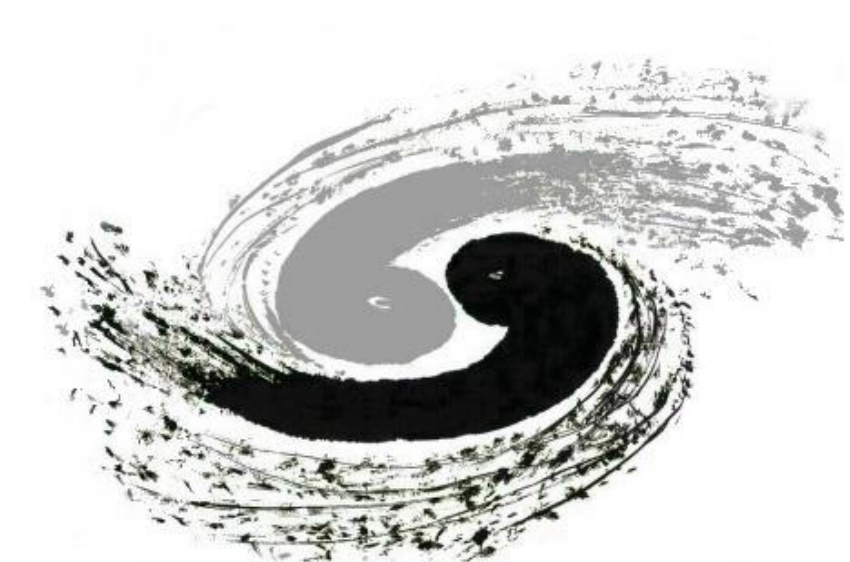


Geometry implementation of CEPC Tracker in CEPCSW and full simulation validation



Xiaojie Jiang (姜啸捷)
on behalf of the CEPC ITK working group

Contact:
jiangxj@ihep.ac.cn

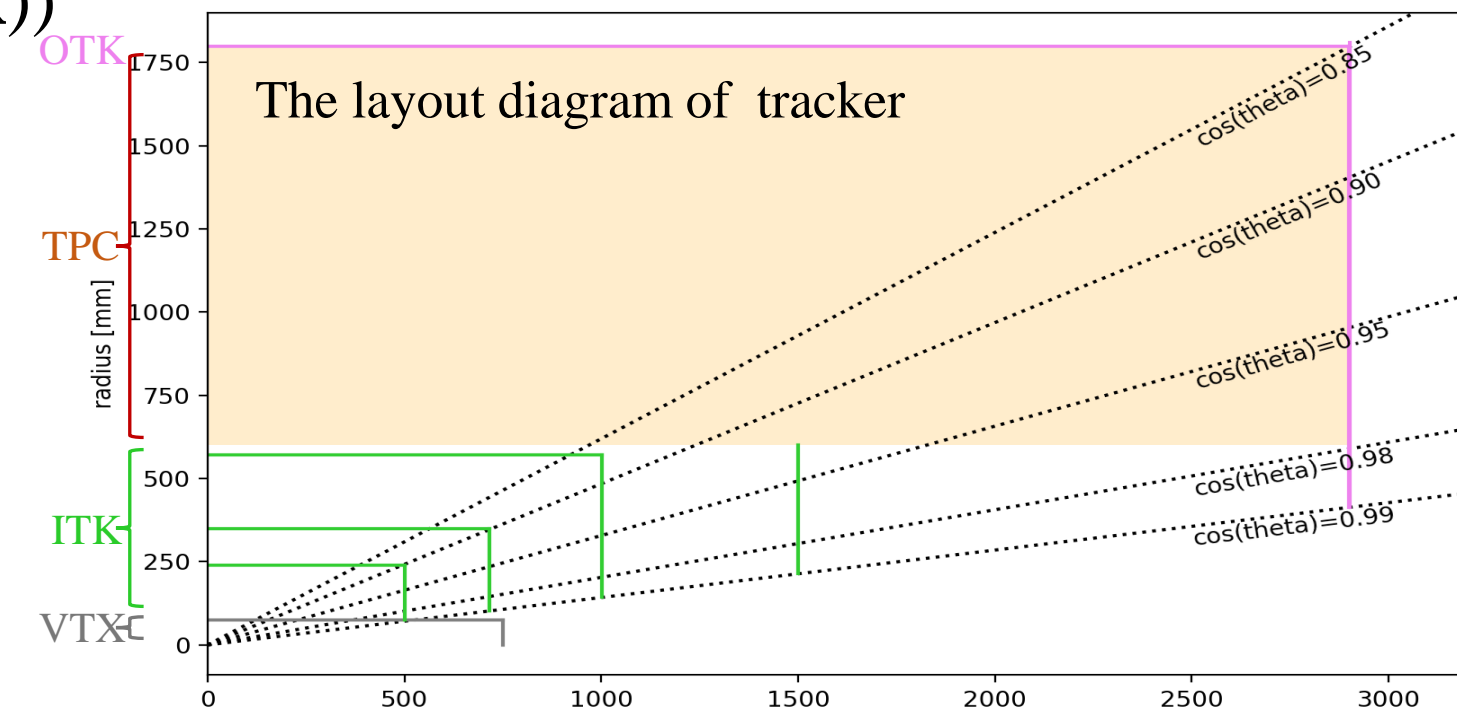
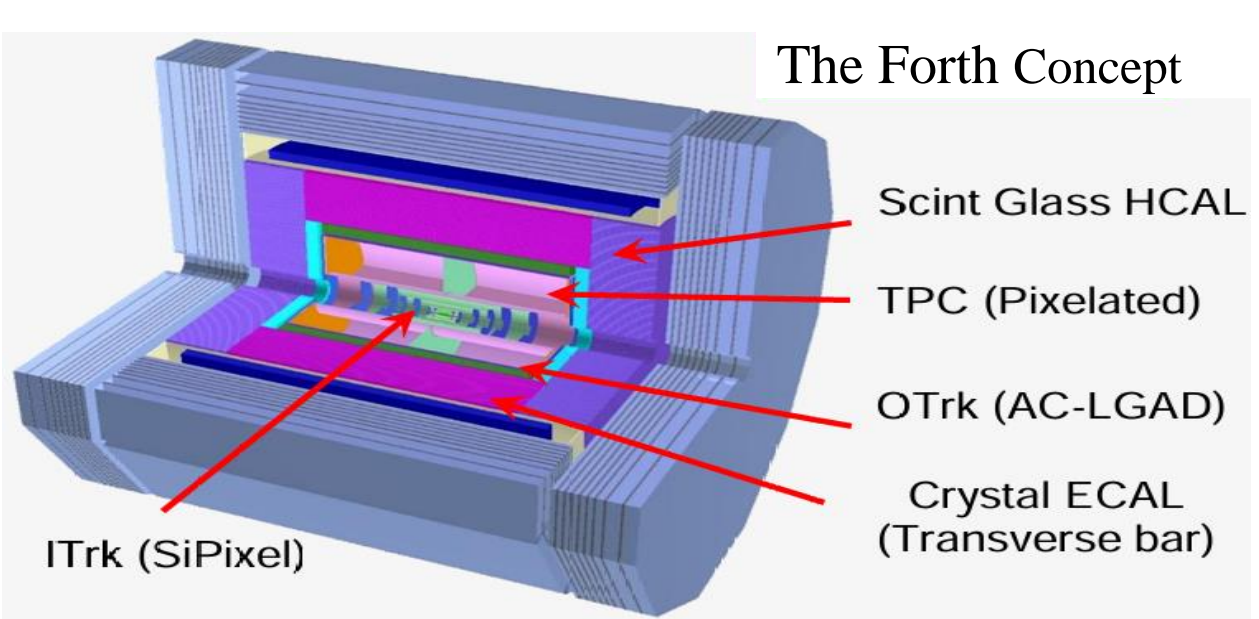
Institute of High Energy Physics,
Chinese Academy of Sciences

1. Abstract

The tracking system of CEPC plays an important role in **tracks reconstruction** and **PID**. The ITK working group reports a preliminary layout design of CEPC tracker based on the 4th CEPC conceptual detector. To verify its reliability and performance, it's necessary and urgent to study the momentum resolution and the PID capability of the tracker system using full simulation implemented in the CEPCSW framework. Meanwhile, a kind of staggered staves geometry of ITK Barrel (ITKB) was created in CEPCSW by DD4hep to better serve the simulation.

2. Introduction

The tracking system of the fourth conceptual detector at CEPC consists of a silicon pixel vertex detector, a silicon tracker of HV-CMOS and LGAD, and a time projection chamber (This poster focus on **inner tracker (ITK)**)



ITK working group layout, compare with the initial

- ❑ The third layer of ITK Barrel **closer** to TPC
- ❑ The ITK Endcaps **cover more area**
- ❑ **Finer** resolution of silicon sensor

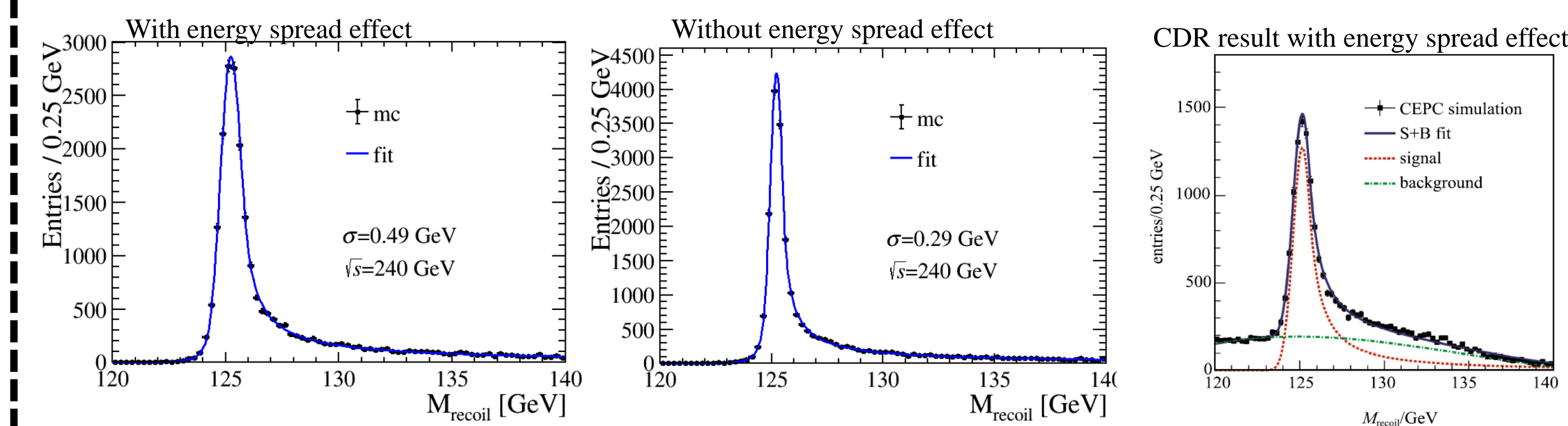
Tool: ILCSOft tracking MarlinTrk (full simulation), maintained, implemented in CEPCSW

4. Recoiled Higgs reconstruction

A validation of physics performance

- ❑ Physics progress: $e^+e^- \rightarrow ZH (\mu\mu\gamma\gamma)$ with $\sqrt{s} = 240$ GeV
- ❑ 30k events applied selection: $nTrks == 2$
- ❑ Take the **energy spread** into considering, $\sigma = 0.17\%$ provided by accelerator TDR
 - Assume the beam energy is 120 GeV (same for e^+ and e^-), use the toyMC to sample with gauss shape

Preliminary results

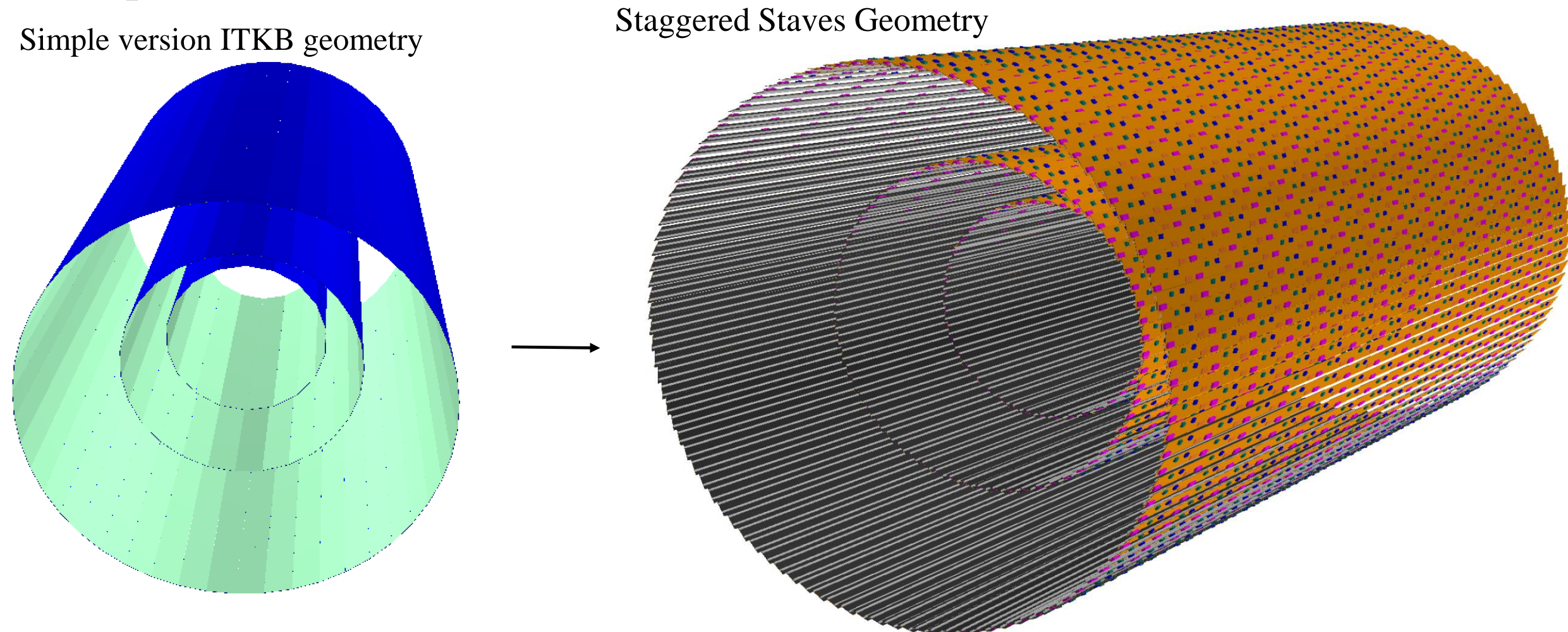


- ❑ The Higgs mass resolution: **0.39%** and **0.23%**
- ❑ The right tail caused by energy loss & beamstrahlung
- ❑ Has a **similar shape** with the previous CDR result

6. Staggered Staves Geometry Construction for CEPCSW

Geometry of ITK Barrel

- ❑ Need a finer geometry to get more precise simulation results
- ❑ Based on the HVCOMS pixel design of ITKB, recreate with DD4hep

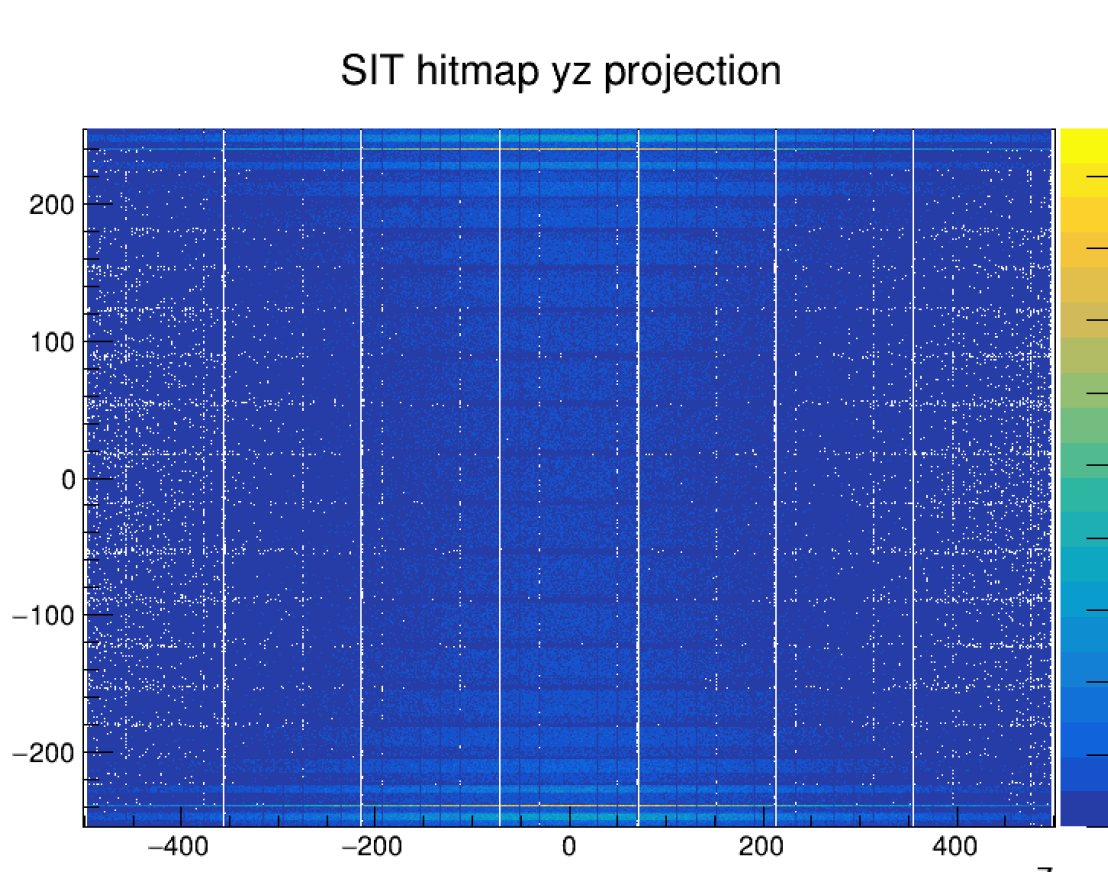
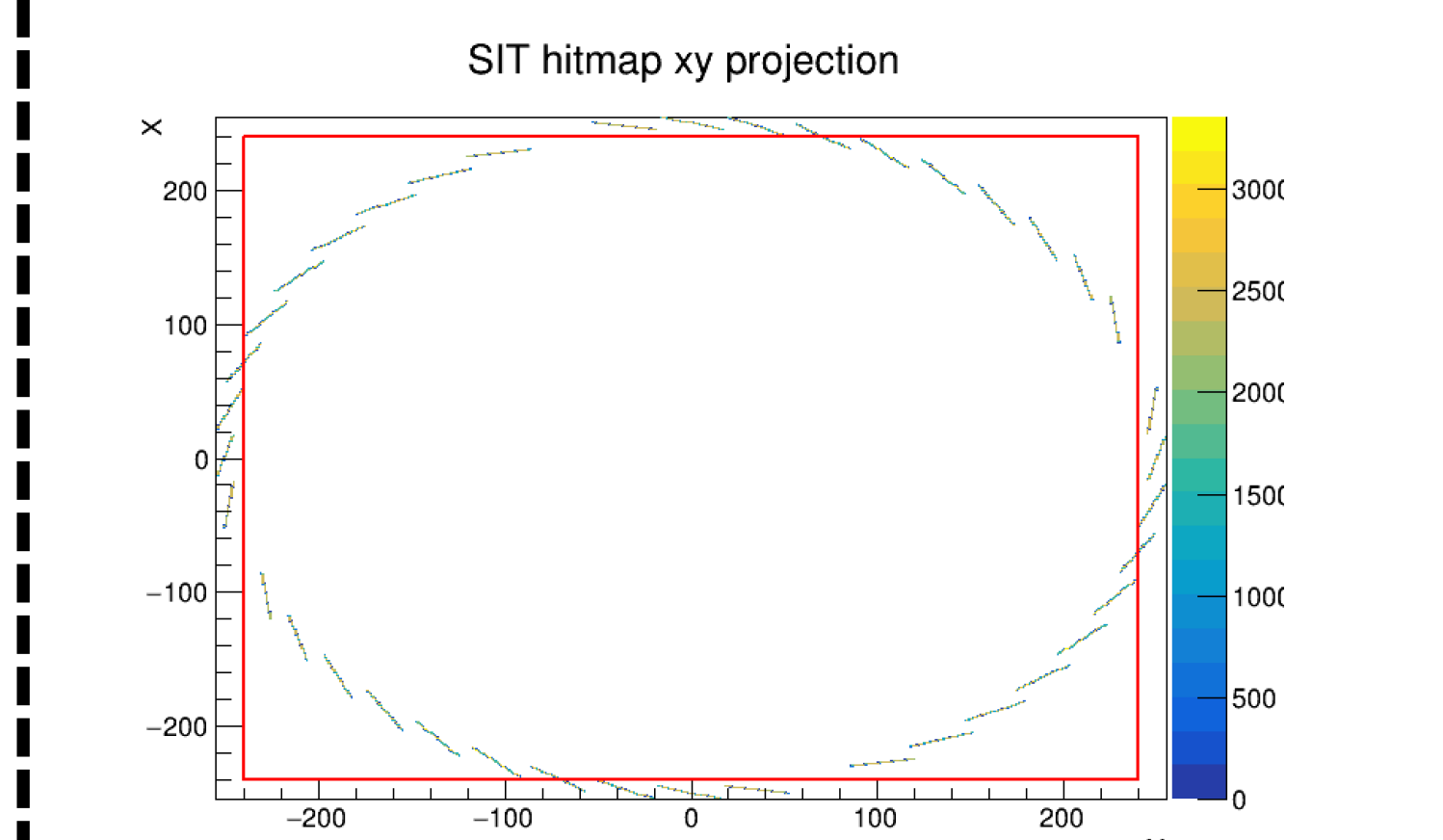
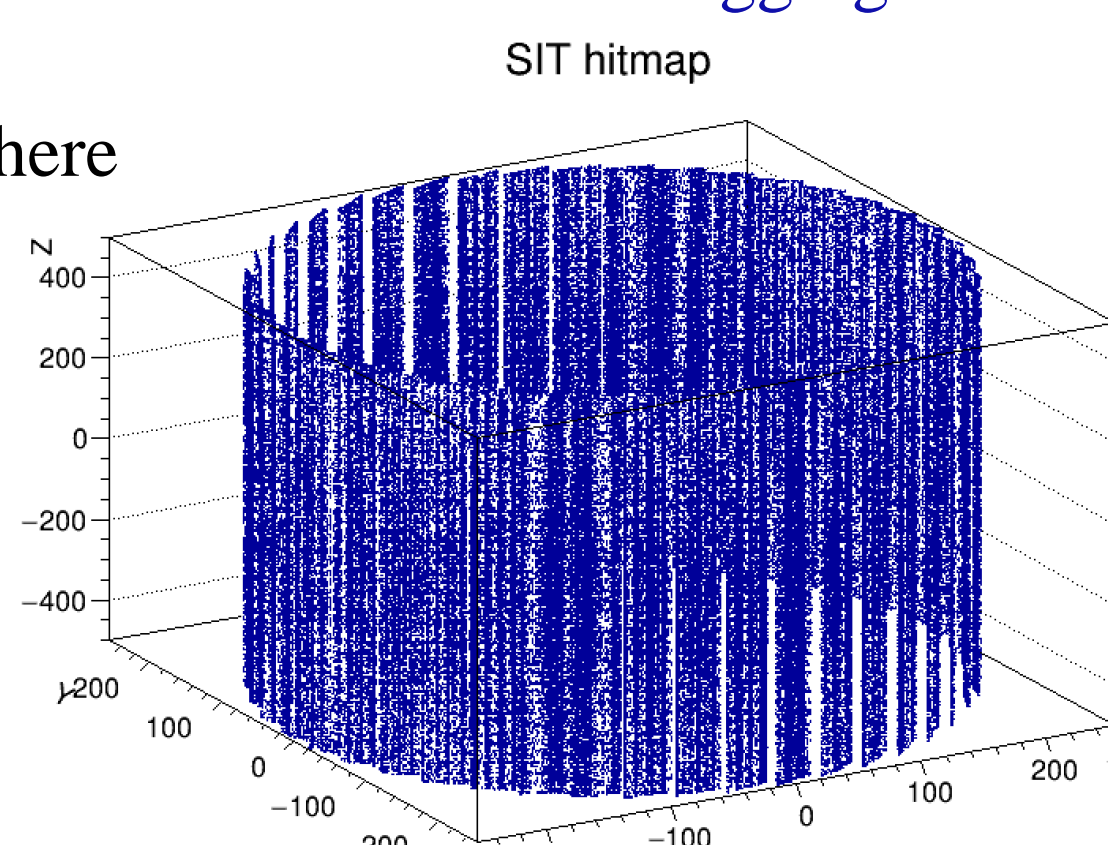


3 layers structure

- ❑ With slices: Support + Ti tube + Flex + DCDC + Data link + Data aggregation + **Optical connector**
- ❑ The sensor is under the flex but not visible here

A very preliminary hitmap study

- ❑ Using ~4M muon events only in 50GeV
- ❑ Only hitmap of 1st layer showed here
- ❑ Set offset for every stave to avoid overlap
- ❑ The white lines in yz projection are gaps between silicon modules



3. ITK momentum resolution

Setting

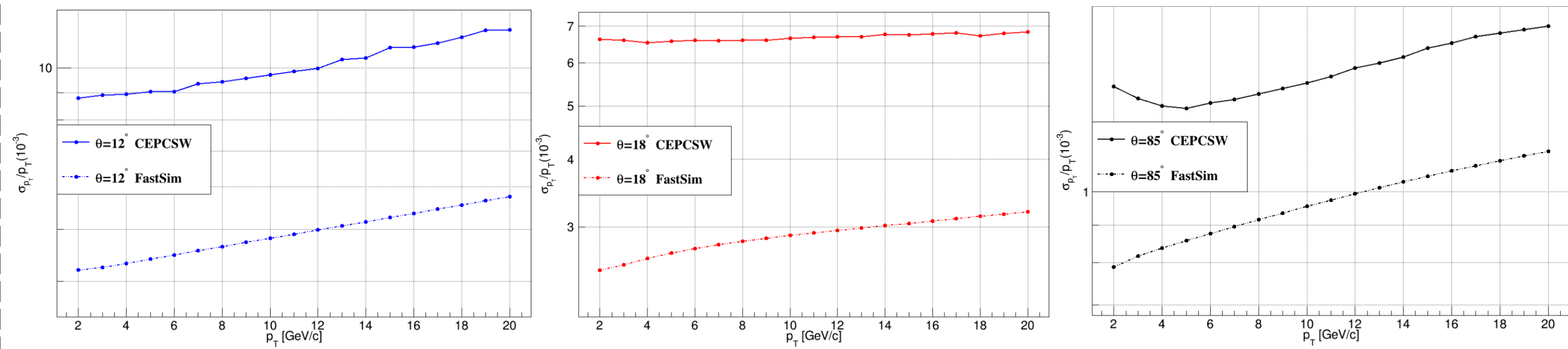
- ❑ Momentum resolution studied using muon events in range [2,20] GeV, for each momentum point 30k events are generated

Three geometrical regions are studied separated

Theta = 12°, Only-ITKE

Theta = 18°, ITKE + part TPC

Theta = 85°, ITKB + TPC



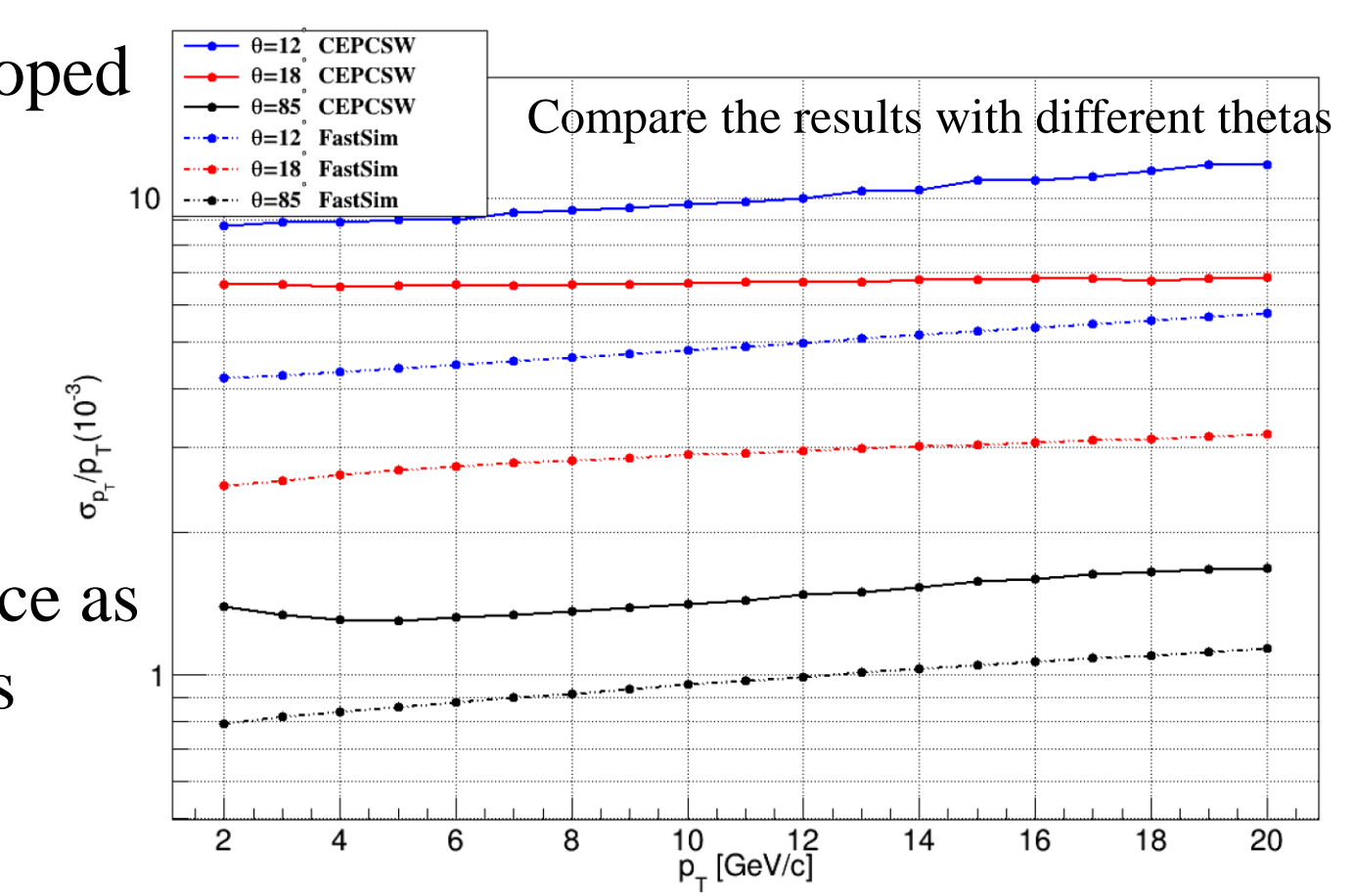
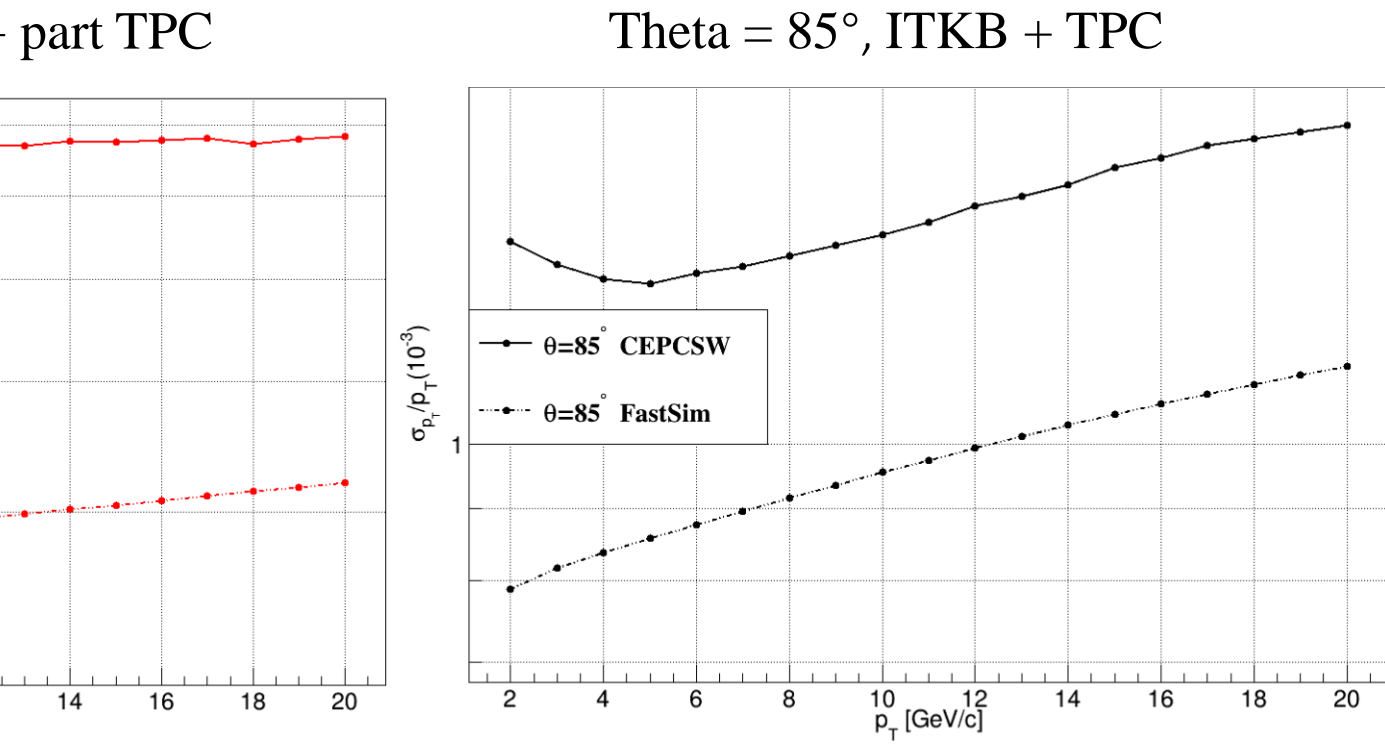
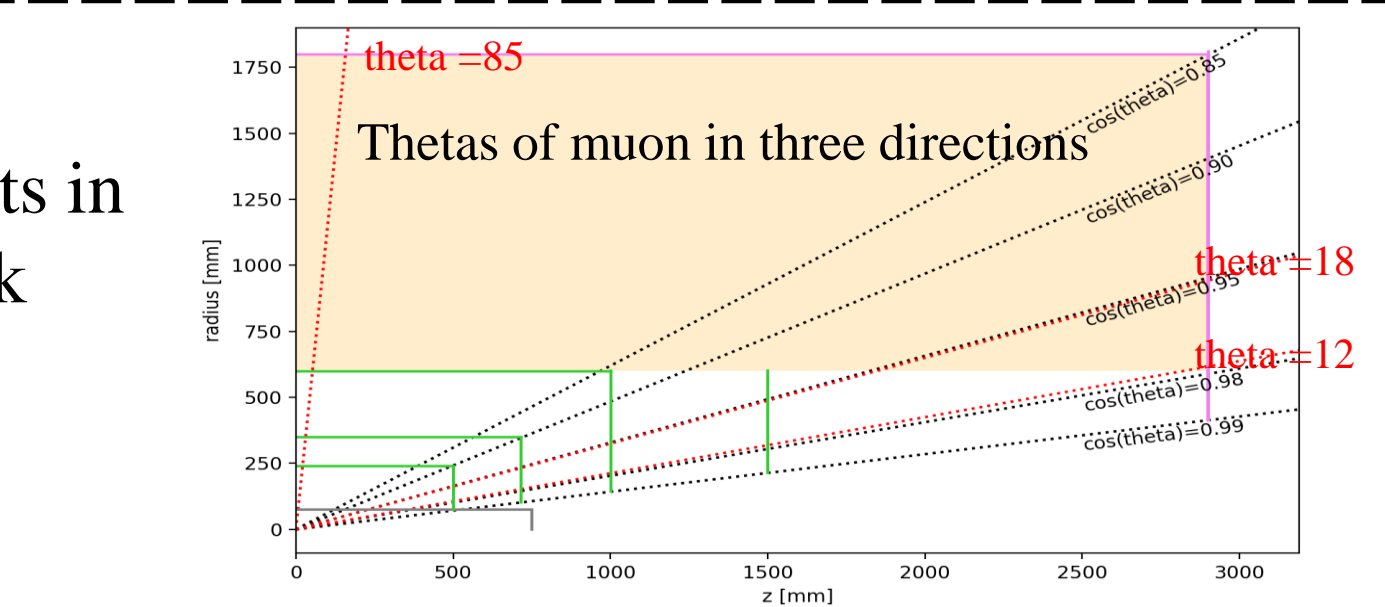
- ❑ FastSim : a matlab fast simulation package developed by Wiener group

- Data provided by Qinglin Geng
- A reference

- ❑ CEPCSW results have the **similar trends** with FatSim

- ❑ The pT resolution of full CEPCSW is about **twice** as bad as FastSim, but still meet CDR requirements

- ❑ Need further study: a strange lift at the low momentum end of full simulation



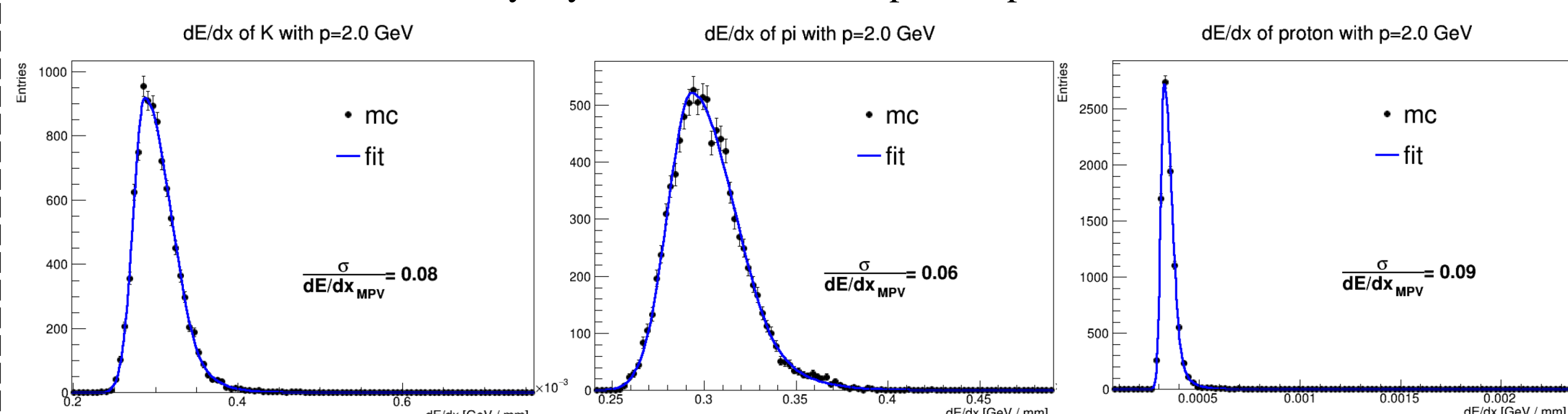
5. PID capacity of ITK endcap

Setting

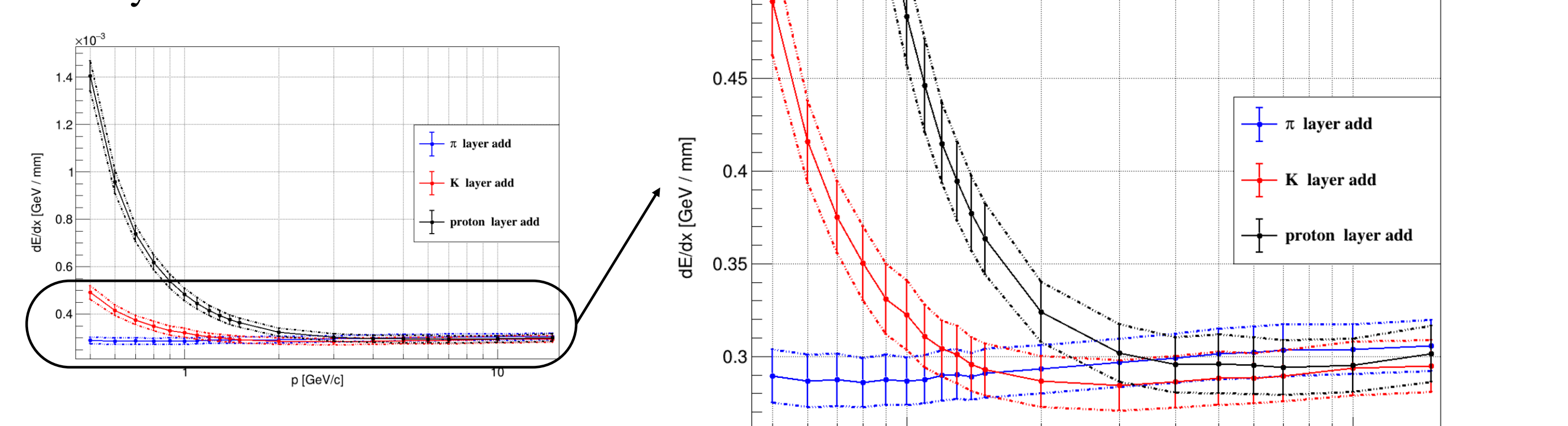
- ❑ 4 **double-layers** ITKE, **300μm** silicon per layer
- ❑ Particles: e^- , μ^- , π^- , K^- , proton, but not show e^- , μ^- results here
- ❑ Momentum: 19 points in 0.5 - 15 GeV
- ❑ Theta: 8.11° - 21.8°, to make sure only ITKE hit
- ❑ 10k events to get Most Probable Values of $\sum \frac{dE}{dx} / hits_num$, **removed the outlier** for every track

Fitting

- ❑ dE/dx distribution fitted by crystal ball PDF, examples @ $p = 2$ GeV



Preliminary results



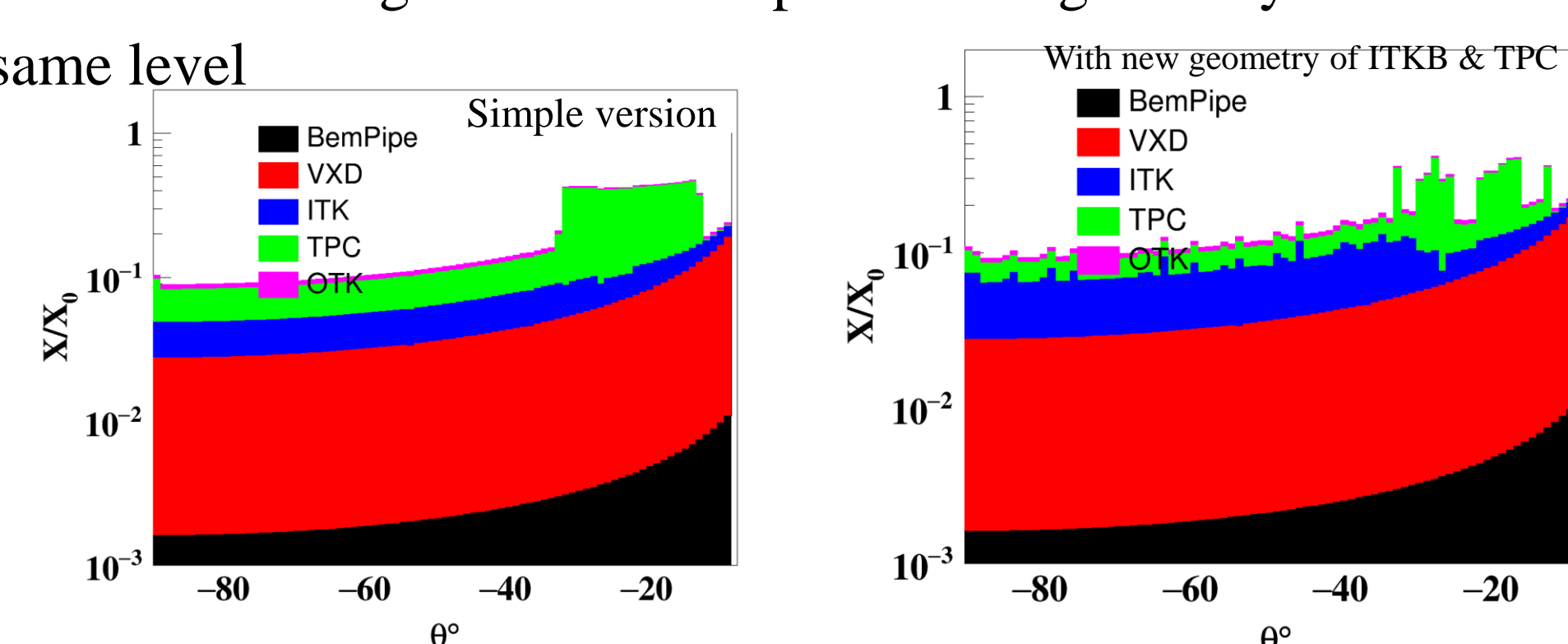
- ❑ Error bar set as 1 sigma
- ❑ Can distinguish kaon, pion, proton when momentum < 1GeV
- ❑ No distinguishing power for any particles with $p > 2$ GeV

7. Material budget study

New geometry of ITKB & TPC implemented in CEPCSW

Compare the material budget with the simple version geometry

- ❑ At the same level



8. Summary

A series of simulation-related work has been performed for the latest CEPC ITK layout

- ❑ Validate the tracker system's momentum resolution capability
- ❑ Validate its physics performance of Higgs reconstruction
- ❑ Check the PID capacity of ITK endcap
- ❑ Create staggered staves geometry of ITKB
- ❑ Calculate the material budget of tracking system