

25G/50G/100G EPON architectures: 1+3 vs. 1+4

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Agenda:

- 1+3: cross generational optical level issues

- 1+3 and 1+4 OLT optical module architectures

For simplicity, only 25G and 100G instantiations are shown.

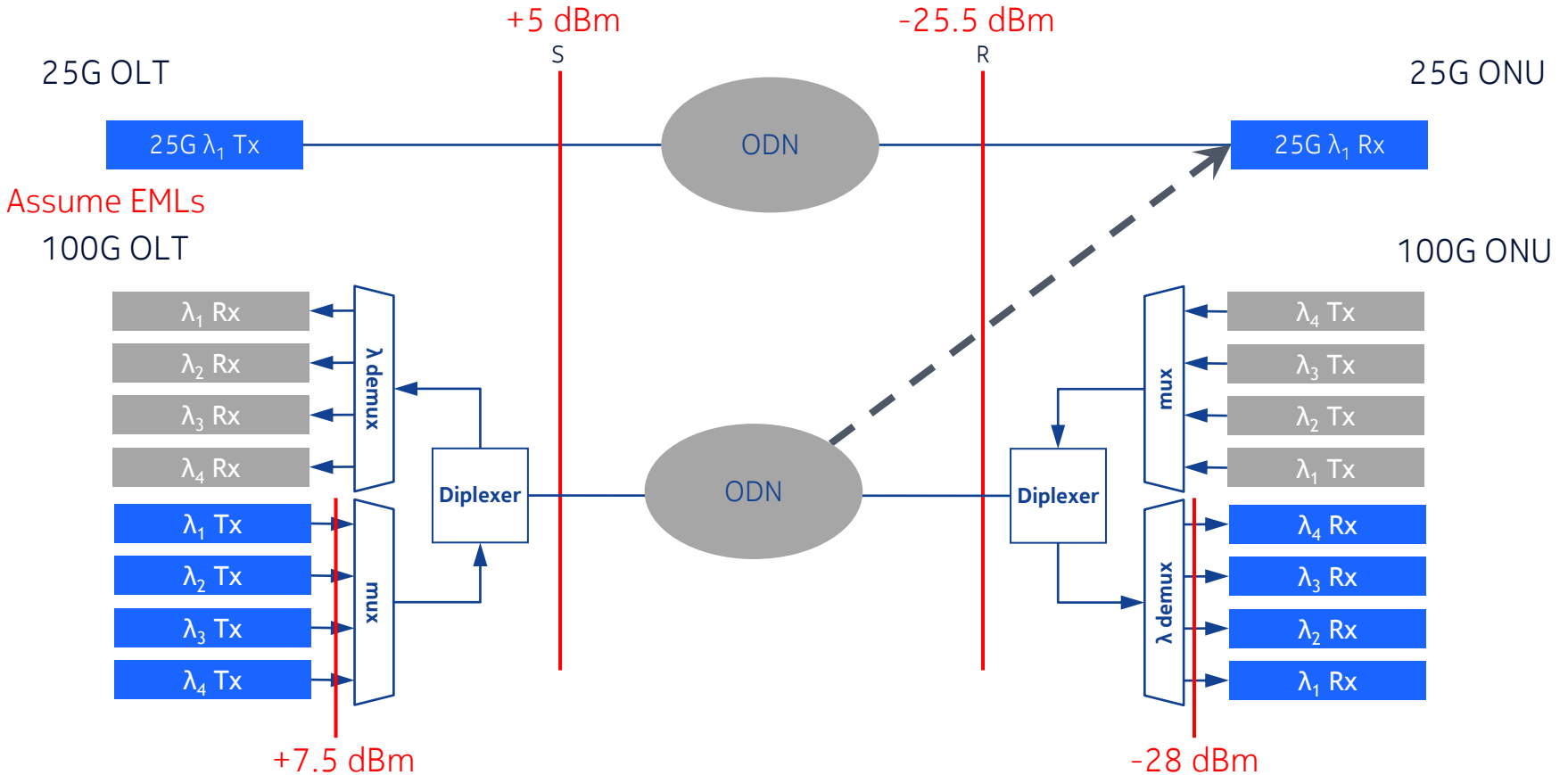
1+3: cross generational optical level issues

Assumed optical values

- 100G mux and demux nominally add ~2.5 dB insertion loss each. Ref: [lee 3ca 1 0716.pdf](#)
- Downstream TDP = 1.5 dB, upstream TDP = 3 dB (provisional values, same as 10G EPON)
- PR30 loss budget
- 1 dB improvement in PR30 APD receiver performance vs. 10G EPON (based on NeoPhotonics yield analysis in [harstead 3ca 1a 0516.pdf](#)) + 5 dB penalty for 25G.
- There will be 1 dB FEC coding improvement in downstream relative to 10G EPON
- Launch power values from [harstead 3ca 2a 0716.pdf](#)

	AVP _{min} (dBm)	ER (dB)
EML	5	8
cooled DML	8	6

1+3 optical levels: downstream. Maintain same R/S for 25G and 100G EPON



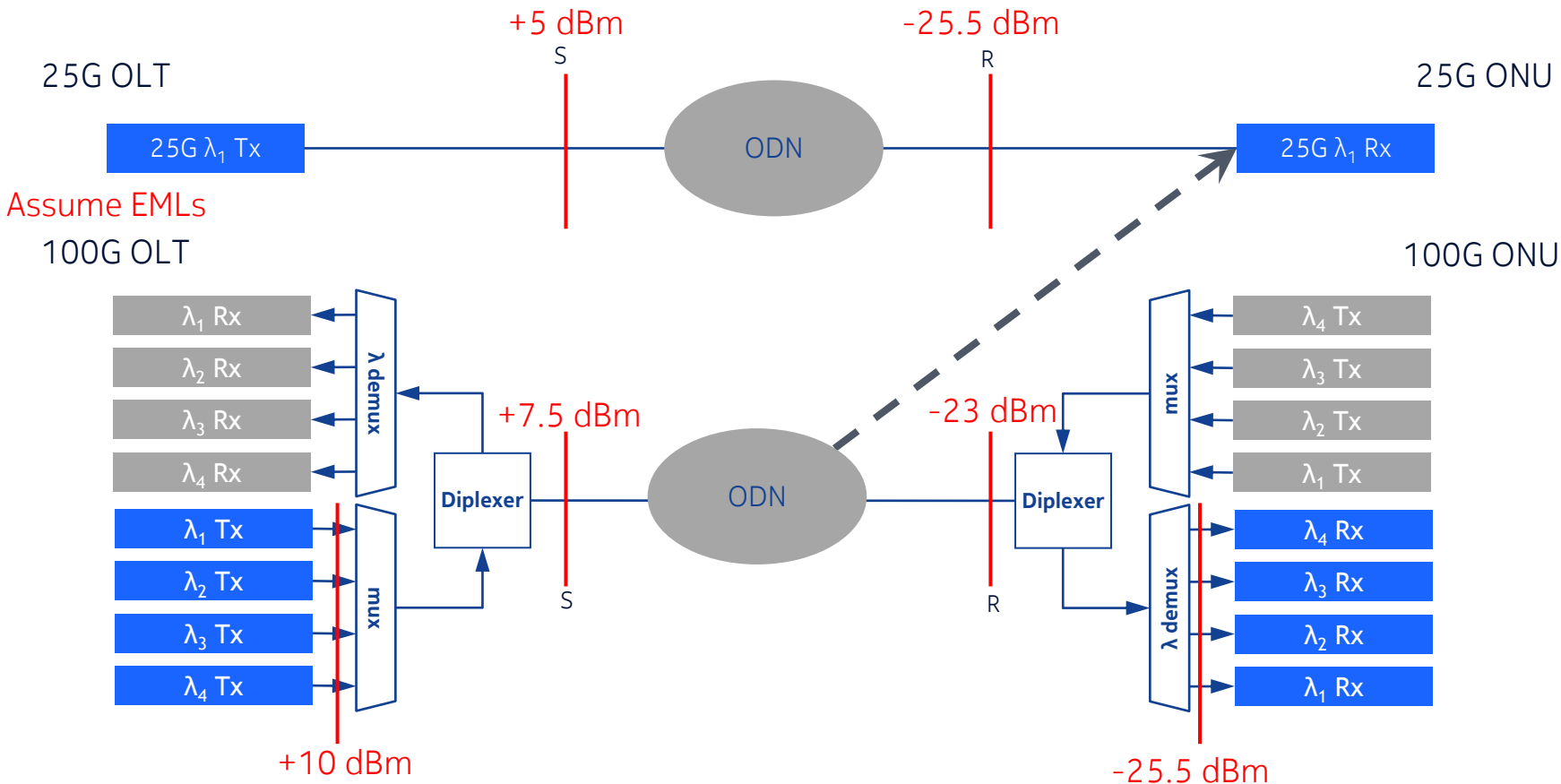
1+3 optical levels: downstream. Maintain same R/S for 25G and 100G EPON:
Not recommended

The 100G ONU receiver must suck up the 2.5 dB loss with better sensitivity. Options:

- a) Select for high performance ONU APD receivers: this will result in low yield, or
- b) add a preamp in front of the ONU demux

In both cases, cost will be added to the 100G ONU.

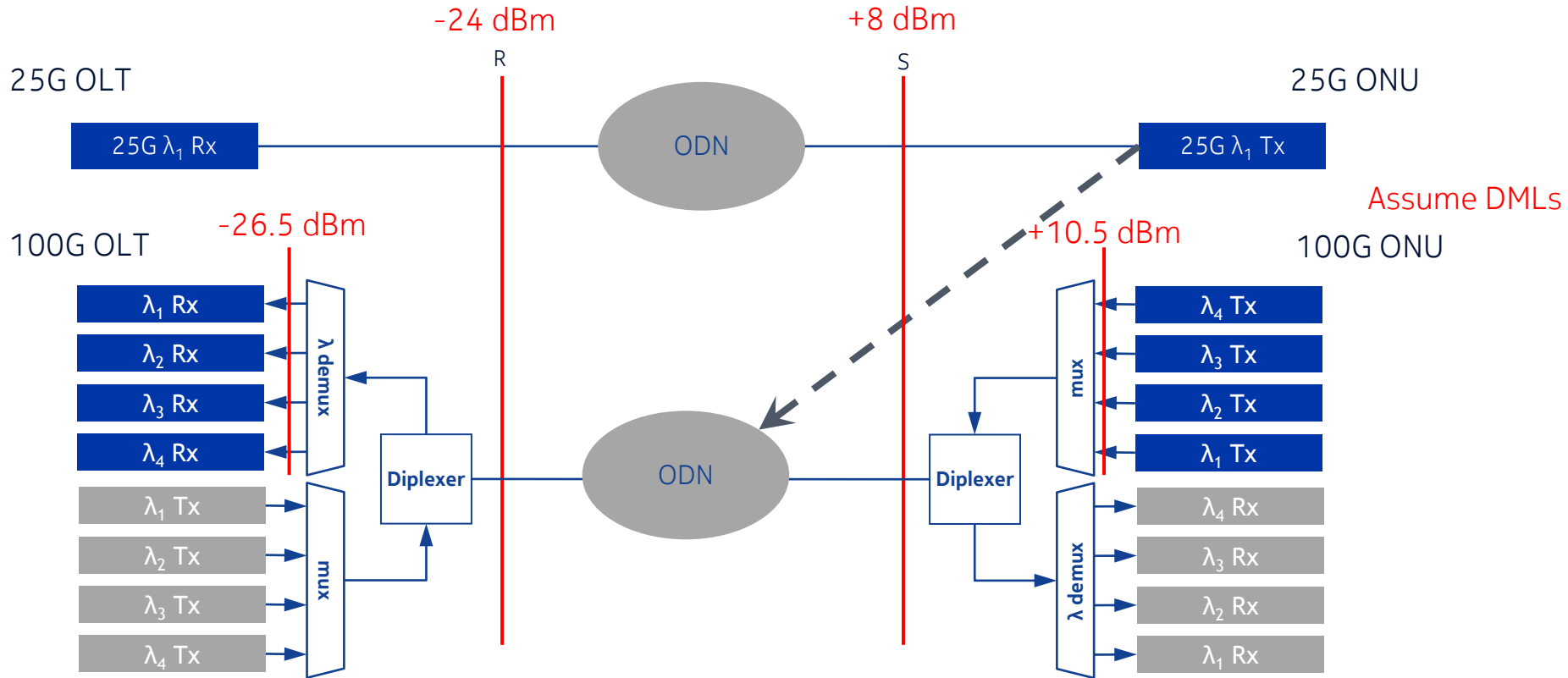
1+3 optical levels: downstream. Different R/S for 25G and 100G EPON



1+3 optical levels: downstream. Different R/S for 25G and 100G EPON

- Assume same (high-yield low-cost) APD receiver performance in the 100G ONU as the 25G ONU.
- The 100G ONU sensitivity is 2.5 dB worse due to demux insertion loss. This requires 2.5 dB more launch power from the 100G OLT. This creates a potential overload problem with the 25G ONUs
- Options to accommodate:
 - a) Change the ODN min loss from 15 dB to 17.5 dB to eliminate 25G ONU overload. But that would violate our Task Force objectives. And what if there are already some 15 dB path loss EPON ODNs out there?
 - b) The 25G OLT transmitters (in the new 100G line card) must have a tighter min/max launch power. This is probably not technically feasible when adding in mux insertion loss variability.
 - c) The original 25G ONUs have to support 2.5 dB higher overload levels to be future-ready for 100G. Is this technically feasible for 10G and 25G APD receivers? T.b.d.
 - d) Upon installation of 25G EPON ONUs, measure ODN loss, and put a pad in front of all 25G EPON ONUs that have measured $< X$ dB ODN loss, the value of X is t.b.d.
- Options (a) and (b) are not recommended. Options (c) or (d) need to be validated.

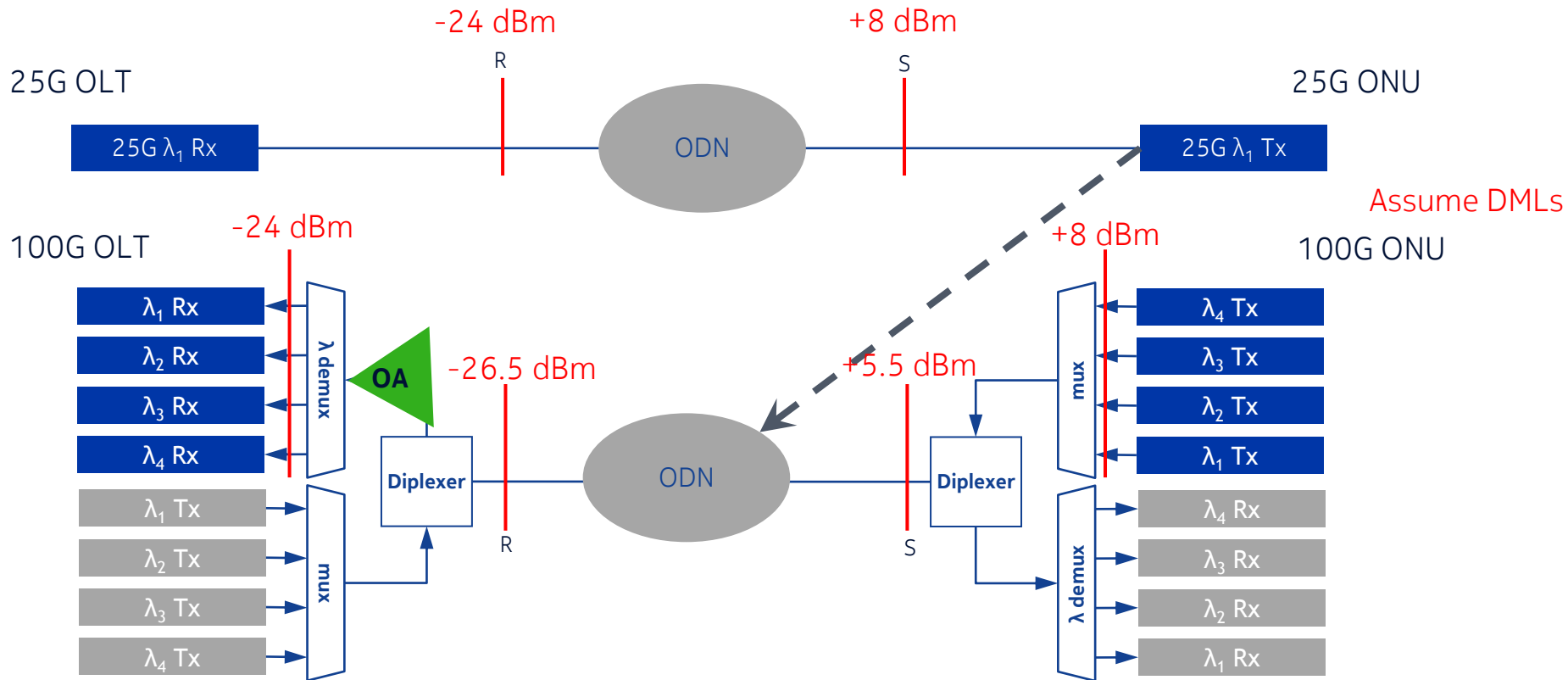
1+3 optical levels: upstream. Maintain same R/S for 25G and 100G EPON



1+3 optical levels: upstream. Maintain same R/S for 25G and 100G EPON: Not recommended

- Maintain the same 100G OLT sensitivity to support existing 25G ONU transmitters.
- To launch at the same optical levels as 25G ONUs, 100G ONU transmitters will probably require optical post-amplification to overcome mux losses. Either
 - Each Tx needs a post amp to launch +10.5 dBm into the mux. Or
 - A common post-amp after the mux
- The OLT may also require a pre-amp to attain -26.5 dBm
- Requiring optical amplification at both the ONU and OLT is probably not a cost-optimized architecture for 100G EPON. An optimal architecture would be to put all OA into an OLT pre-amp.

1+3 optical levels: upstream. Different R/S for 25G and 100G EPON



1+3 optical levels: upstream. Different R/S for 25G and 100G EPON

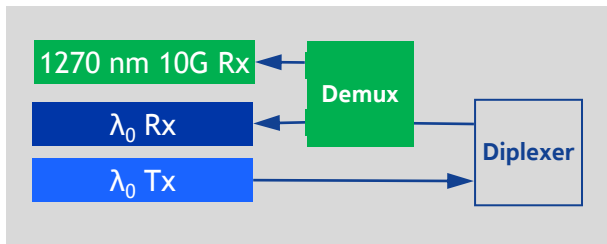
- To overall cost-optimize 100G, put all the improvement at the OLT side via optical preamp, and no post-amps in the 100G ONU.
- **Caveats, to be validated:**
 - The 1+3 100G OLT receiver needs to support a wider dynamic range, because the 25G ONUs are transmitting 2.5 dB hotter than the 100G ONUs
 - It is not clear that we could obtain the required sensitivity with an SOA preamp. We might need an EDFA preamp. In which case we would need all upstream wavelengths, including 25G upstream, in the C-band.
- 1+4: it can also optimize 100G EPON with an OLT preamp, but without
 - requiring wider dynamic range
 - requiring 25G wavelengths in the C-band (if EDFA required)

1+3 and 1+4 OLT optical module architectures

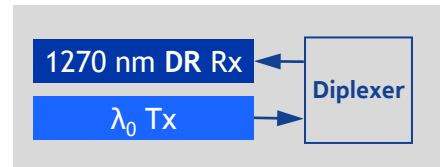
25G OLT optical module architecture: WDM and TDM co-existence with 10G EPON

Case 1: WDM co-existence

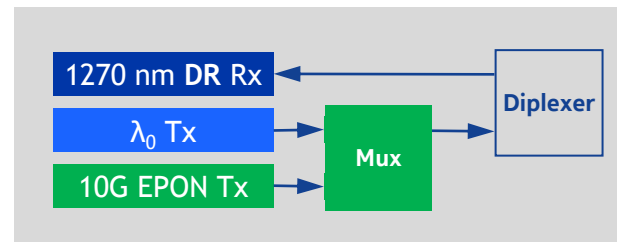
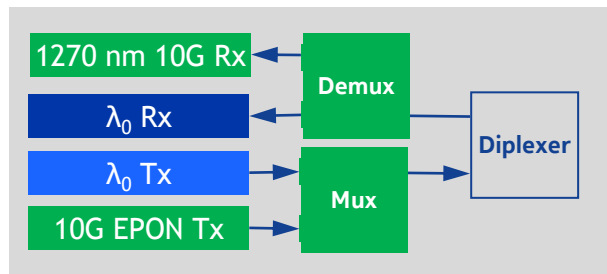
Support 25/10 and 25/25 ONUs



Case 2: TDM co-existence



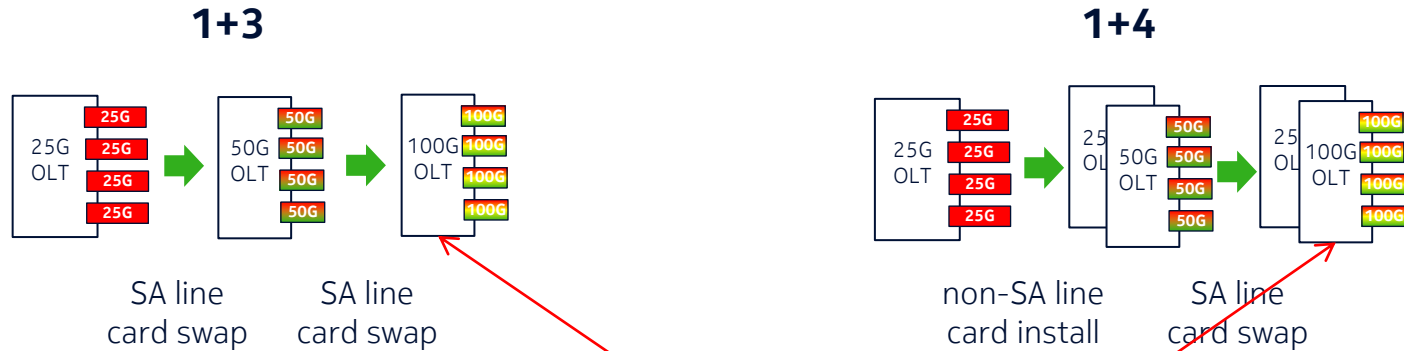
Support 25/10, 25/25 and 10/10 ONUs



- TDM co-existence has cleaner 25G OLT optics
- Both WDM and TDM co-existence with 10G EPON will impact 100G OLT optics...

OLT upgrade paths, NG-EPON only

Either WDM or TDM co-existence can be supported

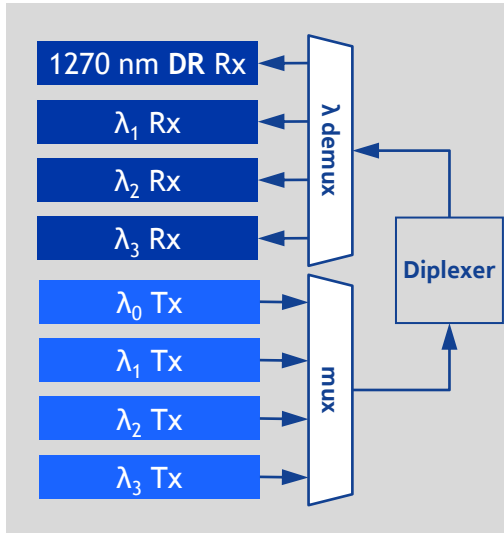


Compare 100G OLT optics, 1+3 vs. 1+4

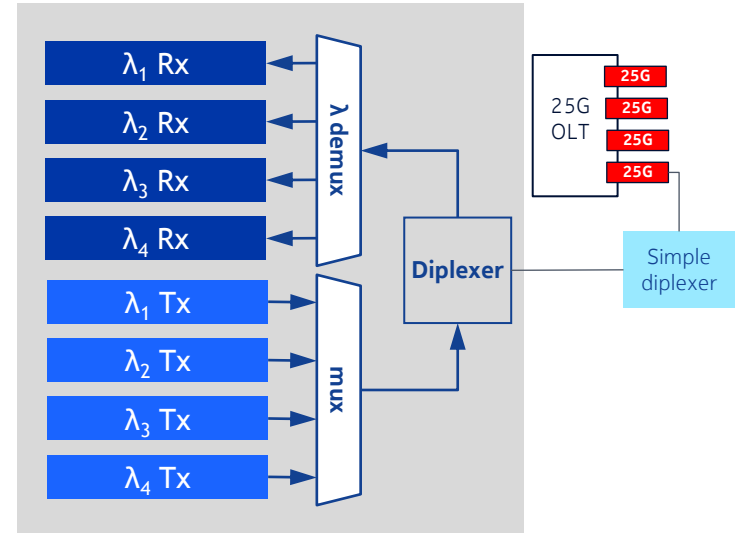
100G OLT optical module architecture, supporting 25/10 and 25/25 ONUs

Case 1: 802.3ca specifies TDM co-existence with 10G EPON

1+3



1+4

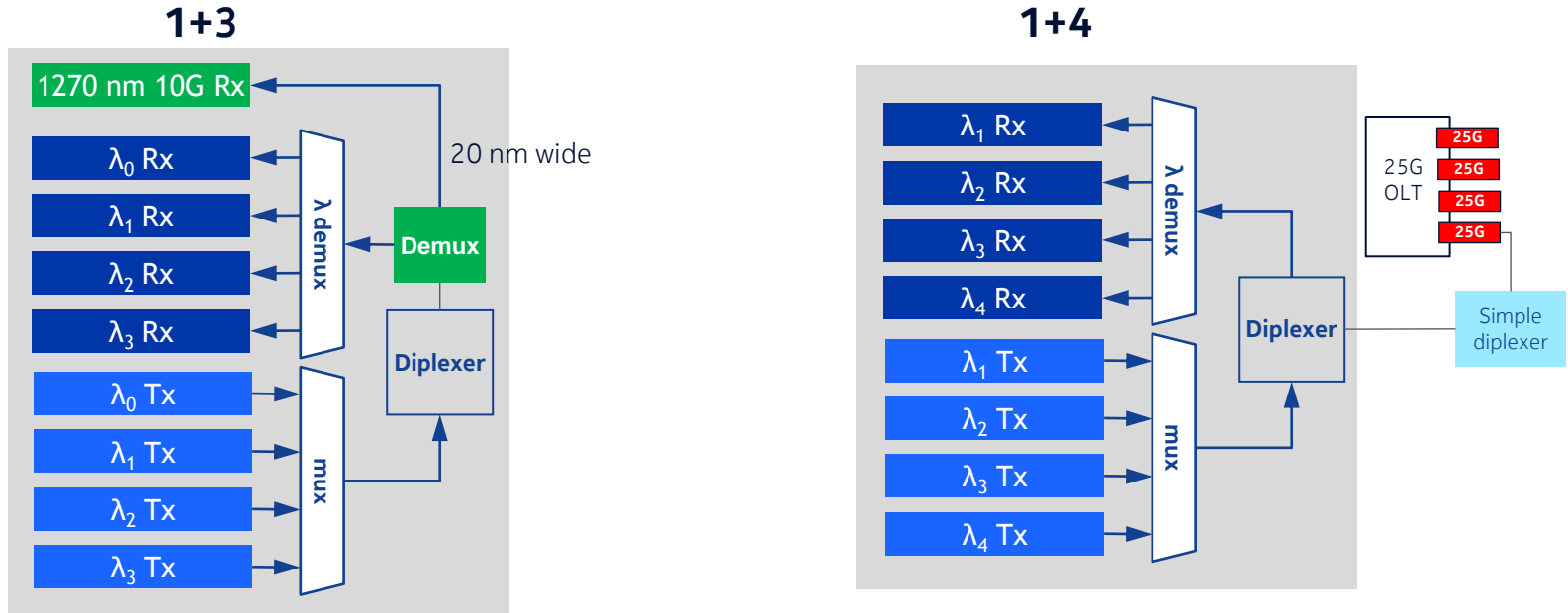


- Same optics
- 1+3 must support a dual rate receiver on λ_0

DR=dual rate

100G OLT optical module architecture, supporting 25/10 and 25/25 ONUs

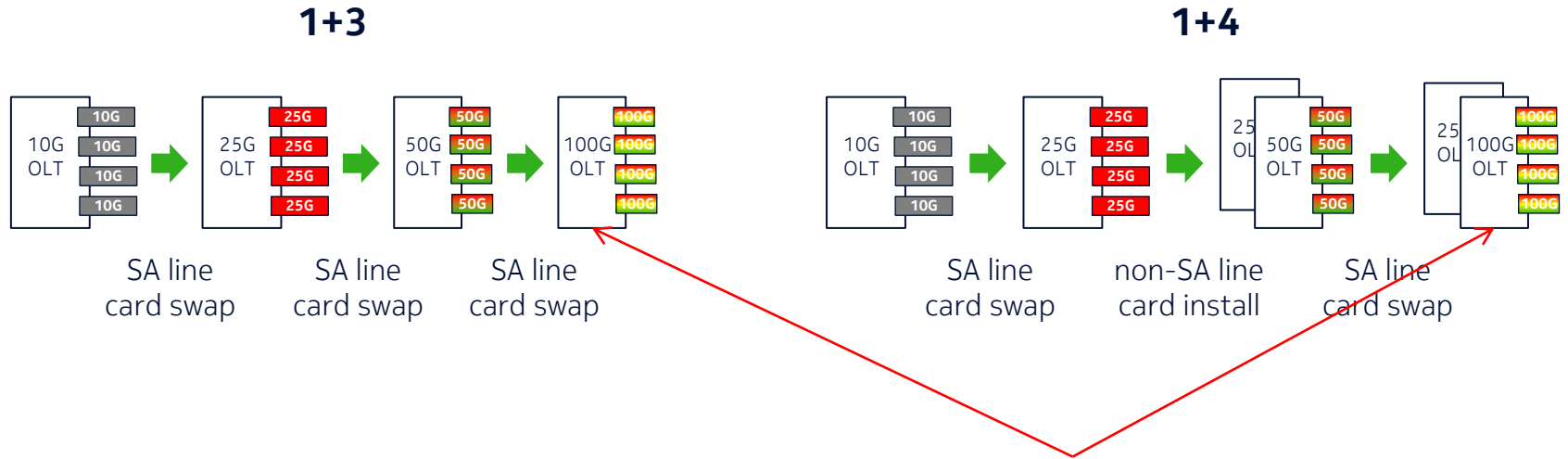
Case 2: 802.3ca specifies WDM co-existence with 10G EPON



- 1+4 has cleaner 100G OLT optics
- Because with WDM co-existence, 1+3 must carry forward 10G upstream

OLT upgrade paths, with 10G EPON co-existence: Case A: Swap out the 10G EPON line card.

Either WDM or TDM co-existence can be supported

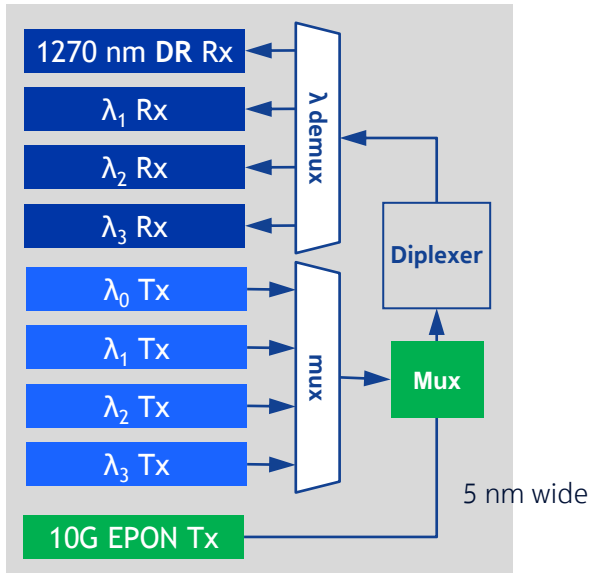


Compare 100G OLT optics, 1+3 vs. 1+4

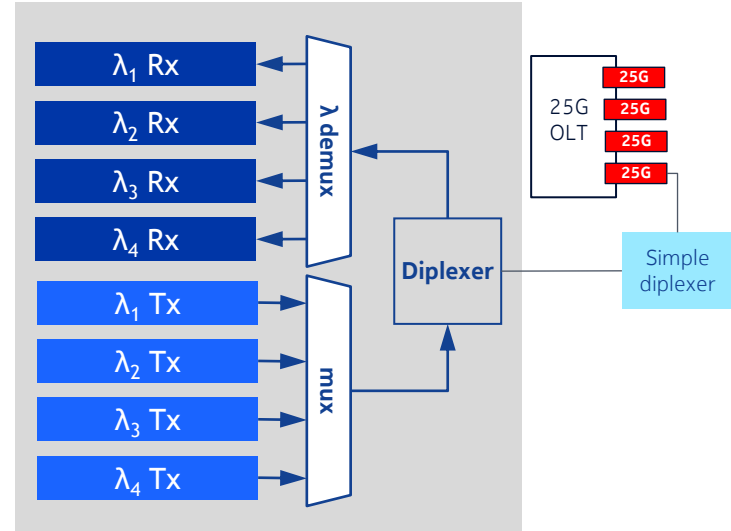
100G OLT optical module architecture, supporting 25/10 and 10G EPON ONUs

Case A, TDM co-existence with 10G EPON

1+3



1+4



- 1+4 has cleaner 100G OLT optics
- 1+3 must carry forward 10G EPON Tx

DR=dual rate

100G OLT optical module architecture, supporting 25/10 and 10G EPON ONUs

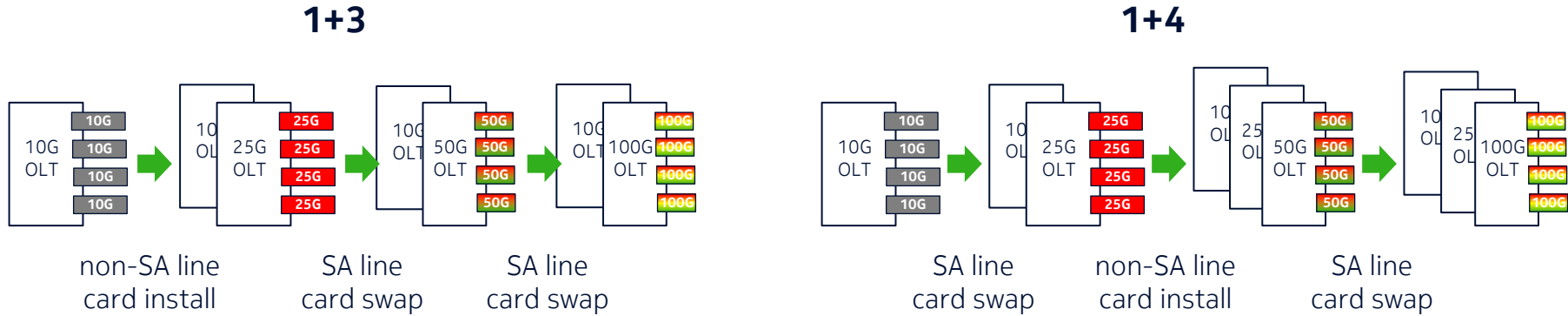
Case A, WDM co-existence with 10G EPON



- 1+4 has cleaner 100G OLT optics
- 1+3 must carry forward 10G EPON Tx and Rx

OLT upgrade paths, with 10G EPON co-existence: leave 10G EPON line card

Case B: Leave 10G EPON line card in place.



- This is not a valid path! 25/10 ONUs and 10/10 ONUs on the same ODN cannot be served by separate line cards. They share the same 10G upstream channel which must be controlled by a single MAC.

SA=service affecting

Conclusions

1. Do not require the same S/R optical levels for 25G and 100G EPON due to 100G mux/demux insertion losses
2. 1+3 forces cross-gen optical level constraints on 100G EPON. The best options to mitigate are:
 - a. Higher overload (higher dynamic range) for the 25G ONU receiver, (or installing pads on some, but not all, 25G ONUs), and
 - b. Higher overload (higher dynamic range) for the 100G OLT pre-amp receiver
3. If an EDFA preamp is required for the 100G OLT preamp, 1+3 would force all upstream wavelengths, including 25G upstream, into the C-band.
4. 1+3 must carry forward 10G EPON OLT optics to 100G EPON.
 - This adds complexity and cost to the 100G OLT optics and increases the risk that it may not fit into a practical pluggable form factor.

Not saying that 1+3 can't be done, but before deciding, these technical issues (2a, 2b, 3 and 4) should be investigated.

NOKIA

Table 75-1—Power budgets

Description	Low Power Budget		Medium Power Budget		High Power Budget		Units
	PRX10	PR10	PRX20	PR20	PRX30	PR30	
Number of fibers	1						–
Nominal downstream line rate	10.3125						GBd
Nominal upstream line rate	1.25	10.3125	1.25	10.3125	1.25	10.3125	GBd
Nominal downstream wavelength	1577						nm
Downstream wavelength tolerance	–2, +3						nm
Nominal upstream wavelength	1310	1270	1310	1270	1310	1270	nm
Upstream wavelength tolerance	±50	±10	±50	±10	±50	±10	nm
Maximum reach ^a	≥10		≥20		≥20		km
Maximum channel insertion loss	20		24		29		dB
Minimum channel insertion loss	5		10		15		dB

^aA compliant system may exceed the maximum reach designed for given power budget as long as optical power budget and other mandatory optical layer specifications are met.

1+3 downstream: what about installing pads on 25G ONU splitter ports?

- Can't install a pad on every 25G ONU splitter port. Some 25G ONUs may already be at 26.5-29 dB ODN loss. So must know the ODN path loss of every 25G ONU, and only install a pad to splitter ports corresponding to <X dB loss.
- In this way you are essentially modifying an existing ODN to reduce its min/max ODN loss (option 2c).
- You can't argue that because you have a potential overload on one ONU that you don't have to worry about max loss on another ONU on the same ODN.
 - Our objectives state we must meet the power budgets of 10G EPON. There is a 14 dB dynamic range in ODN loss specified.
 - Why that dynamic range is important: the first PON standard, ATM PON in the 1990s, specified 15 dB. It was recognized that in multi-stage splitting, you can have such a wide range. This has been carried forward. And not without reason: many operators engage in multistage splitting.
- There are operational issues associated with the deployment of the pads. Some operators want to avoid the costs of splitter cabinets (and associated rights of way) and connectorized splitters—they want the lower opex from hard-wired (spliced) splitters that are often buried. These operators would be forced to place the attenuators at the customer premises. Which will be costly. This issue was described in section 4.7 of the NG-EPON ad hoc TR.