

GM-10/45 Radiation Detector

(Note: This document should be printed in landscape mode)

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Overview

The GM-10 and GM-45 contain a thin window geiger mueller tube, capable of detecting alpha, beta, and gamma / x-ray radiation. Each time a radiation particle enters the sensing window, it is detected, and the software on the attached computer is informed of this event.

The difference between the two models is the size of the tube - the GM-45 has a much larger surface area tube (over 23 times as large). This means that it can detect many more particles, giving a better reading.

By adding up the number of detections per minute, the Counts Per Minute (CPM) is calculated and displayed. This number is a relative indicator of the amount of radiation present.

Due to various sources of radiation, both man-made (fallout from nuclear testing in the 1950's and 1960's) and natural (such as radon, cosmic rays, and the like), there is always some background radiation present.

This background radiation level varies, depending on your location, and even the local weather. There are also short term statistical variations. This means that the CPM will vary over a short period of time, centered over what can be considered the actual average value.

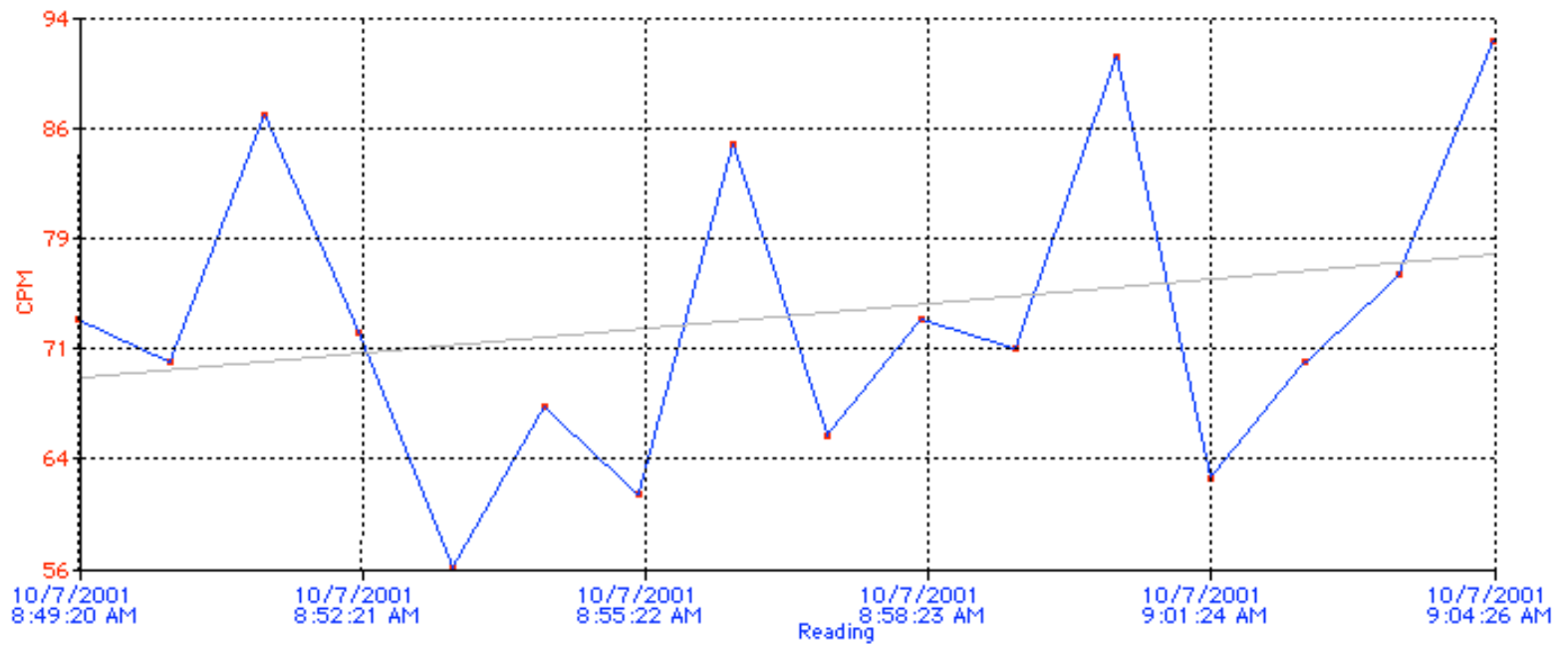
Since the GM-10 and GM-45 are self powered by the computer's serial port, no batteries or external power adapters are needed! You can operate them anywhere you can take your computer or laptop!

Included with the GM-10/45 is a copy of the Rad (Radiation Acquisition and Display) software package. Free updates to this software may be obtained from the GM-10/45 web site, <http://www.blackcatsystems.com/GM/>

Please be sure to visit the GM-10/45 website frequently, to get software updates, and to read about the various uses for your radiation detector. We also welcome your comments, questions, and suggestions, our email address is rad@blackcatsystems.com

GM - 10 Radiation Detector

Upstairs



Main

Setup

Graph

Statistics

Recording

Record every readings

☒ Enable recording

Set File

☒ Include timestamp

Macintosh HD:Desktop Folder:Real Basic:Radiation:Untitled

Software Requirements

Macintosh

MacOS version 7.6 to 9.2 (MacOSX not supported)
8MB Free memory after operating system requirements
Available serial port (serial to USB adapter may be used)
USB Port for USB detectors

Windows

Windows 95, 98, NT, 2000, XP
64MB memory
Available serial port (serial to USB adapter may be used)
USB Port for USB detectors

Installation

Copy the folder from the CD-ROM to your computer's hard drive. To run the program, open the folder, and double click on the Rad application icon. The first time you run the software, you'll need to enter the registration code, which is on a sticker on the CD envelope.

Quick Startup

Plug the GM-10 into a free serial port. Go to the Setup pane, and select that port from the pop up menu. The software will update the counts per minute (CPM) in the main pane every second. The graph will be updated once a minute (this update rate may be changed, see the detailed instructions below).

Menus

File:Open Recording File

Clears the data in the graph, and loads it with data from the selected recording file. Useful to review previously stored readings.

File:Page Setup...

The usual page setup window, to prepare for printing.

File:Print

Allows you to print out the graphing window. The size of the printed window is proportional to the size of the window on your monitor. If the size of the printout is too small, try enlarging it in the Page Setup window, if your printer supports enlargement..

File:Quit

Quits the program.

Edit:Copy Graph

Copies the graph image to the clipboard, so that it may be pasted into other applications, such as word processing documents.

Tabs within the Rad program

There are six tabs, each of which is dedicated to a particular feature of the software:

Main

Setup

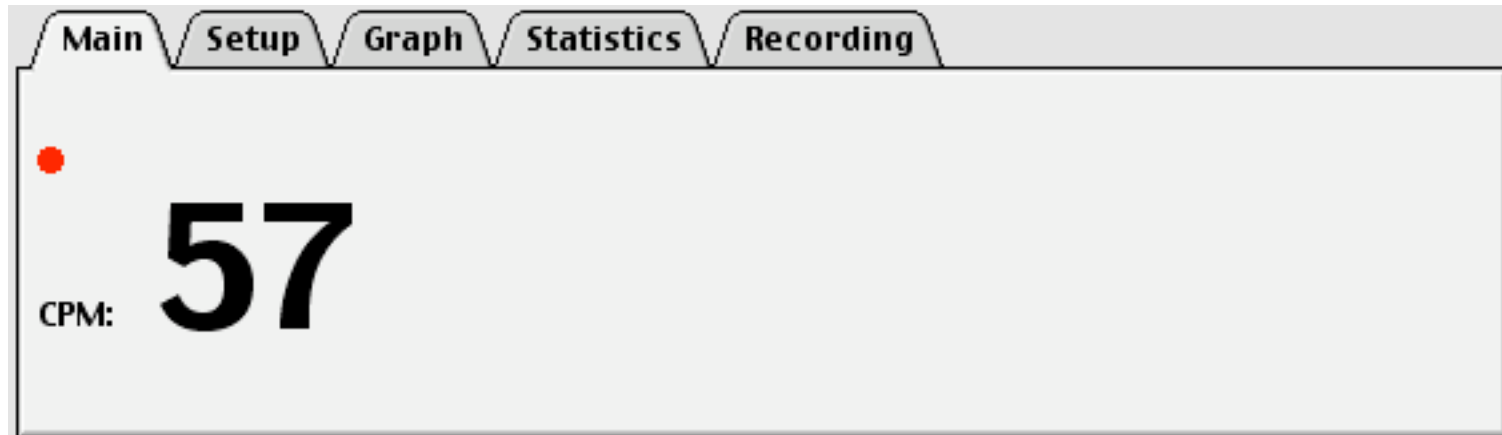
Graph

Statistics

Recording

FTP

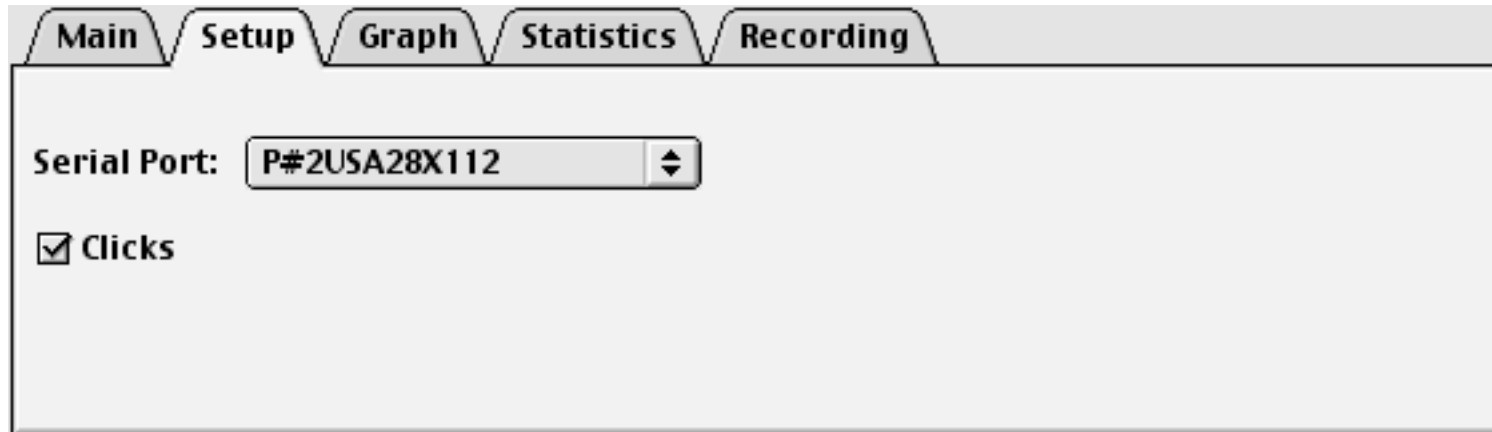
Main



Displays the counts per minute (CPM), updated each second, averaged over the past minute.

A small indicator in the upper left corner blinks red each time a radiation particle is detected.

Setup



The screenshot shows a software window titled "Setup" with five tabs: "Main", "Setup", "Graph", "Statistics", and "Recording". The "Setup" tab is selected. Inside the window, there is a "Serial Port:" label followed by a dropdown menu displaying "P#2USA28X112". Below this, there is a checked checkbox labeled "Clicks".

Serial Port

Used to select which of the computer's serial ports the GM-10 is plugged into. An additional option, called "Dummy Data", allows the software to produce simulated readings without an actual GM-10 connected.

Clicks

When checked, the software produces an audible click each time a radiation particle is detected.

Alarm / CPM

When Alarm is checked, the software will compare the current reading against the value in the CPM box. When it exceeds it, a system beep sound will be generated. The exact sound will depend on what sound you have specified for the alert sound for your computer. The beep will be generated each time the graph is updated (see Update Rate in the Graph tab).

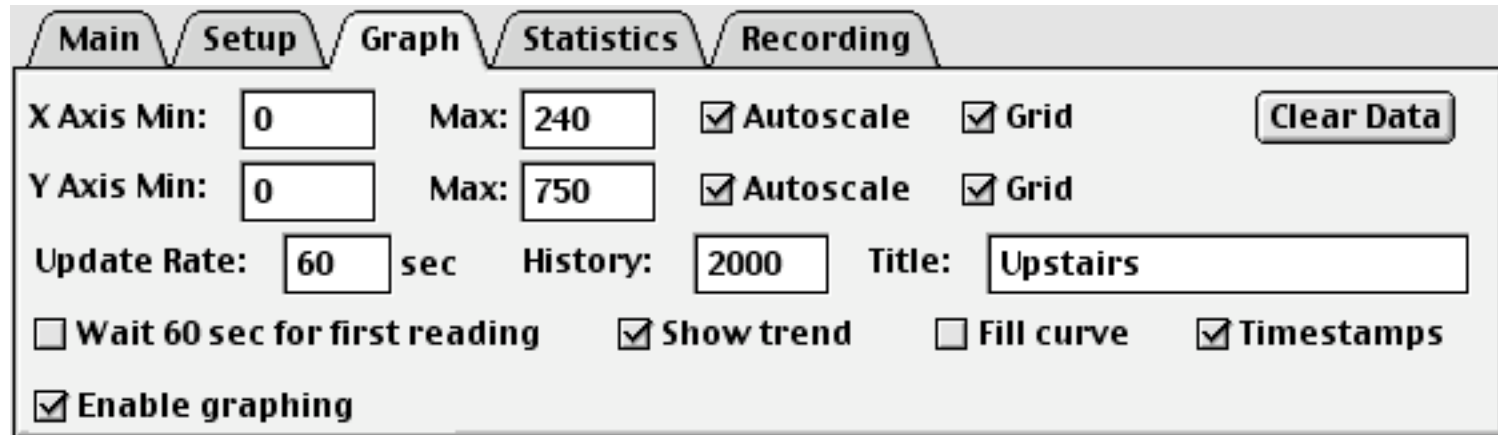
Filtering

A number from 0 to 1 applies filtering. 1 would be no filtering, 0 would be infinite filtering.

Multiplier and Offset

Applied to the CPM, can be used for custom scaling to other units.

Graph



| Main | Setup | Graph | Statistics | Recording |
|---|-------|-------|------------|-----------|
| X Axis Min: <input type="text" value="0"/> Max: <input type="text" value="240"/> <input checked="" type="checkbox"/> Autoscale <input checked="" type="checkbox"/> Grid <input type="button" value="Clear Data"/> | | | | |
| Y Axis Min: <input type="text" value="0"/> Max: <input type="text" value="750"/> <input checked="" type="checkbox"/> Autoscale <input checked="" type="checkbox"/> Grid | | | | |
| Update Rate: <input type="text" value="60"/> sec History: <input type="text" value="2000"/> Title: <input type="text" value="Upstairs"/> | | | | |
| <input type="checkbox"/> Wait 60 sec for first reading <input checked="" type="checkbox"/> Show trend <input type="checkbox"/> Fill curve <input checked="" type="checkbox"/> Timestamps | | | | |
| <input checked="" type="checkbox"/> Enable graphing | | | | |

X Axis Min

The minimum, or leftmost, value for the x axis of the graph display.
There is a similar value for the Y axis.

X Axis Max

The maximum, or rightmost, value for the x axis of the graph display.
There is a similar value for the Y axis.

Autoscale

When checked, the minimum and maximum values for the axis are automatically set by the software.

Grid

When checked, a grid for the corresponding axis is drawn.

Update Rate

Specifies how often the graph is updated with a new reading, in seconds. A typical value is 60 seconds, so the graph updates once a minute. While it is possible to update at a faster rate, this results in each graphed value actually containing

information that has already been graphed in previous points. The counts per minute are averaged during this period, so you will notice a ramp up until one update period has occurred. It is possible to select update rates less than 60 seconds. If so, the CPM will be normalized to a 60 second period, and such readings will jump around much more due to the shorter averaging period.

History

Specifies the maximum number of datapoints to display in the graph. When the number of points exceeds this value, old data is discarded, and the graph scrolls to the left.

Wait 60 sec for the first reading

Normally this is left checked. It instructs the software to wait 60 seconds (one minute) before graphing the first datapoint, otherwise an incorrect low value will be displayed, while the counts per minute (CPM) ramp up to the correct value.

Show trend

When checked, a light gray trend line will be drawn through the datapoints, showing the best fit. This makes it easy to see what the overall trend is - whether radiation levels are increasing, decreasing, or remaining constant.

Fill curve

When checked, the area under the curve is painted.

Clear Data

When clicked, the data in the graph is erased.

Timestamps

When checked, the x axis of the graph is the date/time of the reading.

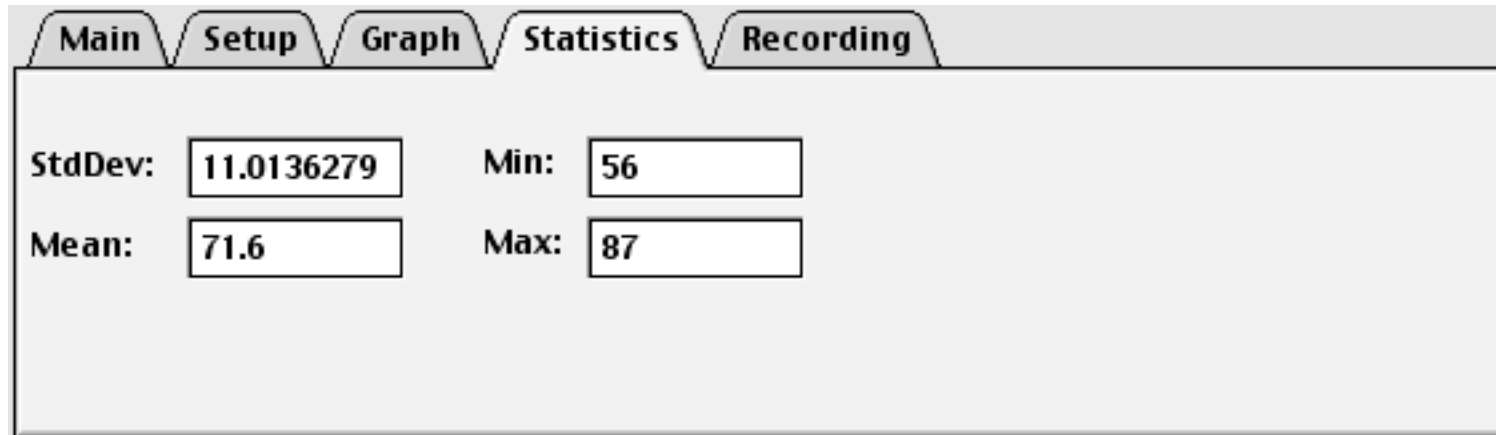
Enable graphing

When checked, each reading is displayed on the graph. Must be checked for the graph to update.

Title

The title of the graph is specified here.

Statistics



This pane shows statistics for the graphed data, namely the:

Mean

This is the average of all of the datapoints.

Min

This is the minimum graphed datapoint.

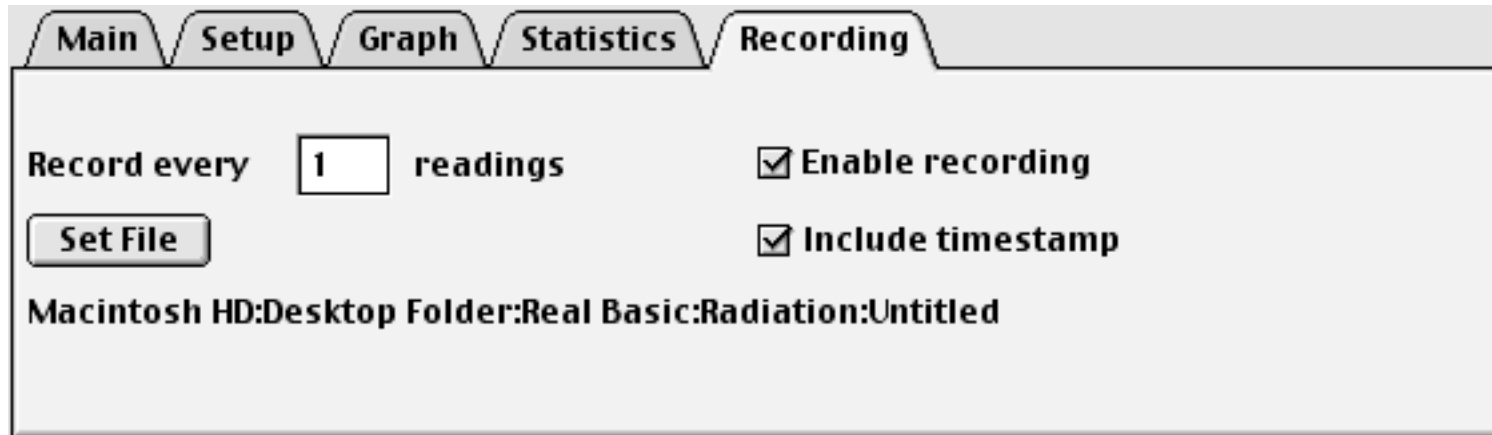
Max

This is the maximum graphed datapoint.

StdDev

This is the standard deviation of all of the datapoints. Typically, the standard deviation is approximately equal to the square root of the mean value. This is only true for truly random radiation events, and for long averaging periods. In most cases, the standard deviation displayed will be slightly above or below the square root of the mean. It will definitely be higher if there is an overall trend occurring, such as the background radiation levels increasing or decreasing.

Recording



The screenshot shows a software window with five tabs: Main, Setup, Graph, Statistics, and Recording. The Recording tab is selected. Inside the Recording tab, there are two rows of settings. The first row has a label 'Record every' followed by a text box containing the number '1' and the word 'readings'. To the right of this is a checkbox labeled 'Enable recording' which is checked. The second row has a button labeled 'Set File' on the left and a checkbox labeled 'Include timestamp' which is also checked. Below these settings, the file path 'Macintosh HD:Desktop Folder:Real Basic:Radiation:Untitled' is displayed.

The software can store readings in a text file, for use with other programs. Each line of text in the file contains one reading, optionally with a timestamp.

Record every __ readings

Specifies how often data is written to the file. Typically, this is set to 1, indicating that every time the graph is updated with new data, that data should be written to the file.

Set File

When clicked, the user is prompted to specify the name of the file that data is written to. The complete name and path to the specified file is displayed under this button.

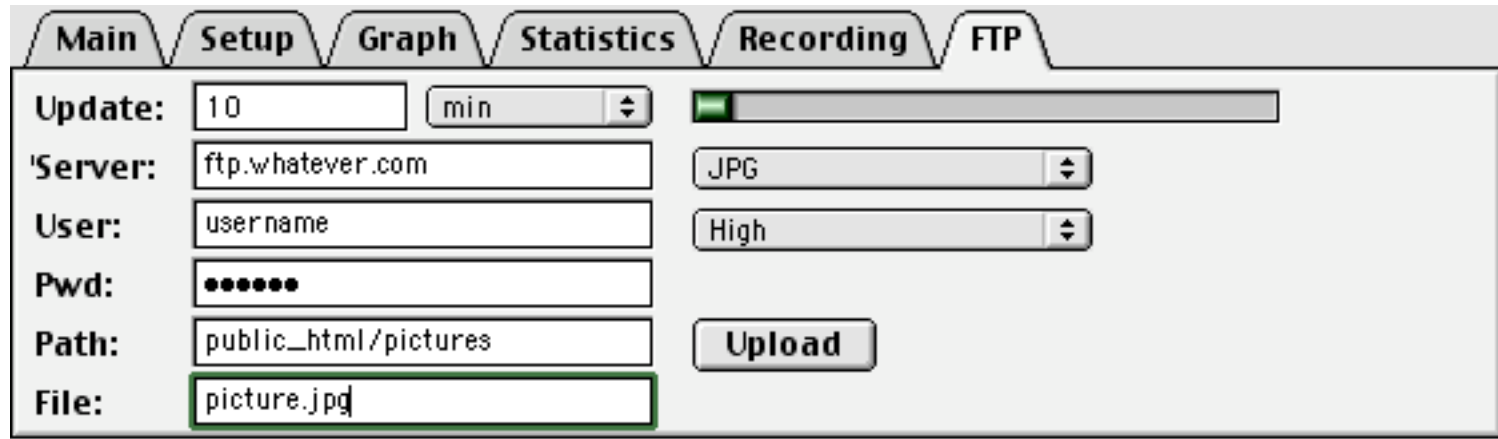
Enable recording

When checked, data is written to the specified file.

Include timestamp

When checked, a timestamp is included on each line written to the file, making it easy to graph the data in another program, such as a spreadsheet.

FTP



The screenshot shows a software interface with a tabbed menu at the top: Main, Setup, Graph, Statistics, Recording, and FTP. The FTP tab is selected. The pane contains the following fields and controls:

- Update:** A text box with '10' and a dropdown menu with 'min' selected. To the right is a progress bar.
- Server:** A text box containing 'ftp.whatever.com'.
- User:** A text box containing 'username'.
- Pwd:** A text box containing seven dots.
- Path:** A text box containing 'public_html/pictures'.
- File:** A text box containing 'picture.jpg', which is highlighted with a green border.
- On the right side, there are two dropdown menus: the first shows 'JPG' and the second shows 'High'.
- At the bottom right is an 'Upload' button.

This pane configures the software to automatically upload an image of the graph to your ftp/webs server, so it may be displayed on your website. This allows you to make the graph of radiation data available on the web for others to look at, or for remote display applications.

You can specify how often to upload a new image, such as every hour. The progress indicator in the upper right of the pane will show how much longer until the next automated upload.

Please note that QuickTime version 4.0 or better is required to use this feature. QuickTime is available for free from Apple Computer, for both Macintosh and Windows systems. The URL is <http://quicktime.apple.com>

The trickiest part of setting up this feature is the path into which the image file will be stored on the remote server. You may need to contact your ISP to determine what this path is. Usually, public_html is the root of your website, and you can have additional directories from there.

Update

Controls how often to upload a new picture. Enter the time and select the appropriate units, such as 10 minutes, 1 hour, 30 seconds, etc. Off may be selected to disable uploading of images.

Server

Enter in the name of the server for uploads. You may have to ask your ISP for the name of the server to use.

User

Enter in the user login name to access the server.

Pwd

Enter in the password to access the server.

Path

This is the path to the directory into which the image file will be uploaded.

File

This is the name of the file which will be created, and uploaded.

Format

Select one of these three format types:

BMP

JPG

PNG

Compression

This specifies how much compression to be applied to JPG images. The more compression, the smaller the file, but the worse the picture quality.

Passive FTP

Enables passive FTP transfer mode. Useful if you have a firewall preventing active FTP from working.

Upload

Clicking this button will force a graph upload to occur.

Running Multiple Detectors on one Computer

It is possible to run multiple detectors on one computer, with Rad version 1.5.0 and later. In order to do this, you need to run one copy of Rad for each detector.

To do this, each copy of Rad must be in its own directory, and you must have a local copy of the Rad preferences file in the same folder as each of the copies of Rad. You can make a copy of this file, which is called “RadGM Prefs” and is located in the Windows folder for Windows systems, and the Preferences folder for MacOS systems. MacOSX systems have a separate Preferences folder for each user.

Rad will then read the local copy of the Preferences file, and use it. This allows you to specify a unique serial port to use for each copy of Rad, so that each copy communicates with one of the detectors.

Troubleshooting

1. Make sure the serial port select is not being used by other program (fax software, internet/modem, software, etc).
2. Make sure the serial cable is firmly connected and tight at both the computer and GM-10. if a USB/serial adapter is used, be sure to plug it into the computer before starting the Rad software.
3. It is normal to read about 10 to 15 counts per minute (CPM) from normal background radiation. These values could be lower, or higher, depending upon the conditions at your location.
4. Be sure not to touch the detector tube at the end of the GM-10 unit, or subject the GM-10 to sharp shocks or drops. While the tube is protected by a mesh, it can easily be damaged. Such damage is not covered by the warranty.

Using Your GM-10

There are many uses for the GM-10. These include:

Monitoring background radiation levels

Detection of increased background levels due to radon

Detection of increased background levels due to man-made sources (fallout, nuclear power plant accidents, etc)

Detection of radioactive materials (both natural and man-made)

Monitoring background radiation levels

Background radiation levels vary throughout the world, due primarily to minerals in the local soil. Here at our location in central Maryland, USA, we typically see about 10 CPM. In the basements of homes with elevated radon levels, this can and does increase substantially.

A good suggestion is to monitor background conditions for a period of time, to see what typical values are measured at your location. That way, a baseline can be established for comparison purposes. If subsequent readings are significantly elevated above this baseline, then it is fair to assume that some event has occurred to raise background radiation levels.

It's quite common to see variations over the course of a day, or several days, as much background radiation is due to naturally occurring radioactive products (typically radon decay) which are blown in with the wind, and therefore are subject to changing weather conditions.

Common radioactive materials

There are many slightly radioactive materials found around the home. These include:

Sodium free salt - contains Potassium Iodide rather than Sodium Iodide. There is a naturally occurring isotope of Potassium which is slightly radioactive, emitting beta radiation. As a result, anything which contains Potassium is itself slightly radioactive. Placing the GM-10 next to a small pile of such salt substitute will show an elevated reading.

Smoke detectors - most contain a very small (1 microcurie) Americium 241 source, which emits both alpha rays (stopped by the plastic case) and gamma rays, some of which will be detected by the GM-10.

Uranium bearing materials - some older products (such as Fiesta ware dishware, vaseline glass, etc) contain small amounts

of uranium oxide, and are slightly radioactive. Many stone and brick building materials naturally contain small amounts of uranium and/or thorium and daughter products, and are also slightly radioactive.

Camping lamp mantles - some of the older ones contained thorium, and were quite active alpha emitters.

Experiments with the GM-10

Below you'll find examples of just a few of the many experiments that can be performed with the GM-10 radiation detector. Many of these are ideal hobbyist / science class / science fair experiments. If you have additional experiments you've performed, we'd enjoy hearing about them. Send details to us at support@blackcatsystems.com

Radioactive dust

Obtain some recently deposited dust from around the house. Two good examples are dust wiped from a TV set or monitor, or clothes dryer lint just after the clothes are done. Place the dust in front of the GM-10. If you have even the slightest amount of radon in your home (and most homes do), you will see elevated readings over background. This is due to the radon daughter products, primarily Pb_{214} and Bi_{214} . Each has a short half life, about half an hour, so the radiation levels fall off quite quickly. If plotted, a nice double exponential curve is obtained. For this to work, you need at least some level of radon in your home. Depending on your location, the level of radon varies. Some locations have almost no radon present in the soil.

Blocking radiation with absorbers

Place a safe low level radiation source, ideally a beta source (such as a small piece of vaseline glass, or even a small pile of potassium iodide (salt substitute from the grocery store)) in front of the GM-10 to get readings significantly above background levels. Place varies thickness of absorbing materials (such as pieces of paper) in between the source and GM-10, to block some of the radiation. If you record the thickness (actually the basis weight or mass per unit area) and CPM readings, you should obtain a nice exponential decay plot.

Revision History

June 13, 2004 - Version 2.0.0a2 released

Fixes to graph display to prevent clipping.
Automatically looks for RECORDING.TXT file and will load it if it exists.
Added filtering.
Added multiplier and offset.
Added display of mean, min, max, and std dev on graphs
Hopefully uses less CPU time.

Novmeber 23, 2003 - Version 2.0.0a1 released

New ftp routine used.

May 10, 2003 - Version 1.5.0 released

Added alarm.
Added individual preferences files.

February 17, 2002 - Version 1.3.0 released

Added ability to print out graphs.

Fixed a bug which could cause a lockup if the program trie to ftp the graph and there was no response from the server.

November 4, 2001 - Version 1.1.0 released

October 7, 2001 - Version 1.0.0 released

GM-10 Specifications

Size: 4.25 by 2.6 by 1.2 inches (108 by 66 by 30 mm)

Weight: 3.6 ounces (102 grams)

Window: Mica, 1.75 mg/cm²
0.36 inch / 9.1 mm diameter

Radiation detected:

Alpha - Above 3 MeV

Beta - Above 50 keV

Gamma / X-Ray - Above 7 keV

Power requirements: Self powered from computer

Computer Hardware Requirements:

USB version - USB port

Serial versions - One available serial port

Computer Software Requirements:

Windows 95/98/2000/NT

Macintosh MacOS 7.6 to 9.2, OSX 10.1.2 or later
(USB runs in Classic under MacOSX)

Software Features:

Built in graphing

Ability to store data to disk for further analysis

User selectable integration times

Built in statistics package

Trend line may be superimposed over graphed data
"Geiger Counter" clicking may be enabled

Package includes:

GM-10 Unit

CD-ROM with software for both Windows and Macintosh

USB Version:

Built in USB cable

Serial version:

Appropriate serial cable - please order the correct
version for your system, three are available:

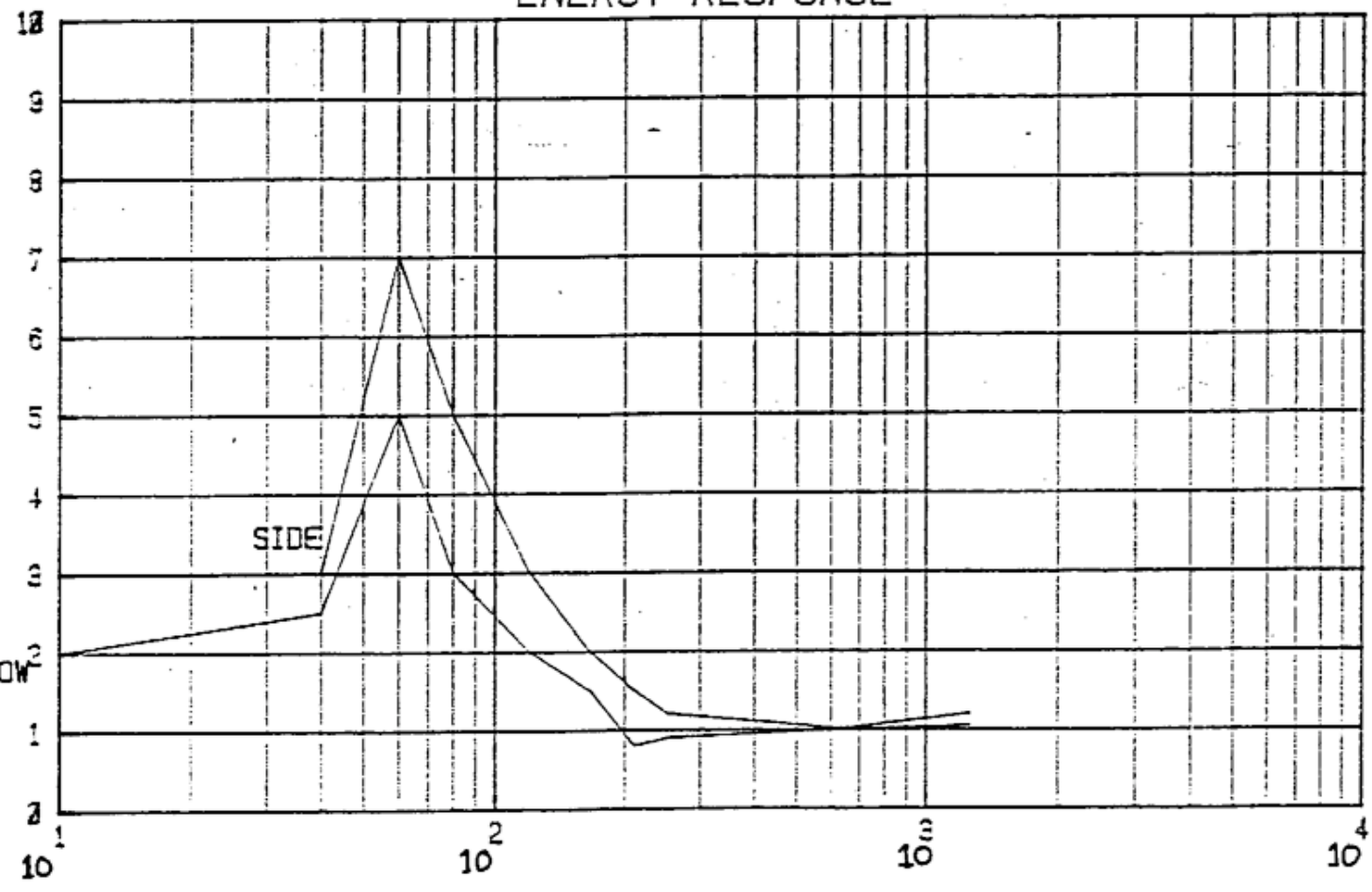
1. Windows with 9 pin serial port
2. Windows with 25 pin serial port
3. Macintosh with 8 pin serial port

Gamma Energy Response

RELATIVE COUNT RATE

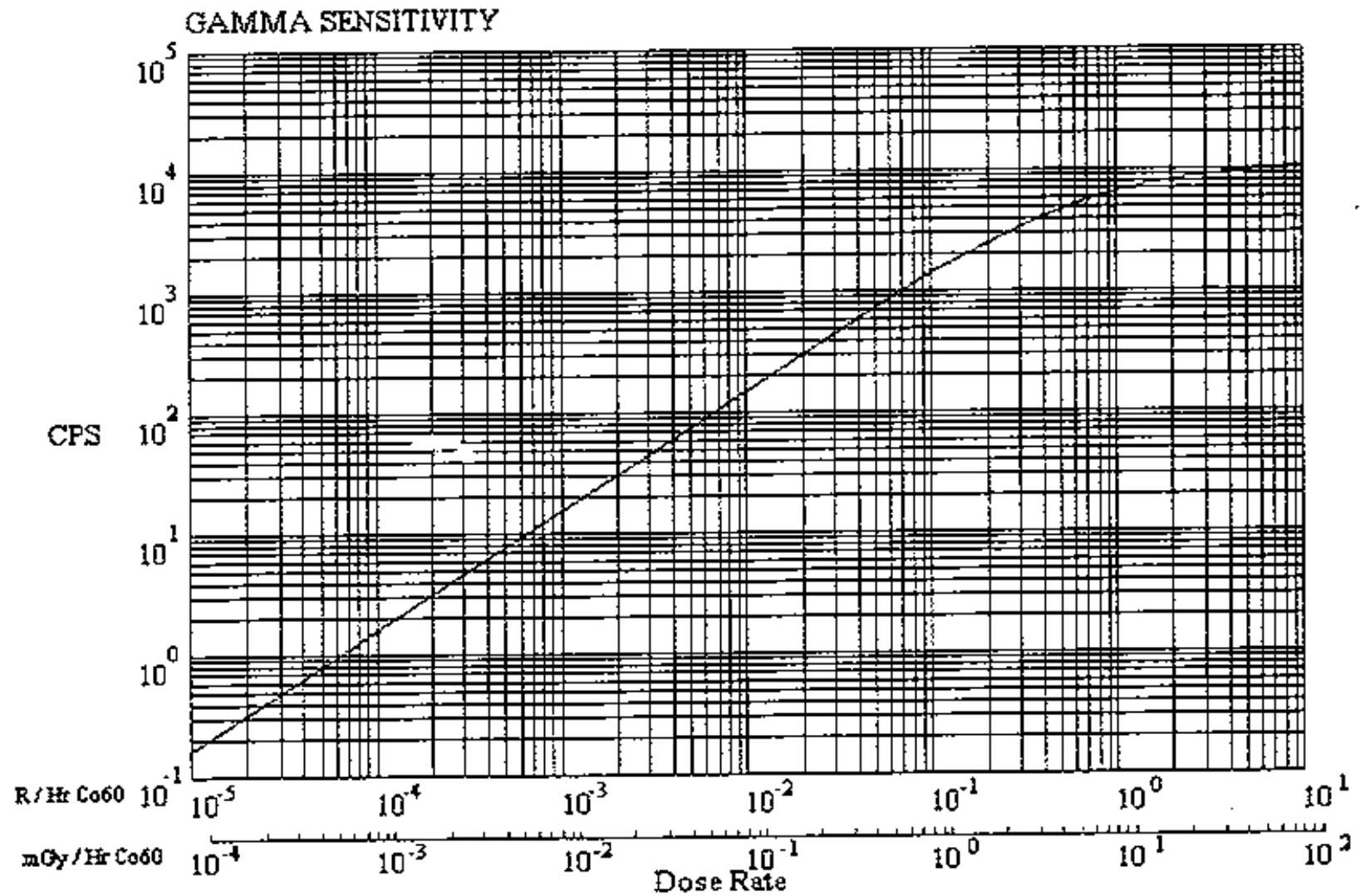
WINDOW

ENERGY RESPONSE

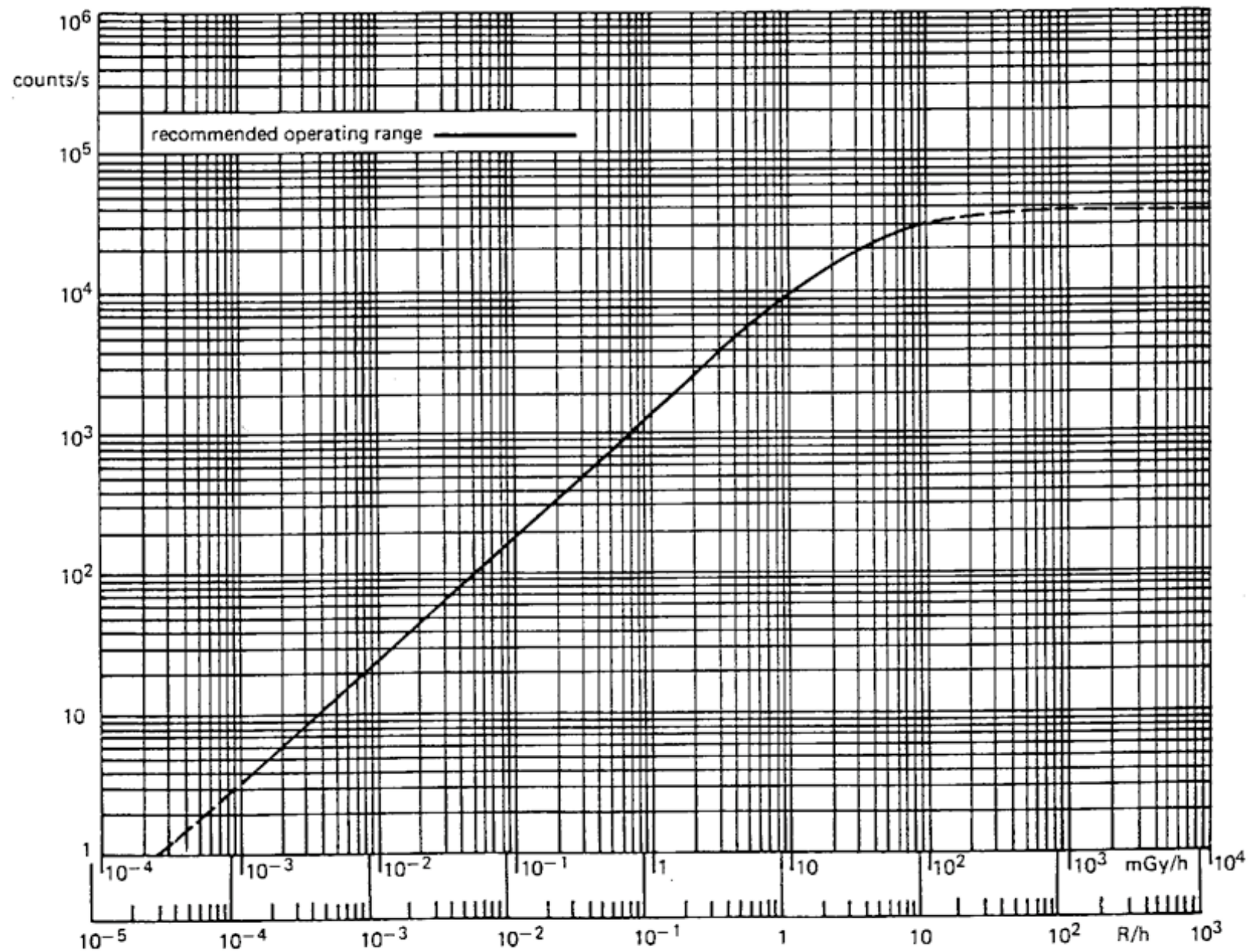


PHOTON ENERGY (KEV)

Cobalt 60 Sensitivity



Cesium 137 Sensitivity



Typical counting rate as a function of dose rate (^{137}Cs)

GM-45 Specifications

Size: 5.3 by 3.4 by 1.5 inches (135 by 86 by 38 mm)

Weight: 9.3 ounces (264 grams)

Window: Mica, 1.75 mg/cm²
1.75 inch / 44.5 mm diameter

Radiation detected:

Alpha - Above 3 MeV

Beta - Above 50 keV

Gamma / X-Ray - Above 7 keV

Power requirements: Self powered from computer

Computer Hardware Requirements:

USB version - USB port

Serial versions - One available serial port

Computer Software Requirements:

Windows 95/98/2000/NT

Macintosh MacOS 7.6 to 9.2, OSX 10.1.2 or later
(USB runs in Classic under MacOSX)

Software Features:

Built in graphing

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User selectable integration times

Built in statistics package

Trend line may be superimposed over graphed data
"Geiger Counter" clicking may be enabled

Package includes:

GM-10 Unit

CD-ROM with software for both Windows and Macintosh

USB Version:

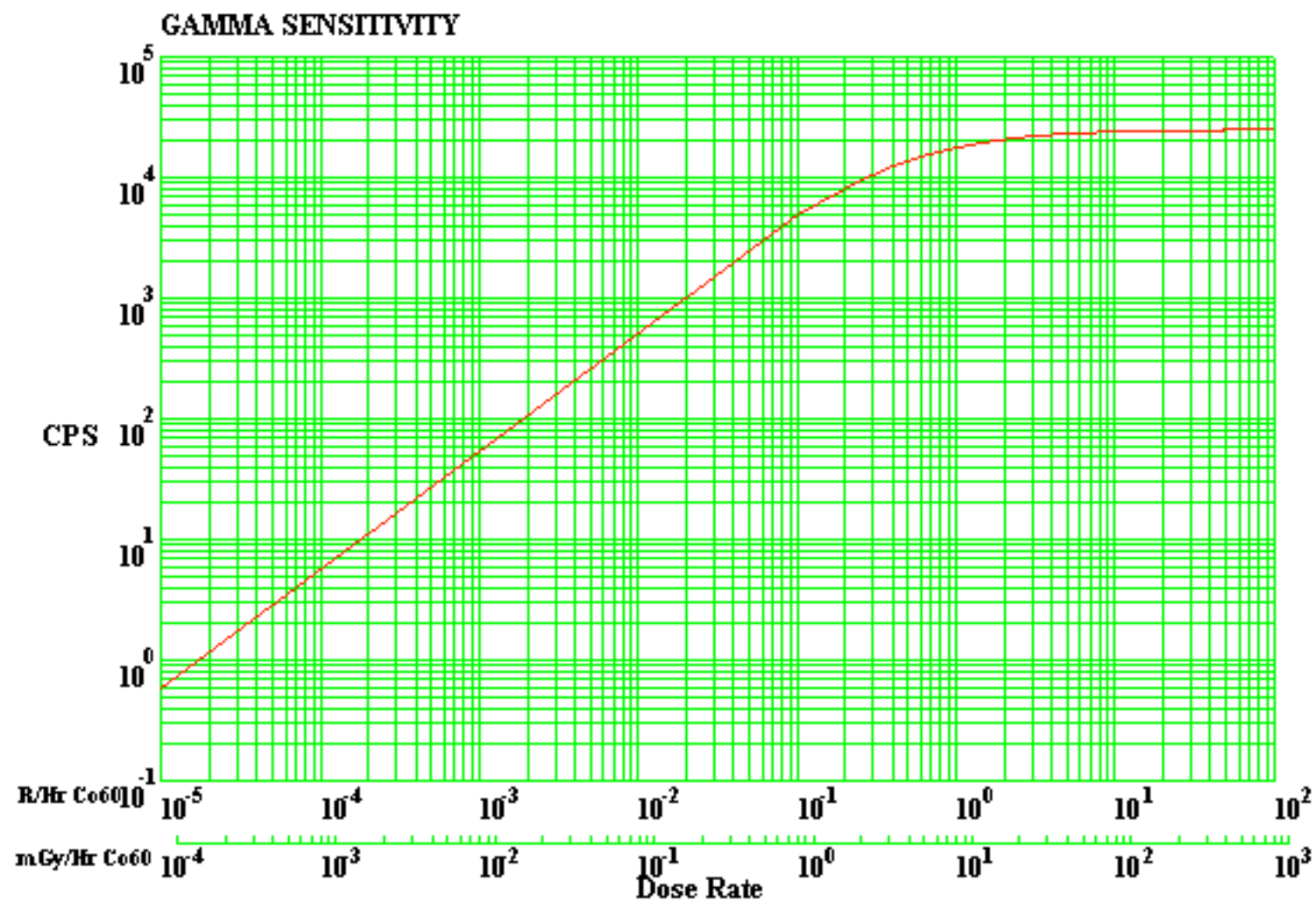
Built in USB cable

Serial version:

Appropriate serial cable - please order the correct
version for your system, three are available:

1. Windows with 9 pin serial port
2. Windows with 25 pin serial port
3. Macintosh with 8 pin serial port

Cobalt 60 Sensitivity



Frequently Asked Questions

What computers/OS versions are required?

The GM-10/45 works with Windows and MacOS:

Macintosh:

- * MacOS 8 to 9.2, MacOSX native not yet supported, PPC required
- * Serial port required (USB/serial adapter, not included, may be used)
- * USB version also available

Windows:

- * Windows 98, ME, NT, 2000, XP. Most Windows 95 versions should work as well, except the first releases, which have serial port problems.
- * Serial port required for serial version.
- * USB version also available

Can I use a USB/serial adapter?

Yes! You can also use the USB version of the GM-10, now available.

We've tested the Keyspan USB Twin Serial Adapter on the Macintosh, and it works fine.

We've also tested the Keyspan High Speed USB Serial Adapter on Windows, and it too works

well.

How do I convert CPM to mR/hr?

Conversion of CPM (counts per minute) to mR/hr is dependent on the type and energy of the particles detected. That is, there is no one conversion factor.

Most radiation survey meters are calibrated to Cs137 (cesium). It turns out that the conversion factor for the GM-10 to convert CPM to uR/hr is very close to 1 (0.95, but 1 is close enough for most purposes). This means that 1000 CPM is about equal to 1 mR/hr for Cs137.

There is a [graph](#) available showing the relative sensitivity for other gamma energies. For example, at 60 keV (Americium 241) it is 7. So you would get about 7000 CPM for 1 mR/hr.

You may also wish to take a look at our page that [briefly describes the various units of radiation](#)

Can I use a GM-10 with Linux? What is the serial protocol?

While a software package for Linux for the GM-10 is not included, you can write your own.

Reading data from the GM-10 is very simple:

- * Open the serial port to receive data at 57600 baud, 8 data bits, 1 stop bit, no parity

- * Make sure the DTR line is asserted, to provide power to the GM-10. This is the normal state of the serial port after it has been opened., so normally you don't need to do anything.
- * Every time the GM-10 detects a radiation particle, it transmits one byte of data, the value is undefined.
- * Counting the number of bytes received over one minute will determine the CPM. Other averaging periods may be used as well
- * A rolling or sliding window average may give the best visual results. The GM-10 software updates every second, and averages over one minute, or another user-specified time period.

You can also connect the GM-10 to a microcontroller, if you are familiar with such interfacing. You'll need to apply power (12V) between the DTR (+) and Tx (-) lines, and count the pulses coming back on the Rx line. You may need to condition the voltages of the pulses coming back, which will typically vary between 1 and 11 volts, with a positive pulse (about 20 microeconds wide) for each particle of radiation detected.

What's the difference between the GM-10 and GM-45?

Essentially, the GM-45 has a much larger detector surface area, so it will give a higher reading (CPM) for a given intensity of radiation, compared to the GM-10. This is especially the case for alpha rays.

The GM-10 detector is a cylinder 2.125 inches long and 0.59 inches in diameter, with a active window diameter of 0.36 inches.

The GM-45 detector is called a "pancake" style, and has a 1.75 inch active window, and a length of 0.5 inches.

You can take a look at the [Specs](#) page for a full comparison between the two units.

Can I measure radon levels with the GM-10 or GM-45?

Not directly, but you can take indirect measurements which are influenced by the radon levels present. Radon undergoes an alpha decay, this alpha particle can be detected by the GM-10 and GM-45. Several of the daughter products of radon are also radioactive, with alpha and beta rays produced, these two are detected.

The reading from the GM-10 or GM-45 (in CPM) is comprised of both these radiations from radon, as well as background cosmic radiation levels. These background levels are usually fairly constant in a particular location, so that variations in the CPM readings are quite likely to be due to variations in the radon levels. That is, an increase in the CPM is likely to be due to an increase in the radon level.

Conversion to pCi/L of radon would be somewhat complicated. It maybe possible to take several measurements using the canisters which are sent into a lab for analysis, recording the readings from the GM-10/45 as well during each canister test. Comparing the CPM vs the pCi/L from the lab may allow a correlation between future CPM readings and estimated pCi/L concentrations of radon.

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