SiPM as Photon Counter for Cherenkov Detectors

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Introduction

Silicon photomultipliers (SiPMs) are very new type of photon counting devices that show great promise to be used as detection device in combination with scintillators/Cherenkov radiators. SiPM is essentially an avalanche photo-diode operated in limited Geiger mode. They have been considered as potential read-out devices for DIRC counter of the PANDA detector which is one of the large experiment at FAIR- the new international facility to be built at GSI, Darmstadt. In addition, the potential use of SiPM includes medical diagnosis, fluorescence measurement and high energy physics experiments. The SiPM module is a photon counting device capable of low light level detection. It is essentially an opto-semiconductor device with excellent photon counting capability and possesses great advantages over the conventional PMTs because of low voltage operation and insensitivity to magnetic fields. In many of the high energy physics experiments, the photon sensors are required to operate in high magnetic fields precluding the use of convensional PMTs. This problem can be over come with the use of SiPMs. SiPM operating in Geiger mode, a very large gain ($\sim 10^6$), magnitude of which is determined by the internal diode capacitance and applied over-bias voltage, comparable to that of PMTs can be achieved. A SiPM consists of matrix of micro cells (known as pixels), typically between 100 and 10000 per mm^2. Each micro cell acts as digital device where the output signal is independent of the number of photons absorbed. When all the cells are connected in parallel, the SiPM becomes an analog device thereby allowing the number of incident photons to be counted.

Detailed R&D studies with SiPM are needed for the use of this device to PANDA experiment. With this motivation in mind, we have developed a SiPM test facility and have tested several commercially available SiPM for their performance study and comparison with other photon counting devices.

Test Setup

Different types of SiPM manufactured by Hamamatsu and Zecotek with different sizes of pixels and active area have been tested by our group so far. A list is provided in Table 1.

TABLE I: SiPM details: MPPC1 and MPPC2 are from Hamamatsu and MAPD3N is from Zecotek.

Device	Active Area [mm^2]	Pixel size [μm]	Pixel Density [1/mm^2]
MPPC1	(1x1)	100	100
MPPC2	(1x1)	25	1600
MAPD3N	(3x3)	7	15000

During the measurement all devices were mounted in a light tight box and were illuminated by a pico-second pulsed diode laser (make Pico-Quant) of 660 nm wavelength as well as LED with λ = 460 nm. In order to be able to distinguise between single and multi-photon peaks, the laser intensity was controlled. The Voltage and current on the SiPM were controlled by high precision multimeter. We have also measured the particle detection efficiency (PDE) as a function of wavelength of the incident photons. For this, a monochrometer that spans wavelength from 200 to 800 nm was used. Different intensity filters were used for light intensity attenuation. The photo-sensitivity of different SiPMs was normalised with a PIN diode which itself was calibrated by the producer.

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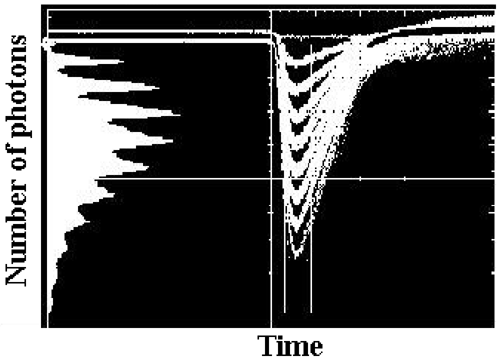

FIG. 1: A typical SiPM spectrum from Hamamatsu MPPC triggered by laser light. Different peaks correspond to different photo peaks, hence, the number of pixels fired. In this case upto eight photon peaks are seen. Photograph taken from digital oscilloscope with histogramming mode on.

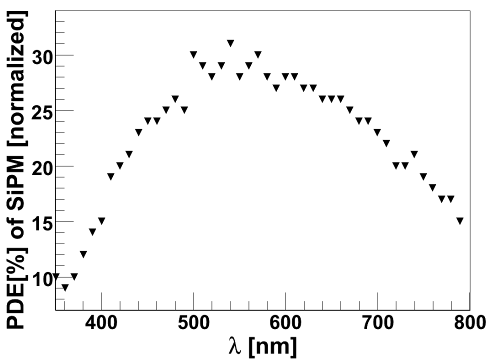

FIG. 2: Photon detection efficiency distribution of MAPD3N as a function of wave length normalized with data from ref.[1] at $\lambda = 450$ nm.

Test Results

The dark count of the MPPCs were measured at 0.5thr and 1.5thr and found to be in agreement with the specifications provided by the supplier. Fig. 1 shows a typical SiMP spectrum for low intensity laser light, showing upto eight individual peaks corresponding to different number pixels fired. In fig.2 and Fig.3, we plot the photon detection efficieny (PDE) distribution as a function of the

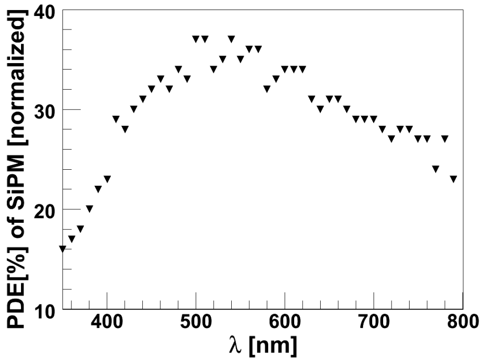

FIG. 3: Photon detection efficiency distribution of MPPC normalised with data from ref.[2] at λ=450 nm.

wavelength λ for Zecotek make MAPD3N and Hamamatsu make MPPC. For MAPD3N, the distribution has been normalized with PDE=24.5% at $\lambda = 450$ nm[1] and for MPPC, PDE=32.4% at λ=450 nm[2]. It is to be noted that the present data for MPPC shows much broader distribution extended over larger wavelength range as compared to the report of Hamamatsu.

Acknowledgments

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References

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