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 used in measuring a particle's momentum or energy: the electromagnetic and the strong (hadronic) interactions. A particle's type is usually identified through 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 detector with huge amount of mass in order to have enough interactions in the detecting volume. We will not discuss these types of detectors in detail. Instead, any specific detector systems may be assigned as a research project as mentioned below in the grading policy part. 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 professor instructors and TAs. Most of the coding and simulation work will be helped by the TA. The instructors will guide discussions on detection and detector related physics.

Learning objectives and textbook

Learning outcomes The course aims to develop the following abilities: (1) to 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. If you have questions about GEANT4, or any computing related issues, please contact the TA (name and contact info will be provided) for help. The class meets Tuesday and Thursday from 9:30 AM to 10:50 AM in room 155 of Fondren Science Building.

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 computed as 40% from the simulation HW reports, and the 3 in-class presentations (of dedicated literature research projects) each carrying a 10% weight. The hands-on class project with its journal type report plus a class presentation has a weight of 30%. 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	

Other policies:

Disability Accommodations Students needing academic accommodations for a disability must first register with Disability Accommodations & Success Strategies (DASS). Students can call 214-768-1470 or visit http://www.smu.edu/Provost/ALEC/DASS to begin the process. Once registered, students should then schedule an appointment with the professor as early in the semester as possible, present a DASS Accommodation Letter, and make

	appropriate arrangements. Please note that accommodations are not retroactive and require advance notice to implement.
Religious Observance	Religiously observant students wishing to be absent on holidays that require missing class should notify their professors in writing at the beginning of the semester, and should discuss with them, in advance, acceptable ways of making up any work missed because of the absence. (See University Policy No. 1.9.)
Excused Absences for University Extracurricular Activities	Students participating in an officially sanctioned, scheduled University extracurricular activity should be given the opportunity to make up class assignments or other graded assignments missed as a result of their participation. It is the responsibility of the student to make arrangements with the instructor prior to any missed scheduled examination or other missed assignment for making up the work. (University Undergraduate Catalogue)

Schedule:

Dates	Reading and class discussions	Notes
1/21	Introduction to the course and the class. Linux basics C and C++ basics	Week1 Set up the accounts
1/23	C and C++ basics	
1/28	C and C++ basics	Week 2
1/30	C and C++ basics	
2/4	Introduction/example about ROOT	Week 3
2/6	Introduction/example about ROOT	Textbook study starts
2/11	Sections 1.1.1 – 1.1.5. assign GEANT4 simulation HW1 Assign topics for class presentation 1	Week 4
2/13	Sections 1.1.6 – 1.1.10.	
2/18	Sections 1.2.1 – 1.2.2. assign GEANT4 simulation HW2	Week 5
2/20	Class presentation 1	
2/25	Sections 1.2.3 – 1.2.4. assign GEANT4 simulation HW3 Assign topics for class presentation 2	Week 6
2/27	Sections 1.3.	
3/3	Sections 1.4. assign GEANT4 simulation HW4	Week 7
3/5	Class presentation 2 assign reading of chapters 2, 3 and 4	

3/10	Sections discussion and summary of chapters 2, 3 and 4 Assign class hands-on project	Week 8
3/12	Sections 5.1 assign GEANT4 simulation HW 5 Assign topics for class presentation 3	
3/16 - 20	Spring Break	Week 9
3/24	Sections 5.2	Week 10
3/26	Sections 5.3 – 5.4 assign GEANT4 simulation HW 6	
3/31	Sections 5.5 – 5.6	Week 11
4/2	Sections 5.7 – 5.8 assign GEANT4 simulation HW 7	
4/7	Sections class presentation 3 Assign reading of chapter 6, not required.	Week 12
4/9	Sections 7.1 – 7.3 assign GEANT4 simulation HW 8	
4/14	Sections 7.4 – 7.6	Week 13
4/16	Sections 8.1 assign GEANT4 simulation HW 9	
4/21	Sections 8.2 – 8.3	Week 14
4/23	Chapter 9 assign GEANT4 simulation HW 10	
4/28	Chapter 11	Week 15
4/30	Sections hands-on report (journal paper type) and class presentation	

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