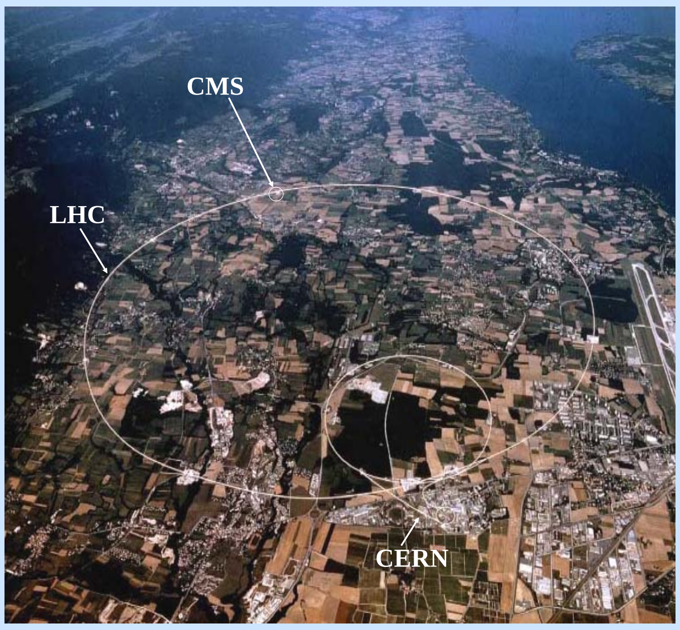
The CMS Tracker Electronics

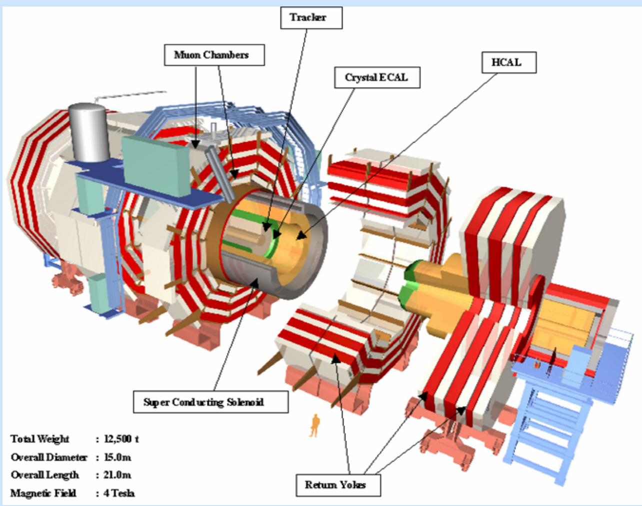


People have long sought to understand the Universe at its most fundamental level. What it is made of? How is it held together?

The Large Hadron Collider (LHC), currently under construction at CERN, Geneva, is our latest attempt to probe the Universe at its smallest scales and to unlock some of its secrets.

CERN has been Europe's centre for particle physics research for 50 years.

Once completed in 2007 the LHC will collide beams of protons at higher energies than anywhere else in the world. It could uncover a wide range of new physics and providing us with answers to many currently unsolved mysteries.

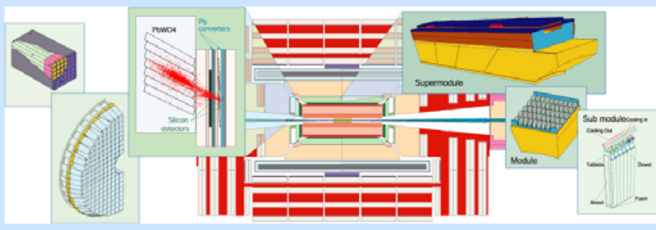


The LHC has the potential to provide us with answers to many currently unsolved phenomena. However, the Universe does not give up its secrets easily. An experiment is needed to observe the proton-proton collisions.

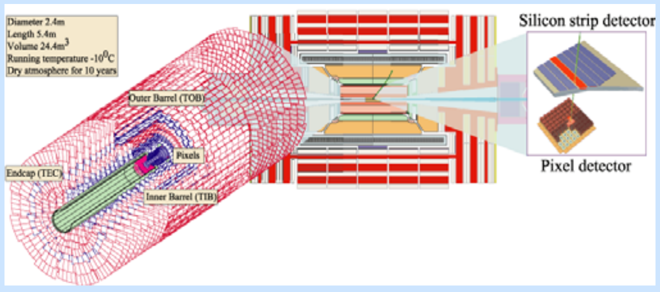
The Compact Muon Solenoid (CMS) is one such experiment, consisting of -

- A detector weighing 12,500 tonnes and containing the world's largest super conducting solenoid, which at full strength contains enough energy to melt 18 tonnes of solid gold.
- A sophisticated data acquisition system, that will have to cope with a data rate equivalent to 10,000 Encyclopaedia Britannicas being recorded each second.
- A multination national collaboration of 2000 scientists and engineers from 159 institutes and 36 countries. Their task is to build and maintain this mammoth project and to comprehend the meaning of this massive volume of data that CMS will produce.

There are four institutes which make up the UK CMS collaboration, with the funding provided by PPARC. One of these institutions is the CCLRC Rutherford Appleton Laboratory (RAL). RAL is involved in three of the CMS sub-detectors: the ECAL End Cap, the Tracker and the Trigger.

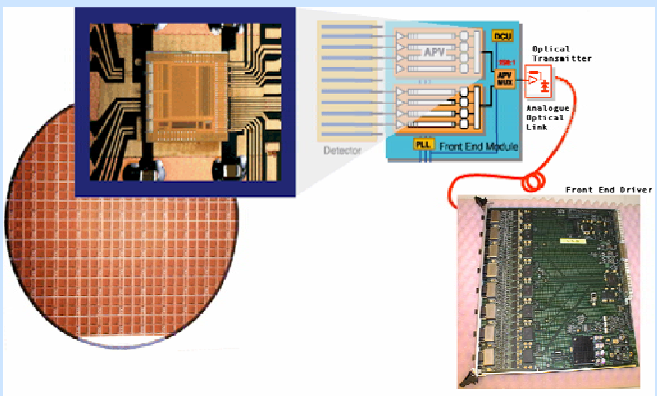


The ECAL consists of 80,000 lead tungstate crystals, with a total mass equivalent to approximately 24 adult African elephants. As photons and electrons pass through the lead tungstate crystals they produce light, the amount of light being proportional to their energy. In the ECAL End Cap the light is collected by vacuum phototriodes (VPTs). RAL is responsible for ensuring that the VPTs can be used in the powerful magnetic field used in CMS, for the design of the high voltage system for the VPTs, and for building half the end cap detectors.



The CMS will have the world's largest all silicon tracker, with 220m^2 of silicon. The innermost region of the Tracker consists of a 75 million silicon pixel detector. The outermost region of the Tracker consists of 9 million silicon strip detector.

RAL and Imperial College London (IC) are responsible for the Tracker readout system. The Tracker silicon strips are read out using 75,000 APV chips. Each APV amplifies and stores the data from the Tracker for every proton-proton collision. The data from the APV chips are transmitted along optical fibres to 440 Front End Drivers (FED) at a total rate of 1320Gbytes/s (equivalent to 290 DVD/s).

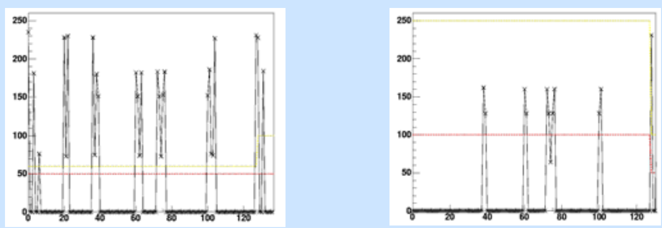


The proton-proton collisions will occur at 40 million times per second. This produces an enormous data rate, which is reduced by two methods:

- CMS has designed a trigger system that rapidly identifies interesting events. APVs reject events unless they are flagged as interesting.
- A FED can identify the silicon strips that have detected particles by applying a signal (hit) finding algorithm. By removing those strips without signal from the data stream, the data rate can be reduced by a factor of 60.

Part of the author's current work is the design, maintenance and testing of the FED low level configuration and read out software.

He has recently been testing the FED hit finding algorithm. This involves inputting test patterns into the FED. Using different configuration settings the FEDs observed output data was compared against the expected output.



The above graphs show the results from recent tests of the hit finding algorithm. The FED has two threshold values it uses to distinguish the signal from noise. The left graph shows the FED output with low values for the hit finding thresholds. The right graph shows the FED output after increasing the thresholds. The hit finding algorithm is performing as expected.

This work as been done as part of an optional year in employment placement, during my MPhys Physics degree, at the University of Wales, Aberystwyth.

The Year in Employment Scheme (YES), established in 1977 by the University of Wales Aberystwyth's Careers Advisory Service is an optional scheme open to all students of all disciplines. It allows well motivated and able students to take a year out between their second and final years to work in industry, commerce or the public sector at home or abroad.