EXECUTIVE SUMMARY

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Aims & Objectives

The aim of the project was to build a cosmic ray detector suitable for school-based demonstrations. The original brief detailed a prototype of a neon tube array built by scientists at CERN and the intention had been to develop a larger array. However this type of apparatus was found to perform poorly and it was decided that a different method would be employed.

The objectives:

- To carry out research into the physics of cosmic rays and their detection and decide upon a method to be employed
- Carry out investigations on an experimental test stand and use the data obtained to design the detector
- Construct the detector and carry out testing
- Produce educational materials for schools including posters
- Develop a website

Research

Extensive research was carried out into the origins and composition of cosmic rays, the flux of their secondary muons at the Earth's surface and the techniques employed in modern detectors. It was decided that the most appropriate detector type for schools would be an apparatus involving scintillators. When a charged particle such as a muon passes through the material it causes ionisation and upon recombination a photon is emitted. This photon is detected via a photomultiplier tube, which converts the optical signal to an analogue electrical signal. This is passed through a discriminator to change it to a digital pulse.

Experimental Investigations

A test stand was constructed with scintillators from an experiment involved with the MINOS project. The scintillators, together with a Hamamatsu M16 photomultiplier tube array, were placed inside an optical box and the resulting electrical signals were processed using modules in a NIM crate. The major problem that was experienced with this set up was noise occurring in the electronic components. The technique of coincidence counting was employed in order to reduce this and isolating the cables resulted in an improvement. Calculations were performed upon the experimental data and theoretical flux data in order to calculate the scintillator dimensions and separations that would be suitable for the final detector. A Java software tool was employed to calculate the solid angle of sky that a given arrangement would cover.

Designing the Detector

The detector was designed in the shape of two concentric octagonal barrels in order that two, three or four-way coincidence could be obtained in each of four different directions. It was considered that a count rate of approximately $0.5 s^{-1}$ would be suitable for a demonstration of the technique and the geometry of the 16 scintillators

was designed accordingly. The main structure of the detector consists of three octagonal plates held together with studding. The outer two plates are made of transparent polycarbonate and the middle plate of black Delrin in order to assist in the light-sealing of the scintillators, which are held by slots in the central and rear plates. An LED display showing the paths of the through-going muons is mounted on the front plate. The photomultipier tube is held on the central axis of the detector by a small plate attached to the studding.

Electronics

The original plan had been to use a miniaturised discriminator which fits onto the end of the PMT. However when tests were carried out on this component it was shown to exhibit a problem with crosstalk between the channels which, despite extensive investigations, has not yet been resolved. At the current time the apparatus relies on the bulkier NIM crate for operation.

Coincidence Logic and Display

A field programmable gate array was used to programme the operation of the detector and its LED display. Several VHDL programmes were downloaded onto the chip in order to allow the user to select two, three or four-way coincidences. Counters can be incremented for moun events in each of four directions, therefore measuring the angular distribution. For every resulting coincidence the LEDs are lit according to the scintillators that have been traversed.

Posters & Website

Two A1 posters were produced, which can be downsized to A4 in order to double as handouts. One involves the origin and composition of cosmic rays and the other is designed around the methods employed to detect them. The website, which acts as a means of sharing information between the group and also and education tool for students, is located at:
http://pc26.hep.ucl.ac.uk/3C41/

Summary

The detector is complete but is currently relying on the NIM crate until the problem with the miniaturised electronics is solved. Once the NIM crate has been replaced by the smaller components, which will fit inside the structure, the result will be a fully portable detector that can be taken to schools for demostrations. All of the objectives have been met and the website will remain online to be updated with further developments.