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## Digital Signal Processing for 100G/400G Optical Fiber Connectivity Links

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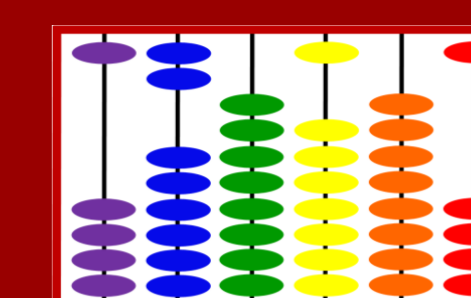
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# Digital Signal Processing for 100G/400G Optical Fiber Connectivity Links

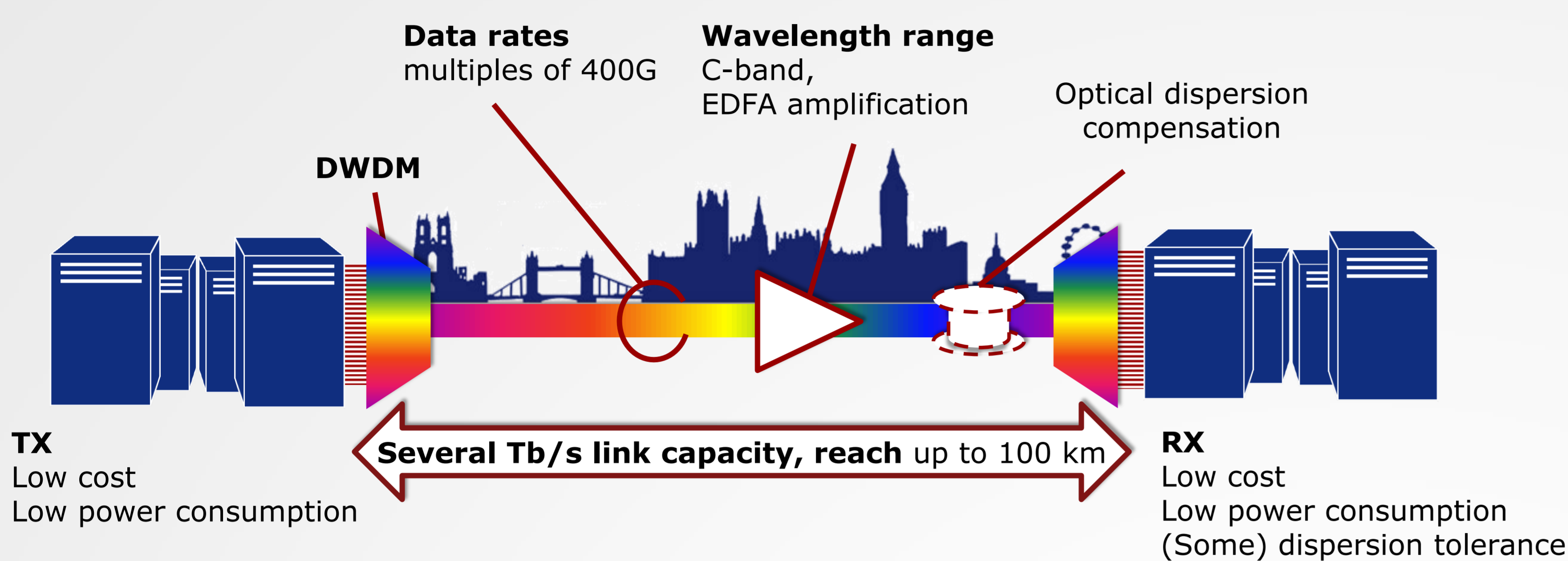


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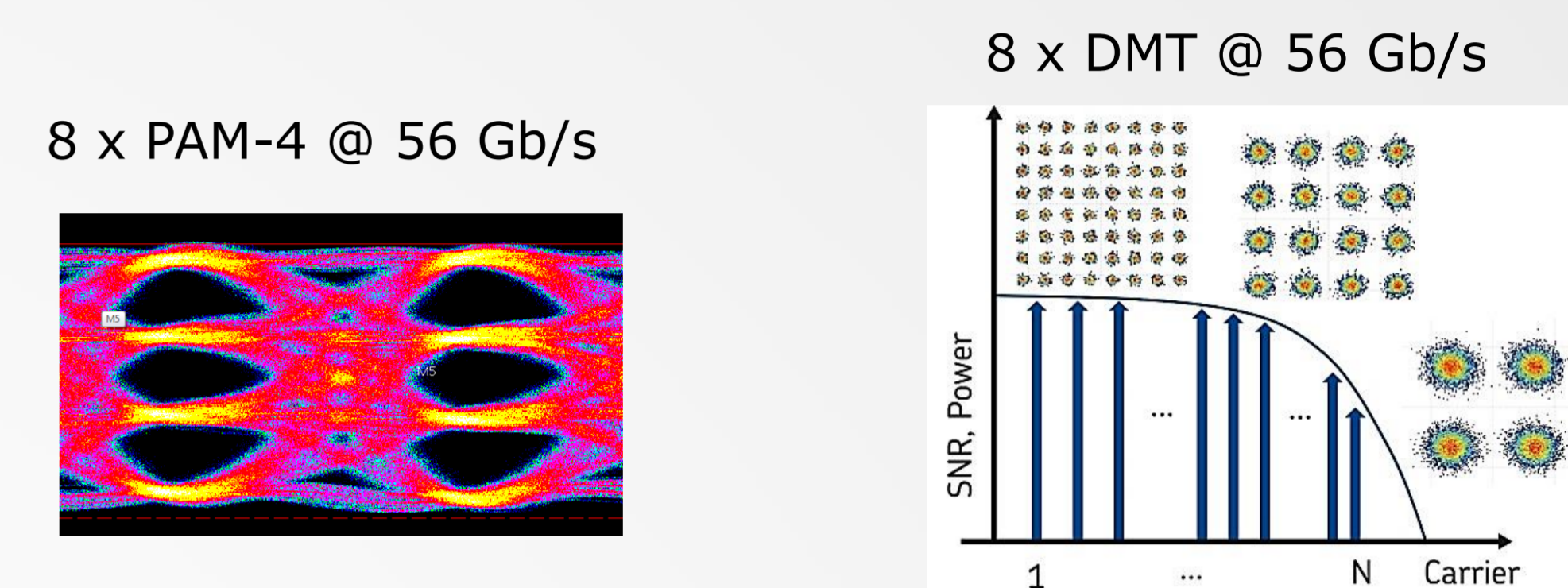
niei@fotonik.dtu.dk

## Motivation – DWDM Interconnections

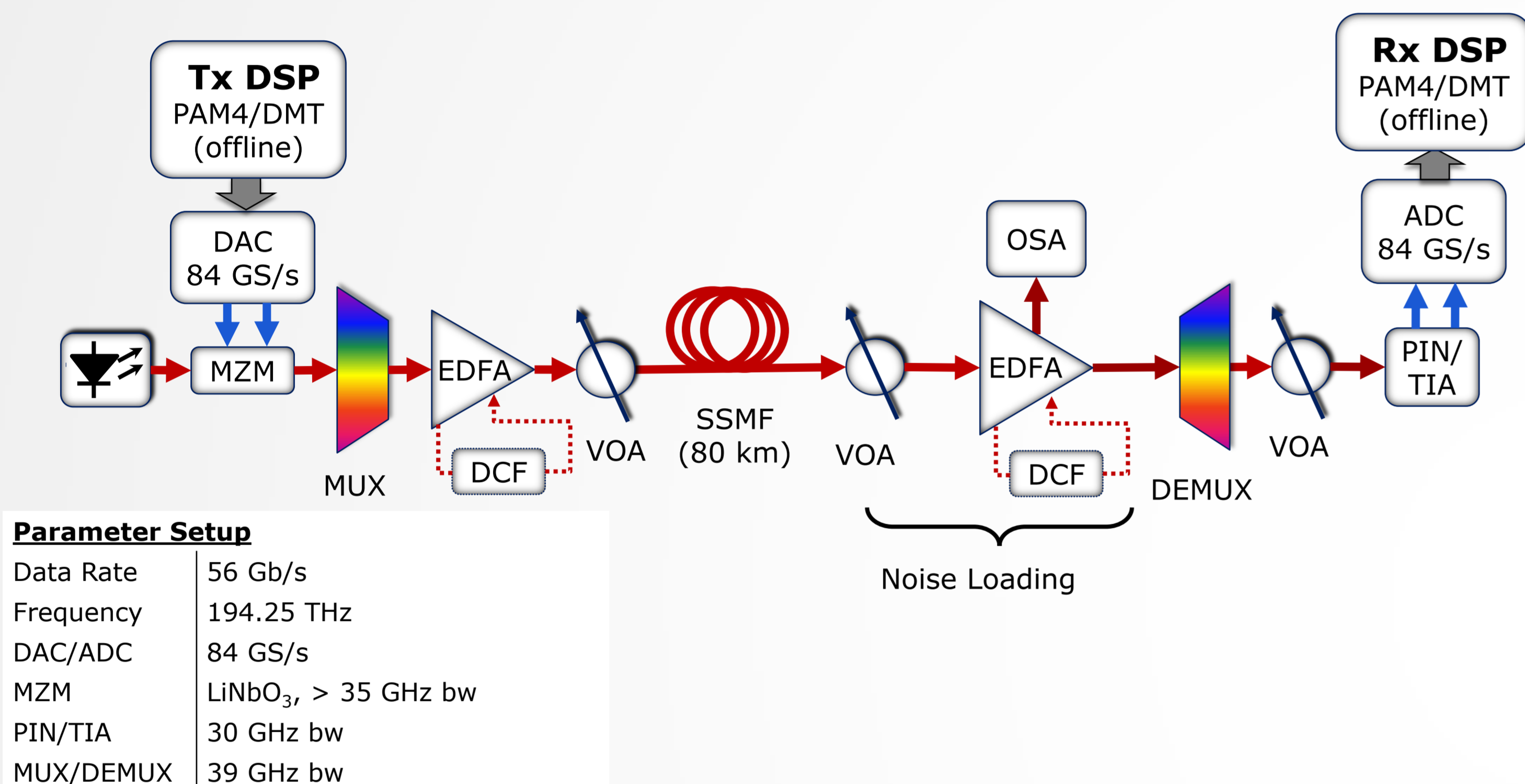


### Low-Cost Approach (Scale up from short reach)

- 400G direct detection
- 8x50G DWDM/ 4x100G WDM



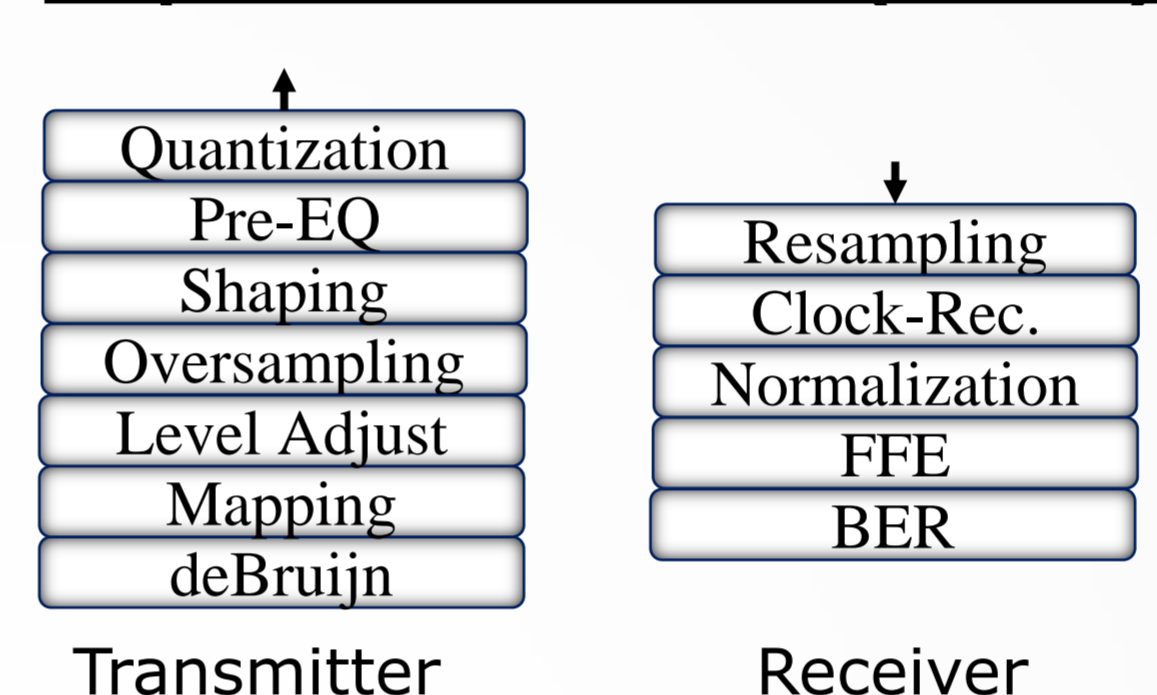
## Experimental Setup



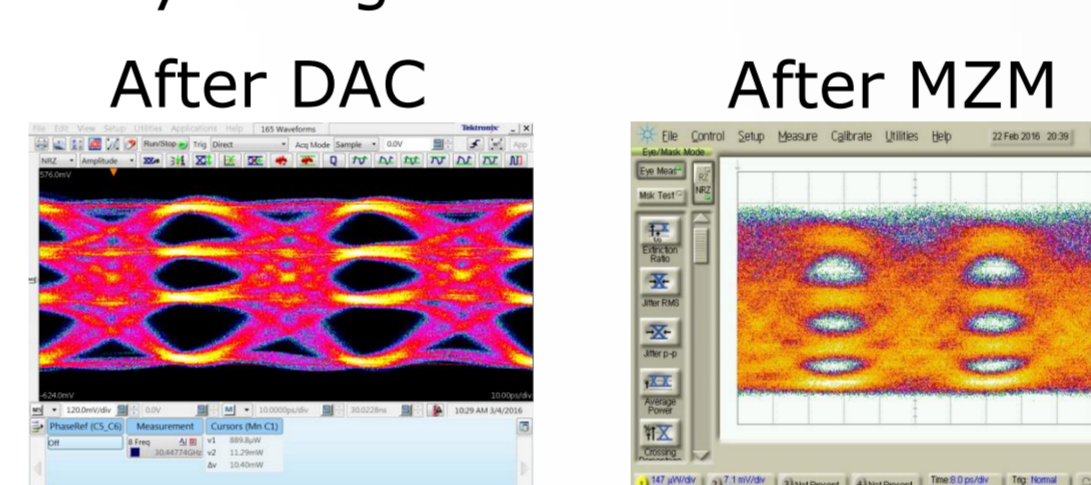
**Parameter Setup**

Data Rate	56 Gb/s
Frequency	194.25 THz
DAC/ADC	84 GS/s
MZM	LiNbO <sub>3</sub> , > 35 GHz bw
PIN/TIA	30 GHz bw
MUX/DEMUX	39 GHz bw

### Four-level pulse amplitude modulation (PAM-4)

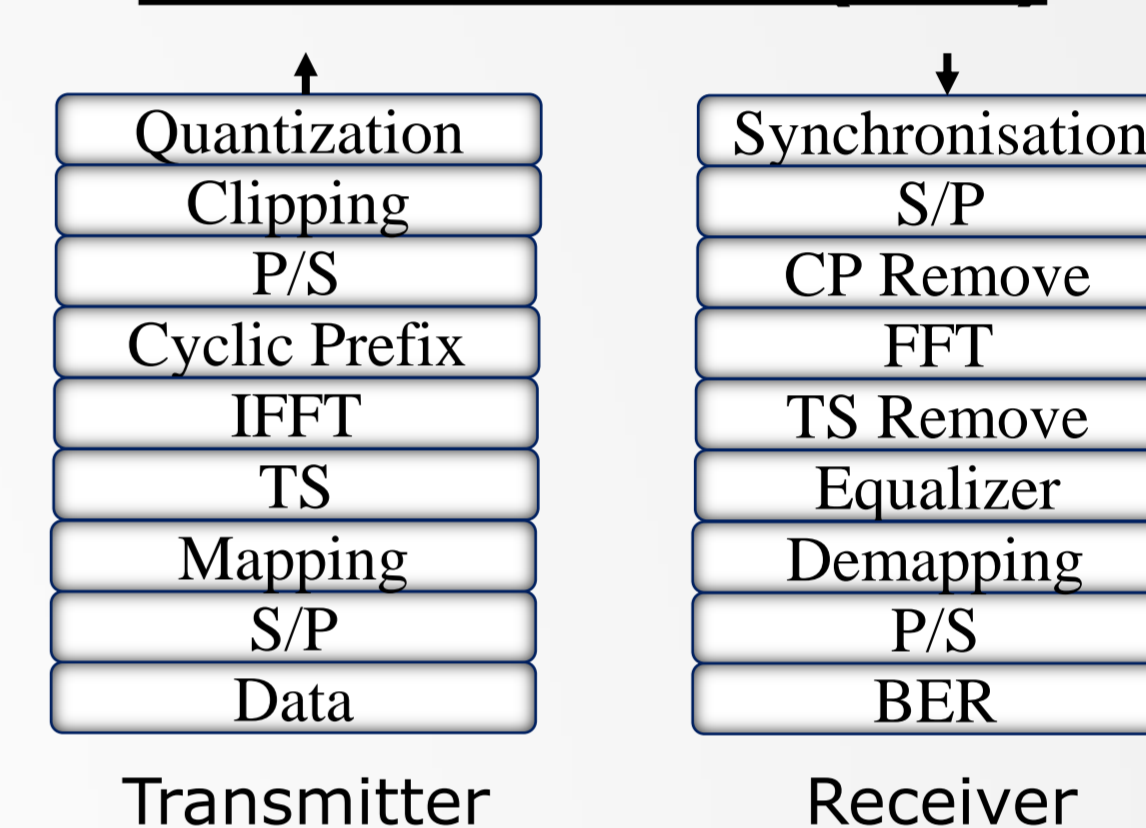


PAM-4 Eye Diagrams used for transmission



### DSP

#### Discrete Multitone (DMT)

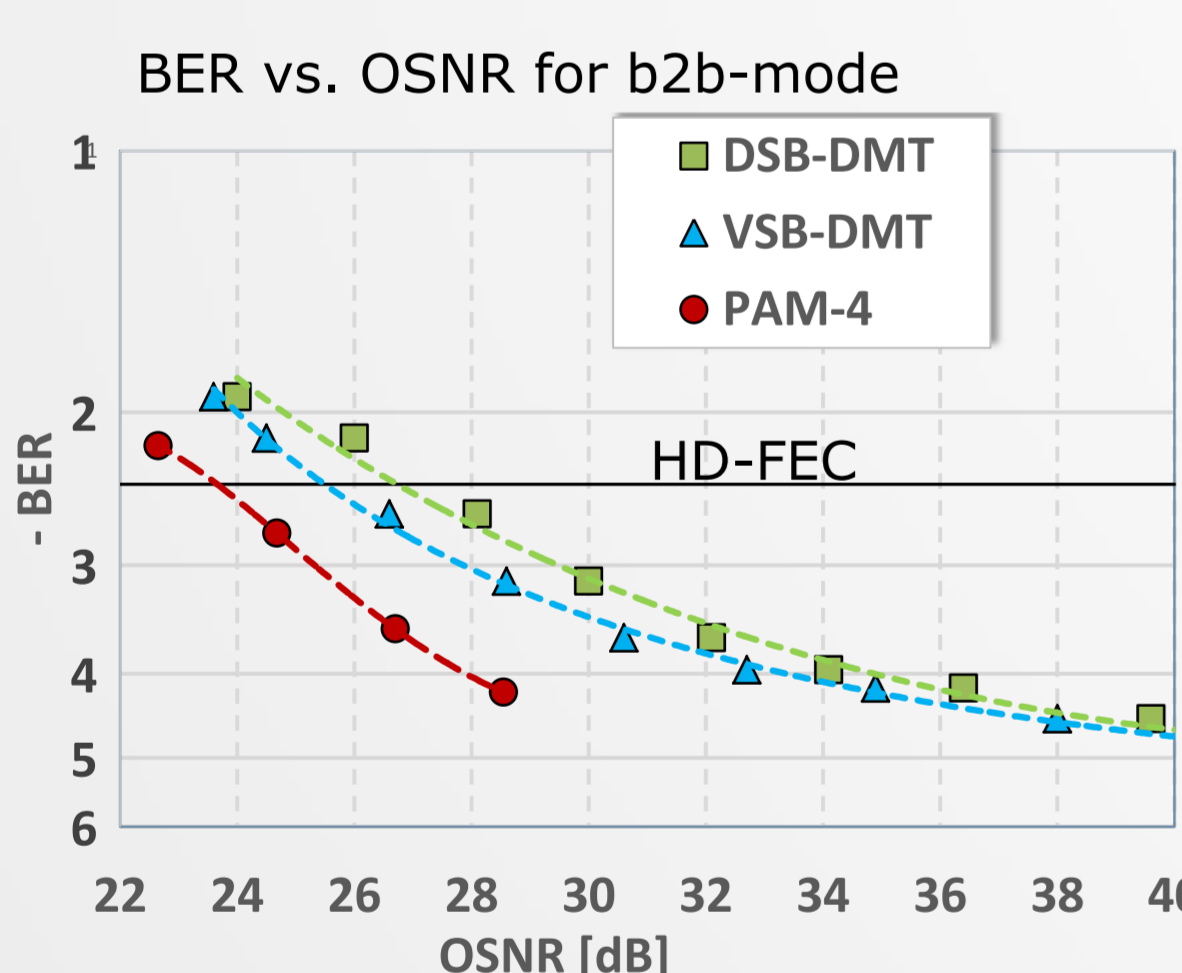


**DMT Parameters**

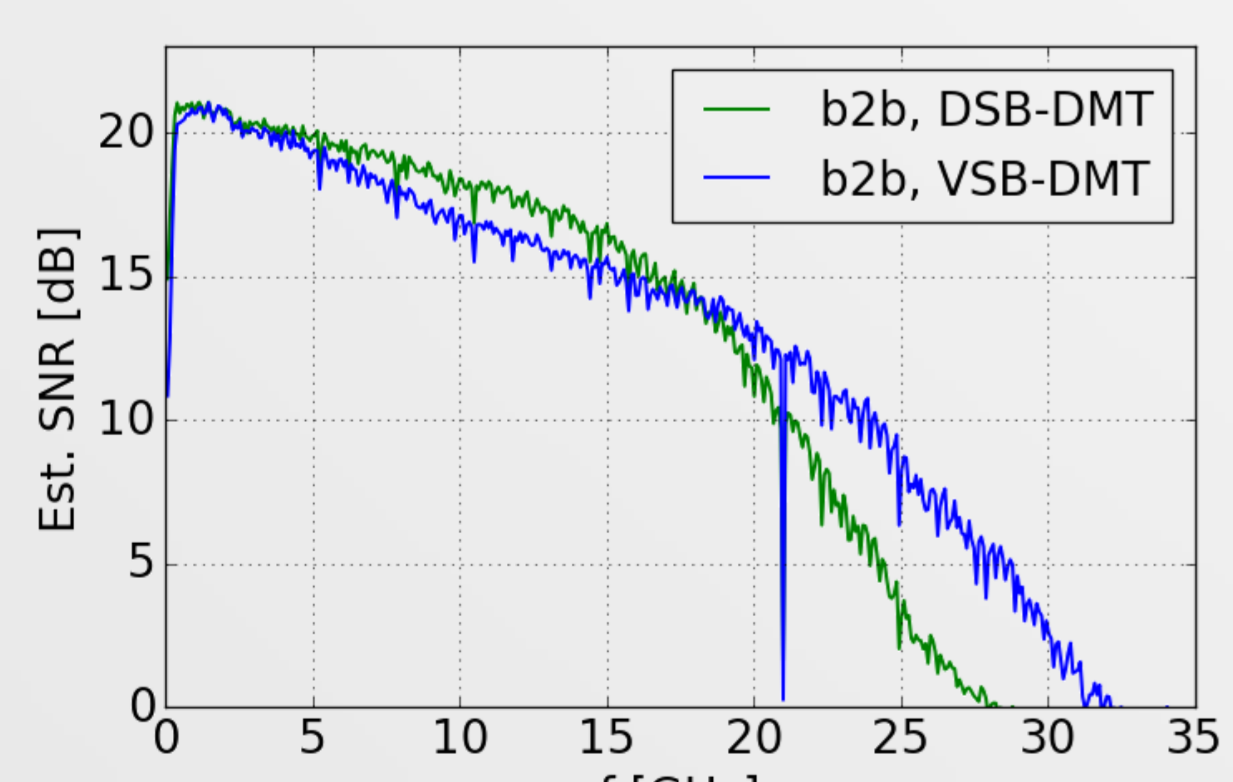
FFT length	1024
Oversampling	1.05
Max. used subcarriers	486
OFDM Frame	123 Symbols + 5 training symbols
Equalizer	1-tap, Decision-Directed
Bit & Powerloading	Chow's & Cioffi's algorithm

## Experimental Results @ 56 Gbit/s

### Optical b2b performance

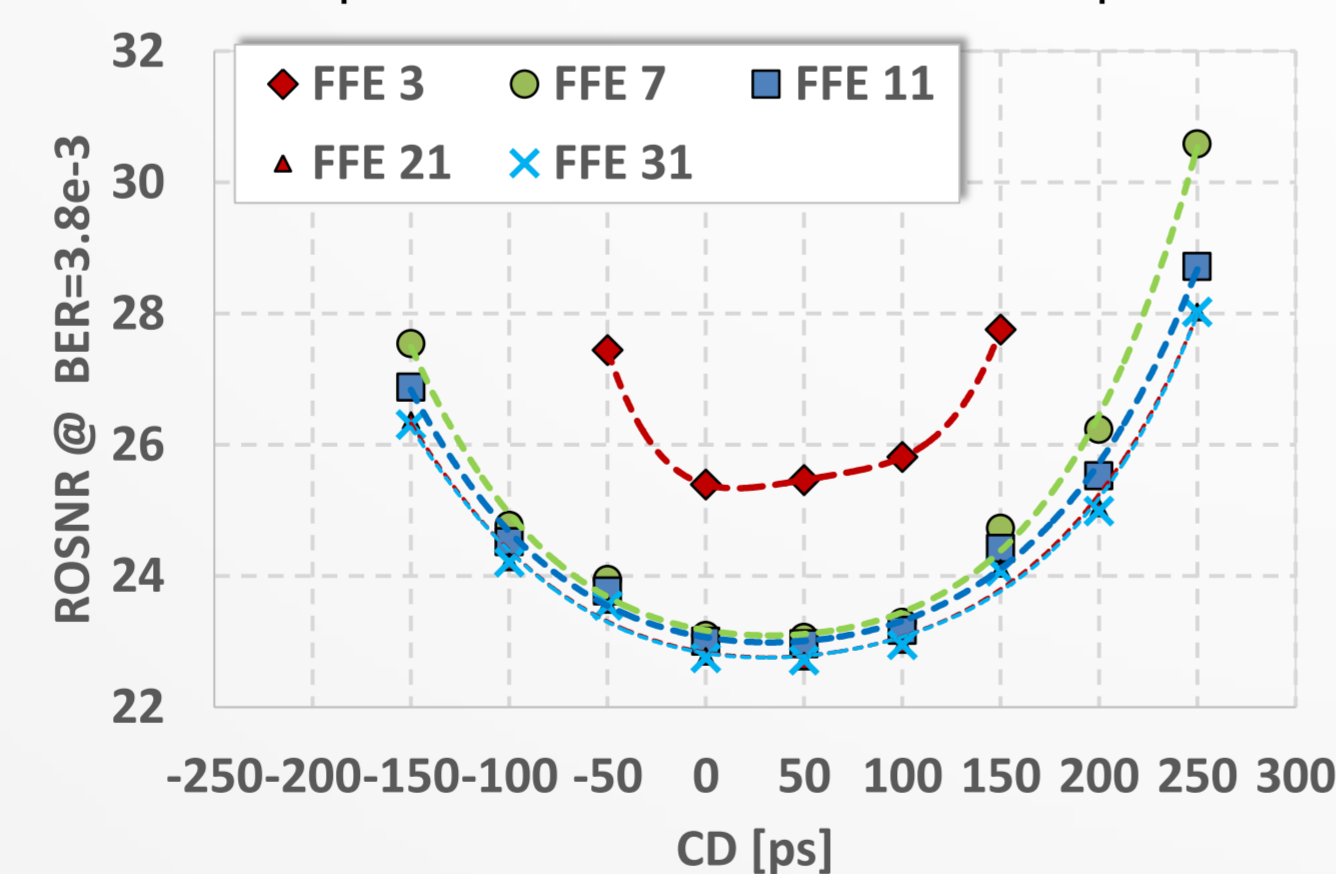


Estimated SNR of double sidband DMT (DSB-DMT) and vestigial sideband DMT (VSB-DMT) at optical b2b



### Residual Dispersion & PAM-4

Required OSNR at the FEC-limit of 3.8e-3 vs. residual dispersion with different FFE tap count



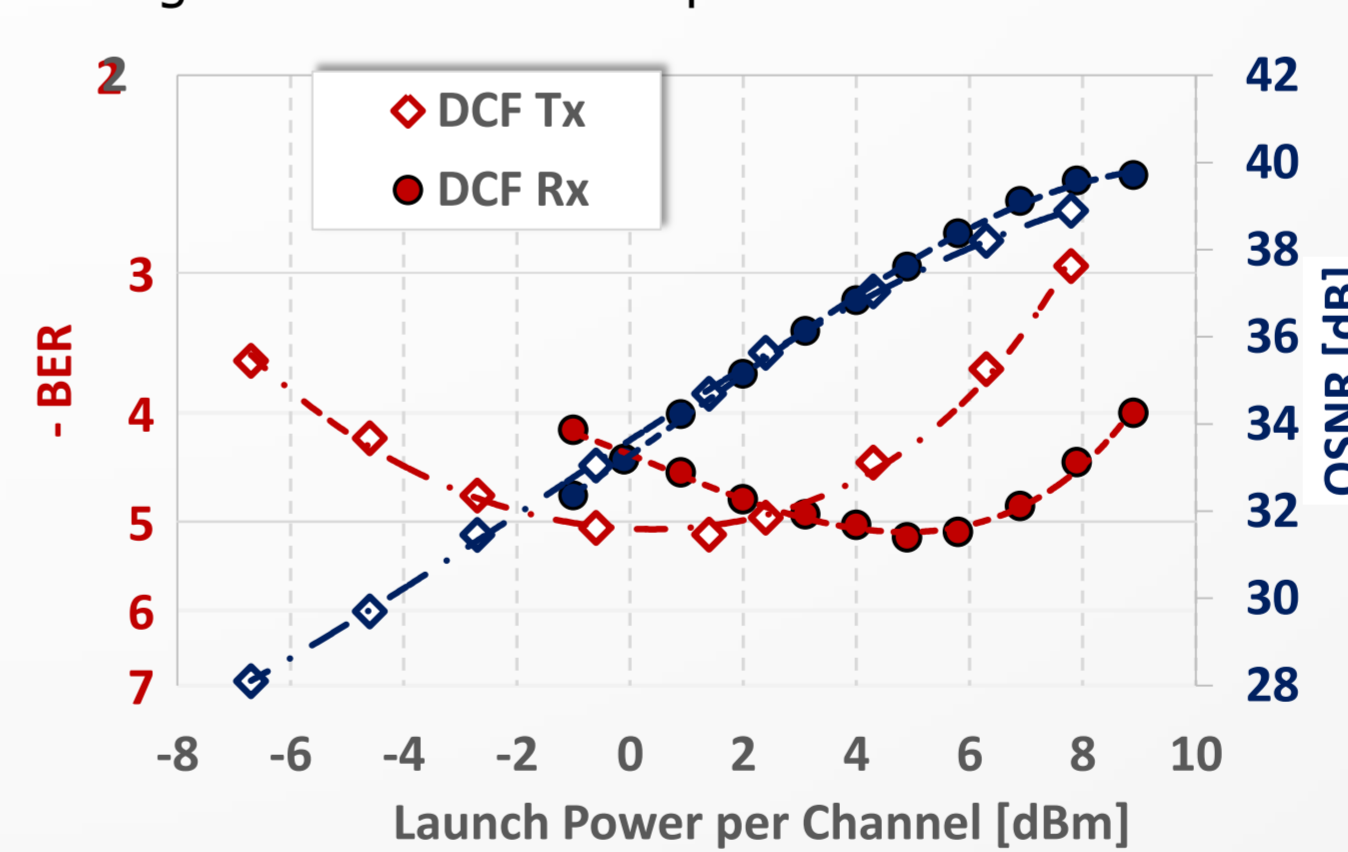
### Results

Format	HD-FEC	OSNR b2b	OSNR 80 km
PAM-4	3.8e-3	~ 23.8 dB	~ 24.8 dB
DSB-DMT	3.8e-3	~ 25.7 dB	~ 27.2 dB
VSB-DMT	3.8e-3	~ 27 dB	~ 31 dB

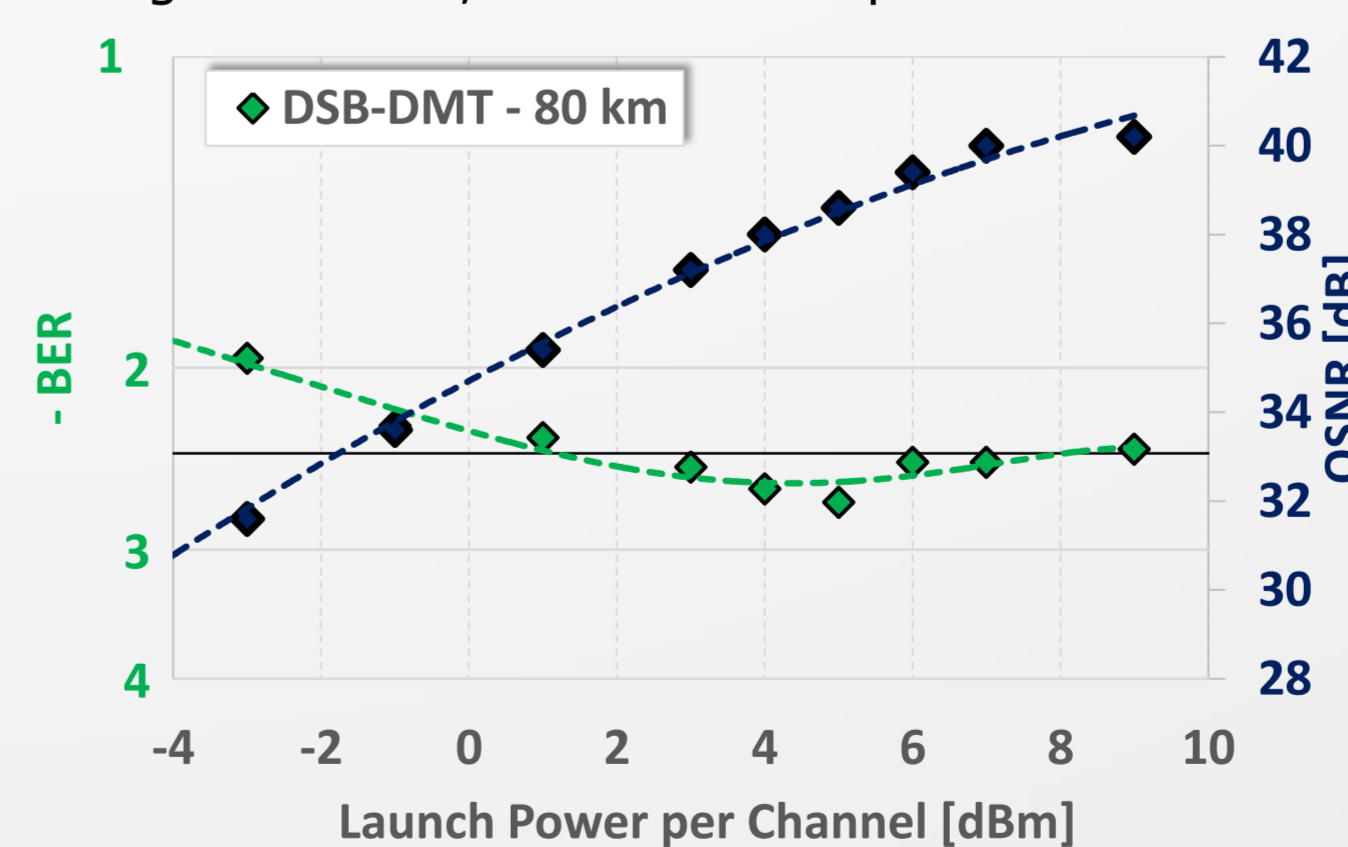
### Transmission over 80 km SSMF

#### Launch Power

Optimum launch power into 80 km SSMF using PAM-4: Where to put the DCF?

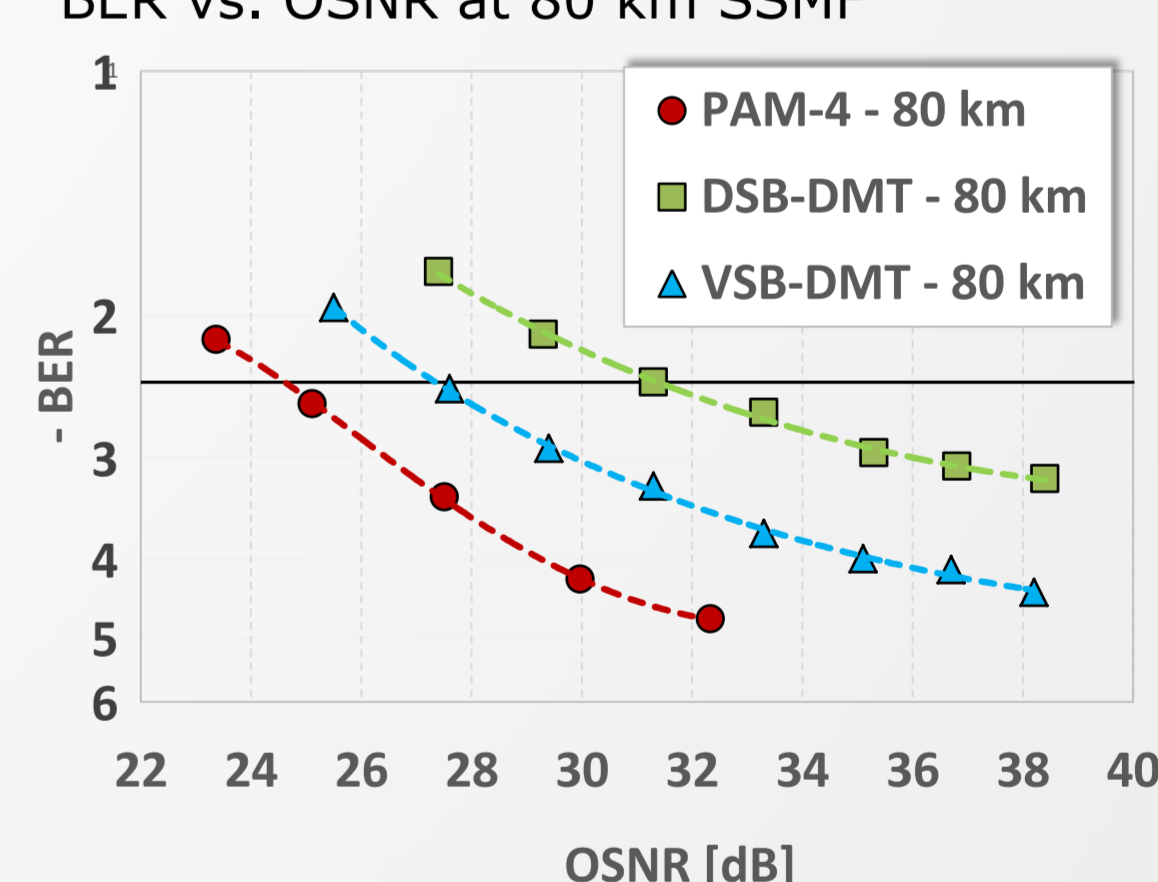


Optimum launch power into 80 km SSMF using DSB-DMT; DCF is not required!

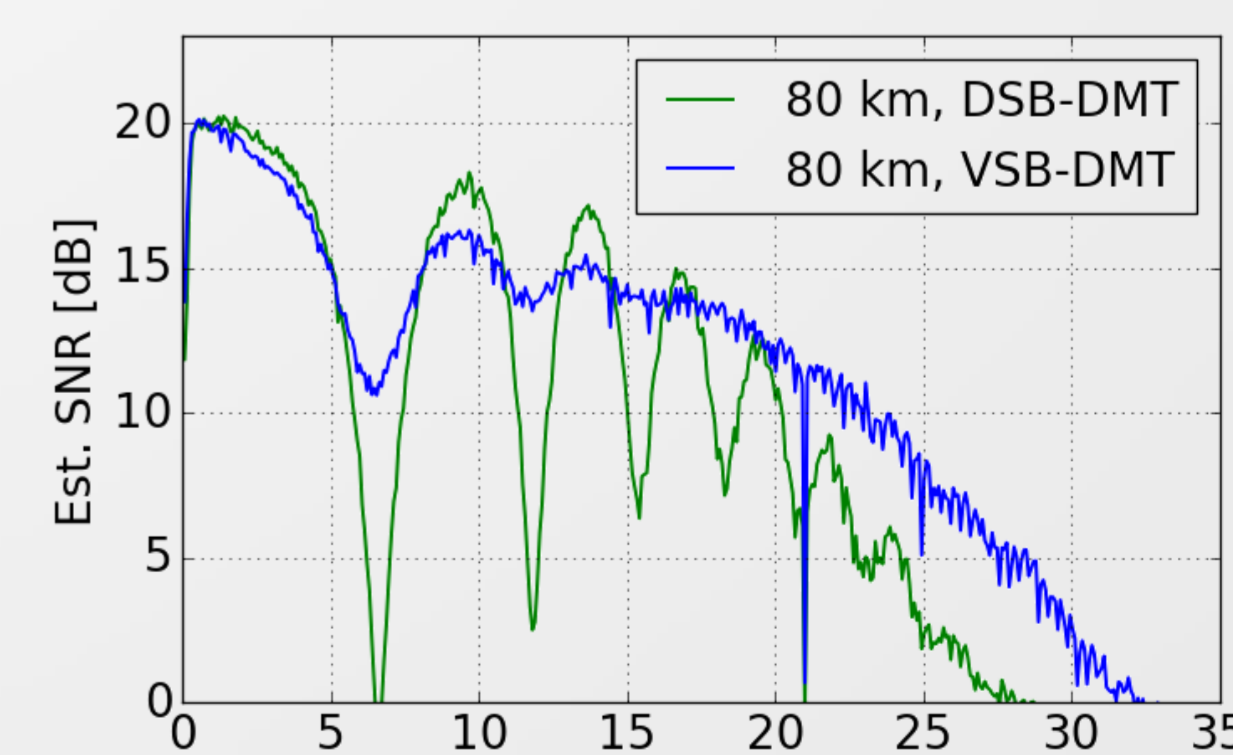


#### OSNR Performance

BER vs. OSNR at 80 km SSMF



Estimated SNR of double sidband DMT (DSB-DMT) and vestigial sideband DMT (VSB-DMT) at 80 km SSMF



## Conclusion

- PAM-4 and vestigial sideband DMT show a lot of potential for a low-cost solution for next generation of inter-data center interconnections
- PAM-4 outperforms DSB-DMT and VSB-DMT in terms of required OSNR at the FEC-threshold for the b2b-case and even for 80 km SSMF
- DMT does not require any DCF → 5 dB higher power margin for DMT compared to PAM-4

## Acknowledgement

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### References

[1] N. Eiselt, et al., „Experimental Comparison of 56 Gbit/s PAM-4 and DMT for Data Center Interconnect Applications“, Photonische Netze, 17. ITG Fachtagung, 2016, Leipzig