

Study of cosmic ray with plastic scintillator detector

S. Shaw¹, N. Nandi², S. Chatterjee³, P. Chawla³, S. Roy^{3,*},
R. P. Adak³, S. Biswas³, S. Das³, S. K. Ghosh³, and S. Raha³

¹Vidyasagar University, Vidyasagar University Road,
Rangamati, Medinipur, West Bengal-721102, INDIA

²Raja Peary Mohan College, 1 Acharya Dhruba Pal Road,
Uttarpara, Hooghly, West Bengal- 712258, INDIA and

³Bose Institute, Department of Physics and CAPSS,
EN-80, Sector V, Kolkata-700091, INDIA

Introduction

Several plastic scintillator detector modules have been fabricated using BC400 material, to measure the cosmic ray flux in Kolkata (altitude ~ 11 metres from sea level) [1]. The weekly variation of the cosmic ray flux has also been studied. The pulse height distribution for the cosmic rays is obtained using a Digital storage oscilloscope (DSO). The method of measurement and experimental results are presented in this article.

Experimental Set-up

To measure the cosmic ray flux, three paddle plastic scintillators, named Sc-01, Sc-02 and Sc-03, of dimension $20\text{ cm} \times 20\text{ cm}$, $20\text{ cm} \times 18\text{ cm}$ and $10\text{ cm} \times 10\text{ cm}$ respectively, have been used. The detectors are placed in a specialised aluminium rack one upon the other as shown in FIG 1. The overlapping area of the scintillators is made equal to the area of the smallest scintillator (100 cm^2). Positive high voltage (HV) is applied to all the Photomultiplier tubes (PMT). The signals from the scintillators have been fed to the leading edge discriminator. Thresholds to the discriminator are set at -50 mV . From the discriminator, the digitised signals are sent to the coincidence module. The 3 fold coincidence output is counted using a scalar counter. This count has been recorded for different PMT biasing voltages ranging from $+1200\text{ V}$ to $+1800\text{ V}$ in intervals of 50 V . Data for each voltage

setting has been taken for a time duration of 150 minutes. The ratio of the obtained cosmic ray flux (3 fold coincidence rate) to the standard value of cosmic ray flux at sea level (which is $\sim 1\text{ cm}^{-2}\text{ min}^{-1}$ [2]) is defined as the efficiency of the detector setup. The pulse height spectrum for muon is also obtained from plastic scintillator. All the data analysis has been performed using ROOT, a data analysis framework developed by CERN [3].

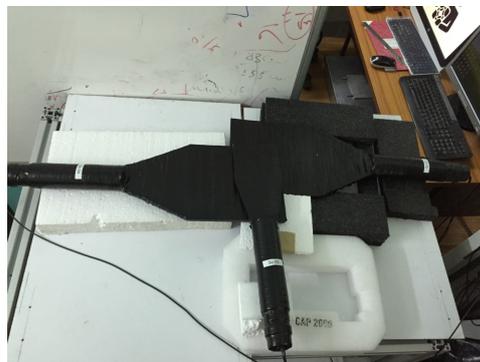


FIG. 1: Set-up with three plastic scintillator paddles for cosmic ray flux measurement.

Results

The 3 fold coincidence count per minute per cm^2 (flux) from the setup of three detectors as a function of applied voltage is shown in FIG 2. So from the definition mentioned above, one can say the intrinsic efficiency of the set-up increases with voltage and reaches a plateau at $\sim 72\%$ from 1400 V to 1650 V . Above this voltage PMT starts to give mul-

*Electronic address: shreyaroy2509@gmail.com

multiple signals resulting a steep rise in the efficiency curve.

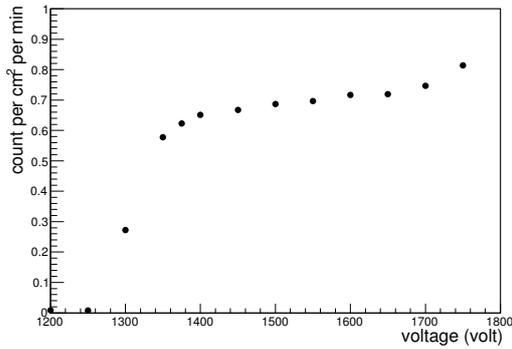


FIG. 2: 3 fold coincidence count per minute per cm^2 as a function of voltage.

The variation of the cosmic ray muon flux over time is measured keeping +1650 V to all three scintillators and measuring the 3 fold coincidence. The actual flux is then calculated taking the efficiency 72%. The actual cosmic ray flux over weeks is shown in FIG 3. It is found that there is a fluctuation of 0.03 (σ) about the mean value of 1.002 per cm^2 per minute.

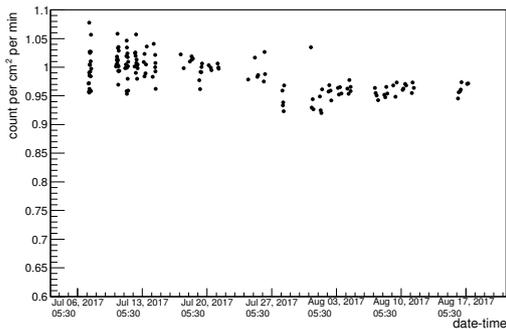


FIG. 3: Weekly variation of cosmic ray flux in Kolkata.

To obtain an energy spectrum of the cosmic rays, the signals from the PMT has been sent to the DSO. In the quick measure mode, the pulse height can be directly read out from the display of the DSO. Pulse heights from

all three scintillators have been recorded from the DSO triggering it by the 3 fold coincidence signal, confirming that a real signal from a cosmic ray particle. The distribution of triggered pulse height for one scintillator is shown in FIG 4. The plot is fitted well with a Landau function. The Most Probable Value (MPV) from the distribution is found to be 675.2 ± 10.3 mV.

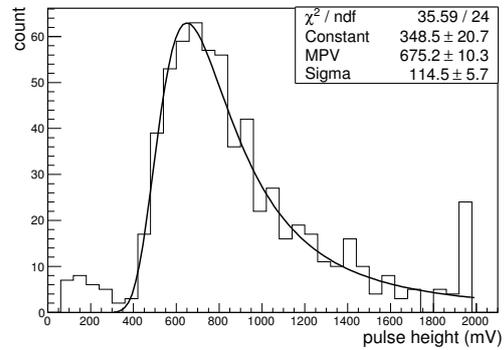


FIG. 4: Pulse height spectrum from a plastic scintillator.

Summary and Outlook

The efficiency of scintillator detector is measured and it is found to be $\sim 72\%$. The cosmic ray flux in Kolkata has been measured using three plastic scintillator detectors for more than a month. A simple method is used to get the pulse height distribution for muon from plastic scintillator detector using a DSO. The pulse height distribution is fitted well with Landau distribution.

References

- [1] S. Roy et al., "Measurement of angular variation of cosmic ray intensity with plastic scintillator detector", Proc. of ADNHEAP conf. at Bose Institute, Kolkata (To be published in Springer book series).
- [2] Particle Data Group, website: pdg.lbl.gov.
- [3] ROOT, A Data Analysis Framework - CERN, website: root.cern.ch.