CHICOS
Portable Cosmic Ray Detector Operation Manual Experiments 1-5

Bob Coutts

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Detector Face :
Switch Positions and Functions

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Beeper This switch controls the beeper. If it is on, you will hear a beep every time a coincidence occurs. You may want to switch the beeper off.

On
Off

*

Coincidence This switch selects what is to be counted. If it is in the upper
Upper paddle position, the detector tells you the hit rate for the upper paddle.
Coincidence The center position gives the coincidence rate for both paddles.
Lower Paddle The bottom position gives the bottom paddle rate.

*

Count

Start position
Count for 60 sec

This switch starts the count when lowered from the start position. Return it to the middle position, once you've recorded your data.

*

Reset

Start Position
Clear counter

This switch clears the digital display for the next measurement. Be sure to raise it back up before the next trial.

Switching Sequence

1. Move the **Beeper** switch to **"**off" and the **Coincidence** switch to the "coincidence" (center) position during the entire experiment, so that the detector will count coincidences.

2. Be sure to plug in the power supply. There is no 'on and off' switch. The numbers light up when it's plugged in.

3. Place the two lower switches (**Count and Reset),** in their start position.

4. Move the **Count** switch to the "Count for 60 seconds" position. The counting will start as soon as the switch is moved. Wait till the counting stops, when the time is up.

5. Record your data in the data table.

6. Lower the **Reset** switch to clear the digital display.

7. Raise both the **Reset** and the **Count** switches back up to their start positions, to prepare for the next count.

8. Start at number 4 again, and repeat as many times as necessary.

Operating hints:

Be sure the counter is on a level surface each time you take a measurement. The only exception is Experiment number II.

Be sure you follow the switching sequence. The counter will count when you switch another way, but will not give the same result.

The counter is a delicate, expensive piece of equipment. Be careful to not bump it or drop it. Set it down carefully each time you move it. If you are going to take it into the field, be sure you have a pillow underneath for shock absorption and padding. Use a seat belt to hold it in position while traveling by car.

The counter runs off of 12vdc. You can either plug it into the wall with the ac-dc 12v converter or plug into the cigarette lighter/power supply in your car or use the portable 12v battery provided.

Experiment 1

Direction vrs. Count Rate

Purpose: To determine the dependence of count rate, at a given altitude, on direction (NSEW)

Equipment:

CHICOS Portable Cosmic Ray Detector,
12 vDC power source
compass

Procedure:

1. Make sure your detector is level and facing East.
2. Plug the detector into the power source.
3. Follow the switching sequence on page 3
4. Record your data in the data table below.
5. Repeat your measurement for a total of five times
6. Find the average value.
7. Rotate your detector to North and repeat steps 3-6
8. Rotate your detector to West and repeat steps 3-6
9. Rotate your detector to South and repeat steps 3-6

Data table I

Direction	**Trial 1**	**2**	**3**	**4**	**5**	**AVE**
East						
North						
West						
South						

What is the relationship between direction and count rate based on the data you collected?
Make a graph of average count rate vrs direction

Experiment 2
Count Rate Vrs Angle Up From Horizontal

Purpose

To establish a relationship between count rate and the angle which the detector makes with horizontal. Also, to discover the primary direction of cosmic rays relative to the Earth's surface.

Equipment

CHICOS portable cosmic ray Detector
12 vdc power source
horizontal lab bench
strong chord to lift one end of the detector and something solid above the detector to tie it to
(the detector has a built-in protractor and weighted string to determine angle with horizontal)

Procedure

1. repeat the steps 3-5 in experiment 1
2. tilt the detector 10 degrees and repeat #1
3. tilt the detector 10 more degrees (to 20 degrees) and repeat #1
4. tilt the detector 10 more degrees, for every 10 degree increment, all the way to 90 degrees and measure the count rate at each 10 degree increment five times
5. find and record all your average values for each angle
6. make a graph of count rate vrs angle
7. examine your graph and attempt to determine which function connects count rate with angle

Data Table II

Angle with horizontal	Trial 1	2	3	4	5	Ave
0^0						
10						
20						
30						
40						
50						
60						
70						
80						
90						

How does the count rate vary with angle of the detector from horizontal ? Use a graphing calculator to find the function.

Do cosmic rays come in from space vertically ?

Experiment 3

Count Rate Vrs Altitude (Low Altitude)

Purpose

To establish a relationship between altitude and count rate

Equipment

the CHICOs Portable Cosmic Ray Detector
a 12 volt power supply (Car cigarette lighter/power source)
means of transportation up in the (low-altitude) mountains
an altimeter (A Casio Pathfinder multi-purpose watch will work)

Procedure

1. Drive your detector to the beach, follow a canyon road
2. Zero out your altimeter
3. Follow steps 3-5 in experiment 1 (obtain five values each time you stop)
4. Record your count rates and your altitude in the data table for experiment 3.
5. Proceed up the canyon to 100 feet of altitude gain
6. Do steps 3 and 4
7. Continue up the canyon every 100 feet of altitude gain, till you get to the highest point in the canyon.
8. Find all your average values and make a graph of count rate vrs altitude.

Data Table **Experiment 3**

Altitude (Ft)	Trial 1	2	3	4	5	Ave
0						
100						
200						
300						
400						
500						
600						
700						
800						
900						
1000						
1200						
1300						

How does altitude relate to count rate ?

Make a graph of count rate vrs altitude.

Try to decide which function best describes your graph.

Experiment 4
Count Rate Vrs Altitude (High Altitude)

Purpose

To establish a relationship between altitude and count rate

Equipment

the CHICOs Portable Cosmic Ray Detector
a 12 volt power supply (Car cigarette lighter/power source)
means of transportation with a 12v power source, for travel up in the (high-altitude) mountains
an altimeter (A Casio Pathfinder multi-purpose watch will work, also any GPS device which gives altitude is OK, but it's slower)

Procedure

1. Drive your detector to the beach
2. Zero out your altimeter
3. Follow steps 3-5 in experiment 1
4. Record your count rates and your altitude in the following table.
5. Proceed up the road to 500 feet of altitude gain
6. Do steps 3 and 4, be sure to obtain at least five values each time you stop.
7. Continue up the highway every 500 feet of altitude gain till you get to the highest point you can drive.
8. Find all your average values and make a graph of count rate vrs altitude. If you can get to 10,000 feet, the graph would be more revealing. This means you may have to drive over a few hundred miles.

Data Table **Experiment 4**

Altitude (Ft)	Trial 1	2	3	4	5	Ave
0						
500						
1000						
1500						
2000						
2500						
3000						
3500						
4000						
4500						
5000						
5500						
6000						
6500						
7000						
7500						
8000						
8500						
9000						
9500						
10,000						

How does altitude relate to count rate ?

Make a graph of count rate vrs altitude.

Try to find a function which describes the relationship between altitude and count rate.

Experiment 5:

Underground

Equipment:

Altimeter, meter stick, 5-meter rope, CHICOS Portable Cosmic Ray Detector with portable 12 v dc source and wagon, digital still camera

Procedure:

I. **Determine dimensions of the tunnel and the overbearing rock and soil without a geological contour map**

a. Place the 5-meter rope vertically along the side of the entrance to the tunnel and take a close (10m) picture of the entrance. Later, from the photo, determine the height of the tunnel entrance with a dividers, using the image of the 5m rope as a measuring unit.
b. Back up 100m or so from the tunnel entrance and take another photo of the tunnel entrance showing the top of the overbearing rock and soil. Measure the actual distance from the tunnel face to where you took the picture.
c. Measure the distance from the tunnel entrance to the middle of the tunnel to get the length of the tunnel
d. Use the measured dimensions to find the height of the overbearing rock, assuming it is nearly cylindrical in shape
e. Use this assumption and the measured dimensions to create a thickness v count rate curve.

II. Determine the count rate v depth into the tunnel data

a. record the altitude of the tunnel

b. measure the count rate out side of the tunnel, repeat 5 times and find the average

c. measure the count rate at the entrance to the tunnel

d. proceed 10 m into the tunnel and find the count rate

e. proceed another 10 m and count again

f. continue to the middle of the tunnel

III. Proceed to Dr. Walter Gekelman's plasma Physics lab at UCLA

a. Measure count rate at the entrance to the building (find altitude)
b. proceed to basement lab
c. measure count rate at the entrance to the lab
d. proceed to the middle of the lab and measure
e. proceed to the far end of the lab and measure
f. determine the composition of the roof to Walter's lab

IV. Proceed to as many other tunnels and caves as possible and collect data

V. Produce graphs of count rate v thickness. (thickness profile)

Experiment 5: Underground Detection

Data Table

Location (GPS)	
Length of Tunnel	
Initial Count Outside of Tunnel	
Elevation of Tunnel Entrance	
Type of Rock/Soil	

Location	Counts/min 1	2	3	4	5	Average Value	Check

Entrance							
10 m							
20							
30							
40							
50							
60							
70							
80							
90							
100							

Spin-offs

a. Once several sets of data have been accumulated, values an attenuation value can be assigned to each material through which the radiation has passed. Just calculate the difference in depth and divide it into the difference in count rate. Do this for each 10 m increment and find an average.
b. Also, you can effectively take a **COSMIC RAY IMAGE** of the overbearing rock structure in a tunnel, by just continuing to read values all the way to the other end of the tunnel. Take a value every 10 meters all the way from one end to the other. As you pass the minimum value for cosmic rays(the maximum attenuation) you will eventually re-acquire some value which will begin to increase as the rock overhead gets thinner. The resulting single line series of values, paints a linear slice of the

rock structure as cosmic rays see it. This works only in tunnels with two ends through a mountain.

Helpful Hints for the experiments:

Experiment 1

There is no relationship between direction in the horizontal plane and count rate. This experiment was written to familiarize the user with the switching procedure and to facilitate working with the device in general.

Experiment 2

Finding a level surface with a place above it to tie a support rope, is the hardest part. You could use a ring stand instead. The picture on the cover shows the device suspended at 30 degrees from horizontal. This experiment shows very nicely the fact that the majority of cosmic rays travel vertically. Also, the function that best describes the relationship between angle with horizontal and count rate is the Cosine function. The horizontal projection of the area of the paddles is the effective collection surface.

Experiment 3

This experiment gets the device out of the classroom. Be sure to take considerable care handling the device. It is fragile and repair cost is high. Set it on a pillow and use your seat belt to hold it while driving. It really is best to have an assistant hold the device, read the altimeter and watch out for traffic. Be careful when driving and pick a safe place to pull off of the road each time.

The results of this experiment are less than desirable. If you are a believer that the count rate increases with altitude, then you might see an upward trend in the count rate, but you do have to have a good imagination. The fact that you can do a real experiment near to home, is why Experiment 3 is done.

Experiment 4

This adventure may require you to drive a few hundred miles, but the results are very rewarding. The graph starts to kick in at a few thousand feet and when the numbers start to change significantly, it's a real thrill. Your assistant can calculate the average values as you travel and plot them on a graph. If you are alone, you can do the averages as you wait for the counter to count. By the time you get to the top you'll have very nice results. Although the graph should be exponential, it is quite linear under several thousand feet.

The next step is an automated data-gathering device on a hot air or helium filled balloon or travel on a research aircraft with access to its altimeter.

A fifth experiment is being planned, which will correlate high energy emissions from the sun with changes in the average value of the detected particles on the Earth surface, using the entire CHICOS array.

Experiment 5

You must investigate the tunnels and/or mines first to be sure they are safe. If the tunnels are highway tunnels they are very dangerous and you must be very careful. It is

recommended that you wear a safety vest and helmet. Also it is best to have a team member warn the oncoming traffic that you are in the tunnel. If you can enter a mine legally, be sure to wear a safety helmet and bring more than one flashlight. Watch out for holes in the floor, they may be several hundred feet deep. Do not enter any mine without permission.

If you want to do the experiment in Dr. Gekelman's lab at the UCLA PLASMA center, call first.

Useful Web Sites

CHICOS Cosmic Ray Observatory
www.chicos.caltech.edu

NASA's Cosmic Ray Site and links
helios.gsfc.nasa.gov/cosmic.html, and /links.html

Stanford Linear Accelerator
www2.slac.stanford.edu/vvc/cosmic_rays.html
" " " " " /cosmicrays/default.htm

Caltech
www.srl.caltech.edu/personnel/dick/cos_encyc.html

Imagine
imagine.gsfc.nasa.gov/docs/science/know_|1/cosmic_rays.html

Nature Magazine (Uranium Detector)
www.nature.com/nsu/030317/030317-7.html

Potential New Experiments

Expt 6 Magnetic Deflection

Equipment:
CHICOS PCRD, Helmholtz Coil large enough to fit the PCRD into, two power sources, one for the PCRD and one for the Helmholtz Coil

Procedure
1.Without the Helmholtz coil, run Expt I, steps 1-6
2. Place the PCRD in the Helmholtz coil before turning either one on.
3.Turn the Helmholtz coil on
4. Repeat Expt I, steps 1-6
5. Compare the data

Expt 7 Co-ordinating Barometric Pressure with count rate (Constant Altitude)

Equipment (barometer, PCRD)

Procedure:

1. Measure and record the barometric pressure
2. Measure the count rate five times and take the average
3. Wait till the barometric pressure changes.
4. Repeat step 1 and 2
5. Repeat step 4 and 5 for at least a one month period so as to get the largest change in barometric pressure possible.
6. Co-ordinate data with other schools to form a data base over one year's time..
7. Make a graph of count rate vs barometric pressure
8. Convert pressure into air density.
9. Find and report the relationship between barometric pressure (air density) and count rate using as much data as possible.