A.D.O.M
Anna Chang
July 16, 2007

Abstract

In this experiment, a balloon deployable muon detector was sent up in a tethered weather balloon to a height of about 1000ft to count muon coincidence rates. The data was then compared to count rates at ground level and at sea level. The detector is made of a single scintillator panel and two photomultiplier tubes at opposite corners. There is a QNET Board, XBEE Transmitter, and a voltage supply on the gondola. There should be a much higher count rate at 1000ft then at sea level because muons only have a lifetime of 2.2 microseconds and are created at a height of 15km above the ground.

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July 26, 2007

Experimental Procedure

Purpose: The purpose of this experiment is to compare muon count rates at different altitudes at Santa Cruz.

Equipment: A balloon deployable detector, tethered weather balloon, Helium, stopwatch, 1000ft of nylon string and a laptop.

Payload: Scintillator panel with 2 photomultiplier tubes (PMT), QNET board, XBEE transmitter, 9.6 NiCad Battery, voltage supply.

Setup: Connect power from the voltage supply to the QNET board (audio jack), XBEE transmitter (9V battery snappers), and the PMT (banana clips). Plug in the battery at the top left hand corner of the power supply. Do not force; the connector only goes in with the right polarity. Check the voltages with a voltmeter. Set up the XBEE transmitters. The XBEE with the serial port should be connected to the QNET board. A null modem adapter and a gender changer are needed to connect. Connect the ground XBEE with the USB port to the computer. Install any hardware if necessary and run X-CTU. Set up communications. Refer to the XBEE document for more details on the ADOM website. Check to see if there is communication between X-CTU and the QNET board.

**NOTE: X-CTU does not capture text. To capture text, refer to *"How to Capture Text with X-CTU"* in the Equipment section.**

Set up the Helium balloon and attach the gondola.

Procedure:

**NOTE: Be sure to keep a record of events and the time that they occur. For example, if 5 minutes into the launch, the wind picks up, record that event as it may become useful in describing sources of error.**

On the laptop computer, set coincidences with the command "WC 00 13". Save the settings with "SA1". Start the counter with the command "RB". Start releasing 1000 ft of line and type the "DS" command every 2 minutes and record the coincidences under S4. Convert the number to

decimal using a scientific calculator on the computer. At 1000 ft, record the time and take one set of data for 30 minutes. Continue to type the command "DS" every 2 minutes. After 30 minutes has elapsed, type in "DS" to display the scalars. Reel the balloon in after noting the time and type the "DS" command every 2 minutes and record the coincidences under S4. Analyze the data and compare with data at other altitudes.

Analysis:

**NOTE: There is a program that will analyze the data and will give the number of coincidences every two minutes, under the Miscellaneous section.** Convert the hexadecimal value of the coincidences to decimal if you have not already done so. Put these

values in a column in an Excel spreadsheet. In another column, set up a formula where the next cell equals the cell next to it minus the cell to the top left. (see Figure 1) Since data was taken at two minute intervals, set up a column where a cell is equal to the cell next to it divided by 120 sec. (see Figure 2) This is converting the data into a count rate of Hz. Then finally set up a column where the first value is 2 and each cell below it is equal to the cell above it plus 2. (see Figure 3) This column is the time. Now graph time versus the count rate.
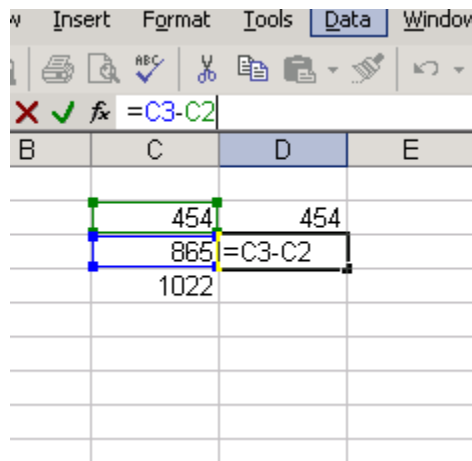
## Figure 1

Insert · Format · Tools · **Data** · Window

$f_x$ =C3-C2

| B | C | D | E |
|---|---|---|---|
|  | 454 | 454 |  |
|  | 865 | =C3-C2 |  |
|  | 1022 |  |  |

## Figure 2
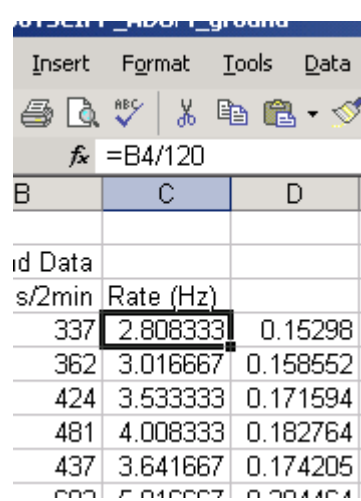
Insert · Format · Tools · Data

$f_x$ =B4/120

| B | C | D |
|---|---|---|
| d Data |  |  |
| s/2min | Rate (Hz) |  |
| 337 | 2.808333 | 0.15298 |
| 362 | 3.016667 | 0.158552 |
| 424 | 3.533333 | 0.171594 |
| 481 | 4.008333 | 0.182764 |
| 437 | 3.641667 | 0.174205 |

## Figure 3
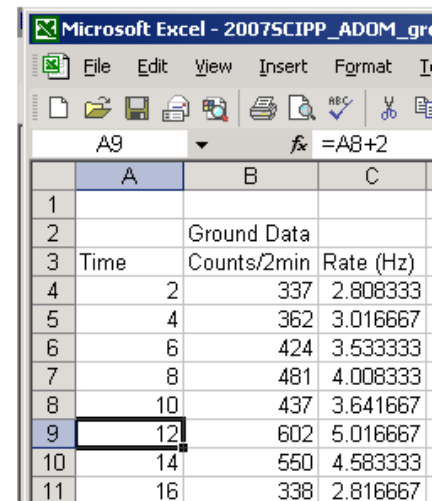
Microsoft Excel - 2007SCIPP_ADOM_gr...

File · Edit · View · Insert · Format · T...

A9    $f_x$ =A8+2

| | A | B | C |
|---|---|---|---|
| 1 |  |  |  |
| 2 |  | Ground Data |  |
| 3 | Time | Counts/2min | Rate (Hz) |
| 4 | 2 | 337 | 2.808333 |
| 5 | 4 | 362 | 3.016667 |
| 6 | 6 | 424 | 3.533333 |
| 7 | 8 | 481 | 4.008333 |
| 8 | 10 | 437 | 3.641667 |
| 9 | 12 | 602 | 5.016667 |
| 10 | 14 | 550 | 4.583333 |
| 11 | 16 | 338 | 2.816667 |

# How to Capture Text with or with out X-CTU
Anna Chang
July 26, 2007

With X-CTU
- Set up the detector and plug in power
    - o Refer to "How to Set Up ADOM in the equipment section" for details
- Connect the ground XBEE to a computer via the USB port
    - o Install any hardware if necessary
- Run the program X-CTU
- Take note on the COM Port number
- Set up communications
    - o Set the baud rate to 19200 and the flow control to XON/XOFF
- Under the "Modem Configuration" tab, click the "read" button.
    - o If there is an error box, reset the XBEE or disconnect and reconnect
- Once there is communication, exit out of X-CTU
- Go to "HyperTerminal"

HyperTerminal
- Open HyperTerminal
    - o If this is the first time using HyperTerminal, a message will pop us asking for the area code. For this experiment, cancel out of that message because we are not going to be making any phone calls
- Name the connection click Ok
- Under the Connect using box, select the COM Port that is connected.
    - o If you are capturing text using X-CTU, select the COM port that you took note of
- Click Ok and set the bit rate to 19200 and the Flow Control to X on / X off. Click Ok.
- In the terminal window, type in RE and the QNET Board info will pop up.

Refer to the [ADOM Webpage](#) for trouble shooting.

Procedure for Performance Testing
Anna Chang
July 23, 2007

- Set up the detector with the GPS.
- Type in "DG" in HyperTerminal and check to see if there are at least 3 satellites.
    - If not, move the GPS outside or by a window until there are at least 3 satellites.
- In HyperTerminal, type in:
    - "WC 00 13" - Sets coincidences
    - "WC 01 05" – Changes window to about 100ns
    - "WC 02 00" – Changes d to 48 ns
    - "WT 01 00"
    - "WT 02 02"
    - SA1 – saves settings
    - CD – Counter disable, stops the flow of data from coming in
- In the HyperTerminal window under the Transfer drop down menu, select Capture Text
    - Give the file a name, usually in this format: Serial Number, Project Name, Date.
    - Example: 5535ADOM070723
    - 55535 is the Serial Number of the QNET Board, ADOM is the project name, and the date is July 23, 2007.
- In HyperTerminal, type in this series of commands: "H1", "H2", "DC", "DT", "DG", "DS", "TH"
- To start the data, type in "CE" to enable the counters
- Wait half an hour
- Disconnect after taking data
- Upload data file to QNET eLab
- Run Performance Study on data

Calibration of A.D.O.M

In order to get the optimal muon counts, the detector's four adjustable voltages need to be set so noise is reduced, but the most amount of muons get detected. The four voltages are two that supply the PMT voltage and two that are on the comparator or discriminator. The procedure used to set these voltages is called plateauing. Plateauing is adjusting one voltage at a time until the count rate is relatively stable. A graph of a plateau is shown in **Figure 1**.
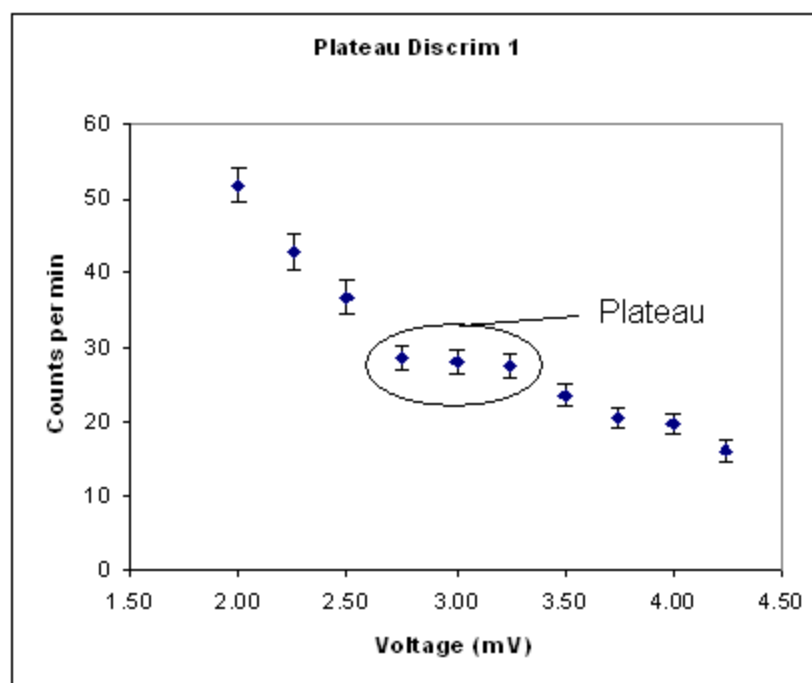


**Figure 1**

Materials

Balloon Deployable Detector
Voltage Supply (In case of A.D.O.M, a 9.6 NiCad battery)
Voltmeter
Screwdriver
Computer with HyperTerminal and Excel or Spreadsheet

Timer or watch

<u>Procedure</u>

Set up the QNET board to singles counts using HyperTerminal. For a procedure on how to do this, refer to the QNET manual. Raise the PMT voltages by turning the screw on the potentiometer on the voltage supply until there is a singles count rate of 200 Hz (counts per second). Then raise the Discriminator voltages on the QNET board until the count rate drops to about 20Hz. These are the starting voltages to plateau at. Change to coincidences via HyperTerminal. Choose a PMT voltage and run the detector for 2 minutes at each voltage. To reduce the uncertainty, repeat for multiple trials. Graph voltage vs. count rate and look for a plateau. Set the voltage to a point in the middle of the plateau and plateau any of the other 3 voltages. When the four voltages have been plateaued, switch to singles. If the singles rate is over 200Hz, then the signal has too much noise. Either raise the discriminator voltage or lower the PMT voltage. The ideal count rate for the balloon deployable detector is a singles rate of 200Hz and a coincidence rate of 10Hz.

First I plateaued the PMT voltages and found a plateau for PMT 1 at 7.15V and for PMT 2 at 7.50V. Next I plateaued the discriminators and found plateaus at .300V for Discriminator 1 and .125V for Discriminator 2. I plateaued the PMT again to check that the settings are still in a range of no noise and counts. My plateau settings are in **Figure 2** below.

| **Settings** | | Count rate | |
|---|---|---|---|
| Discriminator 1 | .275V | Singles | Coicidences |
| Discriminator 2 | .125V | ~4000 | 4.583333 |
| PMT1 | 7.25V | | |
| PMT2 | 7.30V | | |

**Figure 2**

However, when I checked my coincidence rate, I was only getting a rate of 3 Hz. I checked my singles rate and was surprised to be getting a rate of 600Hz. If the expected rate is a singles rate of 200Hz and a coincidence rate of 10Hz, then my detector is not being very efficient. So I stretched my settings to the very edge of the plateau; I raised the PMT voltage right before noise over runs the count rate to get more counts, but also raised the discriminators to filter out the weaker noise. My final settings are in **Figure 3** below.

**Settings**

Count rate
Discriminator 1
.300V

Singles
Coincidences
Discriminator 2
.185V

|  |  |
|---|---|
|  | 209.8 |
|  | 3.55 |
| PMT1 | 7.35V |
| PMT2 | 7.40V |

**Figure 3**

Although the number of coincidences went down, the singles rate drastically dropped due to the relatively large increase in the discriminator thus eliminating noise. My actual data and graphs are in an Excel file named Plateau-Fixed.

# Voltage Supply

Anna Chang
June 6, 2007

## Description

The voltage supply consists of one 9.6V battery and three voltage regulators; one that is fixed and two that are adjustable and will be constructed on a perforated board.
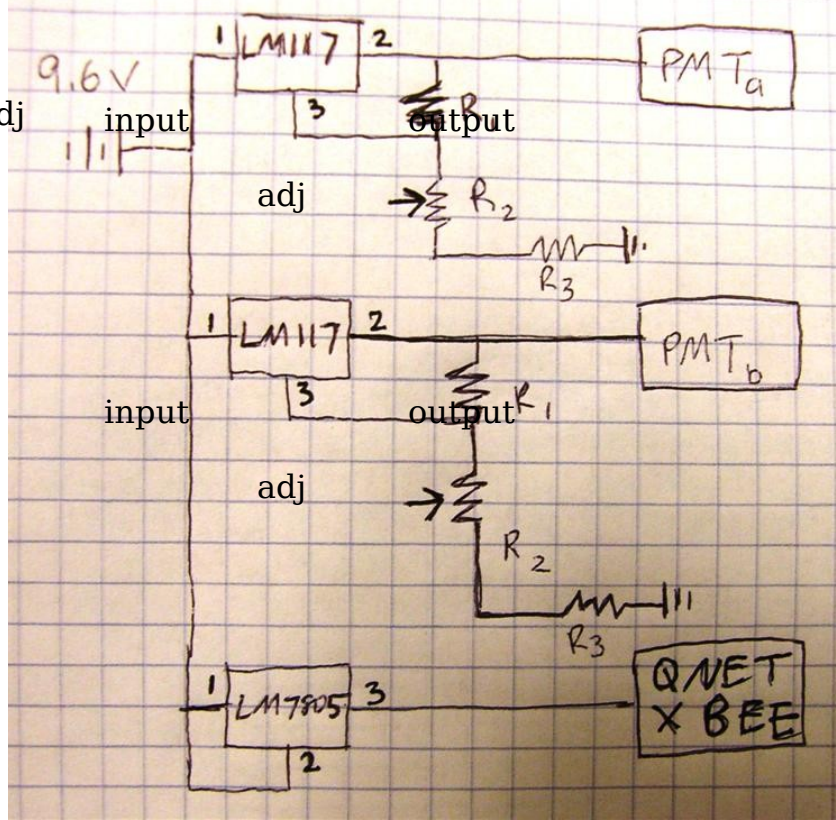
## Function

Each electronic component requires a different voltage. The photomultiplier tubes (PMTs) needs to be adjustable around the range of 5-8V. The X-Bee takes a range of 5-14V and the QNET board needs 3-8V. We decided to use one 9.6V NiCad battery to power all the electronics because of the weight requirement of 6lbs and the simplicity of having a common ground. There are three voltage regulators to bring the voltage down. One is a LM 7805 that puts out a fixed 5V for the QNET and XBEE and the other two are LM1117 identical adjustable regulators for the PMTs. The fixed 5V regulator needs to have a heat sink installed due to the power that needs to be dissipated from the current draw of both the QNET and XBEE so the style chosen is a TO-220.

## Power Connections

The battery is connected with a three prong header. It is impossible to plug power in backwards. The PMTs use banana clips and the QNET board uses an audio jack. All the connectors must be securely attached and there must be no possibility of shorting.

## Schematic

$R_1 = 330\Omega$
$R_2 = 1k\ \Omega$ adj
$R_3 = 1k\ \Omega$

input          output

ground