CPEC Tracking System Optimization

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On behalf of the CEPC Tracker Team

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Contents

1. Motivation by now
2. Research on Scale 5
3. The general results
4. Summary

Motivation by now

find out **the influence on momentum resolution by the number of DC layers** in barrel geometry

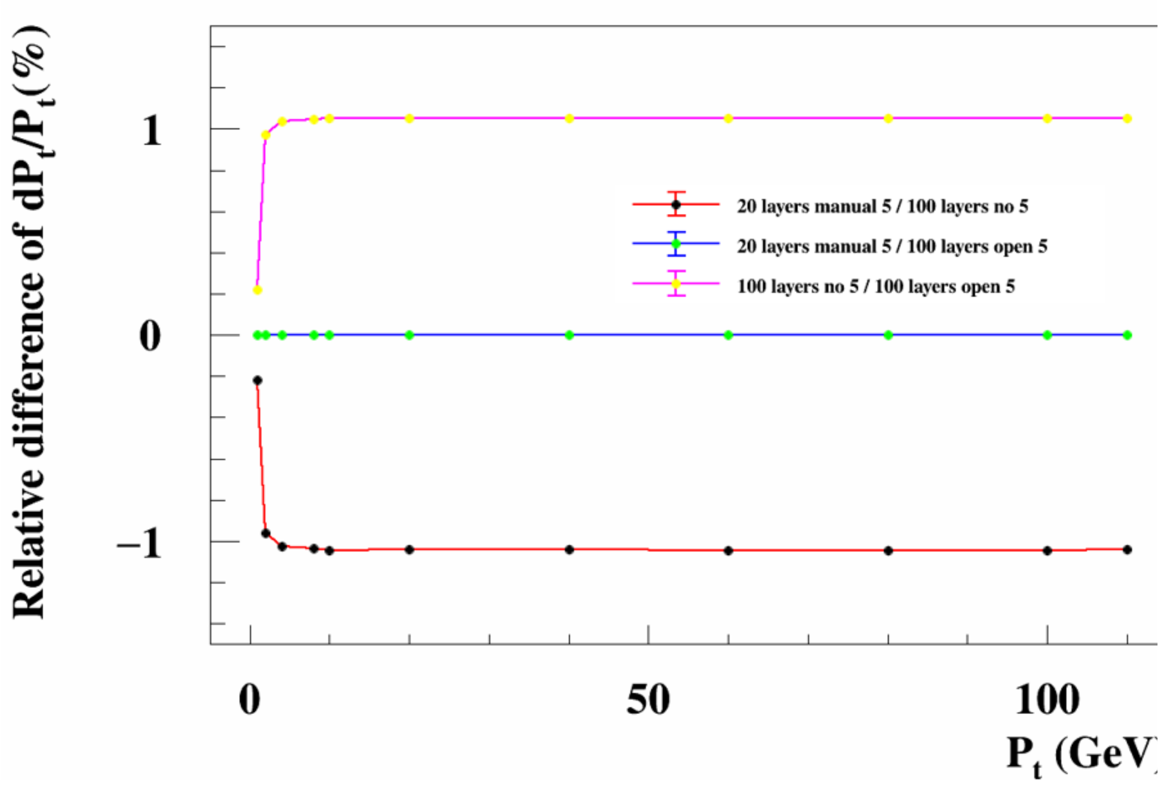
Research on Scale 5

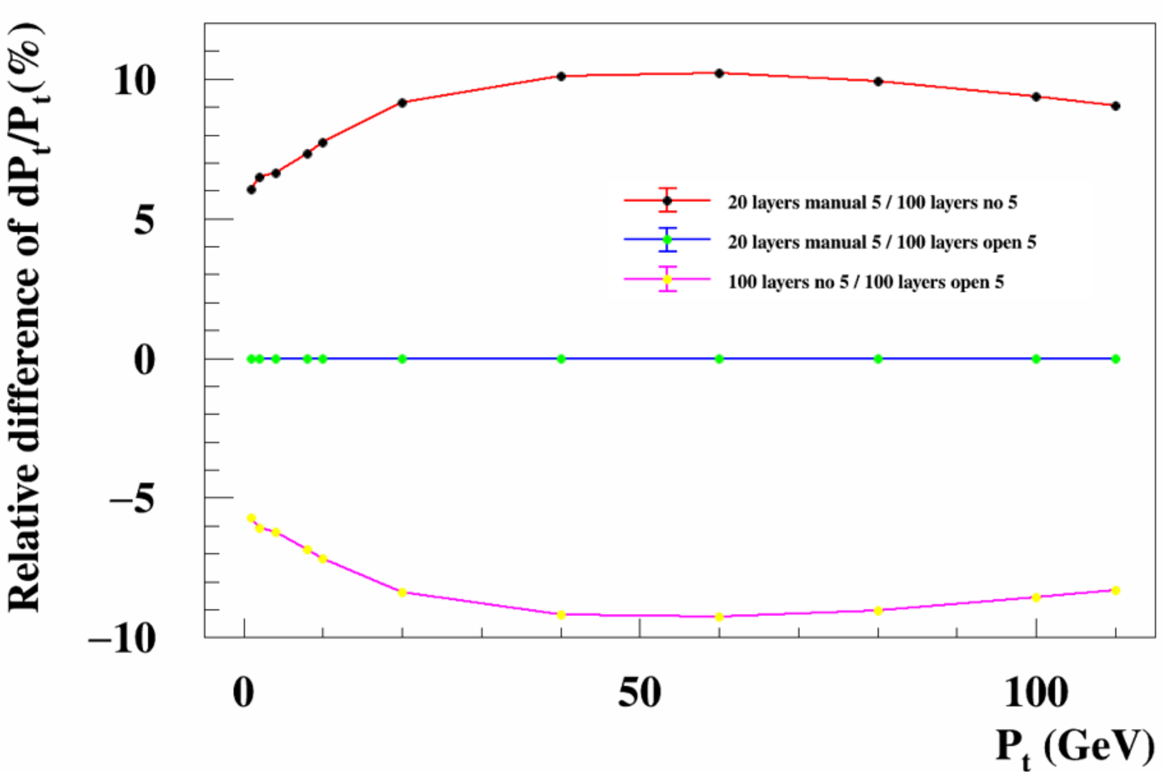
At previous report, I misunderstood a statement in ‘LDT user’s guide’ which is about what does it do if the flag ‘Scale down by factor 5’ is on.

This time we corrected it that the right way is the layers are divided by 5, the thickness is multiplied by 5 and the resolution is divided by $\sqrt{5}$. While the way to do scale 5 by manual is going to be singed by ‘manual 5’ in the following plots.

Research on Scale 5

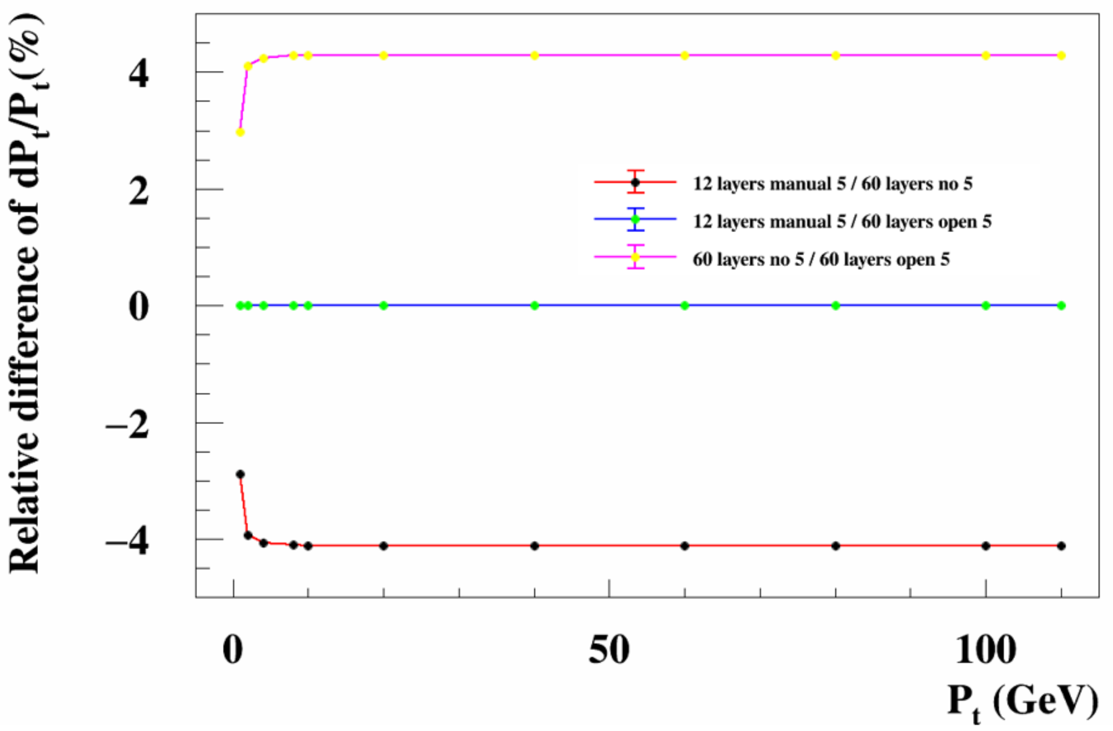
Compare 100 layers with $\sigma_{RPhi} = 100\mu m$ and thickness = 0.001 ; left : no multiple scattering ; right : open it

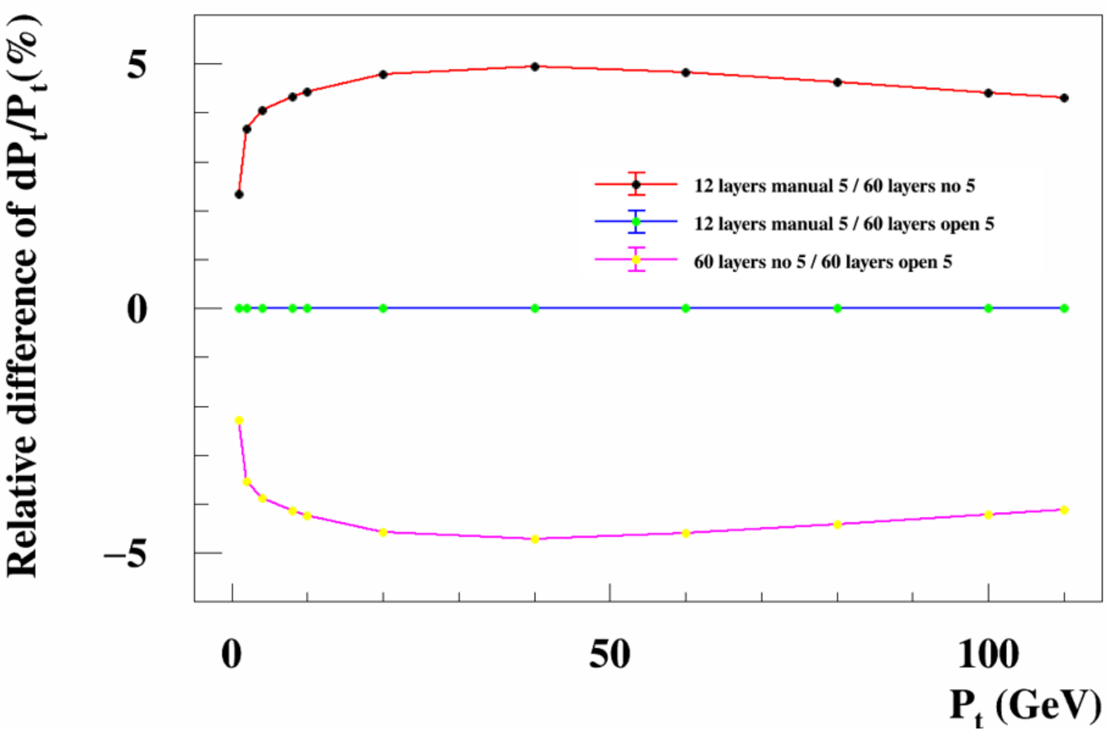




Research on Scale 5

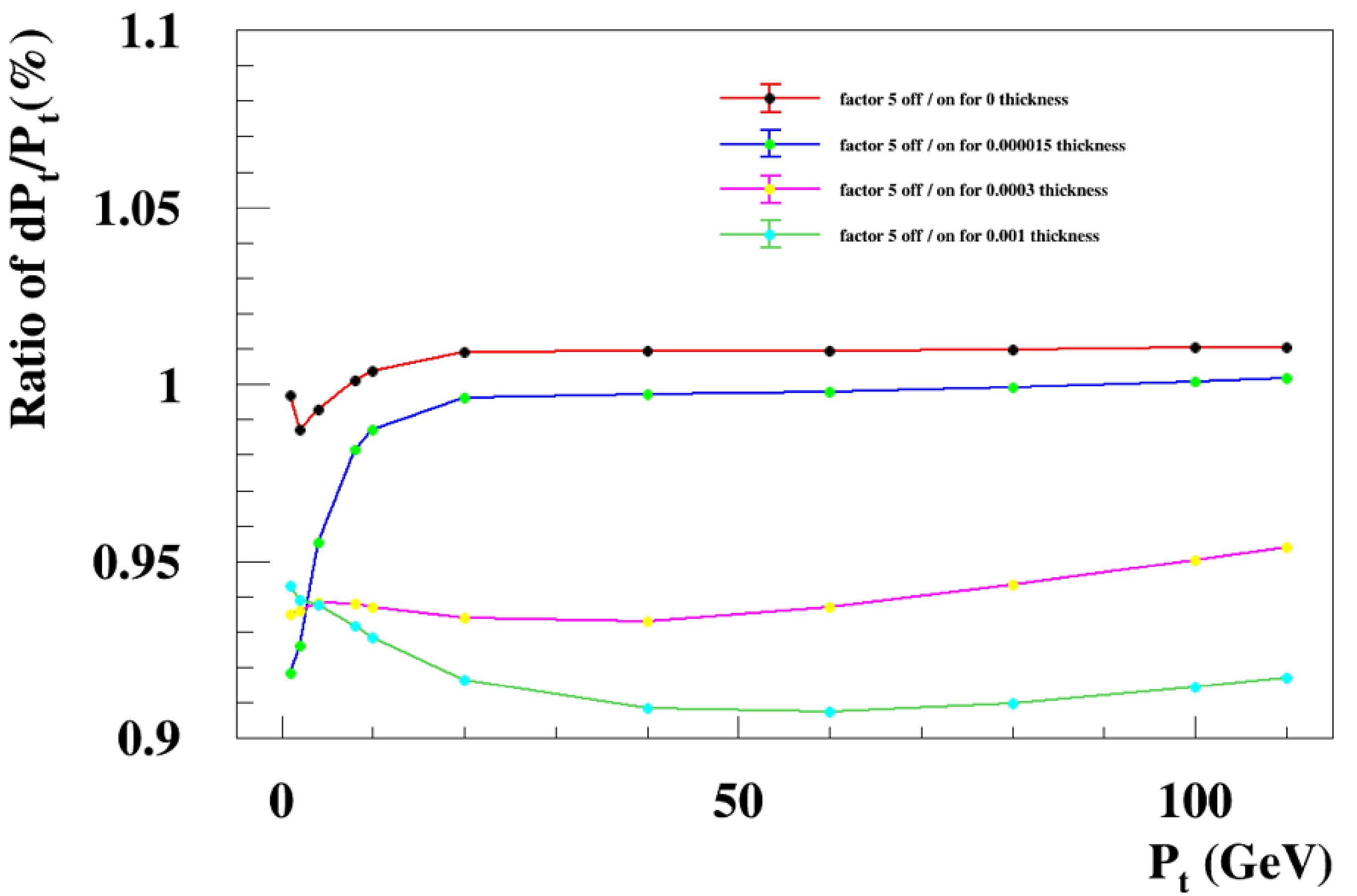
Compare 60 layers with $\sigma_{RPhi} = 100\mu m$ and thickness = 0.001 ; left : no multiple scattering ; right : open it





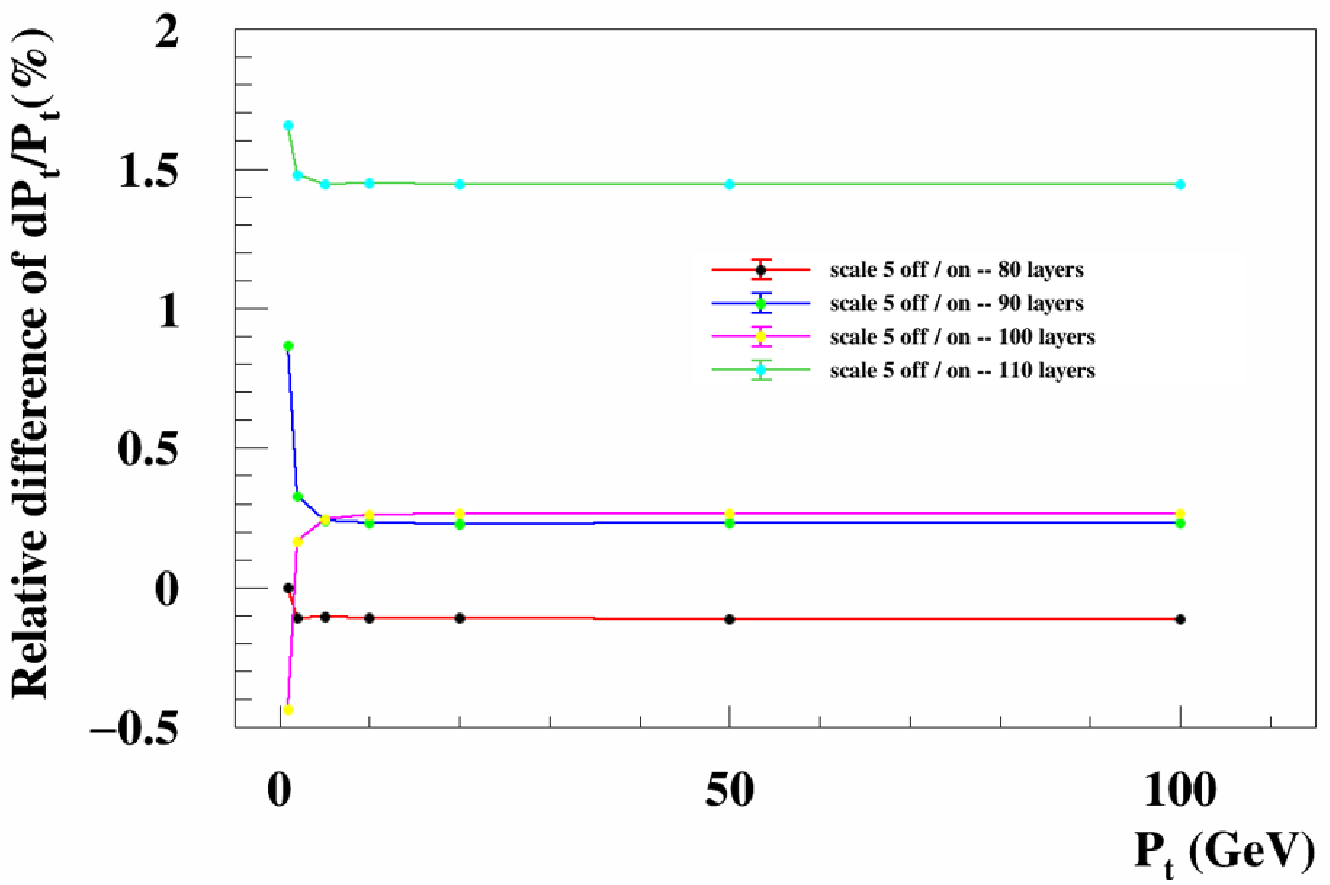
Research on Scale 5

Compare different thickness for 100 layers with $\sigma_{RPhi} = 100\mu m$; open multiple scattering



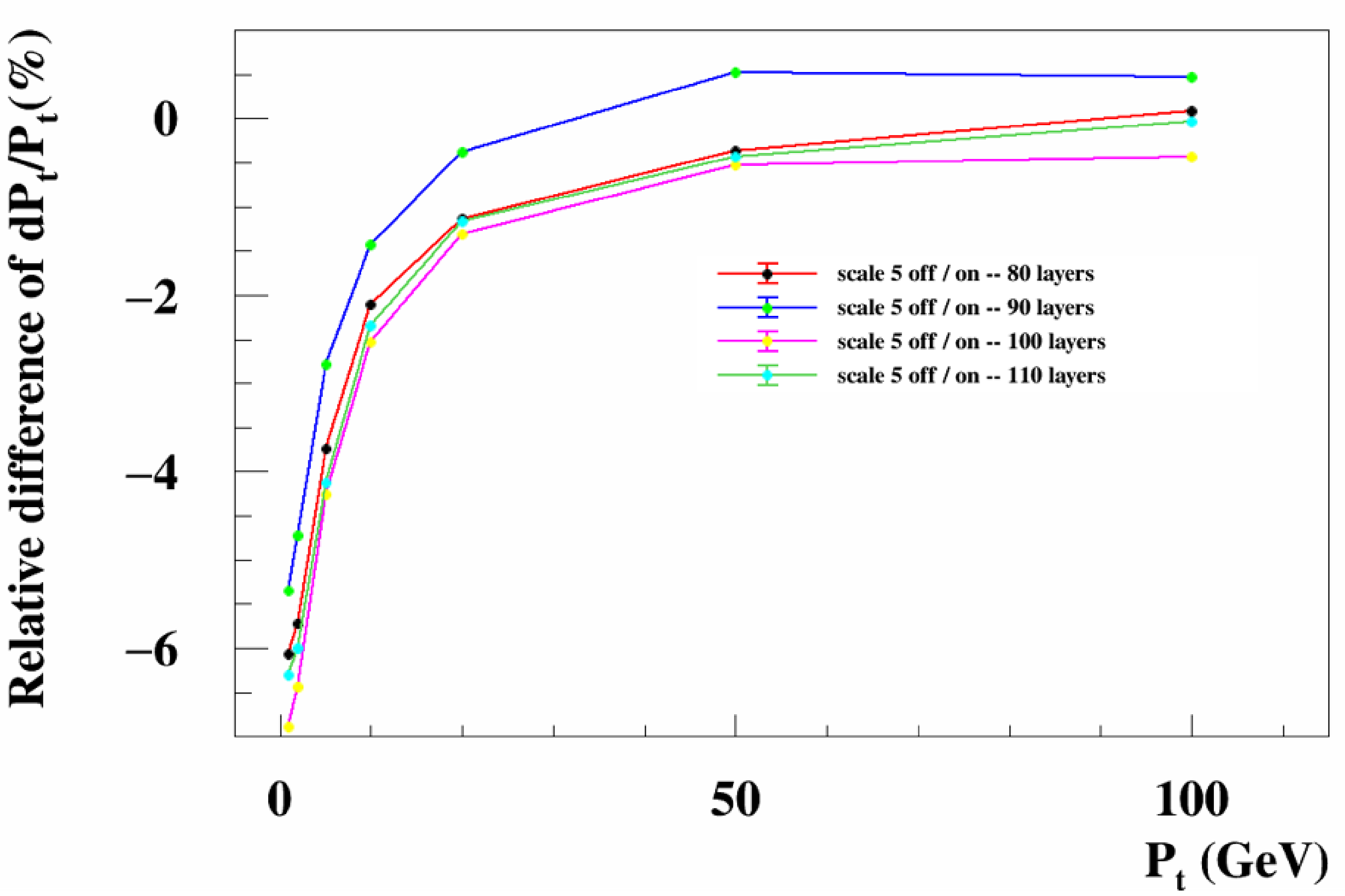
Research on Scale 5

Compare 80, 90, 100, 110 layers with $\sigma_{RPhi} = 100\mu m$ and total thickness = 0.003356 ; no multi-scattering



Research on Scale 5

Compare 80, 90, 100, 110 layers with $\sigma_{RPhi} = 100\mu m$ and total thickness = 0.003356 ; open multi-scattering



Research on Scale 5

To conclude,

1. Without multiple scattering, the fitting track process can be understood very well (such as the method of least squares). The resolution of Pt is decided by resolution of detector, while the different positions of layers for detector could take different influence to dPt/Pt too, which can explain why the scale 5 would take difference (with layers are divided by 5, the positions shall be changed).

2. Considering multiple scattering, the different layers shall have correlations to each other because a random process of multiple scattering at one layer could affect the track in the following parts. So the scale 5 absolutely would cause difference, while the less thickness of each layer causes the less influence, which is corresponding to the results ahead.

3. Though the scale 5 could causes difference, we compared it in range of 80 – 110 layers which is almost what we really care in the following research and the results testified the difference is reliable.

The general results

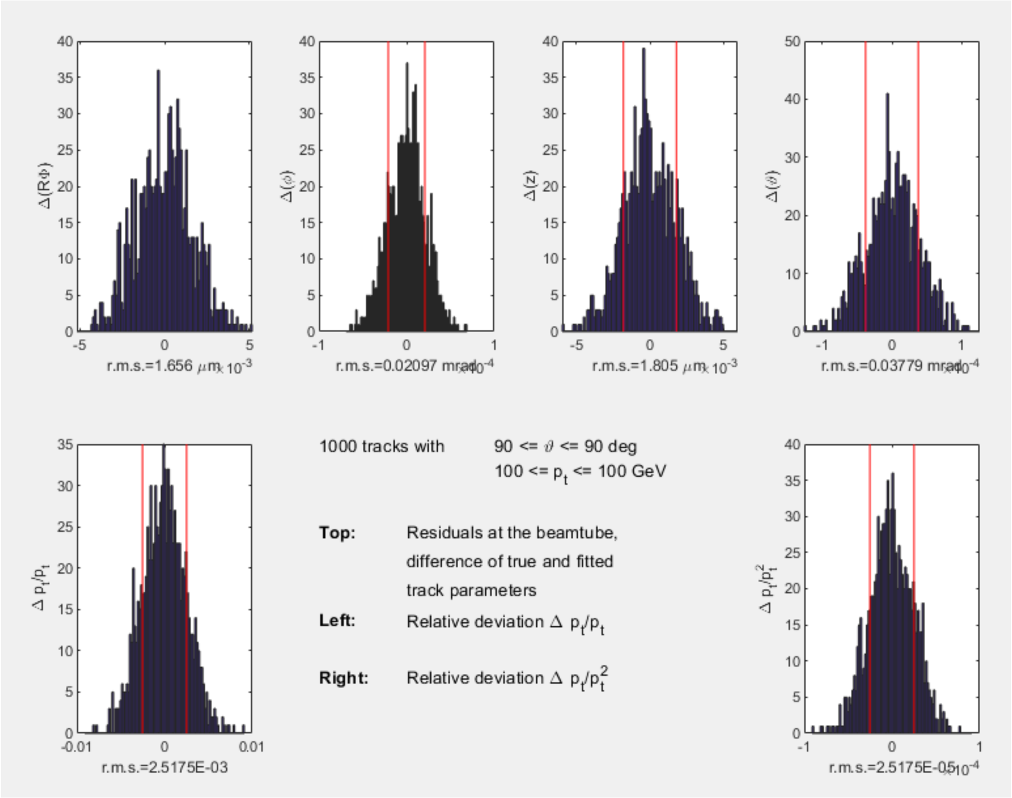
At last report, we presented two general curves on influence of different layers for dPt/Pt, while the number of tracks simulated was too small to make them clear enough.

This time we amplified the tracks by 10 times from 1000 to 10000.

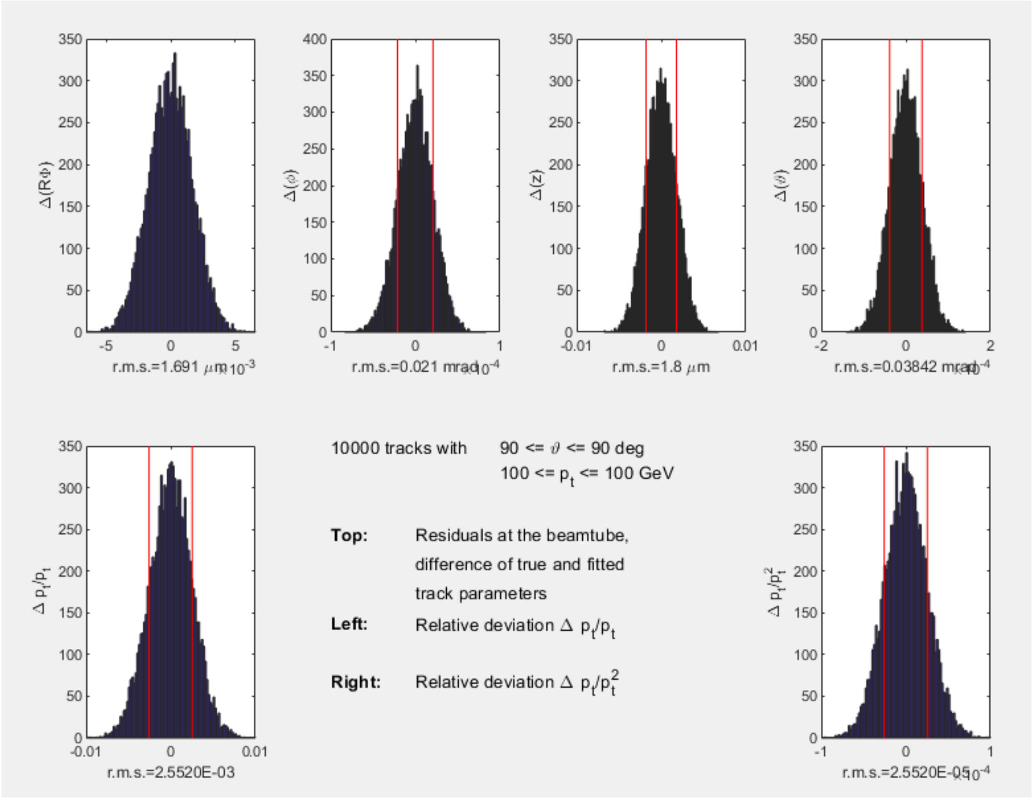
We check out the ratio of dPt/Pt from 10 to 150 layers in DC comparing with that from 0 layer, with σ_RPhi=100μm and total thickness = 0.003356, while the scale 5 is turned off.

The general results

The distribution of parameters by 1000 tracks.

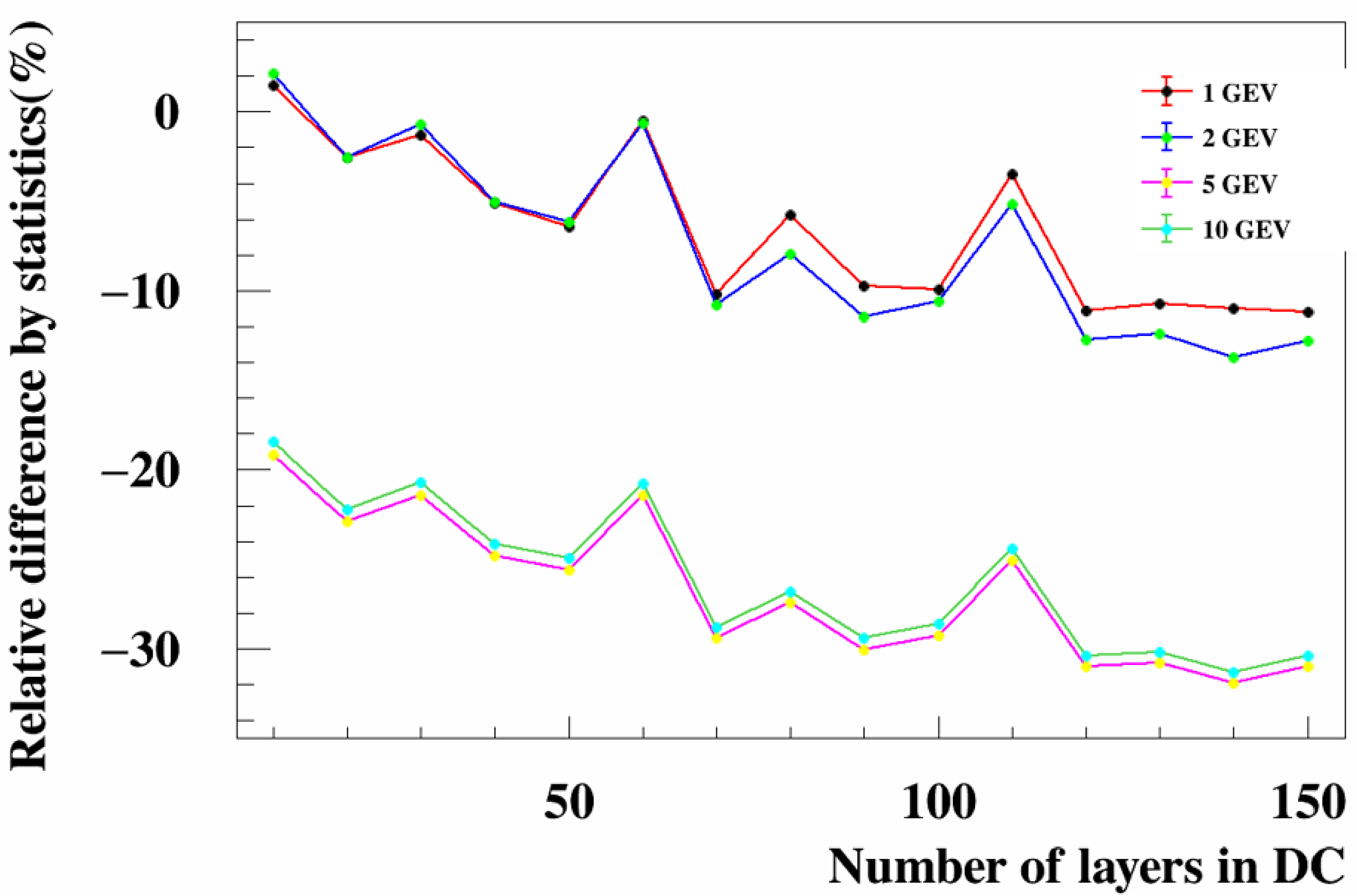


The distribution of parameters by 10000 tracks.



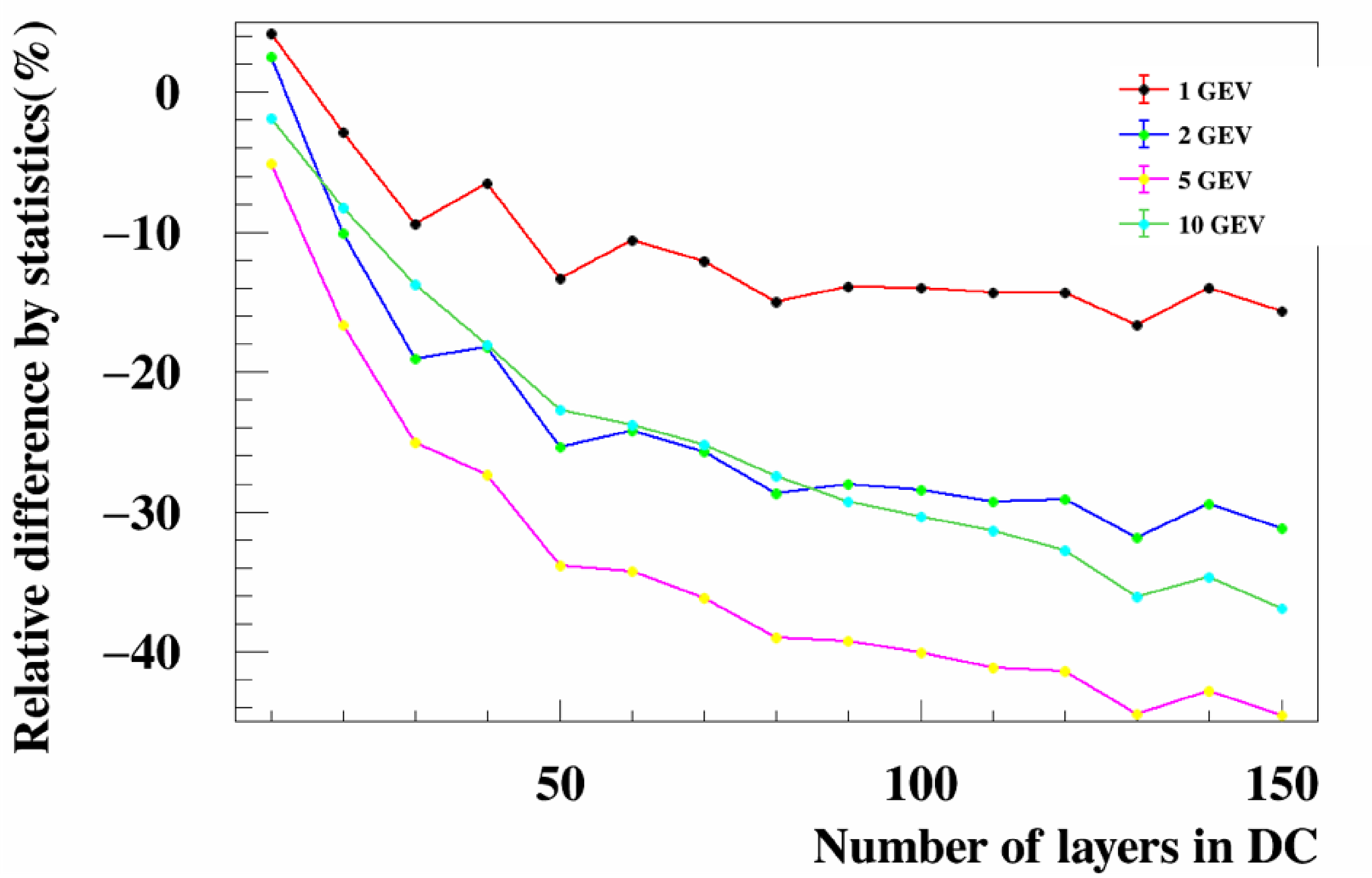
The general results

the influence from statistics for dPt/Pt by comparing 1000 tracks to 10000 tracks without multiple scattering



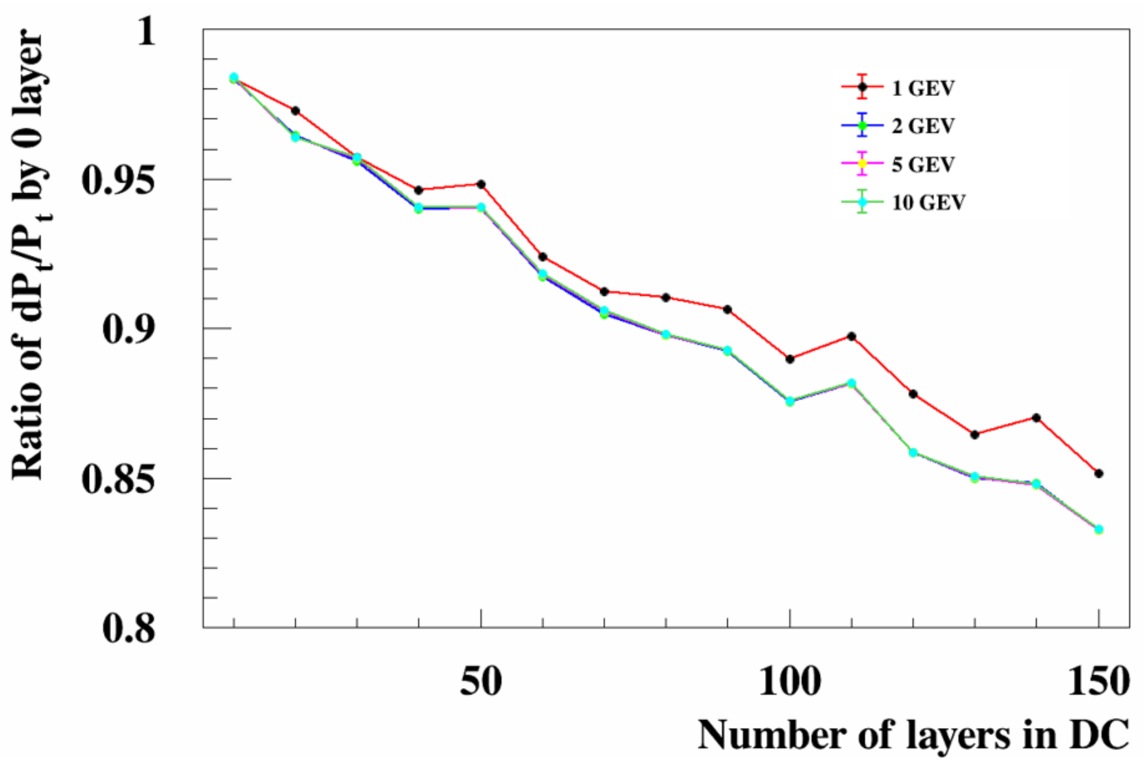
The general results

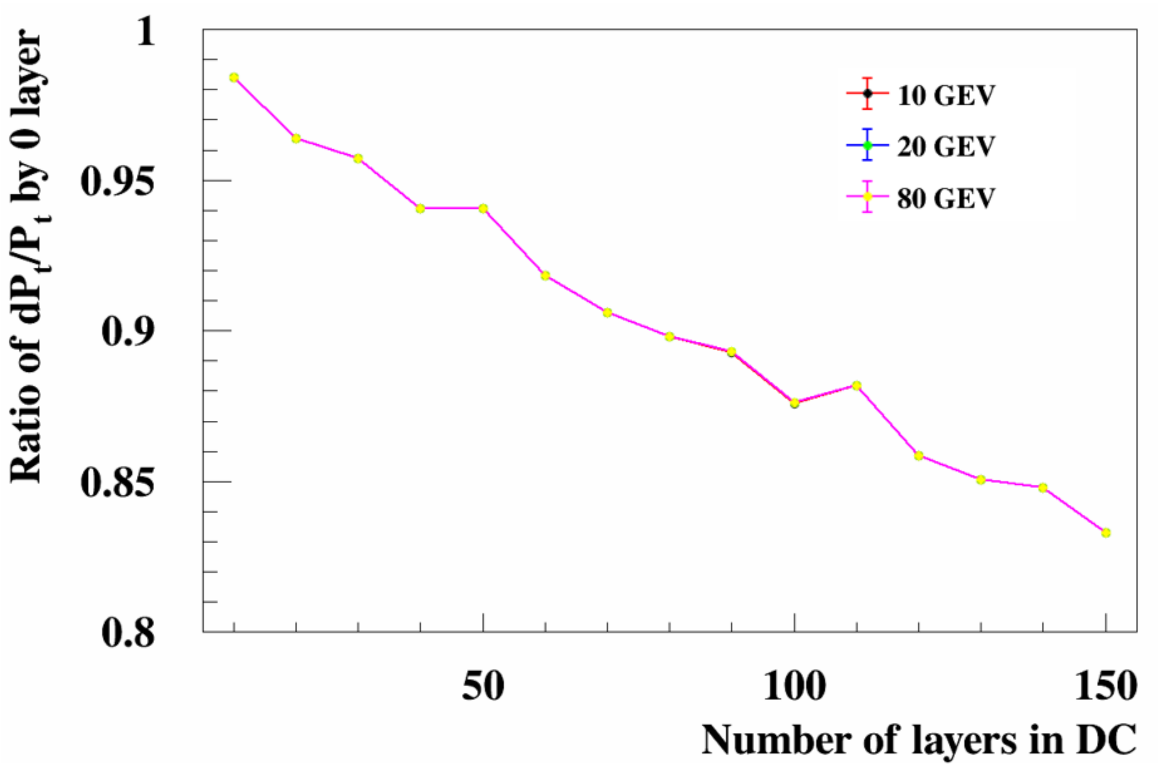
the influence from statistics for dPt/Pt by comparing 1000 tracks to 10000 tracks with multiple scattering



The general results

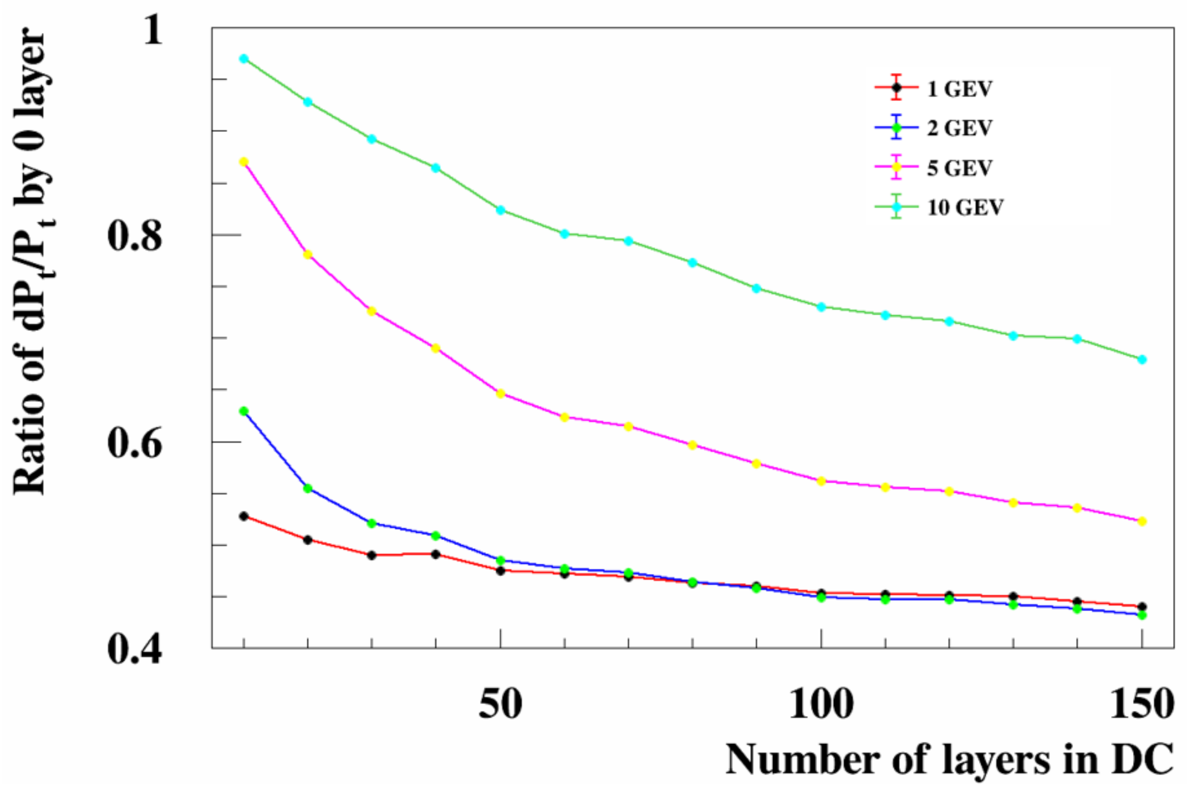
The general result of momentum resolution by 10 to 150 layers in DC, while the multiple scattering is off.

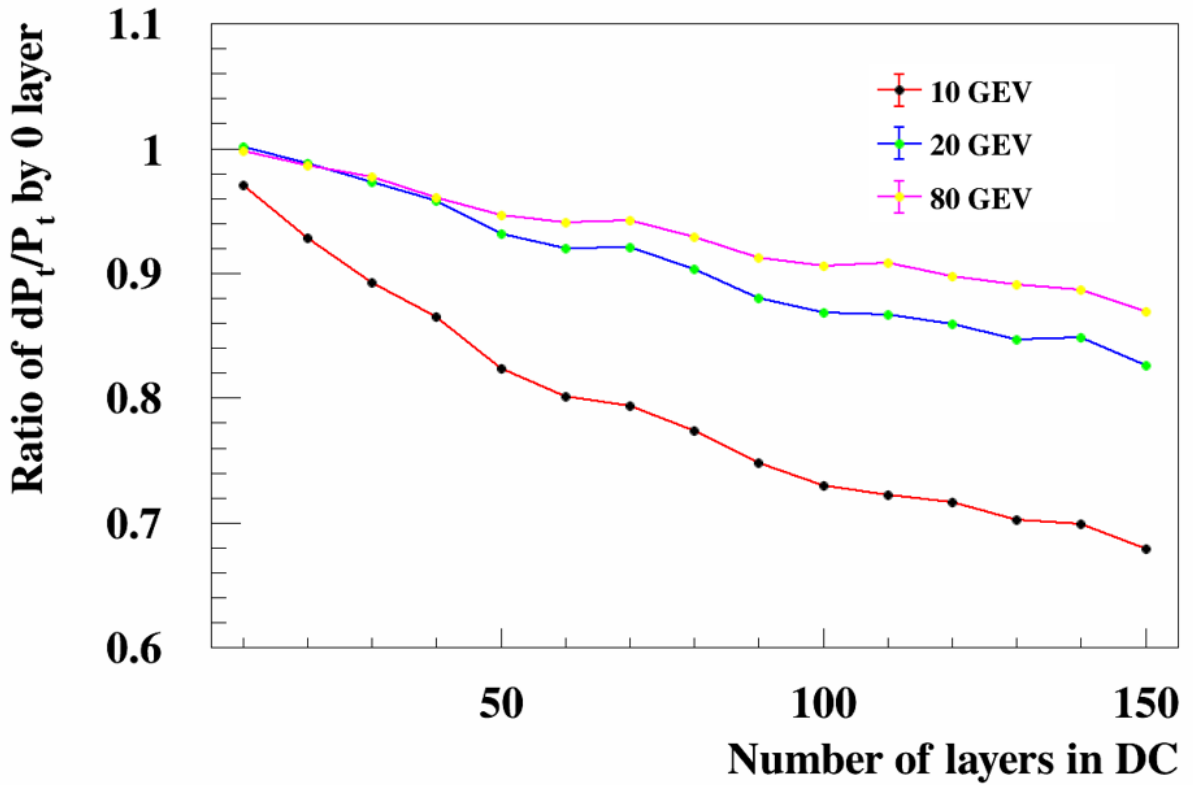




The general results

The general result of momentum resolution by 10 to 150 layers in DC, while the multiple scattering is on.





The general results

To conclude,

1. The statistics affects the results much, while more momenta needs more tracks to get a better fitted Gaussian distribution. By comparing the momentum resolution from 1000 tracks and 10000 tracks, we could believe it that our general results are reliable.
2. Without multiple scattering, the dPt/Pt decreases with the number of layers in DC increases obviously, which is corresponding to our initial conjecture.
3. Considering multiple scattering, the general trend of momentum resolution is still more layers takes better resolution. But the changing rate becomes flat when the number of layers catches a range because of the multiple scattering.

Summary

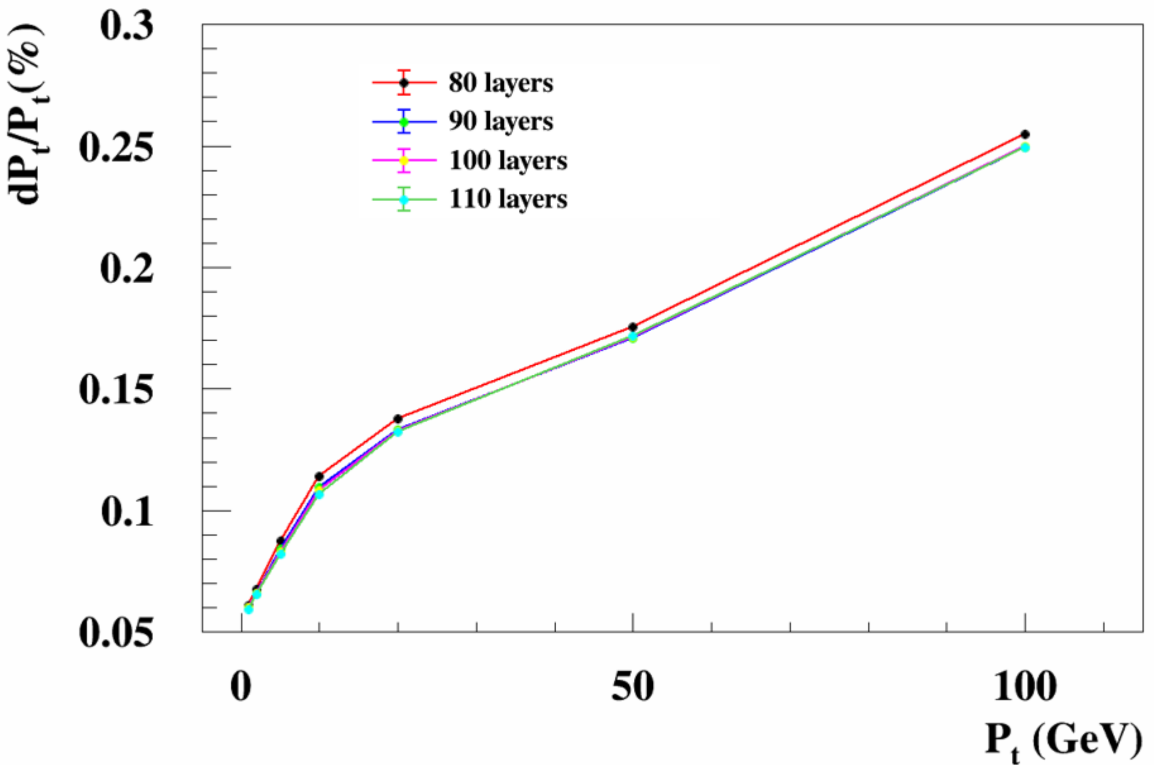
1. The scale 5 is just a mathematic way to make detector setups simpler, we have totally understood it. This method absolutely could cause difference which is much small if there is no multiple scattering, while this difference would be a little obvious if the multiple scattering is considered. By checking its influence from 80 to 110 layers, the idea is that we could use it if we have a request on simulation speed and just want to check a result cursorily, but we **had better turn off it** if we want to get the results more exact.
2. By amplifying the tracks number, we could get a general conclusion that more layers could take less resolution for momentum but this trend would become flat if the number has arrived a value. What is more, if we really want to change the number of layers in DC, the global position, the material budget, and the total radius of it shall be changed. So here we just give a general suggestion that **the 90 to 110 layers in DC** seems a good range for the following researches.

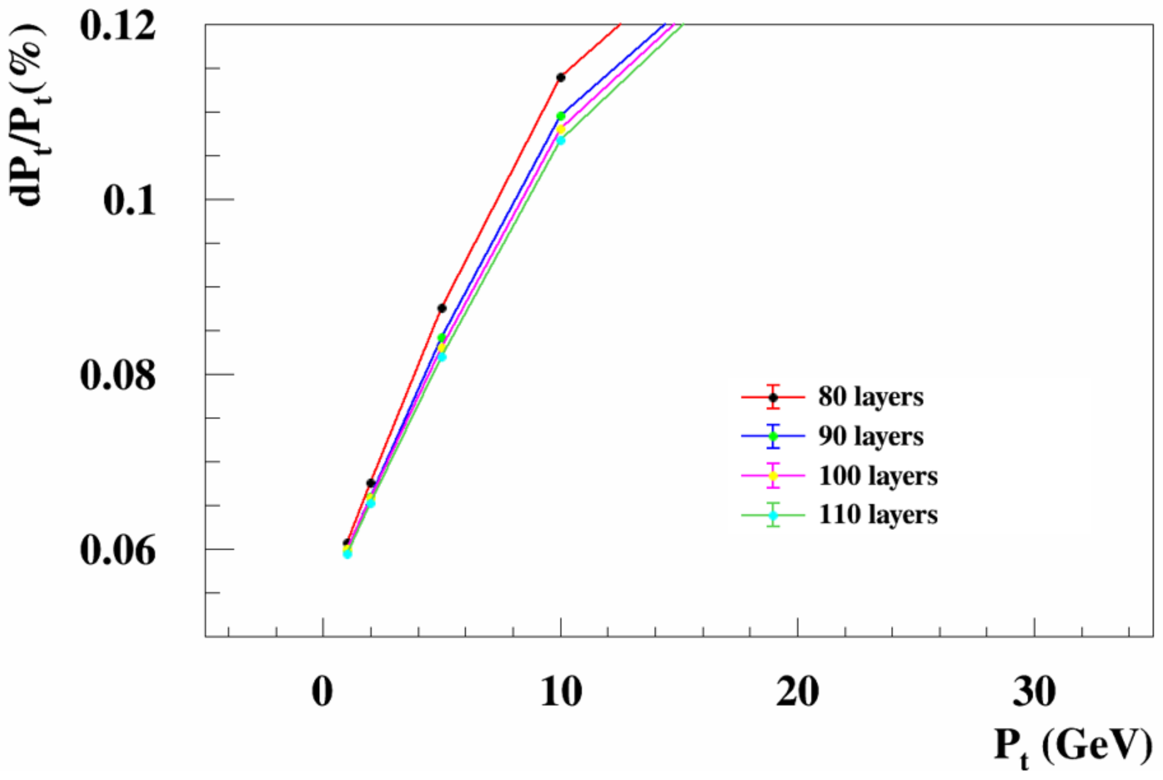
Thanks

Questions & Suggestions

Backup

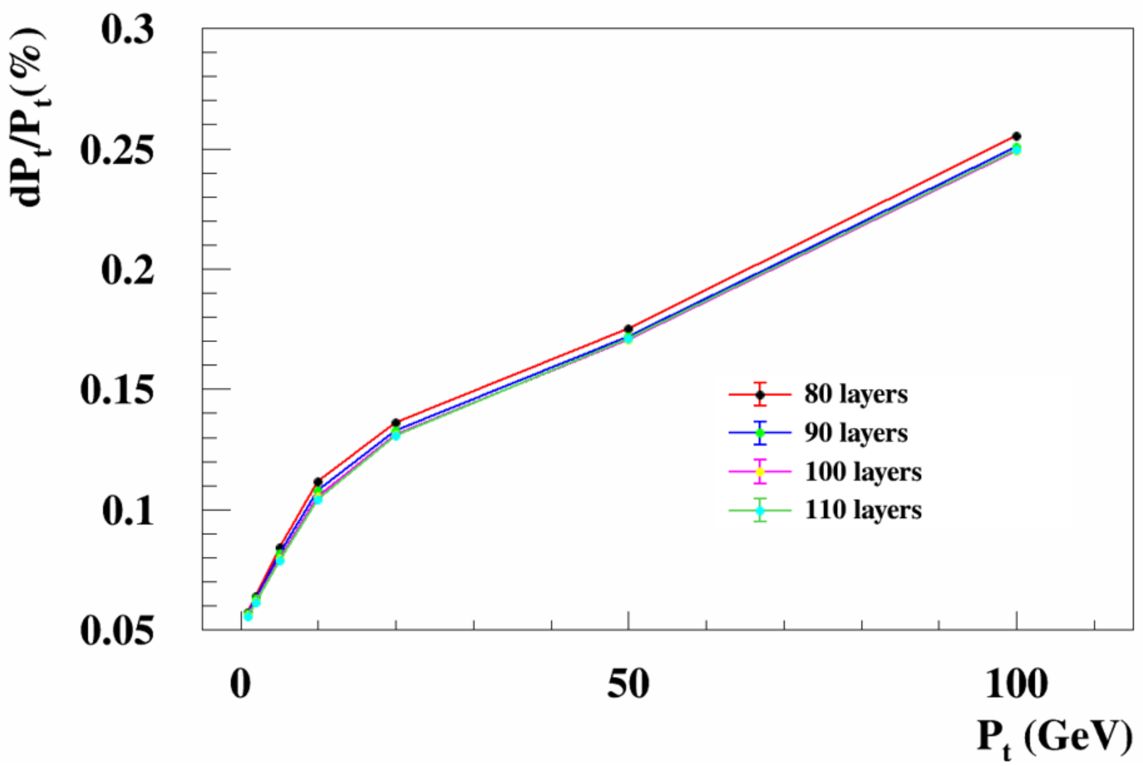
Compare 80, 90, 100, 110 layers with $\sigma_{RPhi} = 100\mu m$ and total thickness = 0.003356 ; open multi-scattering ; open scale 5

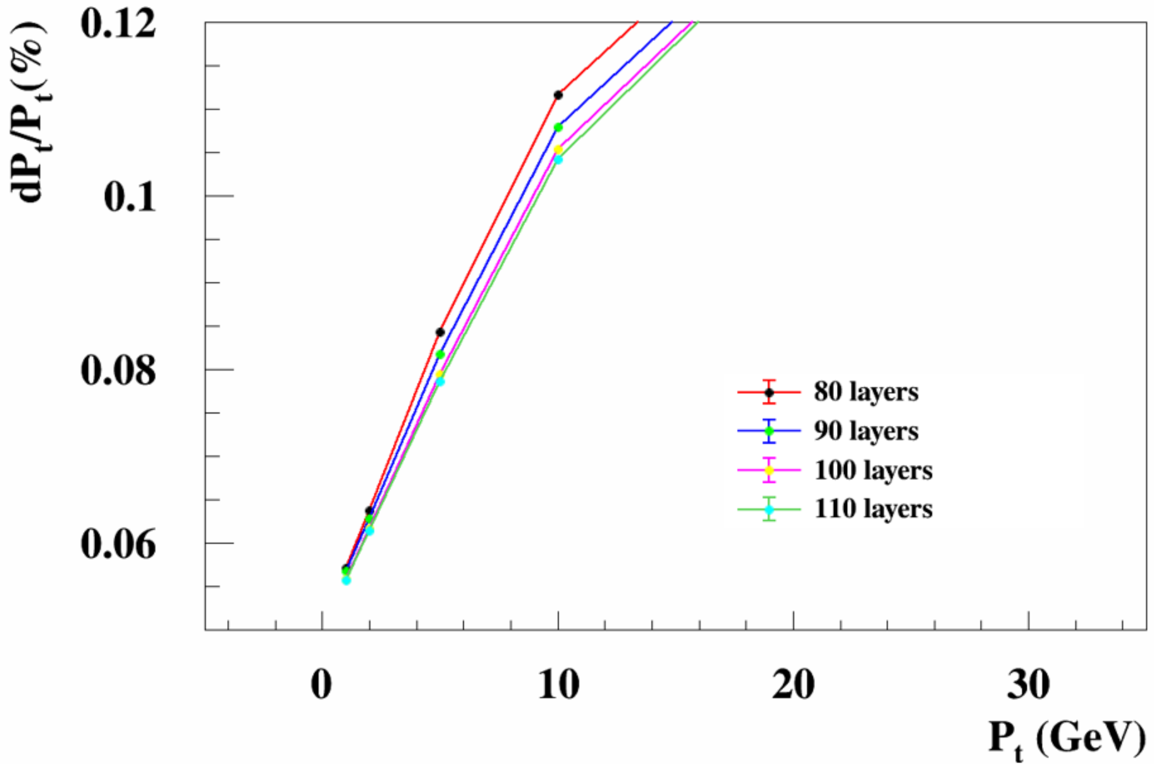




Backup

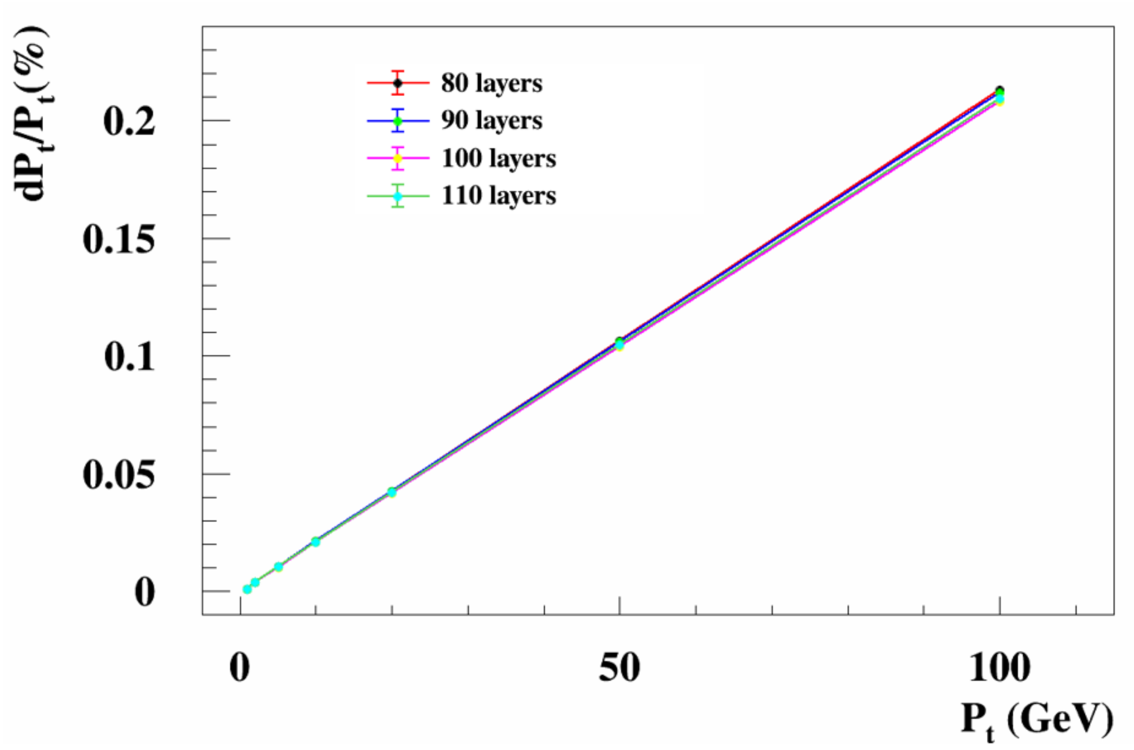
Compare 80, 90, 100, 110 layers with $\sigma_{RPhi} = 100\mu m$ and total thickness = 0.003356 ; open multi-scattering ; no scale 5

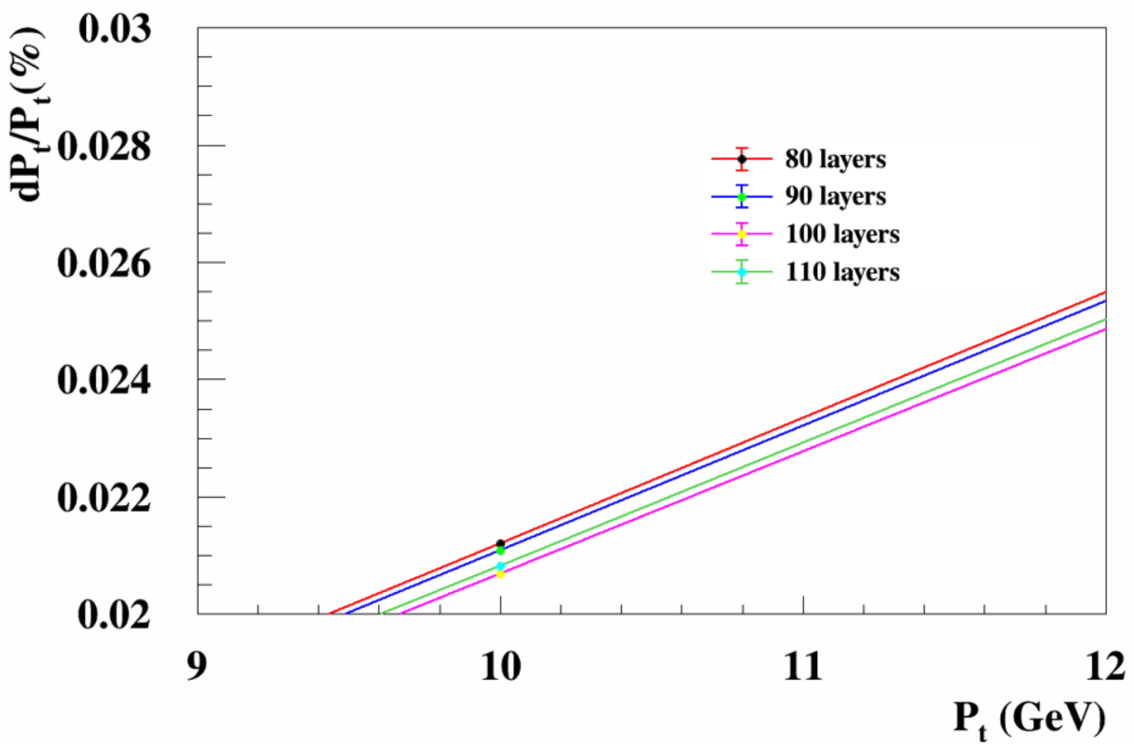




Backup

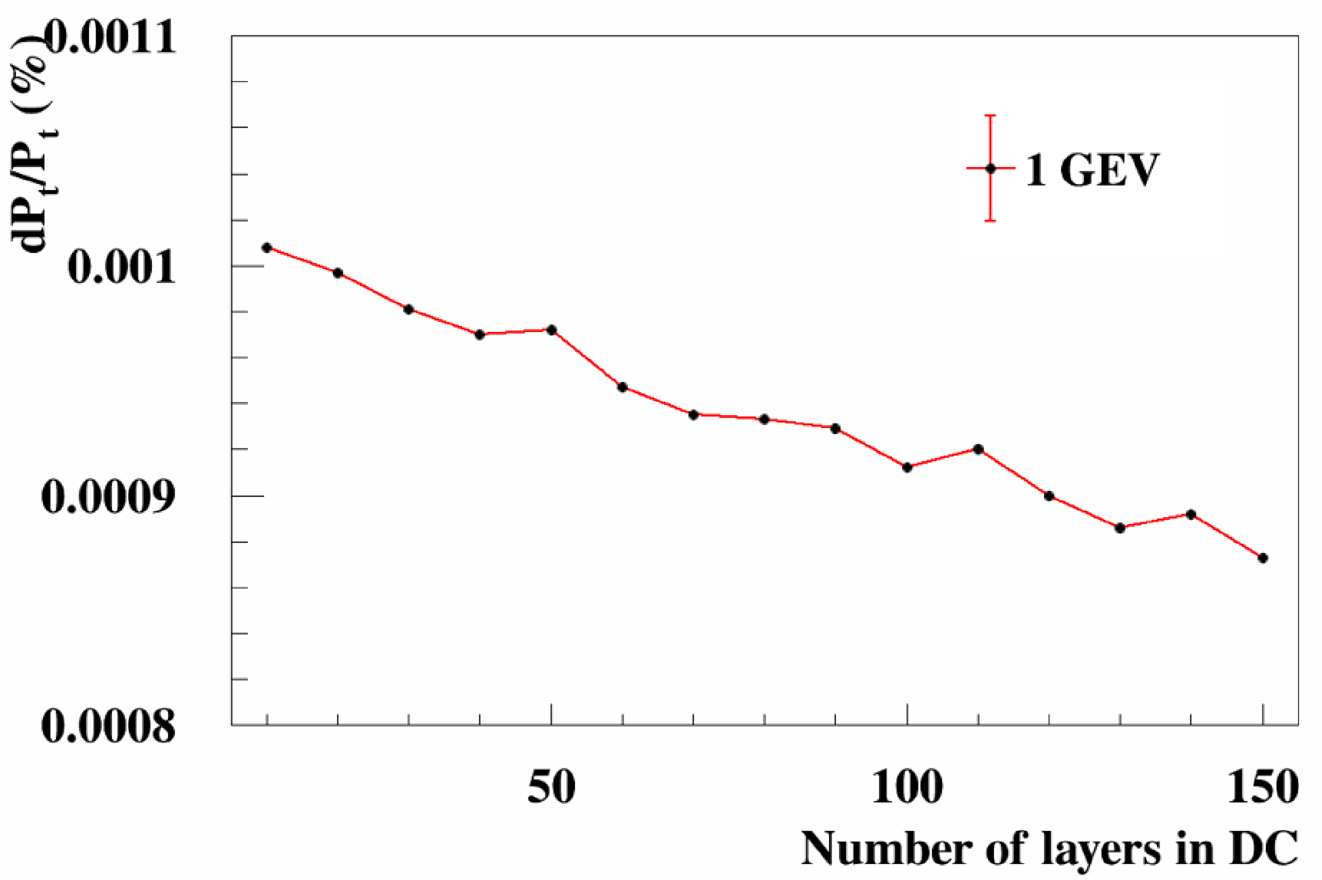
Compare 80, 90, 100, 110 layers with $\sigma_{RPhi} = 100\mu m$ and total thickness = 0.003356 ; no multi-scattering ; no scale 5





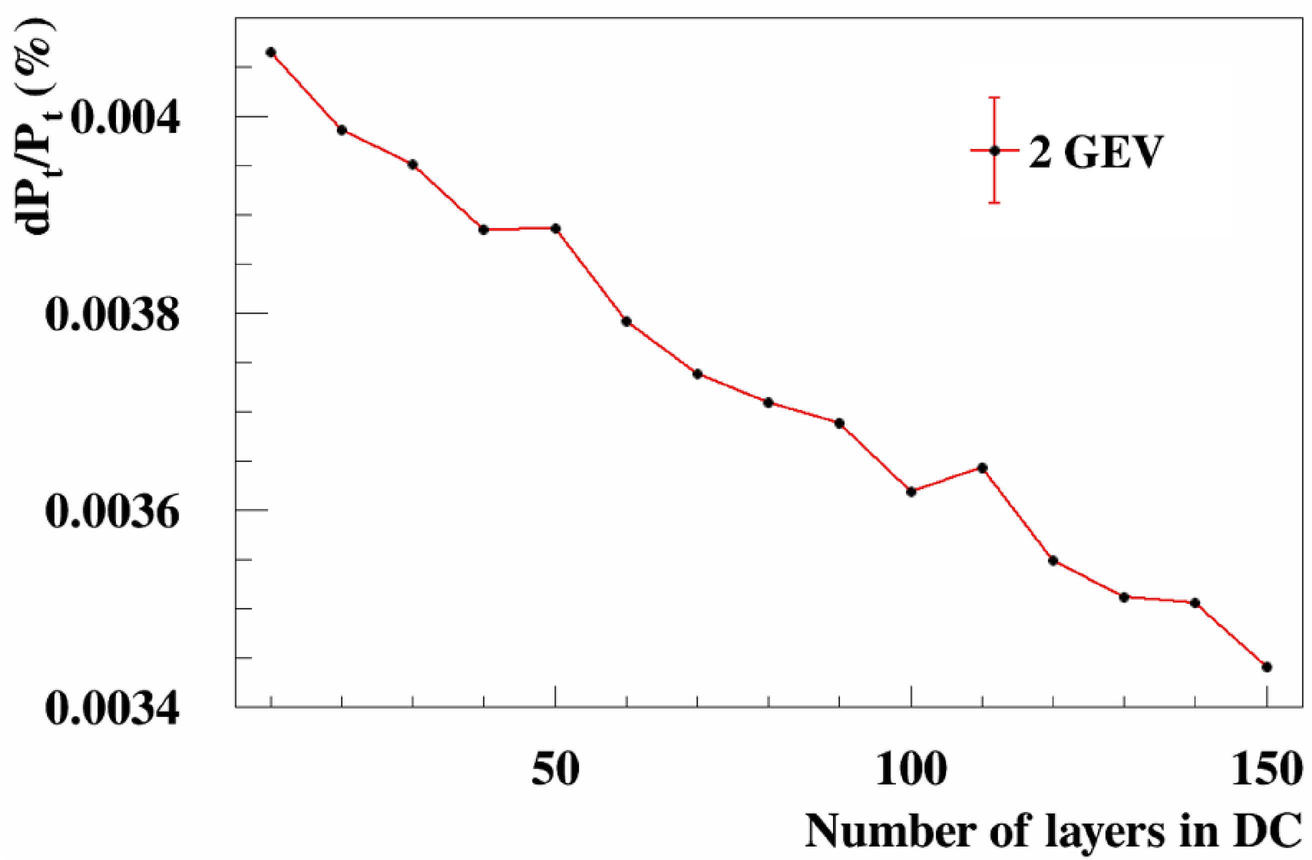
Backup

the value of dPt/Pt in **The general results**, without multiple scattering



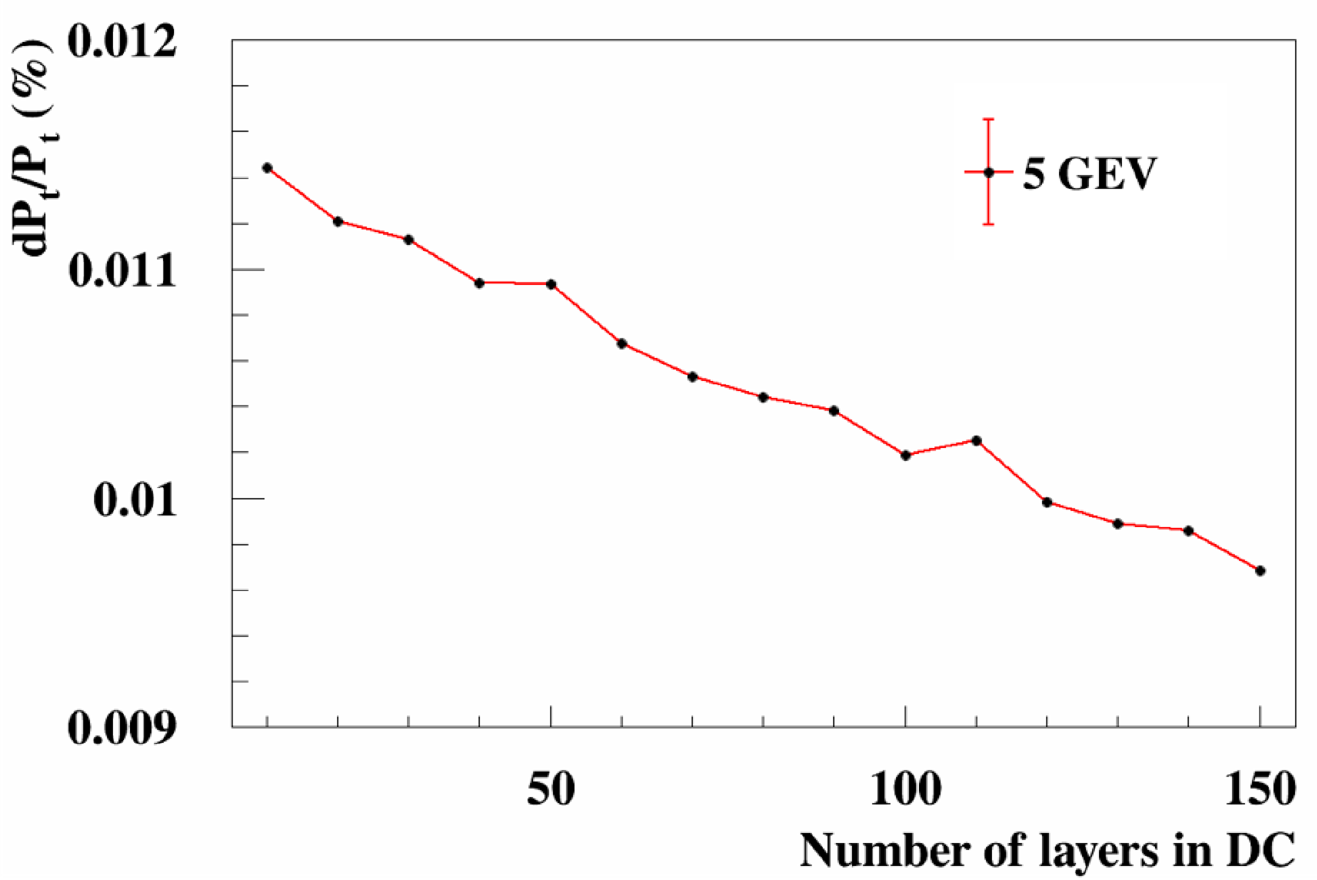
Backup

the value of dPt/Pt in **The general results**, without multiple scattering



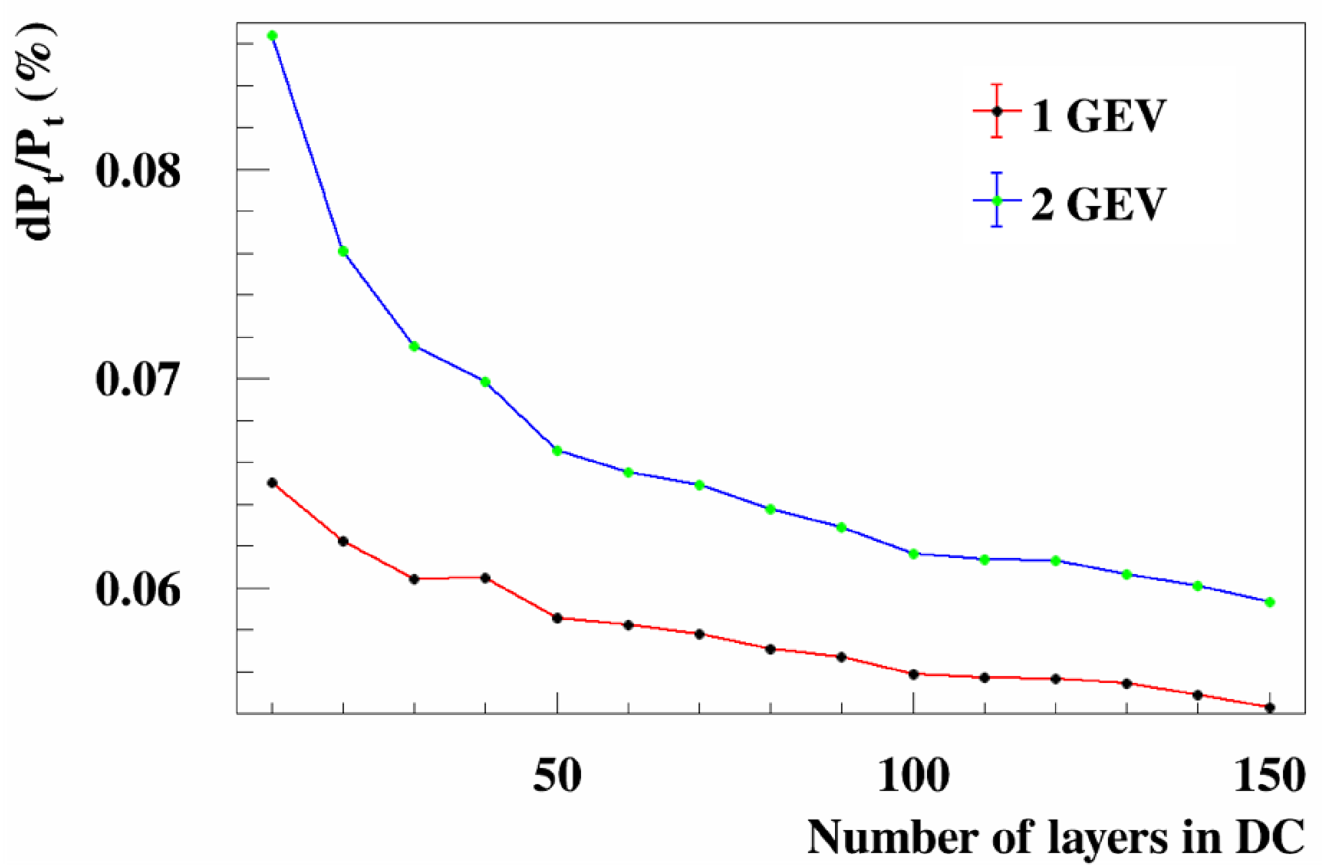
Backup

the value of dPt/Pt in **The general results**, without multiple scattering



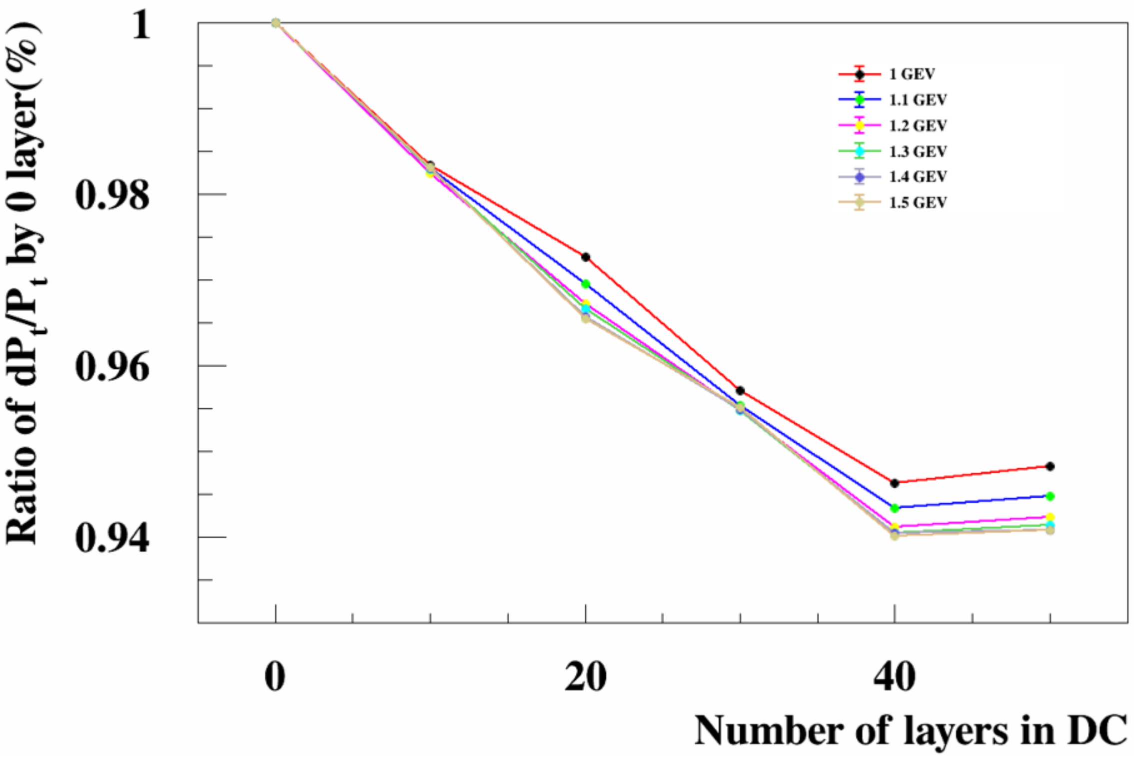
Backup

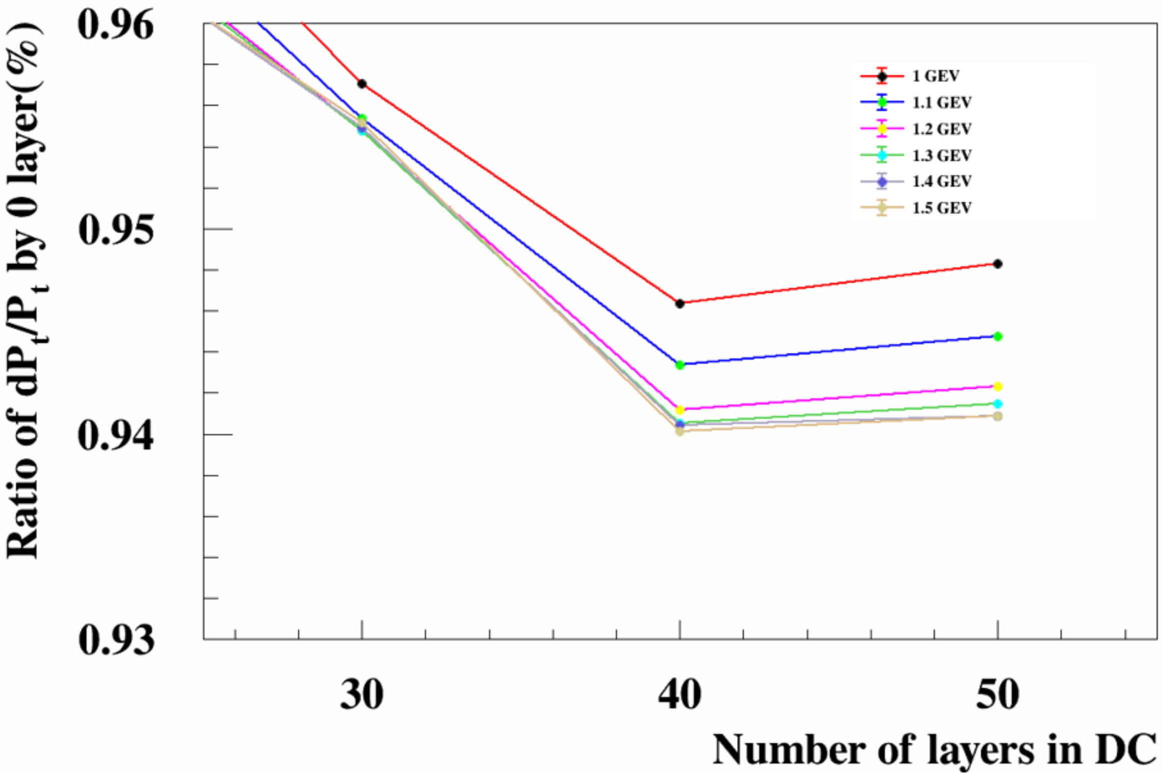
the value of dPt/Pt in **The general results**, with multiple scattering



Backup

the ratio of momentum resolution in **The general results** without multiple scattering around 1 GeV





Backup

```
LiC Detector-Toy (barrel)
SDT-CEPC
Version:                 6 + 3 + DC + 2
Vertex Detector (VTX)

Number of layers              :   8
Description (optional)        :   |-Beamt.--|--------------------------------------Vertex detector--------------------|
Names of the layers (opt.)    :   XBT,      VTX1,     VTX2,      VTX3,       VTX4,       VTX5,      VTX6,     XVTXSHELL
Radii [mm]                    :   14.5,     16.0,     18.0,      37.0,       39.0,       58.0,      60.0,     65.0
Upper limit in z [mm]         :   4225,     62.5,     62.5,      125,        125,        125,       125,      145
Lower limit in z [mm]         :  -4225,    -62.5,    -62.5,     -125,       -125,       -125,      -125,     -145
Efficiency RPhi               :   0,         1.0,      1.0,       1.0,        1.0,        1.0,       1.0,      0.0
Efficiency 2nd coord. (eg. z):  -1
Stereo angle alpha [Rad]      :   pi/2
Thickness [rad. lengths]      :   0.0015, 0.0015,   0.0015,   0.0015,     0.0015,     0.0015,   0.0015,   0.0015
error distribution            :   0
0 normal-sigma(RPhi) [1e-6m]  :   2.8, 6, 4.0, 4.0, 4.0, 4.0
           sigma(z)   [1e-6m]  :   2.8, 6, 4.0, 4.0, 4.0, 4.0
1 uniform-d(RPhi) [1e-6m]     :   4.0
          d(z)     [1e-6m]     :   4.0

```

VTX-setups

Backup

```
CMOS Tracker (CIT)

Number of layers               :    4
Description (optional)         :    |-------------CMOS tracker------------|----TPC Inner Wall ----|
Names of the layers (opt.)     :     CIT1,          CIT2,       CIT3,          XTPCW1
Radii [mm]                     :     78.0,         238.0,      398.0,          399.0
Upper limit in z [mm]          :    150.0,         750.0,      1300.0,         2900.0
Lower limit in z [mm]          :   -150.0,        -750.0,     -1300.0,        -2900.0
Efficiency RPhi                :     1.00,          1.00,       1.00,          0.0
Efficiency 2nd coord. (eg. z):        -1
Stereo angle alpha [Rad]       :     pi/2
Thickness [rad. lengths]       :   0.0065,        0.0065,     0.0065,          0.002
error distribution             :        0
0 normal-sigma(RPhi) [1e-6m] :      7.2
          sigma(z)     [1e-6m] :     86.6
1 uniform-d(RPhi) [1e-6m]      :      7.2
           d(z)     [1e-6m]    :     86.6
```

CIT-setups

Backup

```
Time Projection Chamber (TPC)(DC)(TPC --> DC by setting some paremeters in LDT)
sigma^2=sigma0^2+sigma1^2*sin(beta)^2+Cdiff^2*6mm/h*sin(theta)*Ldrift[m]
Number of layers              :   could be changed
Radii [mm]                    :   400,1400
Upper limit in z [mm]         :   2900.0
Lower limit in z [mm]         :  -2900.0
Efficiency RPhi               :   1
Efficiency z                  :   1
Thickness [rad. lengths]      :   could be changed
sigma0(RPhi) [1e-6m]          :   100
sigma1(RPhi) [1e-6m]          :     0
Cdiff(RPhi)  [1e-6m/sqrt(m)]  :     0
sigma0(z)    [1e-6m]          :  2828
sigma1(z)    [1e-6m]          :     0
Cdiff(z)     [1e-6m/sqrt(m)]  :     0
```

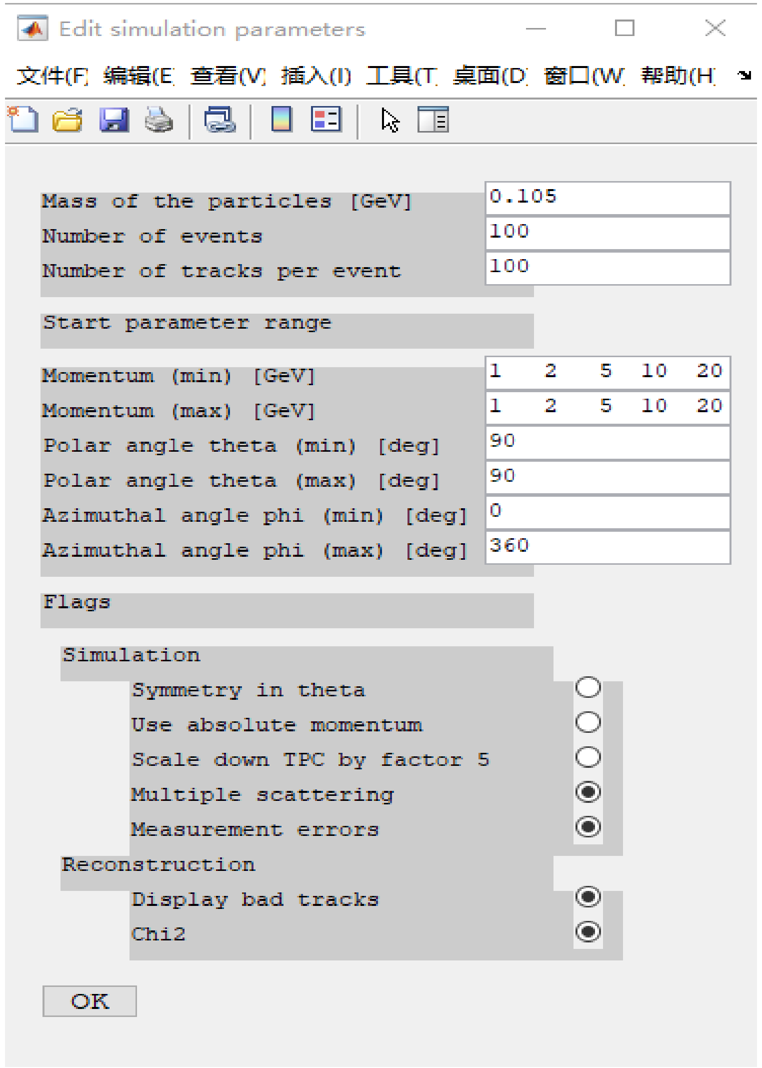
DC-setups

Backup

```
CMOS Tracker (CET)

Number of layers                :    3
Description (optional)          :  TPC outer wall  |--------------External Tracker--------------------------------------------|
Names of the layers (opt.)      :     XTPCW2,  CET1,    CET2
Radii [mm]                      :    1401.0,   1411,    1800
Upper limit in z [mm]           :      2900.0,   2900.0,    2900.0
Lower limit in z [mm]           :     -2900.0,  -2900.0,    -2900.0
Efficiency RPhi                 :       0.0,     1.0,    1.0
Efficiency 2nd coord. (eg. z):                   -1
Stereo angle alpha [Rad]        :                pi/2
Thickness [rad. lengths]        :     0.010, 0.0065,    0.0065
error distribution              :         0
0 normal-sigma(RPhi) [1e-6m]    :       7.2
         sigma(z)    [1e-6m]    :      86.6
1 uniform-d(RPhi) [1e-6m]       :       7.2
          d(z)    [1e-6m]       :      86.6

Magnetic field and beam spot

Solenoid magnetic field [T]     :    3.0
Range in x [mm]                 :   -0.0   0.0
Range in y [mm]                 :   -0.0   0.0
Range in z [mm]                 :   -0.0   0.0
```

CET-setups

Backup



Simulation-parameters