



The World (of Data Storage) is No Longer FLAT



Dr. Ken Anderson, CEO

***As fast as Hard Drives,
Capacities like Tape,
Costs like CD's***



Available in late 2017

- 6 TB Magazine capacity
- 80MB/s transfer rate

The Base Technology has been Proven

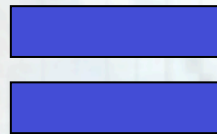


Video Demonstration of Gen 1 Prototype
<https://vimeo.com/125712793>

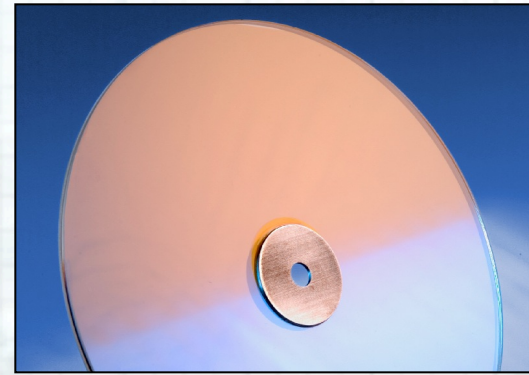
Holographic Data Storage. So cheap its almost free...



800 DVDs, 40 BDXL



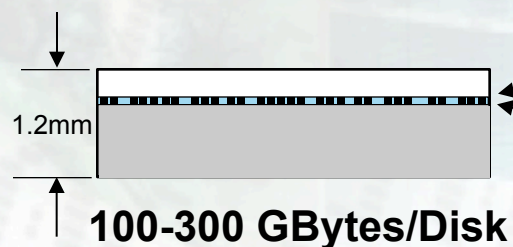
1 Holographic Disk



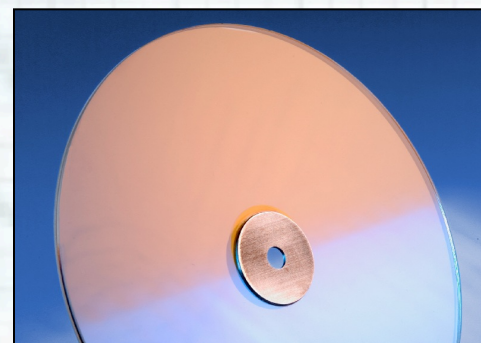
*By 2020, Holographic Disks will cost less \$0.50/TB.
That is 50x less than today's cheapest memory.*

Surface Versus Volumetric Recording

BDXL
data stored on **2D surface**

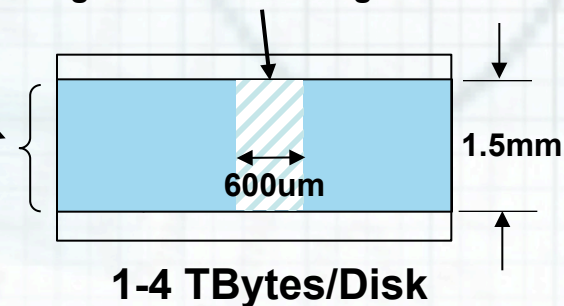


Holographic
data stored in **3D volume**



Data
Layer

800 Images x 10M bits/image x 28k locations/disk



10x Data Capacity Improvement over BDXL

The Holographic Advantage

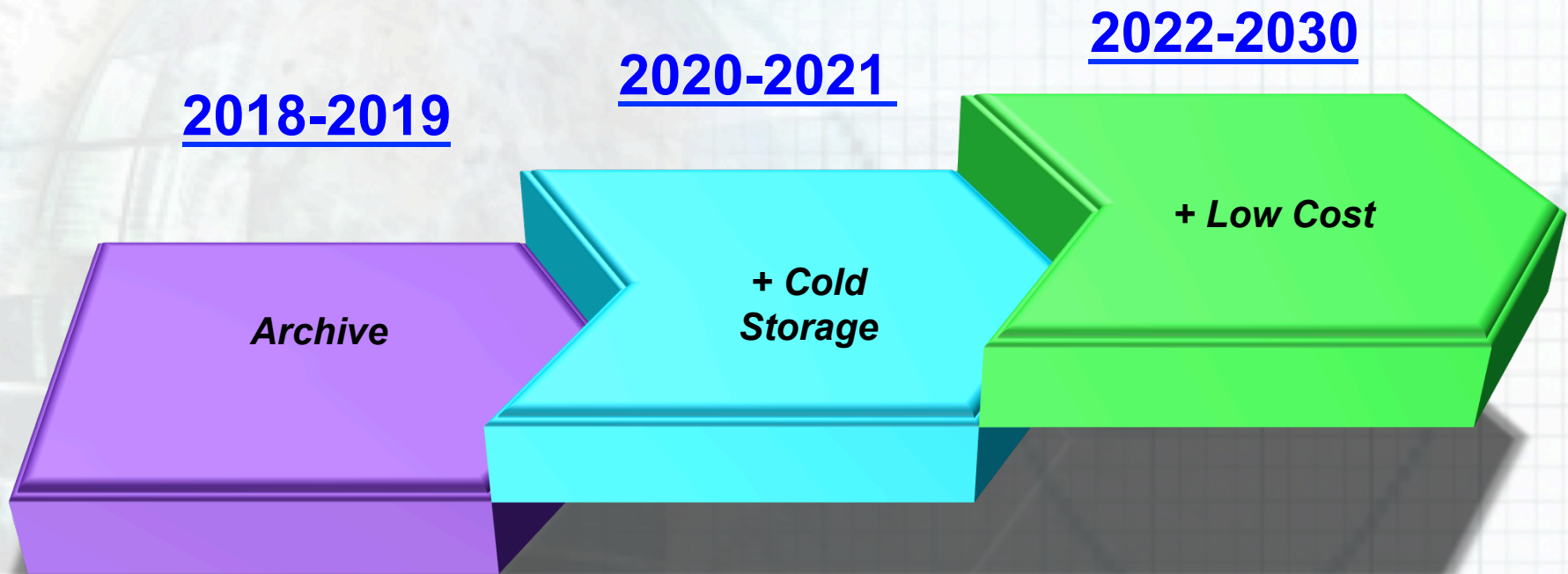
- ✓ Random access
 - ✓ Get to your data 20x faster than tape
- ✓ Tier 2.5+ storage solution
- ✓ Replace 10 tape drives with 1 holographic drive*
- ✓ Environmentally Robust
 - ❑ *Temp, humidity, dust, head/tape wear*
- ✓ 50 Year Media Life

- ✓ Ultra Low Cost Media
- ✓ Transfer Rate
 - 80MB/s Gen 1
 - Up to 500MB/s Gen 2
- ✓ Scalable Capacity
 - 16TB/card (known tech)
 - >4**PB**/card Physical limit

Three Phase Product Strategy



Long Term Target, Short Term Goals



- Launch 1TB product
- Small to Medium Scale Manufacturing Ramp
- Establish Archive Integration Partners

Drive Cost: \$10k, Media Cost - \$5/TB

- 4TB Product Launch
- Medium to Large Scale Manufacturing Ramp
- Establish Cold Storage Integration Partners

Drive Cost: \$1k, Media Cost - \$0.5/TB

- 8TB Product Launch
- 2x every 2 years
- 1PB/media Maximum
- Very Large Scale Manufacturing Ramp

Drive Cost: \$500, Media Cost - \$0.10/TB

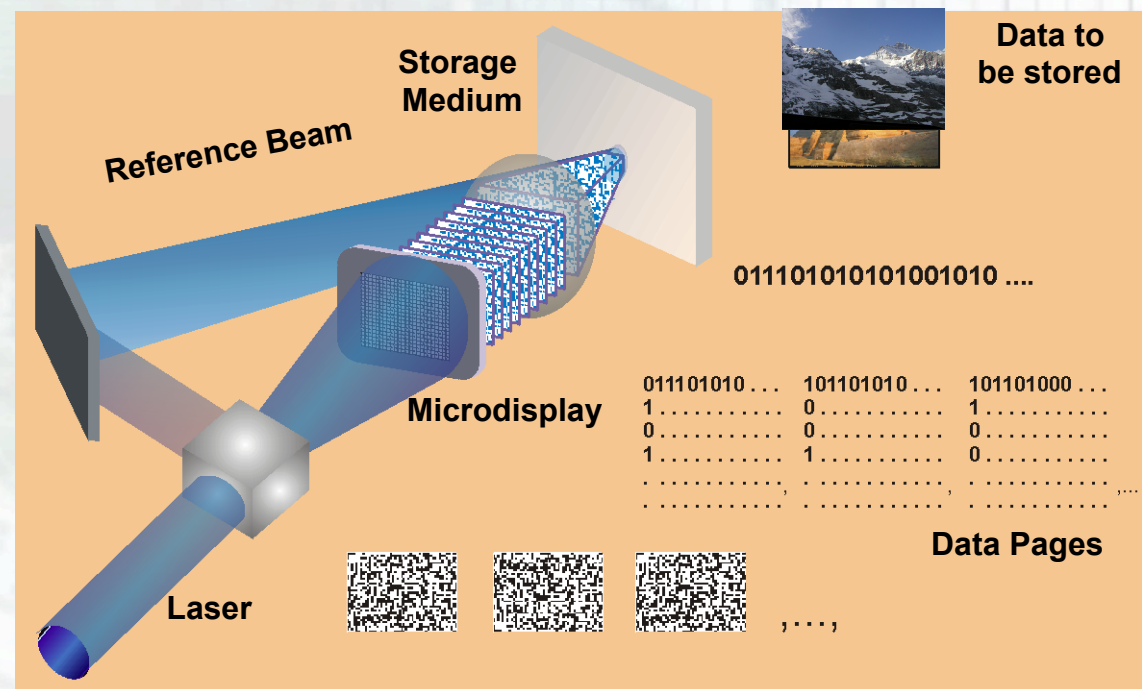
- ✓ ***What is Holographic Data Storage (HDS)?***
- ✓ ***What is the status of the technology?***
- ✓ ***Where does holographic fit in the storage Hierarchy?***
- ✓ ***What are the cost projections?***
- ✓ ***How does the technology scale in the future?***

How does Holographic Storage Work?



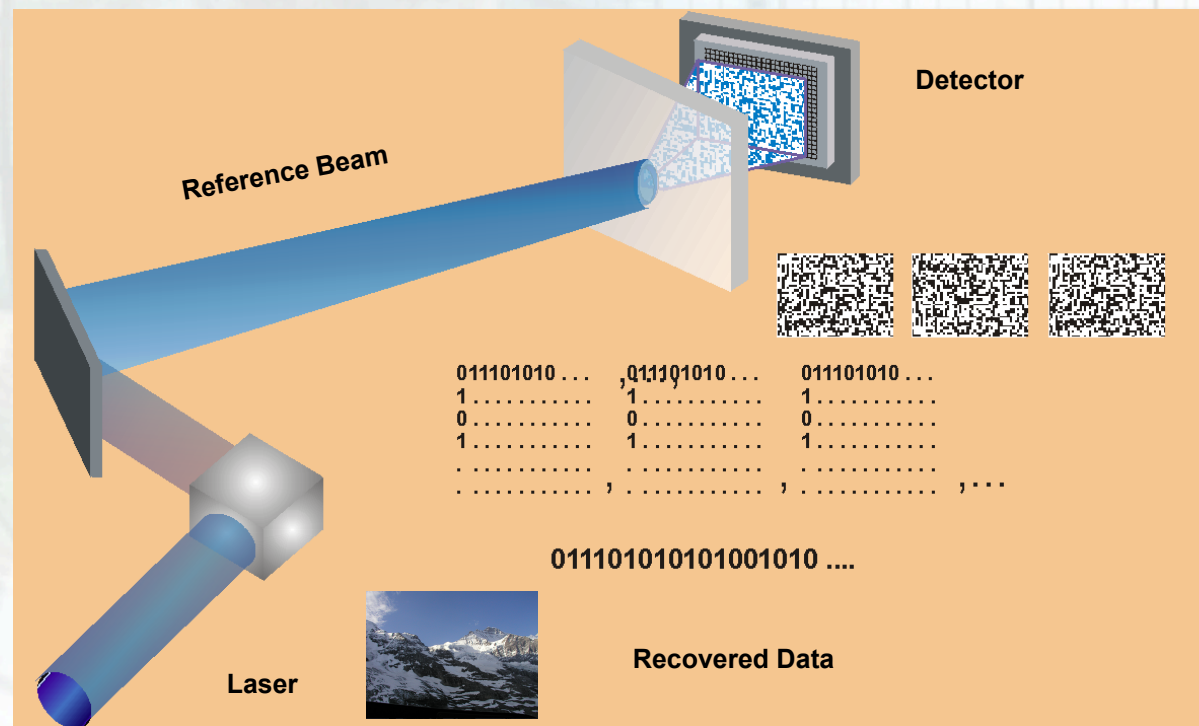
Writing Data

- ✓ Data is converted into an image and focused into the media
- ✓ Interference pattern of data is captured with photosensitive polymer media
- ✓ 800+ images of data stored in one location.
- ✓ Pages are distinguished using a “reference beam” to create a unique pattern in the media.

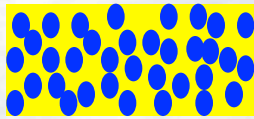


Read Process

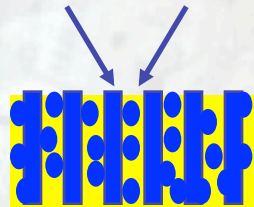
- ✓ Media is illuminated with laser at the correct angle
- ✓ Image of reconstructed data is read with high speed CMOS camera
- ✓ Data is converted to original file format



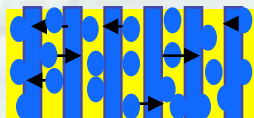
Photopolymer Media Mechanism



Active layer consists of monomers and photosystem dissolved in a matrix. Monomer and matrix have different refractive indices.



Holographic exposure produces a spatial pattern of photoinitiated polymerization. Polymerized monomer is immobilized.



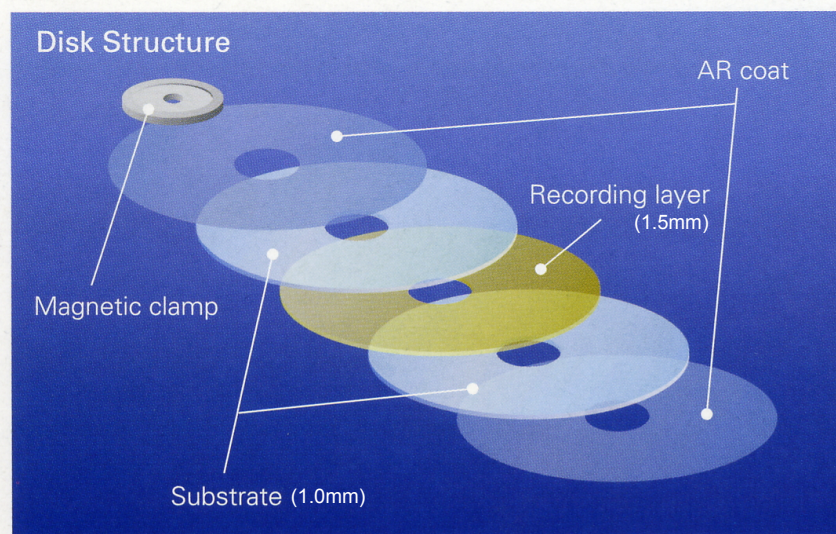
Concentration gradient in unreacted monomers induces net diffusion.



Diffusion produces a compositional gradient, establishing a permanent refractive index grating (Δn).

Disk Media Design Concept

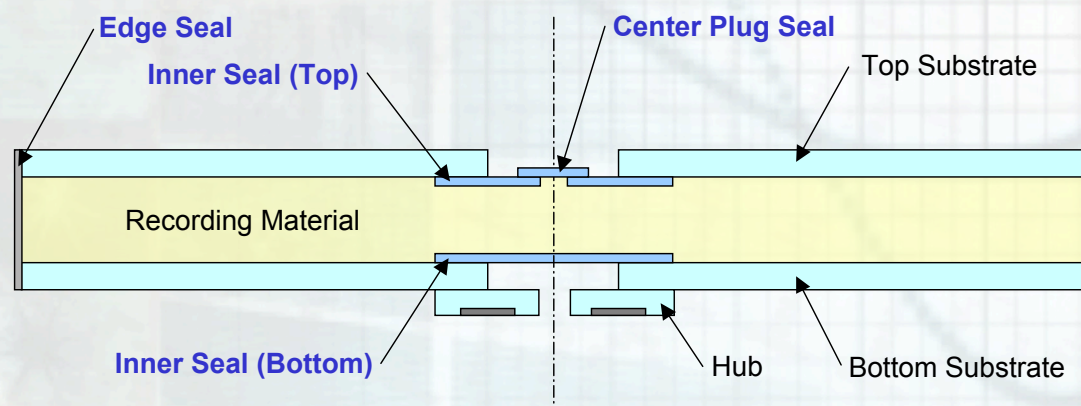
- ✓ Simple structure - the photopolymer recording material is just sandwiched between two clear substrates with AR.
- ✓ Metal plated hub on disk media - magnetically chucked by drive spindle, same as 5.25" MO/UDO.



Sealing Processes

■ Requirements for Sealing

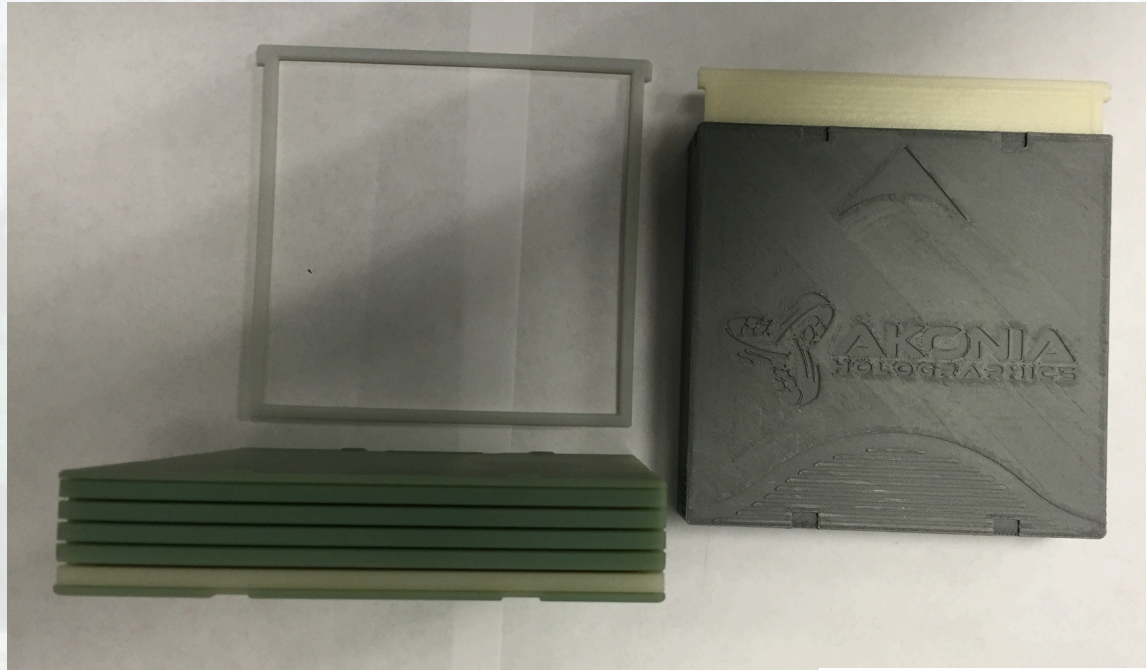
- Protecting recording material from ambient moisture and gas
- Making recording material flow smooth during dispensing



Say Goodbye to Disks



Tape Compatible Magazines of Holographic Cards



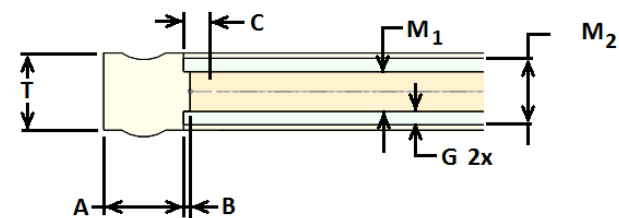
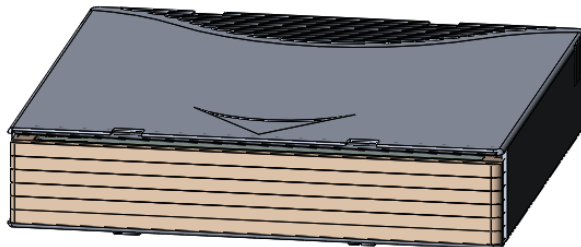
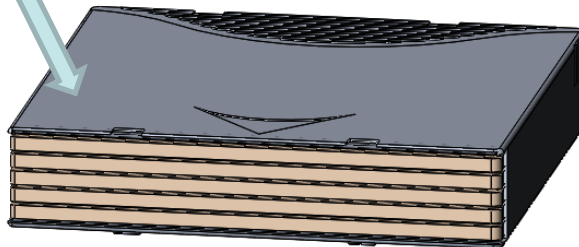
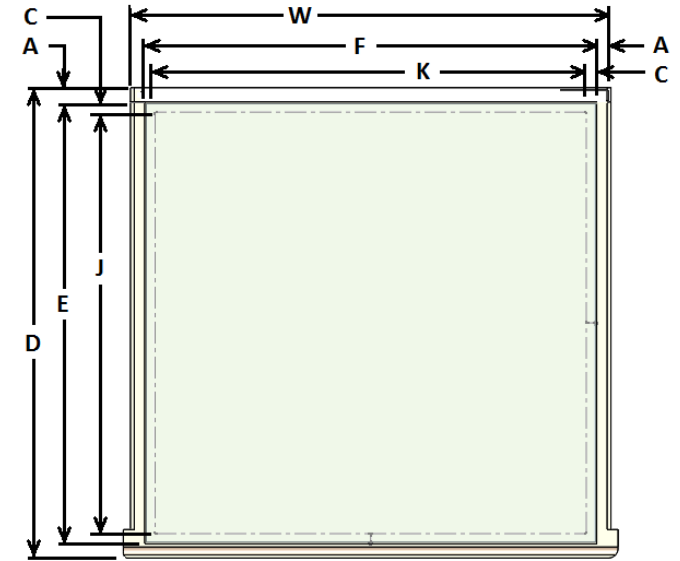
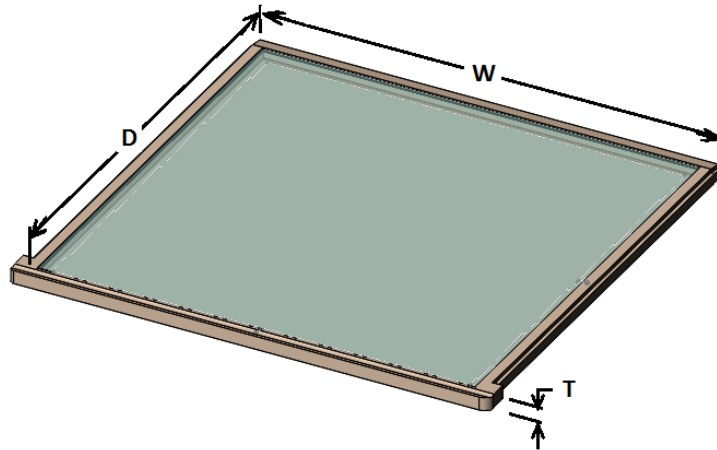
1TB Holographic Cards x 6 =



Media coupon for LTO Cartridge



coupon form factor
(Recommended)

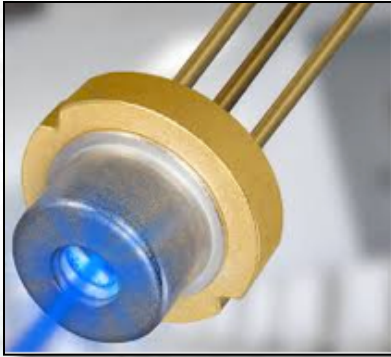


6 coupon (alternate tight pack form factor)

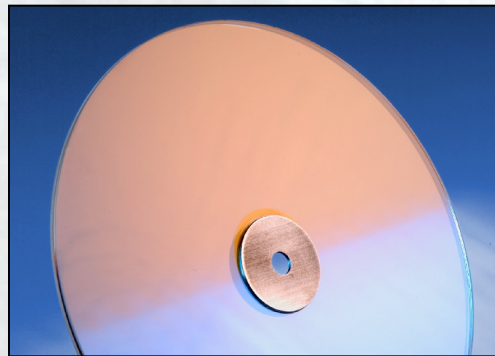


Why Holographic Data Storage and Why Now?

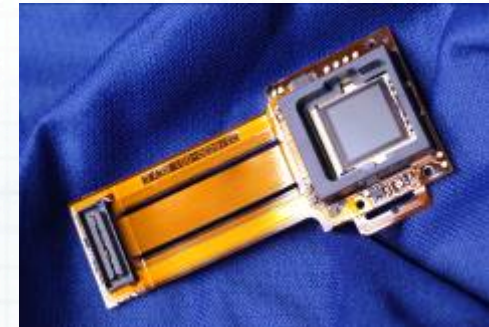
A Confluence of Technology has Occurred



**Inexpensive/high power
Blue Diodes/LEDs**



**Akonia's
Tapestry™ Photopolymer
Media**



**Large Format/High Speed
Micro Displays**



High Speed Electronics



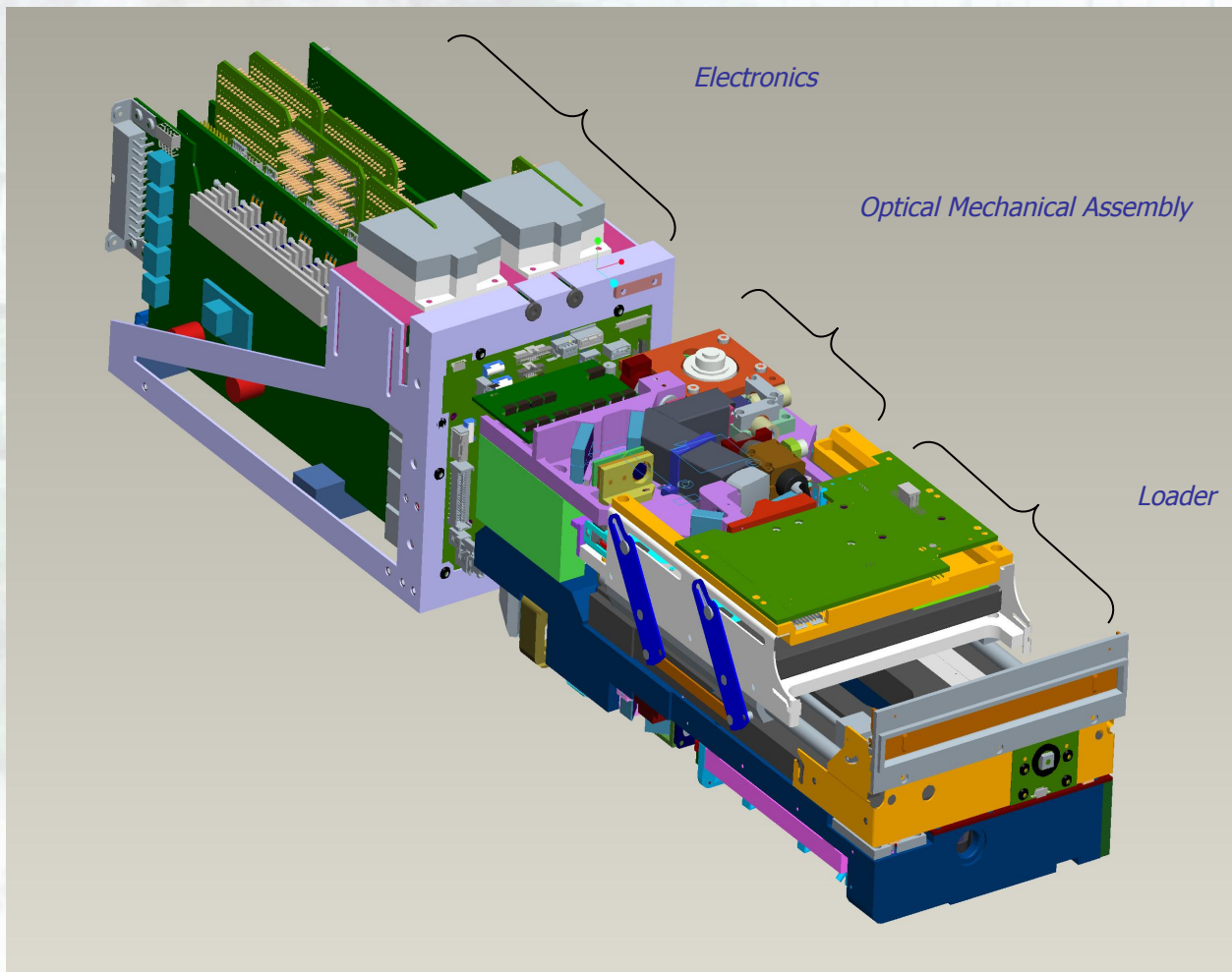
**Large Format/High Speed
CMOS cameras**

... The rest is packaging
(Not simple, but very doable)

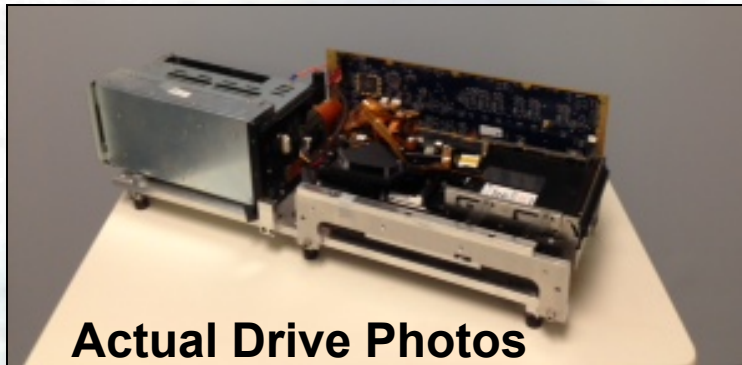
The Technology has been Proven



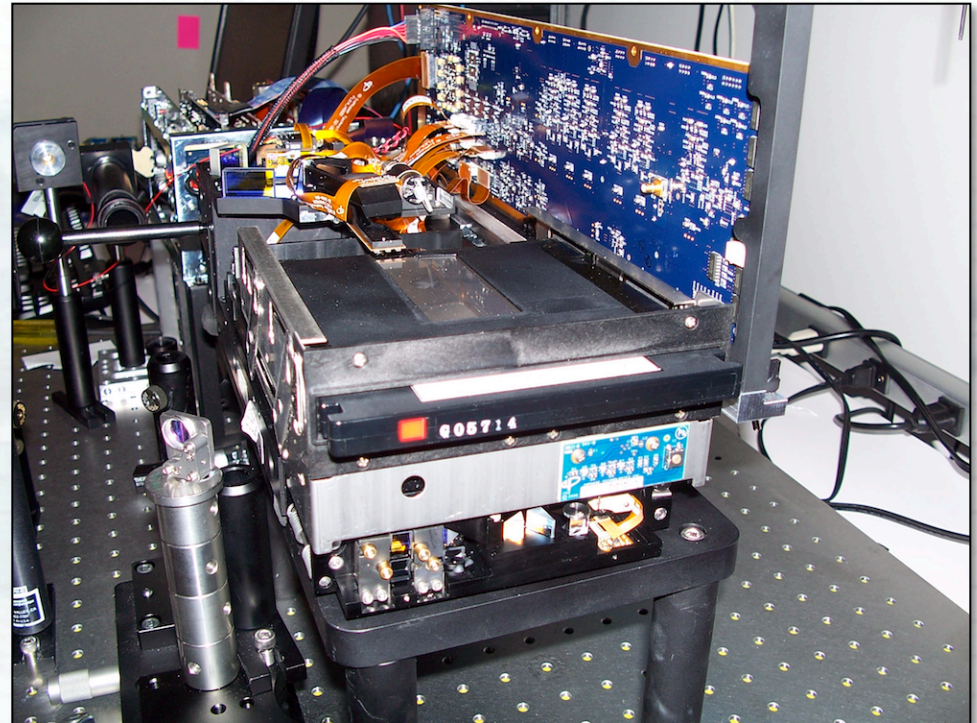
Akonia's Gen 1 300GB Prototype HDS Drives 20MB/s Transfer Rate



The Base Technology has been Proven



Actual Drive Photos

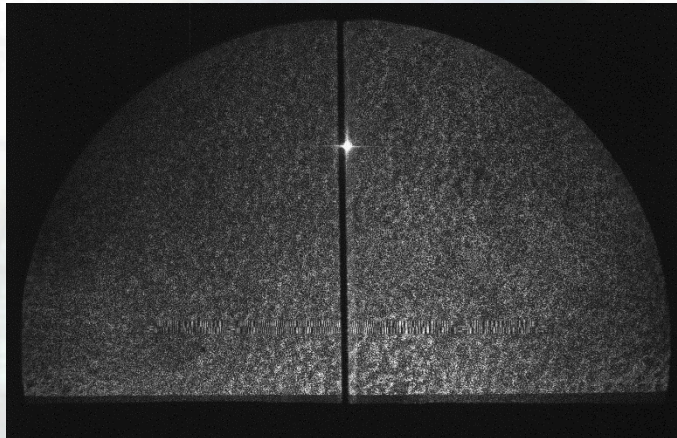


- 52 Prototype drives designed and built (2009)
- 300GB Prototype Holographic Drives
- 20MB/s Transfer Rate
- 95% Complete (Some firmware & Interface was still left)
- Writing and Reading 300GB Routinely

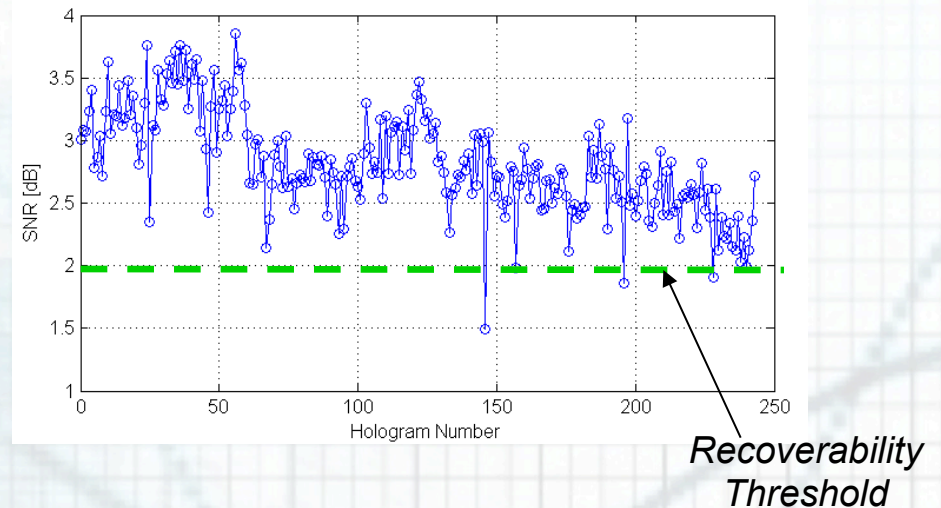
2Tb/in² Density Experiment Results



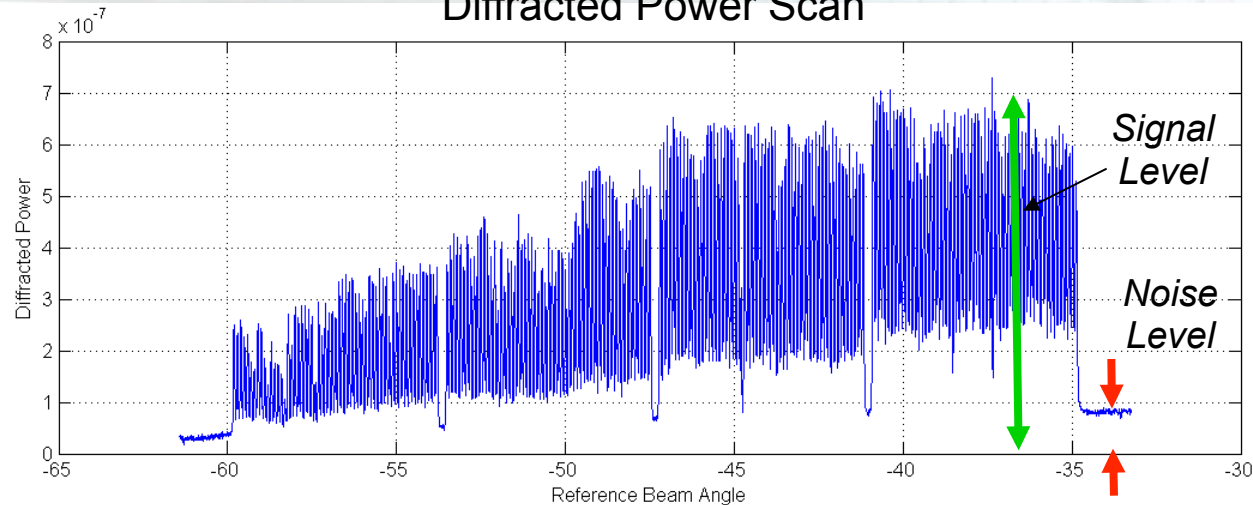
Hologram Image



SNR



Diffacted Power Scan



2Tb/in² density book:

- Avg. SNR: 2.8 dB
- 98% above threshold
- DRED media filtering improvements lowered noise

***Note: InPhase Prototypes were at 430Gbit/in²**

So fast, you might get a ticket....



10X Advantage Over Tape*



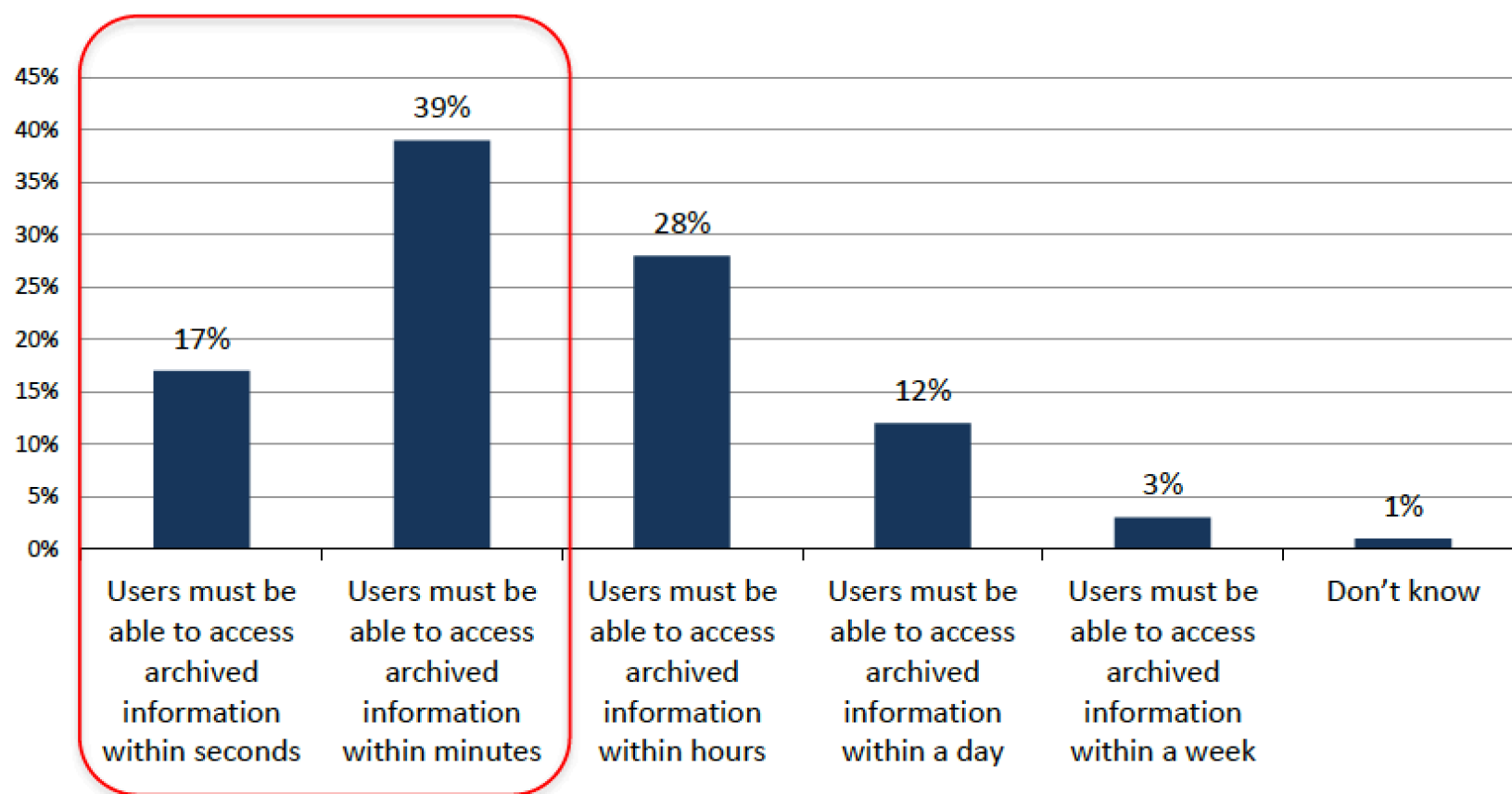
10 Tape Libraries



1 Akonia Library

- Transfer rate advantage when reading 1GB files or less

What is the typical requirement among your users in terms of retrieval time for information stored on long-term storage resources (i.e., archive systems)? (Percent of respondents, N=353)

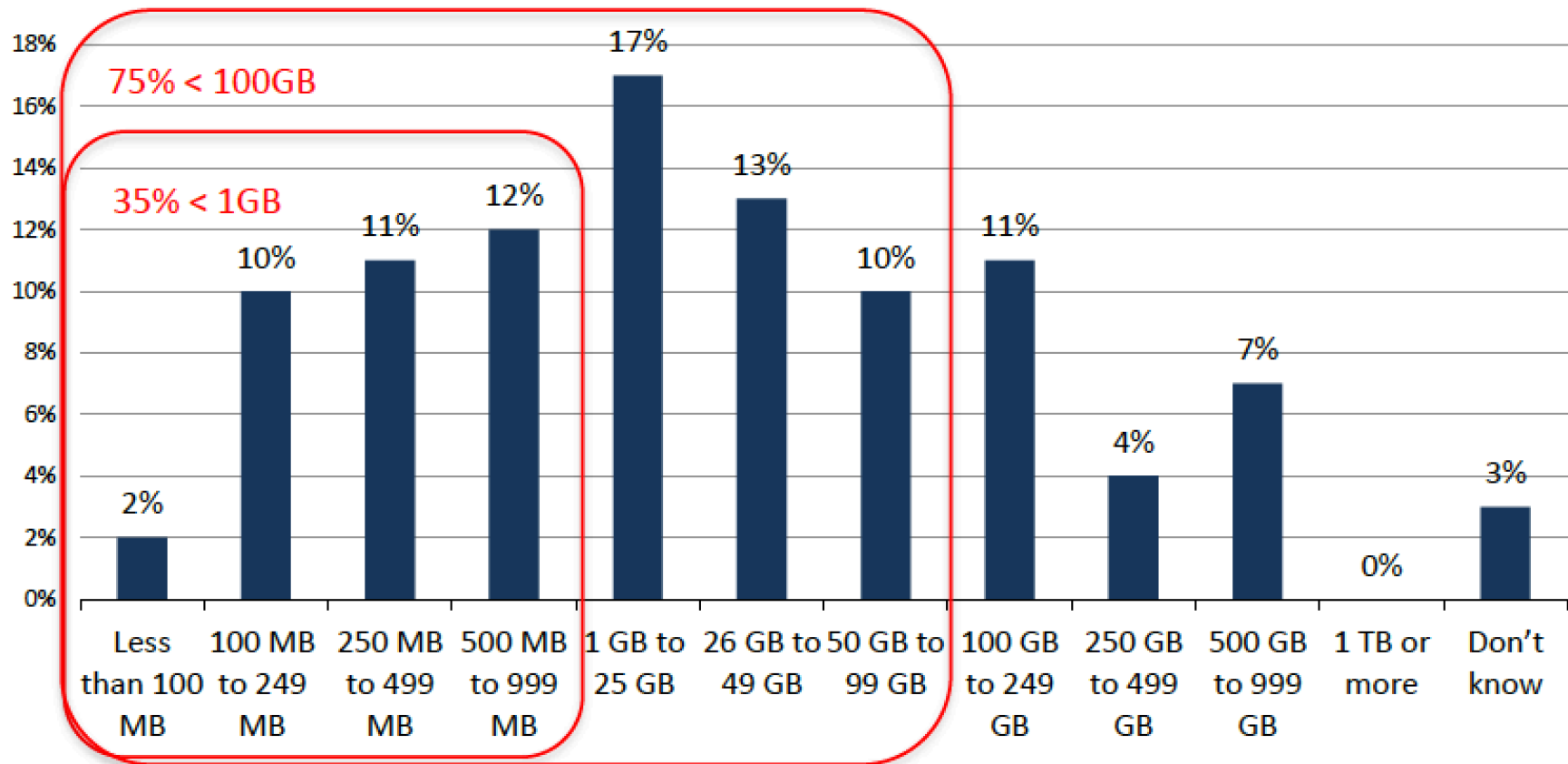


Source: Enterprise Strategy Group, 2014.

File Size Distribution of Data



On average, approximately how much information does IT retrieve as part of a typical retrieval exercise? (Percent of respondents, N=335)

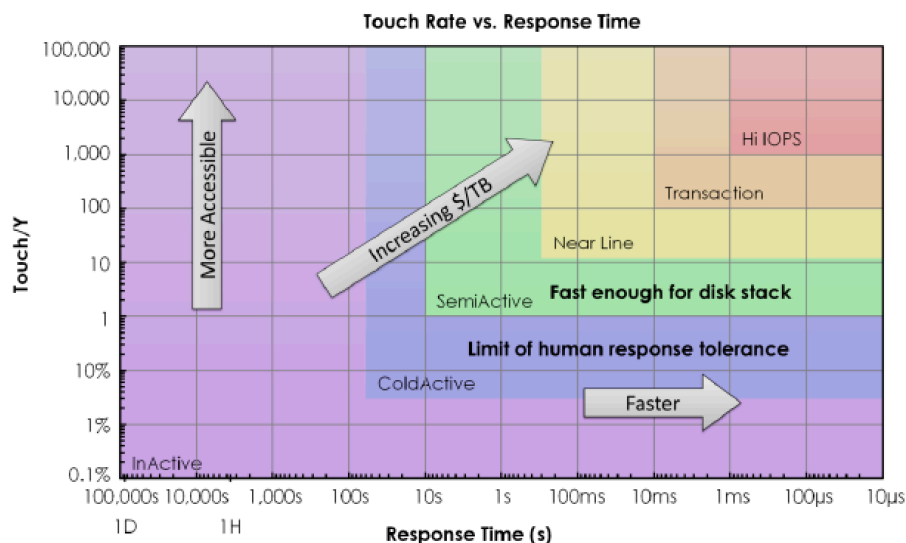
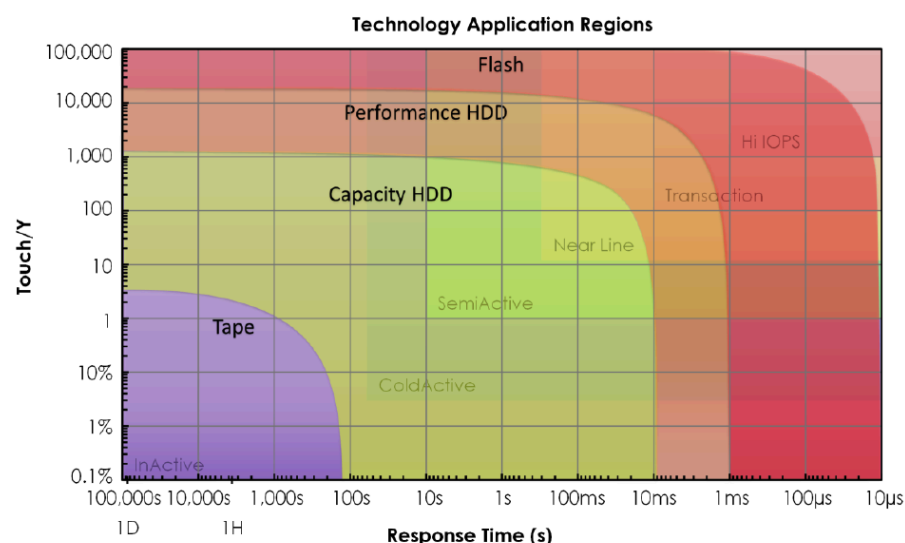


Source: Enterprise Strategy Group, 2014.

Touch Rate:

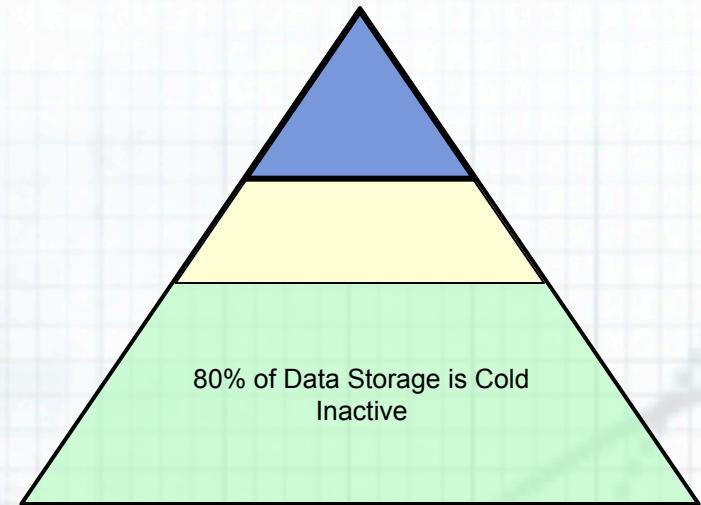
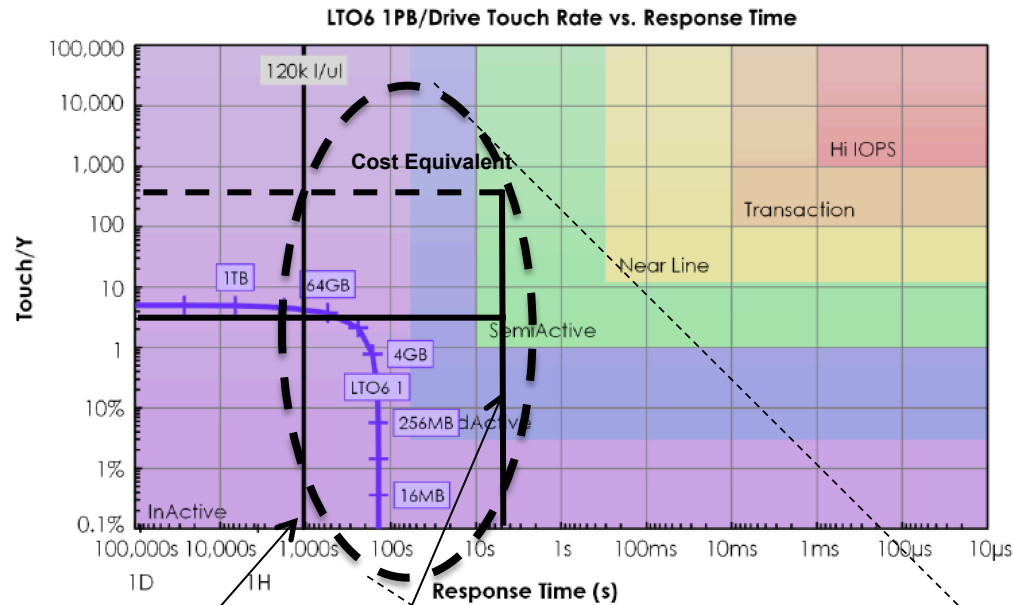
A metric for analyzing storage system performance

By Steven Hetzler and Tom Coughlin, 2015

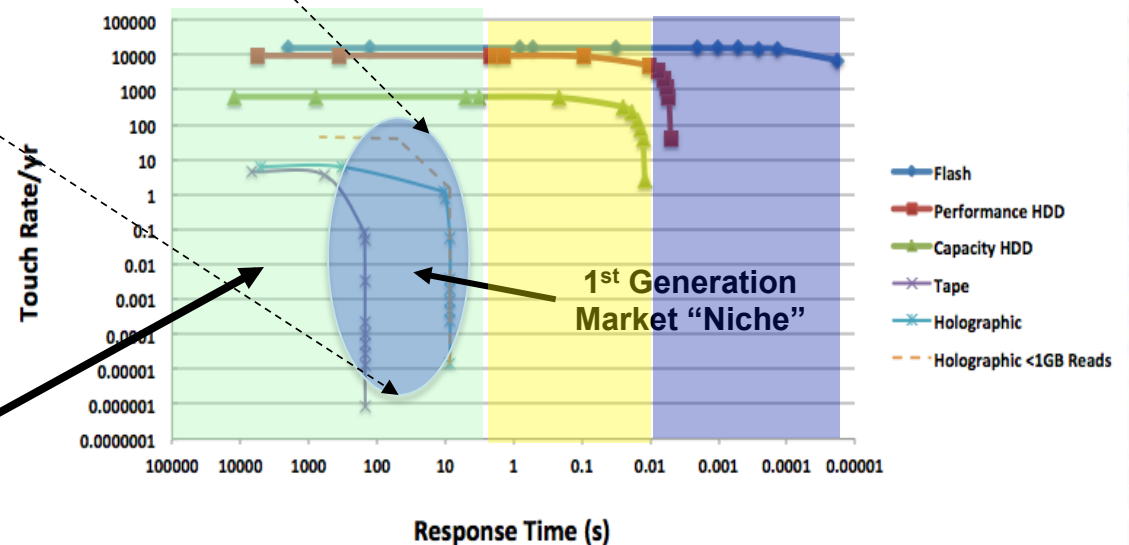


$$Touch/Y = \frac{ObjectSize(MB) \times 1000}{ResponseTime(s) \times Capacity(TB) \times 31.5}$$

Small File Touch Rate of Holographic



Data Storage Touch Rate Curves

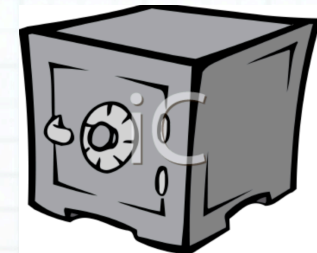



Addressable Market

HDS—the faster, cheaper, better solution



Akonia's Holographic Storage Technology



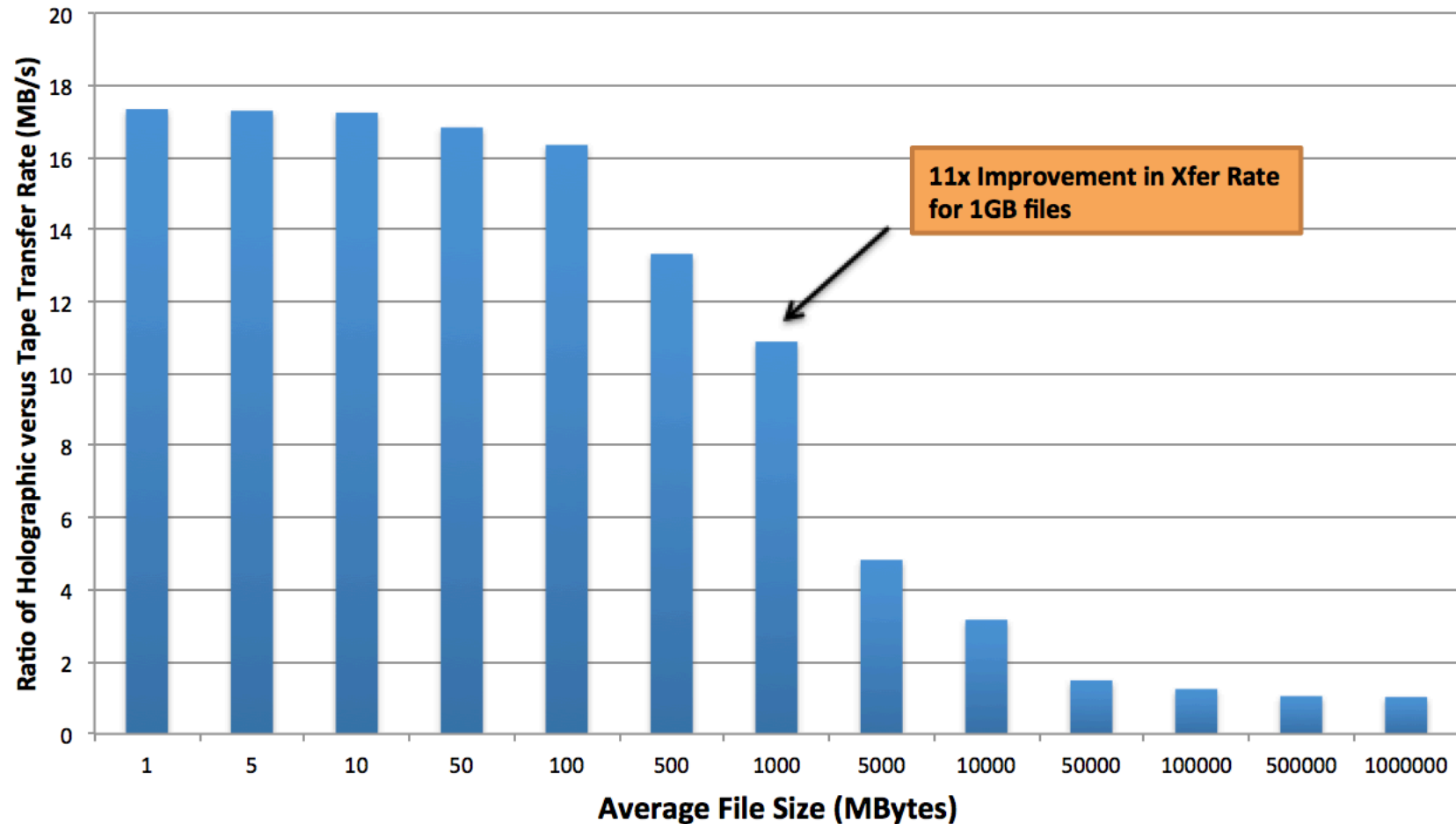
		Tape	Hard Disk Enterprise	Hard Disk Desktop	BluRay	SSD
Cost/TB Media	\$4-6	\$24	\$112	\$40	\$450	\$400
Cost/TB System	\$20-\$30	\$100	\$270	\$60	\$485	\$600
Total Cost of Ownership (TCO)	1x	3.7x	15x	4.8x	13.2x	14.2x

- ✓ Random Access = Low Latency (5-7s)
- ✓ Plastic = Ultra low cost (\$4-\$6/TB media costs)
- ✓ 10x IOPS advantage over tape for <1GB files

Advantage 1: Random Access!



HUGE Aggregate Xfer Rate Advantage of Holographic Over Tape for Filesizes <10GB

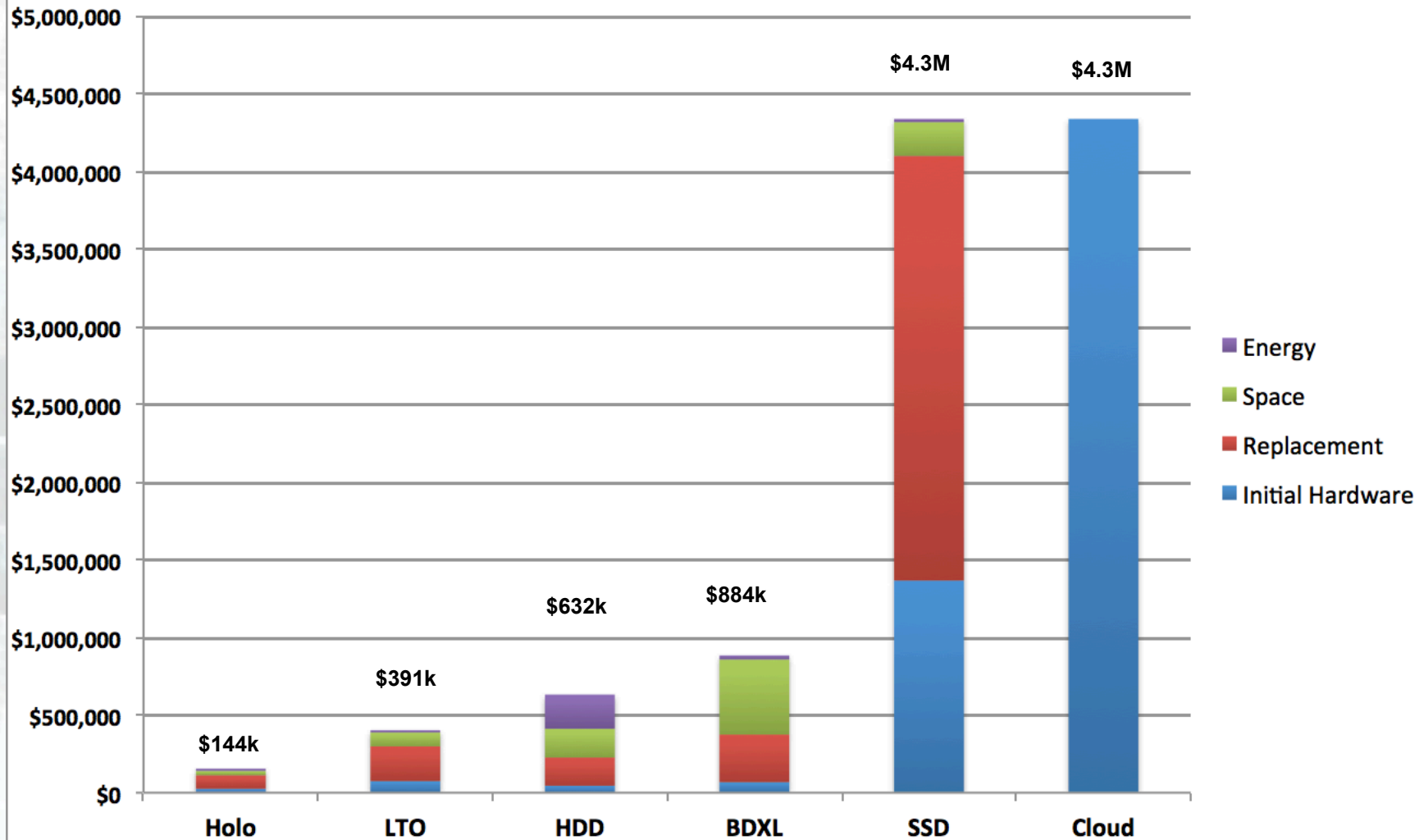


Average Overhead time for Tape = 10 Second (Load) + 70 second rewind + 70 second fast forward = 150 seconds
Average Overhead time for HDS = 7 second access + 30milliseconds seek = 10.03Seconds

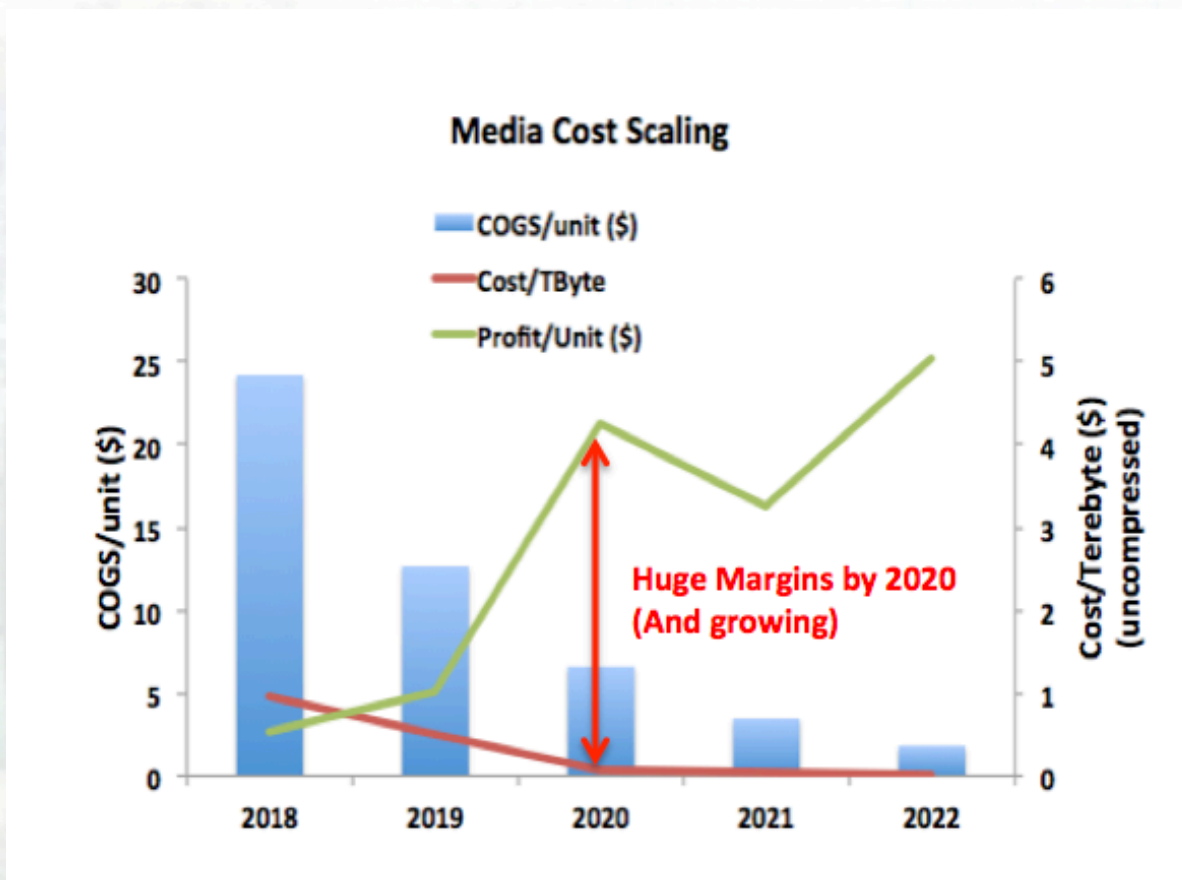
4.4x TCO Advantage over Magnetic Disk



20 Year TCO of 1PB of Storage



Media Cost Scaling



<\$0.50/Terabyte by 2020
>8x cost advantage over tape media or Hard Drives

Patented New Technologies for Future Growth

Product Generation	Gen 1: 2017	Gen 2: 2020	Gen 3: 2022
Bit Density Capacity (LTO Volume)	1.0 Tb/in ² 6 TB	4 Tb/in ² 24 TB	8 Tb/in ² 48 TB
Product Speed	80 MB/s	250 MB/s	500MB/s

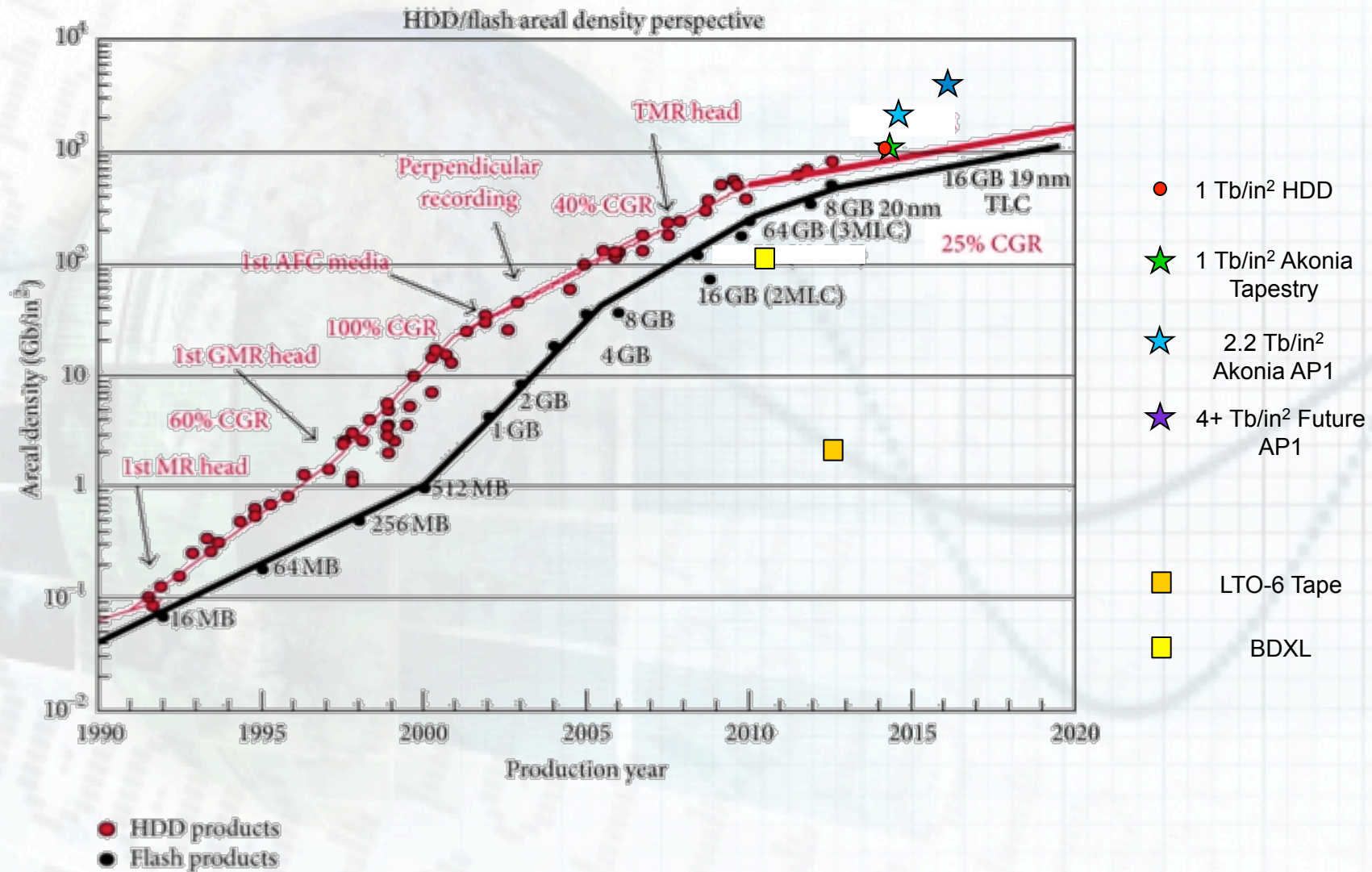
**Homodyne²,
Phase Quadrature²**

Dynamic Aperture¹

**Partial Response,
Channel improvements
Analog Phase Display**

1. US Patent Application: 13/875,071
2. US Patent: 8233205

Areal Density Trends



Marchon, et al., "The Head-Disk Interface Roadmap to an Areal Density of 4Tbit/in²," Advances in Tribology, vol. 2013

Holographic Shannon Limit

- Shannon capacity

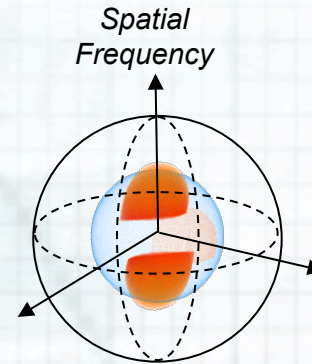
$$C = B \log_2(1 + S/N)$$

- Usable band volume

$$B = f_G \frac{4\pi}{3} \left(\frac{2n_0}{\lambda} \right)^3$$

- For slab-like media,

$$f_G \approx 0.1$$



Claude Shannon

- Areal density in 1.5 mm thick media with $\lambda = 405 \text{ nm}$
- Shannon capacity of HDS medium ($S/N = 1.0$)

$$(1.5 \text{ mm}) \times B = 165 \times 10^{12} \text{ in}^{-2} \quad \sim 165 \text{ Tbit/in}^2$$

165 TB/media

Take Home Message

- 5 to 10 second latency removable storage
- 50 year lifetime
- Technology ramp promises media <\$0.50/TB by 2020
 - It's plastic!
- Scalable up to 165TByte/Media
- Drives have been built and technology proven
- Next Steps...
 - Cost reduction, simplification
 - Testing
 - Manufacturing ramp

Wanted!

- Development Partners (integration, manufacturing, etc)
- “Friendly Customers” – Beta testing and help with product optimization
- Strategic and VC Funding
- Contact: ken@akoniaholographics.com

Thank You!



AKONIA
HOLOGRAPHICS

BRINGING DATA STORAGE SOLUTIONS TO LIGHT

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