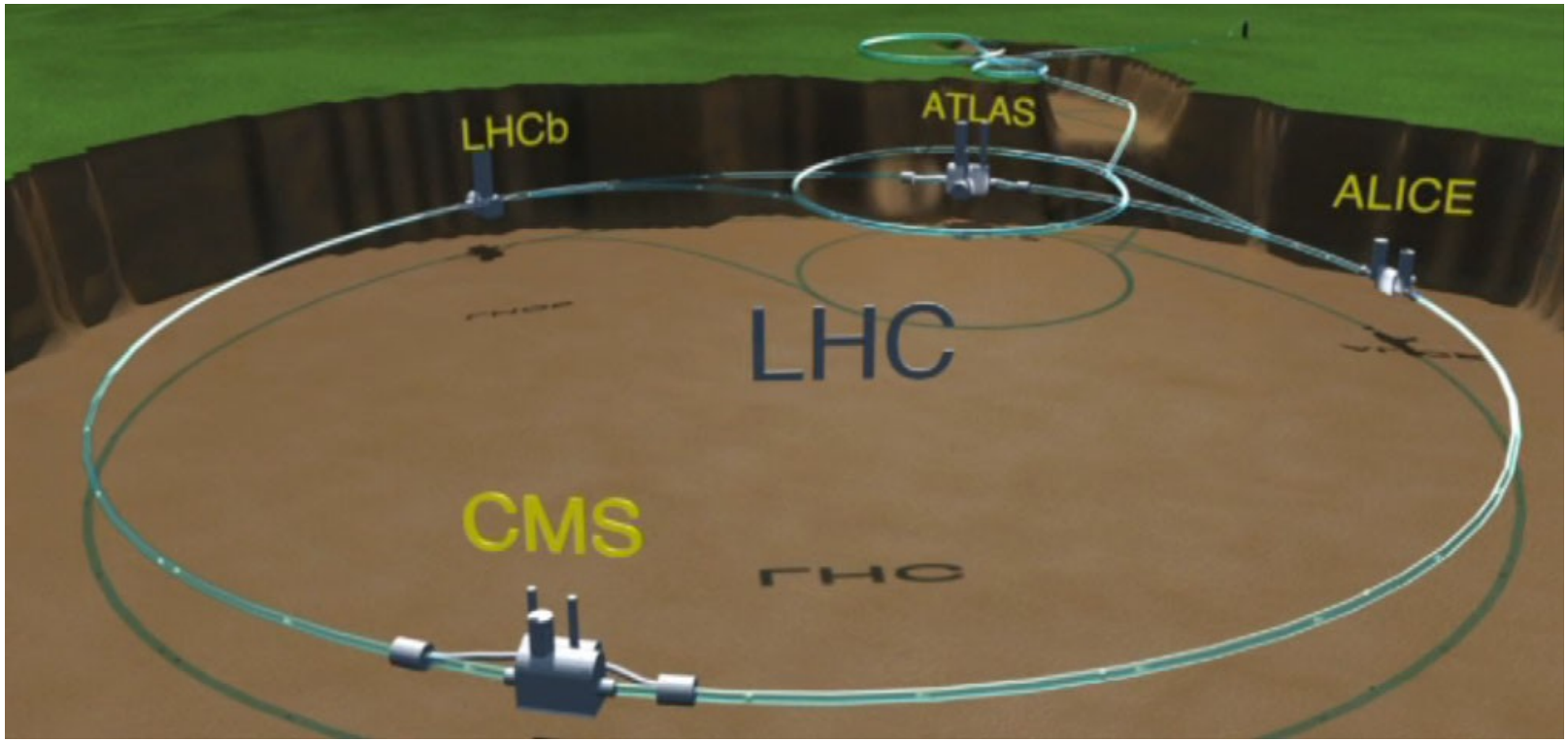
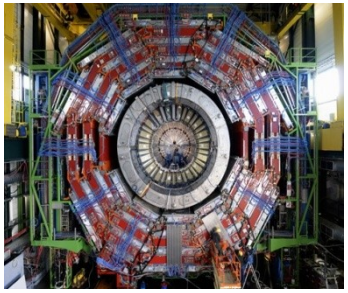
The LHC CMS project



What we need

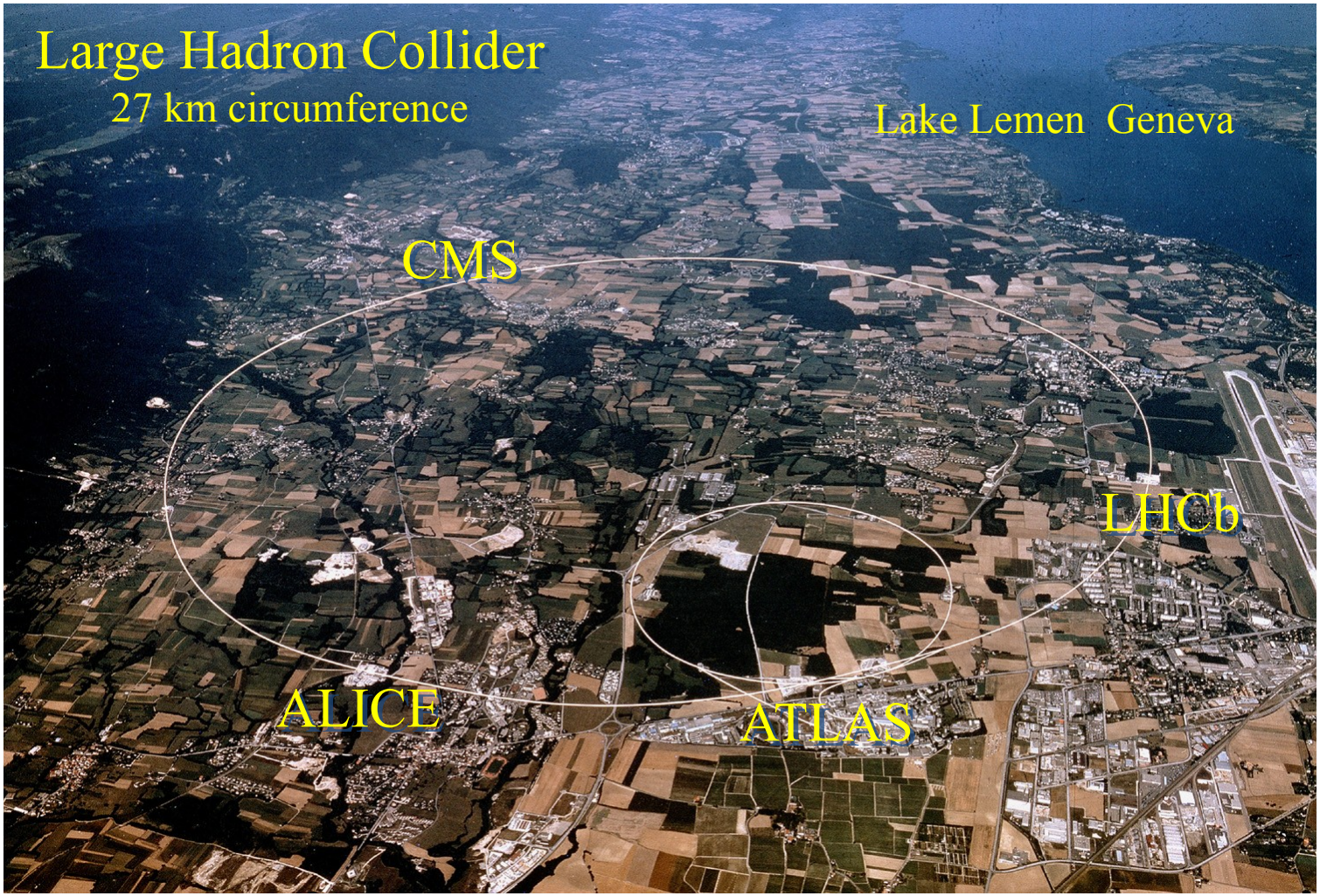
Accelerators: powerful machines to accelerate particles to extremely high energies and bring them into collision with other particles



Detectors: gigantic instruments that record the particles as they "stream" out from the point of collision

ComputIng Grids: to collect, store, distribute and analyse the vast amount of data

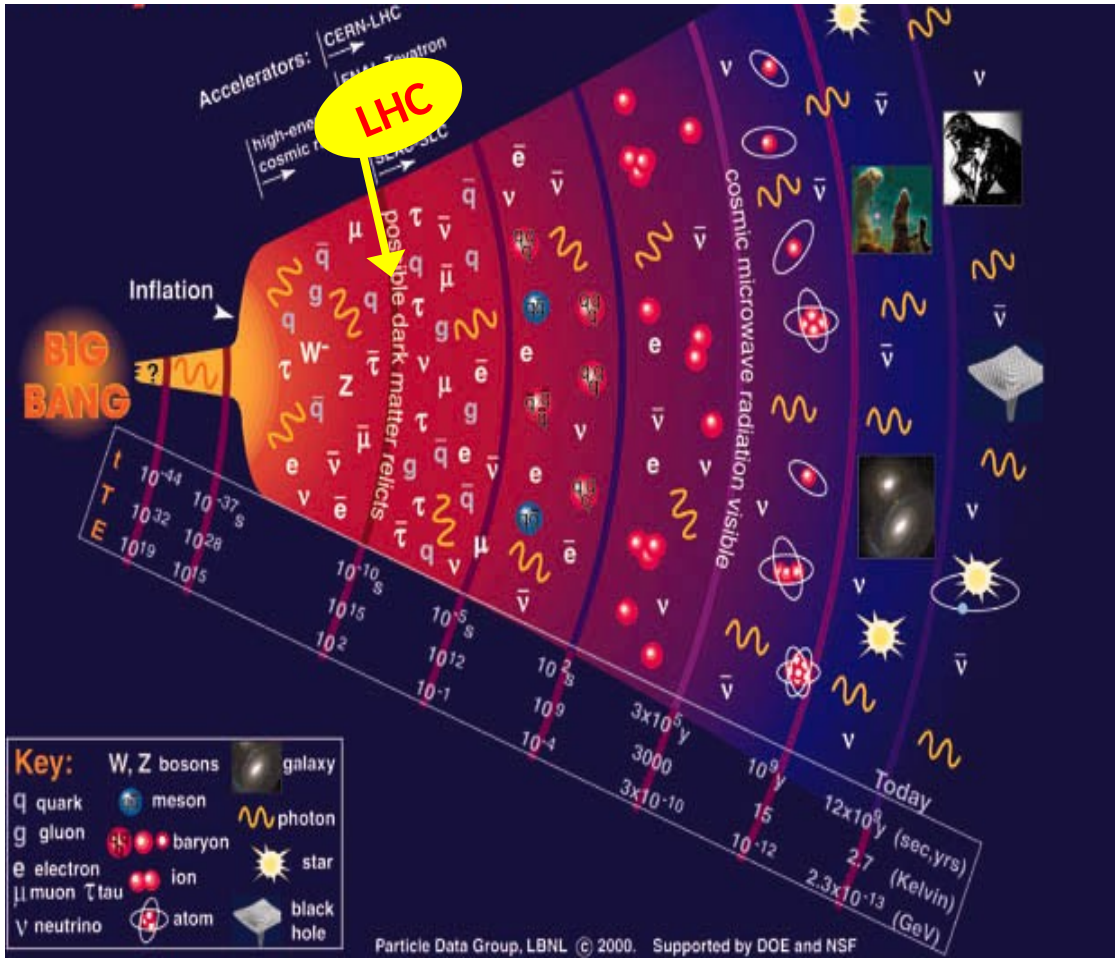
People: worldwide collaboration of scientists, engineers, technicians to design, build and operate a complex instruments

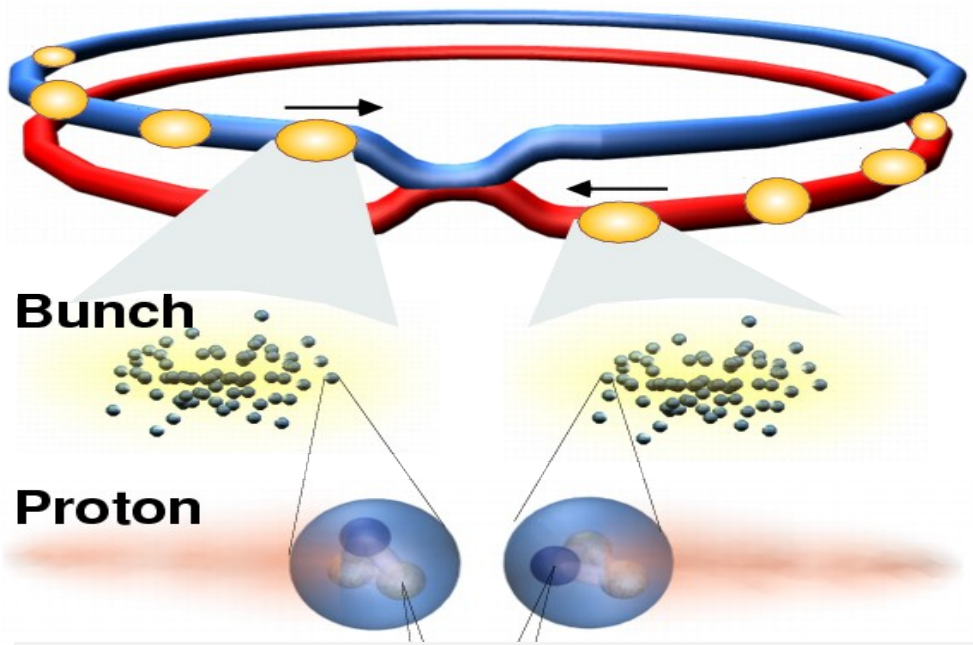

Large Hadron Collider
27 km circumference
Lake Lemen Geneva
CMS
LHCb
ALICE
ATLAS

The LHC allow us to recreate particles *rarely* seen in nature since 10^{-12} seconds after the Big Bang

A Brief History of Time

10^{-43} s	*Quantum gravity era*
10^{-35} s	*Grand unification era*
10^{-10} s	*Electro-weak era*
10^{-4} s	*Protons and neutrons*
100 s	*Nuclei*
0.3 Myr	*Atoms formed*
1 Gyr	*Galaxy*

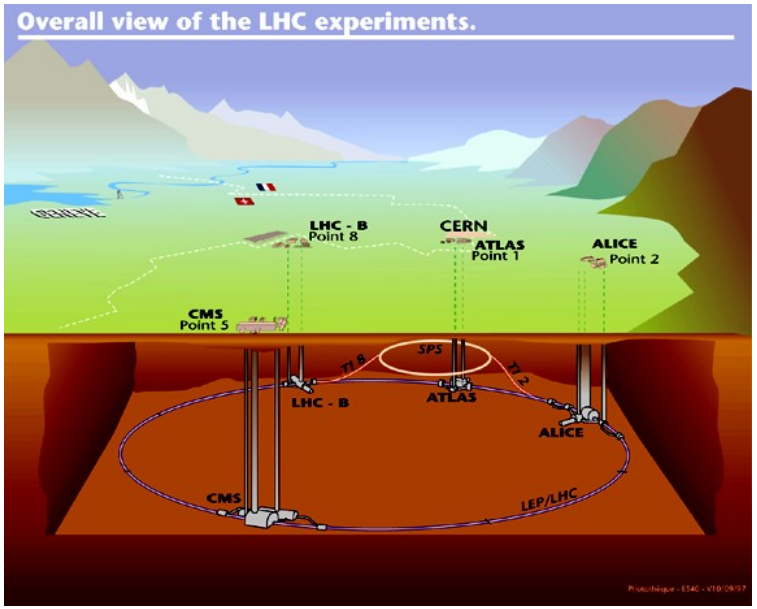




Proton – Proton	2808 X 2808 Bunches
Protons/Bunch	1.1×10^{11}
Beam Energy	7 TeV (7×10^{12} eV)
Luminosity	10^{34} cm^{-2} sec^{-1}
Crossing Rate	40 MHz
Collisions	~10^{9} Hz

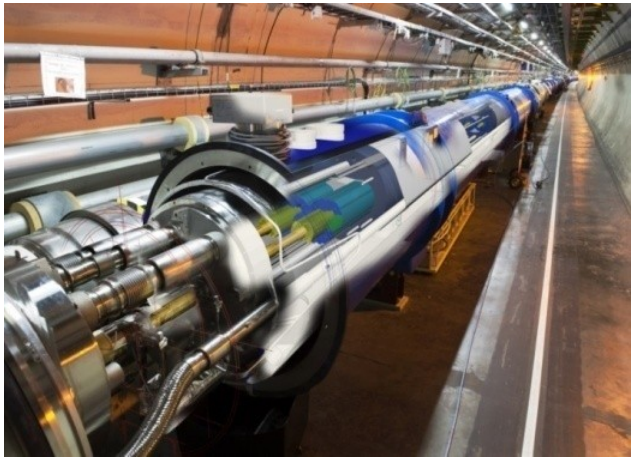
The LHC CMS project

The accelerator

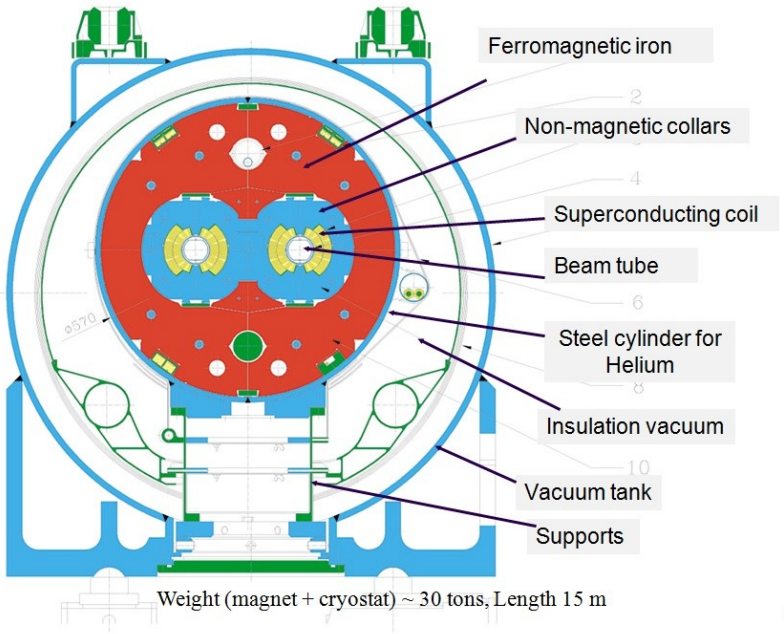


To reach the required energy in the existing 27 km tunnel, the super conducting magnets operate at **83 Kilogauss** (200'000 x Earth's field) in super fluid helium.

Protons travel in a tube with **better vacuum & colder than interplanetary space at T = 4-20 ^{o} K**



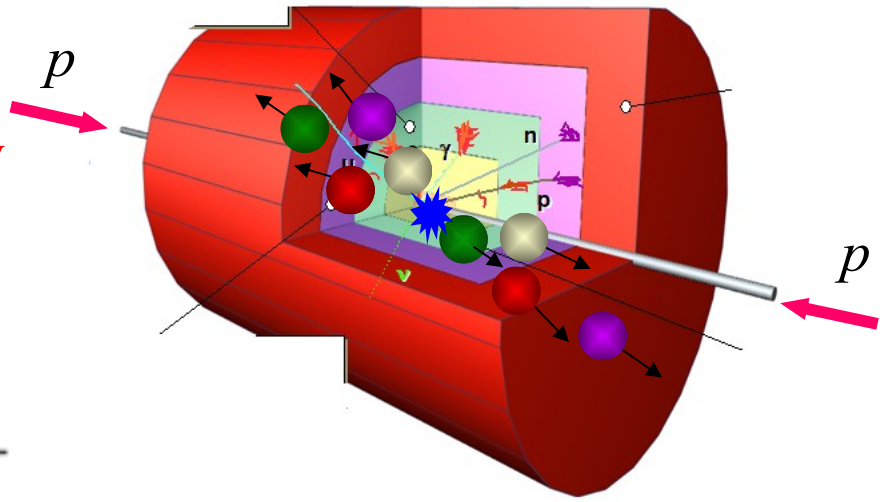
1232 Main Dipoles + 448 Main Quadrupoles cooled by 120 Tons of Liquid Helium

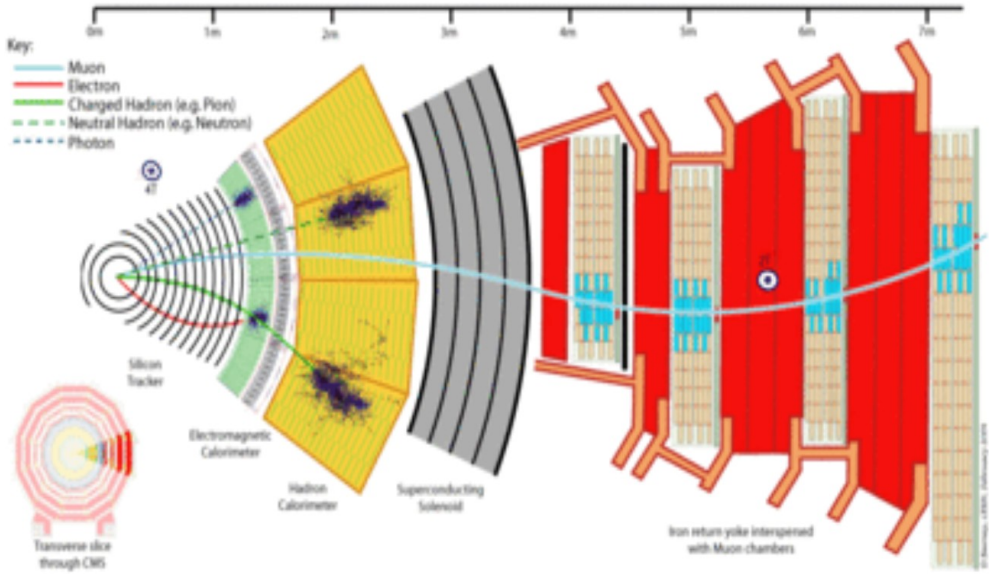


Coverage of full solid angle

Measurement of momentum and/or energy

Detect, track and identify all particles (mass, charge)



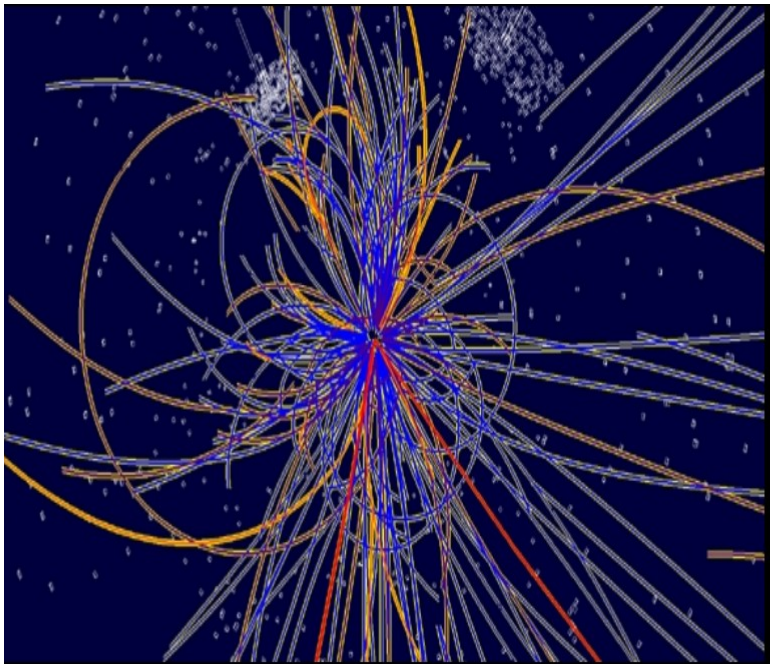


Relevant scale is the nuclear interaction length λ_L (for Fe 16.8 cm).

$\lambda_L \approx 10\ X_{0,}$ so hadronic showers are longer than EM

HCAL sits behind ECAL

Experimental Challenge



High Interaction Rate

- *1 billion interactions/s*
- *Data can be recorded for only ~100 out of the 40 million crossings/sec*
- *Level-1 trigger decision will take ~2-3 ms*

Large Particle Multiplicity

- *~ <20> superposed events in each crossing*
- *~ 1000 tracks stream into the detector every 25 ns need highly granular detectors with*

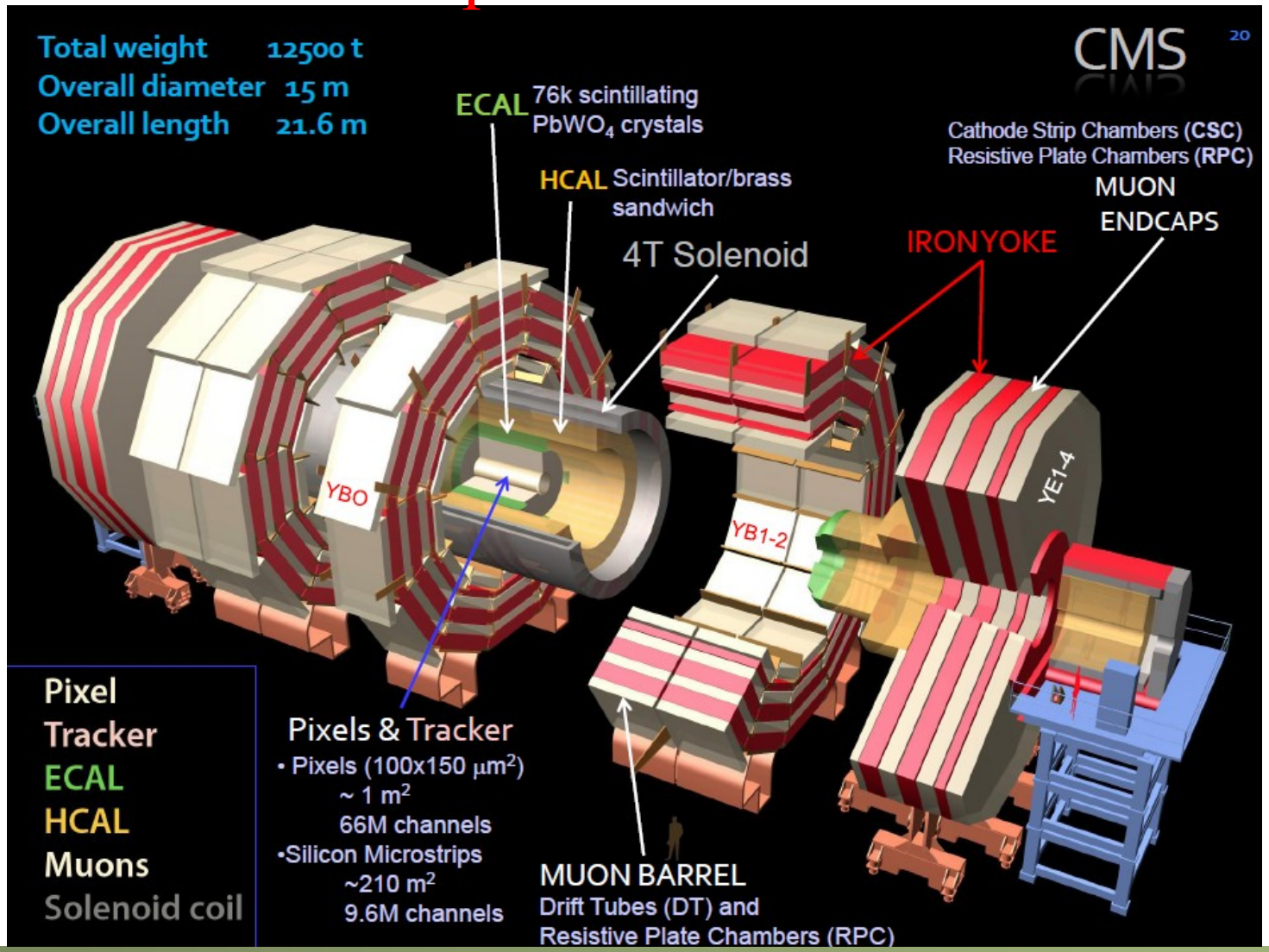
High Radiation Levels

- *radiation hard (tolerant) detectors and electronics*

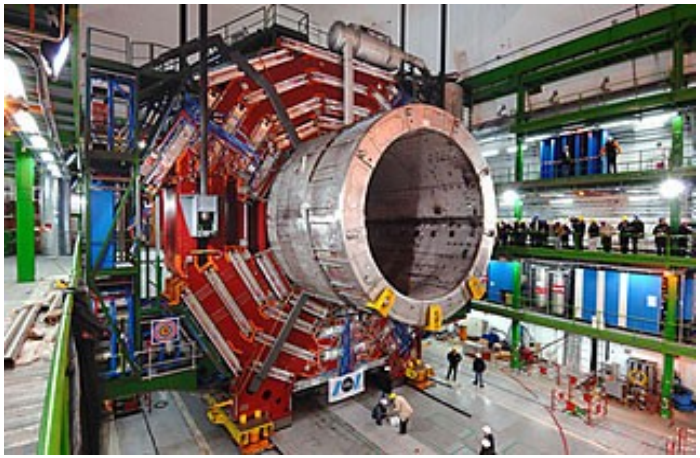
We need

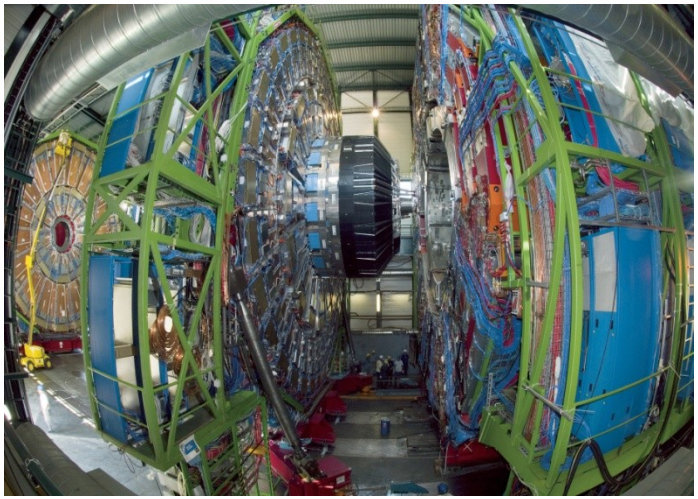
- High frequency of sampling (40 MHz)
- High resolution in space and time (100 μm and few ns)
- No dead time
- High data storage capability (TB)

The Compact Muon Solenoid

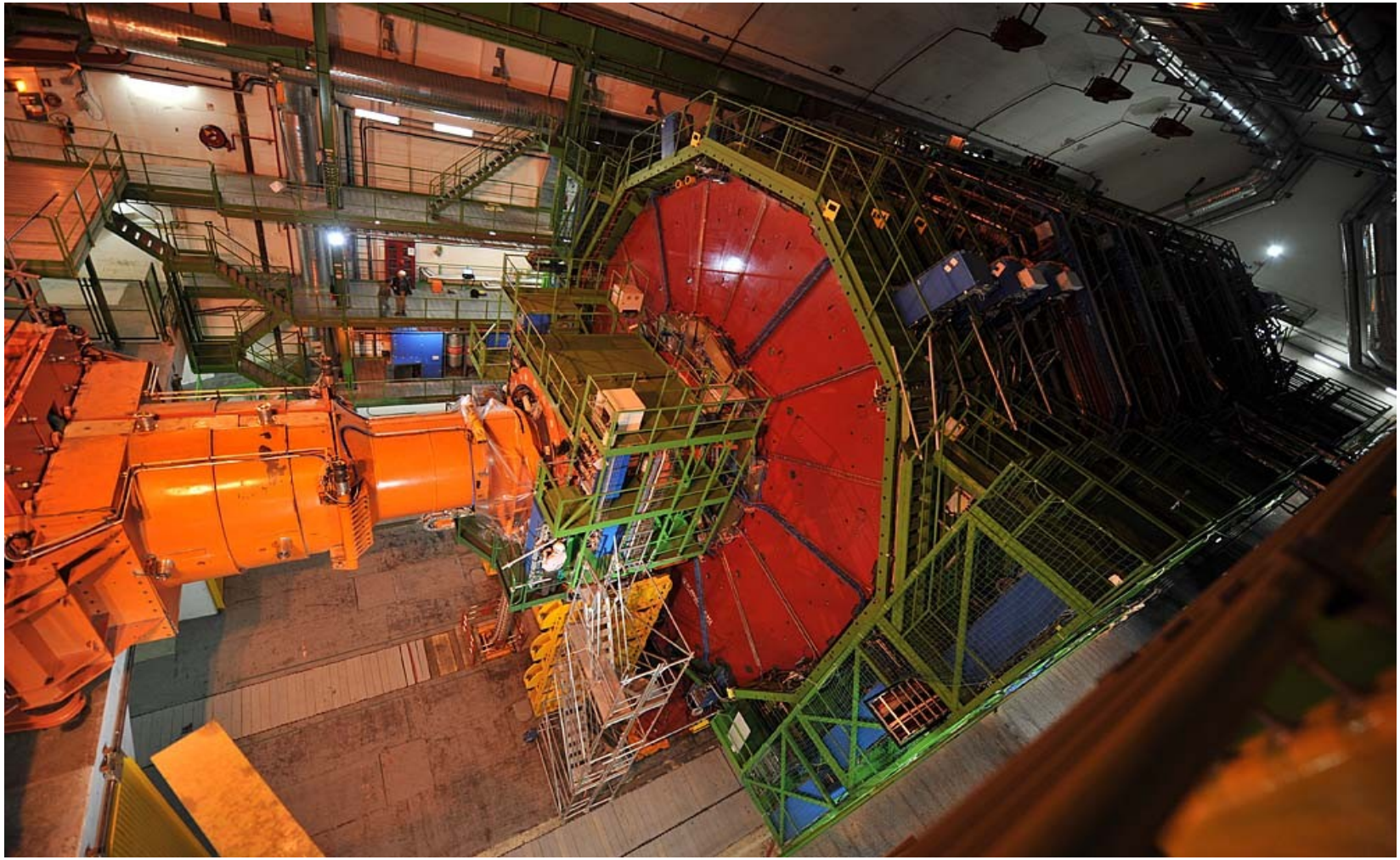


The Compact Muon Solenoid



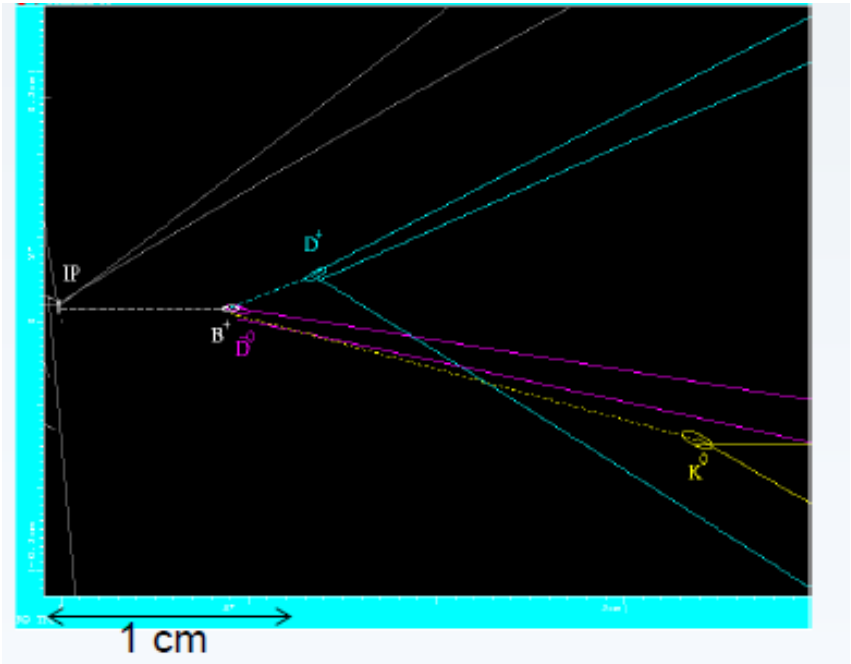


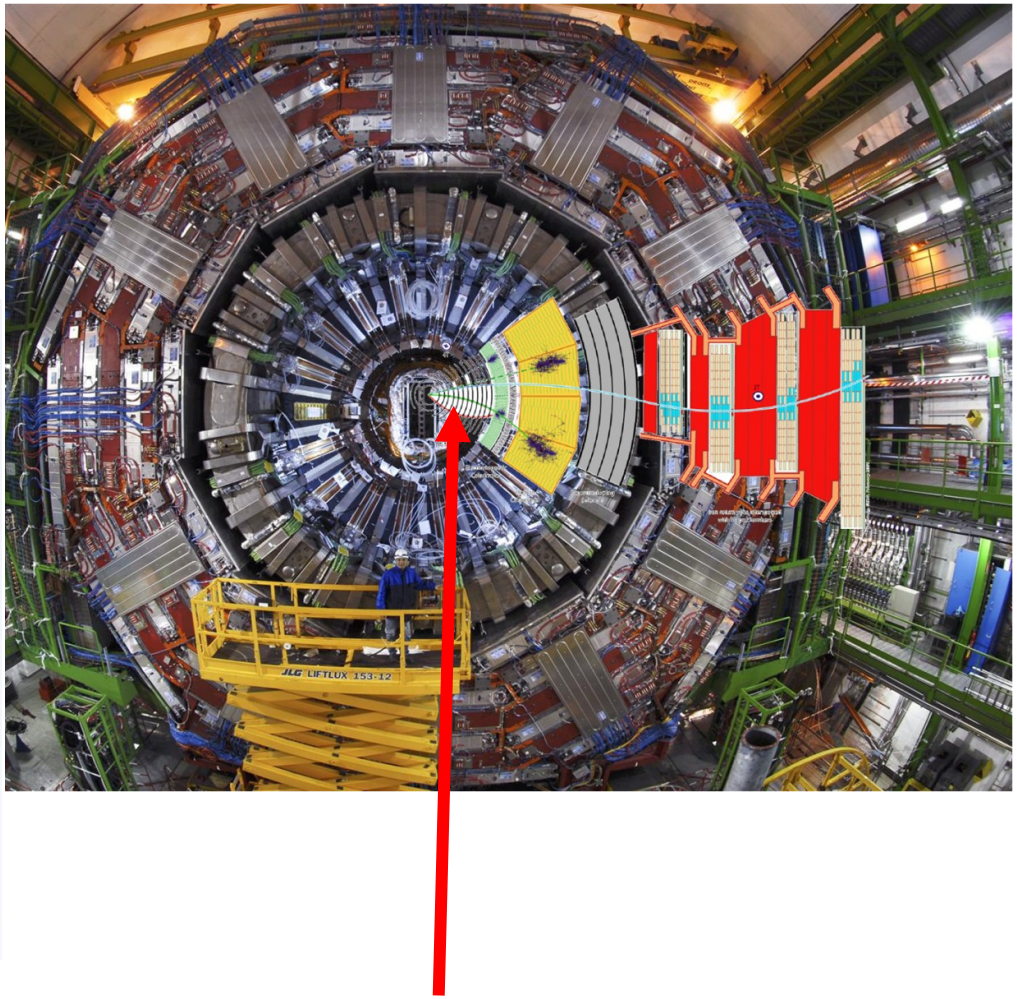
Gigantic, but "compact"



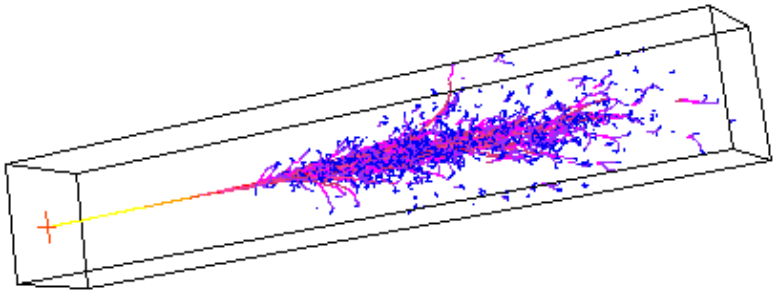
The detector

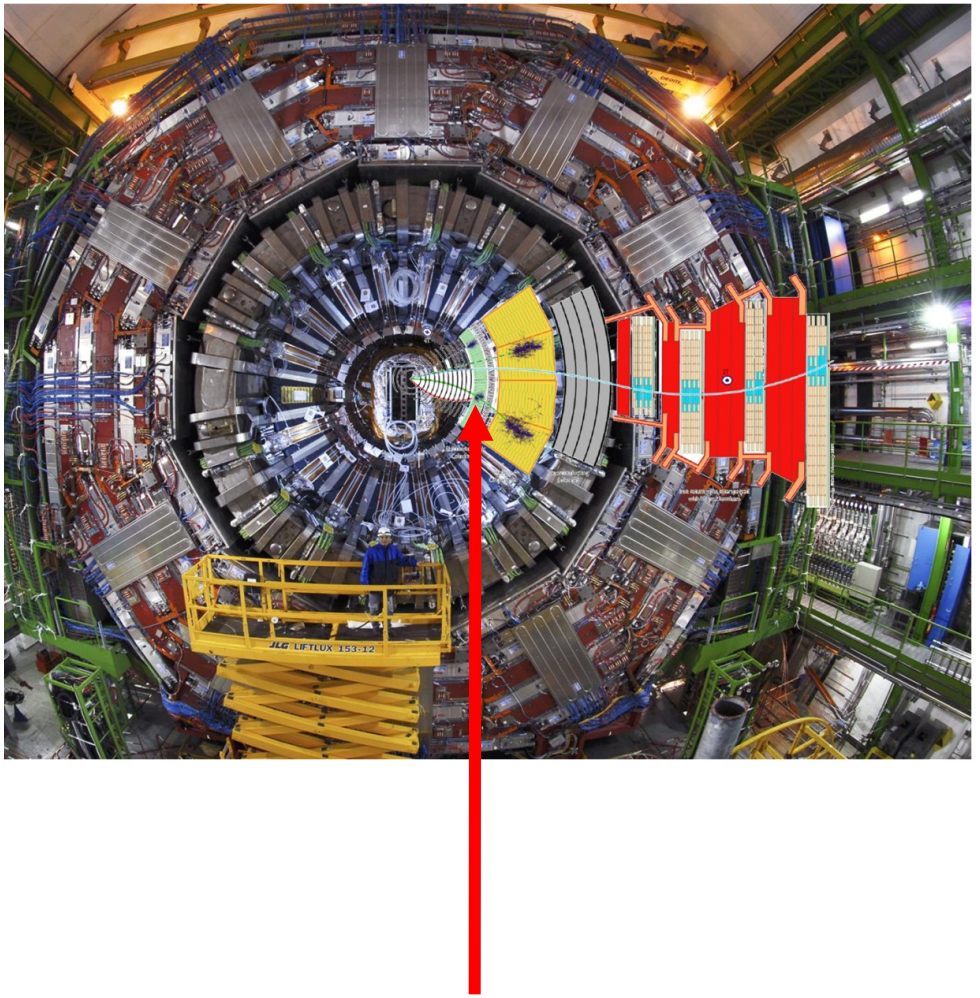
Momentum/charge of **tracks and secondary vertices** are measured in central tracker (Silicon layers).



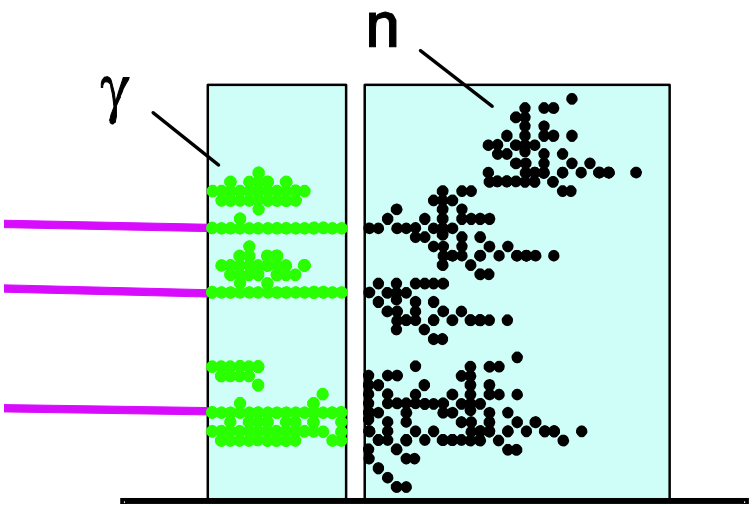


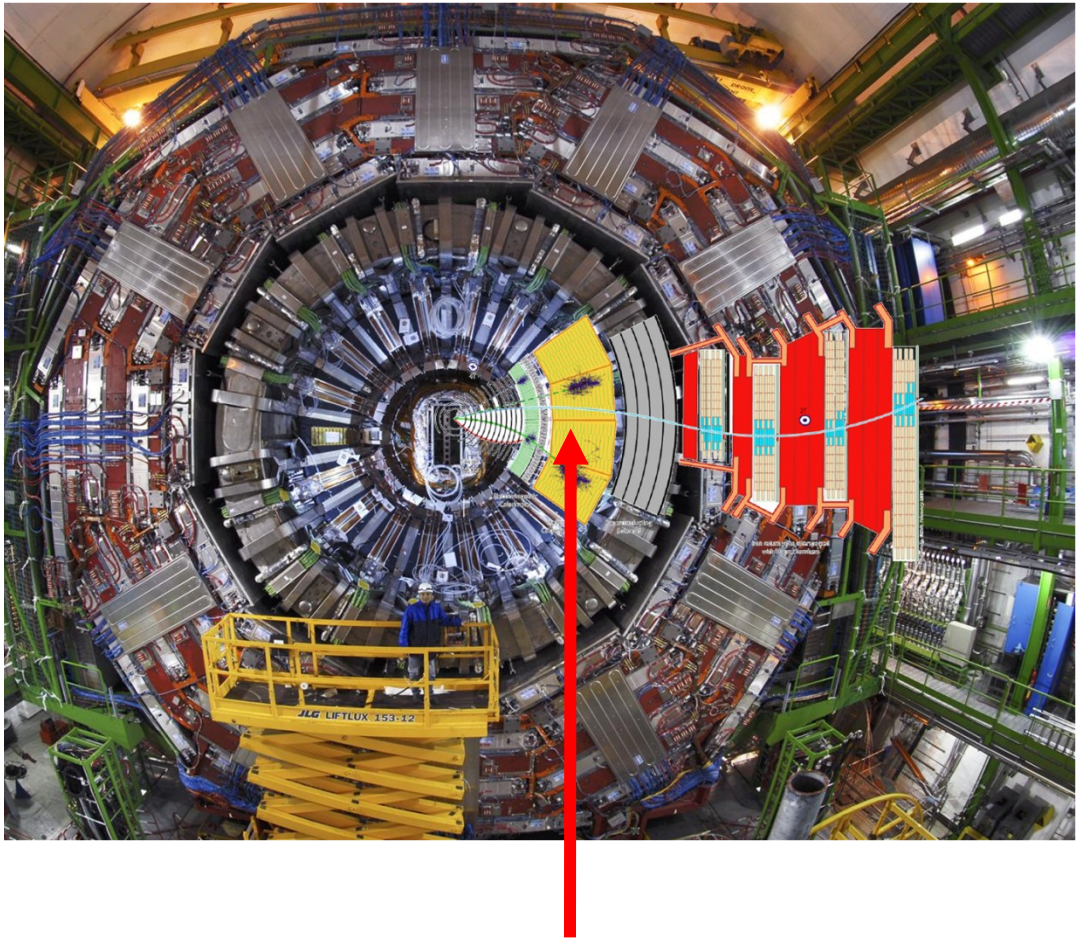
Energy and positions of **electrons and photons** measured in a high resolution electromagnetic calorimeter.





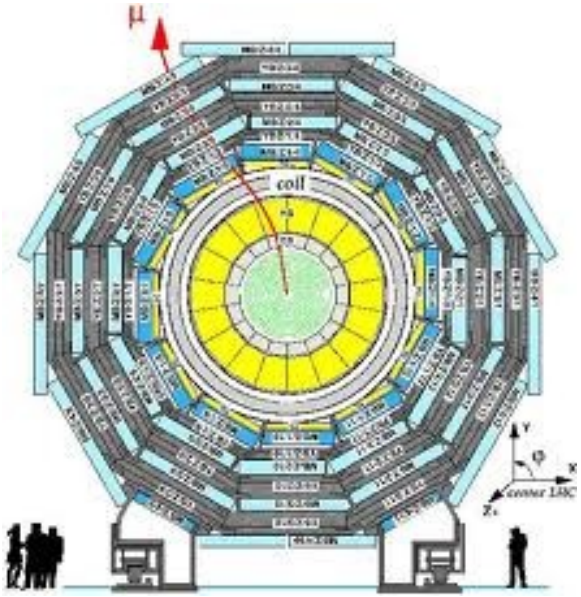
Energy and position of **hadrons** measured mainly in hadronic calorimeters.

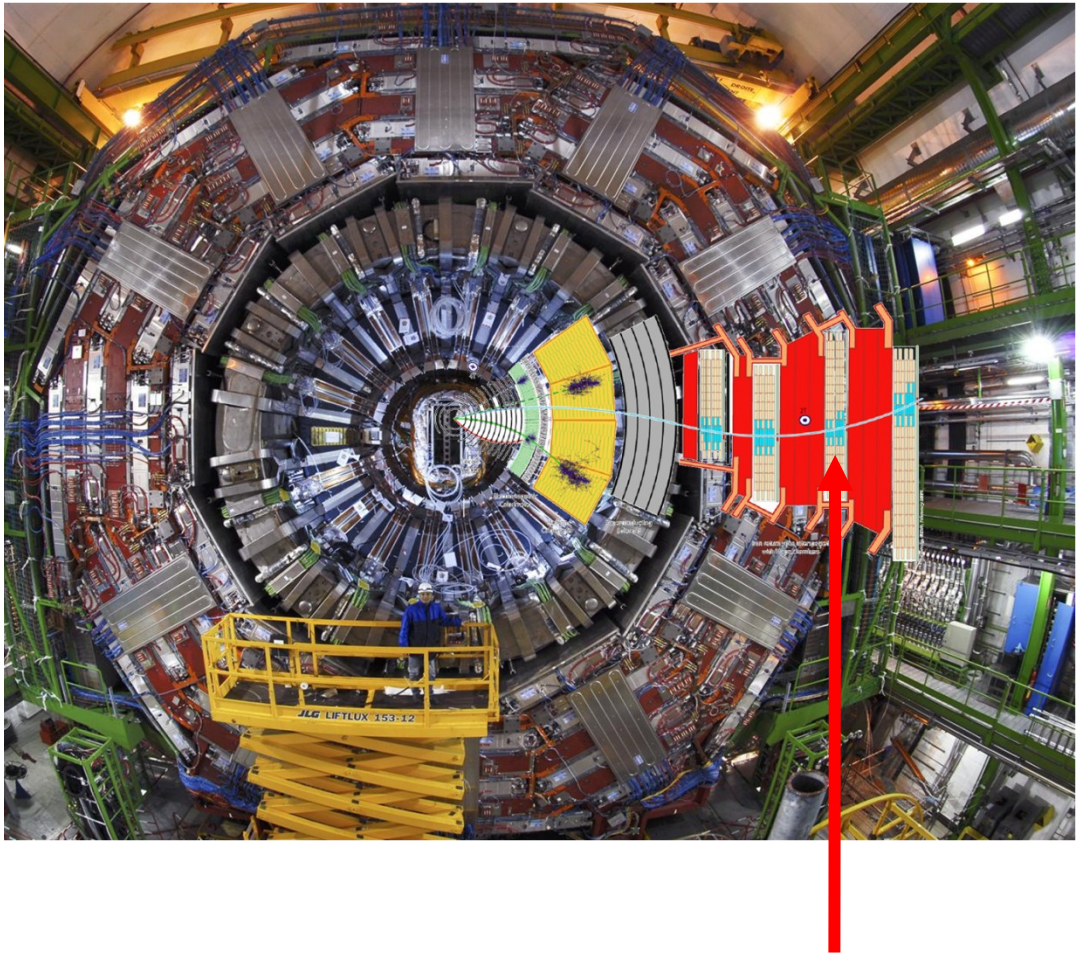




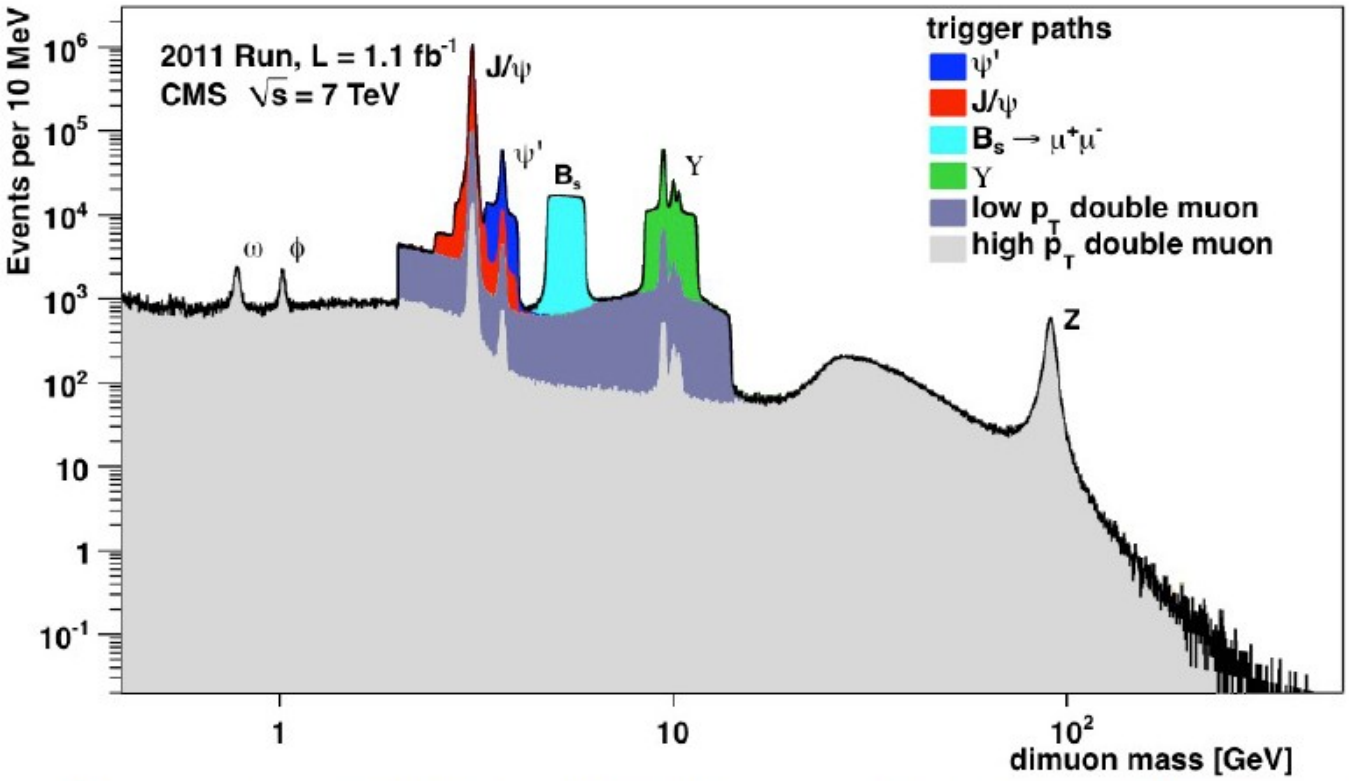
The detector

Muons identified and momentum measured in external muon spectrometer





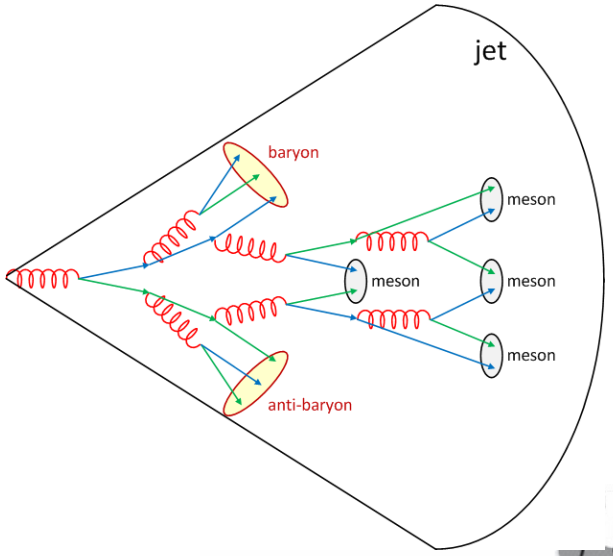
Double muon invariant mass is a wonderful signature for physics

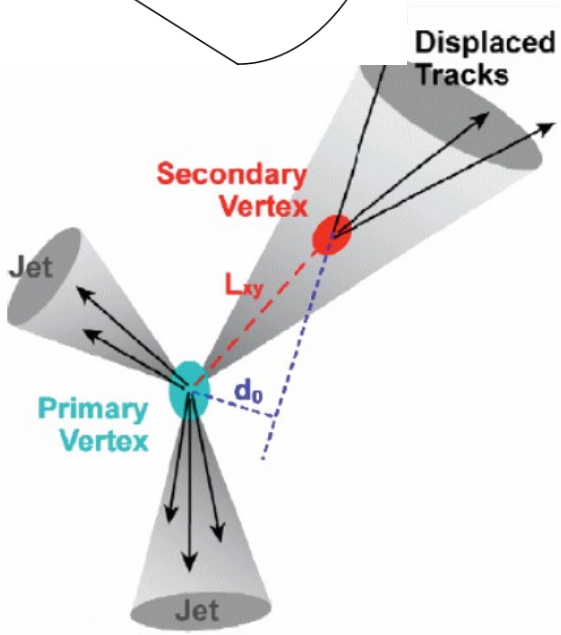


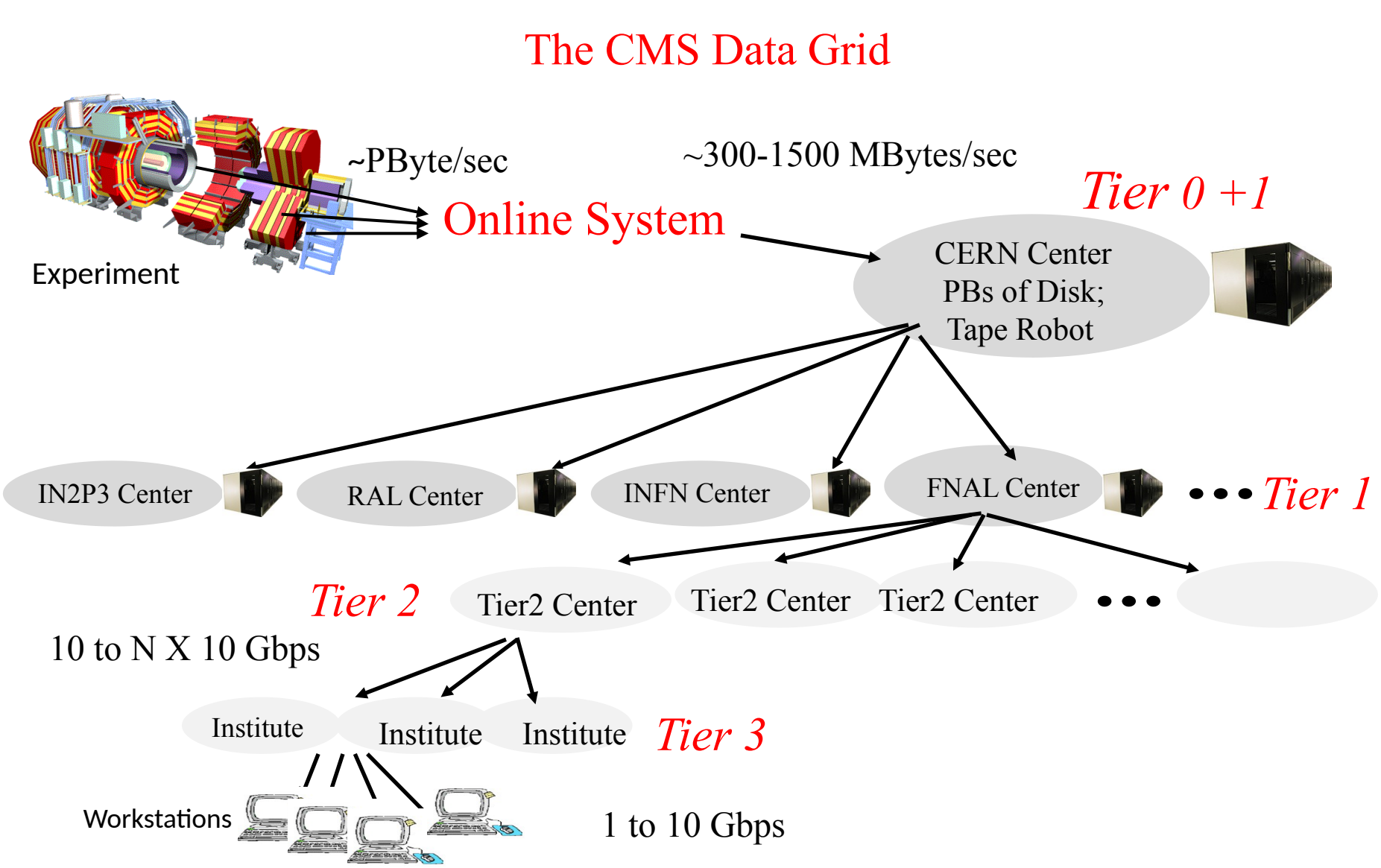
Jets

- Bunch of particles generated by hadronisation of a common otherwise confined source (Quark, gluon fragmentation)

- Signature is the energy deposit in electromagnetic and hadronic calorimeters plus several tracks in the central tracker detector



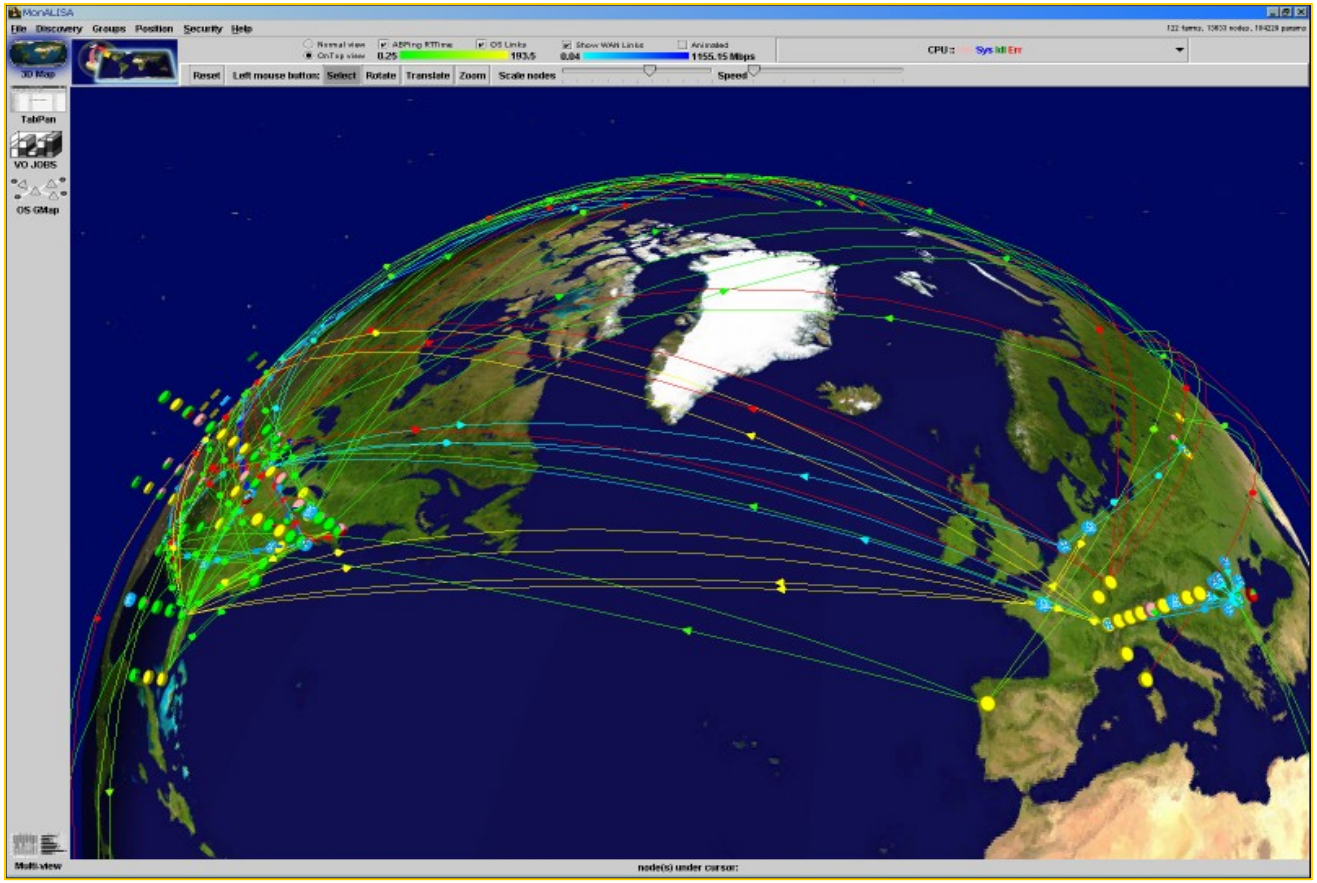



The CMS Data Grid
~PByte/sec
~300-1500 MBytes/sec
Experiment
Online System
Tier 0 +1
CERN Center
PBs of Disk;
Tape Robot
IN2P3 Center
RAL Center
INFN Center
FNAL Center
Tier 1
Tier 2
Tier2 Center
Tier2 Center
Tier2 Center
10 to N X 10 Gbps
Institute
Institute
Institute
Tier 3
Workstations
1 to 10 Gbps

370 Sites

40,000 computers

Tens of Thousands of Grid jobs running concurrently



High Energy Physics and CMS

Explore the exiting domain of universe basic laws

World wile collaboration (science with no frontiers)

Important technological development (GRID, Microelectronics, Sensors)

Represent an incredible boost factor for applied science

Offers opportunities to young scientists for career enhancement

OPPORTUNITY for master and PhD studies in Bari

if you are interested contact us