socionext™
for better quality of experience

Technical Feasibility of 100Gb/s per lane SerDes for Backplanes

January, 2018

Hiroki Miyaoka, Toshiaki Sakai
Socionext Inc.

Agenda

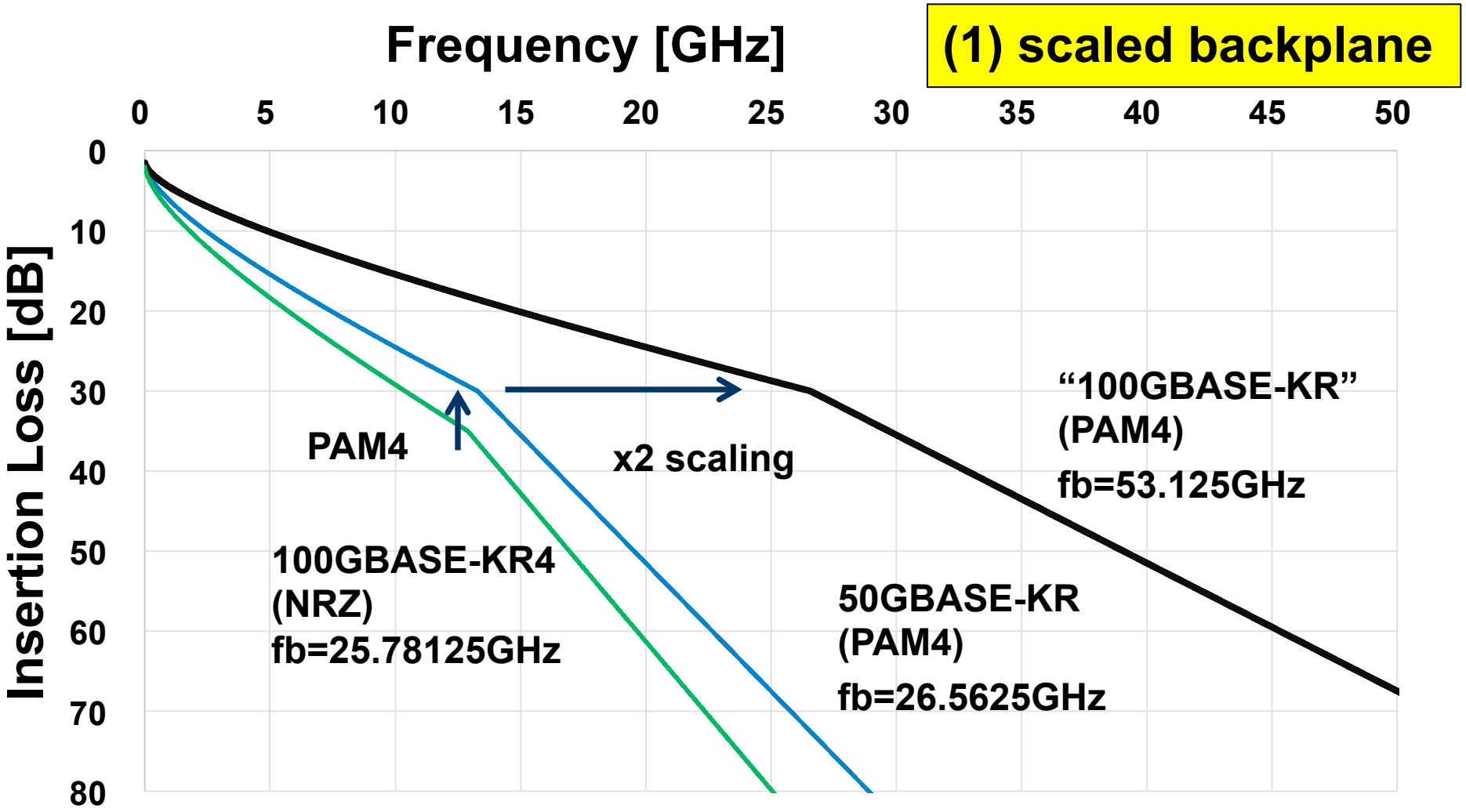
1. Overview
2. Channel Simulation
   - 2.1 Scaled PCB Backplane
   - 2.2 Cabled Backplane
   - 2.3 PCB (Tachyon) Backplane
3. Conclusion

1. Overview

- **To see the feasibility of 100Gb/s per lane electrical backplane transmission by simulation.**
- **PAM4 modulation is assumed.**
- **3 types of backplane model were studied.**

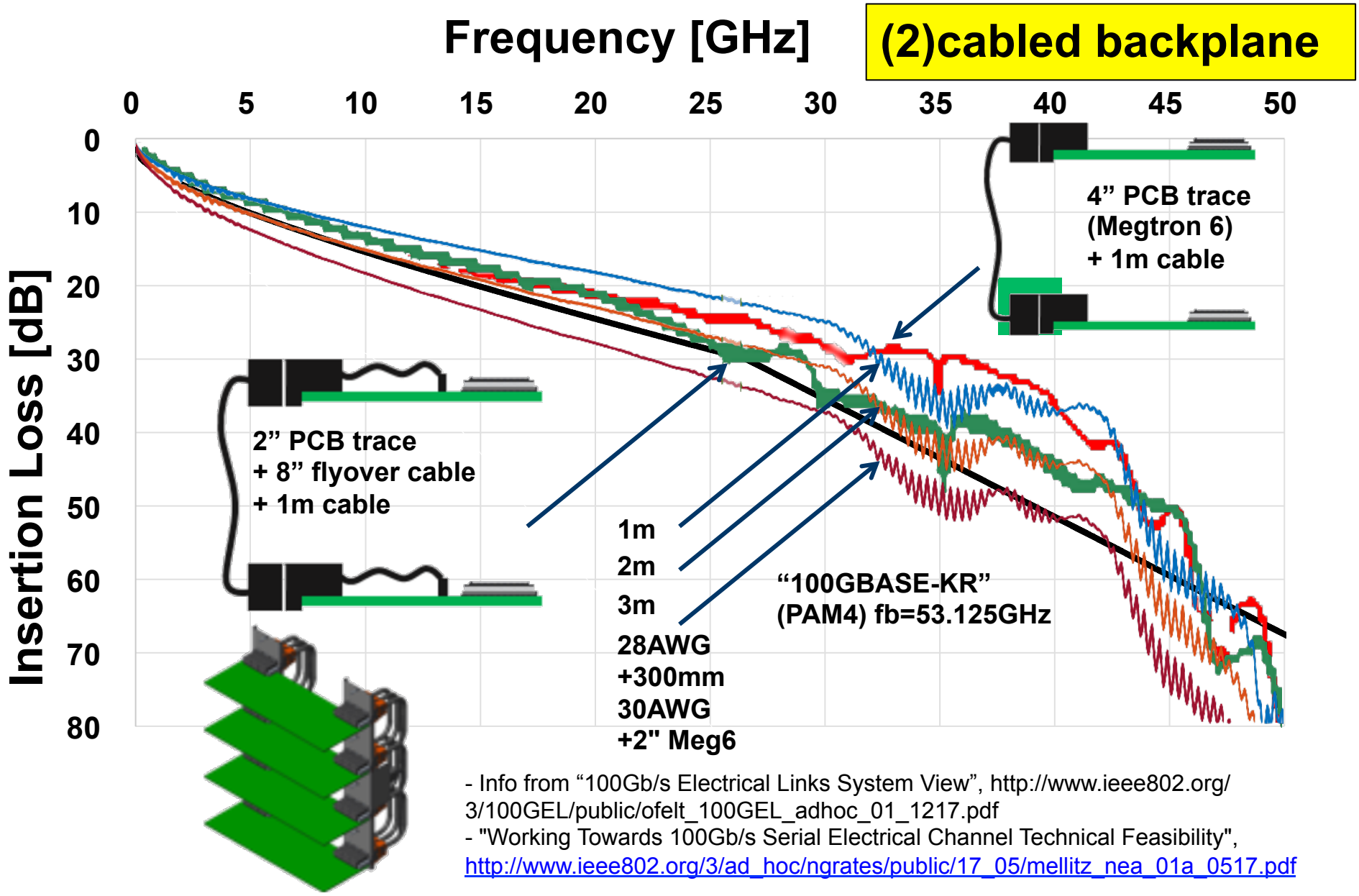
type	by	IL (no PKG)	reference
(1) scaled	TE (original)	34.3dB @28GHz	802.3cd
(2) cabled	Samtec	29.6dB (2m) @28GHz	**IEEE802.3 NEA**
(3) PCB (Tachyon)	Samtec	28.4dB (13") @29GHz	100GEL SG

1.1 channel insertion loss target (1/4)



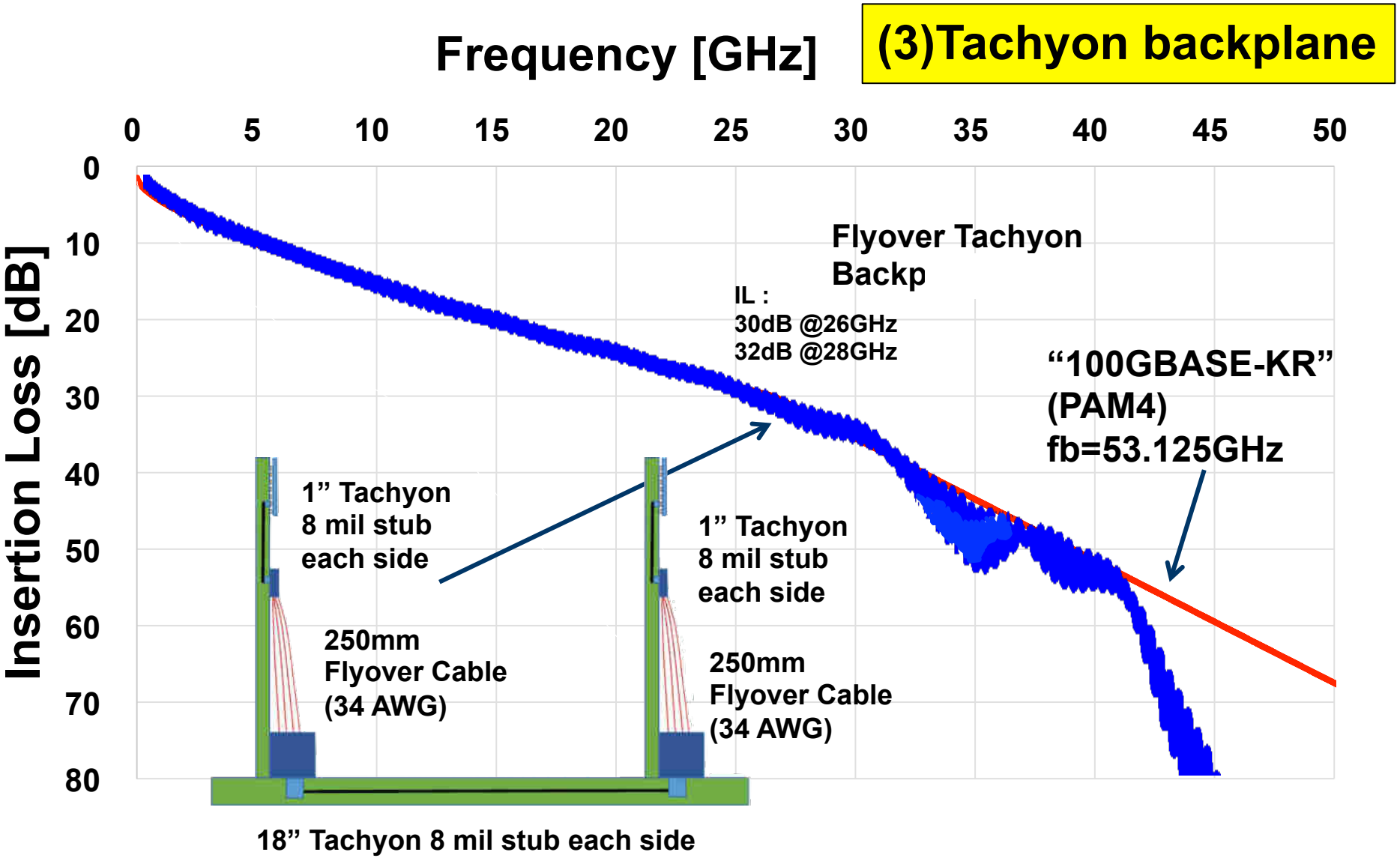
If PAM4 modulation is selected, 30dB insertion loss at Nyquist frequency (26.5625GHz) is an appropriate target.

1.1 channel insertion loss target (2/4)



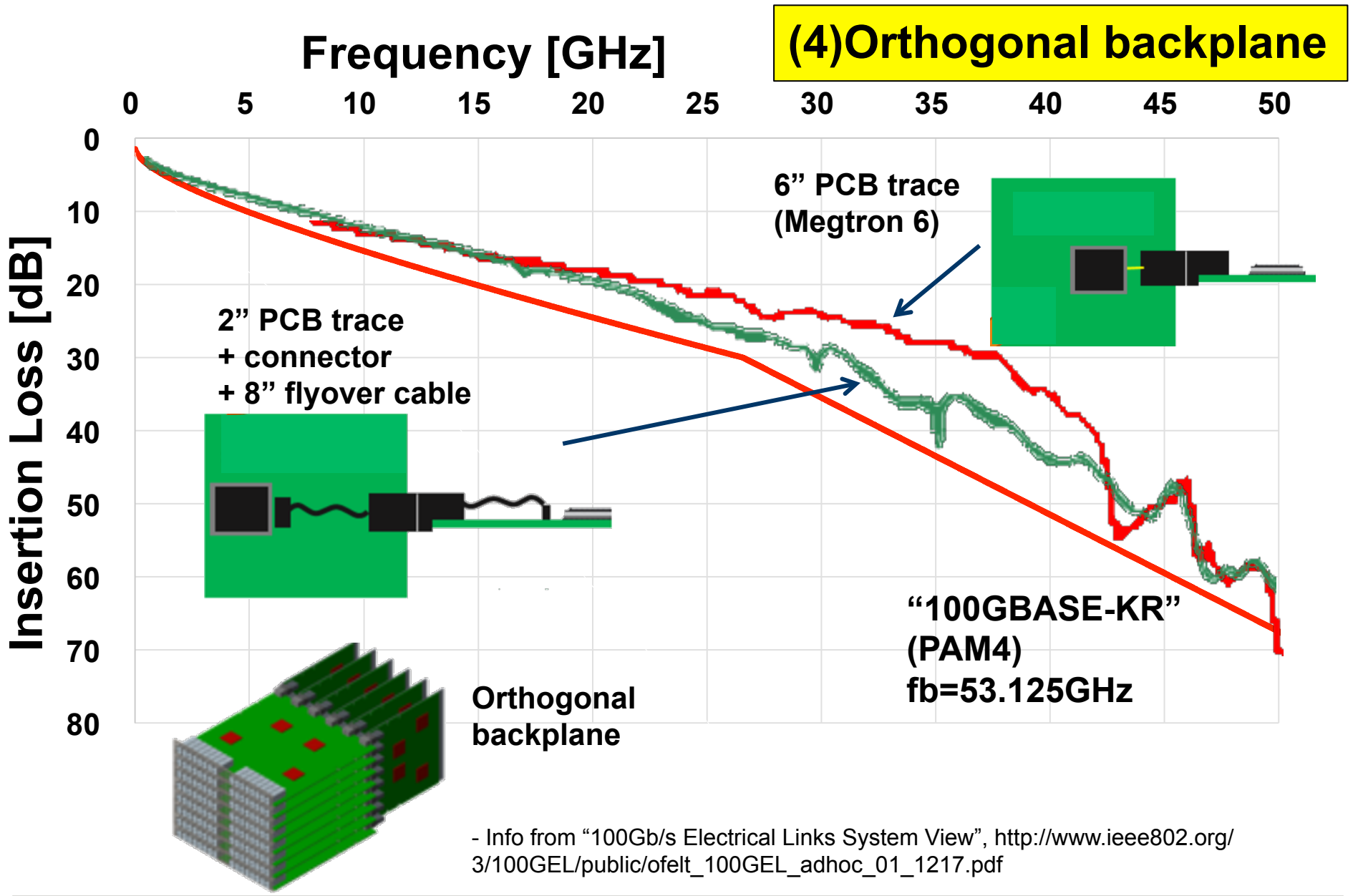
- Info from “100Gb/s Electrical Links System View”, http://www.ieee802.org/3/100GEL/public/ofelt_100GEL_adhoc_01_1217.pdf
- "Working Towards 100Gb/s Serial Electrical Channel Technical Feasibility", http://www.ieee802.org/3/ad_hoc/ngrates/public/17_05/mellitz_nea_01a_0517.pdf

1.1 channel insertion loss target (3/4)



- Info from "Initial Backplane Models for IEEE 802.3 100Gb/s per Lane Electrical Study", http://www.ieee802.org/3/100GEL/public/tools/backplane/mellitz_100GEL_adhoc_01_010318.pdf

1.1 channel insertion loss target (4/4)

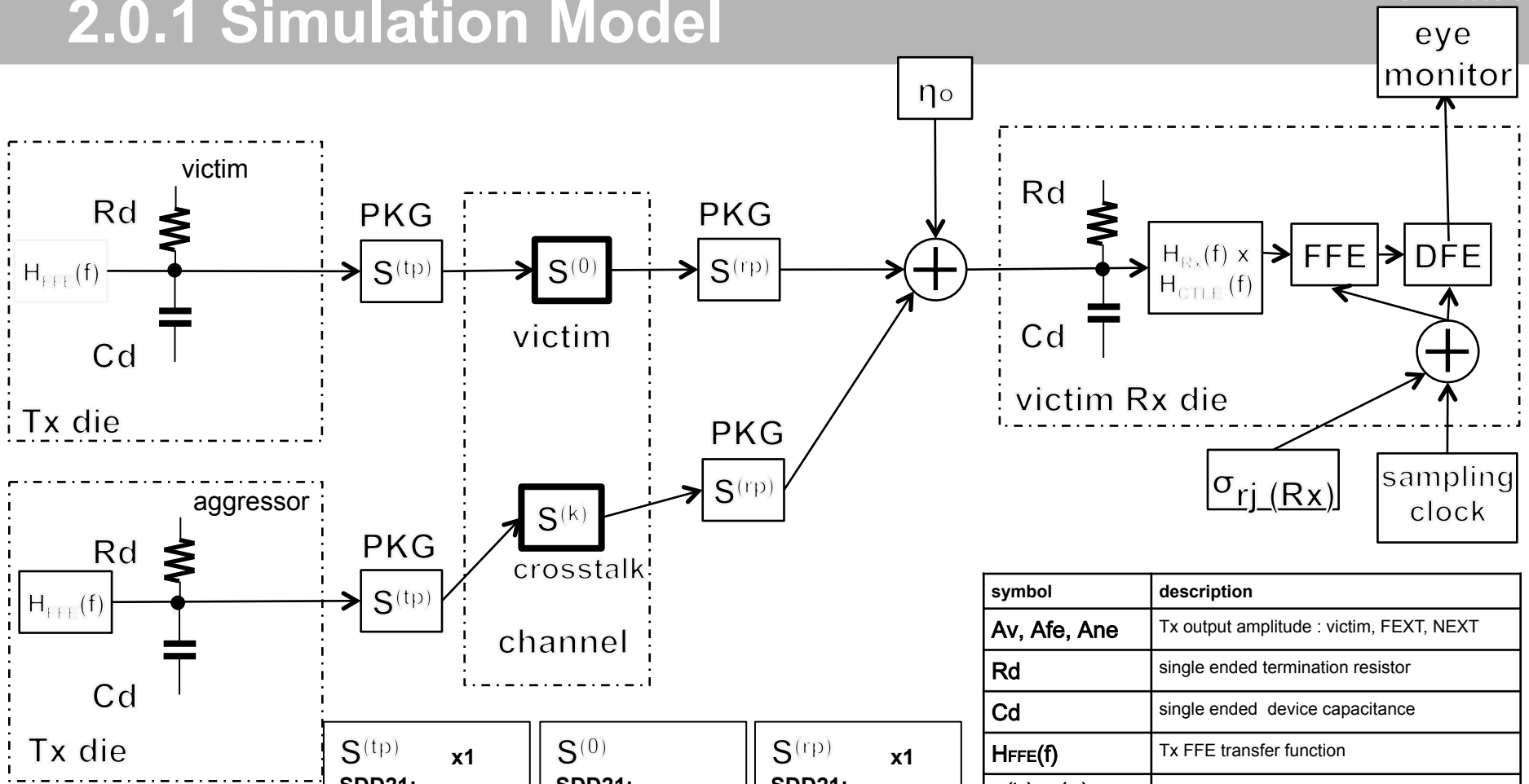


- Info from “100Gb/s Electrical Links System View”, http://www.ieee802.org/3/100GEL/public/ofelt_100GEL_adhoc_01_1217.pdf

socionext™
for better quality of experience

2. Channel simulation

2.0.1 Simulation Model



$S^{(tp)}$ x1	$S^{(0)}$	$S^{(rp)}$ x1
SDD21: -2.74dB @14GHz -4.81dB @28GHz SDD22: -26.8dB @14GHz -12.4dB @28GHz	SDD21: -34.3dB @28GHz SDD22: -16.2dB @28GHz	SDD21: -2.76dB @14GHz -4.81dB @28GHz SDD11: -22.0dB @14GHz -15.5dB @28GHz
measured 27mm-trace	x2 frequency scaled backplane	measured 27mm-trace

SDD21 (27mm, PKG, die-to-die) : 43.9dB @28GHz

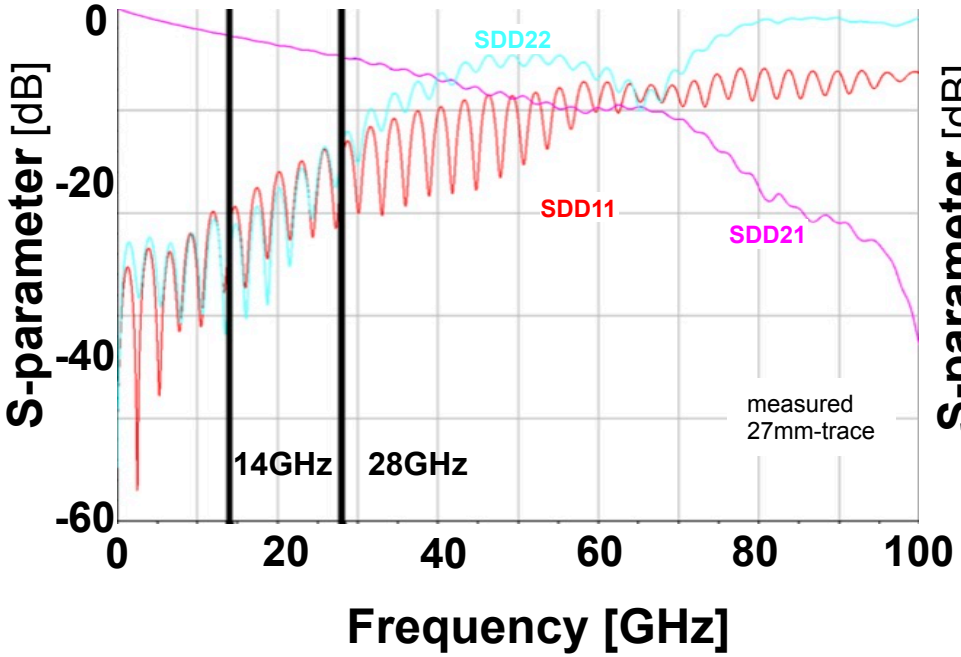
symbol	description
Av, Afe, Ane	Tx output amplitude : victim, FEXT, NEXT
Rd	single ended termination resistor
Cd	single ended device capacitance
$H_{FFE}(f)$	Tx FFE transfer function
$S^{(tp)}$, $S^{(rp)}$	PKG model Tx/Rx
$S^{(0)}$	channel under test
$H_{Rx}(f)$	Rx noise filter
$H_{CTLE}(f)$	Rx CTLE transfer function
η_0	one-sided noise spec
Add	Dual-Dirac jitter, peak to peak Tx : before FFE Rx : considered as eye margin
σrj	random jitter, RMS Tx : before FFE Rx : considered as eye margin

2.0.2. PKG Characteristics

In this simulation, measured PKG characteristics are used.

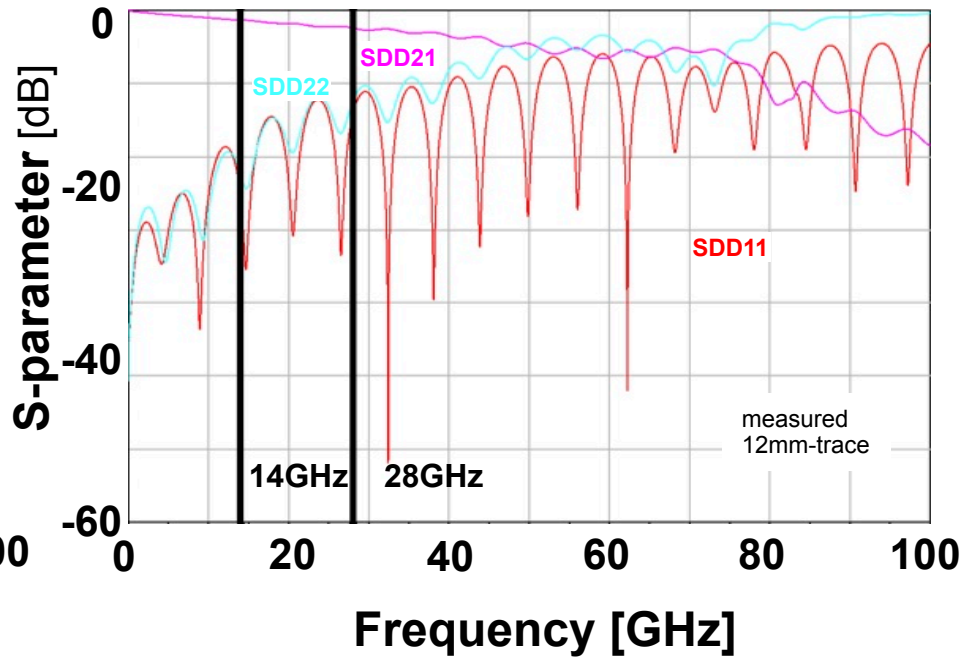
27mm PKG (BGA)

SDD21: -2.76dB @14GHz , -4.81dB @28GHz
SDD22: -26.8dB @14GHz, -12.4dB @28GHz



12mm PKG (BGA)

SDD21: -1.29dB @14GHz, -2.40dB @28GHz
SDD22: -22.3dB @14GHz, -12.5dB @28GHz



note : No xtalk is considered in PKG model.

2.0.3 Simulation Set Up

- ✓ Static Channel Model Simulation
- ✓ Behavior model using MatLab
- ✓ PAM4 around 53Gbd (106Gbps),
- ✓ Jitter, noise and crosstalk are considered.
- ✓ Tx jitter, (DJ, RJ) included. : Basically RJ is the same as 50G-PAM4 (conservative).
- ✓ Rx/CDR jitter (DJ, RJ) are considered as eye opening margin.
- ✓ crosstalk noise in channel S-parameter
- ✓ device noise as eta0 : The same as 50G-PAM (conservative)
- ✓ device capacitance is the same as 50G-PAM4. (conservative)
- ✓ Impedance are nominal : 50-ohm single ended

- ✓ T-spaced FFE
  - ✓ Rx FFE parameters are set to minimize ISI.
- ✓ CTLE coefficients are optimized for each channel. (See back up slides.) Band width is the same as 50G-PAM4. (conservative)
- ✓ PKG model is based on current design (not a COM PKG model) for 50G-PAM4. (conservative)

item	value	unit
pattern	PRBS13Q	
DJ_Tx	60	mUI
RJ_Tx	10	mUI
EOJ_Tx	0	UI
SNR_Tx	32.5	dB
Rt_Tx	50	ohm
Cd_Tx	160	fF
Av	0.8	Vppd
AVx	1.2	Vppd
BER	1.0E-4	
eta0	1.64E-08	V^2/GHz
DJ_Rx	0	UI
Rt_Rx	50	ohm

socionext™
for better quality of experience

2. Channel simulation

2.1 scaled PCB backplane

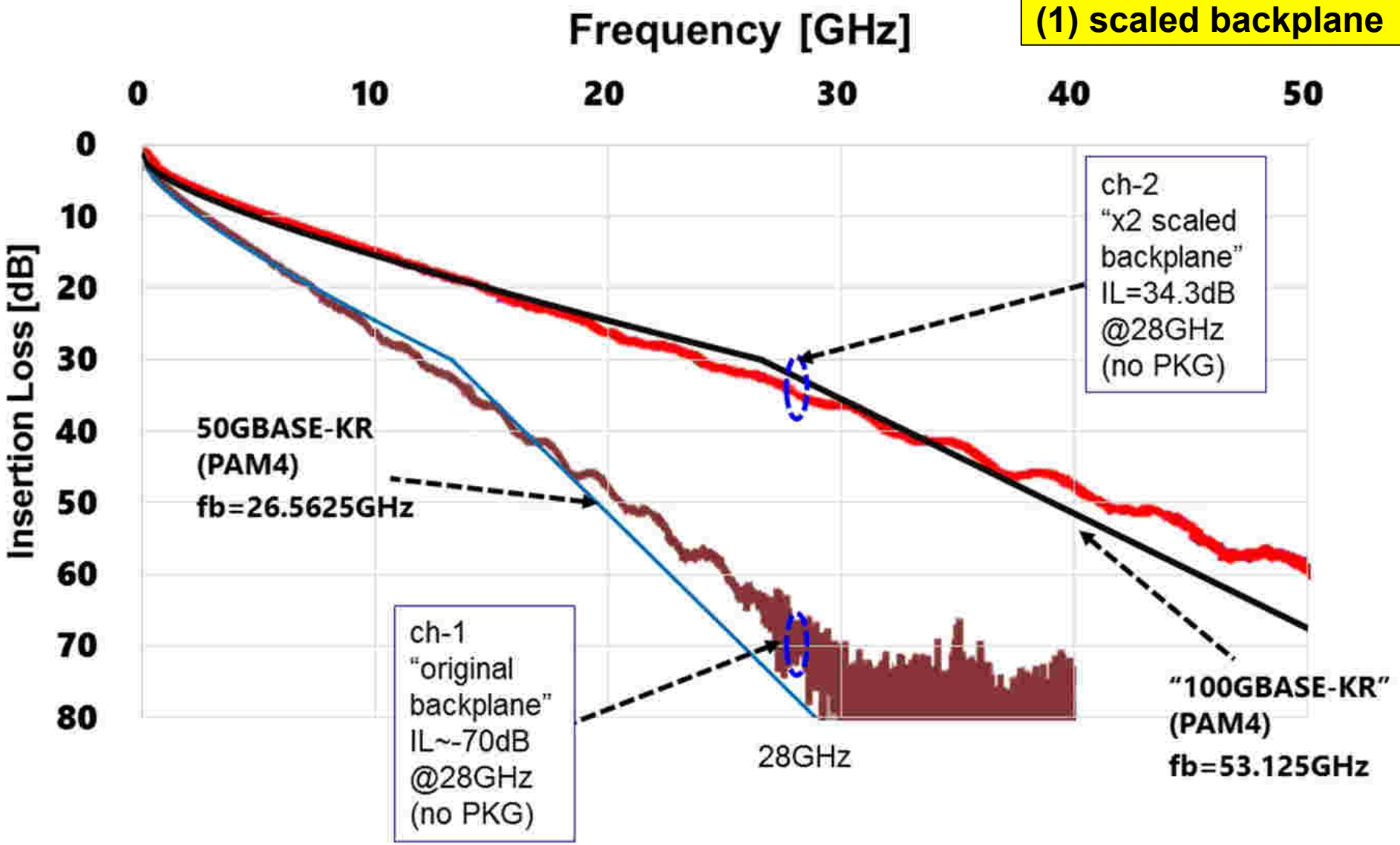
2.2 cabled backplane

2.3 PCB (Tachyon) backplane

type	by	IL (no PKG)	reference
(1) scaled	TE (original)	34.3dB @28GHz	802.3cd
(2) cabled	Samtec	29.6dB (2m) @28GHz	**IEEE802.3 NEA**
(3) PCB (Tachyon)	Samtec	28.4dB (13") @29GHz	100GEL SG

2.1.1 Channel Characteristics

(1) scaled backplane



Based on
http://www.ieee802.org/3/cd/public/channel/Reference_document_for_TE_Connectivity_Backplane_S-Parameter_Channels_07_28_16.pdf
http://www.ieee802.org/3/cd/public/channel/TEC_STRADAWhisper40in_Meg6_Channel_IEEE802_3_cd_Cu_07282016.zip

2.1.2 Simulation Summary

(1) scaled backplane

item			unit	#A1	#A2	#A3	#A4	#A5	#A6	#A7	#A8	#A9	#A10	#A11	#A12
baud rate			Gbd	28	56										
channel		type		ch-1	ch-2										
Tx	FFE	tap/pre		4/2	4/2						9/5	1/0 (no FFE)			
	RJrms		mUI	5	5	10			5	10					
	SNR		dB	32.5											
Tx/Rx	PKG	freq		x1	x2	x1		x2	x1						
Rx	CTLE	freq		x1	x1	x1/2	x1	x1/2							
	fr	x fb	GHz	x3/4	x3/4	x3/8	x3/4	x3/8							
	FFE	tap/pre		1/0	1/0 (no FFE)							9/5	54/5	32/5	54/5
	DFE	tap		12	12					24			1		0
	RJrms		mUI	5	5	10			5	10					
eye	width EW4	upp	mUI	119	17	0	0	68	1	8	0	112	83	82	0
		mid		179	64	31	0	129	40	56	0	160	115	115	0
		low		119	17	0	0	69	0	7	0	112	84	82	0
	height EH4	upp	mV	28	3	0	0	16	0	1	0	23	34	33	0
		mid		31	5	1	0	20	2	4	0	25	36	36	0
		low		29	3	0	0	16	0	1	0	23	34	34	0

criteria : EW4≥100mUI, EH4≥20mV

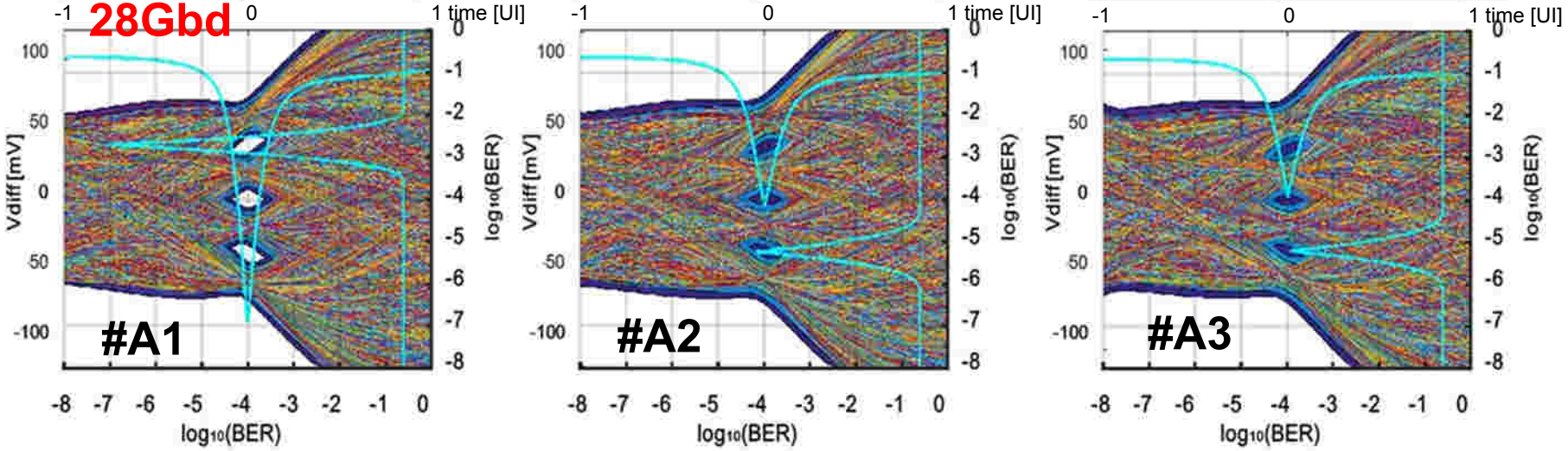
2.1.3 Simulation Result (#A1~#A6)

(1) scaled backplane

#A1: 28Gbd operation with “modified original” channel. (2-NEXT/2-FEXT only, to meet “COM” criteria 3.0dB.)
- Original PKG characteristics

#A1 -> #A2 : At 56GBd, even with improved channel, PKG, fr, CTLE and RJ, eye is almost closed.

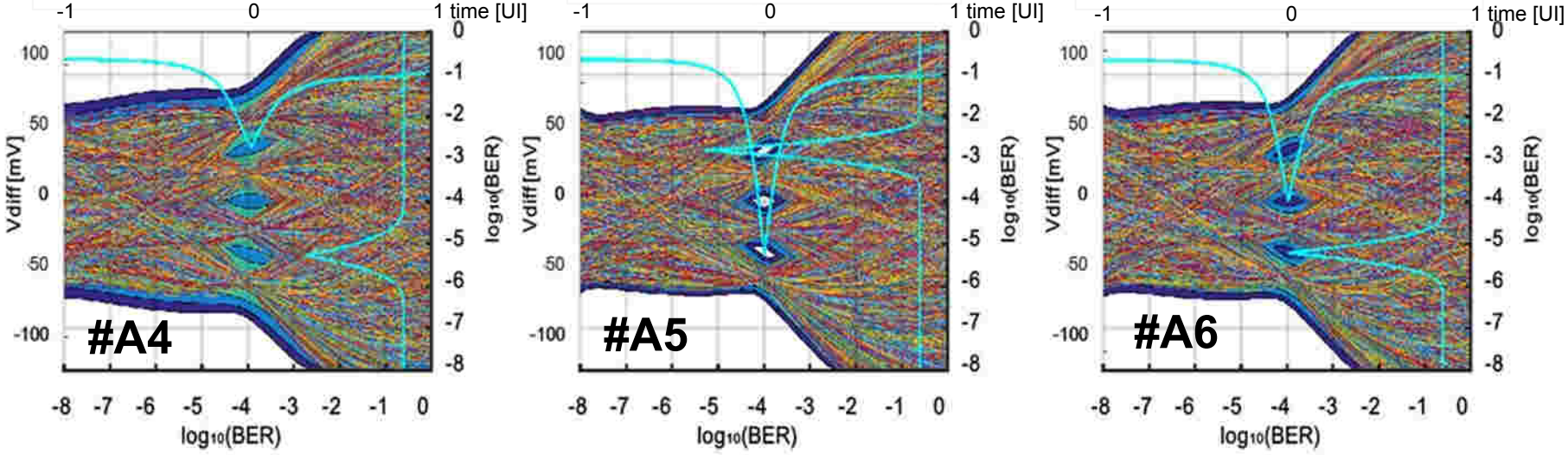
#A2->#A3 : With more realistic assumptions, eye is still closed.



#A3 -> #A4 : Higher fr and CTLE BW do not help.

#A3 -> #A5 : Improvement of PKG characteristics helps a lot, if it is feasible.

#A3 -> #A6 : Reduction of RJ helps some, but not significant.

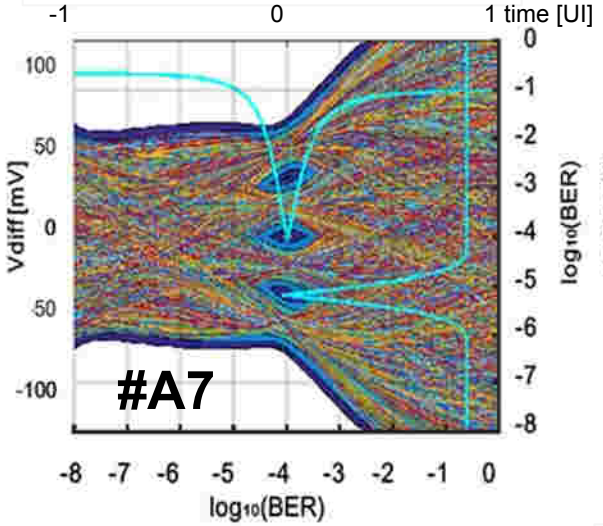


socionext

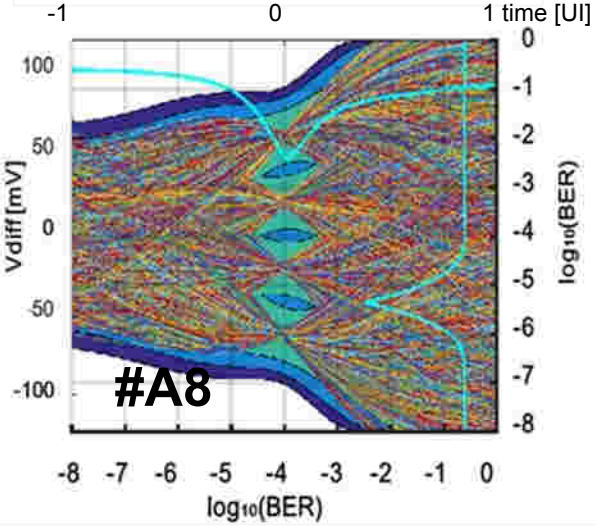
2.1.3 Simulation Result (#A7~#A12)

(1) scaled backplane

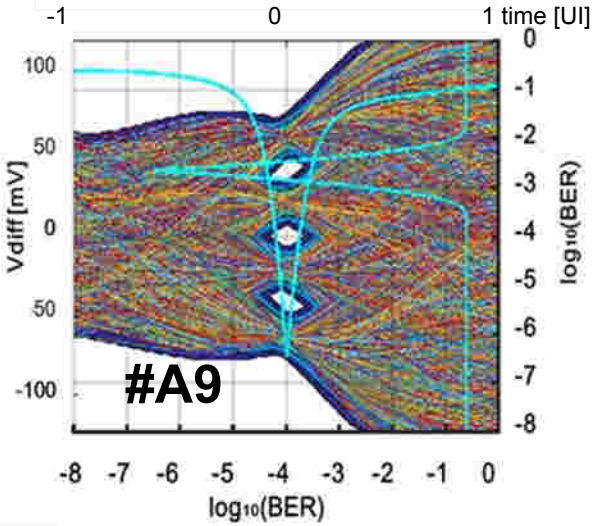
#A3 -> #A7 : 24-tap DFE helps some, but not significant.



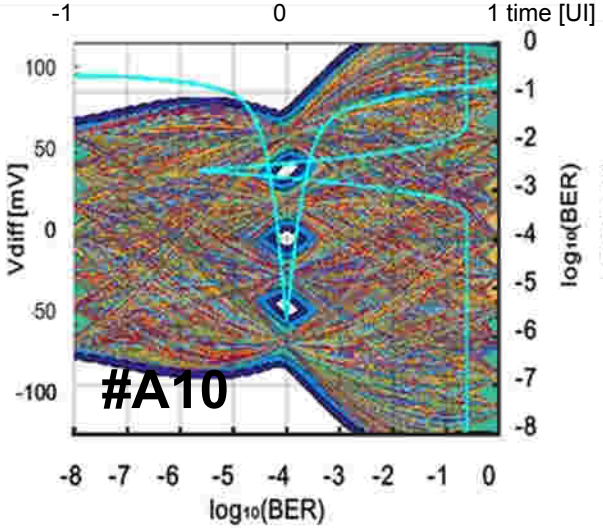
#A7 -> #A8 : Tx FFE 9-tap, 5-pre does not help at all. Reduction of Tx swing causes worse result.



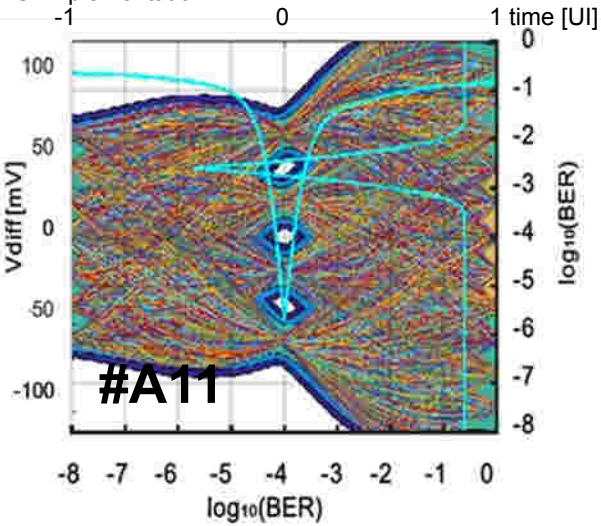
#A8 -> #A9 : No Tx FFE (1/0) and more Rx FFE (9/5) help to open eye, significantly.



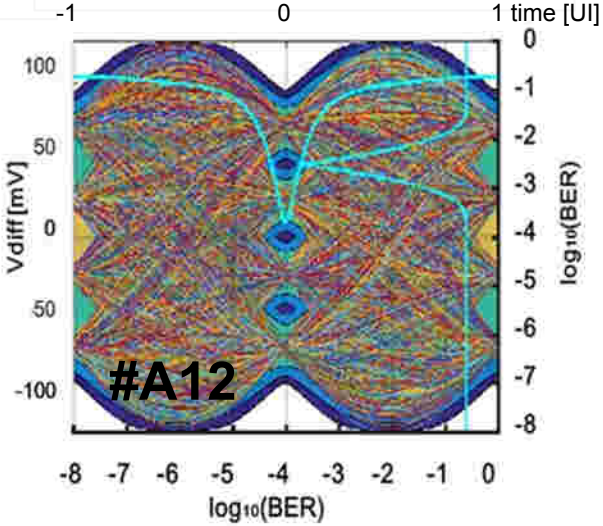
#9 -> #10 : Rx FFE 54-tap, 5-pre and Rx DFE 1-tap, degrade some. To realize multiple tap DFE with many tap FEE is tough in real silicon implementation.



#A10 -> #A11 : Rx FFE 32-tap, 5-pre, reduction of FFE tap does not affect so much, with this channel. It may affect bumpy channel. Reduction of FFE taps is necessary in rea Si implementation.



#A10 -> #A12 : No DFE on Rx closes eye, completely.



2.1.5. Simulation Summary (FFE tap, Tx or Rx)

With this assumption, Rx FFE has an advantage.

better

same

item			unit	#A7	#A7'	#A8	#A8'	#A9	#A9'
noise				yes	no	yes	no	yes	no
baud rate			Gbd	56					
channel		type		ch-2					
Tx	FFE	tap/pre		4/2		9/5		1/0 (no FFE)	
	RJrms		mUI	10					
	SNR		dB	32.5	N/A	32.5	N/A	32.5	N/A
Tx/Rx	PKG	freq		x1					
Rx	CTLE	freq		x1/2					
	eta0		V^2/Hz	1.68E-8	0	1.68E-8	0	1.68E-8	0
	fr	x fb	GHz	x3/8	N/A	x3/8	N/A	x3/8	N/A
	FFE	tap/pre		1/0 (no FFE)				9/5	
	DFE	tap		24					
	RJrms		mUI	10					
eye	width EW4	upp	mUI	8	140	0	176	112	176
		mid		56	220	0	226	160	226
		low		7	140	0	177	112	177
	height EH4	upp	mV	1	39	0	44	23	44
		mid		4	43	0	48	25	48
		low		1	38	0	45	23	45

Considering real SI implementation, 24-tap DFE is not feasible, however.

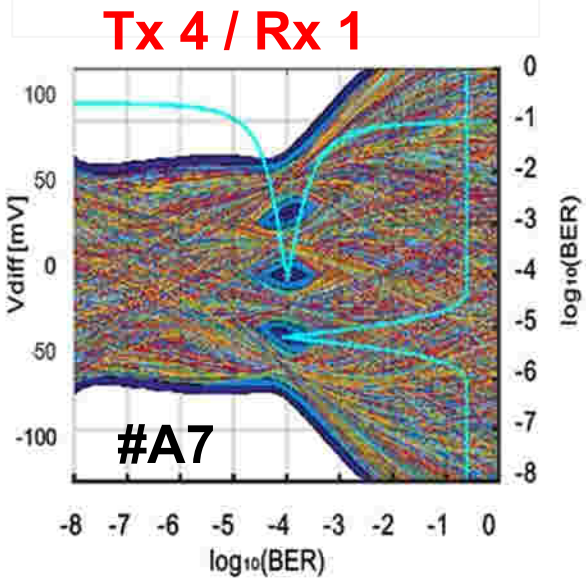
worse

better

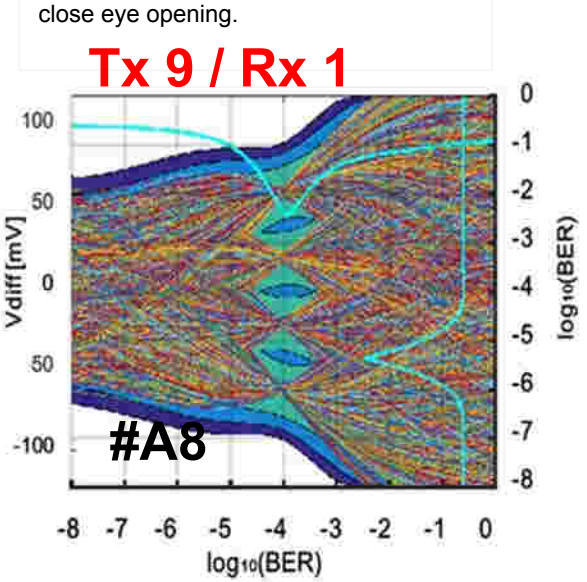
(1) scaled backplane

2.1.5 Simulation Result (#A7~#A9,#A7'~#A9', FFE taps)

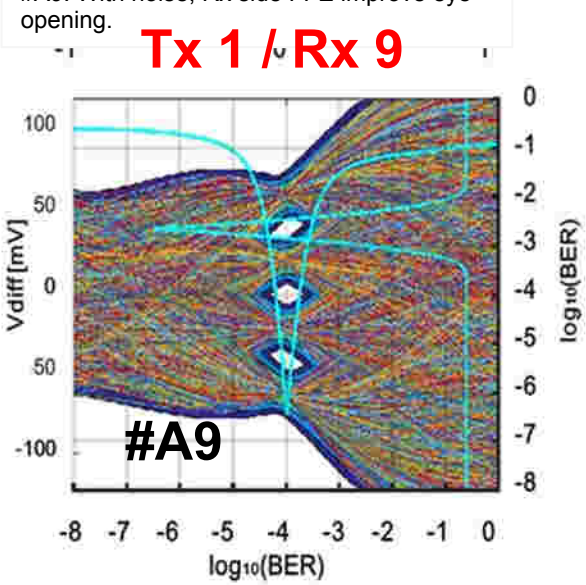
#A7: With 24-tap DFE, eye is almost closed.



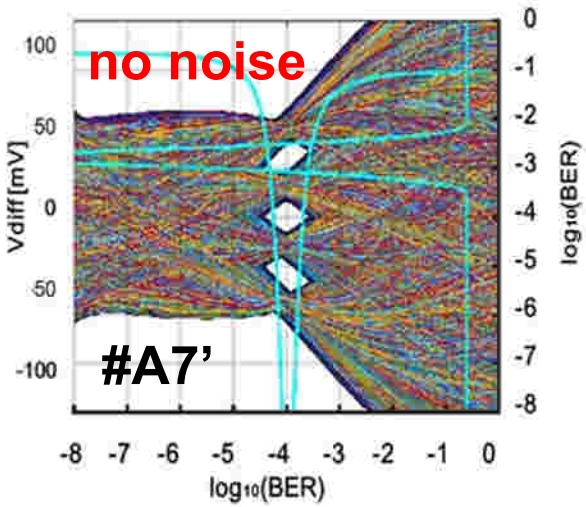
#A8: With noise, more taps on Tx side close eye opening.



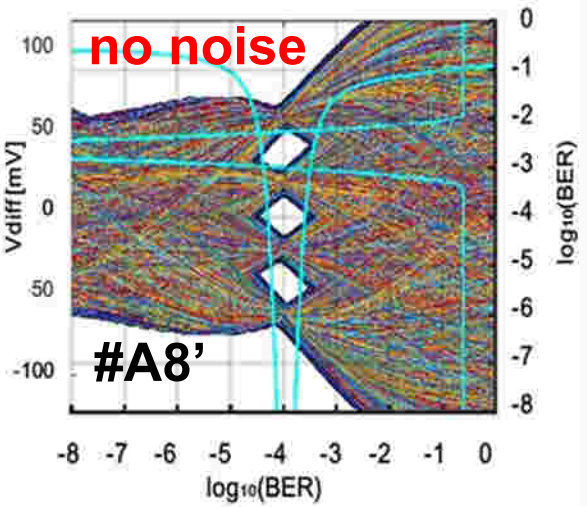
#A9: With noise, Rx side FFE improve eye opening.



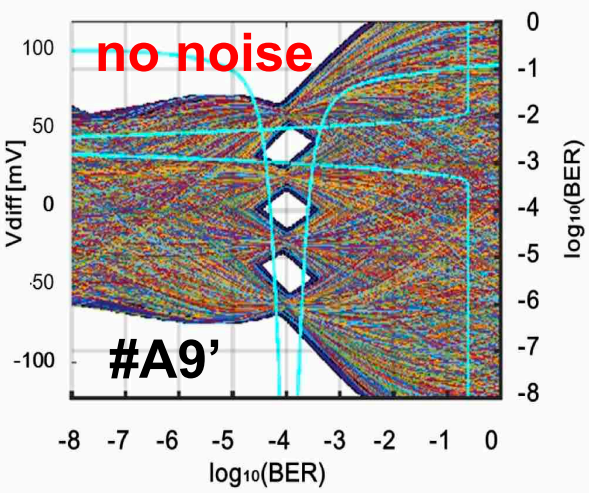
#A7': If eta0 is "0" and Tx-SNR/Rx bandwidth is"unlimited", the eye improves significantly. To see the effect of device noise.



#A8': Without noise, more taps on Tx side improve eye opening, significantly.



#A9': Without noise, Rx side FFE and Tx side
FFE have no difference.



(1) scaled backplane

socionext™
for better quality of experience

2. Channel simulation

2.1 scaled PCB backplane

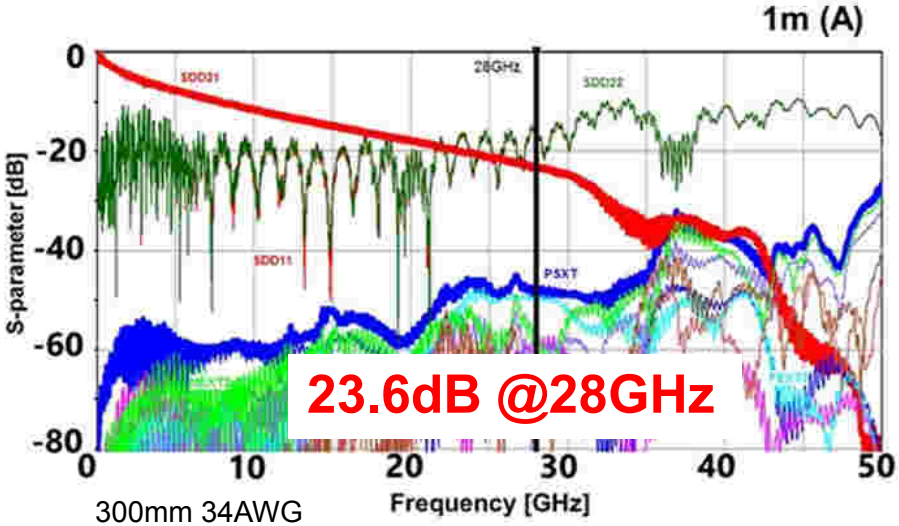
2.2 cabled backplane

2.3 PCB (Tachyon) backplane

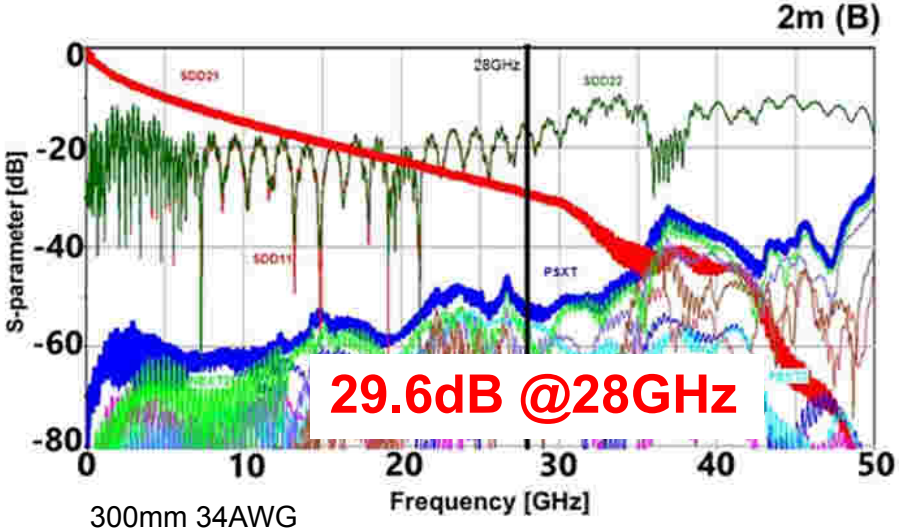
type	by	IL (no PKG)	reference
(1) scaled	TE (original)	34.3dB @28GHz	802.3cd
(2) cabled	Samtec	29.6dB (2m) @28GHz	**IEEE802.3 NEA**
(3) PCB (Tachyon)	Samtec	28.4dB (13") @29GHz	100GEL SG

2.2.2 Channel Characteristics (1/2)

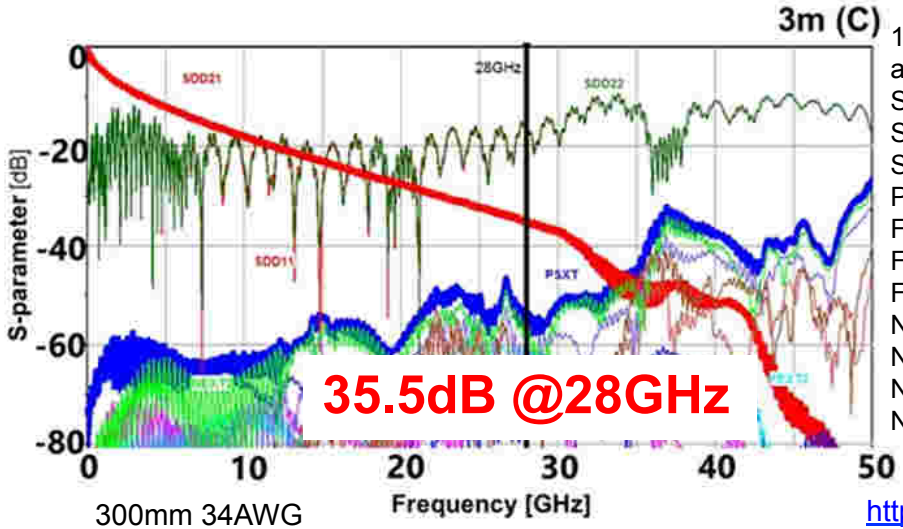
(2) cabled backplane



300mm 34AWG
1000mm 28AWG
300mm 34AWG



300mm 34AWG
2000mm 28AWG
300mm 34AWG



300mm 34AWG
3000mm 28AWG
300mm 34AWG

1m (A)
at f = 28GHz
SDD21= -23.6dB
SDD22= -15.0dB
SDD11= -14.8dB
PSXT = -49.1dB
FEXT1 = -62.5dB
FEXT2 = -59.5dB
FEXT3 = -50.3dB
NEXT1 = -74.6dB
NEXT2 = -59.4dB
NEXT3 = -71.5dB
NEXT4 = -74.9dB

2m (B)
at f = 28GHz
SDD21= -29.6dB
SDD22= -15.2dB
SDD11= -15.1dB
PSXT = -53.8dB
FEXT1 = -69.2dB
FEXT2 = -65.4dB
FEXT3 = -56.0dB
NEXT1 = -75.3dB
NEXT2 = -59.6dB
NEXT3 = -71.2dB
NEXT4 = -75.9dB

3m (C)
at f = 28GHz
SDD21= -35.5dB
SDD22= -15.2dB
SDD11= -15.1dB
PSXT = -57.1dB
FEXT1 = -74.6dB
FEXT2 = -71.2dB
FEXT3 = -62.2dB
NEXT1 = -74.0dB
NEXT2 = -59.6dB
NEXT3 = -71.5dB
NEXT4 = -75.7dB

3m (C)
at f = 26GHz : SDD21= -33.4dB, SDD22= -17.3dB, SDD11= -17.7dB PSXT = -53.8dB, FEXT1 = -76.7dB, FEXT2 = -75.1dB, FEXT3 = -61.2dB NEXT1 = -59.5dB, NEXT2 = -57.9dB, NEXT3 = -64.4dB, NEXT4 = -65.3dB
at f = 24GHz : SDD21= -31.2dB, SDD22= -23.7dB, SDD11= -24.8dB PSXT = -50.2dB, FEXT1 = -78.7dB, FEXT2 = -76.0dB, FEXT3 = -58.7dB NEXT1 = -55.6dB, NEXT2 = -53.8dB, NEXT3 = -65.8dB, NEXT4 = -60.1dB

http://www.ieee802.org/3/ad_hoc/ngrates/public/17_05/mellitz_nea_02_0517.zip
http://www.ieee802.org/3/ad_hoc/ngrates/public/17_05/mellitz_nea_03_0517.zip
http://www.ieee802.org/3/ad_hoc/ngrates/public/17_05/mellitz_nea_04_0517.zip

2.2.4 Simulation Summary

(2) cabled backplane

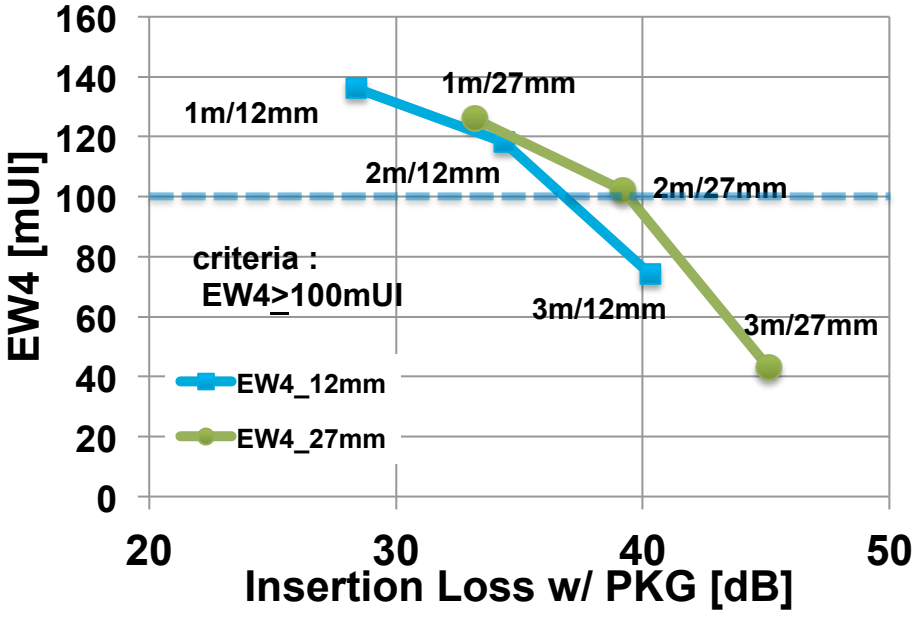
item			unit	#1	#2	#3	#4	#5	#6	#7	#8	#9	#10	#11	#12
baud rate			Gbd	56			53.125	52	48	56			58		
channel	type	cabled BP		1m(A)	2m(B)	3m(C)				1m(A)	2m(B)	3m(C)	2m(B)		
	IL	no PKG	dB	23.6	29.6	35.5	34.0	33.4	31.2	23.6	29.6	35.5	30.5		
		w/ PKG	dB	33.2	39.2	45.1	43.2	42.4	39.7	28.4	34.4	40.3	40.4		35.4
Tx	FFE	tap/pre		1 / 0											
	RJrms		mUI	10											
	SNR		dB	32.5											
Tx/Rx	PKG	trace	mm	27						12			27		12
Rx	CTLE			HF : 2p-1z, LF : 1p-1z (See CTLE parameter page)											
	eta0		V^2/GHz	1.64E-8											
	fr	x fb	GHz	x 3/8											
	FFE	tap/pre		54 / 5										106/5	
	DFE	tap		1											
	RJrms		mUI	10											
eye	width EW4	upp	mUI	126	104	43	79	88	122	138	120	74	93	98	111
		mid		164	144	81	114	126	156	179	162	113	131	137	151
		low		126	102	44	78	89	123	136	118	75	93	98	111
	height EH4	upp	mV	63	45	14	29	34	52	67	54	27	38	42	49
		mid		67	49	16	31	37	55	71	58	30	40	45	52
		low		63	45	14	29	35	52	67	54	27	38	42	49

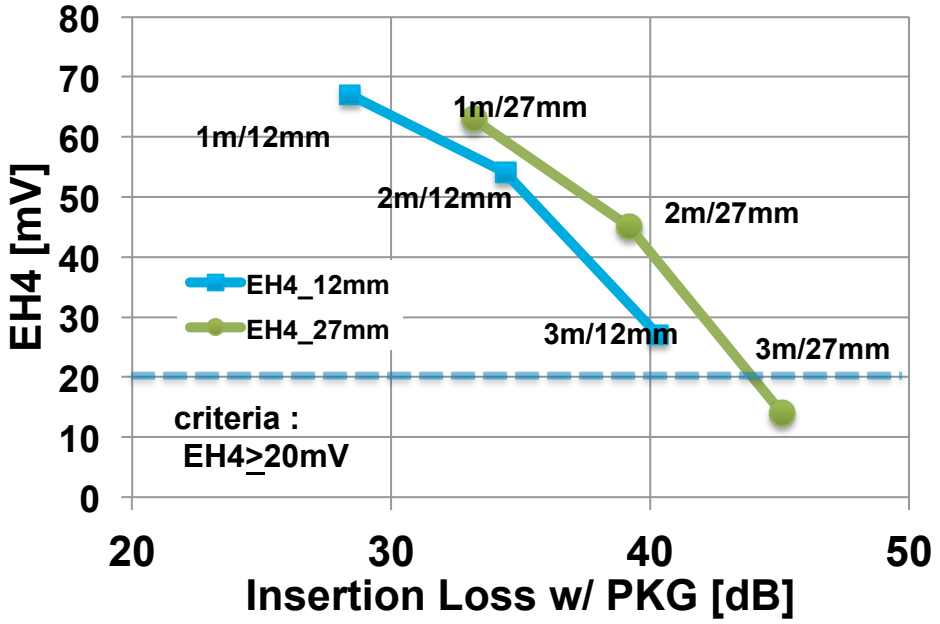
criteria : EW4≥100mUI, EH4≥20mV

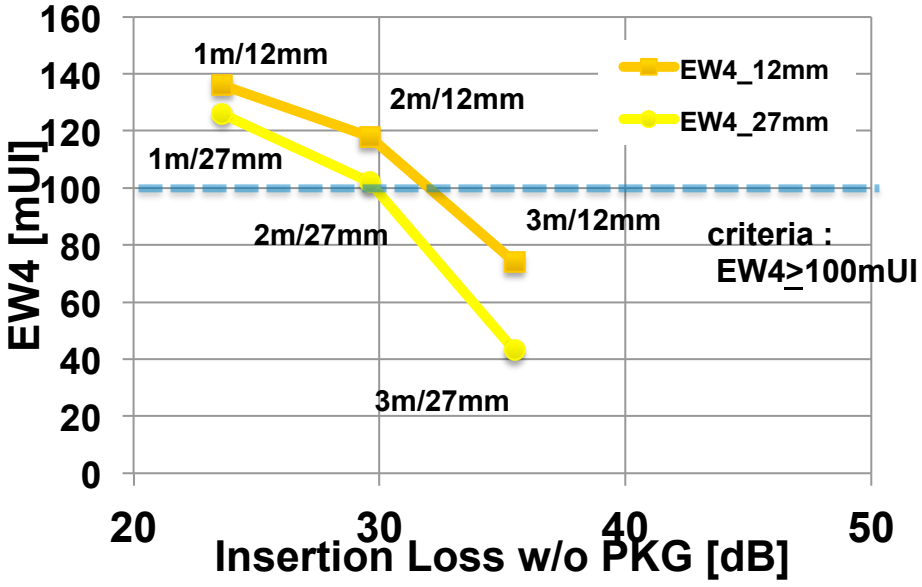
- ✓ 2m cabled BP can be used, though it is marginal and depending on PKG.
- ✓ Number of FFE taps (54->106) does not affect significantly.

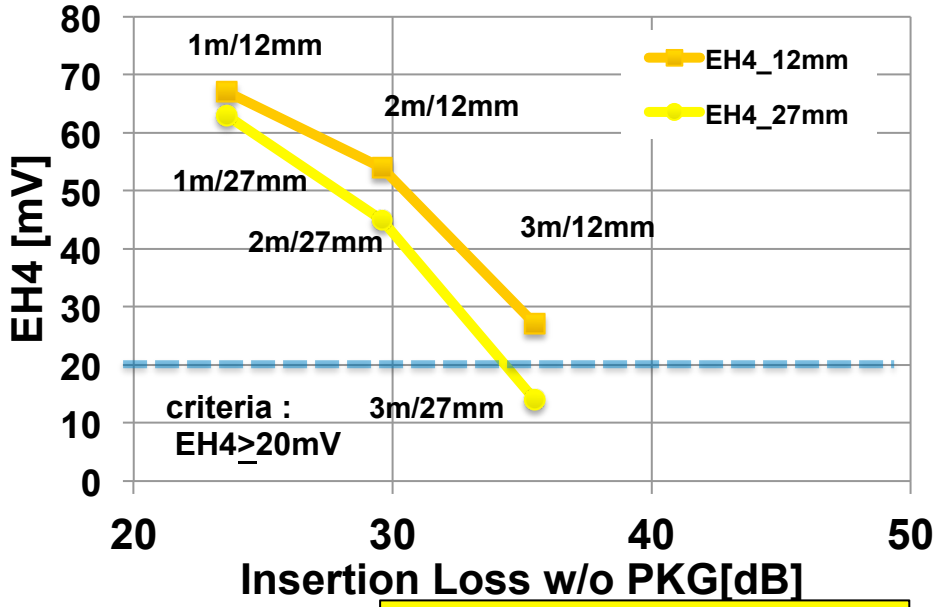
- PKG IL (Tx + Rx, @56Gbd=28GHz) : 4.8dB (12mm), 9.6dB(27mm)

2.2.4 Simulation Summary (insertion loss @28GHz)





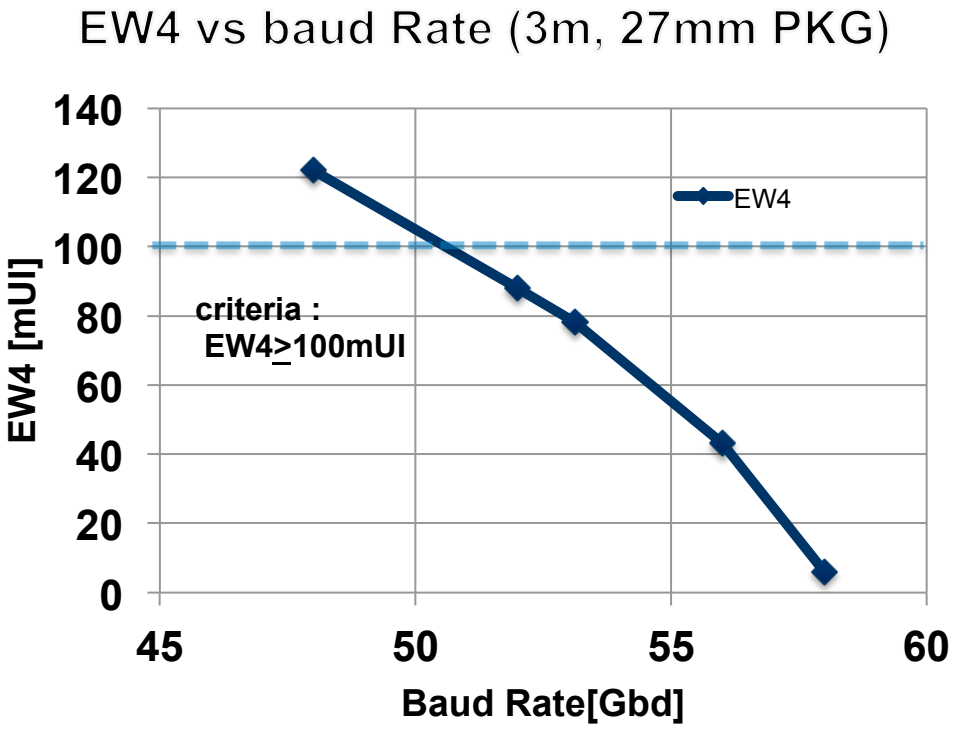


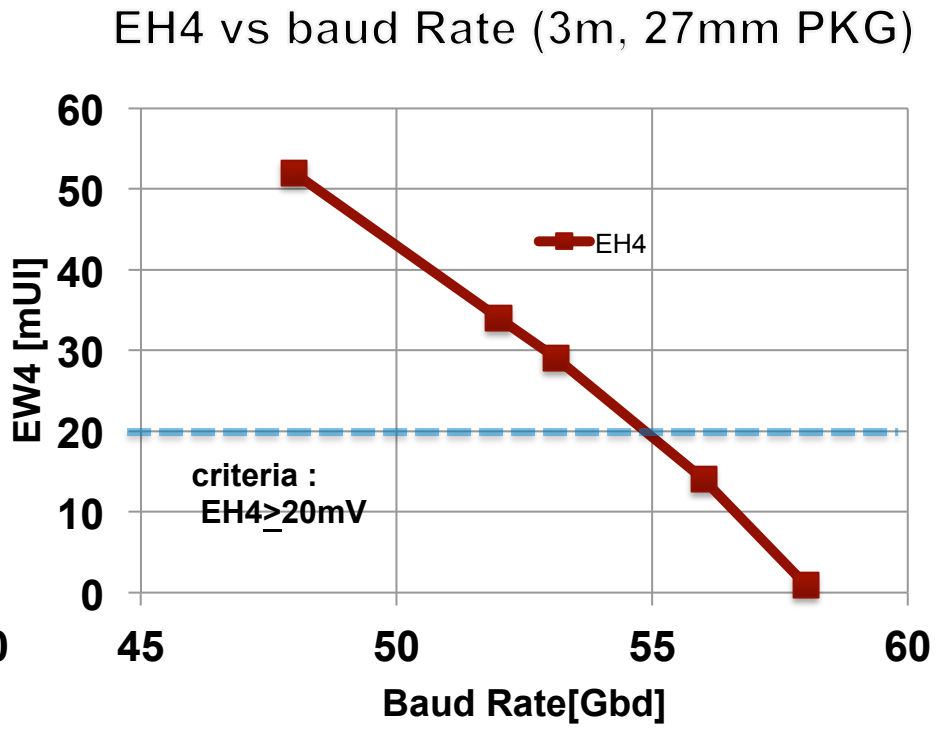


(2) cabled backplane

2.2.4 Simulation Summary (baud rate)

(2) cabled backplane





Eye opening is strongly depends on baud rate.

socionext™
for better quality of experience

2. Channel simulation

2.1 scaled PCB backplane

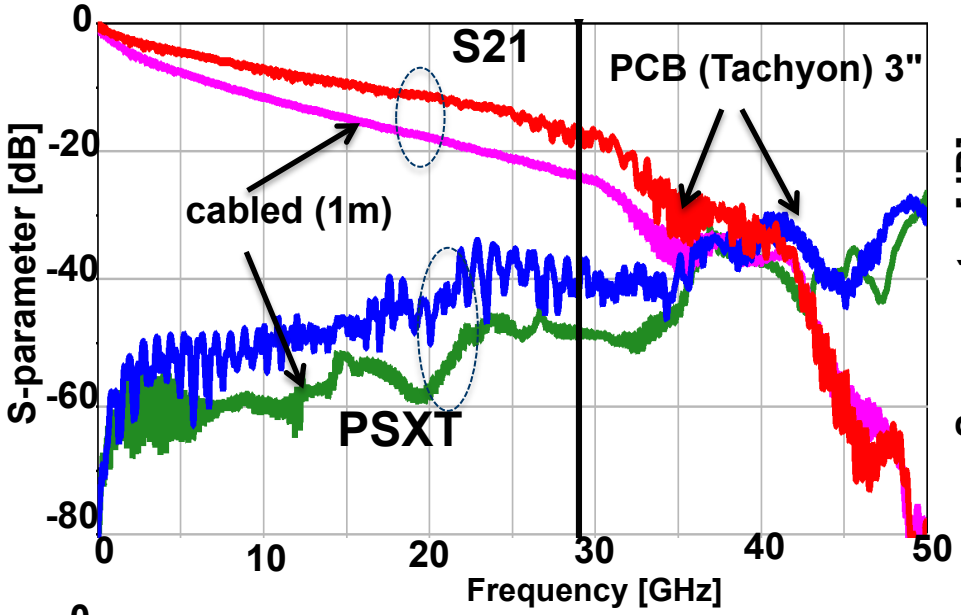
2.2 cabled backplane

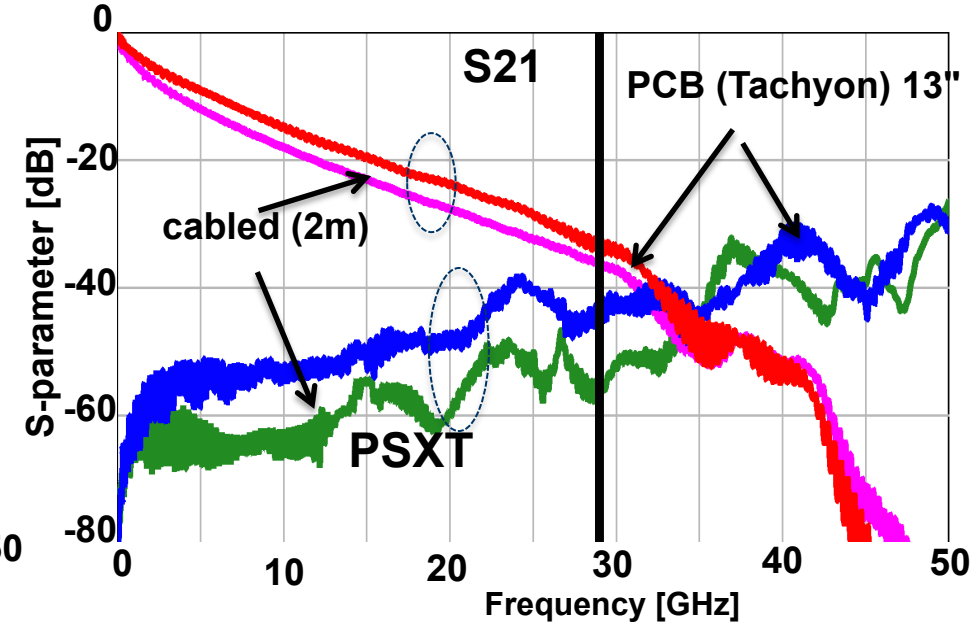
2.3 PCB (Tachyon) backplane

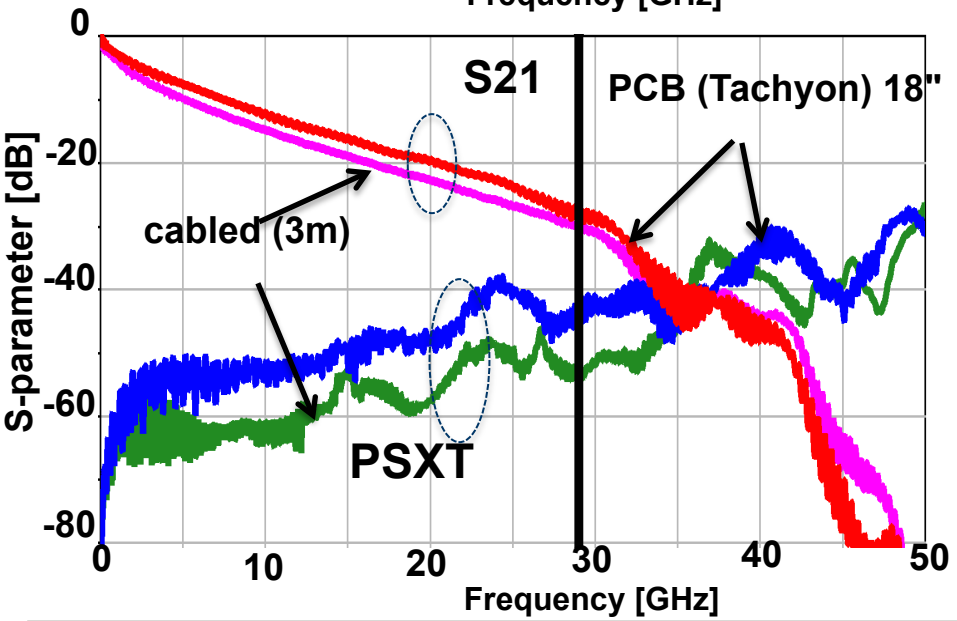
type	by	IL (no PKG)	reference
(1) scaled	TE (original)	34.3dB @28GHz	802.3cd
(2) cabled	Samtec	29.6dB (2m) @28GHz	**IEEE802.3 NEA**
(3) PCB (Tachyon)	Samtec	28.4dB (13") @29GHz	100GEL SG

2.3.1 channel characteristics

(3) PCB backplane



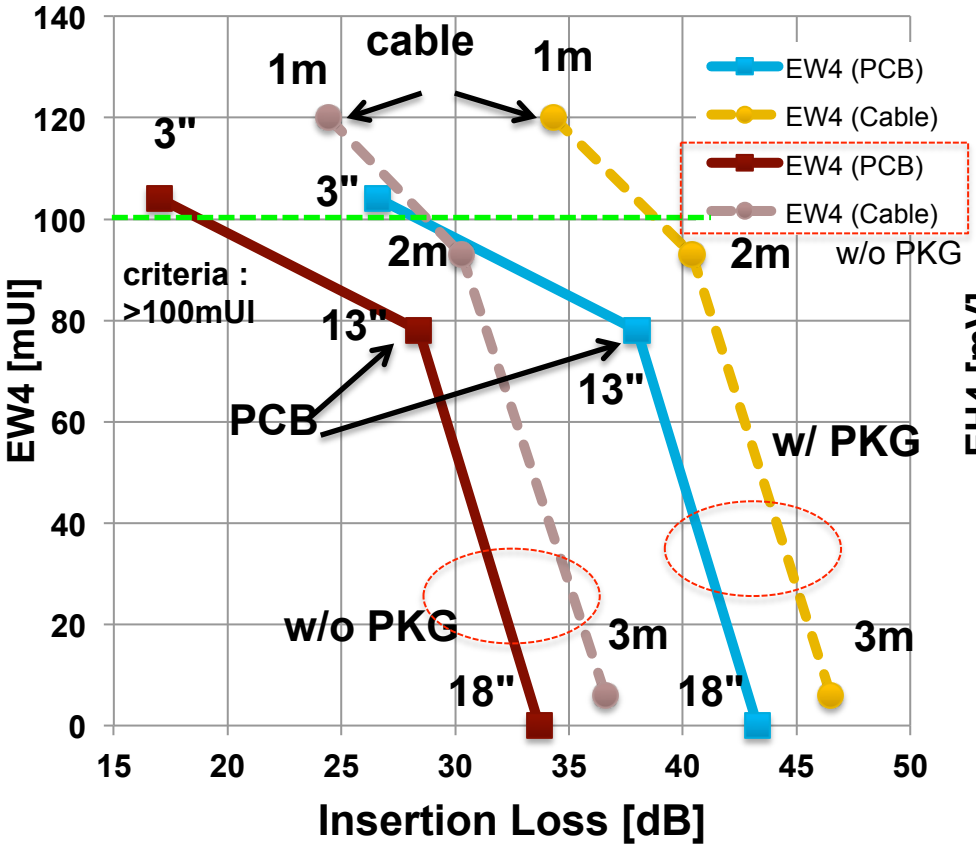


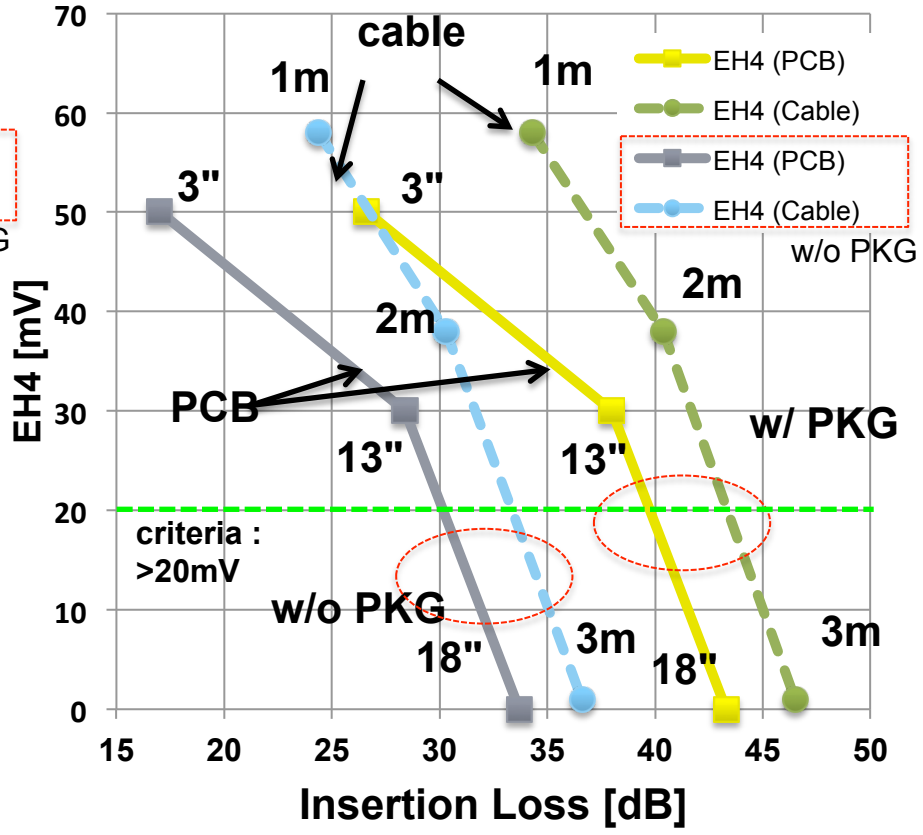


- PCB (Tachyon) backplanes have better IL at Nyquist, however xtalks (PSXT) are worse.
- Also, physical length of PCB backplanes are too short for practical usage.

2.3.2 Simulation Result (58Gbd)

(3) PCB backplane





With improved material (Tachyon), PCB backplane performance is marginal and physical length may not be enough for practical usage.

socionext™
for better quality of experience

3. Conclusion

3. Conclusion (1/2)

1. In case of 53Gbd PAM4, without improved channel characteristics (30dB at Nyquist, PAM4) no transmission is feasible.

2. Even with improved channel, reduction of reflection, and crosstalk are mandatory.

3. PKG affects transmission performance a lot.
Improvement of PKG characteristics will improve margin.
   - At 53Gbd, PKG-IL / total-IL = 12~17% (12mm PKG), 21~29% (27mm PKG) : not negligible small

4. Appropriate equalization is necessary, considering performance, power and area in real Si implementation.
   - It is a trade off issue both channel and SerDes design.
   - Like FEC, "heavy" equalization will require more power and Si area.
   - Further investigation is under going.

3. Conclusion (2/2)

5. With cabled backplane, 100Gb/s transmission with 30dB @28GHz channel seems feasible.

6. Baud rates affect eye opening significantly.

7. Even with better material (like Tachyon), "legacy" PCB backplane structure may not be practical.

Thank you!

socionext™
for better quality of experience

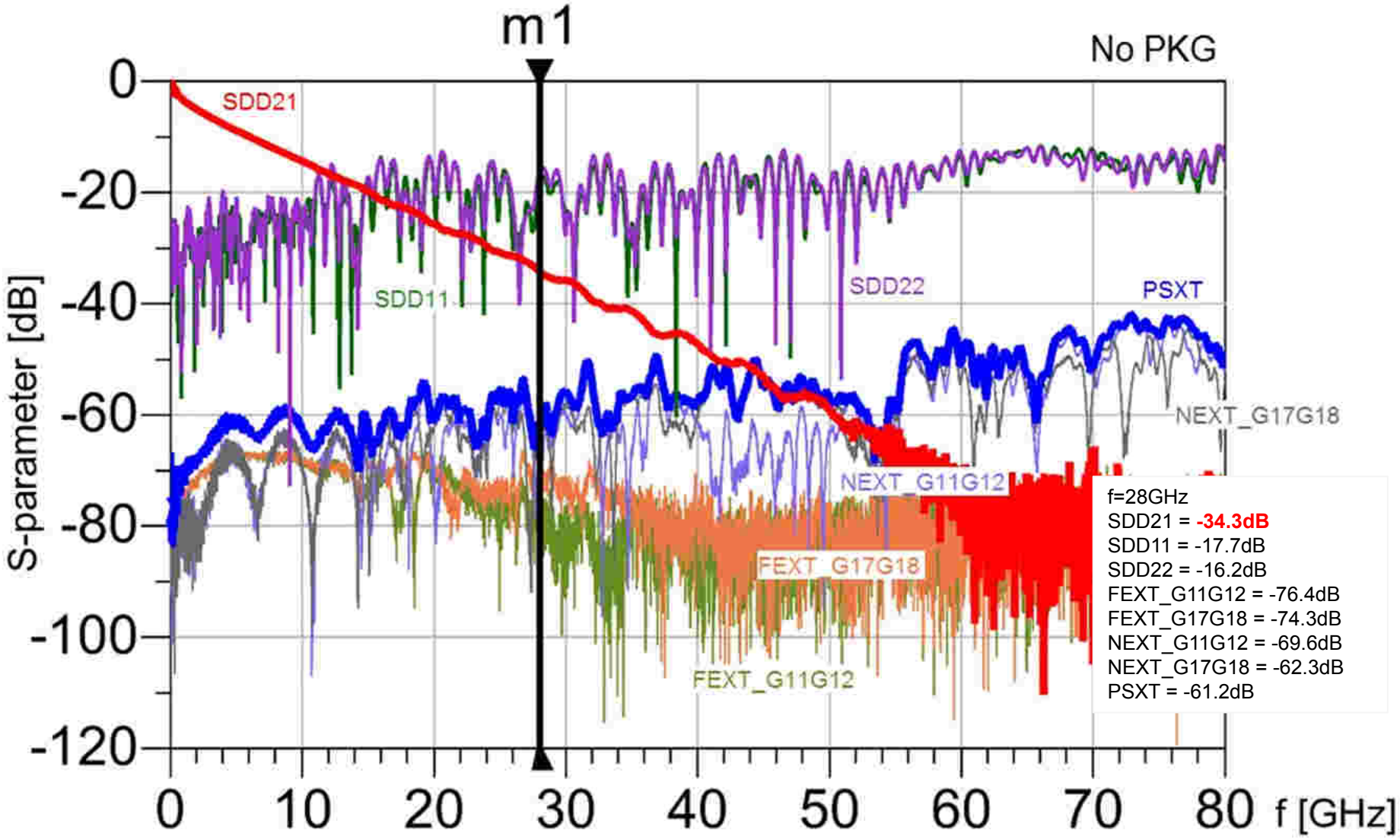
back up slides

- A-2.1 scaled PCB backplane
- A-2.2 cabled backplane
- A-2.3 PCB (Tachyon) backplane

A-2.1.1 Channel Characteristics (scaled cd backplane)

- This is a feasibility study of “100GBASE-KR”(backplane) transmission.
- For this simulation, “scaled frequency” model from public available 802.3cd channel for 53Gb/s transmission (40 inch backplane) by TE Connectivity is used.
  http://www.ieee802.org/3/cd/public/channel/TEC_STRADAWhisper40in_Meg6_Channel_IEEE802_3_cd_Cu_07282016.zip
- The scaled frequency channel itself is not feasible to realize in terms of PCB material standing point, probably.
  - However, some of cabled backplane or orthogonal mid-plane can/may achieve similar channel characteristics. So, it is a good starting point.
- Crosstalk is set to satisfy “COM>3dB” in original (28Gbd) condition.

A-2.1.2 Channel Characteristics



- Based on following backplane channel model, and simply two times scaled the frequency.
http://www.ieee802.org/3/cd/public/channel/TEC_STRADAWhisper40in_Meg6_Channel_IEEE802_3_cd_Cu_07282016.zip

COM with original S-param @14.0GHz, 12mm/30mm PKG
8-FEXT/8-NEXT : 1.19dB/0.37dB
2-FEXT/2-NEXT : 3.64dB/2.76dB ← This is used for this simulation.
0-FEXT/0-NEXT : 4.07dB/3.17dB

A-2.1.3 Simulation Set Up

- ✓ Static Channel Model Simulation
  - ✓ Behavior model using MatLab
  - ✓ PAM4 at 56Gbd (112Gbps) as reference PAM4 28Gbd (56Gbps, #A1)
- ✓ Jitter, noise and crosstalk are considered.
  - ✓ Tx jitter, (DJ, RJ)
  - ✓ Rx/CDR jitter (DJ, RJ) are considered as eye opening margin.
  - ✓ crosstalk noise in channel S-parameter
  - ✓ device noise as eta0
- ✓ Impedance are nominal : 50-ohm single ended
- ✓ PKG model : S-parameter
- ✓ T-spaced FFE
  - ✓ FFE tap parameters are optimized to minimize ISI at Rx.

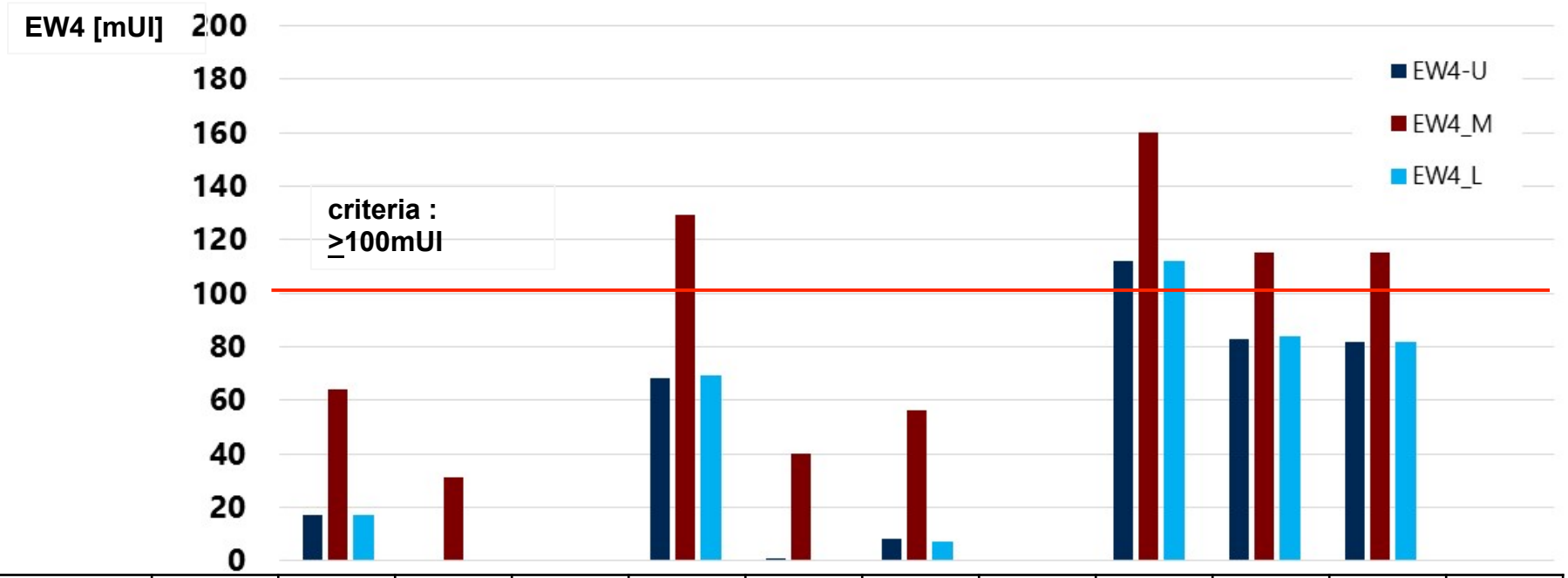
simulation parameters

item	value	unit
modulation	PAM4	
pattern	PRBS13Q	
DJ_Tx	60	mUI
RJ_Tx	10	mUI
EOJ_Tx	0	UI
SNR_Tx	32.5	dB
Rt_Tx	50	ohm
Cd_Tx	160	fF
Av	0.8	Vppd
AVx	1.2	Vppd
BER	1.0E-4	
eta0	1.64E-08	V^2/GHz
DJ_Rx	0	UI
Rt_Rx	50	ohm

CTLE parameters

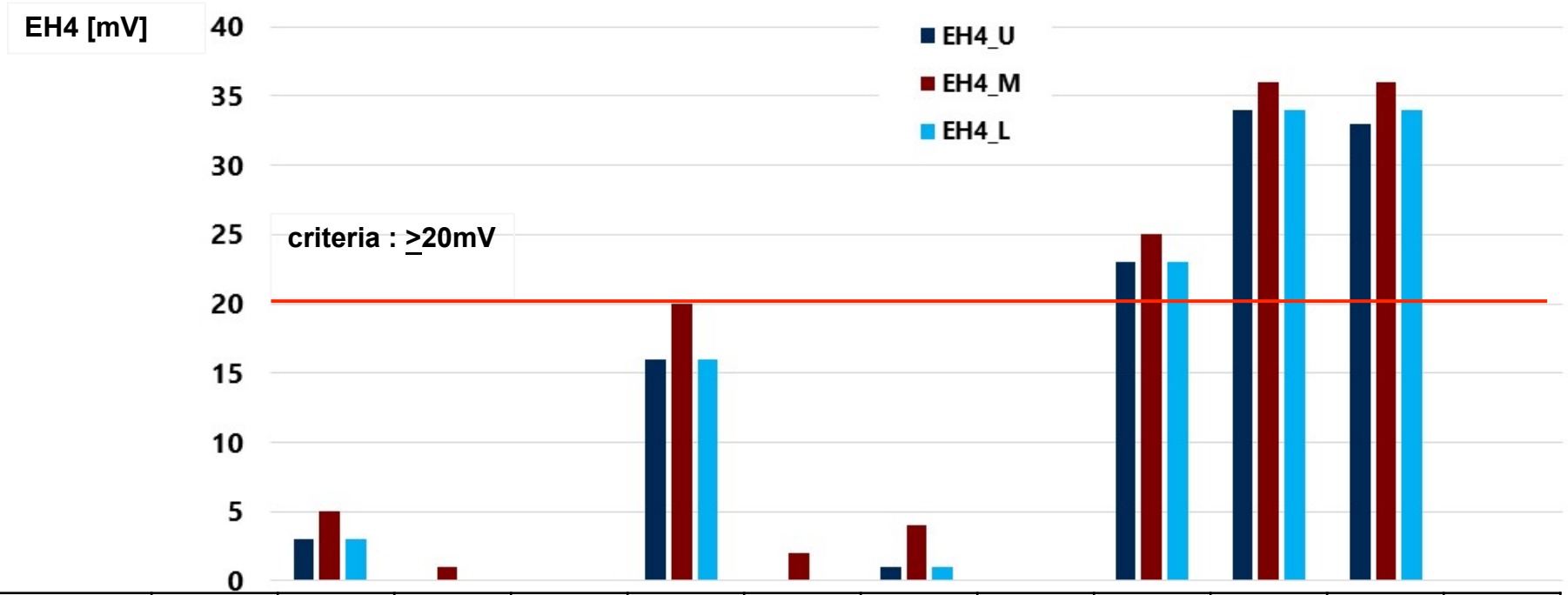
parameter	freq.	symbol	unit	#A1	#A2	#A3	#A4	#A5	#A6	#A7	#A8	#A9	#A10	#A11	#A12
pole	HF	fp1	fb	1.0	1.0	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
		fp2		0.4	0.4	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
	LF	fLF		0.011	0.011	0.010	0.010	0.011	0.010	0.010	0.010	0.010	0.010	0.010	0.010
zero	HF	fz	fb	0.081	0.081	0.076	0.092	0.077	0.076	0.081	0.061	0.061	0.025	0.042	0.025
	LF	fLF		0.007	0.007	0.006	0.006	0.007	0.006	0.007	0.007	0.007	0.007	0.007	0.007

A-2.1.4 Simulation Summary (EW4)



item		unit		#A2	#A3	#A4	#A5	#A6	#A7	#A8	#A9	#A10	#A11	#A12
baud rate		Gbd		56										
channel		type		ch-2										
Tx	FFE	tap/pre		4/2						9/5	1/0 (no FFE)			
	RJrms	mUI		5	10			5	10					
Tx/Rx	PKG	freq		x2	x1		x2	x1						
Rx	CTLE	freq		x1	x1/2	x1	x1/2							
	fr	x fb		x3/4	x3/8	x3/4	x3/8							
	FFE	tap/pre		1/0 (no FFE)							9/5	54/5	32/5	54/5
	DFE	tap		12					24			1		0
	RJrms	mUI		5	10			5	10					
eye	width EW4	upp	mUI	17	0	0	68	1	8	0	112	83	82	0
		mid		64	31	0	129	40	56	0	160	115	115	0
		low		17	0	0	69	0	7	0	112	84	82	0

A-2.1.4 Simulation Summary (EH4)

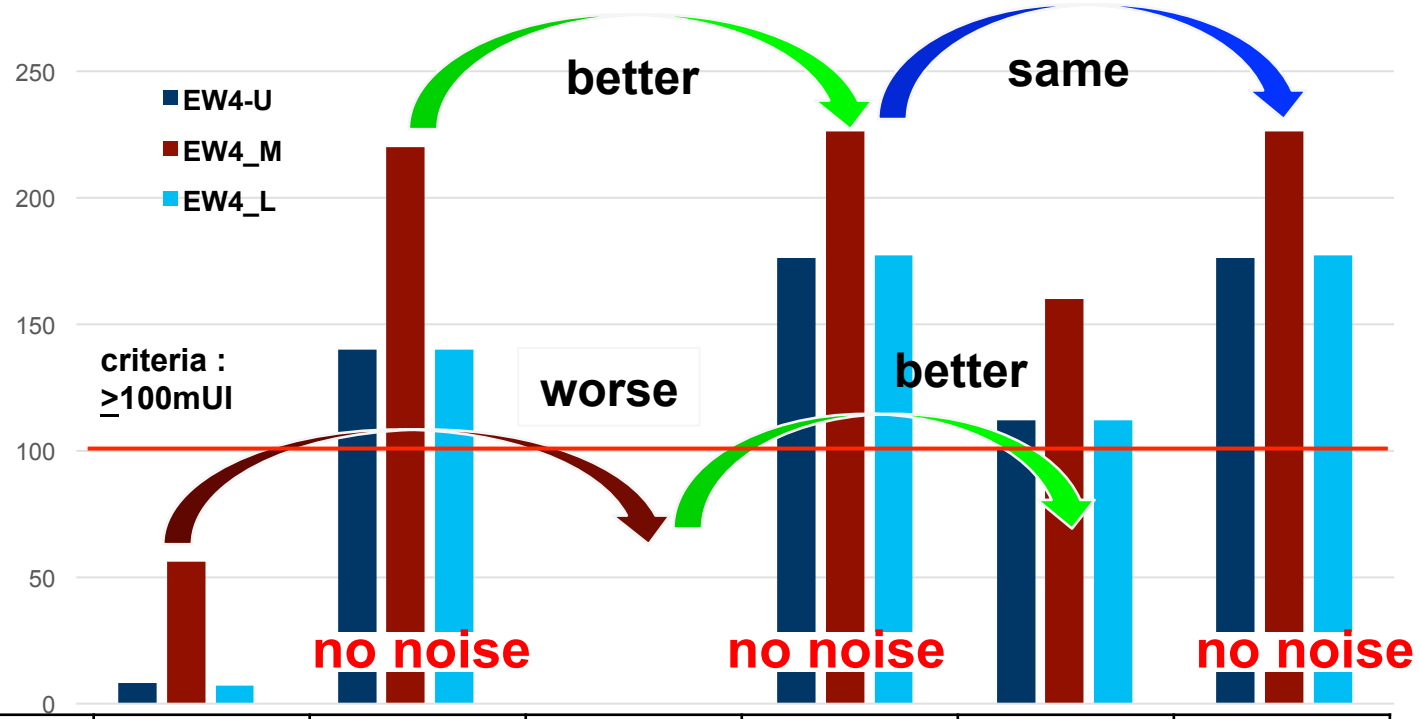


item		unit		#A2	#A3	#A4	#A5	#A6	#A7	#A8	#A9	#A10	#A11	#A12
baud rate		Gbd		56										
channel		type		ch-2										
Tx	FFE	tap/pre		4/2						9/5	1/0 (no FFE)			
	RJrms	mUI		5	10			5	10					
Tx/Rx	PKG	freq		x2	x1		x2	x1						
Rx	CTLE	freq		x1	x1/2	x1	x1/2							
	fr	x fb		x3/4	x3/8	x3/4	x3/8							
	FFE	tap/pre		1/0 (no FFE)							9/5	54/5	32/5	54/5
	DFE	tap		12					24		1			0
	RJrms	mUI		5	10			5	10					
eye	height EH4	upp	mV	3	0	0	16	0	1	0	23	34	33	0
		mid		5	1	0	20	2	4	0	25	36	36	0
		low		3	0	0	16	0	1	0	23	34	34	0

A-2.1.5 Simulation Summary (FFE taps)

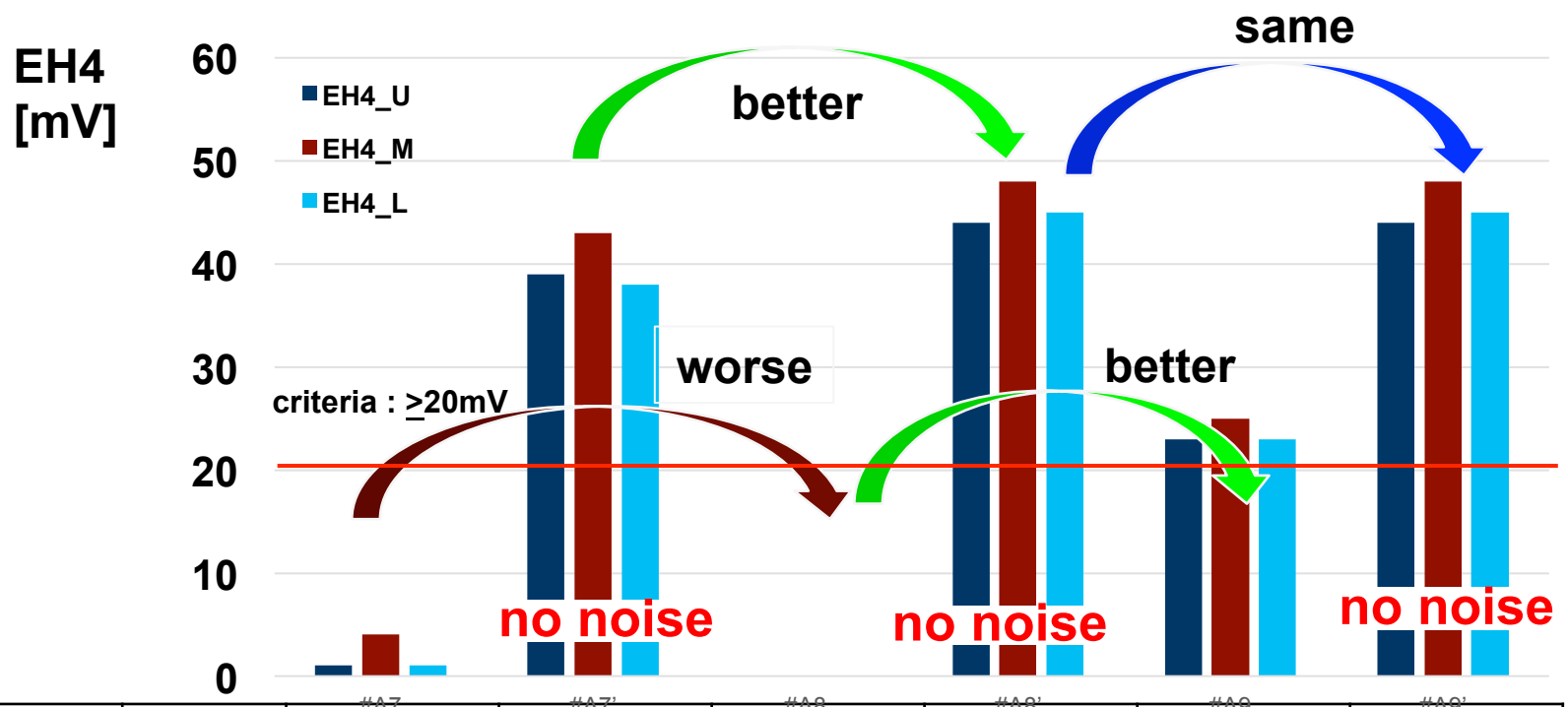
EW4 [mUI]

- In this simulation, FFE tap coefficients are forced to minimize ISI.
- So, Tx FFE taps like c(-1), c(1), c(2) will decrease output swing, this smaller swing causes worse eye opening.
- With no noise case, exact same result as Rx FFE is observed.



item		unit		#A7	#A7'	#A8	#A8'	#A9	#A9'
Tx	FFE	tap/pre		4/2		9/5		1/0 (no FFE)	
	SNR	dB		32.5	N/A	32.5	N/A	32.5	N/A
Rx	eta0	V^2/Hz		1.68E-8	0	1.68E-8	0	1.68E-8	0
	fr	x fb		x3/8	N/A	x3/8	N/A	x3/8	N/A
	FFE	tap/pre		1/0 (no FFE)				9/5	
	DFE	tap		24					
eye	width EW4	upp	mUI	8	140	0	176	112	176
		mid		56	220	0	226	160	226
		low		7	140	0	177	112	177
	height EH4	upp	mV	1	39	0	44	23	44
		mid		4	43	0	48	25	48
		low		1	38	0	45	23	45

A-2.1.5 Simulation Summary (FFE taps)



item		unit		#A7	#A7'	#A8	#A8'	#A9	#A9'
Tx	FFE	tap/pre		4/2		9/5		1/0 (no FFE)	
	SNR	dB		32.5	N/A	32.5	N/A	32.5	N/A
Rx	eta0	V^2/Hz		1.68E-8	0	1.68E-8	0	1.68E-8	0
	fr	x fb		x3/8	N/A	x3/8	N/A	x3/8	N/A
	FFE	tap/pre		1/0 (no FFE)				9/5	
	DFE	tap		24					
eye	width EW4	upp	mUI	8	140	0	176	112	176
		mid		56	220	0	226	160	226
		low		7	140	0	177	112	177
	height EH4	upp	mV	1	39	0	44	23	44
		mid		4	43	0	48	25	48
		low		1	38	0	45	23	45

socionext™
for better quality of experience

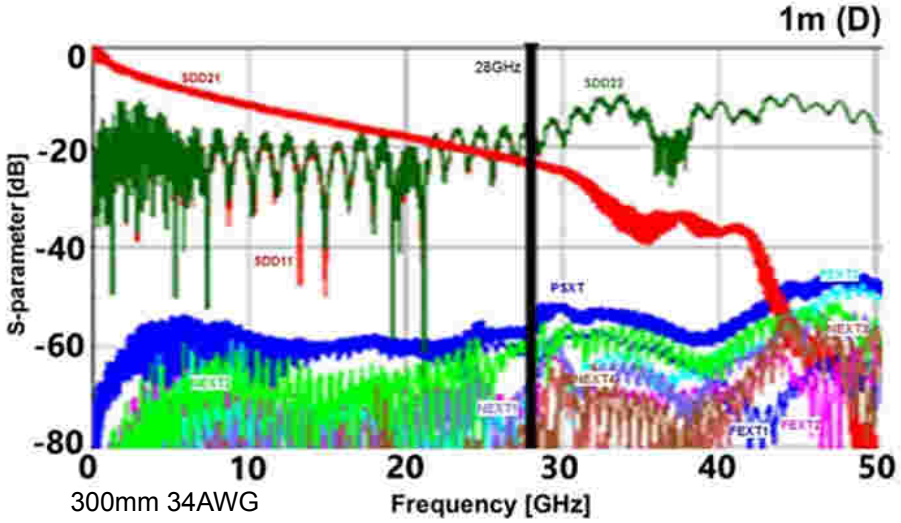
back up slides

- A-2.1 scaled PCB backplane
- A-2.2 cabled backplane
- A-2.3 PCB (Tachyon) backplane

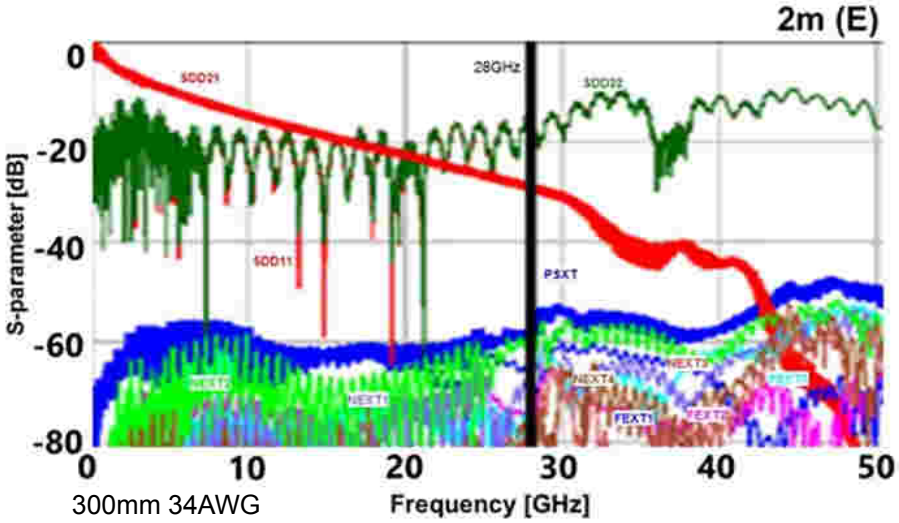
A-2.2.1 Channel Characteristics

- **To see the feasibility of “100GBASE-KR”(backplane) transmission.**
- **For this simulation, public available channels for 100Gb/s transmission by Samtec at IEEE802.3 NEA site* are used.**
  These include all the component from PKG ball to PKG ball.
  http://www.ieee802.org/3/ad_hoc/ngrates/public/17_05/mellitz_nea_01a_0517.pdf
  - http://www.ieee802.org/3/ad_hoc/ngrates/public/17_05/mellitz_nea_02_0517.zip
  - http://www.ieee802.org/3/ad_hoc/ngrates/public/17_05/mellitz_nea_03_0517.zip
  - http://www.ieee802.org/3/ad_hoc/ngrates/public/17_05/mellitz_nea_04_0517.zip
- **Insertion loss breakdown @28GHz**
  cable loss : ~6dB/m
  PKG (both side) : ~9.6dB (27mm), ~4.8dB (12mm)
  other component : ~5.6dB

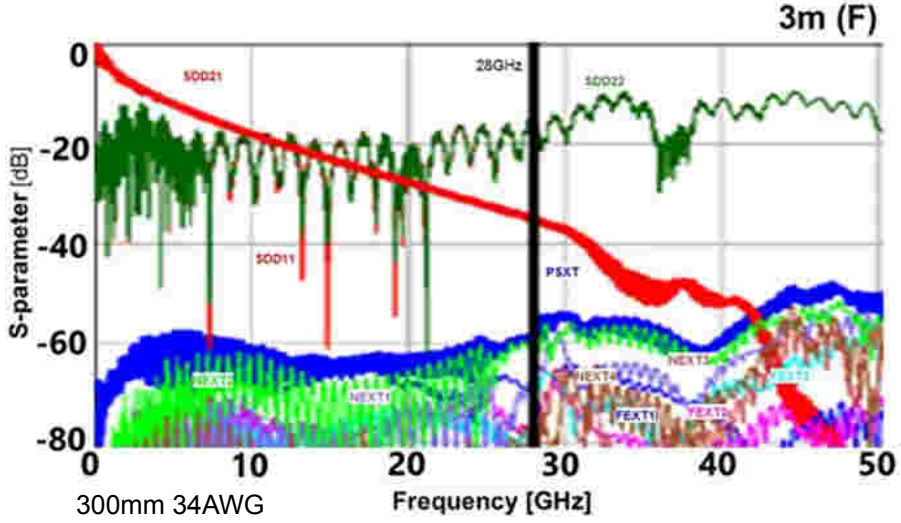
A-2.2.2 Channel Characteristics (scaled xtalk)



300mm 34AWG
1000mm 28AWG
300mm 34AWG



300mm 34AWG
2000mm 28AWG
300mm 34AWG



300mm 34AWG
3000mm 28AWG
300mm 34AWG

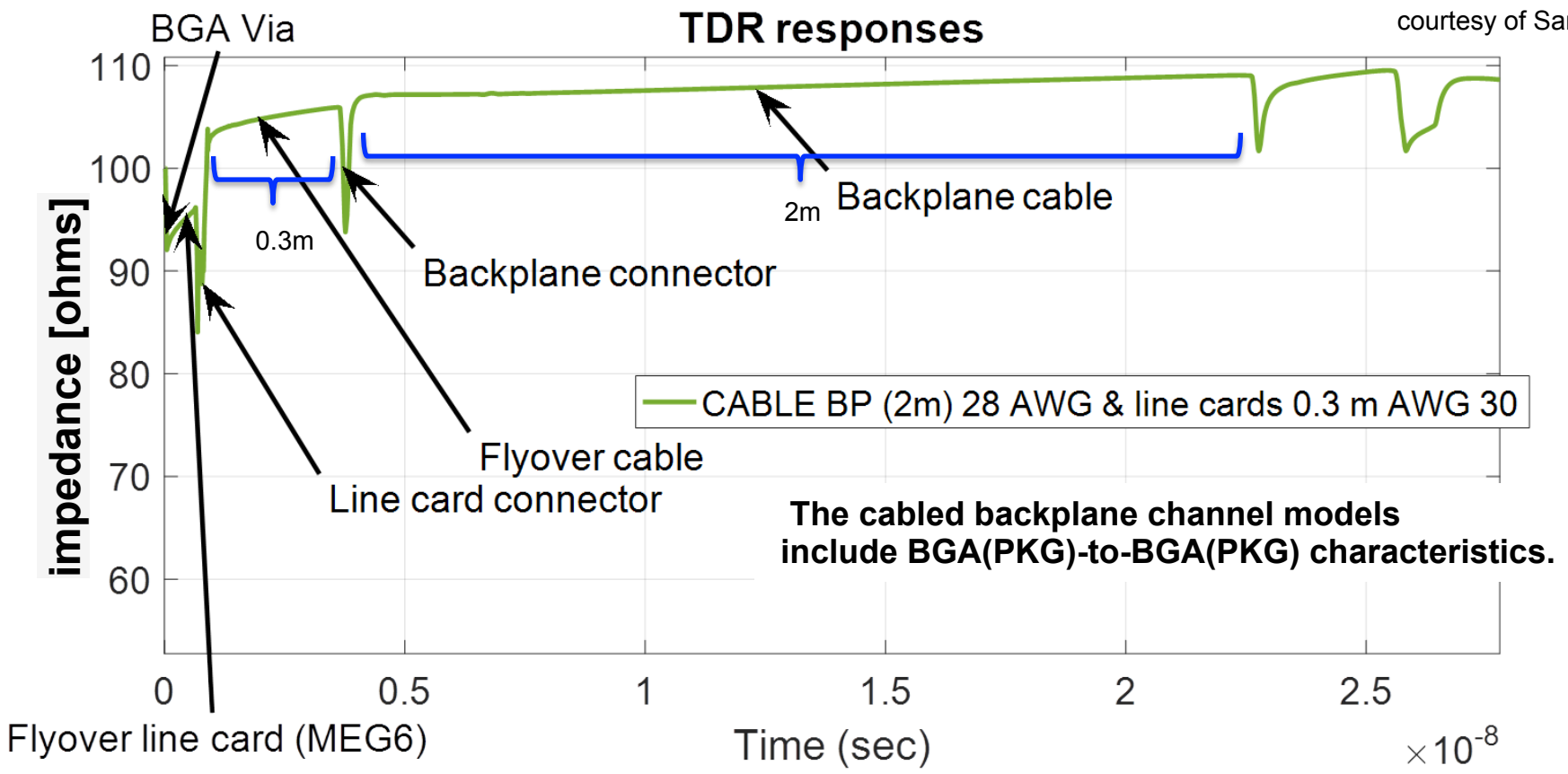
1m (D)
at f = 28GHz
SDD21= -23.6dB
SDD22= -15.0dB
SDD11= -14.8dB
PSXT = -55.7dB
(-6.6dB fr original)
FEXT1 = -63.6dB
FEXT2 = -76.9dB
FEXT3 = -63.6dB
NEXT1 = -68.6dB
NEXT2 = -58.0dB
NEXT3 = -76.8dB
NEXT4 = -72.0dB

2m (E)
at f = 28GHz
SDD21= -29.6dB
SDD22= -15.2dB
SDD11= -15.1dB
PSXT = -58.3dB
(-4.5dB fr original)
FEXT1 = -68.8dB
FEXT2 = -78.9dB
FEXT3 = -69.7dB
NEXT1 = -69.1dB
NEXT2 = -59.8dB
NEXT3 = -78.5dB
NEXT4 = -74.6dB

3m (F)
at f = 28GHz
SDD21= -35.5dB
SDD22= -15.2dB
SDD11= -15.1dB
PSXT = -58.0dB
(-0.9 dB fr original)
FEXT1 = -72.1dB
FEXT2 = -80.1dB
FEXT3 = -72.4dB
NEXT1 = -68.6dB
NEXT2 = -59.0dB
NEXT3 = -77.6dB
NEXT4 = -73.8dB

To see the effect of xtalk, frequency is scaled (x2, FEXT/NEXT only)

A-2.2.2 Channel Characteristics (TDR, 2m cable example)



A-2.2.3 Simulation Scondition (CTLE parameters)

parameter	freq.	symbol	unit	#1	#2	#3	#4	#5	#6	#7	#8	#9	#10	#11	#12
pole	HF	fp1	fb	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
		fp2		0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
	LF	fLF		0.011	0.008	0.007	0.007	0.007	0.008	0.013	0.009	0.007	0.008	0.008	0.009
zero	HF	fz	fb	0.041	0.029	0.025	0.026	0.028	0.028	0.027	0.039	0.035	0.029	0.015	0.016
	LF	fLF		0.008	0.006	0.005	0.005	0.005	0.005	0.009	0.006	0.005	0.006	0.006	0.006

parameter	freq.	symbol	unit	#1′	#2′	#3′	#4′	#5′	#6′	#7′	#8′	#9′	#10′	#11′	#12′
pole	HF	fp1	fb	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
		fp2		0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
	LF	fLF		0.011	0.008	0.007	0.007	0.007	0.008	0.013	0.009	0.007	0.008	0.008	0.009
zero	HF	fz	fb	0.041	0.029	0.025	0.026	0.028	0.028	0.027	0.039	0.035	0.029	0.015	0.016
	LF	fLF		0.008	0.006	0.005	0.005	0.005	0.005	0.009	0.006	0.005	0.006	0.006	0.006

parameter	freq.	symbol	unit	#21	#21′	#22	#22′	#23	#23′	#24	#25	#30	#31	#32
pole	HF	fp1	fb	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
		fp2		0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
	LF	fLF		0.011	0.011	0.008	0.008	0.007	0.007	0.010	0.006	0.016	0.011	0.009
zero	HF	fz	fb	0.040	0.040	0.032	0.032	0.026	0.026	0.035	0.025	0.031	0.036	0.032
	LF	fLF		0.008	0.008	0.006	0.006	0.005	0.005	0.008	0.004	0.013	0.008	0.007

PCB (Tachyon) BP

- Since the parameters are “optimized” at no noise condition, the parameters are the same for with and no noise.
- The assumption is that noise is random and average is “0”.

A-2.2.4 Simulation Summary (w/ noise, with xtalk)

item			unit	#1	#2	#3	#4	#5	#6	#7	#8	#9	#10	#11	#12
baud rate			Gbd	56			53.125	52	48	56			58		
channel	type	cabled BP		1m(A)	2m(B)	3m(C)				1m(A)	2m(B)	3m(C)	2m(B)		
	IL	no PKG	dB	23.6	29.6	35.5	34.0	33.4	31.2	23.6	29.6	35.5	30.5		
		w/ PKG	dB	33.2	39.2	45.1	43.2	42.4	39.7	28.4	34.4	40.3	40.4		35.4
Tx	FFE	tap/pre		1 / 0											
	RJrms		mUI	10											
	SNR		dB	32.5											
Tx/Rx	PKG	trace	mm	27						12			27		12
Rx	CTLE			HF : 2p-1z, LF : 1p-1z (See CTLE parameter page)											
	eta0		V^2/GHz	1.64E-8											
	fr	x fb	GHz	x 3/8											
	FFE	tap/pre		54 / 5										106/5	
	DFE	tap		1											
	RJrms		mUI	10											
eye	width EW4	upp	mUI	126	104	43	79	88	122	138	120	74	93	98	111
		mid		164	144	81	114	126	156	179	162	113	131	137	151
		low		126	102	44	78	89	123	136	118	75	93	98	111
	height EH4	upp	mV	63	45	14	29	34	52	67	54	27	38	42	49
		mid		67	49	16	31	37	55	71	58	30	40	45	52
		low		63	45	14	29	35	52	67	54	27	38	42	49

criteria : EW4≥100mUI, EH4≥20mV

- ✓ 2m cabled BP can be used, though it is marginal and depending on PKG.
- ✓ Number of FFE taps (54->106) does not affect significantly.

- PKG IL (Tx + Rx, @56Gbd=28GHz) : 4.8dB (12mm), 9.6dB(27mm)

A-2.2.4 Simulation Summary (w/o noise, with xtalk)

item			unit	#1'	#2'	#3'	#4'	#5'	#6'	#7'	#8'	#9'	#10'	#11'	#12'
baud rate			Gbd	56			53.125	52	48	56			58		
channel	type	cabled BP		1m(A)	2m(B)	3m(C)				1m(A)	2m(B)	3m(C)	2m(B)		
	IL	w/ PKG	dB	33.2	39.2	45.1	43.2	42.4	39.7	28.4	34.4	40.3	40.4		35.4
Tx	FFE	tap/pre		1 / 0											
	RJrms		mUI	10											
	SNR		dB	N/A											
Tx/Rx	PKG	trace	mm	27						12			27		12
Rx	CTLE			HF : 2p-1z, LF : 1p-1z (See CTLE parameter page)											
	eta0		V^2/GHz	0											
	fr	x fb	GHz	N/A											
	FFE	tap/pre		54 / 5										106/5	
	DFE	tap		1											
	RJrms		mUI	10											
eye	width EW4	upp	mUI	149	143	119	139	141	164	158	146	141	138	143	139
		mid		191	188	167	178	186	201	201	191	186	182	188	182
		low		147	138	116	137	143	165	154	143	143	137	143	138
	height EH4	upp	mV	79	69	53	63	66	79	80	71	66	65	70	67
		mid		85	75	58	67	71	83	85	75	71	69	74	71
		low		79	69	53	63	67	79	80	70	67	65	70	67

✓ Reduction of device noise affects a lot, though only partial realization is realistic.

criteria : EW4≥100mUI, EH4≥20mV

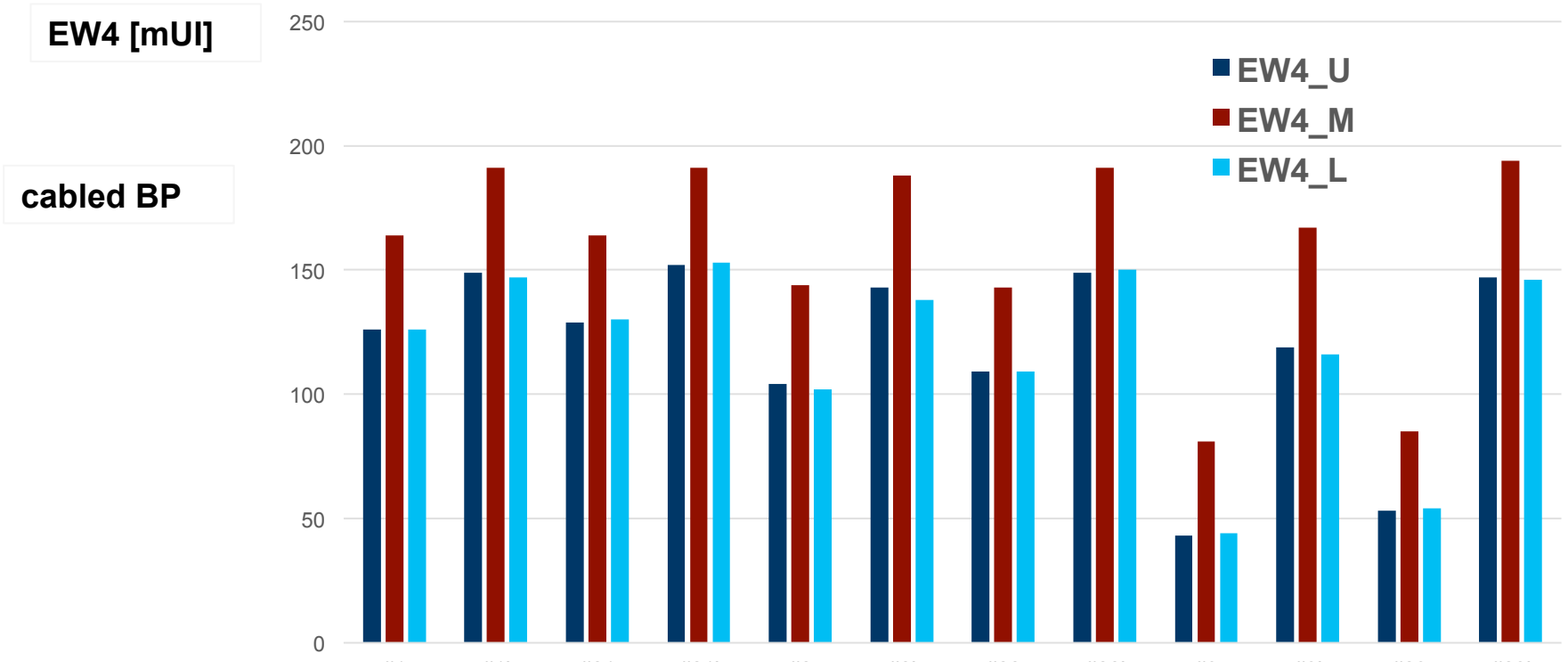
A-2.2.4. Simulation Summary (w/ or w/o noise, xtalk amount)

item			unit	#1	#1'	#21	#21'	#2	#2'	#22	#22'	#3	#3'	#23	#23'
baud rate			Gbd	56											
channel	type	cabled BP		1m(A)		1m(D)		2m(B)		2m(E)		3m(C)		3m(F)	
	IL	w/ PKG	dB	33.2				39.2				45.1			
	xtalk	freq xfb / PSXT		x1		x2		x1		x2		x1		x2	
Tx	FFE	tap/pre		1 / 0											
	RJrms		mUI	10											
	SNR		dB	32.5	N/A	32.5	N/A	32.5	N/A	32.5	N/A	32.5	N/A	32.5	N/A
Tx/Rx	PKG	trace	mm	27											
Rx	CTLE			HF : 2p-1z, LF : 1p-1z (See CTLE parameter page)											
	eta0		V^2/GHz	1.64E-08	0	1.64E-08	0	1.64E-08	0	1.64E-08	0	1.64E-08	0	1.64E-08	0
	fr	x fb	GHz	x3/8	N/A	x3/8	N/A	x3/8	N/A	x3/8	N/A	x3/8	N/A	x3/8	N/A
	FFE	tap/pre		54 / 5											
	DFE	tap		1											
	RJrms		mUI	10											
eye	width EW4	upp	mUI	126	149	129	152	104	143	109	149	43	119	53	147
		mid		164	191	164	191	144	188	143	191	81	167	85	194
		low		126	147	130	153	102	138	109	150	44	116	54	146
	height EH4	upp	mV	63	79	69	86	45	69	53	82	14	53	19	75
		mid		67	85	73	92	49	75	56	88	16	58	22	82
		low		63	79	69	87	45	69	53	83	14	53	20	76

- Further reduction of xtalk noise helps some, but not significantly, since "original" PSXT is relatively small (-53.8dB, 2m).

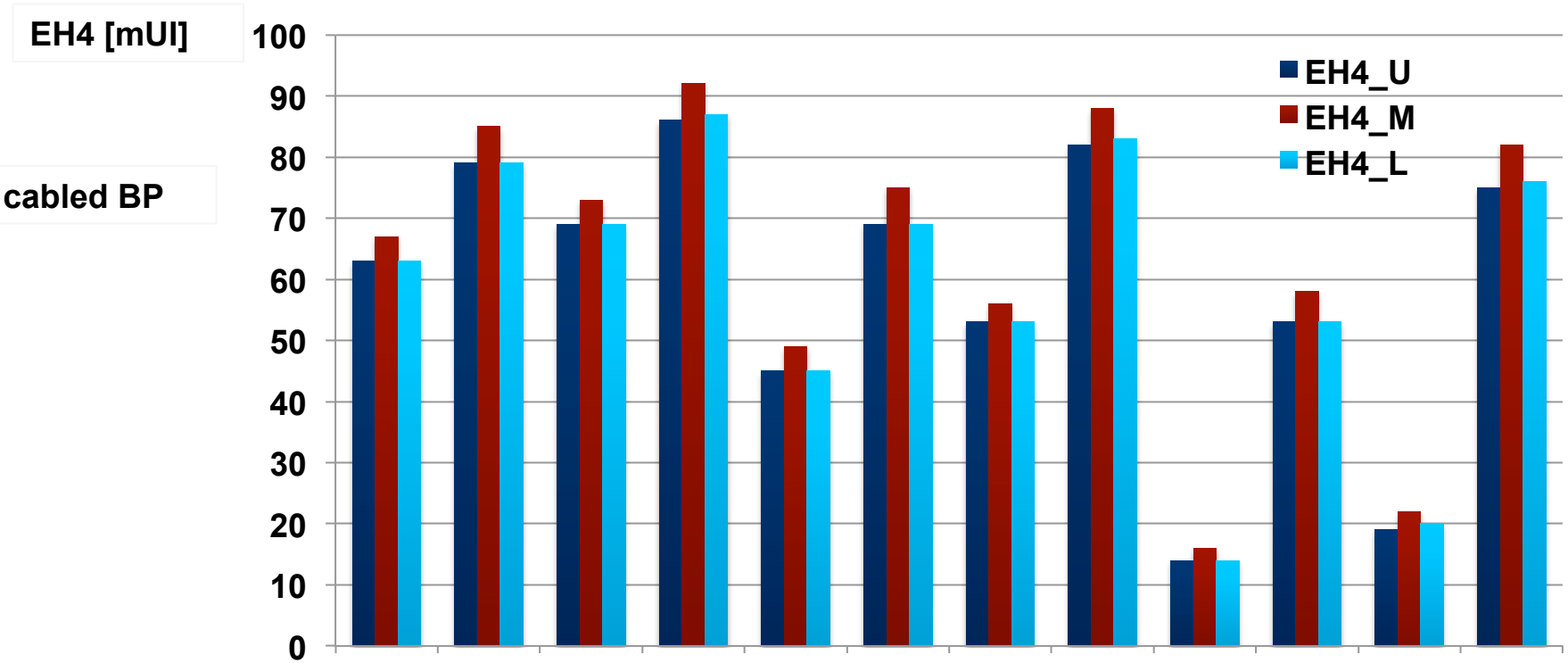
criteria : EW4≥100mUI, EH4≥20mV

A-2.2.4 Simulation Summary (w/ or w/o noise, xtalk amount)



item			unit	#1	#1'	#21	#21'	#2	#2'	#22	#22'	#3	#3'	#23	#23'
channel	cabled BP			1m(A)		1m(D)		2m(B)		2m(E)		3m(C)		3m(F)	
	IL w/ PKG		dB	33.2				39.2				45.1			
	xtalk	freq-scale		x1		x2		x1		x2		x1		x2	
Tx	SNR	dB		32.5	N/A	32.5	N/A	32.5	N/A	32.5	N/A	32.5	N/A	32.5	N/A
Rx	eta0	V^2/GHz		1.64E-08	0	1.64E-08	0	1.64E-08	0	1.64E-08	0	1.64E-08	0	1.64E-08	0
	fr	x fb		x3/8	N/A	x3/8	N/A	x3/8	N/A	x3/8	N/A	x3/8	N/A	x3/8	N/A
eye	width EW4	upp	mUI	126	149	129	152	104	143	109	149	43	119	53	147
		mid		164	191	164	191	144	188	143	191	81	167	85	194
		low		126	147	130	153	102	138	109	150	44	116	54	146
	height EH4	upp	mV	63	79	69	86	45	69	53	82	14	53	19	75
		mid		67	85	73	92	49	75	56	88	16	58	22	82
		low		63	79	69	87	45	69	53	83	14	53	20	76

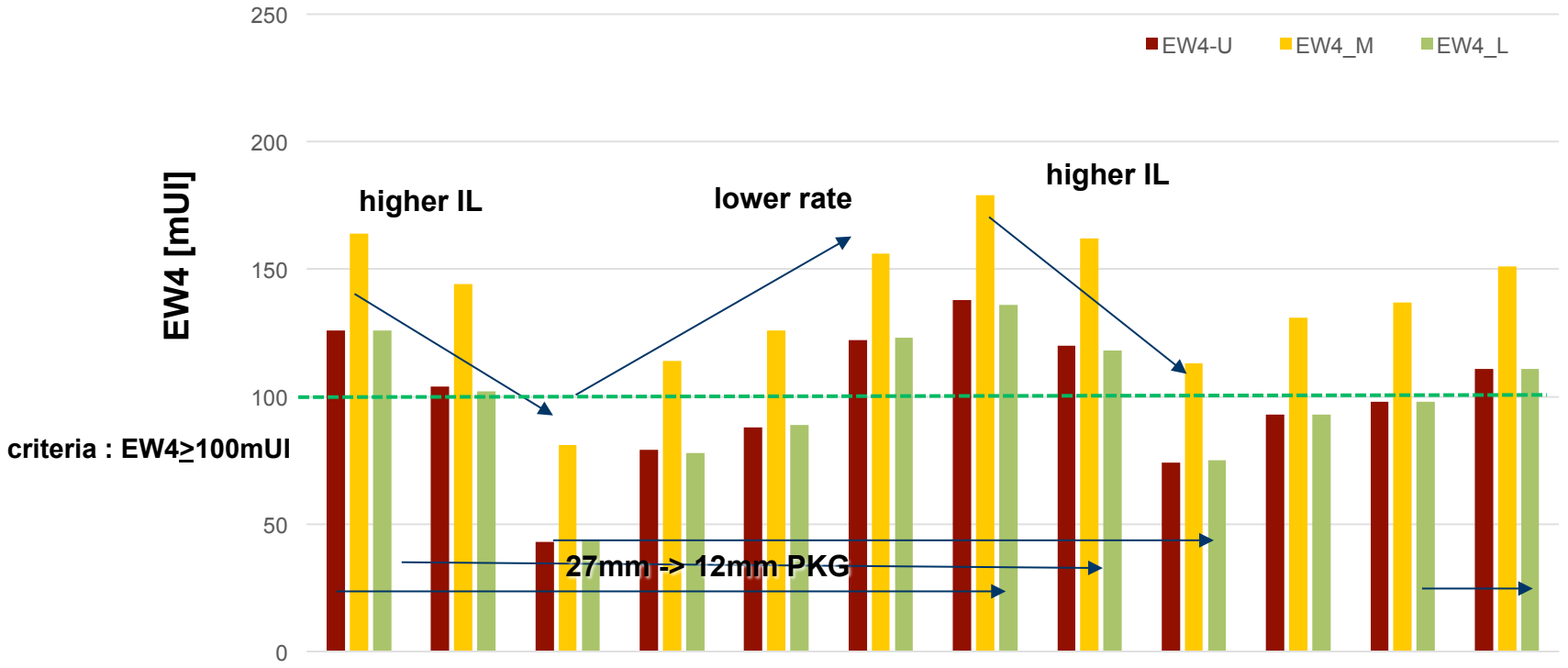
A-2.2.4 Simulation Summary (w/ or w/o noise, xtalk amount)



item			unit	#1	#1'	#21	#21'	#2	#2'	#22	#22'	#3	#3'	#23	#23'
channel	cabled BP			1m(A)		1m(D)		2m(B)		2m(E)		3m(C)		3m(F)	
	IL w/ PKG		dB	33.2				39.2				45.1			
	xtalk	freq-scale		x1		x2		x1		x2		x1		x2	
Tx	SNR	dB		32.5	N/A	32.5	N/A	32.5	N/A	32.5	N/A	32.5	N/A	32.5	N/A
Rx	eta0	V^2/GHz		1.64E-08	0	1.64E-08	0	1.64E-08	0	1.64E-08	0	1.64E-08	0	1.64E-08	0
	fr	x fb		x3/8	N/A	x3/8	N/A	x3/8	N/A	x3/8	N/A	x3/8	N/A	x3/8	N/A
eye	width EW4	upp	mUI	126	149	129	152	104	143	109	149	43	119	53	147
		mid		164	191	164	191	144	188	143	191	81	167	85	194
		low		126	147	130	153	102	138	109	150	44	116	54	146
	height EH4	upp	mV	63	79	69	86	45	69	53	82	14	53	19	75
		mid		67	85	73	92	49	75	56	88	16	58	22	82
		low		63	79	69	87	45	69	53	83	14	53	20	76

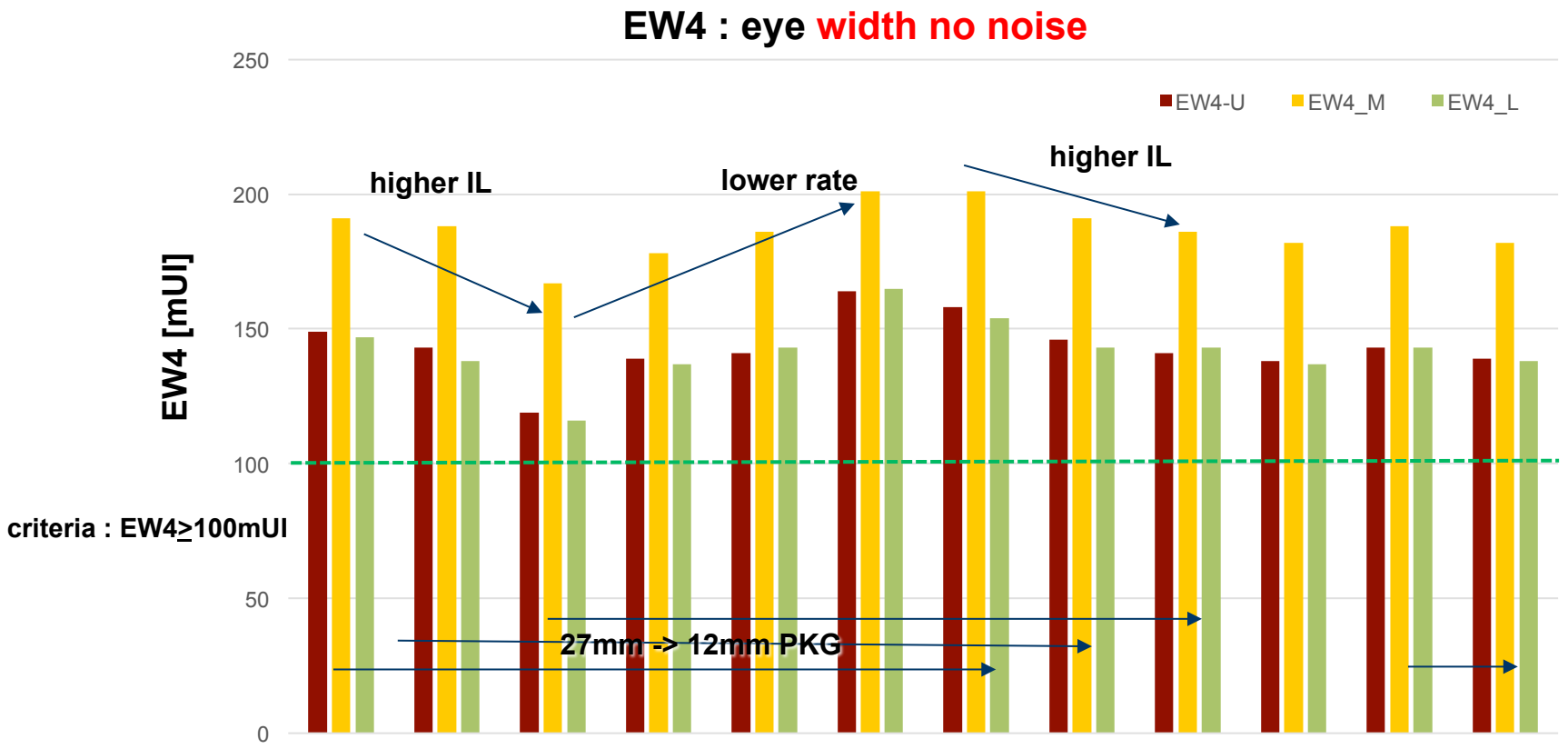
A-2.2.4 Simulation Summary

EW4 : eye width with noise



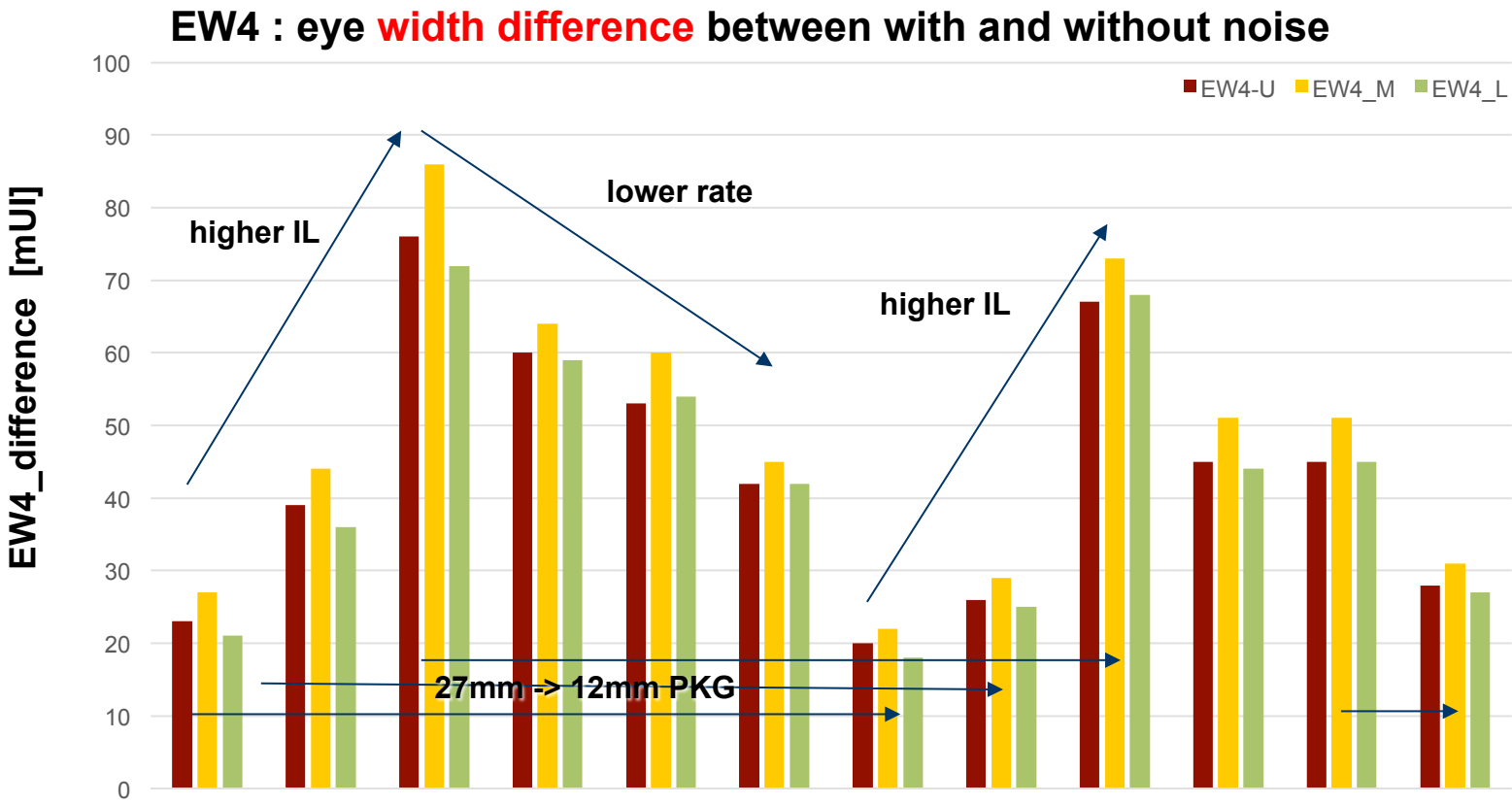
	#1	#2	#3	#4	#5	#6	#7	#8	#9	#10	#11	#12
Gbd	56			53.125	52	48	56			58		
channel	1m(A)	2m(B)	3m(C)				1m(A)	2m(B)	3m(C)	2m(B)		
IL [dB]	33.2	39.2	45.1	43.2	42.4	39.7	28.4	34.4	40.3	40.4		35.4
PKG [mm]	27						12			27		12
FFE	54 / 5 (total/pre)										106/5	

A-2.2.4 Simulation Summary



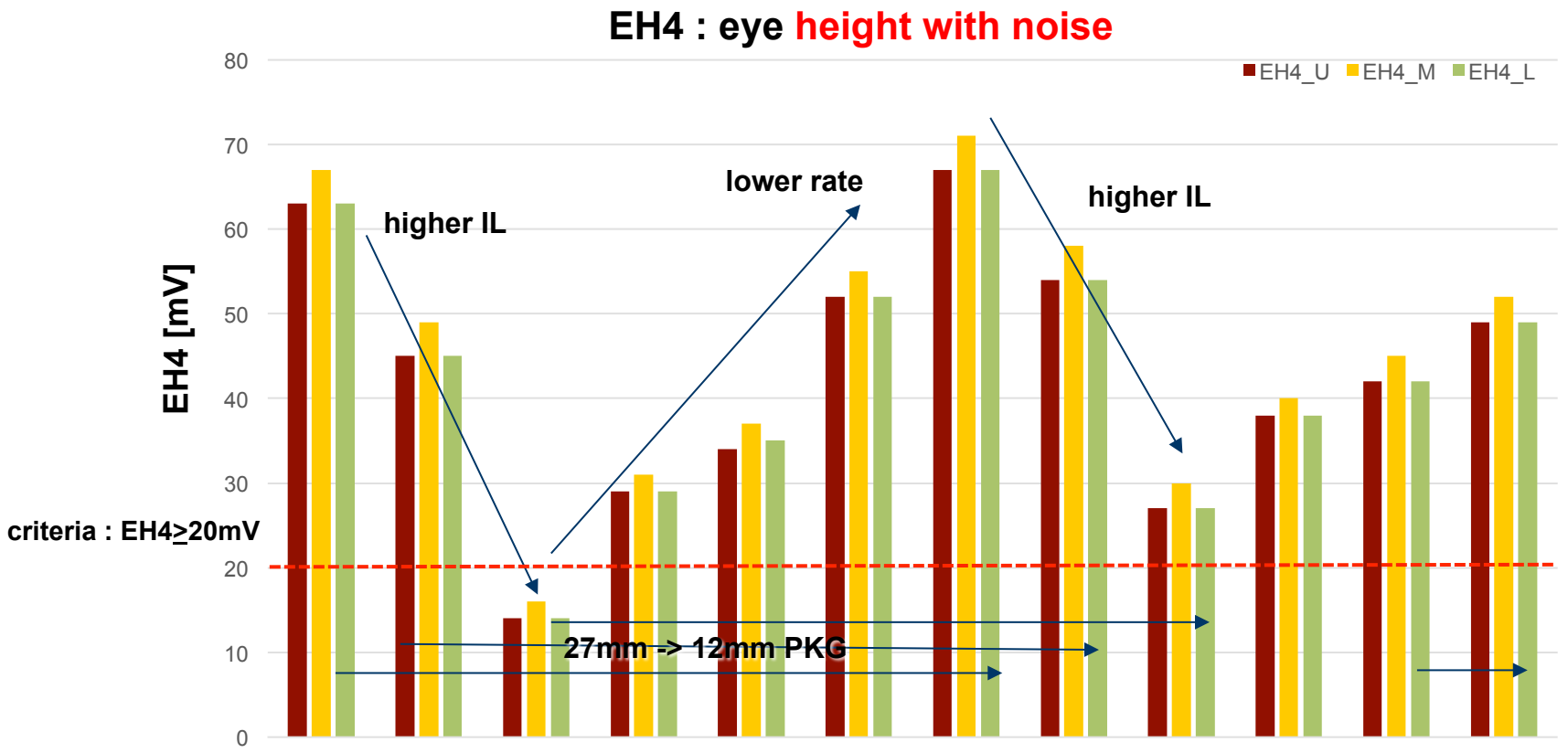
	#1	#2	#3	#4	#5	#6	#7	#8	#9	#10	#11	#12
Gbd	56			53.125	52	48	56			58		
channel	1m(A)	2m(B)	3m(C)				1m(A)	2m(B)	3m(C)	2m(B)		
IL [dB]	33.2	39.2	45.1	43.2	42.4	39.7	28.4	34.4	40.3	40.4		35.4
PKG [mm]	27						12			27		12
FFE	54 / 5 (total/pre)										106/5	

A-2.2.4 Simulation Summary



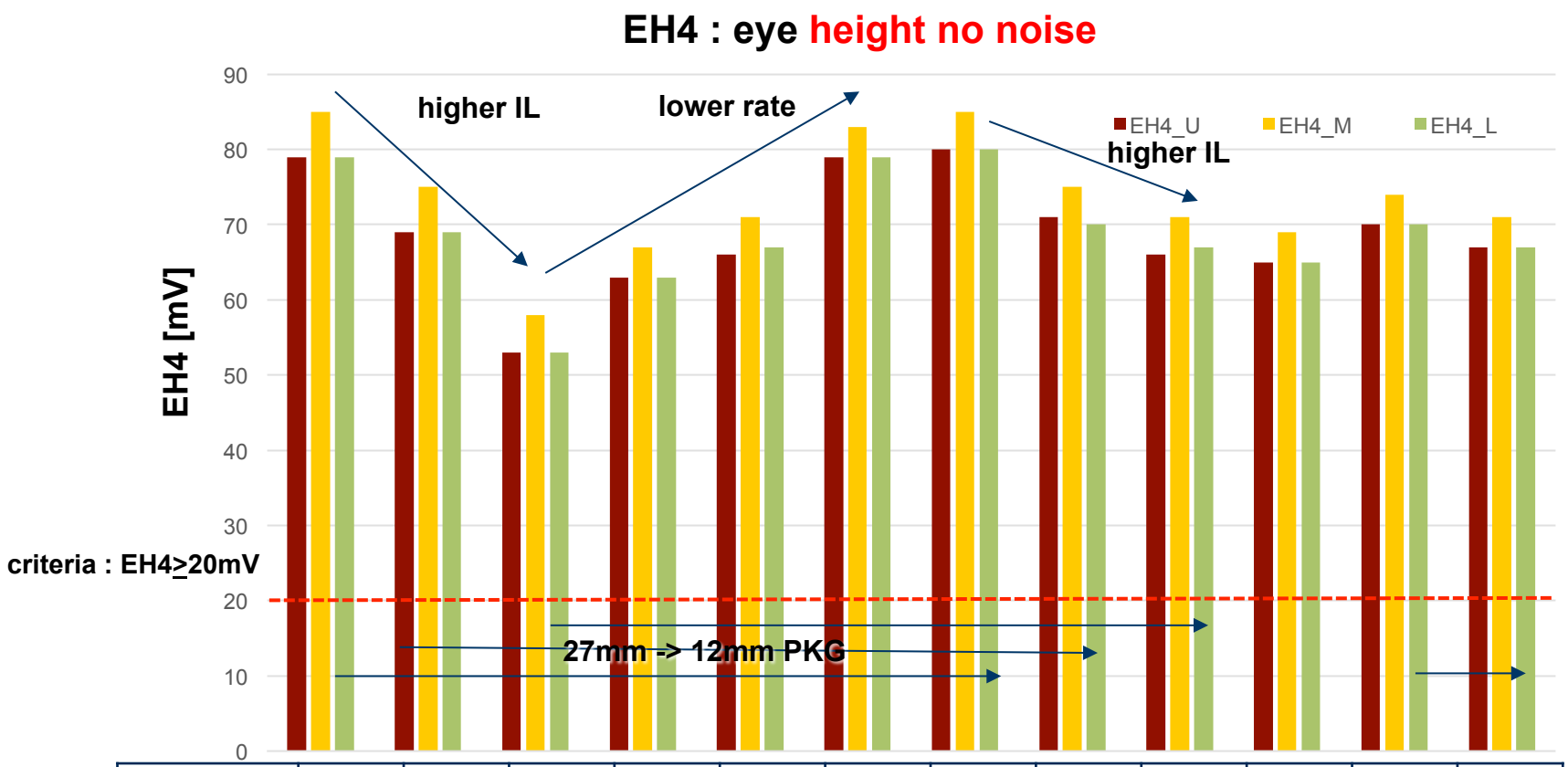
	#1	#2	#3	#4	#5	#6	#7	#8	#9	#10	#11	#12
Gbd	56			53.125	52	48	56			58		
channel	1m(A)	2m(B)	3m(C)				1m(A)	2m(B)	3m(C)	2m(B)		
IL [dB]	33.2	39.2	45.1	43.2	42.4	39.7	28.4	34.4	40.3	40.4		35.4
PKG [mm]	27						12			27		12
FFE	54 / 5 (total/pre)										106/5	

A-2.2.4 Simulation Summary



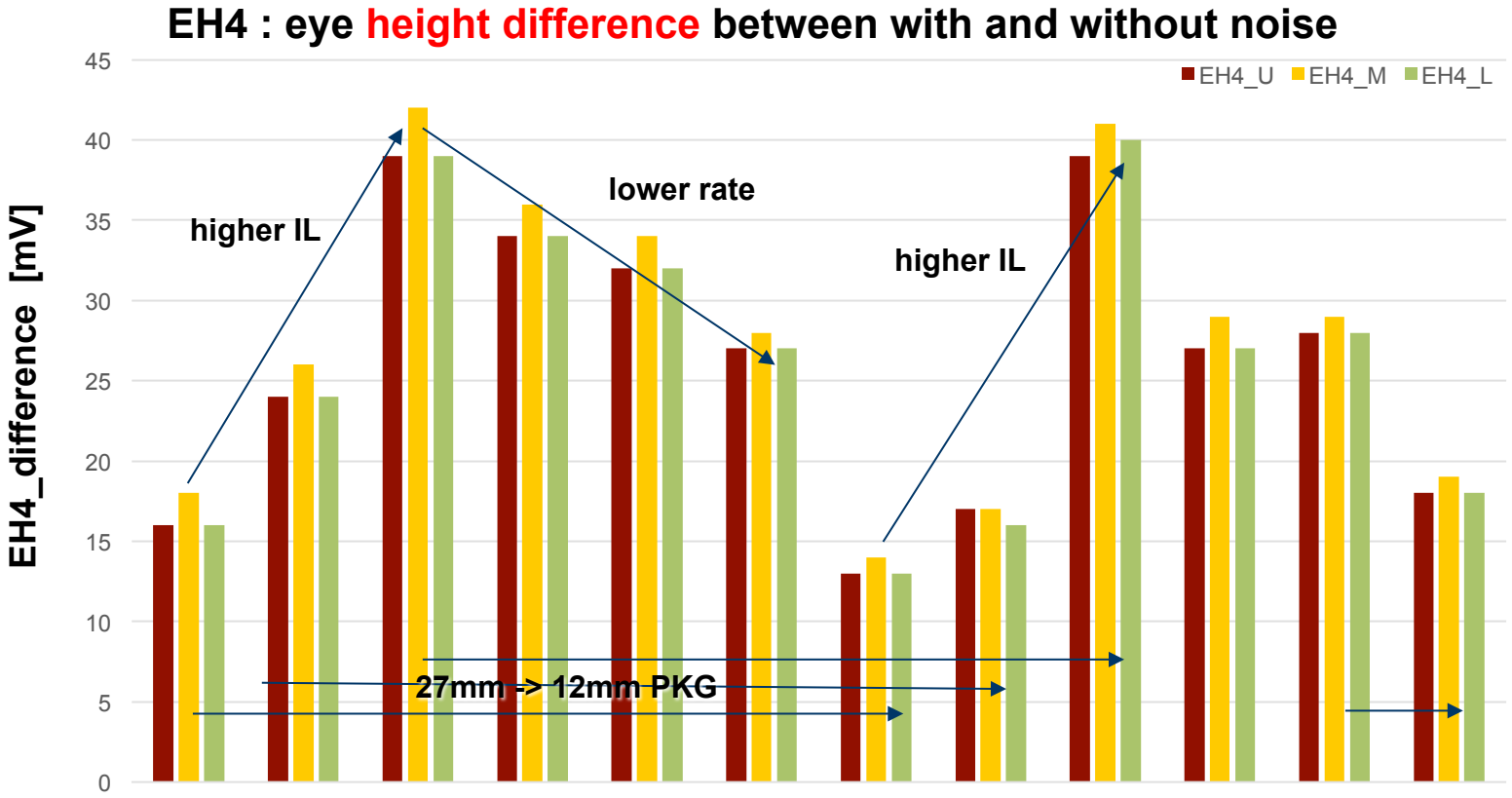
	#1	#2	#3	#4	#5	#6	#7	#8	#9	#10	#11	#12
Gbd	56			53.125	52	48	56			58		
channel	1m(A)	2m(B)	3m(C)				1m(A)	2m(B)	3m(C)	2m(B)		
IL [dB]	33.2	39.2	45.1	43.2	42.4	39.7	28.4	34.4	40.3	40.4		35.4
PKG [mm]	27						12			27		12
FFE	54 / 5 (total/pre)										106/5	

A-2.2.4 Simulation Summary



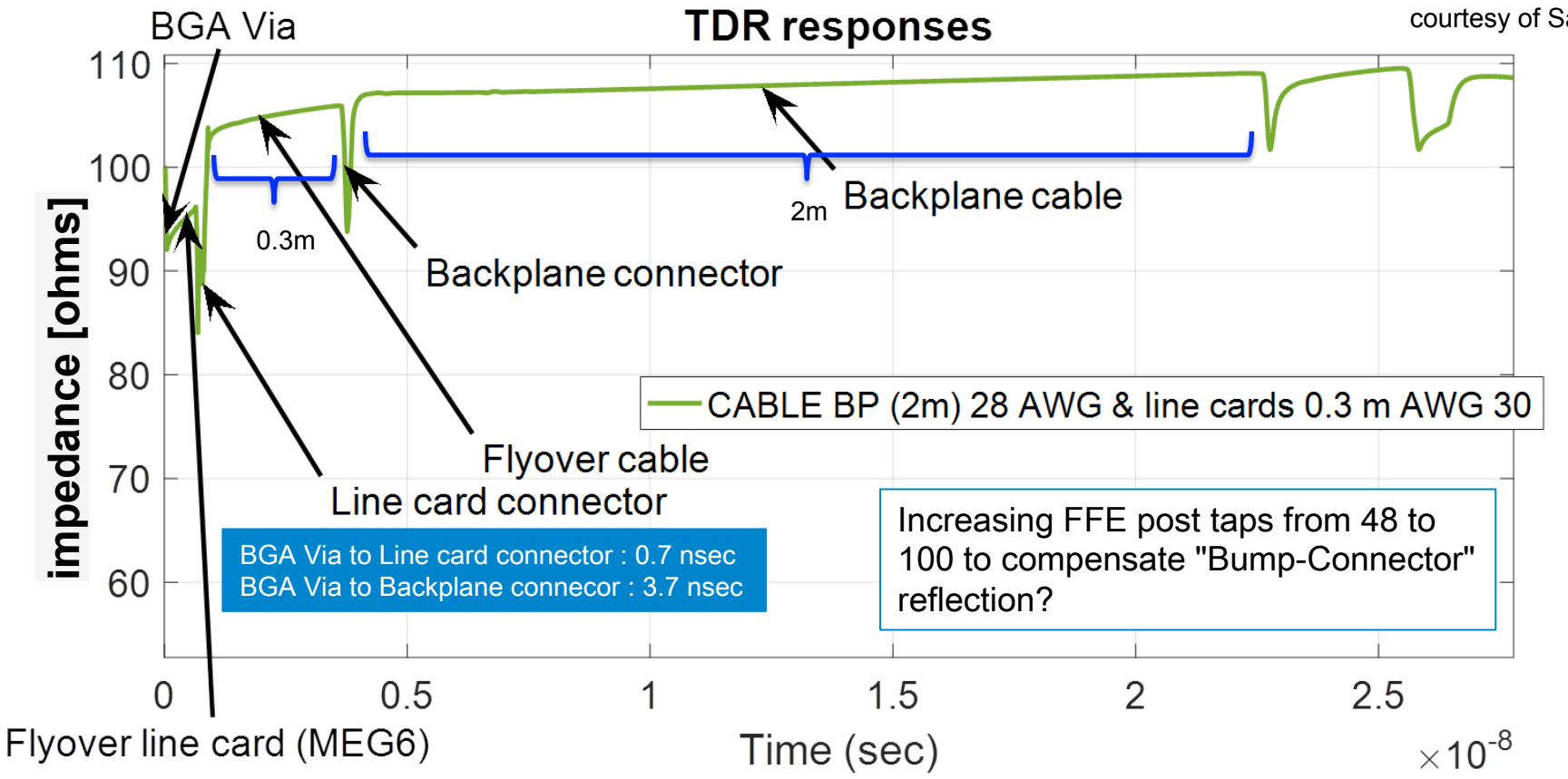
	#1	#2	#3	#4	#5	#6	#7	#8	#9	#10	#11	#12
Gbd	56			53.125	52	48	56			58		
channel	1m(A)	2m(B)	3m(C)				1m(A)	2m(B)	3m(C)	2m(B)		
IL [dB]	33.2	39.2	45.1	43.2	42.4	39.7	28.4	34.4	40.3	40.4		35.4
PKG [mm]	27						12			27		12
FFE	54 / 5 (total/pre)										106/5	

A-2.2.4 Simulation Summary

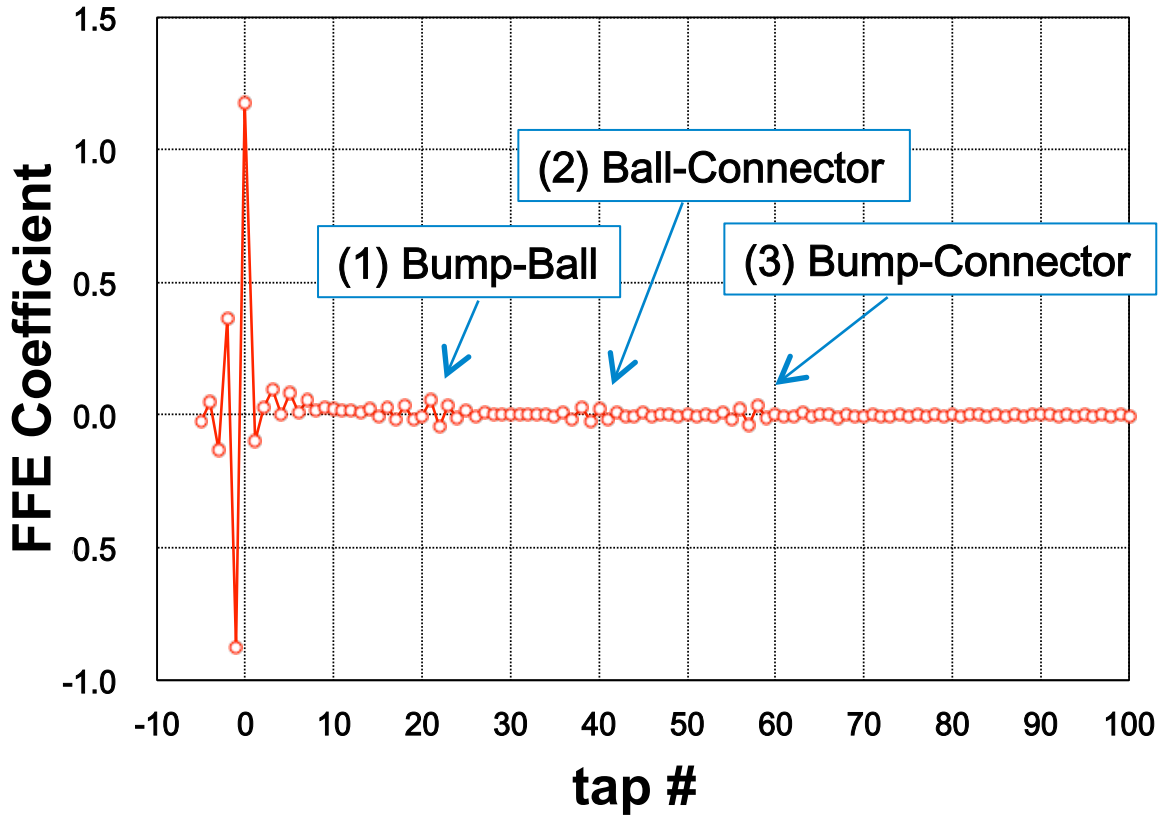


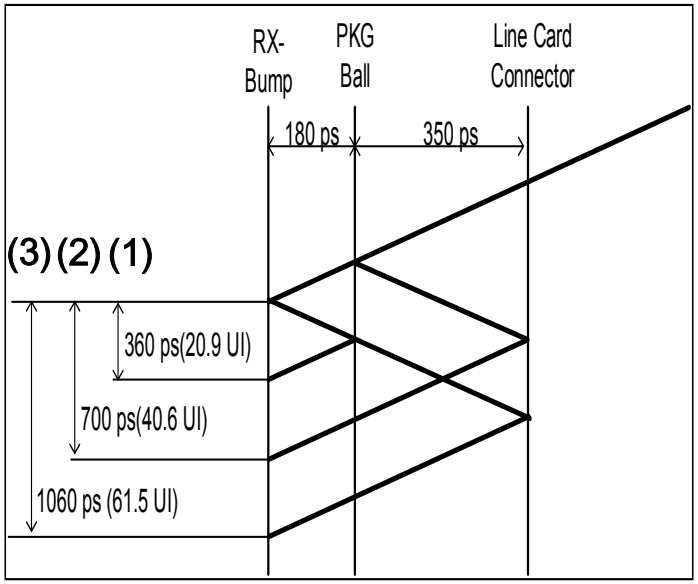
	#1	#2	#3	#4	#5	#6	#7	#8	#9	#10	#11	#12
Gbd	56			53.125	52	48	56			58		
channel	1m(A)	2m(B)	3m(C)				1m(A)	2m(B)	3m(C)	2m(B)		
IL [dB]	33.2	39.2	45.1	43.2	42.4	39.7	28.4	34.4	40.3	40.4		35.4
PKG [mm]	27						12			27		12
FFE	54 / 5 (total/pre)										106/5	

A-2.2.5 number of FFE taps?



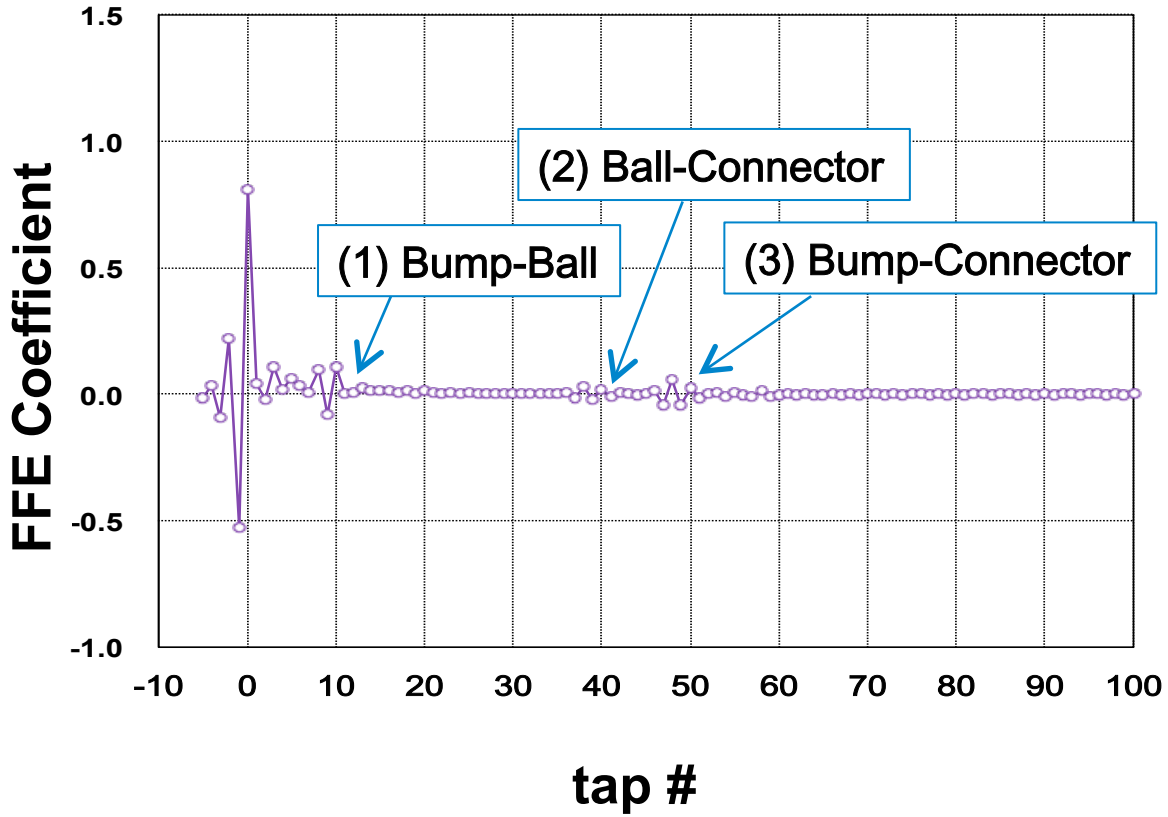
A-2.2.5 FFE tap effect (2m cable, 27mm PKG, #11)

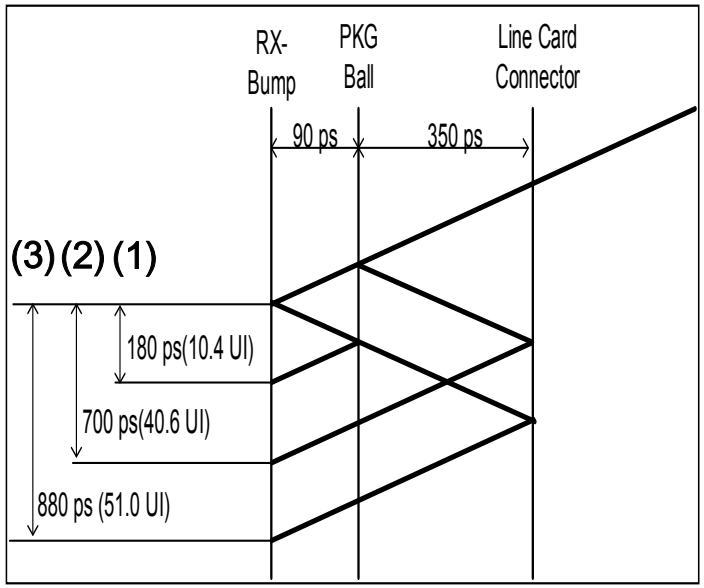




Increasing FFE post taps from 48 to 100 to compensate “(3) Bump-Connector" reflection, but the effect is limited.

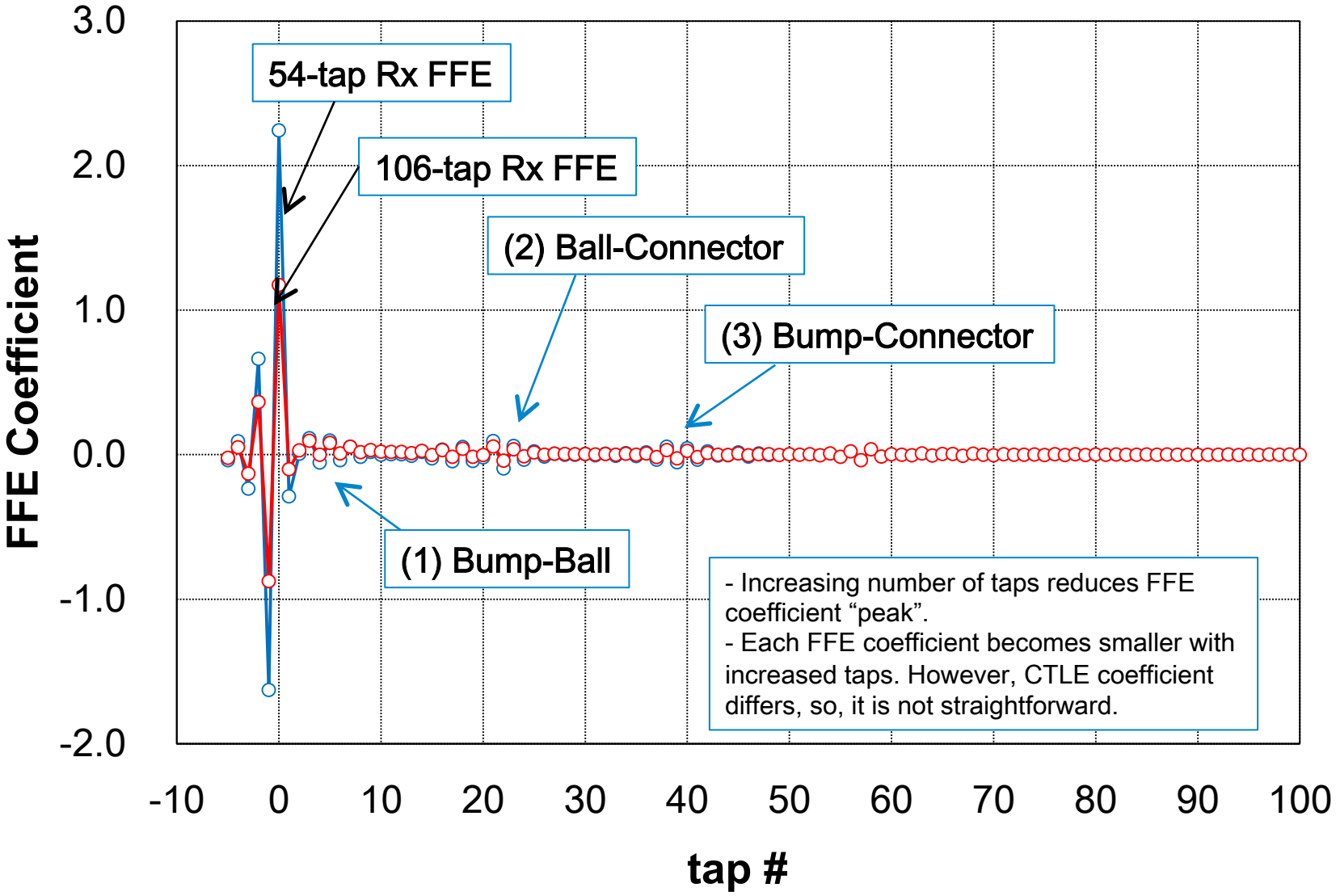
A-2.2.5. FFE tap effect (2m cable, 12mm PKG, #12)





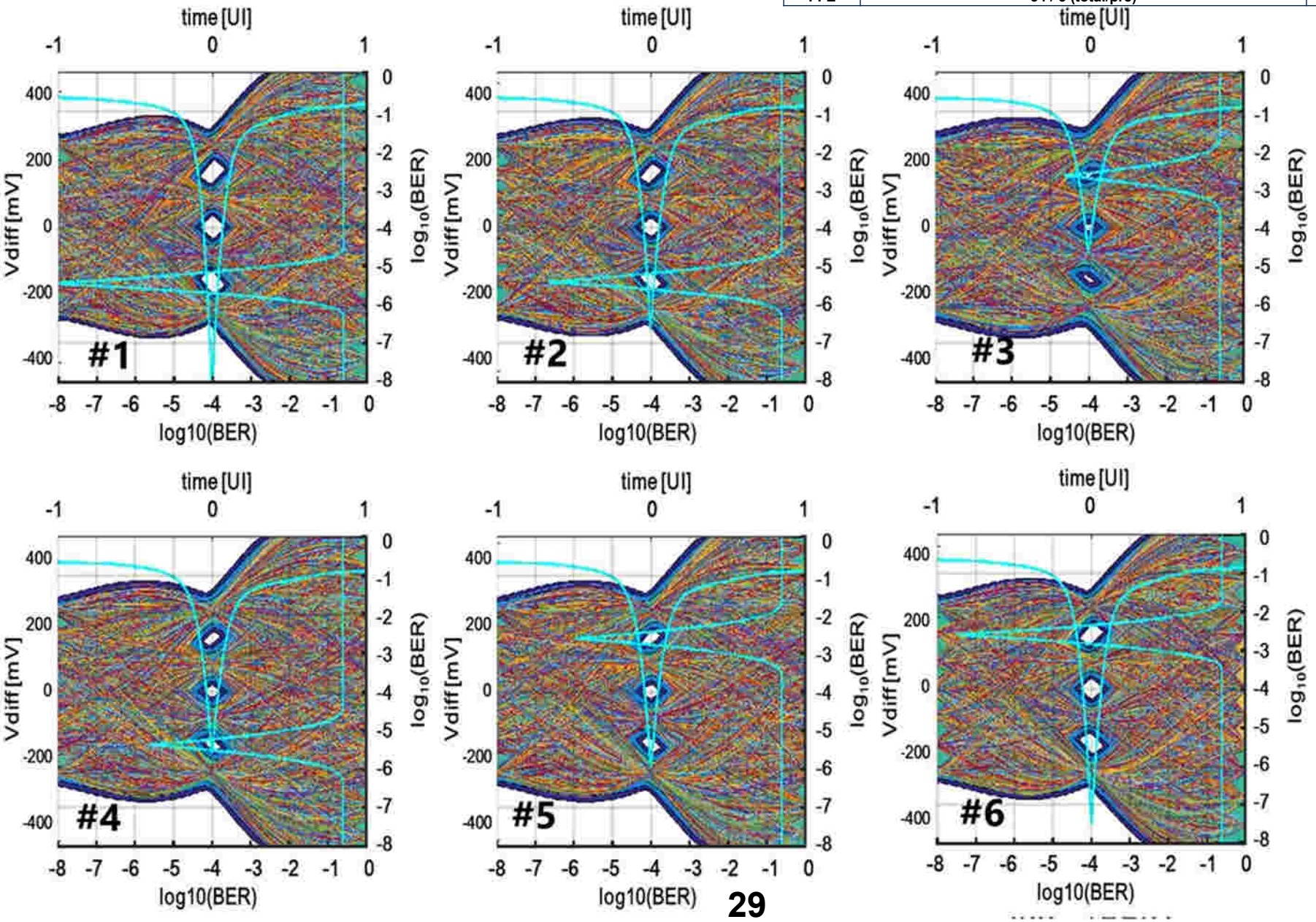
Increasing FFE post taps from 48 to 100 to compensate “(3) Bump-Connector" reflection, but the effect is limited.

A-2.2.5 FFE tap effect (2m cable, 27mm PKG, #10/11)



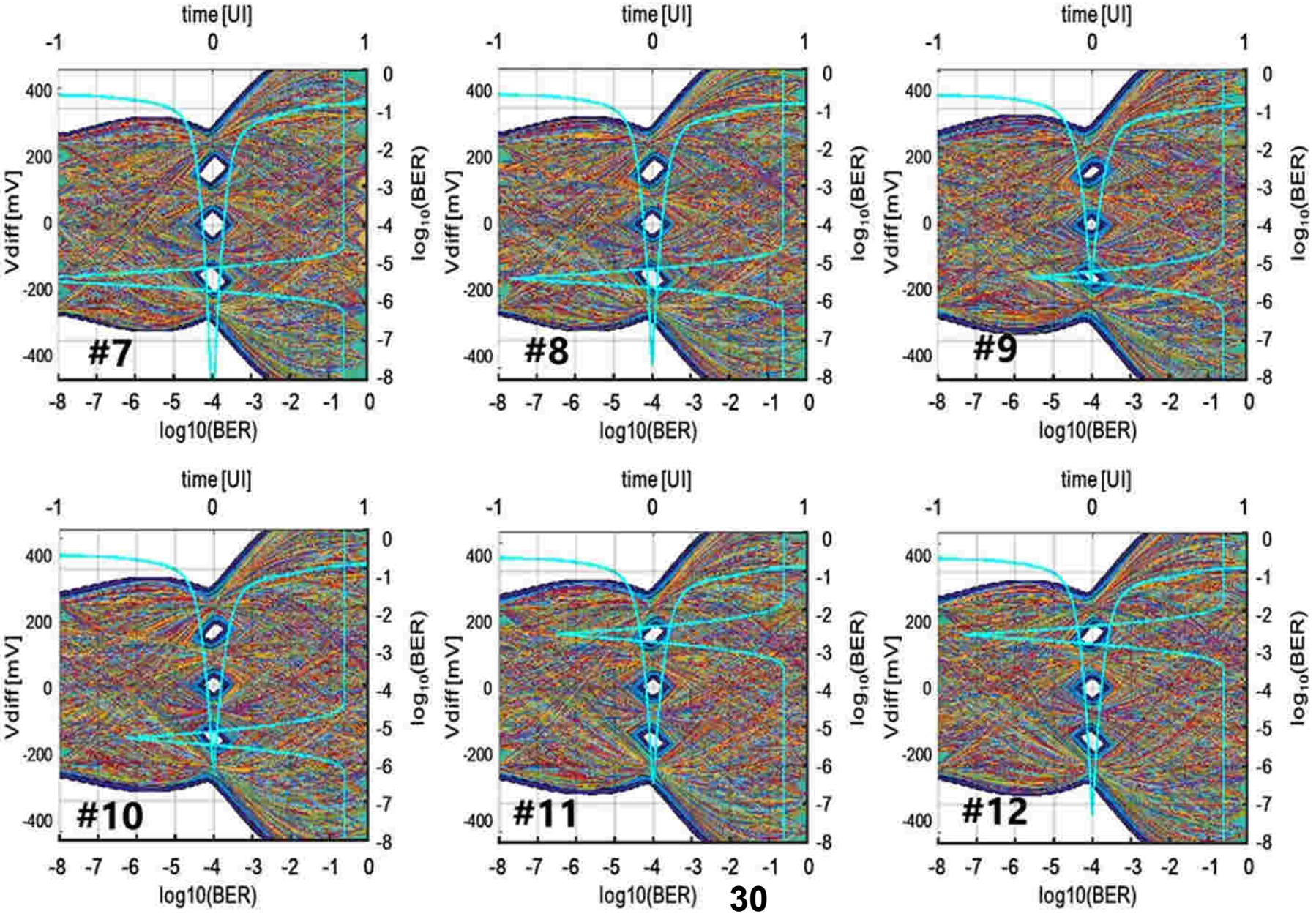
A-2.2.A Simulation Result (#1~#6)

	#1	#2	#3	#4	#5	#6	#7	#8	#9	#10	#11	#12
Gbd	56			53.125	52	48	56			58		
channel	1m(A)	2m(B)	3m(C)				1m(A)	2m(B)	3m(C)	2m(B)		
IL [dB]	33.2	39.2	45.1	43.2	42.4	39.7	28.4	34.4	40.3	40.4		35.4
PKG [mm]	27						12			27		12
FFE	54 / 5 (total/pre)										106/5	



A-2.2.A Simulation Result (#7~#12)

	#1	#2	#3	#4	#5	#6	#7	#8	#9	#10	#11	#12
Gbd	56			53.125	52	48	56			58		
channel	1m(A)	2m(B)	3m(C)				1m(A)	2m(B)	3m(C)	2m(B)		
IL [dB]	33.2	39.2	45.1	43.2	42.4	39.7	28.4	34.4	40.3	40.4		35.4
PKG [mm]	27						12			27		12
FFE	54 / 5 (total/pre)										106/5	



socionext™
for better quality of experience

back up slides

- A-2.1 scaled PCB backplane
- A-2.2 cabled backplane
- A-2.3 PCB (Tachyon) backplane

A-2.3 PCB (Tachyon) backplane

1. PCB (Tachyon) backplane models were open to public on 01/03/2018. (by Samtec)

   http://www.ieee802.org/3/100GEL/public/adhoc/jan03_18/mellitz_100GEL_adhoc_01_010318.pdf
   - http://www.ieee802.org/3/100GEL/public/tools/backplane/mellitz_100GEL_adhoc_02_010318.zip
   - http://www.ieee802.org/3/100GEL/public/tools/backplane/mellitz_100GEL_adhoc_03_010318.zip
   - http://www.ieee802.org/3/100GEL/public/tools/backplane/mellitz_100GEL_adhoc_04_010318.zip

2. Additional simulations were run using these channels.
   - PCB (Tachyon) backplanes have similar channel insertion loss, but higher xtalk results worse eye opening than cabled backplane. (13" PCB vs 2m cabled)
   - Also, 13" PCB backplane may be too short for practical usage.

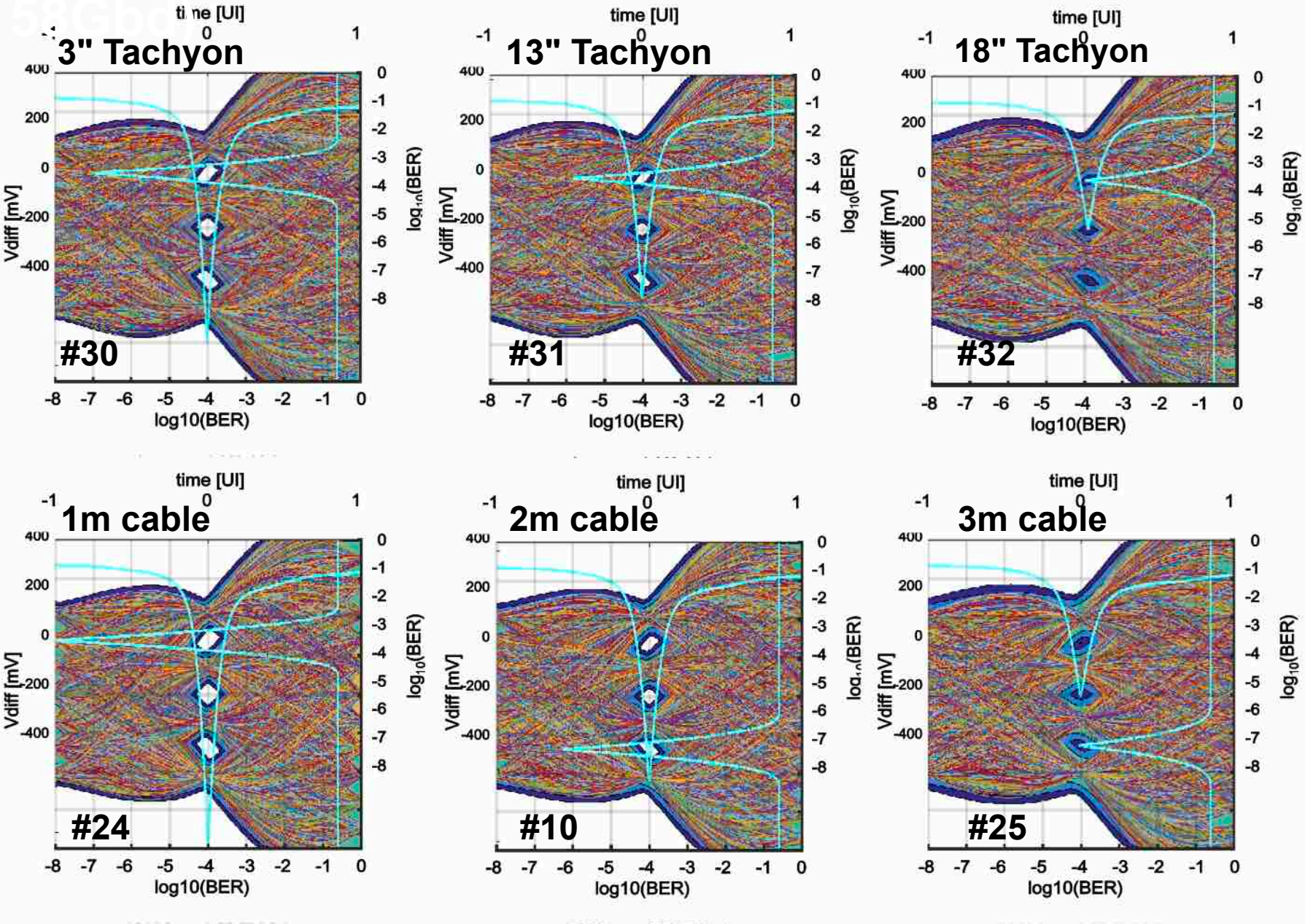
A-2.3.2 PCB backplane simulation result (1/2)

item		unit		#30	#30'	#31	#31'	#32	#32'
baud rate		Gbd		58					
channel	type	PCB (Tachyon) BP		3" (7.6cm)		13" (33cm)		18" (45.7cm)	
	IL	w/ PKG	dB	26.6		38.0		43.3	
		no PKG		17.0		28.4		33.7	
	xtalk	PSXT [dB]		-41.6		-45.6		-46.1	
Tx	FFE	tap/pre		1/0					
	RJrms	[mUI]		10					
	SNR	[dB]		32.5	N/A	32.5	N/A	32.5	N/A
Tx/Rx	PKG	trace [mm]		27					
Rx	CTLE	HF		2p/1z					
		LF		1p/1z					
	eta0	V^2/GHz		1.64E-8	0	1.64E-8	0	1.64E-8	0
	fr			x 3/8	N/A	x 3/8	N/A	x 3/8	N/A
	FFE	tap/pre		54/5					
	DFE	tap		1					
	RJrms	mUI		10					
eye	width EW4	upp	mUI	104	117	78	105	0	53
		mid		151	167	120	151	19	88
		low		110	126	80	106	4	59
	height EH4	upp	mV	50	60	30	45	0	17
		mid		56	67	34	49	1	19
		low		51	61	31	46	1	20

A-2.3.2 PCB backplane simulation result (2/2)

item		unit		#30	#30'	#24	#24'	#31	#31'	#10	#10'	#32	#32'	#25	#25'
baud rate		Gbd		58											
channel	type	BP		3" (PCB, 7.6cm)		1m (cabled)		13" (PCB, 33cm)		2m (cabled)		18" (45.7cm)		3m (cabled)	
	IL	w/ PKG	dB	26.6		34.3		38.0		40.4		43.3		46.5	
		no PKG		17.0		24.4		28.4		30.3		33.7		36.6	
	xtalk	PSXT [dB]		-41.6		-49.6		-45.6		-54.0		-46.1		-58.0	
Tx	FFE	tap/pre		1/0											
	RJrms	[mUI]		10											
	SNR	[dB]		32.5	N/A	32.5	N/A	32.5	N/A	32.5	N/A	32.5	N/A	32.5	N/A
Tx/Rx	PKG	trace [mm]		27											
Rx	CTLE	HF		2p/1z											
		LF		1p/1z											
	eta0	V^2/GHz		1.64E-8	0	1.64E-8	0	1.64E-8	0	1.64E-8	0	1.64E-8	0	1.64E-8	0
	fr			x 3/8	N/A	x 3/8	N/A	x 3/8	N/A	x 3/8	N/A	x 3/8	N/A	x 3/8	N/A
	FFE	tap/pre		54/5											
	DFE	tap		1											
	RJrms	mUI		10											
eye	width EW4	upp	mUI	104	117	120	145	78	105	93	138	0	53	6	107
		mid		151	167	158	187	120	151	131	182	19	88	38	154
		low		110	126	121	146	80	106	93	137	4	59	6	108
	height EH4	upp	mV	50	60	58	75	30	45	38	65	0	17	1	45
		mid		56	67	61	80	34	49	40	69	1	19	4	49
		low		51	61	58	76	31	46	38	65	1	20	1	45

A-2.3.2 Simulation Result (PCB-BP Tachyon,



socionext™
for better quality of experience

- references

References

1. Richard Mellitz, et al, "Working Towards 100Gbs Serial Electrical Channel Technical Feasibility", mellitz_nea_01a_0517.pdf
http://www.ieee802.org/3/ad_hoc/ngrates/public/17_05/mellitz_nea_01a_0517.pdf
channel models :
http://www.ieee802.org/3/ad_hoc/ngrates/public/17_05/mellitz_nea_02_0517.zip
http://www.ieee802.org/3/ad_hoc/ngrates/public/17_05/mellitz_nea_03_0517.zip
http://www.ieee802.org/3/ad_hoc/ngrates/public/17_05/mellitz_nea_04_0517.zip

2. Tom Palkert, et al, "SERDES for 100Gbps", palkert_nea_02_0517.pdf
http://www.ieee802.org/3/ad_hoc/ngrates/public/17_05/palkert_nea_02_0517.pdf

3. Phil Sun, "100Gb/s Single-lane SERDES Discussion", sun_nea_01a_0517.pdf
http://www.ieee802.org/3/ad_hoc/ngrates/public/17_05/sun_nea_01a_0517.pdf

4. Joel Goergen, "The Reality of Channels Operating at 100Gbps", goergen_nea_01_0517.pdf
http://www.ieee802.org/3/ad_hoc/ngrates/public/17_05/goergen_nea_01_0517.pdf

5. Rob Stone, "100G Electrical Interfaces in the Datacenter Desirable Solution Attributes", stone_nea_01a_0517.pdf
http://www.ieee802.org/3/ad_hoc/ngrates/public/17_05/stone_nea_01a_0517.pdf

6. Tom Palkert, et al, "Interconnect for 100G serial I/O ports", palkert_nea_01_0517.pdf
http://www.ieee802.org/3/ad_hoc/ngrates/public/17_05/palkert_nea_01_0517.pdf

7. Ali Ghiasi, "System Evolution with 100G Serial IO", ghiasi_nea_01a_0517.pdf
http://www.ieee802.org/3/ad_hoc/ngrates/public/17_05/ghiasi_nea_01a_0517.pdf

8. Beth Kochuparambil , "100Gb/s per Lane for Electrical Interfaces and Electrical PHYs Study Group: Status and Work**",** cfi_kochuparambil_01a_1217.pdf
http://www.ieee802.org/3/100GEL/public/kochuparambil_100GEL_adhoc_01_1217.pdf

9. Mark Gustlin, et al, "100Gb/s Electrical Links System View", ofelt_100GEL_adhoc_01_1217.pdf
http://www.ieee802.org/3/100GEL/public/ofelt_100GEL_adhoc_01_1217.pdf

socionext™

for better quality of experience