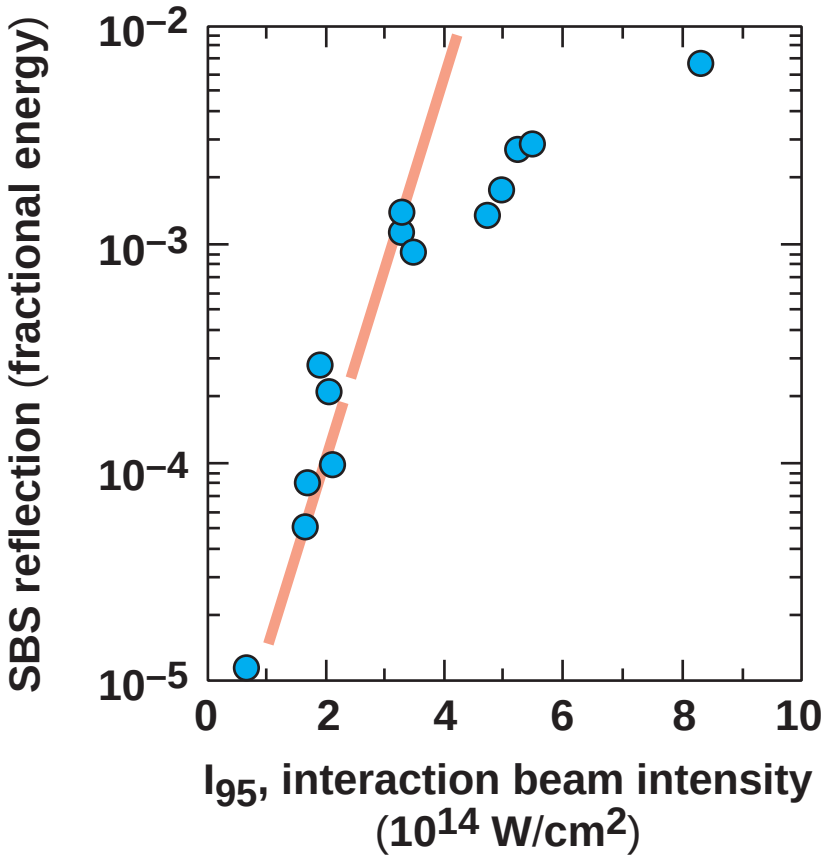
Stimulated Brillouin Scattering in Very Long Velocity Scale-Length NIF Plasmas



W. Seka
University of Rochester
Laboratory for Laser Energetics

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Stimulated Brillouin Scattering in Very Long Velocity Scale-Length NIF Plasmas

W. Seka, D. D. Meyerhofer, R. S. Craxton, S. P. Regan, R. E. Bahr, R. W. Short, and B. Yaakobi

Laboratory for Laser Energetics, U. of Rochester

J. Fuchs

LULI, Ecole Polytechnique, Palaiseau, France

D. Montgomery

Los Alamos National Laboratory

B. Afeyan

Polymath Inc., Pleasanton, CA

SBS has been investigated in plasmas relevant to direct-drive NIF ignition targets with particular attention paid to long velocity-gradient lengths. The plasmas were produced with ramped (3 ns) and staggered laser pulses using thick CH targets. All beams were smoothed with 1-THz SSD (smoothing by spectral dispersion). These plasmas have very long velocity gradient scale lengths (L_v > 0.5 mm), temperatures of 1 to 2 keV, and density profiles corresponding to NIF targets in the transition region between foot pulse and main pulse. This region is most prone to SBS. We observed increased single-beam SBS levels compared to previous experiments, but they remained below 1% for direct-drive ignition conditions. SBS reflectivities with reduced or no SSD bandwidth will also be presented. This work was supported by the U.S. Department of Energy Office of Inertial Confinement Fusion under Cooperative Agreement No. DE-FC03-92SF19460.

Contributors

- S. P. Regan
- D. D. Meyerhofer
- J. Fuchs[1]
- R. Bahr
- D. Montgomery[2]
- R. S. Craxton
- R. W. Short
- B. Yaakobi
- B. Afeyan[3]

[1] Ecole Polytechnique, Palaiseau, France
[2] Los Alamos National Laboratory
[3] Polymath, Pleasanton, CA

Summary

SBS in long-scale-length plasmas with full beam smoothing continues to indicate low scattering levels

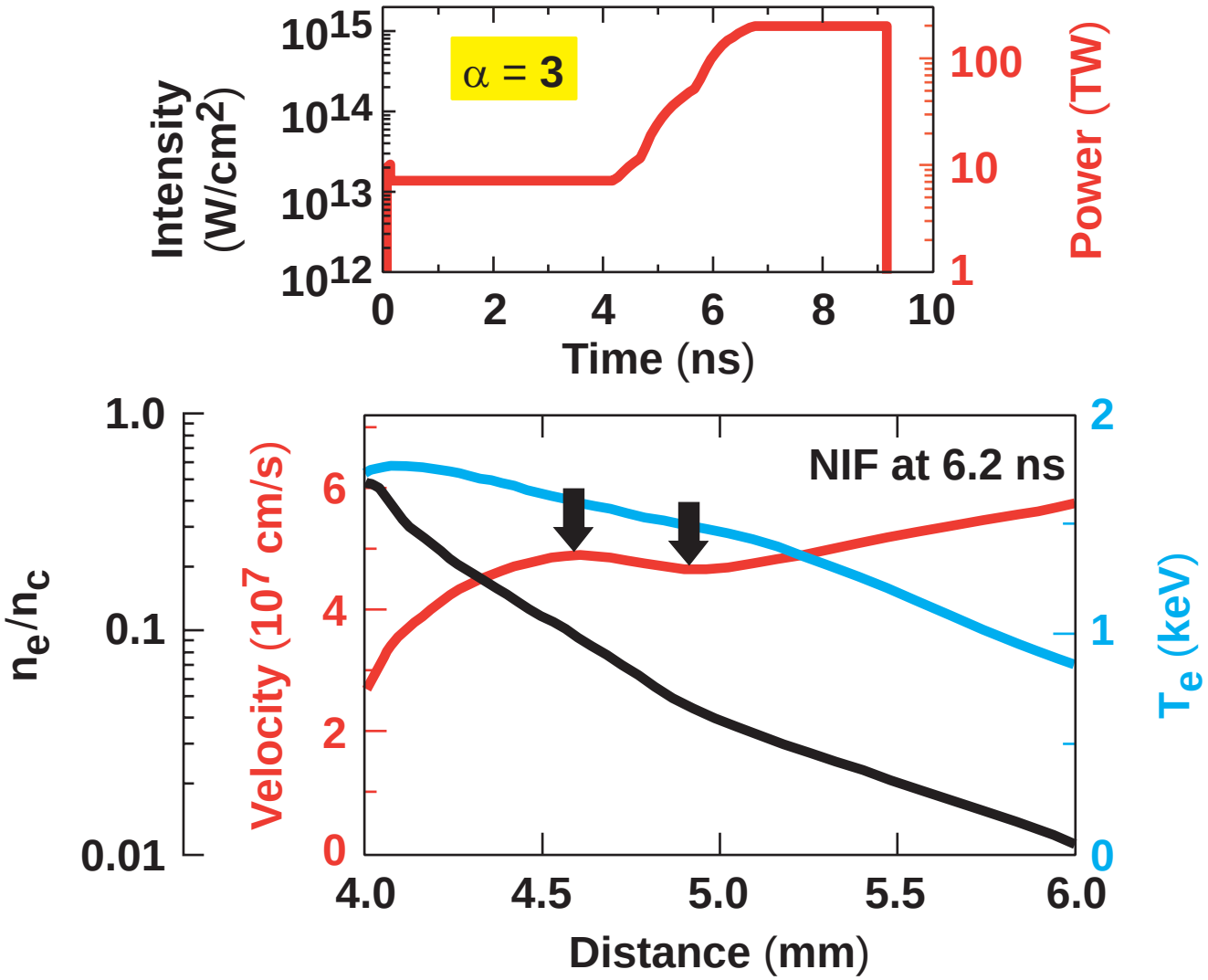
UR LLE

- NIF-like plasmas with long density- and velocity-gradient scale lengths have been produced.
- Full beam smoothing has been implemented: 1-THz, 2-D SSD with polarization smoothing (PS).
- SBS levels of << 1% are observed under conditions similar to NIF direct-drive ignition implosions (transition between foot and main pulse).
- Thresholds and scattering levels appear close to predictions for smooth beams.

Outline

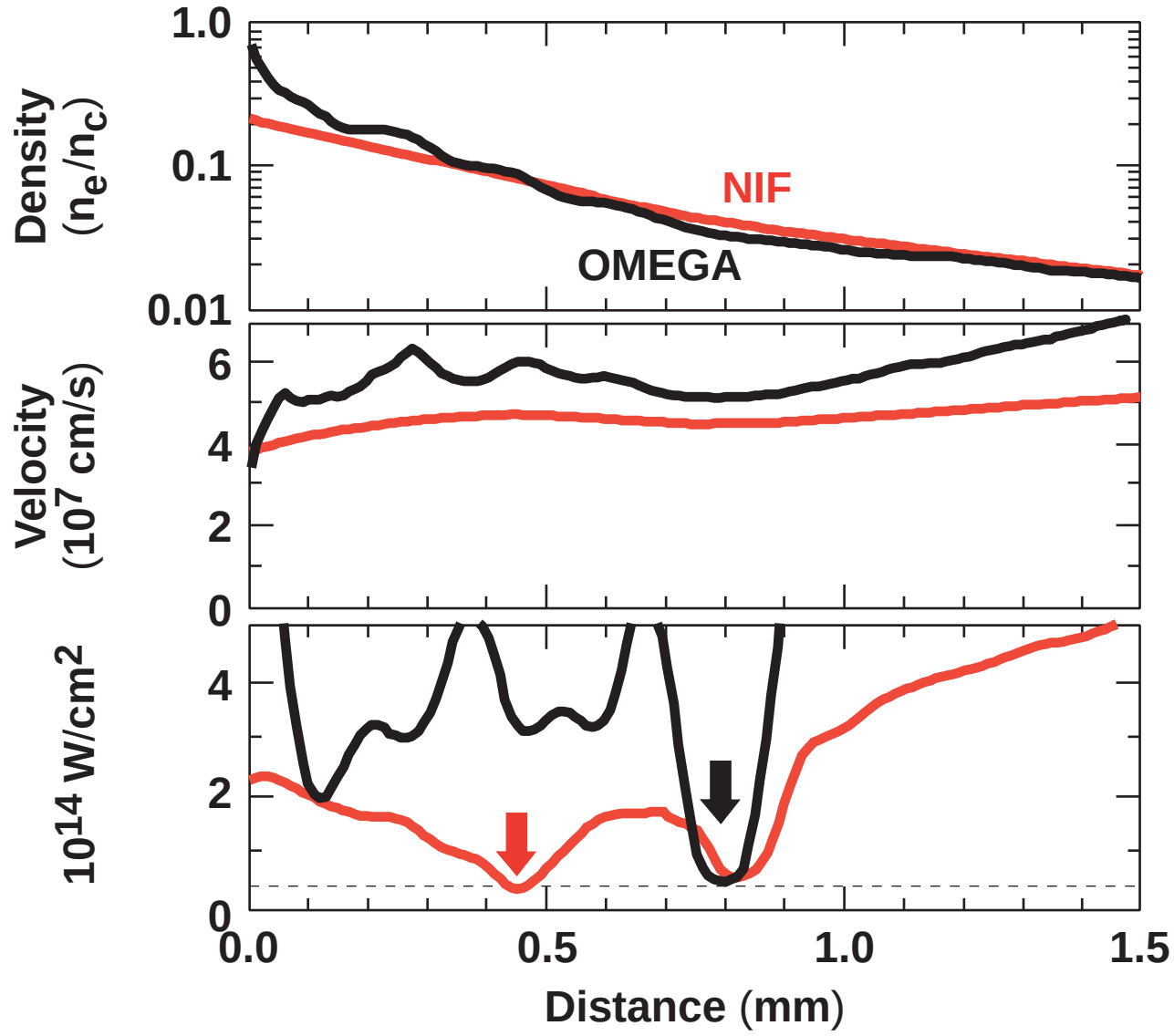
- Plasma generation and plasma conditions
- Comparison between simulated plasma conditions and predictions for NIF ignition targets
- Experimental setup
- SBS results for various smoothing conditions
- Conclusions

The NIF direct-drive ignition target is most prone to SBS at t ~ 6 ns



E10690

OMEGA LPI plasma conditions closely resemble NIF ignition targets at the start of the main pulse



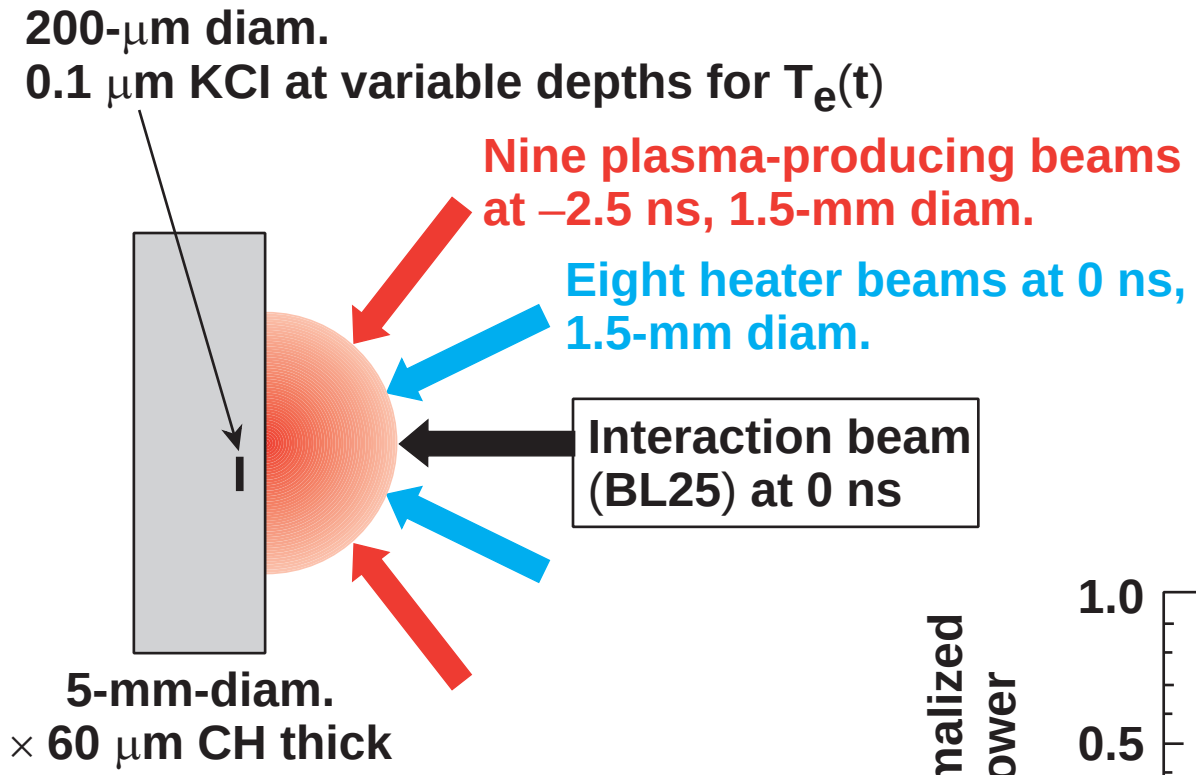
Radial density profile

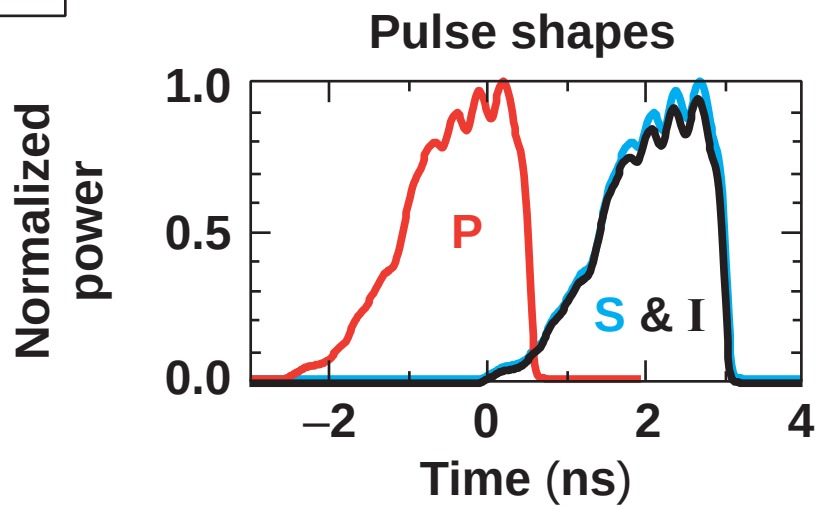
Expansion velocity

SBS gradient threshold

E10691

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

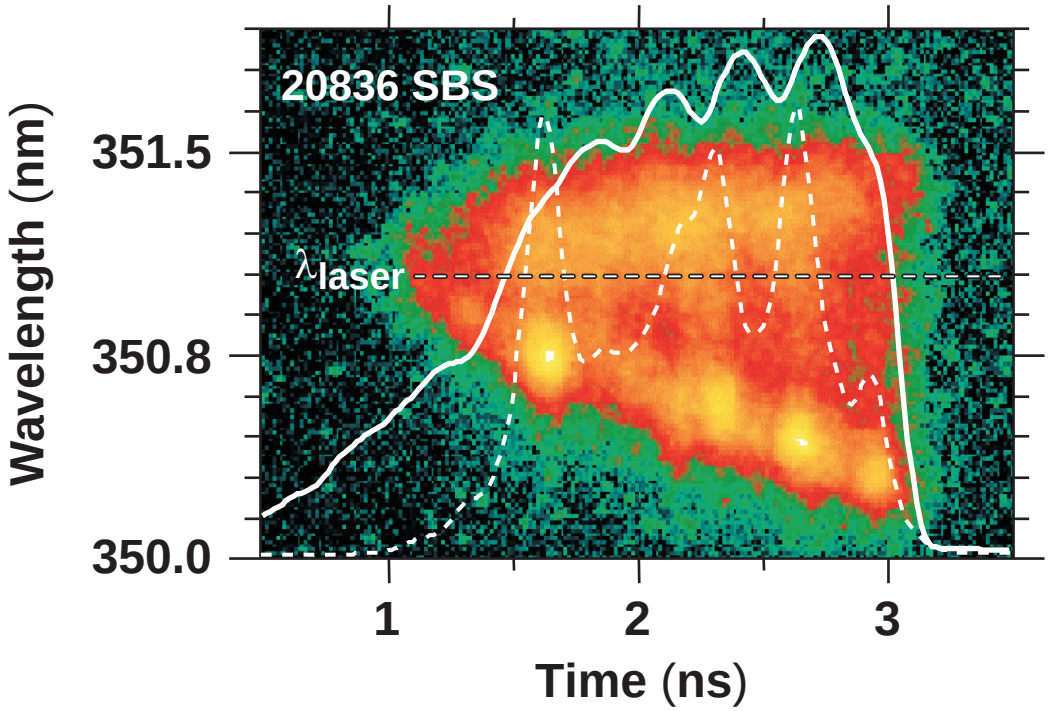




E10692

The increasing blue shift of the observed streaked SBS spectra is reasonably understood

- **2-D SSD, 0.5 THz, PS, 7.4×10^{14} W/cm^2, R_{SBS} = 0.7%**
- **Minimum-threshold SBS shifts are obtained from 2-D *SAGE* predictions and simple SBS theory.**
- **Slightly red-shifted component (M ~ 0.8) originates at >0.5 n_c → SBS seeded by reflection from n_c surface (?).**

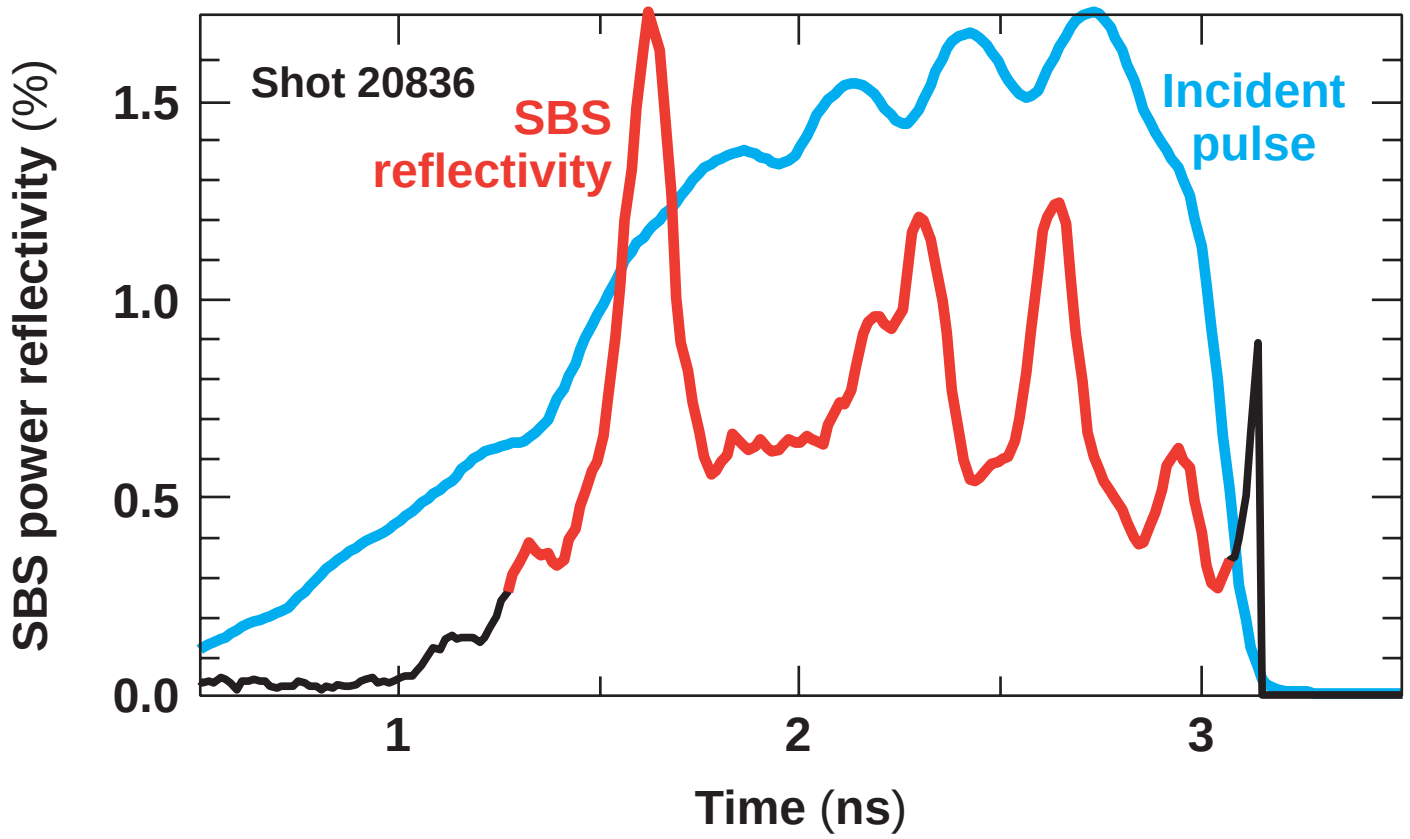


E10693

The modulations in the SBS signal appear to be related to the plasma evolution

UR LLE

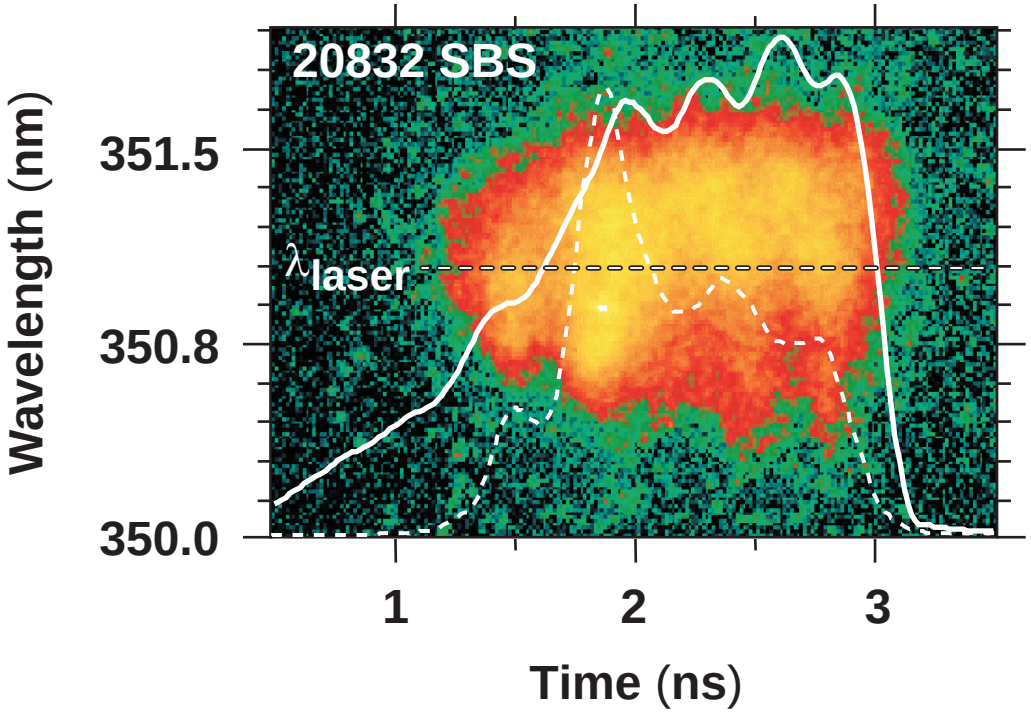
- 2-D SSD, 0.5 THz, PS, 7.4×10^{14} W/cm^2, R_{SBS} = 0.7%



E10694

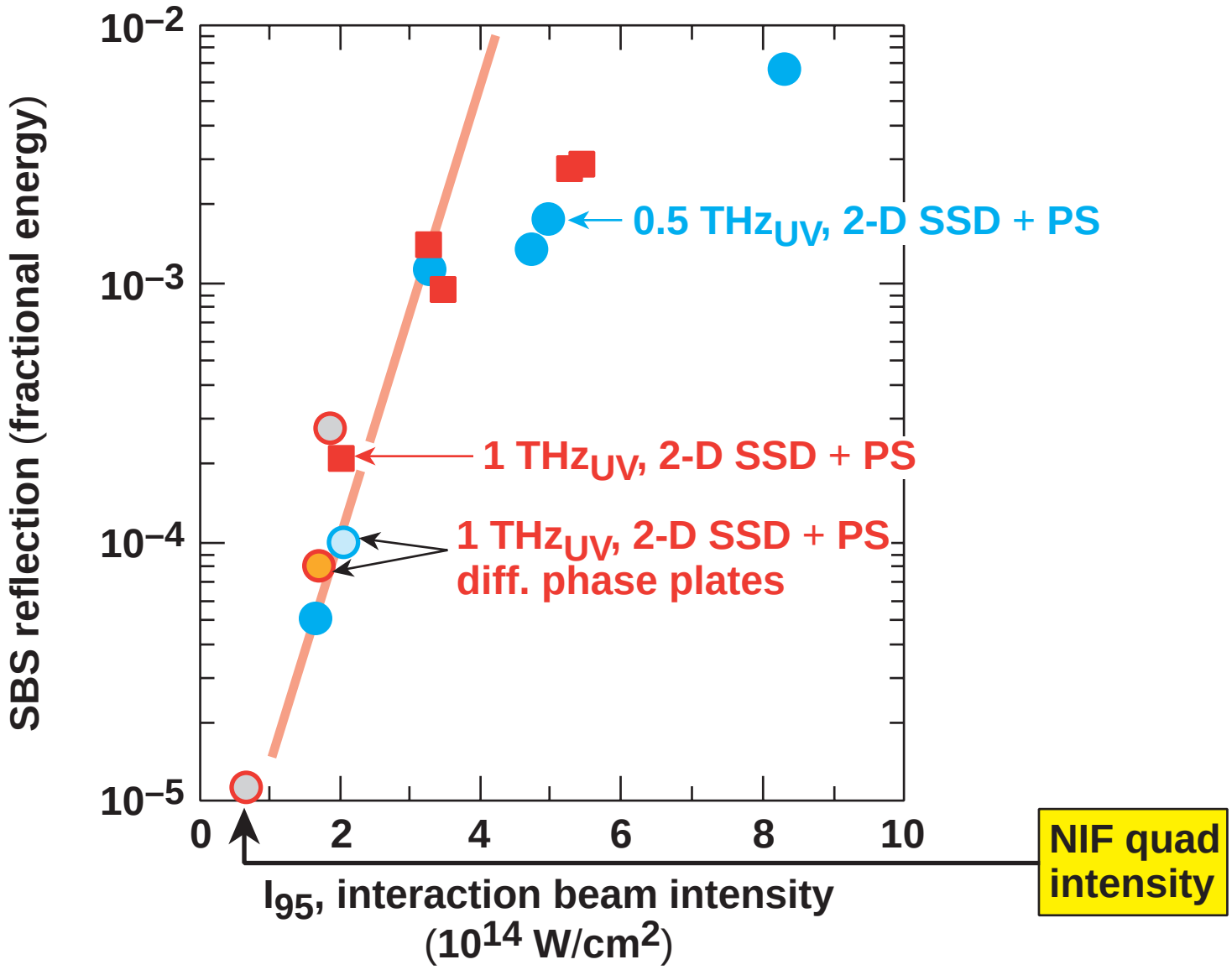
Best smoothing (2-D SSD, 1 THz, PS) leads to SBS spectra without blue-shifted component

- **2-D SSD, 1 THz, PS, 5.4×10^{14} W/cm^2**
- **R_{SBS} = 0.3%**



E10695

Full beam smoothing has reduced SBS levels significantly

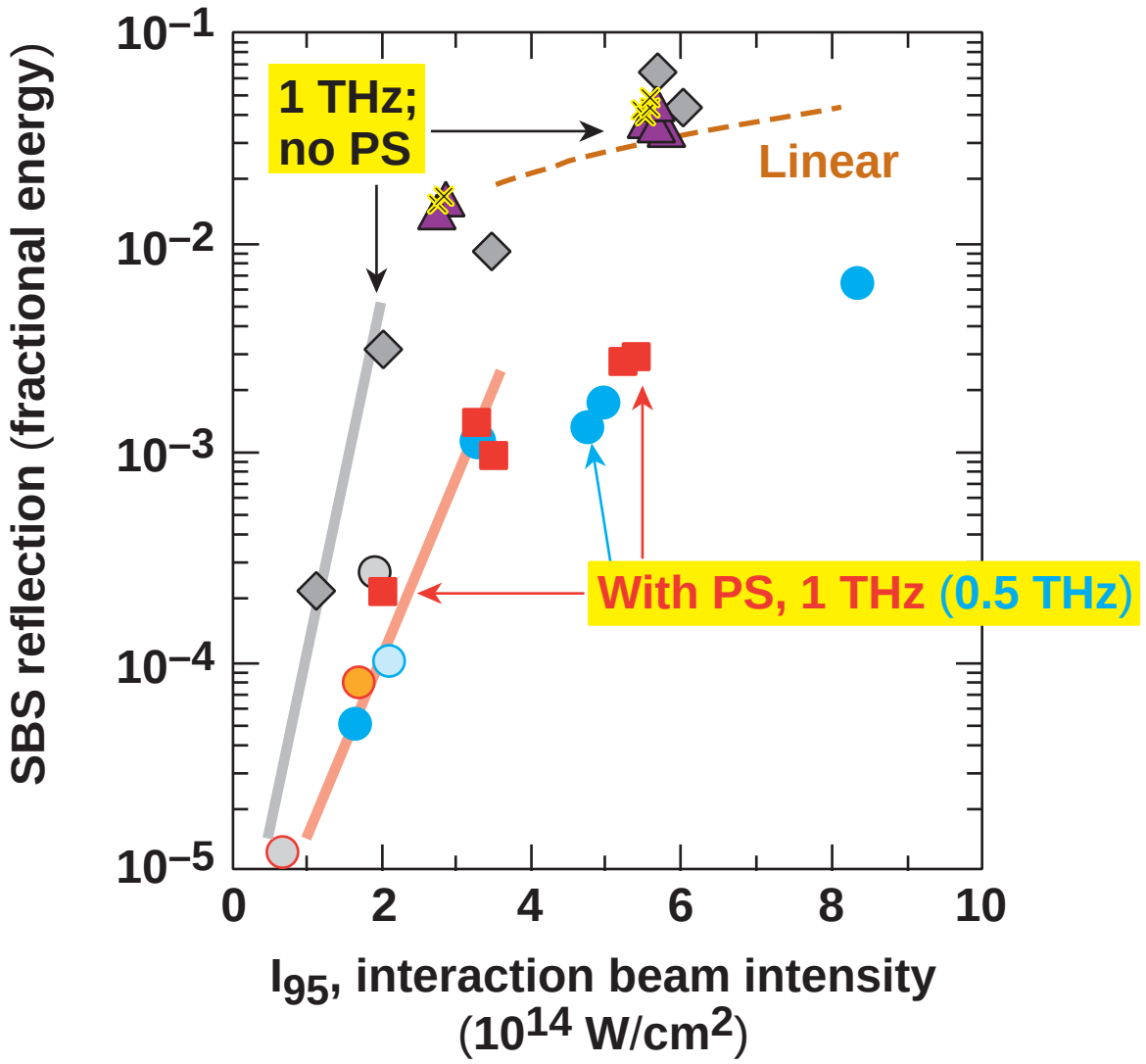


E10696

SBS predictions for NIF direct-drive targets still rely on extrapolations but the theoretical and experimental understanding is improving

- NIF density scale lengths around 6 ns exceed OMEGA scale lengths ($\rightarrow 2\times$ lower threshold on NIF).
- The SBS growth rate at 10^{14} W/cm^2, 2 keV, and 0.1 n_c is $\gamma \sim 10^{12}$ s^{-1} ~ correlation time of speckle structure at 1-THz SSD $\rightarrow$ expect smooth beam SBS interaction.
- Expect meaningful extrapolation from OMEGA to NIF.
- NIF SBS levels are expected to remain well below 1%.

For SBS polarization smoothing effectively reduces the interaction beam intensity by 2×



E10698

Summary/Conclusion

SBS in long-scale-length plasmas with full beam smoothing continues to indicate scattering levels

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- NIF-like plasmas with long density- and velocity-gradient scale lengths have been produced.
- Full beam smoothing has been implemented: 1-THz, 2-D SSD with polarization smoothing (PS).
- SBS levels of << 1% are observed under conditions similar to NIF direct-drive ignition implosions (transition between foot and main pulse).
- Thresholds and scattering levels appear close to predictions for smooth beams.
- 0.5-THz 2-D SSD smoothing shifts SBS farther into the coronal region with overall scattering levels unchanged from 1 THz.