SIMULATION OF THE HYBRID DETECTOR MuTe FOR VOLCANO TOMOGRAPHY

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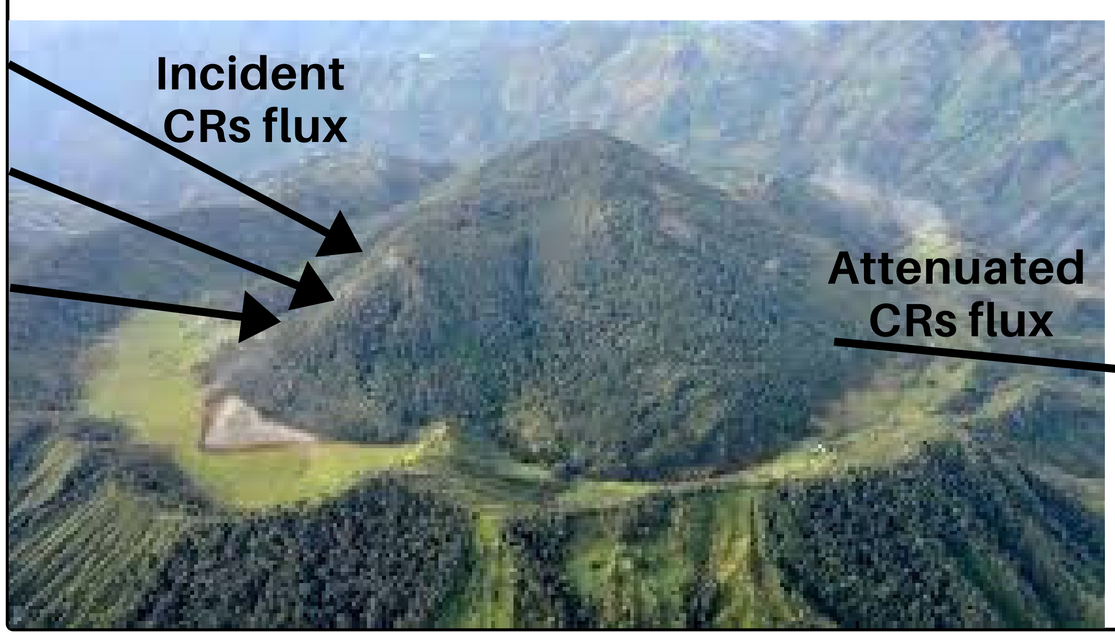
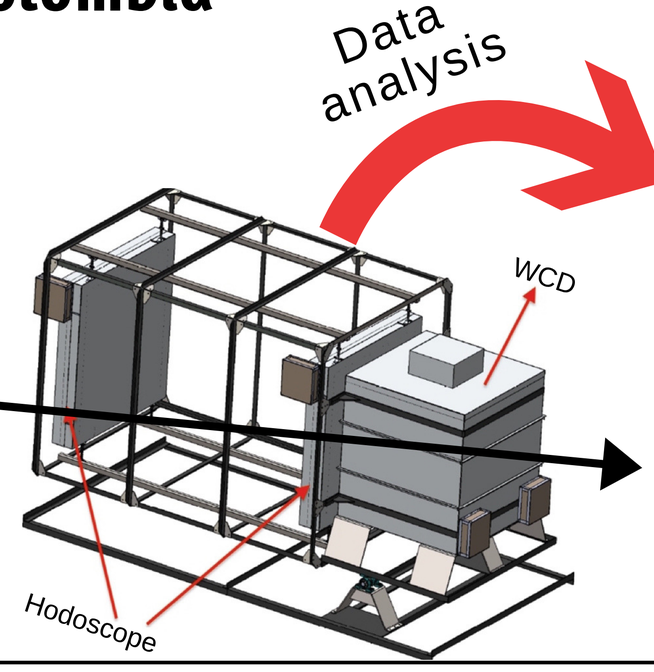
We present the simulation results of the Muon Telescope (MuTe) detector designed to perform the volcano muongraphy in Colombia. The MuTe is composed of two independent detectors: a scintillator bars Hodoscope, to estimate the direction of arrival of the particles; and a Water Cherenkov Detector, to differentiate between the components of the Extensive Air Showers (EAS). In this work we propose the muon detection trigger for MuTe, based on a set of conditions that must occur in a specific order in the hodoscope and in the WCD. From the scintillator bar simulation it was obtained that the 3 GeV muons must generate more than 37 photoelectrons in the photosensor (SiPM), i.e. around 2.08 MeV. Therefore, to determine the direction of arrival of a particle, it must generate 37 photoelectrons in two scintillator bars on the front panel and then on the rear panel, to finally be classified in the WCD. To analyze the WCD response, the unit of measurement VEM (Muon Vertical Equivalent) was estimated and it was obtained that the number of photoelectrons generated is around 203. The corresponding deposited energy is approximately 240 MeV. On the other hand, simulations were carried out corresponding to the response of the WCD to the background flux of cosmic rays at the base level of the Cerro Machin volcano (2650 m s.n.m). From this it was obtained that the charge histogram presents two peaks: the first dominated by the electromagnetic component and the second by the muon component of the EAS. The first peak corresponds to 0.024 VEM while the second one is around 1.034 VEM, that is, the difference between the two allows estimating if the incident particle is a muon. The results presented will be used in the calibration of the MuTe.

Cerro Machín volcano tomography in Colombia





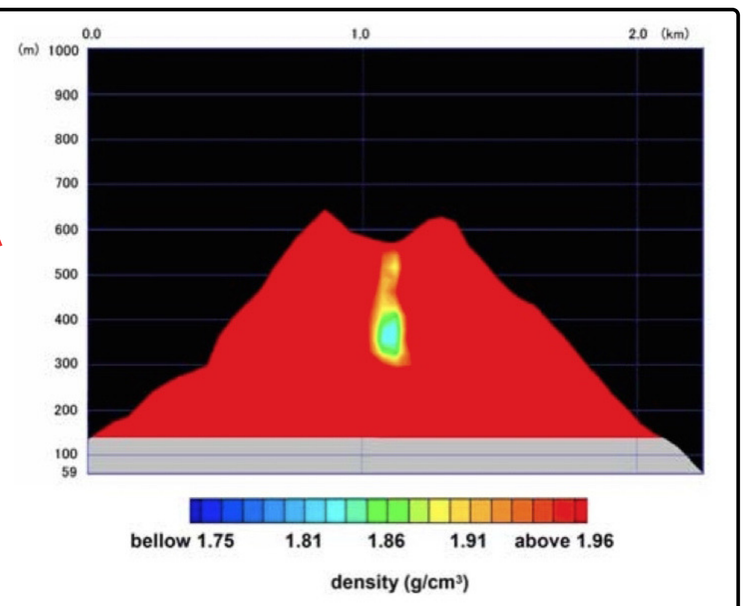


Figure 1. Average density profile given by the data processing result of atmospheric muon flow in Mt. Iwodake [1].

Scintillator bars simulation

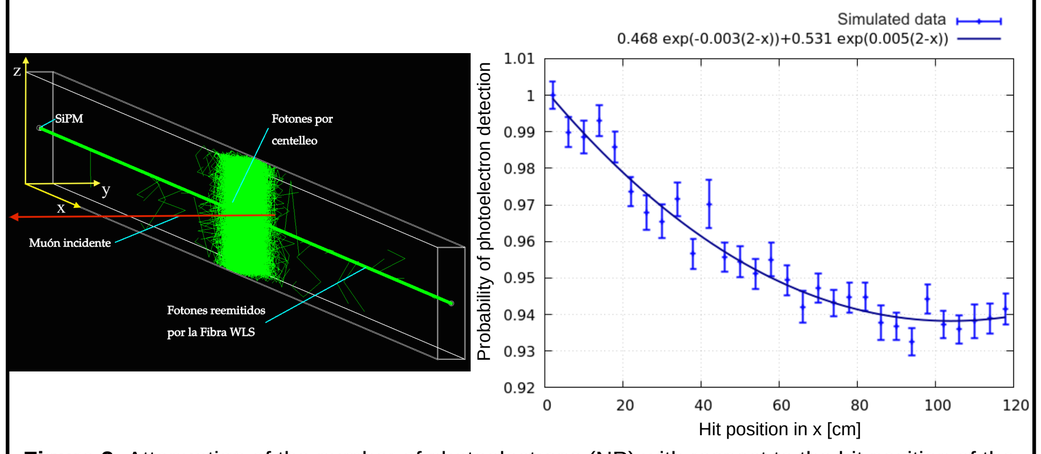


Figure 2. Attenuation of the number of photoelectrons (NP) with respect to the hit position of the muon in the bar. At 118 cm of the SiPM the NP decreases about 6% of the initial position.

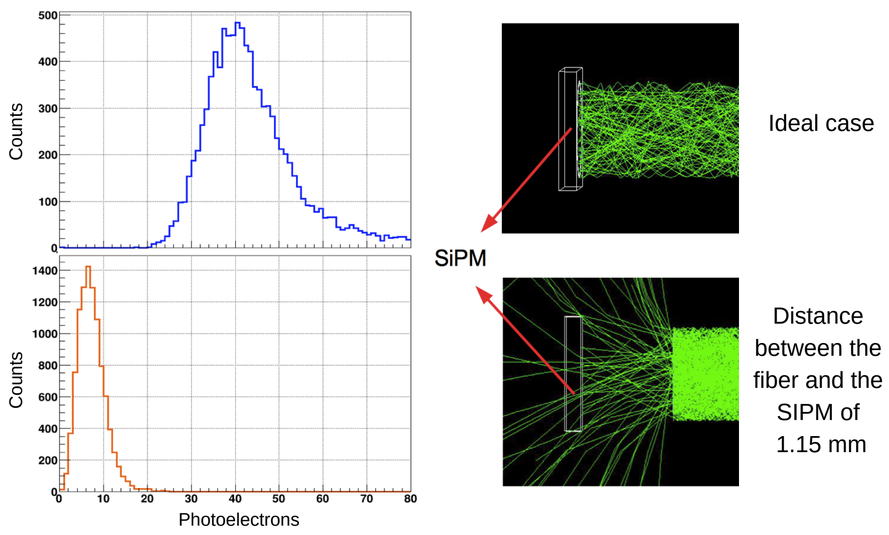


Figure 3. Evaluation of the SiPM and fiber coupling. In the second case the signal obtained is 80% less than in the ideal case.

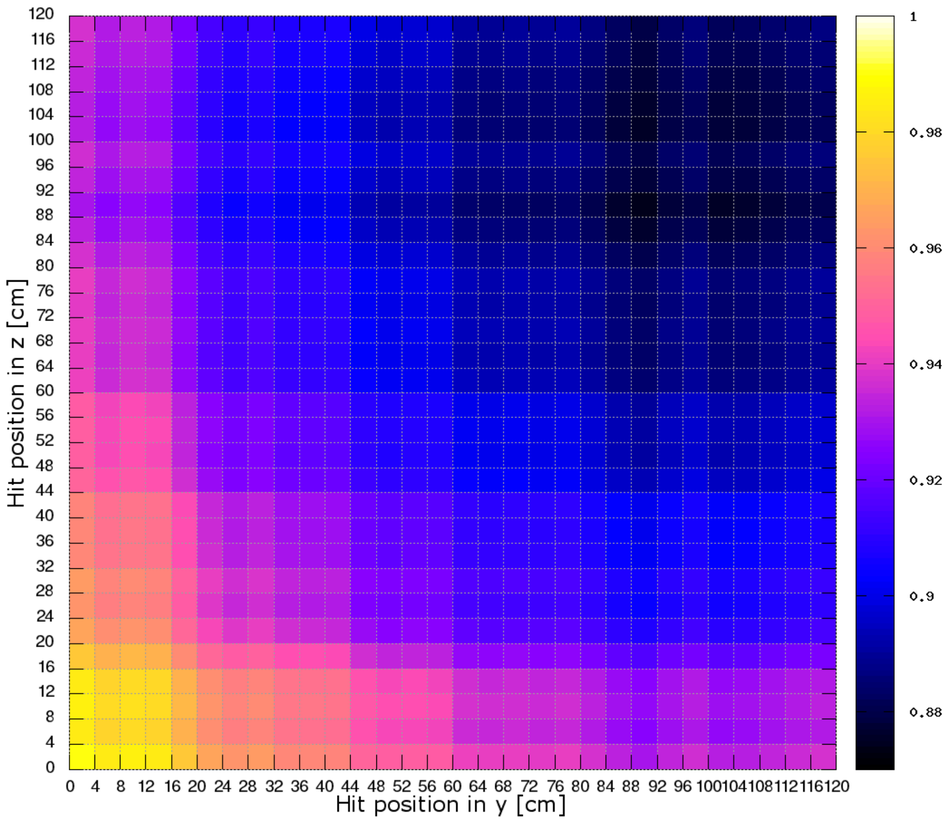
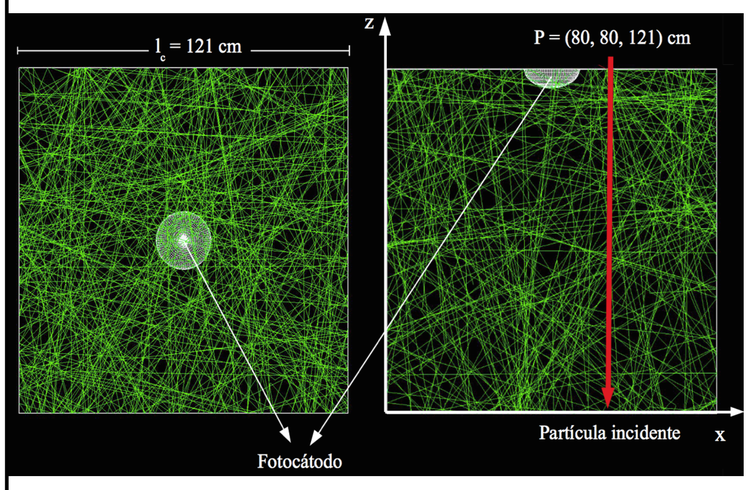


Figure 4. Attenuation of the number of photoelectrons with respect to the impact position of the muon in the panel of the hodoscope. The furthest pixel from the SiPM has an attenuation around 12% compared to the nearest pixel.

WCD simulation



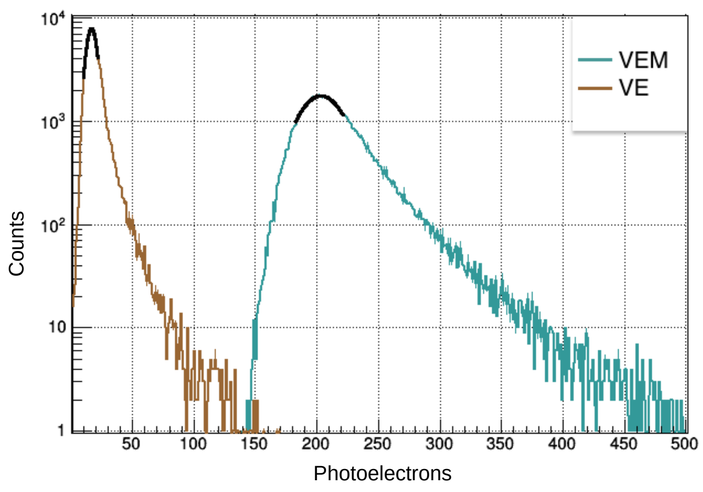


Figure 5. Number of photoelectrons produced by the vertical incidence of 3 GeV muons (VEM) and 20 MeV electrons (VE) on the WCD. The mean number of photoelectrons of the VEM is approximately 203 and for VE IS 17, i.e. 8% of the VEM.

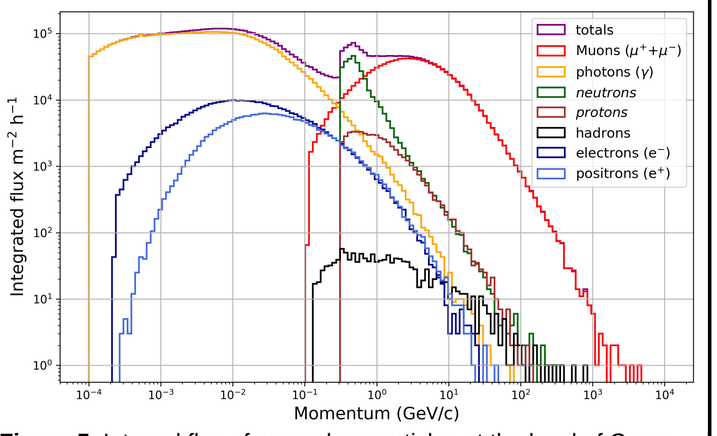


Figure 5. Integral flux of secondary particles at the level of Cerro Machín volcano (2750 m s.n.m.) simulated with CORSIKA and corrected by geomagnetic field with MAGCOS [2, 3].

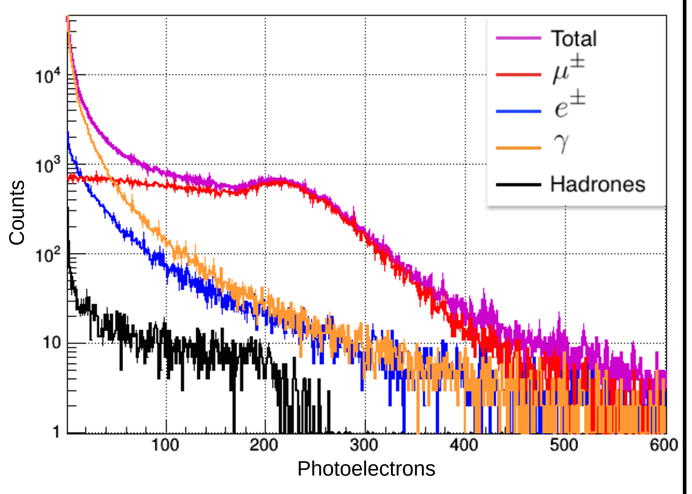


Figure 6. Number of photoelectrons produced in the PMT due to the incidence of a total flux of secondary particles on the WCD at Machín level.

Conclusions

The response of the MuTe hybrid detector to charged particles was obtained, such as the correlation between the response of the plastic scintillator bars and the response of the WCD. With this correlation the muon detection trigger of the MuTe was proposed: 37 photoelectrons in the bars of each panel and 203 photoelectrons in the WCD.

The percentage difference between the signals produced, when the muon hits the ends of the bar is about 6%, similar to the experimental results made by [4] where the attenuation is around 11%. In the panels of the Hodoscope this attenuation is around 12%.

However, the number of photoelectrons reported in the experiment of [4] can reach a maximum average value of 12. This excess of photoelectrons that is presented in the simulation can be associated to the simulation of the SiPM as a continuous surface, because the real device has a matrix of detection pixels, where two or more photons that arrive in a time window of 10 ns [5], produce a single photoelectron.

Regarding the response of the WCD, it was obtained that the VEM is around the 203 photoelectrons. While the response of WCD to electrons that cross the detector vertically, is around the 17 photoelectrons, which is equivalent to 8% of the VEM.

References

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