

Optimal Polarization Launch for Raman Depletion Minimization in GPON and TWDM-PON Coexistence



M. Cantono - A. Mecozzi - V. Curri - R. Gaudino
 DET - Politecnico di Torino, Corso Duca degli Abruzzi 24, 10129, Torino, Italy
 Department of Physical and Chemical Sciences, University of L'Aquila, 67100, L'Aquila, Italy
 mattia.cantono@polito.it



ABSTRACT

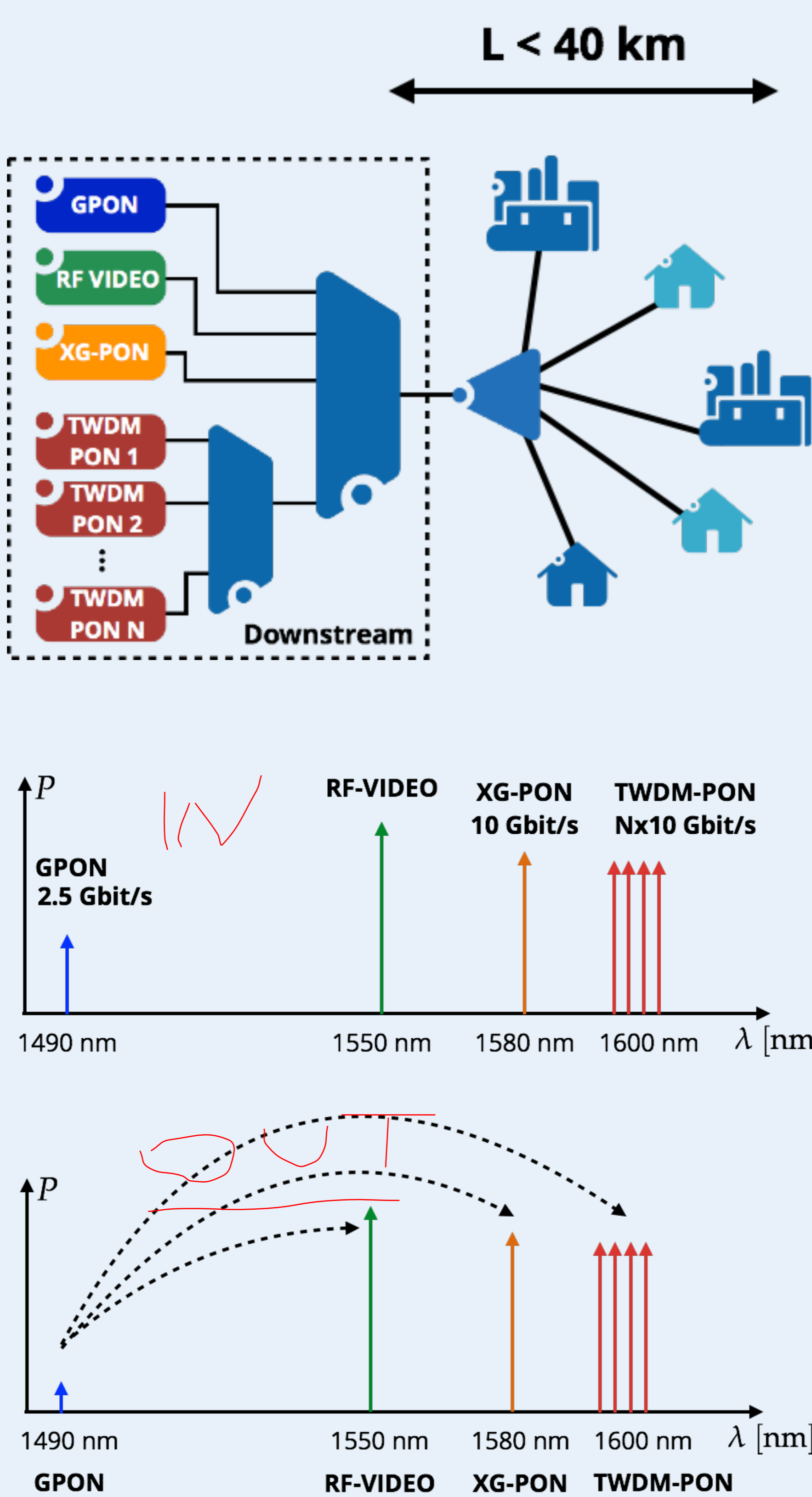
TWDM-PON (ITU-T G.989) will induce relevant extra attenuation when operating in full coexistence with GPON due to Raman nonlinearity. We give a detailed analysis of optimal polarization launch options.

MOTIVATIONS

The new **NG-PON2** will be based on Time and Wavelength Division Multiplexed PON (TWDM-PON), as specified in ITU-T G.989.

TWDM-PON will co-exist in the same PON tree with previous standards, i.e. **GPON, XG-PON** and **RF-Video**.

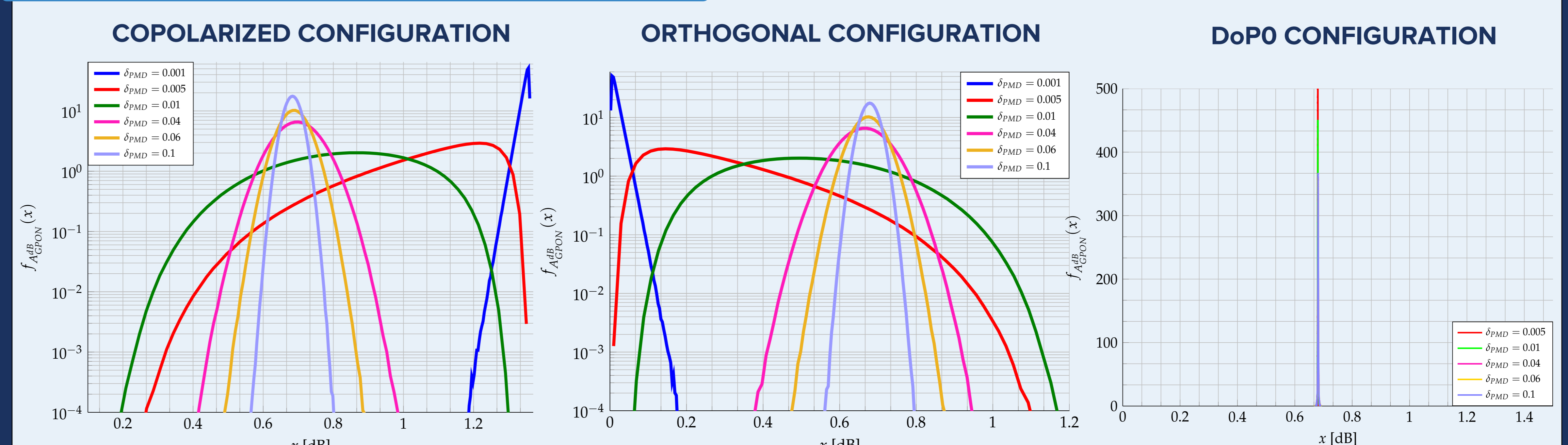
In this situation, **TWDM-PON may significantly deplete power from the lower wavelengths due to nonlinear Raman effects in the fiber**: the lower lambdas acts as Raman "pumps" for the TWDM-PON but, due to the typical power levels, the **gain on the TWDM-PON is irrelevant**, but in turns there is a **significant power depletion on the "pumps"**, e.g. GPON.



SYSTEM RESULTS

We considered **1.5×10^7 simulations** with the following system parameters: link length 20 km, δ_{PMD} i.e the PMD coefficient of the fiber in a range from 0.001 to 0.1 ps/sqrt(km), link loss equal to 0.22 dB/km, Either 4 or 8 active TWDM-PON channels with power per channel P_{TWDM}

PROBABILITY DENSITY FUNCTIONS

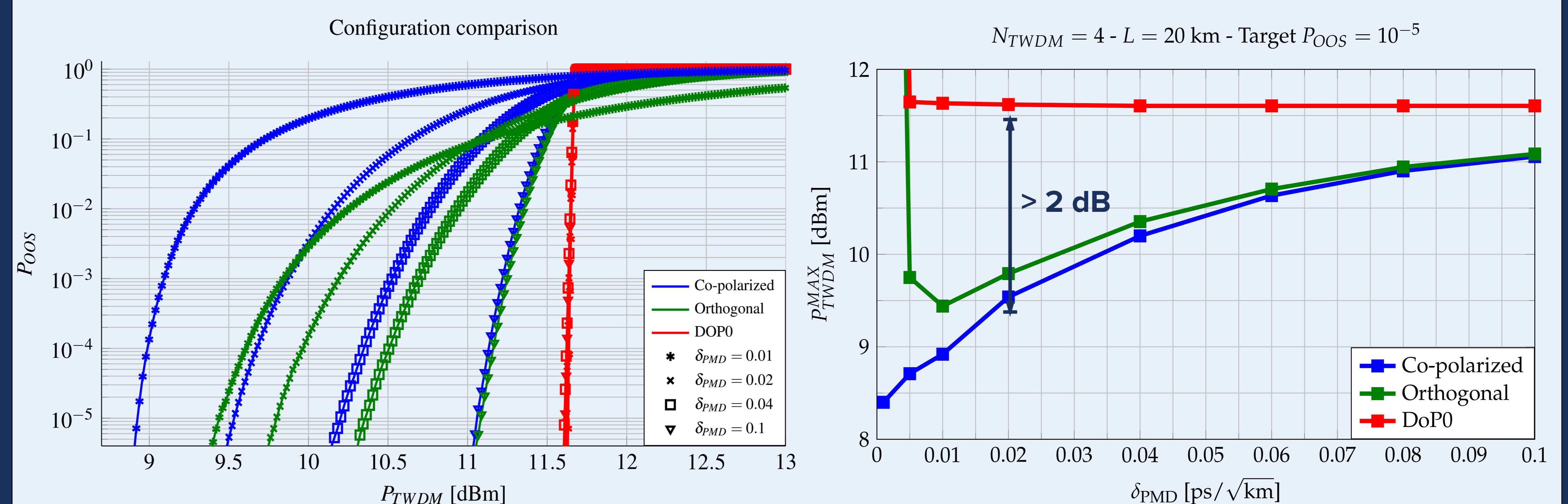


PDF of the SRS induced depletion of the GPON channel for $P_{TWDM} = 10$ dBm and 4 active TWDM-PON channels.

- The PDFs of the **copolarized and orthogonal** configurations have a **significant statistical spread**.
- The PDFs of the **DoPO** are **Dirac delta** centered around an average value. The behavior of the SRS depletion is thus **completely deterministic, independently on the PMD value**. This is due to the fact that, in this scenario, the **TWDM channels maintain the zero composite DoP**, and the Raman depletion is independent on random SOP evolution.

OUTAGE PROBABILITY & MAXIMUM ADMISSABLE TWDM-PON POWER

We can evaluate the **outage probability of GPON**, i.e. the **probability that the SRS induced depletion is larger than 1 dB**. Based on this result, we evaluated **maximum admissible TWDM-PON power per channel** able to guarantee a **target outage probability** for GPON of **10^{-5}** .

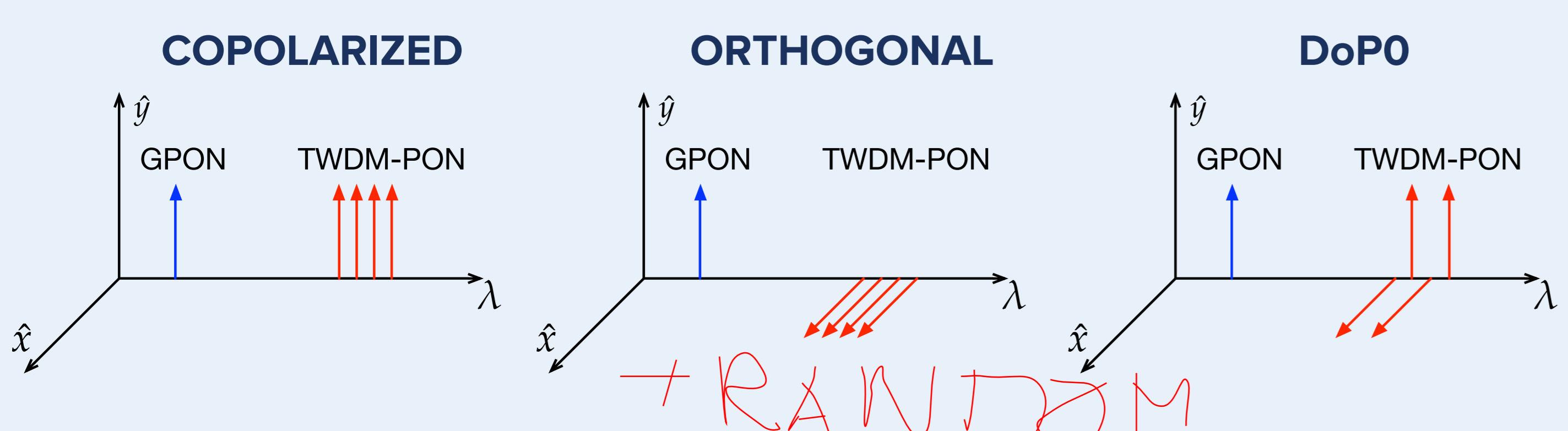


The **advantage of the DoPO** configuration is evident: maximum power per channel **higher than 2 dB for reasonable PMD values** (e.g. 0.02 ps/sqrt(km)).

- **DoPO outperforms the other configurations** for any reasonable PMD value.
- The orthogonal configuration would give 0 depletion for PMD values asymptotically close to zero.
- The random launch [3] has performance in between DoPO and orthogonal configuration.

METHODOLOGY

- We focus on the **Raman TWDM-PON - GPON interaction** in the **downstream (DS)**, and the **stochastic polarization effects** in the transmitter and in the fiber.
- We use **Monte Carlo simulations** to determine the statistics of the **Raman induced depletion on GPON as function of the initial polarization configurations** and fiber Polarization Mode Dispersion (**PMD**). Is there an **optimal configuration** able to minimize Stimulated Raman Scattering (SRS) depletion?
- **Previous works [3]** considered only **random input states** of polarization (**SOP**) and made use of a **Gaussian approximation** for the statistics of the GPON depletion
- We consider **three** different polarization launch **cases**



- Based on the simulative results, we computed the **outage probability of GPON channel** (i.e. the probability that the depletion is larger than half the GPON system margin) as function of the transmitted power of TWDM-PON channels.

CONCLUSION

- The **DoPO condition should be enforced in all TWDM transmitters**, since the additional implementation complexity increase is actually worth paying in any full-coexistence scenario.
- On the contrary, **polarization alignment between GPON and TWDM-PON is not worth the effort** since it would give further advantages only for unrealistically low PMD values.
- The **same results**, besides from numerical differences, will hold **for the interaction of TWDM-PON with XG-PON and RF-Video**.

BIBLIOGRAPHY

- [1] ITU-T Recommendation G.989.2
- [2] E. S. Son et al., "Statistics of Polarization-Dependent Gain in Fiber Raman Amplifier," JLT **23**, 1219-1226 (2005).
- [3] V. Curri et al., "Outage probability due to Stimulated Raman Scattering in GPON and TWDM-PON coexistence", OFC2014, Paper M31.2
- [4] D. Marcuse et al., "Application of the Manakov-PMD...", JLT, 15-9,(1997)

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