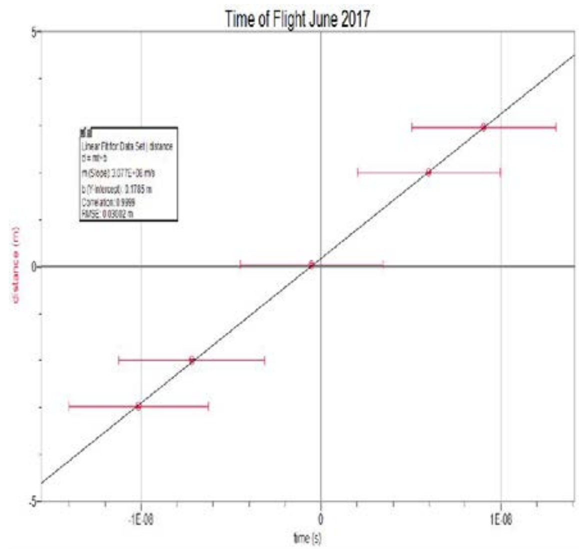
UC QuarkNet Annual Report Information
September, 2017

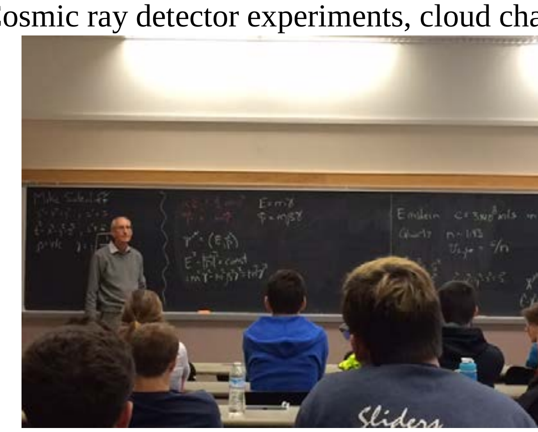
It was a busy year for the QuarkNet group at the University of Cincinnati. Two teachers participating in International Cosmic day organized by DESY on November 5th

The summer workshop was held at Summit Country day school. Two teachers spent 4 days building a jig for the muon speed experiment and for the eclipse experiment for the summer. One teacher built a tracking telescope to take the experiment to the totality path in Tennessee while the other used the muon speed jig to participate with a fixed telescope that stayed in Cincinnati.



Results from the muon speed were very precise but gave a speed 3.08 x 10^8 m/s with a correlation r=0.99 and RMSE= .03.

On Saturday January 21th five teachers and 25 students participating in a LHCb masterclass held at the University of Cincinnati. UC physics Majors helped with teaching multiple stations including Rolling with Rutherford, Fermilabyrnth games, Cosmic ray detector experiments, cloud chamber, and E&M apparatus. Mentor Mike Sokoloff gave his famous talk on relativity and Dr. Henry Schneider conducted the data analysis.



On March 3rd, eighteen physics students, along with their teacher Jeff Rodriguez, from Anderson High School participated in the LHCb Masterclass with Firenze, Barcelona, Paris, and Suceava. On March 12 sixteen physics students from McAuley High School with their teacher Lisa Nissen participated in the LHCb Masterclass with Marseille, Genova, Valencia, and Milano Bicocca.

From March 13-17, Two Quarknet teachers joined others around the world in sharing their flux data in the sixth annual International Muon week.

Four high school students completed a 6 week internship working on a research project at University of Cincinnati. Two high school juniors was from a suburban high school and one high school senior was from an inner city public school and one junior from a Catholic high school. They split into two groups. One group worked with MINOS data while the other worked with LHCb data.

The purpose of MINOS research this summer was to understand how long-baseline neutrino experiments, like MINOS, analyze detector data to extract neutrino oscillation parameters. By utilizing the ROOT Data Analysis Framework, they first learned basic properties and differences of different types of neutrino interactions through Monte Carlo (simulated) data. Neutrinos interact with other subatomic particles through the weak force. Charged current (CC) interactions occur when a neutrino of any flavor converts to its partner charged lepton (e.g.) through exchange of a boson. Neutral Current (NC) interactions take place when a neutrino interacts with a Z^0 boson yet does not convert into a charged lepton. Unlike CC events observed in the detector, NC events all look the same no matter the neutrino flavor and therefore are insensitive to neutrino oscillations and are removed from the oscillation analysis. I developed a selection method based on the event length of separate NC and CC events. I then fit the MINOS data reconstructed energy spectrum to a Monte Carlo spectrum oscillated with different sets of values for the oscillation parameters. The best-fit value for $sin^2(\theta_{23})$ is almost 1 and the best-fit parameter for Δm^2_{32} is 0.0022, closely matching the MINOS published results. The study of these neutrino oscillations could potentially help us solve the long-standing puzzle of matter-antimatter asymmetry.

The purpose of the LHCb research was to identify signal and background events in decay channels of nuclear particles that have been recorded but never seen by humans, such as $D^{*+} \rightarrow D^0 \pi^+ \rightarrow K^- \pi^+ \pi^- \pi^+$, $D^{*+} \rightarrow D^0 \pi^+ \rightarrow K^- \pi^+$, D^0-bar $\rightarrow K^+ \pi^- \pi^+ \pi^-$, and $\Lambda_c^+ \rightarrow pK^- \pi^+$. Along with executing codes through ROOT data framework on terminal for analyzing different decay modes and amount of signal and background events being attained, we also used Mathematica to estimate the % of Lambda C^+ and D^+ remaining at certain times of the decay. Furthermore, by using the terminal, we produced 1D and 2D histograms to test cuts of actual decay variables (D^0_M, D^*_M, Dbar_M) on other variables such as IPCHI2, FDCHI2, PT, ENDVERTEX, TAU, and TAUCHI2. We found that D^0_TAU > .275 ps cut on D^0_M, Dbar_FDCHI2 < 100 on Dbar_M, and Lambda C^+ > 1.5 ps integrate cut along with D^+_TAUCHI2 < 2 ps cut on D^+_M on invariant mass distribution eliminate the most background events and let the most signal events pass through allowing the decay to complete without surrounding distractions. We are fairly certain that the events classification is not entirely precise due to experimental reduction and statistics; however, after this research period, we are sure that the variables stated above will yield the highest signal events and minimize the number of background events. This research is a starting point for an extensive further research that would clean up the decay channels stated in the beginning. Further research can use these findings to verify how precise these variables are as well as recording the accurate measurements of the cuts that need to be placed.