The Compact Muon Solenoid Detector

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CMS detector overview

- Silicon Strip Tracker
- Silicon Pixel Tracker
- Electromagnetic Calorimeter (ECAL)
- Endcap Muon Detectors
- Barrel Muon Detectors
- Hadronic Calorimeter (HCAL)
- Superconducting Solenoidal Coil
- Iron Yoke
The CMS Solenoid

- CMS is built around a superconducting solenoid generating a magnetic field of 4 Tesla
- The current necessary for this - 20 kA...
- Superconducting NbTi wire cooled to ~4K
- 13m length, 6m inner diameter - enough to fit the tracker and calorimeters inside
- (cost ~80 MCHF)
Magnets in particle detectors

ATLAS A Toroidal LHC Apparatus

CMS Compact Muon Solenoid
Two ways to detect a particle (in CMS)
Two ways to detect a particle
(in CMS)

See the track

Or

Catch
Two ways to detect a particle (in CMS)

Tracking detector

Or

Calorimeter
Particle identification in CMS
The Inner Tracker

- Measures the trajectories of charged particles
  \[ \text{momentum} = \frac{1}{\text{curvature}} \]
- The biggest silicon detector in history, over 220m$^2$ of silicon
- Inner part - 3 layers of pixel detectors, outer part 10-11 layers of silicon microstrips
- 75 milions of read-out channels
Event „pile-up“

In the LHC, several proton-proton collisions can occur in a single bunch crossing (The image shows an event with 29 reconstructed vertices)
Electromagnetic Calorimeter

- Electron and photon energy measurement
- ~80 000 PbWO$_4$ crystals
- Homogeneous detector - crystals act as both the absorber and the scintillator
- Very good energy resolution
Figure 2: A section through one quadrant of the ECAL.
Hadron Calorimeter

- Jet energy measurement
- Brass absorber interleaved with scintillator layers
- Steel blocks with embedded quartz fibers in the "forward" part
The Muon System - Drift Tubes

- Muon trajectory measurement (barrel)
- Measured quantity - drift time of electrons produced by the passing muon
- Known drift velocity → distance measurement (~50-200µm precision)
- **Alignment** very important
Trigger

Level-1 trigger. 40 MHz input:
- Specialized processors (25 ns pipelined, latency < 1 s)
- Local pattern recognition and energy evaluation on prompt macro-granular information from calorimeter and muon detectors
- Particle identification: high p, electron, photon, muon, jets, missing E_t

High trigger levels (> 1). 100 kHz input:
- Large network of processor farms
- Clean particle signature. All detector data
- Finer granularity precise measurement
- Effective mass cuts and event topology
- Track reconstruction and detector matching
- Event reconstruction and analysis
The $H \rightarrow \gamma\gamma$ channel

One of these plots contains the (simulated) Higgs boson signal.

Can you spot it?
The $H \rightarrow \gamma \gamma$ channel

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Can you spot it?
The $H \to \gamma\gamma$ channel

One of these plots contains the (simulated) Higgs boson signal.

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The $H \rightarrow \gamma\gamma$ channel

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Once more:
A proton-proton collision
as seen by CMS

CMS Experiment at the LHC, CERN
Data recorded: 2012-May-27 23:35:47.271030 GMT
Run/Event: 195099 / 137440354