Chromatic Dispersion Analysis Regarding comment #208

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IEEE 802.3dj Interim

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Supporters

- Frank Effenberger, Futurewei
- Ryan Yu, Innolight
- Mark Kamber, Semtech
- John Johnson, Broadcom
- Roberto Rodes, Coherent
- Nobuhiko Kikuchi, Hitachi
- Eric Maniloff, Ciena
- Angie Lambert, Corning
- Vince Ferretti, Corning

Overview

- This contribution provides an overview of the latest data set
- Chromatic dispersion accumulated over 1 km is evaluated at four extreme wavelengths
  - 800G-FR4: 1264.5 and 1337.5 nm
  - 800G-LR4: 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 coating 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:

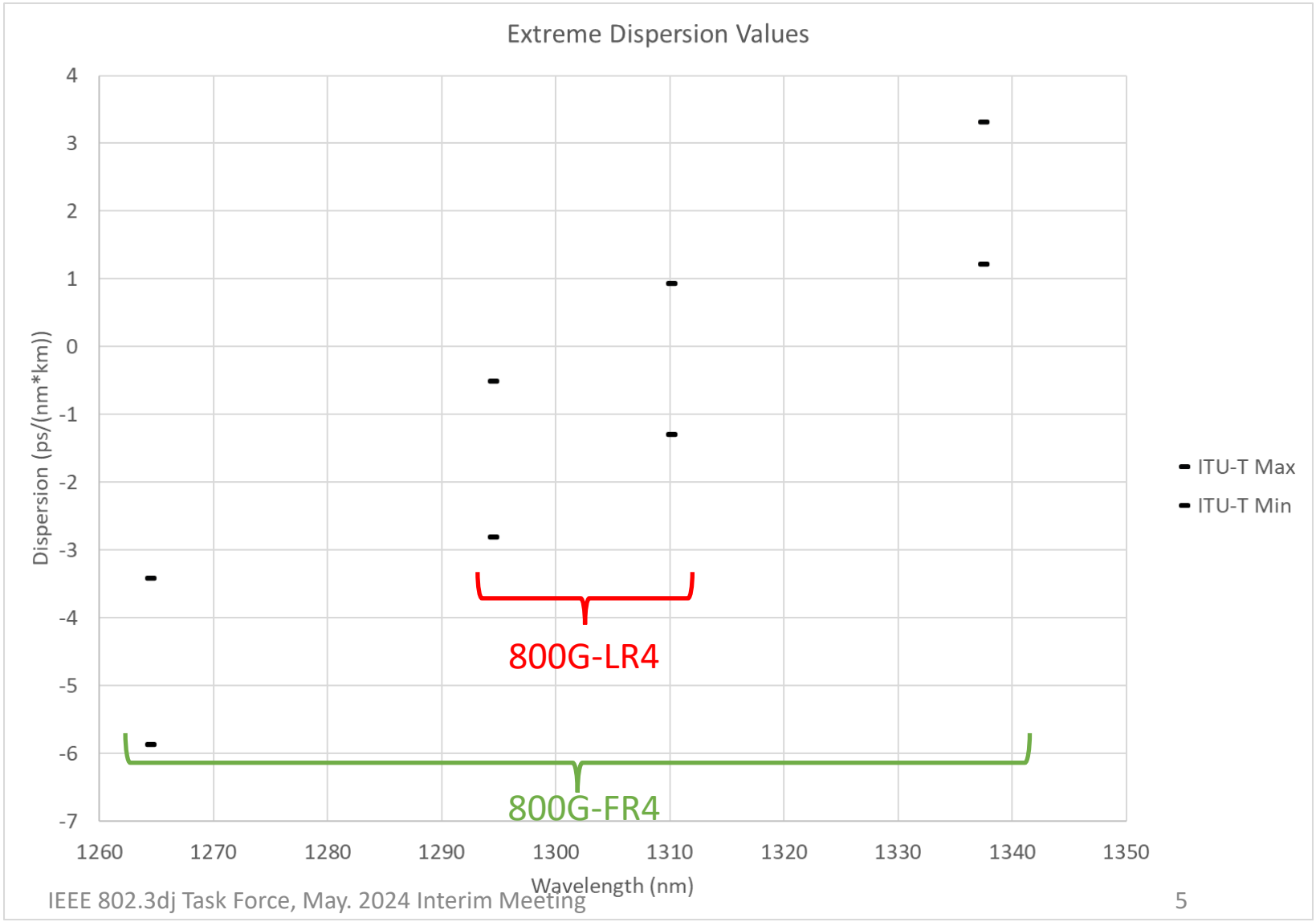
0.092 ps/(nm^2*km)

- Lambda0:

1300 or 1324 nm

Note:

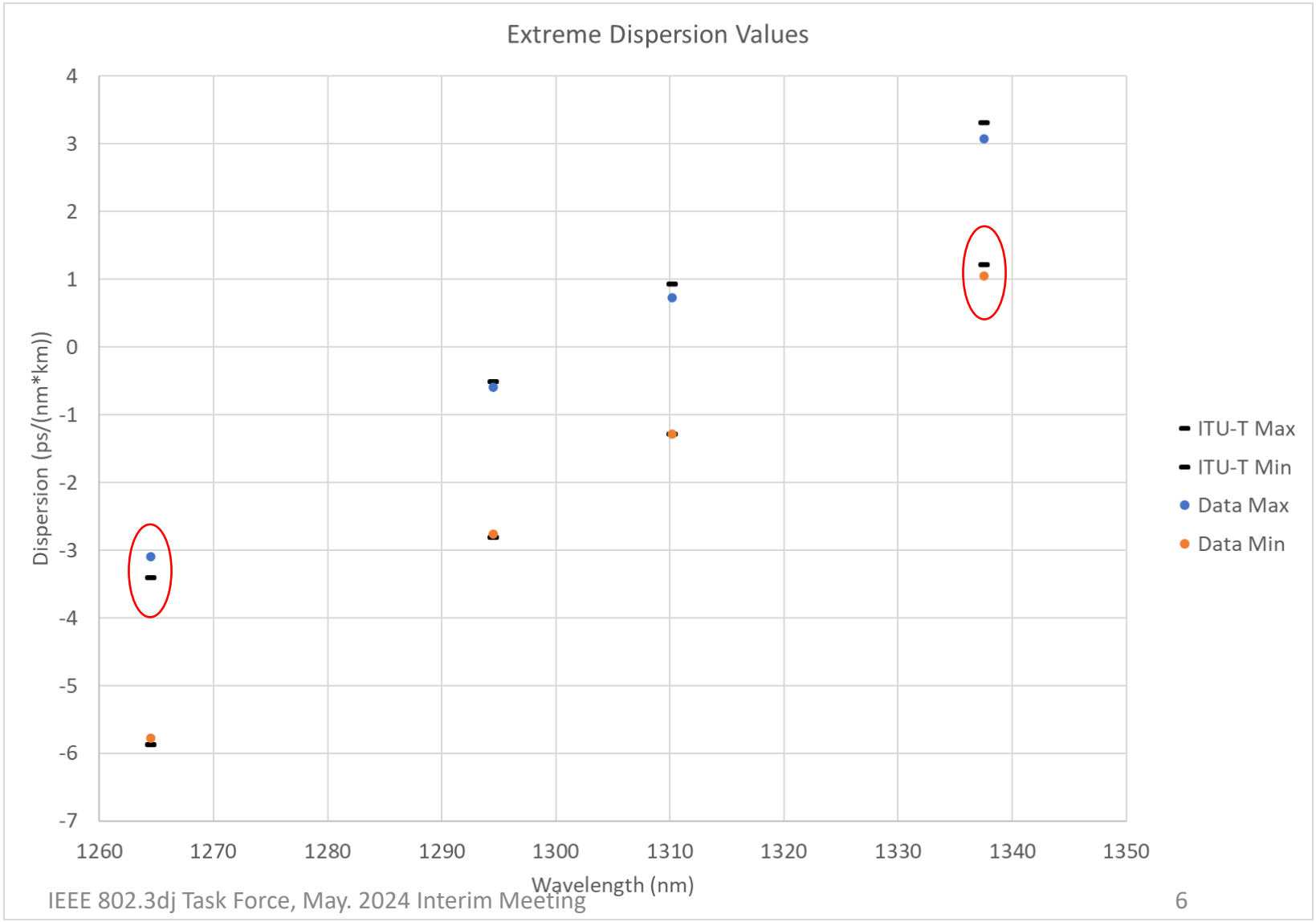
Dispersion over 1 km



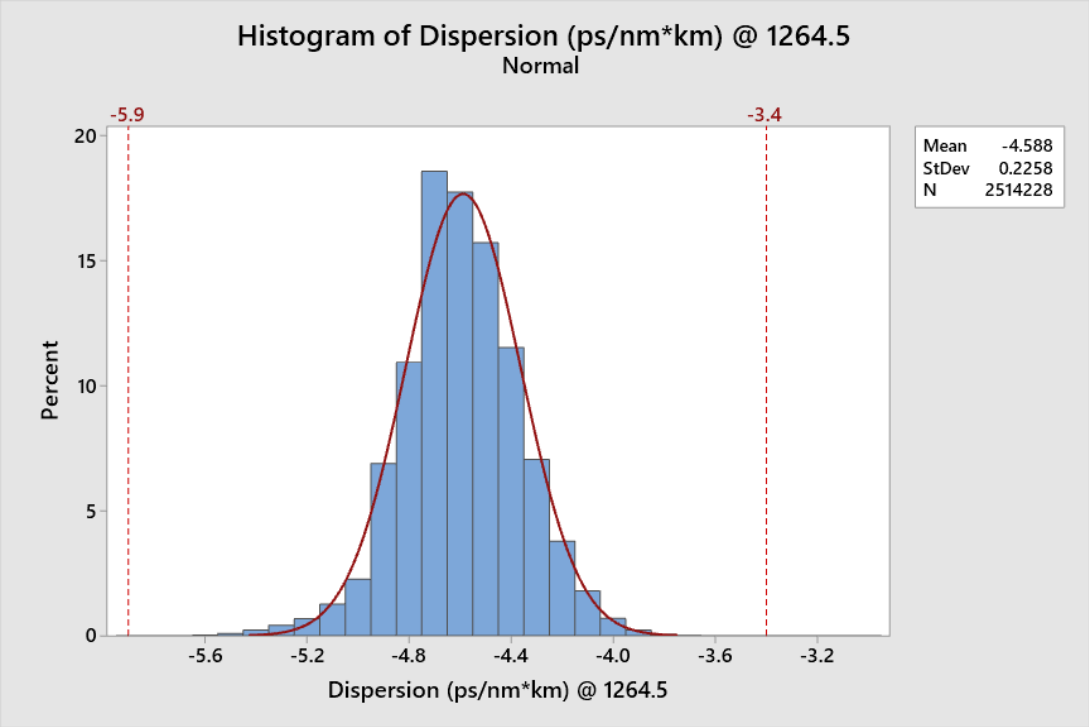
Most extreme dispersion values from the entire data set

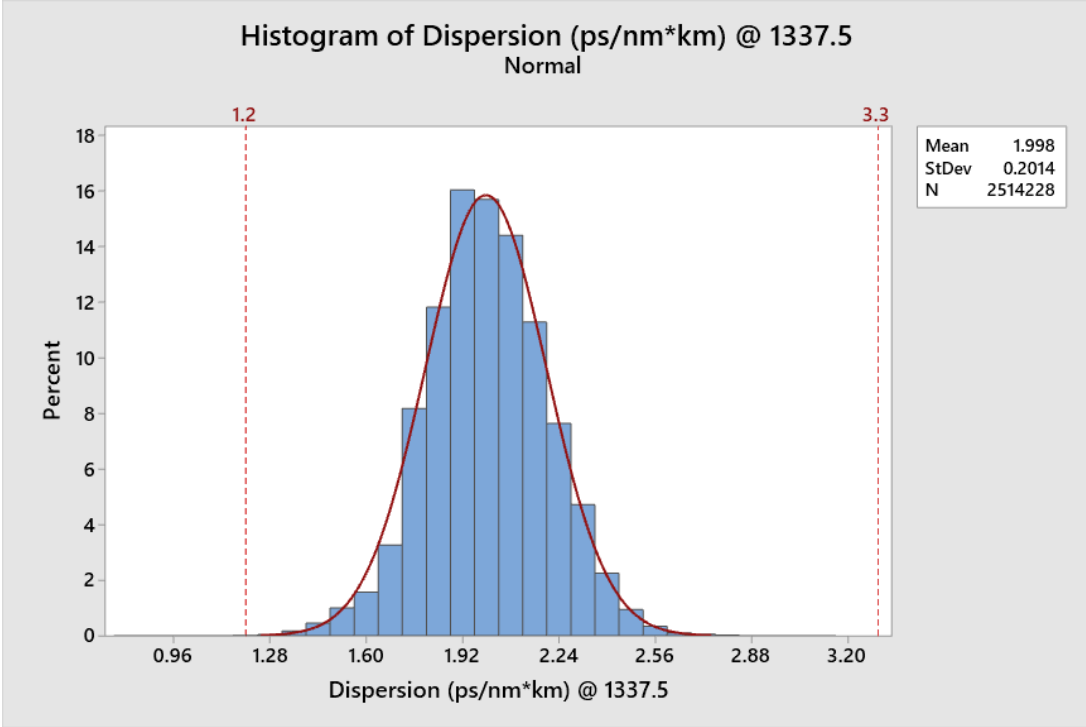
	Min	Max
Lambda0	1302	1324.2
Slope0	0.074	0.092

- A small number of fibers in data set have values outside ITU-T values at 800G-FR4 wavelengths
- Occurs with extreme zero dispersion wavelengths and smaller slopes



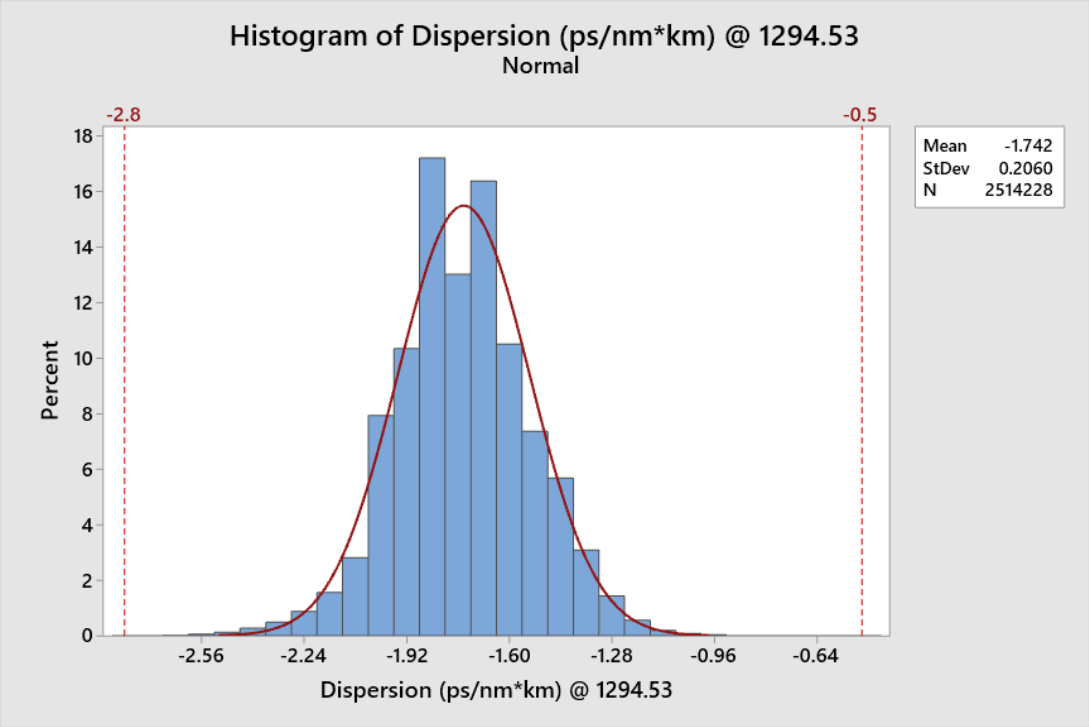
Histograms for 800G-FR4 wavelengths at 1 km with entire data set

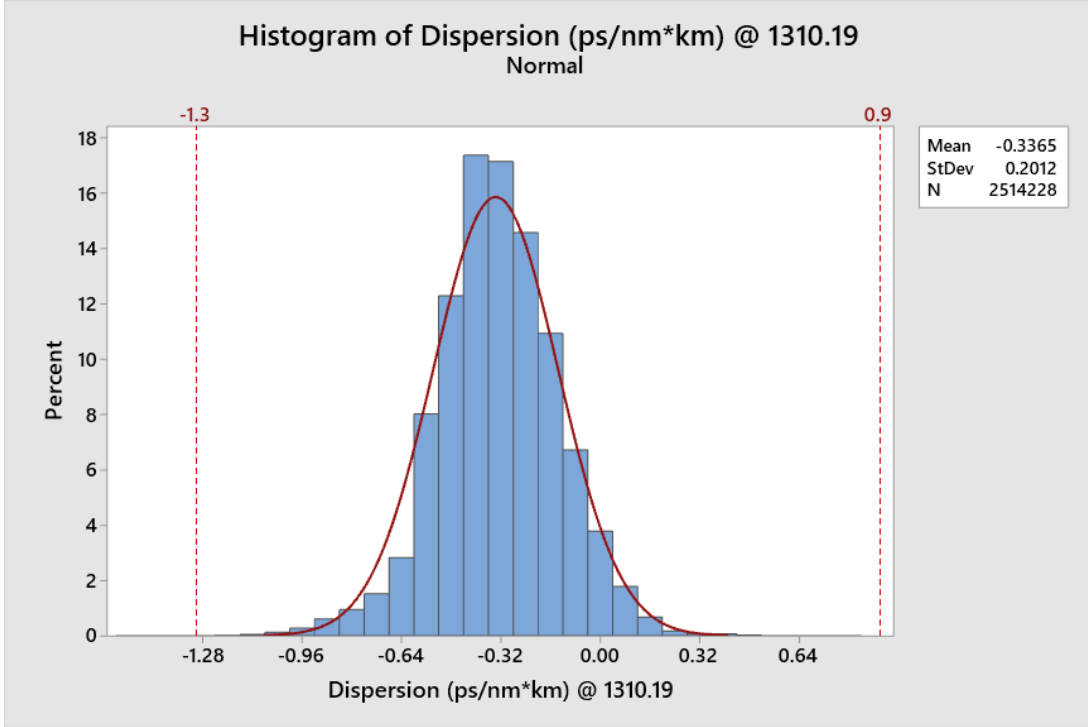




- Fit to normal distribution
- Most values well within extreme cases (red lines)

Histograms for 800G-LR4 wavelengths at 1 km with entire data set





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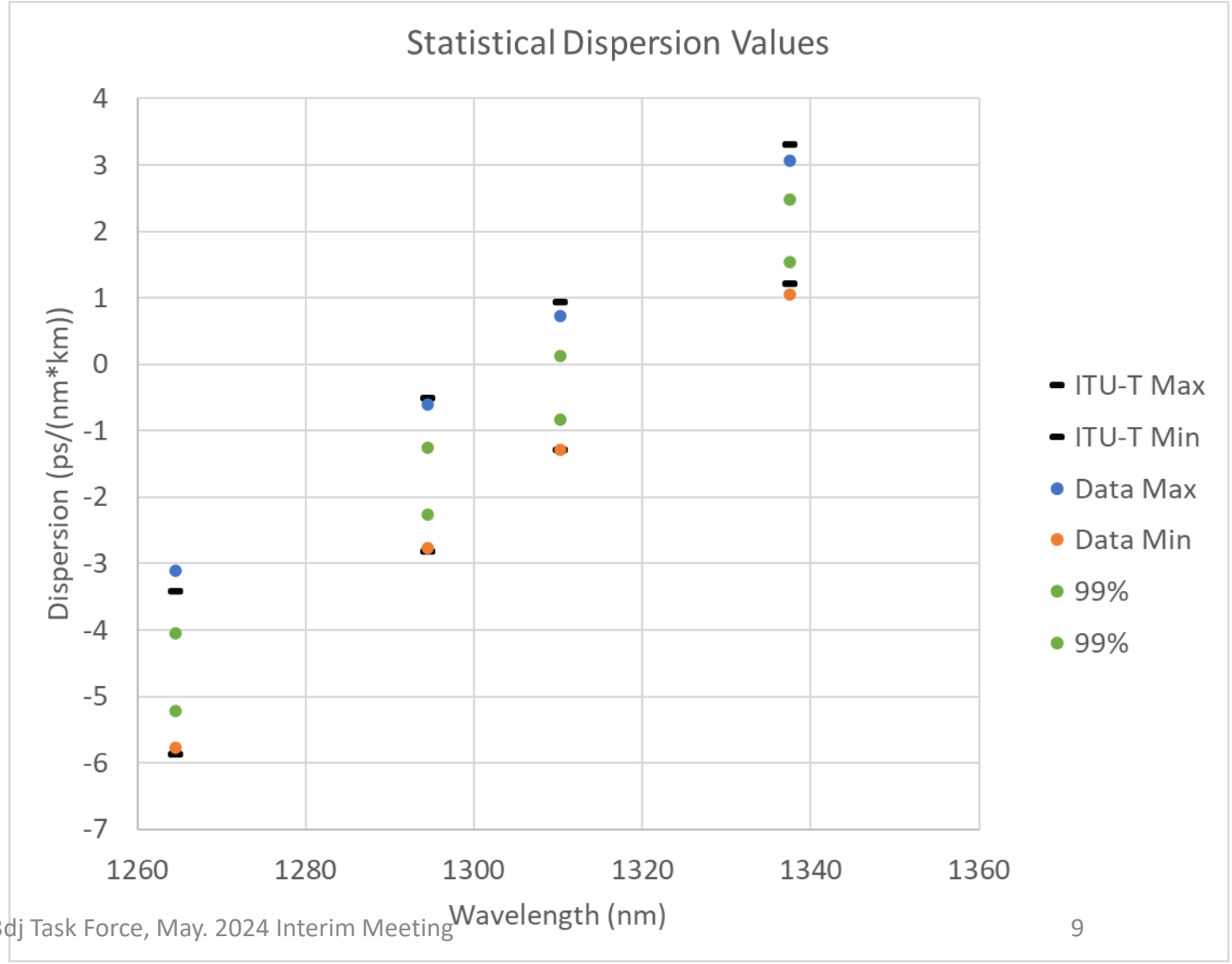
- Most values well within extreme cases (red lines)

Statistics of entire data set

	CWDM		LAN-WDM	
	1264.5	**1337.5**	**1294.53**	**1310.19**
ITU-T Max	-3.41	3.31	-0.51	0.93
Data Max	-3.1	3.07	-0.6	0.73
99.999%	-3.58	2.84	-0.88	0.51
99.99%	-3.75	2.8	-0.93	0.47
99.9%	-3.88	2.66	-1.05	0.35
99%	-4.05	2.48	-1.26	0.13
99%	-5.21	1.53	-2.27	-0.84
99.9%	-5.47	1.36	-2.49	-1.03
99.99%	-5.6	1.23	-2.6	-1.15
99.999%	-5.69	1.11	-2.7	-1.23
Data Min	-5.77	1.05	-2.76	-1.28
ITU-T Min	-5.87	1.22	-2.81	-1.29



Statistics of entire data set (continued)

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ITU-T Max	-3.41	3.31
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99.999%	-3.58	2.84
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Data Min	-5.77	1.05
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LAN-WDM	
1294.53	**1310.19**
-0.51	0.93
-0.6	0.73
-0.88	0.51
-0.93	0.47
-1.05	0.35
-1.26	0.13
-2.27	-0.84
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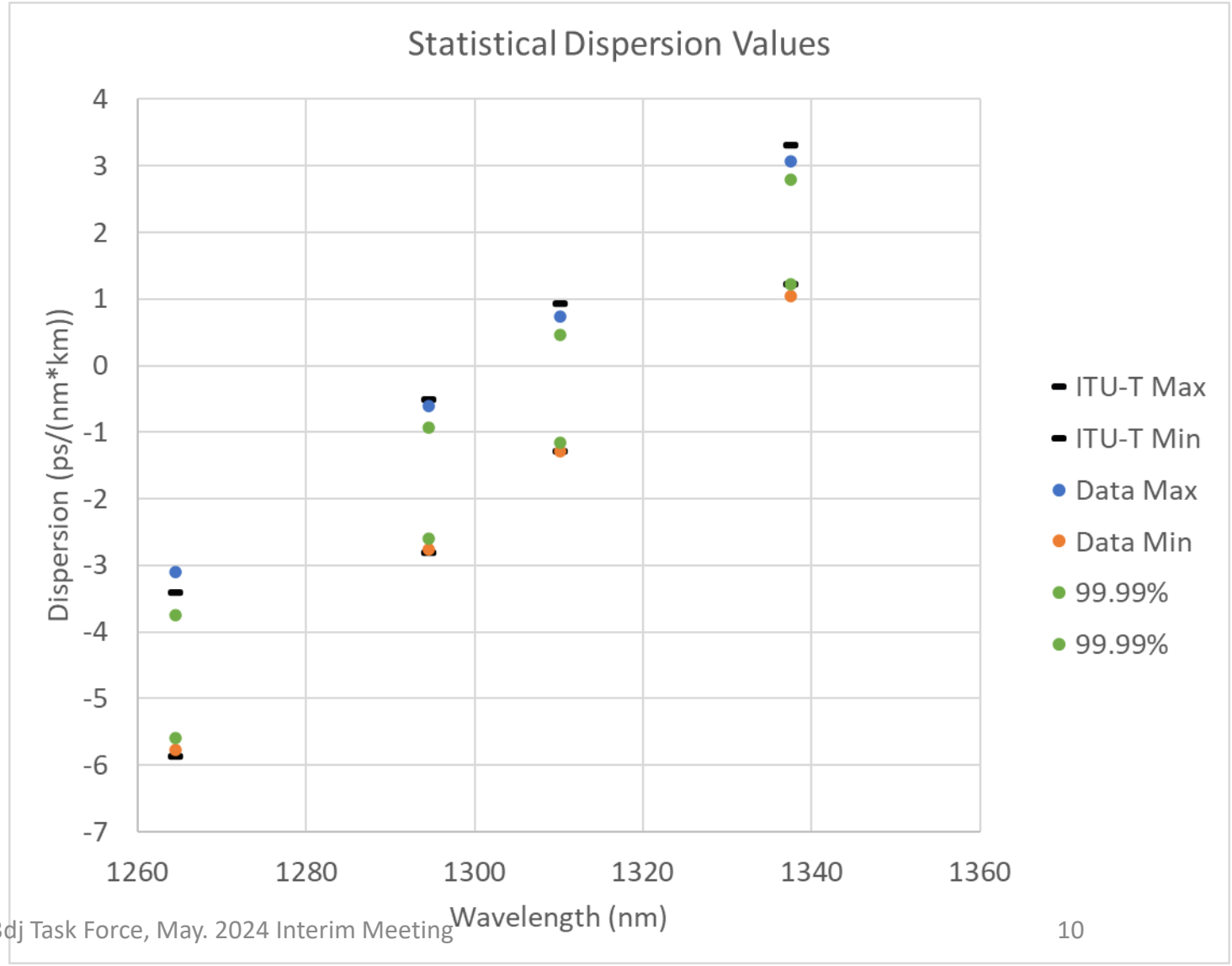
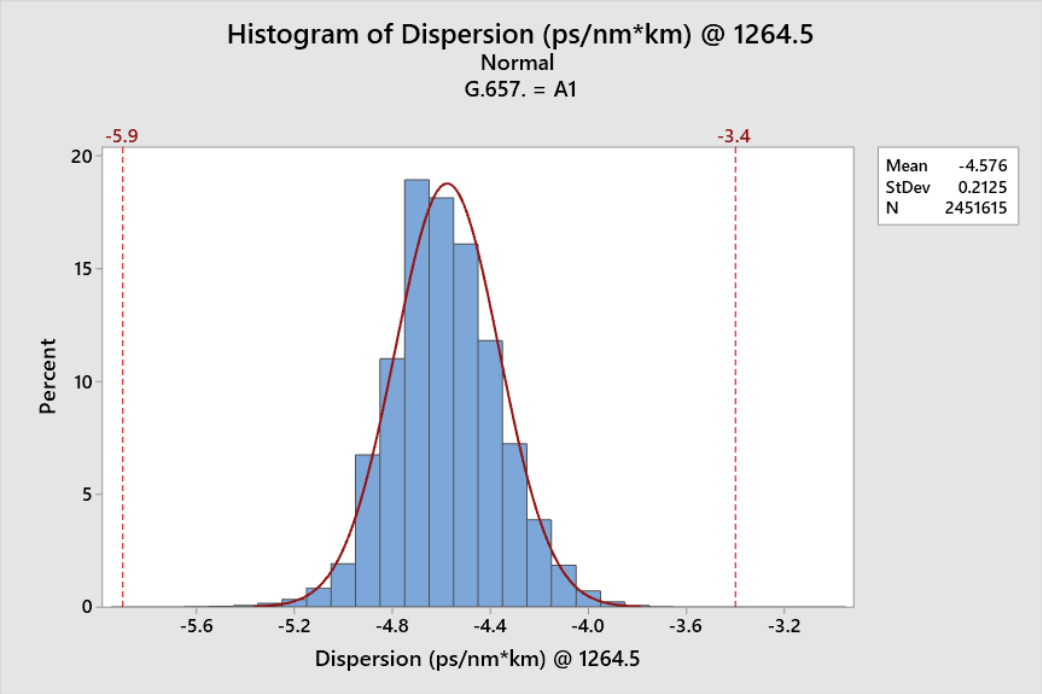


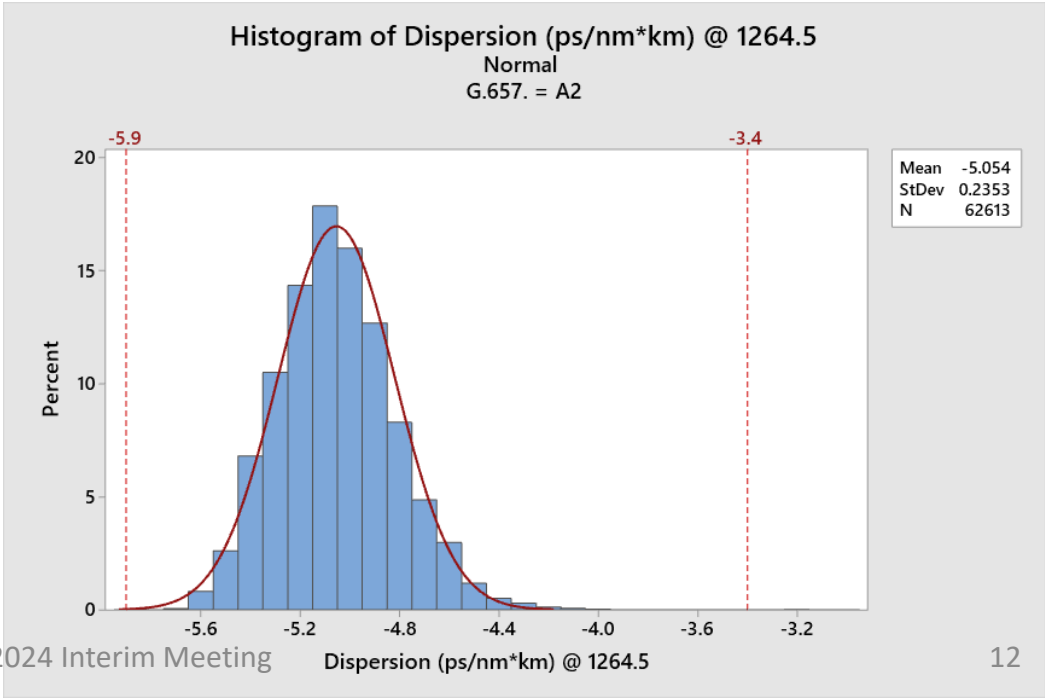
Compare dispersion values for different subsets

- 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 coating diameter
  - Different manufacturing years
  - Different manufacturers
- Focus on dispersion values at 800G-FR4 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 and lower volume in this data set
- Similar standard deviation, A2 has mean that is more negative





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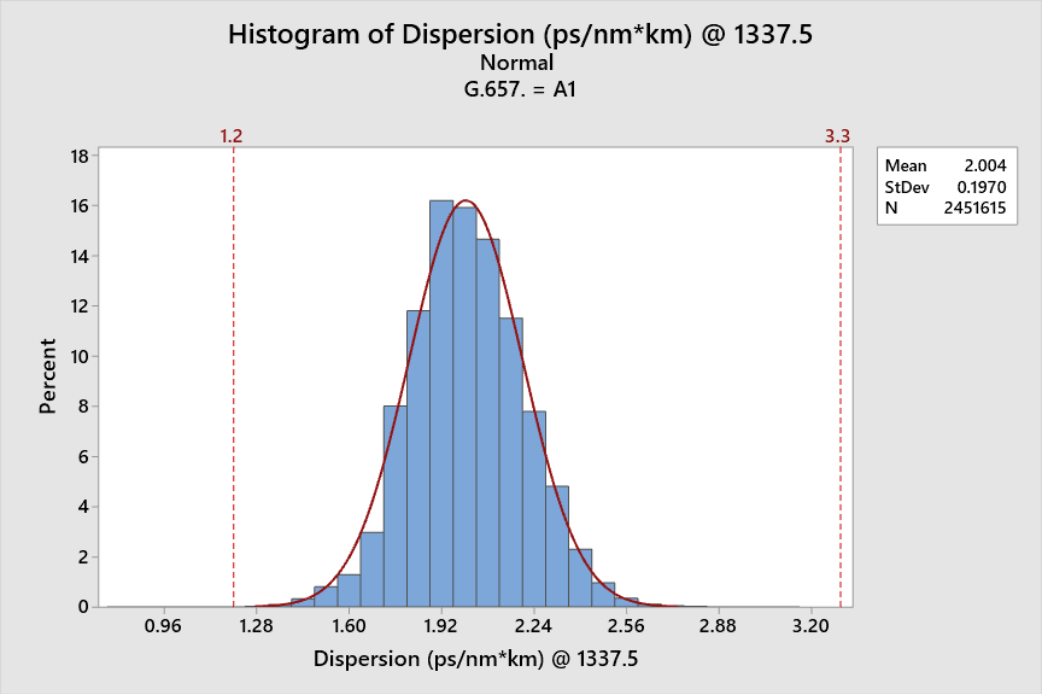
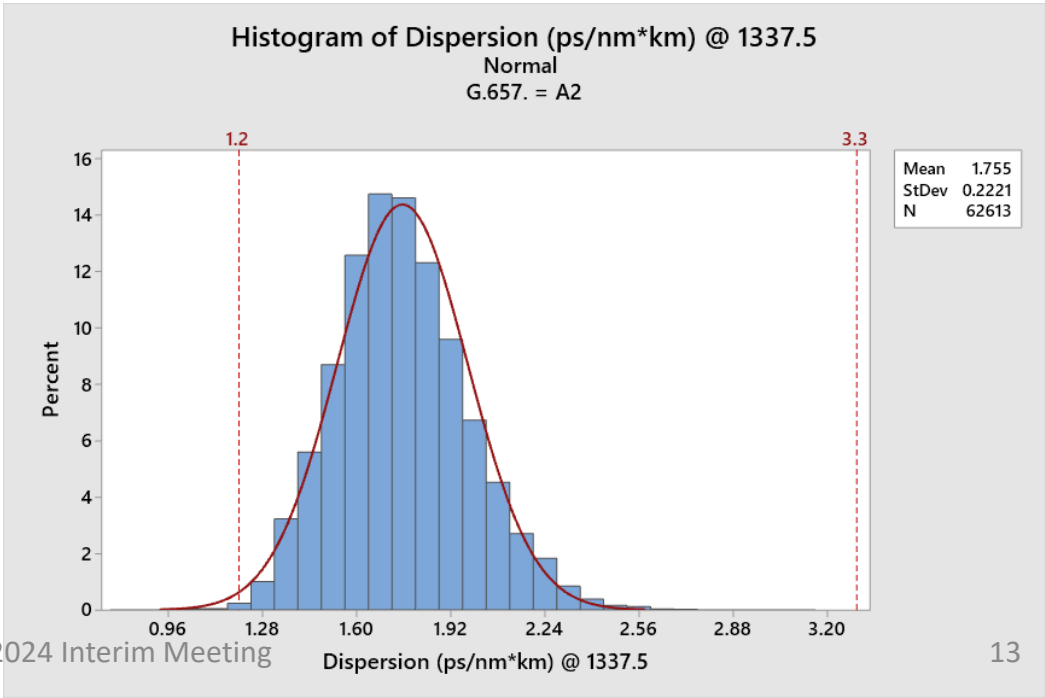
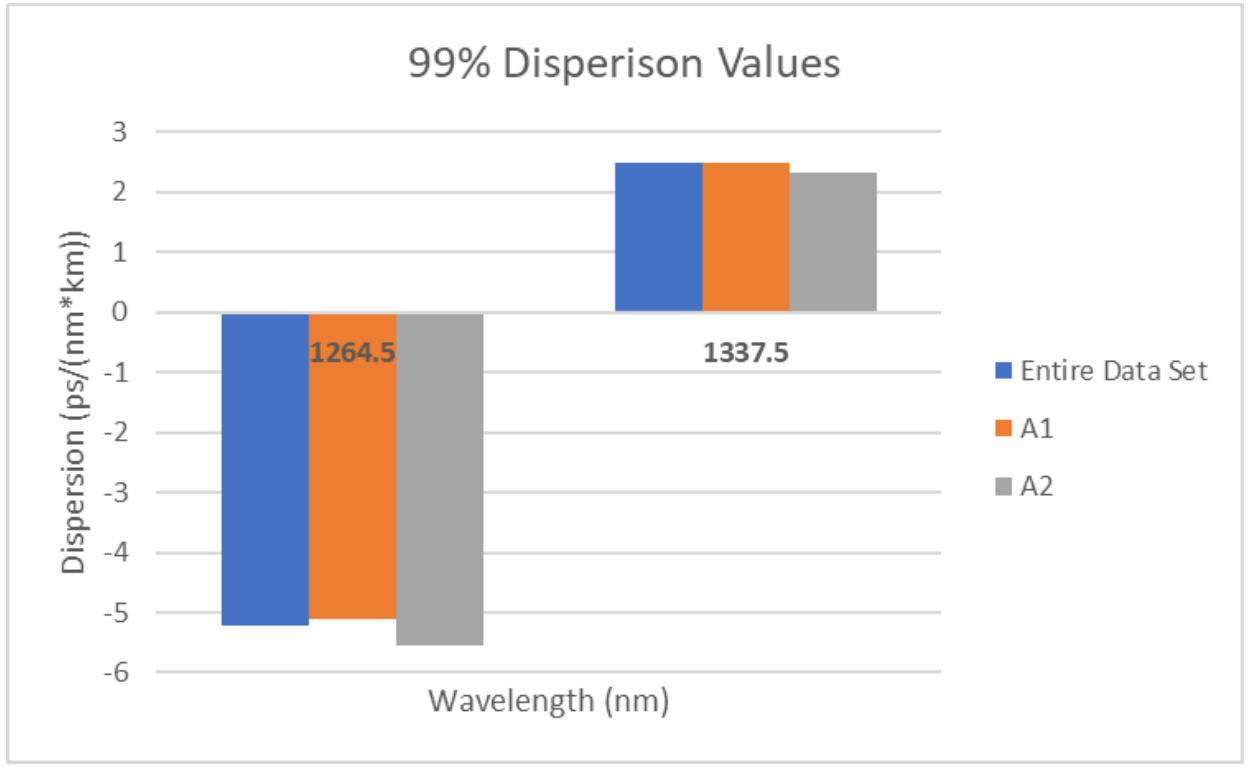


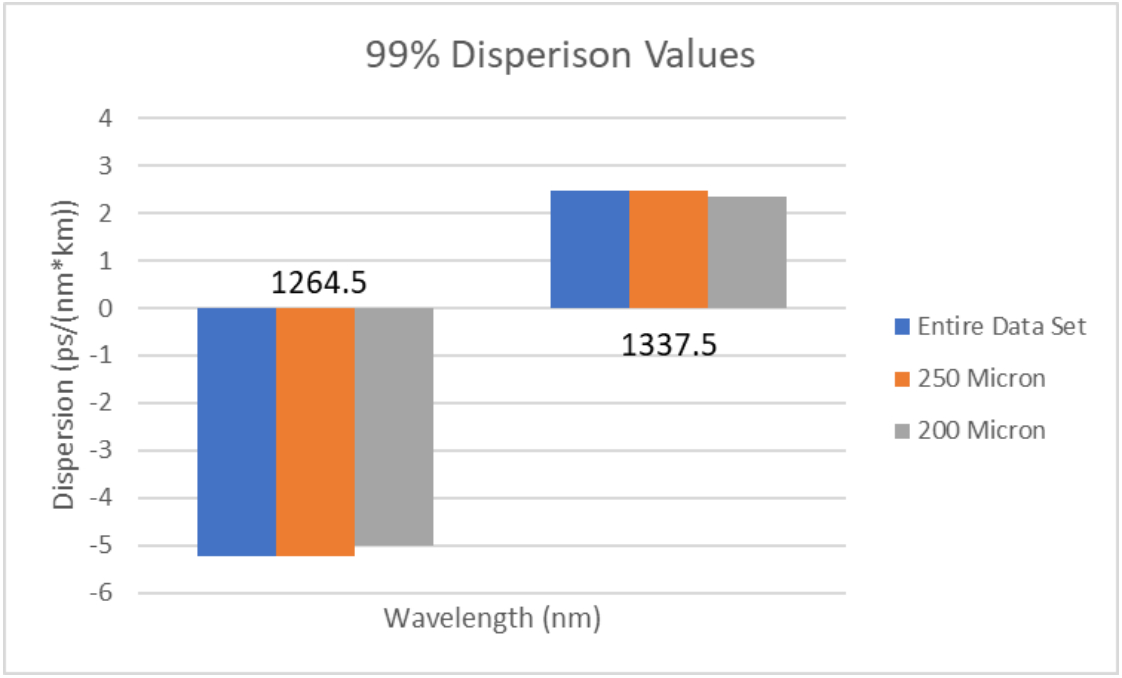


G.657.A1 vs .A2 fibers



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

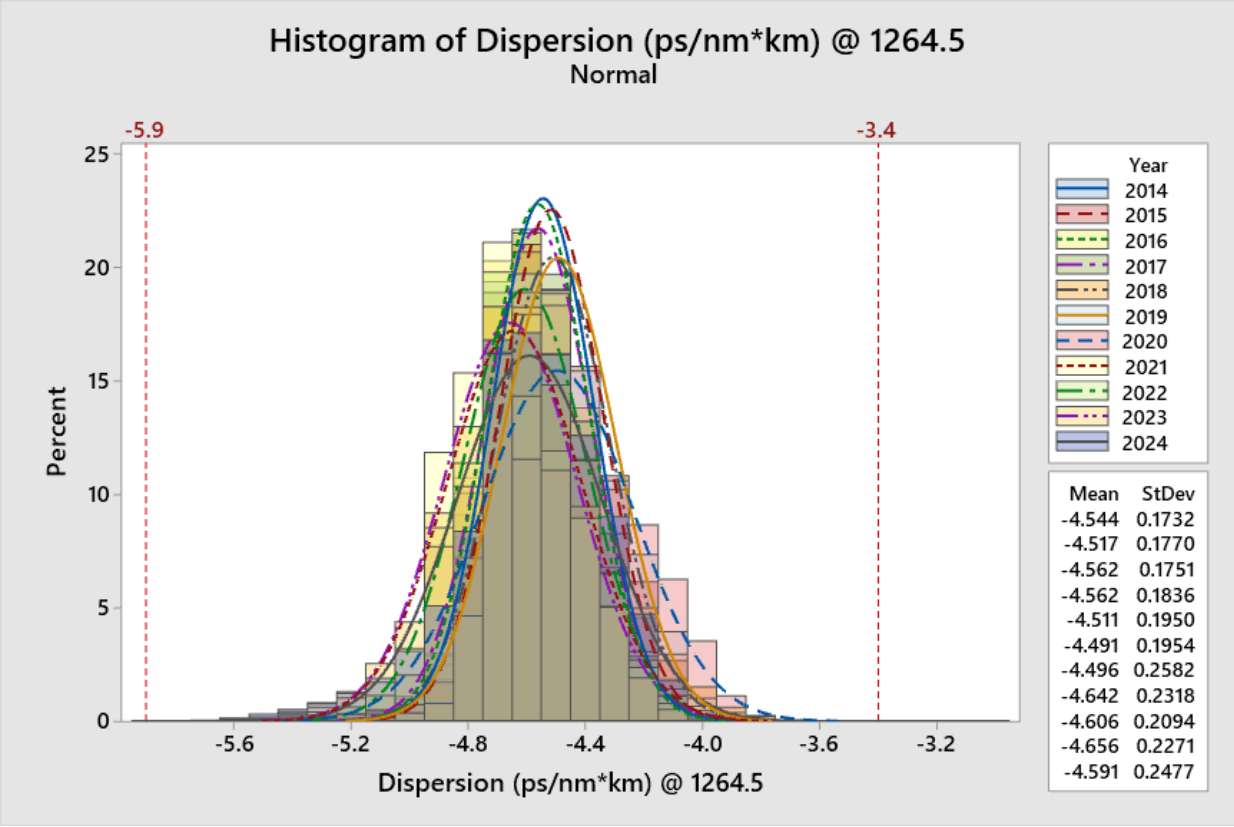
250 vs. 200 micron coating diameter

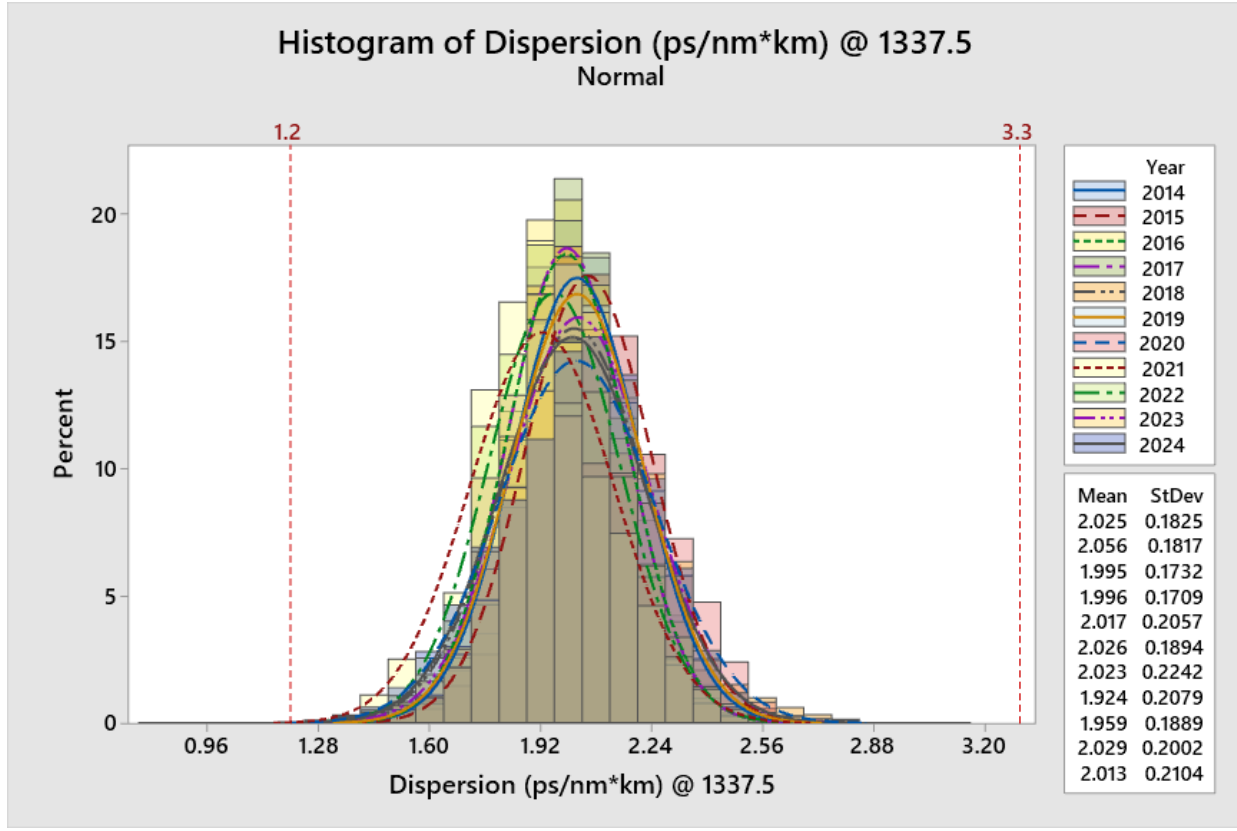


- 200 micron coating is a new option for reduced cable size
- Dispersion slightly better for 200 micron

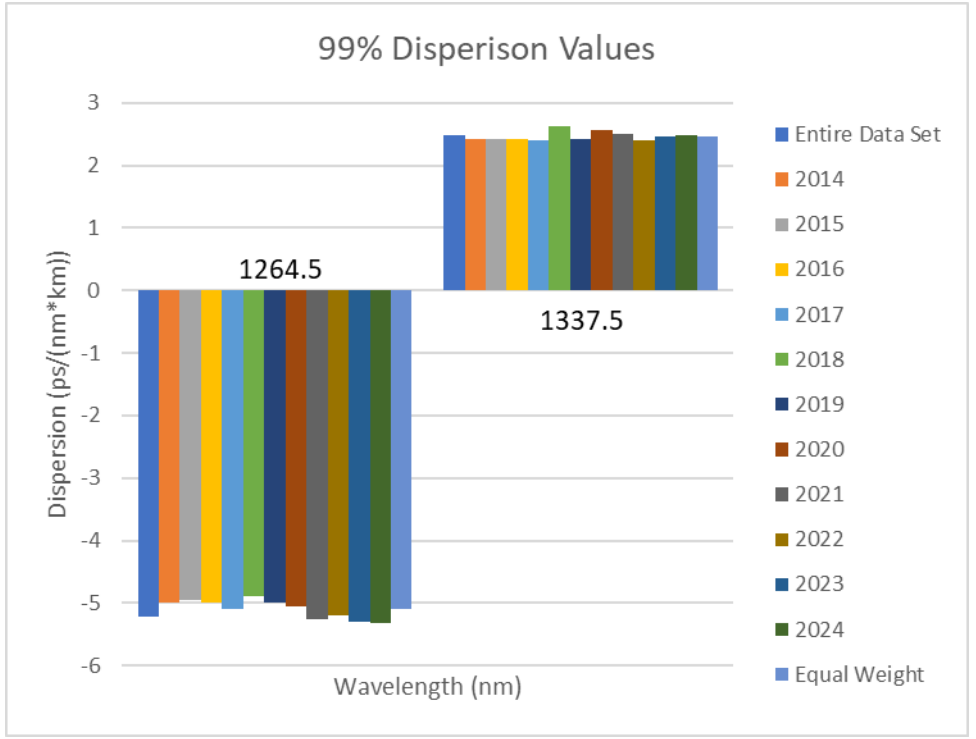
Dispersion values over time

- Little change over the years



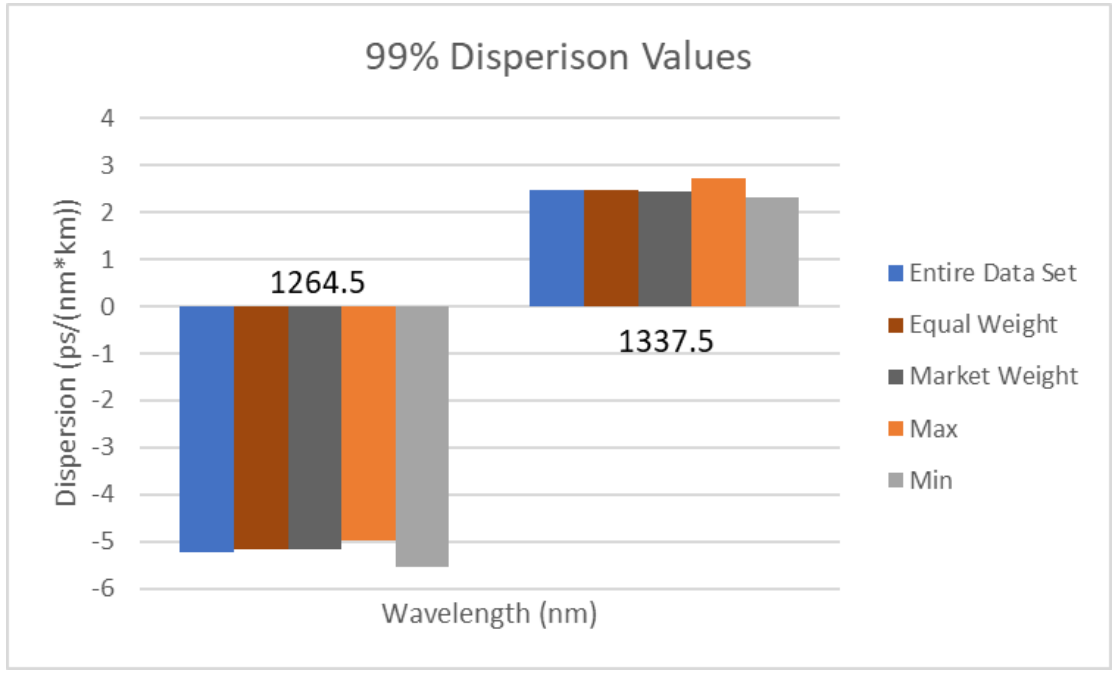


Dispersion values over time



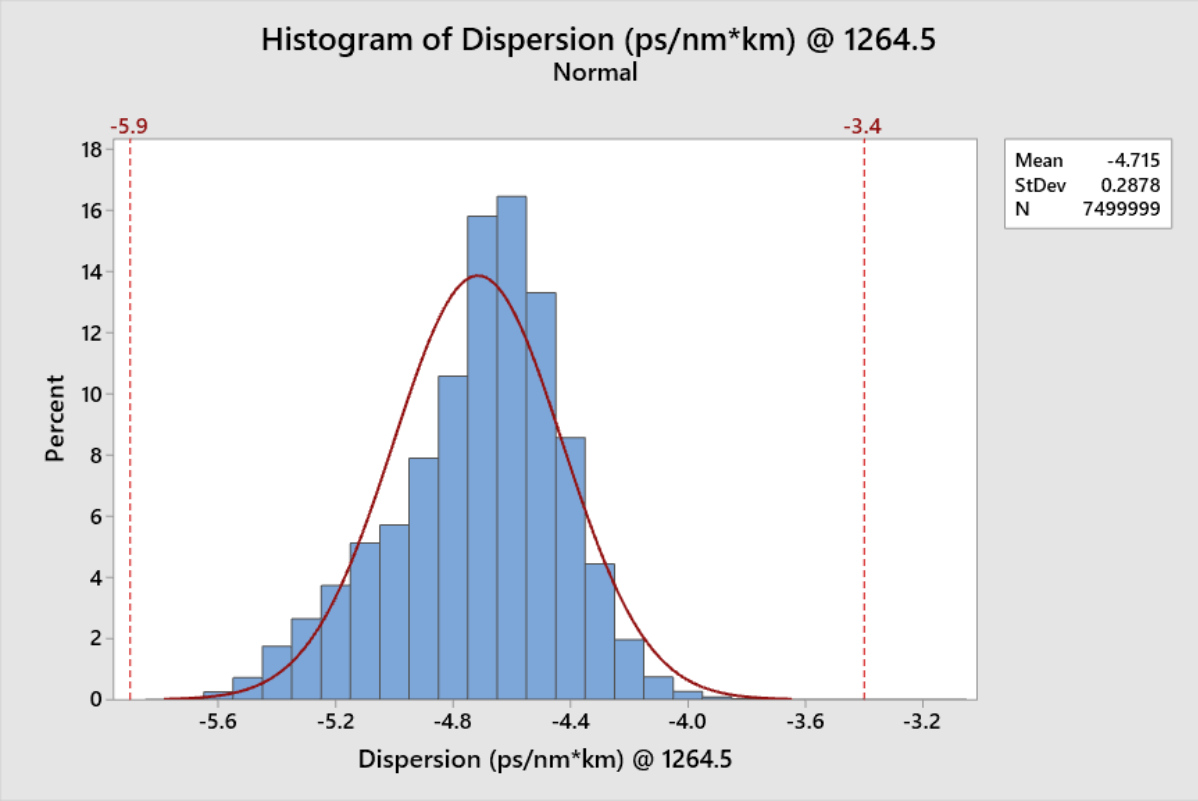
- Small variations over time
- Recent years have higher percentage of A2
- No obvious trend preventing models developed around current fibers being used over fibers manufactured in last 10 years

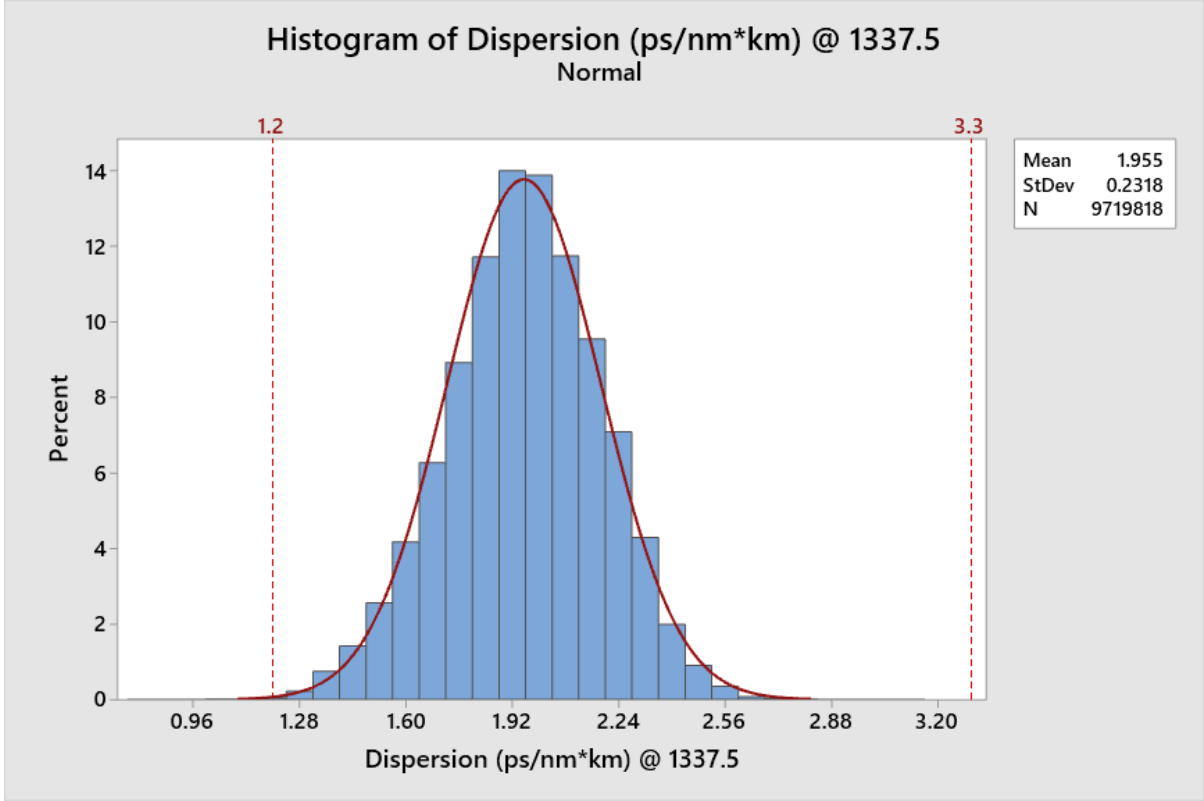
Dispersion parameters by different manufacturers



- 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