10-609 Geiger Detector

Purpose:
To detect particles emitted by a radioactive source, and provide an audible “click” for each event that occurs in the sensitive volume of the detector. The random nature of radioactive decay becomes evident.

Specifications:
Detector: Halogen-quenched Ne stainless steel Geiger-Müller tube
End window: mica, 1.5-2.0 mg/cm2 areal density
Sensitivity: 18 cps/mR/hr (Co60);
Gamma > 0.01 MeV
Beta > 0.2 MeV
Alpha > 4 MeV
Range 0 - 8 mR/hr
Operating Voltage: 500
Dead time: 90 us

Required Accessories:
Graph paper, meter stick, timer or stop clock, radioactive source. Requires 4 AAA batteries, not included.

Operation:
When the unit detects a particle, an audible chirp will be heard and the red LED will flash. When measuring alpha or beta sources, direct the perforated end plate at the source. The Geiger-Müller tube, visible through the clear top, is oriented behind this plate. Care should be taken to protect the mica end window. It is extremely fragile.

Background:
Background radiation is always present. With no particular radioactive source nearby, clicks will be heard indicating that some radiation is present for that particular locale. This background count should be made to be able to correct experimental readings as needed. The number of clicks heard over an arbitrary interval of time represents the rate of decay of the radioactive material being sampled. The activity of the source and the distance from source to detector determine the rate at which clicks will be heard. The radioactive source should be kept far enough away from the detector so that individual clicks can be counted, except that for demonstrations purposes, the source might be abruptly brought near the detector to show the continuous cascade of sound, and show the effect of distance on count rate. Radioactive decay and the emission of light by atoms have the common property that they can only be described in statistical terms. Individual atoms or nuclei decay at random. The time of an individual decay can neither be predicted nor controlled. We can predict only the average behavior of a very large number of them.

Procedure:
To study this randomness, the detector should be positioned so that clicks are at least a half second apart. Once the source and detector are in position, do not move them. Make a few 10 second practice counts, and then count continuously for twenty minutes, recording the number during each 10 second interval. The number of counts per interval will vary.

Make a bar graph of the results, plotting the number of intervals, N, in which k clicks are heard, as a function of k. From this graph, you should be able to estimate the average counting rate. Now, add the count obtained in the second 10 second interval to the count obtained in the first, and divide by two to find the average counting rate over a 20 second interval. Then add the count found in the third interval to the sum of the counts in the first two intervals, and divide by three to find the average over the 30 second interval. Continue this process until you have the average counting rate over a period of 15 to 20 minutes. Plot the average counting rates obtained in this way as a function of the total count used for each successive calculation. Compare and interpret the two graphs.

Students should start their graphs of average count versus total number of counts at different initial times, say a minute or two apart. Comparing these graphs, they will find that, although the individual graphs look different at the beginning, they all converge to the same average counting rate.

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The analysis takes a long time. To speed up the numerical work, have students work in pairs, one adding and one dividing, to find the averages. Students should make a histogram (bar graph) of the number of intervals versus the clicks per interval, and a separate graph of average rate of decay versus total count. These should both tend to converge on the same average count rate.
Since only a small fraction of the particles emitted by the sample hit the counter, the counting rate is less than the rate of decay of the total sample. By comparing the fraction intercepted to the whole spherical region traversed by the particles, some assessment can be made. The efficiency of the detector is not known, but is certainly less than 100%.

Time Allocation:
To prepare this product for an experimental trial should take less than five minutes. Actual experiments will vary with needs of students and the method of instruction, but are easily concluded within one class period.

Feedback:
If you have a question, a comment, or a suggestion that would improve this product, you may call our toll free number.