UNIVERSITÀ
DEGLI STUDI DI MILANO-BICOCCA

COURSE SYLLABUS

Nuclear and Subnuclear Physics Laboratory

2324-3-E3001Q065

Aims

Education to the use of nuclear instruments and methods with applications in particle physics, in environmental analysis and medical diagnostics.

Contents

- Introduction to the base principles for ionizing radiation detection

- Practical experiences with alpha radiation detectors for spectroscopic and radiation-matter interaction measurements

- Practical experiences with gamma radiation detectors for spectroscopic or PET-like measurements, analysis of radiatio-matter interaction or of Compton effect

- Practical experiences with organic scintillators for detection and characterization of cosmic rays

- Practical experiences with inorganic scintillators coupled to SiPM detectors for gamma radiation and cosmic rays detection

Detailed program

Introduction to particle detection: particle sources, dosimetry, particle-matter interaction base principles, base principles of more standard particle detectors for spectroscopy or interaction time measurement, signal processing, data acquisition and data analysis.

Practical experiences on one of the 7 experiences available in the laboratory: gamma spectroscopy, Compton measurement, alfa spectroscopy, Rutherford experiment, experience with scintillators+SiPM detectors, PET-like, Coscmic muons measurements.

In particular the experiences are focused on the following activities:
- Alpha, beta and gamma spectroscopy: optimization, calibration and characterization of solid state detectors; measurements of activities; measurements of the range-energy curve and of the specific ionization of alpha particles;

- Measurements of gamma rays absorption and released energy, angle and time correlations in nuclear decays, Compton effect, and measures with PET-like apparatus.

- Characterization of cosmic rays at ground: time of flight, speed and lifetime of muons using plastic scintillators and coincidence/anticoincidence/veto techniques.

- Gamma and cosmic rays measurement with inorganic scintillating crystals coupled do SiPM detectors: characterization and comprehension of the specific properties of SiPM detectors, optimization of working points and parameters for data acquisition, gamma spectroscopy measurements comparing the performances of scintillating crystals made of different compounds.

Prerequisites

- Base knowledge of root programming for data analysis
- Base knowledge of statistical data analysis

Teaching form

- **Frontal introductory lessons**: 12 hours organized in 2 hours lessons, given for all the students at the beginning of the first semester. They are fundamental to acquire the basics about the to the topics that will be developed during the practical experiences in the laboratory

- **Practical part:** 84 hours organized in 2 mornings of 4 hours each at week, to be attended at choice in the first or in the second semester (until filling of the available places). Groups composed of 2 or 3 students are assigned one single practical experience among those available, to be developed during the whole duration of the laboratory. The semester preference will be expressed through a specific questionnaire that will be published on the e-learning page after notifying the registered users via the forum. Before the practical part begins, students will be invited by the referring professor to express their preferences regarding group composition and experience selection. The final assignment of the experience will be made by the professor, taking into account the expressed preferences and practical needs of the laboratory.

Textbook and teaching resource

- Handouts and records of the introductory lessons

- Reference book: G.F.Knoll, “Radiation Detection and Measurement”

- Practical guides for each experience

- Instrumental manuals

- Gamma/beta and alpha radiation tables

- Reports from previous years' students about the practical experiences

Semester

Frontal introductive lessons given collectively for all the students attending the course at the beginning of the first semester.

Practice at student's choice to be attended during the first or the second semester until saturation of availability.

Assessment method

\ - **In itinere tests**: there are no in itinere tests but an integral part of the final evaluation is given by the observation and direct interaction of the teacher with the students in the laboratory. The following are assessed: degree of commitment and active involvement, ability to ask questions aimed at understanding and deepening what one does, aptitude to tackle problems in a critical and constructive way, exploiting all the resources made available by the teacher but also deepening, if necessary , independently.

\ - **Written test**: Final group report regarding the experience that took place during the laboratory course, to be submitted one business week before the oral examination. The report must briefly but completely illustrate the physics problem under consideration, the instrumentation used, the experimental procedure, the critical and statistical analysis of the data, the comparison with expectations and the conclusion. The report must be sent to the teacher at least one week before the scheduled date for the oral exam

\ - **Oral exam**: Each student must also undergo an interview, the date of which must be agreed upon with the professor. The interviews can be conducted individually or together by the members of each group. The interview will focus on the laboratory report but also on the topics explained during the introductory lessons. The following will be assessed: the degree of understanding and in-depth analysis of all aspects related to the experience carried out (subject of physics, detectors used, signal electronic reading chain and its optimization, methodology used for the measurement, data analysis and comparison with expectations), the clarity and completeness of the exposition, the critical spirit in the analysis of the results obtained and the aptitude to find explanations if they differ from expectations.

Office hours

Everyday, after checking via email the teacher availability

Sustainable Development Goals

GOOD HEALTH AND WELL-BEING | QUALITY EDUCATION | GENDER EQUALITY