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Anastasiia Sheveleva, Christophe Finot

## ► To cite this version:

Anastasiia Sheveleva, Christophe Finot. All-fibered high-quality 28-GHz to 112 GHz pulse sources based on nonlinear compression of optical temporal besselons. Conference on Lasers & Electro-Optics Europe, Jun 2021, Munich, Germany. pp.CD-P18. <hal-03183255>

**HAL Id: hal-03183255**

**<https://hal.science/hal-03183255v1>**

Submitted on 31 May 2021

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# All-fibered high-quality 28 GHz to 112 GHz pulse sources based on nonlinear compression of optical temporal besseles

A. Sheveleva, C. Finot

Laboratoire Interdisciplinaire Carnot de Bourgogne, UMR 6303 CNRS-Université Bourgogne Franche-Comté, 21000 Dijon, France

## Introduction

**GOAL** : generation of high-quality pulse trains at high repetition rates

**Besselon** waveform [1] :

1. CW + temporal sinusoidal phase

$$\psi(t) = \exp(iA_m \cos(\omega_m t))$$

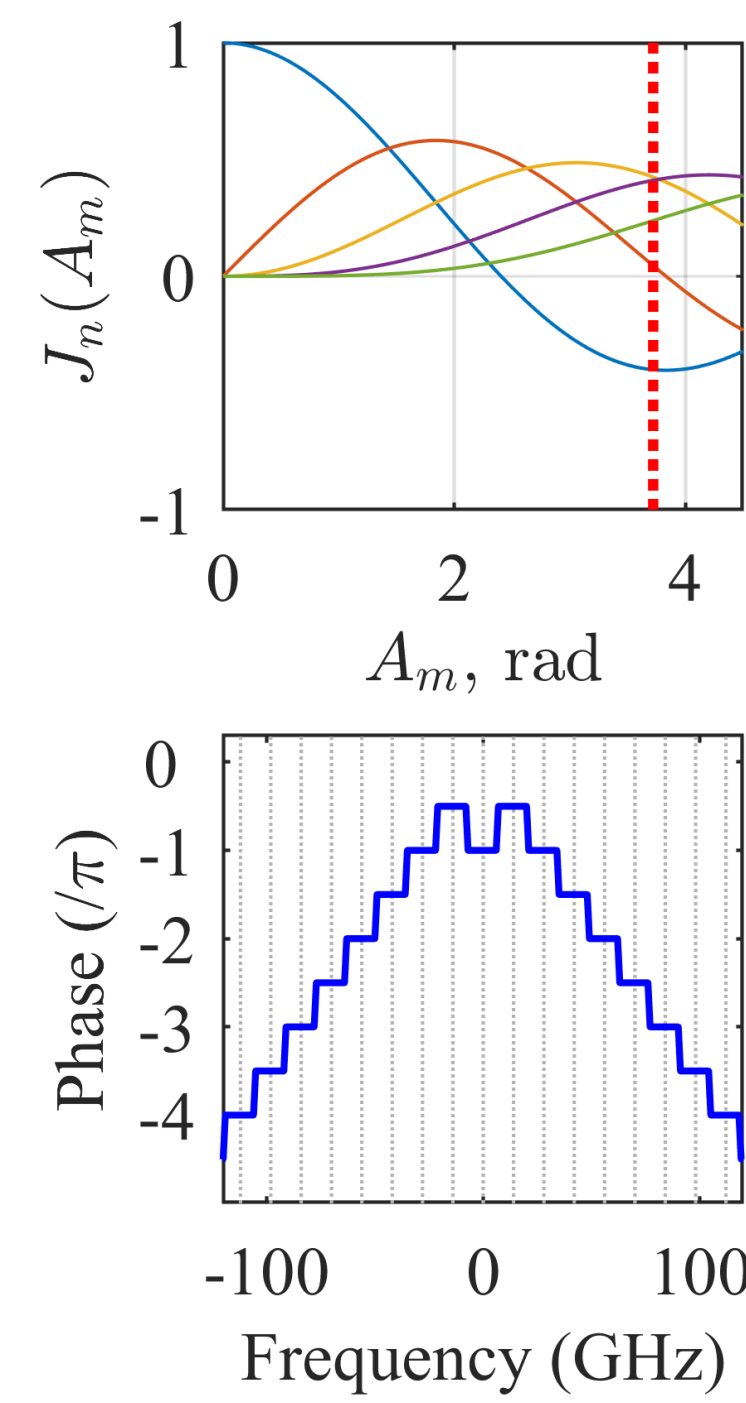
⇒ Jacobi-Anger expansion :

$$\psi(t) = \sum_{-\infty}^{\infty} J_n(A_m) \exp(in\omega_m t)$$

$\omega_m = 2\pi f_m$  - repetition rate

$A_m$  - modulation amplitude (rad)

$J_n$  - Bessel function of the first kind of order  $n$



⇒ subsequent spectral lines have a  $\pi/2$  phase shift

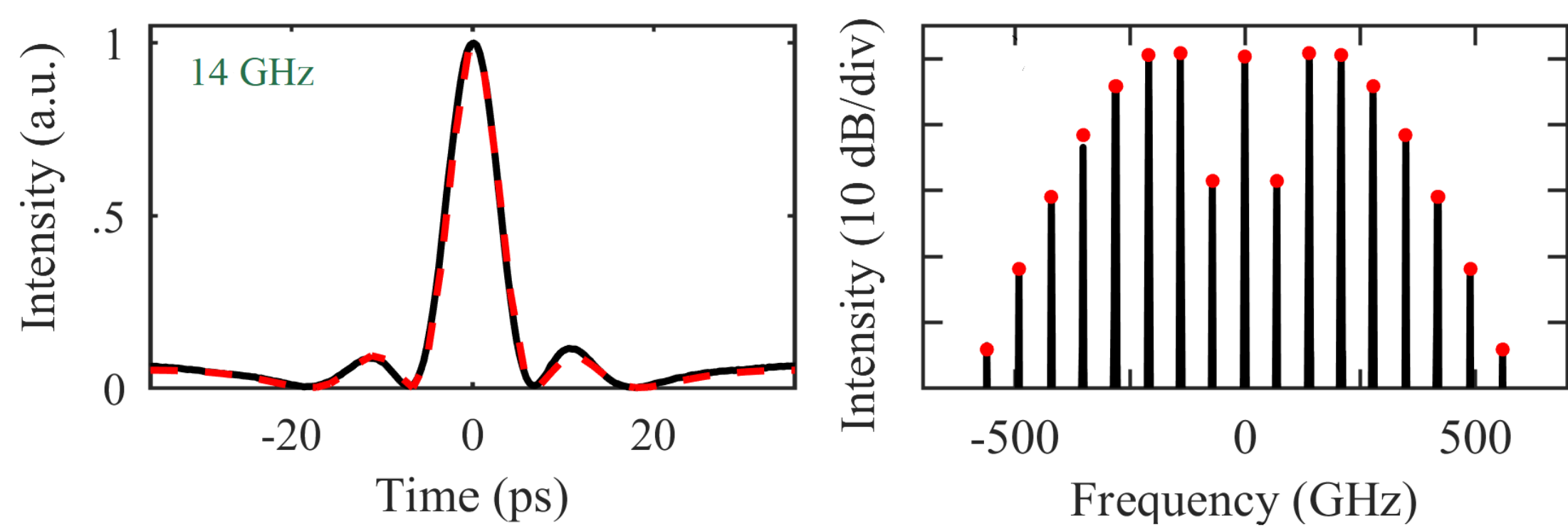
2. Triangular spectral phase to cancel out the phase offset [2]

⇒ Fourier transform limited waveform

⇒ high extinction ratio

⇒ full theoretical description available

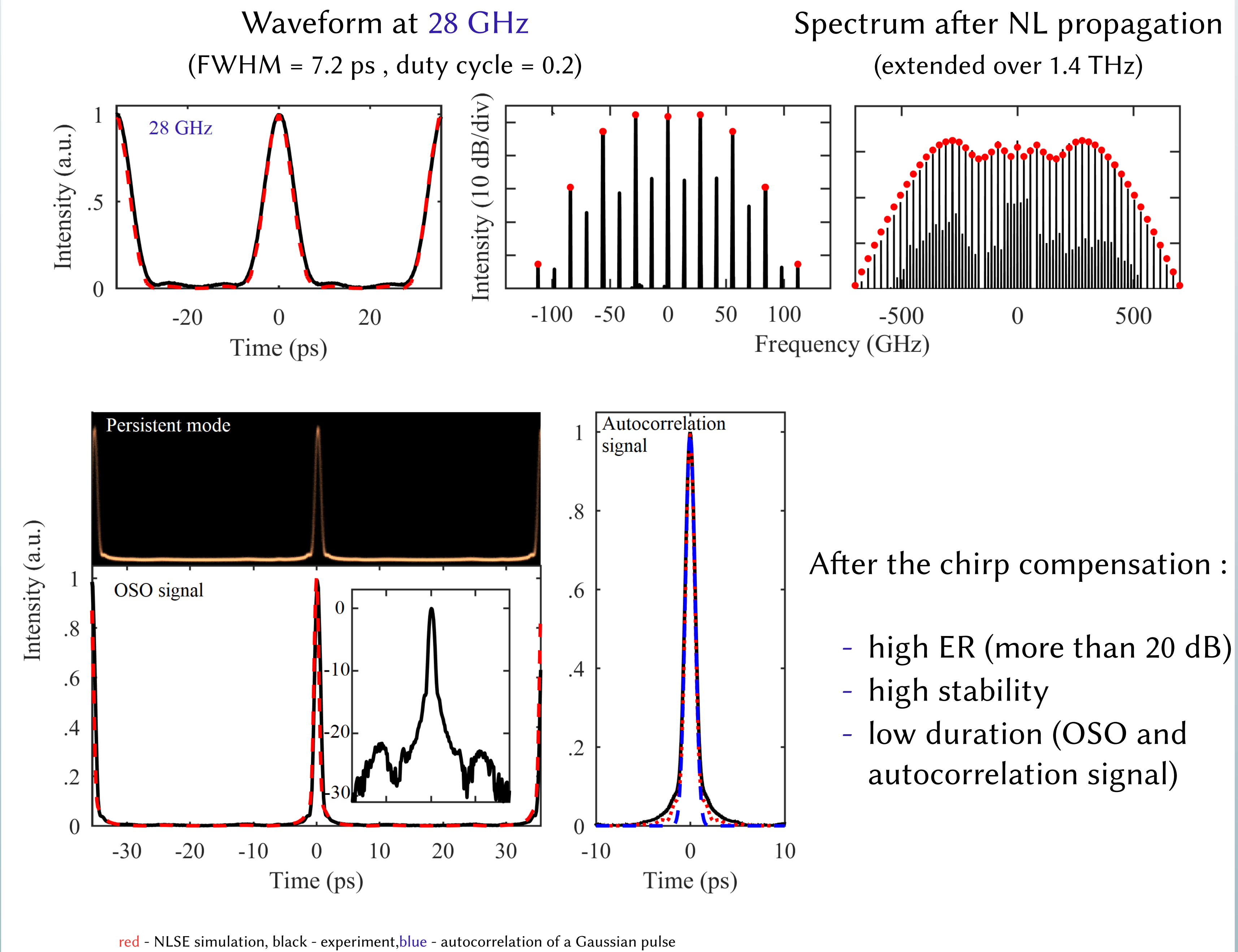
Besselon waveform generated at 14 GHz and  $A_m = 3.72$  rad (FWHM = 7.2 ps, duty cycle = 0.2)



red - theory, black - experiment

## Results at 28 GHz, 56 GHz and 112 GHz

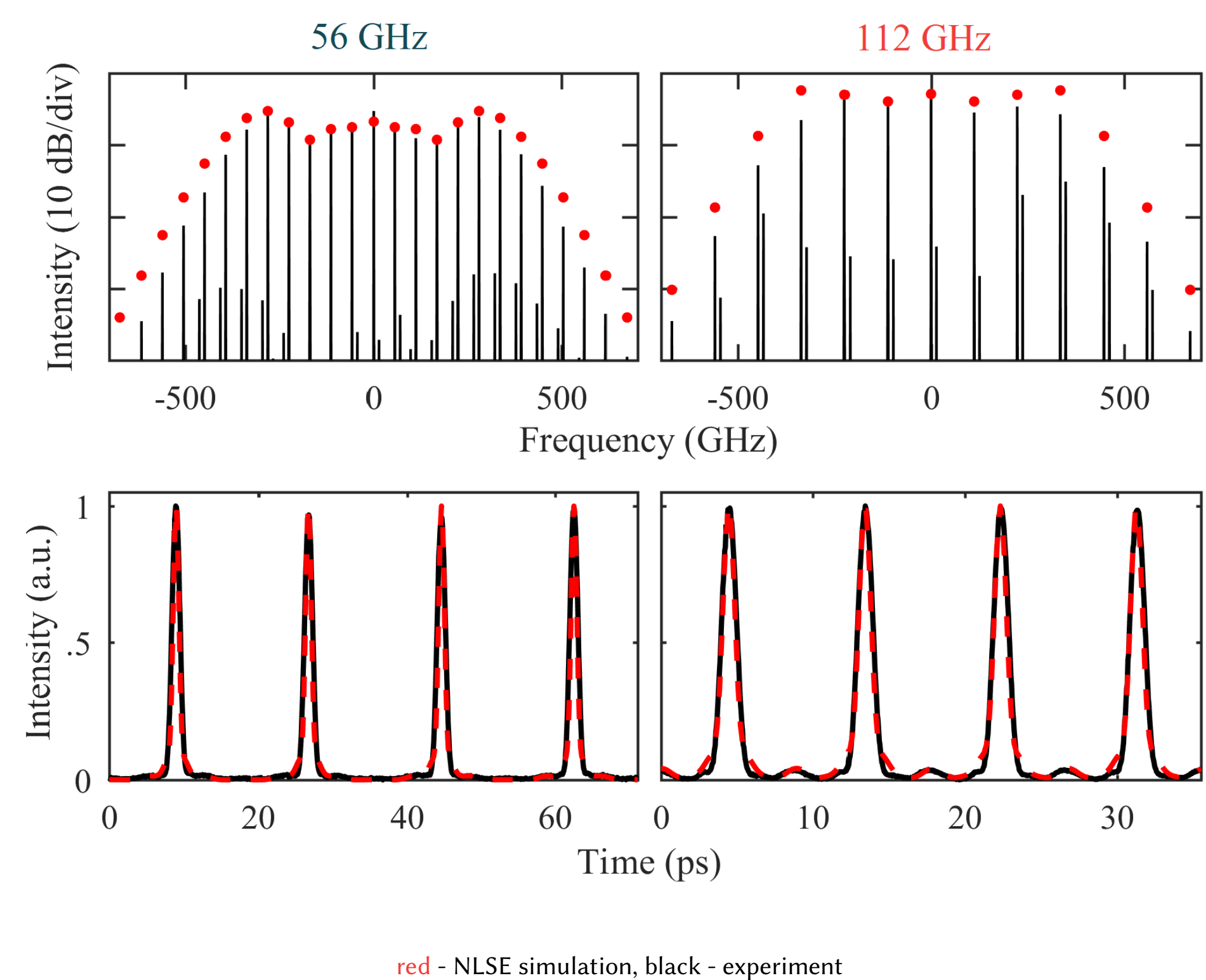
1. Phase-notch filter to multiplex the repetition rate before the nonlinear stage [3]



After the chirp compensation :

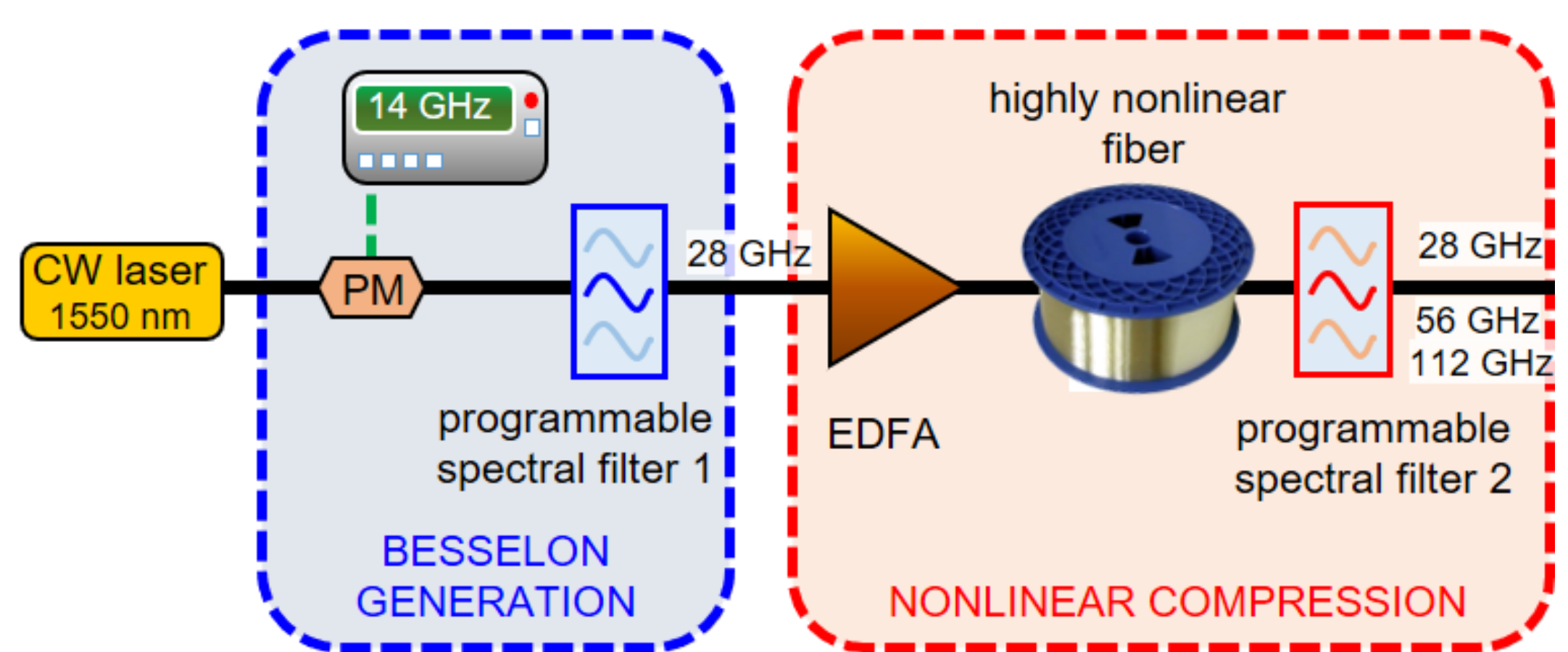
- high ER (more than 20 dB)
- high stability
- low duration (OSO and autocorrelation signal)

2. Attenuation of spectral lines of the NL-broadened spectrum to further multiplex



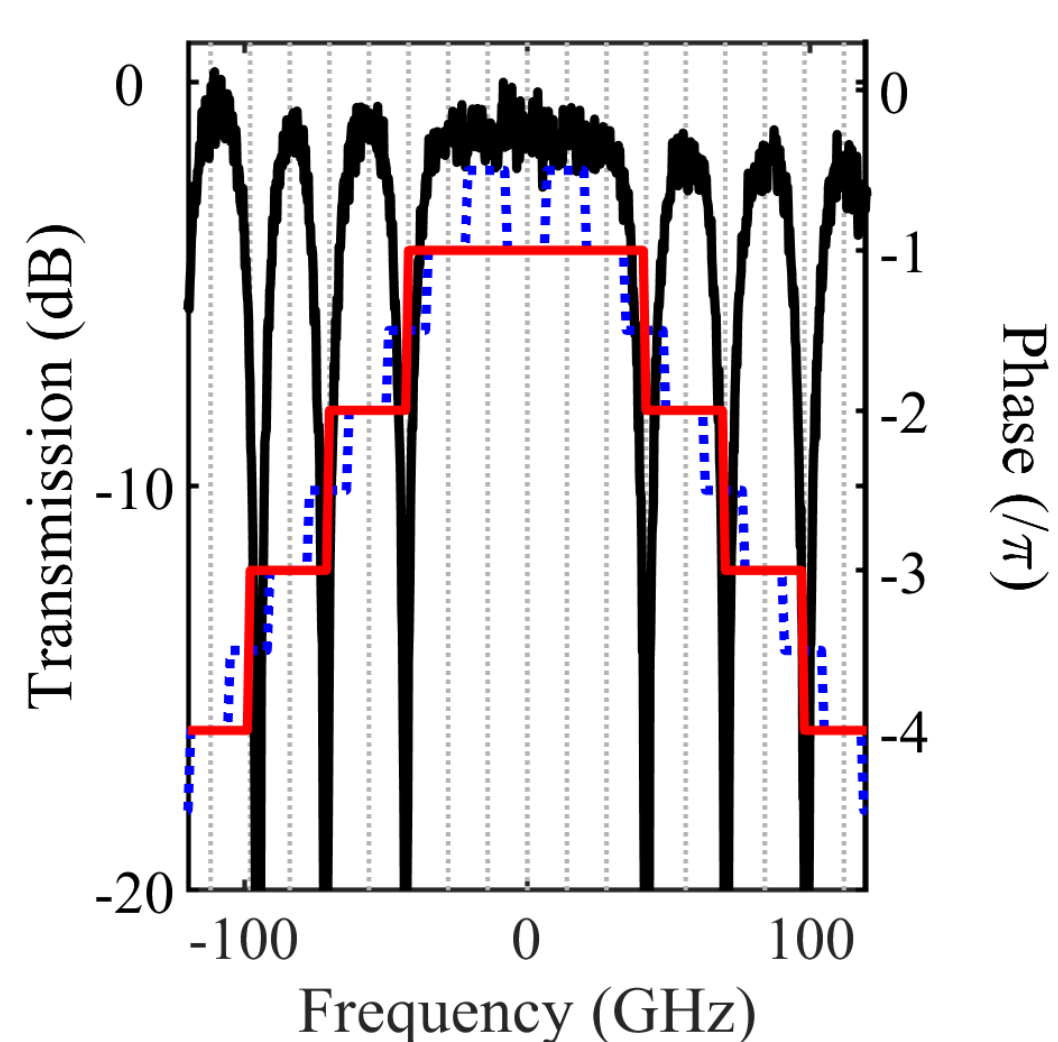
	28 GHz	56 GHz	112 GHz
FWHM, ps	0.78	0.83	0.94
Duty cycle	0.022	0.074	0.105

## Experimental setup



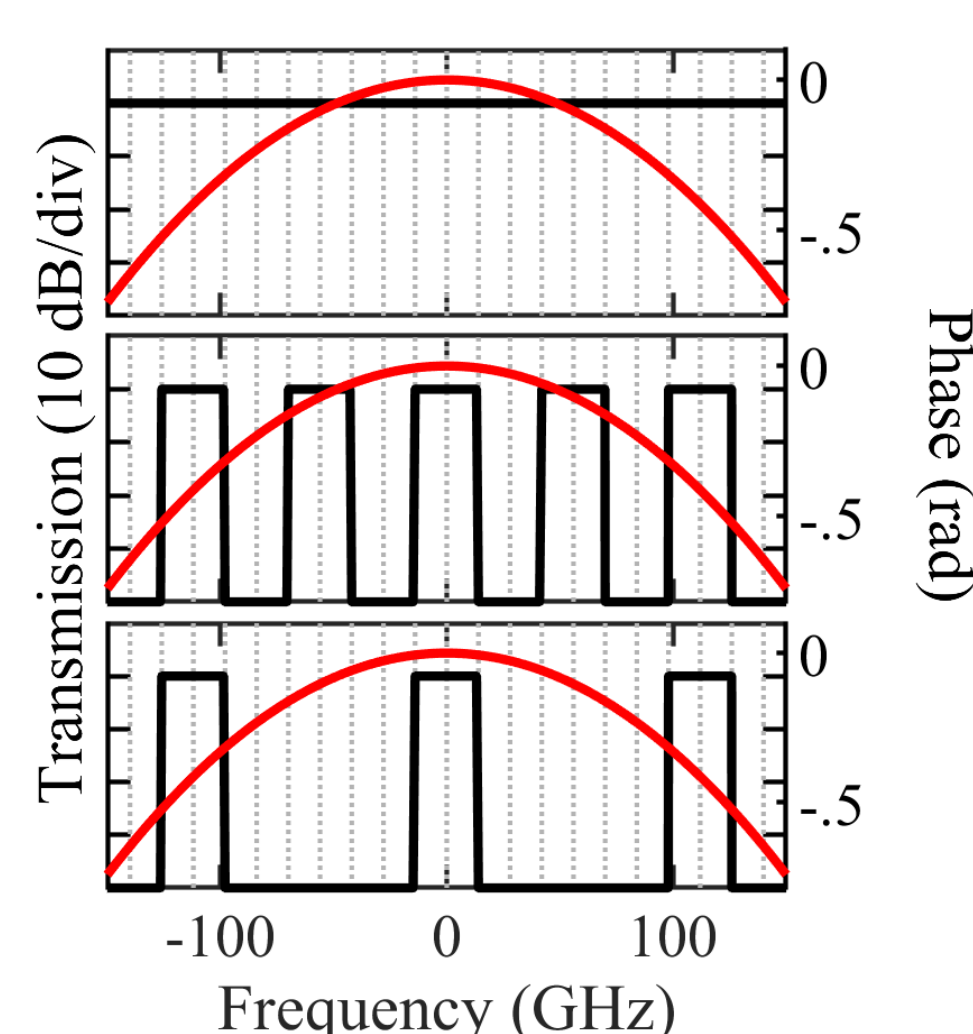
### WaveShaper 1

- Only phase profiles for 14 GHz (blue) or for 28 GHz (red)
- black - ASE signal



### WaveShaper 2

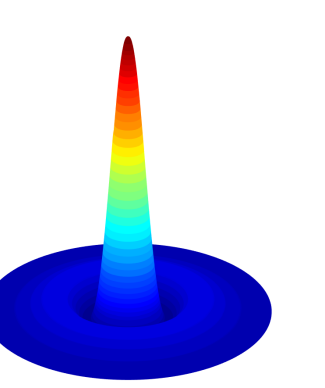
- Quadratic spectral phase for chirp compensation (red)
- Filters used for multiplexing (black)



HNLF :  $L = 1$  km,  $\gamma = 10$  /W/km,  $\beta_2 = 0.89$  ps<sup>2</sup>/km,  $\alpha = 0.5$  dB/km

## Conclusion

- high repetition-rate source
- simple setup (single phase modulator)
- high-quality pulse trains at 14 GHz, 28 GHz, 56 GHz and 112 GHz



## References

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5. D. Marion and J. Lhermite, "Electro-optically modulated lasers: pulse energy and contrast enhancement derived from theoretical spectrum," *Opt. Lett.* 45, 2664-7 (2020)

