

400GBase-LR4 Dispersion Testing

Marco Mazzini

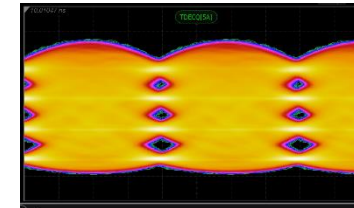
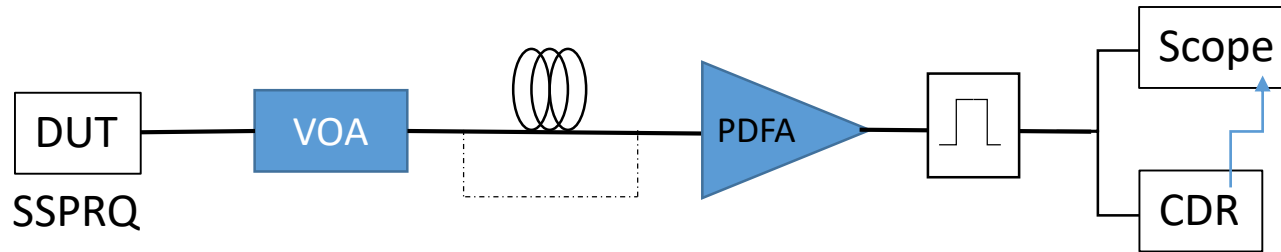
Brian Welch

Caveats and Disclaimers

- Measurements are performed on a 100G/L transceiver designed/optimized for 2km performance
 - Additional design optimizations (chirp, transition time, etc.) would likely be performed for a true 10km transceiver.
- To create dispersion corners very long fiber reaches are required
 - Over 30km in some cases → High Attenuation
 - Requires the use of a PDFA before scope. Noise (addition) effects of PDFA have not been analyzed or de-embedded from results.

Background.

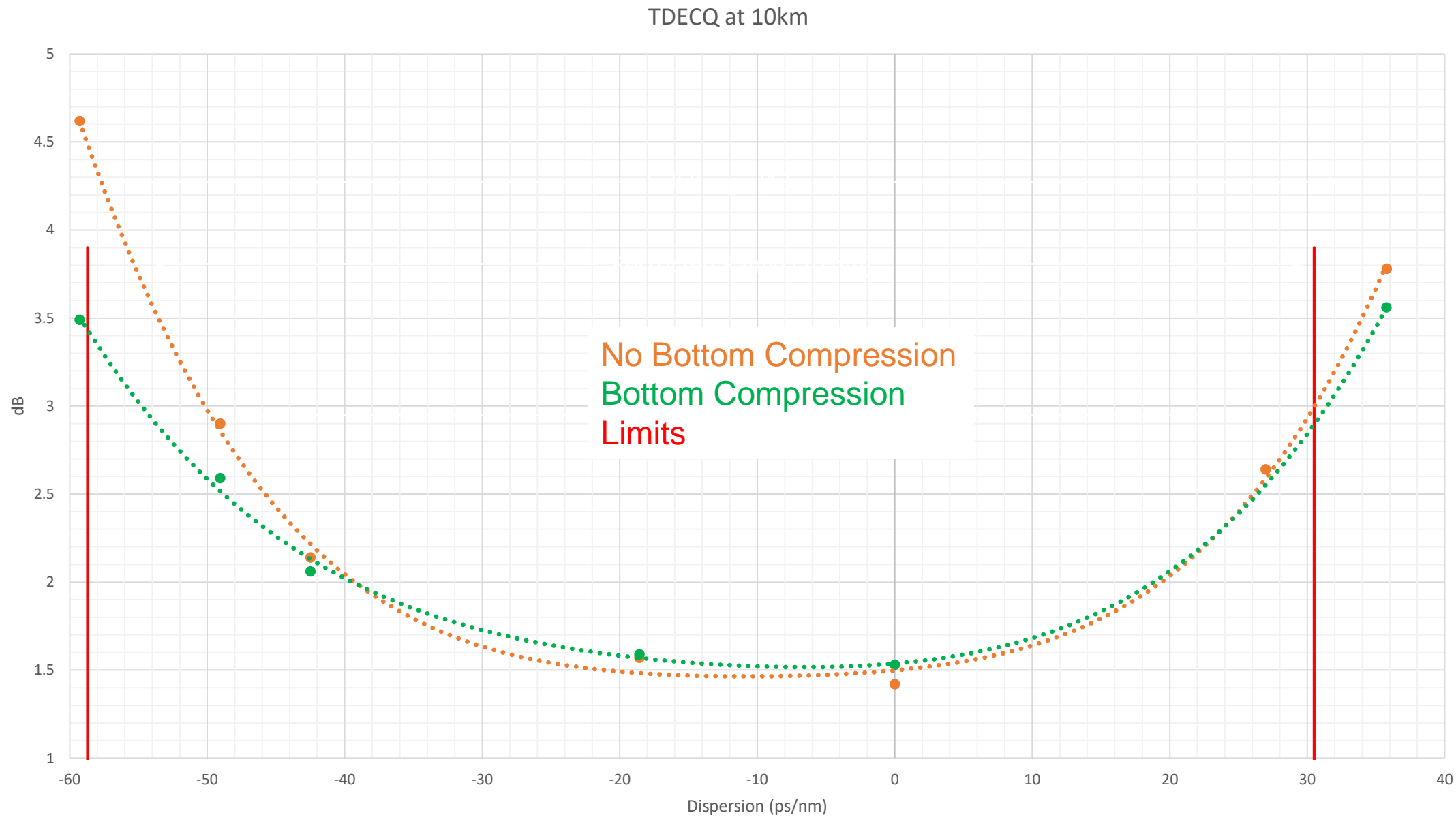
Previous presentations ([mazzini 3cu adhoc 070319](#), [welch 3cu 01 0719](#)) measured negative dispersion penalties and possible mitigations.



Fiber code	CD22 +BZS	CD22 +Fiber4	CD22	BZS	Btb	Btb	TMGBA	TMGBA +Fiber2	Unit
Total dispersion	-59.28	-49.06	-42.49	-18.57	0.00	0.00	26.97	35.77	ps/nm
Wavelength	1309.56	1309.56	1309.56	1309.56	1309.56	1317.76	1317.76	1317.76	nm
Est PMD	0.36	0.31	0.27	0.24	0	0	0.28	0.33	ps
Est DGD (SF=3)	1.08	0.92	0.82	0.71	0	0	0.83	0.99	ps
Total lenght	19.539	12.211	1.5	18.039	0	0	24.666	34.822	km
OSNR	36	36	36	36	36	36	36	33	dB

- To keep linear region into the fiber a PDFA and avoid non-system related penalties on scope, a pre-amplifier has to be inserted - this limits the system OSNR to ≈ 36 dB for all negative cases and to ≈ 33 dB for worst case positive one.
- *Note: for positive CD measurements, laser wavelength was tuned at 1317.76nm by heating DUT $>70^{\circ}\text{C}$, while for negative it has been cooled.*

TDECQ vs. Dispersion



Summary of experiments.

Uniform level case

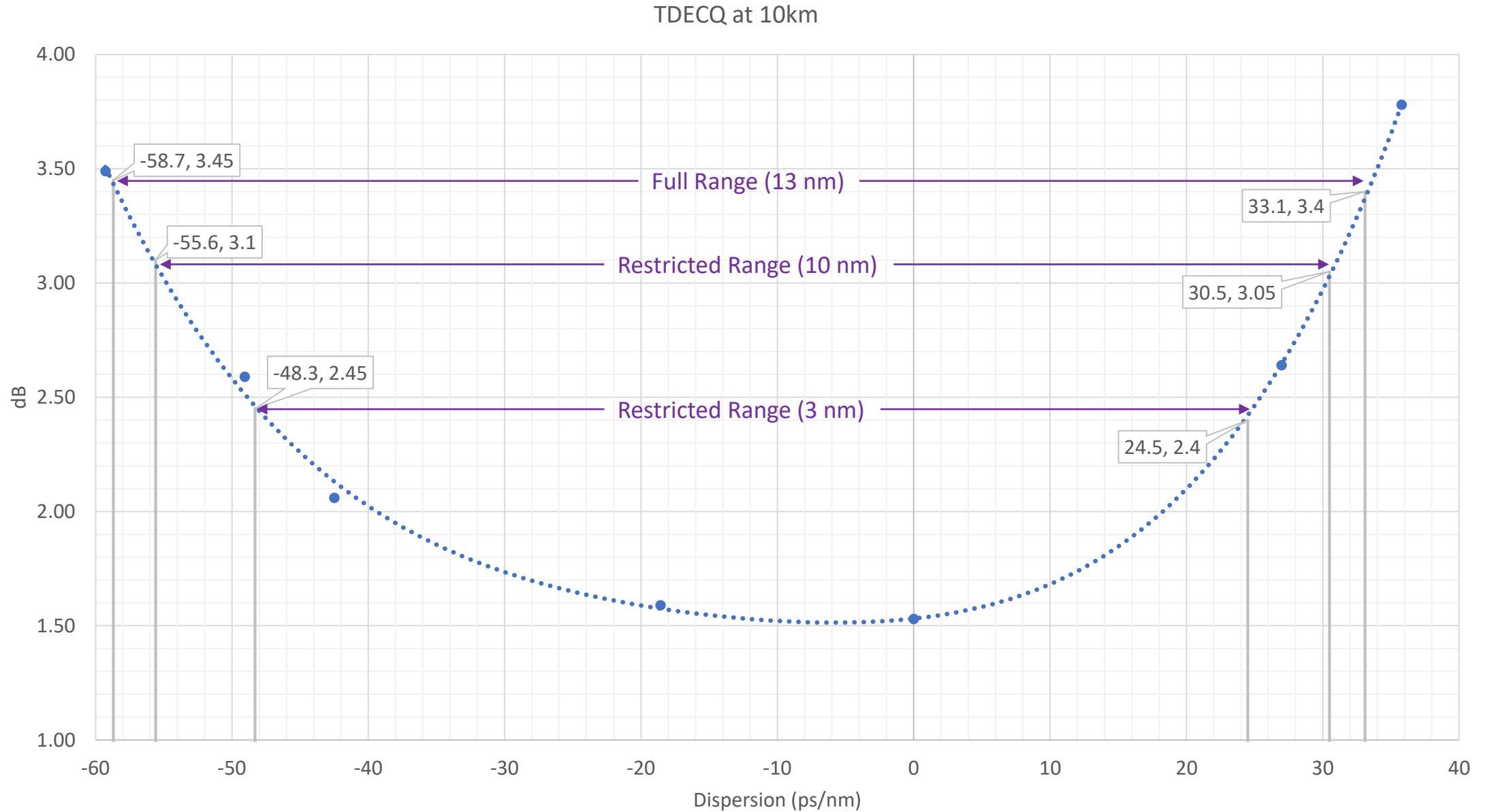
Fiber code	CD22 +BZS	CD22 +Fiber4	CD22	BZS	Btb	Btb	TMGBA	TMGBA +Fiber2	Unit
Total dispersion	-59.28	-49.06	-42.49	-18.57	0.00	0.00	26.97	35.77	ps/nm
Wavelength	1309.56	1309.56	1309.56	1309.56	1309.56	1317.76	1317.76	1317.76	nm
Est PMD	0.36	0.31	0.27	0.24	0	0	0.28	0.33	ps
Est DGD (SF=3)	1.08	0.92	0.82	0.71	0	0	0.83	0.99	ps
Total lenght	19.539	12.211	1.5	18.039	0	0	24.666	34.822	km
TDECQ/SECQ	4.62	2.9	2.14	1.57	1.37	1.42	2.64	3.78	dB
Est CD penalty (TDECQ-SECQ)	3.25	1.53	0.77	0.2	0	0.05	1.27	2.41	dB
Ceq	1	0.88	0.74	0.65	0.69	0.78	0.94	1.03	dB
TDECQ-10*Log(Ceq)	3.62	2.02	1.4	0.92	0.68	0.64	1.7	2.75	dB

Bottom compression case

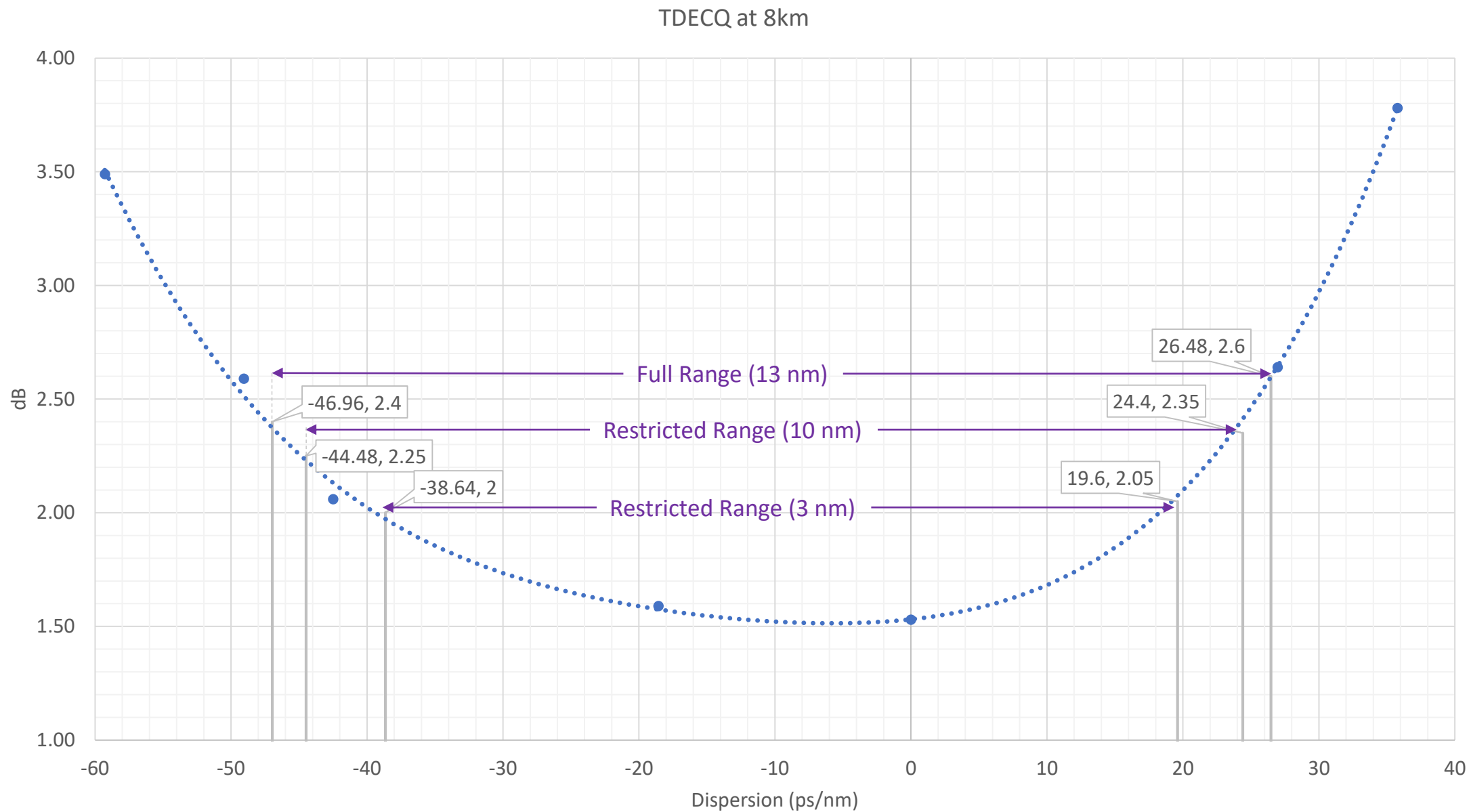
Fiber code	CD22 +BZS	CD22 +Fiber4	CD22	BZS	Btb	TMGBA +Fiber2	Unit
Total dispersion	-59.28	-49.06	-42.49	-18.57	0.00	35.77	ps/nm
Wavelength	1309.56	1309.56	1309.56	1309.56	1309.56	1317.76	nm
Est PMD	0.36	0.31	0.27	0.24	0	0.33	ps
Est DGD (SF=3)	1.08	0.92	0.82	0.71	0	0.99	ps
Total lenght	19.539	12.211	1.5	18.039	0	34.822	km
TDECQ/SECQ	3.49	2.59	2.06	1.59	1.53	3.56	dB
Est CD penalty (TDECQ-SECQ)	1.96	1.06	0.53	0.06	0	2.03	dB
Ceq	1.12	1.05	0.95	0.95	0.66	1.08	dB
TDECQ-10*Log(Ceq)	2.37	1.54	1.11	0.64	0.87	2.48	dB

- Assuming 3.9dB as maximum TDECQ value (proposed in [lewis 3cu adhoc 061919 v2](#)).
- ON NEGATIVE DISPERSION, bottom compression allows to achieve this limit with no changes in current IEEE TDECQ reference receiver and methodology, neither limiting foreseen link characteristics.
- ON POSITIVE DISPERSION, uniform level spacing is enough to meet this proposal (Bottom compression improving by 0.2dB TDECQ).

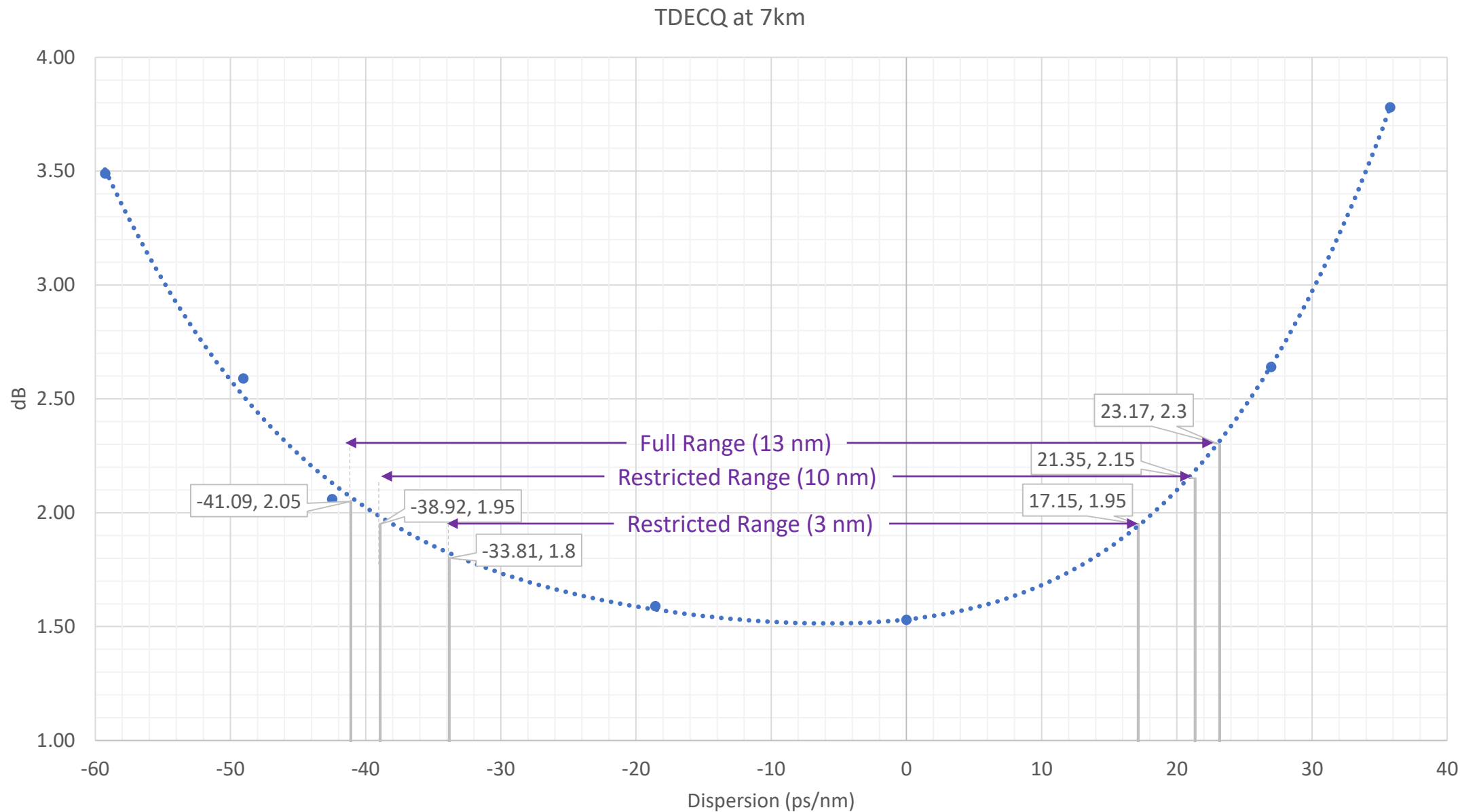
TDECQ at 10km



TDECQ at 8km



TDECQ at 7km



TDECQ Summary

	Full Range (13nm)	Restricted Range (10nm)	Restricted Range (3nm)
TDECQ @ 10 km (dB)	3.45	3.1	2.45
TDECQ @ 8 km (dB)	2.6	2.35	2.05
TDECQ @ 7 km (dB)	2.3	2.15	1.95

- At 10km at least **0.4 dB margin** to a 3.9 dB TDECQ spec
- At 8km at least **1.3 dB margin** to a 3.9 dB TDECQ spec
- At 7km at least **1.6 dB margin** to a 3.9 dB TDECQ spec

Thank You