# Report of QuarkNet Activities at UIC and CSU during 2021-2022

The QuarkNet Program at the University of Illinois at Chicago and Chicago State provides mentoring, organization, and collaborative structure to students and teachers at eight 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. A slightly reduced 2022 summer workshop, focused on developing analyses for the Moon Shadow, was held at New Trier High School August 10-11.

**Publications from previous projects:**

During the fall, students and teachers finished analyses on MUSE1 (Muon Underground Shielding Experiment at MINOS) and the 2017 Eclipse project2. Articles on both appeared in *The Physics Teacher* January 2022.

**Moon Shadow**

During the year, teachers at five locations have been collecting data to attempt to measure the shadow of the moon in muons at the earth’s surface. After a first assessment of results the group determined that the orientation of telescopes should remain fixed at a unique zenith angle for each school. This avoided realignments that were necessary every two days to track the moon’s position at its meridian crossings. The group currently collects data for the Moon Shadow experiment at four zenith angles: 70, 60, 55, and 26 degrees. This project addresses the largest uncertainty in upper limits of muons coming from the sun determined in our 2017 eclipse project. No astronomy group has reported an observation of the shadow at low energy3. 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.

**Summer Workshop**

The UIC summer workshop (August 10-11 2022) was attended by two teachers and four students. Standard analysis procedures for the Moon Shadow experiement were developed. Initial results will be shared among school groups in a fall meeting. We abandonded our regular summer workshop format because of last minute teaching changes, plus one teacher was still involved in his CERN internship.

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. These were created for teachers to use with their classrooms throughout the country during the pandemic and remain very popular.

Teacher Valsamis has recruited a large number of students interested in QuarkNet activities beyond our normal cosmic ray.

**Pyramid**

Garcia is principle investigator of an experiment that is building a scintillation tracker to image the interior of the pyramid at Chichen Itza. It is planned that data will be hosted on QuarkNet’s e-Lab; be available to all users. We anticipate that high schools in the UIC-CSU Center will participate in the calibration process during the next academic year.

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| Mark Adams  UIC Professor Emeritus of Physics | Edmundo Garcia-Solis CSU Physics Professor  Associate Provost of Research and Grant Administration |

## References:

1. Eleanor Anne Winkler, Paul Graham, Nathan A. Unterman, et al., Beyond the Classroom: Profiling Muon Flux in Relation to Overburden in Fermilab’s MINOS Tunnel, Phys. Teach. 60, 110 (2022); https://doi.org/10.1119/5.0025659
2. Tamar A. Dallal, Jacob M. Miller, Michelle Matten, et al., Solar Eclipse and Cosmic Ray Flux, Phys. Teach. 60, 100 (2022); https://doi.org/10.1119/10.0009417
3. Storini, M.*,* Smart, D.F. and Shea, M.A*, Cosmic Ray asymptotic directions for Yangbajing (Tibet) experiments,* International Cosmic Ray Conference, 2001.