Modal noise measurements relevant to 400G-SR4.2

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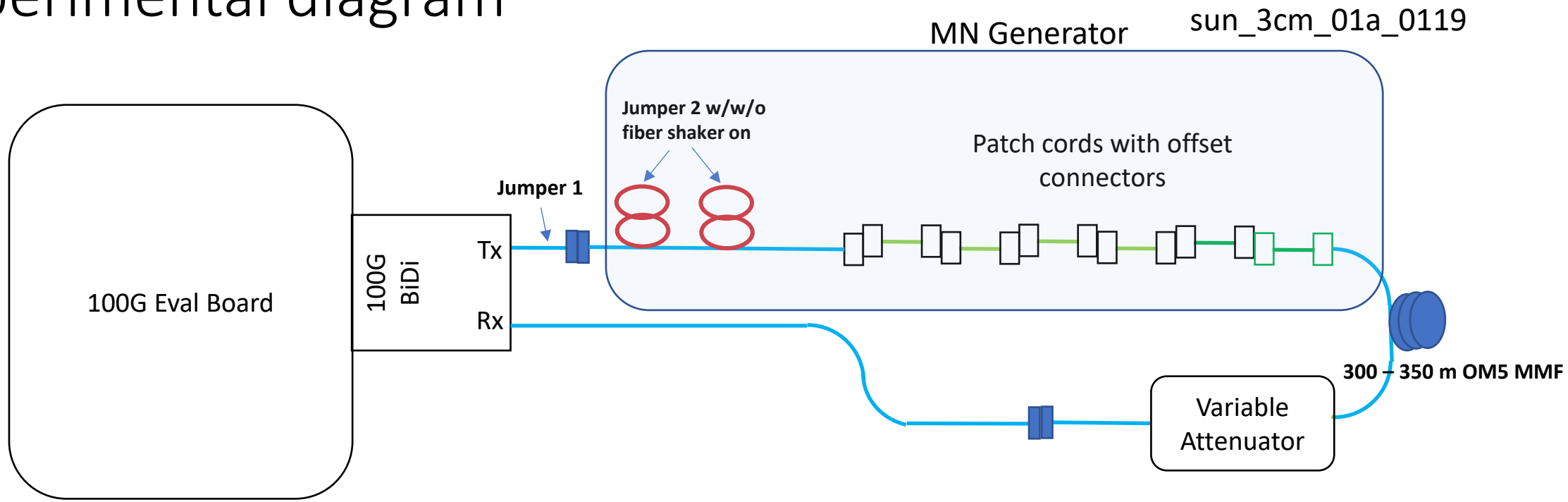
IEEE P802.3cm Task Force Ad Hoc

Overview

- The purpose of this study is to measure penalties due to modal noise, using real parts, in back-to-back (BtB) and long length regimes
- Back-to-back (BtB) and transmission experiments carried out with offset jumpers and fiber shaker
- Two 100G BiDi transceivers used along with fiber near minimum OM5 compliance
- 300 to 350m fiber is used to create near-worst case eye closure as measured by SECQ, as well as create a σ_{rms}*CD*length product near worst-case
- Received power measurements are not better than ± 0.1 dB and perhaps higher
- Small power penalties from modal noise generation are observable at BER 1e-5 and 1e-6. But it is not obvious that penalties are beyond the measurement error at 2.4e-4, where they are generally smallest.
- These data show no evidence of “falling off a cliff” when modal noise is introduced with near worst-case eye closure.

Experimental diagram



Two 100G BiDi transceivers tested
Errors estimated by FEC decoder
Look at power penalty at 1e-4 BER
Received power is measured by the power detector built into Rx (also by an external power meter)
Offset jumpers on slide 5-8:

- ***4 connections w/ 1.5 dB total EF insertion loss***
- ***2-6 µm offset per connection***

Worst-case 850nm fiber had EMB of 4875 MHz-km, compared to 4700 MHz-km OM4 and OM5 spec limit

Lowest BW 910nm fiber had EMB of ~3900 MHz-km, compared to ~3100 MHz-km for OM5

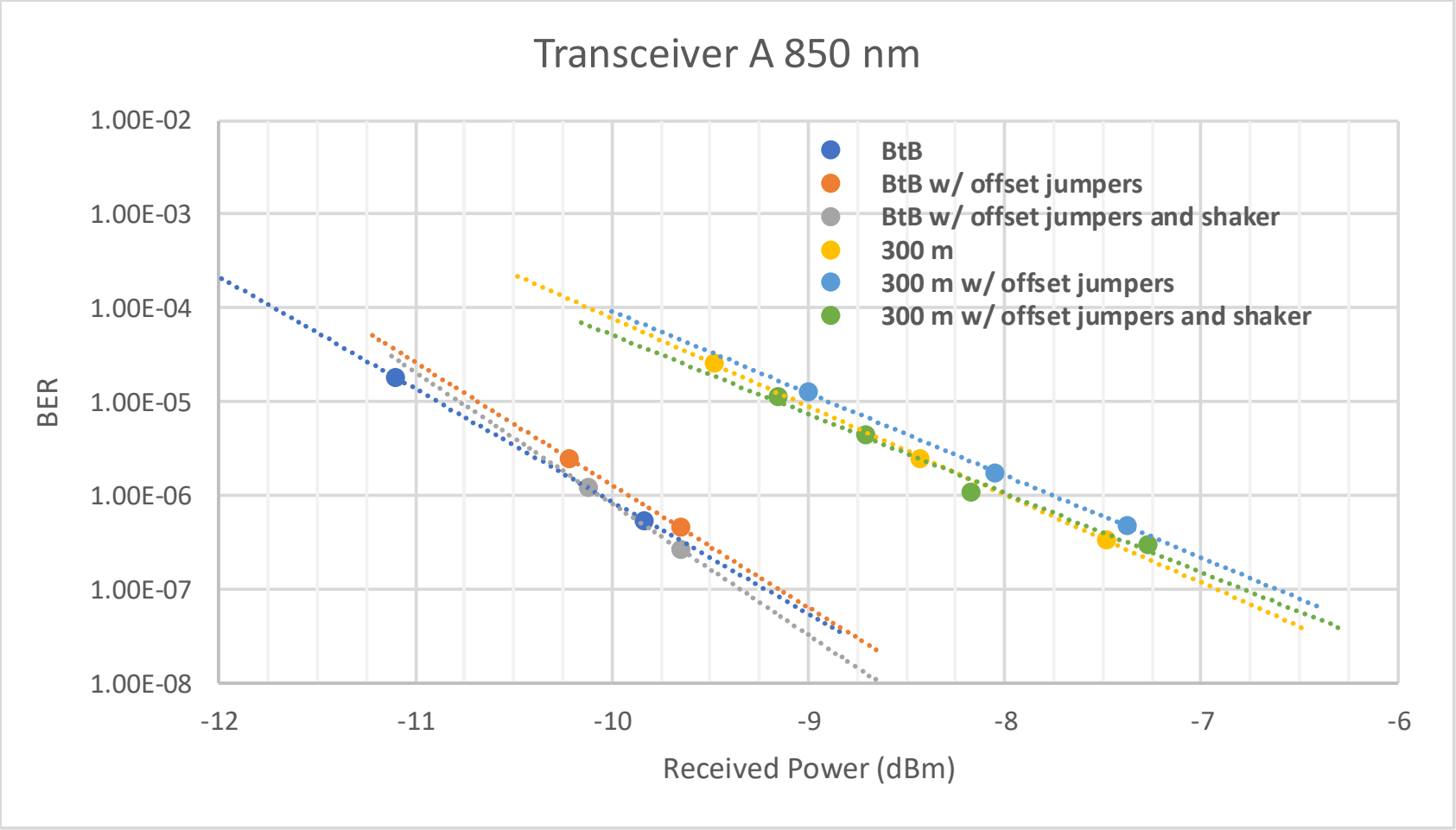
Offset jumper on slide 9 courtesy of Jose Castro at Panduit. EF loss is 1.1 dB, recommended by Jose for use with other jumpers and shaker to sum up to near 1.5 dB

Longer fiber is used to mimic worst-case eye closure

	TX A		TX B	
Wavelength (nm)	857	906	857	907
RMS spectral width (nm)	0.3	0.34	0.29	0.37
Tx TDECQ (dB)	3.0	2.6	2.7	2.7
Tx SECQ + OPC + 310m	3.9	4.6	3.8	4.4
Tx SECQ + OPC + 360m			4.3	

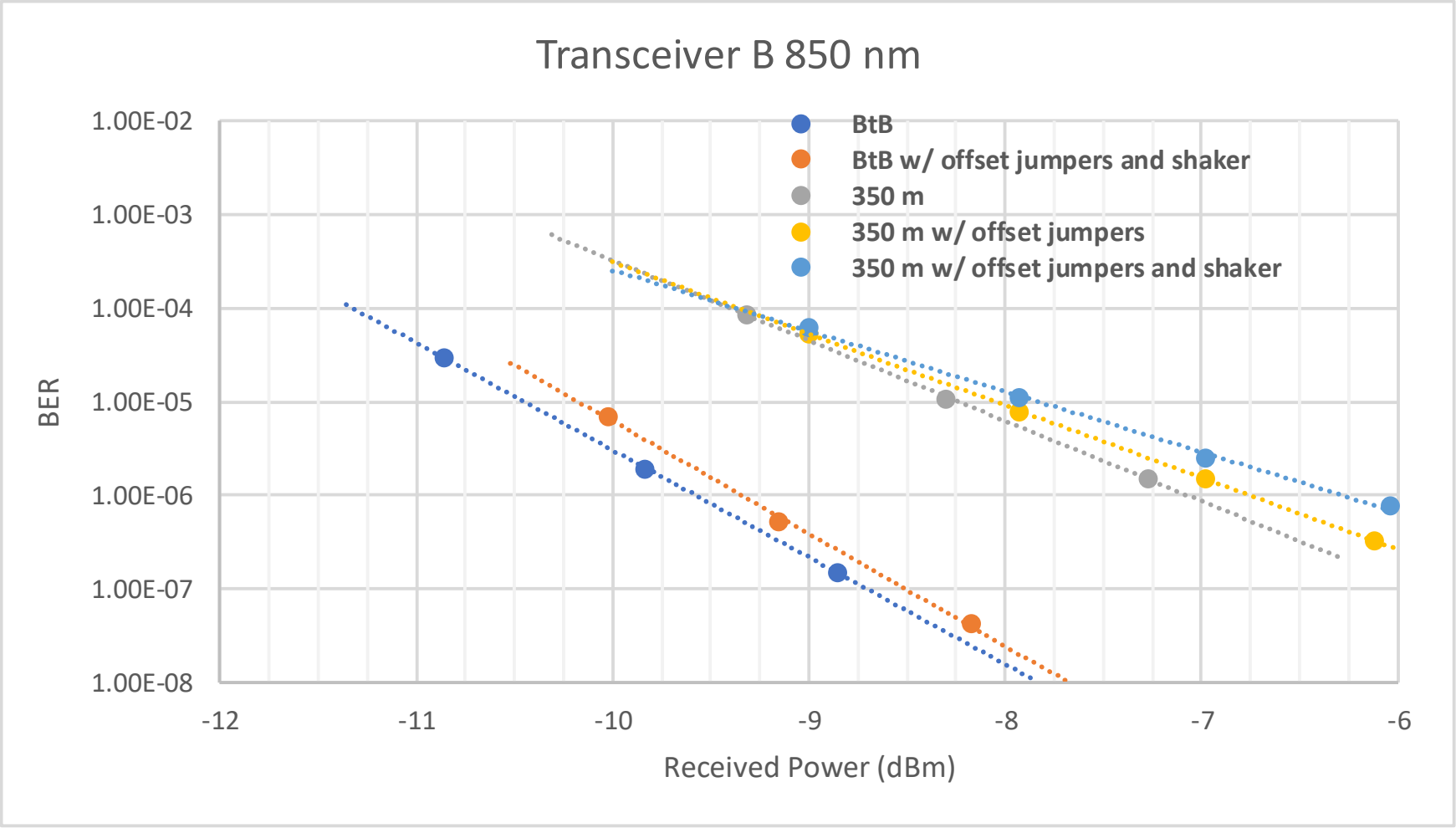
- The two 100G BiDi transceivers do not have worst-case TDECQ or spectral width
- However by using long fiber with low bandwidth, we can achieve SECQ values near 4.5 dB and test modal noise with near worst-case eye closure

Penalties between BER 1e-5 and 1e-6 are < 0.2 dB, perhaps within measurement error, and will be smaller at BER 2.4e-4; Penalties with 300m fiber remain small → not falling off cliff



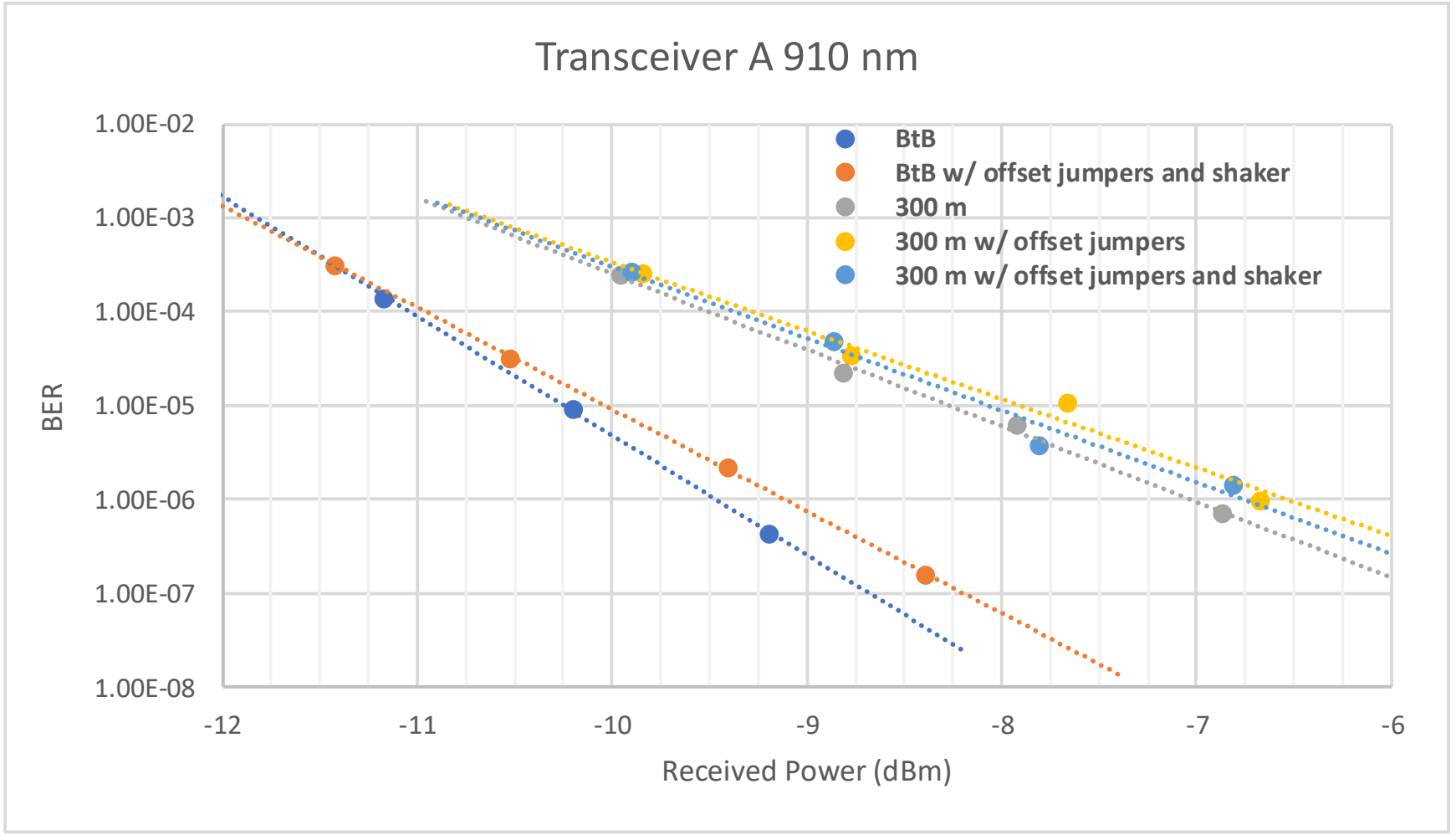
TDECQ = 3.01 dB
SECQ @ 300 m = 3.89 dB

Penalties at BER 1e-5 are non-zero at 0.2-0.3 dB, but should be smaller at BER 2.4e-4
Penalties with 350m fiber are well controlled → no cliff nearby



TDECQ = 2.69 dB
SECQ @ 350 m = 4.29 dB

Penalties at BER 1e-5 are non-zero at 0.2-0.3 dB, but negligible at BER 2.4e-4
Penalties with 300m fiber are well controlled → no cliff nearby

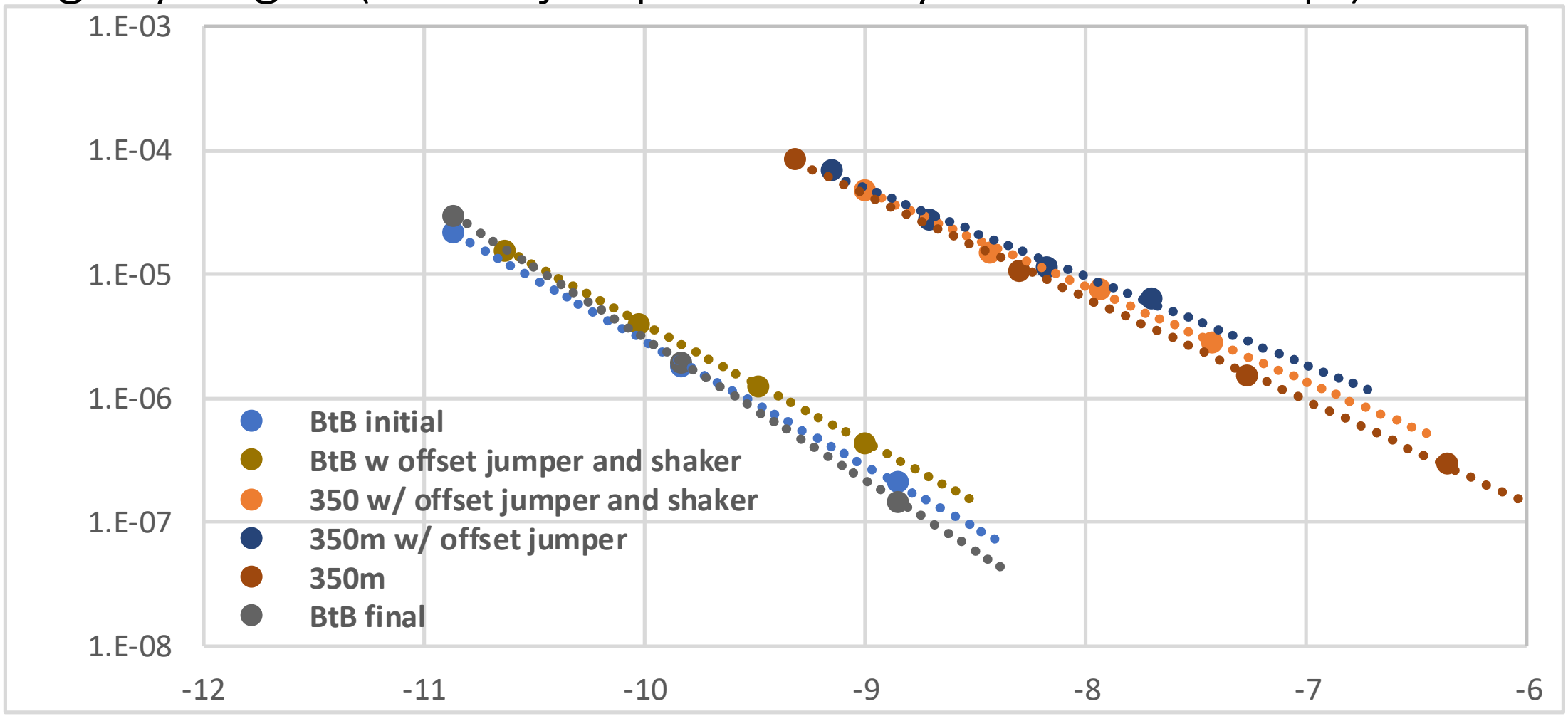


TDECQ = 2.56 dB
SECQ @ 300 m = 4.58 dB

Penalties vs. BtB are within error; Penalties at 300m at BER 2.4e-4 are real but just outside error at 0.25 dB
This link is not near a cliff in penalty

TDECQ = 2.68 dB
SECQ @ 300 m = 4.43 dB

BtB modal noise penalties at 1e-5 and 2e-4 are within measurement error. MN penalties with 350m fiber are only slightly larger. (1.1 dB jumper courtesy of Panduit Corp.)



Conclusions

- Observed modal noise penalties at BER 2.4e-4, measured with real parts, are not inconsistent with the current 0.1 dB allocation, as modeled in http://www.ieee802.org/3/cd/public/Oct18/king_3cd_01_1018.pdf
- Modal noise penalties remain ~ few tenths of a dB in links with 300 to 350m low bandwidth fiber, where SECQ is near 4.5 dB
- The “Pcross” effect, whereby signal borne noise drives penalties to rapidly increase as the eye closes, is not significant for the links studied