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Weierstraß-Institut für Angewandte Analysis und Stochastik

Pulse Splitting by Third-Order Dispersion

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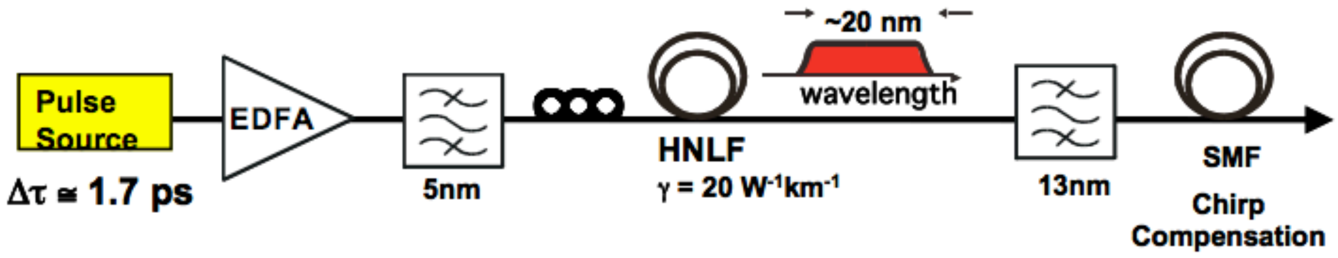
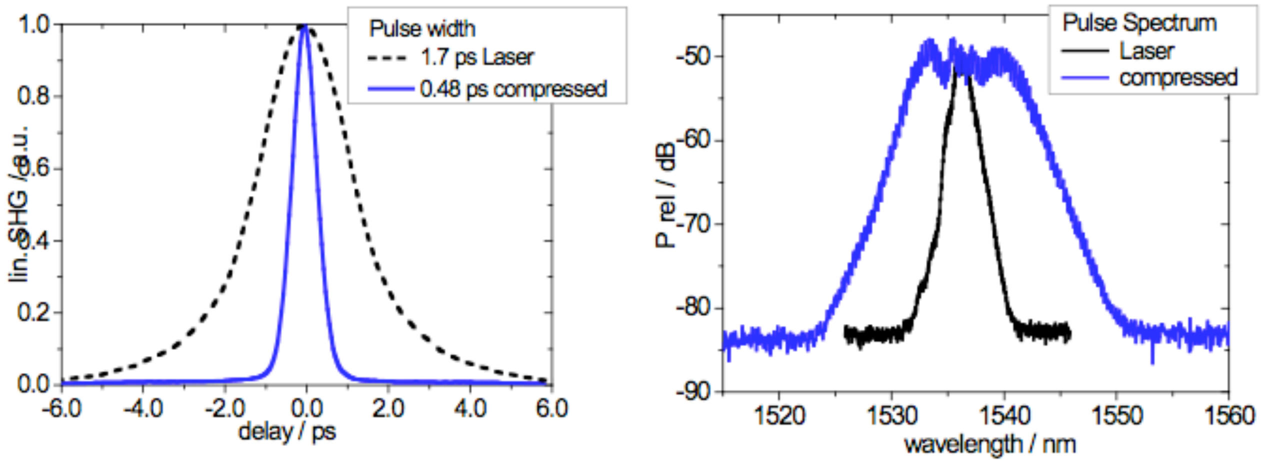
SC-generation (normal dispersion)





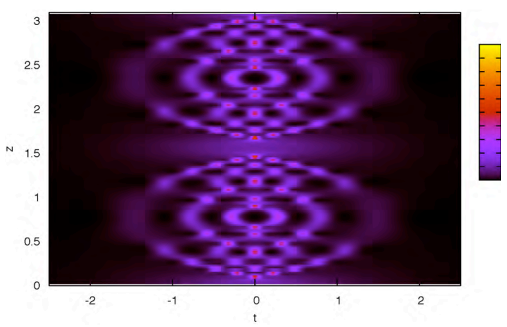
Propagation Equation

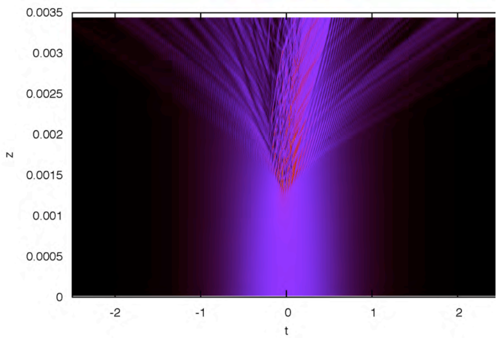
Generalized Nonlinear Schrödinger Equation (GNLS)

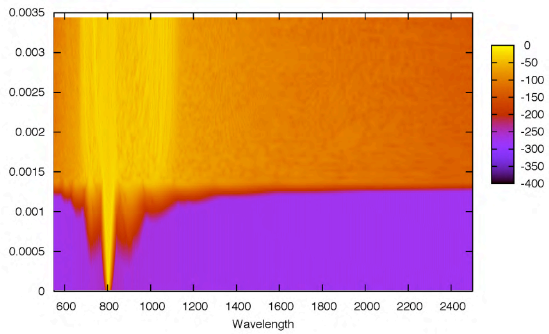
$$\frac{\partial A}{\partial z} = -\underbrace{\frac{1}{2}\alpha A}_{\text{Absorption}} \underbrace{-\frac{i}{2}\beta_2\frac{\partial^2 A}{\partial \tau^2} + \frac{1}{6}\beta_3\frac{\partial^3 A}{\partial \tau^3} + \frac{i}{24}\beta_4\frac{\partial^4 A}{\partial \tau^4}}_{\text{Dispersion}}$$

$$\underbrace{+i\gamma|A|^2 A}_{\text{SPM}} - \underbrace{a_1\frac{\partial}{\partial \tau}\left(|A|^2 A\right)}_{\text{self steepening}} - \underbrace{i a_2 A\frac{\partial}{\partial \tau}\left(|A|^2\right)}_{\text{Raman Scattering}}$$

Propagation of (sub-)picosecond Pulses along z . $\tau = t - z/v_g$.







New Model Frame: Bandelow/Mielke, DFG Resarch Center Matheon D14.

Pseudospectral Method

periodic boundary conditions: $\omega_n = n\, 2\pi/T$, n = 0, 1, 2, . . .

FFT:

$$A(z,\tau) = \sum_{n=-N/2}^{N/2} \tilde{A}_n(z) \mathrm{e}^{i\omega_n \tau}$$

8th-order Runge-Kutta scheme with adaptive stepsize control

$$\frac{\partial \tilde{A}_n(z)}{\partial z} = \frac{i}{2}\beta_2 \omega_n^2 \tilde{A}_n(z) - \frac{\alpha}{2}\tilde{A}_n(z) - \frac{i}{6}\beta_3 \omega_n^3 \tilde{A}_n(z) + \frac{i}{24}\beta_4 \omega_n^4 \tilde{A}_n(z) + i\gamma \tilde{\Psi}_n(z) + a_1 \tilde{\Phi}_n(z) - i a_2 \tilde{\Xi}_n(z)$$

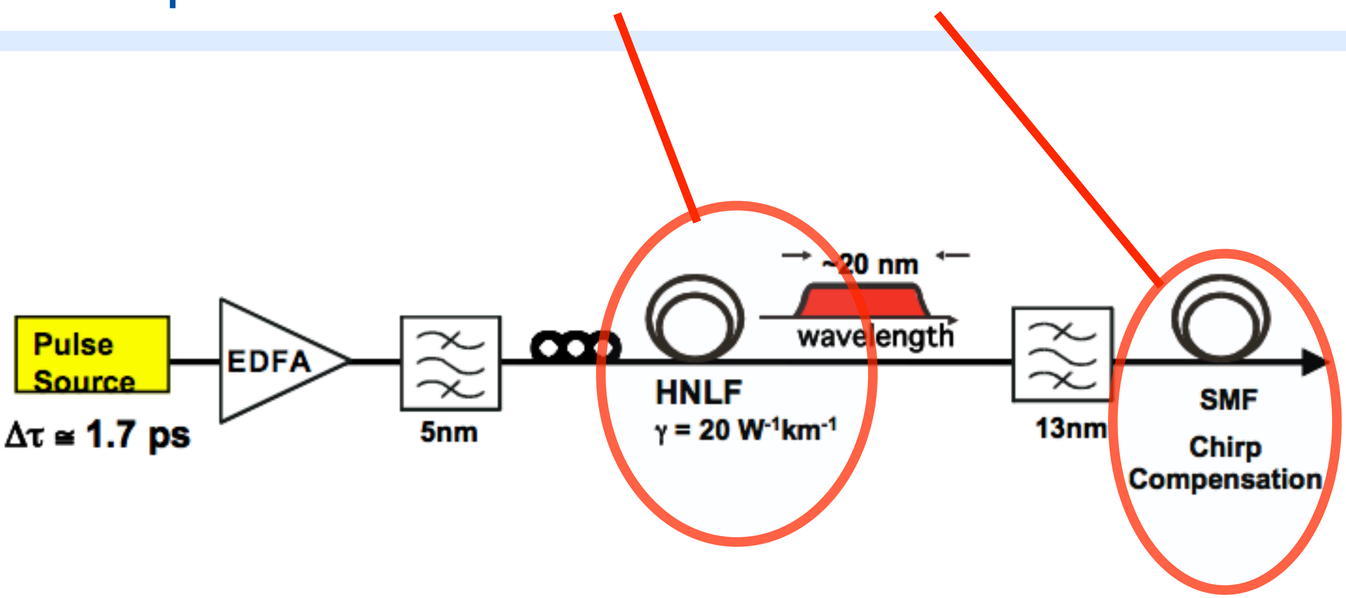
The nonlinearities

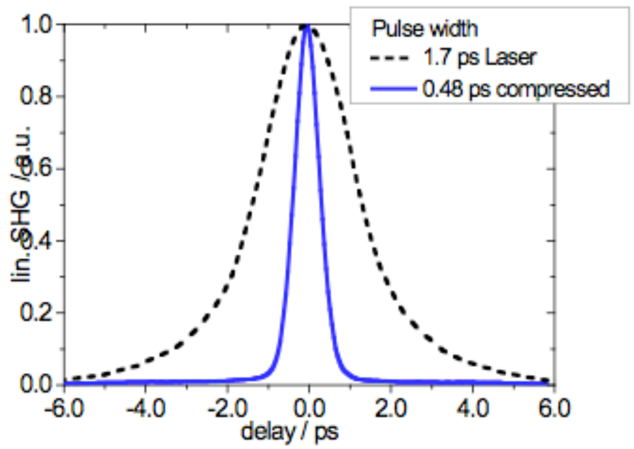
$$\Psi = |A|^2 A\,,\ \Phi = \frac{\partial}{\partial \tau}\left(|A|^2 A\right)\,,\ \Xi = A\frac{\partial}{\partial \tau}\left(|A|^2\right)$$

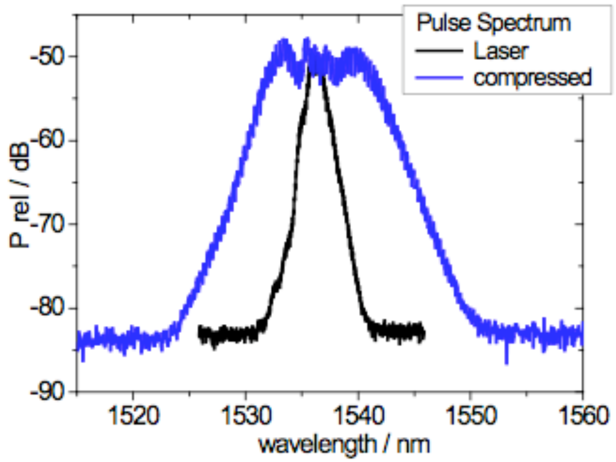
are evaluated in the time-domain:

$$\tilde{A}_n,\ i\omega \tilde{A}_n \xrightarrow{\text{IFFT}} A,\ \partial_\tau A \xrightarrow{\times} |A|^2 A = \Psi,\ A\partial_\tau |A|^2 = \Phi \xrightarrow{\text{FFT}} \tilde{\Psi}_n,\ \tilde{\Phi}_n,\ \tilde{\Xi}_n$$

Pulse Compression via HNLF and SMF







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Propagation Equation

NLS for next purposes:

$$\frac{\partial A}{\partial z} = -\frac{i}{2}\beta_2 \frac{\partial^2 A}{\partial \tau^2} + i\gamma |A|^2 A$$

$$L_D = T_0^2/|\beta_2|, \quad L_{NL} = 1/(\gamma P_0)$$

Pulse Compression by simple Formulas

Initial pulse: $A(0,t) = \sqrt{P_0} sech(t/T_0)$

Characteristic lengths:

$$L_{NL} = 1/(\gamma P_0), \quad L_D = T_0^2/|\beta_2|$$

Optimum compression factor *(Tomlinson et.al. JOSA B, 1984)*

$$F_c = \frac{T_0}{T_c} = 0.63\sqrt{\frac{L_D}{L_{NL}}} = 0.63 T_0 \sqrt{\frac{\gamma P_0}{|\beta_2|}}$$

Hence, for large compression:

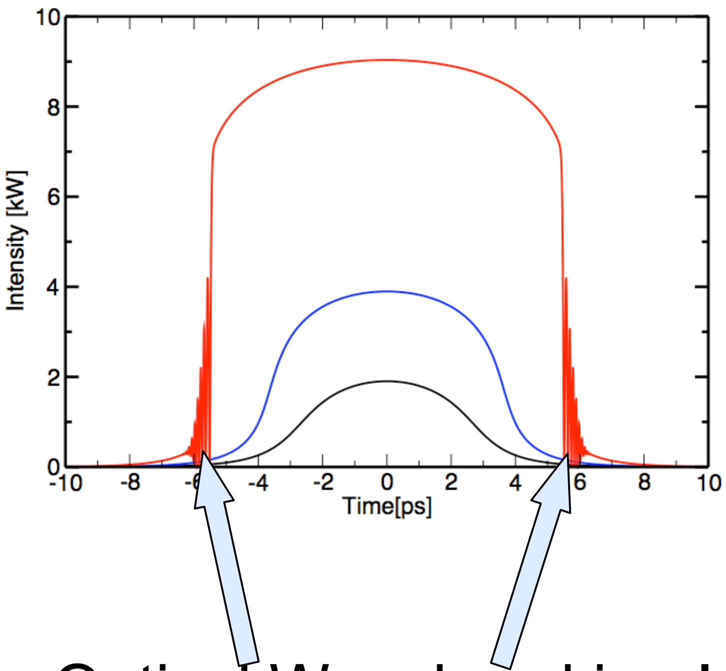
HNLF with $\beta_2 \gtrsim 0$ close to ZDW, and

γP_0 Large!

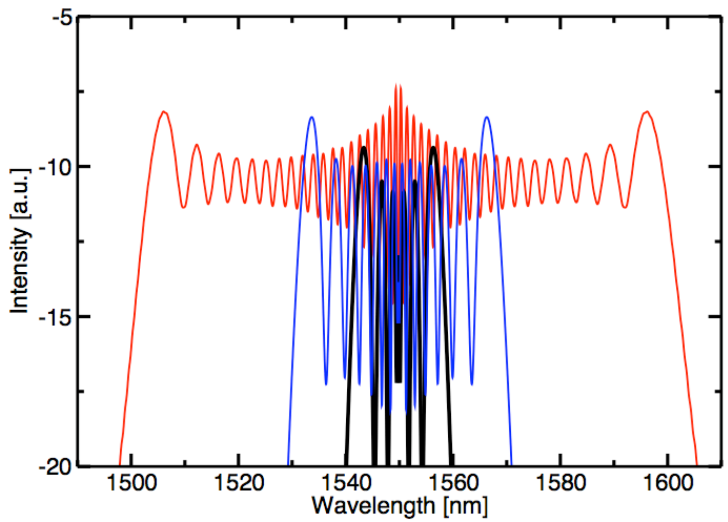
Optical Wavebreaking

Evolution of a sech-pulse through a HNLF with normal dispersion

Pulse shape:



Pulse spectrum:



Optical Wavebreaking !

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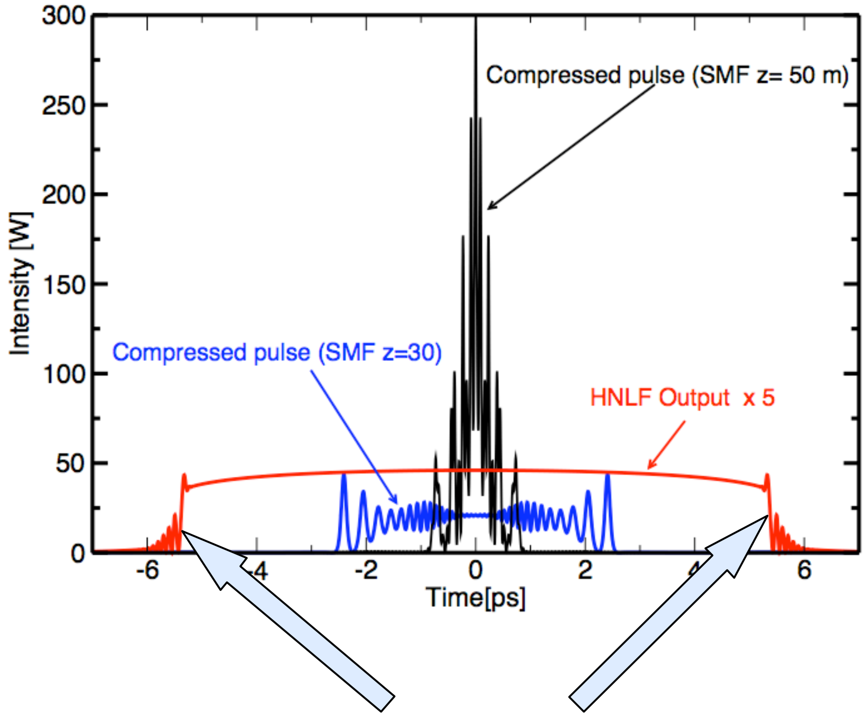
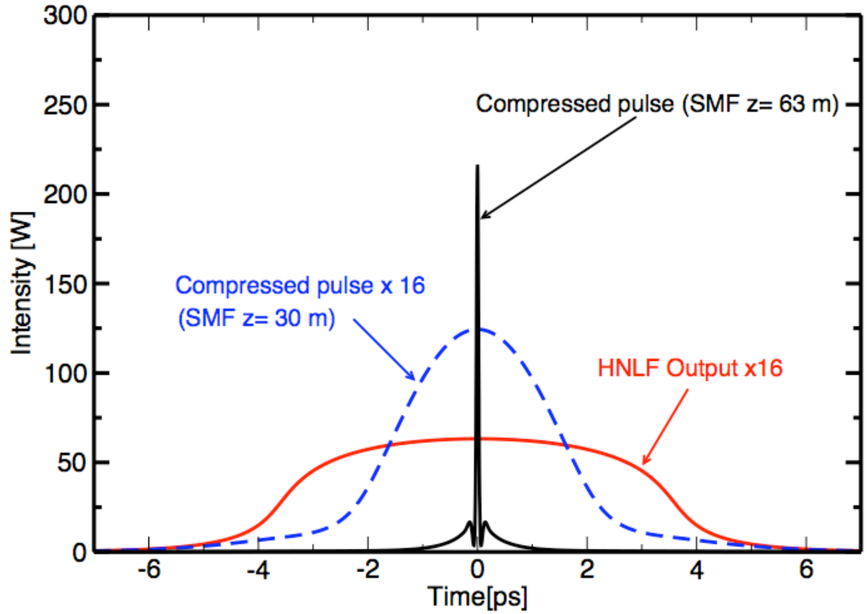
Exclusion of Optical Wavebreaking

Pulse Shapes after HNLF and SMF

high power:



moderate power:



Optical wavebreaking !

No optical wavebreaking.

Propagation Equation

GNLS for next purposes:

$$\frac{\partial A}{\partial z} = -\frac{i}{2}\beta_2\frac{\partial^2 A}{\partial \tau^2} + i\gamma|A|^2 A$$

$$L_D = T_0^2/|\beta_2|, \quad L_{NL} = 1/(\gamma P_0)$$

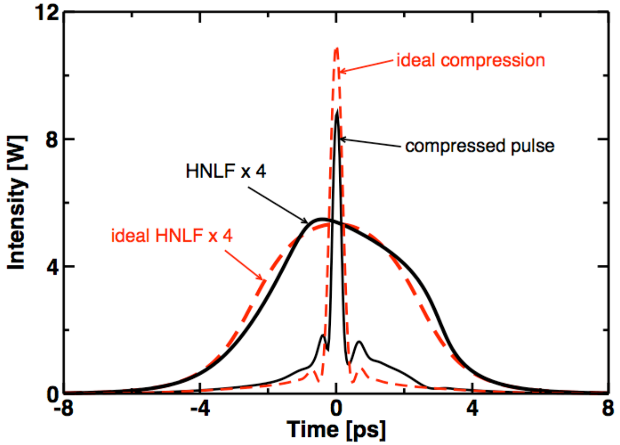
$$+\frac{1}{6}\beta_3\frac{\partial^3 A}{\partial \tau^3}$$

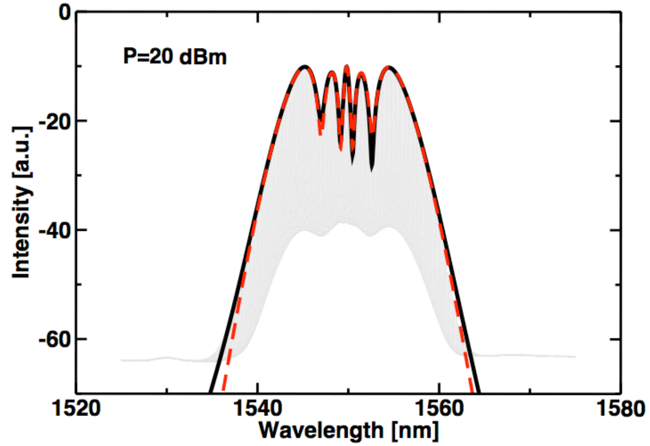
"Perturbation", introduces:

$$L'_D = T_0^3/|\beta_3|$$

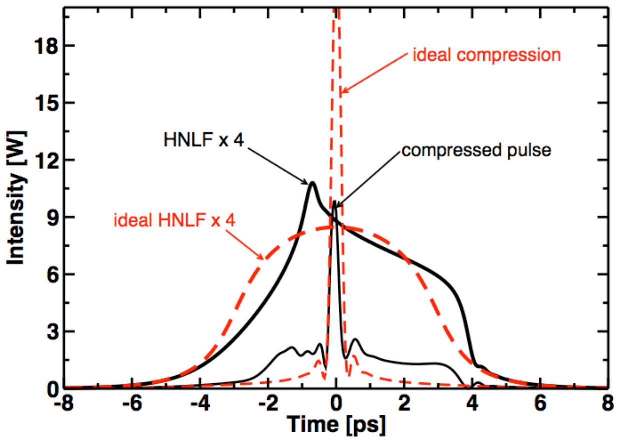
Pulse Compression

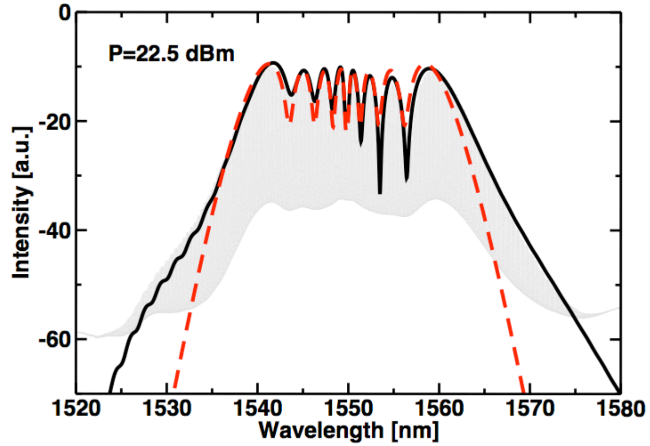
Low power:





Medium power:

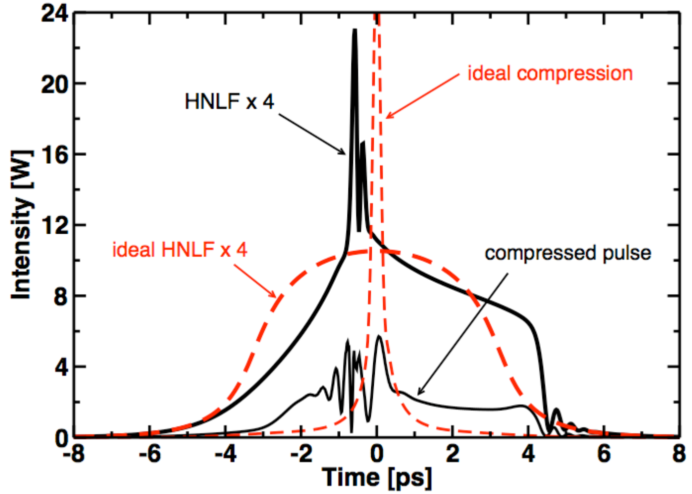


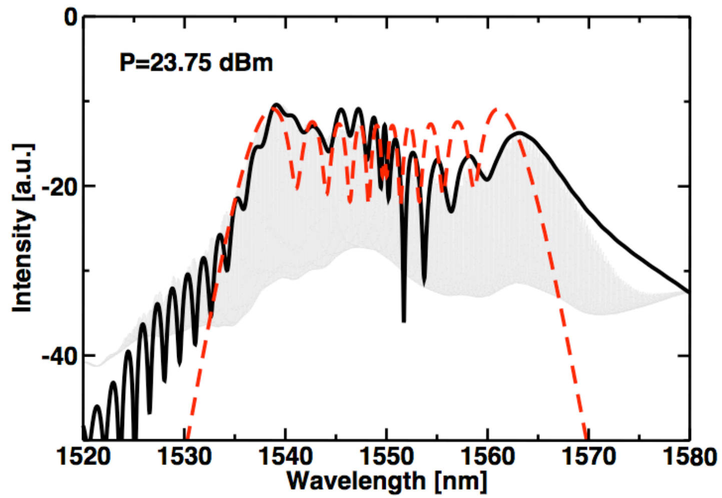


Demircan et. al., to appear in IEEE PTL 2006, WIAS Preprint #1108

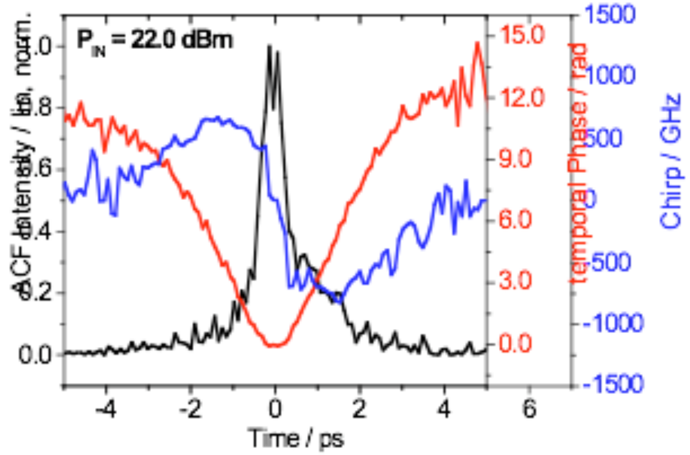
Pulse Splitting

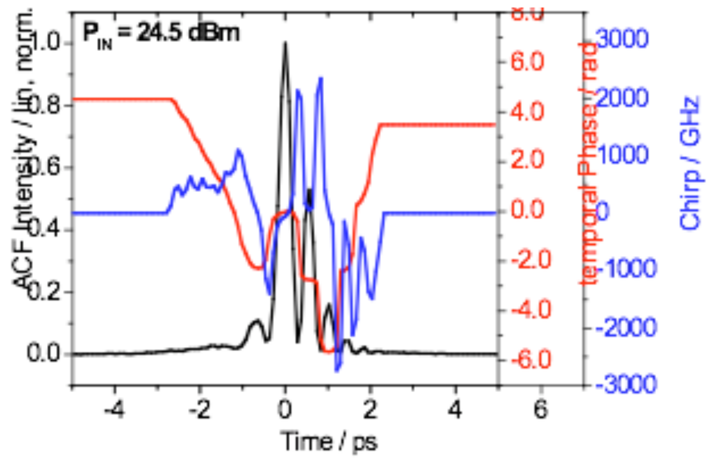
High power:





(FROG-) **Measurements** (HHI):





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Summary

Pulse compression via SC generation analyzed.

Limiting Effects:

•Optical Wavebreaking

•Pulse Splitting

Pulse Splitting via β_3 represents a fundamental limit.

Thank you for your Attention!