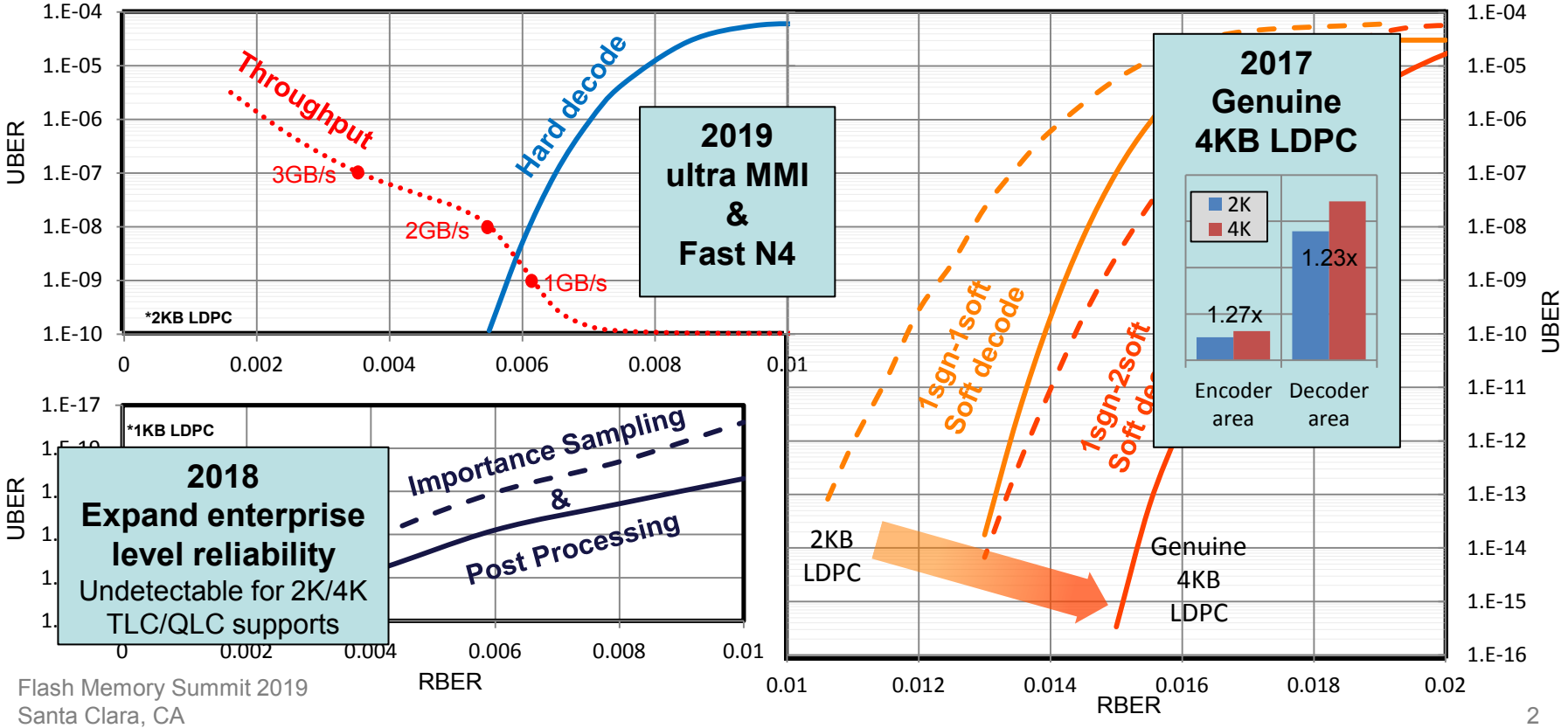
Ultra MMI : an LDPC decoder that ~~doubles~~ **6x** throughput at end-of-life.

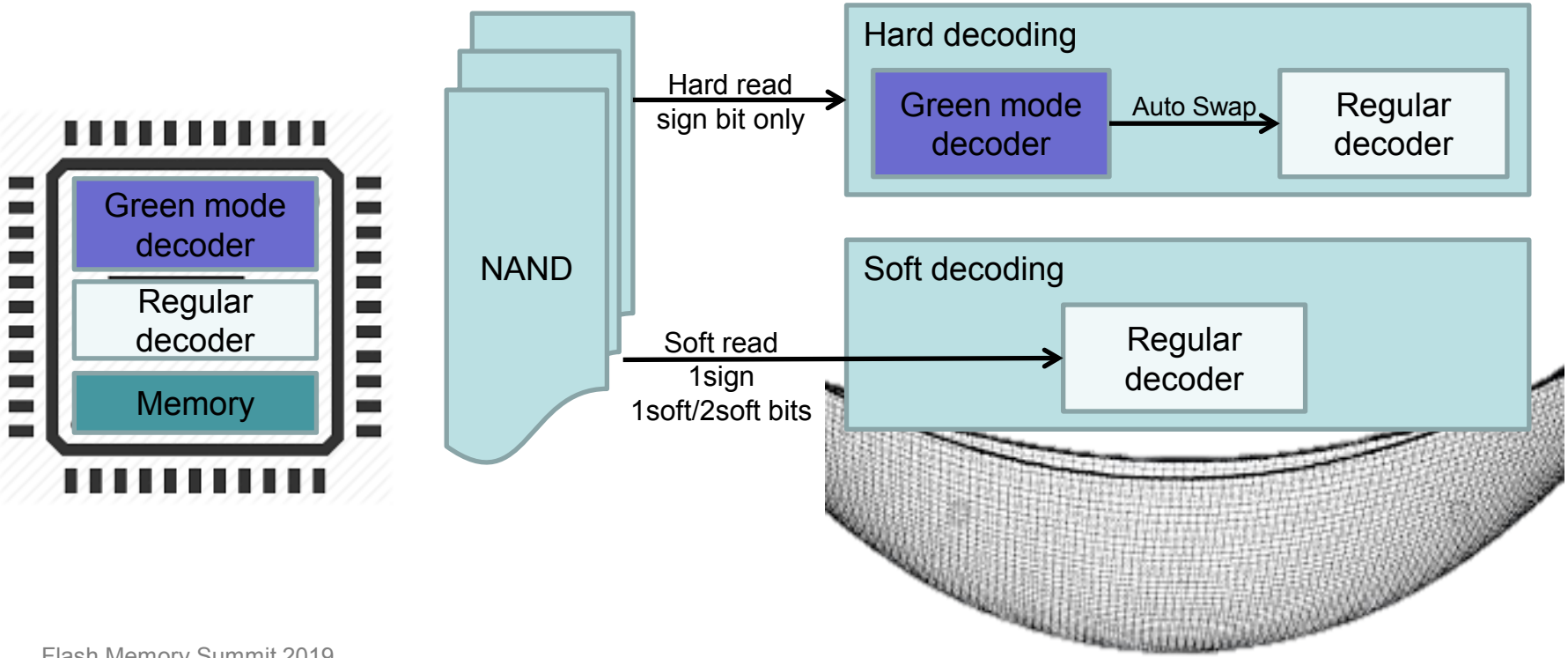
Dr. Shiuan-Hao Kuo

ECC team

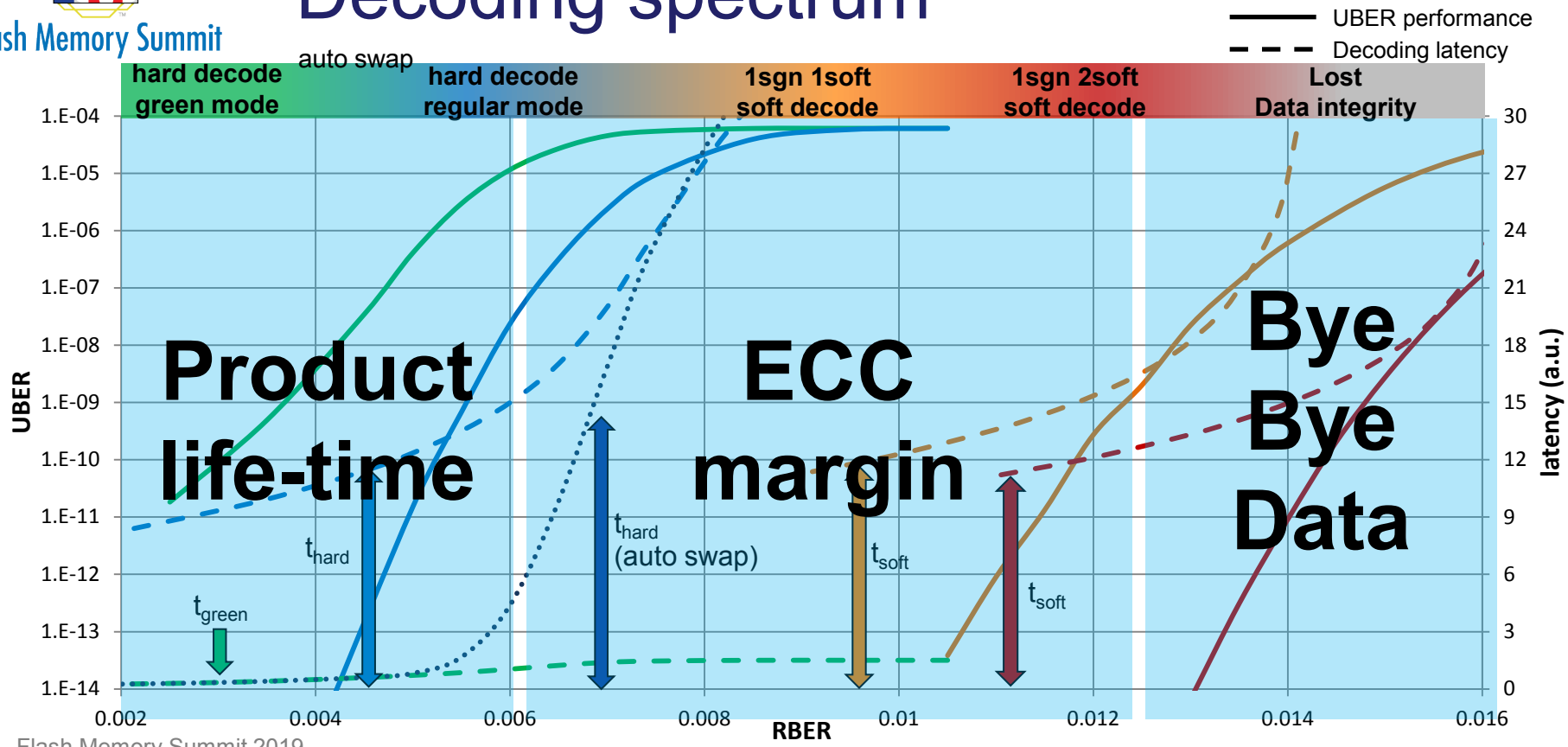
LDPC for NAND flash



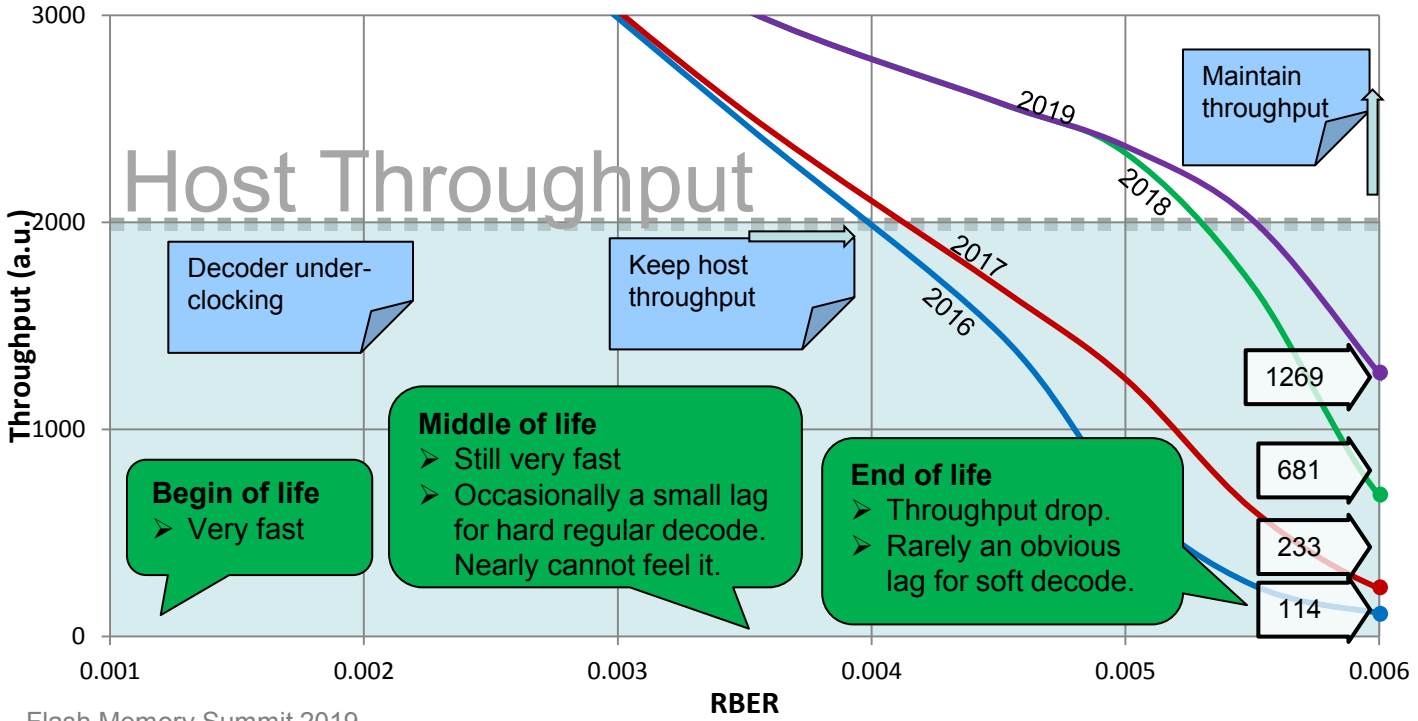
LDPC decoder / decoding flow



Decoding spectrum



User experience and Design effort



4th generation Green mode Overview

4th gen Green Mode : MMI

Area	nearly negligible	+0%
Peak Power	more accurate strategy	+2~5%
Correction rate 0.999 (FER1e-3)	minor improvement	+0.06% RBER
Throughput @ 0.6% RBER	0.466 bytes/cycle => 1.362 bytes/cycle	+192%

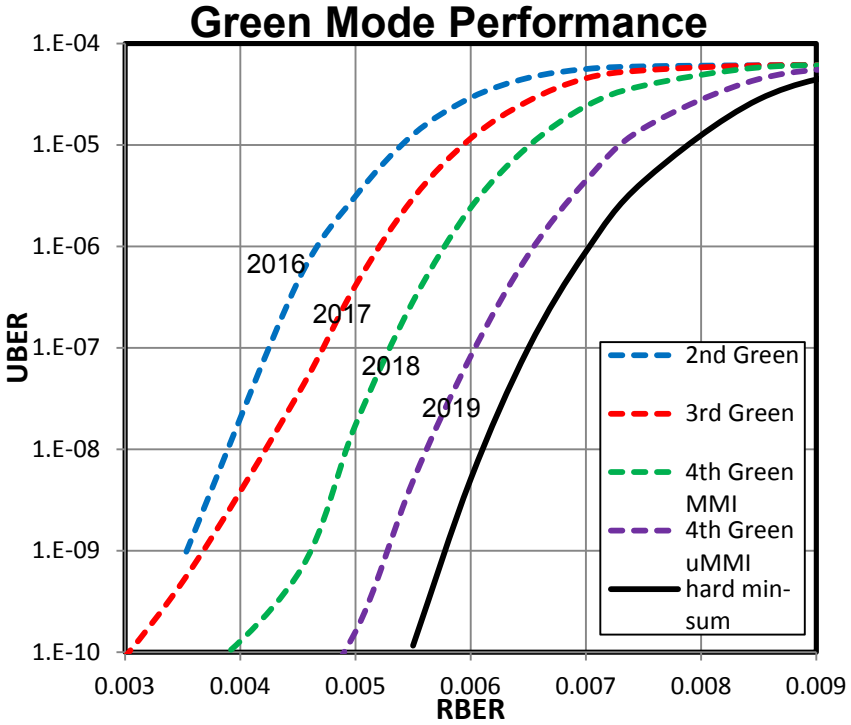
4th gen Green Mode : ultra MMI

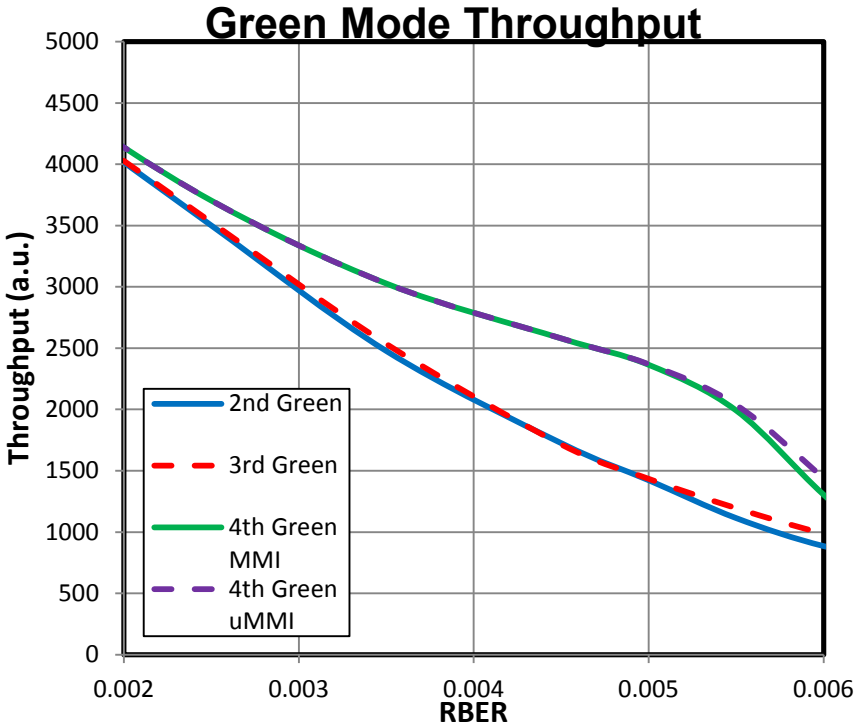
Area	Small increment	+0.69%
Peak Power	highly aggressive strategy	+5~10%
Correction rate 0.999 (FER1e-3)	major improvement	+0.11% RBER
Throughput @ 0.6% RBER	0.466 bytes/cycle => 2.539 bytes/cycle	+445%

4th gen Green Mode : Zero

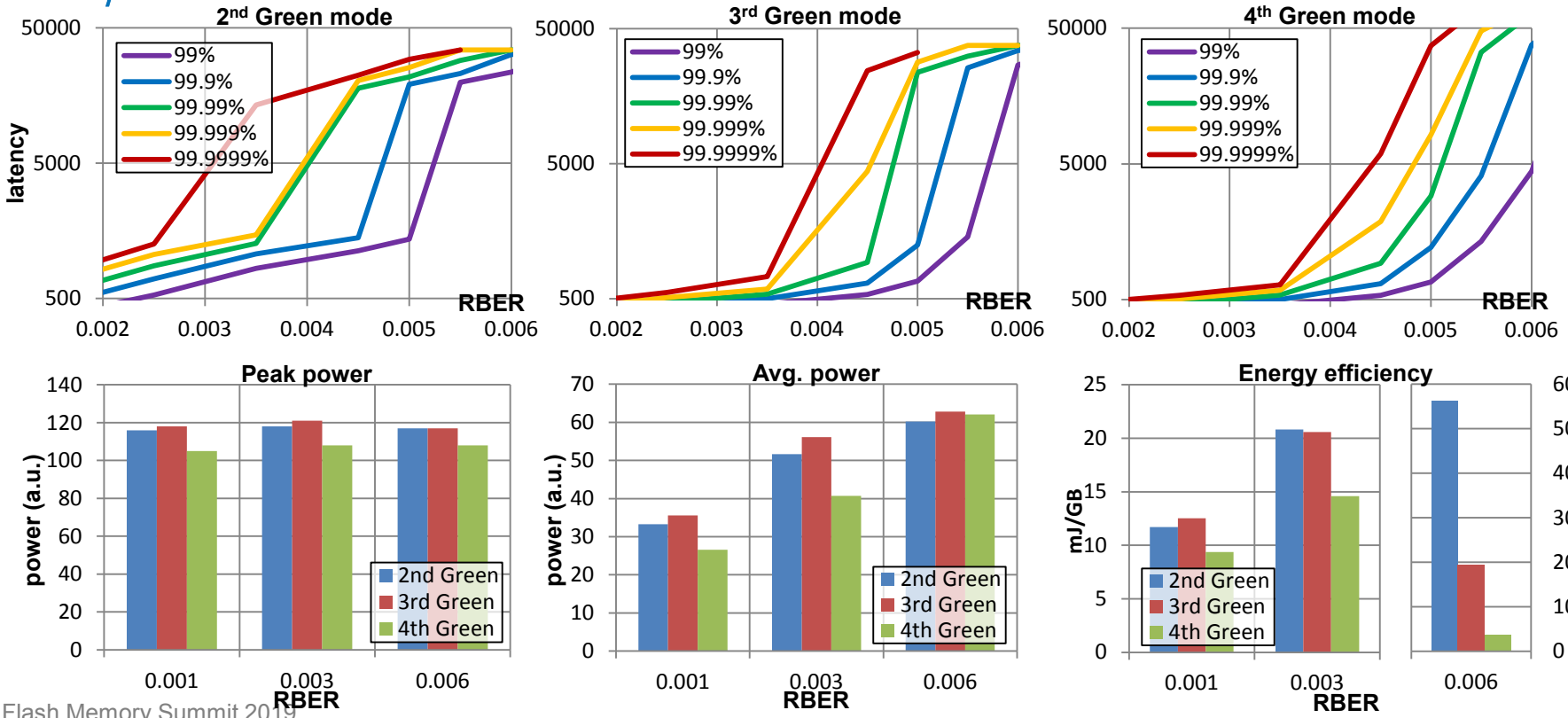
Area	No change	+0%
Peak Power	Less memory access, lower toggle rate	-15~20%
Correction rate & throughput	No change	-

SMI Green mode



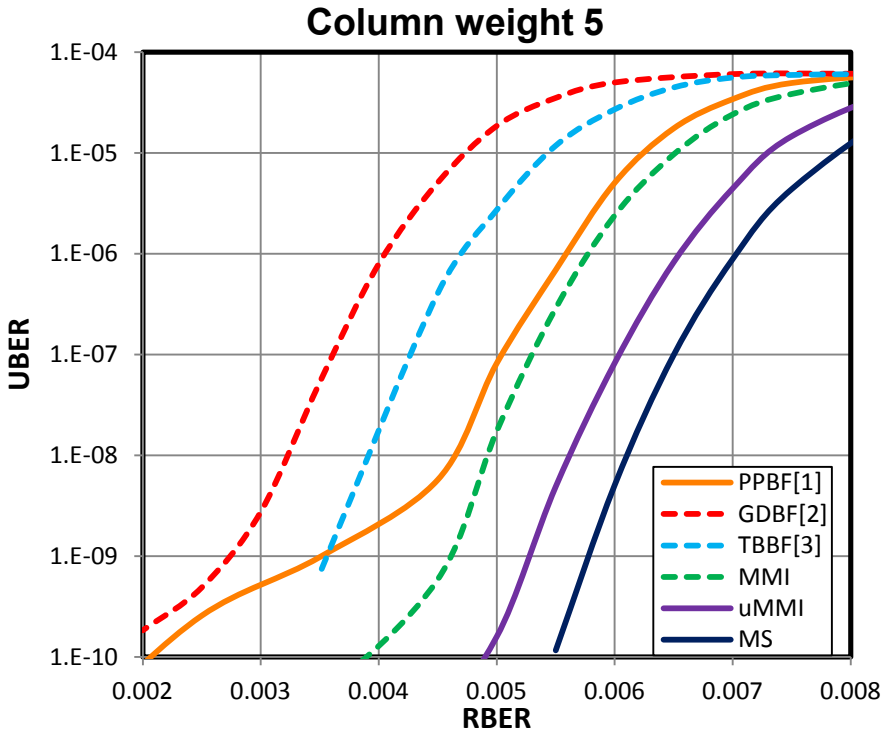


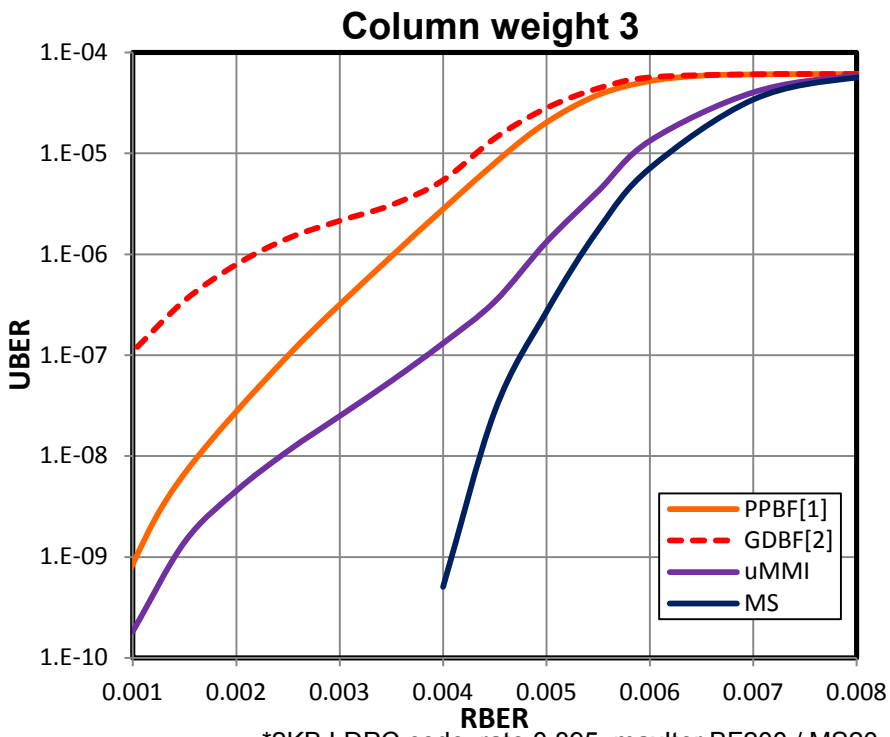
SMI Green mode – QoS, power



Flash Memory Summit

Mainstream algorithms

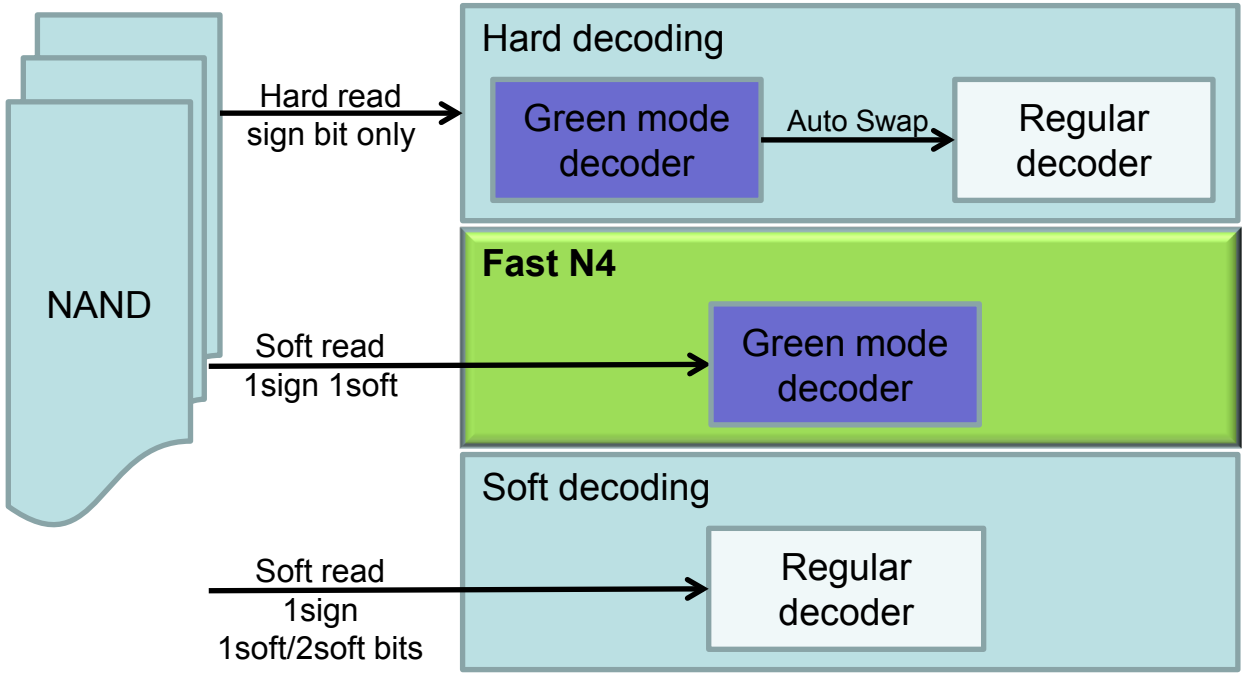




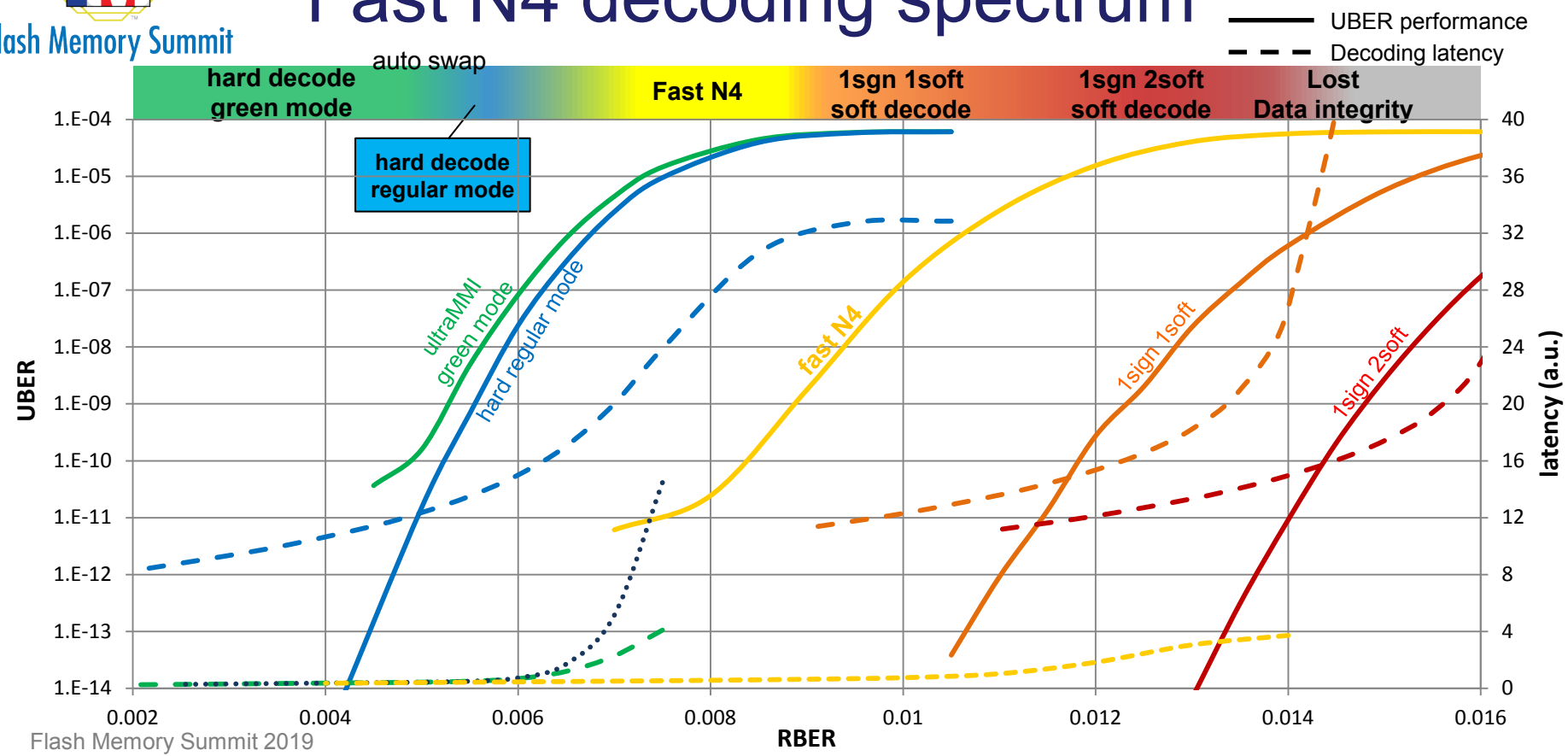
*2KB LDPC code, rate 0.895, maxIter BF200 / MS20

[1] K. Le, el al., "A probability parallel bit-flipping decoder for low-density parity-check codes," *IEEE Trans. Circuits Syst. I, Reg. Papers*, Vol. 66, No. 1, pp. 403-416, Jan. 2019.
[2] T. Wadayama, et al., "Gradient descent bit flipping algorithms for decoding LDPC codes," *IEEE Trans. Commun.*, Vol. 58, No. 6, pp. 1610-1614, Jun. 2010.
[3] D. V. Nguyen and B. Vasic, "Two-bit bit flipping algorithms for LDPC codes and collective error correction," *IEEE Trans. Commun.*, Vol. 62, No. 4, pp. 1153-1163, Apr. 2014.

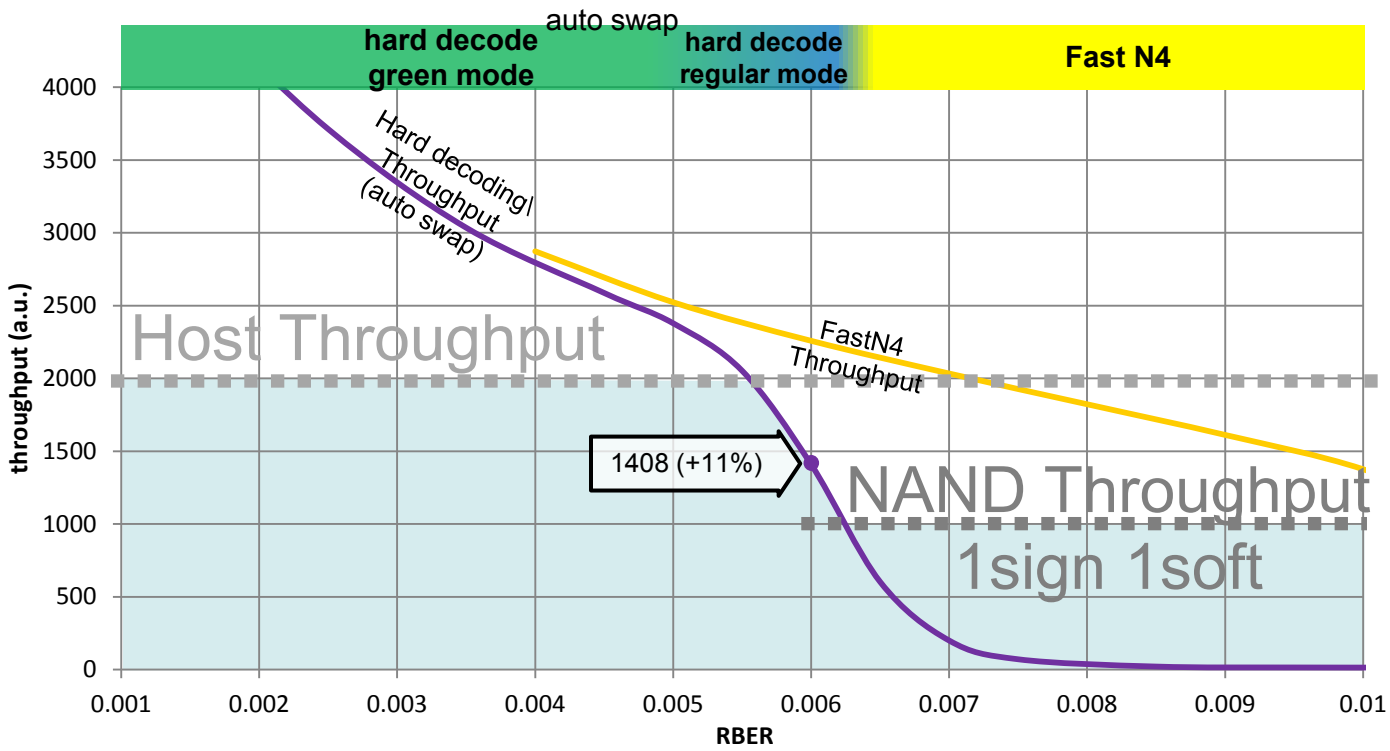
5th generation Green Mode

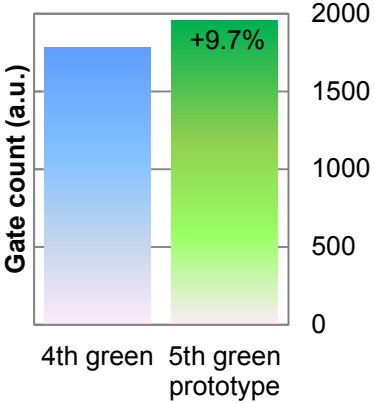


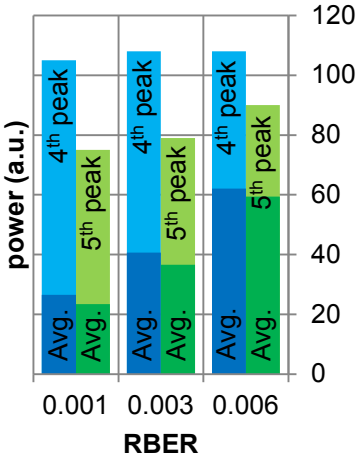
Fast N4 decoding spectrum



5th green mode prototype

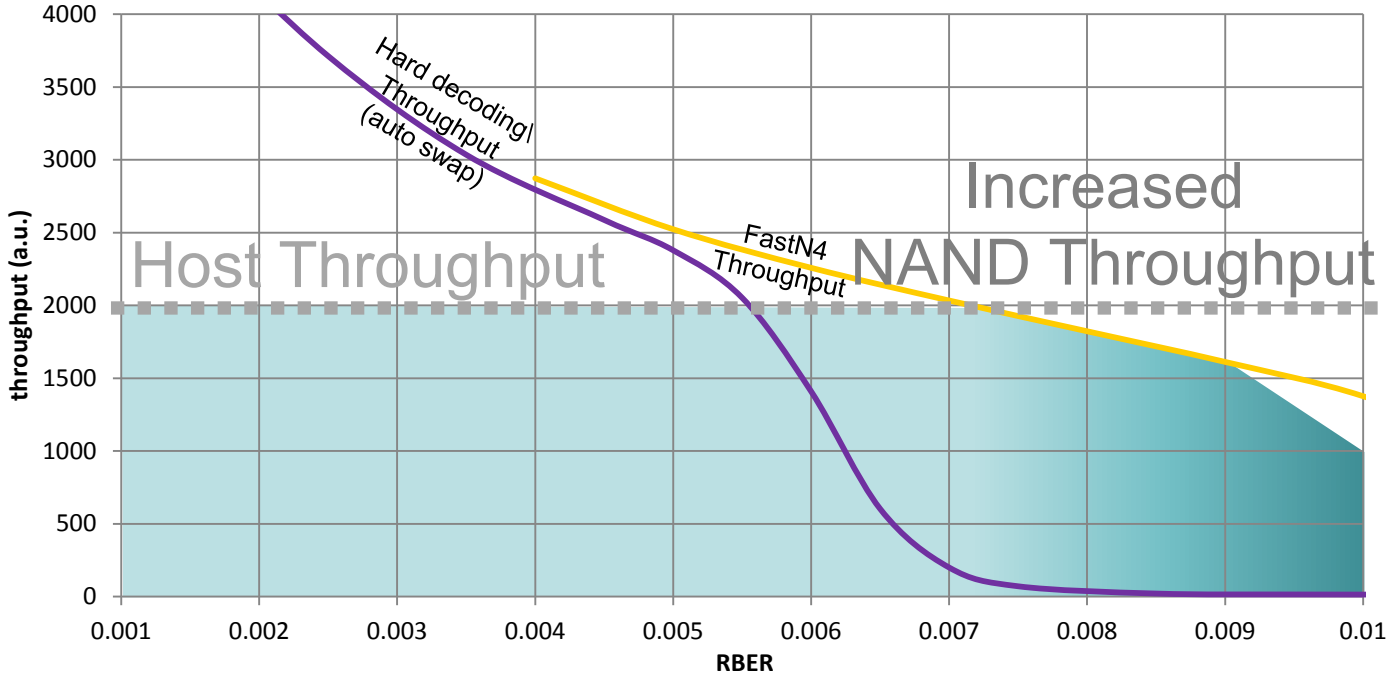




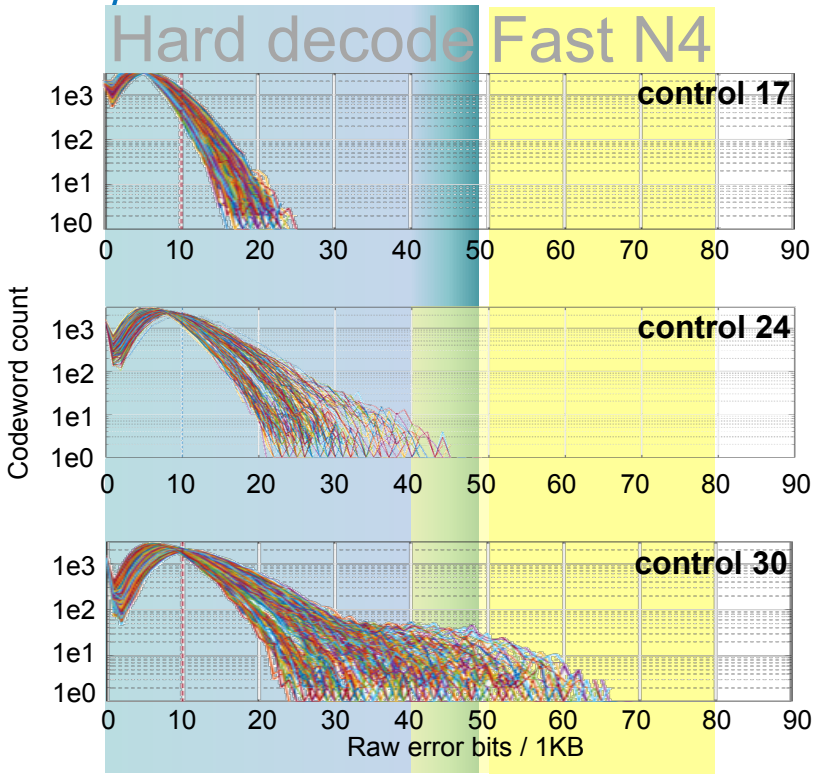


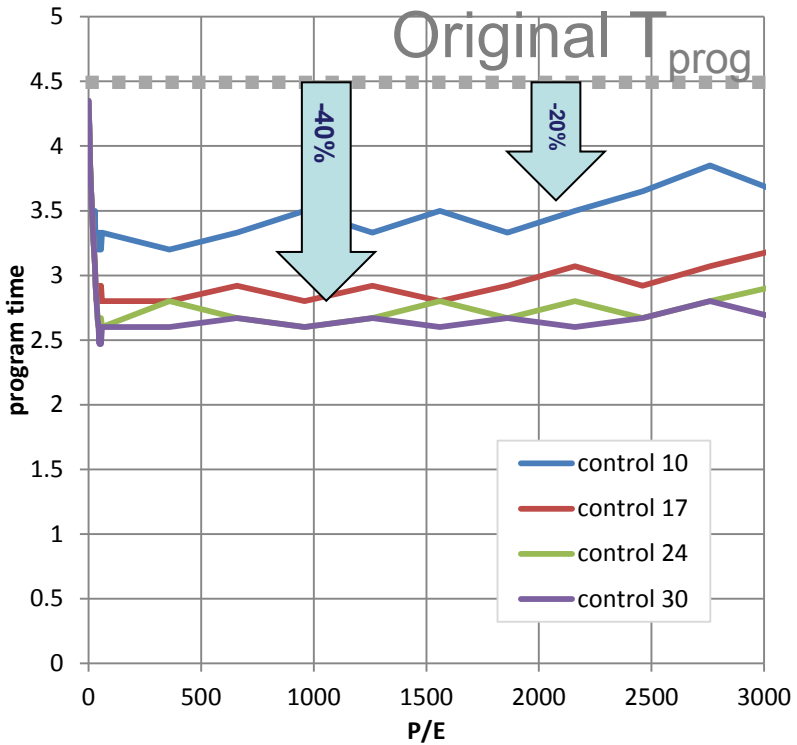
Fast N4 scenarios

- A controller that never loses speed

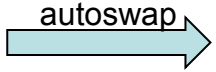


Fast N4 scenarios – programming time

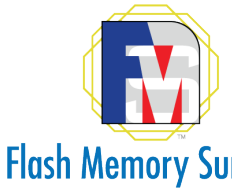




Fast N4 scenarios – burst write

- Other than run-time T_{prog} adjustment, the same method can power a write throughput thruster.
- Burst write phase
  - Burst write quota.
  - Very short T_{prog} (ex. Control 40~50).
- Recovery phase
  - Green mode ultraMMI 

fast N4.
  - Direct fastN4 mode



SiliconMotion

www.siliconmotion.com

Thanks for your attention!

Visit our booth #413 for more information