Name of research institute or organization:

Department of Physics, University of Rome La Sapienza, Italy
Department of Physics, Abant Izzet Baysal University, Turkey
Department of Physics, Carnegie-Mellon University, Pittsburgh PA, USA

Title of project:

Test for a new concept of an EAS detector for UHE neutrinos

Project leader and team:

Prof. Maurizio Iori, project leader
Prof. Jim Russ, Prof. Haluk Denizli, Ali Yilmaz, Şeyma Atik

Project description:

Aim of the tests and their results:
The TAU - shoWER (TAUWER) experiment aims to detect particle showers originated from Ultra High Energetic (UHE) tau-neutrinos which get the short path trough the inside of the earth. A prototype detector is working on the terrace of the Sphinx Observatory at Jungfraujoch (3580 m a.s.l.), Switzerland.

Traditional Photomultipliers (PMT) are well-engineered photon detectors and stable in operation [1]. The recent developments made on solid state detectors, so called Silicon PhotoMultipliers (SiPMs), make the SiPM to an alternative to the conventional photomultipliers (PMTs). The SiPM are multi-pixel avalanche photodetectors working in the Geiger mode. This device has remarkable properties such as a very compact size, high quantum efficiency, good charge resolution, fast response time (< 100 ps), large gain (10^6) and very low power consumption with low bias voltages.

The prototype of the detector station, shown in Figure 1, consists of two pairs of scintillator counters (20 x 20 cm^2, 1.4 cm thick) named 'towers', separated by 60 cm. The distance of one pair is 160 cm corresponding to 5.3 ns of time of flight (TOF) of a horizontal track crossing the two scintillating tiles.

The site where this station is located provides an opportunity to understand if the prototype

Figure 1. Prototype detector installed on the Sphinx terrace to test upward/downward particles' separation and environmental effects.

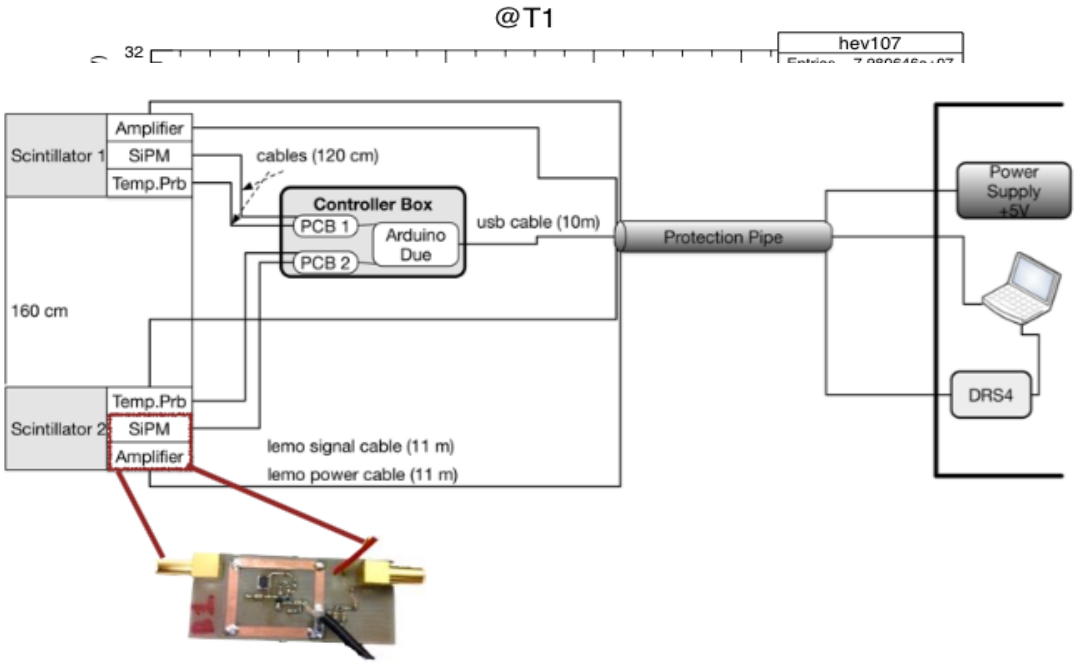

Figure 2. Block diagram of the experimental set-up used for data acquisition.

detector works safely (or not) under hard environmental conditions (the air temperature changes between 20 ^{0}C and -25 ^{0}C). The detector prototype is using a silicon photomultiplier (SiPM) produced by SensL, optimized for blue light and a DRS4 chip used to digitize the SiPM signal. Measurements at different temperatures with varying bias voltage were performed to reconstruct tracks to test the SiPM.

Figure 2 shows the SiPM device, which is installed on a board with a readout circuit and an ultra low noise 0.05 to 4 GHz amplifier (Mini Circuits PSA- 5454+) which were developed at the University of Rome, La Sapienza. A temperature sensor close to the SiPM connection can be used to adjust properly the bias voltage against temperature variations with a resolution of 0.1 ^{0}C.

To have a fix efficiency, the gain, dependent on the temperature, must be constant. By a microprocessor, the SiPM bias voltages in a range between 5 V and 33 V are controlled with increments of 0.05 V by a code written in C++. The code uses Serial Peripheral Interface (SPI), a synchronous serial data protocol. This library allows us to communicate with SPI devices (temperature sensor and voltage regulator board), with the Arduino as the master device.

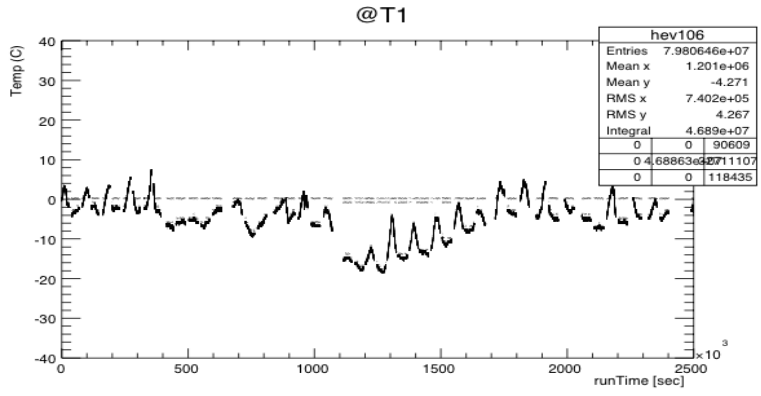

Figure 3. Temperature variation inside the read-out box during the running time of 674.19 hours.

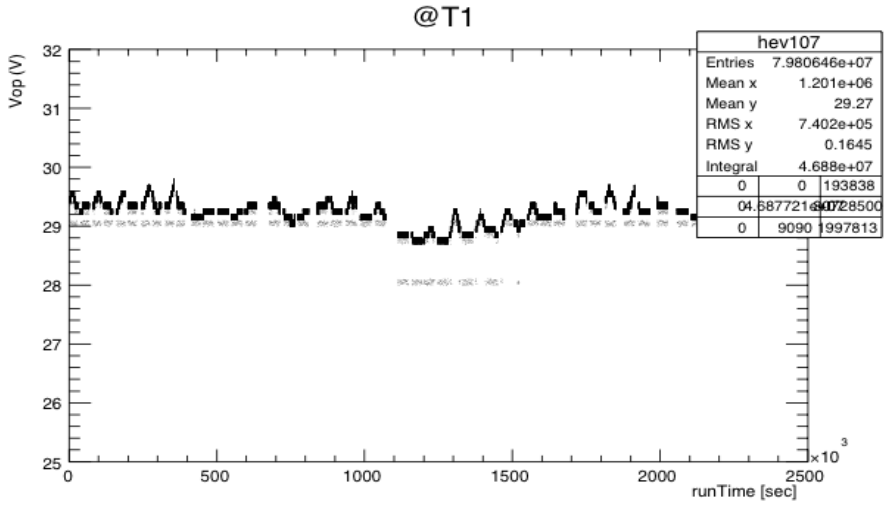

Figure 4. Adjusted SiPM bias voltage during the running time of 674.19 hours.

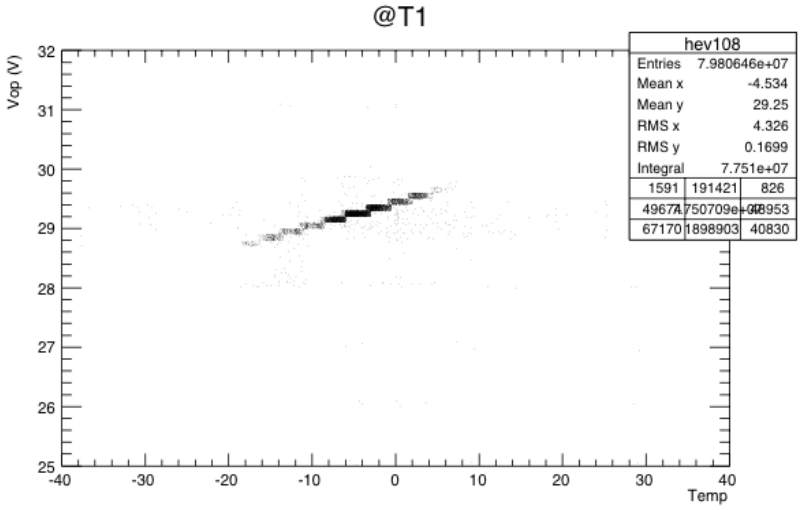

Figure 5. Operating voltage as function of temperature.

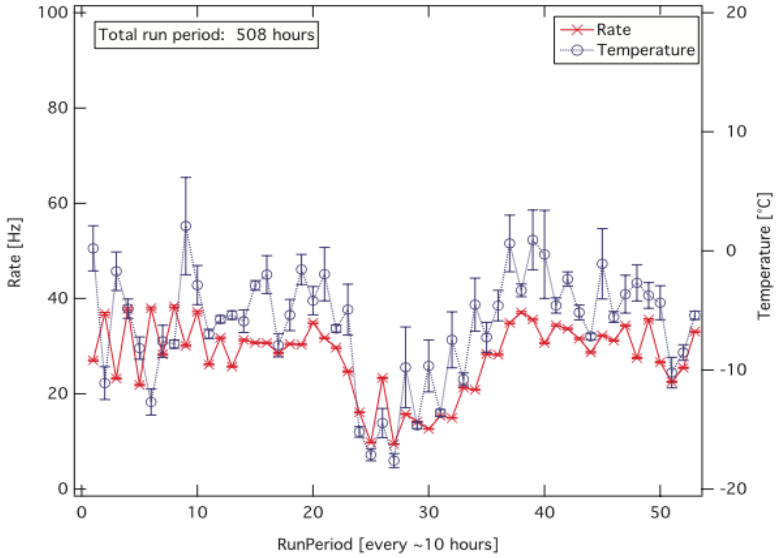

Figure 6. Triggering rate as a function of run period (red) and the temperature variation as a function of run period (blue).

Due to the outside temperature changes (between 20 ^{0}C and -25 ^{0}C), each counter box is protected by a Jackodur extruded polystyrene foam (XPS) insulator (more information in reference [2]). The average temperature inside the read-out box is oscillating between -18 and 4 ^{0}C and the triggering rate is changing between 18 and 40 Hz.

As shown in Figure 6, the triggering rate is well correlated with temperature in time. The DAQ program was rewritten in C++ to save data in a ROOT analysis framework. The gain of SiPMs is insensitive to the temperature variation due to the slow control program using Arduino SPI library. The prototype was successfully tested during harsh environmental conditions on the terrace of the Sphinx Observatory, with new improvements on the slow control system. The triggering rate was correlated with the temperature.

In 2014, we did extensive tests with silicon photomultiplers (SiPMs). These test results were presented at the 31th International Physics Congress [3] and published in review [1,2] .

References:

[1] Iori, M., I. O. Atakisi, G. Chiodi, H. Denizli, F. Ferrarotto, M. Kaya, A. Yilmaz, L. Recchia and J. Russ, SiPM application for a detector for UHE neutrinos tested at Sphinx Station, Nuclear Inst. and Methods in Physics Research, A, doi: 10.1016/j.nima.2014.11.076, 2013.

Key words:

Cosmic rays, neutrino, silicon photomultiplier, time of flight

Scientific publications and public outreach 2014:

Conference papers

[2] Iori, M. et al., SiPM application for a detector for UHE neutrinos tested at Sphinx Station, Proceedings 4th Roma International Conference on Astroparticle Physics, Rome, Italy, May 22-24, 2013, Nuclear Instruments and Methods in Physics Research, A, **742**, 265-268, 2014.
http://www.sciencedirect.com/science/journal/01689002/742

[3] Yilmaz, A., S. Atik, H. Denizli and M. Iori, Preliminary results of a prototype detector of TAUWER Experiment Working at Sphinx Observatory Center, Turkish Physical Society, 31th International Physics Congress, Bodrum, Turkey, July 21-24, 2014.

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