



Standardization path for 50G/200G/400G ER PMD requirements

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■ Background

There are market needs for

- 50GbE 40km
- 200GbE 40km/80km
- 400GbE 40km/80km

Technically, **50G 40km** and **200G 40km** come earlier.

■ Proposal of this presentation

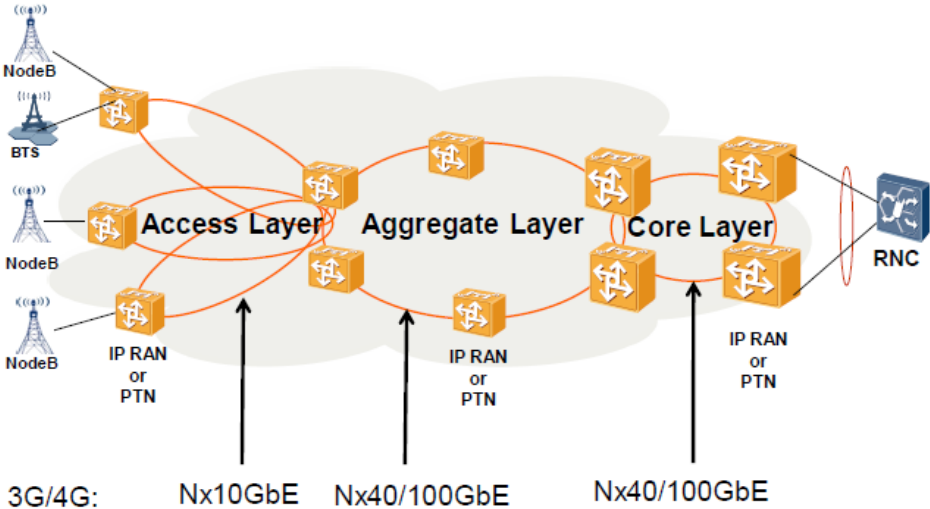
- Among multiple requirements, start their standardization with 50GbE/200GbE 40km reach as the initial step.
- When starting, we should consider the commonality with 400GbE 40km which comes next.

Market need



Urgent needs for multiple rates, 50G, 200G and 400G extended reach PMD for 5G Mobile Backhaul Network

Bandwidth in 5G Mobile Backhaul Network



From [wang_ecdc_01_0916](#)

Required reach
40km and 80km in aggregation layer

Required rate
50G, 100G, 200G, 400G

Review: Technical approach for ER PMD



■ Optical transmission performance evaluation

(sone_ecdc_01a_0716)

Reach extension of 400GBase-LR8 can be achieved with some of the following approaches

- 1) APD-receiver,
- 2) higher power EML
- 3) Stronger FEC

■ FEC options for extended reach 50G/200G/400GbE

(wang_ecdc_01_0316)

There are several stronger HD-FEC options than KP4.

Technical difficulty differences between 200GbE and 400GbE



Technically 200GBase-ER4 is easier than 400GBase-ER8 as it is 4-lane solution. 200GbE commercial productions may come earlier than 400GbE.

Difficulty differences between 400GBase-ER8 and 200GBase-ER4

	400G-base ER8	200G-base ER4
Number of lanes	8-lane	4-lane
WDM-mux loss	3dB (8λ)	2dB (4λ)
WDM-demux loss	3dB (8λ)	2dB (4λ)
Worst-case dispersion	-203.3ps/nm - +37.5ps/nm	-113.4ps/nm - +37.5ps/nm

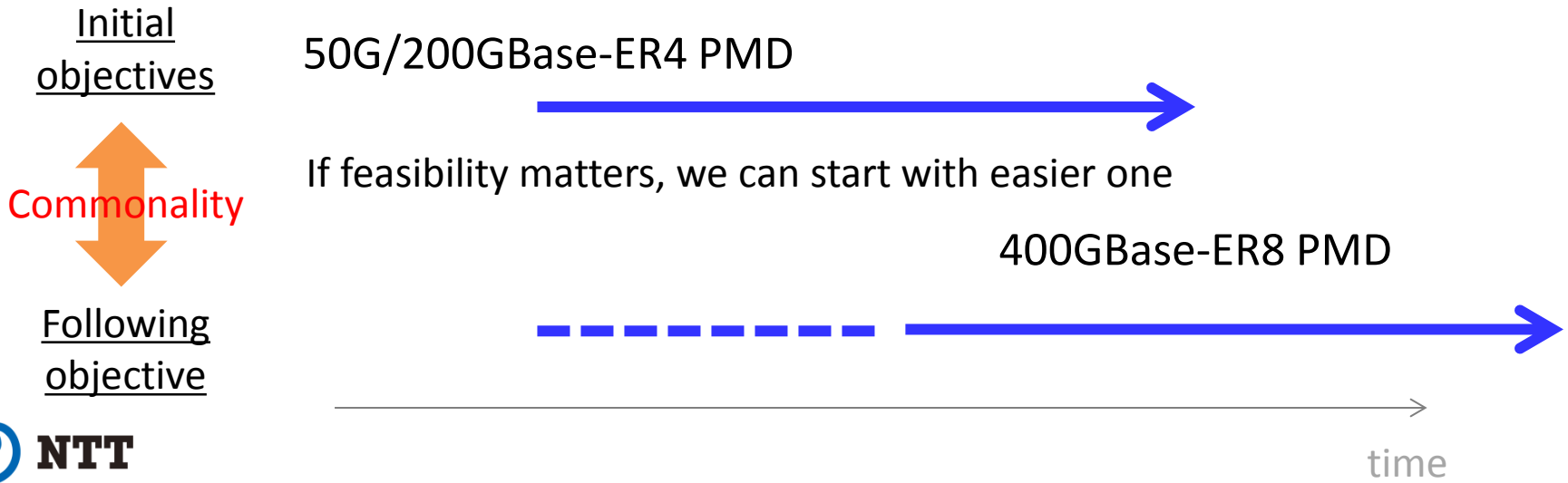
Discussion steps for standardization



- Among 50G/200G/400G requirements, **we can start with the 50G/200GbE 40km standardization** that have relatively small technical hurdles.
- Keep in the mind that we must **ensure the commonality with the following 400GbE 40km standardization.**

Market requirements for ER PMD (50G, 200G, 400G.)

→ derivations of 50G PAM4/lane solution have many aspects in common.



Example: Commonality between 200GbE and 400GbE



Given the reaches of 200GBase-LR4/400G-baseLR8 can be extended to 40km, 200GBase-ER4/400G-Base-ER8 can have much commonality.

- Modulation format 50Gb/s PAM4
- 800GHz spaced WDM grid

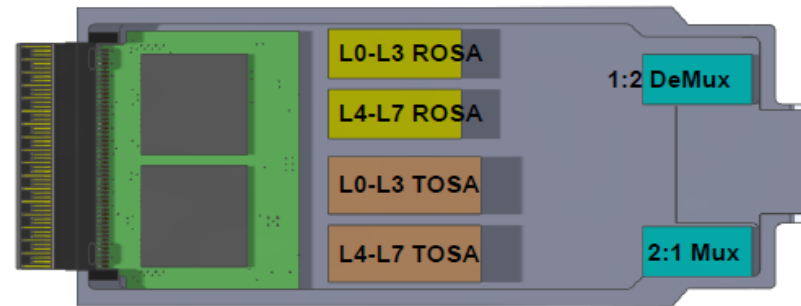


200GbE TOSA/ROSA can be subcomponents for 400GbE too.

λ	200G	400G
1273.54		L0
1277.89		L1
1282.26		L2
1286.66		L3
1295.56	L0	L4
1300.05	L1	L5
1304.58	L2	L6
1309.14	L3	L7

400GBase LR8 implementation example
From :cole_3bs_02a_1114

Appendix: Example CFP2 Layout



- Among multiple extended reach requirements, developing 50GBase-ER/200GBase-ER4 will be a first step to develop 400GBase-ER8.
- We should consider the commonality among 50G-ER, 200G-ER4, and 400G-ER8 from the initial step.



Innovative R&D by NTT

Thank you



Innovative R&D by NTT

Backup slides

Experimental evaluation result (sone_ecdc_01b_0516)

Evaluation results

KP4 FEC (limit = 2E-4)

Stronger FEC (limit = 1E-3)

Min. Rx sensitivity (EML#1): -22.8 dBm

-23.9 dBm

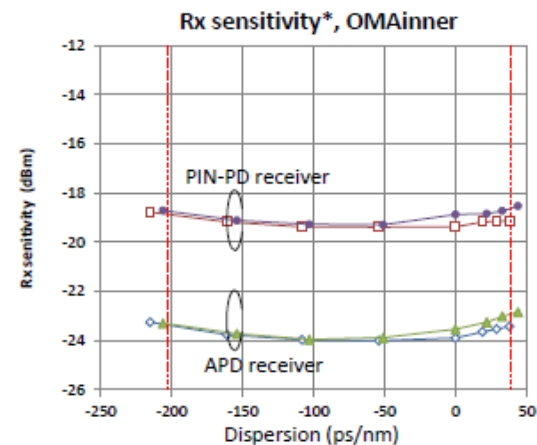
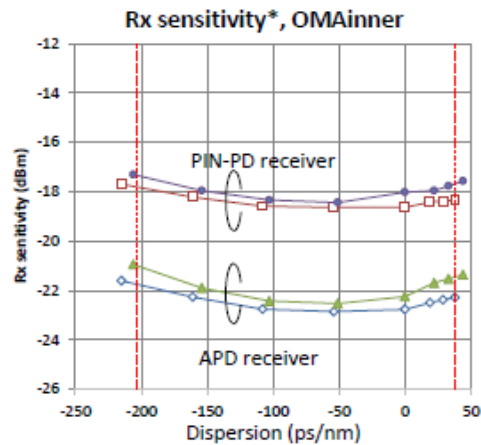
Min. Rx sensitivity (EML#2): -22.2 dBm

-23.5 dBm

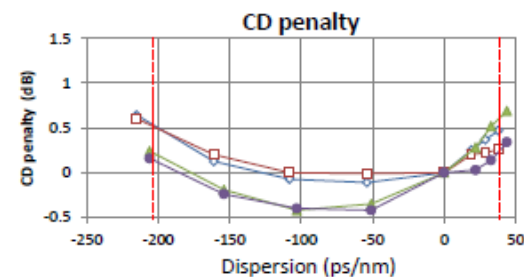
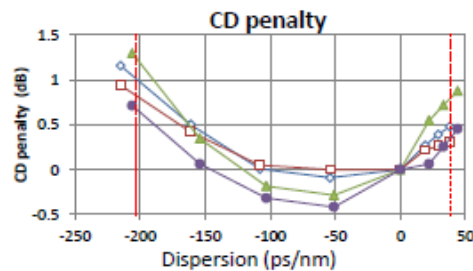
CD penalty : ~ 1.5 dB

~ 0.5 dB

- EML#1+APD
- EML#1+PIN-PD
- △— EML#2+APD
- EML#2+pin-PD
- Target dispersion
-203.3 to +38.5ps/nm



* Without 8λ WDM demux loss



Worst-case dispersion for 40km SMF transmission



Table 123-5—Wavelength-division-multiplexed lane assignments

Lane	Center frequency	Center wavelength	Wavelength range
L ₀	235.4 THz	1273.54 nm	1272.55 to 1274.54 nm
L ₁	234.6 THz	1277.89 nm	1276.89 to 1278.89 nm
L ₂	233.8 THz	1282.26 nm	1281.25 to 1283.27 nm
L ₃	233 THz	1286.66 nm	1285.65 to 1287.68 nm
L ₄	231.4 THz	1295.56 nm	1294.53 to 1296.59 nm
L ₅	230.6 THz	1300.05 nm	1299.02 to 1301.09 nm
L ₆	229.8 THz	1304.58 nm	1303.54 to 1305.63 nm
L ₇	229 THz	1309.14 nm	1308.09 to 1310.19 nm

Worst-case dispersion for SMF transmission

■ Negative dispersion[8lane]

$$0.93 \cdot \lambda \cdot [1 - (1324 / \lambda)^4] = -203.3 \text{ ps/nm}$$

■ Negative dispersion[4lane]

$$0.93 \cdot \lambda \cdot [1 - (1324 / \lambda)^4] = -113.4 \text{ ps/nm}$$

■ Positive dispersion

$$0.93 \cdot \lambda \cdot [1 - (1300 / \lambda)^4] = +38.5 \text{ ps/nm}$$

4 x LR8-value

Table 123-12—Transmitter compliance channel specifications

PMD type	Dispersion ^a (ps/nm)		Insertion loss ^b	Optical return loss ^c	Max mean DGD
	Minimum	Maximum			
400GBASE-FR8	$0.0465 \cdot \lambda \cdot [1 - (1324 / \lambda)^4]$	$0.0465 \cdot \lambda \cdot [1 - (1300 / \lambda)^4]$	Minimum	19.8 dB	0.8 ps
400GBASE-LR8	$0.2325 \cdot \lambda \cdot [1 - (1324 / \lambda)^4]$	$0.2325 \cdot \lambda \cdot [1 - (1300 / \lambda)^4]$	Minimum	17.6 dB	0.8 ps