Super-PON
Chromatic Dispersion Considerations

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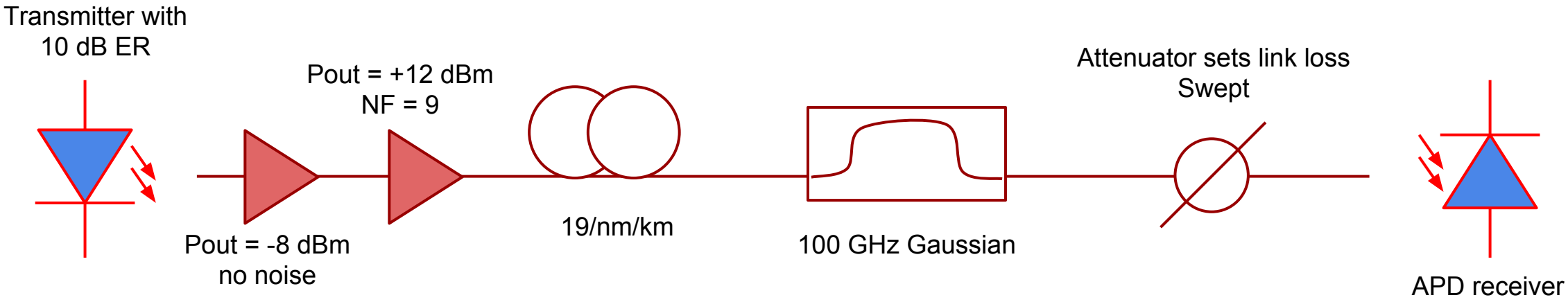
Google Fiber

Overview

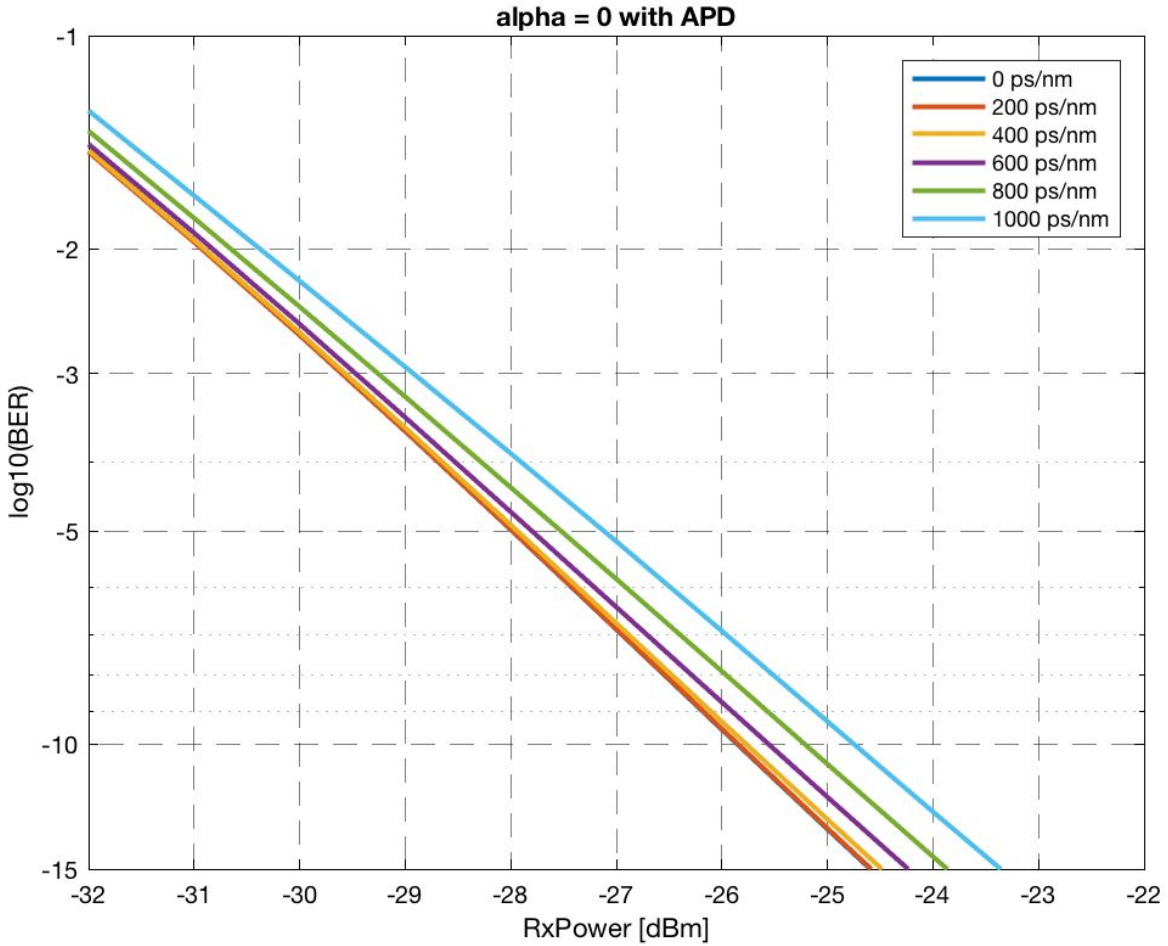
- VPI simulations were used to quantify the tolerance to chromatic dispersion of transmitters with different alpha parameters
- Downstream: APD receiver, -0.5 to +0.5 alpha, high ER
  - DCM not needed for downstream
- Upstream: optical preamp, 0-3 alpha, low ER
  - DCM will greatly increase ONU transmitter options for upstream

Downstream assumptions

- A high extinction ratio is needed since the signal is boosted by amplifier
  - External modulation will offer higher extinction ratios at 10 Gb/s
- A low or negatively chirped EA modulators are possible because of the lower required transmit power
- ONU receiver will be an APD

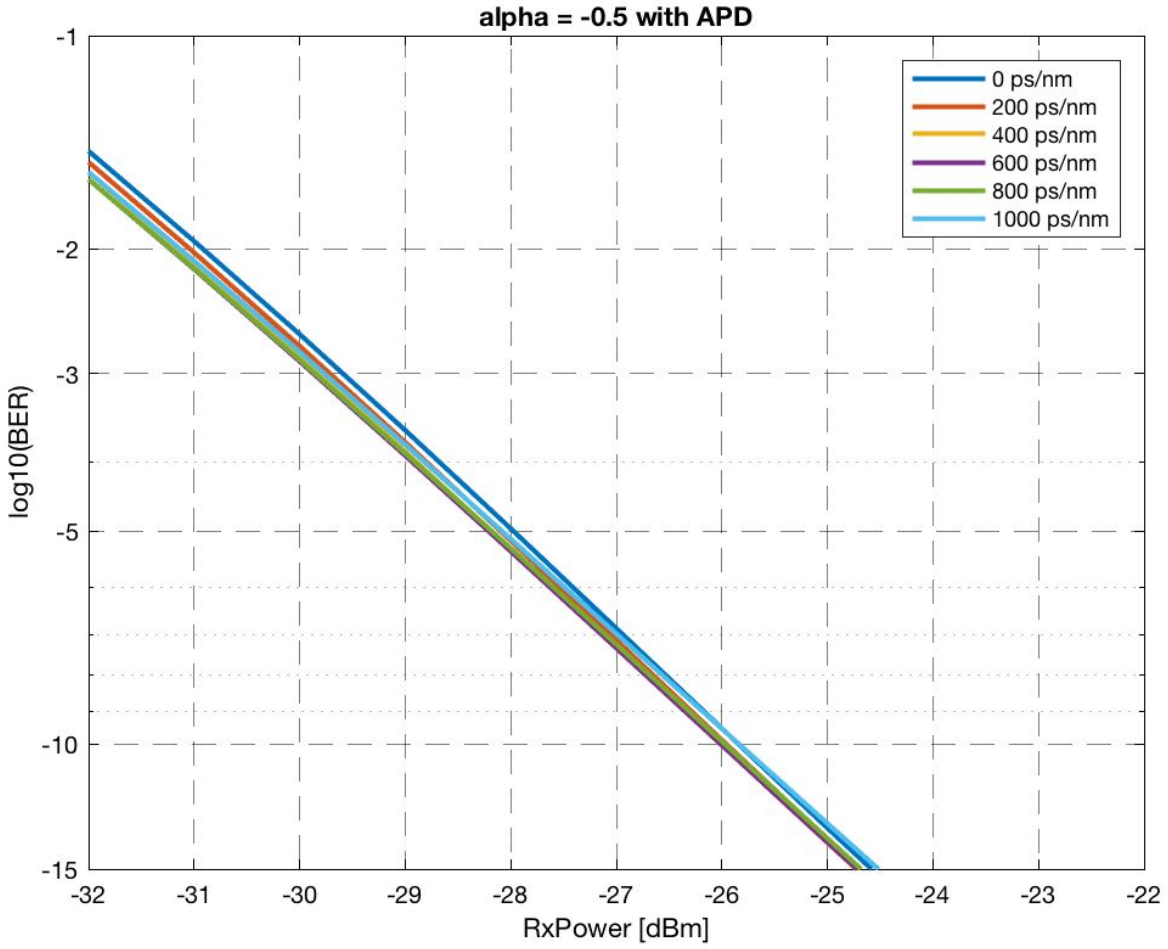


Modulation depth = 0.9 (ER = 10 dB), alpha = 0



- 1000 ps/nm of chromatic dispersion results in around 0.6 dB penalty at BER=10^{-3}
- 1000 ps/nm is around:
  - 58 km in the C-band
  - 53 km in the L-band
- No DCM needed if OLT transmitters are chirpless EMLs

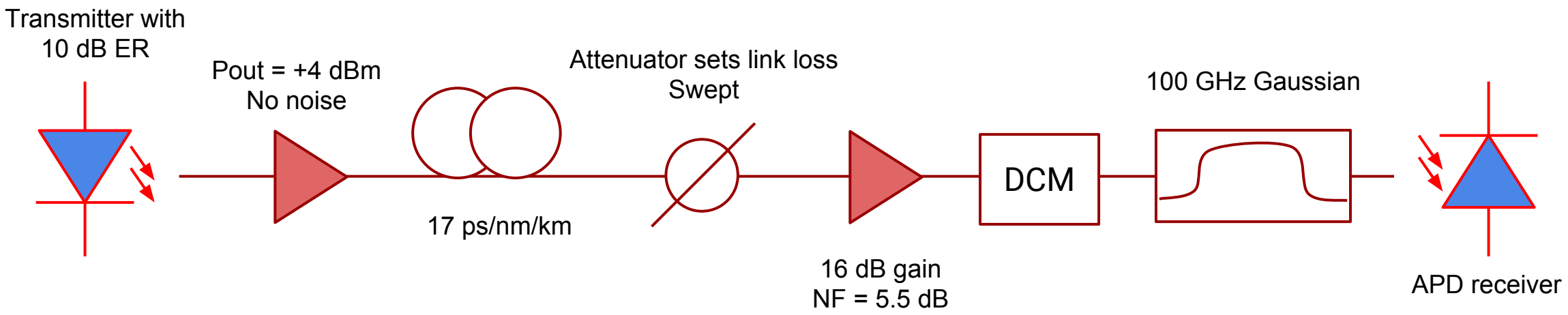
Modulation depth = 0.9 (ER = 10 dB), alpha = -0.5



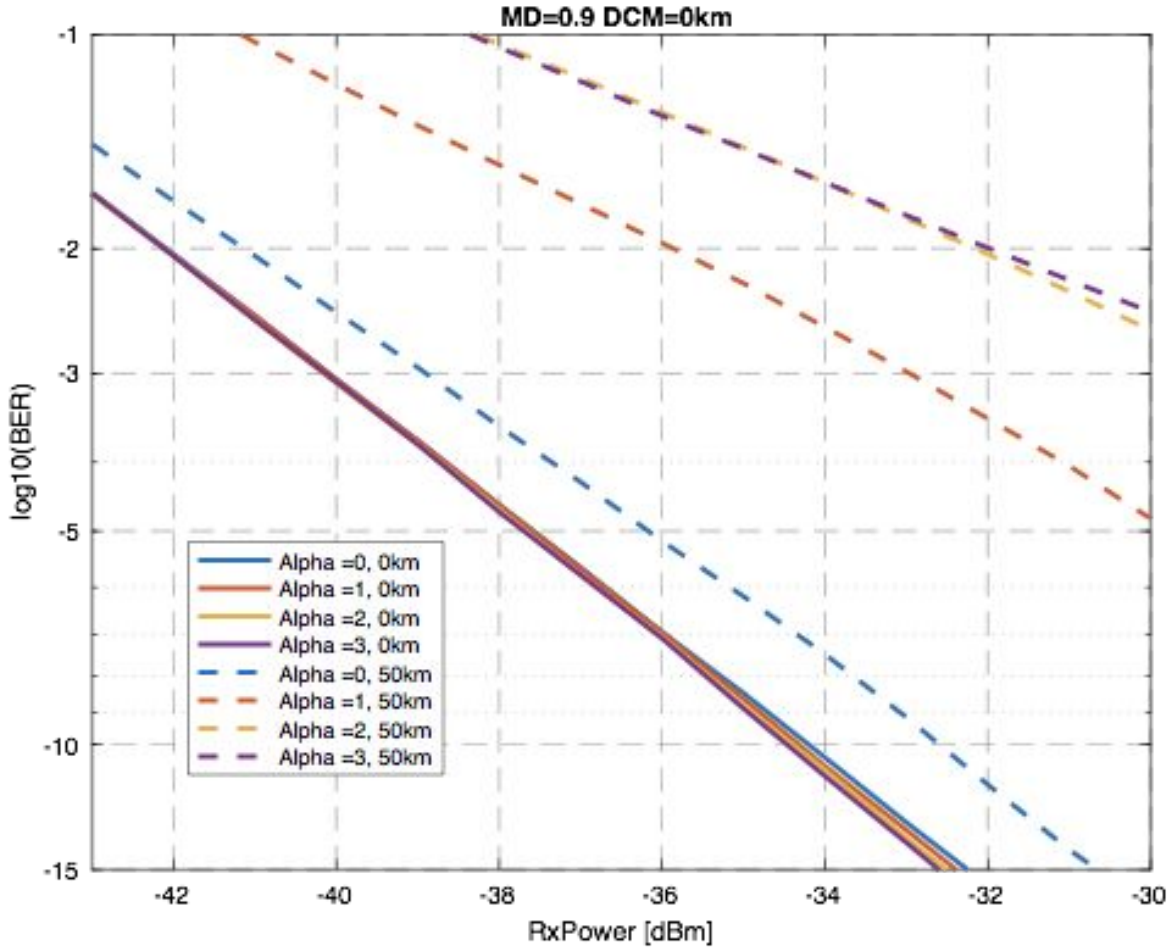
- Sensitivity gain for all residual dispersion >0
- Peak gain at 600 ps/nm
- No DCM needed if OLT transmitters are specified to be negative chirp
- Potentially made possible by the lower output power required (boosted by EDFA)

Upstream assumptions

- ONU transmitter is required to be relatively high power >2 dBm @ 10 Gbps
  - No booster amplifier on the ONU side
- DML lasers are preferred for low cost and higher launch power
- OLT receiver will contain an optical preamplifier

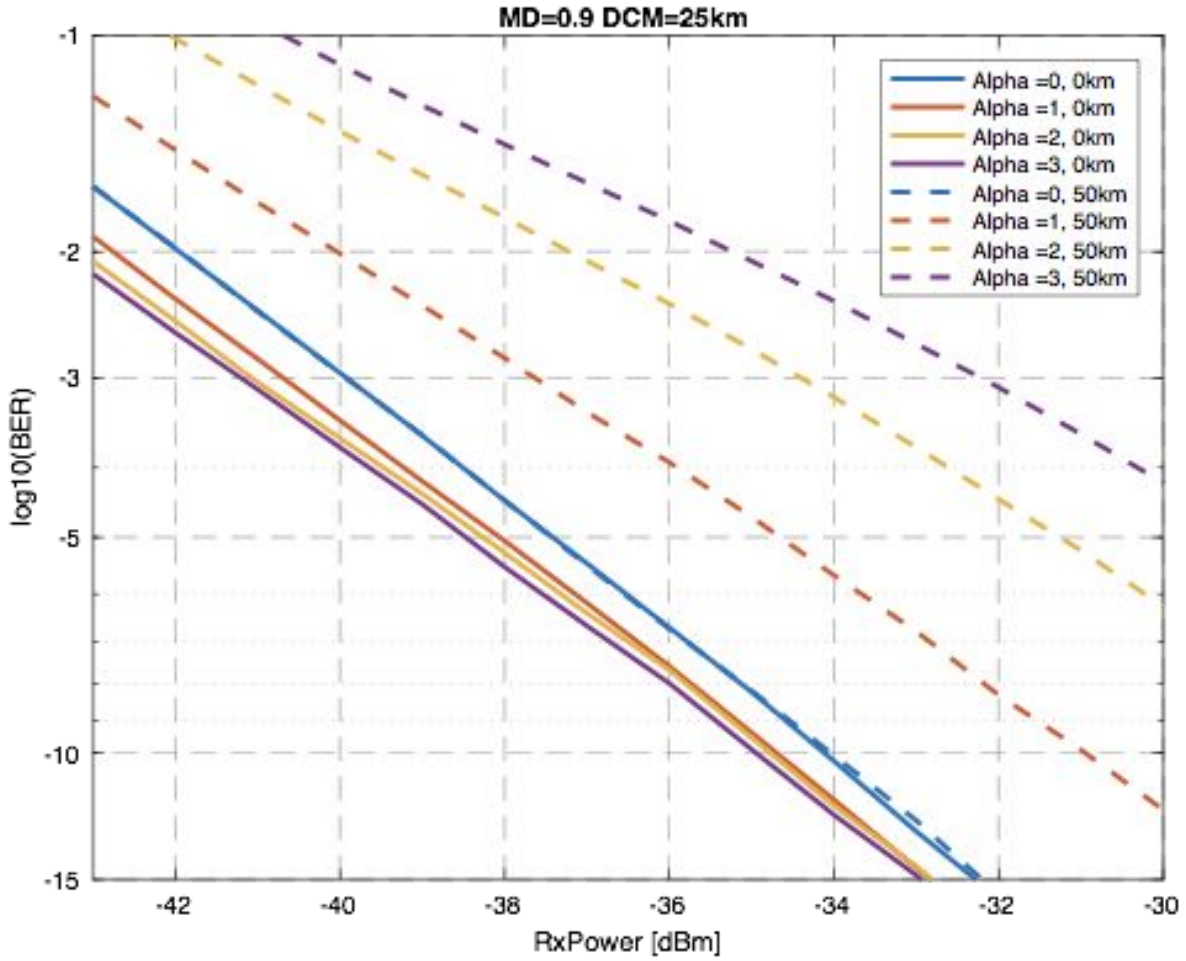


Modulation depth = 0.9 (ER = 10 dB), DCM = 0 km



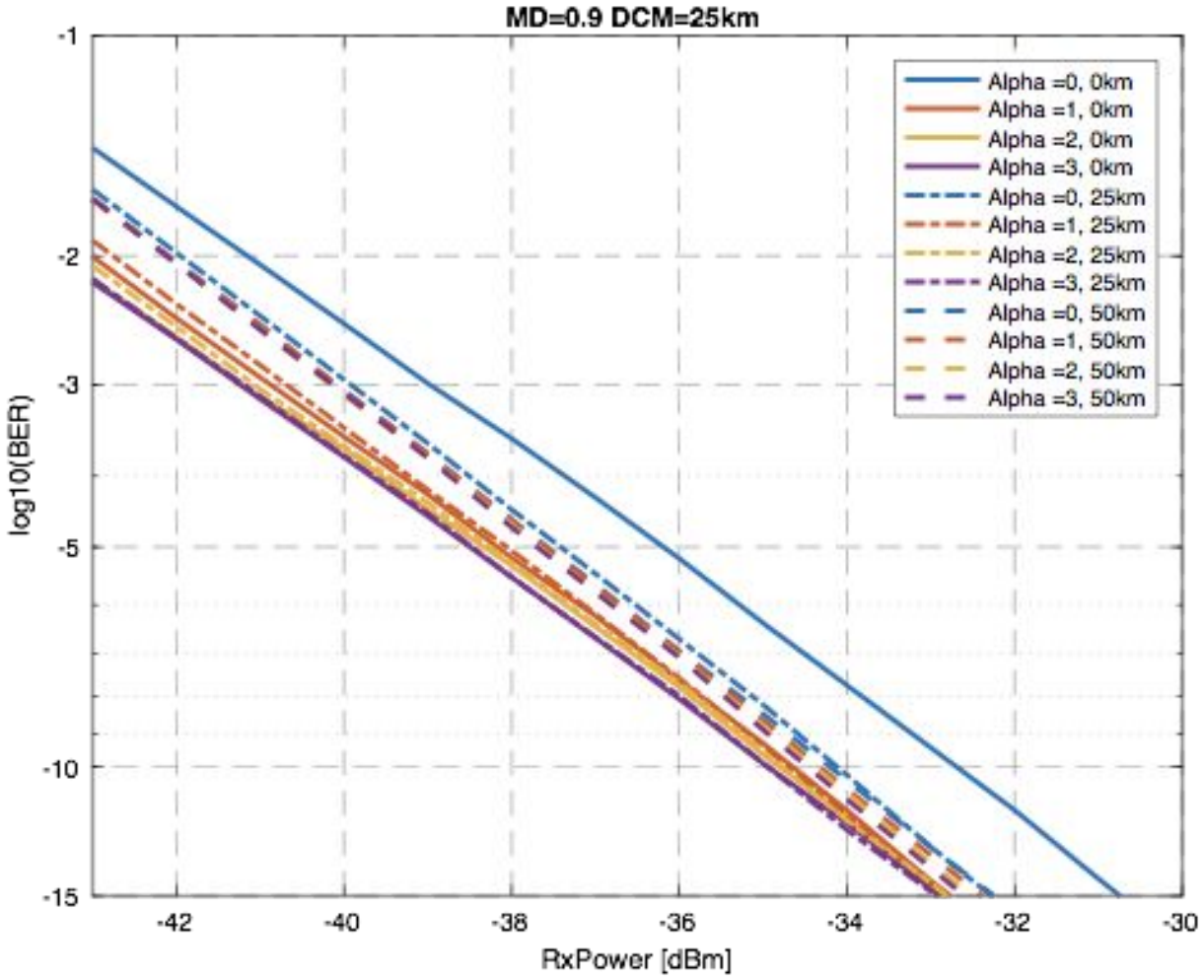
- Can see that higher chirp DML lasers cannot pass a 50 km link without a DCM
- Chirpless EML still has ~1.5 dB penalty from CD

Modulation depth = 0.9 (ER = 10 dB), DCM = 25 km



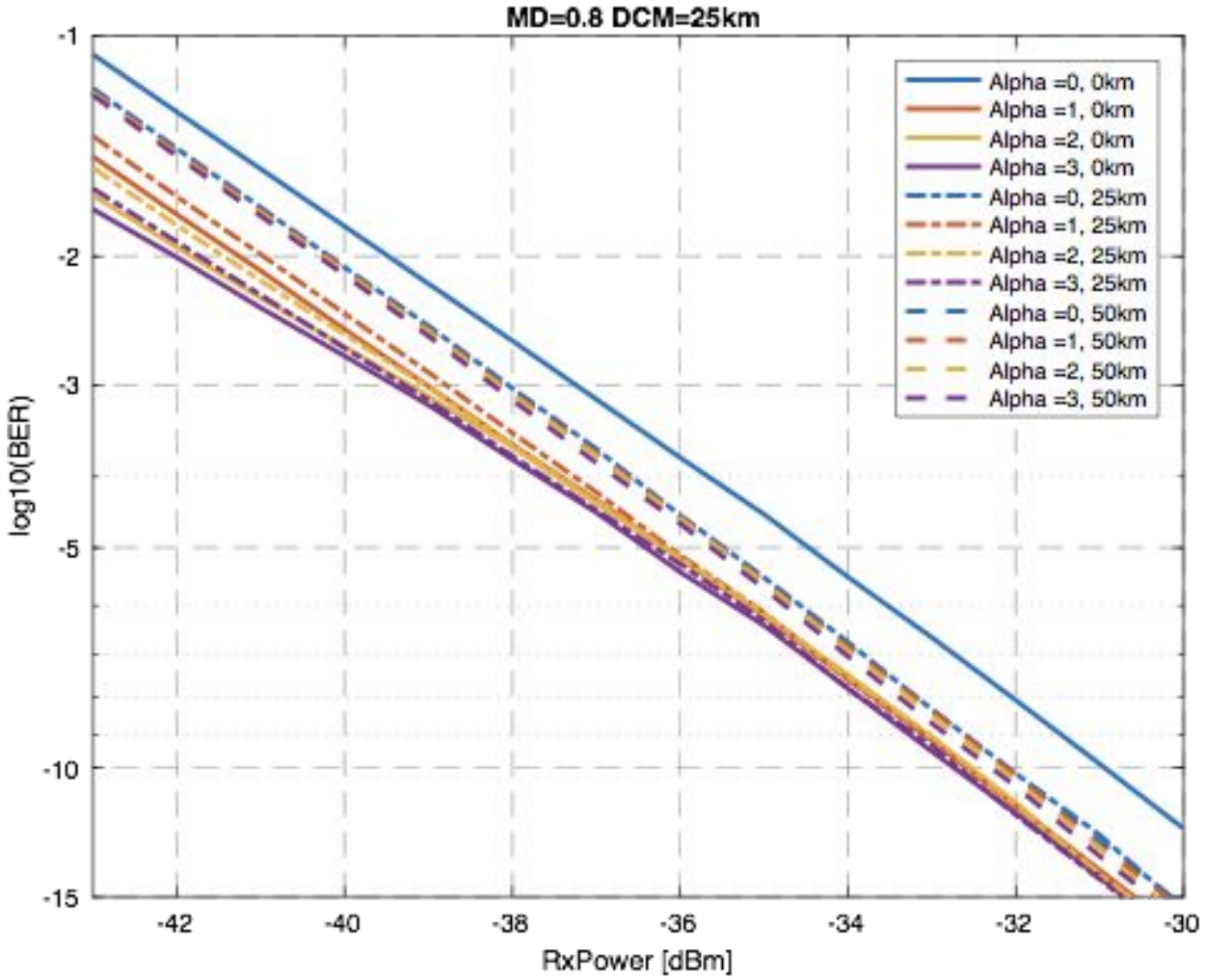
- Chirpless transmitter has similar performance at 0 or 50 km
- +ve chirped transmitters have gain at 0 km and penalty at 50 km
- Penalty is ~2 dB even for the alpha=1 case, which is a low-chirp DML

Modulation depth = 0.9 (ER = 10 dB), DCM = 50 km



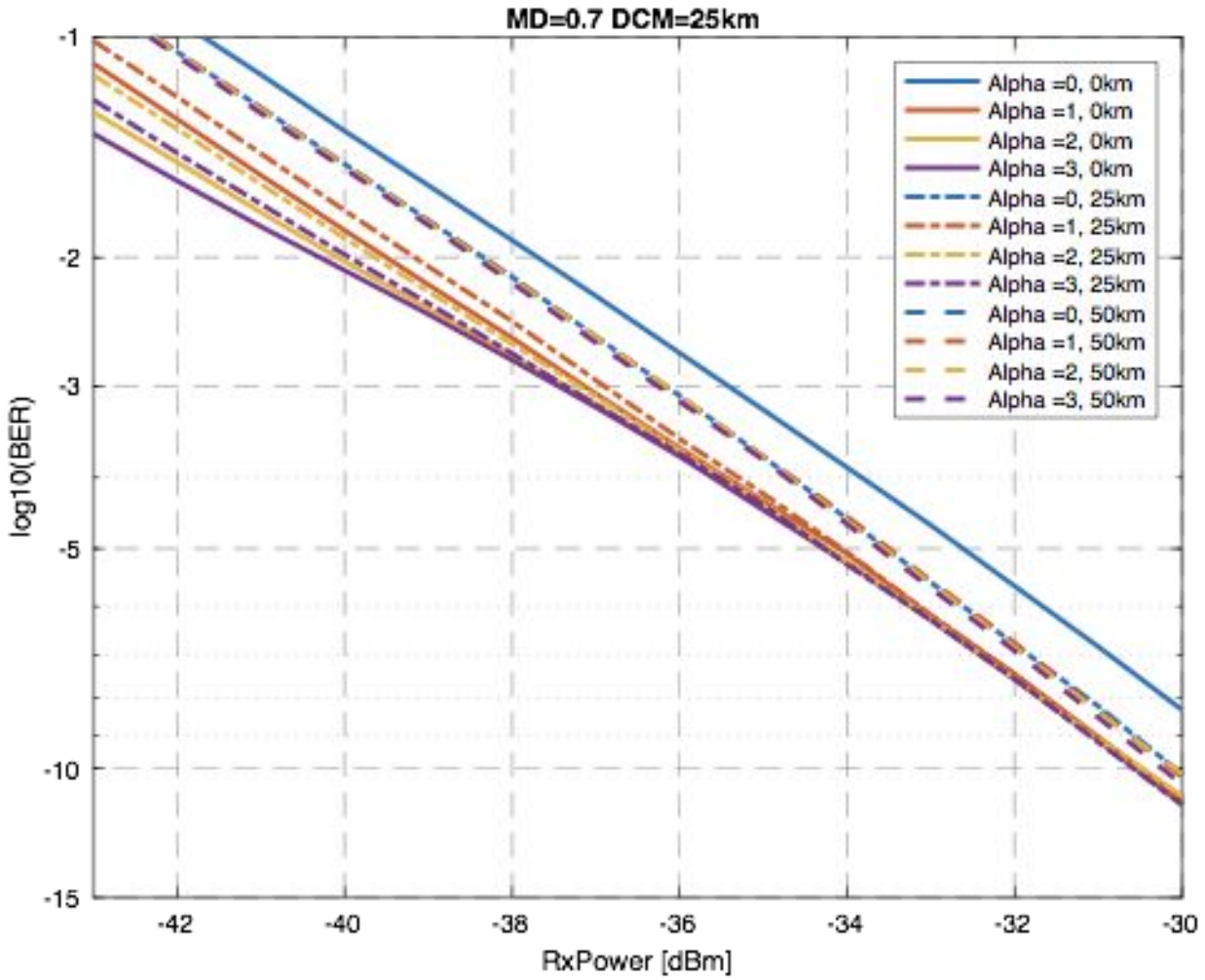
- Chirpless transmitter
  - ~1 dB penalty at 0 km, from the DCM
  - No penalty for 25 km or 50 km
- +ve chirped transmitters
  - No penalty at 50 km (dispersion neutral)
  - Improvement in sensitivity for 25 km and 0 km
- Both chirpless EMLs and +ve chirped DMLs can be supported if a DCM is used
- DCM comp >= max length of ODN

Modulation depth = 0.8 (ER = 7 dB), DCM = 50 km



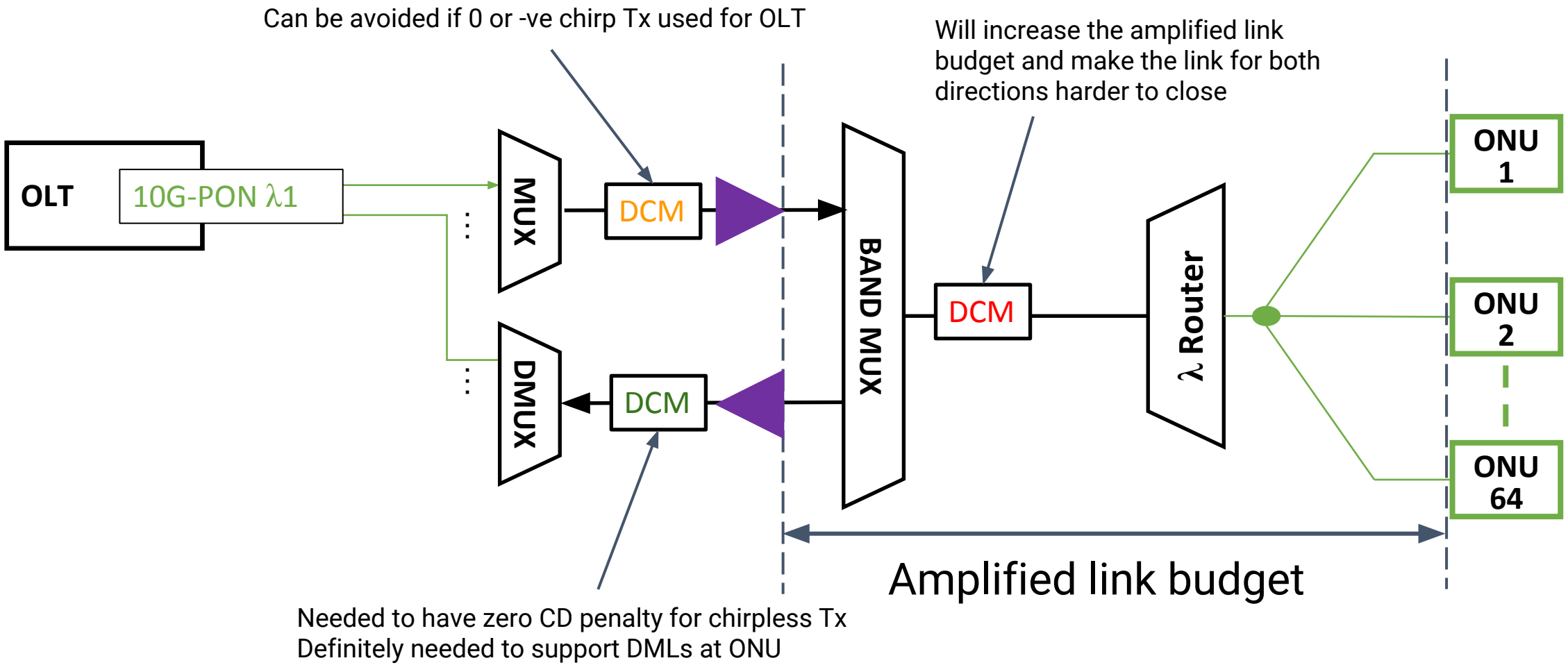
- Similar story for relative performance of different lengths of propagation
- ~2 dB penalty from reduced ER compared to ER = 10 dB

Modulation depth = 0.7 (ER = 5.2 dB), DCM = 50 km



- Similar story for relative performance of different lengths of propagation
- ~2 dB penalty from reduced ER compared to ER= 7 dB or ~4 dB penalty from ER = 10 dB
- Larger penalty from reducing ER than expected
- Reduced performance likely from the increase of noise on the zeros

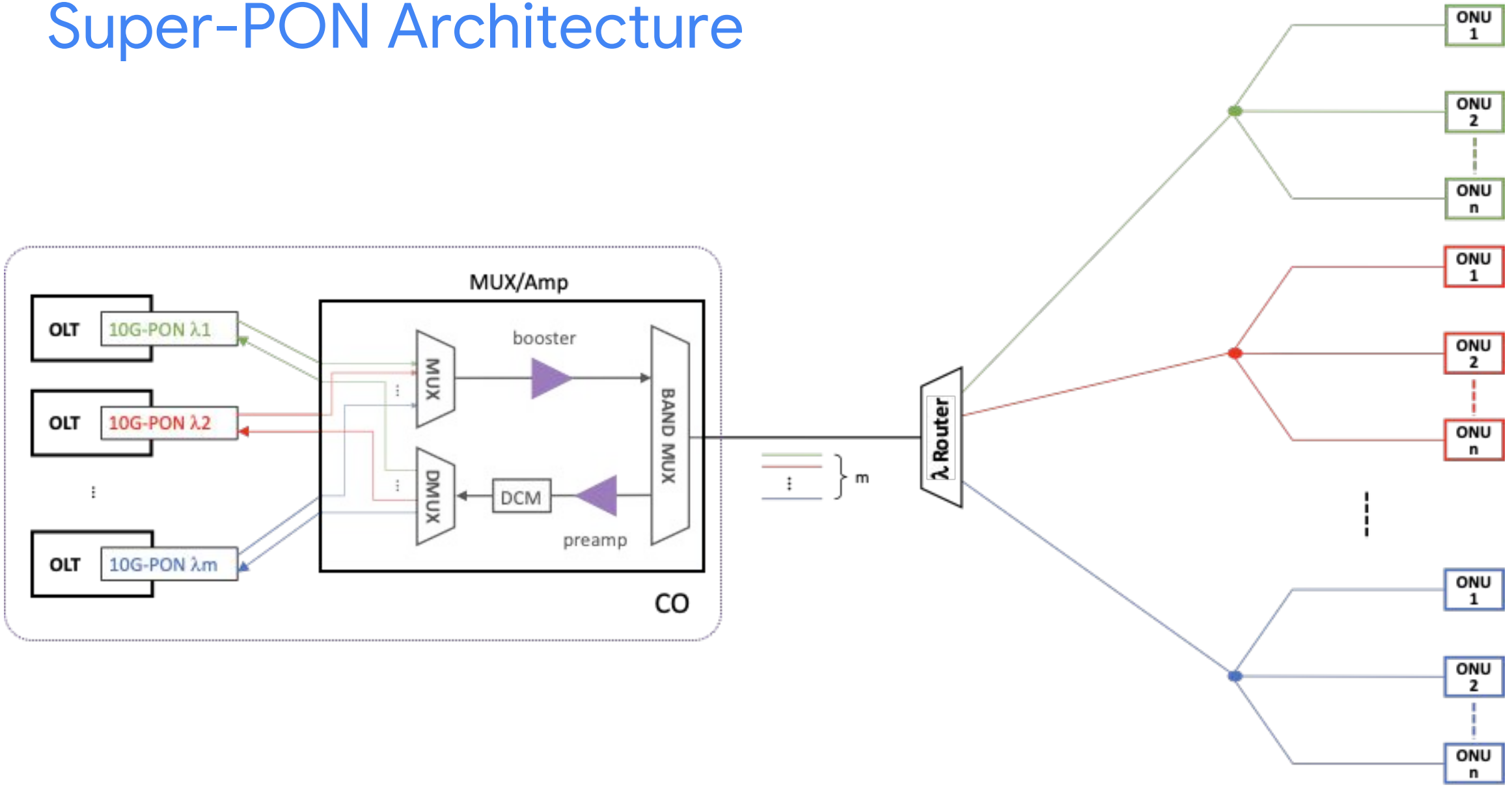
Placement of DCM



Conclusions

- For Super-PON upstream at the speed of 10Gb/s, a single dispersion compensation module (DCM) placed between the optical preamplifier and the demultiplexer is able to resolve the chromatic dispersion issues for any link length within the 50 km limit
- The DCM enables the use of multiple ONU transmitter types to all cover the 50 km range
- The upstream DCM should compensate for at least the maximum link distance of the desired ODN length, so for at least 50 km
- For Super-PON upstream at the speed of 2.5Gb/s, dispersion compensation is likely to not be an issue, with or without DCMs

Super-PON Architecture



Thank you