Feasibility of 800G LR4 and 800G ER8 with PAM4 IMDD

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IEEE 802.3 B400G Study Group, August 19, 2021

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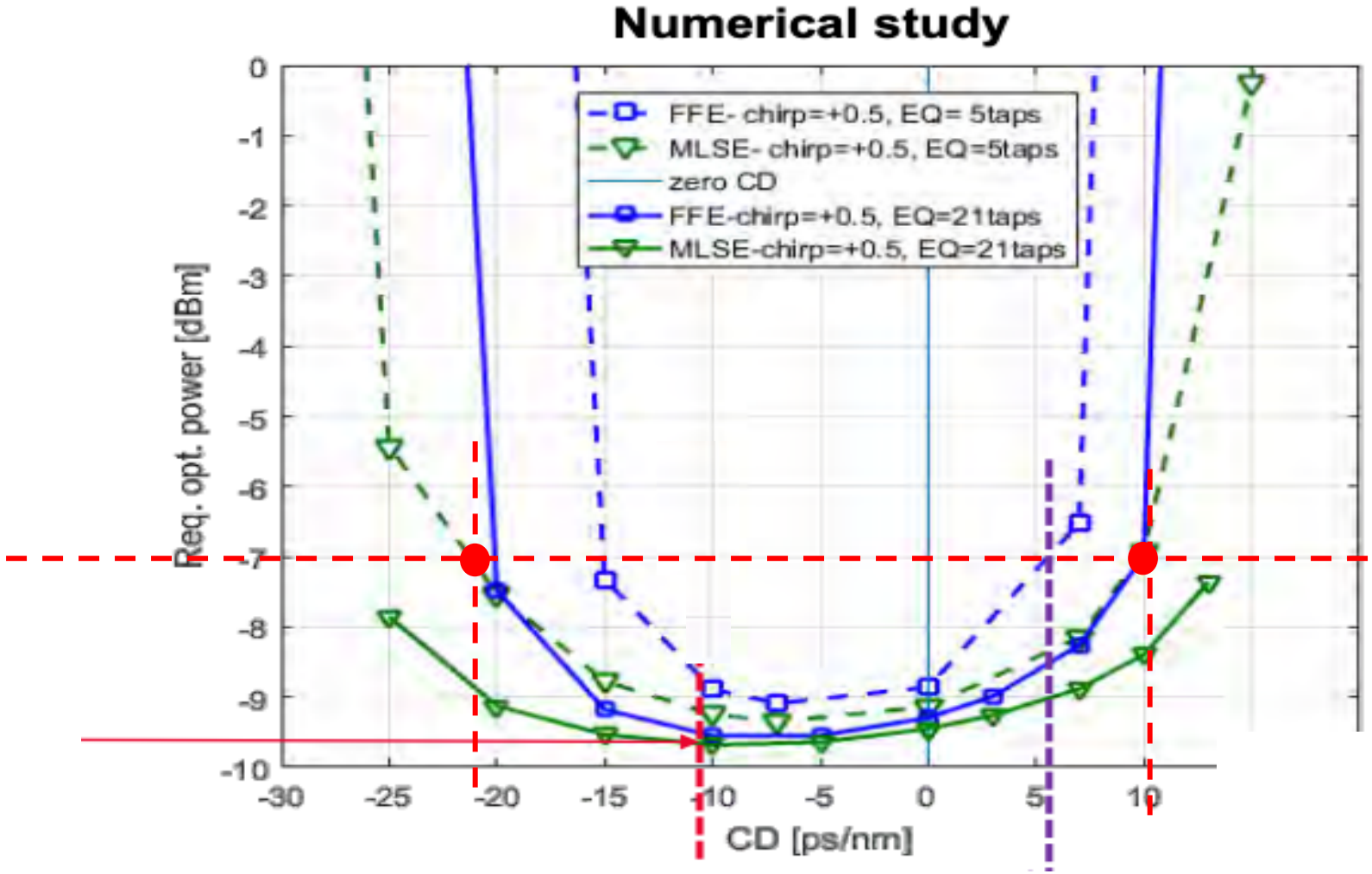
- Zhan Su, ZTE
- Philip Sun, Credo
- Xi Wang, Marvell
- Xue Wang, H3C
- Helen Xu, Huawei
- Kevin Zhang, Renesas

800G LR Objective and This Contribution Focus

- 800G LR objective adopted by IEEE B400G Study Group
- Many options under considerations
  - T. Zhang, et al, “Considerations on the "10km @ 800Gb/s" objective”, July 19, 2021, IEEE B400G SG
  - C. Lam, et al, “Coherent-Lite for beyond 400GbE”, July 21, 2021, IEEE B400G SG
  - T. Zhang et al, “Technical Feasibility of 800K 10km Objective”, August 10, 2021, IEEE B400G SG
- This contribution focus on 800G LR4, with 4x200G PAM4 as main technical option
  - Channel plan with reasonable dispersion level tolerance
  - Target to take advantage of DSP developed for 800G DR4/FR4
  - Leverage of work done within the industry for 100Gb/s extended reach optical specs
    - Proper scaling of dispersion tolerance with proper wavelength channel plan
  - Potential cost advantage vs. alternatives

Tech. Feasibility: CD Tolerance Range for 200G PAM4



- Choose MLSE, EQ> 5Tap as DSP option baseline
- CD_min. ~ -21.5 ps/nm
- CD_max ~ +11 ps/nm

DP < 2.7dB

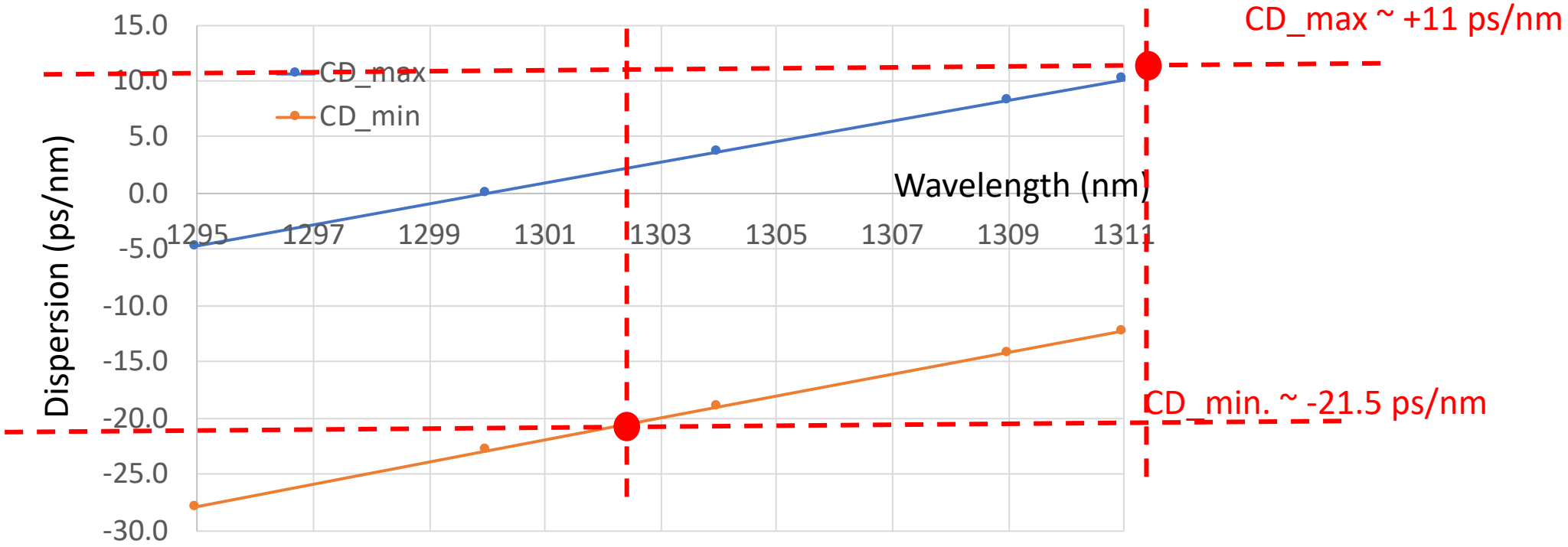
Maxim Kuschnerov, Lin Youxi
Huawei Technologies

03.05.2021

IEEE P802.3 B400G Study Group, Interim Teleconference, 3 May 2021

Tech. Feasibility: CD Tolerance Relate to Wavelengths

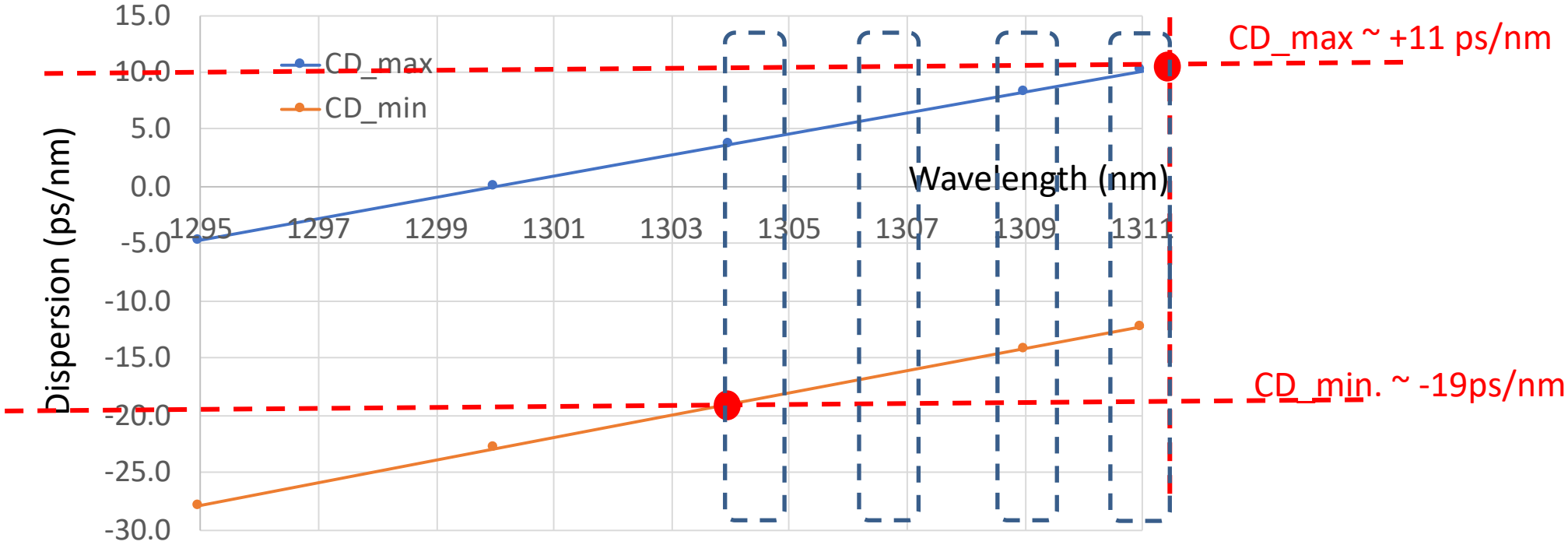
- #1 tech. Concern is dispersion tolerance
- Dispersion range defined by ITU spec. for 10km, for different wavelength λ
  - CD_Min= 0.2325*λ*(1-(1300/λ)^4)
  - CD_max=0.2325*λ*(1-(1324/λ)^4)



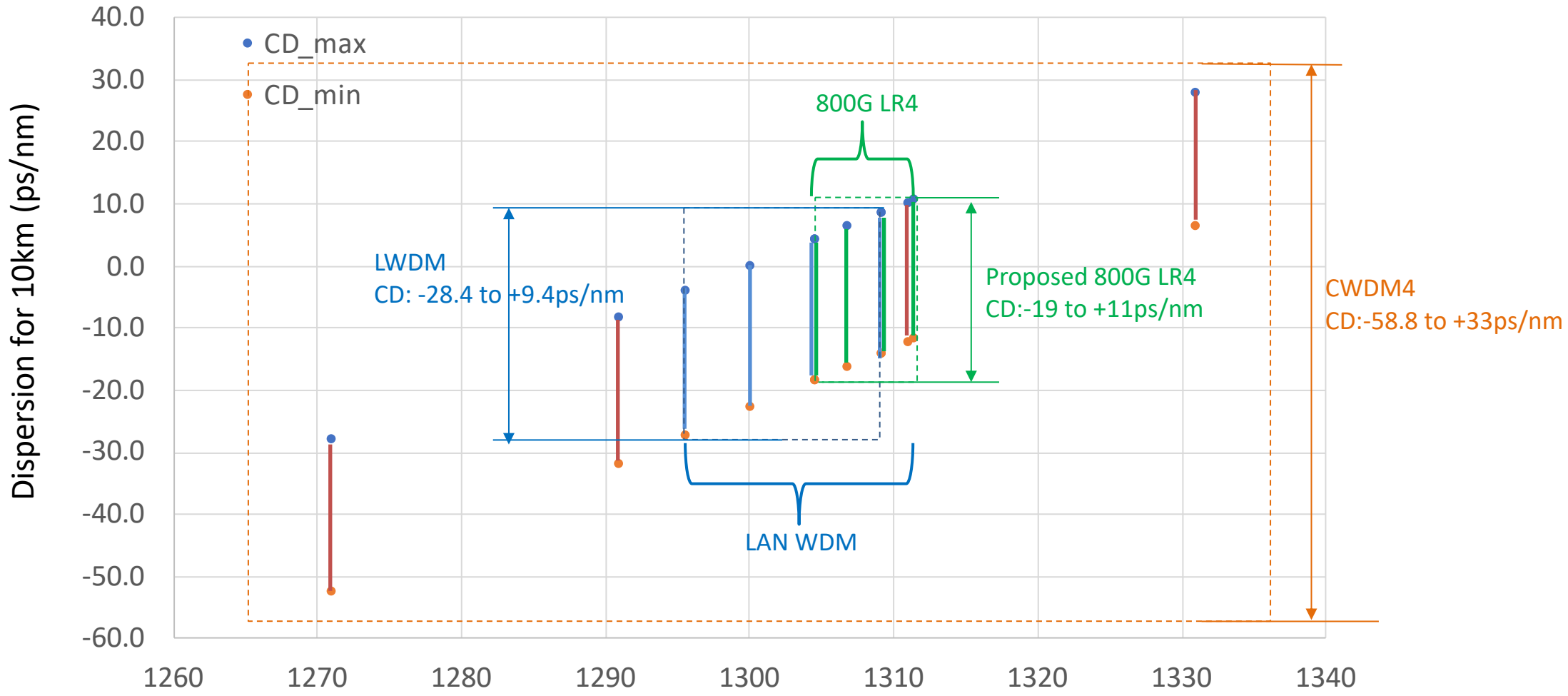
Tech. Feasibility: LR4 Channel Wavelengths Choice

- Propose to adopt wavelengths with 400GHz Channel Spacing

Channel #	Min.	Typical	Max.	Unit
λ0	1304.06	1304.58	1305.1	nm
λ1	1306.33	1306.85	1307.38	nm
λ2	1308.61	1309.14	1309.66	nm
λ3	1310.9	1311.43	1311.96	nm



800G LR4 Channel Plan vs. LWDM, CWDM

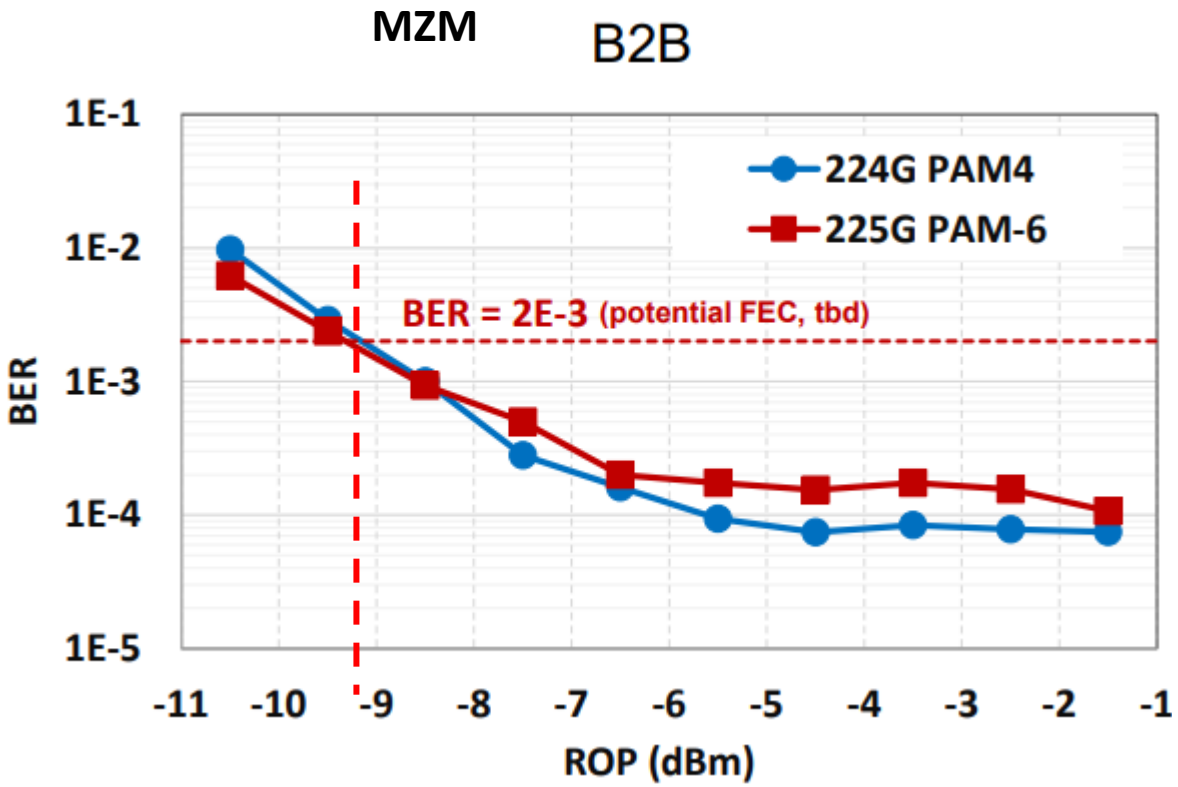


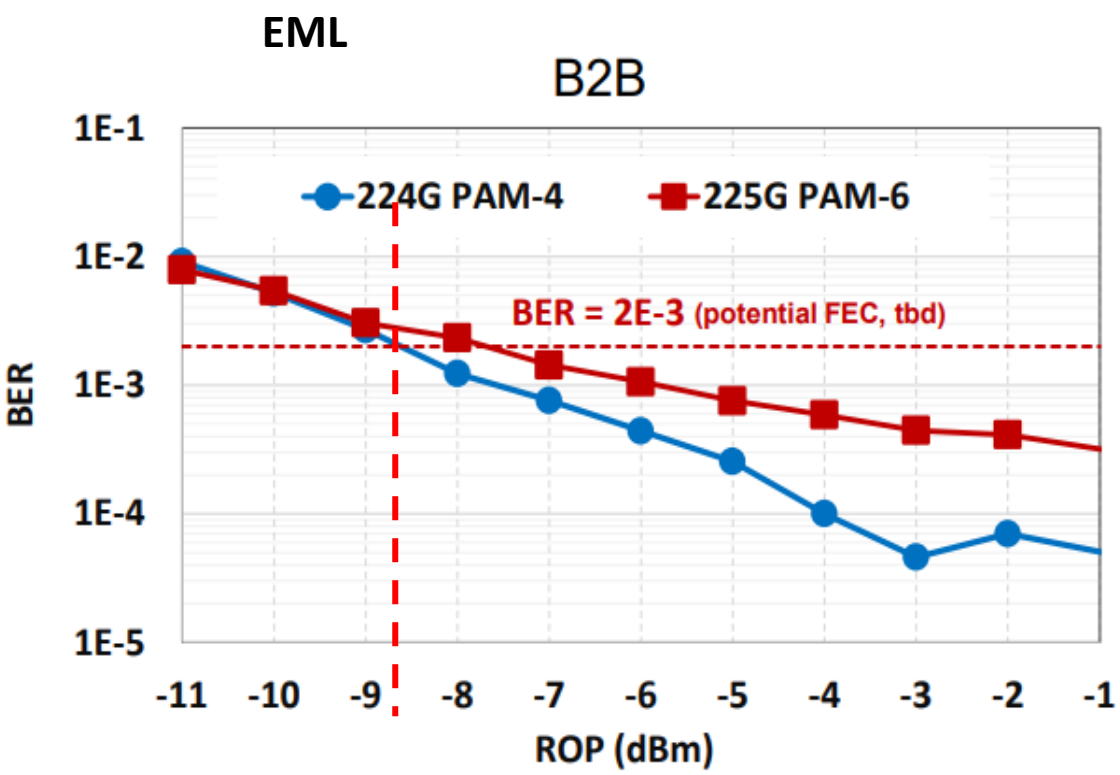
DSP Requirement for 800G LR4 vs. LWDM, CWDM

	Channel Plan (nm)	Max. Dispersion (Ps/nm)	Min. Dispersion	DSP Requirement
800G LR4 Proposal	L0=1304.58 L1=1306.85 L2=1309.14 L3=1311.43	+11	-19	MLSE + Modest # of Taps (>5)
LAN WDM	L0=1295.56 L1=1300.05 L2=1304.58 L3=1309.14	+9.4	-28.4	MLSE + Large # of Taps (> 21), Feasibility not clear
CWDM	L0=1271 L1=1291 L2=1311 L3=1331	+33	-58.8	Out of the question for IMDD

Tech. Feasibility: RX sensitivity @ 224G

Initial MZM vs EML Evaluation results Reference





Technical feasibility of 200G/lane optical

Source: [Technical feasibility of 200G/lane optical (ieee802.org)]

Maxim Kuschnerov, Lin Youxi
Huawei Technologies

03.05.2021

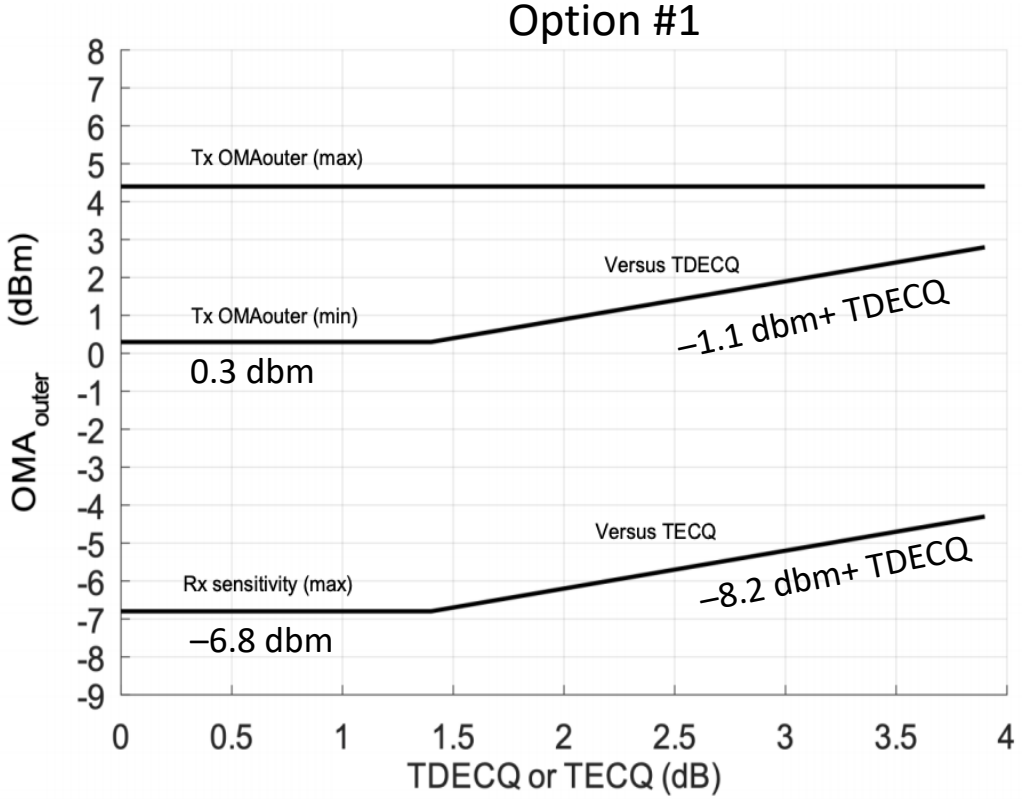
IEEE P802.3 B400G Study Group, Interim Teleconference, 3 May 2021

Tech. Feasibility: Preliminary Link Budget Discussion

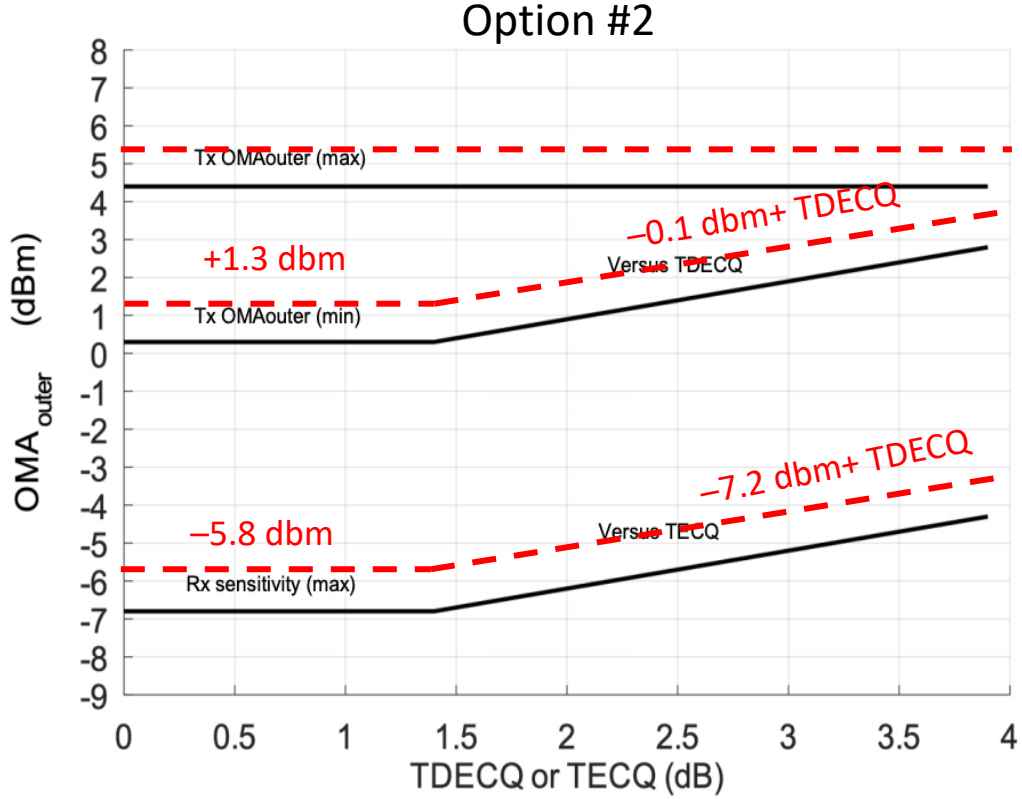
The published 100G Lambda MSA 400G LR4-10 specification can be informative to develop a baseline proposal for the SG (100G Lambda MSA 400G LR4 Spec. Hyperlink)

- Detail spec. will be discussed later, with options to adjust Tx/Rx spec.

Option #1



Option #2



800G LR4 Feasibility Summary

- 800G LR4 Technical feasibility Proposed
  - Channel wavelength plan proposed at
    - L0=1304.58nm
    - L1=1306.85nm
    - L2=1309.14 nm
    - L3=1311.43nm
  - CD tolerance levels
    - Max. +11ps/nm
    - Min. -19ps/nm

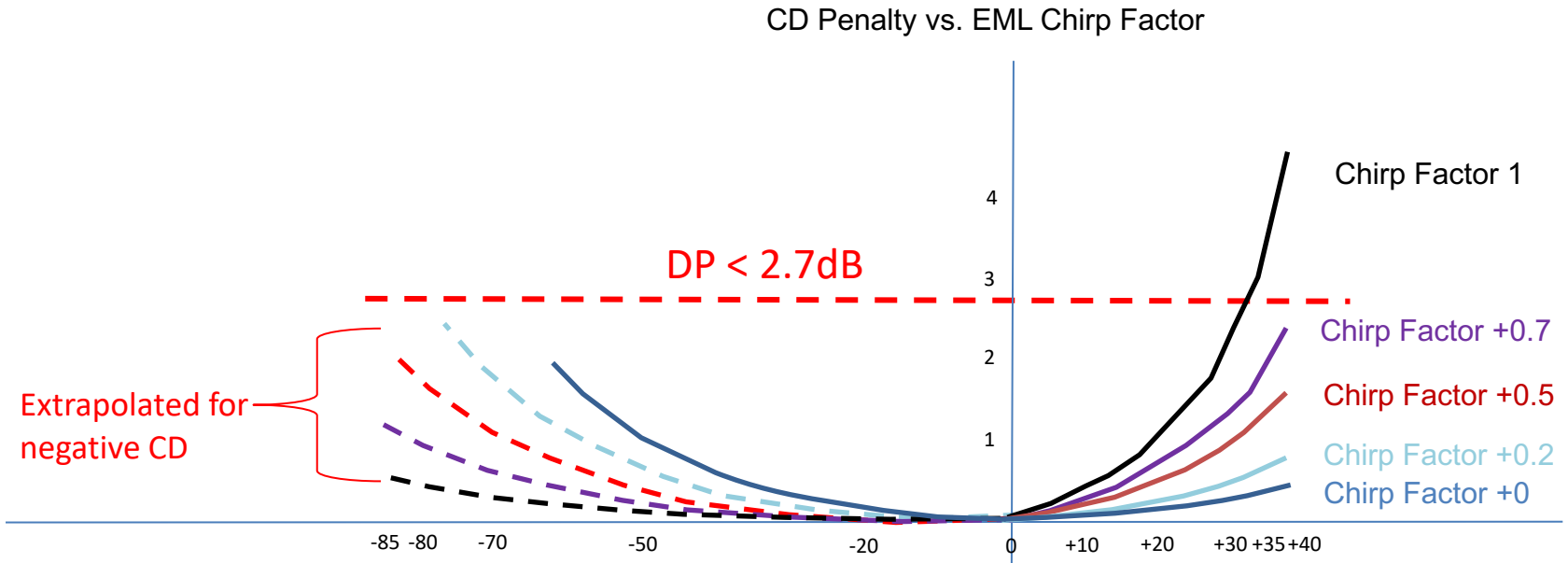
  - Link budget proposal with 2 options:
    #1 option: Tx/Rx stay the same as 400G LR4-10
    #2 Option: increase Tx power, with relaxed Rx sensitivity by 1dB

800G ER8 Objective and This Contribution Focus

- 800G ER objective adopted by IEEE BY400G WG
  - *Define a physical layer specification that supports 800 Gb/s operation:*
    - *over a single SMF in each direction with lengths up to at least 40 km*

- This contribution focus on 800G ER8
  - Channel plan with reasonable dispersion level tolerance
  - Target to piggyback DSP silicon developed for 8x100G
    - leverage related work done in the industry for 100Gb/s extended reach optical specs
      Proper scaling of dispersion tolerance with proper wavelength channel plan
  - Potential cost advantage vs. alternatives

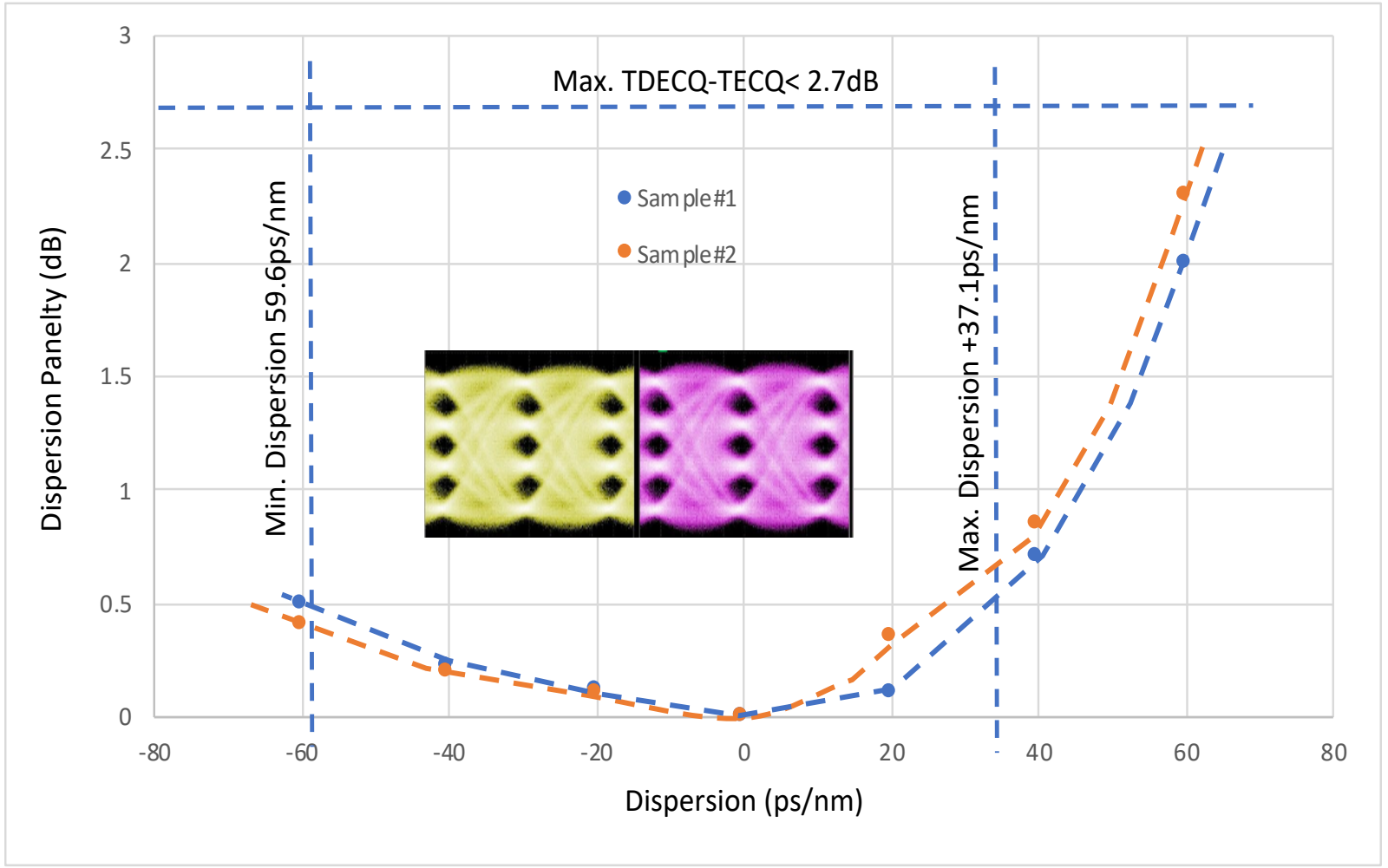
CD Penalty at 53GBaud for EML Transmitter



- Solid line reference from Yu Xu, et al, "Further Technical Study for 400GE with 4*100G PAM4", May 23, 2019, IEEE 802.3cu Task Force Interim Meeting
- Dash line extrapolated for positive chirp data on negative dispersion side

- EMLs tend to have positive chirp, incur higher penalty with higher positive dispersion, and much more tolerance for negative dispersion
- With chirp +0.5 as baseline, it is feasible to extend negative dispersion to -85ps/nm, if we set 2.7dB as max. for dispersion penalty

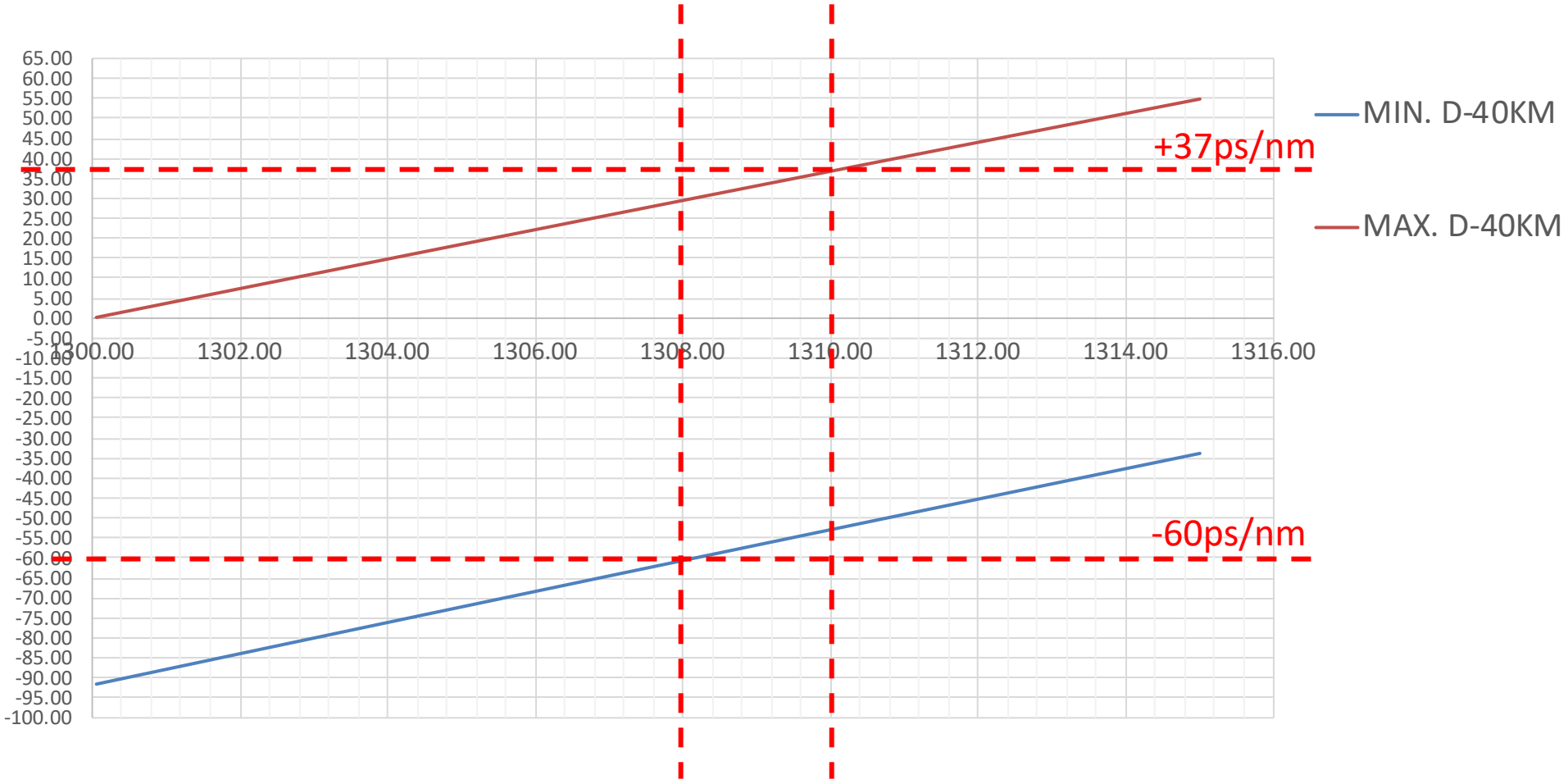
Test Data on Silicon Photonics MZM



R. Yu and D. Pan, OFC'2021, M36A.5, "Silicon Photonics Applications for 5G and Data Centers"

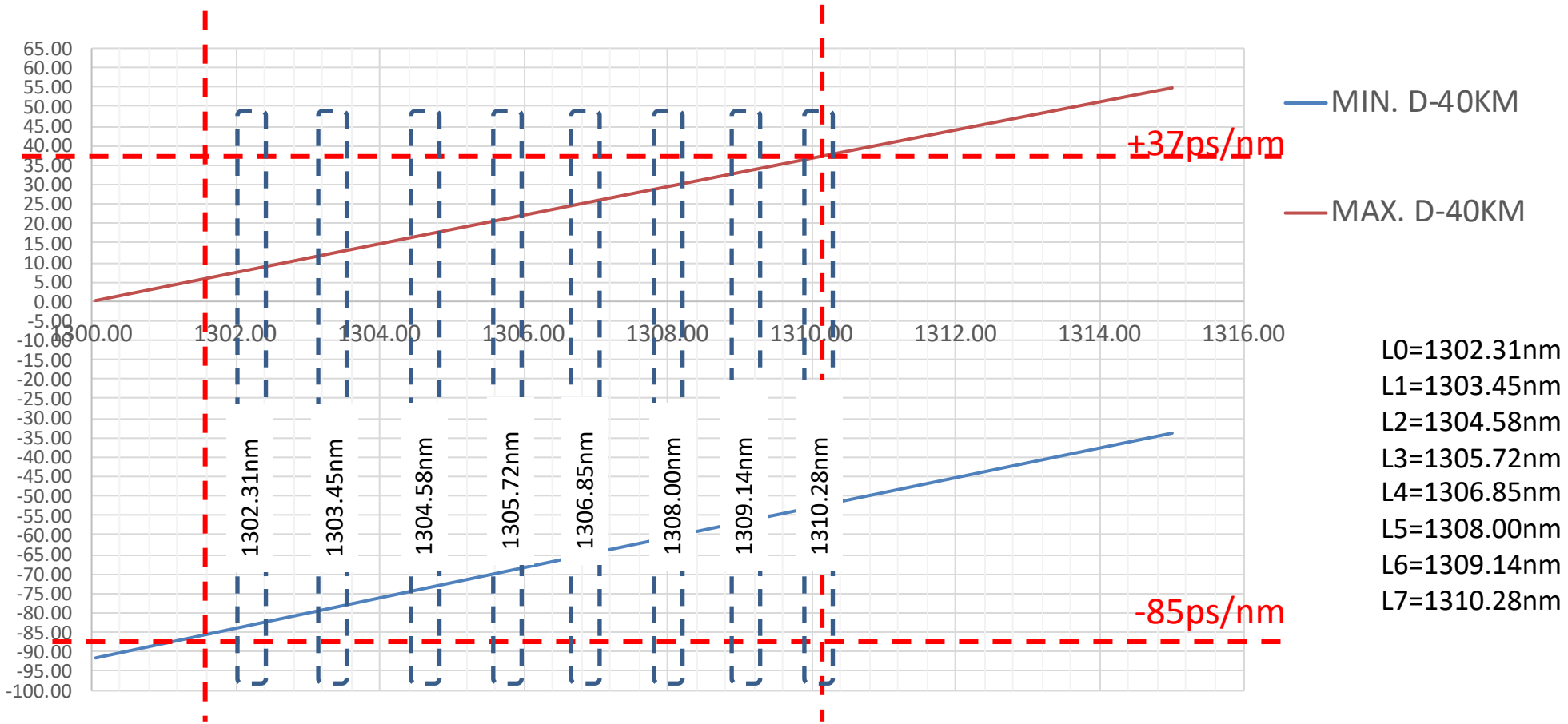
Tech. Feasibility: CD Tolerance for 40km Reach

- Dispersion range defined by ITU spec. for different wavelength λ, per Km of transmission
  - CD_Min= $0.02325*\lambda*(1-(1300/\lambda)^4)$; CD_max=$0.02325*\lambda*(1-(1324/\lambda)^4)$
  - If we limit CD tolerance to -60 to +37ps/nm, then wavelengths need to be limited to 1308-1309nm, very tight to fit 8 wavelengths



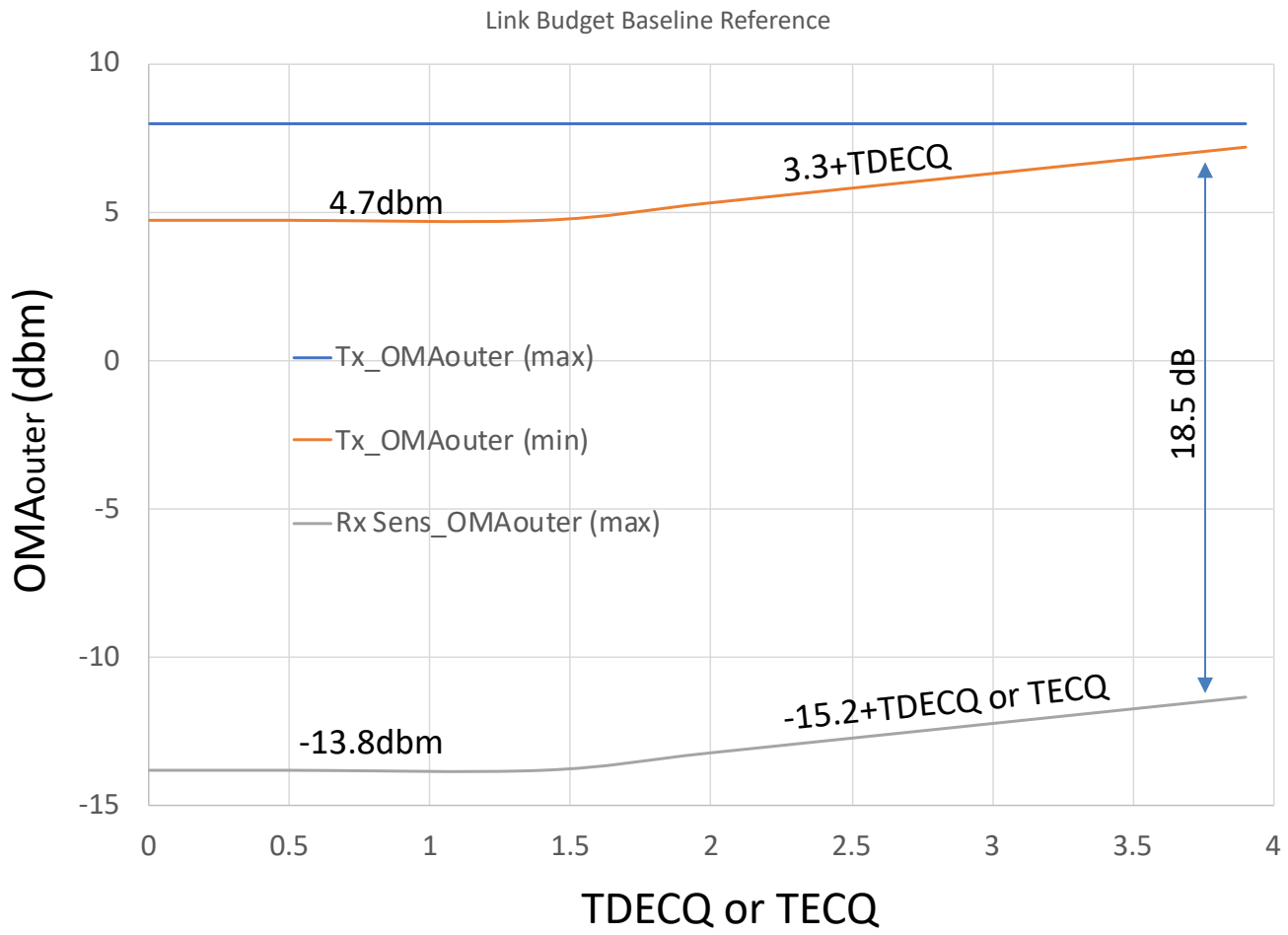
Tech. Feasibility: CD Tolerance for 40km Reach

- If we can relax dispersion tolerance to -85 to +37ps/nm, wavelengths can be much wider from 1301.6 to 1310nm.
- Possible to fit 8 channels from 1302.31nm to 1310.28nm, with 200GHz Channel spacing



Link Budget Discussion

- Tx and Rx spec.:
  A future baseline proposal would be able to developed leveraging knowledge gained from the published 100G Lambda MSA's 100G ER1-40 specification
  (100G Lambda MSA 100G ER1-40 spec. hyper link)



800G ER8 Feasibility Summary

- 800G ER8 Technical feasibility Proposed
  - Channel wavelength plan proposed at
    - L0=1302.31nm
    - L1=1303.45nm
    - L2=1304.58nm
    - L3=1305.72nm
    - L4=1306.85nm
    - L5=1308.00nm
    - L6=1309.14nm
    - L7=1310.28nm
  - CD tolerance levels
    - Max. +37ps/nm
    - Min. -85ps/nm
  - Tx and Rx link budget proposal with 100G Lambda MSA 100G ER1-40 as a baseline starting point

Thank You!