Ultraviolet radiation detector to obtain the rate of particles at different heights

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Abstract.
The nature and origin of cosmic rays remains one of the greatest puzzles of modern astrophysics after more than 50 years since their first registration. Several ground experiments have reported the rate registered at its height of operation. To continue with the study of cosmic rays, we propose obtain the rate at different heights in the Earth's atmosphere, developing a small and portable ultraviolet radiation detector, consisting of a scintillation plastic, a PMT, and a fast DAQ system. In this work we present the design and construction of the UV detector and the rate recorded in the Sierra Negra Volcano near Puebla, Mexico (4200 m.a.s.l).

1. Introduction
The Earth’s atmosphere is subject to constant arrival of atomic nuclei, mostly protons, known as primary cosmic radiation; during its trajectory to the surface, by interacting with atmospheric nuclei, produce a variety of elementary particles, identified as secondary cosmic rays. In order to obtain the rate of cosmic particles, we design a portable ultraviolet radiation detector, which consists of a scintillator plastic, thick 1 cm, radius 6 cm, threshold energy approximately 1 MeV; the interaction of high energy cosmic rays with scintillation plastic molecules, produces photons, the light is detected using a photomultiplier tube (PMT), the PMT converts photons into an electrical signal, finally, it is processed by a DAQ system of high speed. In this paper, we present the portable ultraviolet radiation detector, and the laboratory calibration, the next step will be to test the detector performance, operating during the journey from university city of BUAP campus (2200 m.a.s.l) to Pico de Orizaba national park (4200 m.a.s.l) in Mexico. The data obtained will be compared with the rate registered by experiments operating at heights known as AUGER, HAWC, LAGO.

2. Ultraviolet radiation detector setup
To obtain the continuous rate of the cosmic rays at different heights, it is necessary a detector operating for each specific height; for this reason we developed a small and portable ultraviolet radiation detector, the main purpose of the experiment is obtain the cosmic rays rate of experimental form in the range of heights 2200-4200 m.a.s.l, approximately.

The UV detector [1] consists of a scintillator plastic as first transducer, see figure 1. Scintillation detectors make use of special materials, when exposed to ionizing radiation, they...
emit a small flash of light. This phenomenon occurs when radiation interacts with matter, exciting and ionizing one large number of atoms and molecules, when they return to their steady state, emit photons in the visible spectrum or around it.

Figure 1. Scintillation plastic as a medium radiator, thick 1 cm, radius 6 cm, threshold energy approximately 1 MeV. Used in the UV radiation detector to obtain the rate of particles at different heights.

To obtain useful information from scintillation plastic, a photodetector is added [2], which converts the photons into an electrical signal. The photodetector most frequently used for a scintillator detector is a photomultiplier tube (PMT), see figure 2, this device, has a photocathode, an electron multiplier chamber and a polarization base as main parts; the first part of the PMT is a thin layer of a special material that emits electrons (more know as photoelectrons) when photons pass through the photocathode. The second part of the PMT, is an array of electrodes polarized with an active (semiconductor devices) or passive (resistive) base, to keep a gradual distribution of voltage in each electrode and achieve gains of the order up to $10^6$, resulting a current pulse in the PMT output pin; connecting a load resistor in the output, a voltage is generated in the order of a few millivolts, which is processed by a DAQ system for further analysis, in order to obtain information about the incident radiation.

Figure 2. The UV detector contains one R1463 photomultiplier tube from the Hamamatsu company with an ultraviolet entrance window and a multialkali photocathode.

The DAQ system has as main computer an FPGA Xilinx, see figure 3, this controls the information of: a digitalization board every 10 ns; a GPS and a temperature-pressure sensor every second; a high voltage source to control the constant gain of the photomultiplier [3], every minute. The time intervals assigned, are with the purposes of autocalibrate the UV detector during the trajectory of operation in the journey.
3. Ultraviolet radiation detector testing and preliminary results

As a first step in the calibration process of the UV detector, we measured the response of the PMTs to a single photoelectron (SPE) signals [4], figure 4. From these measurements we can obtain the signal shape for any event figures 5, 6.

Figure 4. Single photoelectron response of PMT R1463, for different voltages: 1.25 kV (green signal), 1.30 kV (red signal) and 1.35 kV (black signal).

Figure 5. Traces recorded at a height around 4200 m.a.s.l.

Figure 6. Zoom of some traces recorded.
The UV detector was operating in Sierra Negra Volcano near Puebla, Mexico (around 4200 m.a.s.l), The rate recorded is presented in figure 7.

![Histogram of particles](image)

**Figure 7.** Histogram of particles recorded every 5 milliseconds with DAQ system. The maximum peak is around 140, for one second are needed 200 histograms, with this considerations the rate is around \(28 \times 10^3\) particles/second.

HAWC located at 4100 meters above sea level, reports a flow of \(26 \times 10^3\) particles per second. It is indicating that our detector operates properly.

4. **Conclusions**

In this paper, was presented the portable ultraviolet radiation detector, together with results obtained at a height of 4200 meters above sea level. The next step will be to test the detector performance, operating during the journey from university city of BUAP campus to Pico de Orizaba national park. The data obtained will compared with the number of registered particles per second, provided by experiments operating at heights known as AUGER, LAGO, etc. Will create a database with free access, recording the profile signal processed by DAQ system, generated by each particle, for further and off line analysis, by students or researchers interested.

5. **Bibliography**

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