COSMIC RAY

Open source detectors and information

ABOUT COSMIC RAYS DETECTING PROJECTS OTHER WEBSITES

DETECTOR CONSIDERATIONS

Energy

Muons created by the interaction of cosmic rays and our atmosphere lose their energy gradually by ionisation of the material through which they pass. As they start with high energies they have the capacity to ionise many atoms before their energy is exhausted.

Also, as they travel at nearly the speed of light (~0.998c), they tend not to ionise very efficiently and hence can travel through substantial lengths of matter, some metres of lead, before being stopped.

Consequently, coincidence detection methods are the only real reliable way to discriminate between terrestrial radiation and cosmic sources.

Penetrative Terrestrial Radiation

I've been very surprised just how penetrative local terrestrial radioactive sources can be. For example, some natural gamma sources can have energies up to 1.3 MeV and so could penetrate some MMs of lead. Consequently, in all detector array designs either Geiger–Müller or Scintillator or Si Pin Photodiode detectors, this can cause false detections. This particularly becomes a problem of detectors with small surface areas (aperture). Consequently, it is recommended that radiation shielding be included in your design to reduce the problem and increase reliability.

Compton Scattering

Compton Scattering is an effect where an interaction between charged electrons within the detector and high energy photons results in the electron being given part of the energy, causing a recoil effect of another high energy photon, which may enter into the adjacent detector causing a false coincidence detection.

In other words placing detectors that use a high voltage potential like Geiger–Müller, photomultipliers tubes, or spark chambers too close to each other may cause cross-talk interference in coincidence mode, and so radiation shielding should be added or the detectors spaced further apart. However, increased spacing also has the negative effect of decreasing the aperture of the detector and so the expected count.

Geiger–Müller Tube Detector Pulse Width

The Geiger–Müller tube is a very good detector of Muons however, it would seem that filtering out background radiation using a simple coincidence detector system alone is problematic due to the Geiger–Müller tube response and decay time (Pulse Width) when a muon has passed through and is detected.

Consequently, the wider the Pulse Width the greater the number of false positives. This means a pulse shorting or quenching circuit is also needed to shorten the Pulse Width to a period closer to the expected flight time of the Muon between tubes, but not too narrow that the electronics cannot measure relative coincidence. Some improvement might also be achieved by spacing the tubes further apart, but this also has the negative effect of decreasing the aperture of the detector.

Detectors using Scintillators and Photomultiplier Tubes (PMT)

The major advantage of Scintillator–Photomultiplier Detector over a Geiger–Müller Detector is that a PMT has a very fast response time and is so more accurate than Geiger–Müller Detector in coincidence mode. Also, as scintillator panels are used, they have a larger surface area, meaning a greater number of muons can be counted compared to other terrestrial sources, further increasing their accuracy and count rate.

The major disadvantage of Scintillator–Photomultiplier detectors is cost, complexity, and limited longevity of the PMT.

Detectors using Solid State devices

Solid–state devices particularly Si Pin Photodiodes are capable of measuring both gamma rays and their energy, but also come with their own issues and compromises. Such as greater complexity, noise (requiring more amplification), and small aperture size. But also have the benefit of low voltage, power, and greater longevity.

Some types SiPin Photodiodes can be designed to work with scintillator panels and so can have a much larger surface area, further increasing accuracy. Nevertheless, this also increases cost.

Shielding

Muons can travel at nearly the speed of light, they tend not to ionise very efficiently and hence can travel through substantial distance through matter, some metres of lead, before being stopped.

Consequently, shielding can play an important role in reducing false detections from local terrestrial and environmental radioactivity. This role is however hindered by the unavoidable presence of natural radioactive decay which occurs in all materials, some more than others. For example, even lead contains natural isotopes Pb–210, which undergoes beta decay, with the consequent emission of a gamma–ray.

Why again, coincidence detection methods are the only real reliable way to discriminate between terrestrial radiation and cosmic sources.

Creator

This website was designed and developed by Robert Hart in Adelaide South Australia.
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