EVALUATION OF PROPOSED FEC CODES FOR EPOC

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LDPC CODES FOR ACTIVE AND PASSIVE PLANTS

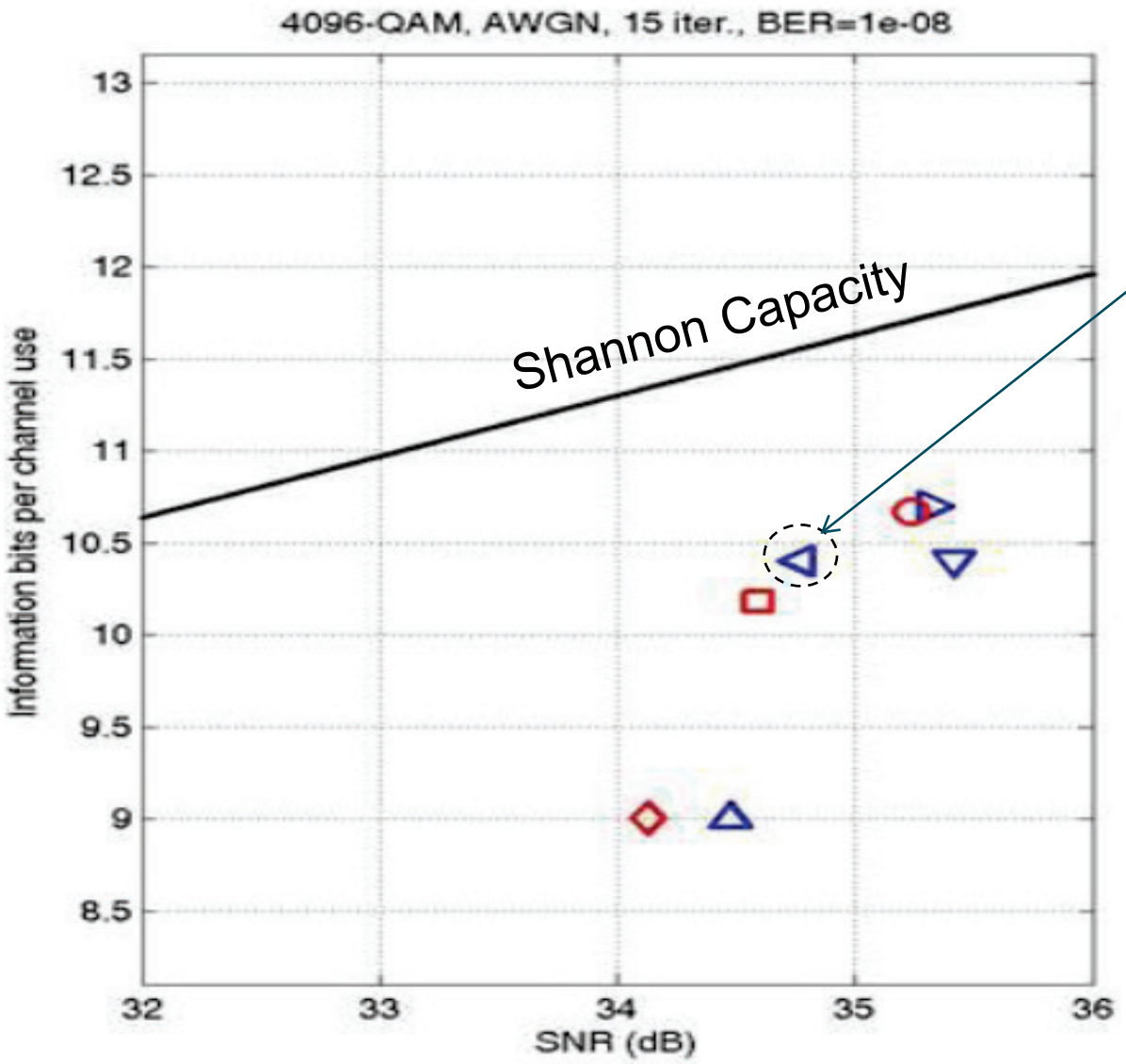
Summary of analysis results for this presentation:

Codeword Size	Plant	Rate	Codeword size	Information size	Systematic	Encoder Processing	SNR@BER=1e-8 (4096QAM) 15 iterations	SNR@BER=1e-8 (1024QAM) 15 iterations
Long	Active	89%	16200	14400	Yes	2	35.2dB	29.7dB
	Passive	89%	16560	14760	No	1 + 2	35.3dB	29.8dB
Medium	Active	85%	5940	5040	Yes	2	34.6dB	29.2dB
	Passive	87%	5400	4680	Yes	1 + 2	35.4dB	29.9dB
Short	Active	75%	1120	840	Yes	2	34.1dB	28.7dB
	Passive	75%	960	720	No	1 + 2	34.5dB	29.4dB
Medium-Long	Passive	87%	10800	9360	No	1 + 2	34.8dB	29.3dB

Encoder processing:

1. Polynomial multiplications
2. Back-substitution

SPECTRAL EFFICIENCY



Passive 87% (10800,9360)

Active 89% (16200,14400)

Passive 89% (16560,14760)

Active 85% (5940,5040)

Passive 87% (5400,4680)

Active 75% (1120,840)

Passive 75% (960,720)

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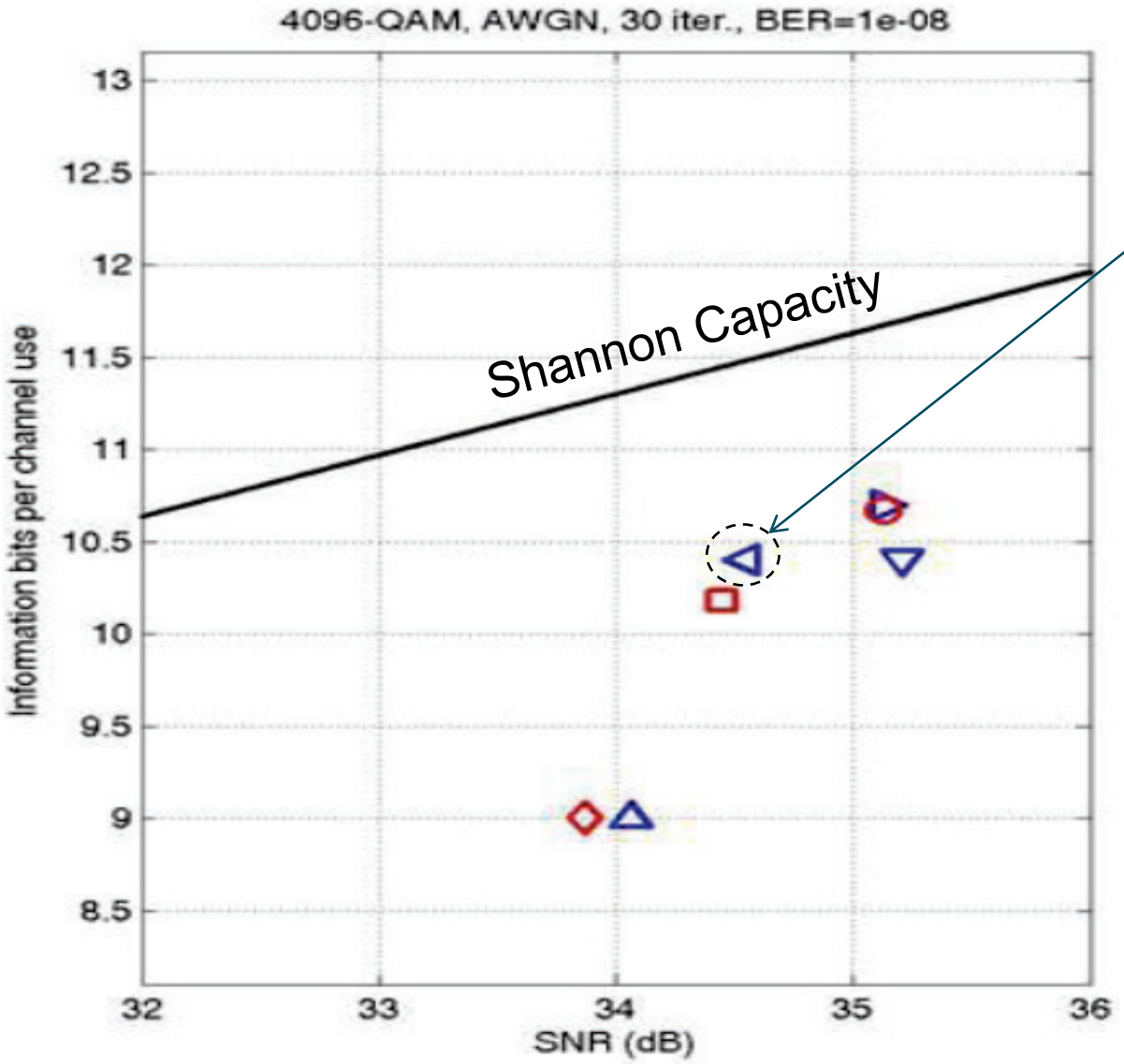

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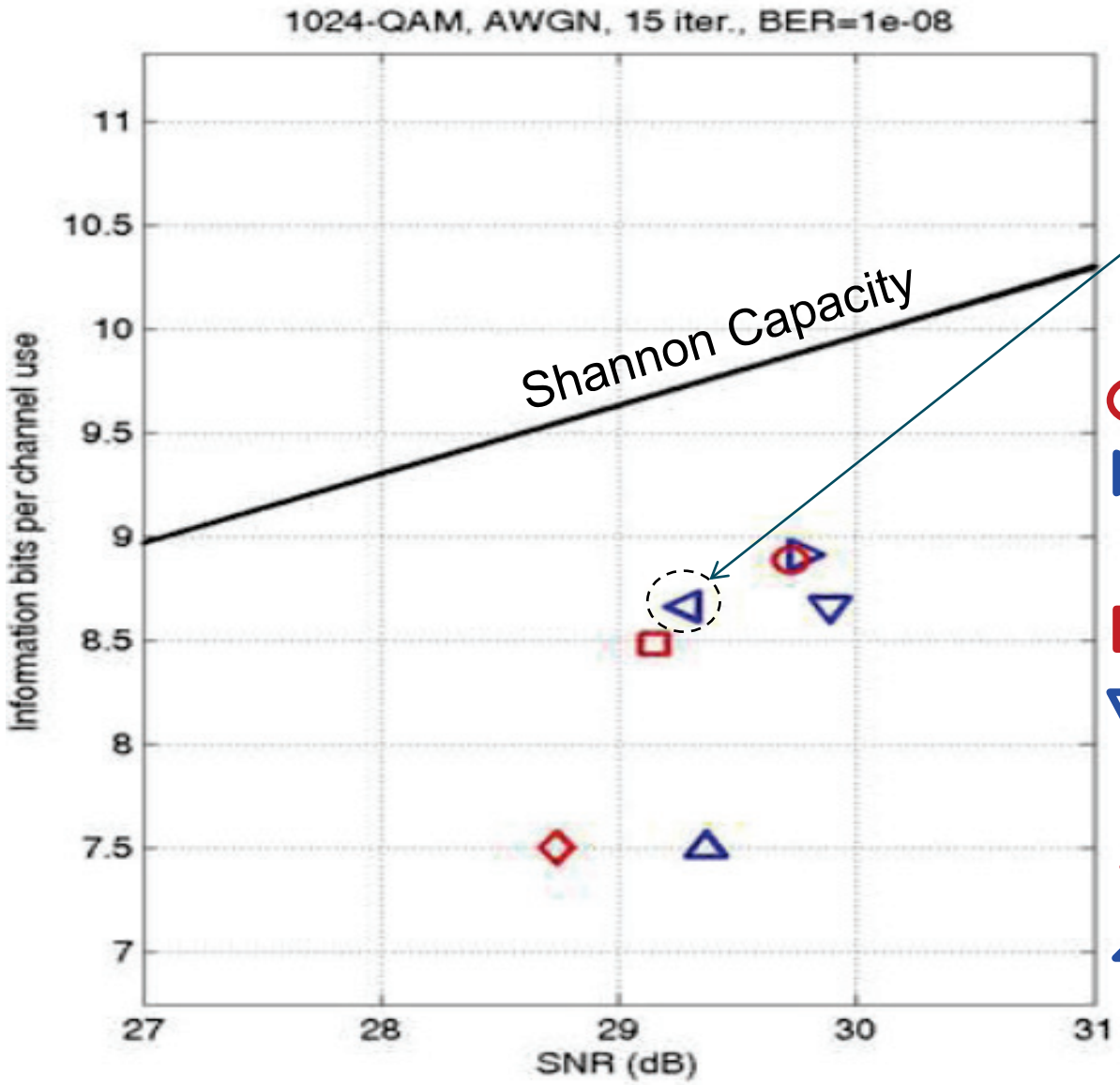

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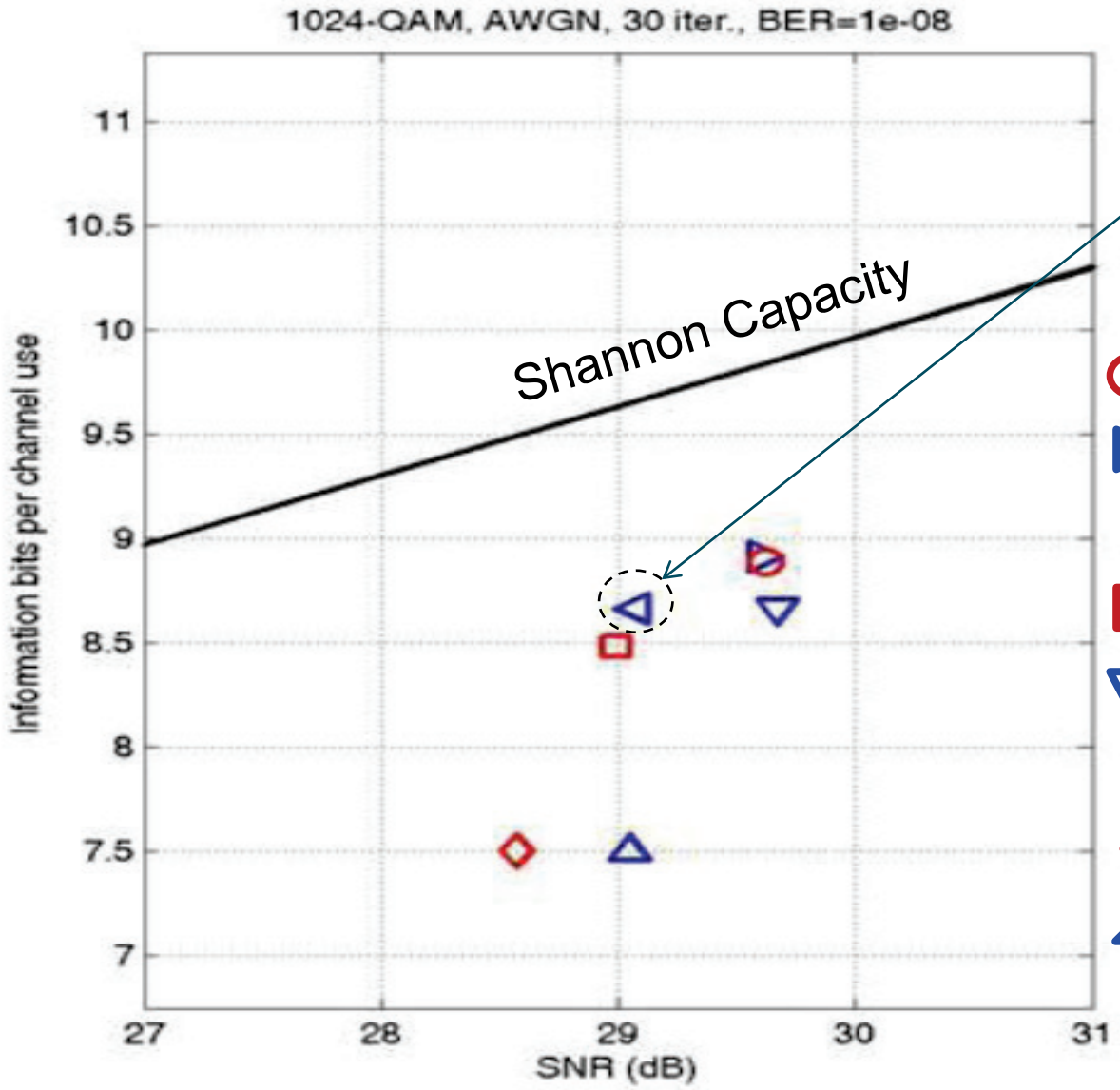

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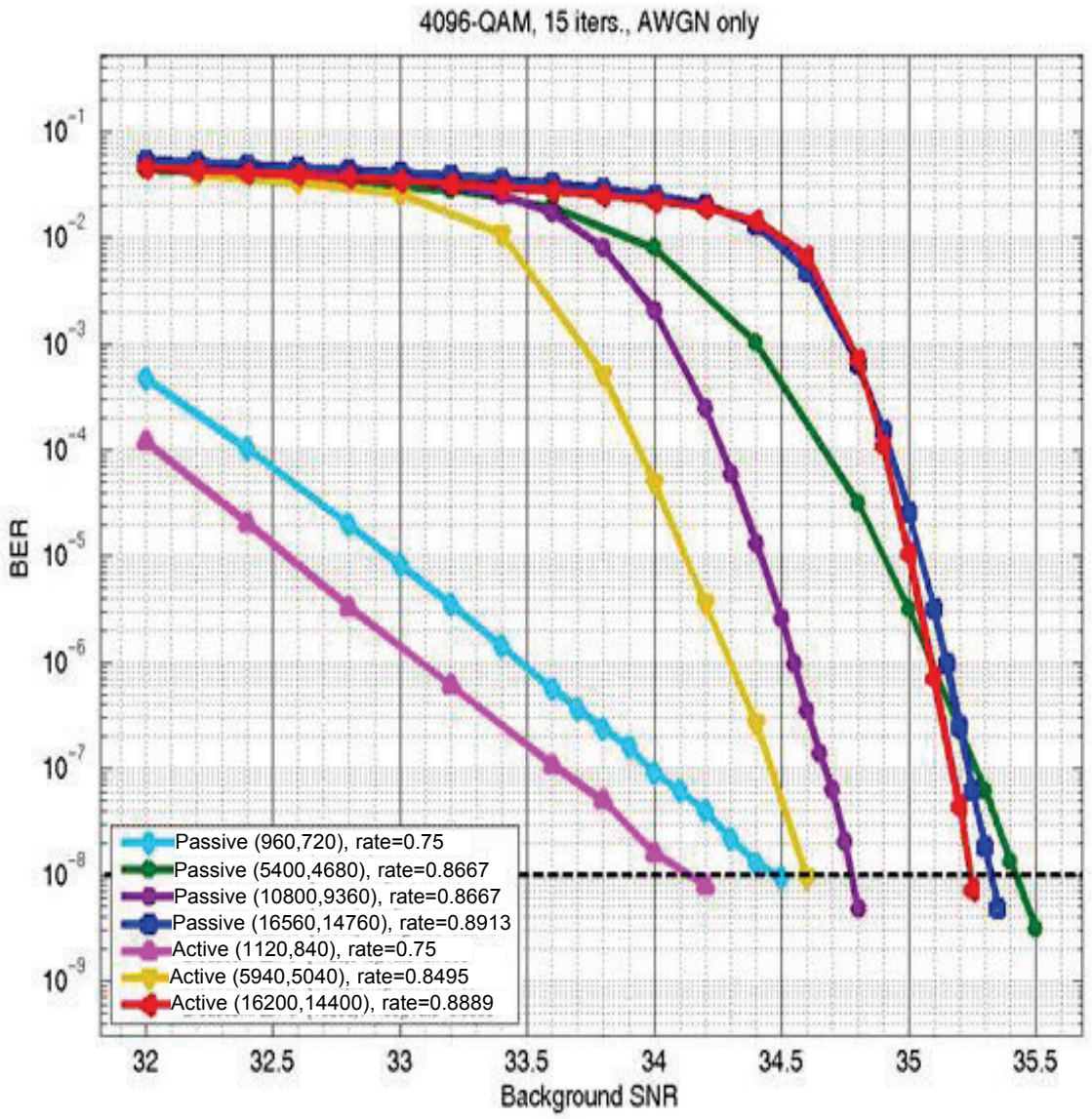
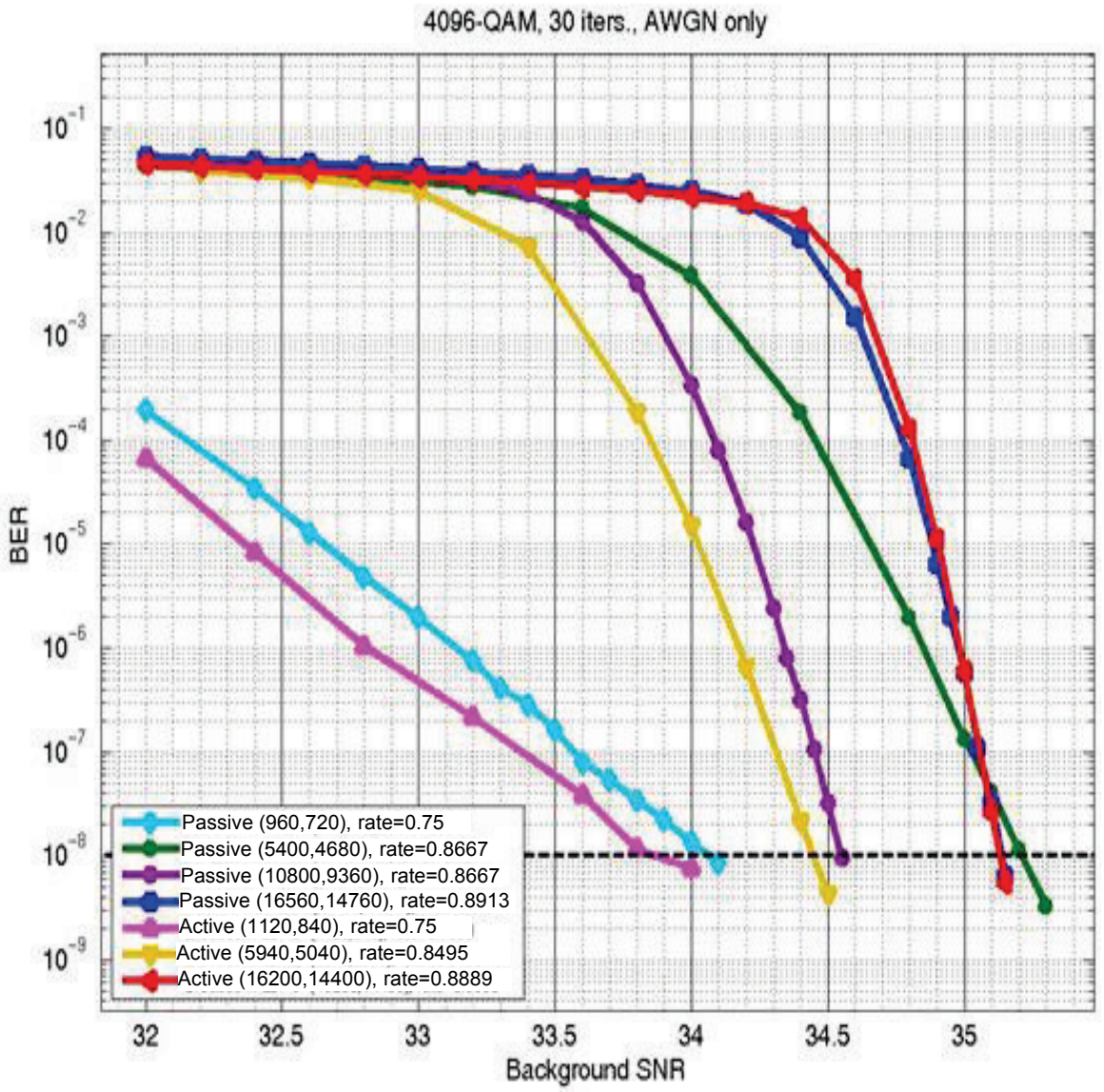
PERFORMANCE IN AWGN





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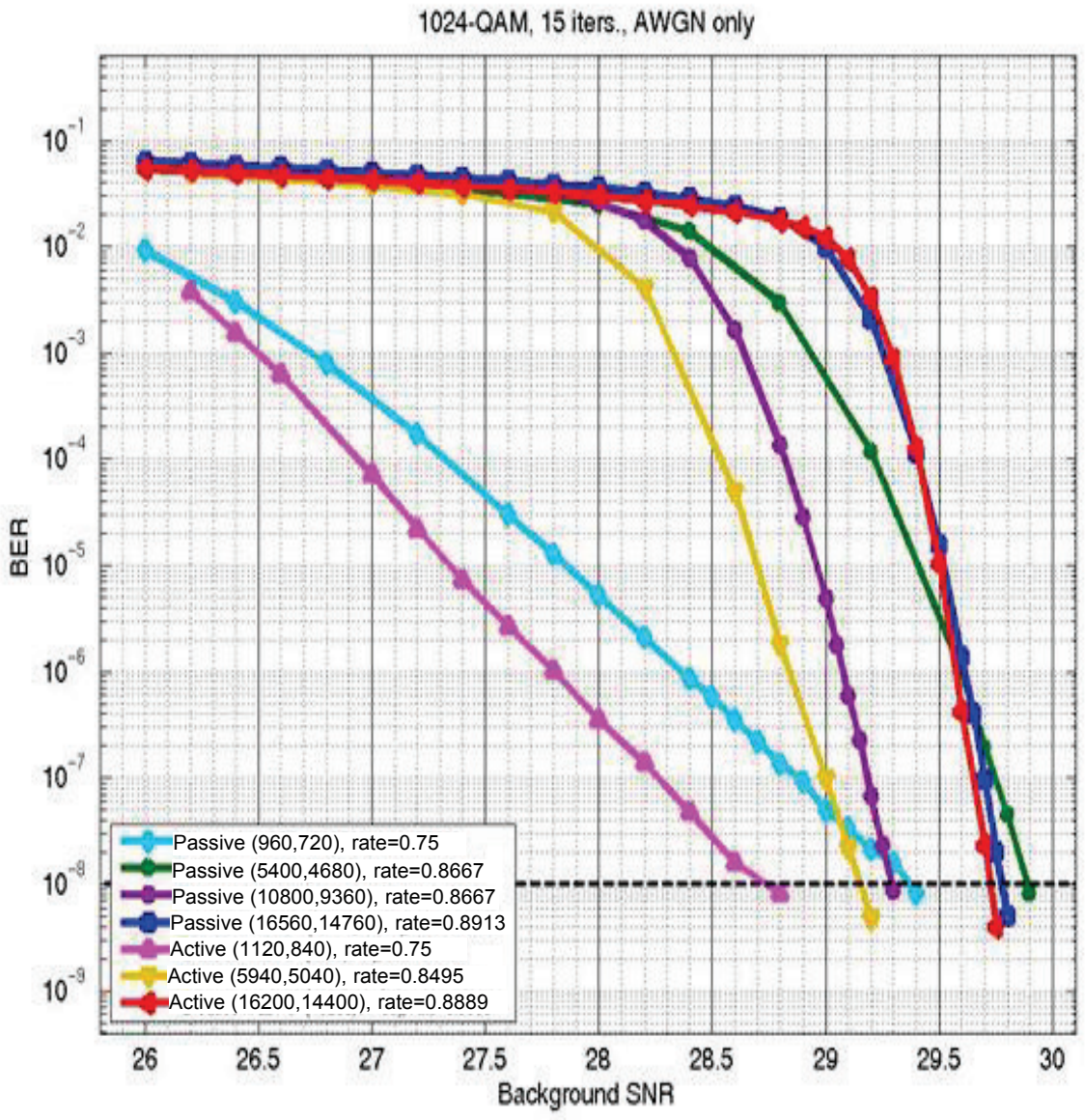

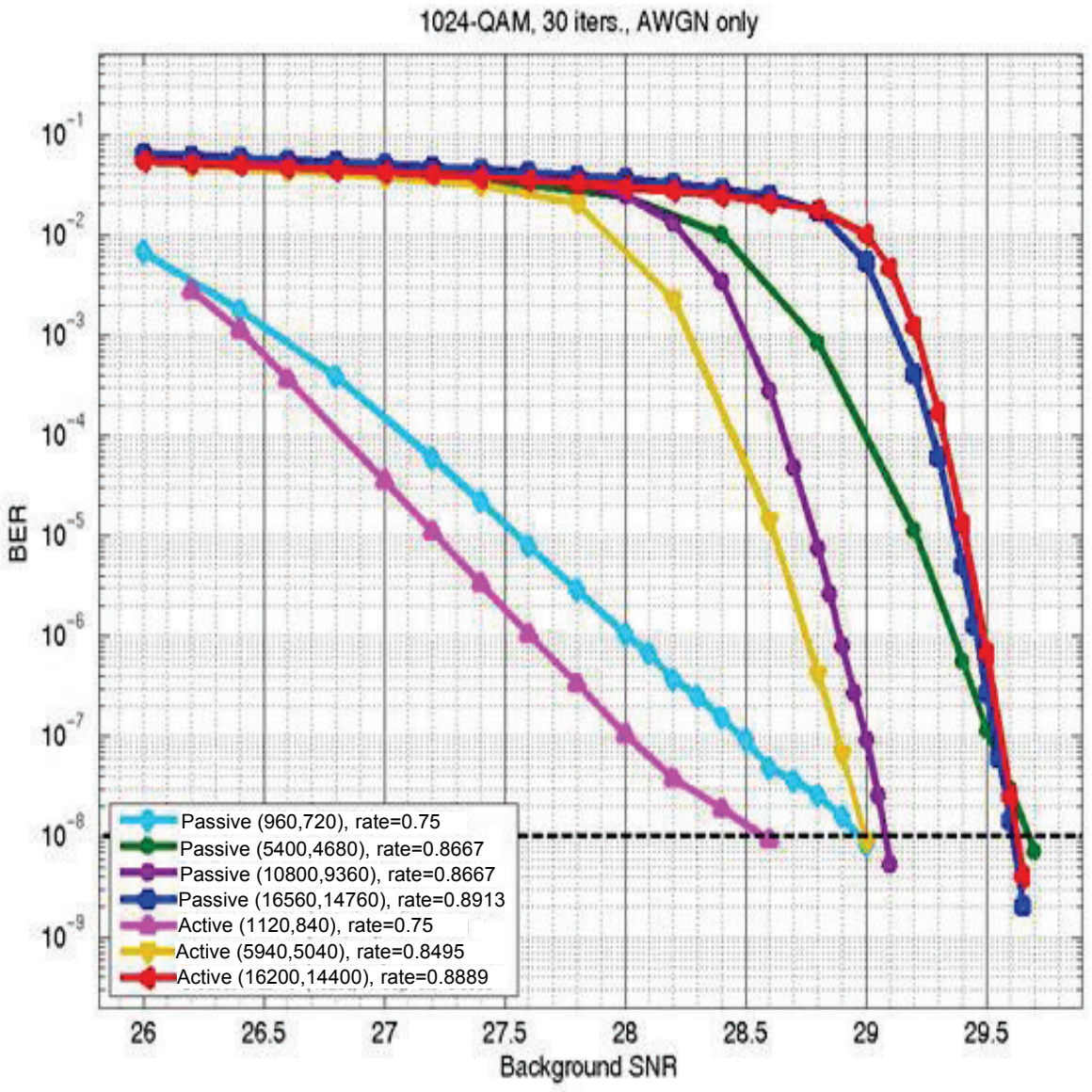

SYSTEMATIC ENCODER AND DECODING

Active code parity-check matrix (systematic)

93	271	-1	83	26	208	245	200	-1	175	331	17	86	-1	337	-1	238	81	-1	307	-1	165	-1	47	76	73	150	349	139	331	118	345	27	294	-1	145	279	97	106	160	143	-1	-1	-1	-1
274	115	329	338	124	-1	293	-1	69	64	342	-1	88	139	-1	137	212	-1	157	195	357	81	194	1	159	56	72	126	277	156	32	111	175	-1	306	224	-1	206	-1	29	106	334	-1	-1	-1
134	355	175	24	253	242	-1	187	94	26	87	302	-1	191	323	22	-1	245	294	240	84	76	342	345	174	269	329	-1	214	-1	-1	-1	-1	218	104	40	197	73	229	63	-1	270	72	-1	-1
-1	-1	184	70	247	14	22	7	285	54	-1	352	26	108	10	298	123	139	117	-1	336	49	202	359	342	-1	224	106	-1	273	177	245	98	355	178	176	147	-1	280	-1	-1	-1	221	208	-1
253	273	90	-1	-1	151	311	320	339	-1	295	148	48	91	62	100	232	146	200	135	12	-1	179	-1	-1	232	-1	21	331	313	349	34	97	187	38	-1	235	52	170	58	-1	-1	-1	257	0

Sent out information data

Sent out parity

Passive code parity-check matrix (non-systematic)

0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46
0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0
0	-	203	-	-	188	278	-	-	313	-	-	-	-	56	308	248	206	142	25	309	-	355	257	-	-	-	-	99	-	42	-	303	-	-	-	-	197	126	359	308	257	342	113	-	318	109
0	61	-	-	-	-	-	-	319	106	-	250	153	-	-	283	32	-	-	-	-	225	-	284	-	132	71	113	-	-	130	173	194	287	129	19	294	307	-	-	265	233	-	274	-	-	318
-	61	113	-	-	-	268	330	-	-	142	-	-	-	-	-	-	-	202	-	279	282	-	132	99	-	203	129	26	347	-	74	181	352	84	-	293	353	212	309	-	199	-	-	303	-	210
-	-	113	183	-	302	-	-	221	153	349	5	334	256	269	-	-	208	61	240	-	40	-	-	194	-	-	-	-	123	-	-	-	-	1	147	288	-	109	-	122	333	152	-	275	42	142
-	-	-	183	244	-	-	89	-	-	105	-	301	331	-	-	-	194	-	237	155	-	36	-	-	142	248	-	182	51	51	-	-	191	-	107	54	91	-	18	254	-	75	225	111	200	116
-	-	-	-	244	189	45	352	118	-	-	59	-	340	99	267	122	-	-	-	-	-	213	-	159	86	-	352	-	-	-	163	151	339	225	326	-	-	147	170	-	-	7	198	110	300	35

Sent out parity

Sent out information data

Unsent Punctured
360 Information bits

- Impact on the average number of iterations to achieve BER=1e-8 (flooding decoding)
  Example on long size codes
  - Passive code: average 10.2 iterations
  - Active code: average 8.35 iterations

Power issue

ENCODING PARITY CALCULATIONS

All active codes low-density parity check matrix have one style

X	0	0	0	0
X	X	0	0	0
0	X	X	0	0
0	0	X	X	0
0	0	0	X	X

Encoding: back-substitute

X: a shifted L X L identity matrix,

0: a all zero L X L matrix

Passive codes low-density parity check matrix have three styles

X	0	X	0	0	X
X	X	0	0	0	0
0	X	X	0	0	0
0	0	X	X	0	X
0	0	0	X	X	0
0	0	0	0	X	X

X	0	0	0	X
X	X	0	0	0
0	X	X	0	0
0	0	X	X	X
0	0	0	X	X

X	X	0	0	X
X	X	0	0	0
0	X	X	0	0
0	0	X	X	X
0	0	0	X	X

Encoding:

Pre-encoding: Using Gaussian elimination to find two polynomials and an inverse of one polynomial

Step 1: Multiplications on polynomials

Step 2: back-substitute

CONCLUSION

Summary

- **Three LDPC FEC codes for active plant and four proposed LDPC FEC codes for passive plant have been evaluated**
  - Active plant: Long (16200,14400) 89%, Medium (5940, 5040) 85%, and Short (1120, 840) 75%
  - Passive plant: Long (16560,14760) 89%, Medium-Long (10800,9360) 87%, Medium (5400,4680) 87%, and Short (960,720) 75%
- **AWGN channel performance for all codes has been presented**
  - Similar sizes, code rates, spectral efficiencies, and AWGN performance
- **Encoding and decoding complexity and power considerations have been discussed**
  - Systematic active codes use fewer iterations (including zero for successful parity check)
  - Non-systematic passive codes require more iterations (at least one for recovering punctured information)
  - Strictly lower diagonal active code parity matrices directly encode with back-substitution
  - Non-upper diagonal passive code parity matrices require additional multiplications using polynomials found with Gaussian elimination before encoding with back substitution

Recommendations for separate minimum implementation complexity PHY layers

- **FDD use three LDPC FEC codes for active plant exclusively for Node + N, N ≥ 0**
- **TDD use four proposed LDPC FEC codes for passive plant exclusively for Node + 0 only**

MOTION PROPOSAL

Move to:

Adopt that FDD mode exclusively use the three LDPC FEC codes (as adopted in Technical Decision #81, Motion #15 from Geneva 2013 for active plant) for Node + N, N ≥ 0.

Moved:

Second:

Technical decision, 75% or greater

Yes:

No:

Abstain:

Thank You