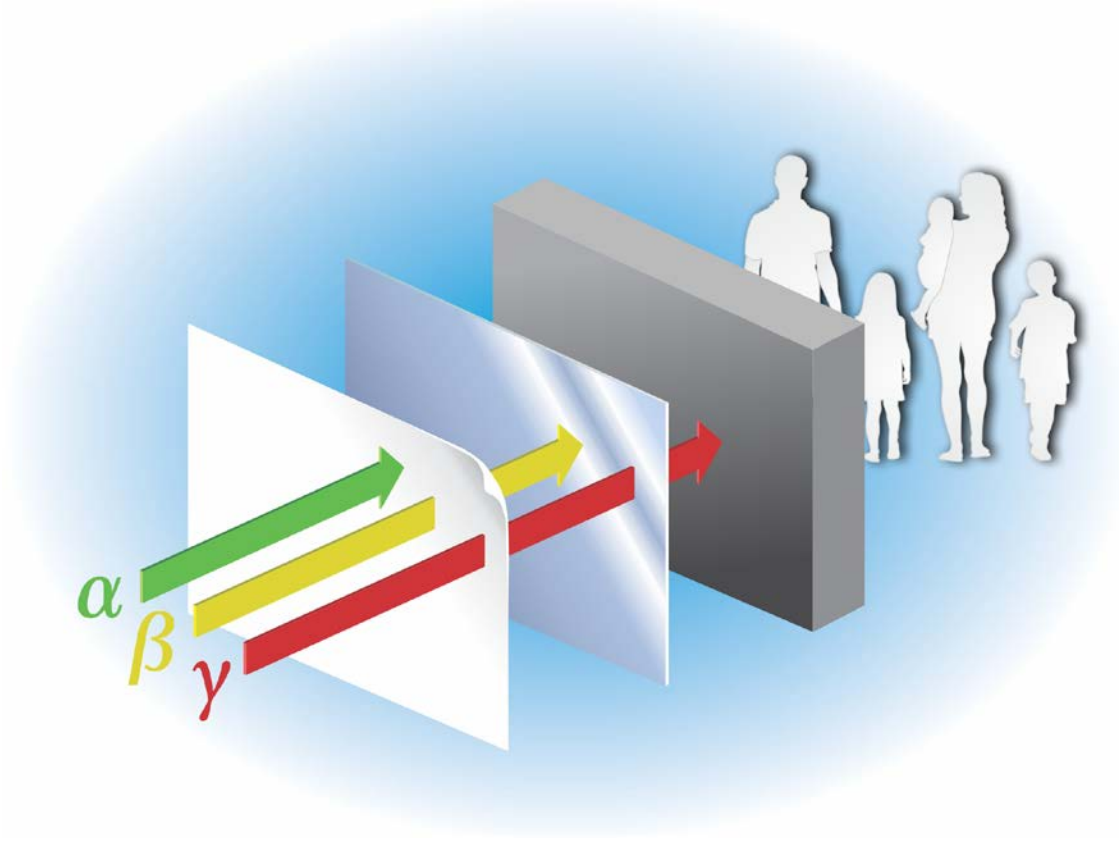
Buyer's Guide to Geiger Counters

What you need to know!



Purchasing a Geiger Counter?

With so many Geiger counter models available online, it's easy to become confused as to what features you need to look for in your purchase. The first question to ask yourself is why are you purchasing a Geiger Counter and what are your applications? The answers to these questions will help refine your search for a model that will best satisfy your needs.

What others purchase Geiger counters:

- To check radiation levels in your environment, home, food, water, and surroundings.
- Living close to a nuclear power plant.
- A first responder who needs a reliable and accurate Geiger counter for work.
- Interested in science and want to perform nuclear experiments?
- Survivalist being prepared for a nuclear accident or emergency?
- Gadget lover who wants to play with these instruments to satisfy your curiosity.
- Prospecting for uranium ore or radioactive materials is an interest.
- Checking old vintage Fiestaware plates or old glow-in-the-dark clock hands for radioactivity?

What's a Geiger Counter?

Before we look at the features you need to look for in a Geiger Counter, let define what a Geiger counter is. Geiger Counters are instruments that can detect and measure radioactivity. They do so using a Geiger Mueller tube. The original design by H. Geiger and E.W. Mueller in 1928 hasn't changed very much. The basic sensor functioning remain the same.

Radiation, as it passes through the GM tube, ionizes the gas within the tube. This ionization, create a momentary conductive path between the wire at the center of the tube (Anode) and the wall of the tube (Cathode), see figure 1 resulting in a 'click' sound. The ionization initiates a momentary avalanche of electrons accelerate by the high voltage potential used to power the GM tube. By measuring the number of the clicks, the instrument indicates the radiation levels.

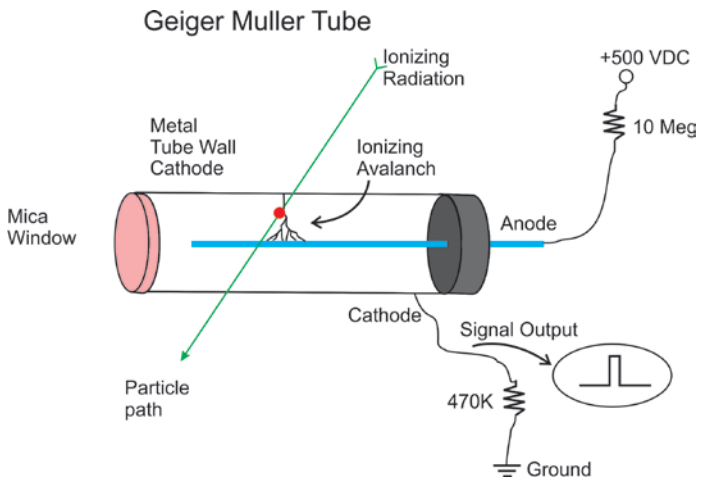


Figure 1

The GM tube sensor is the heart of the Geiger counter and to be a Geiger counter, the device has to contain a Geiger-Mueller (GM) tube.

Radiation Detection

There are three primary radiation types associated with radioactivity.

Radioactivity is the spontaneous emission of energy from the nucleus of certain elements, most notably uranium. There are three forms of energy associated with radioactivity; alpha, beta and gamma radiation. The classifications were originally made according to the penetrating power of the radiation, see figure 2

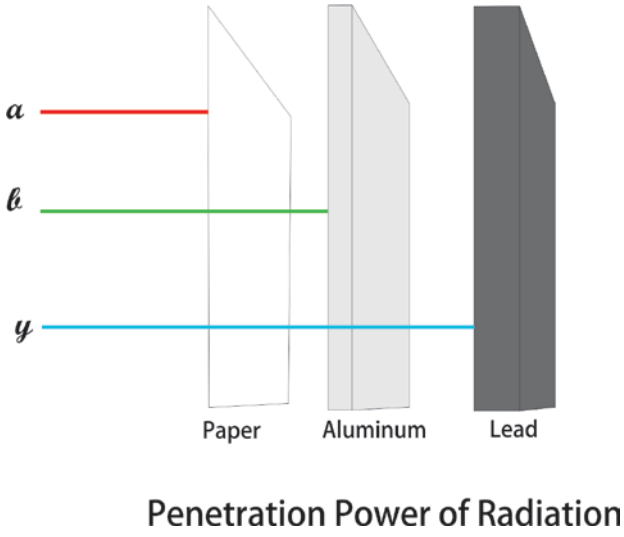


Figure 2

Alpha rays were found to be the nuclei of helium atoms, two protons and two neutrons bound together. Alpha rays have a net positive charge. Alpha particles have the weak penetrating ability; a couple of inches of air or a few sheets of paper can effectively block them.

Beta rays were found to be electrons, identical to the electrons found in atoms. Beta rays have a net negative charge. Beta rays have a greater penetrating power than Alpha rays and can penetrate 3mm of aluminum.

Gamma rays and **x-rays** are high-energy electromagnetic radiation (high energy photons). This classification of radiation has the greatest penetrating power. High energy gamma rays are able to pass through several centimeters of lead and still be detected on the other side. Gamma rays are produced naturally from the decay of some radioactive materials.

X-rays on the other hand, is man-made radiation used in medicine and dentistry. While x-rays are electromagnetic radiation their frequency is so high that the radiation is also ionizing.

Inexpensive GM tubes only detect beta, x-ray and gamma radiation. So if your Geiger counter uses one of these styles GM tubes it is blind to all alpha particle radiation. While alpha particles are stopped by a piece of paper, the situation changes once alpha radiation is inside the body, then the effects are more harmful than beta or gamma radiation. (See "Q" factor in testing food for radioactivity.) So materials that radiate Alpha particles are harmful if ingested or inhaled. But are not dangerous when external to the human body. The skin can easily block alpha radiation.

More expensive GM tubes have a thin mica window that allows alpha particle radiation to penetrate into the interior of the GM tube and ionize the gas for detection. It is generally more fragile than the beta-gamma GM tubes because of the thin mica window. The mica window allows one to detect the alpha radiation from radium and polonium. This type of Geiger counter may also be used for prospecting, experiments, and general field work. In addition, it can measure total radiation from materials including alpha radiation. Most laboratory grade Geiger counters use this style tube.

The common thread connecting these types of radiation is that they all are ionizing radiation. Meaning they are capable of ionizing the gas atoms inside a GM Tube which allows for their detection.

Images Scientific Instruments has a free online radiation penetration calculator you can use. http://www.imagesco.com/geiger/cal/

Natural Background Nuclear Radiation:

Nuclear radiation is a normal part of our life on planet Earth. We are bombarded with nuclear radiation every day. Background radiation, from natural sources on earth and cosmic rays will cause the Geiger counter to click randomly a number of times every minute. In my corner of the world I have a background radiation that triggers the counter 22-34 times a minute. When performing radiation checks to see if a material is radioactive or contaminated with

radioactive material, this background radiation count is usually deducted from the reading to evaluate if a material is radioactive.

What Geiger Counters Do Not Detect:

Geiger counters do not detect cell phone radiation. Do not detect radio frequency (RF) or electromagnetic field (EMF) radiation. EMF radiation is emitted from power transformers and other types of power electrical inductors. They cannot detect microwave radiation from a microwave oven. Nor can they detect neutrons.

EBAY

If you search on ebay for Geiger counters, radiation detectors or radiation monitors you will run across numerous radiation detection devices. Let's look at a few. There is a lot of government surplus for sale on ebay. The CD-715 model is a popular model, see figure 3.

Figure 3

These detectors were made to be used in a high radiation field one would find in a post nuclear attack or nuclear reactor incident. The radiation meter provides the scale of detectable radiation, see figure 4.

Figure 4

The meter scale of the CDV-715 is rated in rads/hr. A knob provided a range of 0.1 - 0.5 Rad to 100 - 500 Rad's. Today's Geiger counters are far more sensitive, and measure radiation in fractions of millirads. A millirad

is 1/1000 of a rad. The CDV-715 is not a Geiger counter. It doesn't have a GM tube, instead it uses an ionization chamber.

If you open a CDV-715 you can see the ionization chamber, see figure 5.

Figure 5

The CDV-715 only detects beta and gamma radiation, and only at high radiation levels. I would not recommend this as a purchase.

Similar is the CDV-700, which looks similar, but uses a GM tube, see figure 6.

Figure 6

The CDV-700 is more sensitive than the ionization chamber CDV-715. The CDV-700 meter shows the scale, see figure 7.

Figure 7

The GM Tube on the CDV-700 is only beta and gamma sensitive. Since most of these units are vintage 1950-1960's I do not have any idea as to their accuracy or if they can be calibrated accurately. Now if your only reason is to purchase a working Geiger counter and can find a working unit for $50-$75.00 buy it. When you reach the $100.00 mark you can purchase an inexpensive modern Geiger Counter that has greater sensitivity.

Accuracy:

Two basic types are analog and digital. The digital Geiger counter is typically more accurate as you can obtain an exact count of radioactive particles detected. Where as the analog meters average out reading, and do not provide a display for the detected particle count. A digital readout from the GCA-06W is shown in figure 8 below.

Figure 8 shows the Counts Per Second (CPS) on the top line of the LCD. The second line shows the equivalent radiation level. This second line's equivalent radiation level is a running three second average. This is provided to smooth out the reading so it's not jumping every second in response to second by second changes in the CPS count.

Figure 8

Let's discuss accuracy. While many Geiger counter vendors make a claim high accuracy for their Geiger counter, it simply is not true. Here is where you have to ask what is the reference point for the vendor to say their instrument is accurate? Because it is not enough to say an

instrument is calibrated, nor is it enough to say the Geiger counter has an accuracy of 1%, 5%, 10%, or 20% anyone can say that! Because without a real reference point to compare accuracy too, accuracy means nothing. So how would you as a buyer know or be able to check this?

Fortunately the United States Government has a license standard for Geiger Counters. This is a Nuclear Regulatory Commission (NRC) certification for accuracy. NRC certification can only be performed by a nuclear laboratory licensed by the United States Government to perform such certifications. Without this certification, there is no reference point, for any claim that Geiger Counter accuracy is valid. Below figure 9 is a picture on an **NRC certification label for the GCA-07W**.

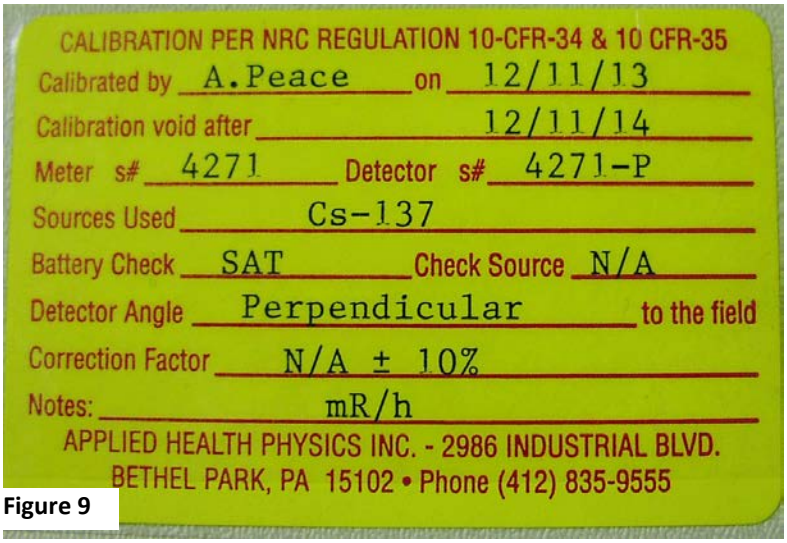


Figure 9

So if a seller claims their Geiger Counter is accurate, you can ask, "Is your Geiger Counter NRC certifiable?" If not, their Geiger counter is probably not accurate to pass NRC certification. But many times a seller will not just say this outright. Instead the seller hedges and states that the NRC certification is expensive and is not "currently" offered as an option. You can respond. "If I purchase your model and send the unit out for NRC certification will it pass? And if it fails NRC, can I return the Geiger Counter for a full refund?" The seller's answers to those questions will tell you what you need to know to make a purchasing decision.

*** All digital Geiger counters sold by Images SI Inc. can be NRC certified to their accuracy.**

Where to Obtain NRC Certification:

There are a number of independent laboratories that are licensed by the U.S. Government to test Geiger counters for their accuracy, and if it is accurate provide an NRC certification label

attached that will be attached to the Geiger Counter. The certification is good for one-year. The laboratory my company uses is:

Applied Health Physics Inc.
2986 Industrial Blvd
Bethel Park, PA 15102
(412) 835-9555

GM Tubes: Internal or External:

In the internal instrument, the Geiger-Mueller tube is built into the case, enabling one hand operation, leaving the other hand free. Figure 10 shows the GCA-06 internal model.

Figure 10

and connected to the instrument via a cable, see figure 11. Figure 11 shows the GCA-06W with an external probe/wand. This kind of instrument is more suited for 'probing' radiation levels in tight spots. It's easier to move a probe around to check for radiation, then it is to move the entire instrument.

I prefer external wands, I find them much easier to work with.

For the external instrument, the tube is located outside the case at the end of a probe or wand

Figure 11

How to read a Geiger Counter

The Geiger counter measures the radiation levels in different ways. Analog meters can provide a reading in Counts Per Minute (CPM) and their equivalent Radiation Level. For example lets look at the meter face to a common analog Geiger counter, see figure 12.

Figure 12

At its most sensitive scale a count of 500 CPM is equivalent to a radiation level of 0.5 mR/hr. This model Geiger counter has a 10X and 100X switch to select ranges to 5 mR/hr and 50 mR/hr respectively. To obtain the Counts Per Second (CPS) divide the CPM by 60. So a CPM reading of 300 is equal to 5 CPS (300/60 = 5).

Digital Geiger Counters

Digital Geiger Counters have a digital display. The digital display has a number of advantages, such as providing an accurate and exact count of the detected radioactive particles in either the CPS or CPM measurement and their equivalent radiation level. The analog display approximates the number of clicks per minute.

Figure 13

Figure 13 shows a digital display from a GCA-07, the Counts Per Second (CPS) on the top line of the LCD. The second line shows the equivalent radiation level. This second line's equivalent radiation level is a running three second average. This three second average smooths out the reading so it's not jumping every second in response to the changes in the CPS.

Imperial or Metric Measurement(s)

The digital display also allows you to change from Imperial measurements (mR/hr) to Metric measurements (mSv/hr) with a flip of a switch. Figure 14 shows a digital display from a GCA-07, the Counts Per Second (CPS) on the top line of the LCD as before. The second line shows the equivalent radiation level using metric measurements of mSv/hr. This second line's equivalent radiation level is also a running three second average, as explained before.

Figure 14

Switch from Imperial to Metric Measurements

CPM Measurments:

When switching to the CPM mode the digital screen changes, see figure 15.

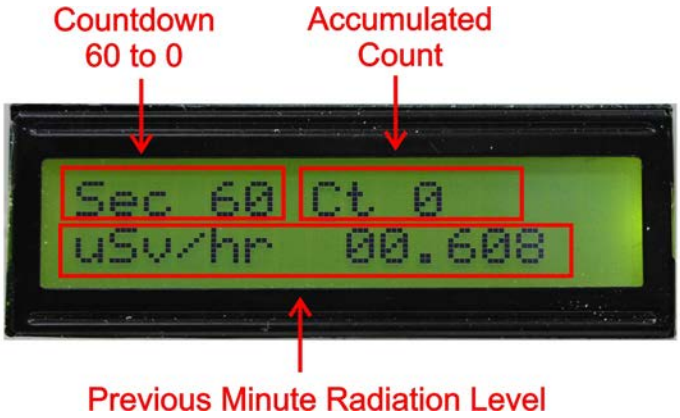


Figure 15

The count down tracks how many seconds have elapsed in the current time period measurement. The count is the accumulated count of the number of radioactive particles detected. The second line shows the previous minute radiation level. One can also switch from Imperial measurement uR/hr to metric measurement uSv/hr in CPM mode.

Figure 16 shows a count that has just started.

Figure 16

Figure 17 shows a count with a elapsed time of 10 seconds.

Figure 17

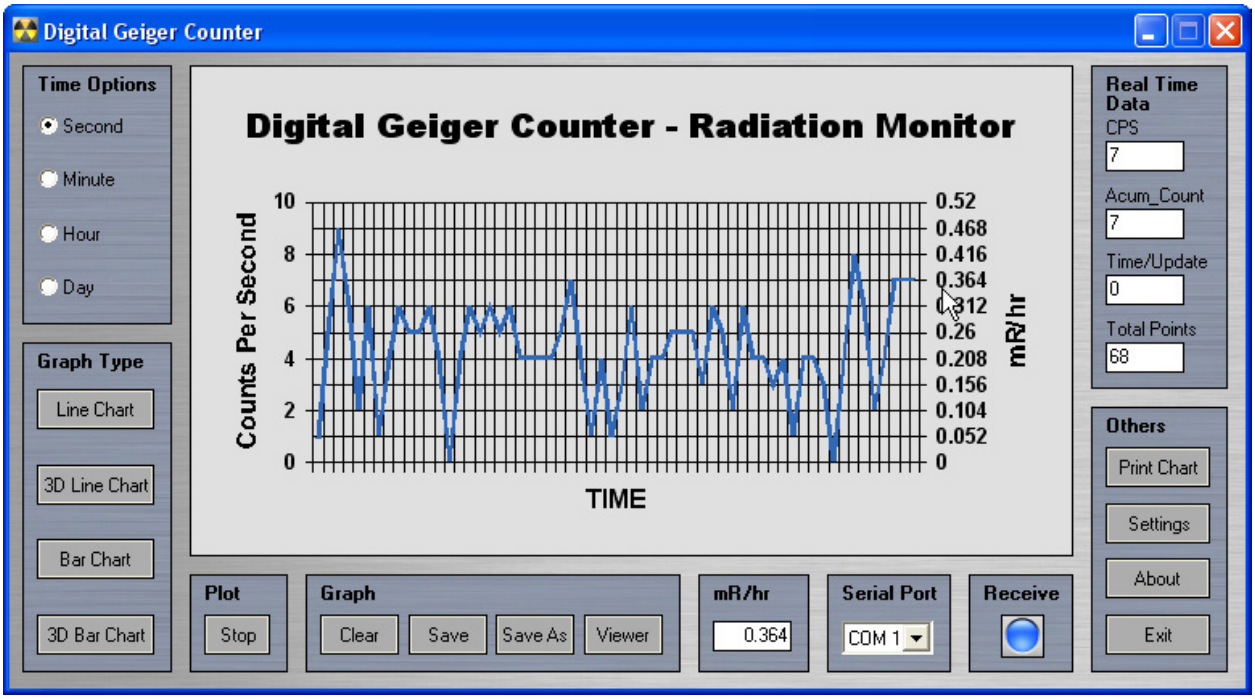
Range

The range of your Geiger counter tells you how much radiation you can measure. Typically analog meter Geiger counters range from 1 to 100 mR/hr. Although some can go as high as 500 mR/hr. With digital Geiger counters the typical range is 1 to 200 mR/hr. However the GCA-06 and GCA-07 series of digital geiger counters range from 1 to 1000 mR/hr.

Data Logging / Software:

Does your Geiger Counter come with data logging or radiation charting software?

The radiation charting software allows one to chart radioactivity over long periods of time. It allows radiation data to be saved in files and pulled up into other programs like excel. The radiation charting software for Images SI Inc. is shown in Figure 18.



This radiation charting software is free for downloading from Images SI Inc. website for any compatible Geiger counter..

Data Loggers - Digital Output

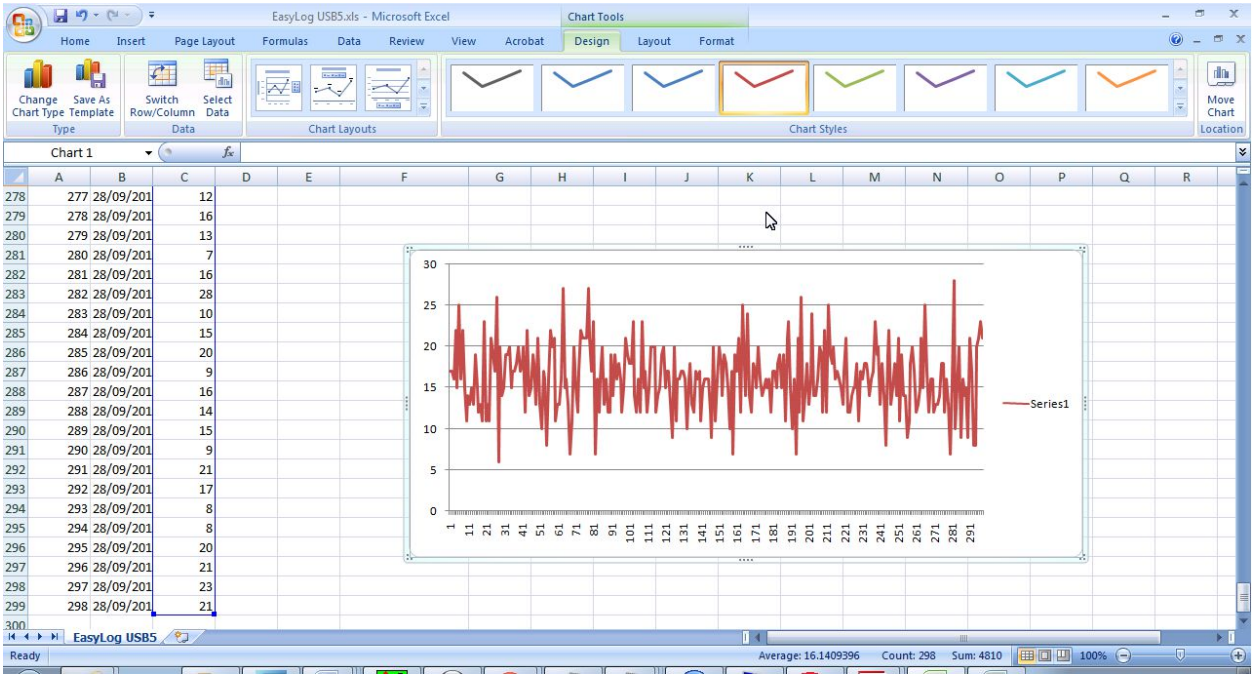
Modern Geiger Counter usually has a digital outputs that outputs a +3-5V pulse with each detection of a radioactive particle. I have tested the Lascar DataQ EL-USB-5 Data Logger, see figure 19.

For anyone interested in data loggers you need to look for in a data logger that counts events. Setting up this data logger is simple. Install the program and USB driver on your PC. Install the battery (provided) in the EL-USB-5. Plug the data logger into a free USB port. Run the installed program.

Connecting the Data Logger to the Geiger Counter.

This particular Datalogger has two alligator clip wires we attach the Geiger Counter's digital output too. Many Geiger counters output their digital pulse via a 3.5 mm jack. So we can make a simple interface using a 3.5 mm plug. The red wire connects to the center terminal of a 3.5 mm plug. The black to the ground or outside terminal of the 3.5mm plug. Then plug the 3.5mm plug into the digital output of a Geiger Counter.

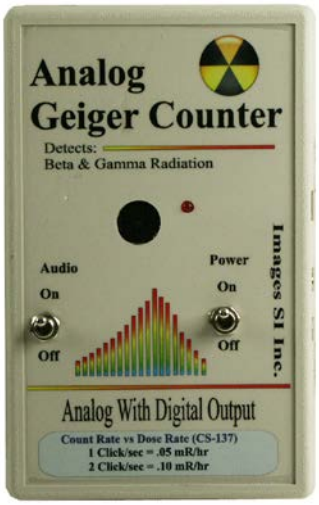
Once your data are recorded, you reconnect the Logger to the computer and save the recorded test data as a text file. I recorded 298 minutes of background data from a GCA-07. The instructions to import the text data into an Excel spreadsheet are provided in the Data Logger instructions. Once the data is inputted into Excel it can be manipulated and graphed, see figure 20 below. The average Count Per Minute (CPM) was 16 with a min count of 6 CPM and a maximum of 28 CMP.



Working Within a Budget:

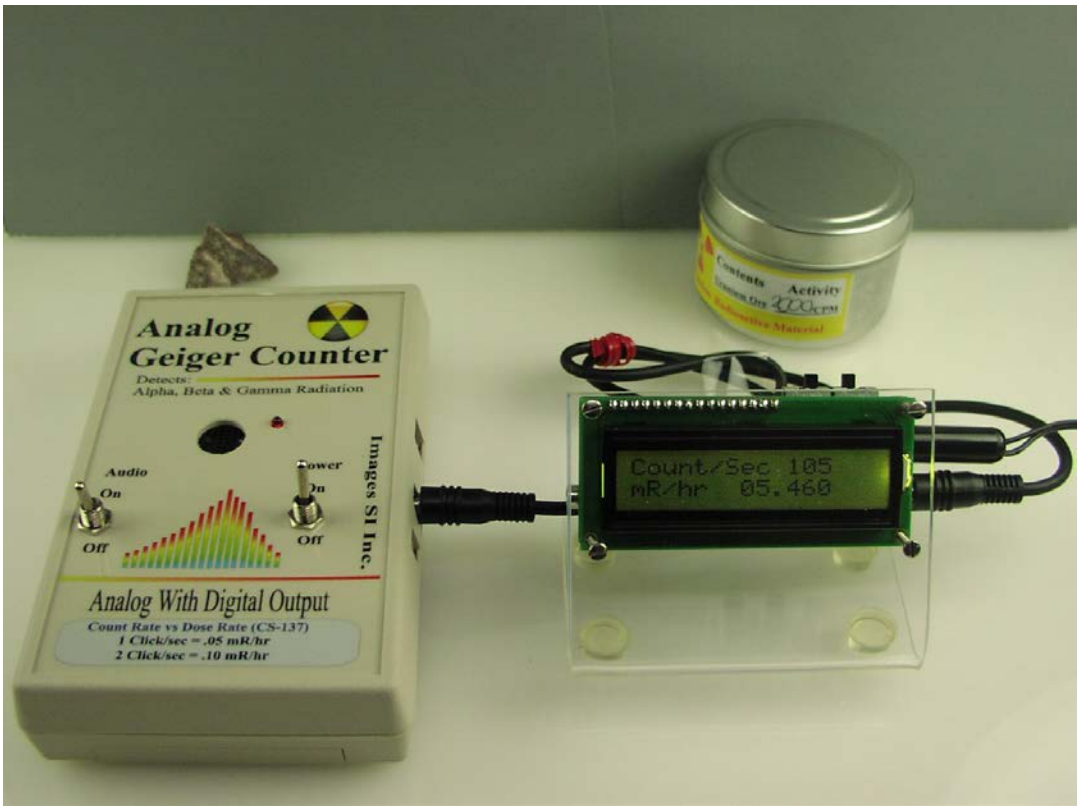
Digital Geiger counters can cost $400.00 plus. So what do you do if you want a decent instrument but don't have that money to purchase one. You can search Ebay for discounts, buy a kit and build it yourself. You could also take an inexpensive Geiger counter and add a digital meter to it. Let's examine this last option a little more.

The GCA-01 shown in figure 21, may be purchased for under $100.00 as a kit or for $129.95 assembled and tested.



This Geiger counter has a digital output. Which means it outputs a digital pulse for each radioactive particle it detects. If this Geiger counter is used in conjunction with a Digital Meter Adapter (DMAD) you can make a digital Geiger counter for the price of an analog geiger counter,see figure 22.

The DMAD Adapter may be used with any Geiger Counter that outputs a TTL Digital pulse for each radioactive particle detected. Since the DMAD is a general device, the radiation conversion will not be exact since different GM tubes have different responses. The CPS or CPM counts will be exact. The DMAD may be purchased as a kit for $59.95 or assembled and tested for $89.95. In figure 23, shows the DMAD connected to a inexpensive Geiger Counter.



The DMAD also allows one to use the Images SI Inc. free radiation charting software. The DMAD

Ease of Use:

Having a great Geiger counter that is a pain to use is no bargain. Some Geiger counters use a push the button to rotate through menu options to select different modes and ranges. If you read the reviews on these types of Geiger Counters most customers find this type of menu selection frustrating. The engineers at Images SI Inc. looked at this modality and decided against it. Look at figure 24, all models can be easily selected from the front panel switches. Another option that received bad reviews are membrane switches. The advantage of membrane switches are they allow a flat profile on the Geiger counter case. The disadvantage(s), the microcontroller needs to see the key press when it is pressed or the option pressed is not initiated. And they don't have the positive feel of a standard switch closure.

You want a Geiger counter that is easy and intuitive to use. Not one that requires you to reference a manual to make mode selections.

Warranty:

The standard warranty is one year parts and labor for any factory defects. An exception to the warranty is the GM tube which is fragile and could be broken easily if not handled properly.

Quick Recap:

Let's review the options covered in this paper.

1) Determine your interest and application.
2) What radiation do you need to detect.
3) Geiger Counter Accuracy. Can it be NRC Certified?
4) Digital or Analog - Imperial/Metric or Both
5) Range
6) Data Logging and Radiation Charting Software
7) Ease of Use
9) Working within your budget
10) Warranty

Disclaimer:
I could not obtain permission from other manufacturers to list their Geiger Counters in this Buyer's Guide. While manufacturers have no problem with listing the positive aspects of their products, they are concerned with the specific not-so-positive aspects. So I was limited in what products I could show and list. Since I work for Images SI Inc. I have full access and permission to use their products and pictures. The information provided here are general guidelines for purchasing a Geiger counter, and are applicable to all Geiger counters.

Tell me what you think. Good, Bad or Ugly. This document will be updated and expanded. If there is something you want to know about that is missing tell me. I will do my best to add relevant material that you want to read. Send all comments to:
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Other PDF Guides Being Written To Be Sent:

Using Geiger Counters for checking environment and food for radioactive contamination.

Prospecting with a Geiger Counter

How to use a Geiger Counter, list of nuclear experiments.