Nondestructive Analysis of Geological Sites Through Muon Transmission Imaging

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Muons are elementary particles produced by cosmic radiation that have a very consistent flux, making them useful for experimentation. Muons have been used in experiments to detect magma flow in volcanoes and discover new chambers in pyramids. Similarly, this project aims to detect changes in muon flux when observing a cliff or mountain, providing a way to discover caverns without physically altering any terrain. After measuring the rate of muons over a variety of angles, the data taken at the cliff can be compared to expected results calculated by a computational model. Irregularities could indicate a region of low or high density, which might imply the existence of a cavern or area of high density rock. Preliminary data was used to create a statistical model to predict trends in muon flux. This model was then compared to experimental data taken at Bandelier National Monument. The experiment counted muons for 48 hours at a certain angle before changing the angle to look at a different slice of the cliff. Due to time constraints, data was collected up to 65° and is currently still being collected. The statistical model followed experimental data, but further analysis implied that a greater spacing is needed between the detectors in order to improve resolution. Next, a simulation was created in C to replicate real world conditions. The simulation calculates the distance traveled by a muon using raycasting and then calculates the minimum energy to travel that distance. This method determines relative rates of muons based on the environment, and matches the data taken at Bandelier well. Both the simulation and the statistical model agree that a greater spacing between detectors is needed to see finer detail on the cliff, which has been changed for our current experiment.

Awards Won:

Second Award of $2,000