Riga Technical University

University of Latvia

RTU/LU Course

General data

Code	HEP003
Course title	Particle Detectors
Course status in the programme	Obligatory
Course level	Doctoral Studies
Course type	Academic
Field of study	High-Energy Physics
Responsible instructor	Kārlis Dreimanis
Volume of the course: parts and credits points	1 part, 2.0 Credit Points, 3.0 ECTS
Language of instruction	EN
Possibility of distance learning	Not planned
Abstract	This obligatory course is aimed at giving the student a broad understanding of the theoretical framework governing particle-material interactions, as well as of the materials, technologies and methods used in modern particle detectors. The course will begin with a brief historical overview of particle detectors and a summary of the basic properties of various detectable, long-lived particles. The course will then cover the theoretical aspects of particle-material interaction, introducing concepts such as scattering, radiation and nuclear interaction length, energy loss, Bragg curve and bremsstrahlung radiation. Following this, the course will focus to both the theory and application of the various detector materials and technologies, including silicon strip and pixel detectors, liquid and solid scintillators, Cherenkov detectors, calorimetry systems, proportional wire chambers etc. Finally, the course will switch to covering the multi-detector and multi-technology particle physics experiments, including the large experiments situated at the LHC. This will also include a brief discussion of the detector read-out methodology and read-out chains in such experiments.
Goals and objectives of the course in terms of competences and skills	The goal of this course is to introduce the student to the particle detection methods, technologies and devices. The objective of this course is to provide the student with the necessary competences to understand the basic functionality of particle physics experiments and, to an extent, particle acceleration devices. This course will provide the student with the understanding of the theoretical principles behind particle-matter interaction. Furthermore, the student will be able to understand, explain and justify the use of different particle detection techniques and technologies in the detection of different particle species. They will also be able to understand and explain the reasons behind the structure of given particle physics experiments, as well as to apply all the knowledge gained throughout this course to their experimental work.
Structure and tasks of independent studies	The independent studies will be predominantly in the form of further reading. The students will be pointed towards the best sources of information for both the strengthening their theoretical understanding of particle-matter interaction and for further developing their understanding on particle detection devices and experiments in practice. For the latter, the student will be pointed towards not only the more common literature type, such as textbooks and journal papers, but also the Technical Design Reports (TDRs) of various experiments, such as the experiments at the LHC. In addition to further reading, a part of the independent studies will be the task of preparing a short, thorough report on a selected topic, such as a specific detection method or experiment, which will be evaluated as part of the assessment of this course.
Recommended literature	1. Knoll, Glenn F., Radiation Detection and Measurement, ISBN: 9780471073383 2. Delaney, C. F. G., Radiation Detectors: Physical Principles and Applications, ISBN: 0198539231 3. Martin B. R., Particle Physics, ISBN: 9781118912164
Course prerequisites	Physics, mathematics
Courses acquired before	-

Course contents

Content	Full- and part-time intramural studies		Part time extramural studies	
	Contact Hours	Indep. work	Contact Hours	Indep. work
Radiation Detectors: their performance and applications. Radiation Detectors in CERN Physics Experiments	6	-	-	-
The structure of nuclear physics equipment based on radiation detectors. Radiation detectors and their metrological support	6	12	-	-
Solid state physics concepts and underlying principles of radiation detectors: excitons, radiation defects their relaxation	6	12	-	-

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Semiconductor detectors for x-ray, gamma ray and charged particles detection	8	12	-	-
Scintillator detectors. Aging of detectors	6	12		
Total:	32	48	-	-

Learning outcomes and assessment

Learning outcomes	Assessment methods
The student can follow, understand and explain the theoretical concepts of particle-matter interaction, including the various energy loss mechanics and the radiation and nuclear interaction length.	Examination: oral examination. Assessment: the student will be able to orally clearly explain the concepts learned.
The student understands and can explain the working principles of various particle detection mechanisms and technologies as well as determine the best detection method for various detectable particles.	Examination: oral examination. Assessment: the student will be able to orally clearly explain the concepts learned.
The student can explain in detail the principles behind the large multi-technology, multi-detector experiments and the reasons for a given architecture of particular experiments, as well as the basics of the overall operation of such experiments.	Examination: report and presentation. Assessment: the student will be able to introduce and explain concepts both covered in the lectures and outside the lecture content.

Evaluation criteria of study results

Criterion	%
Coursework: preparation of a detailed report on a given topic	40
Presentation of the prepared report	10
Oral examination	50
Total:	100

Course planning

Part	Semester			CP	ECTS	Hours per Week			Tests			Tests (free choice)		
	Autumn	Spring	Summer			Lectures	Practical	Lab.	Test	Exam	Work	Test	Exam	Work
1.		*		2.0	3.0	8	-	-	-	*	*			