Characterisation of Hamamatsu SiPM for cosmic muon veto detector at IICHEP.
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Abstract
A test setup is built to characterise the SiPM and to measure muon detection efficiency of extruded plastic scintillator detector. In the setup, light from the scintillator is readout by SiPMs using two embedded WLS fibres. The SiPM was calibrated using LED source, but alternate calibration procedures using radio-active source data as well as noise data were also established. The SiPM is studied at various over voltages (VOV) and determined the operating VOV by optimising the muon detection efficiency and noise rate. The muon position along the length of the scintillator is measured using timing information from both sides of the fibres. Results from our characterisation studies of SiPM, e.g. after pulse, cross-talk, recovery time etc. will be presented in this poster.

Mini-ICAL detector with veto

- 10 layers of RPC between 11 layers of iron.
- 85 ton magnet.
- Veto walls of extruded plastic scintillator.

Main Objectives
1. About Silicon Photomultiplier.
2. Calibration using LED.
3. Calibration using random trigger and radio-active source data.
4. Study of correlated noise in SiPM.
5. Deciding VOV for SiPM operation.
6. Recovery time of SiPM.
7. Conclusion.

About Silicon Photomultiplier
- S13360-2050VE: Hamamatsu.
- Total size of 2mm x 2mm with 1584 pixels.
- Breakdown voltage: (53 ± 5)V + overvoltage of 3V.
- Spectral range: 320 - 900 nm, -dG/dT = 2%.

Calibration using LED
The integrated charge is calculated using the equation:

\[ Q_{int} = \frac{1}{7} \int_{0}^{t} V(t)dt \]  (1)

where R = 120 ohm as shown in Fig. Total collected charge is fitted with a function:

\[ f(y) = N \times \sum_{i} R_i \times e^{-(y-a_i)^2/2\sigma^2} \]  (2)

where N is the number of photoelectron (p.e.) peaks, \( R_i \) is the peak height, \( \mu \) is the gain of SiPM and \( \sigma \) is the gaussian width of p.e. peak.

Scintillator counter schematic.

SiPM circuit diagram.

Calibration using random trigger and radio-active source data

Study of correlated noise
Correlated noise e.g., cross-talk and afterpulse along with primary Dark Count Rate (DCR) can deteriorate the SiPM performance. The most common method to measure DCR and correlated noise rate is to study the output pulses from SiPM at controlled temperature in a dark environment. Time difference between two consecutive peaks and amplitude of the second pulse is required to calculate these parameters [1, 2].

Deciding VOV for SiPM operation

Recovery time of SiPM

Conclusion
- Optimised value of VOV is decided to be (2 - 3) V.
- Noise Rate at VOV = 3V is of order of tens of kHz at a threshold of one photoelectron.
- Correlated noise is found to be (4 - 8)% of the total noise.
- Recovery time varies from (20 - 50)ns for different VOVs.

References

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