

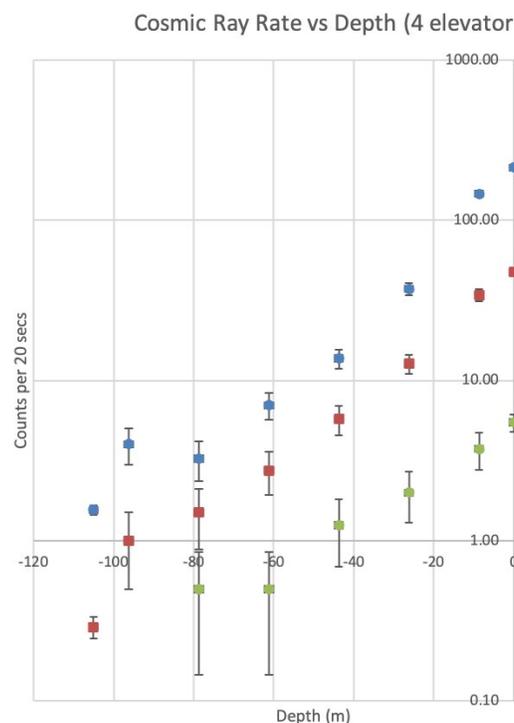
Department of Physics
University of Illinois at Chicago
845 West Taylor St.
Chicago, IL 60607
Tel: (312) 996-3403

Report of QuarkNet Activities at UIC during 2018-2019

The QuarkNet Program at the University of Illinois at Chicago and Chicago State provides mentoring, organization, and collaborative structure to students and teachers at ten Chicagoland high schools that host cosmic ray detectors. UIC provides detectors so that schools can carry out physics experiments based on detecting cosmic ray muons. During yearly summer week-long workshops new students are recruited and trained. Back of the Yards High School joined the Center this year.

MUSE

Throughout the entire year, six schools carried out an experiment at Fermilab to measure cosmic ray rates in the MINOS tunnel 105m underground as a function of distance from the access shaft. A proposal was submitted in December 2018, approved in March 2019, and data-taking took place from March through May 2019. Preparation began during last year's 2018 summer workshop where muon rates were studied as a function of overburden. Students decided to develop a proposal during the fall and to submit TSW-1548 to Fermilab before winter break. Cosmic Ray Fellow Nate Unterman serves as spokesperson. Prototypes were developed during the winter. Analysis was carried out during several meetings May through August. Initial results were reviewed at the July summer workshop and presented at the International Cosmic Ray Conference in Madison in July. Final results will be presented by teachers and students at the AAPT conference in Orlando Jan. 2020. Participants were also excited to observe neutrino interactions with their detectors in the MINOS tunnel. Results from a secondary goal of measuring cosmic ray rates versus depth is shown below, along with a photo of collaboration members.



MUSE Collaborators at the MINOS access shaft.

Students and teachers from the 2017 QuarkNet Eclipse project submitted an article on their cosmic ray measurement to *The Physics Teacher*. The article has been accepted pending responses to reviewer comments.

Summer Workshop

The UIC summer workshop (July 8-12, 2019) was attended by three teachers and seven students. It was hosted at New Trier High School. Research groups with participants mixed from five high schools carried out two separate studies: the speed of muons and the rate of multiple muons in cosmic ray air showers. For the shower study two detectors were configured in nested tetrahedrons and the Shower e-Lab tool was used to correlate the detectors in time. In each detector three counters were configured horizontally in an equilateral triangle to study rates versus separation distance with the fourth detector completing a pyramid. Participants measured the rate of single versus multiple muons at two different sized pyramids. Using relative timing and positions of the scintillators, a mechanical model was used to reconstruct the direction of showers that contained at least three muons. Data was well documented and will be available for study by other Centers in the future.

The Fermilab industrial campus was toured midweek where participants learned about the superconducting magnet facility. The D0 experiment was also toured and the Standard Model discussed. Students used the rolling with Rutherford activity to estimate the size of scattering objects, improving their results with several levels of correction factors.

During the next grant period UIC and CSU will continue to visit high school sites to mentor teachers and students and help them carry out experiments utilizing their cosmic ray detectors. Additional

analyses will be performed with the MUSE data. The Center will host a week-long workshop next summer at UIC, as well as sponsor a winter weekend mini-workshop at a local high school.

Adams is a member of QuarkNet staff. He coordinates Cosmic Ray Teacher Fellows and continues to upgrade the e-Lab analyses.

Mark Adams
UIC Professor Emeritus of Physics

Edmundo Garcia
CSU Professor of Physics