

# **100GBASE-FR2, -LR2 Baseline Proposal**

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802.3cd 50 Gb/s, 100 Gb/s, and 200 Gb/s Ethernet  
Task Force

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Chris Cole

# Contributors & Supporters

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## Contributors & Supporters:

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## Supporters:

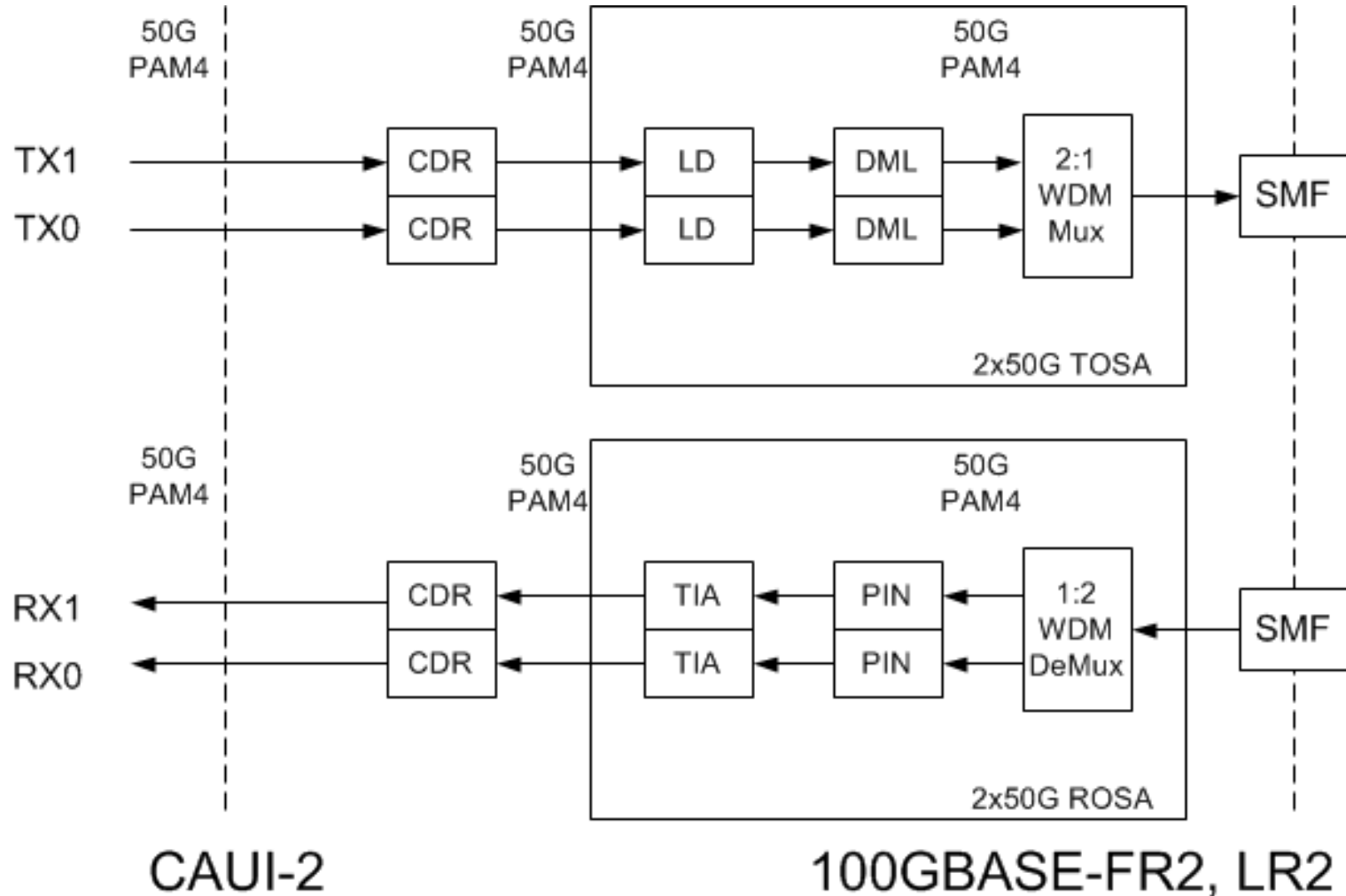
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# Background

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- 50G PAM4 WDM technology was identified as the next technology step for SMF PMDs and 8x50G PAM4 WDM was proposed for 400 Gb/s Ethernet in X. Song, et. al, "[Considerations on Options for 400GE Optical Interfaces](#)," 400 Gb/s Ethernet SG, May 2013.
- 2x50G PAM4 WDM (100G) per fiber was identified as an alternative for 400G PSM4 PMD in C. Cole, "[400Gb/s 500m PMD Alternatives](#)," 400Gb/s Ethernet TF, May 2014.
- Rationale and specs for 2x50G PAM4 CWDM2 100 Gb/s 2km & 10km SMF PMDs were presented in: C. Cole, "[100 Gb/s SMF PMD Specifications and Objectives Proposal](#)," 50, Next Gen 100 & 200 Gb/s Ethernet SG, Jan. 2016
- 4x50G PAM4 WDM 200 Gb/s 2km & 10km SMF PMDs were presented in: C. Cole, "[200GBASE-FR4 & -LR4 Baseline Proposal](#)," 400Gb/s Ethernet TF, May 2016

# 100BASE-FR2, -LR2 Example Block Diagram



# Transmit Characteristics

Description (PAM4)	100GBASE-FR2	100GBASE-LR2	Unit
Reach	2	10	km
Signaling Rate, each lane	26.5625	26.5625	GBd
Operating BER	2.4E-04	2.4E-04	
Average power, each lane (max)	4.7	5.3	dBm
OMA <sub>outer</sub> , each lane (max)	4.5	5.1	dBm
OMA <sub>outer</sub> , each lane (min)	-1.2	-0.4	dBm
Diff. in launch power between any two lanes (OMA <sub>outer</sub> ) (max)	4	4	dB
Launch Power in OMA <sub>outer</sub> minus TDECQ, each lane (min)	-2.2	-1.4	dBm
TDECQ, each lane (max)	2.4	2.5	dB
Extinction ratio (ER) (min)	4.5	4.5	dB
RIN OMA (max)	-136	-136	dB/Hz

# Receive Characteristics

Description (PAM4)	100GBASE-FR2	100GBASE-LR2	Unit
Signaling Rate, each lane	26.5625	26.5625	GBd
Operating BER	2.4E-04	2.4E-04	
Receiver reflectance (max)	-26	-26	dB
Receiver Sensitivity ( $OMA_{outer}$ ), each lane (max)	-6.5	-8.2	dBm
Difference in receive power between any two lanes ( $OMA_{outer}$ ) (max)	4.1	4.6	dB
Stressed receiver sensitivity ( $OMA_{outer}$ ), each lane (max)	follow 200G FR4	follow 200G LR4	dBm
Conditions of stressed receiver sensitivity test	follow 200G FR4	follow 200G LR4	

# Illustrative Link Power Budgets

Description (PAM4)	100GBASE-FR2	100GBASE-LR2	Unit
Power Budget (for maximum TDECQ)	6.7	9.3	dB
Operating Distance	2	10	km
Channel Insertion Loss	4	6.3	dB
Maximum Discrete Reflectance	-35	-35	dB
Allocation for Penalties (for maximum TDECQ)	2.7	3	dB
Modulation Penalty	4.8	4.8	dB
MPI Penalty	0.3	0.5	dB

# WDM Lane Assignments

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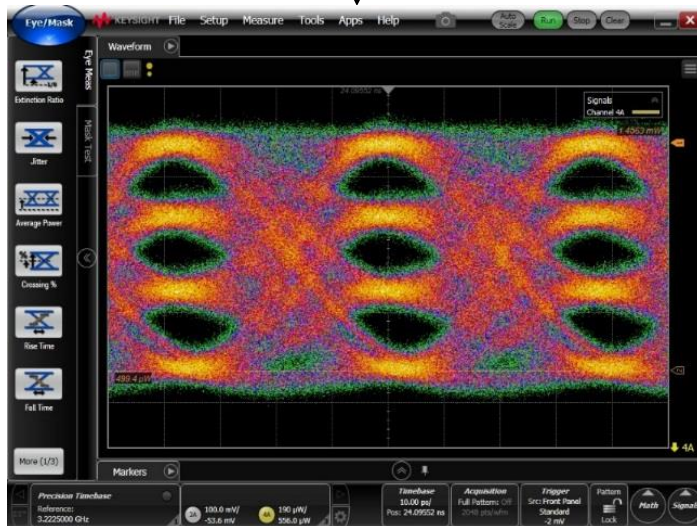
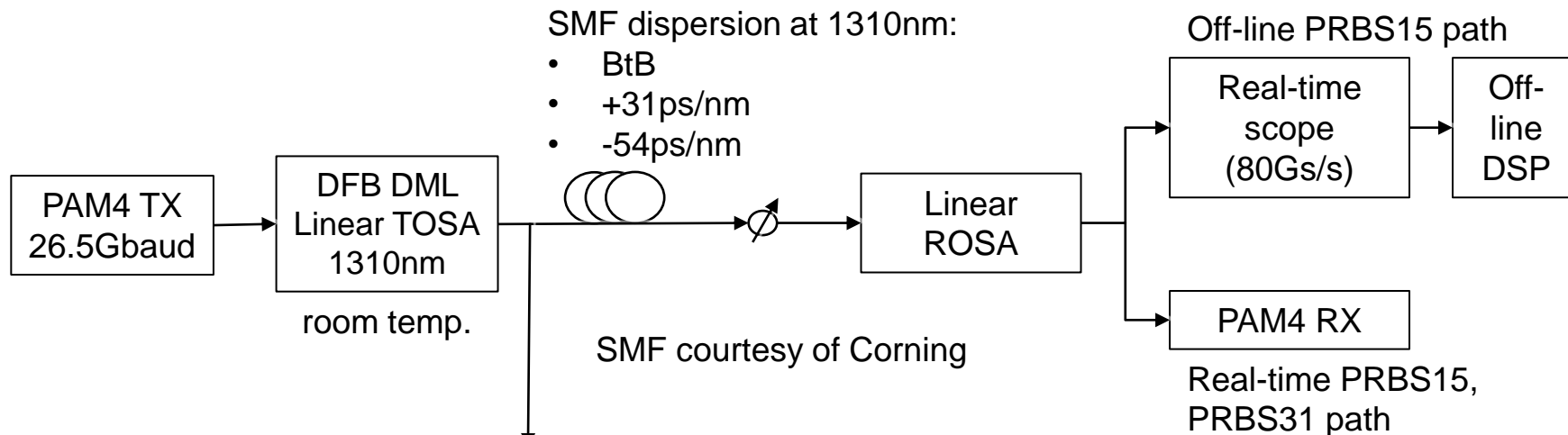
<b>100GBASE WDM Lane</b>	<b>Center Wavelength nm</b>	<b>Wavelength Range nm</b>
L0	1271	1264.5 to 1277.5
L1	1311	1304.5 to 1317.5



# Optical Margin

Description (PAM4)	100GBASE-FR2	100GBASE-LR2	Unit
Receiver Sensitivity ( $OMA_{outer}$ ), each lane, pre-DeMux (max)	-6.5	-8.2	dBm
DeMux Loss	1	1	dB
Cross-talk penalty	0.2	0.2	dB
Modulation Penalty	4.8	4.8	dB
Receiver Sensitivity ( $OMA_{inner}$ ), each lane, post-DeMux (max)	-12.5	-14.2	dBm
Receiver Sensitivity ( $OMA_{inner}$ ) single lane (typical measured)	-17	-17	dBm
Optical Margin	4.5	2.8	dB

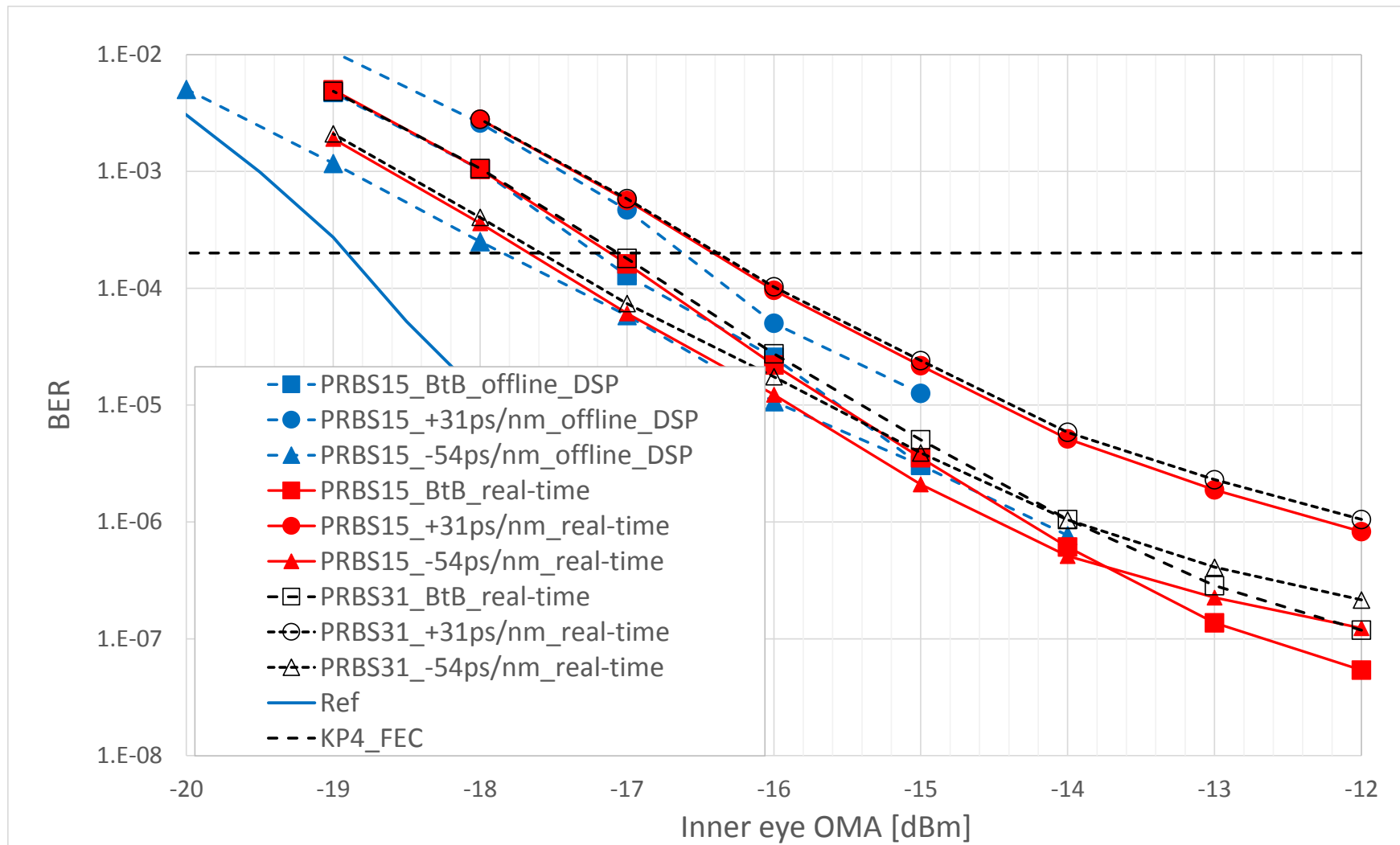
# Supporting Data Measurement Set-up



Data presented at the May 2016 IEEE 802.3 Interim Meeting in Whistler, Canada:

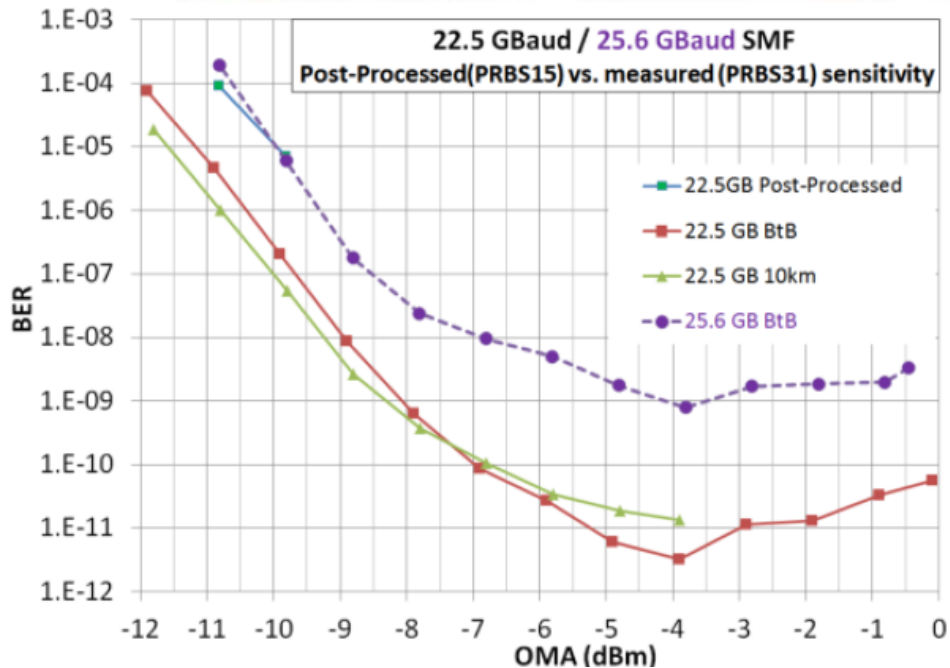
[http://www.ieee802.org/3/bs/public/16\\_05/cole\\_3bs\\_01a\\_0516.pdf](http://www.ieee802.org/3/bs/public/16_05/cole_3bs_01a_0516.pdf)

# Off-line & Real-time DSP Supporting Data

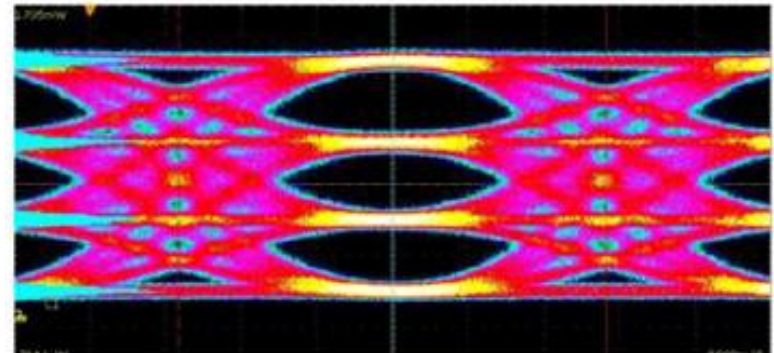


# Supporting Data & Demonstration

OFC 2015: M. Mazzini, M. Traverso, et. al, "25GBaud PAM-4 Error Free Transmission over both Single Mode Fiber and Multimode Fiber in a QSFP form factor based on Silicon Photonics," Los Angeles, CA, March, 2015.



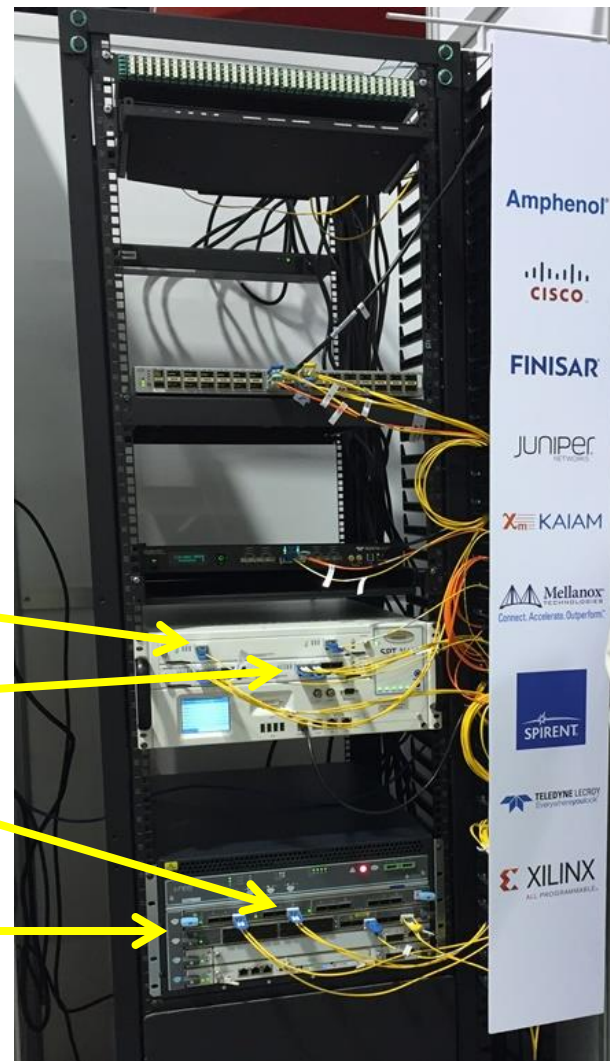
SNR=28.8 dB, ER=11 dB



# Supporting Data Demonstration Set-up

## OFC 2016 Ethernet Alliance Booth

- March 21 – 24, 2016
- 100Gb/s Ethernet live-traffic demo
- Standard QSFP28 KR4 FEC ports
- Error-free operation each of 4 days
- Spirent Tester
- QSFP28 modules with 4:2 Mux and “LR2” TOSA & ROSA (2x 50G PAM4 CWDM2)
- Juniper Switch



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Thank you

