Users Guide for ADC Calibration of N20

Neil Thompson

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1 Overview

This purpose of this guide is to instruct people in how to determine the gains and pedestals of the photomultiplier tubes (PMTs) used in the N20 detector. N20 is a set up of twenty scintillator bars arranged into four rows and five planes and also has two veto planes (see fig. 1). The dimensions of the bars are: width = 10 cm, height = 10cm, length = 1.6m. Each bar has two PMTs, one at each end, and the electronics they are connected to include, Analogue to Digital Converters (ADCs) and multihit Time to Digital Converters (TDCs). When the trigger logic accepts an event, the ADCs collect charge into their capacitors during an ADC time gate of about 100ns. This value of charge is then converted to a digital signal. When the ADC gate is closed and there is no signal reaching the ADC from the PMT, there is still a digital value present and this is known as pedestal. This is can be due to the minimum level of charge that is always in the capacitor and also a few other possible scenarios such as direct current offsets. The pedestal corresponds to a digital value (channel number) of around about 200. The channel number above pedestal, is directly proportional to energy deposited through the scintillator and also to the gain of the PMT, which depends on its voltage supply. The PMTs should be roughly gain matched by altering the PMT voltages so that each ADC channel (e.g. na.nd.n1.LE[0]) gives a channel number output of about 1000 for a proton peak or less if the PMT is on a veto. To determine the pedestal and gain constants for each PMT, a macro called Adc_Cal.C can be used. These constants should be entered into the database db_na.nd.dat. The macro needs to be edited in order to be used for either a changed N20 set up or database. Therefore it would be wise to copy the macro to a different name before changing it.

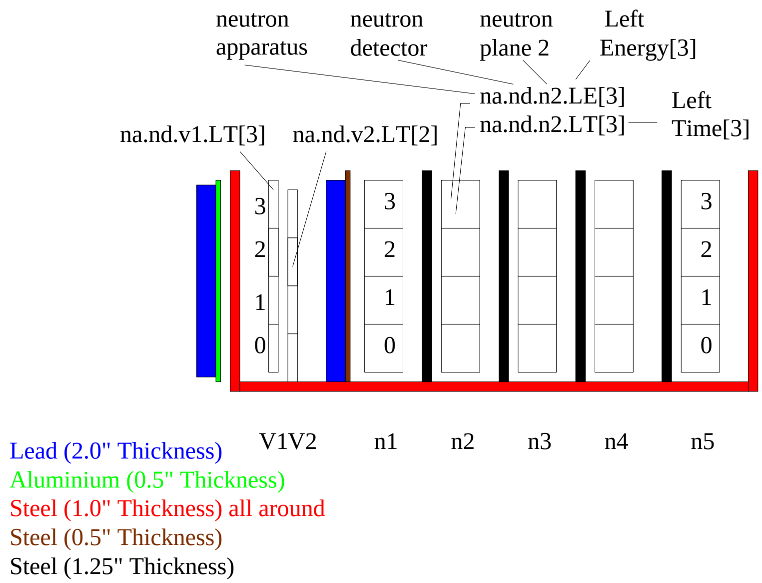

Figure 1: This is a side on schematic of N20

2 Pedestal Determination

There are two methods for determining the pedestals in this macro. The first method(A) is to cut on the raw ADC (e.g. na.nd.n1.LE[0]) with the number of corresponding TDC counts equal to zero (e.g na.nd.n1.LTcounter[0]==0). The second method(B) is to cut on the raw ADC before the start of the ADC gate (e.g. na.nd.n1.LT[0]*1e6+0.295<-0.1). Cuts on the ADC time gate should be check by plotting ADC vs TDC (e.g T->Draw("na.nd.n1.LE[0]:na.nd.n1.LT[0]", "abs(na.nd.n1.LT[0]*1.0e6)<8&&abs(na.nd.n1.LE[0])<5000") see fig. 2). The peaks are both found by fitting a guassian distribution which is centered on the bin with the highest count number.

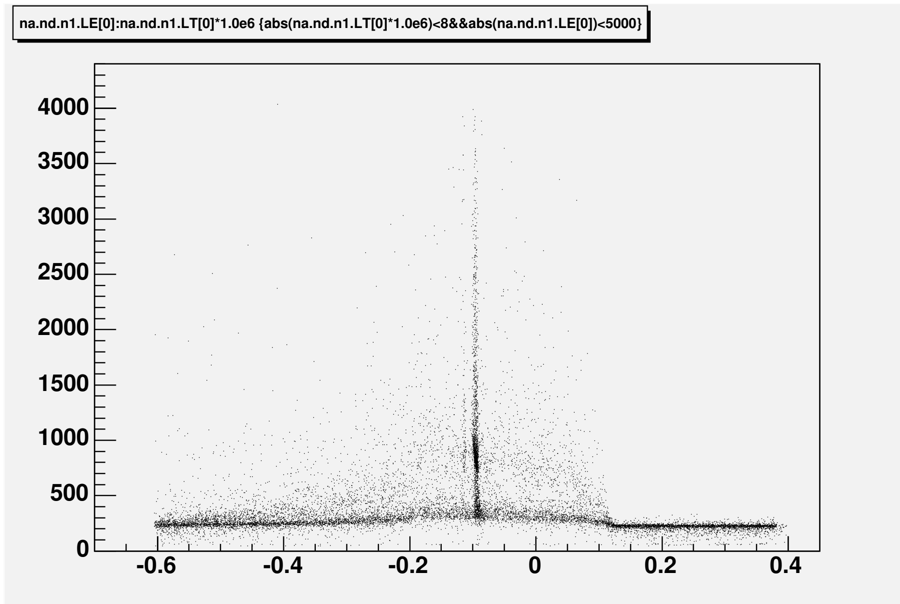

Figure 2: Left adc (channel number) versus Left time(us). The horizontal line at the bottom is the pedestal in the ADCs and it is here because the all the ADC channels are always read during a trigger even for the PMTs with no hits (i.e just pedestal) . The dark vertical line is the proton peak. The width gives an indication of the ADC time gate. The curvature at the bottom of the peak is due to the walk effect (The variation on the PMT signal rise time with the ADC value). The second peak to the left should not be there and is currently under investigation.

3 ADC Gain Determination

The cut used to select the proton peak is very simple, but it requires that the pedestals for each PMT have been found and entered into the database. It involves selecting only hits within the ADC gate and also selecting on a pedestal corrected ADC term (na.nd.n1.AmplPedCor_LaHits[0]>200) to remove any pedestal. The corresponding term for ADC, in the next or previous plane that is in the same row and side, is also cut on. This cut selects protons because they go straight through the planes of the neutron detector with little deviation. To obtain the peak, a Landau distribution is fitted. To ensure that the fit is successful, the user has to edit some arrays that define the start and end fit range for the left and right ADCs.

For example : LP_cor_start[18]=490; LP_cor_end[18]=900;

RP_cor_start[18]=450; RP_cor_end[18]=1100;

This does mean you will have to run the macro a couple of times until all the fits are satisfactory. Once the value for the peak is determined, the gain(MeV/Channel No.) for that PMT is calculated using:

$gain = Edep/peak$

where Edep is the energy deposited by a proton in the scintillator bar and peak is the proton peak in channel numbers. Edep is calculated using the Bethe-Block formula which depends on the particle(proton), it's momentum(1.5GeV), the material(scintillator), the material density and the width of the bar.

4 Results

The following figures are given as an example of the results you should expect. The results were obtained using the first 100000 events on the N20 run 2279. You should always check that graphs agree with the fitted histograms. In some cases where a fit has not worked well you may have to adjust a fit range parameter for the proton peaks. When a fit to a pedestal histogram looks a bit suspect, you should use your better judgement as locating the peak with your own eyes might be more reliable and in any case you have two pedestal methods that should give the same result.

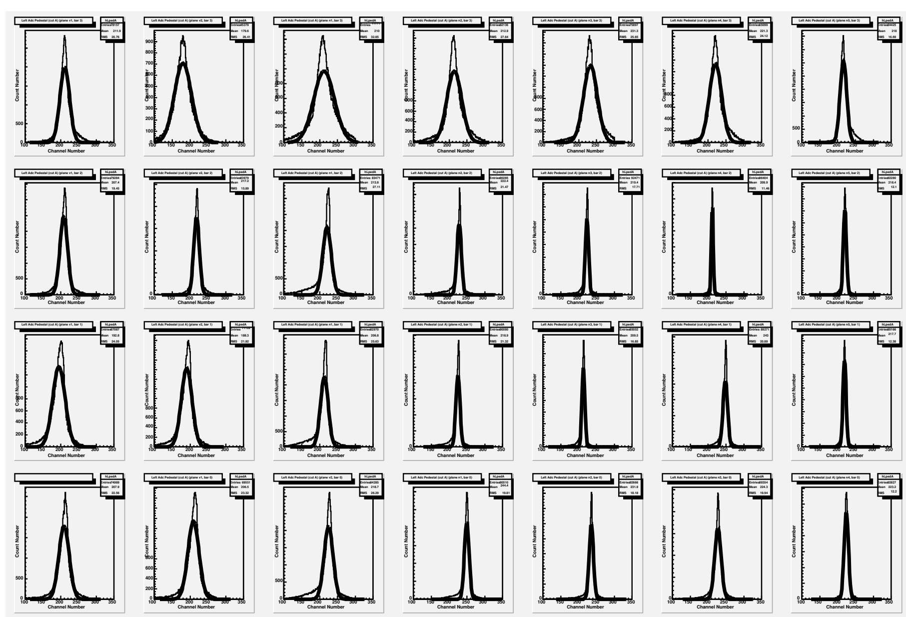

Figure 3: Left ADC Pedestals (counts/Ch. No.) (method A)

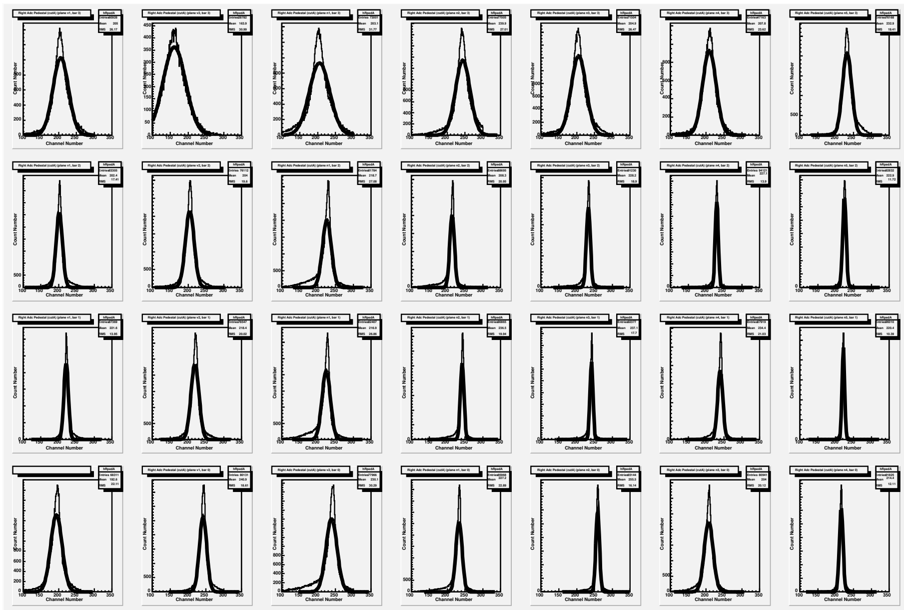

Figure 4: Right ADC Pedestals (counts/Ch. No.) (method A)

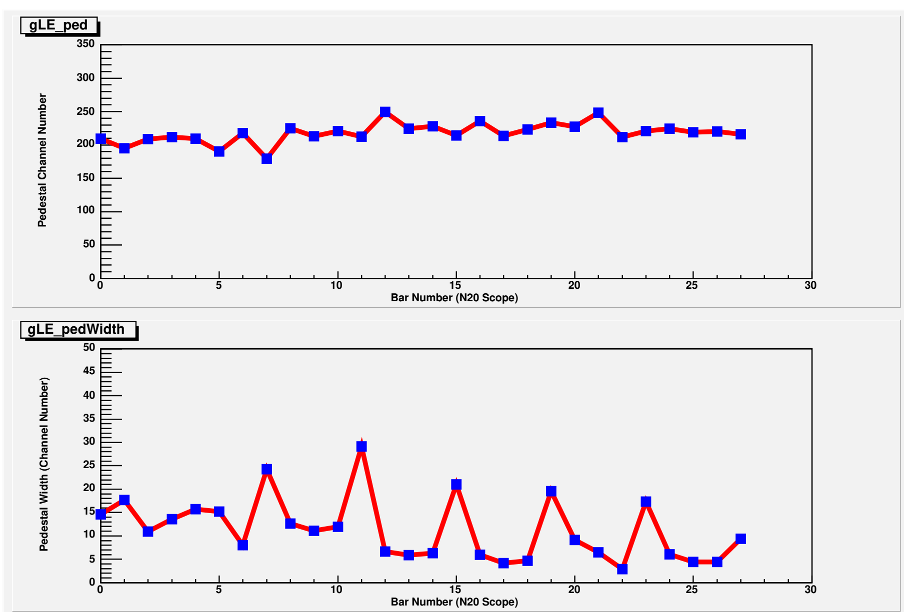

Figure 5: Left ADC Pedestal and the fit sigma (method A)

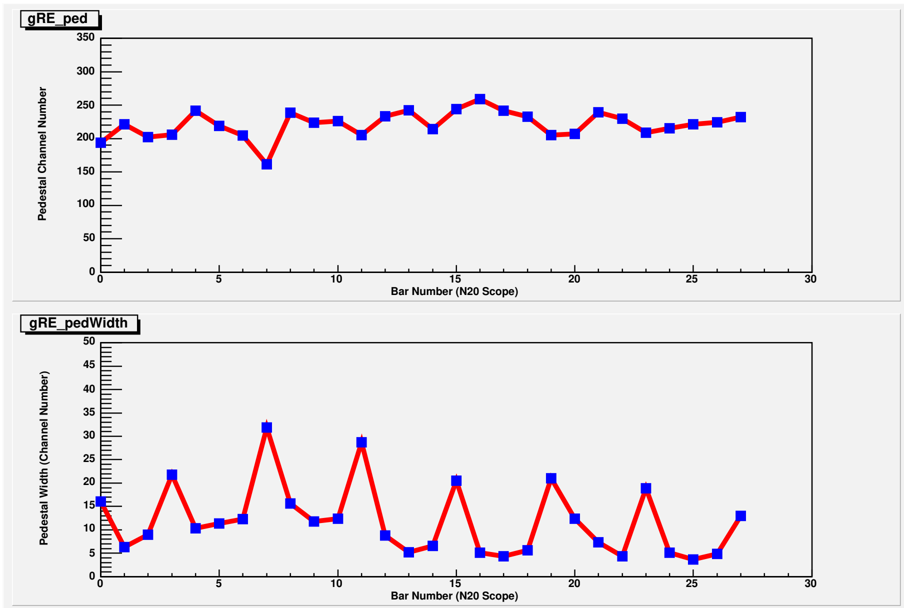

Figure 6: Right ADC Pedestal and the fit sigma (method A)

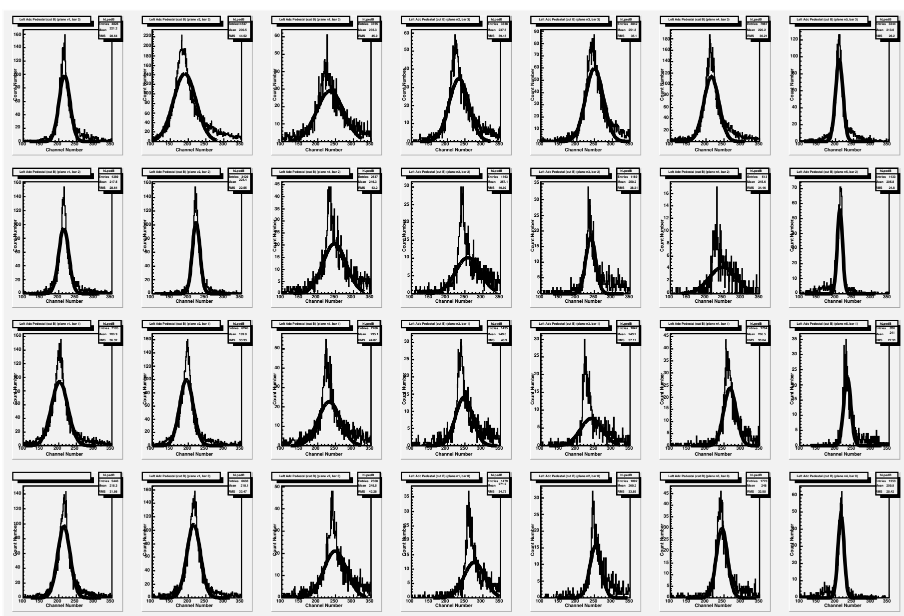

Figure 7: Left ADC pedestals (counts/Ch. No.)(method B)

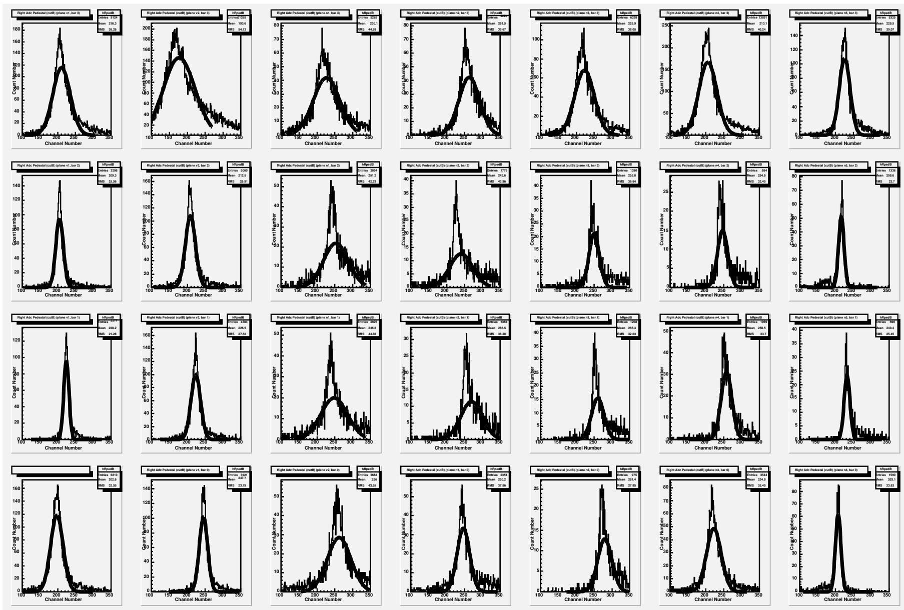

Figure 8: Right ADC pedestals (counts/Ch. No.)(method B)

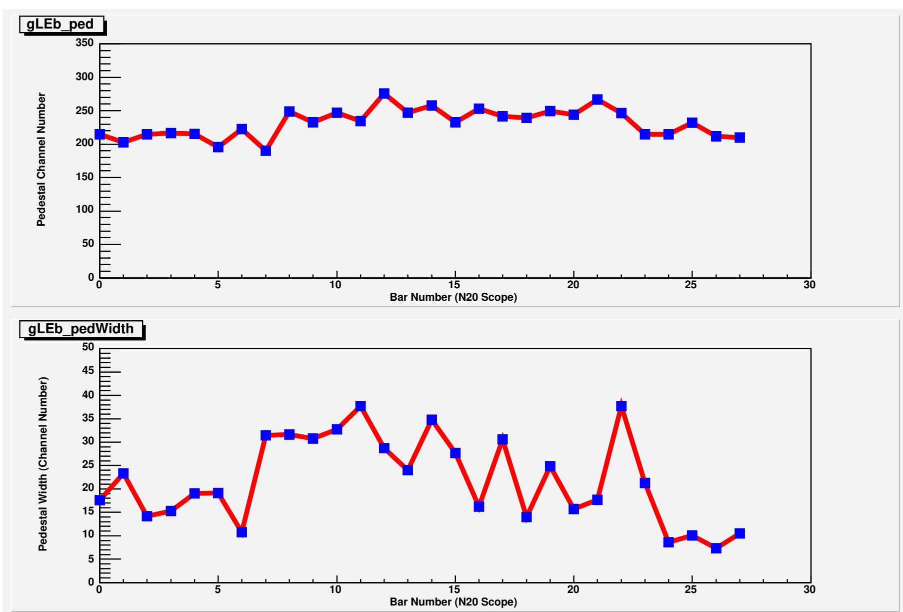

Figure 9: Left ADC Pedestal and the fit sigma (method B)

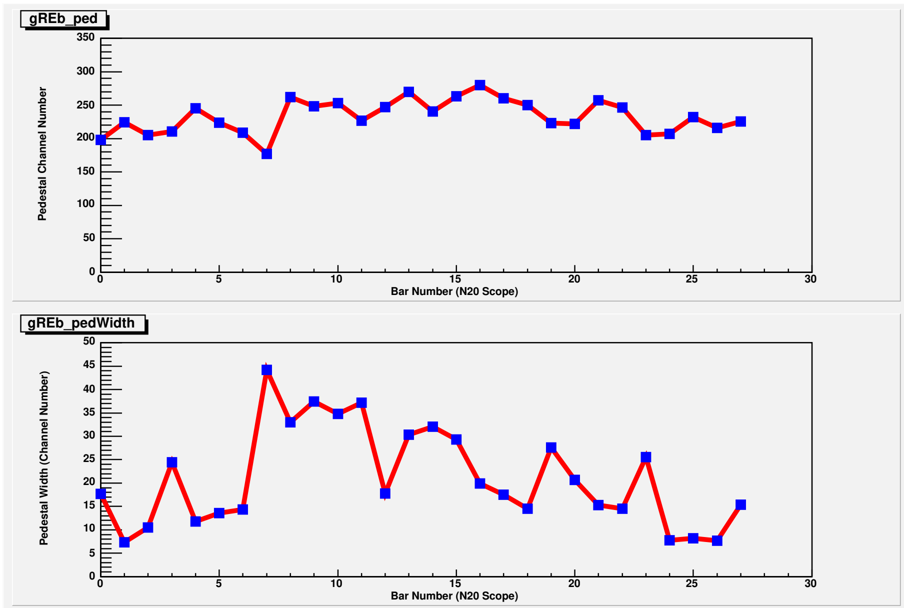

Figure 10: Right ADC Pedestal and the fit sigma (method B)

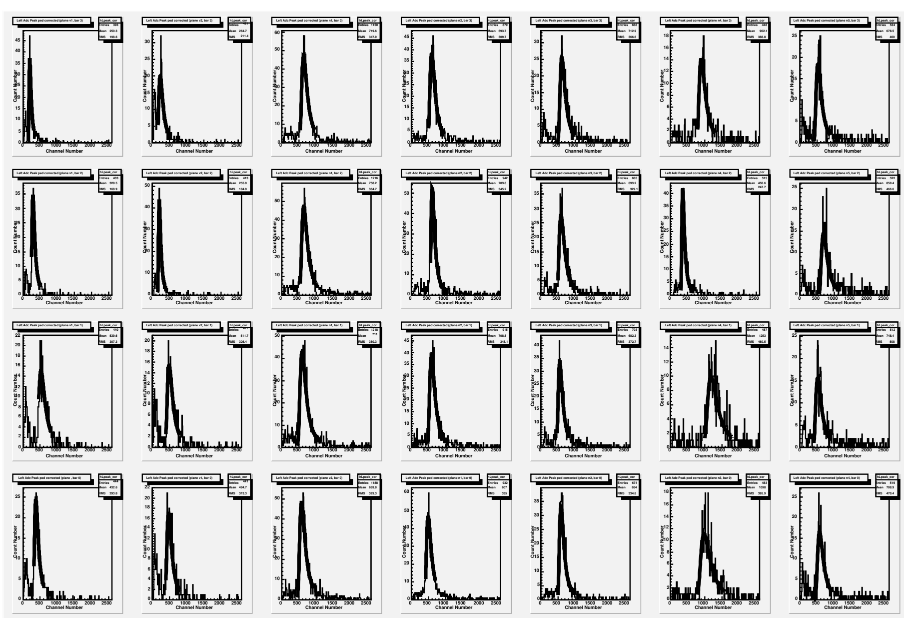

Figure 11: Left ADC proton peak (counts/Ch. No.)

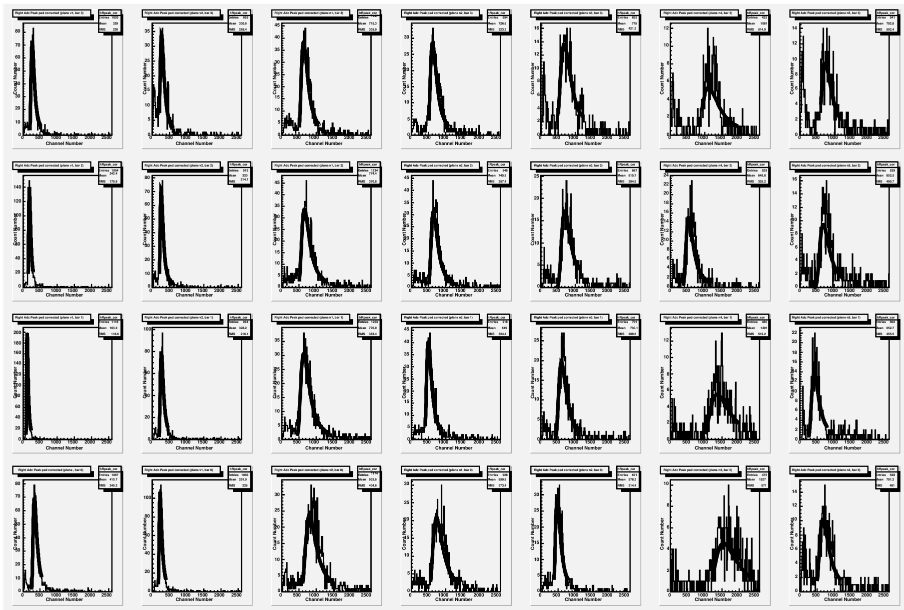

Figure 12: Right ADC proton peak (counts/Ch. No.)

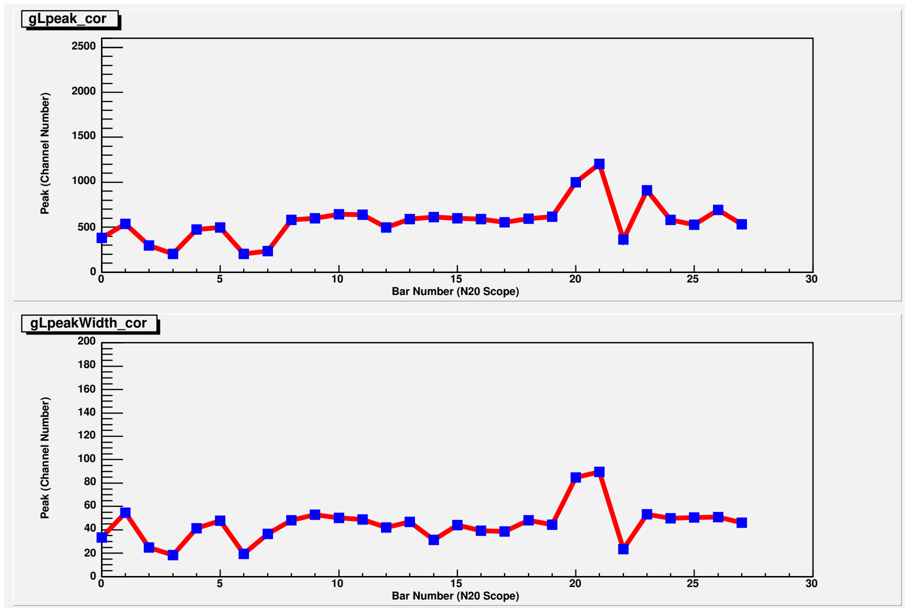

Figure 13: Left ADC proton peak (in Channel Numbers) after pedestal subtraction (for each bar label in the scope of N20 (i.e. 0-27, including the vetos) and the peak widths (in Channel Numbers).

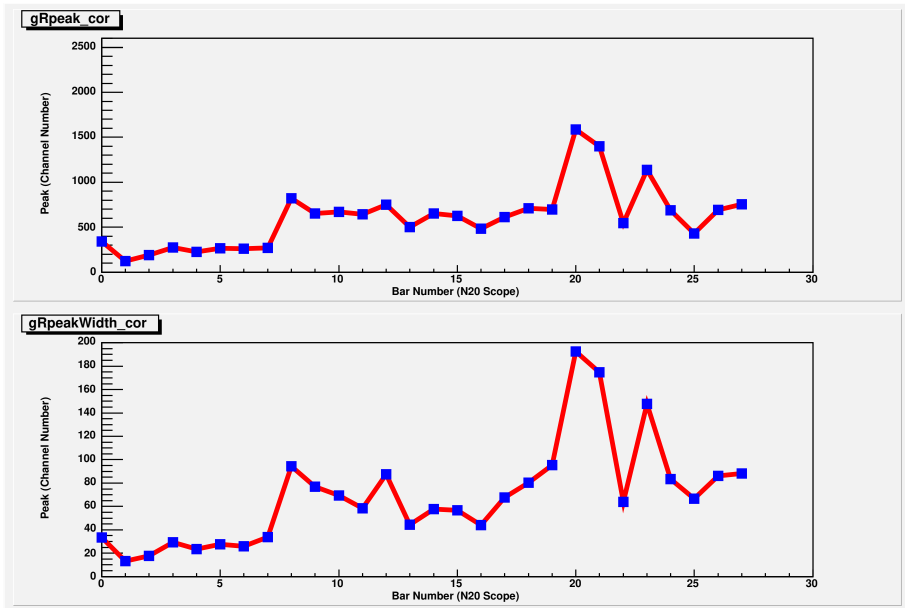

Figure 14: Right ADC proton peak (in Channel Numbers) after pedestal subtraction (for each bar label in the scope of N20 (i.e. 0-27, including the vetos) and the peak widths (in Channel Numbers).

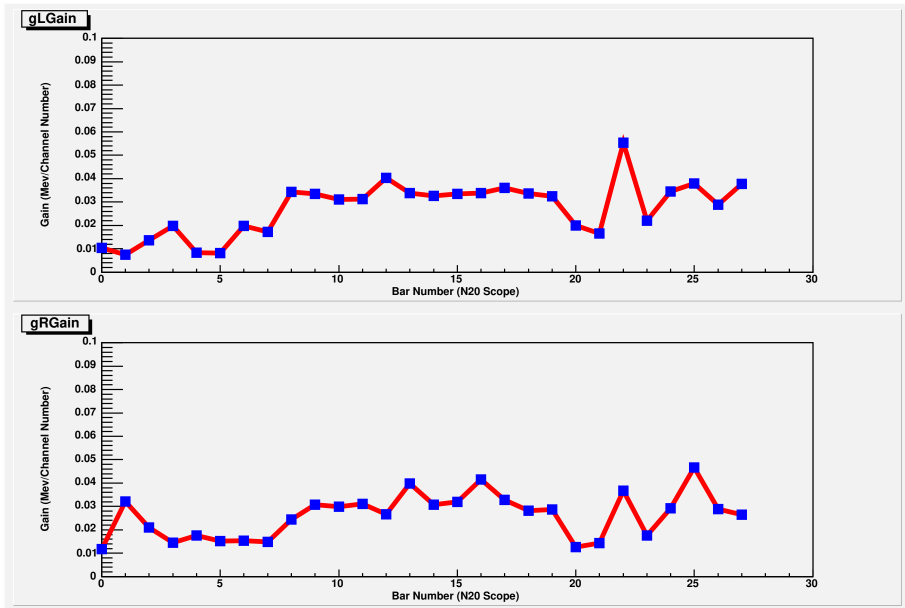

Figure 15: PMT gains (MeV/Channel Number) for each bar. These gains are used to multiply the ADC values to convert them into energy.

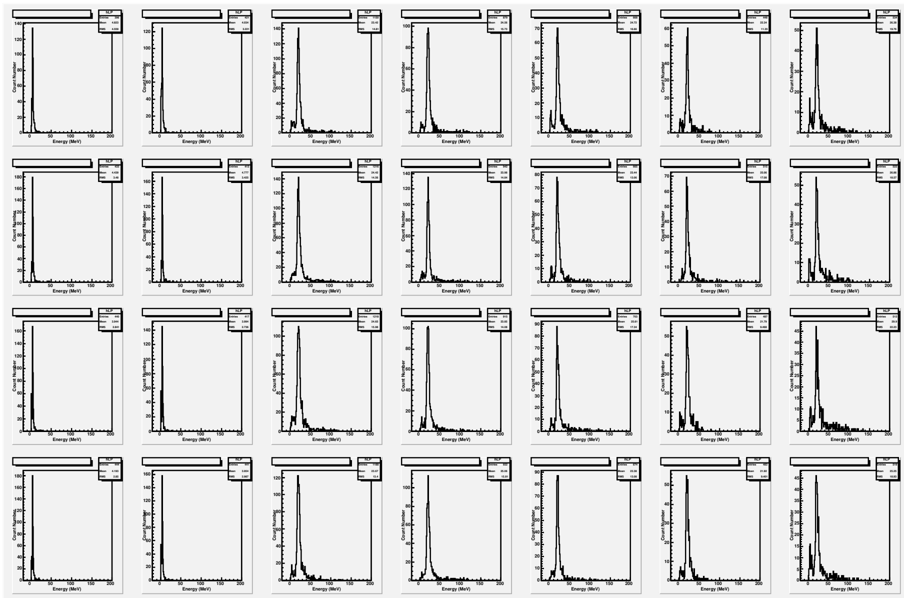

Figure 16: Final gain matched proton peaks for each left hand PMT. The veto bars should have a distribution around 4 MeV and the scintillators should have its energy distribution around 20 MeV.

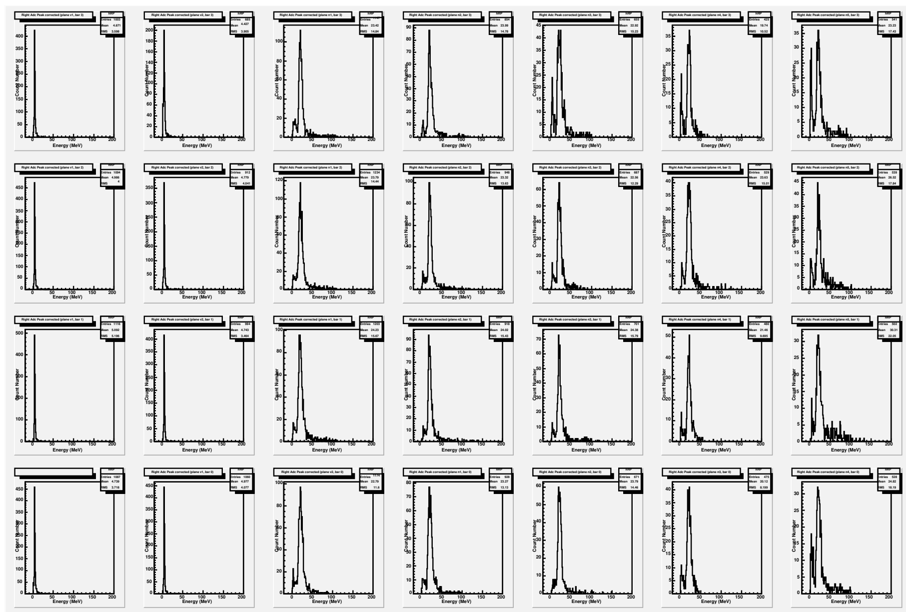

Figure 17: Final gain matched proton peaks for each right hand PMT. The veto bars should have a distribution around 4 MeV and the scintillators should have its energy distribution around 20 MeV.

5 Future Improvements

This macro needs to be changed in order for it to be used with the final set up of the Hall A neutron detector. It needs to be made more general when it comes to what type of bars are in each plane. At the moment it assumes that the first two planes contain vetos and the other planes contain UVA type scintillator bars. This affects the way the information is read in and also the way in which the gains are calculated because that calculation relies on the bar width. Also the gain calculation makes no allowance for the absorption of energy from the proton in the scintillators and shielding and the effect this has on the proton momentum. At lower momentum the proton can actually deposit more energy and this means the scintillators in the last plane should receive more energy per hit.

6 Where to Find the Files

The current database file for N20 is called db_na.nd.dat. It can be found on the work disks on the ifarm. The location is /w/work3503/e02013/db/20050123 but can also be found using /work/halla/e02013/disk1/db/20050123/ which has a few symbolic pointers leading to the same directory. The Adc_Cal.C macro can be found at /work/halla/e02013/disk1/replay. The analyzer files for the GEN experiment can be found in /work/halla/e02013/disk1/agenlib. The most important files for understanding how the N20 data is analysed are THaScintPlane.cxx and THaNeutronDetector.cxx.