Vanderbilt 2012 Quarknet Report (10th year)

Teacher participants: James Anderson, Meaghan Berry, Gayle Dawson, Diana Gigante, Kim Hawtin, Nick Horton, Terry King, and Aimee Ragland.
Active but scheduling conflicts: Scott Carter and Kevin Handerhan.

Vanderbilt participants: Bill Gabella, Kelly Holley-Bockelmann (Vanderbilt Professor of Astronomy), and Med Webster.

Significant teacher accomplishments: Brenda Ball (Pless) introduced Austin Lawson to the idea of cosmic rays in her introductory science class at Blackman High School several years ago, and he was so intrigued that he asked to do a high school senior thesis on them this year. Brenda brought him to Vanderbilt so that he could see the cosmic ray tracks in our cloud chamber, and he wrote a senior thesis, "The effects of Atmospheric Variations on Muon Detection Rates." He used a Quarknet muon counter set for the muon rates which he compared with temperature, air pressure, humidity, and wind speed. His paper shows that the muon rate does not depend upon any of these at the limits of his measurements.

Our 2012 Quarknet program was led by Bill Gabella and Med Webster. Our theme this year was gravity with additional short sessions on the Higgs boson, superluminal neutrinos and the use of files with our muon counters.

Our meeting this year closely followed the Higgs boson announcement. Bill Gabella was on shift when some of the CMS data was taken, so he presented the case for the Higgs, and we continued with a discussion of what went wrong with the neutrino speed measurement and the prospect for fresh data.

In order to increase awareness and use of the e-Lab facility with file transfers, we included brief reviews of the procedures for writing files with the muon counters and transmitting the files to the e-Lab. During the 2011-12 academic year we had muon counters in three schools. Our teachers have been enthusiastic about having the muon counters in their classrooms and doing simple counting experiments, but, despite past training sessions in our annual meetings and a visit by Bob Peterson, they have underutilized the e-Lab facility.

Our program focused mainly on gravity, we brought eight teachers first to Vanderbilt for discussions of gravity and then brought them to LIGO (Livingston, La.) to see a prime example of current gravity research. After a bit of history of gravity, we set up the dark matter problem by contrasting the rotation curves of galaxies with that of our solar system. This provided a personal touch when we related the rotation curve for our galaxy to Doppler measurements we made when we visited the Green Bank Radio Observatory several years ago. The Doppler shift itself was demonstrated by one of our teachers with the "buzzer on a string" he twirls about his head for his physics classes. We prepared our group for the LIGO trip by showing fringes with a classical Michelson Interferometer and by having discussions of the form and incredibly tiny amplitude expected for gravitational waves. The Hulse-Taylor pulsar measurements provide indirect evidence for gravitational waves and provide us with an opportunity to show how science develops

by comparing the status of gravitational waves today with the status of neutrinos between Pauli's conjecture and the Reines and Cowan detection. Since black holes are involved with many of the probable sources of gravitational waves, we asked a real astronomer to talk about her work, see Figure 1.

Fig. 1 Guest Lecturer Professor Kelly Holley-Bockelmann discussing the fate of objects which fall into a black hole.

We were fortunate to have scheduled our LIGO visit during a maintenance interval so we were able to see the work being done on the delicate, cascaded vibration suppressor mounts. Our view of the 4 kilometer arms receding into the distance from the LIGO bridge was a stark contrast to the small, delicate work on the optics. We had good discussions with LIGO scientific staff which illuminated the goals and the mechanisms of the experiment. A significant side benefit of the tour was the opportunity to play with the impressive collection of physics demonstration apparatus which has been assembled by the LIGO outreach staff.

In addition to work with the Quarknet teachers we host several eighth grade students from University School of Nashville for their Internship Day each year. The students use a set of muon counters to measure the speed of cosmic ray muons. Bill Gabella described our procedure at the "100 years of cosmic rays" session of the Atlanta APS meeting emphasizing 1) the enthusiastic student response, 2) that data collection and spread sheet analysis can be accomplished in one morning, 3) the ease of sharing and analyzing the data with Google docs familiar to these students and used by many high schools in the

area, and 4) that the interchange of counters to cancel variations in counter response times is good experimental technique that can be justified with simple algebra familiar to eighth grade students.