DI.103.HEP Particle Detectors Fundamentals I

1. Study program

1.1. University	University of Bucharest
1.2. Faculty	Faculty of Physics
1.3. Department	Department of Theoretical Physics, Mathematics, Optics, Plasma and Lasers Department of Structure of Matter, Atmospheric and Earth Physics, Astrophysics
1.4. Field of study	Physics
1.5. Course of study	Master of Science
1.6. Study program	High Energy Physics (in English)
1.7. Study mode	Full-time study

2. Course unit

2.1. Course unit title	**Particle Detectors Fundamentals I**							
2.2. Teacher				Conf. Dr. Oana Ristea, Lect. Dr. Mihaela Pârvu				
2.3. Tutorials instructor(s)								
2.4. Practicals instructor(s)				Conf. Dr. Oana Ristea, Lect. dr. Mihaela Pârvu				
2.5 Year of study	1	2.6. Semester	2	2.7. Type of evaluation	E	2.8. Type of course unit	Content[1)]	**DF**
							Type[2)]	**DI**

[1)] fundamental (DF), specialized (DS); complementary (DC)
[2)] compulsory (DI), elective (DO), noncompulsory disciplines (DFC)

3. Total estimated time (hours/semester)

3.1. Hours per week in curriculum	**4**	distribution: Lecture	**2**	Practicals/Tutorials	**2**
3.2. Total hours per semester	**56**	distribution: Lecture	28	Practicals/Tutorials	28

Distribution of estimated time for study	**hours**
3.2.1. Learning by using one's own course notes, manuals, lecture notes, bibliography	**44**
3.2.2. Research in library, study of electronic resources, field research	**18**
3.2.3. Preparation for practicals/tutorials/projects/reports/homeworks	**28**
3.2.4. Exams	**4**
3.2.5. Other activities	**0**

3.3. Total hours of individual study	**90**
3.4. Total hours per semester	**150**
3.5. ECTS	**6**

4. Prerequisites (if necessary)

4.1. curriculum	Equations of mathematical physics, Electricity, Atomic physics, Nuclear physics, Optics, Quantum physics, Statistical physics
4.2. competences	Physical data processing and numerical methods

5. Conditions/Infrastructure (if necessary)

5.1. for lecture	Classroom (preferably, but not required, multimedia facilities)
5.2. for practicals/tutorials	Experimental setups from the Laboratory of Nuclear Physics, the Laboratory of Nuclear Spectroscopy and Detectors

6. Specific competences acquired

Professional competences	• Identification and proper use of the main laws and principles of physics in a given context; identification and use of notions • Solving physics problems under imposed conditions • Creatively applying the knowledge acquired in order to understand and model the processes and physical properties • Communication and analysis of information of a didactic, scientific and popular character in the field of physics • Use / development of specific software tools
Transversal competences	• Efficient use of information sources and resources for communication and training, including in a language of international circulation • Carrying out professional tasks in an efficient and responsible manner, in compliance with the legislation, ethics and deontology specific to the field.

7. Course objectives

7.1. General objective	Investigating the main properties of the detector; of the mechanisms by which the different types of radiation interact with matter depending on the type of particle, energy. Detector classes; specific applications in nuclear physics, particles, astrophysics and other fields
7.2. Specific objectives	Highlighting to each subject tackled the essential problems needed to understand the phenomena that will allow the student to form a way to think and develop creatively the problems to be solved.

8. Contents

8.1. Lecture [chapters]	Teaching techniques	Observations
General properties of detectors	Systematic presentation - lecture. Examples	4 hours
2) Main Physical Phenomena Used for Particle Detection and Constructive Classes of Detectors: Ionization in gases: Detectors without amplification, proportional counters, Geiger counters, streamer detectors, in liquids, and in solid media. Scintillation counters: Photomultipliers and photodiodes. Cerenkov effect and detectors. Transition radiation and detectors. Other principles: Cloud chamber, bubble chamber, streamer chamber, spark chamber, nuclear emulsions, halide crystals, thermoluminescence, plastics, fluorescence, radio detection, bolometric detectors at cryogenic temperatures (millikelvin).	Systematic presentation - lecture. Examples	10 hours
3) Classes of Detectors: a) Track Detectors: multi-wire proportional chambers, planar drift chambers, cylindrical wire chambers (proportional, time projection chambers), gaseous detectors, semiconductor tracking detectors, scintillating fibers. b) Calorimeters: electromagnetic, hadronic, cryogenic, other applications. c) Particle Identification: charged particles (via time	Systematic presentation - lecture. Critical analysis. Examples	14 hours

of flight, energy loss through ionization, Cerenkov, transition radiation); identification with calorimeters, neutron detection. d) Neutrino Detectors. e) Muon Detection. f) Ultra-high-energy shower detection. g) Cryogenic detectors for dark matter.		
Bibliography: 1) G.F. Knoll, Radiation Detection and Measurement, Wiley, 2000 2) W.R.Leo, Techniques for Nuclear and Particle Physics Experiments, (Springer-Verlag, Berlin, 1987 and 2003). 3) C. Grupen, B. A. Swartz, Particle Detectors, Cambridge University Press 2008 4) Claus Grupen, Astroparticle Physics, Springer-Verlag Berlin Heidelberg 2005 4) Particle Data Group, http://pdg.lbl.gov 5) I. Lazanu, Mihaela Parvu, Detectori de particule - Îndrumar de laborator, aplicatii numerice şi probleme – forma electronic		
8.2. Tutorials [main themes]	Teaching and learning techniques	Observations
Numerical applications and simulations		6 h
8.3. Practicals [practical activities, projects, etc.]	Teaching and learning techniques	Observations
1. Investigation and analysis of signals in detection systems using gas, scintillators, and semiconductors, along with associated electronic modules. 2. Experimental determination of detection characteristics for different types of detectors. 3. Testing a scintillator-based spectrometric chain with a "phoswich" detector (sandwich detector capable of discriminating gamma signals from neutrons—fast and slow). 4. Spatial and temporal correlations for gamma radiation investigated with scintillator detectors.	Guided work	4 h 12 h 4 h 2 h
Bibliography: I. Lazanu, Mihaela Parvu, Detectori de particule - Îndrumar de laborator, aplicatii numerice şi probleme – forma electronic		

9. Compatibility of the course unit contents with the expectations of the representatives of epistemic communities, professional associations and employers (in the field of the study program)

In order to sketch the contents, to choose the teaching / learning methods, given the special importance of the discipline for applications in modern physics and technology, the holders of the discipline consulted the content of similar disciplines taught at universities in the country and abroad (Heidelberg, University of Cambridge, University of Cambridge Gent, Laussane). The content of the discipline is according to the requirements of employment in research institutes in nuclear physics and engineering, medical laboratories that use nuclear methods in investigation and treatment (according to the law).

10. Assessment

Activity type	10.1. Assessment criteria	10.2. Assessment methods	10.3. Weight in final mark
10.4. Lecture	- coherence and clarity of exposition - correct use of equations/mathematical methods/physical models and theories - ability to indicate/analyse specific examples	Oral examination	70%
10.5.1. Tutorials	- ability to use specific problem solving methods - ability to analyse the results	Homeworks/writen tests	10%
10.5.2. Practicals	- ability to use specific experimental methods/apparatus - ability to perform/design specific experiments - ability to present and discuss the results	Lab reports	20%
10.5.3. Project [only if included in syllabus]			
10.6. Minimal requirements for passing the exam Correct understanding of the concepts and phenomena, the ability to work with them and obtain accurate numerical results on topics imposed.			
Requirements for mark 5 (10 points scale) • Carrying out all the activities during the semester • Obtaining note 5 by summing the points obtained at the activities during the course and examination, according to the weights specified			

	Teacher's name and signature	Practicals/Tutorials instructor(s)
Date 25.09.2024	Conf. Dr. Oana Ristea, Lect. Dr. Mihaela Pârvu	Conf. Dr. Oana Ristea, Lect. dr. Mihaela Pârvu

Date of approval

Head of Department
Lect. Dr. Roxana Zus