

The Future of Tape Storage

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MSST 2026



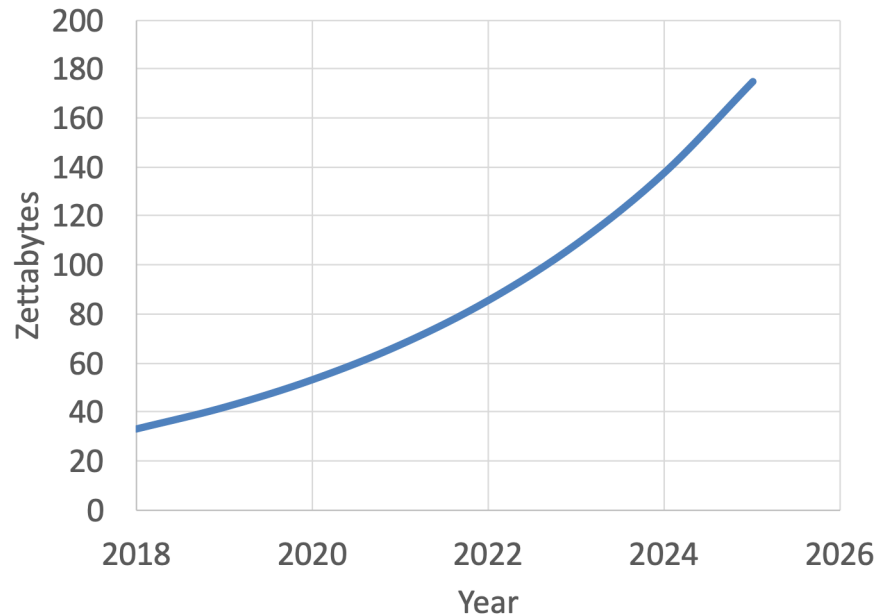
Outline

- Tape's renaissance
- Scaling challenges in magnetic recording
- Tape research demos and the INSIC Tape Roadmap
- LTO10 and tape system level innovation
- Summary

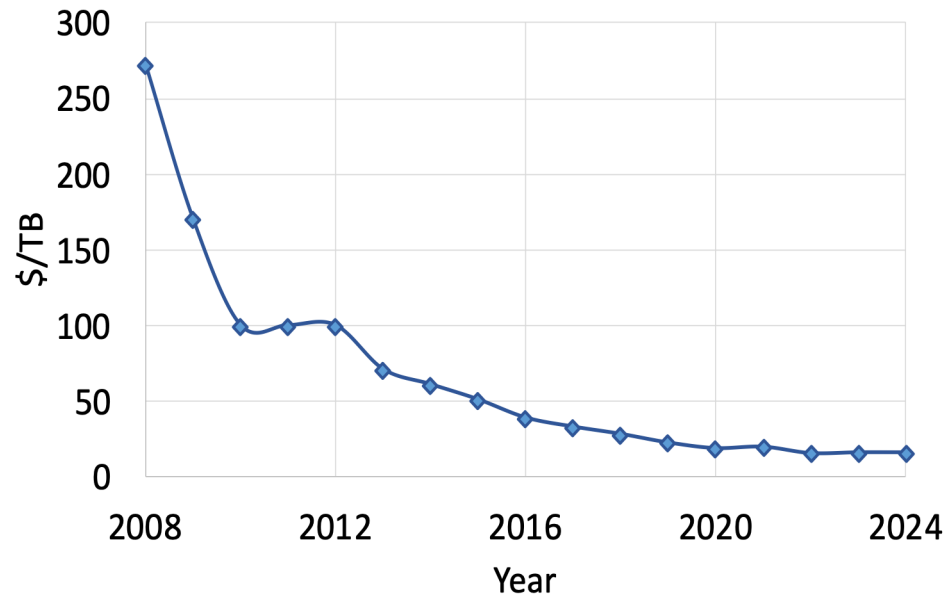
Tape's Renaissance

Data is growing exponentially while HDD scaling has stagnated

Data Growth



HDD \$/TB Shipped



Refs: Data growth projections from IDC White Paper – #US44413318, Cost Scaling Data, Georg Lauhoff:
https://digitalpreservation.gov/meetings/DSA2025/010201_lauhoff_LoC2025_IBM_G_Lauhoff.pdf

Recent trends in HDD and SSD

ZME SCIENCE

Home - Future

Hard Drive Prices Have Surged 60% in Just Four Months as Data Centers Snap Up Every Available Unit

Building a PC is becoming a luxury as AI companies hoard the world's digital storage supply.



by Tudor Tarita — February 24, 2026 in Future, News AA

WD: “We're pretty much sold out for calendar year 2026... We also have robust commercial agreements through calendar year 2027 and one through calendar year 2028.”

Seagate: “Our nearline capacity is fully allocated through calendar year 2026... Multiple cloud customers are discussing their demand growth projections for calendar 2028

Forbes

SSD Storage Capacity Prices Are Over 20 Times HDD Storage Capacity Prices

By [Thomas Coughlin](#), Contributor. © Covering Digital Storage Technology &...



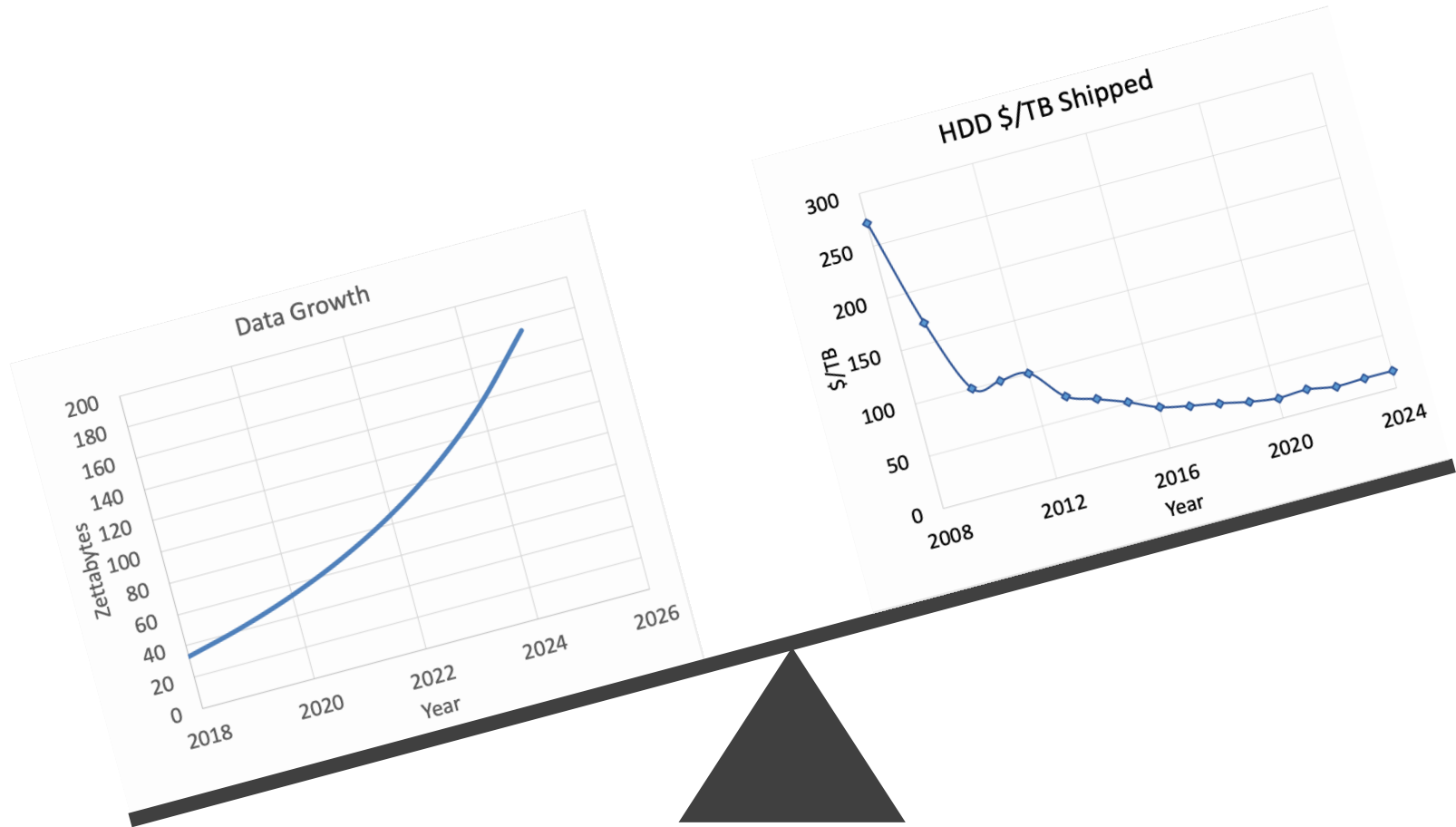
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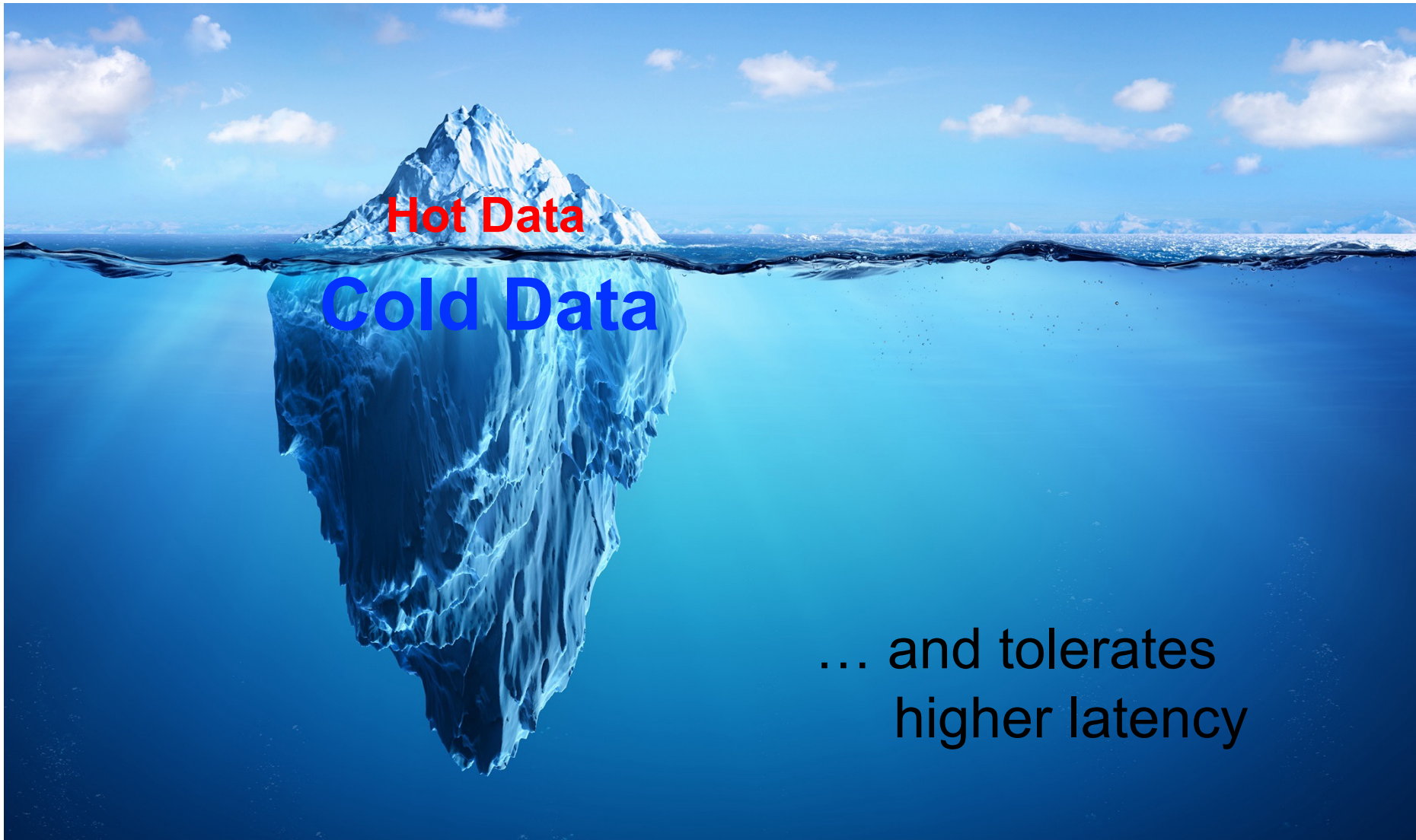
The costs of storage to support AI and other enterprise workloads have exploded. Especially for solid state drives, SSDs, used for primary storage to support the high bandwidth memory, HBM, demand of graphical processing units, GPUs.



The Data Center is Out of Balance



A large fraction of data is cold...



... and tolerates
higher latency

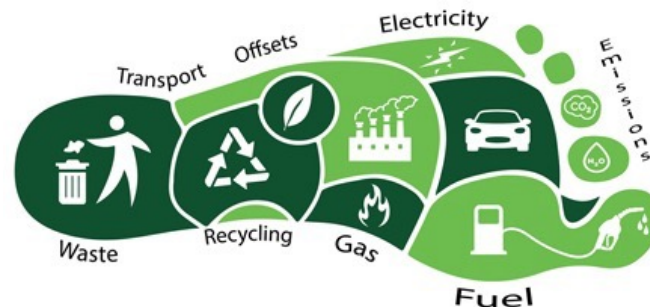
Why is tape exciting again?

Cost Savings



@ hyperscale HDD Cost 3.7x Tape*

Sustainability



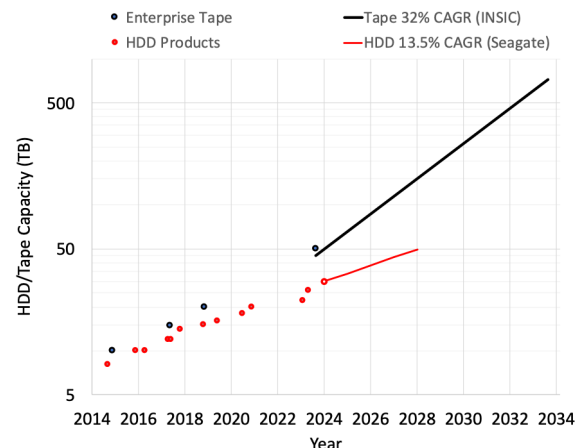
27PB Tape Archive has 96% Lower CO2e than HDD

Security



Airgap, Encryption
Quantum Safe

Scaling



INSIC Tape Roadmap

Tape Scaling

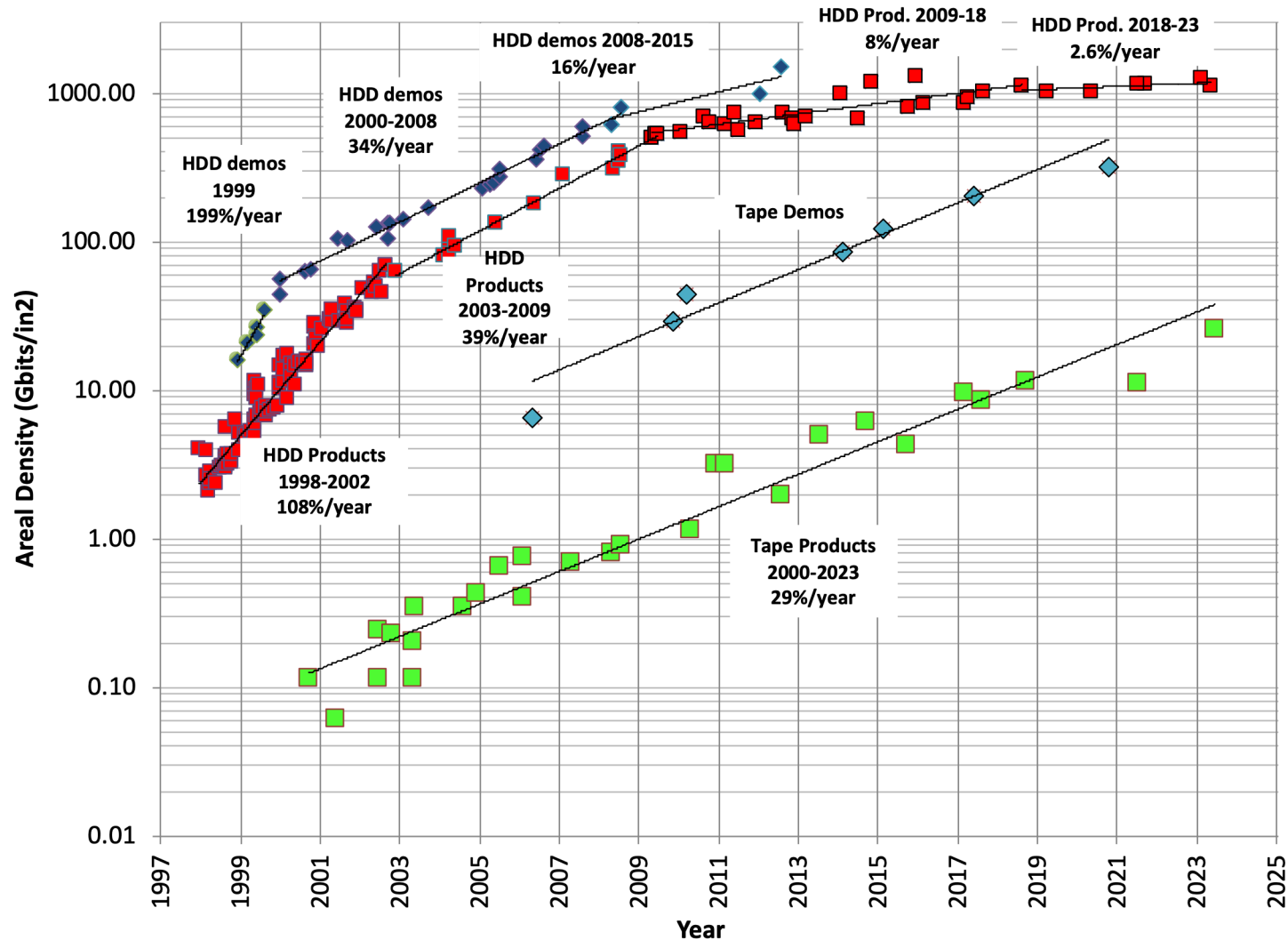
Product Year	IBM 726 1952	LTO10 2025	TS1170 2023	Demo 2020 SrFe Tape
Capacity	2.3 MB	30 TB	50 TB	580 TBytes
Areal Density	1400 bit/in ²	23.2 Gbit/in ²	26.1 Gbit/in²	317 Gbit/in ²
Linear Density	100 bit/in	550 kbit/in	555 kbit/in	702 kbit/in
Track Density	14 tracks/in	42 ktracks/in	47 ktracks/in	452 ktracks/in



Areal
Density
>**18.6M** x

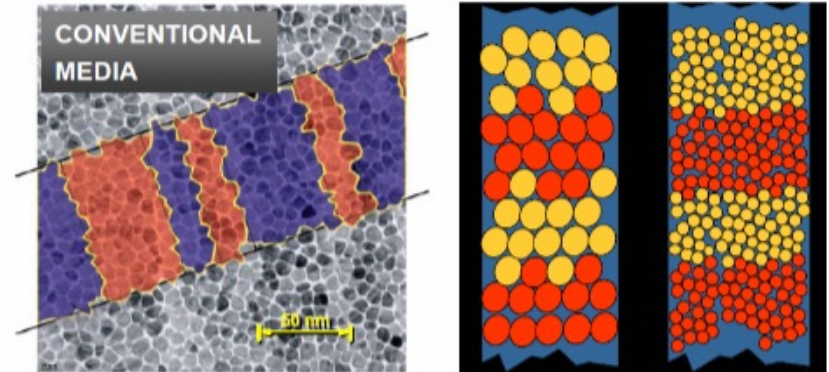
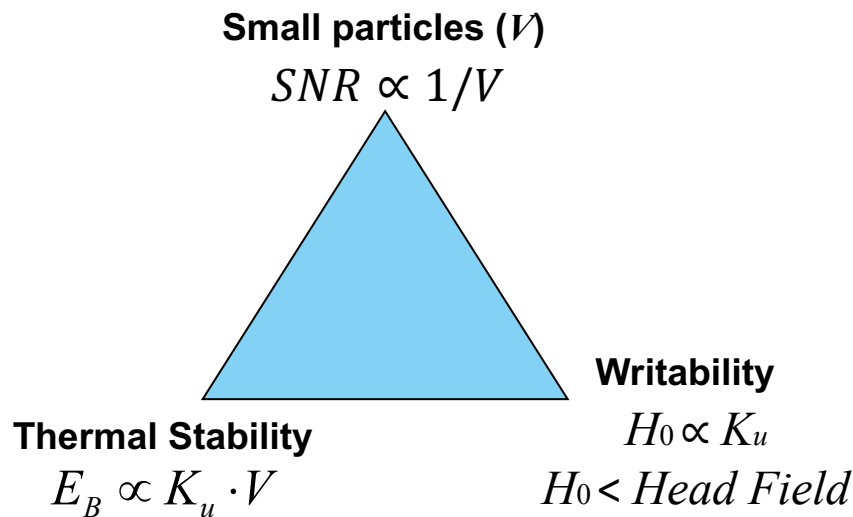


Areal Density Scaling



Superparamagnetic Limit

Magnetic Media “Trilemma”:



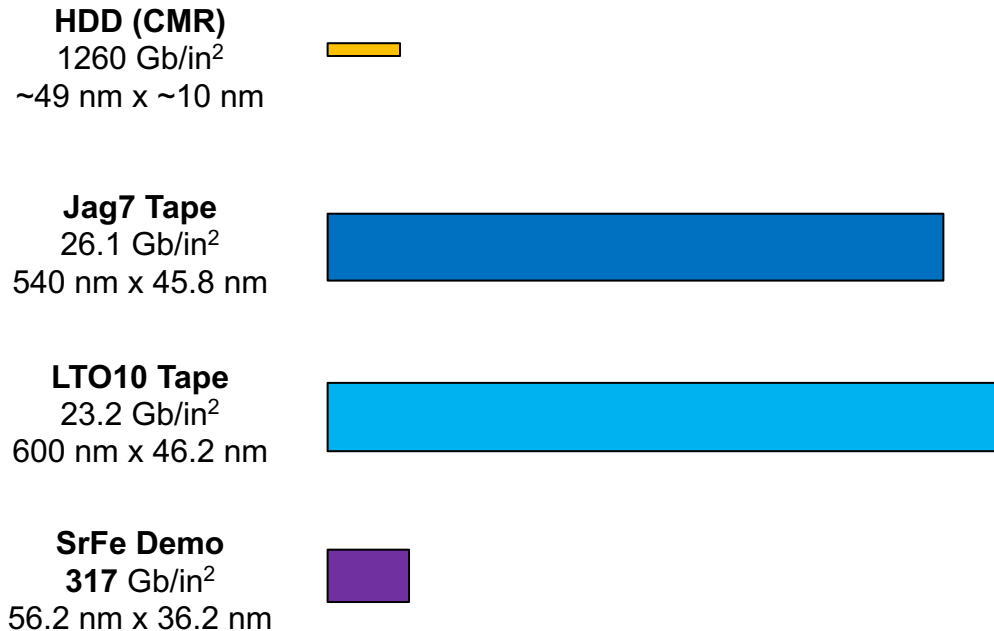
HDD has reached the limit of (known) materials to produce larger write fields.

Tape operates at areal densities far from the superparamagnetic limit and has the potential to continue scaling for many years

Technologies to go beyond the superparamagnetic limit:

- Energy Assisted Magnetic Recording: **HAMR**, (MAMR)

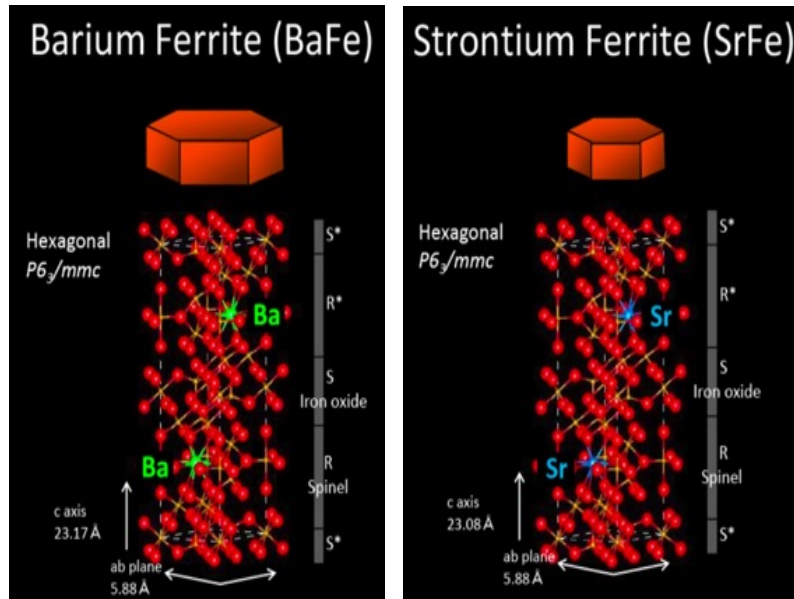
Storage Bit Cells and Extendibility



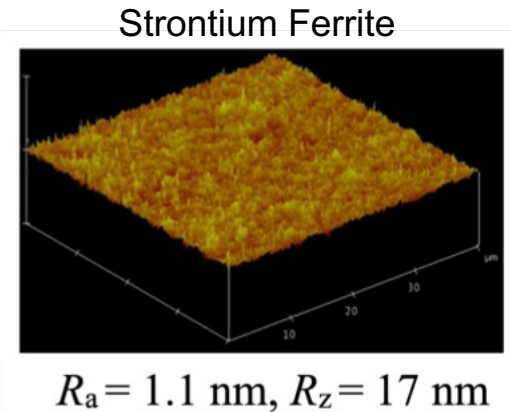
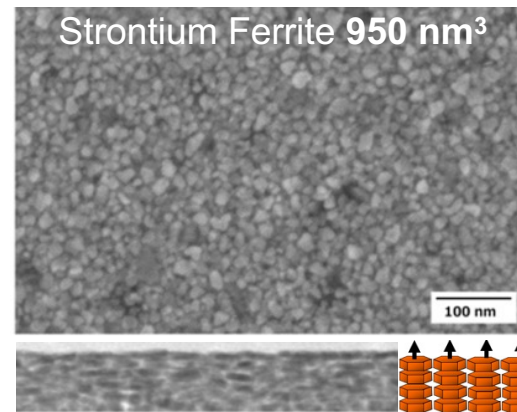
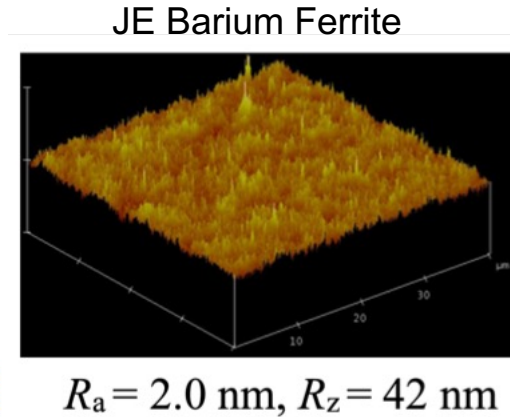
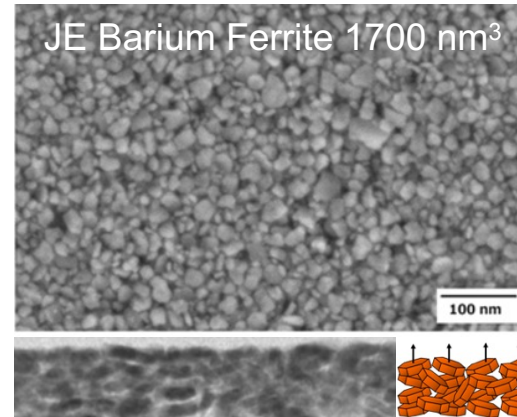
→ Most potential for future scaling is tape track density

Media Technology: BaFe versus SrFe

BaFe and SrFe are both stable oxides



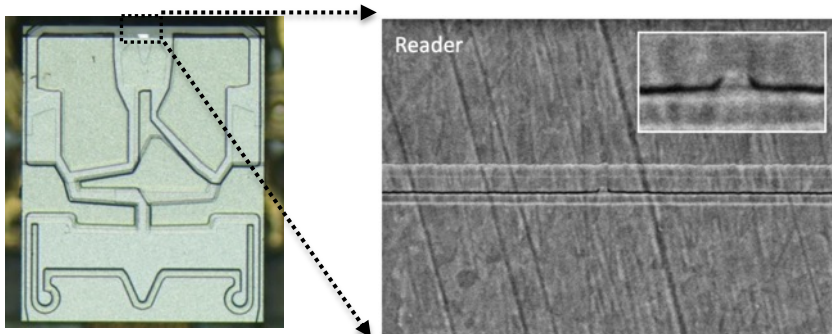
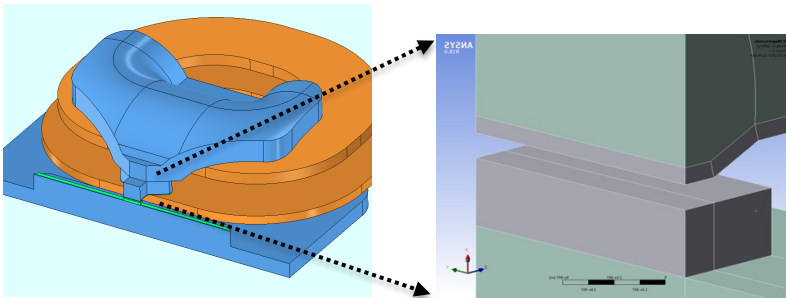
	BaFe	SrFe
M_s (Am ² /kg)	72	92
K_u (10 ⁵ J/m ³)	3.3	3.5



- Enhanced magnetic properties of SrFe enables scaling to smaller particles
- **Demo media** uses smaller 950nm³ particles and smoother tape
- Enhanced perpendicular orientation of SrFe particles
- New high moment writer technology to write increased coercivity media
- New low friction head technology

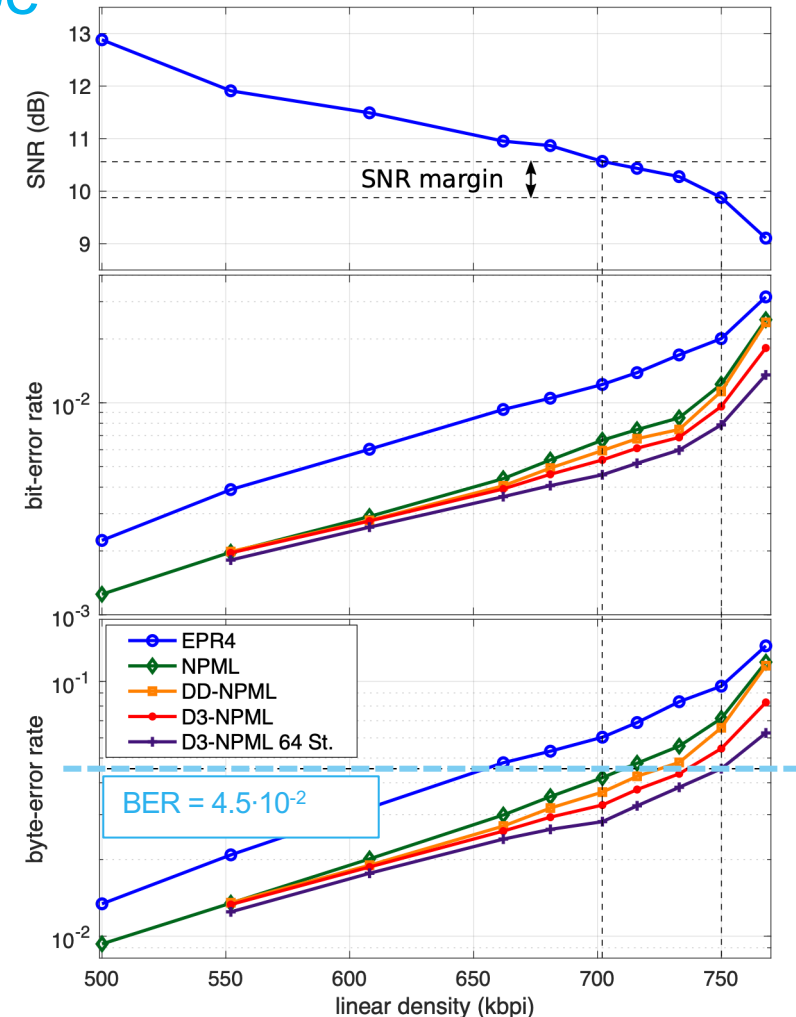
Recording Performance of SrFe Tape

- High-moment tape writer
- 29nm-wide TMR reader (HDD)
- Iterative ECC decoding $\rightarrow$ UBER 10^{-20}



HDD slider

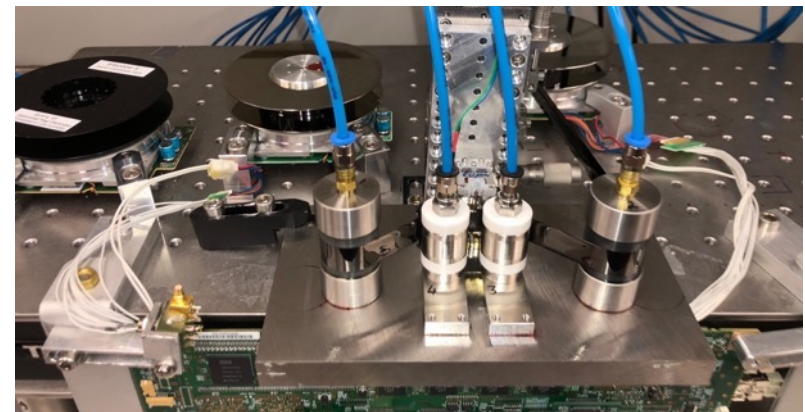
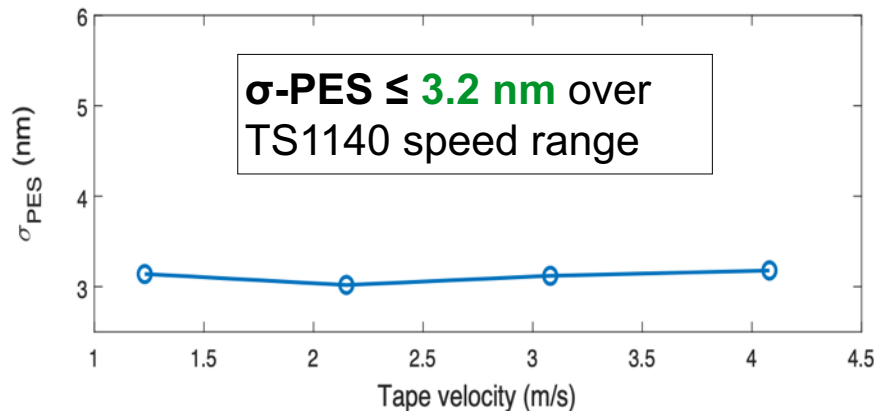
SEM Image of 29nm TMR Reader



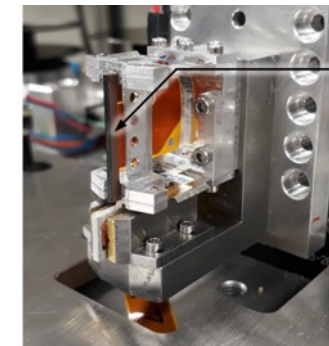
SrFe demo tape supports a **linear density of 702kbpi** with a 29nm reader and provides an operating margin of ~ 0.7 dB SNR

Track-following Performance on SrFe Demo Tape

- New TBS servo pattern with 36deg azimuth angle
- New X4 FPGA platform with 4-channel averaging
- Low disturbance tape path with new prototype track-following actuator and new low-friction head
- H-inf based optimized track-following controllers



Low disturbance tape path

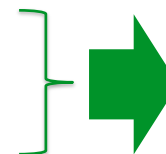


Low friction Tape head

Prototype actuator

$$\text{Track Width} = 2 \cdot \sqrt{2} \cdot 3 \cdot \sigma_{PES} + \text{Reader Width} \quad (\text{INSIC method})$$

Reader Width = 29nm
 $\sigma_{PES} \leq 3.2$ nm



Track width = 56.2nm
Track density = 451.9 ktpi

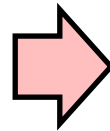
317Gb/in² Areal Density → Potential Cartridge Capacity



29 JE cartridges (20TB)



Tape	Thickness (um)	Length (m)	Length Scale Factor	Areal Density (Gb/in ²)	AD Scale Factor	Capacity (TB)
JE	4.6	1163	1	11.7	1	20
Demo	4.3	1244	1.07	317.3	27.12	580.2



**Potential Cartridge Capacity:
580 TB !**



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3101311

317 Gb/in² Recording Areal Density on Strontium Ferrite Tape

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Other Recent Tape Demos

IEEE TRANSACTIONS ON MAGNETICS, VOL. 58, NO. 4, APRIL 2022



Evaluation of Sputtered Tape Media With Hard Disk Drive Components

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²Western Digital Corporation, Rochester, MN 55901 USA

“We demonstrated that such sputtered tape could achieve an areal density of **400 Gb/in²** under shingled magnetic recording conditions.”

SONY

OPA-01

1

Challenge of Media Noise Suppression with Oxidation Control in Granular Structure for CoPtCr-based Sputtered Tape towards 400 Gb/in²

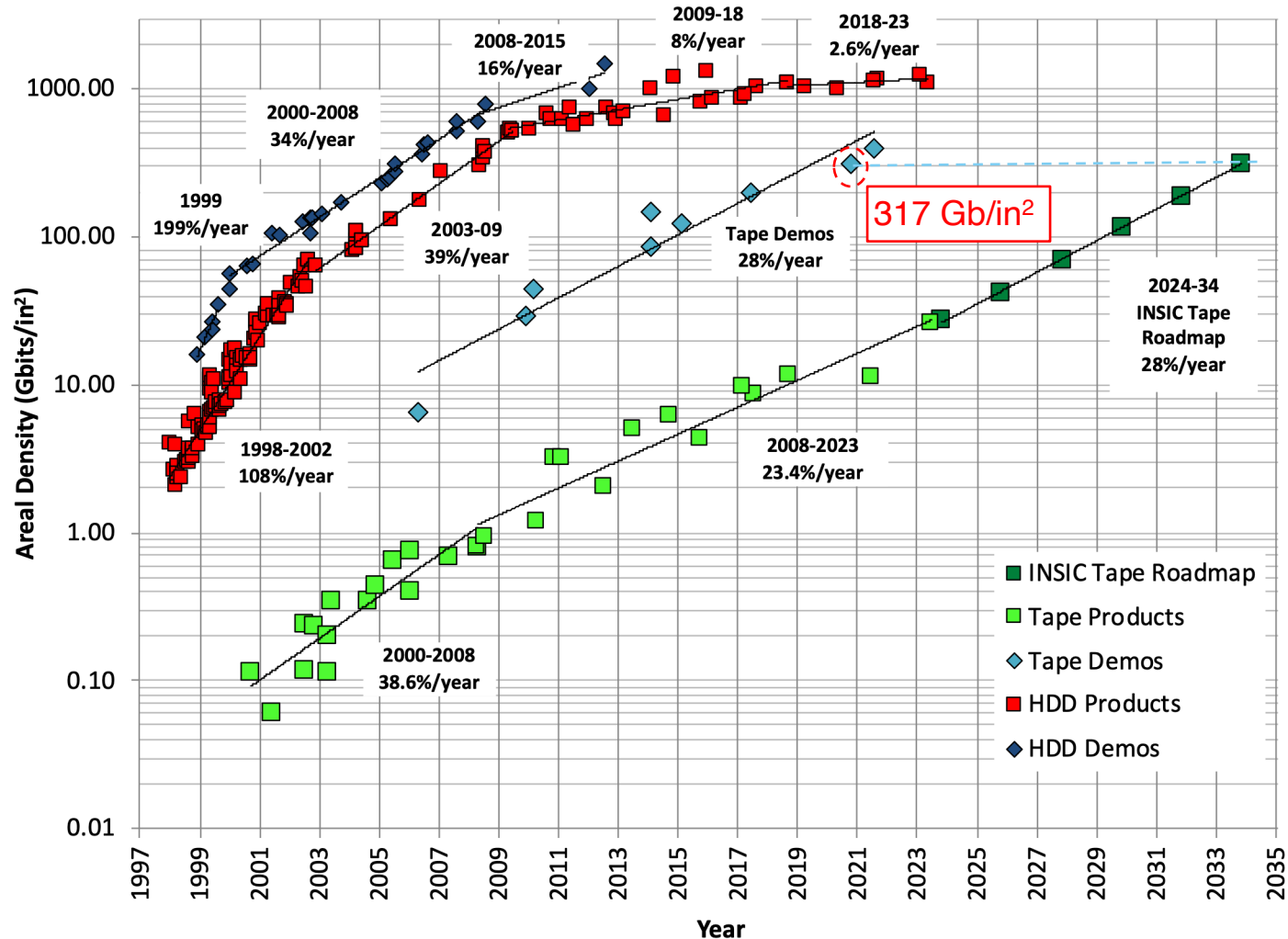
Junichi Tachibana¹, Hiroyuki Kobayashi¹, Teruo Sai¹, Satoshi Kodama¹, Takashi Aizawa¹,
Atsushi Yamaguchi,¹ and Shin Saito²

¹Sony Storage Media Solutions Corporation, Tagajyo, Miyagi 985-0842, Japan, Junichi.Tachibana@sony.com

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INSIC 2024-2034 Tape Roadmap: Areal Density Scaling

Recent tape demos support the sustainability of the INSIC Tape Roadmap



LTO-10: Biggest Leap Since LTO-1

IBM LTO-10 FH Drive (GA'd 2025/06/13)

- 30TB(1.7x LTO-9)
- **40TB (2.2x LTO-9)**

Faster Interfaces:

- 32G FC (4x LTO-9)
- 12G SAS (Mini-SAS HD)

LTO-10 drive has significant technology improvements in ASICs, mechanisms, and write/read heads from LTO-9.

25 Years of LTO technology!

- 400x capacity increase
- 20x data rate increase



IBM Diamondback Tape Library

Delivers ultra-high-capacity, long-term data storage with the air-gapped cyber resiliency only tape can provide.

IBM Diamondback Specs:

- Up to 61 PB native capacity with LTO-10 40TB
- Up to 46 PB native capacity with LTO-10 30TB
- Up to 14 tape drives & 1548 cartridges

New: Climate-Controlled Diamondback

Features and Benefits:

- *Easy to deploy and service*
- Small footprint (OCP rack)
- *Customer serviceable*, high-performance robot with dual grippers to increase performance and reliability.
- *Designed to easily **scale out**.*

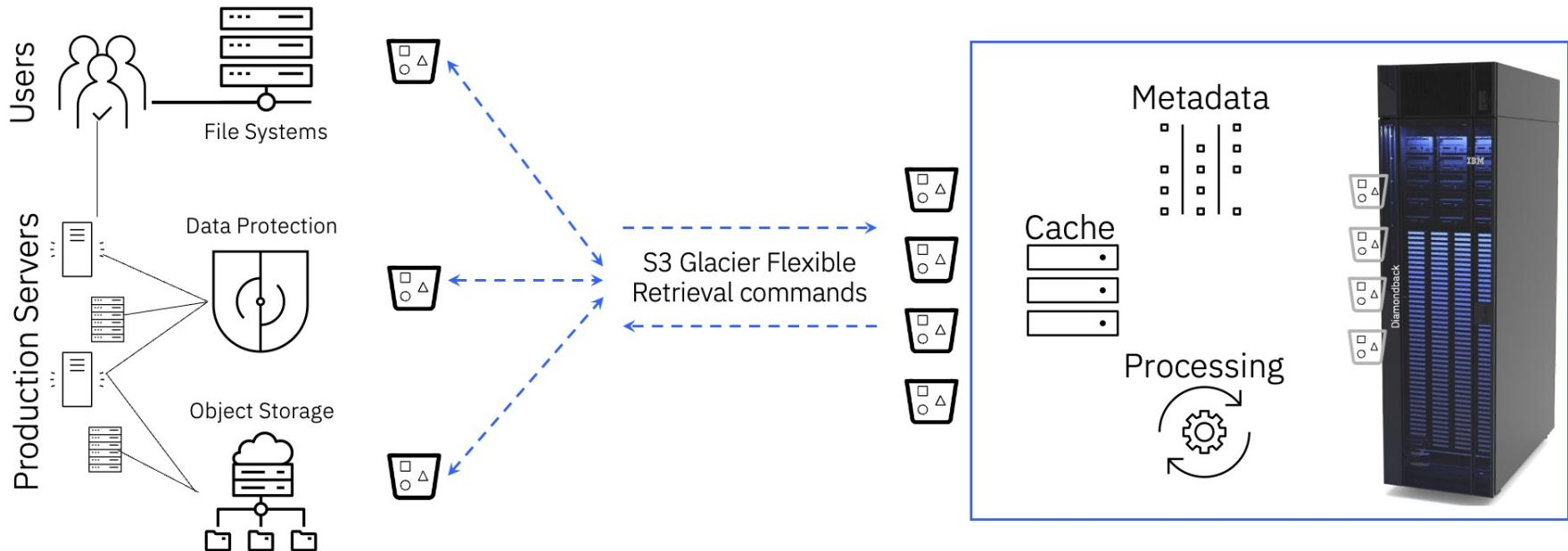


IBM Storage Deep Archive

- **Object Store built on the Diamondback Library** with integrated servers and software in a single OCP rack:

- *S3 Glacier compliant interface*
- *Install-and-go deployment*
- *Simple administration*

- No tape management software requirements.
- No knowledge of a tape interface needed.
- S3 Glacier storage class handles all latency in the communications.



→ A highly integrate-able, easy to use platform that transparently uses tape storage.

Summary

- HDD areal density and cost scaling have significantly slowed in recent years
 - Areal density scaling is reaching limits with PMR technology
 - HAMR technology has started to re-enable areal density scaling, but \$/GB scaling initially low.

- Tape has a sustainable roadmap for at least another decade and beyond
 - Areal density projected to scale with up to 28% CAGR
 - Capacity scaling with up to a 32% CAGR

- IBM Deep Archive and Diamondback aim to make tape easier to integrate, deploy, use and manage.
 - S3 Glacier interface enables transparent use of tape storage

Thank you