

Experimental Techniques in Particle Physics

Code: 44081
ECTS Credits: 6

2025/2026

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

Contact

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Teachers

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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

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

Activities and Methodology

Title	Hours	ECTS	Learning Outcomes
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Type: Directed			
Discussion, Work Group, Group Exercises	20	0.8	2, 1, 3
Particle interactions with matter	25	1	2, 1, 3
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Type: Supervised			
Study of real detectors	30	1.2	2, 1, 3
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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	2, 1, 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.Grunen and B.Shwartz, "Particle Detectors", Cambridge Monographs on Particle Physics, Nuclear Physics and Cosmology 26
- C.Grunen, "Astroparticle Physics", Springer 2005
- S.Eidelmann and B.Swartz, in "Handbook of Particle Detector and Imaging", C.Grunen 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

Groups and Languages

Please note that this information is provisional until 30 November 2025. You can check it through this [link](#). To consult the language you will need to enter the CODE of the subject.

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