SUMITOMO ELECTRIC

Consideration on optical crosstalk and required wavelength block filter for receiver

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Introduction

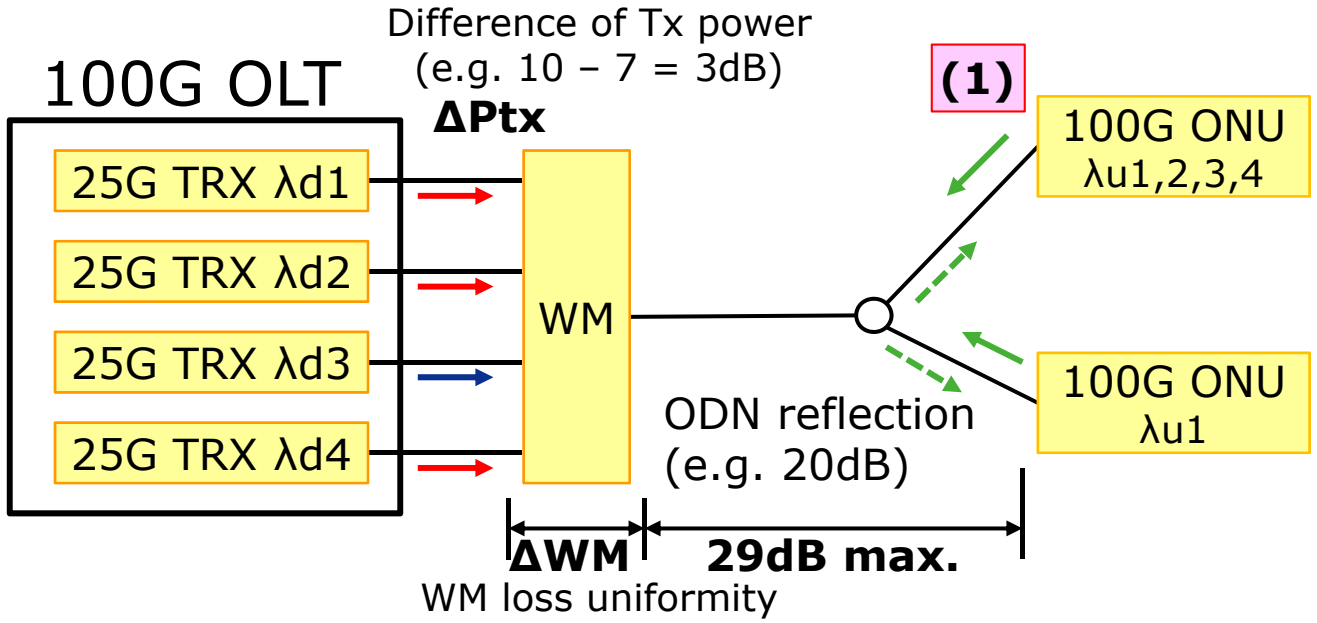
- To decide wavelength allocation, required wavelength block filter for receiver and its feasibility need to be clarified, especially in the case of 800GHz grid channel spacing.

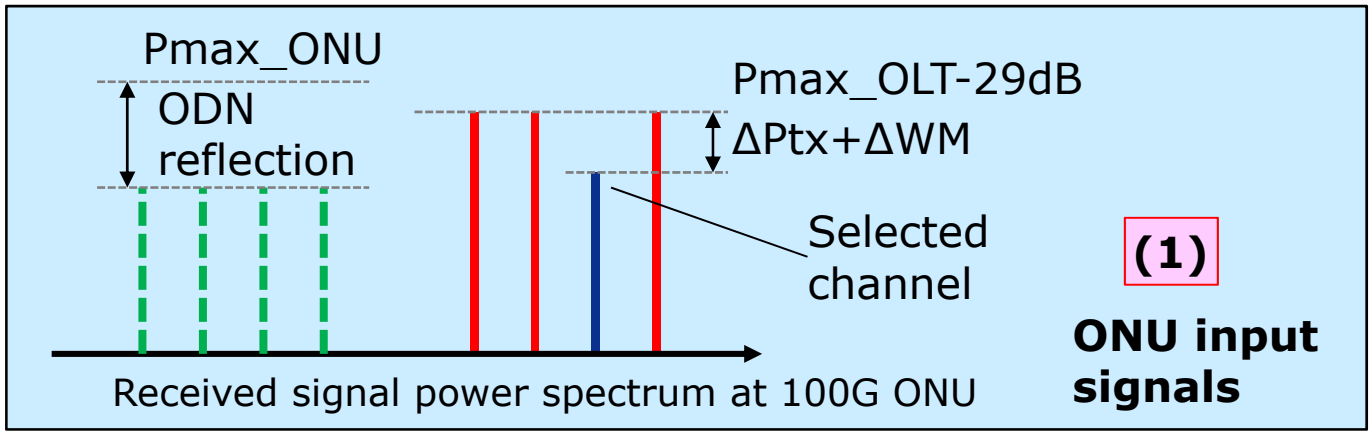
- Required isolation of wavelength block filter for upstream Rx is severer than that of downstream Rx, because OUNs are placed in different locations which have different ODN loss.

- We estimate the required isolation and show its feasibility in the case of 800GHz LAN-WDM.
  - ✓ Model of optical crosstalk for downstream and upstream
  - ✓ Estimation of optical crosstalk penalty
  - ✓ Estimation of the required WDM filter isolation
  - ✓ WDM filter isolation example

Model of downstream optical crosstalk

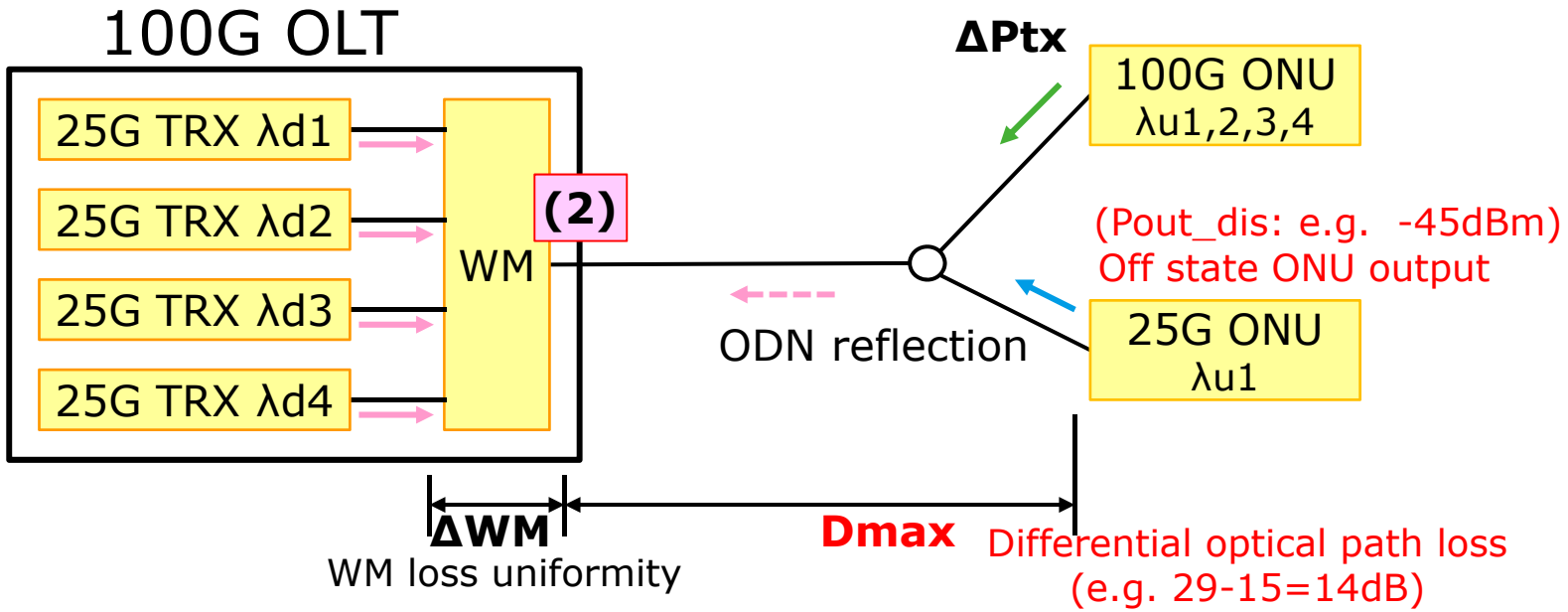
- Optical crosstalk sources of downstream signal
  - ✓ OLT downstream signals from other lanes
  - ✓ Reflected ONU upstream signals from ODN

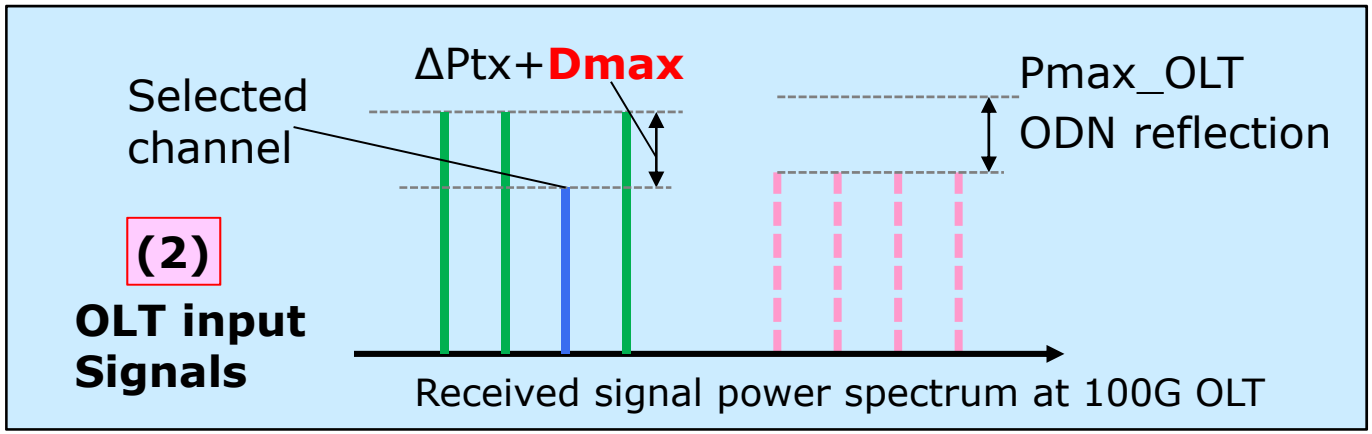




Model of upstream optical crosstalk

- Optical crosstalk sources of upstream signal
  - ✓ Need to consider differential optical path loss (Optical path loss depends on ONU location)
  - ✓ Need to consider off state ONU optical output power





Rough estimation of optical crosstalk penalty

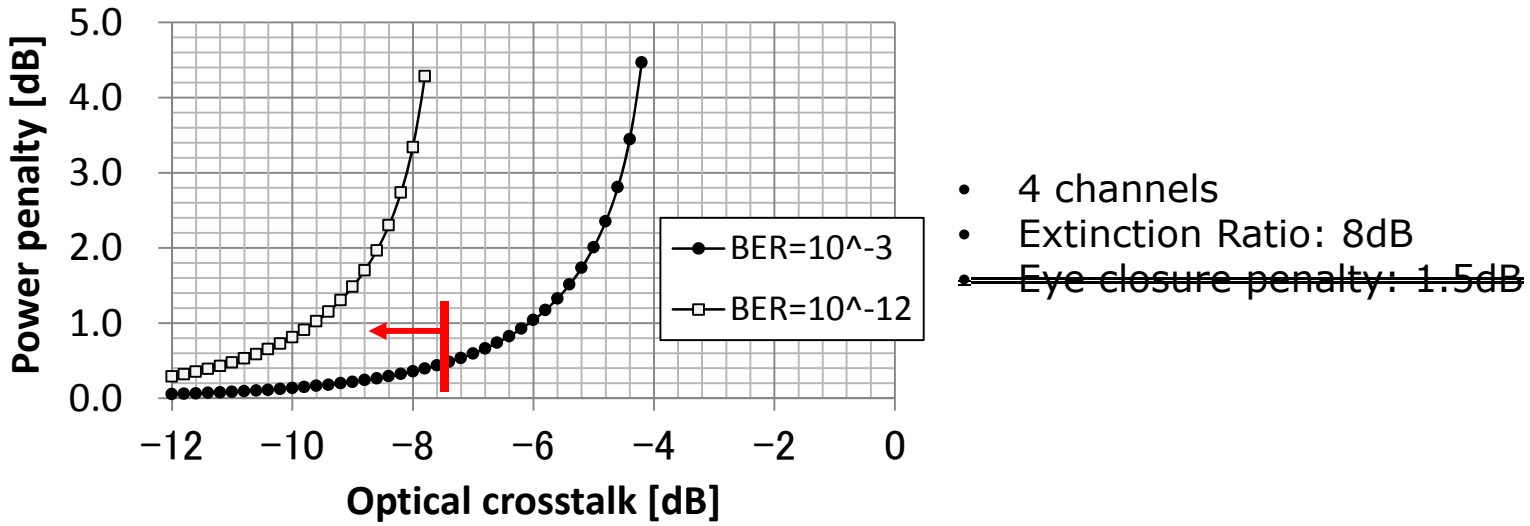
- Optical crosstalk power penalty (Pc) can be estimated using following equation

$$Pc\ [dB] = -5\log10[1-10^{(2Cc/10)}/(k-1)\times Q^2\times((r+1)/(r-1))^2]$$

Where
Cc :Optical crosstalk [dB]
Q: $Q=\sqrt{2}\ \mathrm{erfc}^{-1}(2\times BER)$
k: number of channels
r: Linear extinction ratio taking eye closure penalty into account

Reference: ITU-T G.Sup.39

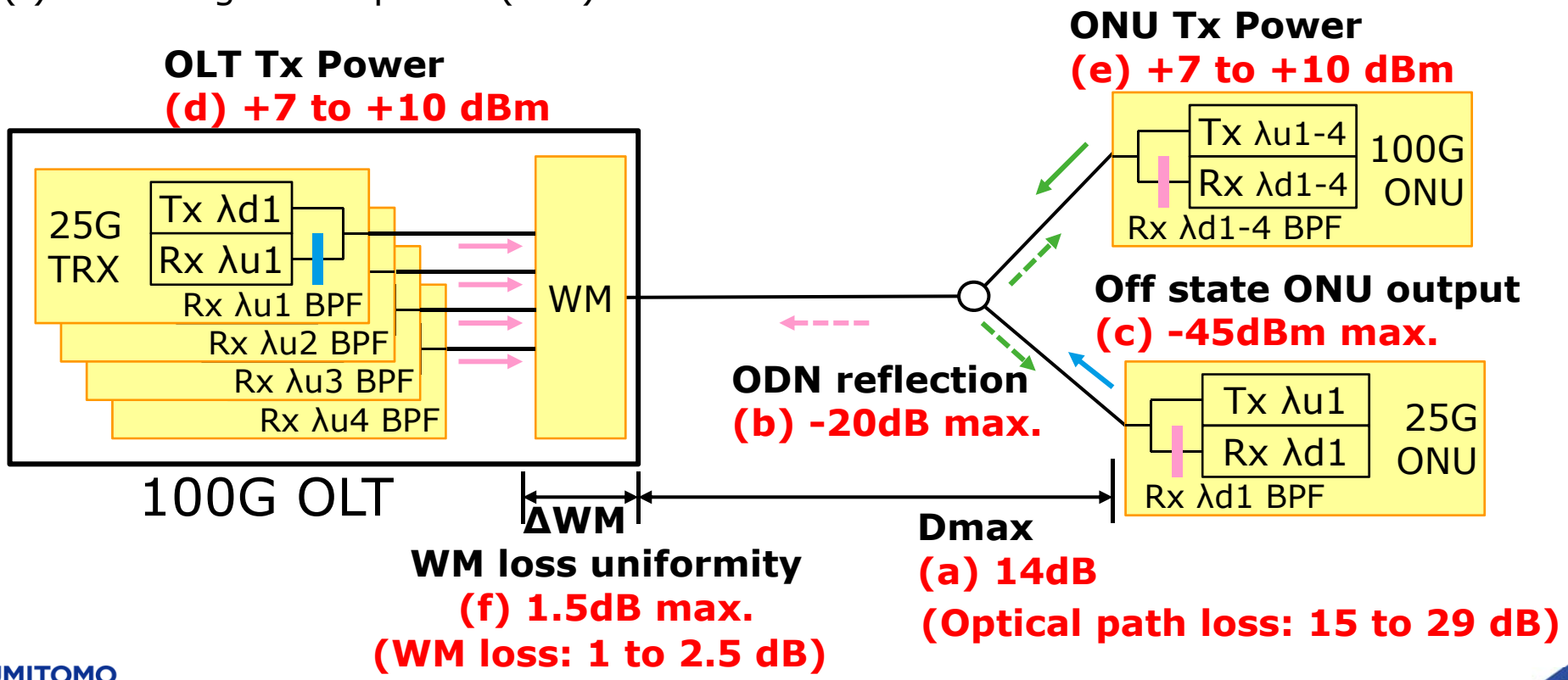
- Optical crosstalk <-7.5dB is preferable to achieve Power penalty<0.5dB @BER=10^{-3}



Optical power penalty vs optical crosstalk

Required isolation of wavelength block filter (Specification assumption for calculation)

- Specification assumption for calculation
  - ✓ (a) Optical path loss: 15 to 29dB, same as 10G-EPON
  - ✓ (b) ODN reflection: -20dB, same as 10G-EPON
  - ✓ (c) Off state ONU output: -45dBm, same as 10G-EPON
  - ✓ (d) OLT Tx power each lanes: +7 to +10dBm, both 25G lane and 100G lanes
  - ✓ (e) ONU Tx power each lanes:+7 to +10dBm, both 25G lane and 100G lanes
  - ✓ (f) Wavelength Multiplexer (WM) loss: 1 to 2.5dB



Required isolation of wavelength block filter for ONU (Worst case estimation)

- Required isolation for ONU
  - ✓ Adjacent channel isolation: >18dB
  - ✓ Non adjacent channel isolation: >35dB
  - ✓ These isolations are commonly doable in the case of 800GHz LAN-WDM filter. 100GBASE-LR4 filter spec is even severer than these value.

	Optical source	λ	Tx out [dBm]	ODN loss [dB]	WM Loss [dB]	Rx filter isolation [dB]	Rx input [dBm]
(1)	**OLT Tx Signal channel**	λd2	+7 (Tx Power min)	29 (Loss max)	2.5 (Loss max)	0.5 **Passband loss**	**-25**
(2)	OLT Tx Other channel	λd1	+10	29 (Loss max)	1 (Loss min)	18 **Adjacent channels**	-38 (Crosstalk value)
		λd3	+10	29	1	18	-38
		λd4	+10	29	1	35	-55
(3)	ONU Tx reflection	λu1	+10	20 (ODN reflection)	-	35 **Non adjacent channels**	-45
		λu2	+10	20	-	35	-45
		λu3	+10	20	-	35	-45
		λu4	+10	20	-	35	-45
						Total crosstalk: Σ(2)+Σ(3) – (1)	**-7.6 dB**

Tx Power Max.

Target: <-7.5dB

Required isolation wavelength block filter for OLT (Worst case estimation)

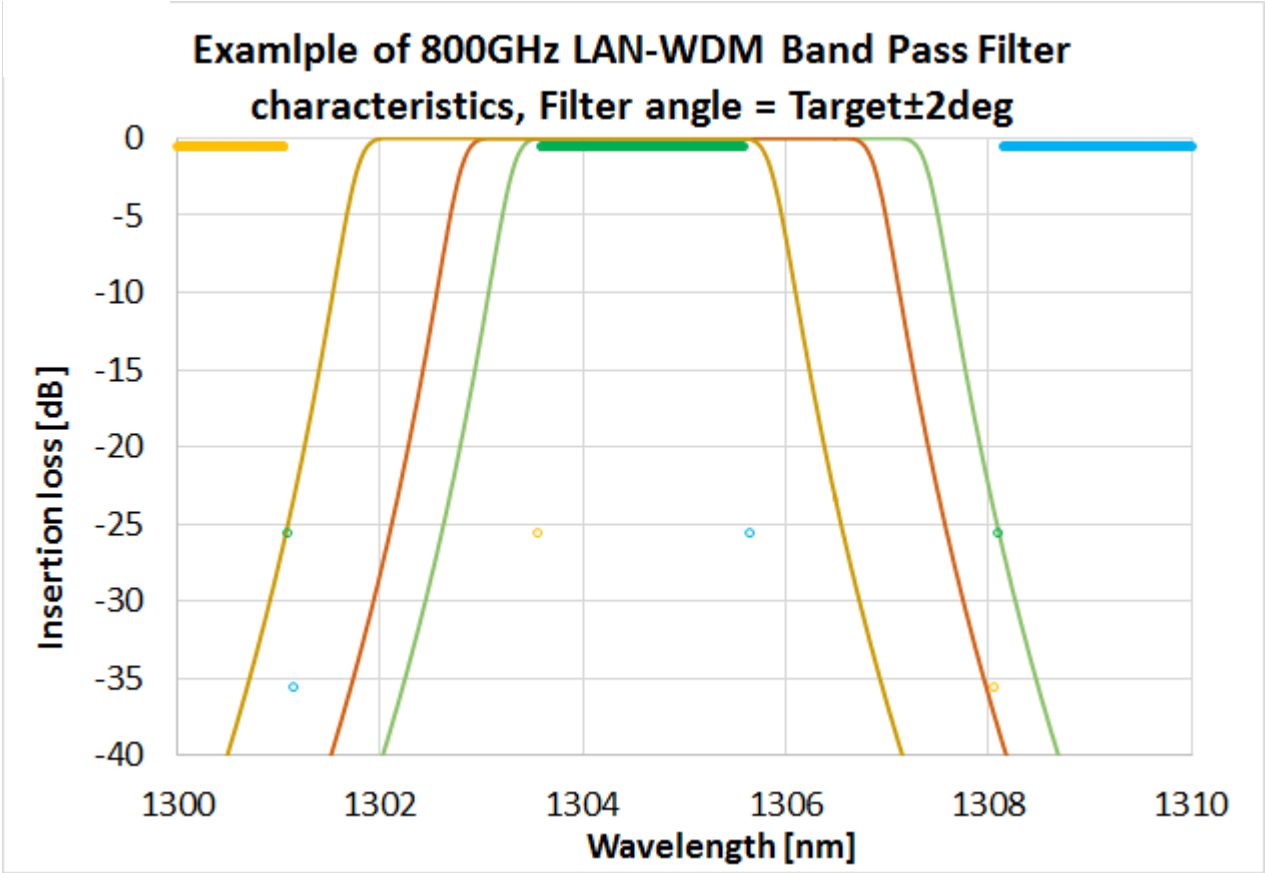
- Required isolation for OLT
  - ✓ Adjacent channel isolation: >31dB
  - ✓ Non adjacent channel isolation: >37dB
  - ✓ These isolations are doable in the case of 800GHz LAN-WDM filter, but need tighter spec than 100GBASE-LR4 filter.

	Optical source	λ	Tx out [dBm]	ODN loss [dB]	WM Loss [dB]	Rx filter isolation [dB]	Rx input [dBm]
(1)	**ONU Tx Signal channel**	λu2	+7 (Tx Power min)	29 (Loss max)	2.5 (Loss max)	0.5 (Passband loss)	**-25**
(2)	Off state output ONU Tx (N=32)		-45 (x32)	15 (Loss min)	2.5 (Loss max)	0.5 (Passband loss)	-48
(3)	ONU Tx Other channel	λu1	+10	15 (Loss min)	1 (Loss min)	31 (Adjacent channels)	-37
		λu3	+10	15	1	31	-37
		λu4	+10	15	1	37 (Non adjacent channels)	-43 (Crosstalk value)
(4)	OLT Tx reflection	λd1	+10 (Tx Power Max.)	20 (ODN reflection)	1 (Loss min)	37 (Non adjacent channels)	-48 (Crosstalk value)
		λd2	+10	20	1	37	-48
		λd3	+10	20	1	37	-48
		λd4	+10	20	1	37	-48
				Total crosstalk: (2)+Σ(3)+Σ(4) – (1)			**-7.5 dB**

Target: <-7.5dB

Example of 800GHz LAN-WDM filter design (Simulation)

- 800GHz LAN-WDM filters are commonly used in 100GbE optics
  - ✓ Passband loss: <0.5dB, (0.3dB typical), almost same as CWDM grid filter.
  - ✓ Temperature dependency: Δ0.25nm for -40 to 85deg.C
  - ✓ Filter angle need to be controlled ±2deg for ONU and ±1.5deg for OLT, and these angles can be controlled under collimated optical coupling system.



Summary

- Allowable optical crosstalk of 100G-EPON are estimated.
- Required isolations of wavelength block filter for OLT and ONU are estimated.
- 800GHz LAN-WDM grids for 100G-EPON are doable in terms of WDM filter performance
  - ✓ ONU filter specification is looser than 100GBASE-LR4
  - ✓ OLT filter specification is tighter than 100GBASE-LR4.
  - ✓ We show example of 800GHz LAN-WDM filter characteristics

Thank you

Appendix
Revised wavelength allocation example with 800GHz grids 4λ

- This allocation example offers,
- ✓ Lowest cost of 25G-EPON optics
  - Use uncooled DML for US, PR20 is currently available
  - Focusing optical coupling system can be adoptable
  - No need for dispersion management
- ✓ Middle cost of 100G-EPON PR20 optics
  - Based on currently available 25G DML or EML
- ✓ 100G-EPON PR30 optics
  - Based on high power EML such as SOA integrated EML

Candidate Transmitter Devices

		PR20 (25dB)	PR30 (29dB)
100G	DS	EML	High power EML
	US	EML, DML	High power EML
25G	DS	EML	High power EML
	US	DML	Future possibility

Blue; Cooled, Red; Uncooled