Preliminary simulation of silicon carbide detector

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1 Introduction

The thesis has been based on PRAGUE project, particularly it is focused on the simulation and experiments with prototypes of SiC detectors and further simulation of a new SiC assembled in the stack configuration. The main goal of the PRAGUE project is the design, realization and characterization of a real-time depth-dose distribution detector system based on thin SiC multilayers for conventional and laser-accelerated proton beam in the energy range between 30 MeV and 150 MeV [**?**].

2 Materials and methods

2.1 Detector

In accordance with the project objectives, 60 SiC detectors will be assembled in stack configuration. In order to fulfill the objective on simulation and optimization of the assembled detectors in stack configuration a preliminary simulation with just 3 SiC detectors has been performed to check beam dosimetric information along the beam axis. The project considers two different kinds of detectors and the features are presented in Table 1 and 2. The details of the first detector and its construction is shown in figure 1. The graphical representation is shown in figure 2.

N of layer	**Size,** mm^2	**Thickness,**μm	**Material**
1	9.5x9.5	0.1	Ni_2Si
2	9.5x9.5	0.2	SiC
3	9.9x9.9	10	SiC
4	10x10	350	SiC
5	10x10	10	Al

Table 1: Data on the Detector 1

The main difference between the two detectors is the presence of a PCB layer in the latter, represented as a slab of three layers: the material on the top

N of layer	Size, mm^2	Thickness,μm	Material
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3	9.9x9.9	10	SiC
4	10x10	350	SiC
5	10x10	10	Al
6	10x10	53.34	Co
7	10x10	1016	$FR4$
8	10x10	53.34	Co

Table 2: Data on the Detector 2

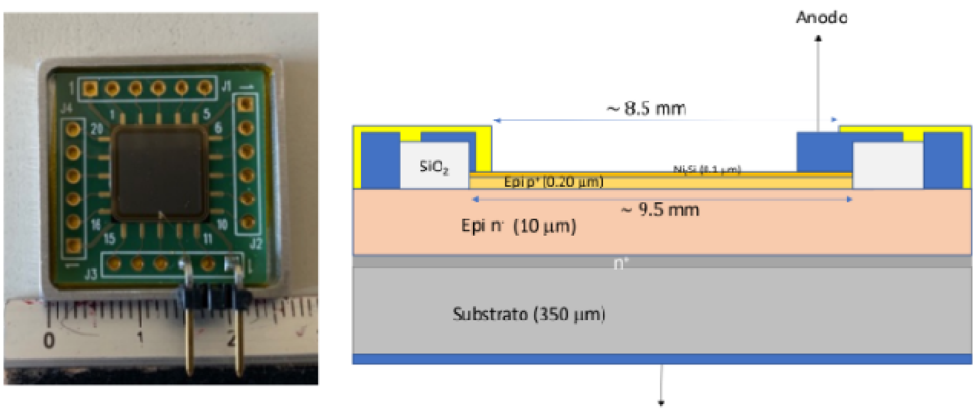

Figure 1: Design and materials

and bottom layers is copper with the thickness of 0.05334 mm while the middle layer is considered as FR4 material with the thickness of 1.016 mm (see in table 3).

Epoxy	Percent	GlassFiber	Percent	FR4	Percent
O	7.8	SiO_2	81.0	Epoxy	44.0
C	46.1	Na_2O	6.0	Glass	56.0
H	46.1	B_2P_3	13.0	Density	1.9 g/cm^3

Table 3: FR4 composition

2.2 Beam line

A preliminary experiment is designed based on the radiobiology beamline designed at the 18 MeV proton cyclotron facility at the National Centre of Accelerator (CNA, Seville, Spain). According to the description in Ref. [?], the initial beam was modelled as composed of protons with mean energy 18 MeV

(a) Detector of the first configuration

(b) Detector of the second configuration

Figure 2: Detectors in perspective view

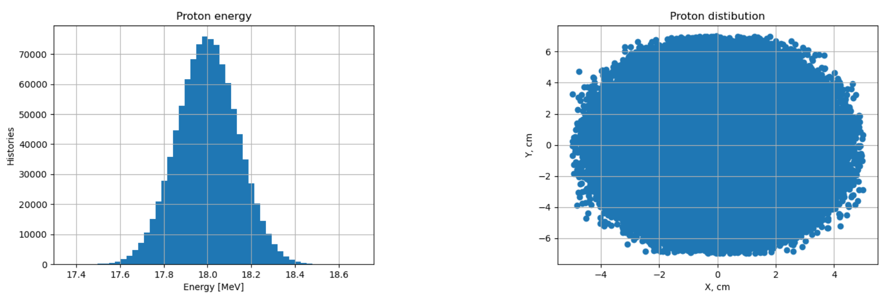

Figure 3: Space and energy distribution

and spread 0.14 MeV (σ), while the transverse profile was a 2D Gaussian elliptical having $\sigma_x = 12mm$ and $\sigma_y = 20mm$. To ensure correctness on part of the code TOPAS used for the simulations with respect to the beam generation, the phase space scorer module of the code was used to characterise the beam. After determining the energy distribution, the spatial distribution and emittance were determined with using of the data from phase-space scorer and it was confirmed that the code indeed reproduced the beam profile as desired (see in figure 3 and 4).

2.3 Simulation

Simulation of the detectors designed and assembled by INFN-LNS medical group has been performed using the TOPAS tool [**?**]. Preliminary results include the simulation of the detectors and the beamline. A physical quantity like energy deposited has been scored on the active layer (indicated as a yellow layer).

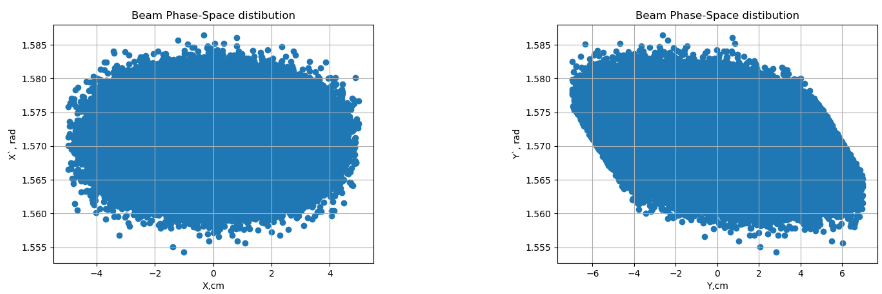

Figure 4: Phase Space distribution

3 Results

In order to define the placement for the detector the range of the proton beam has been simulated and the data have been used to create a matrix to depict it (see figure 5). As can be inferred from figure 5, the beam range is approximately 3.5 m (87 bins of 4 cm), which is corresponded with the result from SRIM tool.

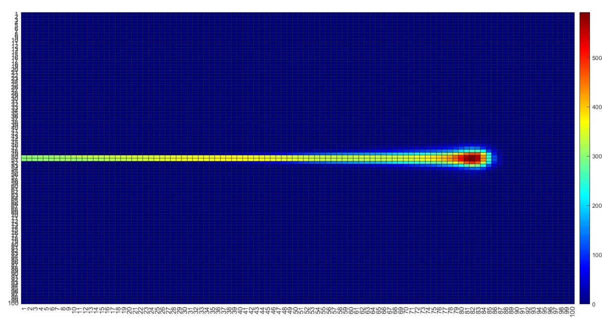

Figure 5: Energy deposition of the proton beam in Air phantom with 2x2x2 m parameters

For preliminary evaluation, the detectors have been placed at 1 cm distance from each other and the detector with the first configuration has been positioned followed by two detectors with the second configuration. The beam line is placed at the distance of 5 cm from the first detector (see in figure 6). As a result of the scoring of the active layer of the first, second, and third detector energy deposited are 35.7070 MeV, 40.3448 MeV, and 0.1429 MeV respectively. The view of the simulation is presented in figure 7.

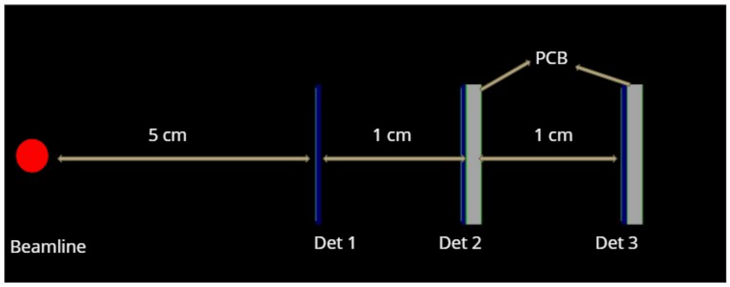

Figure 6: Simulation of detectors with the beam line

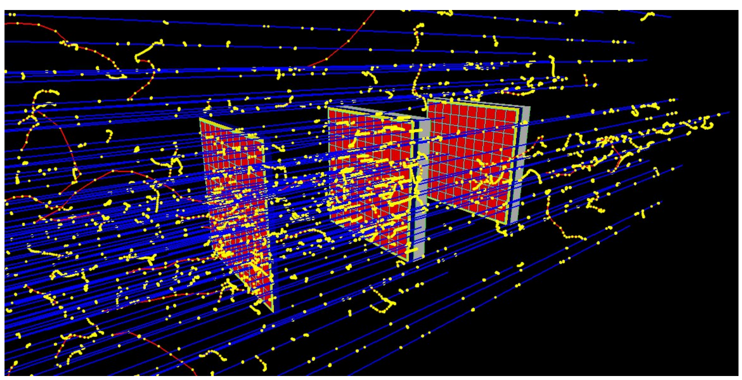

Figure 7: Simulation View

4 Conclusion/Next steps

For further simulation of the detector with the beam, it is necessary to obtain real parameters of the proton beam to compare with future experimental results. By now, it is clear that the collimator should be simulated as defined in the PRAGUE project to focus the beam along with the Z-axis. After accomplishment previous tasks, the simulation will be performed again and assess deposited energy in the active layer.