Experimental Techniques in Particle Physics

Code: 44081
ECTS Credits: 6

2024/2025

Degree	Type	Year
4313861 High Energy Physics, Astrophysics and Cosmology	OT	0

Contact

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Teachers

Thorsten Lux

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Teaching groups languages

You can view this information at the end of this document.

Prerequisites

No specific prerequisites are set for this course.

Objectives and Contextualisation

The main purpose of this course is to give an overview of the experimental technique used in particle physics. It covers from the basic principles used to the integration of a full complete detector.

Competences

- Formulate and tackle problems, both open and more defined, identifying the most relevant principles and using approaches where necessary to reach a solution, which should be presented with an explanation of the suppositions and approaches.
- Understand the bases of advanced topics selected at the frontier of high energy physics, astrophysics and cosmology and apply them consistently.

Learning Outcomes

1. Design a detector for a specific problem of physics.

2. Understand the different techniques for particle detection (scintillation, ionisation, Cherenkov light, etc.)
3. Understand the fundamentals of interaction of radiation with matter.

Content

Particle Interactions with matter

- General Considerations
- Atomic ionization and excitation
- Small angle multiple difusion
- Photon interactions with matter
- Electromagnetic Cascades
- Interactions of high-energy muons
- Cherenkov radiation and transition radiation

Review of electronic circuits and other technical aspects

- Circuits with reactive elements
- Propagation of electrical signals in cables

Detection Techniques

- Overview
- Photon detectors
- Scintillators
- Cherenkov radiation detectors
- Transition radiation detectors
- Thread cameras
- Gas Microdetectors
- Resistive plate chambers
- Time projection chambers
- Semiconductor detectors

Experimental Design Equipment

- Context: fixed target experiments, in the center of mass, or without beaming • Measures of position, time, quadrumoments; particle identification
- Trace and vertex detectors
- Calorimeters
- Muon spectrometers
- Fixed target Beams: Experiment design
- Colliding beams: Experiment design
- Experiments with neutrinos
- Searching for the proton decay
- Other searches: dark matter, double beta decay

Activities and Methodology

Title	Hours	ECTS	Learning Outcomes
Type: Directed			
Discussion, Work Group, Group Exercices	20	0.8	1, 2, 3

Particle interactions with matter	25	1	1, 2, 3
Type: Supervised			
Study of real detectors	30	1.2	1, 2, 3

Theory lectures, exercises and expositions by the students. Classwork and Homework.

Annotation: Within the schedule set by the centre or degree programme, 15 minutes of one class will be reserved for students to evaluate their lecturers and their courses or modules through questionnaires.

Assessment

Continous Assessment Activities

Title	Weighting	Hours	ECTS	Learning Outcomes
Attendance and participation to lectures	15%	45	1.8	1, 2, 3
Homework Detection Techniques	30%	10	0.4	2
Homework Full Detectors	30%	15	0.6	1
Homework Physics Phenomena	25%	5	0.2	3

Homework consisting on three sets of problems addressing sequentially the physics effects used, the detection techniques and the full detectors covers 85% of the evaluation mark. The additional 15% is based on attendance and participations to lectures.

In the case of not passing (all or any of) the indicated continuous evaluation activities, the teaching team will study case by case and propose to the student how to recover the subject (by presenting an alternative work and/or taking an exam in September, according to the case)

This subject/module does not foresee the single assessment system.

The email address of the professor responsible of this course is martinez@ifae.es

Bibliography

- W.R. Leo, "Techniques for Nuclear and Particle Physics Experiments, A How-to Approach", Springer 1987
- W.S.C. Williams, "Nuclear and Particle Physics", Oxford University Press 1991
- P. Marmier and E.Sheldon, "Physics of Nuclei and Particles", Academy Press 1969
- S.Tavernier, "Experimental Techniques in Nuclear and Particle Physics", Springer 2010
- C.Grupen and B.Shwartz, "Particle Detectors", Cambridge Monographs on Particle Physics, Nuclear Physics and Cosmology 26
- C.Grupen, "Astroparticle Physics", Springer 2005
- S.Eidelmann and B.Swartz, in "Handbook of Particle Detector and Imaging", C.Grupen and I.Buvat editors, Springer 2012
- Particle Data Group, chapter 26, http://pdg.lbl.gov/pdg.html

- Lectures by Katherina Mueller at UZH,
  https://www.physik.uzh.ch/en/teaching/PHY461/HS2021/lectures.html

Software

None

Language list

Name	Group	Language	Semester	Turn
(TEm) Theory (master)	1	English	second semester	morning-mixed