10 CONCLUSION AND FUTURE DEVELOPMENT

Caroline Robson

Over the space of 11 weeks the group has achieved the main aim of the project, which was to design an apparatus for the detection of cosmic ray muons although at the present time it still relies on bulky electronics and so is not portable enough for school demonstrations. This is due to complications with the final electronics.

It was decided at the beginning of the project, based upon evidence that the neon tube apparatus being developed in the department was not an effective means of detecting muons, that another method of detection would be required. A scintillation detector was considered the most viable option for school-based demonstrations due to the fact that it can be produced on a small scale and for relatively little cost compared to other methods such as spark chambers and Cherenkov detectors. It was also considered to be a potentially durable piece of equipment, which could be built in such a manner that people can look inside it and see the separate components. For this reason the two end plates of the detector were made from a tough polycarbonate so as to be both transparent and resistant to small impacts.

Experiments were carried out using scintillators from a previous experiment related to the MINOS project. The investigations carried out on the test stand served a dual purpose. Firstly they enabled the group to become accustomed to the technique of coincidence detection and also acquire an idea of the problems that may arise in the use of the particular electronic components that would be a part of the final detector. In particular, the PMT used in the test stand was eventually transferred to the detector so the group was already confident of its operating capabilities and the care issues of this sensitive component. The elimination of noise was another important problem to solve and a great deal of time was spent working on the electronics to solve the issue. Secondly, the results acquired in two-and three-way coincidence tests using the geometry of the MINOS scintillators together with a tile made of the Kuraray scintillator allowed the group to arrive at a suitable geometry for the detector. A software programme was written in the Java language in order to calculate the solid angle coverage of a scintillator arrangement given by the user. This was used together with the experimental data to produce the final design.

The design was developed around three octagonal plates, between which the components sit. At the back, 16 tiles were arranged in two concentric octagons to give the option of two, three or four-way coincidences once the electronics had been added. The arrangement was designed in this way in order to give the maximum amount of flexibility in the chip logic in order to be able to design a suitable program for the LED display on the front.

The original intention had been to use miniaturised electronic components in order to reduce the bulk of the detector. Despite extensive testing of the new components it was concluded due to time constraints that the development of an easily portable version would have to wait until after the presentation. The problem lay in the crosstalk between the discriminator channels whenever one of them received a signal. It was considered important to have a working model to demonstrate the concept to people, if necessary using the older electronics contained in the NIM crate.

The LED display was designed in such a way that it would demonstrate visually the scintillators that have been hit and hence give an idea of the muon trajectory, within the constraints of the solid angle coverage of the scintillators. A Field Programmable Gate Array was used to control the dislplay, taking as its input the signals from the NIM crate. NIM-TTL converters were used to turn the logic pulsed from the discriminators into a signal readable by the FPGA. The chip on the board was programmed using the VHDL language and several different programmes were downloaded in order to give the maximum flexibility in the implementation of the detector. These programmes included the ability to choose between two-way and three-way coincidences and the choice of five different counters, one each for the different angular detection capabilities.

At the time of writing the construction is complete and the detector is in its testing phase. The end of the project has seen the production of a complete detector although it is still using the older NIM electronics while the problem with the miniaturised discriminator is solved. There are plans to carry on with the work in order to complete the finished portable detector which will be transported to schools for demonstrations, together with the posters and handouts that were produced as part of the project. The website will remain online and will be updated according to any future developments.

A considerable amount of specialist expertise beyond that of the group was required in the making of the working detector. The group would like to thank:

Brian Anderson (electician and optical component specialist)
Derek Attree (engineer)
Dr Mark Lancaster (supervisor)
Matthew Warren (electrical engineer and FPGA specialist)
Dr David Waters (supervisor)