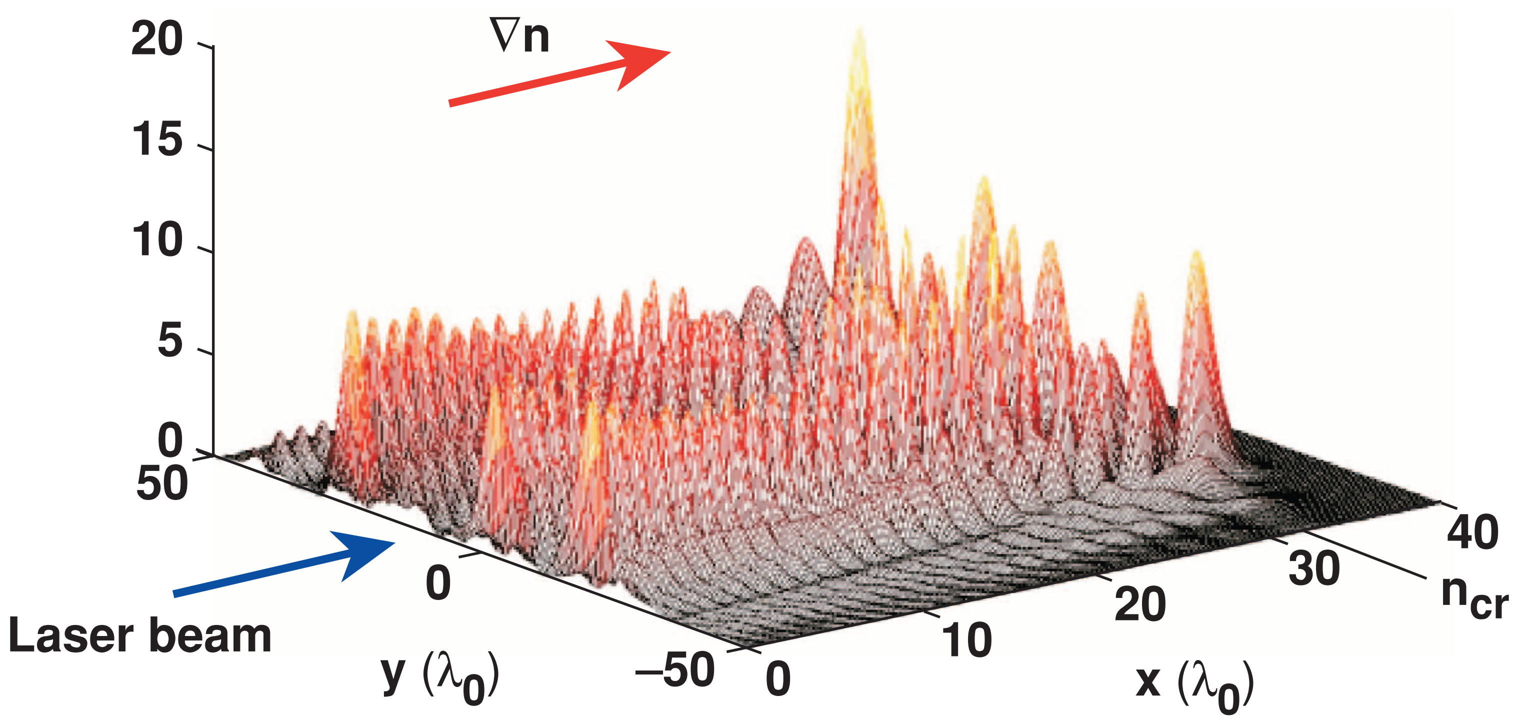
Modeling of Laser-Plasma Interaction Near the Critical Density



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Summary

Nonlinear propagation of laser beams near critical density has been studied with a non-paraxial model

- Near critical density the characteristic spatial and temporal scales for backward SBS and beam self-smoothing are similar.
- The spectrum of backscattered light
  - has a red shift, which increases moderately with the increase of laser beam intensity, and
  - is consistent with the experimental results on OMEGA.
- The backscattered light intensity decreases moderately with the increase of SSD bandwidth.

Outline

- Nonparaxial modeling of light propagation near critical density
- The backscattered light spectra with and without SSD smoothing
- Oblique incidence of a laser beam on a critical-density surface and multiple-beam irradiation

The model can describe the interplay between following processes

1. Backward SBS in an inhomogeneous plasma
2. Reflection from the critical-density surface
3. Beam self-smoothing due to self-focusing
4. Interaction between different beams under multiple-beam irradiation

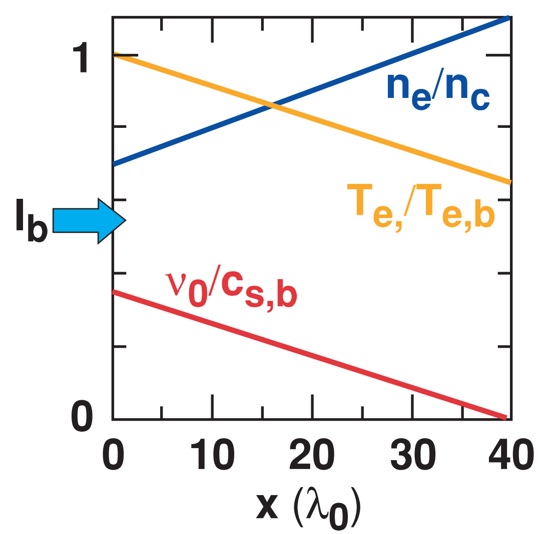
Modeling of SBS and self-focusing near critical-density surface requires non-paraxial description of light propagation

- 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.

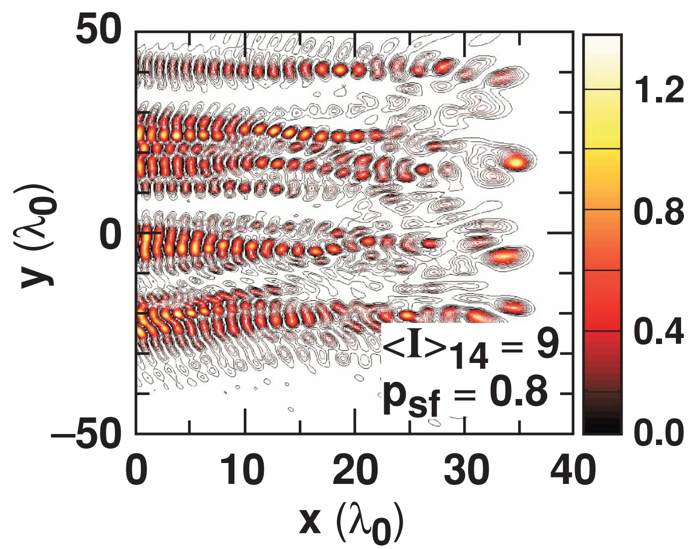
DPP beam f/6

$T_{e,b} = 2$ keV

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



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



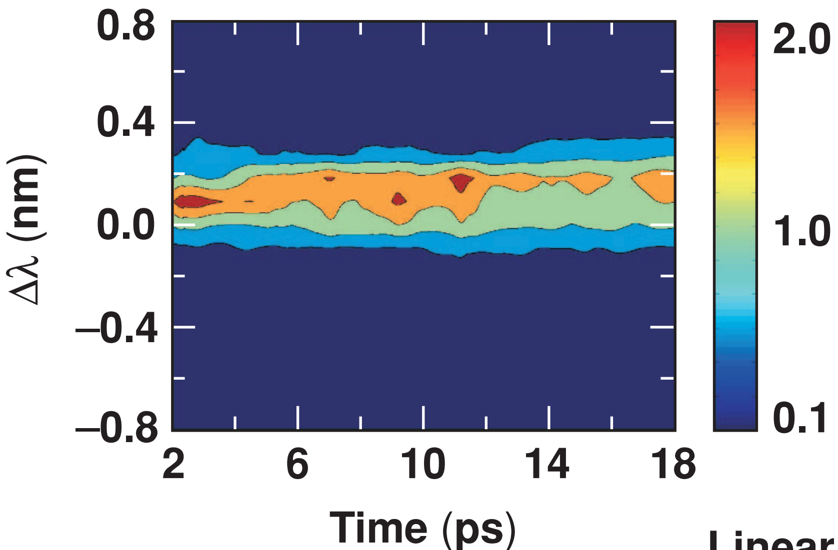
The inhomogeneity scale of laser intensity is comparable to the laser wavelength.

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

Average self-focusing parameter:
$p_{sf} = 0.09 <I>_{14}$

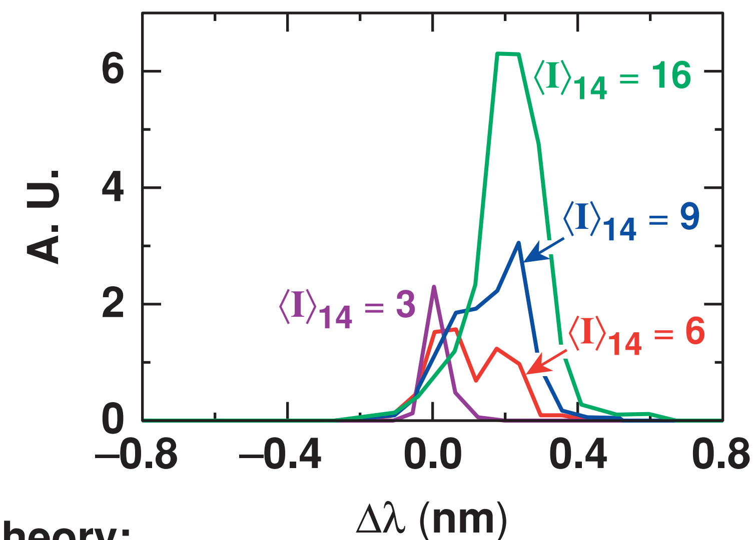
- Frequency spectrum is integrated over angles

$\langle I \rangle_{14} = 9$ $G_{SBS} = 7.7$



Average backward SBS gain:
$G_{sbs} = 0.85 <I>_{14}$

Reflectivity spectrum



Linear theory:
$\Delta\lambda = 0.27$ nm

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

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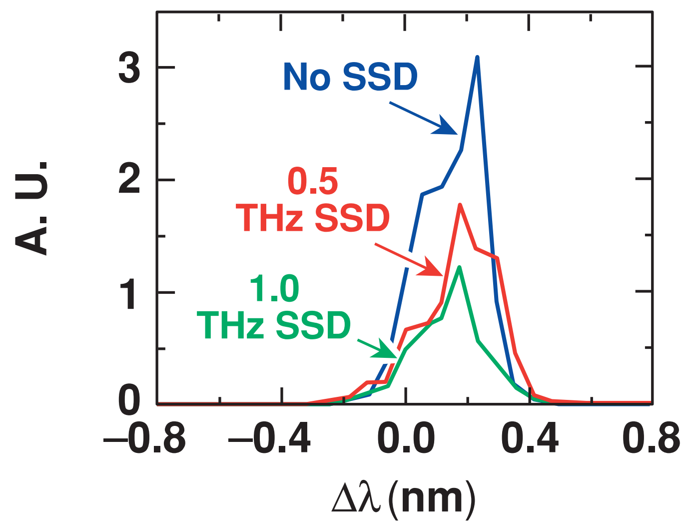
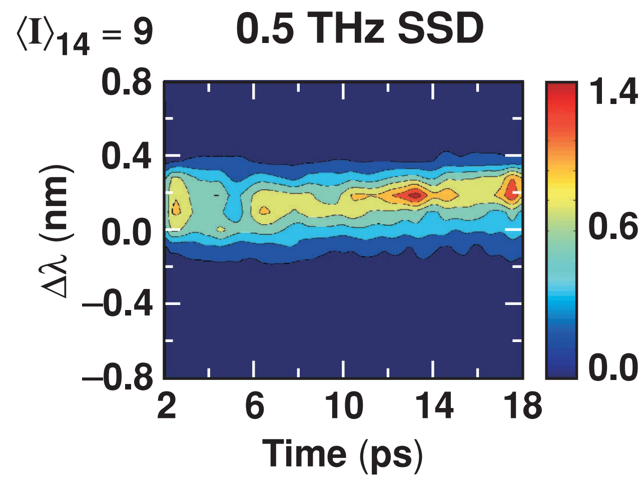
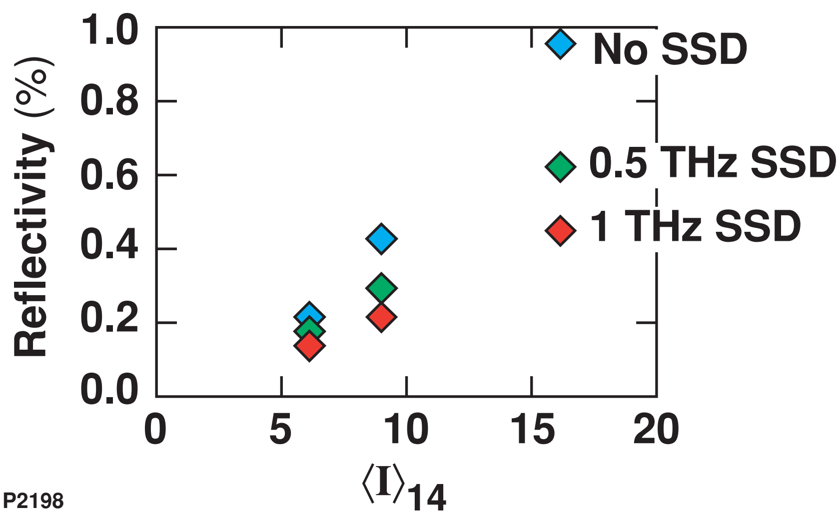
The intensity of backscattered light moderately decreases with the increase of SSD bandwidth

Reflectivity spectrum

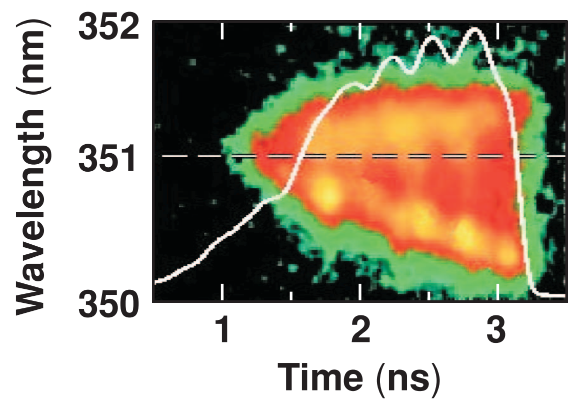


Spectra from simulations





Spectra from OMEGA experiments



Experimental spectra are compared with simulations in the talk of W. Seka.

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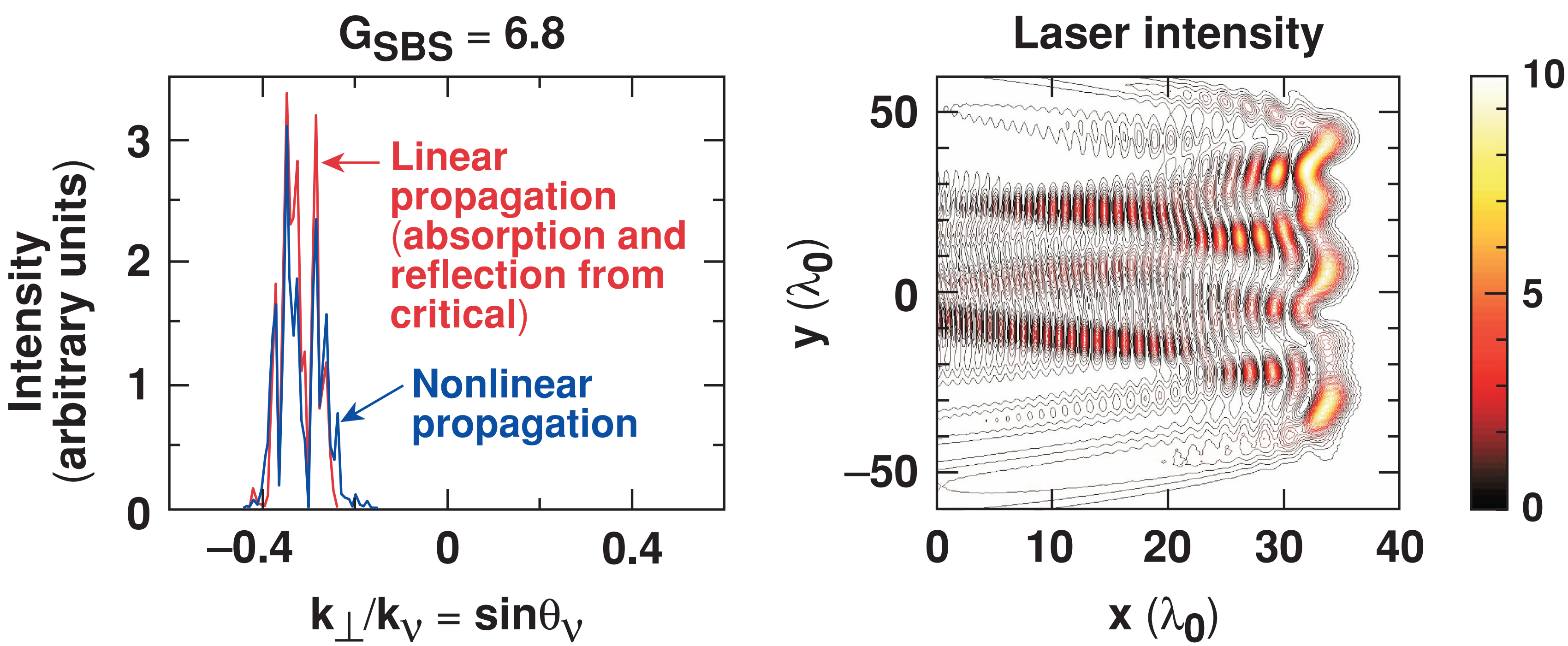
The non-paraxial model allows study of nonlinear light propagation for oblique incidence on the critical-density surface

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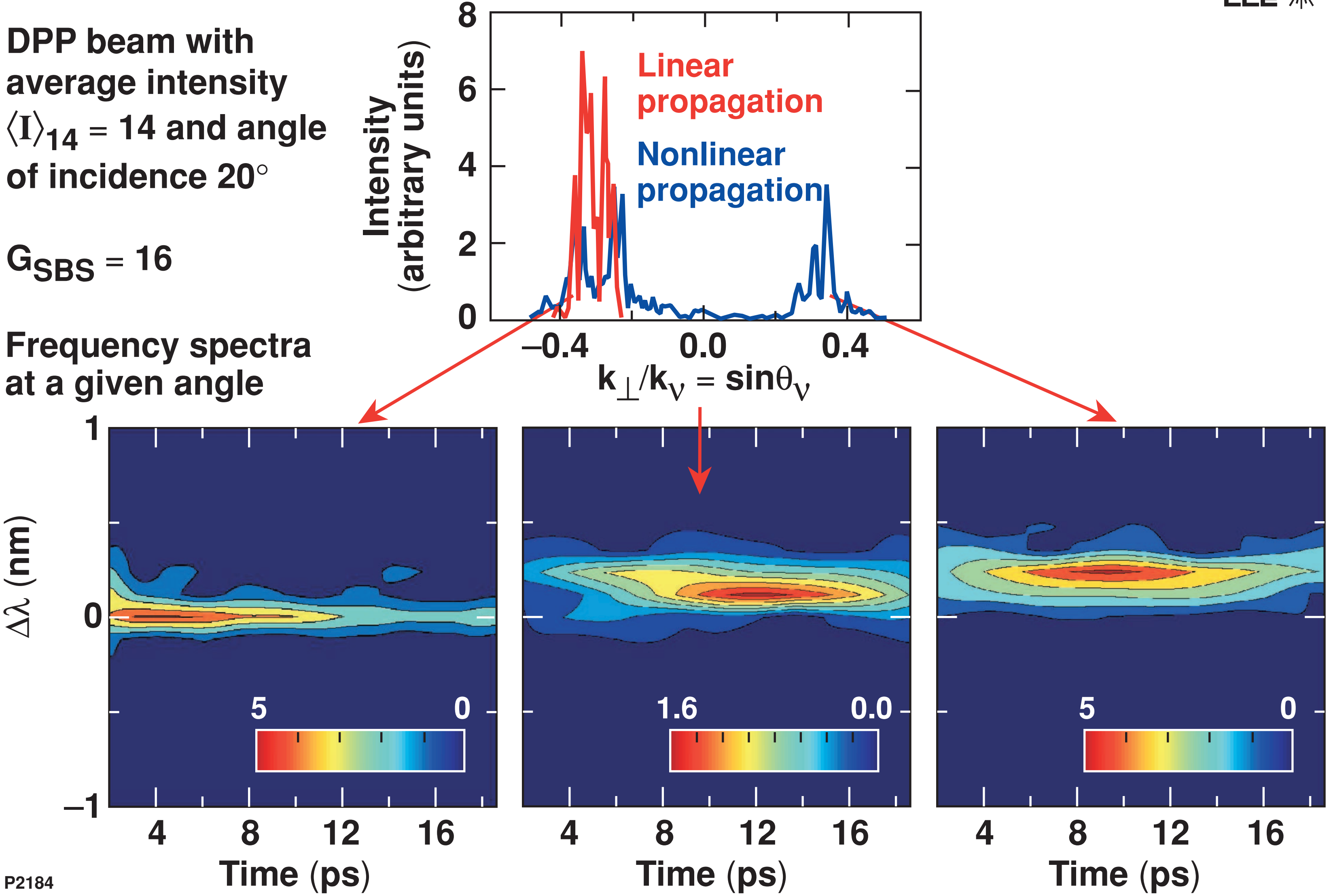
The spectrum of backscattered light is determined by backward SBS and reflection from the critical-density surface

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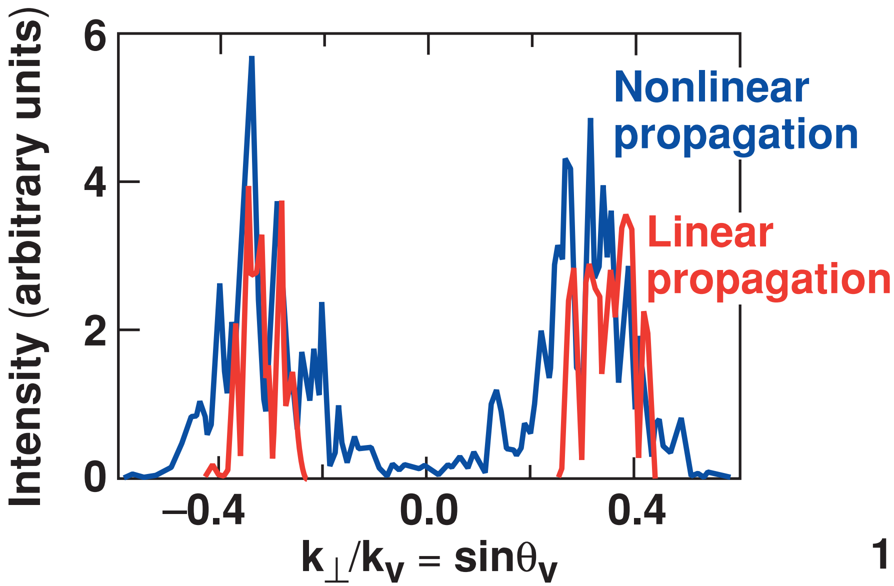
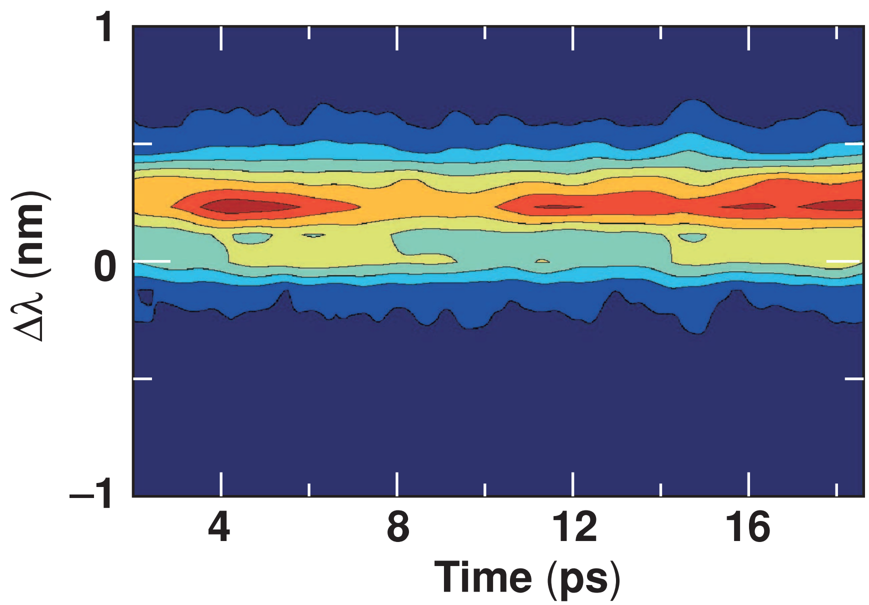
The angular and frequency width of backscattered light increase under crossed-beam irradiation



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

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

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- The spectrum of backscattered light
  - has a red shift, which increases moderately with the increase of laser beam intensity, and
  - is consistent with the experimental results on OMEGA.
- The backscattered light intensity decreases moderately with the increase of SSD bandwidth.
- Our model allows the characterize of inhomogeneity of laser energy absorption. Larger scale simulations are in progress.