OSNR Link Budget Methodology

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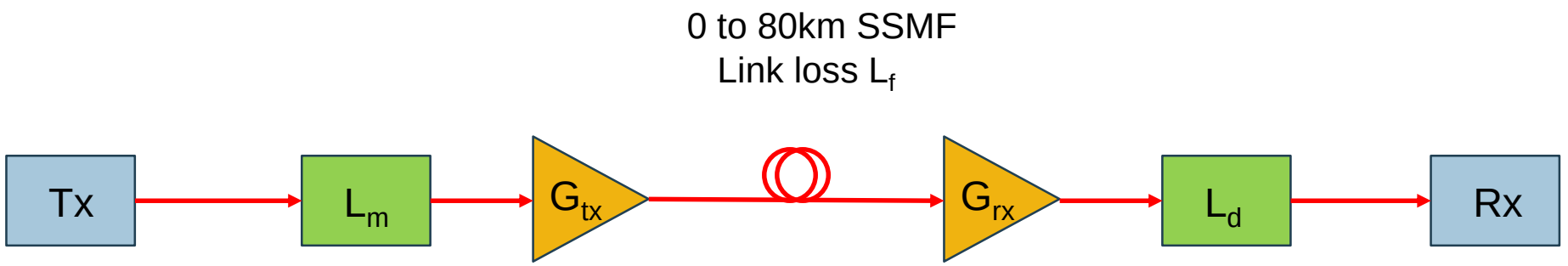
Goals

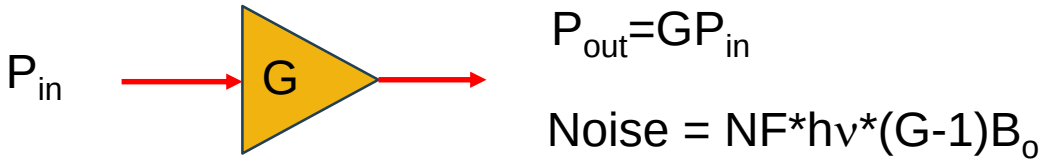
- Develop an OSNR link budget methodology for DWDM point-to-point (P2P) systems
- Simulate a reference P2P DWDM link to help drive 400G Tx/Rx optical specs.
- Provide experimental data on 400G B2B OSNR sensitivity as a guide on required OSNR spec.

Point-to-Point Amplified DWDM Reference Link



Optical Signal-to-Noise Ratio (OSNR)

Optical Amplifier
(e.g. EDFA)



$$OSNR = P_{out} / Noise$$

OSNR = ratio of signal power to optical noise

P_{out} = signal power of a DWDM channel of interest

Noise = amplified spontaneous emission noise power in both optical polarizations

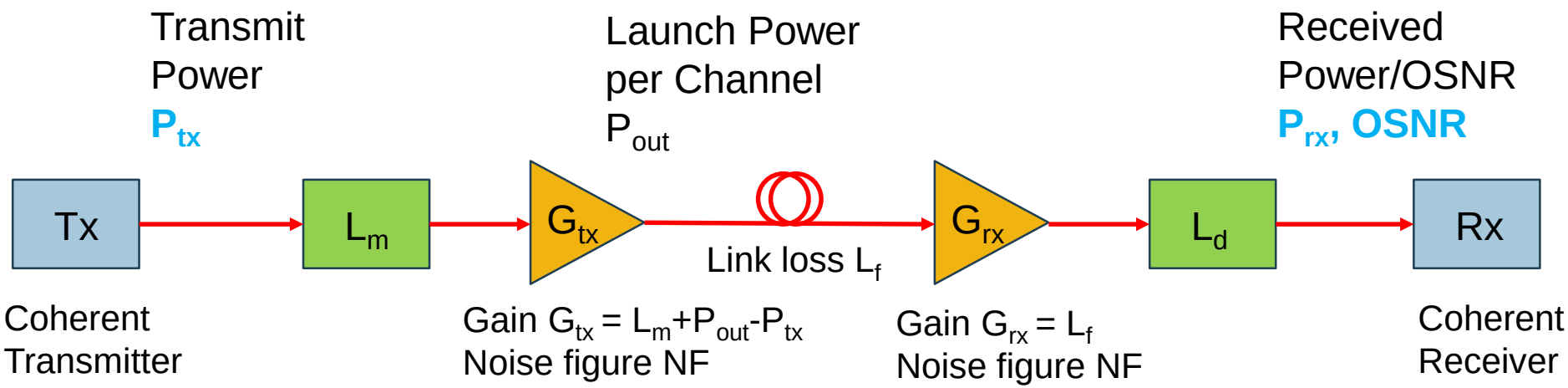
G = amplifier gain

NF = amplifier noise figure

$h\nu$ = photon energy at wavelength of interest (e.g. 1550 nm)

B_o = optical bandwidth for noise measurement (typically 0.1 nm)

OSNR Reference Link Model



$$OSNR_{dB} = 58 + P_{out} - L_f - NF - TX_{loss} - G_{ripple} - OSNR_{penalties}$$

$$TX_{loss} = 10Log\left(1 + \frac{10^{-\frac{L_f}{10}} 10^{\frac{P_{out}}{10}}}{10^{-\frac{L_m}{10}} 10^{\frac{P_{tx}}{10}}}\right)$$

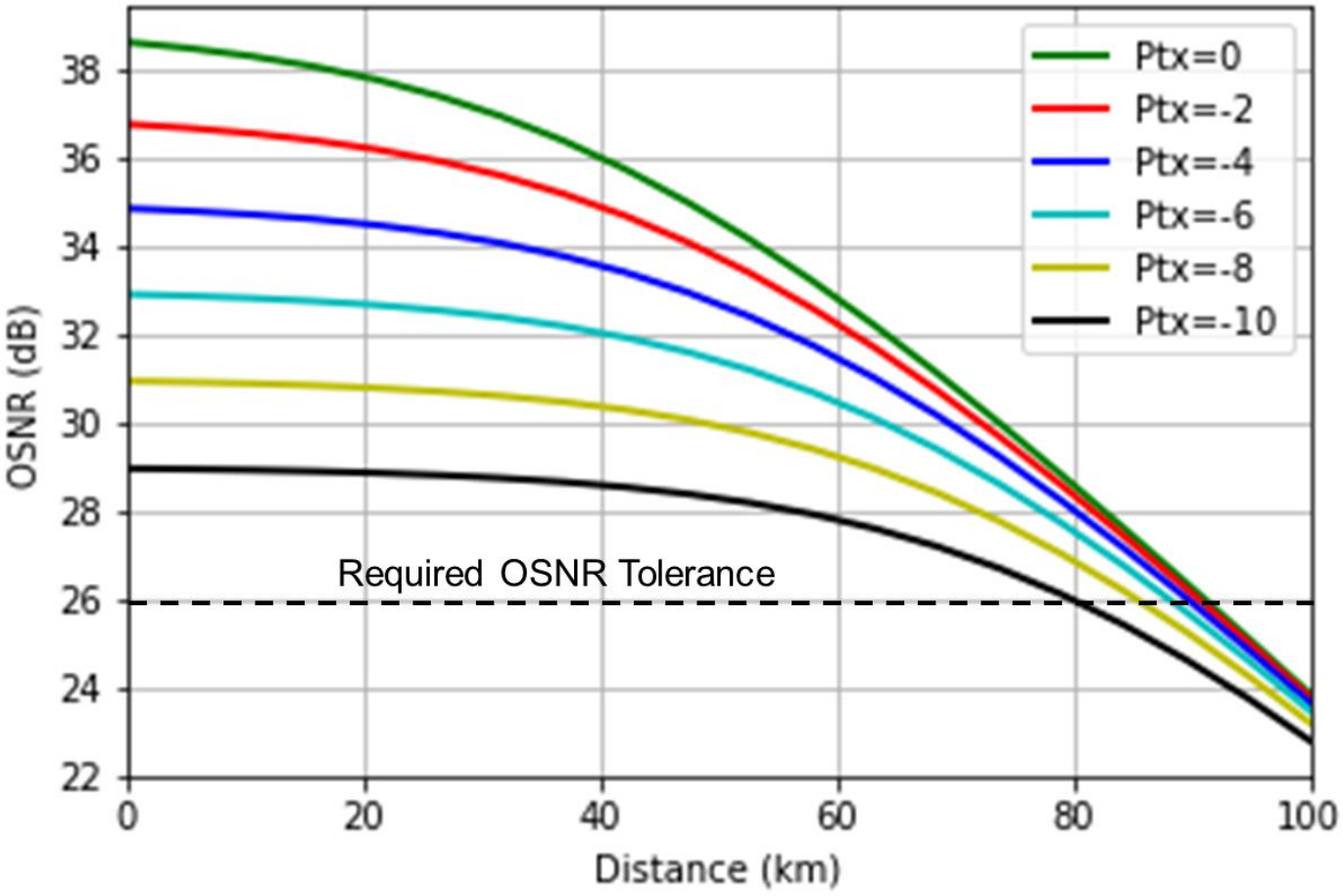
G_{ripple} = penalty due to DWDM amplifier gain ripples

$OSNR_{penalties}$ = various transmission penalties due to CD, PMD, PDL, etc.
(note these penalties maybe different for 100G vs. 400G)

OSNR Link Budget Calculation: Case 1

- P_{tx} = variable 0 to -10 dBm
- P_{out} = 0 dBm
- L_m = 10 dB (patch panels, DWDM Mux, etc.)
- NF = 6 dB
- L_f = (0.25 dB/km) x distance
- G_{ripple} = 1 dB
- $OSNR_{penalties}$ = 2 dB

OSNR Link Budget Calculations: Case 1

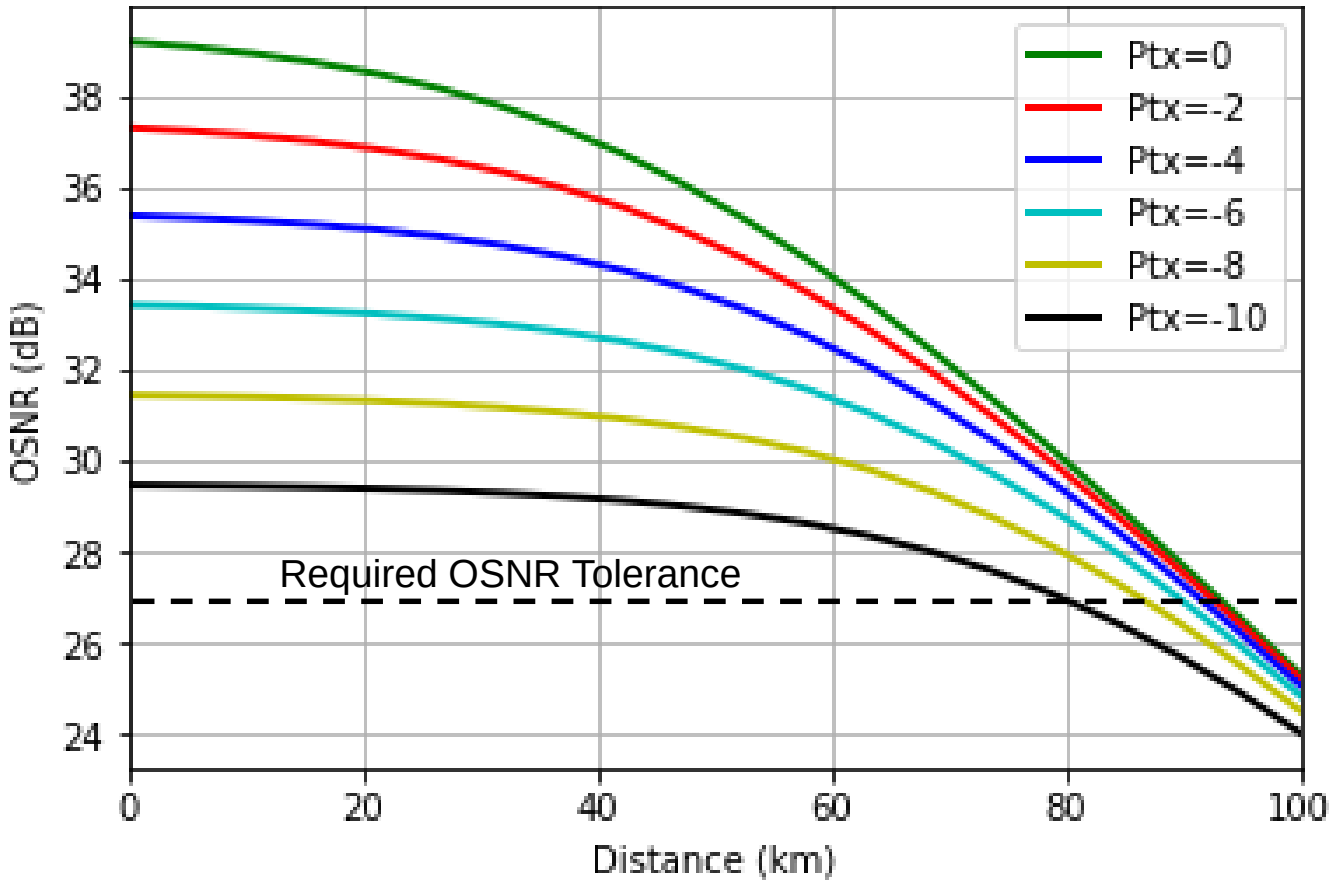


Note OIF ZR specs. are min. Tx power = -10 dBm, and required OSNR = 26 dB

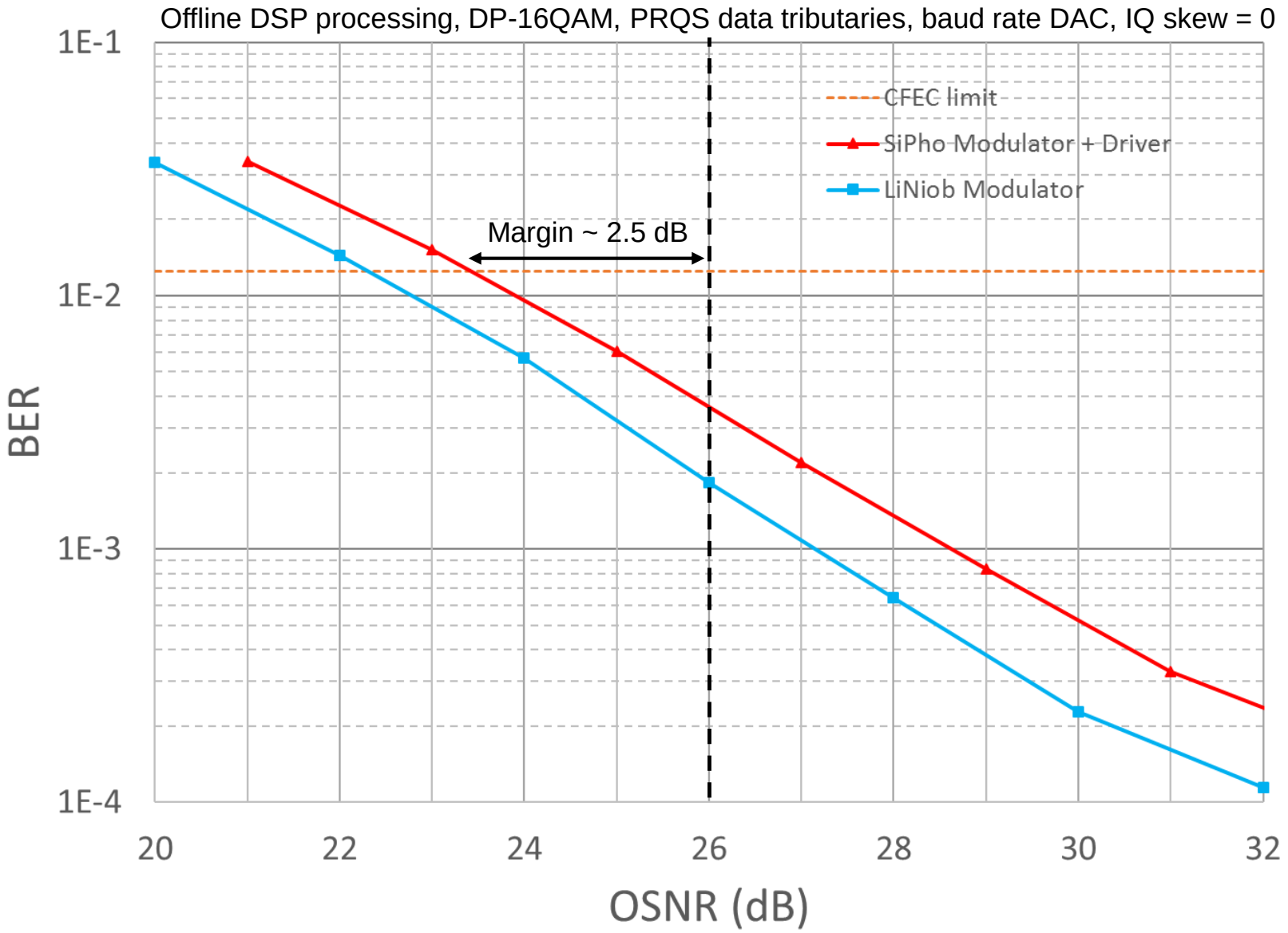
OSNR Link Budget Calculation: Case 2

- P_{tx} = variable 0 to -10 dBm
- P_{out} = 1 dBm
- L_m = 10 dB (patch panels, DWDM Mux, etc.)
- NF = 5.5 dB
- L_f = (0.25 dB/km) x distance
- G_{ripple} = 1 dB
- $OSNR_{penalties}$ = 2 dB

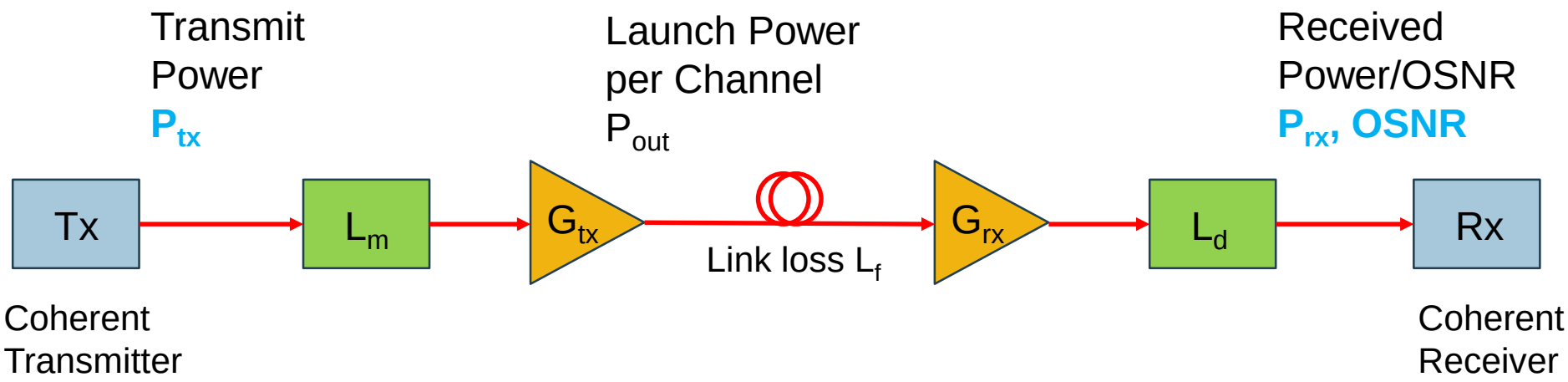
OSNR Link Budget Calculations: Case 2



Experimental Data on 400G (60Gbaud) DP-16QAM Back-to-Back OSNR Sensitivity



Rx Power



$$P_{rx} = P_{out} - L_d - G_{ripple}$$

- P_{out} = 0 dBm
- L_d = 10 dB (patch panels, DWDM Demux, etc.)
- G_{ripple} = 1 dB

=> P_{rx} = 0 – 10 – 1 = -11 dBm

- Add 1 dB margin to get OIF ZR spec. -12 dBm

Conclusions

- Developed methodology for OSNR link budgets, valid for both 100G and 400G DWDM systems
- Simulated a reference DWDM link for 400G applications
- Provided measurement data on 400G DP-16QAM OSNR B2B receiver sensitivity
- Link budget analysis shows the following optical specs are reasonable for 400G over 80km:

Tx Min. Output Power = - 10 dBm
Required OSNR Tolerance = 26 to 27 dB
Rx Min. Power = - 11 to -12 dBm