

Introduction

- The hit rate of the CEPC silicon tracking system, induced by beam background processes, will impact irradiation, data rates, and the design of the detector.
- The study of hit rate can also help develop methods to decrease the hit rate resulting from beam induced background.
- Pair production background represents the most important detector background at CEPC, as induced particles position is near IP and difficult to be shielded.

Pair Production

- Pair production^[1]: electron-positron pairs are produced via the interaction of beamstrahlung photons with the strong electromagnetic fields of the colliding bunches.
- Electrons and positrons of pair production are generated near IP, with low generated momentum ($\sim 0.12\text{GeV}$) and close to beampipe ($\cos(\theta)\sim 0.99$).

CEPC Silicon Tracker

- CEPC silicon tracker consists of Inner Tracker Barrels (ITK-Bs), Inner Tracker Endcaps (ITK-Es), Outer Tracker Barrel (OTK-B), and Outer Tracker Endcaps (OTK-Es), as shown in Fig.1. The detailed positions of the detector layout are tabulated in Table.1.

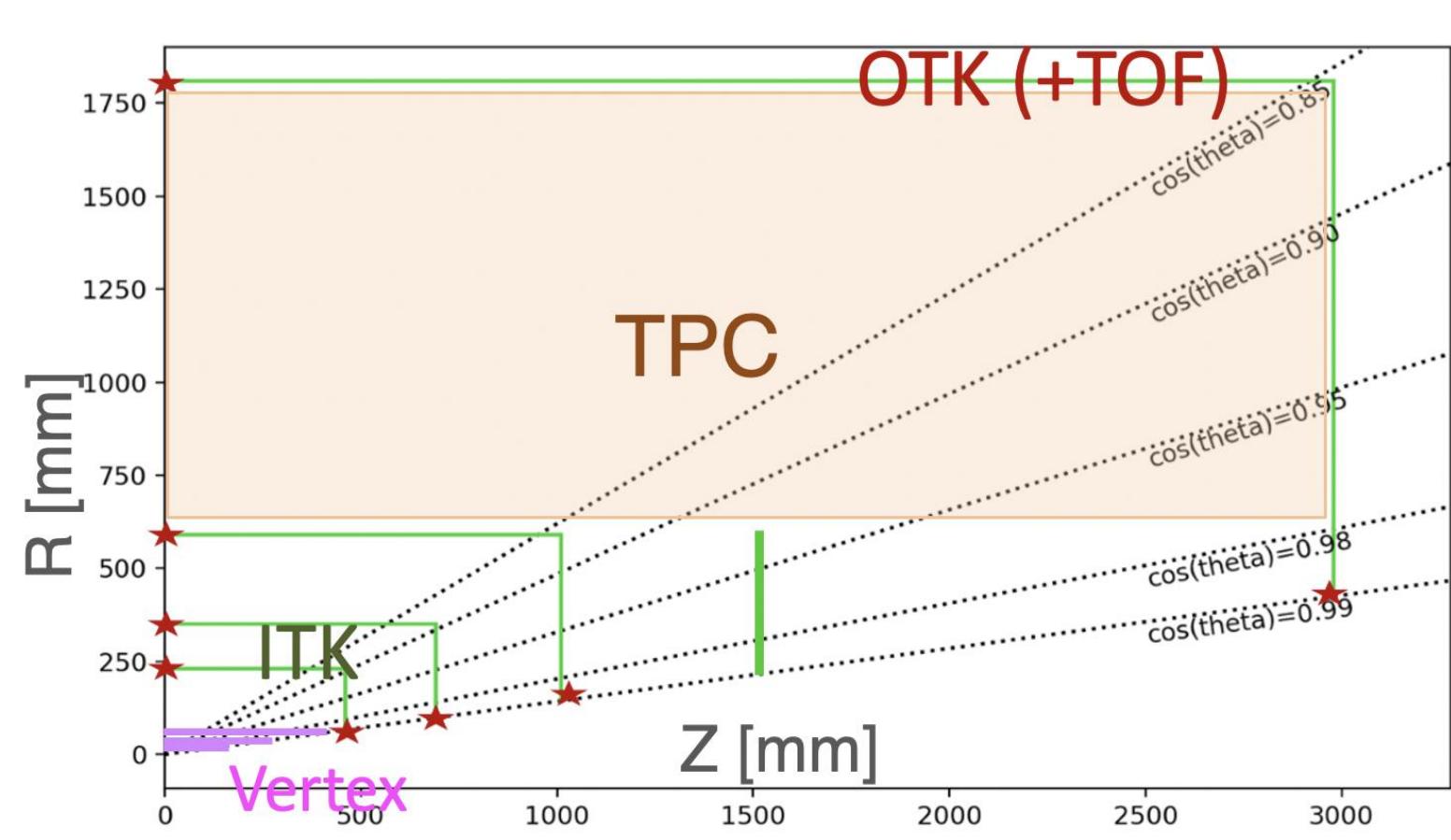


Fig.1 The layout of CEPC tracker system

Endcap	Z [mm]	R_{in} [mm]	R_{out} [mm]
ITK-E1	500.5	75	240
ITK-E2	715	101.9	350
ITK-E3	1001	142.6	600
ITK-E4	1500	213.7	600
OTK-E	2903	406	1810

Barrel	R [mm]	Half Z [mm]
ITK-B1	240	500.5
ITK-B2	350	715
ITK-B3	600	1001
OTK-B	1800	2000

Table.1 The position of CEPC silicon tracker

Introduction to CEPCSW

- The silicon tracker background evaluation is based on CEPC offline software, CEPCSW^[2], developed based on Geant4 and edm4hep, within the Gaudi framework.
- CEPCSW incorporates precise description of detector geometry, comprehensive simulation of physics processes, detector digitization, and reconstruction.

Silicon Tracker Hit Rate

- The pair production generator is provided by MDI group. The detector hit rate is defined as the number of particle hits per area per second. The estimated results of maximum and average hit rates for individual silicon tracker detector are shown in Fig.2.

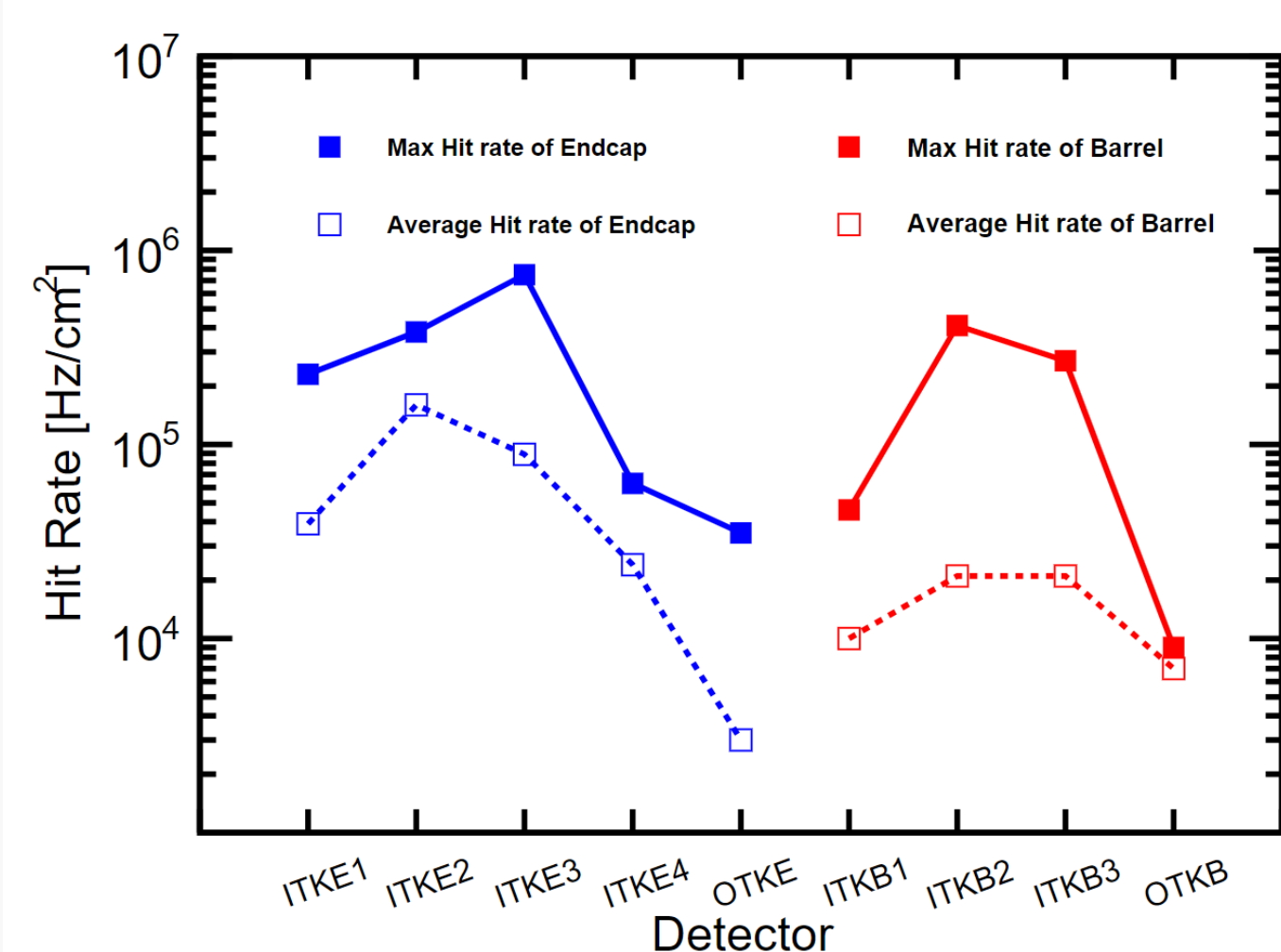


Fig.2 The hit rates for individual silicon tracker detector

- As shown in Fig.2, for ITK, the highest max hit rate region is the 3rd layer of endcap (ITK-E3), while the highest average hit rate is the 2nd layer of endcap (ITK-E2).
- The detailed investigation of maximum hit rates appeared on ITK-E3 induced by beam background will be elaborated in the next section.

ITKE3 Hit Map

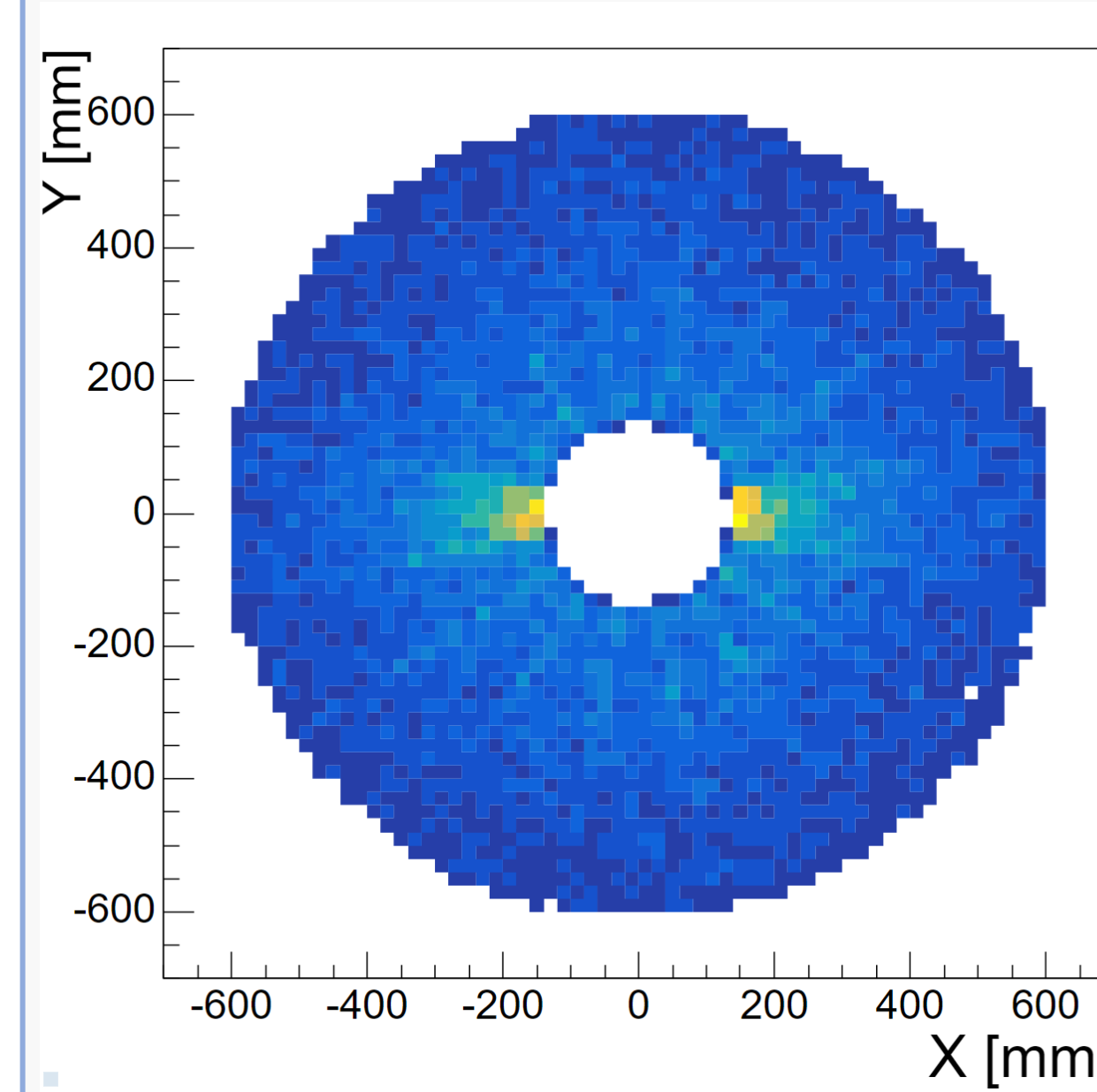
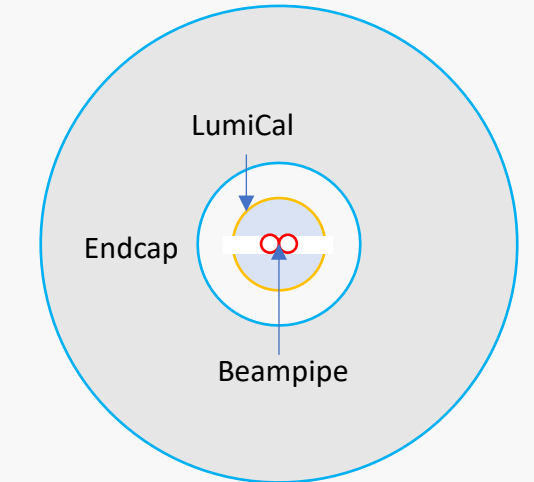


Fig.3 The Hit map of ITK-E3

- As shown in Fig.3, the highest hit region in ITK-E3 near $\phi=0$ and $\phi=\pi$ is caused by the gap structure of LumiCal at $z\sim 1000\text{mm}$.



- This results shows that **material distribution close to beampipe has great impact on hit map.**

Impact from beampipe

- The magnet in the beampipe leads to the increase of the material budget and the interaction background particles, as shown in Fig.4.

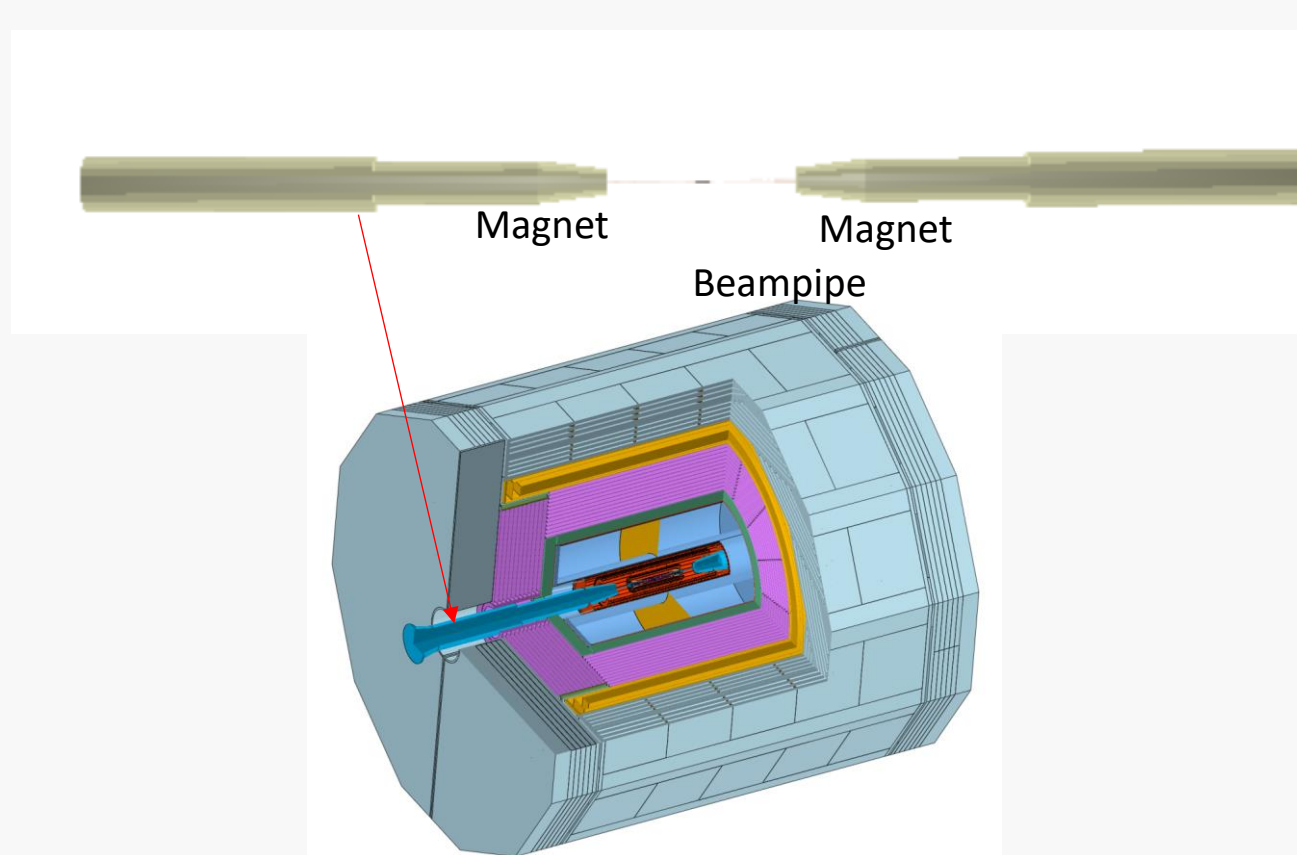


Fig.4 The magnet in CEPC

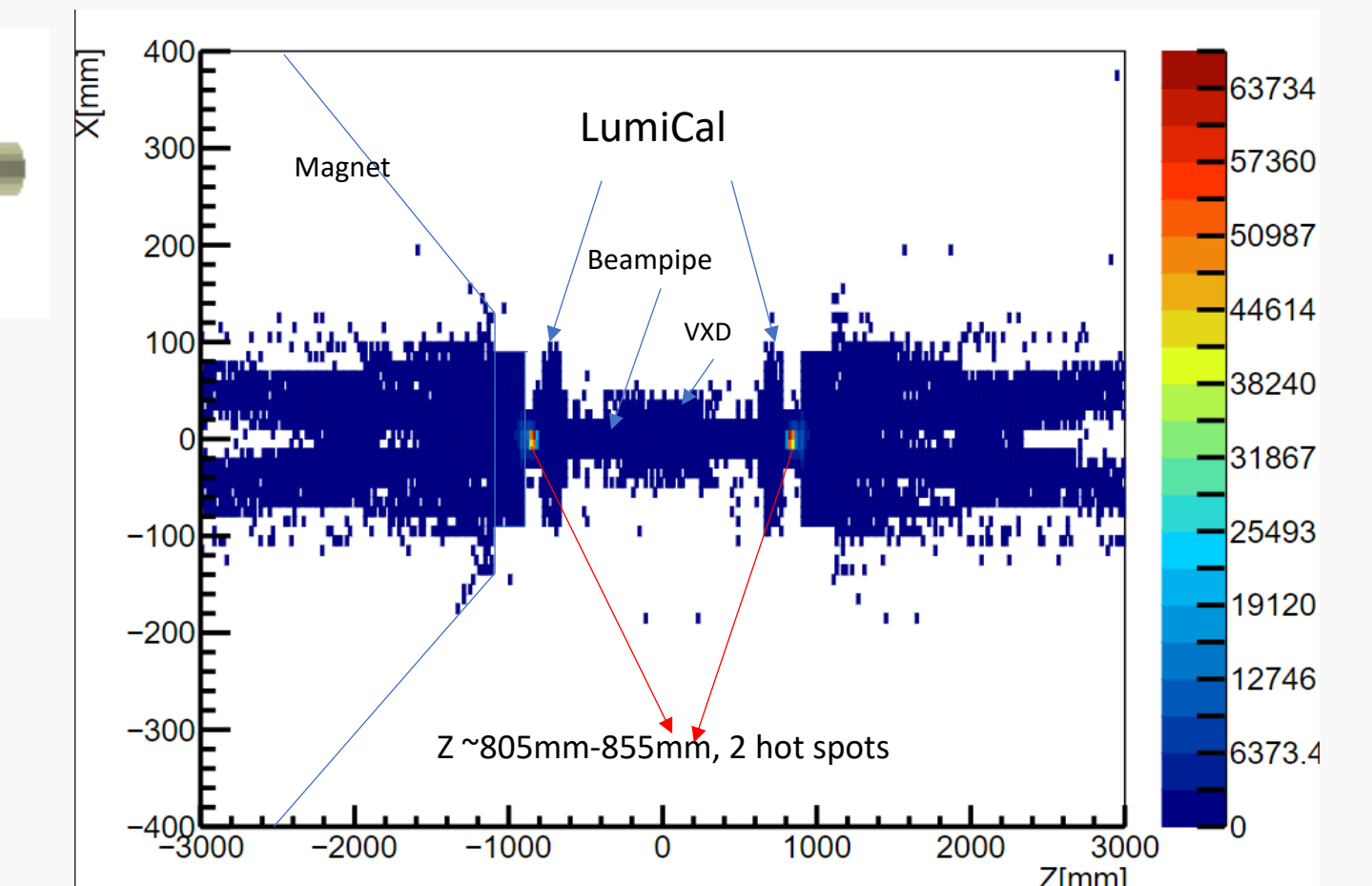


Fig.5 The interaction position of primary particle

- The interaction of background particles mainly occur between 805mm and 855mm in z axis, as shown in Fig.5.
- After interaction, the background particles might be absorbed, or create more tracks and secondary particles.

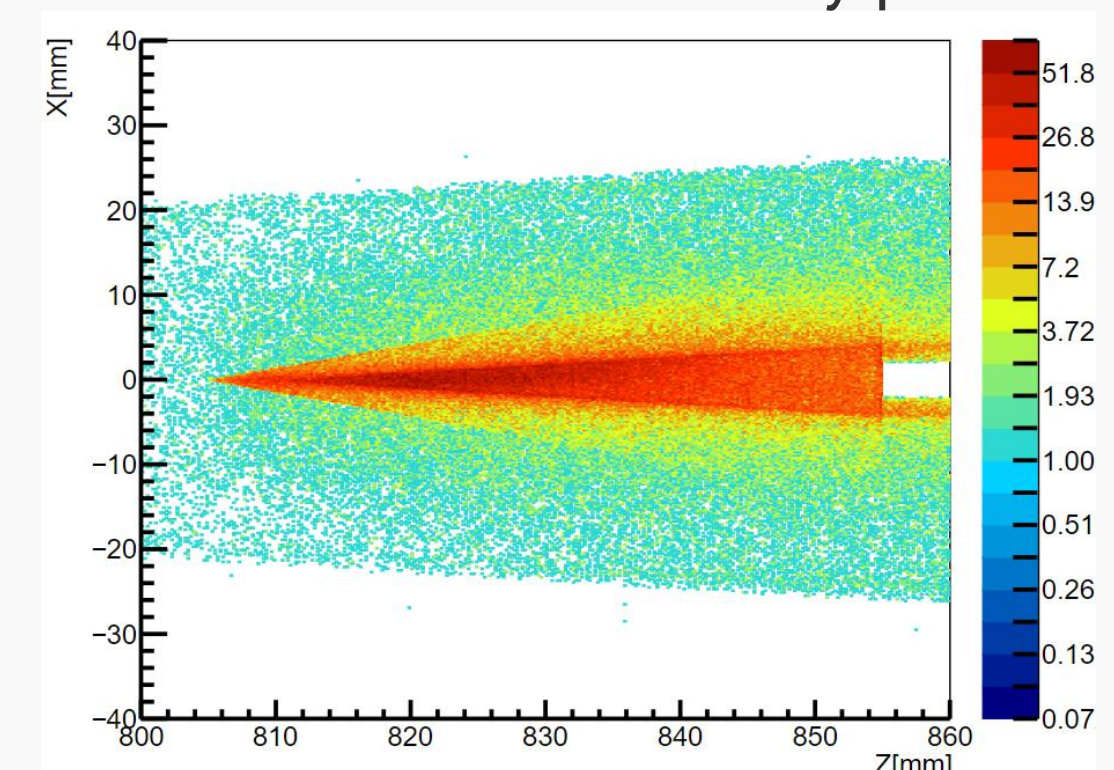
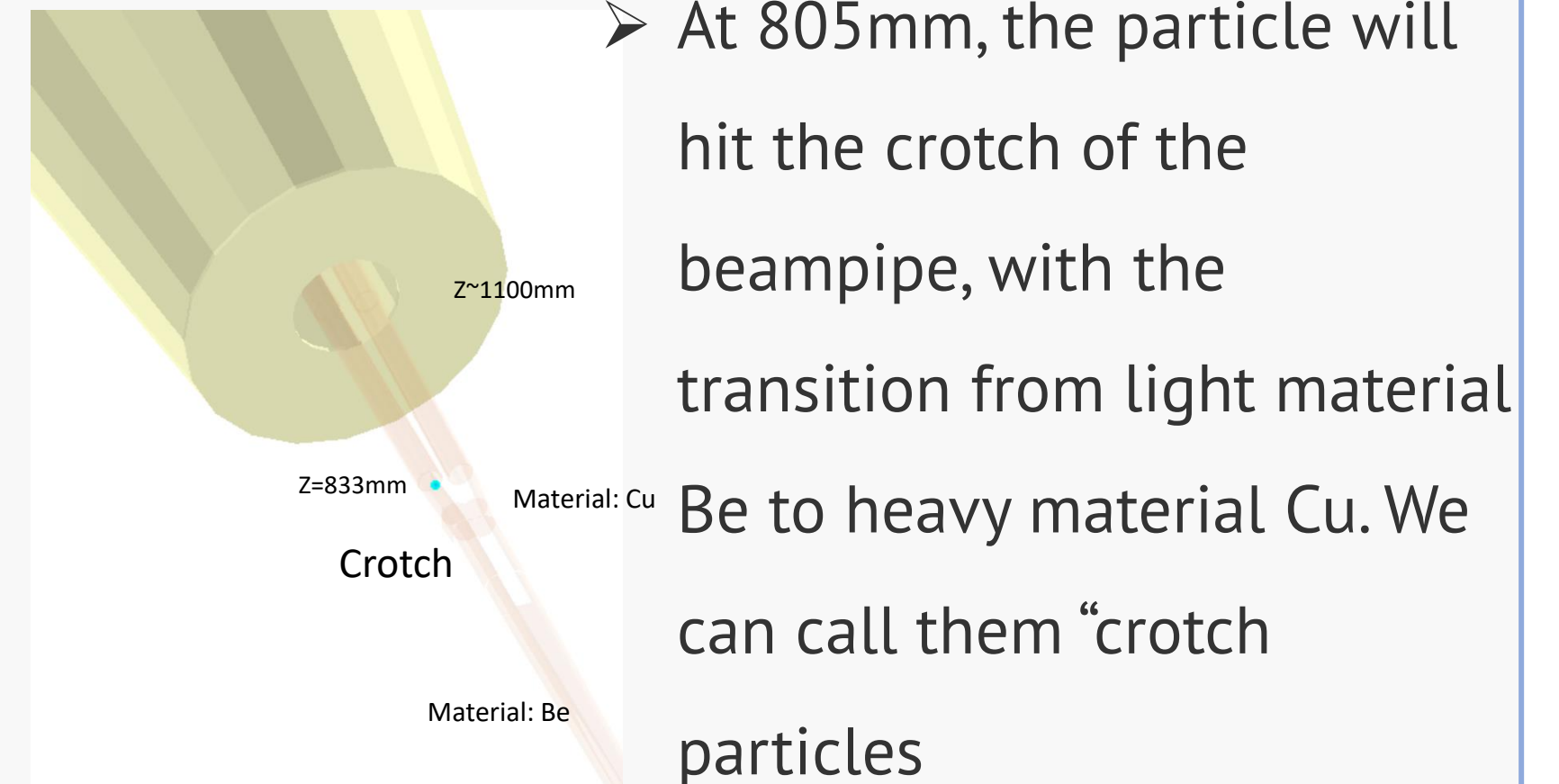


Fig.6 most particles end in crotch region



- At 805mm, the particle will hit the crotch of the beampipe, with the transition from light material Be to heavy material Cu. We can call them "crotch particles"

- Since ITK-E3 is at $z\sim 1000\text{mm}$ close to the beampipe, the secondary particles generated between 805mm and 855mm are more likely to hit ITK-E3.

Hit by beampipe crotch particles

	Z [mm]	Average hit rate [10^4 Hz/cm^2]		Crotch Particle Fraction [%]
		All particles	No Crotch particles	
ITKE1	500.5	3.9	3.1	20.5
ITKE2	715	16	12	25.0
ITKE3	1001	8.9	6.6	25.8
ITKE4	1500	2.4	1.8	25.0
OTKE	2903	0.30	0.23	23.3

- The particles that interacts in crotch region (only about 50mm length) bring about 25% of the hit on the sensors in the detector region, as shown in Table.
- Optimization of shielding to reduce the beam background will be performed in future study.

Summary

- The max hit rate and average hit rate study for the CEPC silicon tracking system, induced by beam background processes has been studied.
- The crotch of the beampipe with heavier materials, introduces more particle interaction.
- The particles that interact in crotch region bring about 25% more hits, mainly on ITKE3, which can be reduced by shielding optimization in future.

Reference

- [1] Dong, M., et al.: CEPC Conceptual Design Report: Volume 2 - Physics & Detector (2018) arXiv:1811.10545 [hep-ex]
[2] CEPCSW, <https://code.ihep.ac.cn/cepc/CEPCSW>