Transient stimulated Brillouin scattering dynamics in polarization-maintaining optical fiber

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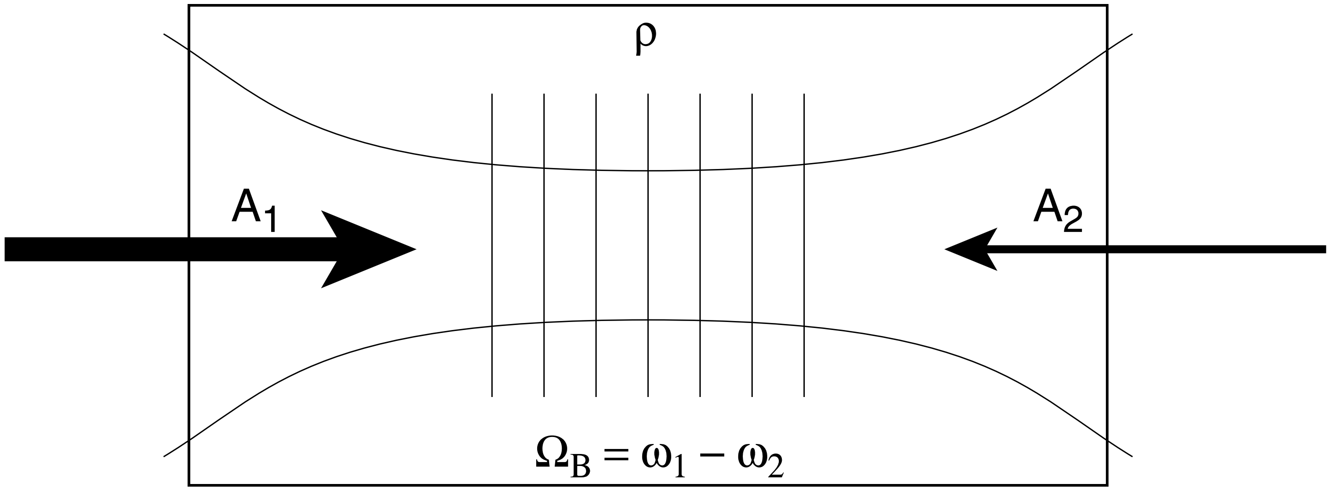
Acknowlegments: Laboratory for Laser Energetics

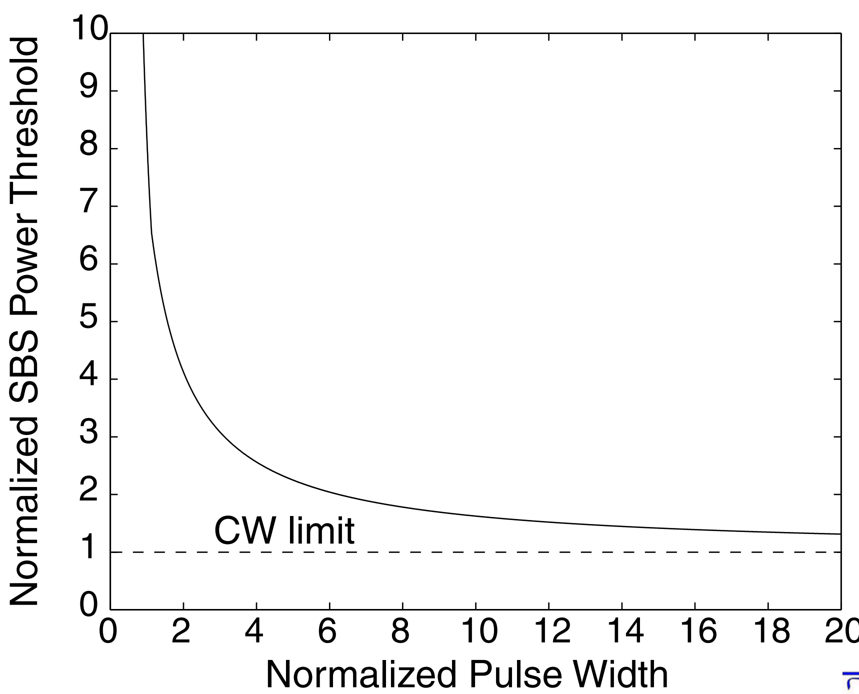
Stimulated Brillouin Scattering



Amplification: $$I_2(z) = I_2(L)e^{gI_1(L-z)}$$

Generation: $$P_{th} = \frac{G_{th}\lambda}{2g}$$

☞ **Short optical pulses have a higher power threshold.**



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SBS Generation From Noise

- Coupled Wave Equations for SBS.

$$\frac{\partial A_1}{\partial z} + \frac{n}{c}\frac{\partial A_1}{\partial t} = i\kappa\rho A_2$$

$$-\frac{\partial A_2}{\partial z} + \frac{n}{c}\frac{\partial A_2}{\partial t} = i\kappa\rho^* A_1$$

$$\frac{\partial \rho}{\partial t} + \frac{\Gamma_B}{2}\rho = i\alpha A_1 A_2^* + f$$

$$\kappa = \frac{\omega_1 \gamma_e}{2nc\rho_0}$$

$$\alpha = \frac{\gamma_e q^2}{8\pi\Omega_B}$$

A_1 → Pump Field

A_2 → Stokes Field

ρ → Density Fluctuations

f → Langevin Force Driving Term

- Langevin noise source initiates SBS[1].

$$\langle f(z,t)\rangle = 0$$

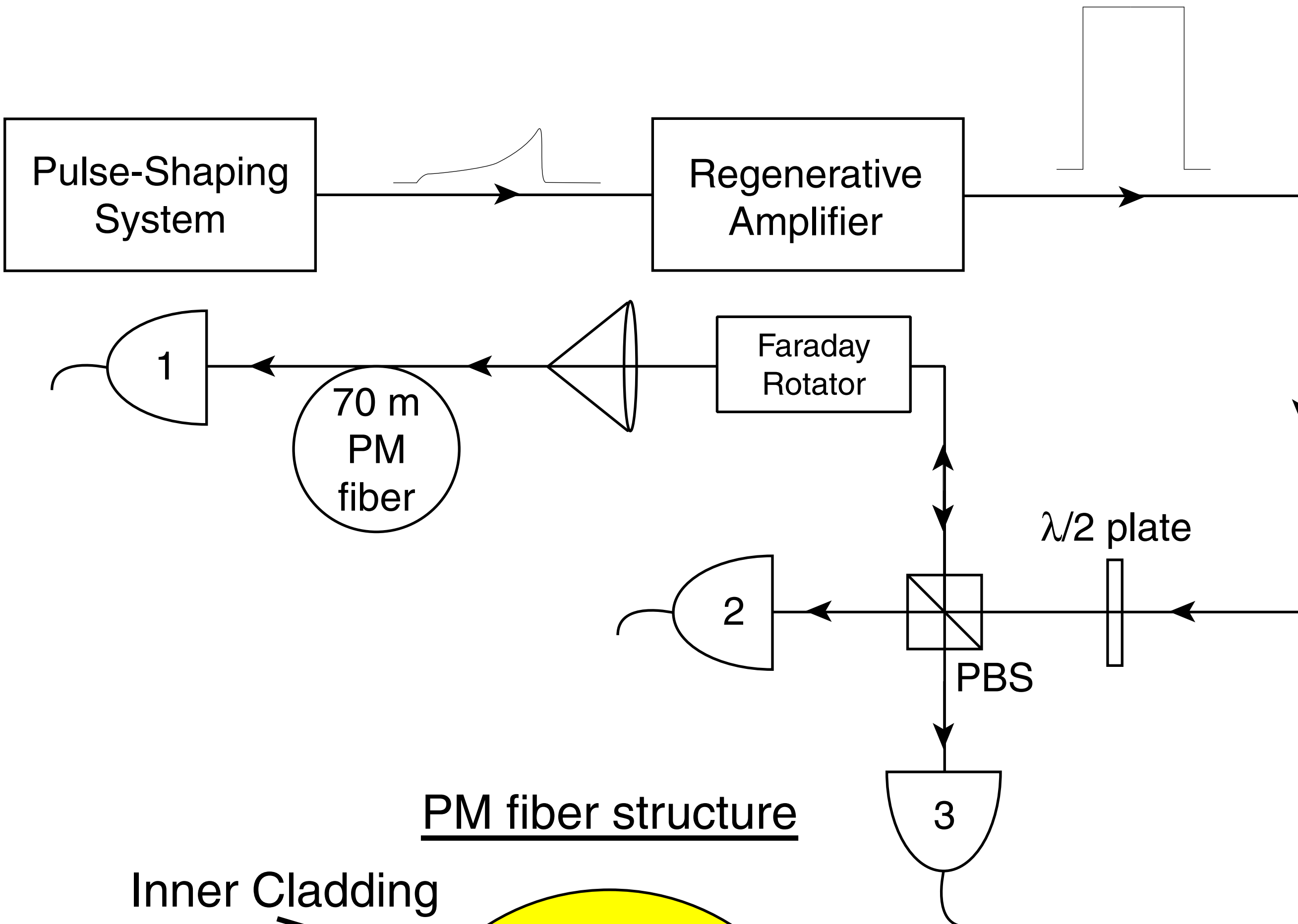
$$\langle f(z,t) f^*(z',t')\rangle = Q\delta(z-z')\delta(t-t')$$

Strength of Flucutations: $$Q = \frac{2kT\rho_0\Gamma_B}{v^2 A}$$

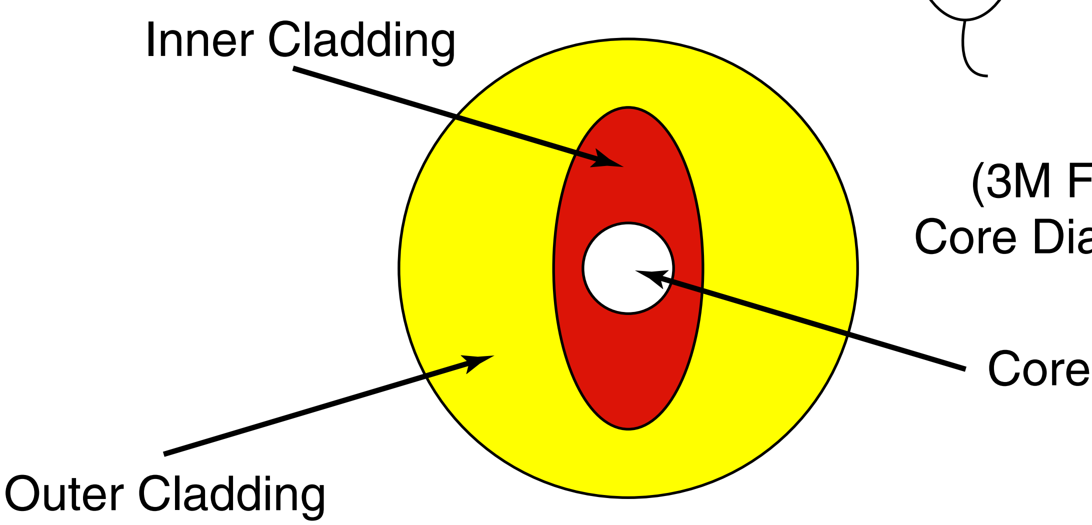
- We solved these equations numerically near the threshold for SBS.

[1] R. W. Boyd, et al, Phys. Rev. A, **42**, 5514 (1990).

Experimental Setup



PM fiber structure



(3M FS-PM-5121)
Core Diameter: 7.2 μm

Advantages of PM fiber:

- Experimentally ideal
- Avoid optical damage

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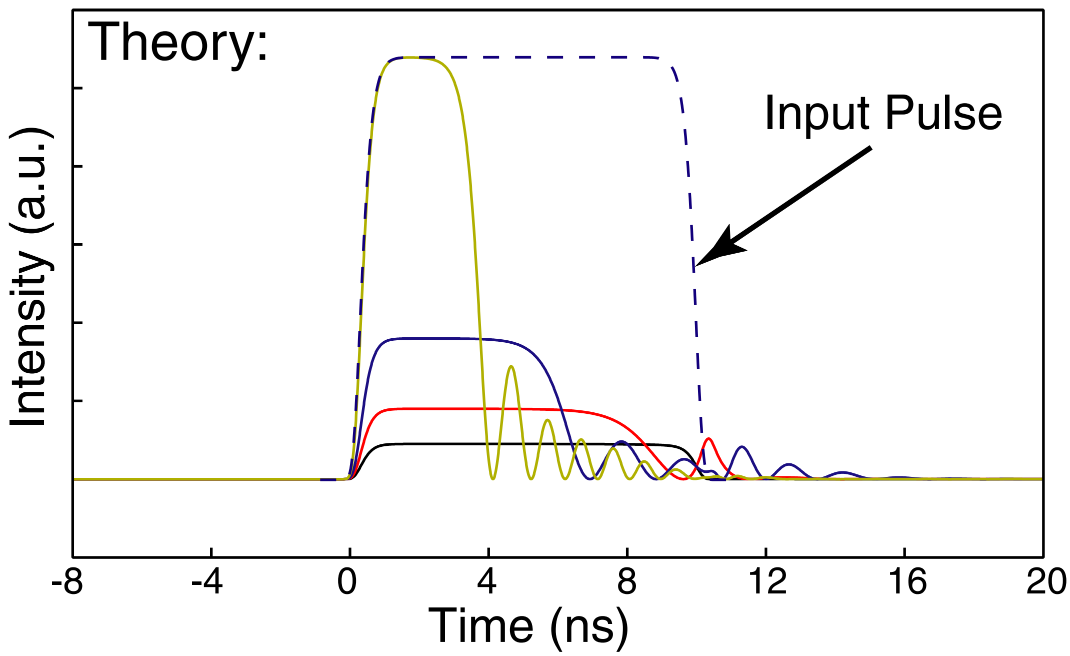
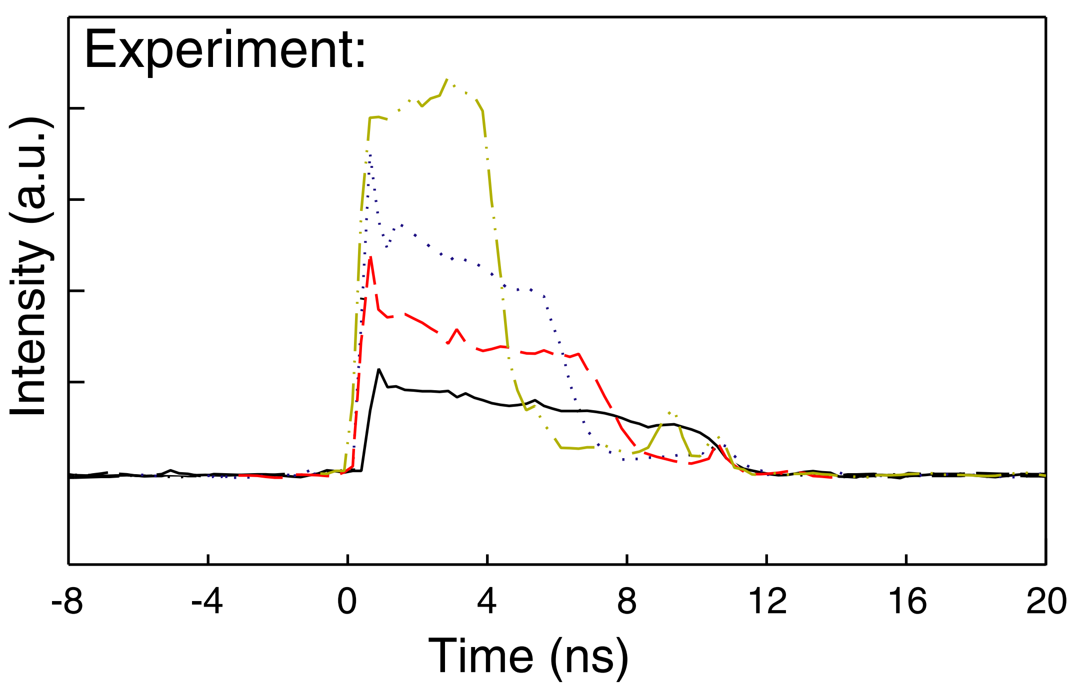
Transmitted Pulse





→ Pulse is effectively narrowed.

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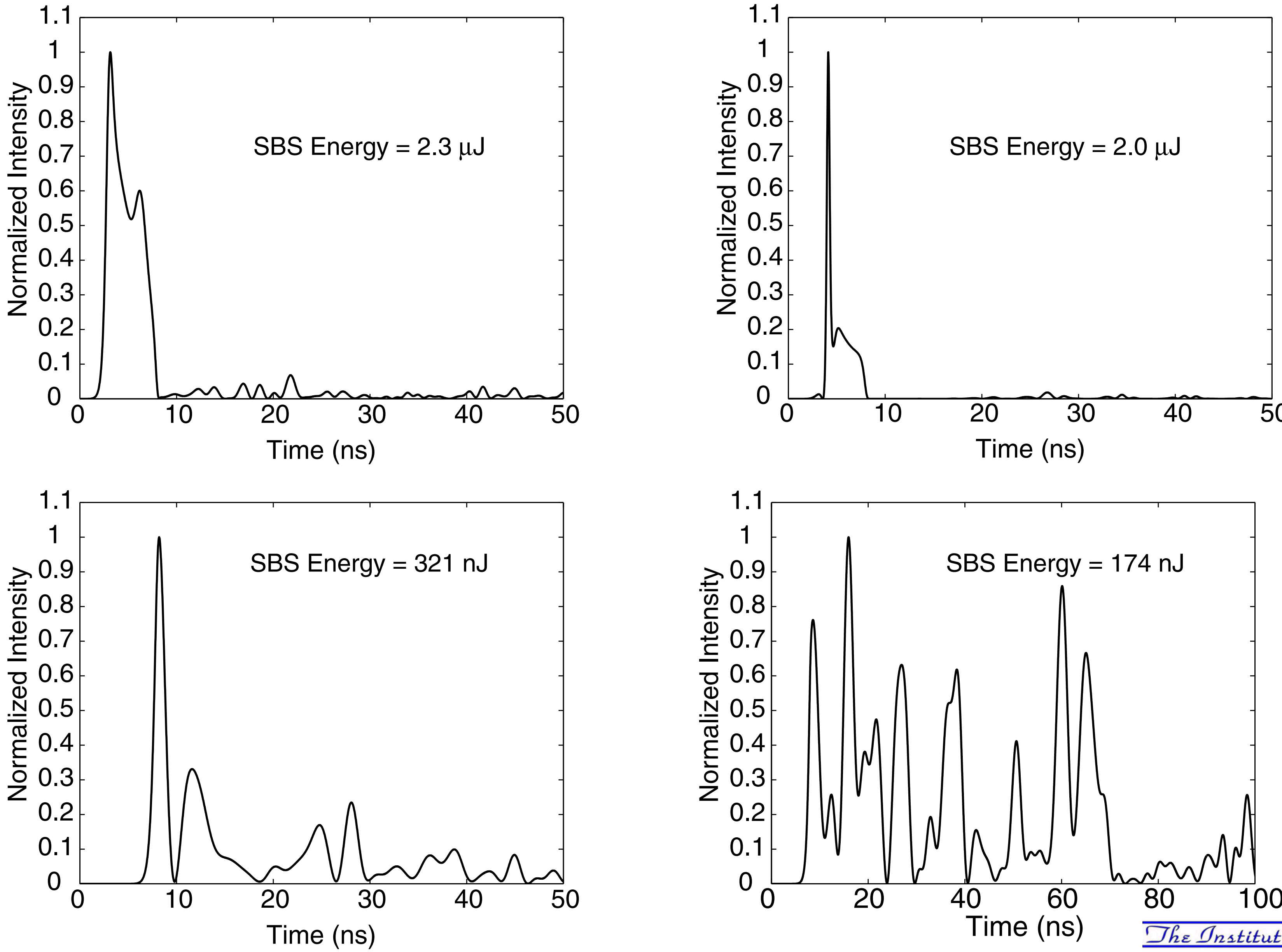
Theoretically Modeled SBS Pulse



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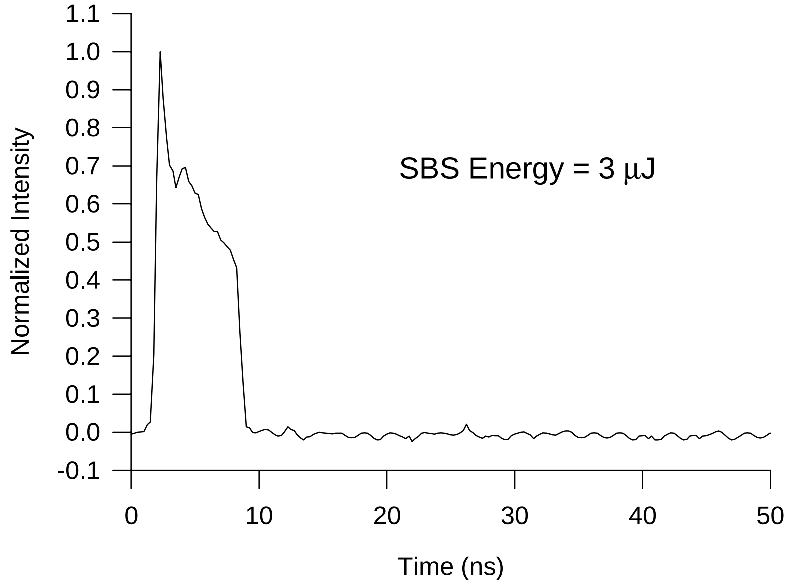
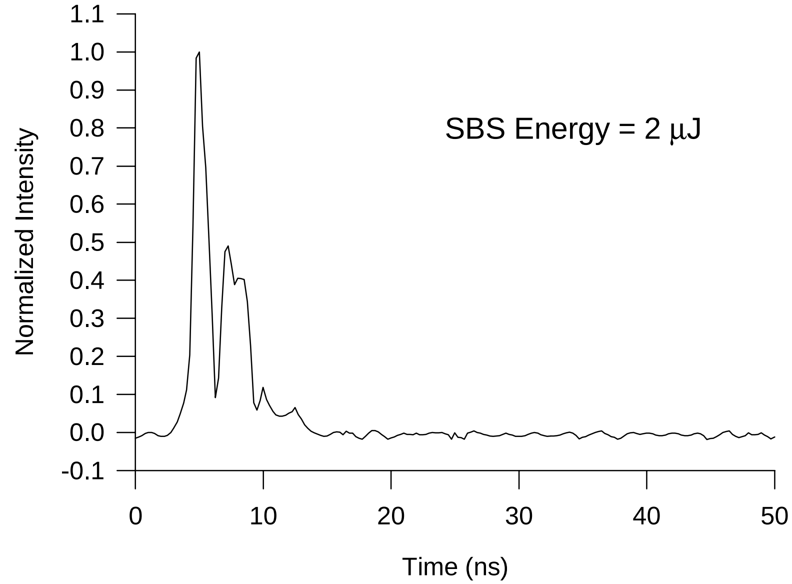
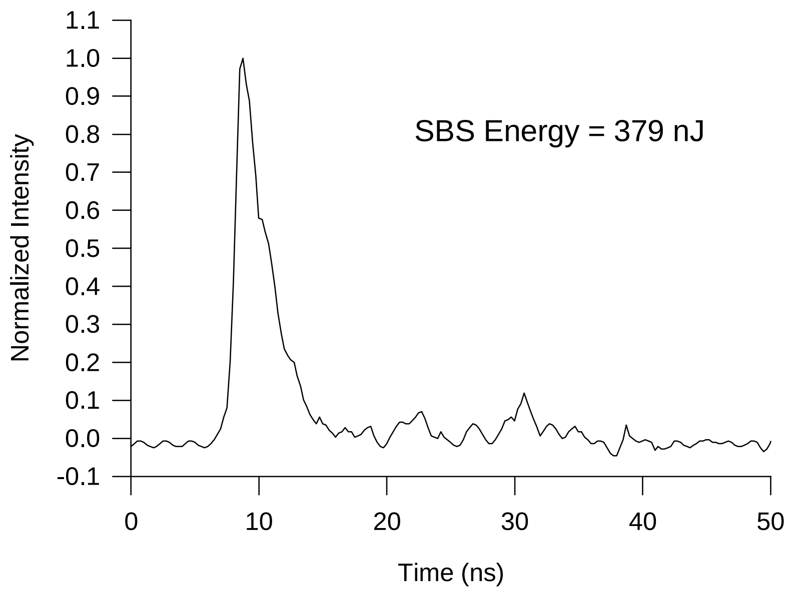
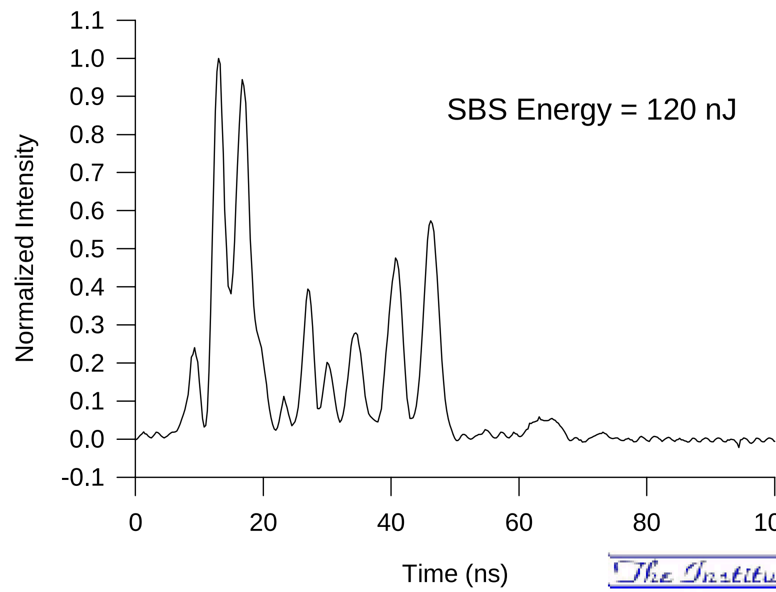
Experimental SBS Pulse









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Conclusions

- Polarization-maintaining fiber is useful in studying transient SBS in fibers since there is no decrease in the threshold power from depolarization effects.

- In a long fiber, SBS is generated through out the length of the fiber.

- A Langavin noise source model accurately explains the reflected SBS signal.

- The pump pulse is narrowed on transmission through the fiber as a result of pump depletion.

- Well above the threshold power for SBS, the reflected pulse is narrower than the input pulse (SBS pulse compression).