Cosmic ray detection made easy

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RADIATION

Cosmic ray detection made easy

Every second cosmic rays hit the Earth. Their discovery, made at the beginning of the 20th century, was the starting point of several other important discoveries and, somehow, the beginning of the study of particle physics. At ground level the radiation of cosmic origin is fundamentally composed by muons [1]. In an undergraduate physics laboratory, detection of cosmic rays can be done using several different devices, such as a cloud chamber [2], telescopes of scintillation detectors or gas detectors. A popular way to use gaseous detectors in cosmic ray detection is to put two Geiger tubes in coincidence [3, 4]. The temporal coincidence signals corresponding to the passage of a muon by two Geiger counters can eliminate the background events due to radioactive disintegration. Unfortunately, in an undergraduate laboratory it is not always easy to get the electronic modules to build the coincidence system. Do-it-yourself coincidence circuits exist [5], but a simpler solution can be found if you have access to Geiger counters with computer acquisition. Automatic acquisition Geiger counters can record the date and time of an event, so that the time coincidence between events detected by different counters can be made afterwards by software. In our experience we used GM-10 Geiger counters from Black Cat Systems [6] and the acquisition software supplied with the equipment. Each Geiger counter was connected to a different communication port and the acquisition program was running in different windows—one for each counter (figure 1). The data collected were stored in different files (one for each Geiger). After acquisition was stopped a 'homemade' program read the data files and found which events were acquired simultaneously by all three Geiger counters.

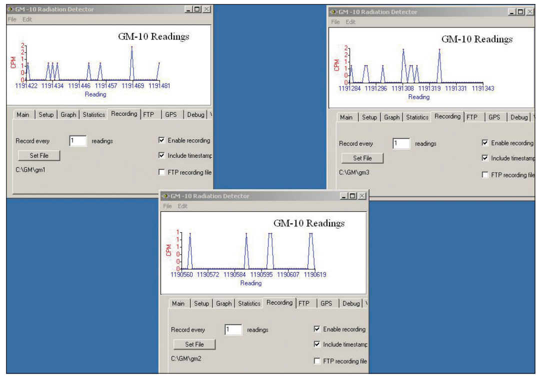

Figure 1. *Print screen of the acquisition windows.*

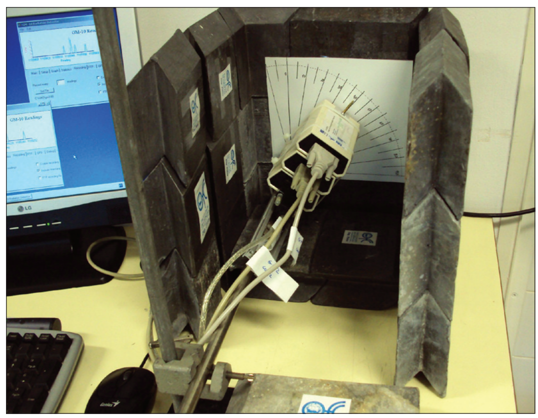

Figure 2. *The Geiger counters telescope inside lead shielding.*

The GM-10 Geiger acquisition program allows the acquisition of events within a minimum interval of one second. For time coincidence this is a very large interval when compared with other coincidence experiments using Geiger counters, which typically have coincidence intervals of the order of a millisecond. This is extremely important because the rate of accidental coincidences between two counters is proportional to the product of the event rates for each counter multiplied by the coincidence time interval. To minimize this problem we used three Geiger counters on top of each other, forming a telescope. Despite this, it was found that under normal conditions the coincidence of three Geiger counters still was not enough to eliminate a sufficient number of accidental coincidences. This is due to environmental radioactive decays, which dramatically increase the number of accidental coincidences. To make the number of total coincidences clearly distinct from accidental coincidences due to background, the Geiger counters were shielded, almost all around, by lead bricks (figure 2). With the shield we then got more than a factor two difference between the total number of coincidences and accidental coincidences, when the telescope was vertically aligned. A further improvement in background reduction (about 10% in our experiment) can be achieved if the Geiger counter window is covered with aluminum adhesive tape, blocking the alphas from radon decay.

At ground level, the rate of cosmic rays depends on the zenith angle. It is expected that the event rate will be proportional to the square of the cosine of the zenith angle [1], which is in fact observed in figure 3 with the data acquired with our telescope. In this plot, each data point corresponds approximately to one day of acquisition. The presented event rate is already subtracted from the accidental event rate, estimated from the product of the three Geiger count rates times the square of the coincidence time interval (which was 1 s in our case). For the moment, provided enough lead bricks are available for shielding, this is an easy way to demonstrate the detection of cosmic rays. If in a future software update an acquisition time of a fraction of a second is allowed, then a significant decrease in accidental coincidences could be achieved and the lead bricks would no longer be needed.

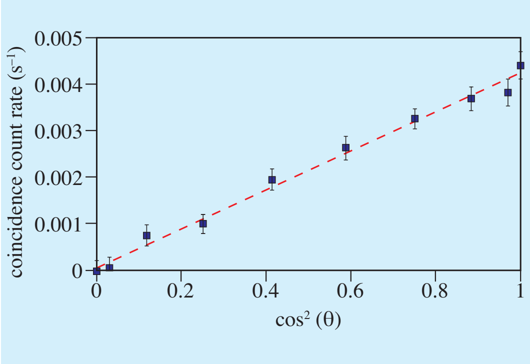

Figure 3. *Event rate dependence on the cosine of the zenith angle.*

References

[1] http://pdg.lbl.gov/2011/reviews/rpp2011-rev-cosmic-rays.pdf
[2] http://teachers.web.cern.ch/teachers/document/cloud-final.pdf
[3] Blanco F *et al* 2006 Geiger counters offer powerful way to teach detection methods *Phys. Educ.* **41** 204
[4] Wibig T, Kołodziejczak K, Pierzynski R and Sobczak R 2006 Educational studies of cosmic rays with a telescope of Geiger–Müller counters *Phys. Educ.* **41** 542
[5] Goldader J D and Choi S 2010 An inexpensive cosmic ray detector for the classroom *Phys. Teach.* **48** 594
[6] www.blackcatsystems.com/GM/products/GM10GeigerCounter.html

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