FDDI Channel Modeling: comparison of data sets

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IEEE P802.3aq 10GBASE-LRM Task Force

Sept 2004 Interim Meeting, Ottawa

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Discovering Beyond Imagination

Acknowledgment

Production data shared anonymously from three companies:

Draka

OFS

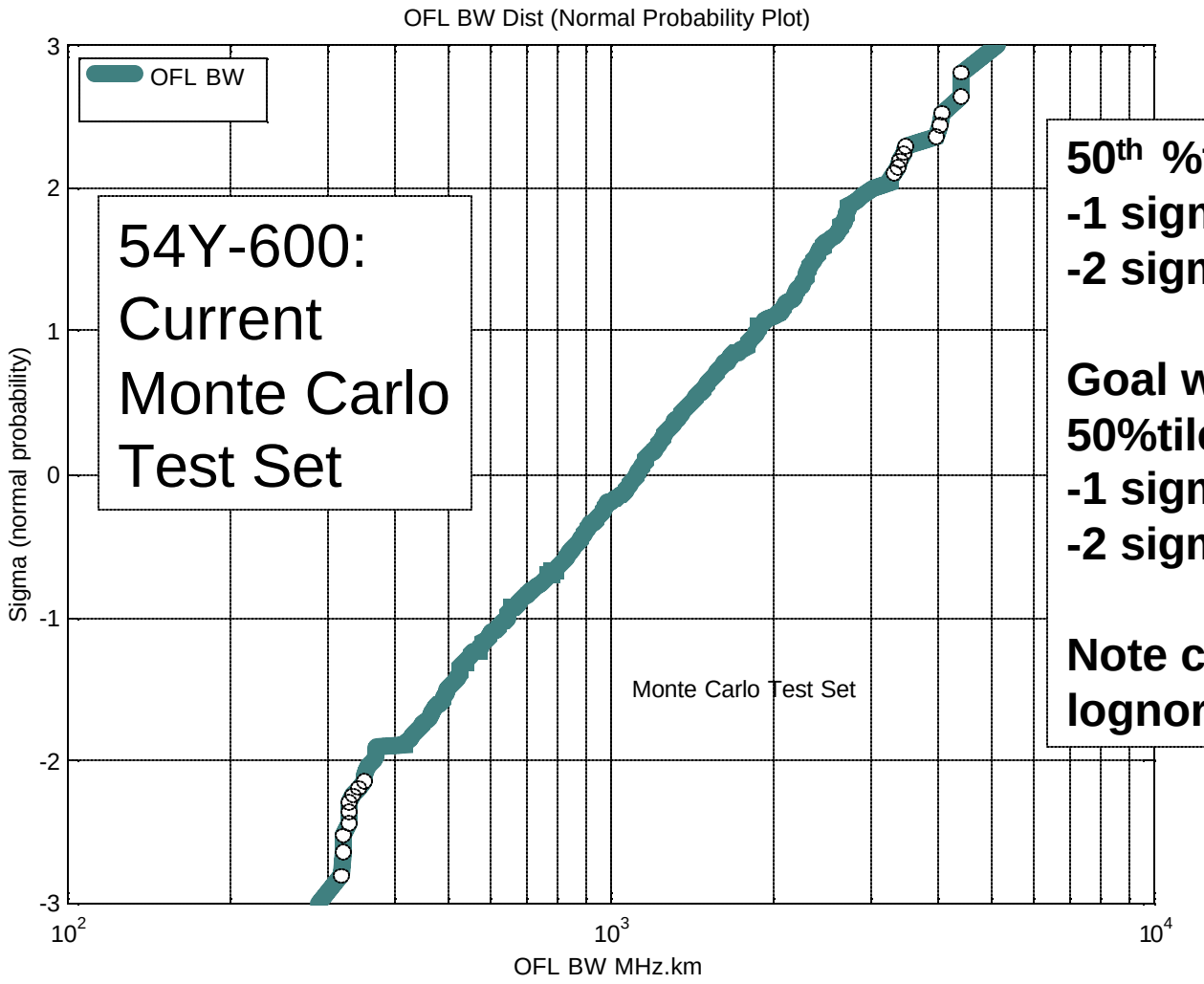
Corning

Summary/Purpose/Outline

1. More detailed comparison of DMD and BW metrics for Monte Carlo set vs. available data for installed base
2. Purpose is to make informed revisions to Monte Carlo set to better match important characteristics of installed base
3. Using OFL BW data, DMD range, scatter plots,
4. Using offset effective modal BWs & DMD slopes

Additional Data on DMD "Kinks" (sharp change of DMD curve at a mid-radial location) in support of Task 1 recommendation.

OFL BW distribution – Gen54



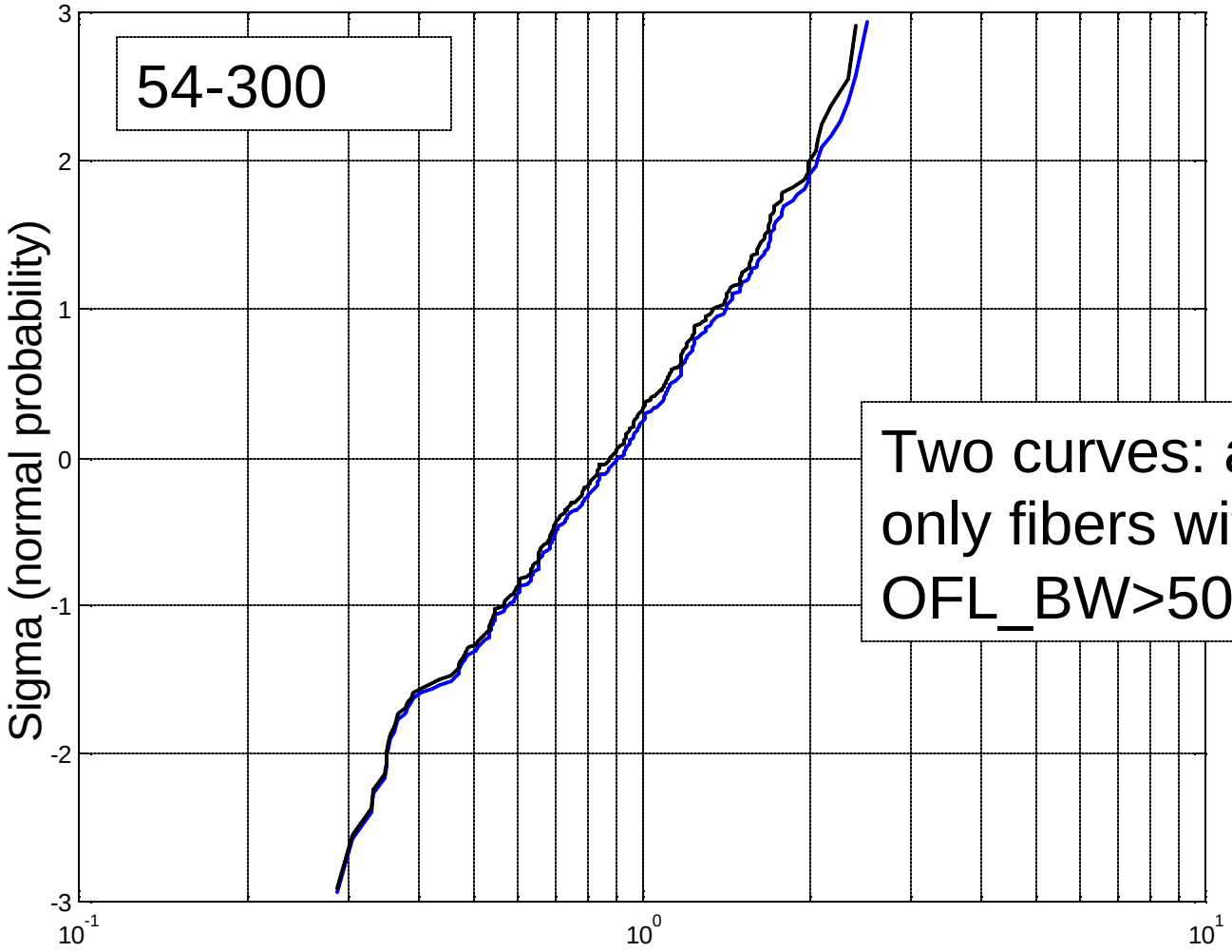
50^{th} %tile ~ 1000+MHz.km
-1 sigma ~650MHz.km
-2 sigma~350-400MHz.km

Goal was
50%tile ~ 900-950
-1 sigma~600
-2 sigma~400

Note curve retains lognormal form.

600 fibers in this subset

DMD range distribution



Two curves: all data, and only fibers with OFL_BW>500MHz.km

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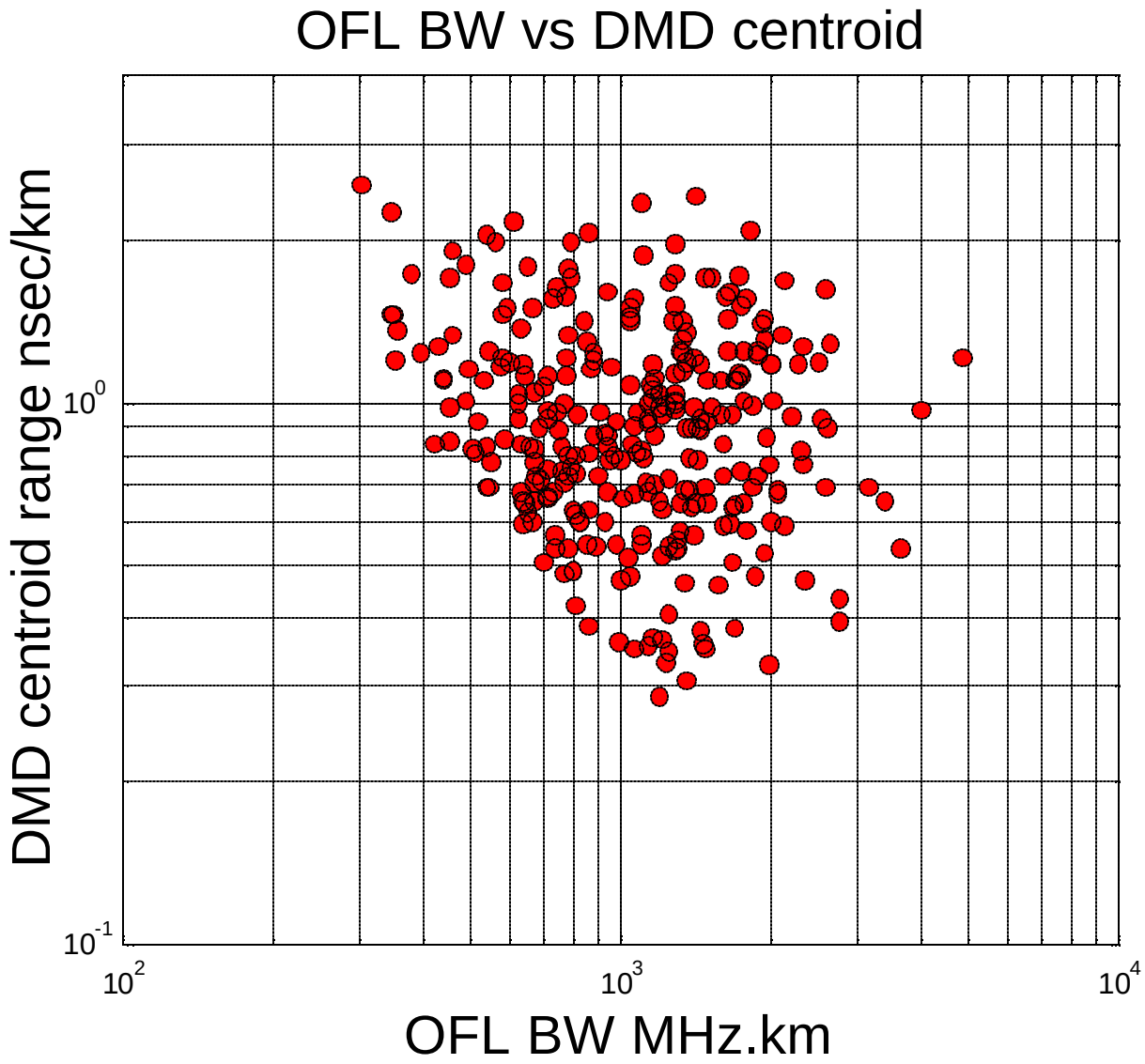
Gen54YY DMD range vs. OFL BW

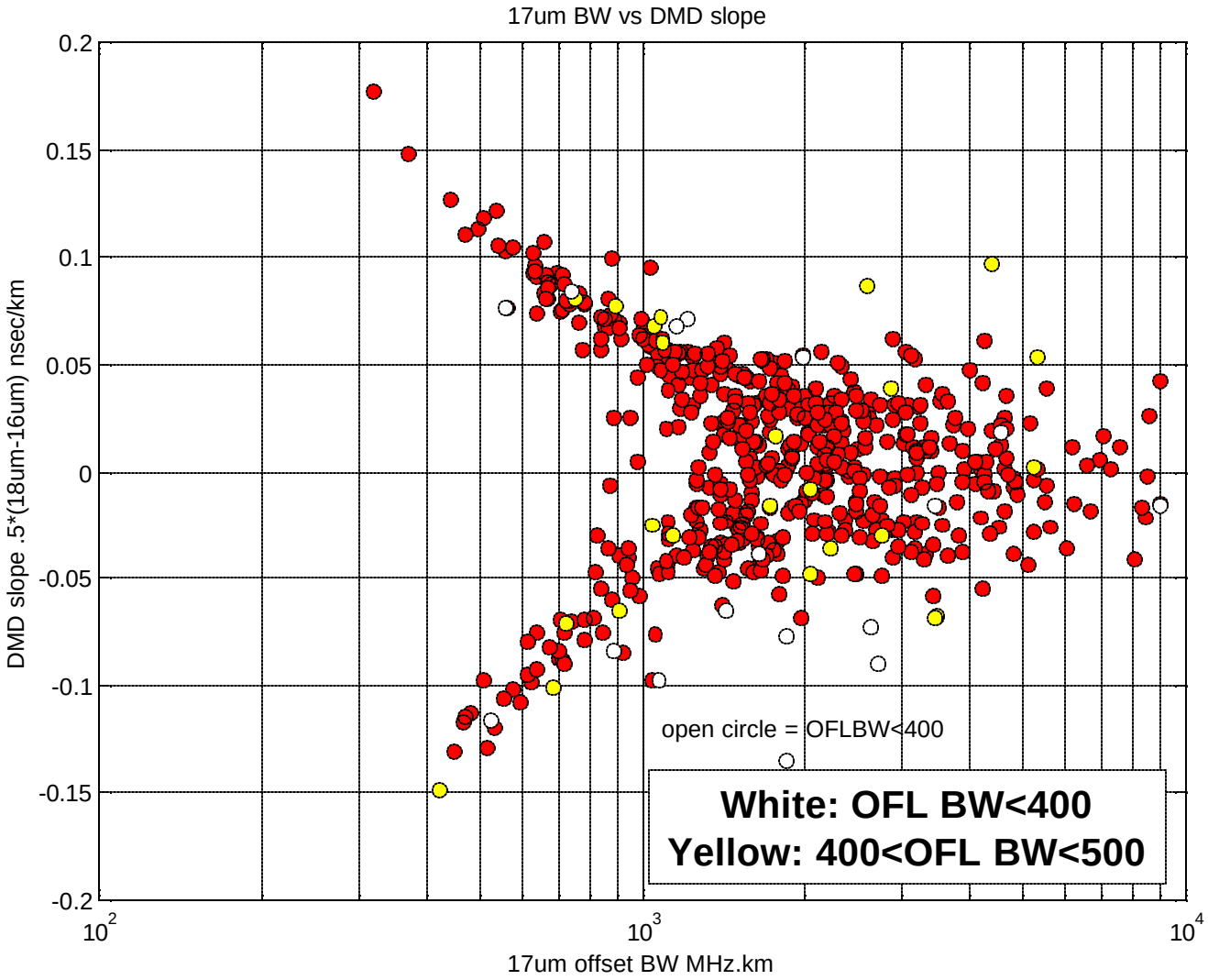


Gen5P54Y: DMD slope vs. offset BW

54Y-600

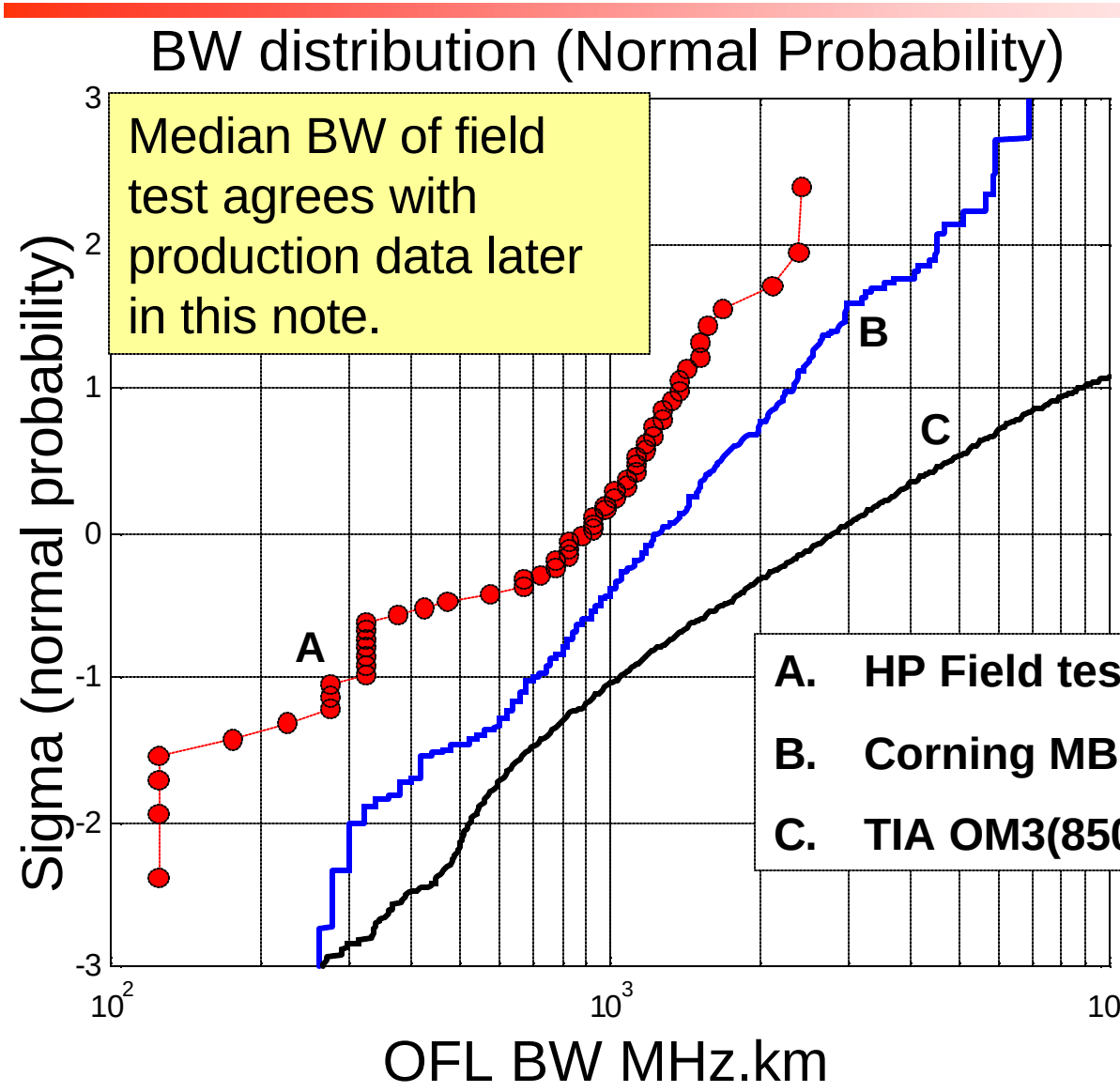
The plot of DMD slope vs offset BW at 17um has this characteristic shape in both MBI310data and the Cambridge Rev2 65 fibers.

Low BW is due to a slope in the DMD.



600 fibers in this set

FDDI-EDC Monte Carlo Development



Development was based on curves A & B

A. HP Field test measured OFL BWs

B. Corning MBI310 310 fibers

C. TIA OM3(850nm) 5000 fibers

Comparison to data – BW&DMD

a. MBI310 profile data → calculated mode delays/DMDs

   set of 310 mode delays calculated from index profiles at the time of the MBI work. Extension of set of 237 profiles used in MBI and IWCS 1998 paper (Abbott, Hackert, Harshbarger, Cunningham, DiMinico, White). First “Monte Carlo” analysis.

b. OFL BW distribution data being shared by fiber manufacturers.

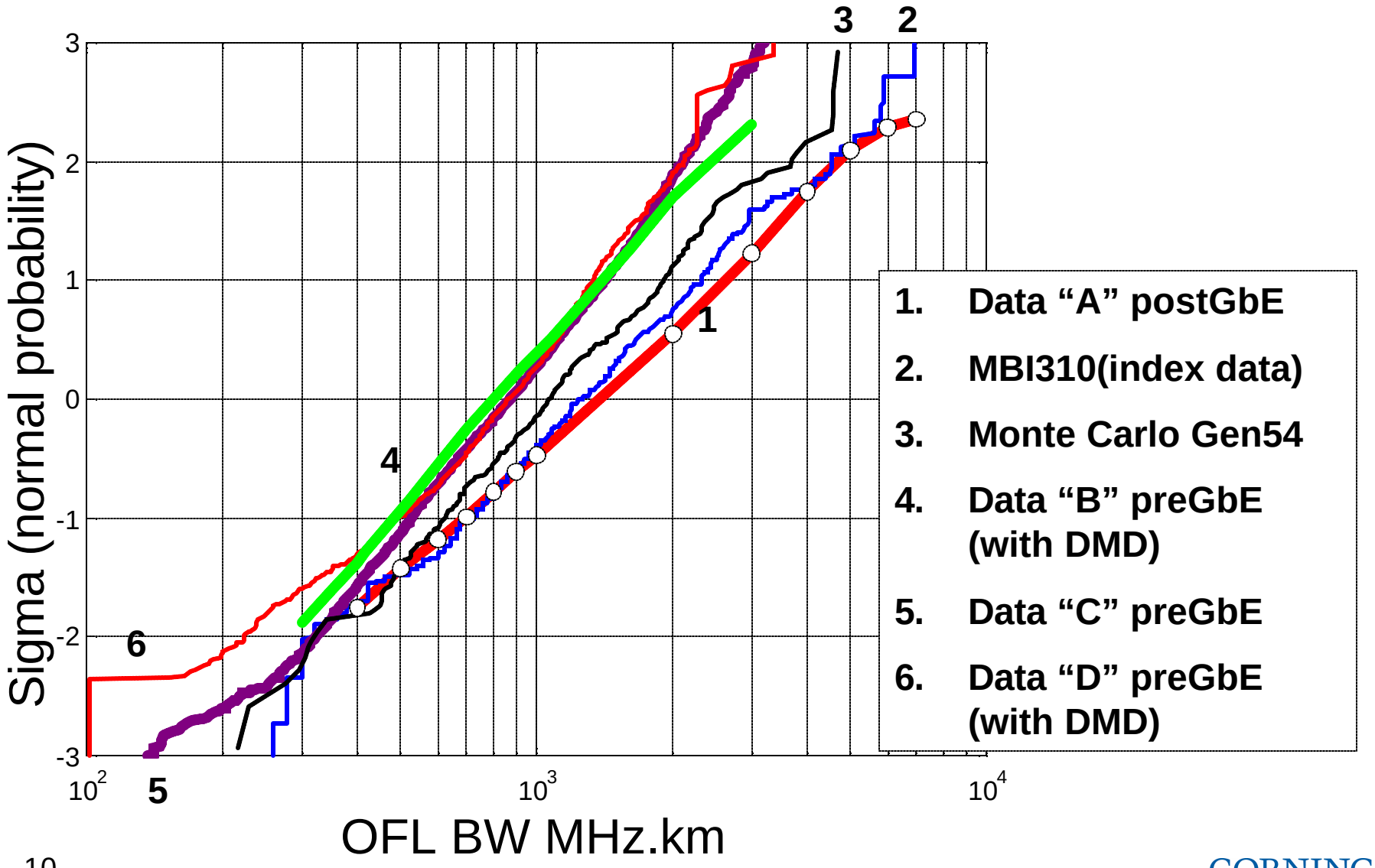
   Production Data set B – post-GbE (2001-2004) BW

   Production Data set C – pre-GbE (1998) BW & DMD

   Production Data set D – pre-GbE (1999) BW

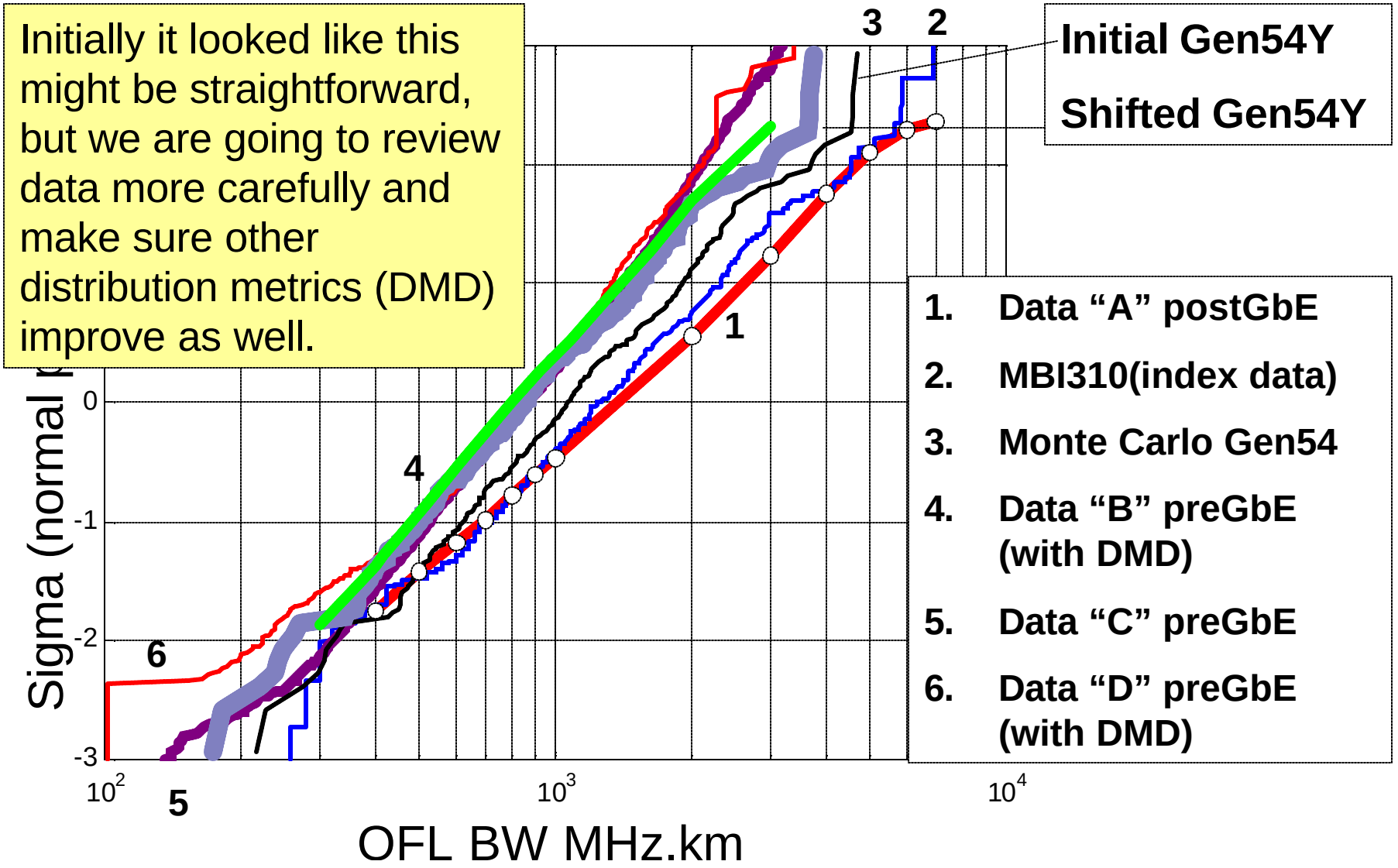
   Production Data set E - pre-GbE (early 90s) DMD&BW

Comparison to available data



Shifting Monte Carlo 20% to match BW data

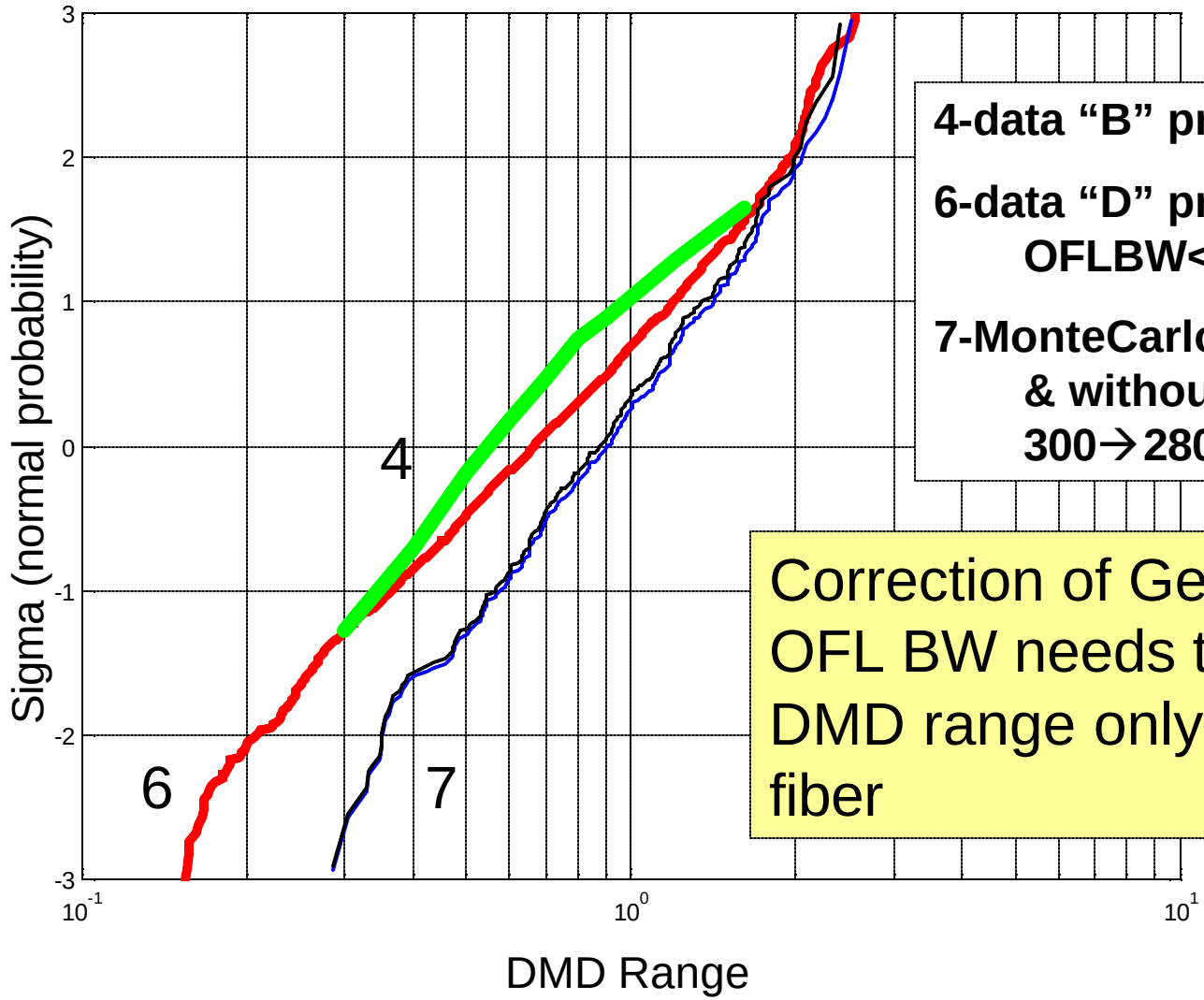
Initially it looked like this might be straightforward, but we are going to review data more carefully and make sure other distribution metrics (DMD) improve as well.



Comparison to data: DMD

- MBI310 profile data – calculated DMD
- DMD Production data “B”
- DMD Production data “D”

DMD range distribution



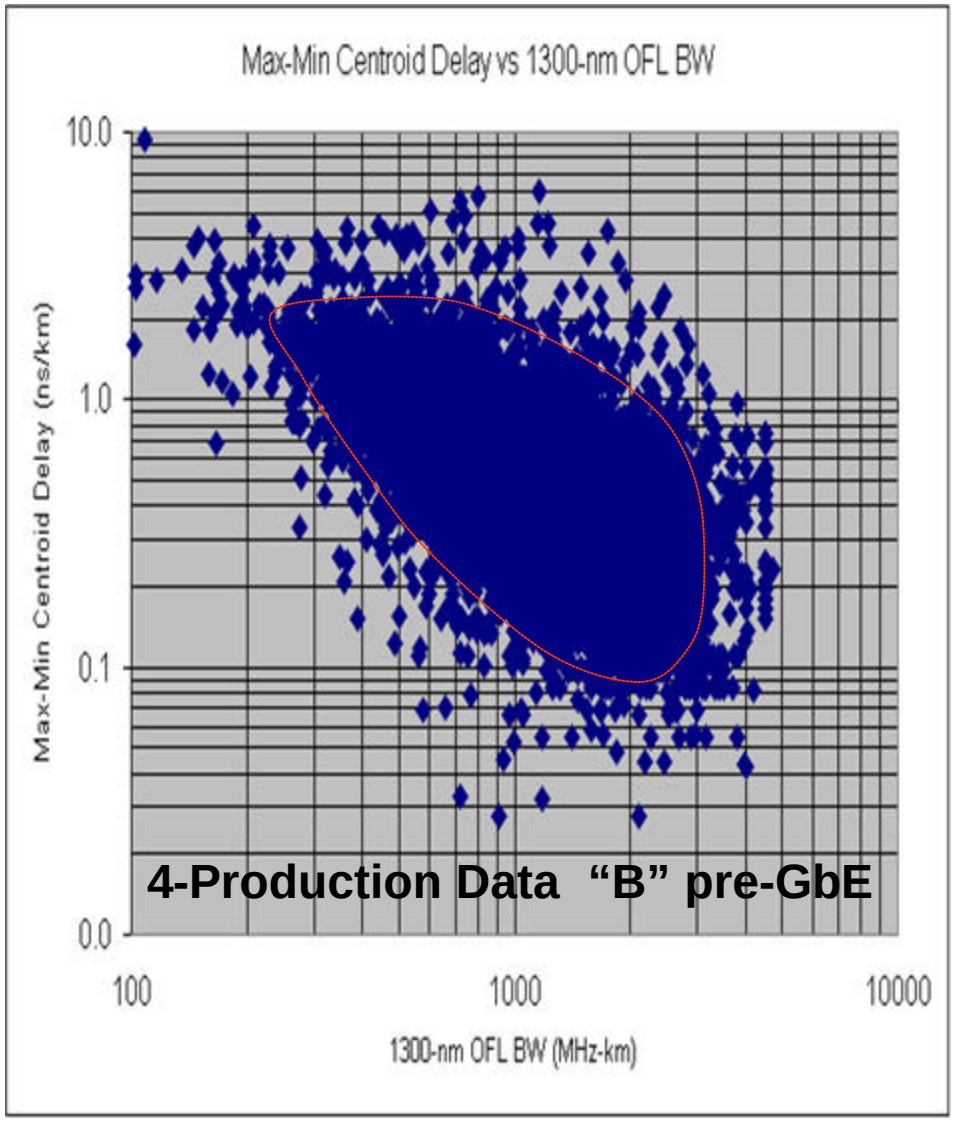
4-data "B" pre-GbE all BWs

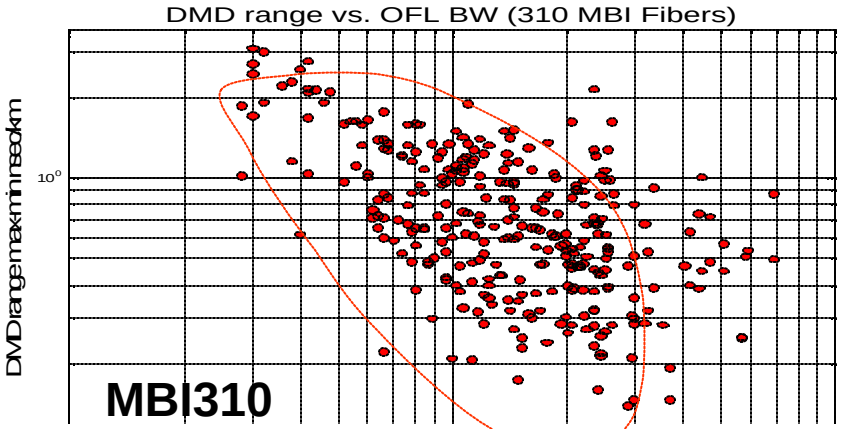
6-data "D" pre-GbE filtered OFLBW<500

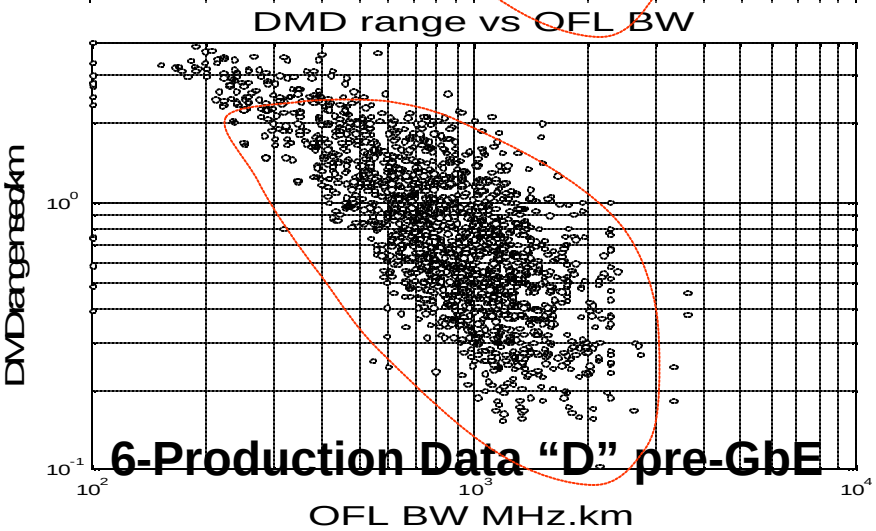
7-MonteCarlo DMDrange with & without OFLBW filter. 300→280

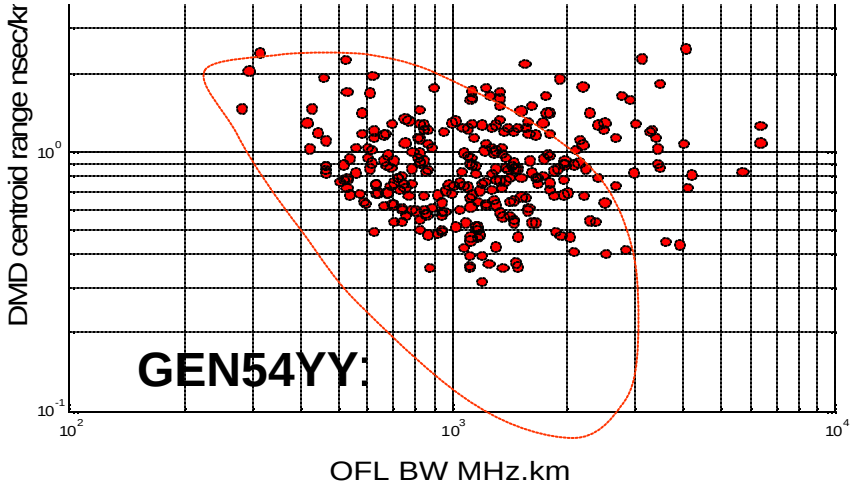
Correction of Gen54 to align OFL BW needs to modify DMD range only for high BW fiber

DMD range vs OFL BW





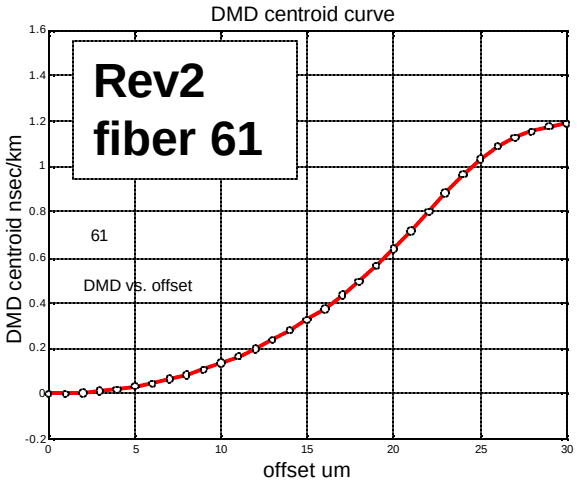


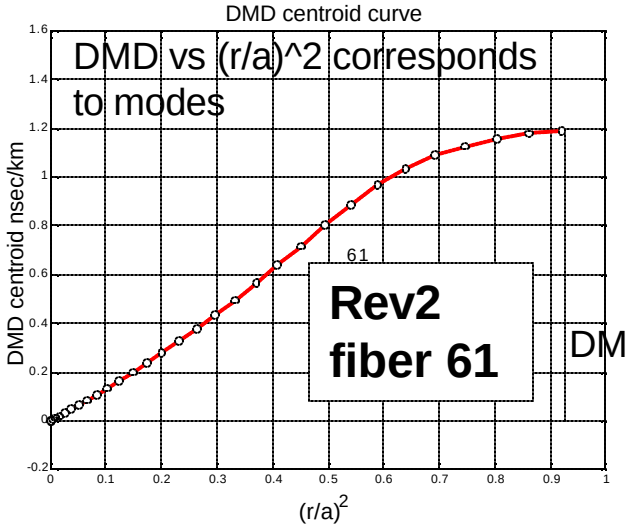


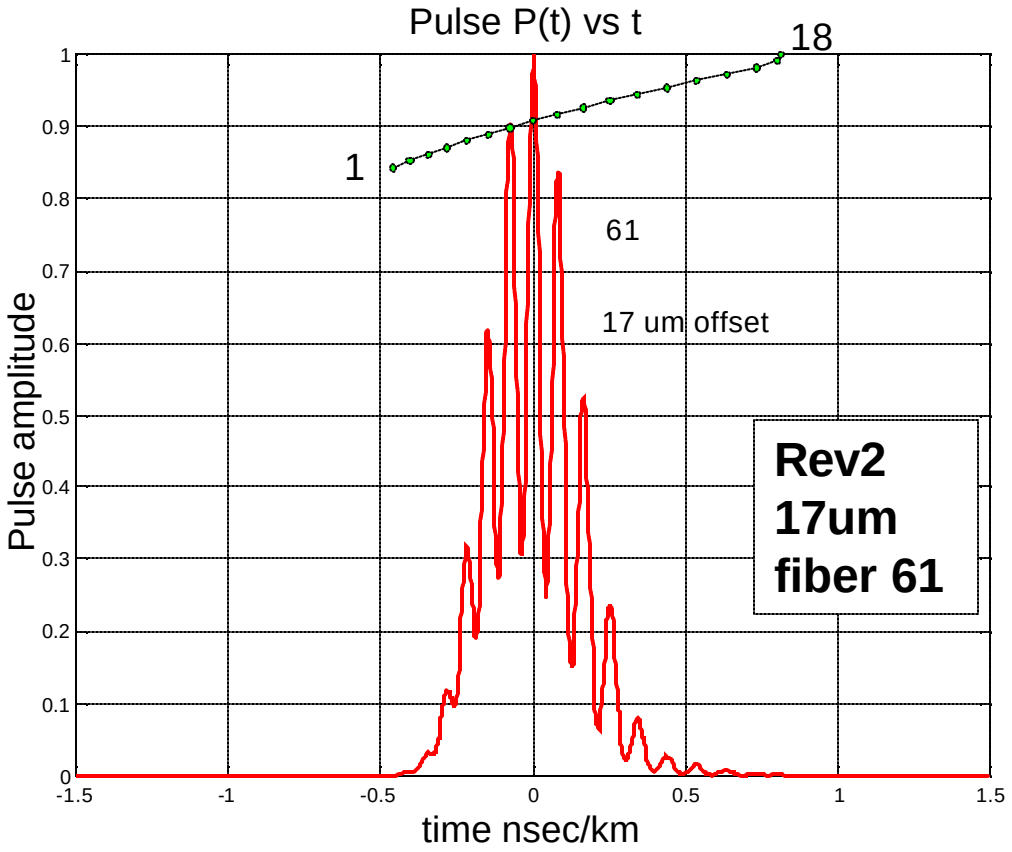
Comparison to data: offset BW & DMDslope

- MBI310 profile data – calculated DMD & offset BW using profile data
- Cambridge Rev 2 examples for reference
- Older DMD data is typically only centroid (no offset BW stored). The older data can be used for DMD slope although the spot size must be assumed. Offset BW can only be estimated by deconvolving the DMD to generate estimated mode delays, since the full DMD pulses were not saved.

Example offset BW—fiber65Rev2 17um offset

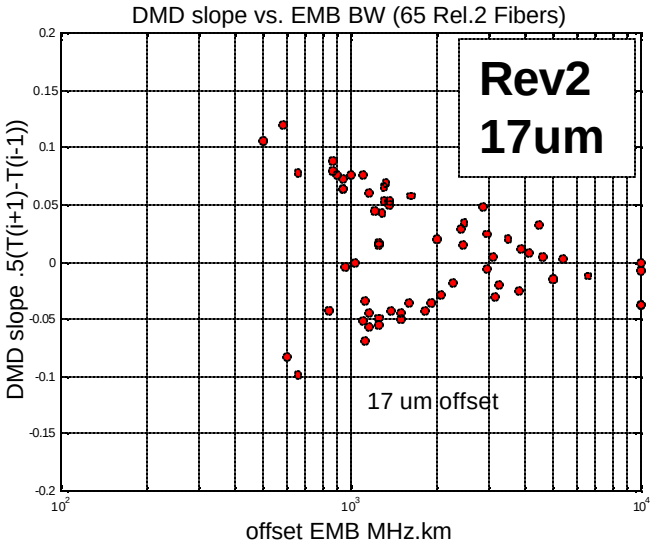


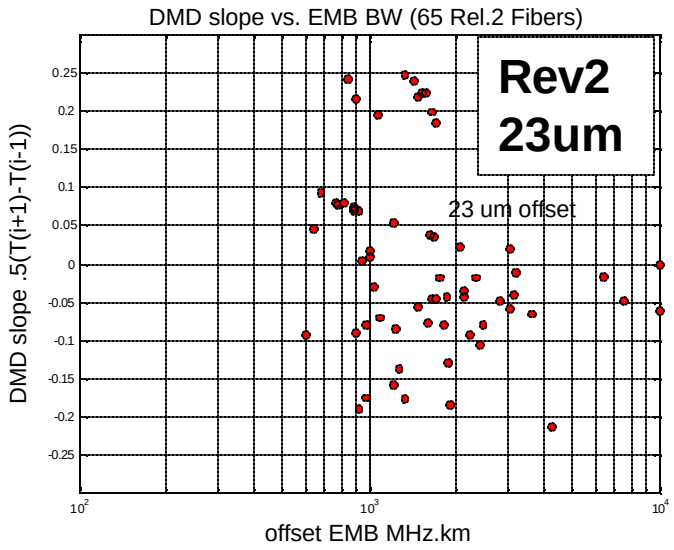




Note pulse is ‘Gaussian’ not 3-impulse.

DMD slope vs. offset BW

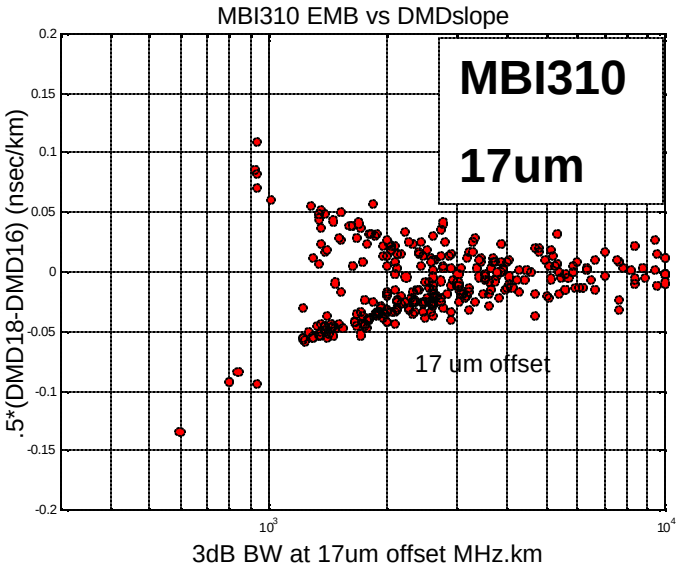


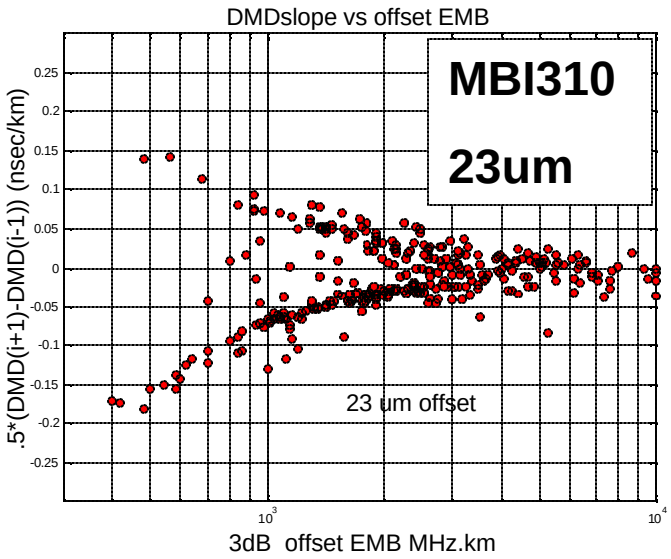


Slope vs. EMB has "V-shaped" structure along with outliers inside the "V". Points with offset EMB>2000MHz. km are no-problem for this launch.

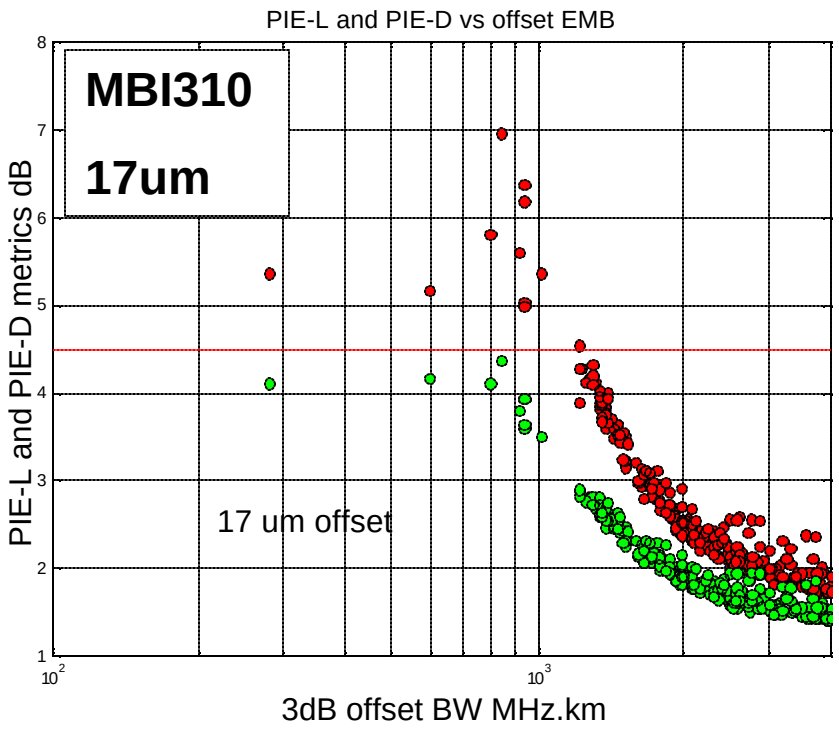
Rev2 23um data doesn't follow the pattern.

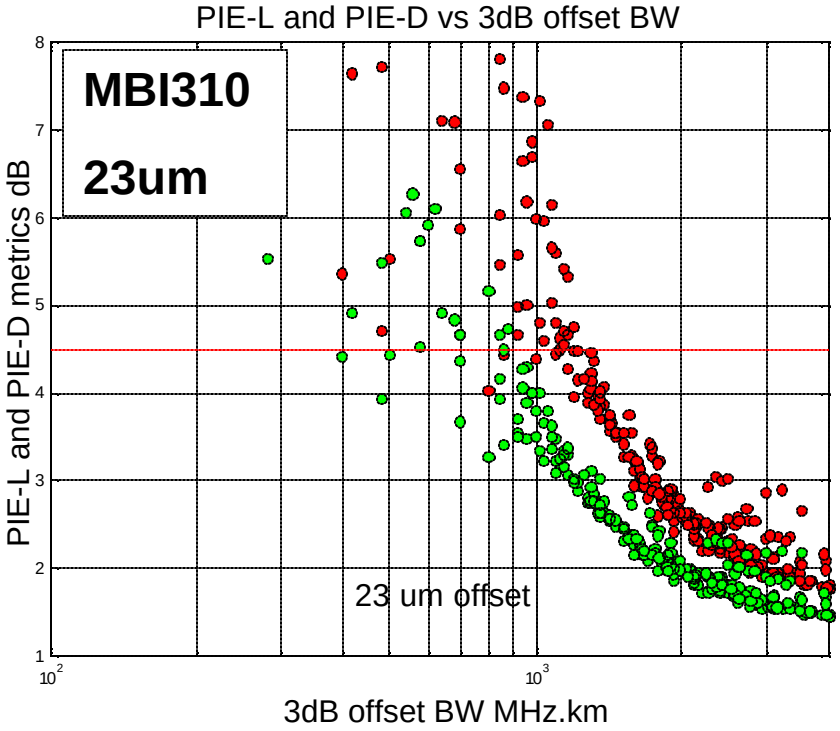
Note these MBI310 plots include fibers with OFL<500





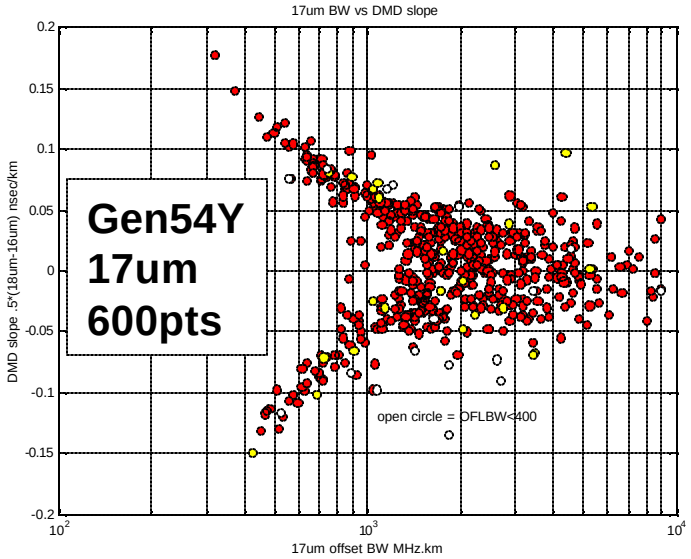
Importance of offset EMB to PIE-metrics

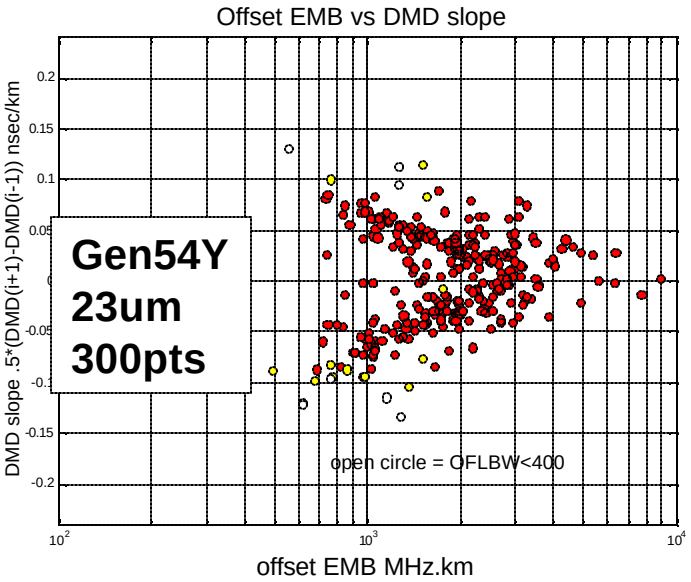




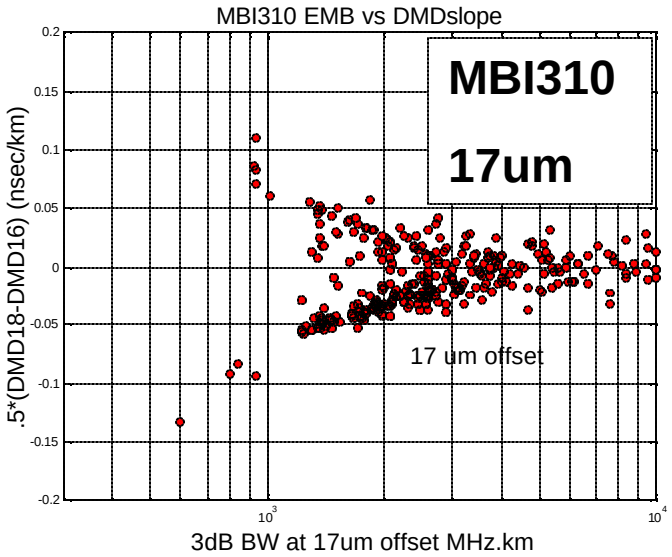
DMD slope and offset EMB correlate; offset EMB and PIE-metric performance also correlate.

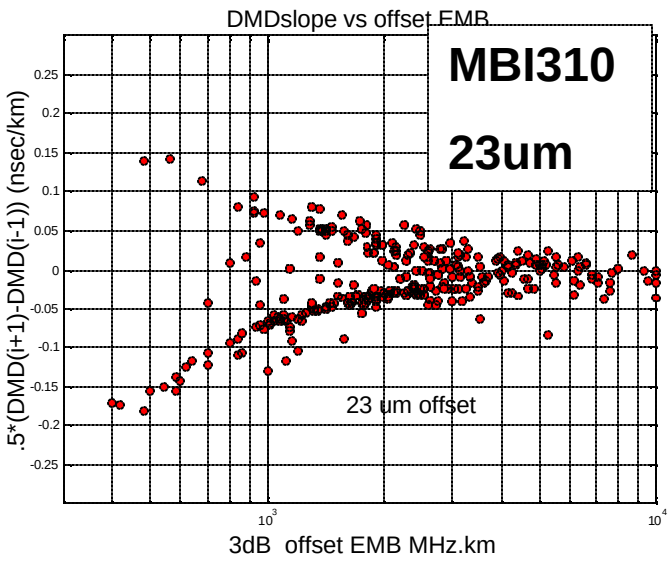
Gen54Y DMDslope vs offset BW





The Gen54 mode delays retrain the V-structure but show lower peak BWs than the MBI310, consistent with the pre-GbE DMD & OFL BW data





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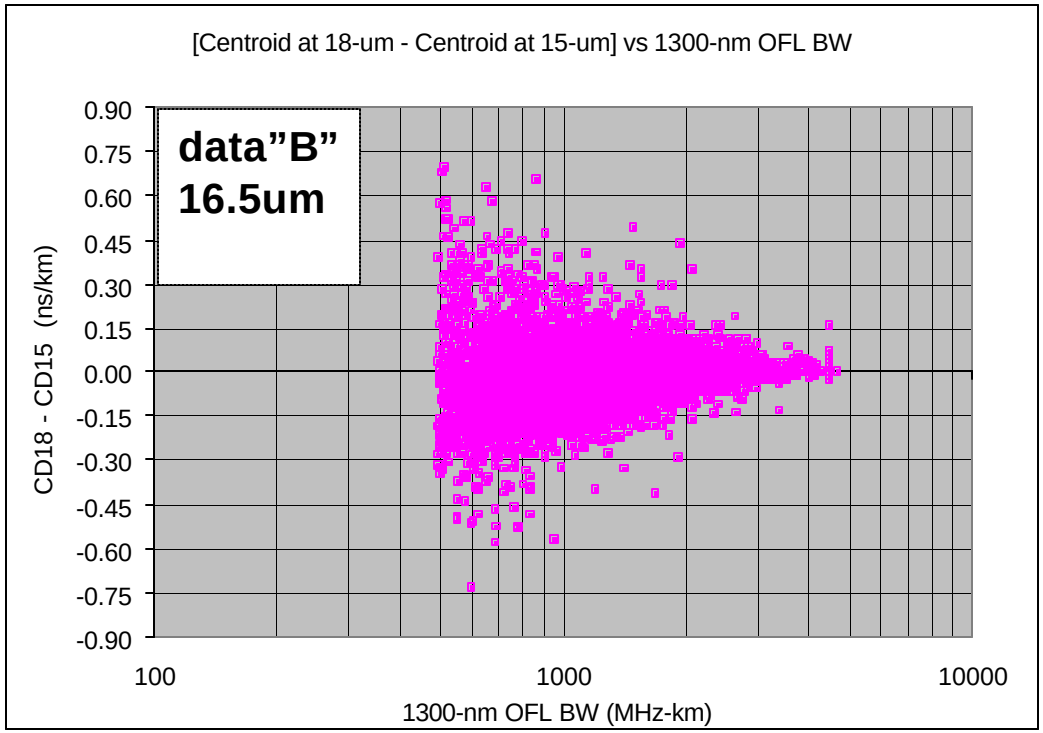
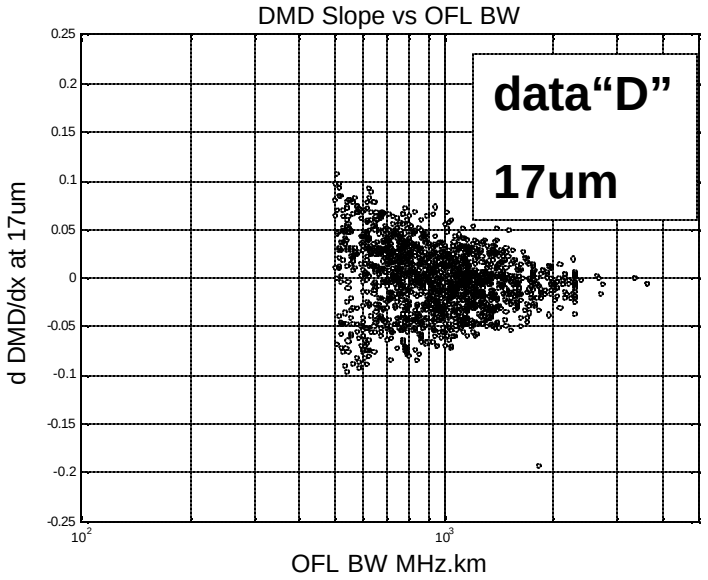
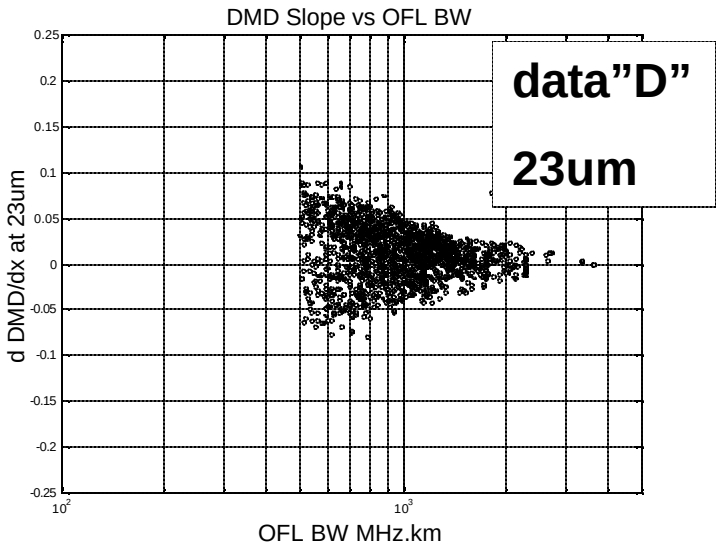
DMDslope vs OFL BW







The advantage of plotting DMDslope vs. OFL BW is that this information is available in the historical production data sets "B" and "D".

Note OFL BW does not correlate with slope the same way as local EMB.

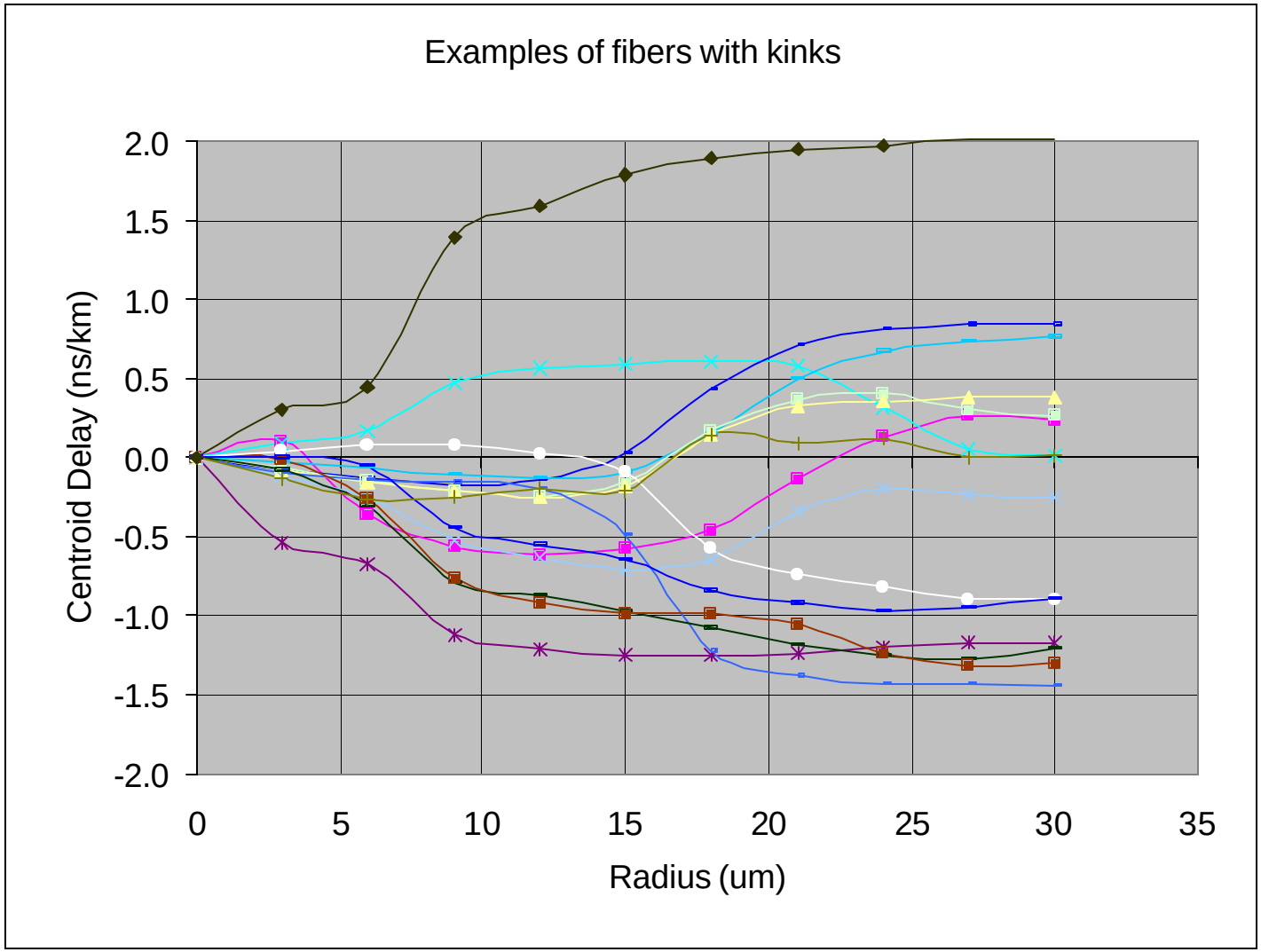
Additional Data on Kinks

Historical DMDs are being reviewed to quantify the frequency of “kink-like” changes in DMDs.

DMD vs Radial Position (Manufacturing Data)

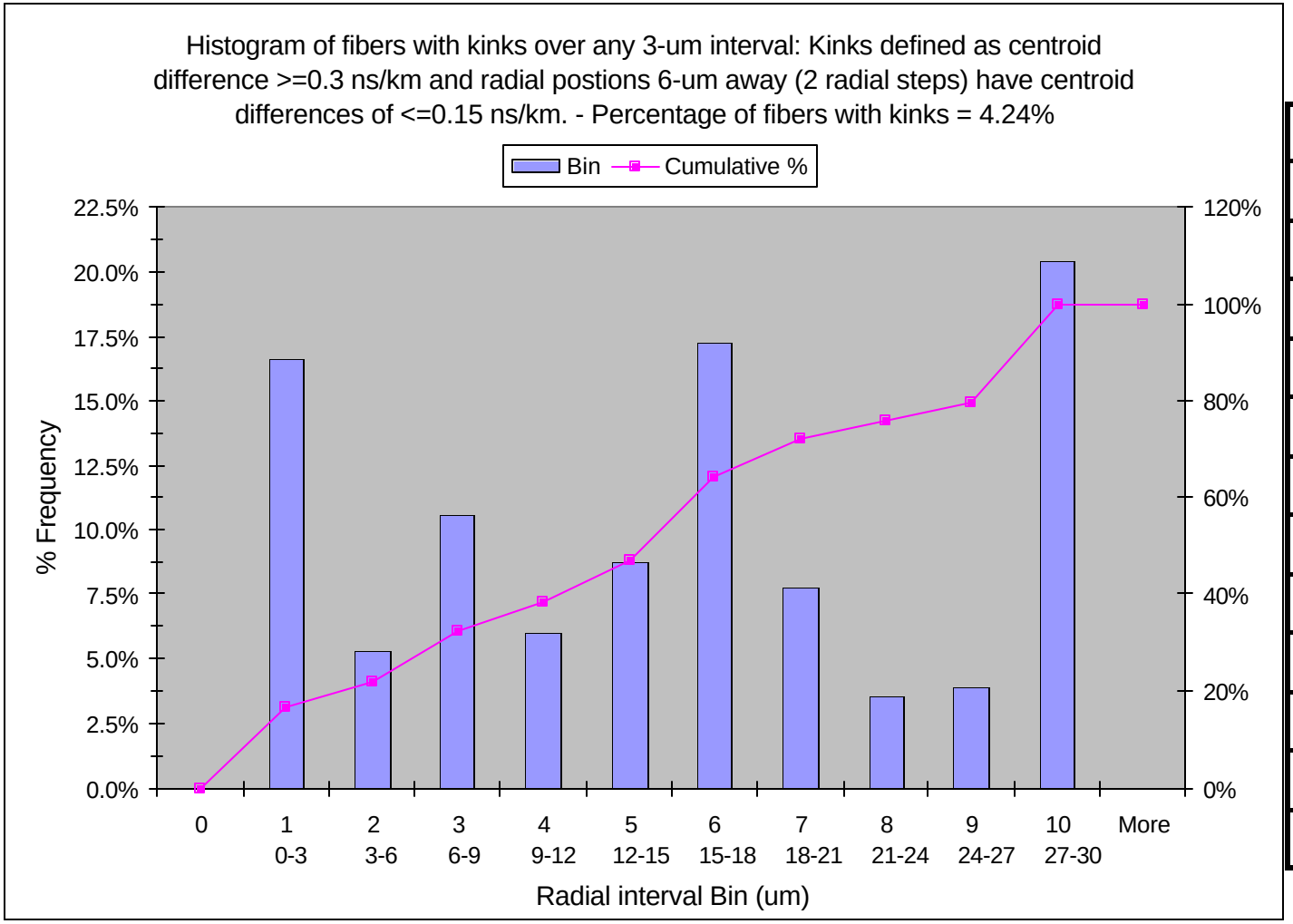
- 1998 Production fiber – better than earlier fibers
- ~6500 fibers between 1.7 km and 8.8 km.
- 1 or 2 fibers from each preform.
- Samples from near center of preform only
  - ends contain 2 – 3X more high DMD slope fiber
- Steps size: 3 um. Laser spot size: ~9 um.
- Filtered for 160/500 MHz-km bandwidth unless noted.

Examples of fibers with kinks



Historical Examples DMDs with kink-like transitions.

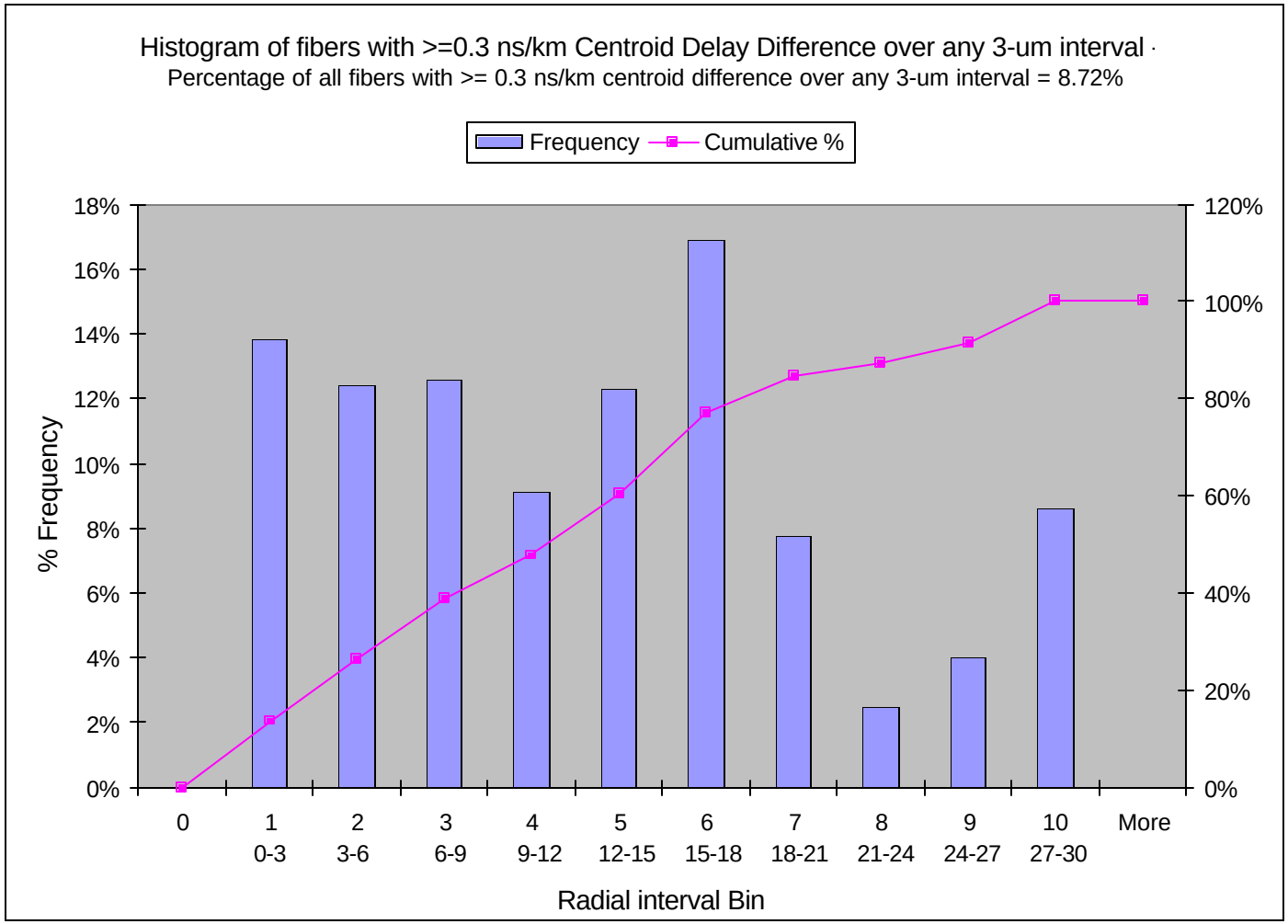
Kinked fiber histogram ~6500 Real 1998 Fibers.



Radial Interval (um)	% Kinks
0-3	0.727%
3-6	0.232%
6-9	0.464%
9-12	0.263%
12-15	0.386%
15-18	0.757%
18-21	0.340%
21-24	0.155%
24-27	0.170%
27-30	0.897%
Total	4.240%

11 – 27um: 1.9% have kinks

Fibers with CD2-CD1 >=0.3 ns/km histogram.



Radial Position		%> 0.3 ns/km over 3 um
0	3	1.20
3	6	1.09
6	9	1.11
9	12	0.78
12	15	1.09
15	18	1.48
18	21	0.65
21	24	0.22
24	27	0.35
27	30	0.74
0	27	7.98
0	30	8.72
11	27	4.05

11-27um: 4% have slopes >.3nsec/km over 3um

Recommendation

Evidence of installed base DMD slope supports inclusion of Kinks as in 108 fiber Cambridge Model approved by task 1

The Gen54YY Monte Carlo data should be shifted to better agree with pre-GbE production OFL BW data as well as available DMD data. The Monte Carlo distribution can be checked with the 4 basic plots. Revisions should show improvement in both OFL BW and DMD range distribution as well as the scatter plots.