School on DM dark matter & Nu neutrino 2018

School and Workshop on Dark Matter and Neutrino Detection

Experiments

ICTP SAIFR · FAPESP · ICTP · unesp · IFT - UNESP · Fermilab · CAPES · CBPF · Northwestern University · COFI

EXPERIMENT #1

Characterization of gamma background with inorganic scintillators

Federico Izraelevitch
Instituto Dan Beninson/UNSAM/CNEA – CONICET, Argentina

In this laboratory students will work with a sodium iodide detector coupled to a PMT to measure the environmental gamma background. Groups of two or three students will characterize the detector and study its performance, like efficiency, linearity and resolution. They will quantify the gamma background present in the lab in the way it is done in a rare event search experiment.

EL TPCito – Illustration of Time Projection Chamber

Franciole Marinho[§] & Laura Paulucci[†]
[§]Universidade Federal de São Carlos, Brazil
[†]Universidade Federal do ABC, Brazil

When a particle enters a time projection chamber (TPC) volume it may interact with the fluid it holds exciting and ionizing the matter. Electrons can therefore be collected by applying high electromagnetic fields in this volume. This technique is commonly used for rare events detection due to its good charged particles trajectory reconstruction and calorimetry performance. Scintillation light can also be detected. In this laboratory students will operate a small TPC with a coupled photomultiplier tube (PMT) to detect light from the interaction of alpha particles in a gaseous argon/nitrogen mixture. Groups of 2-3 students will analyze the initial ionization signal as well as the electroluminescence (EL) one in order to characterize the electron drift as a function of the variables of the system (cathode/anode voltages, argon/nitrogen mixture).

EXPERIMENT #3

Particle detection with CCDs

Juan Estrada[§] & Aldo Rosado Fernandes[†]

[§]Fermilab, Estados Unidos

[†]CEFET/RJ, Brazil

In this Lab the students will learn how to use scientific CCDs as particle detectors. They will explore the signals produced by the readout electronics to understand the basic ideas of the signal processing involved. The participants will interact with a fully working system that will allow them to observe cosmic ray interactions and identify the traces produced by different particles. They will then use data taken using an x-ray source to calibrate the sensors in energy. The students will then use this information to produce selection criteria for cosmic muon tracks and use these events to measure the energy loss of Minimum Ionizing Particles in silicon.

Cosmic ray detection through their Extensive Air Shower: the original Pierre Auger measurement

Xavier Bertou
Centro Atómico Bariloche/CNEA – CONICET, Argentina

In 1938 Pierre Auger reported the first observation of EAS by looking at coincidences of particle detectors separated by up to 20 m and estimated the primary energy to be above 10^{12} eV. In this laboratory practice we will repeat part of the Auger measurement by using 4 scintillator detectors in coincidence, looking at the rate variation as a function of the distance between them and estimating the particle density in an EAS by using a central detector in a triangle of detectors. The results will be interpreted in terms of particle cascade in the atmosphere and an estimation of the primary particle energy will be done. As cosmic rays are one of the main backgrounds of underground experiments, an estimation of the overburden needed to shield an experiment will be done, based on the inferred primary energy.

SiPM: a novel photon detector becoming a classic

Horacio Arnaldi
Centro Atómico Bariloche/CNEA, Argentina

The silicon photomultiplier, also named multi-pixel photon counter, is a solid state device composed of numerous diodes operating in Geiger avalanche mode. It is a novel device, introduced and improved notably in the last 10 years, and has excellent single photon counting capabilities, but still presents some strong temperature dependence. In this laboratory practice, different SiPM will be operated and their temperature response characterized, by measuring gain, noise level, and crosstalk. While there are many areas of application of SiPM in Dark Matter and Neutrino physics experiments, we will focus on a biochemistry use of the sensor, by measuring light emitted by Luciferin (from fireflies for example), used as a tracer in many biological activity measurements.

ARAPUCA effect: trapping light inside a reflective box

Ana Amelia Machado[§] & Ettore Segreto[†]
Henrique Vieira de Souza[†] & Bruno Passarelli Gelli[†]
[§]Universidade Federal do ABC, Brazil
[†]UNICAMP, Brazil

We will mount an experimental set-up which will allow to measure the trapping effect of an ARAPUCA.The ARAPUCA is a reflective box with an acceptance window made of a dichroic filter coated with two different wavelength shifters, one per each side. An opportune choice of the shifters can make the acceptance window transparent to light only in one direction: the light which enters in the box is not able to exit and it is trapped inside the box. A semiconductor photosensitive device is installed on the internal surface of the box and can detect the trapped light. It will be shown that a normal glass window does not produce any kind of trapping and that the ARAPUCA window produces a significant increase in the amount of detected light.

EXPERIMENT #7

High-speed data acquisition and optimal filtering based on programmable logic for single-photoelectron (SPE) measurement setup

Herman Pessoa Lima Júnior[§] & Rafael Antunes Nobrega[†]

[§]Centro Brasileiro de Pesquisas Físicas, Brazil

[†]Universidade Federal de Juiz de Fora, Brazil

The students will have a short introduction on how to design and synthesize a digital circuit inside an FPGA device, learn about a digital filter used to optimize detection efficiency and understand how and why it is important to evaluate the Single Photoelectron (SPE) spectrum of a Photomultiplier Tube (PMT). Groups of 2 or 3 students will operate a setup with an 8” PMT to measure and compare the SPE spectrum built with and without the optimal filter.

EXPERIMENT #8

Proof of principle of a Neutrino mass measurement

Kazu Akiba
Instituto de Física – UFRJ, Brazil

The most precise method to measure the neutrino mass relies in the knowledge of nuclear decays and the precise measurement of the energy of beta-rays (electrons) coming from a proton decay. This energy is maximal when the neutrino remains at rest and different from the massless neutrino hypothesis. In this lab exercise we attempt to make a measurement of the end point energy of electrons from a Sr90 source with a magnetic field and a position sensitive silicon pixelated sensor, connected to a Timepix . We will discuss what values are important to be controlled in order to minimise the uncertainties and attempt a real time measurement.

Measurement of the muon decay time

Irina Nasteva
Instituto de Física – UFRJ, Brazil

In this experiment students will study the muon decay using plastic scintillator detectors. They will measure the time taken by a muon to decay into an electron. To this end, they will select muon event candidates and subsequently identify events with a clear signature of muon decay. This signature is given by a light signal from the muon decay, followed by the light signal coming from the electron. Students will discuss the experimental setup, take data, and analyze it to estimate the muon decay time.

EXPERIMENT #10

Analysis of Fermi LAT gamma-ray observations

Rodrigo Nemmen
Raniere Menezes & Fabio Muffo Cafardo
IAG – USP, Brazil

The Fermi Gamma-ray Observatory has revolutionized our understanding of the high-energy universe. Over the last 10 years, the Fermi Large Area Telescope has been observing the entire sky from space every three hours in the 100 MeV to 500 GeV energy range. In this lab activity, I will give a short presentation highlighting the main results and importance of the Fermi Telescope – particularly for dark matter indirect searches. The talk will be followed by a hands-on tutorial where the students will get familiar with the analysis of space-based gamma-ray observations.

Instructions at the web page

In the hands-on activity on Fermi LAT gamma-ray observations, we will learn how to analyze gamma-ray data for a dwarf galaxy, do a simple estimate of the DM cross section and reproduce the analysis described in Ackermann et al. (2015). We ask that the participants interested in this activity follow this installation tutorial and install the software required on their laptops before the lesson. Note that it involves the download of >2GB of data.

School on DM & Nu 2018 — dark matter & neutrino

School and Workshop on Dark Matter and Neutrino Detection

Experiments

- Each student will participate in one experiment per day during the second week
- Each participant will be asked to rank the 10 experiments in order of preference
  - Number each one from 1 to 10, with 1 being the one in which you are most interested in
- We will try to accommodate as much as possible the individual interests
- We recommend to choose different types of detectors or experimental techniques to acquire a broader view

ICTP SAIFR · FAPESP · ICTP · unesp · IFT - UNESP · Fermilab · CAPES · CBPF · Northwestern University · COFI