PhD Physics course at Bari University (XXXVI Cycle)

Title	Geant4: Beginners Course
Proponent	Dr. Annamaria Mazzone (IC CNR)
# CFU (1 CFU = 8 hours)	1.25
Schedule	March-April 2021
Brief Summary of the course	This is a course based on Geant4 version 10.6. This short course will cover all aspects of Geant4 from the basic building blocks of Geant4 through intermediate topics, interspersed with examples that build a progressively more complex application extensible to real use. **Objectives:** • Acquire basic knowledge and experience in using the Geant4 simulation toolkit
Programme	This Short Course provides an overview of Geant4, its capabilities and how they can be used in an experimental simulation application the course is divided into 5 sessions.

	Session 1 - Introduction to Geant4 *Introduction to Geant4* *- Overview of Geant4* *- Basic concepts* *- Kernel structure and key classes* *- User classes* Session 2 - Material and geometry *Defining material and geometry* *- User detector construction class* *- Material* *- Solid, logical volume, physical volume* *- Placement, replica, parameterized volume* Session 3 - Physics *Physics overview* *- Particle, tracking, physics process* *- Production cut* *- User physics list* Session 4 - Primary particle generation and Exercise *Primary particle generation* *- User primary generation action class* *- Particle gun* *- Other primary generators* Session 5 - Detector sensitivity, user actions and Exercise *Detector sensitivity* *- Sensitive detector class* *- Hit and hits collection* *- User action classes for extracting hit information*
Recommended texts	Geant4 User's Documents page. This page gives you an overview of all available documents which are created and maintained by the Geant4 international collaboration. https://geant4.web.cern.ch/support/user_documentation
Assessment methods	Users presentations and Q/A *Users presentations* *- Duration of each talk will be approximately 15 minutes.*

PhD Physics course at Bari University (XXXVI Cycle)

Title	Programming with Python for Data Science
Proponent	Dott. Domenico Diacono (INFN)
# CFU (1 CFU = 8 hours)	**2/3**
Schedule	TBD
Brief Summary of the course	**This is an entry level course.** It doesn't require a previous Python or programming knowledge, and contains an introduction to Python fundamentals, to the most used Python structures for procedural and object oriented programming, and to the basic of ML. A special attention will be given to the libraries that are required for a successful data analysis: NumPy, Pandas, Matplotlib, Seaborn. **The course will be held in Italian, all course materials will be in English.**
Programme	-Python installation: Anaconda, Jupyter Notebooks -Built in types, list and dictionaries -Conditionals, Loops and list comprehensions -Definition of function and modules -Scripts, interaction with files, Error trapping -Modules and namespaces -Numpy -Pandas -Matplotlib / seaborn -How to use the data libraries: an example of machine learning problem -Exercises
Recommended texts	**Imparare Python,** Mark Lutz, O'Reilly
Assessment methods	At the end of the course each student must write an original python code that solves a problem of his own research field.

PhD Physics course at Bari University (XXXVI Cycle)

Title	Hollow Core Waveguide Devices
Proponent	Pietro Patimisco Arianna Elefante
# CFU (1 CFU = 8 hours)	2 CFU
Schedule	II SEMESTER
Brief Summary of the course	The circular waveguide has found extensive use in optical communications systems as well as for single-mode laser beam delivery. This course provides a description of wave propagation in a circular waveguide and a detailed study of the coupling conditions between a laser beam and the optical modes of the waveguide. Chapter 1 deals with "step-index" fiber and propagation modes will be determined by solving the wave equation in cylindrical coordinates. In chapter 2, hollow-core waveguides (HCWs) will be introduced: they are composed of a capillary tube surrounded by a highly reflective inner wall. A theoretical discussion of laser-HCW mode coupling as well as waveguide propagation losses will be provided when the lowest order hybrid mode is excited within the HCW. The course ends with a laboratory activity consisting in an experimental study of a mid-infrared laser beam coupling with a cylindrical Ag/AgI HCW.
Programme	1. **Step-Index Waveguides**. The scalar Helmholtz equation. Homogeneous equation in Cylindrical Coordinates. Electric and Magnetic Field Distribution. Boundary Conditions. Hybrid Modes HE and EH. Linearly Polarized Modes LP. The Fundamental HE_{11} Mode. 2. **Hollow Core Waveguides**. Mode Analysis of a straight circular HCW. Metallic/Dielectric HCW. Attenuation Coefficient. Launch conditions and mode coupling. Propagation Losses. Single-mode output conditions. 3. **Laboratory activity**. Realization of a low-loss mode coupling of a Gaussian-like, mid-infrared laser beam with a silver/silver iodide HCW using a proper focusing lens. Measurement of propagation losses and analysis of the HCW output.
Recommended texts	Clifford R. Pollock, Michal Lipson - Integrated Photonics (2003, Springer) Xingcun Colin Tong - Advanced Materials for Integrated Optical Waveguides (2014, Springer)
Assessment methods	Report on laboratory activity

PhD Physics course at Bari University (XXXVI Cycle)

Title	Nuclear Astrophysics
Proponent	Giuseppe Tagliente
# CFU (1 CFU = 8 hours)	2
Schedule	February - April
Brief Summary of the course	The nuclear processes generate the energy that makes stars shine. The same processes in stars are responsible for the synthesis of the element present in the universe. Nucleosynthesis, energy production in the stars, and other topics overlapping astrophysics and nuclear physics make up the science of nuclear astrophysics. Like most fields of physics, it involves both theoretical and experimental activities. The purpose of this course is to explain these concepts with special emphasis on nuclear processes and their interplay in the stars
Programme	Lesson 1. Aspects of nuclear physics and astrophysics. Lessons 2-3. Nuclear and thermonuclear reactions Lessons 4-6. Processes of Nucleosynthesis Lessons 7-8. Nuclear physics experiment for astrophysics
Recommended texts	Material will be provided

Assessment methods	The students will give an oral presentation on the course arguments

PhD Physics course at Bari University (XXXVI Cycle)

Title	Laser Physics and Applications
Proponent	Dr. Annalisa Volpe
# CFU (1 CFU = 8 hours)	2
Schedule	
Brief Summary of the course	Lasers are now commonplace throughout many aspects of everyday life, e.g. optical communication, industrial processing, spectroscopy and many bioscience applications. The course starts with a review of the basic physics of optical cavities and the spontaneous/stimulated emission from materials leading to laser amplifiers and oscillators. Examples of lasers are presented including systems for continuous wave and pulsed beam operation. The final component of this course is a short review on laser applications, with a focus on ultrashort laser applications.
Programme	Interaction of electromagnetic radiation with matter (absorption, spontaneous and stimulated emission). Elements of a laser system: optical cavity, active medium, laser gain conditions. Laser modes (transversal and longitudinal). Characteristics of Laser Light. Generation of short and ultra-short laser pulses: Q-switching and mode-locking. Gas and solid state state laser, fiber and semiconductor lasers. Laser Applications. Focus on ultrashort laser pulses applications in industrial and research fields.
Recommended texts	M. Csele, Fundamentals of light sources and lasers, Wiley 2004 Elijah Kannatey-Asibu, Jr., Principles of lasers materials processing, Wiley 2009
Assessment methods	Individual report on a laser system and application.

PhD Physics course at Bari University (XXXVI Cycle)
proposal for English Language Course

Title	Preparing a scientific presentation in English
Proponent	Dott.sa Carmela M. White
# CFU (1 CFU = 8 hours)	2
Schedule	Da concordare, preferibilmente incontri settimanali di due ore , preferibilmente quando sarà possibile riprendere la didattica in aula ma comunque da completare entro giugno 2021
Brief Summary of the course	Course Objectives: guiding students in the re-elaboration of their acquired knowledge of English for a more effective communicative competence in a scientific and academic setting, reinforcing their English language skills and blending them with their scientific and communication skills through • pronunciation exercises and guided oral practice to improve pronunciation and acquire greater confidence speaking in English • functional- rhetorical, syntactic-morphological and lexical analysis of authentic specialist field texts chosen individually by participants • syntactic-morphological exercises on specific problem points • preparation of a 10' slide-supported presentation of research work
Programme	• brief introduction to the phonetic system of English and IPA • reading numbers and equations aloud in English • brief review of tenses, passive voice & impersonal 'it' • some difficult verb patterns • use of -ed and -ing forms • use of articles • reducing sentences to bullet points and vice versa • brief review of logical and time connectors • describing devices • presenting and discussing results • brief analysis of scientific article organisation • presentations: organisation • presentations: creating good visual aids • presentations: delivery • presentations: dealing with questions
Recommended texts	• handout materials provided in lessons • grammar reference text (optional) • at least two research articles in English, to be chosen by participants for scientific interest and approved for suitability by the instructor
Assessment methods	• class participation and self-study exercises • preparation of personal vocabulary booklet or file • functional, grammatical, and lexical analysis of 2 or more specialist articles from the literature • preparation of slides (visual support) and script (discursive) for a 10' presentation on a research topic • subsequent performance of presentation

Bari, 09 dicembre 2020 Carmela M. White

PhD Physics course at Bari University (XXXVI Cycle)

Title	Hadron Physics
Proponent	Giuseppe Eugenio Bruno
# CFU (1 CFU = 8 hours)	2
Schedule	June
Brief Summary of the course	Hadrons are the particles that feel the strong nuclear force. This force is described by the theory of QCD, a field theory whose constituents are quarks (the particles) and gluons (the force carriers). The study of Hadron Physics is part of a wide spectrum of research that aims to describe the nature of the matter that we observe in the Universe. It sits at the interface between particle-, or high-energy physics, and nuclear physics. From particle physics it shares a "reductionist" philosophy - a desire to understand everything from basic constituents. On the other hand it involves the study of the structure of composite particles, and thus shares a great deal of common ground with nuclear structure physics, such as a study of effects that are "emergent properties" due to the interaction of several constituents. An overview of the forefronts of the broad field of hadron physics will be given in the first half of the course. In the second half the focus will be on two : i) the physics of the quark gluon plasma and ii) the physics of the proton as studied from DIS and future prospects.
Programme	QCD, confinement and the structure of the hadrons. **Hadron spectroscopy:** overview. **Recent achievements and state of the art in Hadron structure:** electromagnetic form factors and the proton radius puzzle; Nucleon form factors. Parton distribution function. **Hadronic interactions. Hadron physics at high energy densities:** the quark gluon plasma. **Future:** the Electron Ion Collider
Recommended texts	To be defined

Assessment methods	Solution of numerical exercises and/or oral examination

PhD Physics course at Bari University (XXXVI Cycle)

Title	Fundamentals in advanced programming using C++ programming language
Proponent	Francesco Cafagna
# CFU (1 CFU = 8 hours)	4
Schedule	May-June
Brief Summary of the course	This course focuses on an introduction to the fundamental concepts founding the evolution from procedural to object-oriented programming. The C++ programming language - thanks to its general purpose, memory control, strong type-check design - will be used as a case study for such an evolution; for this the language base grammar, along with the base functionalities that better adhere to the object-oriented paradigm, will be treated. The core language feature will be interleaved with an overview of the major novelties introduced by the more recent standard updates. Lesson plan foresees a number of exercises, tuned to deepen the theoretical argument treated in each session.
Programme	**Lesson 1 and 2.** **Course introduction and layout:** - **From procedural programming languages to the object oriented ones.** - **Programming: an introduction.** - **Programming: base concepts.** - **Programming: the jargon.** - **Basic introduction to the tools and techniques used to build an executable.** **Lesson 3 and 4.** - **An object oriented programming language: C++.** **The C++ base grammar:** - **Base types.** - **Expressions and statements.** - **Functions.** - **Pointer and reference.** - **Examples and exercise.** **Lesson 5 and 6.**

	C++ advanced functionalities: - **Aggregate types: Structure and Union.** - **Function overloading.** - **Namespaces.** - **Template programming.** - **Examples and exercises.** **Lesson 7.** **Class:** - **An introduction and general properties.** - **Class members: creator, destructors, methods and helper functions.** - **Manage access to the class members: public, private.** - **Operators and overloading.** - **Modern C++. New Class design paradigm introduced since C++11.** - **Examples and exercises.** **Lesson 8 and 9.** **Class advanced functionalities:** - **Derived class.** - **Inheritance and polymorphism.** - **Examples and exercises.** **Lesson 10.** **The Standard Template Library: STL.** - **An introduction and general properties.** - **In-depth view of the STL objects used in the course: string, containers, functionals and algorithms.** **Hints on Object Oriented programming: some example of popular structural patterns.**
Recommended texts	- Lecture slides and examples. - B. Stroustrup, The C++ programming language (Third edition), Addison – Wesley - B. Stroustrup, Programming -- Principles and Practice Using C++, Addison -Wesley ISBN 978-0321543721. December 2008. - S. Oualline, Practical C++ Programming (Second Edition), O'Reilly - S. Meyer, Effective C++ Third Edition, Addison-Wesley ISBN-13: 978-0321334879 (any edition of this book is worth consulting) - S. Meyer, Effective Modern C++, O'Reilly Media, Incorporated; ISBN-13: 978-1491903995 - D. Vandevoorde & N.M. Josuttis, C++ Templates – The complete Guide, Addison-Wesley ISBN-13: 978-0201734843 - H. Sutter, Exceptional C++: 47 engineering Puzzles, Programming Problems and Solutions. Reading, MA: Addison-Wesley.
Assessment methods	A presentation and discussion on an exercise proposed by the student. The exercise will be related to the student research project, and use techniques, functionalities and tools threated during the course.

PhD Physics course at Bari University (XXXVI Cycle)

Title	Atom-photon interactions
Proponent	Dr. Francesco Vincenzo Pepe (Università di Bari)
# CFU (1 CFU = 8 hours)	2
Schedule	8 class lectures between February and April
Brief Summary of the course	The course will provide the basic concepts, results and mathematical tools of low-energy Quantum Electrodynamics. The first part will be review of QED, its elementary processes and the perturbative computation of transition rates. In the second part, non-perturbative analysis methods will be introduced, and a fully quantum theory of atom-laser interaction will be presented, also focusing on its relevance for optical trapping and atom manipulation.
Programme	1. Electrodynamics in Coulomb gauge. Constants of motion. Transverse and longitudinal fields. Quantization. Gauge invariance and minimal coupling. Dipolar approximation. 2. Processes. Review of the basic processes of atom-photon interactions. Feynman diagrams. Perturbative estimate of transition rates. 3. Non-perturbative methods. Properties of the resolvent. Self energy and partial resummation. Lifetimes and energy shifts. The Lamb transition. 4. The dressed atom approach. Quantum treatment of the atom-laser interaction. Dressed states. Fluorescence triplet. Master equation for the dressed atom. Dipolar forces.
Recommended texts	C. Cohen-Tannoudji, J. Dupont-Roc, G. Grynberg "Atom-Photon Interaction: Basic Processes and Applications" WILEY-VCH Verlag GmbH & Co (2004)
Assessment methods	Final seminar

PhD Physics course at Bari University (XXXVI Cycle)

Title	LabView: introduction and data acquisition
Proponent	Leonardo Di Venere Fabio Gargano
# CFU (1 CFU = 8 hours)	2
Schedule	May – July 2021
Brief Summary of the course	The course aims to provide the students basic knowledge of LabView fundamentals. This software is widely used both in research and industrial environments, especially in applications where communication with one or more instruments and fast and on-line analysis are required. In addition, the native parallelization of all the operations performed makes this software ideal to fully exploit the computing power. This course includes an introduction to LabView environment, from the basic principles of programming to the typical structure of data acquisition. The course will include several practical sessions dedicated to exercises and data acquisition. A basic knowledge of the programming principles is required.
Program	1. General introduction to Labview: front panel, block diagram, VIs, project, error handling. 2. Basic structures: while and for loops, case structures. 3. Arrays: 1D and multidimensional arrays, vectorized functions 4. Events, event-driven programming 5. Sub VIs: connector pane and icon editing. 6. File I/O: accessing and writing files 7. Hardware data acquisition: communication protocols, data acquisition 8. Introduction to state machine programming
Recommended texts	Lecture notes. National Instruments tutorial.
Assessment methods	Lessons, exercise sessions, development of a simple project on a case of interest

PhD Physics course at Bari University (XXXVI Cycle)

Title	Neutrino Physics
Proponent	Marilisa De Serio Alessandra Pastore (INFN)
# CFU (1 CFU = 8 hours)	2 CFU
Schedule	April - May
Brief Summary of the course	Neutrino oscillations are the most compelling evidence to date for physics beyond the Standard Model. The course is intended to provide an overview on neutrino physics, with special emphasis on neutrino oscillation phenomenology and on their implications. The course will also briefly cover the role of neutrinos in the Early Universe.
Programme	• Neutrino properties. • Phenomenology of neutrino oscillations. Oscillations in matter, MSW effect. • Neutrino sources and detection, conventional and unconventional neutrino beams, current experimental overview. • Neutrino masses and nature: evidence and implications. • Open questions in neutrino physics: what's next
Recommended texts	C. Giunti and C. W. Kim, **Fundamentals of Neutrino Physics and Astrophysics**, (Oxford University Press, USA, 2007) Selected papers on specific topics provided during the course
Assessment methods	Seminar on a selected topic