COURSE UNIT (MODULE) DESCRIPTION

Course unit (module) title	Code
World of Particles	

Course Summary
Concepts of modern particle physics are often complex, since they rely on ideas that go well beyond the daily human experience. The general public is often aware of radiation sources and its real or perceived hazards; many people are intrigued by the vast difference in scales of the physical world between the microcosm and the macrocosm; some people have heard of peculiar properties of matter at extreme conditions or about the Higgs boson discovery at the Large Hadron Collider at CERN. These are just a few examples for the fact that topics of particle physics are perceived as interesting to many people. The course „The World of Particles“ aims to introduce the principle concepts to the topics above, present scientific reasoning and the guiding principles for some of the forefront scientific and engineering research, as well as the historic ideas that lead to modern particle physics and the associated technologies.

Lecturer(s)	Department(s) where the course unit (module) is delivered
Coordinator: Thomas Gajdosik **Other(s): Andrius Juodagalvis, Aurelijus Rinkevicius, Albinas Plėšnys, Christoph Schaefer (TBC)**	Faculty of Physics

Study cycle	Type of the course unit (module)
First	General university studies

Mode of delivery	Period when the course unit (module) is delivered	Language(s) of instruction
Face-to-face	**Autumn or Spring**	English

Requirements for students	
Prerequisites: English B1, school level Mathematics	**Additional requirements (if any):**

Course (module) volume in credits	Total student's workload	Contact hours	Self-study hours
5	130	54	76

Purpose of the course unit (module)		
The aim of the course „World of Particles“ is to present concepts, implications and applications of modern particle physics to students. The students will acquire some basic knowledge, ideas, and guiding principles that go beyond the daily experience, i.e. consequences of special relativity and of the uncertainty principle, the vastness of the scales from the microcosm to the entire universe, etc. Though often not easy to understand, these ideas are necessary to describe the phenomena encountered at extremely small distances and/or at high (particle) energies. The students will understand the influence of particle physics research on current technological and societal developments and they will be more thoroughly educated to think critically.		
Learning outcomes of the course unit (module)	**Teaching and learning methods**	**Assessment methods**
- The student will be able to identify the manifestations of fundamental interactions in physical phenomena and know the fundamental constituents of matter	Lecture, seminars, tutorial, group work, and individual study	Midterm test, Final Exam, presentations, evaluating the presentations of other students
- The student will be able to critically address the paradoxes related to special relativity	Lecture, seminars, group work, and individual study	Midterm test, Final Exam, presentations, evaluating the presentations of other students
- The students will learn the scientific method of problem solving and practice its application	Lecture, seminars, group work	Midterm test, Final Exam, presentations, evaluating the presentations of other students
- The students will learn to select and use sources of information on current developments of particle physics and on technology, that is related to it, and analyze relevant examples	Lecture, seminars, group work	Midterm test, Final Exam, presentations, evaluating the presentations of other students
- The students will learn the role of fundamental research to technological and societal developments	Lecture, seminars, group work	Midterm test, Final Exam, presentations, evaluating the presentations of other students
- The students will learn team work, the application of general ethical rules, and rules of scientific research to the assigned tasks	Group work, seminars	Presentations and evaluating the presentations of other students
- The students will learn the evaluation of scientific material and to present orally complex information in a concise, clear, and reasoned manner	Group work	Presentations and evaluating the presentations of other students

Content: breakdown of the topics	Contact hours								Self-study work: time and assignments	
	Lectures	Tutorials	Seminars	Workshop	Laboratory work	Internship/work	E-learning	**Contact hours**	**Self-study hours**	**Assignments**
1. Historical motivation and Philosophical introduction; history of particle physics before accelerators, history of particle physics with accelerators, scientific method	6		4					**10**	**2**	**Answering review questions about the lecture on moodle**
2. Special Relativity; explanation of space-time diagrams, scales (microscopic/macroscopic), time dilation / length contraction, frames of reference, symmetries and conservation laws, meaning of mass	4		2 +2					**8**	**16** **+8** **+2**	**Reading the first 6 chapters of „Special Relativity“ by D. Hogg** (in this reading the more complicated mathematical formulas and calculations can be ignored) **+ doing homework exercises** (simple calculations and drawing space-time diagrams; the calculations and the drawing of the space-time diagrams are explained and practiced in a seminar before) **+ answering review questions about the lecture on moodle**
3. Concepts of Quantum Mechanics; quantization, double slit experiment (particle-wave duality), „what is measurement?“	4							**4**	**2**	**Answering review questions about the lecture on moodle**
4. Standard Model of Particles (SM); fundamental forces, elementary particles, underlying symmetries, Higgs mechanism, detecting particles, tutorial	4	2	2					**8**	**4** **+2**	**Reading the section „The Standard Model“ of „The particle adventure“** **+ answering review questions about the lecture on moodle**
5. Cosmic Rays (as an example of Standard Model physics and of physics beyond the Standard Model); origin and observation of the cosmic rays	2		0					**2**	**1**	**Answering review questions about the lecture on moodle**
6. Technology and Society; particle physics inspired technologies that affected society, ideas about new technologies	6		6					**12**	**3**	**Answering review questions about the lecture on moodle**
7. Midterm Exam and Preparation for the Final Exam			4					**4**	**24**	**Individual study of the learning material to prepare for the exams**
8 Student presentation sessions			6					**6**	**12**	**Preparing a seminar in the small group to be presented at a specified presentation session**
Total	**26**	**2**	**26**					**54**	**76**	

Assessment strategy	Weight ,%	Deadline	Assessment criteria

Presenting the seminars	**25**	**At the specific arranged presentation session**	• Grade from the lecturer 15%, following predefined formal criteria: ◦ logical consistency of the presentation ◦ fitting into the assigned timeframe ◦ answering questions to the presentation ◦ being understandable to the audience ◦ presenting the theme in an adequately detailed manner • grade of the audience 5% • grade from the fellow students in the group that prepared the presentation (averaged) 5%
Evaluating the presentation of other students	**5**	**After each presentation is given and before the end of the course**	The student has to write a grade with an explanation in emokymai.vu.lt (Moodle). This explanation shows how much (s)he understood from the seminar and how serious we can treat the evaluation. Each presentation has to be evaluated and counts a unit. The points are normalized to 5%, each presentation counting as one unit.
Midterm test	**30**	**Arranged time**	Grading the multiple choice test by the computer system (Moodle). We plan 30 questions. Full points are given only for fully and correctly answered questions, but 75% should be reachable with a feedback on not correctly answered questions.
Final exam	**40**	**Exam time**	Grading the multiple choice test by the computer system (Moodle). We plan 40 questions. A few questions from the Midterm exam can appear again. Full points only for fully and correctly answered questions, but 75% should be reachable with a feedback on not correctly answered questions.
Bonus points	**5**		For exceptional engagement. Examples for exceptional engagement would be: the student coming with questions about the course subject outside the normal course times, helping other groups doing their presentations, presenting the homework in a clear way that helps other students understand it better.

Author	Year of publication	Title	Issue of a periodical or volume of a publication	Publishing place and house or web link
Compulsory reading				
D. Hogg	1977	Special Relativity This relatively old book is still the best available. Special Relativity was introduced 1905, but it still did not make it to the popular general understanding. Counting from 1905, this booklet is rather new. But most importantly, it is a really well written and educational booklet that is available for FREE. The booklet is of a small enough size: students can read it without spending too much time. Any more modern book contains either much more material or is written on a much lower level, like the series "For dummies". Rewriting a perfectly written teaching supplement does not make any sense, especially when one has to cite it as the original work and the student then sees, that there is not really any difference. Many of the exercises in the book are also at a low enough level: students can try to solve them without a deeper Mathematical introduction. At the same time, these exercises also explain the methodology of physics in the sense, that the essence of a physical theory is its possibility to predict a phenomenon. And for this prediction the calculation of the prediction is essential. Therefore an introduction into physics without mentioning the need for calculation is doomed to fail from the beginning.	47p.	http://cosmo.nyu.edu/hogg/sr/sr.pdf
Particle Data Group	© 2014	The particle adventure, section: The Standard Model		https://particleadventure.org/standard-model.html
Optional reading				
D. Griffiths	2008	Introduction to Elementary Particles	2nd edition 978-3527406012, 470p.	Wiley-VCH
T. Gajdosik	2013	Special Relativity for Particle Physics: notes on Mathematics for Physics	31p.	VU http://web.vu.lt/ff/t.gajdosik/files/2014/01/sr4wop.pdf
Reading for fun				
Particle Data Group	© 2014	The particle adventure: other sections		http://www.particleadventure.org/
CERN	2020	Accelerating science		https://home.cern/

Extended course description:

The announcements that Lithuania joined the European Organization for Nuclear Research (CERN) as an associated member in 2018 have caught the public's eye. The associate membership opened new possibilities for Lithuanians to participate in one of the most ambitious scientific and engineering efforts in the human history. The range of activities open to Lithuanians makes it increasingly important that many students, not only physicists or engineers, get a deeper understanding of what is happening at CERN.

A range of topics will be presented during the course, namely the historical introduction to particle physics, its relation to philosophical concepts of reasoning and evaluation, the presentation of current and possible future technological developments based on fundamental research in particle physics, as well as a short introduction to the field of particle physics itself. The presented topics will enable the attendees to understand and critically evaluate the news, current developments, and possibly even future developments related to particle physics.
Besides the lectures, the students are expected to come to the seminar sessions that happen after the lectures. These sessions will be of several kinds: one time we plan to watch a movie, the next session we plan to discuss the movie.
A third type of the seminars will be discussions in small groups about the general concepts presented at the lecture. Planned discussions include a debate of possible technological implementations of particle physics concepts presented during the lecture.
There will be at least one session explaining how to calculate in Special Relativity and solving problems, as Special Relativity is the first topic where this course goes completely beyond everyday experience. This specific seminar session is directly related to the homework for Special Relativity.
There will be three students' presentation sessions in these seminars, carried out in at least two parallel sessions. This division will help that every student can actively participate. In the presentation sessions the students are expected to give a presentation about an assigned subject. This presentation should be prepared in a small group of up to four students. If the student has an own idea about an interesting subject, this subject can be chosen if the lecturers agree. A reflective discussion of the given seminars is planned after the presentations.
One of the last sessions will be a tutorial about particle detection (a masterclass).