Optical Channel Model Proposal update

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- This presentation updates the previous optical channel model proposal for IMDD applications in rodes_3dj_optx_01a_240222 and rodes_3dj_01a_2401

- The update addresses the comments during rodes_3dj_optx_01a_240222 regarding:
  - slope distribution values
  - Fitting of proposed model to measured data in castro_3dj_optx_01_240222

- This presentation provides values for chromatic dispersion values on 800G-LR4 based on the updated model proposal

Recap on 10km objective split and discussion

In March 2023, .3dj approved the split on the 10km objective.

As shown in cole_3dj_01c_2303, the two objectives have distinct market use cases

- LR4: low-cost and high-volume
- LR1: high-performance and legacy fiber

cole_3dj_01c_2303

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10km Duplex SMF Objectives Proposal / IEEE P802.3di / Plenary Session / March 15, 2023 / C. Cole / Quintessent

10km Duplex SMF Distinct Market Use-cases

- IMDD LR4
  - Low-cost (leverages high-volume DR4/FR4 DSP)
  - Standard 10km reach link budget
  - ≤ 10km links
- Coherent LR1
  - High-performance
  - 10km reach link budget with additional insertion loss
  - ≤10km links with additional loss, ex. optical switching
 - >10km links
  - legacy fiber links

10km Duplex SMF Objectives Proposal / IEEE P802.3dj / Plenary Session / March 15, 2023 / C. Cole / Quintessent

>99.99% of the links can benefit from lower cost IMDD, by leaving <0.01% of corner cases from legacy fibers to be served by LR1 coherent modules

# Channel proposal model evolution

- In January's interim meeting, rodes_3dj_01a_2401 introduced an optical channel model proposal
- From the initial proposal, this is meant to be a transparent and data driven model
- In a first update, rodes_3dj_optx_01a_240222 introduced a shift on ZDW, and ZDW-Slope correlation
- In this presentation, we propose to update the slope mean and standard deviation based on latest data
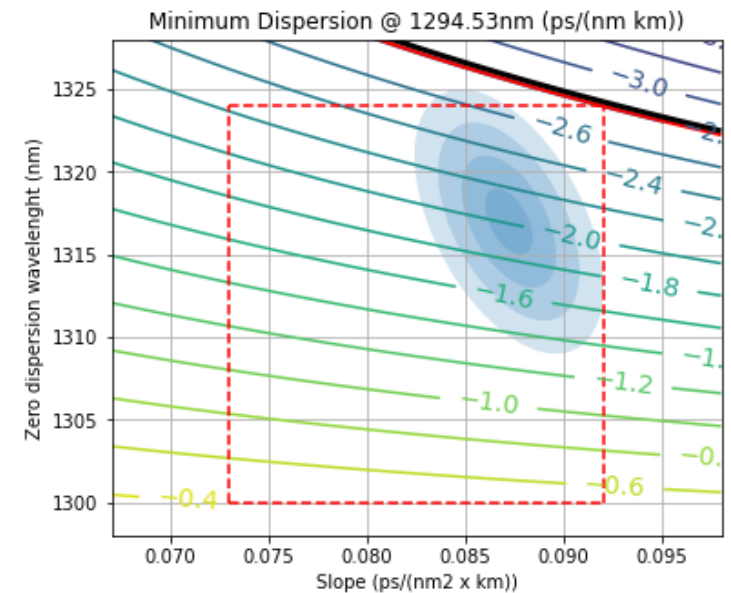
rodes_3dj_01a_2401

rodes_3dj_optx_01a_240222
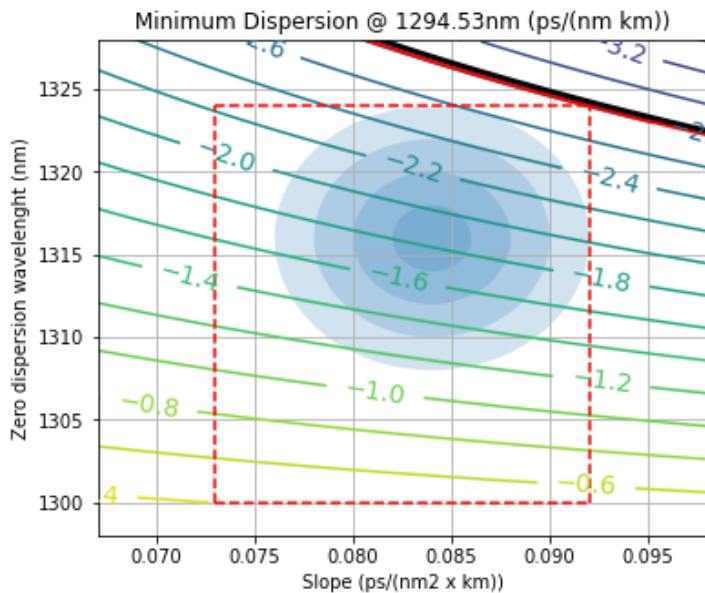
This update

- ZDW: mean= 1316, std= 2
- Slope: mean= 0.084, std= 0.002
- Correlation = 0
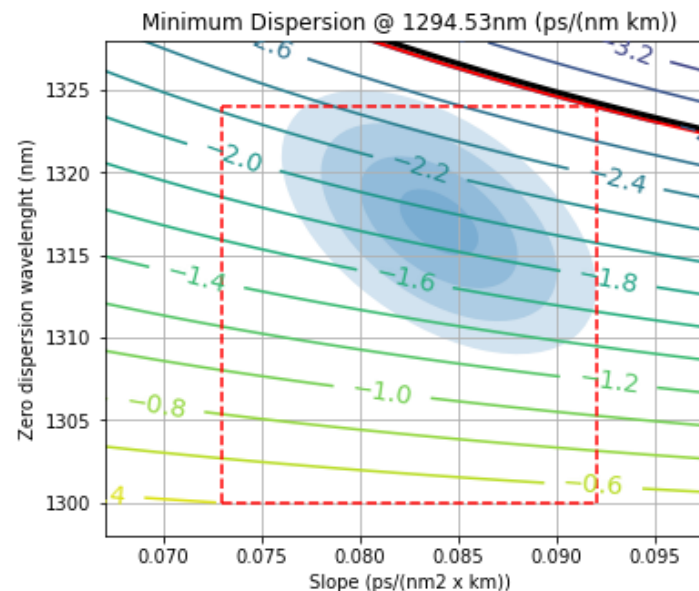
- ZDW: mean= 1317, std= 2
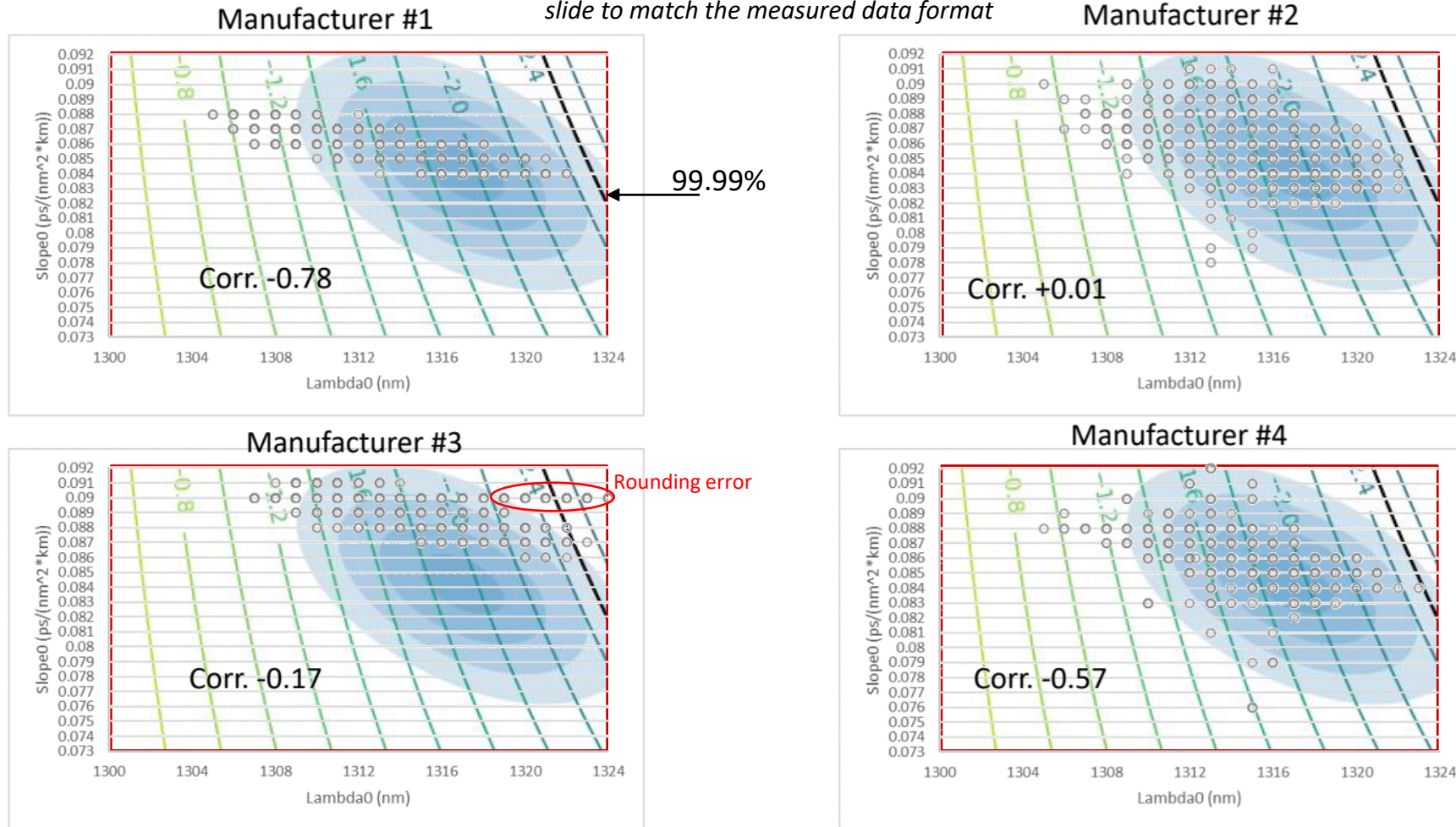- Slope: mean= 0.084, std= 0.002
- Correlation = -0.5

- ZDW: mean= 1317, std= 2
- Slope: mean= 0.0872, std= 0.0012
- Correlation = -0.5

How latest model fit new available data?

New measured data presented in castro_3dj_optx_01_240222 indicates a slope might have tighter distributions and higher mean
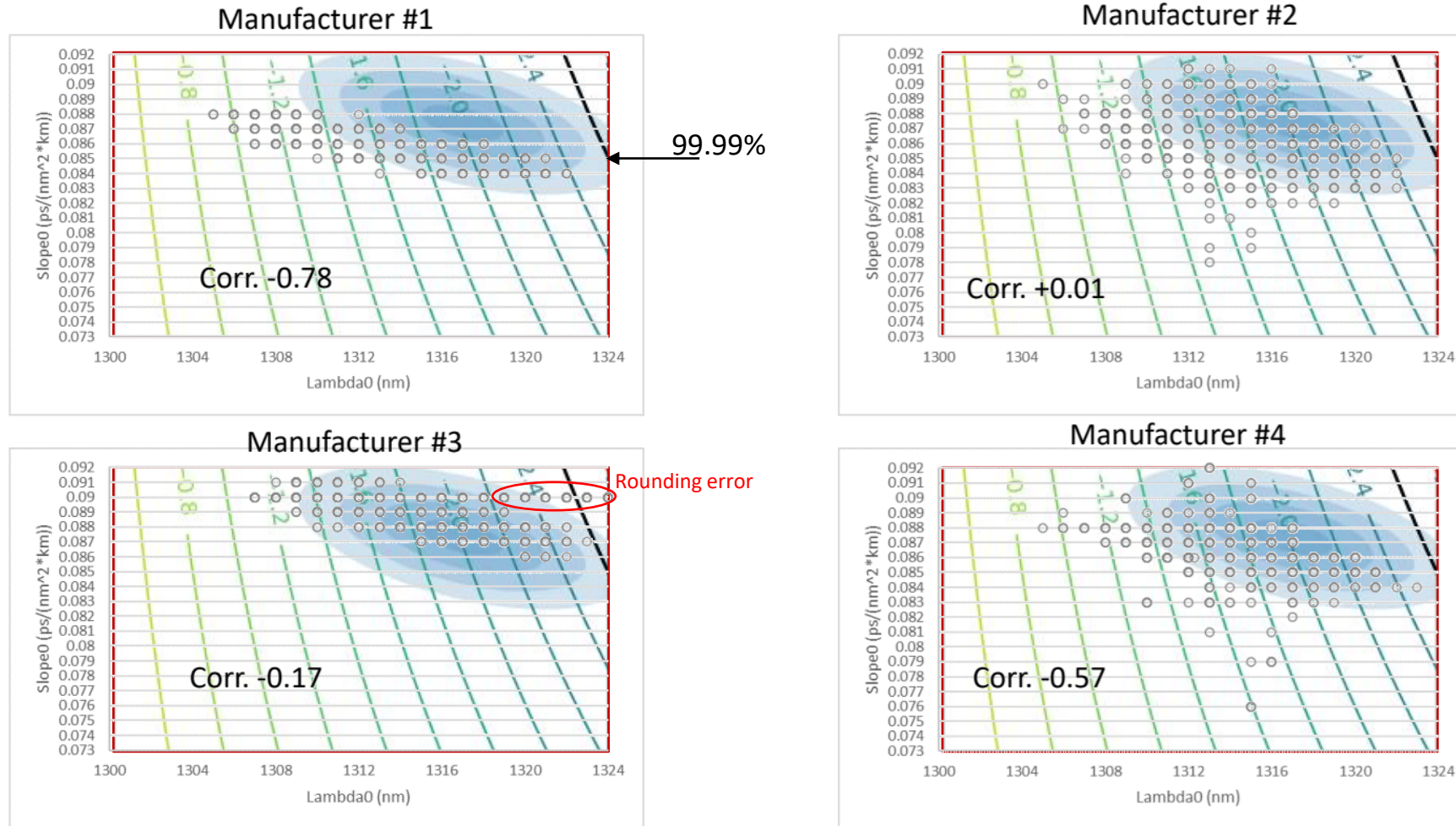
How new model fit new available data?

The new model better fits the manufacturer distributions with larger dispersion
All other manufactures show much better dispersion value than the assumed by the model

castro_3dj_optx_01_240222

Measured data on qualified fibers from a large fiber vendor

- 42182 samples of measure data from a large fiber vendor

- The data shows a negative correlation between ZDW and S0 of -0.7

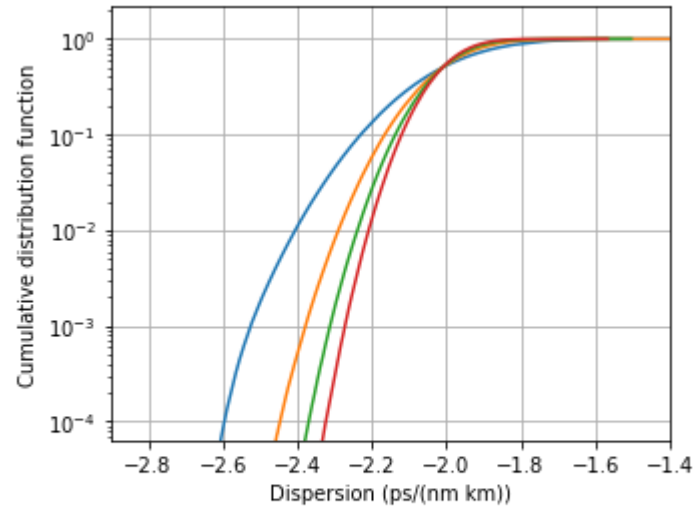- This data also indicates we are proposing a conservative model

42182 samples
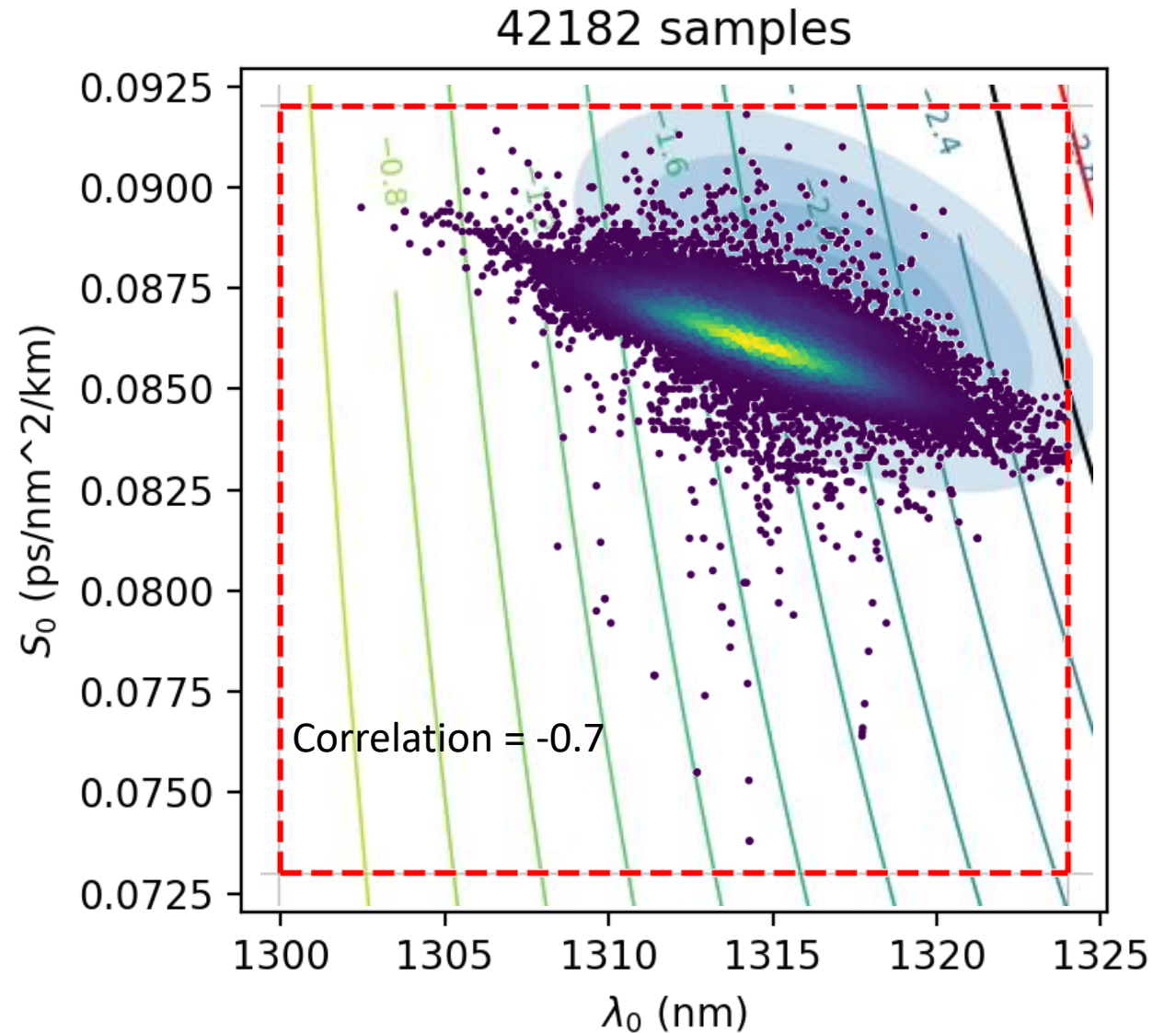
800G-LR4 dispersion values with link segmentation

Using the same MonteCarlo analysis explained in rodes_3dj_01a_2401 (slide#16), we can recalculate min and max dispersion values for LWDM
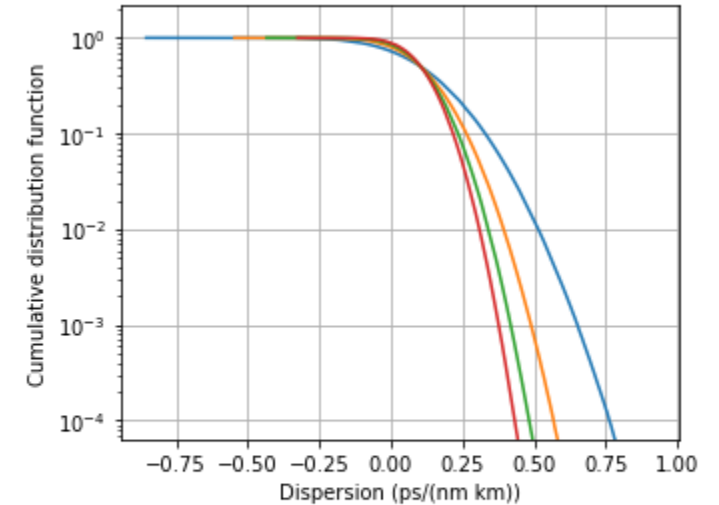
Minimum dispersion @ 1294.53 nm

ZDW=N(1317.0, 2.0), S0=N(0.0872, 0.0012), Corr= -0.5

Legend:
- 1 segments: 1E-2=-2.41, 1E-3=-2.53, 1E-4=-2.60
- 2 segments: 1E-2=-2.29, 1E-3=-2.38, 1E-4=-2.45
- 3 segments: 1E-2=-2.24, 1E-3=-2.31, 1E-4=-2.37
- 4 segments: 1E-2=-2.21, 1E-3=-2.27, 1E-4=-2.32

Maximum dispersion @ 1310.19 nm

ZDW=N(1309.0, 2.0), S0=N(0.0872, 0.0012), Corr= -0.5

Legend:
- 1 segments: 1E-2=0.51, 1E-3=0.65, 1E-4=0.76
- 2 segments: 1E-2=0.39, 1E-3=0.49, 1E-4=0.57
- 3 segments: 1E-2=0.34, 1E-3=0.42, 1E-4=0.48
- 4 segments: 1E-2=0.31, 1E-3=0.38, 1E-4=0.43

Dispersion (ps/nm)	
Minimum	Maximum
-23.2	4.3

Comparing to the new available data

New valuable data presented in parsons_3dj_01_2403 includes:

- \> 1.6 million fibers
- Collected data 2014-2023, 10 years total
- 5 manufactures

Measured data with proposed model comparison. Normalized and single segment

1294.53 nm	Minimum D (ps/(nm*km))		
	parsons_3dj_01_2403	Proposed Model	Margin
99.99%	-2.38	-2.59	8.8%
99.9%	-2.27	-2.53	11.5%
99%	-2.14	-2.41	12.6%

| 1310.19 nm	Maximum D (ps/(nm*km))		
	parsons_3dj_01_2403	Proposed Model	Margin
99.99%	0.48	0.76	58.3%
99.9%	0.37	0.65	75.7%
99%	0.19	0.51	168%

Confidence level in the model results in 2 orders of magnitude higher confidence on real data shown in parsons_3dj_01_2403

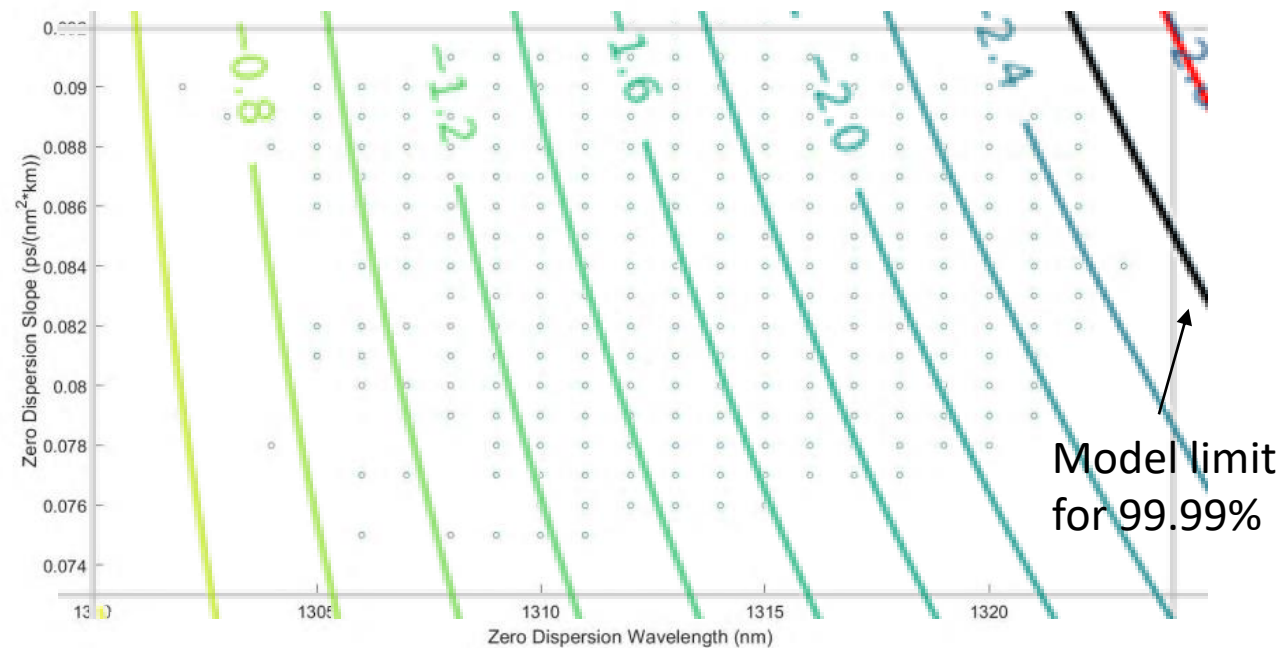Data shows model is very conservative on maximum dispersion

Overlapping parsons_3dj_01_2403 data with model 99.99% confidence single segment limit

Vast majority of fibers are found in a narrow wavelength and slope range
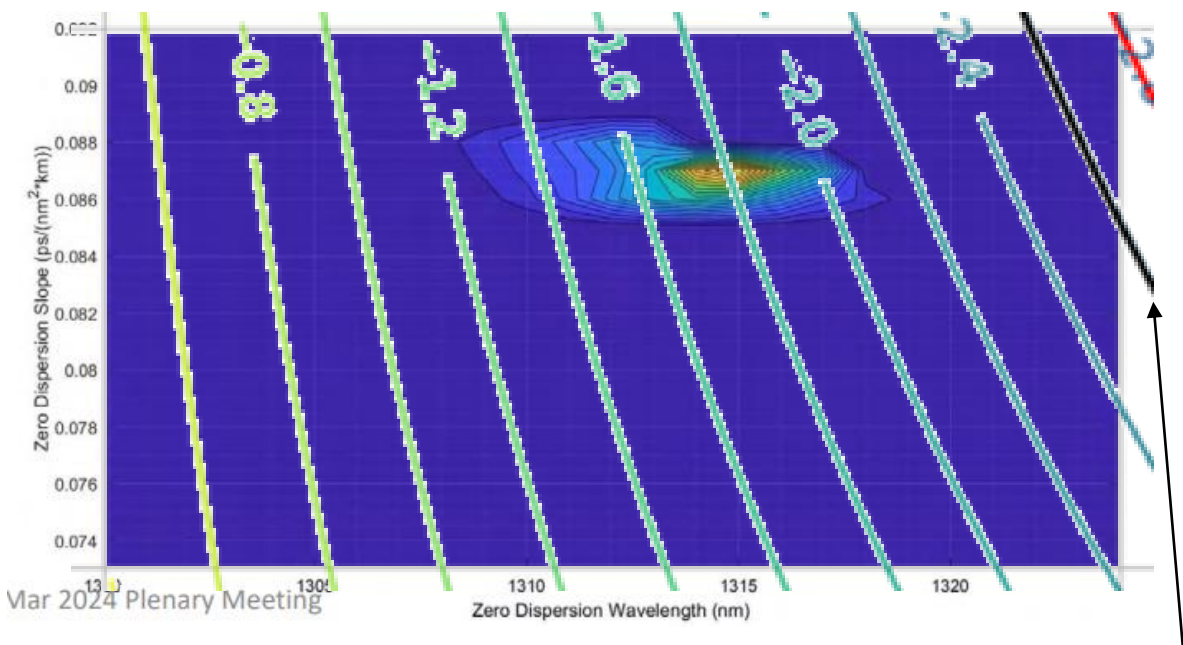
Fibers found with wide range of wavelength and slope values

Model limit for 99.99%

Model limit for 99.99%

Reminder of why we care about small CD reductions

- CD penalty is small until we get close to the edge (corresponding to a CD range limit of ~28 ps/nm)

- Small relieves on CD specs by focusing on 99.99% of the links can result in significant improvements on yield and cost reduction

- Current state of CM1, with its approximation error shown in rodes_3dj_01a_2401 and stassar_3dj_01a_2401 will drastically increase CD penalty at around -25ps/nm leading to unnecessary cost and yield fall out

rodes_3df_01c_2207
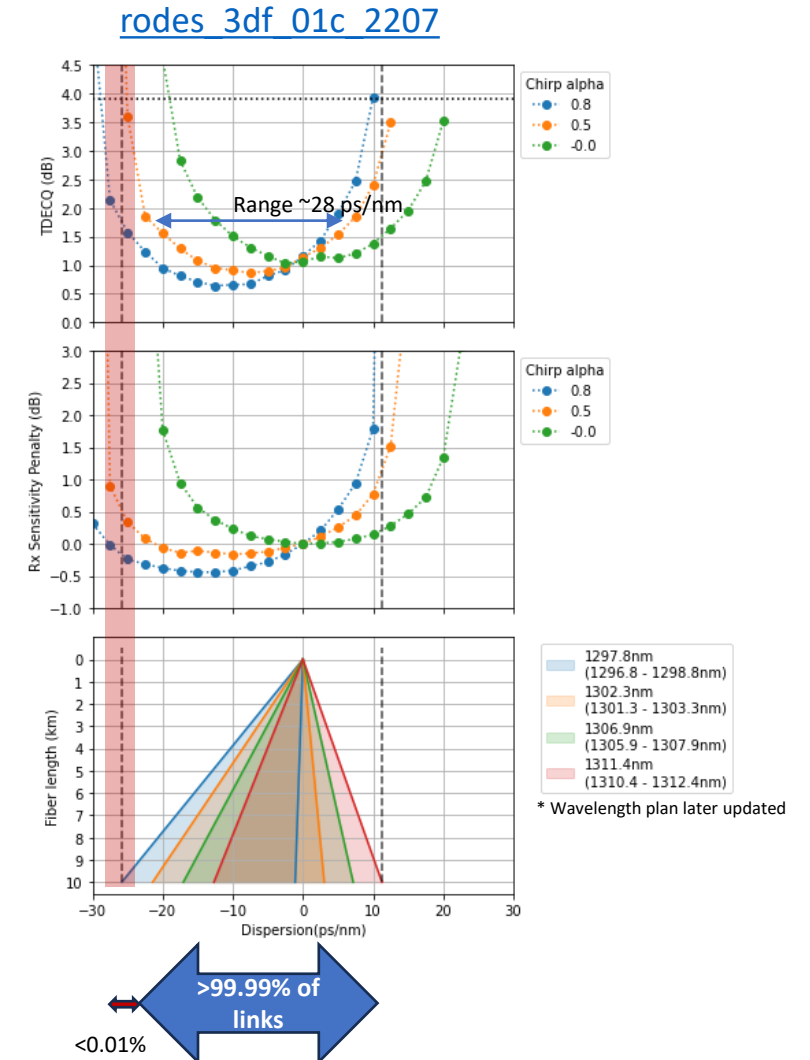
Summary

- This presentation updates the proposed optical channel model in rodes_3dj_optx_01a_240222 . The update increases the slope mean and reduces the slope standard deviation to accommodate concern during the last presentation resulting on more conservative distribution assumptions

- As previously asked during rodes_3dj_optx_01a_240222, we overlap the proposed model to the new available real measured data in castro_3dj_optx_01_240222 and parsons_3dj_01_2403, confirming the proposed model to be conservative based on the available data

- The authors recognize the ongoing effort by ITU of generating a statistical channel model IEEE can reference to (CM1). However, the known approximation errors described in the Liaison response and the pending analysis to be done by ITU makes current CM1 problematic for LR4 and future PMDs

- The values we have today are very conservative, and as we get more analysis and data including from ITU-T we will adjust them. However, today they represent the best starting point for the standard baseline.