CMS (Compact Muon Solenoid) will be one of two general purpose detectors at the CERN Large Hadron Collider. Its main feature is a strong solenoidal magnetic field. The detector consists of an inner tracker with an embedded pixel detector, a crystal electromagnetic calorimeter, a copper-scintillator hadron calorimeter and a muon system made up of tracking chambers and special trigger chambers. This paper outlines the design and the status of the CMS experiment. The physics potential of CMS is illustrated using a selected set of physics channels.

1 Introduction

The Large Hadron Collider (LHC) at CERN will provide proton-proton collisions at a centre-of-mass energy of $\sqrt{s} = 14$ TeV with a design luminosity of $\mathcal{L} = 10^{34}$ cm$^{-2}$s$^{-1}$ and a bunch crossing interval of 25 ns.

The search for high-mass objects and rare signatures requires high $\sqrt{s}$ and high luminosity. The LHC fulfills these requirements, but the high luminosity leads to difficult experimental conditions. The total cross-section at the LHC is very large, i.e. about 100 mb, which results in an interaction rate of $\sim 10^9$ Hz at the design luminosity. The online event selection must reduce this to about 100 events/s for storage. The detection of processes with signal to total cross-section ratios of about $10^{-12}$, as for example a 100 GeV Higgs boson, will be a difficult experimental challenge.

At design luminosity a mean of $\sim 20$ minimum bias events will be superimposed on the event of interest resulting in about 1000 charged tracks every 25 ns in the pseudorapidity range of $|\eta| < 3$. Such high particle densities will make track reconstruction difficult. The high particle fluxes coming from the interaction region will also lead to high radiation levels and a large flux of low energy neutrons in the experimental area. Therefore radiation-hard detectors and front-end electronics are required.

2 Detector Setup

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 initial lower luminosities in order to fully exploit the physics potential offered by the LHC. The main design objectives are:

- a high performance and redundant muon system
- a high resolution electromagnetic calorimeter
Fig. 1. Longitudinal view of 1/4 of the CMS detector.

- a high quality central tracking system
- full calorimetric coverage

The layout of the detector is shown in Fig. 1. A 13 m long superconducting coil is the heart of CMS. It has a bore of 5.9 m and provides a 4 Tesla solenoidal field parallel to the beam direction. The magnetic flux is returned through a 1.5 m saturated iron yoke (1.8 Tesla) instrumented with muon chambers. The bore of the magnet is large enough to accommodate the inner tracker and the calorimetry inside the coil.

The overall dimensions of the CMS detector are: a length of 21.6 m, a diameter of 14.6 m and a total weight of 14500 tons.

2.1 Inner Tracker

The inner tracking system of CMS is designed to reconstruct high-$p_T$ muons, isolated electrons and hadrons in $|\eta| < 2.5$ with a momentum resolution of $\Delta p_T/p_T \approx 0.15p_T \pm 0.5\%$ ($p_T$ in TeV).

The tracking volume is given by a cylinder of a length of 6 m and a radius of 1.3 m surrounding the interaction region. Three different detectors have been chosen to satisfy the resolution and granularity requirements. The layout in the barrel part is as follows: silicon pixel detectors, with a cell size of 150 mm × 150 mm, are placed closest to the interaction region at radii of 4 and 7 cm at low luminosity ($10^{33}$ cm$^{-2}$s$^{-1}$) and 7 and 11 cm at design luminosity ($10^{34}$ cm$^{-2}$s$^{-1}$). These are