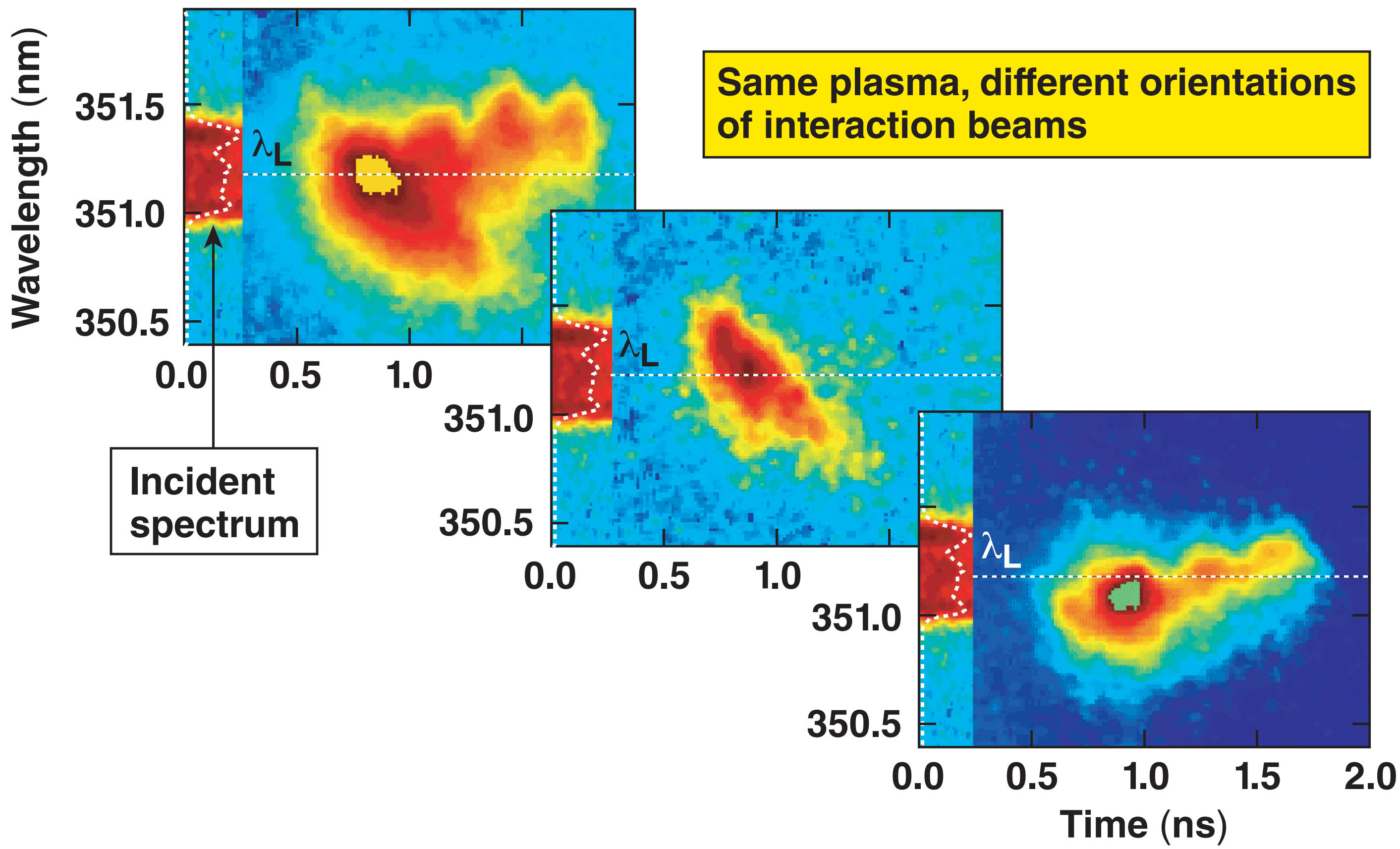
Stimulated Brillouin Scattering in Long-Scale-Length Plasmas



W. Seka
University of Rochester
Laboratory for Laser Energetics

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Collaborators

H. Baldis

University of California, Davis
Lawrence Livermore National Laboratories

S. Depierreux

Commissariat à l'Energie Atomique, France

R. S. Craxton, S. P. Regan, C. Stoeckl, R. W. Short,
B. Yaakobi, and R. E. Bahr

University of Rochester
Laboratory for Laser Energetics

Summary

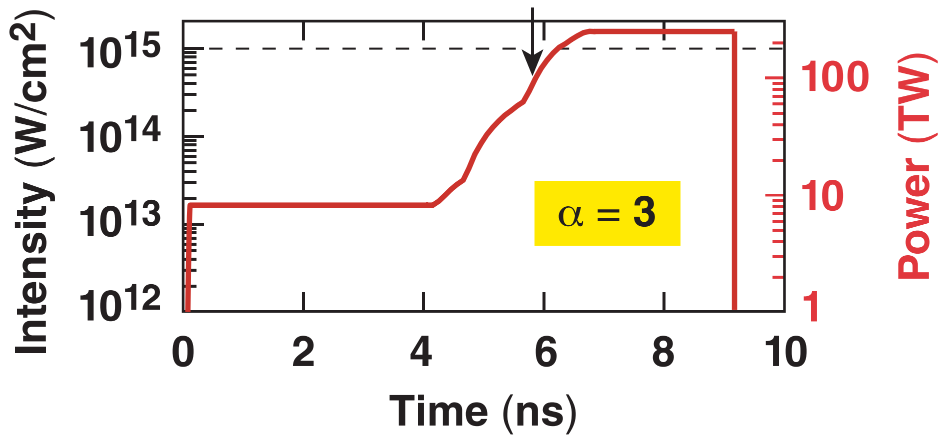
SBS in the present long-scale-length experiments saturates ~1% and is now reasonably understood

UR LLE

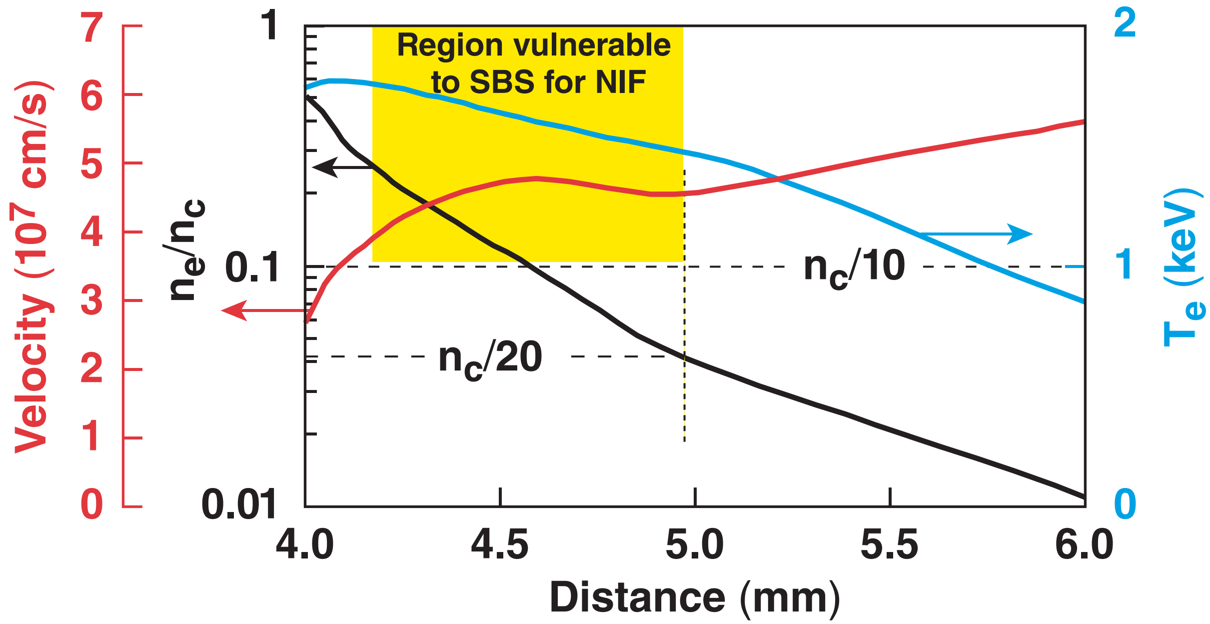
- OMEGA long-scale-length experiments have flat velocity regions similar to the NIF.
- **SBS is observed in <u>these</u> regions. Pf3d simulations and standard SBS gain calculations agree well with observations.**
- **SBS extrapolation to NIF direct-drive implosion experiments predicts no problems in the low-density region.**
- The detailed NIF and OMEGA plasma profiles differ near n_c.
  - Velocity gradients near n_c are steeper in OMEGA experiments.
  - NIF SBS gains near n_c are higher due to gentler density and velocity gradients.
  - More detailed analysis is required.

Motivation

NIF direct-drive plasma conditions predicted by *LILAC* point toward a window of SBS vulnerability



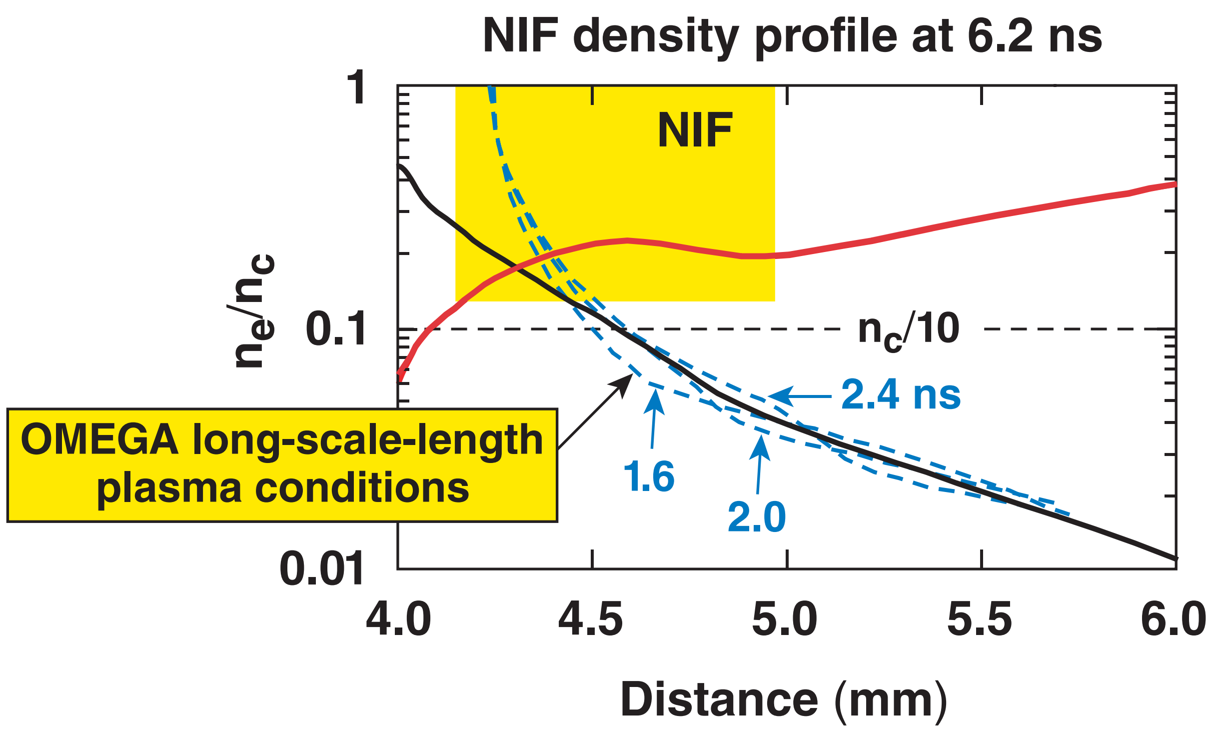
NIF direct-drive plasma conditions at 6.2 ns



E13880

OMEGA long-scale-length conditions are tailored to reproduce NIF conditions

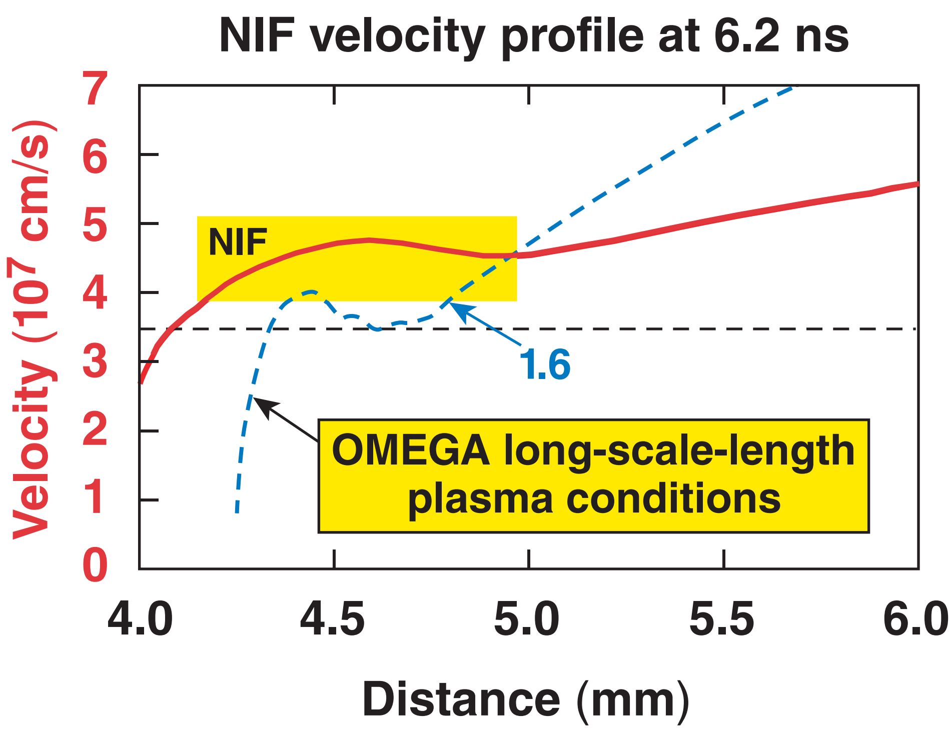
SAGE predictions for OMEGA long-scale-length experiments are close to NIF conditions below $n_c/4$.



E13881

OMEGA long-scale-length velocity profiles have flat sections like NIF profiles but over much shorter distances

Comparison of *LILAC* NIF plasma conditions at 6.2 ns with OMEGA long-scale-length experiments as predicted by the 2-D code *SAGE.*



E13882

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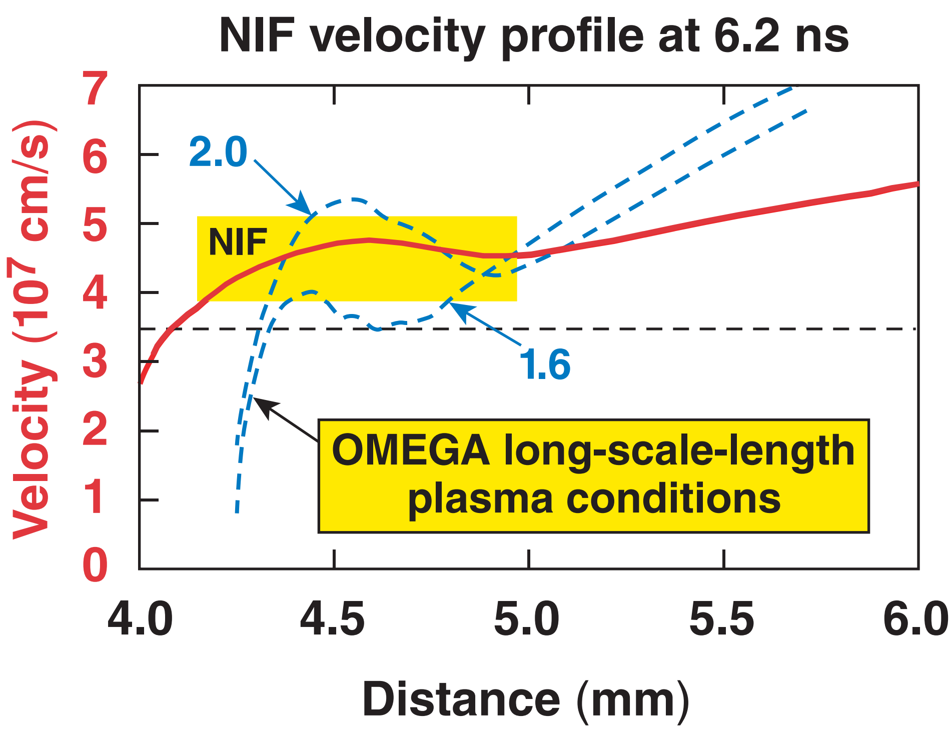

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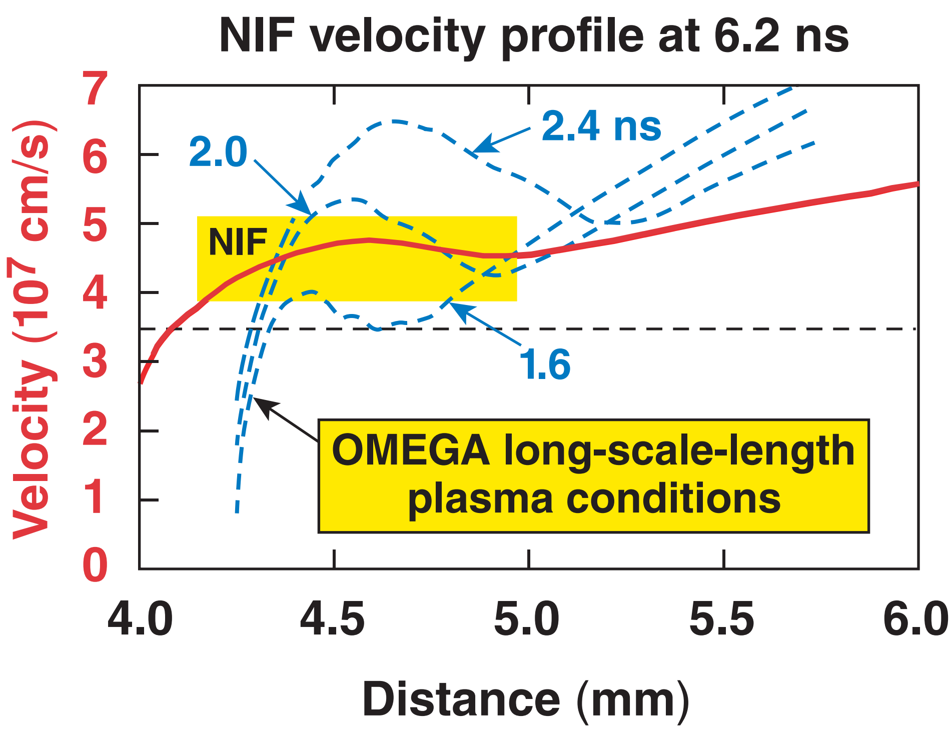

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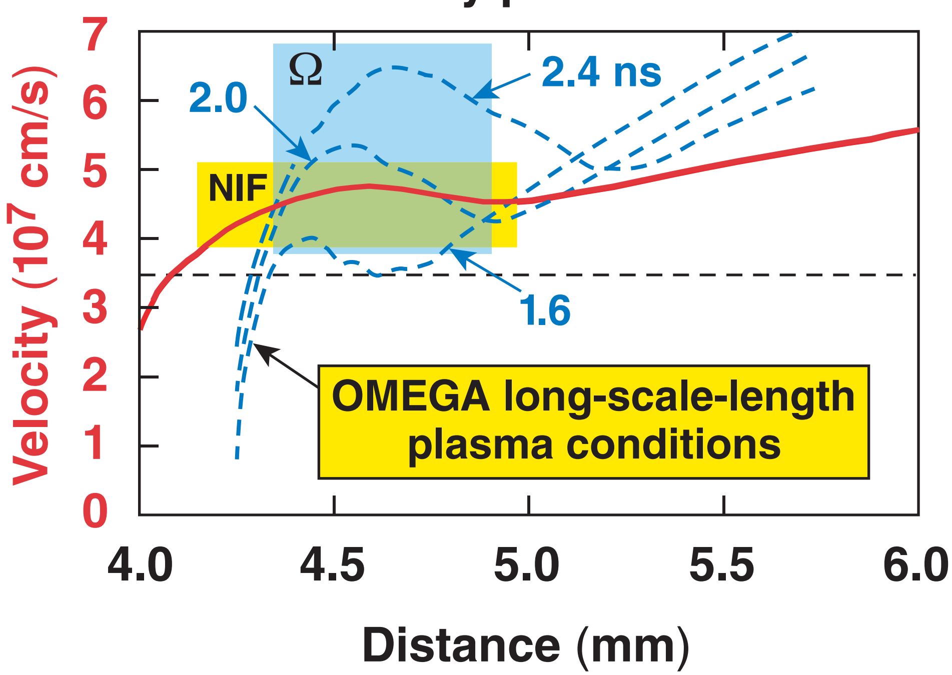
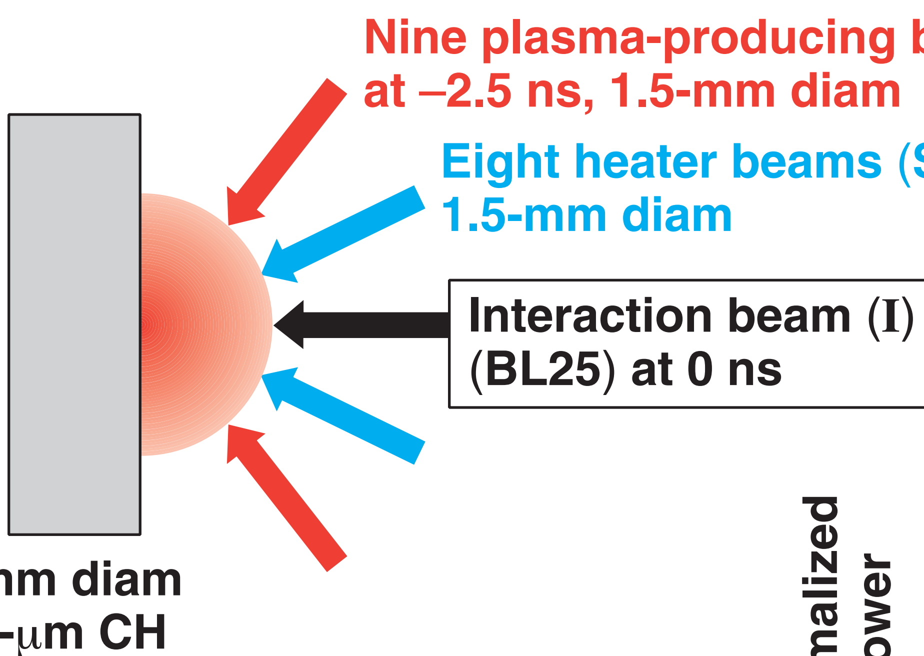
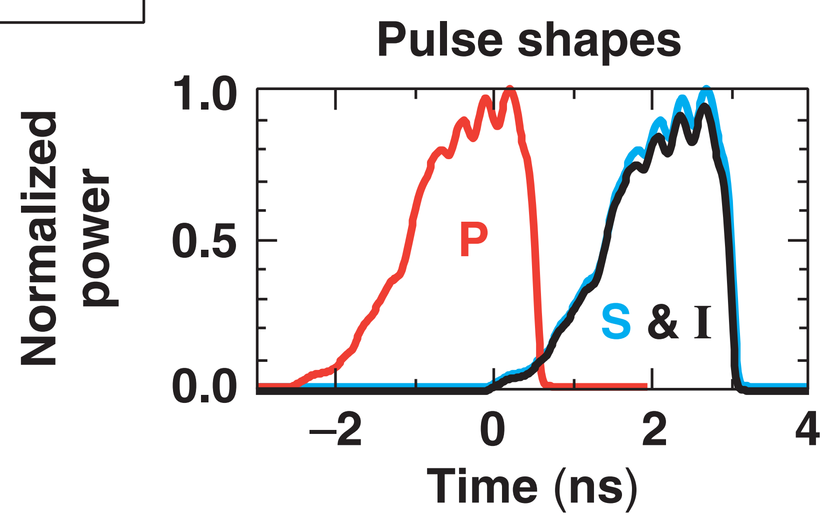
NIF velocity profile at 6.2 ns



E13882

NIF plasma conditions are produced on OMEGA with staggered multiple-beam irradiation of solid CH targets



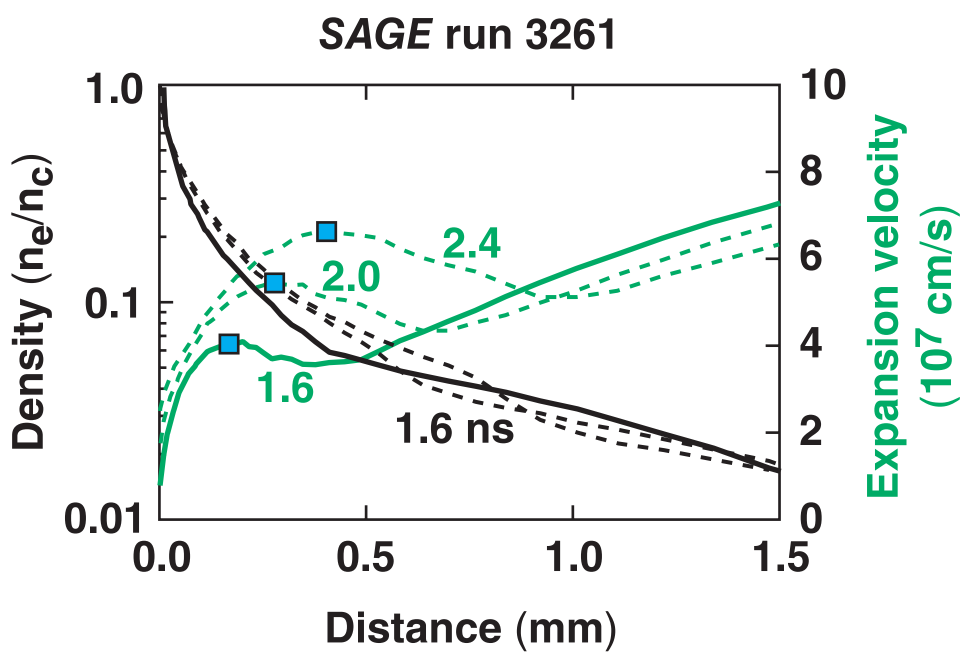


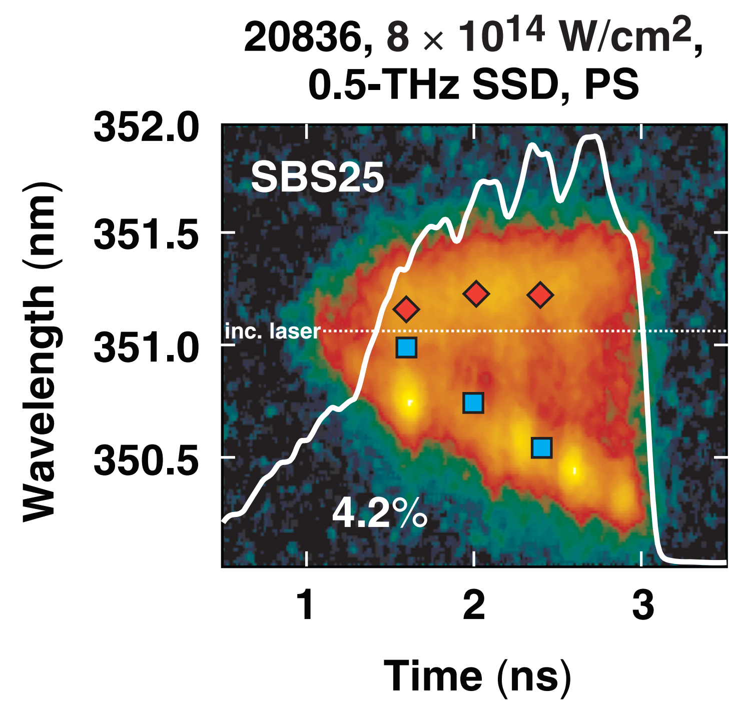
E10692b

SBS at normal incidence with a slowly evolving velocity "bump" exhibits blue-shifted SBS over the entire pulse that is sensitive to beam smoothing

UR LLE

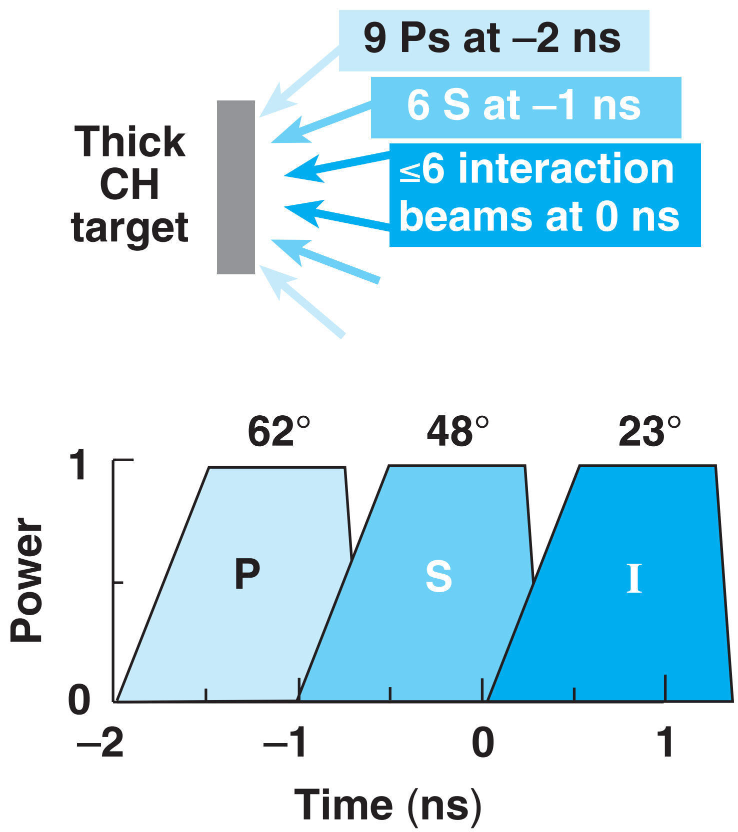
$I \approx 5 \times 10^{14}$ W/cm^2

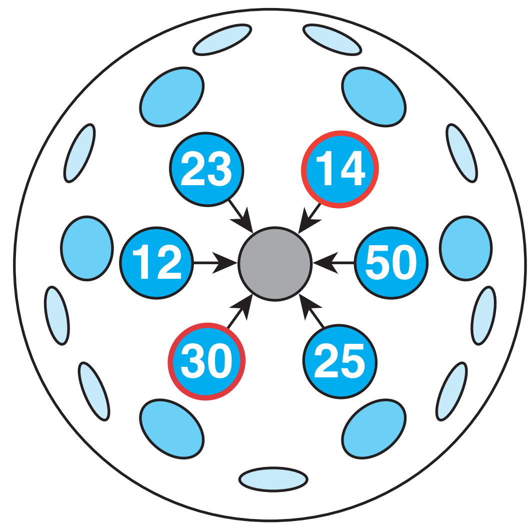




E11942a

Multiple interaction beams at oblique incidence allow the identification of optical seeding of SBS





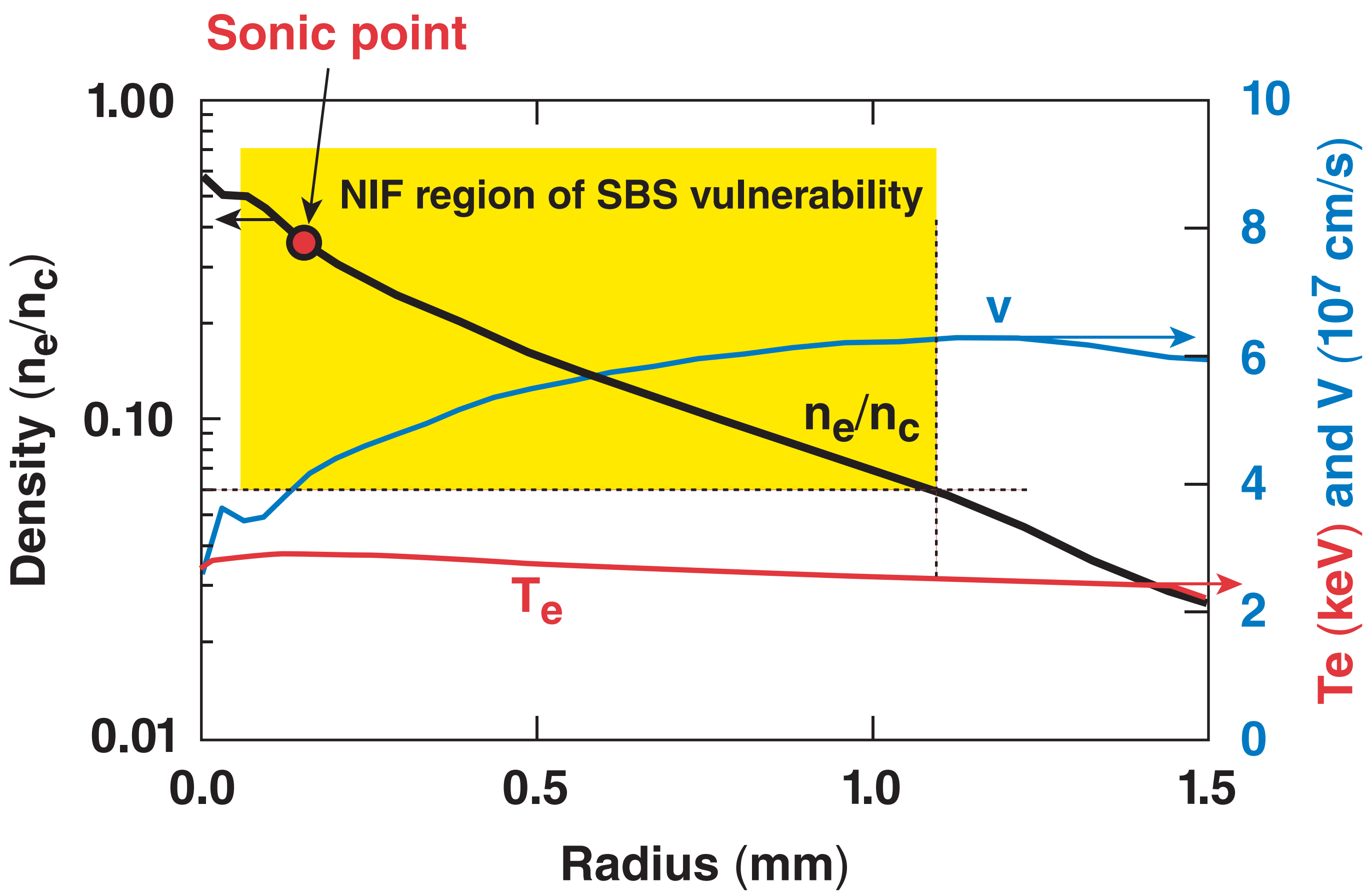
- Beam 30 only avoids EM seeding from any specularly reflected light.
- Beam 14 only provides specularly reflected light.
- Firing both beams permits the study of EM seeding of SBS.

E10977b

NIF plasma conditions are reasonably well approximated by OMEGA experiments for $n_e < n_c/4$

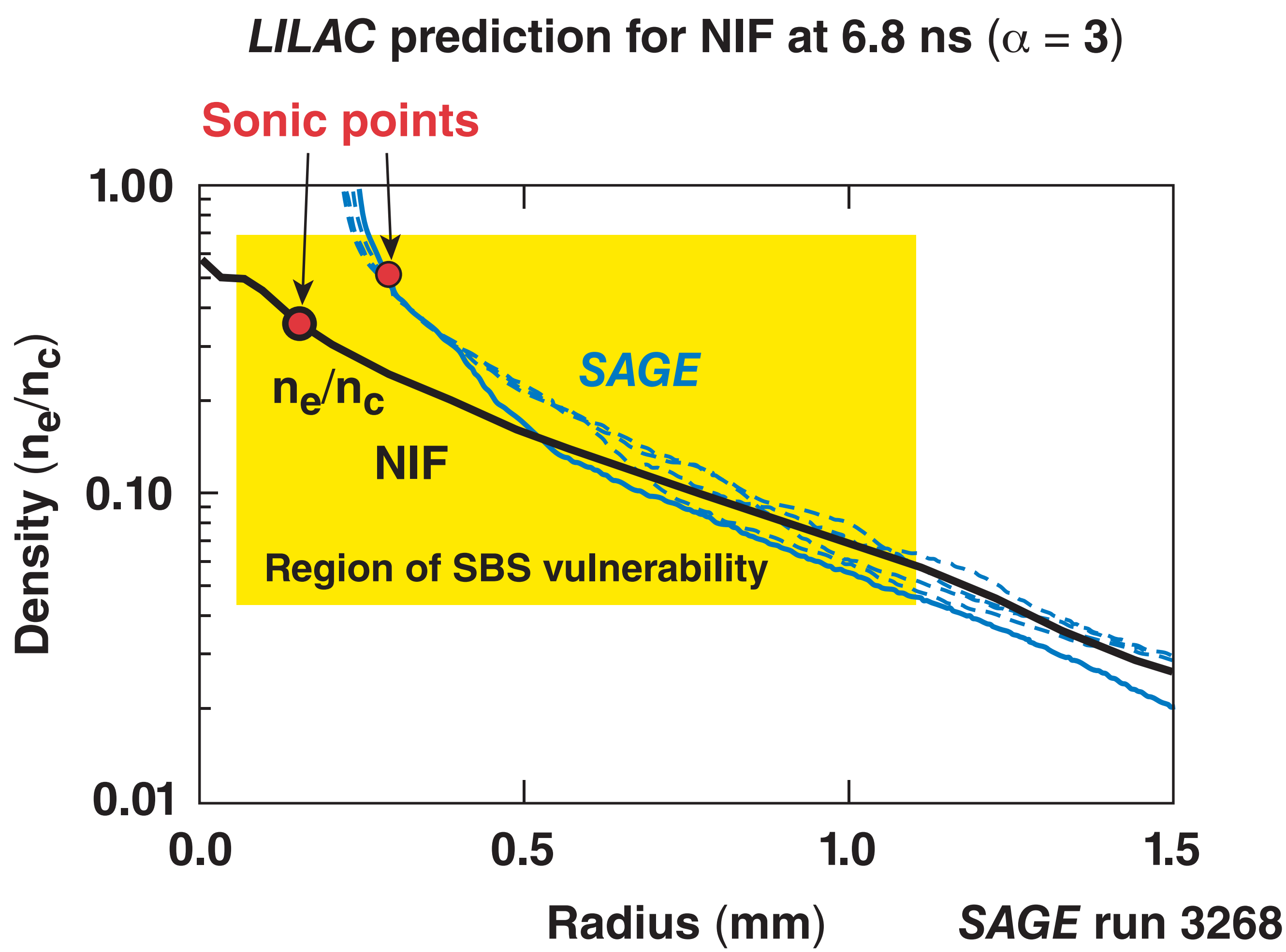
UR LLE

LILAC prediction for NIF at 6.8 ns ($\alpha = 3$)



E13883

NIF plasma conditions are reasonably well approximated by OMEGA experiments for $n_e < n_c/4$



E13884

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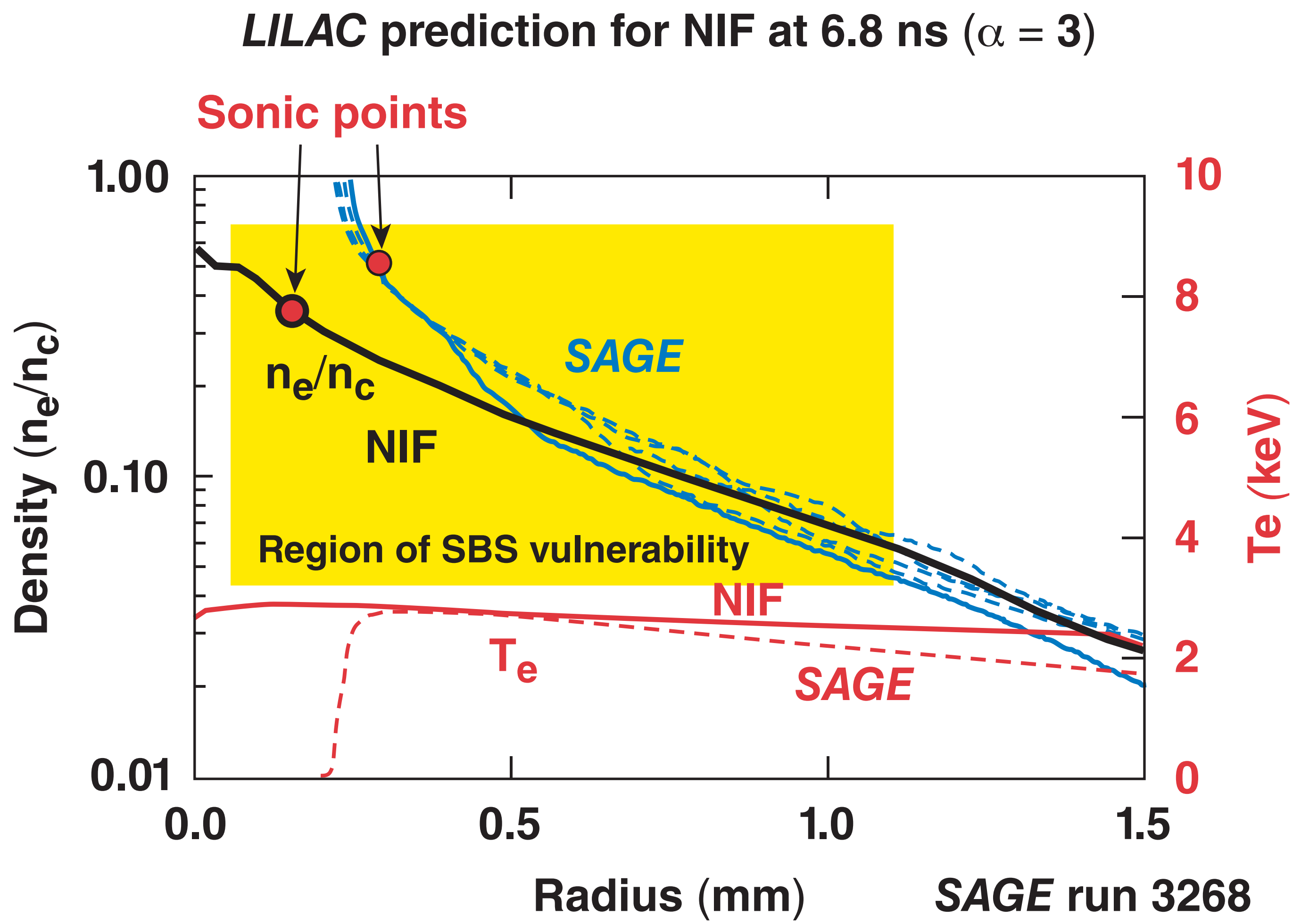

E13884

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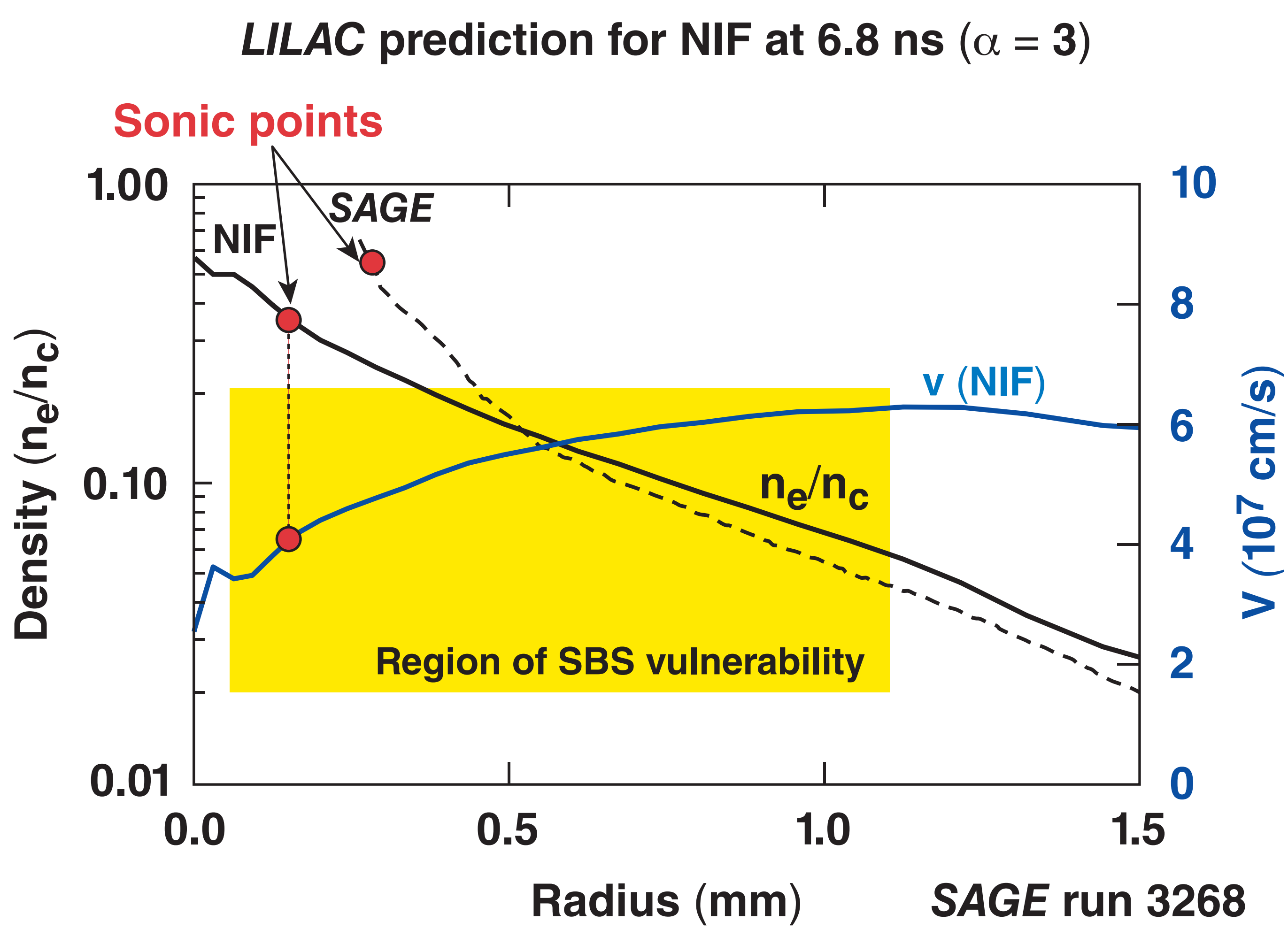
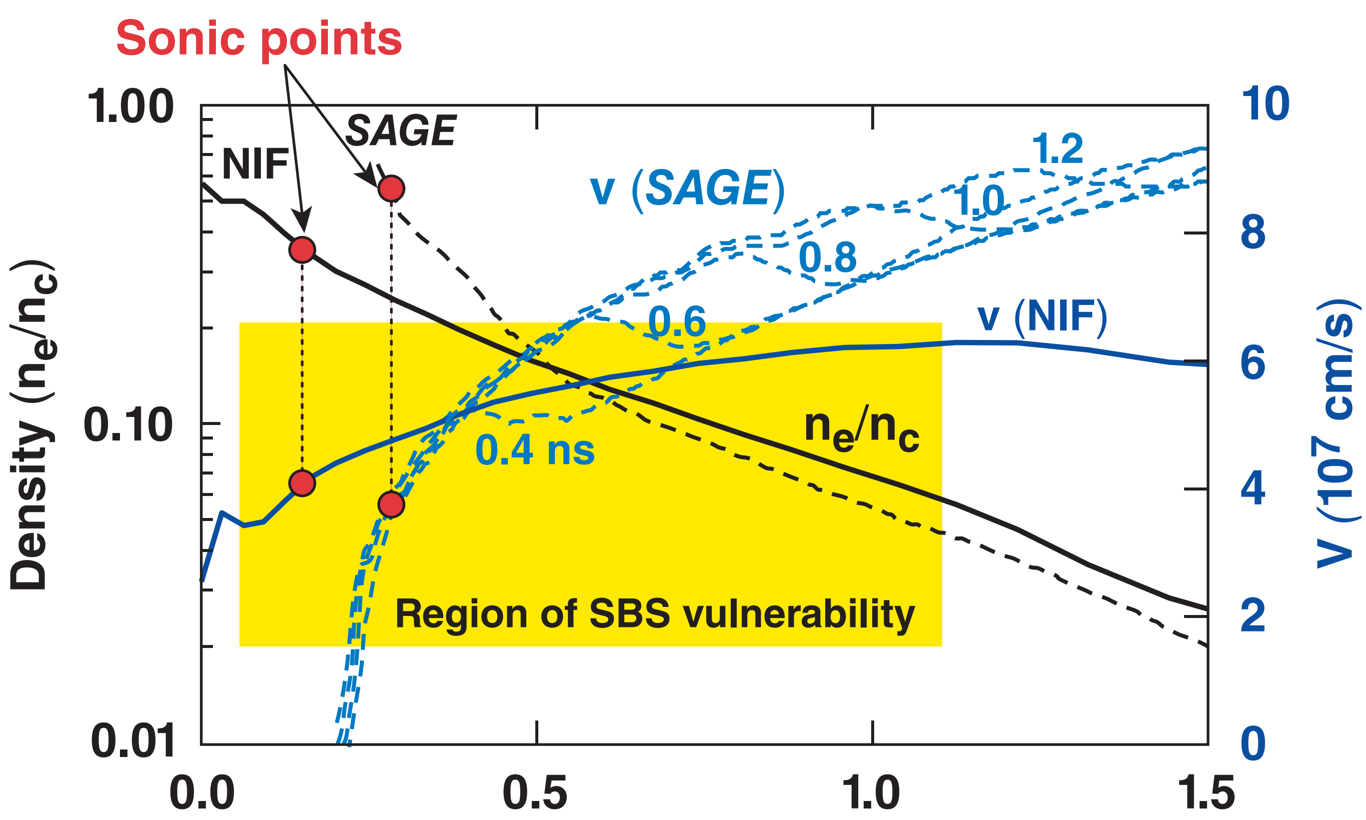
UR LLE



E13885

NIF plasma conditions are reasonably well approximated by OMEGA experiments for $n_e < n_c/4$

LILAC prediction for NIF at 6.8 ns (α = 3)



SAGE run 3268

E13885

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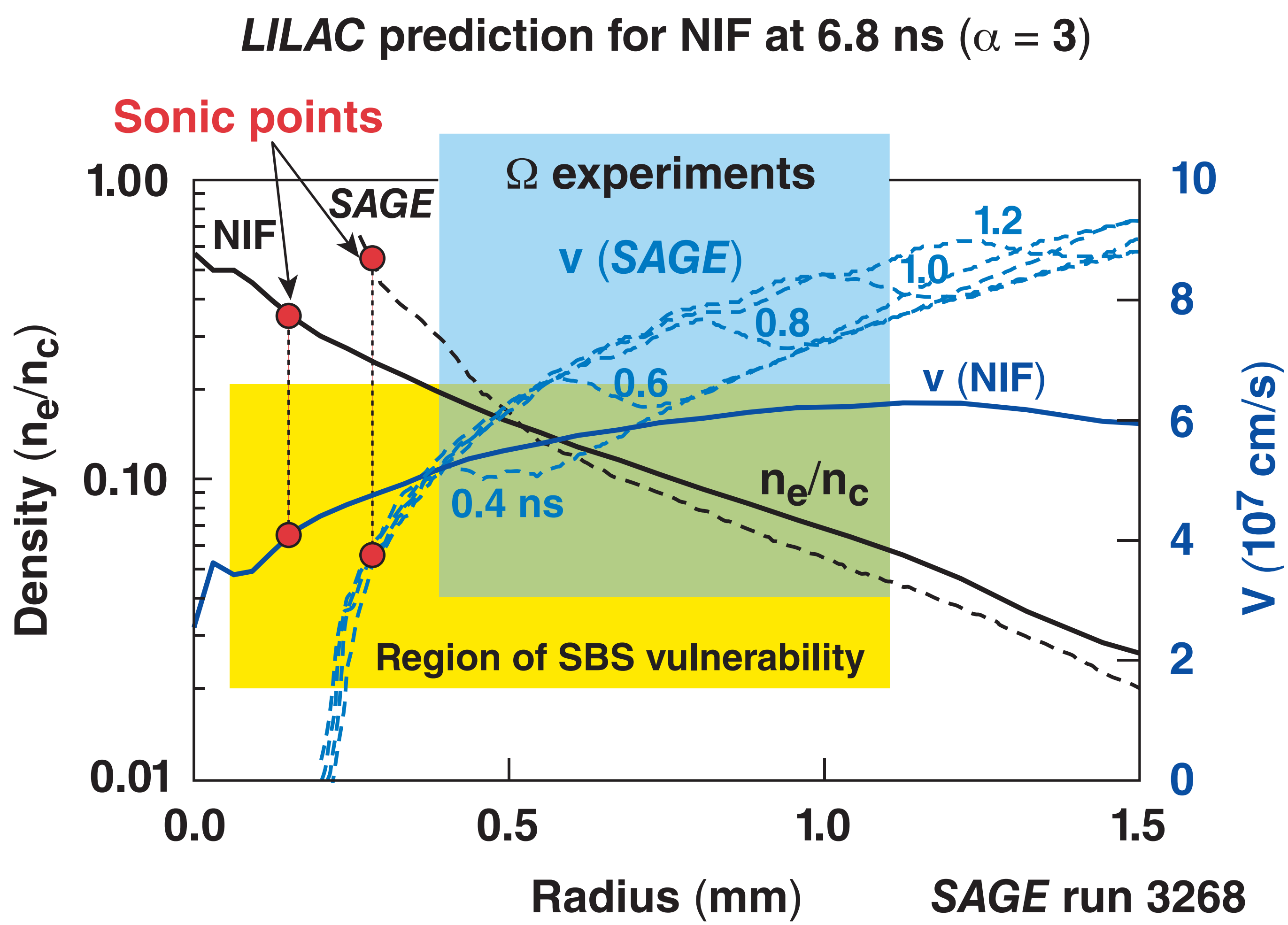
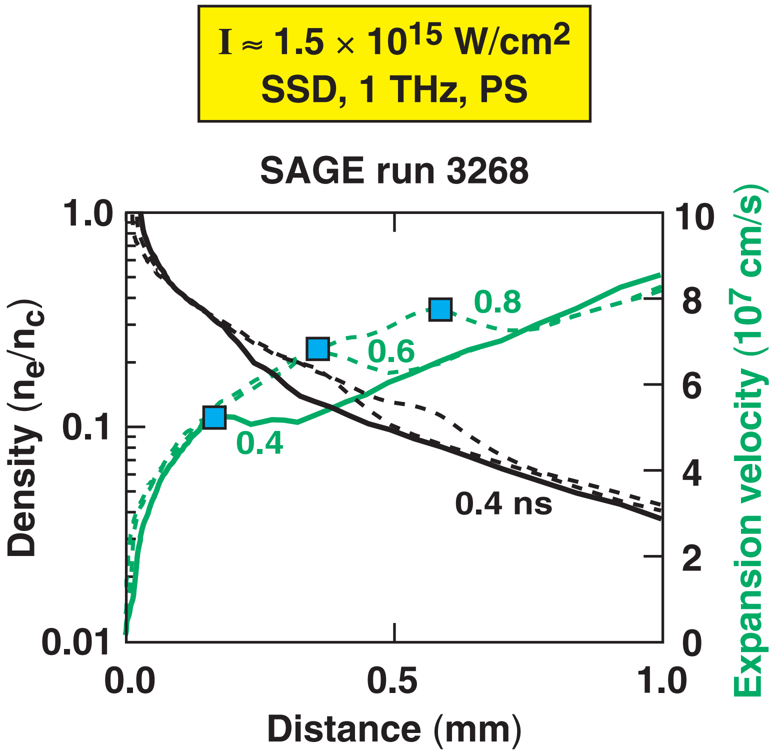
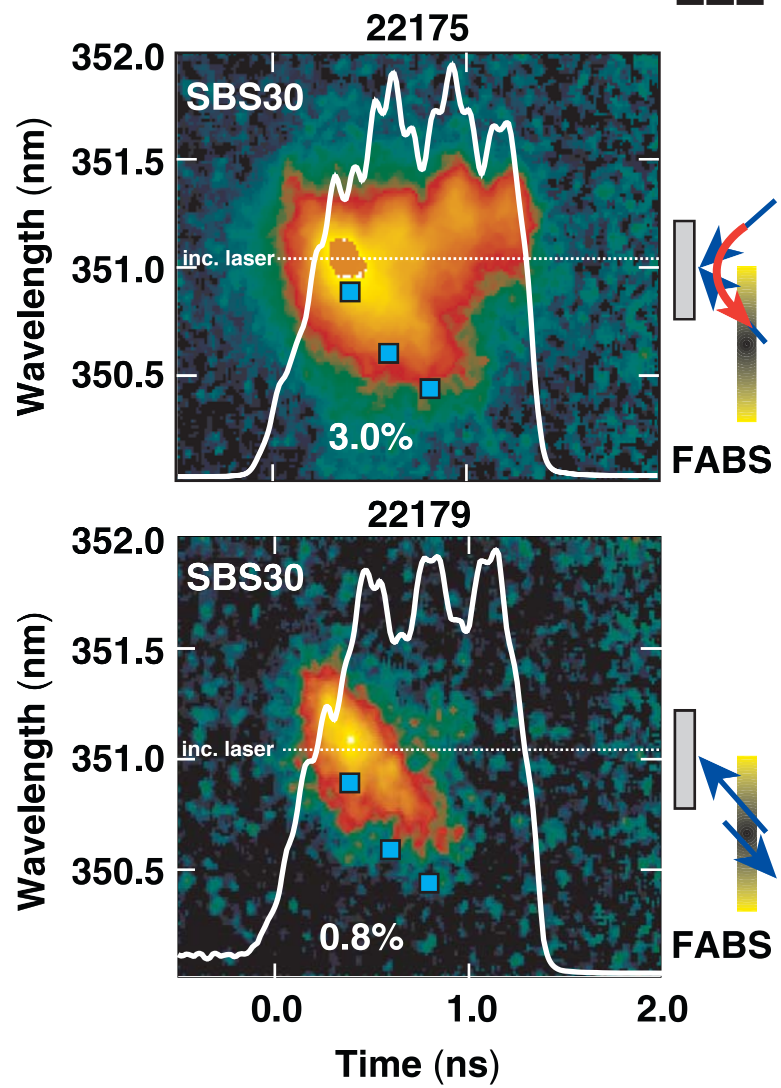


E13885

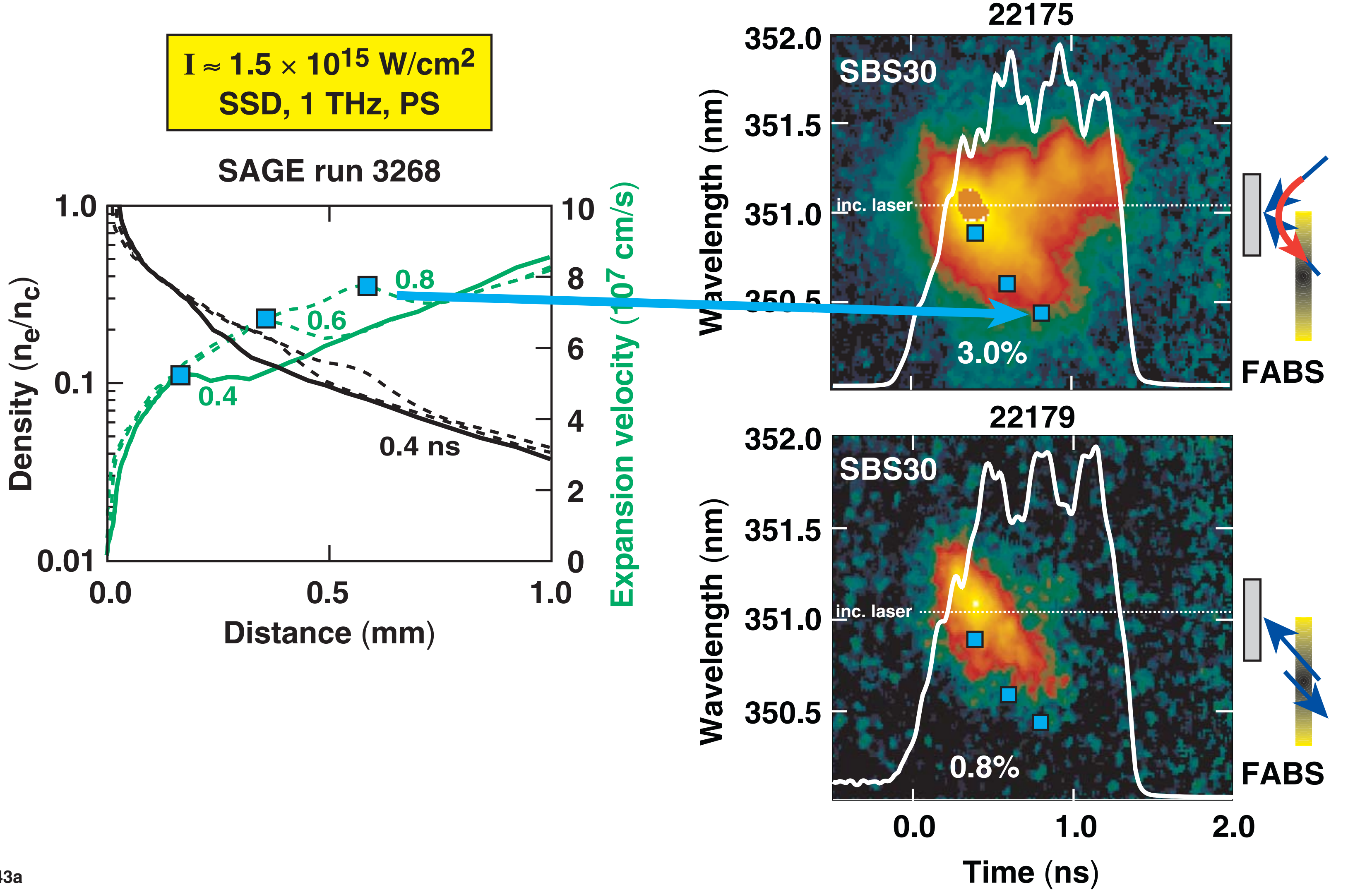
The fast-evolving velocity bump leads to early quenching of the blue-shifted SBS feature while the EM-seeded red feature disappears without seed





E11943a

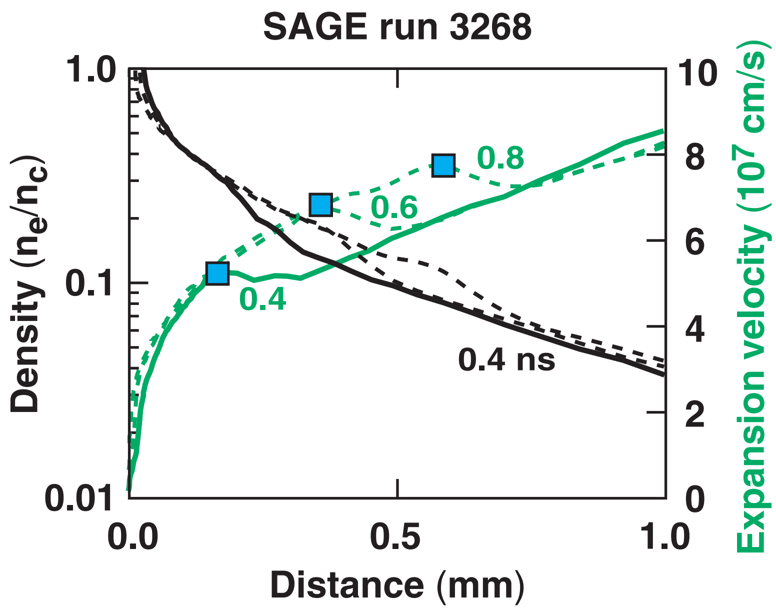
The fast-evolving velocity bump leads to early quenching of the blue-shifted SBS feature while the EM-seeded red feature disappears without seed

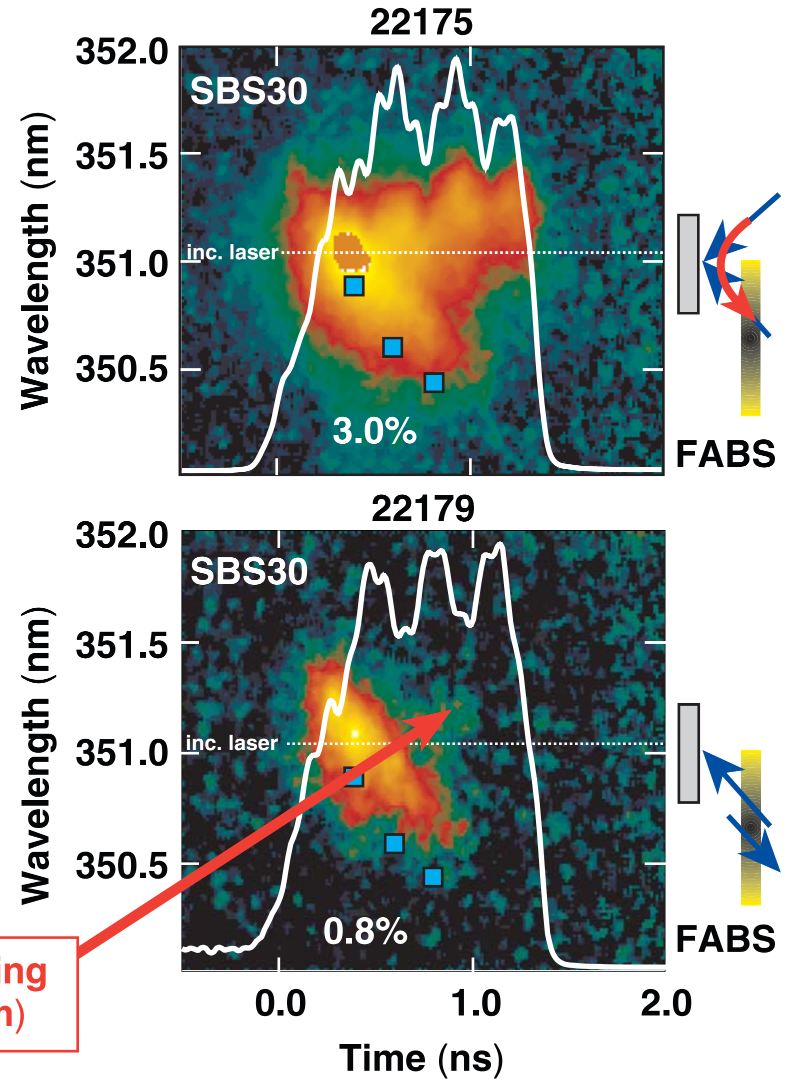


E11943a

The fast-evolving velocity bump leads to early quenching of the blue-shifted SBS feature while the EM-seeded red feature disappears without seed

I ≈ 1.5 × 10^{15} W/cm^2
SSD, 1 THz, PS



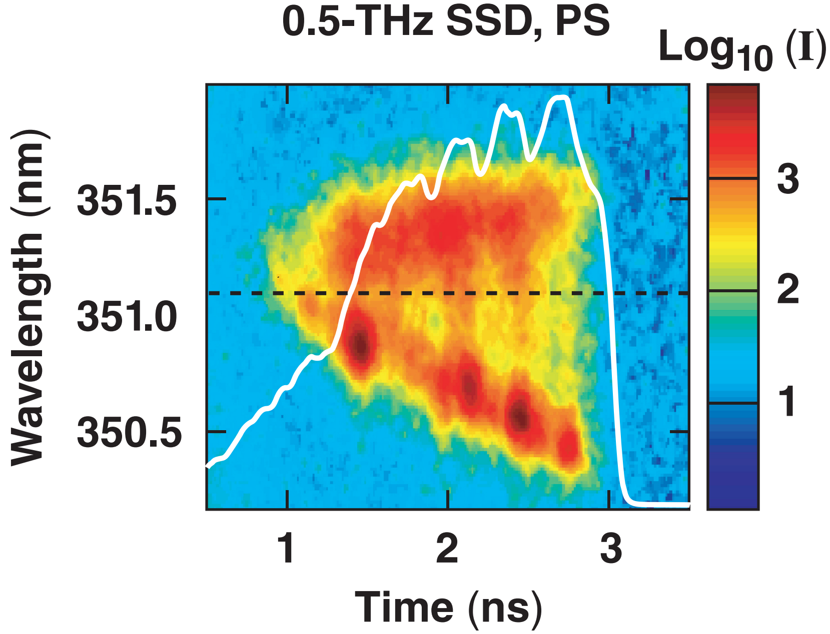


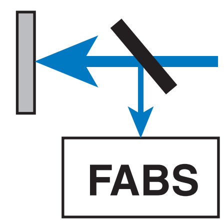
No opposing beam (no seeding by specularly reflected beam)

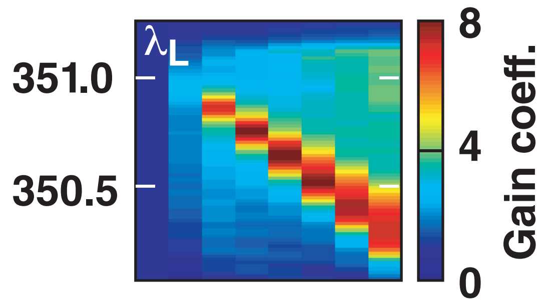
E11943a

Standard SBS gain predictions* for OMEGA long-scale-length plasma experiments agree very well with observations

20836, 8 × 10^{14} W/cm^2,
0.5-THz SSD, PS







SBS gain for peak (average) intensity = 8 × 10^{14} W/cm^2 (saturated inside high-intensity speckles of 3 to 5× average intensity)

*C. J. Randall *et al*., Phys. Fluids 24, 1474 (1981).

E13879

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20836, 8 × 10[14] W/cm[2],
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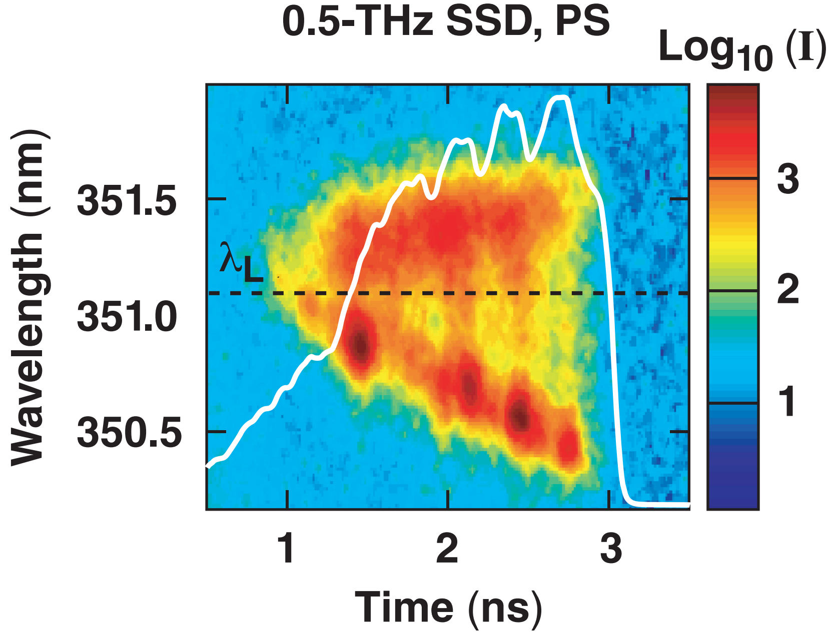

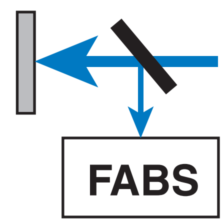

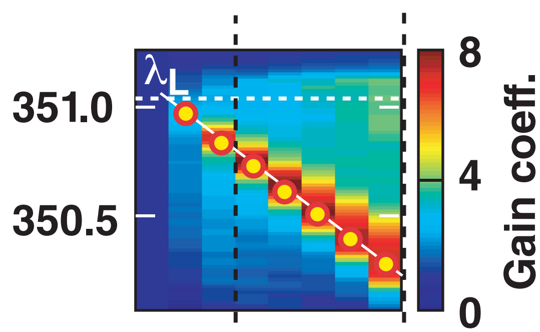

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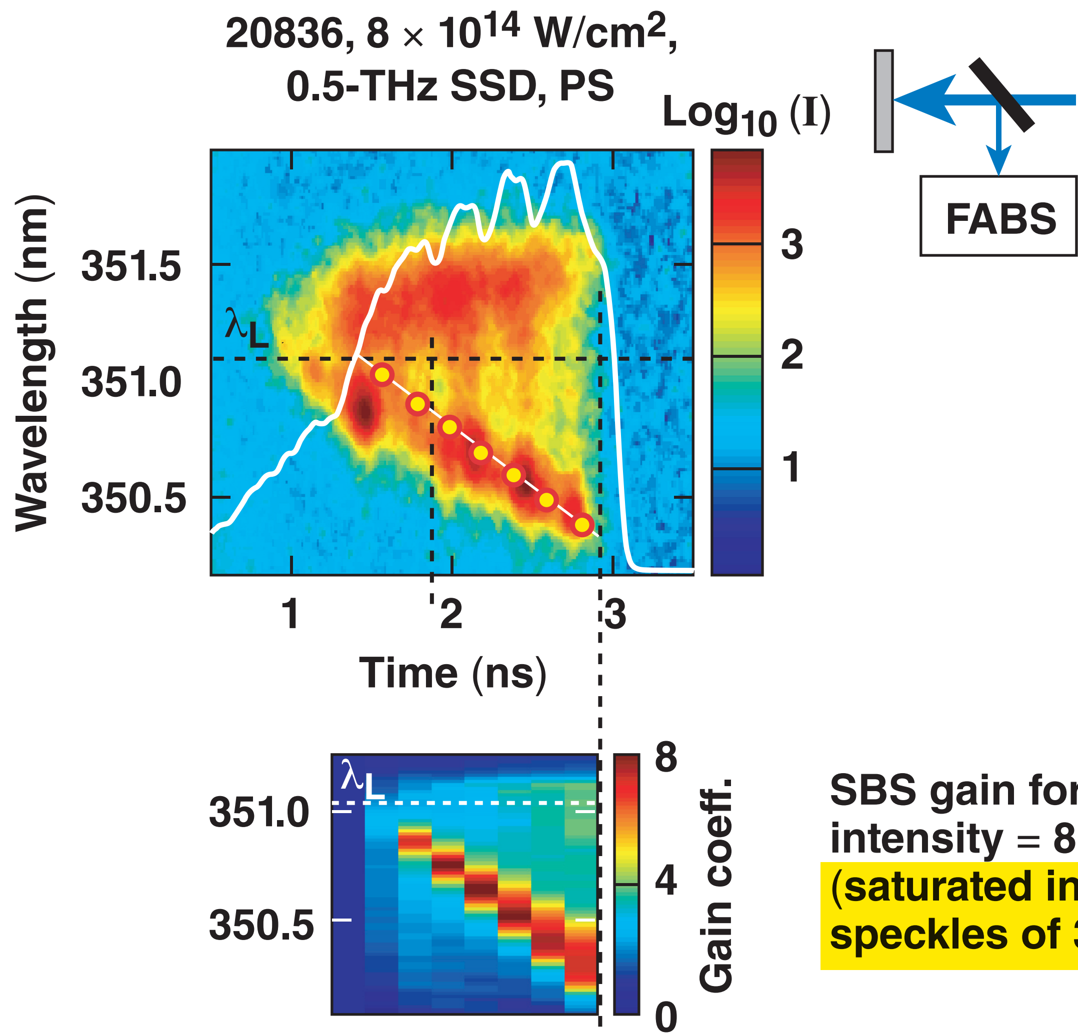

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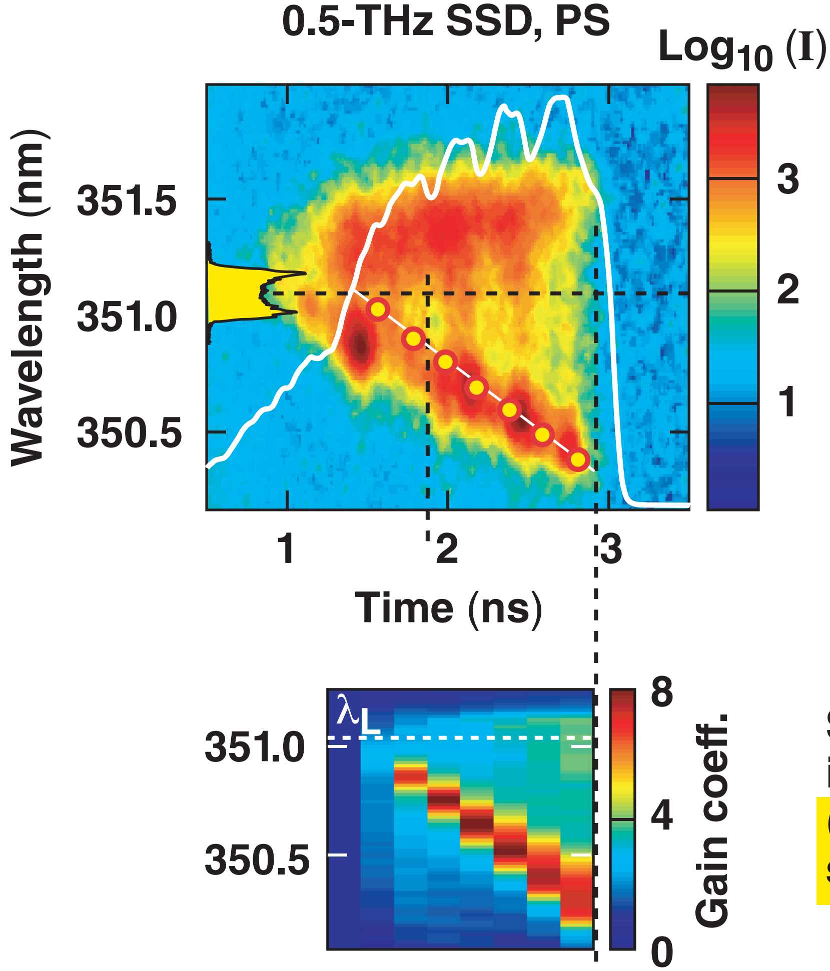

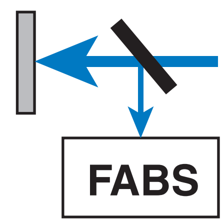

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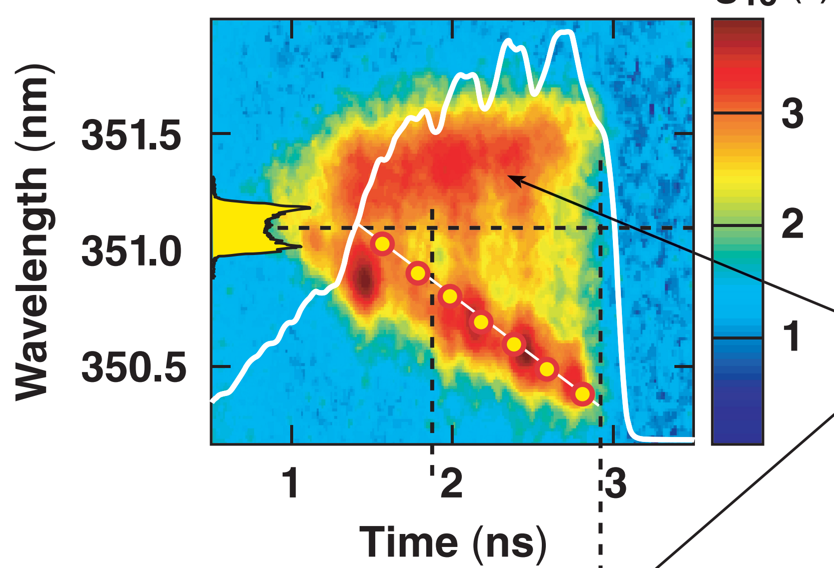
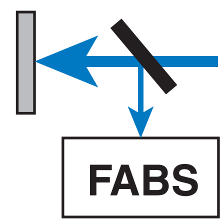
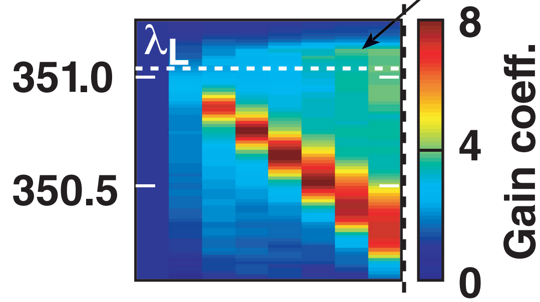




Low SBS gain is easily observed in the presence of an opposing beam. (EM seed amplified by SBS gain)



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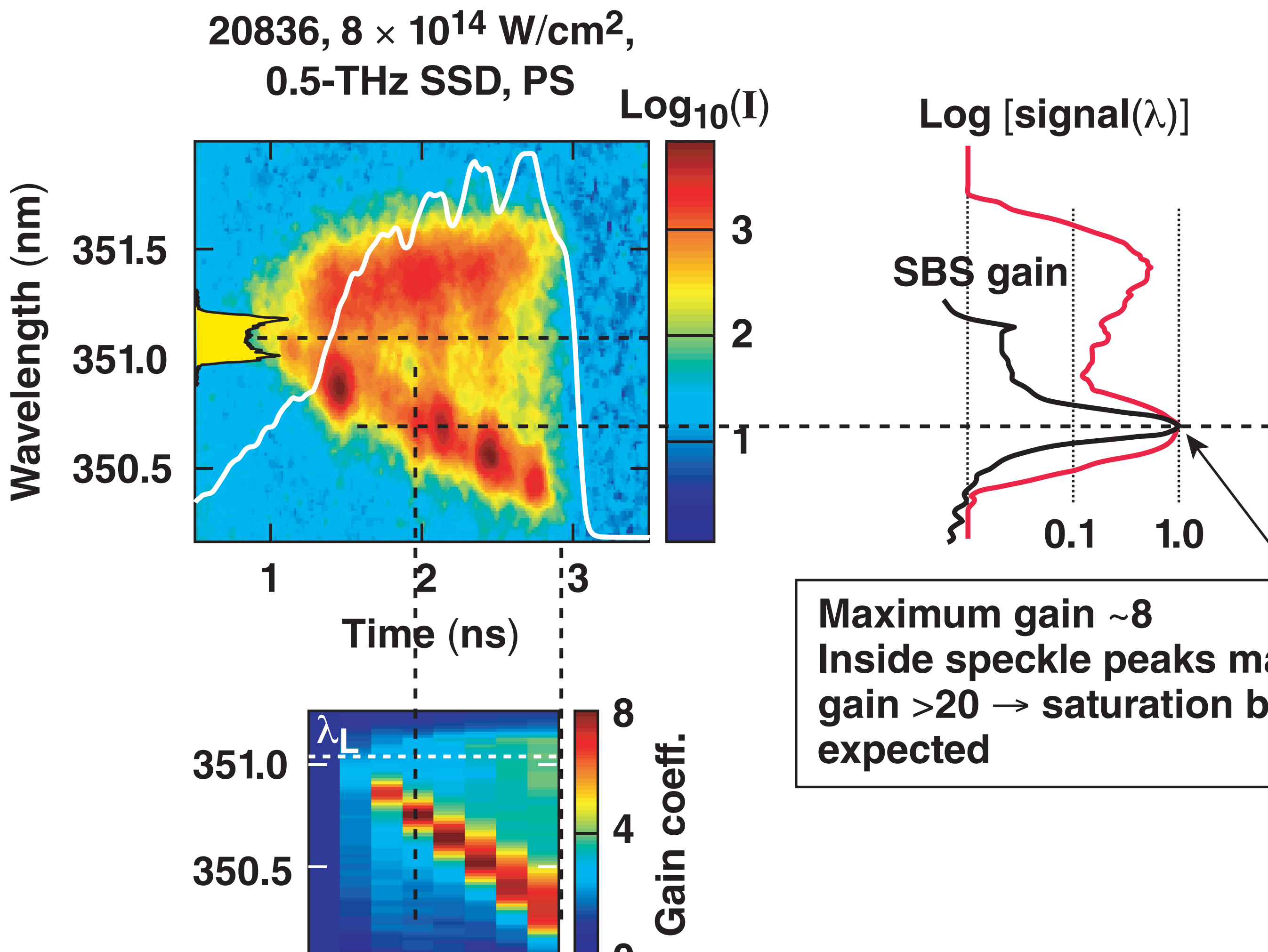


Maximum gain ~8
Inside speckle peaks maximum gain >20 → saturation brodening expected

E13886

*C. J. Randall *et al.*, Phys. Fluids 24, 1474 (1981).

LPI simulations confirm SBS growth from thermal noise in the underdense region

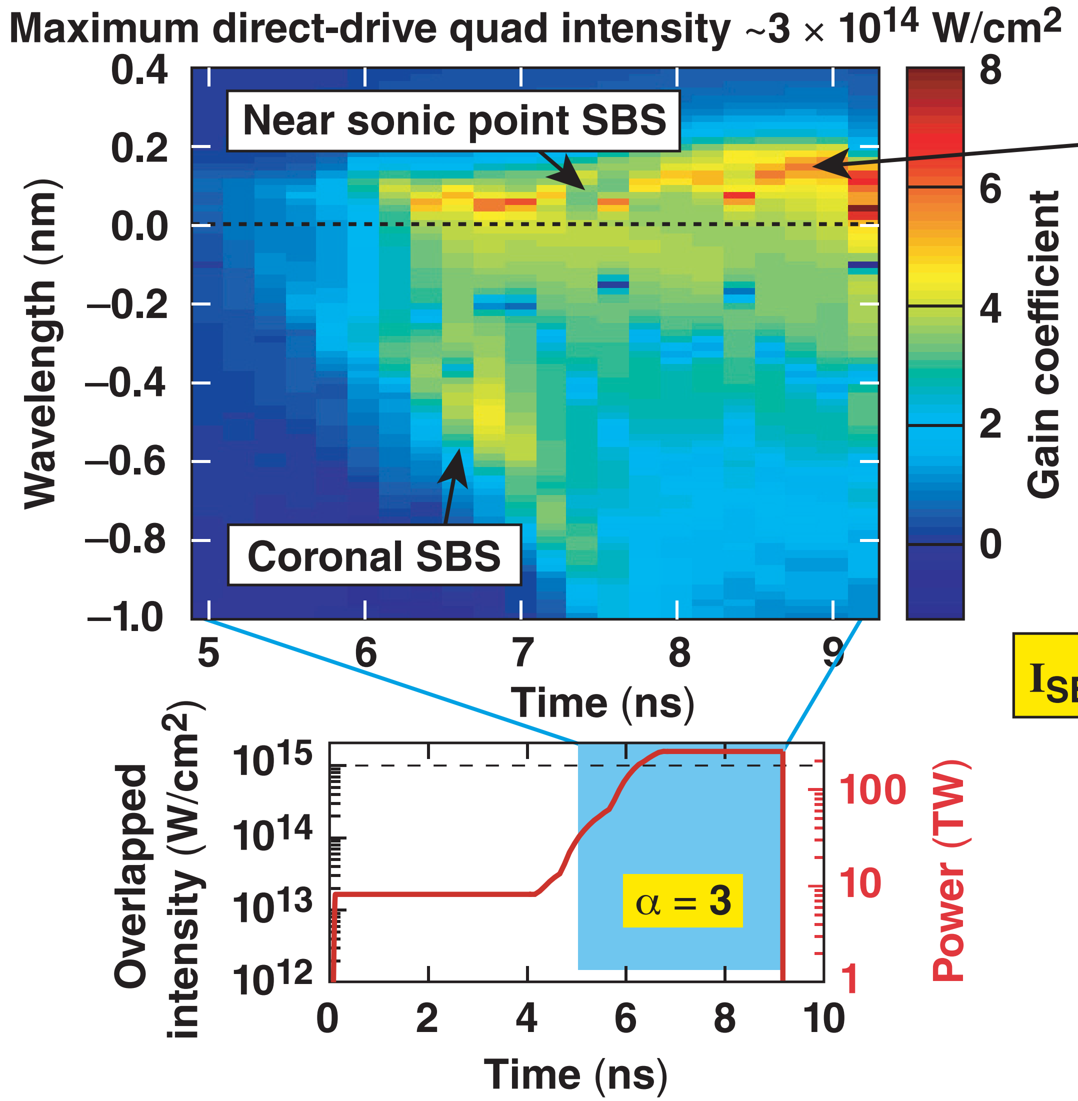
- **Velocity bumps are responsible for significant SBS gains.**
- **Pf3d and standard SBS gain calculations* using *SAGE* predictions for the plasma correctly predict the measured SBS blue shifts and gains.**
  - **Standard SBS gains are consistent with observations when speckle intensities are included (growth from thermal noise).**
- **Gain of the red-shifted SBS component is much lower, but EM seeding makes it easily observed.**

E13887

*C. J. Randall *et al*., Phys. Fluids 24, 1474 (1981).

SBS gain predictions for the NIF quad are similar to OMEGA in low-density corona; high-density SBS may be higher on the NIF

UR LLE



EM-seeded SBS ⇒ more detailed analysis required

$I_{SBS} = I_n \exp(G^* I_{inc}^{speckle})$

E13888

Summary/Conclusions

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