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COSMIC RAYS EXPERIMENT AT ANTARCTICA – CRE@AT

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Abstract: The CRE@AT is a muon detection system entirely developed at the Brazilian Center for Research in Physics, destinated to the study of cosmic rays at the south pole and its relation with atmospheric processes and climate changes, specially clouds formation rate.

INTRODUCTION

Cosmic rays are composed by stable charged particles generated in high energy cosmic reactions. The collision of cosmic rays with Earth's atmosphere creates showers of secondary particles, and its main subproduct at ground level is the muon. It has been proposed [1] that the clouds formation rate is directly affected by the incidence of cosmic rays on the atmosphere, which varies globally about 15% over a solar cycle because of changes in the strength of solar winds. Considering this possibility, the flux of muons at ground level might be an important parameter to understand the climate behaviour.

The CLOUD experiment [2], from CERN, uses a proton synchrotron and a cloud chamber to emulate the interaction of cosmic rays with the atmosphere and study its role in the clouds formation. Due to the climate system's intrinsical complexity, other experiments performed in real and clean systems can add important information on this discussion.

- The south pole was chosen for this study due to its clean and simple climate system and because of its large variation in cosmic rays incidence over a solar cycle (50%).

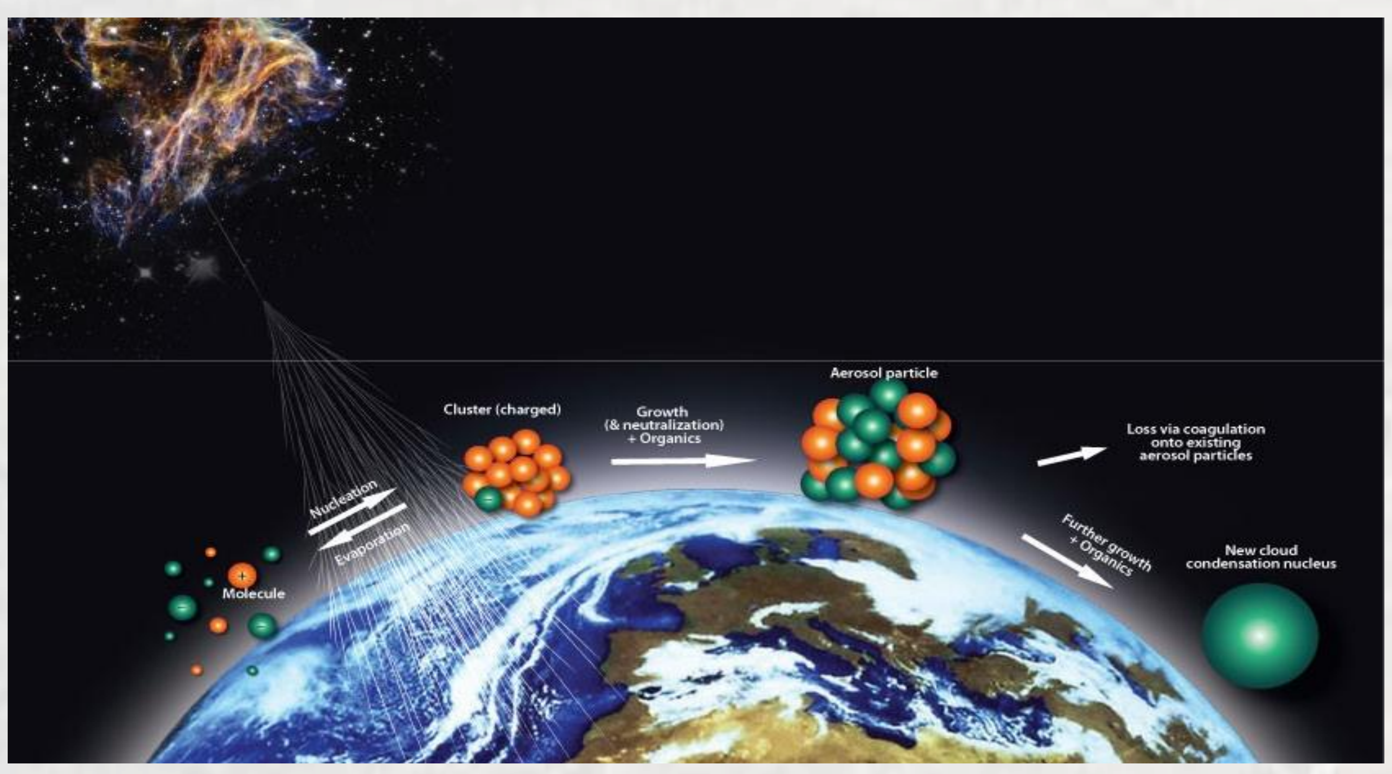

Figure 1 – Cloud formation through cosmic rays reaction mechanism [3]

OBJECTIVES

- The first aim of this work is to obtain a precise measurement of muon flux at ground level on the south pole and relate it with the clouds formation rate.
- Some particular features, such as thin atmosphere, ortogonal magnectic field lines, and altitude may contribute to the study of cosmic rays.
- Furthermore, the experiment may integrate a network of cosmic rays detectors, monitoring large scale events such as global atmospheric showers.

DEVELOPMENT

The project is divided into three main parts:

1. Detection: responsible for generating optical signal due to muon interaction, amplifying it, converting the signal into electrical analog pulse and digitalizing it.
2. Acquisition: encompasses the signal processing, recording and transmiting.
3. Infrastructure: stable low voltage power supply to the experiment must be provided, as well as high voltage supply to the photomultiplier.

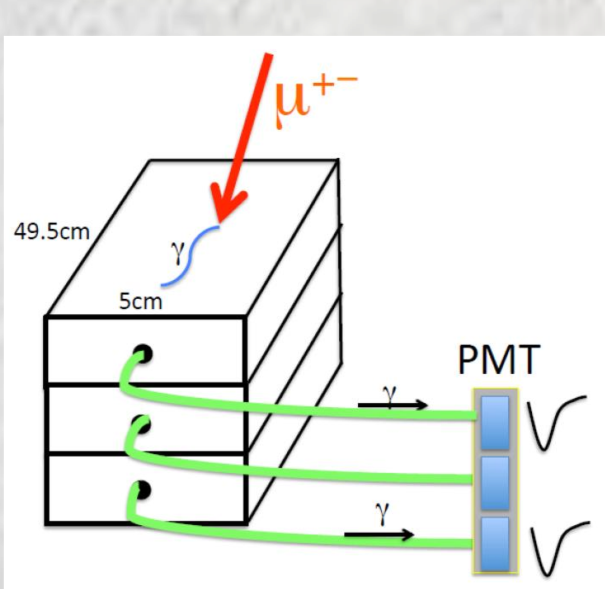

Figure 2 - SciTile detectors

Figure 3 – Dark box of CRE@AT inside Criosfera I

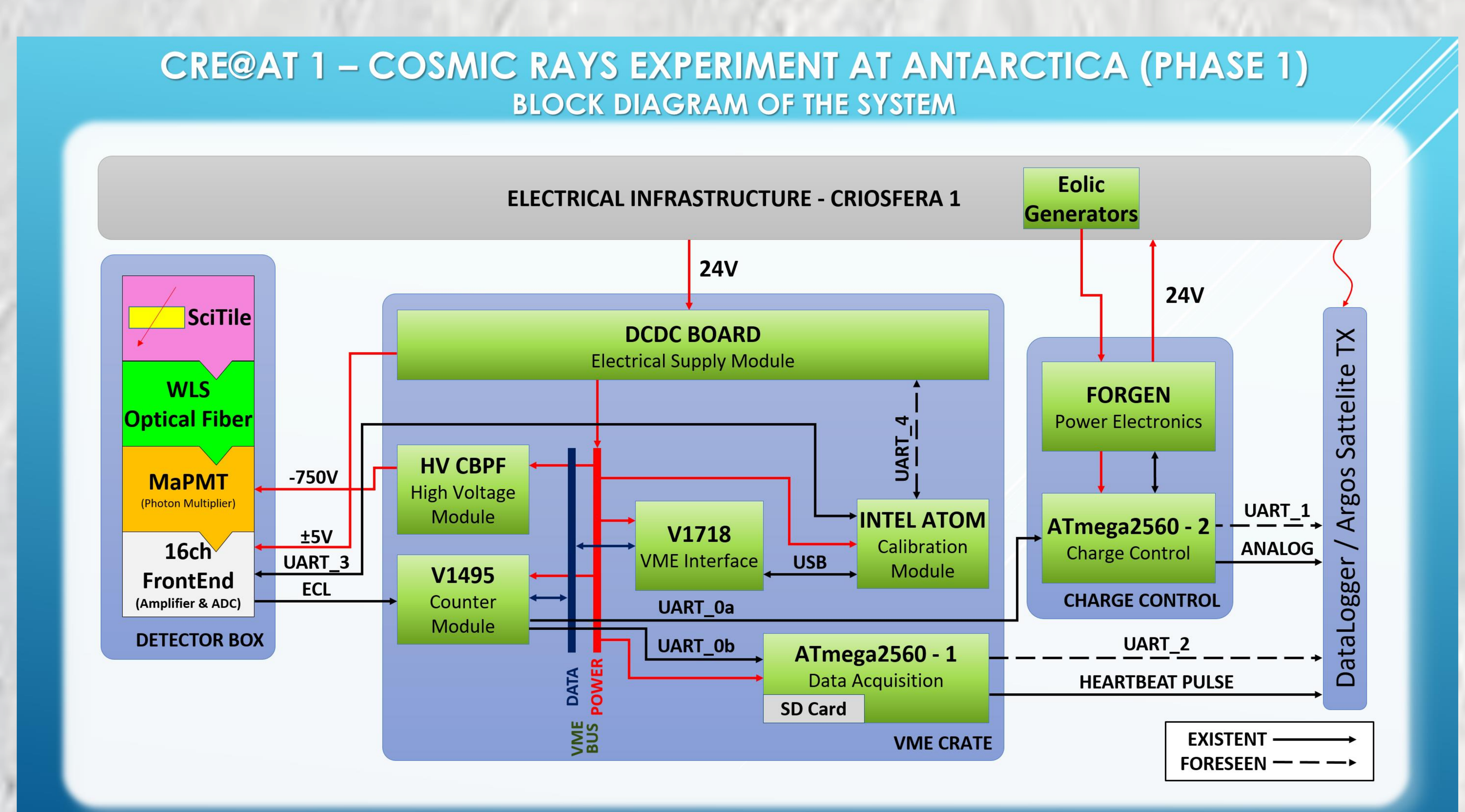

Figure 4 – CRE@AT 1 schematic

In order to measure the muon flux, a scintilating plastic material in form of a retangular strip (tile) was used to produce optical signal, as shown in figure 2. The tiles are arranged in a matrix of three lines and five independent rows. The photons are carried by wavelenght shifter fibers to a photomultiplier, which amplifies the optical signal by an avalanche effect of electrons, increasing its energy. A front-end (FEE) board is responsible for the secondary amplification, filtering the signal to eliminate noise through threshold, and discriminating it into ECL pulses.

The digitilized ECL signal is sent to a FPGA, where the counting of events is made through coincidence of pulses logic, as shown in figure 5. The events are summed in the registers during a set time of gate, then serialized and transmitted via UART serial bus to the ATmega2560 microcontroller, which records the data in a SD card. The microcontroler receives time information via I2C serial protocol from a real time clock (RTC) module, and sends periodically a heartbeat pulse (functioning check of the system) to the Argos Satelite DataLogger, stablishing one-way communication with CBPF.

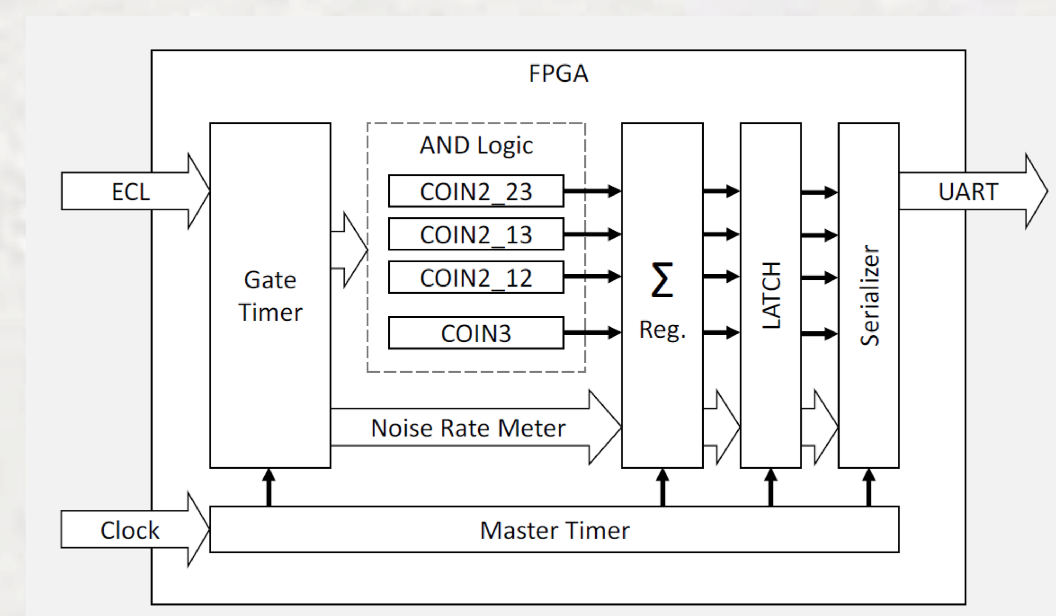

Figure 5 – FPGA logic diagram of blocks

RESULTS

The first phase of the experiment is already operational inside the autonomus CRIOSFERA I brazilian module at Antarctica (84ºS 79ºW) . The data collected is retrieved in anual missions to the continent, supported by the Brazilian Antartic Program (PROANTAR). Figure 6 and 3 show pictures of the Criosfera I, in the time of CRE@AT first phase's arrival, and the open box of the experiment inside the module, respectively.

Figure 6 – CRE@AT's first phase arrival at Antartica

The first measurements at Antarctica where done during the experiment's calibration phase. The result is shown in figure 8, the graph of flux per coincidence group. The calculated mean flux of muons, at the time of the calibration, was 281 muons $s^{-1}m^{-2}$. This result is higher than the obtained by CRE@AT 2 at CBPF, as expected.

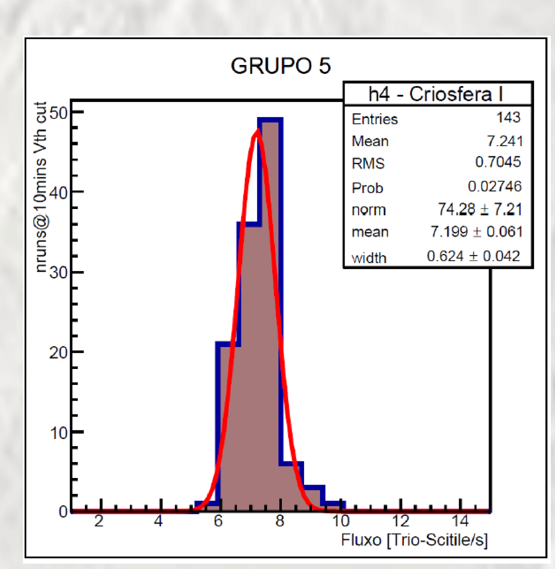

Figure 7 – Histogram of group 5

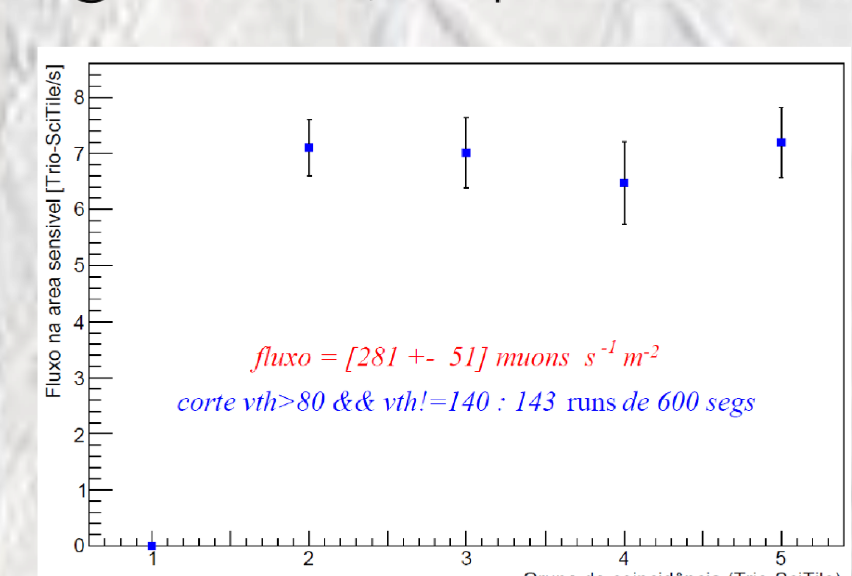

Figure 8 – Flux of muons at the Criosfera I module

CONCLUSION

The third phase of the experiment is currently in development at CBPF. The new configuration has a tracking system that provides the muon direction during its passage through the detectors. Together, both CRE@AT 1 and 3 will stand as the brazilian cosmic experiment at the south pole, collecting data that will be matched with weather measurements at the Criosfera Module, in order to obtain correlations between cosmic rays and the climate changes.

[1] K.S.Karslaw, R.G.Harrison,J.Kirkby,"Cosmic Rays, Clouds and Climate",29-11-2002; [2] https://home.cern/about/experiments/cloud; [3] F. Marcastel, "CERN CLOUD research team adds new pieces to puzzle of cloud formation," 25-08-2011.