The Detector and Detectives

CMS is a large technologically advanced detector comprising many layers, each designed to perform a specific task. Together these layers allow CMS scientists to identify and precisely measure the energies and momenta of all particles produced in collisions at CERN’s Large Hadron Collider (LHC).

**Electromagnetic Calorimeter**

Nearly 80,000 crystals of lead tungstate (PbWO₄) are used to measure precisely the energies of electrons and photons. A ‘preshower’ detector, based on silicon sensors, helps particle identification in the endcaps.

**Hadron Calorimeter**

Layers of dense material (brass or steel) interleaved with plastic scintillators or quartz fibres allow the determination of the energy of hadrons, that is, particles such as protons, neutrons, pions and kaons.

**Muon Detectors**

To identify muons (essentially heavy electrons) and measure their momenta, CMS uses three types of detector: drift tubes, cathode strip chambers and resistive plate chambers.

**Superconducting Solenoid**

Passing 20,000 amperes through a 13 m long, 6 m diameter coil of niobium-titanium, superconductor cooled to –270°C, produces a magnetic field of 4 teslas (about 100,000 times stronger than that of the Earth). This field bends the trajectories of charged particles, allowing their separation and momenta measurements.

**Tracker**

Finely segmented silicon sensors (strips and pixels) enable charged particles to be tracked and their momenta to be measured. They also reveal the positions at which long-lived unstable particles decay.

**Pattern Recognition**

New particles discovered in CMS will be typically unstable and rapidly transform into a cascade of lighter, more stable and better understood particles. Particles travelling through CMS leave behind characteristic patterns, or ‘signatures’, in the different layers, allowing them to be identified. The presence (or not) of any new particles can then be inferred.

**Trigger System**

To have a good chance of producing a rare particle, such as a Higgs boson, the particle bunches in the LHC collide up to 40 million times a second. Particle signatures are analyzed by fast electronics to save (or ‘trigger on’) only those events (around 100 per second) most likely to show new physics, such as the Higgs particle decaying to four muons in the figure below. This reduces the data rate to a manageable level. These events are stored for subsequent detailed analysis.

**Data Analysis**

Physicists from around the world use cutting-edge computing techniques (such as the Grid) to sift through millions of events from CMS to produce plots like the one on the left (a simulation) that could indicate the presence of new particles or phenomena.

**The Compact Muon Solenoid Experiment**

37 countries, 155 institutes
2000 scientists, including about 450 students
http://cms.cern.ch

---

12 500 tonnes
21 m long
15 m diameter

---

**Muon Detectors**

To identify muons (essentially heavy electrons) and measure their momenta, CMS uses three types of detector: drift tubes, cathode strip chambers and resistive plate chambers.

**Superconducting Solenoid**

Passing 20,000 amperes through a 13 m long, 6 m diameter coil of niobium-titanium, superconductor cooled to –270°C, produces a magnetic field of 4 teslas (about 100,000 times stronger than that of the Earth). This field bends the trajectories of charged particles, allowing their separation and momenta measurements.

**Tracker**

Finely segmented silicon sensors (strips and pixels) enable charged particles to be tracked and their momenta to be measured. They also reveal the positions at which long-lived unstable particles decay.

---

**Pattern Recognition**

New particles discovered in CMS will be typically unstable and rapidly transform into a cascade of lighter, more stable and better understood particles. Particles travelling through CMS leave behind characteristic patterns, or ‘signatures’, in the different layers, allowing them to be identified. The presence (or not) of any new particles can then be inferred.

**Trigger System**

To have a good chance of producing a rare particle, such as a Higgs boson, the particle bunches in the LHC collide up to 40 million times a second. Particle signatures are analyzed by fast electronics to save (or ‘trigger on’) only those events (around 100 per second) most likely to show new physics, such as the Higgs particle decaying to four muons in the figure below. This reduces the data rate to a manageable level. These events are stored for subsequent detailed analysis.

**Data Analysis**

Physicists from around the world use cutting-edge computing techniques (such as the Grid) to sift through millions of events from CMS to produce plots like the one on the left (a simulation) that could indicate the presence of new particles or phenomena.