

Masterclass

In late February, 5 teachers brought some of their students to JHU to participate in the annual WZH Masterclass project. During the morning, lead teacher Jeremy Smith gave a talk summarizing some basic principles of particle physics and the structure of the CMS detector; following his presentation, mentor professor Dr. Morris Swartz explained the event display software used in the iSpy website, and how to interpret the characteristic signatures of W and Z bosons. After a lunch break, students broke into small groups of 2-3 and analyzed a set of 100 events, categorizing each as a W or Z candidate – and in one or two cases, a potential Higgs candidate – and populating an online spreadsheet with the masses of all candidates with a neutral charge, as well as the relative frequency of W^+ vs. W^- bosons. Following the data analysis, Dr. Swartz led a brief discussion of the results and their implications, and the students joined several other centers in a videoconference to share their results and ask questions of each other. Both students and teachers reacted positively to the event, and we look forward to participating again next year.

Summer Student Research

Summer students conducted research in a variety of topics, ranging from particle physics to astrophysics. Several cosmic ray detectors were set up during the internship, and students were able to conduct and analyze several different experiments. Most notably, one student collected a lot of data for the time-of-flight experiment and was able to measure the speed of cosmic ray muons with better than 5% accuracy. A group of three students learned how to use the 2.5 meter student radio telescope, and by using radio data from the entire Milky Way, were able to construct a galactic rotation curve that provides indirect evidence for dark matter. One student researched neutrinos, and gave several presentations on the strange behavior of neutrinos, especially with respect to their oscillations between mass and flavor states. A pair of students became interested in the calculations of quantum mechanics, and essentially spent all their time reproducing some of the famous problems encountered by undergraduates in a quantum mechanics course, including the square well potential, harmonic oscillator and the spherical harmonics of the hydrogen atom. Two students became interested in astrophysics, one focusing on black hole types and properties and the other on the origin, research and evidence for the dark matter hypothesis. Finally, one student researched special relativity and its importance in high-energy physics.

Student research culminated in a series of peer presentations summarizing their work, and the printing of a 3'x4' poster to be mounted and displayed in their home schools. Please see the JHU page on the QuarkNet site for abstracts and links to these posters.

Teacher Workshop

The JHU Experimental Particle Physics Group sponsored its annual QuarkNet Workshop in the Bloomberg Center the week of July 24 through July 28. This was the 16th year JHU has been part of the national QuarkNet program. This year's workshop maintained its size at 20 teachers, and two Quarknet Fellows (one in the Teaching and Learning group and the other in the Cosmic Ray group) and also included eight high school students who were doing summer research at JHU within the Quarknet program. Five of the teachers were new to the workshop and fifteen had been in the program before. As is standard from past years, the teachers came from a wide variety of backgrounds. There were both male and female teachers representing Baltimore City and non-Baltimore City schools, public and private schools, single sex and regular schools, secular and religious schools, as well as schools from both Maryland and Pennsylvania.

Teacher Workshop: AM

The workshop format was talks in the morning and "lab" in the afternoon. From the particle physics group, Morris Swartz gave a talk on the basics of quantum mechanics, to help some of the new teachers feel more comfortable with the topics covered by other professors. Andrei Gritsan gave an updated presentation of his work on the CMS experiment probing the Higgs Field. From the cosmology group, Mark Kamionkowski provided a brief overview of gravitational waves, detection of same using LIGO, and a hypothesis put forth by his group that the discovery of merging black holes could be a candidate for dark matter. Also from the cosmology group, Tobias Marriage explained the use of the 2.5 meter radio telescope by undergraduates at JHU, and showed the teachers that they could also use the device from their own schools. Finally, Bill Blair from the astrophysics group gave a presentation on the August solar eclipse, as well as viewing tips and demonstrations that could be used in the classroom to explain why eclipses happen. Jeremy Smith, one of the lead teachers of the JHU group, gave the first talk of the week, welcoming new teachers to the group and providing a broad overview of what QuarkNet is, and some of the historical topics leading to the discovery of the Standard Model.

The teachers have indicated in the past that they also enjoy hearing talks by other scientists who are not necessarily in the particle physics or astronomy groups, so a variety of other professors came to share some of their research. This included two from the Earth & Planetary Sciences department: Sabine Stanley talked about the magnetic history of Mars and Kevin Lewis talked about some of the geological data gathered by the Curiosity rover. Three people came from the Biophysics department: Sarah Woodson talked about the roles of non-coding RNA molecules in the cell; Elijah Roberts shared his "in silico" modeling of the complex decision-making processes inside cells, and Greg Bowman discussed a protein that moves nucleosomes back and forth along the DNA molecule called chromatin. Finally, we had three speakers from the applied sciences: Mark Foster talked about ultra-fast optical image processing; Dave Clader from JHUAPL discussed the history and progress of quantum computing; and Peter Gehring from NIST explained the parallels between particle physics and the study of phonons in materials science, using neutron diffraction as a probe.

Teacher Workshop: PM

The afternoon time was less structured than it has been in some past summers, and this was met with approval by some teachers and dislike by others. Newer teachers were given opportunities to try out some of the activities from the Data Portfolio, including the Dice Histograms, Pennies, Top Quark, Quark Workbench and Rolling with Rutherford activities. New teachers also got the chance to see a large cloud chamber being operated by Barry Blumenfeld, who was teaching a survey course in modern physics during the summer semester. Some of the veteran teachers brought their cosmic ray muon detectors and did some testing and analysis of the newer labs such as the Muon Lifetime Data Express, Time of Flight and Shower studies. Following Toby Marriage's presentation on the 2.5m radio telescope, some teachers worked on setting up their computer software to be able to use the telescope from their home schools. Finally, all teachers were given the opportunity to build and test a "mystery tube," a device that is designed to teach students the value of using models to explain experimental evidence.

Mentor: Morris Swartz

Lead Teachers: Jeremy Smith & Kevin Martz