

Chromatic Dispersion Analysis Regarding comment #208

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IEEE 802.3dj Interim

May 2024

Supporters

Overview

- This contribution provides an overview of the latest data set
- Chromatic dispersion accumulated over 1 km is evaluated at four extreme wavelengths
 - CWDM: 1264.5 and 1337.5 nm
 - LAN WDM: 1294.53 and 1310.19 nm
- Results from total data set as well as subsets are included
 - G.657.A1 fiber vs. G.657.A2 fiber
 - 200 and 250 micron cladding diameter
 - Each year from 2014-2024
 - Different manufacturers
- Future contributions will use this data set for modeling and to propose dispersion values for channel model for FR4 and LR4

Information about the data set

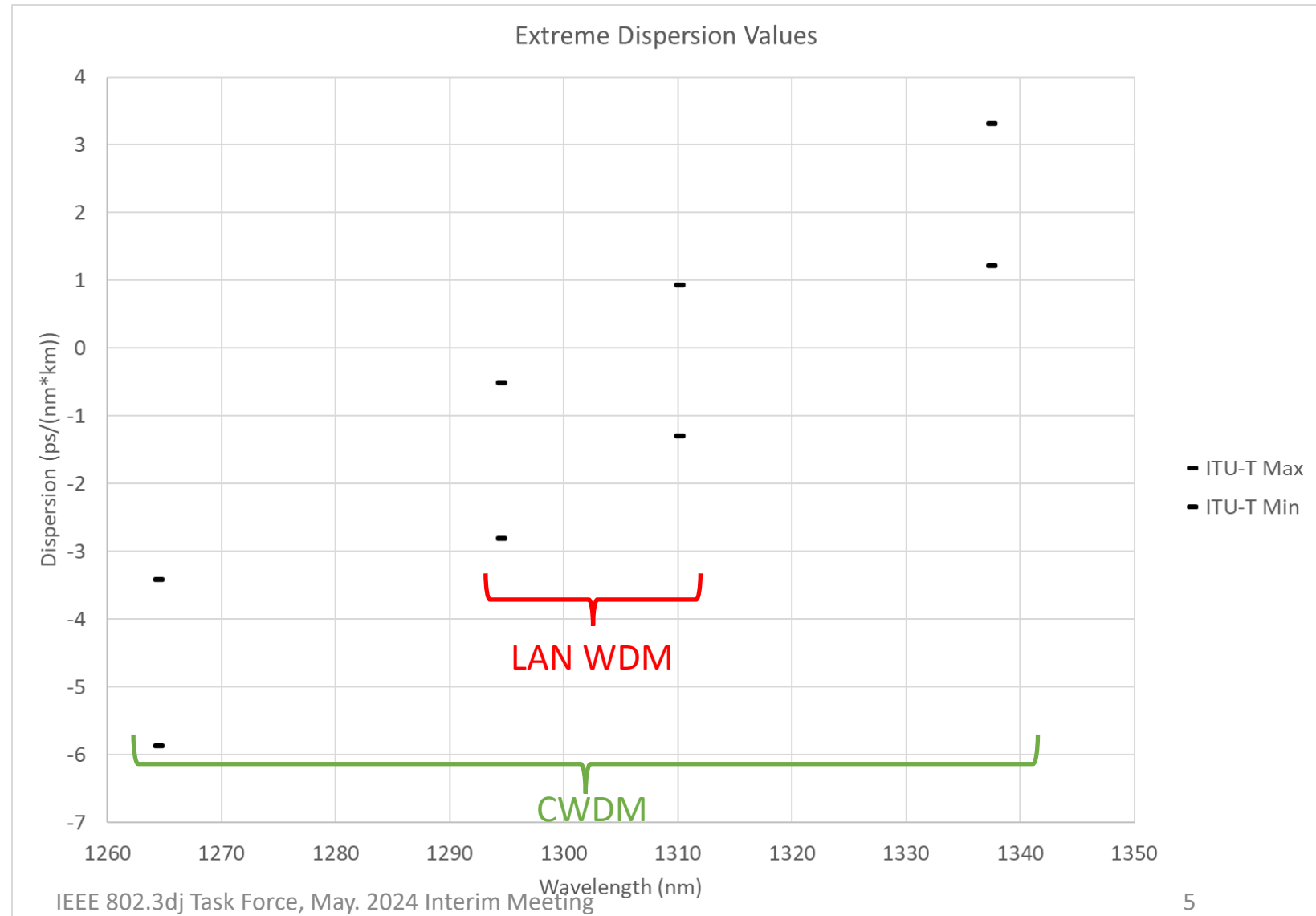
- This data set includes >2.5 million fibers
- Fibers compliant to ITU-T standards
 - G.652.D/G.657.A1
 - G.657.A2
- Fibers were shipped from 2013-2024
- Six manufacturers are included with factories in North America, Europe, and Asia (including China)
- Of top 10 global fiber manufacturers (weighted by market share)
 - This data set covers 64% of top 10 market
 - ITU-T data set covers 68% of top 10 market

Extreme dispersion values allowed by ITU-T standards

- Slope:
 $0.092 \text{ ps}/(\text{nm}^2 \cdot \text{km})$

- Lambda0:
1300 or 1324 nm

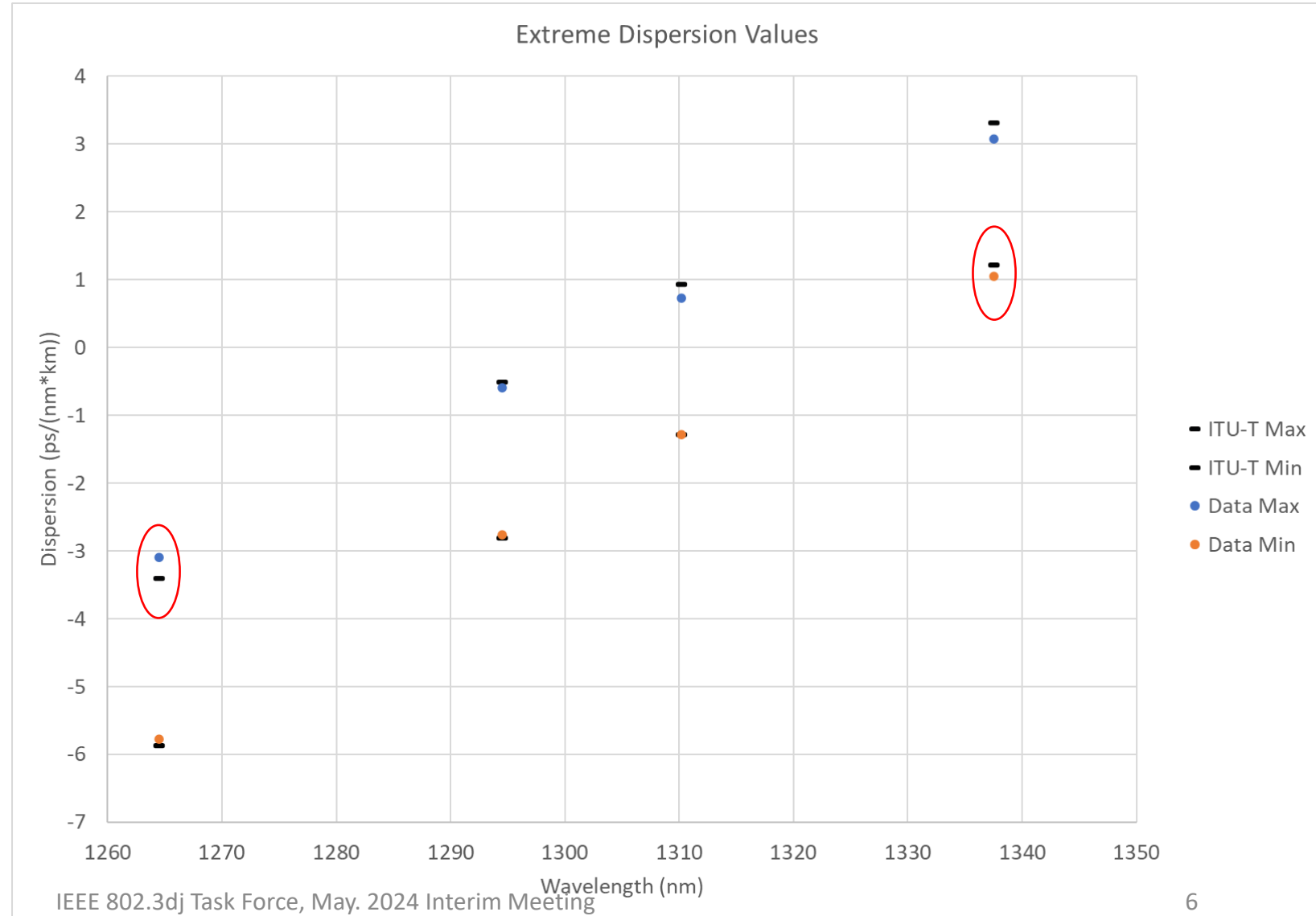
Note:
Dispersion over 1 km



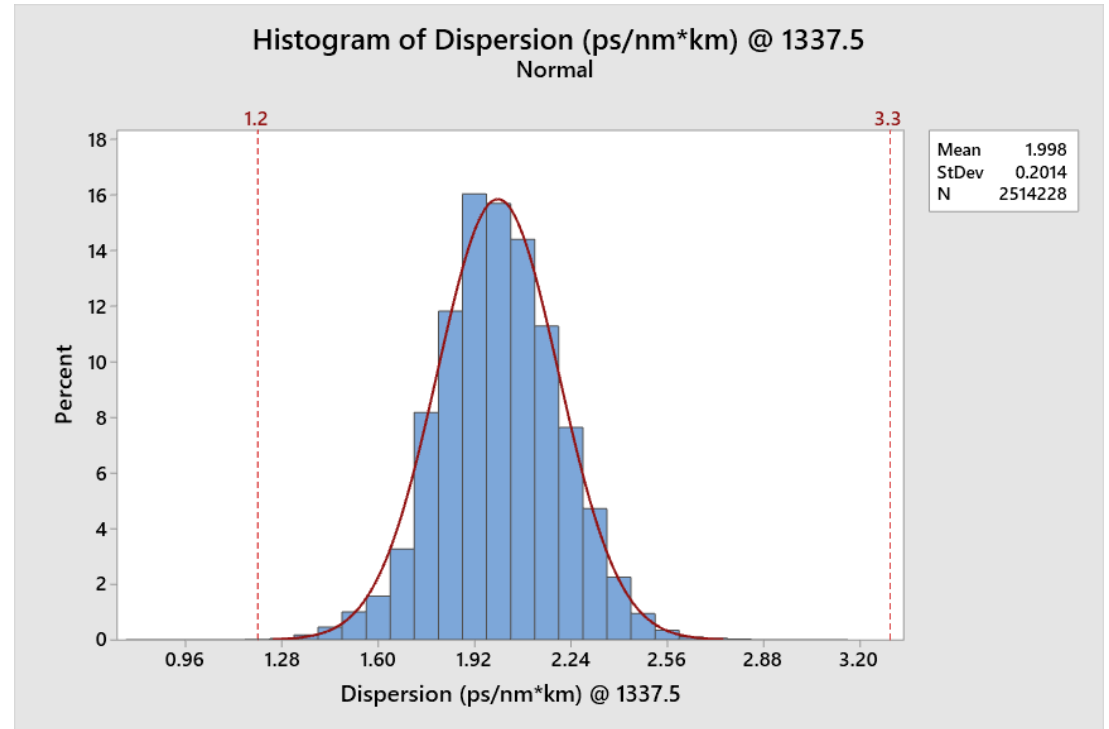
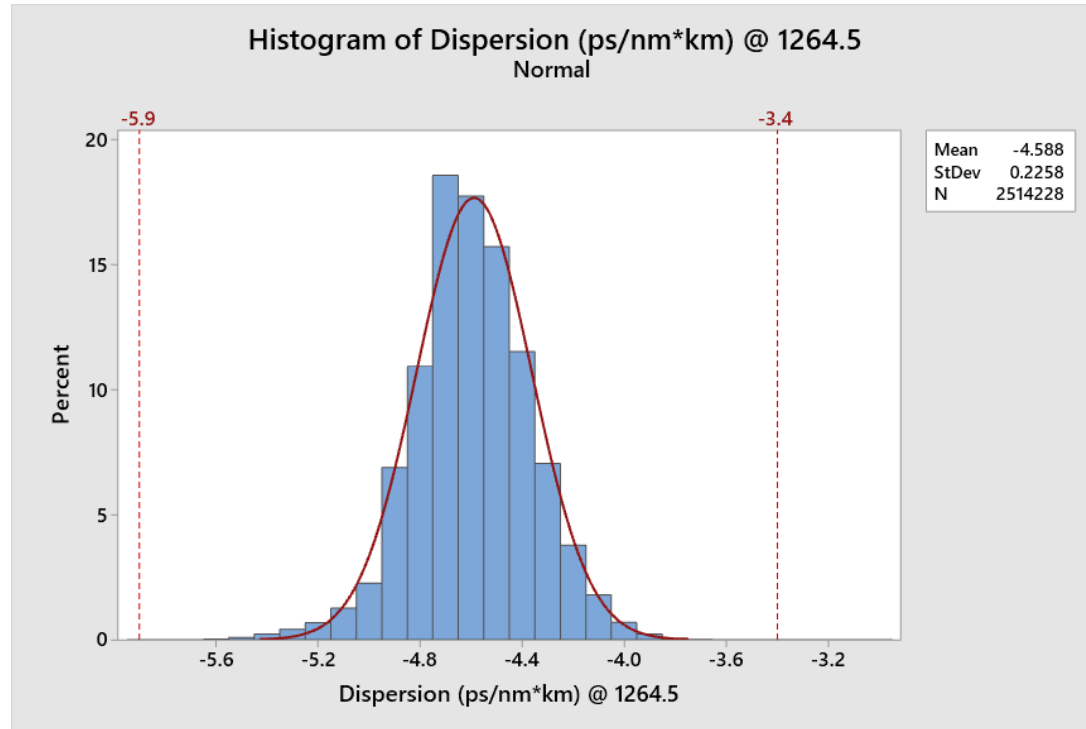
Most extreme dispersion values from the entire data set

	Min	Max
Lambda0	1302	1324.2
Slope0	0.074	0.092

- A small number of fibers in data set have values outside ITU-T values at CWDM wavelengths
- Occurs with extreme zero dispersion wavelengths and smaller slopes

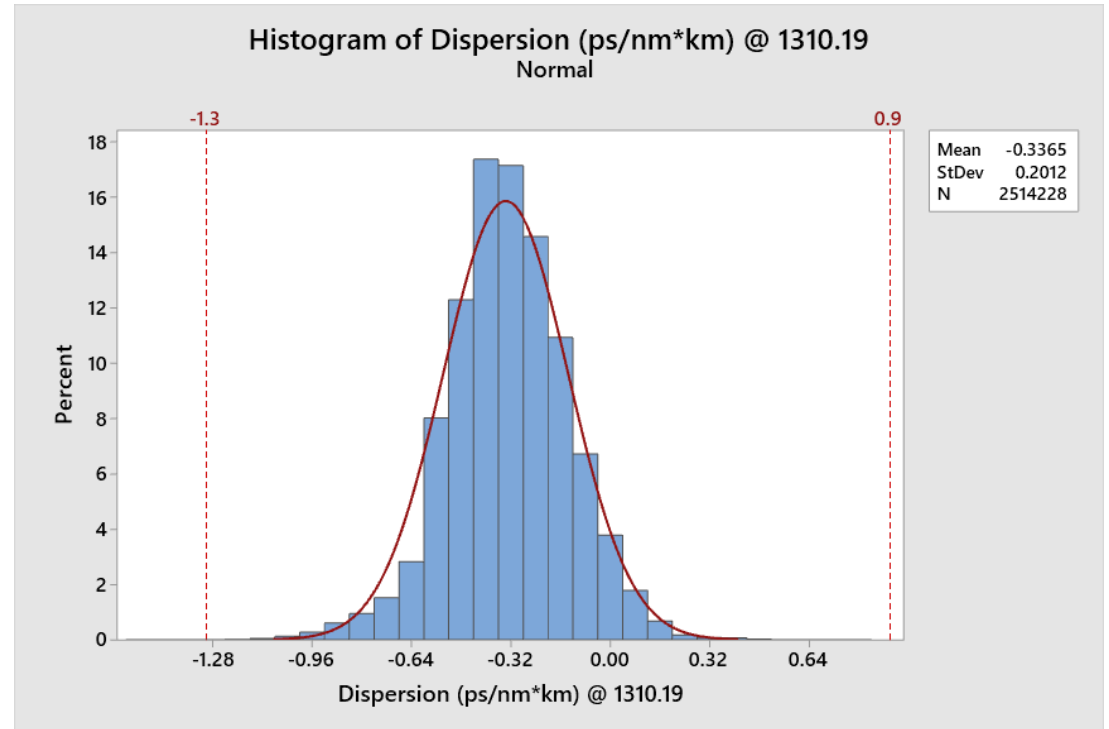
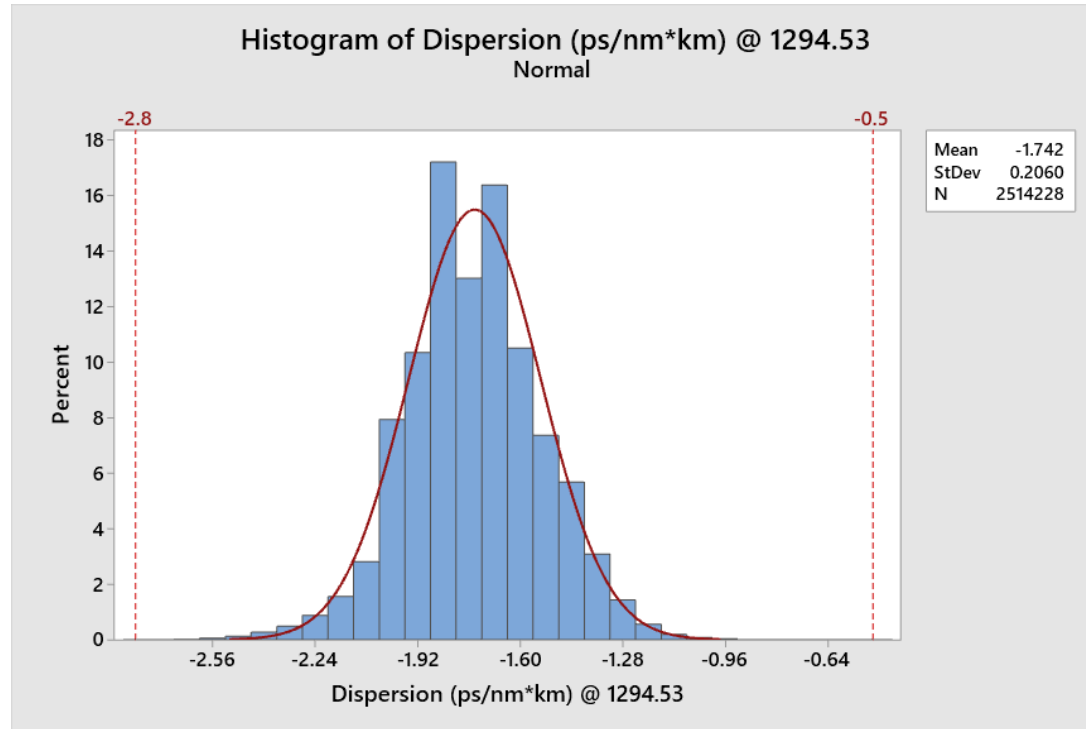


Histograms for CWDM wavelengths at 1 km with entire data set



- Fit to normal distribution
- Most values well within extreme cases (red lines)

Histograms for LAN WDM wavelengths at 1 km with entire data set

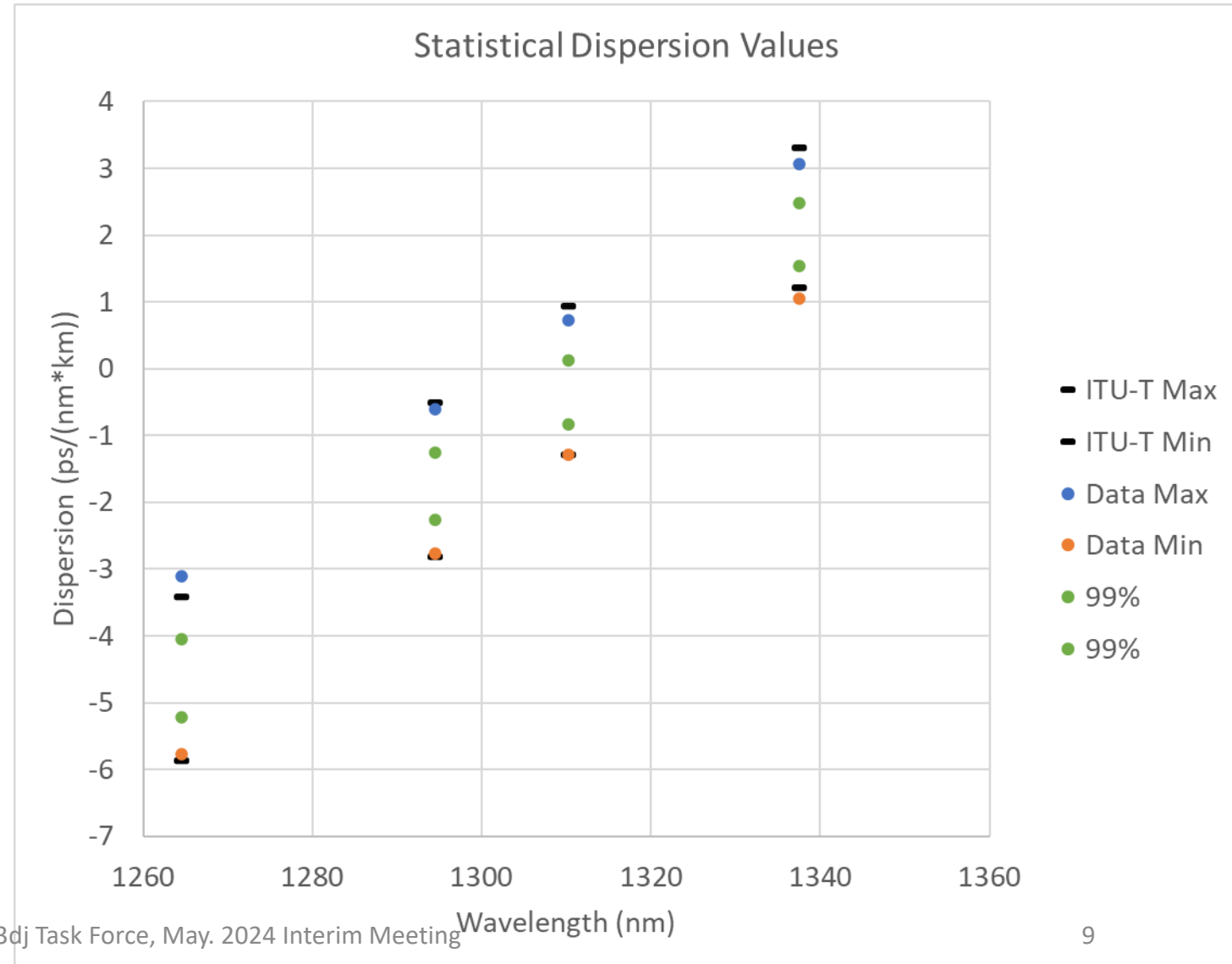


- Fit to normal distribution
- Most values well within extreme cases (red lines)

Statistics of entire data set

	CWDM	
	1264.5	1337.5
ITU-T Max	-3.41	3.31
Data Max	-3.1	3.07
99.999%	-3.58	2.84
99.99%	-3.75	2.8
99.9%	-3.88	2.66
99%	-4.05	2.48
99%	-5.21	1.53
99.9%	-5.47	1.36
99.99%	-5.6	1.23
99.999%	-5.69	1.11
Data Min	-5.77	1.05
ITU-T Min	-5.87	1.22

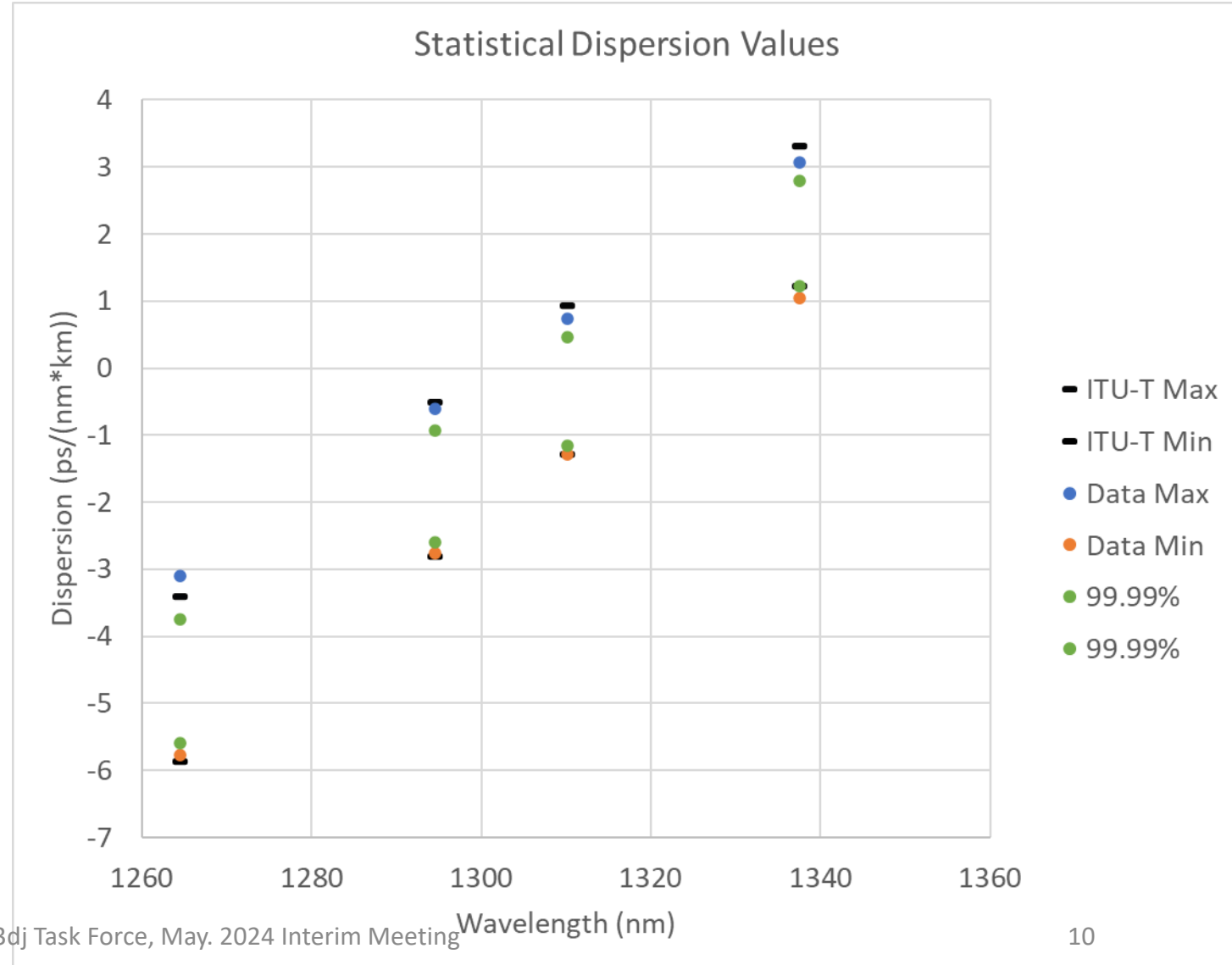
	LAN-WDM	
	1294.53	1310.19
ITU-T Max	-0.51	0.93
Data Max	-0.6	0.73
99.999%	-0.88	0.51
99.99%	-0.93	0.47
99.9%	-1.05	0.35
99%	-1.26	0.13
99%	-2.27	-0.84
99.9%	-2.49	-1.03
99.99%	-2.6	-1.15
99.999%	-2.7	-1.23
Data Min	-2.76	-1.28
ITU-T Min	-2.81	-1.29



Statistics of entire data set (continued)

	CWDM	
	1264.5	1337.5
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99.9%	-3.88	2.66
99%	-4.05	2.48
9%	-5.21	1.53
99.9%	-5.47	1.36
99.99%	-5.6	1.23
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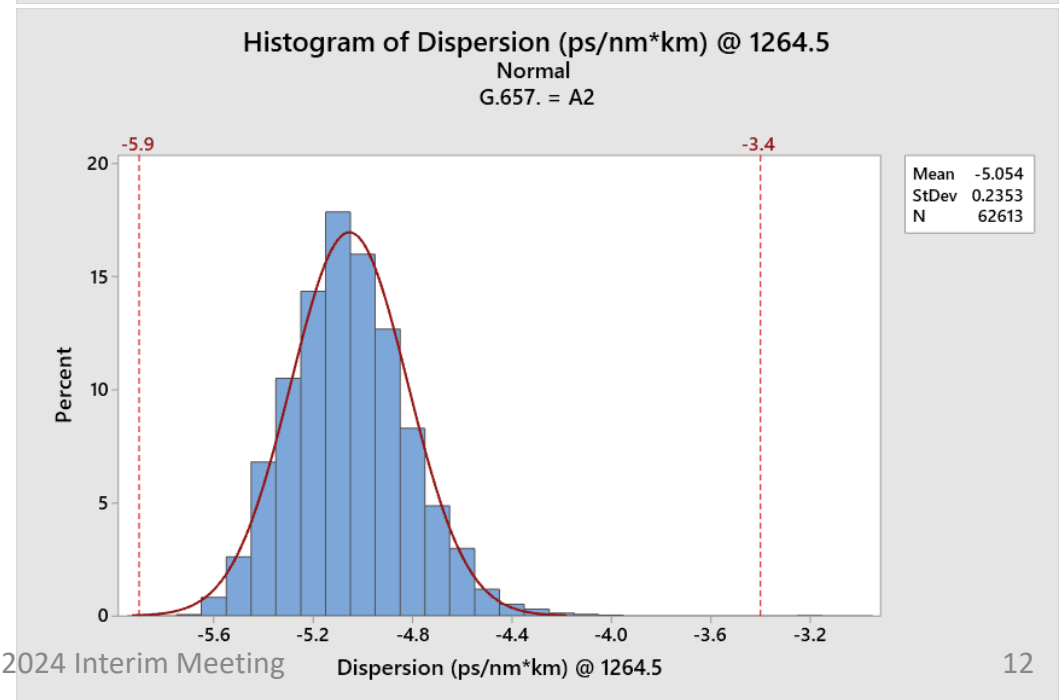
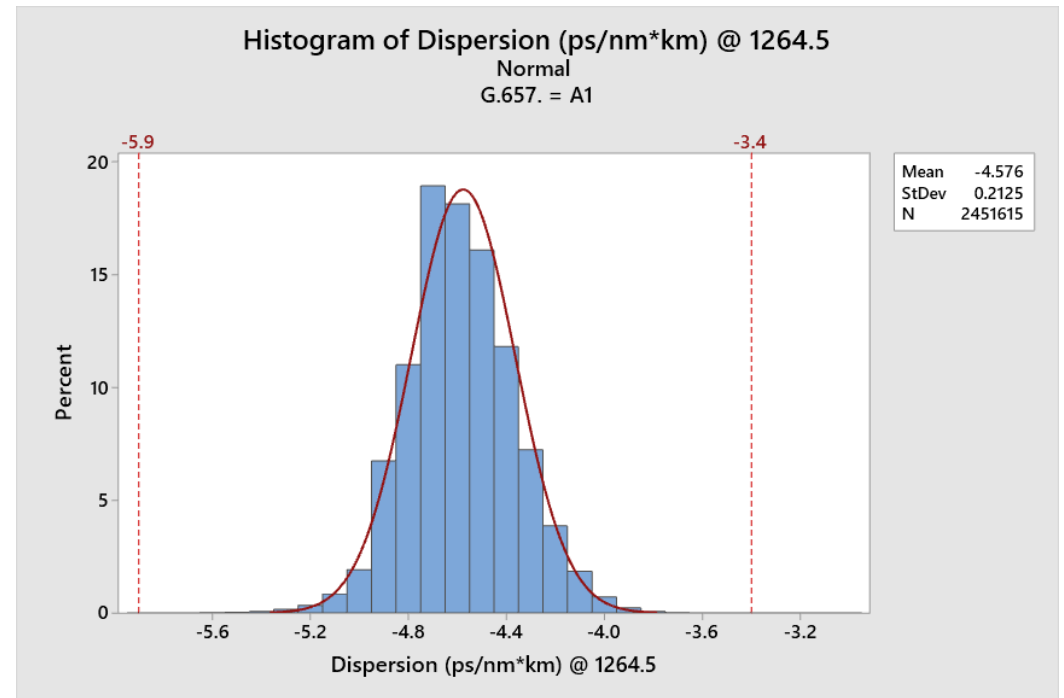


Compare dispersion values for different subsets

- Look at 99% values for subsets of entire data set
 - Since different subsets have different numbers of fibers, doesn't make sense to look at 99.99%
 - Want to avoid “chasing noise”
- Subsets considered
 - A1 and A2 fiber
 - 200 and 250 micron cladding diameter
 - Different manufacturing years
 - Different manufacturers
- Focus on dispersion values at CWDM wavelengths since they provide largest variation
 - 1264.5 nm (most negative)
 - 1337.5 nm (most positive)

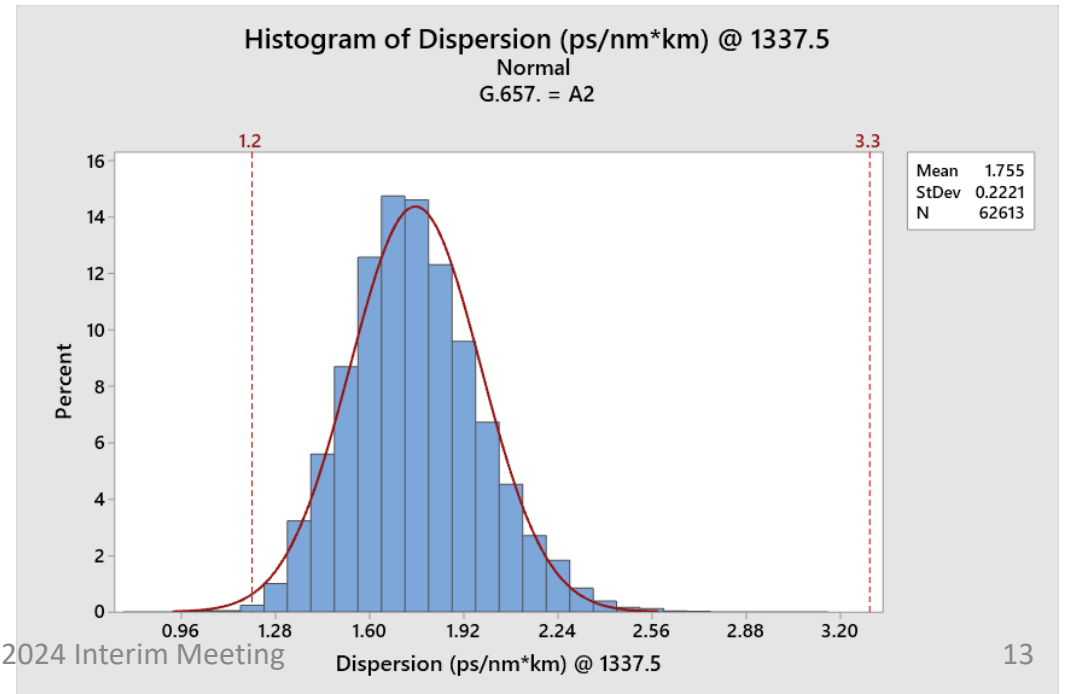
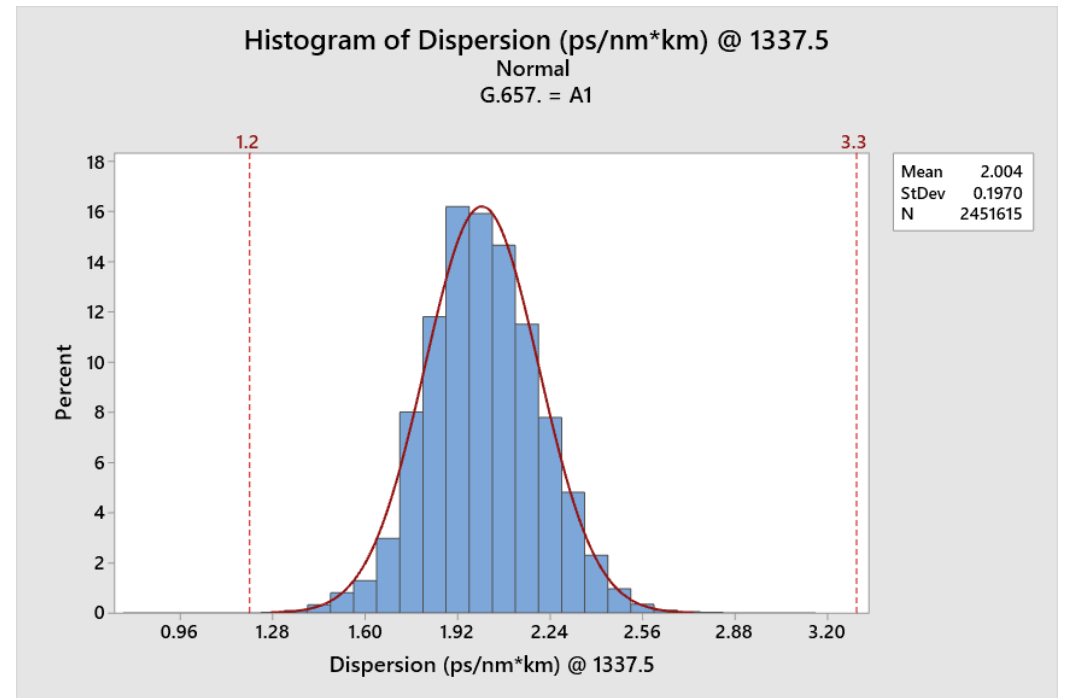
Compare G.657.A1 to G.657.A2 fiber

- Both A1 and A2 are bend-insensitive
- A2 has smaller bend radius
- Top graph has G.652.D/G.657.A1
- A2 fiber is newer, lower volume, and usually used in inside plant
- Similar standard deviation, A2 has mean that is more negative

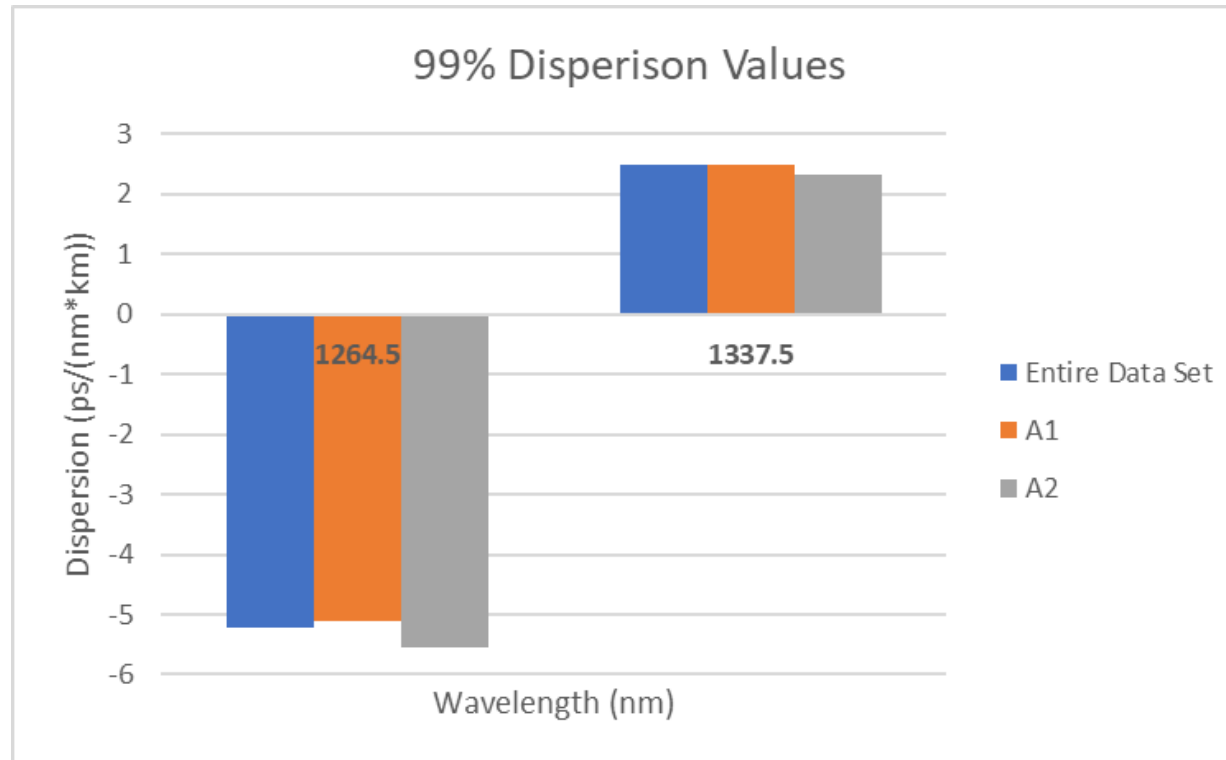


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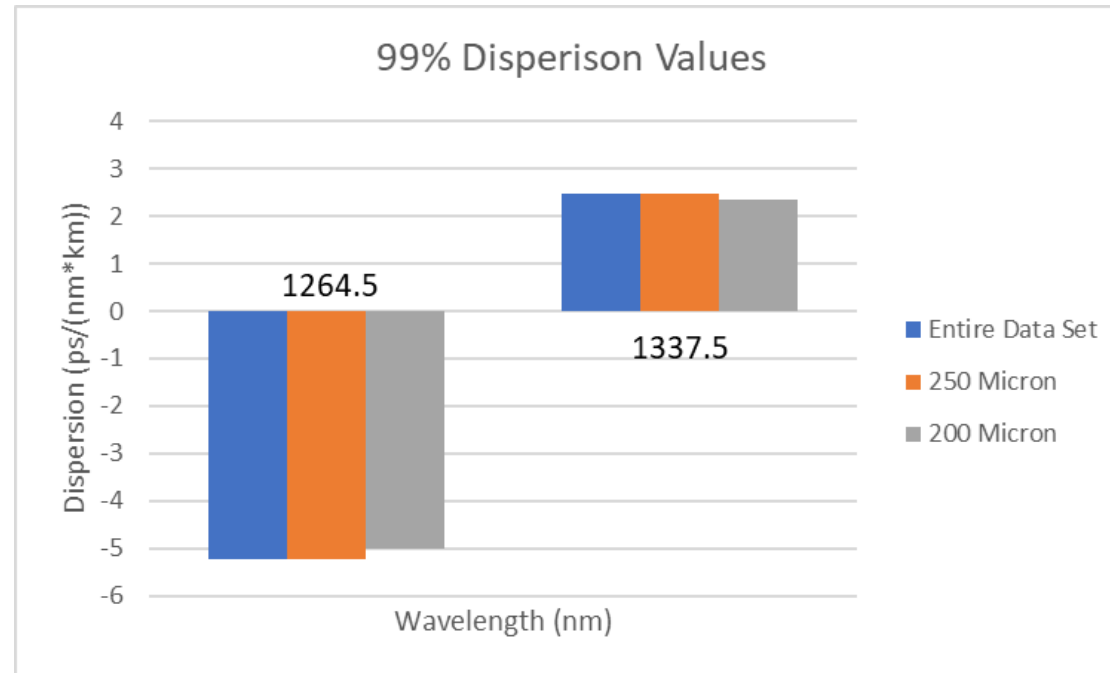


G.657.A1 vs .A2 fibers



- Distributions for .A2 fiber shifted more negative than .A1 fiber
- Fewer .A2 than .A1 fibers

250 vs. 200 micron cladding diameter

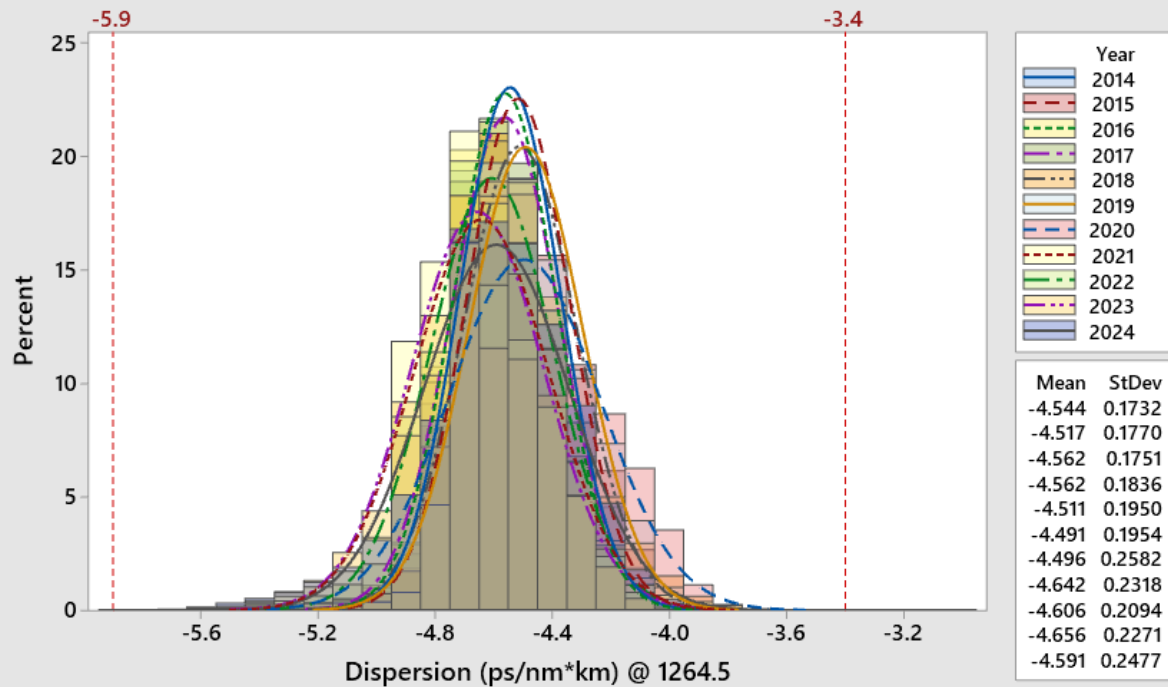


- 200 micron cladding is a new option for reduced cable size
- Dispersion slightly better for 200 micron

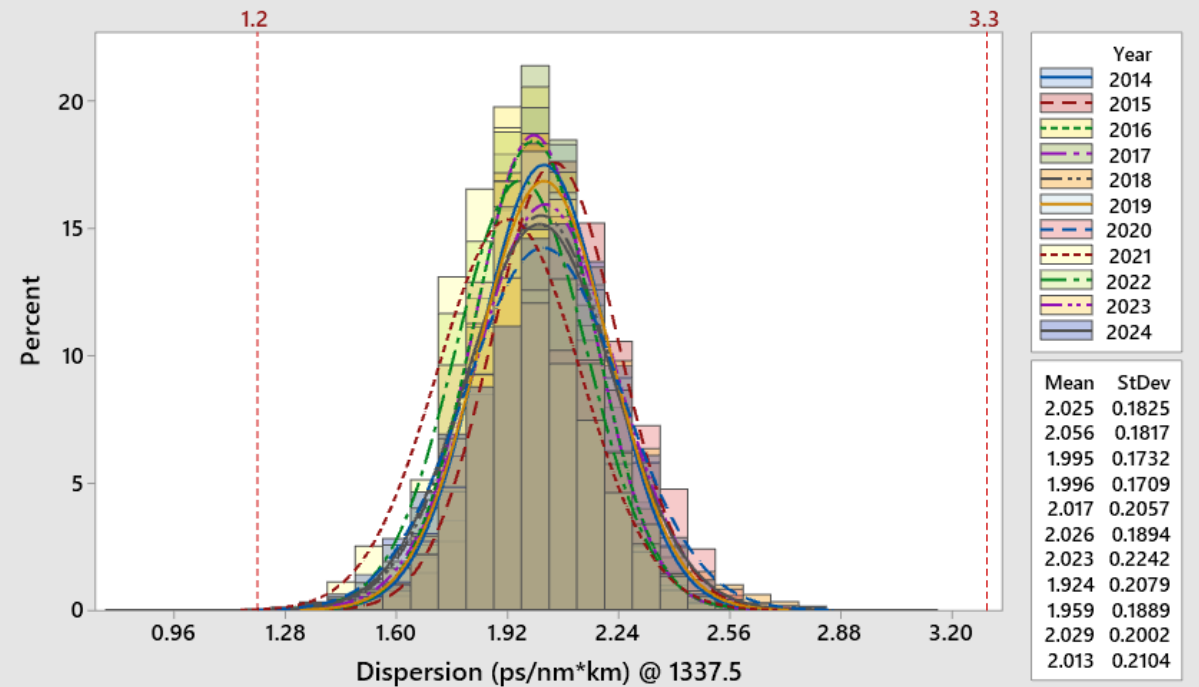
Dispersion values over time

- Little change over the years

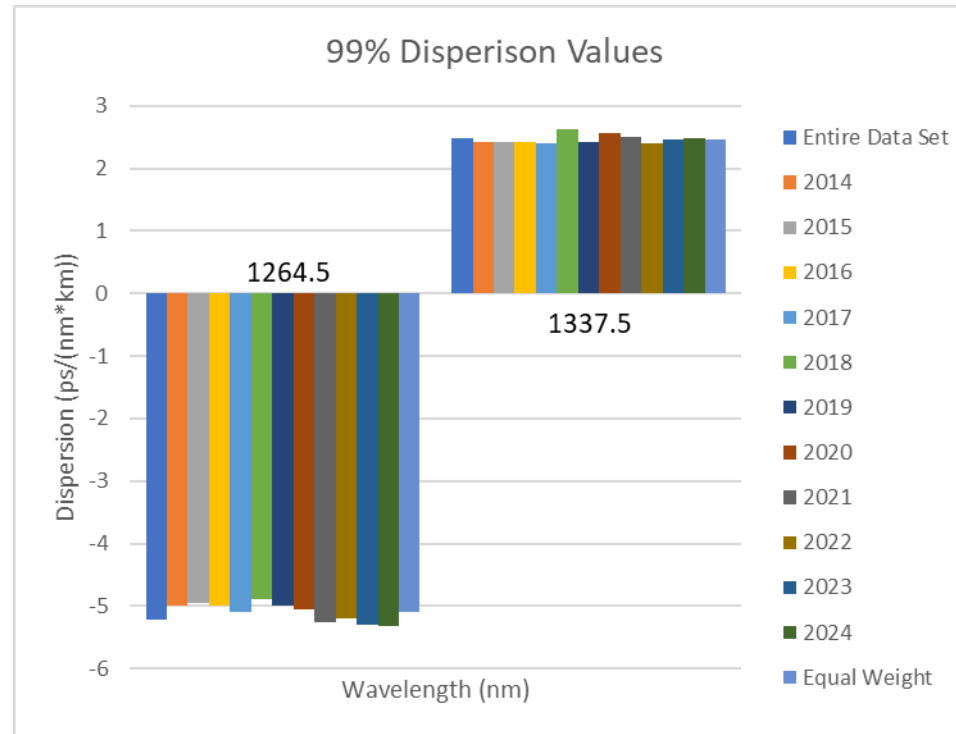
Histogram of Dispersion (ps/nm*km) @ 1264.5
Normal



Histogram of Dispersion (ps/nm*km) @ 1337.5
Normal

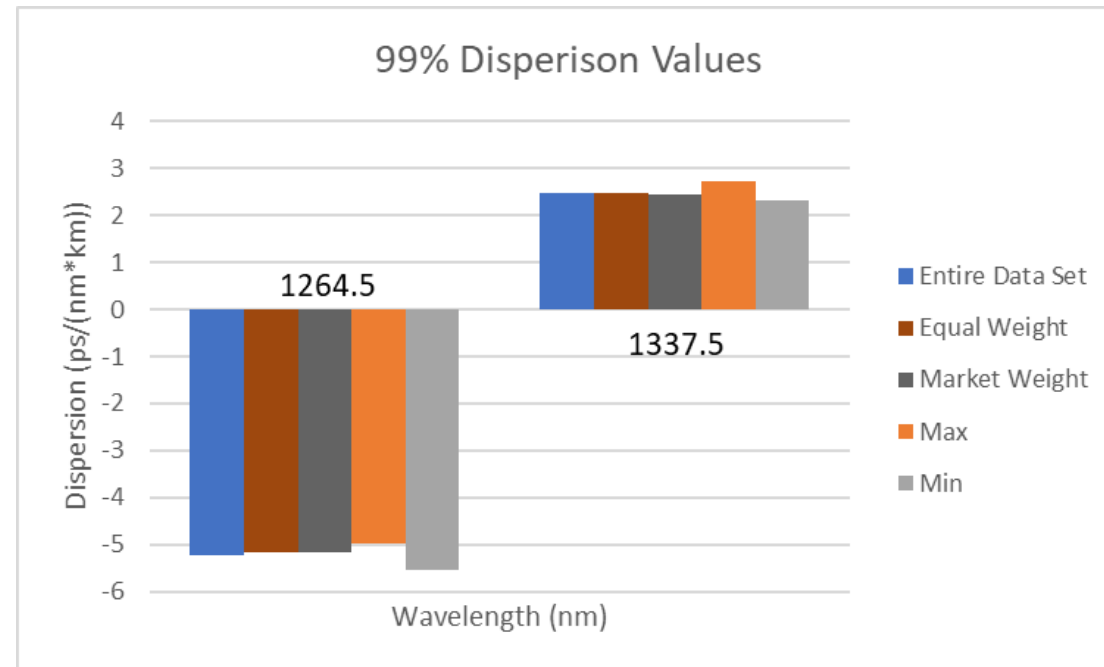


Dispersion values over time



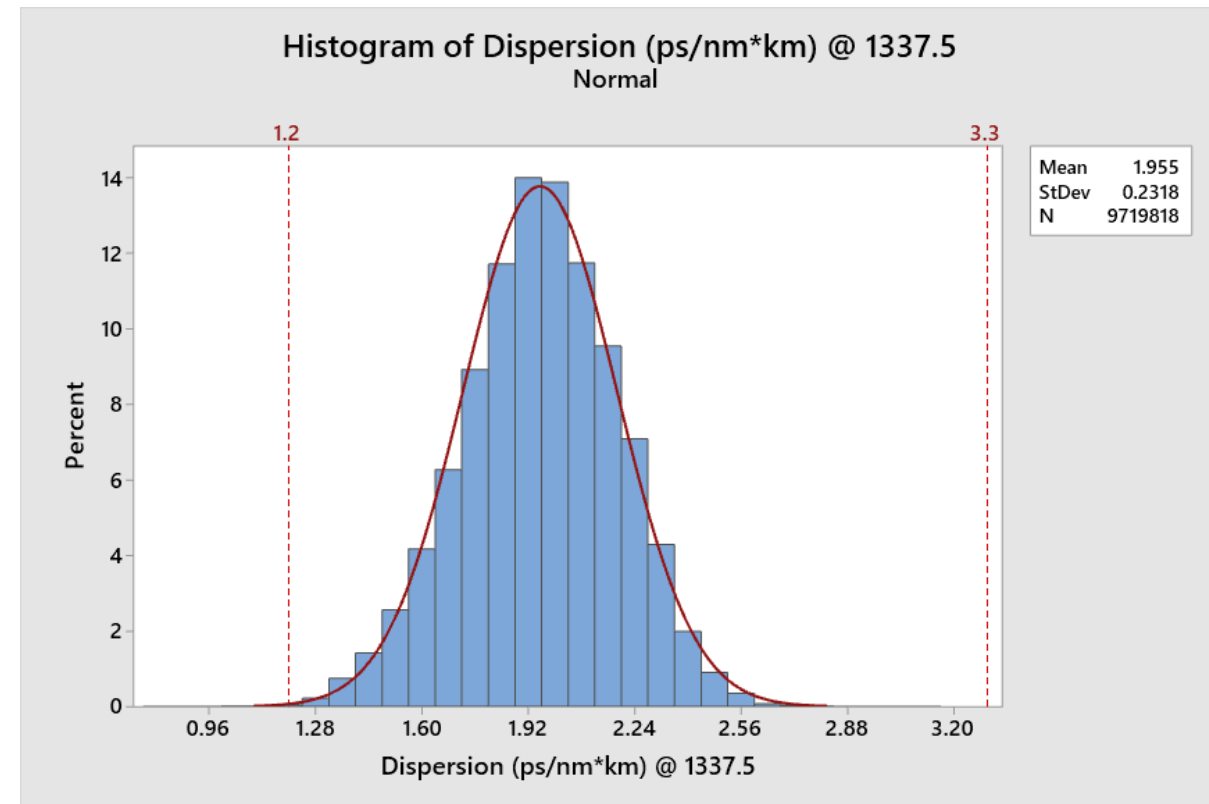
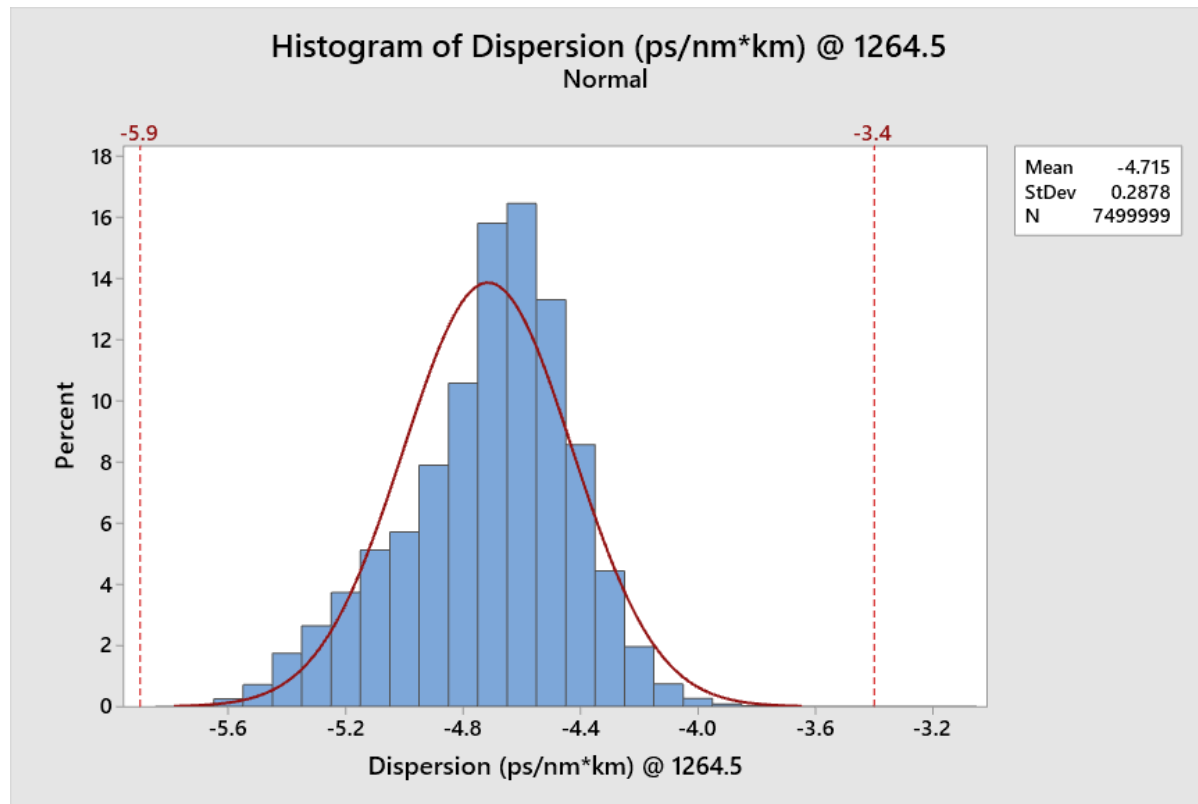
- Small variations over time
- Recent years have higher percentage of A2
- No obvious trend preventing models developed around current fibers being used over fibers manufactured in last 10 years

Dispersion parameters by different manufacturers



- Include values when weighing sources equally or by market share
- Max and min of manufacturers
- A1/A2 mix varies by manufacturer

Entire data set histogram weighted by market share



An easy process to compare other fiber data to this data set

- We are a “contribution driven organization”. If you feel that this data set is missing key data, please present the missing data at a future meeting.
- Collect zero dispersion wavelength (λ_0) and slope (S_0) pairs
 - Treating wavelength and slope as independent variable is too conservative
- Calculate dispersion over 1 km at 1264.5 nm and 1337.5 nm for each fiber
 - $D = 1264.5 * \frac{S_0}{4} \left(1 - \left(\frac{\lambda_0}{1264.5} \right)^4 \right)$
 - $D = 1337.5 * \frac{S_0}{4} \left(1 - \left(\frac{\lambda_0}{1337.5} \right)^4 \right)$
- Find mean, standard deviation, and 99% value of dispersion values and compare to values in this contribution

Conclusions

- Latest fiber data set was reviewed
- Presented statistics for entire data set and subsets
- This data set represents a significant portion of the fiber market
- This data set can be used to develop models and determine dispersion parameters for 800G-FR4 and 800G-LR4