A CAUI-4 Chip-to-Chip Link Study

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For IEEE 802.3bm

Jan 22-23, 2013

Purposes

- Explore the solution space for the CAUI-4 chip-to-chip link under the assumptions of
  - Tx FIR+Rx CTLE equalization
  - No FEC
  - Channel IL from 15 - 20 dB, with xtalk

I. Channel Model Methodologies

A Generic Channel Loss Model (I)

- **A 3rd order polynomial example for magnitude**

$$|S_{21}|(dB) = \begin{cases} a_0 & f_1 \le f \le f_2 \\ b_0 + b_1\sqrt{f} + b_2 f + b_3 f^2 + b_4 f^3 & f_2 \le f \le f_3 \\ c_0 + c_1 f & f_3 \le f \le f_4 \\ d_0 & f_4 \le f \le f_5 \end{cases}$$

where *f* is in GHz, and

$$a_0 = b_0 + b_1\sqrt{f_2} + b_2 f_2 + b_3 f_2^{\,2} + b_4 f_2^{\,3}$$

$$c_0 = b_0 + b_1\sqrt{f_3} + b_2 f_3 + b_3 f_3^{\,2} + b_4 f_3^{\,3} - c_1 f_3$$

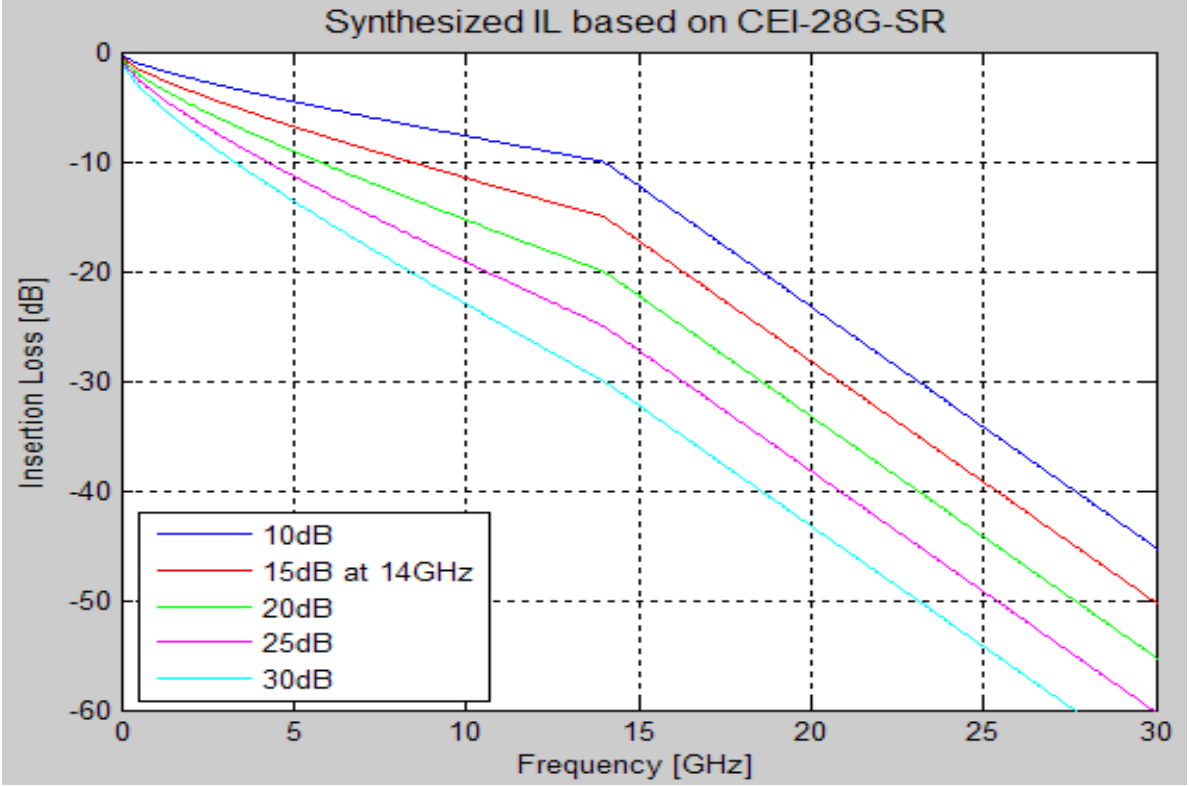
$$d_0 = c_0 + c_1 f_4$$

A Generic Channel Loss Model (II)

- **Phase response estimated via Hilbert Transformation**
  - Designed as minimum phase + linear phase
    - Minimum phase to force causality
    - Linear phase to comprehend the nominal propagation delay

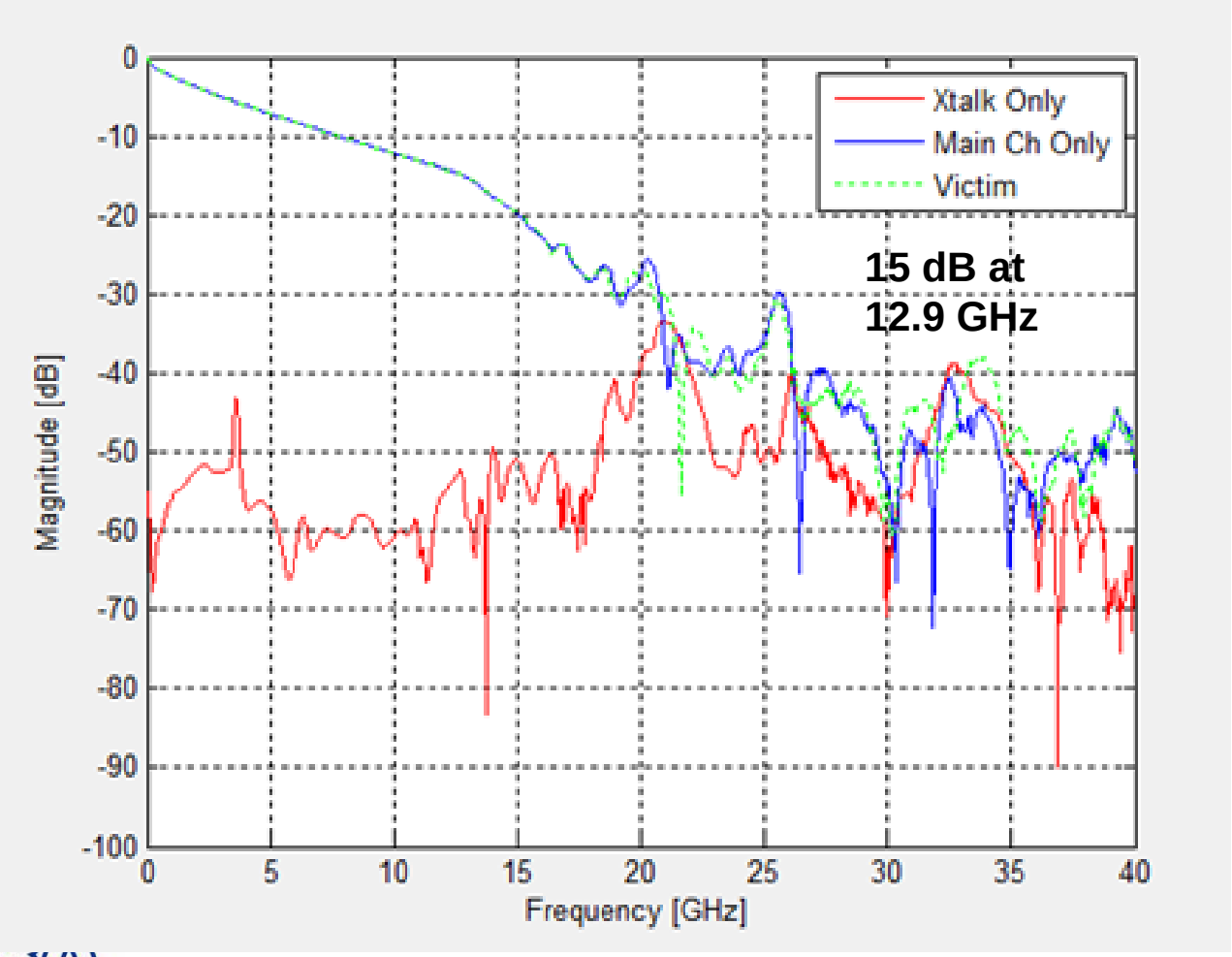
Synthesized Channel IL Examples

- To enable the sweeping of a range of ILs



Comprehending IL+Xtalk

- Xtalk (both FEXT and NEXT) from measurement is combined with the IL

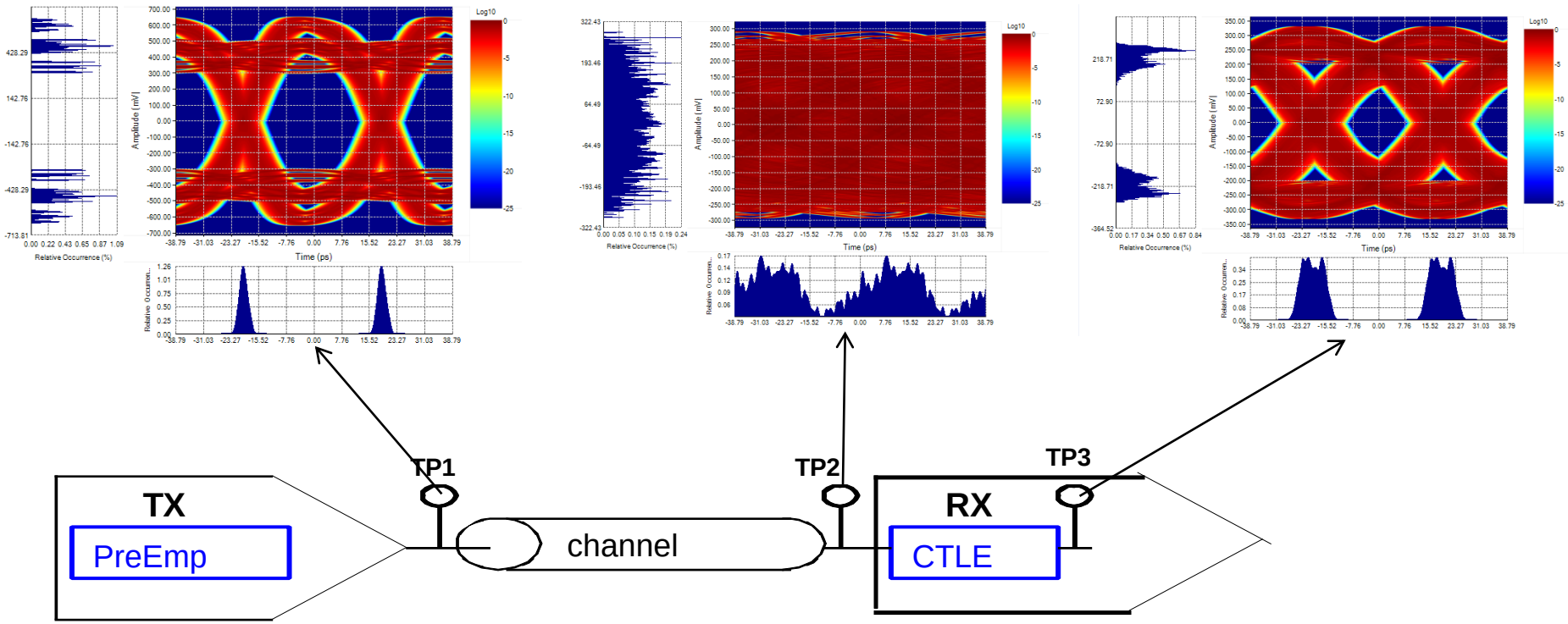


II. Simulation and Solution Space Exploration

Simulation Setup

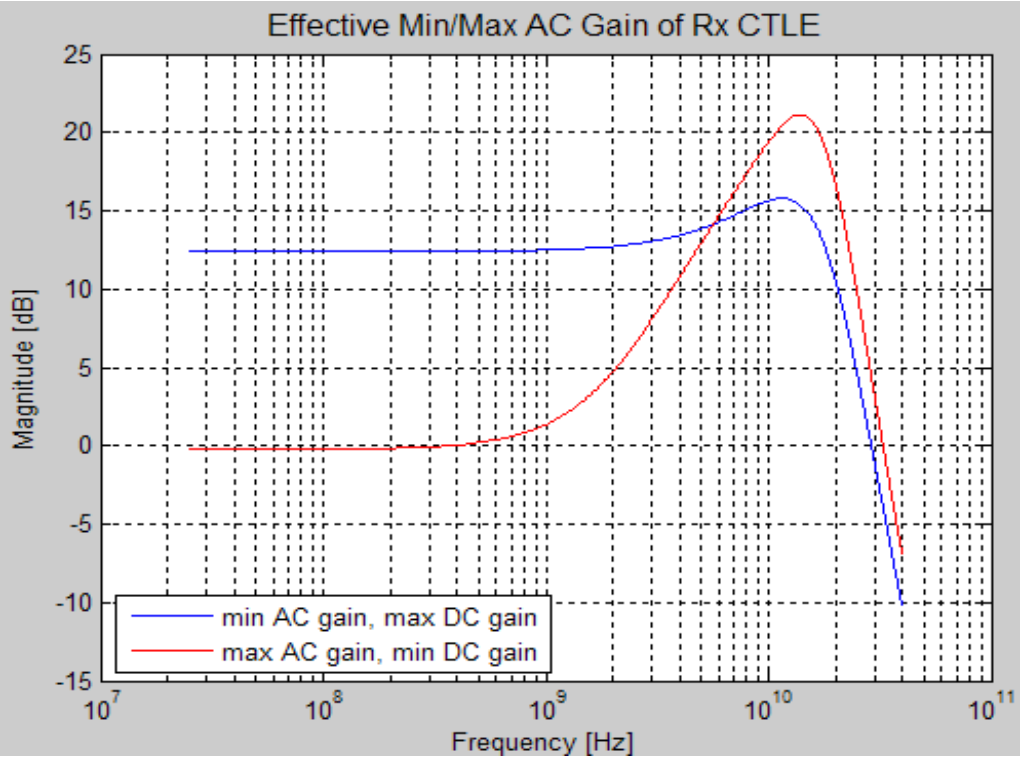
- Data rate
  - 25.78 Gbps
- Data Pattern
  - PRBS2^10-1
- Tx
  - A 3-tap FIR (c-1, c0, c+1)
  - Vod = 1000 mV
  - Jitter
    - BUJ: 0.15 UI, DCD: 0.035 UI, RJ: 0.15 UI
  - Noise
    - RN: 1 mv rms
- Rx
  - CTLE
- Both Tx and Rx models have been correlated with actual device measurements
- Channel
  - 3 channel with ILs of 15, 18, 20 dB, with xtalk from a 25-28 G channel/connector measurement

Simulation Examples

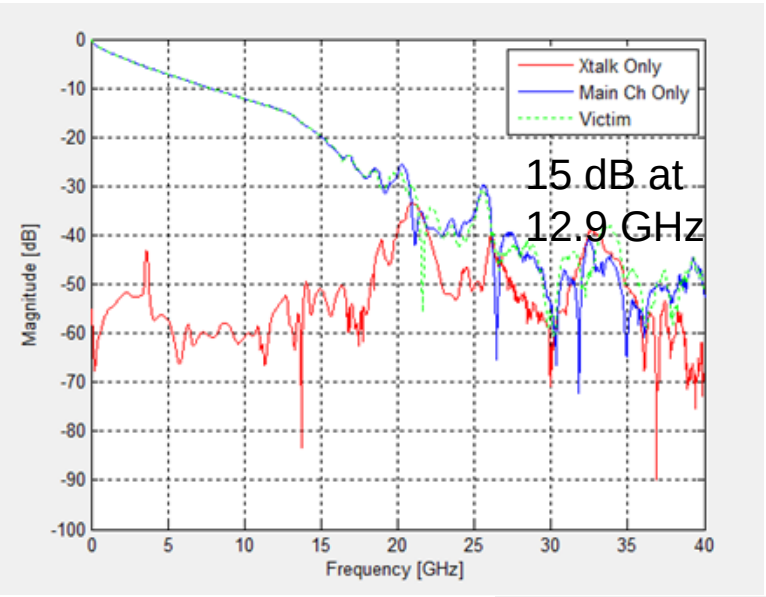


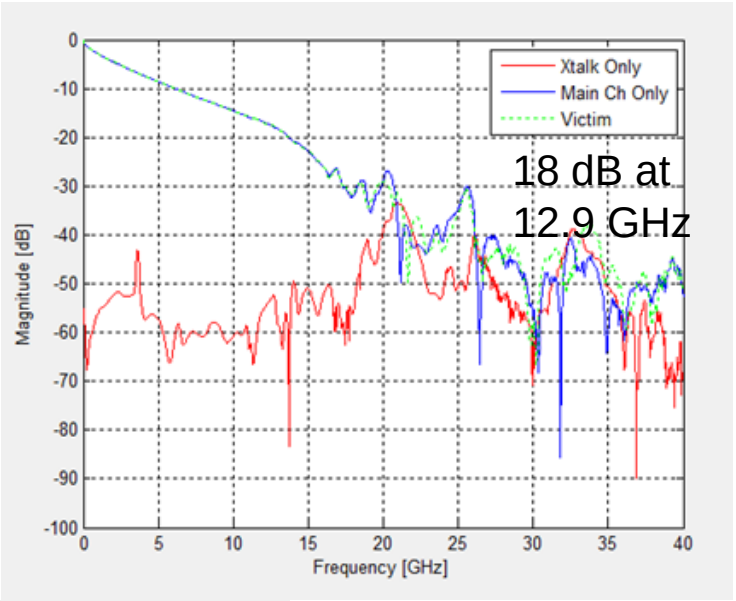
More on CTLE

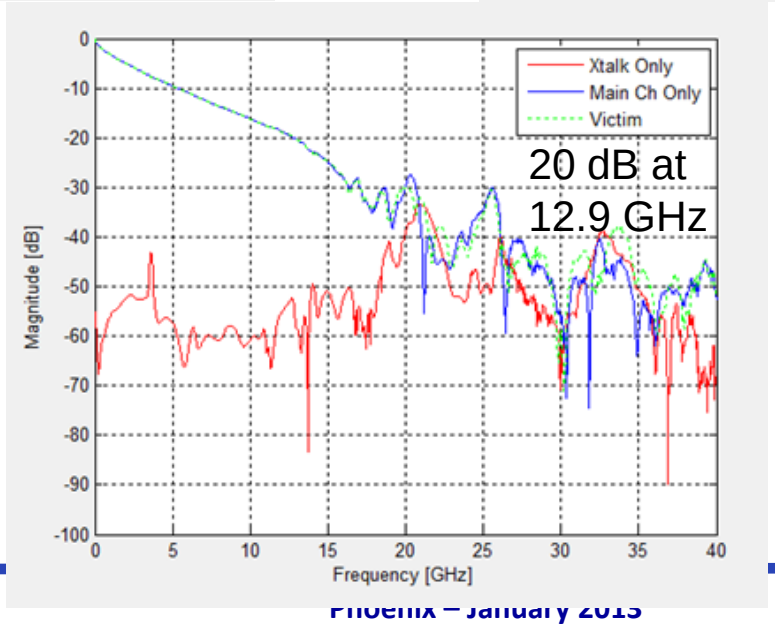
- **Both DC and AC gains are important**
  - Maximum AC gain is achieved via minimum DC gain, and vice verse



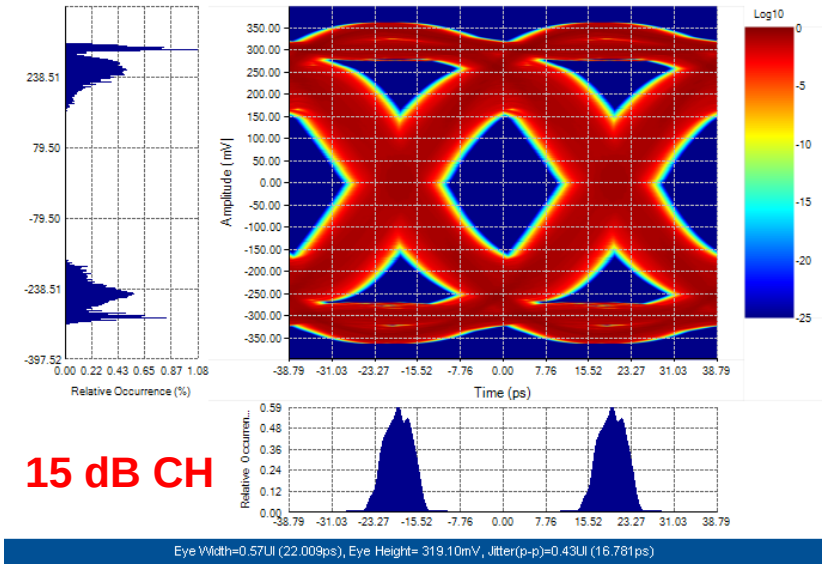
Channels for Simulation



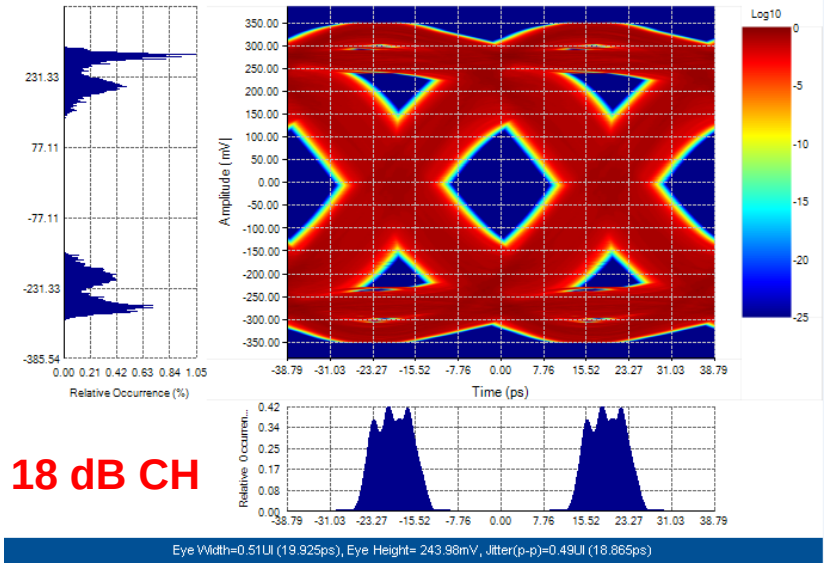




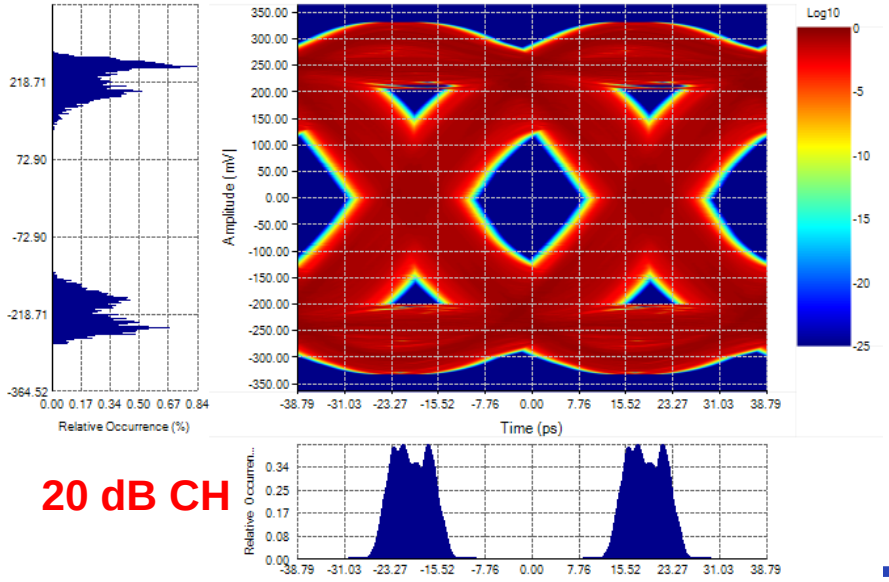
Simulation Results at the CTLE Output



15 dB CH



18 dB CH



20 dB CH

CH IL (dB)	EW (UI)	EH (mv)
15	0.57	319.1
18	0.51	244.0
20	0.50	237.8

III. Summary and Closing Remarks

Summary

- A link solution space exploration is carried out for CAUI-4 chip-to-chip at 25.78 Gbps, and for channels with a range of ILs and xtalk
  - ILs are15, 18, 20 dB at Nyquist (12.9 GHz)
  - Xtalk from a 25-28 G channel/connector measurement
- We have found that Tx FIR + Rx CTLE is sufficient to compensate those channels, and to achieve the link BER objective of 1e-12 with margin

CH IL (dB)	EW (UI)	EH (mv)
15	0.57	319.1
18	0.51	244.0
20	0.50	237.8

- We believe that 20 dB channel objective for CAUI-4 chip-to-chip is feasible
  - Enable more applications (e.g., Interlaken)
  - Aligned with CEI -28G MR chip-to-chip