IEEE P802.3 Plenary Meeting, March 10-15, 2024

Chromatic Dispersion for the 800G-LR4 Baseline Based on refined SMF channel model

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Background

- In the November 2023 IEEE 802 plenary meeting, the baseline proposal for 800GBASE-LR4 (rodes_3dj_01a_2311) was approved, with the chromatic dispersion (CD) values of its four wavelength channels “to be specified”

Transmitter compliance channel specifications

Dispersion								Max mean DGD
Lane0		Lane1		Lane2		Lane3		
Minimum	Maximum	Minimum	Maximum	Minimum	Maximum	Minimum	Maximum	
TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	0.8 ps

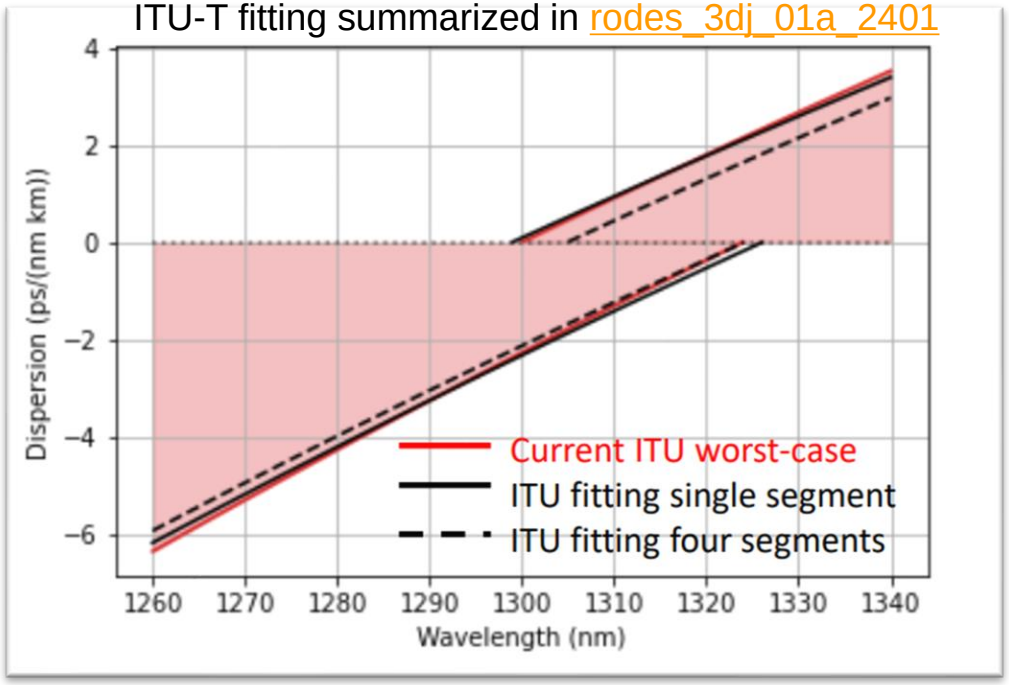
CD values to be specified once ITU-T statistical data gets available

- In December 2023, IEEE 802.3 WG received the liaison from ITU-T SG15 regarding the statistical CD properties of G.652 / G.657 fiber, which was posted at: https://www.ieee802.org/3/minutes/jan24/incoming/SG15-LS86_Redacted.pdf
  Additional attachments were also posted at: https://www.ieee802.org/3/minutes/jan24/index.html.

Key takeaway messages from the ITU-T liaison

1) It is good that the ITU-T SG15 is using the statistical methodology for assessing the fiber CD properties.
2) The ITU-T SG15 liaison provided fitting functions of CD values of eight fiber vendors at a confidence level of 99.99%, without providing ZDW distributions.
3) It is good that ITU-T looks forward to “continued communications to align our work as much as possible”. “Specifically, any comments on the initial results, as well as suggestions on how to improve them would be most welcome. ”

ITU-T fitting summarized in rodes_3dj_01a_2401



The Chromatic Dispersion (CD) Model

- In rodes_3dj_01a_2401, a SMF channel model is proposed with two Gaussian distributions to cover the limits of the ITU ZDW and slope specs within 4 sigmas (~99.99%). Distributions values were:
  1) For CD_{min}, use the maximum center ZDW: $ZDW_{c,max}$=1316nm, and sigma=2nm,
  2) For CD_{max}, use the minimum center ZDW: $ZDW_{c,min}$=1308nm, and sigma=2nm,

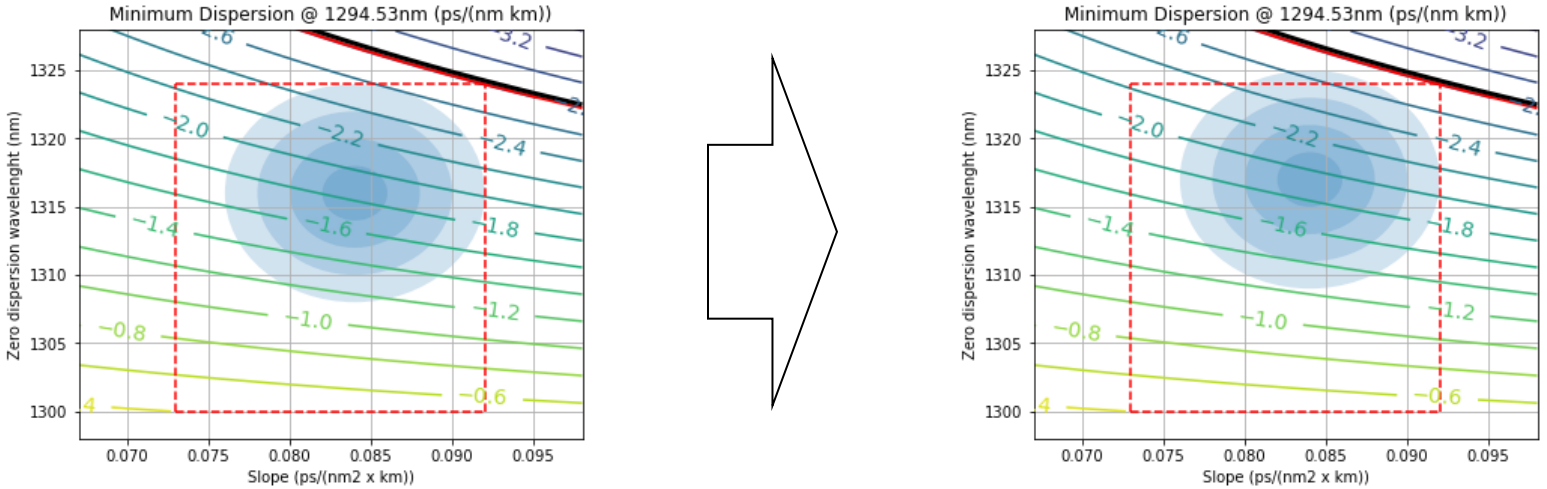
  Dispersion slope at ZDW (S_0) has a Gaussian distribution: N(0.084,0.002)ps/nm^2/km.

- Here, we refine the above model with two proposed modifications:
  1) ZDW asymmetry observed in the ITU-T liaison with ZDW towards longer wavelengths
  2) ZDW and S0 are not independent, but tend to have a negative correlation

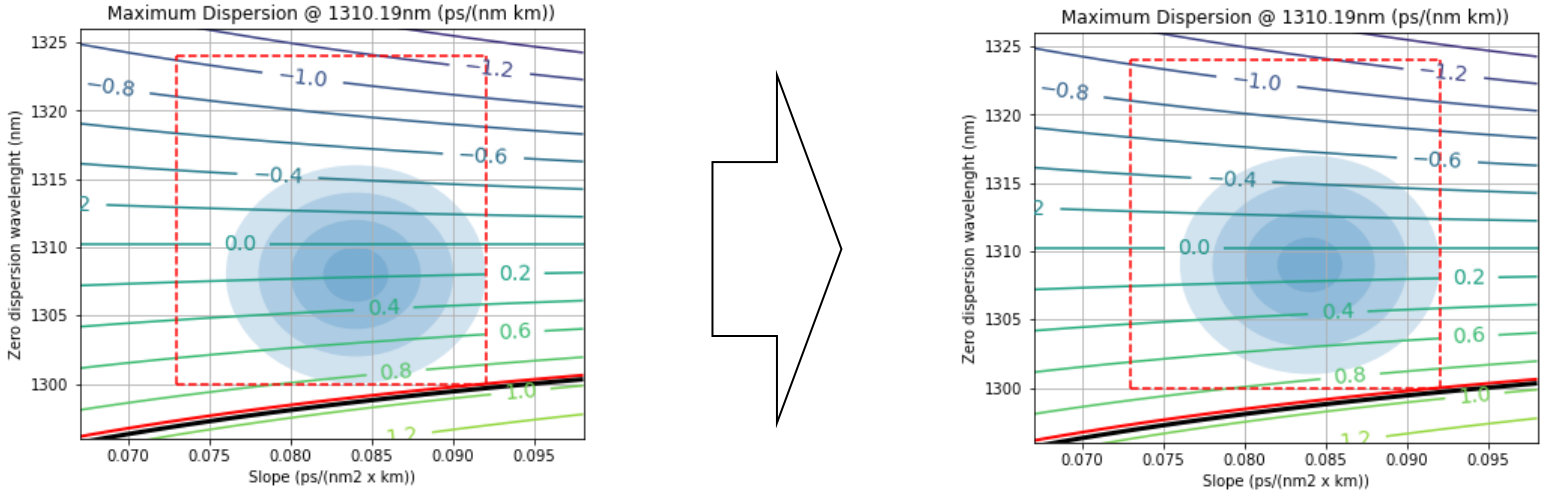
Improvement #1

Based on expert's feedback and ITU statistical data analysis, ZDW distributions are shifted towards longer wavelengths. Therefore, we propose to break symmetry on the SMF channel model to reflect this shift:

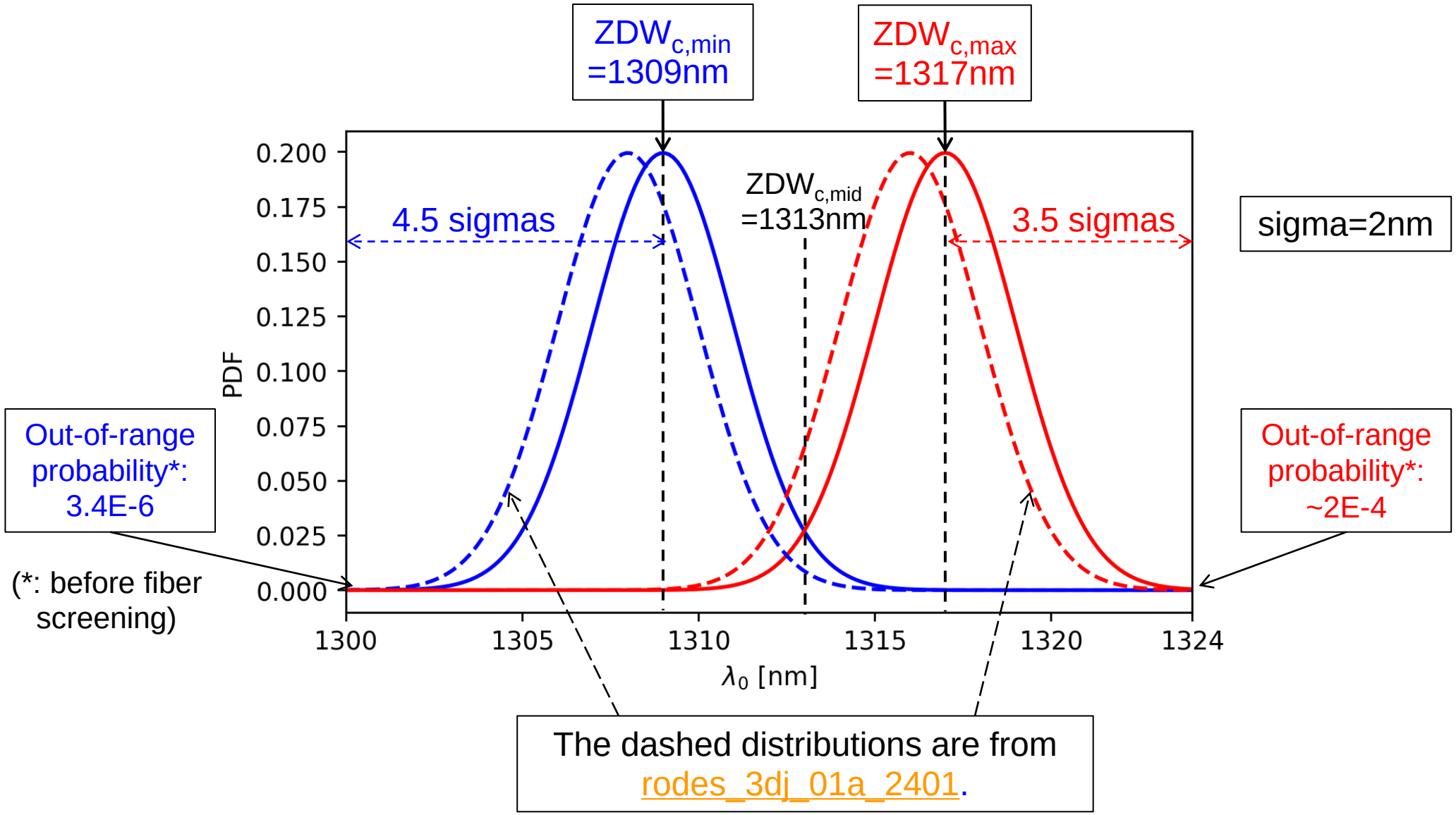
ZDWmean for minimum dispersion:
Change from 1316 nm to 1317 nm



ZDWmean for maximum dispersion:
Change from 1308 nm to 1309 nm



Chromatic Dispersion (CD) Model - Visualization



Dispersion limits for 800G-LR4 with proposed changes in the channel model

Using the same MonteCarlo analysis explained in rodes_3dj_01a_2401 (slide#16), we can recalculate dispersion values

Original model in rodes_3dj_01a_2401

PMD type	Dispersion (ps/nm)	
	Minimum	Maximum
800GBASE-LR4	-21.9	4.9

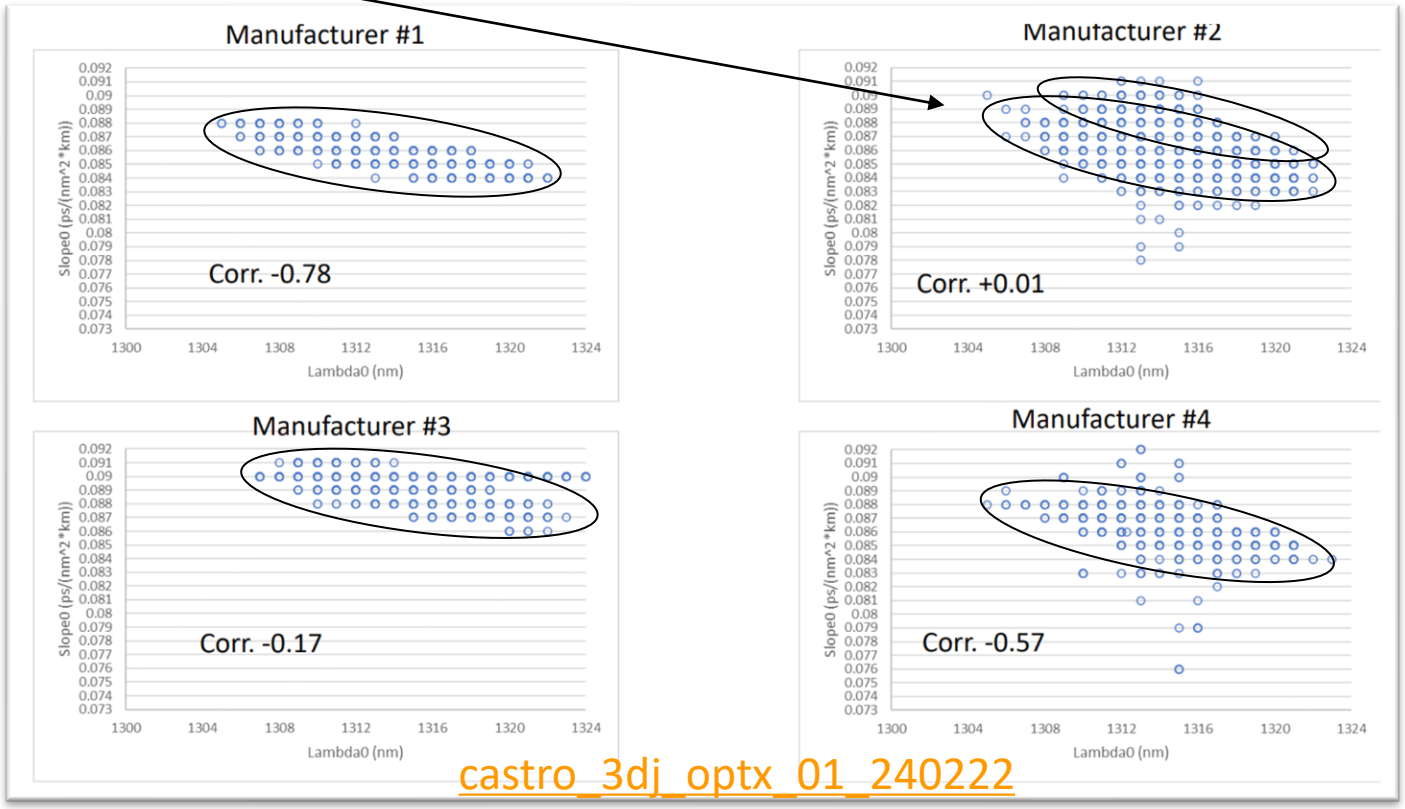
#1: shift toward longer ZDW

PMD type	Dispersion (ps/nm)	
	Minimum	Maximum
800GBASE-LR4	-22.8	4.1

Improvement #2: Negative ZDW and S0 correlation

Based on theoretical analysis in liu_3dj_01_2401 and recent study in castro_3dj_optx_01_240222 using a SMF FD solver of 11 measured refractive index profiles, there is a negative correlation between ZDW and S0.

It is worth mentioning that, in one experimental data shown in castro_3dj_optx_01_240222, the computed value show correlation close to zero.

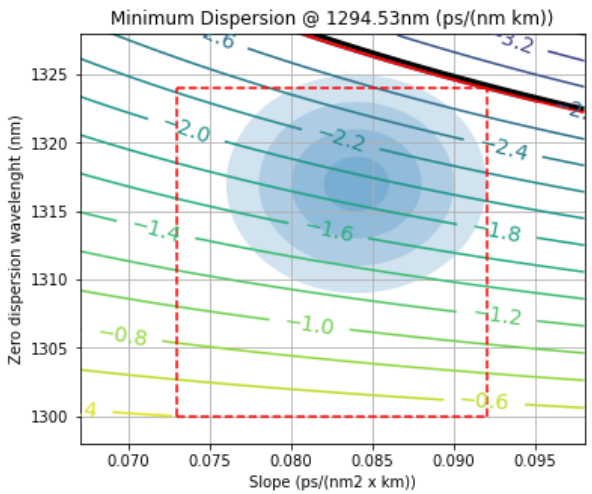


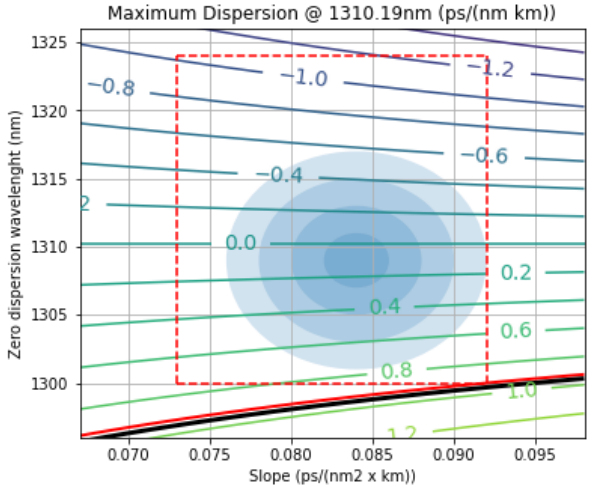
castro_3dj_optx_01_240222

Improvement #2: Negative ZDW and S0 correlation

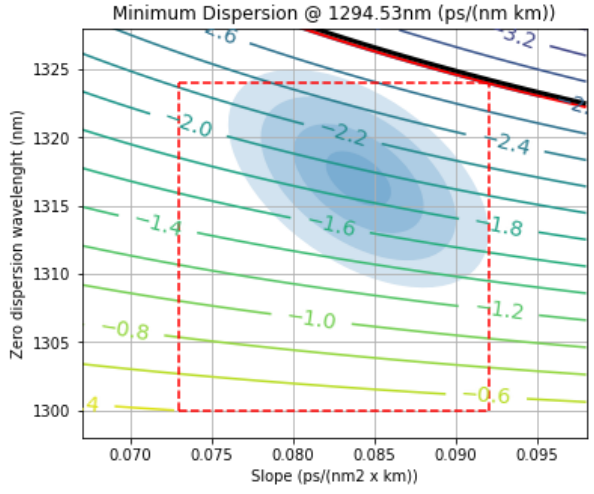
Based on these observations. A potential improvement on the proposed SMF channel model would add a -0.5 correlation between ZDW and Slope

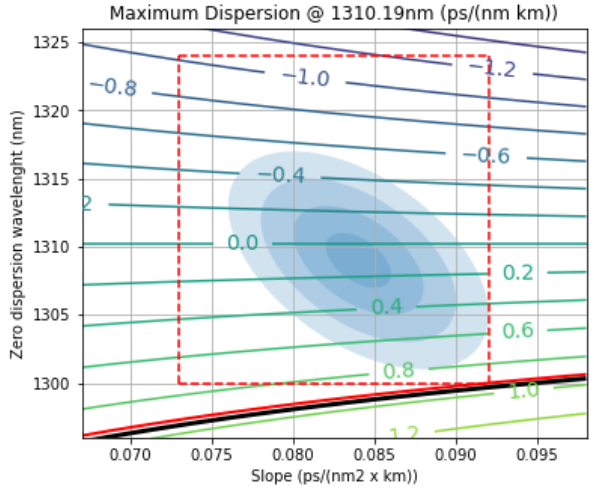
Independent ZDW and Slope





This proposal with negative correlation





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#1: Shift towards longer ZDW

PMD type	Dispersion (ps/nm)	
	Minimum	Maximum
800GBASE-LR4	-22.8	4.1

#2: Add negative correlation of ZDW and S0

PMD type	Dispersion (ps/nm)	
	Minimum	Maximum
800GBASE-LR4	-22.3	4.2

*Includes also #1

Summary

1) This presentation refines the channel model previously presented and calculates the values with the proposed changes for 800G-LR4.
2) Proposed refinement of the channel model includes:
    1) Shift of ZDW distribution towards longer wavelengths
    2) Negative correlation of ZDW and Slope
3) It is good that the ITU-T SG15 is using the statistical methodology for assessing the fiber CD properties.
4) As agreed in the January 2024 802.3 interim meeting, 802.3 can use more than one model for CD specification, and we believe the model proposed in this contribution is well suited for 800G-LR4.

Thank you!