

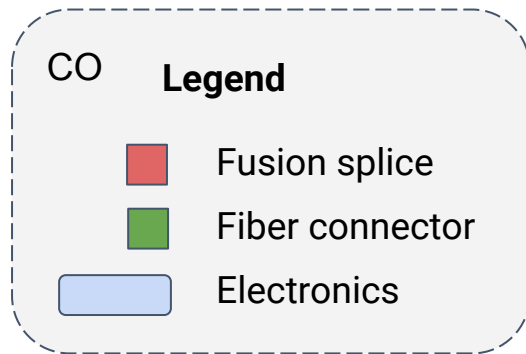
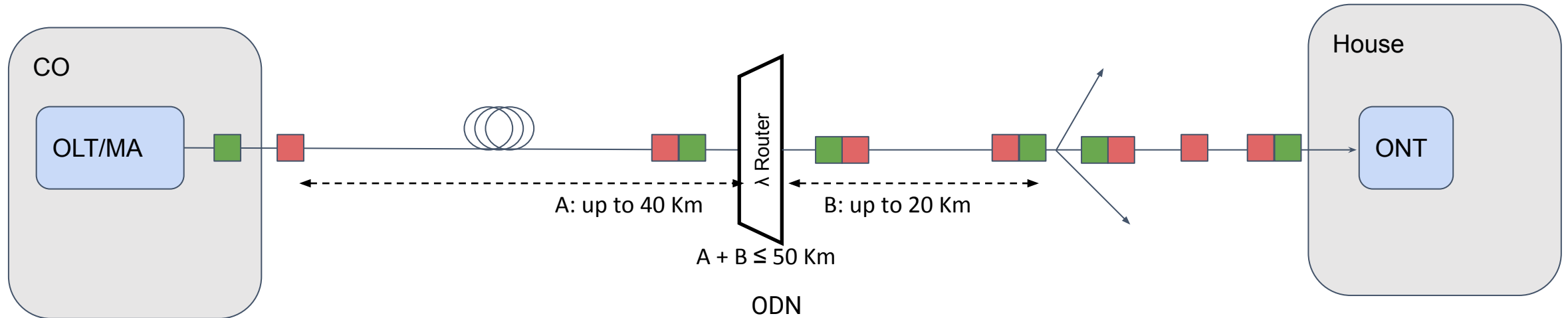
# Super-PON Link Budget Analysis

## Revised Fiber loss

IEEE P802.3cs, November 12, 2019

Liang Du (Google)

# Loss of ODN Components



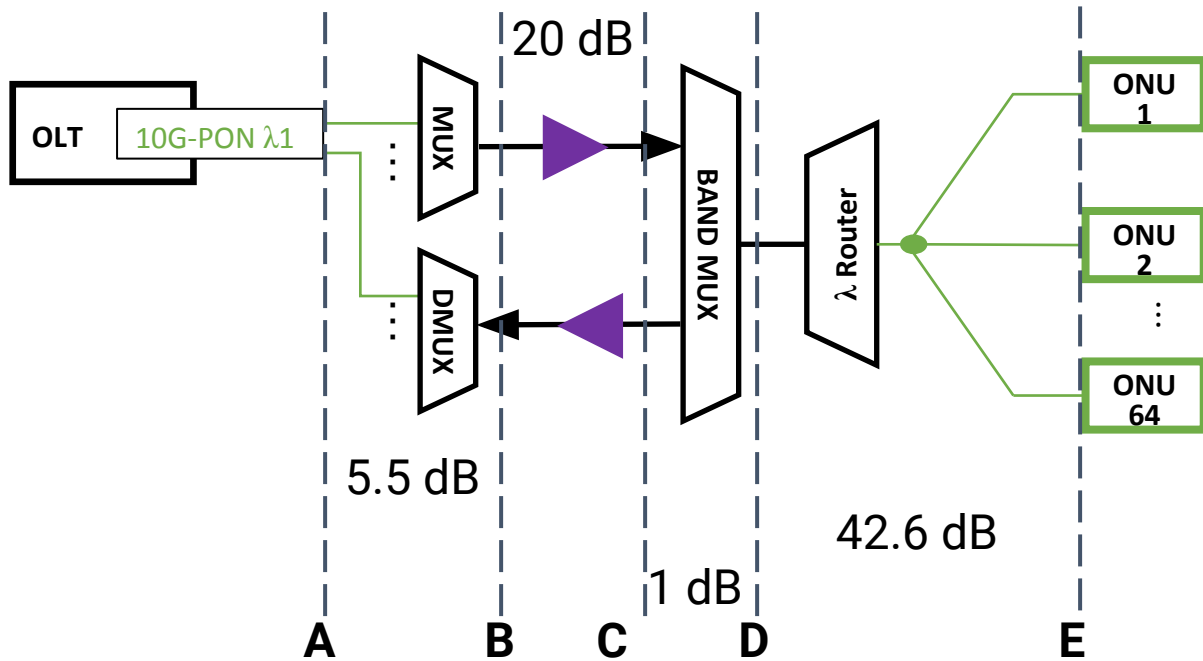
# Loss of ODN Components

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 last meeting
Splices	17	0.05	0.2	1	7 for components/cable changes, 10 for inline
AWG	1	6.6	6.6	6.6	Highest of 3 vendor presentations
Splitter (x64)	1	21.5	21.5	21.5	Assumes 3.5 dB per 2x
<b>Total</b>				<b>42.6</b>	

## Method for high-count items

- Assume one case is worst case
- All other instances are the typical case
- Single count items are always at worst case

# Downstream power levels



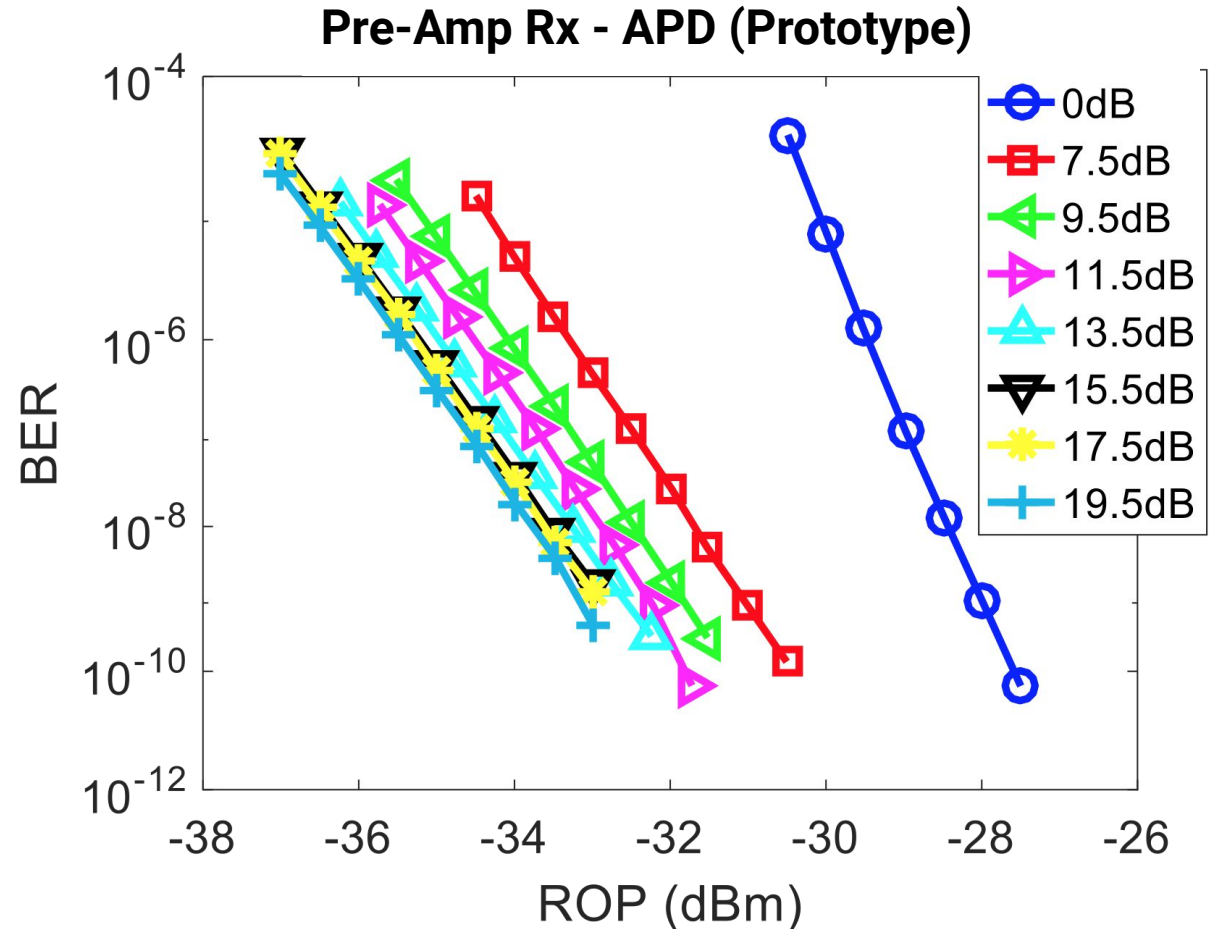
- Class 3 laser is needed to close the DS link budget
- Higher than most inline amplifiers

Location	DS/WL [dBm]	DS total [dBm]
A	-0.4	
B	-5.9	6.1
C	14.1	26.1
D	13.1	25.1
E	-29.5 PR40	

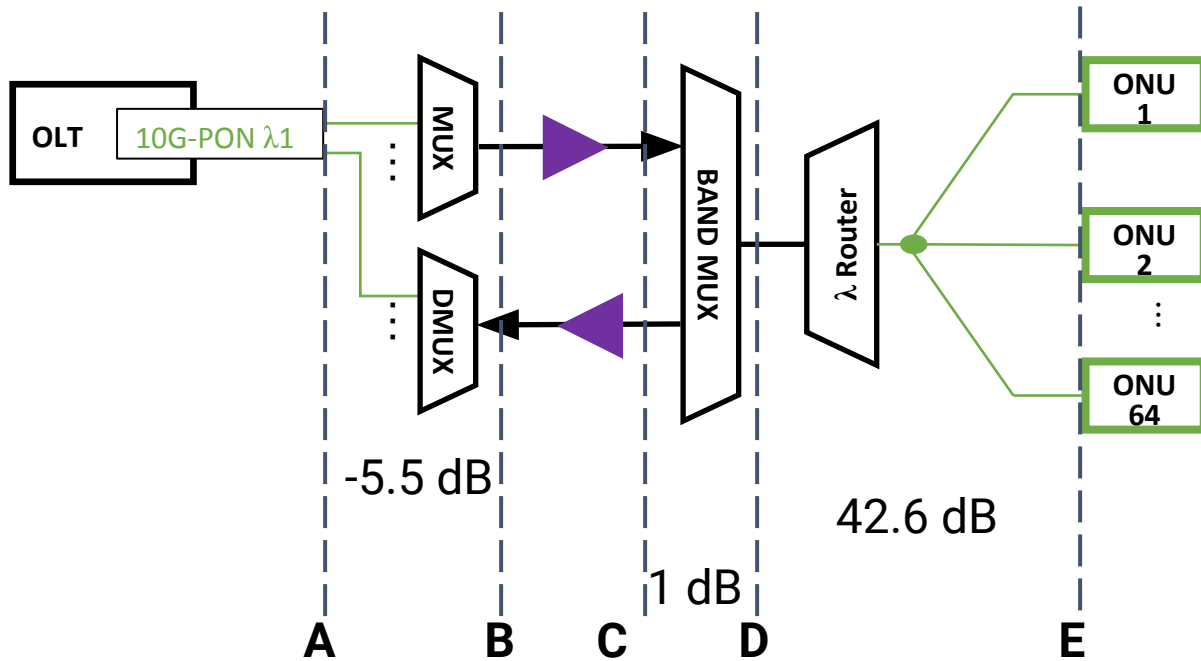
# Performance: EML + pre-amp (10G)

Early samples shows we can achieve RX sensitivity -38dBm at BER=1e-4

- measured at the input of pre-amp
- ER=8.5dB



# Upstream power levels



- 4.6 dBm ONT launch power is required at 8.5-dB ER

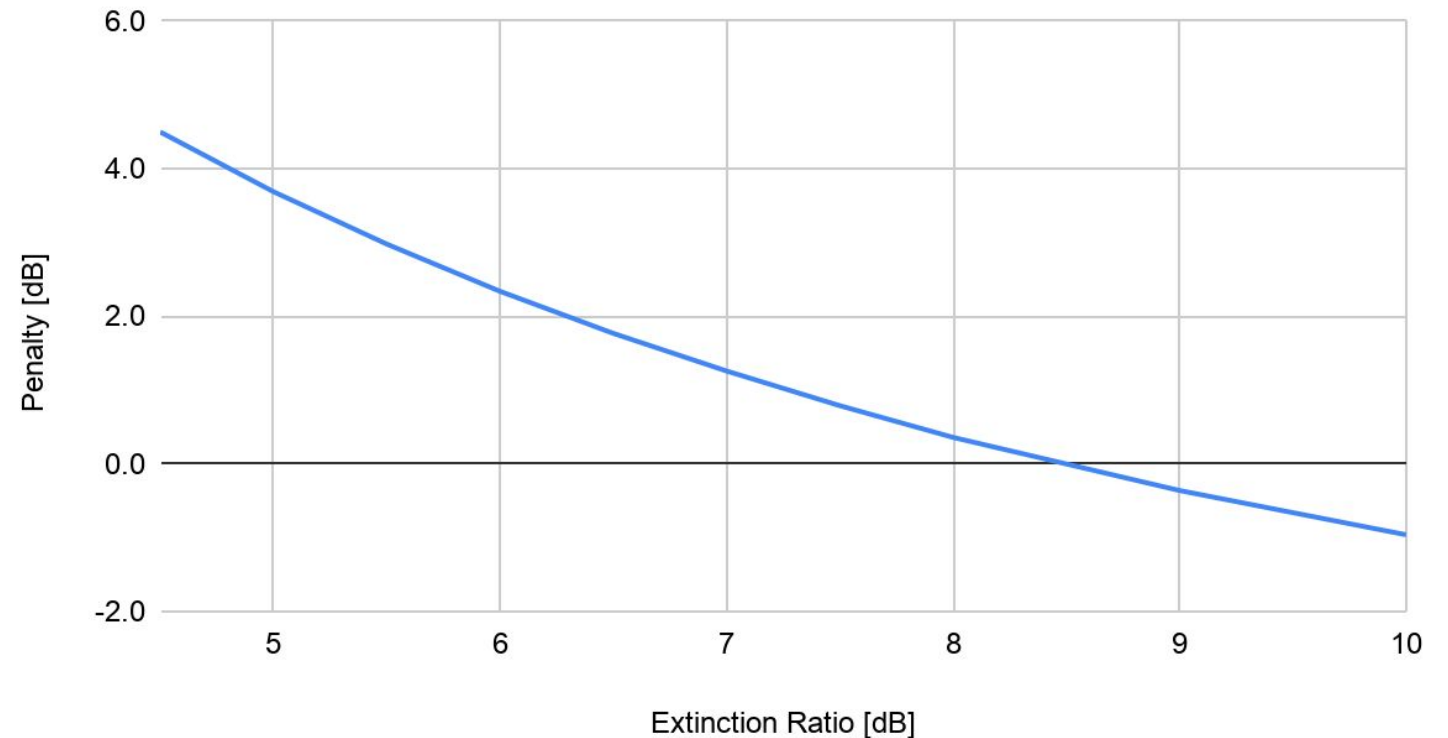
Location	US/WL [dBm]	US total [dBm]
A	-17.5	
B	-12	0
C	-37	-25
D	-38	-26
E	4.6	

# Penalty from ER

$$Q = \frac{I_1 - I_0}{\sigma_1 + \sigma_0} \propto \frac{P_1 - P_0}{\sqrt{P_1} + \sqrt{P_0}} \propto \sqrt{2P_{ave}} \frac{\sqrt{ER} - 1}{\sqrt{ER} + 1}$$

ER (dB)	Power adjustment (dB)
10	-0.95
9.5	-0.66
9	-0.35
8.5	0.00
8	0.38
7.5	0.80
7	1.26
6.5	1.78
6	2.35
5.5	2.98
5	3.70
4.5	4.52

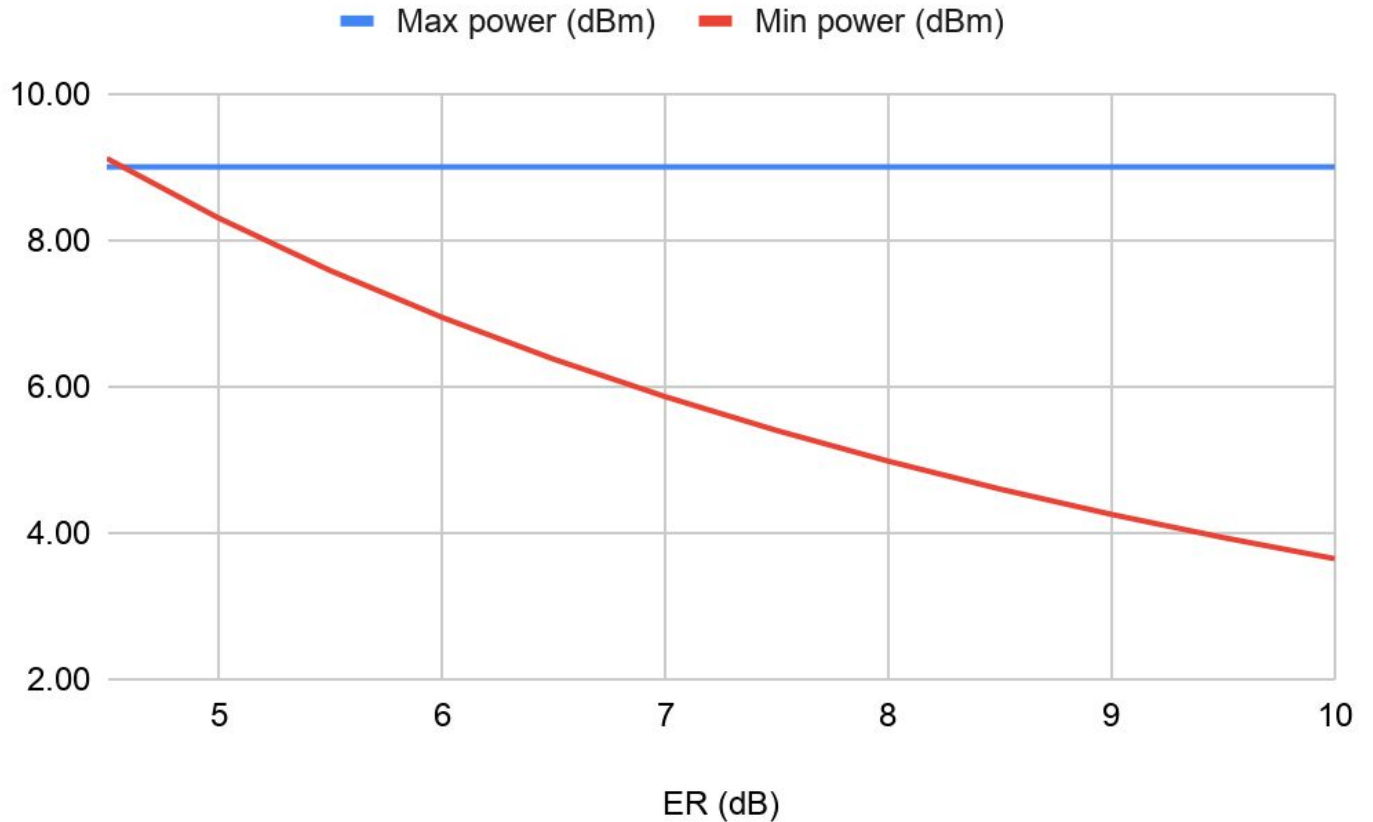
Penalty from ER 8.5 dB



# ONT launch power 10-Gb/s US

ER (dB)	Max power (dBm)	Min power (dBm)
10	9.00	3.65
9.5	9.00	3.94
9	9.00	4.25
8.5	9.00	4.60
8	9.00	4.98
7.5	9.00	5.40
7	9.00	5.86
6.5	9.00	6.38
6	9.00	6.95
5.5	9.00	7.58
5	9.00	8.30
4.5	9.00	9.12

ONT launch power

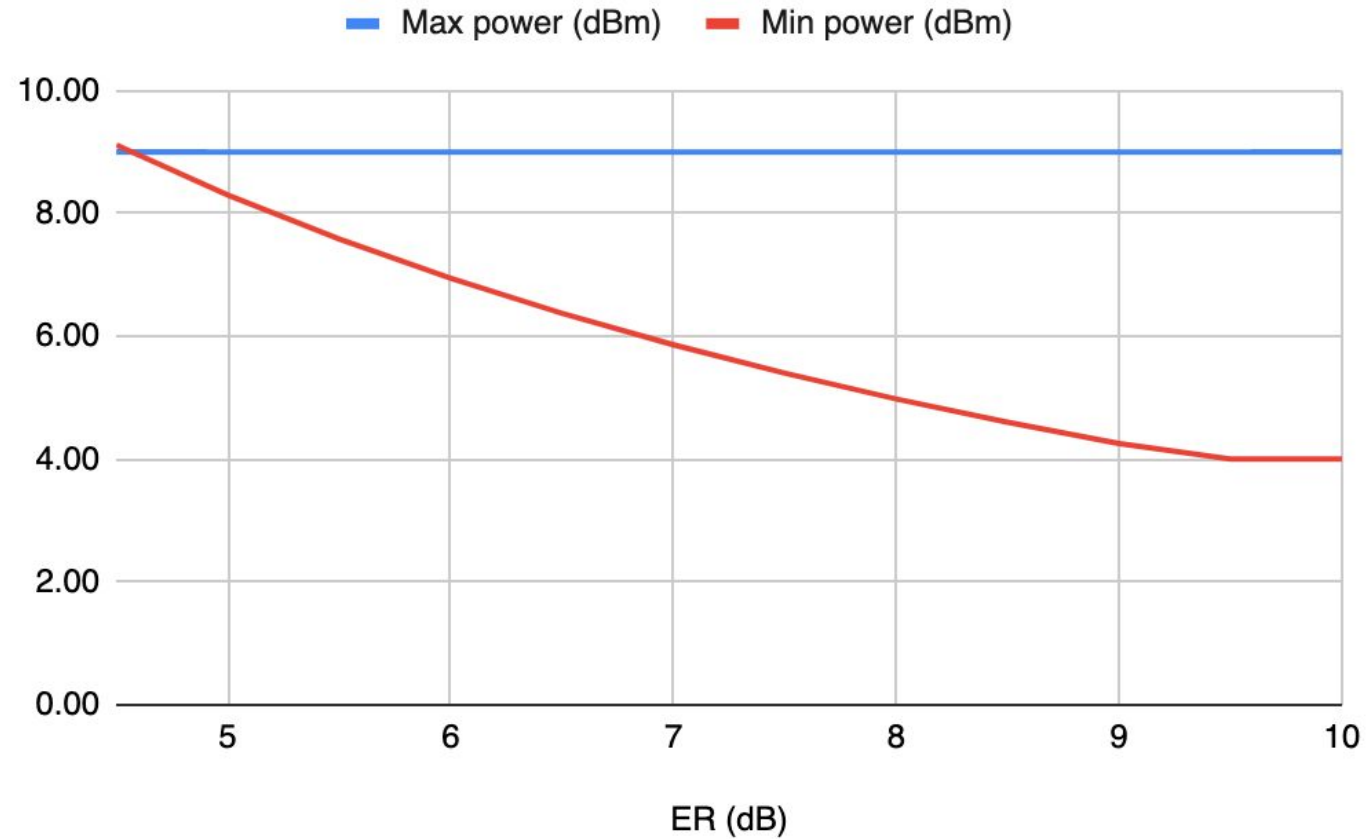




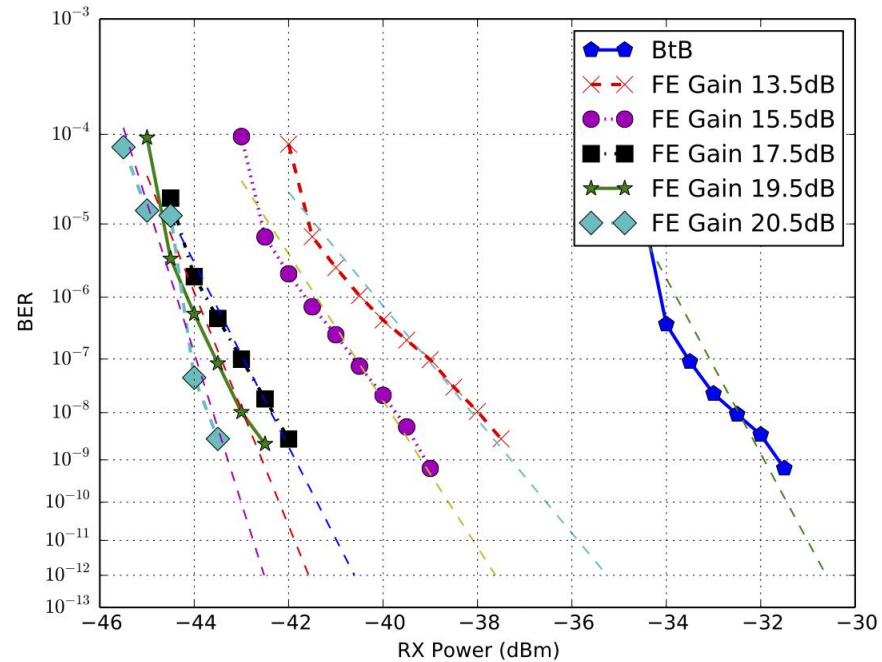
# ONT launch power 10-Gb/s US (5-dB DR)

ER (dB)	Max power (dBm)	Min power (dBm)
10	9.00	4.00
9.5	9.00	4.00
9	9.00	4.25
8.5	9.00	4.60
8	9.00	4.98
7.5	9.00	5.40
7	9.00	5.86
6.5	9.00	6.38
6	9.00	6.95
5.5	9.00	7.58
5	9.00	8.30
4.5	9.00	9.12

ONT Launch power



# ONT launch power 2.5-Gb/s US



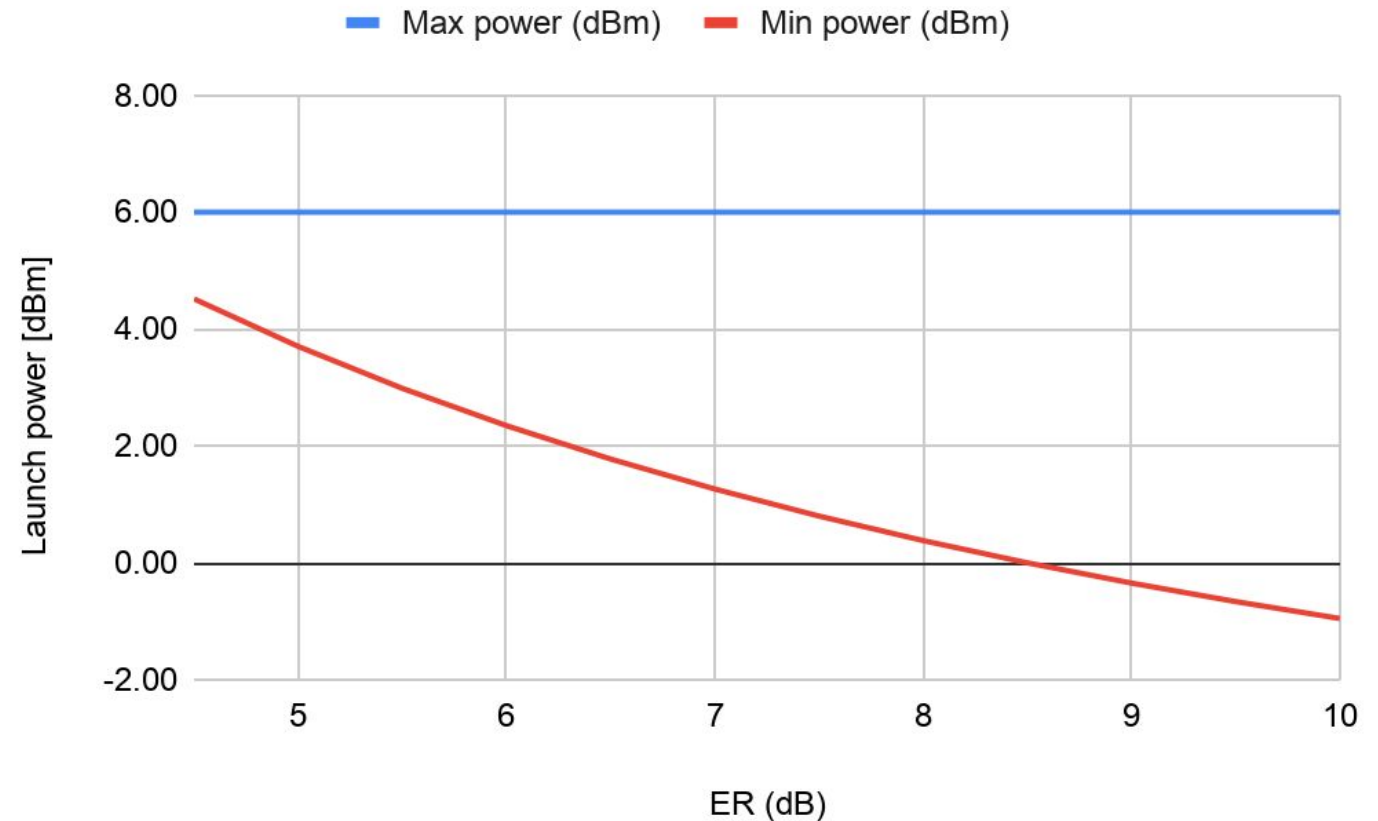
1.25 Gb/s US sensitivity results

- Bit rate: 1.25G -> 10G = 9 dB
- Sensitivity @ BER= $10^{-4}$ : -45 dB -> -38 dB = 7 dB
- Using linear interpolation to 2.5 Gb/s
  - 2.33 dB higher than 1.25 Gb/s
  - 4.67 dB lower than 10 Gb/s
  - $\sim$ -42.6 dBm @ 2.5 Gb/s

# ONT launch power 2.5-Gb/s US

ER (dB)	Max power (dBm)	Min power (dBm)
10	6.00	-0.95
9.5	6.00	-0.66
9	6.00	-0.35
8.5	6.00	0.00
8	6.00	0.38
7.5	6.00	0.80
7	6.00	1.26
6.5	6.00	1.78
6	6.00	2.35
5.5	6.00	2.98
5	6.00	3.70
4.5	6.00	4.52

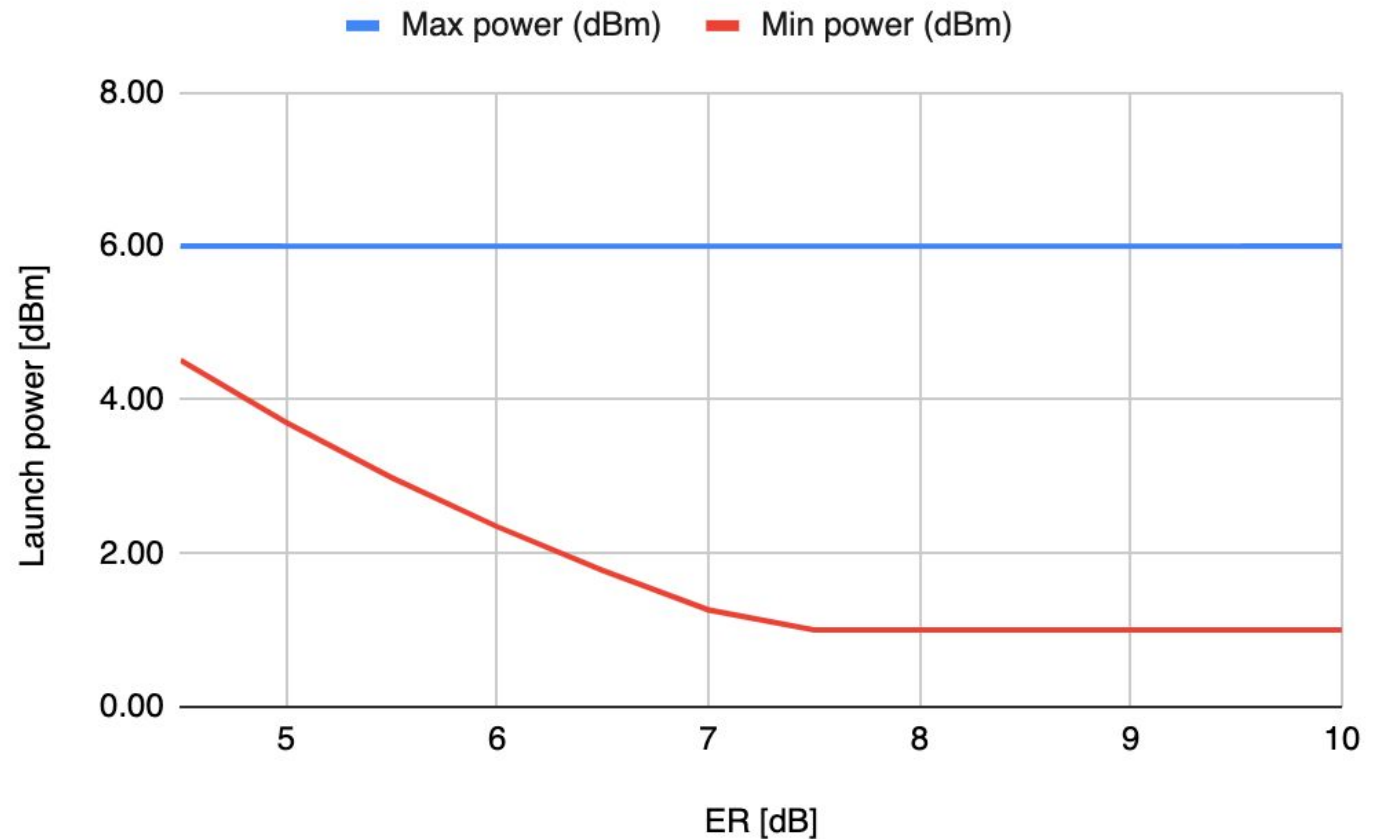
ONT Lanuch power



# ONT launch power 2.5-Gb/s US (5-dB DR)

ER (dB)	Max power (dBm)	Min power (dBm)
10	6.00	1.00
9.5	6.00	1.00
9	6.00	1.00
8.5	6.00	1.00
8	6.00	1.00
7.5	6.00	1.00
7	6.00	1.26
6.5	6.00	1.78
6	6.00	2.35
5.5	6.00	2.98
5	6.00	3.70
4.5	6.00	4.52

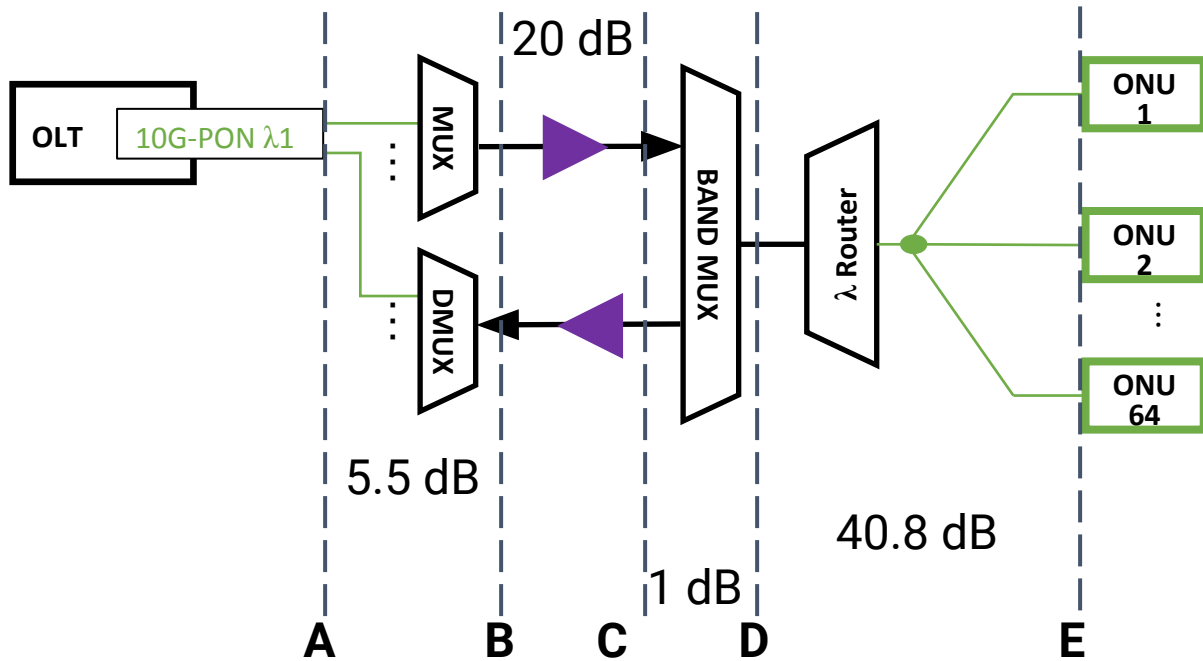
ONT Launch power



# Loss of ODN Components with low-loss AWG

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 last meeting
Splices	17	0.05	0.2	1	7 for components/cable changes, 10 for inline
AWG	1	4.8	4.8	4.8	Using Broadex values
Splitter (x64)	1	21.5	21.5	21.5	Assumes 3.5 dB per 2x
<b>Total</b>				<b>40.8</b>	

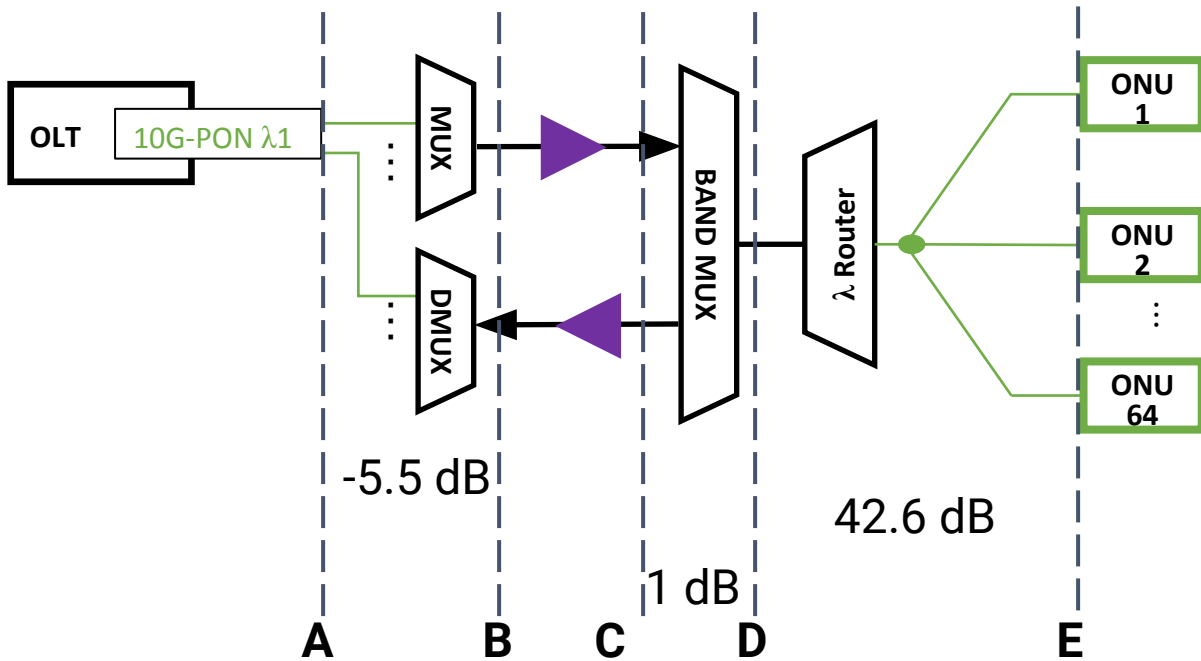
# Downstream power levels



- Class 3 laser is needed to close the DS link budget
- Close to powers of inline amplifiers

Location	DS/WL [dBm]	DS total [dBm]
A	-2.2	
B	-4.1	4.3
C	12.3	24.3
D	11.3	23.3
E	-29.5 PR40	

# Upstream power levels



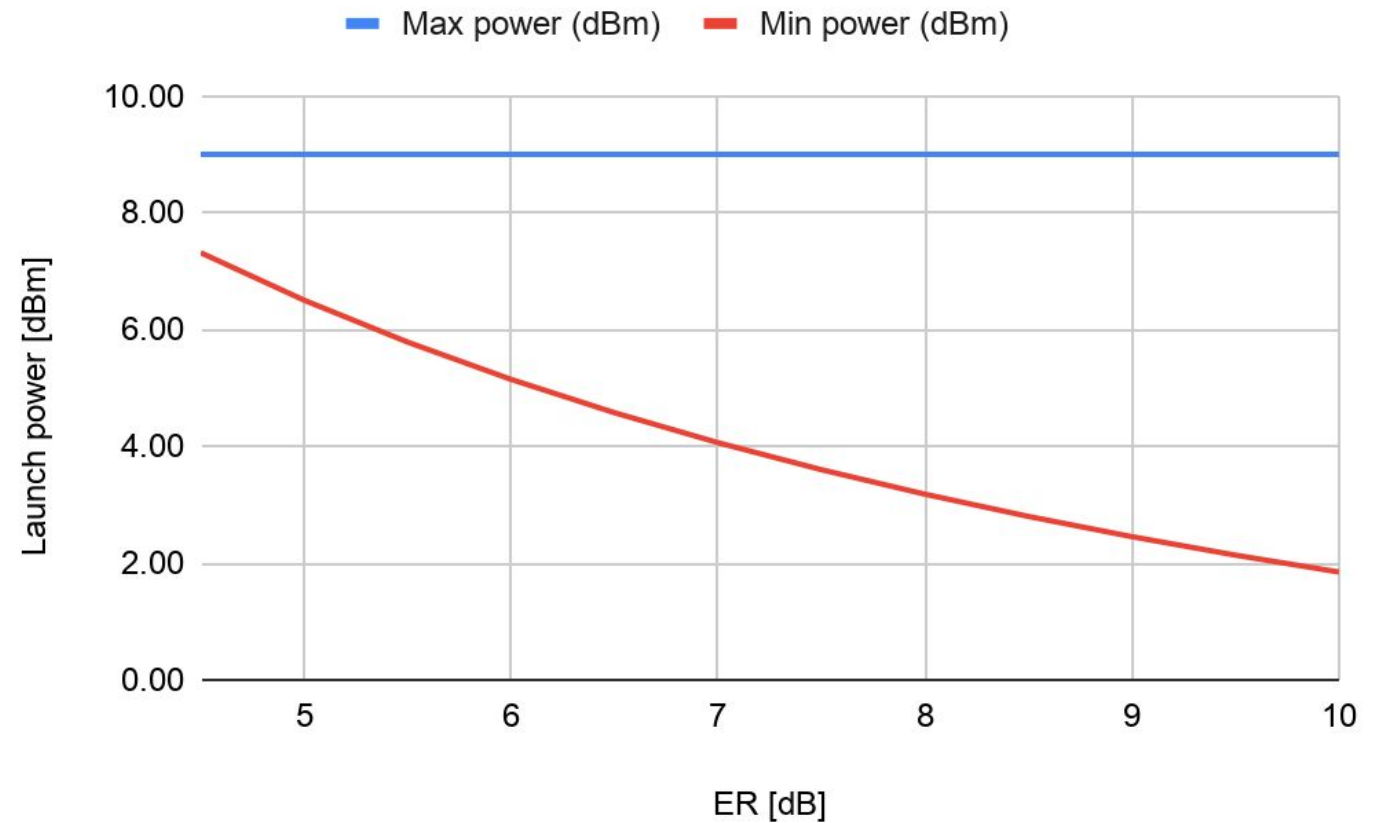
- 2.8 dBm ONT launch power is required at 8.5-dB ER

Location	US/WL [dBm]	US total [dBm]
A	-17.5	
B	-12	0
C	-37	-25
D	-38	-26
E	2.8	

# ONT launch power 10-Gb/s US with low-loss AWG

ER (dB)	Max power (dBm)	Min power (dBm)
10	9.00	1.85
9.5	9.00	2.14
9	9.00	2.45
8.5	9.00	2.80
8	9.00	3.18
7.5	9.00	3.60
7	9.00	4.06
6.5	9.00	4.58
6	9.00	5.15
5.5	9.00	5.78
5	9.00	6.50
4.5	9.00	7.32

ONT launch power

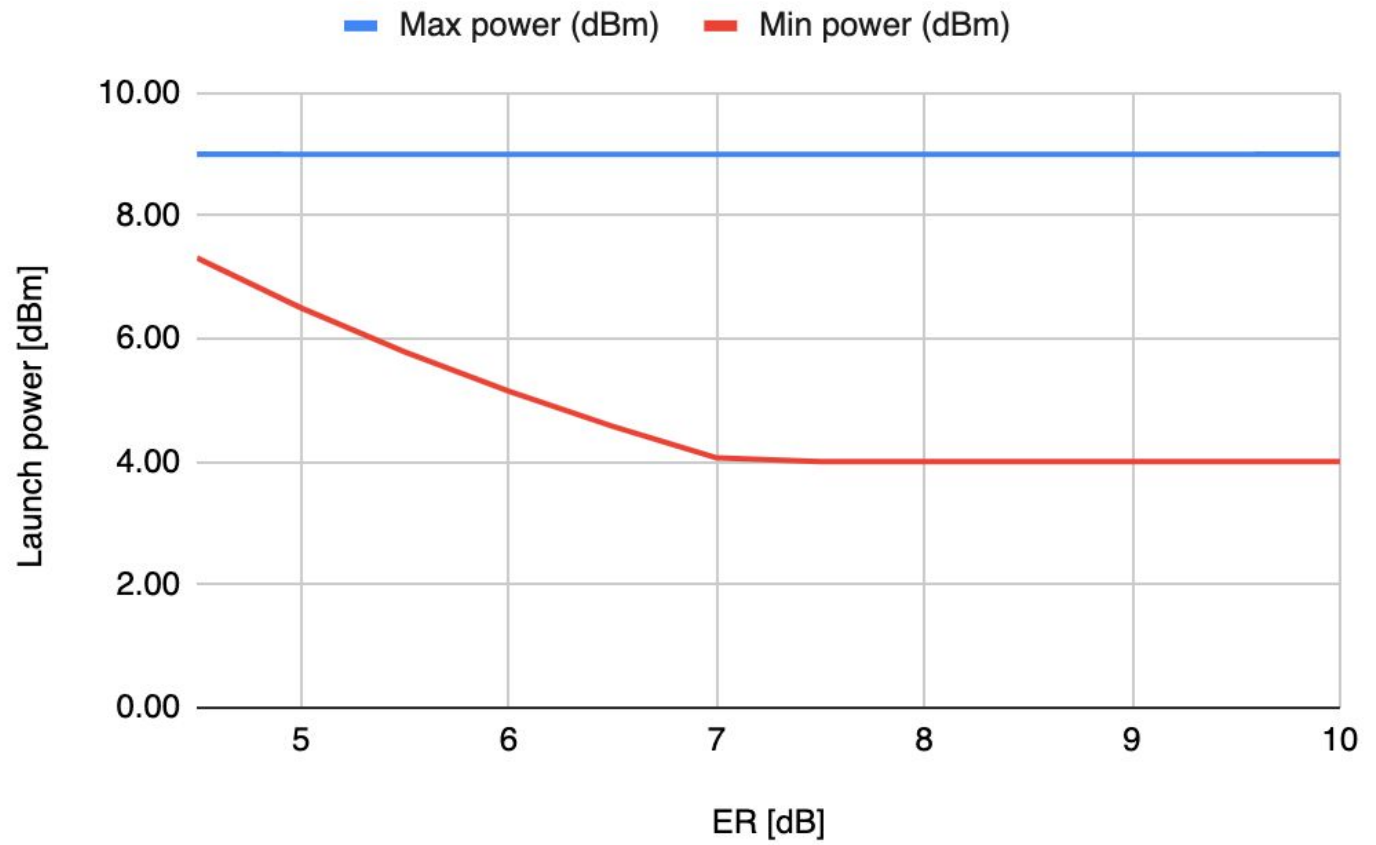




# ONT launch power 10-Gb/s US with low-loss AWG (5-dB DR)

ER (dB)	Max power (dBm)	Min power (dBm)
10	9.00	4.00
9.5	9.00	4.00
9	9.00	4.00
8.5	9.00	4.00
8	9.00	4.00
7.5	9.00	4.00
7	9.00	4.06
6.5	9.00	4.58
6	9.00	5.15
5.5	9.00	5.78
5	9.00	6.50
4.5	9.00	7.32

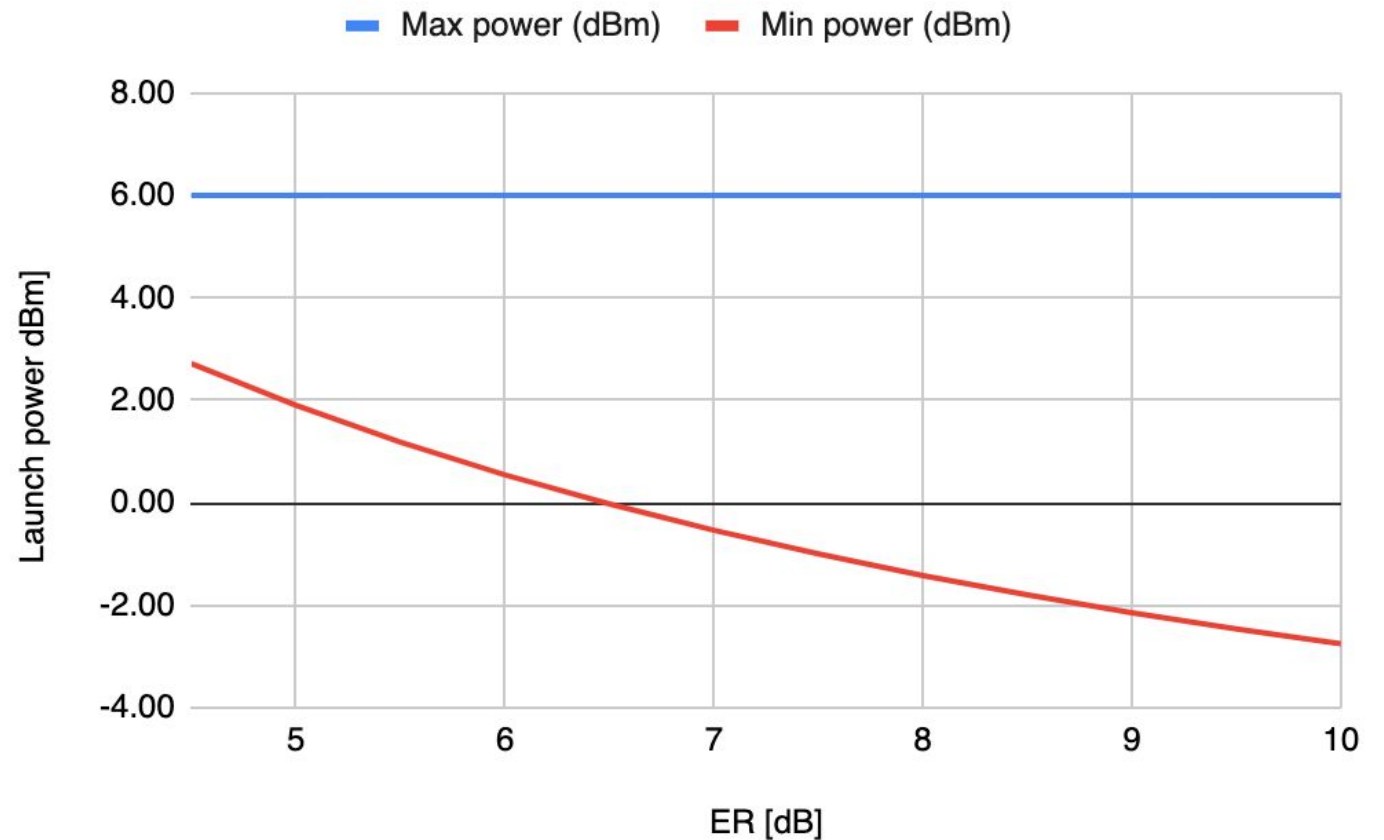
ONT Launch power



# ONT launch power 2.5-Gb/s US with low-loss AWG

ER (dB)	Max power (dBm)	Min power (dBm)
10	6.00	-2.75
9.5	6.00	-2.46
9	6.00	-2.15
8.5	6.00	-1.80
8	6.00	-1.42
7.5	6.00	-1.00
7	6.00	-0.54
6.5	6.00	-0.02
6	6.00	0.55
5.5	6.00	1.18
5	6.00	1.90
4.5	6.00	2.72

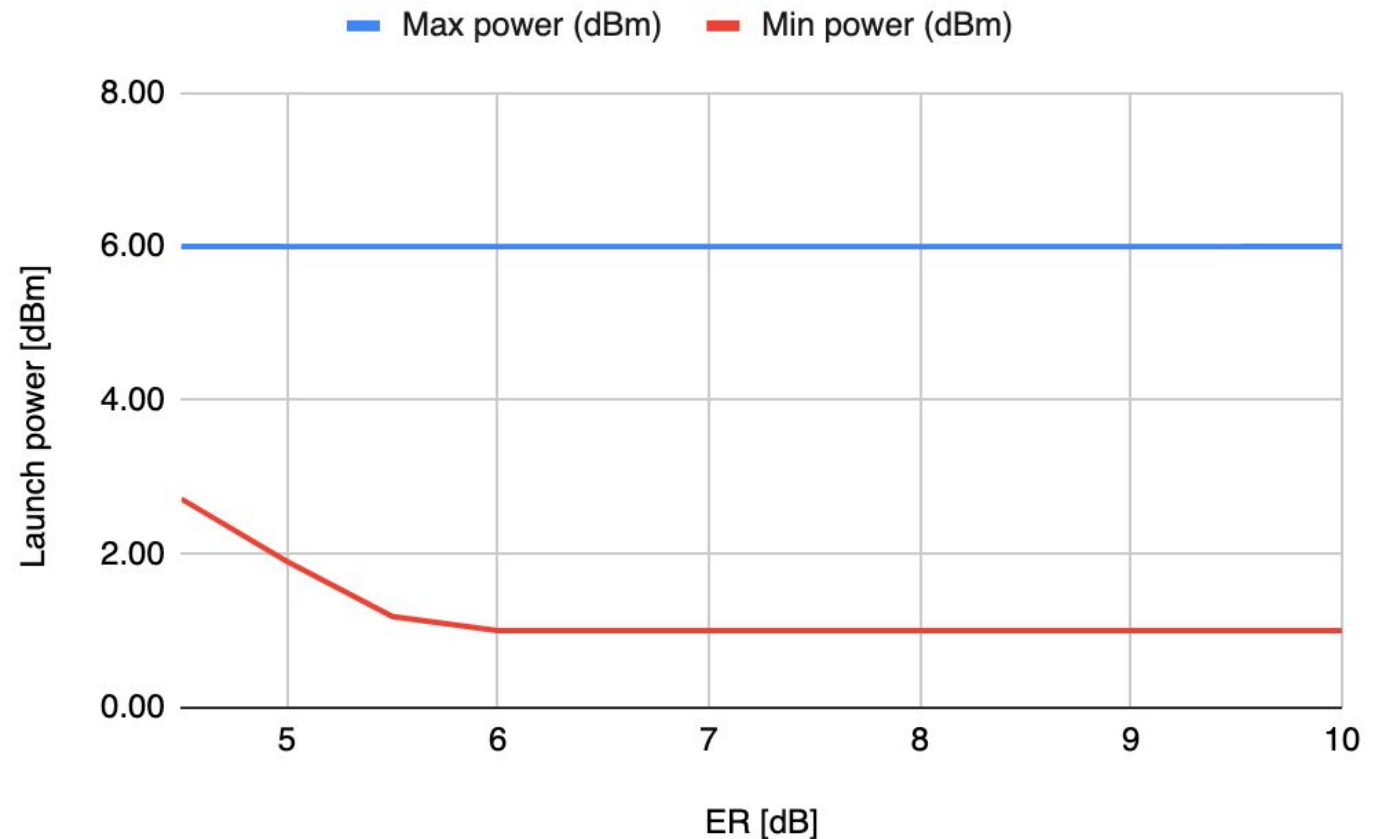
ONT Launch power



# ONT launch power 2.5-Gb/s US with low-loss AWG (5-dB DR)

ER (dB)	Max power (dBm)	Min power (dBm)
10	6.00	1.00
9.5	6.00	1.00
9	6.00	1.00
8.5	6.00	1.00
8	6.00	1.00
7.5	6.00	1.00
7	6.00	1.00
6.5	6.00	1.00
6	6.00	1.00
5.5	6.00	1.18
5	6.00	1.90
4.5	6.00	2.72

ONT Launch power



# Proposal

- Does allowing a minimum of 1 dBm launch power for a 2.5-Gb/s US signal and a maximum of 9 dBm launch power for a 10-Gb/s US signal cause problems for TDM coexistence?
- If not, adopt the launch powers / extinction ratios shown in slides 17 and 19 for the 10 Gb/s and 2.5 Gb/s upstream speeds respectively for the next P802.3cs draft

Thank you