Baseline Proposals for 800GBASE-DR4, 800GBASE-DR4-2, and 800GBASE-FR4

Also Including: 200GBASE-DR1/DR1-2,400GBASE-DR2/DR2-2, 1600GBASE-DR8/DR8-2

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Overview

- Intent of this presentation is to **begin** baseline formation for 200G/L SMF standards at 500m and 2km.

- Expectation is that continuing refinement will be required, and that such work will be expedited by having a consolidated working draft of the various specifications.

Building the Spec

- Leveraging 100G/L specs (ie, 400G-DR4, 100G-FR1, 400G-FR4).

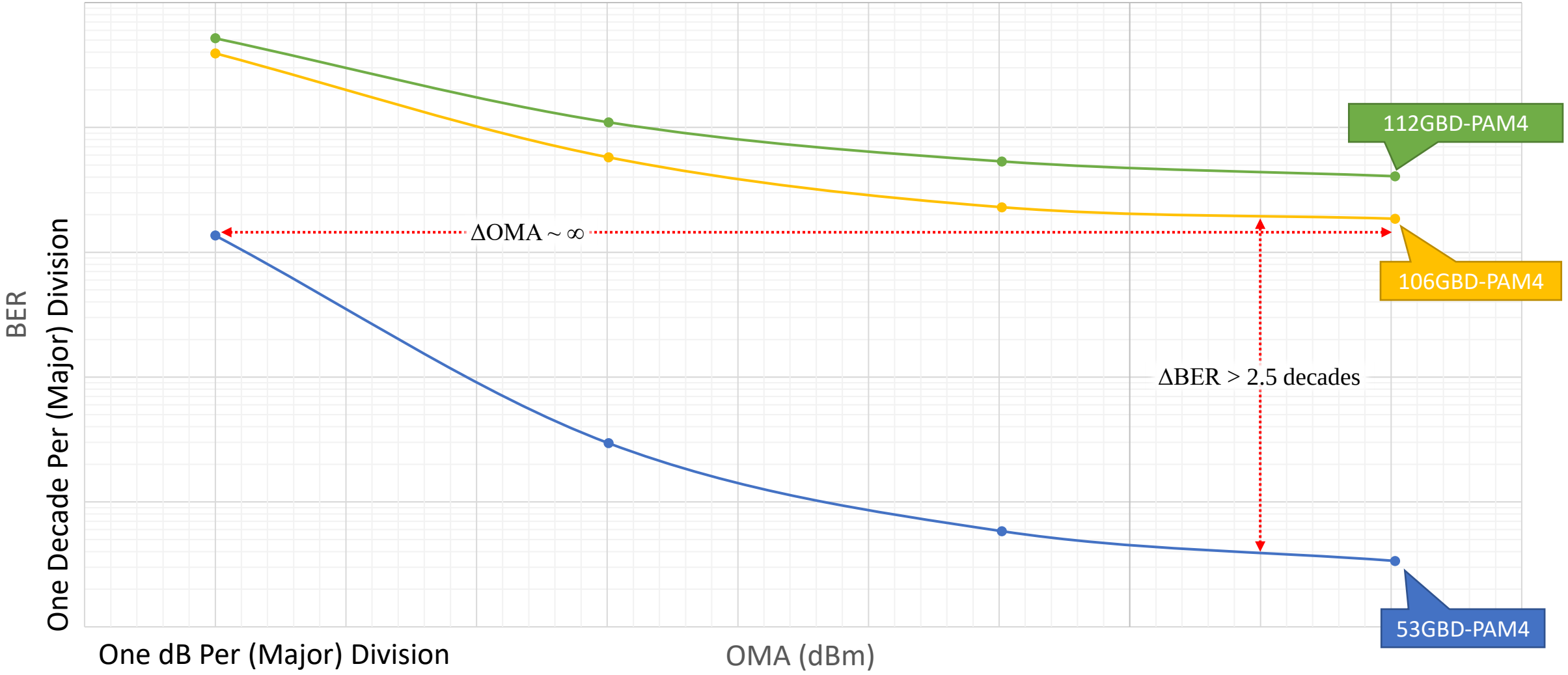
- Initial focus is on understanding/projecting effects on the optical receiver, and scaling/shifting against the 100G/L specs as needed.
  - Transmitter performance had been investigated previously, including in welch_3df_01a_220315.pdf

- Receiver evolution looks at the following:
  - Relative degradation of 200G/L receiver vs. 100G/L receiver, holding BER and equalizer constant
    - Capturing differences between 106.25GBD-PAM4 (6% overhead) and 112.5GBD-PAM4 (12%).
  - Effects of equalizer scaling, specifically focusing on longer FFE and addition of DFE
  - Effects of TECQ composition on receiver performance (specifically RIN component)

- Specifications are aligned as follows: Single-λ at 500m, Single-λ at 2km, Multi-λ at 2km

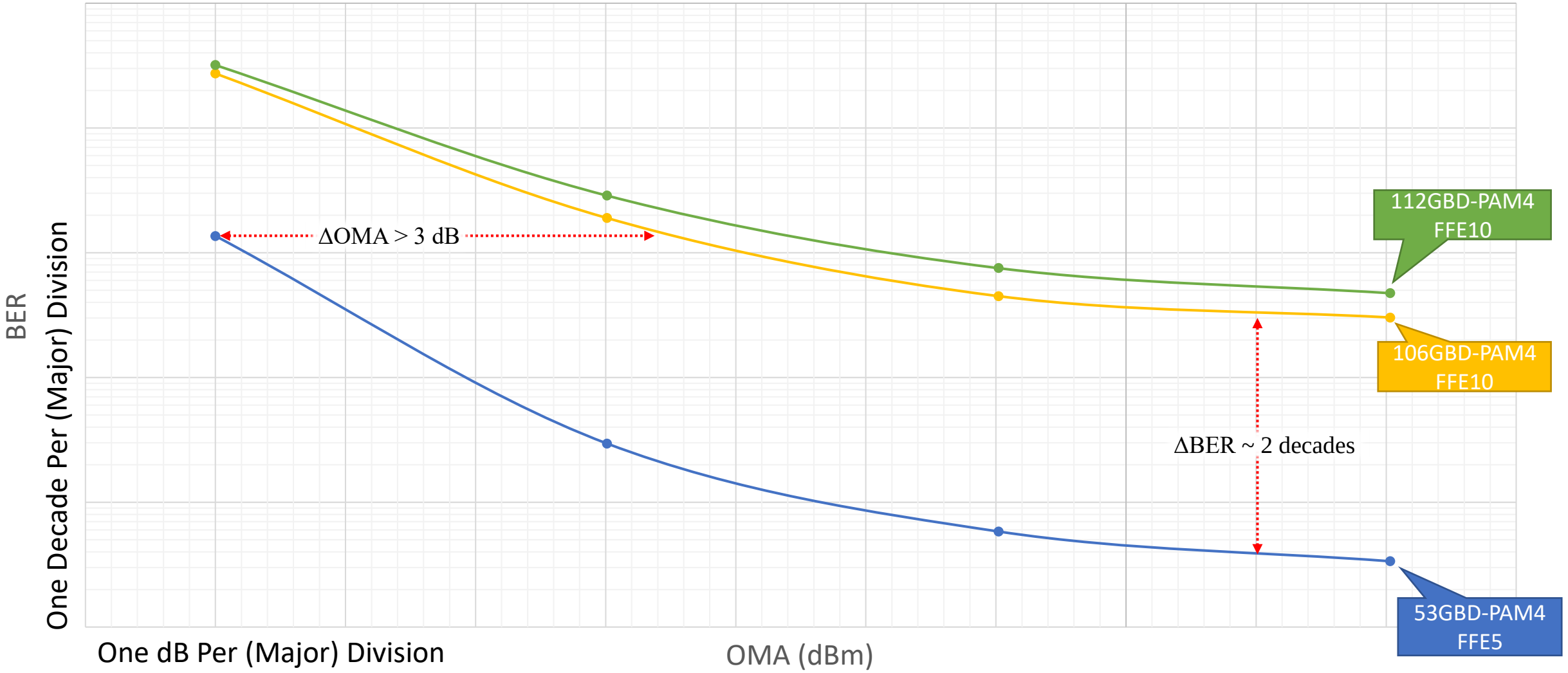
Receiver Evolution – Scaling Rate

TDECQ ~ 3.4dB
EQ = FFE5



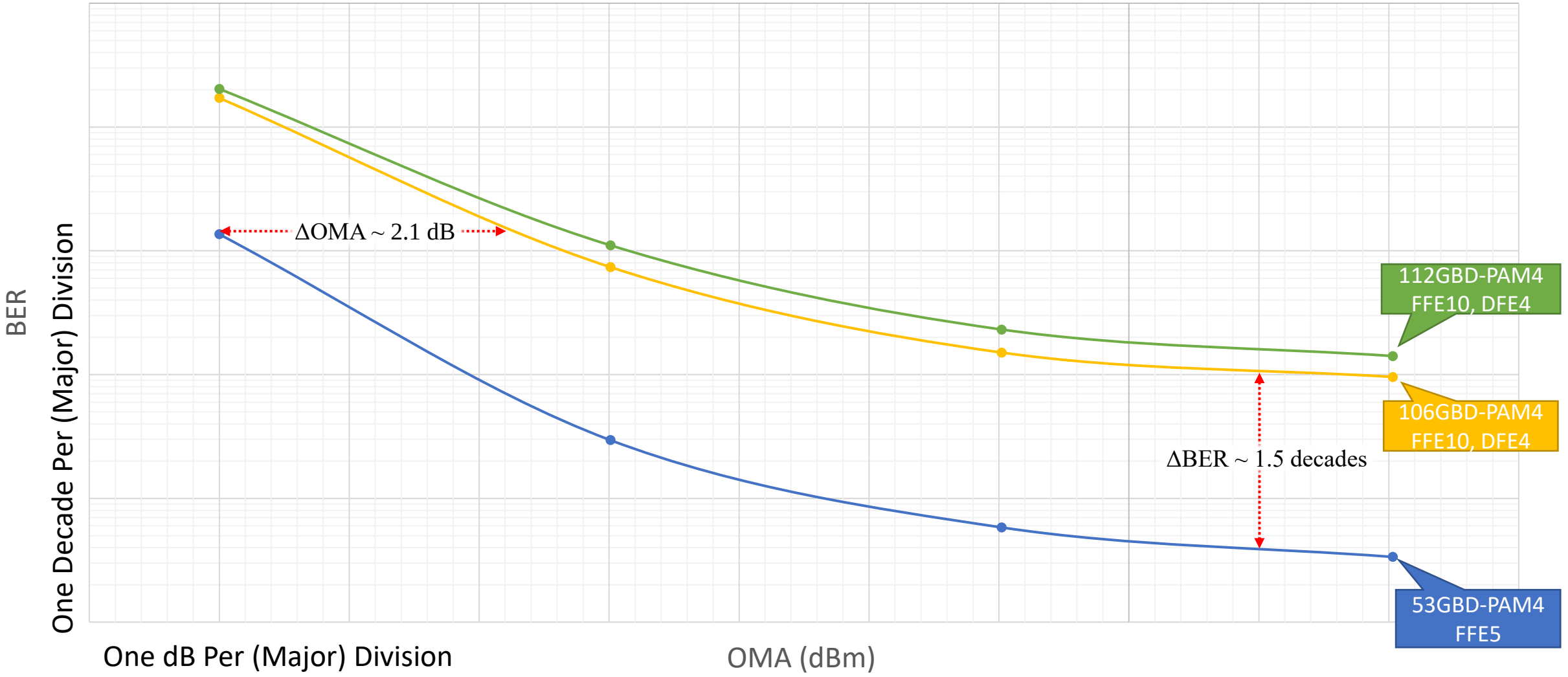
Receiver Evolution – Scaling FFE

TDECQ ~ 3.4dB



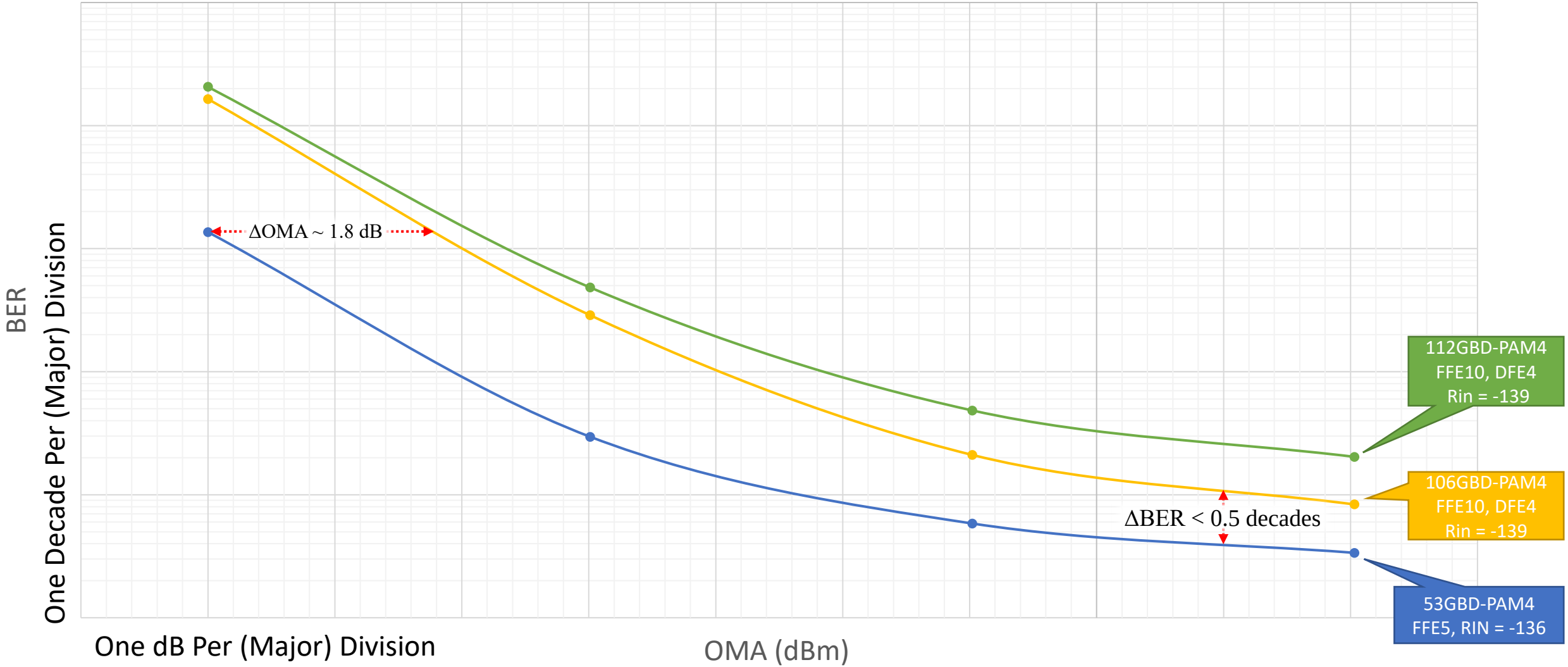
Receiver Evolution – Adding DFE

TDECQ ~ 3.4dB



Receiver Evolution – Scaling Rin

TDECQ ~ 3.4dB



Receiver Scaling

- More equalization required than 100G: FFE10+DFE4 used here
  - DFE2 May be sufficient: DFE taps 3&4 are minimal in all cases, tap weight up to 0.5 used for DFE1
    - Note: DFE error propagation not taken into account.
  - FFE depth beyond 10 taps shows no appreciable benefit in these analyses
- Improved Rin (and by extension TDECQ composition) beneficial
  - More of the TDECQ coming from ISI
  - Biggest benefit to noise floor performance
- Performance impairment in going to 112GBD (vs. 106GBD) seems moderate but needs further investigation
  - Power & technology tradeoffs still needs to be understood

Baseline Proposals

PPM offset tightened following 802.3ck precedent
More work needed on 6% vs 12% overhead FEC

Proposed Receiver Specifications

Description	200GBASE-DR1 400GBASE-DR2 800GBASE-DR4 1600GBASE-DR8	200GBASE-DR1-2 400GBASE-DR2-2 800GBASE-DR4-2 1600GBASE-DR8-2	800GBASE-FR4	Unit
Signaling rate, each lane (Range)	106.25 - 112.5 ± 50 ppm	106.25 - 112.5 ± 50 ppm	106.25 - 112.5 ± 50 ppm	GBd
Modulation Format	PAM4	PAM4	PAM4	
Lane wavelengths (range)	1304.5 to 1317.5	1304.5 to 1317.5	1264.5 to 1277.5 1284.5 to 1297.5 1304.5 to 1317.5 1324.5 to 1337.5	nm
Damage threshold, each lane	5	5	5.4	dBm
Average receive power, each lane (max)	4	4	4.4	dBm
Average receive power, each lane (min)	-4.9	-6.1	-6.2	dBm
Receive power, each lane (OMA_{outer}) (max)	4.2	4.2	3.7	dBm
Receiver reflectance (max)	-26	-26		dBm
Receiver sensitivity (OMA_{outer}), each lane (max) for TECQ < 1.4dB for 1.4 dB ≤ TECQ ≤ 3.4 dB	 -2.9 -4.3+TECQ	 -3.5 -4.9+TECQ	 -3.6 -5 + TECQ	 dBm dBm
Stressed receiver sensitivity (OMA_{outer}), each lane (max)[†]	-0.9	-1.5	-1.6	dBm
Conditions of stressed receiver sensitivity test:				
SECQ[†]	3.4	3.4	3.6	dB
OMA_{outer} of each aggressor lane	2.1	1.5	1.4	dBm

Increased 1dB vs. comparable 400G specs

Increased 0.2 dB vs. comparable 400G spec

Proposed Transmitter Specifications

Increased 1.2 dB vs. comparable 400G spec

Description	200GBASE-DR1 400GBASE-DR2 800GBASE-DR4 1600GBASE-DR8	200GBASE-DR1-2 400GBASE-DR2-2 800GBASE-DR4-2 1600GBASE-DR8-2	800GBASE-FR4	Unit
Signaling rate, each lane (Range)	106.25 - 112.5 ± 50 ppm	106.25 - 112.5 ± 50 ppm	106.25 - 112.5 ± 50 ppm	GBd
Modulation Format	PAM4	PAM4	PAM4	
Lane wavelengths (range)	1304.5 to 1317.5	1304.5 to 1317.5	1264.5 to 1277.5 1284.5 to 1297.5 1304.5 to 1317.5 1324.5 to 1337.5	nm
Side-mode suppression ratio (SMSR), (min)	30	30	30	dB
Average launch power, each lane (max)	4	4	4.4	dBm
Average launch power, each lane (min)	-1.9	-2.1	-2	dBm
Outer Optical Modulation Amplitude (OMA_{outer}), each lane(max)	4.2	4.2	3.7	dBm
Outer Optical Modulation Amplitude (OMA_{outer}), each lane(min) for TDECQ < 1.4dB for 1.4 dB ≤ TDECQ ≤ 3.4 dB	 0.2 -1.2+TDECQ	 0.9 -0.5+TDECQ	 1 -0.4+TDECQ	 dBm dBm
Transmitter and dispersion eye closure (TDECQ), each lane (max)	3.4	3.4	3.6	dB
TECQ (max)	3.4	3.4	3.6	dB
| TDECQ - TECQ| (max)	2.5	2.5	2.5	dB
Average launch power of OFF transmitter, each lane (max)	-15	-15	-16	dBm
Extinction ratio, each lane, (min)	3.5	3.5	3.5	dB
Transmitter transition time (max)	17	17	17	ps
Transmitter over/under-shoot (max)	22	22	22	%
RIN_x OMA (max)	-139	-139	-139	dB/Hz
Optical return loss tolerance (max)	21.4	21.4	17.1	dB
Transmitter reflectance (max)	-26	-26	-26	dB

Increased 1dB vs. comparable 400G specs

Deceased 3 dB/Hz vs. comparable 400G specs.

Proposed Link Budget

Increased 0.2dB vs. comparable 400G specs

Description	200GBASE-DR1 400GBASE-DR2 800GBASE-DR4 1600GBASE-DR8	200GBASE-DR1-2 400GBASE-DR2-2 800GBASE-DR4-2 1600GBASE-DR8-2	800GBASE-FR4	Unit
Power budget (for max TDECQ)			8.0	dB
for extinction ratio ≥ 4.5 dB	6.4	7.7		dB
for extinction ratio < 4.5 dB	6.5	7.8		dB
Operating distance	500	2000	2000	m
Channel insertion loss	3	4	4	dB
Maximum discrete reflectance	-35[c,d]	-35[c,d]	-35[d]	dB
Allocation for penalties (for max TDECQ)			4	dB
for extinction ratio ≥ 4.5 dB	3.4	3.7		dB
for extinction ratio < 4.5 dB	3.5	3.8		dB
Additional insertion loss allowed	0	0	0	dB

[c] See 140.10.2.2 for details and specification as a function of the number of discrete reflectances within the channel
[d] Maximum value for each discrete reflectance with 4 discrete reflectances above -55 dB within the channel

Summary and Next Steps

- There seems to be a reasonable path to 200G/L specifications for 500m and 2km SMF objectives.
  - More receiver equalization and better Rin seem to be the best improvements available
  - Further investigation needed on 106GBD (6%) vs. 112GBD (12%) performance
    - Including power & technology comparisons
    - FEC/BER tradeoffs still being investigated

- Further analysis planned across different TDECQ values and compositions
  - Thus far the focus has been on the stressed case.

Thank You