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Design and construction of Cosmic Muon Veto for the mini-ICAL detector at IICHEP, Madurai

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A 51-kiloton magnetised Iron Calorimeter (ICAL) detector, using Resistive Plate Chambers (RPCs) as active detector elements, aims to study atmospheric neutrinos. It will be the flagship experiment at the India-based Neutrino Observatory (INO) which is proposed to be housed in a cavern at the end of a 2 km tunnel in a mountain near Pottipuram (Tamil Nadu). A prototype - 1/600 of the weight of ICAL, called mini-ICAL was installed in the INO transit campus at Madurai, in order to gain experience in the construction of a large-scale electromagnet, and in order to study the detector performance and test the ICAL electronics in the presence of a fringe magnetic field. The 4 m × 4 m × 1.1 m mini-ICAL magnet with 11 iron layers, and 2 m × 4 m × 1.1 m active detector using 20 RPCs which is housed in the central region of the magnet, have been in operation for about 4 years and collecting cosmic muon data. A proof-of-principle cosmic muon veto detector (CMVD) of about 1 m × 1 m × 0.3 m dimensions was set up a few years ago, using scintillator paddles. The measured cosmic muon veto efficiency of ~99.98% and simulation studies of muon induced background events in the ICAL detector surrounded by an efficient veto detector were promising. This led to the idea of constructing a bigger cosmic muon veto around the mini-ICAL detector.

CMVD will comprise of Veto walls on three sides and the top of the mini-ICAL will be built using extruded scintillator strips (donated by Fermilab). The top layer (the roof) of mini-ICAL will have four layers of scintillator strips and standing Veto walls on three sides (left, right, posterior) will each have three layers of scintillator strips. The layers of each veto wall will be staggered (by 15 mm) so as to minimize the effect of inter-strip gaps. There will be no anterior veto wall, so as to allow for maintenance of the mini-ICAL detector. Strips of 4500-4700 mm in length, 50mm wide and 10 or 20 mm thick are used to construct the veto shield that aims at 99.99% efficiency to tag cosmic muons. Double clad WLS fibres ~1.4 mm in diameter (from Kuraray) are inserted into two extruded fibre holes along the length of the strip and separated by 25 mm to collect the light signal. Hamamatsu SiPMs of 2 mm x 2 mm active area will collect the light on both sides of the fibres. In total, 712 strips, 6.6 km of fibre and 2848 SiPMs will be used. All the four veto walls/stations are designed to be movable from their designed positions, thus enabling better service access to the mini-ICAL.

The SiPM signals are amplified using a trans-impedance stage of gain ~1200 ⊠ and fed to the DRS4 sampler, operating at 1 GS/s. The sampling window is so chosen as to cover the entire SiPM's signal profile, as also the trigger latency of mini-ICAL. On receiving the cosmic muon trigger from mini-ICAL, the sampled data is digitised. Either a zero-suppressed pulse profile data or an integrated signal charge data of all hit channels of CMVD will be transferred to the backend. The muon veto efficiency of the CMVD is computed by extrapolating the muon tracks recorded by the mini-ICAL onto the veto walls and matching them to the CMVD hits there. 72 FPGA-based DAQ boards, each hosting 40 trans-impedance amplifiers, five DRS4 and ADC chips each besides network interface are being developed. Customised SIPM bias supply units along with extensive configuration, control and calibration of the detector elements as well as electronics are also being designed.

Details of the design, fabrication, quality control and construction of the detector including the electronics, trigger and DAQ systems planned will be briefly presented.

In-person participation

Yes

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