A Compact Muon Tracking System for didactic and outreach activities

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Introduction

We present a cosmic ray telescope based on the use of plastic scintillator bars coupled to ASD-RGB1S-M Advansid Silicon Photomultipliers (SiPM) through wavelength shifter fibres. The system is comprised of 200 electronic channels organised into 10 couples of orthogonal planes allowing the 3D reconstruction of crossing muons.
Two monolithic PCB boards have been designed to bias, readout all the SiPMs enclosed in the system, to monitor the working parameters and to remotely connect the detector. To make easier the display of muon tracks to non expert users, two LED matrices, triggered by particle interactions, have been implemented.
To improve the usability of the muon telescope, a controller board unit permits to select different levels of trigger and allows data acquisition for refined analyses for the more proficient user. A first prototype, funded by INFN and deployed in collaboration with NYUAD, is operating at the Toledo Metro station of Naples, while two further detectors will be developed and installed in Abu Dhabi in the next few months.

Telescope layout

Fig. 1: Muon telescope on display in the Toledo Metro station in Naples.

The telescope is composed of 10 horizontal scintillation levels. A level consists of 2 orthogonal planes, each one made out of 10 plastic scintillator bars positioned next to each other, see Fig. 2.
The two planes are coupled on top of each other facing perpendicular directions. There are two viewing panels to see the path, as in Fig. 1, on two perpendicularly adjacent faces of the telescope.

Fig. 2: The two planes, with 10 bars each, that make a level.

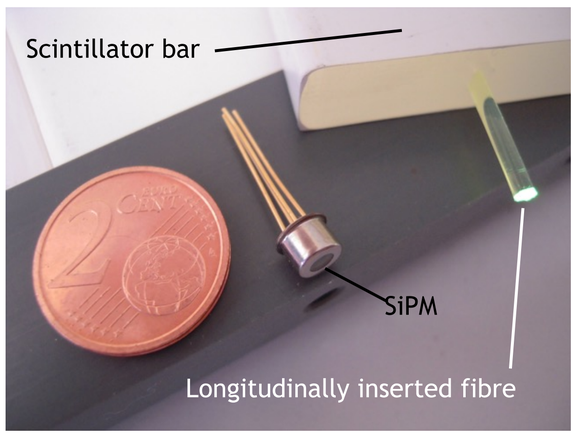

Fig. 3: Advansid SiPM next to a scintillator bar with a fibre inserted.

Each of the two planes per level is connected to a different view. There are 100 channels per view and 200 in total. The viewing panels consist of a matrix of LEDs, one for every scintillator bar, which are triggered by the interaction of charged particles (mainly muons).

Behind each viewing panel there is a monolithic PCB board, see Fig. 4, coupled to the 10 planes facing that direction. The boards enclose readout, trigger logic and allow monitoring of the working parameters such as voltage and temperature.

Fig. 4: The two custom PCB boards used to operate the detector.

Scintillator bars and SiPMs

The scintillator bars are made out of doped polystyrene and produce blue light of a wavelength close to 450nm. To better propagate the light output and to maximise the SiPM quantum efficiency, wavelength shifter fibres have been embedded into each bar, as shown in Fig. 3.

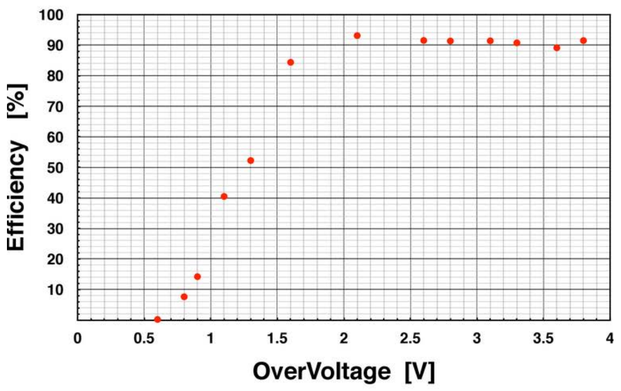

Fig. 5: SiPM efficiency at different overvoltages.

One SiPM is optically coupled to the end of each fibre: 20 per level. Each SiPM is connected to a PCB board to be biased and read. The efficiency of a single channel reaches 90% when an overvoltage equal to or above 2V is applied, see Fig. 5. The overvoltage being applied through the PCB is 2.5V.

Outreach

Tracking muon paths in such an interactive way, using LED matrices, can serve as an introduction to the world of subnuclear particles for people with no background in physics. It becomes possible for them to visualise how high energy particles cross the Earth every second. Two more telescopes are currently being built for these outreach purposes and will be on display at New York University in Abu Dhabi by October 2015.

The NYU Abu Dhabi new campus on Saadiyat island, Abu Dhabi, where the two telescopes will be assembled and operated for students and the public.