Universidad Zaragoza

Academic Year/course: 2021/22

68367 - Physics and engineering of particle detectors

Syllabus Information

Academic Year: 2021/22
Subject: 68367 - Physics and engineering of particle detectors
Faculty / School: 100 - Facultad de Ciencias
Degree: 628 -
ECTS: 6.0
Year: 01
Semester: Second semester
Subject Type: Optional
Module:

1. General information

1.1. Aims of the course

This course will provide an updated overview on i) the radiation and particle detection physics and ii) the state of the art and R&D on particle detectors applied in different fields of Science in particular in the Astronomy and Particle Physics fields. The course focuses on practical aspects, while providing a general overview of the detection techniques and relevant applications for each of them. The students will specialize in a technique of their choice, on which they will base their laboratory activities: it is expected that the hardware and software skills they will acquire will guide them to an adequate application of that technique to a specific case. For this task, the integration of knowledge and skills acquired in other courses, like *Advanced Instrumentation* or *Astroparticle Physics I and II*, will be useful.

1.2. Context and importance of this course in the degree

The outstanding development of radiation and particle detection techniques propelled by the Nuclear and Particle Physics field boosted the progress achieved by Astronomy, Astrophysics and Astroparticle Physics along the second half of the twenty century. The knowledge of the most advanced techniques, as well as the acquisition of a wide overview of all the available techniques, is necessary for a good understanding of the present situation of those fields, and their prospects for the future.

1.3. Recommendations to take this course

This course complements and follows the first semester *Advanced Instrumentation* course, being highly recommended to follow both. This course will apply the most adequate instrumentation tools for each detector type and the laboratory activities will be a continuation of those taken in *Advanced Instrumentation*.

2. Learning goals

2.1. Competences

At the end of the course, students should be more competent to:

? Use common techniques and computer tools to model, simulate and analyze data in the different fields of Astronomy and Particle Physics.
? Analyze, process and interpret experimental data from the Particle Physics and Astronomy fields.
? Operate instruments and apply experimental methods from the Particle Physics and Astronomy fields.
? Delve into a research topic and learn the most recent progress and present research lines in the Cosmology, Astrophysics, Particle and Astroparticle Physics.

2.2. Learning goals

To pass the course, students must prove to be able to:

? Describe the interaction mechanisms of different particles in matter.
? Learn how particle detectors work and the historical development of the different techniques
? Discriminate observables and signals associated to the interaction of radiation and particles in the most commonly used detectors.
? Identify the most suitable detector according to radiation type, energy range or physics goal.

? Use different types of radiation detectors and interpret the obtained results.
? Use instrumentation specifically designed to be applied in detection techniques for different radiation and particles.

2.3. Importance of learning goals

The progress in knowledge comes from the development of improved devices able to detect particles and radiation with increasing precision or even by identifying processes that were not detectable before. The interpretation of the information provided by those devices will allow testing the present theory describing the specific phenomenon under study. The more appropriate the detectors to the object of study, the better the results obtained and the more robust the conclusions to be drawn.
The learning results of this course will enable the student to use correctly different types of detectors, conducting experiments, analyzing data and solving problems in the laboratory and evaluating the relevance, adequacy or operability of the different types of detectors according to the experimental problem faced. At the same time, and in combination with the other courses of the subject, they will offer the student the necessary ground to design and implement novel applications of the detection techniques and to contribute to the development of new detection techniques, adapted to the requirements of a specific project.

3. Assessment (1st and 2nd call)

3.1. Assessment tasks (description of tasks, marking system and assessment criteria)

Students must prove the achievement of the learning goals by means of the following assessment tasks:

- E02 - Case studies, problem and question-solving and other assigned activities: 10%
- E05 - Assessment tests: 10%
- E06 - Laboratory work: 40%
- E01 a - Written reports corresponding to laboratory work: 30%
- E01 b - Other written reports: 10%

To pass the course, the global mark obtained by averaging all the assessment tasks should be at least 5.0 (over 10.0). Moreover, marks corresponding to E05, E06 and E01a should be also at least 5.0 (over 10.0) each.

Passing the course by means of an unique global examination

The course is intended to be followed having in-person lectures and laboratory sessions and performing the assessment tasks previously described. In any case, the student could opt for a global examination, according to the rules of the University of Zaragoza.
This global examination will take place on the dates fixed by the Science Faculty and will include both written and laboratory exams.

4. Methodology, learning tasks, syllabus and resources

4.1. Methodological overview

The learning process of the course is based on:

- Lectures with active participation
- Problem-based learning
- Case studies
- Laboratory sessions
- Assigned reports
- Laboratory reports
- Tutorial sessions
- Small group work
- Autonomous work and study
- Assessment tasks

4.2. Learning tasks

The foreseen activities to help students to achieve the learning goals include:

1. Attendance and active participation in lectures (20 h, 100% in-person)
2. Case studies, discussion and debate on topics of the subject (10 h, 70% in-person)
3. Solving of exercises and problems related to the laboratory sessions (10 h, 70% in-person)
4. Laboratory sessions (20 h, 90% in-person)

5. Preparation and presentation of reports (20 h, 0% in-person)
6. Preparation of laboratory reports (18 h, 0% in-person)
7. Tutorial sessions (in-person or online) (10 h, 50% in-person)
8. Autonomous study (40 h, 0% in-person)
9. Oral or written examination (2 h, 100% in-person)

All the activities designed to be in-person will be converted into online activities (total or partial online, with limited number of in-person attendees) if the sanitary situation leads the competent authorities and the University of Zaragoza to issue provisions in this regard.

4.3. Syllabus

1. Physical fundamentals of radiation and particle detection
2. Introduction to radiation and particle detectors:
    a. Historical evolution
    b. General performance parameters (calibration, efficiency, resolution, dead time, response time, ?)
3. Radiation detectors
    a. Photodetectors (PMTs, CCDs, ?)
    b. Radiotelescopes and interferometers.
    c. Gamma and X-ray telescopes
4. Particle detectors
    a. Gaseous detectors
    b. Semiconductor detectors
    c. Scintillators
    d. Calorimeters
    e. Others
5. Detection of neutrons, neutrinos and exotic particles

4.4. Course planning and calendar

Calendar for in-person sessions and tasks presentations

The dates corresponding to the beginning and end of each semester, as well as the allocated time schedule for the course will be published before the course registration at the webpage of the Science Faculty. The calendar of global examinations will also be available at that webpage.
The deadlines for the presentation of reports and assessment tasks, tests or activities will be stablished by the teachers of the course in the first week.
The scheduling of laboratory sessions will be agreed upon individually with each student among a reasonable range of proposed dates.

4.5. Bibliography and recommended resources

http://psfunizar10.unizar.es/br13/egAsignaturas.php?codigo=68367