

The University of Iowa

Quarknet 2018 Summer Institute

Principal Investigator:

Dr. Yasar Onel

Associate Professors:

Dr. Jane Nachman, Dr. James Wetzel

Teacher\Mentors:

Michael Grannen

Students:

Adam Edwards, Max Herrmann, Logan Quick, and Joshua Turner, Mizuki Wittmer, Roger Wittmer

During the summer of 2018 The University of Iowa gathered the assistance of 6 students from Bettendorf High School for entry level research and lab experience in the High Energy Physics Department. Dr. Yasar Onel, Dr. Jane Nachtman, and Dr. James Wetzel gave the research topics to the students, and Bettendorf High School teacher Mike Grannen guided the research. The four research topics included data collection by muon detectors, to search for a correlation between solar activity and muon flux; construction of a black box and photomultiplier tube (PMT) holding apparatus for 6 large scintillating panels; experimental error measurements to expand on research from 2017 and 2016 summer Quarknet institutes involving the recovery of quartz scintillating cubes; and lastly using a virtual machine to analyze data from the CMS experiment at CERN to look for unique decay which could signify the detection of a new particle.

Muon Detector:

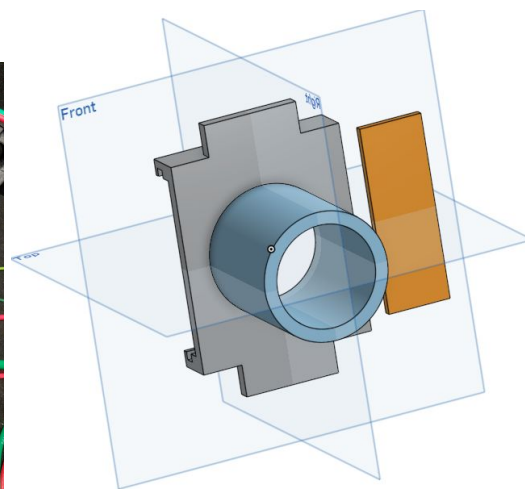
The University of Iowa stores a few Quarknet Muon Detectors over the years which are available to be taken by science teachers to use in their classroom and expose their pupils to particle physics. The Bettendorf students spent the first part of the summer connecting all of the different detectors to a computer to make sure that all of the components are in working order. Detector 6115 (Paris) was left set up from last summer, so we initially plateaued this detector and corrected the labels for the potentiometers, since some of the original stickers were falling off, and the values originally on the potentiometer were slightly off from the experimental values. After calibration of Paris, we then looked at the detectors that were still in storage. To check for problems, we switched out one component at a time, making sure that the Data Acquisition Board (DAQ) would still be able to communicate with the computer correctly. After

troubleshooting a few issues, we were able to get all but one detector, 5047 (Carl) up and running and handed off a detector to two high school teachers.

The second half of the summer the students collected data from muons and compared the flux of muons through the detector to changes in solar activity including solar wind, magnetic field strength, and solar wind speed. Data was only collected for 10 days, therefore the results we find cannot be used as strong evidence arguing for a correlation between muon flux and solar activity. However, if data could be collected for weeks or months, then we might be able to find a consistent trend. We learned part way through the summer that the IceCube Observatory in Antarctica could trace neutrinos to blazars in distant galaxies, and further research could be used to compare muon detections to some aspects of blazars observable in the northern hemisphere.

Black Box:

Dr. Onel gave our group six scintillating panels that are each 6 feet long with the goal of constructing an apparatus that would house the panels and could be used to collect data similar to the smaller Quarknet detectors. The students designed, then constructed a 7 foot plywood box, lined the interior with a black fabric, and placed holes to allow high voltage cables and signal cables to pass through the box. The students printed a holder for the PMT which included a back slide to keep the PMT flat against the scintillating panel. The students were able to test the PMTs in the black box using a Tektronix 2467 and search for a signal. We were able to observe the change in the oscilloscope, but could not freeze the display to compare the signal with what the spike should look like. Further study will require the completion of the other 4 PMT circuit boards and a data acquisition board to be able to collect data from all 6 PMTs at the same time.



Scintillating Cubes:

The scintillating cubes testing builds from progress made last summer with the 2017 Quarknet group. Our task last summer was to measure the recovery of irradiated quartz cubes by exposure to ultraviolet light. This summer we took measurements to quantify the experimental error with the measurement setup from last summer. To do this, we repeated the measurement process multiple times to measure the variation of placing the cubes in the apparatus. We found that the 3D printed holder was just slightly larger than the cubes which allowed for the cube to be oriented at a slightly different angle each time we placed the cubes in the apparatus. The difference between being rotated clockwise and rotated counterclockwise results in about a 30 percent difference in the transmission of light through the cube in the UV spectrum. We found that we could gather consistent measurements by rotating the cubes counterclockwise in the apparatus every time when placing the cubes. In the future we could find more ways that might improve our experimental design which could include decreasing the distance between the fiber optic cables and the scintillating cubes.

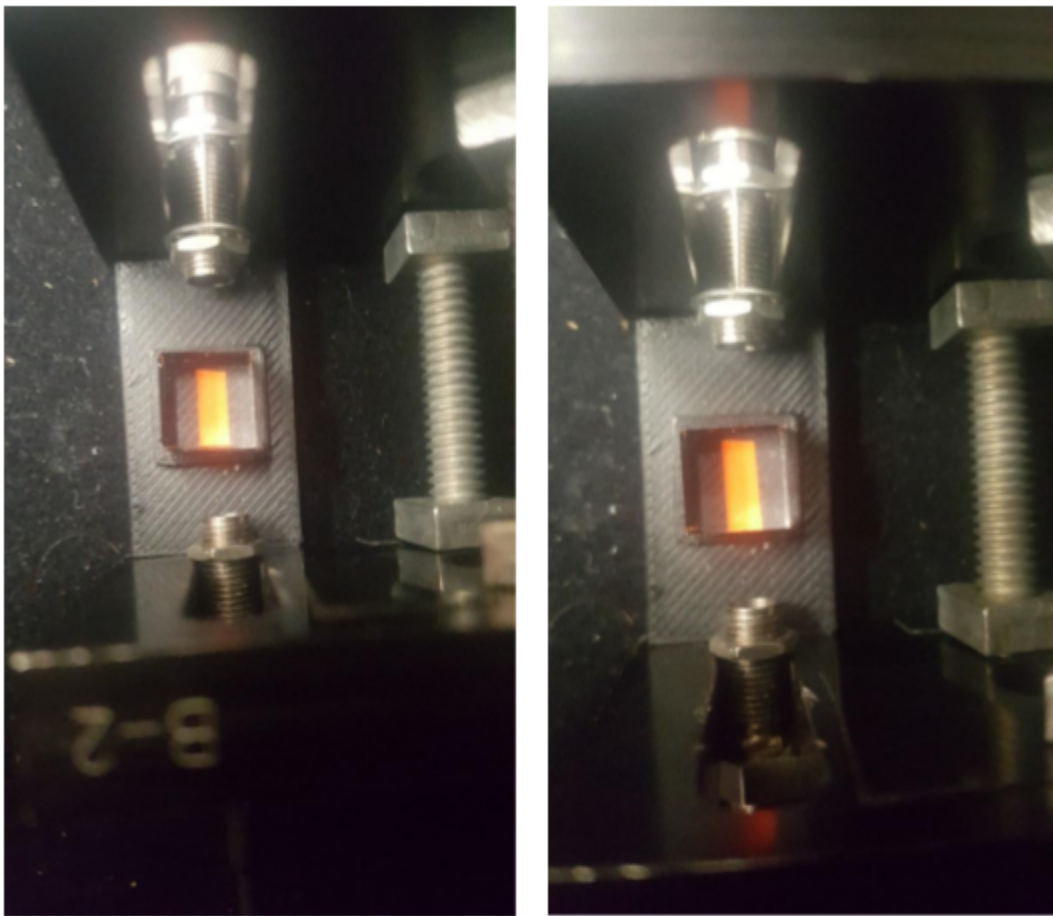


Figure 1: Pulsed light enters from the top of the image through a quartz fiber passes through the cube and enters the quartz fiber at the bottom of the image. The difference in the orientation of the cube is slight, but does affect the results.

Virtual Machine

The virtual machine was used to search for evidence of new particles by sifting through past collisions at CMS and searching for unique events. The first part of the time spent on this project was spent setting up the machine to find evidence of a known particle decay, then after making sure that we understood the code building process, we searched for evidence of a new decay.