

# Advanced Lab II: Lab Template

LAB #?: A Lab

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*PH326 Section ? Lab Group ?*

*Experiment Date: ...*

*Report Due Date: ...*

## Abstract

Should be 4-8 sentences. 1-2 about the physics you are investigating, 1-2 about the apparatus and method, 1-2 about the results. If results are quantitative, quote number and errors. Summarize briefly your conclusions.

Grade	Score
Abstract and Cover Pg.	
Fig. & Plt.	
Data & Error Ana.	
Writing	
Total	

## 1 Introduction

Write a brief introduction stating the objective of the laboratory. This section should be brief. One paragraph is generally fine.

## 2 Apparatus

Describe the apparatus using clearly labeled figures. The figures can include diagrams, photographs, block diagrams. Don't forget to write captions for your figures. The captions should include a few sentences about what the figures describe.

## 3 Data Collection

This contains the raw data and the starting point of your data analysis. This is where we find table(s) and spectra of raw data collected, including units and, if applicable, errors. To make good tables, think about all the information you need to carry out further calculations. For example, you may have taken data over different time periods: your table would then indicate integrated number of counts, length of time over that the data were taken and finally count rate deduced. The latter column can then be used for further analysis. Also, do not put the errors in different columns, instead write the results as  $X \pm \Delta X$ . Again explain things carefully in the caption. You need to include some text explaining how the data presented in the tables and plots were collected and/or deduced from basic calculations. Some information may be needed for further calculation, such as distance from the source, etc things that did not change in the whole data collection. This can appear in the text outside of the tables. If you collect many spectra, only show a few examples (label them as examples in the caption). You can put the others in the Appendix. Same for tables if you have a lot of data. For some labs, you may be asked to include sketches of oscilloscope traces with both axes labeled including units.

A NaI(Tl) scintillation detector was used in recording  $\gamma$  emissions produced by  $^{137}\text{Cs}$  and  $^{60}\text{Co}$ . Other things occurred. Some results were found with  $\pm$  errors. You might have used the MAESTRO<sup>®</sup> software. Maybe an you will reference something in appendix A.

## 4 Data Analysis

This section explains your data analysis and how you calculated/estimated the experimental uncertainties. You are often asked to carry data analyses involving different datasets and/or aiming at answering different problems. Create as many subsections as necessary. In each of them, you need to put the relevant information needed to carry out your calculations recalling the tables presented in Section 3. You may wish to put in key equations (including the ones used in error propagation), and a sample calculation. Make sure you define well the variables you are using in your equations. Present the qualitative results of the data and error analysis. This is typically one or more plots and a table. Write a few paragraphs describing the results including errors. Compare your results with models if applicable. Discuss successes, shortcomings. Make an attempt to explain why things may not have worked as expected. Look at your error bars; Do you think it would have been worth taking data for longer? Do you suspect a problem with systematic errors? In general, what conclusions about the physics you investigated may or may not be drawn based on your results and why? Think carefully about the physics, what the apparatus actually measured, and what the results, including errors actually show.

Signals rise time was  $\approx 20 \mu\text{s}$  and a fall time that is large comparatively at  $\approx 300 \mu\text{s}$ . Some data tables might look like:

Source	Energy (keV)	Peak (bin)	Fit FWHM (bin)	Net Area (bin)	Net Count Rate (s)
$^{137}\text{Cs}$	$661.657 \pm 0.0003$	$1 \pm 1$	1	$1 \pm 1$	1
$^{60}\text{Co}$	$1173.228 \pm 0.0003$	$1 \pm 1$	1	$1 \pm 1$	1
	$1332.492 \pm 0.0004$	$1 \pm 1$	1	$1 \pm 1$	1
$^{40}\text{K}$	$1460.822 \pm 0.0006$	$1 \pm 1$	1	$1 \pm 1$	1

Tab. 1: Spectral information from MAESTRO<sup>®</sup>. Energy from [2]

A fancy equation:

$$\text{Energy} = mx + B \quad (1)$$

You may use [3] to do some error analysis.

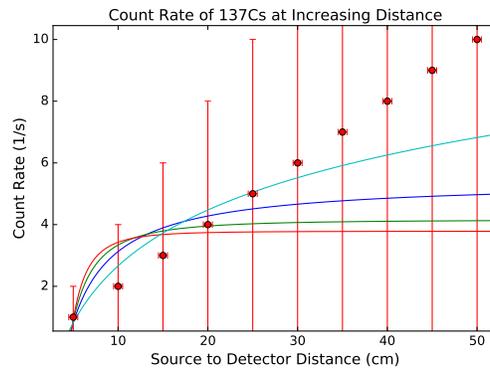


Fig. 1:  $r^{-1}$ =Blue,  $r^{-2}$ =Green,  $r^{-3}$ =Red,  $r^{-4}$ =Cyan, Data=Red points

## 5 Conclusion

What conclusions can you draw based on the results from your report? This is not a summary of the report or a recap what you did.

## **6 Contributions**

List briefly the contributions of each team member to report preparation.

## References

- [1] Lawrence Wiencke, Professor for PHGN-326. A Lab Report Guideline. Colorado School of Mines, Physics Department, 2017.
- [2] S.Y.F. Chu, L.P. Ekstrm, and R.B. Firestone1. “The Lund/LBNL Nuclear Data Search”, Last Modification:February 1999, <http://nucleardata.nuclear.lu.se/nucleardata/toi/perchart.htm>
- [3] John R. Taylor, Professor at the University of Colorado Department of Physics.“An Introduction to Error Analysis: The Study of Uncertainties in Physical Measurements” Second Edition, 1982.

## A Some common mistakes to avoid when writing reports

When you get your report back, read the comments as well as the grade. The comments represent an effort by the instructor to help you improve.

### A.1 Writing

Dont use 30 words when 10 would do. Read each paragraph of your report carefully. Then cross out as many words as you can while keeping the sentences coherent and without changing the essential points in the paragraph. Eliminating content-free fluff will improve the clarity of your report. Apply the So what? test to eliminate vague or content-free sentences. Heres an example. The PMT is an important tool that scientists often use to make complex measurements in the laboratory. In a lab report this sentence fails the so what? test by a huge margin. A common feature of student writing is the smushing of too many ideas into a long tangled sentence. These sentences convey just one clear piece of information. The writer was trying to explain something but failed. Use shorter sentences when possible. Look at the adjectives you are using. Where possible make them numeric. For example, the first counter had larger signals than the second becomes the first counter had signals that were about twice as large as the signals on the second counter as estimated by looking with an oscilloscope. Search and replace In order to with To. In order is technical version of umm. Oscilloscope not O-scope Run a spell checker and proof read. Dont be that group who turns a lab report with Compton Shattering as the title. Circulate the near final draft with enough time for your group to all read it carefully. Everyone in your group should share responsibility for final proof reading of the report. Make an appointment with the Mines writing center if your group is struggling with report writing.

### A.2 Formatting and Figures

Each tables and figures is accompanied by a caption. The caption should convey meaningful information specific to that figure. In some cases it can be appropriate to group similar plots together, label them A, B, C and have one caption. Make sure the figures as they appear in your report are large enough to read easily, including the axis labels and features you want the reader to notice. The default font size of Mathematica figures is much too small for lab reports. Assume that that key features or text too small to be seen easily by the grader will be treated as invisible when the report is graded. All font should be at least size 10. This includes the abstract, body of the report, captions, labels. Use 1 margins. Not 1.5 or 2. Do not refer to colored features in a figure of a report that has been printed in black and white and submitted for grading. Accompany a table of results with a plot. Nearly all of the major results in these labs should be displayed in tabular form and in plots. Make sure your plots include axis labels with units and captions. Data points should have errors bars, or a discussion explaining why they are not shown. Use a leading zero and a space before the units, ie 0.1 km (not .1 km or 0.1km or .1km)

### A.3 Instruments and Science

Work out the full process in which a gamma ray striking a NaI detector leads to a current emerging from the cathode or dynode output of the photomultiplier tube. Hint: With the exception of pair production, photoelectrons are created in the NaI scintillator and in the photomultiplier photocathode coating. These are not the same photoelectrons. You will need to write a coherent description of this process, including what happens in the NaI scintillator, for a number of your reports. For some reason groups tend to stumble on the NaI part. Just because your calculator or spreadsheet tells you a number has 10 significant figures, does not mean that your result, as described by this number, is also good to 10 significant figures. Use a number of significant figures appropriate to the data you collected or the result you obtained from your data analysis. Keep in mind that the possible accuracy of the final results of most experiments in this course range between 1% and 10%.  $1.040203 \pm 0.23452$  makes no sense at all for several reasons. Neither does  $1.0 \pm 0.234$  It should be probably be  $1.0 \pm 0.2$  See discussion in Taylor. Think carefully before invoking the Deus Ex Machina of background noise or radiation to (not) explain things that you dont understand in your data or results. Your instructors were student once. They also know about this infamous bumpy carpet. Should you

need to make this claim, and in some cases it may be justified, you also need to support it. Discuss carefully what these backgrounds might be and explain why you think they are large enough to matter.

#### **A.4 Conclusion**

Your report conclusion is not a recap or summary of what you did, or a summary of your results. Rather it is a discussion of the conclusions that can be drawn from your results. And yes, this is more challenging to because you really have to think. And this is precisely why a conclusion is required and not a summary or recap.