Channel Metrics: Benchmarking with TIA OM3 model results & recent IEEE work

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Discovering Beyond Imagination

Summary of *.pdf files (Part1, Part2)

Part1

1. Introduction to ISI vs EMB & TIA OM3 results, Phyworks/Cambridge81 results plotted similarly; Limiting Curve

2. "Figure of merit for a Figure of merit" (the Channel Metric)

3. Two "BW metrics" used for TIA OM3 analysis, comparison to Phyworks/Cambridge81 results

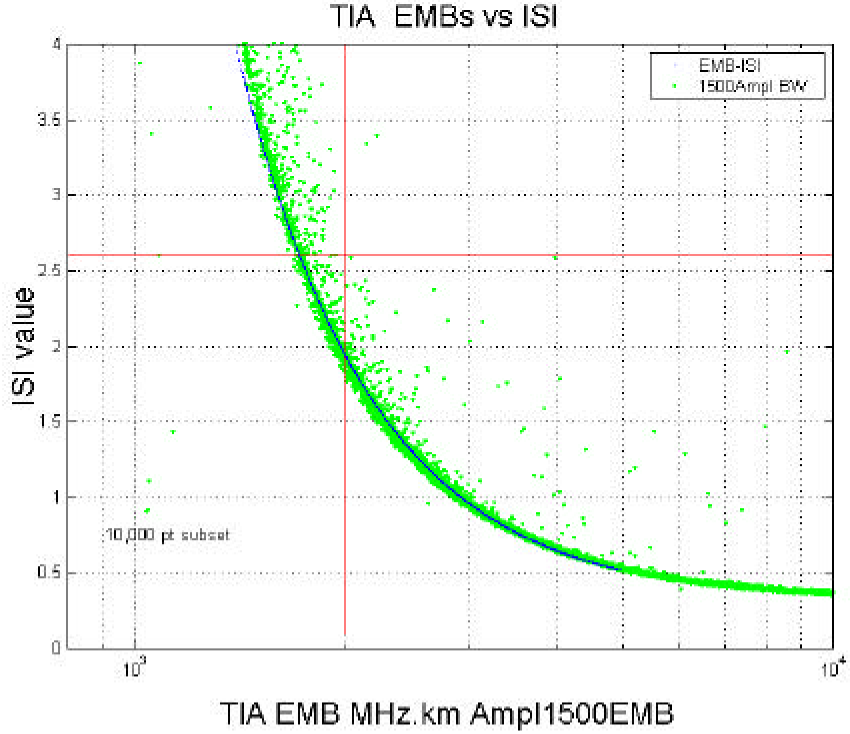
4. IFR & PE metrics compared on TIA OM3 & Phyworks/Cambridge81 data

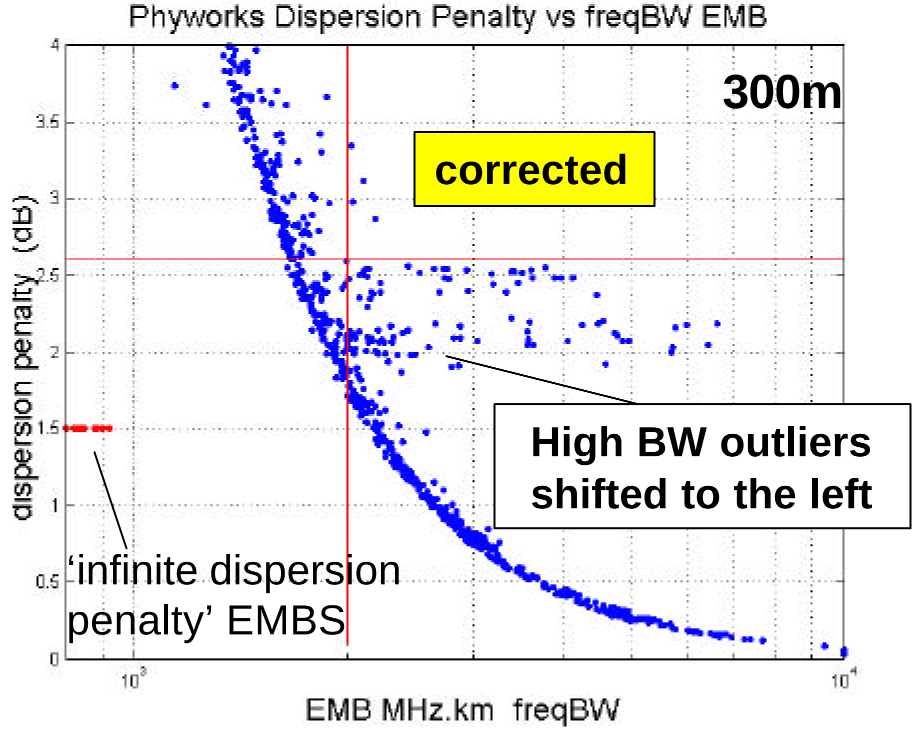
5. Discussion/Conclusion/ Loose Ends

Part2

Corrections in BW metric results added, will circulate revised version Tues. pm.

f_bit metric: TIA vs Phyworks/Cambridge





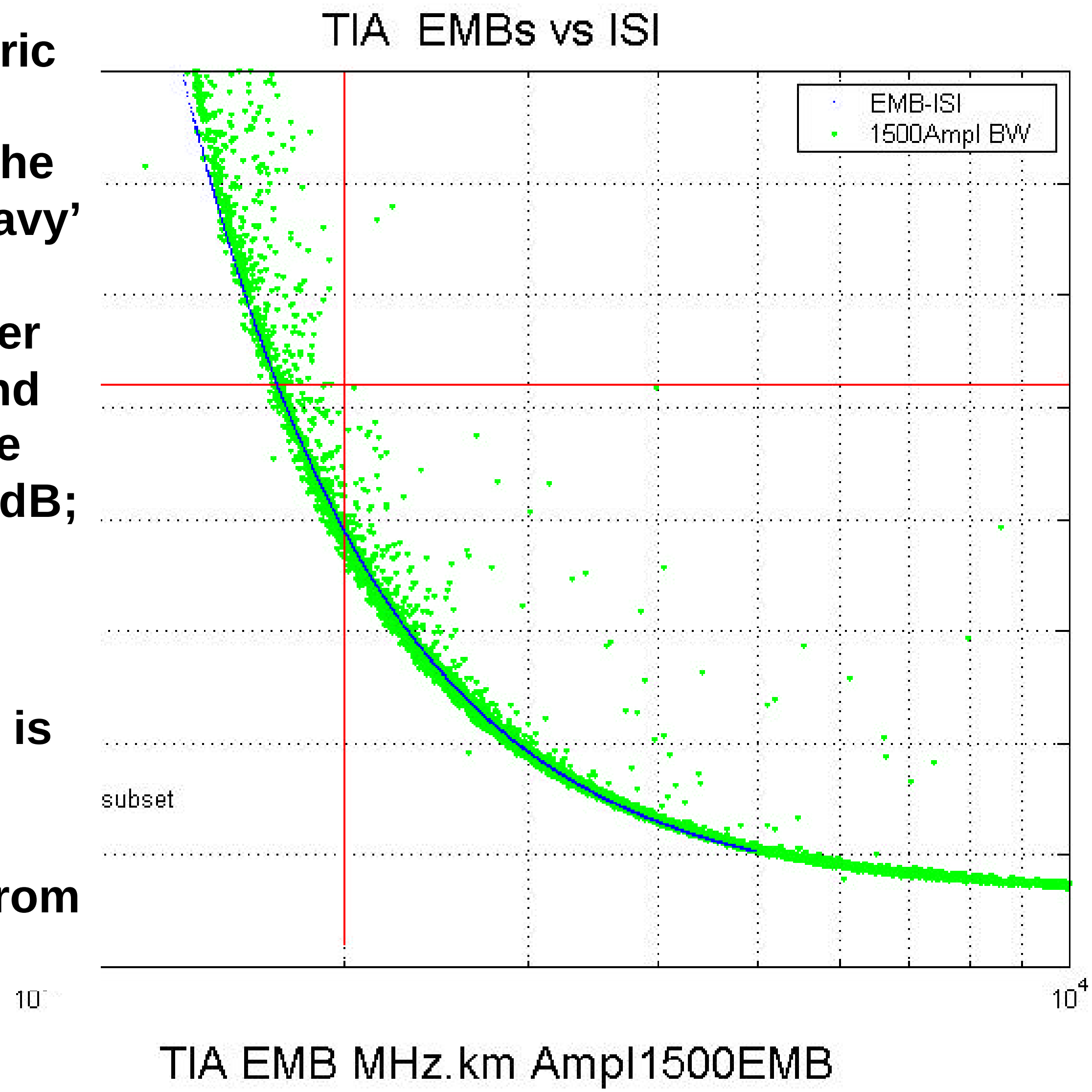
The f_bit or freqBW metric takes a single value on the |H(f)| curve corresponding to half the bit rate (5000MHz for a 10GHz bit rate) and extrapolates to the -3dB level to generate a metric with units of MHz or MHz.km . If the amplitude itself is used a metric similar to IFR or P_E arises.

The f_bit metric is <u>similar for Phyworks data</u> except outliers don't fully map.

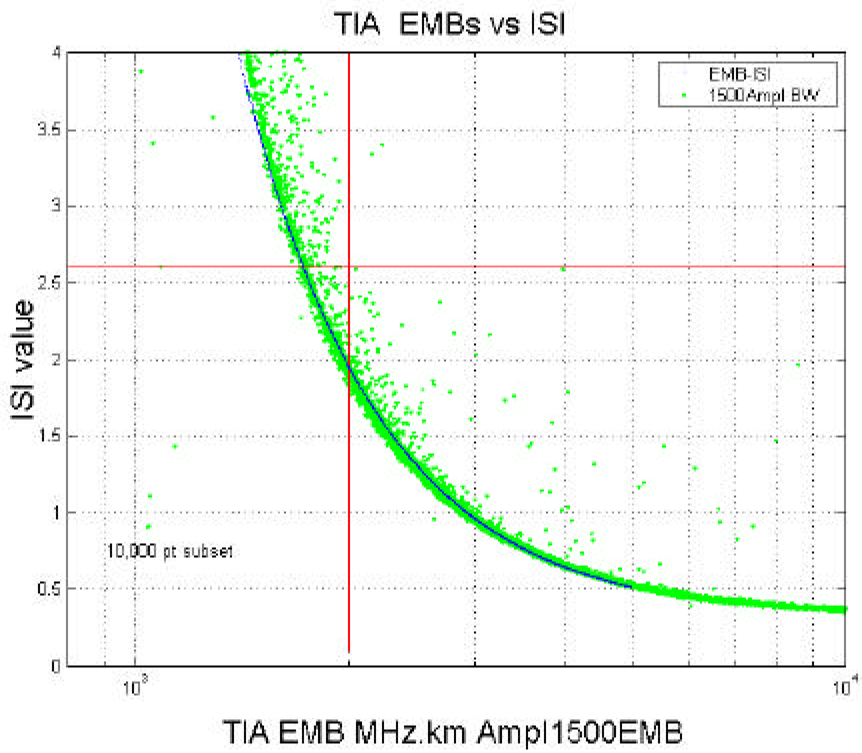
f_bit metric: TIA

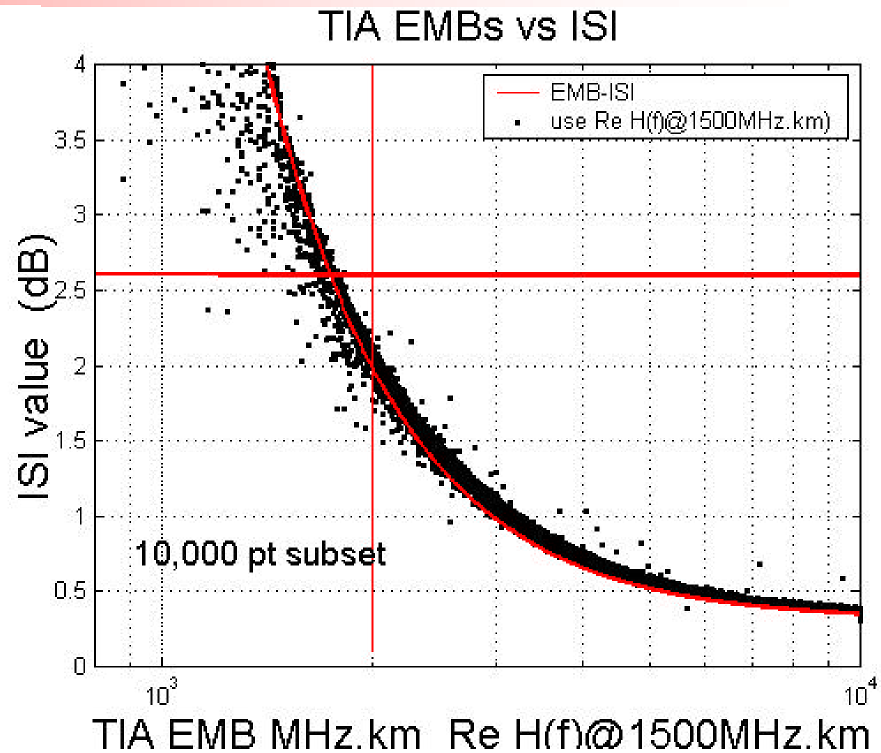
On these plots the f_bit metric is exactly as defined on the previous slide; however, if the transfer function |H(f)| is 'wavy' it probably makes sense to define the metric as the lower of the previous definition and the first frequency where the transfer function reaches -3dB;

That is, for the 300m 10GbE example, if the normal -3dB BW is <1500MHz.km, then it is used; if the -3dB BW>1500MHz.km, then the f_bit extrapolation is used from 1500MHz.km



f_bit metric: |H(f)| vs Re H(f) (TIA data)





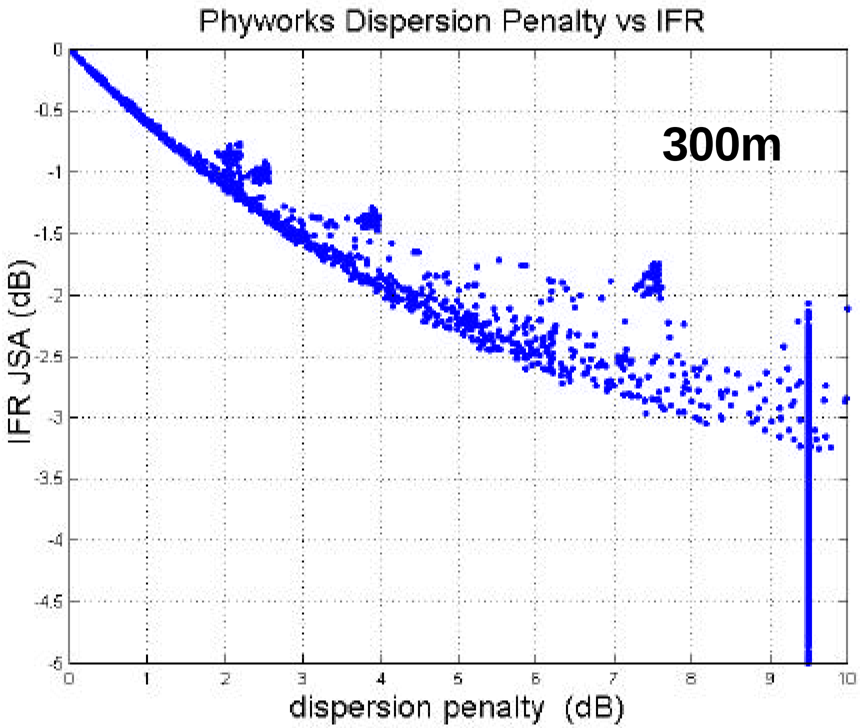
By applying the f_bit protocol to Real H(f) rather than |H(f)|, the TIA data collapses <u>even better</u> at high EMBs and shifts the 'failing' ISI (>2.6dB) points below 1770 EMB so that EMB can be used to efficiently predict a passing ISI. However, the fact that the Phyworks/Cambridge data did not collapse remains to be explained.

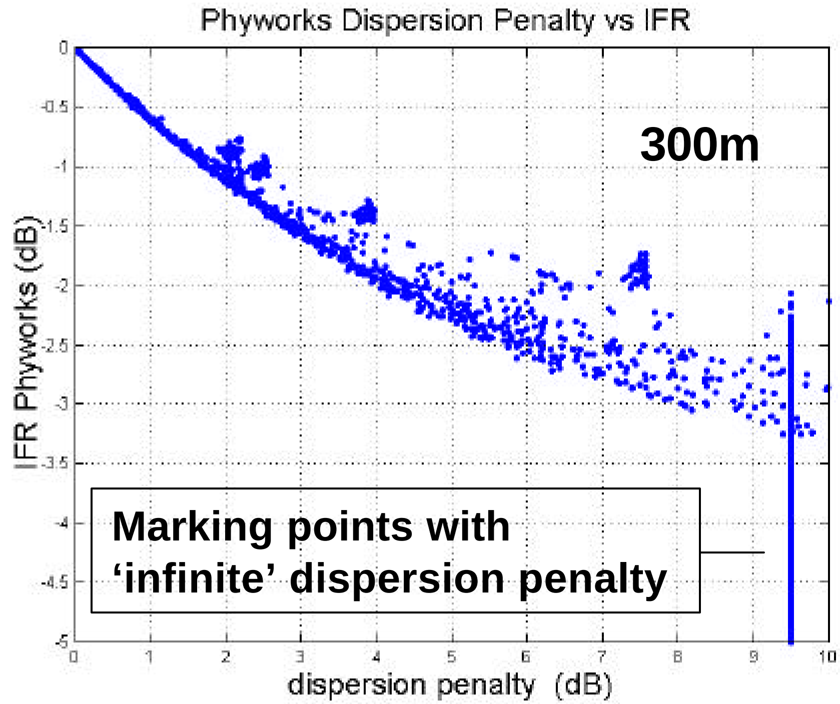
Discussion

The motivation of the f_bit metric is that the ISI measurement occurs exactly at a specific bit rate, and that the analysis of the Fourier Transform should be based on that bit rate.

The excellent agreement between ISI and EMB in the TIA data set suggested this was on the right track and it is confirmed with the Phyworks data set. The agreement is best, as expected, for fibers for which an extrapolation from 1500MHz.km is appropriate. For non-EDC 300m 10GbE fibers, this is a practical requirement, and for other lengths & bit rates we expect similar results for non-EDC fibers.

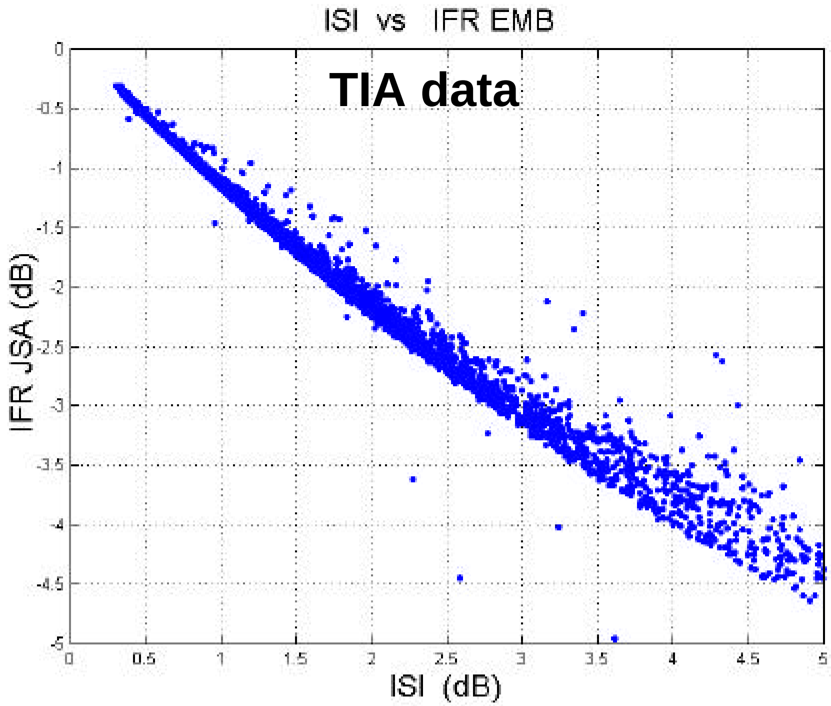
IFR metric – check of Phyworks metric

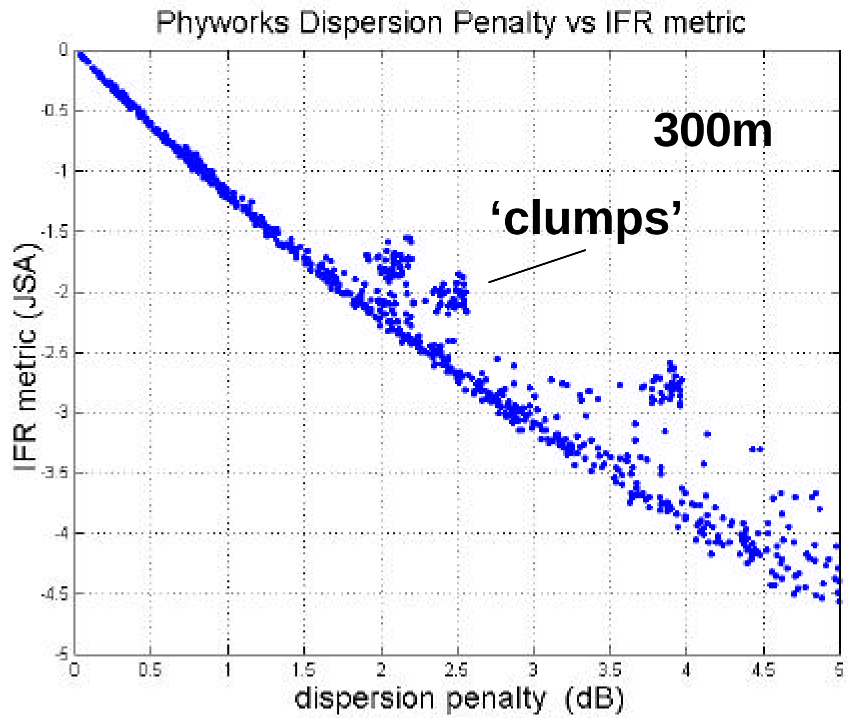




Excellent agreement; minor differences probably due to JSA taking a coarser step size in |H(f)|. The high EMB outliers on the dispersion penalty vs EMB plot become the 'clumps' in the plot above; in addition some points in the calculation have 'infinite' dispersion penalty are were assign 1000dB; when reset to 9.5dB these points appear on the plot associated with poorer fiber. The 'infinite' dispersion penalty fibers correspond to ISI reaching ~3.6dB as in TIA modeling

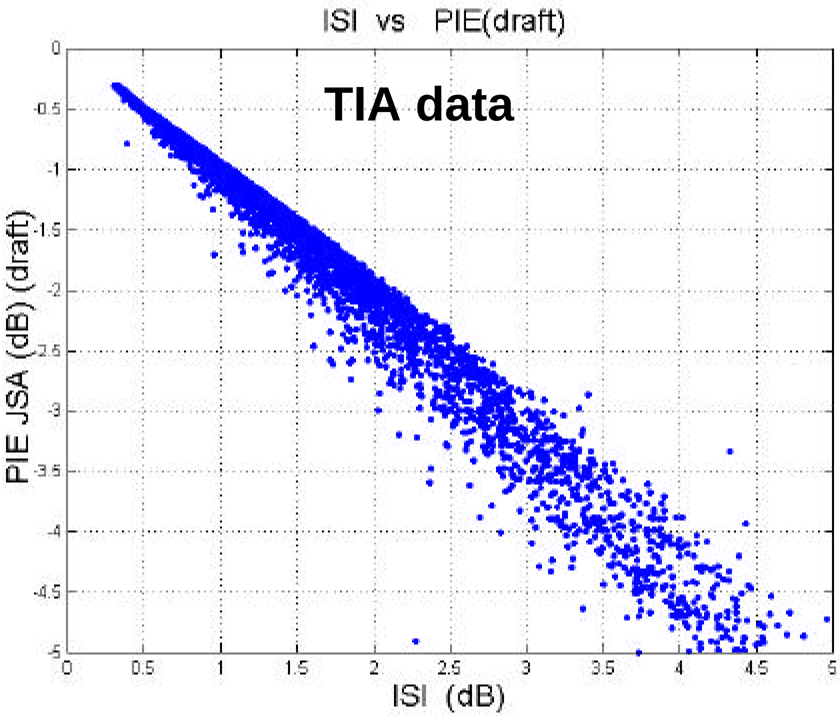
IFR: TIA data vs Phyworks

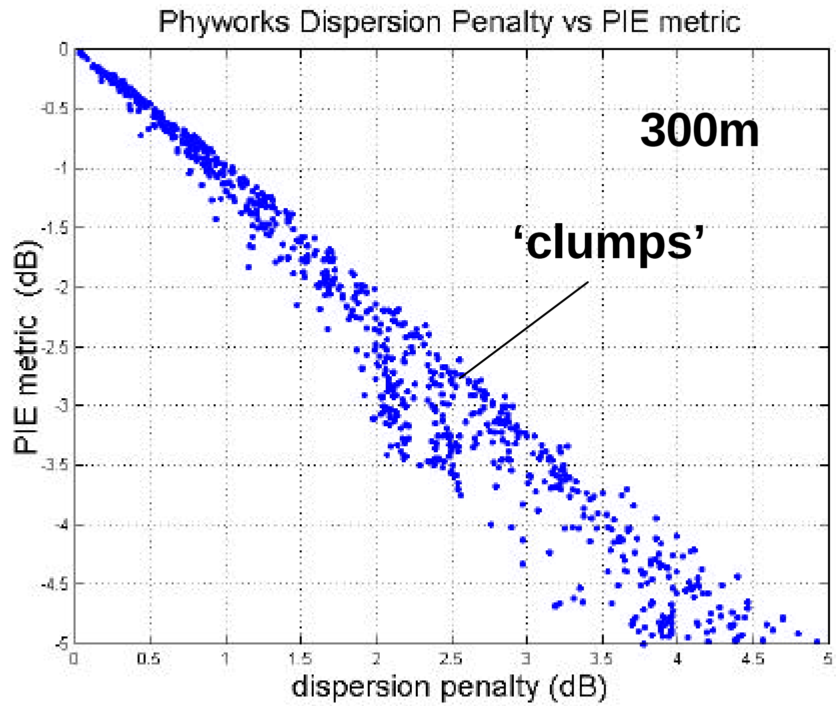




Here we have multiplied Phyworks IFR by 2 to generate a 1:1 slope for small dispersion penalty (high EMB) fibers. We multiplied TIA IFR_JSA by 2 and subtracted 0.31 and also generated a 1:1 slope in the TIA data. The TIA data does not show "clumps" but the high EMB data does not collapse as nicely for high EMB fibers (though larger data set of 10,000 pts)

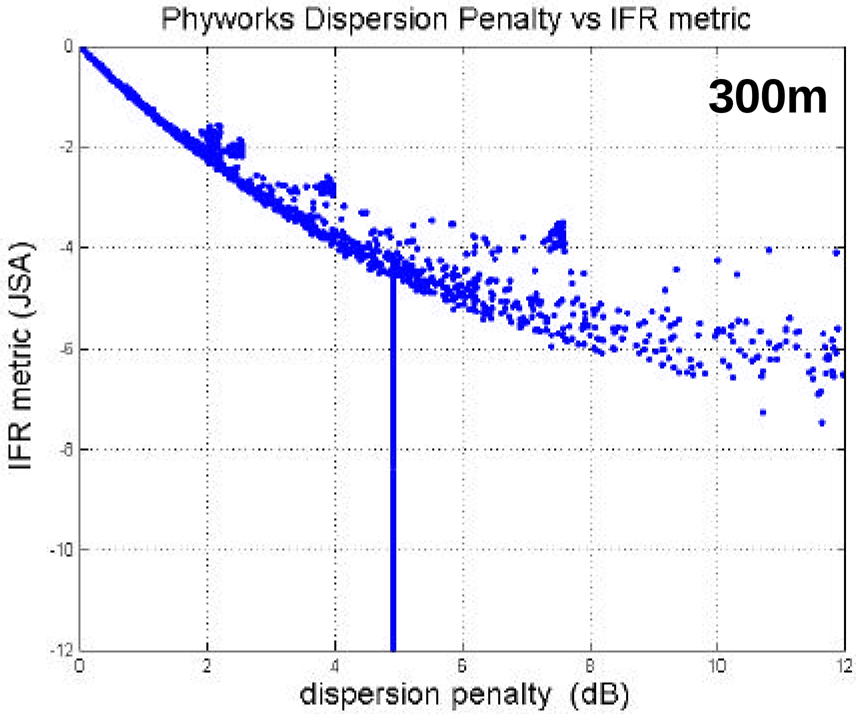
1.414*P_E metric: TIA & Phyworks

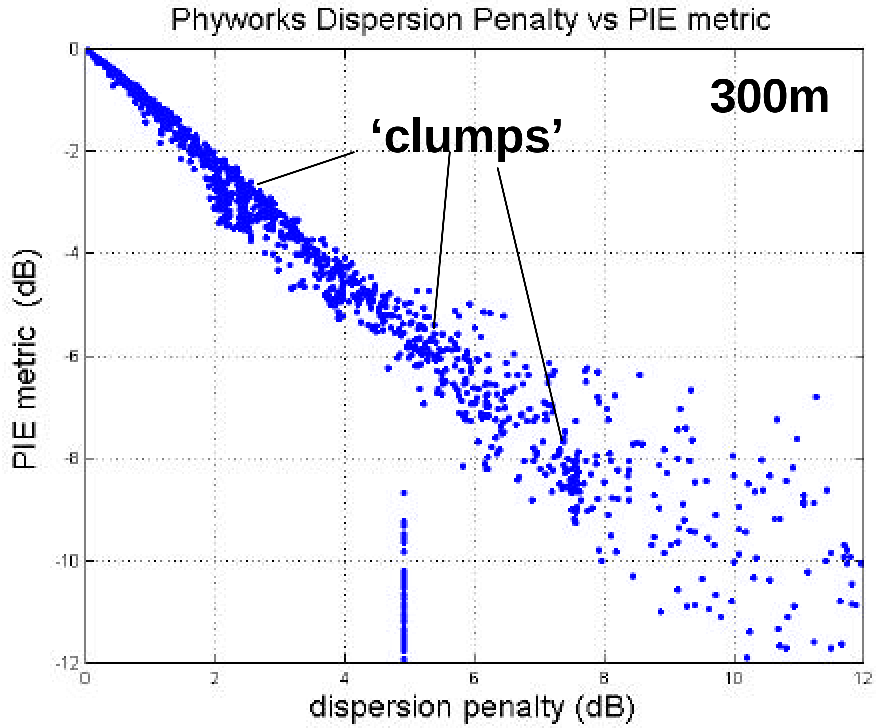




We find that when we multiply the P_E metric by 1.414 we get an approximate linear relation between P_E and dispersion penalty for the Phyworks model as well as between P_E and ISI for the TIA (IBM) model. We again subtracted 0.31 for TIA model to match ISI.

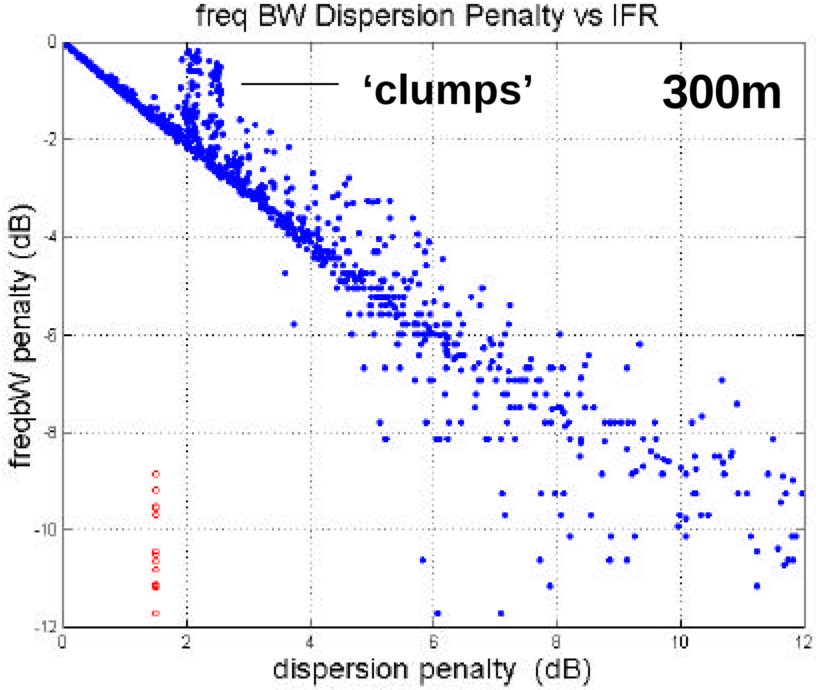
IFR vs P_E using Phyworks data

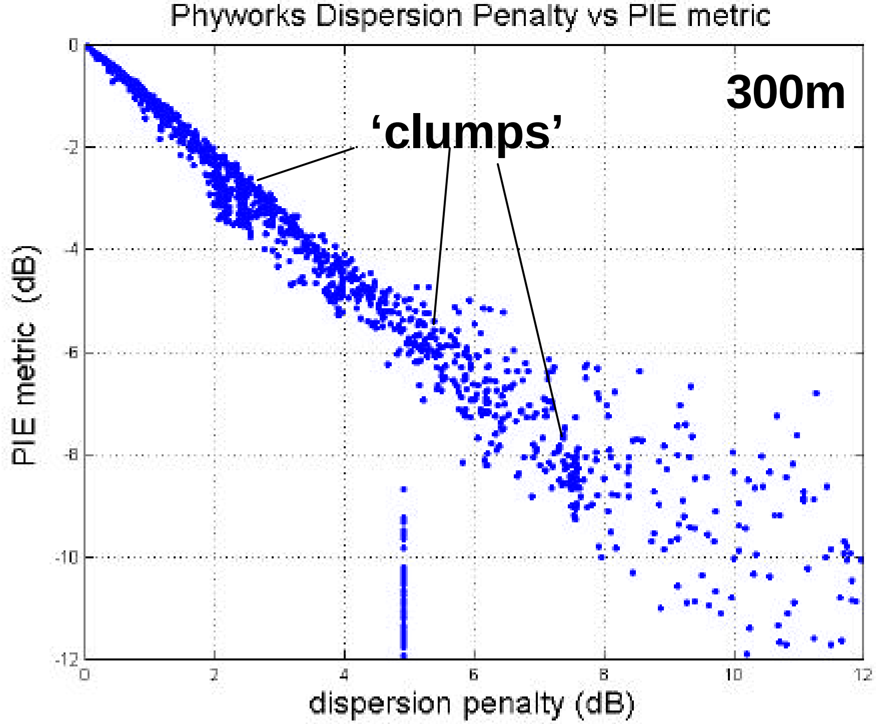




If IFR and P_E are scaled to give a 1:1 slope with dispersion penalty at high EMB (low dispersion penalty), (a) IFR better collapses the data for high EMB fibers; (b) P_E gives a better 1:1slope over a wider range of dispersion penalty; (c) the "infinite dispersion penalty" fibers show up at 2*IFR = -4dB and 1.414*P_E = -8dB, so that P_E seems more useful with low EMB fibers; (d) P_E metric puts 'clumps' nearer the group; IFR keeps 'clumps' tighter.

dB_freq vs. P_E using Phyworks data





We can generate a dispersion penalty metric using JUST the amplitude at f_bit (1500MHz.km) and compare it to the other metrics. We find the agreement is better for cases with low dispersion penalty (like IFR) and worse for some outlier clumps and lower performing fibers. The "infinite penalty" cases are handling correctly by extrapolating to 1500MHz.km from the -3dB if less than 1500MHz.km.

Discussion/Conclusion/ Loose Ends

1. f_ bit metric collapsed TIA data the best – also worked with Phyworks. May warrant review by EDC group for non-EDC examples. dB_freq was 1:1 just like P_E.

2. IFR collapses the data the next best (would |H(f)|^2 give a 1:1 fit? Would integration only to 10GHz improve?). Consistent with IEEE link model (3.6dB ISI = start of eye closure problems)

3. P_E collapses the data in a 1:1 proportion to ISI or dispersion penalty but with larger scatter. May handle Phyworks outliers & “infinite dispersion penalty” better. Not physically motivated for non-equalizer case?