ESCARAMUJO PROJECT IN MÉXICO.

UNIVERSIDAD AUTÓNOMA DE CHIAPAS

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INTRODUCTION

Cosmic Rays (CR).

They are subatomic particles from outer space. When CR arrive to our planet, they interact with the nuclei of molecules in the atmosphere, creating a shower of secondary particles in its path. For our experiment, muons are produced by the interaction of charged pions in the atmosphere by:

$$\mu^- \to e^- + \bar{\nu}_e + \nu_\mu, \quad \mu^+ \to e^+ + \nu_e + \bar{\nu}_\mu.$$

Fig. 1. Muon Decay

Muons.

Muon (μ) is a massive elementary particle that belongs to the second generation of leptons. Its mass is 200 times the electron mass, and its lifetime is longer than other unstable particles (2.2 microseconds). At sea level the ratio between the number of positive and negative muons is N + / N = 1.28

Average lifetime of the muon.

The muon decay probability follows an exponential law, where the distribution function of its lifetime depends on t and can be written as:

N (t) = No exp (−t/τ_μ)

where τ is the mean lifetime of the muon and No is a normalization factor. In vacuum τ_μ = 2.197μs for both μ^- and μ^+. The muon flux at sea level is 1 muon per square centimeter per minute. When the muon desintegrates or decays, it emits an electron, which allows us to calculate and detect it with a detector.

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Scintillator detectors.

Scintillation detectors (Fig. 2) are made by special materials that radiate when are ionized. Then it emit a small flash of light, it twinkle.

This phenomenon occurs when the radiation interacts with matter by the exitation and ionization of a large number of atoms and molecules. When they return to their ground state they emits photons with energy range in the visible spectrum or near to it.

Fig. 2.Plastic scintillator plates.

Photodetector.

It turns the scintillation light into an electrical signal. In this case, the photomultiplier (PM) solid-state silicon SiPM 6x6 mm2 type (Micro FC-60035-SMT sign) were used. whose efficiency is used to detect the minimum ionizing particle is very high.

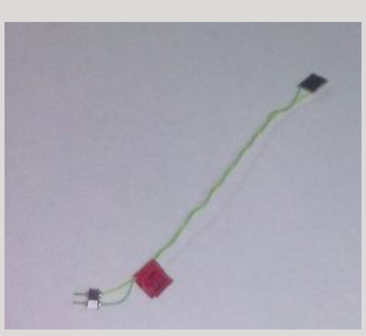


Fig. 3. Silicon photomultiplier detector

The project

Escaramujo is an initiative to promote scientific development and integration in Latin America. It consists of a series of Laboratory worshops for High Energy Physics, Astroparticle and Instrumentation, given by Federico Izraelevitch. It is conducted in 10 emerging institutions in different countries.

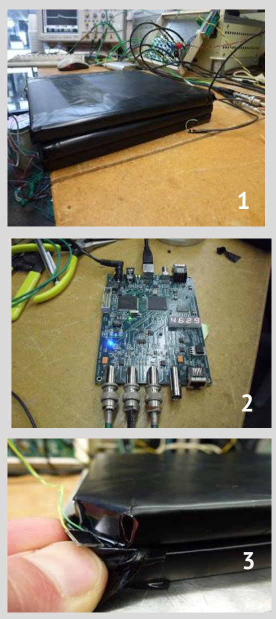
Fig.4. Participating countries.

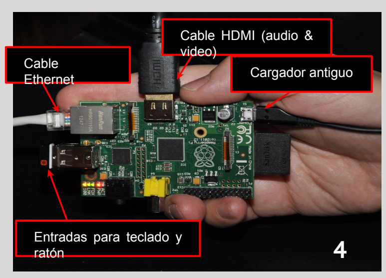
Activities Structure

The laboratories are based on a cosmic ray detector designed specifically for the project. Students make the assembly, the running and data collection during the courses. After each course, a device remains in the academic institution to be used by teachers and scientists. All institutions shall remain bound in the form of community, working jointly and contributing to the global effort in cosmic ray physics. In particular, this initiative will attempt to make a contribution to the already established network LAGO (Latin American Giant Observatory, http://labdpr.cab.cnea.gov.ar/lago/).

The detector

It is a pile of plastic scintillators (1) (EJ-200, Eljen Technology), whose signal is measured with the PM described in Fig. 3. (2) The data acquisition is performed by a converter TDC (time-to-digital converter, QuarkNet) (3). The data are collected with a minicomputer Raspberry PI2 (4).





Operation.

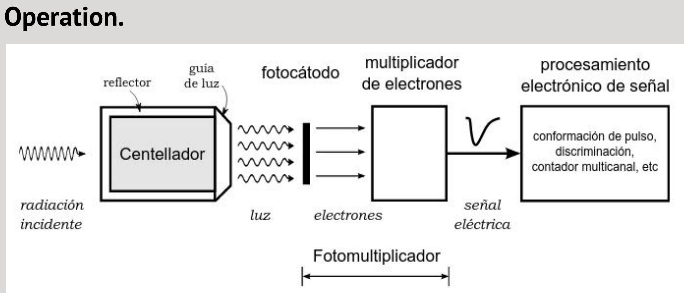


Fig. 5. General outline of the detector operations.

Ionizing radiation interacts with the scintillator material and gives part of its energy (or all) as ionization and excitation. The absorbed energy is released as visible light directed to PM. The photocathode of PM absorbs photons and emits photoelectrons, so that they are magnified. The output power of the PM is processed electronically. The detector produces a signal proportional to the energy deposited in the active medium of electric charge sensor.

The experiment.

To perform these data collection mechanisms is needed: A discriminator detector, a matching module and a system to record the occurring times pulses.

To identify events in which the muon stopped in the scintillator plate QuarkNet 2 has a time window called VETO.

Thus, when the circuit detects a double coincidence detectors 1 and 2 the 200ns time window duration VETO opens.

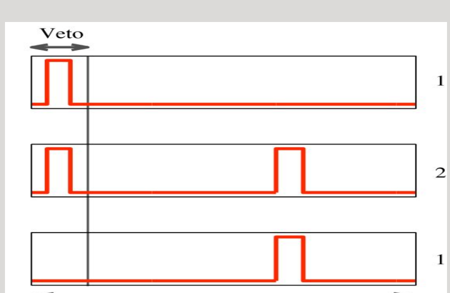


Fig.6. Time window or veto.

For example, in FIG. 6 one can see that plates 1 and 2 recorded within the VETO signal, but 3 is not recorded. Data acquisition on the three channels are then triggered, in this example, the decay generates 1 pulse per event in 1 plate, 2 in the 2nd and 1 in the 3rd plate. After the accumulation of enough number of events, they can be adjusted to an exponential temporal distribution funtion to obtain the half-lifetime of the muon (Fig.7). Then one uses a computer tools (Root / c ++) to process the information for further analysis.

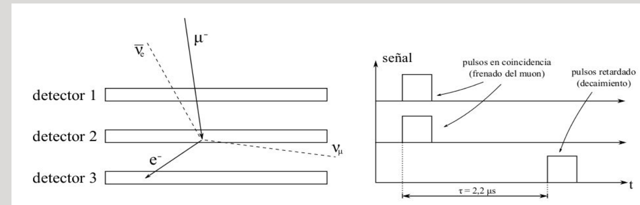


Fig. 7 Muon decay seen in the pulse detector.

ESCARAMUJO IN CHIAPAS

Activities during the course.

1.- Detector assembly.

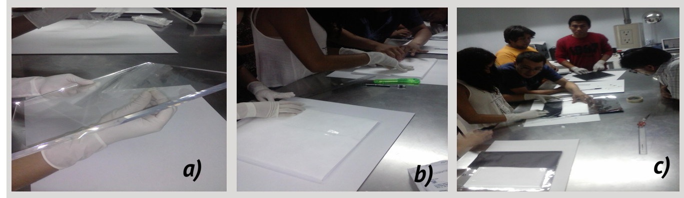


Fig.8. a)Unpacking the scintillator. b) y c) Lining to optimize capture of light from the signal.

2.- Placing the SIPM in the scintillator and final configuration of the prototype.

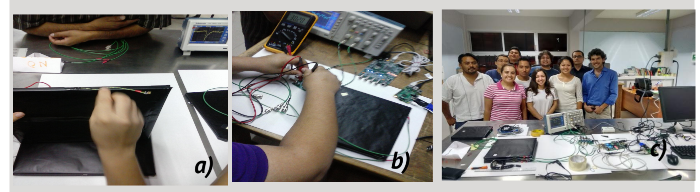
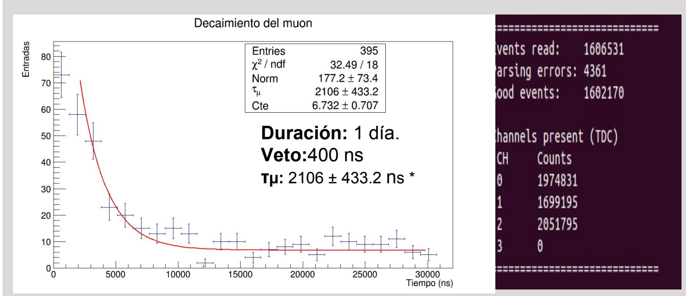
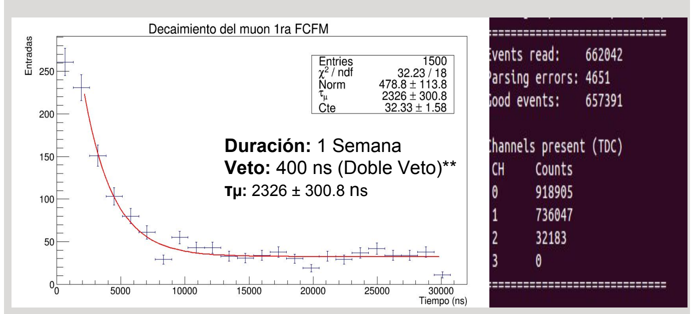


Fig.9. a) SiPM placement. b)Finished prototype and c)Group Escaramujo-Chiapas.

Results.

The first type of study was done in Chiapas was the measurement of the muon decay. Some results:





* [0]*exp(-x/[1]) + [2]

** Veto on the plate QuarkNet and in the code C++

Conclusions.

The Escaramujo project has been a success in UNACH and it is expected to make contact with the other participants institutions.

The measurement of the muon lifetime in the City of Tuxtla Gutierrez Chiapas at an altitude of 522 meters is: 2.11±0.433 μs. This result is in agreement with those reported by the Particle Data Group [3]: 2.197± 2.2 x10⁻6μs.

Acknowledgment

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[1] Detectores centelladores. Dr. Federico Izraelevitch
[2] http://www.escaramujoproject.org
[3] http://pdg.lbl.gov/