

Department of Physics
University of Illinois at Chicago
845 West Taylor St.
Chicago, IL 60607

Report of QuarkNet Activities at UIC during 2020-2021

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-CSU has provided detectors so that schools can carry out physics experiments based on the detection of cosmic ray muons. The 2021 summer workshop was held at New Trier High School July 9-12, with masking and distancing protocols in place for COVID.

Moon Shadow

During the year, teachers Unterman and Valsamis, and mentor Adams developed a new experiment to attempt to measure the shadow of the moon in muons at the earth's surface. Teachers and their student-teams designed and built two support frame prototypes for our cosmic ray telescopes. Unterman's team collected preliminary data. The largest uncertainty in upper limits of muons coming from the sun determined in our 2017 eclipse project (to be published early 2022) is the location of the shadow, since no astronomy group has reported an observation at low energy. If the shadow can be observed, it will allow us to improve our measurement during the next eclipse in the U.S. in 2024. The hope is to involve many other Centers as well.

Students and teachers also finished analyses and submitted two articles on MUSE (Muon Underground Shielding Experiment at MINOS) and the 2017 Eclipse project to *The Physics Teacher*. The articles are scheduled to appear in early 2022.

Summer Workshop

The UIC summer workshop (July 9-12, 2021) was attended by four teachers (one virtually) and one student. Mentors Adams and Garcia, and staff Dave Hoppert also participated. Jason Grey, a new energetic teacher from Proviso West, learned about CRMDs and cosmic ray e-Lab analyses from the experienced teachers. He brought his school's ancient detector hardware for testing. It was decided to ship him a standard CRMD. How to involve more students in these research efforts was also discussed.

Four talks were presented: Dark Matter (virtually by Baxter, Fermilab); NAUM project to image the inside of the pyramids at Chichen Itza (Garcia, CSU); how to use the simple experiment data base (Unterman, NTHS); and Advance Lifetime capabilities (Adams UIC). Experiments explored a simple speed measurement, a muon decay prototype for the g-2 project using AdvanceLifetime tools, and the moon shadow.

The main focus was on assessing the design of the moon shadow experiment. Data was collected in various telescope configurations. There were exciting discussions about the shadow's location and how to optimize the signal over the normal muon rates. A permanent location was identified for New Trier's detector.

The detailed moon shadow design covered: assessment of two prototype frames, data collection at various zenith angles; discussion of alignment criteria in order to optimize shadow signal over the noise from the normal muon rate; measurement of the two-muon background at angles near the horizon; database of moon position over time; data format to be used to extract shadow signal; and signal to noise estimates.

The biggest advance was achieved by using a globe to visualize cosmic ray deflections with respect to a detector fixed on the surface, combined with a discussion of a paper reporting on a Monte Carlo of cosmic ray deflection¹. The group used that information to modify the detector geometry and alignment plans.

Unterman and Adams continue to collect standard data sets for cosmic ray analyses in e-Lab for QuarkNet groups who don't have a detector or current accesses to their detector. These have proven very popular for teachers to use with their classrooms throughout the country during the pandemic.

During the next grant period UIC-CSU will continue to mentor teachers and students and help them carry out experiments utilizing their cosmic ray detectors. The Center will collect moon shadow data and has scheduled a half-day workshop in January, 2022. The Center hopes to host a week-long workshop next summer at UIC.

Adams is also a member of QuarkNet staff. He coordinates Cosmic Ray Teacher Fellows and continues to upgrade the e-Lab analyses, using the UIC-CSU Center as a testbed for new projects. Garcia has returned from his term at NSF and plans to reenergize efforts at some of our schools on the south of Chicago.

Mark Adams
UIC Professor Emeritus of Physics
Tel: (630) 508-7459

References:

1. Storini, M., Smart, D.F. and Shea, M.A, *Cosmic Ray asymptotic directions for Yangbajing (Tibet) experiments*, International Cosmic Ray Conference, 2001.