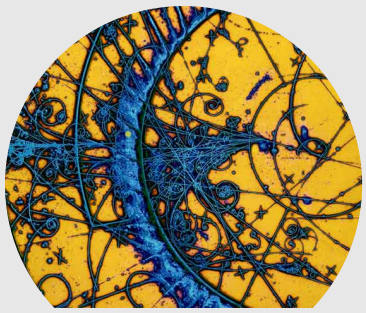

# NPRE Laboratory

NPRE 451

## Instructor Info


Dr. Fang

by appointment

Talbot 225E

mingf2@illinois.edu


## Course Info

Prereq: NPRE 445

Mon & Wed

09:00AM - 09:50AM

Online

## Lab Info

Wed/Fri

05:00-08:50PM/1:00-4:50PM

101B Talbot Laboratory

## TA Info

Gregory Romanchek (romanch2@illinois.edu), Kholod Mahmoud (kholodm2@illinois.edu)

Office Hrs: by appointment

Talbot 224, Talbot 225E

Ceser Zambrano (ceserz2@illinois.edu), Sean Siewert (siewert3@illinois.edu)

Office Hrs: by appointment

## Overview

*Last edited on 2025/01/14.* Radiation detection and instrumentation; radiation dosimetry and shielding; basic measurements in nuclear engineering; engineering applications; digitizer data acquisition and experimental control.

## Reading Material

Required Text

Tsoulfanidis, N., & Landseberger, S. *Measurement and Detection of Radiation* ("MDR"). Fourth or fifth Edition. CRC Press.

Recommended Texts

Knoll, G. F., *Radiation Detection and Measurement*. Fourth Edition. John Wiley & Sons Inc. 2010. ("Knoll")

Leo, W. L., *Techniques for Nuclear and Particle Physics Experiments: A How-To Approach*. Springer Verlag. 1994. ("Leo")

Evans, R.*The Atomic Nucleus*, Krieger Publishing Company, Inc. 1955

Slides and papers presented during the lectures are available on Canvas.

## Grading Scheme

| | |
|---|---|
| 25 | Lab Reports (25)–these are required work products and the course cannot be passed without submission of all the reports |
| 25 | *Open Lab* Presentation (10) and Paper (15) |
| 15 | Midterm Exam |
| 20 | Final Exam |
| 5 | Video quizzes (5)–these are required work products and the course cannot be passed without submission of 70% of the quizzes |
| 10 | Interactive session (10)–these are required work products for the presenters and the course cannot be passed without presenting |

Grades will follow the standard scale: A+ = 97.5-100; A = 93.5-97.4; A- = 89.5-93.4; B+ = 86.5-89.4; B = 82.5-86.4; B- = 79.5-82.4; C+ = 76.5-79.4; C = 72.5-76.4; C- = 69.5-72.4; D+ = 66.5-69.4; D = 64.5-66.4; E/F <65. Curving is at the discretion of the instructor.

## Notes

Make sure you enable notifications on Canvas to receive notifications of assignments.

Requirements to pass this course: submit with positive outcome (1) at least 70% of the quizzes. Collect all the lab data and submit all the lab reports.

## Learning Objectives

- Become familiar with radiation detection principles and techniques.
- Gain skills in conducting experiments and interpreting the results.
- Learn data processing techniques applied to radiation detection.
- Learn to critically review a technical paper and provide helpful criticism to your peers' work and improve scientific writing skills.

## Homeworks: Laboratory Reports

After completing each laboratory session, students are expected to write a report on each experiment. Although you are encouraged to discuss the report with fellow students, all lab reports need to be written individually. Report writing guidelines are available on Canvas. The deadline for submitting the lab reports is 8 days after the day of the lab, e.g., on Thursday if the lab was on Wednesday, unless announced otherwise. In a case of extenuating circumstances, please contact the instructor as soon as you are aware of them. Ten points will be subtracted per day (the highest possible score is 100 points), for all late reports. Lab reports are to be submitted electronically on the Canvas portal (in .pdf).

# FAQs

## Do we use radioactive sources in this course?

Yes, we do. We will use mostly low-activity check sources, therefore radiation dosimeters are not required. However, please take the general Laboratory Safety Training and the Radiation Safety Awareness Training courses at this link: `https://www.drs.illinois.edu/` after enrolling, and before 01/25/2025.

## Why do we measure radiation?

A precise measurement of radiation is important for many applications. A few examples are the radiation protection of operators working in nuclear power plants, or the characterization of nuclear reactions for physics or astronomy studies.

## What is the *Open Lab* section of the course?

The *Open Lab* gives students a unique hands-on opportunity to creatively experiment with radiation detection concepts. Further details about the *Open Lab* will be discussed in class.

## What is the schedule of the first week of class?

During the first week, instead of the lab session, we will have a regular class.

## How do I attend lectures and labs online?

Videos of lectures will be posted on Canvas, and labs will be in person

## Laboratory Reports (cont'd)

Plagiarism prevention software will be used to compare submitted reports against a database of academic papers to identify areas of overlap between the submitted assignment and existing papers. Reports will be graded separately for the writing. Report writing guidelines are available on Canvas, please review them before writing your first report.

## Laboratory Notebook and Quizzes

A laboratory notebook needs to be maintained by the students. It will be graded by the TA during the last lab session (lab 9). Students need to be ready to show all the lab notebooks to the TA (electronic and paper versions of the notebook are acceptable).
To reinforce concepts learned in class, you will submit answers to assigned quizzes in class. The quizzes can be multiple choice or numerical (please bring a calculator) and will concern past topics discussed in class and the subject of the upcoming lab. The grade will be either pass (1) or fail (0). To get a pass grade you need to answer correctly to at least 55% of the questions in the quiz. The quiz grade P is P = 10 x ($N_P/N$), where $N_P$ is number of submitted quizzes evaluated as a *pass*, N is the total number of assigned quizzes.

## *Open lab* Presentation and Paper

Small groups of students (up to 4 students per group) will plan and design an experiment to address a radiation detection problem of their interest. Each group will describe the problem, the methods used in their experiment, and the main findings in an oral presentation (10 out of 25 points) and a written paper (15 out of 25 points). The paper will also include a brief review of the relevant literature.
Each group will also review the paper of, at least, one other group, and receive at least one review by fellow students. Students will incorporate their edits into the final draft, to be submitted to the instructor three days after the date of the final exam, unless otherwise stated. The *Open Lab* reports will be submitted and uploaded on Canvas in one electronic copy. The *Open Lab* talks will be entirely graded by the students, who evaluate the oral presentations given by their fellow students according to a rubric provided by the instructor and available on Canvas.

## Extra credit

One extra credit (EC) will be assigned to each student in class using the following criterion if F$\geq$95% EC=1 else EC=0 where F is the percentage of students who submit course evaluation.

## Diversity and Inclusivity Statement

All members of this class are expected to contribute to a respectful, welcoming and inclusive environment for every other member of the class.

## Accommodations for Students with Disabilities

Students with learning needs that require special accommodation are encouraged to contact the instructor and the Disability Resources and Educational Services (DRES) at +1 (217)333-4603 or disability@illinois.edu, as soon as possible, to make an appointment to discuss your learning needs and to obtain an accommodation letter, if needed. Accommodations are not retroactive, but begin the day you contact your professor with a current letter of accommodation from DRES.

## Academic Integrity

The Code of Policies and Regulations Applying to All Students will be applied in all instances of academic misconduct committed by students. This applies to all exams, presentations, assignments and materials distributed in this course. Students are expected to present and submit original written reports, which truthfully represent the time and effort devoted into the work. Plagiarism is an ethical violation in which students copy text, HW solutions, and/or tables/graphs from other sources. Students caught plagiarizing will be subject to an academic integrity violation that can result in reduced or failing grade for a lab or the class, and expulsion from UIUC.

## Class Schedule (In-person lectures are in red)

### MODULE 1: Introduction to Nuclear Measurements

| | | |
|---|---|---|
| 01/22 *W* | Introduction, Radiation Safety, Instrument Overview | MDR Ch. 1 |
| 01/27 *M* | Counting Statistics | MDR Ch. 2 (2.1-2.14), NPRE451-Handout1 |
| 01/29 *W* | Uncertainty propagation and dead time | MDR Ch. 2 (2.15-2.18), 2.21, 5.6.2 |

### MODULE 2: Electron and Gamma-ray Detection

| | | |
|---|---|---|
| 02/03 *M* | Interactive lecture | |
| 02/05 *W* | Review of Nuclear Physics, Radioactive Sources | MDR Ch. 3, NPRE451-Handout2 |
| 02/10 *M* | Charged-particle interactions with matter I | MDR Ch. 4 (4.1-4.7) |
| 02/12 *W* | Charged-particle interactions with matter II, Intro to Gas detectors | MDR Ch. 4 (4.1-4.7) |
| 02/17 *M* | Gas detectors | MDR Ch. 5.1 - 5.6 |
| 02/19 *W* | Gamma-ray radiation interactions with matter | MDR Ch. 4.8 Knoll 3.III |
| 02/24 *M* | Inorganic Scintillators | MDR 6.1-2 Knoll 8.II |
| 02/26 *W* | Compton scattering and Klein Nishina equation; From Detection to Measurement (Efficiency, Solid angle) | MDR Ch. 8. |
| 03/03 *M* | Interactive lecture | |
| 03/05 *W* | Semiconductor Diode Detectors I | Knoll Ch. 11 MDR Ch 7.1-4 |
| 03/10 *M* | Semiconductor Diode Detectors II | Knoll Ch. 11 MDR Ch 7.1-4 |
| 03/12 *W* | MID TERM 1 EXAM | |
| 03/17 *M* | Spring Break | |
| 03/19 *W* | Spring Break | |
| 03/24 *M* | Interactive lecture | |

### MODULE 3: Neutron detection

| | | |
|---|---|---|
| 03/26 *W* | Neutron Detection Principles (I) | MDR 3.9 MDR 4.9 |
| 03/31 *M* | Neutron Detection Principles (II); Scattering kinematics | MDR 3.9 MDR 4.9 |
| 04/02 *W* | Interactive lecture | |
| 04/07 *M* | Slow Neutron Detection | MDR Ch. 14.1-14.4 |
| 04/09 *W* | Fast Neutron Detection (I) | MDR Ch. 14.5-14.10 |
| 04/14 *M* | Fast Neutron Detection (II); Neutron Spectroscopy | MDR Ch. 14.5-14.10; 6.10 13.7 |
| 04/16 *W* | Neutron activation | MDR 14.8 14.11 |

| | | |
|---|---|---|
| 04/21 *M* | Dosimetry | Knoll 19.VII |
| 04/23 *W* | Passive Detectors | 19.VIII |
| 04/28 *M* | Electronics readout | slides |
| 04/30 *W* | Signal Readout Devices (PMTs and SiPMs) | MDR Ch 7 |
| 05/05 *M* | Exam preparation/extra interactive session | |
| 05/07 *W* | MID TERM 2 | |
| 05/09 *F* | Final exam 7pm-10:00pm, Room TBD. | Each group will present the open lab work in a 20-min (max) presentation followed by 10 min of questions. |
| 05/15 *R* | Submit the final version of open lab report by midnight via the Canvas submission link on the homepage | Send the report to your peers for review by 05/12. Send comments back by 05/14. |

Open-lab Groups: TBD
Interactive lectures: Two groups present to the entire class. Meet in-person in CIF-0018.

## Lab Schedule

| | | | |
|---|---|---|---|
| *Lecture* | 01/23, 01/24 | *R, F* | Report Writing; Data fit; Radioactive Decay(MDR 3.7) |
| Lab #1 | 01/30, 01/31 | *R, F* | Introduction to Lab Equipment<br>Examples of *Open Lab* Projects |
| Lab #2 | 02/06, 02/07 | *R, F* | Counting Statistics |
| Lab #3 | 02/13, 02/14 | *R, F* | Proportional Counters and Geiger-Mueller Counters |
| Lab #4 | 02/20, 02/21 | *R, F* | Alpha Spectroscopy |
| Lab #5 | 02/27, 02/28 | *R, F* | Demonstration of Compton Scattering Using Coincidence Measurements |
| Lab #6 | 03/06, 03/07 | *R, F* | PMTs and Inorganic Scintillation Detectors |
| *Open Lab* | 03/13, 03/14 | *R, F* | *Open Lab* presentations: motivations and planned objectives. Groups of students present an outline of their proposed open lab project and review one or more papers relevant to their project. By the end of the lab, they discuss an outline of the open lab with the instructor. The assignment for the following week is a literature review relevant to the open lab project. |
| No lab | 03/20, 03/21 | *R, F* | Spring Break |
| Lab #7 | 03/27, 03/28 | *R, F* | HPGe Detectors: Efficiency Calibration and spectroscopy |
| Lab #8 | 04/03, 04/04 | *R, F* | Neutron Radiation Shielding. Thermal Neutron Detection. |
| Lab #9 | 04/10, 04/11 | *R, F* | Fast Neutron Detection: Organic Scintillators, Pulse Shape Discrimination and Spectroscopy |
| *Open Lab* | 04/17, 04/18 | *R, F* | Working time |
| *Open Lab* | 04/24, 04/25 | *R, F* | Working time |
| *Open Lab* | 05/01, 05/02 | *R, F* | Working time |

Peer review groups: TBD



Logo adapted from CERN courier https://cerncourier.com/in-the-tracks-of-the-bubble-chamber