THE COMPACT MUON SOLENOID

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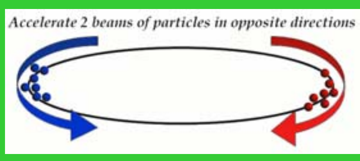
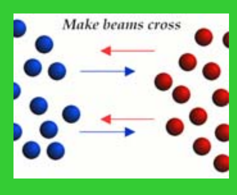
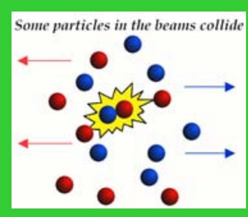
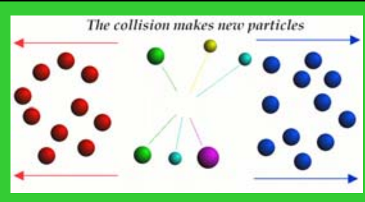
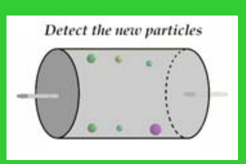
Typical Particle Physics experiment:



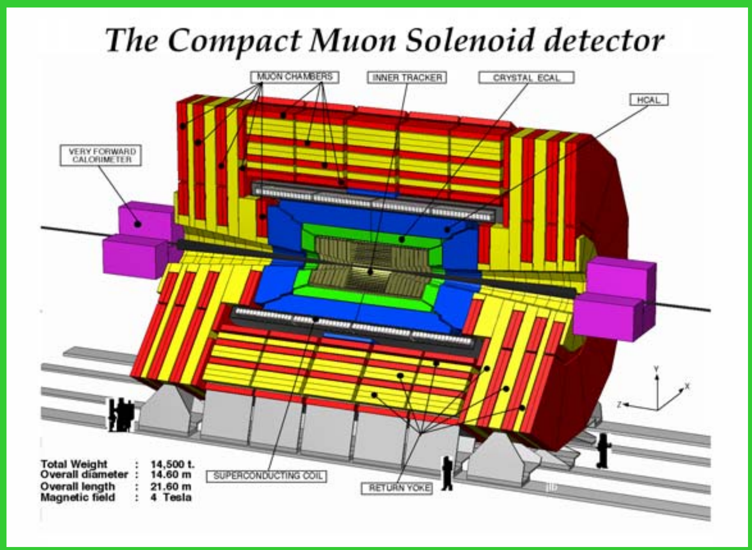








And start again...



What is CMS?

The Compact Muon Solenoid (CMS) will be a particle detector at the cutting-edge of science. It's gigantic size reflects the complexity of this machine: 15 metres tall and 22 metres long, CMS will weigh 15000 tons!

CMS will be fitted into the world's most powerful particle accelerator ever built, the Large Hadron Collider (LHC) at CERN, Geneva. Due for completion in 2005, CMS will be a next-generation instrument for CERN and will be used by Particle Physicists from around the world.

Why is CMS being built?

Particle Physicists try to understand how the Universe was created according to the "Big Bang" theory. Particle Physics are therefore aiming to answer the most noble of all questions: "Where do we come from?"

The Large Hadron Collider (LHC) will reproduce these extreme conditions by accelerating and colliding particles around an underground circular ring 27km in circumference!

Many theories of Particle Physics will be confirmed or rejected by LHC and CMS, including the long-sought "Higgs Boson" described below.

Who is building CMS?

CMS is destined for CERN, the European Organisation for Nuclear Research, on the French/Swiss border near Geneva.

The UK is part of the large international CMS collaboration, which comprises 30 countries and over 144 Institutes. UK institutes are the University of Bristol, Brunel University, Imperial College and CLRC Rutherford Appleton Laboratory.

The UK carries large responsibilities towards the success of CMS in the design, construction and management of the multi-million pound project.

My Work

Automation

Why is automation needed?

Automation is needed due to the complexity of CMS. The detector is composed of millions of individual components assembled together, which rules out possibility of manual testing. Scientists therefore need to set up automated testing of each individual component in order to guarantee the final success of CMS.

What is my involvement?

I am responsible for the development of automated, computer-controlled testing for a device central to CMS, the "Vacuum Phototriode". It is the device that converts a response from the detector into a measurable electric current in parts of CMS.

I have designed a complete testing procedure that will be used on over 16000 devices. The computer independently carries out all the testing and decides on acceptability of each device.

This screen is a summary of the results of the test as presented to the scientists. 48 devices are tested together, and the result for each is colour coded.

- = Failed
- = Borderline
- = Passed

Figure 1: Final screen

Bonding Agent

Why is glue needed in CMS?

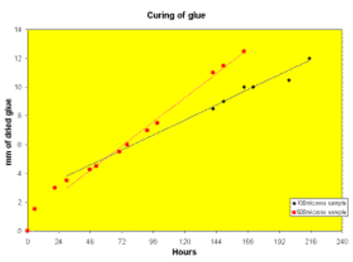
Most components of CMS are robust and can therefore be fixed mechanically. Some, on the other hand, are extremely fragile, and need to be handled with care. This and optical arguments make glue a proposed bonding agent for some CMS devices.

What is my involvement?

I have been testing the suitability of different glues for the task described above. CMS will run for 10 years during which the glue must stay unaltered in an intense radiation environment. Many properties of the glue must be studied carefully, including the curing (drying) time. The glue must dry completely and within a reasonable time to make it easy to use.

Figure 2 is a plot of drying of 2 samples 12 millimetres long. The samples vary in thickness.

The blue data is for a glue sample 100 microns (1/10th of a mm) thick, whereas the red data is for a sample 5 times thicker.



This data was taken using a new technique which involves monitoring the change in coloration of a stain as the glue dries.

Figure2: Curing time

It is interesting, and may be surprising, to note that the thick sample cured faster than the thin sample. The thin samples dried completely in approximately a week, which is acceptable for CMS purposes.

The Higgs Boson

What is the Higgs Boson?

Postulated by Peter Higgs from Edinburgh University, the existence of a 'Higgs Boson' is predicted by one of the most important modern theories in Particle Physics. It aims to answer the question: "What is the origin of Mass?". One of the two main goals for CMS will be to test this theory.

What is my involvement?

Among the startling features of the theory is the fact that physicists cannot predict what the mass of this new particle would be. This leads to the constraint that the CMS detector must be able to detect the particle over a wide range of masses. This is difficult because, at best, only one event in 1000000000000 (10^{12}) will involve a Higgs Boson!

I am generating computer-simulated data to study the sensitivity of the detector for all Higgs Boson masses detectable by CMS.

Figure 3 is a typical result from such simulation. The curve filled in yellow is due to known particles being created and forming a signal similar to that of the Higgs Boson. The discovery of the Higgs Boson would be through a peak in the signal unexplainable with known particles, such as the orange peak here.

This histogram is a simulated signal from a 400 GeV Higgs Boson decaying to 2 Z Bosons.

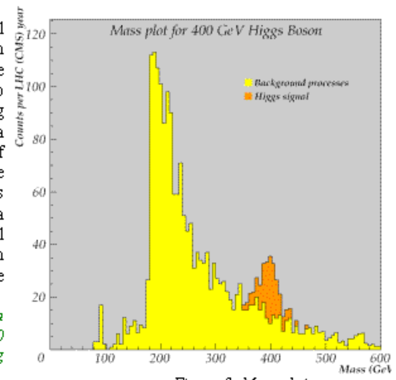


Figure 3: Mass plot

THE PLACEMENT SCHEME

This work has been carried out at the Rutherford Appleton Laboratory during the placement year of my four-year undergraduate MPhys degree course in the Department of Physics at the University of Bath. The University has run a successful placement scheme for thirty-five years, which allows students to experience technical work placements at some of the leading industrial and research organisations in the UK, Europe, and beyond. These include CERN, Alcatel, British Aerospace, Siemens and many others.