CAS PY 485 - Computation for Experimental Physics

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Course Dates: See timetable below
Course Time & Location: See timetable below
Course Credits: 3

Course Description.

The course provides an introduction to the experimental methods used in modern high energy particle physics. The course will include a survey of modern experimental particle physics where students will familiarize themselves with the Standard Model of particle physics. We will then cover interactions of particles with matter and discuss several major detector technologies. The course will cover statistical and computational methods for experimental particle physics surveying basic elements of probability, point estimation, fitting, and confidence intervals.

The course will be a mixture of lectures, tutorials, and discussions with hands-on exercises. Familiarity with modern programming language (C++ or PYTHON) and UNIX is recommended.

Hub Learning Outcomes

The Hub outcomes for the course will be:

- Digital/Multimedia Expression (DME): *Students will (1) craft and deliver responsible, considered, and well-structured arguments using media and modes of expression appropriate to the situation; (2) demonstrate an understanding of the capabilities of various communication technologies and be able to use these technologies ethically and effectively; (3) demonstrate an understanding of the fundamentals of visual communication, such as principles governing design, time-based and interactive media, and the audio-visual representation of qualitative and quantitative data.*

  In this course, you will be engaged in the analysis of physics data through C++ or Python-based scientific computing modules. You will present your analysis results via a wide array of visualizations for quantitative physics data, including ROOT, an open-source toolset widely used in high energy physics. You will use visualizations ranging from histograms, multi-dimensional graphs to interactive visualizations and animation, as a way to communicate the physics phenomena you have studied. You will learn how to choose the most powerful visualization method and basic design principles governing scientific visualization to communicate your result.

- Research and Information Literacy: *Students will (1) search for, select, and use a range of publicly available and discipline-specific information sources ethically and strategically to address research questions; (2) demonstrate understanding of the overall research process and its component parts, and be able to formulate good research questions or hypotheses, gather and analyze information, and critique, interpret, and communicate findings.*

  In this course, you will survey existing scientific literature and technical reports to obtain an in-depth understanding of particle theory and detectors. The final project of the course will follow closely a real-world particle physics data analysis where you will need to formulate a clear hypothesis, generate Monte Carlo simulation, and use appropriate statistical methods to analyze the data. You will also document your results in a scientific report.

Books and Other Course Materials

Slides of each lecture will be posted on the BU Web Blackboard before classes.
Recommended reading:

- David Griffiths, Introduction to Elementary Particles, ISBN: 978-3527406012
- Robert N. Cahn and Gerson Goldhaber, The Experimental Foundations of Particle Physics, ISBN: 978-0521521475

Courseware

The cource will utilize BU Web Blackboard.

- ROOT documentation (https://root.cern/doc/master/index.html)
- Particle Data Group (http://pdg.lbl.gov/)

Assignments and Grading

- Homework (50 %) - They will consist of computational exercises covering the lecture topics of each week. 2 homework assignments during the four week period. The assignment weights will be: 20 points for HW1 and 30 points for HW2.
- Presentation (20 %) - Each student will make a short presentation (15 min) reviewing an important historical paper from a high energy physics experiment. The presentation will be given during the last week of the course, in an additional meeting to be scheduled.
- Final Project (30 %) - A take home final project will be given as a final exam which will consist of a computational exercise which will be developed from the methods taught during the course. The final project will be due on the day of the final lecture.

Community of Learning: Class and University Policies

1. **Attendance & Absences:** Students are expected to attend all lectures. A valid reason for absence should be communicated in advance to the instructor, if possible. More than 2 unjustified absences will lead to a one-step grade reduction.

2. **Assignment Completion & Late Work**. Homework assignments must be returned by sending an email message to the instructor by the deadline stated in the assignment, before the beginning of class. Each homework assignment will clearly state the material that needs to be sent. Students may request an extension for valid reasons by sending an email message to the instructor before the deadline. Any unjustified late work will lead to a one-step grade reduction.

3. **Academic Conduct Statement,** Students should know and understand BU's Academic Conduct Code, available on-line at http://www.bu.edu/academics/policies/academic-conduct-code/ Cases of suspected academic misconduct will be referred to the Dean's office.

Outline of Class Meetings:

Date	Topic	Notes
Week 1, Class 1	Introduction to the course Introduction to the Standard Model, Unix, and C++	
Week 1, Class 2	Introduction to Python and ROOT	HW 1 Assigned
Week 1, Class 3	Advanced topis in ROOT for HEP	
Week 2, Class 1	Probability and statistics with ROOT	HW 1 Due
Week 2, Class 2	Particle accelerators and colliders	HW 2 assigned
Week 2, Class 3	Particle detectors	
Week 3, Class 1	Monte Carlo methods	HW 2 Due
Week 3, Class 2	Fitting	Final project assigned
Week 4, Class 1	Confidence intervals	
Week 4, Class 2	Multivariate techniques	Final project due