Ethernet PON Fiber Considerations

IEEE 802.3ah INTERIM MEETING

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Discovering Beyond Imagination

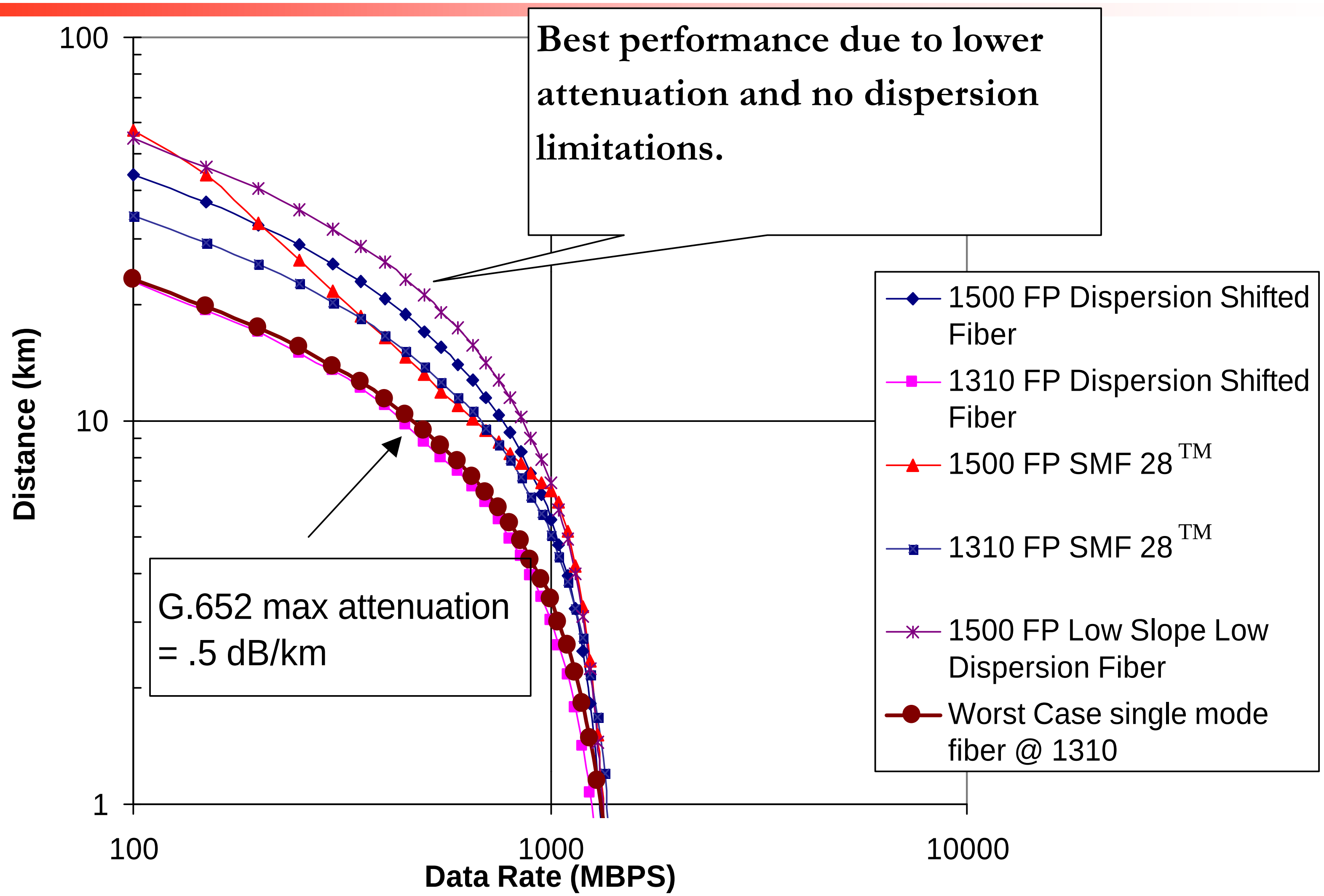
Outline

- FP Link Budget Graphs
- Fibre Standards Recommendations from ITU
- FP Laser Spectra Considerations
- Dispersion Limitations
- Summary

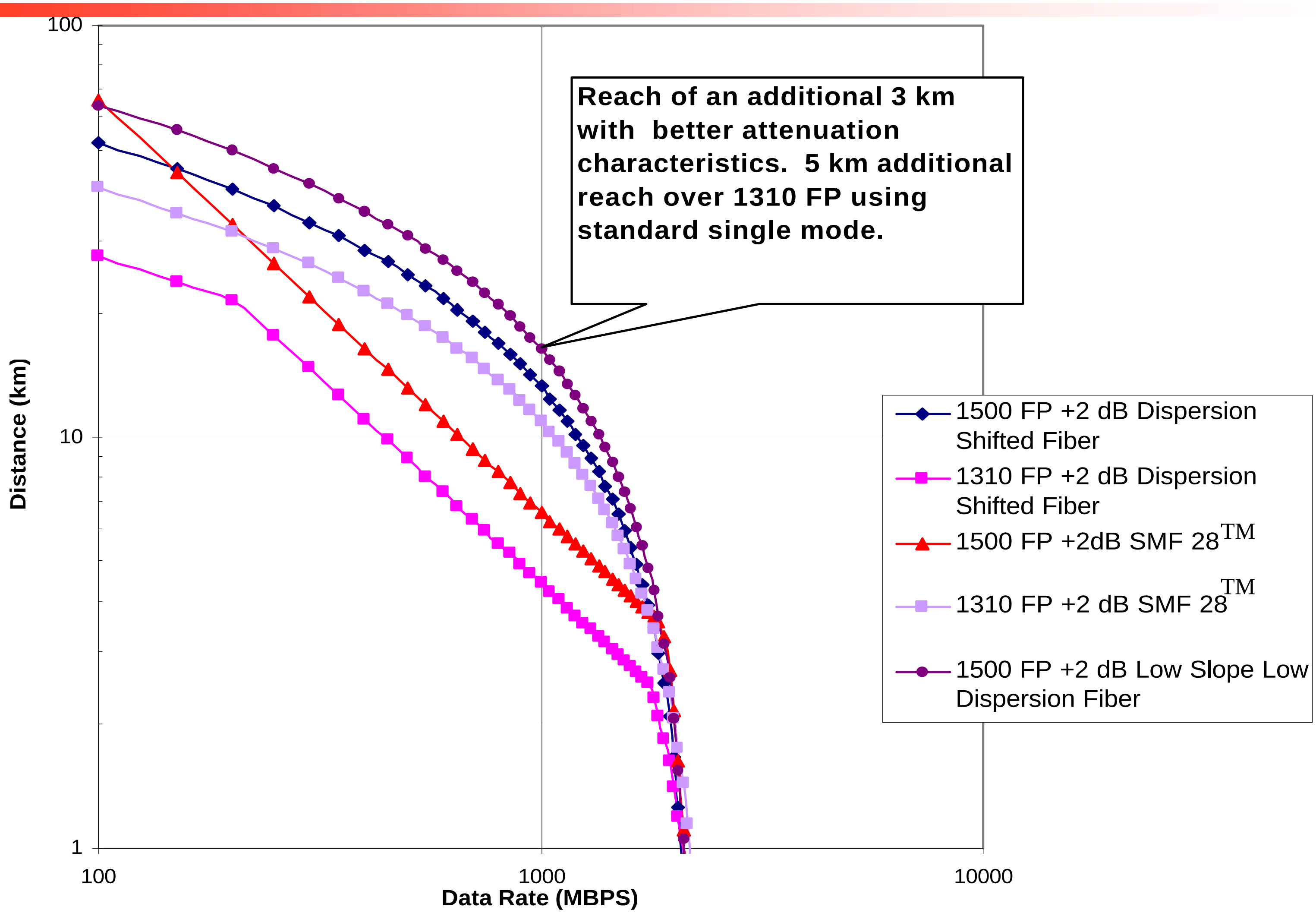
Link Budget Graph Assumptions

- Power Budget of 24 dB between TX and RX
  - Rx sensitivity of -24 dBm at 1 GBPS
  - 1 mW Laser source
  - BER 10^{-9}
- Fixed Losses of 22.5 dB (Class B)
  - Splice losses (4 X .07dB): 0.28 dB
  - Connector Losses (3 X .75 + 3 X .5 dB): 3.75 dB
  - Splitter Loss: 14.45 dB
  - Link Margin 4 dB
- G.652 Fiber and Dispersion Shifted Fiber Attenuation and Dispersion Characteristics

FP Laser Data Rate vs. Distance



FP Laser Data Rate vs. Distance
Receiver Sensitivity -26 dBm



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G.652.C Fibre Attributes

Attribute	Detail	Value
Mode field diameter	Wavelength	1 310 nm
	Range of nominal values	8.6-9.5 μm
	Tolerance	± 0.7 μm
Cladding Diameter	Nominal	125.0 μm
	Tolerance	± 1 μm
Core concentricity error	Maximum	0.8 μm
Cladding noncircularity	Maximum	2.0%
Cable cut-off wavelength	Maximum	1 260 nm
Macrobend loss	Radius	37.5 mm
	Number of turns	100
	Maximum at 1 550 nm	0.50 dB
	Maximum at 16XX* nm	0.50 dB
Proof stress	Minimum	0.69 GPa
Chromatic dispersion coefficient	λ_{0min}	1 300 nm
	λ_{0max}	1 324 nm
	S_{0max}	0.093 ps/nm^2•km
Uncabled fibre PMD coefficient	Maximum	** ps/√km

G.652.C Cable Attributes

Attribute	Detail	Value
Attenuation coefficient	Maximum at 1 310 nm	0.4 dB/km
	Maximum at yyyy nm ***	****
	Maximum at 1 550 nm	0.35 dB/km
	Maximum at 16XX* nm	0.4 dB/km
PMD coefficient	M	20 cables
	Q	0.01%
	Maximum PMD_Q	0.5 ps/√km

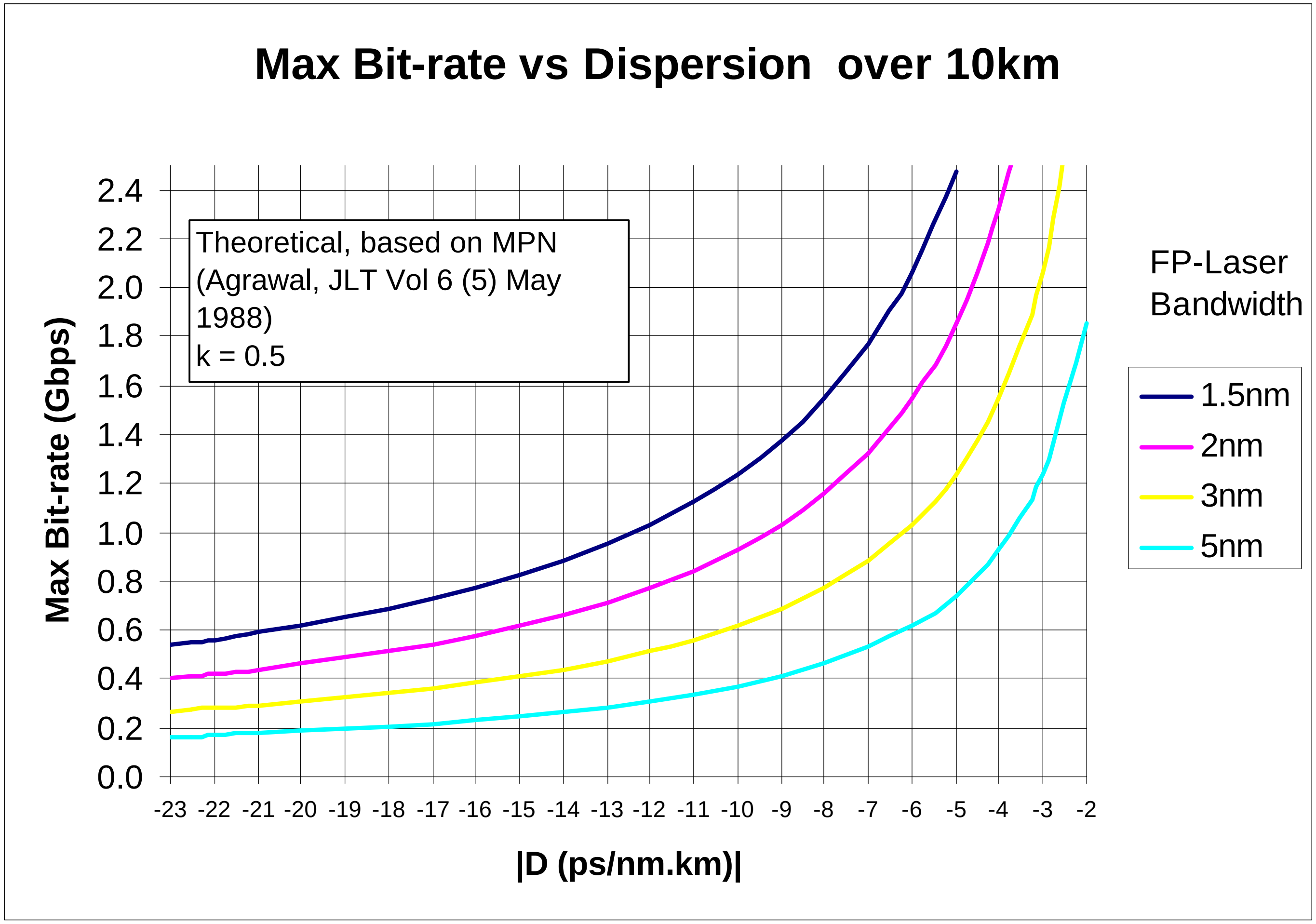
*** NOTE - The upper wavelength of this band has not been fully determined. However, XX is less than or equal to 25 nm.**

*****NOTE - The wavelength, yyyy, is recommended to be 1 383 nm ≤ yyyy ≤ 1 480 nm, and agreed between buyer and seller. If the water peak (1 383 nm), is specified, then both longer and shorter wavelengths may be used in the extended band. If the specified value is greater than the water peak, then only wavelengths greater than yyyy may be used in the extended band.**

******NOTE - The sampled attenuation average at yyyy nm shall be less than or equal to the value specified at 1 310 nm after hydrogen ageing according to IEC 60793-2 regarding the B1.3 fibre category (see also Appendix V [B.2]).**

Low Water Peak Specification

Maximum Bit-rate for a Given Δλ



$$B \leq [1/(\pi|D|L\Delta\lambda)].[\ln\{kQ/(kQ - 0.863)\}]^{0.5}$$

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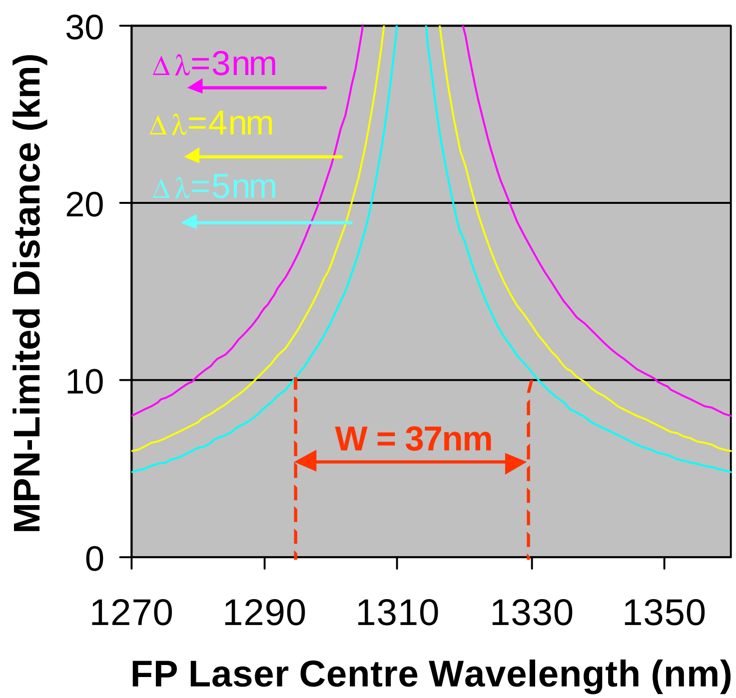
Another Look at MPN Limitations

MPN operating window



<u>G.652 Compliant Fibre</u>

Slope = 0.093ps/(nm^2.km)

λ_0 max = 1318nm

λ_0 min = 1306nm

($\pm$ 2σ values for typical fibre distribution i.e. 95% of all fibre)

<u>MPN Parameters:</u>

$\Delta\lambda$ = RMS spectral width of laser (manufacturer range 3-5nm)

Bit rate = 1.25Gbps

Agrawal k value = 0.8

- Dispersion generates wavelength ‘window’ in which system operates with negligible MPN impairment (penalty < 1dB)

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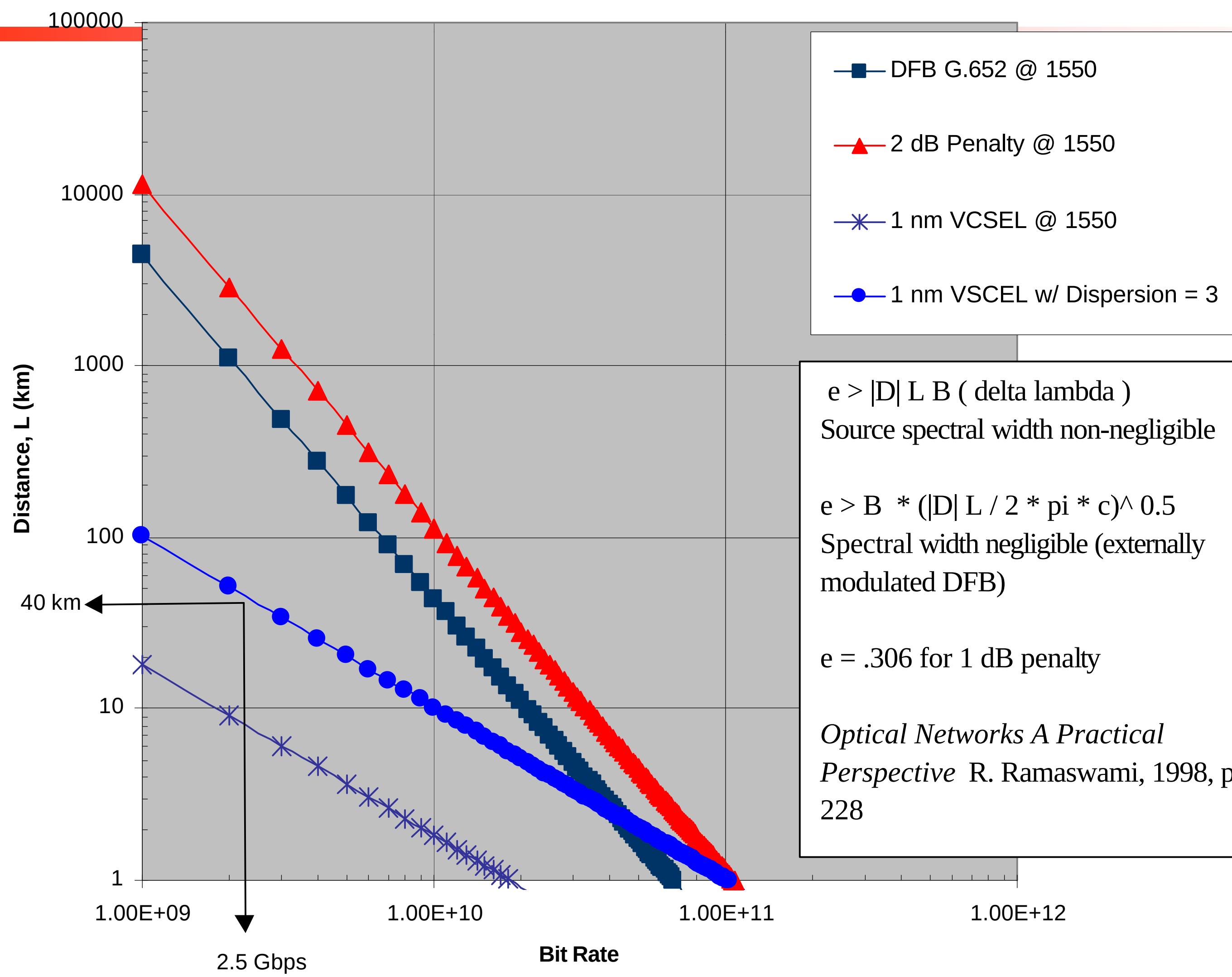
Study Group 9/Question 16 J.scm

"Optical amplifiers are used for compensation of optical transmission/splitter loss required for access networks. Dispersion compensation fibers are used for compensation of the chromatic dispersion of access network fibers. This fiber provides the reverse chromatic dispersion in advance in order to prevent degradation of CSO by transmission of 1.55μm optical signal over 1.3μm zero-dispersion access fibers."

Dispersion Limitations of G.652 Fibre
1 dB Penalty due to Dispersion



e > |D| L B (delta lambda)
Source spectral width non-negligible

e > B * (|D| L / 2 * pi * c)^ 0.5
Spectral width negligible (externally modulated DFB)

e = .306 for 1 dB penalty

Optical Networks A Practical Perspective R. Ramaswami, 1998, pg. 228

Summary

- Important to use the right fiber the first time!
  - Fiber can be engineered as part of total systems solution.
  - Include other ITU-T single mode standard specifications other than G.652 (example G.655, G.XXX for future use).
- Standard should help you engineer the links
  - Opportunities for fiber, electronics, and electro-optics to improve data rate, extend distance, and/or add overlay λ's for additional services/bandwidth.

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