THE IMPACT of POLARIZATION MODE DISPERSION on OPTICAL DUOBINARY TRANSMISSION

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Introduction

- The optical duobinary data-coding is a promising technology for the implementation of ultra-dense WDM systems with spectral efficiency close to the Nyquist limit.
- Working at bit-rates as high as 40 Gbit/s, Polarization-Mode Dispersion (PMD) could strongly impair system performance.
- The purpose of this work is to compare the impact of PMD on optical duobinary with respect to its impact on NRZ in a OC-768 FEC-inclusive scenario.

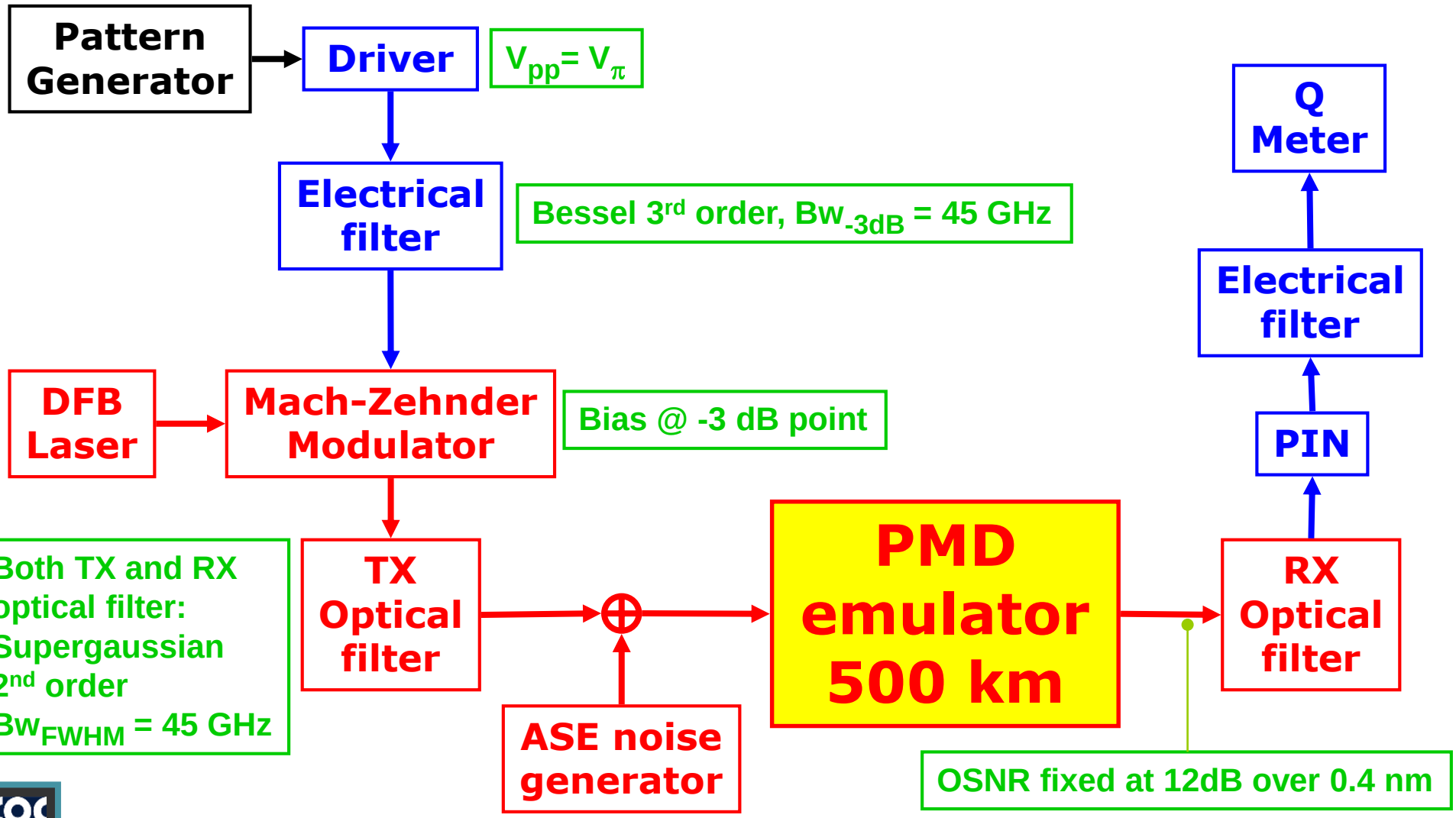
System and simulation parameters

- Bit-Rate: 40 Gbit/s (OC-768)
  - with RS(255,239), 7% overhead: 42.65 Gbit/s
  - with RS(255,223), 14% overhead: 45.72 Gbit/s
- Monte-Carlo runs: 10000
- Simulated bits for each run: 4096
- Q evaluated over triplets of bits in order to avoid the ISI effect

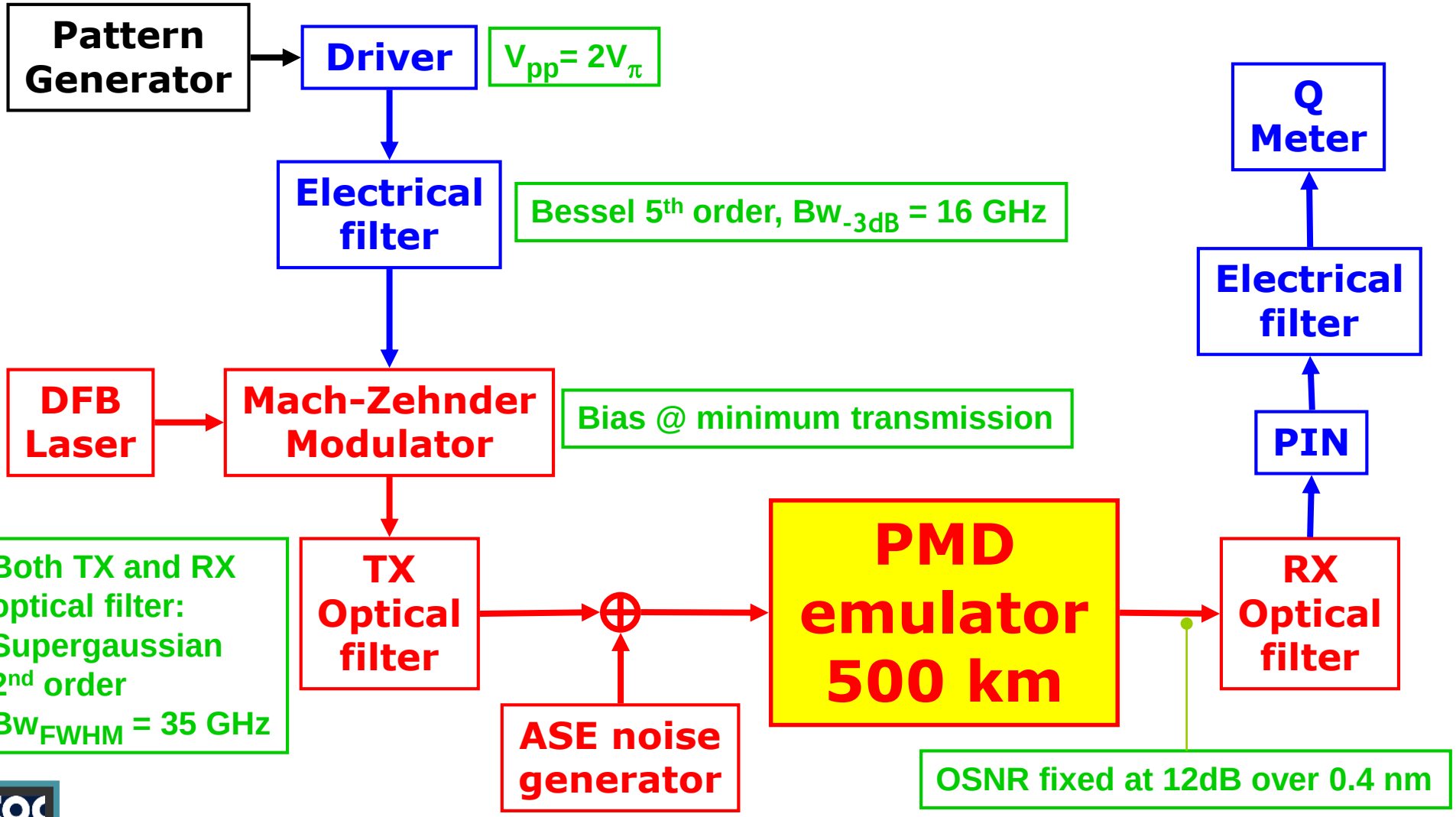
PMD emulator

- Simualtion performed using the optical system simulator OptSim
- PMD emulator based on the well-known waveplates model
  - Equivalent link length: 500 km
  - PMD values analyzed: 0.1 to 0.3 ps/$\sqrt{km}$
  - Monte-Carlo simulations with 10,000 runs for each PMD value
  - Same PMD realizations for NRZ and duobinary

NRZ system layout



Optical duobinary system layout



Filter optimization

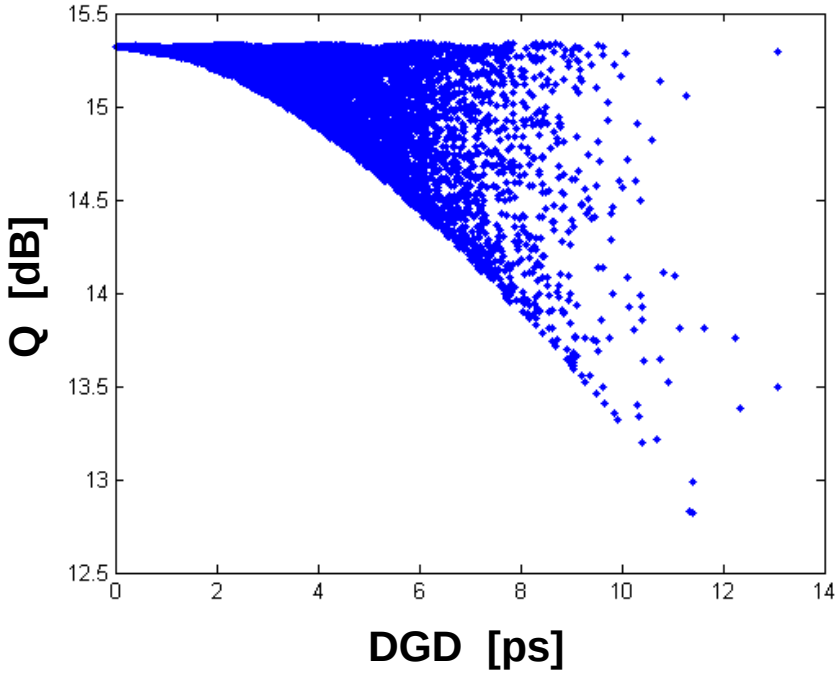
- Optical filters have been used both at TX and RX side
  - It has been demonstrated that the TX filter is necessary in Ultra Dense WDM systems when channel spacing is less than 75 GHz,

    see POSTER P3.07 and also G.Bosco et al, *"On the use of NRZ, RZ and CSRZ modulation at 40 Gbit/s with narrow DWDM channel spacing,"* JLT, Sep. 2002.
- Optical and electrical filters bandwidth have been optimized in a back-to-back configuration:
  - Optical filters shape: supergaussian, order 2
  - Electrical filters shape: Bessel
  - Optimized for WDM transmission with 50 GHz spacing
  - Only ASE noise and ISI impairments have been considered during optimization
- Maximum back-to-back Q values obtained:
  - 13.0 dB for NRZ
  - 15.3 dB for Duobinary

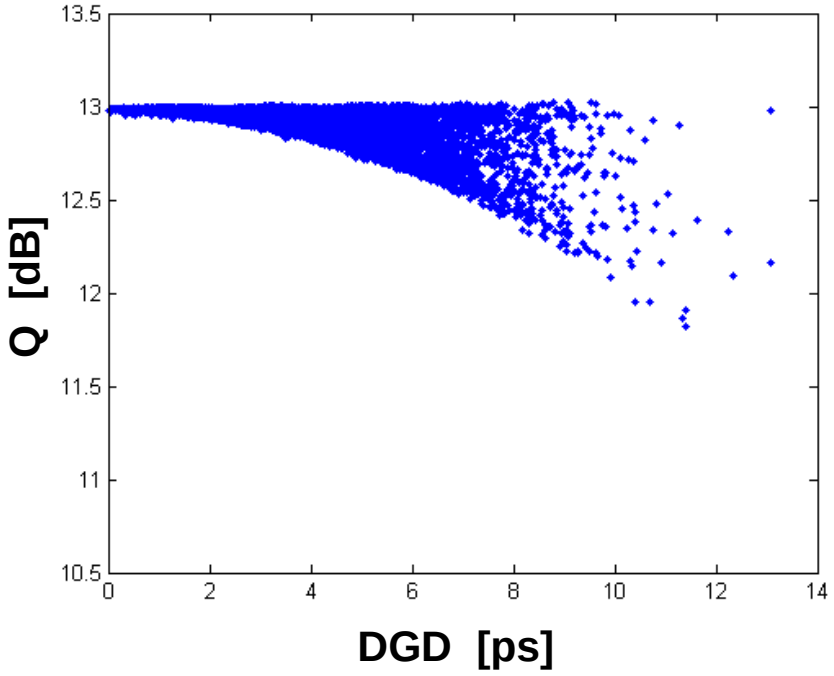
Simulation results: Q vs DGD

δ_{PMD}=0.175 ps/√km

Duobinary



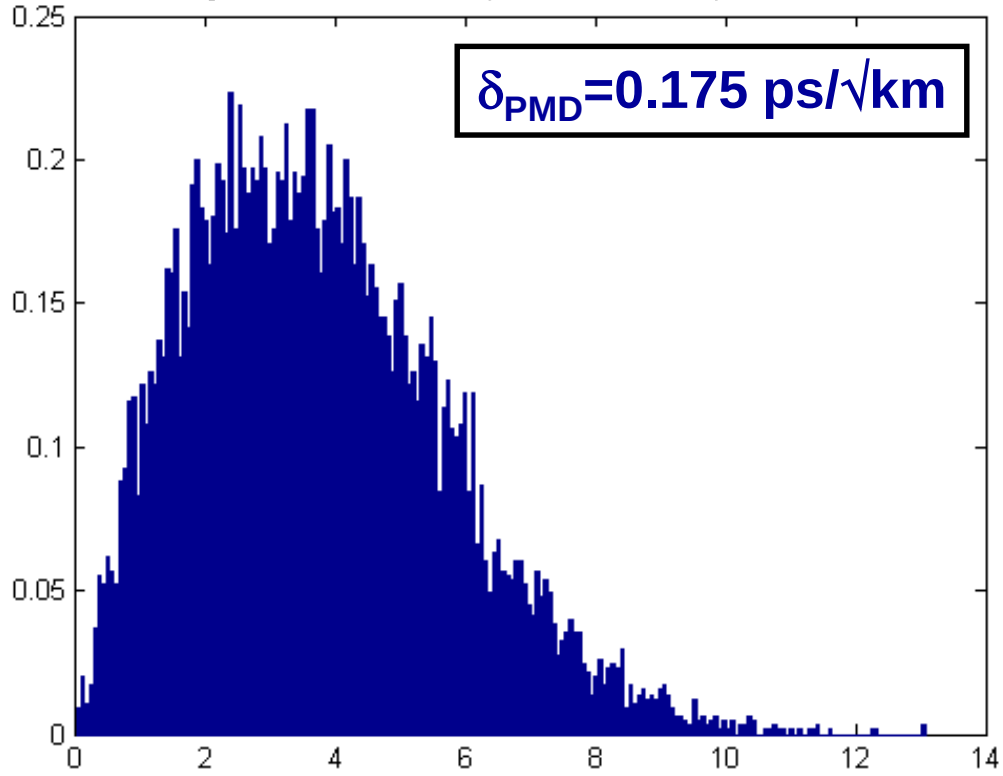
NRZ



- Note the different flat top level due to different back-to-back performance
- Less Q values spreading, like for NRZ, indicates more PMD resilience

Simulation results: DGD distribution

DGD probability density function

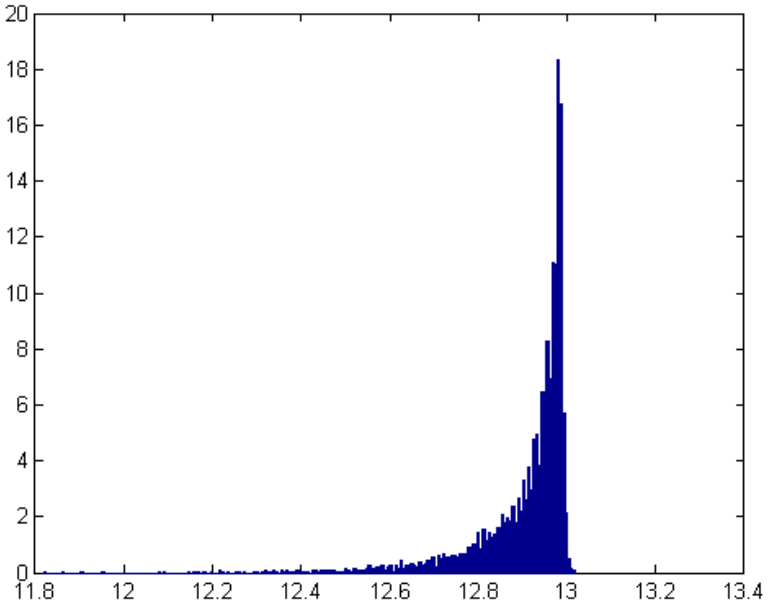


It has been verified a good agreement with the theoretical predicted Maxwellian distribution of DGD values

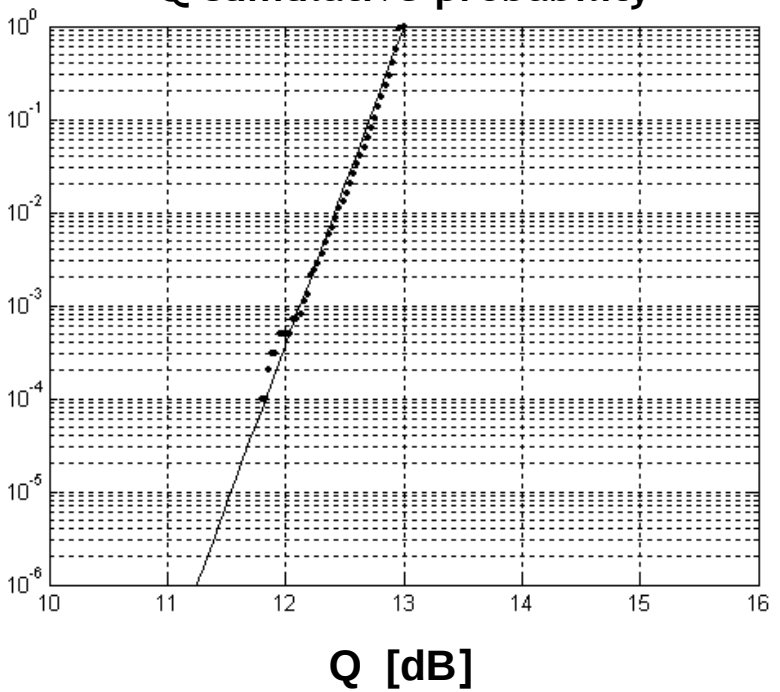
Exponential fitting: NRZ

δ_{PMD}=0.175 ps/√km

Q probability density function



Q cumulative probability

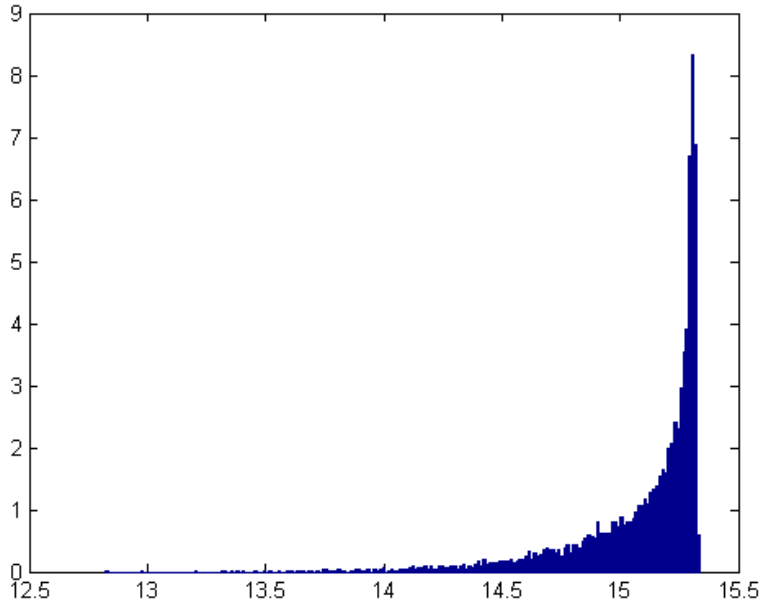


- Q values distributed following an exponential function
- Least square fitting of cumulative probability with an exponential function, in order to extend the evaluation below 10^{-4}

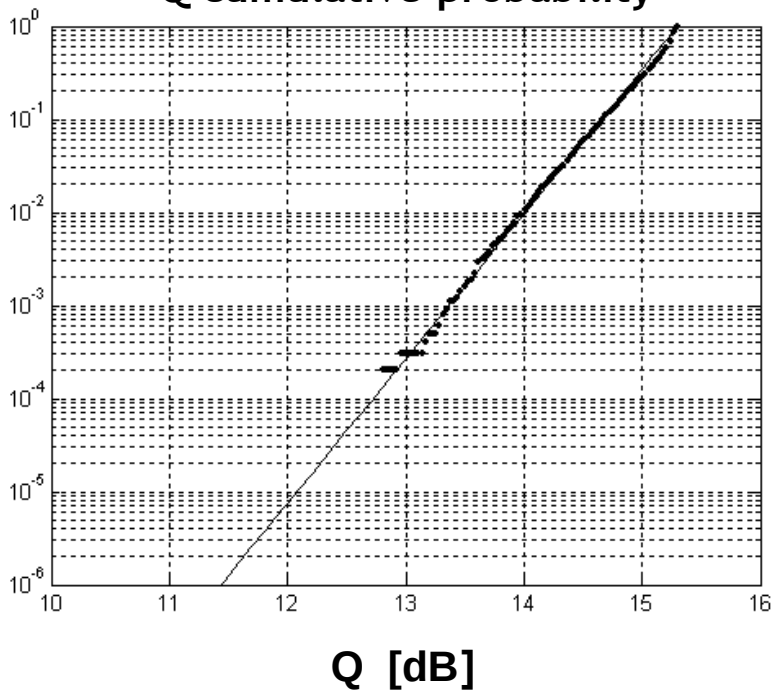
Exponential fitting: duobinary

δ_{PMD}=0.175 ps/√km

Q probability density function

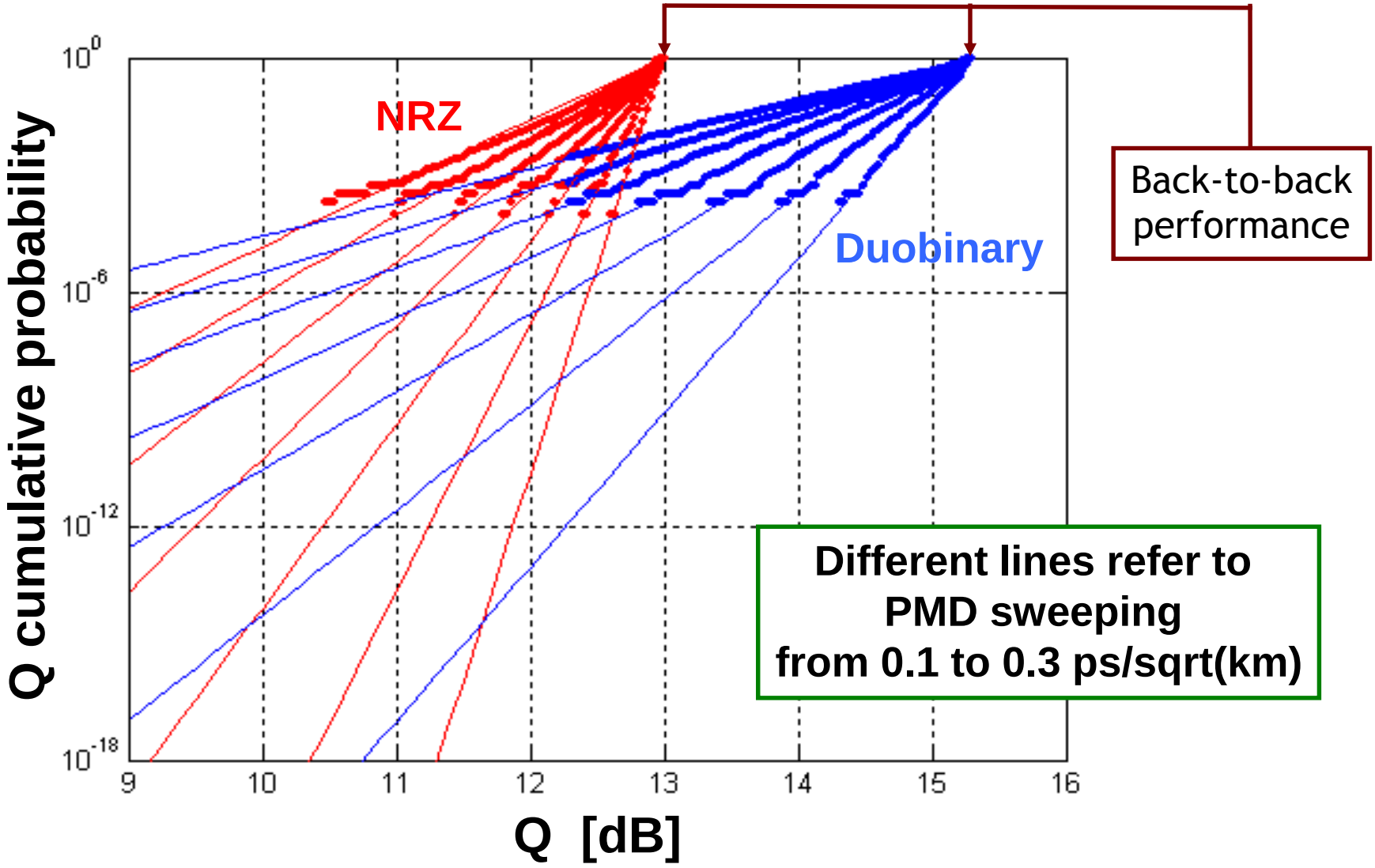


Q cumulative probability



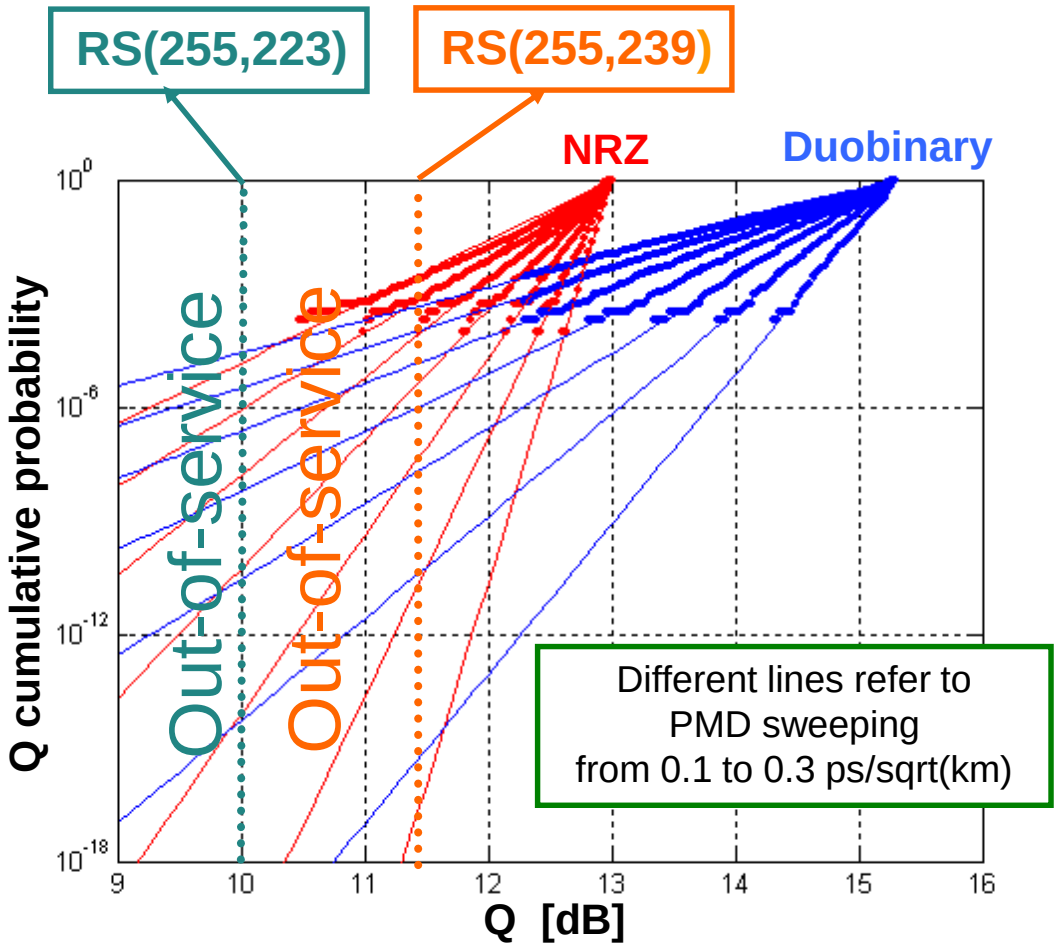
- Given the same PMD value, the Q cumulative probability for duobinary shows a reduced slope with respect the NRZ one: this means stronger PMD impact
- But duobinary presents better back-to-back performance

Cumulative probability density function



Out-of-service evaluation

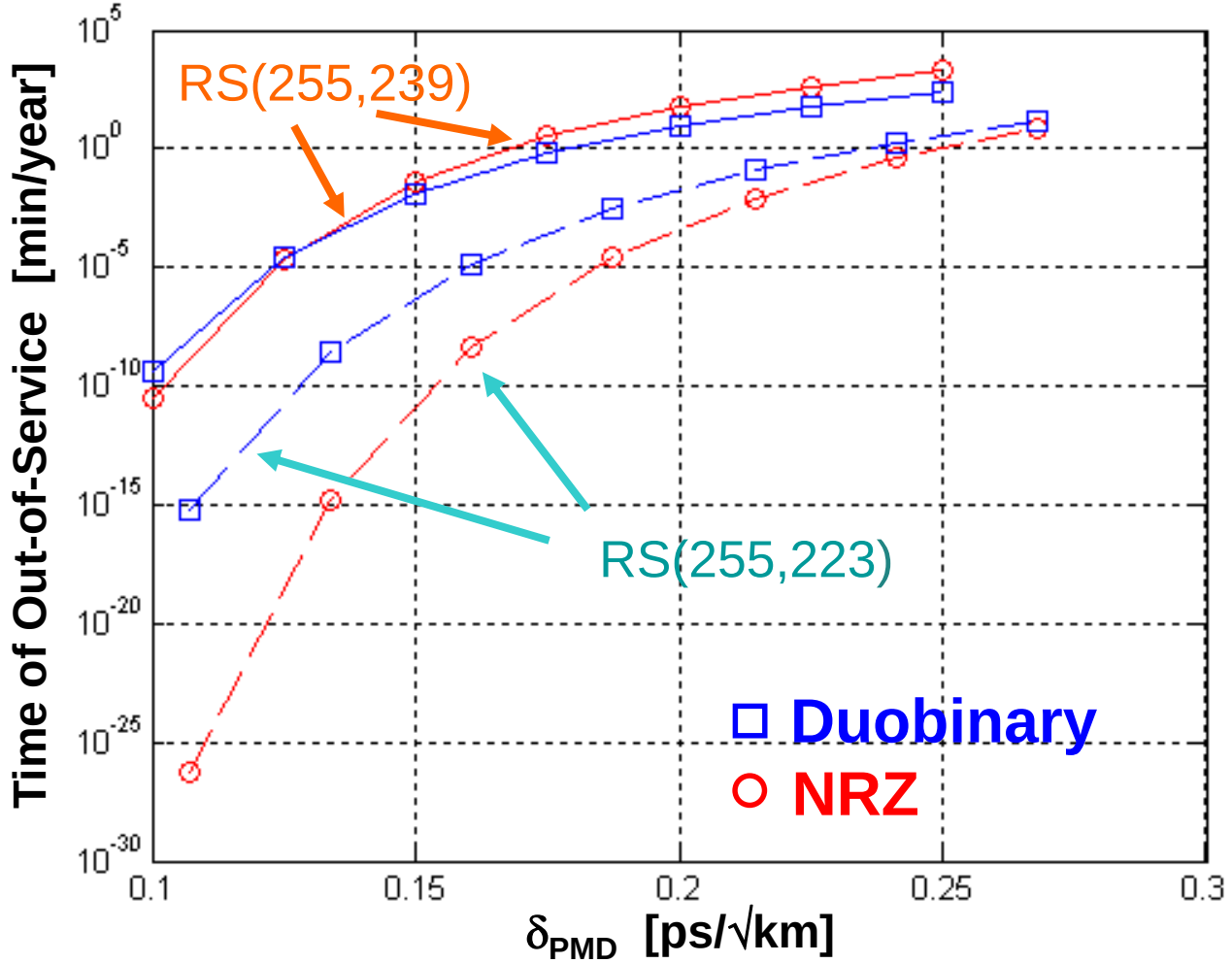
- For a given Q value, the cumulative probability is the percentage of PMD realizations inducing a Q lower than that value
- Since each run is independent of each other, we can assume the percentage of runs as a percentage of time
  - Therefore, for a given Q value, the cumulative probability becomes the percentage of time with Q values lower than that level: fixing a minimum Q for system in-service we can evaluate the percentage of out-of-service



- Target BER is 10^{-13}
  - RS(255,239) need Q_{input}=11.5 dB
  - RS(255,223) need Q_{input}=10.0 dB

Time of out-of-service

Percentage of out-of-service has been converted in minute per year for better understanding



Conclusions

- The impact of PMD is stronger on duobinary than on NRZ.
- Due to its better intrinsic performance, duobinary may still result convenient in some conditions (like in the RS(255,239) scenario).
- When more powerful FEC codes, like RS(255,223), are used, the advantages of duobinary vanish and the use of NRZ may result more convenient.

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