

Prelab: Read this lab handout and write a goal statement in your lab book. Copy the table below into your lab book and fill in all of the columns except the last one. Use Walker sections 32(1), 32(2) and Appendix E as a reference in filling out the table. You can also query the web site <http://www2.bnl.gov/CoN/> for nuclear properties. Walker 32(7) is also useful.

Equipment: In this investigation, you will use the same equipment as for lab E1. Refer to and follow the set up instructions for lab E1. Use the Histogram Radiation vs Bin screen as you did in that lab. **NOTE ABOUT EFFICIENT USE OF TIME IN THIS LAB:** You will make many measurements of count rates in this lab. In order to finish the lab during the class period, we suggest counting for 30 seconds for each measurement. Set your software to count for 30 consecutive 1-second intervals. As you did in Lab E1, open a new Table Tall Window → Table so that you can view a list of your data.

Part A: Effects of Source/Detector Positioning and Background Radiation

1. Place the Geiger tube above a source and observe the count rate. What could you do with the source to make a significant change in the count rate?
2. Adjust the height of the tube above the source to give a count rate of 25-50 per second. Use the Meter box to view the count rate. Make a hypothesis about what causes the variation in count rates. In this part and the next part (3), you'll need to use the Radiation vs. Time graph to have the computer calculate the mean and standard deviation of your data. Record the mean and standard deviation.
3. Now remove the source from under the Geiger tube. Make sure all radioactive sources are far away. Watch the count rate for about thirty seconds. Why are counts registered even when the sources are removed? Are there other sources of radioactivity in the room? What might they be? List (and the label) the most likely ones first (if you're not sure, see Walker p. 1075). You have measured what is called the background rate. Record the mean and the standard deviation for the background rate.

In the remainder of the lab (and in all future radioactivity experiments), it is important to realize that the background rate is always there. Therefore, any measured count rate from a radioactive source must be significantly (say, 3x) above the background count rate to be considered "real."

Part B: Effects of Intervening Objects on the Detection Rate of α , β , and γ rays

4. In the following section, follow the instructions for one alpha, one beta and one gamma source. You will only need one source at a time. You should have already reproduced the following table in your lab book. Record the half-lives for the radioactive isotopes you actually use in the right-most column.

Source Type	Radio-active Parent Isotope	Electric charge of Parent Isotope Nucleus	Atomic Mass No. of Parent Isotope	Particle Emitted	Charge Of Particle Emitted	Atomic Mass No. of Particle Emitted	Daughter Isotope	Charge of Daughter Isotope	Atomic Mass No. of daughter isotope	Half life ($T_{1/2}$) of Parent Isotope Nucleus
α	^{241}Am									
β^-	^{204}Tl									
β^-	^{90}Sr									
γ	^{137}Cs									
γ	^{60}Co									

5. Now, make another large table in your lab journal (covers 2 complete pages) with alpha, beta, and gamma as the columns and Observations 7 – 10 (see below) as rows for each column. It does not matter which source you investigate first. **NOTE:** Unlike the beta and gamma sources, the alpha source is exposed and can fall out of the red/blue plastic holder. For this reason, you must obtain the alpha source directly from the instructor or work service helper, and you must return it directly to them (not to any other lab group) when you are finished.

6. a) Place a source under the Geiger counter. Adjust the height of the Geiger counter on the ring stand and use the wooden 1cm spacers so that there is 2.0 cm of space between the top of the source and the bottom of the detector (for the alpha source, use 1cm).
- b) Make sure that a count rate significantly higher (at least 10 times) than the background is obtained; if not, use a different source. For an alpha source, make sure that the side of the source with the open hole is facing the Geiger counter. For a beta or gamma source, compare the count rates with different sides of the source facing the detector; use the side that gives a higher count rate. Once you have an acceptable count rate, mark the location of your source as follows: put a blank piece of scrap paper on the base of your ring stand and tape it, so that the paper is flat and will not move.
- c) Center the source as accurately as you can directly underneath the detector window. For a beta or gamma source, next trace the outline of your source on the paper, using a pen. For an alpha source only, obtain 21 cardstock spacers. Put the spacers on the paper, and trace the outline of the spacers. Then put the source on top of the spacers, and trace the outline of the source on the topmost spacer. In the remainder of the lab, do not move the detector, and make sure the source is always at the same location whenever you take data. Finally, record the average count rate with your source at this location.

Do #7 for the alpha source ONLY: (a polonium source is superior to an americium source here)

7. a) If your source is ^{241}Am do the following (for ^{210}Po sources skip to part b.) Place a single piece of paper between the source and the detector. Measure the count rate with the paper in place. SUBTRACT the count rate using the paper from the count rate without the paper; this is the count rate for alpha particles that you want (^{241}Am also emits gamma rays, which we do not want to count here, thus we are subtracting them). Show clearly in your lab book your calculations. Continue on to part b
- b) Remove five of the spacers (5 spacers = 0.25 cm) and repeat the data collection (for ^{241}Am , do this both with and without paper shielding). Does the alpha particle count rate decrease noticeably? If so, why? Is anything "shielding" the detector from the alpha particles when there is no paper? How many additional 0.25-centimeters of distance between source and detector are required to reduce the alpha particle count rate to 1/10 (or less) of its original value?

Do #8-#10 for the beta and gamma sources ONLY:

8. Place a sheet of white (not black) plastic between the source and the counter.
 - a) What is the new count rate? (and how can you tell if the count rate changed if the count rate jumps around? What counting mode would be best to use in this part? Why?)
 - b) How many sheets of plastic are required to reduce the average count rate to 1/10 (or less) of its original (i.e., without any intervening plastic) value? If you run out of space to add more plastic, you may end this experiment and just report the maximum number of sheets you used, and the fraction by which the count rate was reduced.
9. Place sheets of copper between the source and the counter. Use enough sheets so that the total thickness of the copper is the same as the thickness of one square of the plastic. Determine the new average count rate. Add or remove copper sheets to find the minimum number of copper sheets that will reduce the count rate to 1/10 or less of the original count rate. Report all results.
10. Place a square of the lead (there are two kinds of lead: thick and thin; use the **thick** squares) between the source and the counter. What is the new count rate? How many sheets of lead are required to reduce the average count rate to 1/10 of its original value?

Analysis Questions

11. Why were you instructed in step 3 to make sure all other sources were far from the tube? To what source does this instruction particularly apply? Remember this lesson in future experiments with the Geiger tube.
12. Why isn't the alpha source enclosed in plastic as are the beta and gamma sources?
13. An important lesson from the above series of activities has to do with radiation protection. List at least three factors (other than shielding and counter/source separation distance) that influence the total amount of radiation one's body might encounter from a radioactive source (i.e., the total number of decay particles that hit your body). Explain why each of the factors influences the amount of radiation you receive.
14. Explain why the α 's are the least penetrating rays and why the γ 's are the most penetrating rays; use the properties of the individual rays and the impulse-momentum version of Newton's 2nd law to do this. There are at least two separate reasons why α 's are the least penetrating rays and why the γ 's are the most penetrating rays

15. Give two reasons (again using Newton's 2nd law) that a lead sheet was more effective shielding than a copper sheet.

Conclusion