Reconsiderations on 50G and 100G EPON

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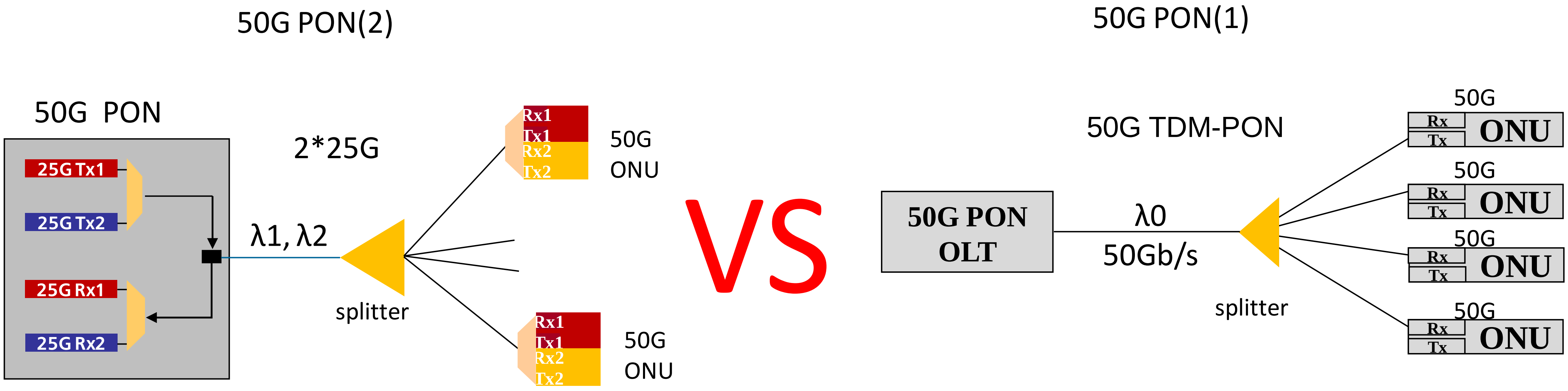
PON evolution in China Market

- Next generation PON after 10Gb/s is expected to satisfy the service requirements around 2025
- From massive deployment point of view, most probably to evolve from 10G platform (OLT) directly to 50G/100G
- TDM PON (EPON and GPON) has been successfully deployed and operated in China for many years mainly for residential broadband access, showing great advantages. Hence we suggest to consider and evaluate the possibility of a single wavelength system with enhanced line rate such as 50Gb/s, when developing next generation PON system

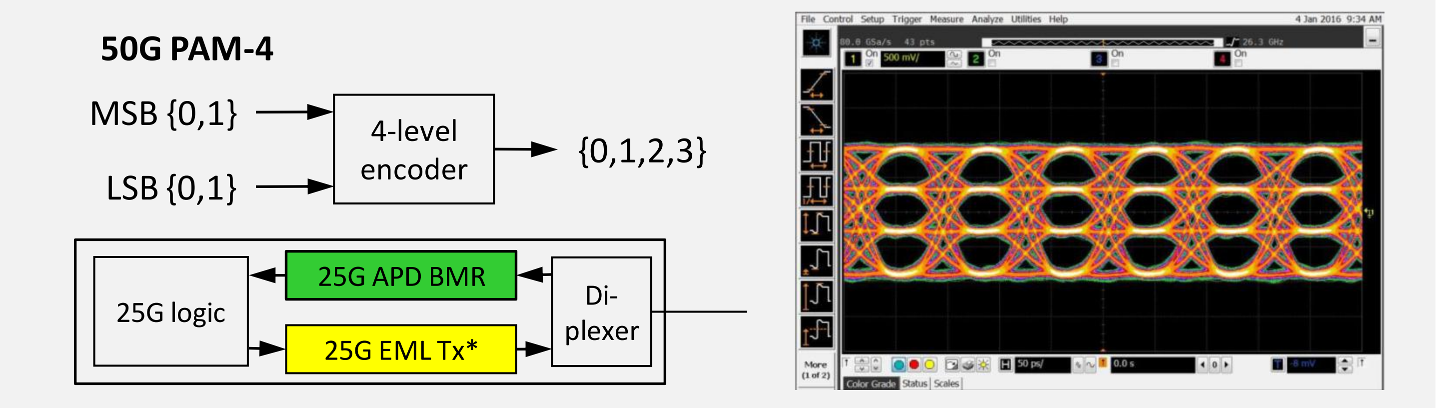
System Architectures for comparison



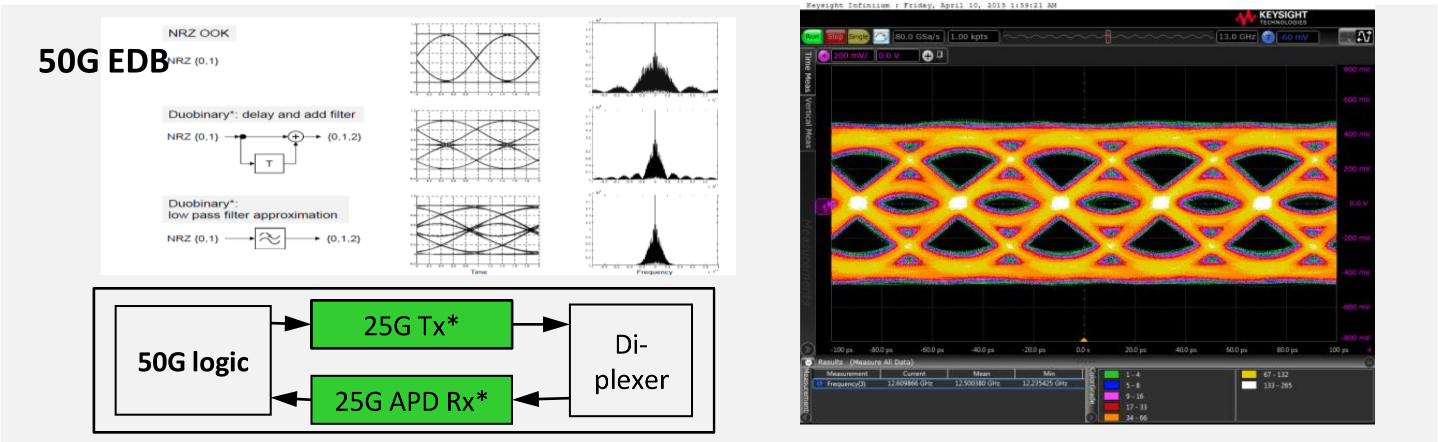
- 50G PON may have two architecture options:
  - 50G TDM-PON (named as 50G PON(1) for communication convenience)
  - 2x25G based (named as 50G PON(2) for communication convenience)
- Correspondingly, 100G PON may have also two architecture options:
  - 4x25G based 100G PON (named as 100G PON(4) for communication convenience)
  - 2x50G based (named as 100G PON(2) for communication convenience)

Candidate technologies for 50Gbps Tx/Rx(1)

Reuse the industry chain in 200GbE and 400GbE



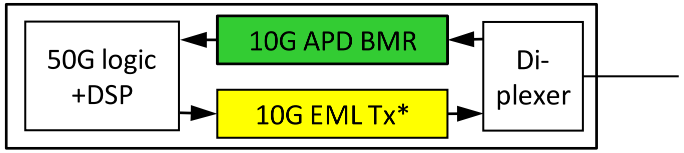
Reuse existing 25G optics in data center

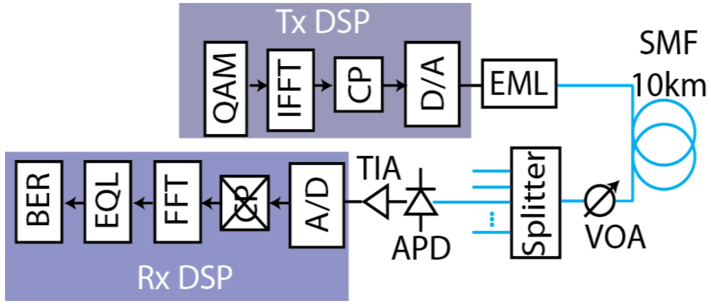


There are several candidate technologies for 50Gb/s per wavelength, but utilizing the existing 25G optics assisted with advanced modulation seems the most promising technologies

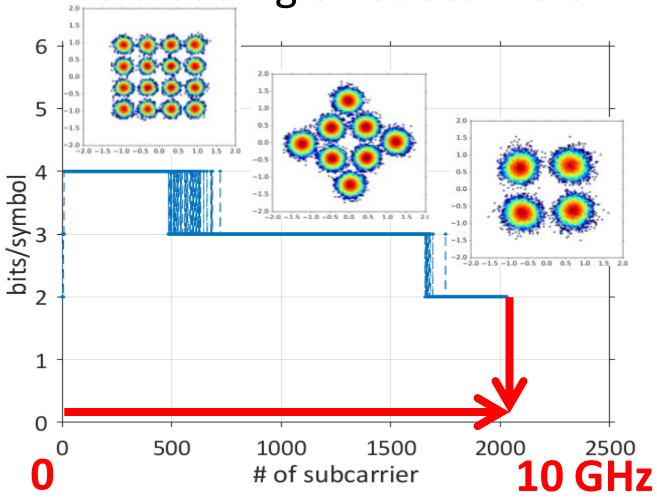
Candidate technologies for 50Gbps Tx/Rx(2)

50G Discrete Multitone Modulation using 10G optics

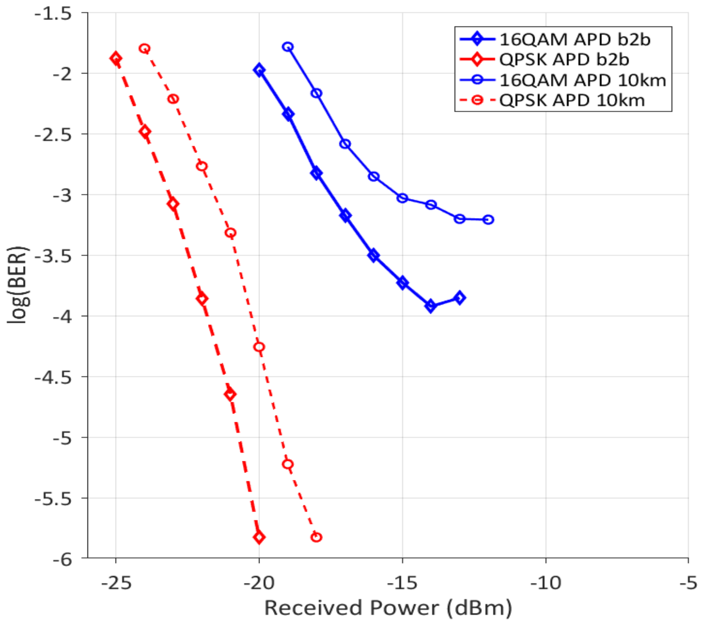




bit loading on subcarriers



QPSK and QAM bit loading of 10G spectrum using DSP at Tx and Rx

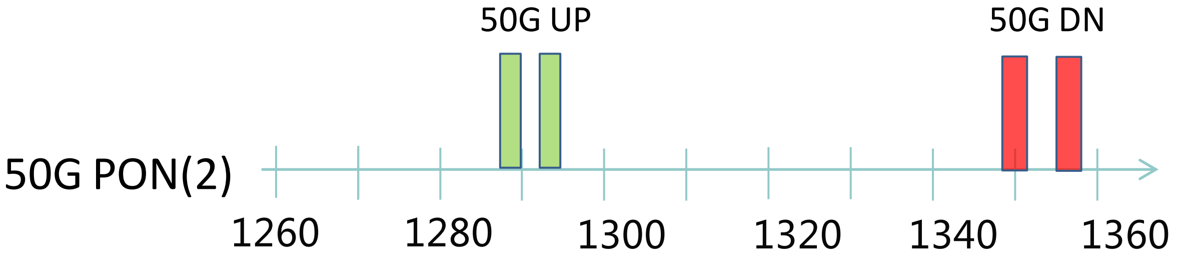


Receiver sensitivity b2b at BER=10^{-3} : QPSK @ 19.69 Gbps =-21.5 dBm; 16-QAM @ 39.38 Gbps =-15.5 dBm

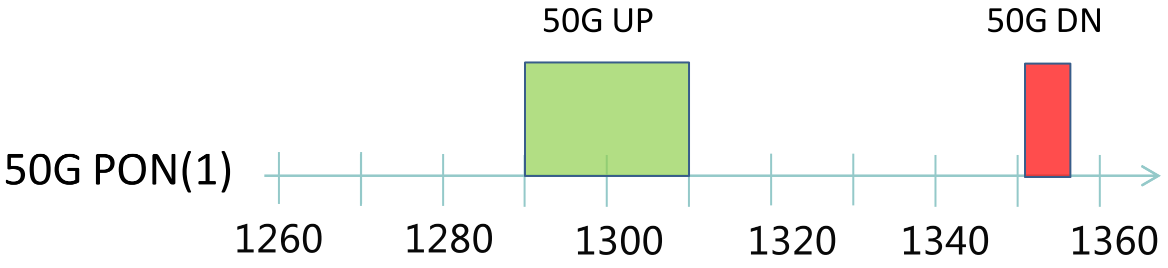
50G PON Wavelength plan comparison

- From wavelength aspect, upstream of 50G PON is the emphasis in order to insure low cost ONU.
- Downstream wavelength of 50G PON is expected to be cooled and narrow band, and is much easier to get appropriate wavelength resource.

25Gb/s per lane



50Gb/s per lane



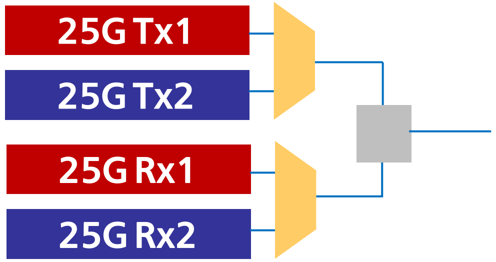
(Note: the value of the wavelengths are just examples)

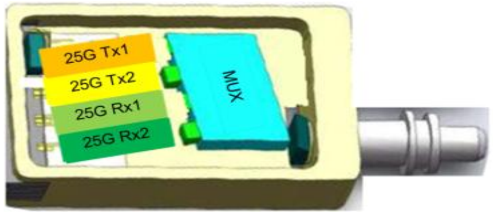
- Compared with 50G PON(2), wavelength demand and constraints of 50G PON(1) are less. And it will reduce complexity of wavelength allocation, and may loosen the channel width of upstream (even uncooled is possible).

Comparison of 50G PON(1) and 50G PON(2)

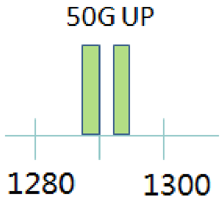
Take 50Gb/s PAM4(25GBaud) as an example (Re-using 200GE and 400GE industry chain)

2*25G

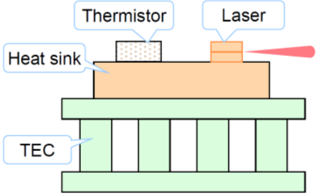




2~3nm channel width

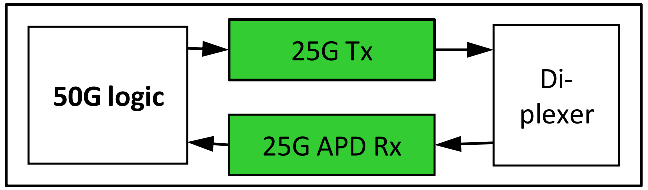


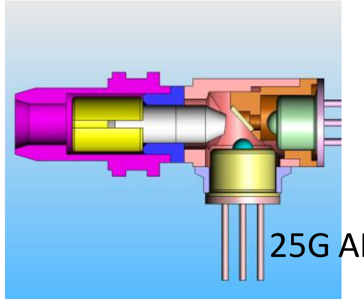
cooled



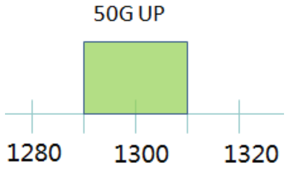
VS

1*50G



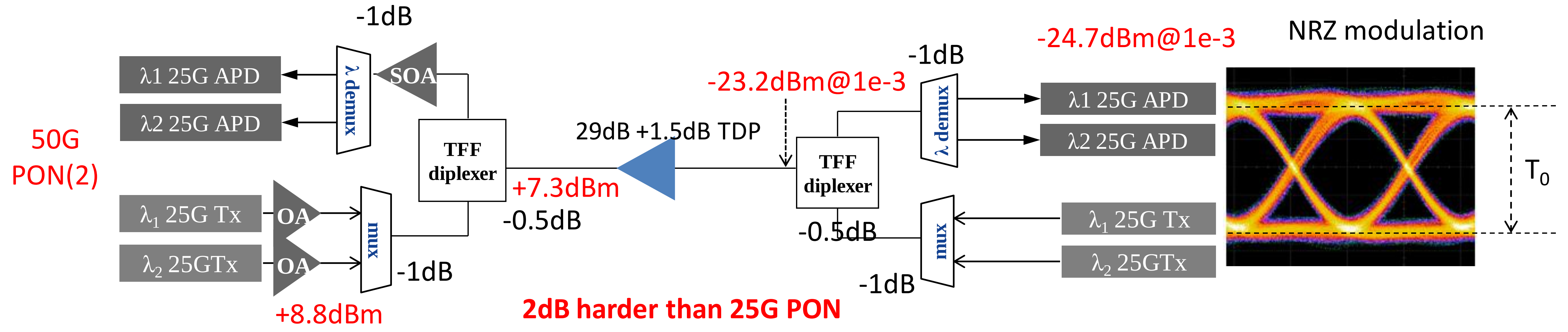


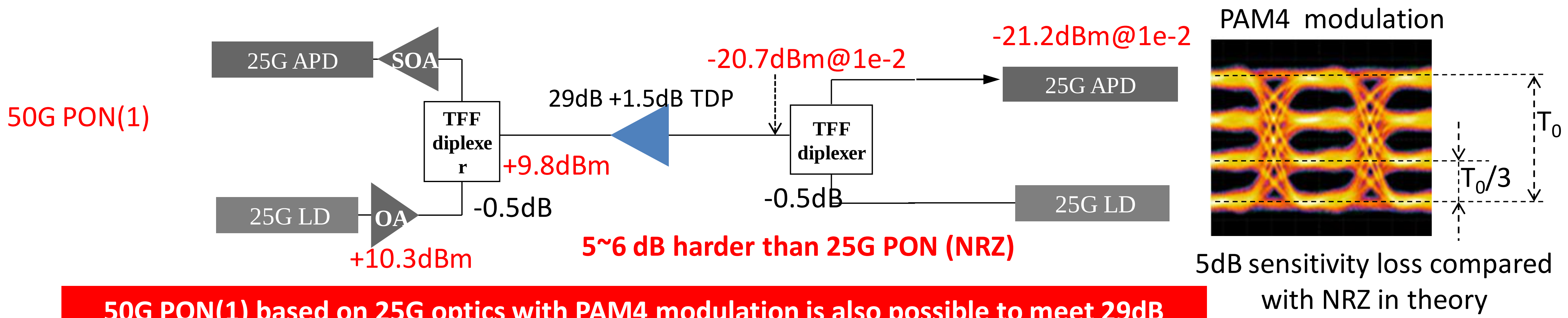
20nm channel width



uncooled

50G PON(1) vs 50G PON(2) Power budget analysis





50G PON(1) based on 25G optics with PAM4 modulation is also possible to meet 29dB power budget with optical amplifier and enhanced FEC.

Industry Chain in Ethernet PtP Network

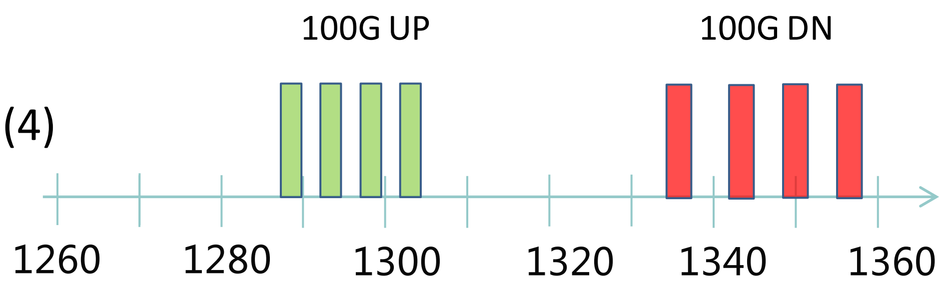
		10GbE	25GbE	40GbE	50GbE	100GbE	200GbE	400GbE
500m	10G	-	-	-	-	-	-	-
	25G	-	-	-	-	-	-	-
	50G	-	-	-	-	-	4X50G	-
	100G	-	-	-	-	1X100G	-	4X100G
2km	10G	-	-	-	-	-	-	-
	25G	-	-	-	-	-	-	-
	40G	-	-	1X40G	-	-	-	-
	50G	-	-	-	1X50G	-	4X50G	8X50G
	100G	-	-	-	-	-		
10km	10G	1X10G	-	4X10G	-	-	-	-
	25G	-	1X25G	-	-	4X25G	-	-
	50G	-	-	-	1X50G	-	4X50G	8X50G
	100G	-	-	-	-	-	-	-
40km	10G	1X10G	-	4X10G	-	-	-	-
	25G	-	1X25G	-	-	4X25G	-	-
	50G	-	-	-	-	-	-	-
	100G	-	-	-	-	-	-	-

- More and more Ethernet work are based on 50Gb/s per lane

100G PON(2) vs 100G PON(4) comparison

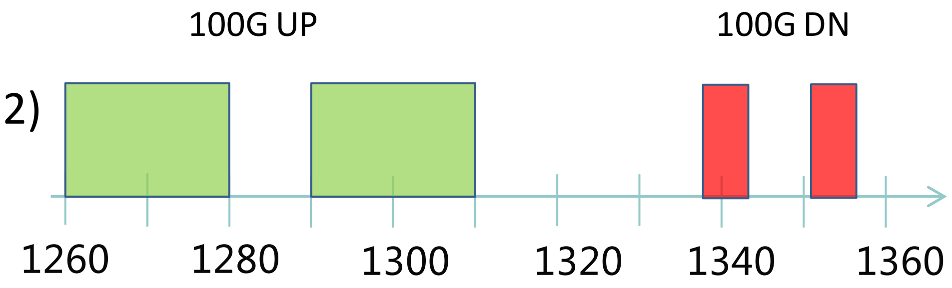
25Gb/s per lane

100G PON(4)



50Gb/s per lane

100G PON(2)



	4* 25G	2*50G
transmitter	**4** 25GEML/DML	**2** 25G EML/DML
Receiver	**4** 25G APD	**2** 25G APD
Cool or uncool	Cooled	Uncooled
Mux/Demux	4 cascaded filters	2 cascaded filters
Modulation Format	NRZ	PAM4
Electronics	25G LDD, TIA	50G PAM encoder and Decoder
Extra required launch Power compared with 25G PON	**4dB**	**7~8dB**
Reusing existing Industry Chain	25GE & 100GE	50GE,200GE, 400GE

There is no clear advantage for 100G PON(4) compared with 100G PON(2), it deserves more study on 50Gb/s single wavelength

Motions

- Motion 1

The task force should analyze and compare the following solutions for 50G PON:

1) Single wavelength TDM-PON with 50Gb/s line rate

2) Two-wavelength TDM/WDM-PON with 25Gb/s line rate per lane

and choose the best one for 50G EPON.

- Motion 2

The task force should analyze and compare the following solutions for 100G PON:

1) Two wavelength TDM/WDM-PON with 50Gb/s line rate per lane

2) Four wavelength TDM/WDM-PON with 25Gb/s line rate per lane

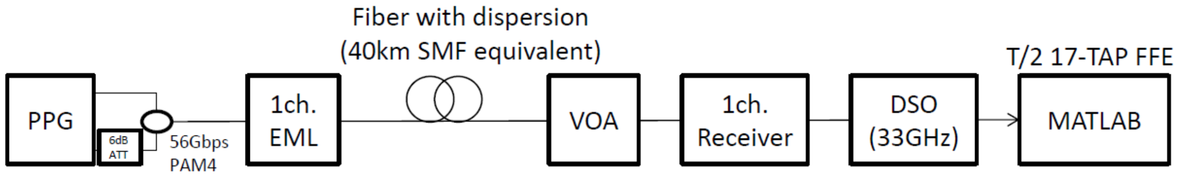
and choose the best one for 100G EPON.

Backup-PAM4 feasibility reference

Optical transmission feasibility for 400GbE extended reach PMD

Evaluation overview and summary of results

1ch. 56Gbps PAM4 optical transmission experiments using different EMLs and an APD/PIN-PD receiver. Dispersion of fiber is set assuming worst-case dispersion for LAN-WDM transmission over 40km SMF.



Tx	Fiber dispersion [ps/nm]	Rx	KP4 (limit=2E-4) Min. receiver sensitivity*1 [dBm]	KP4 (limit=2E-4) CD Penalty [dB]	Stronger FEC(limit=1E-3 *2) Min. receiver sensitivity*1 [dBm]	Stronger FEC(limit=1E-3 *2) CD Penalty [dB]
EML#1 ER=5.6[dB] 1304.3nm(L6)	-203 / 0 / +38	PIN-PD receiver	-18.6	~1.5	-19.4	~0.5
EML#2 ER=5.8[dB] 1308.9nm(L7)	-203 / 0 / +38	APD receiver	-22.8	~1.5	-23.9	~0.5

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* 1 OMAinner, Without WDM-demux, value at zero ps/nm
* 2 tentative BER limit assuming possible FEC(s) stronger than KP4

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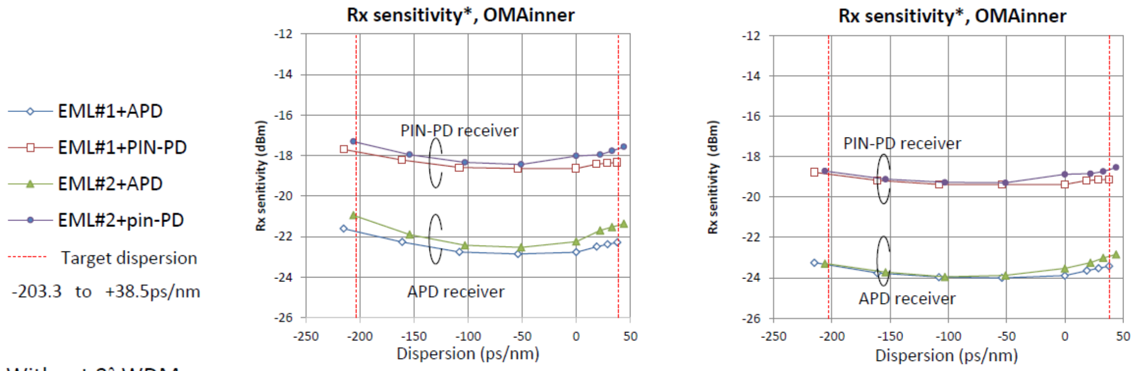
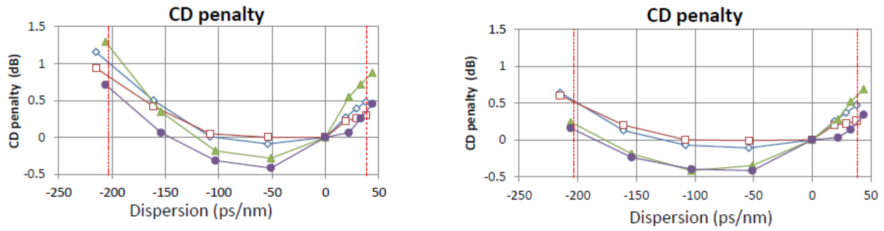
Evaluation results

	KP4 FEC (limit = 2E-4)	Stronger FEC (limit = 1E-3)
Min. Rx sensitivity (EML#1):	-22.8 dBm	-23.9 dBm
Min. Rx sensitivity (EML#2):	- 22.2 dBm	-23.5 dBm
CD penalty :	~ 1.5 dB	~ 0.5 dB



* Without 8λWDM demux loss



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http://www.ieee802.org/3/ad_hoc/ngrates/public/16_05/sone_ecdc_01b_0516.pdf