NSE 115
Hands-on HP Survey Laboratory

1. PURPOSE

The purpose of this laboratory is to investigate the shielding effects of different materials using radiation sources and detectors.

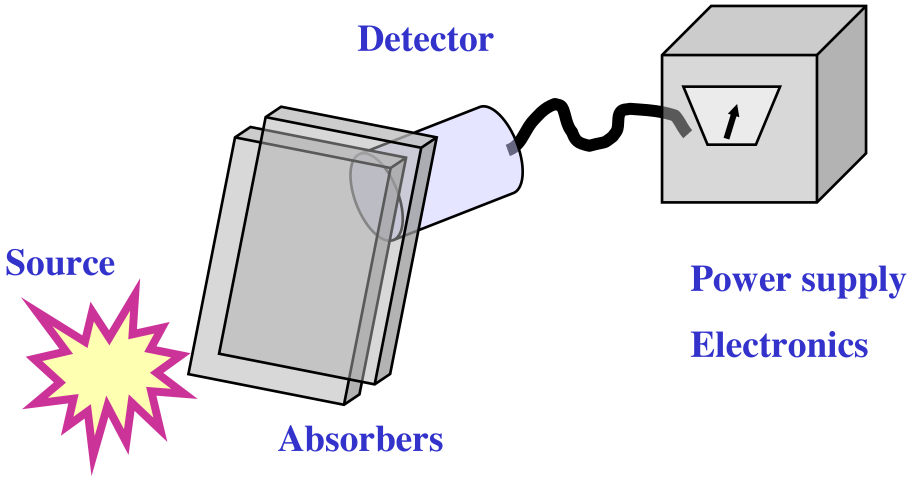

Figure 1: Sketch of Experimental Setup

2. BACKGROUND

The most common types of radiation encountered in nuclear systems are alpha and beta particles, neutrons and gamma rays. Charged particles lose their energy as they move through an underlying medium through ionization; nuclear interactions are also possible. Neutrons lose their energy through individual scattering events, and eventually may be captured in the nuclei of the medium. Gammas interact with matter in three distinct ways: photoelectric effect, Compton scattering and pair production (This was discussed in lecture).

Consider a beam of <u>*gamma*</u> radiation incident on an absorber of finite thickness. As radiation interacts with the absorber, the intensity of the beam in decreased, and the magnitude of the decrease is a function of the absorber thickness. This process is described by the equation below[1]:

$$I = I_o \cdot e^{-\mu x} \tag{1}$$

where I_o is original intensity, I is final intensity, x is the absorber thickness (in cm), and μ is the linear attenuation coefficient (a tabulated quantity). If we rearrange this equation and take the natural log of both sides, we find:

$$\ln\left(I/I_o\right) = -\mu x \tag{2}$$

The half value thickness is defined as the thickness of absorber that will cut the intensity in half, i.e.,

$$\ln\left(I/I_o\right) = 0.5 \tag{3}$$

If we plug this into Equation (2), we obtain

$$\ln\left(0.5\right) = -\mu x_{1/2} \tag{4}$$

Where $x_{1/2}$ represents the thickness of the absorber necessary to reduce intensity to ½ the original amount. Equation (4) can be further modified as follows:

$$x_{1/2} \cong 0.693/\mu \tag{5}$$

Or,

$$\mu \cong 0.693/x_{1/2} \tag{6}$$

Experimentally, $x_{1/2}$ is measured and μ is calculated and tabulated.

[1] This equation primarily describes the behavior of gamma-ray interactions in matter

3. PROCEDURE

1. Set up the electronics as shown in Figure 1 *(This will be done for you before you begin the lab)*.
2. Make sure the detector is turned on
3. Determine the background count rate of the detector – you will subtract this value from each of the subsequent data points you collect
4. Place the source at a distance of ~3 cm from the detector, let the reading on the detector "stabilize"[2]
5. Record the count rate on the last page of this lab.
6. Keeping detector – source distance constant, place a sheet of absorber[3] between the source and the detector and take another reading – again – let the detector "stabilize"
7. Record your results.
8. Continue adding sheets until the count rate is at most 25% of the initial value (the value you recorded with no absorber between the detector and the source).
9. Plot the net count-rate data on semi-log paper.
10. Determine $x_{1/2}$
11. Repeat steps 1 – 10 for a second absorber

Table 1: Data on 3" x 3" Absorbers Used in Lab Experiment

Absorber Specifications	Atomic Number[4]	Thickness of Absorber [in]	Mass of Absorber [g]
Aluminum	13	0.005	2.08
Copper	29	0.005	6.66
Wood	5-6?	0.064	3.62

2 Your detector may have a "fast" and "slow" response position – try both of these and see if it makes a difference in the reading you get.
3 The instructor has a variety of absorbing materials – metals, plastics, wood, select two types
4 The atomic number of elements is based on the proton number. For compounds it can be estimated as the product of each element and its fractional abundance in the material. Some types of radiation interactions can be strongly dependent on the atomic number, as well as the energy of the radiation

4. ANALYSIS AND DISCUSSION

1. What type of detector did you use for this experiment (gas-filled, solid state, scintillator, other…)?
2. How difficult was it to take measurements using this detector?
3. What type of radioactive source was used?
4. How far was the source from the detector?
5. What kind of absorbers did you use?
6. Could you calculate a half value thickness for your absorbers from the data? Did you have to extrapolate beyond your count rate data in order to do so?
7. What were your half value thicknesses? What are your μ values?
8. What conclusions could you draw about the radiation absorption characteristics of your two absorbers? Are they similar? Are they different?
9. If you were to expand this experiment, what other questions would you want to see answered?
10. If you were to redesign this experiment, how would you do it?

5. DATA SHEET –RADIATION ABSORPTION

Detector Description – write down the specifications of your detector (manufacturer, model number, calibration date, type of probe)				
Radioactive source description – write down what you know about the source utilized in thisexperiment (describe):				
	Absorber Material #1 (specify) ____________________		Absorber Material #2 (specify) ____________________	
Measurement Number	Gross count rate, cpm or microR/hr	Net Rate, cpm or microR/hr	Gross count rate, cpm or microR/hr	Net Rate, cpm or microR/hr
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				
11				
12				
13				
14				
15				
Source to Detector Distance: ________________________				

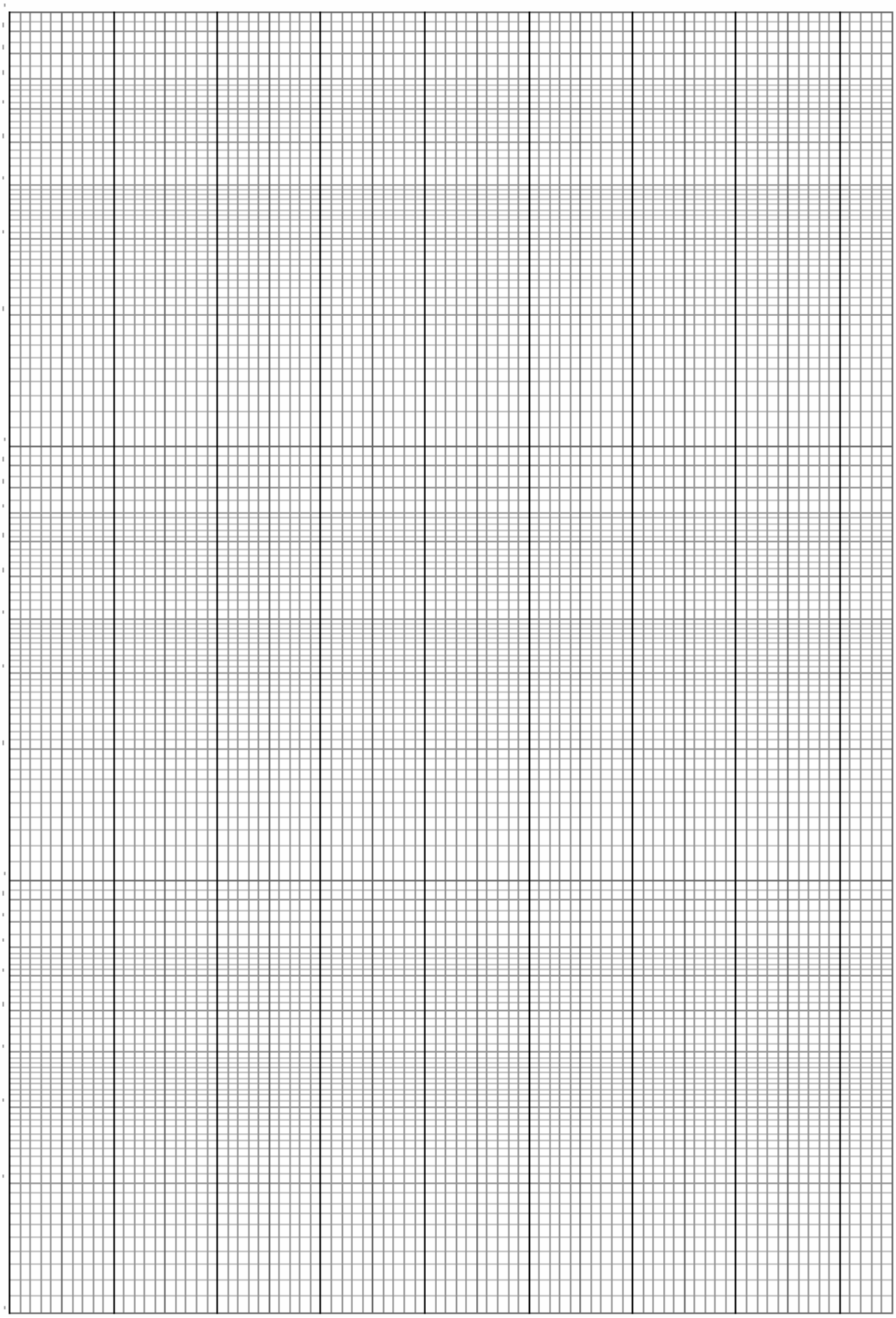

Figure 2: Thickness of Absorber, (units?)