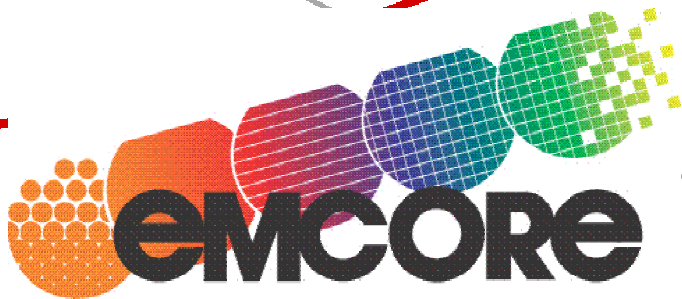


# 10G transmission over OM3 MMF with relaxed TOSA specifications

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# Objectives for this Work

## HSSG 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 SME
  - at least 100m on OM3 MMF
  - at least 10m over a copper cable assembly

Help the Task Force select:

- a minimum reach for the enterprise PMD on MMF
- Tx requirements that support the chosen reach with low cost

Study the tradeoffs between Tx and fiber properties and reach:

- Multiple Tx properties could be relaxed
- OM3 MMF is available with both 2000 and 4700 MHz-km minimum modal bandwidths; fiber with higher bandwidth will support extended reach
- Transmission experiments are necessary to validate modeling

## Approach for Initial Study

Select TOSAs with parameters outside the current 10GBASE-SR specs

- Spectral widths of ~0.47 and 0.56 nm (vs. max 0.45nm)
- Encircled Flux with power inside  $r = 19\mu\text{m}$  near 79% (vs. min 86%)

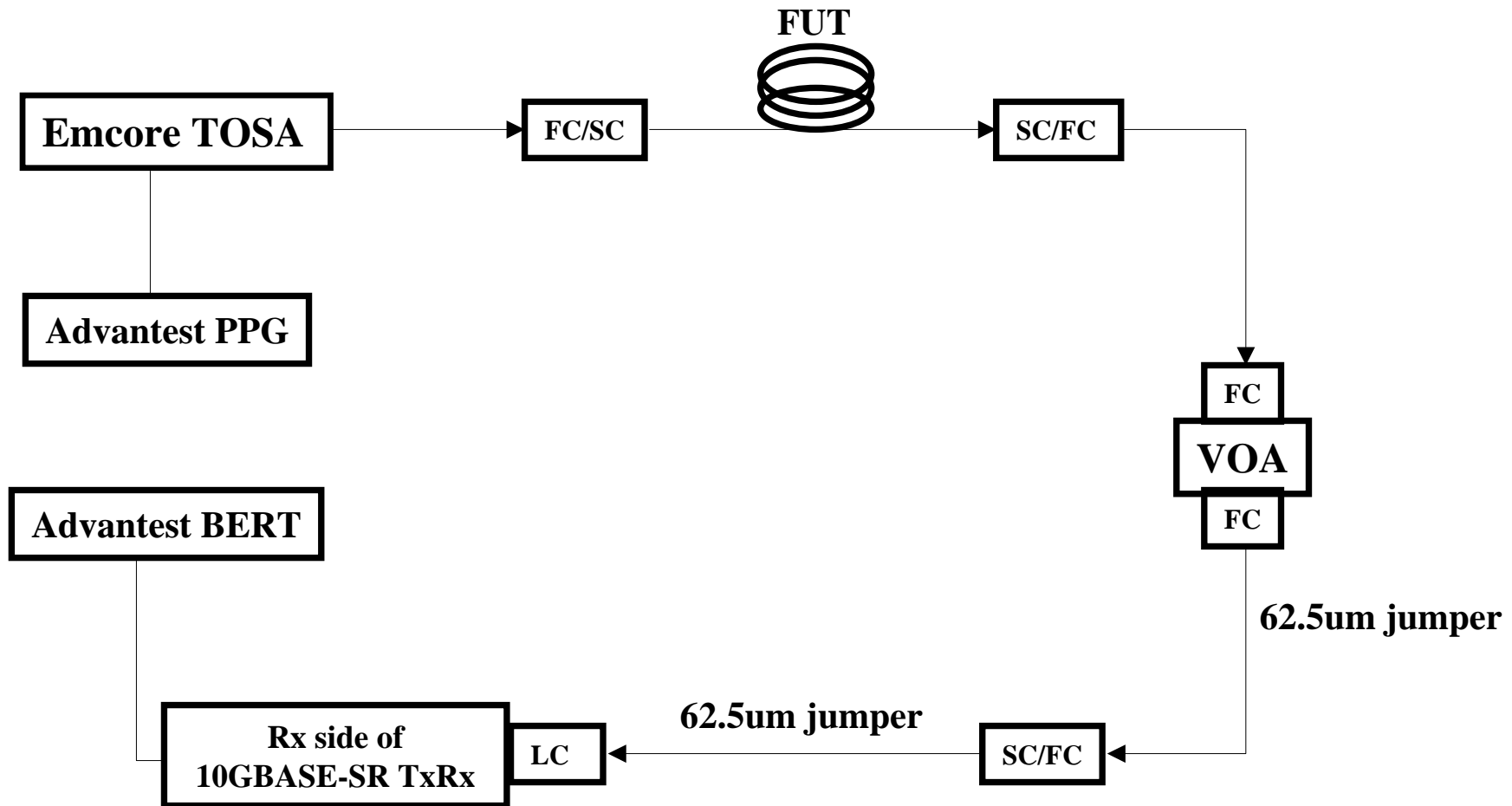
Select a “reference transmitter,” in the sense of low spectral width of 0.21nm and tight encircled flux with power inside  $r=19\mu\text{m}$  of >99%

Select OM3 fibers with EMB of 2200, 2300, and 4440 MHz-km

- 200m length for the two fibers near 2000 MHz-km
- 300m length for fiber near 4700 MHz-km (referred to as “OM3+” fiber herein)
- OM3 fiber with EMB > 4700 MHz-km is referenced in TIA TSB-172 Annex B

Compare transmission penalties between experiment and spreadsheet model

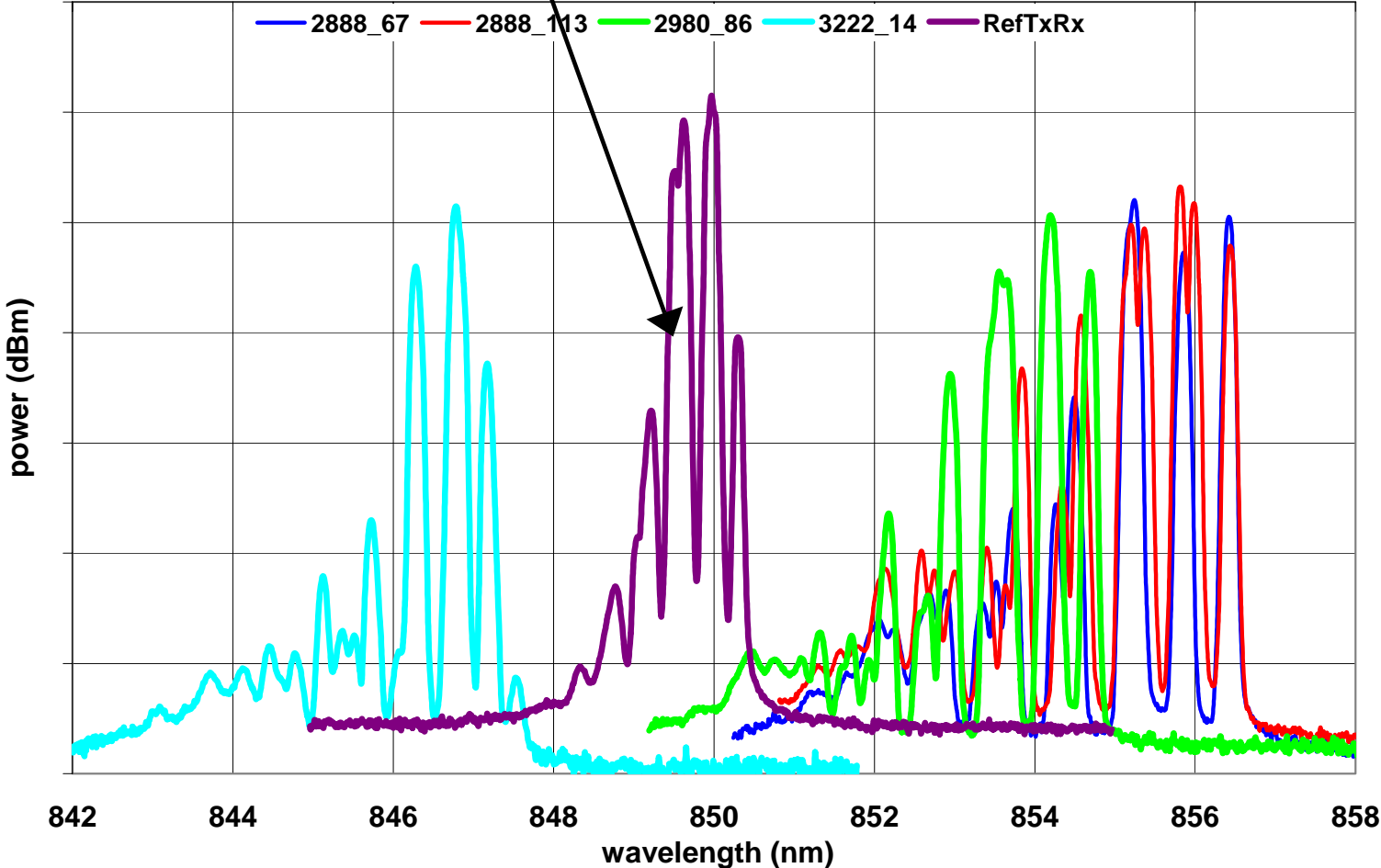
# Experimental Diagram



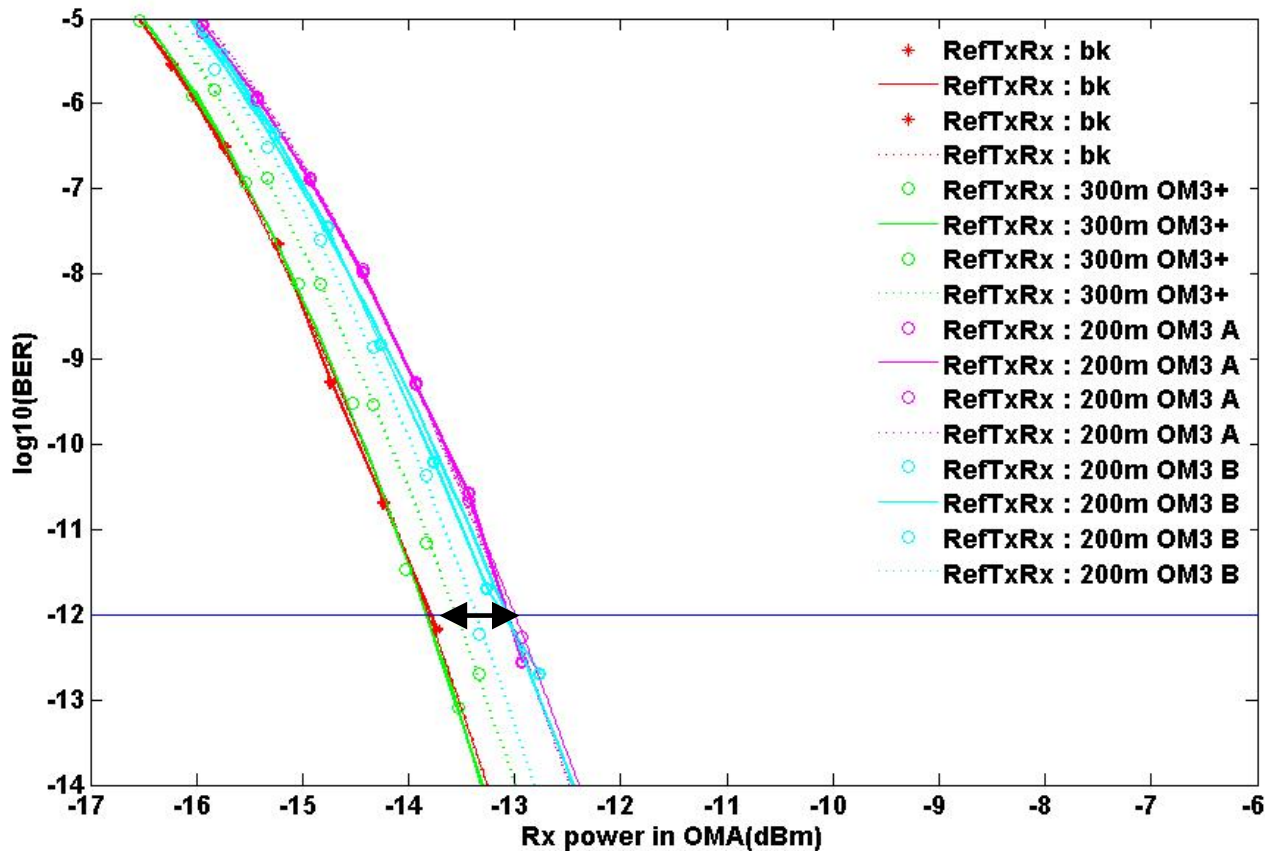
Note: the TOSAs in these experiments were not driven with an optimized RF fixture, leading to sub-optimum eyes and thus lower Rx sensitivity. Follow-up work will correct this deficiency.

# Spectral widths of TOSAs and reference transmitter

“Reference Tx”  
with low spectral  
width and tight  
encircled flux



# Performance with “Reference Transmitter”



Spectral width = 0.21 nm  
Encircled Flux at 19um >99%

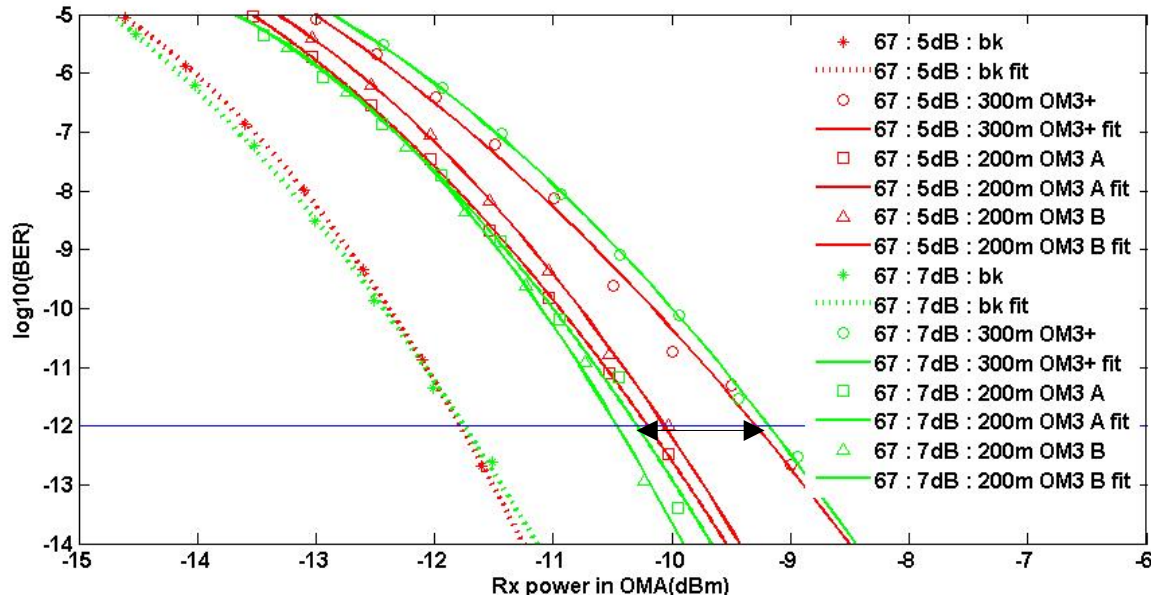
All penalties < 1 dB

Penalties for 300m “OM3+”  
are smaller than 200m OM3

Spreadsheet agrees, predicts  
a difference\* in path penalties  
LP Pen (column V) of -0.4 dB

\* Difference = LP Pen (300m OM3+) – LP Pen (200m OM3)

# Impact of high spectral width TOSA



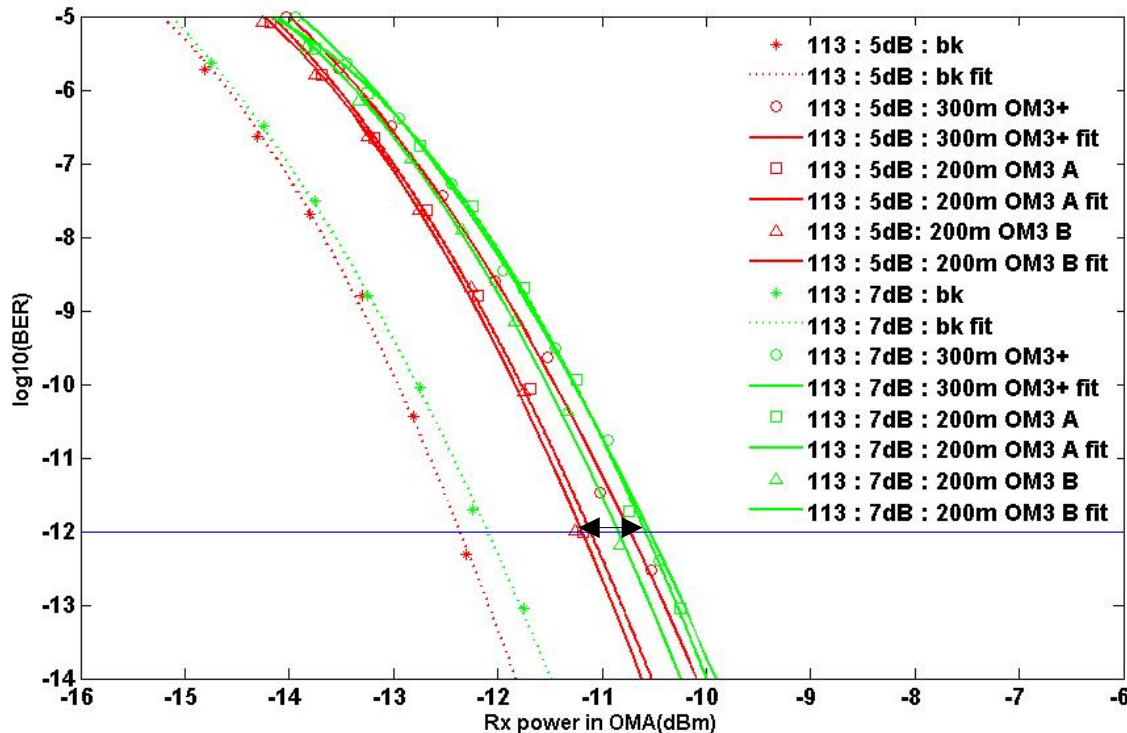
Spectral width ~0.56 nm

## Penalties

- 300m OM3+ : ~ 2.5 dB
- 200m OM3 : 1.3-1.7 dB

• Impact of high spectral width is evident at 300m

• Spreadsheet predicts a difference in path penalties of +1.2 dB



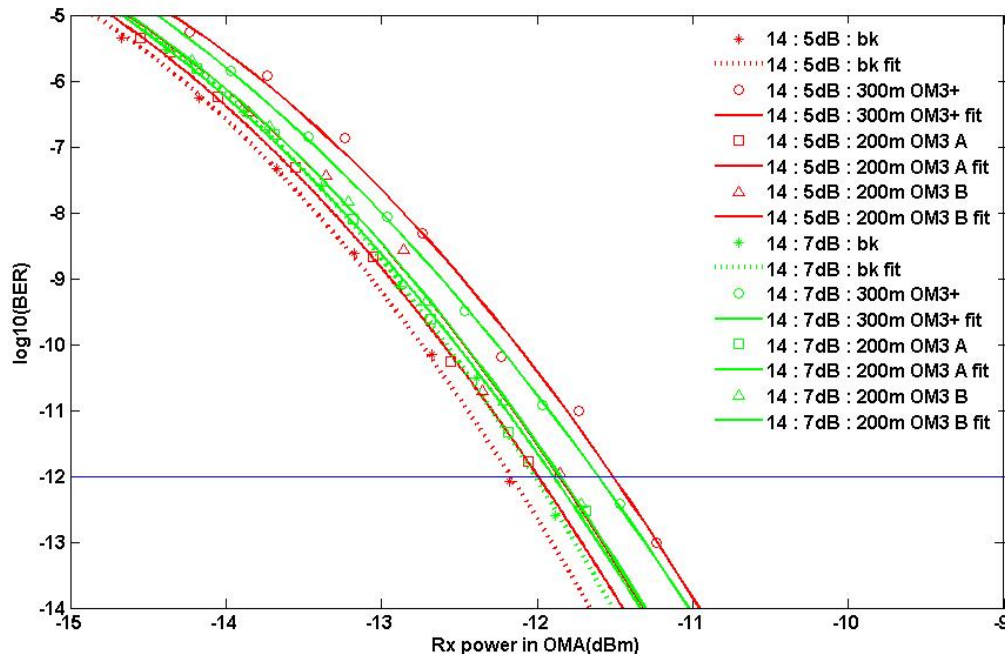
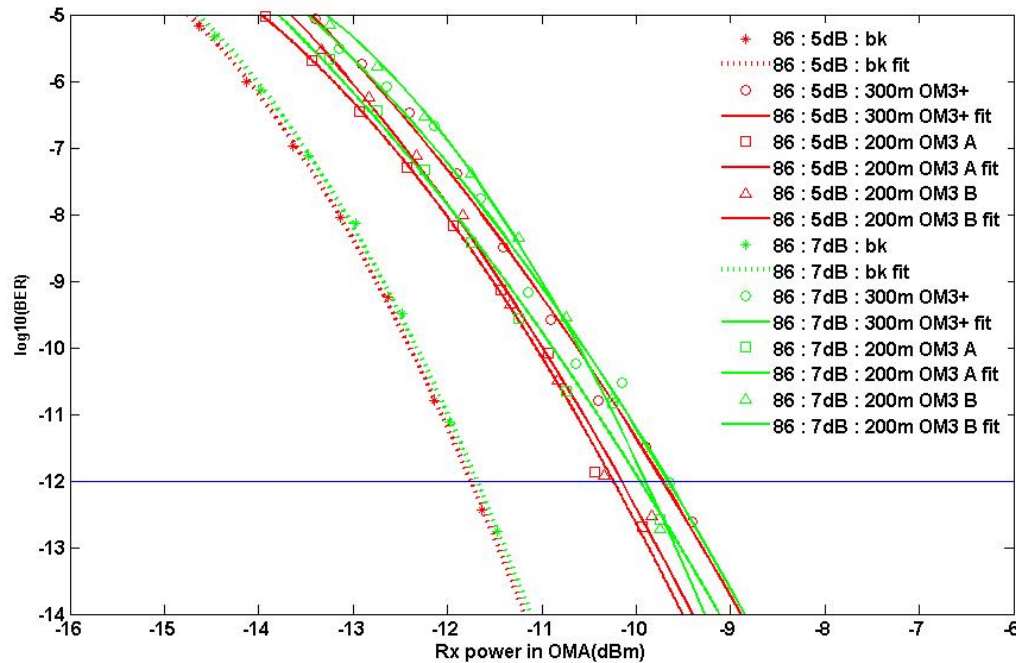
Spectral width ~0.47 nm

## Penalties

- 300m OM3+ : 1.5-1.7 dB
- 200m OM3 : 1.2-1.5 dB

• Spreadsheet predicts a difference in path penalties of +0.5 dB

# Impact of TOSA encircled flux deviation



Spectral width ~ 0.41 nm  
EF (r=19um) ~ 79%

## Penalties

- 300m OM3+ : ~ 2.0 dB
- 200m OM3 : 1.5-1.8 dB

• Spreadsheet predicts a difference in path penalties of 0.3 dB based on spectral width

• Fibers show ~ 0.4 dB larger absolute penalties than for TOSA 113; is this due to encircled flux deviation?

Spectral width ~ 0.24 nm  
EF (r=19um) ~ 79%

## Penalties

- 300m OM3+ : ~ 0.6 dB
- 200m OM3 : ~ 0.2 dB

• All penalties < 1 dB, as in case of the “Reference Tx”



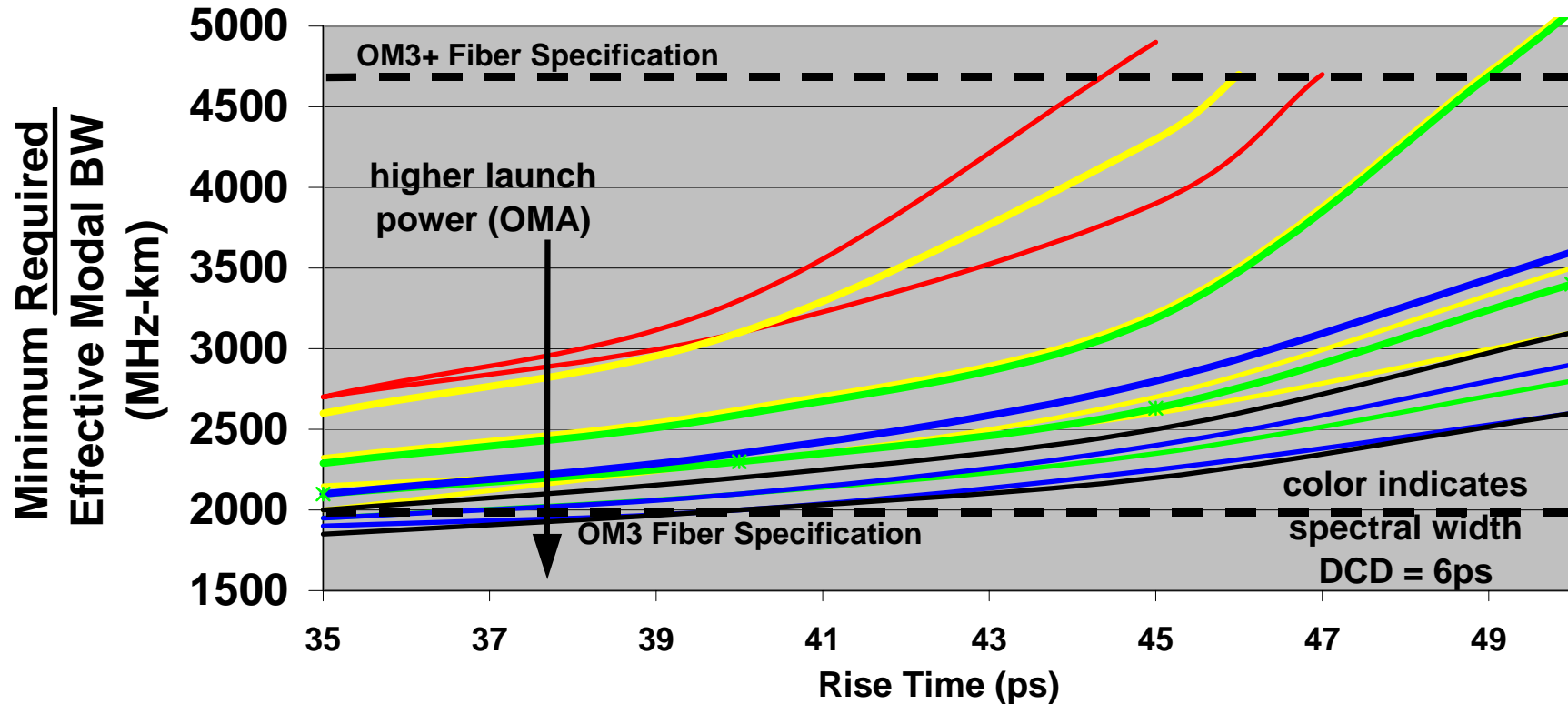
# Detailed summary of fiber and TOSA properties and penalties

Fiber	length (m)	EMBc (MHz.km)	MW 18 (ps/m)	MW 23 (ps/m)	Max SW (ps/m)
OM3+	300	4437	0.122	0.127	0.122
OM3 A	200	2220	0.234	0.24	0.229
OM3 B	200	2292	0.315	0.315	0.227

	TOSA ID	RMS spectral width (nm)	center wavelength (nm)	EF @ 4.5um %	EF @ 19um %	20-80% rise time (ps)	OMA (uW)	ER	300m OM3+	200m OM3 A	200m OM3 B
spectral width failure	67	0.56	855.2	Pass Spec		31.6	667	5dB	2.5	1.6	1.7
		0.55	855.3				885	7dB	2.6	1.5	1.3
	113	0.46	855.8			31.3	722	5dB	1.7	1.3	1.2
		0.47	856.3				884	7dB	1.5	1.5	1.3
EF failure	86	0.41	854.2	5.4	79	31.8	718	5dB	2.1	1.5	1.6
		0.41	854.2				921	7dB	2.0	1.7	1.8
	14	0.24	846.7	5.6	78	38.1	665	5dB	0.7	0.2	0.3
		0.25	846.7				826	7dB	0.4	0.1	0.1
Good	RefTxRx	0.21	849.6	19	99	NA	581	5dB	0.1	0.8	0.6

# IEEE spreadsheet calculations for trading off fiber bandwidth for slower rise/fall times at 300m reach

-- allowable tradeoffs strongly impacted by spectral width assumptions



— -3.8dBm, .55nm	— -3.3dBm, .55nm	— -4.3dBm, .50nm	— -3.8dBm, .50nm
— -3.3dBm, .50nm	— -2.8dBm, .50nm	— -4.3dBm, .45nm	—* -3.8dBm, .45nm
— -3.3dBm, .45nm	— -4.3dBm, .40nm	— -3.8dBm, .40nm	— -3.3dBm, .40nm
— -4.3dBm, .35nm	— -3.8dBm, .35nm		

# Summary

## Transmitter spec relaxation

- Spectral width
  - Penalties rise steeply with reach for higher spectral widths
  - IEEE spreadsheet can be used to model penalties
  - HSSG should be cautious with spectral width relaxation
- Encircled Flux
  - Relaxation may be compatible with reach of 200m on OM3 MMF
  - Tools beyond the spreadsheet model are required to quantify
- Parameters affecting TDP
  - Relaxation of factors affecting waveform quality will be studied
  - These parameters can be balanced by higher fiber bandwidth to maintain reach
  - IEEE spreadsheet can be used to model penalties

High bandwidth OM3 MMF may offer an added degree of freedom for preserving 300m reach while permitting transmitter cost reduction

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