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Construction and Applications of an Inexpensive Muon Detector

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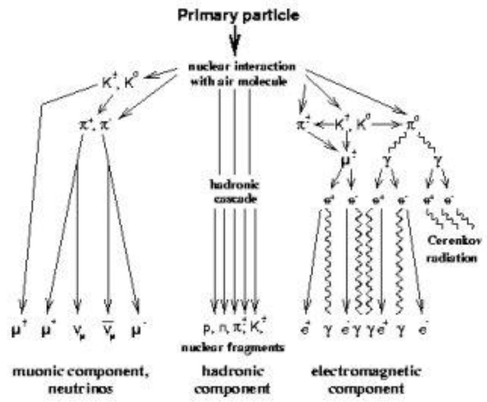
Introduction

This project was the construction of five desktop muon detectors. Which was inspired by Cosmic Watch. Once assembled these detectors would be able to go into the field and take measurements of the density of muons at different locations. The muon detectors that were created for this project are under 100 dollars each. The muon detectors can also encourage other students or classes to engage in physics. Plus, it's cool.

Background

Muons were discovered in 1936, which was the second fundamental particle after the electron. This opened the door for the study of particle physics. Muons originate from the Sun, while they enter earth's atmosphere as decaying cosmic rays. Muons are slightly unstable with a lifecycle of 2.2 microseconds. While muons travel comparative to the speed of light, they are also able to pierce through thousands of meters through the Earths crust. The detectors have three main components: the Arduino Nano, scintillator and silicon photodetector. When a traveling muon passes through the scintillator it produces a light. This light is detected by the photodetector, measured throughout the circuit by the Arduino Nano.

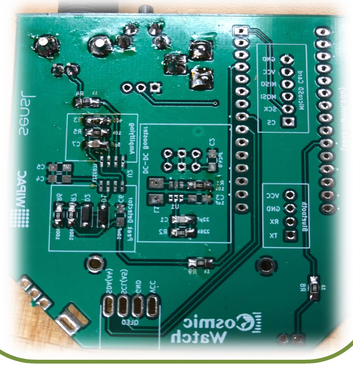
Cosmic Ray



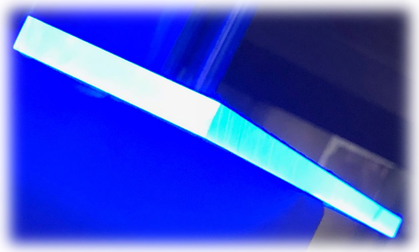
Methods

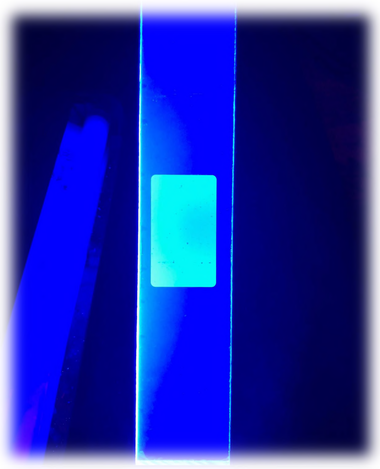
Five detectors were assembled by soldering resistors, capacitors and microchips onto a silicone PCB board. Then a code was uploaded into the Arduino Nanos. The plastic scintillator was machined to 5x5x1 Cm, rough cut sides were sanded, then the sides were flame polished for transparency. Four holes were drilled for mounting onto the photodetector board. The detector were taken to different locations to monitor muons.

PCB Board



Scintillator

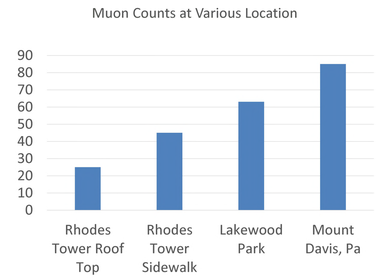




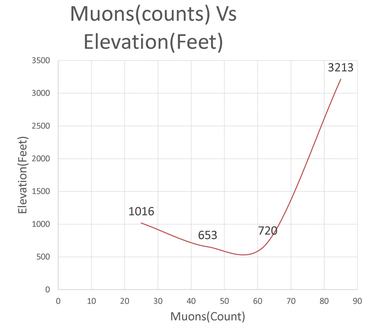
Results

The detectors were taken to Lakewood Park, Mount Davis, sidewalk and roof top of Rhodes Tower. Mount Davis had the highest numbers of count in the 15 minutes. While Rhodes Tower is primarily built with steal and concrete this could have affected the readings due to the magnetic field of the structure. In addition, to measuring muons the detector also detects background radiation.

Data



Location	Counts	Elevation(Feet)
Rhodes Tower Roof Top	25	1016
Rhodes Tower Sidewalk	45	653
Lakewood Park	63	720
Mount Davis	85	3213



Radioactive Source

Conclusion

Five detectors were built and fully functional. Data was recorded in various locations. Our findings found that muon density changed with elevation as well as infrastructure. Buildings interfered with muons trajectory causing less count rate versus open areas. By finding other applications for the detectors, and there usefulness can allow for future study of muons at Cleveland State University.

References

[1] https://github.com/spenceraxani/CosmicWatch-Desktop-Muon-Detector

[2] http://tandem.nipne.ro/~muon1/detector/

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