ERL Status: Next Decisions

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A Brief Recap of History.

- .3bj = SNDR included ISI
- .3bs = SNDR no longer included ISI
  - Introduce SNR_{ISI} but discovered not measurements sensitive enough
- .3cd = Introduce ERL to limit ISI

What does an ERL Value Mean?

- RL and ERL are already included in forward path measurements.
  - i.e. $1 + \rho$ is in IL, an eye diagram measurement, or COM
  - Where ρ is a reflection coefficient
- ERL can be of thought as an average statistically accumulated reflection
  - Defined for a signal pulse and is adjusted for coding (like PAM 4).
    - It is a singe value
  - A 10 dB ERL specification says about 32% of the pulse is traveling backwards.
    - In standard reference environments
  - That reflected pulse is not seen at the receiver until it is re-reflected.
    - That re-reflection is may be real small by the time it hits the original refection point on its way to the receiver. Typically less than a few percent of the original pulse.

What do we need for the standard?

- We really only need to know difference between a reference reflection and an actual one.

What needs to be specified?

- Test points
- Parameters for ERL are
  - N, β_x, ρ_x, N_{bx}. T_{fx}, and Z_t
- ERL min for PMDs

No change in procedure in 93.5A

ERL Status Overview

- No change in procedure in 93.5A
- Parameters for ERL are
  - N, β_x, ρ_x, N_{bx}. T_{fx}, and Z_t

So far

- Locked down β_x, ρ_x ,and Z_t for all PMDs
- User specifies T_{fx} to accommodate fixture
- N is determined from electrical length and f_{step}
  - Duration for TDR and PTDR in UI

Decisions

- N_{bx} and ERL min decision required
- N_{bx} is number of UIs which the gating and weighting function extend
  - Normally related to the number of DFE taps
  - Recommendation: Only used if the test point is Tp0 or Tp5
    - i.e. end of channel
- Can't determine ERL min until N_{bx} is set
  - Let's agree on parameter values and next we can set ERL min
- Address procedure for test points tp0a and tp5a

Adopt N is based on electrical length and min f_{step}

IEEE .3ck type	N	notes
Clause 162 CA Host	800	
Clause 162 CA	3500	Not much difference if N=7000 which requires f_{step} < 5 MHz
CL 163 KR device	200	
CL 163 KR channel	3500	
Annex 120F device	200	
Annex 120F channel	2000	
Annex 120G Host	800	
Annex 120G module	400	

Adopt N_{bx} is as follows

IEEE .3ck type	N_{bx}	note
Clause 162 CA Host	0	
Clause 162 CA	0	
CL 163 KR device	21 (N_b+N_{bg}*N_{bf})	
CL 163 KR channel	21 (N_b+N_{bg}*N_{bf})	Controversial
Annex 120F device	6 (N_b)	
Annex 120F channel	6 (N_b)	
Annex 120G Host	0	
Annex 120G module	0	Controversial But N_{bx} of 0,1,2,3 all have little impact on ERL.

CL 163 KR channel N_{bx} option

Option A:

- N_{bx} of 35 correlates best to channels which have reflections near the end of the channel
  - I.e. 40 UI from Tp0 or Tp5
  - See backup data
- N_{bx} of 35 may pass channel with considerable reflections up to 40 UI which could fail in a system
  - I.e. Beyond the capability of floating taps.

Option B

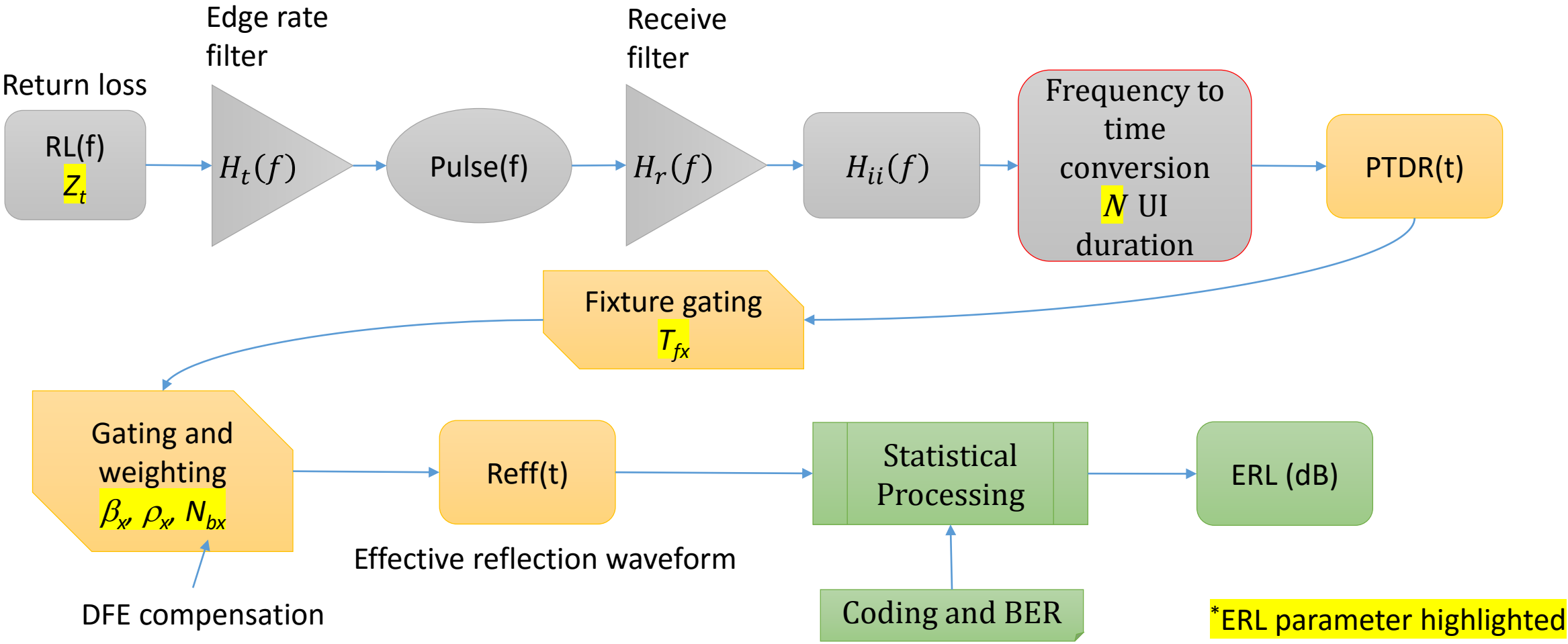
- N_{bx} of 21 is the conservative tact
  - The physical location would be a the bga interface just after the 30 mm package
  - Takes care of the device.

THANK YOU!

Backup

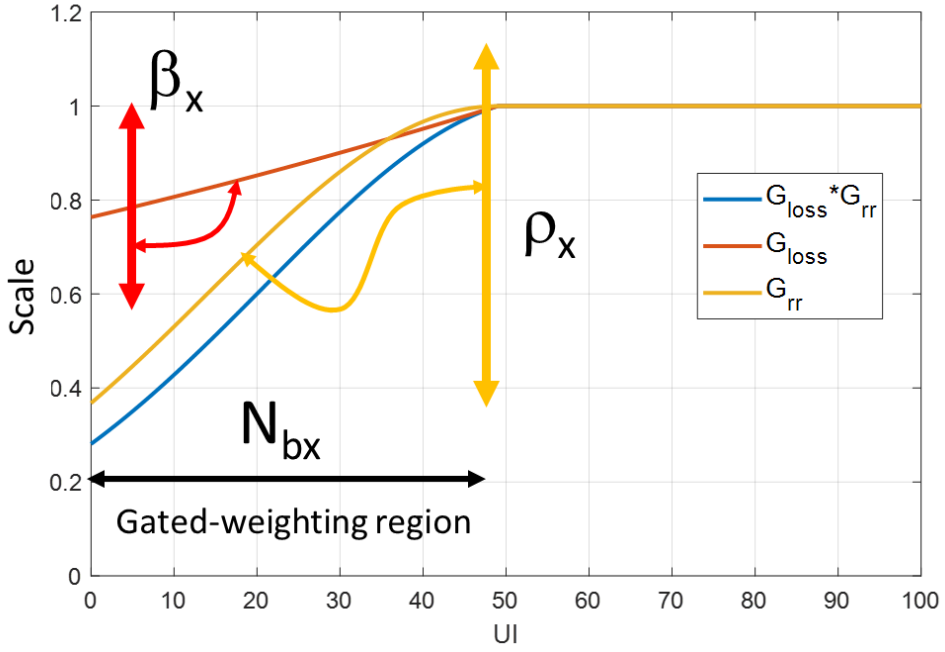
ERL Procedure review

ERL uses Pulse TDR … PTDR(t)



β_x and ρ_x Parameter Recommendation

- Lock down β_x and ρ_x
  - β_x = 0
  - ρ_x =0.618



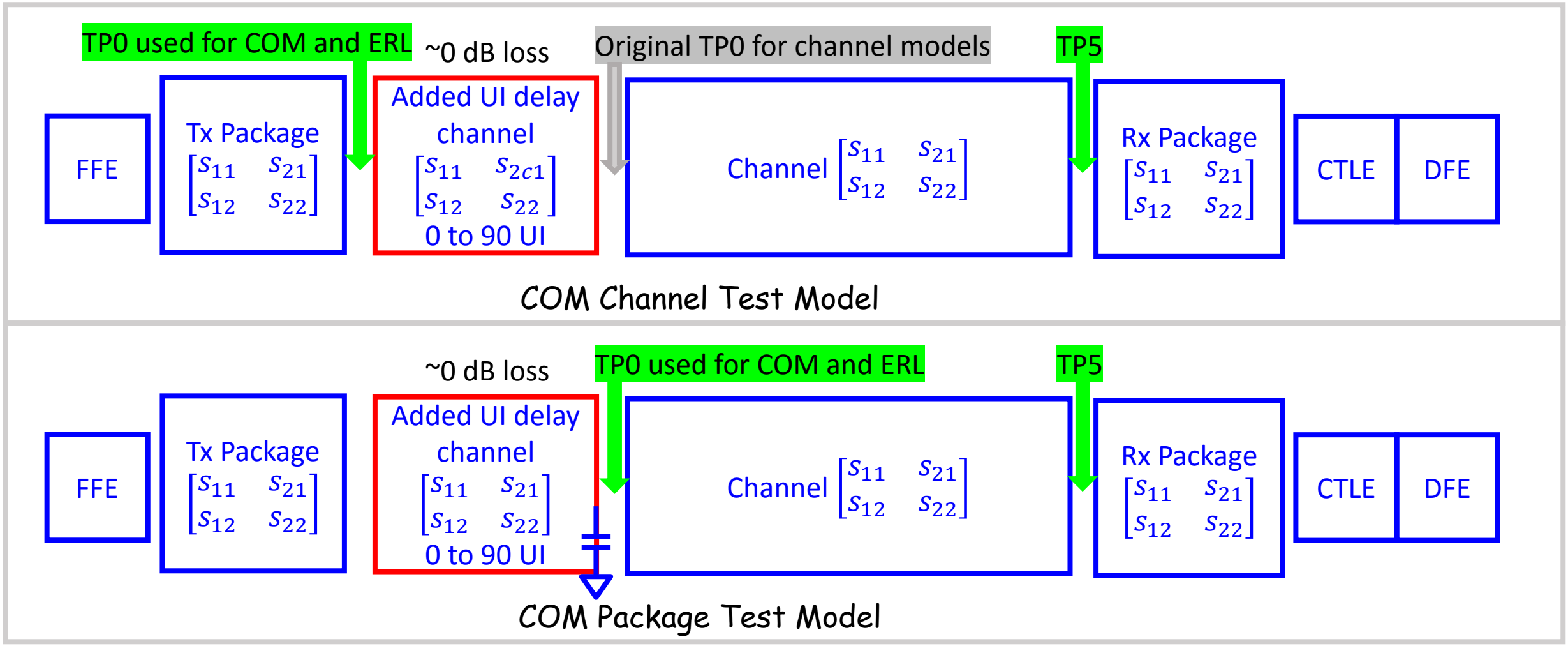
No change in [29] IEEE Std 802.3™-2018, IEEE Standard for Ethernet Annex 93A.5

$$G_{loss}(t) = \begin{cases} 0, & t > T_{fx} \\ 10^{\frac{\beta_x\left(t - T_{fx} - T_b(N_{bx}+1)\right)}{20}}, & T_{fx} \le t \le T_b(N_{bx}+1) + T_{fx} \\ 1, & otherwise \end{cases}$$

$$G_{rr}(t) = \begin{cases} 0, & t < T_{fx} \\ \rho_x(1+\rho_x)e^{-\frac{\left(\frac{t - T_{fx}}{T_b} - (N_{bx}+1)\right)^2}{(N_{bx}+1)^2}}, & T_{fx} \le t \le T_b(N_{bx}+1) + T_{fx} \\ 1, & otherwise \end{cases}$$

- Originally β_x and ρ_x represented an incremental loss factor of a package and permitted back re-reflection
- **Data suggested that the same effect may be achieved by locking down β_x and ρ_x merely adjusting the ERL limit**

Package and Channel COM added delay experiments: *Over 20 thousand simulations represented here*



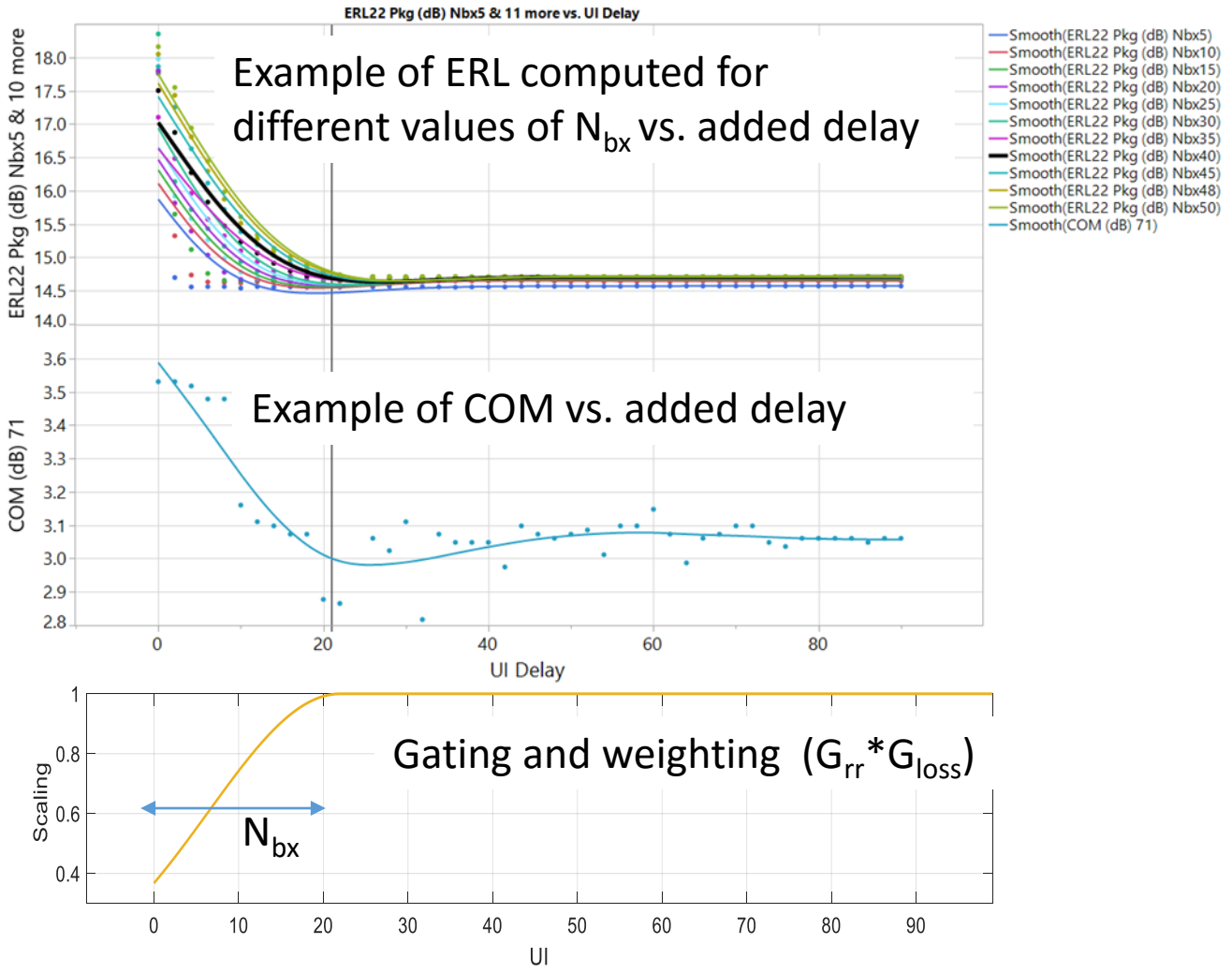
Determining N_{bx} is a correlation exercise

- COM is computed or ~30 selected channel models with `~30 delays
  - This is ~900 COM computations
- For each of the 900 COM computations ERL is computed for each of ~30 N_{bx} values
- The idea is to determine which N_{bx} correlates best to the computation set of ERL vs delay to COM vs delay

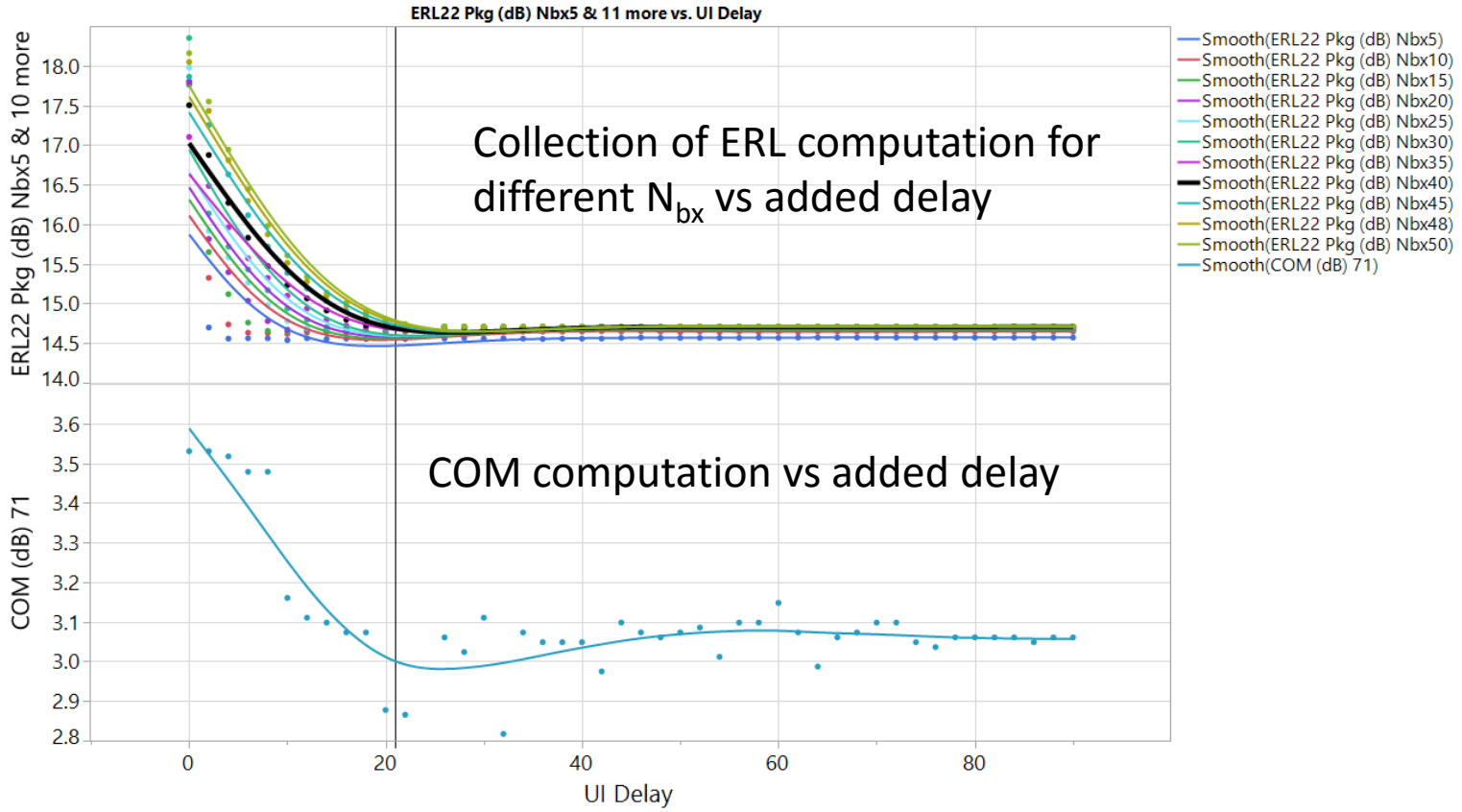
Experiments

How Well Does COM Track ERL?

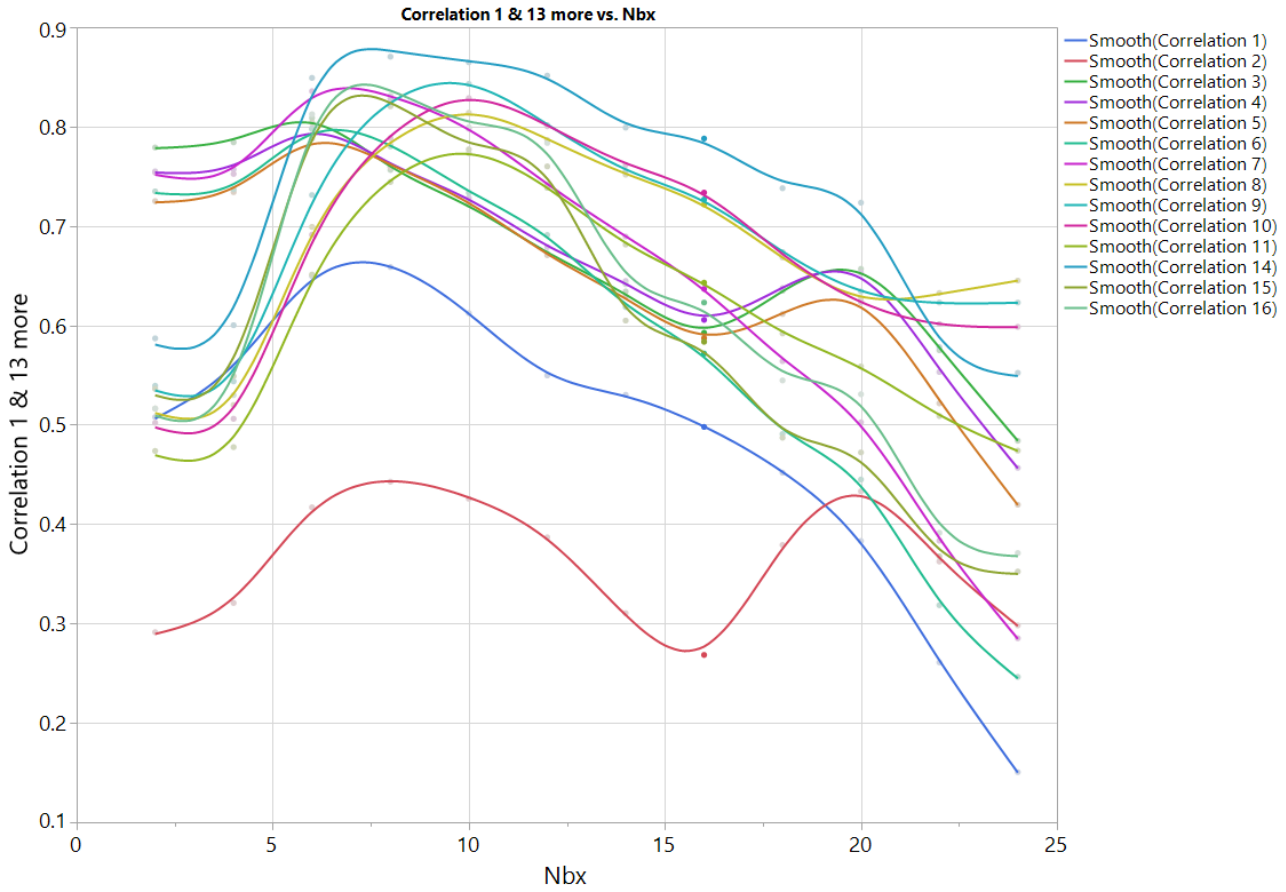
- COM tracks ERL when channel reflections are near the device transmitter or receiver.
  - The curve shape of ERL and COM vs. added delay are similar
  - See backup for added delay experiment (20K simulations)
  - The N_{bx} parameter is related of the equalizer (DFE) reach
  - The gating and weighting inversely track COM and ERL



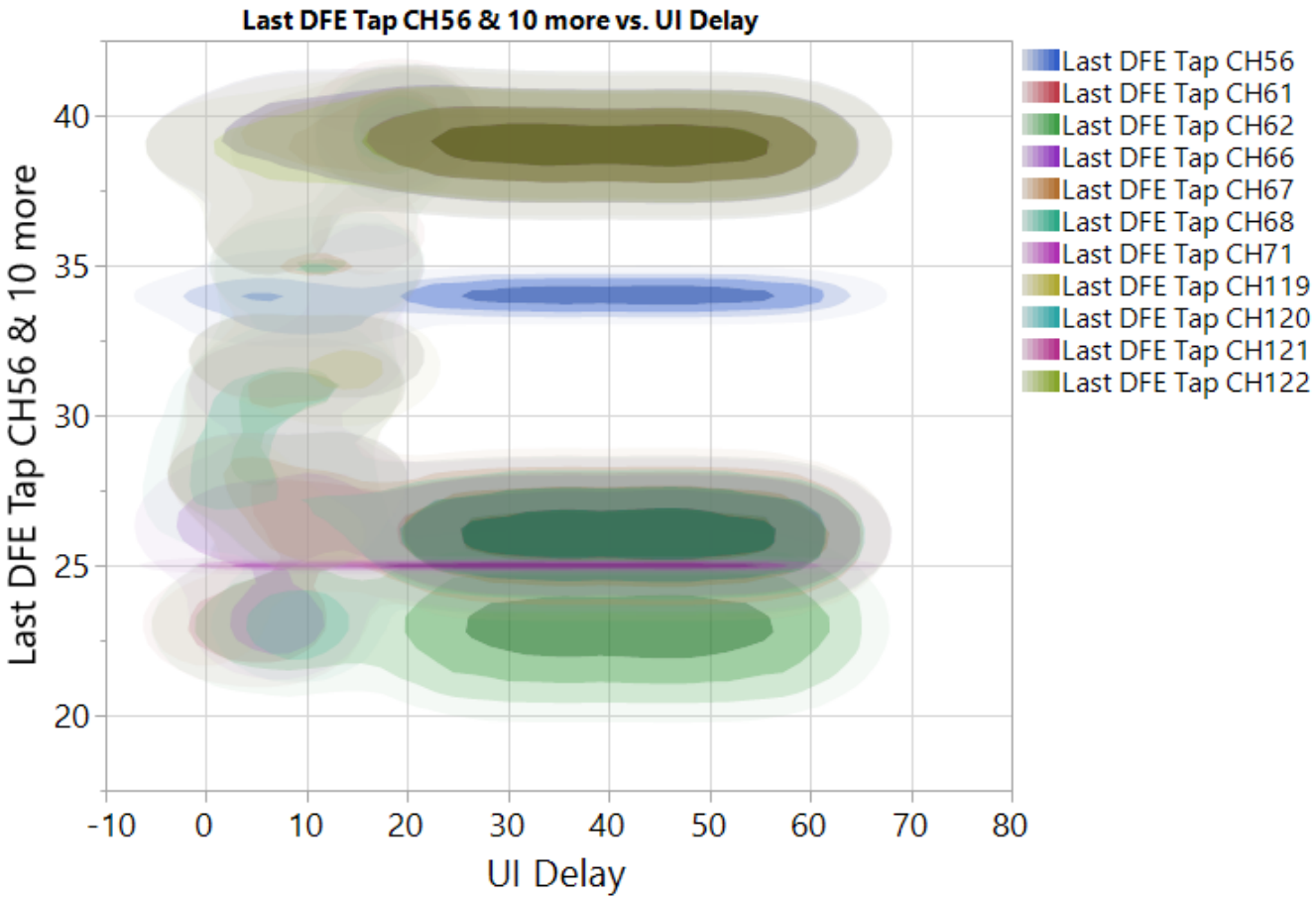
Graphic view finding best correlation of N_{bx} for ERL to COM

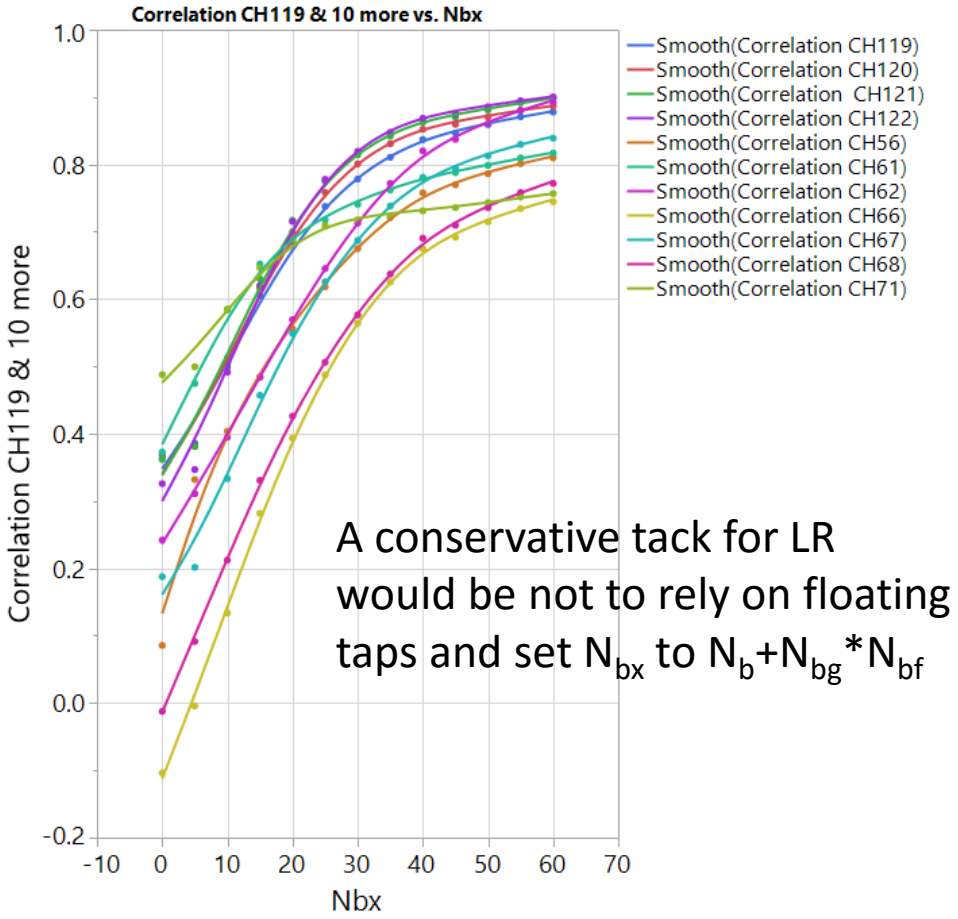


Conservative correlation between COM and ERL vs N_{bx} for DFE6 suggest setting N_{bx}=6



Density contour of last floating tap suggest strong correlation to added delay





A conservative tack for LR would be not to rely on floating taps and set N_{bx} to $N_b+N_{bg}*N_{bf}$

Recommendation. Do include floating taps in ERL.
Too much interaction variability