C.1.7 Zenith Dependence of Muons Flux

SG6215D

Ordering Options

Equipment A	
Code	**Description**
WK5600XDAAAA	SP5600D - Educational Beta Kit
or the all inclusive Premium Version	
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

Purpose of the experiment

Measurement of the zenith dependence of the cosmic ray flux as a function of altitude. The goal of the experiment is to analyse zenith dependence by performing a series of measurements at different zenith angle values.

Fundamentals

Most muons are produced in the upper atmosphere, typically 15km above the surface of the earth. Muons typically lose about 2GeV to ionization before reaching the ground. The average energy of muons on the ground is around 4GeV. When their decay ($E\mu > 100 / \cos\theta$ GeV) and the curvature of the Earth (for $\theta > 70°$) can be disregarded the flux of cosmic muons can be expressed as follows:

$$\frac{dN_\mu}{dS dt dE_\mu d\Omega} = 0.14 E_\mu^{-2.7} \left\{ \frac{1}{1 + \frac{1.1 E_\mu \cos\theta}{115 GeV}} + \frac{0.054}{1 + \frac{1.1 E_\mu \cos\theta}{850 GeV}} \right\} [cm^2\ s\ GeV\ sr]^{-1}$$

Where θ is the zenith angle, and the two terms in the brackets indicate the contribution of the charged pions and kaons. For $E_\mu \sim 3$GeV, the angular distribution of muons is proportional to $\cos^2\theta$ at sea level. The intensity of cosmic muons is only determined by the angular dependence of the zenith on their energy spectrum and their energy. As first approximation, the dependence of the muon flow from φ is considered negligible, which is in fact less than 10% Error! Reference source not found.

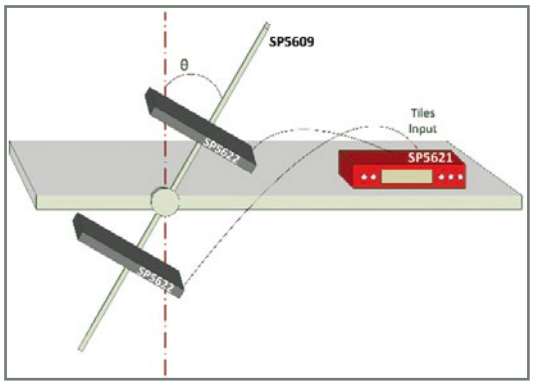
Equipment

SP5620CH - Cosmic Hunter

Model	SP5620CH	SP5622	DT5622
Description	Coincidence Module	Detection System	Detection System
			
	p. 139	p. 139	p. 139

Requirements

The SP5609 - Telescope Mechanics or a similar structure is needed.



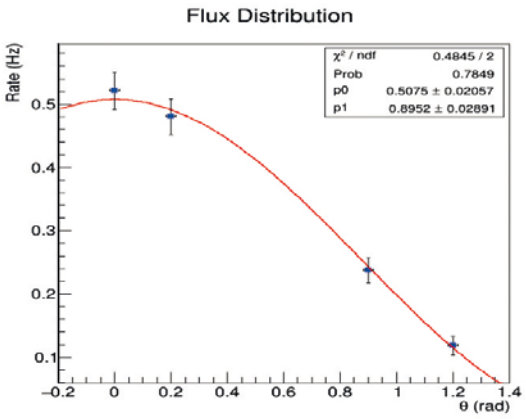
Experimental setup block diagram.

Carrying out the experiment

Set up the SP5609 on a desk or table and assemble the two SP5622 on the vertical arm Error! Reference source not found.. Connect the cable connectors of the two SP5622 to the tile inputs located on the rear panel of the SP5621 module. Power on the SP5621 module and start the acquisition via the front panel START button. When a charged particle crosses the black tile it's energy is converted into scintillation light. The photons which are produced are detected by the photosensor and converted into an electrical signal. The number of counts for each scintillator may be viewed via the SP5621 display. Select double scintillators coincidence mode via the related button on the front panel, and then select measurement integration time. Because the acquisition of events takes place only in the presence of the coincidence, all such events coming from a cosmic particle that crosses only one scintillating tile will automatically be discarded. Determine the solid angle of the muon telescope by fixing the distance of the two scintillating tiles. Be sure to keep this orientation for the duration of the acquisition. Perform the cosmic flux measurement at the first zenith angle value, then rotate the structure to change the angle value and acquire new measurements.

Results

The following plot shows the result obtained by positioning the two detectors at 20 cm distance. The count rate was measured at four values of the zenith angle, θ= [0, 10°, 50°, 70°], to verify the $\cos^2(\theta)$ theoretical trend of the muons flux.



Zenith angle dependence of the muons flux [Fit: $y = p0*\cos^2(p1*x)$]