Study of Atmospheric effects with cosmic muons using portable muon telescope at Agra

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Introduction

Cosmic muons, produced when high-energy cosmic rays interact with Earth's atmosphere, are valuable for atmospheric research due to their sensitivity to atmospheric conditions like pressure and temperature[1]. Muon flux studies help understand cosmic ray interactions and space weather. At Dayalbagh Educational Institute, Agra, a portable muon telescope is used to study the variation of muon flux with atmospheric parameters, such as pressure and temperature[2]. The average muon energy at sea level is $\tilde{4}$ GeV, with a flux of 1 muon/cm^2/min. This paper analyzes the variation of cosmic muon flux.

Muon Telescope

The muon telescope setup consists of two plastic scintillation detectors, referred to as paddles. Each paddle has dimensions of 23.5 cm $\times$ 24 cm $\times$ 2 cm and is arranged in a vertical orientation, as shown in Figure 1.
When a charged particle interacts with the plastic scintillator, it produces scintillation light, which is guided to the photocathode using wavelength-shifting (WLS) fibers. These fibers direct the scintillating photons to the photocathode of a photomultiplier tube (PMT). Upon reaching the photocathode, the photons cause the emission of secondary photo electrons due to the photoelectric effect.
The signal generated by the anode of the PMT is then sent to a discriminator with a preset threshold of -30 mV, which generates a logic signal by comparing the input signal to a preset threshold voltage. This logic signal is subsequently fed into a logic unit (Phillips Scientific, Model 756), and the muon signal is recorded by a scaler (CAEN, Model N1145).

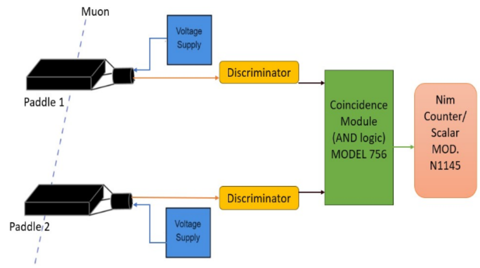

FIG. 1: Schematic diagram of muon telescope set up

Results and Discussion

The cosmic muon flux is influenced by atmospheric parameters such as temperature and pressure. This study, conducted over one month of Aug 2022, examines the percentage fluctuations of cosmic muon flux concerning these factors. Plots of muon count fluctuation with temperature fluctuation and pressure fluctuation in percent as a function of no. of days are shown in Figure 2. Additionally, linear regressions have been performed between muon counts per minute and temperature (in degrees Celsius), as well as between muon counts per minute and pressure (in mbar). It shows an anti-correlation between muon count and pressure, attributed to

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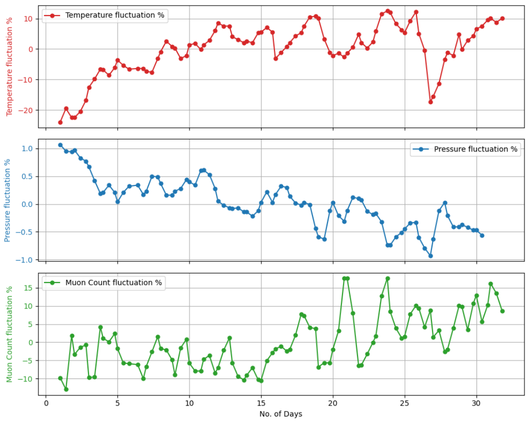

FIG. 2: Percentage fluctuation of muon counts with respect to temperature, and pressure fluctuation on timescale, on x - axis No. of days and on y axis temperature, pressure, and muon count fluctuation (in percent) for one month data of August 2022.

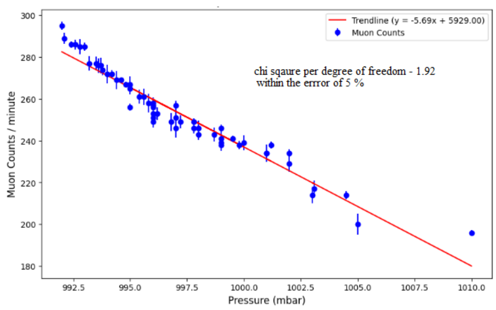

FIG. 3: Variation of muon count per minute over pressure in mbar

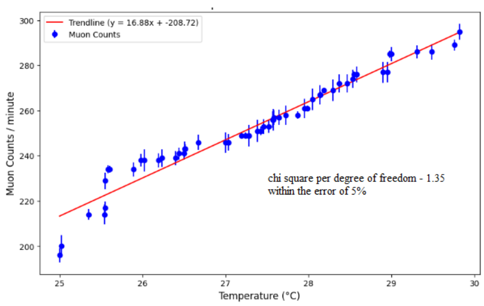

FIG. 4: Variation of muon count per minute over temperature in degree Celsius

atmospheric attenuation, with a pressure coefficient of -5.69 per mbar. Conversely, a positive correlation with temperature is observed, with a temperature coefficient of 16.88 per degree Celsius. This effect may be impacted by inherent noise in the photomultiplier tube (PMT).

To evaluate the goodness of fit for both regressions, the chi-square per degree of freedom have also been calculated. This metric provides insight into how well the model fits the data. For the linear regression of muon counts per minute with respect to pressure, chi square per degree of freedom value is 1.92 with a 5 percent standard deviation. Similarly, for the regression of muon counts per minute with respect to temperature, the chi square per degree of freedom value is 1.35 also with a 5 percent of standard deviation as shown in figure 3 and 4 respectively. The statistical analysis indicates that the fit between the observed data and the regression models is reasonable, with the relationship between muon counts and temperature showing a slightly better fit than the relationship with pressure.

This data has to be corrected for temperature and pressure corrections. The correlation between neutron monitors and our data is being studied. This will finally give us the space weather studies based on the muon telescope.The final study shall provide evidence that muon detection efficiency is an important tool for geomagnetic space science.

Acknowledgments

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References

[1] Sen, A., et al. "Cosmic ray flux and lockdown due to COVID-19 in Kolkata–Any correlation?." Pramana, **95** (2021): 1-8.

[2] Bhatnagar, Sonali. "Muon telescope: An experimental observation of lepton based on coincidence technique." Journal of Physics: Conference Series, Vol. **1804**, No. 1, IOP Publishing, 2021.