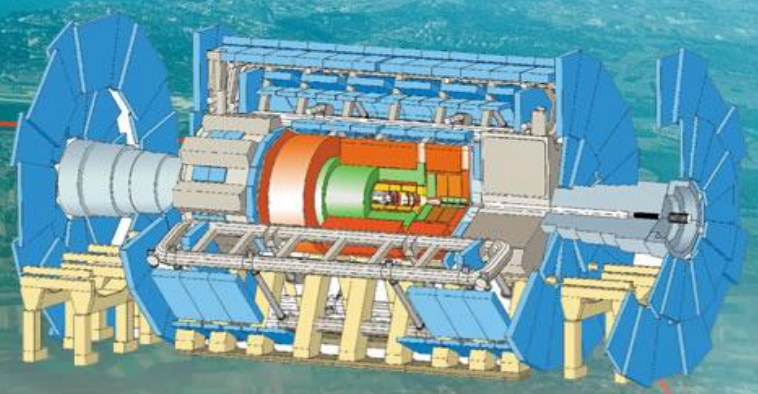
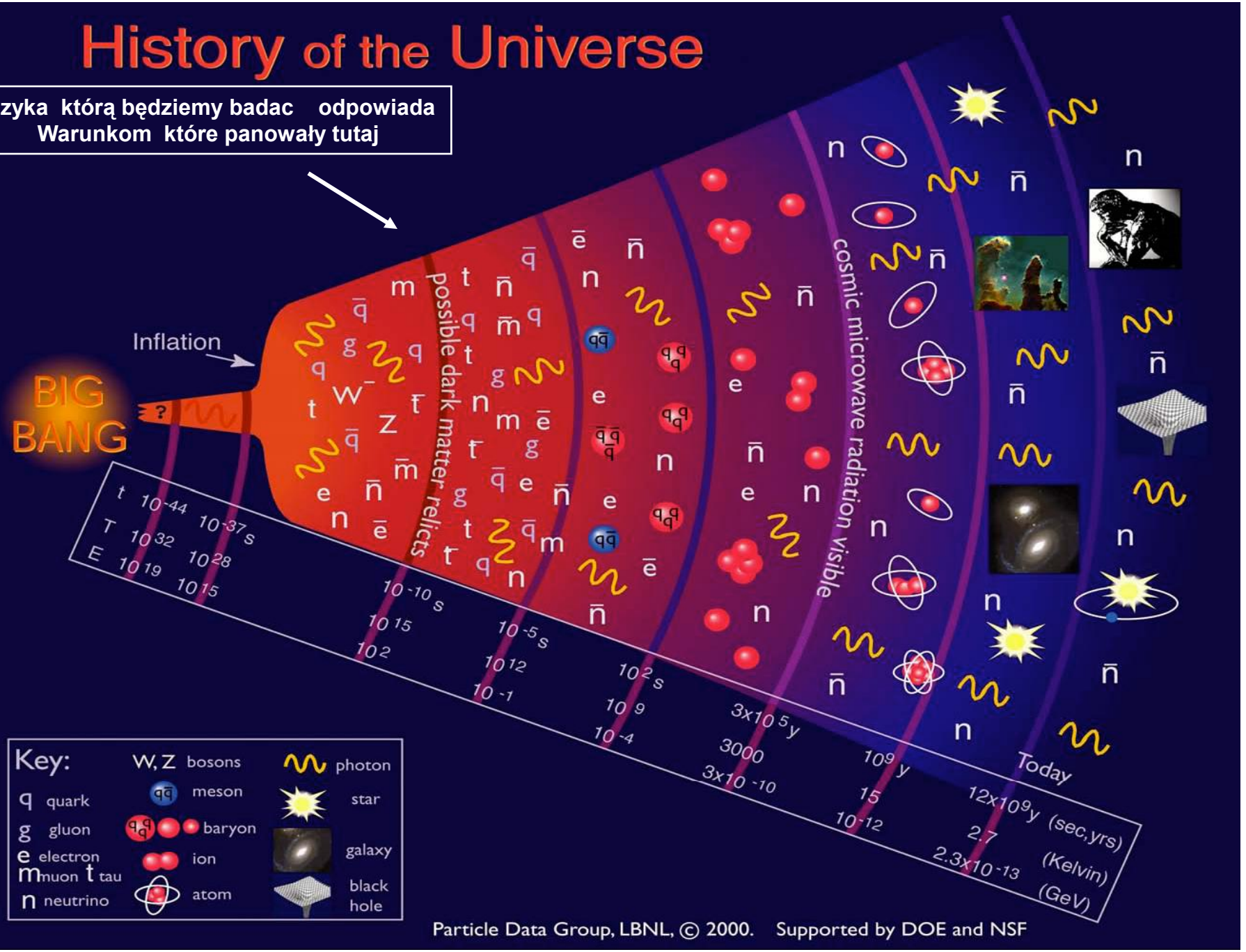
Eksperyment ATLAS
na Wielkim Koliderze Hadronowym



Czyli Wielka Przygoda z Fizyką i nie tylko……

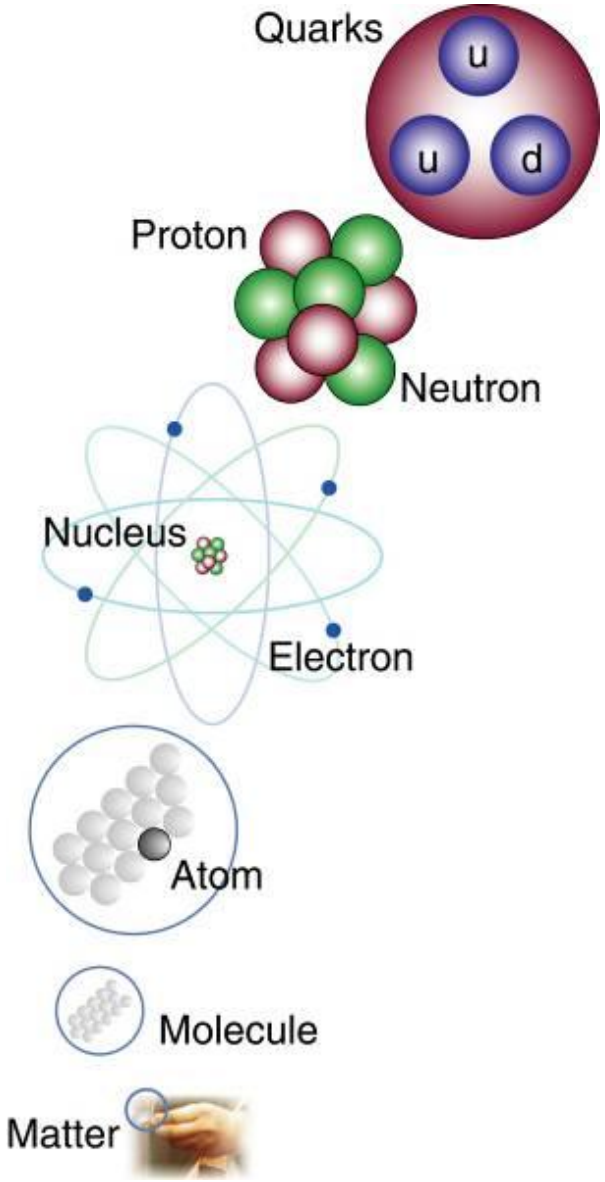
History of the Universe

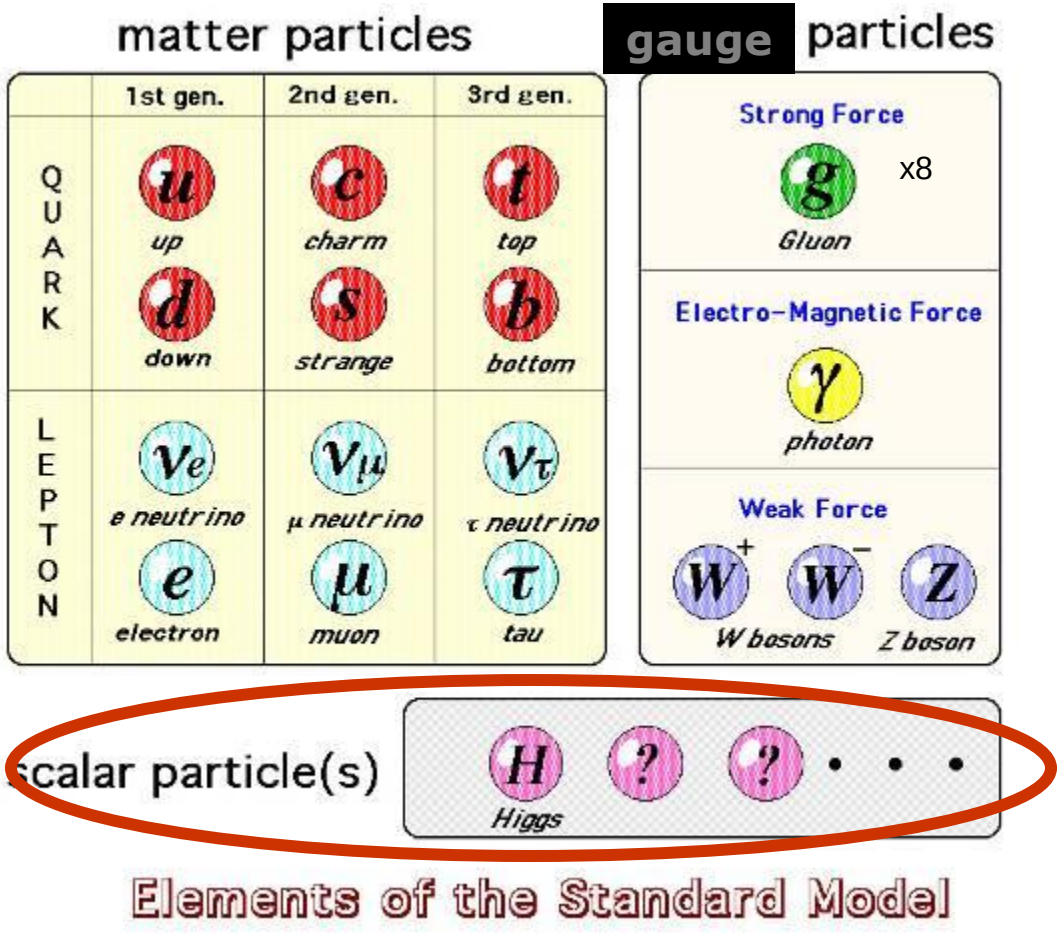
Fizyka którą będziemy badac odpowiada Warunkom które panowały tutaj



Particle Data Group, LBNL, © 2000. Supported by DOE and NSF

The study of elementary particles and fields and their interactions

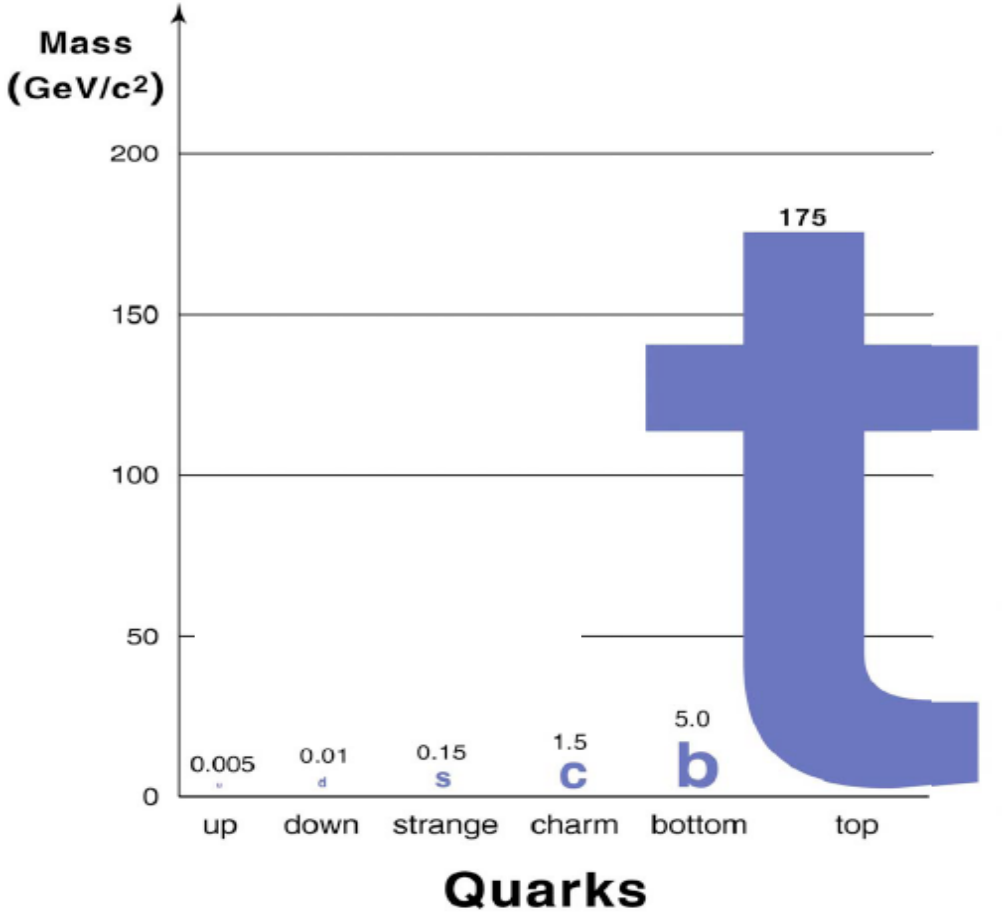




A most basic question is why particles (and matter) have masses (and so different masses)

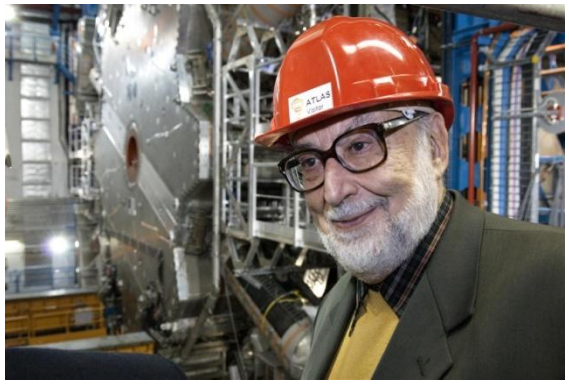
The mass mystery could be solved with the 'Higgs mechanism' which predicts the existence of a new elementary particle, the 'Higgs' particle (theory 1964, P. Higgs, R. Brout and F. Englert)

Peter Higgs



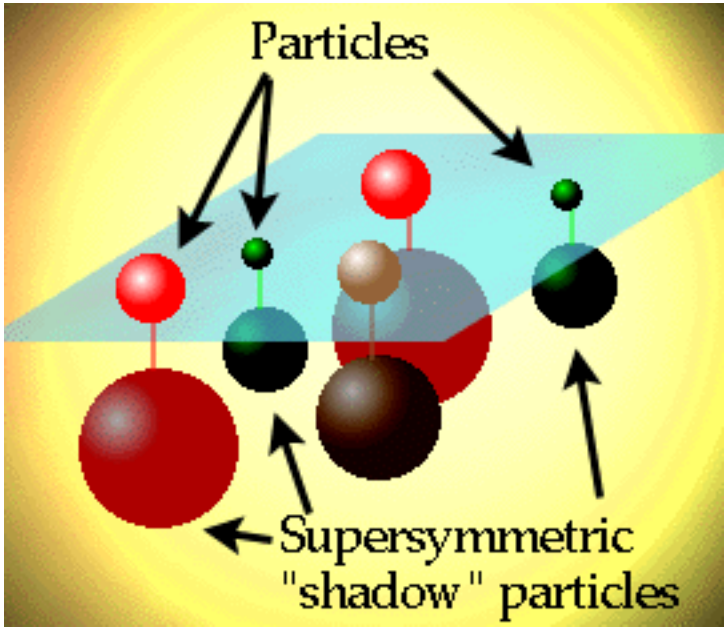
The Higgs (H) particle has been searched for since decades at accelerators, but not yet found…

The LHC will have sufficient energy to produce it for sure, if it exists



Francois Englert

Supersymmetry (SUSY)



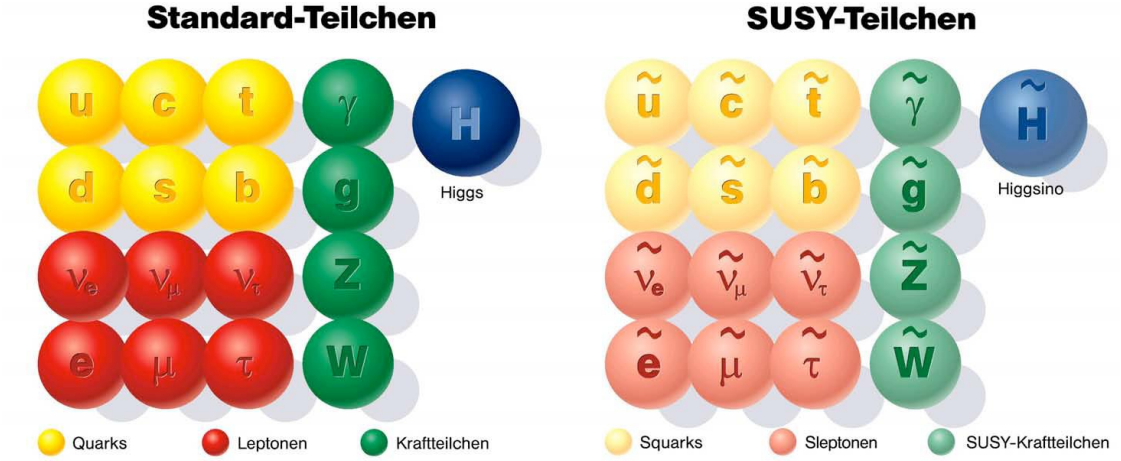
Establishes a symmetry between fermions (matter) and bosons (forces):

- Each particle p with spin s has a SUSY partner p̃ with spin s -1/2

- Examples **q (s=1/2) → q̃ (s=0)** **squark**

g (s=1) → g̃ (s=1/2) **gluino**

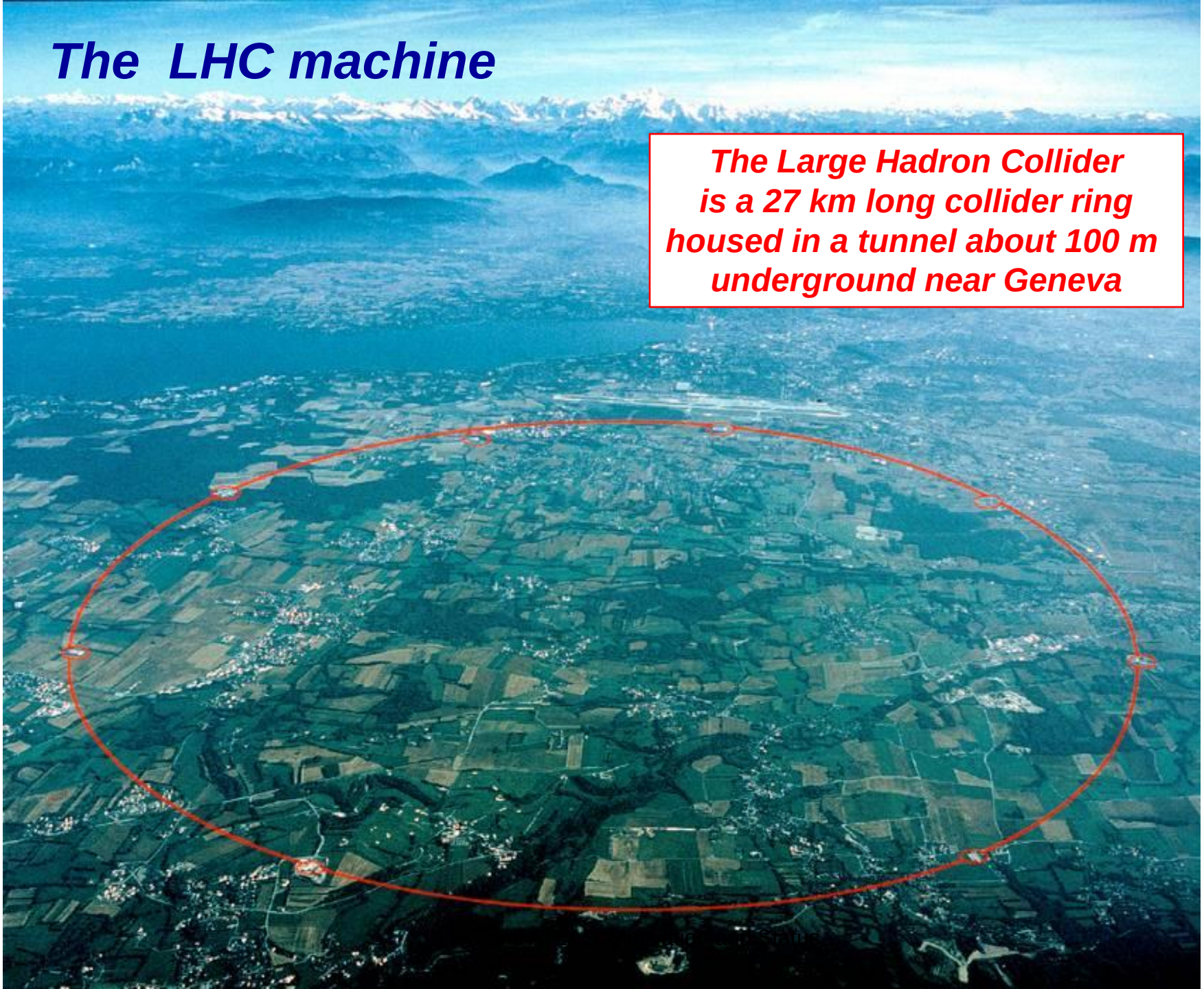
Our known world **Maybe a new world?**



Motivation:

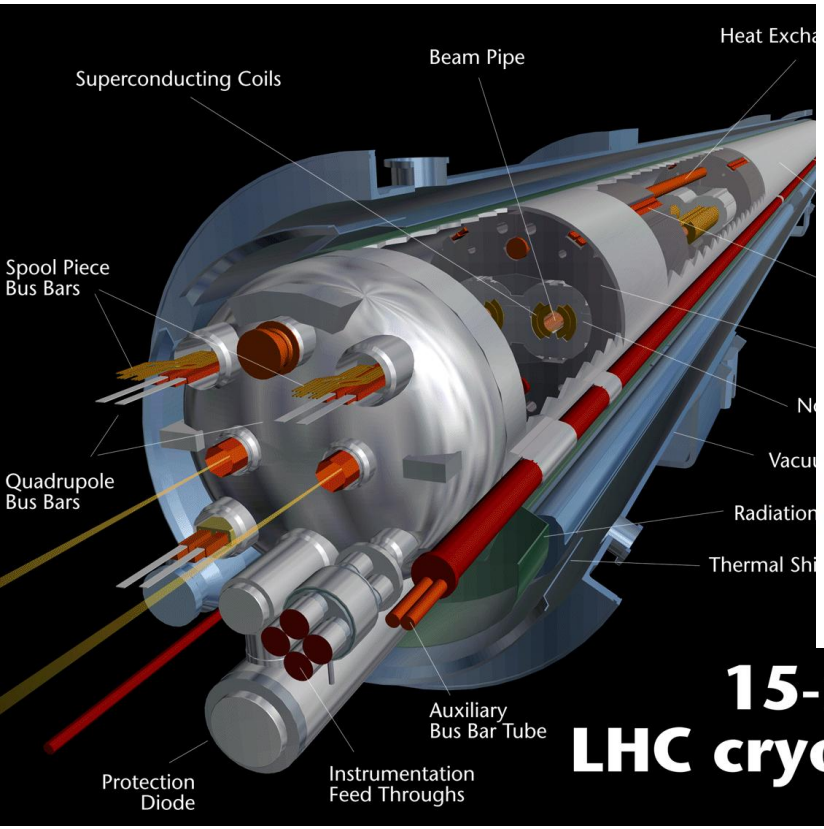
- Unification (fermions-bosons, matter-forces)
- Solves some deep problems of the Standard Model

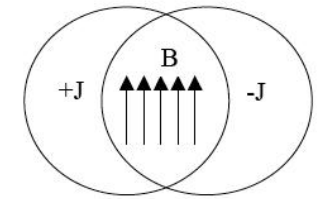
The LHC machine

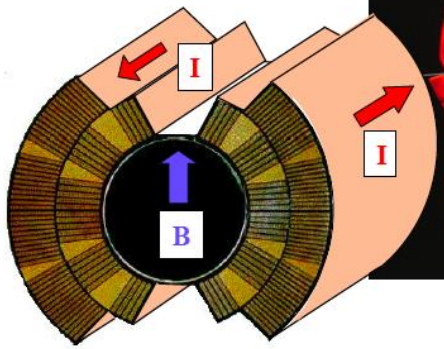


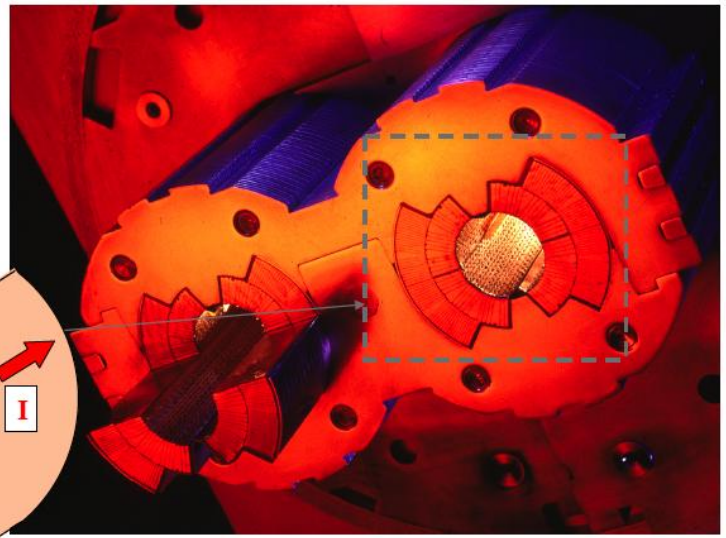
The LHC machine is fully installed and was ready to start operation with single beams on 10th September 2008, but it is now delayed for several months until next spring after an incident that happened on 19th September

LHC Accelerator Challenge: Dipole Magnets









Magnetic Field for Dipoles
p (TeV) = 0.3 B(T) R(km)

Coldest Ring in the Universe ?
1.9 K (CMBR is about 2.7 K)

LHC magnets are cooled with pressurized superfluid helium

For p = 7 TeV and R = 4.3 km
⇨ B = 8.4 T
⇨ Current 12 kA

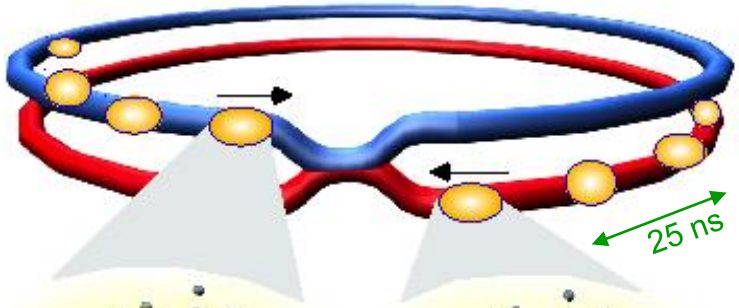
8

Descent of the last dipole magnet, 26 April 2007

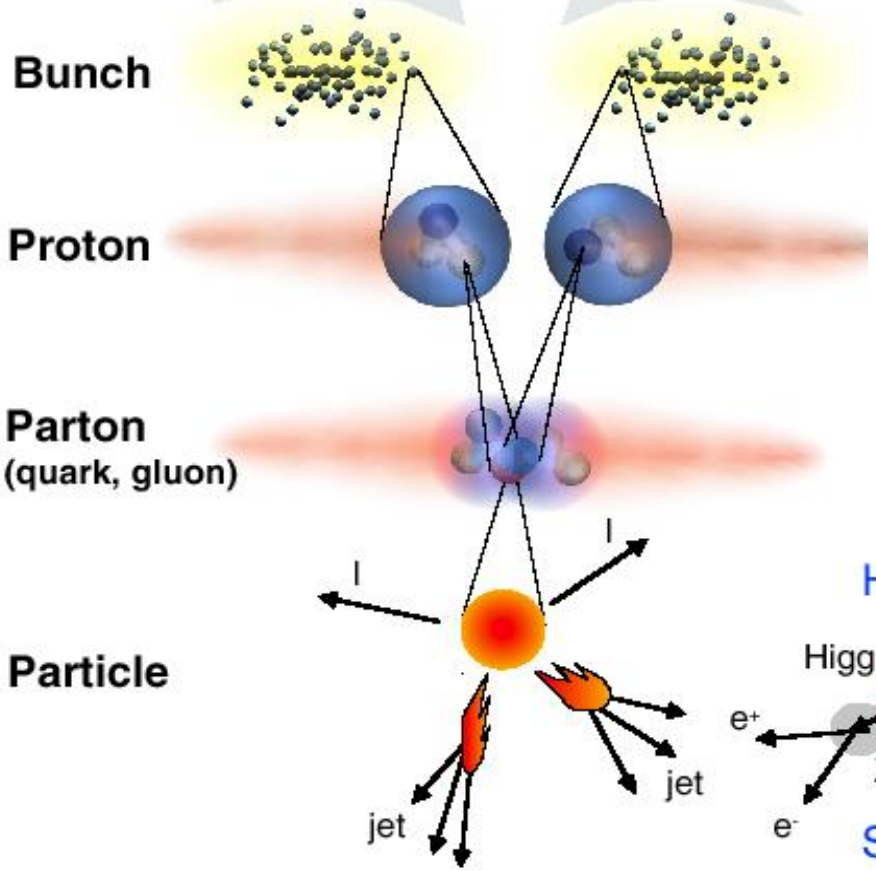
30’000 km underground transports at a speed of 2 km/h!

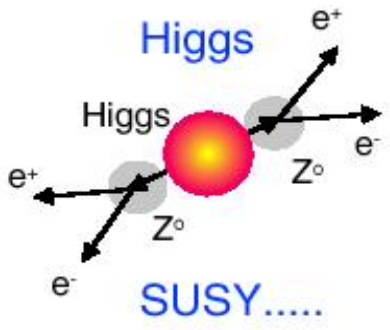
9

Collisions at LHC



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





In the experiments:

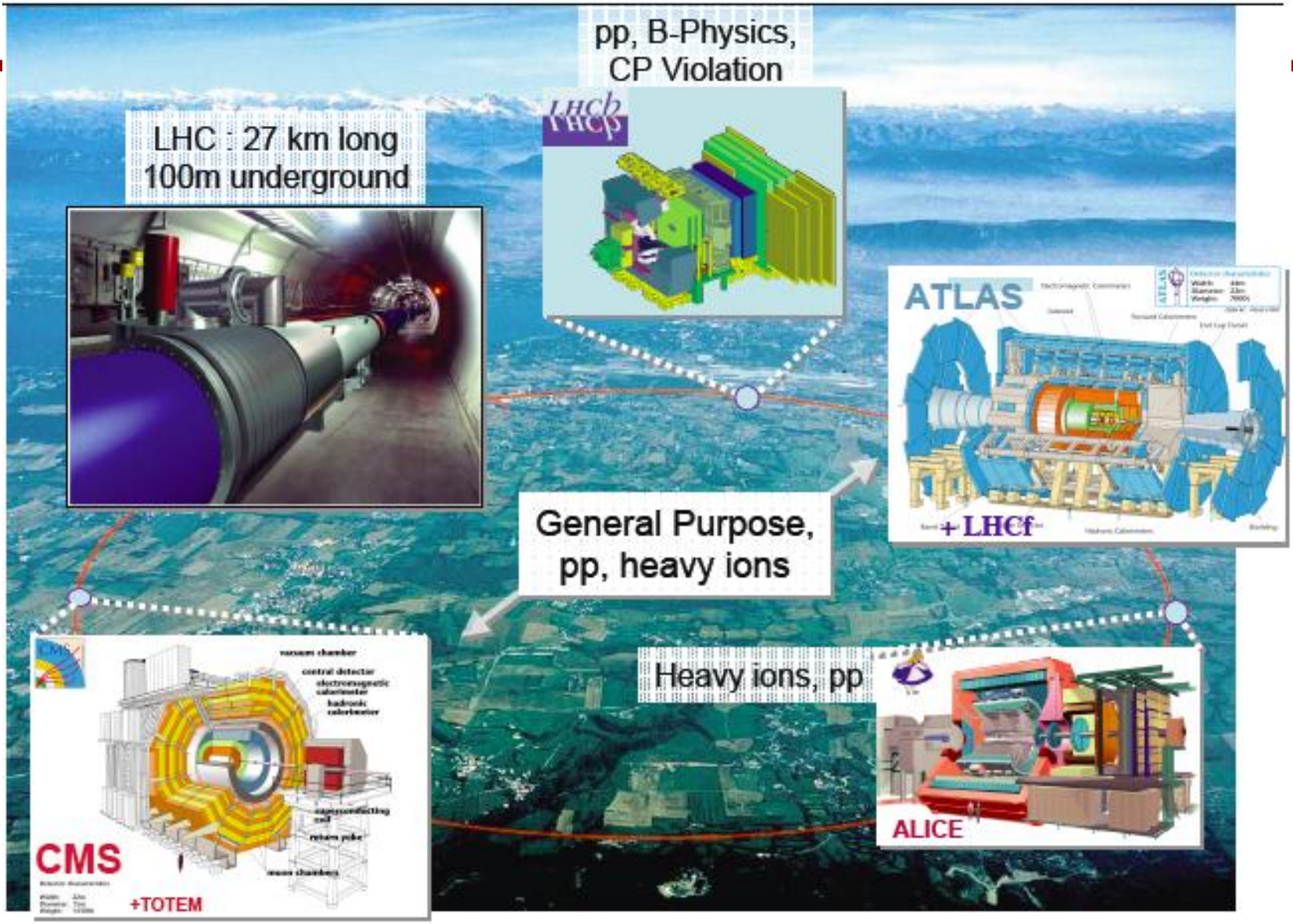
10^9 pp interactions per second

~ 1500 particles (p,n, π) produced in the detectors at each bunch-crossing

Selection of 1 in

10,000,000,000,000

Large Hadron Collider@CERN



Detektory eksperymentów fizyki wysokich energii

- **Detektory** pozwalają na obserwację (rejestrację) serii oddziaływań, podjęcie decyzji czy oddziaływanie jest interesujące, identyfikację produkowanych cząstek, pomiar ich energii i pędu.

- Detektory dla zderzeń przy wysokich energiach muszą być duże, zbudowane z różnych poddetektorów (każdy dedykowany do rejestracji pewnego określonego typu sygnału). Niektóre poddetektory umieszczone są w polu magnetycznym (aby umożliwić pomiar pędu).

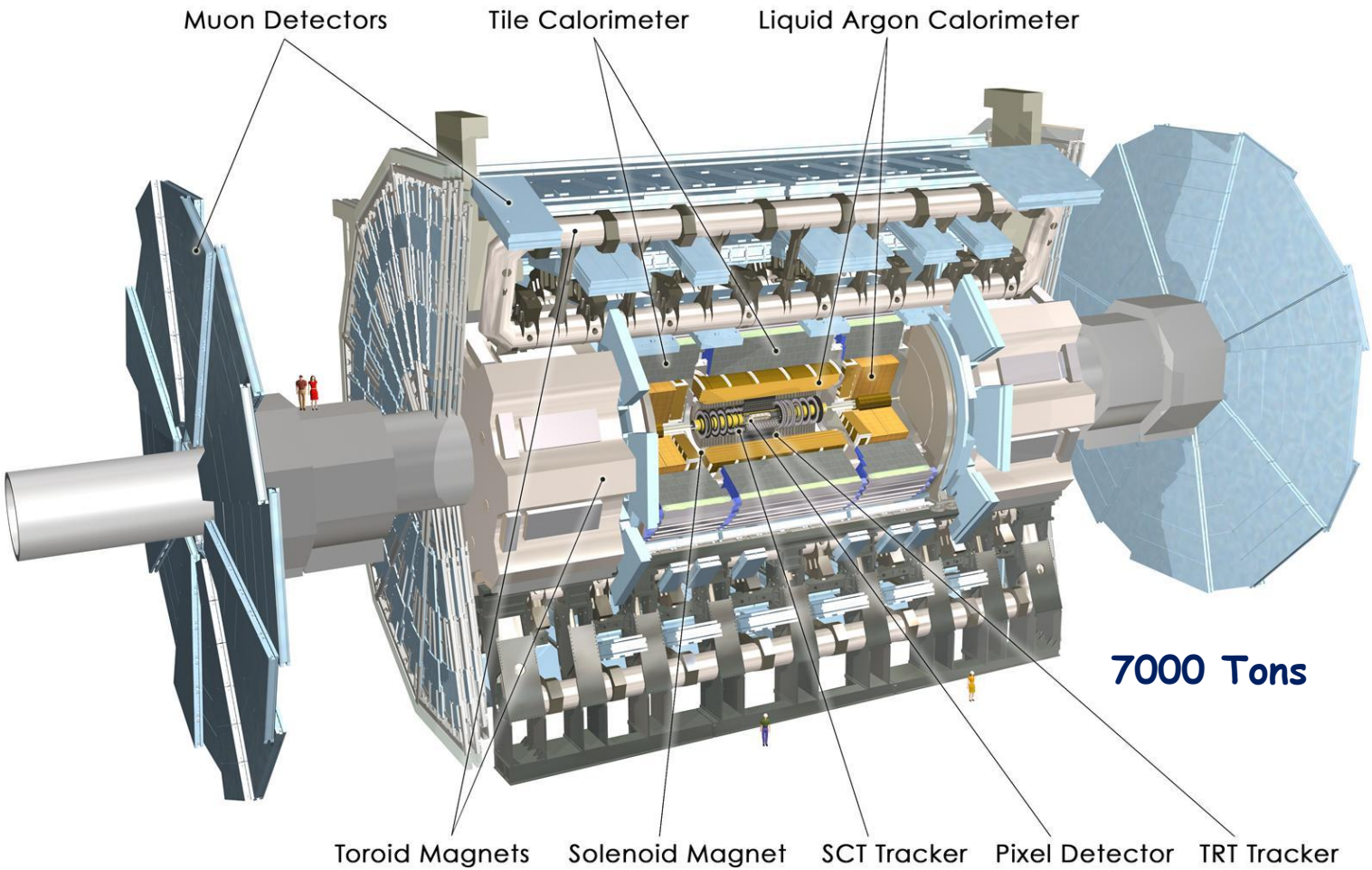
- **Metody pomiarowe** to pomiar absorpcji energii, rekonstrukcja toru na podstawie „śladów” zostawionych w poszczególnych warstwach detektorów, itd. itd...

ATLAS Detector

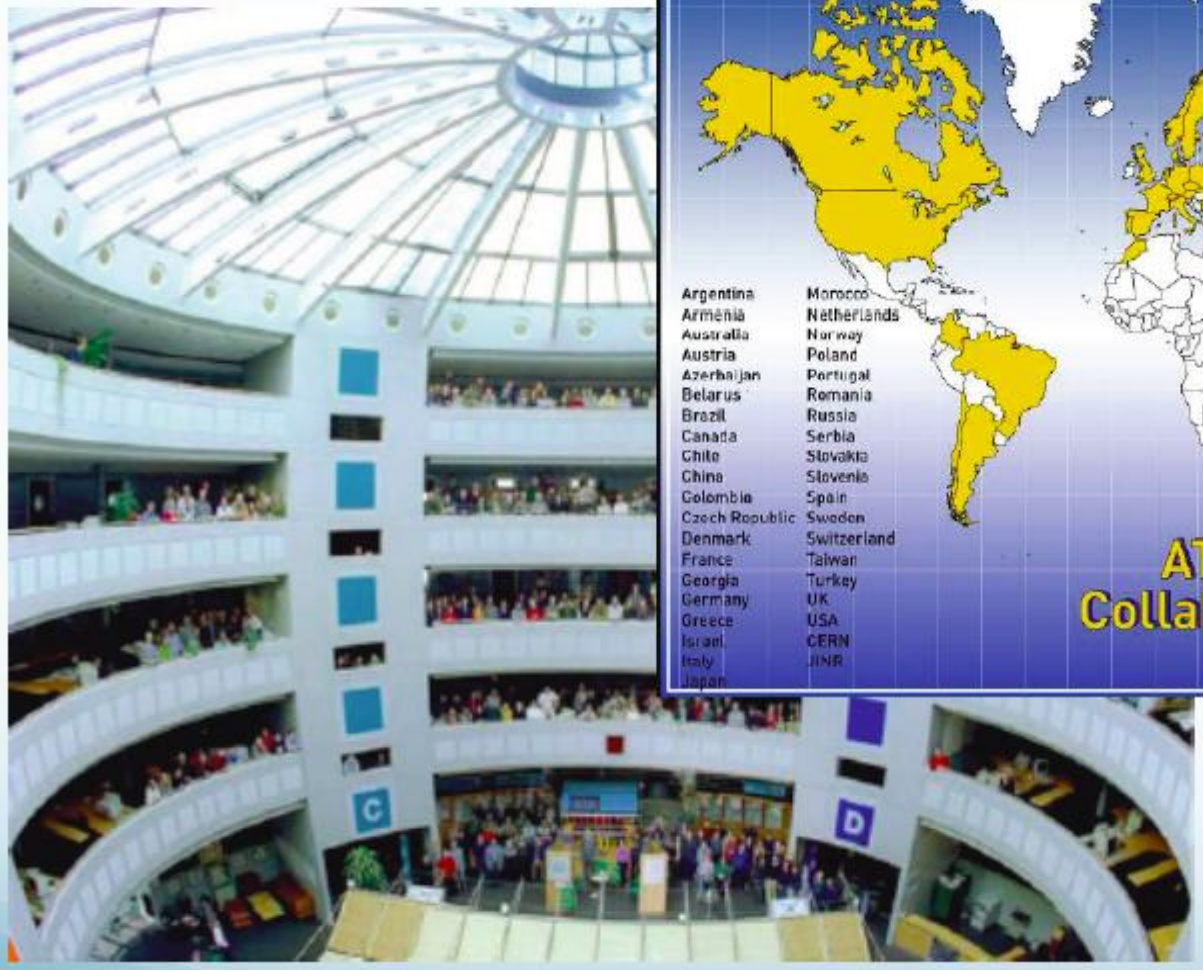
ATLAS superimposed to the 5 floors of building 40

45 m

24 m

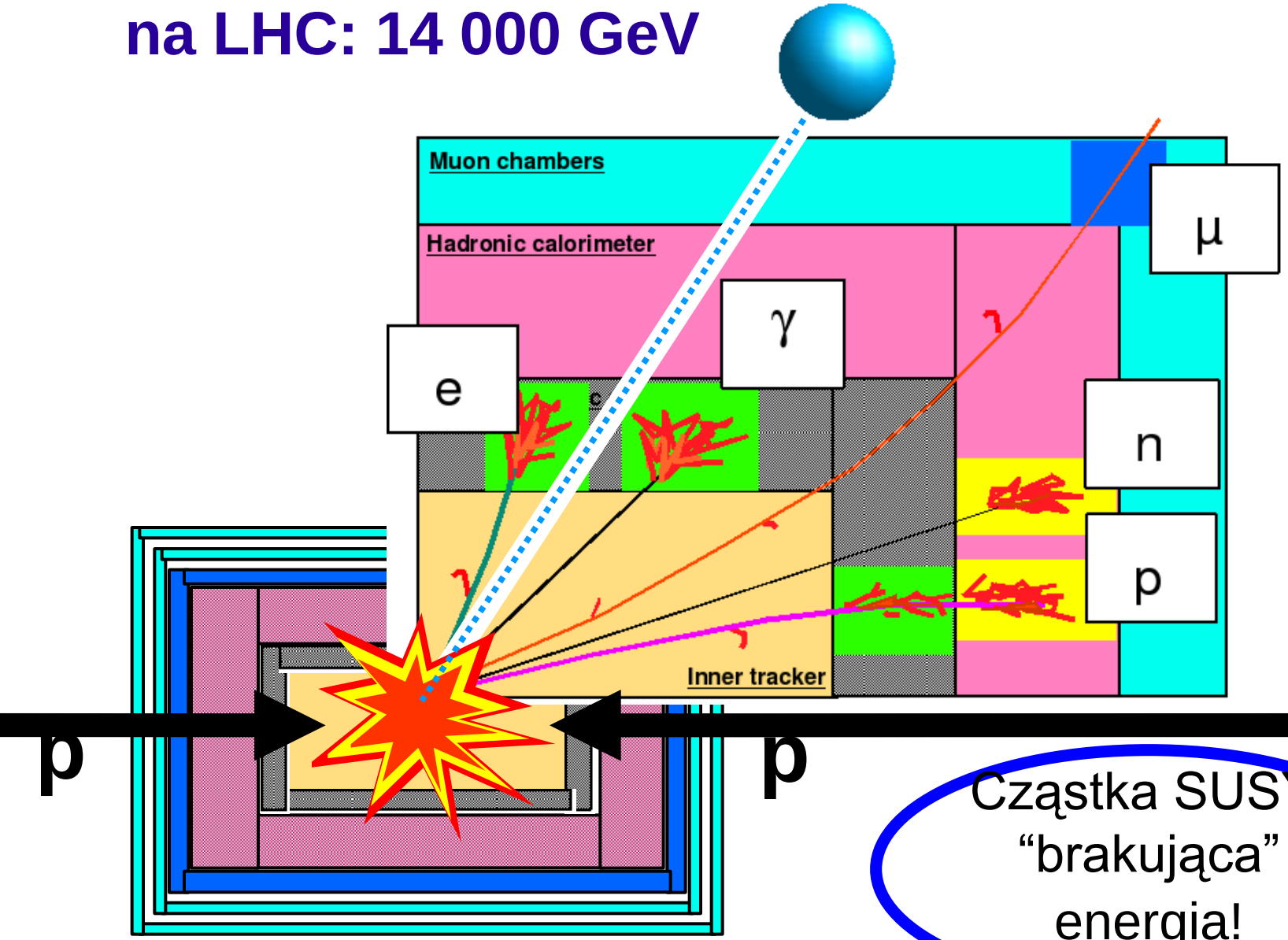


The ATLAS collaboration



ATLAS in the world:
37 Countries
167 Institutions

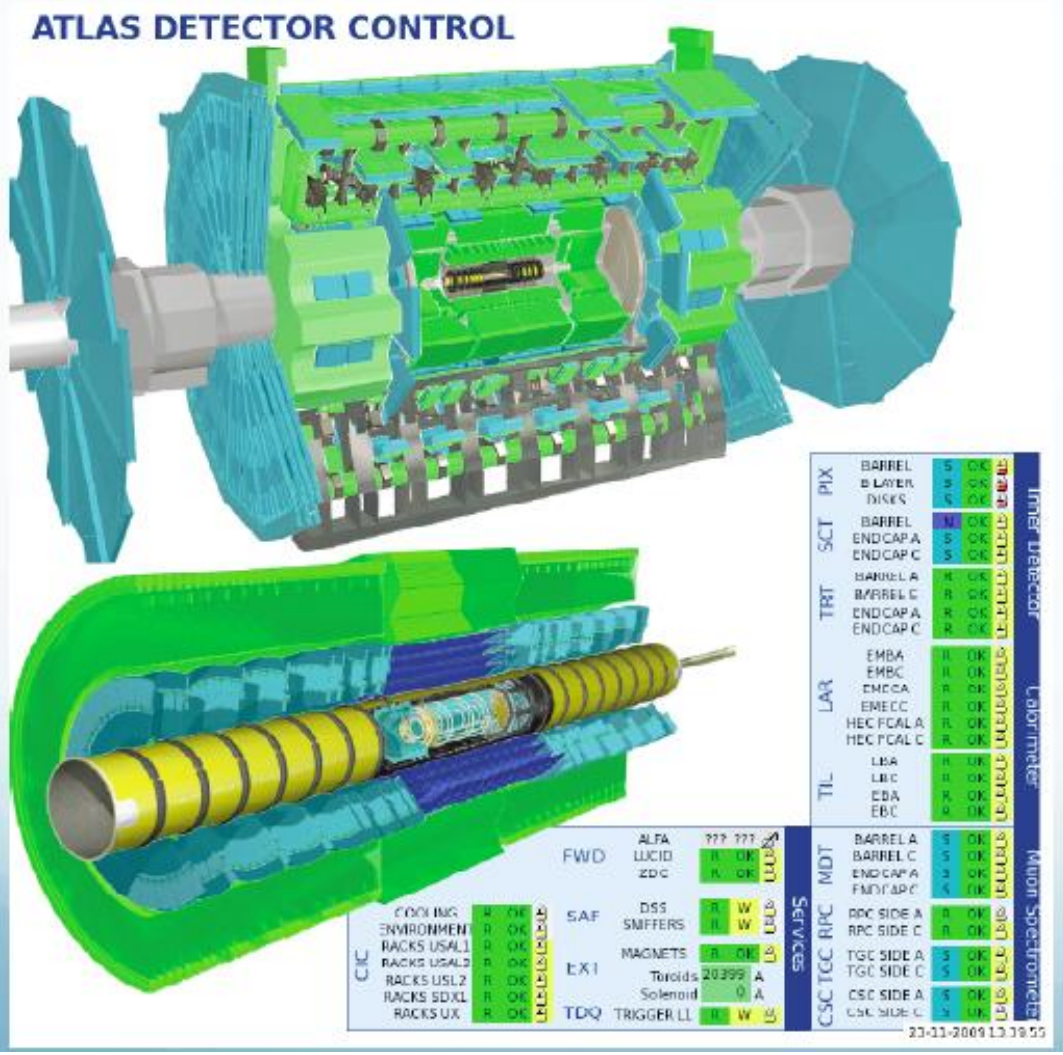
zderzenie proton-proton na LHC: 14 000 GeV



Cząstka SUSY: "brakująca" energia!

ATLAS Status on 20 November 2009

After a vast multi-year programme of cosmic ray data taking and system commissioning ...



- Pixel - off (no stable beam)
- SCT - standby
  - Standby V is 20 V → ~50% hit efficiency (increases with incidence angle)
  - Barrel and endcap increased to 50V for short stable beam periods during collisions
  - Barrel voltage sometimes lower than 20V for beam set up (eg. splash events)
- All other systems (Muon system, Calorimeters, TRT, Forward detectors) on
- Trigger and DAQ ready
- Solenoid off, toroids on
- Waiting for beam ...

1st Beam Splash from Beam-2

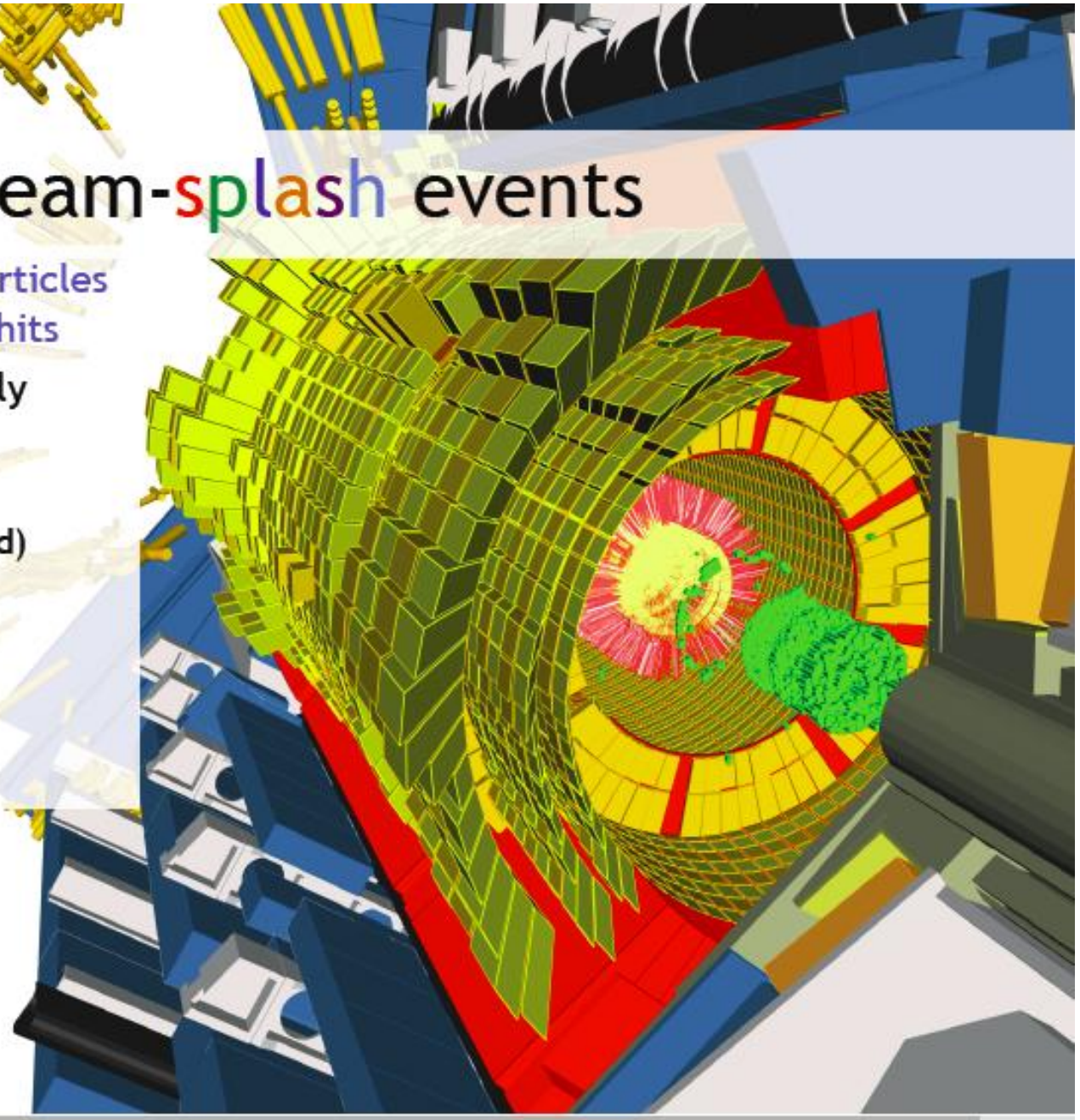
Beam-splash events

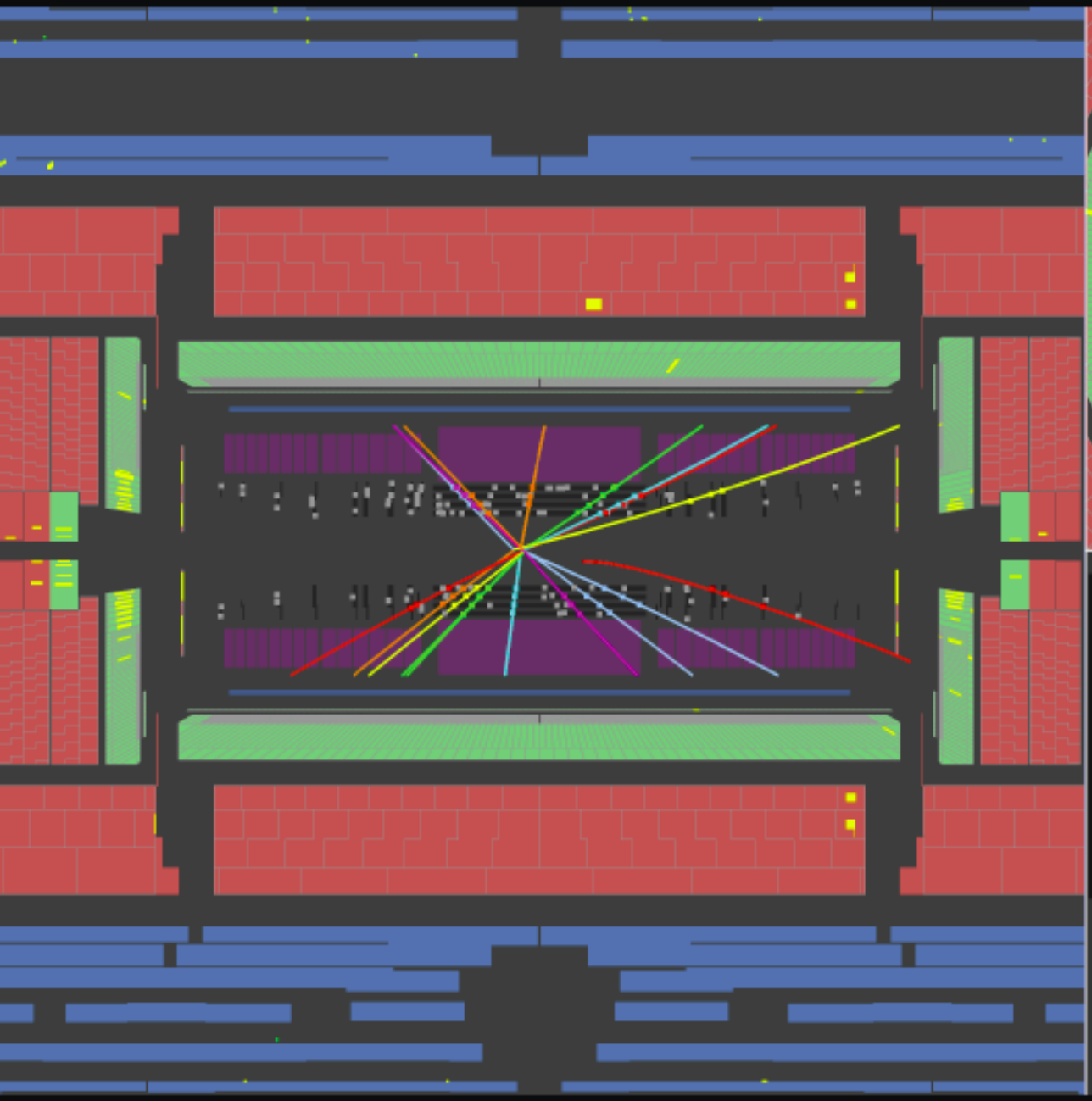
Avalanche of scattered particles from beam-on-collimator hits

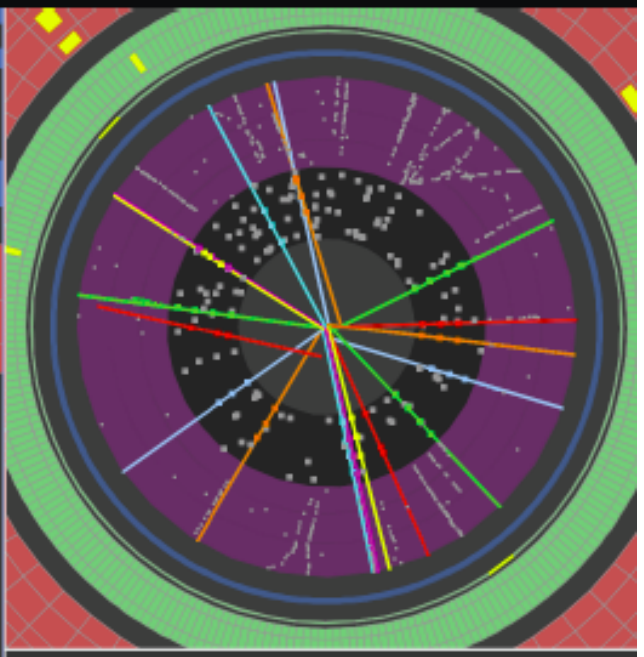
Detectors fully lit, typically

- 300,000 SCT hits
- 350,000 TRT hits (~all passing high-threshold)
- 3000 TeV calo energy sum
- 490,000 MDT hits
- 320,000 RPC hits
- 65,000 TGC hits

2009-11-20, 23:32 CET
Run 140370, Event 2666







ATLAS EXPERIMENT

2009-11-23, 14:22 CET

Run 140541, Event 171897

Candidate Collision Event

Jak w ciągu 1 sekundy wybrać 1 spośród 10^7 ?

LHC (Large Hadron Collider) będzie zderzał przeciwbieżne wiązki protonów z energią środka masy 14 TeV. (Ta energia wystarczałaby na produkcję 15 000 protonów!)

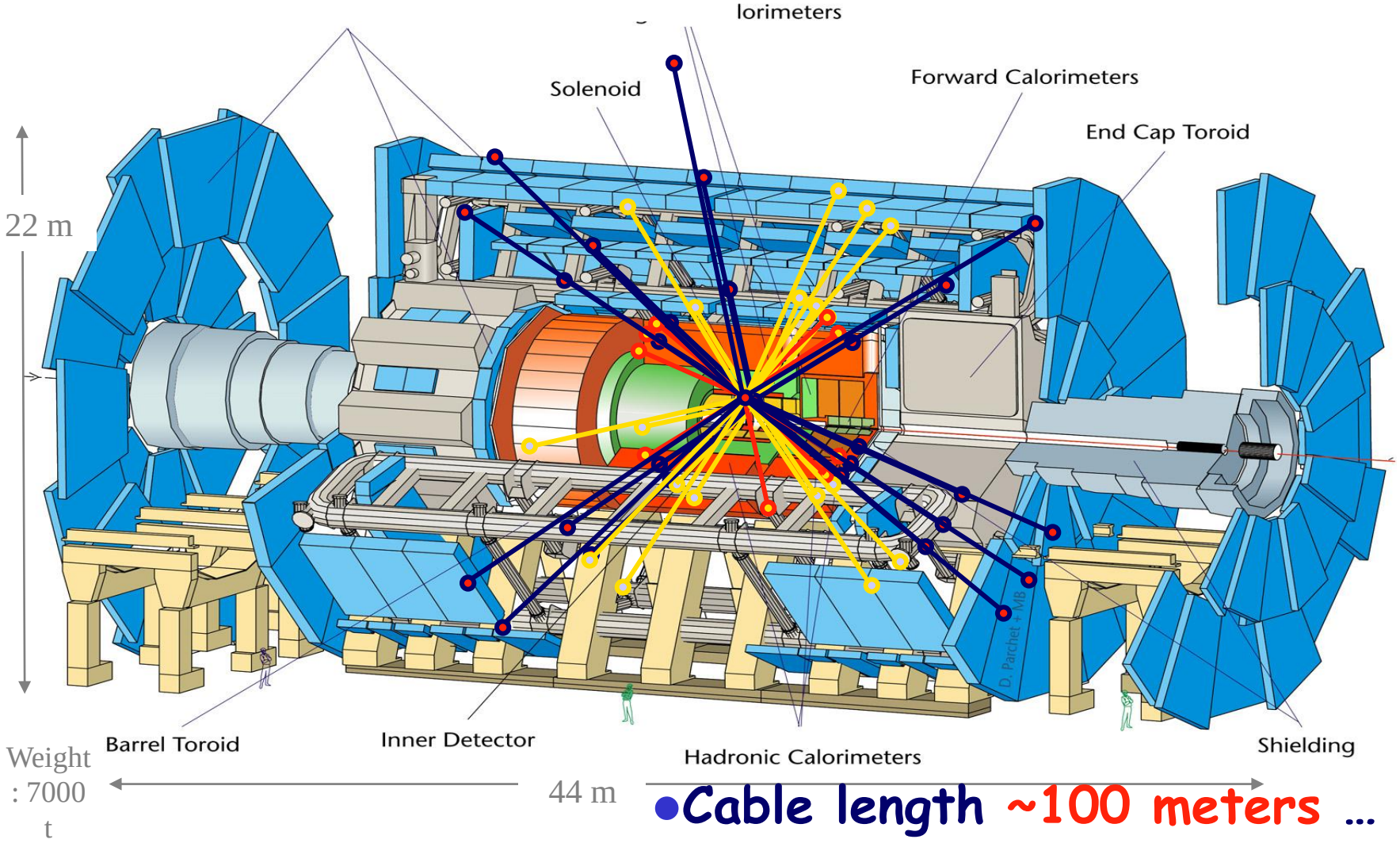
Wiązki protonów będą oddziaływały co 25 ns wewnątrz ogromnego detektora wypełnionego milionami kanałów odczytu elektronicznego.

Każde zderzenie wiązek to ~ 23 pp oddziaływań, każde produkujące strugę (~ 10^3) wychodzących cząstek.

Odstęp pomiędzy kolejnymi zderzeniami wiązek to tylko **25ns**

- 25ns to odległość 8m dla cząstek poruszających się z prędkością światła (to jest mniej niż promień detektora)
- Na raz w detektorze „fale cząstek” od 3 kolejnych zderzeń
- Tylko niewielka cześć tych oddziaływań może zostać zapisana „na taśmie” . System który podejmuje decyzje nazywa się TRIGGER.

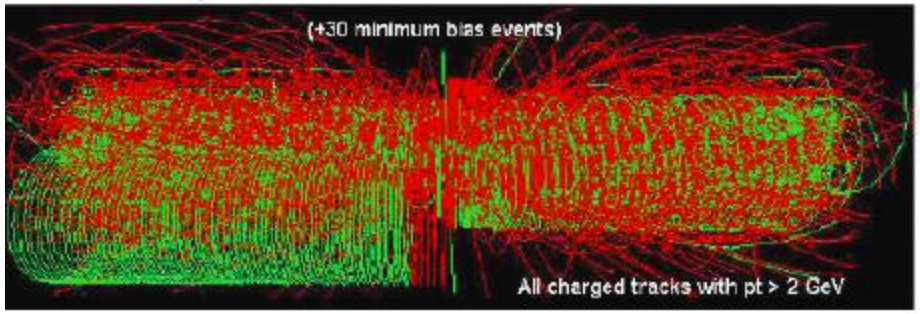
- Interactions every 25 ns …
  - In 25 ns particles travel 7.5 m



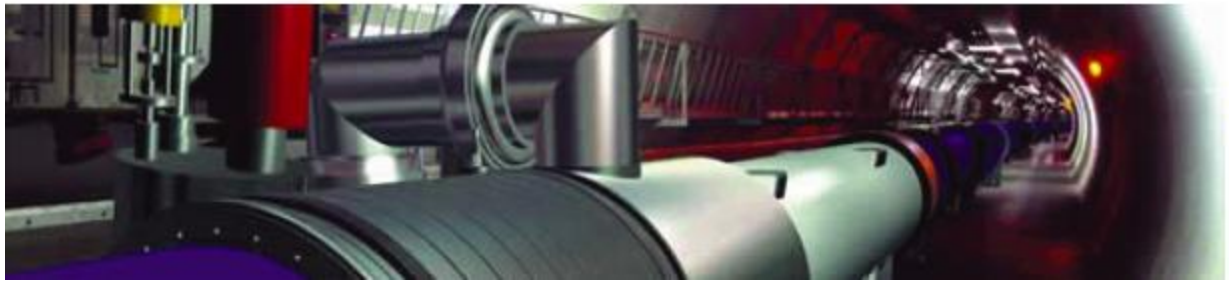
- Cable length ~100 meters …
  - In 25 ns signals travel 5 m

LHC DATA

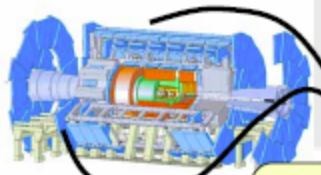
Online computers filter out a few hundred "good" events per sec. Each event is ~1 MB.



Which are recorded on disk and magnetic tape at 100-1,000 Megabytes/sec → ~15 Petabytes per year for all four experiments



Data Flow for Physics Analysis



detector

event filter (selection & reconstruction)

reconstruction

event data

processed data

100%

raw data

10%

batch physics analysis

event reprocessing

analysis

1%

analysis objects (extracted by physics topic)

event simulation

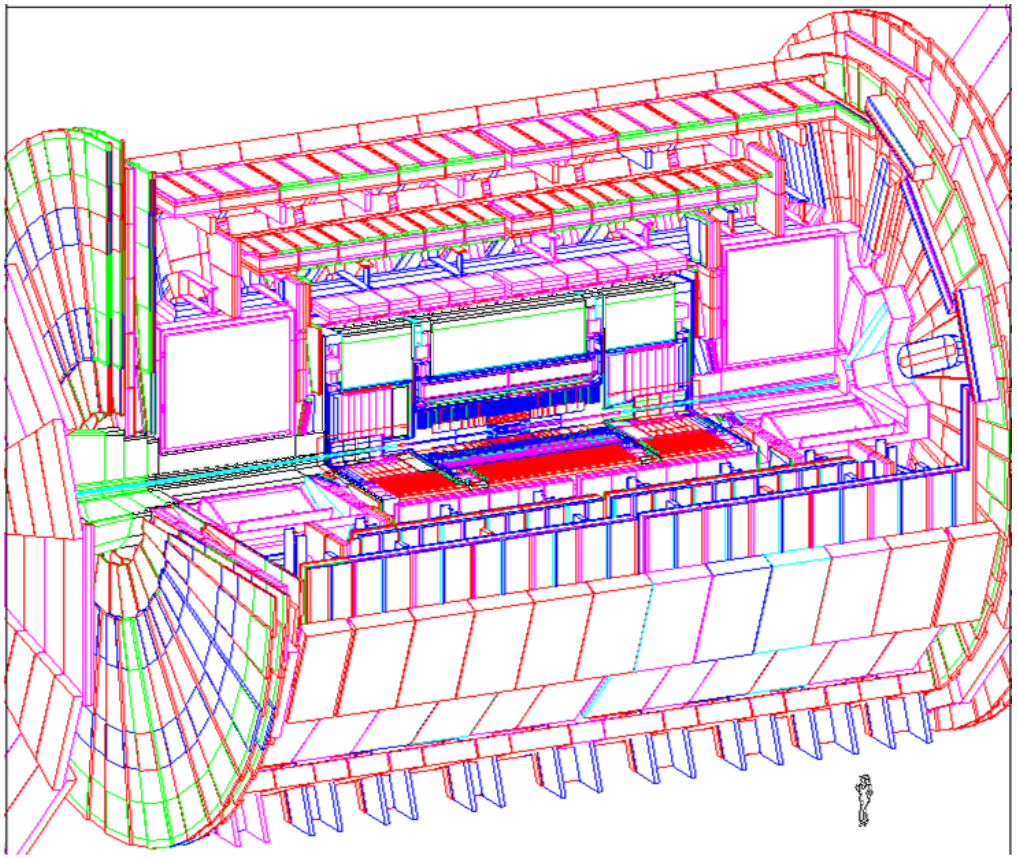
simulation

interactive physics analysis

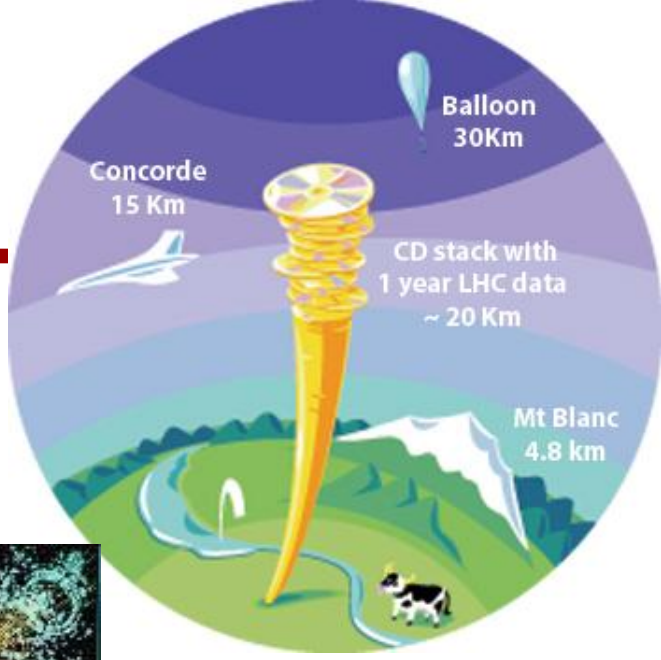
Co to znaczy „zaprogramować" geometrię?

Jaka jest skala problemu?

- **25,5 milionów** oddzielnych elementów
- **23 000** różnych obiektów geometrycznych
- **4 673** różnych typów geometrycznych
- kontrolowanie nakładających się na siebie przypadków
- **1 000 000** sygnałów w detektorze na przypadek



Computing



The LHC experiments will produce 10-15 PB of data per year

1 PB=10^6 GB

This corresponds to ~ 20 million CD (a 20 km stack …)

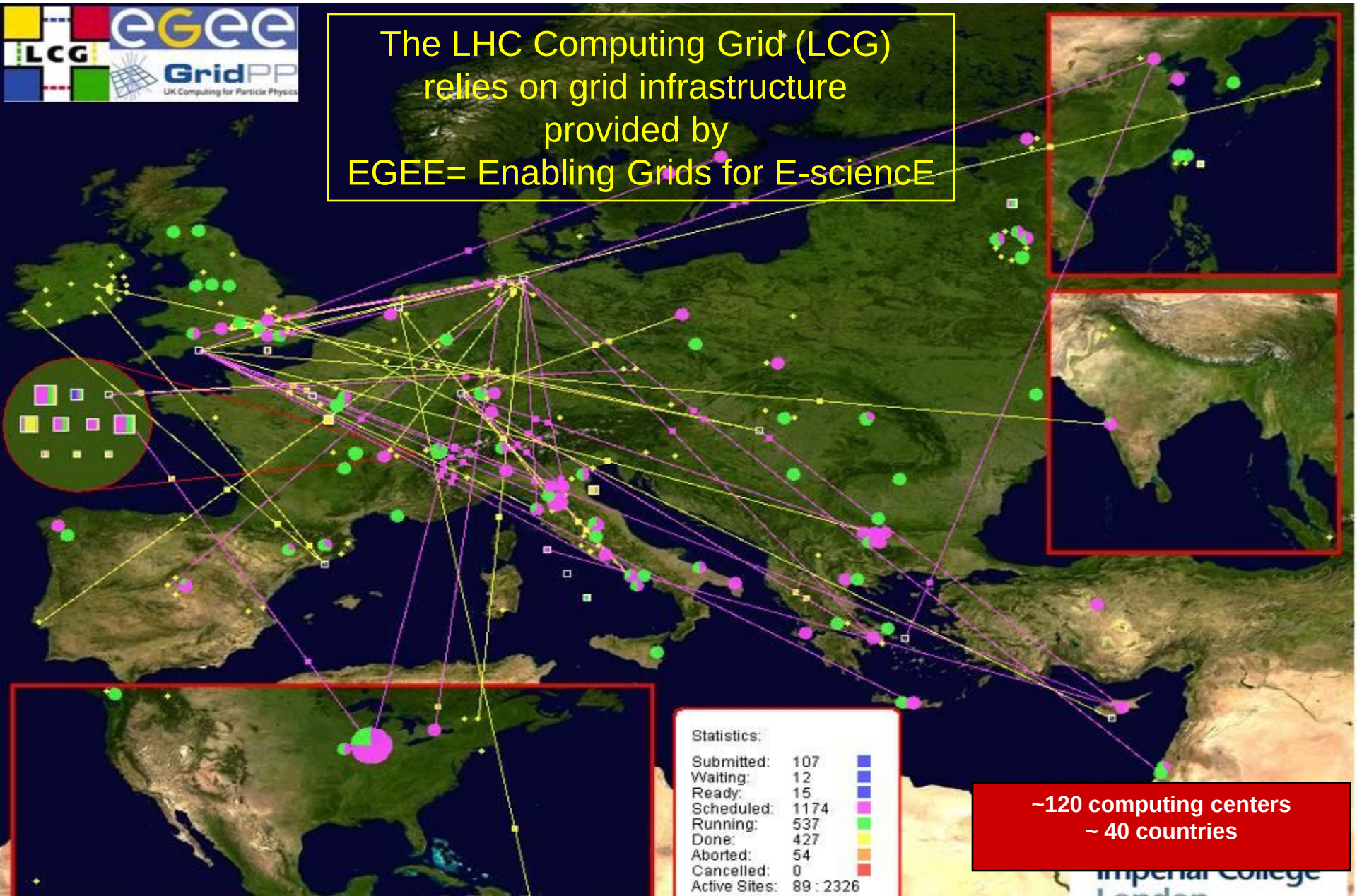
Data analysis requires computing power equivalent to ~100 000 today's fastest PC processors.

The experiment international Collaborations are spread all over the world → computing resources must be distributed.

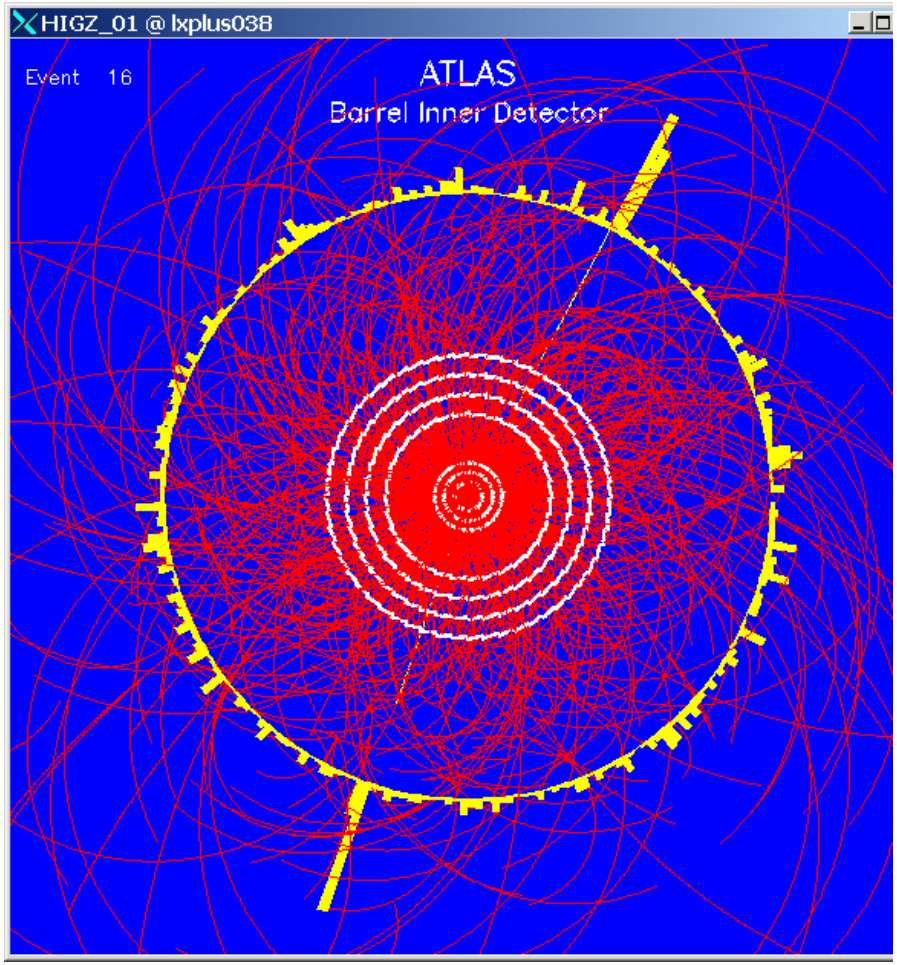
Cooperation of many computer centres all over the world is needed → **Grid**

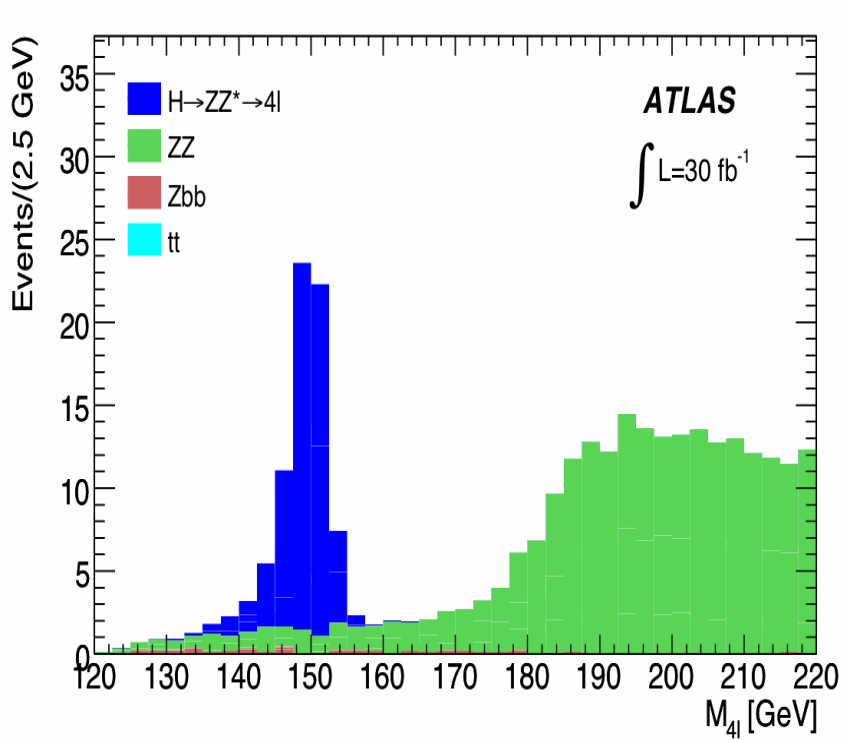
24

The Grid provides seamless access to computing power and data storage capacity distributed over the globe



Possible discovery channel: H->ZZ*->4l





Collecting few numbers …..

Number of turns of the LHC ring made by protons in one second: ~ 11000

Number of proton-proton interactions per second : 1 billion

Number of particles produced per collision : more than 1000

Machine temperature : 1.9 K (the largest cryogenic system in the world)

Weight of CMS experiment: ~ 13000 tons (30% more than the Tour Eiffel)

Amount of cables used to transfer the detector signals in ATLAS : ~ 3000 km

Data recorded by experiments in 1 year: 20 km of CD

Number of involved physicists : > 4000 (from the 5 continents !)

Total cost (accelerator plus experiments) : ~ 5000 MCHF

The most ambitious project in particle physics ever and one of the most ambitious in science in general