Development of large area scintillators for the cosmic hodoscope for characterization of RPCs

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Sixteen large area scintillators have been assembled for characterization of RPCs in NPD using cosmic muons as triggers. At the surface of earth the average energy of muon is 3 - 4 GeV with an average flux of 10,000 muons per square meter per minute. The average area of trapezoidal CMS-RPCs is approximately 2 m^2, and these large area scintillators have been fabricated to fully characterize them in one go covering the entire active area of RPCs where one need not move small sized scintillators every now and then over different active areas of the detector, which becomes very cumbersome for a proposed production rate of five RPCs per month [1]. The hodoscope will therefore provide a global efficiency, rather than a localized efficiency for large area detectors. These scintillators are arranged in two layers, each consisting of eight scintillators. The two layers are separated by a vertical distance of 2100 cm between which six RPCs can be sandwiched simultaneously to evaluate its functional parameters in terms of efficiency, cluster size, strip profile and noise in each strip.

Each of the scintillator measures 180 cm x 18 cm x 1 cm and were cut and polished (upto 10 µm level) in the Centre for Design and Manufacture-BARC from the left over Bicron sheets procured by TIFR for the “Outer Hadron” part (HO) of the CMS experiment. Each of these scintillators is coupled to a separate PMT at each end. The PMTs were procured from Flectron Tubes (ET-9814B, 51 mm diameter, QE ~ 30% and gain ~ 10^6). As the length of these scintillators is quite long, it was decided to have two PMTs at either end, so that the efficiency of the scintillator is not compromised, over its length, while having PMT at one end only. Thereby these 16 scintillators have 32 PMTs powered by the mainframe power supply from CAEN, SY2527. The scintillators were glued to the Perspex light guides with the two component EJ optical cement and Perspex cookies were used to couple them to the 51 mm diameter of the PMTs. EJ-500 is a clear and colorless epoxy cement with refractive index at 1.57. EJ-500 is fully cured at room temperature (20^{o}C) with a working life of 60 minutes. The mixed cement takes 3-4 hours to set and 24 hours to harden, although it takes several days to achieve complete cure. We thoroughly mixed 4 parts by weight resin to one part by weight of hardener (3 parts to 1 part by volume) and allowed air bubbles to rise before applying by setting aside for 15-20 minutes.

Fig. 1, shows the schematic of the scintillator, light guide, cookies, PMT and the HV divider. The whole assembly was then wrapped by a reflector in the inside and doubly wrapped with black tape on the outside. After assembly, the scintillators were tested for any external light leakage by an intense light source. Negative HV had been configured for these PMTs, so as to keep the anode at the ground level. Fig. 2, shows the eight scintillators lined side by side in the top layer (shelf # 9 : C91D91 to C98D98) of the cosmic stand in the RPC Lab. The bottom layer of scintillators is configured in shelf # 2 (A21B21 to A28B28) and the two layers are staggered by 5 cm with respect to each other to take care of the 1 mm of gaps between adjacent scintillators, in each layer, arising due to wrapping of black tape and heat shrink tubes. A,B and C,D refer to the PMTs in mounted in front and back of each scintillator on shelf # 2 and shelf # 9 respectively. From each scintillator, the signals from the two PMTs at either ends are ORed. All the signals from the PMTs arriving at the pulse processing stage pass through a fixed cable delay of 100 ns. Fig. 3 shows the rate curves for some randomly selected PMTs at a threshold of 100 mV. The rates seem to be uniform, as expected, and also the rates from the two ends of any scintillator (A21, B21 and A23, B23) do not vary significantly near the plateau. These curves are also helpful in letting one identify the operational voltages for the respective PMTs. Fig. 4, shows the coincident spectrum between a single scintillator, each from the top and the bottom layers of hodoscope, (C94D94 and A24B24) separated by 1200 cm and is the prime reason for the low statistics. The X-axis shows the channel number. Two different delays at 20 ns and 60 ns were employed and we can see the corresponding shift in Fig.4, which will be used to calibrate the spectrum. Further work is in progress regarding the rate stability of the hodoscope and to OR all the scintillators in each plane and then take a coincidence between the two layers with improved statistics. This coincidence will provide us the cosmic trigger to evaluate the performance characteristics of the RPCs and shall be reported during the symposium. The hodoscope will also be very helpful for the proposed muon tomography programme in the 12th plan, where RPCs shall be used as the active detector element. In light of the upcoming INO programme at BARC, this hodoscope is also capable of characterizing 1 m x 2 m glass RPCs.

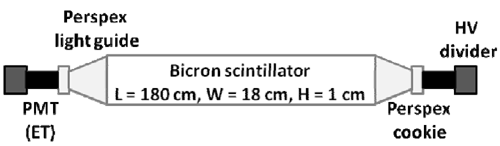

Fig. 1 Schematic of the assembled plastic scintillator with Perspex light guides, Perspex cookies and PMTs at both the ends

Fig. 2 The eight scintillators in the top layer (shelf # 9 : C91D91 to C98D98) of the cosmic rack with PMTs at both the ends

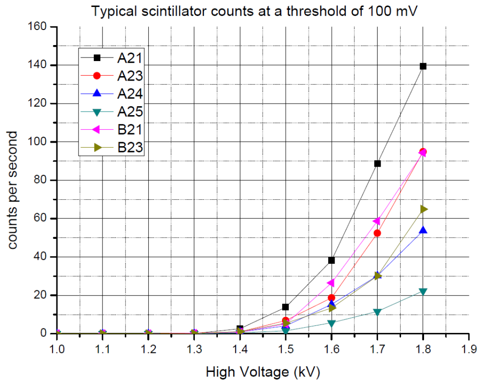

Fig. 3 Typical rate curves from the scintillators for some randomly selected PMTs

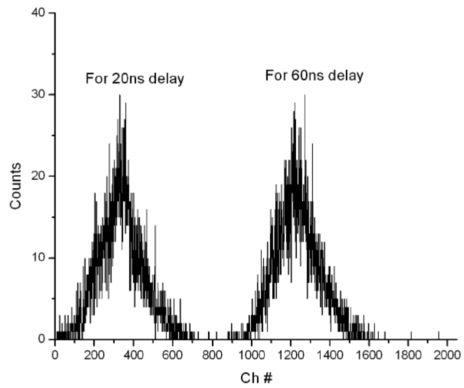

Fig.4 TAC spectrum from one of the scintillator, each in the top (C94D94) and bottom (A24B24) layers for two different delays at 20 ns and 60 ns

References

[1] CMS Muon Tecnical Design Report [CERN/LHCC 97-32]