Status on LDT runs

01/18/2021

Reference: the momentum resolution

- Analytic formula of the momentum resolution

- A simple geometry picture is assumed (as usual)

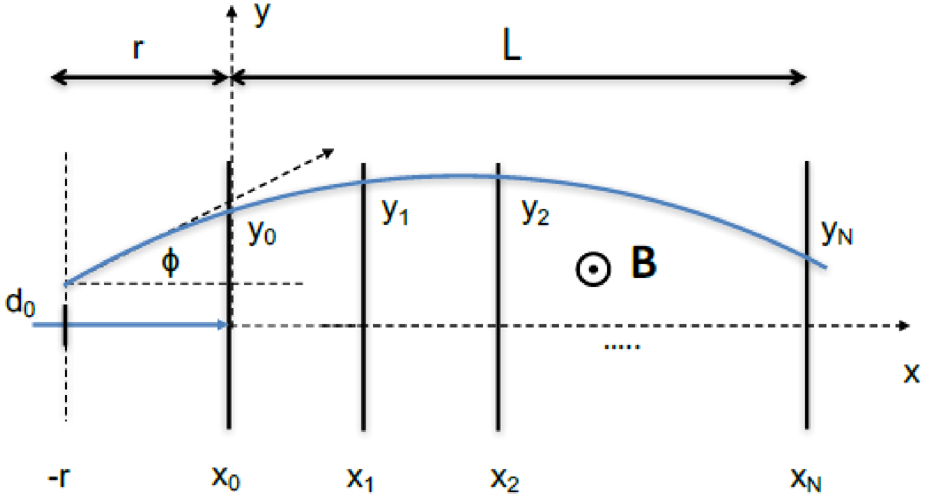

Figure 3: A parabolic track through $N + 1$ equal and equidistant detector planes.

An extension of the Gluckstern formulas for multiple scattering: analytic expressions for track parameter resolution using optimum weights

Z. Drasal[a,b], W. Riegler[b,*]

[a] Charles University, Prague, Czech Republic
[b] CERN EP, Geneva, Switzerland

Abstract

Momentum, track angle and impact parameter resolution are key performance parameters that tracking detectors are optimised for. This report presents analytic expressions for the resolution of these parameters for equal and equidistant tracking layers. The expressions for the contribution from position resolution are based on the Gluckstern formulas and are well established. The expressions for the contribution from multiple scattering using optimum weights are discussed in detail.

Keywords: tracking, multiple scattering, impact parameter resolution, momentum resolution

arXiv:1805.12014 [physics.ins-det]

The basic analytic form and the dependence of parameters (i.e. B, L, σ etc.) is the same as shown in the slide (2021-01-04)

Update configuration - 1

An extension of the Gluckstern formulas for multiple scattering: analytic expressions for track parameter resolution using optimum weights

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[a] Charles University, Prague, Czech Republic
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Momentum, track angle and impact parameter resolution are key performance parameters that tracking detectors are optimised for. This report presents analytic expressions for the resolution of these parameters for equal and equidistant tracking layers. The expressions for the contribution from position resolution are based on the Gluckstern formulas and are well established. The expressions for the contribution from multiple scattering using optimum weights are discussed in detail.

Keywords: tracking, multiple scattering, impact parameter resolution, momentum resolution

Z. Drasal and W. Riegler,
"An extension of the Gluckstern formulas for multiple scattering: analytic expressions for track parameter resolution using optimum weights",
arXiv:1805.12014 [physics.ins-det]

From the reference

Detector resolution
("a")

Multiple Scattering
("b")

$$\frac{\Delta p_T}{p_T}\Big|_{res.} = \frac{\sigma_{r\phi}\, p_T}{0.3\, B_0 L_0^2}\sqrt{\frac{720 N^3}{(N-1)(N+1)(N+2)(N+3)}} \quad (45)$$

$$\approx \frac{12\,\sigma_{r\phi}\, p_T}{0.3\, B_0 L_0^2}\sqrt{\frac{5}{N+5}} \quad (46)$$

$$\frac{\Delta p_T}{p_T}\Big|_{m.s.} = \frac{N}{\sqrt{(N+1)(N-1)}}\, \frac{0.0136\,\mathrm{GeV/c}}{0.3\beta\, B_0 L_0}\sqrt{\frac{d_{tot}}{X_0\,\sin\theta}}\left(1 + 0.038\ln\frac{d}{X_0\,\sin\theta}\right) \quad (47)$$

$$\approx \frac{0.0136\,\mathrm{GeV/c}}{0.3\beta\, B_0 L_0}\sqrt{\frac{d_{tot}}{X_0\,\sin\theta}} \quad (48)$$

The dependence of momentum resolution on p_T and θ (or η) has the general form

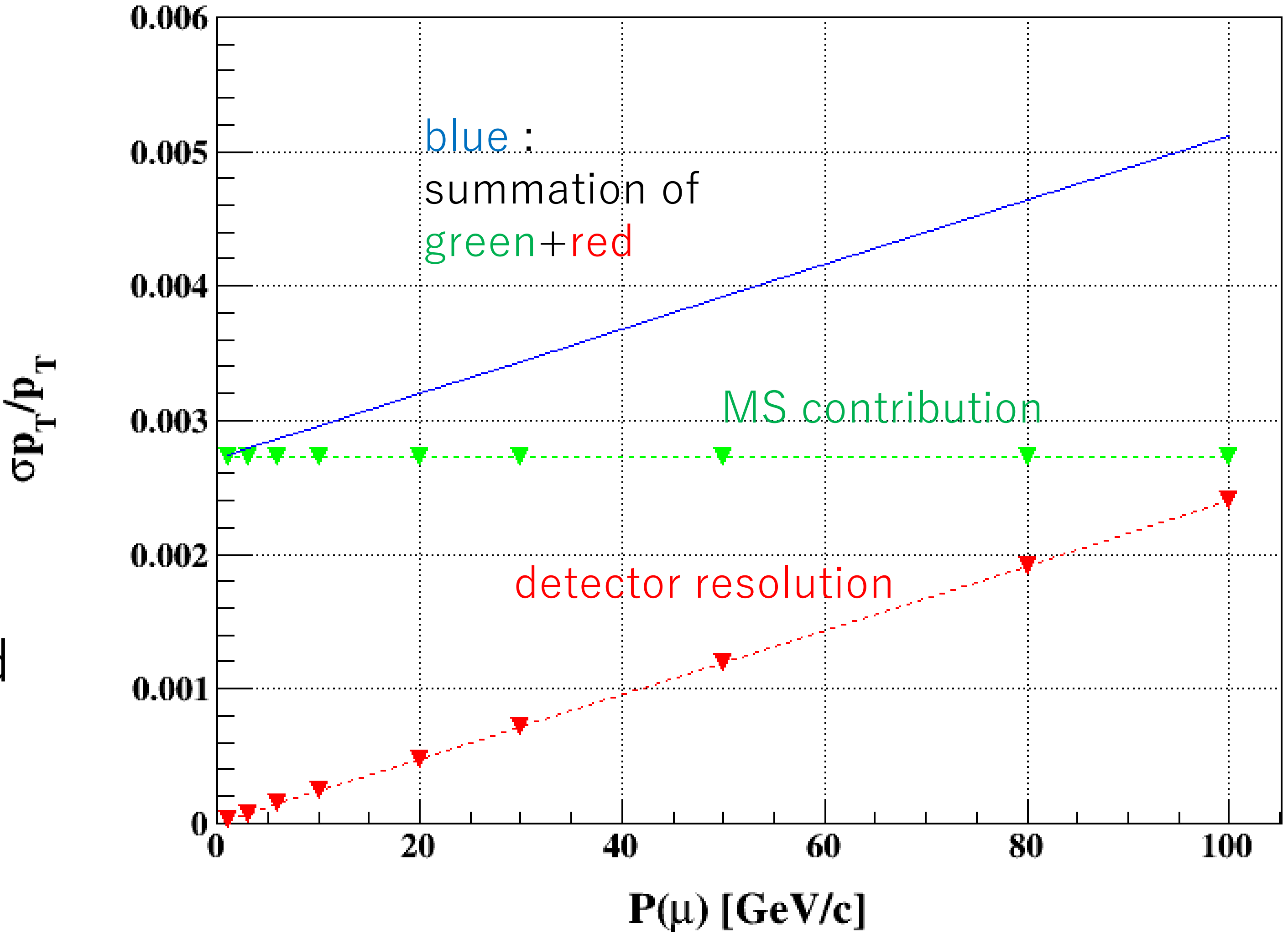
$$\frac{\Delta p_T}{p_T} = a\, p_T \oplus \frac{b}{\sin^{\frac{1}{2}}\theta} \equiv a\, p_T \oplus b\cosh^{\frac{1}{2}}\eta \quad (49)$$

calculation :

-- B: 3 [T],
-- L: 1.8-0.15 = 1.65 [m]
-- N : 6 (=6layer SIT)
-- σ : 5 [μm]
-- d/X_0 (thickness): 0.01362

(d_{tot} = 6 * 0.01362)

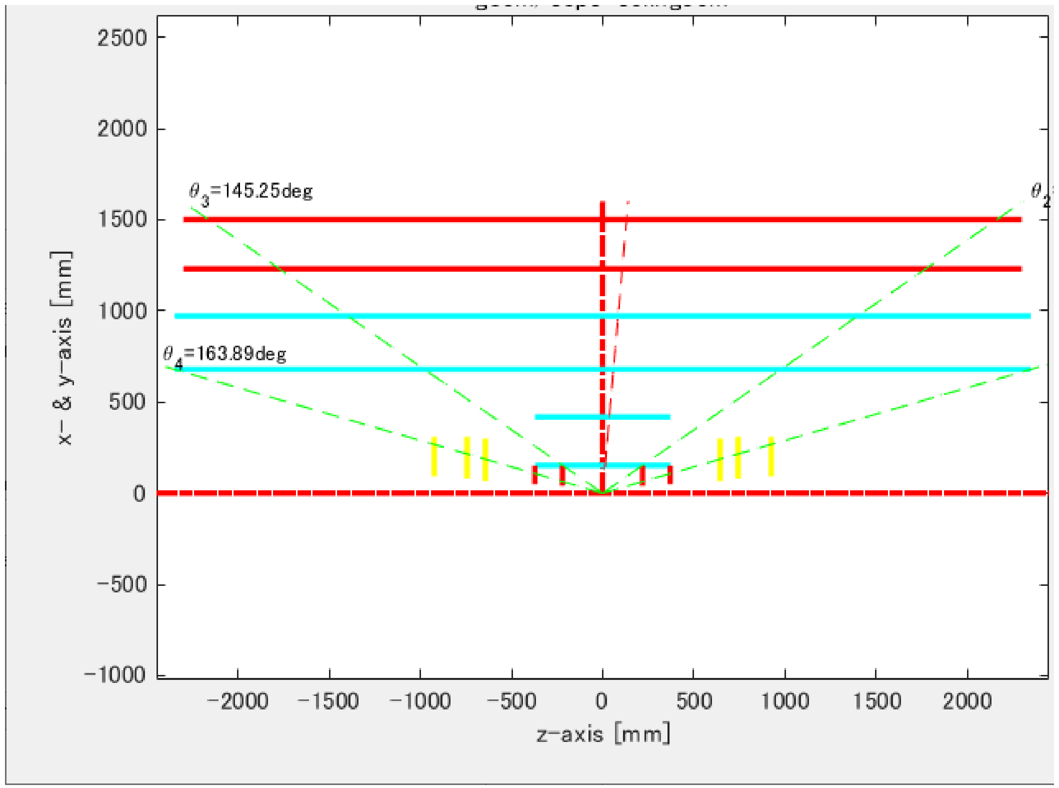
It is the geometry used/discussed in last week. The material of “sensor” and “support frame” is combined as one.

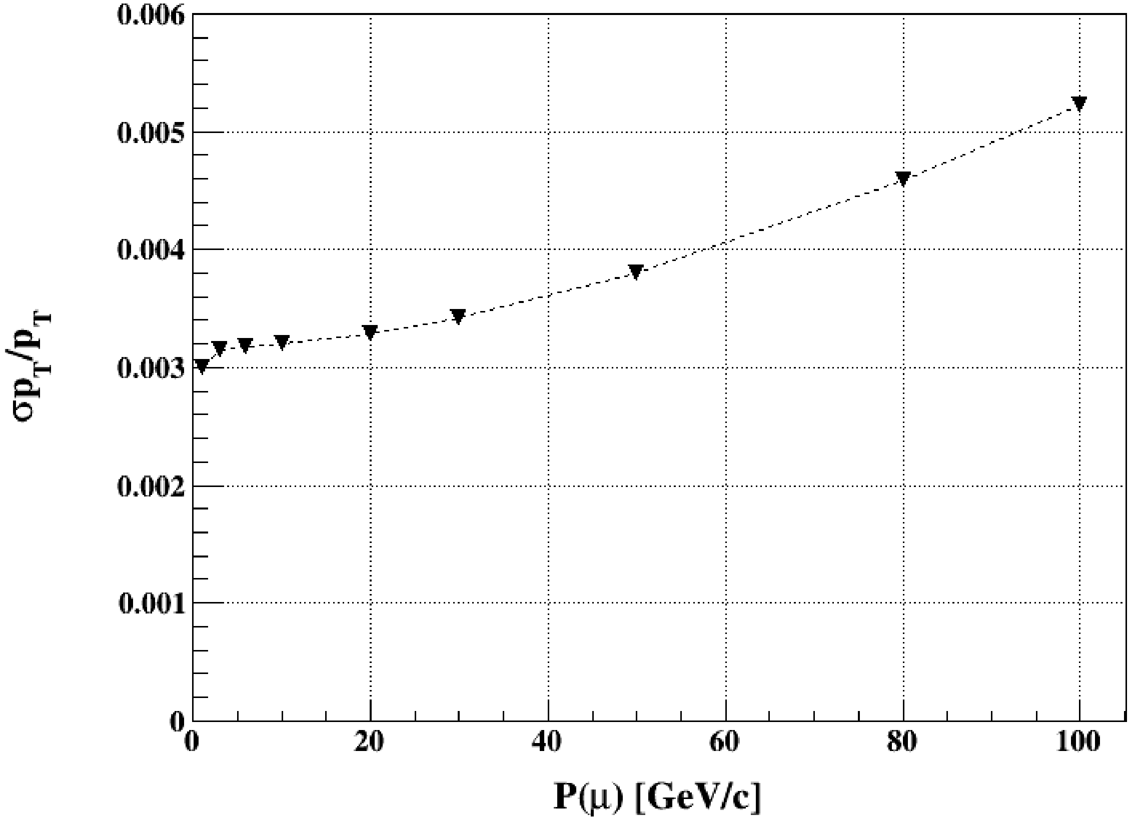


from the LDT simulation

- VXD is removed. Only 6 SITs.

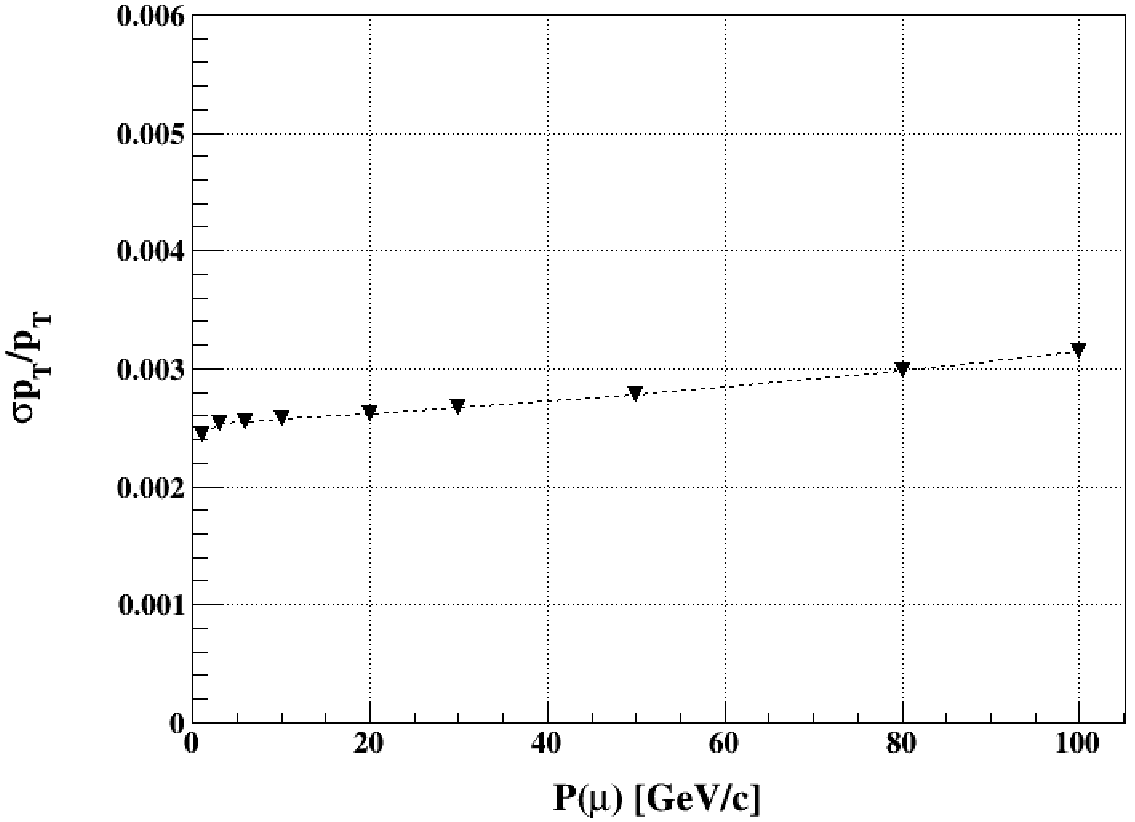
somehow close to the calculation



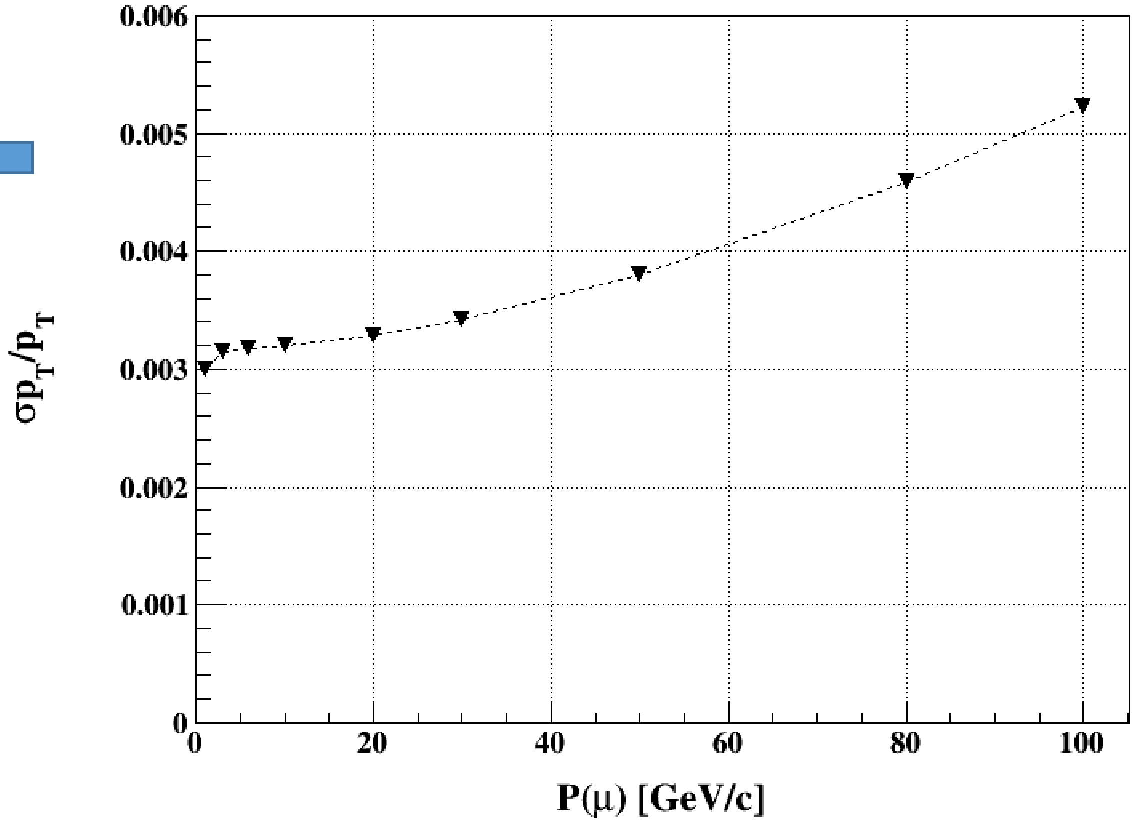


from the LDT simulation

- VXD is there = what we had in last week

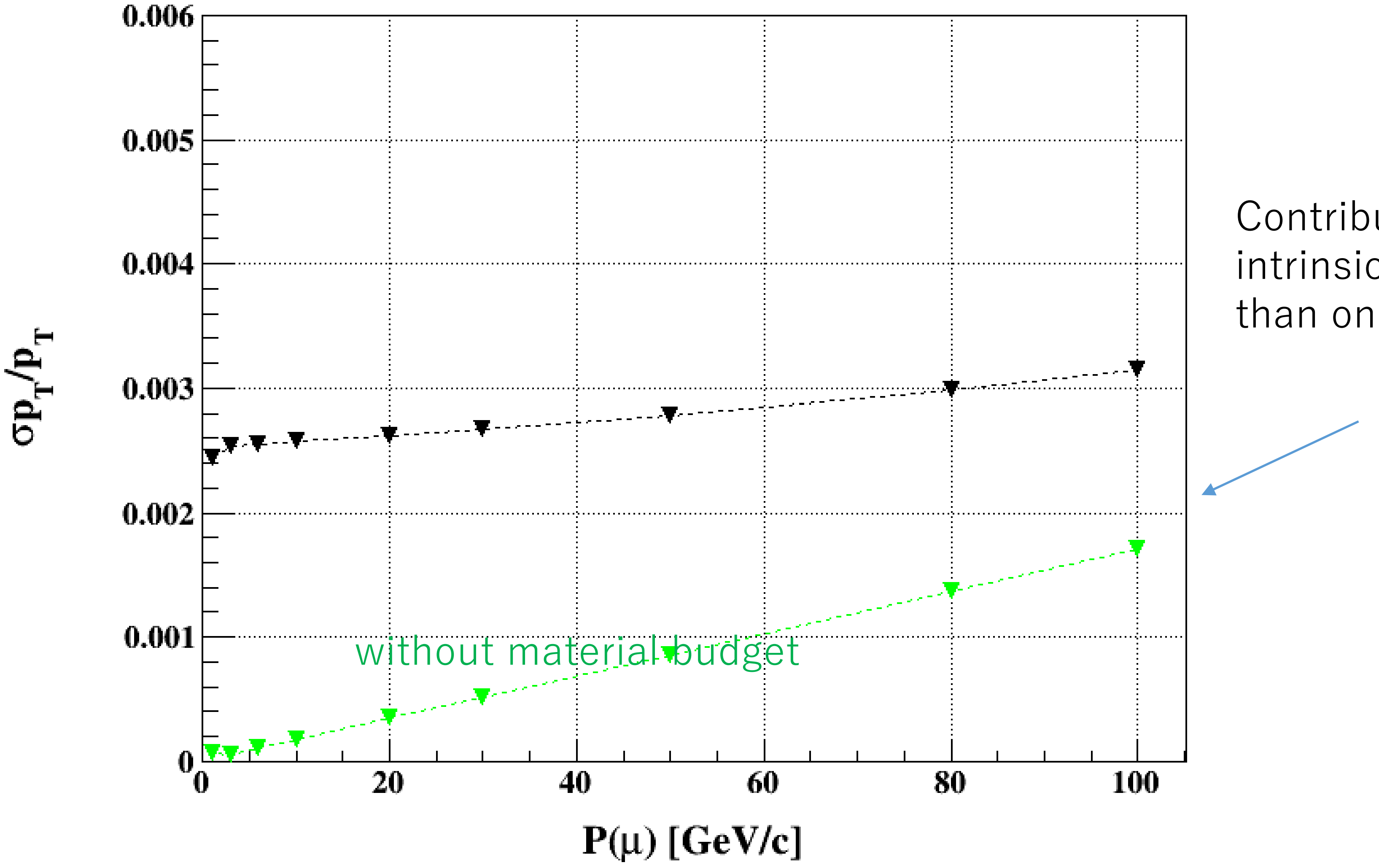


the same as previous page



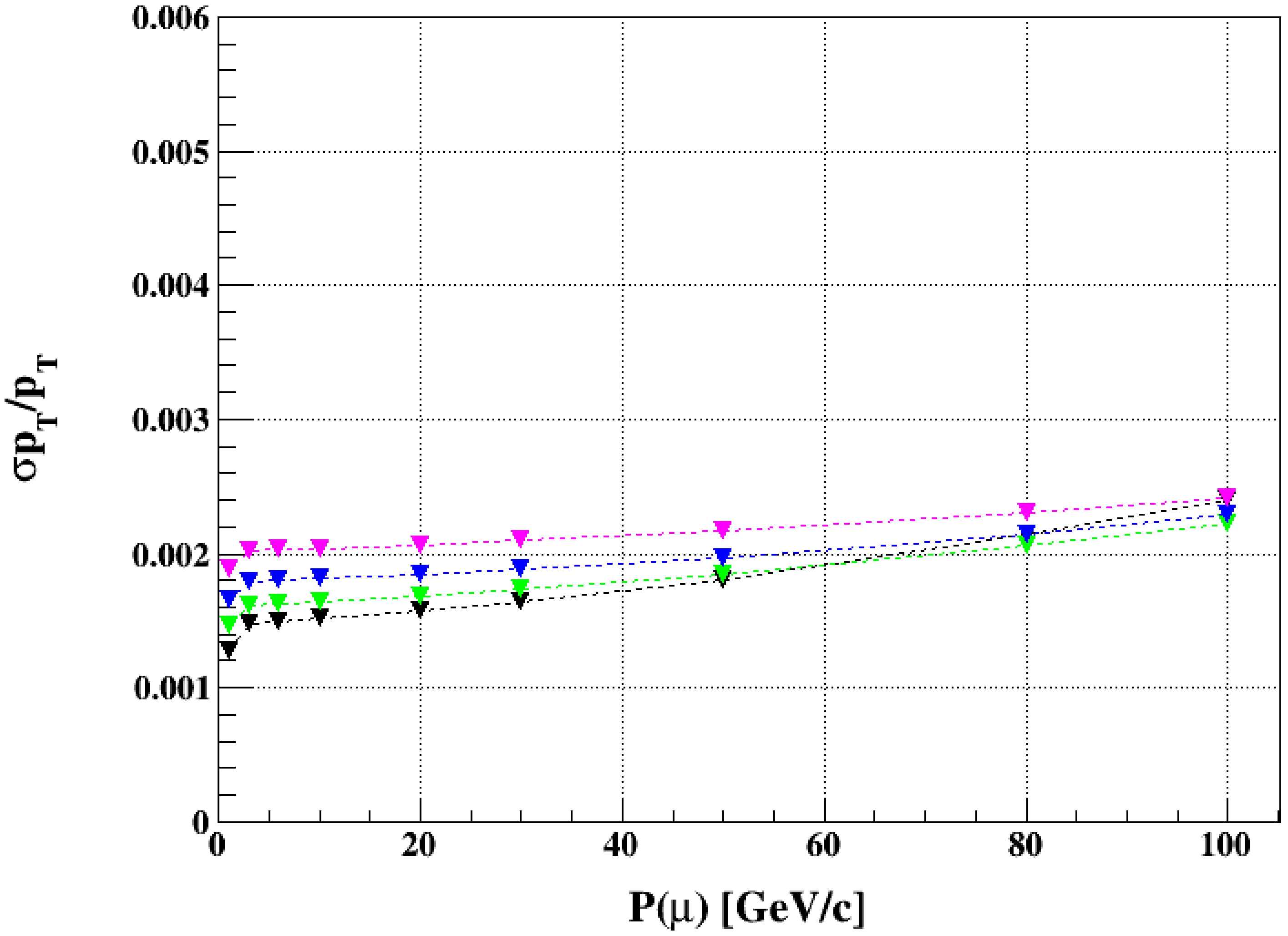
appendix :

- VXD & SIT



Contribution from the detector intrinsic resolution is smaller than only-SIT configuration

Number of SIT layers



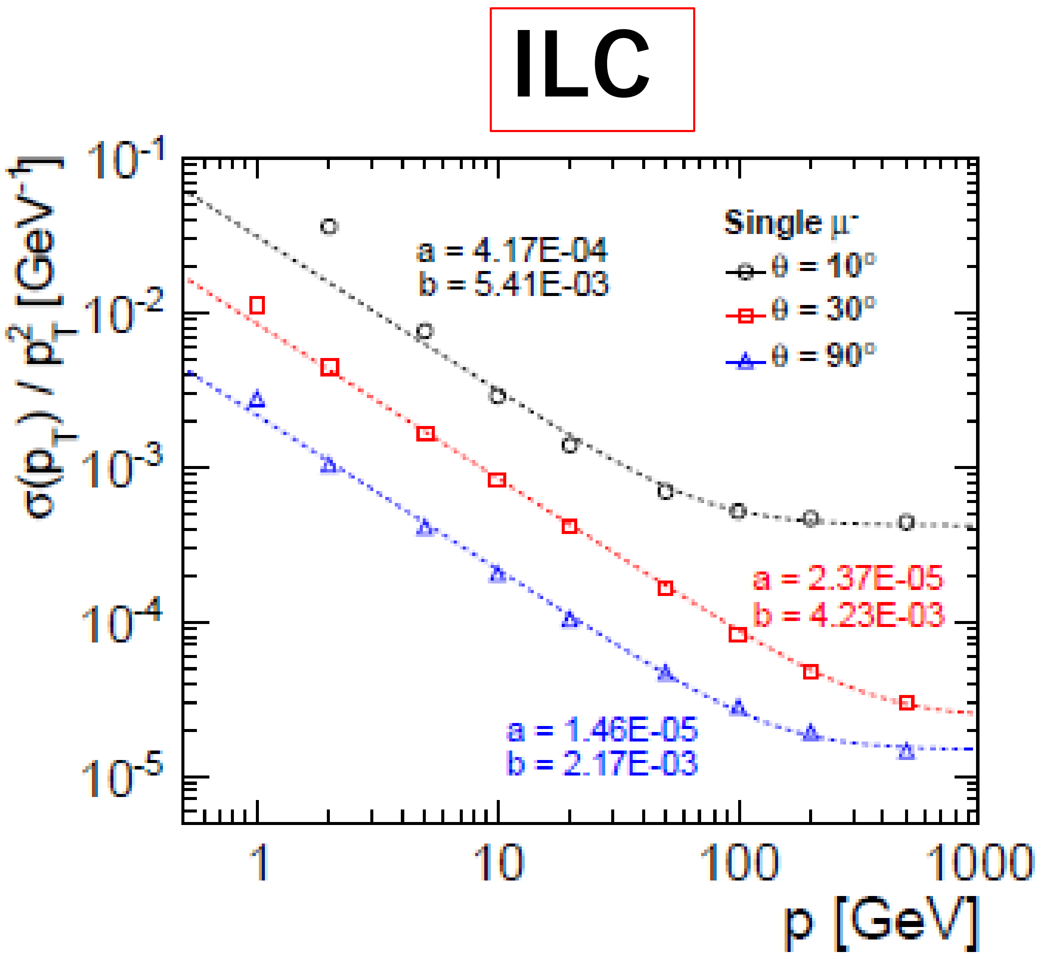
Geometry Setting

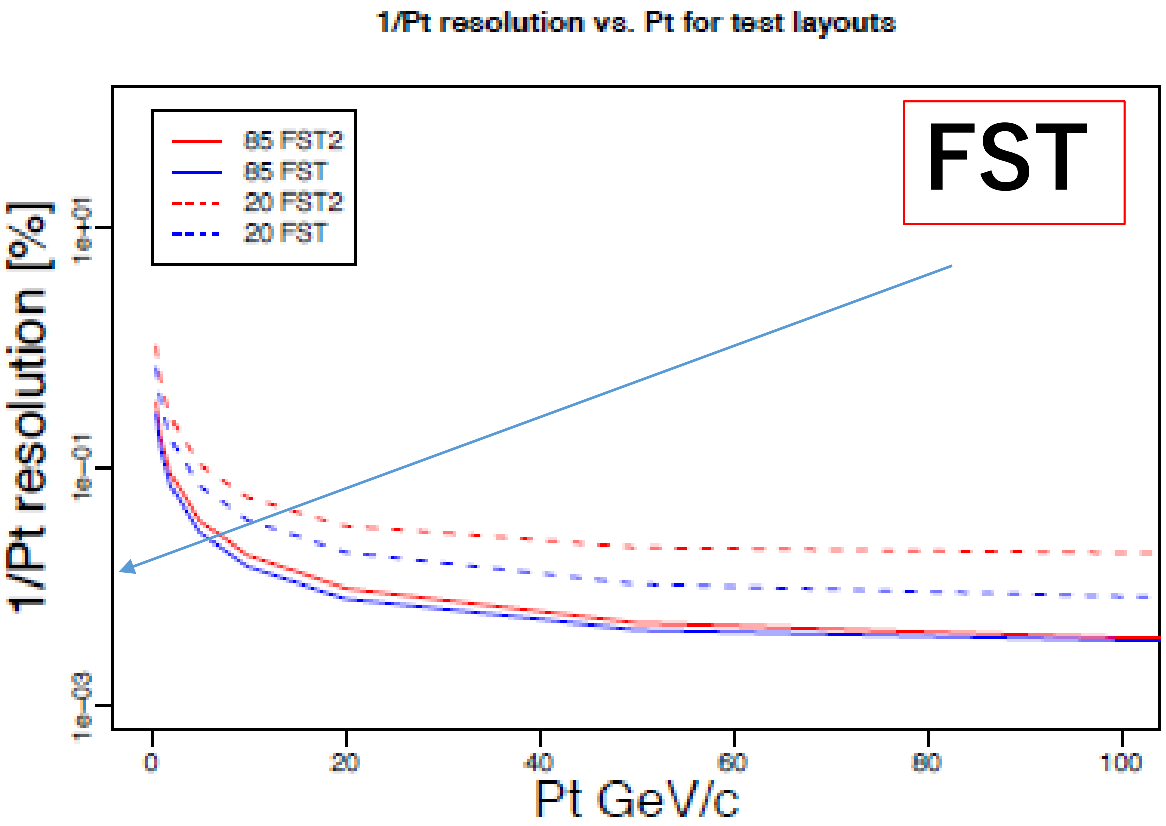
- Rmax = 1.8 m
- Dividing material as initial setting
- Pixel-like, σ=5 μm for Rphi
- VXD setting is as initial
- No DCH yet

```
Silicon External Tracker (SET)

Number of layers                 :   4
Description (optional)           :   |TPC outer wall|-------------External Tracker----------
Names of the layers (opt.)       :   SET1,       XSET1,      XSET2,      SET2,
Radii [mm]                       :   1810.9,     1811.1,     1812.4,     1813.4,
Upper limit in z [mm]            :   2300,       2300,       2300,       2300,
Lower limit in z [mm]            :   -2300,      -2300,      -2300,      -2300,
Efficiency RPhi                  :   0.99,       0,          0,          0,
Efficiency 2nd coord. (eg. z):       0,          0,          0,          0.99,
Stereo angle alpha [Rad]         :   pi/2
Thickness [rad. lengths]         :   0.00213,    0.00468,    0.00468,    0.00213,
error distribution               :   0
0 normal-sigma(RPhi) [1e-6m] :       5
          sigma(z)     [1e-6m] :     250
1 uniform-d(RPhi) [1e-6m]        :
          d(z)     [1e-6m]       :
```

From the CDRs : Momentum Resolution





- thickness : 5%

- geometry : 5 VXD + 5 single-sided SIT

- thickness : 4.5%

- geometry : 6 VXD + 6 double-sided SIT

What parameters can we consider ?

-- B: 3 [T],
-- L: 1.8-0.15 = 1.65 [m]
-- N : 6 (=6layer SIT)
-- σ : 5 [μm]
-- d/X_0 (thickness): 0.01362

in previous page

- thickness
- layer number/composition

-- Material of DCH wall - “1” SIT layer (for radiation length)

-- LGAD like ?

-- track reconstruction / noise / redundancy ? could be considered for the number

Backup

ILC CDR

- Hit resolution better then 5 μm in the barrel
- Less than 0.3% radiation length per layer
- Average power less than 130 $\mu W/mm^2$ in the barrel
- Single bunch time resolution.

Barrel	R	z_{max}	
Layer 1	14	63	
Layer 2	22	63	
Layer 3	35	63	
Layer 4	48	63	
Layer 5	60	63	
Disk	R_{inner}	R_{outer}	z_{center}
Disk 1	14	71	72
Disk 2	16	71	92
Disk 3	18	71	123
Disk 4	20	71	172
Forward Disk	R_{inner}	R_{outer}	z_{center}
Disk 1	28	166	207
Disk 2	76	166	541
Disk 3	117	166	832

The geometry parameters of the vertex detectors are summarised in Table II-2.1. The five barrel sensor layers are arranged at radii ranging from 14 to 60 mm. The vertex detector also has four disk layers supported by carbon-fibre support disks at z positions ranging from about 72 to 172 mm. The innermost disk covers radii from 14 mm out to 71 mm. Forward tracking continues beyond the vertex detector proper with three additional small pixel disks, extending in z from about 207 to 832 mm. The vertex barrel and inner endcaps have $\approx 20 \times 20$ μm pixels. The pixel size increases to $\approx 50 \times 50$ μm^2 for the forward tracker disks. The total area of the vertex barrels is 1.63×10^5 mm^2 and is 0.59×10^5 mm^2 for each set of 4 inner pixel disks and 1.96×10^5 mm^2 for each set of 3 forward pixel disks. The simulation described in the following chapters assumes 0.1% radiation length per layer excluding cables and 20×20 μm pixels for the forward tracker disks.

CEPC CDR

- material budget is smaller than current setting

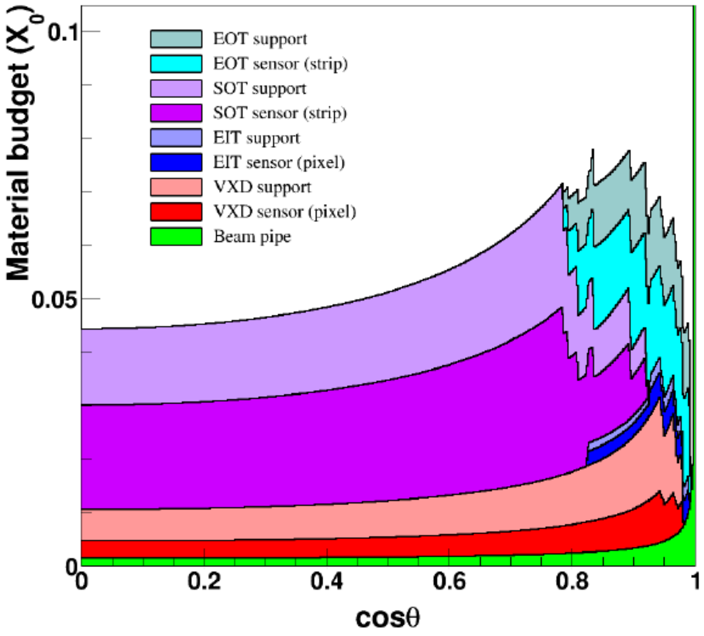


Figure 4.25: The amount of material of the full tracker with the FST option highlighting contributions from the VXD and SOT in the barrel, and the EIT and EOT in the endcap.

The performance of the FST tracker was studied using the same Mokka simulation tool as for the study of the CEPC baseline detector by substituting the baseline tracker with the FST tracker while keeping all other detector elements unchanged. In the simulation, the silicon tracker was represented by planar structures with each plane consisting of a silicon layer of 150 μm thick with a pitch size of 50 μm. Each layer was composed of several ladders which were further divided into multiple sensors. The stereo angles are 7° for the SOT layers and 5° for the EOT layers.

The amount of material of the whole tracker is about 5% in the barrel and about 8% in the endcap as shown in Figure 4.25, including breakdowns from individual components of the tracker. The zigzag structures in the endcap are caused by the alternation and overlap of layers.

back-to-back , thus, 300 μm