Super-PON Link Budget Analysis

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Link budget required

Highlighted optical component losses were revised down to represent *premium* grade components to help reduce the very challenging objectives

Component	count	typical loss [dB]	worst case loss [dB]	Total loss [dB]	comments
Fiber [km]	50	0.24	0.24	12	Revised numbers from Vince (Corning)
Connectors	6	0.2	0.5	1.5	Count from Hawaii meeting (11/19)
Splices	17	0.05	0.2	1	7 for components/cable changes, 10 for inline
AWG	1	4	4	4	5.5 dB from previous contributions. -1.5 dB for MZI to reduce IL
Splitter (x64)	1	20.5	20.5	20.5	Assumes 3.5 dB per 2x -0.5 dB. Premium splitters assumed
Aging Margin	1	2	2	2	Industry practice
Total				**41**	

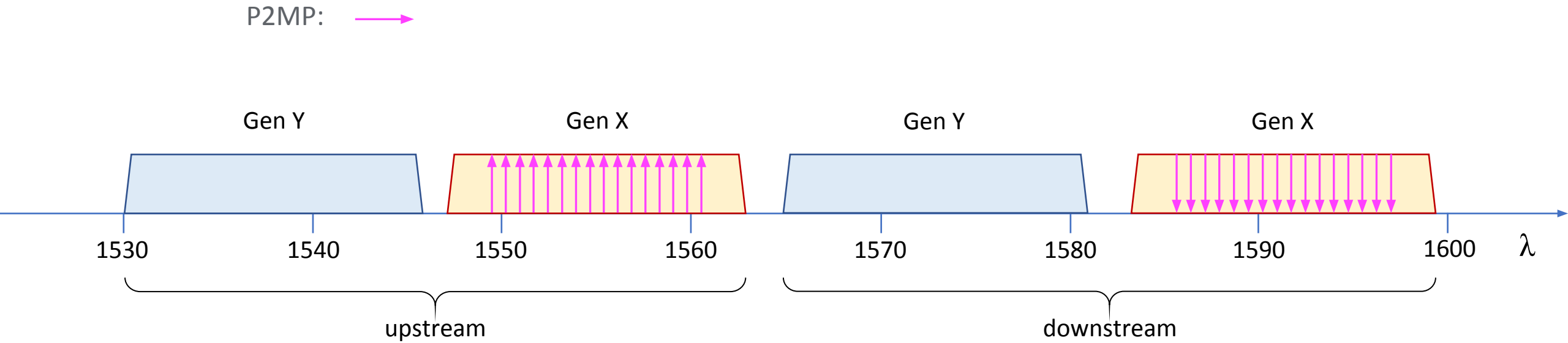
Assumptions

- Raman penalties for US and DS are based on minimum DS powers + 2dB, to allow for channel non-uniformity in the DS channels
- US sensitivity refers to the power into the bidi unit after the optical amplifiers. This is a part of the mux/amp unit

TDP US [dB]	2	
TDP DS [dB]	1	
ONU Rx power [dBm]*	-31	@ ONU interface
OLT Rx Power [dBm]**	-39.1	@ ER=6.0, into the Mux/Amp

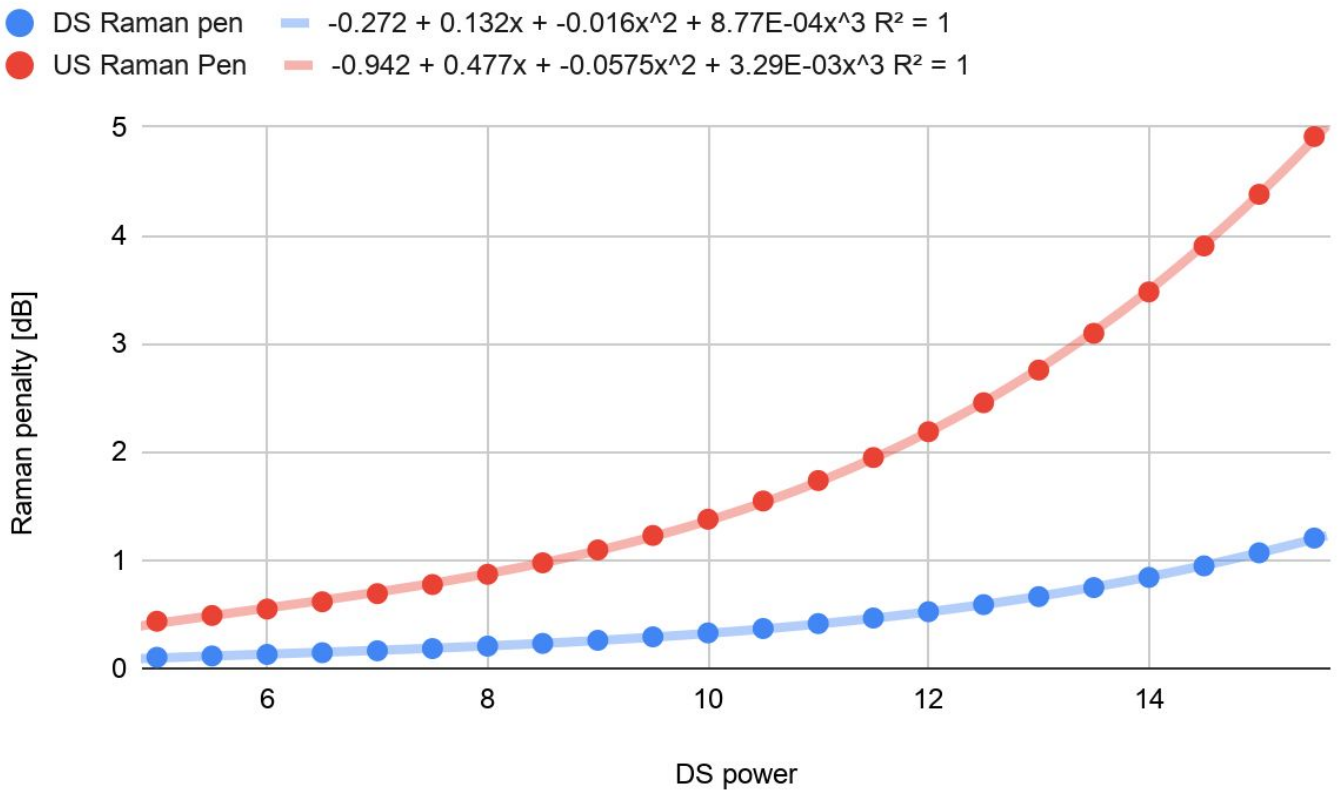
- * 1.5 dB better than PR40 sensitivity for 10G-EPON. 1.5 dB benefit was recommended for LDPC FEC in powell_3ca_1b_0118
- ** From interpolation of results shown in 20190521_Zhao, with 0.6 dB reduction to account for burst-mode transmission

Assumed wavelength plan



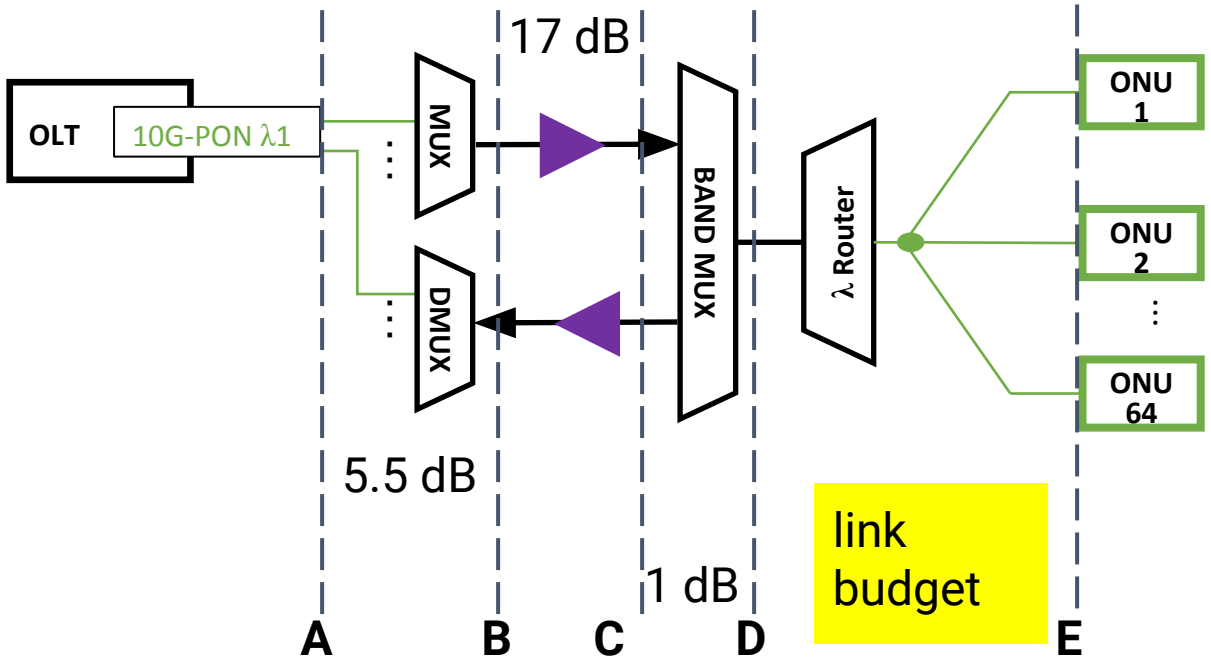
- Just calculating for Raman in current 10G generation
- Assume all DS channels are launched at the same power

Raman penalty: DS in L; US in C



- Numerically solving the Raman penalty ODE produced this penalty graph
- Exact wavelengths are given in slide 7 of 20190312_Ogawa
- This curve is used to calculate Raman power penalties for results in this deck

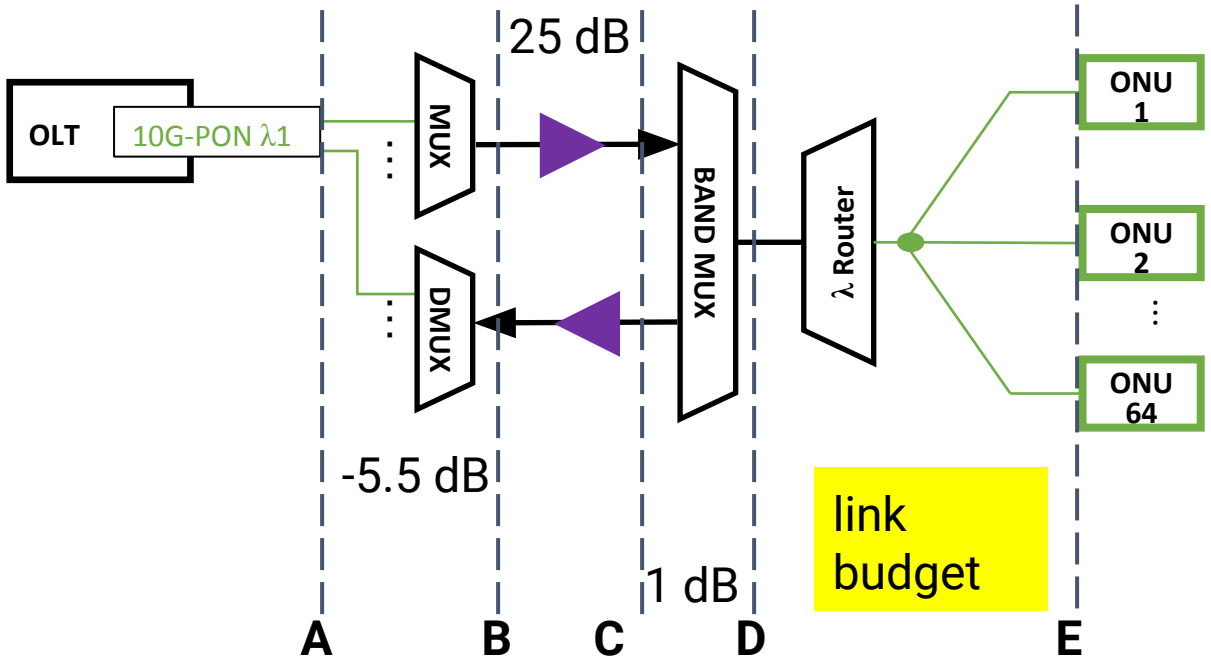
Power levels - DS



Location	DS/WL [dBm]	DS total [dBm]
A	PowDS-11	PowDS+1
B	PowDS-16	PowDS-4
C	PowDS+1	PowDS+13
D	PowDS	PowDS+12
E	-31 (PR40 -1.5)	

- Pow DS is defined as the power exiting the mux/amp
- This is the last active equipment before the signal enters the ODN
- Link budget accounts for maximum transmission penalties, including 1-dB for CD and Kerr NL, and the calculated amount for Raman

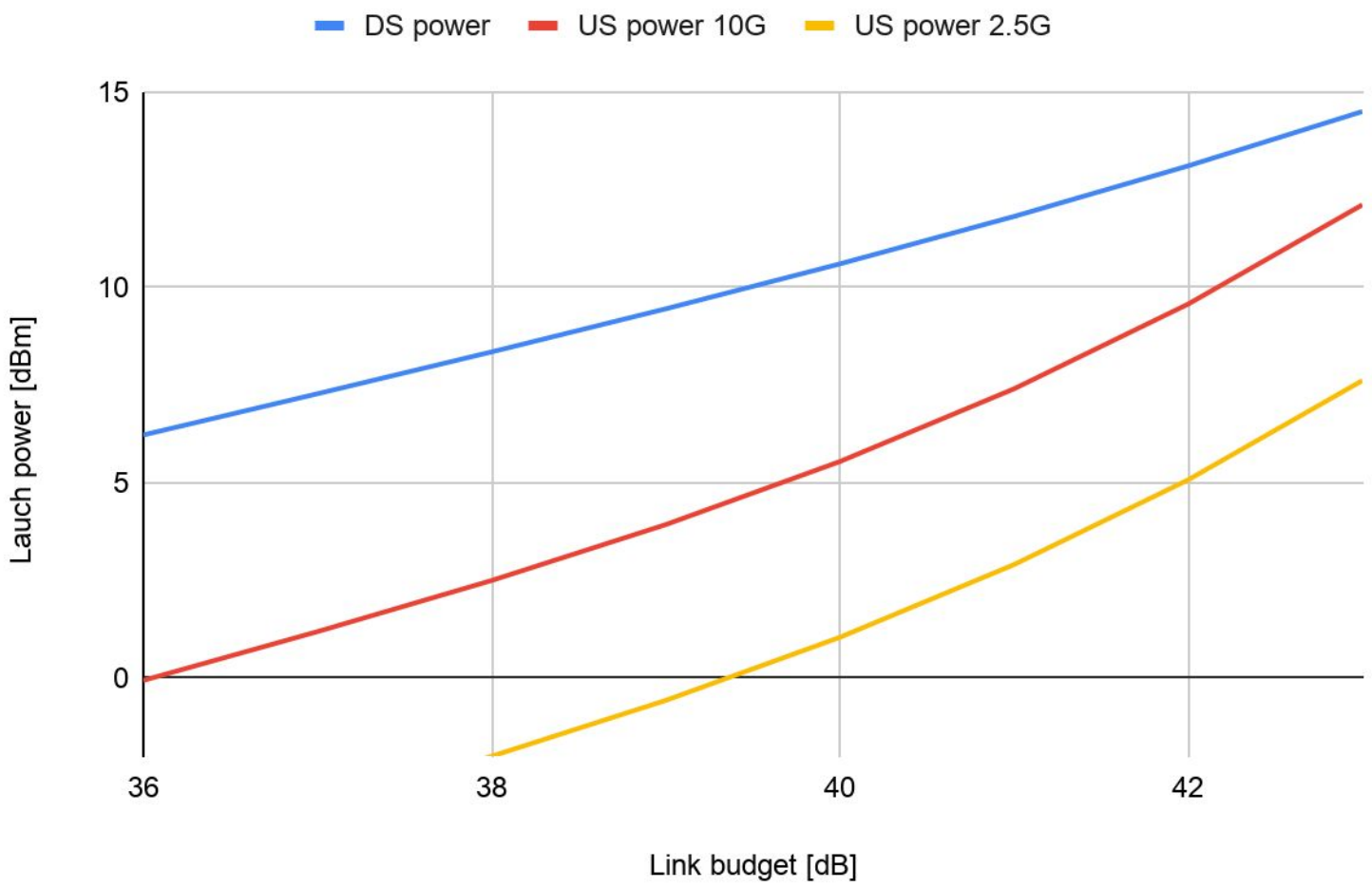
Power levels - US



Location	US/WL [dBm]	US total [dBm]
A	-20.6	
B	-15.1	-3.1
C	-40.1	-28.1
D	-39.1	-27.1
E	PowUS	

- PowUS is defined as the power exiting the ONU
- US sensitivity is defined as the power needed at the mux/amp - ODN interface
- Link budget accounts for maximum transmission penalties, including 2-dB for CD and Kerr NL, and the calculated amount for Raman

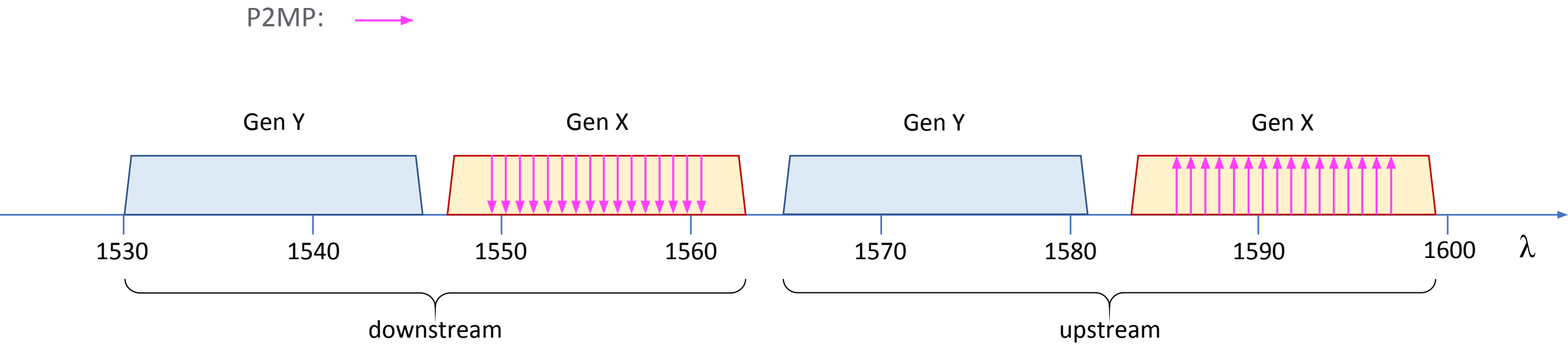
Required output power



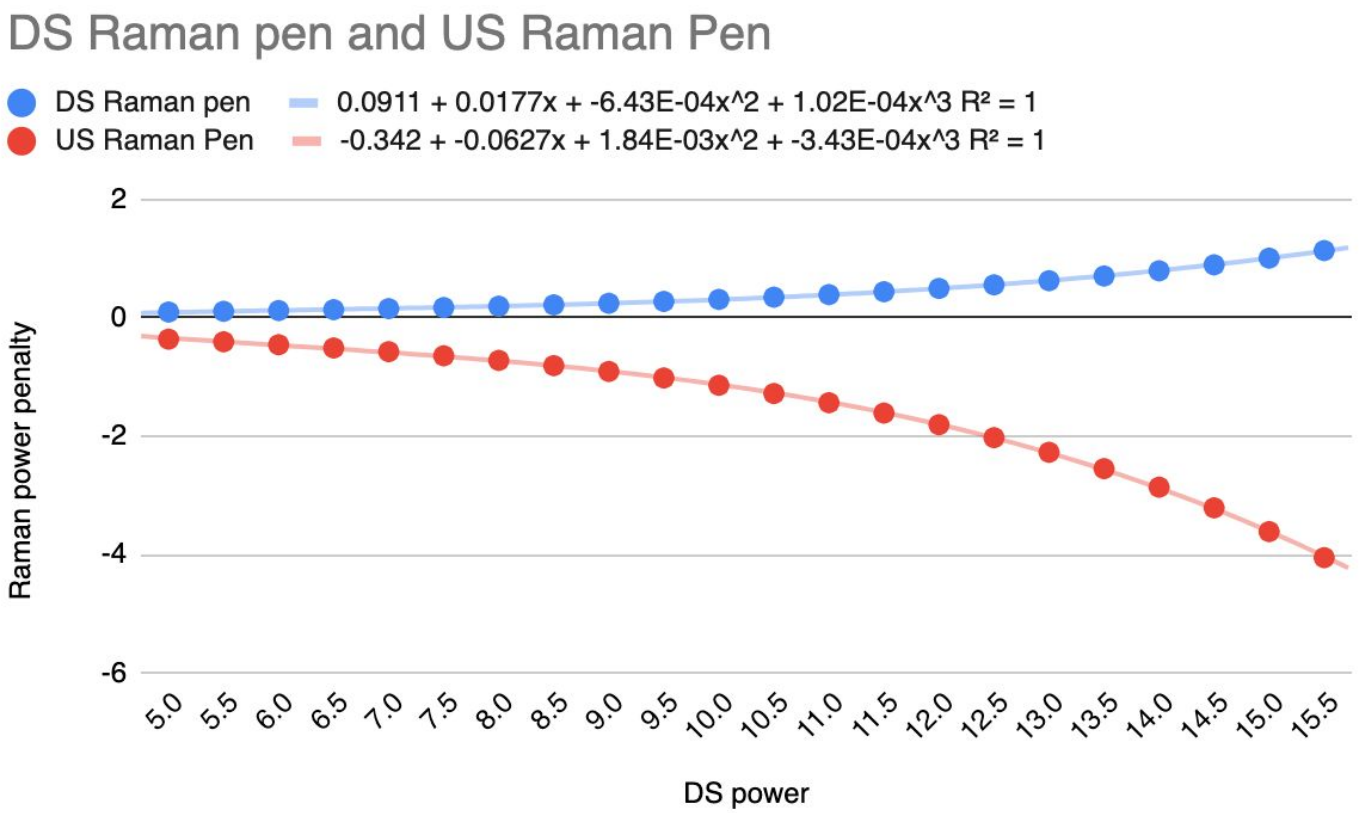
- The required US and DS output power is shown in the graph
- Raman penalty is based on min_DS_power + 2 dB Accounts for the DS not being installed at lowest possible power for all channels
- >3 dB of Raman penalty leads to >7 dBm of ONU output power

Proposal: Use C-band for DS and L-band for US

- Placing the higher powered DS channels on shorter wavelengths (relative to US channels) produces Raman gain on the US channels, rather than loss

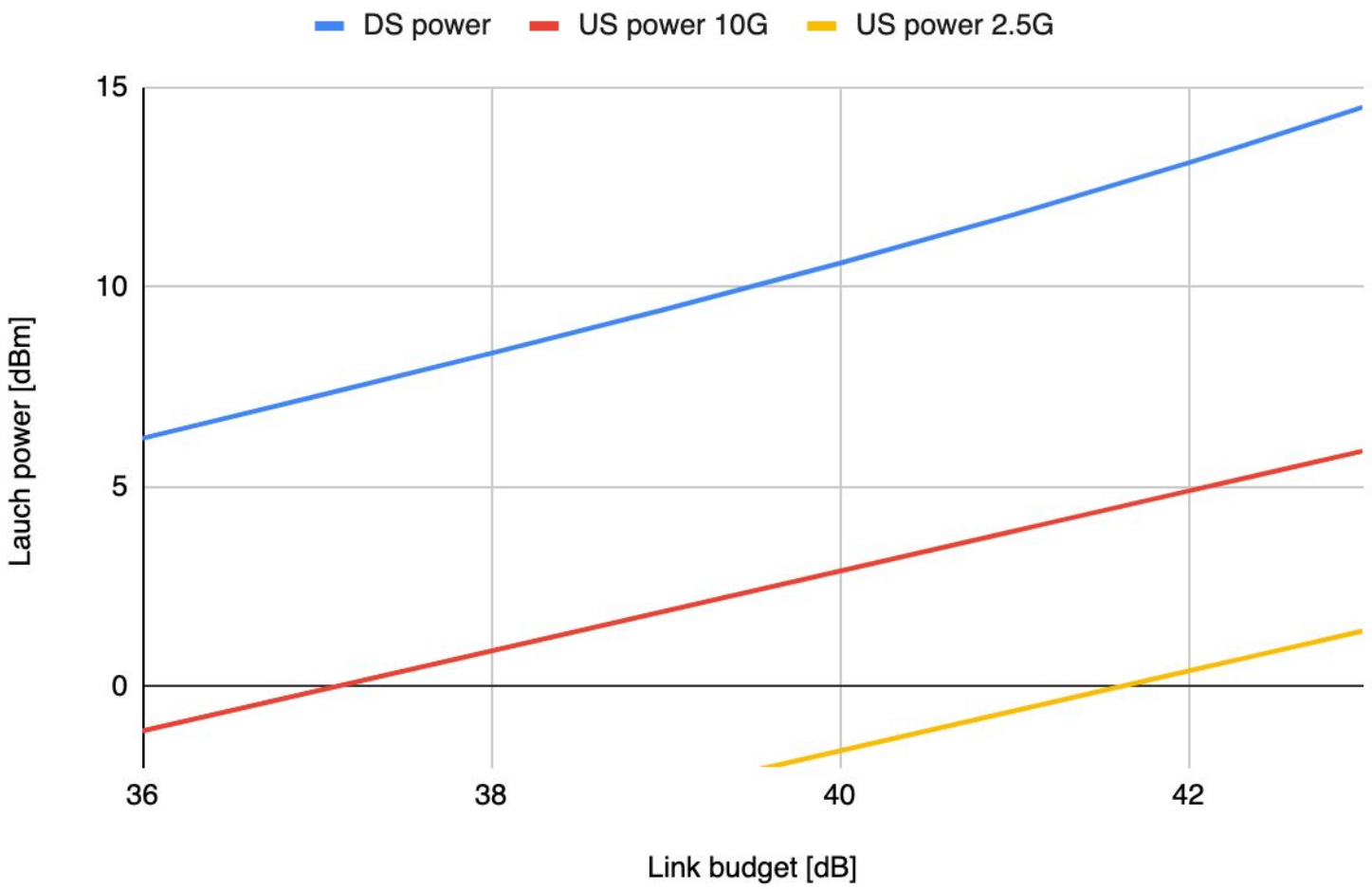


Raman penalty: DS in C; US in L



- Using the C-band for DS and L-band for US moves the higher powered DS signals to the shorter wavelength side
- This creates Raman gain for the US signals, rather than Raman power penalty
- The increase is power should not be included in the link budget as it will contain noise, since it comes from modulated signals rather than a CW pump
- Assume ***ZERO*** Raman penalty for the US signals

Required output power



- The required US and DS output power is shown in the graph
- Without Raman penalties, the required 10G US ONU launch power require is 3.9 dBm, almost identical to that of NG-PON2
- DS powers required at 11.9 dBm per wavelength

Summary

	Required Launch powers [dBm]		
	DS	US 10G	US 2.5G
DS: L - US: C	11.9	7.4	2.9
DS: C - US: L	11.9	3.9	-0.6

- Premium grade optical splitters and CAWGs were assumed to reduce the link budget required
- Operating in DS L-band and US C-band, as per NG-PON2 and this task force's previous intention, results in a large Raman penalty, requiring very high ONU launch powers to close the link budget
- Operating in DS C-band and US L-band avoids Raman penalties on the US channels, allowing the link budget to be close using similar ONU output powers to NG-PON2 specifications

Thank you