Status on SDT simulation

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Status

- Check the geometry described in the CDR
- Check the geometry file in the LDT & how to change it
- Check (read the manual) and run the simulation with the CEPC baseline detector configuration
- Compare the output result

Detector Geometry

・ Geometry file stored under LDT2.0 is “cepc-all.bgeom”

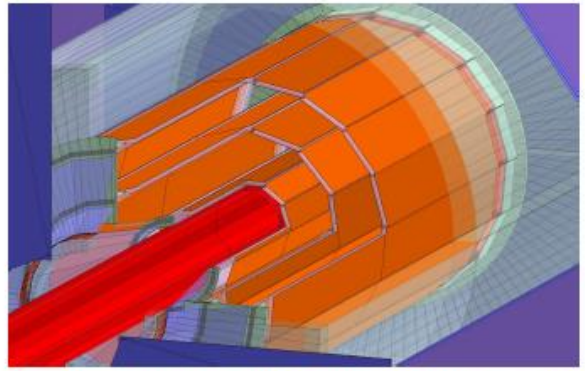


Figure 4.2: Schematic view of pixel detector. Two layers of silicon pixel sensors are mounted on both sides of each of three ladders to provide six space points. Only the silicon sensor sensitive region (in orange) is depicted. The vertex detector surrounds the beam pipe (red).

from CDR vol.2

	R (mm)	$\|z\|$ (mm)	$\|\cos\theta\|$	$\sigma(\mu m)$
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

cepc-all.bgeom: vtx part

```
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]    :
21
```

Detector Geometry

- SIT-

4.2.2.1 BASELINE DESIGN

The silicon tracker of the baseline design consists of four components: the Silicon Inner Tracker (SIT), the Silicon External Tracker (SET), the Forward Tracking Detector (FTD), and the Endcap Tracking Detector (ETD). The overall layout is shown in Figure 4.1 and the main parameters are summarized in Table 4.5.

Detector		Radius R [mm]		$\pm z$ [mm]	Material budget [X_0]
SIT	Layer 1	153		371.3	0.65%
	Layer 2	300		664.9	0.65%
SET	Layer 3	1811		2350	0.65%
		R_{in}	R_{out}		
FTD	Disk 1	39	151.9	220	
	Disk 2	49.6	151.9	371.3	
	Disk 3	70.1	298.9	644.9	0.65%
	Disk 4	79.3	309	846	0.65%
	Disk 5	92.7	309	1057.5	0.65%
ETD	Disk	419.3	1822.7	2420	0.65%

Table 4.5: Main parameters of the CEPC silicon tracker. Silicon pixel sensors are planned for the two inner disks of the FTD whereas silicon microstrip sensors are envisioned for the rest. The column labelled $\pm z$ shows the length of the SIT and SET layers, and the z position of the FTD and ETD disks.

from CDR vol.2

slightly different number 368 ? (comparison with the value in next page)

Description of the cepc-all.bgeom is pasted in the next page

```
21  21
22  22 Silicon Inner Tracker (SIT)
23  23
24  24 Number of layers            :  9
25  25 Description (optional)      : |-----------------------------------------------Inner tracker-----------------------------------------------|TPC inner wall|
26  26 Names of the layers (opt.)  :  SIT1,       XSIT1,      XSIT2,      SIT2,       SIT3,       XSIT3,      XSIT4,      SIT4,       XTPCW1
27  27 Radii [mm]                  :  152.9,      153.1,      154.4,      155.4,      299.9,      300.1,      301.4,      302.4,      329
28  28 Upper limit in z [mm]       :  368,        368,        368,        368,        644,        644,        644,        644,        2350
29  29 Lower limit in z [mm]       :  -368,       -368,       -368,       -368,       -644,       -644,       -644,       -644,       -2350
30  30 Efficiency RPhi             :  0.99,       0,          0,          0,          0.99,       0,          0,          0,          0
31  31 Efficiency 2nd coord. (eg. z):  0,        0,          0,          0.99,       0,          0,          0,          0.99,       0
32  32 Stereo angle alpha [Rad]    :  7*(pi/180), 7*(pi/180), 7*(pi/180), 7*(pi/180), 7*(pi/180), 7*(pi/180), 7*(pi/180), 7*(pi/180), 7*(pi/180)
33  33 Thickness [rad. lengths]    :  0.00213,    0.00468,    0.00468,    0.00213,    0.00213,    0.00468,    0.00468,    0.00213,    0.0051
34  34 error distribution          :  0
35  35 0 normal-sigma(RPhi) [1e-6m] :  7
36  36         sigma(z)    [1e-6m] :  7
37  37 1 uniform-d(RPhi) [1e-6m]   :
38  38          d(z)    [1e-6m]   :
39  39
```

```
58  58 Number of layers            :  6
59  59 Description (optional)      : |TPC outer wall|-------------External Tracker-------------------------------------------|
60  60 Names of the layers (opt.)  :    XTPCW2,       SET1,        XSET1,       XSET2,      SET2,           SET3
61  61 Radii [mm]                  :    1808,         1810.9,      1811.1,      1812.4,     1813.4,         1847.4
62  62 Upper limit in z [mm]       :    2350,         2300,        2300,        2300,       2300,           2350
63  63 Lower limit in z [mm]       :    -2350,        -2300,       -2300,       -2300,      -2300,          -2350
64  64 Efficiency RPhi             :    0,            0.99,        0,           0,          0,              0
65  65 Efficiency 2nd coord. (eg. z):    0,            0,           0,           0,          0.99,           0
66  66 Stereo angle alpha [Rad]    :    7*(pi/180),   7*(pi/180),  7*(pi/180),  7*(pi/180), 7*(pi/180),    90*(pi/180)
67  67 Thickness [rad. lengths]    :    0.00518,      0.00213,     0.00468,     0.00468,    0.00213,        0
68  68 error distribution          :    0
69  69 0 normal-sigma(RPhi) [1e-6m] :    7,            7,           7,           7,          7,              7
70  70         sigma(z)    [1e-6m] :    7,            7,           7,           7,          7,              7
71  71 1 uniform-d(RPhi) [1e-6m]   :
72  72          d(z)    [1e-6m]   :
73  73
```

Detector Geometry

- TPC-

information is scattered .... but (as I remembered) we can confirm the numbers in the CDR

```
40  40 Time Projection Chamber (TPC)
41  41 sigma^2=sigma0^2+sigma1^2*sin(beta)^2+Cdiff^2*6mm/h*sin(theta)*Ldrift[m]
42  42 Number of layers              :   222
43  43 Radii [mm]                    :   384,1716
44  44 Upper limit in z [mm]         :   2225
45  45 Lower limit in z [mm]         :  -2225
46  46 Efficiency RPhi               :   1
47  47 Efficiency z                  :   1
48  48 Thickness [rad. lengths]      :   0.00005194
49  49 sigma0(RPhi) [1e-6m]          :   50
50  50 sigma1(RPhi) [1e-6m]          :   900
51  51 Cdiff(RPhi)  [1e-6m/sqrt(m)]  :   25
52  52 sigma0(z)    [1e-6m]          :   400
53  53 sigma1(z)    [1e-6m]          :   0
54  54 Cdiff(z)     [1e-6m/sqrt(m)]  :   80
55  55
```

4.2.1.1 CEPC TIME PROJECTION CHAMBER

The CEPC TPC consists of a field cage, which is made with advanced composite materials, and two readout end-plates that are self-contained including the gas amplification, readout electronics, supply voltage, and cooling. The TPC has a cylindrical drift volume with an inner radius of 0.3 m an outer radius of 1.8 m, and a full length of 4.7 m. The central cathode plane is held at a potential of 50 kV, and the two anodes at the two end-plates are at ground potential. The cylindrical walls of the volume form the field cage, which ensures a highly homogeneous electrical field of 300 V/cm between the electrodes. The drift volume is filled with Ar/CF_4/iC_4H_{10} in the ratio of 95%/3%/2%. Ionization electrons released by charged particle tracks drift along the electric field to the anodes where they are amplified in an electron avalanche and read out using a Micro-Pattern Gas Detector (MPGD).

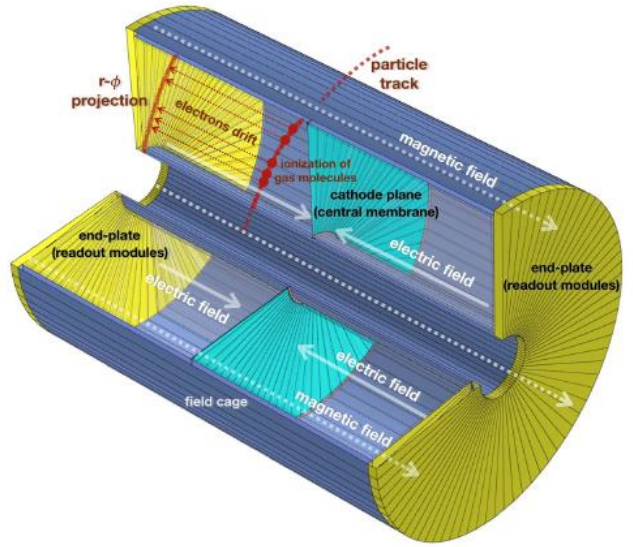
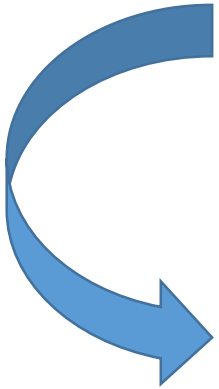


Figure 4.7: Sketch of the TPC detector. The TPC is a cylindrical gas detector with an axial electric field formed between the end-plates (yellow) and a central cathode plane/membrane (light blue). The cylindrical walls of the volume form the electric field cage (dark blue). Gas ionization electrons due to charged particles drift to the end-plates where they are collected by readout modules (yellow).

Detector Geometry

- Magnetic field-

- default parameter in “cepc-all.bgeom”



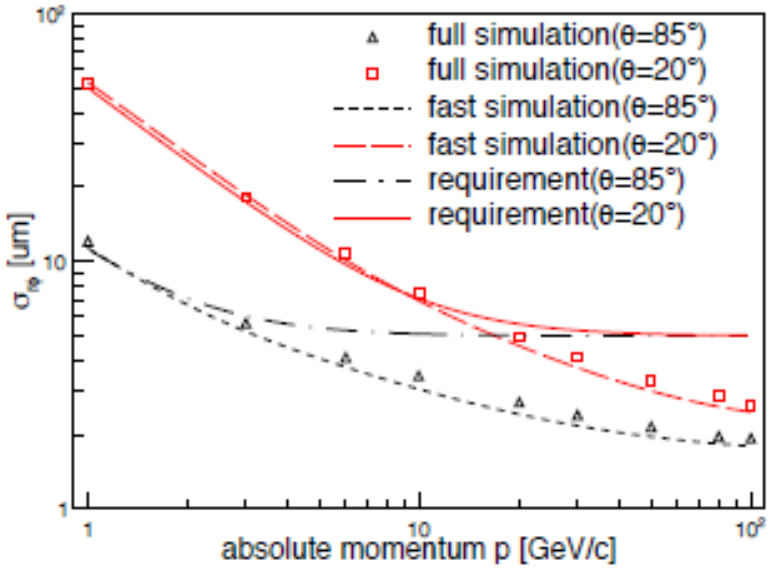
```
74 Magnetic field and beam spot
75
76 Solenoid magnetic field [T]  :   3.5
77 Range in x [mm]             :  -0    0
78 Range in y [mm]             :  -0    0
79 Range in z [mm]             :  -0    0
```

```
74 Magnetic field and beam spot
75
76 Solenoid magnetic field [T]  :   3.0
77 Range in x [mm]             :  -0    0
78 Range in y [mm]             :  -0    0
79 Range in z [mm]             :  -0    0
```

Transverse impact parameter resolution

4.1.3.1 PERFORMANCE OF THE BASELINE CONFIGURATIONS

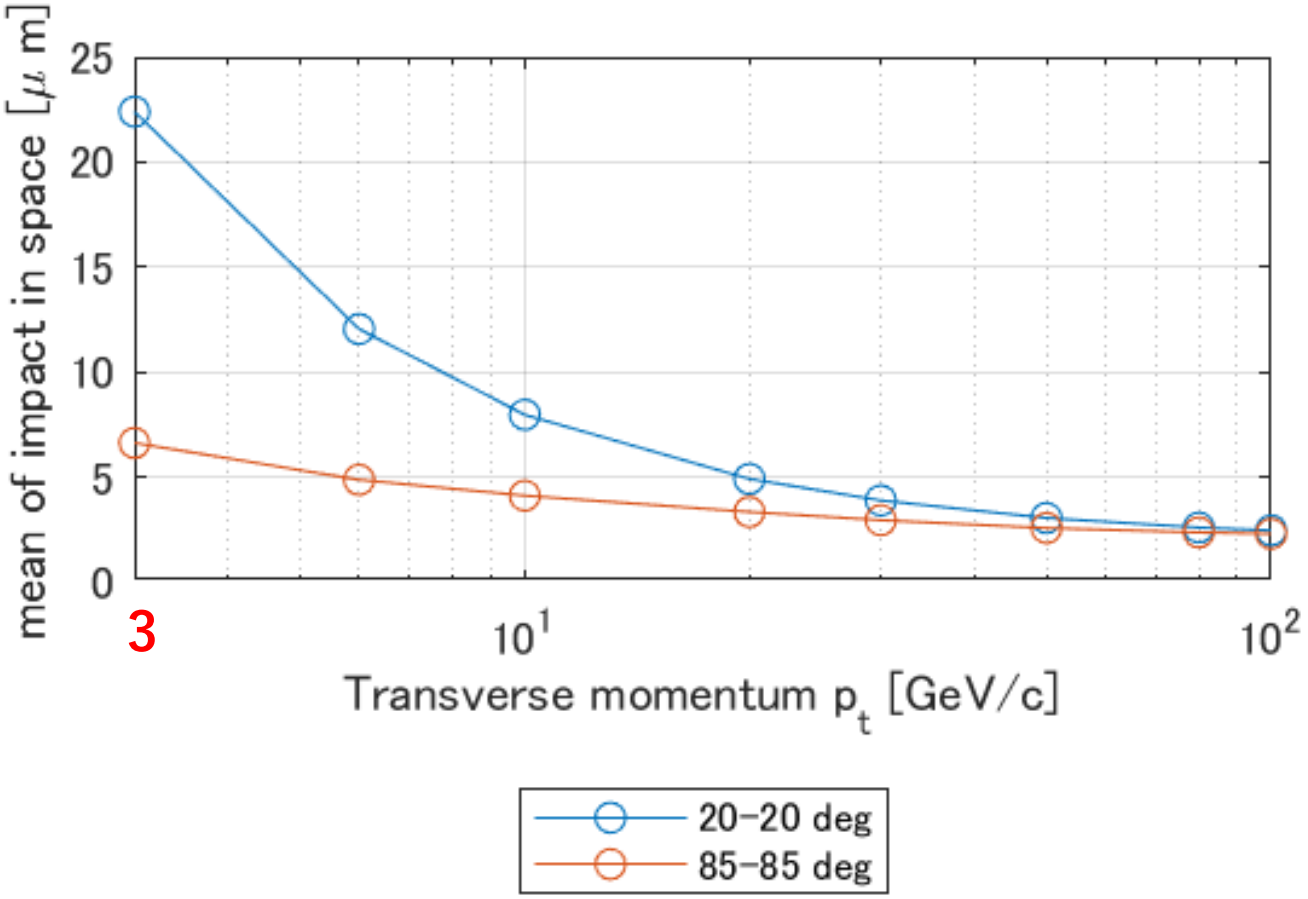
The impact parameter resolution, following from the single-point resolutions provided in Table 4.1, is displayed in Figure 4.3 as a function of the particle momentum, showing that the ambitious impact parameter resolution is achievable.

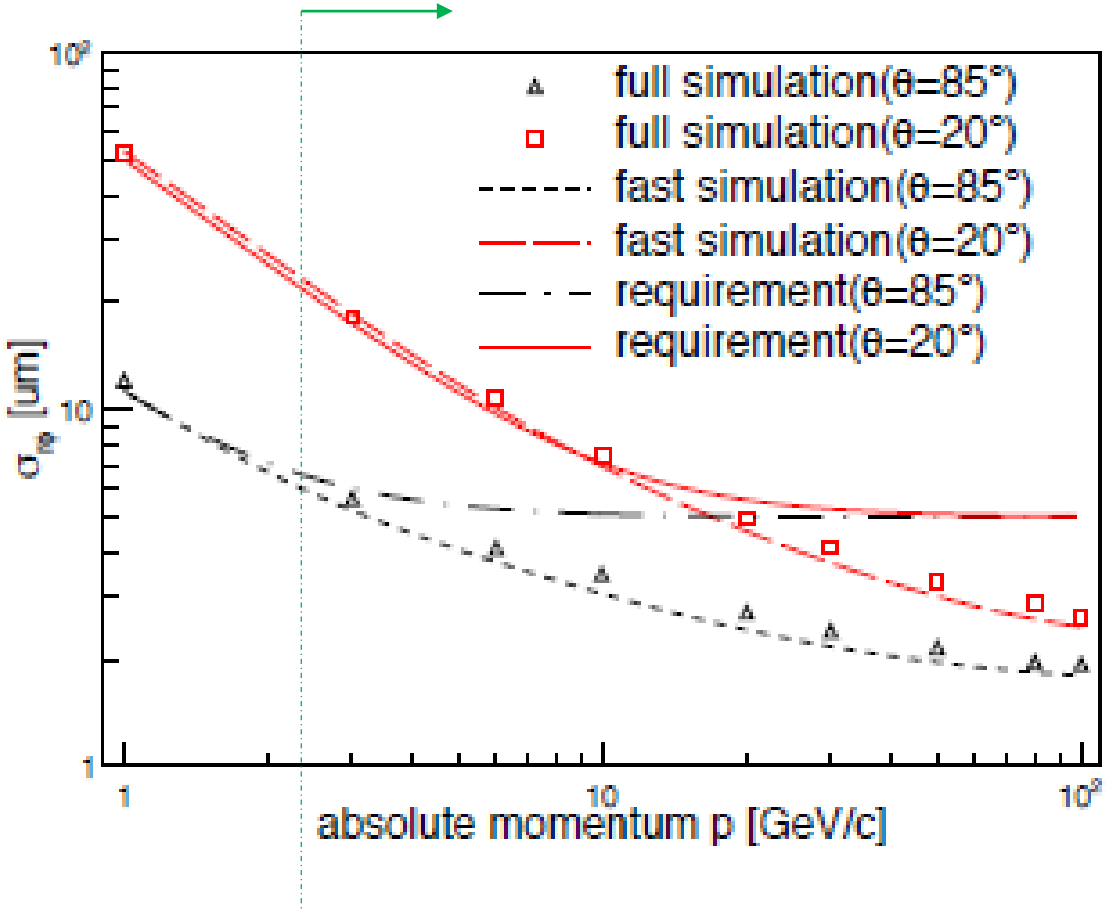


from CDR vol.2

Figure 4.3: Transverse impact-parameter resolutions for single muon events as a function of momentum for two polar angles 20° and 85°. The results are shown for both fast simulation and full simulation method.

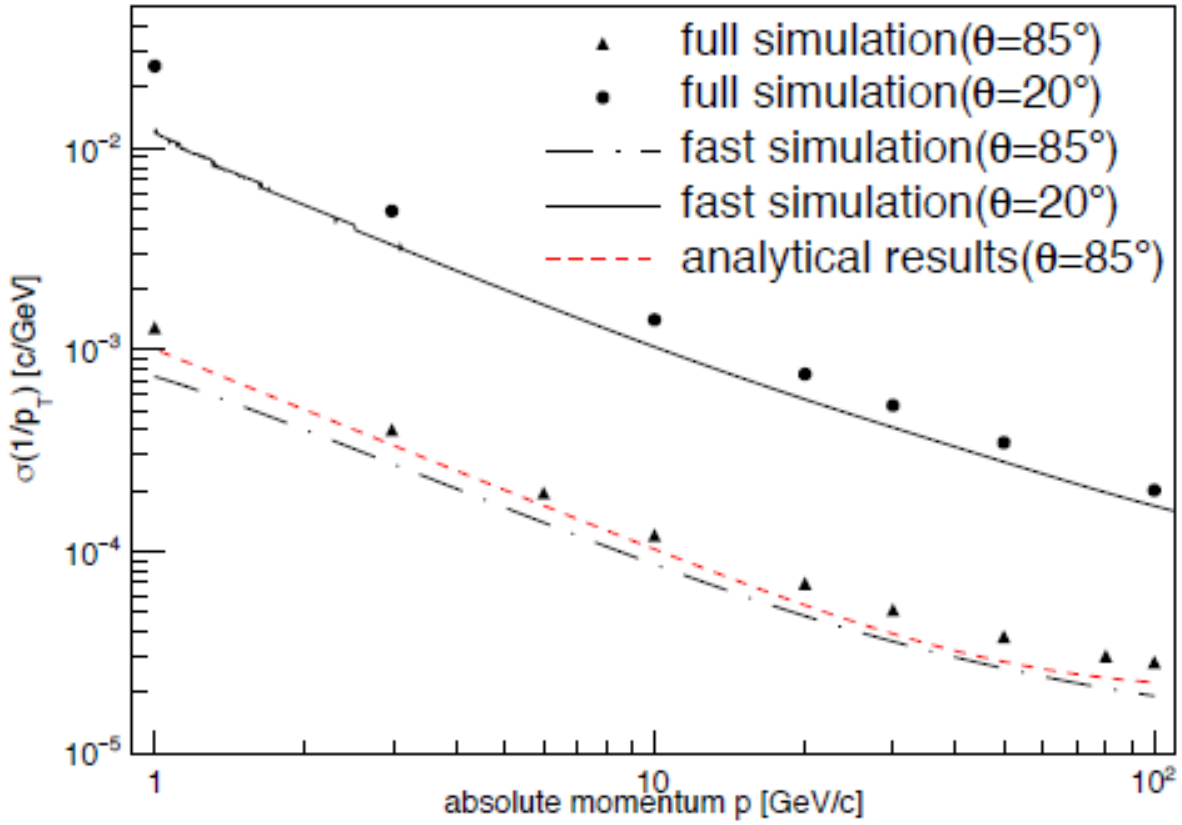
Comparison





At a glance, the simulation result coincide with the one in the CDR, but would need to compare the values. (since they are slightly different)

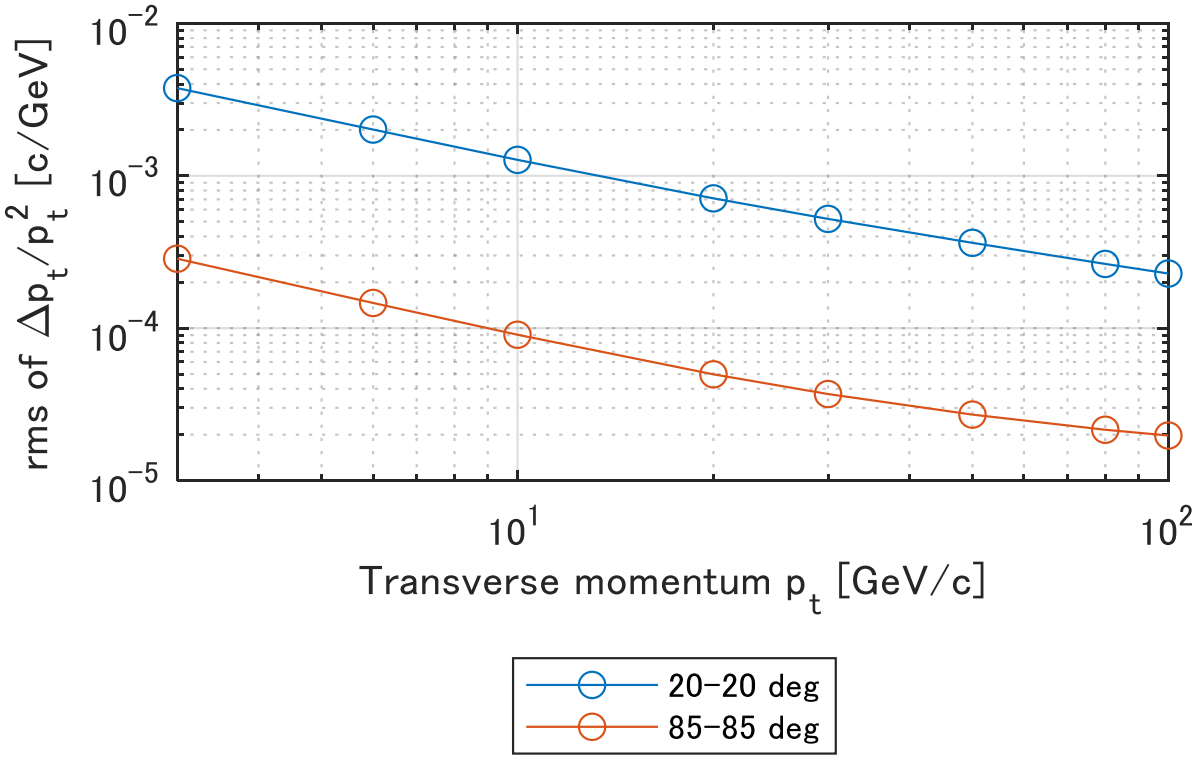
Transverse momentum resolution

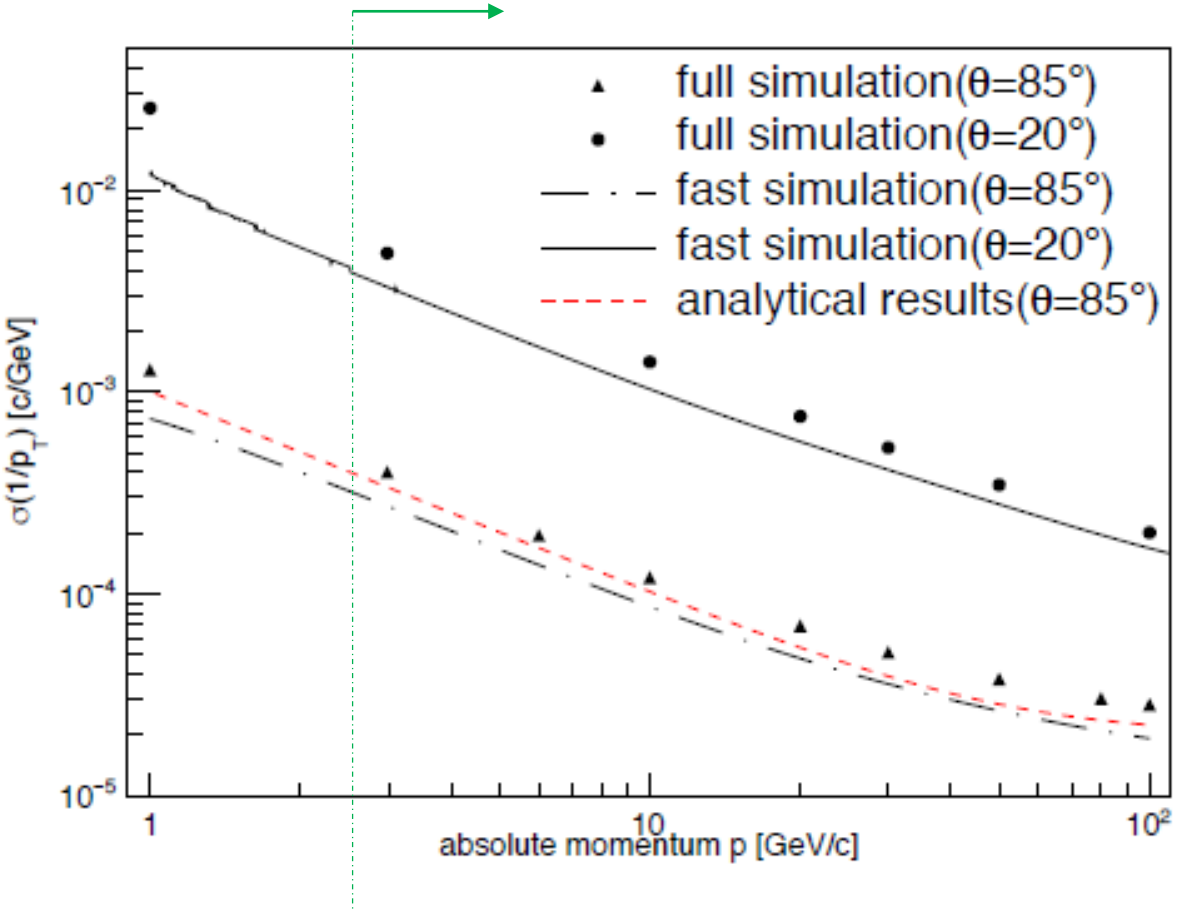


from CDR vol.2

Figure 4.22: Transverse momentum resolution for single muon tracks as a function of the track momentum estimated for the CEPC baseline design with full simulation (dots) and fast simulation (black lines) compared to the analytical results obtained with Eqs. 4.2 and 4.3 (red line).

Comparison


rms of $\Delta p_t/p_t^2$ [c/GeV]
10^{-2}
10^{-3}
10^{-4}
10^{-5}
10^{1}
10^{2}
Transverse momentum p_t [GeV/c]
20–20 deg
85–85 deg


full simulation(θ=85°)
full simulation(θ=20°)
fast simulation(θ=85°)
fast simulation(θ=20°)
analytical results(θ=85°)
$\sigma(1/p_T)$ [c/GeV]
10^{-2}
10^{-3}
10^{-4}
10^{-5}
1
10
10^{2}
absolute momentum p [GeV/c]

Next step

- Change the geometry

  -- removing the TPC

```
40 Time Projection Chamber (TPC)
41
sigma^2=sigma0^2+sigma1^2*sin(beta)^2+Cdiff^2*6mm/h
*sin(theta)*Ldrift[m]
42 Number of layers                 :  0
43 Radii [mm]                       :  0
44 Upper limit in z [mm]            :  0
45 Lower limit in z [mm]            :  0
46 Efficiency RPhi                  :  0
47 Efficiency z                     :  0
48 Thickness [rad. lengths]         :  0
49 sigma0(RPhi) [1e-6m]             :  0
50 sigma1(RPhi) [1e-6m]             :  0
51 Cdiff(RPhi)  [1e-6m/sqrt(m)]     :  0
52 sigma0(z)    [1e-6m]             :  0
53 sigma1(z)    [1e-6m]             :  0
54 Cdiff(z)     [1e-6m/sqrt(m)]     :  0
```