TRANSCEIVER MODULE DATA IN SUPPORT OF COMMENTS #396 AND 397 AGAINST D1.2

Roberto Rodes, Coherent

INTRODUCTION

- This presentation is in support of the comments #396 and 397 to specify TECQ/TDECQmax= 3.4dB, while maintaining current SER target.
- Module with high TDECQ was used to get data on TDECQ measurement capabilities and Rx performance postFEC

HIGH TDECQ MODULE TESTING WITH INNER FEC
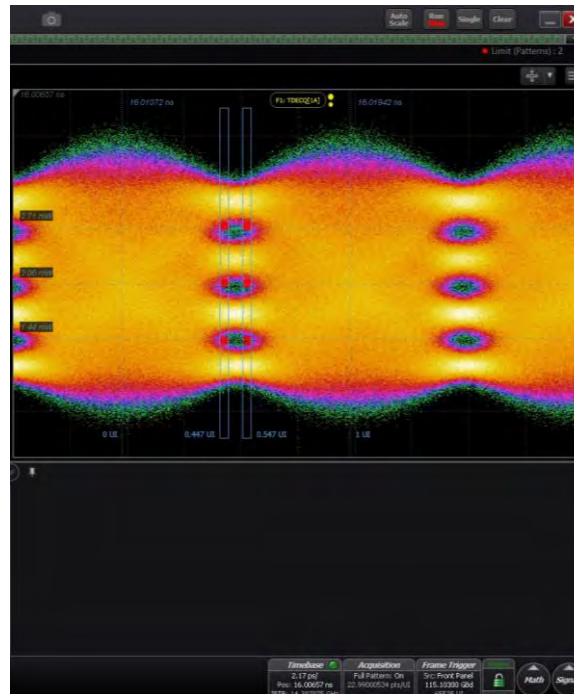
HIGH TDECQ MODULE AT 200G/LANE

- 800G-FR4 module with inner FEC
- 115GBd
- SSPRQ
- 15-tap TDECQ
- All lanes > 3.5 dB TECQ @ 9.6e-3 SER

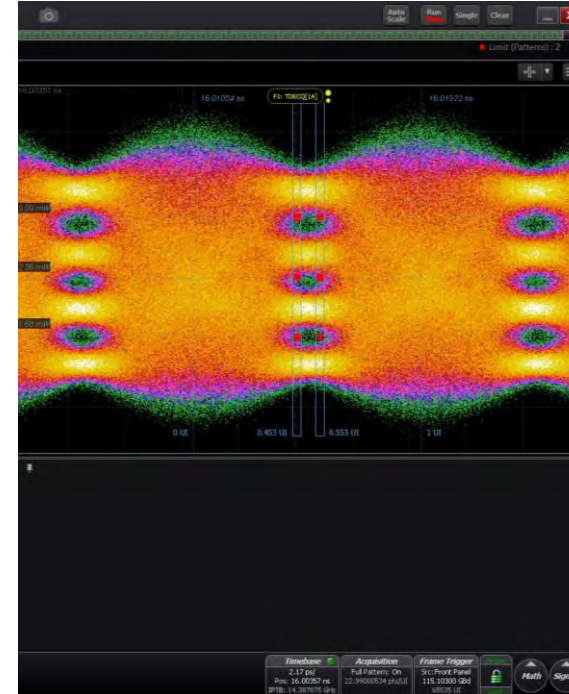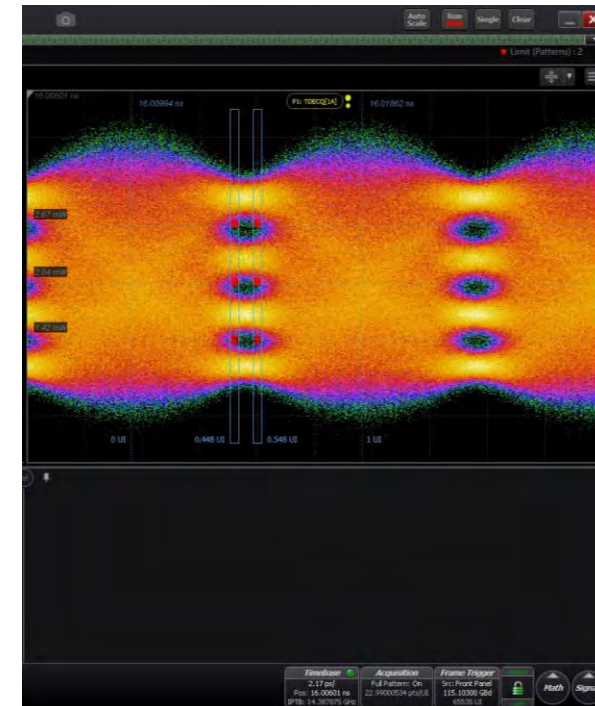| CH	SER	TECQ	Ceq
0	9.60E-03	4.95	1.41
0	6.00E-03	-	1.43
1	9.60E-03	3.72	1.31
1	6.00E-03	4.18	1.35
2	9.60E-03	4.39	1.34
2	6.00E-03	4.47	1.36
3	9.60E-03	3.54	1.25
3	6.00E-03	3.99	1.3
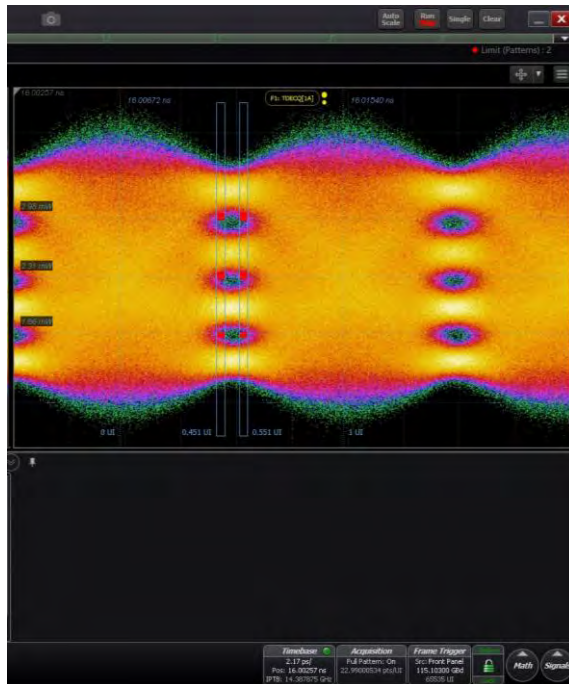
Lane0   Lane1   Lane2   Lane3

IS TDECQ TEST REPEATABILITY AT HIGH SER AN ISSUE?

TECQ testing in the DCA shows good repeatability with ~+/-0.15 dB variation

| CH	Iteration	SER	TECQ	Ceq
0	1	9.60E-03	4.95	1.41
0	2	9.60E-03	5.16	1.39
0	3	9.60E-03	4.99	1.44
0	4	9.60E-03	4.96	1.43
0	5	9.60E-03	5.05	1.43
1	1	9.60E-03	3.72	1.31
1	2	9.60E-03	3.51	1.31
1	3	9.60E-03	3.55	1.35
1	4	9.60E-03	3.45	1.29
1	5	9.60E-03	3.53	1.29

WATERFALL POST INNER FEC BER

All receivers show < 1e-6 BER the SRS spec limit of -1.2* dBm
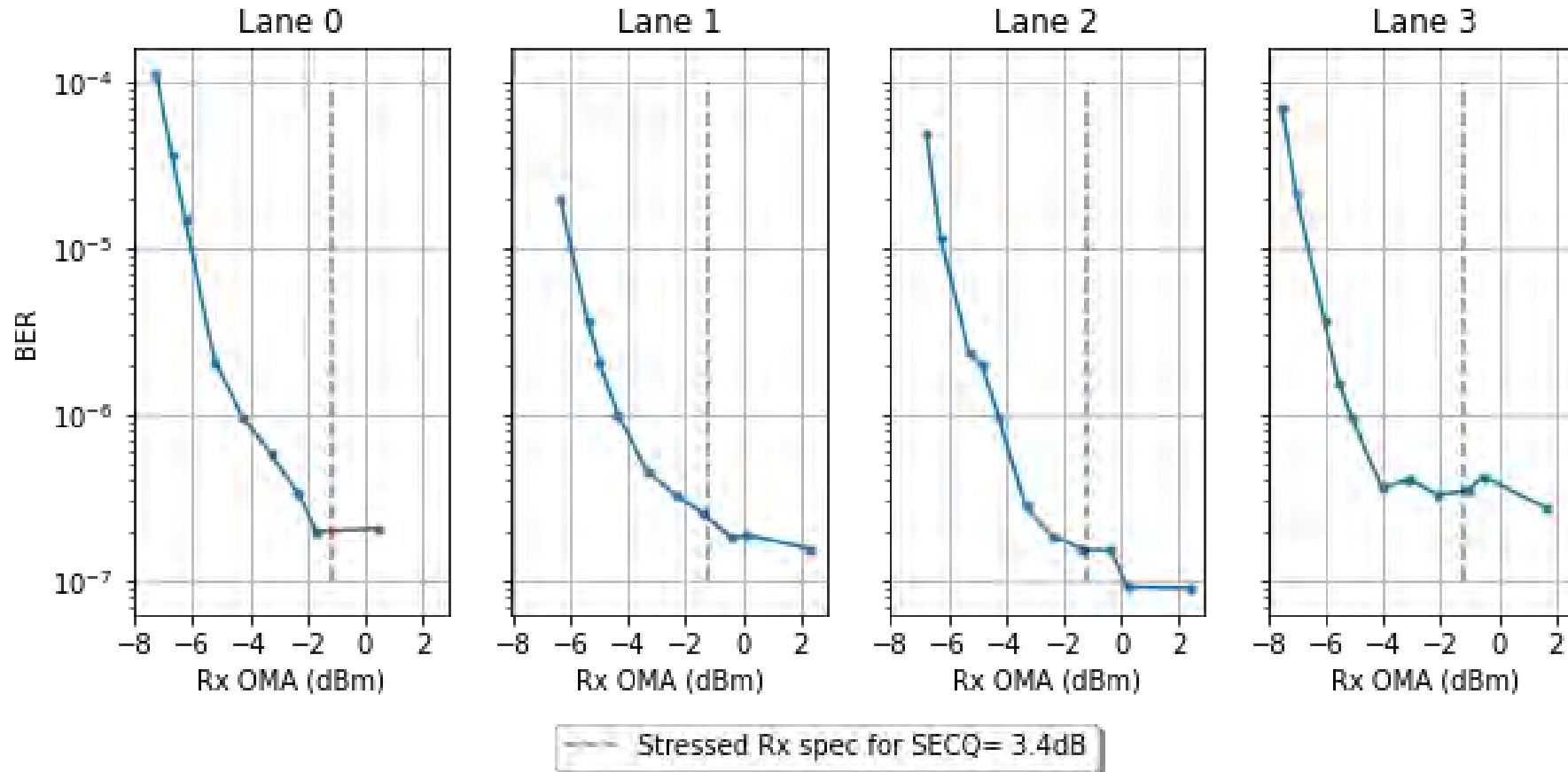
*assumes proposed SECQ/TECQmax= 3.4dB

POST FEC PERFORMANCE

Codeword error ratios measured 2dB margin to SRS spec
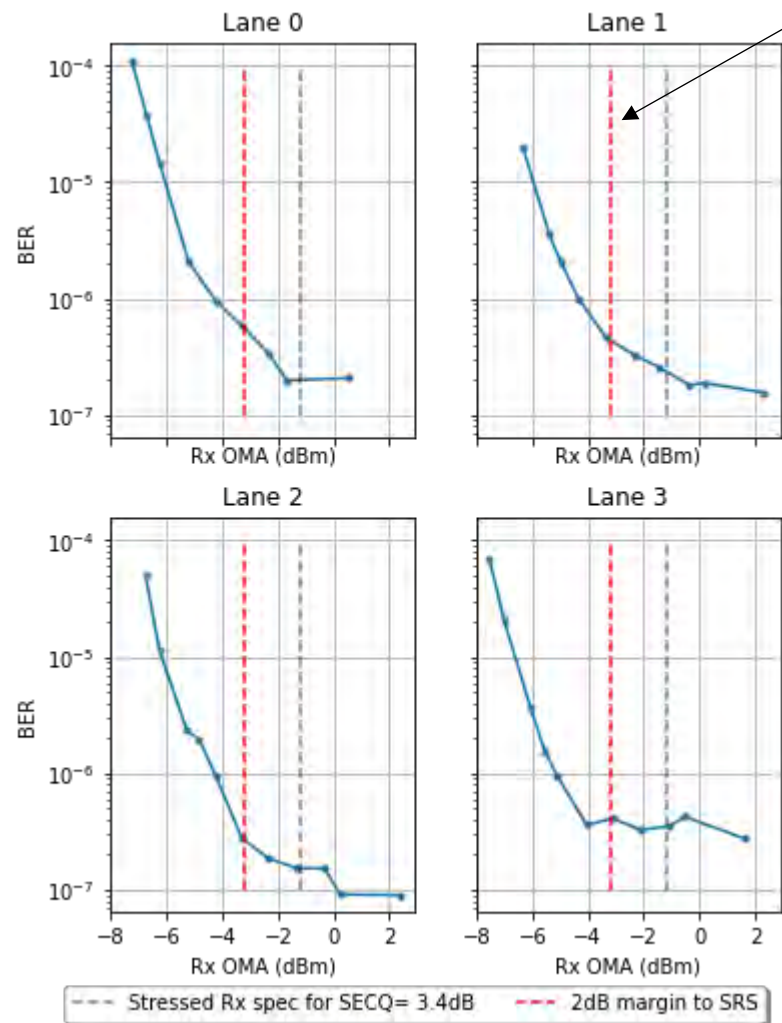
FEC Statistics — PHY # 1 RX — Table View | All Codewords Histogram | Correctable Codewo

Symbol Errors per Codeword

Symbol Errors per Codeword	Codeword Count	All Codewords Percentage
0	2,352,109,805	99.857399
1	2,942,914	0.124940
2	384,949	0.016343
3	30,280	0.001286
4	779	0.000033
5	23	0.000001
6	0	*
7	0	*
8	0	*
9	0	*
10	0	*
11	0	*
12	0	*
13	0	*
14	0	*
15	0	*
>=16	0	*

FEC Statistics — PHY # 2 RX — Table View | All Codewords Histogram | Correctable Codewo

Symbol Errors per Codeword

Symbol Errors per Codeword	Codeword Count	All Codewords Percentage
0	2,362,463,880	99.800461
1	4,292,011	0.181313
2	400,203	0.016906
3	30,535	0.001290
4	853	0.000036
5	18	0.000001
6	0	*
7	0	*
8	0	*
9	0	*
10	0	*
11	0	*
12	0	*
13	0	*
14	0	*
15	0	*
>=16	0	*

FEC Statistics — PHY # 3 RX — Table View | All Codewords Histogram | Correctable Codewo

Symbol Errors per Codeword

Symbol Errors per Codeword	Codeword Count	All Codewords Percentage
0	2,369,223,828	99.921135
1	1,664,010	0.070179
2	193,711	0.008170
3	11,902	0.000502
4	296	0.000012
5	3	0.000000
6	0	*
7	0	*
8	0	*
9	0	*
10	0	*
11	0	*
12	0	*
13	0	*
14	0	*
15	0	*
>=16	0	*

FEC Statistics — PHY # 4 RX — Table View | All Codewords Histogram | Correctable Codewo

Symbol Errors per Codeword

Symbol Errors per Codeword	Codeword Count	All Codewords Percentage
0	2,352,869,559	99.889656
1	2,311,949	0.098152
2	265,579	0.011275
3	21,223	0.000901
4	429	0.000018
5	11	0.000000
6	0	*
7	0	*
8	0	*
9	0	*
10	0	*
11	0	*
12	0	*
13	0	*
14	0	*
15	0	*
>=16	0	*

Legend: --- Stressed Rx spec for SECQ= 3.4dB   --- 2dB margin to SRS

All lanes show good codeword error ratio with margin

TDECQ WITH AND WITHOUT INNER FEC

COMPARING TECQ FOR SAME TX WITH & W/O INNER FEC

800G-FR4 module lane#3
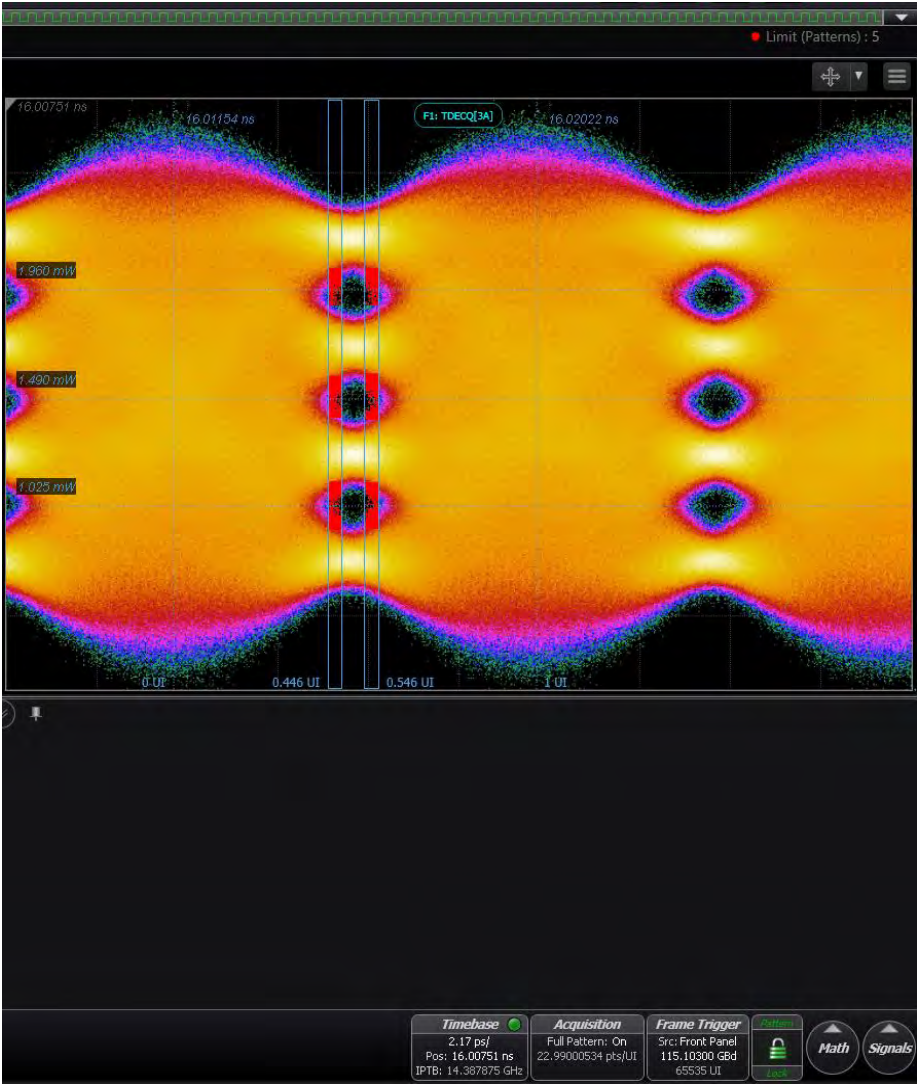
Different module than previous section to meet TECQ with and w/o inner FEC

Using same 4.8e-4 will make innerFEC spec significantly more challenging for the same Tx

SER of 6e-3 shows a similar TECQ value when operating at innerFEC baudrate compared to no innerFEC at 4.8e-4

Baudrate	SER	TECQ	Ceq
107GBd	4.8e-4	3.11	1.14
115GBd	4.8e-4	4.41	1.57
115GBd	6e-3	2.81	1.57
115GBd	9.6e-3	2.6	1.6

RX PERFORMANCE WITH AND WITHOUT INNER FEC. RX SENSITIVITY

Same 800G-FR4 module is tested with and without innerFEC in loopback configuration.
Reducing Rx OMA until lane#3 hits same BER (1e-5) on both configurations.
The same receiver, shows ~2dB better Rx sensitivity with the Transmitter when using innerFEC.
TECQ , which correlates with Rx sensitivity, should reflect that improvement.

preKP4 BER
without Inner FEC

Total FEC Errors / Ratio

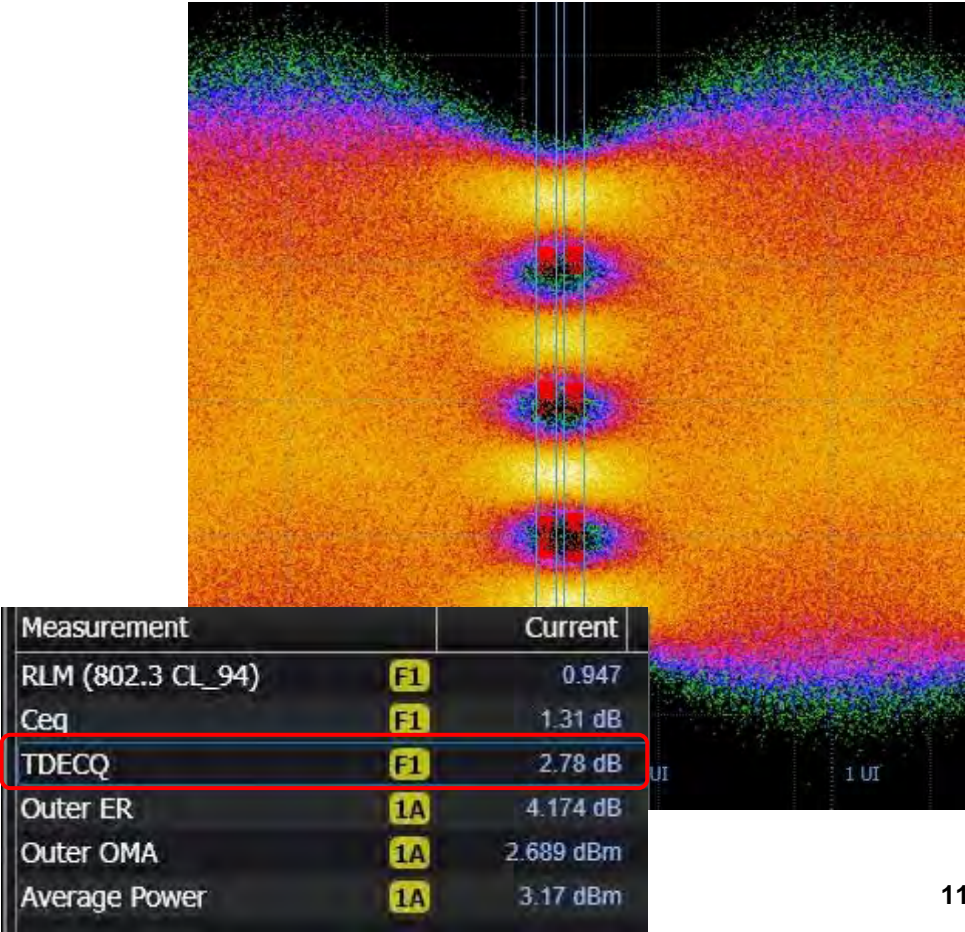| PHY#	Uncorr. CW Error	Corr. CW Error	Corr. Symbol Err.	Corr. Bit Error
1	*	1.469E-2	3.534E-5	3.561E-6
2	*	3.490E-3	8.405E-6	8.435E-7
3	*	2.896E-3	7.210E-6	7.253E-7
4	*	6.486E-2	1.625E-4	1.634E-5

Lane#3 Rx OMA= -3.2 dBm

preKP4 BER
with Inner FEC

Total FEC Errors / Ratio

PHY#	Uncorr. CW Error	Corr. CW Error	Corr. Symbol Err.	Corr. Bit Error
1	*	1.413E-3	3.411E-6	3.590E-7
2	*	5.100E-4	1.269E-6	1.390E-7
3	*	1.247E-4	2.953E-7	3.353E-8
4	*	5.091E-2	1.286E-4	1.522E-5

Lane#3 Rx OMA= -5.1 dBm

FUTURE TDECQ DISCUSSION: HIDDEN MARGIN OF TDECQ, HISTOGRAM SPACING

TDECQ Reference receiver ONLY considers the outlier samples of the eye.
Therefore, histogram spacing has a very large impact on TDECQ value.
Future work: Consider using not only the outliers or reduce spacing of the windows

Measurement		Current
RLM (802.3 CL_94)	F1	0.949
Ceq	F1	1.31 dB
TDECQ	F1	3.72 dB
Outer ER	1A	4.158 dB
Outer OMA	1A	2.670 dBm
Average Power	1A	3.18 dBm

Measurement		Current
RLM (802.3 CL_94)	F1	0.947
Ceq	F1	1.31 dB
TDECQ	F1	2.78 dB
Outer ER	1A	4.174 dB
Outer OMA	1A	2.689 dBm
Average Power	1A	3.17 dBm
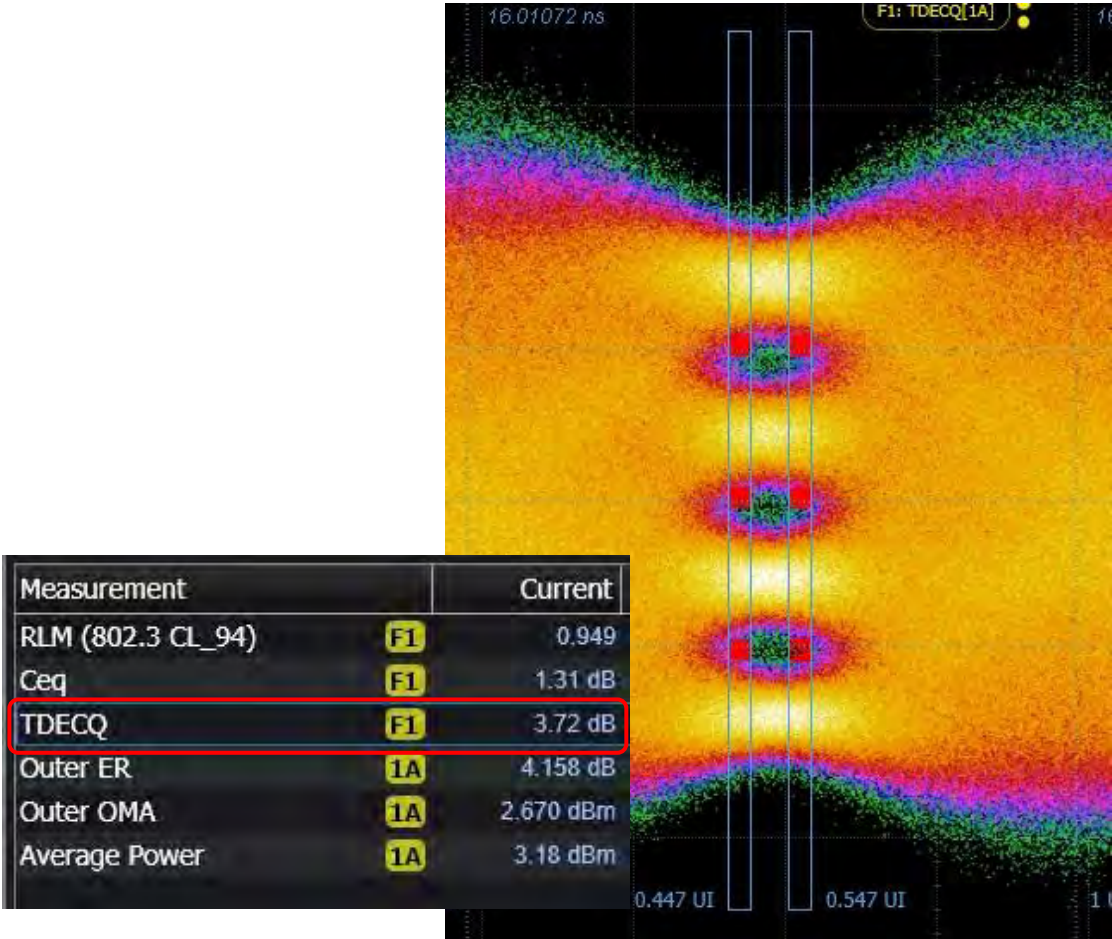
CONCLUSION

- **Proposed specs of TECQ = 3.4dB shows no problem for receivers when using innerFEC**
- **DCA testing showed good repeatability**
- **PostFEC performance justifies the proposed number and SER target compared to FECo PMDs**