

Performance of OM3 and OM4 Fibers with Relaxed Transceivers

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Objectives for this Work

802.3ba Objectives

- Provide Physical Layer specifications which support 40 Gb/s operation over:
 - at least 100m on OM3 MMF
 - at least 10m over a copper cable assembly
 - at least 1m over a backplane
- Support a MAC data rate of 100 Gb/s
- Provide Physical Layer specifications which support 100 Gb/s operation over:
 - at least 40km on SMF
 - at least 10km on SMF
 - at least 100m on OM3 MMF
 - at least 10m over a copper cable assembly

Follow-up work from sun_01_1107

- In previous work, sub-optimum driving of the TOSA gave higher B2B sensitivities between -11.5 and -12.5 dBm (OMA).
 - Rx sensitivities here range from -13 to -13.5 dBm (OMA).
 - Penalty is reduced from 2.5 dB (previously) to 1.7 dB (now) for the same 300m, corner-case not-quite-OM4 fiber with a 0.56 nm RMS spectral width TOSA.
- Effect of spectral width remains under study
- Electrical filter (“rise time converter”) employed to explore slow rise/fall times

Continue to study the tradeoffs between Tx and fiber properties and reach:

- IEEE P802.3ba needs an option for supporting longer reach, approaching 300m, on MMF
- OM4 MMF is commercially available with 4700 MHz-km minimum modal bandwidths
- How can this bandwidth be used?



Approach for Study

Select TOSAs with RMS spectral widths of ~ 0.42 and ~ 0.56 nm

Use a 7.5G B-T filter in front of the TOSA to increase the rise/fall time of the laser from ~ 38 ps to ~ 48 ps

OM3 and “almost OM4” Fibers

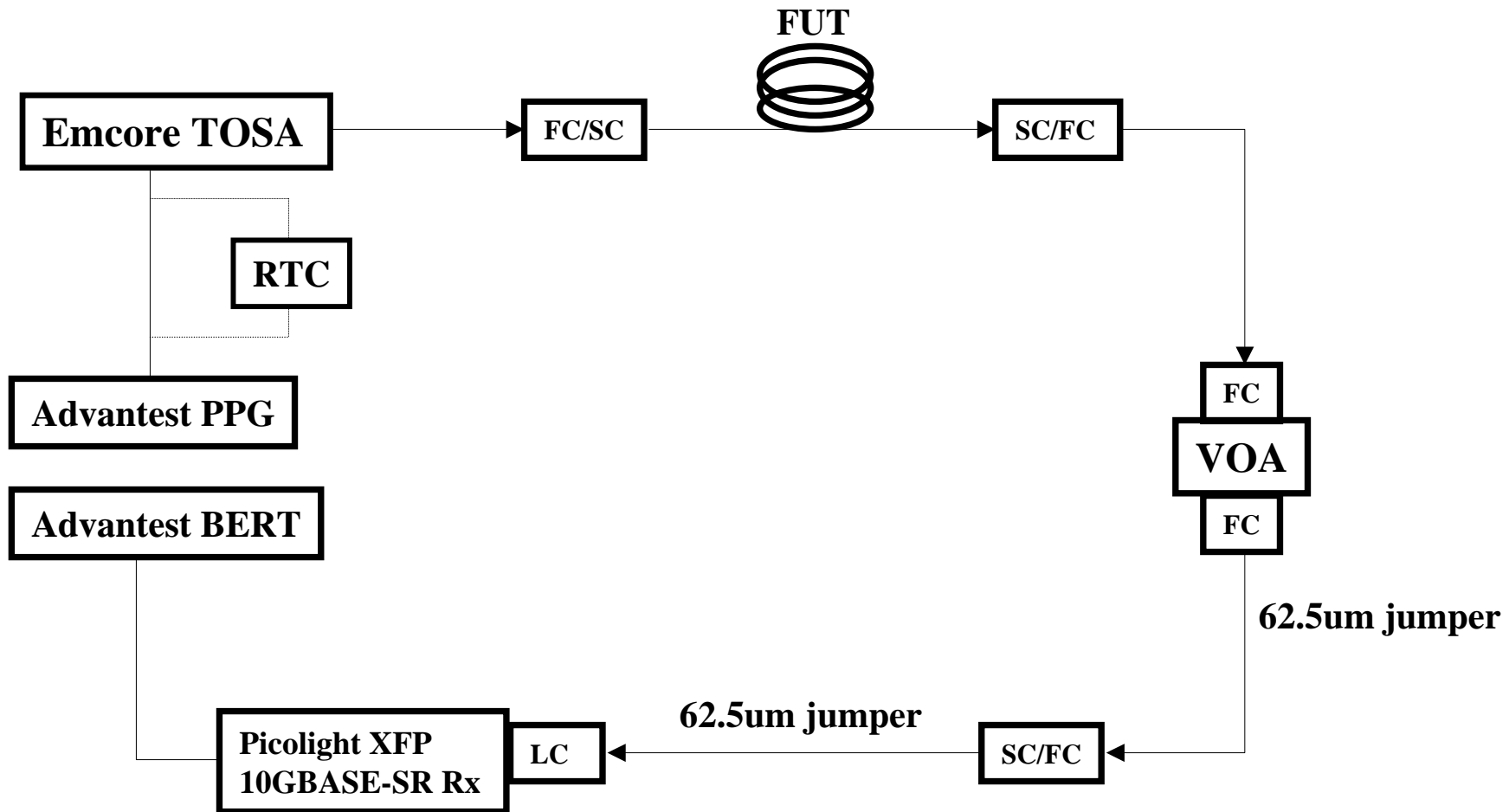
- 100m and 200m length for OM3 fibers with EMB ~ 2600 MHz-km
 - Not a corner-case OM3 fiber, but we had the right lengths on hand
- 100m, 200m, 300m length almost-OM4 fibers, EMB ~ 4300 - 4400 MHz-km
 - Represent the lower bounds for OM4 performance
 - Are labeled “OM4” in the figures, but do not meet OFS’ OM4 specifications

Compare transmission penalties between experiment and spreadsheet model

- Show trends in penalty as fiber or spectral width changes
- These experiments do not combine all of the simultaneous relaxations that have been proposed, so the measured absolute penalties may be lower bounds.



Experimental Diagram



RTC: Rise/Fall time conversion with a 7.5G 4th order BT filter

Optical Eyes at TP3 (TOSA A: RMS spectral width ~0.56nm)

B2B

100m OM3

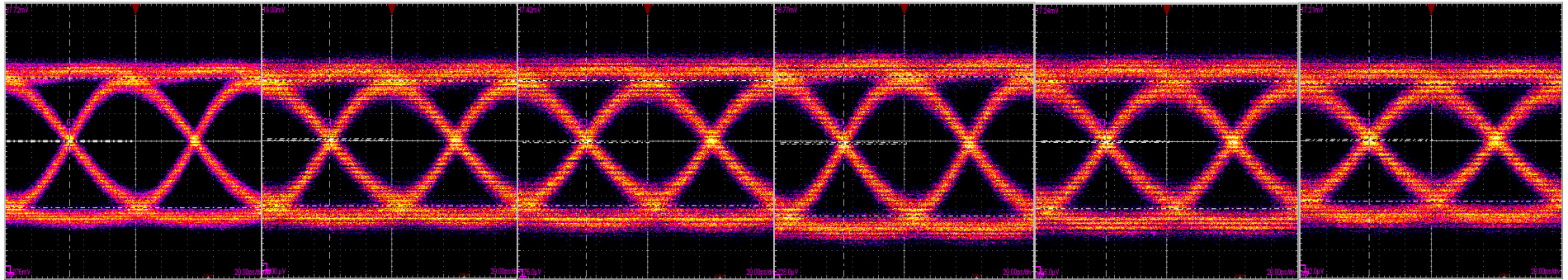
200m OM3

100m OM4

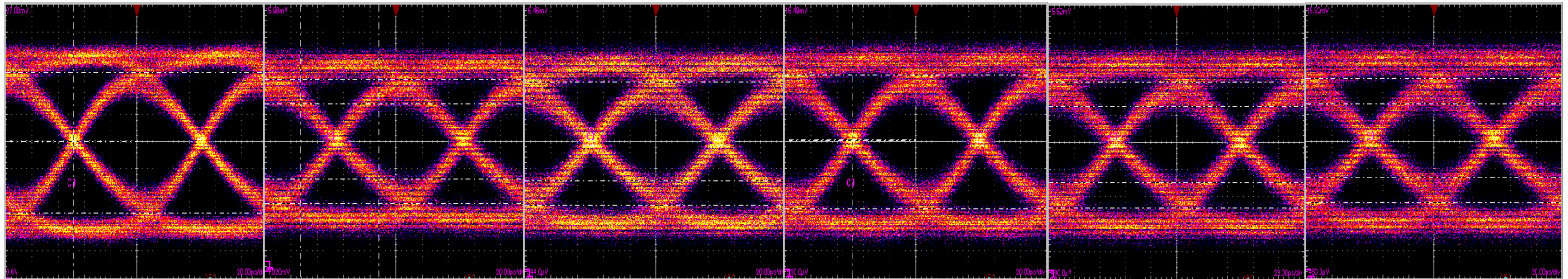
200m OM4

300m OM4

no
RTC

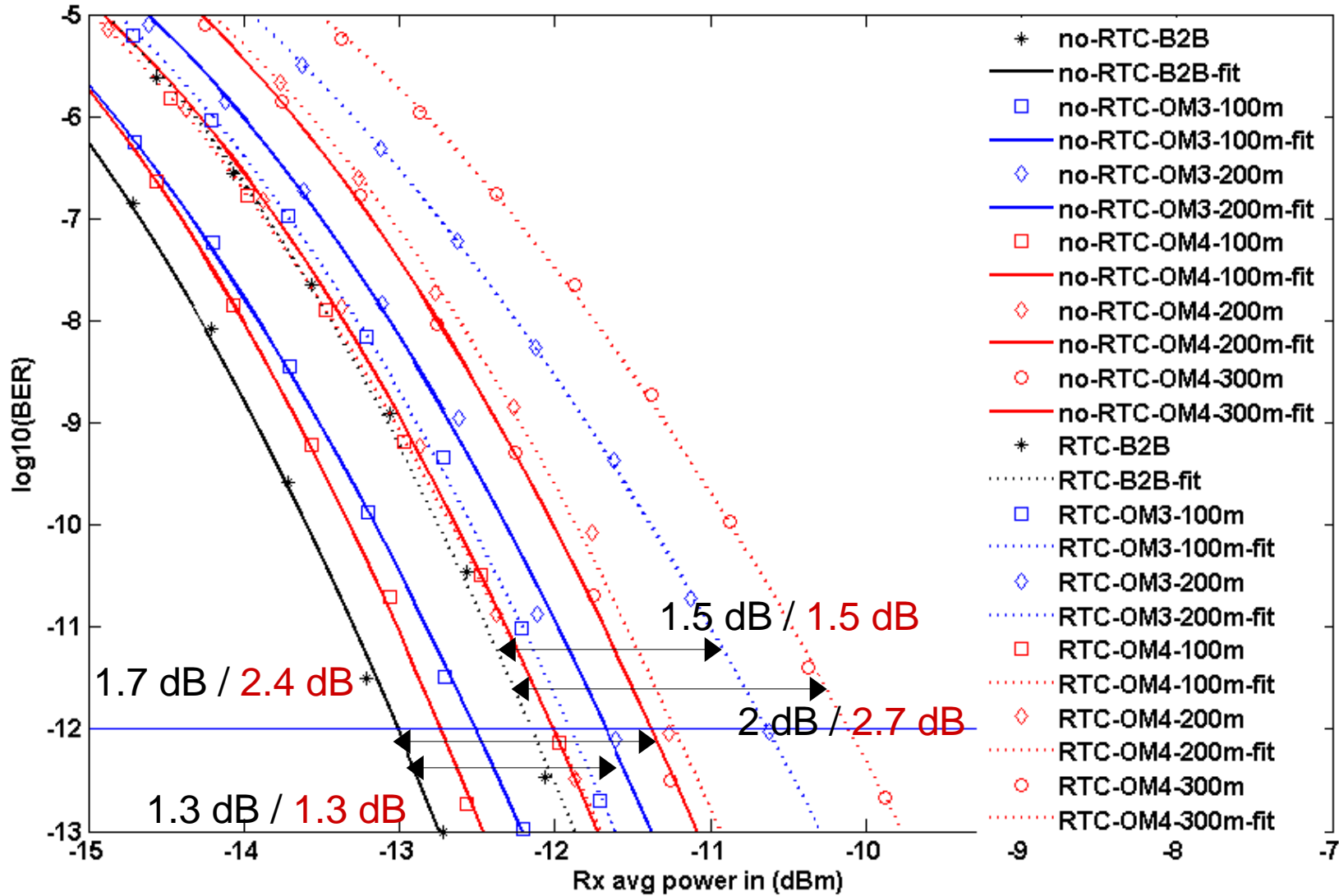


w/
RTC



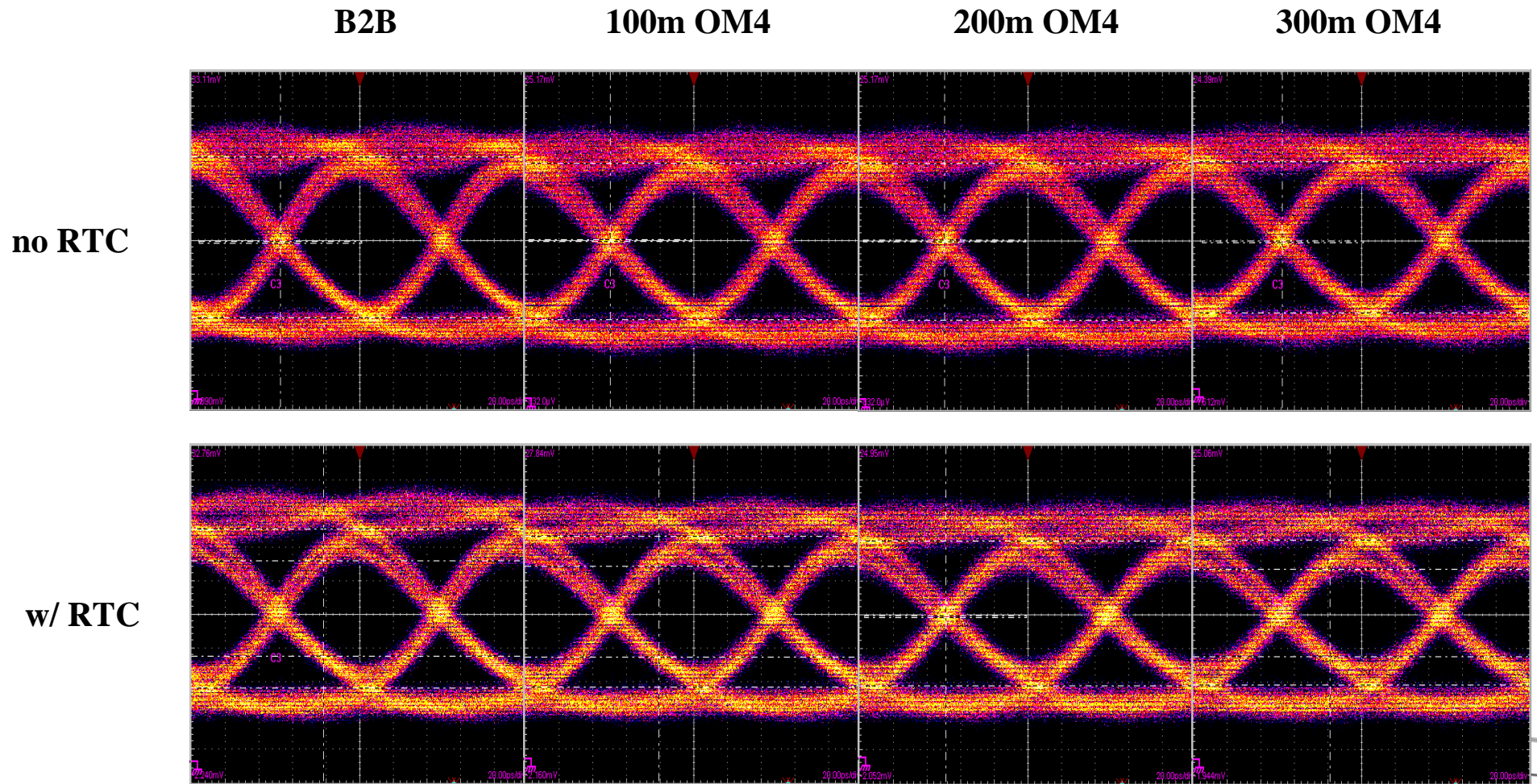
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TOSA A with Spectral Width ~0.56nm



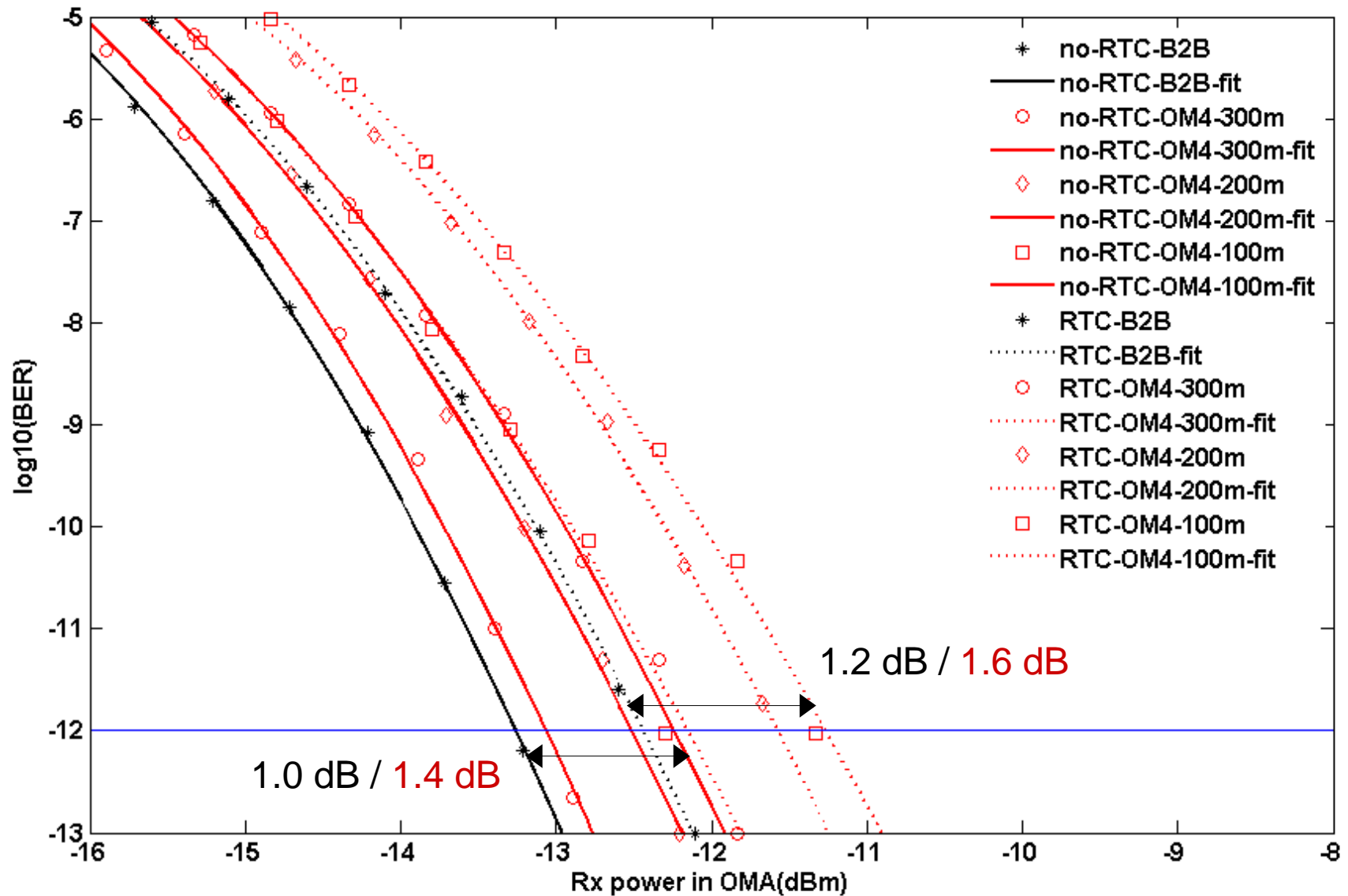
Black = measured penalty; Red = spreadsheet penalty

Optical Eyes at TP3 (TOSA B: RMS spectral width ~0.42nm)



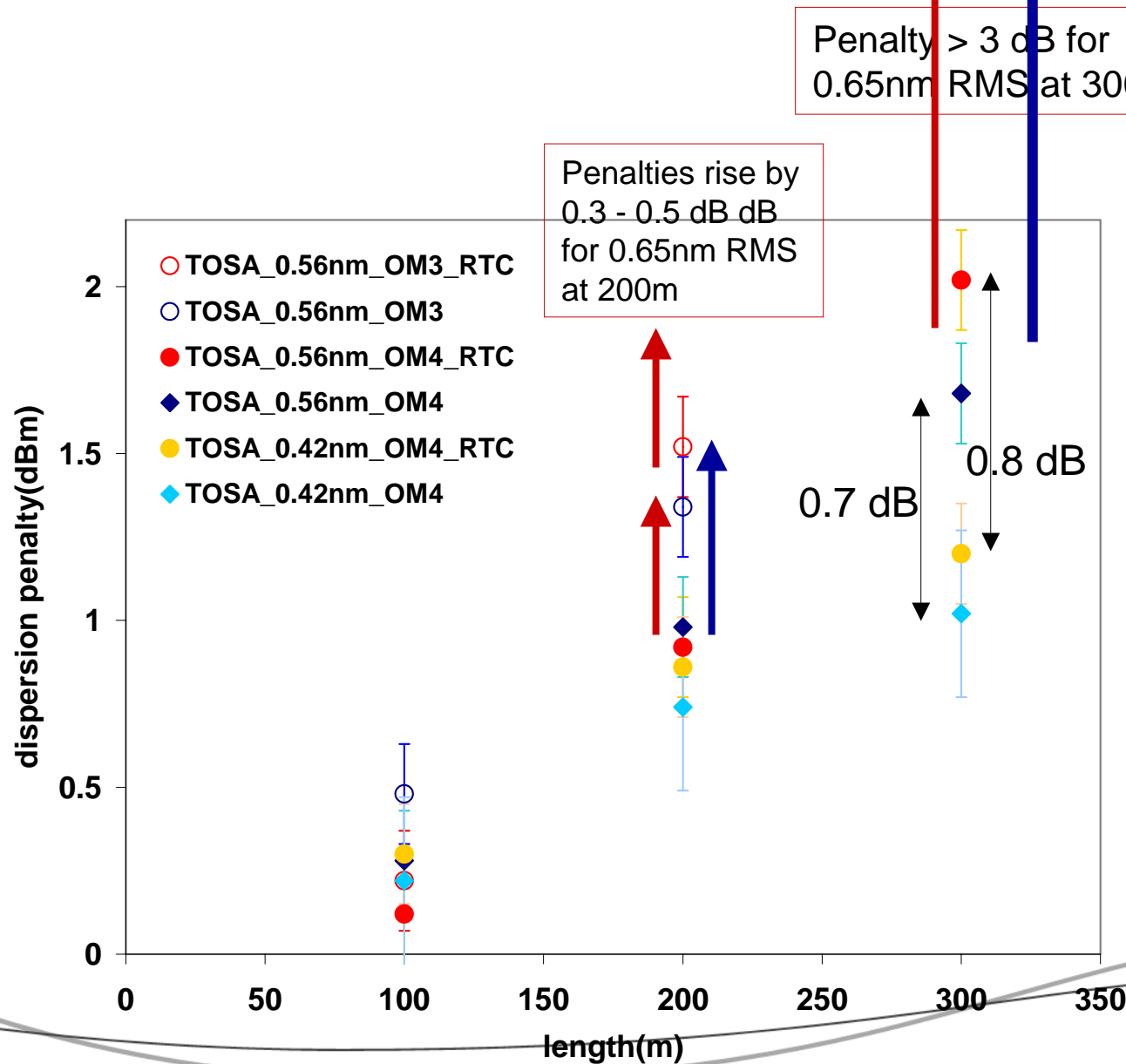
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TOSA B with Spectral Width ~0.42nm



Black = measured penalty; Red = spreadsheet penalty

Penalties vs. EMB, spectral width, and rise time



The spreadsheet model predicts twice the increase in penalty in going from 0.56 to 0.65nm RMS spectral width at 840nm as in going from 0.42nm to 0.56nm RMS at 854nm.

Modeling of a non-retimed PMD at 0.56nm RMS using DCD=20ps and DJ=38ps indicates increase of 0.6 dB at 200m and an “off-the-chart” increase for 300m



Summary

High bandwidth OM4 MMF offers an added degree of freedom for preserving long reach while permitting transmitter cost reduction

Transmitter RMS spectral width relaxation

- For links >200m, penalty increases rapidly with spectral width $\geq \sim 0.55\text{nm}$
- Caution should be exercised when relaxing spectral width
- If spectral width is relaxed to 0.65 nm, it may be desirable to also define a class of Tx with narrow spectral width $\leq 0.45\text{ nm}$

An un-retimed PMD follows current trends for SR in SFP+

- Spreadsheet predictions with $DJ=1.9*DCD$, $DCD=20\text{ ps}$ (jewell_01_0308) indicate that reach of 100m vs. 250m might be obtained by varying a few transceiver specs:
- | | | |
|--|-------------|-----------------|
| | <u>Pisi</u> | <u>V.E.C.P.</u> |
| ➤ 100m OM3, 0.65nm RMS, 45ps R/F time, 2dB connector loss: | < 3.0 dB | 3.7 dB |
| ➤ 250m OM4, 0.45nm RMS, 41ps R/F time, 2dB connector loss: | < 3.0 dB | 3.75 dB |

Experimental study of real parts with relaxed specs with corner case fibers is a necessity



Detailed Summary of Fiber, TOSA and Tx Properties

		center wavelength (nm)	RMS spectral width (nm)	ER (dB)	Tx 20-80% RT (ps)	Tx 20-80% FT (ps)	Launch OMA (dBm)	B2B receiver sensitivity OMA (dBm)
TOSA A	no RTC	855.4	0.56	5	12.7	37.8	-3	-13.0
	w RTC				29.2	47.6	-2.8	-12.1
TOSA B	no RTC	853.53	0.42	5	18.5	38.3	-2.8	-13.2
	w RTC				26.6	48.1	-2.6	-12.4

(de-convolved)

fiber data					TOSA A				TOSA B			
length (m)	EMBc (MHz.km)	MW18 (ps/m)	MW23 (ps/m)	SW (ps/m)	penalty (dBm)		Rx Sens. OMA		penalty (dBm)		Rx Sens. OMA	
					no RTC	w RTC	no RTC	w RTC	no RTC	w RTC	no RTC	w RTC
100	4303	0.122	0.262	0.122	0.3	0.1	-12.8	-12.0	0.2	0.3	-13.0	-12.1
200	4303	0.122	0.262	0.122	1.0	0.9	-12.1	-11.2	0.7	0.9	-12.5	-11.6
300	4437	0.122	0.127	0.122	1.7	2.0	-11.4	-10.1	1.0	1.2	-12.2	-11.2
100	2665	0.297	0.301	0.210	0.5	0.2	-12.6	-11.9				
200	2610	0.307	0.307	0.222	1.3	1.5	-11.7	-10.6				

- Notes:
- 1) Penalties have ± 0.25 dB error bars
 - 2) OM4 fiber limits are MW18, MW23 < 0.14 ("flat mask"), sliding window < 0.11 ps/m
 - 3) OM3 limits are MW18, MW23 < 0.33 ("flat mask"), sliding window < 0.25 ps/m



Measured vs. Spreadsheet Penalties

fiber data				TOSA A (RMS 0.56nm)				TOSA B (RMS 0.42nm)			
length (m)	EMBc (MHz.km)	MW18 (ps/m)	MW23 (ps/m)	penalty (dBm)				penalty (dBm)			
				no RTC	CALC	w RTC	CALC	no RTC	CALC	w RTC	CALC
100	4303	0.122	0.262	0.3	0.3	0.1	0.4	0.2	0.2	0.3	0.3
200	4303	0.122	0.262	1.0	0.9	0.9	1.1	0.7	0.6	0.9	0.7
300	4437	0.122	0.127	1.7	2.4	2.0	2.7	1.0	1.4	1.2	1.6
100	2665	0.297	0.301	0.5	0.4	0.2	0.5				
200	2610	0.307	0.307	1.3	1.3	1.5	1.5				

Parameters used in spreadsheet calculations:

Penalties are the difference in LP_pen at stated reach vs. 2 m. Ts(20-80): 35 ps w/o RTC, 45 ps with RTC; DJ=DCD = 6 ps; RIN(OMA) = -130 dB/Hz; actual values for RMS spectral widths and center wavelengths; other parameters are like those in 10GEPBud3_1_16a.xls

