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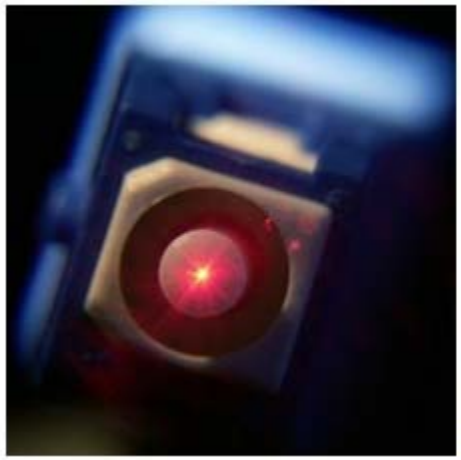
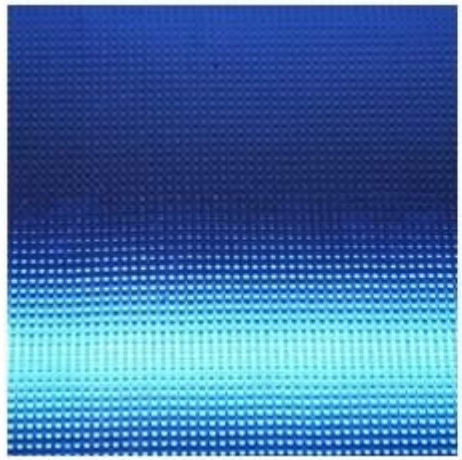
1x40 Gbit/s and 4x25 Gbit/s Transmission at 850 nm on Multimode Fiber

VI Systems GmbH, Berlin, Germany

IEEE 802.3ba Task Force, Orlando, March 2008

J.-R. Kropp, N. Ledentsov, J. Lott, H. Quast

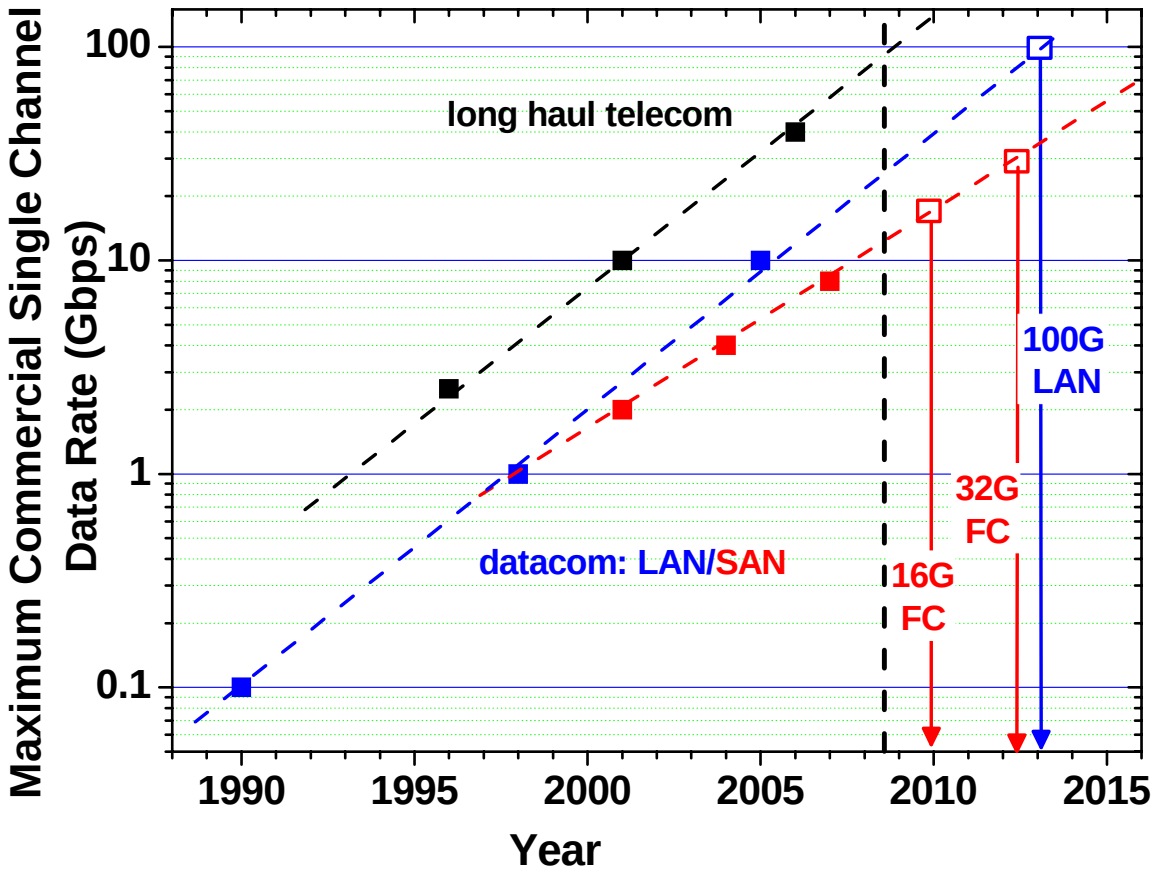
Outline

1. Feasibility of components
   for 4x25G and 1x40G solutions
   for short reach interconnects:
   - novel type of modulated VCSEL
   - photodetectors
   - integrated circuit TIAs and drivers
   - fibers

2. First link performance simulation

3. Proposal

Historic Trend



- Maximum commercial single channel data rate increases 4-fold each 5 years
- 17G VCSELs and 17G Receivers are on the roadmaps

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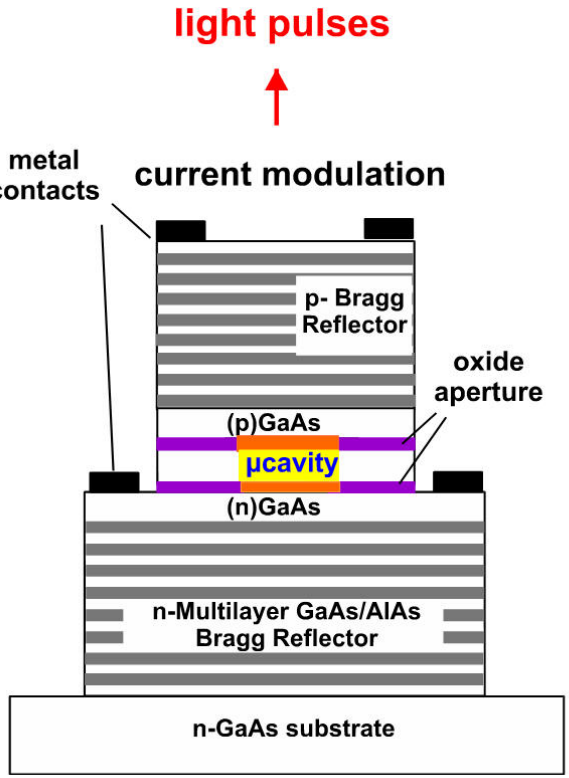
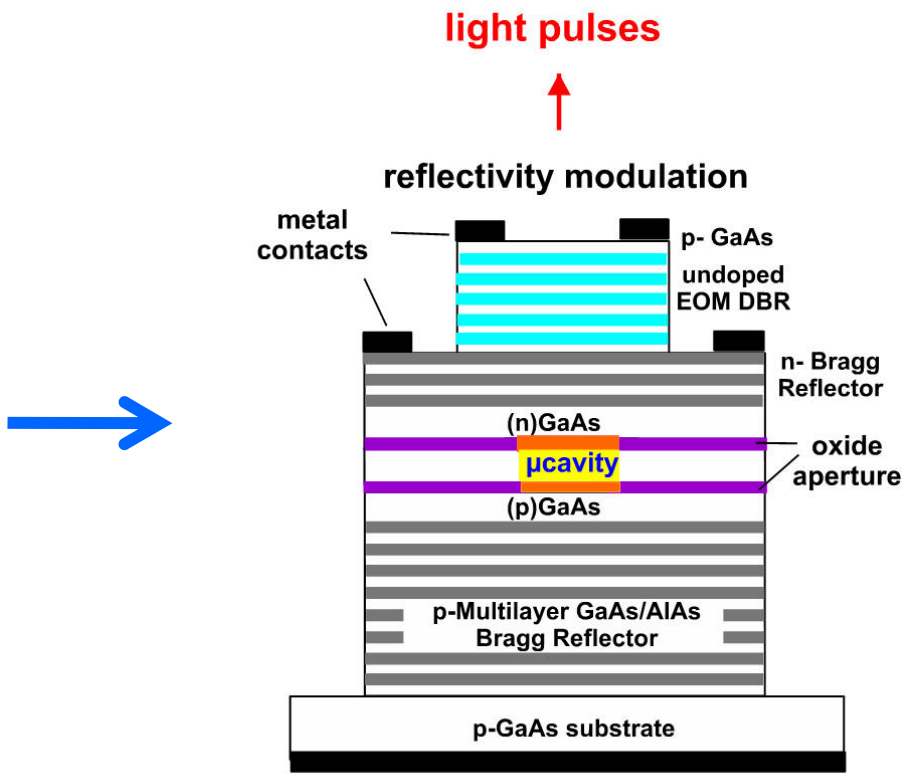
Novel Electro-Optic VCSEL Approach





Today´s VCSELs:

direct modulation of gain medium

Novel EOM VCSEL:

modulation of integrated “modulator section“

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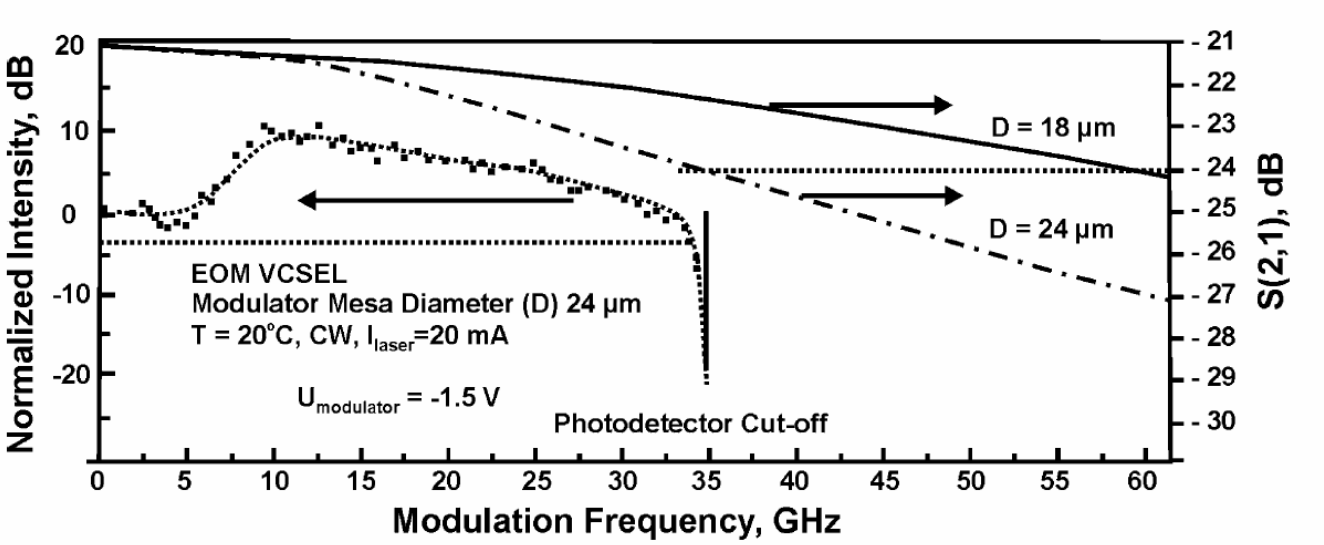
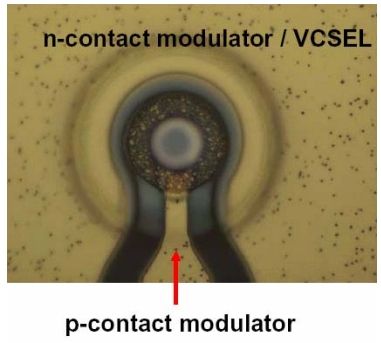
EOM VCSEL: Experimental Results





25 µm

Presented:
Paraskevopoulos et al., ***OFC 2006****,* paper PDP22
*Ledentsov et al. Proc. IEEE Vol.95, p. 1741 (****2007****)*

For related work see also:
van Eisden et al., ***OFC 2008****,* paper JWA42

First generation monolithic electro-optically modulated EOM VCSEL

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Degradation Robustness of EOM VCSEL

- Limitations of standard directly modulated VCSELs:
  - high speed typically requires high drive current densities
  - high current densities cause accelerated degradation
    (see e.g. tatum_01_1106.pdf)

- EOM VCSEL reaches high-speed using a modulator medium
  - moderate drive current densities increase device reliability
  - near-zero current for modulator section
  - no accelerated degradation

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Advantage of EOM VCSEL

- Laser is running CW with moderate current
- No chirp with modulation
- Small spectral line width (single mode emission is possible)
- Modulation characteristic is decoupled from laser current
- Very high speed switching
- Low cost because of standard single-step epitaxial growth and standard VCSEL processing

- High-speed EOM VCSEL was demonstrated and will be available

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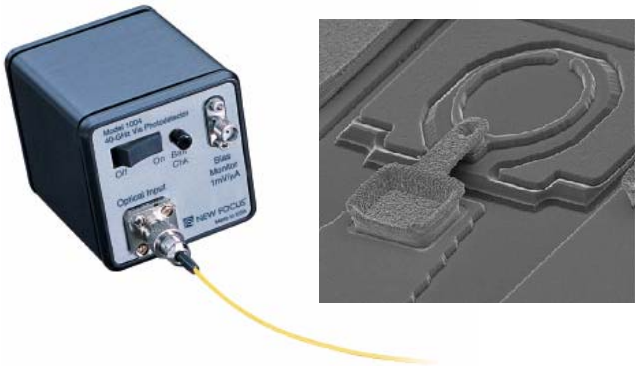
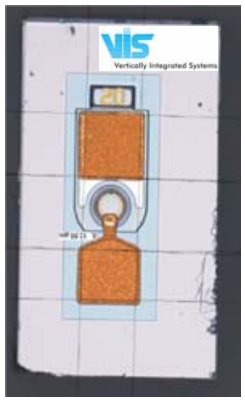
40 Gbit/s 850 nm Photodetectors



40 GHz photodetector



40 Gbit/s pin-PD chip

- → Detectors for 40 Gbit/s at 850 nm are demonstrated
- → Known technology
- → Coupling to MM-fiber is possible
- → Low cost packaging is possible

→ 40 Gbit/s photodetectors for 850 nm are available

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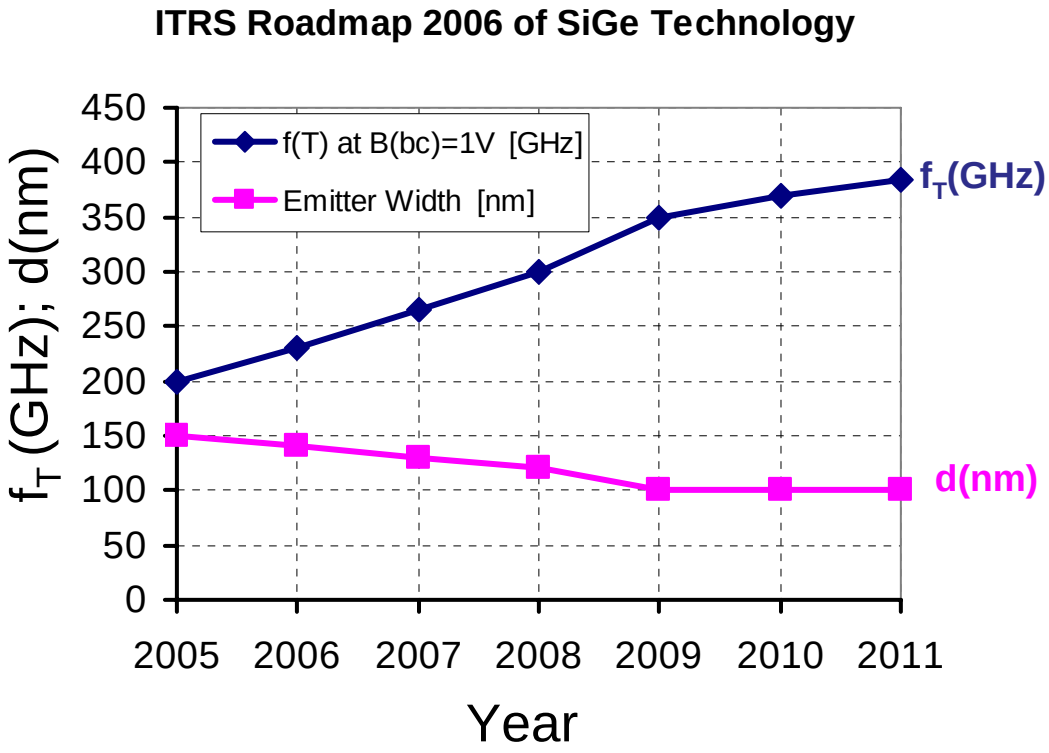
40 Gbit/s Integrated Circuits



f_T up to 300 GHz has been demonstrated with SiGe; see for example:

H. Rücker et al.,
IEEE IEDM 2007

S. P. Voinigescu et al.,
IEEE BC TM 2006

B. Heinemann et al.,
IEEE IEDM 2004

→ >40 Gbit/s has been demonstrated
i.e. with low cost SiGe VLSI technology

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Multimode Fibers

- **OM3** fiber with 2000 MHz·km is a standard product

- Higher speed versions with a bandwidth parameter of up to 4700 MHz·km are available from several suppliers

  - such a higher speed version of MMF is now in discussion as "**OM4**" fiber in a standardization proposal

- Multimode fibers are available to support data rates of 25 Gbit/s and 40 Gbit/s

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   for 4x25G and 1x40G solutions
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2. **First link performance simulation**

3. Proposal

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First Link Performance Simulation

Consider two typical cases for performance evaluation:

Transmission on Multimode Fiber at 850 nm :

- Scenario a)
  - Serial transmission at 28 Gbit/s with NRZ coding according to the proposal of the OIF for the CEI-25 interface
- Scenario b)
  - Serial transmission at 40 Gbit/s with NRZ coding

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Scenario a): 28 Gbit/s

- Fiber: **OM3 Fiber**

  used with a restricted launch condition according to 10 GbE Standard

  effective Modal Bandwidth: 2000 MHz·km

- Transmitter: wavelength 840 nm - 860 nm,
  $\Delta\lambda$ = 0.20 nm (rms spectral width), T_r, T_f = 11 ps;
  OMA power min. = -3.8 dBm; ext. Ratio min. = 3.0 dB;
  detector jitter = 6.0 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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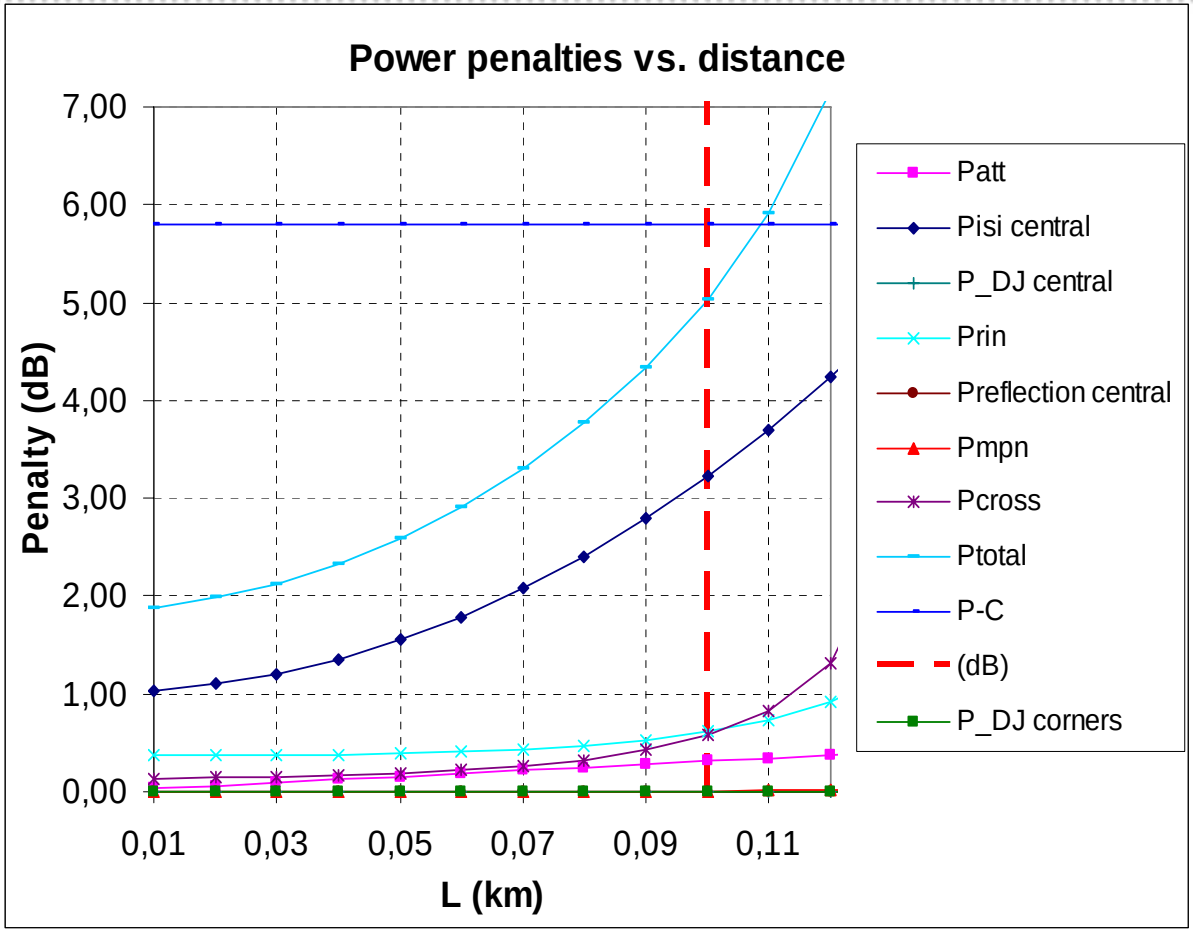
28 Gbit/s First Link Simulation



- OM3 fiber with RML similar to 10 GbE
- Total Power Budget 7.3 dB
- Link length: 100 m
- Power margin: 0.7 dB

→ 100 m distance feasible with OM3 fiber

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Scenario b) : 40 Gbit/s

- Fiber: "**OM4**" Fiber, Very High Grade MMF
  used with restricted launch condition according to the 10GbE Standard
  effective Modal Bandwidth: 4700 MHz·km

- Transmitter: wavelength 840 nm - 860 nm;
  $\Delta\lambda$ = 0.20 nm (rms spectral width); T_r, T_f (20 - 80) = 8 ps;
  OMA power min.= -3.8dBm; ext. Ratio min. = 3.0 dB;
  detector jitter = 5.0 ps; RIN = -130 dB/Hz

- Connectors: 1.5 dB loss by connectors

- Receiver: Bandwidth = 30 GHz; sensitivity OMA = -10.0 dBm

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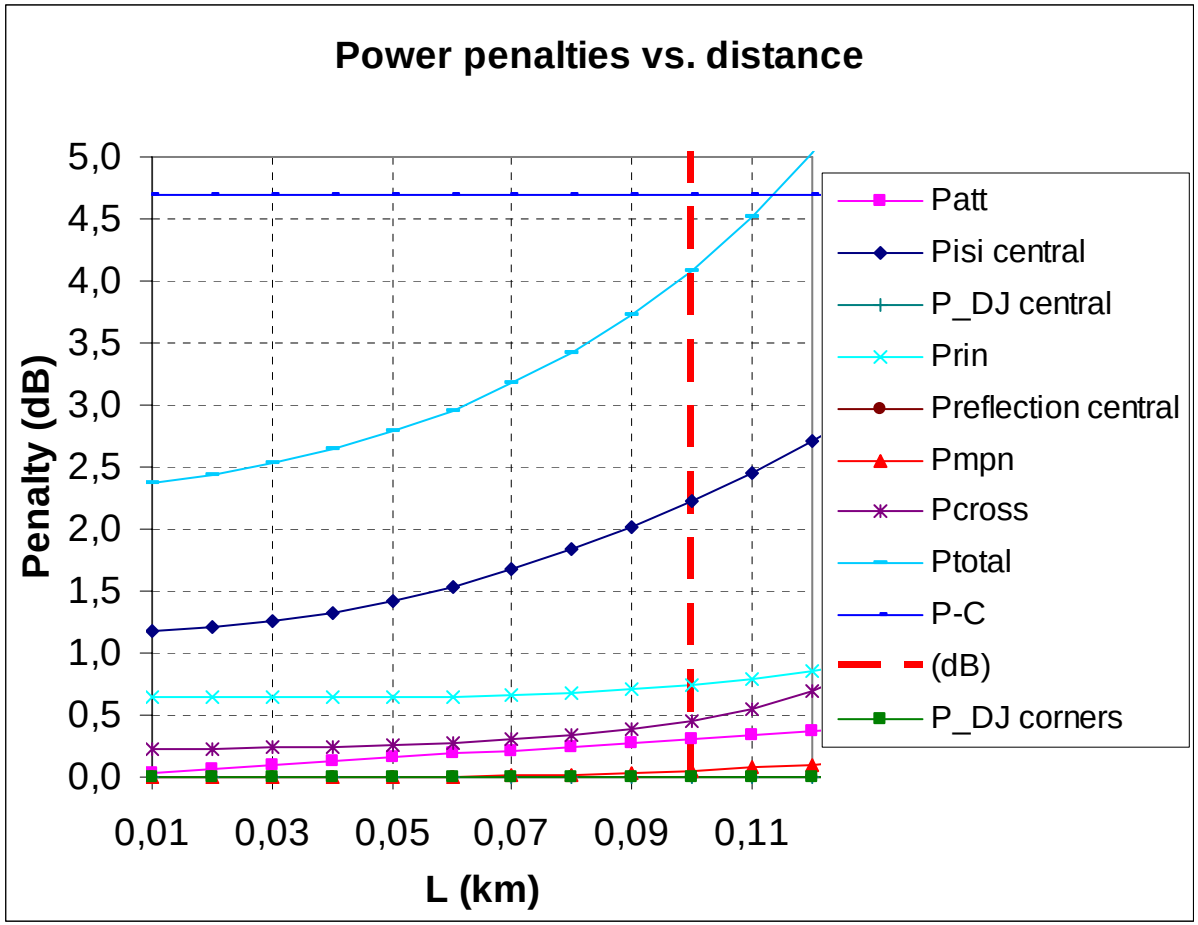
40Gbit/s: First Link Simulation



Fiber bandwidth 4700 MHz·km
with RML similar to 10 GbE

- → Total Power Budget 6.2 dB
- → Link length: 100 m
- → Power margin: 0.6 dB

→ 100 m feasible with “OM4” fiber

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Advantages of 4x25G or 1x40G

- Smaller number of components – lower overall cost
- Only one duplex fiber or one 4+4 fiber bundle per transceiver
- Higher reliability
  - fewer components
  - fewer VCSELs, each requiring low-stress drive conditions
- One set of electronics because of one channel (1x40G)
- Reduced power consumption
- Fiber options:
  - 4x25G can be arranged as a 4-fiber solution
  - or WDM is possible with a single fiber
- Same set of management ICs for LR and SR

Conclusion

4x25 Gbit/s and 40 Gbit/s transmission
at 850 nm on multimode fiber:

- → Components / solutions exist
- → Many advantages
- → Link over 100 m is feasible

Proposal

1. Include a 4x25 Gbit/s solution
   for short reach interconnects on multimode fibers
   in the Standardization (with **OM3**)

2. Include a 40 Gbit/s serial solution
   for short reach interconnects on multimode fibers
   in the Standardization (with “**OM4**”)

3. Support the Standardization of the **“OM4“** fiber

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Thank You !