60166 - Physics in underground laboratories

Guía docente para el curso 2010 - 2011

Curso: 1, Semestre: 0, Créditos: 8.0

Información básica

Profesores

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Recomendaciones para cursar esta asignatura

This course is taught in the second semester of the master and it does not require following any special curricular path. Nevertheless, it is advised to have a degree in physics or, at least, some previous knowledge of particle and radiation detection physics and nuclear and particle physics.

Actividades y fechas clave de la asignatura

- Matriculation from 7/07/2009 to 24/07/2009 and from 01/09/2009 to 08/10/2009
- First course date: 15/02/2010.
- Last course date: 4/06/2010.
- Visit to Canfranc Underground Laboratory (LSC) facilities: the date will be agreed by students and teachers, taking into account the availability of the LSC facilities.
- Examination period: 8-28/06/2010 and 1-14/09/2010. The date for the oral presentations (see below) will be chosen in this period, agreed by students and teachers.

Inicio

Resultados de aprendizaje que definen la asignatura

El estudiante, para superar esta asignatura, deberá demostrar los siguientes resultados...

1:
To be able to compare different underground facilities in terms of radioactive backgrounds and to know the most relevant experiments carried out in them.

2:
To be able to understand and analyze experimental efforts in the search for dark matter or neutrino physics:

detection mechanisms, analysis strategies, shielding/background reduction applied techniques and relevance of their results.

3:
To be able to conveniently present and defend a report about one experiment or detection technique (written and oral).

Introducción

Breve presentación de la asignatura

In this course, students are introduced in the research of rare phenomena in the fields of the Nuclear and Astroparticle Physics carried out at underground facilities.

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Contexto y competencias

Sentido, contexto, relevancia y objetivos generales de la asignatura

La asignatura y sus resultados previstos responden a los siguientes planteamientos y objetivos:

Students are introduced in the research of rare phenomena in the fields of the Nuclear and Astroparticle Physics carried out at underground facilities. They learn the composition of the cosmic rays and to estimate their screening as a function of the laboratory depth. They can describe the main sources of radioactive backgrounds at underground environments, compare the corresponding values at the most important underground facilities and evaluate the most relevant parameters as a function of the experimental goal. They get in touch with some outstanding experimental efforts in the fields of the neutrino physics and the direct detection of the galactic dark matter carried out at underground facilities around the world: detection mechanism, experimental details and results assessment.

This course is recommended for those students interested about knowing the state of the art of astroparticle detection, rare phenomena data analysis, novel detector concepts, ultra low background techniques, underground infrastructures, etc...

Contexto y sentido de la asignatura en la titulación

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Al superar la asignatura, el estudiante será más competente para...

1:
Describe the main components of cosmic rays at sea level.

2:
Estimate cosmic ray screening as a function of the laboratory depth.

3:
Describe the main sources of radioactive backgrounds at underground facilities.

4: Deeply analyze outstanding experiments in the fields of neutrino physics and dark matter direct detection carried out at underground facilities around the world.

5:
Estimate detection rates for double beta decay processes, neutrinos from different sources and galactic dark matter particles in simplified theoretical frameworks.

6:
Design an experiment in the referred fields selecting shielding, detection technique, target, etc. according to the research main goal and experimental constraints.

7:
Defend reports of an experimental work (in written and oral formats).

Importancia de los resultados de aprendizaje que se obtienen en la asignatura:

Astroparticle Physics and, in particular, that carried out underground is an expanding field of the Physics where collide Detector Development, Particle Physics, Cosmology, Astronomy, and Nuclear Physics. Because of that, the topics covered require an interdisciplinary approach which enriches strongly the formation of the students. In Spain, the availability since the end of the eighties of the Canfranc Underground Laboratory has allowed to have wide expertise in this field, and in the next years is expected a boost in the participation in international collaborations starting to work now at the new LSC facilities, requiring technical and scientific staff with a convenient formation in related techniques.

Nevertheless, this course will help students to develop critical and analytical general capabilities, very helpful to face many problems in physics and other related areas.

Evaluación

Actividades de evaluación

El estudiante deberá demostrar que ha alcanzado los resultados de aprendizaje previstos mediante las siguientes actividades de evaluacion

1:
Solving problems and practical works about radioactive background, underground experiments, neutrino physics and dark matter search along the course in a continuous basis: a 30% of the final qualification mark will be derived from them.

2:
Laboratory works and the corresponding “work reports”: 20% of the final qualification mark.

2:
Developing and defending a guided project on one of the subjects dealt with along the course: 50% of the final qualification mark.

2:
Evaluation procedure for those students requiring more than one call or not attending the course

The evaluation in these cases is the same that for those students attending the course. All the relevant material is available at the ADD (Anillo Digital Docente) of the University of Zaragoza and the course can be followed in a non-presence basis. Problems should be solved and sent to the teachers to be evaluated along the course. Concerning work at laboratory and submission and defense of the guided project should be done in (or before) one of the course calls in the examination periods established by the Science Faculty of the Zaragoza University in order to be qualified.

Actividades y recursos

Presentación metodológica general

El proceso de aprendizaje que se ha diseñado para esta asignatura se basa en lo siguiente:

This course is organized by combining theoretical and practical lessons. In order to achieve the intended goals the strategy chosen by the teaching staff consists of using lectures for presenting to the students the basic knowledge required to face the problem solving and, conveniently intertwined, the case analysis – problem solving lessons for applying the previously acquired knowledge in different situations. We briefly describe below the methodology used.

Theoretical lessons:

Lectures for the main group. These lessons aim at the acquisition of basic knowledge required to face the study of the physics problems dealt with at underground facilities. These lessons will be supported by the recommended bibliography, as well as by audiovisual material, powerpoint presentations and complementary information, all of them available for the students at the ADD. Participation of the student along the lectures will be continuously stimulated by the teachers and exercises to be solved will be proposed. Autonomous work of the student is required and tutorial support will be always at student disposal.

Practical lessons:

These lessons can be classified into three different categories:

1. Exercises and case analysis in small groups in the classroom, guided by the teacher. These lessons aim at the application of the acquired basic knowledge to some problems dealt with at underground facilities. These lessons will be supported by audiovisual material and complementary information, available for the students at the ADD. Participation of the student, solving autonomously some of the problems as well as working in reduced teams for others, is mandatory. Participation will be evaluated. Problem solving strategy could require information searches at internet, at bibliographic resources, data analysis, etc.
2. Data taking at the Canfranc Underground Laboratory, analysis of the data and preparation of the corresponding report. Participation of the student in these lessons is mandatory and work will be done by small teams. Work at the laboratory and final report will be evaluated.
3. Development of a guided project chosen by the student among different subjects proposed every course by the teachers, preparation of a written report for the teachers and an oral presentation for the main group. Both, written report and oral presentation, will be evaluated. The student could count on the support of complementary information at the ADD and a tutorial following of the work progress. The correct development of the project could require information searches at internet, at bibliographic resources, laboratory work, data analysis, finding relationships among different course topics, discussion with other students, etc.

Actividades de aprendizaje programadas (Se incluye programa)

El programa que se ofrece al estudiante para ayudarle a lograr los resultados previstos comprende las siguientes actividades...

1:

Theoretical lessons:

3 ECTS: lectures for the main group for the acquisition of basic knowledge required to face the study of physics problems dealt with at underground facilities. The summary of the covered contents and main bibliographic references is the following:

I Introduction. Cosmic radiation. Primary, sea level and deep underground spectra. Interaction with matter.

II Underground facilities. Underground laboratories in Europe and around the world: main characteristics. Gamma, neutron and muon backgrounds. Shielding design. Other underground facilities.

III Neutrino physics. Historical introduction. Neutrino mass: oscillations and double beta decay. Neutrinos from astrophysical and cosmological sources: neutrino telescopes.

IV Search for dark matter candidates: Dark matter evidences from Cosmology to Particle Physics. Detection of galactic dark matter. Interaction rates and distinctive features of the expected signal. Relevant experiments: present status and prospects.

V Other research lines at underground environments.

2:

Practical lessons:

2 ECTS: exercises and case analysis in small groups in the classroom.

1 ECTS: data taking at the Canfranc Underground Laboratory, analysis and preparation of the corresponding report. This activity, being carried out at Canfranc (175 km from Zaragoza) requires a full day of the student time (work at the lab + journey). The date of the activity is accorded with the students at the beginning of the semester and taking into account also the availability of LSC facilities. The corresponding report should be presented never later than the guided project (see below).

2 ECTS: development of a guided project chosen by the student among different subjects proposed at the beginning of the semester by the teachers, followed by periodical tutorial sessions, preparation of a report and oral dissertation for the main group. The written report will be presented one week before the date chosen for the oral presentations. The latter will be agreed by teachers and students and will take place during the examination period approved by the Science Faculty of the UZ.

Planificación y calendario

Calendario de sesiones presenciales y presentación de trabajos

- Visit to Canfranc Underground Laboratory (LSC) facilities: the date will be agreed by students and teachers, taking into account the availability of the LSC facilities.
- Examination period: 8-28/06/2010 and 1-14/09/2010. The date for the oral presentations (see below) will be chosen in this period, agreed by students and teachers.

Bibliografía

Bibliografía básica recomendada

J. Bahcall, *Neutrino Astrophysics*, Cambridge

H.V. Klapdor-Kleingrothaus, K. Zuber, *Particle Astrophysics*, Institute of Physics

T. K. Gaisser, *Cosmic Rays and Particle Physics*, Cambridge

Referencias bibliográficas de la bibliografía recomendada