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

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Introduction

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

Besselon waveform [1] :

1. CW + temporal sinusoidal phase

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

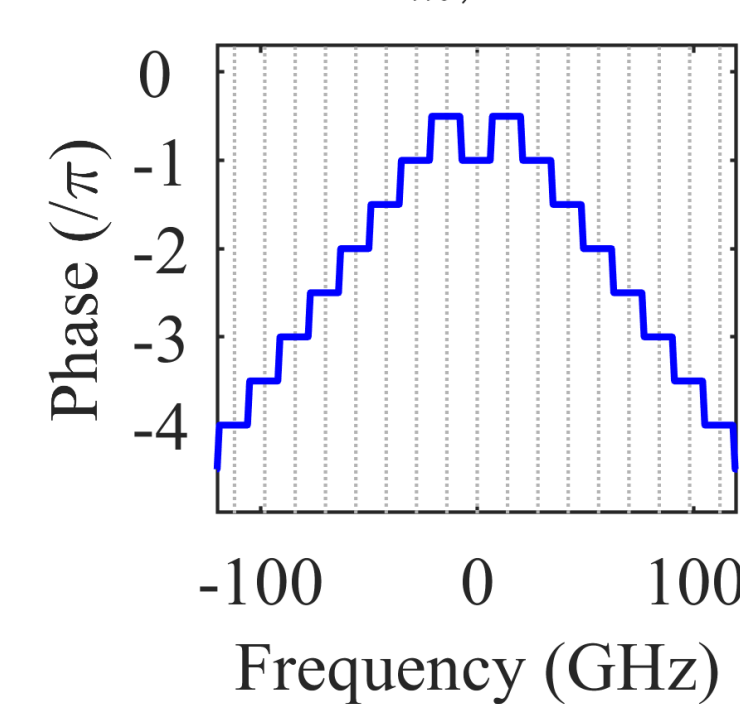
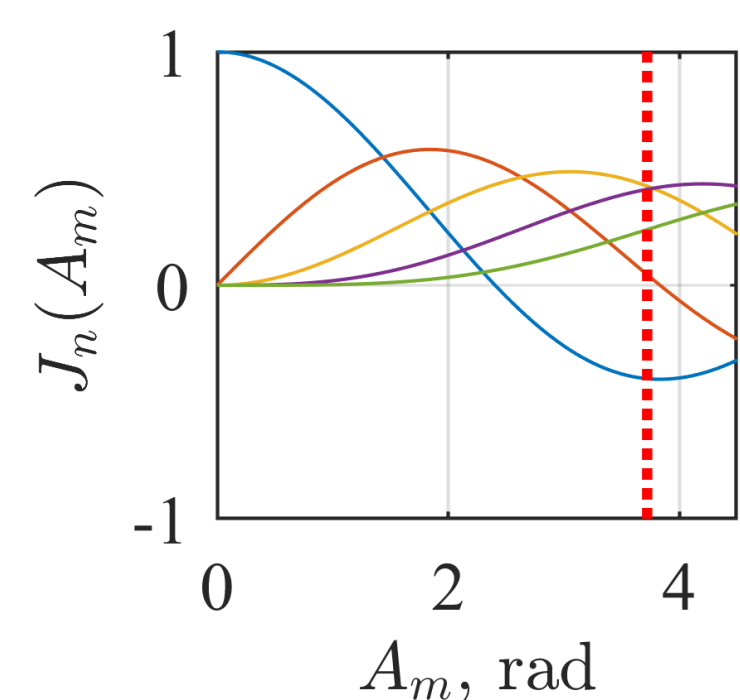
⇒ Jacobi-Anger expansion :

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

$\omega_m = 2\pi f_m$ - 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

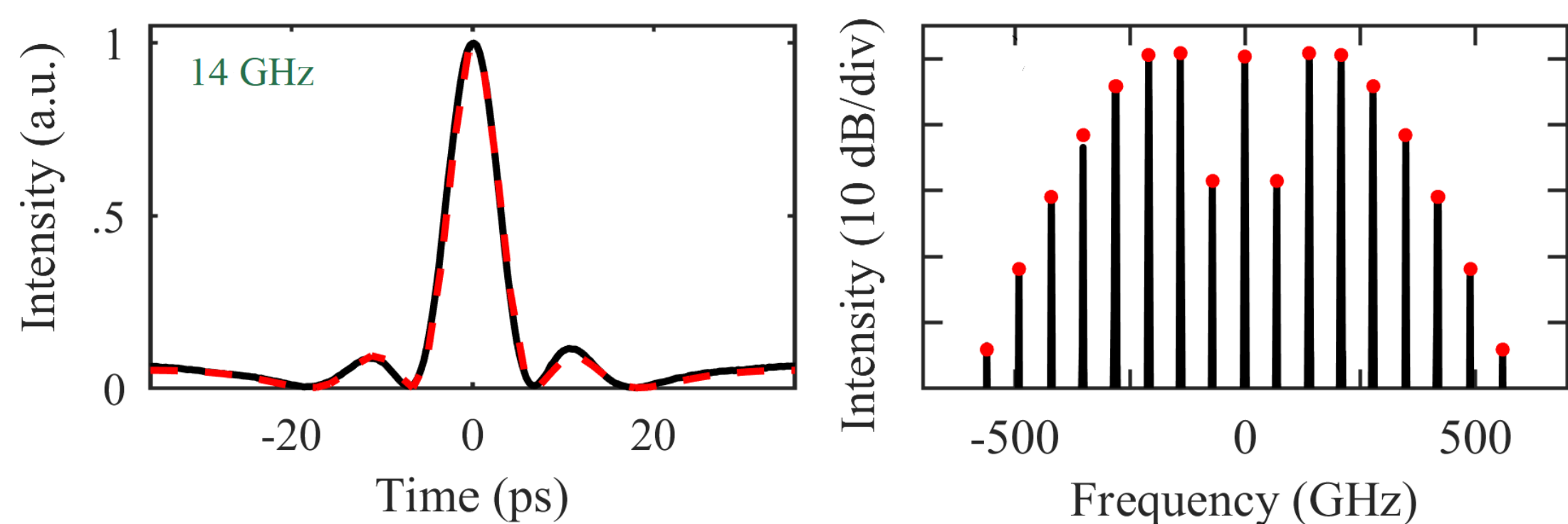
2. Triangular spectral phase to cancel out the phase offset [2]

⇒ Fourier transform limited waveform

⇒ high extinction ratio

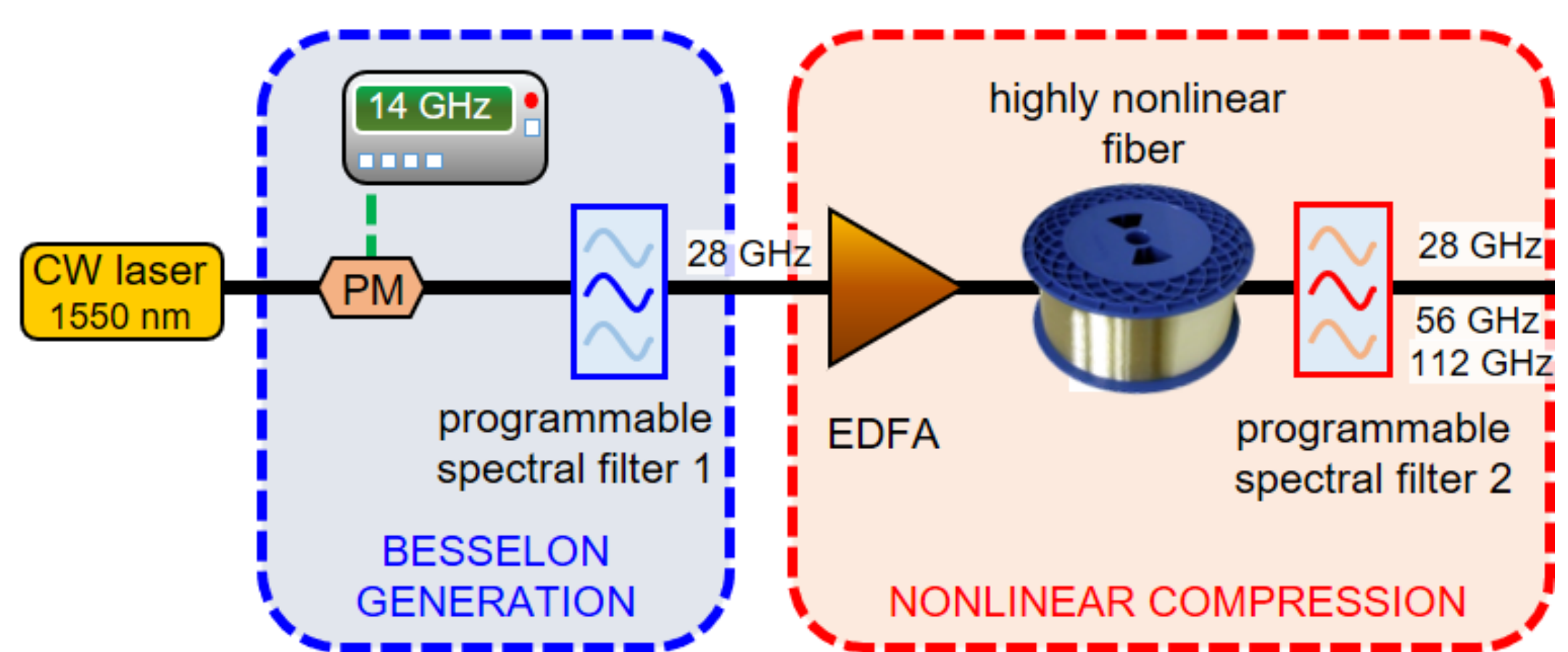
⇒ full theoretical description available

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



red - theory, black - experiment

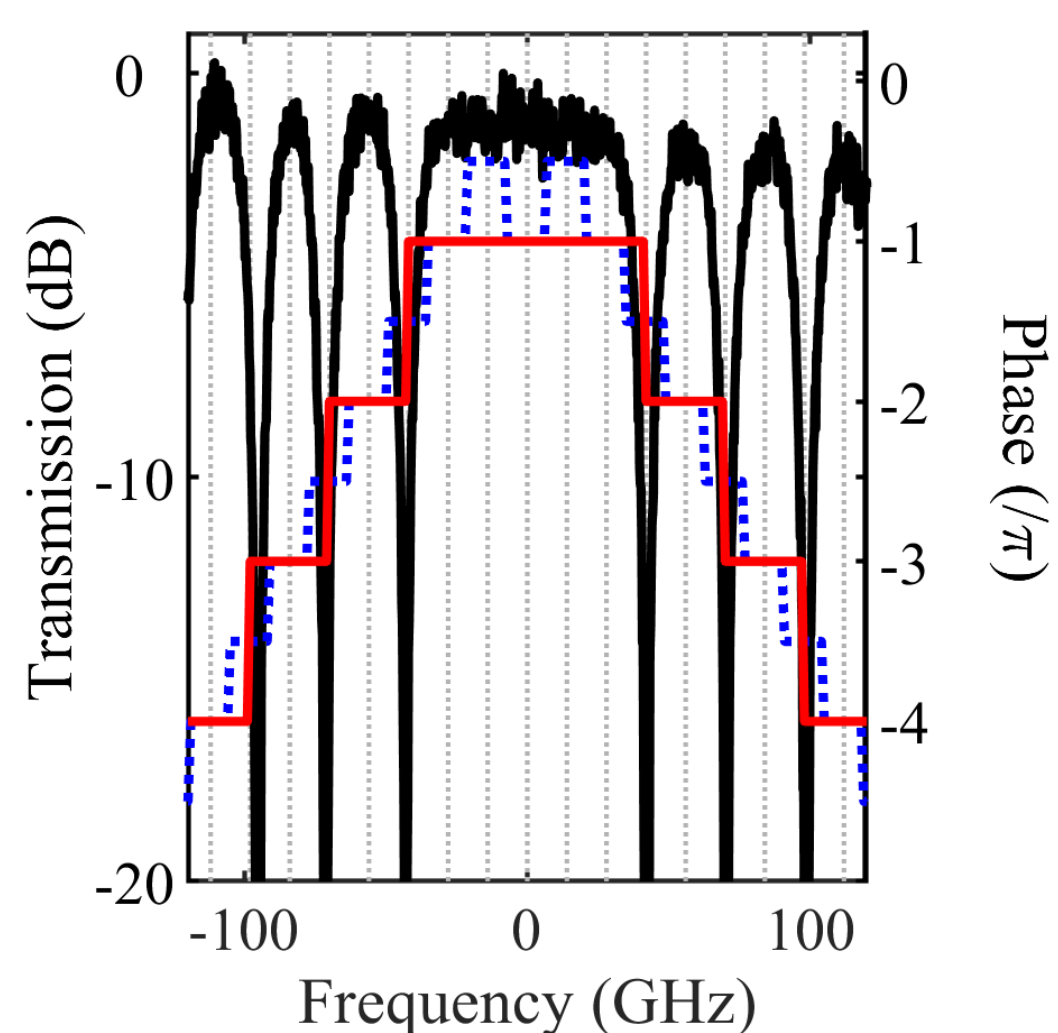
Experimental setup



WaveShaper 1

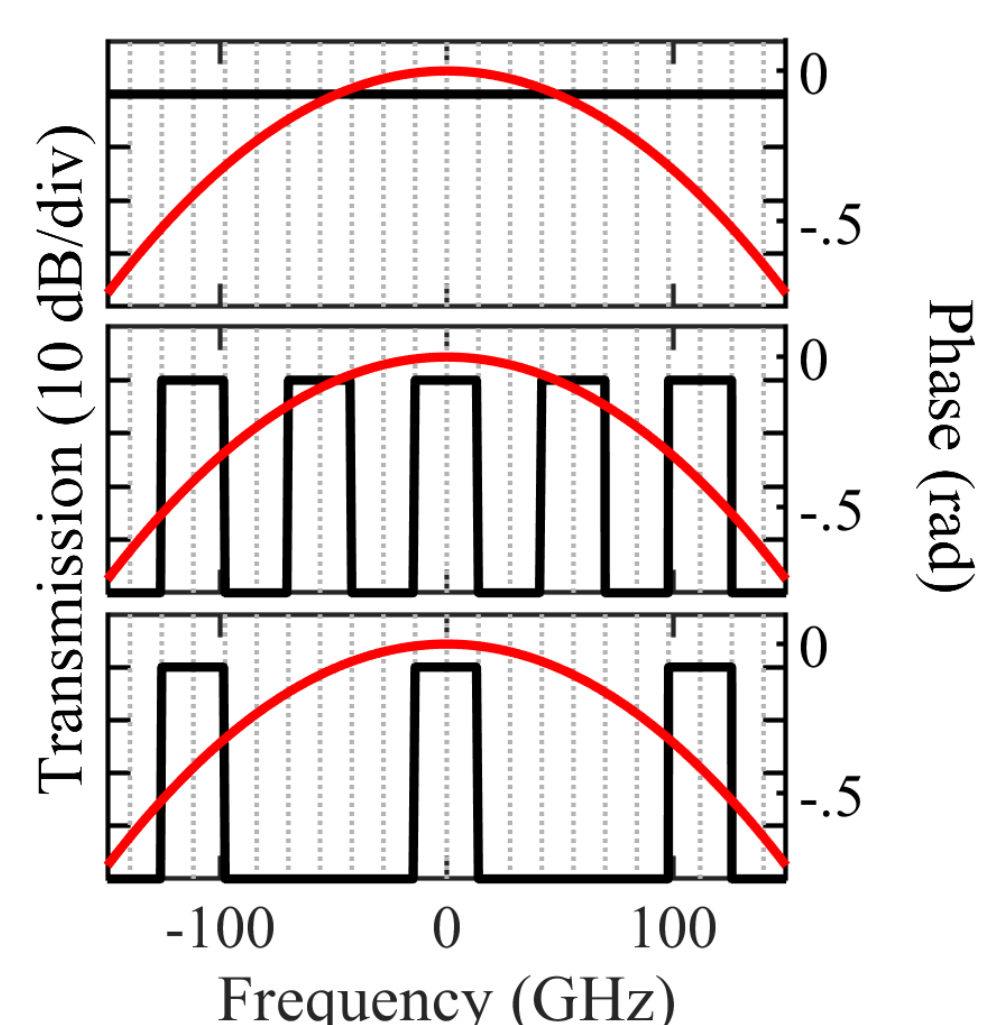
- Only phase profiles for 14 GHz (blue) or for 28 GHz (red)

black - ASE signal



WaveShaper 2

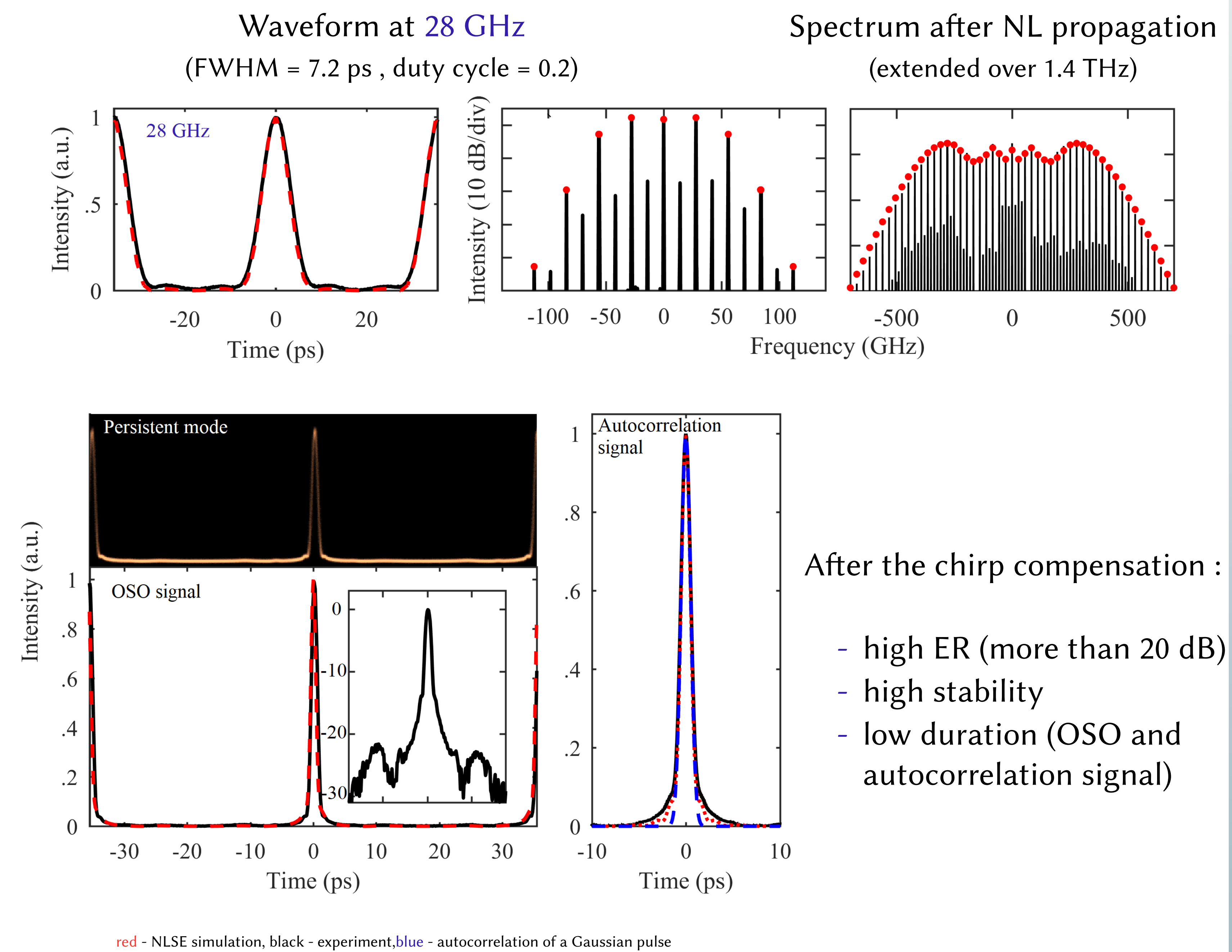
- Quadratic spectral phase for chirp compensation (red)
- Filters used for multiplexing (black)



HNLF : $L = 1$ km, $\gamma = 10$ /W/km, $\beta_2 = 0.89$ ps²/km, $\alpha = 0.5$ dB/km

Results at 28 GHz, 56 GHz and 112 GHz

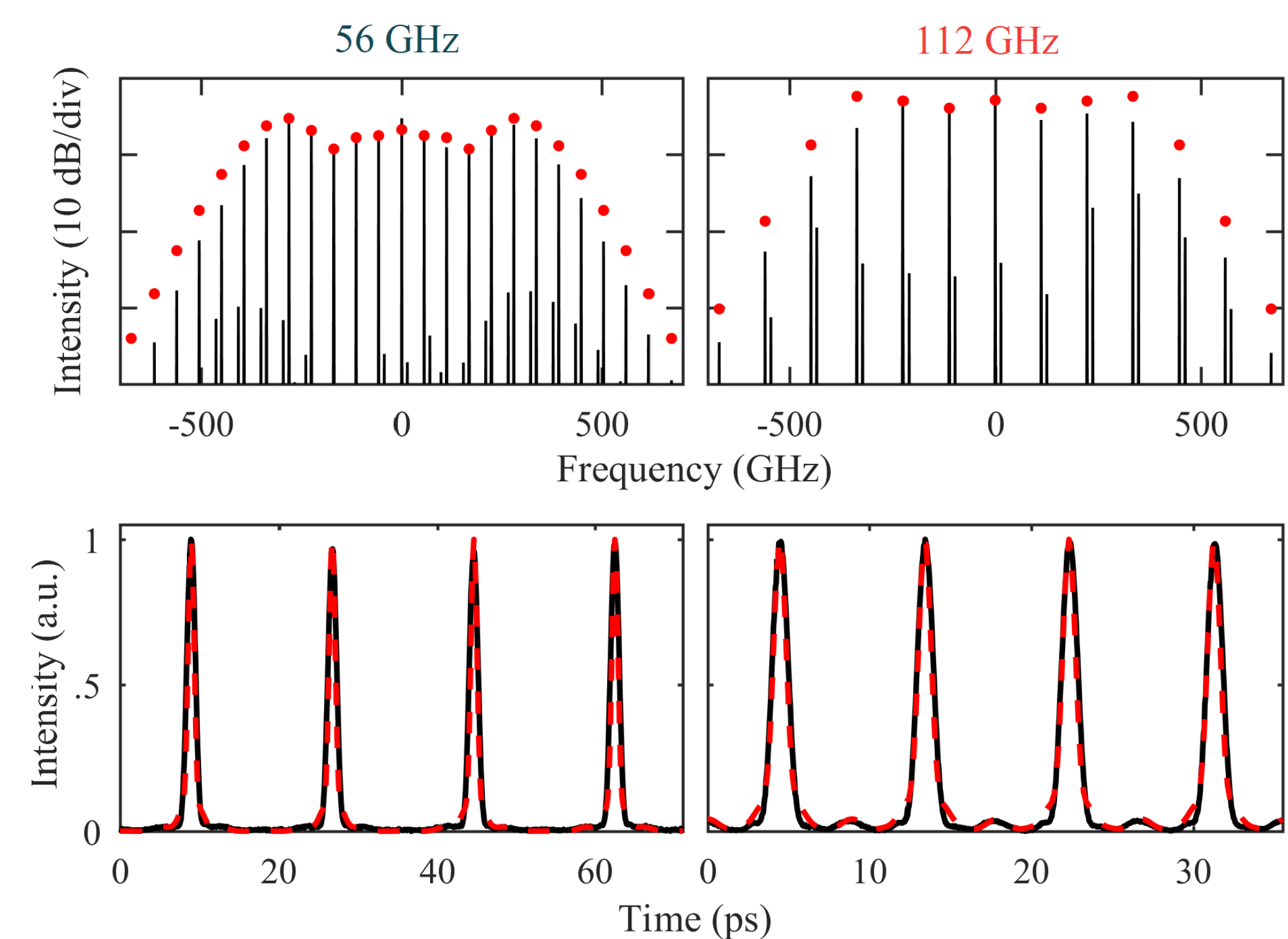
1. Phase-notch filter to multiplex the repetition rate before the nonlinear stage [3]



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

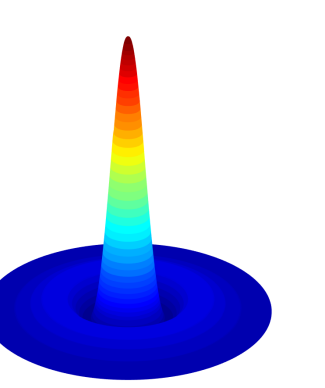


red - NLSE simulation, black - experiment

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

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)

