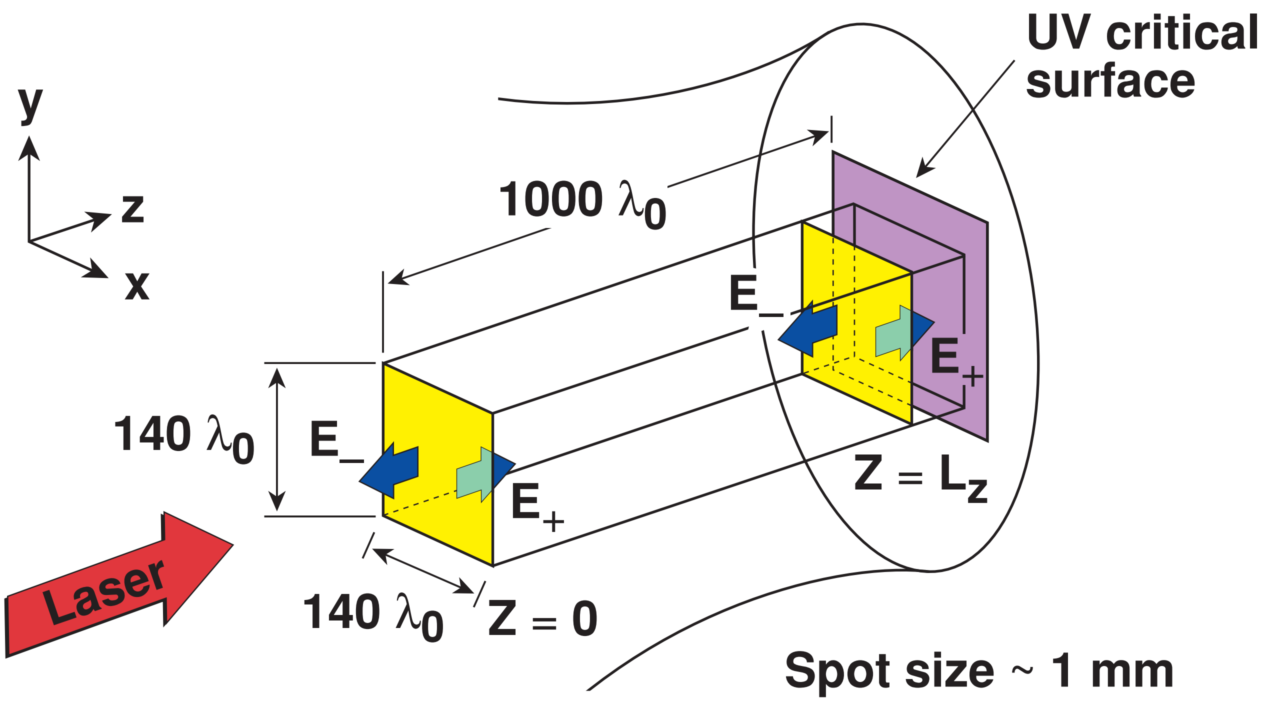
Modeling Laser–Plasma Interaction Physics Under Direct-Drive Inertial Confinement Fusion Conditions



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Summary/Conclusions

OMEGA direct-drive LPI experiments have been successfully modeled using pF3D

- Large-scale simulations relevant to direct-drive OMEGA LPI experiments using pF3D (Berger, Still – LLNL)
  - Simulated SBS backscatter compares favorably in two types of long-scale-length OMEGA experiments.
  - Hydrodynamic evolution of plasma profile is shown to be important.
  - Position and temporal behavior of blue spectral feature are determined by a uniform “shelf” in underdense corona.
- OMEGA experiments do not match exactly the NIF conditions.
  - NIF expansion velocities are lower and more uniform.
  - Simulations are currently underway.

Outline

- Simulations have been made with pF3D.

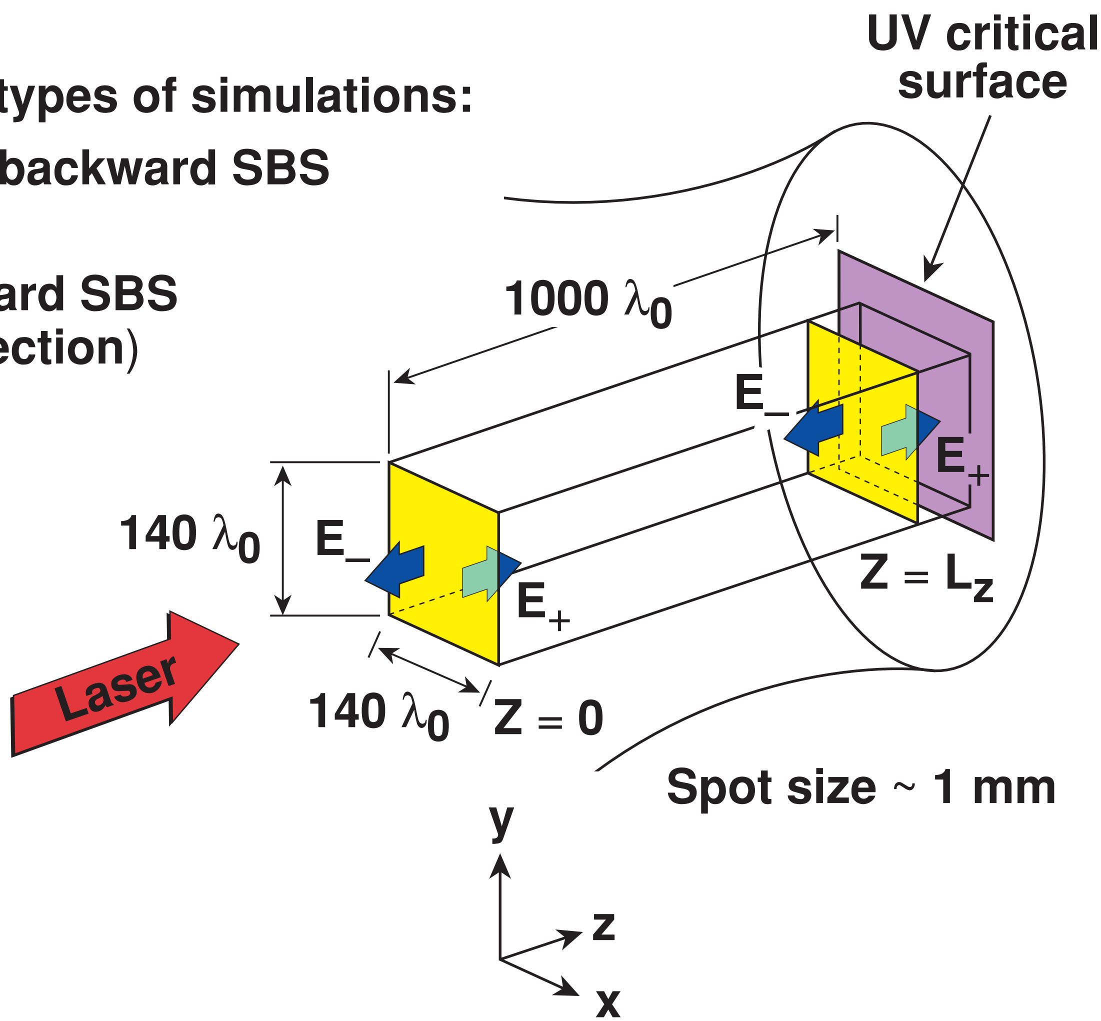
- Simulations include backward SBS.
  - Simulations compared with experiment.
  - Target hydrodynamics

- Extrapolation to NIF targets

Large-scale pF3D simulations of OMEGA direct-drive LPI experiments have been carried out with the correct inhomogeneous plasma profiles

- We have carried out two types of simulations:
  – 3-D "pencil" with no backward SBS (shown to right)
  – 2-D slice with backward SBS (no variation in y direction)

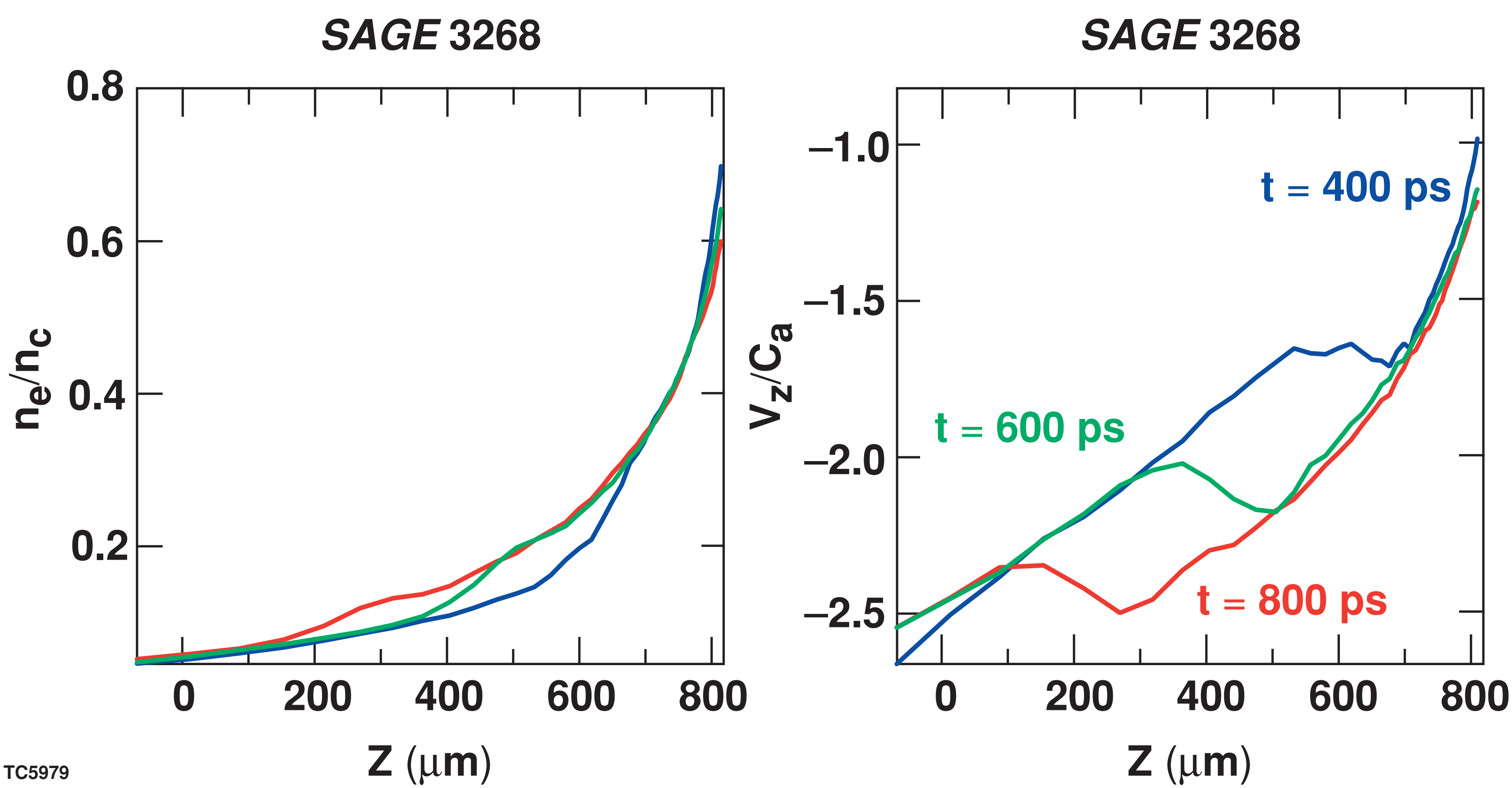
- Plasma hydrodynamic variables are initialized using data from *SAGE* simulations.



TC5980

A "shelf" in the plasma expansion velocity is a common feature of all direct-drive experiments

- Ablation due to the rising pulse of the interaction beam creates a shelf that propagates down the gradient with time.
- Most prominent in multiple beam irradiation.

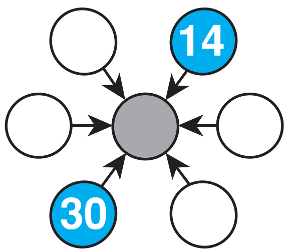


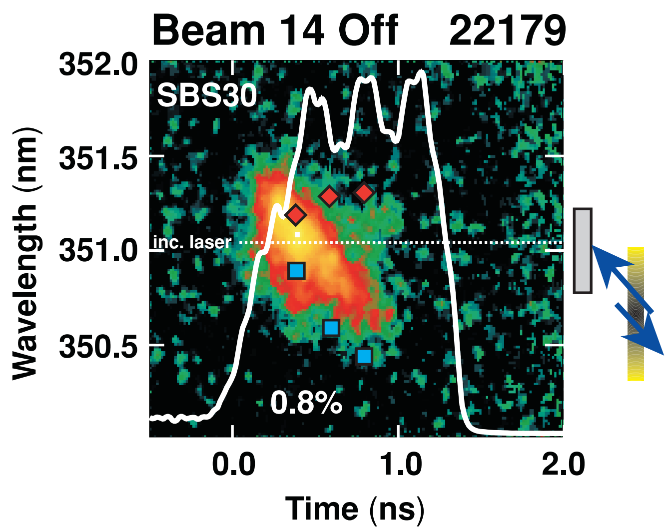
TC5979

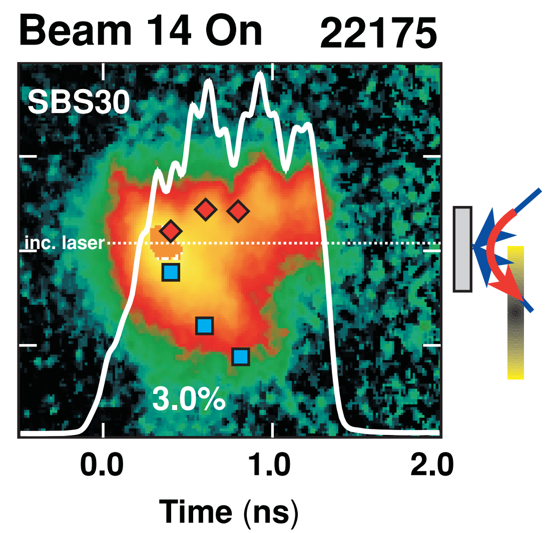
Blue spectral feature in the backscatter is a result of SBS in the underdense corona and is correctly reproduced in pF3D simulations

UR LLE

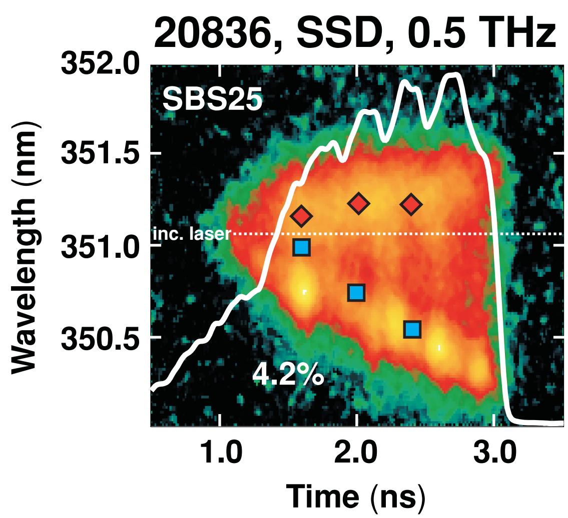
Oblique incidence FABS 30 signal







Normal-incidence backscatter signal

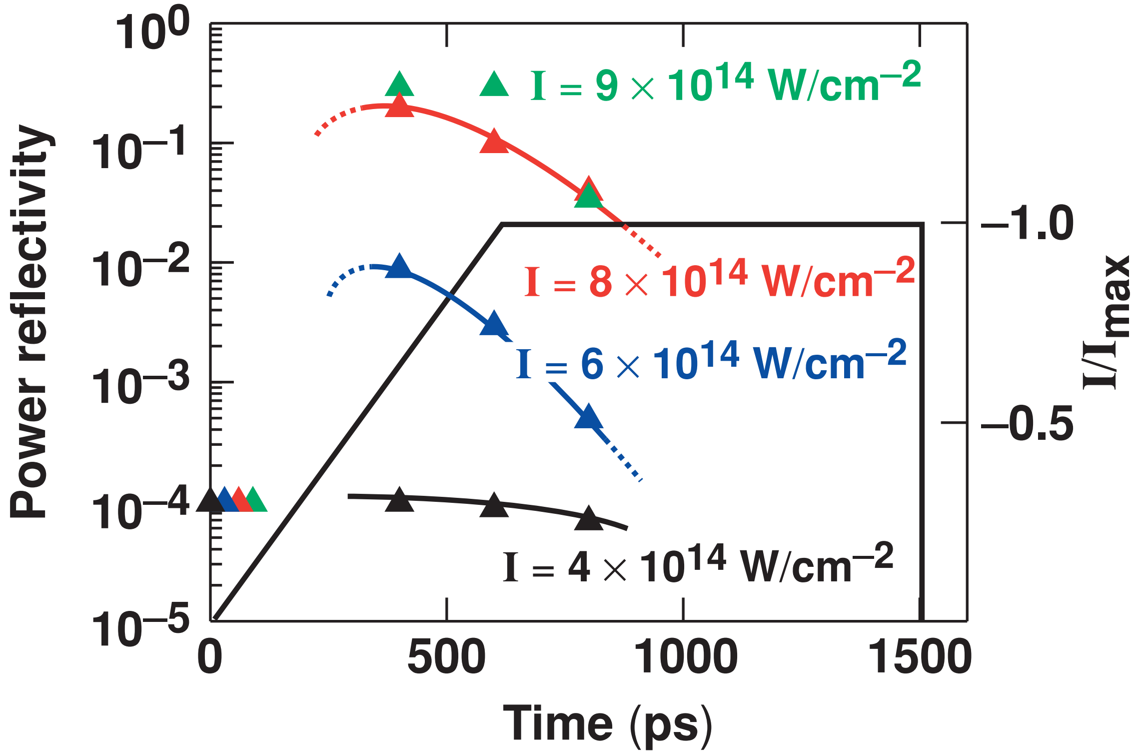


- The red feature is seeded by reflection and originates from near the critical surface.
- Here we model the blue feature only.

TC6080

The level and temporal dependence of the simulated SBS reflectivity are consistent with experiment

- Experiment with multiple interaction beams displays an early "quenching" of SBS signal
- During the later part of the pulse the reflectivity is less than a few percent for all simulated intensities.
- The reflectivity is not far from linear gain estimates due to strong gradients.

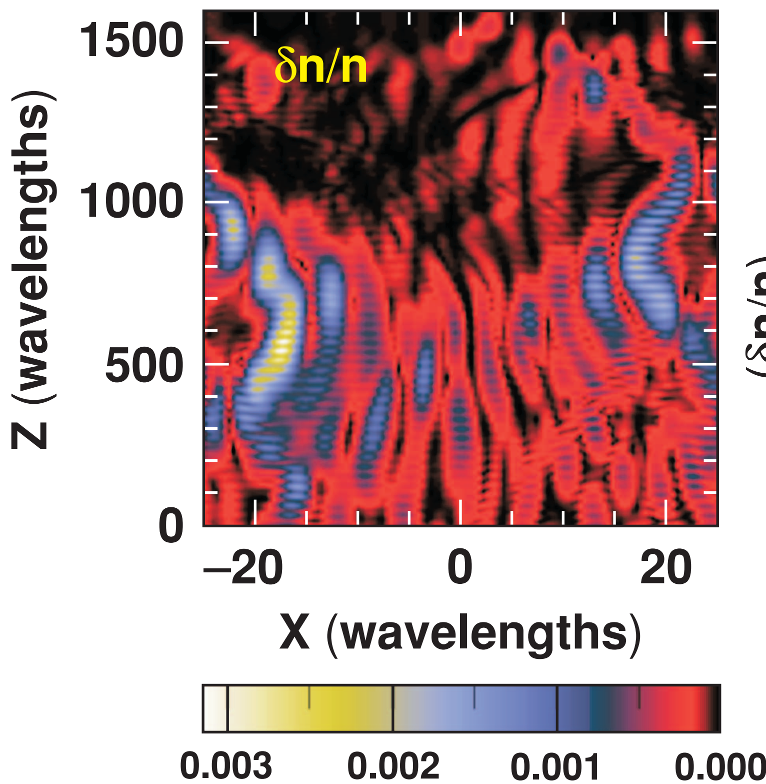


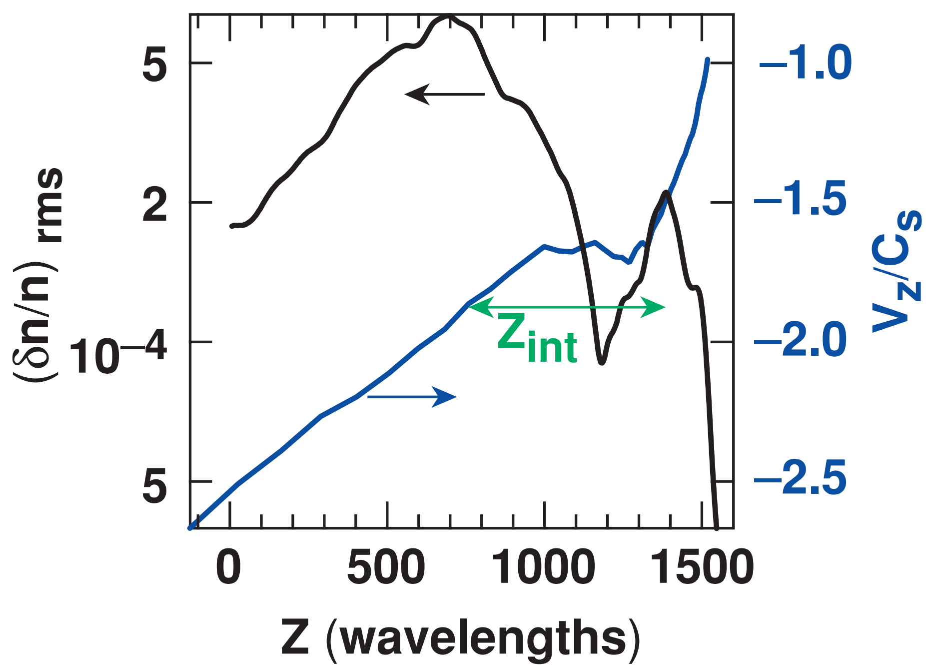
TC5981

Backward SBS occurs primarily in the shelf of ablated material caused by the rising interaction beam

UR LLE

- Due to the nearly monotonic expansion velocity profile, the location of Brillouin IAW determines the spectral shift of the backscattered EM wave.
- This is consistent with the observed experimental blue-shift.

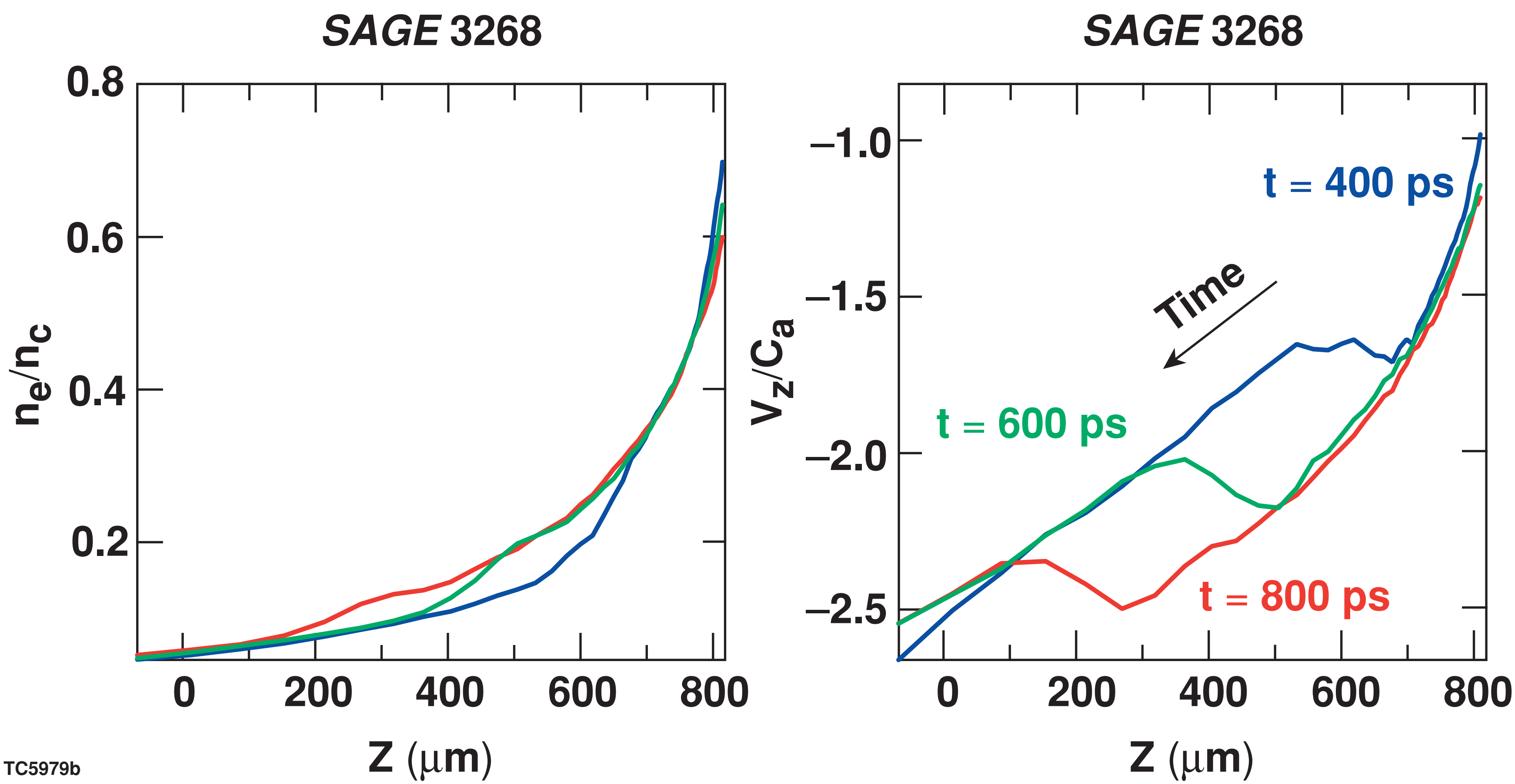




TC5982

The shelf of uniform expansion velocity propagates down the gradient towards lower densities

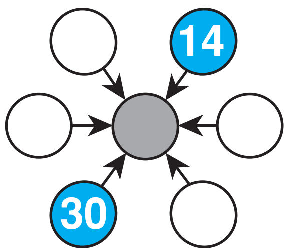
- The gain for SBS depends upon plasma density, and as a result it falls rapidly in time.

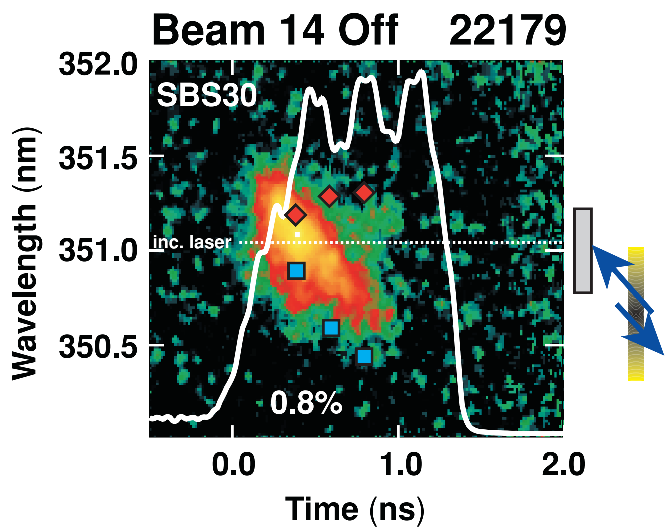


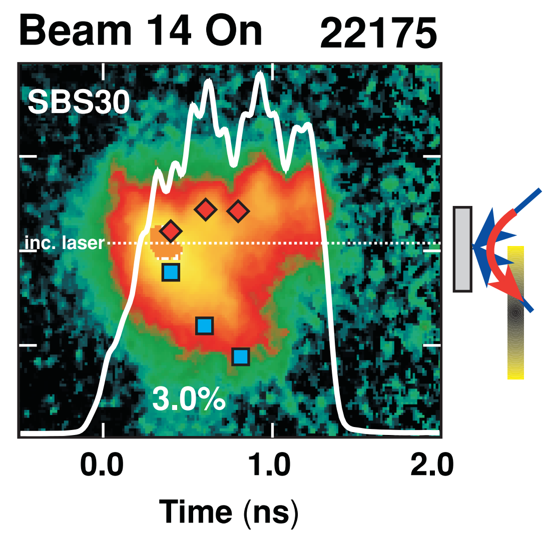
TC5979b

Blue spectral feature in the backscatter is a result of SBS in the underdense corona and is correctly reproduced in pF3D simulations

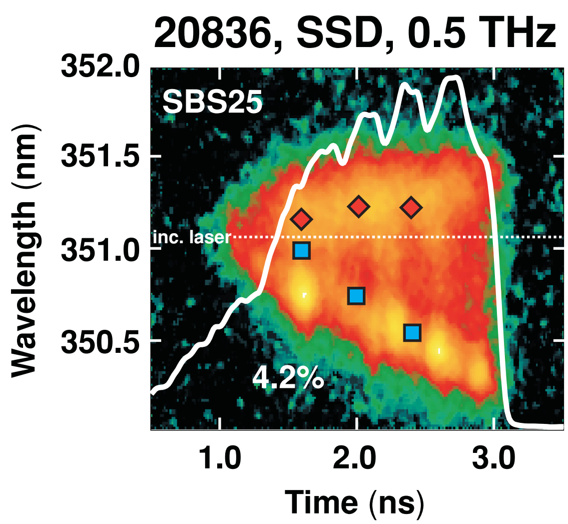
Oblique incidence FABS 30 signal







Normal-incidence backscatter signal



- The difference in the blue spectral feature between the oblique and normally incident cases is due to differences in target hydrodynamics.
- In the normal iteration beam case the hydro evolves more slowly.

TC6080a

Significant SBS can be expected on NIF only if multibeam and/or seeding effects are important

- Simulations are underway with NIF profiles (*LILAC*).
- Expansion velocities are lower, and gradients are weaker.
- The gain in intensity G < 17 due to
  - High IAW damping in DT ~0.3
  - Lower laser intensities
  - Higher plasma temperature
- Crossing beam effects and seeding from critical surface could still give significant SBS.
  - Best investigated by simulation