PHYS444

Computing beyond the standard model of particle physics

This course is designed to provide a glimpse into actual research experience at the frontiers of experimental physics. The example chosen for this class is the Large Hadron Collider. You will learn:

1. The standard model of forces and particles, theories of new particles and forces.
2. Particle interactions with matter, the LHC accelerator and the CMS detector.
3. Simulation of LHC processes.
4. Analysis of LHC data.
5. Machine learning, deep learning beyond the LHC.

Prerequisites:

PHYS371 and PHYS373; or permission of instructor.

Classes:

Lecture: Tuesday, Thursday 2:00 – 3:15 PM (PHYS 3301)

Attendance:

Your attendance is critical to your success. Participation in class and discussion sections will be part of your grade.

Contact Information:

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Email: **jabeen@umd.edu (mailto:jabeen@umd.edu)**

Office hours: Any time is good. You can contact me any time via email. For a meeting just send me an email and we'll schedule a time that is good for you.

Topics Covered

The most important thing to remember about this class: It is not meant to teach you what we have already discovered in the near past. It is about preparing ourselves to be a part of discoveries in the near future.

Physics

1. Introduction to fundamental particles and forces and their properties.
2. The standard model of particle physics. (A theory of (almost) everything (visible))
3. Big, unanswered questions of the day.
4. Theories beyond the standard model. Is there a "chosen one" out there?
5. Analysis of data with emphasis on uncertainties. How are false discoveries made?

6. Fireworks - visualising and analyzing LHC data in terms of physics-objects such as electrons, photons, muons, quarks and neutrinos.

Computing

1. Establish a log book
2. Setting up the Linux environment. Basic Linux commands and writing and executing scripts.
3. Introduction to Python and C++.
4. Using the analysis tool ROOT to graph functions and fits.
5. Simulation of LHC events using Madgrapgh and Pythia.
6. Using machine learning to enhance signal efficiency.
7. Deep learning - beyond the LHC.

Review Papers

Consider these papers as actors exercise by reciting Shakespeare. You may never work at LHC but the skills learned through reviewing these articles will help in any scientific field you decide to pursue.

- **The Hunt for New Physics at the Large Hadron Collider.   (https://arxiv.org/pdf/1001.2693.pdf) https://arxiv.org/pdf/1001.2693.pdf (https://arxiv.org/pdf/1001.2693.pdf)**
- **nature physics portal - looking back - The neutrino - the mystery and the discovery.pdf**
- **High Luminosity Large Hadron Collider HL-LHC. (https://arxiv.org/pdf/1705.08830.pdf)   https://arxiv.org/pdf/1705.08830.pdf**
- **Particle-flow reconstruction and global event description with the CMS detector (https://arxiv.org/pdf/1706.04965.pdf) - https://arxiv.org/pdf/1706.04965.pdf**
- **Observation of a new boson at a mass of 125 GeV with the CMS experiment at the LHC (https://arxiv.org/pdf/1207.7235.pdf) . arXiv:1207.7235v2 [hep-ex] 28 Jan 2013**
- **[Particle physics] Theory Summary and Prospects. (https://arxiv.org/pdf/1408.5866.pdf) arXiv:1408.5866v2 [hep-ph] 15 Sep 2014**
- **Top-quark mass measurements: review and perspectives (https://arxiv.org/pdf/1510.04483.pdf) . arXiv:1510.04483v1 [hep-ex] 15 Oct 2015**
- **α_s review. https://arxiv.org/pdf/1606.04772.pdf (https://arxiv.org/pdf/1606.04772.pdf)**
- **Review of LHC Dark Matter Searches. https://arxiv.org/pdf/1702.02430.pdf**
- **Interpreting the 750 GeV digamma excess: a review (https://arxiv.org/pdf/1605.09401.pdf) . https://arxiv.org/pdf/1605.09401.pdf (https://arxiv.org/pdf/1605.09401.pdf)**
- **Will the LHC Look into the Fate of the Universe (https://arxiv.org/pdf/0807.2601.pdf) ? arXiv:0807.2601v1 [hep-ph] 16 Jul 2008**
- **Jet Substructure at the Large Hadron Collider: A Review of Recent Advances in Theory and Machine Learning (https://arxiv.org/pdf/1709.04464.pdf) . arXiv:1709.04464v1 [hep-ph] 13 Sep 2017**
- **TIME TO MOVE ON? arXiv:1602.05493v1 [hep-ph] 17 Feb 2016   (https://arxiv.org/pdf/1602.05493.pdf)**
- **Flashes of Hidden Worlds at Colliders. arXiv:1702.02524 (http://arxiv.org/abs/arXiv:1702.02524)**

- **Physics: The Large Human Collider**

  Social scientists have embedded themselves at CERN to study the world's biggest research collaboration. Zeeya Merali reports on a 10,000-person physics project.

  https://www.nature.com/news/2010/100324/full/464482a.html

Text

There is no textbook. I will provide all the essential subject material.

Homework

There will be a homework assignment for most weeks. All assignments will be posted on elms. Late homework will not be accepted except in the case of illness verified by a doctor's signature.

Paper Presentation

The student will write a **3000-3750 words paper** (Limit of words for Physical Review Letters). Each student will present their paper at the end of the semester.

Topics for these papers and presentations will be discussed later in the class.

Logbook

You will be allocated a personal logbook where you will keep a record of your work.

https://sites.google.com/a/physics.umd.edu/.....

Grading:

Paper/presentation	50%
Homework	25%
Logbook, Class Participation and attendance	25%

Guest seminars

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Oct	**Guest Speaker**
Oct.	**Guest Speaker**
Nov.	**Guest Speaker**

Academic Integrity:

The University of Maryland, College Park has a nationally recognized Code of Academic Integrity, administered by the Student Honor Council. This Code sets standards for academic integrity at Maryland for all undergraduate and graduate students. As a student, you are responsible for upholding these standards for this course. It is very important for you to be aware of the consequences of cheating, fabrication, facilitation, and plagiarism. For more information on the Code of Academic Integrity or the Student Honor Council, please visit **http://www.studenthonorcouncil.umd.edu/whatis.html (http://www.studenthonorcouncil.umd.edu/whatis.html) . (http://www.studenthonorcouncil.umd.edu/whatis.html)**

Disabilities:

 If you have a documented disability and wish to discuss accommodations, please contact me as soon as possible.