Laser Considerations for Link Budget

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Laser Consideration for Link Budget

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What are the Technical Questions?

Introduction

1. **Is a 1.25Gbps PON link over 10km with a 1:16 split cost effectively possible with today's optical components?**
   - **Downstream: Yes**
   - **Upstream: This document**

Assumptions:

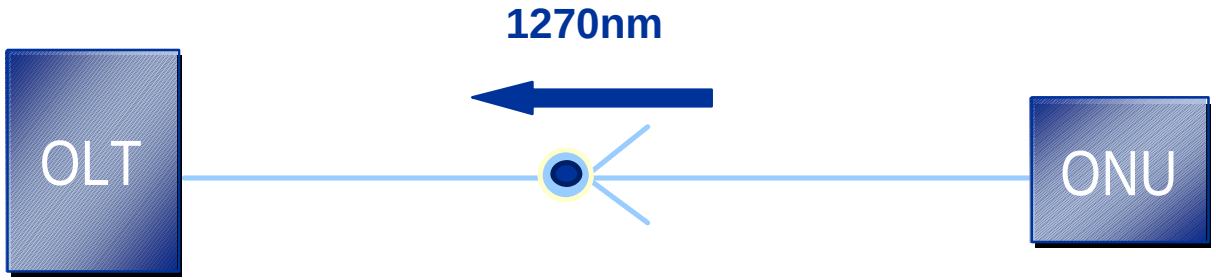
- **ONU: Standard commercially available components**
- **OLT: Ditto**

2. **What effect will VCSELs have on PONs?**

Properties of currently available components

Today's Technology

Parameters for Upstream link



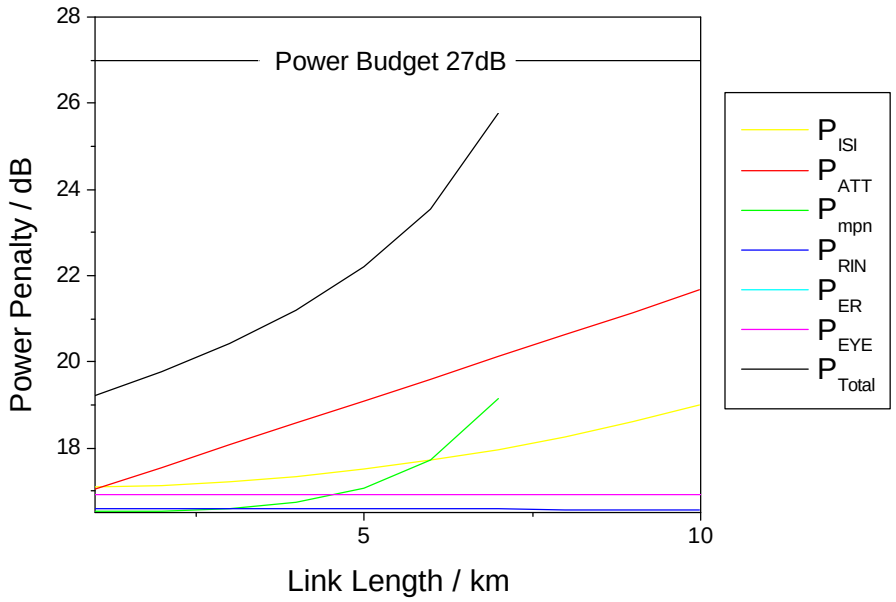
Receiver	Fibre	Transmitter
Sen. = -26dBm RecEYE = 0.3 RecBW = 1000MHz Q = 7.04	BWm = 1000GHz/km So = 0.093ps/nm²km Uo = 1324nm Atten = 0.5dB/km + 1:16 Splitter (14.5dB) Connectors (2dB)	Power = 1dBm Uc = 1270nm Uw = 4nm ER = 9dB $T_{20\text{-}80}$ = 260ps RIN = -120dB/Hz MPN = 0.5

What does the Link Budget say?

Today's Technology

Results for Upstream Link with FP Laser, RMS width = 4nm

Graph of Penalties



Summary of Results @ 10km

P_{ISI} = 2.47
P_{ATT} = 5.14
P_{mpn} = -
P_{RIN} = 0.04
P_{ER} = 0
R_{EYE} = 0.43
P_{Total} = -
+
$P_{Coupler}$ = 14.5
$P_{connector}$ = 2

Total > 27dB !

Link not possible with this configuration!

Where is the problem?

Today's Technology

⇒Link is not possible with standard components

- **The mode partition noise power penalty (P_{mpn}) prohibits link lengths >7km.**
- **Increasing launched power or detector sensitivity is not a solution.**
- **May solve as follows:**
  - **Reducing the data rate.**
  - **Choosing an operation wavelength closer to the zero dispersion point of the fibre.**
  - **Changing the fibre dispersion.**
  - **Reducing the RMS width of the source.**

What can be done?

Today's Technology

Changes to system parameters

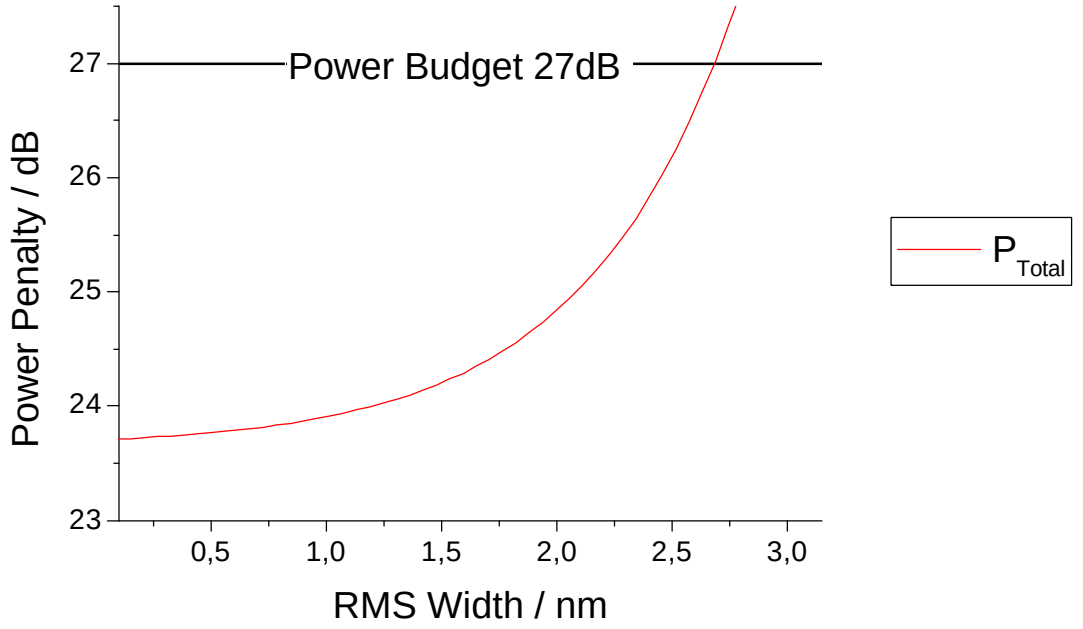
Solution	Comment
Reduce data rate	Not an option
Centre wavelength closer dispersion point	Requires DFB laser, with lower to zero temperature drift, high costs at ONU
Lower dispersion of optical fibre	Only relevant for new installations or with expensive dispersion compensator
Reduce spectral bandwidth	To be checked in detail

Spectral bandwidth a deciding factor

Today's Technology

Possible Solution - Reduction of the spectral bandwidth

Link Loss Vs Laser RMS Width



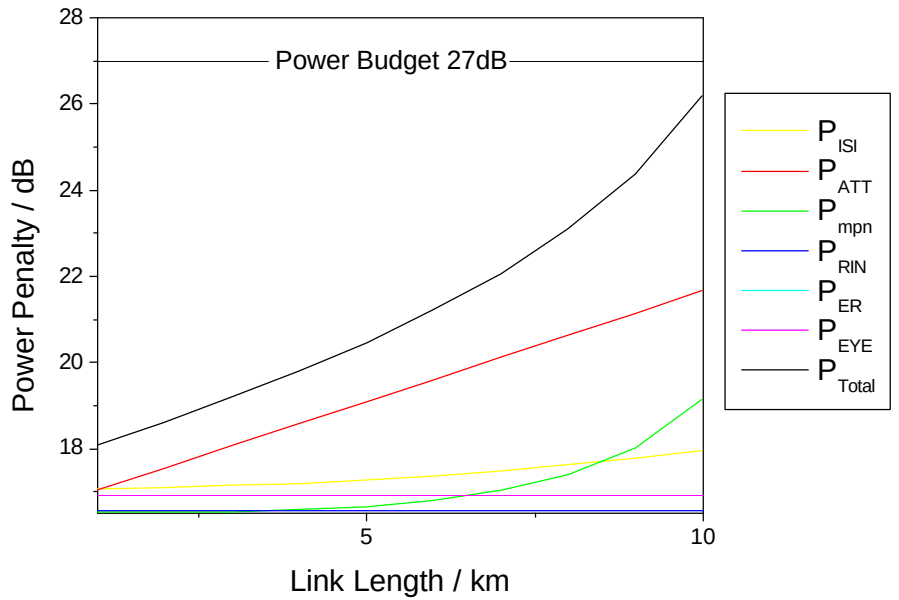
Losses very sensitive to RMS width
£ 2.8nm required for link

Link possible with this configuration

Today's Technology

Results for Upstream Link with FP Laser, RMS width = 2.8nm

Graph of Penalties



Summary of Results @ 10km

P_{ISI} = 1.44
P_{ATT} = 5.14
P_{mpn} = 2.63
P_{RIN} = 0.05
P_{ER} = 0
R_{EYE} = 0.43
P_{Total} = 9.69
+
$P_{Coupler}$ = 14.5
$P_{connector}$ = 2

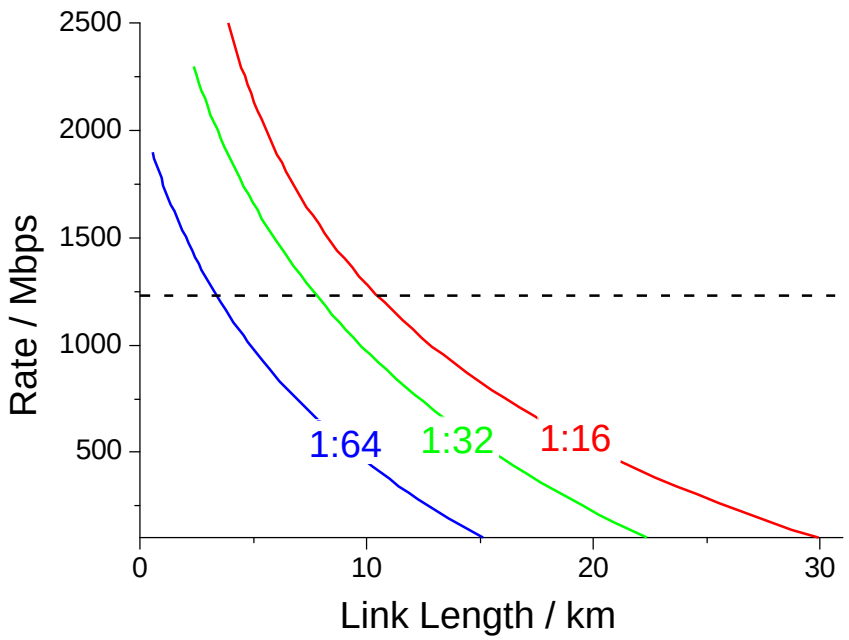
Total 26.2dB < 27dB !

>3km possible with 1:64 split

Today's Technology

What are the limits with FP laser spectral bandwidth = 2.8nm

Reach Length Vs Data Rate



Assumptions

FP RMS Width = 2.8nm

Launched Power = 1dBm

Receiver Sensitivity ~ $B^{1/2}$

Sensitivity at 1.25 Gbps = -26dBm

Currently only two companies with suitable lasers

Today's Technology

Overview of FP laser sources

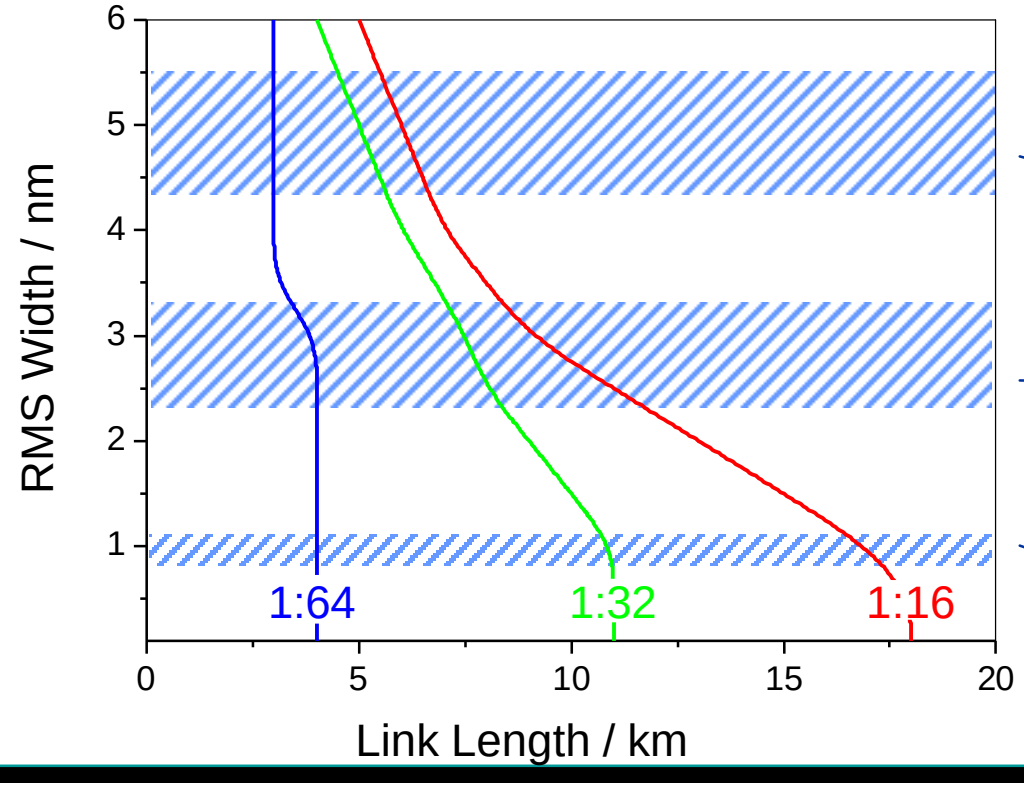
Supplier	Typ. Spectral Width (rms) / nm	Max. Spectral Width (rms) / nm	Source
Agilent	?	2.8	http://literature.agilent.com/litweb/pdf/5988-1570EN.pdf
Alcatel	1.5	2.5	http://www.alcatel.com/telecom/optronics/products/51lmc.pdf
APAC	2	5	http://www.apacoe.com.tw/1310fp.htm
Infineon	2	5	http://www.infineon.com/cgi/ecrm.dll/ecrm/scripts/prod_ov.jsp?oid=25068
Lightron	1	4	http://www.lightron.co.kr/products/LD/LD13x.pdf
Lucent-Agere	2	3	http://www.lucent.com/micro/opto/docs/DS99033-1.pdf
Luminent	2	5	http://www.luminentinc.com/pdf/15fspxt.pdf

>15km Possible with 1:16 split and DFB

Today's Technology

What are the limits? Spectral bandwidth and cost considerations

Reach Length Vs Laser RMS Width



Laser Type and Relative Costs

FP Laser
Relative Costs 100%

Selected FP Laser
Relative Costs 100 ® 200%

DFB Laser
Relative Costs 300%

Longer links possible but with increased ONU costs

Summary

Today's Technology

Components available today

- **A 1.25Gbps Upstream link over 10km and a 1:16 split is not possible with standard commercially available Fabry-Perot lasers.**
- **A spectral bandwidth (rms) of £ 2.8nm is required, implying selection of Fabry-Perot lasers. We believe this is possible with a 0 to 100% increase in ONU optics costs.**
- **DISCLAIMER: OLT receiver sensitivity of -26dBm assumes 0dB loss for burstmode operation and state-of-the-art detectors.**

How about tomorrow?

Tomorrow's Technology

Will VCSELs solve all problems?

VCSELs operating at 1310nm will have a huge impact on performance and costs of ONUs.

Properties of VCSELs compared to FP edge emitting lasers:

- **+ Lower manufacturing costs**
- **+ Narrow RMS width**
- **+ Reduced mode partition noise**
- **+ Higher coupling efficiency into fibre**
- **+ Lower power consumption**

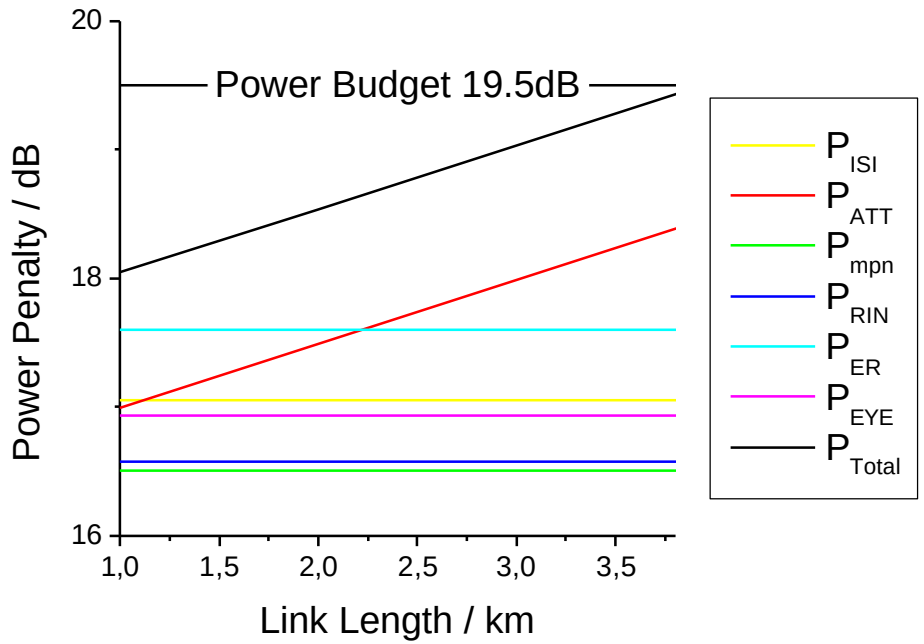
- **- Lower output powers today - in 3 years?**

Promising results from current VCSELs

Tomorrow's Technology

Operation up to 80°C, 0.22mW Launched Power at 25°C

Graph of Penalties



Summary of Results @ 3.5km

P_{ISI} = 0.61
P_{ATT} = 1.78
P_{mpn} = 0
P_{RIN} = 0.07
P_{ER} = 0
R_{EYE} = 0.43
P_{Total} = 2.89
+
$P_{Coupler}$ = 14.5
$P_{connector}$ = 2

Total 19.4dB <19.5dB

>3.5km, 1:16 link possible with -6.5dBm launched power.