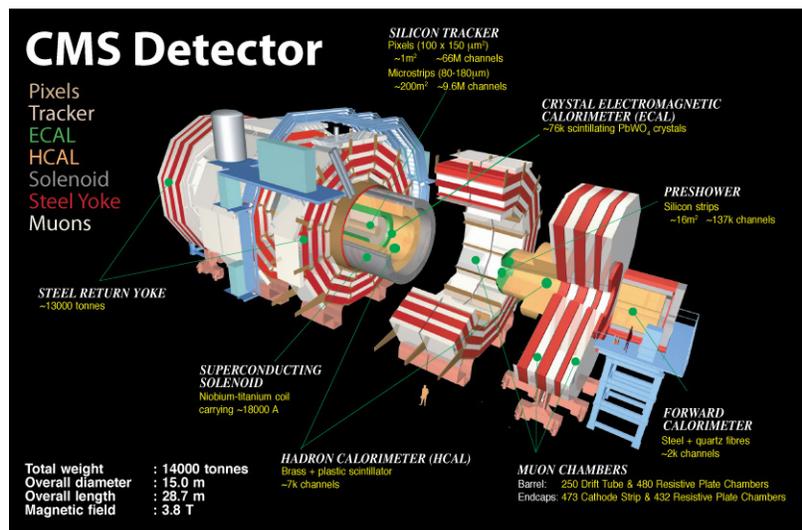


July 19, 2014

## CMS detector .. more closer look

All of us may heard about the Large Hadron Collider, the big tunnel machine at CERN (European Organization for Nuclear Research) and its detectors like the CMS, which designed to deal with the most tiny particles in the universe. We may 'd like to know more about CMS and look closely using simulation of events records at the moment when these elementary particles are created and seen in the detector.

Safinaz Salem

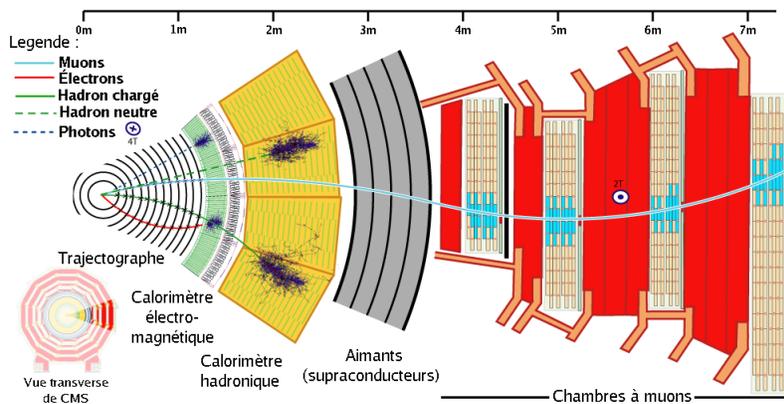


The Compact Muon Solenoid (CMS).

This is the Compact Muon Solenoid (CMS). The aim of it to detect tiny particles which are the fundamental constituents of the matter (like electrons and muons), and which indeed tell how the universe is going on around us. A looking at a tranverse slice of the CMS, we can recognize its different parts or sub-detectors, each functionally designed to detect different particles. These 'layers' are the trackers, calorimeters, muon chambers, and magnet systems.

[http://www.i2u2.org/elab/cms/graphics/CMS\\_Slice\\_elab.swf](http://www.i2u2.org/elab/cms/graphics/CMS_Slice_elab.swf)

<http://cmse-lab.michianastem.org/emcgough>



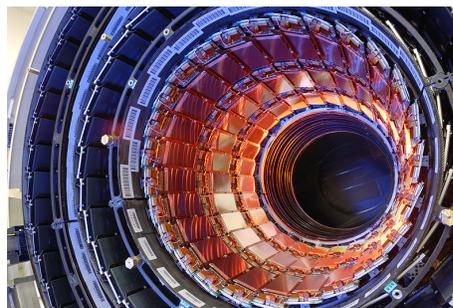
Transverse Slice of the CMS Detector.

- CMS tracker:

It's located in the inner most layer of the CMS. The CMS tracker records the paths taken by charged particles and it can calculate a particle's momentum from its tracking of its path through the CMS's magnetic field (a more curved path equates to a particle with less momentum), because its curvature shows momentum. The tracker is made completely of silicon.

- ECAL (Electromagnetic Calorimeter):

The Electromagnetic Calorimeter is the a barrel section beyond the tracker and before the HCAL. This is where the CMS stops electrons, photons, and jets. It can then measure the energies of these electrons and photons, because they interact electromagnetically (hence the name).



The silicon strip tracker of the CMS nears completion.

- HCAL (Hadron Calorimeter):

The Hadron Calorimeter measures the energy of particles that interact by the strong force, called hadrons, which are particles made of quarks and gluons such as protons and neutrons. These hadrons deposit most of their energy in the HCAL and stop in this layer.

- Muon System:

The Muon System detects muons, which is a one of CMS's key tasks. Muons are charged particles that are just like electrons and positrons but 200 times heavier. The detection of such particles is important because scientists expect muons to be produced in the decay of potential new particles like the Higgs Boson. Muons aren't stopped by the CMS's calorimeters, because they can go through meters of iron without interacting, so that's why their detectors are put at the end of the CMS where they will be the only particles detected.

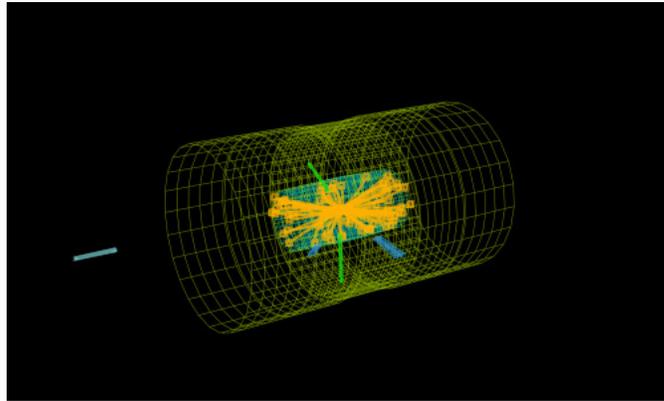


The Large Hadron Collider.

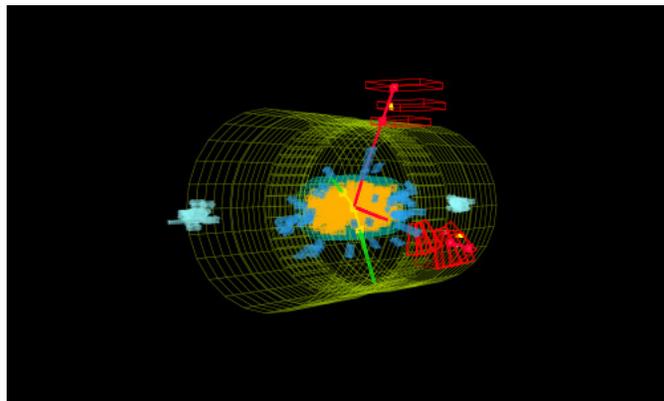
The Compact Muon Solenoid (CMS) is one of two large particle detectors built on the Large Hadron Collider (LHC). The LHC is contained in a circular tunnel of about 27km in circumference for the main ring, 100 meters beneath the borders of France and Switzerland. Inside the LHC, proton-proton beams collide each other, where stronger magnets can accelerate the protons injected into the ring to higher speeds. Then the energy of these explosions should be sufficient enough to turn into mass to create new particles we have never seen before. Like that a new era of exploring particle physics have started.

Now we are ready to see some of the CMS events records according to data collected in in 2012 at a proton-proton centre-of-mass energy of 8 TeV. Using 'quarknet' software, which presents a 3D figure for single events to imagine what's really happen inside the detector at the moment of collision. In the following couple of figures we can see Higgs decay to a pair of photons and decay to a pair of Z bosons, one of which subsequently decays to a pair of electrons and the other Z decays to a pair of muons.

While in the Higgs VH production mode, we expect ot have the following decay channel :  $V^* \rightarrow VH \rightarrow l\bar{l}b\bar{b}$ , this channel has studied in the final CMS collaboration research of Higgs decay to fermions [arXiv:1401.6527 ]. So the Higgs boson is reconstructed from two jets of particles, each of which has been identified as having a high probability of arising from the hadronization of a bottom quark and we finally have a signal of dijets and dileptons.



Event recorded with the CMS detector. The event shows expected decay of the SM Higgs boson to a pair of photons.



Event recorded with the CMS detector. The event shows expected decay of the SM Higgs boson to a pair of Z bosons, subsequently to 4 leptons final states.

<http://quarknet.fnal.gov/resources/cmsdata.shtml>