SALAHADDIN UNIVERSITY – ERBIL

COLLEGE OF EDUCATION

DEPARTMENT OF PHYSICS

Laboratory Manual:

Nuclear Science Experiments

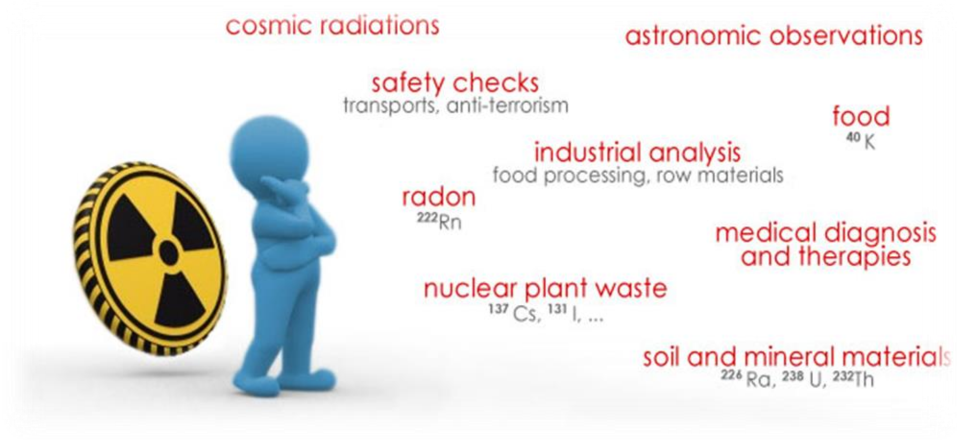

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Table of Contents:

Foreword

The purpose of this laboratory manual is to describe nuclear physics experiments utilizing the latest counting electronics that are in broad use in today's industry.

Precautions with Radioactive Sources

Several types of radioactive sources are required to perform the experiments described in this Laboratory Manual. These include both sealed and unsealed sources with a range of activity. When working with radioactive sources, utilize the three basic principles as low as reasonably achievable:

- **Time:** The simplest way to reduce exposure is to keep the time spent around a radioactive source to a minimum. If time is cut in half, so is the exposure, with all the other factors remaining constant.
- **Distance:** Distance is another effective means to reduce radiation exposure. The formula is known as the "inverse square law" relates the exposure rate to distance. Doubling the distance from a radioactive source reduces the exposure to one-fourth its original value. If the distance is tripled, the exposure is reduced by a factor of nine.
- **Shielding:** Shielding is any material used to reduce the radiation reaching the user from a radioactive source. While a single sheet of paper may stop some types of radiation such as alpha particles, other radiation such as neutrons and photons require much more shielding. Dense materials, such as lead or steel, are used to shield photons. Materials containing large amounts of hydrogen, such as polyethene, are used to shield neutrons.

Theoretical Overview:

Radioactivity:

Radioactive nuclei decay by emitting beta or alpha particles. Often the decay is to an excited state in the daughter nucleus, which usually decays by emission of a gamma-ray. The energy level sequence and therefore the gamma-ray energy spectrum for every nucleus is unique and can be used to identify the nucleus. The energy levels and decay process of ^{22}Na, ^{60}Co and ^{137}Cs are given in Figure 1-1. The term beta decay means β- (electron), β+ (positron) emission or electron capture by the nucleus.

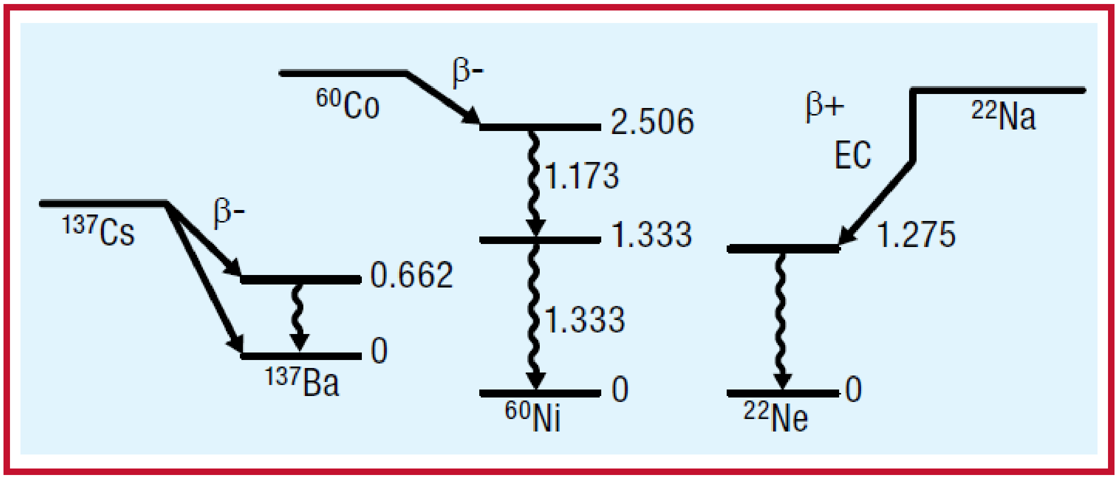


Fig. 1-1: Energy level sequences for ^{137}Cs, ^{60}Co and ^{22}Na (energy levels in MeV)

NaI(Tl) detectors:

The thallium-activated sodium iodide detector, or NaI(Tl) detector, responds to the gamma-ray by producing a small flash of light, or a scintillation. The scintillation occurs when scintillator electrons, excited by the energy of the photon, return to their ground state. The detector crystal is mounted on a photomultiplier tube which converts the scintillation into an electrical pulse. The first pulse from the photocathode is very small and is amplified in 10 stages by a series of dynodes to get a large pulse. This is taken from the anode of the photomultiplier and is a negative pulse.

The NaI(Tl) crystal is protected from the moisture in the air by encasing it in aluminium, which also serves as a convenient mounting for the entire crystal/photomultiplier unit. A schematic is shown in Figure 1-2.

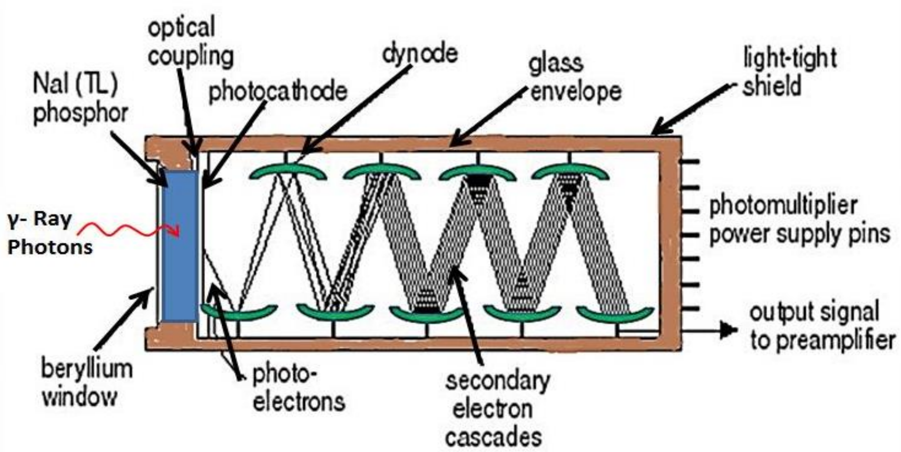
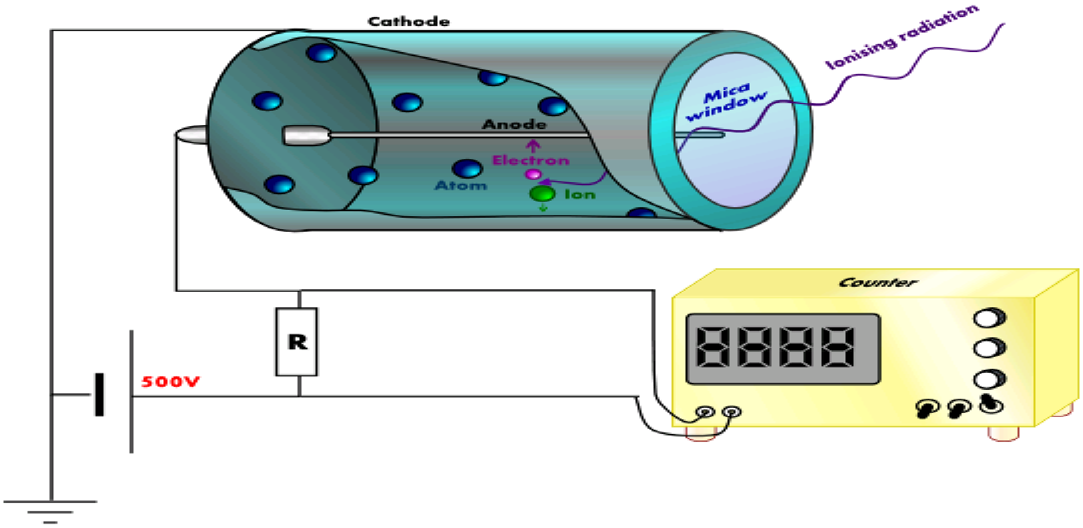


Fig. 2: illustration of a scintillation event in a photomultiplier tube

Geiger-Müller counter:

A Geiger-Müller counter is a pulse-type radiation detector which gives rise to negative pulses due to radiations incident on it. The negative pulses are counted using the counter.

It consists of a cylindrical metallic tube filled with an inert gas like Argon or Neon mixed with some organic vapour at a pressure of about 10 cm of mercury. When any radiation is incident on the GM counter, it sets out a primary ionizing event in the sensitive volume of the counter. The electrons so released are accelerated by the electric field and cause further ionization. The collective effect of such phenomena develops into a progressive avalanche spreading throughout the length of anode causing momentary discharge. This spontaneous discharge lowers down the potential of the anode, giving rise to a negative pulse. During the interval of this negative pulse, which is of the order of 100-200 μ seconds, the counter is inoperative for any radiation incident on it. Hence it is called dead time. This is approximately equal to resolving time. For an accurate assessment of activity, the observed count rate must be corrected for the resolving time.



Gamma-ray interactions with matter:

There are three dominant gamma-ray interactions with matter:

1. Photoelectric effect.
2. Compton effect.
3. Pair production.

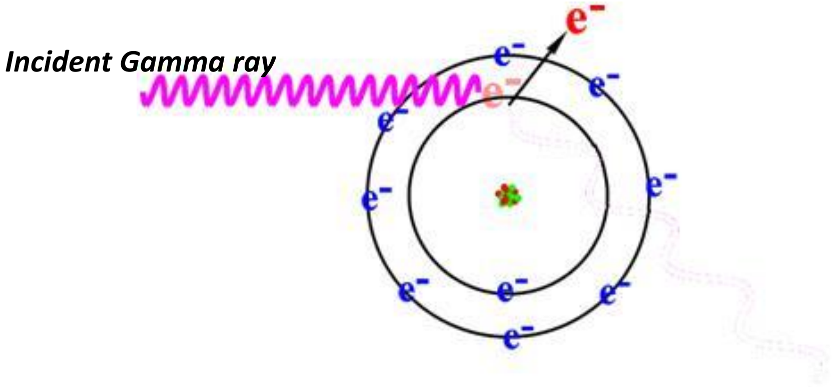
(1) The photoelectric effect is a common interaction between a low-energy gamma-ray and a material. In this process, the photon interacts with an electron in the material losing all of its energy. The electron is ejected with an energy equal to the initial photon energy minus the binding energy of the electron. This is a useful

process for spectroscopy since an output pulse in a detector is produced that is proportional to the gamma-ray energy, as all of the energy of the gamma-ray is transferred to the detector. This produces a characteristic full-energy peak in the spectrum that can be used for the purpose of identifying the radioactive material.

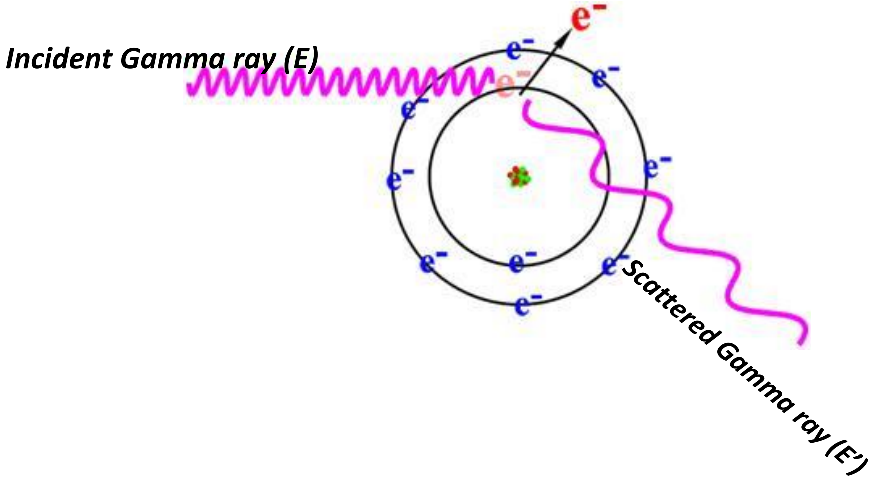
(2) The photon can scatter by a free electron and transfer an amount of energy that depends on the scattering angle. This process is called Compton scattering.

(3) Pair production can occur when the gamma-ray energy is greater than 1.022 MeV and is a significant process at energies above 2.5 MeV. The process produces a positron and electron pair that slow down through *Fig. 3* scattering interactions in the material. When the positron comes to rest, it annihilates with an electron producing a pair of 511 keV gamma rays that are produced back-to-back. These can be absorbed through the photoelectric effect to produce full-energy peaks at 511 keV. A component due to Compton scattering can also be observed. When a photon interacts with the crystal through pair production, one or both of the annihilation photons can escape undetected from the crystal. If one of the photons escapes undetected, then this will result in a peak in the spectrum at an energy of 511 keV less than the full-energy peak. This is called the single escape peak. Similarly, if both photons escape undetected, a peak will appear 1022 keV below the full energy peak, called the double escape peak.

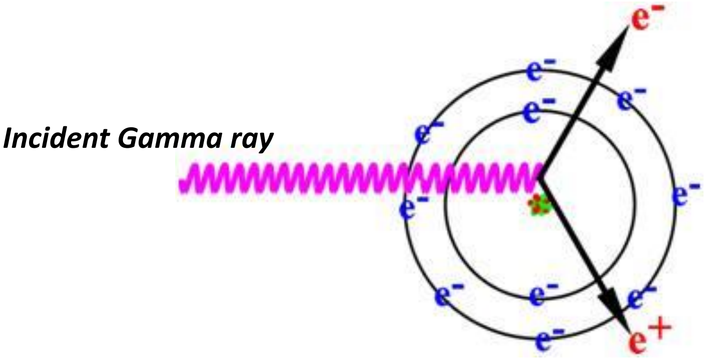
Photo electric



Compton scattering



Pair production



Experiment (1):

Poisson's distribution and Gaussian distribution of Radioactive decay

Fig. 1: Experimental set-up.

❖ Purpose

1. To understand the statistical nature of radiation.
2. To calculate statistical quantities.

❖ Principle

Radioactive decay is a random process. In an experiment, the number of counts obtained will fluctuate due to the statistical nature of the data. One can predict the distribution function that describes the results of many such repeated measurements.

In this experiment, we will see that the frequency of occurrence of a particular deviation from this average, within a given size interval, can be determined with a certain degree of confidence. One hundred independent measurements will be made, and some rather simple statistical treatments of the data will be performed. The average count rate for n independent measurement is given by:

$$N_{ave} = \frac{N_1+N_2+\cdots+N_n}{n} \quad \ldots\ldots\ldots\ldots\ldots(1)$$

N_1: count rate for the first measurement

N_2: count rate of the second measurement

In summation notation N_{ave} can be written as:

$$N_{ave} = \sum_{i=1}^{n} \frac{N_i}{n}$$

The deviation of individual count from mean is ($N_i - N_{ave}$). From the deviation of N_{ave} it is clear that

$$\sum_{i=1}^{n} (N_i - N_{ave}) = 0$$

So the standard deviation (SD)

$$\sigma_{th} = \sqrt{N_{ave}}$$

and the experimental mean square deviation σ_{exp} evaluated from

$$\sigma_{exp} = \sqrt{\sum_{i=1}^{n} \frac{(N_i - N_{ave})^2}{n-1}} \quad \ldots\ldots\ldots\ldots\ldots(2)$$

On the other hand, the statistical theory of error is usually based on the normal (Gaussian) distribution function. The normal distribution function $W(N_i)$ is a continuous function of N_i defined in such a manner that the quantity $W(N_i)$ gives the probability that the value of N_i lies between N_i and $N_i + dN_i$.

The normal distribution function $W(N_i)$ can be written a

$$W(N_i) = \frac{1}{\sigma\sqrt{2\pi}} exp^{\frac{-(N_{ave}-N_i)^2}{2\sigma^2}} \qquad \ldots\ldots\ldots\ldots\ldots(3)$$

Figure (1) illustrates the form of the distribution along with its most important properties.

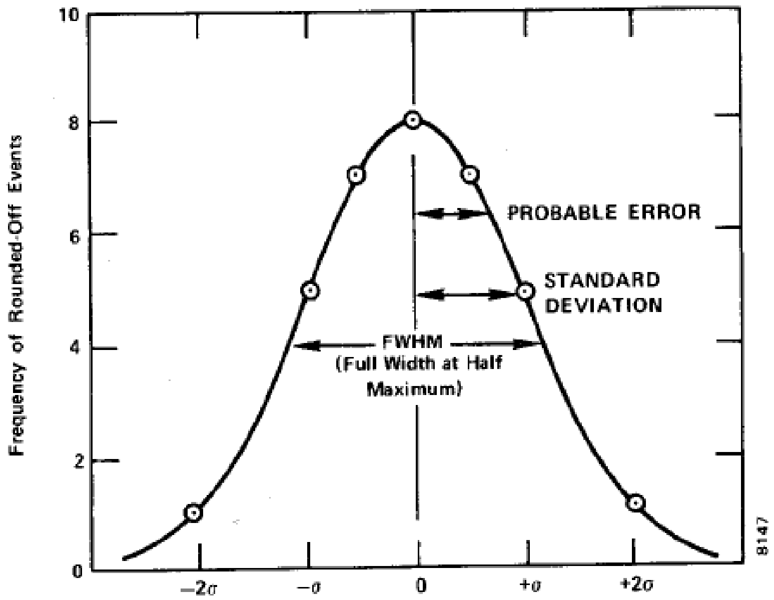


Fig. (1): Typical plot of frequently of rounded–off events vs. rounded–off value.

Equipment

• Geiger-Müller-Counter	13606-99
• Geiger-Mueller counter tube, type B	09005-00
• Base plate for radioactivity	09200-00
• Source holder	09202-00
• ^{137}Cs radioactive source	
• Timer & Counter	
• Screened cable, BNC, l = 750 mm	07542.11

❖ Experiment Guide

1. The experiment is set up as shown in part I.
2. Turn on the Geiger counter and allow it to warm up for a few minutes.
3. Take background activity measurements.
4. Place the Cs-137 into the wooden block.
5. Place the Geiger counter (10 centimetres) from the source.
6. Record the counts per (60 sec) with the source.

1. Repeat this measurement and take 60 independent counts for (60 sec). and record your values in Table (1). The scalar value N_i may be directly in the table since for this experiment N_i is defined as the number of counts recorded for (60 sec). the time interval, and then find N_{ave} from eq. (1).

Table (1)

Run	N_i	$N_i - N_{ave}$	$(N_i - N_{ave})^2$	W(Ni)
1 2 . . . 60				
	N_{ave}=	$N_i - N_{ave}$	$\Sigma(N_i - N_{ave})^2$	

1. Evaluate experiments at (SD) σ_{exp} from eq. (2) and compare it with σ_{th}.
2. Choose a class interval for your reading (not less than ten intervals), find the frequency for each interval and draw a histogram. It's obtained by drawing rectangles whose height are frequencies and widths are the interval or ranges.

Illustration

Suppose we take 100 observation of counting rate per minute of radioactive source, let this observation being as follows:

21 44 45 55 67 78 96

31 46 56 63 64 73 87

74 65 41 54 42 32 48

37 54 83 … 82 74 52

… … … … 71 46 ….

… … … … … …. ….

Total = 60 observation.

The above set of data exhibits no pattern except that the counting rate differs from each other (between 20 and 96). If we present this data in a different way it will provide us with useful information, for this, we can divide the data into 8 intervals, Table (2).

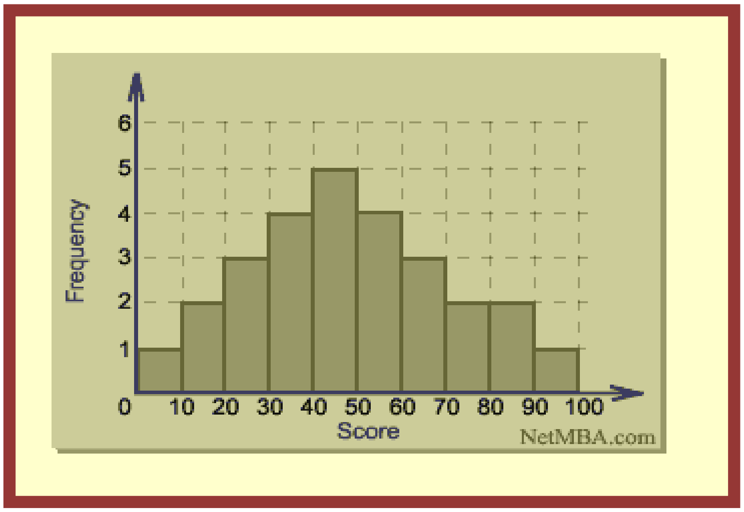
Table (2)

S	Range of counting rate	Frequency of occurrence of counting rate in that range
1	20------------------------- 30	3
2	30--------------------------40	6
3	40------------------------- 50	14
4	50--------------------------60	27
5	60--------------------------70	24
6	70--------------------------80	17
7	80--------------------------90	12
8	90------------------------100	1

The above data called the frequency table. In order to plot this data the interval taken on x-axis and frequency (f) on the y-axis.

The frequency of every interval is marked at the mid-point of that interval and all the points are joined by straight lines. The figure so obtained is called frequency polygon.

3. Evaluate the histogram area from:



Histogram area = width of interval X total no. of trails and match the values of total probability

P= W (Ni) X histogram area

Take midpoint data of interval and draw the distribution on the same graph paper of the histogram compare between the two graphs.

4. Calculate W(Ni) for each record value Ni, σ is taken equal to $\sqrt{N_{ave}}$ and plot W(Ni) as a function of Ni, verify that the (FWHM) as obtained from the graph is equal to 2.354 σ which representing investigation of Gaussian distribution of radioactive decay event.

Questions

- List the formulas for finding the means and standard deviations for the Poisson and Gaussian distribution.
- How close are the standard deviation values when calculated with the Poisson and Gaussian distributions? Is one right (or more correct)? Is one easier to calculate?
- If you make an experiment with the background counts, which distribution can better describe the data well, Poisson or Gaussian?
- Which one describes the Cs-137 data, Poisson or the Gaussian distribution?

Experiment (2):

Operating Plateau for the Geiger-Muller Tube

Apparatus

RAD Lab Program contained:

- Geiger-Muller Tube
- Shelf stand
- Serial cable
- Radioactive Source (Cs-137)
- Computer.

Purpose

To determine the plateau and optimal operating voltage of a Geiger-Müller counter

Theory

Basically, the Geiger counter consists of two electrodes with gas at reduced pressure between the electrodes. The outer electrode is usually a cylinder, while the inner (positive) electrode is a thin wire positioned in the centre of the cylinder. The voltage between these two electrodes is maintained at such a value that virtually any ionizing

particle entering the Geiger tube will cause an electrical avalanche within the tube. The Geiger tube used in this experiment is called an end-window tube because it has a thin window at one end through which the ionizing radiation enters.

The Geiger counter does not differentiate between kinds of particles or energies; it tells only that a certain number of particles (betas and gammas for this experiment) entered the detector during its operation. The voltage pulse from the avalanche is typical>1 V in amplitude. These pulses are large enough that they can be counted in a Timer & Counter without amplification.

All Geiger-Müller (GM) counters do not operate in the exact same way because of differences in their construction. Consequently, each GM counter has a different high voltage that must be applied to obtain optimal performance from the instrument. If a radioactive sample is positioned beneath a tube and the voltage of the GM tube is ramped up (slowly increased by small intervals) from zero, the tube does not start counting right away. The tube must reach the starting voltage where the electron “avalanche” can begin to produce a signal. As the voltage is increased beyond that point, the counting rate increases quickly before it stabilizes. Where the stabilization begins is a region commonly referred to as the knee, or threshold value. Past the knee, increases in the voltage only produce small increases in the count rate. This region is the plateau we are seeking. Determining the optimal operating voltage starts with identifying the plateau first. The end of the plateau is found when increasing the voltage produces a second large rise in count rate. This last region is called the discharge region.

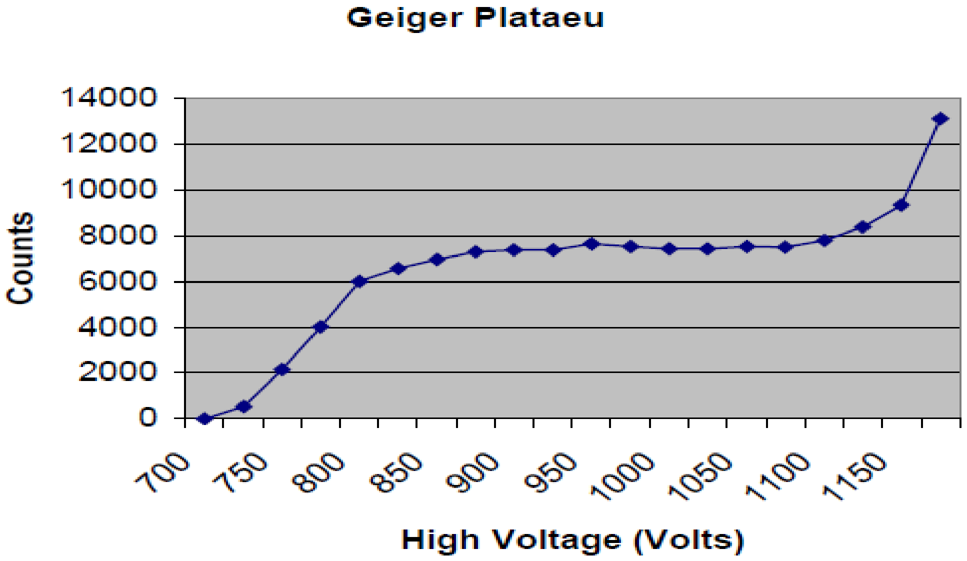
Procedure (Creating a Plateau Chart)

I. Running the unit as stand-alone

1. Place the radioactive source in a fixed position close to the window or in the well of the detector.
2. Put the ST360 into *Count* mode and slowly increase the high voltage until the first bar of the ACTIVITY paragraph lights.
3. Set the Preset Time to 10 seconds and press *COUNT*.
4. When the preset time expires, record the counts and the high voltage setting.
5. Increase the voltage by 20 volts and count data again.
6. When the preset time expires, record the counts and the high voltage setting again.

7. Repeat steps 5 and 6 until the high voltage reaches its upper limit (this is determined by the upper operating voltage limit of the detector).
8. Create an X-Y graph of the data, with "Y" being the Counts, and "X" being the voltage, and plot the chart.

The following chart shows a typical detector plateau.



9. One way to check to see if your operating voltage is on the plateau is to find the slope of the plateau with your voltage included. If the slope for a GM plateau is less than 10% per 100 volts, then you have a "good" plateau. Determine where your plateau begins and ends, and confirm it is a good plateau.

The equation for slope is

$$Slope(\%) = \frac{100(R_2 - R_1)/R_1}{V_2 - V_1} X100,$$

where R_1 and R_2 are the activities for the beginning and endpoints, respectively. V_1 and V_2 and the voltages for the beginning and endpoints, respectively.

Questions

1. Where within the plateau one should select the counter operating voltage?
2. On what factors do the operating voltage of the counter will depend?
3. How does electric potential effect a GM tube’s operation?
4. Will the value of the operating voltage be the same for this tube ten years from now?

Experiment (3):

The deflection of nuclear radiation in a magnetic field

Fig. 1: Experimental set-up.

❖ Purpose

To deflect the path of beta radiation by means of magnetism.

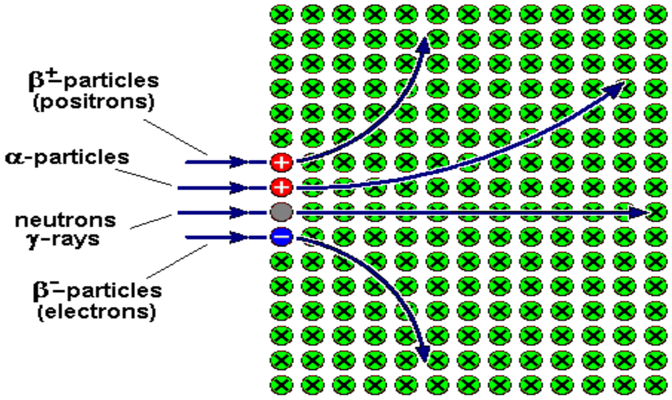
❖ Principle

The Lorenz force acts on β-particles which move perpendicularly to the direction of a magnetic field. At constant velocity and magnetic field strength, the β-particles move through the field in a circular path, the radius of which is dependent upon their velocity and the magnetic field strength.

As β-particles exhibit a continuous energy spectrum, they are deflected by a magnetic field to different extents. This makes it possible to experimentally determine the proportions of the various energy values, for example, by evaluating the count rates C measured for pre-determined paths as a function of the magnetic flux density B.

The simplified experimental set-up used here allows the following knowledge to be won:

a. β-radiation consists of electrically charged particles, as it is deflected by a magnetic field.
b. β-particles have a negative charge, as the direction of deflection is opposite to that which is to be expected to form the three-finger rule.
c. The stronger the magnetic field, the greater the deflection. When the direction of the field is reversed, deflection is in the opposite direction.
d. β-particles have various energies, as they are deflected to different amounts.



Equipment

Geiger-Müller-Counter	13606-99
Geiger-Mueller counter tube, type B	09005-00
Base plate for radioactivity	09200-00
Plate holder on fixing magnet	09203-00
Counter tube holder on fix.magn.	09201-00
Source holder on fixing magnet	09202-00
Defl.magnets f. plate holder,2pcs	09203-02
Sr-90 (beta source)	

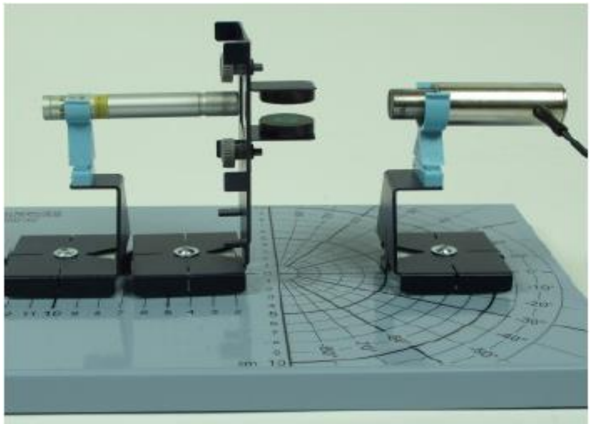
Experiment Guide

2. Turn on the Geiger counter and allow it to warm up for a few minutes.
3. Take background activity measurements.
4. Place the Sr-90 (a beta source) into the wooden block.

Notes on set-up and procedure:

This experiment only gives satisfactory results when the set-up and procedure are carefully carried out. Pay particular attention to the following conditions:

- ✓ The magnetic field should be at the centre point of the angle of graduation.
- ✓ The exit opening of the source of radiation should be in front of the magnetic poles.
- ✓ The distance between the source of radiation and the counter tube window should on no account be changed when the counter tube is moved on the angular scale, as this would lead to large differences in the count rates. Mark the position of the counter tube in the counter holder to avoid displacement of the counter tube.
- ✓ • The counter tube axis runs radially when both of the counter tube holder markers point to the same angle graduation.



5. Place the Geiger counter eight centimetres from the source.

6. Place the magnet holder so that when a magnet is inserted in it, the path of the beta particles is between the Geiger counter and the source.
7. Take a reading with the source and magnet holder in place but without any magnets near them.
8. Move the counter tube holder to the 10° graduation on the angular scale, making absolutely sure that the distance of the counting tube from the source of radiation does not change and that the axis of the counter tube is exactly aligned along with the angle graduation. Start the next measurement and enter the count rate in the following table.
9. Place the two cow magnets into the opening of the magnet holder so that a magnetic field crosses the path of the beta particles and place the distance (d =2 cm) between them.
10. Record the counts per minute for three trials
11. Repeat this measurement with all of the angles from +90° to -90° listed in the following table.
12. Repeat steps (8-10) for (d = 3cm).

Angle	**Without Magnets**	**With Magnets (d=1 cm)**	**With Magnets (d=2 cm)**
in degrees	N (count/min)	N (count/min)	N (count/min)
+90			
+80			
+70			
+60			
+50			
+40			
+30			
+20			
+10			
0			
-10			
-20			
-30			
-40			
-50			
-60			
-70			
-80			
-90			

❖ Questions:

- Which effect do the magnets exert on the movement of the β -radiation?
- Compare the experimental results with the behavior of a conductor carrying current in a magnetic field.
- Which influence does the distance between the magnets have on the deflection of the β -radiation? Explain this observation.

Experiment (4): .

Absorption of gamma in Matter

Fig. 1: Experimental set-up.

❖ Purpose:

- To demonstrate attenuation of gamma rays in the matter.
- To determine the half-value thickness $d_{1/2}$ and the absorption coefficient μ of a number of materials by measuring the impulse counting rate as a function of the thickness of the irradiated material "Lead, iron, aluminium and Plexiglas" are used as absorbers.
- To calculate the mass attenuation coefficient from the measured values.
- To calculate the gamma energy using the mass attenuation coefficient.

❖ Principle:

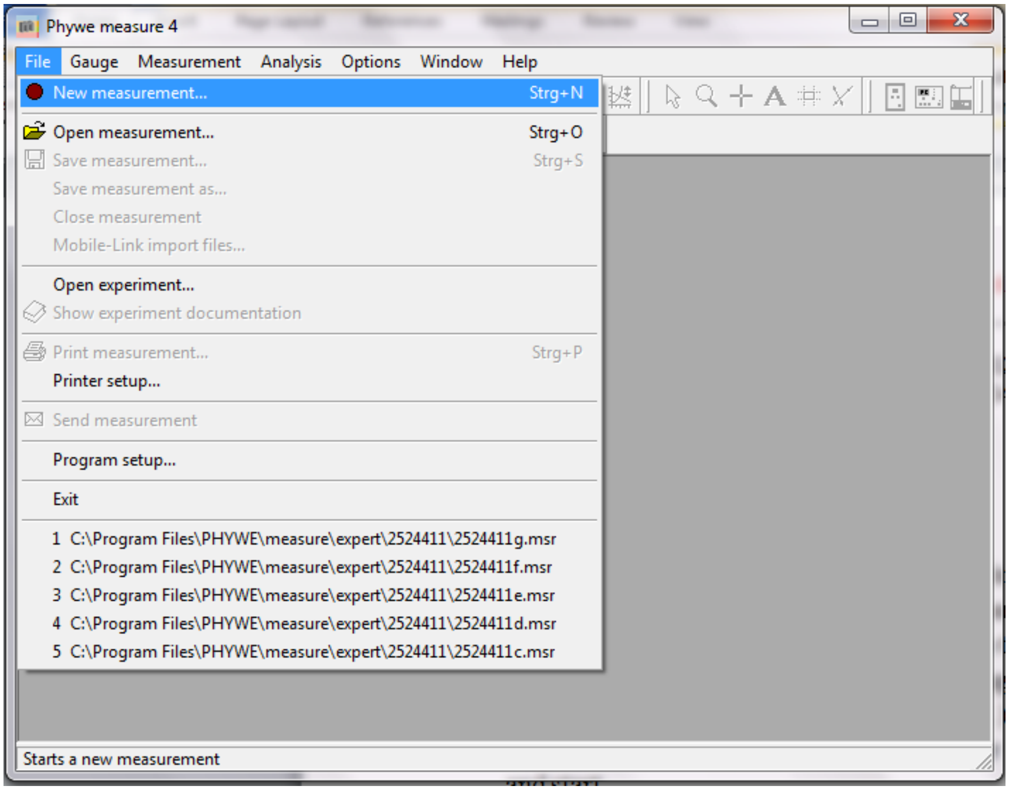
The inverse square law of distance is demon started with the gamma radiation from a Cs^{137} preparation, the half-value thickness and absorption coefficient of various materials determined with the narrow beam system and the corresponding mass attenuation coefficient calculated.

Equipment

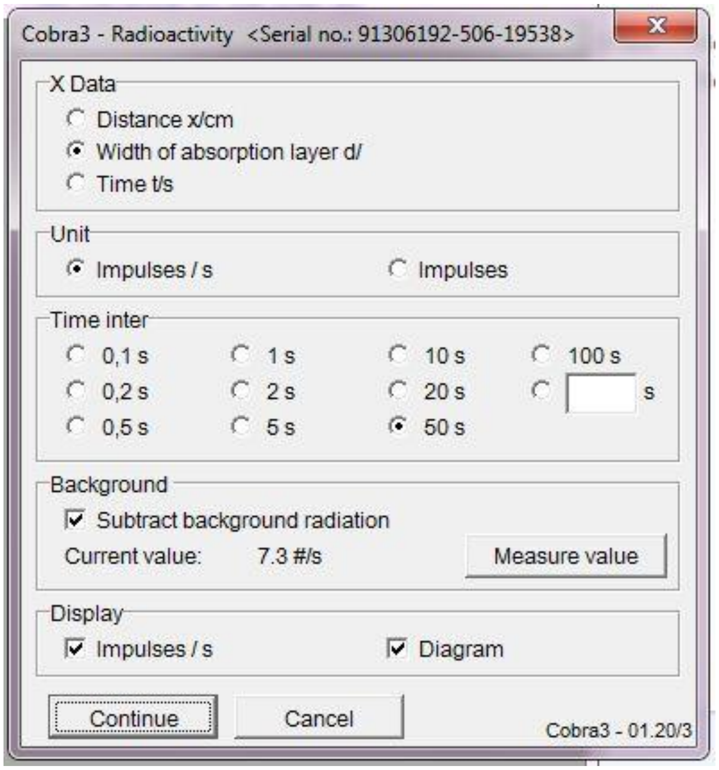
Cobra3 BASIC-UNIT	12150.00
Cobra3 Power supply	12151.99
RS232 data cable	14602.00
Cobra3 Radioactivity Software	14506.61
Counter tube module	12106.00
Unit-construction plate for radioactivity	09200.00
Counter tube, magnet held	09201.00
Source holder, magnet held	09202.00
Plate holder for demonstration board	
with magnet	09204.00
Counter tube, type A	09025.11
Screened cable, BNC, l = 300 mm	07542.10
Vernier caliper	03010.00
Radioactive sources, set	09047.50
Absorption plates for b-radiation	09024.00
Absorption material, lead	09029.01
Absorption material, iron	09029.02
Absorption material, aluminum	09029.03
Absorption material, Plexiglas®	09029.04
Absorption material, concrete	09029.05
PC, Windows® 95 or higher	

❖ Experiment Guide

1. Set up the apparatus as shown in Fig. 1.
2. Start the “ **measure**” program, select the gauge “**Cobra 3- Radioactivity**” and start “ **File → New measurement** “ as shown in Fig.2.



1- Set the “x **data**” to “**width of absorption layer d**”, set the “Unit” to “**impulses/s**”, set the “Time **inter**” to “**100 s**”, set the “Background” to “**subtract background radiation**” and set the “display” to “**impulses/s**” as shown in Fig. 3.



Cobra3 - Radioactivity <Serial no.: 91306192-506-19538>

X Data
○ Distance x/cm
● Width of absorption layer d/
○ Time t/s

Unit
● Impulses / s
○ Impulses

Time inter
○ 0,1 s
○ 0,2 s
○ 0,5 s
○ 1 s
○ 2 s
○ 5 s
○ 10 s
○ 20 s
● 50 s
○ 100 s
○ s

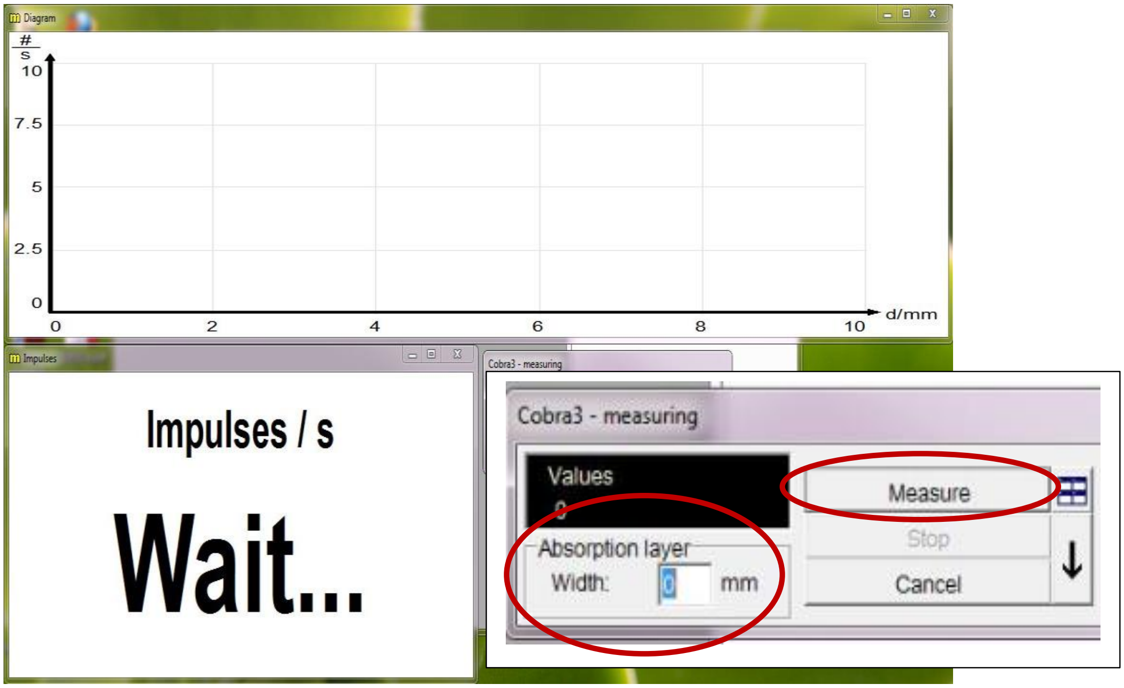
Background
☑ Subtract background radiation
Current value: 7.3 #/s

Display
☑ Impulses / s
☑ Diagram

2- Activate measurement by clicking on <**Continue**>.

3- During the measurement, the distance between the counting tube and the source (Cs^{137}) must not be changed.

4- Initially, enter ”0” in the input field for the absorber layer (cf. Fig. 3) and click on <Measure>. As shown in Fig. 4

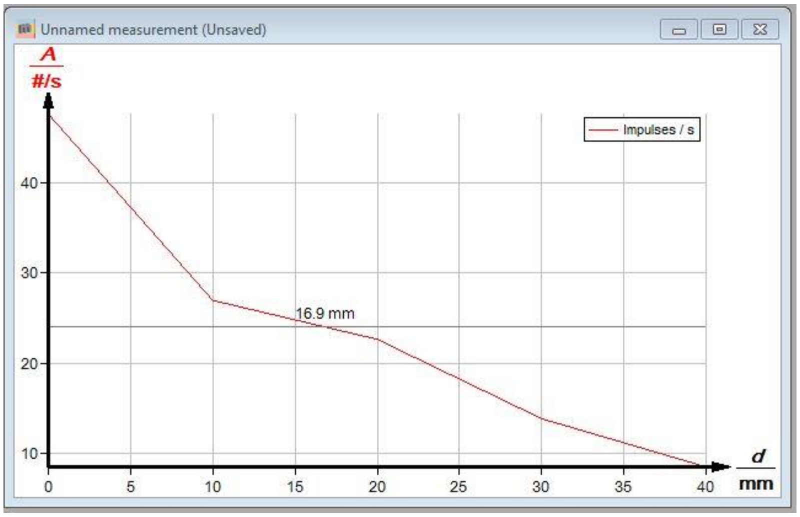


Width: 0 mm

5- After each measurement increase the layer thickness of the lead absorber by **10 mm**, enter the new thickness value of the absorber layer in the appropriate field and click on <**Measure**>. Continue in the same manner until the maximum thickness of **45 mm** has been reached.

6- After the last measurement has been made, click on the <**stop**> button.

7- To Determination of the half-value thickness, both parameters are displayed if the exponential measurement curve in the active image can be seen and then the evaluation functions <**Analysis**>, <**Half-value time /-layer thickness**> are selected and find the "**Half-value time /-layer thickness**" as shown in **Fig. 5.**



8- Repeat the steps (2-9) for the following absorber materials: **Iron, aluminium, Plexiglas**.

9- The attenuation coefficient characteristic for the material (and the energy of the gamma radiation) for a very specific layer thickness d_H the initial quantum flux is reduced to half of its original value.

$$\frac{1}{2} I_0 = I_0 \cdot e^{-\mu d_{\mathrm{H}}}$$

From this, it follows that the half-value thickness d_H is determined by the attenuation coefficient μ.

$$d_{\mathrm{H}} = \frac{\ln 2}{\mu}$$

or

$$\mu = \frac{\ln 2}{d_{\mathrm{H}}}$$

$$\mu_m = \frac{\mu}{\rho}$$

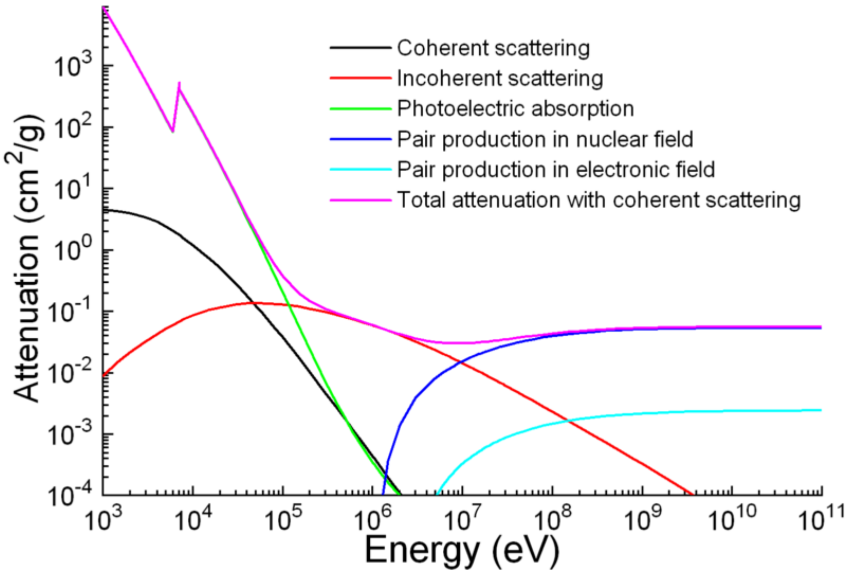
Were μ_m is the mass absorption coefficient by unit (g/cm)

10- Range the data as the table shown below:

Material	Density g/cm^3	Half-value (layer) thickness d_H in cm	Attenuation coefficient μ in cm^{-1}
Lead	11.11		
Iron	7.68		
Aluminium	2.70		
Concrete	1.87		
Plexiglas®	1.19		

11- Plots graph between the density (**ρ**) for that material as a function of the linear attenuation coefficient (**μ**).

12- Find the gamma energy (**E_γ**) using the mass attenuation coefficient of **iron** (**μ_m**) and using the following graph.



Experiment (5):

Verification of Inverse Square Law for Gamma-Ray

❖ Purpose

- To measure the impulse counting rate as a function of the distance between the source and the counter tube.

❖ Principle

The inverse square law of distance is demonstrated with the gamma radiation from a Co^{60} preparation, the cobalt isotope Co^{60} has a half-life of 5.26 years; it undergoes beta-decay to yield the stable nickel isotope Ni^{60}.

As with most beta emitters, disintegration leads at first to daughter nuclei in an excited state, which changes to the ground state with the emission of gamma quanta. Whereas the energy levels of the beta electrons can assume any value up to the maximum because of the antineutrinos involved, the gamma quanta which participate in the same transition process have uniform energy, with the result that the gamma spectrum consists of two discrete. The impulse counting rate N (r) per area A around a point source decreases in inverse proportion to the square of the distance provided the gamma quanta can spread out in straight lines and are not deflected from their track by interactions.

$r_2 = 2\, r_1 \qquad A_2 = 4 \cdot A_1 = \left(\frac{r_2}{r_1}\right)^2 \cdot A_1$

The reason for this is that, as shown by Fig. 3, the area of a sphere around the source through with a beam of ray passes, increases as the square of the distance r. In a vacuum (in the air), therefore

$$\frac{\dot{N}(r)}{A} = \frac{\dot{N}(o)}{A} \cdot \frac{1}{4\pi} r^{-2}$$

If we plot the counting rate N(r) versus the distance r on a log scale, we obtain a straight line of slope – 2.

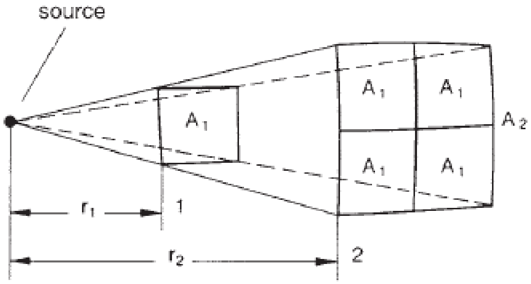


Fig. 3: Law of distance relating to rays which are propagated in a straight line from a point source.

From the regression lines from the measured values in Fig. 4, applying the exponential expression

$$\dot{N}(r) = a \cdot r^b,$$

we obtain the value

$$b = -2.07 \pm 0.01$$

for the exponent.

This thus proves the applicability of the inverse square law.

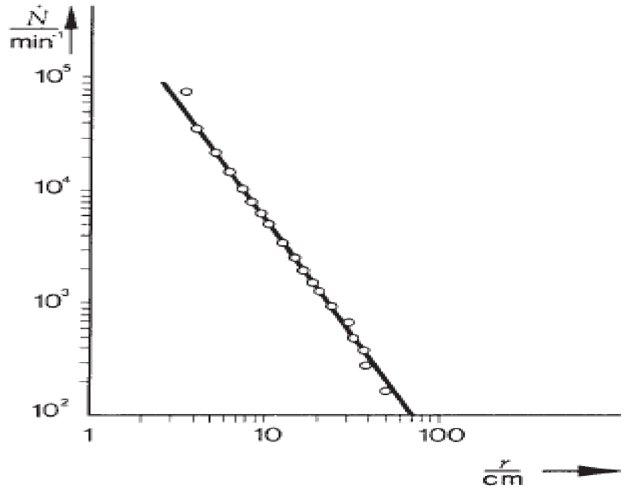


Fig. 4: Counting rate plotted against distance (log-log plot).

Equipment

Geiger-Müller-Counter	13606-99
Geiger-Mueller counter tube, type B	09005-00
Base plate for radioactivity	09200-00
Plate holder on fixing magnet	09203-00
Radioactive sources	
Timer & Counter	
Support rod -PASS-, square, l = 250 mm	02025.55

Procedure

1. Set- up the apparatus as shown in Fig.1
2. Turn on the Geiger counter and allow it to warm up for a few minutes.
3. Take background activity measurements (Nb) for (1min).
4. Place the ^{137}Cs into the wooden block.
5. Place the Cs^{137} source at a suitable distance (r=2 cm) from the detector face.
6. Record the counts per (60 sec) with the source.

7. Change the distance between source and counter face in regular step (1 cm) and repeat the counting rate (n1, n2 and n3) with each change in distance.
8. Find the background count rate (without source) and tabulate data as follows.
9. Plot a graph between n (y-axis) and ($1/X^2$) (x-axis), then from the slope evaluate N using eq. (3).

X/cm	Count / sec			$n = n_{ave}-n_b$	$1/d^2$ (cm^{-2})
	n_1	n_2	n_{ave}		
2					
3					
4					
5					
6					
7					
8					
9					
10					

❖ Questions

- Why it is necessary that the distance between the source and the detector should be greater than the radius of the detector?
- Give the reason, why the graph between n and $1/d^2$ do not pass through the origin.
- Is the calculated value of N representing the exact activity of the radioactive source?
- Explain your answer.