Simulation of performance of the beam position detector

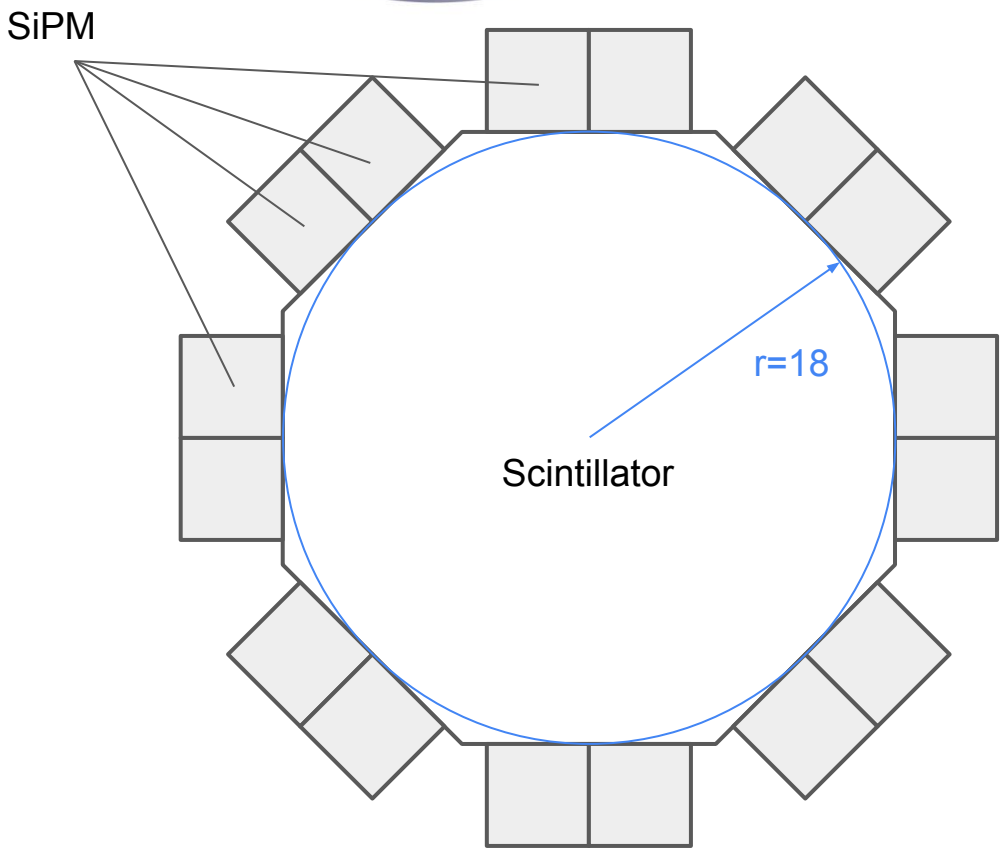
Zimin I.

Goals

- Create the Monte-Carlo model of the beam position detector (Geant4)
- Choose covering of the scintillator
- Create a reconstruction method

Introduction

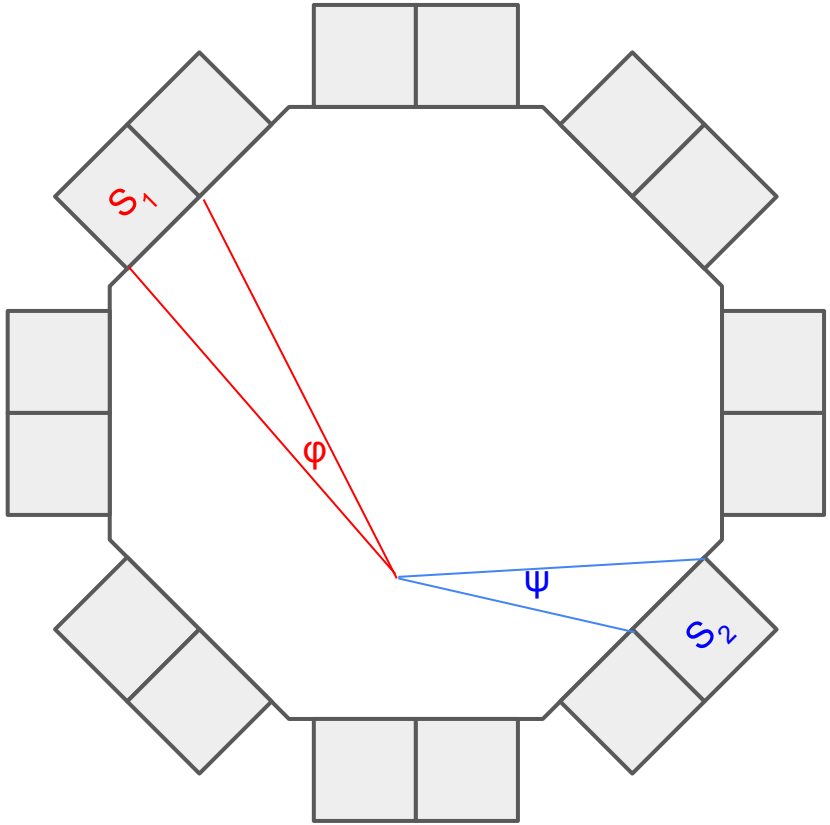
- Scintillator (polystyrene): r = 18 mm, h = 6 mm
- 16 SiPM - 6 * 6 mm
- Covering: paint white/black
- Purpose: find position of the beam



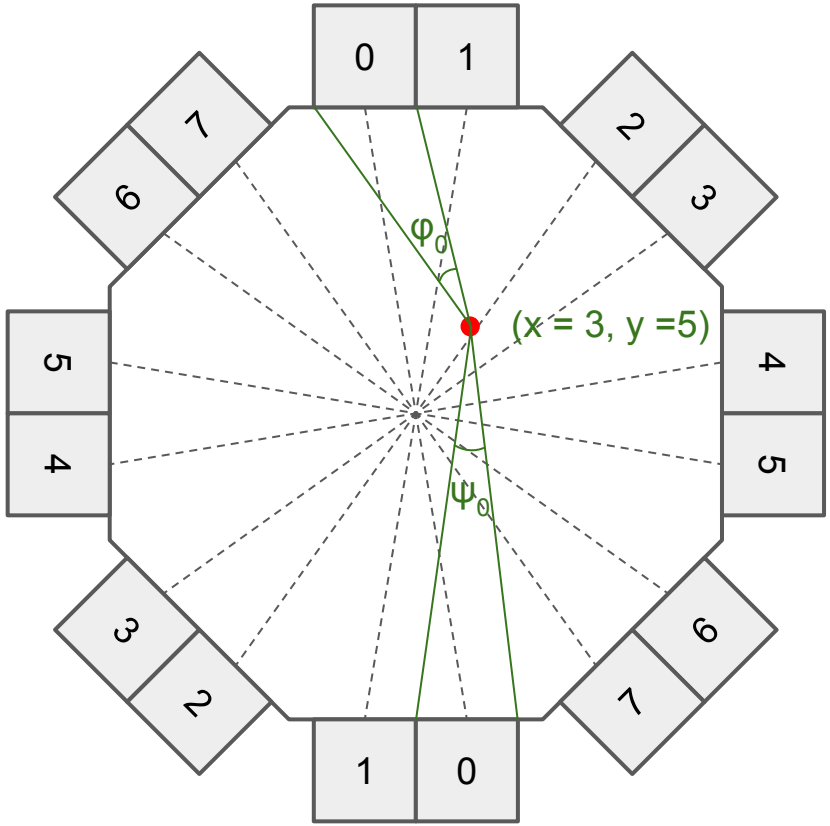
Theory

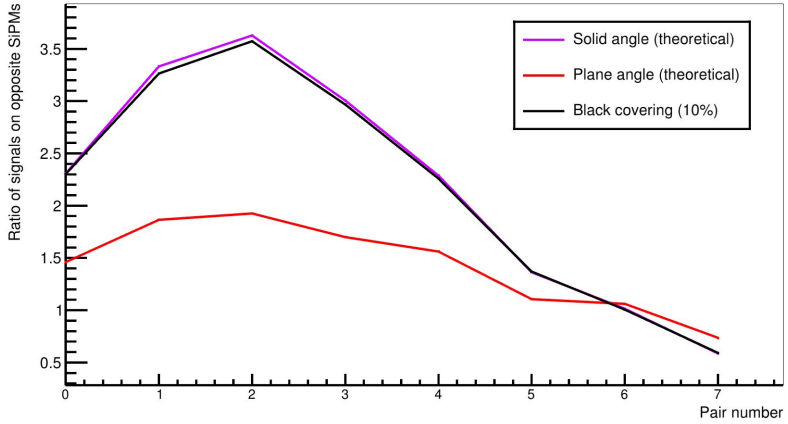
- The detected photon number depends on the ratio of distances between SiPM and the beam entrance point
- The ratio of signals on SiPMs is equal to the ratio of angles [1]

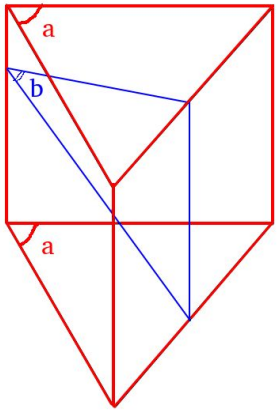
$$\frac{S_1}{S_2} = \frac{\phi}{\psi}$$



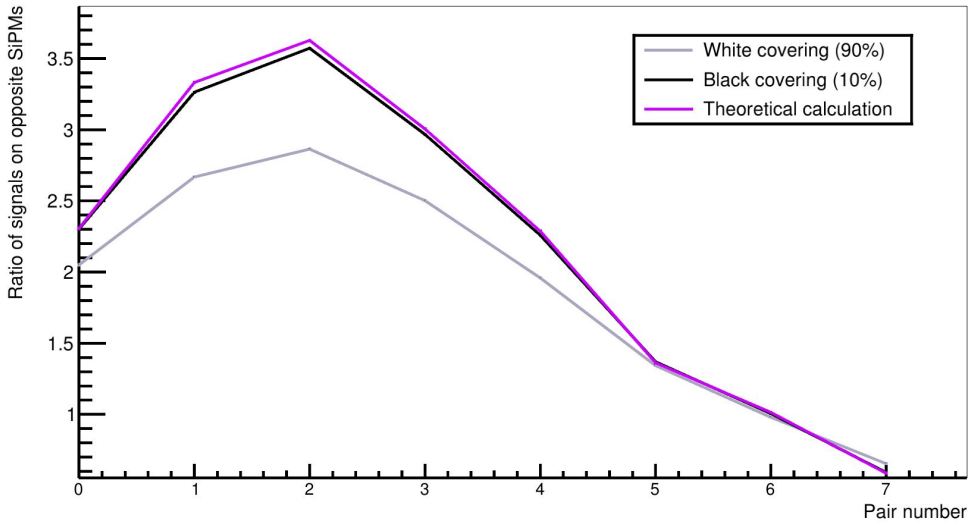
A plane angle vs a solid

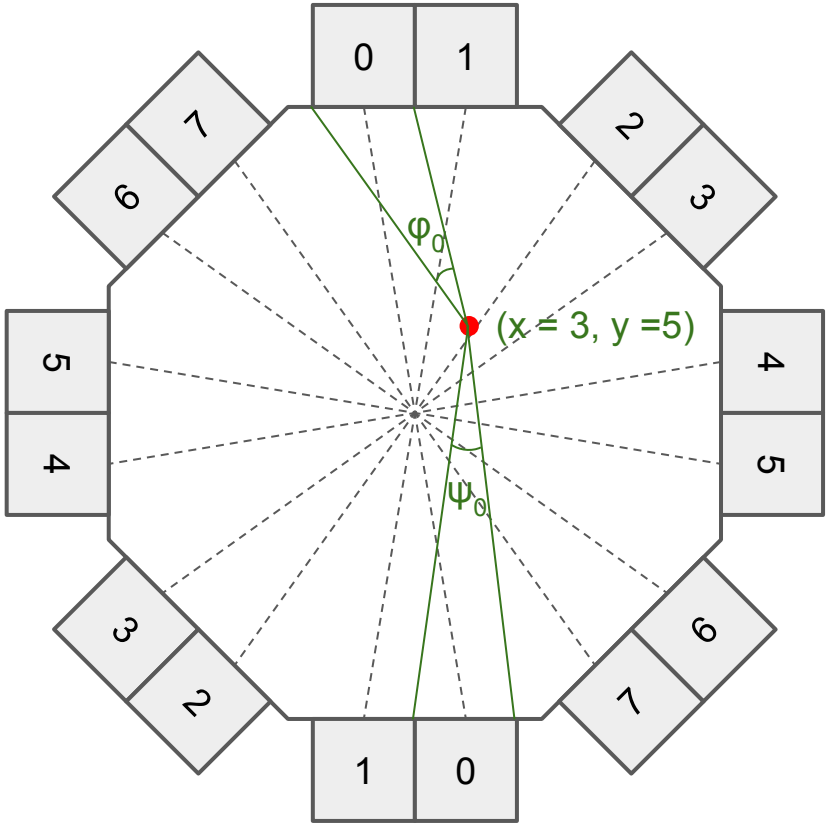






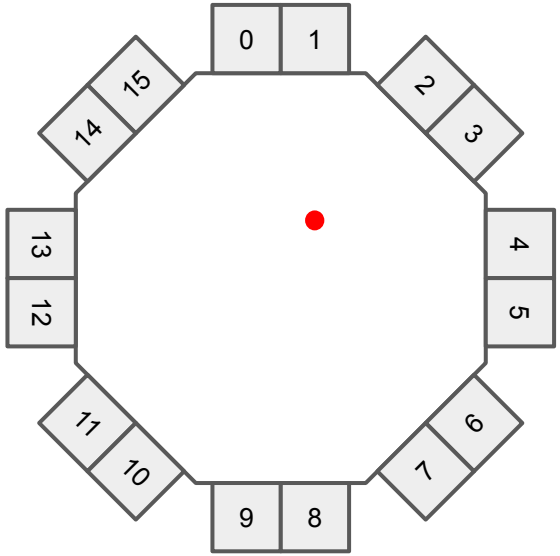
Covering of the scintillator

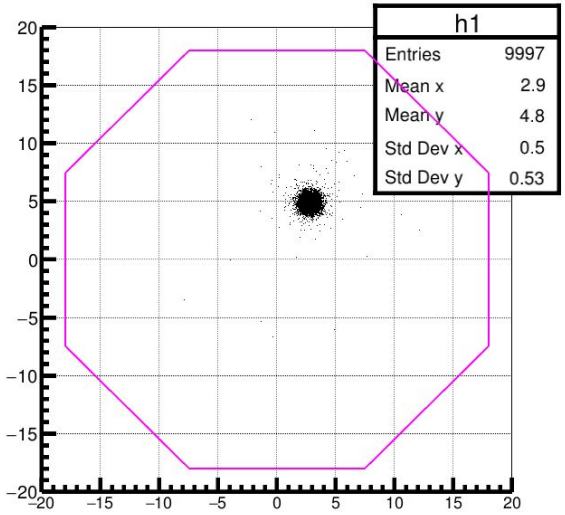




Reconstruction methods

1. By weight $x = \frac{x_0 s_0 + x_1 s_1 + \ldots + x_{15} s_{15}}{s_0 + s_1 + \ldots + s_{15}}$ $y = \frac{y_0 s_0 + y_1 s_1 + \ldots + y_{15} s_{15}}{s_0 + s_1 + \ldots + s_{15}}$





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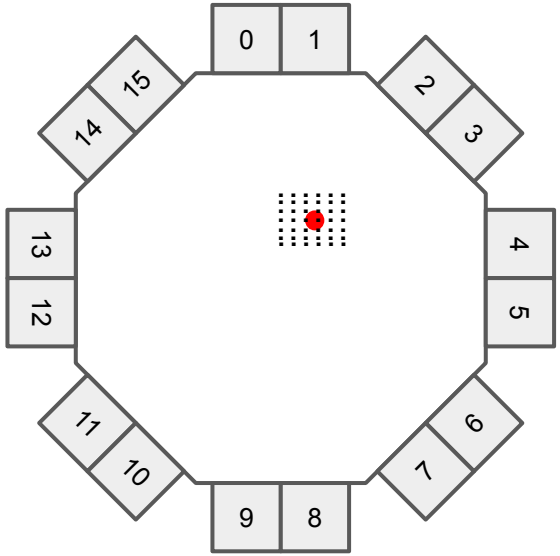
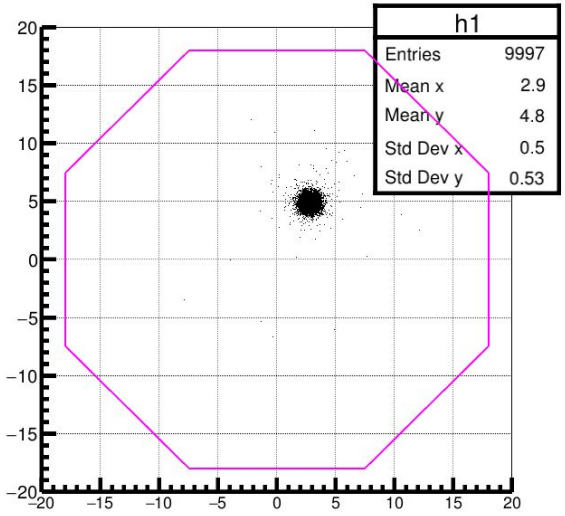
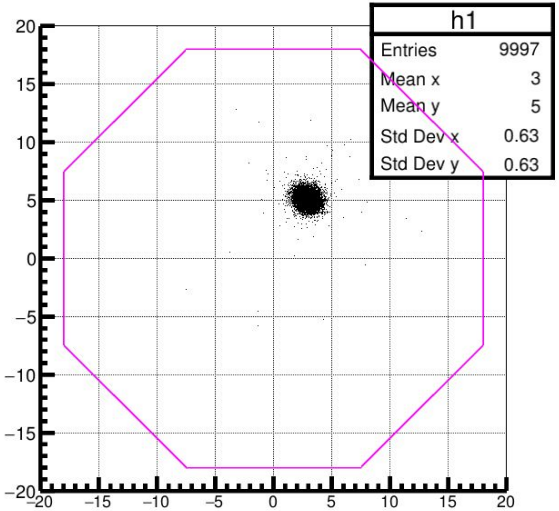
2. By weight + theoretical calculation by angles







Conclusions

- The Monte-Carlo model of the beam position detector was created. It shown that the black covering is better than white for this detector
- Two reconstruction methods was suggested and compared. The first one is not accurate for the periphery of the scintillator. But it works fast. The second one has good accuracy for any region of the scintillator. But it takes time for the execution.

Thank you for your attention!

Literature

1. P. Eckert, P. Achenbach, P. Drexler, P. Herrmann, P. Klag, W. Lauth, J. Pochodzalla, Octagonal-shaped scintillation counter as position detector for low-intensity electron beams, Nucl. Instrum. Methods Phys. Res. A 1041 (2022) 167357, https://doi.org/10.1016/j.nima.2022.167357