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# Pulse doublets generated by a frequency-shifting loop containing an electro-optic amplitude modulator

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## Introduction

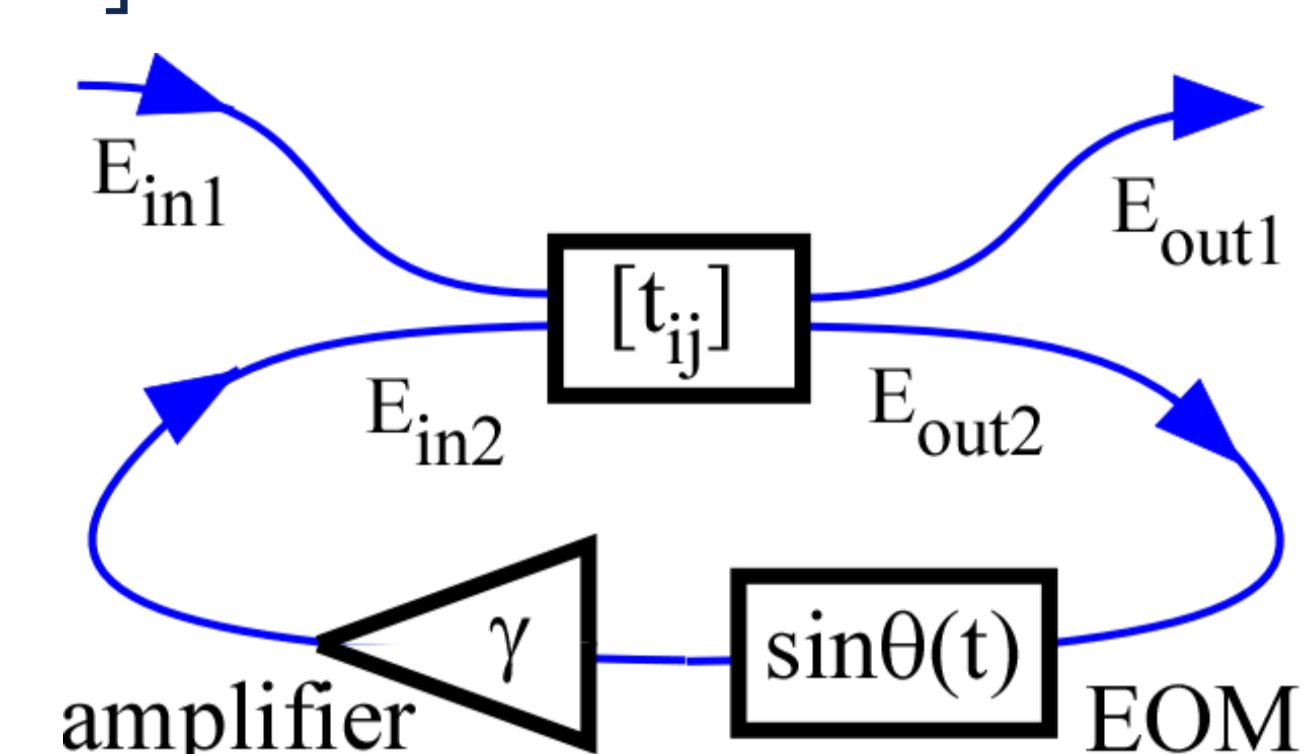
Frequency-Shifted feedback Loops FSL, both active or passive, are promising solutions for pulse generation with high repetition rate. FSL usually contains an acousto-optic frequency shifter AOFS for single-side band modulation [1-3].

This leads to limited tunability and low modulation frequency  $f_m$ .

**Conversely:** the use of in-loop electro-optic amplitude modulators EOM permits high modulation, wide bandwidth and integration [4-5].

However, due to dual-side band modulation, EOM lead to new regimes

→ Here, theoretical and experimental study of FSL with EOM



## Theoretical model

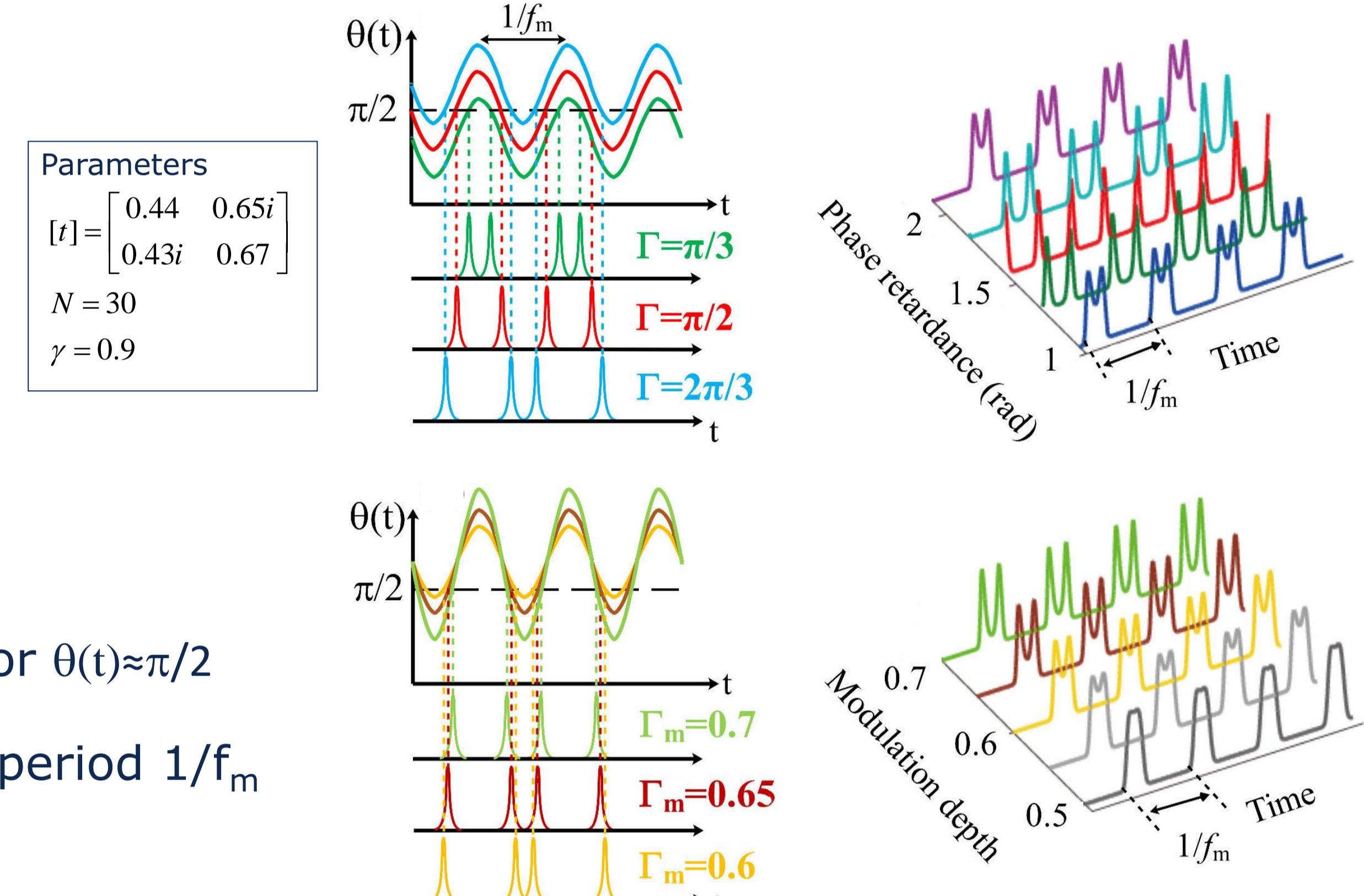
$E_{in1}$  CW:

$$E_{out1}(t) = \left( t_{11} + t_{12}t_{21} \sum_{p=1}^N \left( t_{22}^p \gamma^p \prod_{q=1}^p \sin(\theta(t-q\tau)) \right) \right) E_{in1}$$

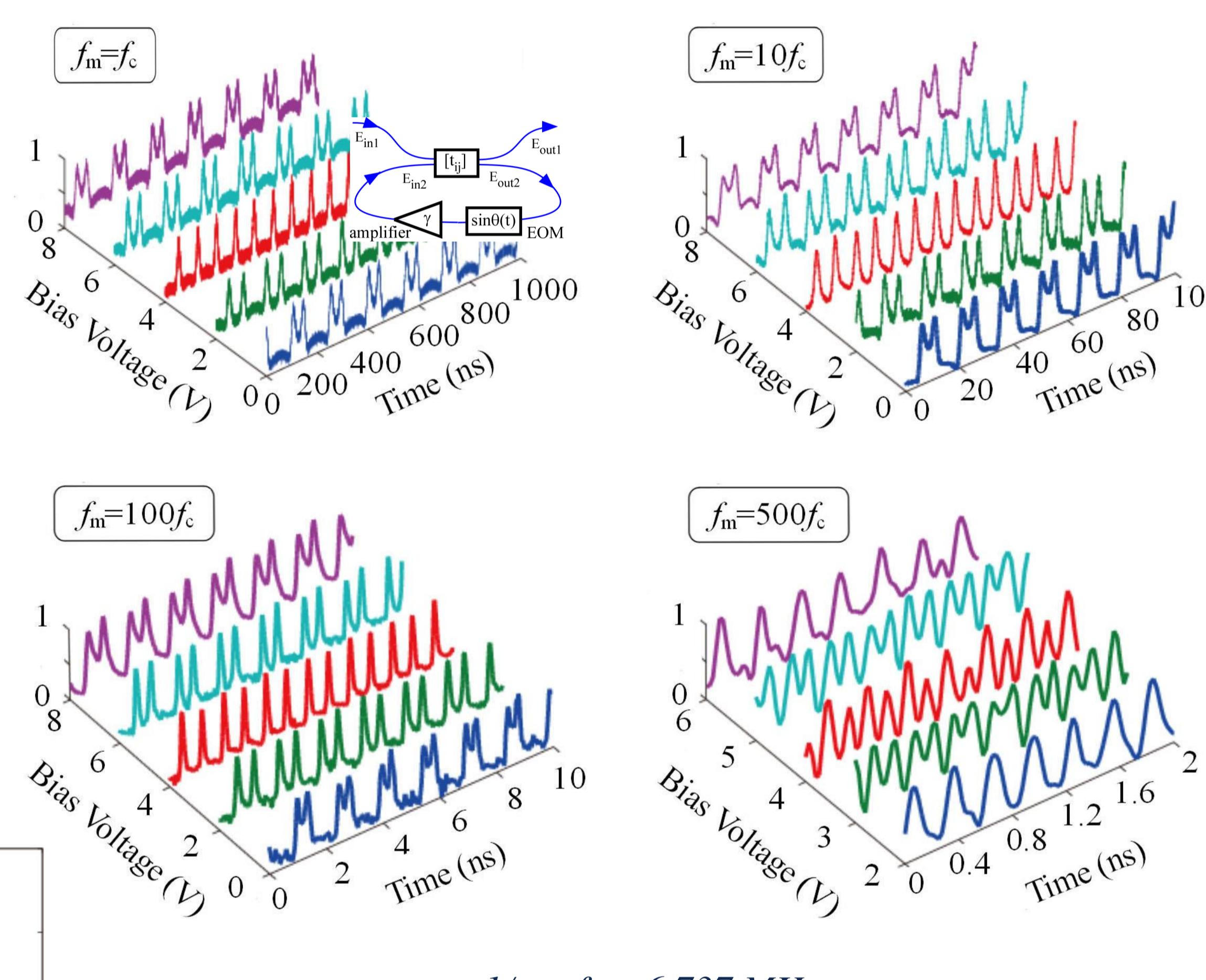
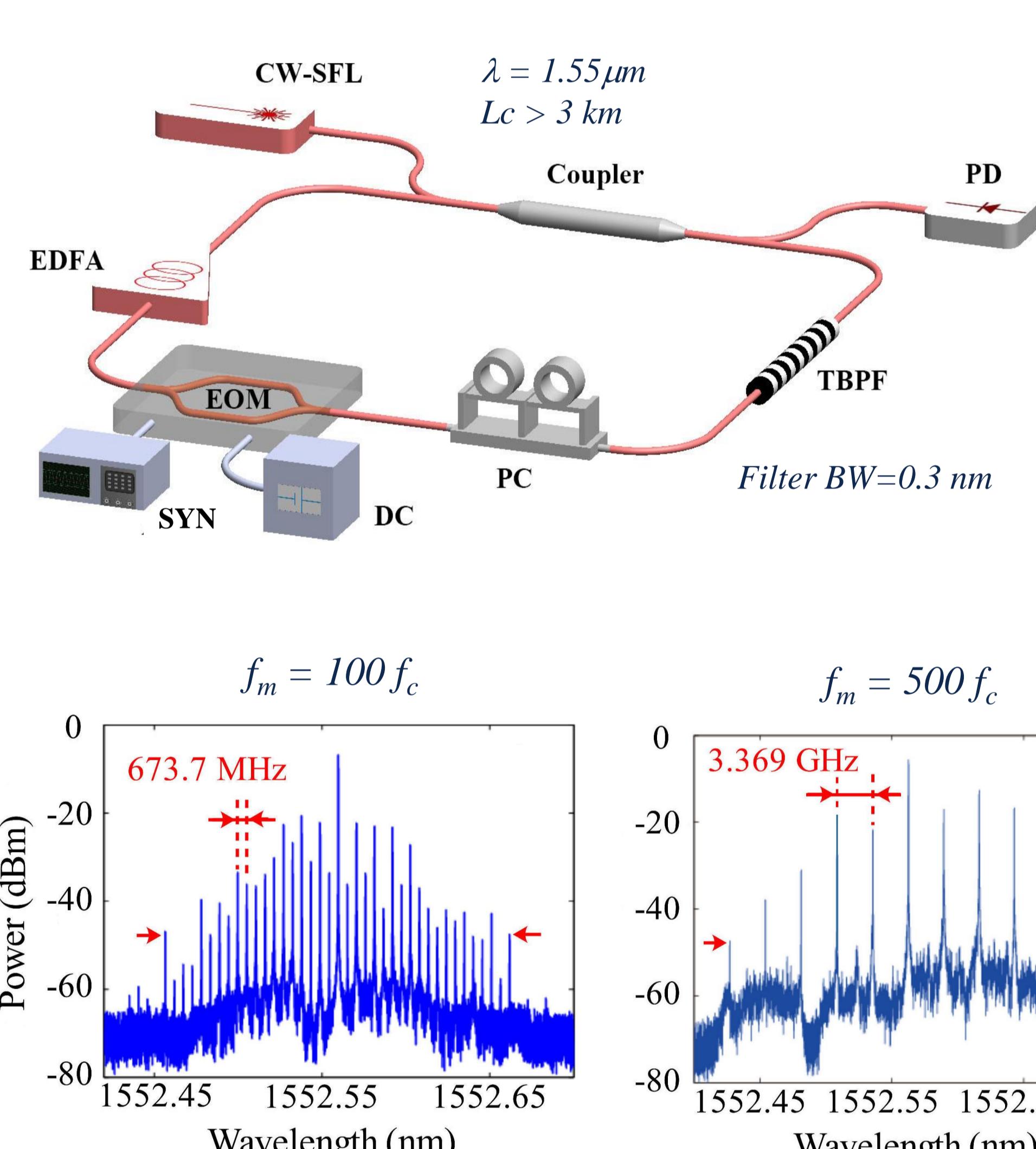
With modulation at  $f_m$ :  $\theta(t) = \Gamma + \Gamma_m \sin(2\pi f_m t)$   $\Gamma$  phase retardance  $\Gamma_m$  modulation depth

For integer Talbot condition [1-2]:  $f_m = n/\tau$

$$\text{If } N \gg 1 \quad E_{out1}(t) = \frac{t_{11} - \gamma(t_{11}t_{22} - t_{12}t_{21}) \sin \theta(t)}{1 - \gamma t_{22} \sin \theta(t)} E_{in1} \rightarrow \begin{cases} E_{out1} \text{ pulsed for } \theta(t) \approx \pi/2 \\ 2 \text{ pulses per period } 1/f_m \end{cases}$$

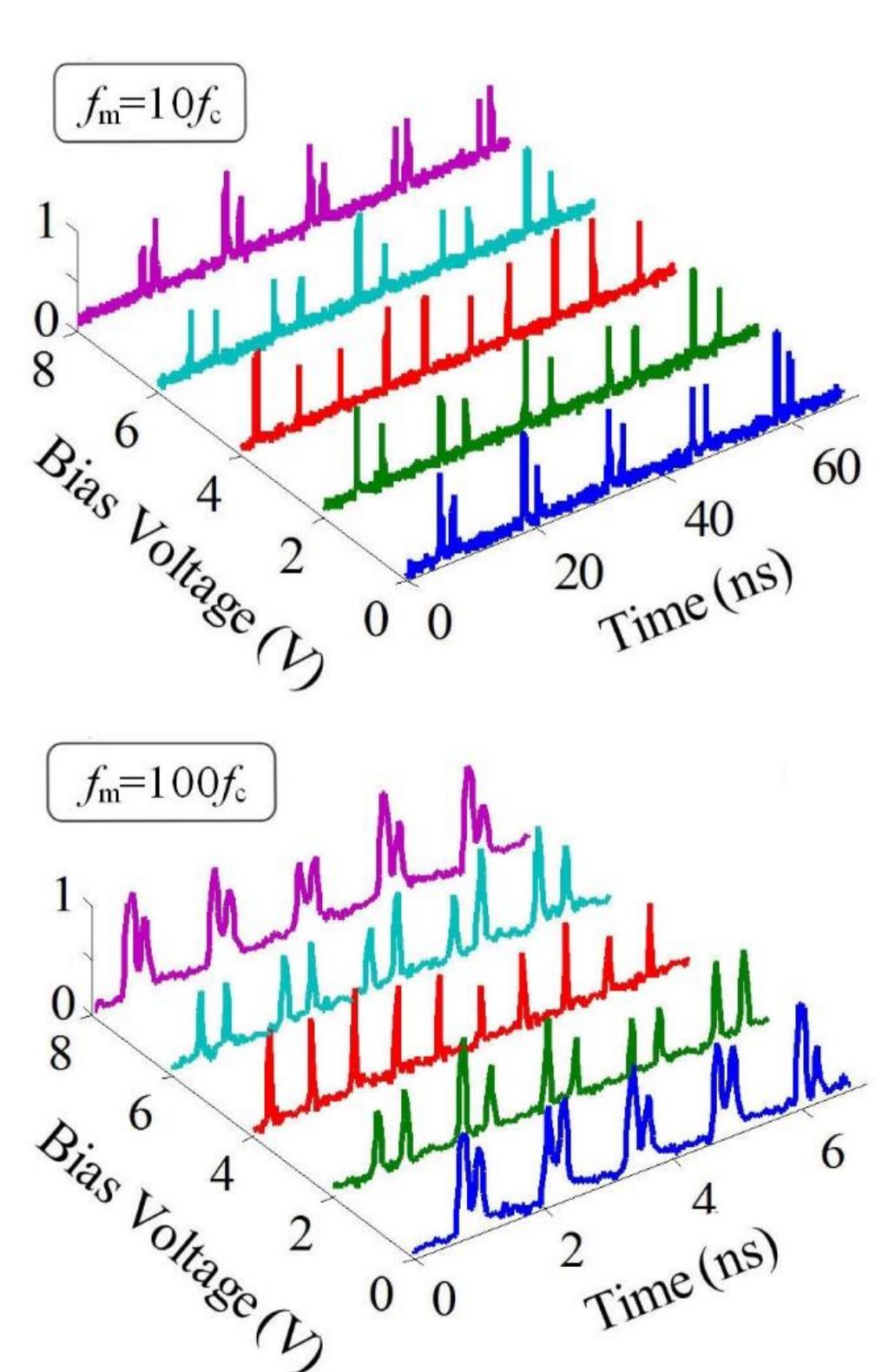
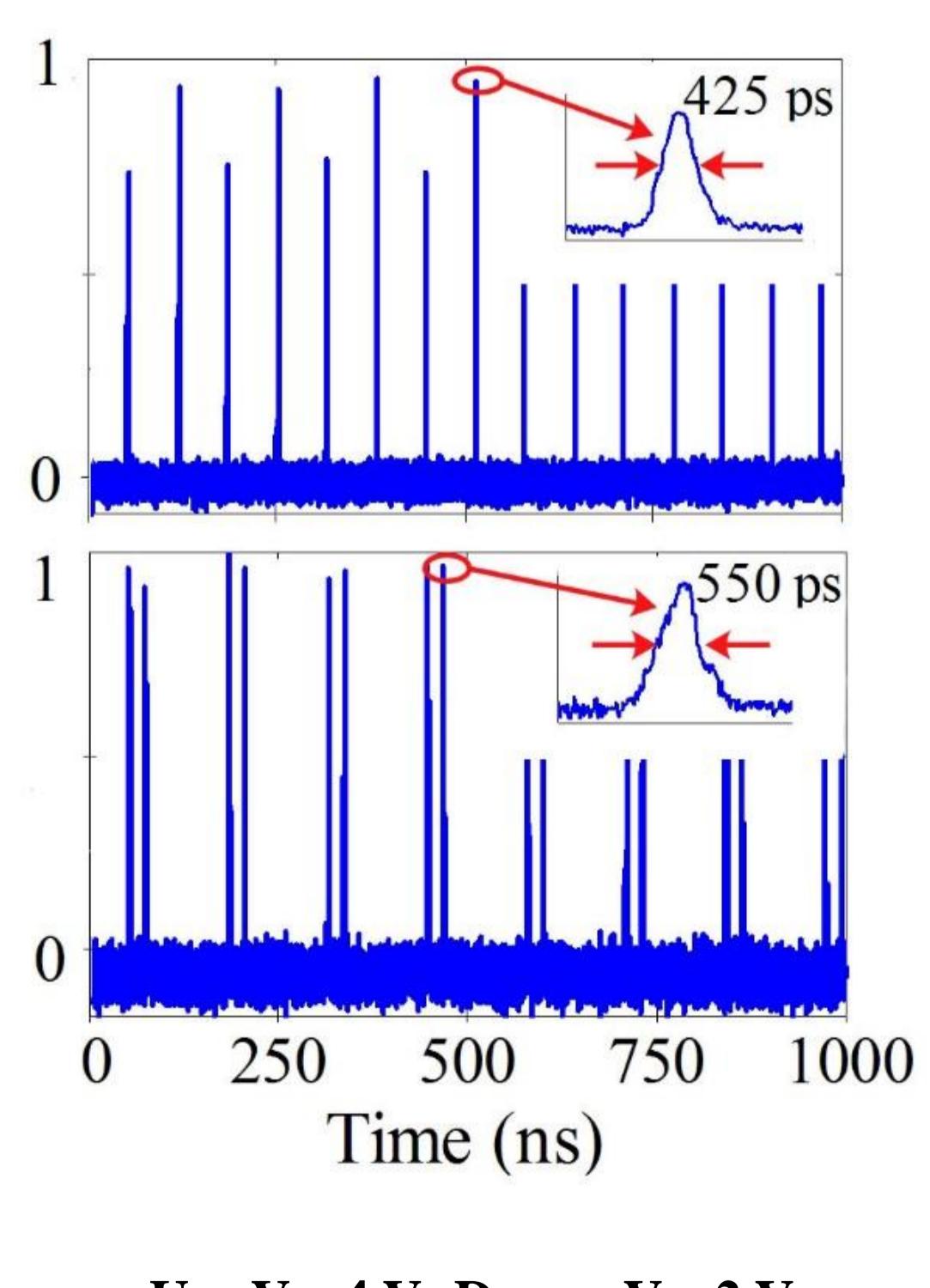


## Experimental results



( H. Yang et al , Optics Express, revision )

## Mode-locked double-pulse regime



## Conclusion

- Observation of original double-pulse regime
- Theoretical model in agreement with experiments
- Repetition-rate tunability from MHz to GHz
- frequency comb width up to 40 GHz
- waveform generation: rectangle, sawtooth,...

## Forthcoming

- Phase modulation vs intensity modulation
- Frequency-to-time mapping (as in [6] with AOFS)
- Repetition-rate tunability from MHz to GHz
- Fractional Talbot condition  $f_m = p/q f_c$  : towards high repletion rates

## References

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- [4] L. Wang et al, CLEO 2017
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- [6] H.G. de Chatellus et al, Optica 2016