Effect of Weather Conditions on Cosmic Ray Detection Rate

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Abstract

The influence of weather on the rate of detection of muons produced by cosmic rays was investigated. Muon rates were measured using a pair of stacked scintillators triggered in a coincident mode. Rates were recorded in one minute intervals for one week and compared to the local measured pressure, temperature, and humidity readings. The count rate was not correlated with pressure. There was a positive correlation with humidity. Temperature had no apparent effect between 50 and 65 degrees F, but negatively correlated above 65 degrees F.

Introduction

Cosmic rays are energetic nuclei and leptons originating from astrophysical sources. When cosmic rays enter Earth's atmosphere, they collide with molecules, creating showers of lighter particles, including muons. Some muons reach detectors on the ground.

Atmospheric pressure can affect the rate at which muons reach the ground. When the atmosphere is denser, fewer muons are seen on the surface of the Earth. Therefore, it is expected that higher atmospheric pressure will lead to a lower detection rate.

The effect of weather on the muon count rate was investigated to compare with the dependence on other factors such as shielding by water, which was studied separately by another group. The effect of pressure, temperature, and humidity on the count rate, as well as the effect of direct sunlight on the detectors were studied.

Setup

We used a Quarknet[1] cosmic ray detector kit with two stacked scintillators (see Figure 3) attached to a data acquisition board. The DAQ board allows control of high voltage, threshold and triggering conditions.

The scintillators were placed outside in a plastic container to protect them from rain. The trigger required a hit on the upper panel to be followed with a signal from the lower panel within 100 ns with a threshold of 1100 mV. Detection rate data were taken every minute. Data runs were done both with a tarp covering the container and without a tarp to see if heating of the scintillator/pmt had any effect.

A Davis Vantage Pro2 weather station was used to record barometric pressure, temperature, and humidity every minute.

Three runs of one week each were completed.

Figure 1. Davis Vantage Pro2 weather station.

Figure 2. Davis Vantage Pro2 console and laptop with analysis software.

Figure 3. The scintillators used in the experiment.

Figure 4. Plastic container with scintillators, covered.

Results

The detection rate did not depend on pressure as expected, but did correlate with temperature and humidity. Shielding the detectors from the sun had no apparent effect.

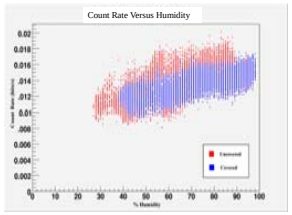

Figure 5. Count rate (Hz) versus Humidity

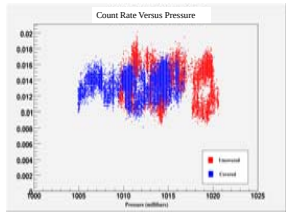

Figure 6. Count rate (Hz) versus Pressure

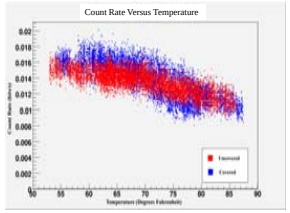

Figure 7. Count rate (Hz) versus Temperature

Uncovered **Covered**

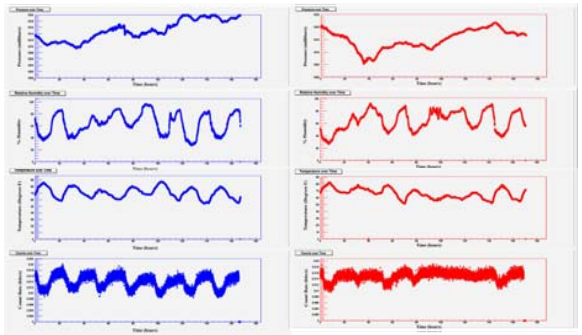

Figure 8. The pressure, humidity, temperature, and count rate versus time for the uncovered detectors. (July 6 – July 13)

Figure 9. The pressure, humidity, temperature, and count rate versus time for the covered detectors. (July 13 – July 20)

Summary

The expected dependence on pressure was not observed, but correlation with temperature and humidity was seen. Humidity and temperature were inversely related during our data runs. Therefore, it remains unclear which variable was responsible for the change in count rate, or if both of them are.

Dependence on pressure has been observed in other muon detection experiments[2]. It is possible the pressure did not vary enough during our experiment or we are at too low of an elevation to see an effect. The expected difference is a 0.2% drop in detection rate per millibar increase in pressure. Our maximum change in pressure was about 12 millibars, which would be a change of 2.4%. This is a change in rate of between 2.4×10^{-4} and 3.2×10^{-4} counts per second, which is smaller than the variation in our count rate data.

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References

1. http://quarknet.fnal.gov
2. http://www.physics.adelaide.edu.au/astrophysics/muon

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