



COURSE UNIT DESCRIPTION

Course unit title	Code
Radiation detectors in CERN experiments	

Annotation
<p>The course is aimed at the development of knowledge on ionizing radiation detectors, the scientific background for the development of these detectors, and the potential offered by the detectors for applications of through the prism of application of the detectors in CERN experiments. Lectures and seminars will include the topics of the ongoing active cooperation of Lithuanian scientists with CERN, and will provide students with essential knowledge and skills to engage in this research. Research-type laboratory works will be carried out in the laboratories developing novel radiation detectors by using the same research facilities, which is currently exploited in CERN-related research projects.</p>

Lecturer(s)	Department, Faculty
<p>Coordinating: prof. habil. dr. Gintautas Tamulaitis Others: prof. dr. Vincas Tamošiūnas, assoc. prof. dr. Tomas Čeponis, assoc. prof. dr. Saulius Nargelas, guest lecturer from CERN.</p>	Institute of Photonics and Nanotechnology, Faculty of Physics

Study cycle	Type of the course unit
Second (Master studies)	Compulsory

Modes of delivery	Semester or period when it is delivered	Language of instruction
Lectures, seminars, laboratory works	3 rd (Autumn) semester	English

Requisites	
Prerequisites: -	Co-requisites (if relevant): -

Number of ECTS credits allocated	Student's workload (total)	Contact hours	Individual work
5	140	48	92

Purpose of the course unit: programme competences to be developed		
<p>The course is aimed at developing student knowledge and skills on ionizing radiation detectors, in solving scientific problems in development of these detectors and application of the detectors in various fields through the prism of current needs and future challenges of CERN experiments. Understanding of the current CERN experiments and scientific and technological challenges put forward by future experiments will be developed. A special emphasis will be put on the currently active collaboration of Lithuanian researchers with CERN, knowledge and skills of students facilitating their joining the collaboration will be developed. Research-type laboratory works will be carried out in the research laboratories, where novel radiation detectors are being developed, by using the research facilities currently exploited for joint VU and CERN research</p>		
Learning outcomes of the course unit	Teaching and learning methods	Assessment methods
<p>Theoretical knowledge and skills in the development of ionizing radiation detectors and solving problems of their application. Understanding and ability to interpret and apply the knowledge on CERN experiments for developing medical equipment and in other application fields, to identify and assess the directions for further research.</p>	Lectures and seminars	<p>Exam with open-ended questions, evaluation of seminar activities</p>

Ability to apply the theoretical knowledge and experimental skills for identifying the origins of experimental problems and to find relevant solutions.	Laboratory works	Control questions, processing and interpretation of results, drawing and reporting in performing laboratory works.
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Course content: breakdown of the topics	Contact hours						Individual work: time and assignments		
	Lectures	Tutorials	Seminars	Workshops	Laboratory work	Internship/work placement	Contact hours, total	Individual work	Assignments
1. Review of CERN experiments, challenges of high energy particle physics: from cosmic rays to supersymmetry; particle accelerators and their properties; ATLAS, CMS and other LHC experiments; engineering challenges of LHC support; colossal data arrays and their processing; current state and future possibilities of cooperation between Lithuanian scientists and CERN.	10		4				14	24	Preparation for seminars, lectures follow-up, preparation for exam.
2. Scintillation detectors. Interaction of ionizing radiation with matter, scintillation processes. Properties of inorganic and organic scintillators defining the key parameters of scintillation detectors: scintillation efficiency, energy and time resolution, radiation hardness, etc. Challenges related to the development of scintillation detectors for future experiments of high-energy particle physics and high-resolution medical imaging techniques. The most promising materials for these detectors and engineering of their properties.	8		4		8		20	39	Preparation for seminars, lectures follow-up, preparation for laboratory work Investigation of Timing Properties of Scintillators, processing and interpretation of experimental results, preparation for exam.
3. Semiconductor-based detectors of ionizing radiation. Processes of electron-hole pair generation in semiconductors exposed to ionizing radiation. Materials for semiconductor detectors, p-n, p-i-n, Schottky junctions and heterojunctions. Damage in semiconductors due to their exposure to ionizing radiation. .	4				8		12	25	Preparation for seminars, lectures follow-up, preparation for laboratory work Investigation of Semiconductor Detector Structures Using DLTS and/or Microwave Absorption and Reflection Measurements, processing and interpretation of experimental results, preparation for exam.
4. Circuit components for signal read-out and processing: photomultipliers and photodiodes, signal shaping and amplification, conversion of analogue to digital converters.	2						2	4	Lectures follow-up, preparation for exam.
Total	24		8		16		48	92	

Assessment strategy	Weight %	Deadline	Assessment criteria
Knowledge and skills in performing laboratory works	30	1st half of December	Preparation to answer theoretical questions, quality of the work description, ability to process and describe the results and make conclusions. Evaluation in 10-point scoring system, the final average scoring being multiplied by the weight coefficient.
Performance in seminars	20	All course	Presentation clarity and outline (up to 3 points); ability to highlight the major points and solved problems (up to 4 points); ability to answer questions related to the presentation (up to 3 points). The final score is multiplied by the weight coefficient.
Exam	50	During the exam session	Five open-ended questions (up to 2 points each). Physical substantiation, depth and extension, presentation consistency and fluency will be evaluated.

Author	Publishing year	Title	Issue of a periodical or volume of a publication; pages	Publishing house or internet site
Required reading				
M. Korzhik, G. Tamulaitis, A. N. Vasil'ev	2020	Physics of Fast Processes in Scintillators	-	Springer International Publishing, https://doi.org/10.1007/978-3-030-21966-6
S. N. Ahmed,	2015	Physics and engineering of radiation detection	-	Amsterdam: Elsevier. (available at VU library: 539.1/Ah12.)
H. Spieler	2014	Semiconductor detector systems	-	Oxford: Oxford University Press. (available at VU library: 621.382/Sp28.)
Recommended reading				
G. Lutz	2007	Semiconductor radiation detectors: device physics	-	Berlin: Springer, 2007. (available at VU library: 539.1/Lu165.)
CERN	-	Accelerating Science: Physics, Accelerators, Experiments, Engineering, Computing	-	https://home.cern/science (Hyperlink verified on 2020.03.22)
sensL	2011	Technical Note: Introduction to SiPM	-	https://www.sensl.com/downloads/ds/TN%20-%20Intro%20to%20SPM%20Tech.pdf (Hyperlink verified on 2020.03.28)