PHYS 6751 – Graduate Laboratory: Nuclear and Particle Fall 2016 Syllabus

Course webpage: http://inpp.ohiou.edu/~meisel/PHYS6751/phys6751_home.html

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Class location: 101 and 208 EAL
Office hours: TBD, Wednesday
Class times: 2:00-3:50pm, Tuesday & Thursday

Overview:

The purpose of this course is to gain hands-on experience with modern experimental techniques in low-energy nuclear physics. This includes the use of common experimental equipment and open-source software used for contemporary nuclear physics research. The bulk of the course will consist of performing four experiments, analyzing the resultant data, and writing a report for each experiment in the style of a modern journal publication.

Classes will primarily consist of team-based work in the laboratory, intermixed with periodic lectures. Active participation in both lectures and labs is expected and will count towards the final grade. The primary assignments will be experimental run-plans, due before the start of each experiment, and scientific reports of the experiment results, written in the style of a journal article, due at the conclusion of each experiment. There will be one presentation and no exams.

Course Structure:

Students will complete four experiments working with a small group, where set-up, data collection, and analysis will take ~3-4 weeks for each experiment. Each student will be expected to keep records of their work in their own lab notebook, which will be collected periodically throughout the semester to gauge progress and involvement. Lectures will be given at the beginning and middle of each experiment portion of the class in order to provide guidance on the relevant science and experimental techniques.

Assignments will consist of experimental run-plans and preparatory calculations, due at the start of each experiment and lab reports, written in the style of a designated journal, due at the completion of each experiment. A rough outline and expanded outline of the report will be due midway through the experiment. In lieu of a final exam, students will present a talk they are assigned on one of the completed experiments in the style of a Division of Nuclear Physics (DNP) Meeting talk (10min for the presentation, followed by time for questions).

Safety:

This lab will contain multiple hazards, so care must be taken at all times. Closed-toed shoes are required and long pants are recommended. Radioactive sources are to be handled by the instructor only, unless told otherwise. When using sources, adhere to the ALARA principle of time, distance, and shielding. See the course webpage for more radiation safety information.

Course catalog #: 11198

Experiments:

The following four experiments will be conducted in a group[1] throughout the semester:

1. Foil thickness determination via α-spectroscopy
    a. *Objective:* Measure the thickness of a provided foil by comparing the measured energy loss of α-particles from a provided α-source to calculations with the software SRIM and/or LISE++
    b. *Gain familiarity with:* α calibration sources, silicon detectors, simple vacuum systems, Monte Carlo calculations of ion interactions with matter
    c. *Report style:* Nuclear Instruments and Methods in Physics Research A (NIMA)
2. Measurement of the ^{197}Au(n,γ) cross-section
    a. *Objective:* Measure the radiative neutron-capture cross section of ^{197}Au by irradiating gold powder with a neutron howitzer and counting radioactive decays from ^{198}Au using a sodium-iodide γ-detection set-up, comparing the result to calculations performed with the software TALYS and previously published data
    b. *Gain familiarity with:* neutron activation, γ calibration sources, γ-spectroscopy, Hauser-Feshbach cross section calculations, the EXFOR database from the National Nuclear Data Center
    c. *Report style:* Physical Review Letters (PRL)
3. Characterization of a foil via Rutherford scattering
    a. *Objective:* Measure the thickness of a provided foil and characterize its composition via Rutherford scattering of α-particles delivered by the tandem at the Edwards Accelerator Laboratory, comparing to calculations performed with the software RUMP
    b. *Gain familiarity with:* complex vacuum systems, low-energy particle accelerators, nuclear scattering, analytic scattering calculations
    c. *Report style:* Physical Review C (PRC)
4. Determination of a neutron long-counter efficiency
    a. *Objective:* Determine the neutron-detection efficiency of a neutron long-counter using a neutron-emitting calibration source, correcting for decays of the source's daughter nuclide
    b. *Gain familiarity with:* neutron detection, fission neutron sources, the Bateman equation
    c. *Report style:* Nuclear Instruments and Methods in Physics Research A (NIMA)

Information on each of the experiments will be made available on the course webpage prior to the start of the section of the course on that experiment.

[1]All students could be in the same group; however, two or more different experiments might be done by two or more different groups simultaneously should the class size be large.

Reports:
Reports will be written in the style of a refereed journal, where the style is specified for each experiment. Reports should be journal-quality and will be graded on the appearance as well as the scientific content.

Three different journal styles will be used:

- Nuclear Instruments and Methods in Physics Research A (NIMA)
    - NIMA is one of the primary journals for publications on recent advances in nuclear instrumentation relating to "accelerators, spectrometers, detectors and associated equipment". Articles are typically more technical in nature, delving into the details of detection set-ups, including the specific equipment that was used and analysis techniques which were employed. A scientific motivation is included, but typically touched-on only lightly.
- Physical Review C (PRC)
    - PRC is one of the primary journals for publications on recent advances in nuclear physics. Articles typically have long and thorough discussions of the scientific motivation, experiment (or theoretical calculation) details, and scientific results. Note that the experiment description is somewhat less technical and detailed than a NIM paper.
- Physical Review Letters (PRL)
    - PRL is one of the primary journals for publications on major recent developments in physics. Articles are very brief (<3750 words, i.e. ~4pages) and focus primarily on the scientific advance that was made. Emphasis is placed on the broader implications for the result that is presented.

Information on each of the above journal styles, as well as example publications, are available on the course webpage.

Presentation:
In lieu of a final exam, each student will be assigned an experiment to present in front of the class at the end of the semester.

The presentation will be 10 minutes, structured as a contributed presentation at the American Physical Society Fall Meeting of the Division of Nuclear Physics (DNP). The talk should contain three parts of roughly equal length: introduction and motivation, experiment and analysis, and scientific results. The presentation should be meeting-quality and will be graded on presentation style, presentation appearance, and mastery of the content. The presentation will be followed by ~2-5 minutes of questions.

Grading:

The final course grade will be determined using the weights listed below. A rubric for each grade-portion is available on the course webpage.

- *Involvement & Participation:* 20% (i.e. 5% per experiment section)
    - Based on active participation in lab activities; i.e. *did you actively lead and discuss tasks in the laboratory?*
- *Lab notebooks:* 20% (i.e. 5% per experiment section)
    - Based on thoroughness of lab notebooks; i.e. *how useful would your notebook be to a person performing the same experiment in the future?*
- *Lab reports:* 40% (i.e. 10% per report)
    - Based on appearance, clear communication, and scientific content
    - The grade for late[2] reports will be multiplied by 0.7 (i.e. 100% → 70%).
- *Final presentation:* 10%
    - Based on appearance, clear communication, and scientific content
- *Pre-experiment run-plans:* 10% (i.e. 2.5% per experiment)
    - Based on thoroughness of preparatory notes; i.e. *will your notes be a useful reference for the experiment and help save time in the lab?*
    - The grade for late pre-experiment run-plans is zero.

The final letter grade will be determined based on the following scale:
90—100% A; 85—89.9% A-; 80—84.9% B+; 75—79.9% B; 70—74.9% B-; 65—69.9% C+;
60—64.9% C; 55—59.9% C-; 50—54.9% D+; 45—49.9% D; 40—44.9% D-; 0—39.9% F

Attendance:

Attendance for all laboratory and lecture meetings is required, with the exception of illnesses and pre-arranged absences. If you are ill or need to be absent, please let the instructor know as soon as possible so that alternative arrangements can be made. Punctuality will be accounted for in the Involvement & Participation portion of the course grade.

Academic Honesty:

Students are expected to act in an academically honest fashion. This includes performing original work and properly citing referenced material. Plagiarism will not be tolerated and may result in a zero grade on an assignment. Note that plagiarism not only includes using others' work without proper citations, but also using your own work which was submitted for a previous assignment in this or another course.

Flagrant academic misconduct may result in a zero grade for the course. The determination of and penalty for academic misconduct will follow the guidelines laid forth in the Ohio University Student Code of Conduct.

[2] Extensions must be requested in advance and will not necessarily be granted.

Planned Schedule: *(Note some "experiment" days may have a lecture component)*

- Aug. 23: Introduction to radiation, experiments, & data analysis
- Aug. 25: Introduction to data analysis & experiment 1
  - *Bring your laptop*
- Aug. 30: Begin experiment 1
  - *Expt. 1 run-plan notes & data analysis tutorial results due at beginning of class*
- Sept. 1: Continue expt. 1
- Sept. 6: Continue expt. 1
  - *Rough outline of paper 1 due at beginning of class*
- Sept. 8: Continue expt. 1
- Sept. 13: Continue expt. 1
  - *Expanded outline of paper 1 due at beginning of class*
- Sept. 15: Introduction to experiment 2
  - *Paper 1 due at beginning of class*
- Sept. 20: Begin experiment 2
  - *Expt. 2 run-plan notes due at beginning of class*
- Sept. 22: Continue expt. 2
- Sept. 27: Continue expt. 2
  - *Rough outline of paper 2 due at beginning of class*
- Sept. 29: Continue expt. 2
- Oct. 4: Continue expt. 2
  - *Expanded outline of paper 2 due at beginning of class*
- Oct. 6: Continue expt. 2
- Oct. 11: Continue expt 2, **Coincides with DNP meeting**
- Oct. 13: Finish expt 2, **Coincides with DNP meeting**
  - *Friday after (the 14th) at 4pm*
- Oct. 18: Take data for expt. 3
  - *Expt. 3 run-plan notes due at beginning of class*
- Oct. 20: Take data for expt. 3
- Oct. 25: Take data for expt. 3
- Oct. 27: Take data for expt. 3
  - *Rough outline of paper 3 (PRC) due beginning of class*
- Nov. 1: Work with expt. 3 data
- Nov. 3: Work with expt. 3 data
- Nov. 8: Work on expt. 3 paper
  - ***Election day. Don't forget to vote.***
- Nov. 10: Work on expt. 3 paper
  - *Expanded outline for Paper 3 (PRC) due at beginning of class*
- Nov. 15: Work on expt 3 paper.
- Nov. 17: Work on final presentation
  - *Paper 3 due at start of class*
  - *Discussion of scientific presentations*
- Nov. 22: Work on final presentation
  - ***I would like to move this class to Nov. 21, if that's agreeable***
- Nov. 24: **No class, Thanksgiving**
- Nov. 29: Work on final presentations
  - *Outline (rough slides) of final presentation due at start of class*
- Dec. 1: Work on final presentation in-class
  - *Refined presentation slides due at start of class*
- Dec. 6 (12:20-2:20pm) Finals presentations
  - *Presentations delivered in-class: 10min presentations + ~5min for questions*