

Advancing Technology for Astrophysics Data towards Yottascale



Die Wissenschaft des Deutschen
Zentrum für Astrophysik

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Astrophysics Chances

Breakthroughs in
Astrophysics Research
used to deliver value
for science, technology,
economy and people



Chances & Challenges

New Insights BUT dealing with very large data sets

Towards Yottabytes

- How to efficiently transport it?
- How to efficiently store it?
- How to efficiently manage it?
- How to efficiently combine and analyze it?

Technologies need to advance to address the chances and challenges efficiently.

Advancing the limits

Image: IBM Research
IBM Fellows and Nobel Laureates Georg Bednorz,
Gerd Binnig and K. Alex Müller in the clean room
at the Binnig and Rohrer Nanotechnology Center
opening on 17 May 2011.

1986: Gerd K. Binnig and Heinrich Rohrer
for the Scanning Tunneling Microscope

1987: J. Georg Bednorz and K. Alex Müller
for high-temperature superconductivity

IBM as an advancer of Technology being strong in and
near Germany

IBM Research in Rüschlikon, Switzerland, had four
Nobel Price winners and is steadily advancing the limits
of Technology

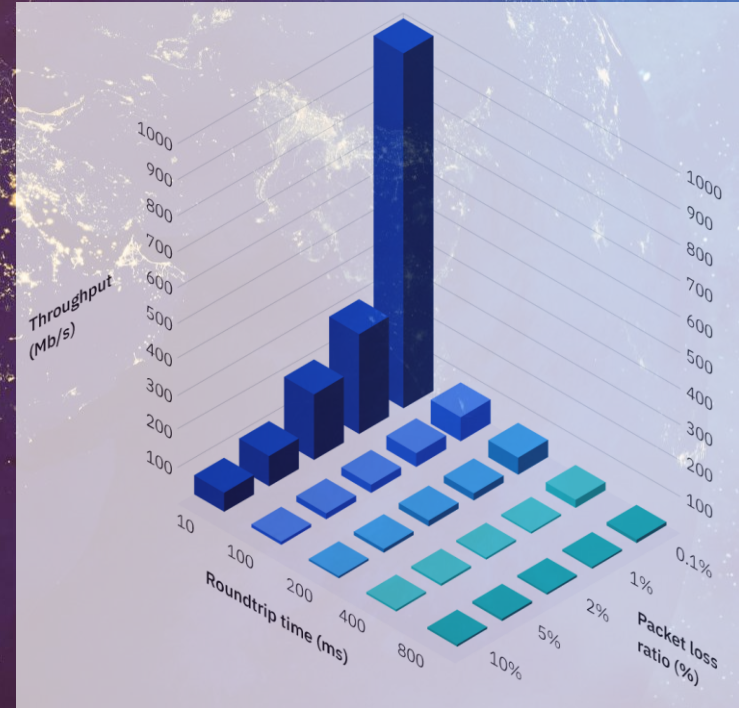
IBM Development organizations in Germany add
capabilities into a global technological innovation
program.

Transporting Data

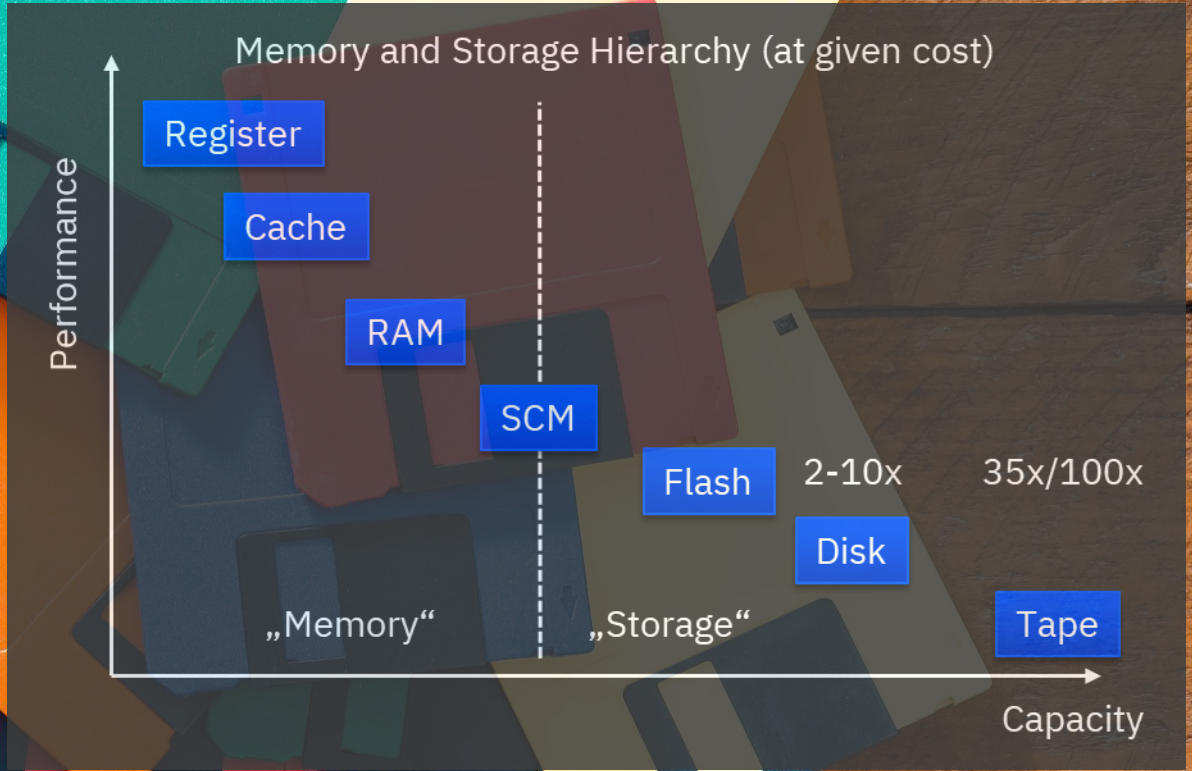
Global Data Transport:

TCP/IP is not efficient
given global networks

A Fast, Adaptive and
Secure Protocol is needed

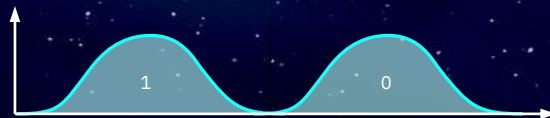


Storing Data



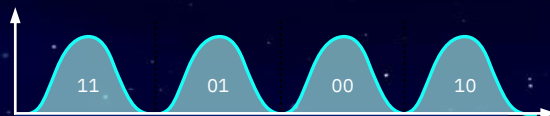
Flash Fundamentals

SLC 1 bit per cell



100'000 P/E cycles

MLC 2 bits per cell



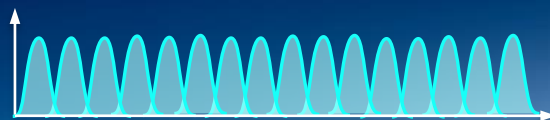
3'000 – 10'000 P/E cycles

TLC 3 bits per cell



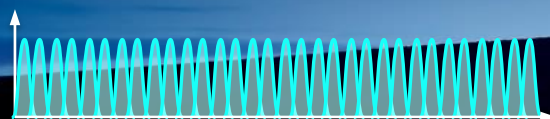
3'000 – 5'000 P/E cycles

QLC 4 bits per cell



~1000 P/E cycles

PLC 5 bits per cell



? P/E cycles

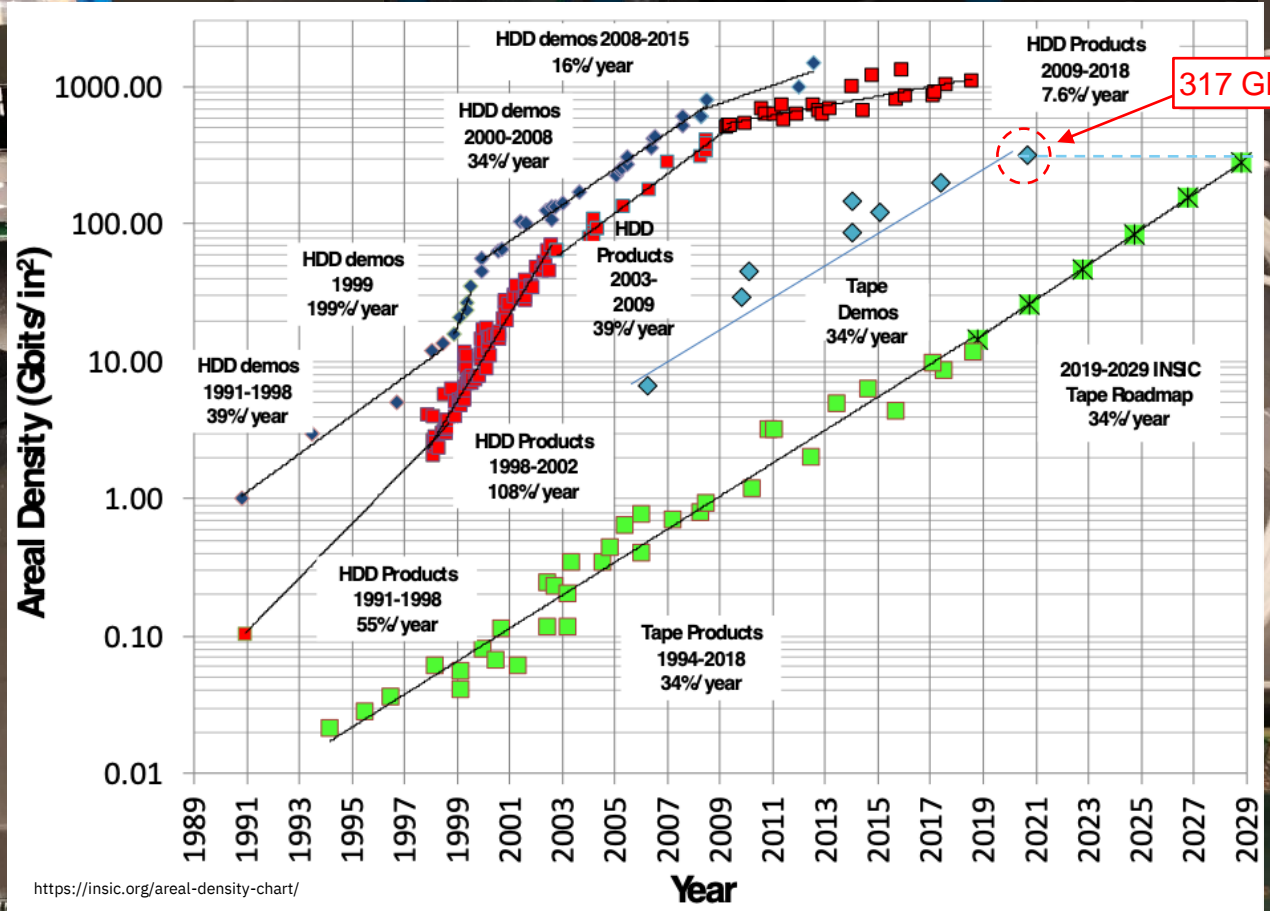


Tape = Top Efficiency!

317 Gb/in² Recording Demo on SrFe Tape
→ 580 TB Capacity or > 10EB per library



29 cartridges today each
20TB will fit in a single
cartridge of 580 TB by end
of decade



Storage Software Functions

Global Namespace

Flexible Architecture

Address Space - 8 Yottabyte

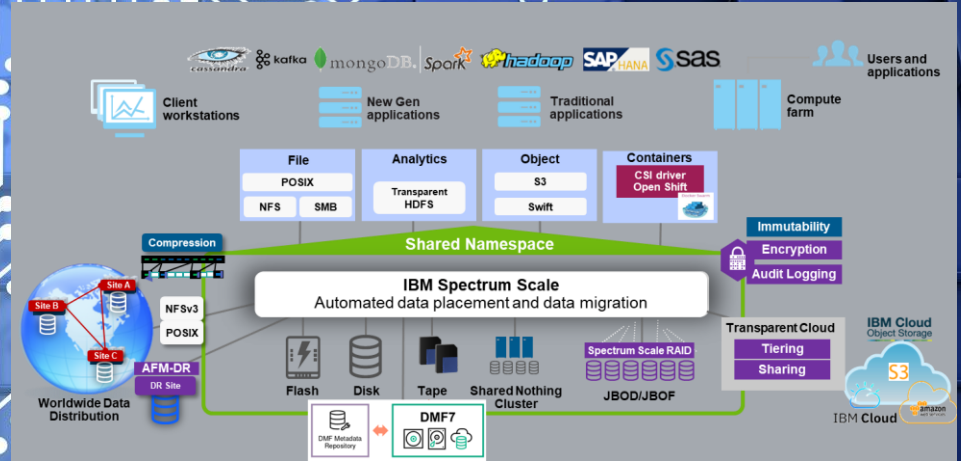
Performance - Parallel Access

Appliance: Erasure Coding

Efficiency – Tiering Flash – Tape
(LTFS/HPSS)

Multiple Protocols & Interfaces

Scalable Metadata Management
(Spectrum Discover)



Example:

Spectrum Scale ORNL Summit

2,5 TB/s @ 250 PB

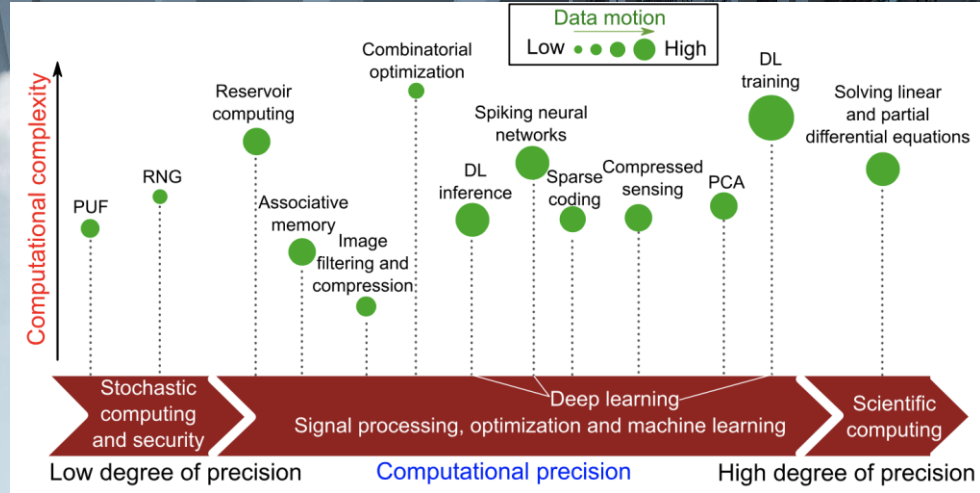
Example:

NVidia GPU Direct support

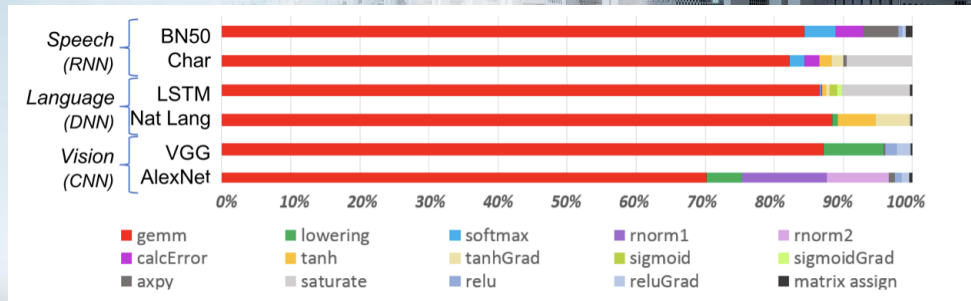
Partnering with Nvidia/Mellanox

Analyzing Data

How to advance fundamental computation capabilities besides semiconductor progress?



Sebastian, Le Gallo, Khaddam-Aljameh, Eleftheriou, Nature Nano., 2020

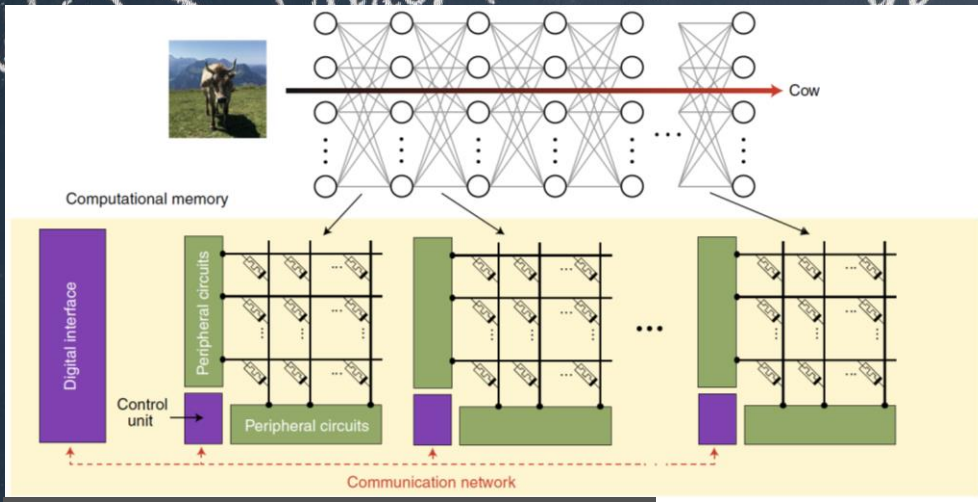


Fleischer and Shukla, IBM Research Blog, 2018

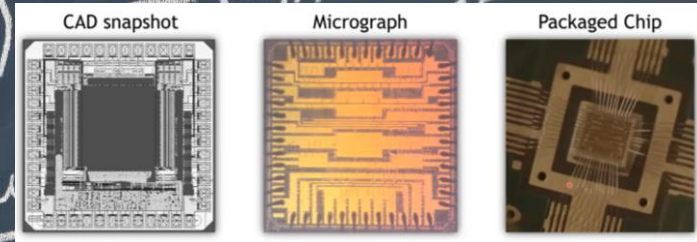
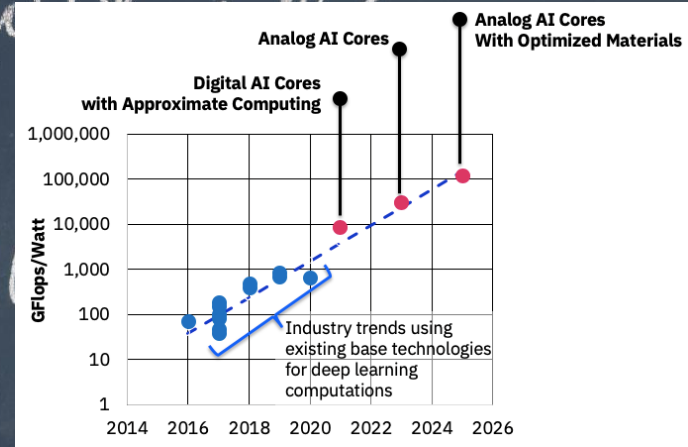
Advancing Computation

In Memory – Analog – Computing

Efficient Matrix Multiplication for Deep Neural Networks



Eleftheriou et al., IBM J. R&D, 2019 Dazzi et al., NeurIPS, 2019



Quantum



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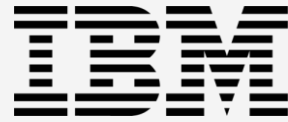
Thank You!

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Thank you



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