Vernier Radiation Monitor

(Order Code: VRM-BTD)

The Vernier Radiation Monitor is used to monitor alpha, beta, and gamma radiation. It can be used with a number of interfaces to measure the total number of counts per specified timing interval.

The Radiation Monitor allows students to

- Detect the presence of a source of radiation.
- Monitor counts/interval (rate) as different thicknesses of a particular type of shielding are placed between the Geiger-Mueller tube of the Radiation Monitor and a beta or gamma source.
- Compare the effect of different types of materials to shield beta or gamma radiation.
- Set up a histogram with a very long run time to show students how initial randomness of data develops first in a Poisson distribution, and then into a Gaussian distribution curve.
- Measure radiation of common radioactive materials, such as lantern mantels or pre-World War II Fiestaware.
- Monitor variation in background radiation at different elevations.
- Monitor radioactivity in the environment over long periods of time.
- Monitor counts per interval (rate) from a beta or gamma radiation source as a function of the distance between the source and the Radiation Monitor.

Collecting Data with the Vernier Radiation Monitor

The Vernier Radiation Monitor obtains power from a data-collection interface, and so the monitor cannot be used independent of an interface.

This sensor can be used with the following interfaces to collect data.

- Vernier LabQuest® 2 or original LabQuest as a standalone device or with a computer
- Vernier LabQuest Mini with a computer
- Vernier LabPro® with a computer or TI graphing calculator
- Vernier SensorDAQ®
- CBL 2™
- TI-Nspire™ Lab Cradle

NOTE: Vernier products are designed for educational use. Our products are not designed nor recommended for any industrial, medical, or commercial process such as life support, patient diagnosis, control of a manufacturing process, or industrial testing of any kind.

Data-Collection Software

This sensor can be used with one of the above interfaces and the following data-collection software.

- **Logger *Pro* 3** Computer
- **LabQuest App** LabQuest 2 or LabQuest
- **DataQuest™ Software for TI-Nspire™**
- **EasyData App** TI-83 Plus and TI-84 Plus calculators
- **DataMate program** TI-73, TI-83, TI-84, TI-86, TI-89, and Voyage 200 calculators
- **LabVIEW™** National Instruments LabVIEW™ software is a graphical programming language sold by National Instruments. It is used with SensorDAQ and can be used with a number of other Vernier interfaces. See www.vernier.com/labview for more information.

When using the Vernier Radiation Monitor:

1. Connect the Radiation Monitor to the interface.
2. Start the data-collection software.
3. The software will identify the Radiation Monitor and load a default data-collection setup.[1] You are now ready to collect data.

How the Radiation Monitor Works

The Radiation Monitor senses ionizing radiation by means of a Geiger-Mueller (GM) tube. The tube is fully enclosed inside the instrument. When ionizing radiation or a particle strikes the tube, it is sensed electronically and monitored by a computer, or by a flashing count light. Radiation is measured in counts in a time interval, as configured in data collection software. About 5 to 25 counts at random intervals (depending on location and altitude) can be expected every minute from naturally occurring background radiation.

The end of the GM tube has a thin mica window. This mica window is protected by the screen at the end of the sensor. It allows alpha particles to reach the GM tube and be detected. The mica window will also sense low energy beta particles and gamma radiation that cannot penetrate the plastic case or the side of the tube. **Note:** Some very low energy radiation cannot be detected through the mica window. The tube is fragile and physical damage to the window is not covered by the warranty.

This sensor is equipped with circuitry that supports auto-ID. When used with LabQuest 2, LabQuest, LabQuest Mini, LabPro, SensorDAQ, TI-Nspire™ Lab Cradle, or CBL 2™, the data-collection software identifies the sensor and uses pre-defined parameters to configure an experiment appropriate to the recognized sensor.

[1] If you are using a LabPro or CBL 2™ for data collection, the sensor will not auto-ID. Open an experiment file in Logger *Pro* or manually set up the sensor.

Further Tips for Monitoring Radiation

To measure gamma and X-rays, hold the tip of the Radiation Monitor toward the source of radiation. Low-energy gamma radiation (10–40 KeV) cannot penetrate the side of the GM tube, but may be detected through the end window.

To detect alpha radiation, position the monitor so the suspected source of radiation is next to the GM window. Alpha radiation will not travel far through air, so put the source as close as possible (within 1/4 inch) to the screen without touching it. Even a humid day can limit the already short distance an alpha particle can travel.

To detect beta radiation, point the end window toward the source of radiation. Beta radiation has a longer range through air than alpha particles, but can usually be shielded (e.g., by a few millimeters of aluminum). High energy beta particles may be monitored through the back of the case.

To determine whether radiation is alpha, beta, or gamma, hold the tip of the monitor toward the specimen. If there is an indication of radioactivity, it is most likely gamma or high energy beta. Place a piece of aluminum about 3 mm (1/8") thick between the case and the specimen. If the indication stops, the radiation is most likely beta. (To some degree, most common radioactive isotopes emit both beta and gamma radiation.) If there is no indication through the back of the case, position the end window close to, but not touching, the specimen. If there is an indication, it is probably alpha or beta. If a sheet of paper is placed between the window, and the indication stops, the radiation is most likely alpha. In order to avoid particles falling into the instrument, do not hold the specimen directly above the end window.

The Radiation Monitor does not detect neutron, microwave, radio frequency (RF), laser, infrared, or ultraviolet radiation. Some isotopes it will detect relatively well are cesium-137, cobalt-60, technicium-99m, phosphorus-32, and strontium-90.

Some types of radiation are very difficult or impossible for this GM tube to detect. Beta emissions from tritium are too weak to detect using the Radiation Monitor. Americium-241, used in some smoke detectors, can overexcite the GM tube and give an indication of a higher level of radiation than is actually there.

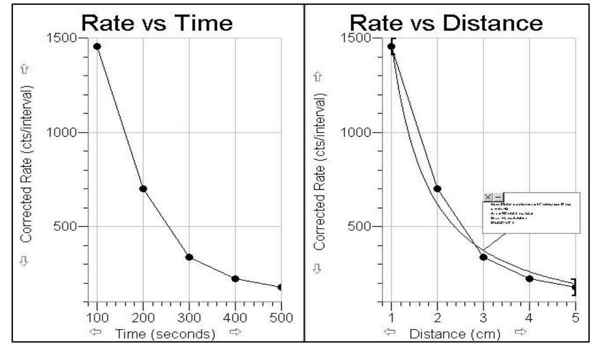
Specifications

Sensor	LND 712 (or equivalent) halogen-quenched GM tube with a mica end window, 1.5 to 2.0 mg/cm^2 thick
Gamma sensitivity	18 cps/mR/he referenced to Co-60
Temperature range	–20–50˚C
Operating range CPS	0–35,000

Suggested Experiments

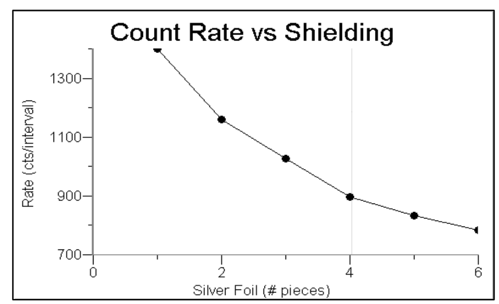
Counts/Interval *vs.* Distance Studies

The data in the two graphs below were collected by monitoring gamma radiation at various distances from a Radiation Monitor. Data were collected with the run intervals set at 100 seconds. After each 100 second interval, the source was moved one centimeter further from the source. Since distance is proportional to time (300 seconds in the first graph corresponds to 3 cm in the second graph; 400 seconds to 4 cm, etc.), a new distance column was made using time divided by 100. The curved fit shown corresponds to distance raised to the –2 power (inverse squared).



Counts/Interval *vs.* Shielding Studies

The data shown here were collected by monitoring gamma radiation with an increasing number of pieces of silver foil placed between the source and a Radiation Monitor. Data was collected with the run interval set at 100 seconds. After each 100 second interval, another piece of silver foil was placed between the source and the Radiation Monitor. Since the number of pieces is proportional to time (300 seconds corresponds to 3 pieces of foil, 400 seconds to 4 pieces of foil, etc.), a new column, pieces of silver foil, was made using *time* divided by 100.



Counts/interval vs. thickness of filter

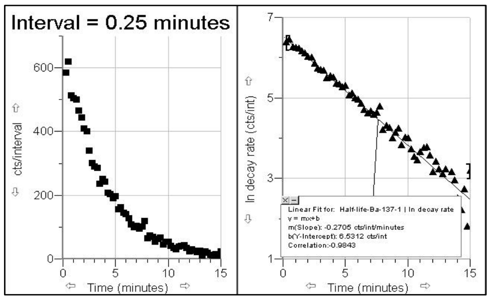
Half-life Determination (Counts/Interval *vs.* Time)

Using a daughter isotope generator, it is possible to generate isotopes with a relatively short half-life. A solution that selectively dissolves a short half-life daughter isotope is passed through the generator. The linear plot of natural log of decay rate vs. time can be used to determine the half-life of the daughter isotope, using the formula

$$\ln 2 = k \bullet t^{1/2}$$

where k is the decay rate constant and t1/2 is the half-life of the daughter isotope (in minutes).

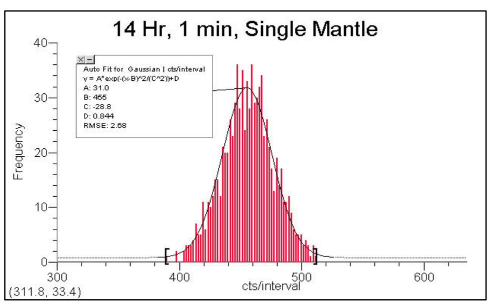
In the plot of natural log of decay rate *vs.* time, the decay rate constant, *k*, is equal to –*m*. Using the slope value of m = –0.217 in the example here, the half-life was calculated to be 3.19 minutes.



Half-life determination

Histogram Data Analysis

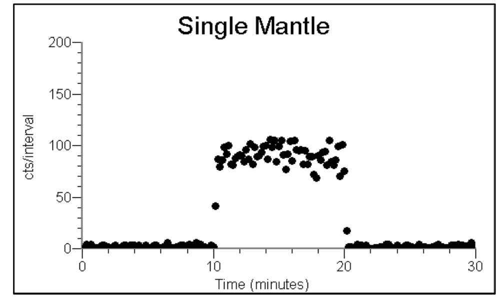
For an easy in-class experiment, set up a histogram with a very long run time and start data collection. Whenever the graph overflows the top of the graph, it will be rescaled. This data collection shows students how initial randomness of data develops into a Gaussian distribution. A gamma radiation source was used.



A distribution graph

Lantern Mantels

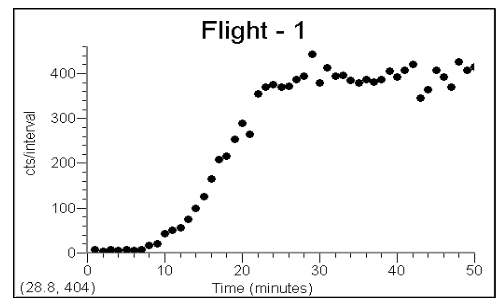
This graph shows a study of old and new Coleman mantle lanterns. These mantles formerly contained thorium and were often used for radiation demonstrations. In the early 1990s, Coleman changed the production methods and now the mantles are not radioactive.



New and old lantern mantles

Background Radiation

Here is an experiment performed in the days before airlines insisted that you turn off your personal computer before takeoff. It shows the counts/interval between takeoff and the time the plane reached its cruising altitude of 39,000 ft.



Radiation during an airline flight

Curricular Materials

Nuclear Radiation with Vernier
by John Gastineau

This book has six experiments written for the Vernier Radiation Monitor. Each of the six experiments has a computer version (for LabPro, LabQuest, or LabQuest Mini), a calculator version (for LabPro or CBL 2™), and a LabQuest version (for LabQuest 2 or the original LabQuest as a standalone device). The Nuclear Radiation CD included with the book contains the word-processing files for all student experiments.

Radioactive Sources

If you don't have radiation sources, you may be able to obtain pre-1990 Coleman lantern mantles or other brands of lantern mantles (for a weak source of Thorium). You may also be able to find pottery, watches, clocks, or minerals that are moderately radioactive.

For something more active, order radioactive minerals from these scientific supply houses. The 2.5 cm disk sources of alpha, beta and gamma radiation are particularly convenient.

Flinn Scientific Inc.
P.O. Box 219
Batavia, IL 60510
Phone (800) 452-1261
www.flinnsci.com

Spectrum Techniques
106 Union Valley Road
Oak Ridge, TN 37830
Phone (865) 482-9937
www.spectrumtechniques.com

Warranty

This product is warranted to the original owner to be free from defects in materials and workmanship for five years from the date of purchase. Vernier will, at its own discretion, repair or replace this instrument if it fails to operate properly within this warranty period unless the warranty has been voided by any of the following circumstances: misuse, abuse, or neglect of this instrument voids this warranty; modification or repair of this instrument by anyone other than Vernier voids this warranty; contamination of this instrument with radioactive materials voids this warranty. Contaminated instruments will not be accepted for servicing at our repair facility. The Geiger-Mueller tube is fragile and physical damage to the entrance window is not covered by warranty. The user is responsible for determining the suitability of this product for his or her intended application.

The user assumes all risk and liability connected with such use. Vernier is not responsible for incidental or consequential damages arising from the use of this instrument

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