Study of cosmic muons with CoF-PMD detector

Krittika Adhikari[2], Jogender Saini[1], Sanjib Muhuri[1*]
[1]*EHEP&A Group, Variable Energy Cyclotron Centre, Kolkata-700064, INDIA*
[2]*Ramakrishna Mission Vivekananda Educational and Research Institute (RKMVERI), Belur, Howrah - 400085, INDIA*

Introduction

Cosmic muons have their own merit in Astroparticle physics and have importance in High Energy Physics experiments. Being high energetic particles, it is used for detector characterization like readiness check, efficiency etc. Moreover muon flux measurements along with theoretical modeling can give various physics inputs and societal applications. An experimental setup towards atmospheric muon flux measurement and its variation has been aimed in this present study.

Experimental setup

The experimental setup used consists of Photon Multiplicity detector (CoF-PMD) [2], plastic scintillators, a Si-oil bubbler, Electronic modules, a low voltage power supply and a mixed signal oscilloscope.

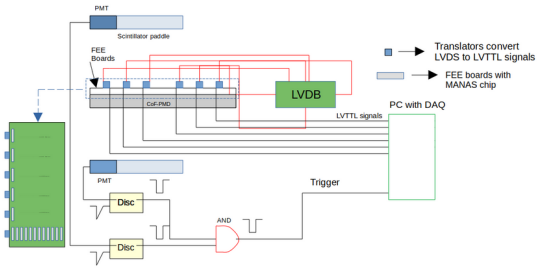

Fig. 1 Schematic diagram of the cosmic setup

Structurally, the three detectors (CoF-PMD, 2 scintillators) are placed parallel to each other with the scintillator on either side of the CoF-PMD detector. They are placed horizontally to receive triggered muon flux from top and bottom. The detectors are connected to negative bias high voltages. Each of the scintillation detectors is connected to voltages of ∼ (1000 − 1050)V. The PMD is operated with 1200V and resulted with low current input. A High voltage Programmable power supply has been used to couple to 220 V AC source. The output from the two scintillators are fed through a discriminator (LED module) via LEMO cables to Majority Logic Units (AND gate) to ensure that correct coincidences trigger to the DAQ for signal recording. It assures the read-out electronics to respond to only those incidents where the cosmic muons pass through all three detectors. The output from the AND gate is sent to a counter module (Quad counter and preset Counter Timer) to keep a count of the coincidences in the two scintillators. This signal is then converted to TTL format using a NIM → TTL convertor (Time Pickoff Control module). The signal of amplitude (4V) is fed as the trigger for data collection. The flowchart of the experimental setup is demonstrated using a schematic as shown in Figure-1.

The read-out plane comprising the FEE boards gets power from a low-voltage power supply via an LVDB (low-voltage distribution board). They are supplied with voltages of -2.5V, 2.5V and 3.3V and a common ground. The translator boards (TB) connect the chain of the FEE board with the DAQ card. Raw data in the TTL format is transferred to the PC via an Ethernet cable. A newly developed DAQ has been used in this setup which draws power from an external 5V power supply.

Detector readiness and scope

CoF-PMD was properly conditioned with continuous gas flow to be operational. The check for the readiness was two-fold for the setup as it is using a completely newly developed DAQ and its working principle. The response to the noise, as shown in Figure-2, is plotted for an

Electronic address: *sanjibmuhuri@vecc.gov.in*

event normalized pedestal mean for a chain of detectors (indicated by channel no).

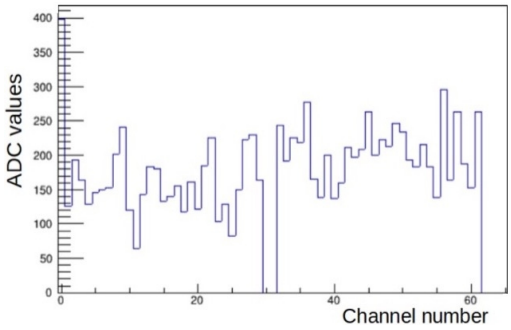

Fig. 2 Pedestal plot with ADC values vs Channel no.

Table 1: Individual and Coincidence rates for cosmic muons from the scintillators.

Time	$Count_{scint1}$	$Count_{scint2}$	Coincidence
When the scintillators are separated by distance of roughly 30cm			
5 mins	870	1900	7
15 mins	1110	3115	9
20 mins	2433	4475	10
When the scintillators are brought closer to one another to 5cm			
30 mins	2800	4330	17
1 hour	5000	8600	31
3 hours	14000	32000	94

Results and discussions

In continuation of earlier work (ref [1]), Geant4 simulation has been performed with a "flat sky generator" for primary particles delivering both μ^- & μ^+. The characteristic muon energy deposit has been reconstructed using Geant4 as shown in Figure-3 (bottom panel) for a wide spectrum of incident muon energy ($0.8 \rightarrow 10$ GeV). The energy deposition profile could be explained by landau (*MPV* = 1.097 MeV), signifying muon in this energy range as the minimum ionizing particle.

The present work accounts for the improvement with the flat sky primary event generator. Newly developed DAQ is the other part for seamless data taking. Followed by the analysis to reconstruct muon tracks and hence flux in the main detector system is foreseen and will be explained in the conference.

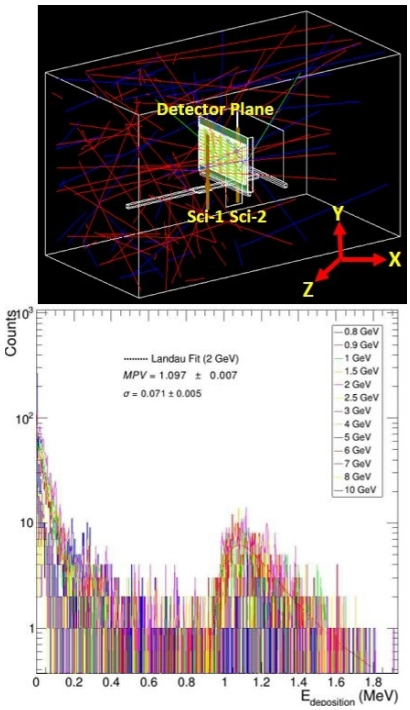

Fig. 3 (Top) Geant4 Event Display, (Bottom) Energy deposition by μ with incident energy 0.8 to 10 GeV.

Acknowledgments

We acknowledge VECC, DAE for supporting the project. Special thanks to ALICE-PMD collaboration for helping with the spared detector module for the project.

References

[1] Anantha Padmanabhan M Nair, Sanjib Muhuri, Subhasis Chattopadhyay, "Simulation for detection of Cosmic Muons using CoFPMD", Proc. of DAE Symposium on Nuclear Physics, Vol 67 (2023)

[2] ALICE Technical Design Report of the Photon Multiplicity Detector (PMD) (1999)