Review of Hewlett-Packard Proposal: Long Wavelength Laser-Based Fiber Optic Links.

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David Cunningham, M. Nowell and Del Hanson*

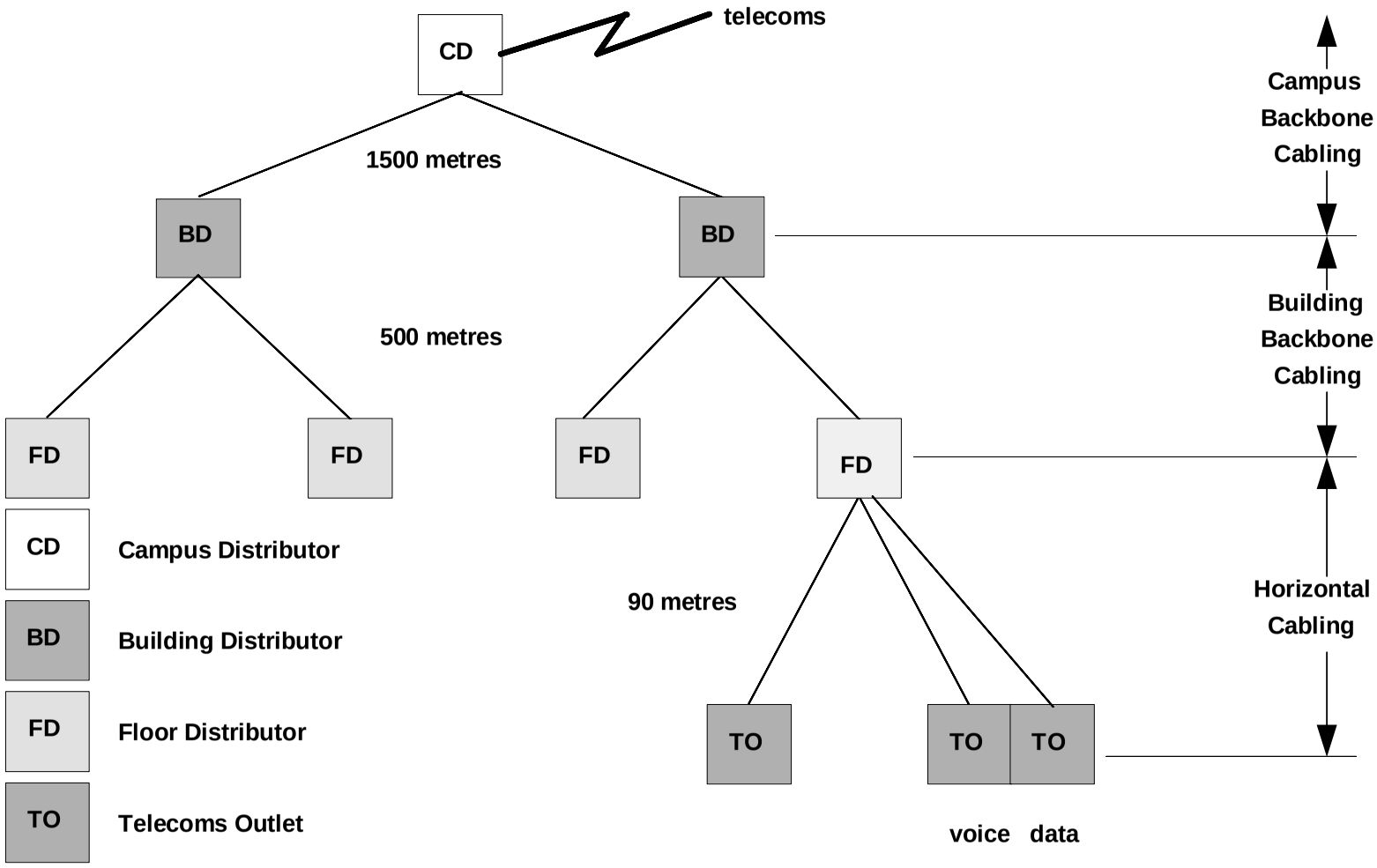
Hewlett-Packard Laboratories
Filton Road
Stoke Gifford
Bristol BS12 6QZ
UK
Phone: +44 117 9228749
e-mail: dgc@hplb.hpl.hp.com

** Del Hanson, Hewlett-Packard, Optical Communications Division*

Outline

- **Need for 62 MMF support in building backbone, 550m links**
- **HP July Proposal: 62 MMF and 1300nm lasers**
- **Modal noise allocations**
- **Technical foundations and status of 50MMF and 1300nm lasers**
- **Longer MMF links with Restricted Mode Launch (RMI)?**
- **Conclusions**

ISO 11801 Cable Model



Summary Fibre Cable Data

- *ISO 11801 cable model and link lengths*
  - *90 m, Horizontal (+ 10 m for patchcords)*
  - *500 m, Building Backbone (+ 50 m for patchcords)*
  - *1.5 km, Campus Backbone (+ 50 m for patchcords)*
- *62.5 MMF dominant in building backbone*
- *Small population of SMF links*
- *300 m, extended horizontal (home run) links important for future installations*

ISO/IEC 11801 Cable transmission performance parameters

Wavelength	*Maximum Attenuation*	*Minimum modal Bandwidth*	Expected Baud Rate Length Product
0.85 um	3.5 dB/km	200 MHz.km	370 MBaud.km
1.3 um	1 dB/km	500 MHz.km	1100 MBaud.km

- 1.25 GBaud, 550m links easily achieved
- ***Based on OFL modal bandwidth link lengths up to approximately 850 m supported***

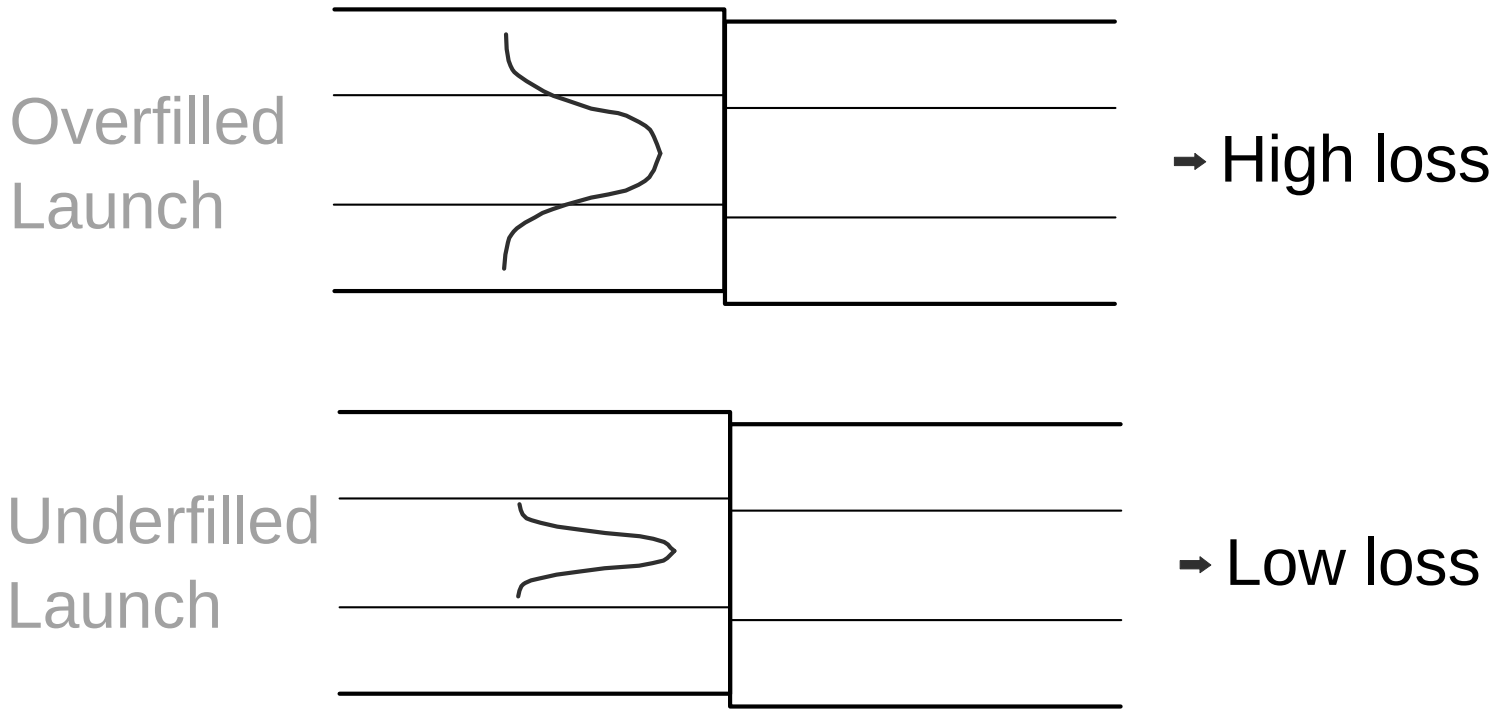
Standards With MSL Allocations (62MMF and 50MMF)

- **ATM Forum:** *622 MBaud*
  - short wavelength lasers, maximum penalty = 1 dB @ 10^-10 BER

- **Fibre Channel:** *1062 MBaud*
  - short wavelength lasers, maximum penalty = 1 dB @ 10^-12 BER

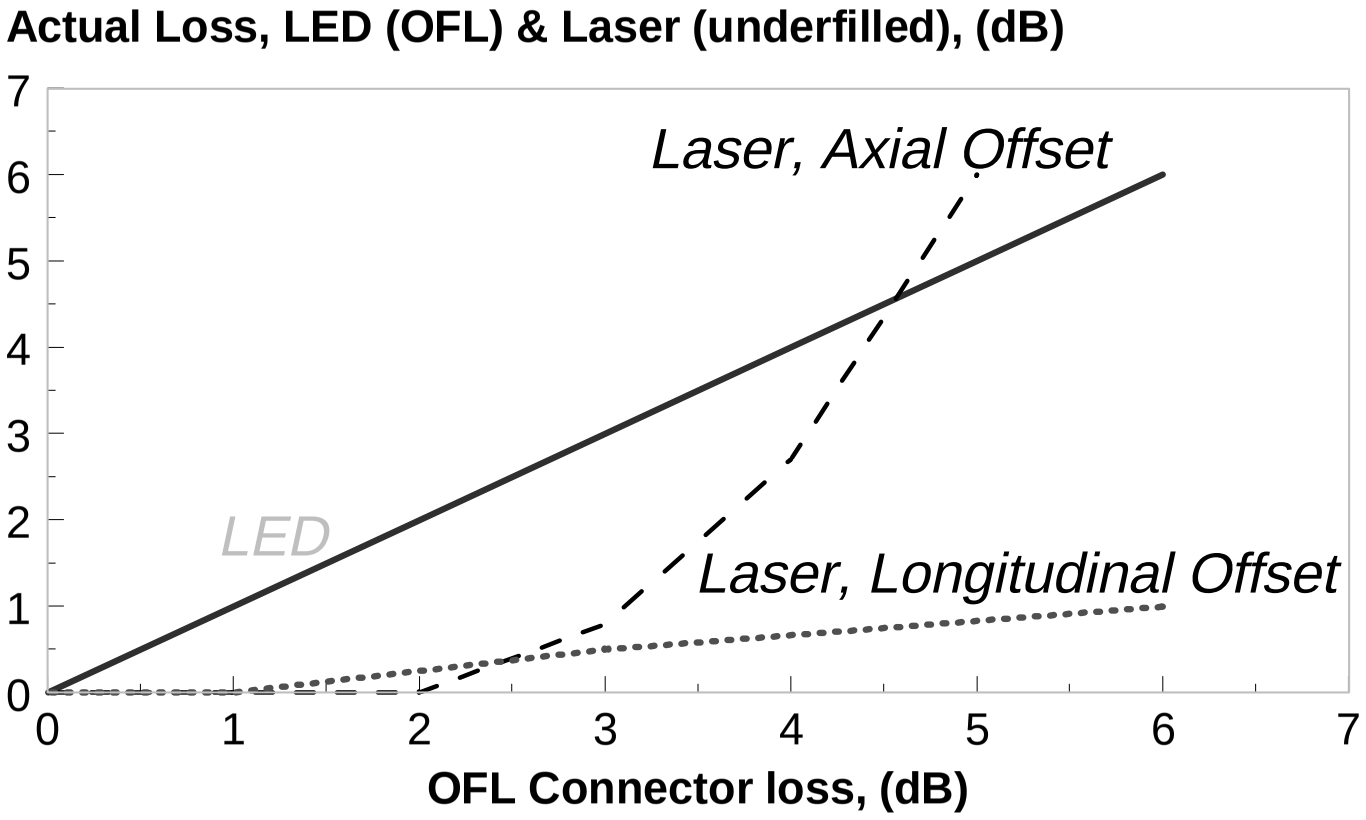
- **Serial HIPPI:** *1200 Mbaud*
  - short and long wavelength lasers, maximum penalty = 1 dB @ 10^-12 BER

Effect of launch condition on loss when lasers are used



- Connector attenuation is a strong function of the laser launch condition when lasers are used

Comparison of attenuation of misaligned connector for different launch conditions



- *Most laser-based transceivers* ***under fill*** *MMF*

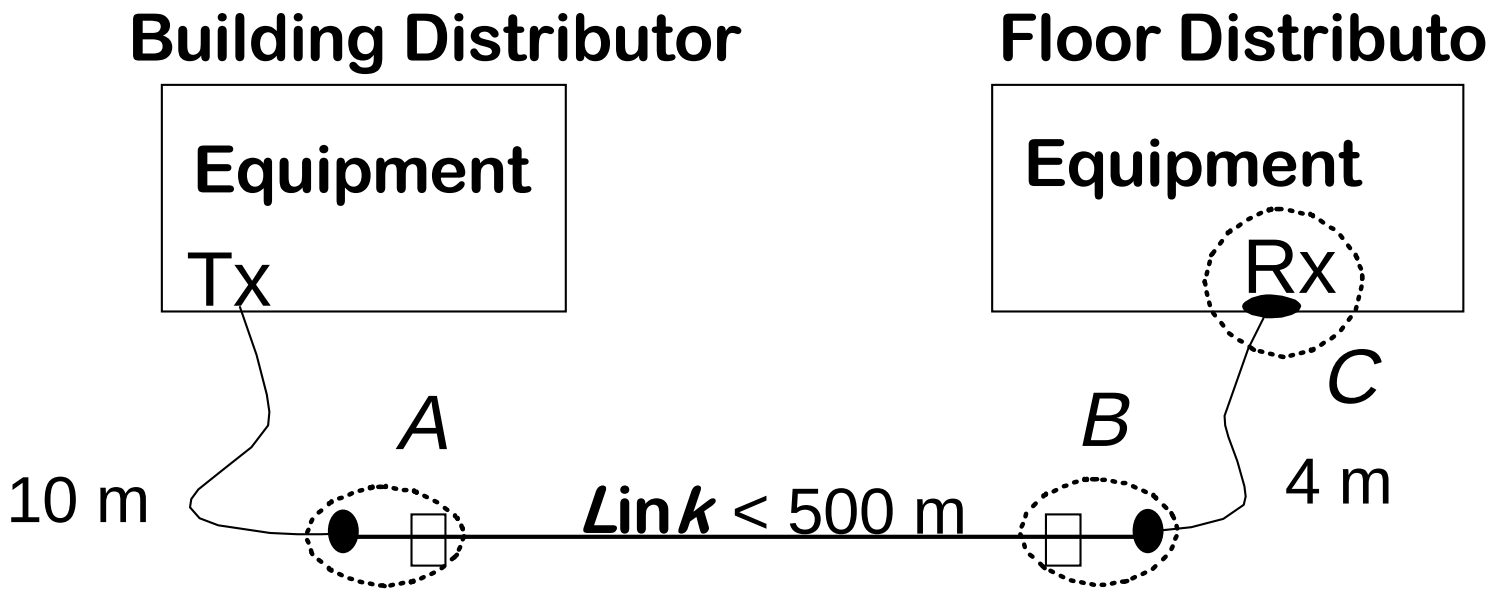
Now called MSL in TIA FO 6.5

MSL Definition Development: *Connector Loss Versus Loss Experienced by Laser*

During ATM Forum/MNTMG debates it was agreed:

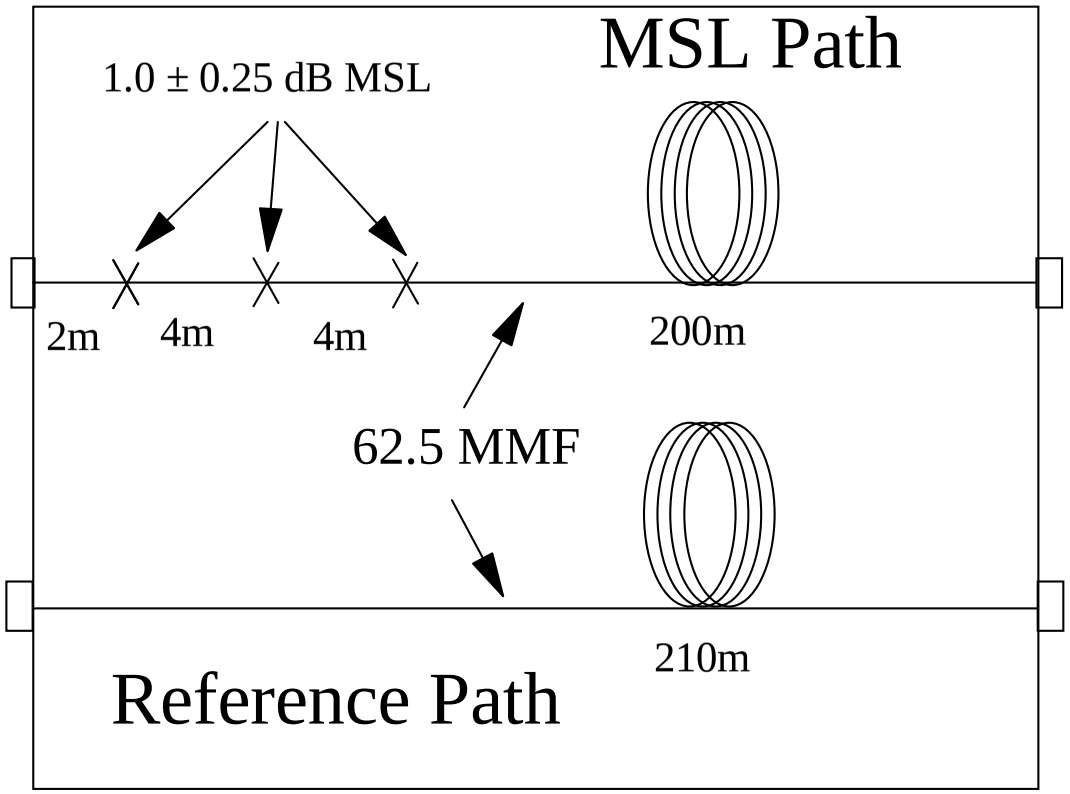
- *Most laser transceivers under fill fiber*
- *OFL connector loss usually greater than loss experienced by laser*
- *Cabling standards define connector loss*
- *MSL defined by worst case connector loss*
- *MSL must be DISTRIBUTED*

ISO/IEC 11801-*based worst case MSL model*



- ***Worst case connector loss (0.75 dB) and splice loss (0.3 dB) lumped together:***
  - *MSL of A = 1.05 dB*
  - *MSL of B = 1.05 dB*
  - *MSL of C = 0.75 dB*
  - *Short patch cords produce highest level of modal noise*
- ***MSL** is **distributed** throughout the link*

TIA FO 6.5 (MNTMG): *Modal Noise Test Equipment*

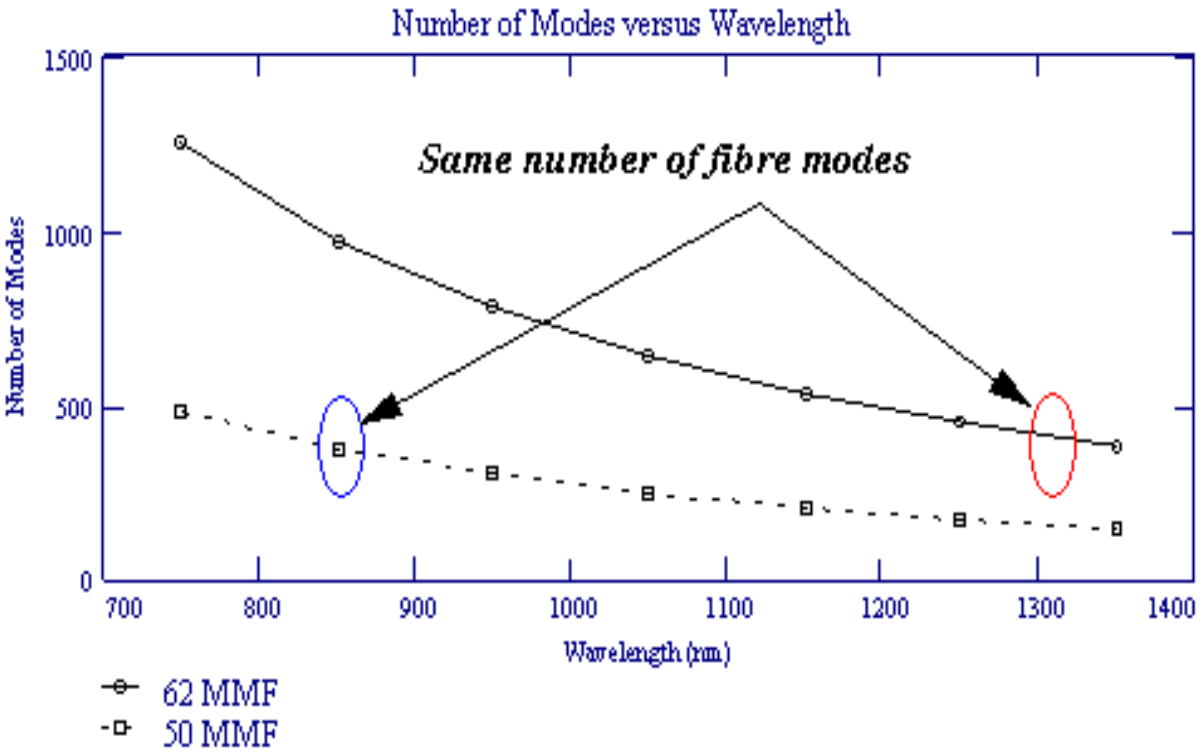


MSL Test box

- **Worst case cable model agreed by simulation**
  - ➡ *MSL Test box*
  - ➡ *MSL fabrication*
  - ➡ *MSL calibration*
- **Measurement procedure maturing**
  - ➡ *Measurements agreed*
- **Round robin testing planned**

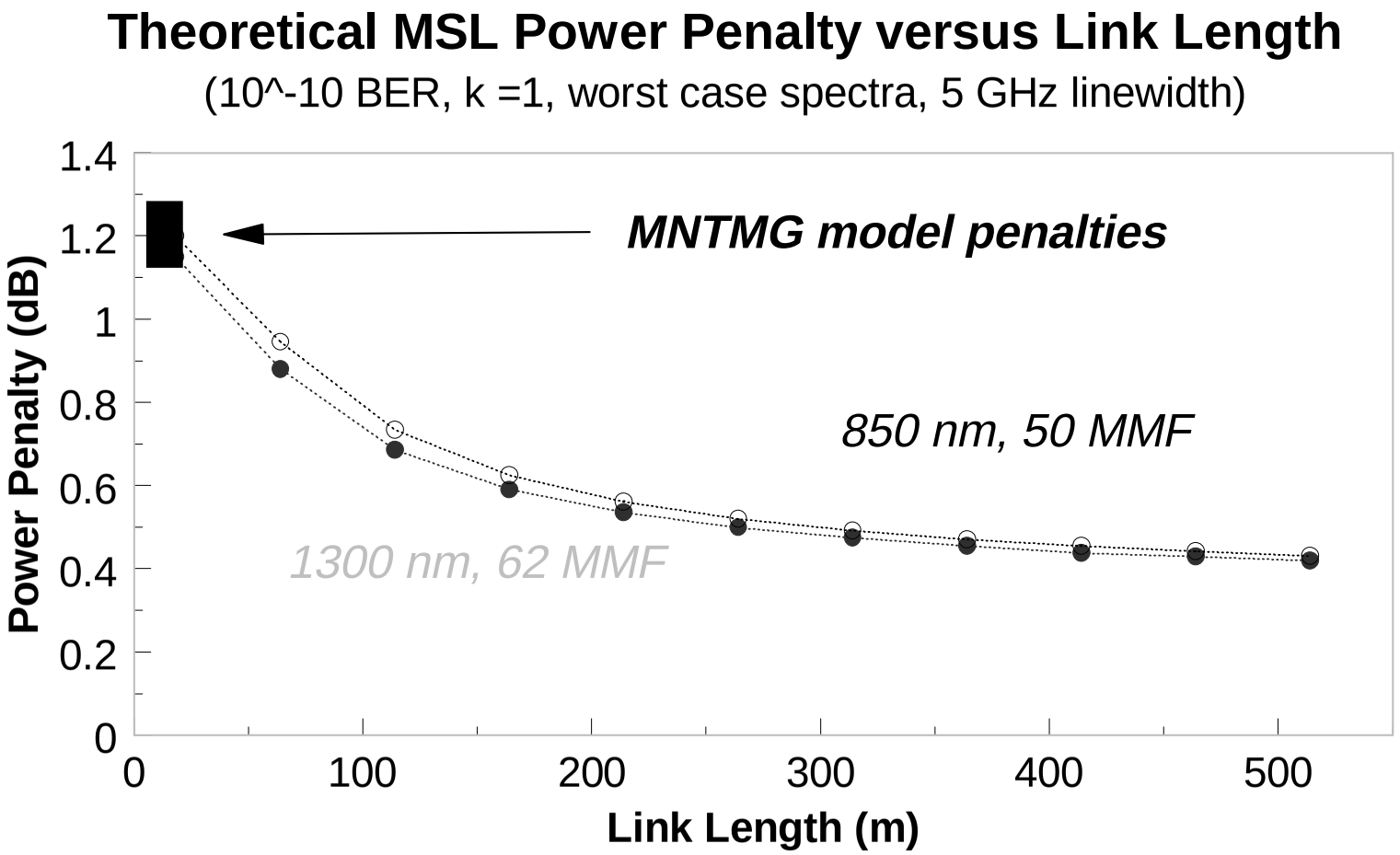
(MNTMG, Modal Noise Test Methodology Group an ad hoc Industry Group [IBM, Honeywell, Hewlett-Packard, Vixel Corp.]

Number of Fiber Modes versus Wavelength



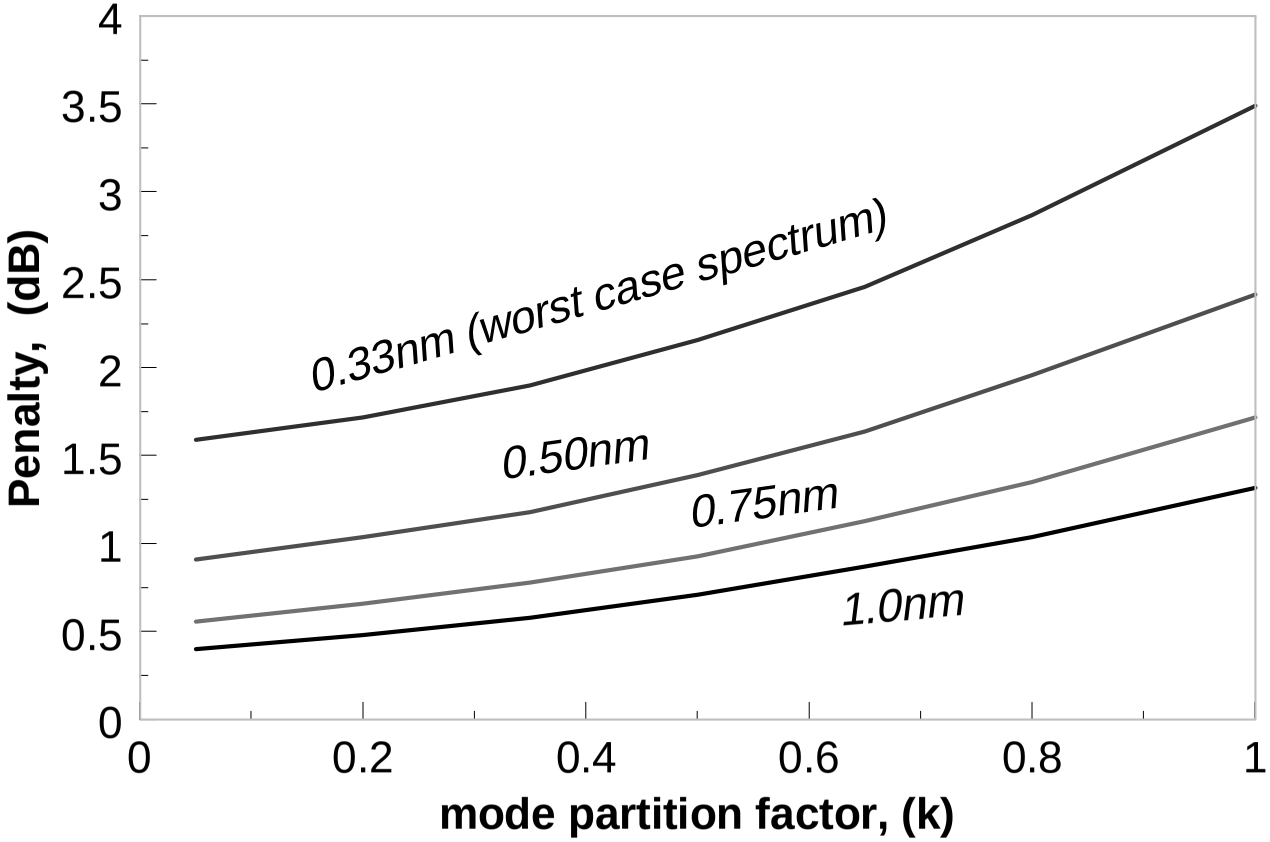
- ***Worst case SW and LW lasers have similar coherence***
- ***Same number of fibre modes at :***
  850 nm in 50 MMF
  1300 nm in 62 MMF
- ***Expect similar power penalties for:***
  Short wavelength 50 MMF
  Long wavelength 62 MMF

ISO/IEC 11801: *Worst Case MSL Model, Power Penalties*



Theory: *Modal Noise Penalty, OFL, 1300nm, 50MMF*

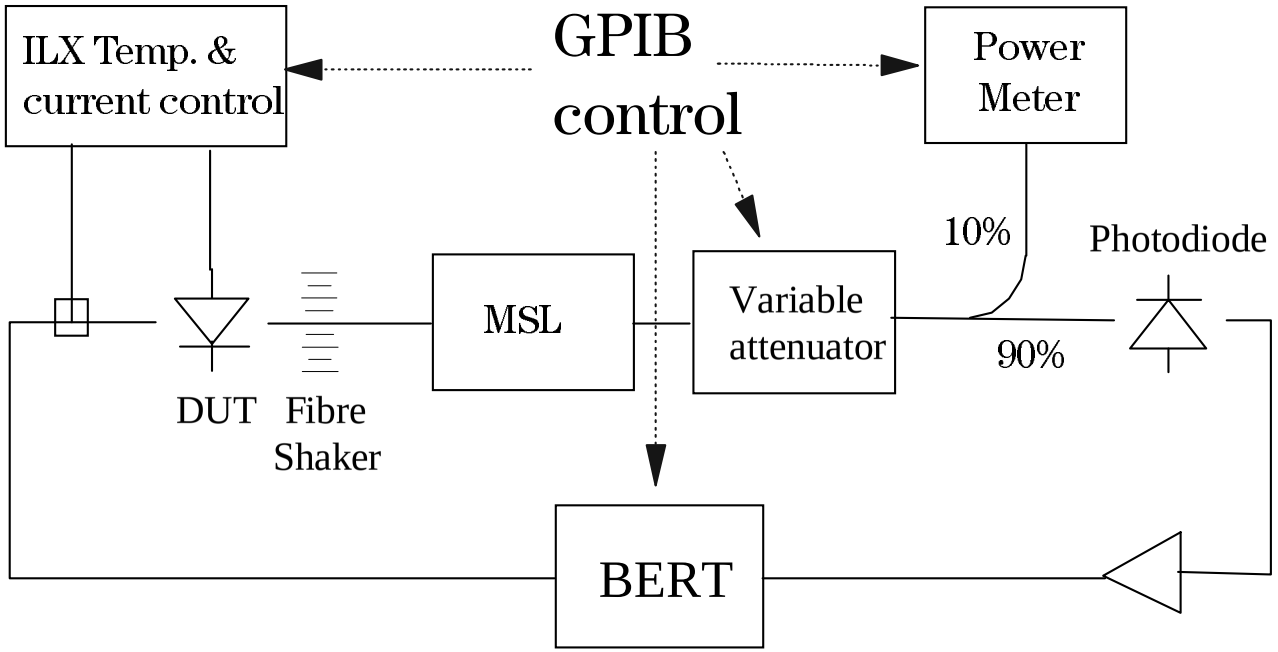
Theoretical MSL Penalty versus k and RMS spectral width



Calculated assuming:

- three 1dB points of MSL separated by 4m, 1st point located 12m from laser
- 0.65nm mode spacing
- 10^-12 BER

Modal Noise BER Power Penalty Measurement Setup



- Shake fibre
- Ramp laser temperature
- Computer controlled

- Three 1 dB Points of MSL

or

- Single 3 dB lumped axial offset loss

Measured modal noise penalties: 1300nm 62MMF

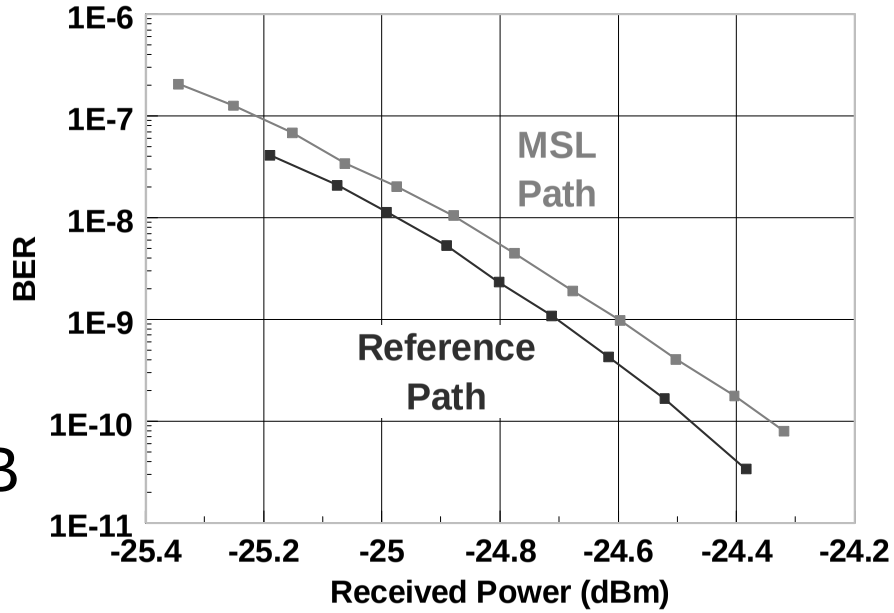
Near worst case lasers:

~ 0.7nm RMS width to maximise worst case modal noise.

Average Penalty = 0.19 dB

Max. Penalty = 0.3 dB

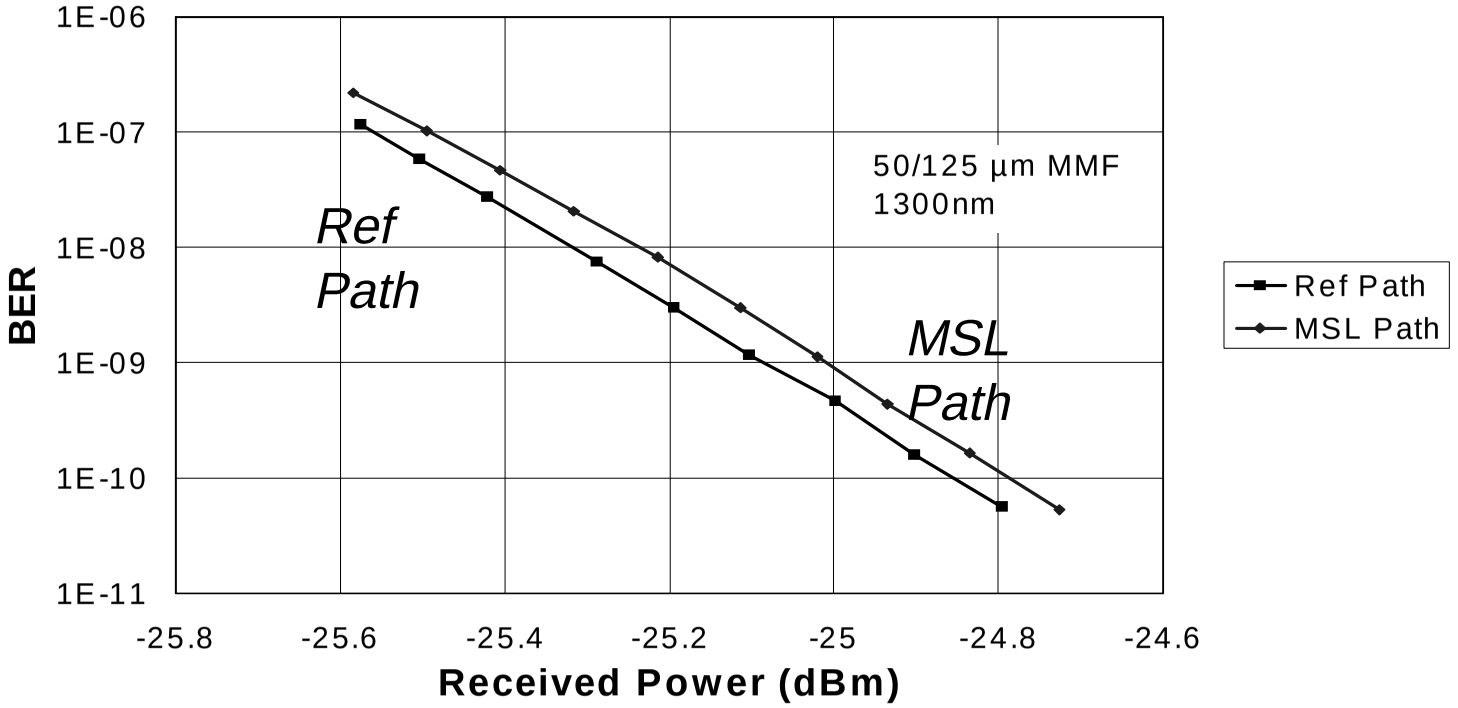
Min. Penalty = 0.1 dB



Measured using:

- *three 1 dB points of MSL separated by 4m, 1st point of MSL located 12m from laser (according to TIA FO6.5 draft standard)*

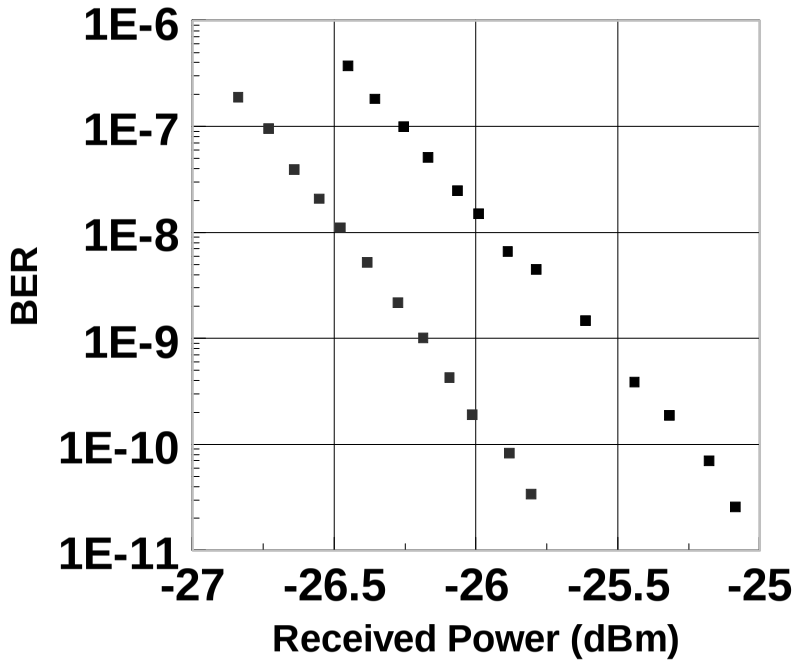
Measured Modal Noise Penalties: 50MMF, 1300nm



- *Penalties < 1 dB for worst case HP, 1300 nm, coaxial lasers <u>even</u> on 50 MMF*

Results: *Measured modal noise penalties, 1300nm, 50MMF, 3 dB Lumped MSL*

Example modal noise power penalty curve



- ***Near worst case lasers***

  ~ 0.7 nm RMS spectral width

- ***Single 3 dB point of MSL***

  - axial offset connector

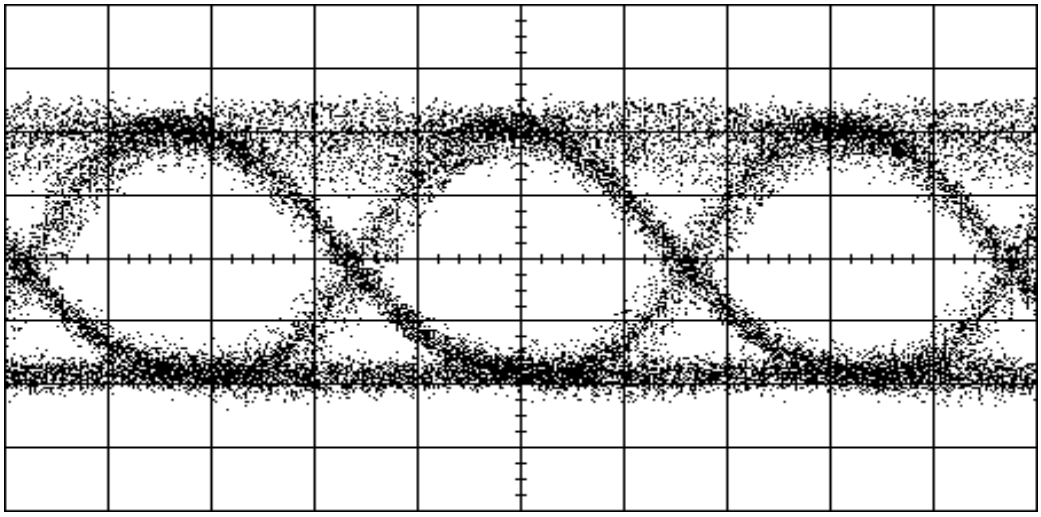
  - 12 m from laser launch

Laser Launch	**Penalties @ 10^-10 BER** minimum	average	**maximum**
Connected Directly to Transceiver	0.4 dB	0.8 dB	***1.2 dB***

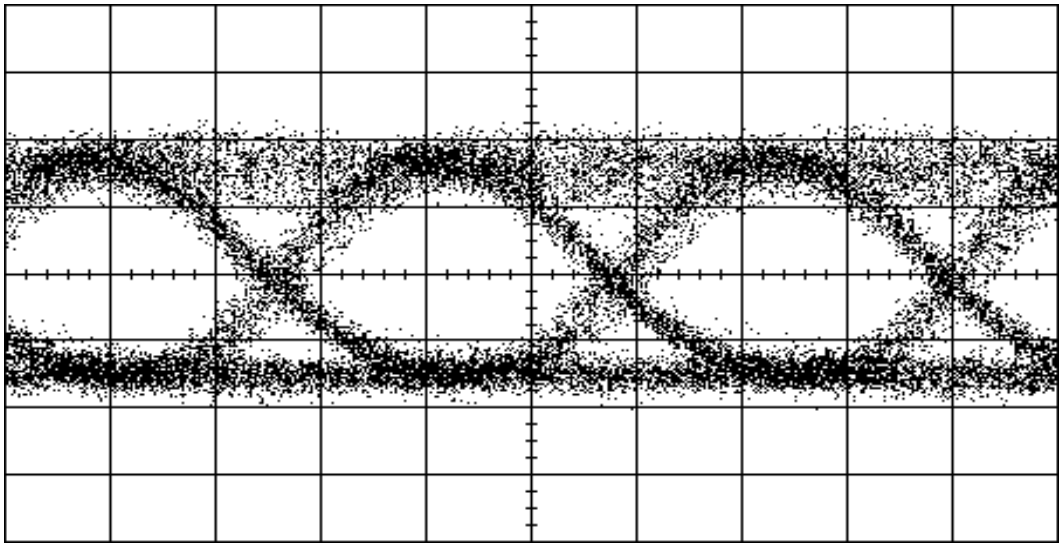
Extending 62 MMF Links using RML:

Initial Results

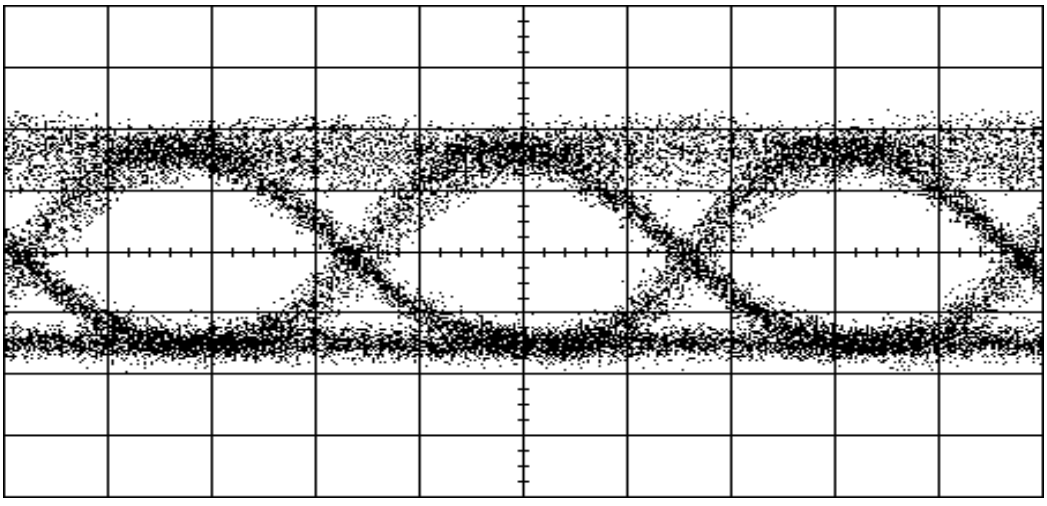
0 km



1 km



2 km



Summary

- **62MMF and long wavelength lasers:**
  - **robust specification**
  - **62 MMF support for majority of installed building backbone, 550 m links**
  - **based on OFL modal bandwidth up to ~ 850m link lengths**
  - **allocate 1 dB modal noise penalty**
- **50MMF and long wavelength lasers:**
  - **convincing results**
  - **HP allocate ~ 1.5 dB modal noise penalty**
  - **further results to be reported by HP at this meeting**
- **RML with lasers:**
  - ***Significant work needed***