ANSEL

Advanced Nuclear Science Education Laboratory

Profs. Frank L.H. Wolfs and W. Udo Schröder

Created with Funds from the
Nuclear Regulatory Commission

Goals of ANSEL

Course Goals are to help students achieve
1. an understanding of our Radioactive Environment on Earth,
2. competence in the practice of detecting and safe handling of radioactivity,
3. capability to critically analyze experimental data.

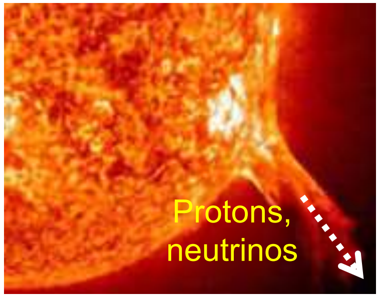
In support of these goals, ANSEL is designed to provide hands-on experience in

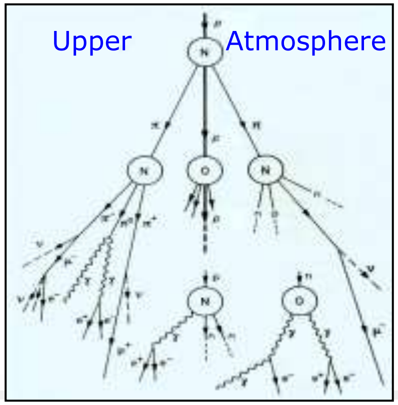
- detecting natural and artificial electro-magnetic and particle radiation,
- the use of diagnostic instruments (radiation detectors) and associated methods of electronic signal processing,
- setting up and conducting experimental studies in radiation science, and
- in data analysis with assessment of factual validity.

Practical relevance is illustrated in applications of radiation in natural science, advanced technology like medical imaging, destruction-free testing of materials, nuclear power.

Relevance of Radiation Science and Technology

Radioactive Terrestrial Environment





$${}^{14}_{7}N + {}^{1}_{0}n \rightarrow {}^{14}_{6}C + {}^{1}_{1}H$$

$$\Downarrow$$

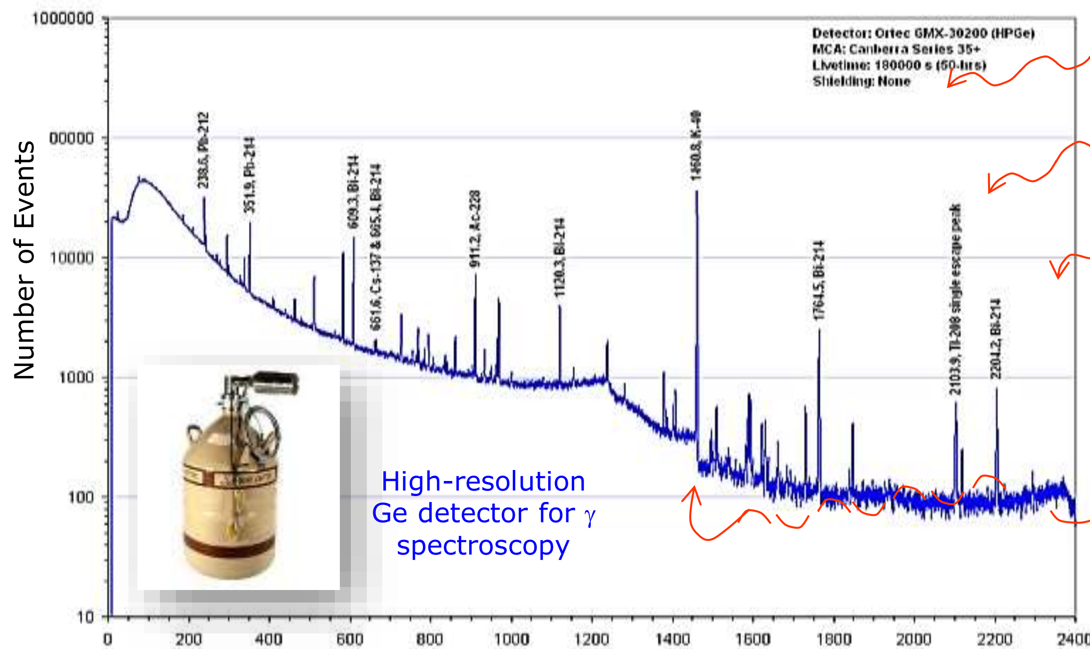
$${}^{14}_{7}N + e^{-} + \bar{\nu}_e$$

Nuclear Isotopes Terminology

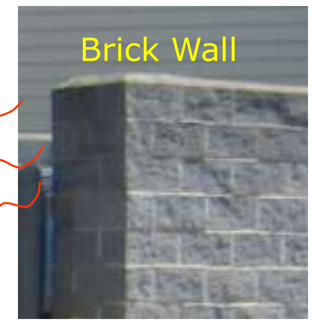
$${}^{N+Z}_{Z}C = {}^{A}C = C - A$$

$$C - 14 = {}^{8+6}_{6}C$$

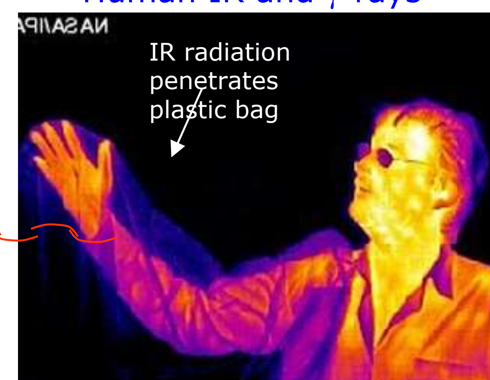
Energy Spectrum of γ-rays Emitted from Brick Wall



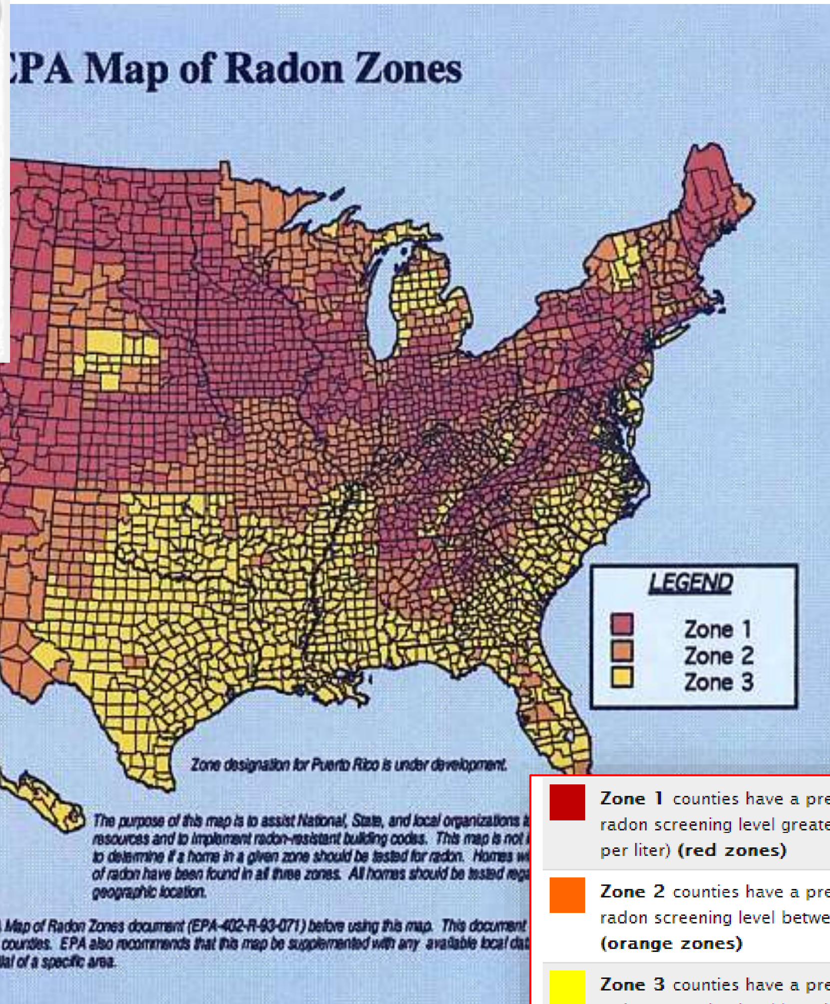
Energy Deposition of Environmental Radiation (keV)



Human IR and γ-rays



Detecting Radon Exposure Levels



NRC-Committee Report on Health Risks of Exposure to Radon BEIR VI:

1999: Increased potential for lung-cancer in (15,400 - 21,800) cases/year in U.S. due to residential radon exposure.

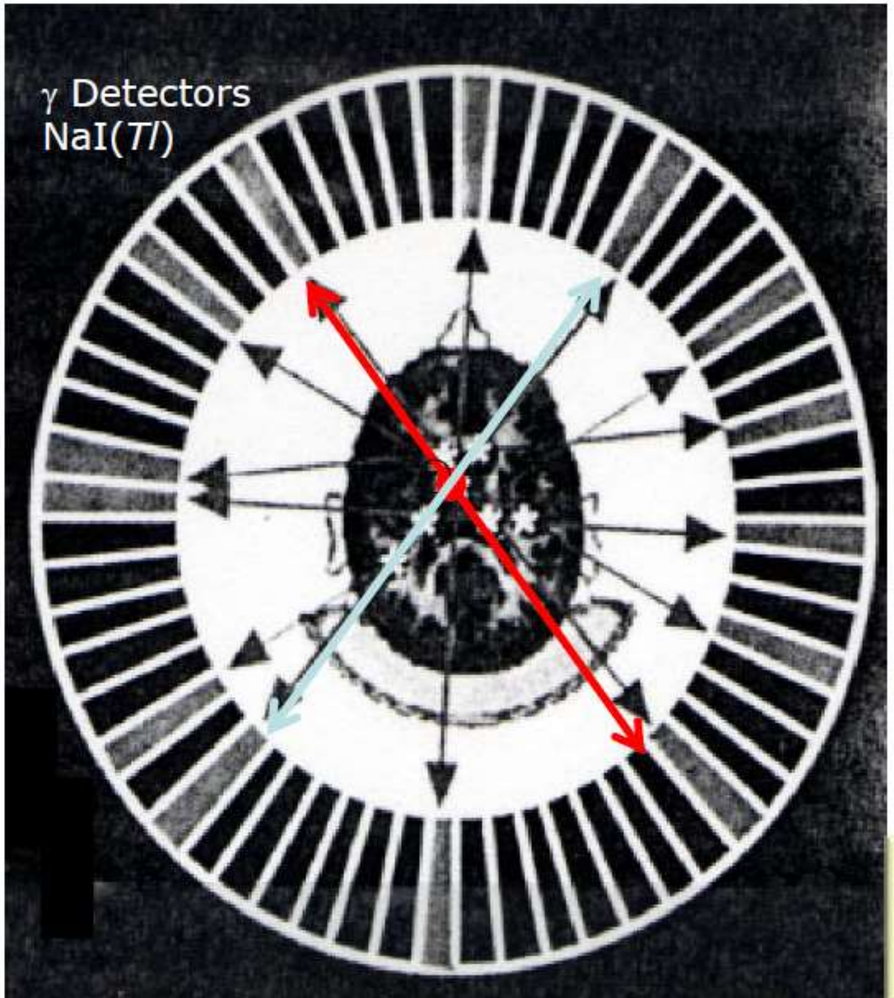
Health Effects of Exposure to Radon: BEIR VI, http://books.nap.edu/catalog/5499.html

	Zone 1 counties have a predicted average indoor radon screening level greater than 4 pCi/L (picocuries per liter) **(red zones)**	**Highest Potential**
	Zone 2 counties have a predicted average indoor radon screening level between 2 and 4 pCi/L **(orange zones)**	**Moderate Potential**
	Zone 3 counties have a predicted average indoor radon screening level less than 2 pCi/L **(yellow zones)**	**Low Potential**

$> 4 pCi/L \approx 0.4$ rem/a$=4$ mSv/a

Radiation Technology in Medical Diagnostics and Therapy

Positron emission tomographic (PET) virtual slice through patient's brain



Administer to patient
radioactive water: $H_2{}^{17}O$
radioactive acetate: $^{11}CH_3COOX$

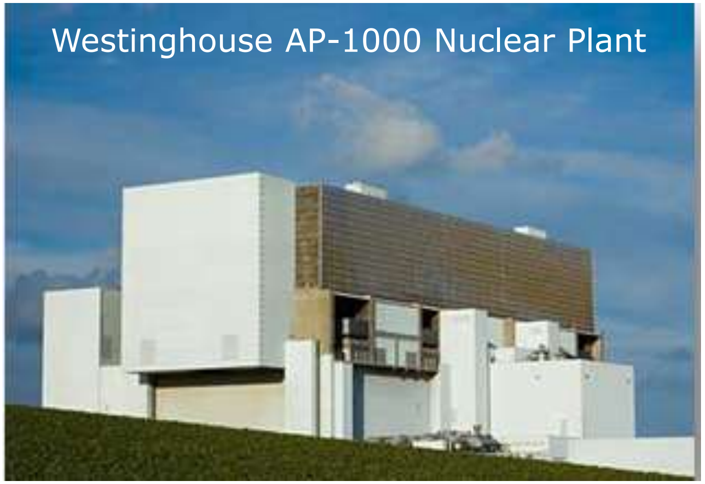
Observe ^{17}O or ^{11}C β^+ decay by

$$e^+ + e^- \rightarrow 2\gamma(511\ keV)$$

Positron e^+ (anti-matter) annihilates with electron e^- (its matter equivalent of the same mass) to produce pure energy (photons, γ-rays). Energy and momentum balance require back-to-back (180^0) emission of 2 γ-rays of equal energy

Target internal organs (eye, brain,..) with radiation destroying cancer cells. Radio-pharmaceuticals, ion beams,…

"Carbon-Free" Energy & Security Technology



Westinghouse AP-1000 Nuclear Plant

All containerized cargo coming into seaports in the United States is scanned by radiation diagnostic equipment. Automatic scans of inbound cargo for special nuclear and other radioactive material. Differentiation is possible because of specific interaction of radiation (absorption) with matter.

70 MW floating nuclear power plant (Rosenergoatom)

Nuclear fission reactors produce -20% of U.S. electricity, neutrons, gamma rays, radioactive medium-weight to transuranic isotopes. → reprocessing of fuel, reuse or incineration of used fuel elements ("waste")

Novel: Simpler, safer, modular reactor designs. Example: floating NPPT. Coming: Fusion demonstrator reactors.

Purpose of ANSEL

Course Goals are to help students achieve a
1. factual understanding of our natural radiation environment,
2. competence in the practice of detecting and handling radioactivity safely,
3. capability to critically analyze experimental data.

In support of these goals, ANSEL is designed to provide hands-on experience in

- detecting natural and artificial electro-magnetic and particle radiation,
- in the use of diagnostic instruments (radiation detectors) and associated methods of electronic signal processing and
- data analysis with assessment of factual uncertainty.

Practical relevance is illustrated in applications of radiation in natural science, medical imaging, and destruction-free testing of materials.

Regular ANSEL Schedule

Weekly lecture (M TBA, B&L 407) <u>during ≈ 6-9 weeks</u>

- to introduce & discuss scientific background of experiments; basic physics of atomic nuclei;
- to relate principles of radiation detection and measurement to modern applications in physics, chemistry, etc.;
- to introduce principles of data reduction and analysis;
- to practice effective ways of scientific communication.

Two weekly lab periods (T&R 2.00–4.40 p.m., B&L 156/177)

- to discuss experimental procedures
- to conduct various experiments
- to prepare and set up data acquisition for long data taking run (individual responsibility)

ANSEL attendants may obtain lab keys from the PAS Main Office ($ deposit).

ANSEL attendants must take the UR course & exam on radiation safety to work with radioactivity.

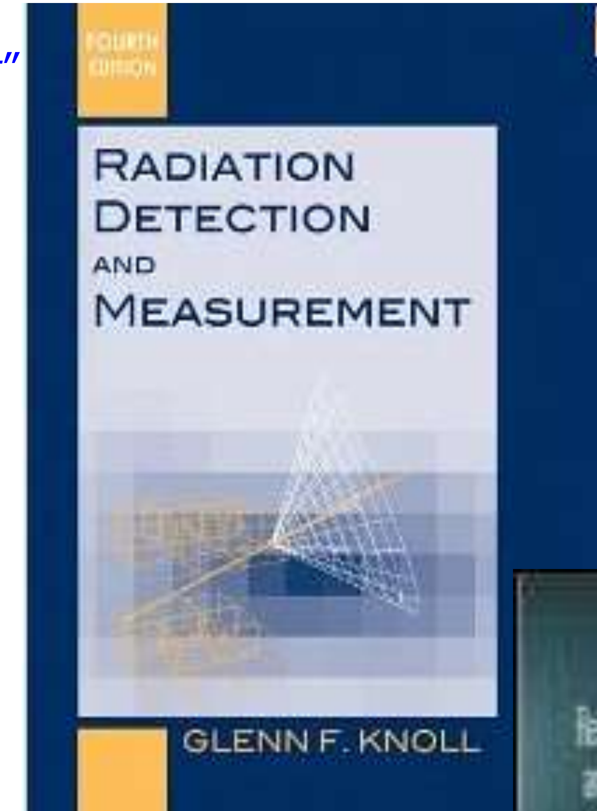
Ansel Textbooks, References, Websites

- Main textbook
  “*Radiation Detection and Measurement*”
  by Glenn F. Knoll.

- Good reference for data and error analysis:
  “Data Reduction and Error Analysis”
  by Philip R. Bevington and D. Keith Robinson

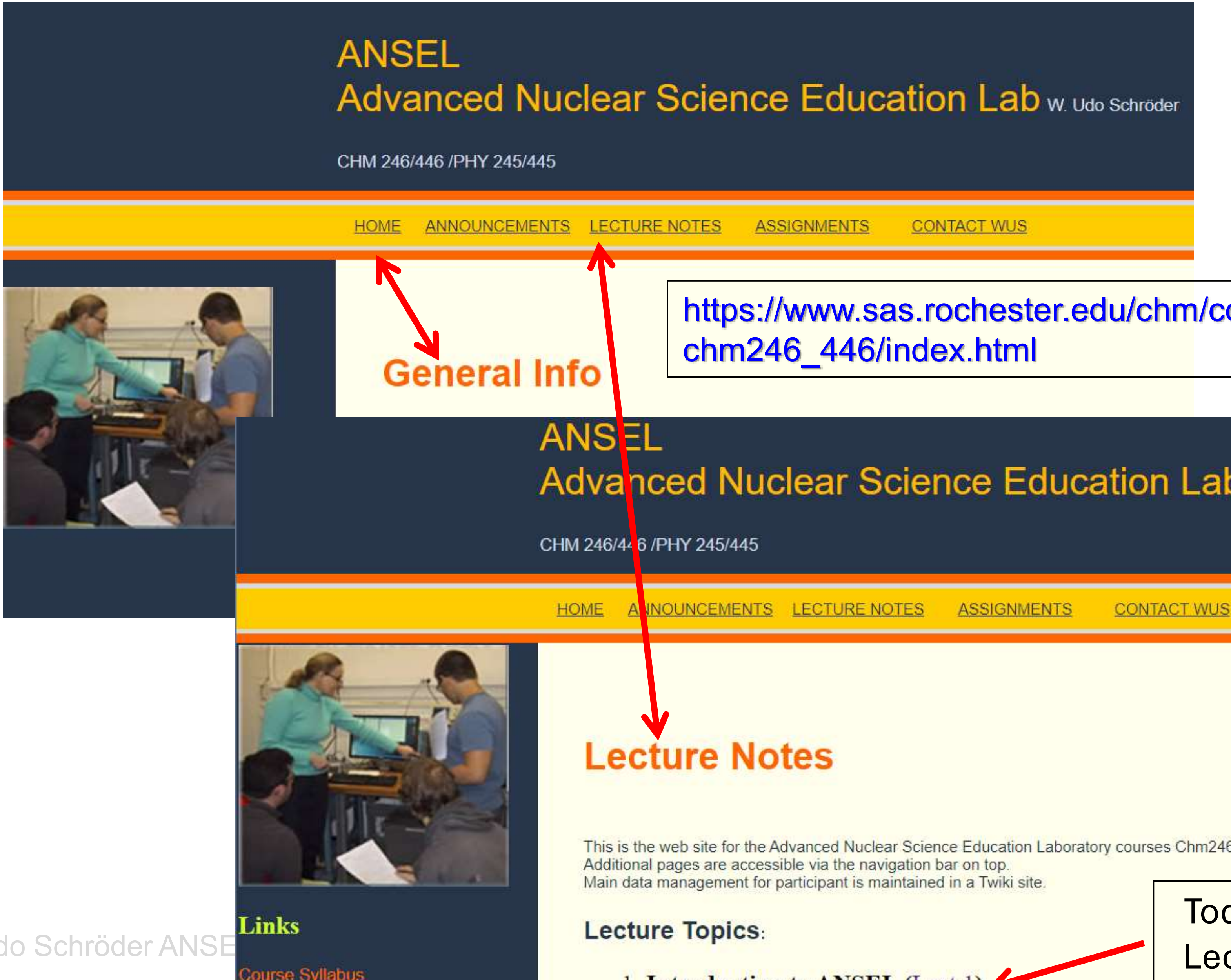
- Various ancillary tables, graphs

→ **Bound lab logbooks**
(B&N bookstore,...).



➡ Course website
(www.sas.rochester.edu/chm/courses/chm246_446/index.html)
Data storage, reference materials,
Twiki(http://teacher.pas.rochester.edu:8080/wiki/bin/login/ANSEL/WebHome?origurl=/wiki/bin/view/ANSEL/WebHome)

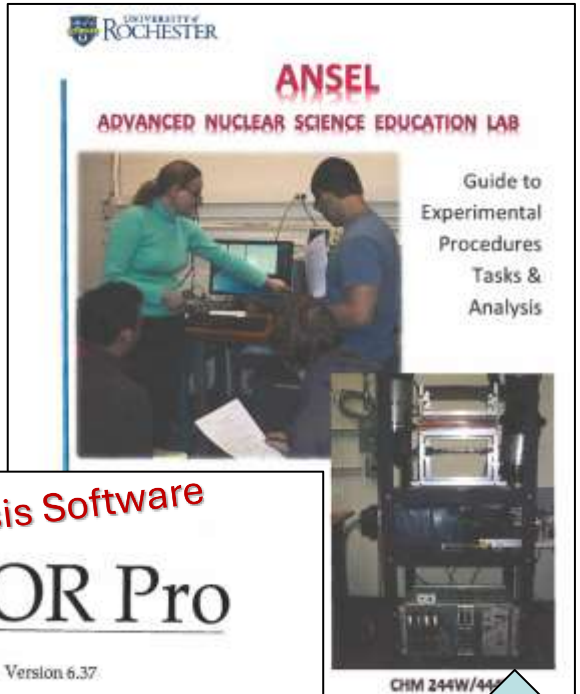
Resources: ANSEL Course Website 2024

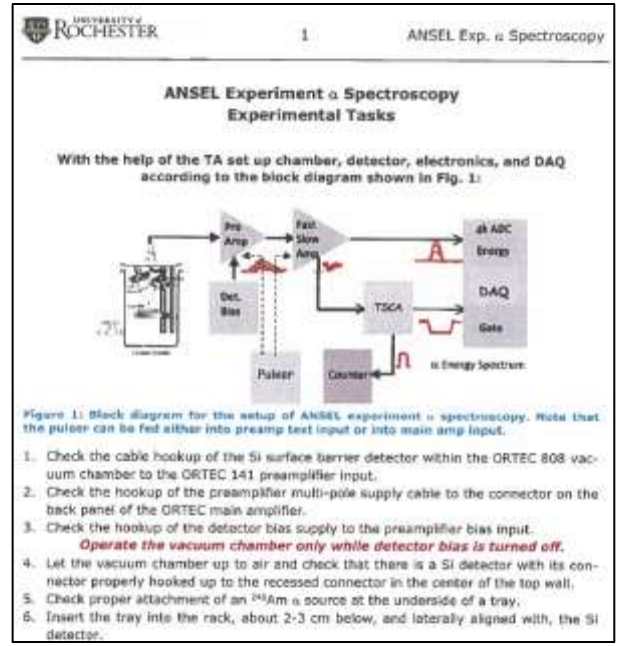


https://www.sas.rochester.edu/chm/courses/chm246_446/index.html

Today's Lecture

Resources for Experimentation & Analysis




UNIVERSITY of ROCHESTER 1 ANSEL Exp. α Spectroscopy

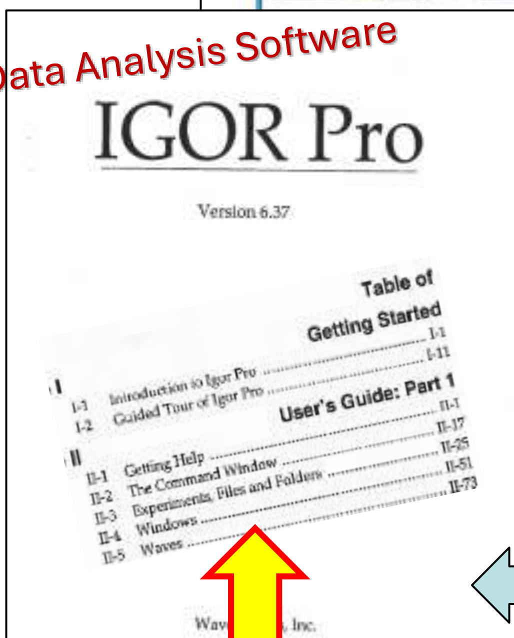
ANSEL Experiment α Spectroscopy
Experimental Tasks

With the help of the TA set up chamber, detector, electronics, and DAQ according to the block diagram shown in Fig. 1:

Figure 1: Block diagram for the setup of ANSEL experiment α spectroscopy. Note that the pulser can be fed either into preamp test input or into main amp input.

1. Check the cable hookup of the Si surface barrier detector within the ORTEC 808 vacuum chamber to the ORTEC 141 preamplifier input.
2. Check the hookup of the preamplifier multi-pole supply cable to the connector on the back panel of the ORTEC main amplifier.
3. Check the hookup of the detector bias supply to the preamplifier bias input.
   Operate the vacuum chamber only while detector bias is turned off.
4. Let the vacuum chamber up to air and check that there is a Si detector with its connector properly hooked up to the recessed connector in the center of the top wall.
5. Check proper attachment of an ^{241}Am α source at the underside of a tray.
6. Insert the tray into the rack, about 2-3 cm below, and laterally aligned with, the Si detector.

Data Analysis Software


IGOR Pro

Version 6.37

Table of

Getting Started

Wav..., Inc.

ANSEL Manual contains Task Sheets → define goals of experiments and data analysis, give guides to perform successful experiments.

IGOR = data processing software (PC & MAC) to treat and reduce data produced with available DAQ hardware

Resources

1. The ANSEL Twiki*:
   - Download software & useful course materials like equipment manuals.
   - Upload expt. data, analysis setups, etc.

>>>> *Quick review of the ANSEL Twiki* (cf. link given in initial message).

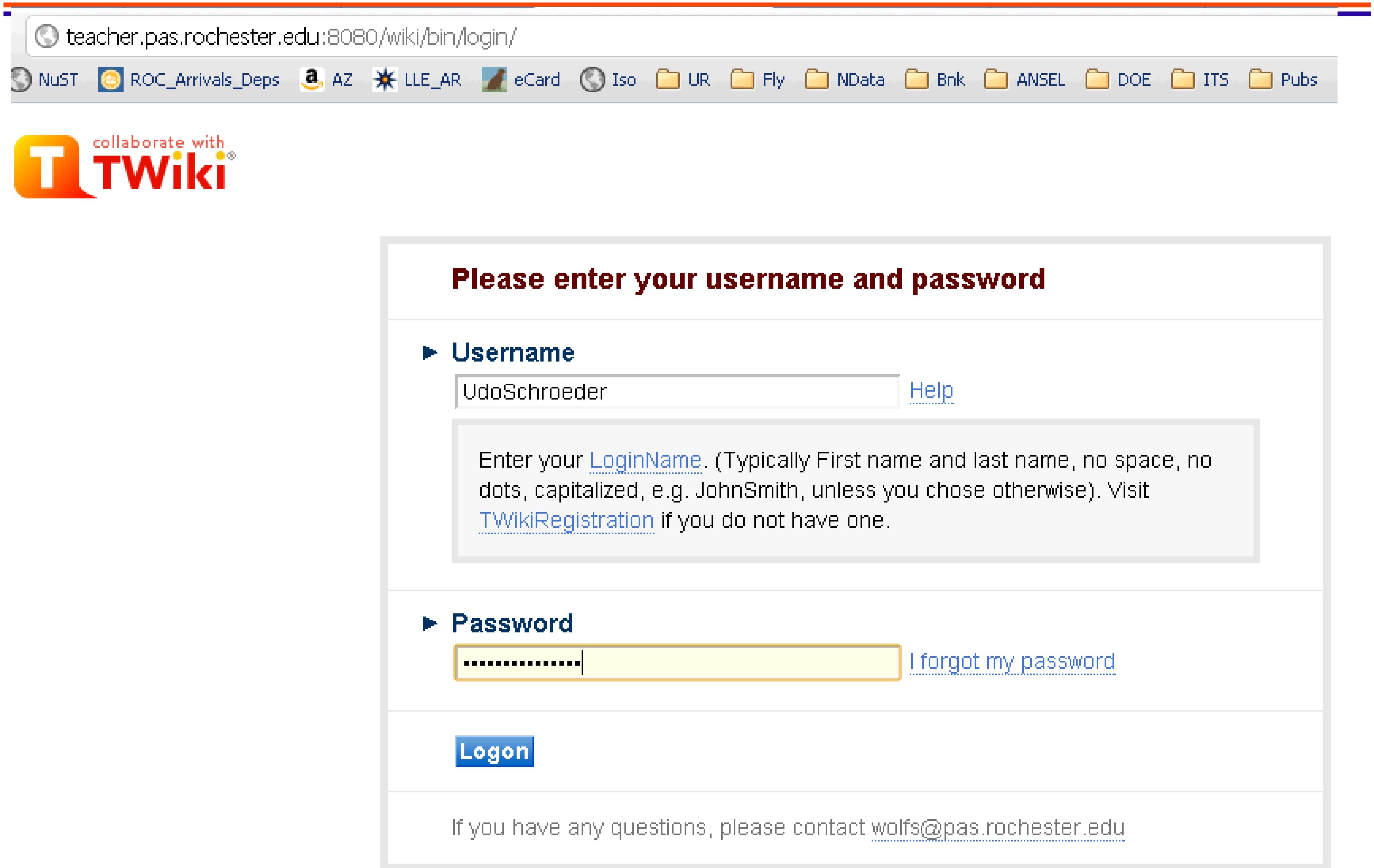
2. Software:
   - Data collected during the experiments can be stored in event-by-event data files for off-line analysis.
   - All experiments provide data files in ASCII format, which can be processed with a variety of tools.
   - Samples of analysis using ***Igor*** will be provided. Igor is available at no cost for use in this course and runs on Windows and Mac OS. It is available on the ANSEL TWiki (see earlier page).

3. Room access:

- Access to the lab rooms requires a key which can be obtained from the main office (B&L 206). The $20 deposit can be recovered upon return of the key).

*Maintained by F. L. H. Wolfs

http://teacher.pas.rochester.edu:8080/wiki/bin/view/ANSEL



Use of ANSEL TWiki

collaborate with TWiki

TWiki.org

Jump | Search | Edit | Attach

Tags: create new tag view all tags

Welcome to the Advanced Nuclear Science Education Laboratory (ANSEL) Web

Available Information

- Radiation Safety
- Lecture Notes
- ANSEL Group Assignments
- ANSEL Calendar
- Equipment Manuals
- Experiment Manuals
- ANSEL Equipment
- NaI Data Files
- Useful links
- Useful Documents
- Software
- Student Pages
- Final Presentations
- N2 Log of Germanium Detector
- WaterSamplesSurvey
- Contact Information

IGOR Pro 9 can be downloaded from here
To activate IGOR use the following information:
Serial Number: 84335
Activation Key: MVSY-MMJD-LDUP-MENY-PDYX-XANG-EJV

Recent changes in ANSEL web:

- Web Statistics
- Page Aidan Galgano
- Page Iris Gardner
- Page Sage Loomis
- Page Shirley Yang
- Page Amelia Heilbronn
- Page Katie Lee
- Page Braden Lenn
- Page Gwendoline Saarie
- Page Hengrui Zhang
- Student Pages 2026
- Student Pages
- Frank Wolfs
- Lecture Notes 2025
- Experiment Four 2025
- Zhiyan Yu
- more...

ANSEL Web Utilities

- Search - advanced search
- WebTopicList - all topics in alphabetical order
- WebChanges - recent topic changes in this web
- WebNotify - subscribe to an e-mail alert sent when topics change
- WebRss, WebAtom - RSS and ATOM news feeds of topic changes
- WebStatistics - listing popular topics and top contributors
- WebPreferences - preferences of this web

Use of ANSEL TWiki

teacher.pas.rochester.edu:8080/wiki/bin/view/ANSEL/StudentPages2026

Home | ANSEL Web | P | View | Edit | Account

collaborate with TWiki

Jump | Search | Edit | Attach

Student Pages Spring 2026

This page contains links to individual student pages. Students can use these pages to save data, data analysis packages, and other relevant documents. Each student should only modify their page(s).

- Adrian Galgano
- Iris Gardner
- Amelia Heilbronn
- Katie Lee
- Braden Lenn
- Sage Loomis
- Gwendoline Saarie
- Shirley Yang
- Hengrui Zhang

2026 Group 1: Adrian Galgano, Iris Gardner, Amelia Heilbronn

2026 Group 2: Katie Lee, Braden Lenn, Sage Loomis

2026 Group 3: Gwendoline Saarie, Shirley Yang, Hengrui Zhang

Edit | Attach | Print version | History: r6 < r5 < r4 < r3 < r2 | Backlinks | Raw View | Raw edit | More topic actions

Topic revision: r6 - 2011-01-18 - 02:31:06 - FrankWolfs

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*Maintained by F. L. H. Wolfs

Course Grade Components

1. Experiment preparation and documentation in a well-organized, dated logbook.
   Attendance at measurements with own logbook.

   1a. Homework problems/assignments (PHY445/CHM446 credits)

2. Written lab reports for each of the main experimental segments to be conducted in the lab.

<u>Please note:</u>

- Although the experiments will be conducted by teams of students, each student is required to prepare (e.g., data tables) and document progress of an experiment in a separate dedicated, bound logbook.
- Data analyses and lab reports should be discussed in the teams but must be produced and written individually and separately by each student. Main results and calculations should be written down in the logbook pages following corresponding experimental notes.
- Analysis and statement of statistical and/or systematic uncertainties are important components of each lab report.
- Lab reports should be typed and "publication ready." Appropriate report style is defined in the AIP Style Manual (single column!).
  An equivalent MS Word template is also available.

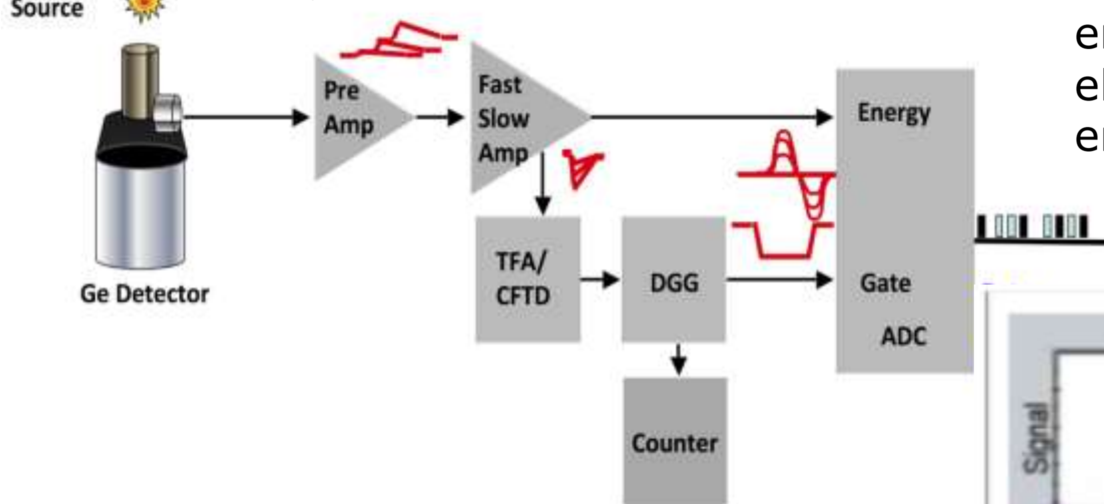
3. Oral presentation about one of the experiments (or a related topic) at the end of the semester.

Questions?

→ Survey over ANSEL experiments

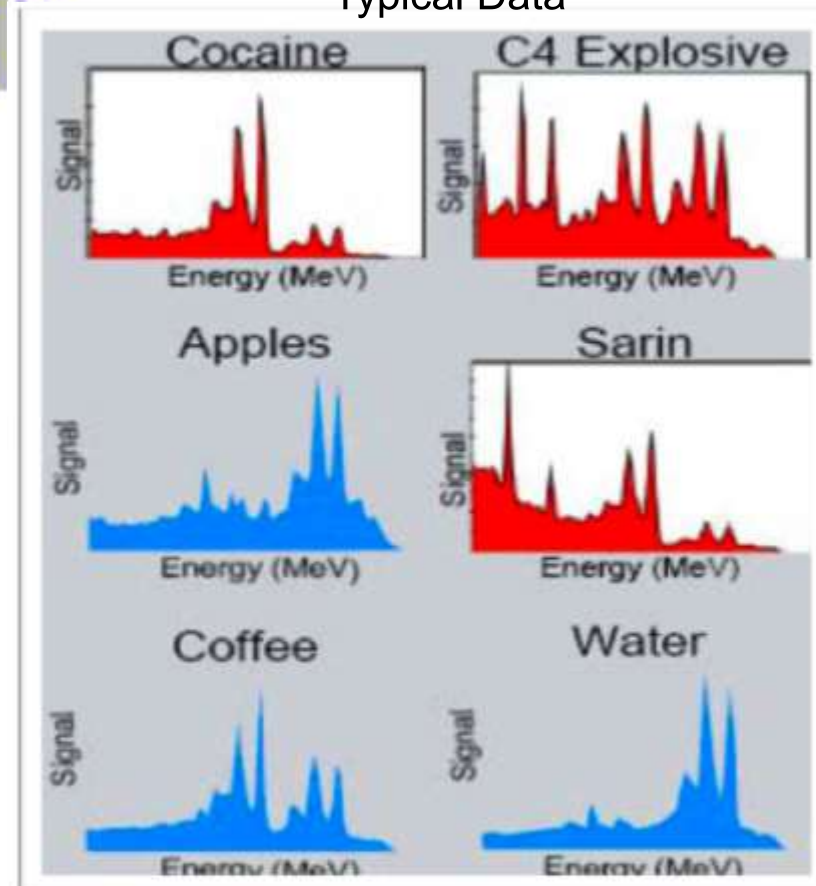
ANSEL Experiment: Gamma-ray (γ) spectroscopy

Typical Counter Experiment



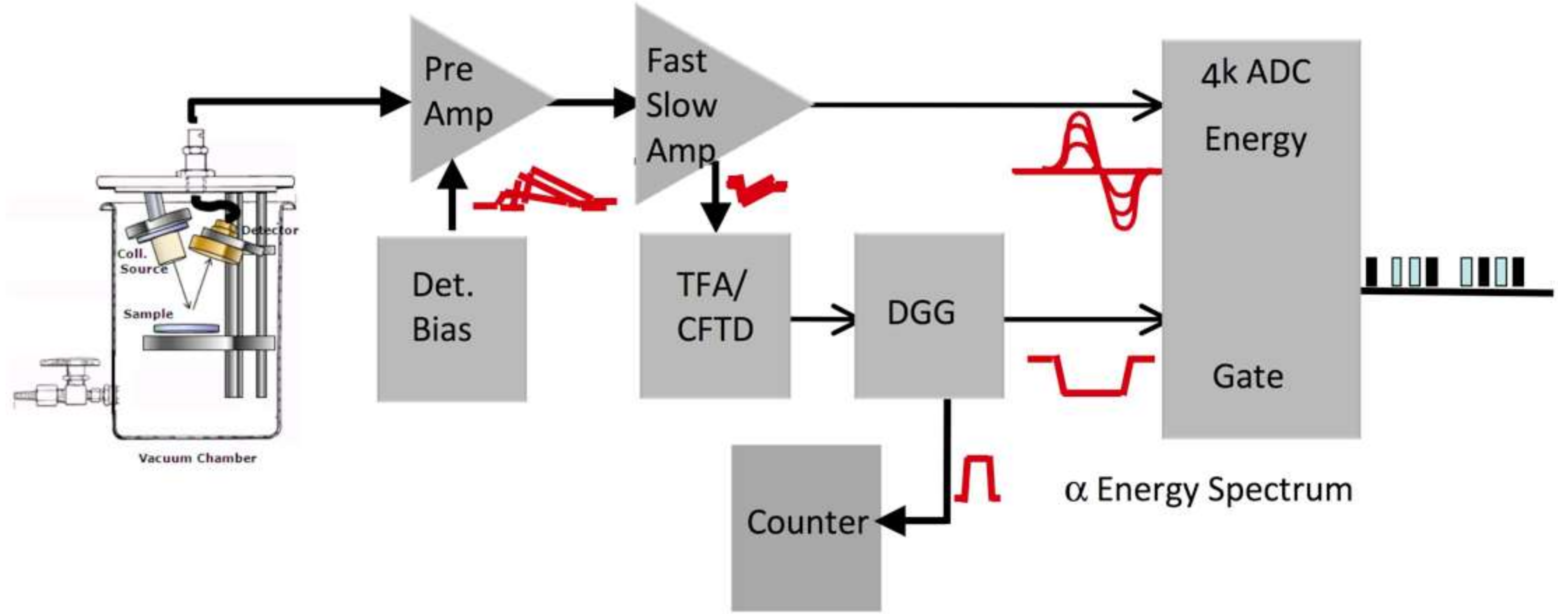
Atomic nuclei absorb and emit energy in discrete quanta → elm photons of discrete energies → isotopic fingerprints

Typical Data



- Practice γ–ray detection/ identification patterns use different detector types.
- Practice electronic signal processing, logic.
- Detector calibration.
- Statistical analysis.

ANSEL Experiment: Alpha Spectroscopy

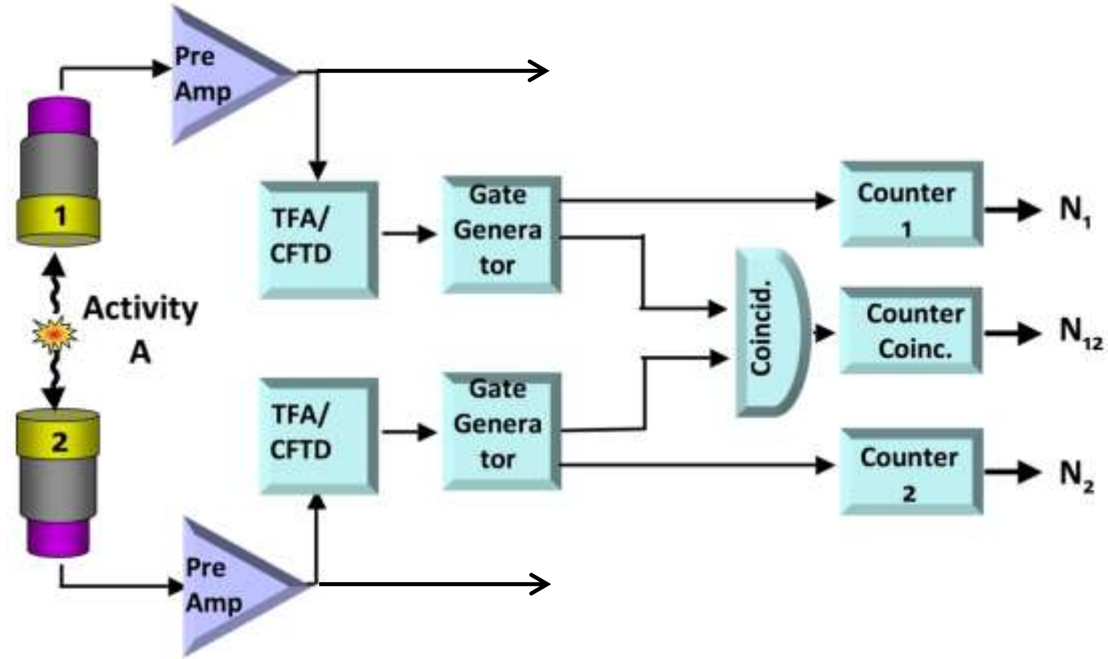


– Destruction-free material testing:
  Use Bethe-Bloch theory to determine thickness of thin films.
  (Use Rutherford-backscattering to determine material composition.)

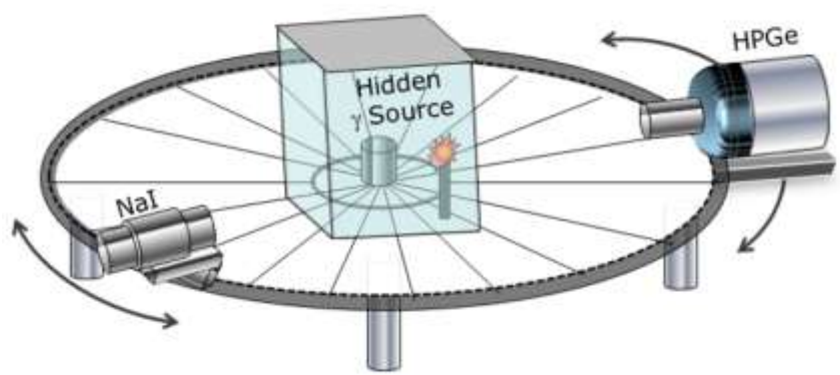
– Demonstrate & explain interaction of particles with matter
– Calibration and optimization of signal processing of silicon detectors.
– Linearity measurements using a pulse generator.

ANSEL Experiment: PET Coincidence Measurements

- Basic nuclear structure from patterns of nuclear decay chains.
- Imaging multi-dim

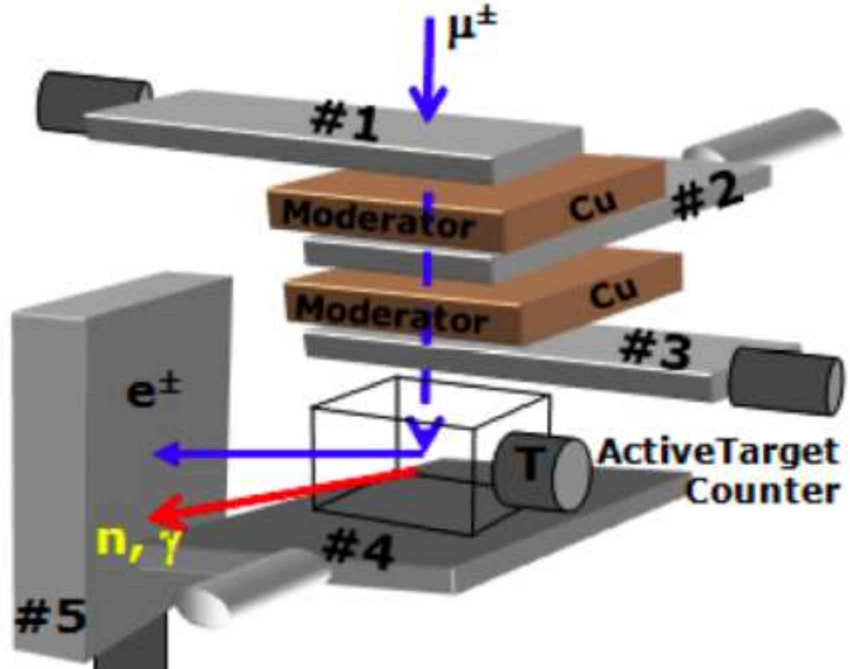


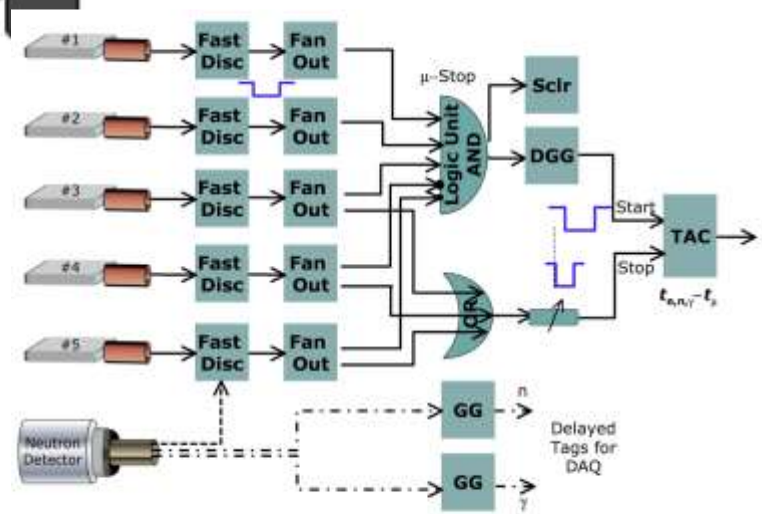
- Use correlated (γ–γ) decay patterns for 3D imaging. Examples: gamma ray tracing (PET) to locate an unknown radiation source.
- How to define and detect simultaneous (coincident) events



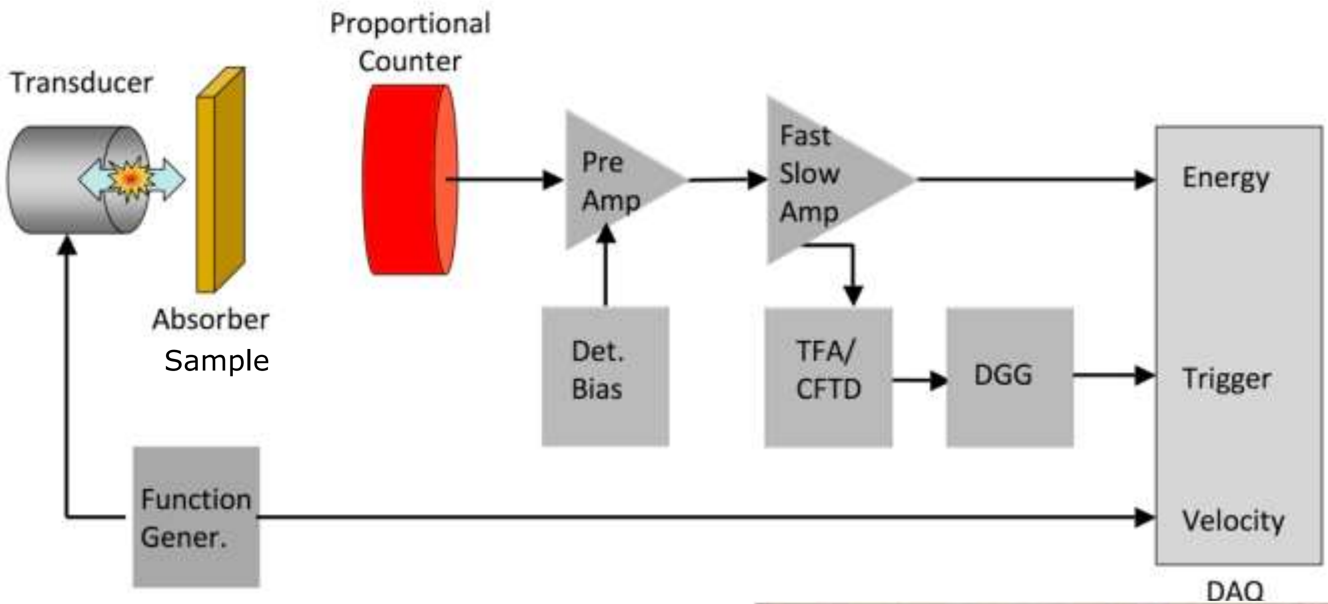
ANSEL Experiment: Muon Radiography

- Radiation in our natural environment: Cosmic rays.
- Identify cosmic muons, measure interactions with organic matter.
  Measure muon stopping power and lifetime.
- Complex experiment, practice definition & use of electronic logic: coincidences (to identify muons) and anti-coincidence techniques (to tag stopped muons).
- (Direct detection of the muon-decay products.)

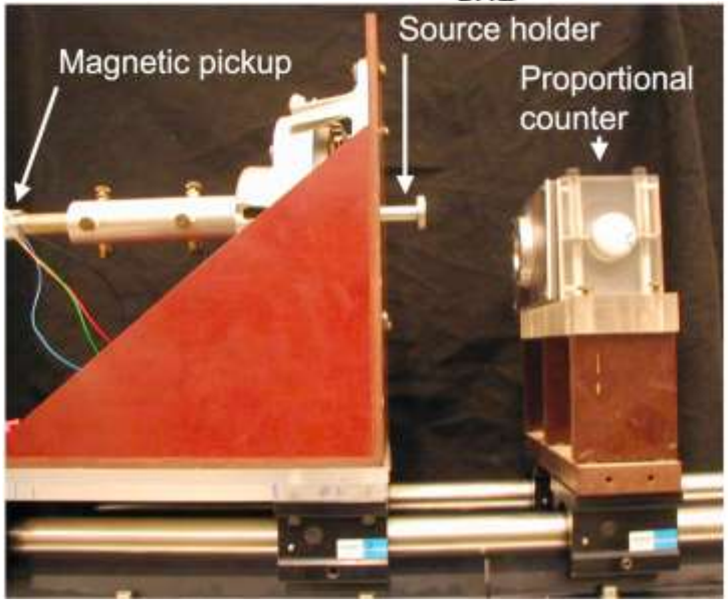




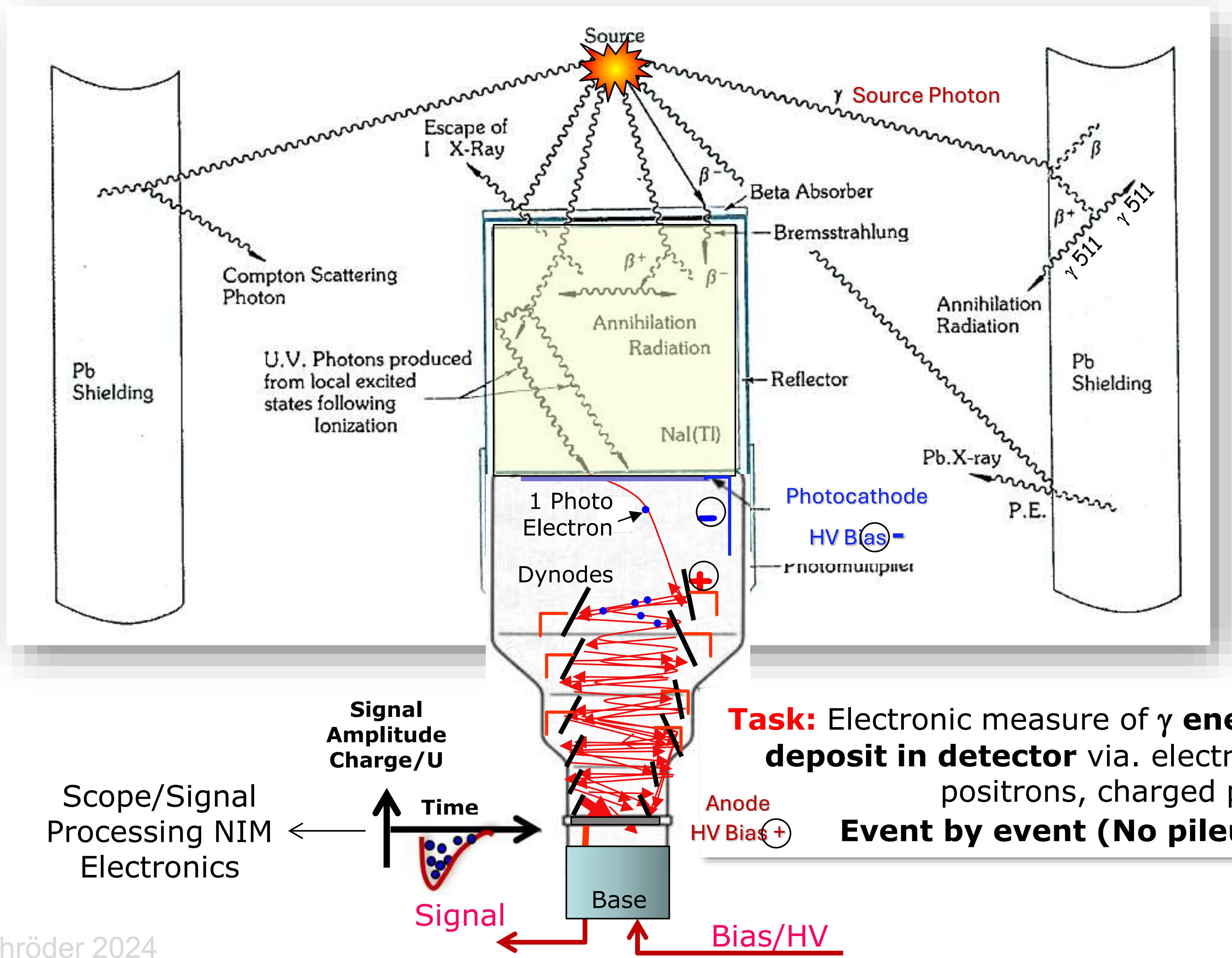
ANSEL Experiment: Mössbauer Precision Spectroscopy



- Ultra-sensitive γ spectroscopy, precise determination of interactions of nuclei with atomic electrons/lattice.
- Use in chemistry, fundamental physics, solid state physics
- Scanning of Doppler-shifted γ- ray energies using a moving source and absorbers=samples to be studied.



Measurements with Scintillation Detectors



Task: Electronic measure of γ **energy deposit in detector** via. electrons, positrons, charged part.
Event by event (No pileup!)

Course Schedule (before Spring break)

- Week of 1/18 & 1/25, 2026:
  - 1/20: Lecture 1 (2:00 p.m., B&L 407), Intro to ANSEL Experiments & Tour
  - 1/22 & 1/27 (2 p.m., B&L 156/177): Lab Experiment 1 Radiation survey detector, radiation laws
- Week of 1/25:
  - 1/26 (9 a.m., B&L 407) Lecture 2 (Electronic signal processing.)
  - 1/29 (2 p.m., B&L 407): Demo practice oscilloscope (Expt. 0) Intro to data acquisition (DDC-8) and data analysis (Igor)- Student Practice (Laptop)
- Week of 2/1:
  - 2/3 & 2/5 (2 p.m., B&L 156/171): Lab Experiment spectroscopy with NaI detectors, analysis. .

- Students take Web-Radiation safety training. Pass exam following course presentation (before Jan 31), to be able to continue with the course.

Experiment/Lecture Schedule

>>>> Take Web-Radiation safety training by end of January.

Month	Day	Group 1	Group 2	Group 3	Report Due
Jan-26					
	20	Lab Intro/Tour (B&L407)	Intro/Tour (B&L407)	Intro/Tour (B&L407)	
	22	Radiation Laws Survey	Radiation Laws Survey	Radiation Laws Survey	
	27	Radiation Laws Survey	Radiation Laws Survey	Radiation Laws Survey	
	29	Sign proc, IGOR (407)	Sign proc, IGOR (407)	Sign proc, IGOR (407)	
Feb	3	Spectroscopy NaI	Spectroscopy NaI	Spectroscopy NaI	
	5	Spectroscopy NaI	Spectroscopy NaI	Spectroscopy NaI	Rep 1
	10	HR Ge Spectroscopy	Gas Detector/PC	Si alpha Spectroscopy	
	12	HR Ge Spectroscopy	Gas Detector/PC	Si alpha Spectroscopy	
	17	Si alpha Spectroscopy	HR Ge Spectroscopy	Gas Detector/PC	
	19	Si alpha Spectroscopy	HR Ge Spectroscopy	Gas Detector/PC	
	24	Gas Detector/PC	Si alpha Spectroscopy	HR Ge Spectroscopy	
	26	Gas Detector/PC	Si alpha Spectroscopy	HR Ge Spectroscopy	Rep 2
Mar	3	Moessbauer Spectr.	Na-NaI: PET/γ-γ Correl	Cosmic Ray Muons	
	5	Moessbauer Spectr.	Na-NaI: PET/γ-γ Correl	Cosmic Ray Muons	
March 9 -16		SPRING Break	SPRING Break	SPRING Break	SPRING Break
	17	Moessbauer Spectr.	NA Lifetime	Cosmic Ray Muons	
	19	Moessbauer Spectr.	NA Lifetime	Cosmic Ray Muons	Rep 3
	24	Cosmic Ray Muons	Moessbauer Spectr.	Na-NaI: PET/γ-γ Correl	
	26	Cosmic Ray Muons	Moessbauer Spectr.	Na-NaI: PET/γ-γ Correl	
	31	Cosmic Ray Muons	Moessbauer Spectr.	NA Lifetime	
Apr	2	Cosmic Ray Muons	Moessbauer Spectr.	NA Lifetime	Rep 4
	7	NaI-NaI: PET/γ-γ Correl	Cosmic Ray Muons	Moessbauer Spectr.	
	9	NaI-NaI: PET/γ-γ Correl	Cosmic Ray Muons	Moessbauer Spectr.	
	14	NA Lifetime	Cosmic Ray Muons	Moessbauer Spectr.	
	16	NA Lifetime	Cosmic Ray Muons	Moessbauer Spectr.	Rep 5
	21				
	23				
	28				
	30				
May	5				

Report #	Due Date	Title-Group 1	Title-Group 2	Title-Group 3
1	19-Feb	LoRes Rad Detection	LoRes Rad Detection	LoRes Rad Detection
2	17-Mar	Hi-Res Spectr., SSD	Hi-Res Spectr., SSD	Hi-Res Spectr., SSD
3	2-Apr	Moessbauer Spectr.	Imaging and γ-γ Correl.	Cosmic Muon Interactions
4	16-Apr	Cosmic Muon Interactions	Moessbauer Spectr.	Imaging and γ-γ Correl.
5	30-Apr	Imaging and γ-γ Correl.	Cosmic Muon Interactions	Moessbauer Spectr.
	5-May	Oral Presentation	Oral Presentation	Oral Presentation

ANSEL Lab Reports: Template

ANSEL Report: Tests with analog and digital nuclear electronics

Jane Doe[1], John Doolittle[2], Justin Thyme[1]

[1]Department of Physics, University of Rochester, Rochester NY 14627
[2]Department of Chemistry, University of Rochester, Rochester NY 14627

jane.doe@ur.rochester.edu

(Experiment performed 01/25/2018 – 2/5/2018, Report submitted 2/28/2018)

Abstract

The first ANSEL experiment entailed hands-on tests of the functionalities of a digital oscilloscope and of various NIM electronic modules to be used in subsequent experiments. The response of a radiation detector was simulated with precision pulse generators and processed with main amplifiers. Discriminators were used to produce digital signals employed to set up trigger logics for the data acquisition system. The linearity of the analog circuitry, tested with a pulse generator, was found to be better than 1%.

1. Introduction (Motivation/Purpose)

The tasks given for the first ANSEL experiments are designed to practice basic operations of digital oscilloscopes, as well as analog and digital electronics. Th… cations for the subsequent experiments with gamma and … electronics is needed to define acceptance criteria and to p… system. The system was to be tested with a pulser calibrat…

2. Experimental setup and procedures

For the first task with analog electronic modules, a low … an ORTEC 419 precision pulse generator. Figure 1 illus… output signal observed on the oscilloscope. Its amplitude … 2µs. This pulse was obtained with the pulser settings ……

Next, the pulser signal was inserted into an ORTEC 57… to lowest coarse (x..) and fine gains (x…). Input polarity … Fig.2, the amplifier output signal shape was less than ideal … 45 mV, which was cor-rected to less than 2 mV by activat…

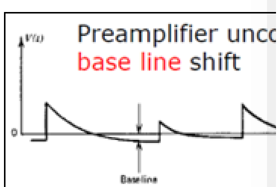


Figure 1: Output pulse shape of an ORTEC 419 precisio… are _ V/division and …µs/division, resp.

Table 1: ORTEC 419 Pulse Shape Para…

The discriminator output signals were duplicated with a Fan-In… signals were used to produce a wider "gate" signal, the other was … producing a copy of the input signal but delayed by an adjustable … width of ____, the delayed signal had a width of only …ns. Undela… were put into a Universal Coincidence Module (Type) to test coinc… The setup is represented by the schematic electronics block diagra… cludes the analog part of the electronics.

In the tests, the delayed signal……. The resulting coincidence … pected, to be equal to …., i.e., equal to _ A similar test was done us…

3. Data Analysis

Describe the results of the various phases of the experiments, as far as a data reduction was done. Include a discussion of statistical and systematic uncertainties.

…………

The approximate pulser signal shape $U(t)$ was observed to have an analytical form given by

$$U(t) = U_0 \cdot t^{\alpha} \cdot \exp\{-\beta \cdot t\} \quad (1)$$

Approximate fit parameters are listed in Table 1, together with their estimated uncertainties.

Use single column format

MS Word Report Template

Title, bylines, dates

Abstract

Main Text

I. Introduction
II. Theory (contingent)
III. Experimental Setup and Procedures
IV. Data Analysis
V. Summary and Conclusions
VI. References

ANSEL Report Contents

Abstract: Brief description of experiment goals and main results.

Structure of Main Report

Introduction: General background and goals of experiment.

Theory: Discuss essential ideas underlying experiment, note and explain formulas used in analysis and interpretation; provide references. Can be omitted in purely technical experiments.

Experimental setup & procedures: Describe briefly experimental detector and electronics setup, note geometry and electronic/DAQ adjustments in sufficient detail for a repeat. Note observations. Include diagrams and sketches of geometric & logic setup.

Data Analysis and discussion: Show raw data, describe systematic and statistical errors and their sources. Show, tabulate and illustrate main quantitative results. Compare to theoretical predictions or literature results.

Summary and conclusions: Describe briefly execution and results of experiments and their comparison to expectations. Suggestions.

Rubrics Example: Mössbauer Experiment

Comments apply to an excellent report graded A-.

1. **General Presentation**
   Abstract: Comprehensive, clear structure of report.
   Narrative, Tasks: Extensive, comprehensive discussions, executed most but not all tasks.

2. **Understanding theoretical background**
   Foundational Principles of MB Spectroscopy:
   Good explanation for recoilless emission/absorption, not for non-res. (background) absorption.
   The Doppler Effect for Photons:
   Math. derivation is missing, plausibility explanation of shape is missing

3. **Experimental Setup**
   Diagrams of general setup and electronics: sketches are shown.
   Principles of measurement have been well explained.
   Anticipated results of measurements Quantitative form given for shape of velocity spectrum for non-resonant absorption.

4. **Experimental Methods, Detail**
   Detection with PC as gas amplification counter with multiple response (escape lines) explained.
   Absorption/transmission as functions of gamma energy well explained
   Energy calibration fit shown.

5. **Velocity Spectrum**
   Discussed how discriminator window was set on PC energy wave.
   Raw velocity spectrum shown, corrected spectrum shown
   Function T(v) not derived or shown. Some misconceptions about resonance absorption vs total absorption.

6. **Results, Completeness, Accuracy**
   Correct absorption dips for isomer shifts and quadrupole HF splittings. However, no comparison to literature, and only brief discussion of nuclear or lattice properties.

ANSEL Lab Tour

See course website for a virtual version