

QuarkNet Staff Monthly Report  
Activities of June, July, and August 2023

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

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**Centers**

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**Lead Teacher Workshop** – Ken, Spencer, and Shane facilitated a workshop on June 10-11 at the University of Notre Dame. Thirteen lead teachers from nine QuarkNet centers shared successes, discussed challenges, and helped staff update documentation for lead teacher expectations.

**Black Hills State University/SURF** – Charlie Payne worked with SURF Education and Outreach staff Chad Ronish and Peggy Norris to provide coding and dark matter workshops on July 5-7. Along with center teachers, they led activities for the public during Neutrino Day events on July 8.

**Boston Center** – The center met August 9-10 at Roxbury Latin School. Ken joined lead teachers Rick Dower and Mike Wadness in facilitating the New Questions in Particle Physics Workshop. Rick added several original elements that enhanced the workshop. The greatest enhancement came, however, on the second day, when Fermilab live streamed the announcement of the new results of the g-2 experiment: the teachers learned about g-2, watched the live stream and talked about it over lunch. Given the time taken by the Fermilab announcement, the group did a shorter version of the W mass activity using a python notebook completed by cosmic ray fellow Nicole Preiser (see below). They finished with implementation plans and a videoconference with Kathy Race.

**Brookhaven National Laboratory/Stony Brook University** – Ken, mentor Dmitri Tsybychev, lead teacher Gillian Winters, and LHC fellow Jeremy Wegner met via Zoom on June 12 to plan the workshop set for June 26-29. Part of the plan was a neutrino workshop built around the NOvA masterclass; as a neutrino fellow was not available, Jeremy was pressed into service given his relevant coding skills and familiarity with the MINERvA neutrino masterclass. Jeremy, Ken, and Shane met on Zoom on June 19 for further planning. On June 20-21, Jeremy facilitated the neutrino workshop to great success.

**Catholic University of America** – Ken met with mentors Katryna Andrusik and Angela McRae on Zoom on July 13 to finalize plans for the CUA workshop, which took place July 17-21. The workshop was partly on Zoom and partly asynchronous. On the first day Ken joined from the University of Mississippi to help them get started. The second day was at CUA: Mark and Ken joined via Zoom to make presentations—Mark on cosmic rays and Ken introducing accelerators and detectors. The teachers got to see both up close on July 19 during their field trip to Jefferson Lab. Ken joined the workshop on July 20 and 21 to facilitate activities, including an experiment with Cosmic Watches and implementation plans with a virtual visit by Kathy Race.

**Colorado State University** – Shane met via Zoom with lead teacher Cherie Bornhorst on July 24 to plan for the 2023 center workshop that will take place in October.

**Fermilab/University of Chicago/College of DuPage** – Spencer and neutrino fellow Mike Plucinski facilitated a NOvA Data workshop at Fermilab on August 3.

**Florida International University** – Shane met via Zoom on June 13 with mentor Jorge Rodriguez and lead teacher Russ Harcha to plan summer activities. They decided that 2023 would be a planning year, and the focus would be to add an additional lead teacher and recruit more teachers

during the 2023-2024 school year. On August 1, Shane met with Jorge Rodriguez, Russ Harcha, Jorge Barrasso (new lead teacher), Joerg Reinhold, FIU Physics Department Chair, Peter Markowitz, FIU Physics and Geoff Potvin, FIU STEM Transformation Institute to strategize for teacher recruitment and to plan for future center activities.

**Florida State University** – On July 26, Shane facilitated a CMS Data Workshop. Also, participants discussed strategies on how to recruit additional teachers for future center activities.

**Hampton University, College of William and Mary, and George Mason University** – Lead teachers Maria Niland and Mike Fetsko and mentor Josh Erlich had a videoconference with Ken on July 10 to prepare for their workshop at William and Mary on August 2-4. Four veteran teachers met on the first day to finalize plans. They were joined by eight more teachers, mostly new to QuarkNet, on the following two days. Ken helped lead the workshop on August 3 and connected in the morning on August 4 via Zoom from Virginia Tech.

**Idaho State University** – On July 26, Ken and LHC fellows Mike Wadness and Maria Niland led the New Questions in Particle Physics Workshop, followed by implementation plans with Kathy Race on Zoom. As usual for this center, members had spent the previous two days on cosmic ray studies with cosmic ray fellow Robert Franckowiak and returned to cosmic rays at the end of New Questions with a presentation by Enrique Arce-Lareta on understanding the output from the QuarkNet Cosmic Ray Detector DAQ. The teachers wrapped up their activities on the morning of July 27.

**Johns Hopkins University** – Coding fellow Peter Apps joined the center's July 24-28 workshop to facilitate a Coding workshop.

**Lawrence Berkeley National Laboratory** – The LBNL center had their large online student/teacher workshop in June. Ken arranged an ATLAS masterclass experience for the group for June 23, 26, and 27. LHC fellow Mike Wadness led everyone through the first segment, and Ken facilitated the final two segments.

**Purdue University** – Ken and lead teacher (and LHC fellow) Marla Glover had a videoconference on June 22 to discuss plans for the summer workshop. The workshop was on July 28-29 with Paul Sedita leading the teachers in a NOvA data workshop. Ken joined on July 29 to assist and meet the new teachers.

**Purdue University Northwest** – Coding fellow Tracie Schroeder joined virtually in the center's June 26-30 meeting to facilitate a coding workshop.

**Queensborough Community College** – The “smallest center” had its workshop, consisting of cosmic ray detector research by mentor Raul Armendariz and lead teacher Steve Barton August 14-18. Ken visited on August 14. Raul and Steve demonstrated measurements they were making from newly-commissioned cosmic ray counters with Ken participating. They discussed the future of the center, and how it was poised to grow. Ken promised to come out to help with a masterclass.

**Rice University/University of Houston** – Shane and Ken met via Zoom on June 6 and June 15 with Rice/Houston mentors Frank Geurts and Darin Acosta and lead teacher Mary Yarbry to plan activities for their upcoming workshop June 19-23. Coding fellows Tracie Schroeder, Chris Hatten, and Kayla Mitchell led IRIS-HEP coding activities for the first three days. Shane was there on Wednesday-Friday, and facilitated a World Wide Data Day workshop on Thursday. Ken came for the last day so they could pilot part of the New Questions in Particle Physics Workshop.

**Rutgers University** – Rutgers had a teacher- and mentor-led student workshop July 5-18. On July 7, Ken facilitated a student investigation of lepton universality using WW data from the OPAL experiment in LEP. This was refined a bit and adapted for the New Questions in Particle Physics Workshop.

**Southern Methodist University** – Shane met with mentor Durdana Balakishiyeva on June 2 to discuss plans for the summer 2023 session which was held on June 26-30. Coding fellow Peter Apps led a coding workshop. Peggy Norris, SURF retired, led an in-development dark matter workshop. Ken came on the final day to develop and pilot the New Questions in Particle Physics Workshop.

**Syracuse University** – Shane met via Zoom with mentor Steven Blusk and lead teachers Michael Madden and Brian Bealer on June 8 to discuss plans for summer 2023. Shane went to Syracuse on August 14-16 to facilitate CMS data and MINERvA data workshops.

**Vanderbilt University** – Mentor Bill Gabella and Ken met online on June 8 to discuss the upcoming Vanderbilt workshop that took place June 19-23.

**University at Buffalo** – Shane facilitated a NOvA data workshop on August 17-18.

**University of Alabama** – Coding fellows Joy Breman and Megan Alvord led a Coding Workshop June 5-7. This was the inaugural workshop of this new center. Ken came on June 7 to assist the facilitators and meet the teachers and give a brief overview of QuarkNet. Ken had a follow-up Zoom discussion with mentor Sergei Gleyzer on June 14.

**University of California Irvine** – Shane and neutrino fellow Mike Plucinski led coding and NOvA data workshops on July 12-14.

**University of California Santa Cruz** – Ken met via Zoom on June 8 with UCSC mentor Jason Nielsen and staff members Natalie Hultgren and Laura Bakken to discuss plans for increasing center activity.

**University of Cincinnati** – The center had its workshop June 20-22. On June 20-21 Ken facilitated a Higgs discovery workshop and supported the new mentor, Conor Henderson, and the new lead teachers, Martin Wells and Emily Rosen. Ken also participated via Zoom with the teachers in their presentation of implementation plans on June 22.

**University of Illinois Chicago/Chicago State University** – A summer workshop took place June 14-15 at New Trier High School, with a focus on the Moon Shadow analysis. The group identified and corrected errors in students' excel spreadsheets and discussed shadow results from all four zenith angles. They decided to declare no signal observed and are estimating upper limits. The group worked on drafts for student presentations of visualization of the Moon Shadow technique, for AAPT in New Orleans. Since the group has held recent workshops at high schools, a half-day workshop took place July 23 in New Trier High School, with a focus on posters about the Moon Shadow analysis for AAPT. Mark returned all the electronics borrowed for QuarkNet from Fermilab PREP over the last two decades.

**University of Minnesota** – Shane met via Zoom on June 20 and July 31 with mentor Greg Pawloski and lead teachers Jon Anderson and Karin Foss to plan for the summer 2023 workshop. The workshop held on August 9-10 focused on CMS data and new questions in particle physics. Several new teachers joined this year's workshop.

**University of Mississippi** – Ken and LHC fellow Joel Klammer facilitated a pilot Belle II data workshop at Ole Miss on July 17, using what they had previously learned about Belle II data from mentors Lucien Cremaldi and Jake Bennett. Jake was on hand for the workshop to introduce KEK, Belle II, and B physics and to offer support. Also, Ken provided a QuarkNet introduction for Ole Miss and, simultaneously, for Catholic University via Zoom.

**University of New Mexico** – Shane met with New Mexico artist/educator Agnes Chavez and Cosmic fellows Nate Unterman and Nicole Preiser on June 19 to continue planning for the 2023 summer workshop. The workshop ran from June 26-29, and focused on cosmic ray studies, STEAM, and using augmented reality (AR) in educational settings. Agnes led the STEAM/AR

portion of the workshop, introducing teachers to her work, and giving teachers the opportunity to build AR experiences they could use in their classrooms. Shane, Nate and Nicole ran the cosmic ray workshop that included an experiment to measure the rate versus altitude during a tram excursion at Sandia Peak that involved three DAQs. Teachers developed a schedule to share their detector; QuarkNet plans to ship them a second detector. Mark discussed with Nate carrying out a special relativity measurement by Kayla Mitchell using the Sandia Peak data. Shane met with Agnes and Nate online on August 25 and 29 to plan cosmic ray detector activities at the Albuquerque Balloon Fiesta this coming October.

**University of Notre Dame** – Dan Kallenberg and Jeff Chorny met with Ken on June 8 to discuss plans for cosmic ray studies and detector testing (especially the Cosmic Watch) in the summer. Ken was the nominal mentor of the Cosmic Ray Studies effort in Notre Dame QuarkNet summer research, though the actual work was done by teachers Jeff Chorny, Dan Kallenberg (Cosmic Ray Fellow), and, in part, Jeremy Wegner (LHC Fellow) along with two high school students. Ken helped them set the direction on experimenting with the Cosmic Watch in particular. Ken used their contributions in a poster (presented virtually and asynchronously) and a proceedings paper for the International Cosmic Ray Conference, ICRC 2023 in Nagoya, July 30 to August 3, for which they are co-authors. Also, the teachers will be co-authors on an upcoming talk that Ken will make in September for the African Conference on Fundamental and Applied Physics, ACP 2023, in South Africa. Ken attended the final summer 2023 presentations for the Center on July 28. On August 25, Ken visited Rebekah Randall at Canterbury High School in Fort Wayne to pick up a cosmic ray detector. They discussed ideas for approaching computer science teachers with QuarkNet activities and data they can use in their classrooms.

**University of Oklahoma** – Ken facilitated a shortened New Questions in Particle Physics Workshop for the OU and OSU centers July 24 and 25. Neutrino fellow Paul Sedita facilitated a short NovA data workshop on July 25. There were so many new QuarkNet teachers that Ken, Paul, and the mentors emphasized some particle physics basics as well. The meeting at OU continued on July 26 with a share-a-thon, implementation plans, and wrap-up.

**University of Puerto Rico Mayagüez** – Coding fellow Danelix Cordero-Rosario led an IRIS-HEP supported short virtual workshop with former QuarkNet teacher-turned university faculty Daniel Gutiérrez for 12 area teachers July 10-12.

**University of South Dakota** – The center held a STEM workshop on July 17-18. LHC fellow Susan Wetzler was scheduled to attend in-person to help facilitate, but due to flight cancellations, had to attend remotely. Shane and Ken met via Zoom on August 3 with mentor Jing Liu and lead teacher Nolan Ortbahn. They discussed next steps in forming the new center and lead teacher expectations.

**University of Washington** – Coding fellows Tiffany Coke and Chris Hatten worked with mentor Shih-Chieh Hsu to plan greater engagement with the area K12 community and met two area teachers to discuss coding and the QuarkNet program on July 10-12.

**Virginia Polytechnic Institute and University Center and Virtual QuarkNet Center** – LHC fellow Mike Wadness and Ken facilitated a New Questions in Particle Physics Workshop for Virginia Tech and the Virtual Center on August 4. Ken was in-person at Virginia Tech while Mike and Ken connected via Zoom with the Virtual Center. Also, they connected virtually with William and Mary for the opening talk by mentor Camillo Mariani. Mike came up with a clever way to do one of the activities that had relied on whiteboard or chalkboard work online. Ken challenged some members of the Virtual Center to complete a W mass python notebook he had started, as they are the better coders. Cosmic fellow Nicole Preiser rose to the challenge and sent Ken a completed notebook a few days later. Ken used this notebook in the Boston workshop the

following week. Also, Ken had a chance to discuss future activities with Camillo and lead teacher Rebecca Jaronski.

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## **Coding**

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Coding fellows led the weeklong Coding Camp 1 (virtual) and Coding Camp 2 (at Fermilab) along with coding sessions at three centers' workshops (Southern Methodist University, Johns Hopkins University, and Purdue University NorthWest) and five IRIS-HEP-supported short workshops at University of Alabama, University of Washington, Rice University, University of Puerto Rico Mayaguez, and the virtual Coding Camp 0. IRIS-HEP increased funding in 2023 to allow for the addition of five short workshops to reach a broader audience and make more space to include marginalized teachers and teachers of primarily marginalized students. We've had to grow the number of coding fellows from 8 to 14 to support the significant increase in workshop offerings. This benefitted the program with a larger pool of teacher leaders and a larger pool of workshop facilitators.

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## **Cosmic Ray Studies**

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During June, e-Lab users made 664 cosmic ray uploads, 40 cosmic ray plots, and 6 posters. An Analysis Report finds 7934 analyses run (in analysis-day units) during the same period. The number of days each analysis was run are 20 Flux, 11 Lifetime, 6 Advanced Lifetime, 2 Performance, 8 Shower, and 6 Time-of-Flight. Mark provided help desk assistance for teachers on the use of geometry files and EQUIP and PyEQUIP installation.

During July e-Lab users made 287 cosmic ray uploads and 41 cosmic ray plots. An Analysis Report finds 2250 analyses run (in analysis-day units) during the same period. The number of days each analysis was run are 19 Flux, 21 Lifetime, 3 Advanced Lifetime, 7 Performance, 16 Shower, and 4 Time-of-Flight. Mark provided help desk assistance for teachers on the following cosmic ray topics: EQUIP and PyEQUIP installation, format of Flux output files, finding a detector in Britain, unfolding rate measurements due to detector acceptance, decoding raw data, ST output line format, shower output file format, and controls for Rate vs Pressure.

During August e-Lab users made 384 cosmic ray uploads, 16 cosmic ray plots, and 3 posters. An Analysis Report finds 1888 analyses run (in analysis-day units) during the same period. The number of days each analysis was run are 13 Flux, 19 Lifetime, 5 Advanced Lifetime, 2 Performance, and 3 Shower. Mark provided help desk assistance for teachers on the following cosmic ray topics: decoding raw data, implementing trigger veto, suggesting new cosmic ray experiments, and controls for Rate vs Pressure.

QuarkNet summer student interns were resident at Fermilab for seven weeks. Under mentoring of Edit and Mark, Jensen and Brian developed event displays and a website for the pyramid project. Jensen read in simulated data and ran parameter files, produced 2D tracker displays and monitoring plots using a Jupyter notebook. Brian produced a 3D view of the detector, found tracks and the pyramid. Everything was integrated into a web page hosted in the e-Lab at <https://i2u2.org/elab/cosmic/pyramid>. After wowing the NAUM collaborators with their displays, the interns presented their research to teachers from the Fermilab/UC/DuPage Center at the end of the summer.

Jensen and another QuarkNet intern Yashas carried out a detailed research project: measuring the muon rate dependence on air quality, correcting for pressure, humidity, and temperature effects. They drafted a paper intended for Fermilab publications which Mark edited, and to which final modifications are being made.

Mark continues to collect data with three detectors: 6119 for upward-muon search data, 6148 for large shower array data, and 6674 for Moon Shadow data.

Cosmic fellows met August 30. Discussion topics included summer workshop planning, Nicole shadowing other facilitators, pyramid project progress and the April 2023 *Physics Teacher* article by Don Lincoln. They also discussed radio horns, the Moon Shadow and Kansas Storms experiments, and planning for 2023 and 2024 eclipses. At the May meeting Joe Wise gave a talk about his Radio-CRMD project, on location from Butan. Nate has obtained permission from his school to build four radio horns. Nate facilitated at the UIC and UNM workshops. Nicole shadowed Nate at UNM.

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### **LHC Physics**

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Ken visited Fermilab on July 13 and 14, where he met Don Lincoln to discuss presenting the g-2 experiment, attended several sessions of Data Camp—and gained insights from the teachers that he later used for the W-mass activity—and sat in on the final session of the CMS Open Data Workshop presented jointly by CERN and Fermilab. These sessions fed into further development of the New Questions in Particle Physics Workshop. In general, development of this workshop was ongoing throughout the summer, improving almost every time it was offered. Elements of this workshop will be made into Data Activities and then be cemented into future workshops.

The LHC fellows met with Ken on Zoom on June 13 to go over summer plans to facilitate and develop workshops. Ken had a videoconference with LHC fellow and Boston lead teacher Rick Dower on June 19 to discuss development of the New Questions in Particle Physics Workshop. They went over some of the concepts and how to use ideas first expressed by the Rice/Houston mentors; Rick developed some ideas for later use in the Boston workshop. On August 23, the LHC fellows and Ken held a virtual mini-camp to brainstorm and work on issues related to International Masterclasses 2024, preparations for which will begin in October. Ken demonstrated a new Google sheet for the CMS Masterclass, inspired by a similar sheet used in the Belle II masterclass, to possibly replace CIMA. The group also spent a lot of time discussing a fundamental revision to the masterclass videoconference. They came up with a plan similar to one the neutrino fellows had discussed. Ken rounded out the mini-camp with ideas about LHC fellows creating data activity documents and new workshops.

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### **Neutrino Physics**

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The Neutrino fellows met with Spencer and Shane on June 20, July 25, and August 22 via Zoom to plan for and to debrief neutrino-based workshops at centers. The group continues to improve the NOvA masterclass measurement based on feedback from teachers and students.

Spencer and Shane met via Zoom with Anne Norrick and Tanaz Mohayai on June 12 to plan for their involvement in the Fermilab-Brookhaven Exchange Workshop for undergraduate students. Neutrino fellows Mike Plucinski, Rebekah Randall, and Ray Hodges joined Spencer and Shane at Fermilab on July 6 to lead undergraduate students during the aforementioned Exchange Workshop through the latest iteration of the NOvA masterclass measurement. The students, along with physicist Anne Norrick, provided valuable feedback. Spencer, Shane, and the fellows continued to meet at Fermilab on July 7 to work on NOvA masterclass documentation.

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## Teaching and Learning

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July 9-14, twenty-four teachers from centers across the country attended the annual Data Camp at Fermilab. Teachers participated in a variety of activities, all of them facilitated by the Teaching and Learning fellows. First, using real data from the CMS experiment at CERN, teachers reconstructed the masses of particles produced in the proton-proton collisions at the Large Hadron Collider. Using simple principles from introductory high school physics such as conservation of momentum and conservation of energy, teachers were able to plot the mass reconstructions and explain how to make the necessary calculations. Having completed this for themselves, the teachers could then translate the complicated ideas from particle physics experiments for their own students. Following the main analysis task, teachers investigated activities from the QuarkNet Data Activities Portfolio, first by trying them out in small groups and then by developing an implementation plan for how they will use some of the activities in their classes. In addition to the data analysis task and teacher implementation plans, teachers also went on tours of Fermilab facilities and attended presentations by physicists.

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## International Masterclasses

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Ken set up CMS masterclass tables in CIMA for groups in Lisbon on July 11 and London on July 14. Ken, Uta Bilow of TU Dresden, and the LHC fellows all had masterclass planning discussions detailed elsewhere in this report. Shane and Spencer also had masterclass discussions with Neutrino fellows.

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## Broader Impacts

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**International Collaborations** – Ken participated in videoconferences of the International Organizing Committee of the African Conference on Fundamental and Applied Physics (ACP) on June 6, June 20, July 4, August 3 and August 24, finalizing speakers, dealing with logistics, and beginning a conversation about a possible associated masterclass for high school students.

Ken had a Zoom discussion on June 9 with Steve Goldfarb of IPPOG, Uta Bilow from TU Dresden, Australian IPPOG representative Jackie Bondell, and Australian teacher Lakshmi Srinivasan to discuss expansion of masterclass in Australia.

Ken has a videoconference with Uta Bilow on August 16 to begin planning International Masterclasses (IMC) 2024. They set dates for IMC 2024 and for associated masterclass circulars.

**CERN Beamline for Schools Competition** – Mark assisted a group of high school students at Phillip’s Exeter Academy with a proposal to the CERN Beamline for Schools competition to build a beamline magnet from fixed NdFeB magnets: “A Radially and Rotationally Adjustable Magnetic Mangle for Particle Beams,” submitted on April 12. The group’s proposal was accepted in summer 2023. Students will build their magnet and test it at CERN in the fall.

**Cosmic Rays at Pyramid** – Biweekly collaboration meetings continued. Mark and Edit discussed factorization of computing tasks for the interns. Mark’s QuarkNet summer interns Jensen and Brian demonstrated their work from this summer to the collaboration: a web page for NAUM, the experiment’s event display for the public with 3D displays of the pyramid and muon tracks, and 2D displays and histograms for use in commissioning the detector. Designs for light-tight boxes holding track planes were finalized.

**AAPT Summer Meeting 2024** – Shane and neutrino fellow Mike Plucinski participated in the AAPT Summer Meeting 2024 on July 15-19 held in Sacramento. During the meeting, Shane led a workshop titled *LHC Physics in the Classroom* that was attended by 13 participants. Also, Shane moderated a session called Data Science in the Undergraduate Classroom. Mike gave a talk during this session on his use of coding in the classroom and in helping to develop the NOvA masterclass measurement. Shane participated in Programs Committee Meetings I and II as he is currently vice-chair of the Contemporary Physics Committee. Shane and Mike also attended other sessions, committee meetings, and poster sessions during their time in Sacramento.

**i.am Angel Foundation Partnership** – Shane met via Zoom on August 3 with Monica Tafoya from the i.am Angel Foundation to discuss plans and potential partnerships between QuarkNet and the i.am Angel Foundation to support schools serving student populations underrepresented in physics, such as the STEM Academy of Boyle Heights in Los Angeles.