SiPM AS AN ALTERNATIVE TO PMT FOR PARTICLE DETECTION

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Abstract

Silicon photomultipliers (SiPM) are replacing traditional photomultiplier tubes in particle detection technologies. Advantages include low operating voltage, compact size (see fig 1), higher photosensitivity, insensitivity to magnetic field and cheaper price tag. Two separate experiments were done onsite to test the abilities of ON Semiconductor SiPMs: gamma spectroscopy and detection of cosmic muons.

Fig 1: An SiPM (right) and a PMT next to each other

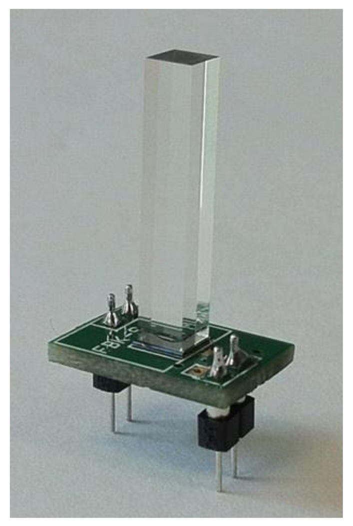

Fig 2: An SiPM with a LYSO crystal on a pin adapter board

When a particle hits the crystal attached to a PMT or SiPM, it releases a burst of photons that enters the photocathode of the PMT or the photo sensitive surface of an SiPM. To convert this burst of light into a large enough current pulse, the PMT utilizes a large voltage supply (fig 3) while the SiPM utilizes Single-photon avalanche diodes or SPADs (fig 4). The difference in the functionality allows the SiPM to overcome many disadvantages presented by the PMT.

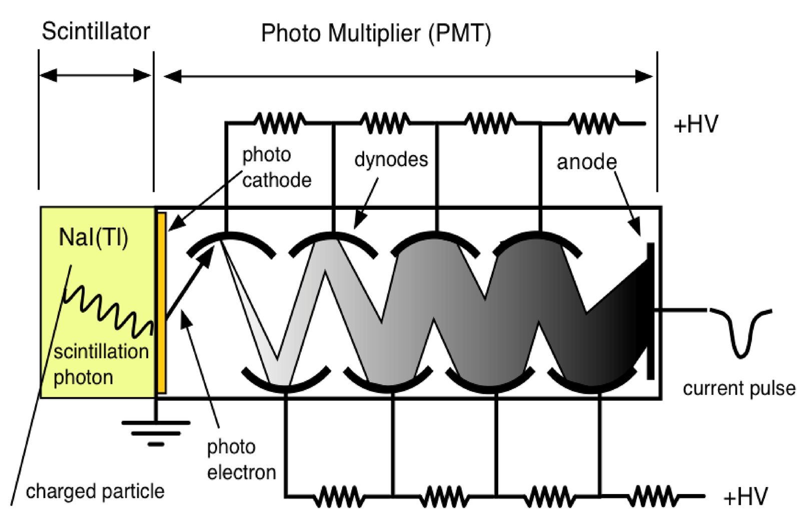

Fig 3: Scheme of a PMT

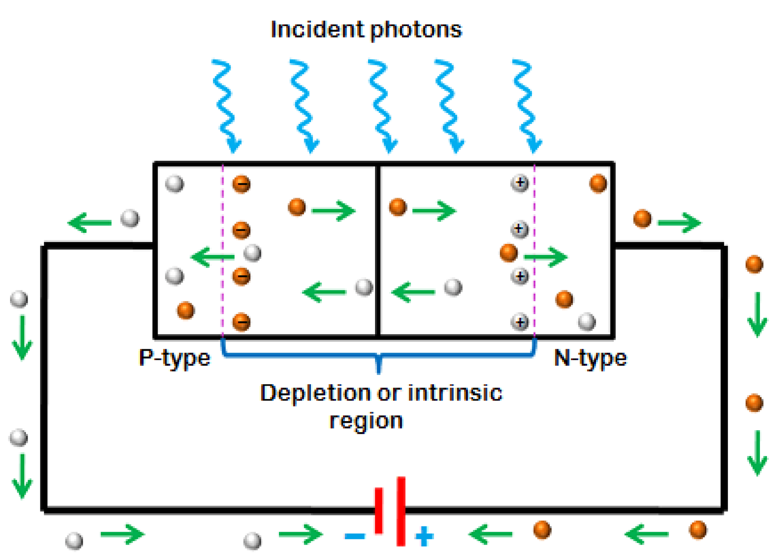

Fig 4: a photodiode circuit

Results and conclusions

The experiments discussed here have been previously done with traditional PMTs. Successful completion of these experiments with SiPM indicate they are much better alternative to PMTs in photon detection technologies.

SiPMs' higher sensitivity make them more viable in LiDAR technology that self-driving cars use. Their insensitivity to magnetic field opens new possibilities for multi-modality imaging in the medical industry.

With all its advantages, SiPM technology has become a powerful tool in cutting edge research at facilities like CERN. The cost effectiveness also makes it a great research kit for undergraduate level particle physics.

Gamma Spectroscopy with SiPM and MCA

Gamma sources were placed on top of the scintillation crystal that is mounted on the SiPM (fig 5). Signals from the SiPM caused by gamma detection were interfaced via a SpechTech UCS30 multi-channel analyzer (fig 6).

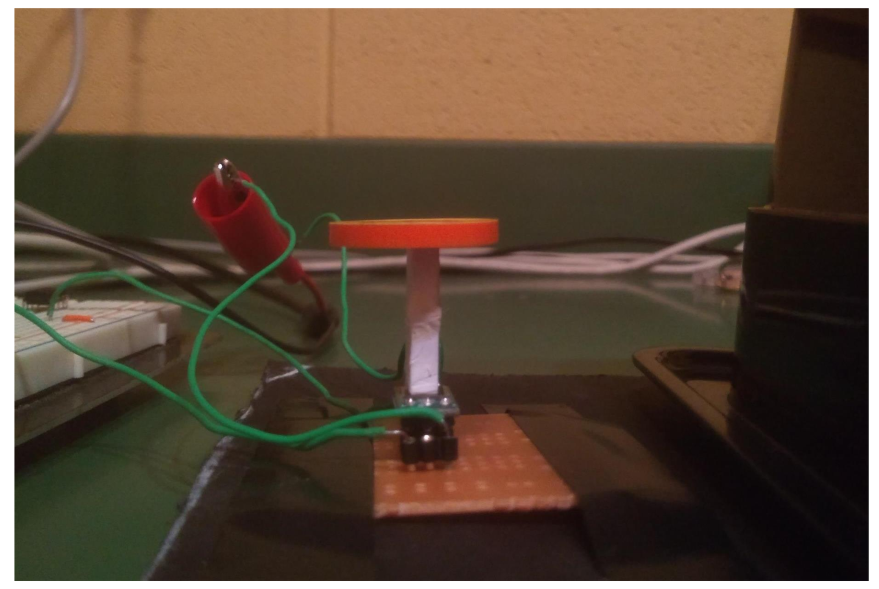

Fig 5: Gamma source on a scintillation crystal

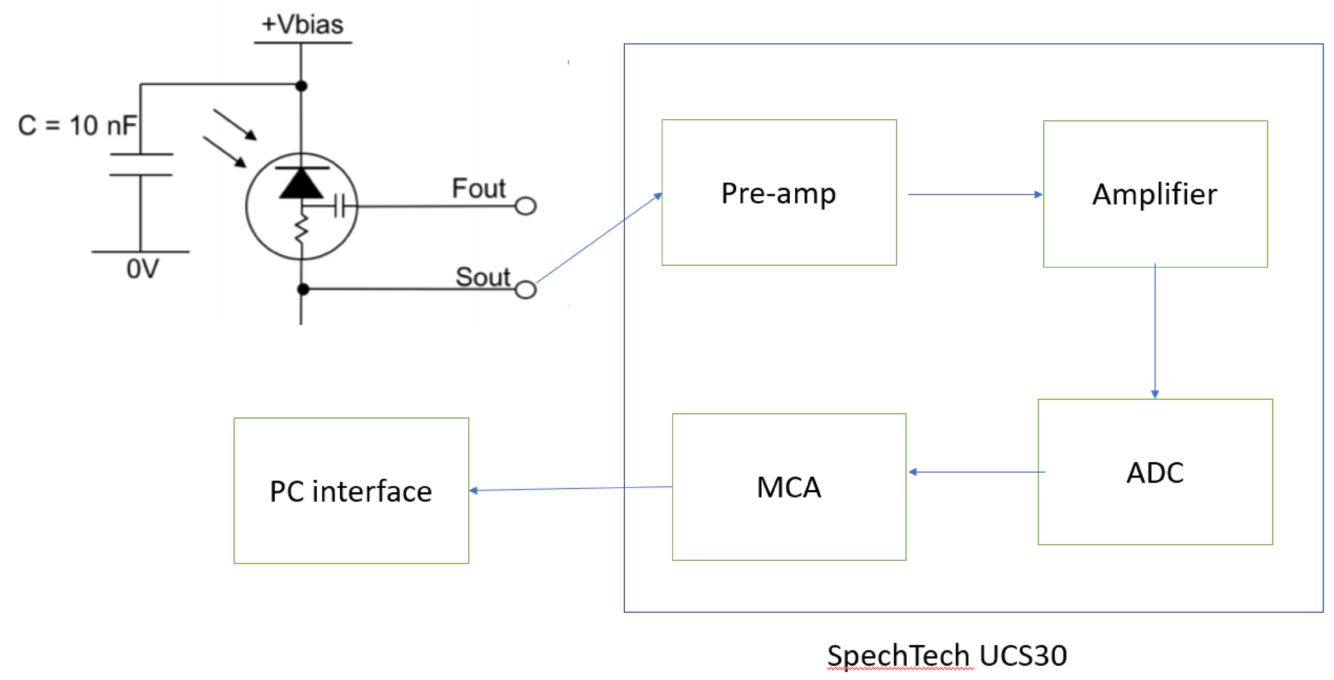

Fig 6: Signal from SiPM goes into SpechTech UCS30 MCA

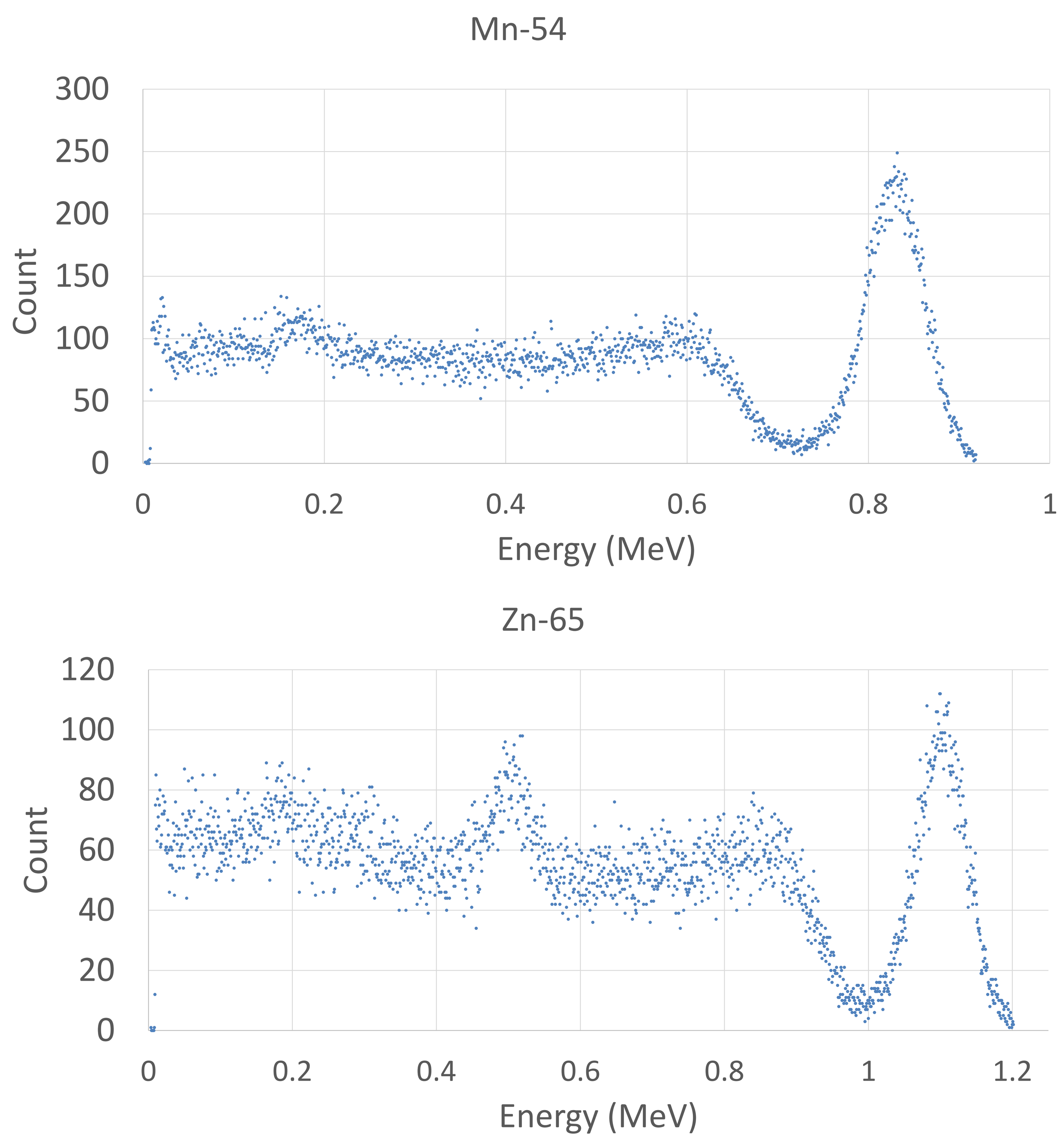

Fig 7: Gamma spectroscopy from a Manganese-54 source (top) and a Zinc-65 source (bottom)

Construction of Muon Telescope with SiPM

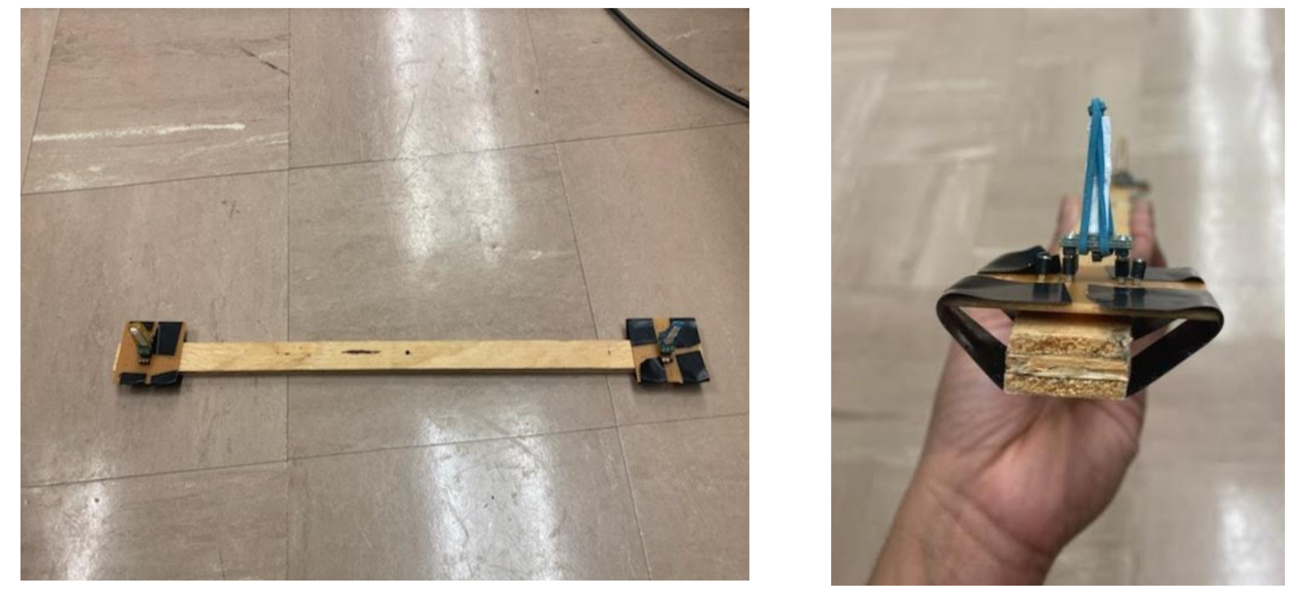

Fig 8: full body of muon telescope (left) and a close up of one of the detectors on the telescope

Two SiPM detectors were used to detect cosmic muons travelling at almost .94c. A single muon travelling parallel to the axis of the telescope would go through both of them almost at the same time creating a coincidence count.

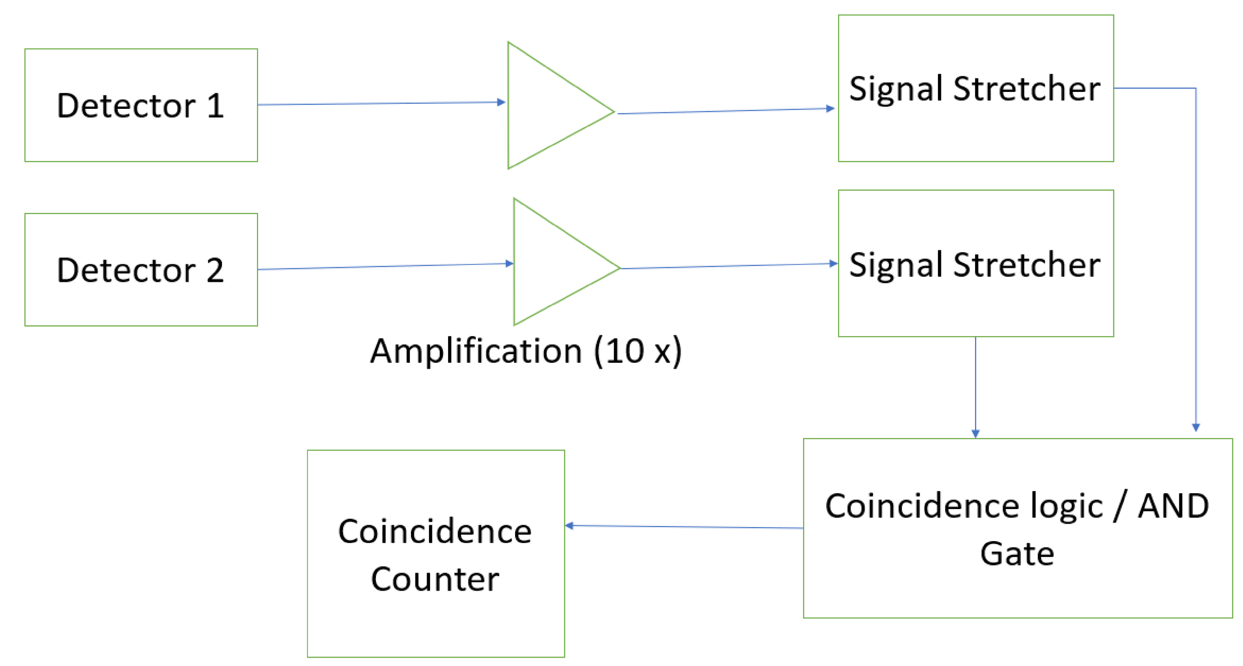

Fig 9: Scheme diagram to get coincidence count from muon detection

This setup can be used to confirm a well-known correlation between the Zenith angle of the telescope and muon distribution. The data presented here was collected in Sakarya, Turkey.

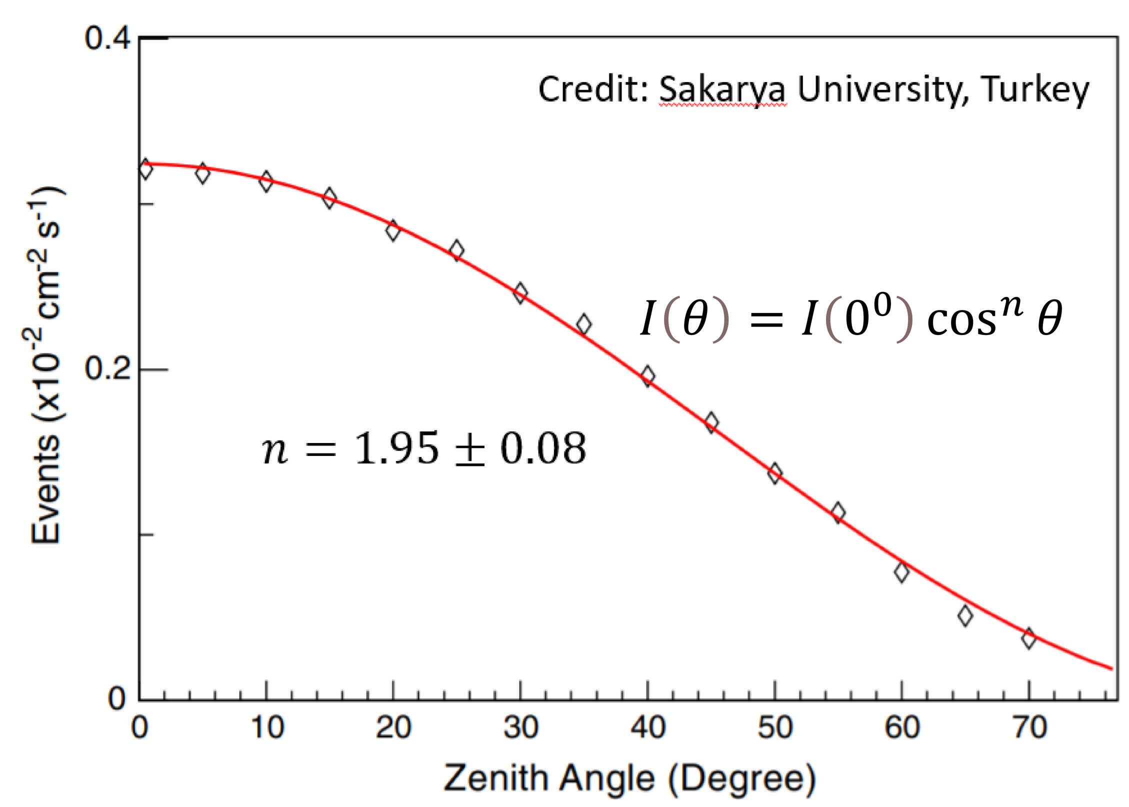

Fig 10: Muon intensity graphed as a function of the zenith angle