Simulations of SiPM based scintillation detector for PANDA

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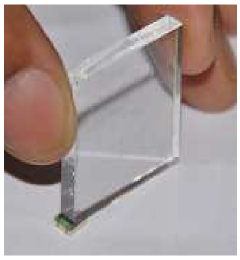
The Facility for Antiproton and Ion Research (FAIR) is a future project at GSI which will extend hadron physics studies up to the charm meson region using antiproton beams together with a state-of-the-art PANDA (acronym for antiProton ANnihilation at DArmstadt) detector. The physics aim, in a broader 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: (i) development of a SiPM based scintillation tile hodoscope for TOF information, (ii) development of a luminosity detector (silicon strip detector), and (iii) simulation studies of these detectors design as well as physics case studies. The present paper reports the initial simulation studies that have been started at Nuclear Physics Division (NPD), BARC, on the silicon photomultiplier(SiPM) based fast scintillation detector (SciTil). The hardware development activities on this SciTil detector, that are also going on in parallel at NPD, has been reported in an another contribution to this proceedings.

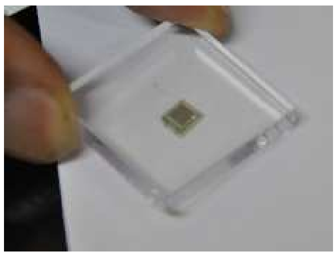
We have started simulation activities with a Monte Carlo simulation program SLitrani. SLitrani stands for LIght TRansmission in ANIosotropic media, with 'S' having the meaning of super. It is a general purpose Monte Carlo program that simulates light propagation in isotropic media (it can also be used for anisotropic media). It is basically built upon ROOT. Therefore, any geometry set-up that is supported by ROOT geometry TGeo can be used. The program SLitrani has been installed and made running at BARC. In order to learn and to start with, we have taken a macro file that was written by a summer student at GSI [2]. We have performed several trial runs and results were verified. We then modified the program to incorporate different geometry, source particle, energy etc. In parallel, we have taken an initiative to implement this new SciTil detector in the PANDAroot simulation framework so that simulations can be performed for this detector in actual geometry configuration along with the full PANDA detector.

A plastic scintillator (equivalent to Bicron BC-408) tile of dimension 3 x 3 x 0.5 cm^3 has been used. Silicon photomultiplier (also known as Geiger-APD) of size 3 x 3 mm^2 is glued to the scintillator tile. Simulations have been performed by placing the SiPM at different locations as shown in Fig.1. The initial aim is to find an optimum position of the SiPM that provides better light collection efficiency. Kaon beams of momentum 1 - 6 GeV/c (that are

Geometry 1



Geometry 2



Geometry 3

Fig.1. Three different geometries used in simulation. Geo-1) SiPM at centre, Geo-2) SiPM at one corner, Geo-3) SiPM at middle of the tile surface.

expected to be produced in pbar - p interaction in PANDA experiments) have been simulated and are passed through the tile. Photons, generated due to the interaction of kaons in the scintillator tile, reach to the SiPM either directly or through several reflections. The collection efficiency (**ε**) is then defined as the fraction of the total number of photons seen by the SiPM (N_{seen}) to the total number of photon produced $N_{generated}$

$$\varepsilon = N_{seen} / N_{generated}.$$

Our initial simulated results for the efficiency are tabulated in Table 1 for three different geometries and three energies of kaon beam. The efficiency also includes quantum efficiency of the SiPM (data for quantum efficiency vs. wavelength taken from Hamamatsu make MPPC). The simulations are also being carried out in different geometry as well as with proton and pion beams.

Table 1.

Kaon Momentum (GeV/c)	**ε** (%) (Geometry-1)	**ε** (%) (Geometry-2)	**ε (%)** (Geometry-3)
1.0	4.10	4.14	4.05
3.0	4.14	4.18	4.03
6.0	4.12	4.19	4.03

The one of the main drawback of G-APDs is that they are bit noisy (since it works in the Geiger mode), that limits the use of this device in a situation where single photon/few photons are expected to be counted. The present simulation shows that in all of these geometries, sufficient number of photons is expected to reach the SiPM. A threshold of few photons can then be applied electronically to make a significant reduction of noise/ dark count.

Such kind of photon detector coupled to plastic scintillator is expected to provide a very fast timing (sub-nano second timing): one of the main ideas behind incorporating this detector in PANDA to provide a fast trigger and additional TOF information. For this, timing analysis is being performed. Results will be discussed.

Acknowledgments:

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References

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