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Cosmic Muon Veto for mini-ICAL at IICHEP, Madurai

Satyanarayana Bheesette[1,*], S.R. Bharathi[1], Alan Bross[5], Pandi Chinnappan[1], V.M. Datar[2], Aditya Deodhar[1], E Craig Dukes[7], Douglas A Glenzinski[5], Robert Craig Group[7], Mamta Jangra[1,3], Jim John[1,3], S.R. Joshi[1], J. Krishnamoorthi[1], Karthikk K.S[1], Gobinda Majumder[1], Veera Padmavathy[1], N. Panchal[1], Nagaraj Panyam[1], S. Pethuraj[1], Anna Pla-Dalmau[5], Jayakumar Ponraj[1], K.C. Ravindran[1], Mahima Sachdeva[1], Mandar Saraf[1], Raj Bhupen Shah[1,3], Kirti Prakash Sharma[1], R.R. Shinde[1], Hariom Sogarwal[3], L. Umesh[1,4], S.S. Upadhya[1], Piyush Verma[1], E, Yuvaraj[1], Vishnu V. Zutshi[6]

[1] Tata Institute of Fundamental Research, Mumbai - 400005, India.
[2] Institute of Mathematical Sciences, Chennai, India.
[3] Homi Bhabha National Institute, Mumbai - 400094, India.
[4] The American College, Madurai - 625002, India.
[5] Fermilab, Batavia, IL 60510-5011, USA.
[6] Northern Illinois University, USA.
[7] Virginia University, USA.

* *Email: bsn@tifr.res.in*

Introduction

A 51-kiloton magnetised Iron Calorimeter (ICAL) detector, using Resistive Plate Chambers (RPCs) as active detector elements to study atmospheric neutrinos, is planned to be built at the end of a 2km tunnel under a 1280m mountain in the Pottipuram Research Centre (PtRC), formerly known as INO [1]. The underground laboratory will be setup near Pottipuram in Tamil Nadu. An 85-ton prototype ICAL detector (~1/600 of total ICAL mass), called mini-ICAL, was commissioned in June 2018.

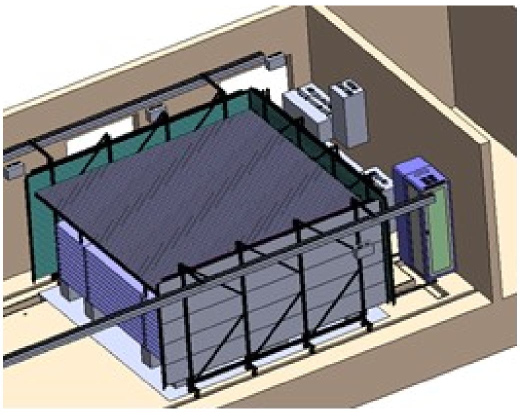

Fig. 1 Sketch showing layout of CMVD around mini-ICAL detector.

This was useful in gaining experience in the construction of a large-scale electromagnet, study the detector performance and to test the ICAL electronics in the presence of fringe magnetic field. This 11-iron layer, 4m×4m×1.2m detector, deploying 20 RPCs is in operation and has collected a large amount of cosmic muon data. A modest proof-of-principle cosmic muon veto detector (CMVD) of size ~1m×1m×0.3m was setup a few years ago, using scintillator paddles. The measured muon veto efficiency of ~99.98% [2] was encouraging enough to perform simulation studies for a shallow depth ICAL detector, surrounded by a 99.99% efficient CMVD, placed at a depth of 100m [3]. The next step was to demonstrate that such an efficiency could be obtained in a large sized CMVD and it was decided to build such a detector around the mini-ICAL detector (Fig.1) on lines similar to the veto detector for the Mu2e experiment at Fermilab [4].

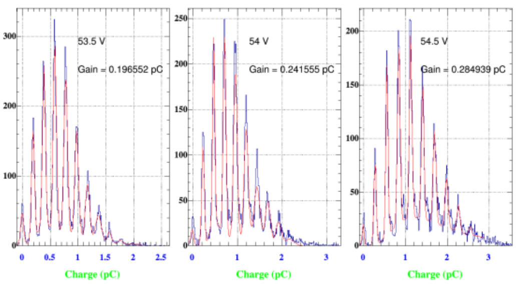

Fig. 2 Single/multiple photon response of SiPM at 3 over-bias voltages. Peaks upto ~8 photons can be clearly identified.

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The veto walls around three sides and top of the mini-ICAL will be built using three (four for the top) staggered (by 15mm) layers of extruded plastic scintillator strips (donated by Fermilab). Strips of 4500-4700mm length, 50mm width and 10 or 20mm thickness will be used to make the veto shield that offers almost 100% geometrical efficiency to tag cosmic muons. 1.4mm dia double clad WLS fibres (from Kuraray, Japan) are inserted into two extruded fibre holes along the length of the strip and separated by 25mm to collect the scintillation light. Hamamatsu SiPM's of 2mm ×2mm active area are used to measure the scintillation on both sides of the fibres. The photon response of a typical SiPM is shown in Fig. 2.

The SiPM assembly for collecting scintillation light from a di-counter of extruded plastic scintillator is shown in Fig. 3. About 750 strips, about 7km of fibre and 3000 SiPM's will be deployed. All the five veto walls/stations are on movable stands, so as to provide service access to the mini-ICAL inside. Fig. 4 shows the assembly of di-counters, which will form a portion of the veto detector wall, in progress.

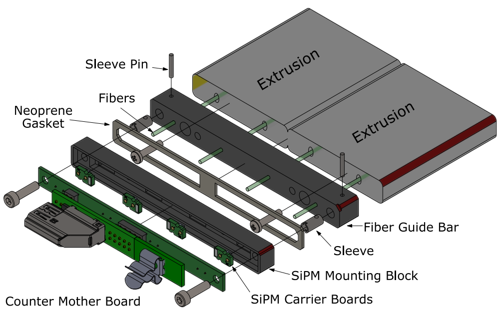

Fig. 3 Readout assembly for 2 extruded scintillator strips.

Coincidence of ORed signals from two out three layers from one side of a station is used to generate a trigger signal, which is further combined with the trigger signal from the other end to form trigger signal from a station (Fig. 5). Trigger signals from five stations are combined to form the final cosmic ray muon veto trigger signal. On Muon Veto Trigger, the DAQ system will measure the produced charge, the arrival time and the position of tracks. However, the acquired Veto data is recorded only if the Muon Veto Trigger coincides with the Main Trigger of the mini-ICAL detector. Extensive configuration, control and calibration of the detector elements are also planned.

Details of the design and construction of the Cosmic Muon Veto detector as well as the electronics, trigger and DAQ systems planned will be presented.

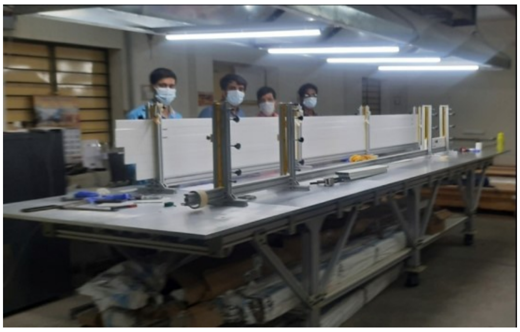

Fig. 4 Assembly of di-counter wall in progress.

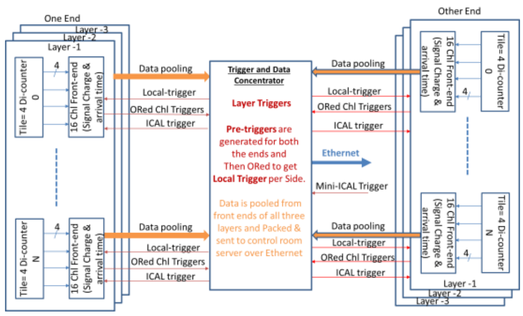

Fig. 5 Schematic of the trigger and data acquisition systems.

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