QCC QuarkNet Center and Cosmic Ray Group 2018 Annual Report

For period Sep 1, 2017 – August 31, 2018

Participants that were stationed at Brookhaven National Laboratory in the Electronic Detector Group are indicated as **"BNL"**

Teacher from BASIS Independent High School, Brooklyn, NY. Lead Teacher at the QCC Center. During summer 2018 completed a 3 week research appointment at QCC. Studied the Hanlon modification to the Swordy plot of primary cosmic ray flux incident on the atmosphere; from the Swordy plot tried to derive the typically quoted flux rates of secondary muons at sea level of 1 per cm^2 per minute. Conducted a literature search on cosmic ray flux rates - predictions and measurements. Taught students and teachers in the QCC Center how to read flux rate plots.

Teacher from Cardozo High School, Bayside, NY. Lead Teacher at the QCC Center. During summer 2018 completed a 3 week research appointment at QCC. Built cosmic ray telescope stands for stacked counters with adjustable heights; the counters' vertical separation will be changed to measure flux per geometrical acceptance. Working with students measured cosmic ray muon rates in Quark Net detectors as a function of coincidence level, gate width, counter separation, pipeline delay, and number of DAQs.

High school student from Bayside high school. Conducted research in the Center for the summer. Sanded and polished several scintillators that were cut on the water jet and/or shaved on the milling machine. Wrapped the counters in 2 layers of Tyvek and black paper. Built 4 scintillator counters each 30 cm x 30 cm very similar to Quark Net counters. Mated 2" pmts to 2 cm thick scintillators. For all four the pmts are glued to UVT acrylic cookies which in turn are glued to the scintillators. The counters are powered up with HV power supplies.

High school student from a Suffolk County high school (BNL). Conducted research at BNL collaborating with the QCC Quark Net Center for the summer. Tested EMCO G30 LV DC-to-HV DC converters which will be sued to power up pmts.; measured the HV out as a function of LV in for different resistive loads, and the current draw. Drew Gerber files and associated circuit drawing to print a DAQ that we are building for cosmic ray detectors.

Undergraduate Student from QCC. Conducted research at the Center for the entire year. Replaced computers with Raspberry Pis on QuarkNet detectors. Automated cosmic ray EQUIP data upload, and download, from the Raspberry Pi to Drop box. Figured out how to run pressure and temperature environmental sensors with an Arduino; these will be used in a cosmic ray DAQ we are building.

Undergraduate Student from QCC. Conducted research in the Center for 2 semesters. Wrote Python code to plot Quark Net cosmic ray detector flux data; determined that the few percent

difference in flux between elab plots and plots made with our Python code was due to the different counting methods: elab counts counter hits (both real and noise) where our Python code counts triggered events (i.e. the "80s" and above in the 2nd word of the EQUIP data file).

Undergraduate Student from QCC. Conducted research in the Center for 2 semesters. Drew and simulated a DAQ FE circuit design performance in Multisim including preamp, discriminator, AND gate, and shapers.

Undergraduate Student from QCC. Conducted research in the Center for 1 semester. Learned how various circuit components will work in a detector DAQ we are designing. Drew and simulated a DAQ FE circuit design performance in Multisim including preamp, discriminator, AND gate and shapers,

Undergraduate Student from QCC. Conducted research in the Center for 1 semester. Drew Gerber files and associated circuit drawings to print a DAQ that we are building for cosmic ray detectors. Including analog and digital components, headers and connectors.

Undergraduate Student from QCC. Conducted research in the Center for 1 semester. Designed a webpage for the Cosmic Ray and QCC Quark Net Center.

Undergraduate Student from QCC. Conducted research in the Center for 1 semester. Wrote Python code to plot Quark Net cosmic ray detector flux data; modified the code making it several times faster.

Undergraduate Student from QCC. Conducted research in the Center for 1 semester. Built and tested a power distribution unit (PDU) for a 4 channel cosmic ray detector.

Undergraduate Student from Suffolk County Community College (BNL). While stationed at BNL conducted research in the Center for 1.5 years. Built a dark box to test scintillator efficiency. Measured scintillator efficiency in detecting cosmic ray muons using a muon telescope. Measured counter performance when using a solid UVT acrylic cookies to mate the PMT to scintillator, versus a silicone optical interface-pad cookie. Tested a DAQ FE circuit design in Multisim and in LTSpice, including preamp, discriminator, AND gate, shapers, peak detector, and sample and hold.

Undergraduate Student from Suffolk County Community College. Conducted research in the Center for 2 semesters. At QCC measured cosmic ray muon rates in Quark Net detectors as a function of coincidence level, gate width, counter separation, pipeline delay, and number of DAQs. At SCCC measured muon time of flight.

Undergraduate Student from Suffolk County Community College (BNL). While stationed at BNL conducted research in the Center for one semester. Measured dark rates, gain, and resolutions for several PMTs; organized data taken over the course of a year for 100 PMTs into a reference catalog.

Undergraduate Student from St. John's University (BNL). Completed a 10-week summer internship at BNL; conducted research at the Center for the entire year. Participated in designing a way to build cosmic ray counters. Cut, sanded, polished, and wrapped scintillator counters, mated pmts and installed in dark boxes. Designed a spring loaded assembly to keep the pmt mated to the scintillator. Installed bulkhead power and signal connectors through the dark boxes. Tested and characterized the performance of LV DC-to-HV DC converters (XP EMCO G30) which will be used in detectors. Wrote assembly instructions for scintillator counters.

Undergraduate Student from City College of NY, CUNY (BNL). Completed a 10-week summer internship at BNL; worked in the Center for 2 semesters. Wrote C software to control an Arduino Mega as a DAQ controller and receiver. Programmed the Arduino to work with a GPS antenna/receiver system to time stamp cosmic ray events.

Master's degree student in physics from Queens College. Conducted research in the QCC Center for 1 semester and the summer. Installed LINUX operating system and Corsika Monte Carlo simulation program for cosmic ray showers. Simulated proton collisions in the upper atmosphere at 10^{15} - 10^{18} eV incident energies, made histograms for time of arrival for secondary particles, and scatter plots of shower lateral distributions, muon density as a function of radial distance from the shower center. Updated the MAC OSX on ~ 30 computers at the Center. Documented a procedure on how to run Corsika simulations.

Undergraduate Student from Northern Illinois University. Conducted research in the QCC Center for 5 weeks during the summer. Installed Fedora and Scientific LINUX operating systems, and the Corsika Monte Carlo simulation programs for cosmic ray shower studies. Simulated proton collisions in the upper atmosphere at 10^{15} - 10^{18} eV incident energies, made histograms for time of arrival of secondary particles, and scatter plots of shower lateral distributions (+/- muons, electrons, positrons, gamma rays).

Undergraduate Student from Vaughn College. Conducted research in the Center for 1 semester. Built 3 scintillator counters each 30 cm x 30 cm nearly identical to Quark Net counters. Built the PDU, mated the 1" pmts to 2 cm thick scintillators. For one counter the pmt is glued with optical resin, the two other counters the pmts are mated with optical grease. All 3 counters have a polished solid scintillator cookie glued to the scintillator.

Adjunct lecturer at QCC. Conducted research in the Center for 2 semesters. Assisted in designing a DAQ front end circuit. Supervised various student projects in the circuit design.

Postdoc - Brookhaven National Laboratory Electronic detector Group (BNL). At BNL has collaborated on this project for two years as a lead research advisor; co-mentored all the students stationed at BNL. Setup NIM electronics test equipment to measure PMT gain and scintillator efficiency; designed a Labview program to acquire PMT and scintillator measurement data from an oscilloscope; wrote software in Python, and C++, to fill and fit charge distributions. Supervised 6 student projects over 5 semesters and two 10-week summer

internship programs at BNL; student results include six symposium posters, one conference poster, and one published conference proceeding.

Assistant professor at QCC. Managed all the student and teacher projects within the QCC Quarknet center.