

QuarkNet Muon Data Analysis with Shower Array Studies

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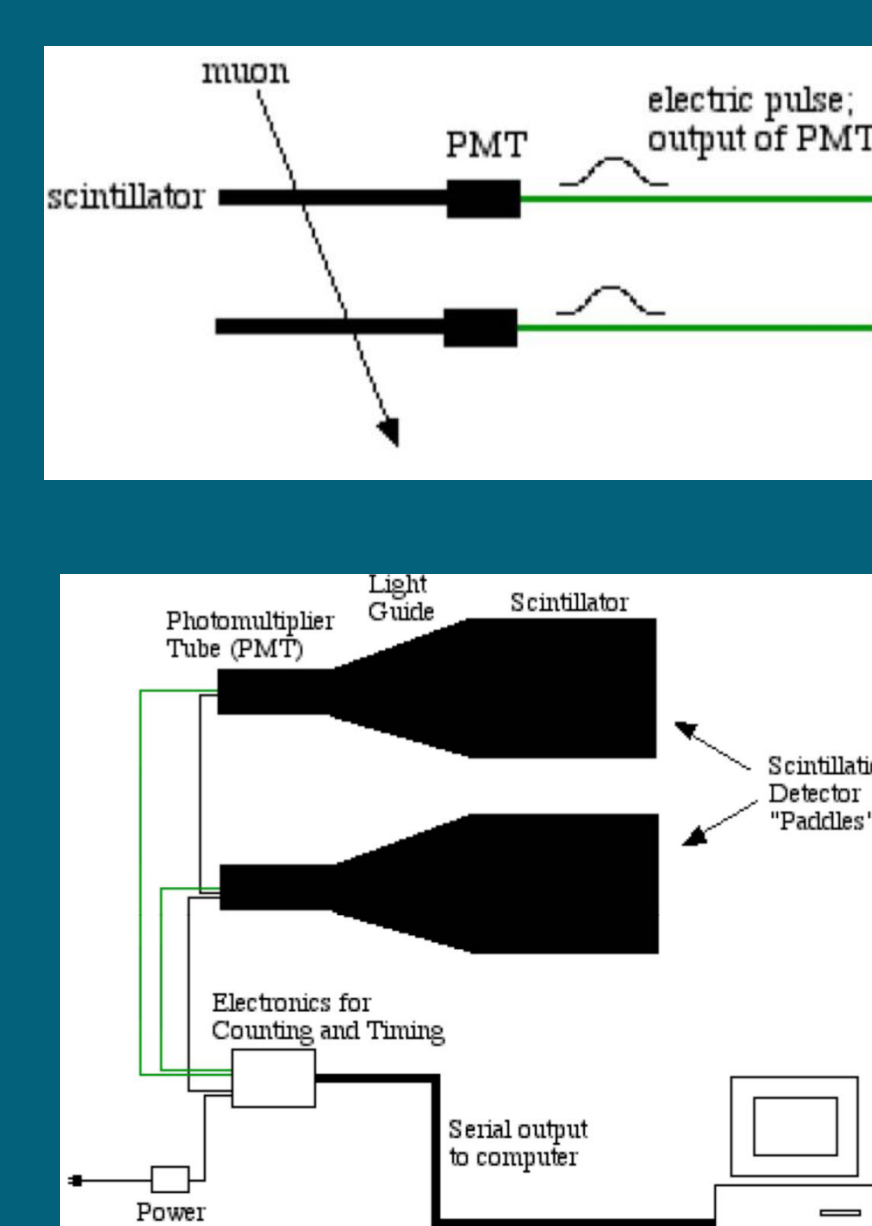
Abstract

In collaboration with Fermilab, the Florida Institute of Technology's Quarknet Project captures and collects data from cosmic ray muons. We use plastic scintillator detectors, photomultiplier tubes, a Data Acquisition (DAQ) card, and a computer to detect these muons. Using various orientations of four detectors, we measure the muon flux. For a muon to be counted, it must pass through all four detectors. For time-stamping our data, we use GPS systems atop our building. Using Fermilab's Cosmic eLabs, we analyze the quality of our data and measure flux and lifetime. Using muon shower array orientation, in which the detectors are oriented side-by-side, we performed muon shower array studies.

QuarkNet

Quarknet is an educational outreach program run by Fermilab, and is sponsored by the National Science Foundation and the Department of Energy. Quarknet provides the basis for understanding basic physics research.

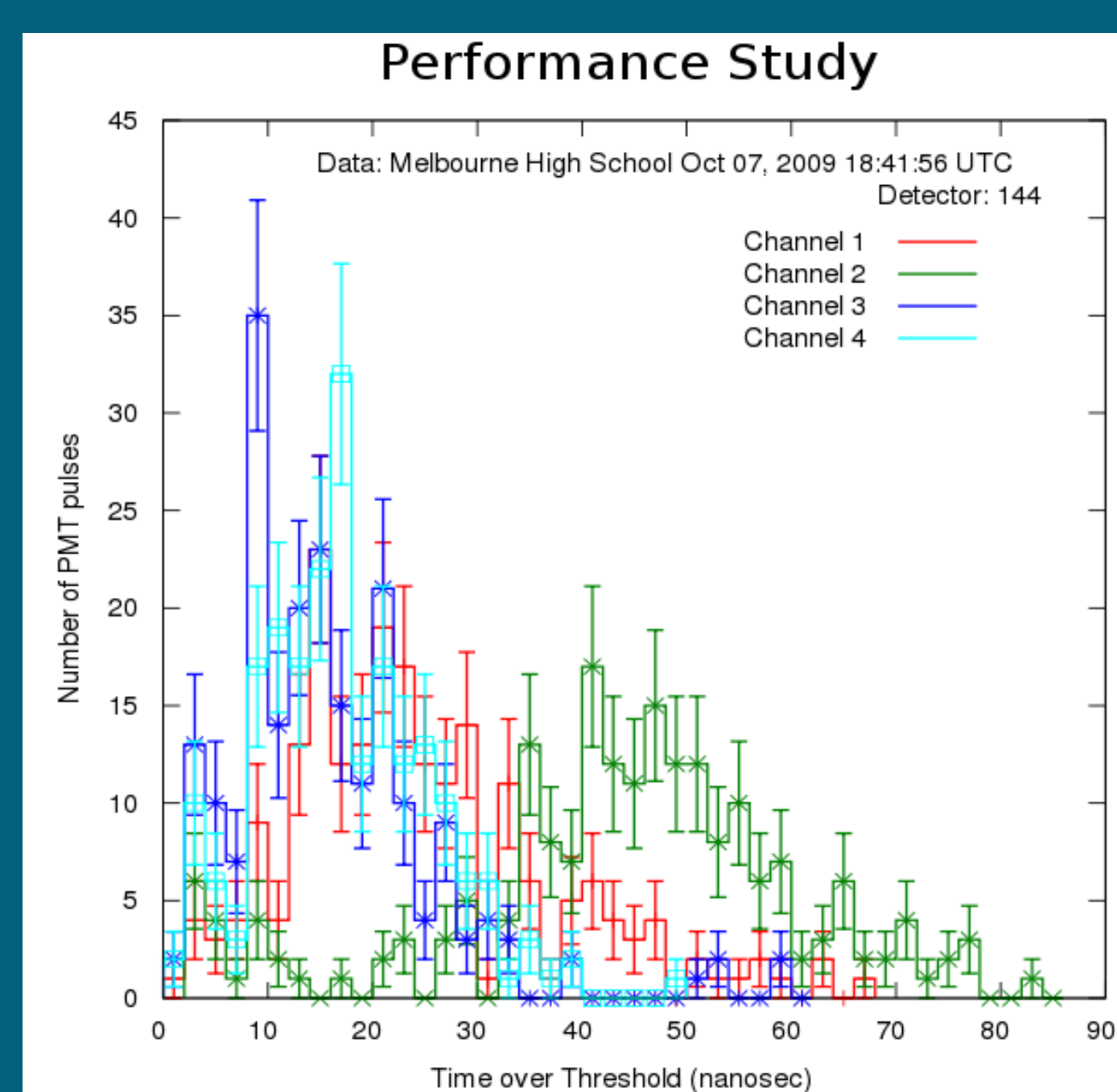
Set Up



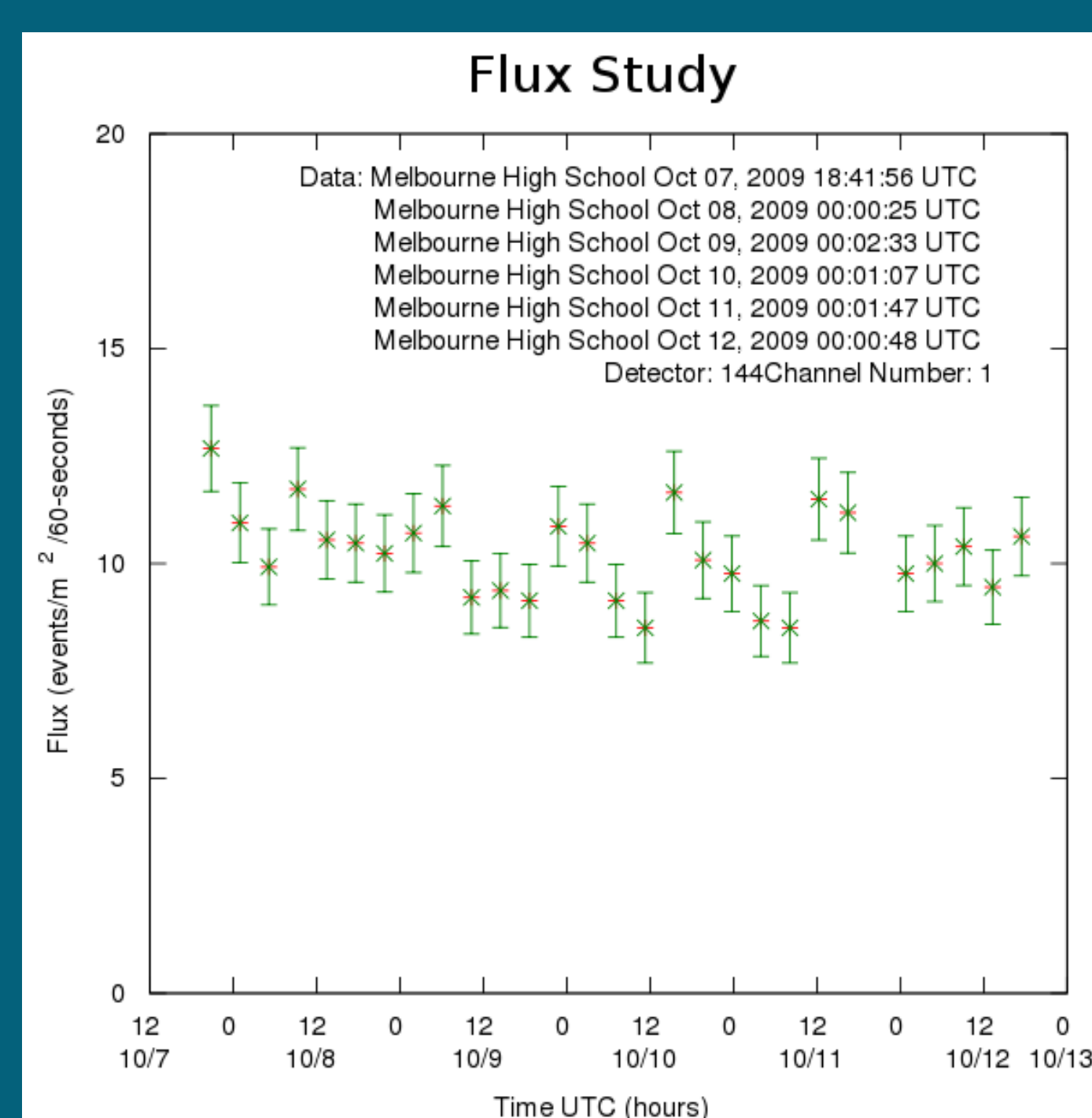
Muons pass through detectors and generate light bursts in scintillator detectors. The Photo Multiplier Tube (PMT) converts light bursts into electric pulses which are read by the QuarkNet DAQ card. The DAQ card connects to a computer which records the data (via HyperTerminal). Data is only used when the collections are at or above threshold level.

Data

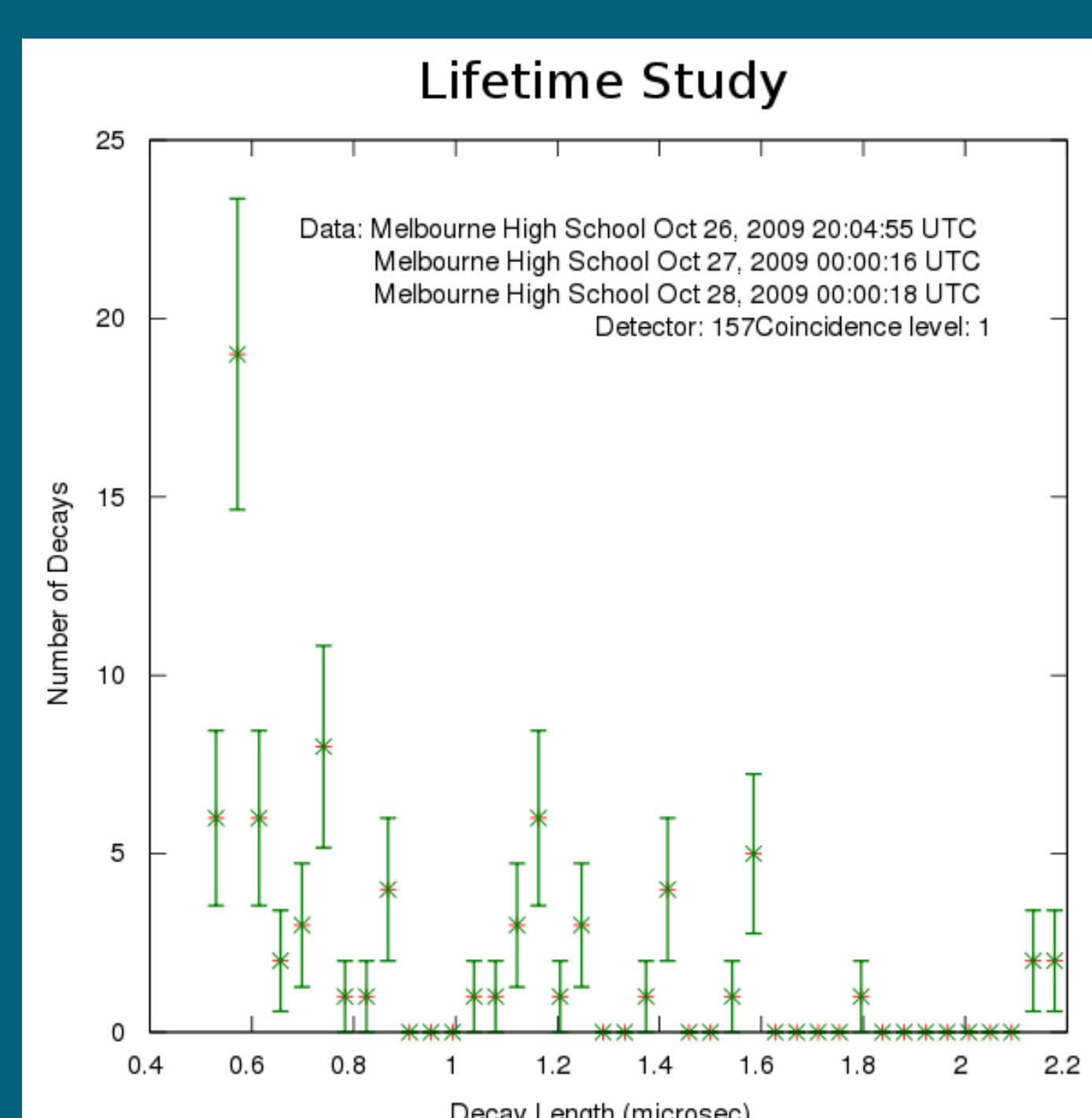
Performance Studies are used to determine the quality of the data. We can see how much "noise" is in the data. If there are many short pulses with few longer pulses, this indicates a noisy counter. Time over threshold is a measure of energy deposited in the scintillator for any given muon.



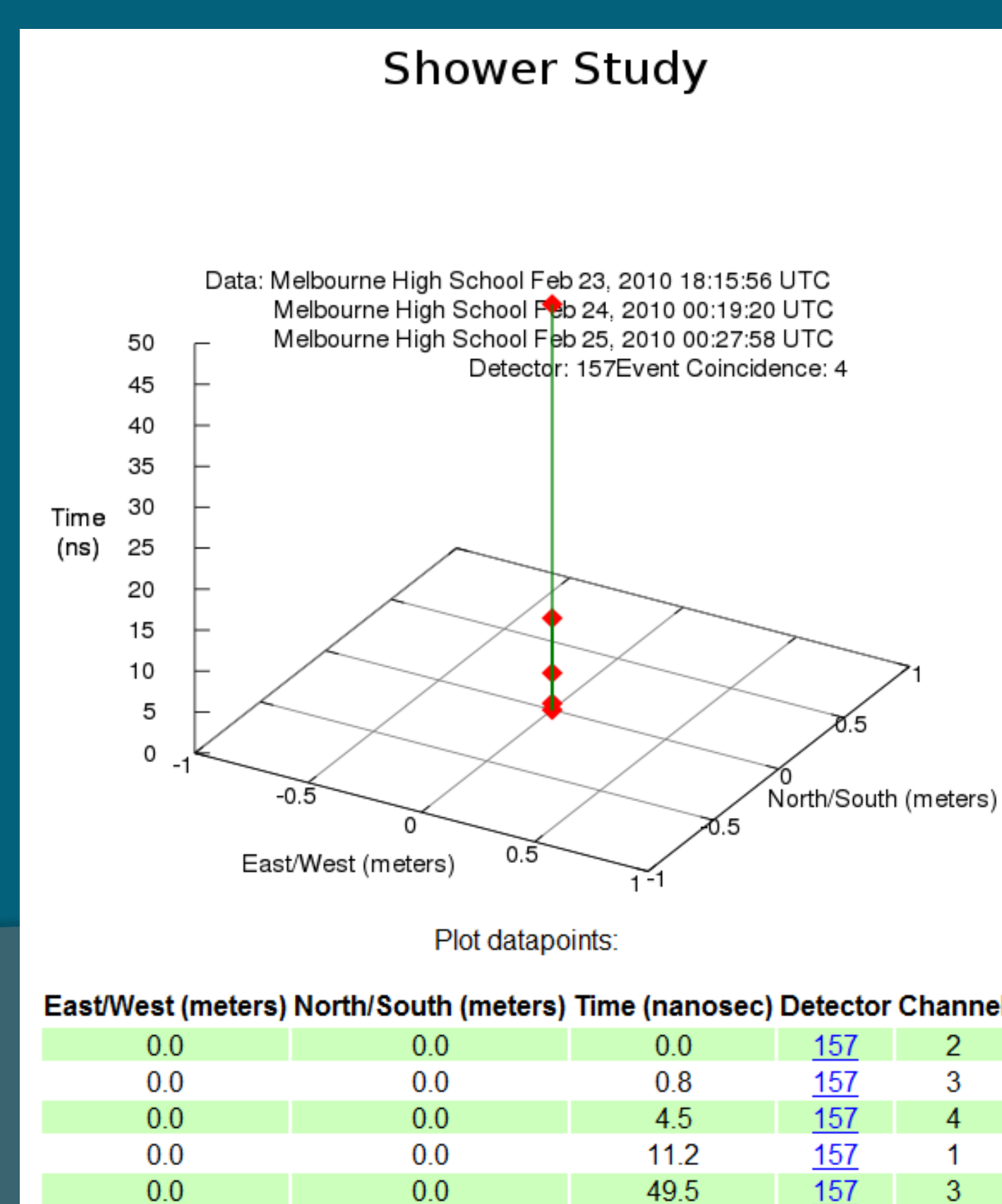
Flux is a detector-independent quantity. It gives the number of particles per amount of time that pass through an area. Flux varies with different thresholds; flux increases with decreasing threshold.



Lifetime Studies determine the difference between consecutive photomultiplier tubes signals. Consecutive signals may be from one muon followed by another or when a muon (1st signal) decays into an electron (2nd signal) and further decays.



Shower Studies look for cosmic ray muons that arrive at or near the same time over a geographic area.



Data Analysis/ Conclusions

Performance Study: Channels 1, 3, and 4 have a time over threshold between the rise and fall of pulses generally between 20 and 30 nanoseconds. Theoretically, every channel should have the same time over threshold value. Channels 1, 3, and 4 are consistent with one another whereas Channel 2 is inconsistent. This means that Channel 2 must have had a threshold that was too high, indicating that it was probably counting noise in its pulse counts.

Flux Study: Our flux average was approximately 10 events/area (meters²)/time(seconds), which is a fairly low flux average. The flux readings are not very sparse and are low, indicating a high threshold.

Lifetime Study: A lifetime study should have an exponential decay curve to the data points. This is identifiable; however, we have several outlier points, which means that our system is picking up noise.

Shower Study: There were 102 data points collected for this shower analysis, and only 5 met our requirements for a shower study graph. We require that at least four muons (a shower event we defined as at least four muons pass through each detector within 100 ns for our one DAQ card).

Future/Current Work

We are currently in the process of upgrading to a USB compatible DAQ card. We also have recently made improvements on data collection in terms of reducing noise and proper maintenance of our GPS systems.

References and Acknowledgements

Cosmic Ray e-Lab: <http://www18.i2u2.org/elab/cosmic/home/>

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