

# Ultrawideband regenerative amplifiers via intracavity acousto-optic programmable gain control

Thomas Oksenhendler, Nicolas Forget, Daniel Kaplan, Pierre Tournois  
*Fastlite, Bât 403, Ecole Polytechnique, 91128 Palaiseau, France*  
[thoksen@fastlite.com](mailto:thoksen@fastlite.com)

Pierre-Mary Paul, Gregory M. Greetham, Frederic Estable  
*Amplitude Technologies, 2, rue du Bois Chaland, 91029 EVRY, France*

CLEO 2006



*Advanced solid-state lasers*

**FASTLITE**

ULTRAFast SCIENTIFIC INSTRUMENTATION

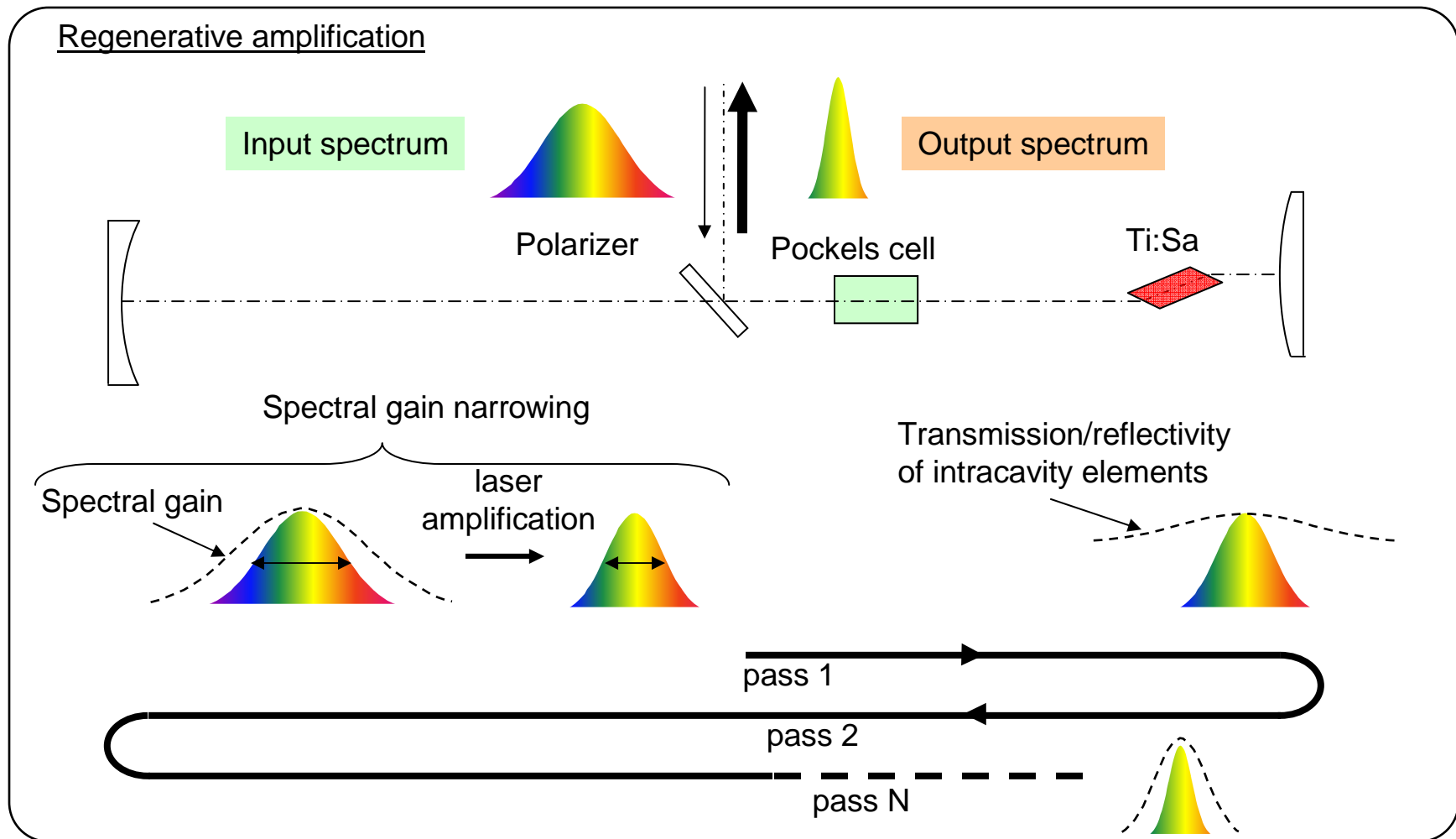
*Breakthroughs in Ultrafast Laser Technology*

# Ultrawideband regenerative amplifiers

- Goals : regenerative amplifier with :
  - sub-20fs pulses at 800 nm,
  - mJ-level,
  - high temporal pulse contrast.
- Problems :
  - gain narrowing => spectrum FWHM < 35nm
  - reliability,
  - pre/post pulses, ASE,
  - stability.

CLEO 2006

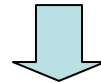
# Ultrawideband regenerative amplifiers



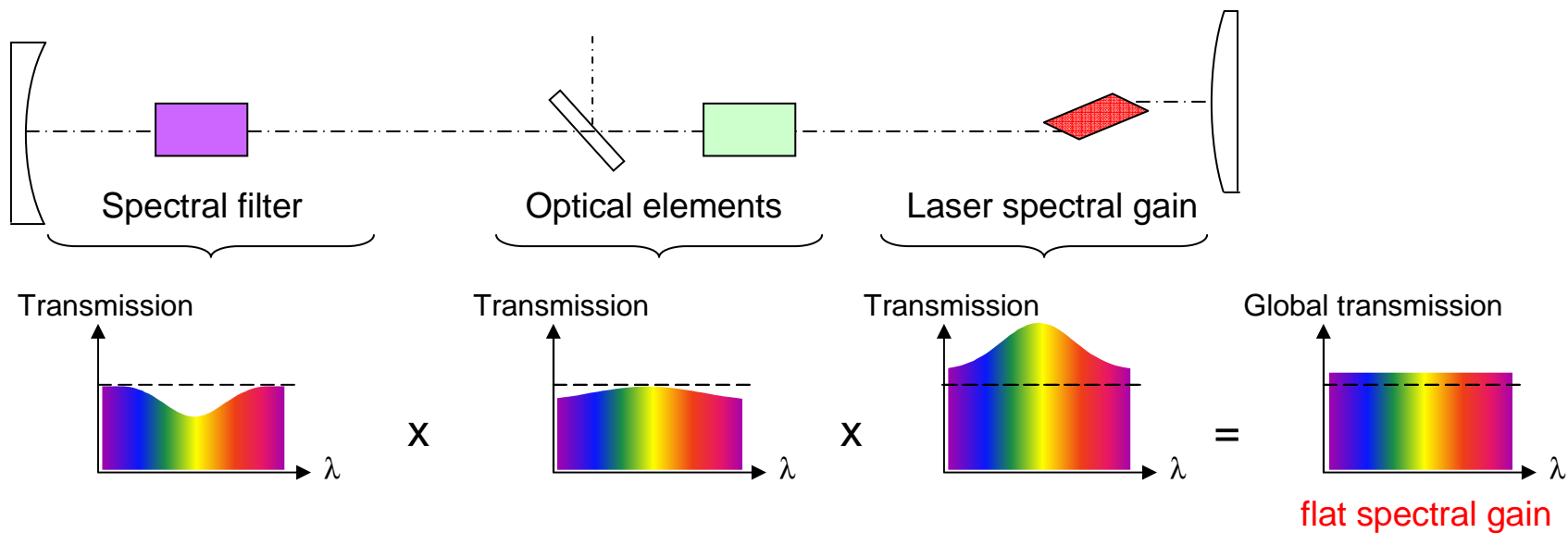
CLEO 2006

# Ultrawideband regenerative amplifiers

Spectral gain narrowing => spectrum FWHM < 35nm



Solution : "Regenerative pulse shaping" <sup>1,2</sup>



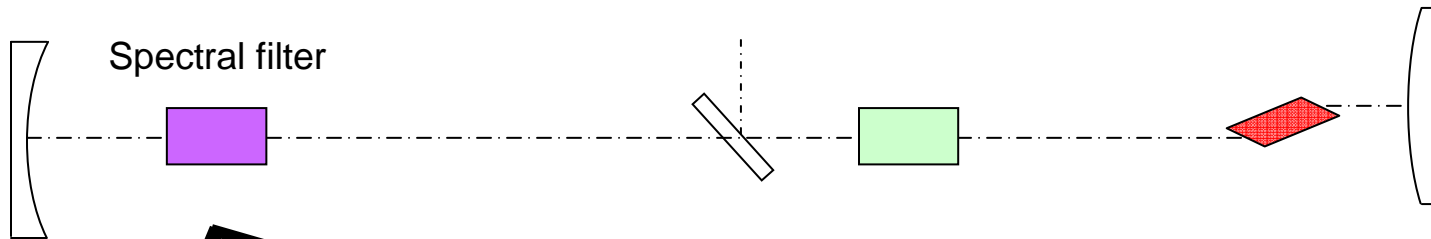
<sup>1</sup> C.P.J. Barty, G.Korn, F.Raski, C.Rose-Petruck, J.Squier,A.C.Tien, K.R.Wilson, Y.V.Yakovlev, K.Yamakawa, "Regenerative pulse shaping and amplification of ultrabroadband optical pulses", Opt.Lett. Vol.21, No.3, pp.219-221 (1996)

<sup>2</sup> C.P.J. Barty, T.Guo, C.LeBlanc, F.Raski, C.Rose-Petruck, J.Squier, K.R.Wilson, Y.V.Yakovlev, K.Yamakawa, "Generation of 18-fs multiterawatt pulses by regenerative pulse shaping and chirped-pulse amplification", Opt.Lett. Vol.21, No.9, pp.668-670 (1996)

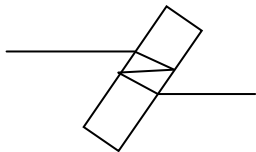
CLEO 2006

# Ultrawideband regenerative amplifiers

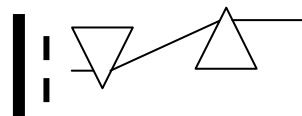
“Regenerative pulse shaping”



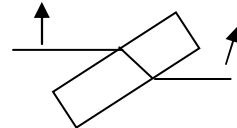
Thin etalon



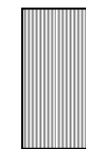
Spectral mask



Birefringent filter



Multiple dielectric layers

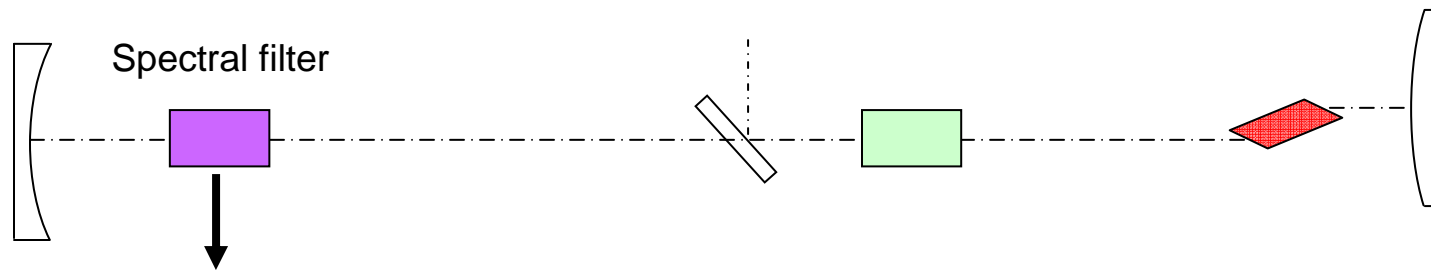


Drawbacks: pulse replica, cavity instability, lack of programmability

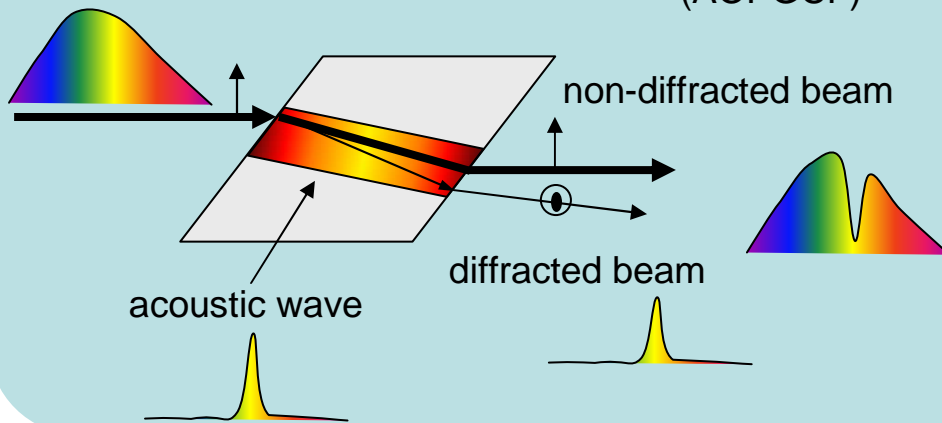
CLEO 2006

# Ultrawideband regenerative amplifiers

## “Regenerative pulse shaping”



### Acousto-Optic Programmable Gain Control Filter (AOPGCF)



- similar to AOPDF
  - ⇒ uses non diffracted beam
- Brewster incidence angle
  - ⇒ low passive losses
- collinear interaction geometry
  - ⇒ efficiency and resolution
- very easy calibration
  - ⇒ crystal physical constants and 1 spectral point

CLEO 2006

# Acousto-Optic Programmable Gain Control Filter

- Advantages :

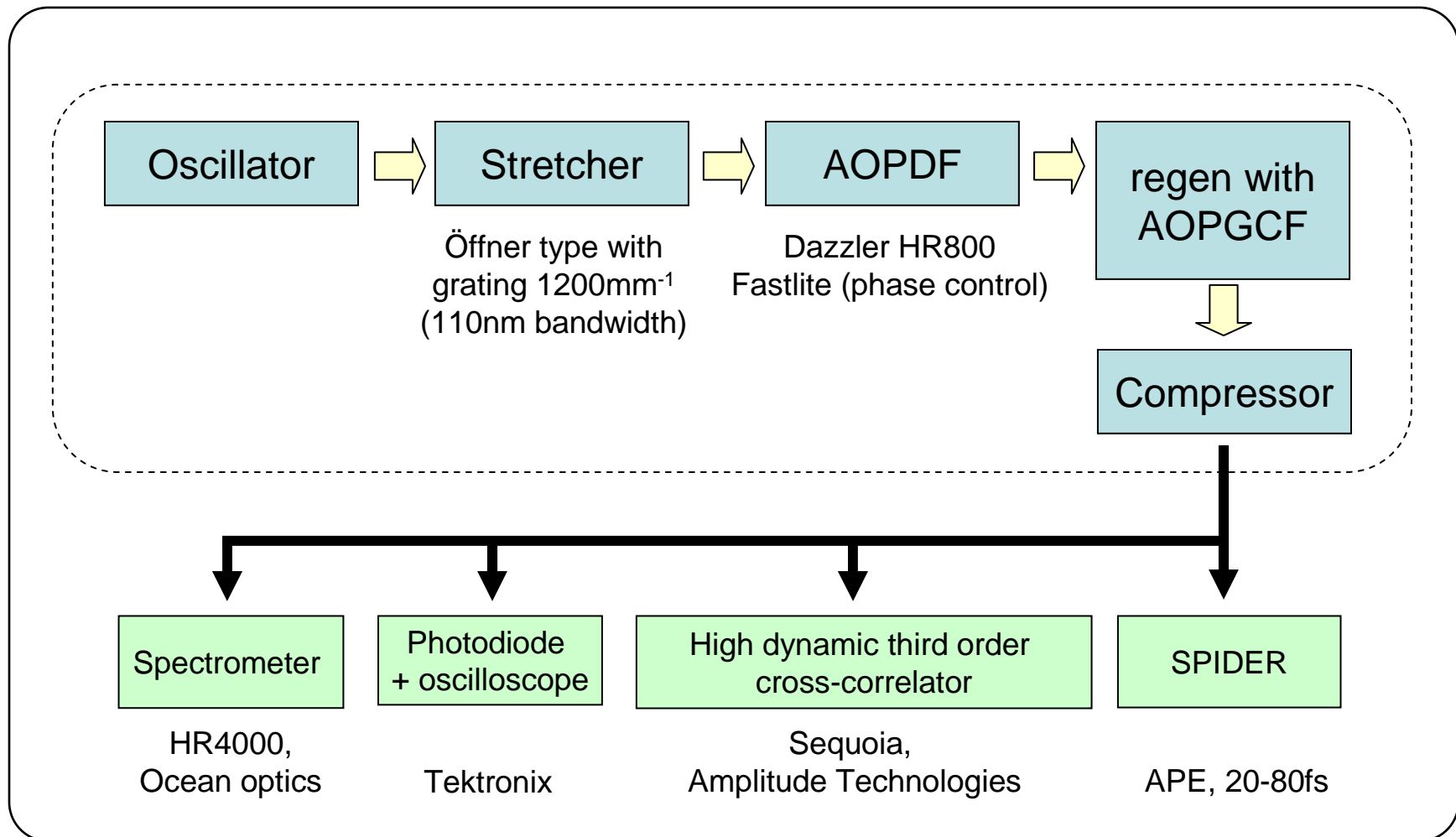
- low residual losses,
- high spectral resolution (1nm)
- no spurious pulses,
- complete software programmability,
- easy installation and calibration

- Drawbacks :

- low damage energy threshold :  $\approx 1 \text{ mJ}/1 \text{ mm}^2$ ,
- dispersion of the TeO<sub>2</sub> crystal :  $\Rightarrow > 200\,000 \text{ fs}^3$  to compensate  
→ Acousto-Optic Programmable Dispersive Filter (AOPDF)

CLEO 2006

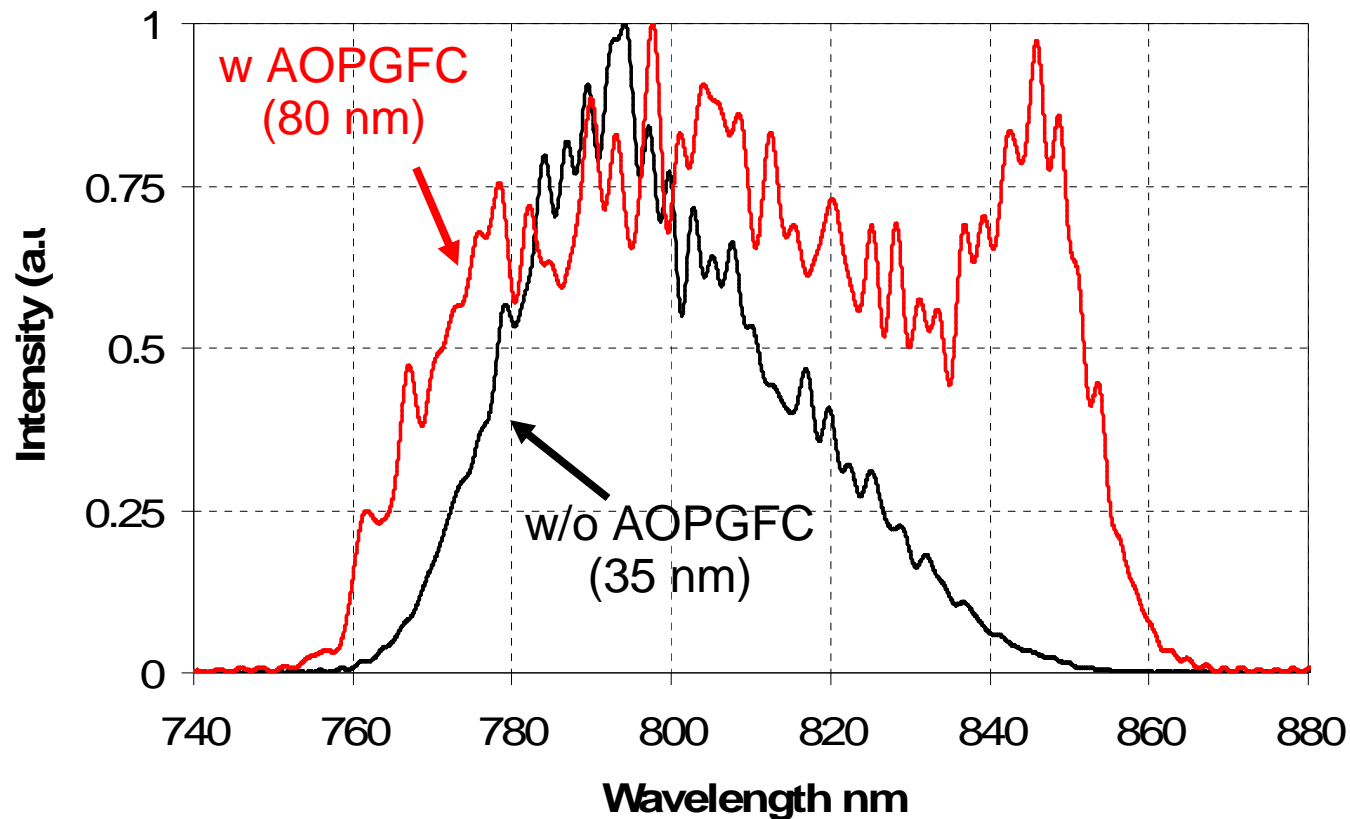
# Experimental setup



CLEO 2006

# Ultrawideband amplification experimental results

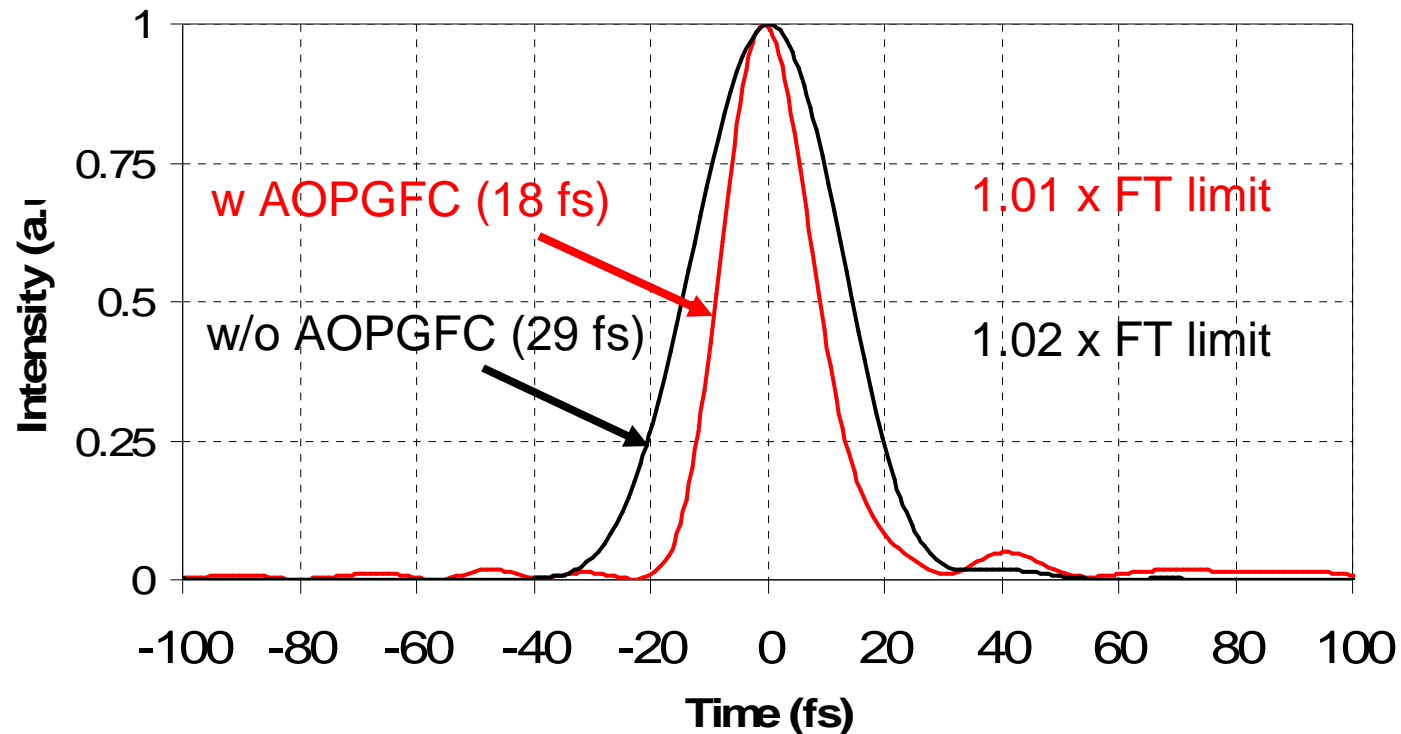
Spectrum enlargement :



CLEO 2006

# Ultrawideband amplification experimental results

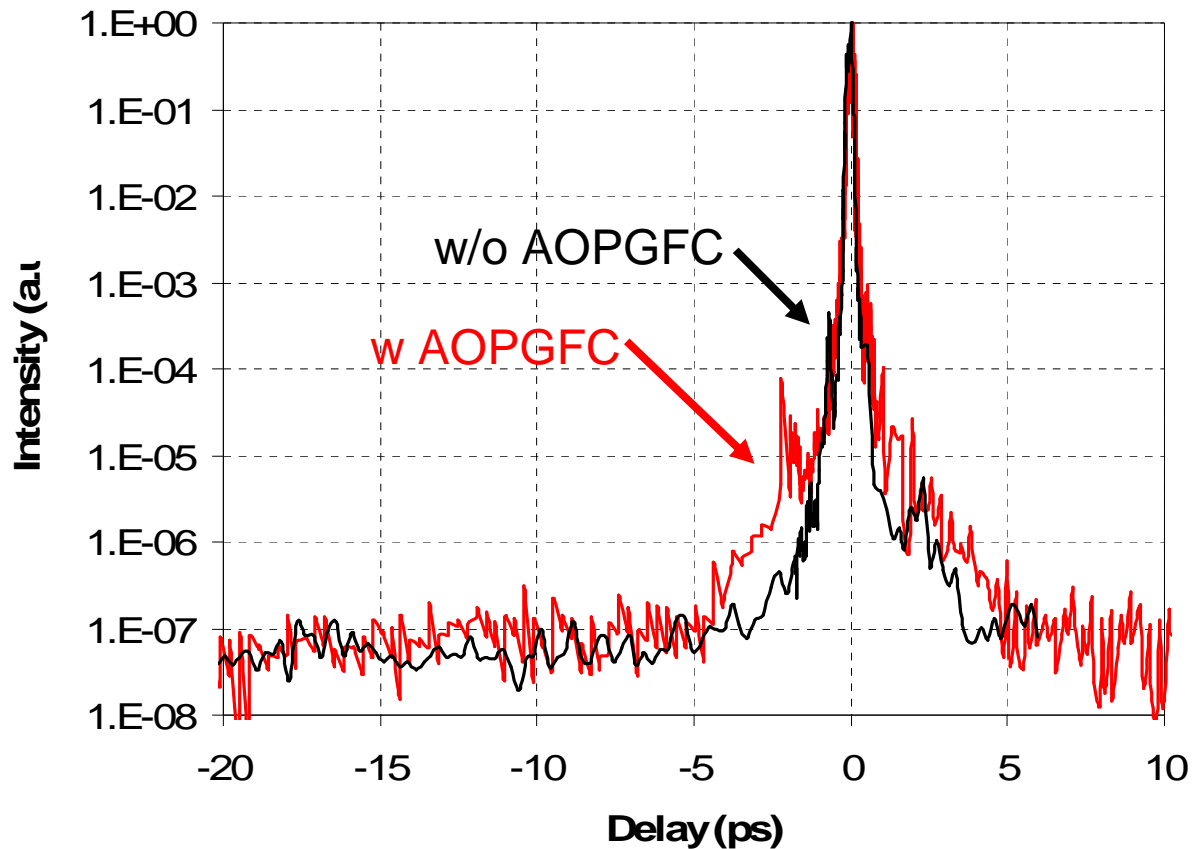
Temporal profile :



CLEO 2006

# Ultrawideband amplification experimental results

Pulse contrast :



CLEO 2006

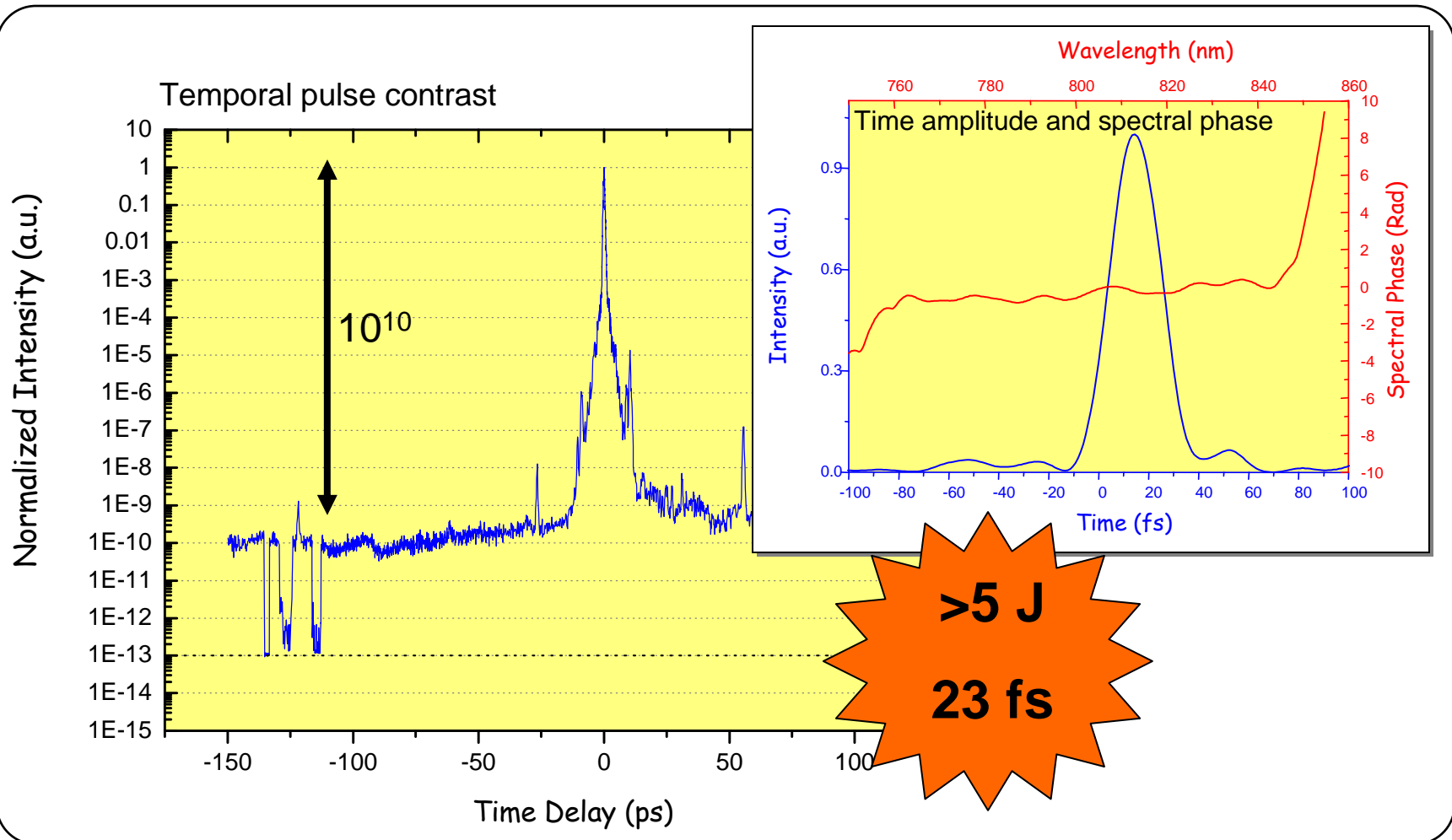
# Conclusions

## Summary :

- spectral enlargement from 35nm to 80nm  $\Rightarrow$  shorter pulses  
– duration 29fs to 18fs FWHM
- no ASE-contrast degradation ( $10^7$ )  $\Rightarrow$  high contrast
- stability of 18fs pulses is 1.2%rms  $\Rightarrow$  reliability
- energy limitation to about 0.5 mJ [without post amplification]

 200 TW laser chain system

# 200 TW laser system



**>5 J**  
**23 fs**

CLEO 2006