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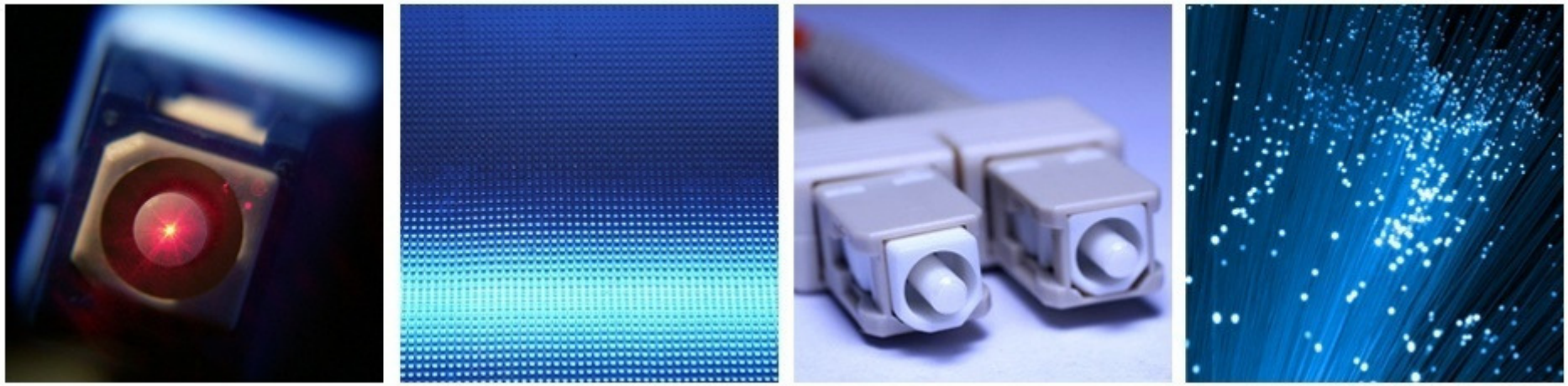
40GBit/s and 100 GBit/s Transmission over OM3 Duplex Fiber



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Support

The presentation will be supported by

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Scope

→ Provide a solution for transmission on duplex OM3 fiber

- with 40 GBit/s (PART A)
- with 100 GBit/s (PART B)

to allow an upgrade of existing OM3 fiber networks

→ Approach: WDM on OM3 fiber

→ Define PMD for both data rates

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PMDs under Discussion

Distance	Fiber	40GBit/s	100GBit/s
100m	OM3 (0.85μm)	4 x 10GBit/s	10 x 10GBit/s
10km	SM (1.3μm)	4 x 10GBit/s 1 x 40GBit/s	4 x 25GBit/s
40km	SM (1.3μm)		4 x 25GBit/s

There are only proposals with 4 x 25GBit/s for SM-fiber (WDM).

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High speed Transmitter for 850nm

- Transmission with 17GBit/s at 850nm have been demonstrated at the OFC 2008
- Several manufacturers have such devices in the lab
- The next step of FC standardization for 17GBit/s transmission will start this year.
- 850nm transmission with up to 40GBit/s was proposed at the IEEE P802.3ba March 2008 Plenary Meeting

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- 20 - 25GBit/s speed is feasible at 850nm.

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Similar PMD for SR as for LR

Distance	Fiber	40GBit/s	100GBit/s
100m	OM3 (0.85µm)	4 x 10GBit/s 2 x 20GBit/s	10 x 10GBit/s 4 x 25GBit/s
10km	SM (1.3µm)	4 x 10GBit/s 1 x 40GBit/s	4 x 25GBit/s
40km	SM (1.3µm)		4 x 25GBit/s

Define a 4 x 25GBit/s PMD for 100m on MMF as for the SM-fiber!
Define a 2 x 20GBit/s PMD for 100m on MMF.

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PART A:
40 GBit/s Transmission over OM3 Duplex Fiber

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40Gbit/s on Duplex OM3

→ „Consider as part of the 40G MMF objective both a multi-fiber and a **duplex fiber**“

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→ Scenario

- Use of duplex OM3 fiber for 40GBit/sec transmission
- Parallel transmission with 2x 20 Gbit/s with NRZ
- as CWDM with 840nm and 860nm on one OM3

→ Upgrade of existing Duplex OM3 Fiber links is possible

- Adequate Bandwidth of 1800MHz*km over the slightly larger spectral window of about 833nm to 867nm is reached by the Standard OM3 fiber (Draka/Corning)

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Channel Spacing for Uncooled Operation

→ Channel Spacing: 20nm

→ Total width of operating wavelength window: 13nm

- Temperature drift of laser (0.07nm/°)
  operating temperature 0°-85°: 6nm
- Manufacturing tolerance of wavelength 7nm

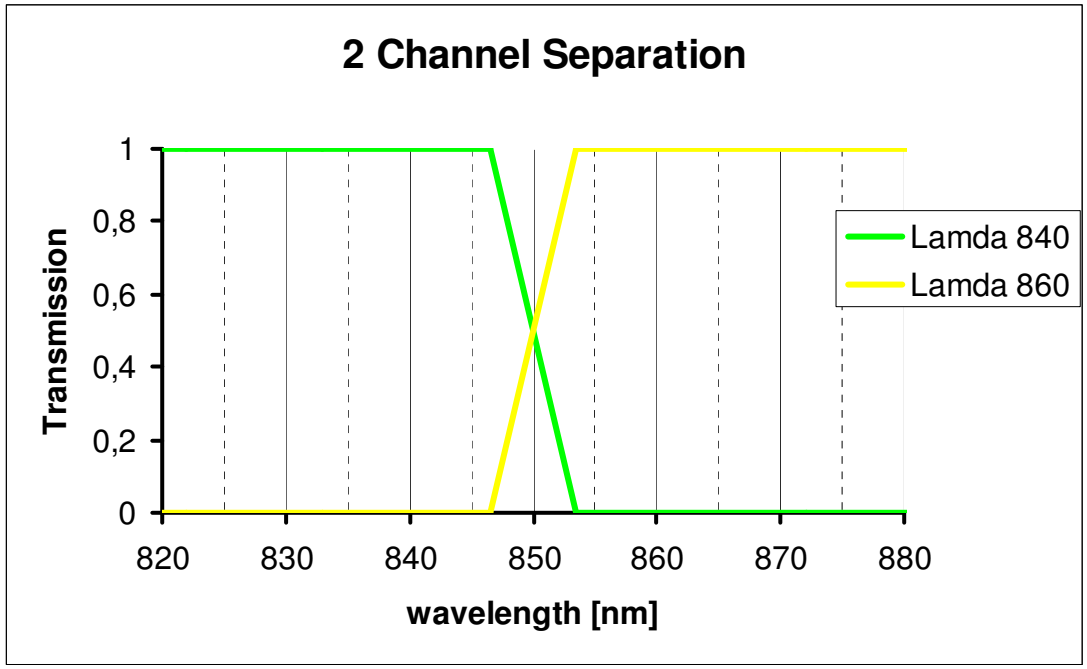
→ Channel separation between windows: 7nm

- easy to reach with standard technology

→ Same channel separation as in 1300nm CWDM systems

2x20G: Simple WDM Filter

- Channel 1: window 833.5nm – 846.5nm
- Channel 2: window 853.5nm – 866.5nm
- One edge WDM filter only
- Moderate spectral edge characteristic is necessary
- Filter can be manufactured by standard Thin Film Technology (Reference: e.g. CubeOptics)



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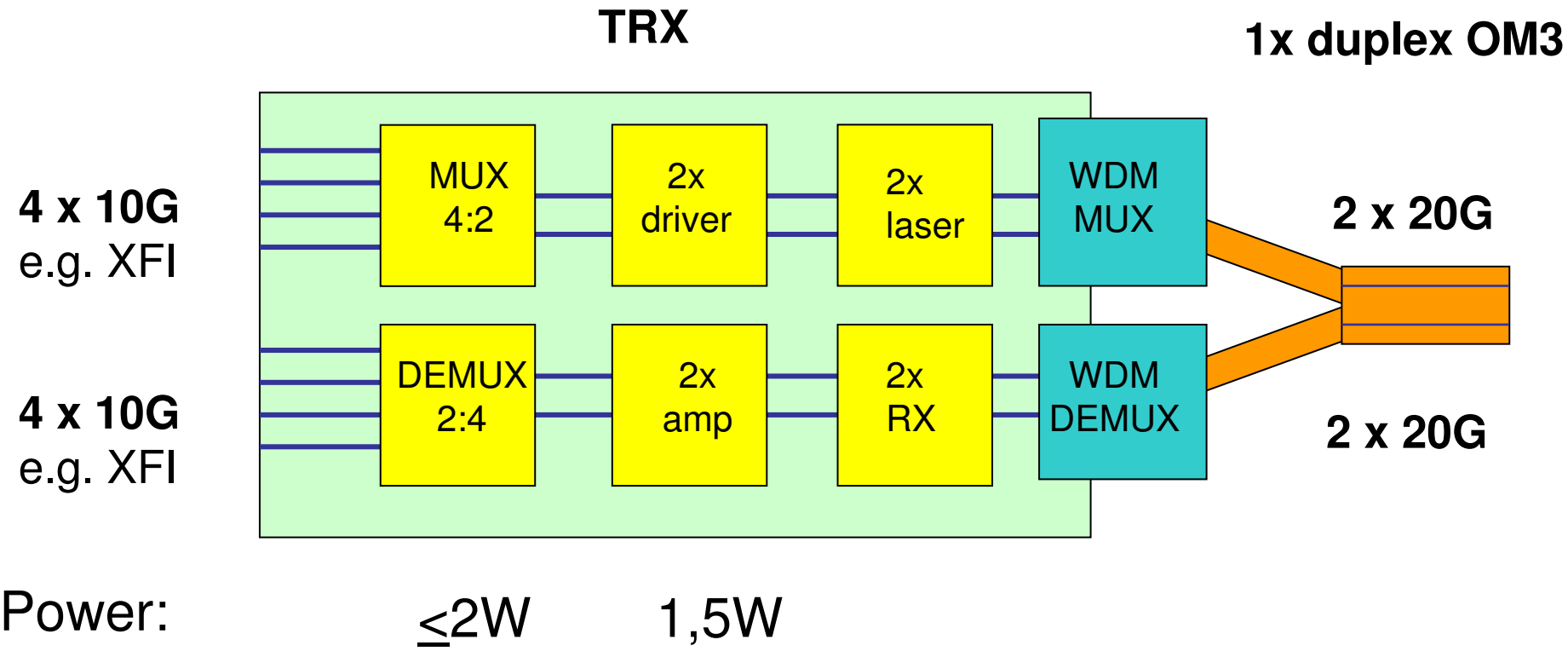
2 + 2 WDM for 40GBit/s



The MUX and DEMUX are simple one stage devices with low power and low cost manufactured based on CMOS or BiCMOS technology.

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Scenario: 20 Gbit/s

- Fiber: **OM3 Fiber**
  used with a restricted launch condition according to 10 GbE Standard
  used effective Modal Bandwidth: **1800 MHz·km** because of extended spectral range of 833nm to 867nm

- Transmitter: wavelength 833 nm - 867 nm,
  $\Delta\lambda$ = 0.45 nm (rms spectral width), T_r, T_f = 15 ps;
  OMA power min. = -3.8 dBm; ext. Ratio min. = 3.0 dB;
  det. jitter = 12.0 ps; RIN = -130 dB/Hz

- Connectors: 1.5 dB loss by connectors

- Receiver: Bandwidth = 15 GHz; sensitivity OMA = -11.1 dBm

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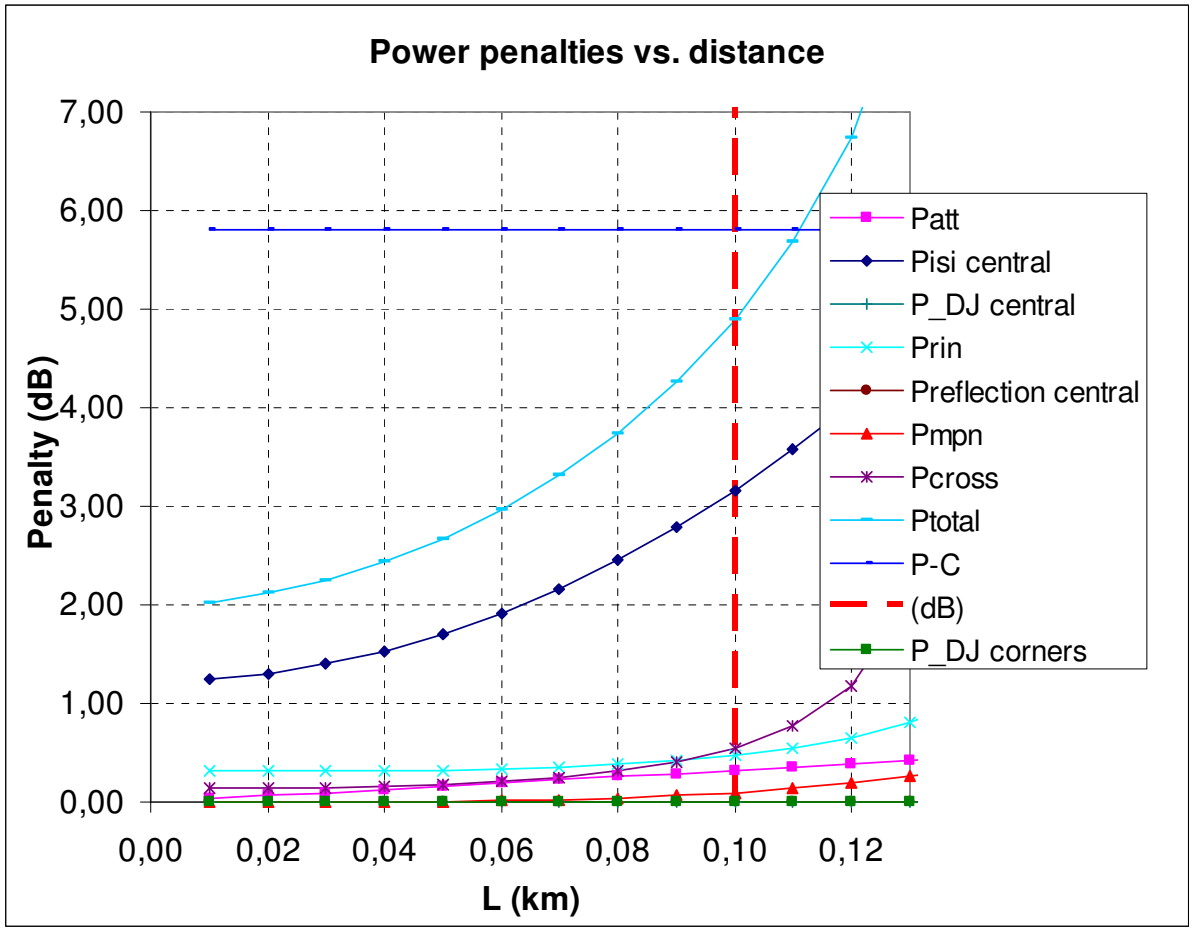
20 Gbit/s Link Simulation



- OM3 fiber with RML similar to 10 GbE
- Total Power Budget 7.3 dB
- Link length: 100 m
- Power margin: 0.9 dB

→ 100 m distance feasible with OM3 fiber

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Cost Estimation

4 x 10GBit/s parallel	Relative Cost	2 x 20GBit/s WDM	Relative Cost
4x TIA	1	2x TIA +DEMUX	1,5
4x Driver	1	2x Driver +MUX	1,5
OSA assembly 4+4	1	OSA WDM assembly 2+2	2
4x Laser / 4x PD	1	2x Laser / 2x PD	0,7
electronic assembly	1	electronic assembly	1,3
PMD Package	1	PMD Package	1
Weighted average at similar volumes	1x		1,4x

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Summary for 40Gbit/s on duplex OM3

- → PMD 100 m 40G over OM3 (2x20G) is feasible
- → 20 GBit/s transmission over FR4 using 90nm CMOS demonstrated (power consumption of 11.8 mW/Gb/s):

  peeters_01_1106.pdf
- → Only slightly higher cost and power than 4x10G parallel

but

- → **standard OM3 duplex fibers can be used**
- → **possible upgrade of existing duplex OM3 fiber links**

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PART B:
100 GBit/s Transmission over OM3 Duplex Fiber

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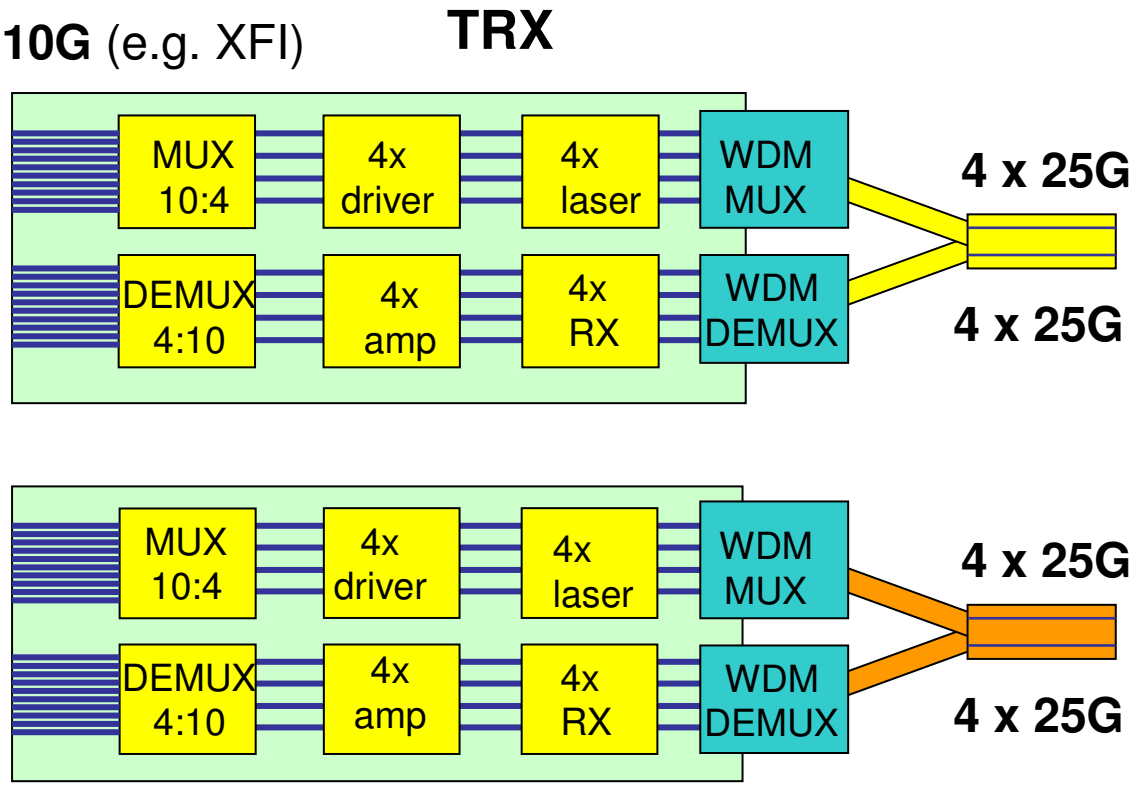
Advantage of similar PMDs

10 x 10G (e.g. XFI)



LR:
LAN-WDM 1300nm

SR:
LAN-WDM 850nm
on OM3 Duplex

- Same electrical interface with same functions
- Most electronic components are the same
- Same form factor as for the SM-application
- Advantage of higher volume for both interfaces

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WDM-Grid at 850nm

- Wavelength channels: 840nm, 847nm, 854nm, 861nm
- Channel Spacing: 7nm
- Width of operating wavelength windows: 3.5nm
- Channel separation between windows: 3.5nm

- Similar concept as the LAN-WDM
  (even with somewhat larger spacing)
- The wavelength window is nearly completely covered by the existing specification window of the OM3 fiber.

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Link Simulation 25 Gbit/s

- Fiber: **OM3 Fiber**
  used with a restricted launch condition according to 10 GbE Standard
  used effective Modal Bandwidth: **1900 MHz·km only** because of slightly extended spectral range of 838nm to 863nm

- Transmitter: wavelength 838 nm - 863 nm,
  $\Delta\lambda$ = 0.45 nm (rms spectral width), T_r, T_f = 11 ps;
  OMA power min. = -3.8 dBm; ext. Ratio min. = 3.0 dB;
  det. jitter = 8.0 ps; RIN = -130 dB/Hz

- Connectors: 1.5 dB loss by connectors

- Receiver: Bandwidth = 20 GHz; sensitivity OMA = -11.1 dBm

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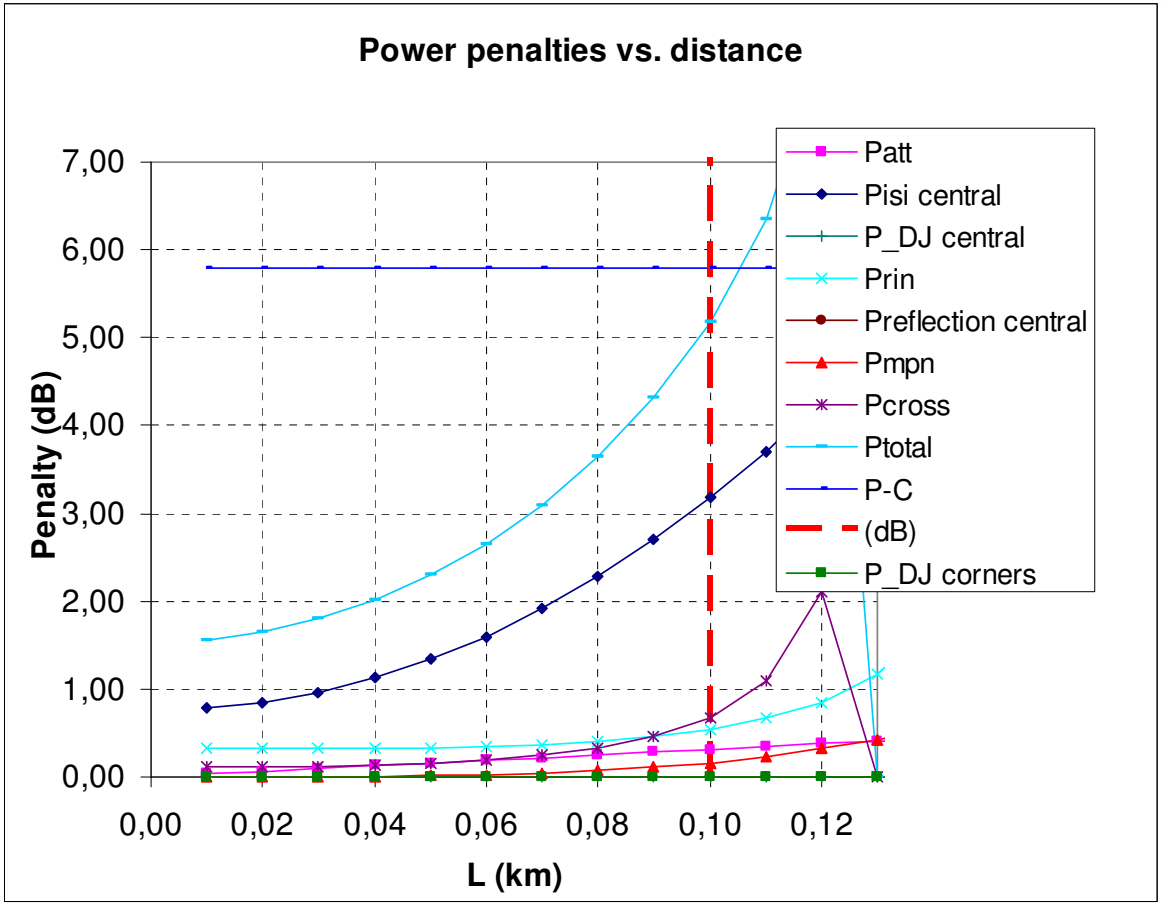
25 Gbit/s Link Simulation



- OM3 fiber with RML similar to 10 GbE
- Total Power Budget 7.3 dB
- Link length: 100 m
- Power margin: 0.6 dB

→ 100 m distance feasible with OM3 fiber

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100G Technical Approach

TOSA:

- → Wavelength stabilization e.g. with temperature control
- → 4 VCSEL cooled with one TEC device
- → this active cooling adds about 0,5 Watts only

Transceiver:

- → Same form-factor as for 1300nm LAN-WDM
- → Same components for electronic interface
- → Lower power for low current driver electronics for VCSEL
- → Lower cost because of VCSEL laser and simpler WDM-TOSA design

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Summary for 100 Gbit/s on duplex OM3

- → Transmission over OM3 Duplex fiber instead of ribbon cable
- → Same electronic components for SR and LR
  (no additional development effort)
- → Easier cable connections
  (less bulky, lower bend radius, reduced space consumption, …..)
- → Potential of higher reliability than the 10x10G approach
  due to less opto-electronic components

but

- → standard OM3 duplex fibers can be used
- → possible upgrade of existing duplex OM3 fiber links

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Summary 40/100G on duplex OM3

- 40 Gbit/s and 100 Gbit/s transmission on OM3 duplex is technically feasible
- upgrade of existing OM3 fiber links is possible
- 2x20G OM3 duplex is competitive to 4x10G ribbon in cost and power consumption
- the proposed PMDs should be included in the standard in addition to the proposed ribbon fiber solutions

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Thank You !