Development of SiPM based scintillation detector for fast timing application in the PANDA experiment

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The Facility for Antiproton and Ion Research (FAIR) is a future project at GSI which will extend hadron physics studies up to the charm meson region using antiproton beams together with a state-of-the-art PANDA (acronym for antiProton ANnihilation at DArmstadt) detector. The physics aim, in a broader sense, is to address the fundamental problems of hadron physics and aspects of Quantum Chromo Dynamics (QCD) at low energies. The proposed work in India[1] will consist of several parts: a) development of silicon photomultiplier(SiPM) based scintillation tile hodoscope for TOF information, b) Development of a Luminosity detector (silicon strip detector), and c) simulation studies of these detector design as well as physics case studies. The present paper reports the initial R&D activities that have been started at NPD, BARC on the development of the SiPM based fast scintillation (SciTil) detector. The simulation activities that also have been started at BARC with this detector is reported in an another contribution to this proceedings.

The SciTil detector is designed to be in the form of a huge barrel and will be sitting on top of the PANDA barrel DIRC detector and in front of the Electromagnet Calorimeter (EMC). The detector will serve for precision time measurement for triggering and determination of time-of-flight. In addition, a good spatial resolution due to its granularity can be obtained. The hodoscope will also provide information on charged-neutral discrimination. The timing detector concept is based on 3 x 3 x 0.5 cm^3 scintillator tiles (matching the front face of crystals of the EMC detector). The scintillator tiles will be read out by SiPMs of appropriate size. The size and positioning of the SiPM on to the tiles for optimum photon counting are being studied. It is foreseen that the detector will consists of about 5700 scintillator tiles and 11500 SiPMs.

The advantages of the SiPM over the conventional photomultiplier tubes are the following: silicon photomultipliers 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. It is an opto-semiconductor device with excellent photon counting capability, high gain, magnetic field insensitivity and compactness in size. 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. They are also being considered as potential readout devices for DIRC Cherenkov counter of the PANDA detector, upgrade of the CMS HO calorimeter. In addition, the potential use of SiPM includes medical diagnosis and fluorescence measurement.

Since it is a very new type of device, a detailed R&D study is needed[2,3]. Also the integration of SiPM to the scintillator for achieving a very fast timing resolution is a new concept and needs detailed study. We have developed a test set-up facility at BARC (Figs. 1 - 2) and have started some initial study. SiPMs are being tested in different conditions. At present Hamamatsu make MPPC of size 3 x 3 mm^2, an array of 2 x 2 with total active area 6 x 6 mm^2 and Bicron make plastic scintillator BC-408 of dimension 3cm x 3cm x 0.5cm are used. For preamplifier, we have used “Photonique SA” make two varieties preamplifier, one with high gain(20x –

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60x) but relatively slow rise time(5ns) and the other with one low gain(10x – 20x) but fast (700ps). The MPPCs are also being tested with local make preamplifier. The I-V characteristic of the MPPC, dark

Fig.1. The SiPM test setup facility at NPD, BARC.

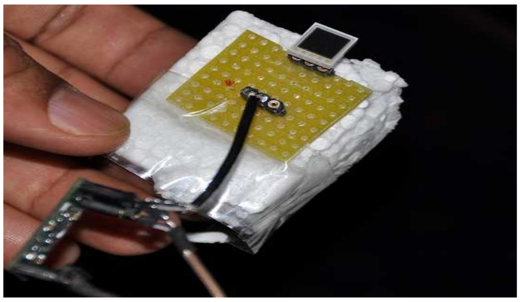

Fig.2. A Hamamatsu MPPC (2 x 2 array) connected to a pre-amplifier (make Photonique SA).

count and signal output are being studied. An alpha source is placed on top of the scintillator tile and the photons (blue light) generated in the scintillator tile are seen by the MPPC (Fig.3).

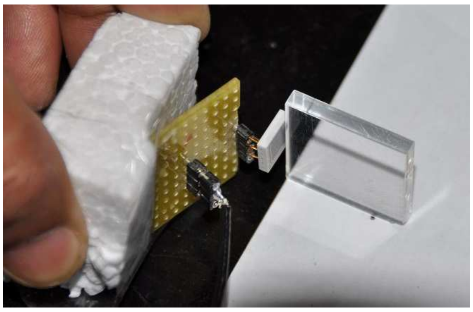

Fig.3. A setup showing the MPPC connected to a scintillator tile (Bicron make BC-408).

In an another configuration (Fig.4), a long piece of scintillator is coupled to several fibres (WLS fibre) with other end of the fibres is connected to a “cookie”. A typical SiPM output signal at bias voltage of 72 Volt ($V_{break\text{-}down}$ = 71 V) is shown in Fig.5.

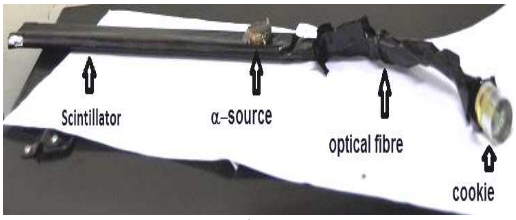

Fig.4. Another setup for SiPM test with green light.

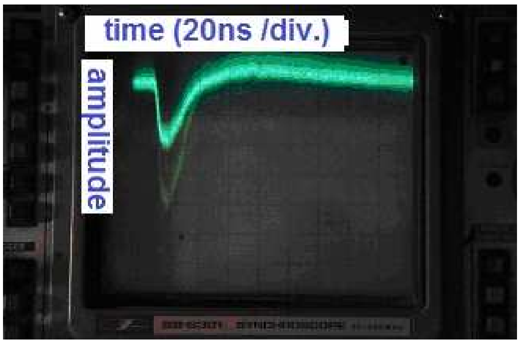

Fig.5. A typical MPPC signal (photograph taken from an oscilloscope).

This kind of detector with plastic scintillator combined with SiPM is supposed to give a fast time response (sub-nano second timing) - one of the main purpose of building this detector to provide a fast trigger for PANDA. A detailed test towards achieving this is in progress. Results will be presented.

Acknowledgments:

The R&D work on this scintillation tile detector is being done in close collaboration with the HAD-1 group at GSI. We thank the GSI team for this.

References

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