P802.3cs Super-PON Link Budget Analysis

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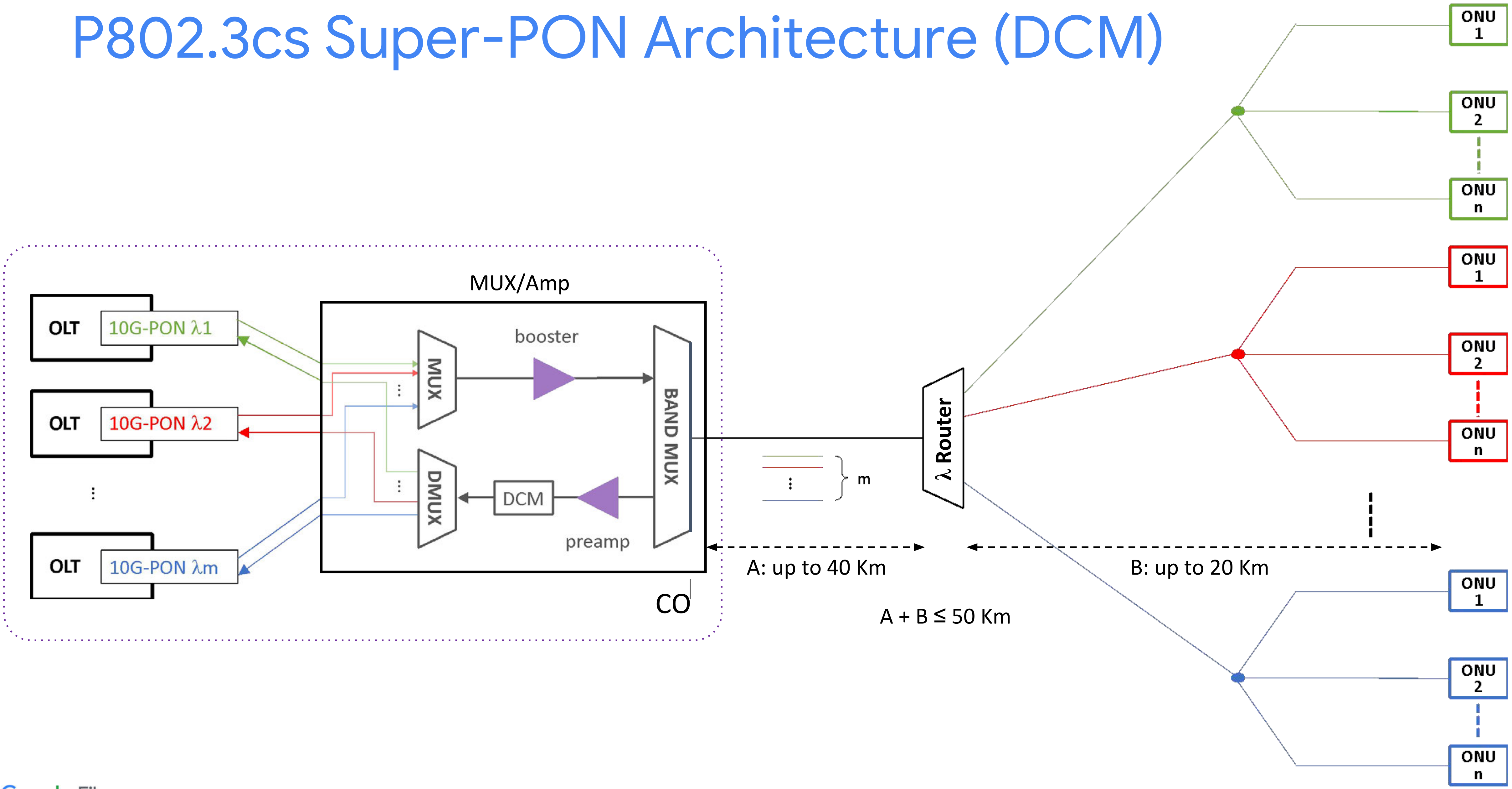
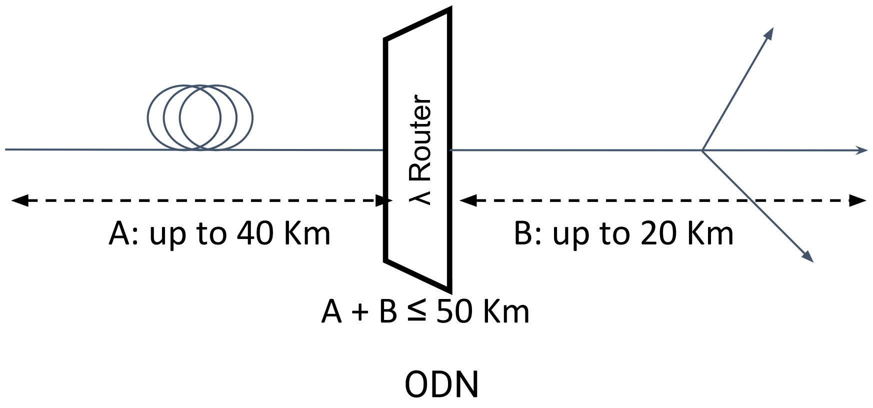
Google Fiber

P802.3cs Super-PON Architecture (DCM)



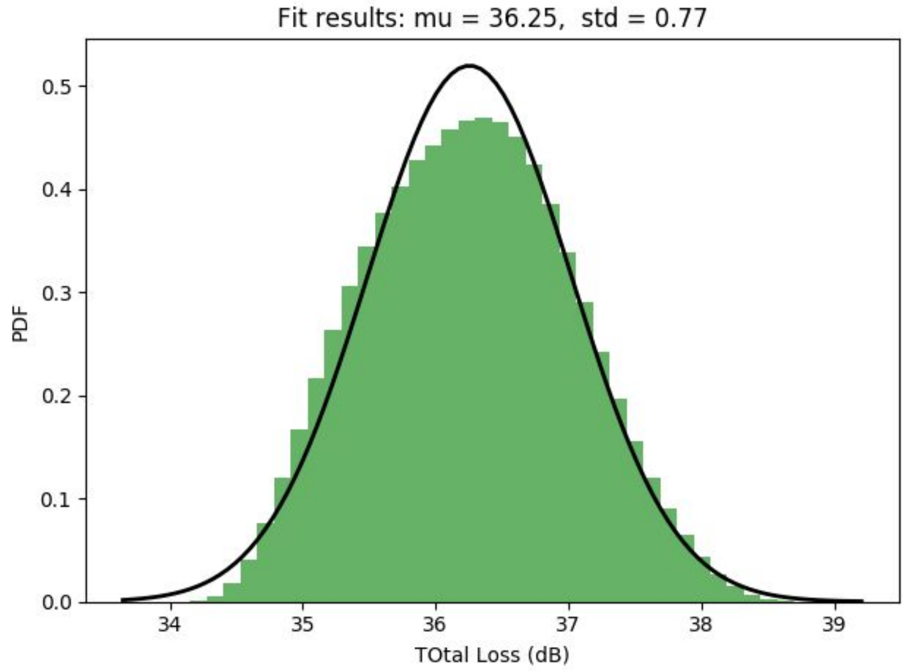
ODN Components



Loss budget (Worst case)		
Components	Loss Max (dB)	Comment
50km Fiber	12	0.24dB/km
λ Router	6.6	4 to 6.6
1x64	21.5	
Total	40.1	

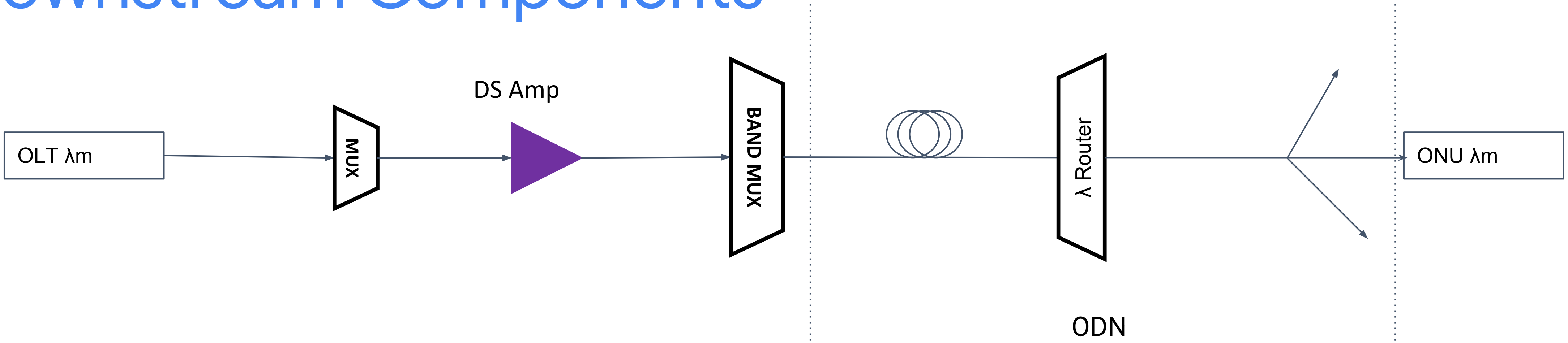
Statistical model: ODN Loss

- Assume the loss values of optical components have a truncated gamma distribution.
- We simulated the statistical distribution of our ODN loss.
- The average+3*sigma value is 38.56 dB.
- Given extra 2.5dB to connector loss and optical impairment etc., we use 41 dB as the maximum loss value of the ODN.



Components	Ave.	Min	Max	Comments
Fiber loss (dB/km)	0.2	0.18	0.22	
λ Router		4.5	6.6	Used a uniform distribution model
Fiber Splicing	0.04	0.02	0.1	one splice every 5km
1:64 splitter	20.5	19.5	21.5	

Downstream Components



- Since we are using boost amplifiers, the TX power of OLT optics is not critical.
- OLT Tx laser chip can be fixed-wavelength EML.
- If we assume the ONU RX sensitivity is -29 dBm, the per-channel launch power after band mux should be larger than 12 dBm.
- The total power after band mux > 12 * 10*log10(16)=24 dBm.

It is possible to achieve this output power while keeping the cost of DS amp in a reasonable range. However, we have not considered:

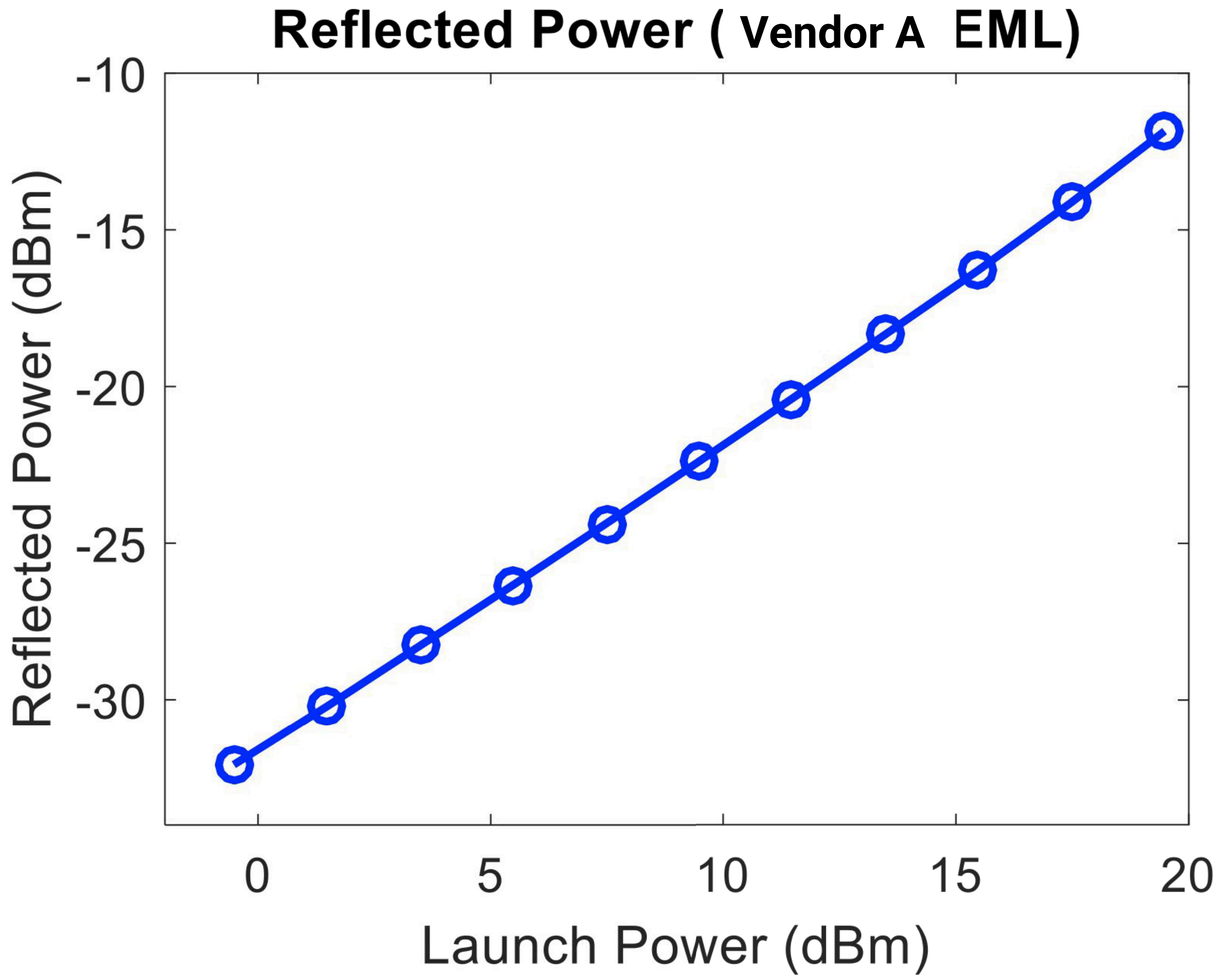
- Dispersion penalty
- High-power nonlinear effects
- Nonuniformity of the output power of TX OLT optics

10G EML Dispersion Penalty

- VPI simulation shows the TDP at different chirp factors.
- With boost amplifier, the requirement of output power of downstream EML laser is greatly relaxed.
- We can afford to bias the EM section to a large negative voltage so that the chirp factor goes to negative regime while keeping the cost of the laser chip low.

Chirp Factor	TDP (50km)
-0.5	<0
0	0.6
0.5	2.5

10G EML Reflected Power vs Launch Power

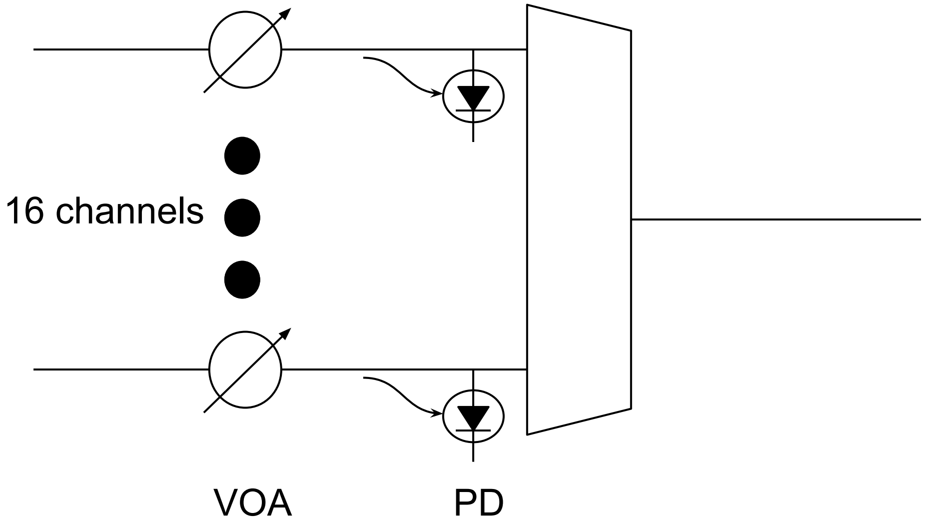


Reflected power linearly up to launch power of 20 dBm, no onset of SBS backscattering observed

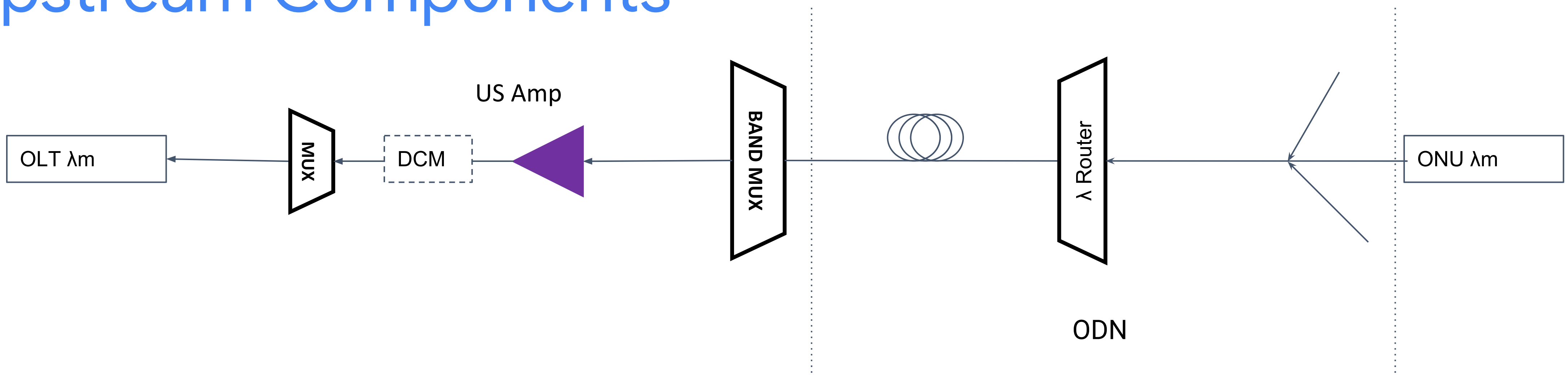
Using VMUX to balance per-channel launch power

We are evaluating the possibility by using VMUX to balance per-channel launch power.
By doing this, we can:

- Relax the maximum power requirement of DS amplifier.
- Relax the TX power range spec of the OLT optics.



Upstream Components



We are considering two chip solutions for the ONU transmitter:

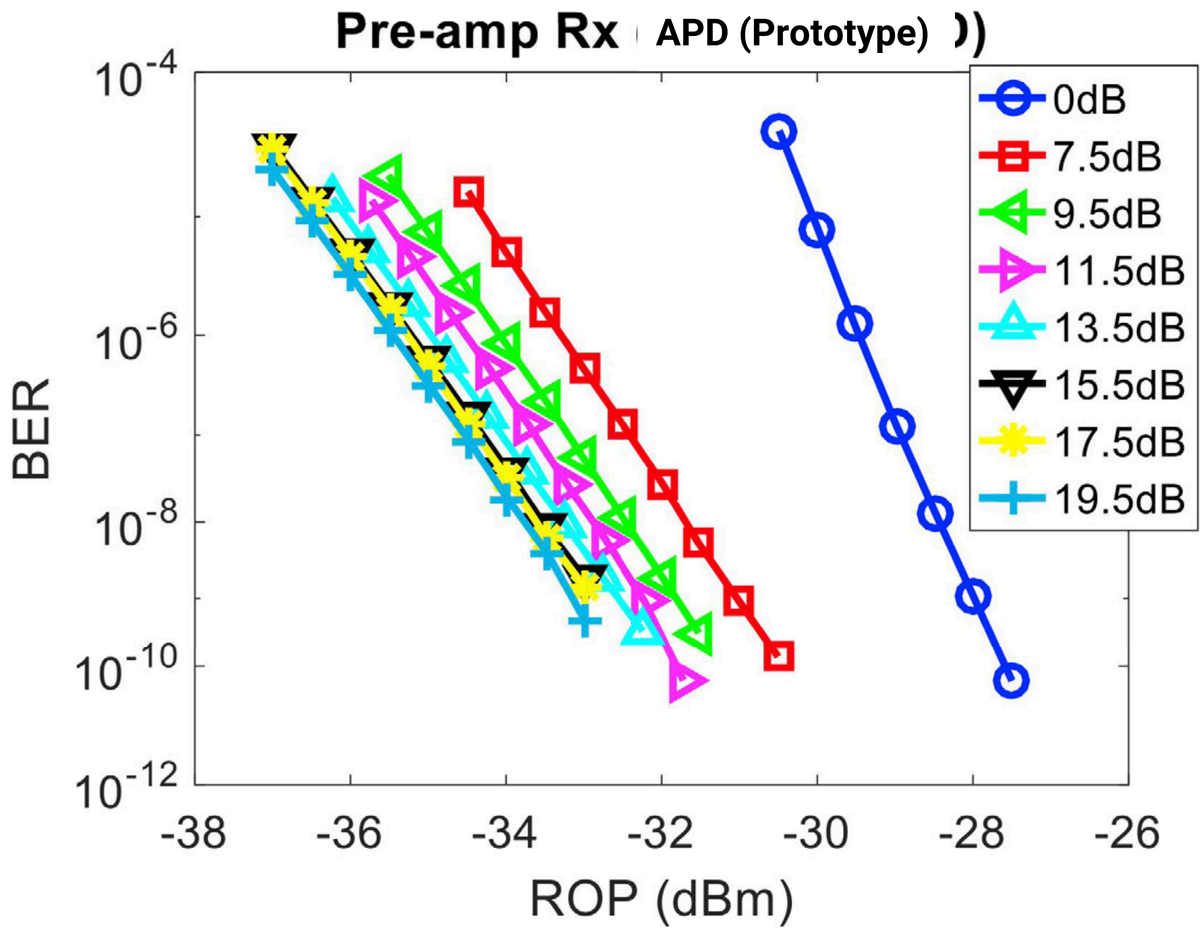
- Tunable EML chip (Gain section + Grating + Electrical Absorber).
  - Don't need dispersion compensation, but higher cost.
- Tunable DML chip (Grating + Gain section).
  - Need dispersion compensation, but overall cost is low.

Performance: EML + pre-amp

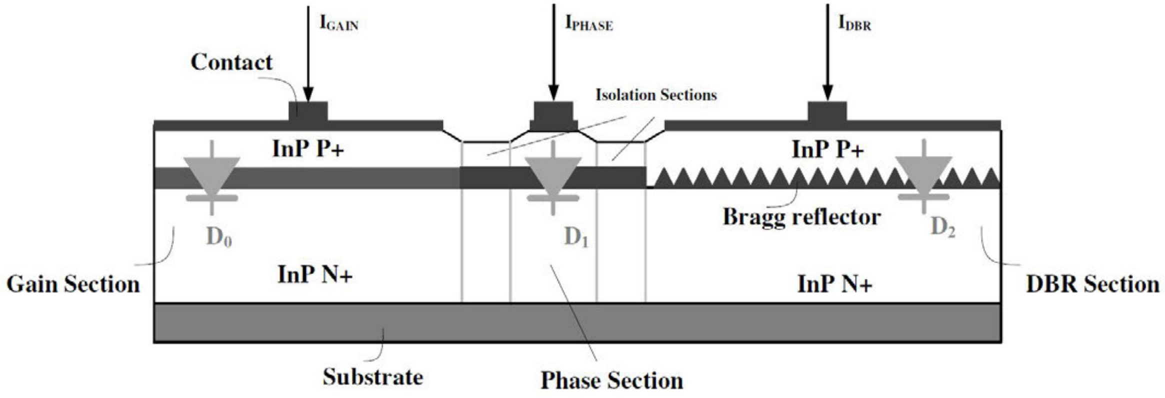
Early sample shows we can achieve RX sensitivity -38dBm at BER=1e-4.

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

Need at least 3 dBm output power from ONU TX.



DML+pre-amp+DCM



- Tunable DBR DML:
  - Lights out from gain section.
  - Wavelength tuning by changing DBR current and TEC temperature.
  - Output power can reach +5dBm at 50 mA bias.
- Things need further exploration:
  - Wavelength drift during the burst

Conclusion

- Discussed the link budget of Super-PON that supports 50 km fiber + 1:64 way splitting.
- The maximum output power of downstream boost amplifier is a limiting factor.
  - While trying to increase the ONU receiver sensitivity, we should also consider to use VMUX to reduce the requirement of maximum output power of DS booster.
- Tunable EML with 3-dBm output is required to close the upstream link.
  - We are evaluating the feasibility and availability
- Tunable DML + DCM is another potential solution.

Thank you