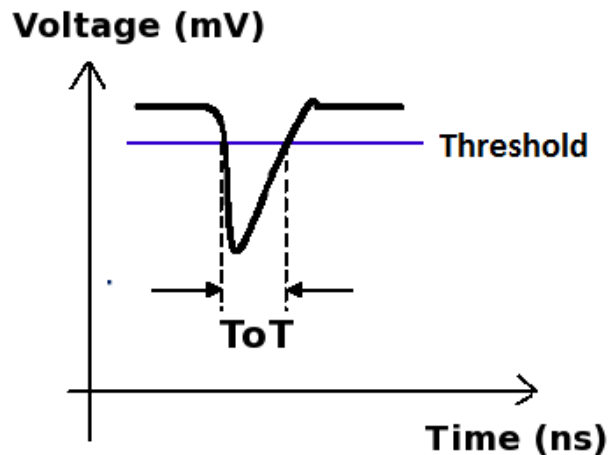


# 1 Worksheet 3: Performance Study

## 1.1 Aim

The aim of this worksheet is to check that the detectors are working and are detecting cosmic 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 constant.

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.

Cosmic Ray e-Lab

Project Map Library Upload Data Posters Site Map Assessment  
View Data Performance Flux Shower Lifetime View Plots Analyses

Performance: Choose data for performance study.

Science requires reliable measurement of variables. You must be able to trust your data in order to draw conclusions that make sense to you and others. Would you believe a bathroom scale that reads 487 pounds when a house cat steps on it? This analysis pathway allows you to check the consistency of the detector recording your data. Big changes in performance can mean two things: some interesting physics occurred or the detector has lost calibration. It's important to know which one happened.

Gain confidence by watching a [performance analysis](#) done, then try yourself by searching for data from "Seaman High School" on "252809" and setting the bin width to "2.25" ns. If you need more detailed instructions, try the Step-by-Step on the right.

Quick Searches: Univ of Birmingham | Birmingham | GBR | All

City: [Univ of Birmingham] Search Data

Advanced Search

Searching 37117 data files from 398 schools in 53 states.

Select school and search for Univ of Birmingham

Help  
Tutorial on performance study  
Step-by-Step Instructions  
FAQs  
States include provinces and countries. Enter the abbreviation  
Related Milestones  
Analyze Data  
Correct Data  
Assemble Evidence  
Legend  
Unstacked data  
Stacked data  
Blessed data  
Add/View comments

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Quick Searches: Univ of Birmingham | Birmingham | GBR | All

City: [Univ of Birmingham] Search Data

Advanced Search

Results 1-1 of 1 for school Univ of Birmingham (Searched 86 files in 0.032 seconds)

Univ of Birmingham  
Birmingham, GBR  
86 data files, 0 blessed, 70 stacked, 53,763,011 total events.  
August 2010, 23 files  
September 2010, 16 files  
October 2010, 2 files  
March 2011, 8 files  
May 2011, 2 files  
July 2011, 11 files  
August 2011, 24 files  
Detector 6411, 9 files

Thu 11	Fri 12	Fri 12	Sat 13
2,315,948 events	2,897,699 events	2,185,959 events	5,336,248 events
Sun 14	Mon 15	Tue 16	Wed 17
222,485 events	913,204 events	4,403,679 events	44,717 events
Fri 19			
78,584 events			

Detector 6430, 15 files

Mon 01	Mon 01	Mon 01	Tue 02
325,514 events	153,054 events	754,344 events	621,793 events
Wed 03	Wed 03	Tue 02	Tue 02
589,715 events	139,860 events	220,216 events	150,274 events
Tue 08	Wed 10	Wed 10	Thu 11
2,644,716 events	29,947 events	3,877,761 events	632,342 events
Thu 11	Thu 11	Fri 12	
938,488 events	2,315,948 events	2,897,699 events	

Select data from Fri 19th August 2011

Click here to start analysis

Analyze  
Run performance study

Help  
Tutorial on performance study  
Step-by-Step Instructions  
FAQs  
States include provinces and countries. Enter the abbreviation  
Related Milestones  
Analyze Data  
Correct Data  
Assemble Evidence  
Legend  
Unstacked data  
Stacked data  
Blessed data  
Add/View comments

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

This analysis looks at the [signals](#) generated when cosmic ray muons passes through a counter. The values are displayed in a histogram.

Gain confidence by running a practice analysis.

[Understand the graph](#)

You're analyzing... Chan1 events Chan2 events Chan3 events Chan4 events Raw Data

Univ of Birmingham Aug 1, 2011 08:07:08 UTC 71232 79158 112052 63072 [View Statistics](#) [Geometry](#)

Total (1 files 325514 events) 71232 79158 112052 63072 [Compare files](#)

Click **Analyze** to use the default parameters. Control the analysis by expanding the options below. Be sure to click the question icon next to "Bin width (ns)."

**Analysis Controls** **Select channels to analyse**

Channels: 1  2  3  4

Bin width (ns):

**Plot Controls** **Use plot controls to change the range of the axis and the title of the plot.**

X-min:  X-max:

Y-min:  Y-max:

Plot Size:

Plot Title:

Figure caption: 

Data: Univ of Birmingham Aug 01, 2011 08:07:08 UTC  
Detector: 6430

**Execution Mode**

Local (estimated time: 00:01:00)

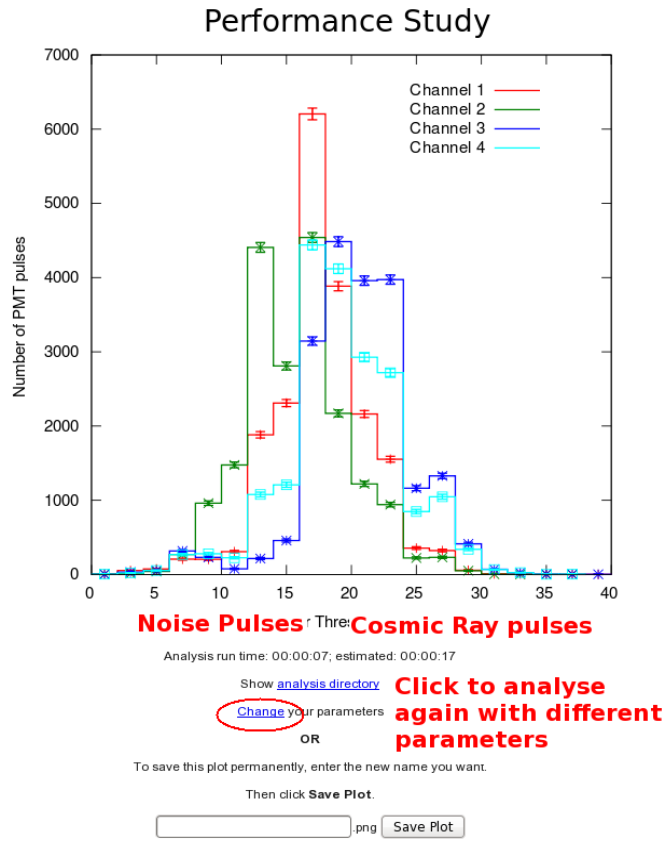
I2U2 Cluster (estimated time: 00:01:55)

Grid (temporarily disabled)

Automatic (estimated time: 00:01:09)

Click on analyze

- 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".

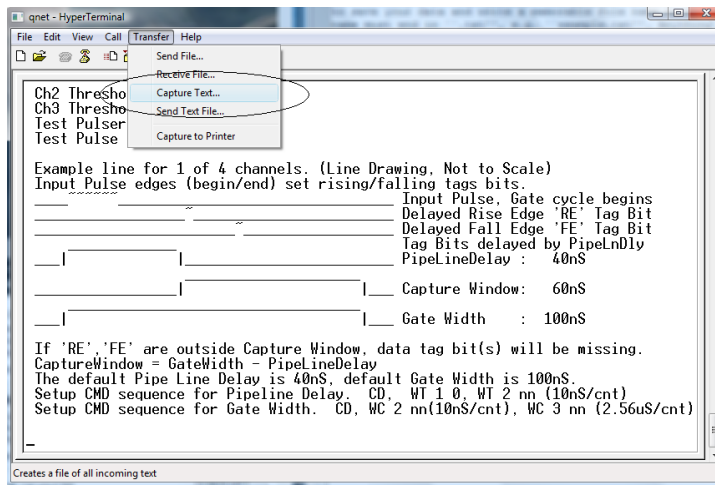


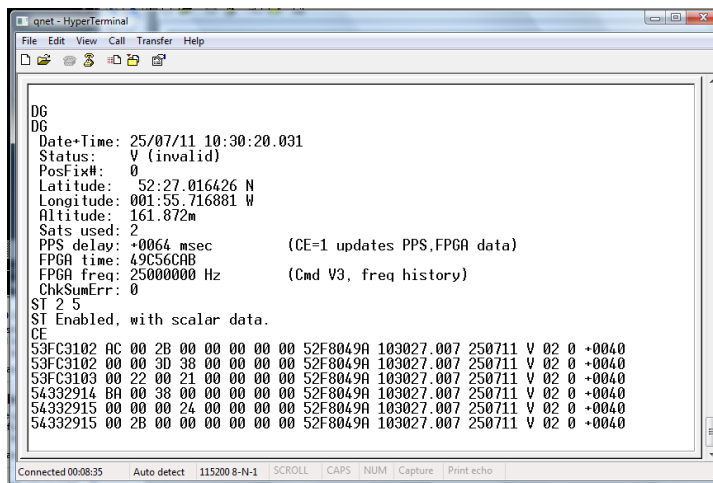
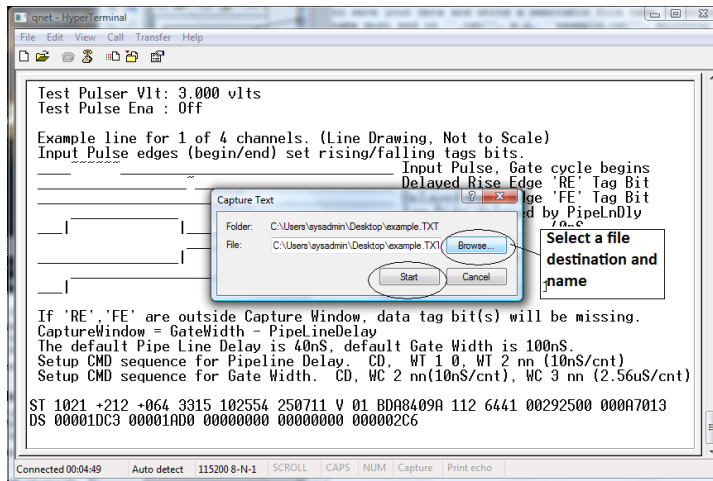
You should get a graph which looks like the one above. The Time over Threshold (ToT) for each pulse is plotted in a histogram. The peak centered on 20ns is due to cosmic rays. The random noise will produce pulses with a lower ToT, and so the smaller peak to the left of the large peak is due to noise. 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”.

**Upload raw data collected by your cosmic ray detector.**

- Select the **detector** associated with the data you are uploading.
- Click **Choose File/Browse** to locate the data file on your computer.
- Click **Upload** to upload the file.

Please do not upload files larger than 2 GB in size. You'll have to split them up into smaller pieces. Questions? See the [FAQ](#)

Choose detector  
6430

Raw Data File: Choose File No file chosen

Optional comments on raw data:

Select your detector and click to find your data file

Once you have selected your file click on "Upload"

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.