Big Data Panel:
The High Energy Physics perspective

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What is big data?

“Big data is high-volume, high-velocity and high-variety information assets that demand cost-effective, innovative forms of information processing for enhanced **insight and decision making.**”

- **Insight:** that’s for NSA 😊
- **Decision making:** that’s for Google, Facebook
  - so they find the best way to push out adds and products 😊

- A big data academic success story:
  - the discovery of Higgs-like particle
How big is the big?

- **Megabytes**: e-books, 10,000 pages of text, RAMs
- **Gigabytes**: all DNA of human egg, DVDs, Mozart complete work
- **Terabytes**: modern hard disk, human brain functional memory capacity, US library of Congress printed collection,
- **Petabytes**: all US academic libraries (2PB), largest climate data archive (6 PB)
  - There are hundreds or thousands of petabyte-scale databases today
- **Exa, Zetta, Yotta...**: all predicted global data by 2019: 0.03YB
How big is the HEP data?

Business emails sent 3000PB/year (Doesn’t count; not managed as a coherent data set)

Google search index 100PB

Facebook uploads 180PB/year

HEP is big... not NSA-big, but big

Current ATLAS data set (an LHC subset). All data: 140 PB

Year 2012

Data presented at CHEP 2013 Amsterdam by Torre Wenaus, BNL

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We are third of the way through the LHC Long Shutdown 1

Beyond 2015 HEP data gets even bigger: trigger rates, event complexity increase steadily through machine and detector upgrades:

- ~15 PB/year LHC raw data now; ~130 PB/year in 2021
  - Very rough estimate for new raw data per year in Run 4: 400 PB
- Storage and processing extrapolations lead to unacceptable costs (flat budget assumption)
  - Storage is largest cost, e.g. ATLAS spends ~60% more money on disk than on CPU
- Very rough CPU estimates can be met due to Moore’s law suppose HEP community is still able to leverage Moore’s law. BUT:
  - Power consumption becomes (is already) an issue
  - Adapting to new processors is much more challenging than in the past
  - Furthermore HEP must change computing model: replacing the free lunch of ever faster processors with the throughput growth by leveraging growth in core count, co-processors, concurrency features
  - Many or most of HEP codes require extensive overhauls
Q2: Plans to meet the challenges

- **Can’t store data? Move it!**: make the most out of the available network:
  - networks optimized for massive data flows, e.g. now testing the first 100Gb transatlantic production link
  - HEP was a pioneer in network-intensive science and international research networks, and continues to lead
  - better network usage translates to more science at lower cost: it is much cheaper to transport data than store it
- **HEP needs more efficient distributed data handling**:  
  - lower disk storage demands, lower operational load (storage is highly labor intensive)
  - send only the data you need, only where you need and by the time you need it. Then, if possible cache it.
  - **Industry** has been at this approach for years: **content delivery networks**
- **Be a pioneer in Data intensive HPC**:  
  - HEP used to be a traditional **High Throughput Computing** domain
  - conquer HPC domain: utilize concurrency, leveraging architectures used in HPCs, make HEP applications more suited to HPC
Q3: Collaboration

- HEP can share its knowledge regarding:
  - How to handle real big data via:
    - Massive disk storage servers at CERN, Tier1 and Tier2
    - Tape storage at CERN and Tier1
    - Data Transfer Services, File catalogues
    - Special secure protocol (GridFTP)
    - Authorisation using industry-standard technology (X509, same as e.g. Nordea certificates), no data encryption because of large overheads, but is possible

- How to manage common data belonging to a huge research community with loose governance:
  - So others won't repeat HEP mistakes
  - HEP could develop common solutions for
  - From HPC community how to utilize concurrency, multicores
  - Long term data archival and preservation

- HEP could learn

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backups
HPC growth predictions: exaflop systems by 2020?

Top: aggregate of the Top 500
Middle: fastest of the Top 500
Bottom: smallest of the Top 500

X86 (Intel+AMD) dominate – a familiar architecture

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Planned network capacity

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Challenge: LHC data analysis

Proton-Proton
2835 bunch/beam
Protons/bunch $10^{11}$
Beam energy 7 TeV ($7 \times 10^{12}$ eV)
Luminosity $10^{34}$ cm$^{-2}$ s$^{-1}$

Crossing rate 40 MHz

Collisions rate $\approx 10^7 - 10^9$ Hz

New physics rate $\approx 0.00001$ Hz

Event selection:
1 in $10,000,000,000,000,000$
An instrument at LHC: ATLAS

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