UNIVERSITAT POLITÈCNICA DE VALÈNCIA

NANOPHOTONICS TECHNOLOGY CENTER

Photonic Integrated Circuits for Radio Beamforming: Part I: Optical Comb and MCF-based Systems for Datacenter Communications

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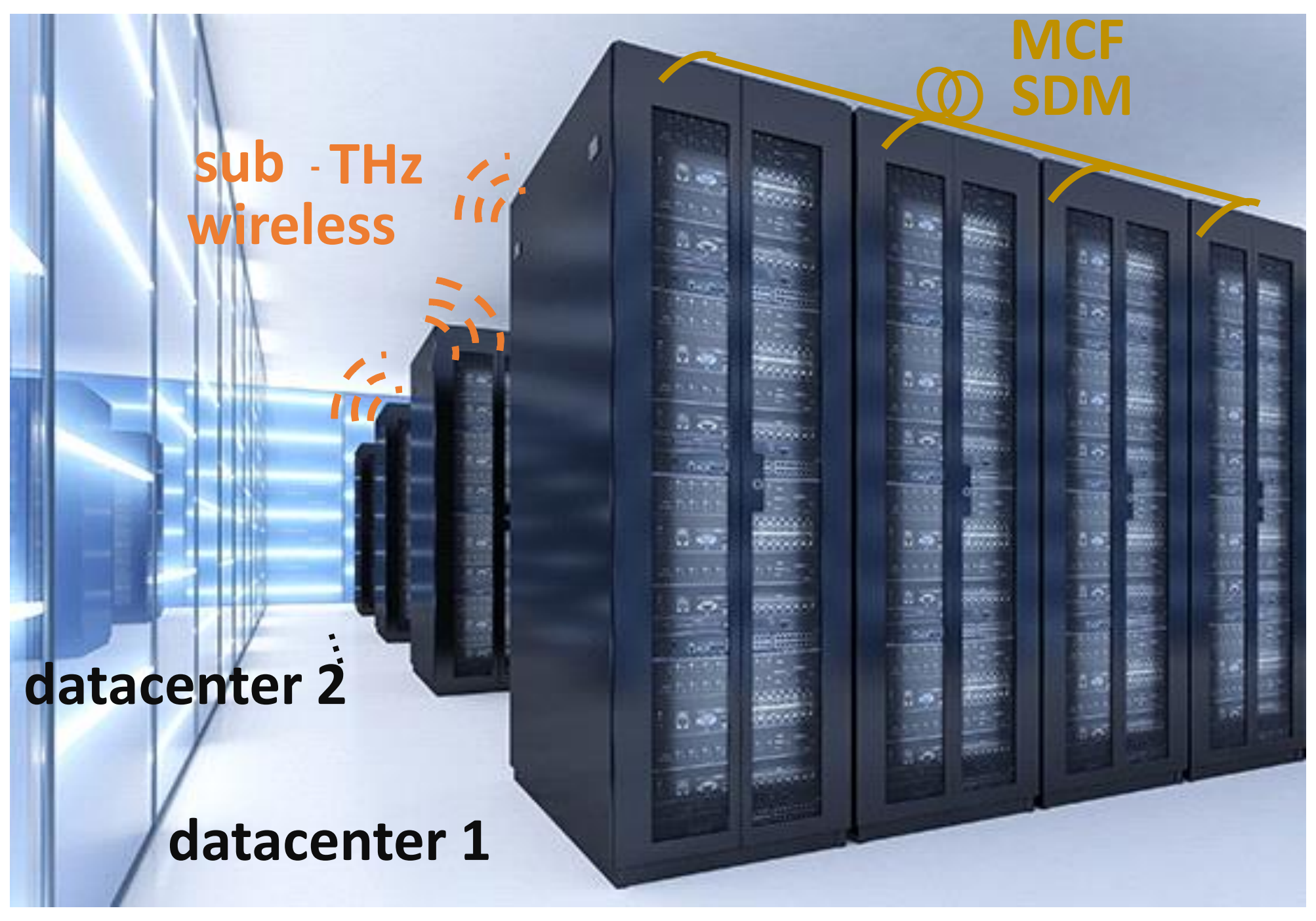
PhD research objectives

- Propose and characterize new integrated photonics and system architectures enabling **efficient radio beamforming for high-bitrate wireless data transmissions**
- Improve current **beamforming architectures** introducing optical fiber comb generation (OFCG) systems and high-capacity optical media as multicore fiber (MCF)
- Enable enhanced capabilities such as **simultaneous multi-antenna digital MIMO processing** and **photonic beamforming**

Application scenario

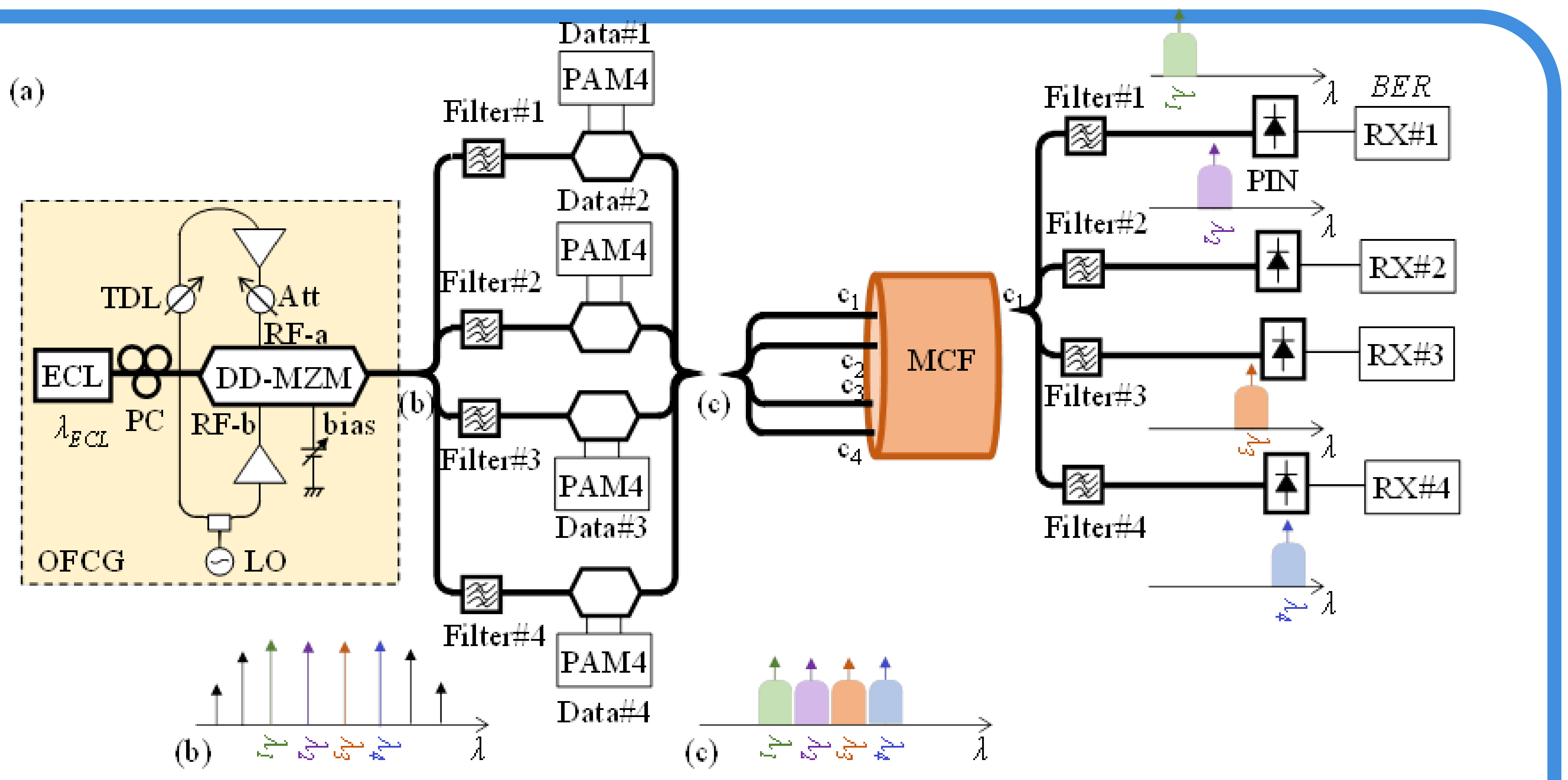
- Advantages using OFCGs and MCFs:
  - ✓ Multi-core fibers enable high-capacity optical transmission by spatial multiplexing
  - ✓ OFCG as a source offers ad-hoc low-latency wireless links at sub-THz frequencies
- Implementation in high-speed datacenters:
  - ✓ Reduced latency (<100 ms)
  - ✓ Centralization of devices → increased energy efficiency
  - ✓ Privileged interconnection
- Further advantages encouraging the transition from traditional service provision to a cloud-based infrastructure:
  - ✓ Energy and cost efficiency
  - ✓ Customers can access to service independently of their physical location or access to equipment
  - ✓ Elastic resource allocation



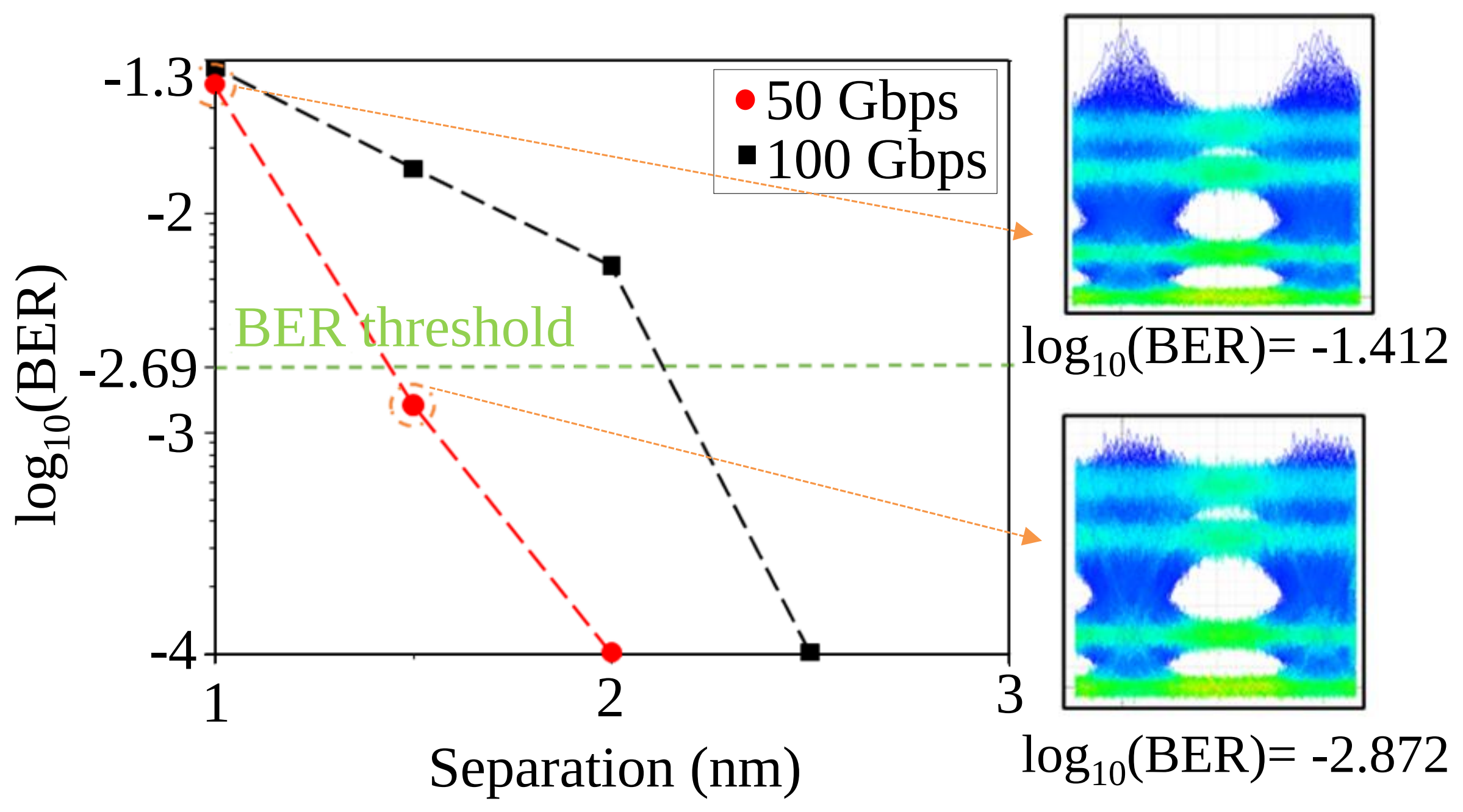
Simulation results and discussion

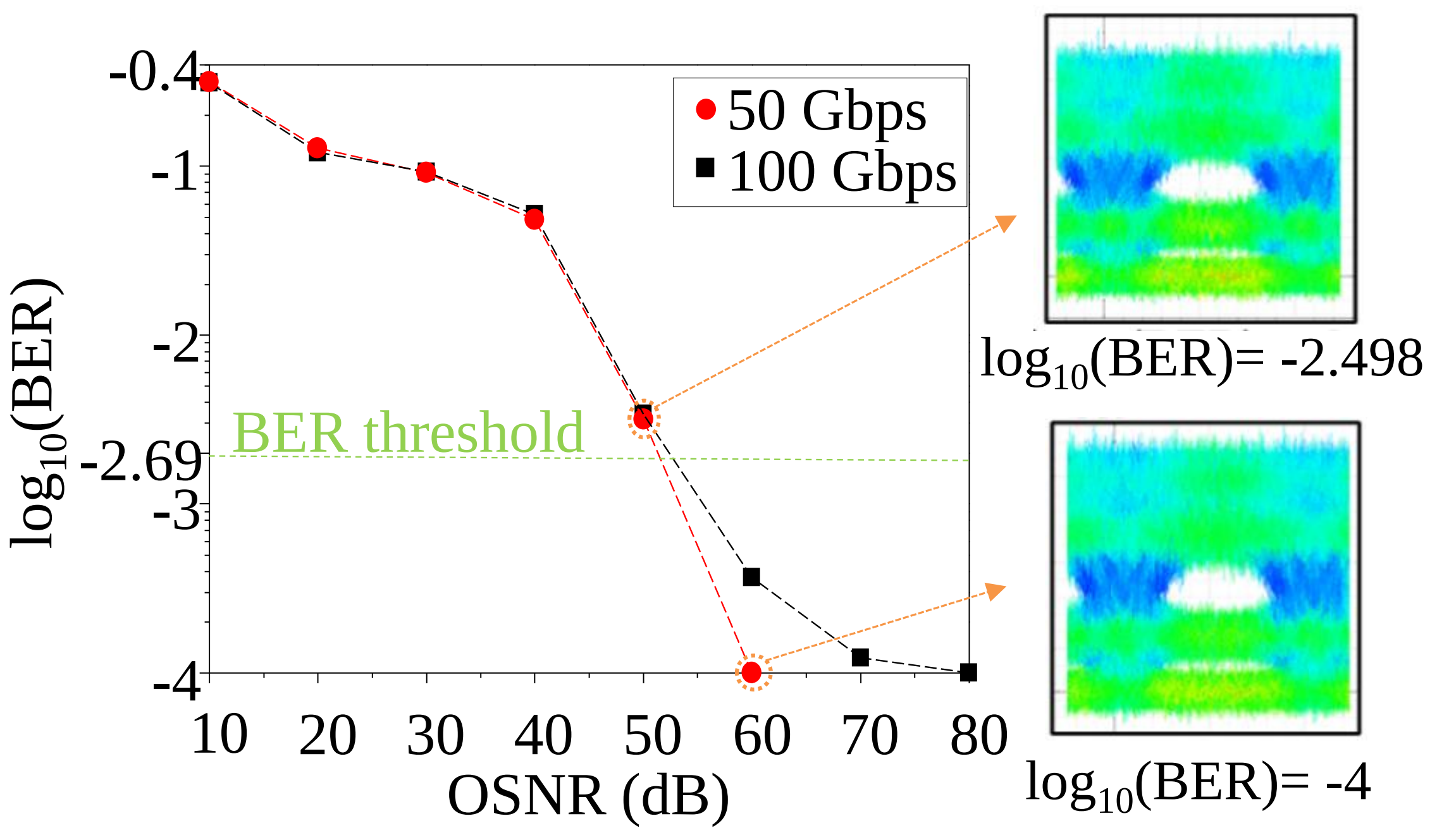
Optical comb generation for PAM4 transmission over 4-core MCF

- OFCG comprises a continuous laser, attenuator, phase shifter and LO
- OSBF selects a channel and isolates it (range 1534 nm-1543 nm)
- PAM4 data modulation (range 50 Gbps, 100 Gbps evaluated)
- 4-core MCF (with 8 µm cores, from 33 to 43 µm core pitch and 0.0058 core-cladding refractive index difference)
- PAM4 receiver demodulates data and calculates BER



Results 1 – Optical fiber transmission analysis

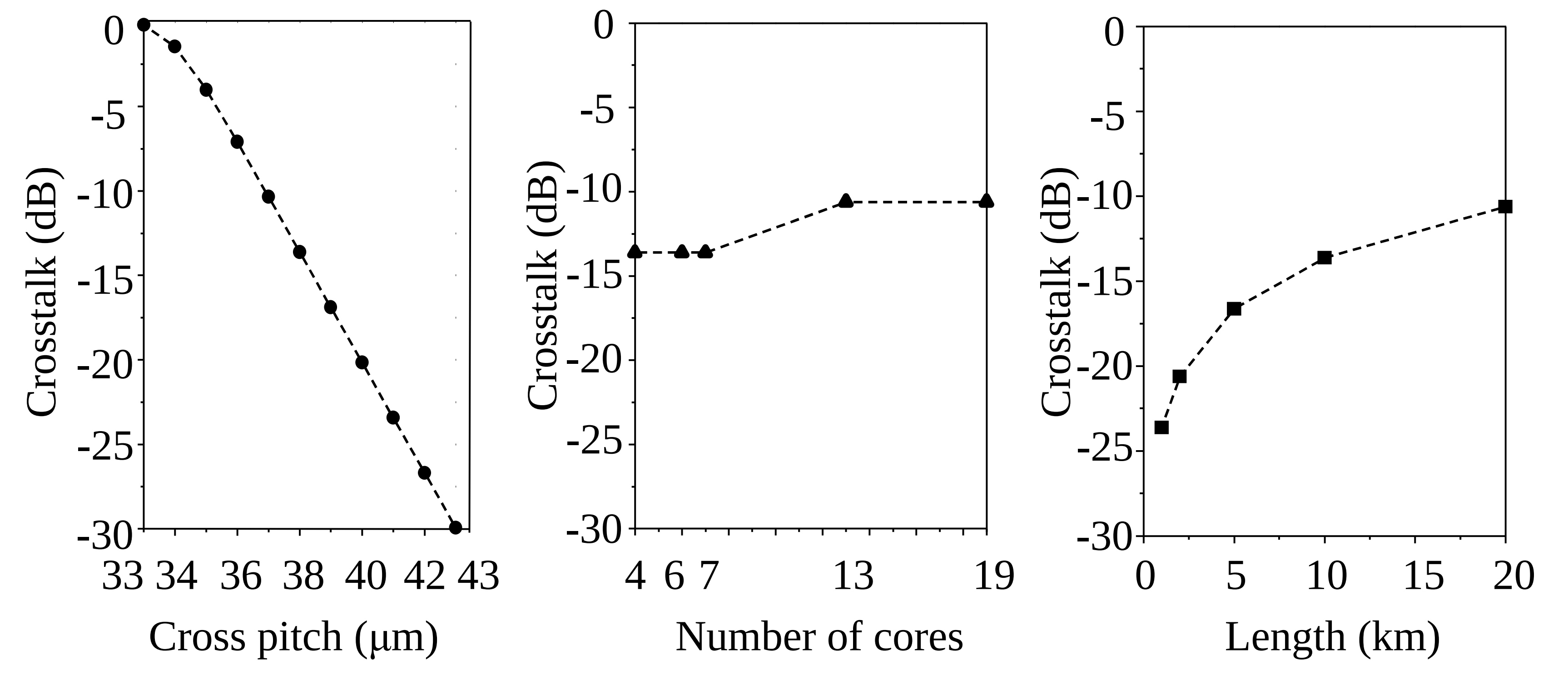




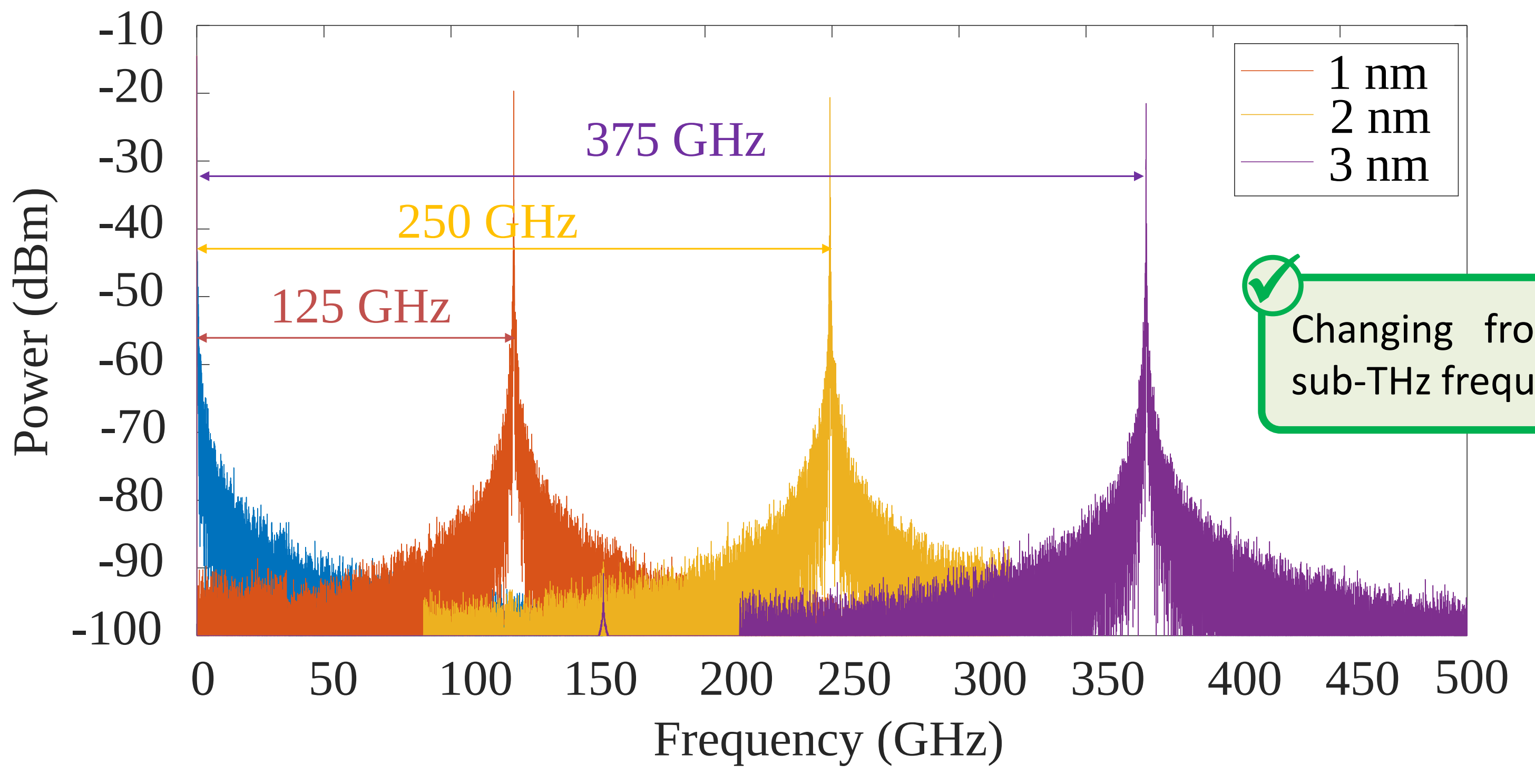
Parameter	Datarate	Max. value to meet the BER threshold requirement
Separation	50 Gbps	≥ 1.5 nm
	100 Gbps	≥ 2.5 nm
OSNR	50 Gbps	≥ 60 dB
	100 Gbps	≥ 60 dB
Optical link length	50 Gbps	≤ 0.5 km
	100 Gbps	≤ 0.3 km
OSBF Bandwidth	50 Gbps	≥ 35 GHz
	100 Gbps	≥ 70 GHz

✓ BER variance between 4-channels ≤ $8.45\cdot10^{-5}$

Results 2 – MCF crosstalk analysis



Results 3 – Frequency upconversion by optical heterodyning



✓ Changing from radio to sub-THz frequencies

Dissemination results

[1] R. Llorente, V. Fito and M. Morant, “Optical combs and multicore fiber as technology enablers for next-generation datacenter infrastructure”, SPIE Proceedings Volume 12027, Metro and Data Center Optical Networks and Short-Reach Links V, 120270E (2022) https://doi.org/10.1117/12.2615351

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