

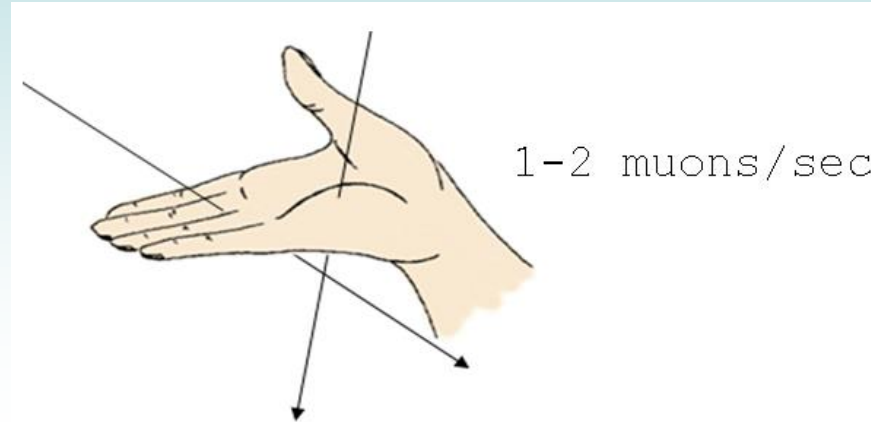
Calibration Instructions for Quarknet Cosmic Ray Detector

How to Plateau the Counters

A friendly guide for students and teachers

Edited by Jeremy Paschke, August 2009
Instructions specific for 6000 series

Expected Flux



Rough estimates say that one or two muons pass through the area of your hand every second.

As you do this calibration process with the Quarknet Cosmic Ray Muon Detector (CRMD), you should expect your counters to detect *approximately* 10 muons per second (between 500 and 1000 counts per minute).

Review on Voltages

There are two voltages you can adjust:

1) Photomultiplier Tube (The PMT is the voltage you will adjust in this calibration process.)

- The PMT voltage amplifies all signals from the tube.
- The PMT voltage is adjusted through the power distribution unit (PDU).



2) Threshold Level

- The threshold voltage can be set at various levels to discriminate against pulses of lesser magnitude.
- The threshold level is adjusted by typing commands on the computer.
- We recommend setting the threshold level to a constant 300 mV, and not adjusting it afterwards.



Common Commands:

CD - Counter Disable will stop the scrolling up of events.

CE - Counter Enable resumes the scrolling up of events.

TL 4 300 - Set Threshold Level of all four counters to 300 mV.

WC 00 3F - Write Counters to read a two-fold coincidence with all four counters activated.

V1, V2 - View settings.

H1, H2 - Help with commands

A Note on Numbering

- These instructions refer to the counters and channels as 0, 1, 2, 3.
- All the hardware and terminal commands refer to channels 0-3.
- Only the e-Lab refers to channels 1-4.

Step A

Set all voltages on the photomultiplier tubes (PMTs) to minimum (0.3 V) by turning potentiometers on the four-way power distribution unit (PDU) all the way counterclockwise.



Step B

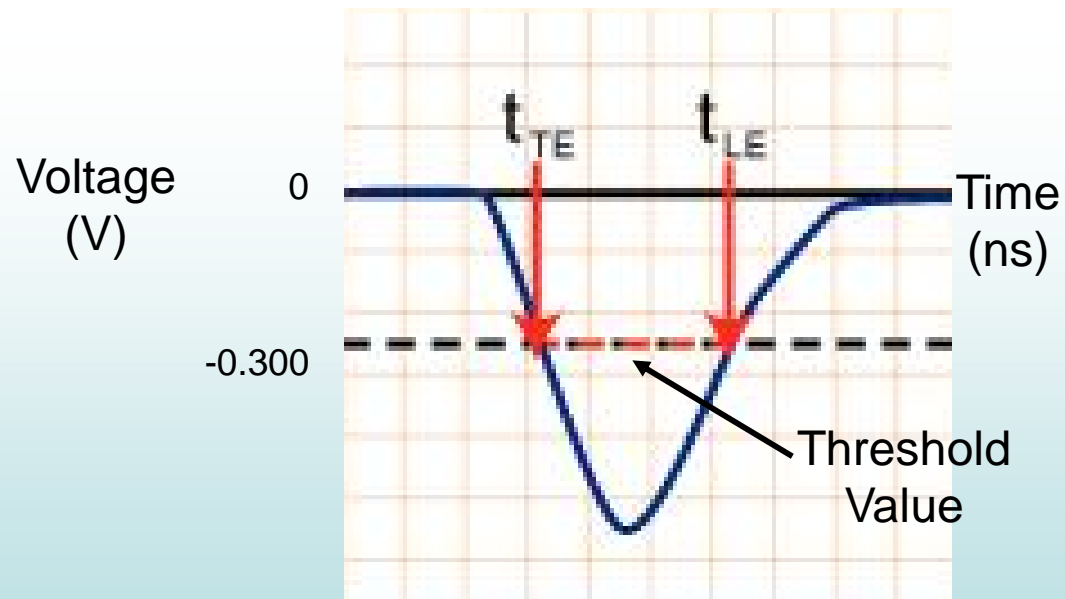
Place counter 0 and counter 1 together in a stacked configuration.



Step C

Set threshold voltage for all four counters to 300 mV.

- In your terminal emulator (*Hyperterm* for PCs, *ZTerm* for Macs), type *TL 4 300* (TL = Threshold level; 4 = all counters; 300 = mV).
- Type *V1* to view the first panel of setting to verify your commands were followed.



Step D

- Increase the PMT voltage for counter 0 until it reads between 40 and 60 events per second.
- Type *WC 00 01* to activate only channel 0 and read a one-fold coincidence.
- Use the digital counter to monitor counts per time until you reach desired range.

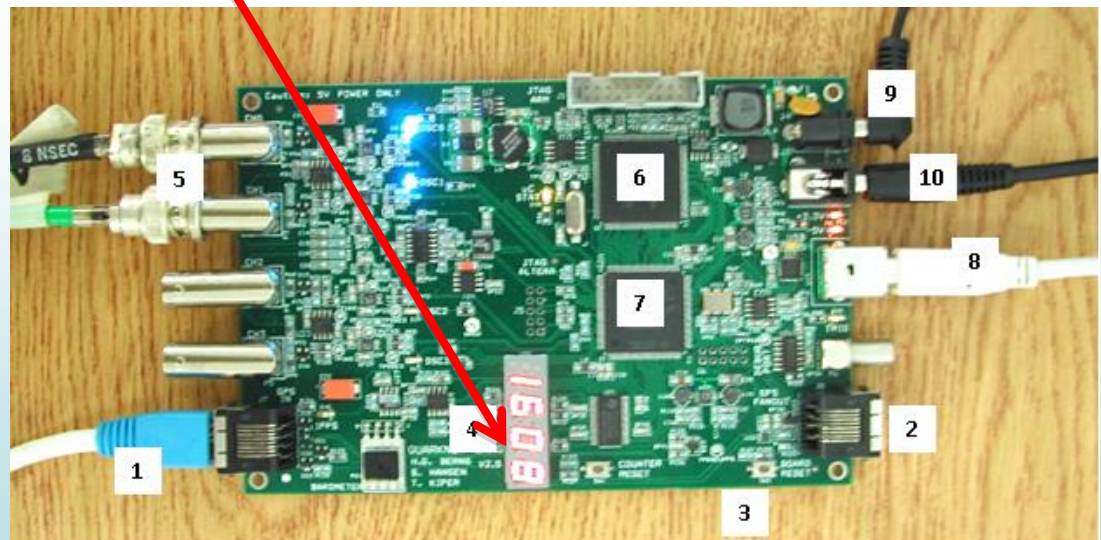


Figure 8. Close-up view of the DAQ: Data Acquisition card.

Step E

Set the DAQ card to accept only channels 0 and 1 with two-fold coincidence.

(Type V1 to check settings are correct.)

There are two ways to accomplish this:

- 1) Activate all four channels (counters) and unplug the two that are not being used.

Type *WC 00 1F*

- 2) Activate only the counters that are being used.

Type *WC 00 13* for channels 0 and 1.

Type *WC 00 15* for channels 0 and 2.

Type *WC 00 19* for channels 0 and 3.

Type *WC 00 16* for channels 1 and 2.

Type *WC 00 1A* for channels 1 and 3.

Type *WC 00 1C* for channels 2 and 3.

Step F

Measure the counts on channels 0 and 1 for one minute at time over increasing PMT voltages.

Type *ST 3 1* to read out counts on each channel and the coincidence counts for each minute. (Mode 3 displays the scalar count from each channel *and* resets the counters after each display. The *1* stands for the time interval you choose in minutes.)

ST	1013	+1018	+000	3316	164720	V 03	00000000	106	6156	004D4900	000A703F
DS	000002A8	000002E2	00000000	00000000	00000113						
	Ch 0	Ch 1	Ch 2	Ch 3	Coincidence						
		Singles			Count						

Step G

Record data in a table.

- The registers in the ST command are in hexadecimal.
- Record the readings for your two scalars of interest and the scalar for coincidence in hex and then convert to decimal.
- Create a data table:

Ask your mentor for a copy of the Excel file:

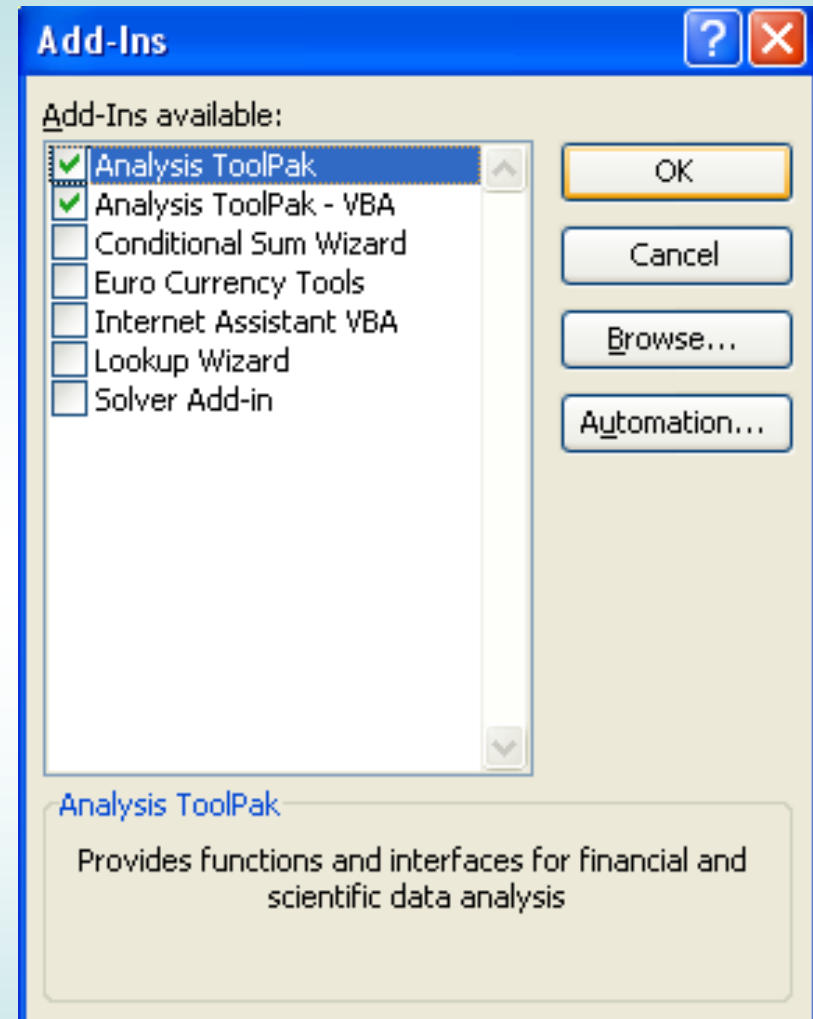
Plateau_Template_2009.xls

Tube Voltage		Ending			Count Rates & Uncertainty (decimal)						Accidental
Ref	Test	Scaler Hex Values			Single		Single		Coincidence		Coincidence
Ch0	Ch1	S0	S1	S4	S0	σ_0	S1	σ_1	S4	σ_4	Rate as %
1.19	0.7	cc5	1b	10	3269	57.17517	27	5.196152	16	4	0.00%
	0.71	ccd	22	13	3277	57.24509	34	5.830952	19	4.358899	0.00%
	0.72	cbd	29	1f	3261	57.10517	41	6.403124	31	5.567764	0.00%
	0.73	c62	2f	1f	3170	56.30275	47	6.855655	31	5.567764	0.00%
	0.74	c26	56	3f	3110	55.76737	86	9.273618	63	7.937254	0.00%
	0.752	c09	74	52	3081	55.50676	116	10.77033	82	9.055385	0.00%
	0.76	c79	89	6c	3193	56.50664	137	11.7047	108	10.3923	0.00%

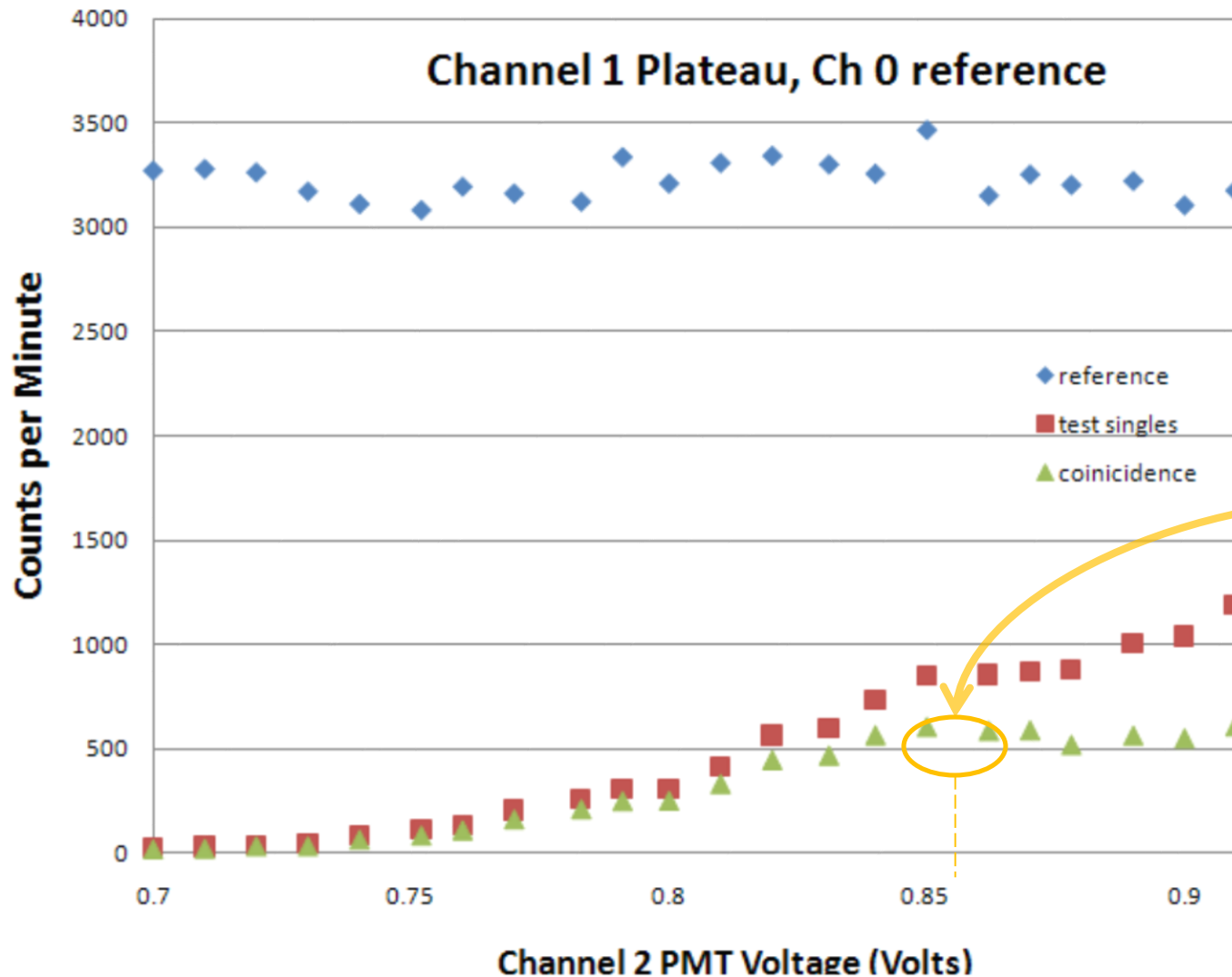
Note: If you have never used the `HEX2DEC()` command in Excel, you will get a “*NAME##*” error in some boxes.

You need to activate the proper tools.

- Go to the *Tools* pull-down menu and select *Add-Ins*.
- Then check the two top boxes: *Analysis ToolPak*, and *Analysis ToolPak – VBA*.
- Click <OK> and the file should now convert hexadecimal to decimal properly.



Step H



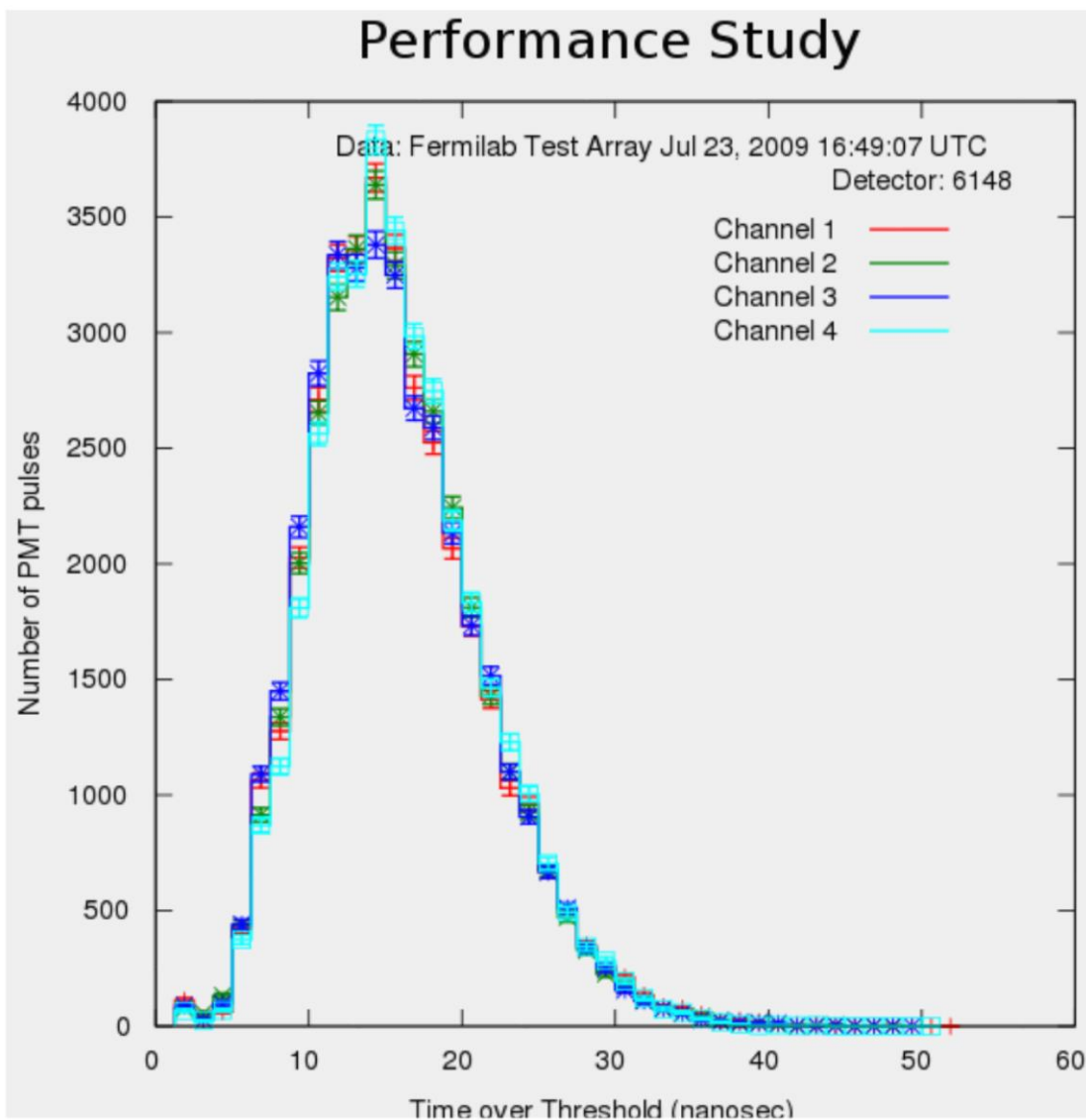
Look for where the coincidence counts level off, or “plateau.”

You should set the PMT voltage near the start of this plateau.

Steps I, J, K

- Now you have found the optimal operating voltage for counter 1. Record this value in your logbook and on the Excel file you are using.
- Repeat the process to calibrate the other three counters. In at least one case you will need to use a new reference counter. Make sure to set the reference counter at a high voltage (about 40-60 events per second).

Step L



- Once the CRMD is plateaued, let it run for a couple hours and capture the file through Hyperterm or Zterm.
- Upload a file to the e-Lab and run a *performance study* on that data.
- Make minor adjustments to PMT voltages to bring all channels together.
- An ideal performance plot shown to the side

- Be aware that the detector might drift over time. This plateau calibration process ought to be repeated at least once a year. It's a good activity for each new group of students.

THE END
of Calibration
(Plateau) Instructions