QuarkNet Staff Monthly Report
Activities of December 2019 and January 2020

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Centers

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Ongoing Staff Efforts – In addition to ongoing contacts and discussions, staff reports the following activities:

Catholic University of America – Kathy Race and Ken had an in-depth conversation with CUA mentors Angela McRae and Rachel Bartek on December 11 about teacher implementation of QuarkNet activities, which went into communication and collaboration between workshops within the center.

Fermilab – Kathy Race and Shane had an in-depth conversation with FNAL mentor Angela Fava and lead teacher George Dzuricsko on December 10 centered around the *Center Feedback Form* developed by Kathy. This discussion focused on center activities over the past two years and included reflection on the degree to which center-level outcomes and success factors were met during this two-year interval. This discussion also provided the opportunity to consider ideas for future center activity.

Rice University/University of Houston – Kathy Race and Shane had an in-depth conversation with Rice mentor Frank Geurts and lead teachers Mary Yarbray, Merrill Willgrubs, and Jason Williamson on December 18 centered around the *Center Feedback Form* developed by Kathy. This discussion focused on center activities over the past two years and included reflection on the degree to which center-level outcomes and success factors were met during this two-year interval. This discussion also provided the opportunity to consider ideas for future center activity.

University of Hawaii – Mark discussed detailed geometry changes for Fermilab data with Michael Jones that is being used as part of a nationwide search for storms and investigated how the cosmic ray rate versus atmospheric pressure depends on the number of muons required in the QuarkNet data trigger. Michael also identified several times that flux plots were incorrect. Edit and Mark are using his samples to repair the split errors. Shane met with Michael Jones, Veronica Bindi, and Mary Kadooka via videoconference on January 31 to plan for the upcoming CMS masterclass (March 14) and CMS workshop for teachers (March 15).

University of Florida – Mentor Darin Acosta came to the AAPT Winter Meeting in Orlando (see below) to give an invited talk on CMS for the 21st Century Physics in the Classroom session. He took time over lunch to discuss the center's problems and needs with Ken and others. They took the first steps toward a plan for Summer 2020.

University of Illinois at Chicago – The MUSE (Muon Underground Shielding Experiment) group presented at the AAPT meeting in Orlando in January. The group met at Ida Crown Jewish Academy on December 8 to finalize analysis. A MUSE meeting was hosted by parents on Sunday, January 5, for students, teachers and parents planning to travel to AAPT. Four teams of students and one teacher, Marybeth Sensor, presented results from MUSE at a session on 21st Century Physics in the Classroom at AAPT.

Mark has established contacts with MINERvA collaborators. They have shared monitoring plots that count the number of muons from NuMI neutrino interactions in the rock. In order to assist in calculating the neutrino charged-current cross section, MUSE would like to have a transverse position measurement. MINERvA is willing to calculate that variable, however, MUSE is discussing how to generate the most unbiased result possible.

Mark met with Jacob Miller, the student finishing the *Physics Teacher* article on the 2017 Eclipse Project, during the AAPT meeting. They edited the paper and drafted answers to the reviewers' comments.

University of Minnesota – Shane met with mentor Greg Pawloski on December 17 to discuss Greg's possible contributions toward an activity on neutrino oscillations using data from the NOvA detector. The plan is to have something for Minnesota teachers to try out during their 2020 workshop. During this meeting, Shane and Greg discussed plans for the 2020 masterclass and workshop as well.

University of Notre Dame – Ken participated in weekly teacher meetings on December 9 and January 27. Dan Kallenberg came with Ken on a Notre Dame International excursion to Hong Kong and Japan where he not only showed the CosmicWatch cosmic ray detector (http://www.cosmicwatch.lns.mit.edu/) that he built with students in Summer 2019, but also learned how groups in Asia use similar detectors.

Virtual Center – Ken participated in the Virtual Center videoconference on December 29. He discussed masterclasses and plans for the coming summer with the group.

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Cosmic Ray Studies

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Statistics from Cosmic Ray e-Lab: 644 (597) uploads; 58 (24) plots; and 0 (2) cosmic ray posters during December (January). Staff provided help desk assistance on the following topics: update geometry records for upward muon search; rate vs. pressure dependence on multi-muons; debugging hot CRMD inputs; EQUIP coincidence definitions; debugging "dead" DAQ channels; replacing Macs with Raspberry Pis; use of scalers during plateauing; and CRMD general setups.

Mark collected data with Fermilab WH15W detectors for muon flux, for multi-muon Large Array studies. He will combine the data with New Trier High School data to track speed over months, to be shared via portfolio. The stacked detector at Fermilab (6119) collected data to calibrate relative timing, so a simplified speed measurement is available for the portfolio. Mark also operated a stacked DAQ in his UIC office to develop a search for upward-going muons. The experiment was calibrated and decommissioned on January 6. Mark designed an analysis path for the upward muon measurement and also developed a technique to measure the beam period of the NuMI beam from MUSE data using Excel tools.

Edit and Mark addressed three issues: flux wrong-date errors; current and new lifetime development; and shower post-processing Python tools. They studied date errors in the split process that lead to wrong-day decisions for flux. Edit is monitoring the 90K thresh files to search for any other occurrences. They debugged lifetime, using two types of lifetime data (short and long trigger gates). Code to correct duplicate counting was tested and improved. Lifetime plots were observed to behave as expected. This final code to fix the existing lifetime analysis was

released to production. For the new lifetime, further tests are required, but a template now exists. It will also be used in the upward muon search.

On January 26, Dave and Mark discussed goals and options for inexpensive detectors like the CosmicWatch. They also met with Spencer, Ken and Dan Kallenberg on January 30 to assess the CosmicWatch for use of cheap detectors in classrooms.

In other news, Mark contacted Oregon mentor Ray Frey about reenergizing their cosmic ray effort. KSU teacher Tracie Schroeder is attempting to collect data for tracking storms across Kansas. Mark and Dave sent Tracie a new DAQ after several rounds of debugging via e-mail and her system is now functioning. Dave Hoppert continues to repair units sent to Fermilab due to the U.S. GPS system failure on April 6 and returns them promptly. This task will continue.

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LHC Physics

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Tom and Joel completed updates to the CMS masterclass measurement in the iSpy event display and the CIMA analysis tool, respectively. Ken completed the online documentation and modifications to the CMS masterclass website. Translations of the latter into the other thirteen languages of the website is ongoing. The CMS masterclass workshops in Delhi, Zhongli (Taiwan) and Orlando were great aids in refining the software and the approach. The LHC fellows had a videoconference on January 28 to discuss the changes to the CMS masterclass measurement and orientations in February. They have subsequently sent e-mail messages to express their availability.

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Neutrino Physics

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Ken, Spencer and Shane continue to work with Sowjanya Gollapinni and Nathaniel Tagg to develop a MicroBooNE masterclass. It looks as though there will not be sufficient data available to pilot this masterclass during IMC 2020, so our plans are now to pilot this with some teacher groups this summer.

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Data Activities Portfolio

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Deborah reviewed and updated the activities *ATLAS Data Express, Signal/Noise Cosmics,* and also worked on a QuarkNet-style STEP UP activity based on *Everyday Actions.* QuarkNet staff will build a half-day workshop around STEP UP activities.

Deborah developed an implementation guide for using the data activities. This includes slides showing how to access the Data Activities Portfolio features. Deborah and Joel revised the pull-down menus for the Data Activities Portfolio.

Deborah, Ken and Shane held several scheduled phone conferences to discuss data activity documents and to plan new activities.

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Increasing Diversity

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In a phone conference call between QuarkNet Ambassadors and STEP UP staff, participants agreed that Deborah would build activities following good instructional design criteria and sound staff development principals. In addition, note the workshops in the Outreach and STEAM categories below.

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Broader Impacts

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American Association of Physics Teachers – Shane, Deborah, Mark, and Ken participated in the AAPT Winter Meeting 2020 in Orlando in January. They started before the meeting with a joint AAPT/QuarkNet outreach activity (see below). In the meeting itself, they and Marla Glover facilitated a CMS masterclass workshop. Shane chaired a session on 21st Century Physics in the Classroom, which was so well-subscribed that it became two sessions. The AAPT program chair presided over the second session, in which students and teachers from schools in the University of Illinois at Chicago center made a series of presentations on their Muon Underground Shielding Experiment (MUSE), in which they used QuarkNet cosmic ray detectors to survey muon rates in the MINOS cavern at Fermilab. Further information on the experiment is in the UIC/CSU section of this report. The program chair was impressed enough to ask for another such session in a year. At the end of the AAPT Winter Meeting, Ken stepped down as chair of the AAPT Contemporary Physics Committee (CPC), which hosted the events described here. Deborah Roudebush stepped up from vice chair to chair of CPC, while Marla Glover became the new vice chair and Shane Wood became a member.

International Collaborations – Ken participated as a facilitator in the CodeIndia program for high school students just outside Delhi, where he worked with about 50 students and 10 teachers on an abbreviated CMS data workshop on December 2 and 3. Ken went on a Notre Dame International program (ND-MAP, Notre Dame - Masterclasses Across the Pacific) to Asia in the first half of January; two teachers joined him. The team facilitated a CMS masterclass workshop in Taiwan and an ATLAS masterclass workshop in Hong Kong; they participated in cosmic ray workshops in Japan and Macao and exchanged practices and ideas with teachers and physicists in all the meetings. Ken was involved in several planning videoconferences for the African School of Fundamental Physics and Applications (ASP) and the associated conference (ACP) over December and January. Ken also had videoconferences on December 20 and January 23 with Uta Bilow at TU Dresden to discuss International Masterclasses coordination and also on January 20 with Kazuo Tanaka of Tohoku University to discuss workshops in Japan.

Outreach – Deborah, Shane, and Ken facilitated particle physics workshops at two high schools in Orlando the day before the AAPT Winter Meeting. The visits to these majority-minority schools were arranged by teaching and learning fellow Adam LaMee. These workshops are a collaboration between AAPT and QuarkNet.

STEAM (Science, Technology, Engineering, Art, and Math) – Shane continued his work with artist Agnes Chavez by planning and facilitating a two-day STEAM workshop for 60 students at Milagro Middle School in Santa Fe, New Mexico, on January 27–28. The student population at

Milagro is majority-minority, with a high number of English-language learners. During this initial two-day phase of the *(I=)UNIVERSE STEAM* workshop, students were immersed in particle physics activities and demonstrations and learned how to use Tag Tool, an iPad-based app for creating projection art. In subsequent phases of this workshop, students will continue to use art to weave together ideas from particle physics and Native traditions/ways of knowing with Agnes, along with Lakota cultural specialist Steve Tamayo, physicists Nicole Lloyd-Ronning (LANL) and Steve Goldfarb (CERN-ATLAS), and Tag Tool developer Markus Doringer. The student projection art that is created in this workshop will be on display during the *Innovation EXPO: Full STEAM Ahead* event on February 13, 2020, and during the Santa Fe Institute Interplanetary Festival coming up in August 2020.