

# AN INVESTIGATION INTO THE MOLAR DETECTOR WITH RESPECT TO EFFICIENCY AND THE EFFECTS OF PRESSURE AND SOLAR INFLUENCES ON MUON RATE

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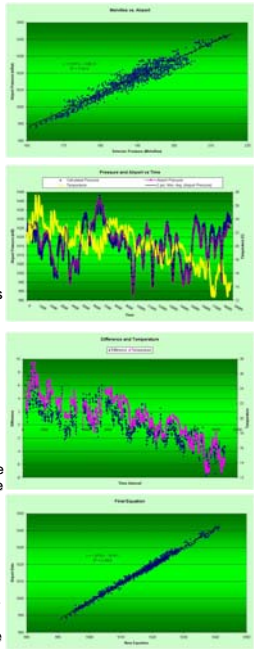
## Pressure Calibration

### Problem:

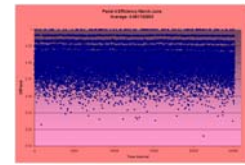
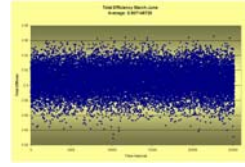
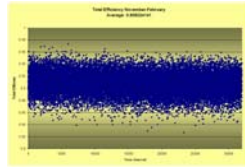
Since the MOLAR detector has been running, the DAQ board has been measuring pressure. However, the data was not calibrated and therefore measured in Melvilles, a unit named after the Director of Muon Computer Interface Technology, Jeffrey Melville. To figure out exactly what a Melville is and how to calibrate it into standard units, I went through a few steps.

- First I graphed Airport Pressure vs. Melville Pressure to find a conversion rate
- When the Equation I found seemed rather inaccurate, I looked for other ways to correct the data
- I graphed temperature vs the difference between ideal pressure and what my first equation had given me.
- I combined the 2 equations (from the slopes of my graph) to create a finalized equation including both Temperature and Pressure
- Final Equation:  

$$\text{Pressure at the airport} = [(\text{Pressure in Melvilles}) + (y \text{ intercept of the pressure vs. pressure graph: } 828.31)] + [(\text{slope of the difference vs. temperature graph: } .8938) * (\text{Temperature as measured on the DAQ board}) + (y \text{ intercept of the temperature graph: } -17.928)]$$
- The final R squared value was .9992

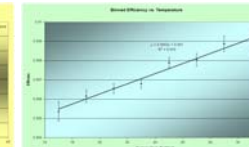
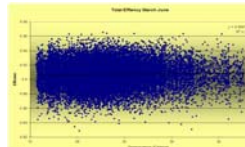


## Efficiency



- Another goal was to look back at MOLAR data and evaluate its efficiency compared to the 2 smaller detectors placed above and below the large panels
- The Efficiency ratio of coincidence hits by all 4 panels detecting a hit divided by how many missed panels either big panel hovered around .9
- Panel 4 by itself had a much higher efficiency, hovering around .98, than Panel 3, which had an average efficiency of about .93
- Note: The small panels are placed on top of the middle of the big panels, where it is most likely to miss a muon

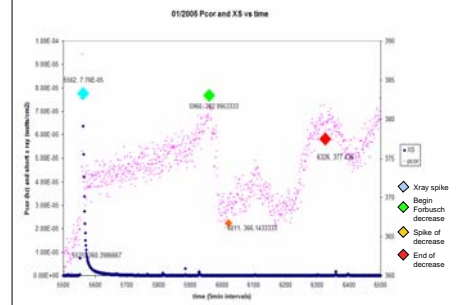
- Another question proposed was whether temperature had any effect on the efficiency of the detectors
- We found that there was also a slight effect that temperature had on Efficiency, but it was only in the order of .0003
- To find out if the effect was statistically significant, we binned together temperature ranges of 2 degrees with sigma error bars and graphed it



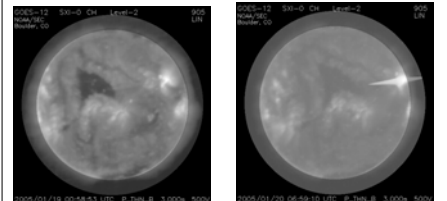
## Solar Influences on Muon Rate

The energetic protons that a strong solar flare produces can result in a GLE (ground level enhancement), resulting in a higher muon rate. An ensuing Forbush decrease ("w" shaped) in the rate is a product of a shift in the earth's magnetic field. X rays are a good indicator of solar flares. The GOES 12 satellite measures the flux of these X-rays and generates data and solar pictures from them. The following graphs and images taken from January show a relationship between spikes in X-ray flux, Flares, and shifting muon rates.

This graph of Muon rate and X ray flux reveals that a spike in X-ray flux on January 20 created a sharp fluctuation in muon rate.



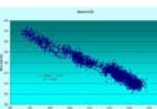
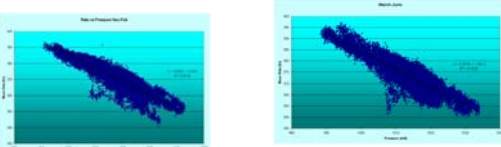
The date of the solar flare in this picture coincides with that of the x-ray spike above. The large black disturbance below is a precursor to this flare.



This coincides with SEC's report of a X 1.7 Solar flare ( the highest of this year) on 2005 Jan 01 0043 UTC

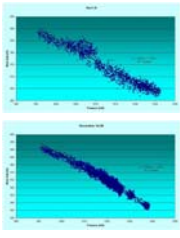
## Finding a definitive coefficient of Pressure on Muon Rate

My goal for the second part of my study on pressure was to narrow down a coefficient we could always use for pressure's effect on muon rate. To achieve this, I needed to find data over the longest period of time possible with little or no solar influence.



Graphs of 4 slowest months

Greg Meade obviously on top of his insanely exciting excel data files



- The most accurate linear trend I could claim would be  $.86 \pm .03$
- This is equal to about a .23 percent change in Muon Rate for every millibar change in pressure
- The only way to get a more accurate coefficient would be to take out all solar influences first (practically impossible) or find more muon data relatively unaffected by solar influences

From left:  
Zach Noyes,  
Greg Meade  
& Jeff Parvin



## DAQ Pressure Calibration

In order to not have to do the pressure calibration on the detector once it has been running, we set out to calibrate the DAQs ourselves. To do so, we needed to build some sort of closed environment in which we could vary the pressure approximately +/- 5% of standard atmospheric pressure that would also fit our necessary equipment. We solved this problem by using a bell jar with a hole in the top and a vacuum pump and fit the wires in through a slit cork that we sealed with clay. We then decreased the pressure to 80 kPa and let it slowly drift back up to 100 kPa. Every 2 kPa we recorded the actual pressure with the barometer along with the reading the DAQ gave for pressure. We then graphed these against each other to get the baseline (y-intercept) and gain (the inverse of the slope) which is used to calibrate the DAQs.

