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The purpose of this experiment is to determine the mean lifetime of a muon through the two-paddle collection process. A muon's lifetime is approximately 2.2 microseconds. It was hypothesized that the longer the trial, the closer the average of a muon's lifetime would be to 2.2 microseconds. One- and two-hour long sessions were performed; one hour being the minimum requirement for data collection and two hours being doubled that time. Using the QuarkNet site averages for the muon lifetimes were collected and analyzed. The average for one hour was 3.582023938 and the two-hour average was 2.704854922. It supported the hypothesis that the longer the trial, the closer it would be to 2.2.

Introduction - The lifetime of any particle is the time required for that particle to decay; for muons, the accepted lifetime is 2.2 microseconds. This experiment is to determine the average lifetime of a muon based on a one-hour and two-hour study. It is said that the longer a trial could be held for, the closer the average of a muon's lifetime would be to 2.2 microseconds. This experiment will incorporate the use of a standard two-paddle setup in a stacked horizontal position, the program HyperTerminal for data collection and the QuarkNet site for data analyzing.

Procedures - Using the standard two-paddle setup for muon data collection, I would use HyperTerminal to collect the data over a one-hour time period and two-hour time period. I ran five trials for each period of time. After having collected the data, it would be uploaded to the QuarkNet site and have a lifetime study done on it; and by using a lifetimeOut file, found within the analysis directory, I would average out the lifetime of the muons in that collection.

Results - The average lifetime of a muon is about 2.2 microseconds. It is also said that the longer the trial, the closer the lifetime of the muon would be to 2.2 microseconds.

Discussion and Conclusions - In conclusion, the results supported the hypothesis. One-hour collection trials had a mean of about 3.582023938 microseconds. For two hours, the mean was about 2.704854922. It is seen that the longer the trial was held for, the closer the average mean would be to 2.2 microseconds. Though, it was still very much off. In a future study, it would be better to run a trial for even longer and determine how long a trial should be to get as close to 2.2 microseconds.

Radioactive Material: How does radioactive material (Americium-241) affect muon counts?

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I'm trying to see if radioactive material will affect the muon's path through the paddles. To test this, I will place Americium-241 between the paddles and then collect data and compare.

Introduction - The purpose of this project is to see if radioactive material will affect muon counts. I am going to put radioactive chips of Americium-241 between the paddles of the particle detector to see if the muon count will dramatically change. I hypothesize that the muon count will decrease with the presence of the Americium-241.

Procedures - Using a normal two-paddle setup, collect data from 9:00 A.M. to 2:00 P.M. for three days. After testing three days, put the radioactive chips of Americium-241 between the two paddles. Then collect data from 9:00 A.M. to 2:00 P.M. for three days. Analyze and compare the results.

Results - If the muon counts using the radioactive chips are very different from the muon counts without the radioactive chips, then the Americium-241 did affect the way muons traveled through the paddles. If not, then the radioactive chips had no effect.

Discussion and Conclusions - I was not able to upload the data because the website was down. Therefore, I cannot complete this project.

Muon Counts: Estimating Muon Counts Dependent on Paddle Distances

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The purpose of this experiment is to estimate muon counts dependent on the distance between the two paddles of a particle detector. I believe the greater the distance between the paddles, the less number of muon counts. To test this, I will collect data with the paddles at different distances and form a graph and an equation. Then I will test a distance and see if the equation can predict a muon count close to the muon count I actually collect from testing.

Introduction - The purpose of this experiment is to estimate muon counts dependent on the distance between the two paddles of a particle detector. The independent variable would be the distance between the paddles and the dependent variable is the number of muon counts. I am assuming that the greater the distance between the paddles, the less number of muon counts. I'm hoping to form an equation that can predict the muon count for any distance between paddles without extrapolating.

Procedures - Collect data, using HyperTerminal. (The muon detector I used was a standard two-paddle set). Collect the data in one-hour increments beginning at 9:00 A.M. and ending at 12:00 P.M. There should be three different trials (9-10,10-11,11-12) for one day. Collect for three different days. On day one, make the distance between the paddles 37 cm*. On day two, make the distance between the paddles 74 cm. On day three, make the distance between the paddles 111 cm. (*One can use any distance as long as they are all equally spaced. I used what was available to me.) After collecting, use Excel to graph your data and create a line of best fit. Use its equation to predict the muon count at a certain distance between paddles. Then actually collect data and test that distance between paddles and see if your muon count is close to the predicted muon count.

Results - If the muon count one actually records is close to the predicted muon count, then the equation is successful and one can predict muon counts in a reasonable range. If the actual muon count is not close to the predicted muon count, then this experiment did not work and the equation cannot be used to predict the number of muons.

Discussion and Conclusions - Unfortunately, I could not analyze any data because the website was down. Maybe when the website is up and running, someone can try to test an experiment similar to this one to see if it is successful.

A Comparative Flux Analysis of Vertical and Horizontal Detector Paddles

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In this experiment, a muon detector consisting of two paddles will be placed in two different positions. The first position will be with the paddles both standing upright in a vertical position. The second position will be with the paddles both lying down in a horizontal position. Data will be recorded using the muon detectors to see if the positioning of the paddles affects the flux.

Introduction - Muons are charged particles classified as lepton particles. The earth is bombarded by millions of these particles every day. Muon detectors are used to measure the flux of these particles. Normally, muon detectors are placed lying in a horizontal position. The purpose of this experiment is to see if placing the muon detector vertically causes a variation in the flux of the muons.

Procedures - The muon detector paddles will be placed horizontally and data will be recorded hourly. Then the muon detector paddles will be placed vertically and data will be recorded at the same hourly rate as horizontally. A performance and flux analysis will be done and then the findings will be compared.

Results - When the paddles were in a horizontal position, the flux was around 2500 flux (events/m^2/60-seconds). When the paddles were in a vertical position, the flux was ~3000 flux (events/m^2/60-seconds).

Discussion and Conclusions - After analyzing the data, it is clear that the flux is higher when the paddles are placed in a vertical position. The flux is 500 greater when placed vertically then when placed horizontally. A reason for this observation could be that as muons enter earth's magnetic field, they accelerate to the opposite pole. For this reason, the paddles being positioned vertically allow for more muons to hit them then when placed horizontally.

Number of Hits vs. Distance of Paddles

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The purpose of this experiment is to prove whether or not the distance between scintillator paddles affects the amount of muons detected. Several tests were done, all one hour in duration, to prove the validity of the hypothesis made. A bookcase was used to spread the scintillator paddles out into three different lengths. These paddles are first connected to photomultiplier tubes then to a data acquisition board (DAQ), where the muons will be counted. The sensitivity of the paddles can be adjusted by using knobs on the black box attached to the DAQ. In this experiment, only the "hits" will be registered. A "hit" is a muon that goes though both paddles at nearly the same time.

Introduction - A muon can be described as an unstable particle similar to that of an electron but much heavier. Muons only exist for less than a second before they decay—2.2 microseconds to be exact. These unstable particles were discovered in 1936 and were originally thought to be electrons, but further studies proved otherwise. These heavier particles are able to penetrate deeper into atoms through the help of cosmic rays that are constantly hitting the atmosphere. These rays can be detected through the use of a particle detector; in this case, two scintillator paddles and a DAQ were used. Since a "hit" has to pass through both paddles at nearly the same time, will increasing the distance between the paddles decrease the number of hits?

Procedures - Gather materials needed (2 scintillator paddles, 2 photomultiplier tubes, DAQ connected to a computer). First, set up the paddles so that they are on top of one another. Adjust knobs on black box so that both of the lights are flashing similarly. Open up HyperTerminal and begin test for exactly one hour. After one hour has passed, stop the test and upload this data onto the QuarkNet website and analyze. Adjust knobs if needed. Once both channels have nearly the same amount of hits, move one scintillator paddle down to approximately 39.4 cm. Run another test for exactly an hour, and move the paddle down another 35.6 cm. Analyze results.

Results - As predicted, the number of hits is inversely related to the distance between scintillator paddles. As the distance between paddles increases, the number of hits decreases. However, as the distance between the paddles increases, the muon count decreases at a decreasing rate. With

each test, the count dropped less dramatically than the one previous. This is shown in Figure 1, as the slope of the line gets less steep as the test progresses.

Discussion and Conclusions - Increasing the distance between paddles proved to cause a decreased number of hits (shown in Figure 1). Having a greater distance between paddles causes the muons to travel a longer distance, making it harder for the muons to reach the second paddle. If this project were repeated, more heights at a slightly smaller interval should be used. This would create a more accurate study and a better graph.