

## Idaho State University QuarkNet Activities for 2018

The thirteenth annual ISU QuarkNet Summer Institute was held July 9 - 13, 2018. QuarkNet veterans Enrique Arce-Larreta of Salt Lake City, Utah, Jodie Hale and Geoffrey Williams of Pocatello, Idaho, Brent Mecham of St. George, Utah, Dr. Steven Millward of Grace, Idaho, Lafe Peavler of Ogden, UT, and Keith Quigley of Roy Utah participated this year. During the institute, these Associate Teachers and Dr. Steve Shropshire plateaued each detector, conducted performance studies, and did a preliminary blessing of each CRD. On Monday participants reviewed data and reports from the total solar eclipse that crossed Idaho in August 2017, discussed ways to use the CRDs in the classroom and availability of web/online resources. Experiments were planned for the week investigating effects of magnetic field on CR detection, time of flight, coincidence and flux studies, and a measurement of the speed of light.

On Tuesday Dr. Erdinch Tatar presented on the DUNE experiment and collaboration, supportive work at ISU, and provided a brief overview of other work at Fermilab and Notre Dame. Teachers explored the new LIGO the e-lab, and discussed ways of using the seismology data in Earth Science and Geology classes.

On Wednesday a tour was provided of the Idaho Accelerator Center (IAC) by Jon Stoner, Director of the IAC. Teachers arranged their CRMDs to run various experiments overnight. A few groups tried some variation of the Time of Flight, while the rest spread the channels at various distances to measure showers.

On Tuesday, Wednesday, and Thursday afternoon CRMD experiments were prepared for overnight collection, with data upload and analysis conduction the following mornings. Time of Flight experiments were tried in various configurations. The issue of having a positive mean or a negative mean was explored. (Are there a lot of muons traveling through the earth?) If the channels are spaced close together, then it might be reasonable to conclude that there are multiple strikes on the channels from different muons and many from off normal paths. The channels each have an error in the time measurement. When calculating the time difference in the two channels, one should see a systematic (repeatable) result. To compensate for the measurement error it becomes necessary to switch the positions of the channels. The resultant data should provide a reading that has switched the error difference. The average of the two switched measurements should eliminate the error. One attempt to eliminate the additional muons included looking for 3 fold coincidence in 3 channels, while using the data from 2 channels. A second attempt included using two channels placed vertically and voiding any data from the coincidence of the vertical plate with the horizontal. There were also three shower studies that were ran and data collected. One study involved looking at channel separation at a given height to ascertain if there is a preferred spacing to detect showers. Two other groups arranged their channels in a spread out configuration but in two separate rooms. The point of their experiment was to look for showers between the two individual systems. The routines were then run multiple times with different settings to ascertain what was being calculated within the routine. Gate widths were also adjusted to look for statistical possibilities of time delay errors.

On Thursday and Friday teachers worked on posters and lesson plans of how they would use the CRMDs in their classrooms. Lesson plans and posters were presented to the group on Friday.

A study suggested for next year is to have stacked systems on each floor of the four story building. Using the shower routine, find the events that are from the “same” muon. The time of flight could theoretically be calculated on an “individual” basis. Can the routine be modified to do many days, or multiple detectors?

During the fall of 2017 and spring of 2018, all eight of the Associate Teachers who participated in the 2017 Summer Institute each used one of the eight ISU detectors to introduce their students to particle physics. All Associate Teachers who participated in the 2018 Summer Institute, as well as Robert Frankowiack (who could not attend this year), will use one of the ISU detectors in this fashion in the fall of 2018 and spring of 2019.