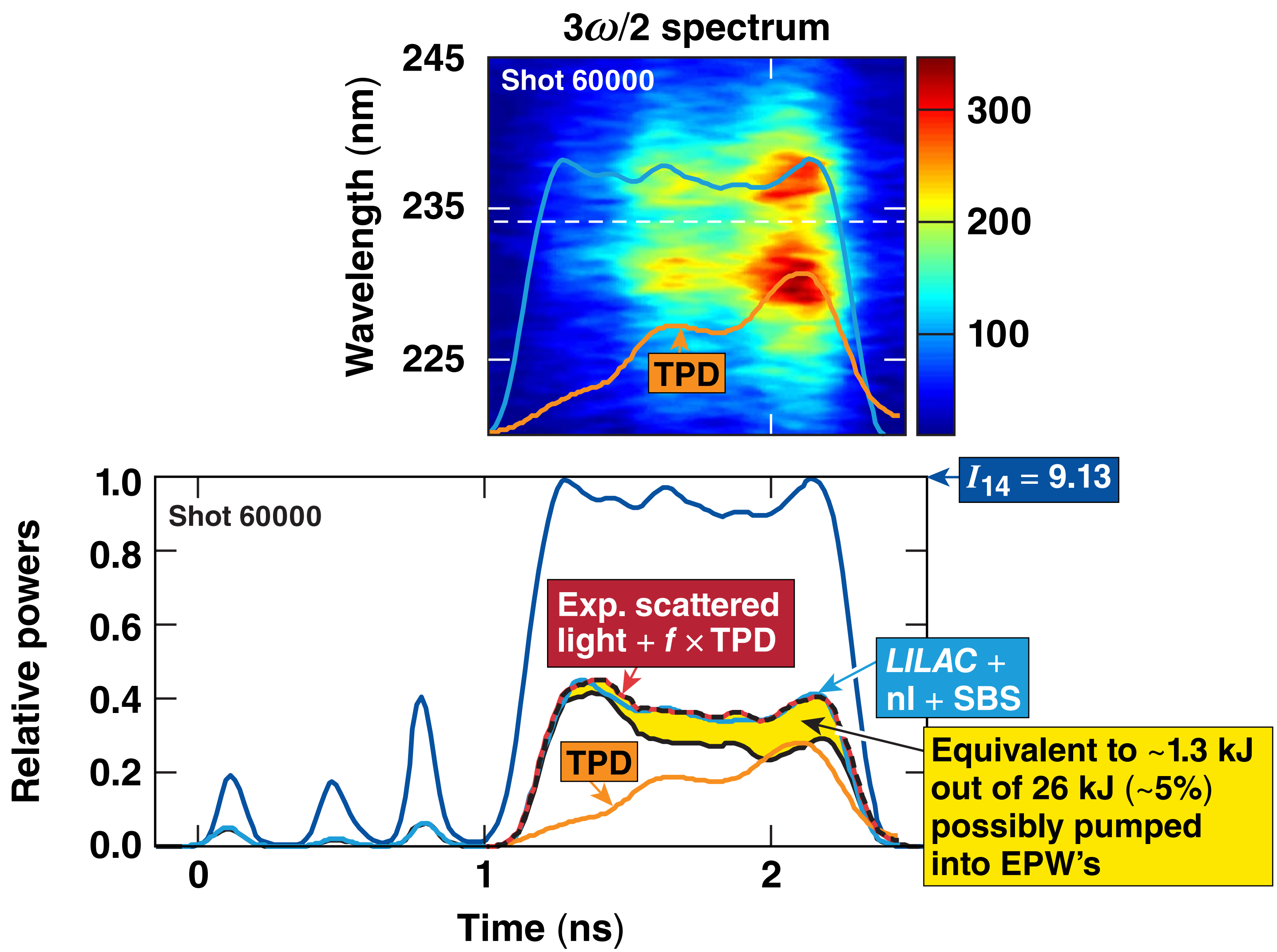


Time-integrated absorption (exp.) = 83%
Simulations with CBET (nonlocal + full SBS) = 84%

No measureable TPD ($3\omega/2$)
No HRXD signals

E19947

$3\omega/2$ spectra are indicative of TPD near the Landau cutoff, typical of the nonlinear state of this instability



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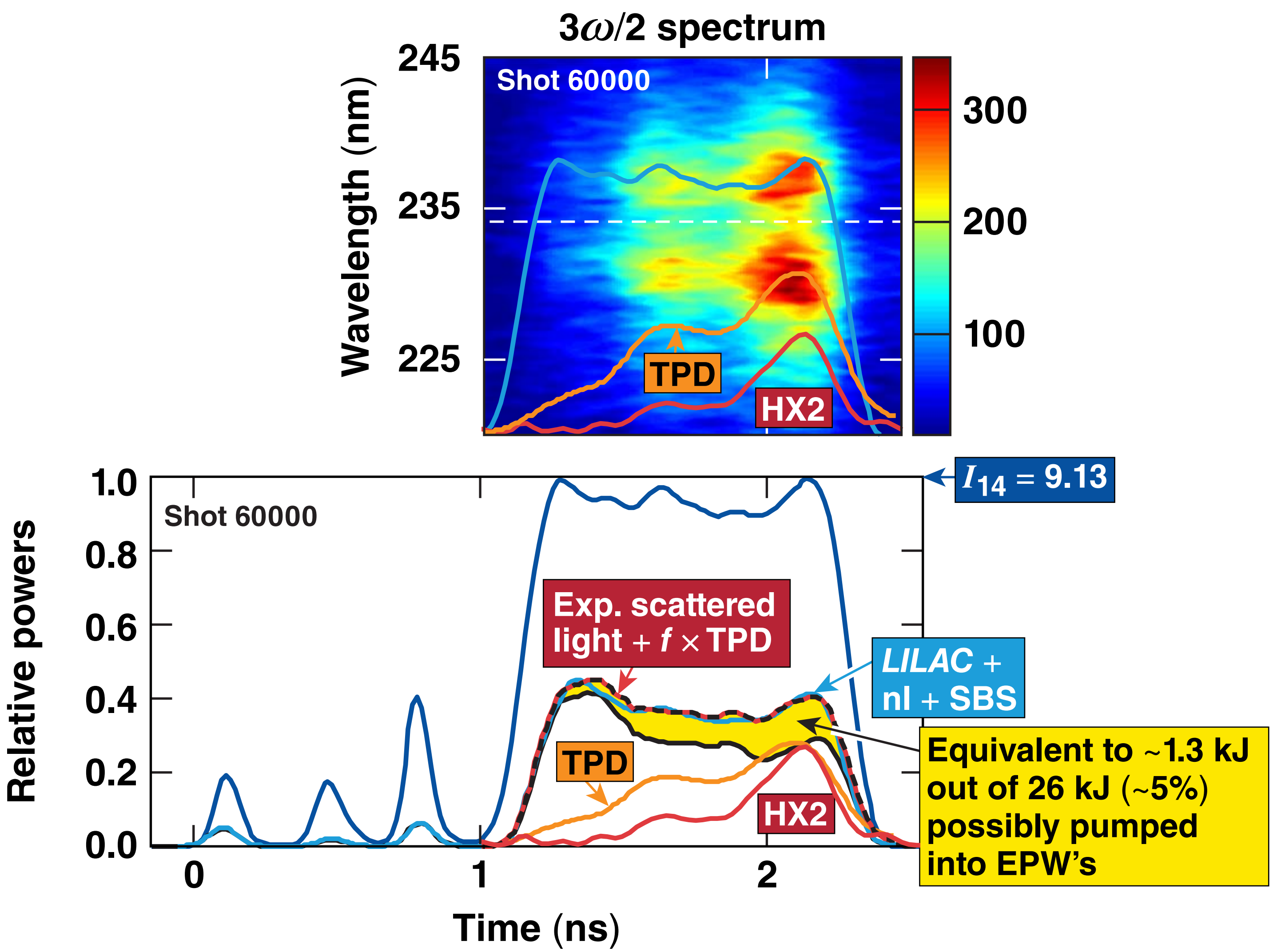
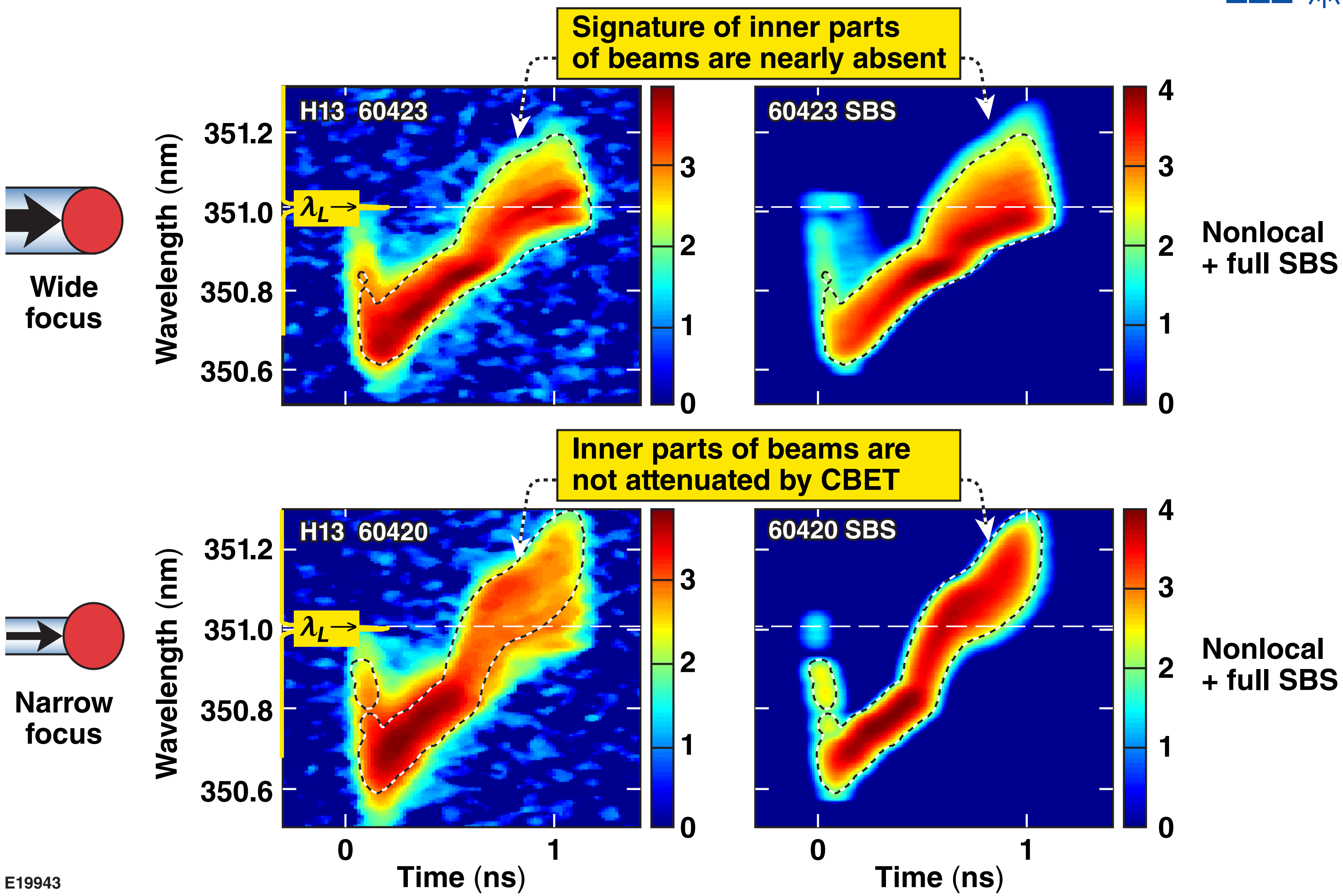


E19911a

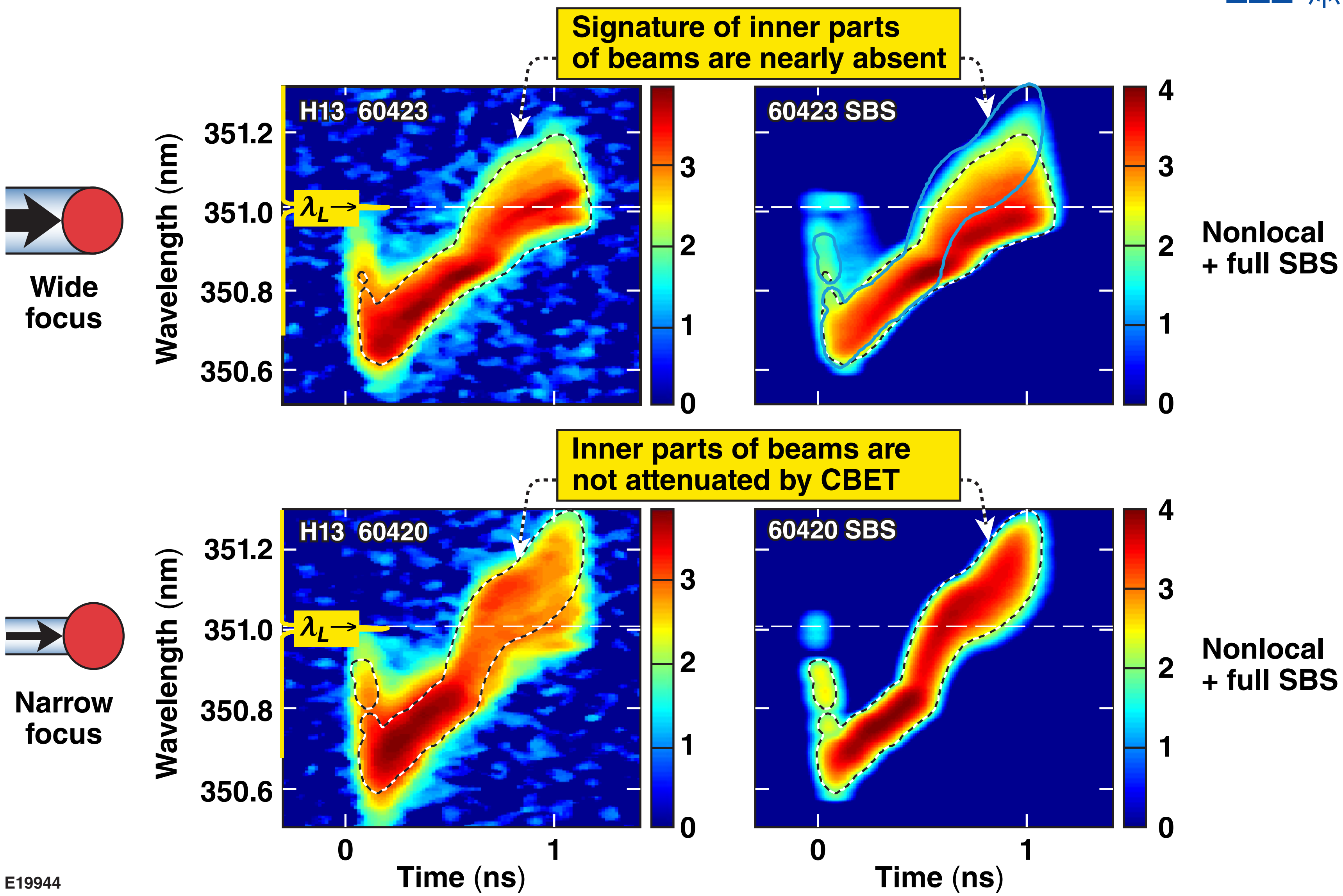
HXRD Ch2: 197 pC → 5.6 mJ_{Hx} ~ 30-J energetic electrons

The scattered-light spectra of imploding targets with narrow- and wide-focus illumination agree with CBET predictions



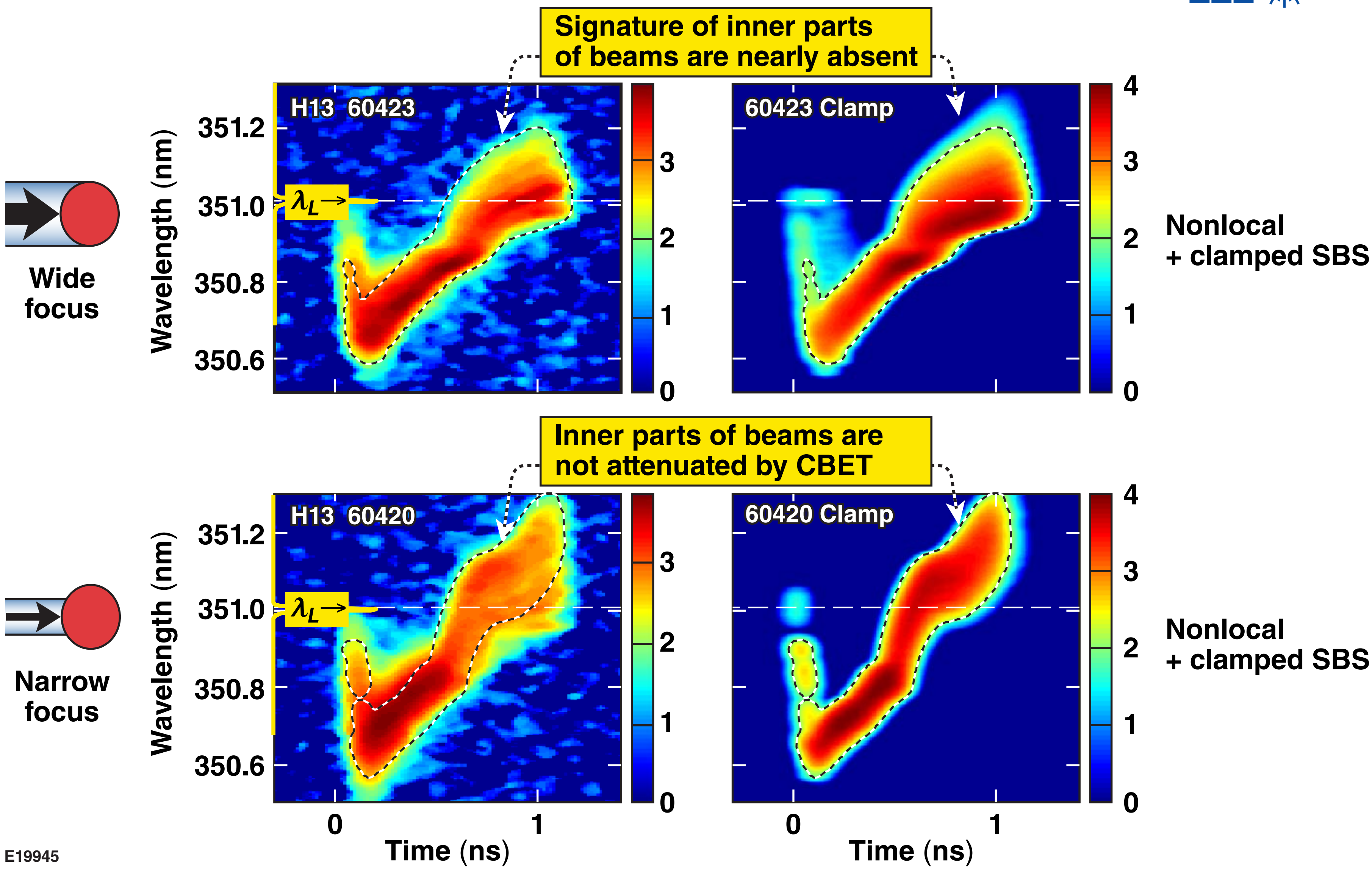
E19943

The scattered-light spectra of imploding targets with narrow- and wide-focus illumination agree with CBET predictions



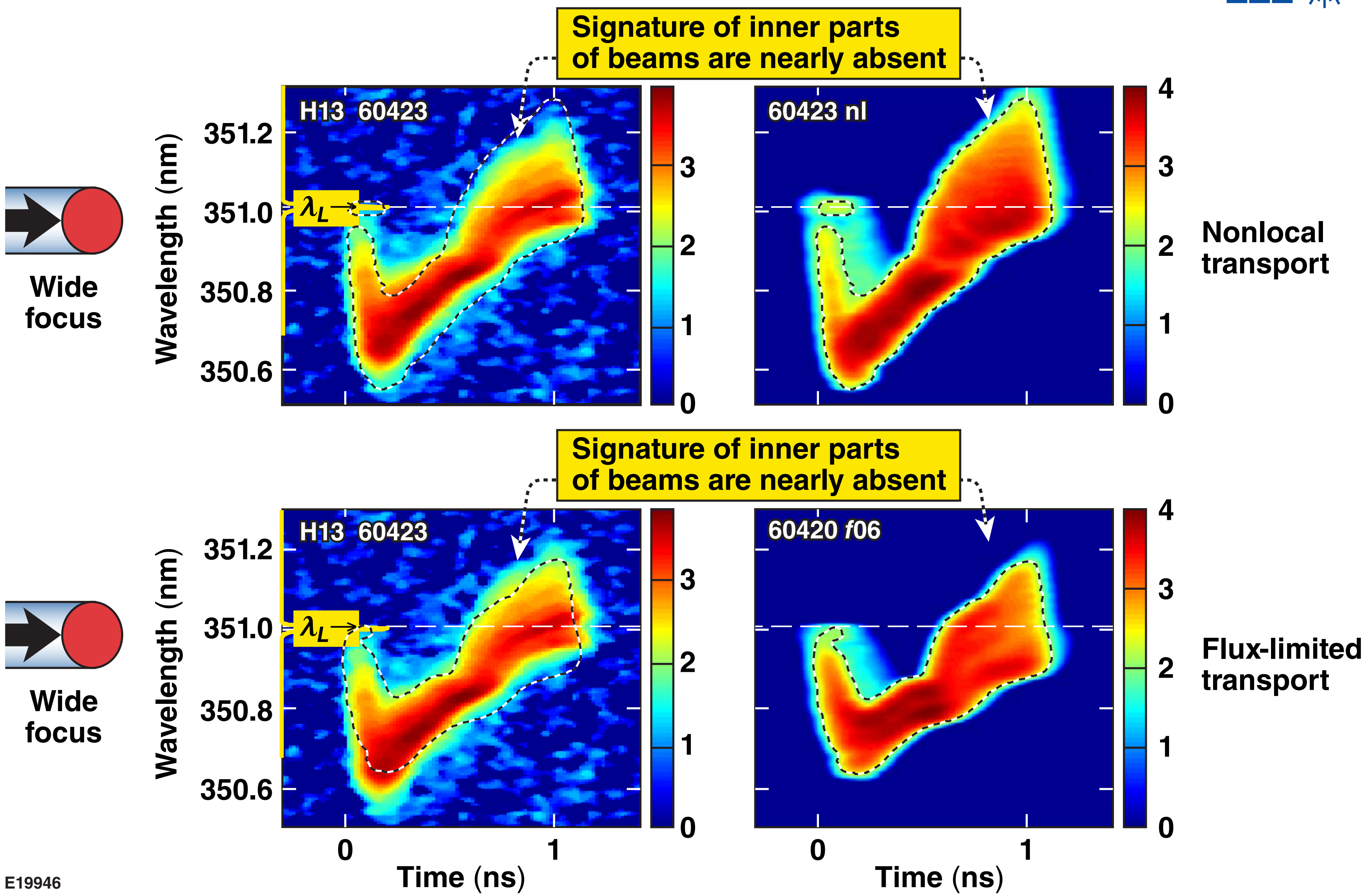
E19944

CBET using the clamped SBS model cannot spectrally be distinguished from the full SBS model



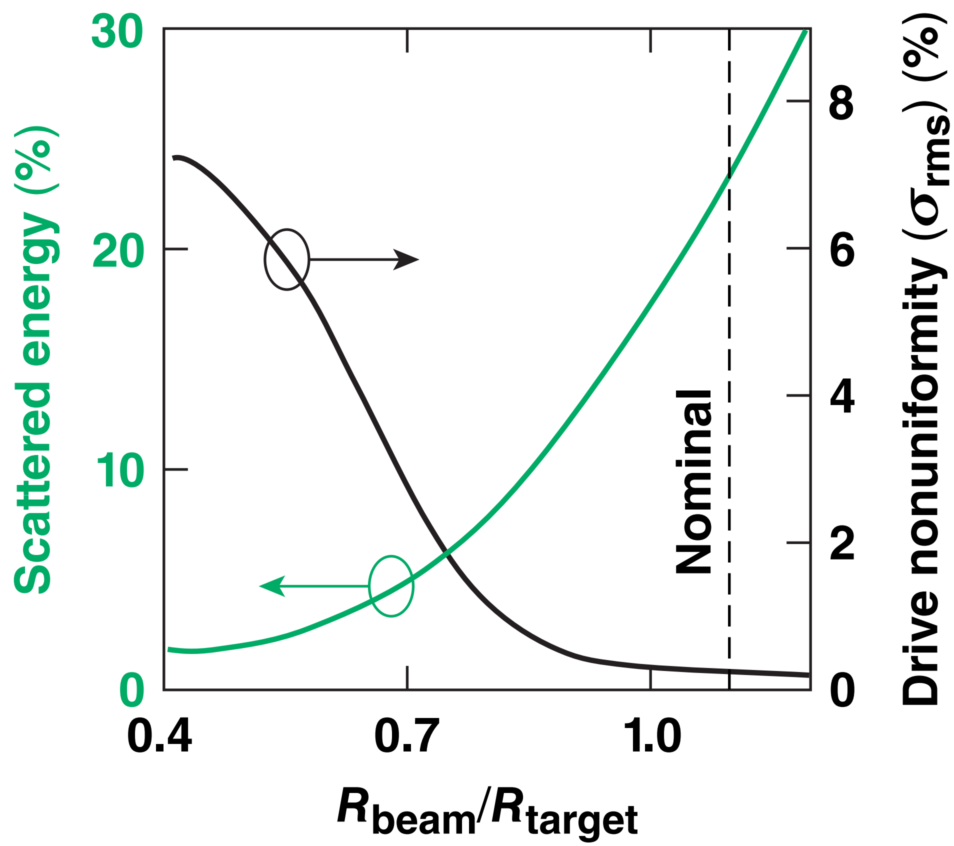
E19945

The scattered-light spectra are poorly modeled with only nonlocal transport or standard *f* = 0.06 flux limiter



E19946

1-D *LILAC* simulations with CBET indicate higher absorption but increased drive nonuniformity for beams smaller than the target



E19912

Summary/Conclusions

The loss of hydrodynamic efficiency in direct-drive implosions caused by cross-beam energy transfer can be reduced by changing the irradiation conditions

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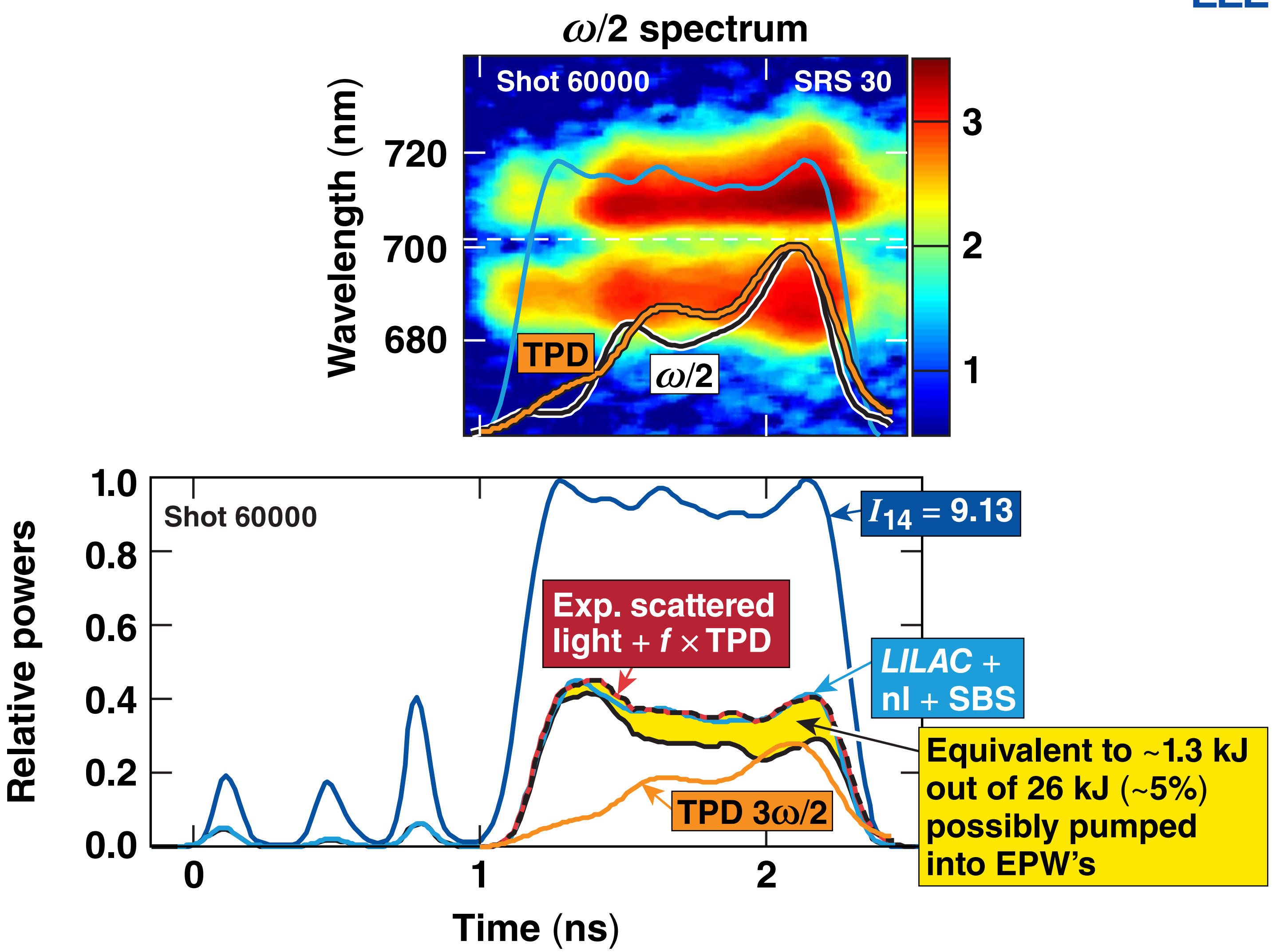
- Experiments with different illumination geometries and detailed spectral analyses have significantly increased our understanding of CBET

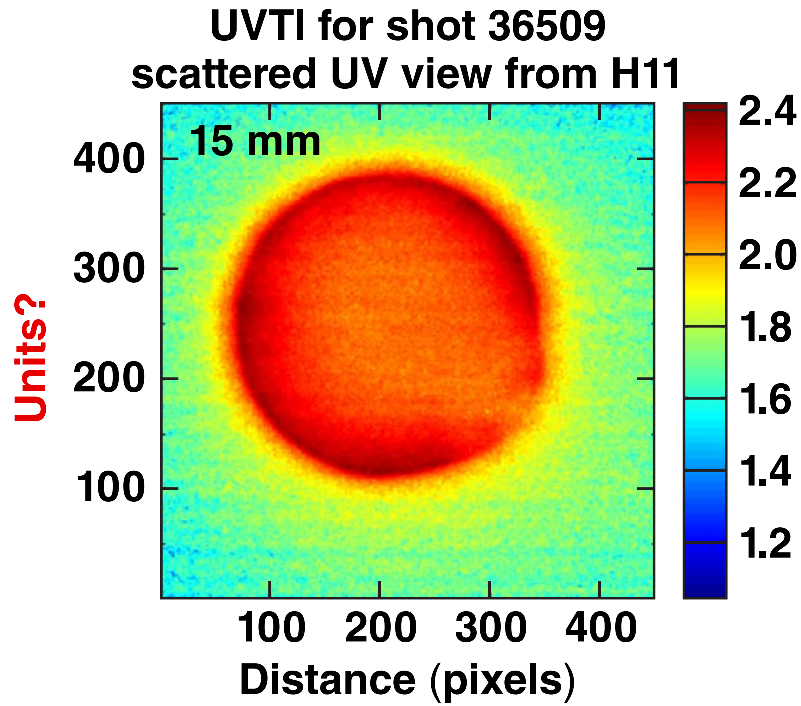
$\omega/2$ spectra probe different phase space of TPD with slightly different time-evolution from $3\omega/2$ spectra

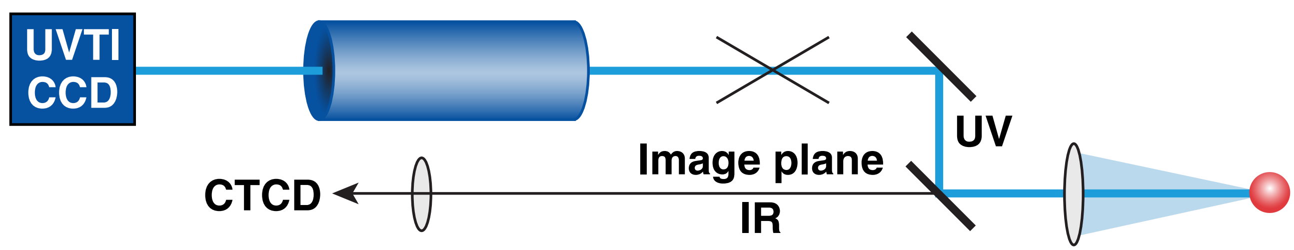


HXRD Ch2: 197 pC → 5.6 mJx → 30- to 60-J preheat

E19913

Time-integrated images of the imploding target are edge-enhanced and may also reflect cross-beam energy transfer





CTCD camera can be converted to $\omega/2$ imaging with a mere change of filter, yielding information on $\omega/2$ generation processes.