

C.1.3 Muons Vertical Flux on Horizontal Detector

SG6212



Purpose of the experiment

*Measurement of the muon vertical flux on a plastic scintillating tile.
Estimation of the detection efficiency of the system by comparison between the expected rate and the measured one.*

Fundamentals




Muons lose about 2 GeV to ionization before reaching the ground with average energy around 4 GeV. The production spectrum, energy loss in the atmosphere and decay of the muons are convoluted in their energy and angular distribution. The integral intensity of vertical muons is

$$I_{\nu} \approx 82 \text{ m}^{-2}\text{s}^{-1}\text{sr}^{-1}$$

and their flux for horizontal detectors is $\approx 1 \text{ cm}^{-2}\text{min}^{-1}$ at energies higher than 1 GeV at sea level, as know in literature².

Equipment

SP5600D - Educational Beta Kit

Model	SP5600	SP5608	DT5720A
Description	Power Supply and Amplification Unit	Scintillating tile coupled to SiPM	Desktop Digitizer 250 MS/s
			
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Requirements

No other tools are needed.

Ordering Options

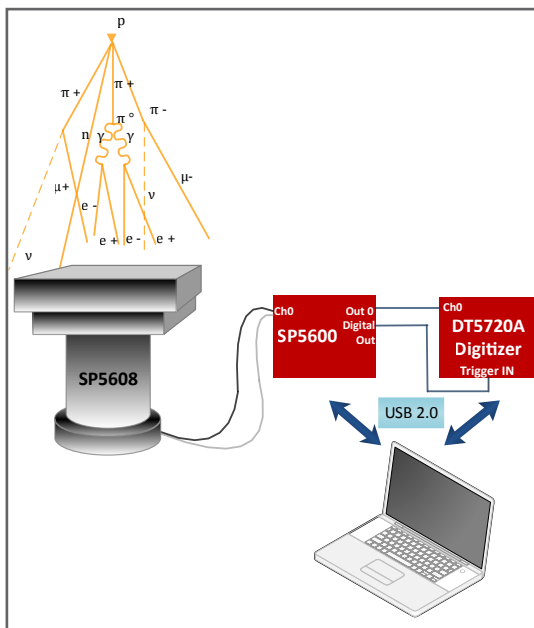
Equipment A	
Code	Description
WK5600XDAAAA	SP5600D - Educational Beta Kit
<i>or the all inclusive Premium Version</i>	
WK5600XANAAA	SP5600AN - Educational Kit - Premium Version
Equipment B	
Code	Description
WK5620CHAAAA	SP5620CH - Cosmic Hunter



Cosmic ray muon radiography is a technique capable of imaging variations of density inside a hundreds of meters of rock. With resolutions up to tens of meters in optimal detection conditions, muon radiography can give us images of the top region of a volcano edifice with a resolution that is significantly better than the one typically achieved with conventional gravity methods and in this way can give us information on anomalies in the density distribution, such as expected from dense lava conduits, low density magma supply paths or the compression with depth of the overlying soil.

www.mu-ray.fisica.unina.it





Experimental setup block diagram.

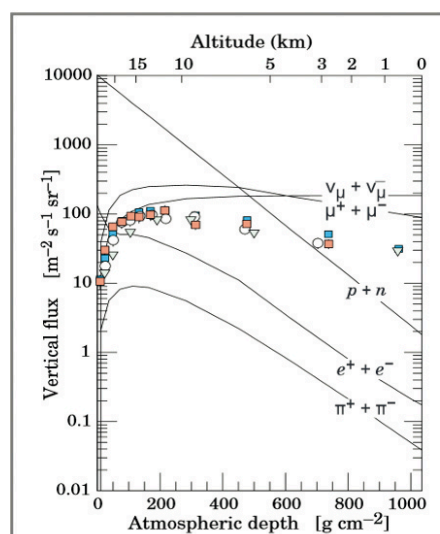
Carrying out the experiment

Open the SP5608 and remove the plastic scintillating tile. Close the SP5608 and connect its power cable and its MCX cable to one channel of the SP5600. Connect the two outputs of the chosen channel to DT5720A: the analog output to the channel 0 and the digital output to “trigger IN” of the digitizer. Use the default software values or optimize the operating voltage of the sensor to reach a higher photon detection efficiency (PDE). The first measurement step is the evaluation of the noise (Dark Count Rate) as a function of the discriminator threshold. Because of the DCR, the system has to be made sensitive to the cosmic ray flux relying on the acquisition time of the sensor signal. The thresholds shall be set to reduce the random coincidence rate below the Hertz level. Switch off the power supply, open the SP5608 top, spread the optical grease on the SiPM and insert the scintillating tile. Close the support top, switch ON the power supply and reset the previous configuration parameters. Measure the muons counting rate and estimate the cosmic flux.

Results

The expected rate of muons across the scintillating tile is very low, requiring a fine tuning of the system in order to achieve a significant reduction of the random count rate and enhance the system sensitivity.

Considering the zenith dependence of flux ($I(\theta) = I_v \cos^2 \theta$) and the integration over the solid angle, the expected cosmic rate due to the geometry system can be estimated and the detection efficiency can be evaluated.

Cosmic vertical flux as a function of altitude and atmospheric depth².

² K.A. Olive et al. (Particle Data Group), Chin. Phys. C, 38, 090001 (2014).