DO.203.1.HEP Frontiers in Particle Physics

1. Study program

1.1. University	Babeș-Bolyai University
1.2. Faculty	Faculty of Physics
1.3. Department	Department of Physics – Hungarian Line of Study
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	Frontiers in Particle Physics							
2.2. Teacher				Prof. Dr. Néda, Zoltán				
2.3. Tutorials/Practicals instructor(s)				Prof. Dr. Néda, Zoltán				
2.4. Year of study	II	2.5. Semester	2	2.6. Type of evaluation	E	2.7. Type of course unit	Content[1)]	**DS**
							Type[2)]	**DO**

[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**	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	**20**
3.2.2. Research in library, study of electronic resources, field research	**40**
3.2.3. Preparation for practicals/tutorials/projects/reports/homeworks	**32**
3.2.4. Preparation for exam	**4**
3.2.5. Other activities	**0**

3.3. Total hours of individual study	**96**
3.4. Total hours per semester	**150**
3.5. ECTS	**6**

4. Prerequisites (if necessary)

4.1. curriculum	Courses in quantum mechanics, special relativity, and classical mechanics. Introduction to particle physics, basic cosmology, and experimental techniques in physics. Familiarity with mathematical methods in physics, including linear algebra and calculus.
4.2. competences	Basic understanding of quantum mechanics, special relativity, and the standard model of particle physics. Familiarity with experimental techniques, including detectors and data analysis, and concepts from cosmology. Ability to apply physics principles to solve theoretical problems.

5. Conditions/Infrastructure (if necessary)

5.1. for lecture	Video projector, black/whiteboard
5.2. for practicals/tutorials	black/whiteboard

6. Specific competences acquired

Professional competences	• Identify and properly use the main principles of particle physics, including symmetries, the quark model, and fundamental interactions. • Solve theoretical and experimental problems in particle physics with qualified guidance. • Understand the principles and applications of particle accelerators, detectors, and experimental techniques like parity and CP violation tests. • Gain rigorous knowledge of neutrino experiments, Higgs boson research, and their connections to cosmology. • Apply particle physics concepts to medical and interdisciplinary applications, interpreting experimental results and communicating findings effectively.
Transversal competences	• Efficient use of sources of information and communication resources and training assistance in a foreign language • Efficient and responsible implementation of professional tasks, with observance of the laws, ethics and deontology.

7. Course objectives

7.1. General objective	Understanding the experimental and theoretical foundations of particle physics, including the quark model, symmetries, and fundamental interactions. Exploring the connection between particle physics, cosmology, and practical applications like medical technologies.
7.2. Specific objectives	Develop the ability to analyze and interpret experimental results in particle physics, including accelerator and detector data. Understand the role of symmetry breaking and fundamental experiments (e.g., CP, parity) in particle interactions. Gain insights into applications of particle physics in cosmology and medicine.

8. Contents

8.1. Lecture [chapters]	Teaching techniques	Observations/ hours
Overview Symmetries and particles	Systematic exposition - lecture.	4 hours
Static quark model Experimental proof of quark model	Systematic exposition - lecture. Examples	4 hours
Particle accelerators Particle detectors Event registration	Systematic exposition - lecture. Examples	6 hours
Basic experiments: parity violation Basic experiments: CP, CPT, kaons	Systematic exposition - lecture. Examples	4 hours
Basics of cosmology Neutrino experiments Higgs boson	Systematic exposition - lecture. Examples	6 hours

Medical applications	Systematic exposition - lecture. Examples	2 hours

Bibliography:

1. Dezső Horváth and Zoltán Trócsányi: Introduction to Particle Physics, Cambridge Scholars, 2019

2. *The book in manuscript,* University of Debrecen.

8.2. Tutorials [main themes]	Teaching and learning techniques	Observations/hours
Discussions, control questions and exercises pertaining to each topic	Problem solving	1 hour/lecture hour

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)

This course unit develops some theoretical competences, which are fundamental for a Master student in the field of modern physics, corresponding to national and international standards. The contents is in line with the requirement of the main employers of research institutes and universities.

10. Assessment

Activity type	10.1. Assessment criteria	10.2. Assessment methods	10.3. Weight in final mark
10.4. Lecture	- Clarity and coherence of exposition - The ability to give specific examples	Oral examination	60%
10.5.1. Tutorials	- Ability to carry out quantitative estimates, identify relationships	Oral examination	40%
10.6. Minimal requirements for passing the exam			
Requirements for mark 5 (10 points scale) At least 50% of exam score and of homeworks.			

Date
10.10.2024

Teacher's name and signature

Prof. dr. Zoltán Néda

[redacted]

Practicals/Tutorials instructor(s) name(s) and signature(s)

Prof. dr. Zoltán Néda [redacted]

Date of approval

Head of Department

Conf.dr. Ferenc Járai-Szabó

[redacted]