C2M Channel Analysis Trends Suggesting COM Parameters Path Forward

Richard Mellitz, Samtec
Mike Dudek, Marvel

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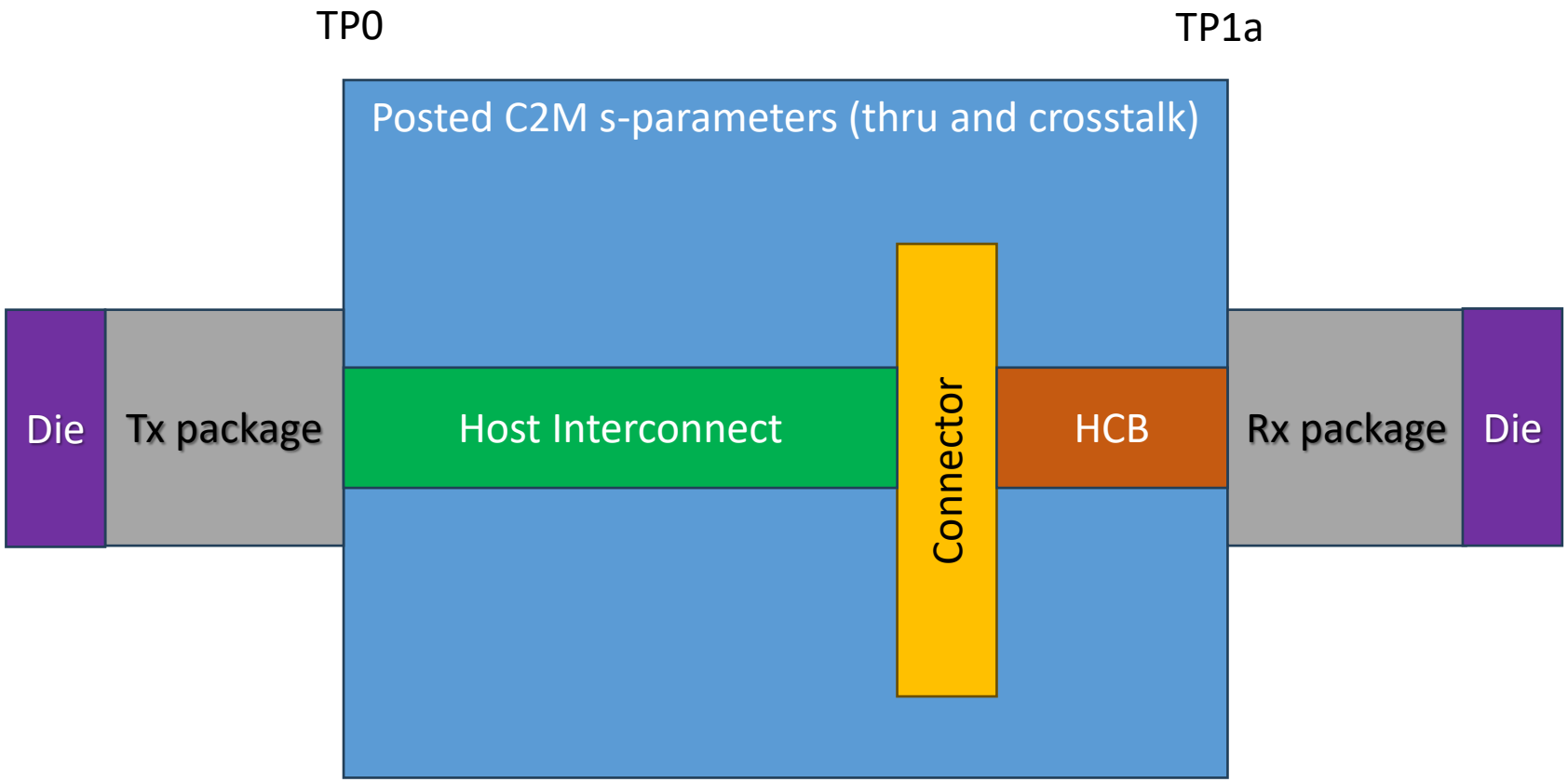
Agenda

- ❑ Investigation Highlights
- ❑ General C2M diagram
- ❑ COM parameters
- ❑ COM results for all posted channels
- ❑ Discussion/Summary

Investigation of the effect of some parameters on COM

- IL die to die loss
  - Shave down posted channels to manageable target selection
  - Die to tp1a loss is 2.4 dB less than die to die loss for this presentation
- Number of Rx FFE taps
  - Floating taps?
- Noise
  - Impact?

COM interconnect diagram



COM Interaction Experiments

- ❑ Compute COM for all posted C2M channels
- ❑ Use a module Rx package model
  - 2.4 dB
- ❑ Vary host package loss to get a rich set of channel loss
  - 2.4 dB, 5.7 dB, 7 dB, and 9.1 dB
- ❑ Pre cursor Rx FFE taps set to 6.
- ❑ Vary Rx FFE post cursor length (just “taps” for short)
  - 15, 24, 60, and 120 taps
- ❑ Vary eta_0 and DER_0

DER_0	eta_0 V^2/GHz
2.4e-04	6.0e-09
2.4e-04	1.25e-08
2.0e-05	6.0e-09
2.0e-05	1.25e-08

COM 4.1 Configuration Highlights

- ❑ Die to die computation (not VEC)
- ❑ Termination impedance (R_d): 45 Ohms
- ❑ RLM = 0.95, SNRTX=33 dB, Add = 0.02 UIpk, sRJ = 0.01 UIRMS
- ❑ Ideal source 20 % - 80 % Rise/Fall Time (T_r): 4.0 ps
- ❑ TX FIR: 2-pre, 0-post
- ❑ Unity gain CTLE (mellitz_3dj_01a_2305, set 2)
- ❑ fr= 0.58 fb
- ❑ Package: benartsi_3df_01a_2211
  - Pkg lengths: 8 mm, 24 mm, 30 mm, 40 mm
  - Respective Loss: 2.4 dB, 5.7 dB, 7 dB, and 9.1 dB
- ❑ Die: mli_3df_02_220316

How many taps? C2M base configuration

FFE_POST_TAP_LEN = 15, 24, 60, 120 (TAPS)

Table 93A-1 parameters			
Parameter	**Setting**	**Units**	**Information**
f_b	106.25	GBd	
f_min	0.05	GHz	
Delta_f	0.01	GHz	
C_d	[0.4e-4 0.9e-4 1.1e-4 ;0.4e-4 0.9e-4 1.1e-4]	nF	[TX RX]
L_s	[0.13 0.15 0.14; 0.13 0.15 0.14]	nH	[TX RX]
C_b	[0.3e-4 0.3e-4]	nF	[TX RX]
R_0	50	Ohm	
R_d	[45 45]	Ohm	[TX RX]
A_v	0.386	V	vp/vf=
A_fe	0.386	V	vp/vf=
A_ne	0.6	V	
L	4		
M	32		
filter and Eq			
f_r	0.58	*fb	
c(0)	0.55		min
c(-1)	[-0.3:0.05:0]		[min:step:max]
c(-2)	[0:.05:0.1]		[min:step:max]
c(-3)	0		[min:step:max]
c(-4)	0		[min:step:max]
c(1)	0		[min:step:max]
N_b	1	UI	
b_max(1)	0.75		As/dffe1
b_max(2..N_b)	0.3		As/dfe2..N_b
b_min(1)	0		As/dffe1
b_min(2..N_b)	-0.15	S	As/dfe2..N_b
g_DC	[-15:1:-3]	dB	[min:step:max]
f_z	25.16	GHz	
f_p1	40.00	GHz	
f_p2	56.00	GHz	
g_DC_HP	[-5:1:0]		[min:step:max]
f_HP_PZ	1.328125	GHz	

I/O control		
DIAGNOSTICS	1	logical
DISPLAY_WINDOW	1	logical
CSV_REPORT	1	logical
RESULT_DIR	.\results\C2M_{date}\	
SAVE_FIGURES	0	logical
Port Order	**[1 3 2 4]**	
RUNTAG	C2M TP1a_COM_model	
COM_CONTRIBUTION	1	logical
TDR and ERL options		
TDR	1	logical
ERL	1	logical
ERL_ONLY	0	ns
TR_TDR	0.01	
N	3000	logical
TDR_Butterworth	1	
beta_x	0	
rho_x	0.618	
TDR_W_TXPKG	0	UI
N_bx	0	
fixture delay time	[0 0]	
Tukey_Window	1	
Noise, jitter		
sigma_RJ	0.01	UI
A_DD	0.02	UI
eta_0	1.25E-08	V^2/GHz
SNR_TX	33	dB
R_LM	0.95	

benartsi_3df_01a_2211
mli_3df_02_220316
minutes_3cwdfdj_2309_unapproved

Table 93A–3 parameters			
Parameter	**Setting**	**Units**	Information
package_tl_gamma0_a1_a2	[0 0.0008455 0.000340225]		
package_tl_tau	0.00644805	ns/mm	
package_Z_c	[92 92 ; 70 70; 80 80; 100 100]	Ohm	
z_p select	[1 2 3 4]		[test cases to run]
z_p (TX)	[8 24 30 40 ; 1 1 1 1; 1 1 1 1 ; 0.5 0.5 0.5 0.5]	mm	[test cases]
z_p (NEXT)	[8 8 8 8; 0 0 0 0 ;0 0 0 0 ;0 0 0 0]	mm	[test cases]
z_p (FEXT)	[8 24 30 40 ; 1 1 1 1; 1 1 1 1 ; 0.5 0.5 0.5 0.5]	mm	[test cases]
z_p (RX)	[8 8 8 8; 0 0 0 0 ;0 0 0 0 ;0 0 0 0]	mm	[test cases]
C_p	[0.5e-4 0.5e-4]	nF	[TX RX]
Filter: Rx FFE			
ffe_pre_tap_len	**6**	UI	
ffe_post_tap_len	15	UI	
ffe_tap_step_size	0		
ffe_main_cursor_min	0.7		
ffe_pre_tap1_max	0.7		
ffe_post_tap1_max	0.7		
ffe_tapn_max	0.7		
Operational			
ERL Pass threshold	10	dB	
COM Pass threshold	3	db	
VEC Pass threshold	10	db	
DER_0	2.50E-05		
T_r	4.00E-03	ns	
FORCE_TR	1	logical	
Min_VEO_Test	0	mV	
PMD_type	C2C		
EH_min	5	Value	
EH_max	1000	Value	
T_O	50	mUI	
samples_for_C2M	100	samples/UI	
ts_anchor	1		
sample_adjustment	[- 8 12]		
EW	1		
MLSE	0		
Local Search	2		

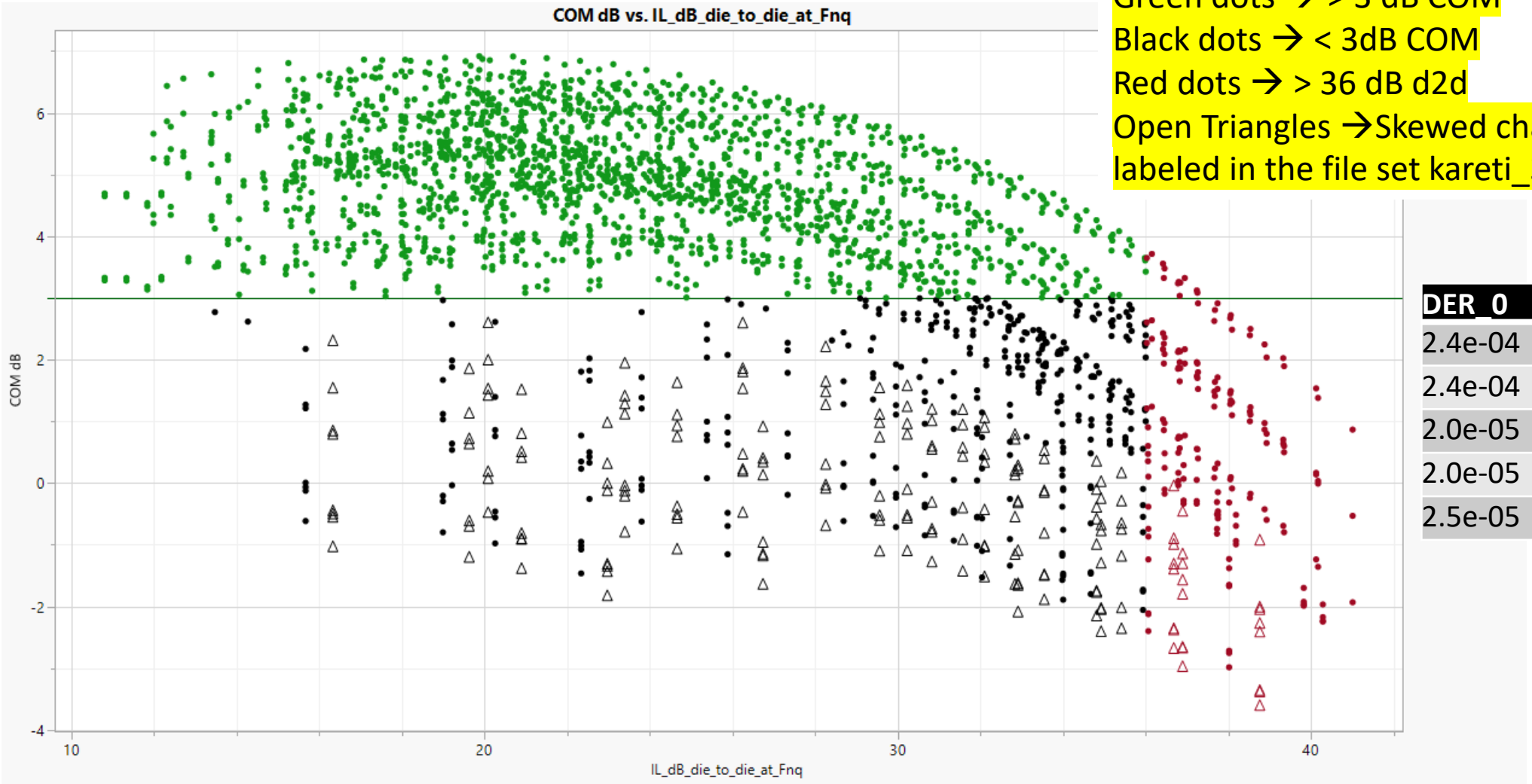
SAVE_CONFIG2MAT	1	
Receiver testing		
RX_CALIBRATION	0	logical
Sigma BBN step	5.00E-03	V
ICN parameters		
f_v	0.588	Fb
f_f	0.278	Fb
f_n	0.278	Fb
f_2	61.625	GHz
A_ft	0.450	V
A_nt	0.450	V

Parameter	**Setting**	
board_tl_gamma0_a1_a2	*[0 6.44084e-4 3.6036e-05]*	1.4 db/in @ 53.125G
board_tl_tau	*5.790E-03*	ns/mm
board_Z_c	100	Ohm
z_bp (TX)	*32*	mm
z_bp (NEXT)	*32*	mm
z_bp (FEXT)	*32*	mm
z_bp (RX)	*32*	mm
C_0	[0.2e-4 0]	nF
C_1	[0.2e-4 0]	nF
Include PCB	**0**	**logical**
Seletions (rectangle, gaussian,dual_rayleigh,triangle		
Histogram_Window_Weight	gaussian	selection
Qr	*0.02*	UI
Floating Tap Control		
N_bg	**0**	0 1 2 or 3 groups
N_bf	4	taps per group
N_f	80	UI span for floating taps
bmaxg	0.2	max DFE value for floating taps
B_float_RSS_MAX	0.1	rss tail tap limit
N_tail_start	16	(UI) start of tail taps limit

- ❑ Floating taps are not used for this set of experiments
- ❑ First determine how many Rx FFE taps are needed
  - Address floating taps base on those results

First look at the C2M channels

Green dots → > 3 dB COM
Black dots → < 3dB COM
Red dots → > 36 dB d2d
Open Triangles →Skewed channels as labeled in the file set kareti_3dj_02_2309



DER_0	eta_0 V²/GHz
2.4e-04	6.0e-09
2.4e-04	1.25e-08
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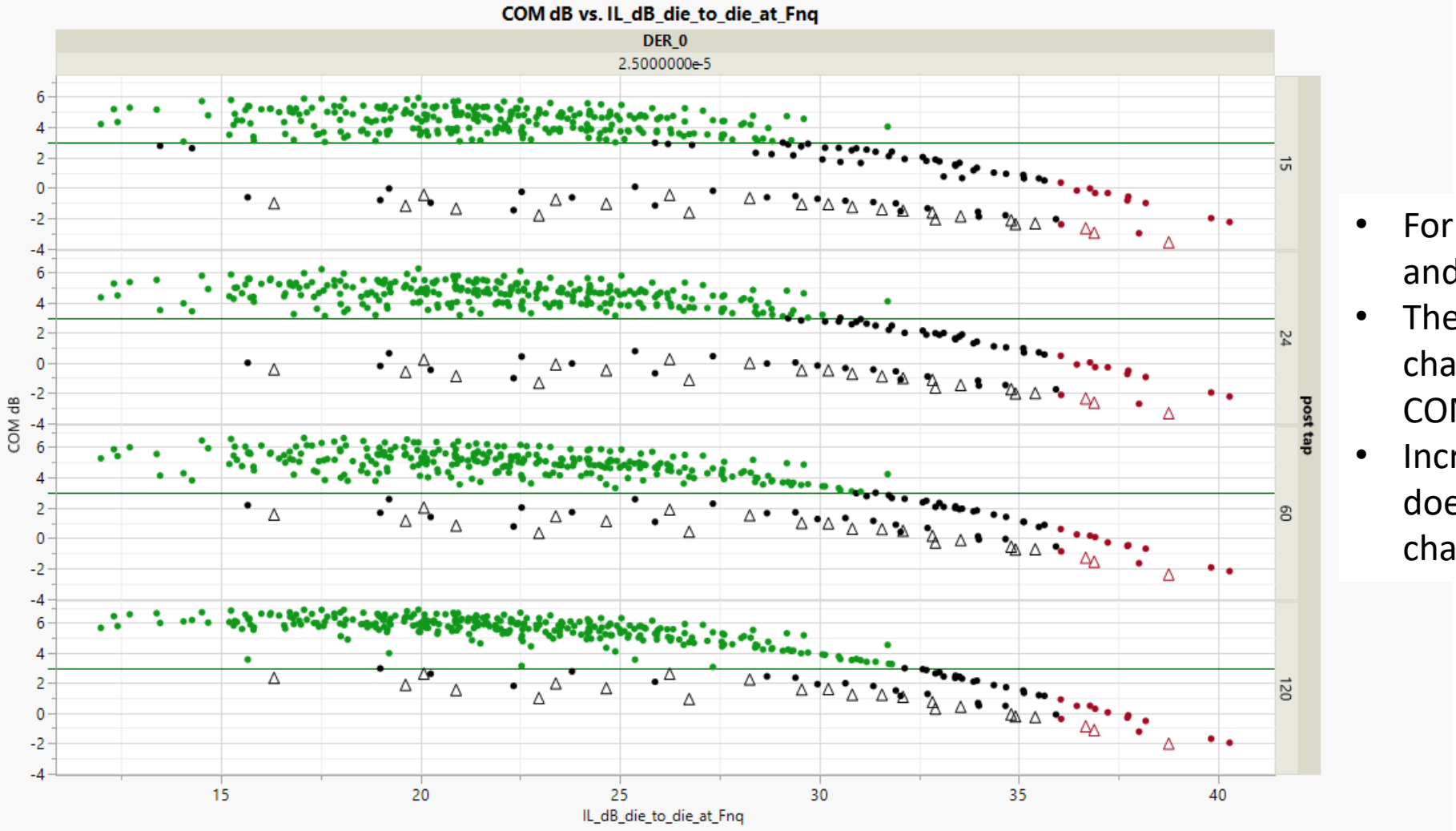
COM vs Rx FFE tap length (C2M)



- For this set of data, DER=2.5e-5 and eta0=1.25e-8 V^2/GHz
- The takeaway is that a lot of channels comfortably exceed 3 dB COM with 24 taps or less
- Increasing number of taps to 120 doesn't make 33 to 36dB loss channels pass

Recap of Sept. 2023 Interim Straw Poll

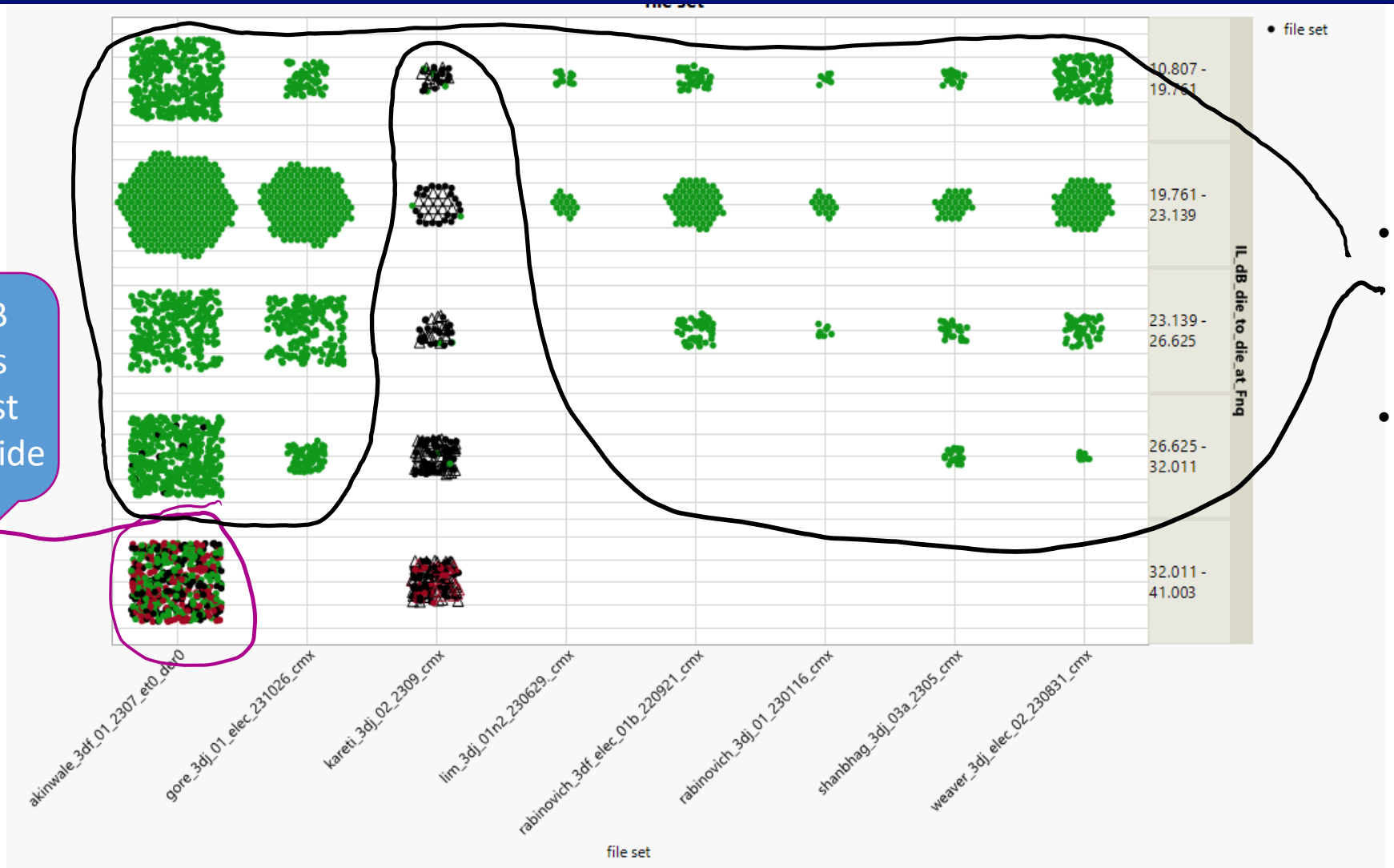
Straw Poll #14:
For the initial 200G/lane AUI C2M ILdd (die-die) target, I believe we should support losses of at least:

A. 26 dB
B. 28 dB
C. 30 dB
D. 32 dB
E. 34 dB
F. 36 dB
G. 38 dB

(Pick one)
Results (all): A: 0 , B: 4 , C: 13, D: 24, E: 9 , F: 16, G: 3

C2M Channel sets

THIS COLLECTION INCLUDES ALL RX FFE, PACKAGE, AND NOISE SELECTIONS

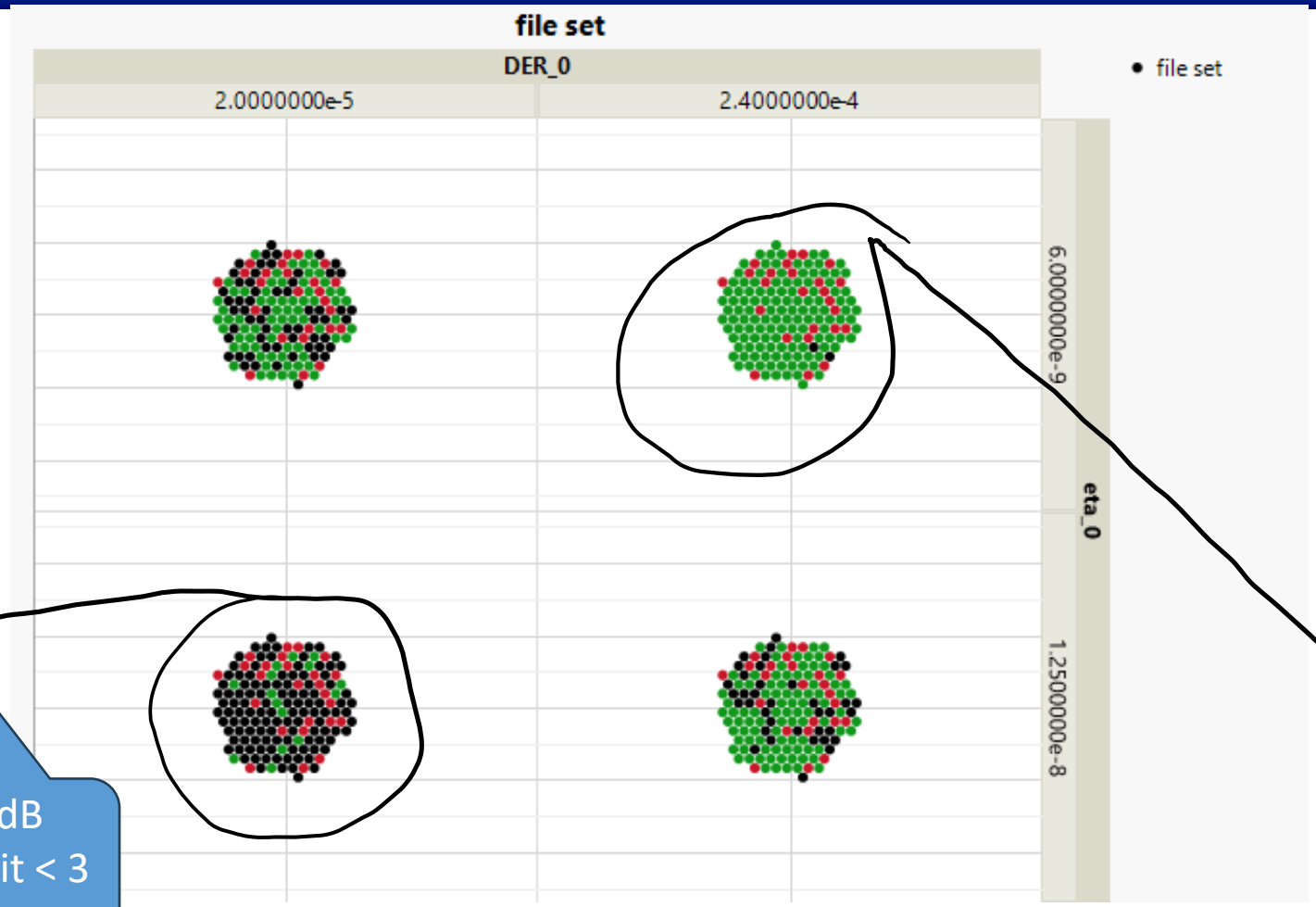


32-41 dB channels of interest See next slide

- 3 dB COM irrespective of Rx FFE post cursor tap choice, DER0, or ETA_0
- Includes all analyzed channels with die-to-die losses of < 32dB except Kareti skewed labeled channels

Channels with IL (die to die) 32 dB to 41 dB

24 RX FFE POST CURSOR TAPS USED IN THIS DATA SET

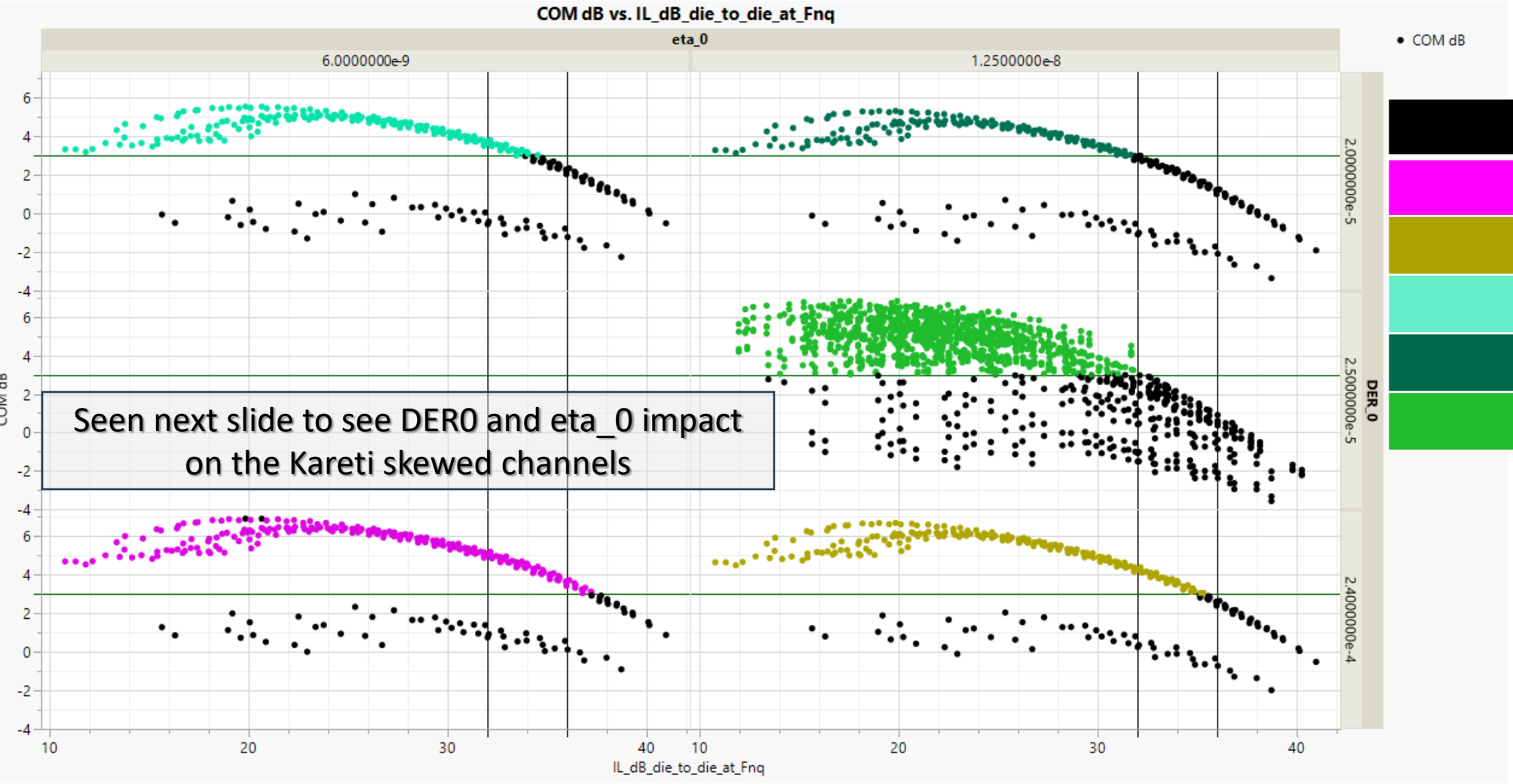


- Green > 3.0 dB COM
- Red > 36 dB ILdd
- Black <3 dB COM

Most 32-41 dB channels exceed 3 dB COM

Most 32-41 dB channels exhibit < 3 dB COM

eta_0 and DER_0: another view



	DER_0	eta_0
	2.4e-04	6.0e-09
	2.4e-04	1.25e-08
	2.0e-05	6.0e-09
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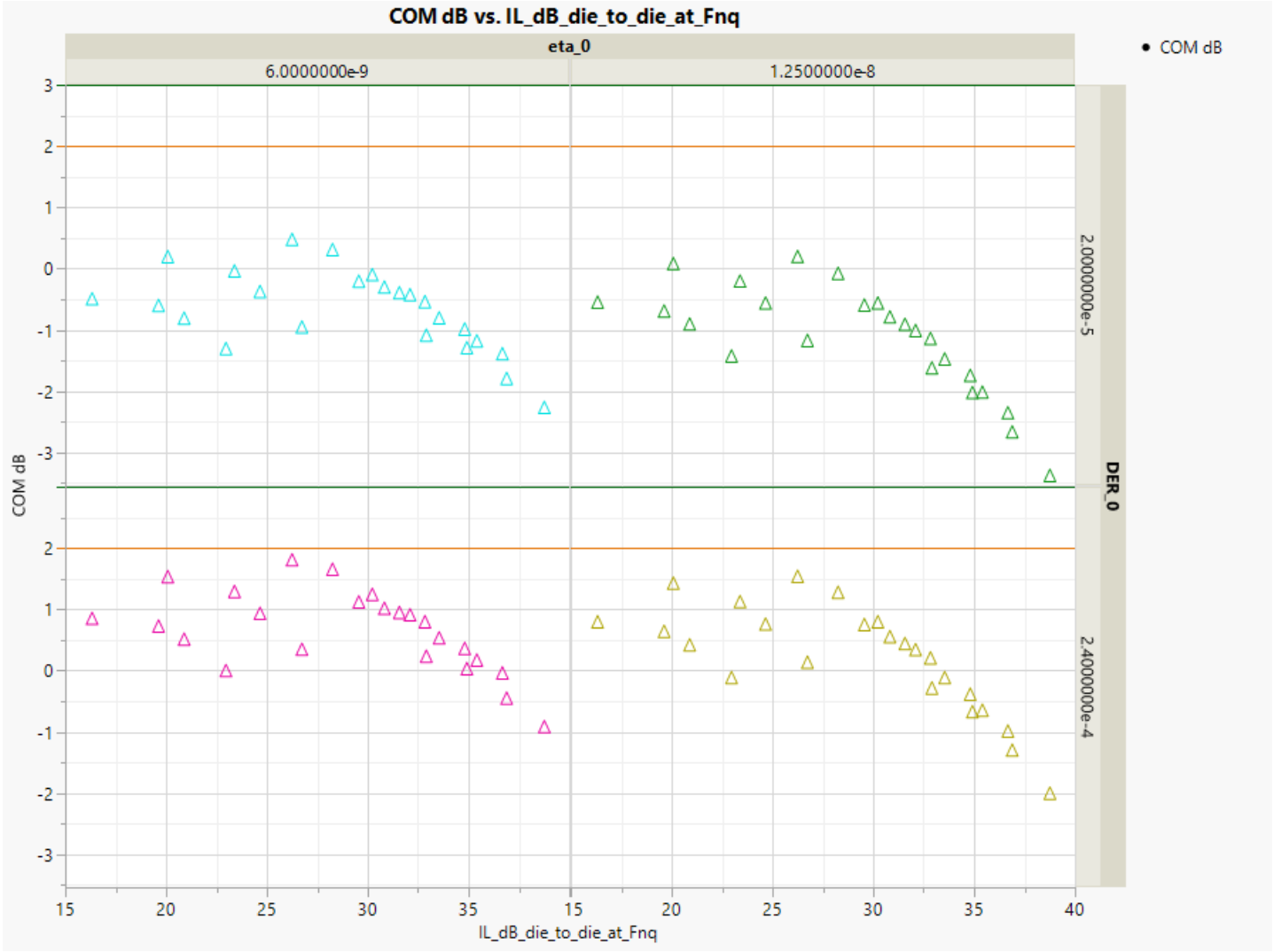
	2.5e-05	1.25e-08

eta_0 and DER_0 Impact on the Kareti Skew Labeled Channels



	DER_0	eta_0
	2.4e-04	6.0e-09
	2.4e-04	1.25e-08
	2.0e-05	6.0e-09
	2.0e-05	1.25e-08

Does not get to 3 dB COM

36 dB IL die to die is possible

- With DER0 and/or eta_0 improvements
- It's likely that MLSE could result achieving ILdd > 36 dB too
  - Work would be required here
- It's clear there are a few classes of channels
  1. Channels that exceed COM 3 dB with 24 or less taps and higher noise
  2. High loss channels that need some help to exceed 3.0 dB COM
  3. The Kareti skew channels, which have low COM at low insertion and at the moment, have no known antidote

Discussion/Summary

- Should 60+ taps be considered?
  - Can we settle on 24 tap?
- Should there be a few classes of C2M Rx?
- Is segmentation acceptable (relaxing DER0) for higher loss channels
- Is lower eta0 worth considering to achieve die to die loss of ~36 dB
- Next steps: Call for proposals
  - “first error” MLSE
  - Revisit Noise for C2M?
  - Need suggestions for sweep parameters for another set of COM runs

Thank You!