UAB
Universitat Autònoma de Barcelona

Experimental Techniques in Particle Physics

Code: 44081
Credits: 6

2026/2027

Degree programme	Type	Course
High Energy Physics, Astrophysics and Cosmology	OP	1

Contact lecturer

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Teaching staff

Thorsten Lux

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Group languages

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

Prerequisites

No specific prerequisites are set for this course.

Objectives

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.

For this course, the use of Artificial Intelligence (AI) technologies is permitted exclusively for supporting tasks, such as bibliographic or information searches and text proofreading. Students must clearly identify which parts involved this technology, specify the tools used, and include a critical reflection on how these tools influenced the process and the final outcome of the activity. Failure to be transparent about the use of AI in this assessed activity will be considered a lack of academic integrity and may result in a partial or total grade penalty, or more severe sanctions in serious cases.

Learning outcomes

- CA10 (Design a detector for a specific physical problem.) Design a detector for a specific physical problem.
- KA14 (Define the fundamentals of the interaction of radiation with matter.) Define the fundamentals of

the interaction of radiation with matter.
- KA15 (Explain the various particle detection techniques (scintillation, ionization, Cherenkov light, etc.).) Explain the various particle detection techniques (scintillation, ionization, Cherenkov light, etc.).
- SA33 (Apply the fundamentals of the interaction of radiation with matter in experimental techniques.) Apply the fundamentals of the interaction of radiation with matter in experimental techniques.
- SA34 (Apply the various particle detection techniques (scintillation, ionization, Cherenkov light, etc.) to address problems in the context of particle physics.) Apply the various particle detection techniques (scintillation, ionization, Cherenkov light, etc.) to address problems in the context of particle physics.
- SA35 (Develop the design of experimental apparatus in particle physics.) Develop the design of experimental apparatus in particle physics.
- SA36 (Use bibliographic tools, online and in English, to deepen the experimental detection techniques in particle physics.) Use bibliographic tools, online and in English, to deepen the experimental detection techniques in particle physics.

Contents

1. Particle Interactions with Matter
1.0 Charged Particles
1.1 Photon Interactions with Matter
1.2 Electromagnetic and Hadronic Cascades
1.3 Hadron Therapy

2. Detection Techniques
2.0 General Aspects
2.1 Photon Detectors
2.3 Cherenkov Radiation Detectors
2.4 Transition Radiation Detectors
2.5 Wire Chambers
2.6 Gaseous Microdetectors
2.7 Resistive Plate Chambers
2.8 Time Projection Chambers
2.9 Semiconductor Detectors

3. Design of Experimental Apparatus
3.0 The Context: Fixed-Target, Center-of-Mass, or Beamless Experiments
3.1 Position, Time, and Four-Momentum Measurements; Particle Identification
3.2 Track and Vertex Detectors
3.3 Calorimeters
3.4 Muon Spectrometers
3.5 Fixed-Target Beams: Experiment Design
3.6 Colliding Beams: Experiment Design
3.7 Neutrino Experiments
3.8 Searching for Proton Decay
3.9 Other Searches: Dark Matter, Double-Beta Decay

Learning activities and methodology

Title	Hours	ECTS	Learning outcomes
Study of real detectors	30	1.2	
Discussion, Work Group, Group Exercices	20	0.8	
Particle interactions with matter	25	1	

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

Continuous assessment activities

Title	Weight	Hours	ECTS	Learning outcomes
Homework Detection Techniques	30%	10	0.4	CA10, KA14, KA15, SA33, SA34, SA35, SA36
Attendance and participation to lectures	15%	45	1.8	CA10, KA14, KA15, SA33, SA34, SA35, SA36
Homework Full Detectors	30%	15	0.6	CA10, KA14, KA15, SA33, SA34, SA35, SA36
Homework Physics Phenomena	25%	5	0.2	CA10, KA14, KA15, SA33, SA34, SA35, SA36

Homework and/or written tests 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 participation 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

Course groups and languages

The information provided is provisional until November 30. After this

date, you will be able to consult the language of each group through this link. To access the information, you will need to enter the course CODE

Type of teaching	Group	Language	Semester	Shift
(TEm) Theory (master)	1	English	second semester	morning-mixed