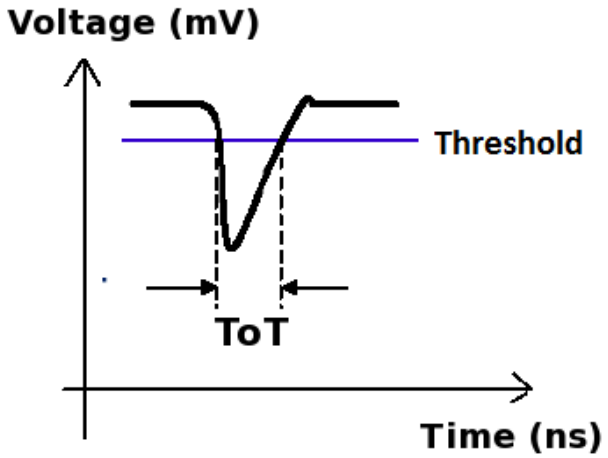
1 Worksheet 3: Performance Study

This section requires taking data with the counters for at least 2 hours. I would recommend even more. You can split the worksheet up into 2 sessions for the week. In the first session, introduce them to the idea of the performance study and allow them to carry out the section "Analysing Data". This allows them to run a performance study on data recorded by the University of Birmingham. After this, set up the counters using the control voltages found in the plateauing worksheet and start recording data. Leave this running overnight and upload the data the next day. Note that with a large amount of data, it can take up to half an hour to upload. It would be a good idea to have it already uploaded for the second session. They can then run their own performance study and spend some time discussing the performance of the counters. If needed, they can change the control voltage or the threshold slightly.

1.1 Aim

The aim of this worksheet is to check that the detectors are working and are detecting comsic rays efficiently. We can do this by using the Cosmic Ray e-lab website to analyse the signals being produced by the counters.

1.2 Introduction



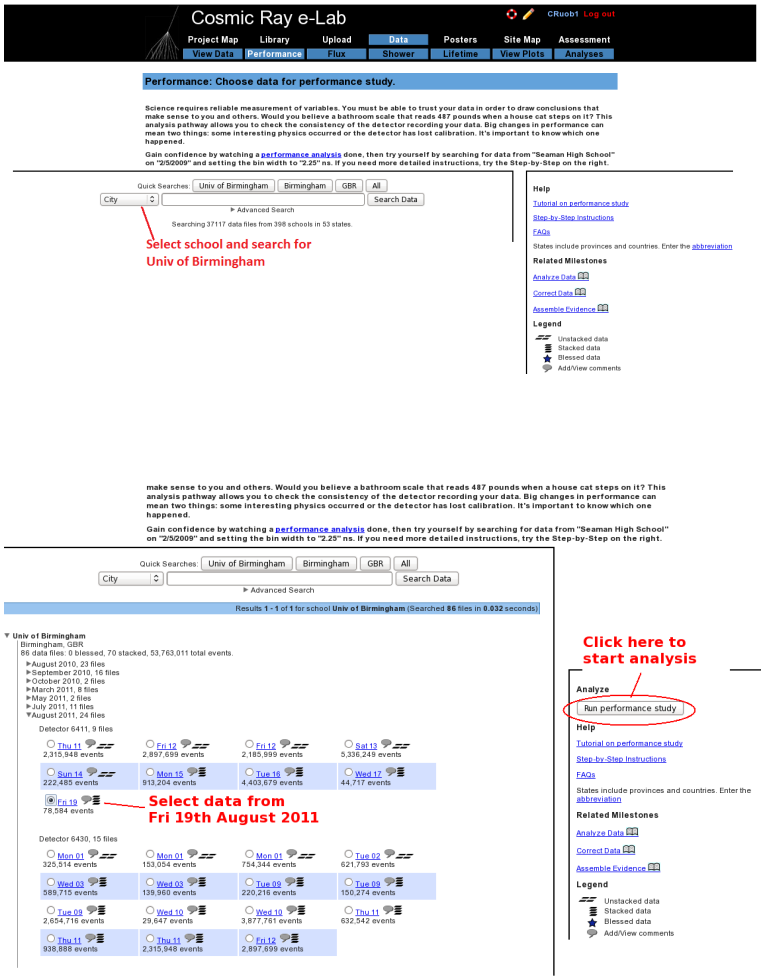
The picture above shows a typical signal which comes from the PMT when it detects a cosmic ray muon. The size of the signal depends on both the control voltage used across the PMT and the amount of energy deposited by the muon as it passes through. Since every muon deposits approximately the same amount of energy, we expect the signal from cosmic rays to be consant.
In reality, the PMT will not only produce signals which come from cosmic rays. There are some which come from other ionising particles passing through or from random flashes of light being emitted. These pulses, which do not come from cosmic rays, are called noise since we are not interested in them, and they make detecting the cosmic rays harder. A single counter will tend to produce more noise pulses than signals. The reason we look for a coincidence between two counters is that it is unlikely for noise to be produced in the two counters at the same time.
But there is another method we use to remove the noise, and that is to set a threshold. Noise pulses are usually much smaller than cosmic ray signals, and so we only accept pulses which are above a certain level, called the threshold. The higher the threshold, the fewer noise pulses get through, but at the same time more cosmic ray signals are missed. The threshold can be set through hyperterm with the command TL n m. n defines the channel which you wish to change, for example counter 1 is channel 0. m is the value of the threshold in mV. I recommend using a threshold of 300mV. So to set the threshold of counter 1 to 300mV, type TL 0 300. To change all 4 counters at once, type TL 4 300.

To test whether the counters are detecting a lot of noise, we want to analyse the pulses which we detect. We do this by measuring the time-over-threshold (ToT) of the pulses. If the height of the pulse is the same, the ToT will also be the same. So we expect all cosmic rays to produce pulses with a ToT of about 20ns. Noise pulses will be much smaller and so will have a smaller ToT. So we will plot a histogram of the time-over-threshold for every pulse we detect from the counter. This will separate the noise from the cosmic ray signals and allow us to check that we shall be able to discriminate between the two sources by imposing an appropriate threshold. We do this by running a Performance Study from the Cosmic e-lab.

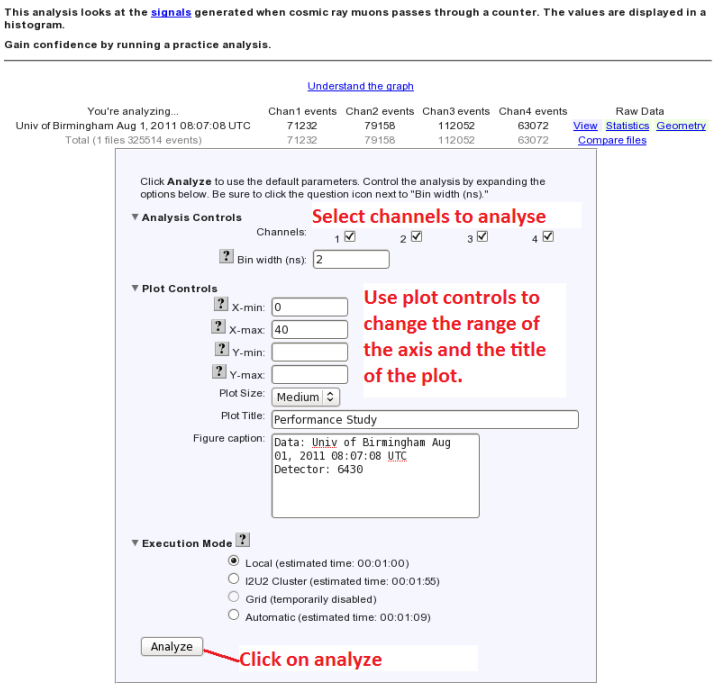
1.3 Analysing Data

We will start by running a Performance Study on data which has already been recorded by us at the University of Birmingham. You can analyse the data by logging onto the Cosmic Ray e-lab. The website is **http://www18.i2u2.org/elab/cosmic/home/**

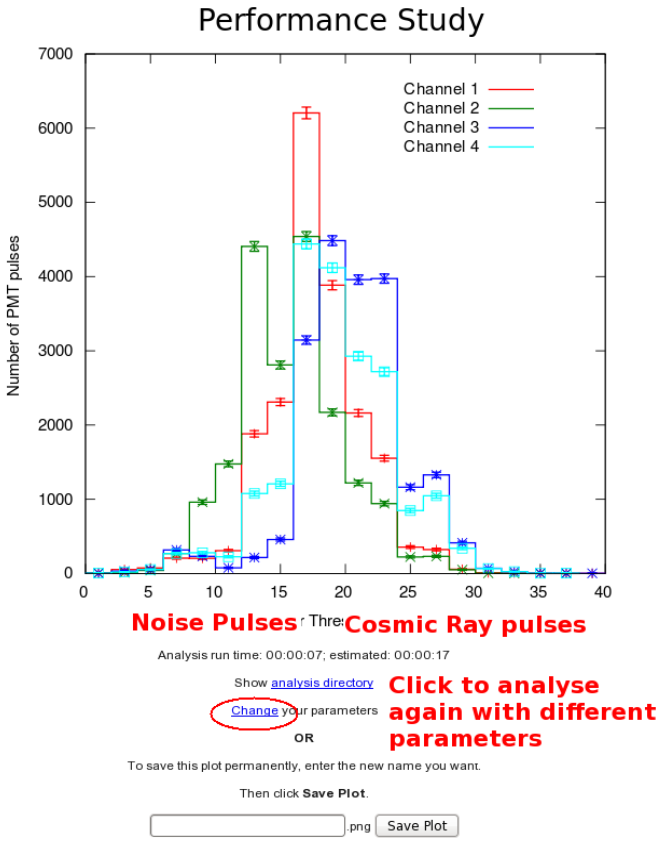
1. Click on the "Data" tab and then "Performance" and you should see the pages below.



2. Search for data from 19/08/2011 from the school "Univ of Birmingham". Select the data from this day to analyse.

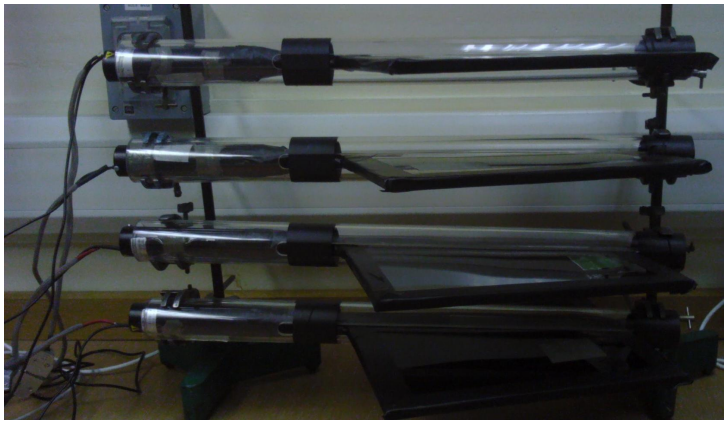


3. You should see the options in the figure above. Select which counters you want to analyse (all of them) and set the bin width to 2ns. Expand the "Plot Controls" tab and you can change the range of the axes and the plot title. Then click on "Analyze".

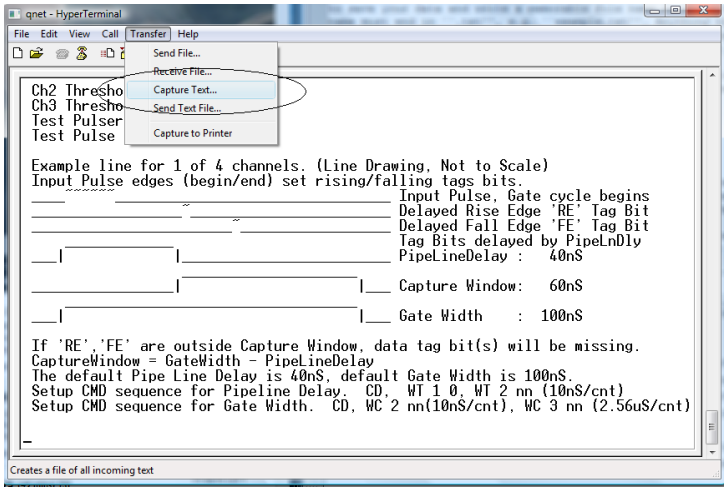


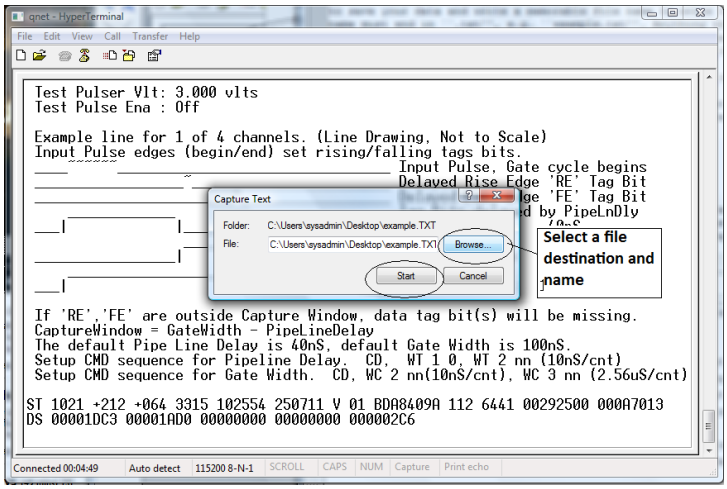
You should get a graph which looks like the one above. The Time over Threshold (ToT) for each pulse is plotted in a histogram. The peak centered on 20ns is due to cosmic rays. The random noise will produce pulses with a lower ToT, and so the smaller peak to the left of the large peak is due to noise. It is nearly impossible to remove the noise altogether, it is just something which we have to learn to live with in particle physics. As long as the noise peak is small, there is nothing to worry about.

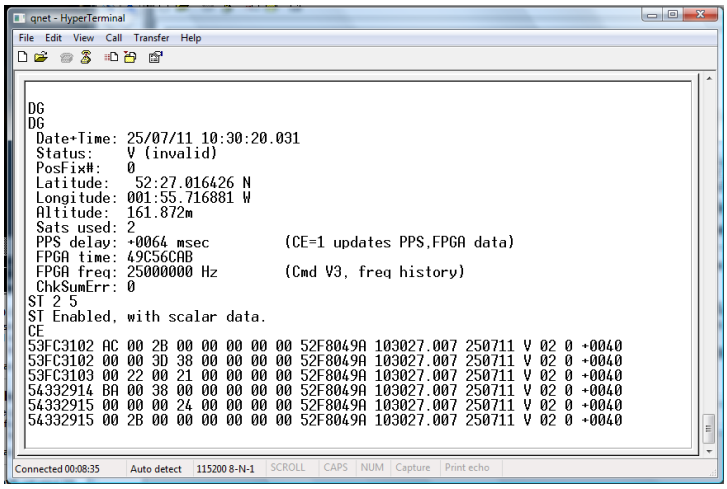
1.4 Collecting Data



Now you can collect data from your counters to run your own performance study. Set up your counters in the stacked configuration shown above and set the control voltages to the optimum voltages found by the plateau method. Before you start taking data, upload your geometry to the Cosmic e-lab website. Open Hyperterminal and follow the steps below to collect data:

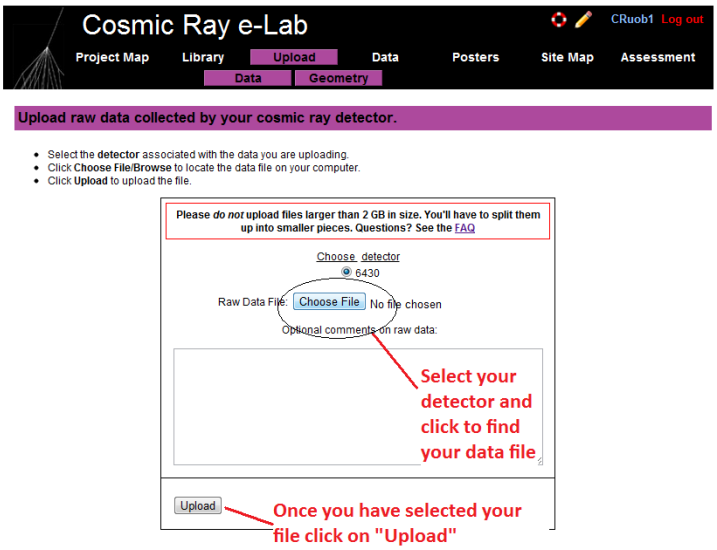






1. Set up the DAQ board to record coincidences between all 4 counters, i.e. a 4-fold coincidence level, by typing WC 00 3F.
2. From the "Transfer" menu select "Capture Text"
3. Choose a file name ending with ".txt" and save your file somewhere memorable. Then select "Start"
4. Anything which now appears in the Hyperterminal window will also be written to the ".txt" file. Start by typing the commands V1, V2, DG, TL, ST 2 5. This ensures your data file contains the necessary information about the detectors.
5. Type the command CE to enable the counters and start writing data to the ".txt" file. Leave this running for about 2 hours. While you are collecting data you can move onto "Analysing Data" to run a performance study on data we have already taken. Make sure that the computer you are using is set to never sleep, otherwise you will not continue to collect data.
6. Once you have collected enough data type the command CD to stop writing out data.
7. From the "Transfer" menu select "Capture Text" and "Stop".

This could be the end of the first session. Leave the computer recording data overnight. Don't forget to set the computer to never sleep. Also make sure they have typed the command CE, or else no data will be recorded.



Once you have collected enough data you can run your own performance study. Upload your data by clicking “Upload” and then “Data”. It is now ready to be analysed. Repeat the steps above with the data you have just taken to obtain your own performance plots. How do they look? Can you trust the detectors to measure the flux of cosmic rays? If the peak of the noise signals is higher than the cosmic ray signal then you have a problem. It could be that your control voltage is too high, so check your plateau again. If that fails then you can increase the threshold slightly to see if that helps.Once you have a detector producing a good performance study, you can have confidence in its ability to observe cosmic rays, and you can prove to other groups that your detector does not have too much noise. Once you are happy with your plot, click on “Save Plot” so that you can easily access it later.