Interaction Experiments Under Direct-Drive NIF Conditions

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Long-scale-length, laser--plasma interaction studies are carried out using up to 30 beams of OMEGA. The goal of these experiments is to examine parametric laser--plasma interaction processes relevant to NIF direct-drive ignition targets. So far, these experiments have shown that neither SBS nor SRS should be significant. Energetic electron production is studied using time-resolved, hard x-ray detectors. Preliminary data suggest that the target preheat due to these energetic electrons will be low enough for direct-drive targets to ignite. More detailed measurements are in progress. In addition, experiments have begun to examine the possibility of multiple-beam-interaction effects. This paper will discuss the present status of these experiments and their relevance to future direct-drive ignition experiments on the NIF. This work was supported by the U.S. Department of Energy Office of Inertial Confinement Fusion under Cooperative Agreement No. DE-FC03-92SF19460, the University of Rochester, and the New York State Energy Research and Development Authority.

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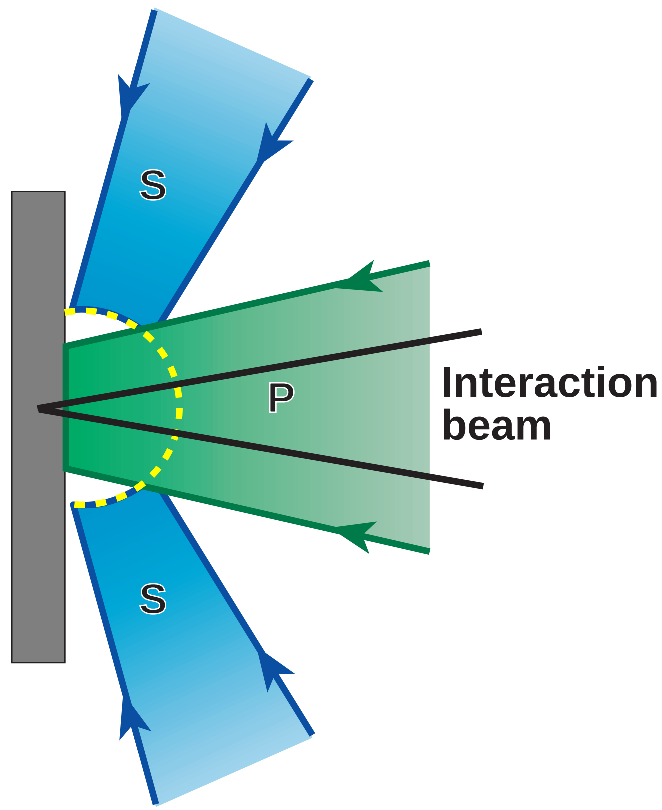

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Outline

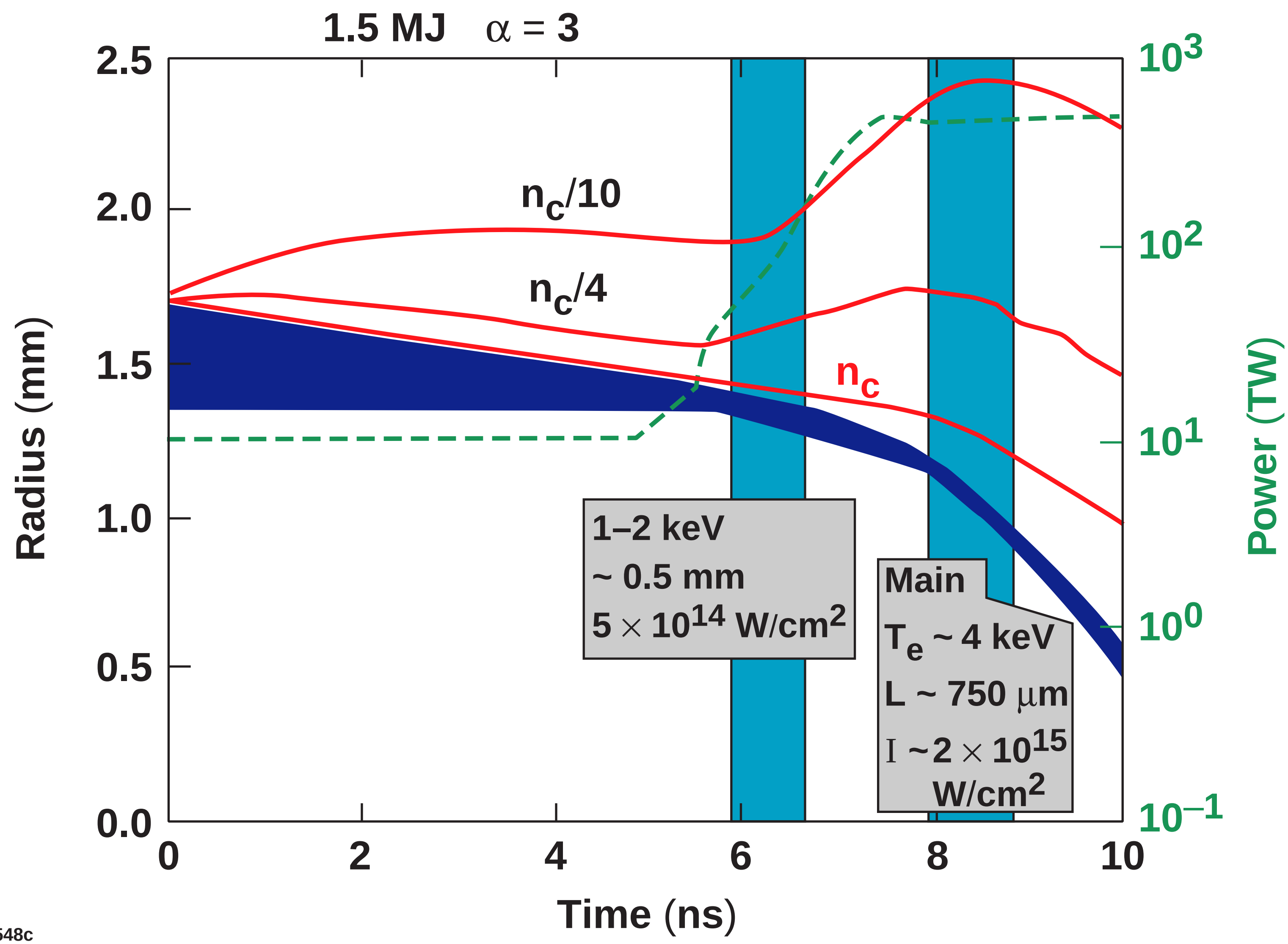
- Coronal conditions in NIF direct-drive ignition targets
- OMEGA approximations of NIF conditions
- Interaction experiments and results
- Hot-electron generation
- Conclusions

Summary

LPI experimental results on OMEGA are promising for the direct-drive NIF ignition design

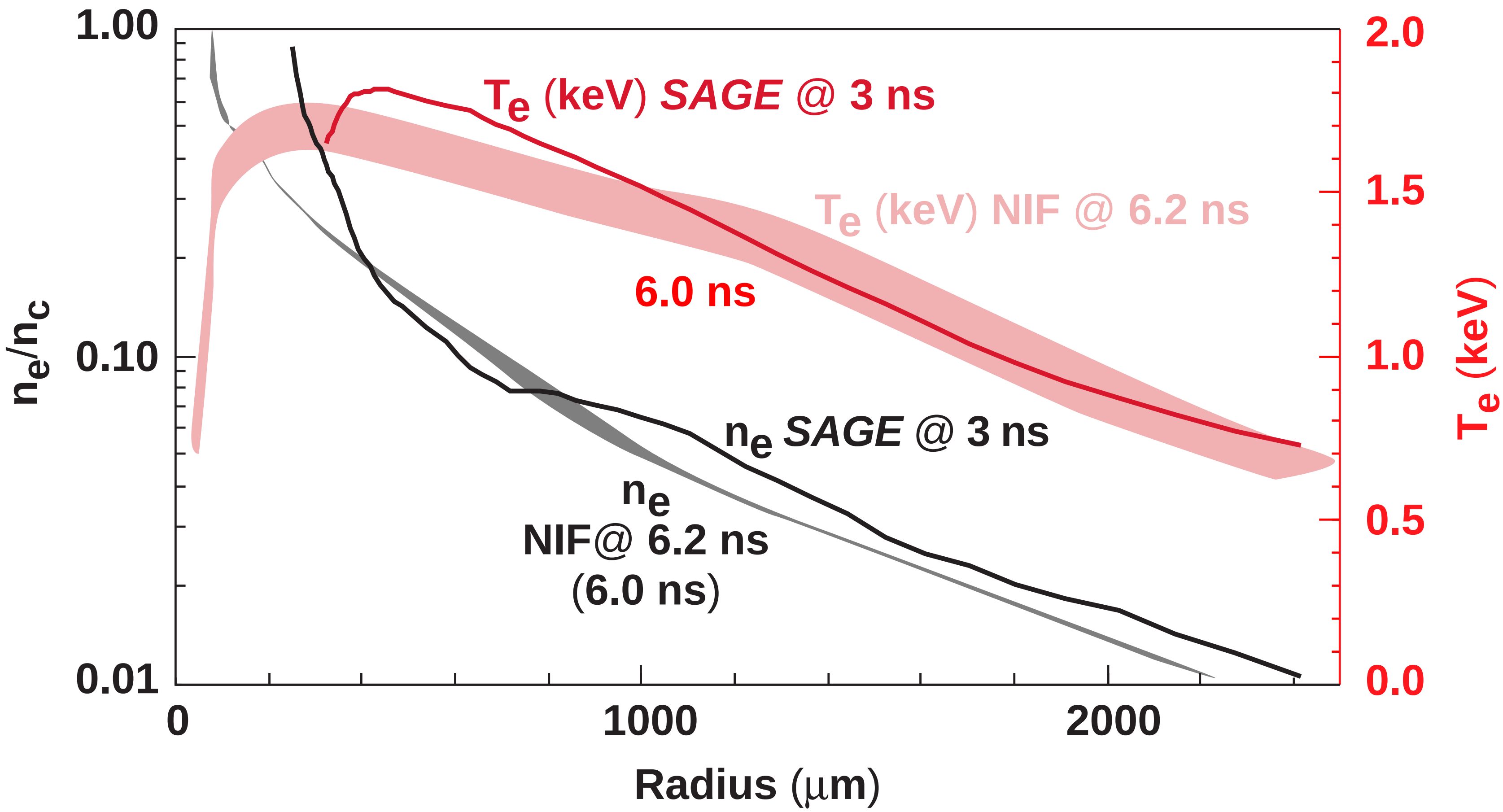
- NIF conditions are well modeled on OMEGA.
- SBS and SRS are detected at nonthreatening levels.
- Hot-electron generation due to TPD instability appears manageable.

Typical parameters of NIF direct-drive designs are accessible on OMEGA



TC4548c

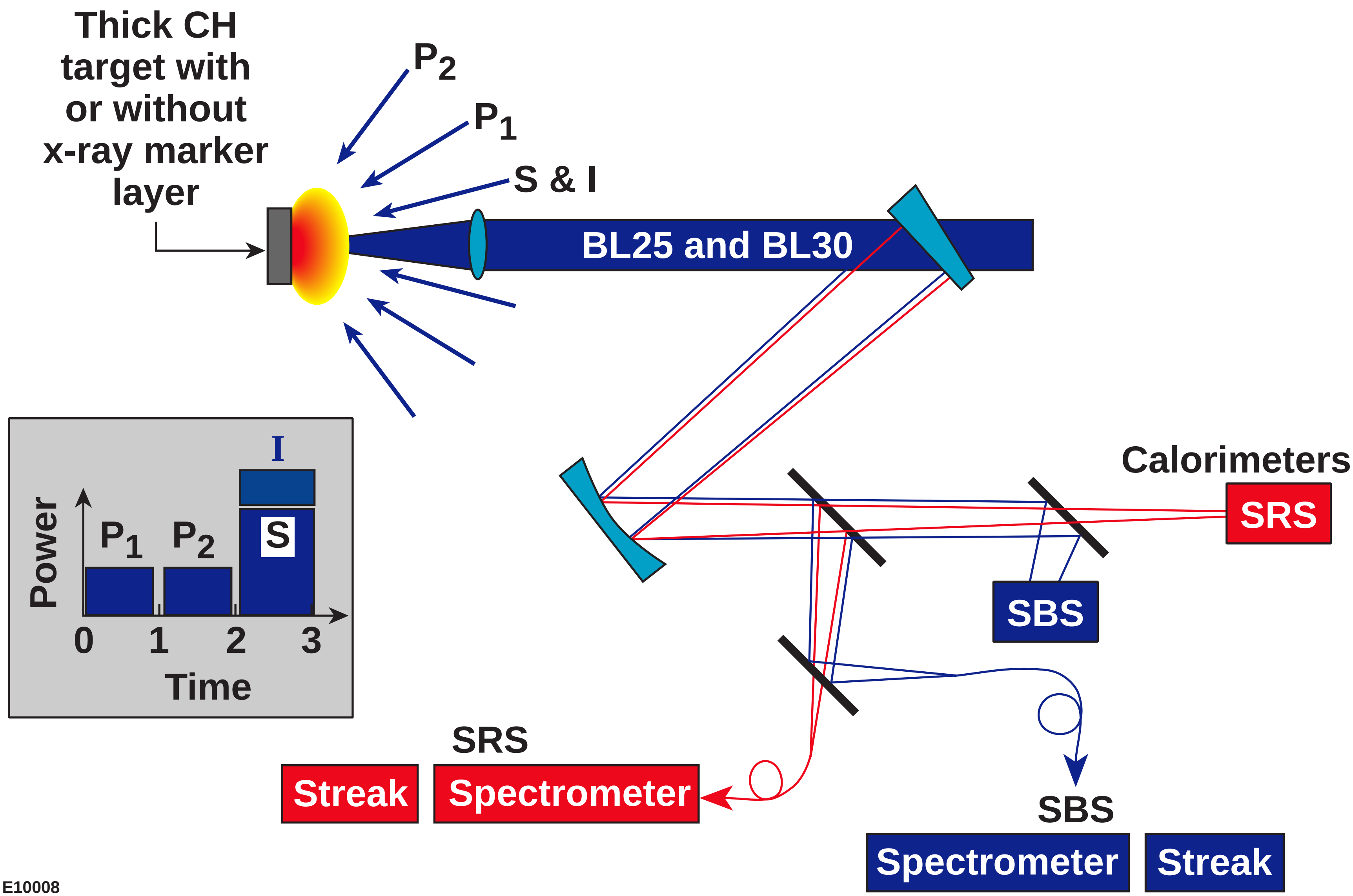
Planar targets irradiated on OMEGA simulate well the transition region of the α = 3 NIF ignition design



- *SAGE* run 3077
- NIF run 03161056

E9679

Two backscatter stations in two adjacent beams permit single and multiple interaction beams and diagnostics



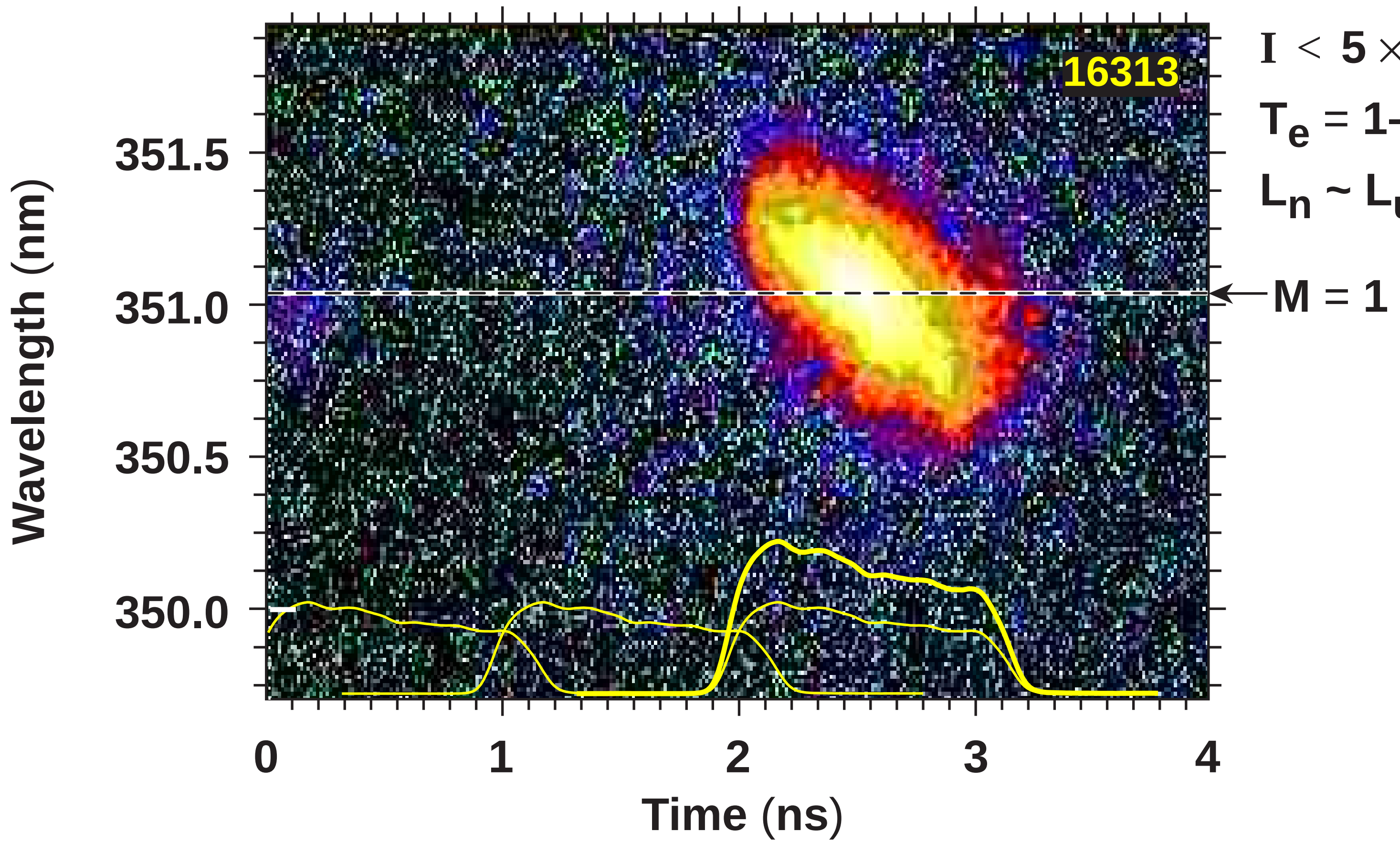
E10008

The OMEGA interaction beam is a good representation of NIF direct-drive irradiation conditions

- E ~ 500 J_{UV}, 1-ns square pulse, DPP with ~250-μm FWHM
- I_{NIF} ~ 1.5 3 10^{15} W/cm^2 (~ peak total overlapped NIF intensity on direct-drive target)
- I_{Ω} ~ 5 3 10^{14} W/cm^2
- *f* /6 focusing optics (NIF quad: *f* /8, i.e., similar speckle characteristics)

NOTE: Peak NIF quad intensity on target: ~ 2 3 10^{14} W/cm^2

The SBS from NIF-scale transition plasmas typically starts near n_c and then proceeds toward lower densities (supersonic region)

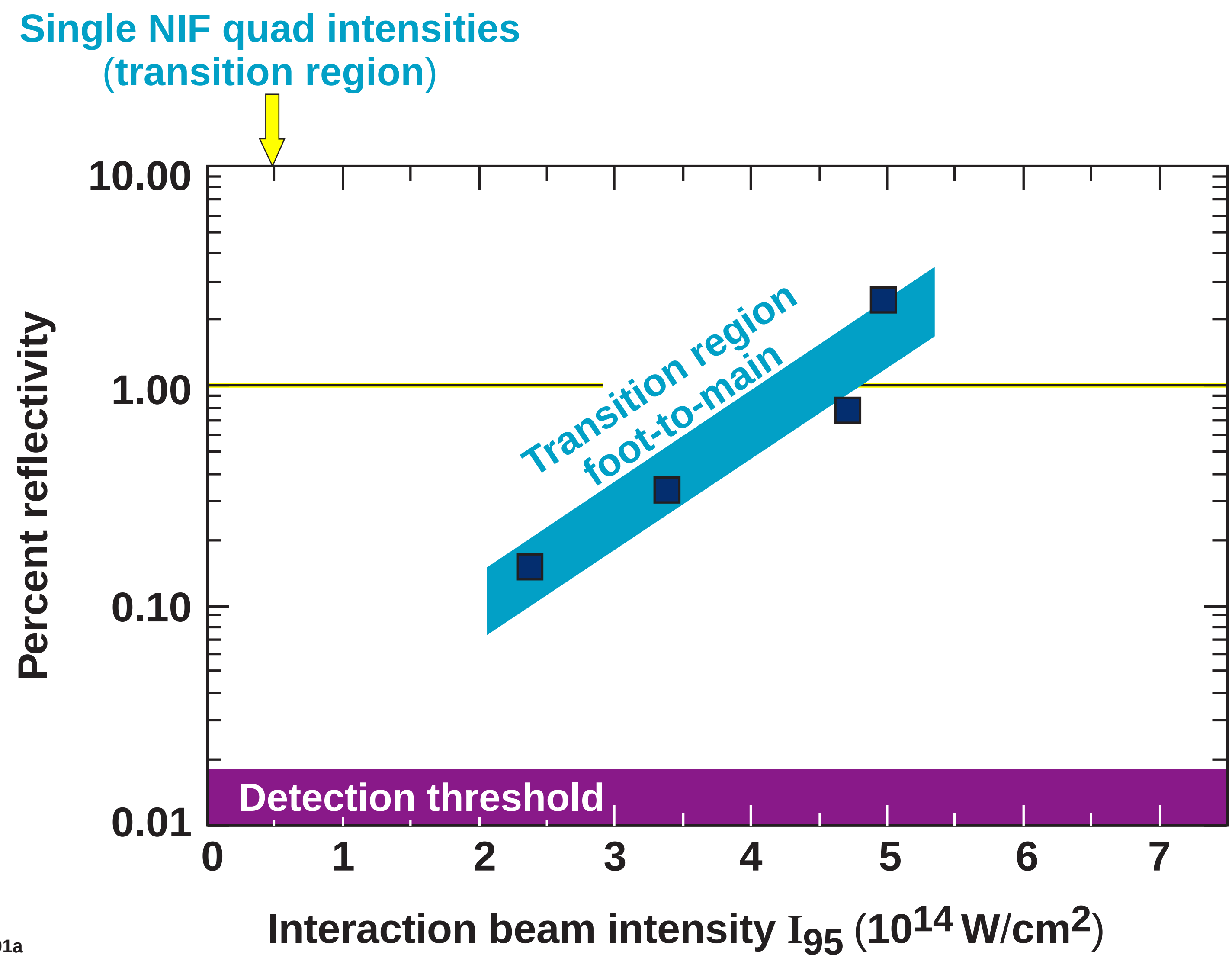


$I < 5 \times 10^{14}$ W/cm^2

T_e = 1–2 keV

$L_n \sim L_u \sim 0.5$ mm

OMEGA long-scale-length experiments indicate that SBS presents little danger for direct-drive NIF ignition targets



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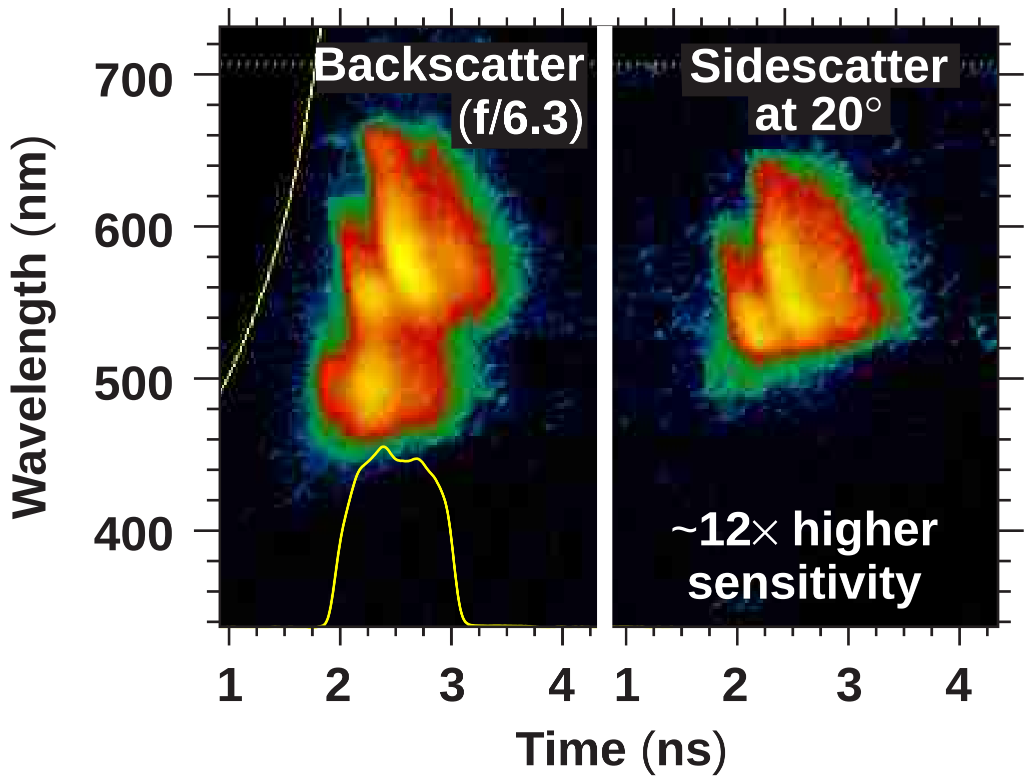
SRS from NIF-scale transition plasma has a significant sidescatter component



Shot 17321

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

- The collimated backscatter component below ~530-nm array may be indicative of SRS filaments.
- NIF transition plasma: density scale length ~ 0.5 mm
  T_e ~ 1–2 keV
  quad intensity ~ 2×10^{13} W/cm^2

E10002

OMEGA long-scale-length experiments indicate that SRS presents little danger for direct-drive NIF ignition targets

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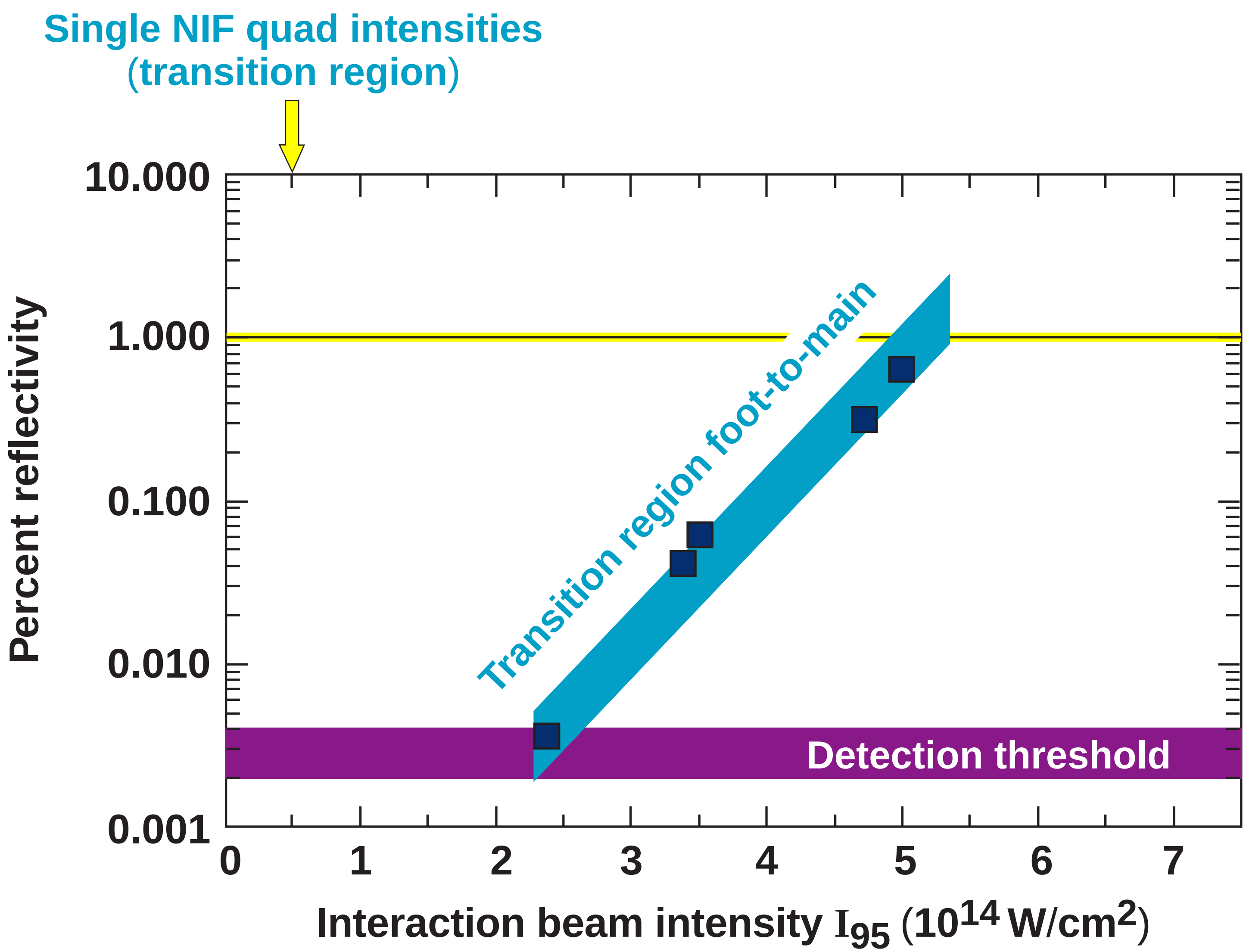

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Energetic electron generation must be diagnosed and kept below ~1% of incident laser energy

Two-plasmon decay instability is likely the primary source of hot electrons.

Current OMEGA implosion experiments show ample evidence of

- $\omega/2$ and $3\omega/2$ emission,
- hard x-ray emission (2-channel scintillator-PMT),
- enhanced charged-particle energies (corona and, at times, fusion particles), and
- $K\alpha$ emission from signature layers.

→ $E_{he} < 10^{-3}\ E_{laser}$

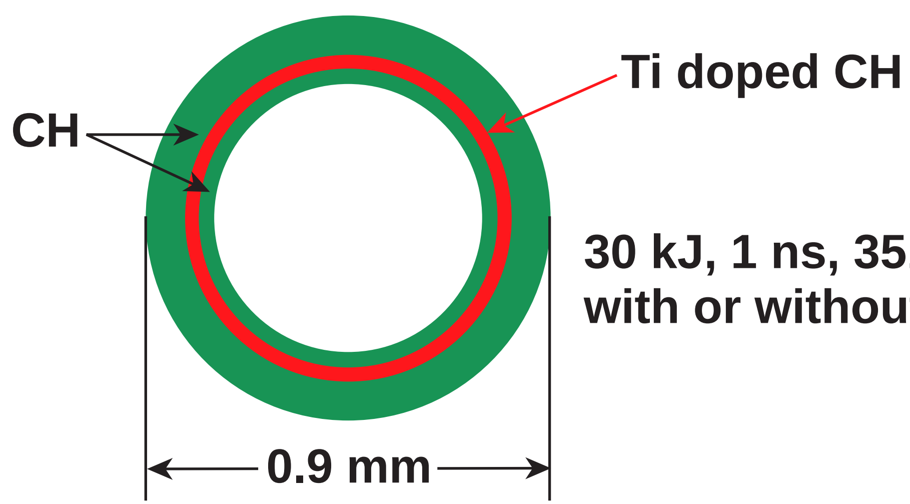
Current NIF-scale interaction experiments show

- $3\omega/2$ emission (correlation with interaction beam is ambiguous) and
- hard x-ray channels scale with interaction intensity/energy.

→ $E_{he} < 10^{-3}\ E_{laser}$ appears to still hold.

Energetic electrons due to the TPD instability are thought to be responsible for charged-particle acceleration and target preheat

- The experiments are carried out with imploding shells containing a Ti signature layer.



30 kJ, 1 ns, 351 nm
with or without SSD

- Total preheat deposited in the shell ~ 0.1% E_{laser}, assuming no photon pumping (overestimate).

E9615a

Summary/Conclusions

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