1 Worksheet 4: Flux Study

This worksheet describes different methods of measuring the cosmic ray flux. It can be done by recording data to be uploaded to the cosmic e-lab, or simply by reading teh scalars on the DAQ board after 1 minute. The main point of this experiment is for them to come up with a research topic of their own. They can investigate any factor which they think will affect teh cosmic ray flux. I would be a good exercise to get them to write a short research proposal, including what they are investigating, how they plan to investigate it and what they expect to find. This will make them think about the best way to carry out the investigation, and will give you the chance to steer them in the right direction. The amount of data they need to record will depend on what it is they are investigating. This will need to be taken into account when running the project. ALso, since there is only one detector, if you want each pupil to perform their own study, they will have to organise themselves to each use it at a different time. This worksheet may therefore need to be run over a few sessions.

1.1 Aim

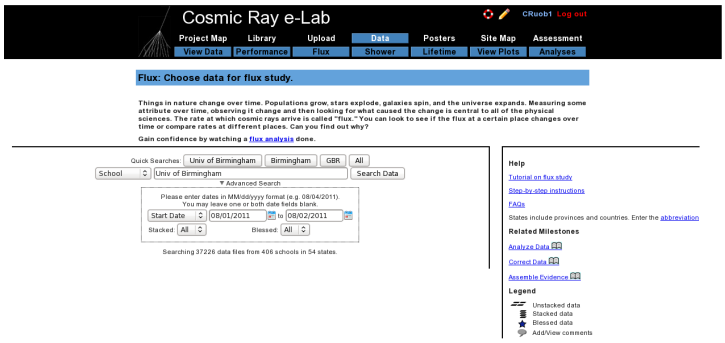
The aim of this worksheet it to find out the flux of cosmic rays and to investigate the different factors which may affect the cosmic ray flux.

1.2 Introduction

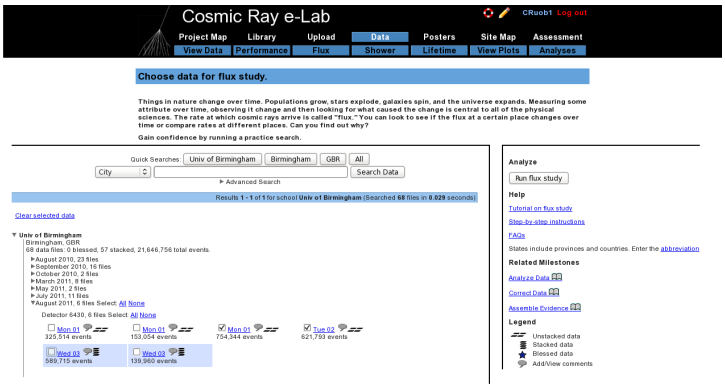
The flux of cosmic rays is the number of cosmic rays passing through a certain area at any given time. It can be measured in different units, but we will measure it in units of $events/m^2/60 - seconds$. That means we are measuring the number of cosmic rays passing through an area of $1m^2$ in every minute. Using the tools in the Cosmic e-lab website (http://www18.i2u2.org/elab/cosmic/home/) it is possible to measure the cosmic ray flux, and monitor how it changes over time. This is the first thing we will do in the worksheet, and then you will have the opportunity to create your own research question and investigate a factor which affects the cosmic ray flux.

1.3 Running a Flux Study

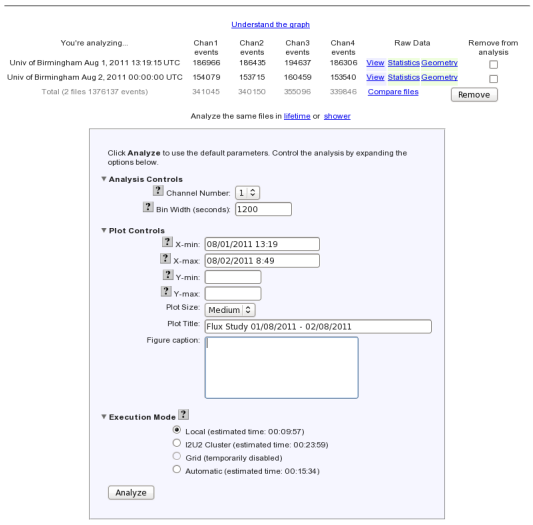
Firstly, we will use some data which has already been uploaded to learn how to perform a flux study. Start by logging onto the e-lab website (http://www18.i2u2.org/elab/cosmic/home/).



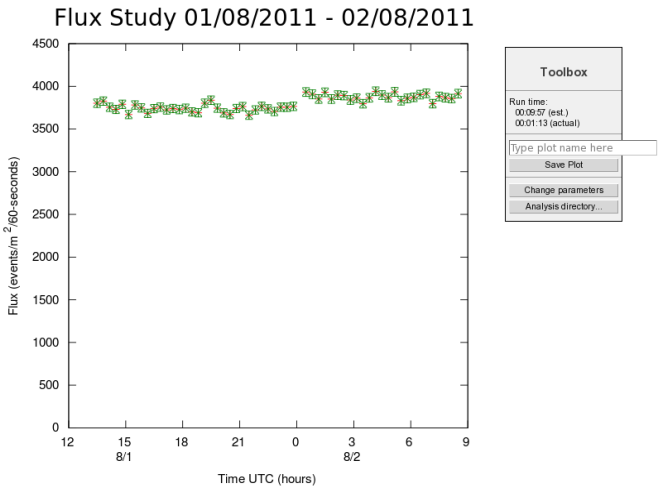
Click on "Data" and then "Flux", and you should see the screen above.



Use the search box to select "School" and find data from the "Univ of Birmingham". Select the data from 19/08/2011 and click on "Run Flux Study".

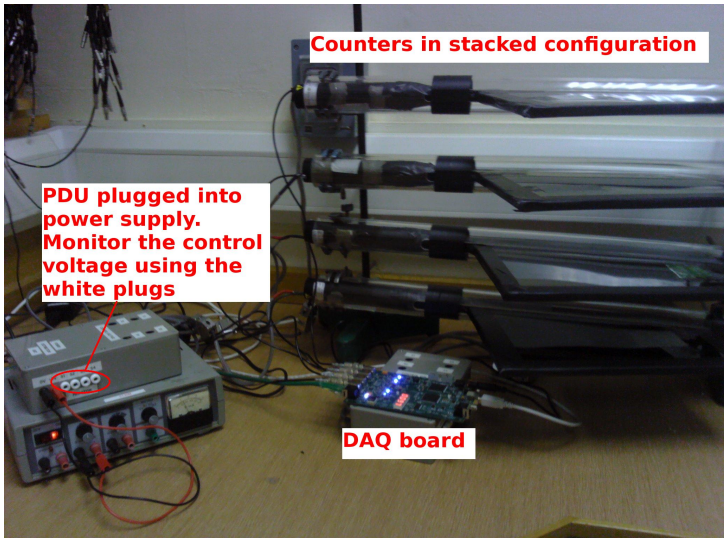


You can change the properties of the plot from the next screen, shown above. If you have collected data over a long period of time, you may want to have a larger bin width, so that the data points are not so cramped. Conversely, if you do not have much data, you may want to use smaller bin widths so that more data points are plotted. Once you have set your own plot title click on "Analyze"

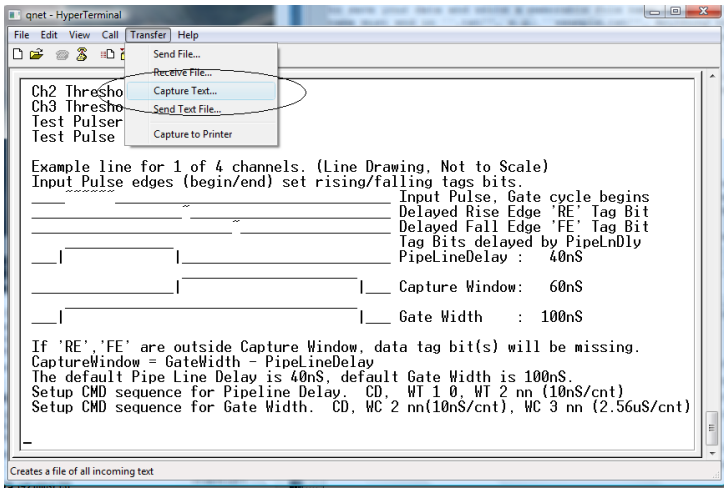


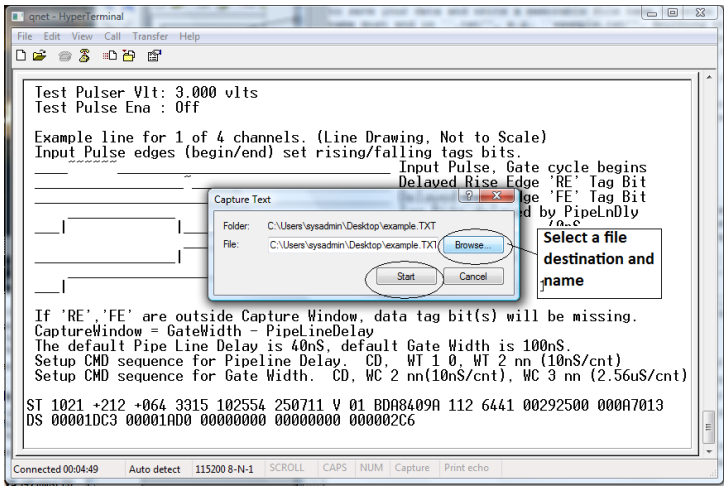
You should obtain a plot which looks like the one above. Click on "Change parameters" to the side if you are not happy with how the graph looks. Now you can take data with your detector to obtain your own flux plot.

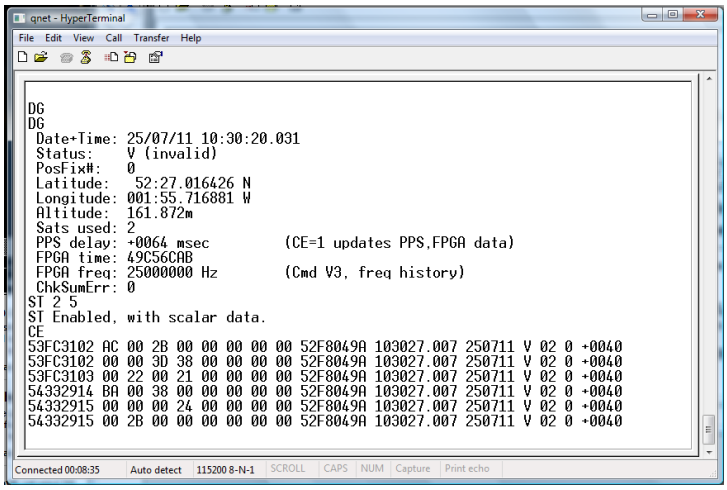
1.4 Taking your Own Data



Set up your counters in the stacked configuration shown above and set the control voltages to the optimum voltages found by the plateau method. Open Hyperterminal and follow the steps below to collect data:







1. Set up the DAQ board to record 4-fold coincidences 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, ST 2 5. This ensures your data file contains the necessary information about the detectors.

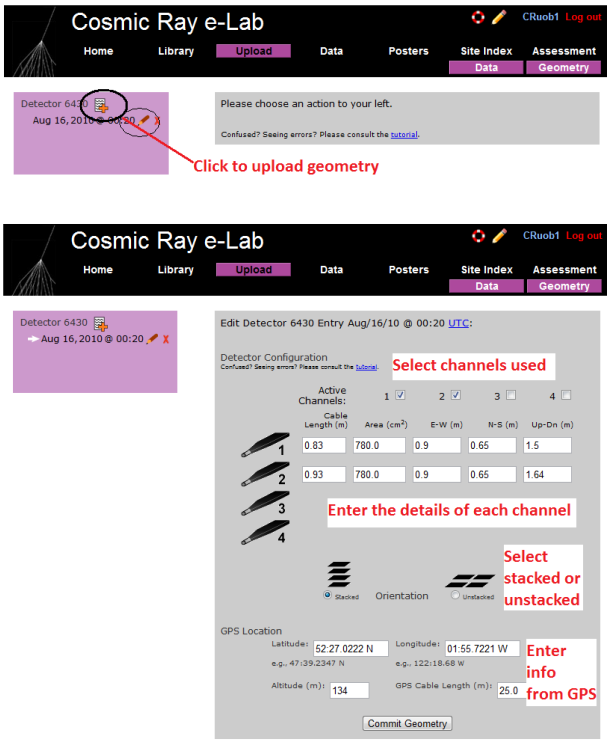
5. Type the command CE to enable the counters and start writing data to the ".txt" file. Leave this running for about 2 hours. Make sure that the computer you are using is set to never sleep, otherwise you will not continue to collect data.

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".

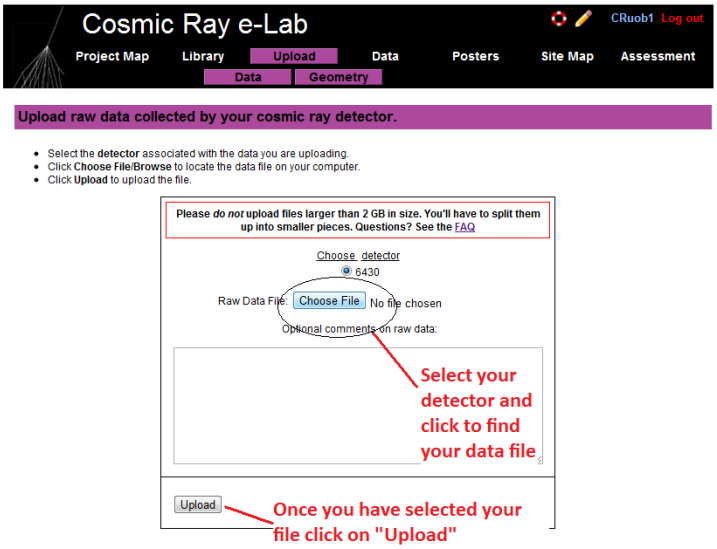
Once you have your data, you can upload it to the Cosmic e-lab website. But before you do that you need to upload the geometry.

- To upload the geomtery of the detector click on the upload tab on the e-lab website and then click on the geometry tab.
- Click on "add entry".



- Fill in the details of the detector setup. First, tick the boxes corresponding to the channels which you are using.
- Next, enter the required details for each counter.
- The cable length is the length of cable from the PMT to the DAQ board.
- The area is the surface area of the counter in units of cm^2.
- The E-W (East-West), N-S (North-South) and Up-Down measurements are the distances of the counters from the GPS antenna. The values do not have to be completely accurate but difference between the Up-Down measurements of your counters should be the distance between the counters, which you can measure quite accurately.

- Next you need to select the orientation of the detector. Select stacked if the counters are on top of each other or unstacked if they are all on the same level. To start with, your detector should be stacked.
- Finally, you need to enter details of the GPS antenna. The longitude, lattitude and altitude measurements can be found by typing the DG command into Hyperterm.
- The GPS cable length is the length of cable connecting the GPS module to the DAQ board.

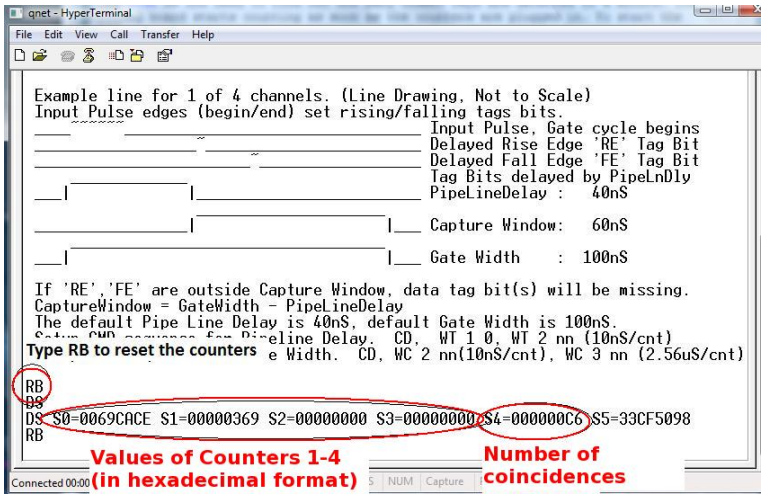


Upload your data by clicking “Upload” and then “Data”. It is now ready to be analysed. Repeat the steps above with the data you have just taken to obtain your own flux studies. How does the flux you measure compare with the flux measured at the University of Birmingham? Does the flux change over the two hours you were collecting data for. Once you are happy with your plot, click on “Save Plot” so that you can easily access it again.

1.5 Alternative Flux Measurements

This is not the only way to measure the flux of cosmic rays. If you merely want to find out the rate of cosmic rays detected by your counters, you can use the DAQ board and Hyperterm.

1. Open up hyperterminal and type WC 00 3F. This will set up the DAQ board to look for coincidences between all 4 counters.
2. We now need to find out how many cosmic rays are detected in a minute. The DAQ board starts counting as soon as the counters are plugged in. To start the counters again you can use the command RB. Type RB and start the stopwatch at the same time.



3. After one minute, type the command DS. This displays the counters on the board and tells you how many cosmic rays have been seen, and should look like the screen above. The numbers are all in a hexadecimal format. The value of S4 is the number of coincidences, i.e. the number of comsic rays detected. You can use MS Excel to convert the hexadecimal number into a decimal number using the hex2dec() function. The values of S0-S3 are the number of pulses above the threshold measured in counters 1-4.

This method is not as accurate as the first method and so you may want to repeat the measurement a few times and take an average. It will not allow you to monitor the flux over time and it is dependent on your setup (i.e. how far apart your detectors are etc.) This means it will not give you an absolute flux. However, it is much easier to use if you want to measure the rate and then change your setup and measure the rate again. You will have to decide which method is the best to use for your own investigation.

1.6 Choose a Research Topic

Now is a good time for them to write their research proposal. They can then carry out their proposal when the detector is free. Possible experiments could be investigating whether the flux changes during the day, or at night time, the distance between the counters, the angle between the counters and the vertical, pressure, altitude. Some are easier to investigate than others, e.g. the day/night effect only requires you to record data overnight. Some may not be possible, e.g altitude may involve moving the detector to different floors of a building. It is thereofer quite important that the pupils check that their research proposal would be feasible before writing it up.

You now have free reign to pick a question which you would like to research yourself. You want a question which is something like "How is the comsic ray flux affected by...?" Think about something which you really think would affect the flux of cosmic rays, and see if you can come up with a prediction of exactly how the flux will be affected. This could either be something to do with how the flux is affected by where you are, do you measure a different rate on higher floors of the building? Does being inside make a difference to the rate you measure? If you want to investigate this type of question you need to be careful to keep the geometry of the detectors the same, they should always be the same distance apart. Or you could investigate whether changing the geometry of the detector affects the rate of cosmic rays which are measured. Does changing the distance between the counters affect the rate? Or the angle of the counters from the vertical? Think about something that you would find interesting to investigate. Ask your teacher if you have an idea but you are not sure how to investigate it.

The most important thing to remember here is to only investigate one variable at a time. If you want to change one thing with the detector, then everything else must be kept exactly the same to make the investigation fair.