Monte Carlo update: PIE metric results, further benchmarking to fiber data

John Abbott	Corning Incorporated
Steve Swanson	Corning Incorporated
John George	OFS
George Oulundsen	OFS
Robert Lingle	OFS
Paul Kolesar	Systimax
Frank Achten	Draka

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Summary

1. PIE-metric results for 5000fiber 54YY Monte Carlo & 108 fiber set.

1a. 17um PIE metric distribution similar for all fibers & OFL>500.

1b. MC can be used to generate smaller test sets for specific launches and to fine tune estimates.

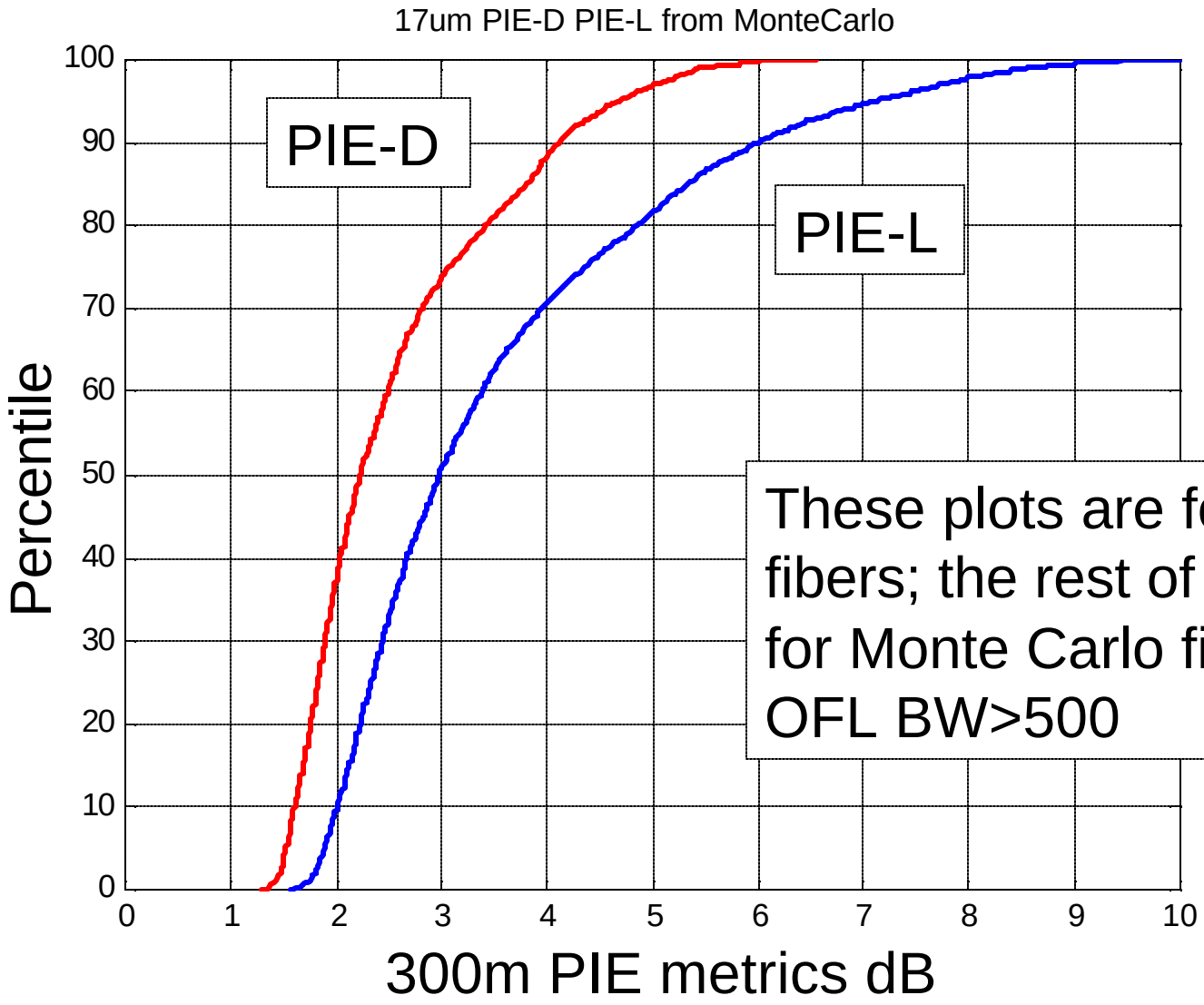
2. Additional benchmarking to fiber data

2a. Local DMD slopes are normally distributed and serve as good modeling tool (validating some OM3 assumptions)

2b. Suggested revision to Monte Carlo distribution to further improve agreement.

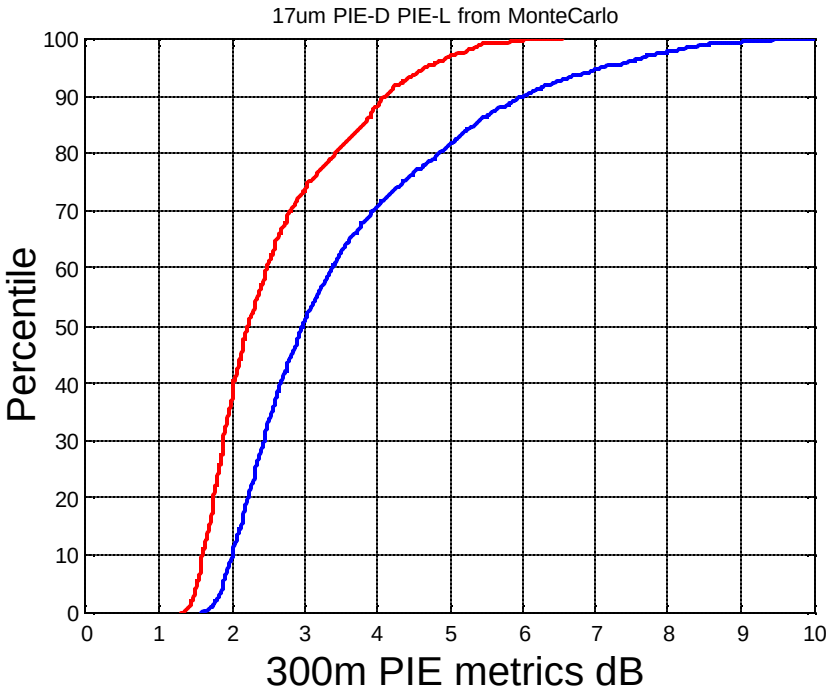
Example Monte Carlo PIE metric results

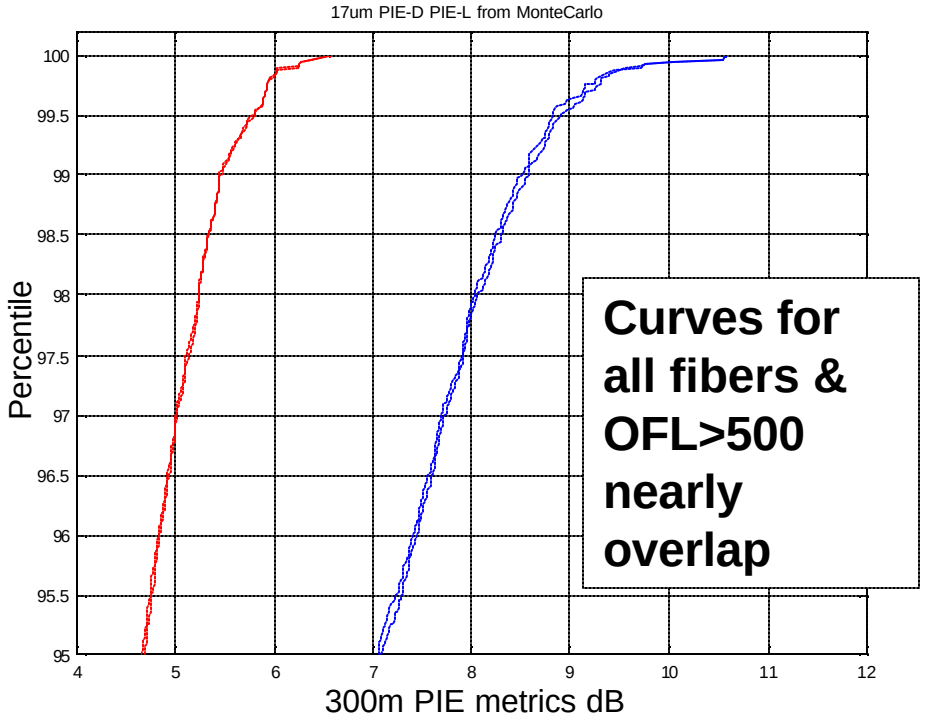
PIE metrics: ALL 5000 FIBERS 54YY (17um offset)



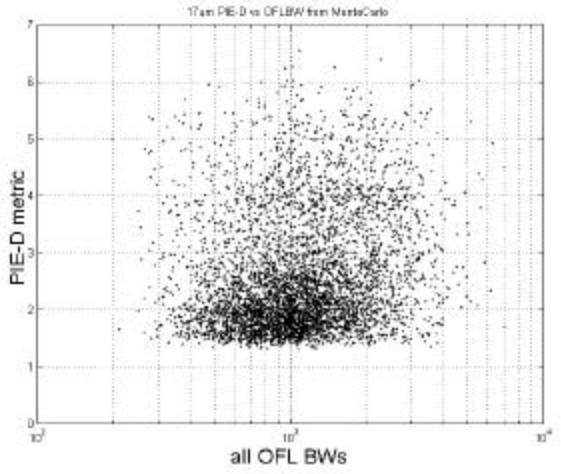
These plots are for all 5000 fibers; the rest of the plots are for Monte Carlo fibers with OFL BW>500

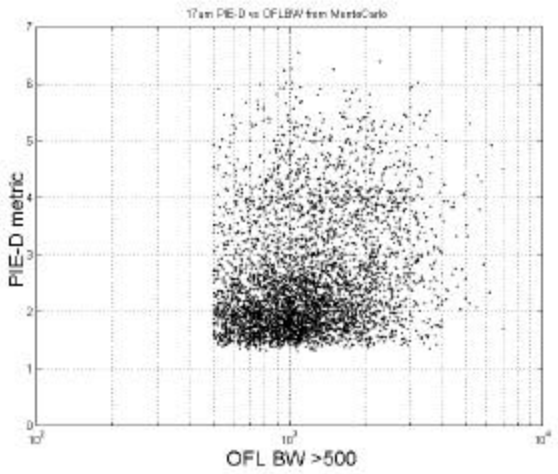
Similar 17um **PIE metrics** for OFL>500





Curves for all fibers & OFL>500 nearly overlap





OFL BW & 17um offset BW don't correlate.

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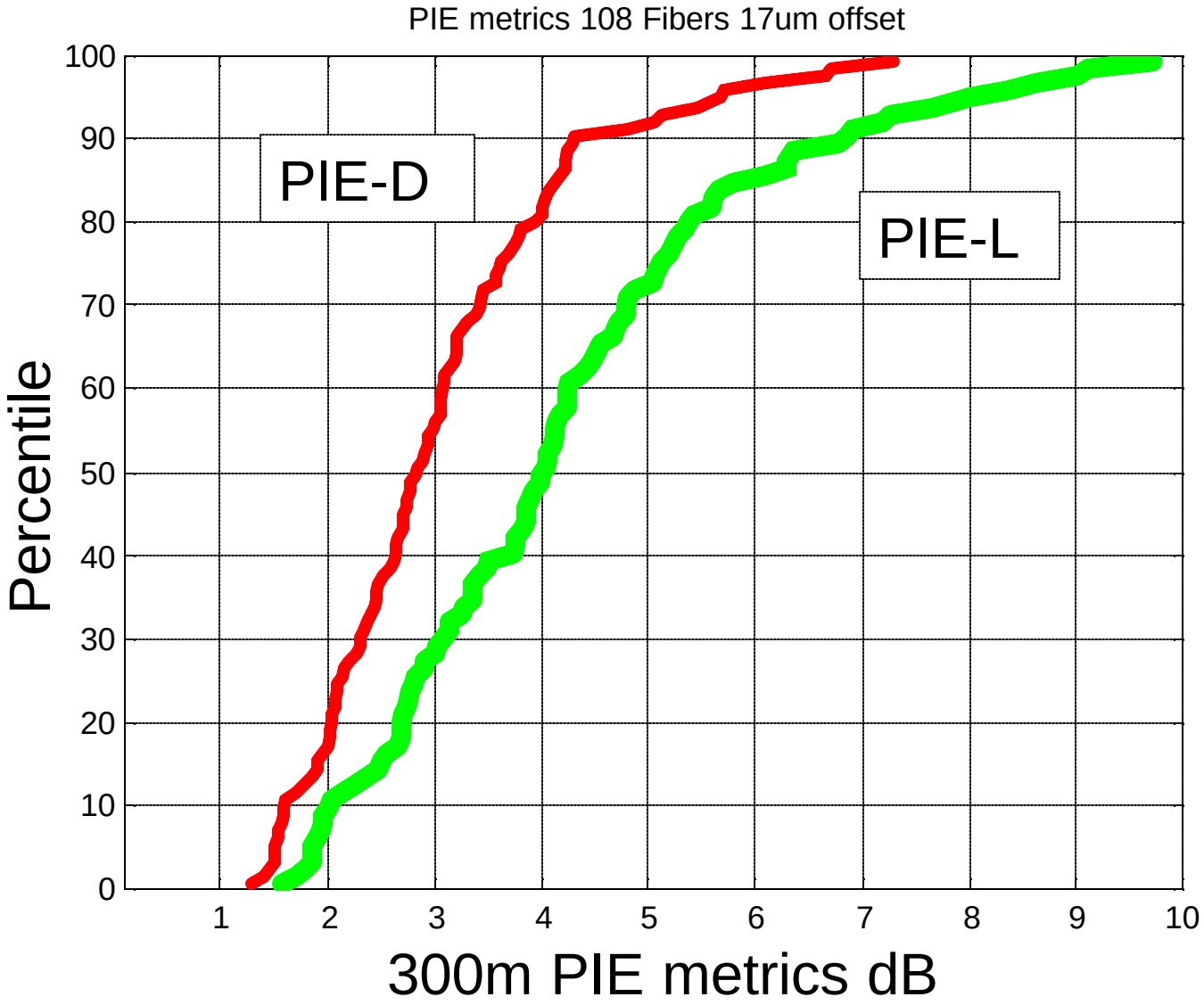
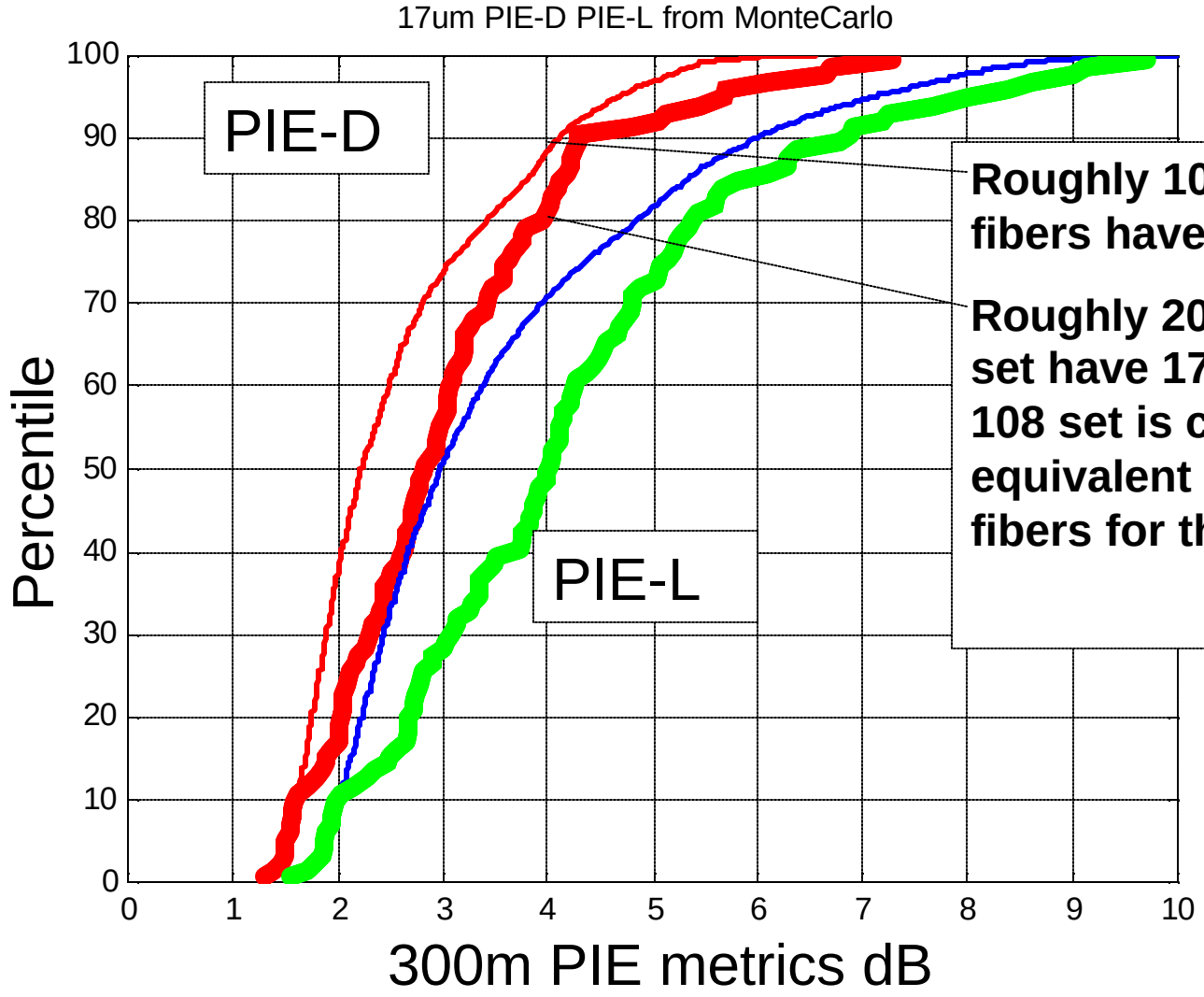
108 fiber results (17um offset)



17um results: MC4620 and 108 fibers

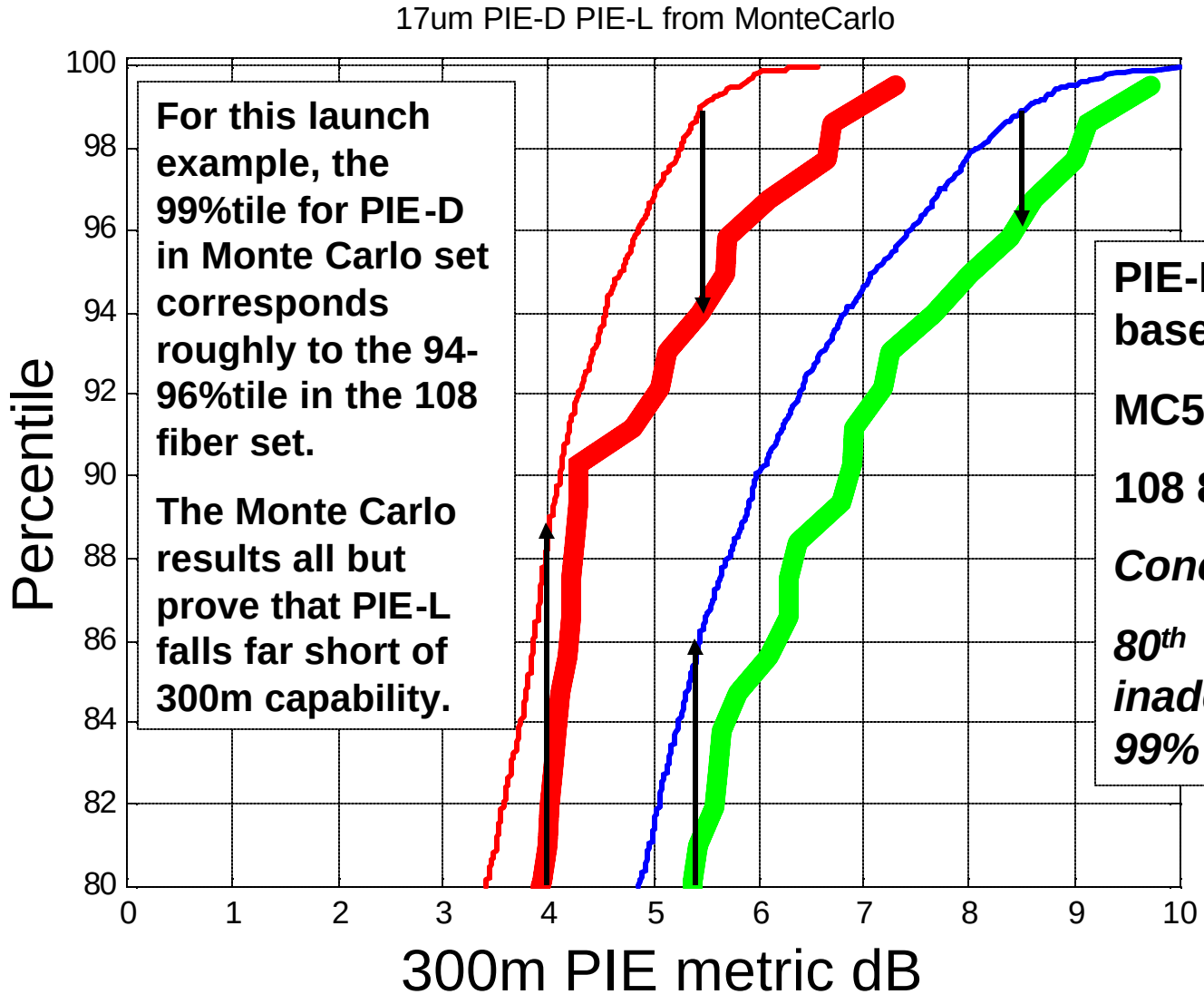
Monte Carlo set has 4620 fibers with OFL BW>500



Roughly 10% of Monte Carlo fibers have 17um PIE-D>4dB.

Roughly 20% of the 108 fiber set have 17um PIE-D>4dB: 108 set is challenging but not equivalent to worst 5% of the fibers for this specific launch.

Closeup of 17um results: MC4620 + 108 fibers



For this launch example, the 99%tile for PIE-D in Monte Carlo set corresponds roughly to the 94-96%tile in the 108 fiber set.

The Monte Carlo results all but prove that PIE-L falls far short of 300m capability.

PIE-D for 99% installed base coverage @ 17 um

MC54YY = 5.5 dB

108 80th %tile = 4.0 dB

Conclusion:

80th %tile of 108 fiber set inadequate predictor of 99% coverage

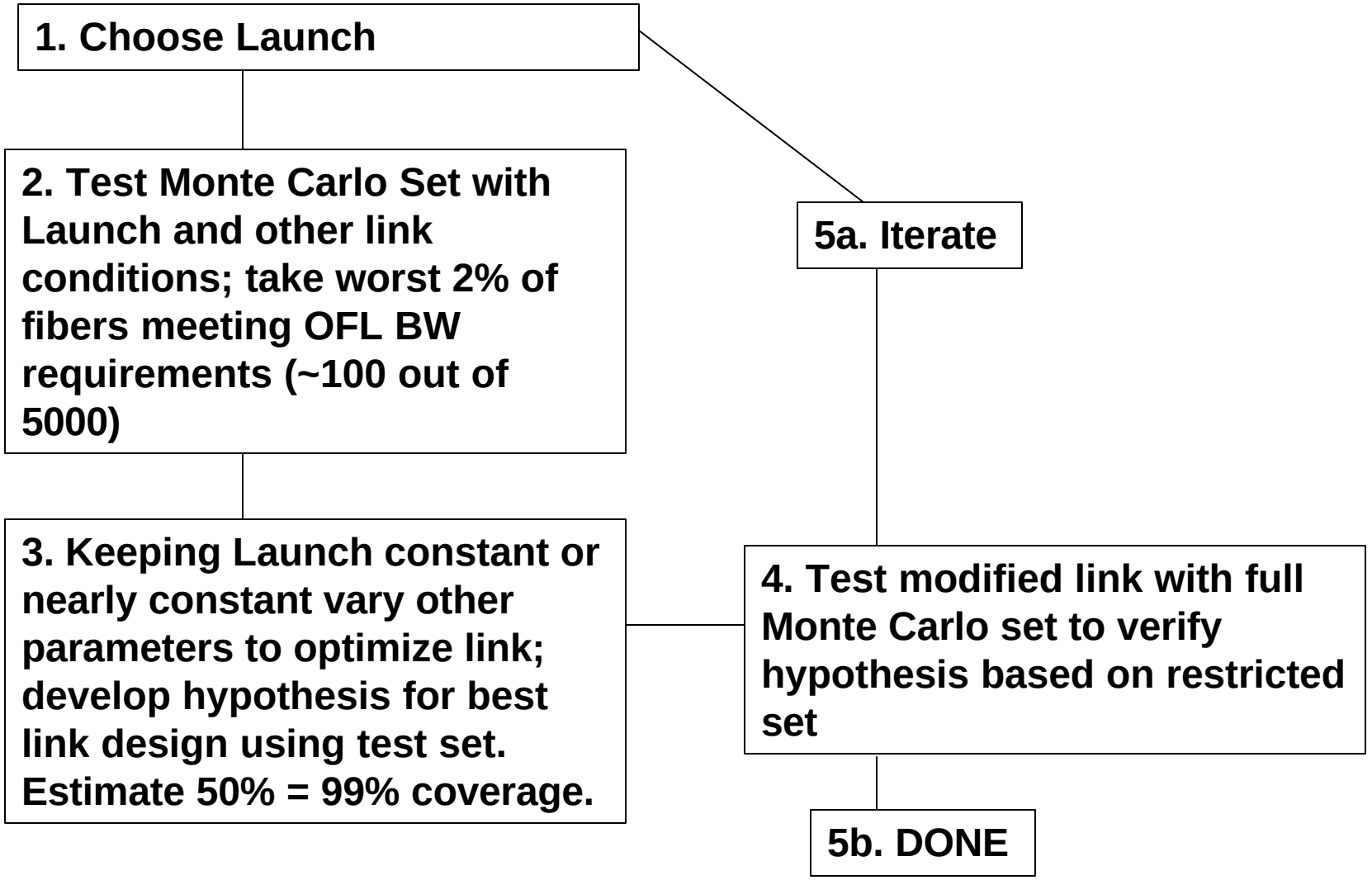
Key Uses for the Monte Carlo Set

1. Verify “percent coverage” to rigor necessary for reliable 99% coverage.
2. Generate specific fiber test sets for specific launches. examples: 100 worst (worst 2%) for offset launch, for center launch, for Vortex launch, etc.

    -> can construct index profiles that match mode delays using perturbation methods.

    -> “worst case” depends on launch condition – cannot define worst case fiber population by just OFL BW or full DMD range.

Monte Carlo Flow Chart



Update on Benchmarking & Improved MC

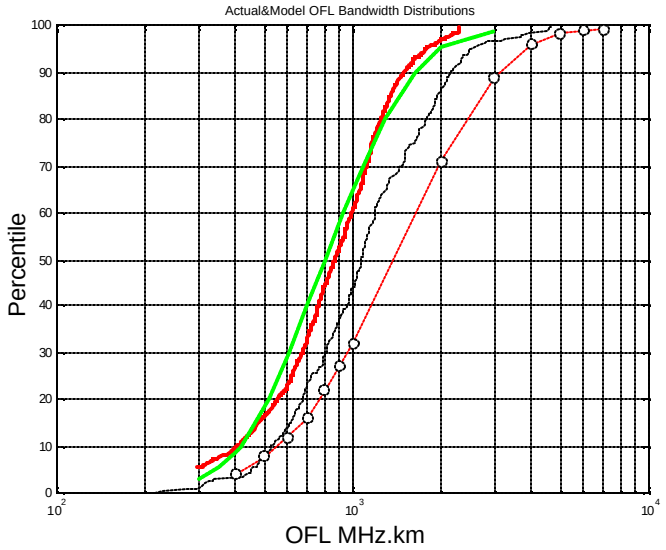
Thanks to Fiber Manufacturers for Sharing Data

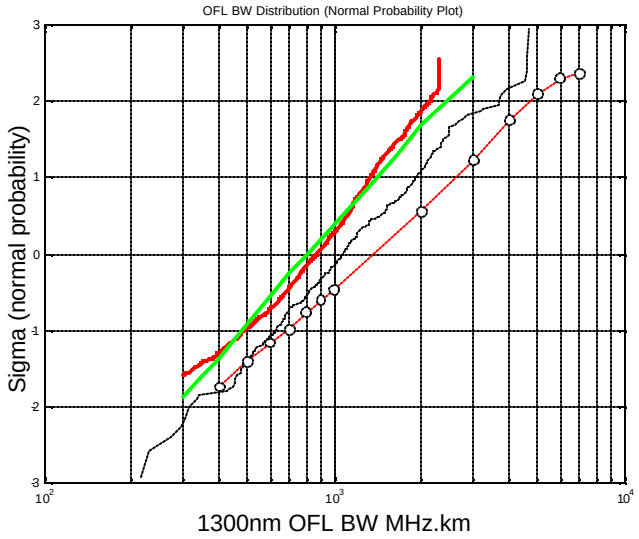
Draka

OFS

Corning

OFL BW distribution – 54YY & Fiber Data





1-(green) Manuf "A" '98 – '99 with DMDs

2-(red) Manuf "B" '98 – '99 with DMDs

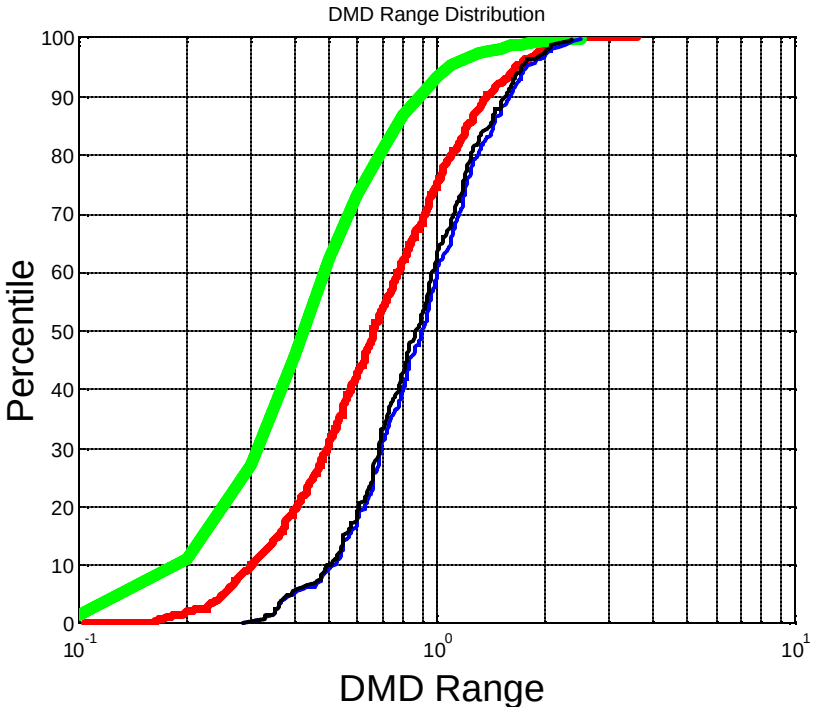
3-(black) MonteCarlo 54YY model set

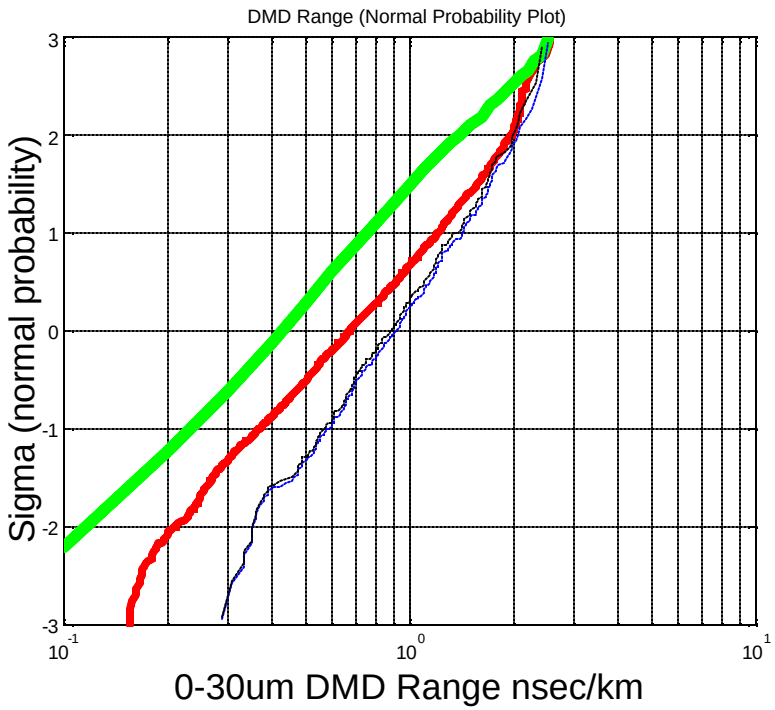
4-(red w circles) Manuf "C" '01 – '04

Improvement goal 1:

1. **shift MC54YY OFL BW closer to Manuf "A" & "B" (installed base)**

DMD range – 54YY & Fiber Data





1 (Green) Manuf "A" – '98 – '99 DMDs for fibers meeting 160/500

2 (Red) Manuf "B" – '98 – '99 DMDs for fibers meeting 160/500

3 (Black/Blue) – DMD range for MonteCarlo 54YY (with & without OFL BW > 500)

Improvement goal 2:

2. shift MC54YY DMD centroid range closer to Manuf "A" & "B" (installed base)

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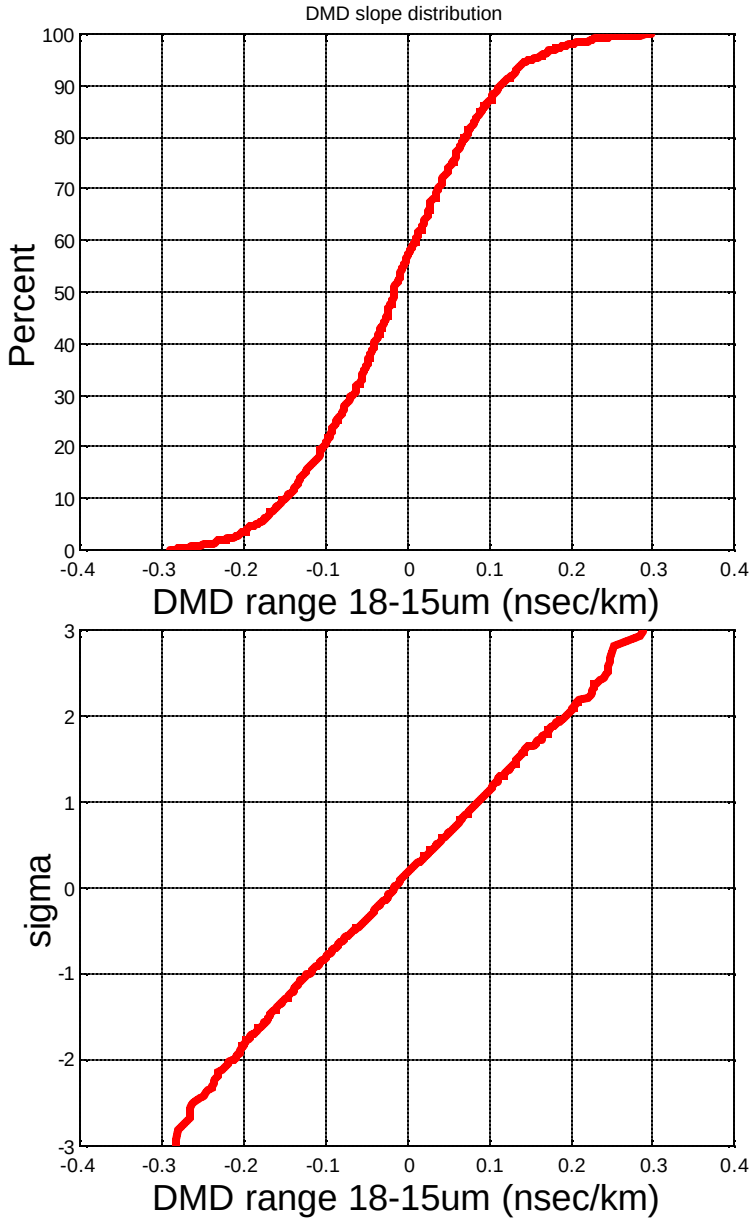
DMD slope distribution



1-red -Manuf "B" '98 – '99

The local DMD slope is normally distributed, validating the TIA OM3 Monte Carlo work as well as the current approach.

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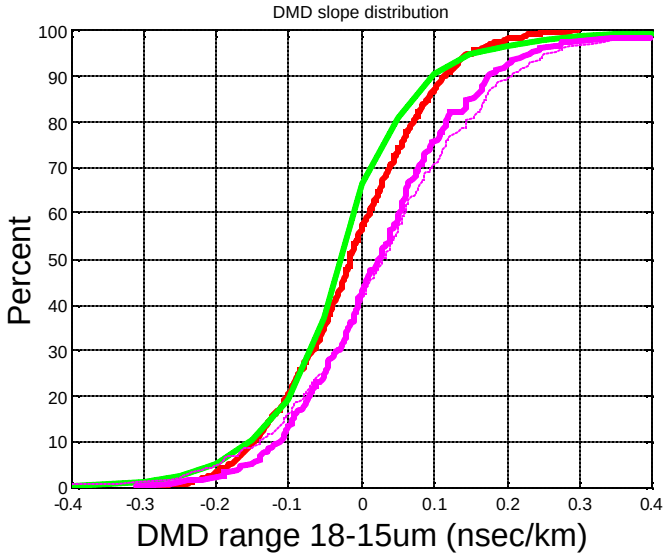
MonteCarlo Improvement – MC67Y

Attached are similar plots including an updated MC distribution. This shows the shifts which can occur.

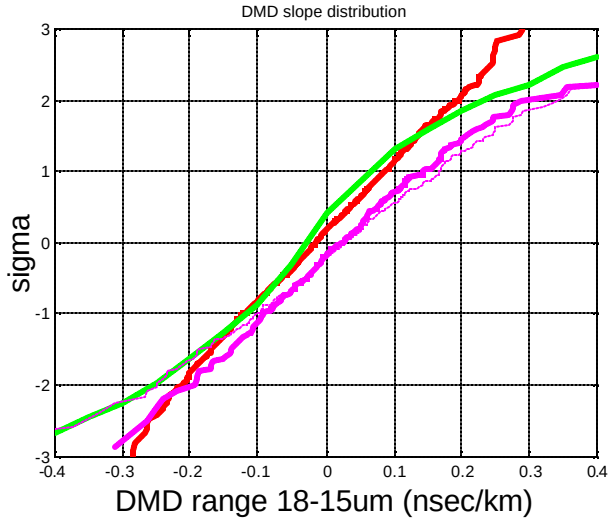
DMD 18um -15um slope distribution--67



1-(green)-Manuf "A" '98 – '99

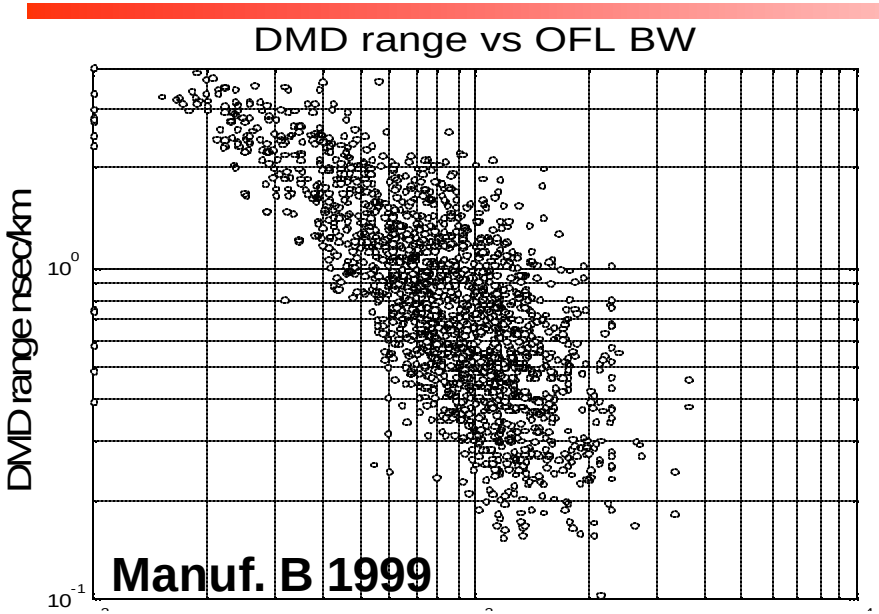
2-(red) -Manuf "B" '98 – '99

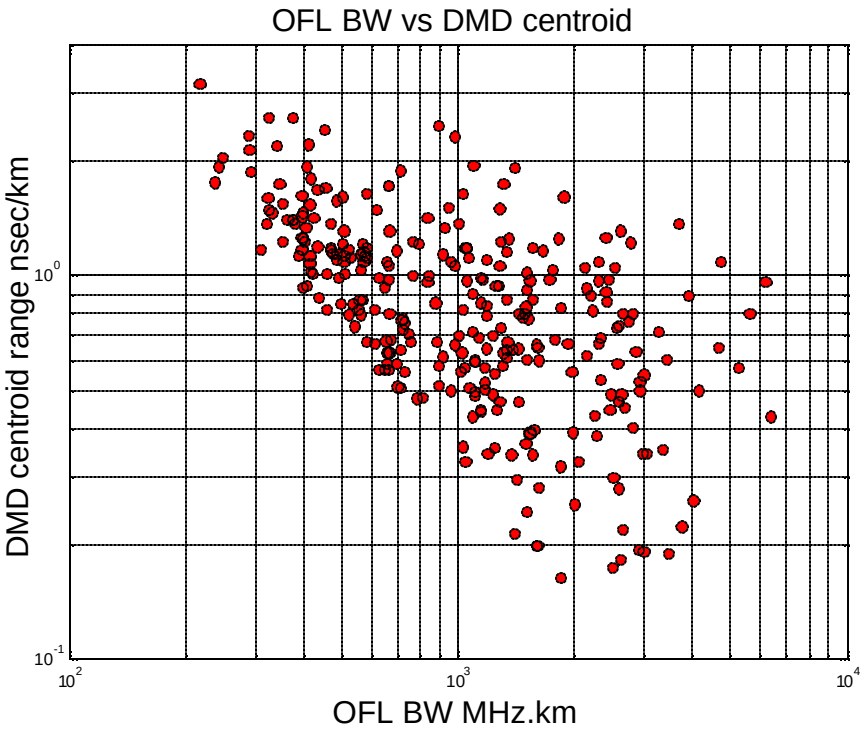
3-(magenta)-MC67Y with **& without fibers with OFL BW<500**

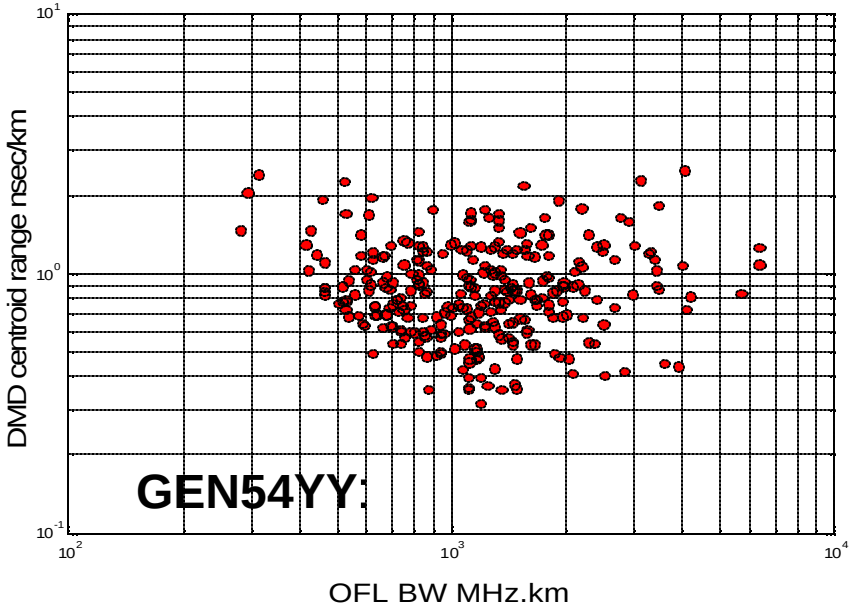


Good agreement with DMD slope in region important for offset launch.

DMD centroid range vs OFL BW – MC67Y







Better agreement – more low DMD range points as seen in fiber data

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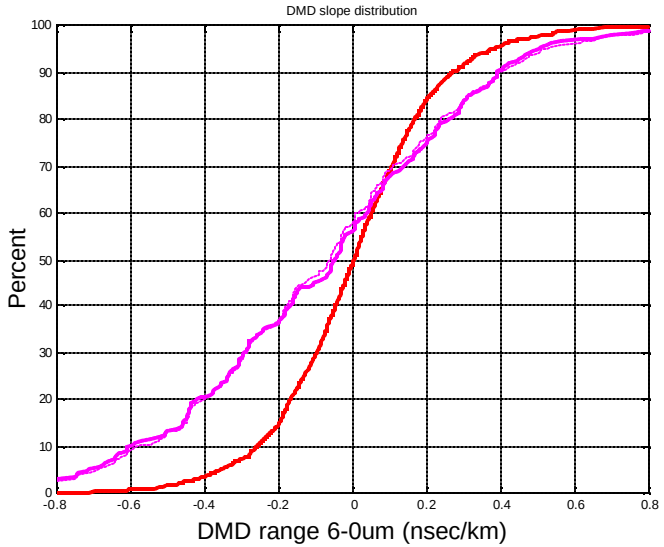
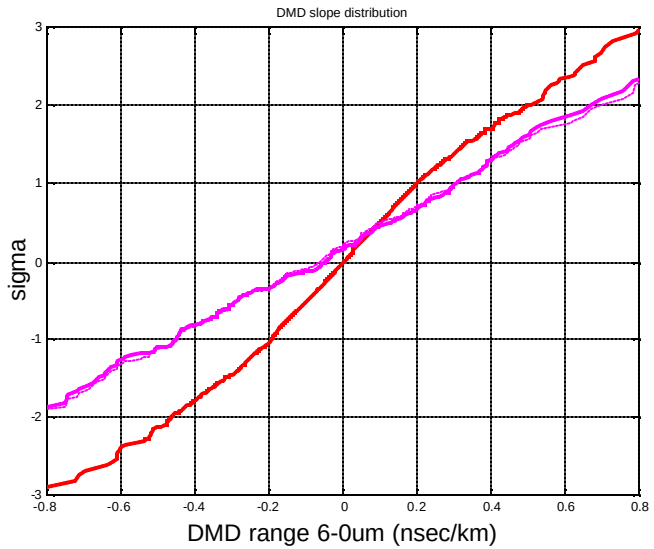
DMD 6um - 0um slope distribution – MC67Y



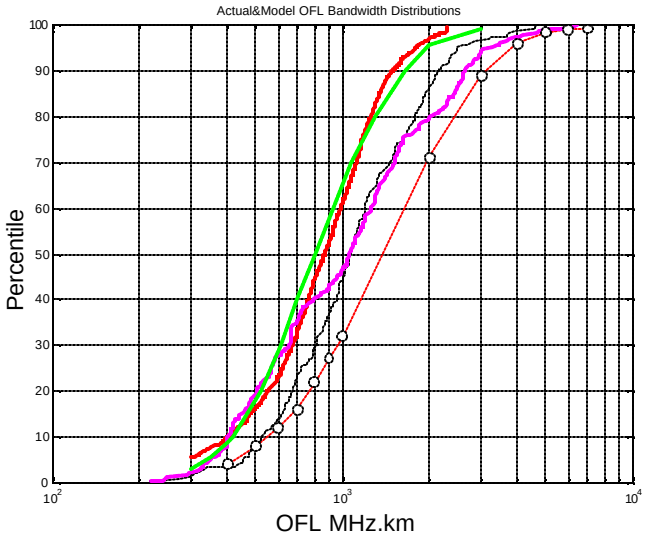
2-red -Manuf “B” 98 - 99

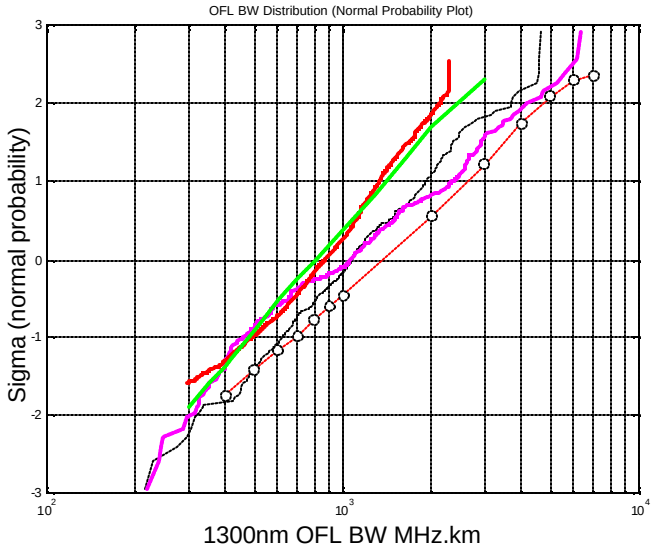
3-magenta-MC67F with & without fibers with OFL BW<500



Opportunity to further improve Monte Carlo agreement with fiber data

OFL BW distribution-MC67 vs. MC54





1-(green) Manuf "A" 98 - 99 with DMDs

2-(red) Manuf "B" 98 - 99 with DMDs

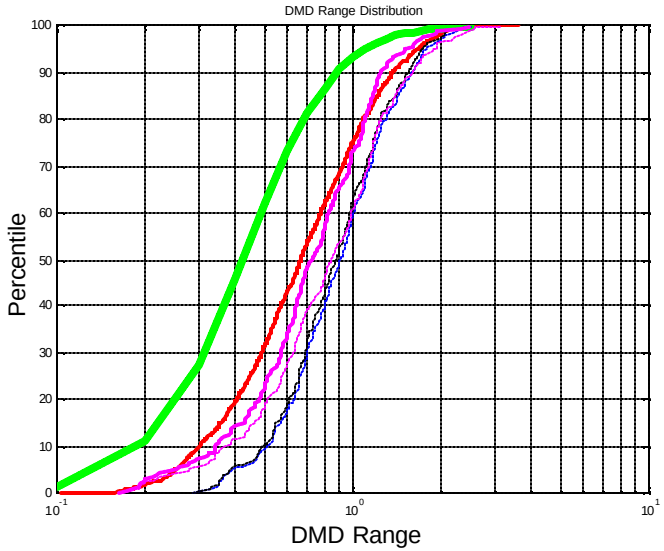
3-(black) MonteCarlo 54YY model set

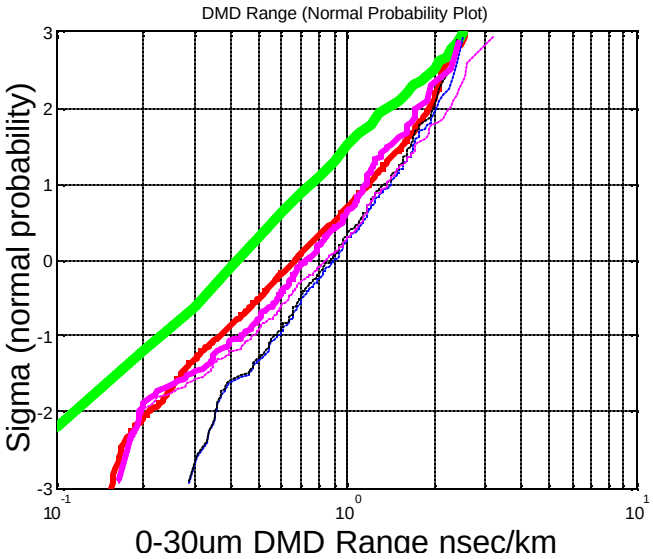
4(circles) Manuf "C" post-GbE

5 (magenta) MC 67Y MonteCarlo set

MC67 – median = 1000, 2sigma = 500MHz.km (agrees with Manuf A&B). Generates higher BWs than A&B; distribution parallels Manuf C

DMD range -67





1 (Green) Manuf "A" – '98 – '99- DMDs for fibers meeting 160/500

2 (Red) Manuf "B" – '98 – '99 - DMDs for fibers meeting 160/500

3 (Black/Blue) – DMD range for MonteCarlo 54YY (with & without 500 requirement)

4 (Magenta/Magenta) – DMD range for MC67Y (with & without 500 requirement)

MC67 now better matches Manuf B

Monte Carlo Improvement – Conclusions

1. Recent adjustments have improved agreement between data and simulation fiber distributions. Further adjustments may be possible by using empirical slope data to drive a MC generation formula.

2. The version 67 Monte Carlo set tracks the fiber OFL data and the fiber DMD range data better. We are now also benchmarking the local DMD slopes which appear to be more important for offset launch BW prediction than previously understood.

Monte Carlo Update Summary

1. 108 fiber set will not accurately predict 99% coverage of installed base because a statistical representation cannot be created based only on max DMD and min OFL BW. Local DMD slope is important.
2. Monte Carlo should be used to predict 99% coverage of launch condition proposals
3. We will continue to improve MC using comparisons to actual fiber data where possible and recommend updates to Monte Carlo assumptions.