Hard Drive Directions

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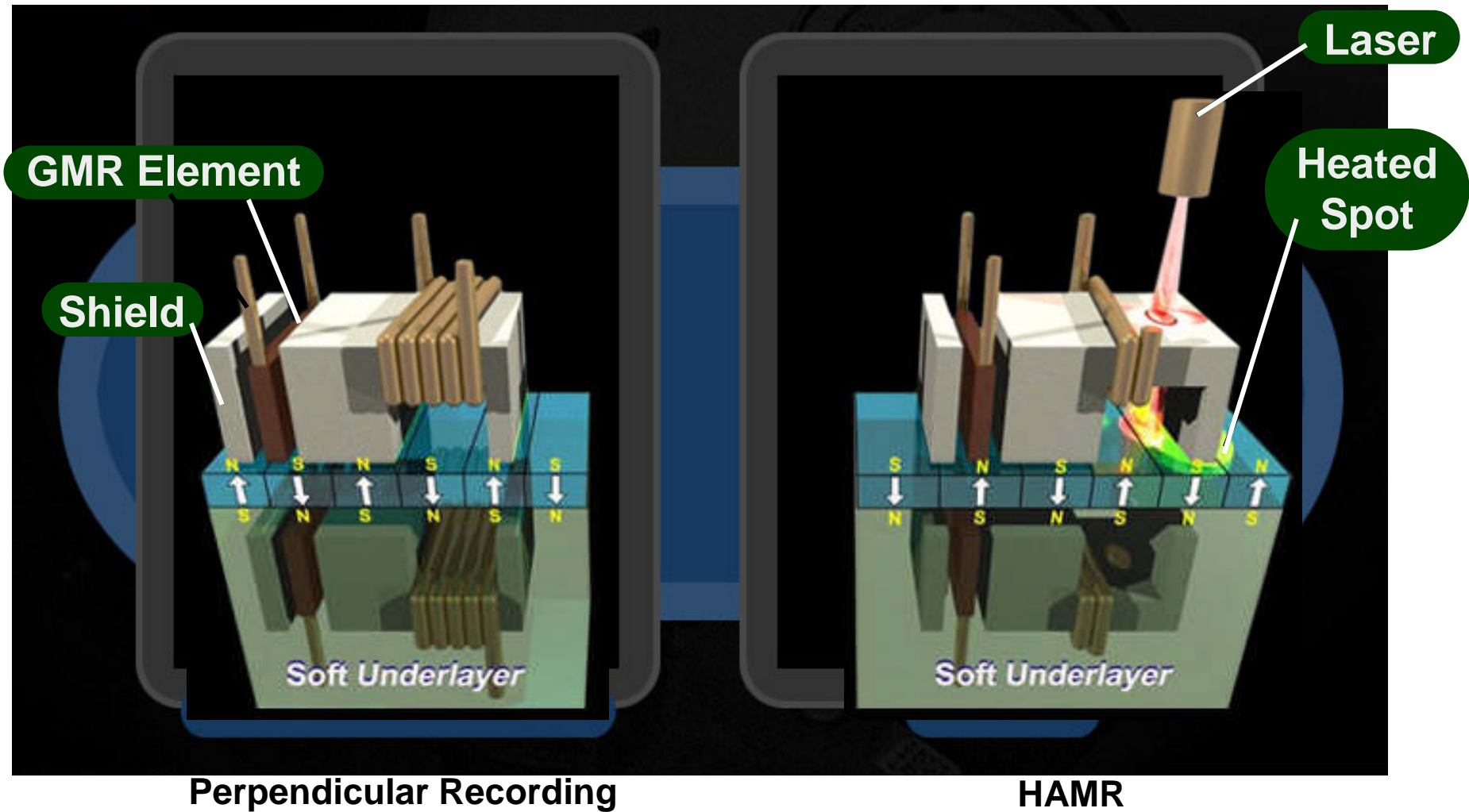
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Areal Density Growth

- **Late 1990s – super paramagnetic limit demonstrated through modeling**

- **Perpendicular expected to extend to 0.5-1 Tb/in²**

- **Additional innovations required at that point**
  - **heat-assisted recording**
  - **bit patterned media recording**

Single particle superparamagnetic limit (estimated)

40%

HAMR+ SOMA

HAMR

Perpendicular Writing & GMR

100%

Charap's limit (broken)

Inductive Writing/ GMR reading

40%

Inductive Writing/ MR reading

Inductive Writing & Reading

gigabit / in²

year

100000
10000
1000
100
10
1
0.1

1989 1991 1993 1995 1997 1999 2001 2003 2005 2007 2009 2011 2013 2015 2017 2019

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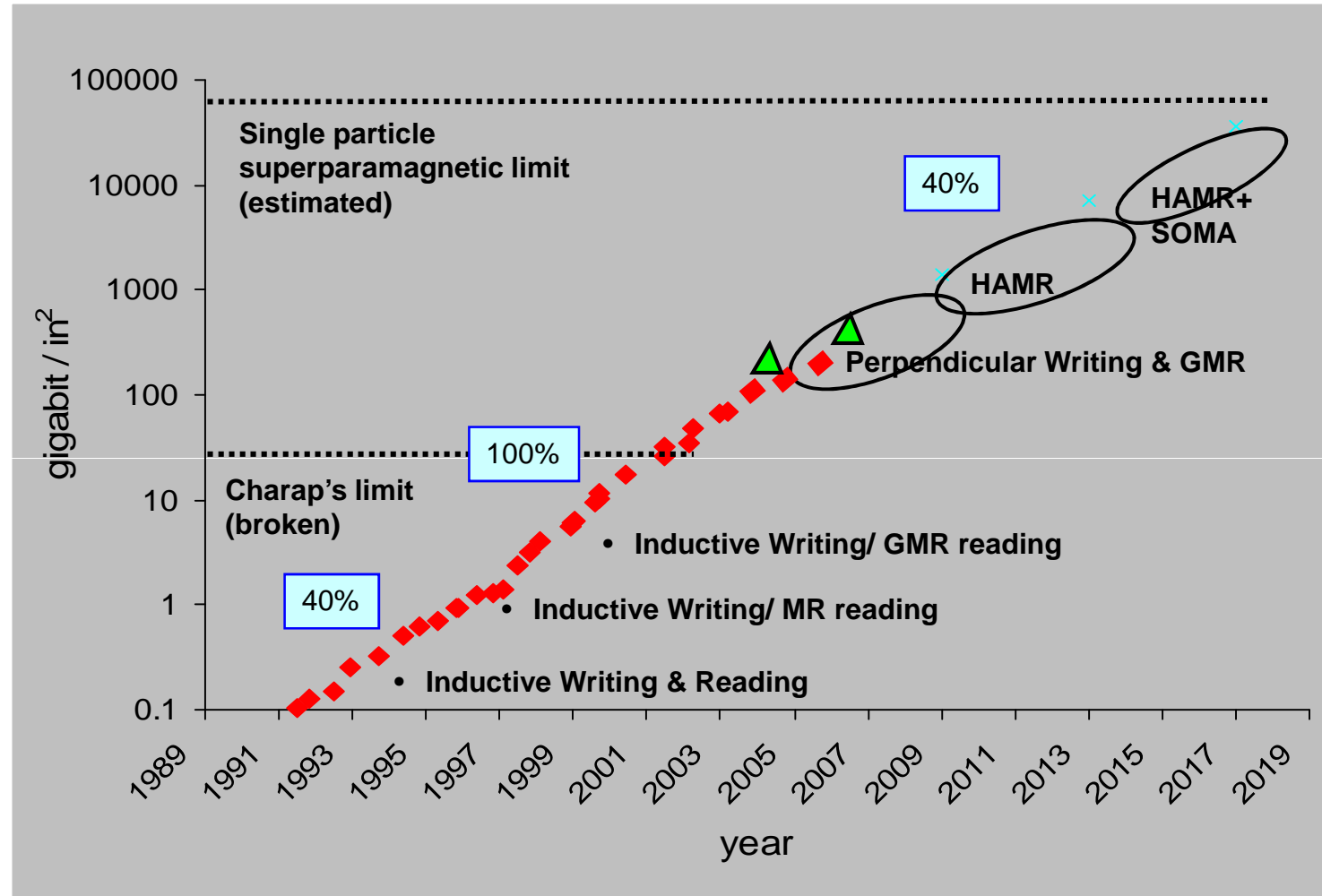
Heat Assisted Magnetic Recording (HAMR)

Laser

GMR Element

Heated Spot

Shield

Soft Underlayer

Soft Underlayer

Perpendicular Recording

HAMR

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HDD Technology Trend

3.5 inch Consumer	2006	2009	2013
Drive Capacity (GB)	750	2,000	8,000
Number of Discs	4	3	3
Capacity (GB/disc)	187	670	2,670
Product Areal Density (Gbpsi)	133	500	1,800
Transfer Rate (Mb/sec)	930	2,000	5,000
RPM	7,200	7,200	10,000
Read Seek Time (ms)	8	7.2	6.5
3.5 inch Enterprise	2006	2009	2013
Drive Capacity (GB)	300	600	2,400
Number of Discs	4	4	4
Capacity (GB/disc)	75	150	600
Product Areal Density (Gbpsi)	108	250	1,000
Transfer Rate (Mb/sec)	975	2,000	4,000
RPM	15,000	15,000	15,000
Read Seek Time (ms)	3.7	3.3	2.8

HAMR

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Solid State Disks

SSD Value Prop

Lower command latency

Access Density (IOPS/GB)

Power (IOPS/WATT)

Inhibitors to Broader Adoption

Price

Endurance concerns

Immature failure mode understanding

Industry Work Needed

Centralized standards activity

Performance standards

Endurance standards

Take Aways

SSD Enable Growth

SSD will co-exist with HDD

Industry Standards work needed

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HDD Intelligence: Self Encrypting Disk Drives

Purposes

- Protect data from exposure due to equipment loss
- Enable instant, secure erase of HDD

Closed encryption device

- Dedicated engine for full interface speed encryption
- Key generated in the drive
- Encryption cannot be turned off
- Encryption Key never leaves the drive
- Drive exposes an open interface for management

NSA support

- Publicly spoken on encryption embedded in the hard drive
- Actively participating in TCG Storage Security work group
- Submitted its security requirements for inclusion in TCG spec

Storage System

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Other Topics

Interfaces: Serial reigns!

- 6 Gbit SAS & SATA deployed in 2010
- FC continues for enterprise storage, but no 8 Gb/s on a drive
- SSD may lead to new interface thinking

4K sectors

- Strong push by drive suppliers
- Requires tough infrastructure changes

Power becoming an ever bigger issue

- Enterprise storage moving to 2.5"
- Ramp load/unload for power saving flexibility

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Summary

◆ **Technology identified for ~100x capacity growth**

◆ **HDDs will continue to be primary storage in most systems**

◆ **SSD use more likely than higher RPM drives**

◆ **Drive-based security examples of added drive intelligence**

◆ **Power becoming more a important consideration**

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