The GSU Neutron Detector

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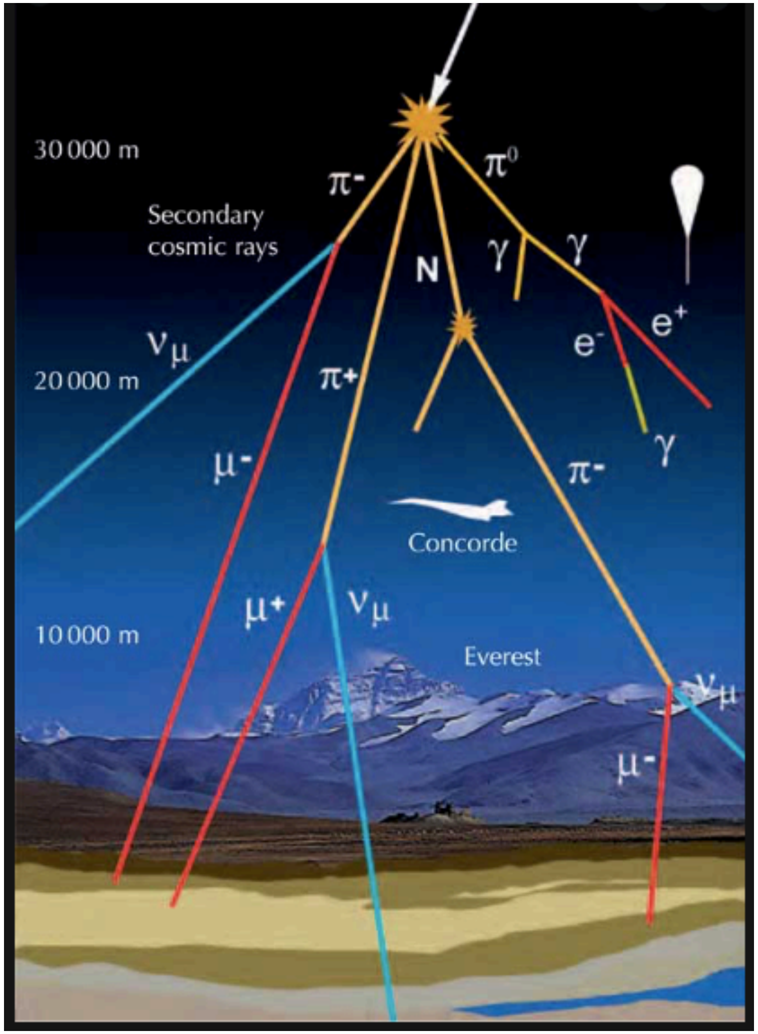
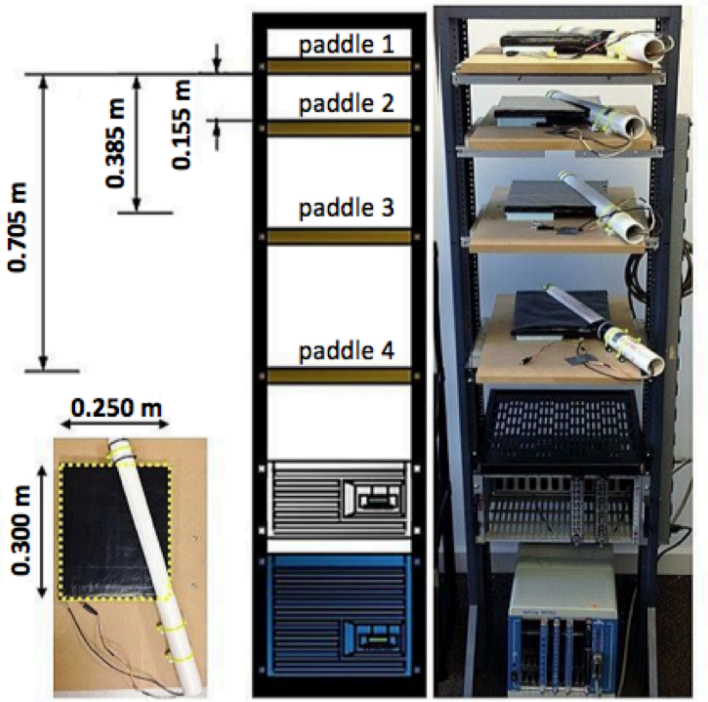
Introduction

- It has long been known that the number of cosmic ray muons and neutrons reaching the surface of the earth depends on many conditions. We know this depends on:
- Location on earth (geomagnetic rigidity)
- Time of day
- Season of the year
- Solar conditions
    - Solar wind
    - Interplanetary magnetic field magnitude and polarity
    - Sunspot cycle
- Temperature
- Barometric pressure



At Georgia State we have a long history of building cosmic ray detectors for different studies

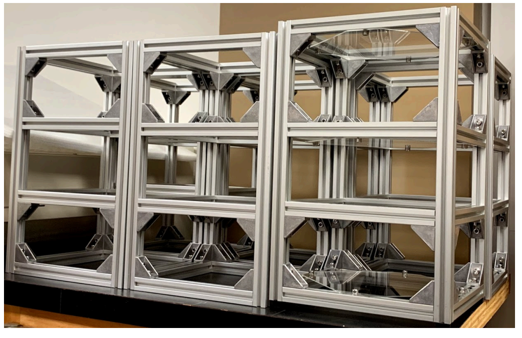
The 'Pot Detector' was originally built to measure muon lifetime. Built from scrap material and a cooking pot, it cost less than $150. It was later converted to a cosmic ray counter. It has been running for 17 years



The four paddle detector is used to study cosmic rays counts using different acceptance angles,

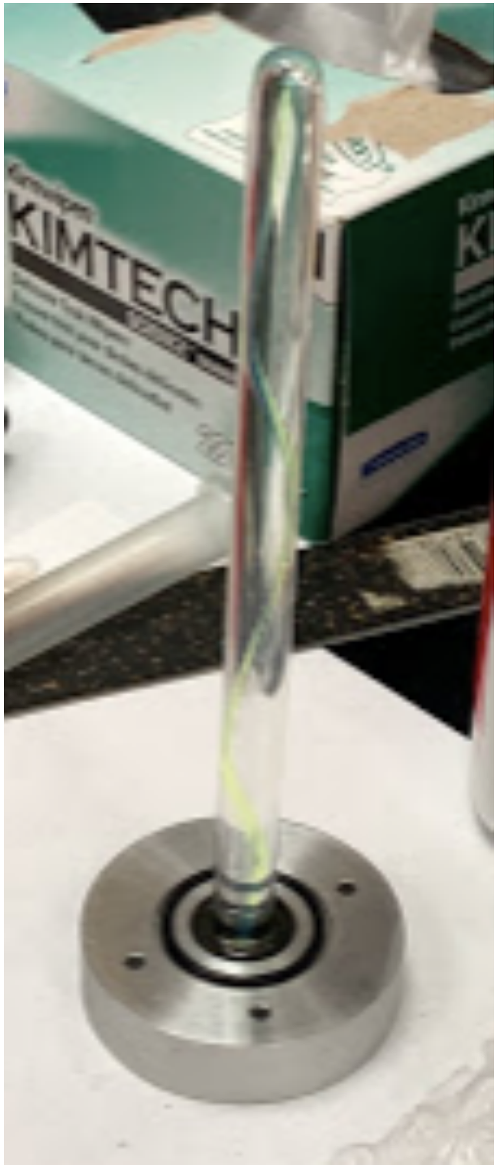
The Muon Telescope

Our latest project is to build muon telescopes that will use SiPm technology and will be portable and relatively inexpensive. The frame will hold plastic scintillator tiles and the acceptance angle can be varied.



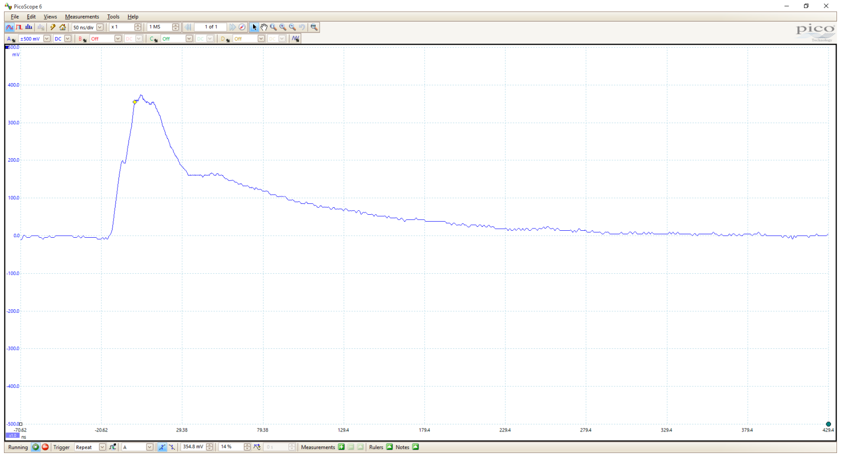
When we started building our muon telescopes we wanted a neutron detector that would fit on the frame. The scintillator tiles could be used to help differentiate between charged particles and neutrons. The neutron detector had to be compact, reasonably light and use SiPM's rather than PM tubes.

- When we started building the muon telescopes we used the designs used by sPHENIX– plastic scintillator plates with embedded wavelength shifting fibers coupled to SiPM's.
- The only practical way to detect neutrons is to use containers full of liquid scintillator.
- The problem was then to find a way to couple the SiPM to a tank full of scintillation liquid.
- Some people have tried immersing the fibers in liquid scintillator, but this has two problems. Some liquids are very chemically aggressive and the fibers are not rigid and would drift around in the tank.
- Putting the fibers into glass tubes was the solution.
- For optical coupling the tube is filled with optical grease.

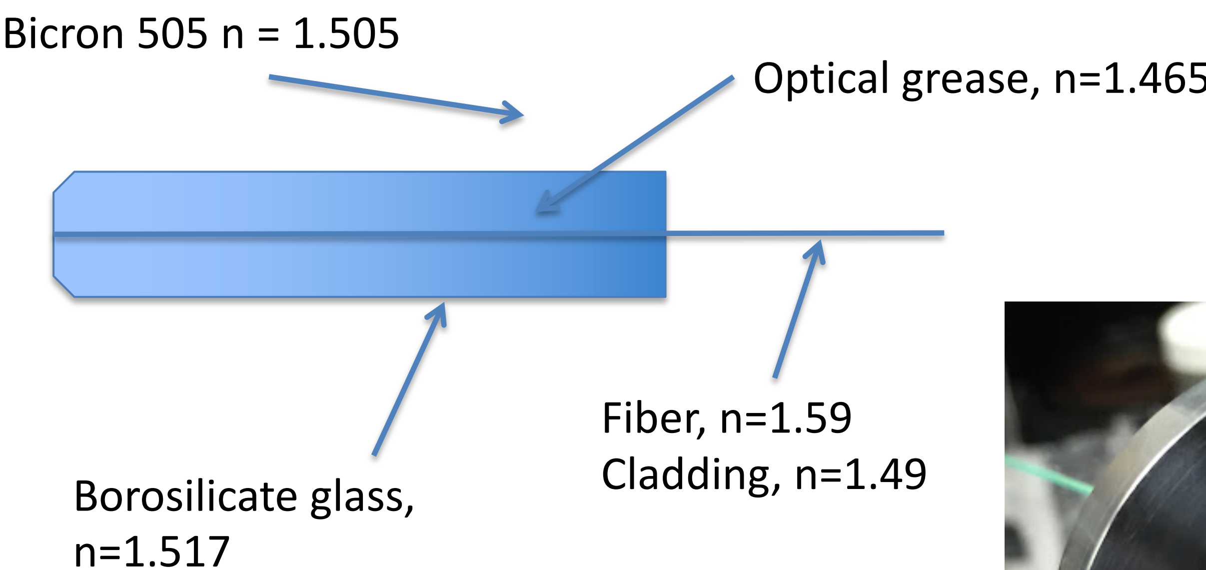


The Prototype

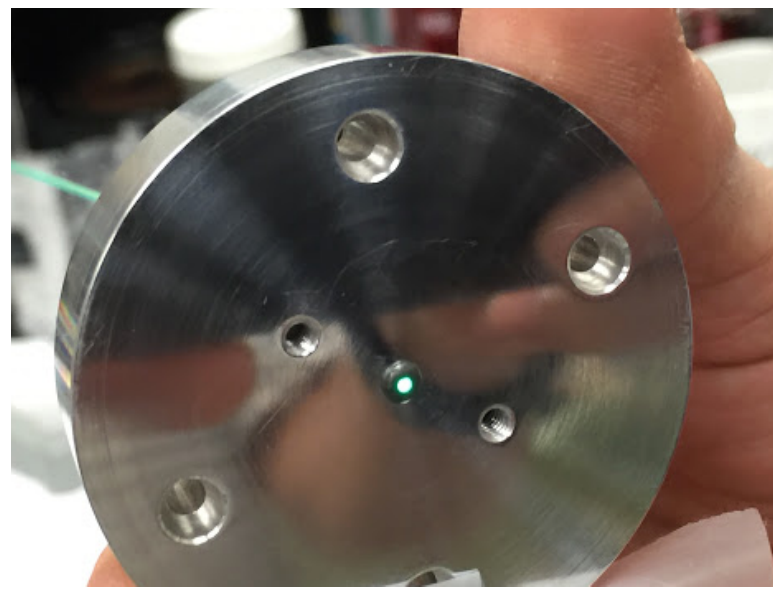
The prototype was made from a water bottle a student left in the lab and never came back for. When it was connected to an SiPM it gave a beautiful signal.



The Light Collection Tube

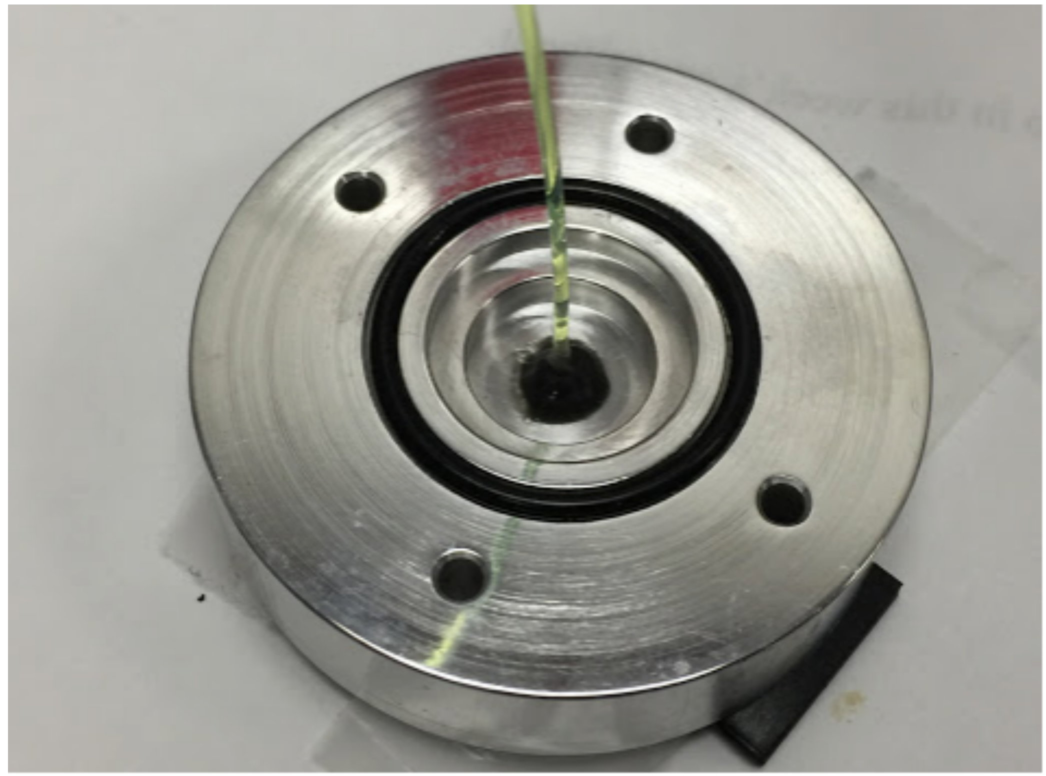


The differences in refractive indices is fairly small.



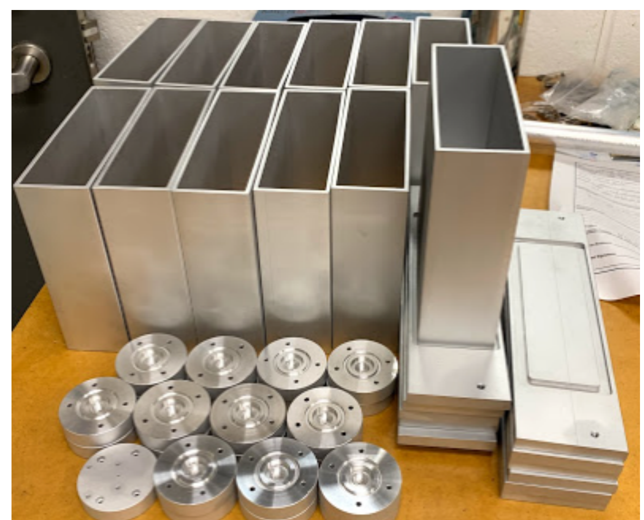
The End Cap

The most important part of the assembly is the end cap. It has to both hold the fiber and the grease tube, prevent the tank from leaking and provide a place to securely attach the SiPM holder.

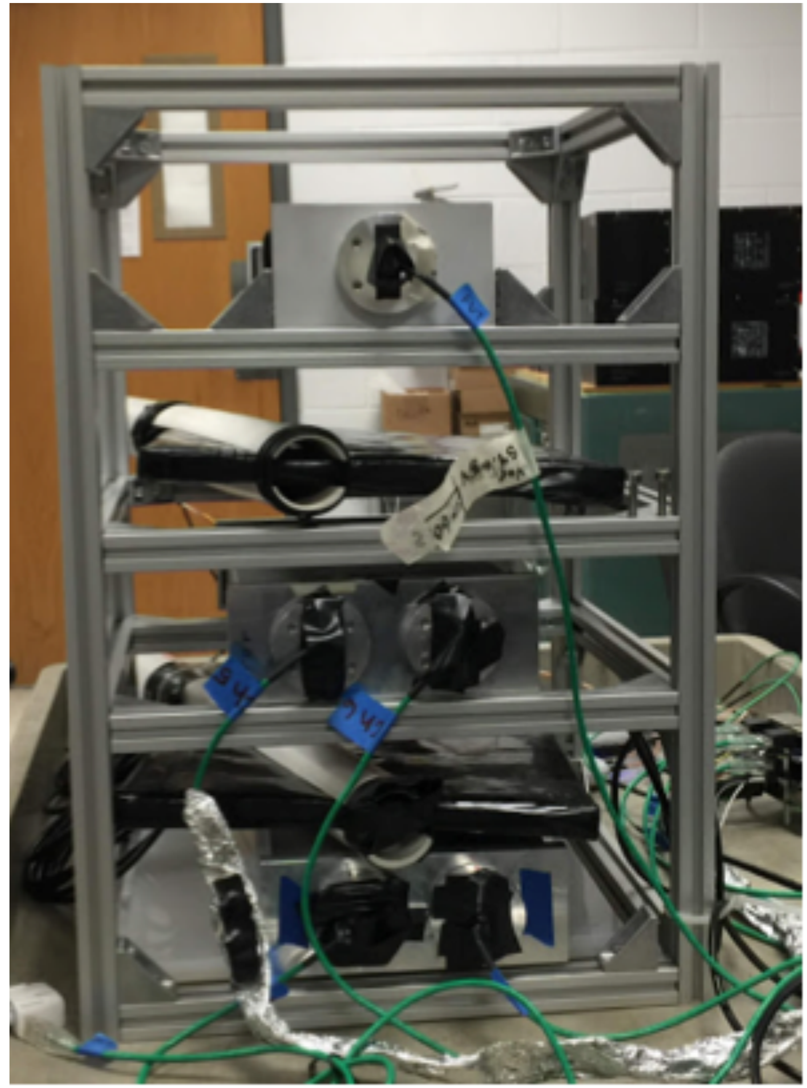


The Mark II-Mark V

In principle any container would work. Our detectors are made from 6061 aluminum which is inexpensive, comes in many sizes,and is easy to machine. This is 6” x 2” standard tubing. We cement the parts together using Araldite 2014 epoxy which is very strong, not electrically conductive and chemical resistant.



The Mark II model had only one tube and SiPM. However, SiPM's are very noisy (about 300,000 dark counts/second) so all our subsequent models have two SiPM's and rely on coincidence to declare a hit.

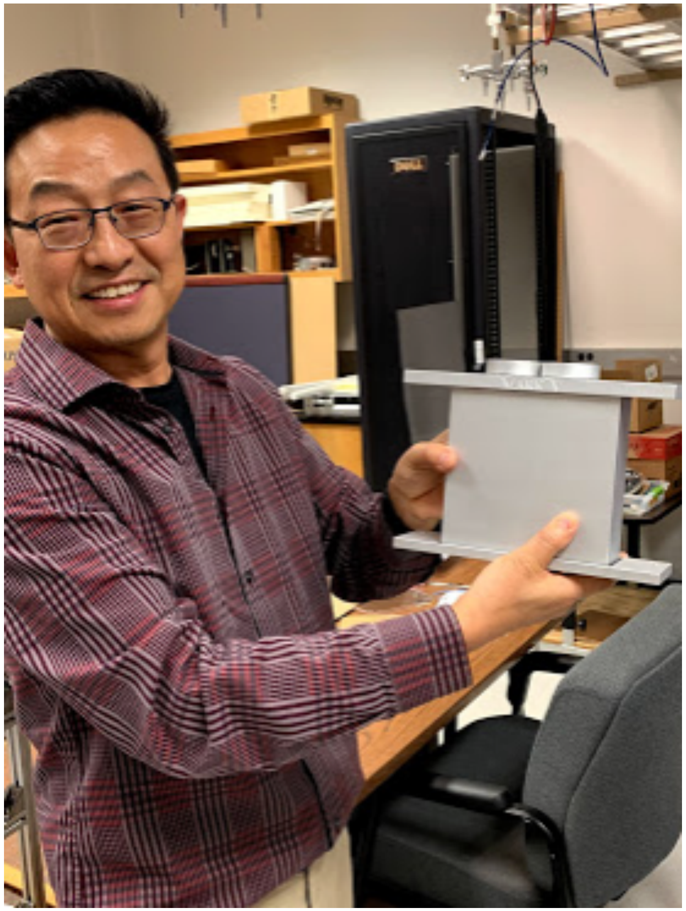


Mark II

Mark III

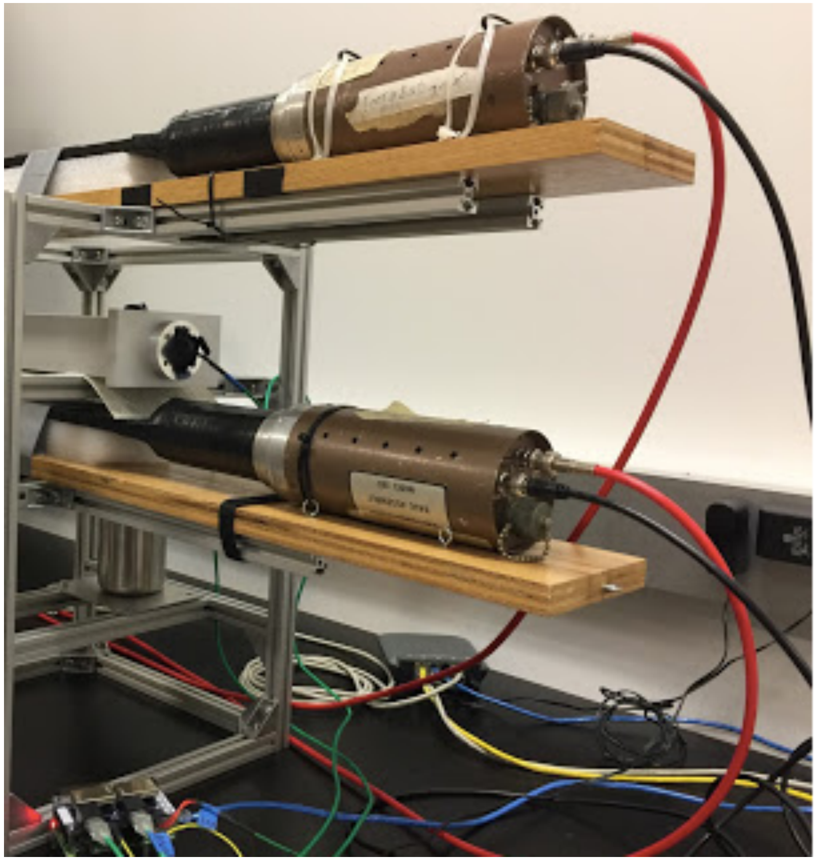
Mark IV

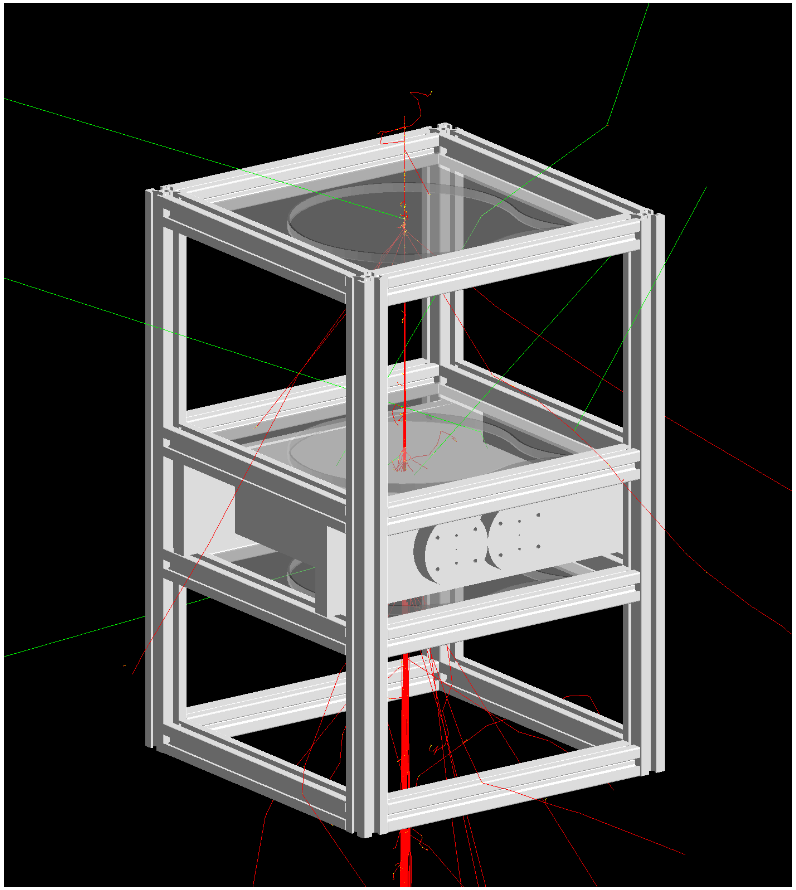
Current design



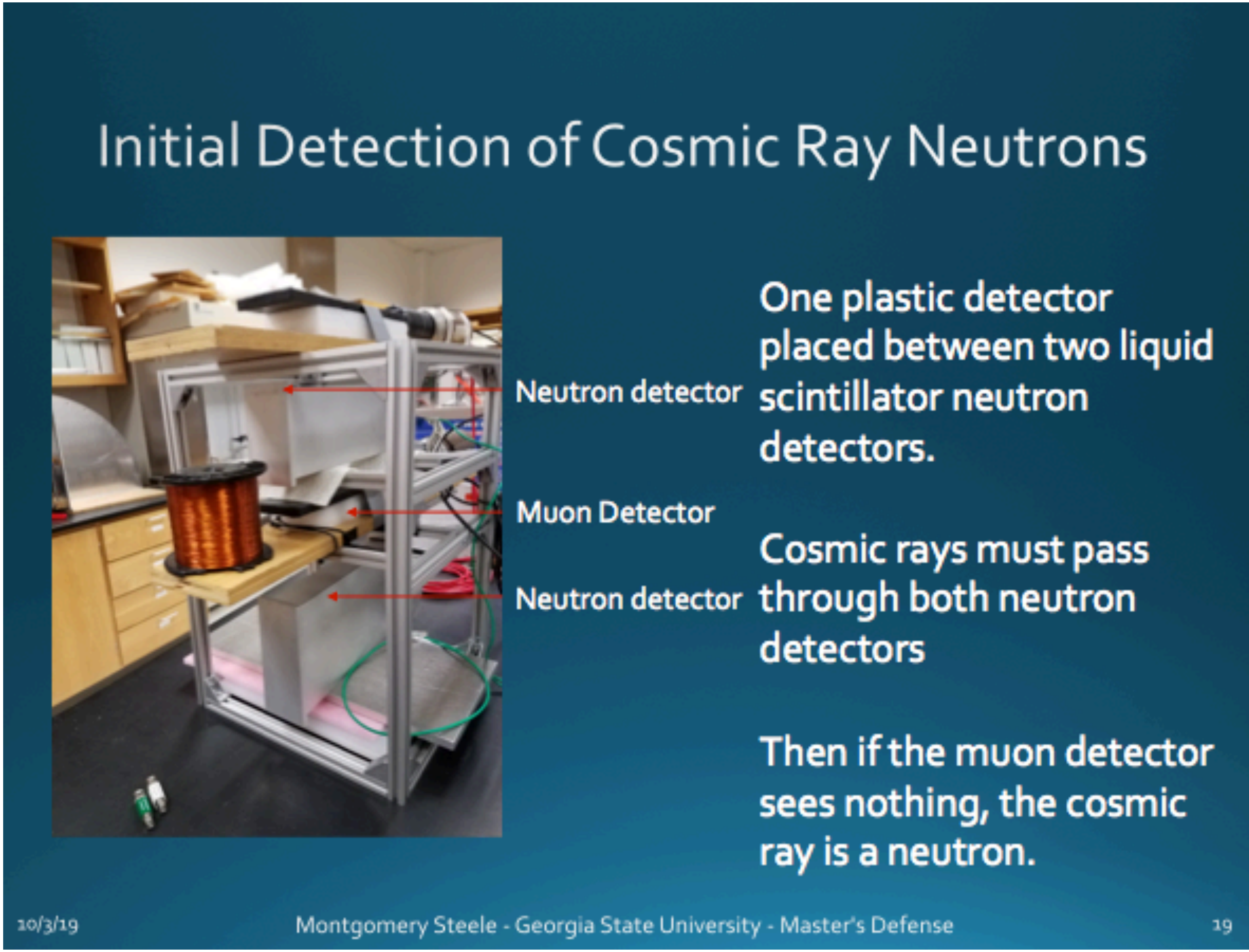
The Mark V is six by six by two inches and has two end caps. The flanges on the side let us bolt it securely to the muon telescope frame.

Performance



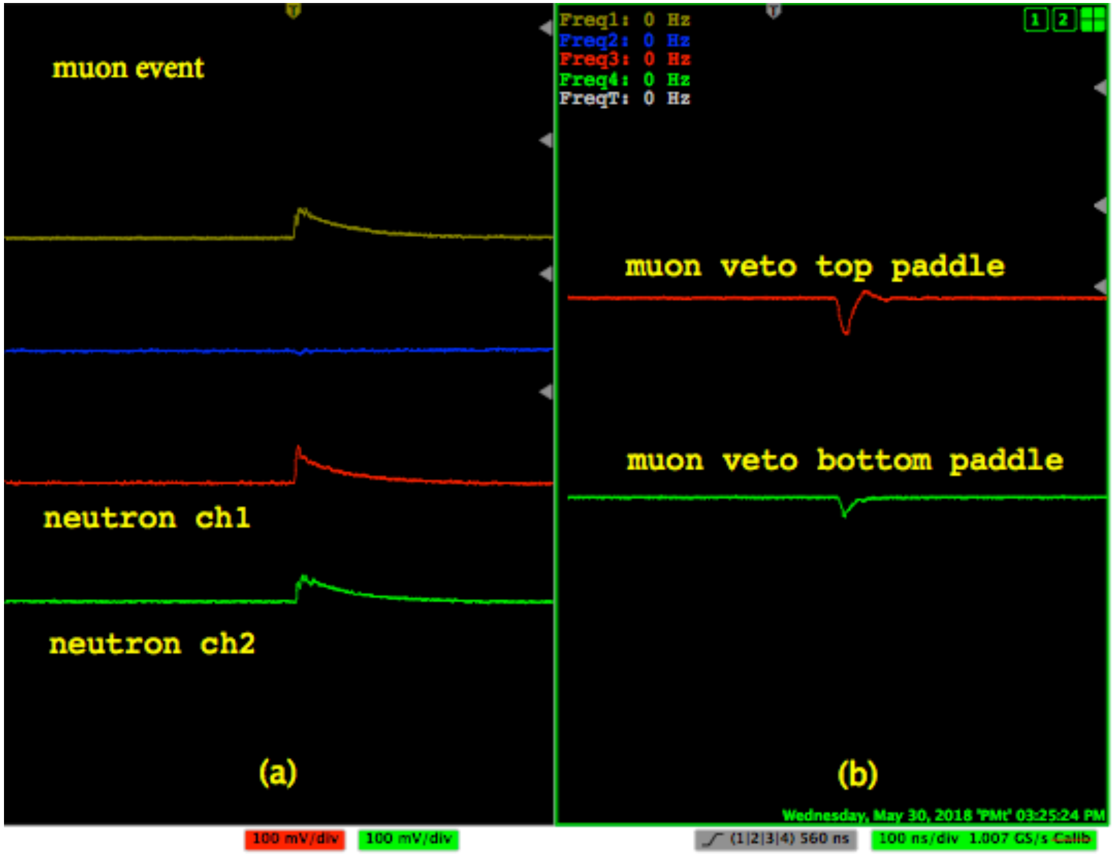


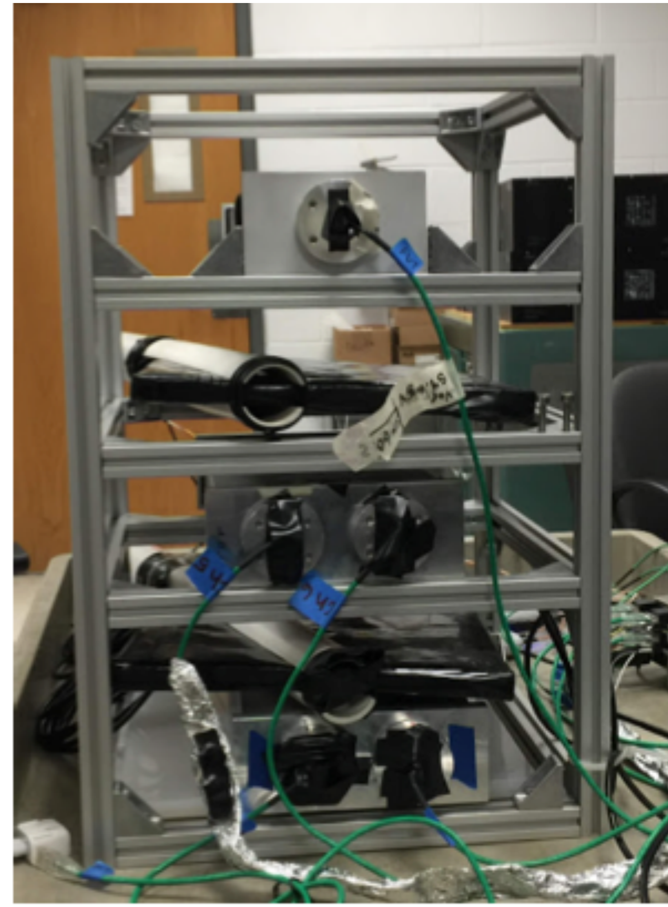
Test set up by Montgomery Steele



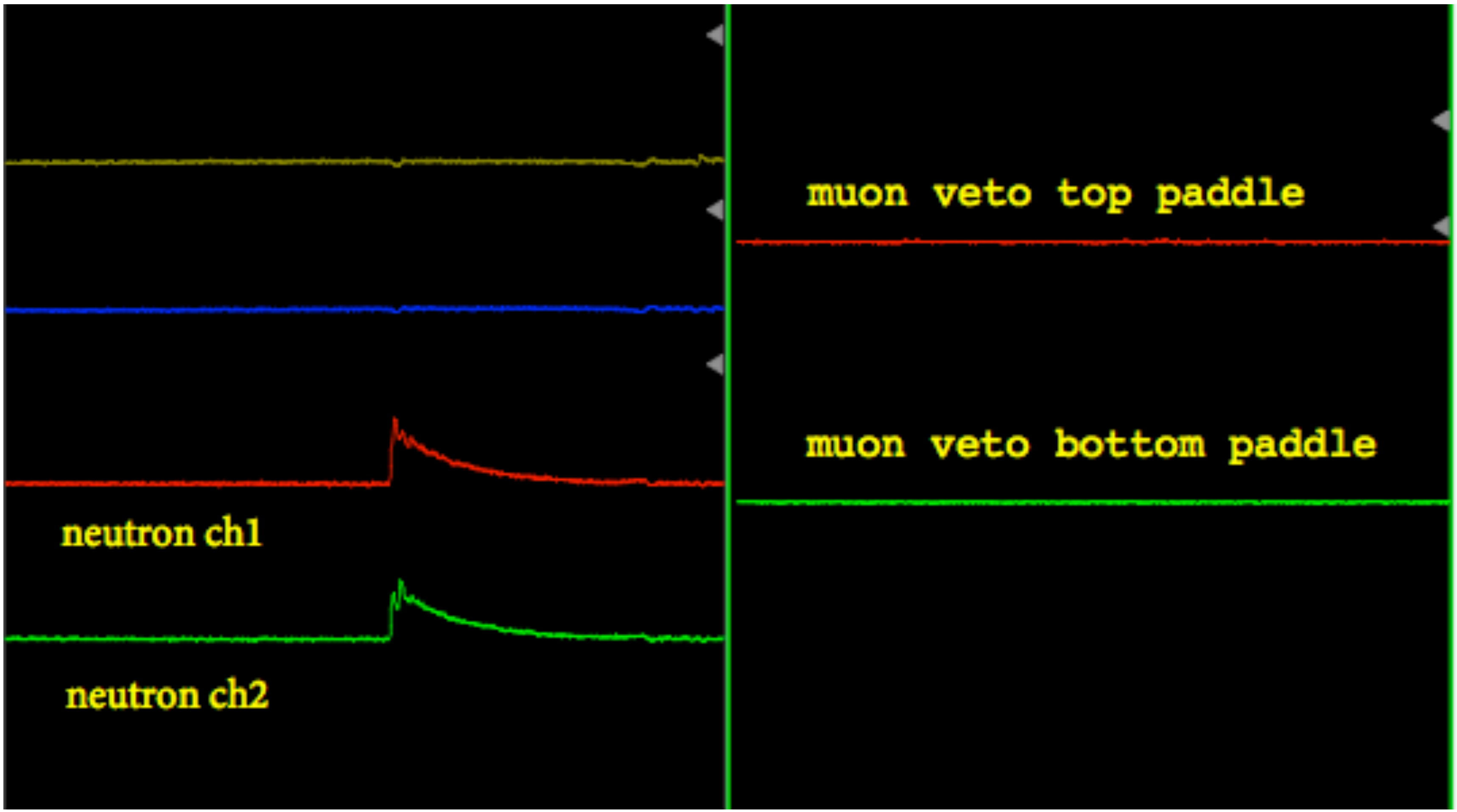
Slide courtesy of Montgomery Steele

Muon Signals

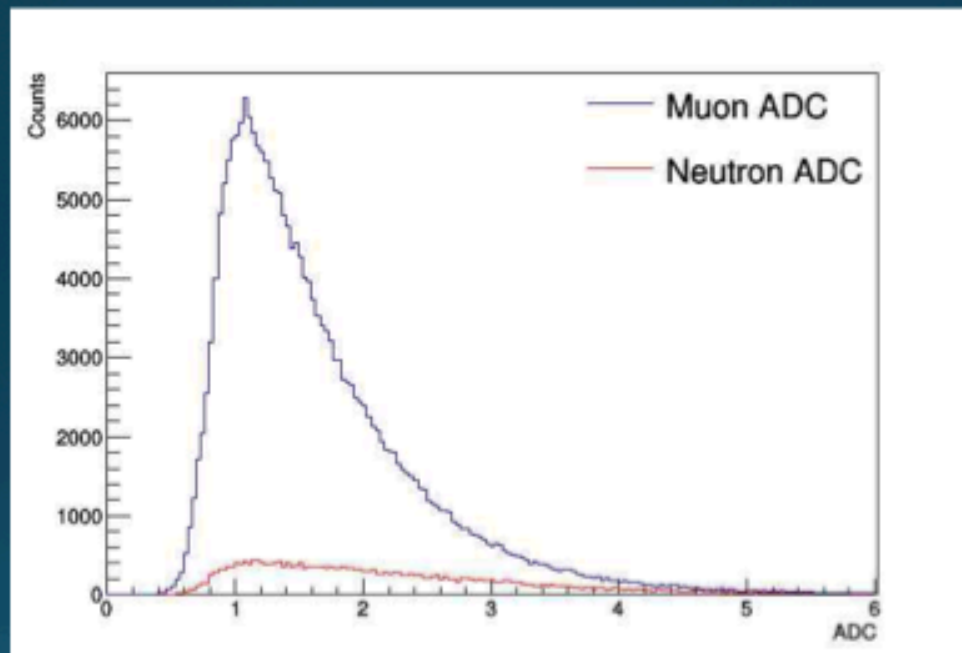




Neutron Signal



Neutron detector ADC spectrum



As expected, cosmic rays comprise ~10% of our detected events!

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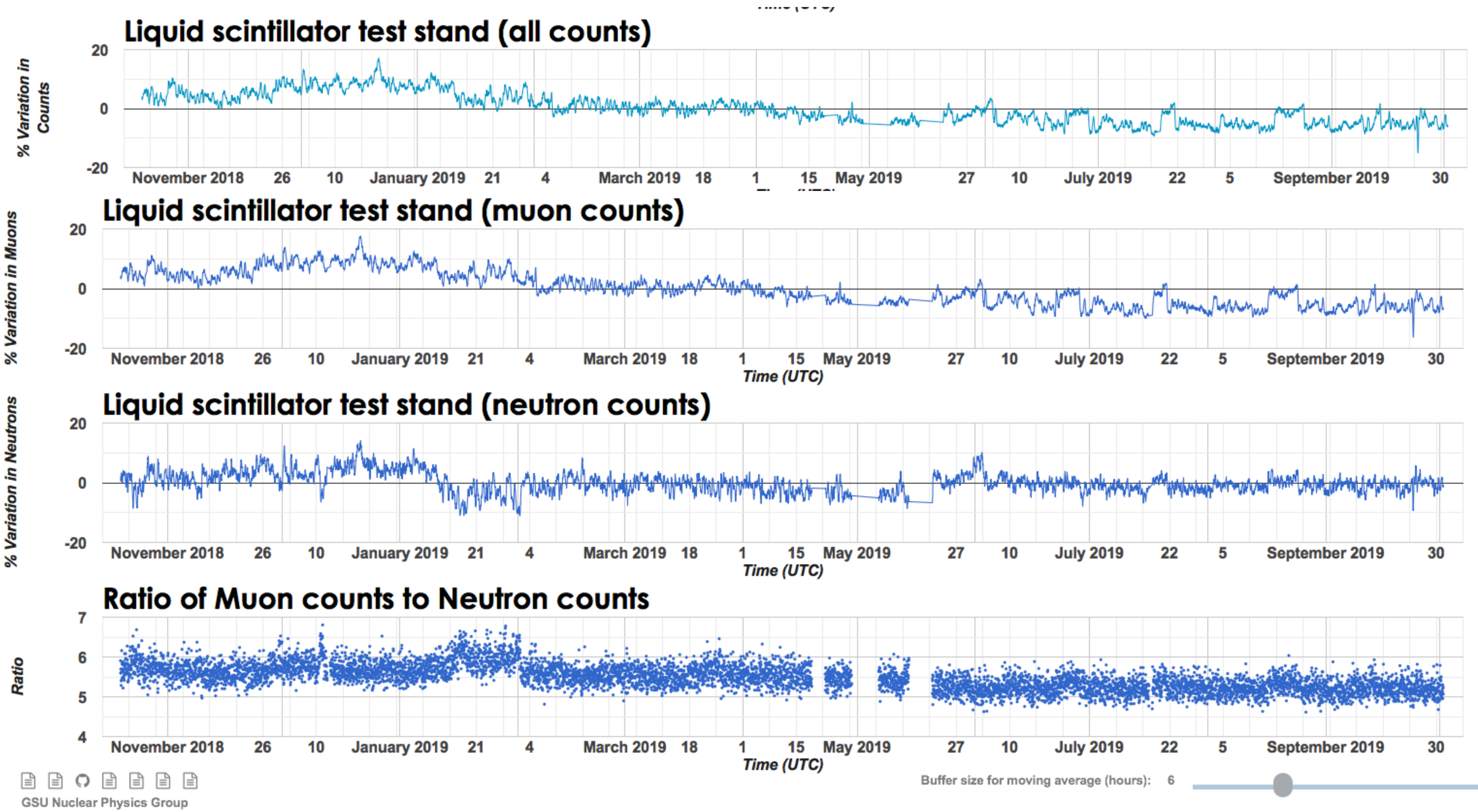
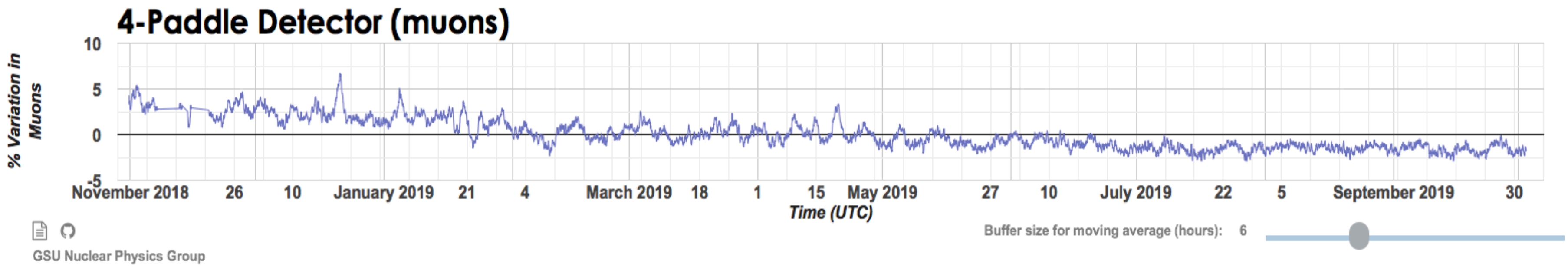
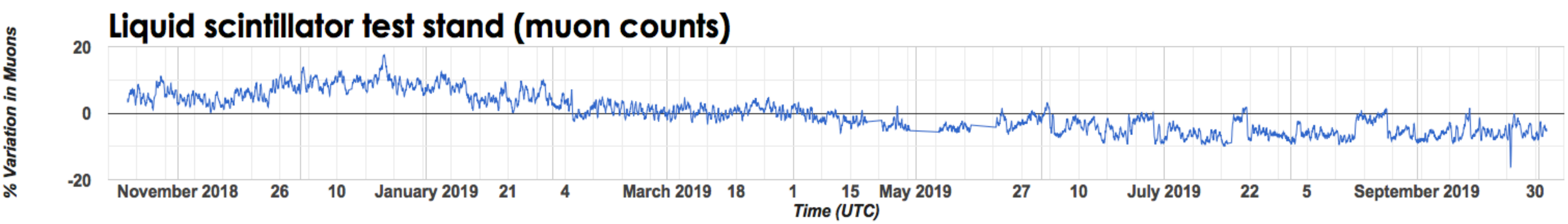
Online monitoring



Comparison with Other Detectors



This data is taken from a cosmic ray detector test stand in Atlanta, GA. It is located in 1 Park Place, Rm. 706. The graph shows the % variation in cosmic rays detected per hour using a running average. The span of the running average can be adjusted using the sli
The detectors in this test stand use a scintillating plastic which can detect cosmic ray muon events.



http://phynp6.phy-astr.gsu.edu/~cosmic/dynamicDisplay

Future work

- Improve signal by adding more fibers to the grease tube
- Calibrate ADC using known neutron energies
- Build more detectors

Deep bows of Gratitude

Dr. Xiaochun He
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Dr. Megan Connors
For letting me play with their group

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Dwayne Torres
Sam Mayberry
Our instrument shop people for their endless patience and help

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Montgomery Steele
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Sawaiz Syed
For electronics and rendering help

The entire Nuclear and Particle Physics Group –Past and Present Me

And Thank You for Your Attention