Improving the Efficiency of the LBCF Through Comprehensive Hardware Rehabilitation

Joseph Jeffers
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Goals

Through concentrated efforts in doing hardware repairs, we will improve the data quality of the Low Background Counting Facility (LBCF) in Soudan Lab.

Background

In the Soudan Underground Mine there are several physics experiments currently running, including MINOS, CDMS, and Cogent. The uniting theme in all of these experiments is the fact that they are looking for rare, unique events, which must be differentiated from the noise. That is where the LBCF Veto Shield (Fig 1) comes in. It was originally installed for the Proton Decay experiment which started in 1989 (Soudan 2). The shield has been revived from disuse after Soudan 2 was removed to begin studying the properties of the muons that enter the mine and the potential for them to produce neutrons in the surrounding rock. In the time since Soudan 2 came to an end, a lot of work was done to replace and ensure the proper functioning of the front-end electronics (though some lingering issues with those were also fixed), but relatively little has been done to got through and replace the tube electronics that have become impotent over the years for various reason, including corrosion from water entering the shield from the surrounding rock (Fig 2). Other issues would come from bad wiring, physical defects in the tubes, or issues with the stretchers that are used to interface the raw data with the multiplexer (MUX) that determines the triggers.

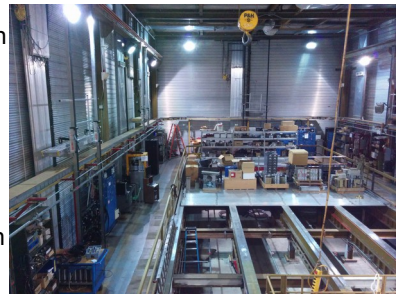


Fig 1 – A view of the shield from the northeast corner on a platform

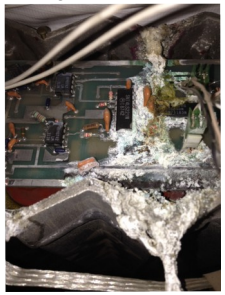


Fig 2 - A Corroded Preamp

Technique

There are a couple steps to fixing issues: a) finding the problem, b) identifying the cause, and c) implementing the solution. I will go over each of these steps in general terms, since everything we encountered seemed to present a unique set of circumstances.

a) Identifying the Problem

The way we would usually find channels that need to be worked on is by using an algorithm to find the rate (in Hz) of every tube in the shield, then we would put this through a cut that would print out the ones we determined to be too high and too low. Sometimes it was much easier than this, as it would be obviously high (above 15 consistently) or low (Blue) on the displays of the data acquisition computers (Fig 3).

Fig 3 - A DAQ with a more endemic issue

b) Identifying the Cause

There are several problems the preamps (the electronics on the tubes) can have, including poor grounding, bad cable connections, broken part, or the really fun ones, issues that deal with the stretcher/MUX and have nothing to do with the preamp itself. To diagnose these issues, we usually would start with a device the determined the individual firing rate of a tube, to see if it was really just hot. If that was fine, we would then check the coincidence rate using an oscilloscope (Fig 4). If one of those things was wrong, this indicates the issue is with the preamp, and this covers most cases.

Fig 4 - An Oscilloscope

c) Determining and Implementing the Fix

Often fixing things was as simple as adding another screw or two to better ground the card, that was usually indicated by a high rate. If that didn't work the fix could also be as simple as making sure all of the cables are snug. If neither of those fixed the problem, replacing the preamp with one that had been tested usually did. If it didn't, this would indicate something intrinsic to the tube, or something wrong with the front end electronics, both are much harder to deal with, but are able to be dealt with, just outside the scope of this poster.

References

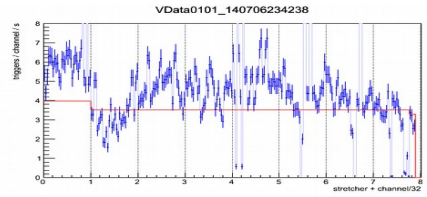
AARM collaboration, (2014) Wiki Page with resources relating to the LBCF. https://zzz.physics.umn.edu/lowrad/vetoshield

Stifter, K. (2013). *Correlating Neutron Multiplicity Meter and LBCF Muon Data.* Retrieved from http://conservancy.umn.edu/handle/11299/158290

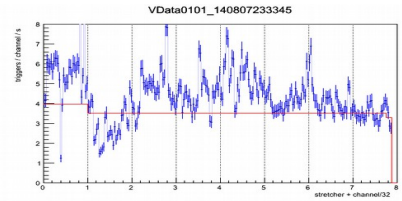
Accomplishments

The work we did one the shield is pretty easy to see from the data. Here is a sample of a before and after plot of the rates of the tubes on one multiplexer. The red line represents a theoretical idea of what they should be on average

Before:



After:



But in a more esoteric sense, we made the data more trustworthy because we went through and fixed channels that were either too hot or cold, and therefore, we are now more sure the data we see does correlate with actual events in the lab.

Further Work

The shield is still not perfect. There are several tubes in the shield that need to be completely removed and replaced that would help with the overall efficiency. Also more tubes could be added in certain places to help tracking particles as they pass through the shield. Though it is a good tool as it stands today after this project.

Acknowledgements

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