4K-Block Format Efficiency and SNR Gain

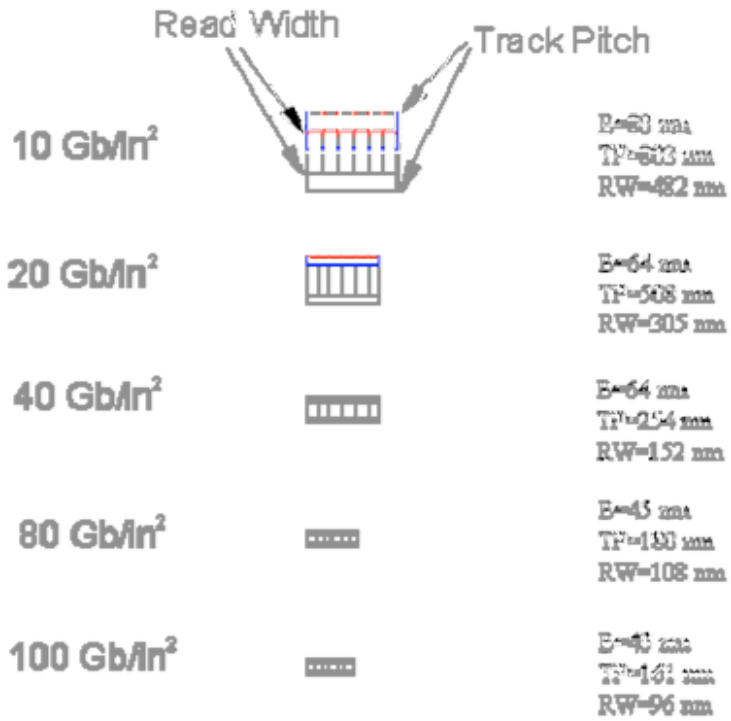
M.Hassner/HGST

Content

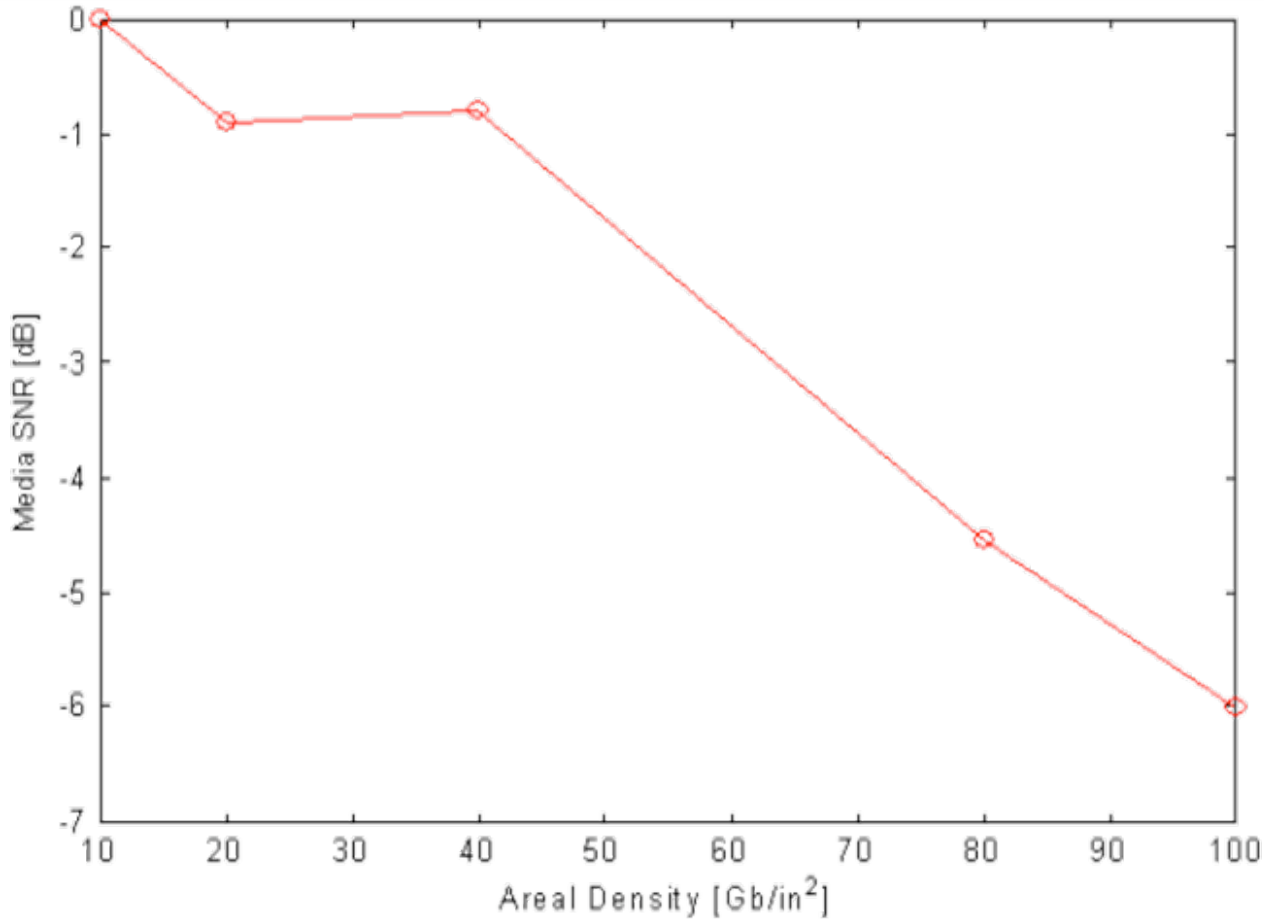
- **4K**-Block Format **Standard Chronology**
  [1998 — 2005]
- **Motivation:** AD-Growth **Bottleneck**
  [1998, IBM Task Force]
  [S.McCarthy/Maxtor,5/30/2001,**DiskCon** Presentation]
- **MARVELL 4K**-Block **Evaluation**
  [T.Doan, 1/31/04, requested by **IDEMA**]
- 4K-**Format** Efficiency/SNR **Gain Estimates**
- **Summary**

- 1998 IBM Task Force Recommendation (M. Hassner)
- 1998 NSIC White Paper (D. Cheng, M. Hassner, B. Lamberts, and R. Wood)
  - 100 GB/in^2 recording → 6 db loss of SNR
  - Signal processing will recover 3 dB
  - Stronger ECC required to recover 3 dB → 4 KB block size
- 2000 IDEMA 4K Block Committee (E. Grochowski, M. Hassner)
- 2002 Hitachi proposal large block ATA standard (D. Colegrove)
- 2003 IDEMA Position Paper
  - Joint position of Hitachi GST, Seagate, Maxtor, and Fujitsu
  - Sent to Microsoft 11/19/2003
- 2004 Microsoft Support for 4K Block Format
  - Support for 4K block will be in "Longhorn" (6/4/2004)

6 Bits and a Track at 10 to 100 Gb/in^2

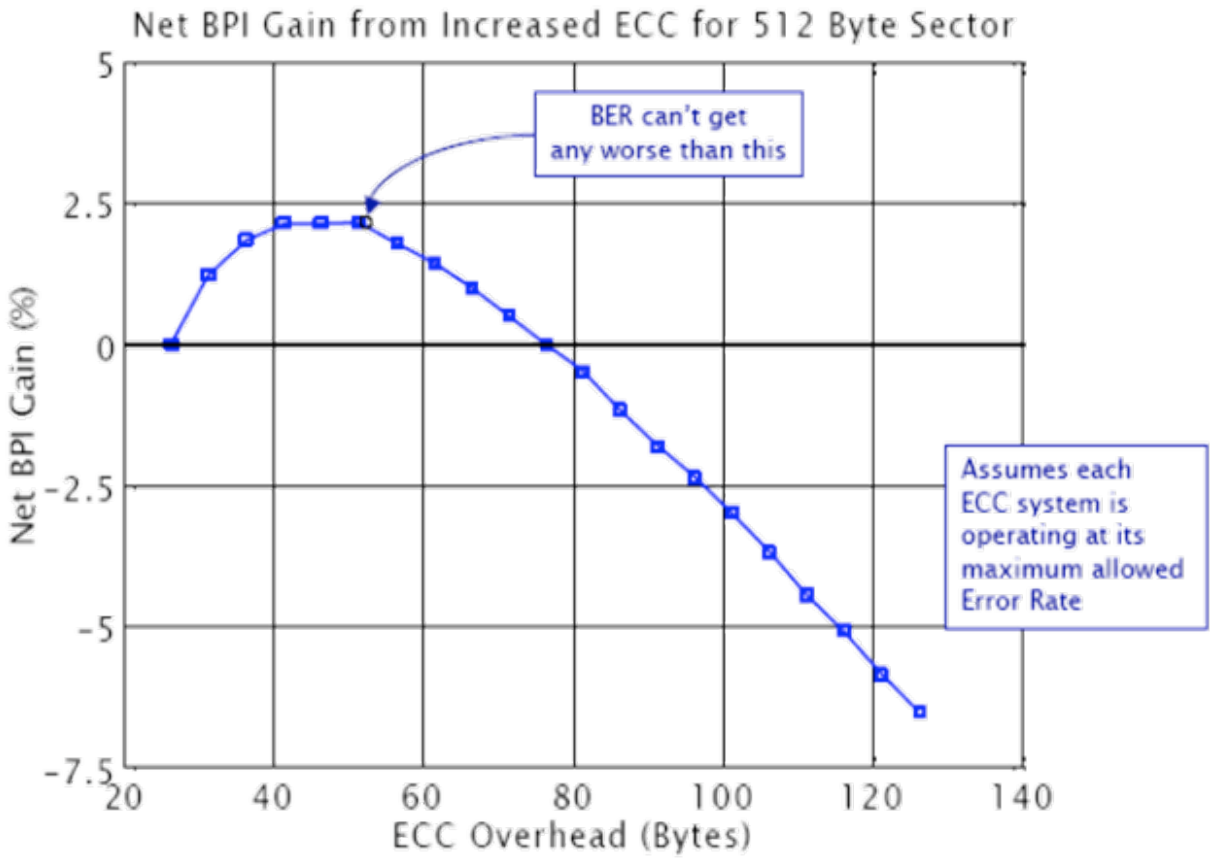


Media Noise at 10 to 100 Gb/in^2



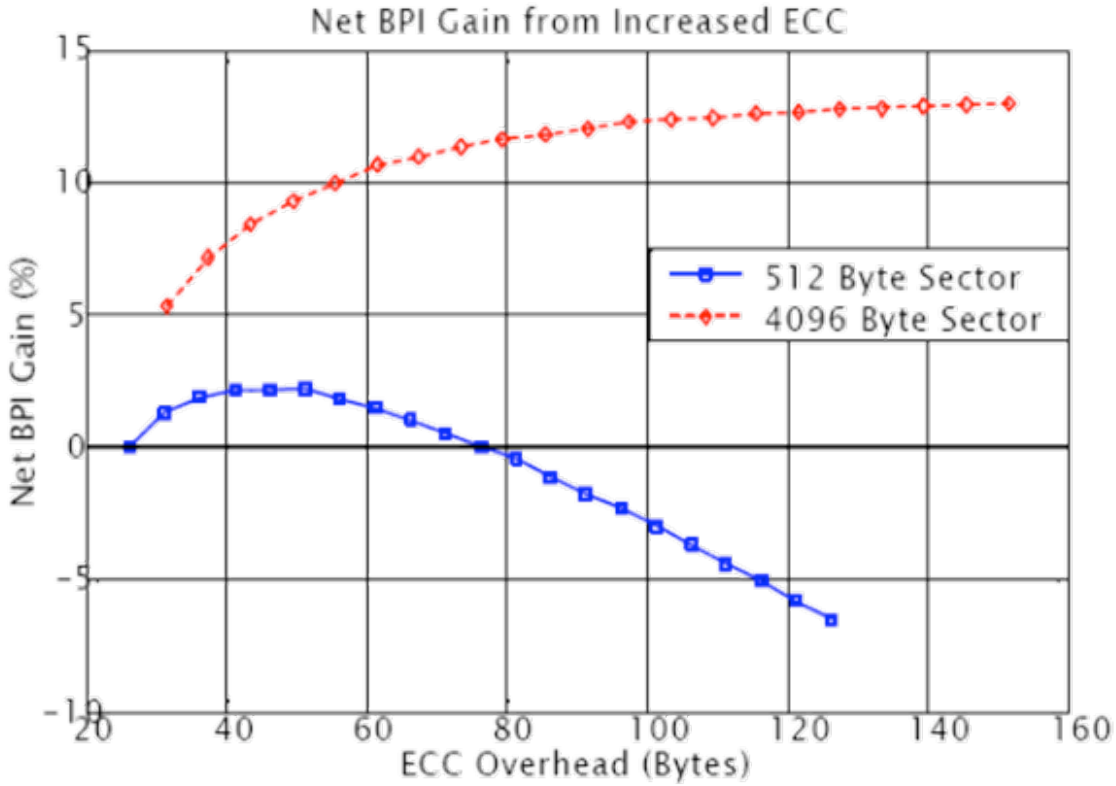
Potential ECC Gains

- Improvements in *Error Correction* on 512 Byte sectors are diminishing



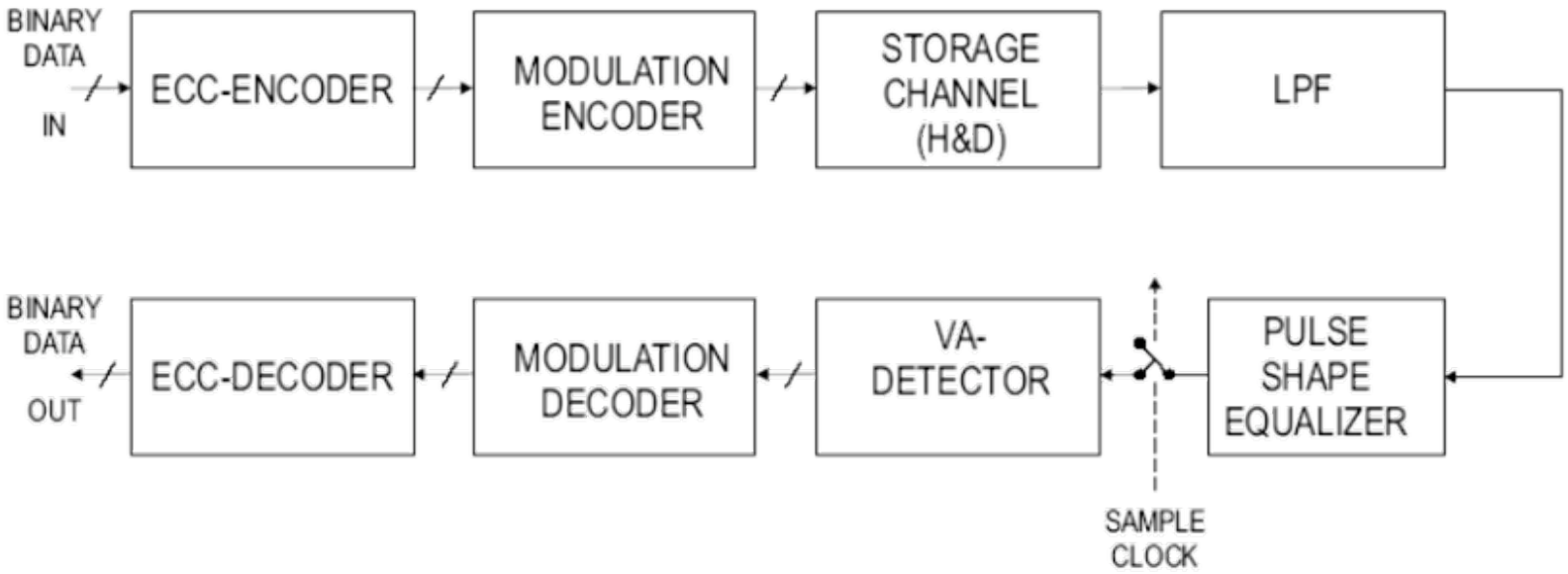
Increased Sector Size

- Longer Sectors improve *Error Correction* capability
  - Even with long sectors, *SNR* and *BER* will get worse



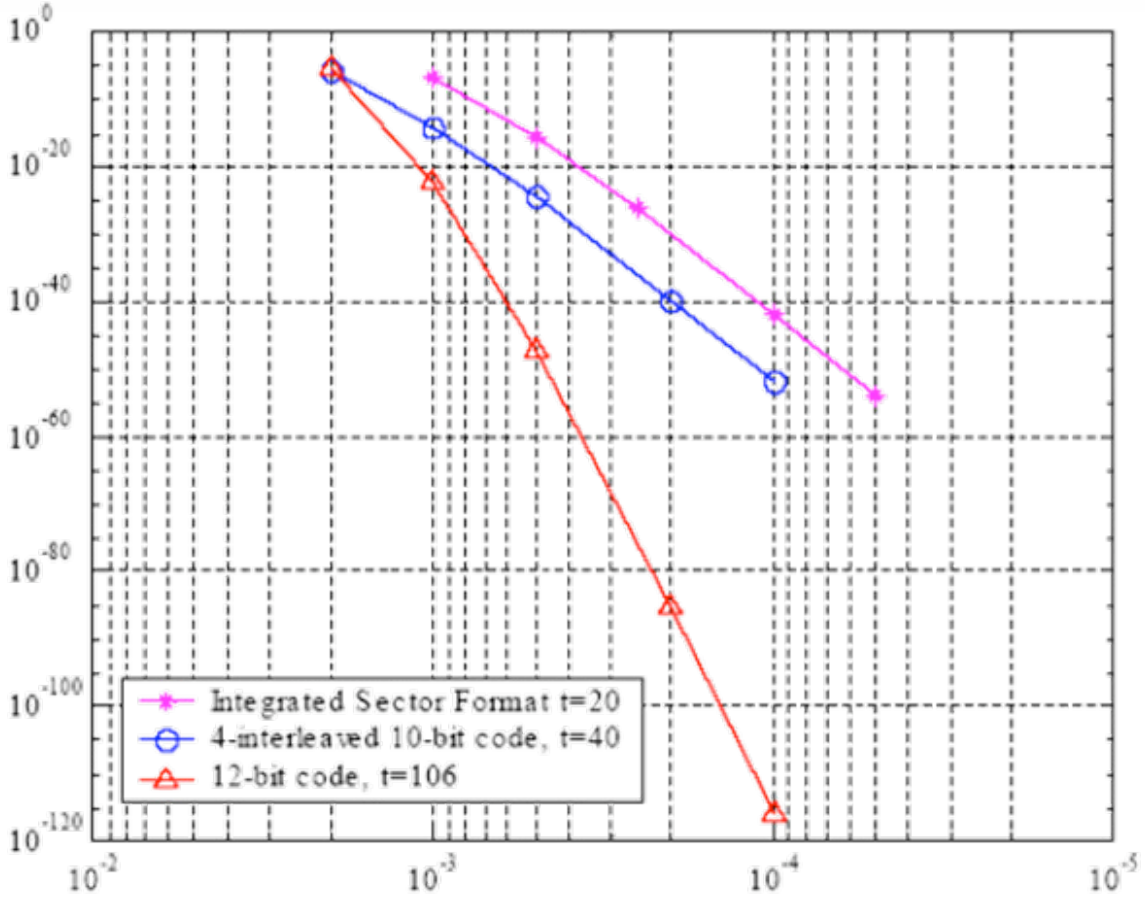
Background

- The IDEMA is proposing 4K bytes sector size. Dr. Martin Hassner (HGST) had a discussion with Marvell on several ECC schemes.
- The schemes discussed are:
  - A. Integrated Sector Format (ISF)
  - B. Interleaved 10-bit ECC (4 interleaves)
  - C. 12-bit ECC w/o interleaving
- We investigated the gain and the complexity of each scheme. The assumptions are:
  - 100 bytes (800 bits) burst correction is needed. Burst corrections are assumed to be performed on the fly for all methods in this comparison
  - Target operating point is raw BER around 1e-3 before ECC
  - For simplicity, bit errors are assumed to be independent



STORAGE CHANNEL
BINARY DATA PROCESSOR

The ECC Schemes: Performance



ISF: [1-3-5-7], [2-4-6-8], each chunk has a second level correction up to 40

Conclusions

- We have investigated several ECC schemes for the 4KB sector format. The 12-bit ECC without any interleaving seems to be very attractive.

MARVELL 4K-Block ECC Gain Calculation

- **Binomial** Error **Distribution** Model
- **Current Bit Error Rate** at Read Channel Output $\approx 10^{-5}$, 9% **Overhead**
- **Assume— Bit Error Rate** at Read Channel Output $10^{-2.8}$, 9% **Overhead**
  - 512-**Byte Sector 10-bit ECC** $[N = 450, t = 40] \rightarrow 10^{-5}$ Byte Error Rate
  - $4K$-**Byte Sector 4-wy interlved 10-bit ECC** $[N = 900, t = 40] \rightarrow 10^{-9}$ Byte Error Rate
  - $4K$-**Byte Sector 12-bit ECC** $[N = 3000, t = 135] \rightarrow 10^{-19}$ Byte Error Rate

4K-Block 12-bit ECC Gains

- 512-**Byte** Sector **Format**
  - 10-bit GF-Implementation/10-bit clock
  - 9%-**Overhead**
  - **ber** $10^{-5} - 10^{-6} \rightarrow$ **BER** $10^{-11} - 10^{-12}$
- $4K$-**Block** Sector **Format**
  - 12-bit GF-Implementation/12-bit clock
  - 5%-**Overhead**
  - **ber** $10^{-3.0} - 10^{-4} \rightarrow$ **BER** $10^{-11} - 10^{-12}$
  - **Format Efficiency Gain** $13 - 14\%$
  - **SNR Gain** $9 - 10\%$

4K-Block Defect Correction

- 512-**Byte** Sector **Format**
  - 10-bit GF-Implementation
  - 9%-**Overhead** [400-bits]
  - **Correctable Defect** Length ≈ 380 **bits**
- $4K$-**Block** Sector **Format**
  - 12-bit GF-Implementation/12-bit clock
  - 5%-**Overhead** [1728-bits]
  - **Correctable Defect** Length ≈ 1700 **bits**

Summary

- **4K-Block** Sector **Short-Term Gain**
  - $22-24\%$-**Capacity** Gain
  - Significantly Improved **Hard Error Rate**
- **4K-Block** Sector **Long-Term Gain**
  - Maintain **AD-Growth** $100Gb/in^2 \rightarrow 1Tb/in^2$ [$12dB$ **SNR-Loss**,NSIC SP Roadmap]
  - **Multilevel/Iterative** Coded **Signal Processor**

References

- **www.idema.org/Long Data Block**
  - **IBM** NSIC White Paper, 1998
  - **DiskCon2001** Presentation, S. McCarthy/**MAXTOR**
  - **DiskCon2001** Presentation, M. Hassner/**IBM**
  - **HGST** Long Block **T13-ATA Committee** Proposal, D. Colegrove, 2002
  - **SEAGATE/MAXTOR/FUJITSU/HGST** 4K-Block Position Letters, 2003
  - **MARVELL** 4K-Block Evaluation, 2004