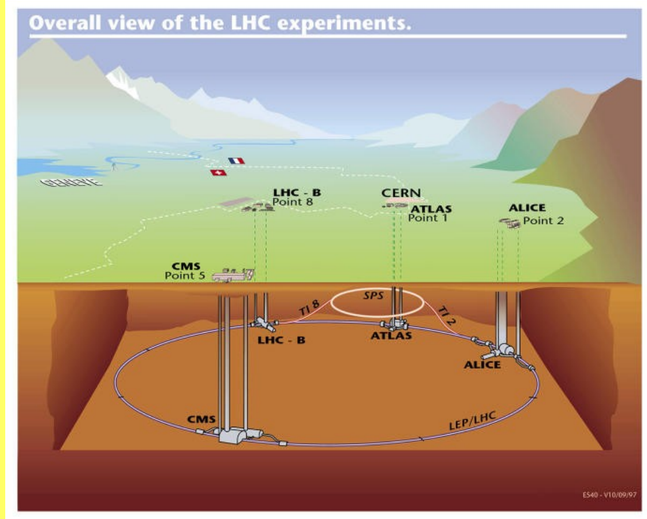
The ATLAS Muon Spectrometer at the LHC

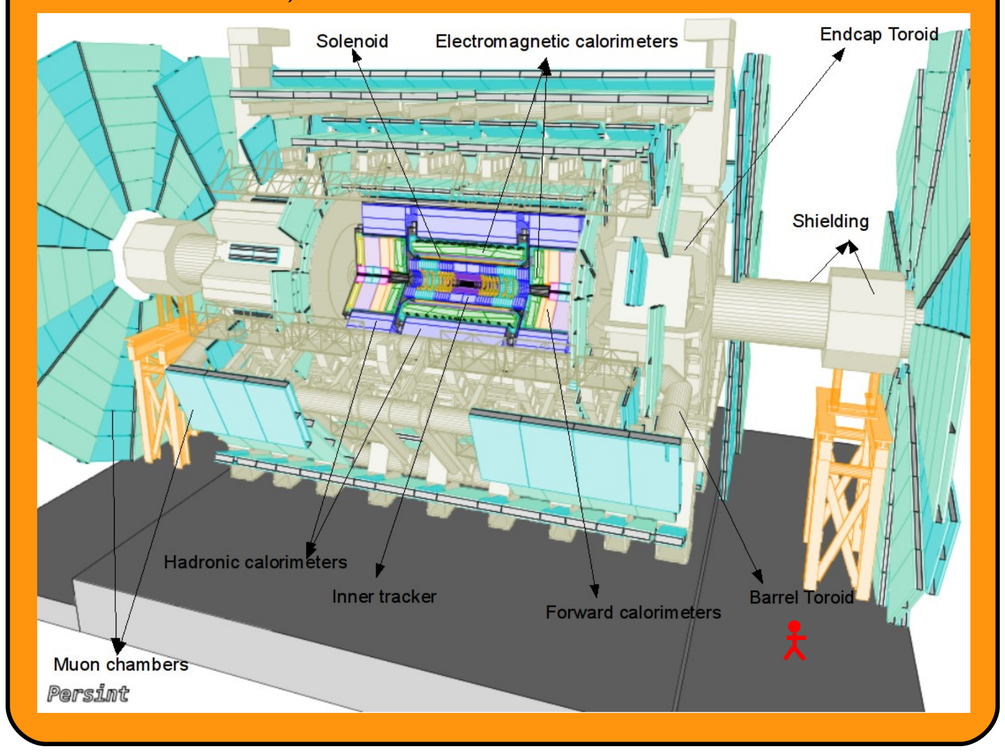
The Large Hadron Collider (LHC)

A 27-kilometer underground accelerator ring, near Geneva (border France – Switzerland).
More than 1 500 superconducting magnets steer and focus the protons in beams that circle in opposite directions.
Very high energy head-on collisions (14 TeV) take place at 4 interaction regions, where large detectors are installed. They register and analyze the debris of the collisions that will reveal new particles and new processes.



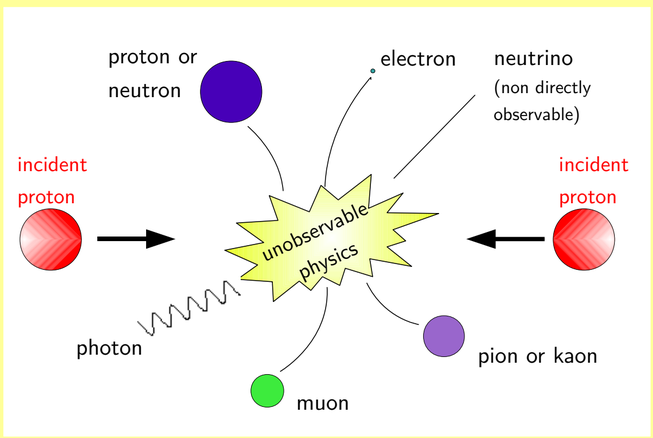
The Atlas detector

Several sub-detectors: Tracking, Calorimeters, MuonSpectrometer.
Magnetic field produced by superconductiong magnet coils in a large volume.
A general purpose detector for discoveries (Higgs boson, Supersymmetry, extra dimensions, ...).

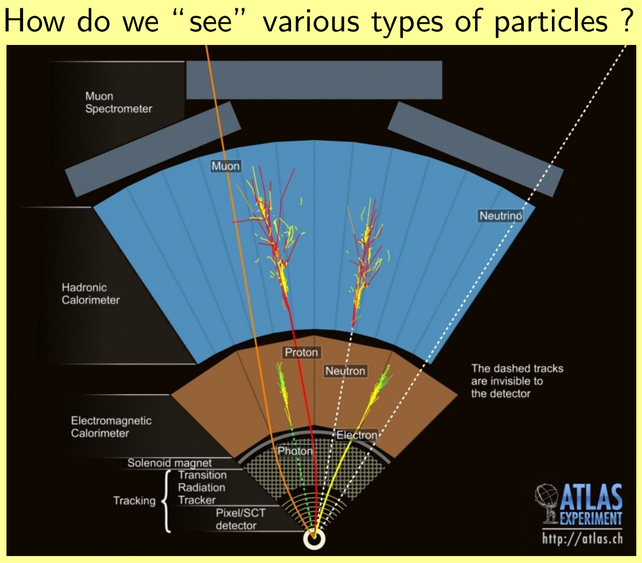


Collision between 2 protons

What do we want to observe ?

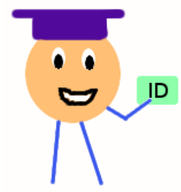


How do we "see" various types of particles ?



What is a muon ?

- It is the charged lepton of the second family, 200 times more massive than the electron.
  → electron mass = 0.5 MeV ~ 8.9 10^{-31} kg
  → muon mass = 105.7 MeV ~ 1,9 10^{-28} kg
- Limited life time : 2.2 10^{-6} s
  → at speed of light travel 659 m before decay



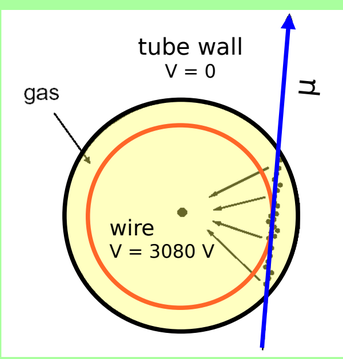
The muon spectrometer

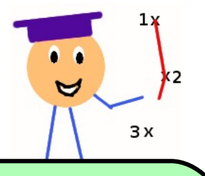
For muon identification and track reconstruction in a magnetic field.
Muons are not stopped in the calorimeters and reach the outer muon spectrometer.
Detected by various types of gaseous detectors:

- Monitored Drift Tubes (MDT) for precision measurements (50 microns) ;
- Resistive Plate Chambers (RPC) for triggering (≈ mm, but fast response)

How is a muon detected in a drift tube ?

The muon ionizes the gas atoms along its path. The produced electrons drift in the electrical field towards the central wire.
Their arrival time is measured from the induced electrical current on the wire.
From this time measurement, the initial position of the ionization electrons is deduced. This information constitutes a "hit".





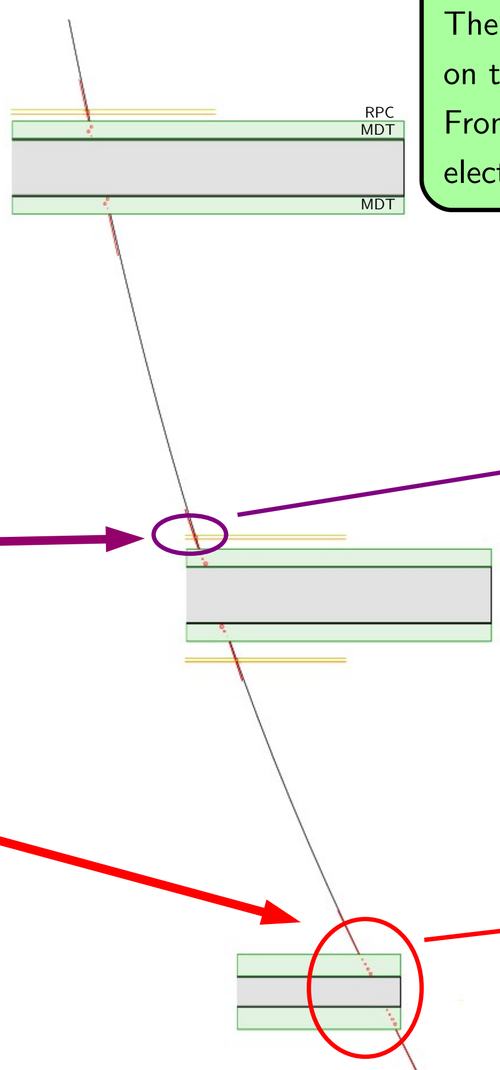
Tracks reconstruction

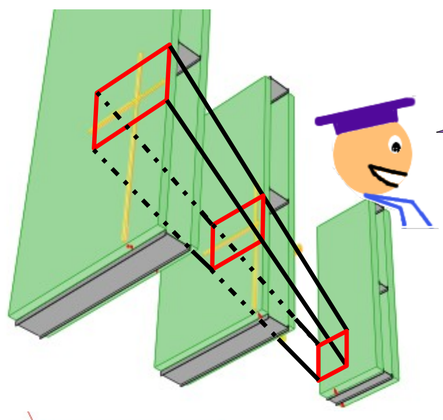
Goal = associate hits to determine the trajectory and the momentum of a muon.

Step 1: using the hits in the trigger detectors (RPC), we define Regions of Interest (RoI) inside which we search for hits in the precision detectors (MDT).

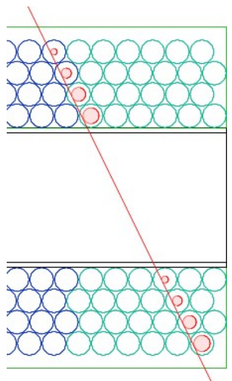
Step 2: In each MDT detector we build "track segments" inside the RoI.

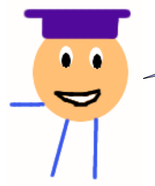
Step 3: We associate segments to form a complete track, and we fit the trajectory using all individual hits (black curve).





Rols are based on the strips crossing. We project the surface they define on the other chambers and look for hits there.



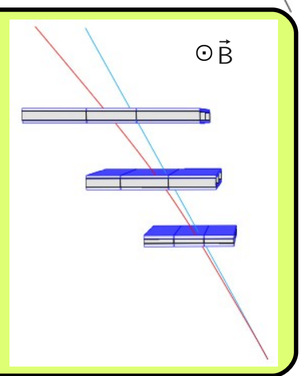


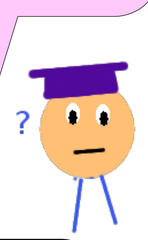
Segments are tangent to the hits

Can you find the muons in this event ?

Measuring the momentum of a muon

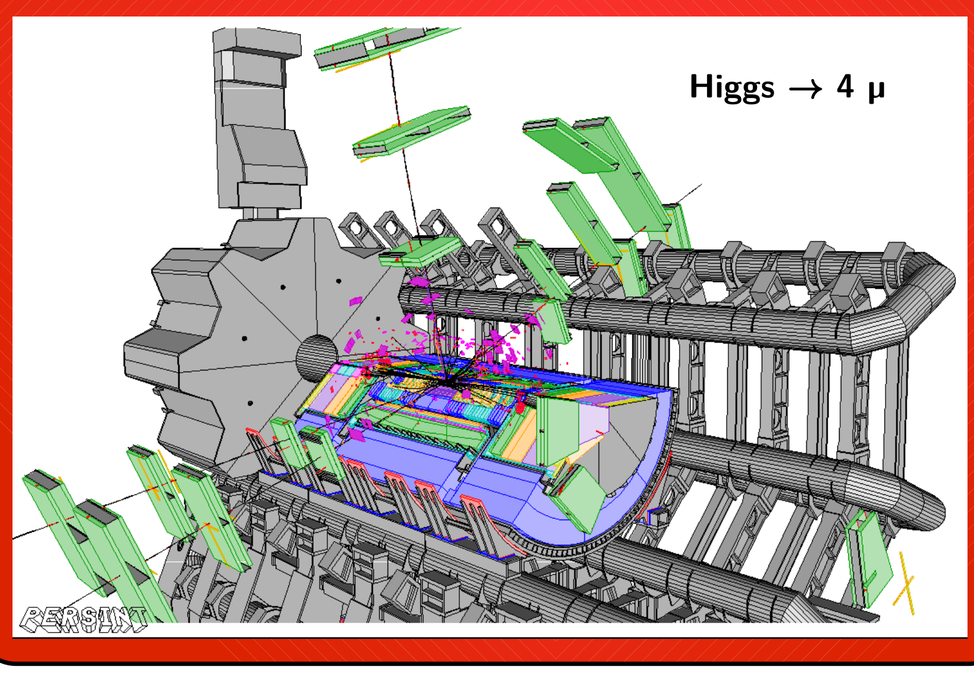
The electrically charged muon has its trajectory curved by the **magnetic field.**
The muon momentum is deduced from the curvature of the track:
→ high momentum muon: nearly a straight track
→ low momentum muon: very curved track
So, **curvature → momentum**.





Which of those 2 muons has the highest momentum ? The red or the blue ?

What can be the result of such a reconstruction ?



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My lab: Irfu cea saclay

My experiment: ATLAS