FEC Proposal Status

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Status

- LDPC studies continuing
  - Examining puncturing, such as presented in jingyinrong_3ca_2_0717
    - Analysis still in progress
- LDPC(18493,15677) with interleaver proposal (laubach_3ca_1_0517) stands

FEC Code Gains, sizes, and latencies

	Length	Rate	NECG [1] (dB)		M Gates (approximately)	Latency (µsec)
			AWGN	Gilbert Burst		
LDPC	(18493,15677)	0.848	2.46	1.85 [2]	Encoder(E): 0.15 to 0.3 Decoder(D): 1.5	E: 2.0 + 0.77 (buffer) = 2.77 D: 2.15 + 0.77 (buffer) = 2.92 [4] Total = 5.69 [5]
RS	(1023, 847)	0.83	1.34	1.35	1.06	E+D: 0.77
RS	(2048,1536)	0.75	1.8 [3]	-na-	3.3	E+D: 1.54

[1] Electrical gain over RS(255,223) of 7.1 dB

[2] Gilbert Burst (with interleaver, no precoding)

[3] Not measured at rBER $1e^{-2}$, study needed

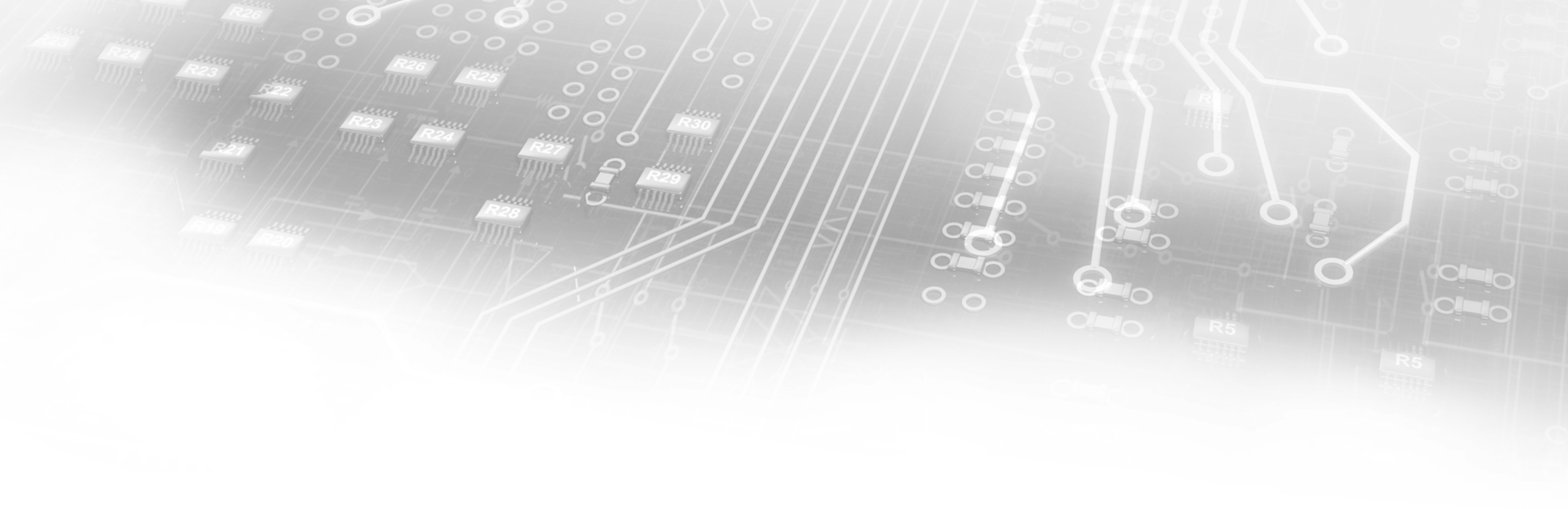
[4] Capped at 15 iterations

[5] Implementation dependent: LDPC encoding and decoding latency can be reduced with more parallel operations, with the cost of additional area; e.g. encoder could be reduced from 2.0 to 0.94 by adding more complex multipliers. In decoder latency could be further reduced by lowering the iteration cap, however this needs further study.

Recent concerns expressed about LPDC (wey_3ca_1_0917) versus RS.

- Some comments
  - From previous meetings: need ≥ 1.5 dB optical gain from FEC to “close the gap”
    - Includes compensating for increased electrical domain ISI/jitter for multi-lane -> rBER from $1e^{-3}$ to $1e^{-2}$. See laubach_3ca_3_0317.
  - One standard: same PCS for 1 x 25G, 2 x 25G, and 4 x 25G: same FEC, line coding, for all power budgets, and for 10G upstream.
    - RS performance vs size falls short for operating at all power budgets and configurations
  - On LDPC error floor: theoretical and semi-theoretical methods do exist. See reference: https://web.stanford.edu/class/ee388/papers/ErrorFloors.pdf. Also hardware matching software simulation can be used.

Thank you



From Prior Presentation

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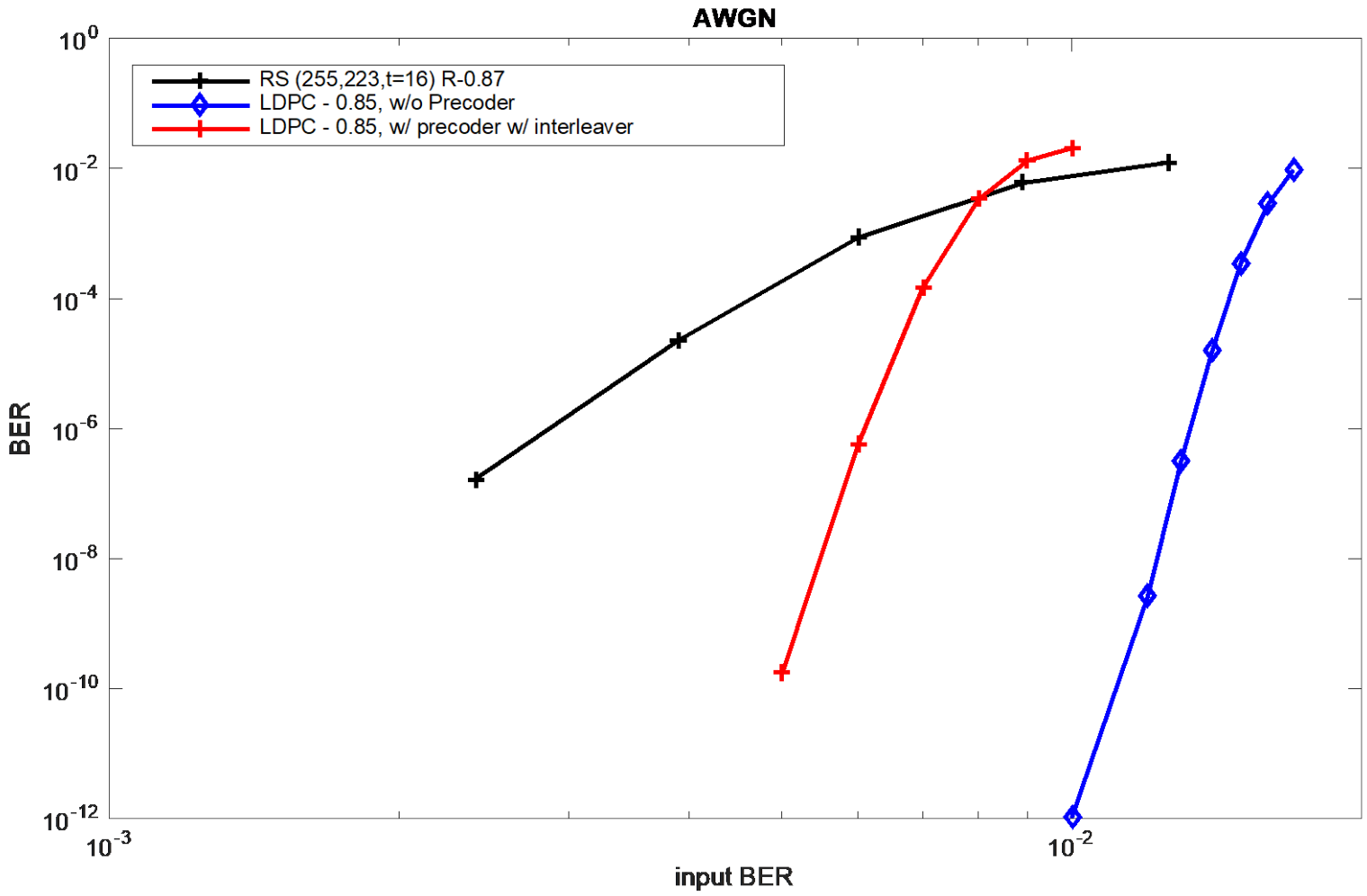
AWGN Performance



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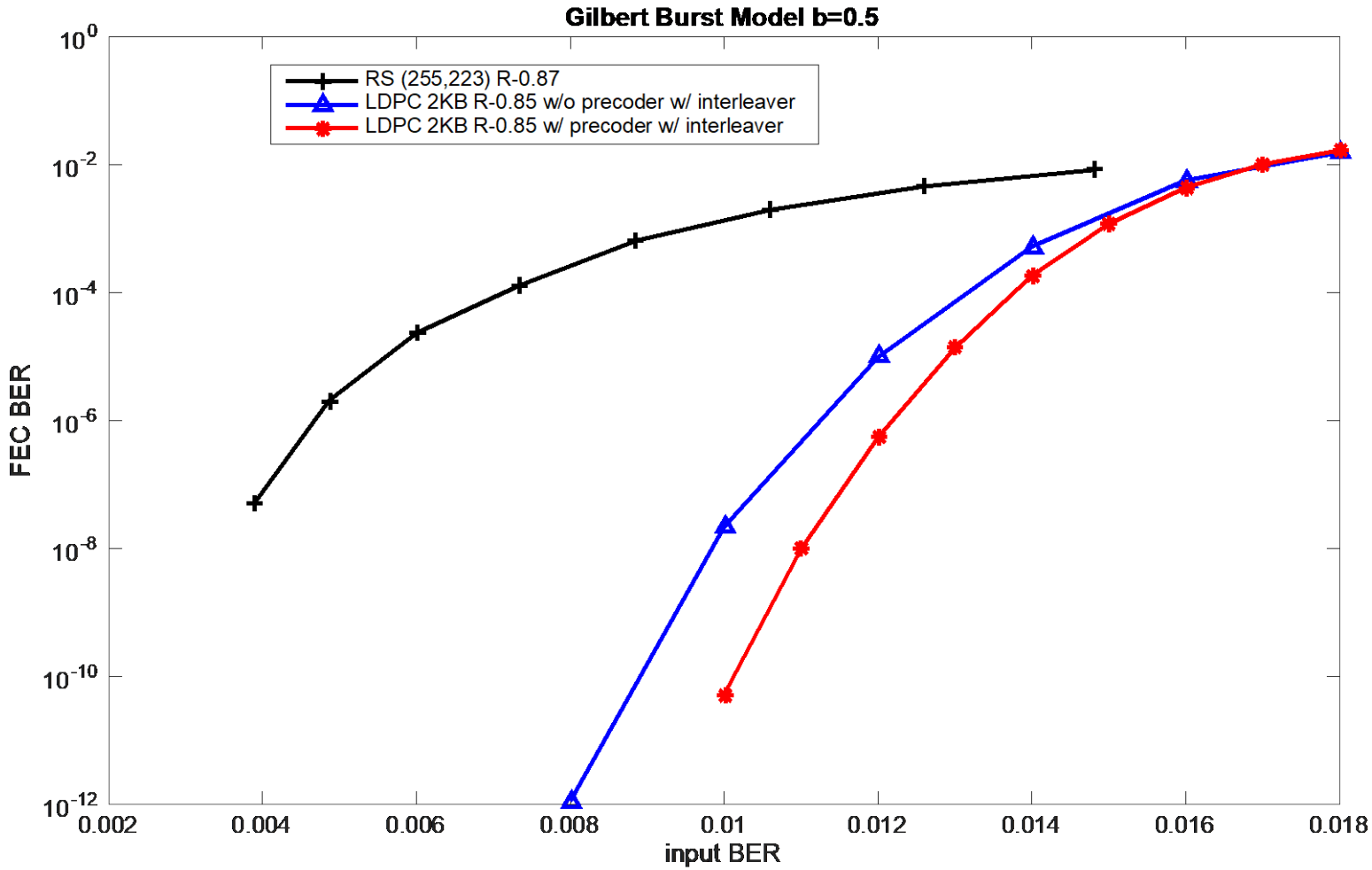
Gilbert burst error performance



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FEC Code Gains

Review from 0517 presentation:

	Length	Rate	Parity	User	Encoded	NECG[1] (dB)		Normalized Die Size [2]	Notes
						AWGN	Gilbert Burst		
LDPC	2kB	0.848	2816	15677	18493	2.46	2.02[3]	7.7	bits (18493,15677)
RS	(255,223)	0.8745	256	1784	2040	0	0	1	S=8, T=16 (10G-EPON)

Additional study results:

	Noise Model + options	NECG[1] (dB)	Electrical -> Optical (dB)	
			x0.7	x0.9
LDPC	AWGN (w/wo interleaver)	2.46	1.7	2.2
	Gilbert Burst (w/interleaver, w/precoder)	2.02[3]	1.4	1.8
	Gilbert Burst (w/interleaver, wo/precoder)	1.85	1.3	1.7

[1] Electrical gain over RS(255,223)

[2] Relative to RS(255,223) size

[3] Corrected from 0517 presentation

Summary

- AWGN-only noise model with pre-coding does impair LDPC performance
  - ~1 dB impact
- The LDPC(18493,15677) 0.848 rate as proposed and x0.7 – x0.9 electrical to optical conversion provides ≥ 1.5 dB optical gain for AWGN-only noise model w/o pre-coding
- The proposed interleaver used without precoding provides gain with Gilbert burst model without impacting AWGN-only performance
- Authors conclusion: the proposed LDPC(18493,15677) 0.848 FEC code with parity code matrix and interleaver stands as is.
- Assumption that use of pre-coding will remain in debate in the Task Force.
  - May be applicable for use over electrical sub-link as suggested in anslow_3bs_04_0715.pdf


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