The University of Iowa Quarknet 2010 Annual Report

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Abstract

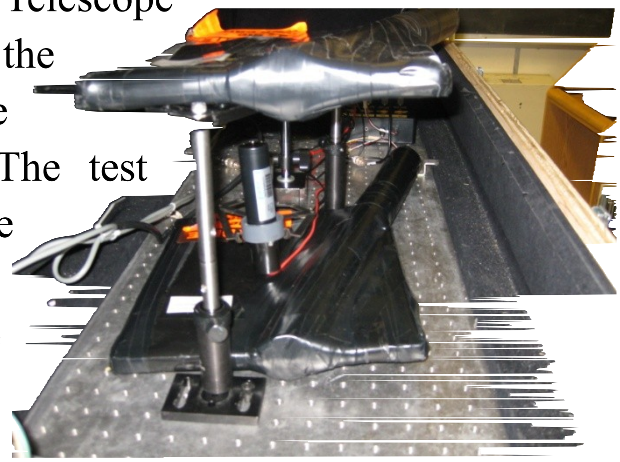
The summer of 2010 found 4 students and 3 teachers involved in many activities related to the high energy particle physics group at The University of Iowa. The teachers and students performed tests on equipment, prepared specimens for beam exposure, machined molds and enclosures, worked on the virtual control room and put on a weeklong institute for 20 high school teachers. All of these activities were focused on the performance and success of Compact Muon Solenoid at CERN's

Large Hadron Collider. The Iowa group also ran a week-long outreach program to 17other teachers from all over the state of Iowa. During this institute, the teachers became updated on the latest high-energy efforts and how it impacts cosmology. They also learned how to use the Quarknet Cosmic Ray Muon Telescope in their classes and made arrangements to use one of the five telescopes we have at the university.

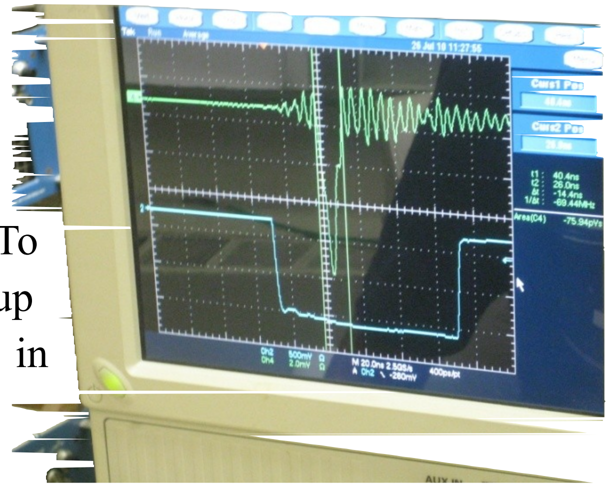
Tests on Equipment: Circuit test

The students and teachers performed many tests on equipment in the lab at The University of Iowa. One such test involved a circuit that was designed to differentiate signals in a photomultiplier tube (pmt) between light signals and muon signals. In the forward calorimeter (HF) of the Compact Muon Solenoid (CMS), light from quartz fibers is used to measure activity in the calorimeter. There exists a chance that muons created in the collision beams could pass through the calorimeter and pass through the face of the pmt which would trigger a signal that was not created by the light from the fibers. This pulse should be shorter in duration (pulse width) than the light signals so a circuit was developed by one of the engineers in the group to digitally differentiating these signals from light signals.

To test this circuit, a pmt and 2 muon counters were arranged to make use of the random cosmic muons mixed with light signals in one of the HF pmt's. The pmt was connected to the circuit and the signals and output of the circuit was measured. The pmt was placed between two of the Quarknet Cosmic Ray Muon Telescope counters. The signals from the counters were used to identify the muons from the light signals. The test properly identified the muons but the circuit proved to be defective. The test led to some refinement of the circuit elements. The test will be repeated after the circuit has been modified.



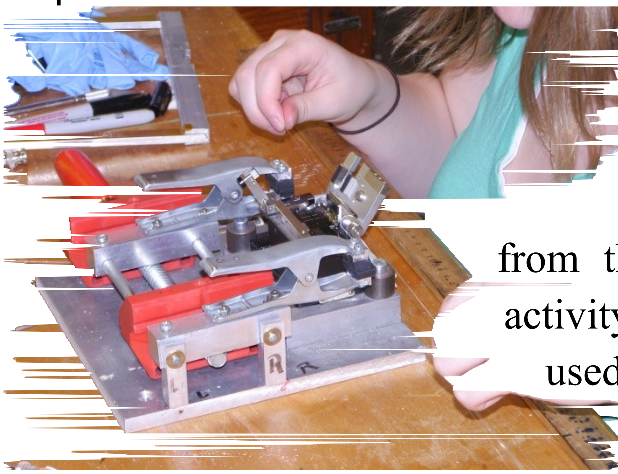
Tests On Equipment: 4-anode pmt's



In order to test the quantum efficiency of pmt's one must establish the smallest light signal that produces a photoelectron that leads to a signal in the pmt. To accomplish this, the students set up a pulsing ultraviolet emitting diode in front of the pmt. The light is then attenuated with neutral density filters between the source and pmt until the smallest signal above the dark current of the pmt is found. The test was done first with a current hf pmt and then with a new, 4-anode rectangular pmt that was proposed to replace the current pmt's in hf. The new pmt's were found to be about 28% better than the current ones. This information will be used to help make a decision whether the tubes in hf should be replaced by the 4-anode types.

The linearity of the 4-anode pmt's was checked by exposing the pmt to the single photoelectron light level and increasing the light until the signal increased by a factor of about 3,000 photoelectrons which would be close to the saturation point of the pmt. The students increased the light and measured the output signal to compare the level of light incident on the tube to its signal level. The linearity of these tubes will be compared to the linearity of the hf tubes and will impact the decision on whether to replace the current tubes in hf.

Specimen preparation: Fiber cleaving



The team cleaved Quartz-core fibers for beam testing at CERN and Fermilab. The fibers were used to bring signals out of samples from the beam to pmt's to measure the activity of the samples. These signals were used to measure the sample's reaction to the beam. The fibers have to be cleaved cleanly as the Quartz is difficult to polish. This assures the light will pass out of the fibers cleanly and pass on to the pmt. These fibers were embedded in a number of devices that interact with particles and produce light. The light is then fed to a pmt outside the beam to measure the light produced by the device in the beam.

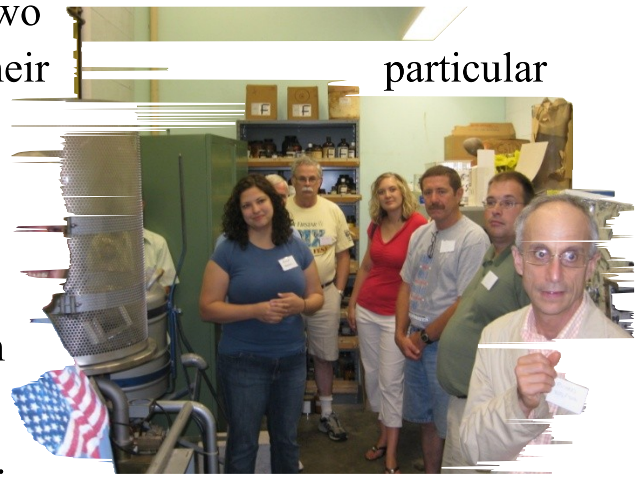
Specimen Preparation: "Silastic" production

Hf in CMS is exposed to high levels of radiation. This makes accurate calorimetric measurements a challenge, especially if the materials degrade with extended exposure to radiation. Currently in hf, Quartz fibers are used to bring light signals out of the calorimeter to the pmt's for detection. A candidate to replace the quartz is a compound made from a silicon based substance laced with p-ter-phenyl (ptp) organic crystals ("Silastic"). The ptp wave-shifts the ultraviolet light produced by particles to violet light more sensitive to the pmt's. The silastic provides a clear substrate for the ptp to make a potentially robust light producing material for use in detectors.

Our group mixed the silastic with different amounts of ptp and machined the molds and embedded fibers for the tests. The samples were then taken to CERN and will be taken to Fermilab for exposure to beams. The group also prepared quartz plates as controls for these substances.

Teacher Institute: Outreach to high school teachers in Iowa

The Iowa group had a week-long institute at the end of July where the teachers attended lectures from physicists and learned how to use the Quarknet Cosmic Ray Muon Telescopes. During the week, lecturers from The University of Iowa particle physics lab, department of education and the astronomy department gave lectures to the attendees. We also took a daytrip to Fermilab in Batavia Illinois. There, we toured the facility and made listened to two astrophysicists present their particular research plan.



The teachers also ran experiments using the Cosmic Ray Muon Telescope and posted their data on the Quarknet site at Fermilab. They learned how to connect and set up the equipment for experiments such as muon half-life, flux and shower measurements. The teachers learned to successfully implement the particular details of the equipment such as setting up coincidences, troubleshooting and using global positioning system. The data sequence for Quarknet was followed and each group of teachers made a poster to go with their data. This training was intended to make the teachers comfortable enough with the system to use it with their students when they get back to school. We dispersed the 5 telescopes around the state so they would have access to them.

Quarknet Summer 2010 Institute July 19-23					
Time	**Monday**	**Tuesday**	**Wednesday**	**Thursday**	**Friday**
08:30	Breakfast	Breakfast	Fermilab Trip	Breakfast	Breakfast

09:00	Welcome/ Intro to Quarknet/Paper work	Intro to Cosmology- Like		Meet with Joe Loria	Dale Stille
09:30				Dr. Yager	
10:00	Tour of U. of Iowa Labs	Muon Concept Development		Muon Project	
11:00					Muon Presentations
12:00	Lunch	Lunch		Lunch	Final Paperwork/reflections
01:00	Intro to Particle Detection & Scopes- Bruecken	Quantum Field Theory- Dr. Norbeck		Dr. Onel- CMS	Travel Home
02:00	Scoping Muons Lab	Dark Matter/ Energy- Like		Work time on Muon Projects	
03:00		Neutrinos- Dr. Reno		Ugur Ukgun	
04:00	Sharing, Reflections and Questions (CLEA)	Sharing, Reflections and Questions		Sharing, Reflections and Questions	
Evening	Journals	Journals	Journals	Journals	