PHYS7363 Syllabus

Course Description, Prerequisites and Instructors

The course, Experimental Particle Detection and Detectors (PHYS7363), is for those who plan to be particle physicists, especially experimental particle physicists. It may also be useful for anyone who needs to understand basic physics and techniques in particle detection, for example, for applications in medical imaging. PHYS7363 focuses on the physics employed in the detection, and the basics of detectors for dedicated purposes, such as the tracking system for location, trajectory and momentum measurements, and the calorimeters for energy measurement.

Elementary particles are detected through their interactions with matter. There are two interactions that are usually used in measuring a particle's momentum or energy: the electromagnetic and the strong (hadronic) interactions. A particle's type is usually identified with information of the particle obtained through a combination of two or three detectors. Particles have to live long enough so that they can pass through the measuring detectors. These are photon (treated as a particle, not a wave), electron, muon, pion, keon, proton and neutron. As neutrinos only interact with matter through weak interaction, they need specially designed detectors with huge amount of mass in order to have enough interactions in the detecting volume. In this course we will not discuss these types of detectors in detail. Particles that have very short lifetime, such as Z, $W^{\pm}$, or τ, for example, are measured through their decay products. We reconstruct back the characteristics of the original particles in the process that we call data reconstruction.

The discussion and study will follow PHYS5380, Concepts of Experimental Particle Physics. Knowledge from PHYS5380 and skills in programming with C++ are required. Familiarity of the Linux OS is also required. On top of these, the prerequisites also include the knowledge of a graduate student in physics with adequate math capability.

This study will be guided by Drs. Durdana Balakishiyeva, Jingbo Ye and Sijing Zhang (dbalakishiyeva@smu.edu, yejb@smu.edu, and sijingz@smu.edu). The instructors will guide discussions on detection and detector related physics.

Learning objectives and textbook

Learning outcome The course aims to develop the following abilities: (1) to

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understand the physics for particle detection, the basic types of detectors for momentum and energy measurements, the basic knowledge of detector readout; (2) the design and layout of a generic detector for collider physics experiment, and how a particle is detected, identified and reconstructed through such a detector system; (3) the use of GEANT4 (geant4.cern.ch), the simulation tool in particle detection and detector designs.

Textbook We will follow mostly this textbook: Particle Detectors, Second Edition by Claus Grupen and Boris Shwartz. ISBN-13**:** 978-0-511-38866-8 or 978-0-521-84006-4. You may also want to consult this text book: Introduction to experimental particle physics, by Richard C. Fernow. ISBN:0 521 37940 7 or 0 521 30170 7, and review articles in PDG (http://pdg.lbl.gov/): especially these review articles: Passage of particles through matter, Particle detectors at accelerators, Particle detectors for non-accelerator physics, Probability, Statistics, Monte Carlo techniques and Kinematics.

Course Format and Information

As this is a high level graduate course, it will be mostly based on guided reading, classroom discussions and presentations. Reading materials will be assigned a week ahead of time together with simulation work in GEANT4. Students are required to have an account at SMU's computing facility where the CERN programing environment is established. The class meets MWFr from 9:00 AM to 9:50 AM in Umphrey Lee Center 0303.

Class attendance is required as classroom discussions together with in-class presentations of your work are an important part of the learning process.

Grading policy: Final grades will be simple average of your class reports. There will be no other written exams. The Numerical grade and letter grade conversion is based on:

Letter	A	A-	B+	B	B-	C+	C	C-	D+	D	D-	F
Numerical (%)	90.0	85.0	80.0	75.0	70.0	66.6	63.3	60.0	56.6	53.3	50.0	

SMU Required Syllabus Statements: please refer to these SMU policies and supports as posted at https://www.smu.edu/OIT/AcademicTech/Instructional-Guidelines/Syllabus/required-syllabus-statements

Covid-19 policy related to this class: we follow SMU's policy posted at https://www.smu.edu/Coronavirus. Students are required to keep social distance when in class. Mask is optional.

Schedule:

Week #	**Reading, class discussion and assignment**	**Notes**
1	Introduction to the course and the class.	Account on M2
2 - 3	Coding skill basics. Run G4 example B1 (a report on this); ROOT basics.	Assignment 1
4 - 7	Particle interactions with matter. Read Chapter 1 G4 to reproduce Fig. 1.1 and Fig. 1.2. Write a report about your work.	Assignment 2
8 - 11	Detection processes Read Chapter 5 Use G4 to construct the 1 m^3 toy detector. Read out the CMOS image sensor, and compare that with the ATLAS pixel readout ASIC. Write a report about this work.	Assignment 3
12 - 14	Basic detectors and particle ID Read Chapters 7, 8 and 9. Write a report on ATLAS LAr or CMS ECAL	Assignment 4

Final Exam: there will be no in-class final exam of this course.