Diagnostics and Upgrades of the Low Background Counting Facility's Muon Veto Shield

John C. Greavu III

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Goals

To improve the functioning of the Low Background Counting Facility's muon veto shield through hardware upgrades and by improvements in the data quality.

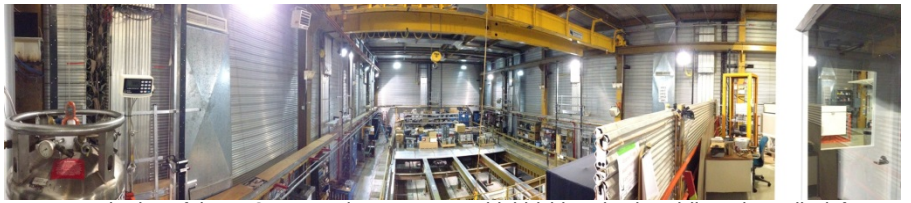
Methods

A 30-channel, ~15 ft. replica piece of veto shielding (below) was transported to PAN 450 from Tate in January. The local setup was used as a test bed for upgrades and for practice with understanding the in's and out's of the veto shielding without having to travel the 200+ miles to Soudan.

The local setup in the new physics building.

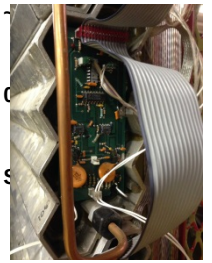
In March, a voltage scan was conducted on the local set-up to test the completely vertical-going muon efficiency of the shield at different voltages. Over spring break, another undergraduate and myself traveled to the Soudan lab to lay down high-voltage cables and prep the facility for a new HV system which we will finish installing over the summer. The new system will allow us greater flexibility and ease. Data analysis was typically done in MATLAB, creating scripts to cut down the enormous size of the data into more manageable pieces. Specifically, the work focused on getting trigger rates over long stretches of time. An entire programming environment has been set up for analysis.

Background



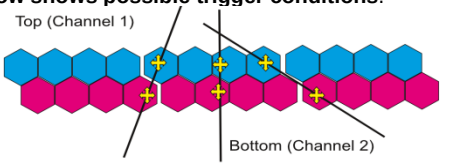
A panoramic shot of the LBCF. An active muon veto shield (shiny aluminum) lines the walls, left over from the Soudan proton decay searches.

The Low Background Counting Facility (above) or LBCF, is a 40 x 35 x 100 cubic ft. hall in the Soudan Underground Laboratory in Soudan, MN. The Soudan Lab exists half-a-mile underground in an old iron mine turned modern physics lab. An active muon veto shield/tracking device lines nearly all of the hall, save for the floor, through which only a week is expected. The muon veto shield is a system of hexagonal gas proportional tubes filled with 90% Ar/10% CO_2. Down each tube is strung a gold wire which outputs binary data (1's and and through a preamp (left) according to if a particle of sufficiently ionizing radiation was detected in a channel. Also in the Facility is a neutron multiplicity meter, capable of fast neutron searches. of backgrounds with ultra-low background environments such as this are crucial for many modern rare-event searches in physics: particularly dark matter and neutrino-less double beta decay hunts.



A close-up of the tube output showing the preamp and data cables. Timestamps in Unix time (to the microseconds) are also output with the data.

The triggering system for the shield follows certain logical conditions. A trigger usually will only be read out if a physically meaningful combination of channels detected something. The figure below shows possible trigger conditions.



Possible particle paths which would constitute a trigger. Also shown is the honeycomb-like arrangement of the double-layered hexagonal tubes in the shield.

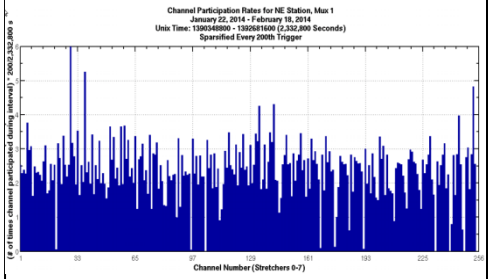
References

1) Fritts, Matthew. "Results of Scan of Bias Voltage of Middle Layer of Test Stack." Physics *NMM & Soudan Veto Shield Analysis Notes.* University of Minnesota School of & Astronomy, 28 Mar. 2014. Web. 5 June 2014. <http://www.hep.umn.edu/cdms/lbcf_restricted/vetoshield/140328/index.html>.

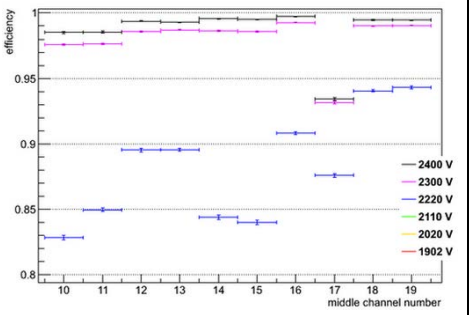
2) Cushman, Priscilla. *Soudan Low Background Counting Facility*. University of Minnesota School of Physics & Astronomy, n.d. Web. 5 June 2014.

Accomplishments

The average rate of triggers in the Soudan mine was determined to be approximately 2-3 Hz. Below is a sample graph of channel rates for the NE station, multiplexer 1, as well as a plot of the March voltage scan on the local setup.



***Above:** channel participation rate in triggers from Jan. 22, 2014 – Feb. 18, 2014 for NE, multiplexer 1. The facility is divided into 4 stations, which are each divided into 2 or 3 multiplexers, which feed to 8 stretchers, each containing 32 channels.*
***Below:** results from the voltage scan.*



A database containing stretcher rates for all of our data is being created using MATLAB scripts we created. Suspiciously high or low channels/stretchers will be physically investigated in the summer by applying our analysis onsite at Soudan.

Acknowledgements

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