60166 - Physics in underground laboratories

Guía docente para el curso 2013 - 2014

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

- The first and last course dates will be available at the official pages of the University of Zaragoza and Science Faculty: https://ciencias.unizar.es/web/horarios.do.
- 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.
- The oral presentations (see below) will take place in the period reserved for the continuous evaluation tests, agreed by students and teachers.
- The global examination will take place in the periods established in the official calendar of the University of Zaragoza for the first and second calls. These periods will be also available at the web page: https://ciencias.unizar.es/web/horarios.do.

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:
Evaluation of the progressive acquisition of competences along the course by

1. Solving problems and practical works 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.
3. Developing and defending a guided project on one of the subjects dealt with along the course: 50% of the final qualification mark. The project should be presented in written format and defended in an oral presentation in the period reserved for the continuous evaluation tests following the official academic calendar of the Science Faculty of the University of Zaragoza.

2:
Global examination

This global examination will be done in one of the two official calls, during the examination periods established by the Science Faculty of the University of Zaragoza. The global examination will have two sessions: theoretical and practical examination of the subject contents (50% of the final qualification) and individual oral defense of the guided project (50% of the final qualification). All the students have the right to do this global examination. For those having passed the course by the continuous evaluation procedure, this global examination is optional, and the best qualification obtained will prevail.

3:
Evaluation procedure for those students 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 and practical works should be solved and sent to the teachers to be evaluated along the course. Work at laboratory and submission and defense of the guided project should be done before the end of the period reserved for the continuous evaluation tests in the official academic calendar of the Science Faculty of the University of Zaragoza in order to obtain a qualification by the continuous evaluation procedure. In other case, the student should go to the global examination in one of the two official calls, during the examination periods established by the Science Faculty of the University of Zaragoza.

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.

References

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

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.
- The oral presentations (see below) will take place in the period reserved for the continuous evaluation tests, agreed by students and teachers.
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Referencias bibliográficas de la bibliografía recomendada

- Bahcall, John N.. Neutrino Astrophysics. Cambridge University Press. 1989
- Gaisser, Thomas K.. Cosmic Rays and Particle Physics. 2nd. Ed. Cambridge University Press. 2010
- Klapdor-Kleingrothaus, H.V. & Zuber, K.. Particle astrophysics. 1st. rev. ed. Institute of Physics. 1999