Use case: Nordic Tier1 for CERN

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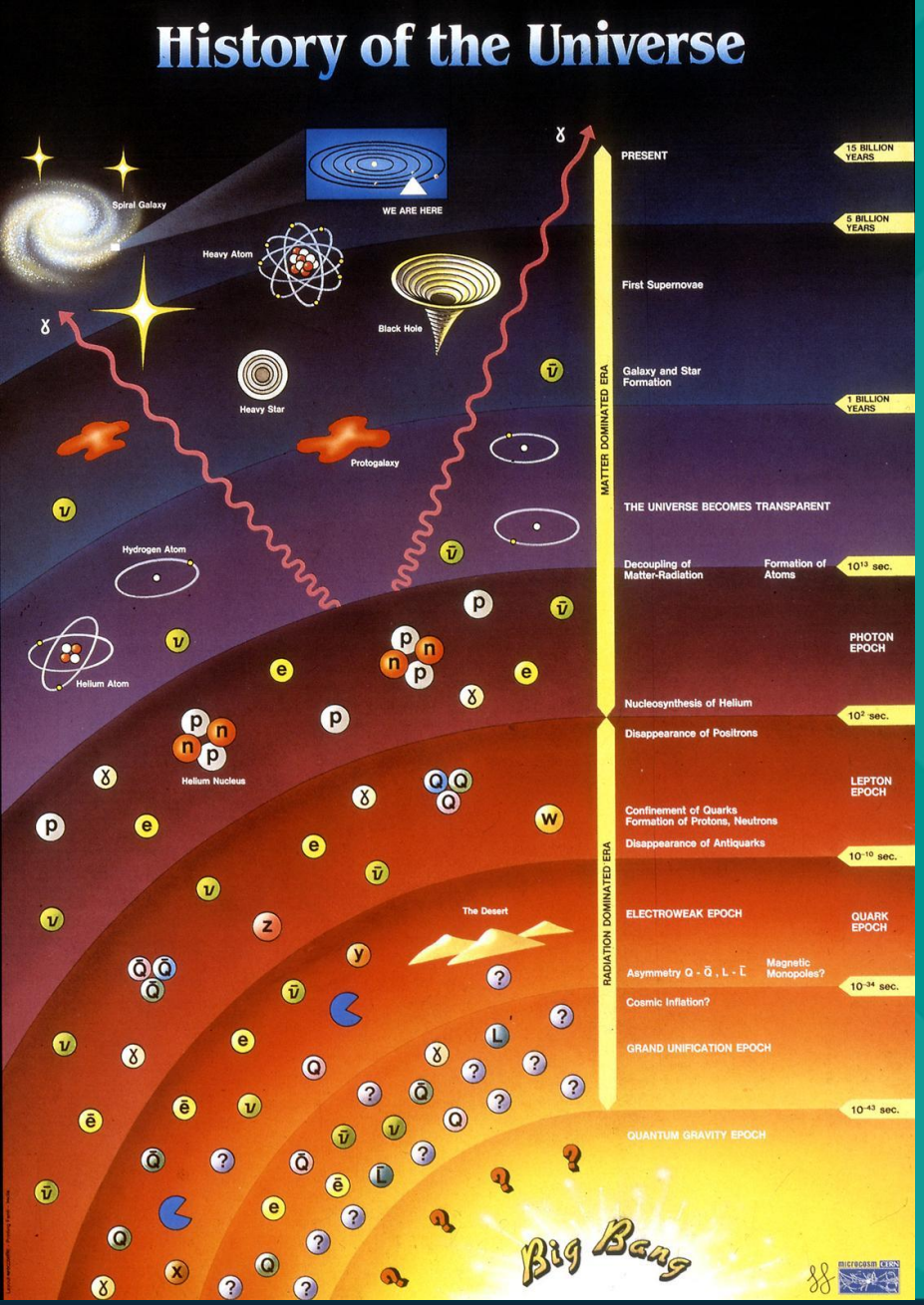
NORDIC E-INFRASTRUCTURE COLLABORATION

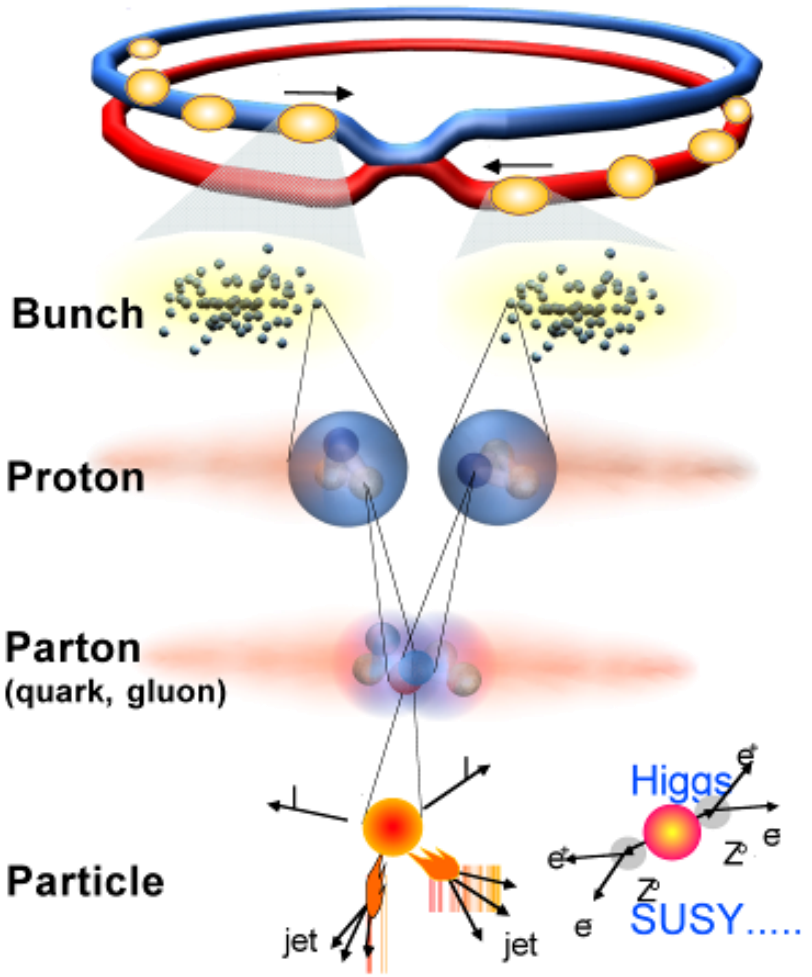


Some of the questions we'd still like to answer

- Why do particles have the masses we observe? What is the origin of mass?
  - Discovery of the Higgs particle at CERN helps
- Are there states of matter at very high density and temperature (Big Bang)?
  - Indications of the Quark-Gluon Plasma get stronger at CERN

- How many space-time dimensions do we live in?
- What is the nature of the Dark Matter and Dark Energy that dominate the Universe?
- Can gravity be added to the theory of the other known forces (Standard Model)?
- Are the known elementary particles fundamental or do they have a structure?
- Why is the electrical charge of the electron equal and opposite to that on the proton?
- Why are there three generations of quarks and leptons?
- Why is there overwhelmingly more matter than anti-matter in the Universe?
- Are protons unstable? Or, why are they stable?
- Do the neutrinos have mass, and if so, why are they so light?
- … and many more …

Large Hadron Collider: a discovery machine



Proton-Proton	2835 bunch/beam
Protons/bunch	10^{11}
Beam energy	7 TeV (7×10^{12} eV)
Luminosity	10^{34} cm^{-2} s^{-1}
Crossing rate	40 MHz
Collisions rate $\approx$	10^{7} - 10^{9} Hz
New physics rate $\approx$	.00001 Hz

Event selection:
1 in 10,000,000,000,000

LHC operations schedule

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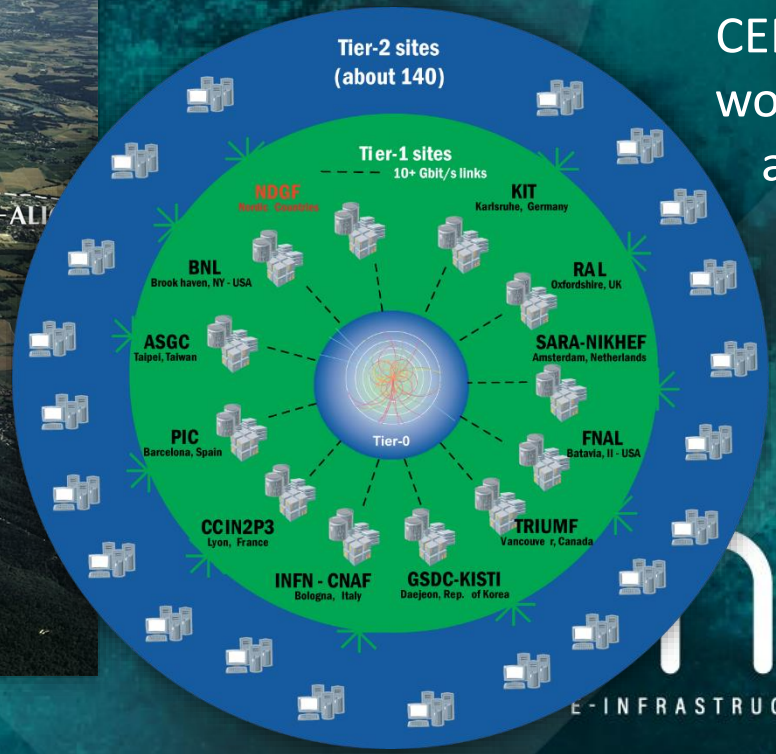
Large Hadron Collider will deliver *Exabytes* of data by 2038



Data are sent from CERN around the world for storage and processing

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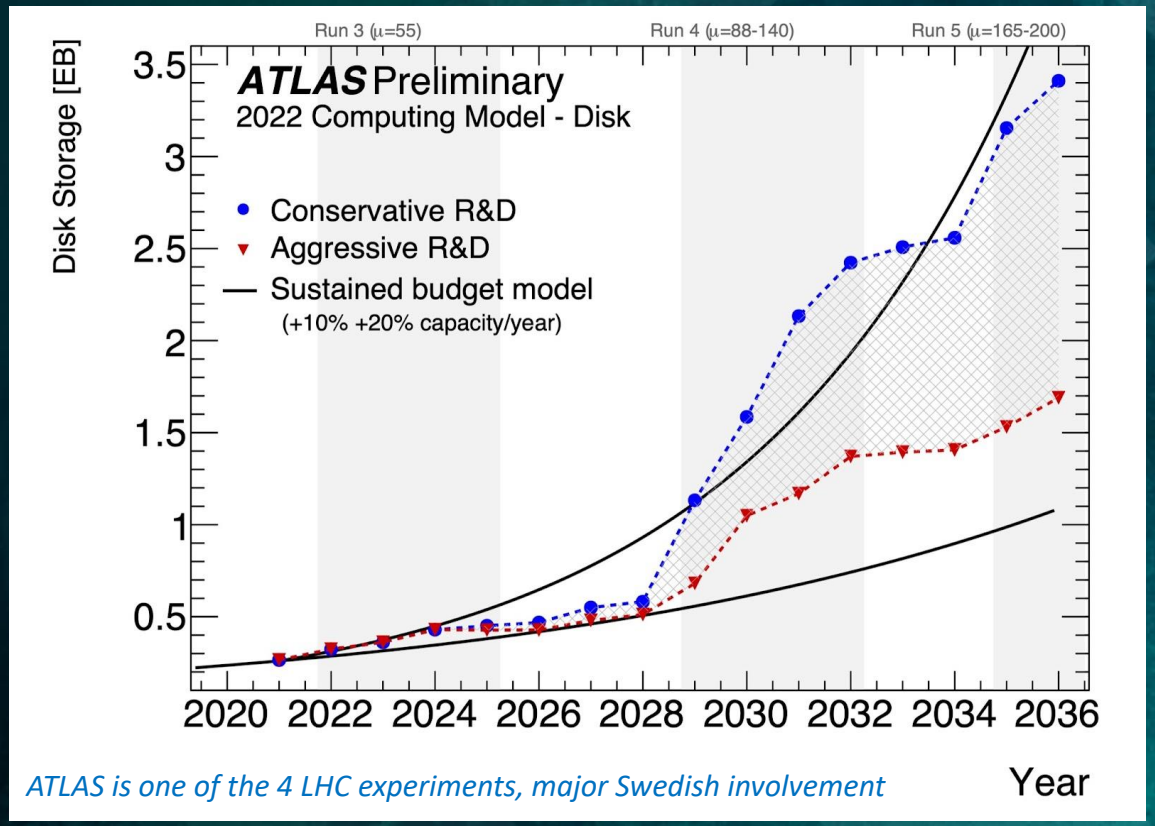

ATLAS is one of the 4 LHC experiments, major Swedish involvement

Data is the challenge

Must be FAIR: Findable, Accessible, Interoperable and Reusable

FAIRness requires a large and sustainable infrastructure

Contrary to CPU/GPU cycles, storage can not be re-used

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In Nordic countries: 20+ Petabytes of LHC data to crunch

… and much more coming

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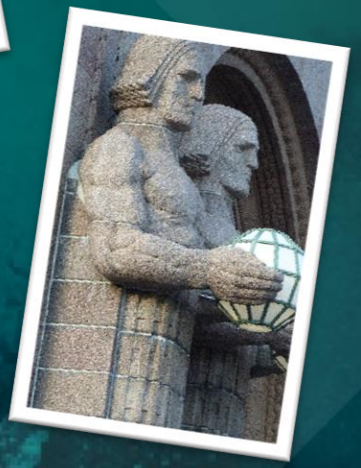

Solution: a *Data Lake* spanning countries
+ special software for data-intensive tasks
https://neic.no/nt1/

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Nordic Tier1 as a user-driven infrastructure

- Proposed by CERN/LHC user communities in 4 Nordic countries
  - In Sweden: Lund, Stockholm and Uppsala Universities and KTH, total of ~60 researchers (not counting students and engineers)
- 2 LHC experiments: ALICE and ATLAS
  - Different requirements and different community sizes (e.g., no ATLAS in Finland, very little ALICE in Sweden)
  - There is even some interest from the LHCb researchers in Uppsala
  - Other non-LHC users: IceCube, EISCAT_3D (under investigation)
- A unique data center that spreads 4 countries
  - No single Nordic data center could meet all the user needs
    - Not even now: **disk and tape storage** is still a unique requirement
  - Services are pledged by the Nordic governments via 4 dedicated MoUs with CERN

Some features and challenges

- Stakeholders: physicists and national research e-infrastructures
  - Physicists obtain funding via research grants
  - These funds are used to acquire hardware, hosted by national data centres
- All facilities are shared with other researchers – non-dedicated
  - CERN requirements are rather special, esp. in terms of I/O, storage and bandwidth
- We have to deliver a common coherent service based on diverse distributed resources
  - While having different funding cycles
  - While complying with different national regulations
  - While speaking different languages
  - While working in different time zones
  - Striving to sustain the service for **decades**

NeIC is our host

- One host: NeIC
  - Nordic Tier 1 is not a project: it is an activity hosted by NeIC
  - No expiration date
- Steered by CERN users and infrastructure providers
  - NLCG committee consists of national LHC physics grant holders and national e-infrastructure providers representatives
  - Dedicated liaison position to maintain day-to-day links to CERN
- Reach beyond Nordic countries
  - Strategic partners in Slovenia and Switzerland