

JHU QuarkNet Annual Report

The JHU Quarknet center had another successful year. In March, teachers and their students participated in the annual LHC Masterclass, with approximately 35 students in total attending. (We held the event on a Sunday so that one of our teachers from a Jewish day school could attend, and because our teachers had previously indicated that weekends were easier than weekdays.)

Over the summer, members from our group diagnosed and returned broken parts for two of the 6000 series cosmic ray detectors (6869 and 6156). Dave Hoppert was his usual self and worked quickly to provide us replacement parts, and we are pleased to report that one of the detectors (6156) has been reassembled and is currently being used by students! They are in the plateau-and-calibrate phase of their research and hope to begin experimenting with the detector soon.

During the last full week of July, we held our annual summer workshop, a 5-day workshop for 17 teachers, with JHU's physics department providing supplemental funding to allow us to have more than the usual number of teachers, and for 5 days instead of 4. (See our agenda page here: <https://quarknet.org/content/2023-jhu-workshop-agenda>) Our theme for the summer was coding, because we had a coding workshop. During the mornings of Mon-Thu, the Coding Fellows Chris DiMenna and Peter Apps took us through the workshop, beginning with some "unstructured playtime" with pre-written Jupyter notebooks, during which time teachers were encouraged to tinker with the notebooks and adjust the Python code to observe how the output changed. After that, we learned a little bit about how to reconstruct invariant mass, and used CMS data from the LHC to reconstruct the mass of muons produced after decays of hadrons and W/Z bosons, which led to a rich discussion of why the mass histogram had the features it did. Finally, teachers were encouraged to explore some other Jupyter notebooks which had been written to be relevant to a typical introductory physics classroom – many of which involved students gathering real-time data using apps such as PhyPhox – and to develop an implementation plan for potential use of these notebooks in their own classroom.

Because JHU has such a large and robust astronomy faculty, we were treated to several talks from both professors at JHU and from research scientists at STScI. Among these talks were: recent results from the JWST mission (Dr. Bill Blair), the upcoming Dragonfly mission that is sending a helicopter drone to Titan (Dr. Sarah Hörst), the recent announcement of a stochastic gravitational wave background from the NANOGrav collaboration (Dr. Marc Kamionkowski), and hypothetical "topological black holes" (Dr. Ibou Bah); we also had an in-theme talk from STScI scientist Dr. María Peña-Guerrero who talked about how she uses coding in her job.

We also heard talks from our stalwart group of experimental particle physicists, who talked about the design of detector hardware (Dr. Morris Swartz, our center's Mentor), the idea of the Higgs Field as a 5th fundamental force (Dr. Andrei Gritsan), and an in-theme talk about machine learning in recognizing jet production events at the CMS detector (Dr. Petar Maksimovic). Finally, we had a mind-blowing marathon talk from Dr. Nima Arkani-Hamed, a theoretical physicist from the Institute for Advanced Study who lives part-time in Baltimore and often visits to give multiple-hour talks on various topics. This year, in a record-breaking 5-hour talk, he explained how to use merely algebra and geometry (i.e. no calculus, tensors or other crazy mathematics) to derive the famous Einstein Field Equations of General Relativity.