

# CONSTRUCTION OF A PORTABLE DETECTOR FOR BACKGROUND MEASUREMENTS

TOWARDS THE DEVELOPMENT OF HAWC

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## SUMMARY

In anticipation of the development of HAWC, it is desirable to have empirical evidence in addition to the Monte Carlo simulations for how the background scales as a function of altitude. A portable, stand-alone detector has been constructed in order to take such measurements. Smaller than the current Milagro outriggers, it is easily transportable, is equipped with its own data acquisition system and can run from a portable generator. Initially, measurements will be conducted between ~6000 and 14000 feet in New Mexico and Colorado however the detector could, in the future, be sent to potential sites for miniHAWC and/or HAWC. This memo describes the set-up and equipment, along with the appropriate settings and configurations so that the system can be assembled and run by anyone otherwise unfamiliar with the experiment.

## GENERAL OVERVIEW

Similar to the current Milagro outriggers, the detector (figure 1) consists of a single photomultiplier tube (identical to those used in Milagro) contained in a 55-gallon steel drum. The interior is sprayed with a rust-inhibiting enamel liner and a Tyvek lining has been mounted over that, including a floating ring at water level, identical to the outriggers. Two stacked and bundled scintillator paddles are included for coincidence and for establishment of the gate and are placed beneath the tank with the paddles centered directly beneath the photomultiplier tube. The tube and paddles are powered by separate high-voltage power supplies which are, in turn, powered by a portable generator. The remaining electronics include a series of NIM modules (included in table 1 and figure 4) housed in a single, standard bin as well as a digital oscilloscope for viewing and saving the data. These electronics are configured such that data can be viewed as it is accumulating and then saved either remotely (via an ethernet connection) or directly onto a floppy disk (when in the field).

The entire system is small enough to be easily carried in the back of a standard-size truck and no one item is too heavy to be carried by hand provided the water is transported in smaller containers. Assuming no contaminants from the tank itself, the water quality can be expected to be identical to Milagro, as it was filled directly from the recirculation system in the pond utility building.

Preliminary data has been gathered at the Milagro site and the results are shown below, along with directions for future work.

## NOTES ON OPERATION

The experiment is relatively straightforward to run, assuming that it is configured properly, the signal situated acceptably in the gate, and that proper delays are established. All the necessary settings are listed below in table 2, including those for the scope. It should be noted that some 'mysterious' variable characteristics were noted when using different NIM modules- possibly because of the age of the modules and/or questionable connections. Because of this, the serial numbers of those used in the preliminary tests are listed here for consistency in the future. For the purpose of conserving the proper delays, cable lengths are given in figure 2, listed in ns. The additional notations (ie 1A, 4B etc.) correspond to the labels on the cables themselves, where the digits correspond to the

lengths where it may not otherwise be noted. This is to avoid interchanging them- again, for consistency.

The two components that require additional explanation are the qVt and the oscilloscope. The qVt is responsible for histogramming and saving the data. Its output is visible on the scope in XY mode however it can also be read directly off of the 3157 qVt interface. The interface allows one to step through the channels manually with the center toggle switch and read the values from the built-in display. It should be noted that the interface is inoperable as long as the qVt is accumulating data. The start/stop on the qVt must be stopped for this to work. This can be done at any time without clearing the qVt if data is to be recorded during a run (clearing is accomplished by simultaneously hitting start/stop and clear). Because of some anomalies in saving the data directly from the oscilloscope (to be described below), it is probably advisable to manually check the position of the pedestal and peak in the data as a calibration point in the analysis. These will be evident when scrolling through the data and, if using the scope simultaneously, a small marker will appear on the screen to indicate your position.

The only qVt control not listed in table 2 is the “Counts Full Scale” setting. This setting will depend on the desired accumulation time and determines how many counts are along the Y axis, which is 5V full scale. In order to be able to interpret the data as shown on the scope, you must know where this knob is set, in addition to where the zero falls on the scope display. The scope cursors are useful for marking these positions before beginning to accumulate data. If the experiment is going to be left running overnight or for any extended period, it is advisable to leave the setting at 32 or 64K. When beginning accumulation, set it at 512 in order to check the operation of the experiment before leaving it unattended. This setting can be changed at any time, however if the data is allowed to accumulate long enough to go off the screen on the scope, it will begin wrapping on low settings.

The qVt's 'Memory' knob indicates which quadrant is storing data. For most purposes, 'Full' is desirable in order to spread the data over all 1024 channels instead of only using one quadrant (256 channels). Finally (and perhaps an obvious point), you MUST save the data before shutting down the NIM bin. The qVt will not store a histogram when powered down!

The digital oscilloscope is very user friendly and no problems ought to be encountered if the settings below are used. The curiosities to note are that when triggering in XY mode, the selected trigger channel must be one of those not being used as an input. As shown in figure 2, X and Y are ch1 and ch2, respectively, however the trigger source is ch3 (see table 2).

Saving data from the oscilloscope is the easiest way to have it in an electronically manipulable format. Using the 'eScope' feature, the system can be accessed remotely and data saved directly to a given computer as follows:

- 1) Enter 128.165.54.119 in your web browser's address bar and use 'milagro' as the username when prompted.
- 2) Click 'Data' above the display, select 'ch2' and 'spreadsheet format' and click 'save'. The only displayed option will be as a .isf file, however you can also save as a .txt or a .csv file. The latter two options will make it easier to deal with later.
- 3) Excel or OpenOffice can be used for simple plots, however you can also use 'txttoroot2.C' (get this script from /home/milagro/public\_html/logBook/2005 on sparky.lanl.gov). This is a simple script that I wrote that will automatically make your plot in ROOT if you begin with the data in .txt format. You will need to edit the line which specifies the path to be read.

4) The data can be interpreted by remembering that there are 1024 channels along X if 'Full' memory is used and that 5V full scale corresponds to the number of counts along Y, determined by the 'Counts Full Scale' setting on the qVt. Charge can be determined by knowing that the qVt records 0.25pC/channel. An example of data taken at Fenton Hill is shown below in figure 6.

If, when saving data remotely using the eScope feature, you find that the data unexplainably repeats when graphed (appearing periodic), then the following procedure should be followed:

1) Save ch1 using "spreadsheet" format under the data menu at the top of your browser. Do the same for ch2, under a different file name.

2) Open both files and cut and past the second column of data from each into a new spreadsheet (using either Excel or OpenOffice). Plot them against each other, using ch1 as X and ch2 as Y. If the data appears shifted left or right, the trigger position on the scope will have to be manually adjusted, however you should no longer see data that looks periodic.

In the field, floppy disks can be used when an internet connection is absent, and the data treated the same way.

#### ONGOING AND FUTURE WORK

Ongoing work includes running a Geant4 simulation for the detector to compare to the experimental results. Vlasios Vasileiou (UMD) kindly modified an existing outrigger model to comply with the materials and dimensions of this tank and results are currently being analyzed.

In addition to transporting the tank to other altitudes this coming summer, it may be desirable to try several runs with the Tyvek lining masked with a dark-colored material. The simplest way to achieve this is simply to line the tank with a black, plastic garbage bag instead of removing the Tyvek, which is more difficult to replace.

Another potentially interesting experiment would be to place a layer of lead on top of the scintillators and beneath the tank in order to exclude electrons and verify that what is seen in the data is, indeed, due to muons.

#### WHERE TO GO FOR HELP

The manuals for most of the NIM modules, as well as the scope, can be found in a filing cabinet in the Milagro office trailers at TA-57. Scott Delay is also familiar with the operation, setup and idiosyncrasies of the experiment and further, questions can still be addressed to me at [dylanspaulding@hotmail.com](mailto:dylanspaulding@hotmail.com).

#### ACKNOWLEDGMENTS

Thanks are certainly due to Scott for his experience and help in setting up the experiment, to Gus for his help in troubleshooting, to Vlasios for adapting the Geant4 code for this experiment, and to David Williams for supplying the HV pick-off schematic.

**TABLE 1: COMPONENTS**

<b>COMPONENT</b>	<b>MODEL NUMBER</b>	<b>SERIAL NUMBER</b>
<i>Power Designs High Voltage Supply</i>	1570	UC7890-00565
<i>Power Designs High Voltage Supply</i>	2K-10	LEEP LP0148
<i>LeCroy Octal Discriminator</i>	623B	A39425
<i>LRS 4-Fold Logic Unit</i>	365AL	65041
<i>LeCroy Dual Gate Generator</i>	222	59296
<i>LRS Gate Generator</i>	222	285284
<i>Ortec Counter</i>	772	258337
<i>LeCroy qVt Interface</i>	3137	62667
<i>Tectronix Digital Oscilloscope</i>	3034B	B025646
<i>LeCroy qVt Analyzer</i>	3001	A68538
<i>Applied Research Inc. Attenuator</i>	-	-
<i>PMT (#119)</i>	-	SA0941

**TABLE 2: COMPONENT SETTINGS**

<b>COMPONENT</b>	<b>POT. SETTINGS</b>	<b>COMMENTS</b>
<i>PD High Voltage Supplies</i>	-	Set at 1900 for paddles, 2000 for tube
<i>LeCroy Octal Discriminator</i>	Ch2= -0.505V Ch3= -0.505V	None
<i>LRS 4-Fold Logic Unit</i>	-	Coinc. Levels pinned at 2, c,d pinned 'off'
<i>LeCroy Dual Gate Generator</i>	Top= 1.565V Bottom= 0.90V	Dial set to 1usec
<i>LRS Gate Generator</i>	-11.35V	Set for 10sec count for rates from paddles
<i>LeCroy qVt Interface</i>	-	Inoperable unless analyzer is stopped
<i>Tectronix Digital Oscilloscope</i>	-	All Settings saved to 'Setup 1, March 11th, 11:55:38, under Save/Recall Display: triggered X/Y, ch1 vs ch2 Trigger: Level= -150mV, neg. slope, auto (untriggered roll), holdoff time= 250.8ns, type= edge, source= ch3 Under 'QuickMenu' : ch1 and ch2 set to DC coupling, 1MOhm, full bandwidth, 'normal', and 'sample' Ch1: 500mV/div, Ch2: 200mV/div
<i>LeCroy qVt Analyzer</i>	Gate Width: monitor point is inoperative Gate Thresh.: -3.845V	Intensify: set to 10th Display: Lin, variable counts full scale (depends on accumulation time) Mode: q Memory: full Gate: External trigger mode
<i>Applied Research Inc. Attenuator</i>	-	20.2dB to make signal acceptable for qVt input, placed inline at qVt
<i>PMT (#119)</i>	-	Gain: 5.78E+07 P/V: 2.49 TTS: 17.27ns Rate: 1.33kHz Late: 3.77% After: 31.98% TTS50: 0.63 Volt: 1900V Pre1: 0.44% Pre200: 0.36%

# EXPERIMENTAL OVERVIEW

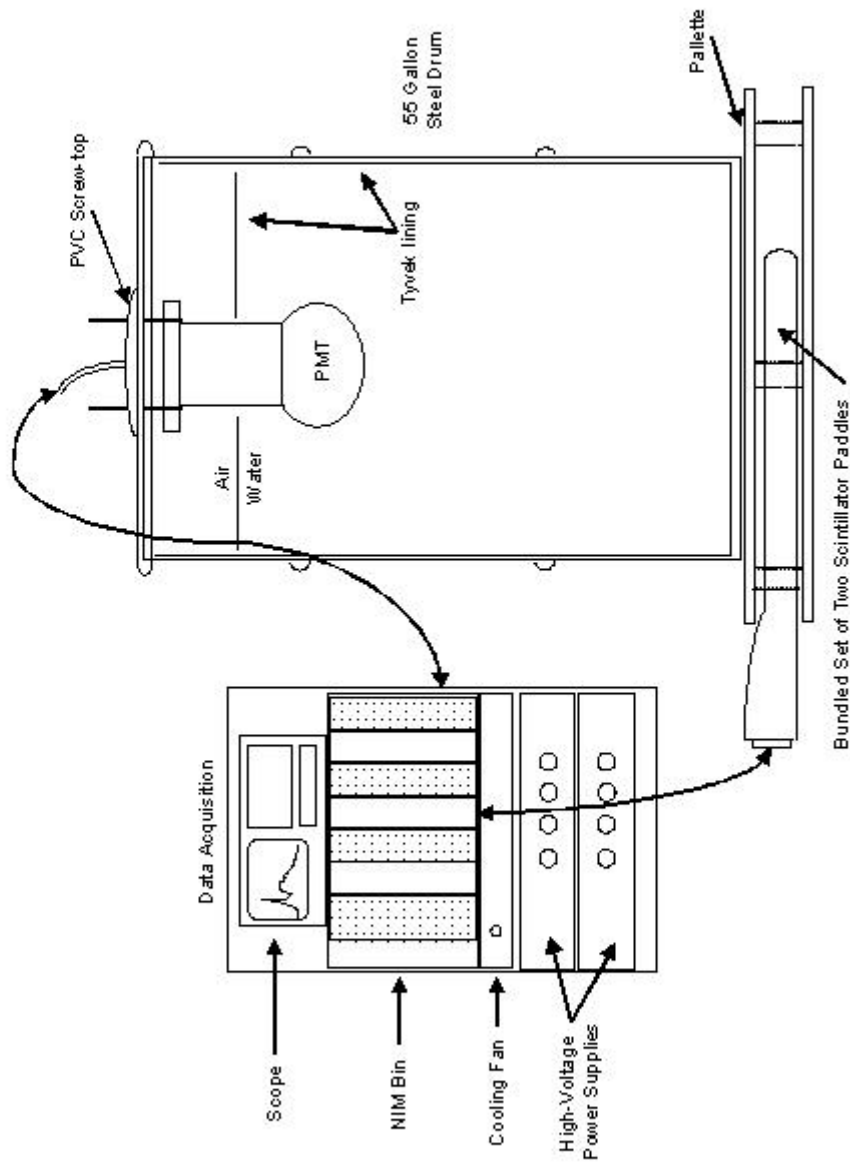
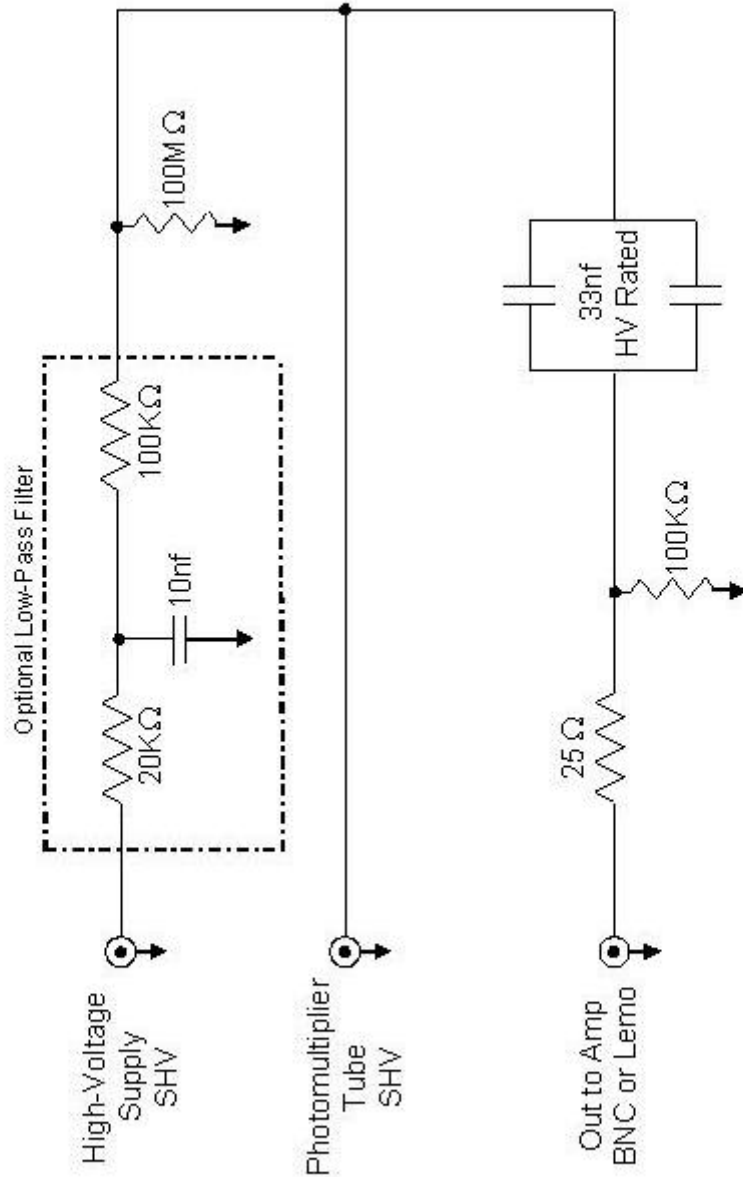


FIGURE 1: THE GENERAL SETUP OF THE EXPERIMENT





For use with 50Ω input impedance. Per David Williams: The 25Ω resistor does the impedance matching from 75Ω to the 50Ω of the NIM module. It should therefore have 1% tolerance. Other tolerances are not critical.

**FIGURE 3: A SKETCH OF THE DIAGRAM FOR THE HIGH-VOLTAGE PICK-OFF BOX THAT WAS CONSTRUCTED FOR THIS EXPERIMENT**

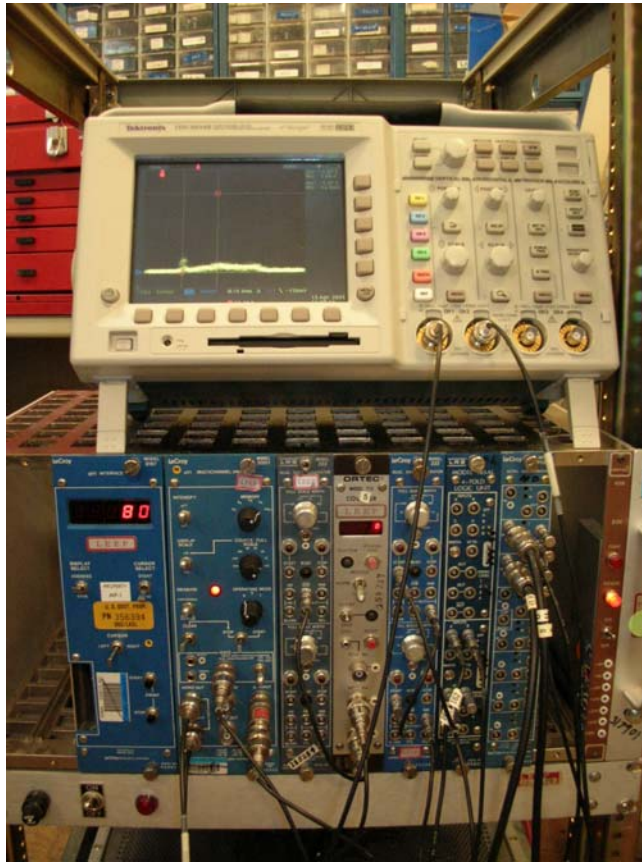


FIGURE 4: NIM BIN ELECTRONICS





**FIGURE 5: TANK AND PADDLE BUNDLE. EXPERIMENT IS RUN AS SHOWN IN LOWER PHOTO**

