Measuring and Modeling the Energy Spectrum of Cosmic Ray Muons

Ionkov, Phillip (School: Los Alamos High School)

Lestone, Anthony (School: Los Alamos High School)

In 1912, Victor Hess observed cosmic rays for the first time. With his discovery, physicists were able to detect and theorize new particles such as the positron, muon, and pion. Hess' discovery of cosmic rays effectively created the field of particle physics. This project aims to measure the energy spectrum of muons created from cosmic ray interaction. One can calculate the minimum energy needed to pass through an amount of lead, so if more and more lead is added, the difference in counts as lead thickness increases will be the number of particles with the calculated energy. Therefore, with enough lead, one can accurately measure the energy spectrum of all muons that are produced from cosmic rays. This project attempts this through a physical experiment and a Geant4 simulation. The physical experiment observes particles over 24 hours. The experiment is conducted with 11 inches of lead, incrementing by 1 inch each time. There exists a hadronic component that needs to be accounted for, however. An equation was used to model the fall-off of these hadrons as lead thickness grew. The model followed experimental data, but the calculated nuclear interaction length of the hadrons was small compared to the known value. The Geant4 model aimed to replicate results from the physical experiment in a theoretical representation of the system. The current model creates a muon of energy 2 GeV and sends it through a set amount of lead 1000 times. It runs the experiment with up to 12 inches of lead at 1 inch increments. The energy is then set to 4 GeV and 6 GeV. The fall off in muon energy from the simulation gives explanation for the error in the physical experiment. This simulation is incomplete and will be improved to generate results similar to the results of the physical experiment.