



CAEN Educational Handbook

Nuclear and Particle Physics Experiments



<https://edu.caen.it>



Purpose of the experiment

Radioactivity detection by using a GM detector..

Fundamentals

In the Nuclear Physics field, ionizing particles play a pivotal role in understanding the fundamental building blocks of matter. These particles possess sufficient energy to liberate electrons from atoms, a process known as ionization. This ionization capability stems from their inherent ability to penetrate matter and impart energy to atomic structures. Ionizing particles in nuclear physics include alpha particles, beta particles, and gamma rays. Alpha particles consist of two protons and two neutrons, making them relatively massive and charged. Beta particles can be either electrons (β^-) or positrons (β^+) and can interact with atomic electrons. Gamma rays are electromagnetic waves of extremely high energy and no mass.

A GM detector is a device specifically designed to detect ionizing radiation. The operational principle of the GM

detector hinges on the ionization generated by incoming radiation. Within the GM detector, there exists a gas-filled chamber, typically containing a low-pressure inert gas, and a central wire electrode running along the chamber's axis. The detector applies a high voltage between its outer casing (anode) and the central wire electrode (cathode), thereby creating an electric field within the gas-filled chamber. When ionizing radiation enters the detector, it interacts with the gas atoms, leading to the formation of ion pairs positively charged ions and free electrons. These free electrons, accelerated by the electric field, travel towards the central wire, inducing additional ionization events through collisions with other gas atoms. This cumulative effect, known as an electron avalanche, generates a detectable electrical pulse. This signal is then amplified and processed by the detector's electronics.

Requirements

No other tools or instruments are needed.

Carrying out the experiment

The experiment involves two data-taking phases: one with rock sample and one without. Begin by placing the GM detector on the desk and powering on the system. The GM detector will immediately initiate measurements and record data every minute during acquisition. Background counts, essential for calibration, should be obtained in the absence of samples, specifically with the GM tube window uncovered. It is advisable to conduct a background acquisition for a minimum of 2 hours. Upon completing the background measurement, place the rock sample in the middle of the open window of the GM detector. Start the new acquisition maintaining the same acquisition time to facilitate straightforward background subtraction.



Experimental setup.

Results

The student is provided with an opportunity to familiarize themselves with the presence of radioactivity within a given rock sample through a straightforward measurement technique. This involves a comparative analysis of the detected counts using a GM (Geiger-Muller) detector, both in the presence and absence of the rock sample. The comparison between the counts with and without the rock sample serves as a means of assessing the radioactivity associated with the specific geological material. An increase in detected counts when the rock sample is present suggests the emission of ionizing radiation from the sample. This increase is indicative of the radioactive properties of the rock, as certain minerals within the sample may naturally emit alpha, beta, or gamma particles, contributing to the overall ionization observed by the GM detector.

CPM Max	37.0
CPM Min	11.0
CPM Mean	22.0
σ_{STAT}	0.1
STD	4.5
Live Time [m]	197

Environmental background

CPM Max	37.0
CPM Min	15.0
CPM Mean	27.2
σ_{STAT}	1.3
STD	5.9
Live Time [m]	197

Rhyolite Rock