Optimization of VXD layout

J. Fu, C. Fu, Z. Liang, G. Ll, B. Liu K. Wu, Z. Zhang

Impact Parameter Resolution:

$$\sigma_{r\phi} = a \oplus \frac{b}{p(\,\mathrm{GeV})\sin^{3/2}\theta}$$

p the track momentum

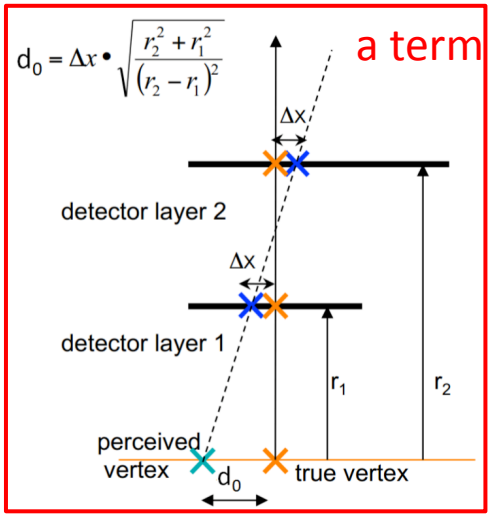
the polar track angle

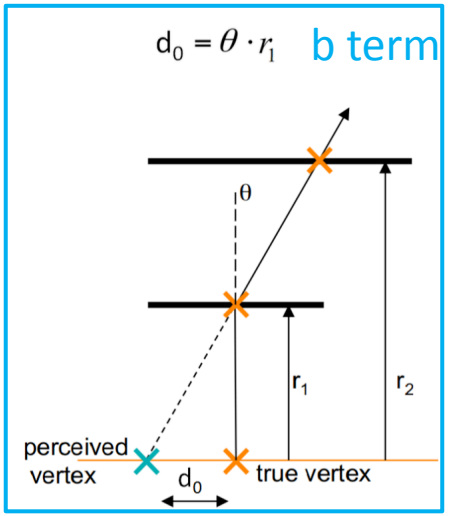
The 'a' term describes the intrinsic resolution of the vertex detector in the absence of multiple scattering and is independent of the track parameters.

The 'b' term reflects the effects of multiple scattering.

The parameters a = 5 μm and b = 10 μm · GeV are taken as the design values for the CEPC vertex detector.

three concentric cylinders of double-layer pixelated vertex detector.

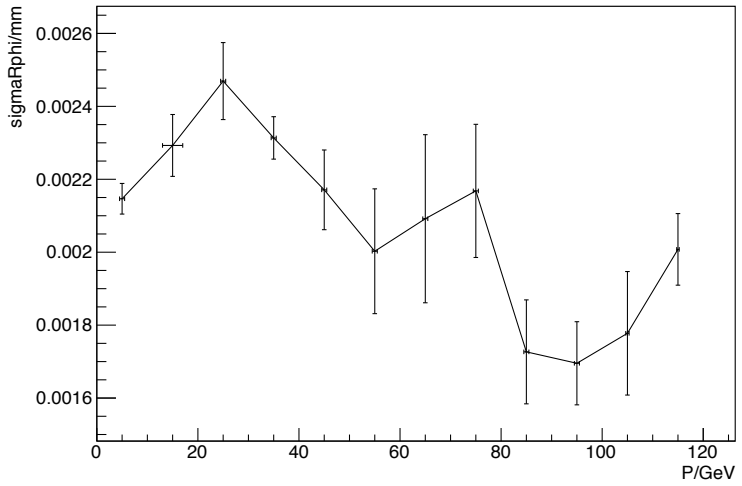




	R (mm)	$\lvert z\rvert$ (mm)	$\lvert\cos\theta\rvert$	σ(μm)
Layer 1	16	62.5	0.97	2.8
Layer 2	18	62.5	0.96	6
Layer 3	37	125.0	0.96	4
Layer 4	39	125.0	0.95	4
Layer 5	58	125.0	0.91	4
Layer 6	60	125.0	0.90	4

Impact Parameter Resolution

Simulation Method

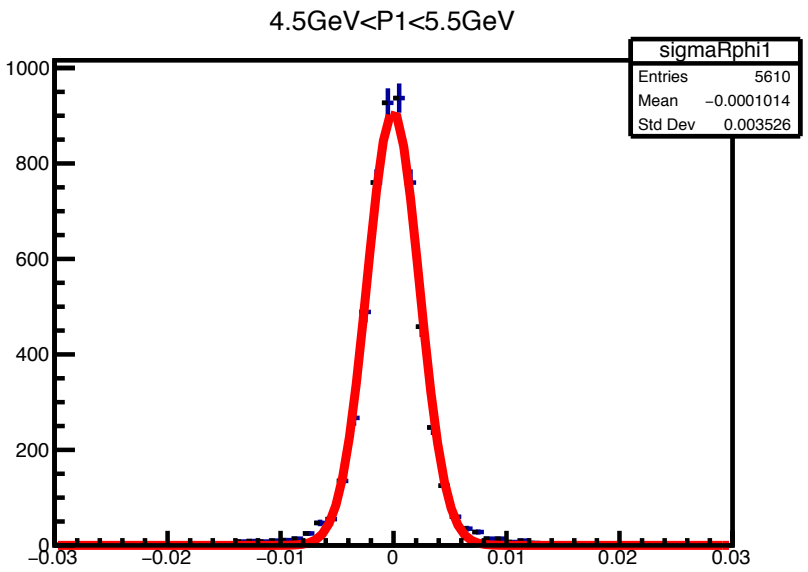


Get in different energy and same angle(85°)

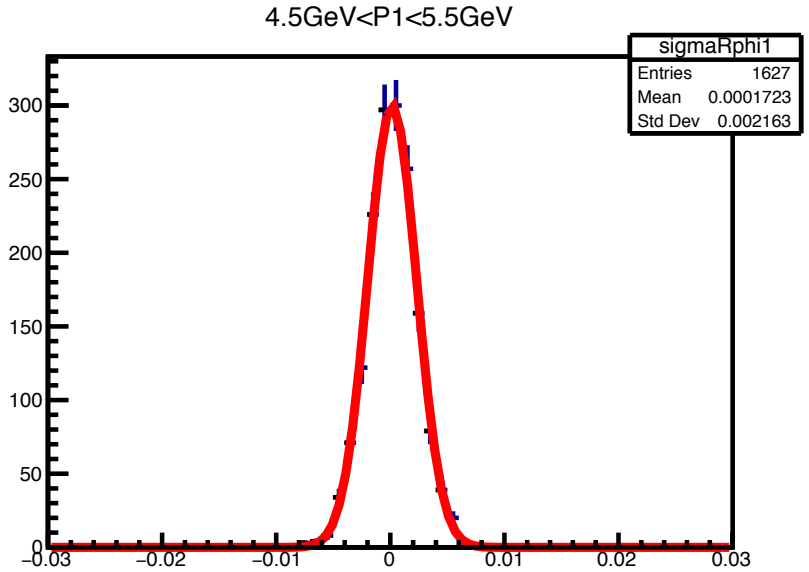
Event:

Simulation tools: Mokka & Marlin

Energy = 5±0.5GeV & full angle



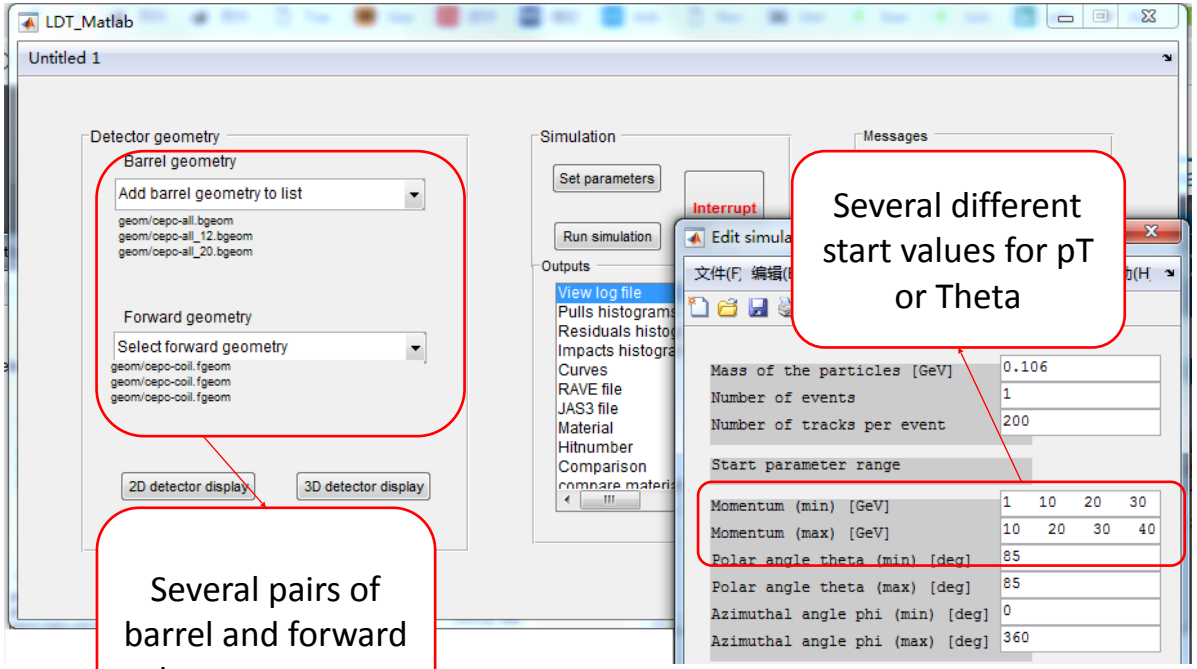
Energy = 5±0.5GeV & θ=85°



LDT for fast layout optimization

- A MATLAB based tool – easy to understand, handle and modify
- Compare track parameter resolutions of various detector setups
- Optimize size and position of the track sensitive devices, and of the detector material budgets
- Start parameters for simulated tracks are user-defined
  - VTX Geometry: Radius, Thickness..
  - Transverse momentum range, range of polar angle θ, number of tracks from the vertex.
- Weakness: Difficult to define new geometry parameters according to personal requests, e.g. rotation angle between two ladders

01 LiC Detector-Toy (barrel)													
02 LDC-basic-Japan													
03 Version:	120208												
04 Vertex Detector (VTX)													
05													
06 Number of layers :	14												
07 Description (optional) :	|-Beamt.-|	Vertex detector											
08 Names of the layers (opt.) :	XBT,	VTX1,	XVTX1,	XVTX2,	VTX2,	VTX3,	XVTX3,	XVTX4,	VTX4,	VTX5,	XVTX5,	VTX6,	XVTX6,	XVTXSHELL
09 Radii [mm] :	14.5,	15.95,	16,	17,	18,	36.95,	37,	38,	39,	57.95,	58,	59,	60,	65
10 Upper limit in z [mm] :	4225,	62.5,	62.5,	62.5,	62.5,	125,	125,	125,	125,	125,	125,	125,	125,	145
11 Lower limit in z [mm] :	-4225,	-62.5,	-62.5,	-62.5,	-62.5,	-125,	-125,	-125,	-125,	-125,	-125,	-125,	-125,	-145
12 Efficiency RPhi :	0,	0.99,	0,	0,	0.99,	0.99,	0,	0,	0.99,	0.99,	0,	0,	0.99,	0
13 Efficiency 2nd coord. (eg. z):	-1													
14 Stereo angle alpha [Rad] :	-pi/2													
15 Thickness [rad. lengths] :	0.0014,	0.00053,	0.00098,	0.00098,	0.00053,	0.00053,	0.00098,	0.00098,	0.00053,	0.00053,	0.00098,	0.00053,	0.00098,	0.0014
16 error distribution :	0													
17 0 normal-sigma(RPhi) [1e-6m] :		2.8,		6,		4,		4,		4,		4,		
18 sigma(z) [1e-6m] :		2.8,		6,		4,		4,		4,		4,		
19 1 uniform-d(RPhi) [1e-6m] :														
20 d(z) [1e-6m] :														

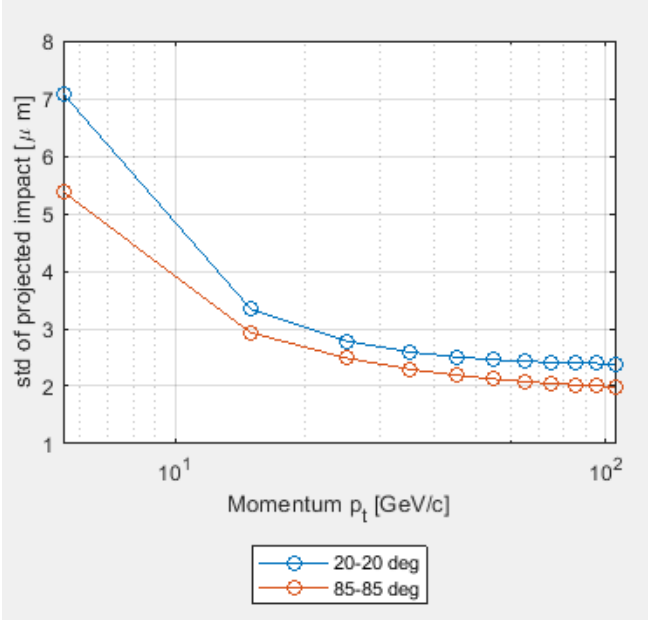


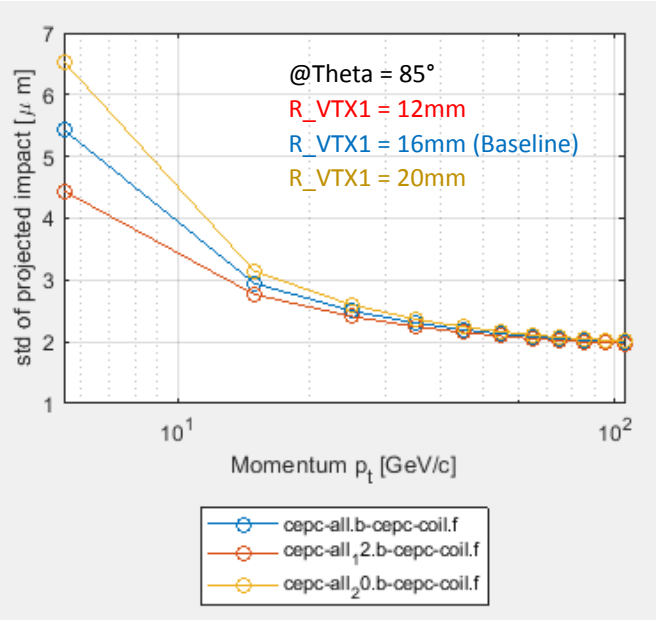
Several different start values for pT or Theta

Several pairs of barrel and forward detector setups

Compare detector setups as function of – momentum – polar angle

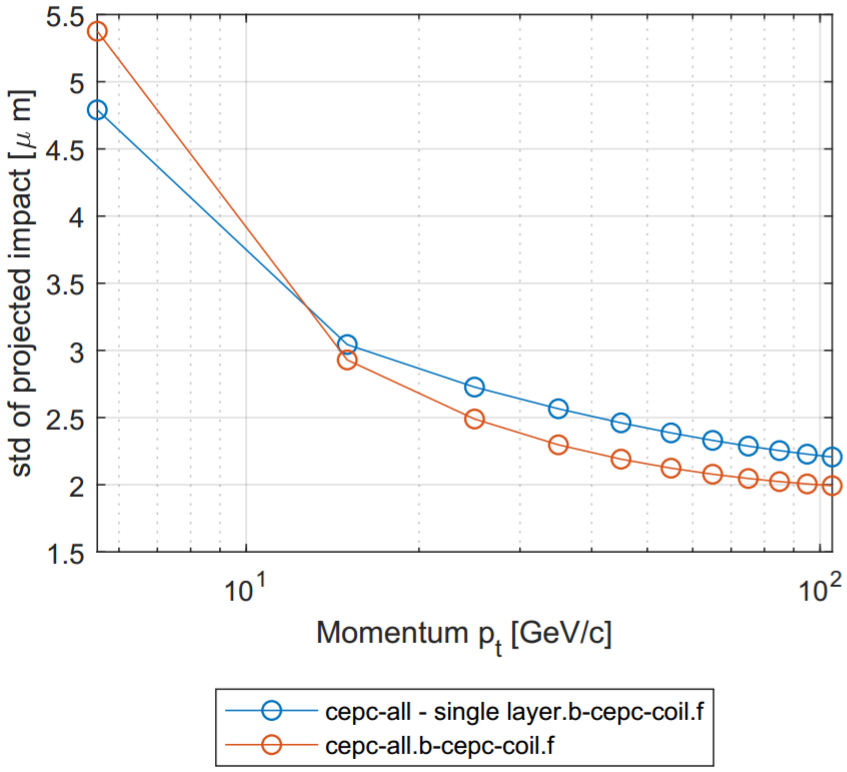
Output:
Impact parameter resolution as a function of pT with different Theta/different R of innermost layer



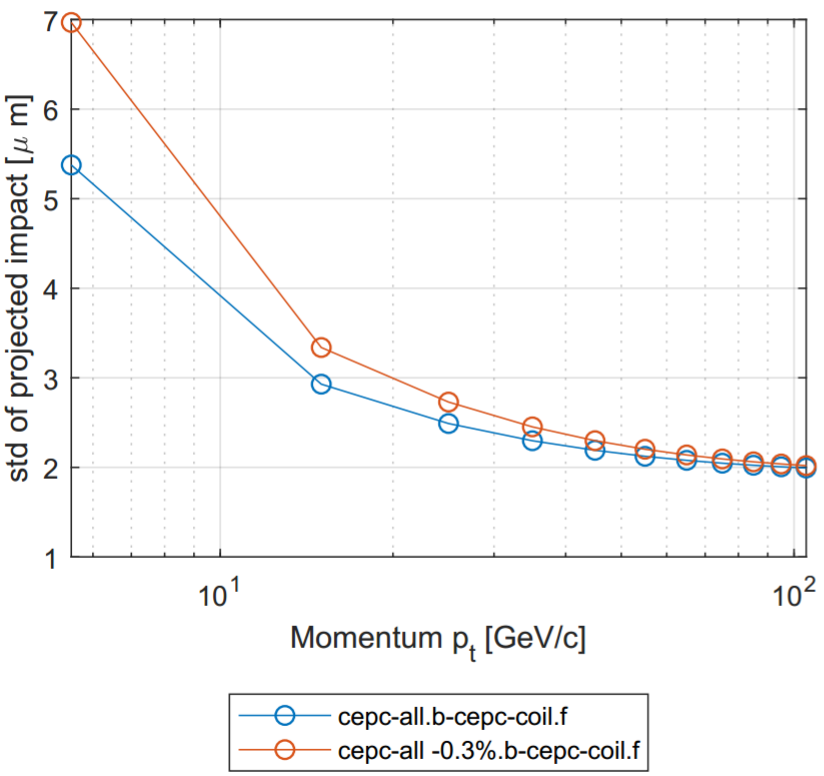


Comparison of different geometries

Double layers vs Single layers



material budget 0.15% X_0 vs 0.3% X_0



Optimization —— Next Step

- LDT:
  - Test more detector geometry parameters
  - Communicate with mechanic engineer for their requests
- Full simulation used to validate the fast results
- TkLayout as alternative way also for cross check, but some technical problems …