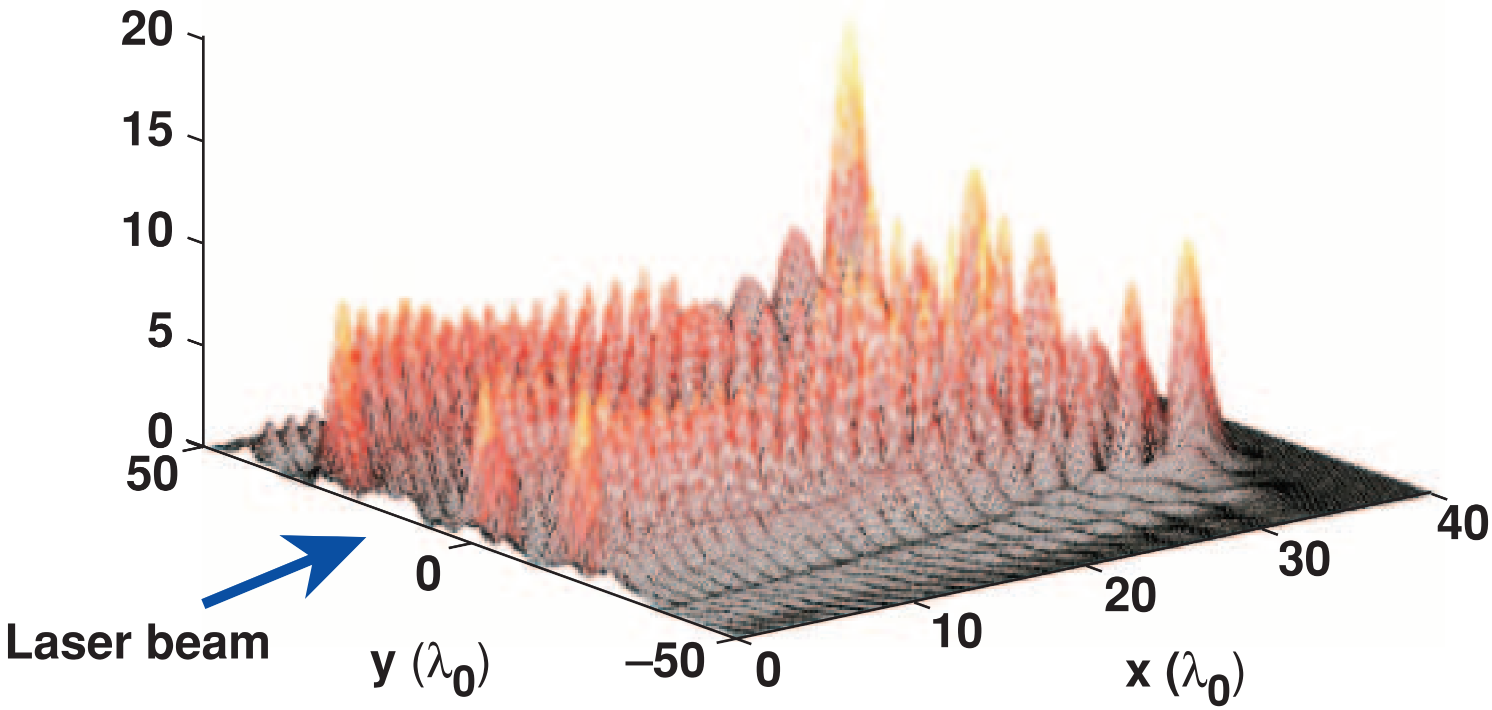
Nonlinear Propagation of Laser Beams in Plasmas Near a Critical-Density Surface



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Summary

Nonlinear propagation of light near critical-density surface has been studied using a non-paraxial modeling capability

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- **Near critical density the characteristic spatial and temporal scales for backward SBS and beam self-smoothing are similar.**
- **The angular and frequency broadening of backscattered light is increased when backward SBS is seeded by reflection from a critical-density surface.**
- **The red feature in the spectrum of backscattered light is consistent with the experimental results on OMEGA.**

Outline

- **Non-paraxial modeling of light propagation near a critical-density surface, which includes:**
  1. **backward SBS in an inhomogeneous plasma**
  2. **reflection from critical-density surface**
  3. **beam self-smoothing due to self-focusing**
  4. **interaction between different beams for multiple-beam irradiation**
- **Angular spreading and frequency broadening of backscattered light**
- **Oblique incidence of a laser beam on a critical-density surface and multiple-beam irradiation**

The spectra of SBS backscattered light from solid CH targets on OMEGA have red and blue components

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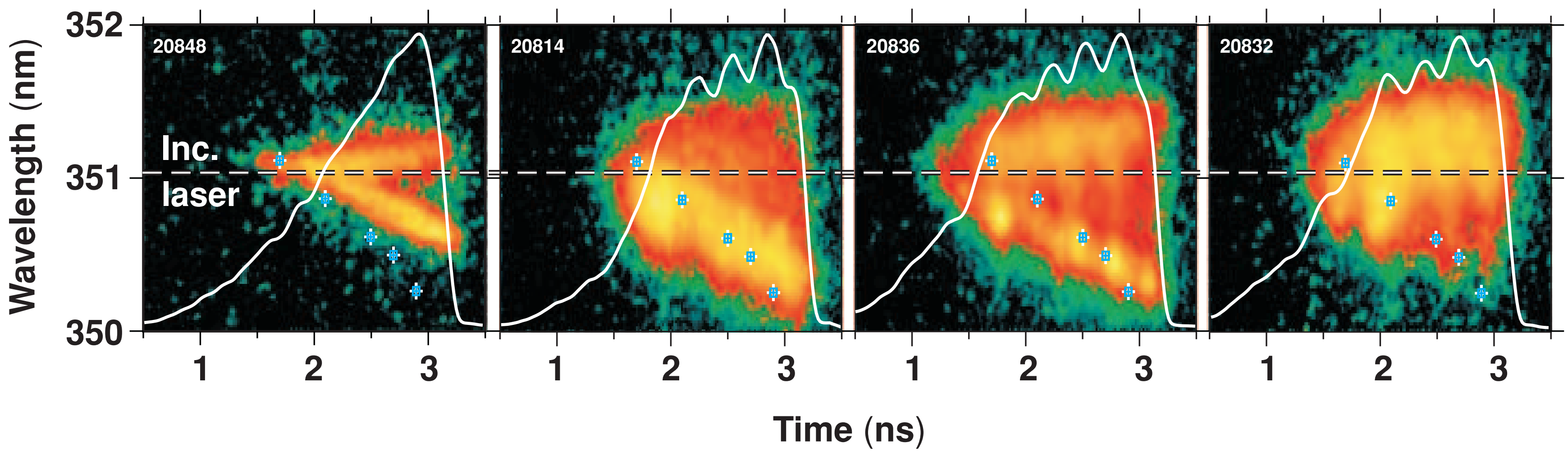
- **Interaction beam at normal incidence**



3×10^{14} W/cm^2	9×10^{14} W/cm^2	9×10^{14} W/cm^2	8×10^{14} W/cm^2
No bandwidth	1-THz, 2-D SSD	0.5-THz, 2-D SSD	1-THz, 2-D SSD
(phase plate only)	(no PS)	with PS	with PS
R_{SBS} ~ 1%	R_{SBS} ~ 4.5%	R_{SBS} ~ 0.7%	R_{SBS} ~ 0.3%

- **Red component:** seeded SBS (reflection off critical)?
- **Blue component:** consistent with SBS growing from noise in hot spots (speckles) whose intensities are halved by polarization smoothing

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Modeling of SBS and self-focusing near critical-density surface requires non-paraxial description of light propagation

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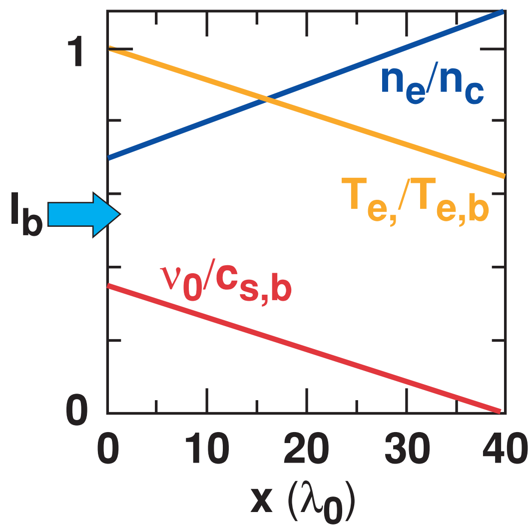
- Simulations are performed with a 2-D non-paraxial code in the region 40 × 200 laser wavelengths.
- Due to absorption and field swelling the average intensity on the boundary $I_b = 0.46 \langle I \rangle$, $\langle I \rangle$ is the average intensity in vacuum.

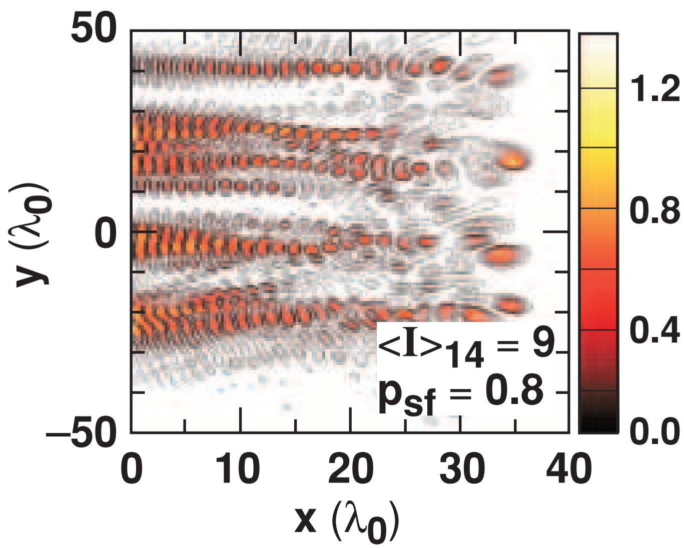
DPP beam f/6

$T_{e,b} = 2$ keV

$\langle I \rangle = (3 \div 16)$ 10^{14} W/cm^2



Profiles of density, flow, and temperature modeling OMEGAplasma near critical density (similar to simulations by *SAGE*).



The inhomogeneity scale of laser intensity is comparable to the laser wavelength.

Average self-focusing parameter:
$p_{sf} = 0.09 \langle I \rangle_{14}$

Average backward SBS gain:
$G_{sbs} = 0.85 \langle I \rangle_{14}$

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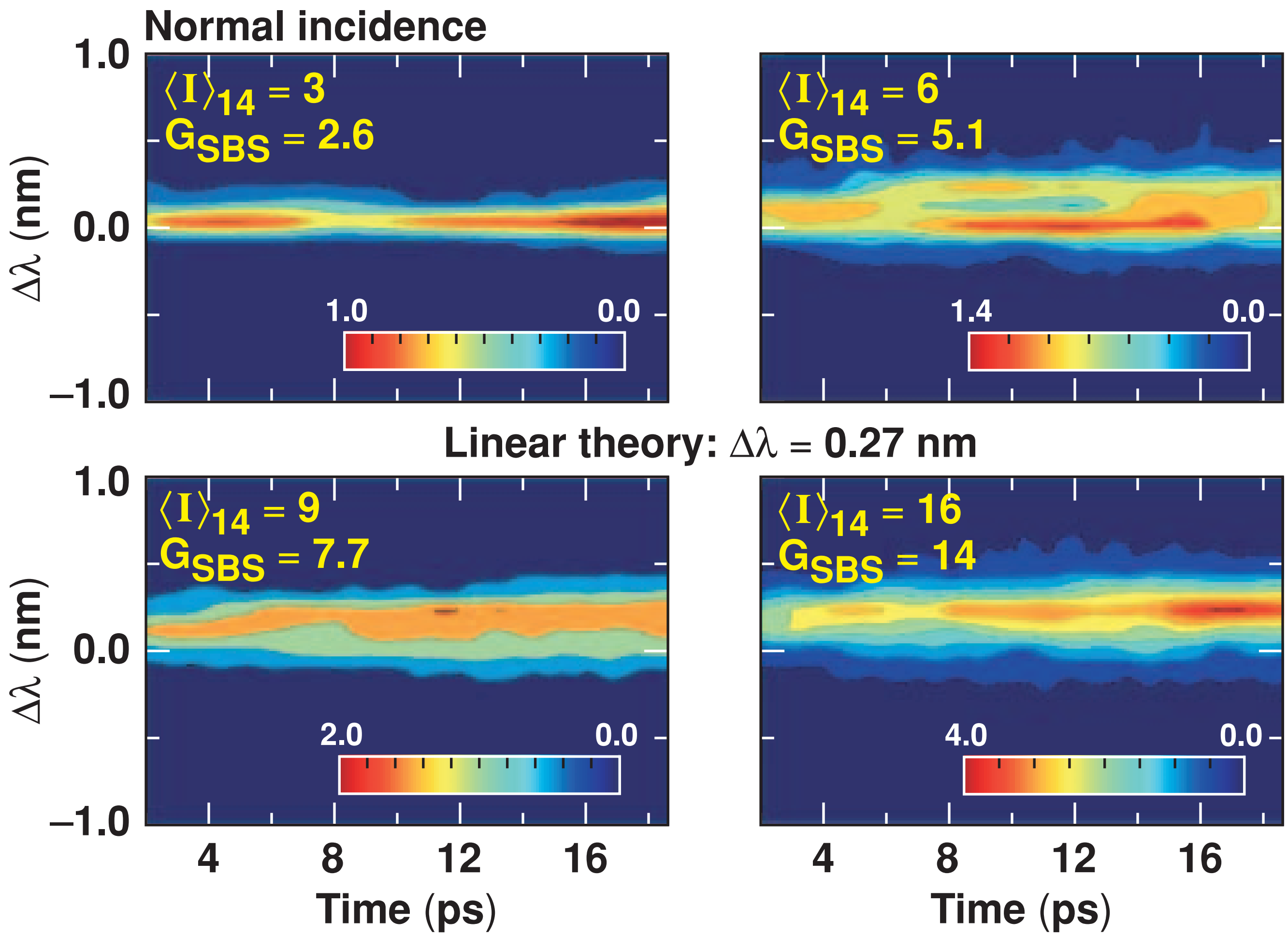
The frequency spectrum of backscattered light develops a red shift that moderately increases with the increase of laser beam intensity

Frequency spectrum is integrated over angles.



Simulation time is about 20 ps; the hydro profiles do not change much.

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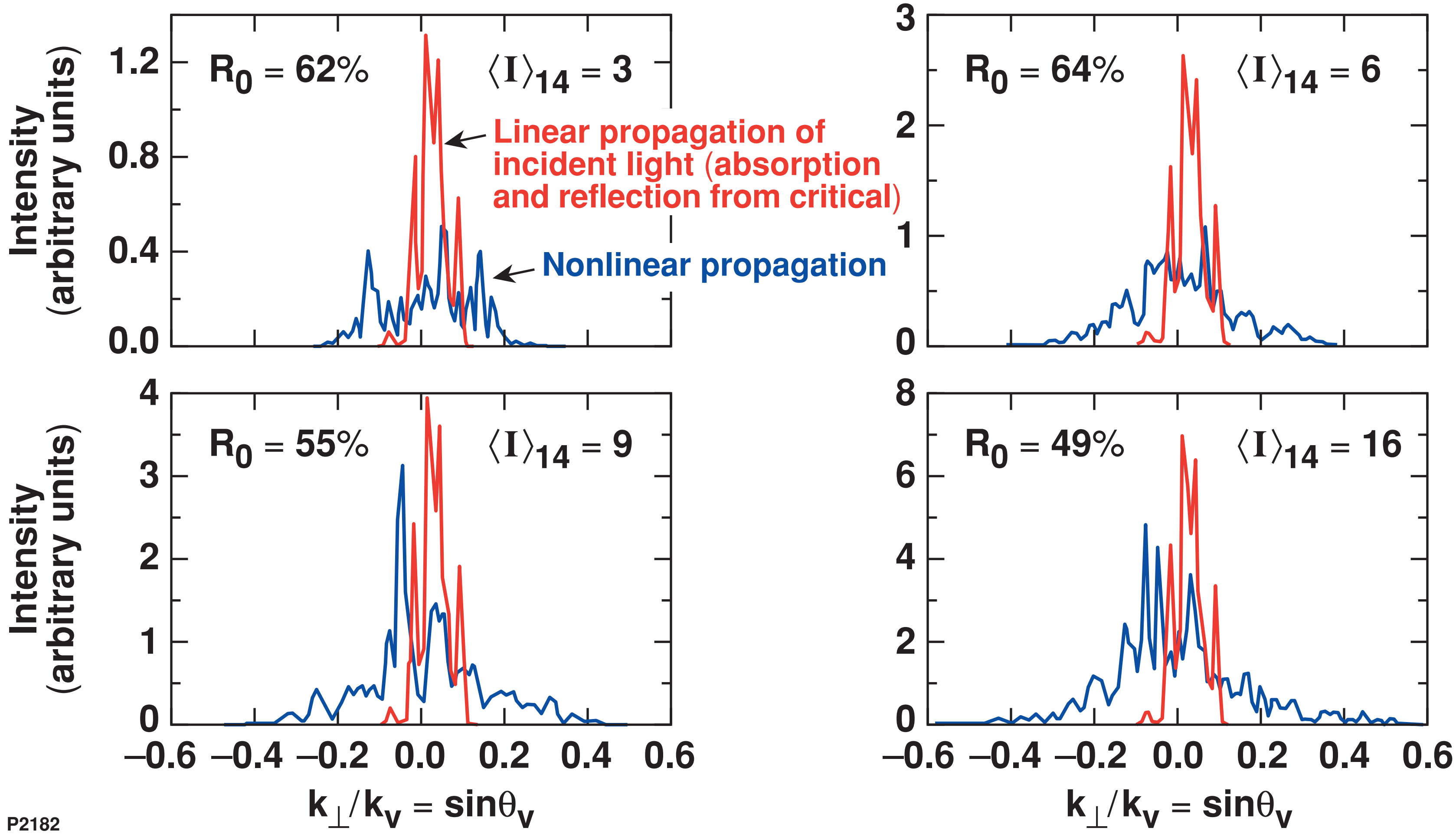
The angular width of the backscattered light increases with increasing incident beam intensity

R_0 – fraction of reflected power that goes into the linear propagation range $k_\perp/k_v = (-0.1 \div 0.1)$



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The non-paraxial model allows study of nonlinear light propagation for oblique incidence on the critical-density surface

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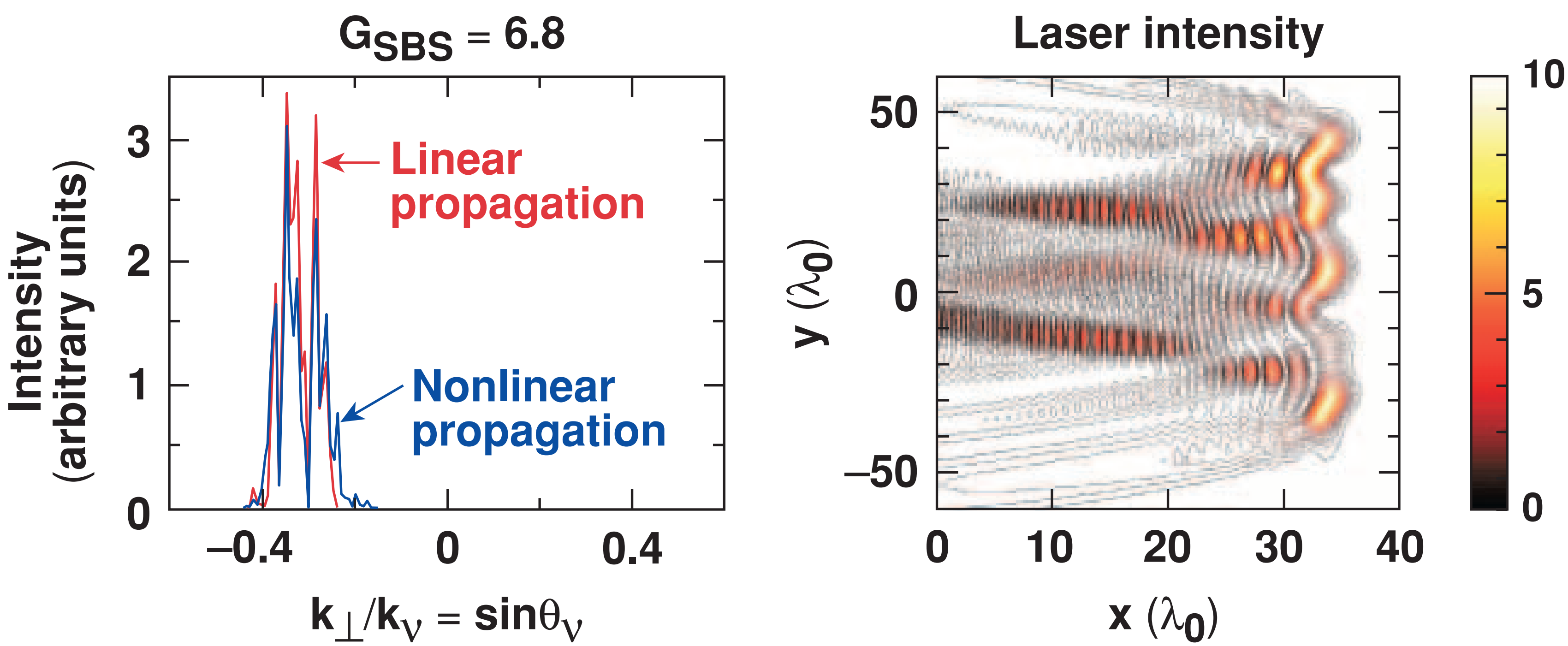
- DPP beam with average intensity $\langle I \rangle_{14} = 6$ and angle of incidence 20°



- No spreading of backscattered light in angle or frequency is observed because reflection from the critical-density surface does not seed backward SBS, and backward SBS, growing from noise, is weak.

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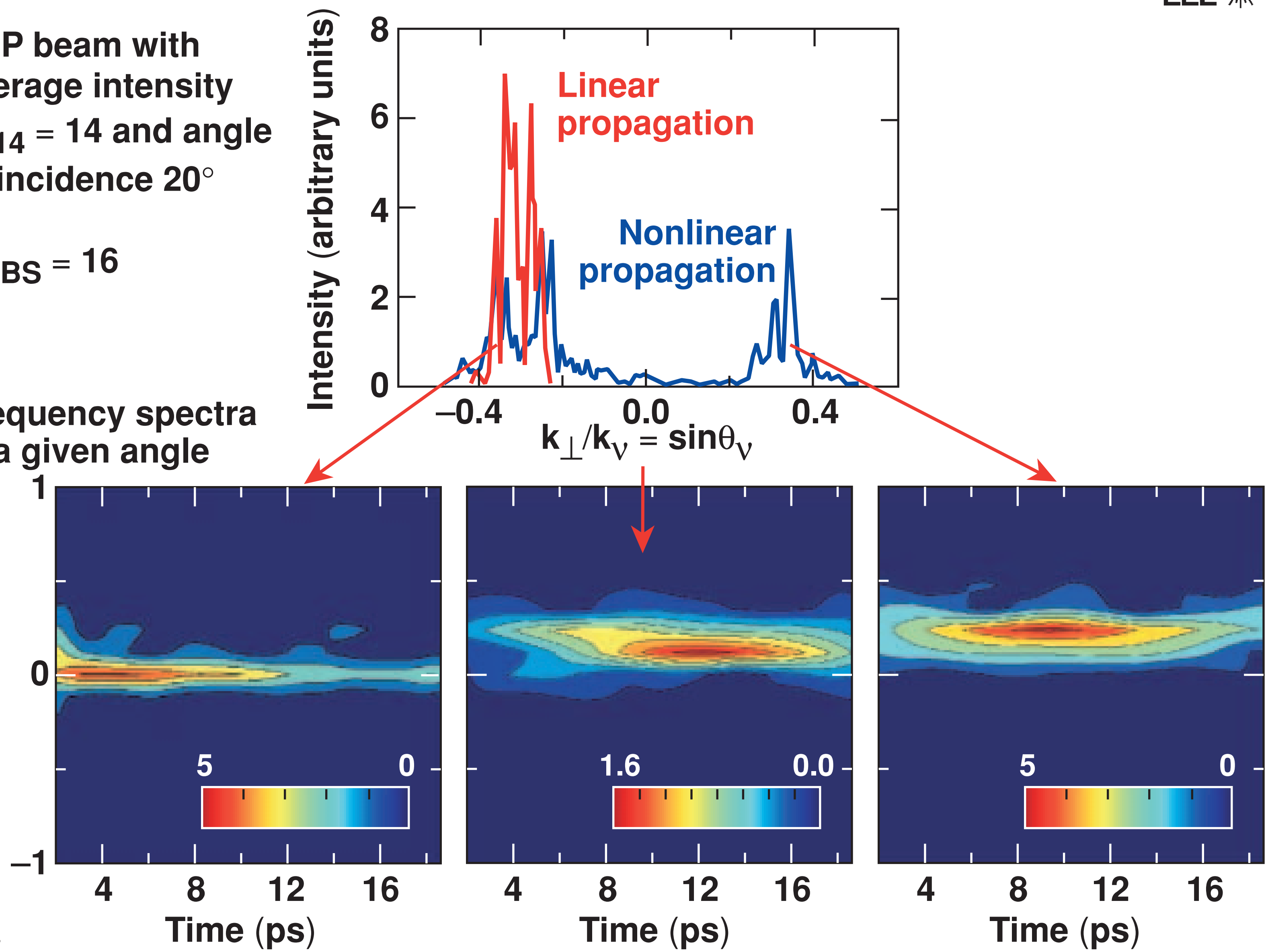
The spectrum of backscattered light is determined by backward SBS and reflection from the critical-density

DPP beam with average intensity $\langle I \rangle_{14}$ = 14 and angle of incidence 20°

G_{SBS} = 16

Frequency spectra at a given angle



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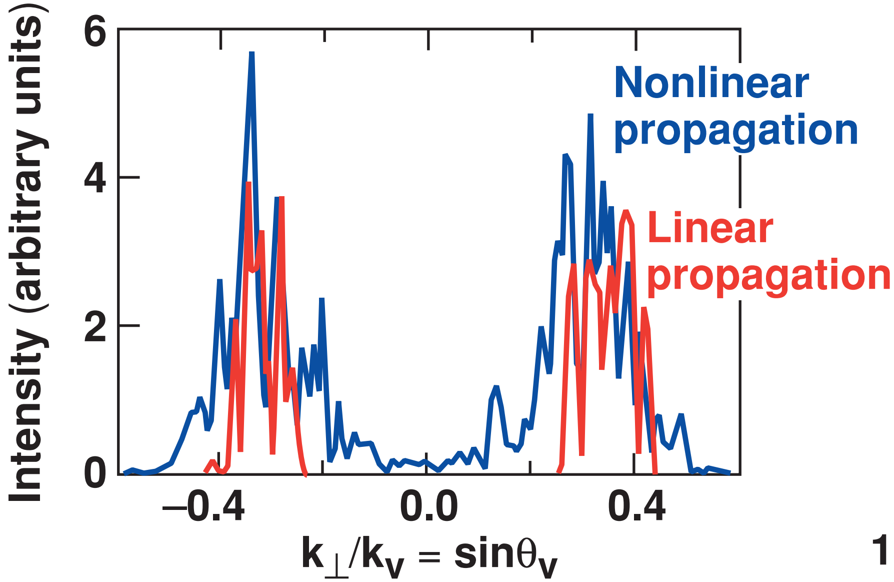
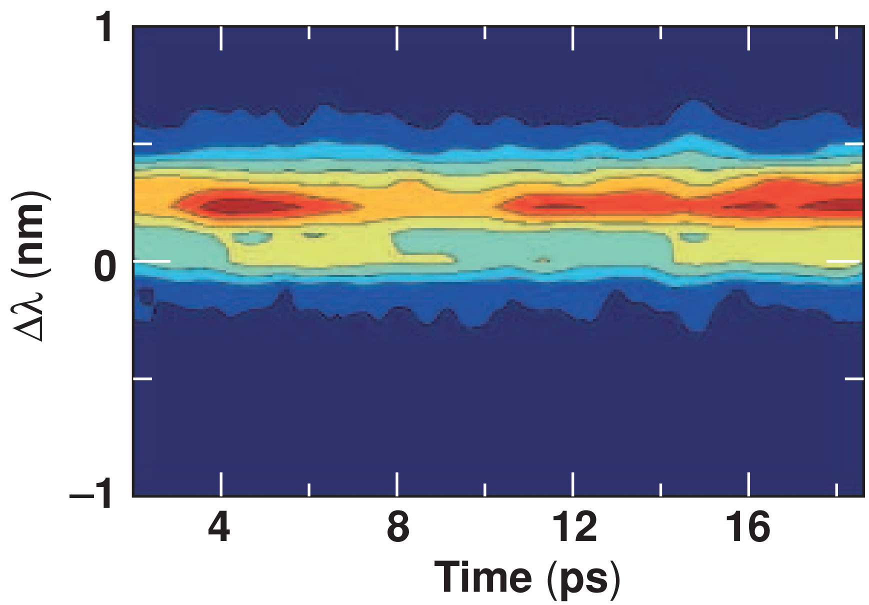
The angular and frequency width of backscattered light increase under crossed-beam irradiation



Two DPP beams with average intensity $\langle I \rangle_{14}$ = 7 in each beam and angle of incidence ± 20°

Gain for one beam G_{SBS} = 7.9

Reflection from critical surface of one beam seeds backward SBS from another beam.



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Summary/Conclusions

Nonlinear propagation of light near critical-density surface has been studied using a non-paraxial modeling capability

- Near critical density the characteristic spatial and temporal scales for backward SBS and beam self-smoothing are similar.
- The angular and frequency broadening of backscattered light is increased when backward SBS is seeded by reflection from a critical-density surface.
- The red feature in the spectrum of backscattered light is consistent with the experimental results on OMEGA.
- The influence of SSD on laser beam propagation near critical density is now under study.