Not only web

Computing methods and tools originating from high energy physics experiments

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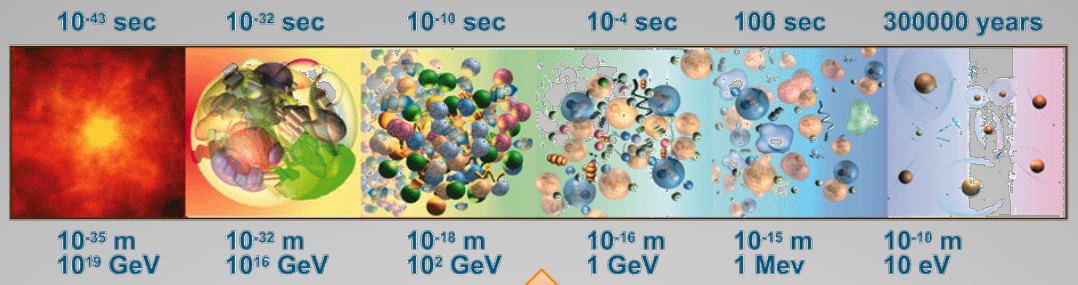
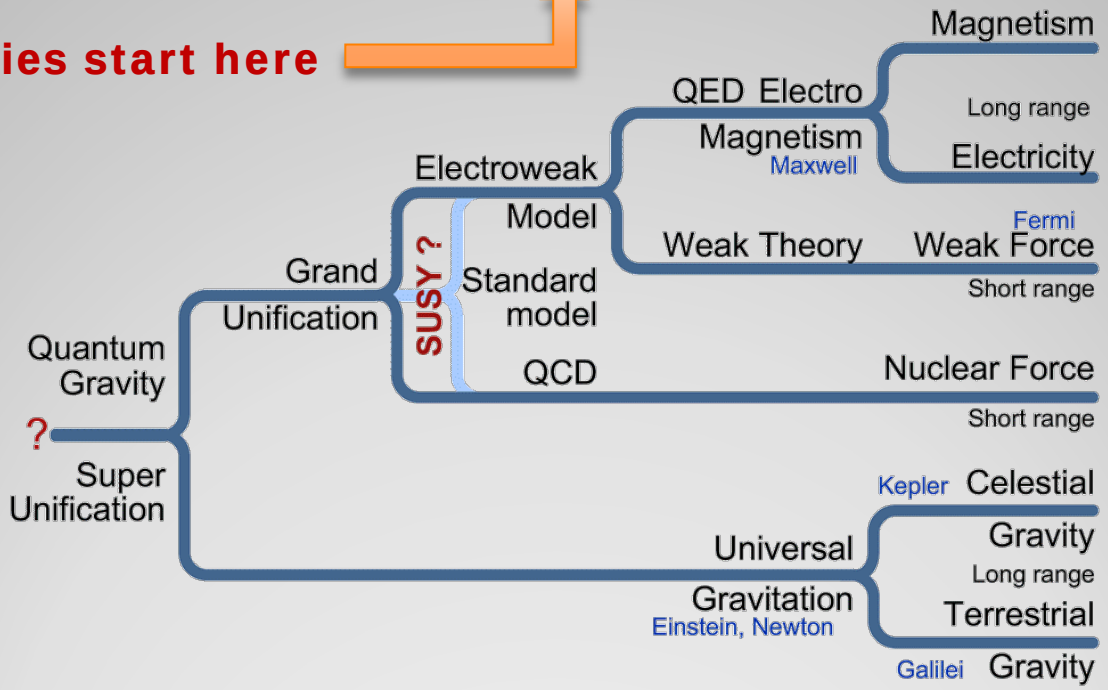
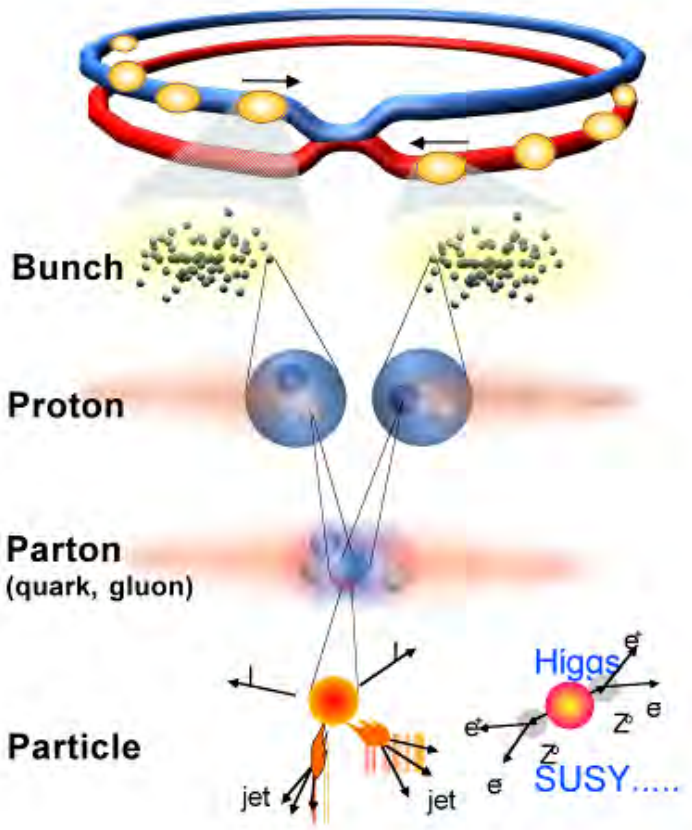
Particle Physics (www.hep.lu.se)
COMPUTE kick-off, 2012-03-02



High Energies start here



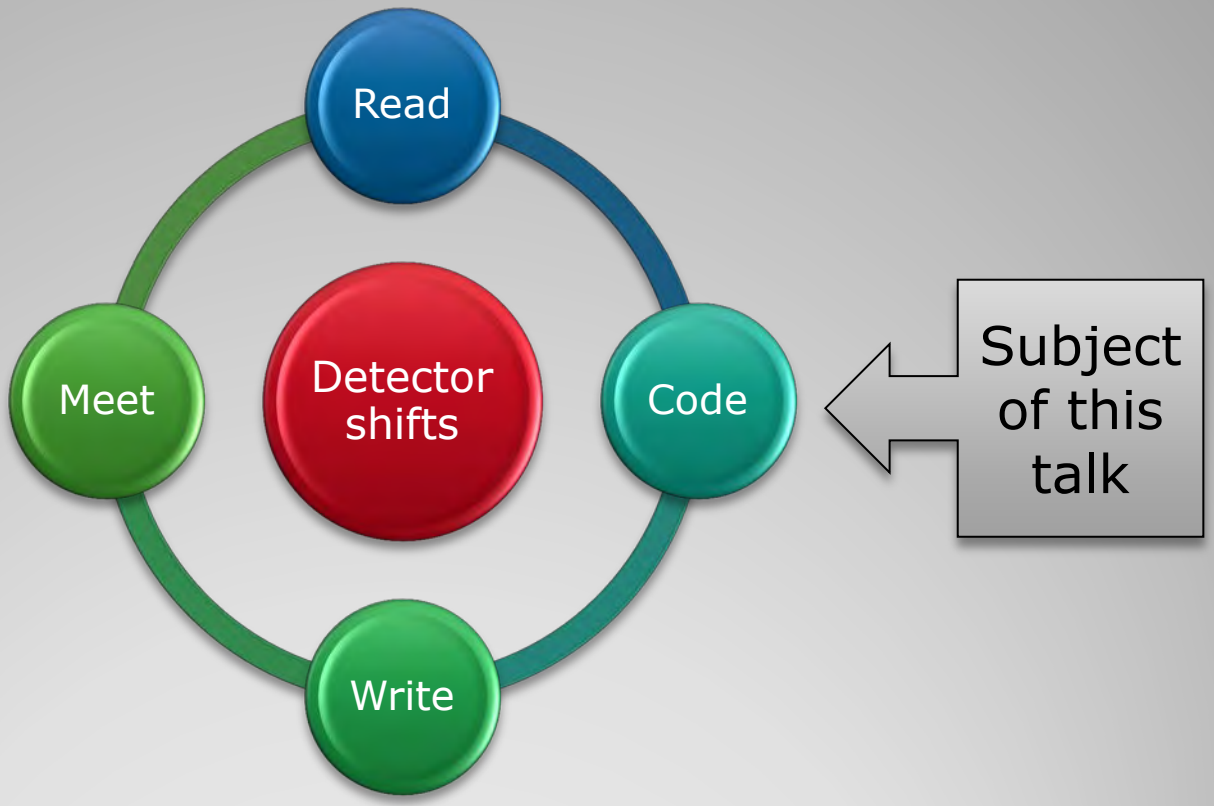
Science of High Energy Physics



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 ≈	10^{7} - 10^{9} Hz
New physics rate ≈	.00001 Hz

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

Experimental tool today: the LHC



A typical LHC physicist's workflow today

Real event, or generation

Detector, or simulation

Hit digitization

Reconstruction

Analysis data preparation

Analysis, results

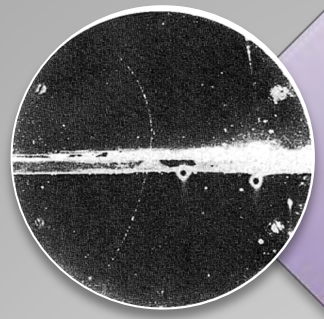
PYTHIA

GEANT4

Distributed computing and storage

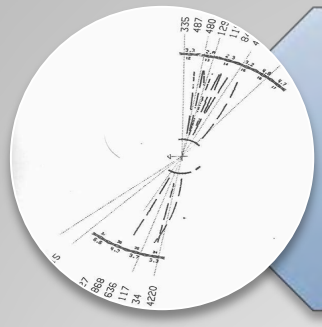
ROOT

Modern HEP data processing workflow



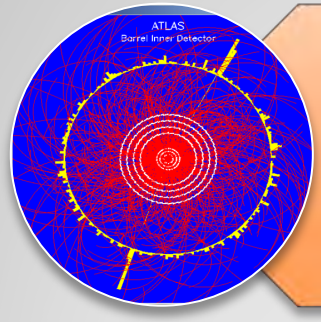
A discovery in 1930-ies

- ~2 scientists in 1country
- pen-and-paper



A discovery in 1970-ies

- ~200 scientists in ~10 countries
- mainframes



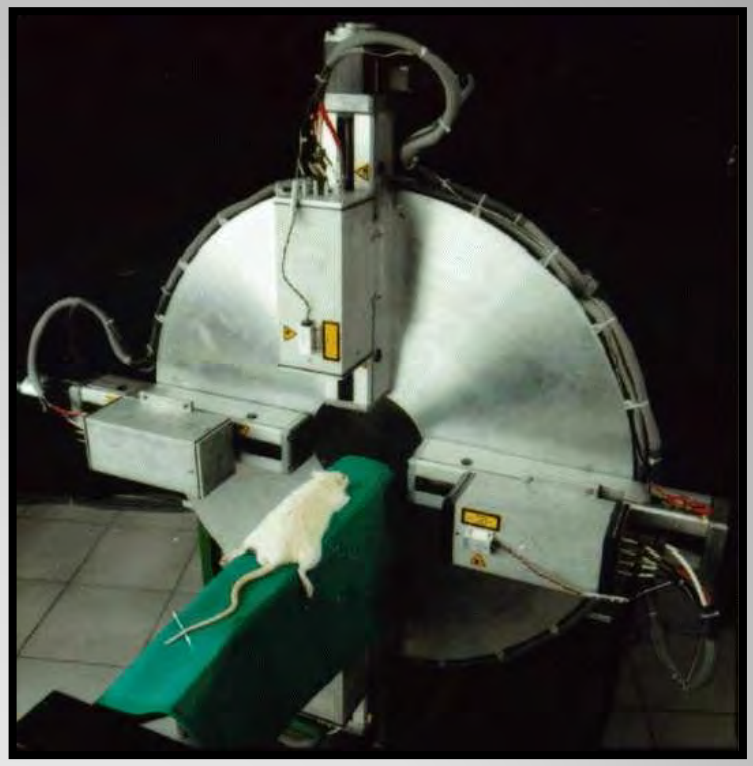
A discovery at LHC

- ~2000 scientists in ~100 countries
- distributed computing and storage

More data, more scientists, more computers

CERN – where the Web was born

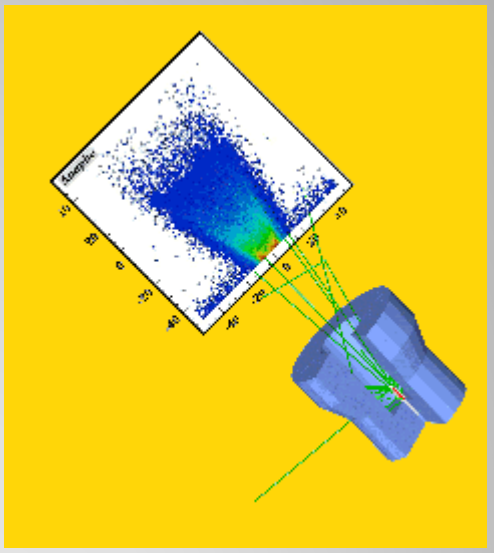
- PET scans
- Radiation therapy
- Computing development
  - Distributed computing and storage (a.k.a. Grid)



But also other things…

GEANT4: software package to simulate interactions of particles with matter

- Simulation is key to experiments involving high energy particles:
  - design of the experimental set-up
  - evaluation and definition of the potential result
  - evaluation of potential risks
  - assessment of the performance of the experiment
  - development, test and optimisation of reconstruction and analysis software
  - contribution to the calculation and validation of the results



A superficial brachytherapy device and the resulting dose distribution, simulated with GEANT4

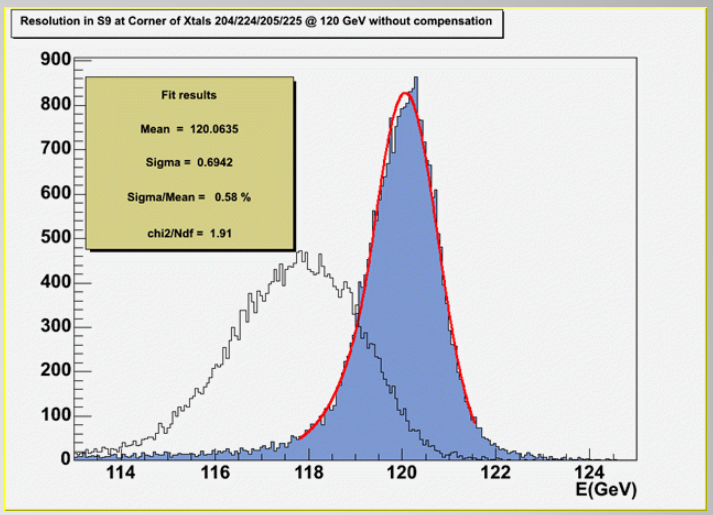
GEANT4 **http://geant4.org**

The principles of GEANT4

- GEANT4 is a simulation tool that provides a general infrastructure for
  - the description of geometry and materials
  - particle transport and interaction with matter
  - the description of detector response
  - visualisation of geometries, tracks and hits
- The user develops the specific code for
  - the primary event generator
  - the geometrical description of the set-up
  - the description of the detector response

ROOT is a C++ based tool and framework (program and library) for data analysis

- C++ as script language with interpreter
- GUI for interactive visualization
- I/O and analysis of large amount of data
- Histograming, plotting, fitting
- Physics and mathematics
- Object organisation
- Parallel analysis via network



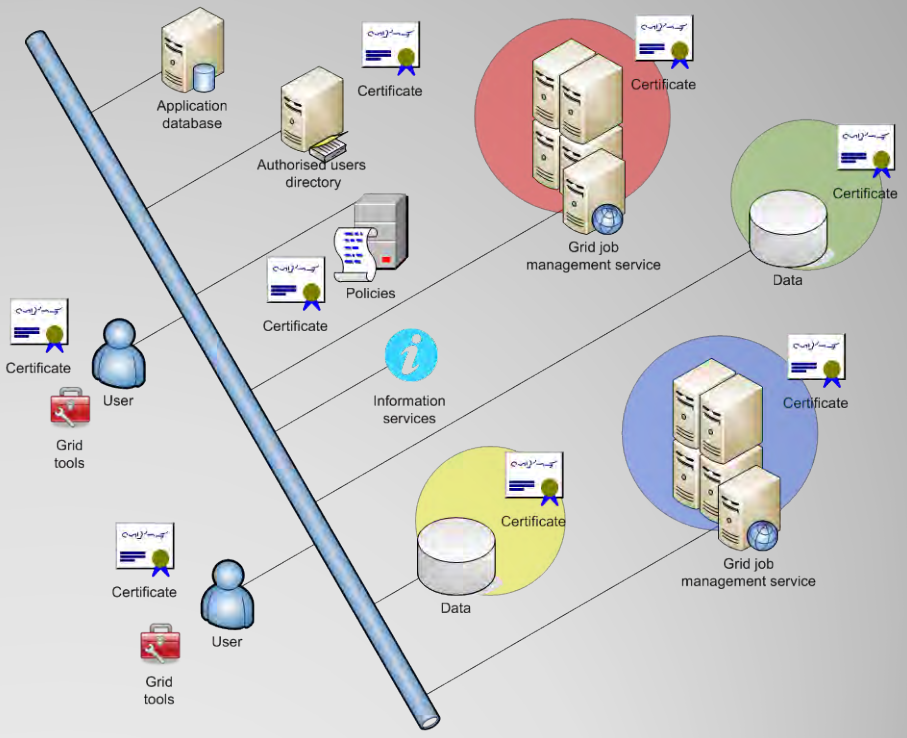
ROOT http://root.cern.ch

- As a tool
  - Makes use of commands to display and manipulate data
  - Commands are in C++
    - (covers ~85% of the full language – including simple templates)
  - Can be used to prototype new code
- As a framework
  - Can be used as a library and be linked from user C++ code (LGPL license)
  - The result can be used by the tool
- Supports user classes
  - User can define new classes
  - Can do this either as a tool or as a framework
  - These can inherit from native ROOT classes

ROOT: Tool and a framework for object-oriented data analysis

ARC is a software enabling usage of distributed computing and storage resources

- Is needed to provide simple and reliable access to hundreds of different resources
- One of many such softwares used in HEP
- Provides a number of services as well as user tools
- Is actually developed in Lund (among other places)



Distributed computing: ARC

http://www.nordugrid.org

ARC concepts

- As a service
  - Provides a common interface to different computers
  - Secure access, single sign-on
  - Task management
    - Including input/output data transfer
  - Information, monitoring, usage accounting
- As a client tool
  - Command-line tool to remotely manage computing tasks
    - Submit, inspect, cancel, retrieve results
  - Manipulations on remote files
  - Handling of access credentials
- As a library
  - Users can create own client tools
  - Available in C++ and Python

Summary

- High Energy Physics requires special software
  - HyperText and its transfer – known now as WWW
  - Monte Carlo generators – such as PYTHIA (see the talk by Torbjörn Sjöstrand)
  - Detector simulation – **GEANT4**
  - Data handling and analysis – **ROOT**
  - Distributed computing solutions – such as **ARC**
- This software is gradually adopted by others
  - WWW is adopted by everyone now
  - Nuclear and astroparticle physics
  - Radiation safety studies
  - Biomedical applications
  - Space applications
  - Material sciences
  - Other computationally-intensive sciences