2017 Quarknet: CERN Cube Recovery

Participants

Mary Grace Armbrust, Adam Edwards, Andrew Haffarnan, Max Herrmann, Roger Witmer, and Joshua Turner

Purpose

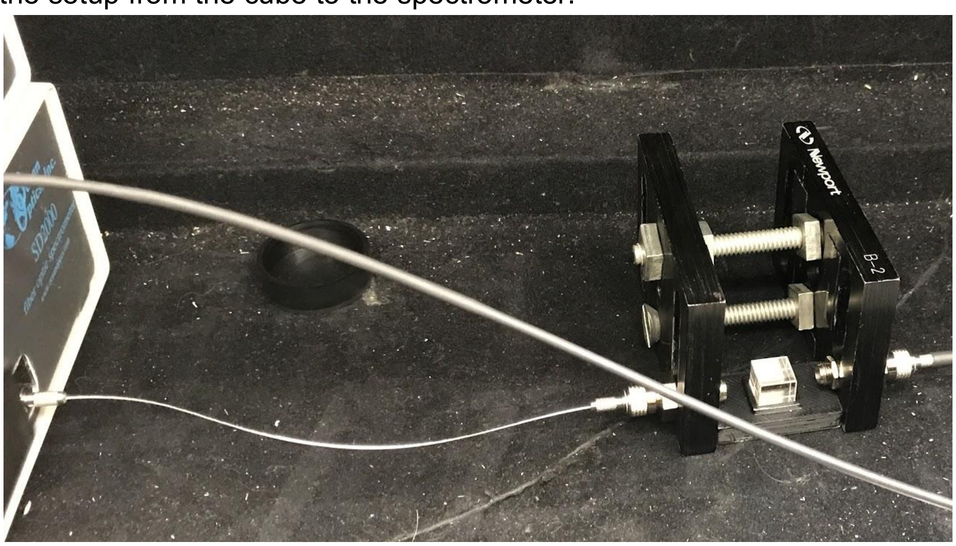
The cube recovery experiment was to test the ability of ultraviolet light to heal quartz which have been damaged by radiation at CMS

Equipment

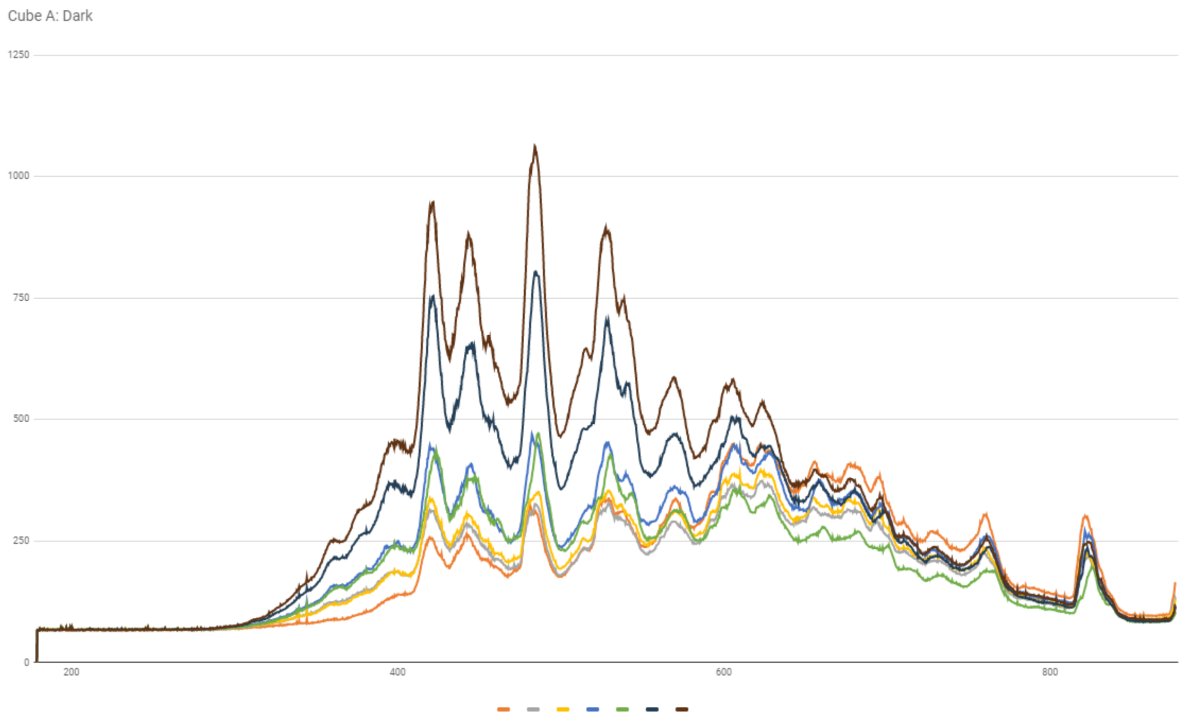
- Xenon Light source
- Ocean optics spectrometer
- Irradiated cubes from CERN
- An ultraviolet lamp
- Light tight box

Procedure

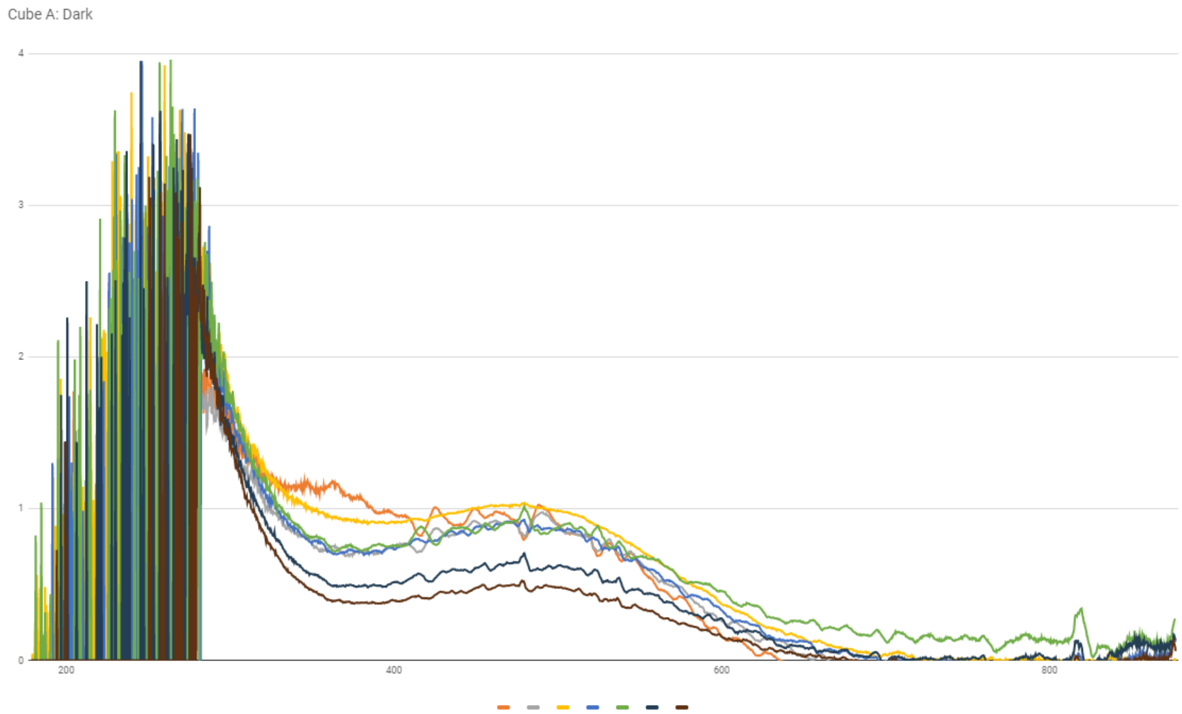
To test the cubes, each cube was placed into a holder which had optical fiber from a xenon light source and a second optical fiber that became the input to light the spectrometer. All cubes had an orange sticker with an arrow on one face, and we placed the sticker side on the bottom with the arrow pointing towards the spectrometer. The whole setup was placed in a light tight box in order to prevent ambient light from interfering with our data. The photo below shows the setup from the cube to the spectrometer.



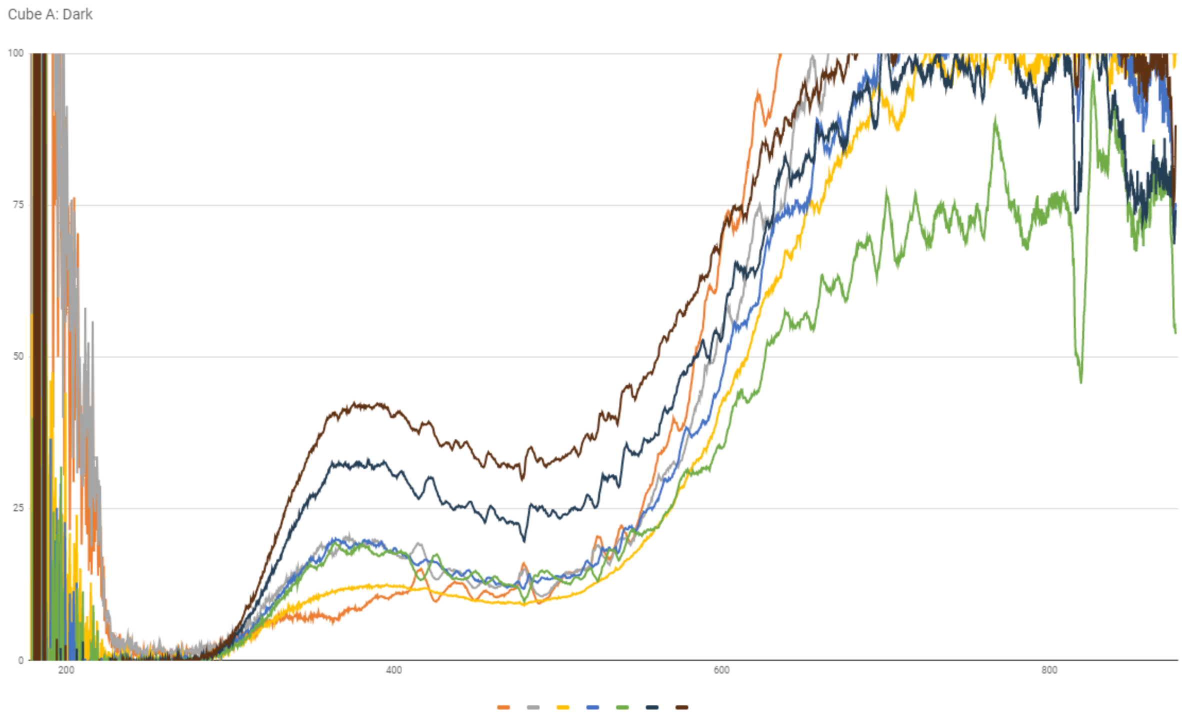
When conducting the experiment, a blank cube, one that has not been exposed to any radiation was placed in the holder in order to measure a control cube. From there, each cube was placed in the holder, the box was shut, and the light source was turned on. Using Ocean Optics-SpectraSuite, we collected the spectrum, transmission, and absorption for each cube. After collecting the data, the cubes were placed under the UV lamp for six intervals of 5 minutes before retesting, then another three exposures to UV for one hour to make a total of three hours and thirty minutes of exposure. The graph below shows an overlay of all the data for the spectrum measurements for cube A. If the UV method works, we would expect to see the plot depicting the spectrum graph to become closer to the spectrum of the xenon lamp without any material in the path gap where the cubes were placed.



The following graph shows the absorption of cube A. The readings for the absorption from 180nm to about 300nm looks to be completely filled in because the xenon light source does not emit light in that wavelength. Therefore when the spectrometer is comparing the blank cube to the irradiated cube, any minimal difference that might occur will be picked up as a large percent difference between the cubes. When analyzing the graph, it would be best to start at a wavelength where the spectrum graph starts to rise, around 325nm. The expectation for the testing is that as the exposure to UV light increases, the amount of the light being absorbed decreases to zero.

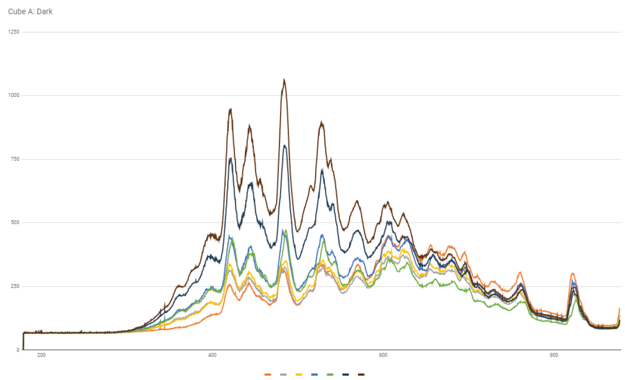


The transmission graph below shows a similar pattern between the 180 and 300nm range as the absorption graph. The same analysis considerations should be taken into account with this graph as well. Disregard the data below 325nm. As the cubes spend more time under the UV lamp, the expectation is that the transmission line becomes closer to 100%.

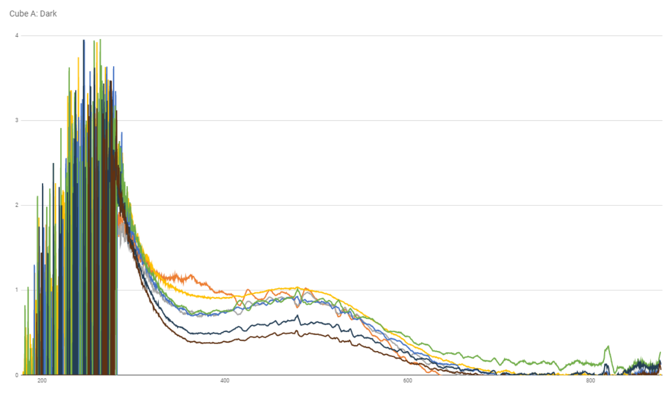


The color code at the bottom of each graph shows the trial number in chronological order with the least exposed test being the color on the far left and the most exposed test on the far right.

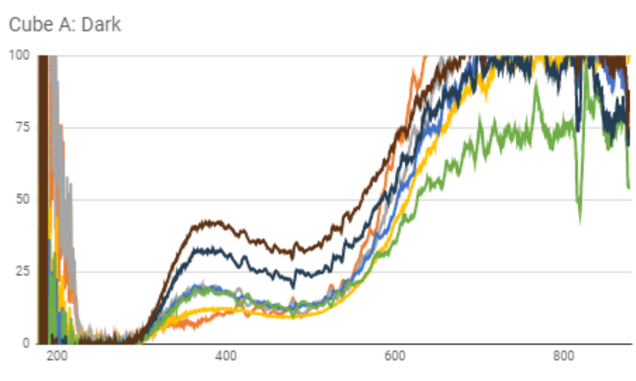
Data



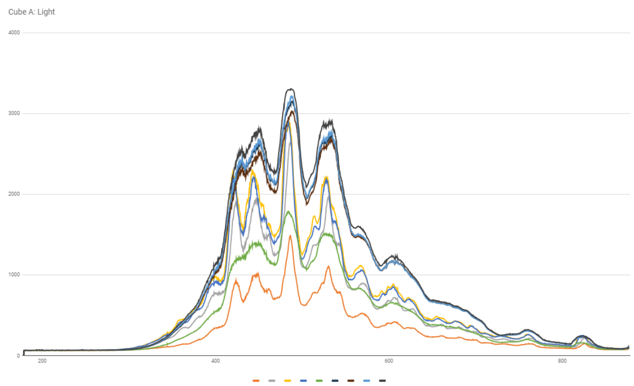
Cube A Dark spectrum



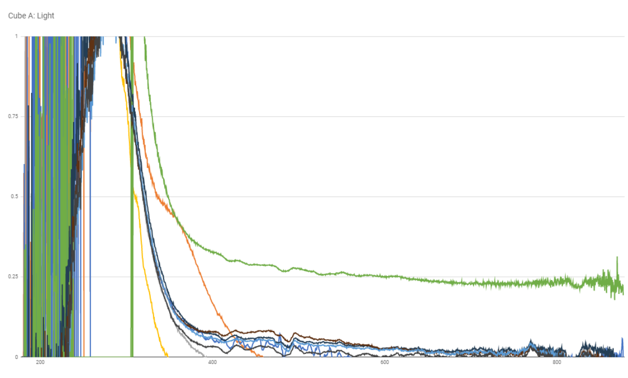
Cube A Dark absorption



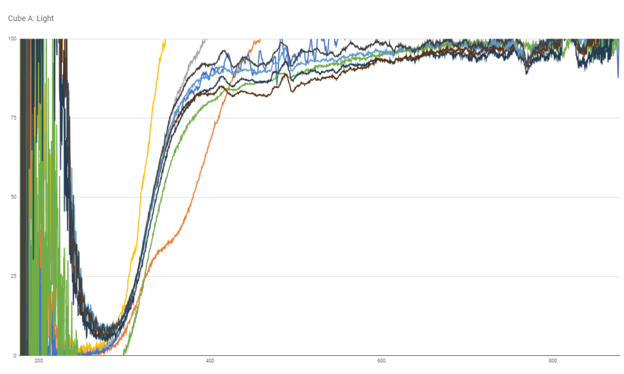
Cube A Dark transmission



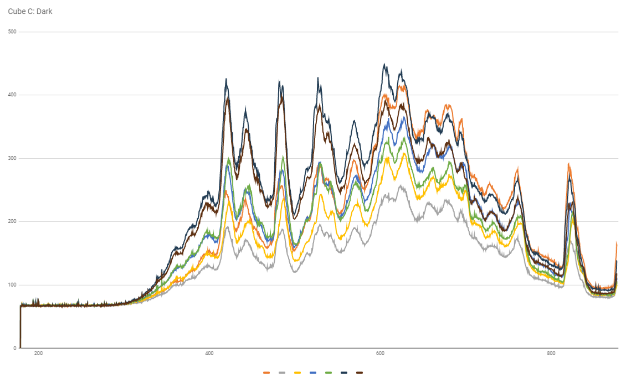
Cube A Light spectrum



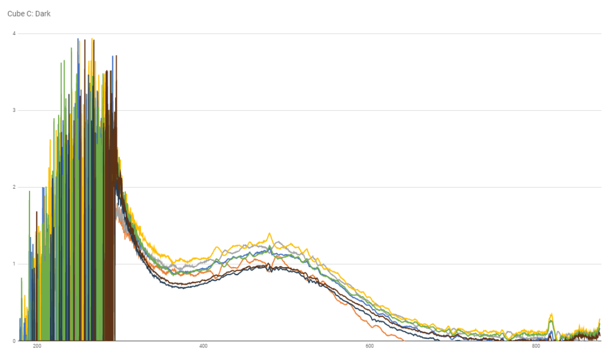
Cube A Light absorption



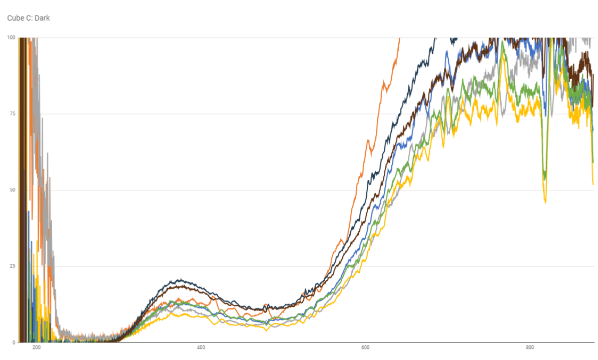
Cube A Light transmission



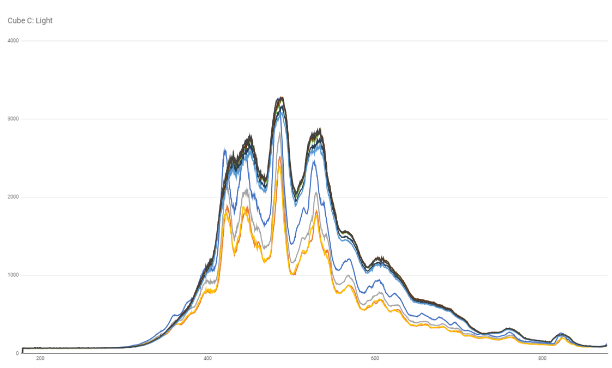
Cube C Dark spectrum



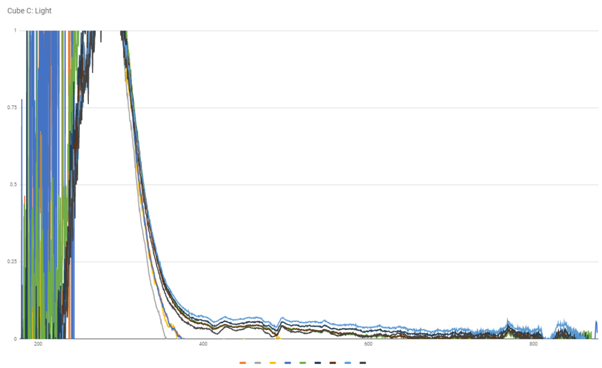
Cube C Dark absorption



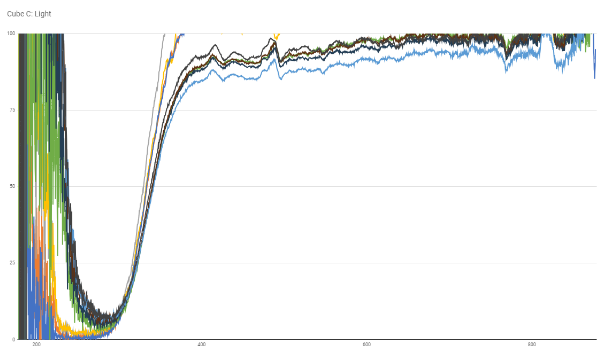
Cube C Dark transmission



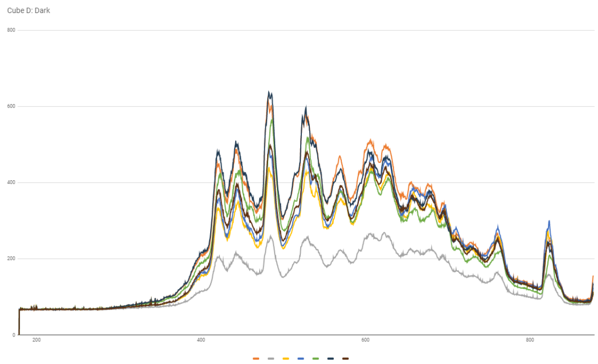
Cube C Light spectrum



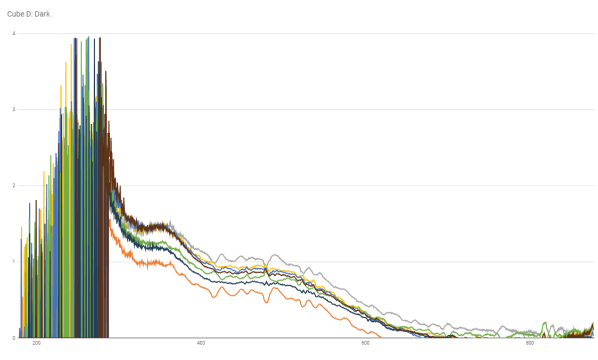
Cube C Light absorption



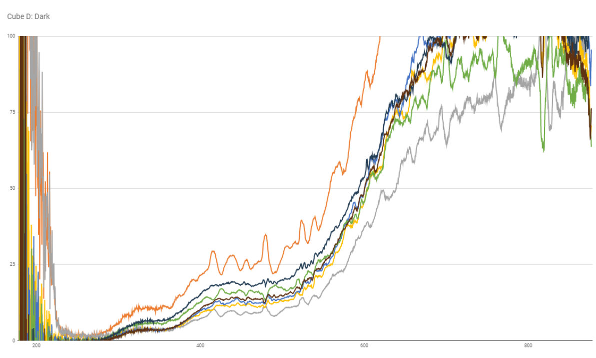
Cube C Light transmission



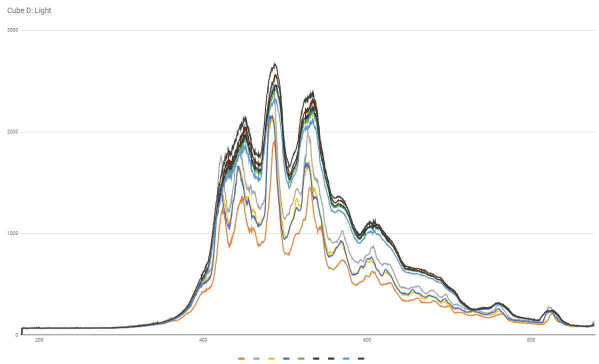
Cube D Dark spectrum



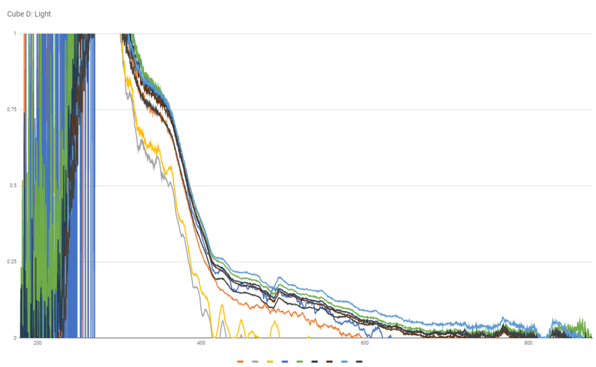
Cube D Dark absorption



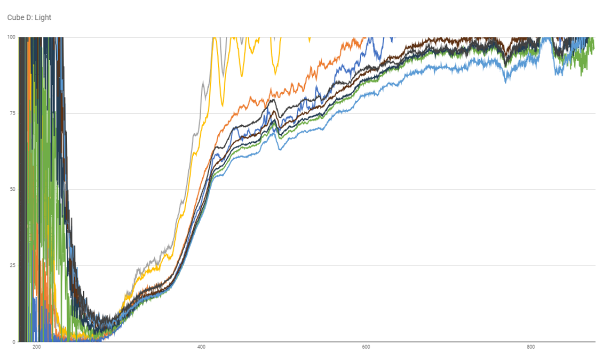
Cube D Dark transmission



Cube D Light spectrum



Cube D Light absorption



Cube A Light transmission

Further Work

The cubes have shown higher transmission values with longer exposure to UV light, so the next steps that can be taken would include much longer exposure time to UV light, as well as using a light source other than the xenon lamp so that the measurements between the 180 and 300nm wavelengths can be analyzed as well.

The University of Iowa
Quarknet 2017 Summer Institute

Principal Investigator:
Dr. Yasar Onell

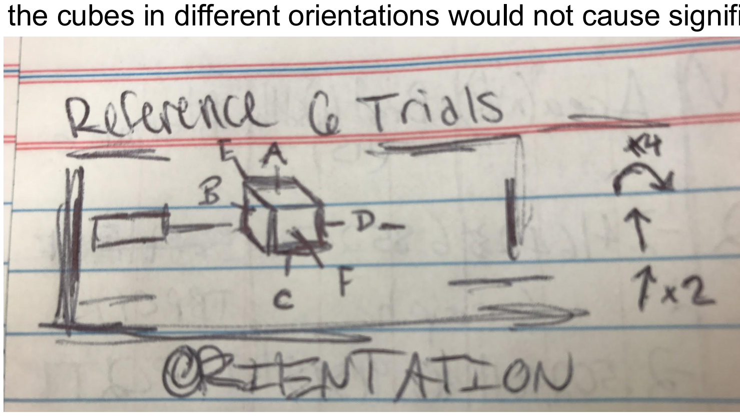
Associate Professors:
Dr. Jane Nachman, James Wetzel

Teacher\Mentors:
Peter G. Bruecken, Michael Grannen and Moira Truesdell

Students:
Mary Grace Armbrust, Adam Edwards, Andrew Haffarnan, Max Herrmann, Roger Witmer, and Joshua Turner

During the summer of 2017, The University of Iowa involved six students from Bettendorf High School and 3 teachers in research activities. The work was directed by our Principal investigator, Dr. Yasar Onel and mentored by three of the teachers, Peter Bruecken, Michael Grannen and Moira Truesdell. The summer activities focused on three projects: Testing the effect of UV exposure on scintillating materials, [muon telescope purpose], and analyzing CERN data to find Z' particles. [These projects were extensions from the 2016 summer work.]

Activity 1: Scintillating cubes:
One of our responsibilities was to test various cubes of scintillating material that had been exposed to a radiation source. To start off, we tested some cubes provided to us by the University of Iowa to determine whether the orientation of the cube changed the amount of transmission and absorption. We determined arbitrarily that a significant difference would be a 10% difference between each of the orientations, which there was not, so we decided that putting the cubes in different orientations would not cause significant enough changes



We tested the absorption and transmission of the cubes with a xenon lamp to establish a baseline, then exposed the cubes to ultraviolet light to further test a hypothesis of Dr. Wetzel's theorizing that exposure to UV light will help scintillating materials recover faster from radiation than if they were left to recover on their own. After exposing the cubes to the UV light, we tested their absorption and transmission again to determine if there was a measurable difference in the rate at which the cubes were "healing."

Activity 2: Cosmic Ray Detector:

Another of our responsibilities was to operate and monitor a cosmic ray detector. Every day we started the detector using the PUTTY application. We measured shower data as well as flux data on a daily basis, starting up testing when we arrive in the morning and ending by 15:00 when we leave.

Activity 3: CERN VM data analysis:

We installed Ubuntu and the Cern VM, and created an initial scatter plot based off of a photon analysis. Several components had to be debugged but the final scatterplot was a success. Initially working with two muons and a photon, we debugged and revised a template analysis to suit our needs. From then on we attempted to search for Z', a new particle, which with we were unsuccessful due to time constraints. The code that was written for the virtual machine can be found in the folder called "python"

Quarknet 2017: Cosmic Ray Detector

Participants:

Mike Grannen, Mary Grace Armbrust, Roger Wittmer, Adam Edwards

Purpose:

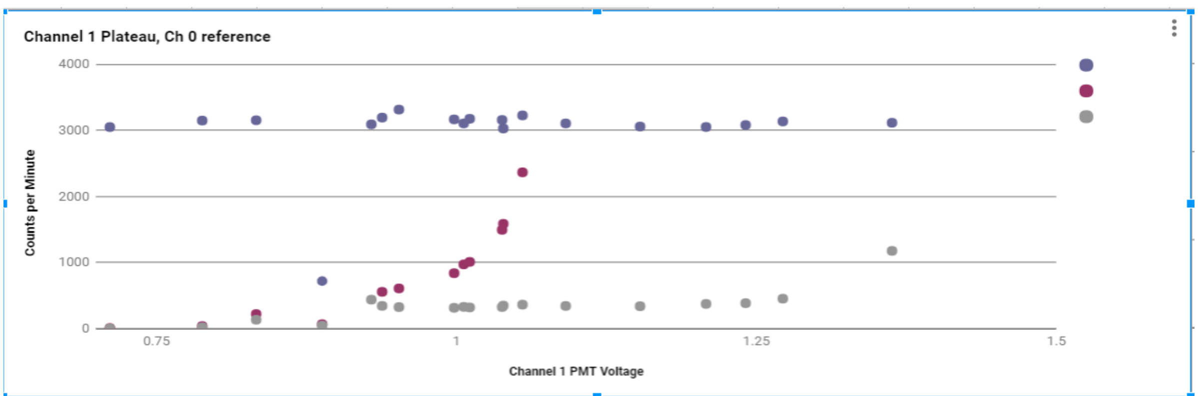
Originally, our purpose was to collect data from cosmic ray events to upload to the Quarknet website for other institutions to use for research; however, most of our time was spent troubleshooting to make sure our equipment was fully functioning.

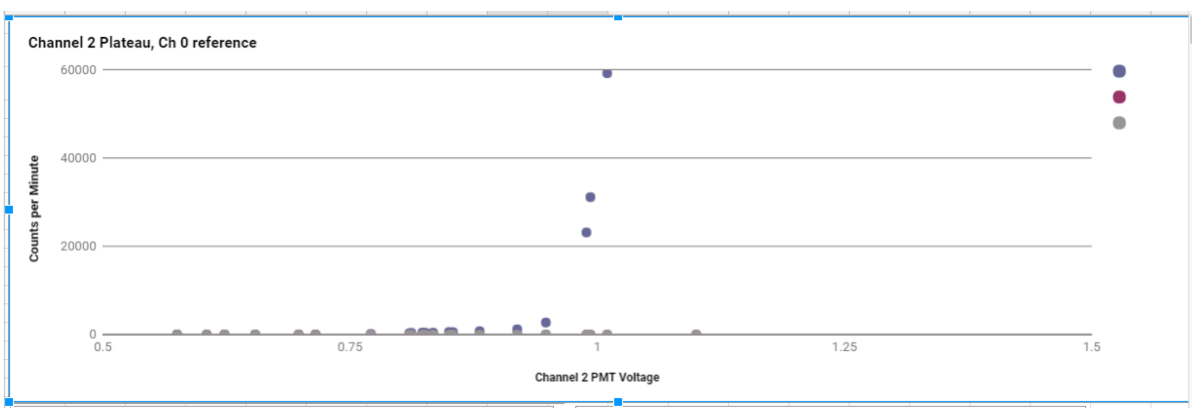
Equipment:

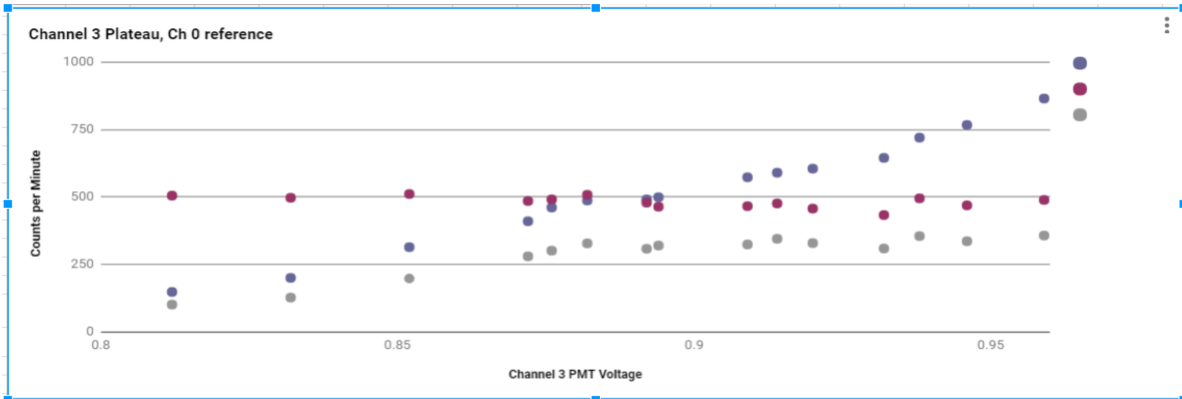
- Counters – Scintillators, photomultiplier tubes and PVC housing.
- BNC signal extension cables.
- QuarkNet DAQ data acquisition board.
- CAT-5 network cable.
- GPS module.
- GPS antenna.
- Temperature sensor.
- 5 VDC power supply.
- PDU power cable.
- Power distribution unit, PDU.
- Power extension cables for PMTs.
- USB cable.
- Personal Computer.

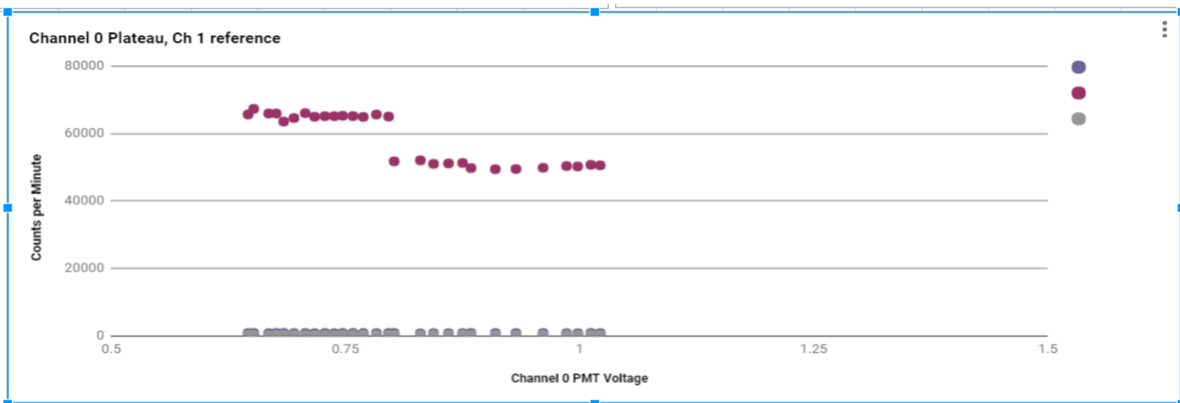
Procedure:

First, we had to set up the panels with the corresponding cables to the power supply and the data acquisition board (DAQ). Once we had everything set up, we ran into a problem with the power supply, where we had a loose connection. We solved this by soldering the wire back in place. Then, we had issues with the plateauing process. The plateauing process is a systematic approach to determine the ideal voltage for each of the cable and panel pairs. (See graphs below). Following along with a PowerPoint from the e-labs website, we used channel 0 as a reference and recorded different voltages for channel 1. This graph turned out very well, as we could observe where the coincidence counts started to level off, which is where you should set the voltage. Next, we tried testing channel 2 with channel 0 as a reference. This one did not turn out as well because there were not any counts from channel 2, so the coincidence count was also zero. After that, we decided to test channel 3 with channel 0 as a reference. This graph looks better; however, the reference points followed a linear trend, when they were supposed to be close to horizontal. The coincidence count follows a very slight increasing linear pattern. Lastly, we tested channel 0 with channel 1 as a reference, and it turned out poorly as well. Our coincidence count was in the 300-400 range with a wide variety of voltages. Whereas channel 0 was giving us extremely high counts, in the sixty-thousands. With all this inconsistency, we decided to do some troubleshooting to find out what the problem was. We tested multiple variables including different panels, different cable and panel pairs, and different orders of panels. All of these tests yielded inconsistent results. Finally, when rearranging the cables into their original configurations, the BNC end on cable A flew off, resulting in our realizing that the connections were poor, which was skewing our data. We had help from two of the engineers at the University of Iowa to fix our connections. As of the end of the summer, we believe that all panels, cables, and connections work, and we are taking this setup back to Bettendorf to collect data for Quarknet throughout the school year.









To fill the time while troubleshooting the CRD, we were given the task to test a different set of scintillating panels. Our first goal was to see if the cover over the scintillating material remained light tight since they were in storage for many years. The six panels were much larger than the Quarknet panels, and were not attached to any PMT's yet. To test the panels, we built a black box from plywood for the panels to rest in. Before closing the box, we covered the panels in a black fabric. The PMT's were placed in a housing and placed onto the optical neck of the scintillating panels. After setting up the panels to an oscilloscope and a high voltage source we observed detections by seeing a voltage drop and slight "ringing". We turned on the lights in order to determine if any ambient light was leaking into the scintillators, but the oscilloscope remained constant. Once we noticed that we were getting detections, and that the box is light tight, we removed the plywood box, and pulled back the fabric to expose the panels. When we checked the oscilloscope with a black room as well as when the lights in the room were on, we noticed no change in the readings. Therefore we are confident that the panels are still in good working order.

The next steps that should be completed before using these panels include, getting PMT's that have the proper diameter to match the optical neck of the panels, as well as create a way to keep the PMT attached to the panel while keeping it light tight. Once those two tasks are completed, the panels should be in good working order for whatever measurements would like to be taken.

Quarknet: CERN Open Data Analysis

Participants:

Jane Nachtman, Mike Grannen, Andrew Haffarnan, Josh Turner.

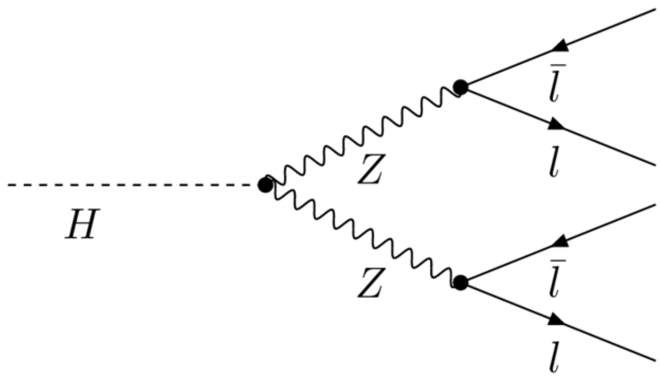
Purpose:

The higgs-boson was a key piece of evidence in assisting to prove the standard model. However, many physicists believe that the standard model is a small, low-energy section of a greater theory. In order to prove this hypothesis, one would need to find new particles that could outline a new model.

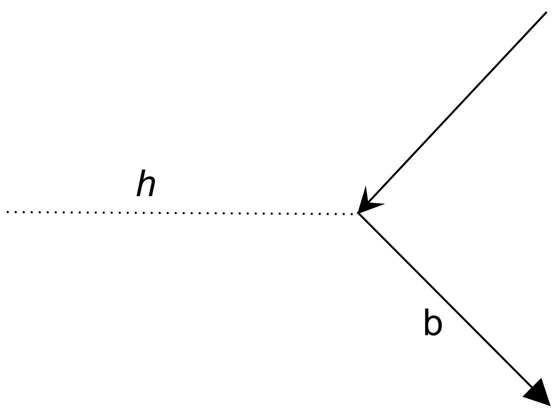
The Compact Muon Solenoid (CMS) at the Large Hadron Collider (LHC) allows public access to data taken before a certain date. We, using said data, are attempting to find a theorized particle. This particle, Z prime (Z'), is theorized to decay into both a higgs-boson and a photon. If this particle is found, it could assist in outlining the new model that many physicists are hoping to find.

Method:

In order to find the theorized Z' we first outlined its decay. According to model that defined it, it would first decay into a Higgs-boson (H^0) and a photon (γ). We then decided how we would find the H^0. The two options that seemed the most reasonable were H^0 to Z pair wherein the Z pair decay to 4 leptons of di-muon pairs,

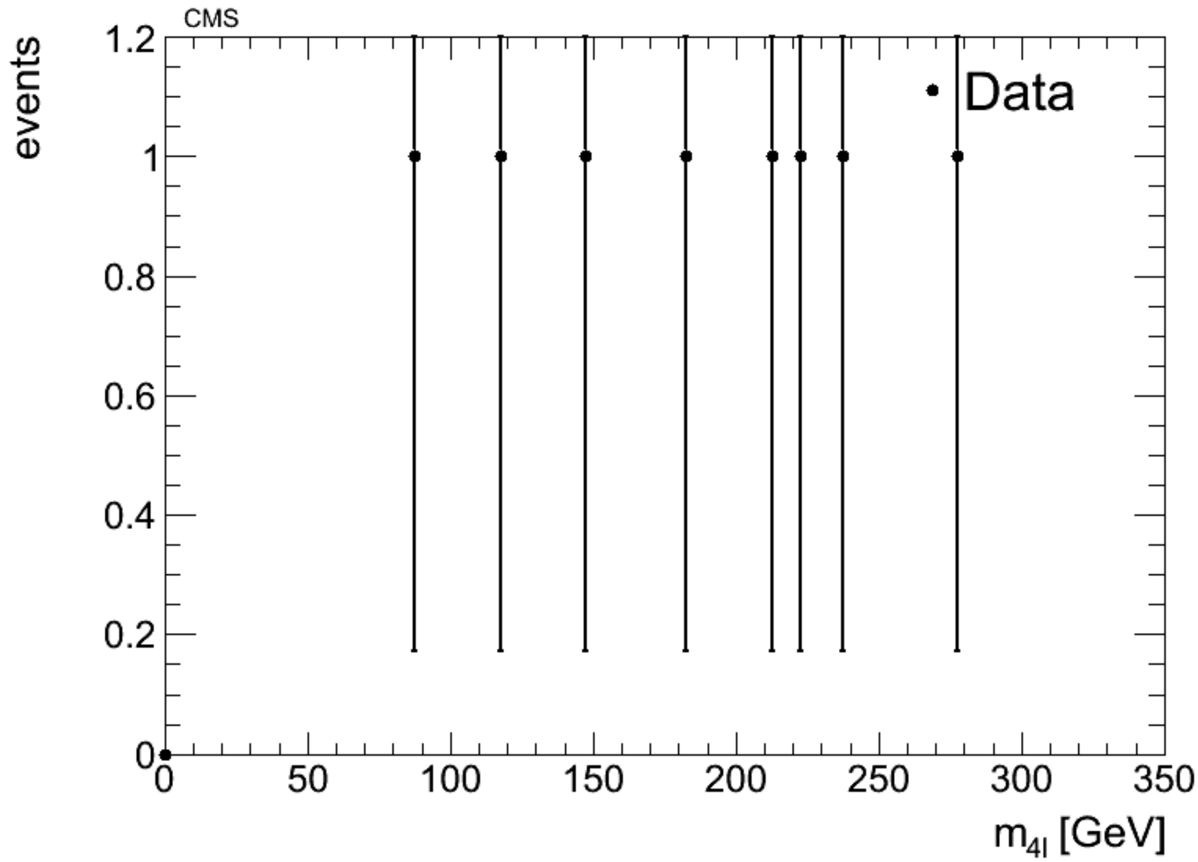


and H^0 to bottom-anti-bottom pair.



We decided to use H^0 to Z pair to di-muon pairs, because it would be the easiest analysis to code. As a preliminary test, we decided to run a program to find the Higgs-boson, as it is a part of Z', and so we need to find the Higgs-boson first. To do this, we coded a program that would find two distinct di-muon pairs.

It was run with approximately 39,500,000 events, and it found 9 candidates. The overall time taken was approximately 36 hours. The graph is shown below.



Conclusion:

In order to search for Z' we would need to further narrow those events by filtering out those that do not have a photon present, because Z' decays into both the Higgs-boson and a photon. However the Higgs-boson alone has already taken 36 hours to find 9 candidates. To do a proper analysis, we would need at least several hundred candidates.Therefore, with our current equipment and timeframe, we found that it is not feasible to search for Z'. If one had access to a computer with a significantly faster processor or were able to export the program onto a network of computers, it would not be difficult to analyse enough events to find a proper amount of data.