PHYSICS (LM38)

(Lecce - Università degli Studi)

Teaching

GenCod A006987

Owner professor SERGIO GRANCAGNOLO

Teaching in italian METODI SPERIMENTALI PER LA FISICA DELLE

Teaching

SSD code FIS/01

Reference course PHYSICS

Course type Laurea Magistrale

Credits 7.0

Teaching hours Front activity hours: 49.0

For enrolled in 2022/2023

Taught in 2022/2023

Course year 1

Language ITALIAN

Curriculum ASTROFISICA,FISICA SPERIMENTALE DELLE INTERAZIONI

Location Lecce

Semester Second Semester

Exam type Oral

Assessment Final grade

Course timetable https://easyroom.unisalento.it/Orario

BRIEF COURSE DESCRIPTION

Short introduction to modern nuclear and subnuclear physics. Particle accelerators: linear accelerators, cyclotrons, synchrotrons, synchrotron light. Semiconductors detectors. Detector systems: trackers, calorimeters, particle identification, trigger, data acquisition. Calorimetry. Examples of experiments in particle physics and astroparticle physics. Examples of applications to nuclear physics.

REQUIREMENTS

Buona conoscenza dell'inglese, in quanto lingua principale utilizzata nella letteratura disponibile.
A good knowledge of classical electrodynamics and special relativity is essential. Basic concepts of quantum mechanics are recommended. Some notions of particle physics might facilitate the comprehension, but are not strictly necessary.

COURSE AIMS

The student acquires the basic knowledge to understand the functioning of the instrumentation and the methods which are typically employed in nuclear and subnuclear physics.

TEACHING METHODOLOGY

Lecture. Flipped classroom.

ASSESSMENT TYPE

Oral exam.

OTHER USEFUL INFORMATION

Il programma può venire adattato per focalizzarsi su specifici aspetti sperimentali. Se interessati a seguire il corso, contattare preventivamente il docente prima dell'inizio del semestre.

Visione d'insieme dei temi trattati nel corso: animazione riguardante il complesso di acceleratori del CERN, la presa dati degli esperimenti e l'analisi sperimentale.
https://home.cern/resources/video/cern/cern-overview-animation

FULL SYLLABUS

Accelerators

Historical accelerators: Van der Graaf and tandem. Linear accelerators. Cyclotrons, synchrocyclotrons and synchrotrons.
Decoupling of longitudinal and transverse modes. Dipoles. Quadrupoles. Transport matrices. Hills equation and its solutions in terms of the Twiss parameters. Betatron function and transverse emittance.
Effects causing deviations from the ideal orbit. Quadrupole errors and tune variations. Closed orbit, dipole errors and integer resonances. Momentum compaction factor and dispersion function. Natural chromaticity. Sextupoles. Resonances from magnet effects. Transverse-longitudinal couplings.
Longitudinal dynamics. Relativistic transition. Radiofrequency cavities. Synchrotron oscillations. Bunch structure. Acceleration. Phase inversion at the relativistic transition.
Solution of Maxwell equations in covariant form: retarded potentials. Liénard-Wiechert expression for the radiation potential emitted by a moving charge. Derivation of the electromagnetic field from the Liénard-Wiechert potential. Relativistic generalization of Larmor's formula: linear acceleration vs circular acceleration.
Computation of the angular spectrum of synchrotron light. Computation of the energy spectrum and polarization states of synchrotron light. Wigglers and undulators.
Examples of accelerators: electrostatic machines, famous accelerators. The CERN accelerators complex. Future colliders. The ESRF synchrotron.

Semiconductor detectors

Band structure of solids. Calculation of the density of charge carriers. Calculation of the chemical potential. Mass action law. Semiconductor materials and their use in radiation detection: silicon, diamond, germanium, high-Z materials.
Doping. The pn junction. Junction capacitance. Johnson-Nyquist noise. Biased pn junction, single sided pn-junction, leakage current. Small pixel effect. The MOS structure.
Strip detectors. Pixel detectors. Hybrid vs monolithic. Typical pixel functionalities.
Examples of application: X-ray computed tomography with spectral resolution, other examples.
Silicon photomultipliers.

Spectrometry and tracking

Measurement of momentum from the sagitta. Influence of multiple scattering and resolution.
Alignment techniques.
Fit to circular trajectory: the Chernov-Oskorov solution and the Karimaki solution.
The Kalman filter.

Calorimetry

Electromagnetic showers. Differences between e/p and gamma showers. Hadronic showers and the role of the neutral pions.
Homogeneous and sampling calorimeters. Radiation length. Moliere radius. Interaction length. Pre-shower detectors. Effect of soft photons and neutrons on the sampling fraction.
Linearity of response. Quenching, saturation and the Texas tower effect. Containment. Components of the resolution of a calorimeter.
Compensation of a hadronic calorimeter. Dual readout.

Particle identification

Time of flight. Transition radiation. Cherenkov light.

Particle detector systems

General purpose detectors. Trigger and data acquisition.

The LHC experiments, with details on the ATLAS detector. Techniques and experiments for detecting neutrinos. Cosmic ray experiments, with details on the CTA UV cameras.
Examples of detectors for physics beyond the standard model: dark matter, neutrinoless double beta decay, axions.

Detection of gravitational waves
Einstein equations. Linearized solutions and the TT gauge. Properties of GW. Sources of GW and the quadrupole formalism.
GW emitted by a binary system. Luminosity. Coalescence. Signals from typical sources.
Detection by means of resonant masses. Interferometers. Laser power. Resonant cavities and dual recycling. Laser stability. Radiation pressure, quantum limit, mirror suspension and gravitational noise.
Example of GW experiments. How to extract information from a GW waveform.

REFERENCE TEXT BOOKS

The material of the class references several textbooks and scientific papers, mostly in English. When treating each topic, the teacher will make sure to point the students to the proper literature.