39th Annual Conference of the Canadian Nuclear Society and 43rd Annual CNS/CNA Student Conference The Westin Hotel, Ottawa, ON, Canada, 2019 June 23-29

Muon event detection via the use of simple hardware and an Android app

JD. Donev[1], CM. Ma[2], JN. Ngo[3] and OQ. Qureshi[4]

University of Calgary, Calgary, Alberta, Canada

soquresh@ucalgary.ca

An Undergraduate Level Submission

ABSTRACT

Muons are elementary particles that constantly bombard the Earth's surface. Teams at MIT were able to construct and provide blueprints for a 'household level' muon detector which needs to be hooked to desktop PCs [1]. The work was further extended at the University of Calgary by allowing the muon detector to instead be able to communicate with mobile devices (such as Android phones). This allows the previously immobile detector to take readings at a range of locations to see comparisons in the muon event rates. Ten-minute trials with the detector were ran at 51.08 lat,-114.13 long, at the top floor of a 13 floor building (approx. 1200m above sea level), then in the basement of said building and then outdoors to see the effects of elevation and ceiling material on muon events. We were able to note readings of 1278, 1856 and 25 and 2600 muon events for basement floor, top floor and outdoors respectively. Further UI development to the Android application can set the foundation for becoming a valuable lab exercise for high school level students.

1. Introduction

One of the fundamental particles in the lepton family are known as muons, μ. The paper is interested specifically in 'cosmic muons' which are produced when high energy cosmic particles such as protons collide with molecules in the upper atmosphere. This results in the production of pions π which decay into the muons μ we are interested in. It is noted that persons having greater amounts of time at higher elevations will be exposed to greater amounts of muon events [2].

As such, our household muon counter is to detect muons created as a 'shower' in the Earth's atmosphere. Physicists are interested in muon collisions because they are used in surface-based particle physics experiments in order to commission and calibrate detectors before they are exposed to beam produced by accelerators. On the other hand, many particle physics experiments are looking for rare events, and the rare signal can be swamped by the muon signal. Those experiments then must be located in deep underground laboratories [3]. It can then be noted that lower elevations with greater roofing material lowers the muon event detection, which is what we investigated in our small experiment.

2. Android application development

As a team of computer scientists, we worked on extending the already established physics foundation of the muon detector and focused on getting that detector to be able to communicate with mobile devices. This led to the development of an Android application from scratch as our May 2018 term project for a software engineering course. Using agile methodologies, each weekly meeting helped sculpt the final minimum viable product (MVP) through iterative feedback. The application was made in Android Studio. Testing of the application was performed using both PC emulation and a physical Android tablet. We first created a simple user interface with a title menu and recording screen, which allows the user to begin collecting data:

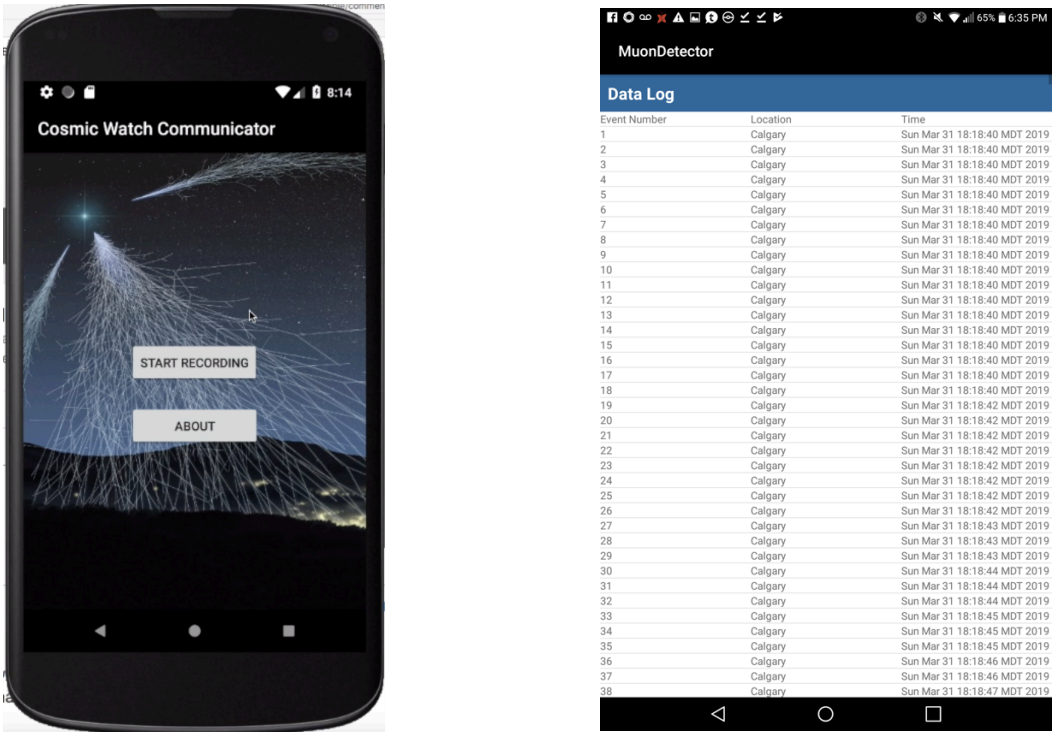

Figure 1: Android application that communicates with the muon detector

The main challenge after this was determining how to connect the muon detector to an Android device. A USB interface was chosen as the simplest method to implement. We eventually were able to communicate with the FTDI Arduino board used in the muon detector. This allowed us to successfully read data from the detector as comma separated values (.csv) and display it on the Android device.

By the end of the term, we had a usable app that received data from the muon detector and displayed details about muon event detection onto the screen. We continued the project after course completion, adding features such as the event log screen to show detailed information about each muon event such as date stamps. This led to us designing our own simple experiment.

3. Experiment discussion

Given our research for the physics behind muon events, we wanted to test whether the effect of elevation along with building material would be noticeable on the readings. We ran six ten-minute trials with the muon detector; one in the basement floor, another at the top floor and the last outdoors on the ground floor. A few of those runs are attached:

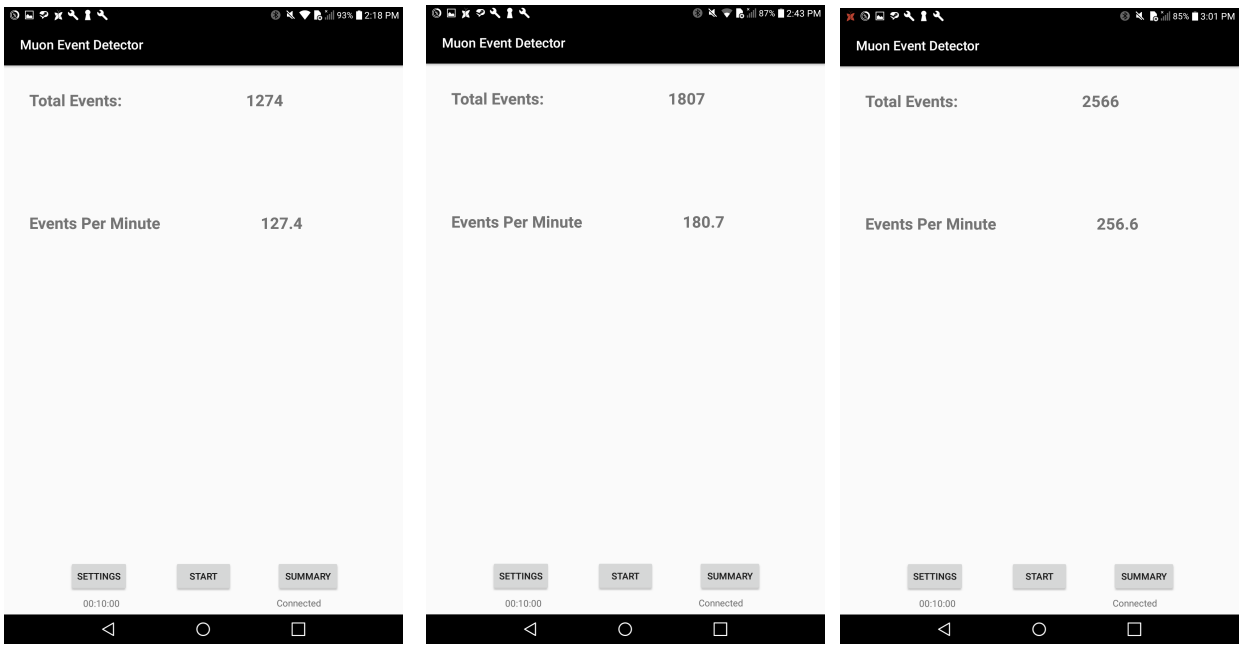

Figure 2: Initial runs of basement floor (left), top floor (middle) and outdoor (right) muon events over a ten-minute interval

In addition to the above, two readings were taken at each location. The average amount of muon events detected per minute at the basement floor were 127.8, 184.6 for the top floor and 260 for the outdoor reading.

We noted that the amount of material above the detector (mostly being cement) did indeed cause fever events to be detected due to interference. The number of events shot up significantly (by about 45%) when readings were taken at the top floor, and more so outside in the open with no material overhead the detector. This leads us to believe that rather than elevation, the greater factor on the reading is the amount of material overhead the detector. For a future experiment, we hope to get access to the very top of ceiling of the building so that we can compare height effects more accurately.

4. Conclusion

The newly developed Android application allowed for the previous stationary detectors that had to be tied to an immobile desktop PC to become transportable and to be allowed to take readings in multiple locations. We were able to explore one such case with how ceilings at the same elevation interfere with muon arrival events. Further experiments that explore varying types of ceiling material or varying elevations can now be explored. In addition, we plan to continue invest our time into polishing the application from a UI perspective and adding more features/functionality, such as the detection of latitude and longitude coordinates. We also want to be able to export the data from these mobile devices onto the cloud where they can be further processed in an application like Excel for example, since we are able to format them as comma separated values (.csv files).

We also believe that construction of the muon detector through the use of very simple, easy to acquire parts would make for an excellent lab exercise for high school students. Through the use of our application, they may be able to explore around and take varying readings across the building to note how changes in elevation and roofing effect muon events.

5. Acknowledgements

The team would like to acknowledge Dr. Zahra Shakeri who provided us with the opportunity to pursue such a project in her software engineering course. Jordan Hanania, a former fellow student, contributed to the hardware end for developing the muon detector inhouse [4]. Finally, S.N. Axani, J.M. Conrad, and C. Kirby from MIT on the blueprints for the construction of the muon detector at our campus [1].

Figure 3: Muon detector connected to an Android tablet

6. References

[1] S. Axani, J. Conrad, and C .Kirby, “The Desktop Muon Detector: A simple, physics-motivated machine- and electronics-shop project for university students,". Available: https://arxiv.org/pdf/1801.03029.pdf

[2] United Nations Scientific Committee on the Effects of Atomic Radiation, “Sources and effects of ionizing radiation” in *UNSCEAR 2008 Report*. New York: United Nations (published 2010). Available: http://www.unscear.org/docs/publications/2008/UNSCEAR_2008_GA-Report-CORR.pdf

[3] Sanford Underground Research Facility, accessed: Mar 28, 2019 http://sanfordlab.org/

[4] J. Hanania, “Development of a desktop muon detector,”. University of Calgary 2016