How to Set Up a Cosmic Ray Detector

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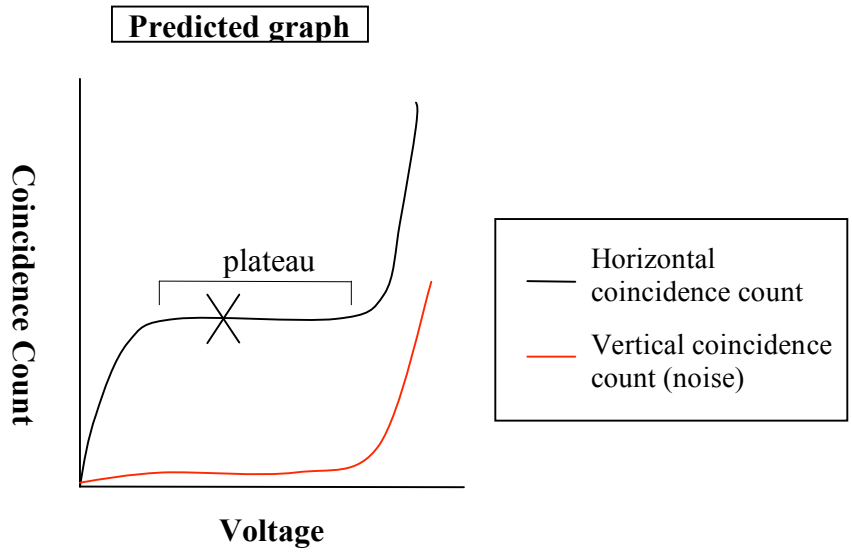
Introduction

To ensure the detector is operating at its optimal level, the voltage of the photomultiplier tubes must be adjusted so that the voltage created when a cosmic ray passes through the scintillator is lower than the level set by the comparator.

On a Graph

Ideally, on a voltage vs. coincidence count graph (shown below), the desired point rests in an area called the "plateau", where the coincident count rate remains relatively constant. Before reaching this plateau, the coincidence count should be increasing rapidly as the voltage increases, and the same should occur after the plateau.



Noise

When the voltage is set too high, there will be something called "phototube noise." This noise is produced when the photons released from the scintillators overexcite the electrons in the phototube, creating noise. Noise interferes with the accurate measurement of coincidence cosmic ray counts and accounts for the rapid increase after the plateau. To monitor the noise, a second coincidence count is taken with the detector's paddles set vertically. This should yield relatively low counts because there is only a small possibility that two different cosmic rays can hit both paddles, in that position, at the same time. When the count rate becomes extremely high, the voltage is too high and there is too much noise.

Measuring the Voltage

Because the singles rate for each paddle is proportional to its voltage, the singles count can be used as an indicator of the voltage level.

Materials

- Very small slotted tip screwdriver (one can be made with a small metal rod)

Procedures

1. For detectors with end mount photomultipliers, two holes must be made in the case that holds the detector at the end where the phototube is to be able to reach the small screw that adjusts the voltage. These holes should be large enough to look through and adjust the knob that controls the voltage. Side mount photomultipliers should have easily accessible screws right through the Lucite panel.
2. Before changing anything, record a preliminary set of data.
    a. Take a timed coincidence count with the detector on its side (the circuit board should be facing up and the paddles in a vertical position).
    b. Turn the detector right side up with the circuit board facing you and the paddles in a horizontal position. Take a singles count for the upper paddle and another coincidence count.
3. Adjust the photomultiplier
    a. If the initial coincidence count is at or below 10, use the slotted-tip screwdriver and turn the screw on the upper paddle half a turn clockwise to increase the voltage slightly. Repeat step 2 and record the data. Continue turning the screw half a turn clockwise and recording the counts until the coincidence ceases to increase. There should be at least 10 data sets.
    b. If the initial coincidence count is higher than ten, turn the screw on the upper paddle counterclockwise two turns then repeat step 3 and record. Continue this pattern until the coincidence rate is lower than ten. Then, as in part *a*, begin turning the screw clockwise half a turn at a time and record the rates each time until the coincidence rate becomes constant. There should be at least 10 data sets.
4. Plot the points on a graph with the single count as the independent variable and the coincidence count as the dependent variable. Determine the optimal singles rate value
5. Adjust the photomultiplier until the singles count is close to that optimal point
6. Take a final data set.
7. Repeat steps 2-6 for the lower paddle.

NOTE:

- Pay attention when the counter passes 1000 because the numbers turn back to 000 after 999 and continue counting. Be sure to keep track of the thousand digits.
- Data taken of natural phenomena is believed to have a margin of error of the square root of the selected measurement.

Sample Data

Data Table

Detector #7							
	Upper Scintillator				Lower Scintillator		
	Coincidence (vertical)	Coincidence (horizontal)	Single		Coincidence (vertical)	Coincidence (horizontal)	Single
Initial	17	70	1057	Initial	9	93	421
	0	0	0		0	22	85
	0	0	0		6	76	237
	0	0	1		7	69	257
	2	3	20		13	68	223
	5	27	167		15	85	343
	7	23	127		17	87	437
	7	70	318		17	109	704
	11	78	403		18	80	806
	14	93	545		14	81	488
	7	88	604		12	101	504
	16	99	696		19	81	957
	16	80	792		11	88	443
	18	88	829	Final	20	89	545
	13	83	912				
	18	87	1180				
	16	76	669				
	14	82	588				
Final	9	95	865				

Graph