Staff members meet remotely every Tuesday to discuss QuarkNet matters in general and every Wednesday to discuss technical issues. In addition, the staff reports the following activities:

**QuarkNet Educational Discussions (QED)** – In August, the staff launched a biweekly series of Wednesday evening Zoom chats for QuarkNet teachers to talk about teaching in the new environment of the 2020 academic year. This continued with a meeting on November 11.

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# Centers

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**Hampton University/George Mason University/College of William and Mary** – The "Virginia Center" had a workshop via Zoom on November 21. This included a talk on gravitation as an emergent phenomenon by mentor Josh Erlich and work on two data activities: Making Tracks II and Particle Transformations, both relatively new. Ken and Mike Fetsko teamed up to facilitate, and Josh helped throughout.

**University of Illinois at Chicago** – While developing responses to reviewers for a *Physics Teacher* article on the 2017 eclipse, we uncovered a discrepancy in modeling of the effect of the earth's magnetic field on low-energy cosmic rays among several astrophysics collaborations. UIC-CSU decided to attempt to measure the low-energy cosmic ray shadow of the moon directly. Mark drafted notes on the expected azimuthal shift and the design criteria required to measure the shift of the shadow with respect to the moon's actual position. UIC plans to construct a prototype. Fellows discussed a possible multi-center effort.

**University of Notre Dame** – Notre Dame continued online teacher meetings each Monday in November except November 30 in recognition of Thanksgiving. The last meeting before the holiday included an in-depth discussion of the Project GRAND cosmic ray experiment.

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# **Cosmic Ray Studies**

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Statistics from e-Lab: 708 cosmic ray uploads, 29 cosmic ray plots, and 4 cosmic ray posters during the October 29 to November 30, 2020 interval. Data captured with a newly designed report finds 3,463 analyses run (in analysis-day units) on 1,659 files during the same period. Mark provided help desk assistance for teachers on the following topics: replacement of CRMD components, muon rates during the upcoming 2020 eclipse, measuring the moon's shadow, and controls available in the Lifetime module. Mark continues to collect data with DAQ 6674 located in his home. He developed cuts for an upward muon analysis leading to a first low statistics measurement of the up/down muon ratio:  $1.3 \times 10^{-4}$ . Backgrounds due to abnormally large signal pulses are still under study. In the main e-Lab effort, Mark is developing a new Lifetime module with enhanced user controls with Edit. A small number of events from DAQ 6674, identified as decays, were uploaded to e-Lab to test the module's logic. The muon selection stage is complete.

Mark contacted g-2 colleagues again because several fellows would like to build a prototype g-2 experiment. Brendan Casey offered technical help from Fermilab and Dave Hertzog, University

of Washington, shared a senior lab writeup that he developed at UIUC. The team developed a test prototype design and began a search for free copper for a muon-stopping layer. Cindy Joe of the Neutrino Division offered MINOS scintillator planes that are otherwise being thrown out during decommissioning. Mark wrote a note detailing how planes could be used in QuarkNet projects, and Spencer arranged for planes to be saved for QuarkNet.

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# LHC Physics

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The two main efforts in LHC Physics were World Wide Data Day (W2D2) on November 12 and the ramp-up of International Masterclasses. Shane and Ken helped teachers prepare their students for W2D2, and Ken scheduled videoconferences and moderators. Ken and Shane, with an assist from Joel Klammer, shepherded W2D2 2020 videoconferences on November 12. There were 15 videoconferences that day with about 40 schools around the world (15 from the U.S.) participating in data analysis. There were 17 videoconference moderators from around the world (7 from U.S. institutions). Shane and Ken also held videoconference tests for W2D2 participants.

Ken also updated the LHC and Neutrino Libraries for International Masterclasses 2021—this work continues—and launched registration for Fermilab-based masterclass videoconferences. The fellows and international collaborators helped as well; please see below.

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# **Neutrino Physics**

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Spencer, Ken and Shane had a Zoom meeting on November 19 with David Martinez of South Dakota School of Mines and Technology and David DeMuth of Valley City State University and several of their colleagues to discuss plans and progress for a future DUNE masterclass. The group plans to continue meeting periodically in the future.

Spencer, Ken, and Shane had a Zoom meeting on November 11 with Kevin McFarland, Rob Fine, Andrew Olivier of Fermilab, and the University of Rochester to discuss future stewardship of MINERvA Masterclass data.

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# Fellows

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The LHC and Neutrino fellows met on Zoom on November 3 and 17. They assisted in both the run-up to W2D2 and in lessons learned afterwards. The fellows discussed good practices for remote online masterclasses for IMC 2021 and helped Ken prepare the LHC and Neutrino Masterclass Libraries for 2021, now live.

The Cosmic Ray fellows met on November 10 and discussed the following topics: lessons from remote teaching; W2D2, ideas for new activities (g-2, moon shadow to address the azimuthal angle shift of shadow versus momentum; material science platform; SiPM R&D); *Physics Teacher* paper submissions; coordination with Coding fellows; Cosmic Watch; December eclipse in Argentina; pyramid tracker use for U.S. 2024 eclipse; Snowmass contribution, and the upcoming Advisory Board meeting. Nate Unterman is investigating whether an MRI magnet could be used.in the g-2 effort. He is investigating a Cosmic Watch from Notre Dame to assist teachers in Argentina with their measurement on December 14.

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# Data Activities Portfolio

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Deborah met with Ken, Shane and Adam to set priorities for the next few months for activity development for the Data Activities Portfolio.

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#### Increasing Diversity

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Deborah and Shane also participated in their respective regional STEP UP meetings. Deborah and Shane developed a survey to obtain feedback from QuarkNet teachers who were trained at workshops last summer. The survey was designed to determine if teachers had implemented any of the lessons and allow the teachers to provide written feedback.

Fermilab Lederman Science Center staff members have established a partnership with the American Indian Center (AIC) of Chicago. On November 18, Mark was invited to AIC to consider participating in QuarkNet cosmic ray activities as part of the UIC-CSU center for a pyramid imaging project.

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# **Broader Impacts**

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**International Collaborations** – Ken continued the collaboration with Archana Sharma of CERN and Life Lab Foundation to build a program for QuarkNet India. They met on Skype on November 2 and November 30, and Ken put together a QuarkNet India group on the QuarkNet website; Archana and Ken collaborated on a Google document for planning.

Ken met with Uta Bilow of TU Dresden on Vidyo on November 6 to plan International Masterclasses 2021. Uta and Ken collaborated on two informational circulars for IMC mentors and tutors and had a videoconference with Francesca Carnesecchi and her colleagues from INFN on November 19 to discuss their participation in Introduction to Masterclasses for their DarkSide contribution. They also met online with Sven Menke of Max Planck Institut on November 24 to discuss how his project to create Monte Carlo maps of radiation from ATLAS might connect with IMC. Ken is interested in how this might lead to a QuarkNet data activity as well. Ken and Uta chaired the Expanding Masterclasses Working Group meeting on Zoom on November 30 in preparation for the upcoming IPPOG meeting.

Please note the international contributions to W2D2 in LHC Physics above. In addition, Ken worked online with moderator Andrea Gozzelino of INFN Legnaro to produce a video interview about the W2D2 measurement on November 4.

**Snowmass Process** – On November 24, Mark presented to a group organized to develop a white paper on cosmic ray efforts in public education and outreach for Snowmass 2021.

**STEAM (Science, Technology, Engineering, Art and Mathematics)** – On November 16, Mark presented an article on STEAM implementation at the Fermilab Education and Public Engagement journal club. On November 23, Shane met with Agnes Chavez on Zoom to discuss future collaborations, including the next iteration of *Projecting Particles* workshops: *Space Messengers,* which will take place in 2021.