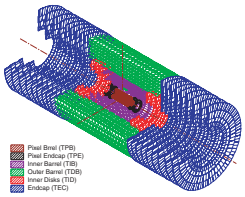
Compact Muon Solenoid

CMS is a world wide collaboration comprising 1543 physicists and engineers from 31 countries and 136 institutions

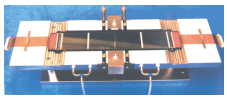
CMS is a general purpose proton-proton detector designed to run at the highest luminosity at the LHC It is also well adapted for studies at the initially lower luminosities. The main design goals of CMS are:

i) a highly performant **muon system**
ii) the best possible **electromagnetic calorimeter** consistent with (i)
iii) a high quality **central tracking** to achieve (i) and (ii)
iv) hermetic **hadron calorimeter**

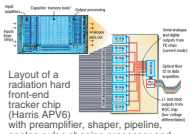
Inner Tracker



The tracking volume is given by a cylinder of a length of 6 m and a diameter of 2.6 m. Fine pitch Si detectors provide precise hits. Pixel detectors placed close to interaction region improve measurement of the track impact parameter and reconstruction of secondary vertices. In the central rapidity region ($|\eta| < 1.5$) the momentum resolution is given by $\Delta p/p_t \approx 0.005 + 0.15\, p_t$ (p_t in TeV)

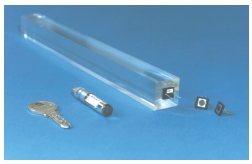


A Si module in its assembly jig. Strips from pairs of 6x6 cm Si detector are bonded together

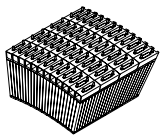


Layout of a radiation hard front-end tracker chip (Harris APV6) with preamplifier, shaper, pipeline, analog pulse shaping processor and multiplexer servicing 128 channels

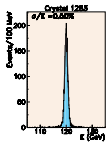
Electromagnetic Calorimeter



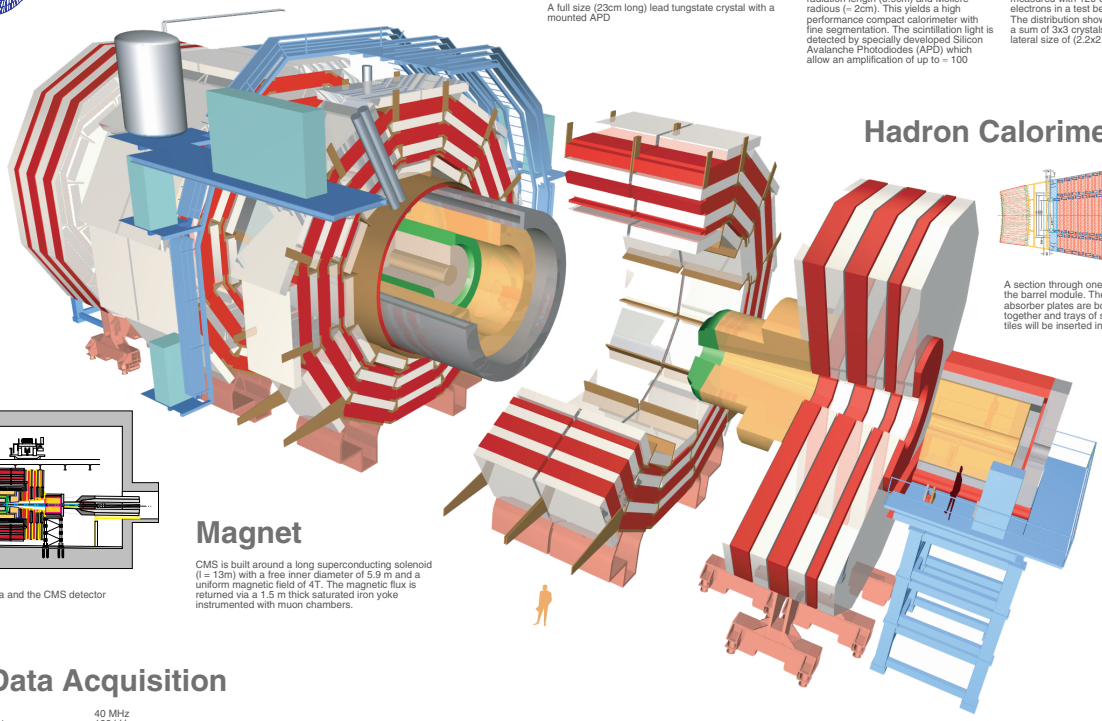
A full size (23cm long) lead tungstate crystal with a mounted APD



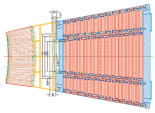
Lead tungstate crystals have a short radiation length (0.9cm) and Moliere radious (~ 2cm). This yields a high performance compact calorimeter with fine segmentation. The scintillation light is detected by specially developed Silicon Avalanche Photodiodes (APD) which allow an amplification of up to ≈ 100



Energy resolution measured with 120 GeV electrons in a test beam. The distribution shown is for a sum of 3x3 crystals with lateral size of (2.2x2.2) cm²

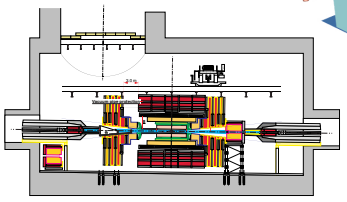


Hadron Calorimeter



A section through one sector of the barrel module. The copper absorber plates are bolted together and trays of scintillator tiles will be inserted in the gaps.

Installation



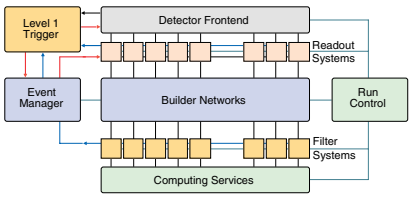
The underground experimental area and the CMS detector

Magnet

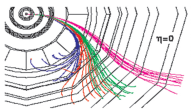
CMS is built around a long superconducting solenoid (l = 13m) with a free inner diameter of 5.9 m and a uniform magnetic field of 4T. The magnetic flux is returned via a 1.5 m thick saturated iron yoke instrumented with muon chambers.

Trigger and Data Acquisition

Collision rate	40 MHz
Level-1 Maximum trigger rate	100 kHz
Average event size	≈ 1 Mbyte
No. of In-Out units (200-5000 byte/event)	≈ 1000
Event builder (1000 port switch) bandwidth	1000 Gbit/s
Event filter computing power	≈ 5 10⁶ MIPS
Data production	≈ Tbyte/day

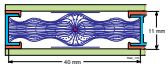


Muons

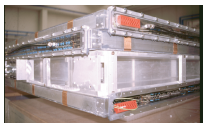


P_t = 3.5, 4.0, 4.5, 6.0 GeV

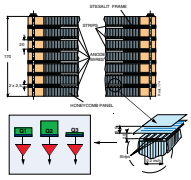
Centrally produced muons are measured 3 times: in the inner tracker, after the coil and in the return yoke. They are identified and measured in four identical muon stations using drift chambers in the barrel, cathode strip chambers in the endcaps and RPCs to assure redundancy in triggering



Drift Tube cross section (4x1 cm²)



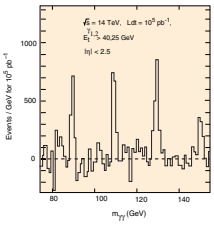
A full size prototype of the barrel drift chamber consisting of three groups of fourdetecting planes



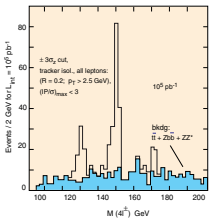
A six layer Cathode Strip Chamber. The detail of one layer is shown. Good resolution is obtained by using the centre of gravity of the charge induced on the strips

Physics Performance

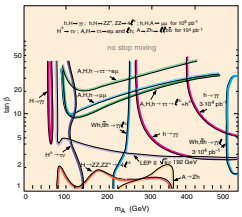
H → γγ



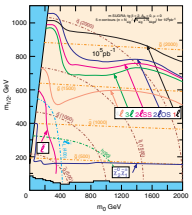
H → ZZ* → 4e,2e 2μ,4μ



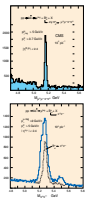
SUSY Higgs



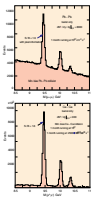
Sparticles



B-Physics



Heavy Ions



Mass Resolution

Hadrons in the Inner Tracker

$\sigma(B^0_s \to \pi^+\pi^-)$	= 27 MeV	at p_t^B ~ 30 GeV

Muons in the Tracker and Muon System

$\sigma(B^0_s \to \mu^+\mu^-)$	= 26 MeV	at p_t^B ~ 30 GeV
$\sigma(\Upsilon \to \mu^+\mu^-)$	= 37 MeV	
$\sigma(H \to 4\mu^\pm)$	= 1.0 GeV	for H(150) → ZZ*

Electrons/Photons in e.m. calorimeter

$\sigma(H \to 4e^\pm)$	= 0.9 GeV	for H(150) → ZZ*
$\sigma(H \to \gamma\gamma)_{Low\ Lum.}$	= 0.6 GeV	for H(100)
$\sigma(H \to \gamma\gamma)_{Hi\ Lum.}$	= 0.8 GeV	for H(100)

Large Hadron Collider