Spectral Coherent Combination of Ultra-Short Pulses

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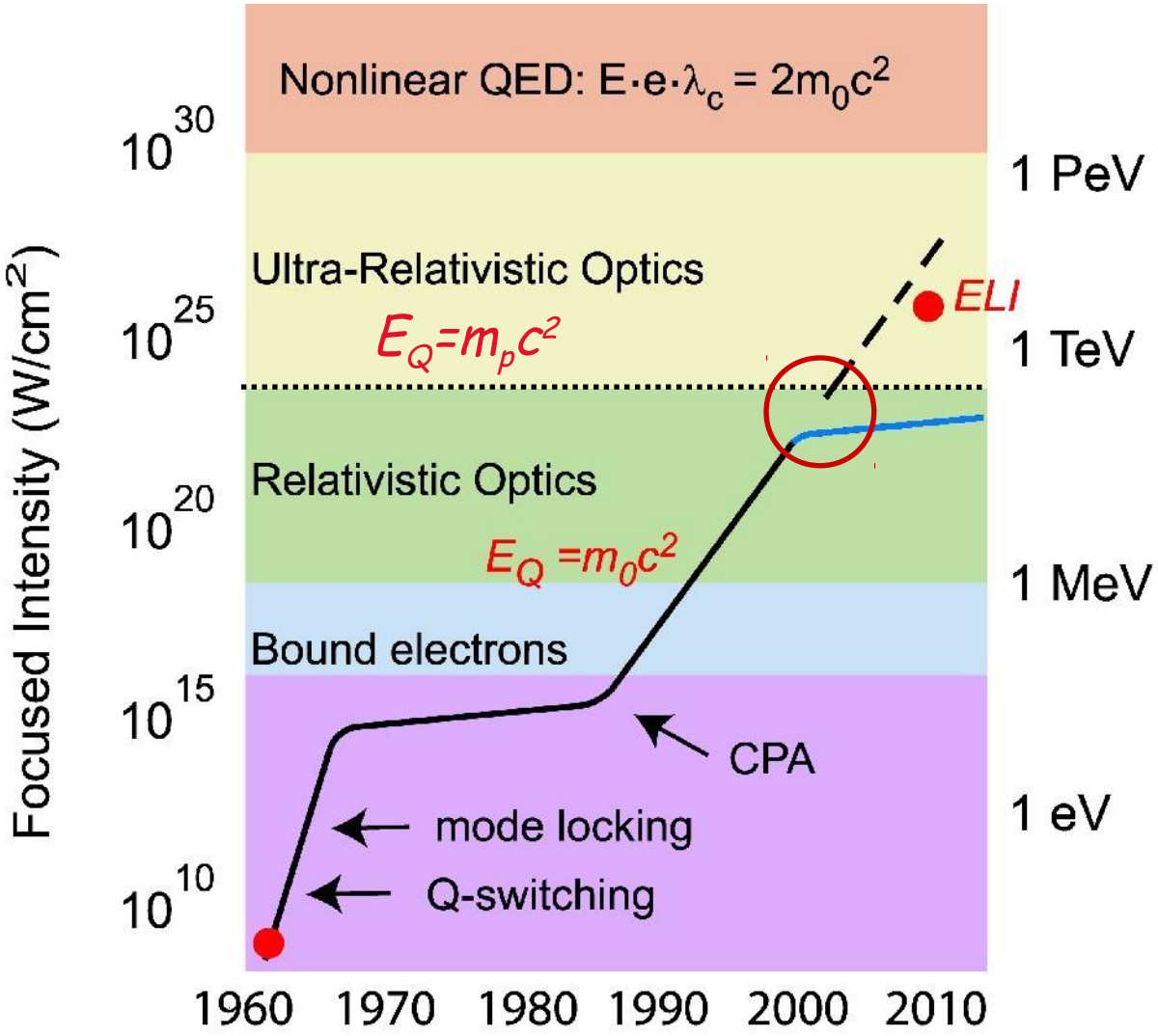
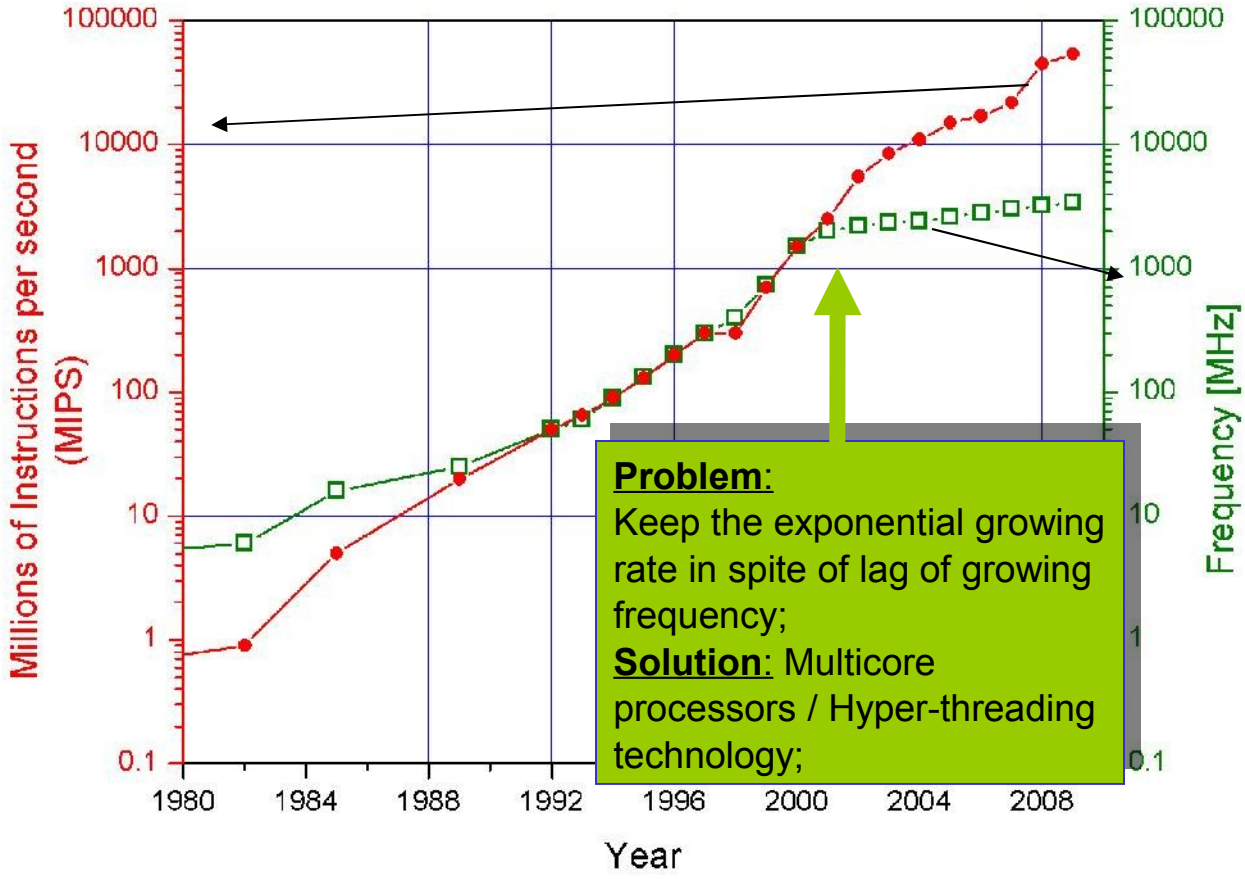
Contents

- The need of laser amplifiers parallelization
- Straight-forward approach: identical amplifiers
- Alternative solution proposed: spectral combination
- Experimental tests of the solution
- Conclusions

History of Laser Intensity



Similarity - Evolution of Microprocessors
Key solution: architecture/organization emphasis



Parallelization is also the ELI solution!!

Use of identical parallel amplification chains.


2 lasers, 10 PW each
Planned ELI-NP facility

Laserlab Europe

extreme light infrastructure

Is there a better way to add power from parallel laser amplifiers?

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10PW +10PW +10PW =...
Preliminary evaluation

100 fs, 1kJ=>10PW

3*identical pulses of 10PW = 30PW

Relevant to ELI
Coherent Beam Combination

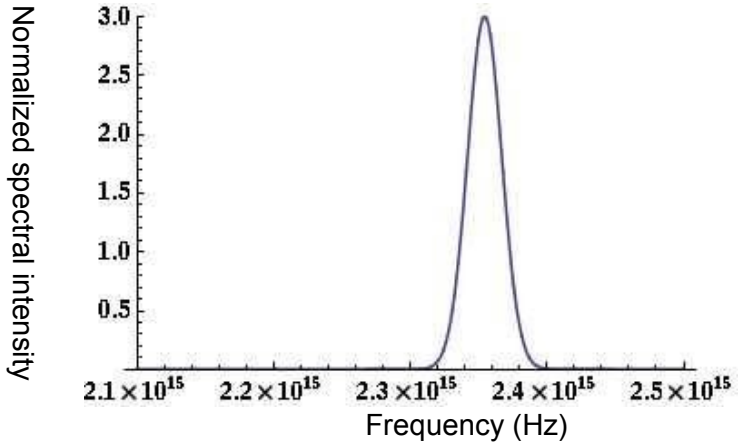
BUT...

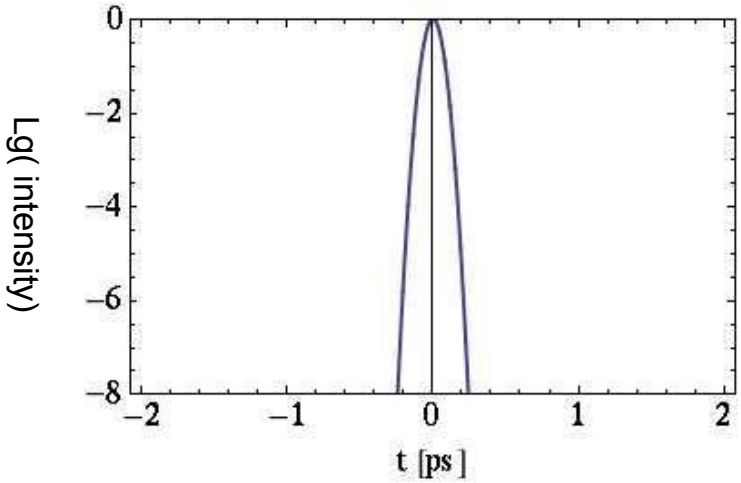
100 fs, 1kJ, **lambda=800nm**, BW_1=8nm =>10PW
100 fs, 1kJ, **lambda=808nm**, BW_2=8nm =>10PW
100 fs, 1kJ, **lambda=816nm**, BW_3=8nm =>10PW

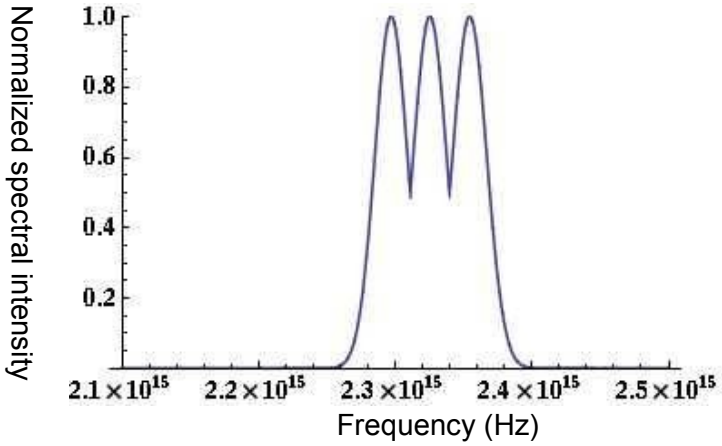
Final pulse duration tau_f~ $1/(BW_1+BW_2+BW_3)$~33fs
Power = 3kJ / tau_f= 90PW

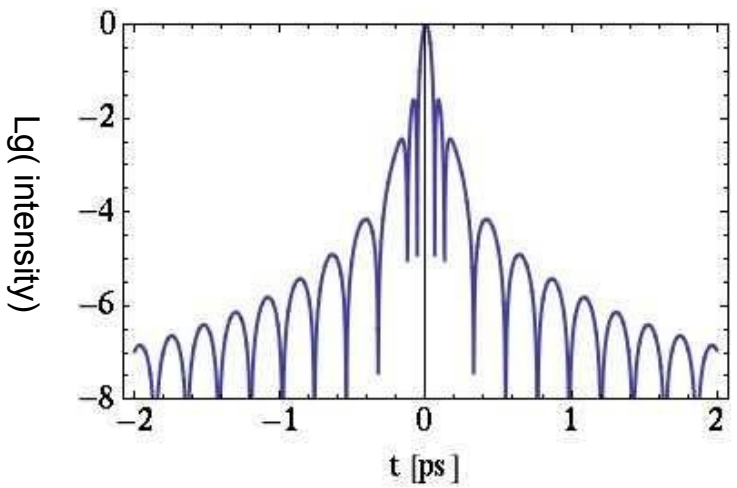
Spectral COmbination of Optical Pulses

10PW+10PW+10PW=...
1D modeling







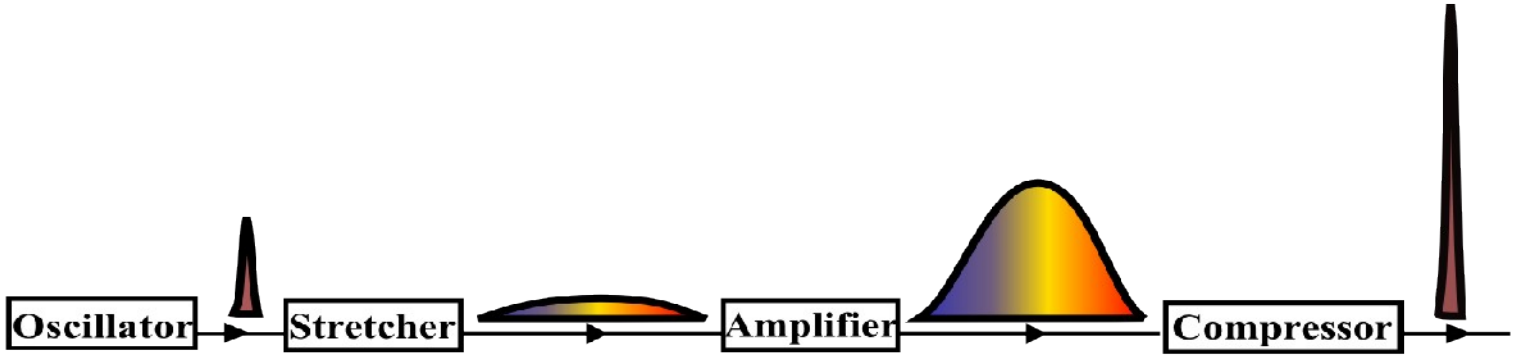


3*(10 nm bandwidth@800nm),
Pulse duration 92 fs, E^2=39.1

3*10 nm bandwidth@800nm+810nm+820nm,
Pulse duration 48 fs, E^2=59.5

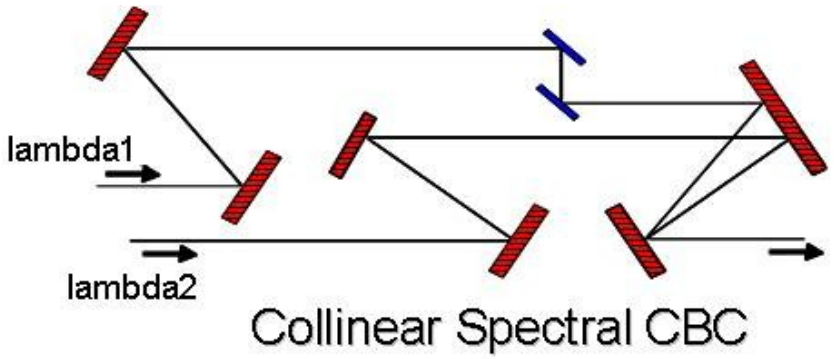
Spectral combination of ultrashort pulses produces shorter pulses

Spectral combination of ultra-short pulses:principle



How to multiplex short pulses with different wavelengths?

Collinear combination

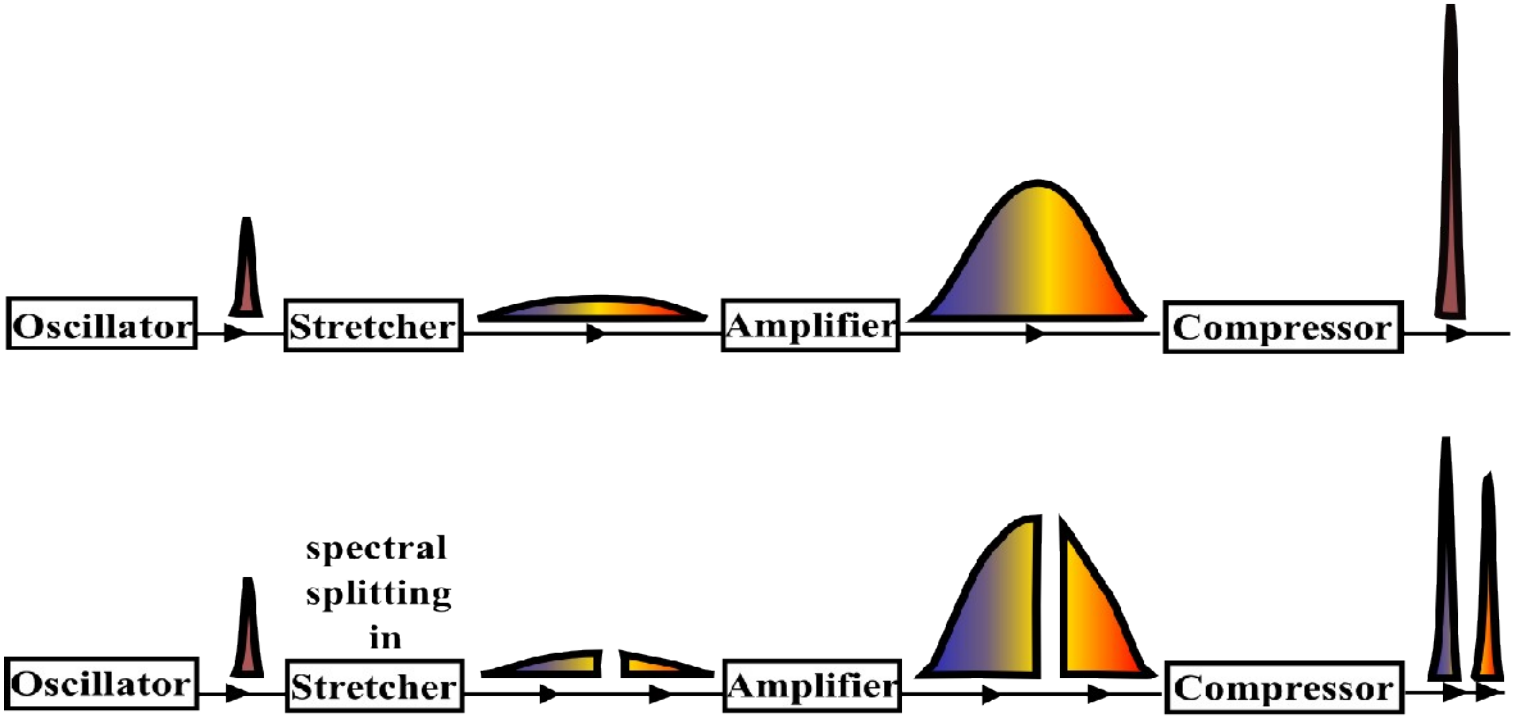


Collinear Spectral CBC

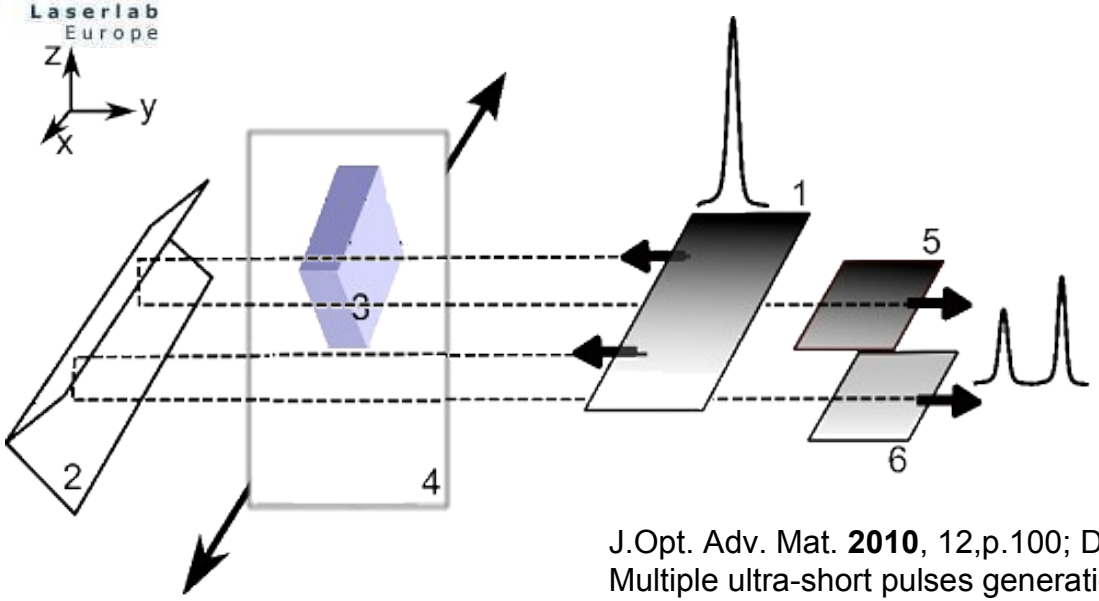
Experimental demonstration of spectral combination of ultrashort pulses

The collinear case

Idea of the experiment

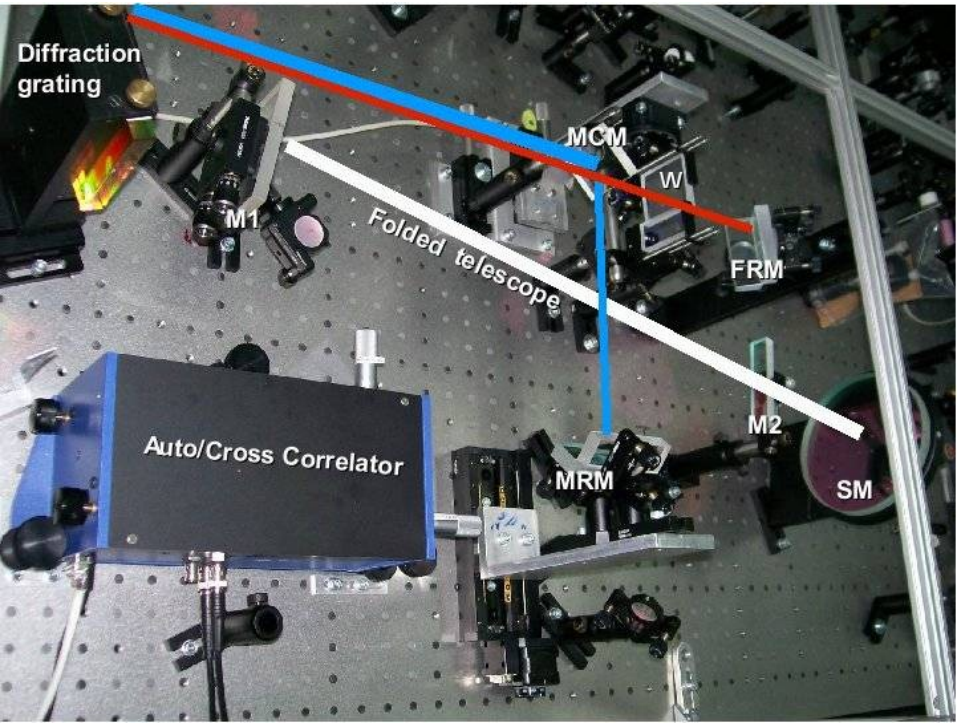


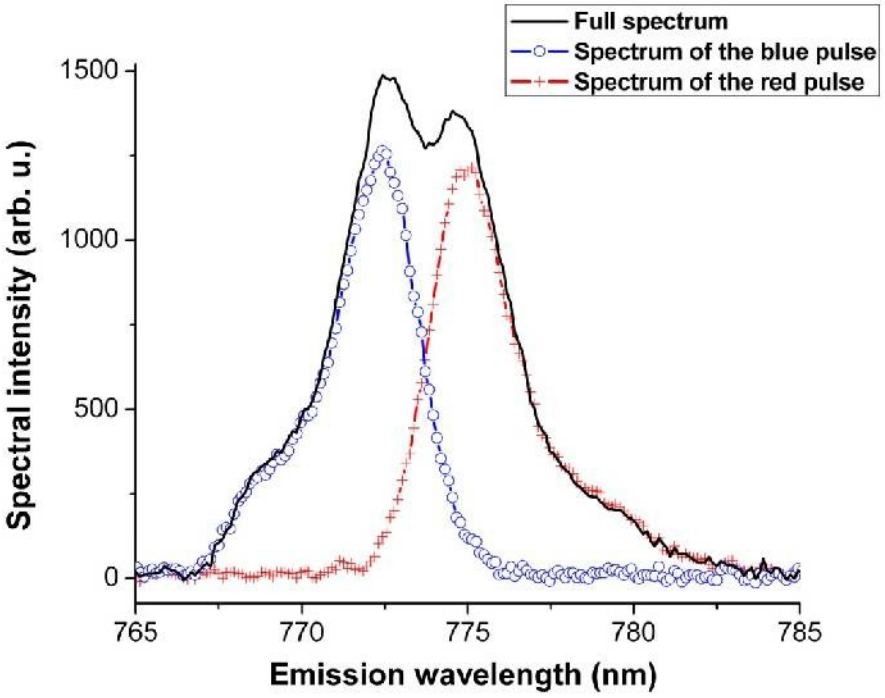
In stretcher generation of spectrally separated optical pulses



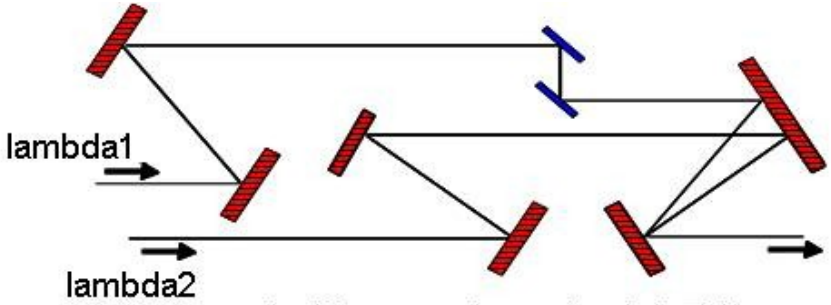
Spatial-spectral chirp

J.Opt. Adv. Mat. **2010**, 12,p.100; D. URSESCU, L. IONEL, R. BANICI, R. DABU, Multiple ultra-short pulses generation for collinear pump-probe experiments

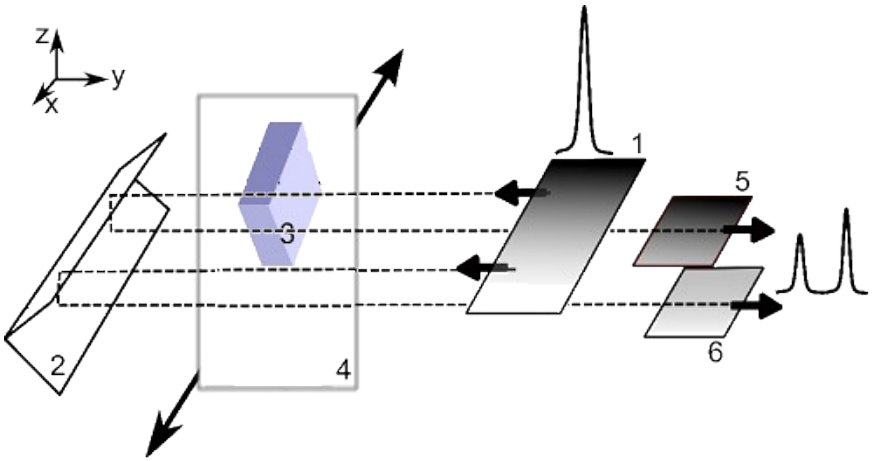


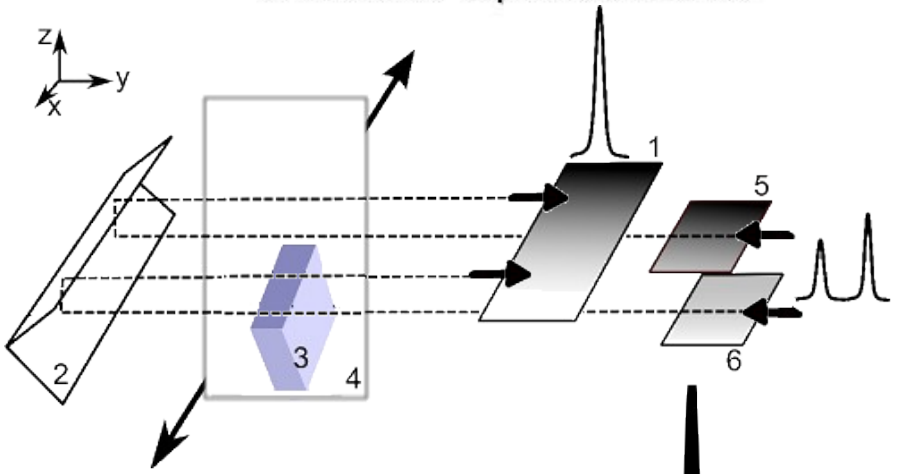


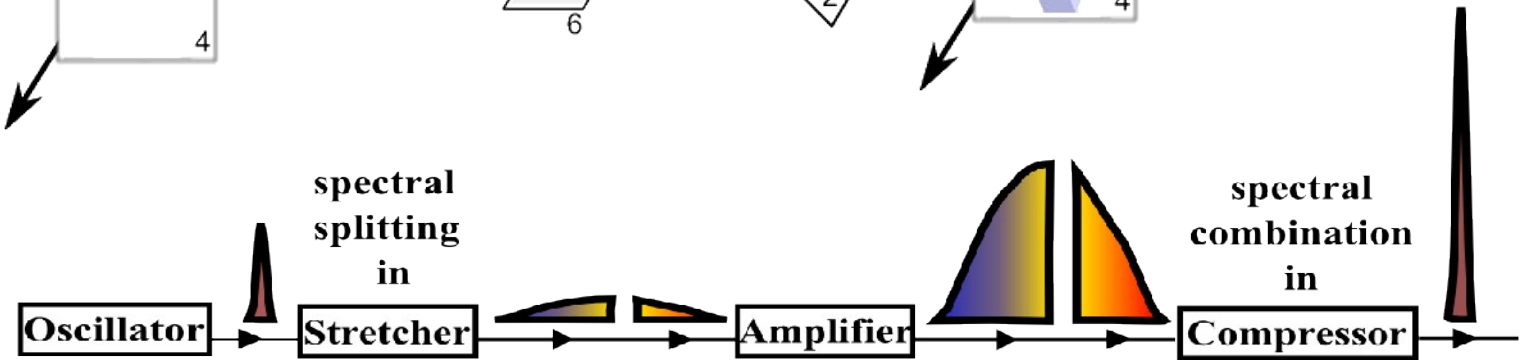
Idea of the experiment



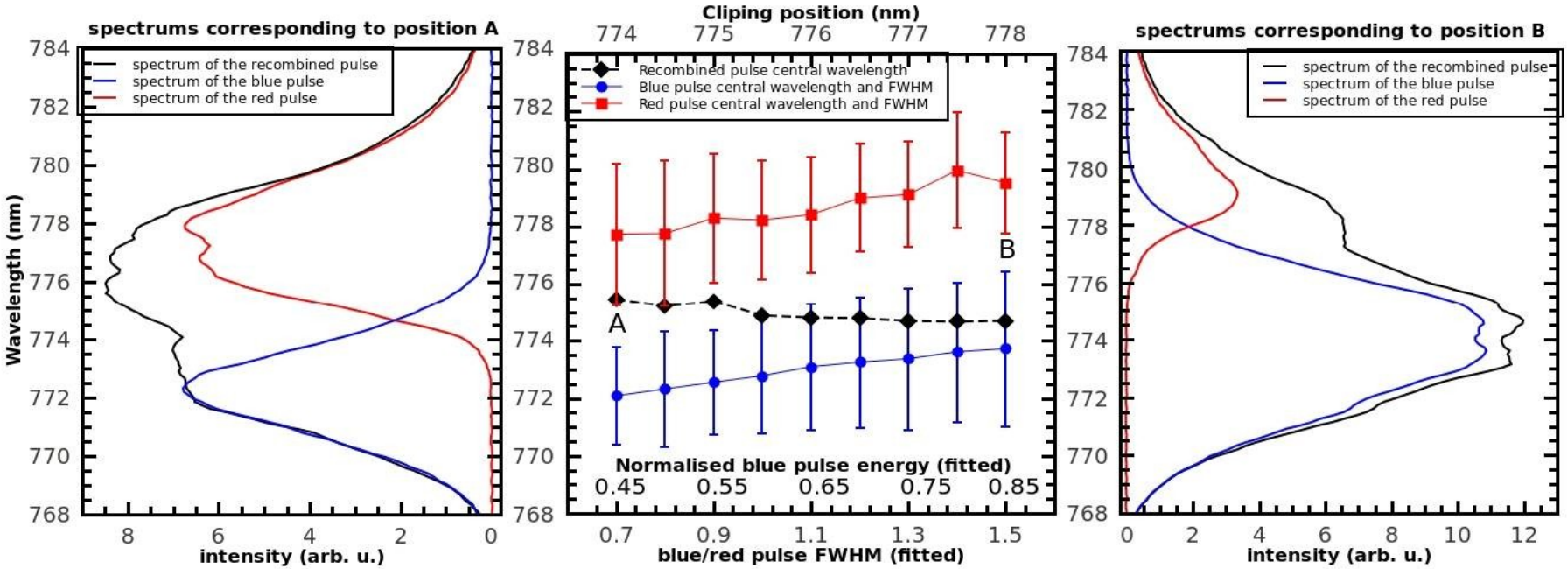
Collinear Spectral CBC



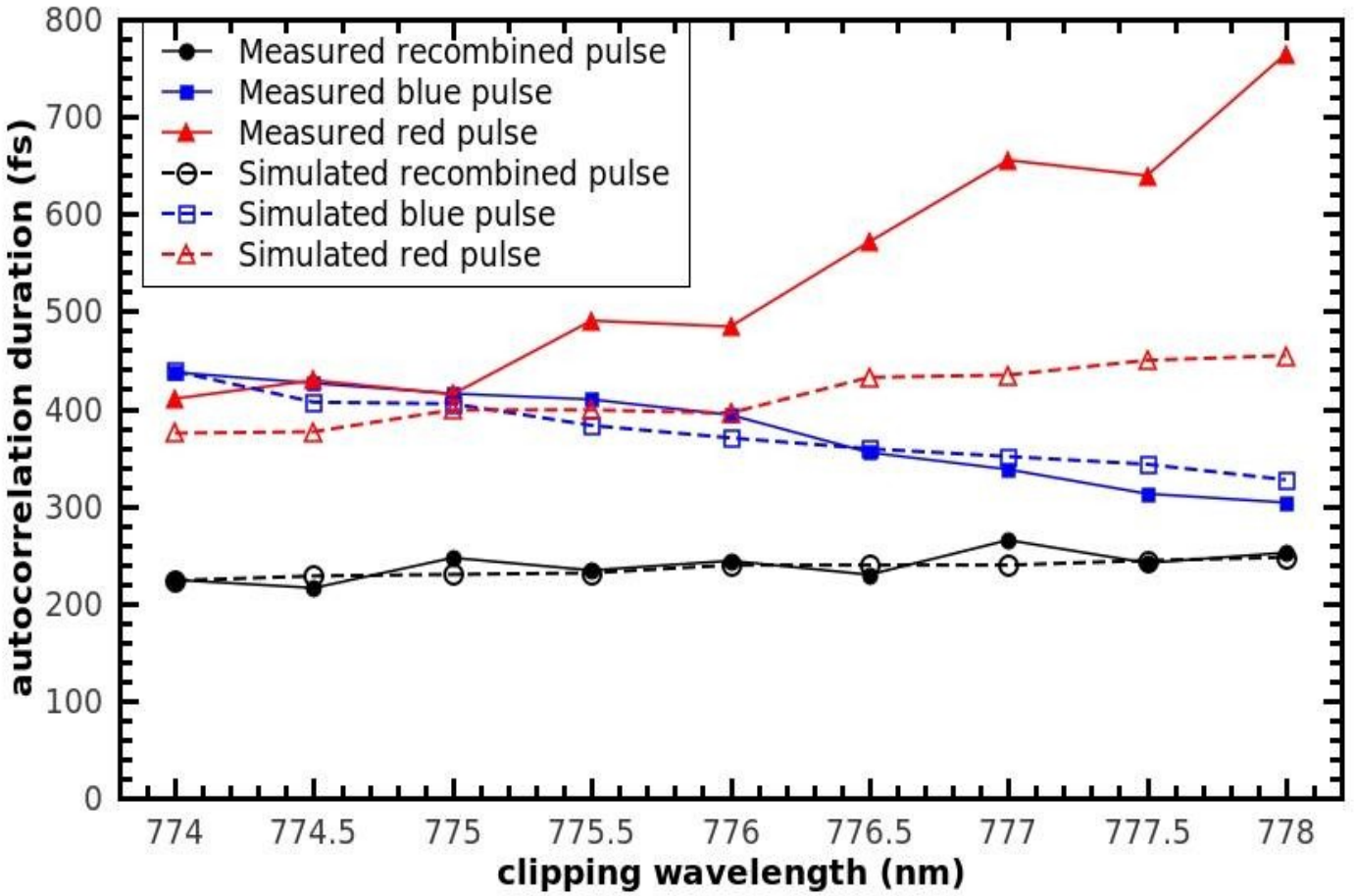




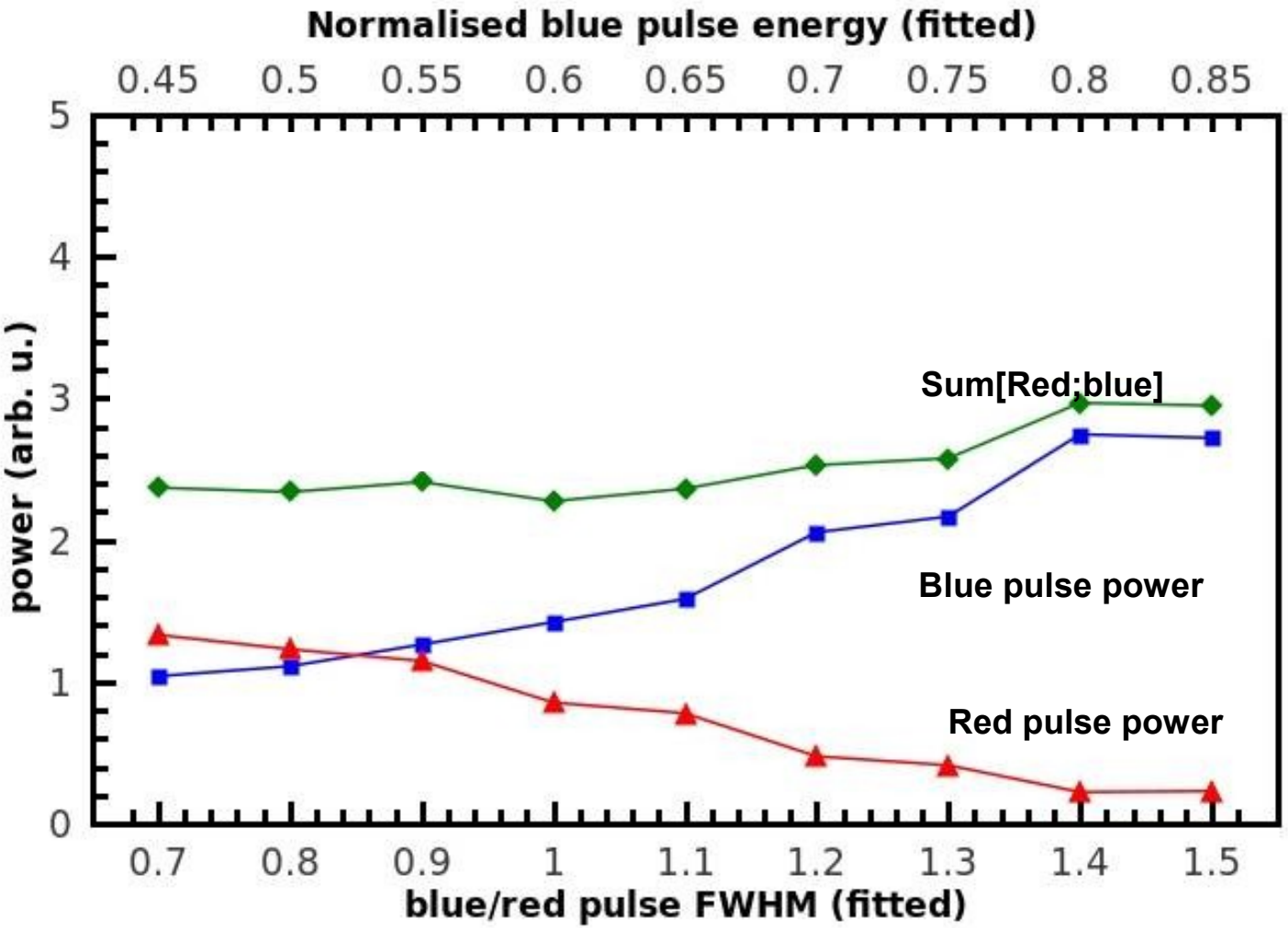
Tuning the spectral composition of the pulses



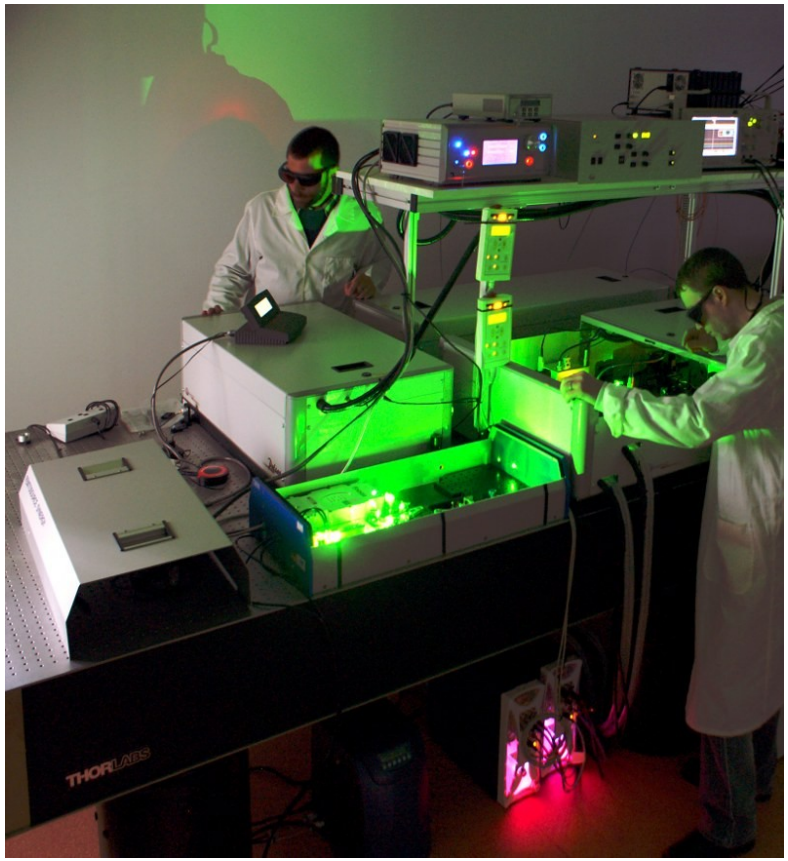
Pulse duration: autocorrelation vs. reconstruction from spectrum

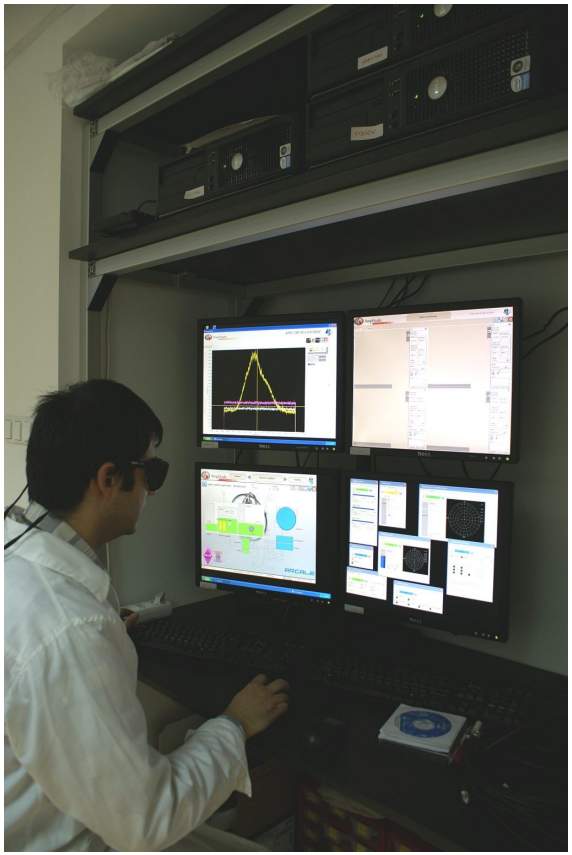


Non-linear power addition: Experimental results



1. Performances
TEWALAS facility@INFLPR





Best result: E_{pulse} = 460 mJ, Pulse-width = 23 fs, P_{peak} ≈ 20 TW

Typical value: E_{pulse} = 400 mJ, Pulse-width = 25 fs, P_{peak} > 15 TW

Conclusions

- parallelization is one possible solution for peak power up-scaling
- spectral combination solution is proposed
- in theory, the SC scales the power with the square of the number of beams
- we provided an experimental test of the SC

Outlook

CBC - From Concept to Completion

- First Step: Fringe-counting, interferometer for optical path shift monitoring;