# Vertex Layout Optimization

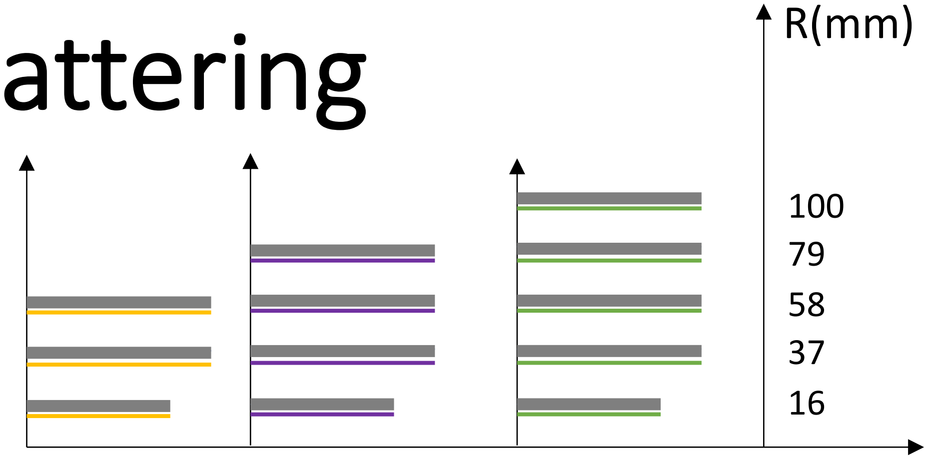
Zhaoru Zhang

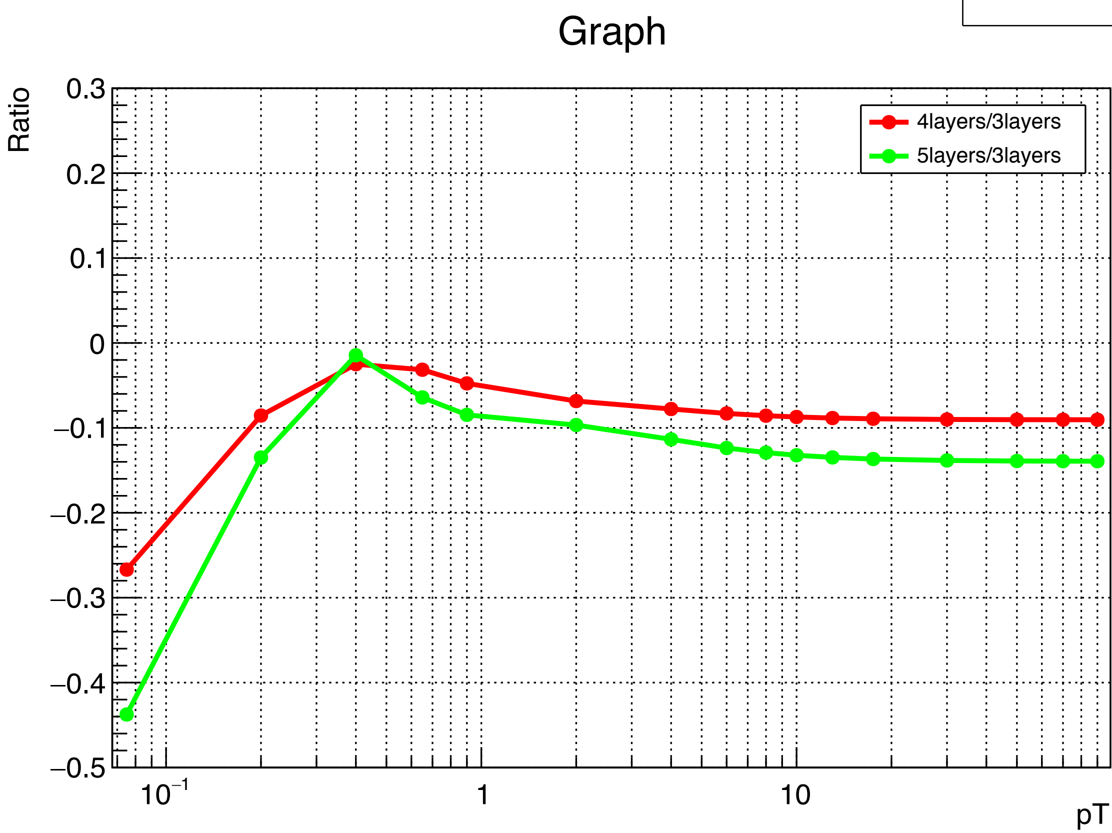
2019.06.21

# What I tested:

- without multiple scattering
- Number of layers
- 1 double layer+ single layers

# without multiple scattering

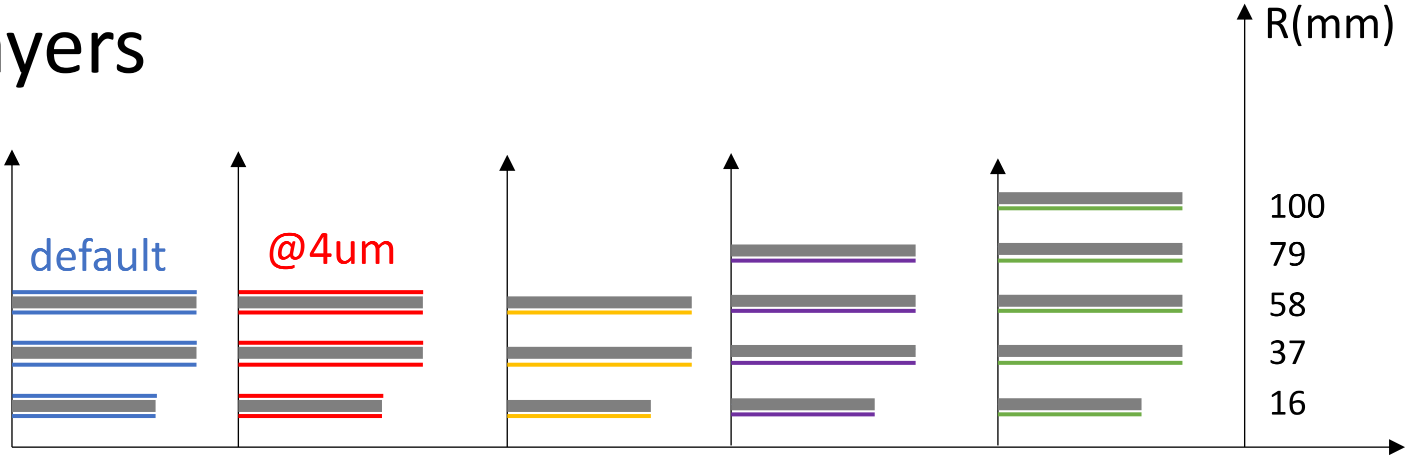


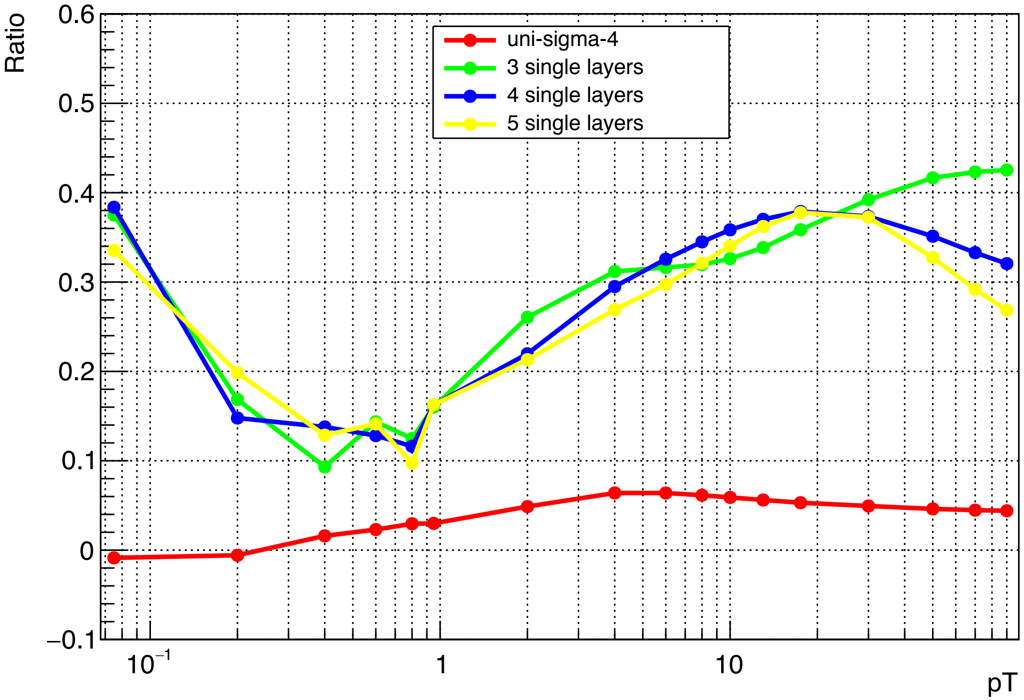




$$\text{Ratio} = \frac{\sigma_{ip}}{\sigma_{ip\_3layers}} - 1$$

# Number of layers

The statistic of each point is 5000



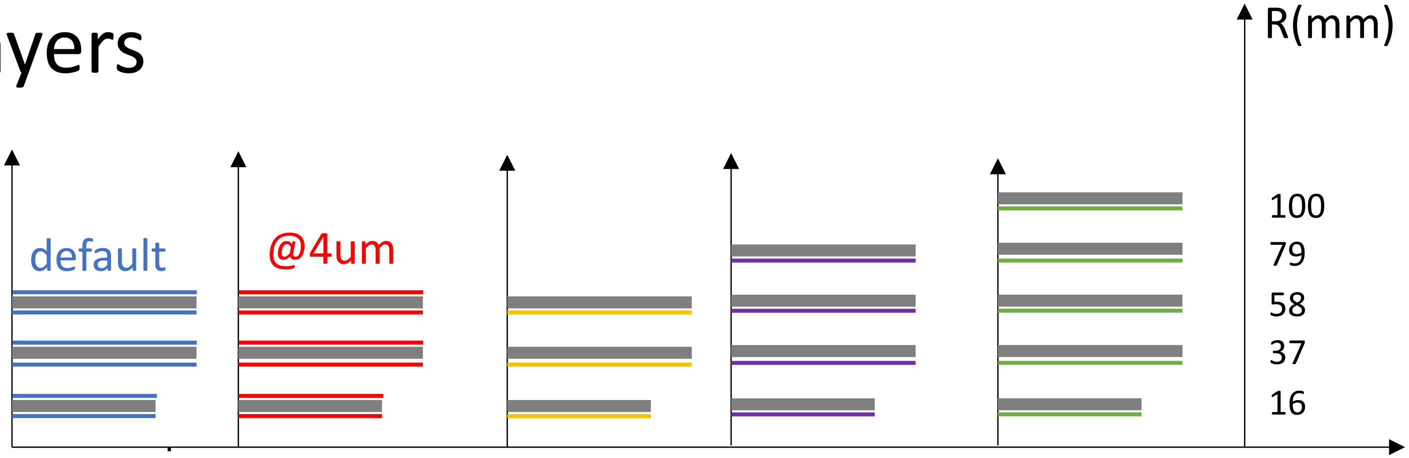

| | 3 single layers | 4 single layers | 5 single layers |
|---|---|---|---|
| R1 | 16 | 16 | 16 |
| R2 | 37 | 37 | 37 |
| R3 | 58 | 58 | 58 |
| R4 | | 79 | 79 |
| R5 | | | 100 |

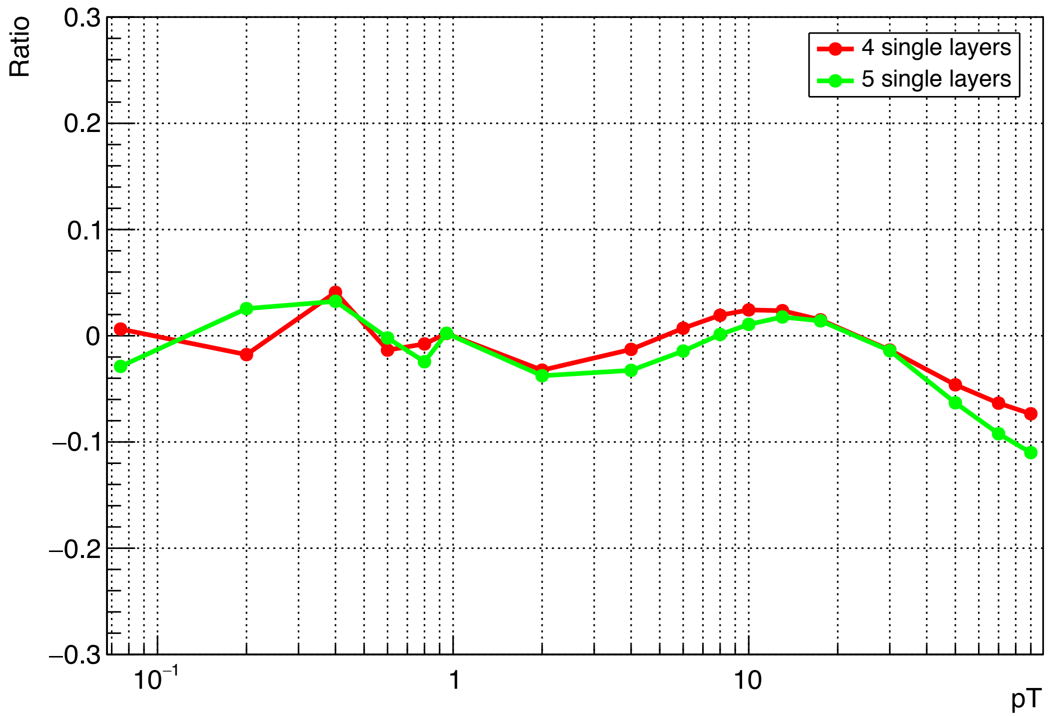
$$\text{Ratio} = \frac{\sigma_{ip}}{\sigma_{ip\_default}} - 1$$

More layers give better resolution in pT>25 GeV
Float in pT<25 GeV

# Number of layers

The statistic of each point is 5000

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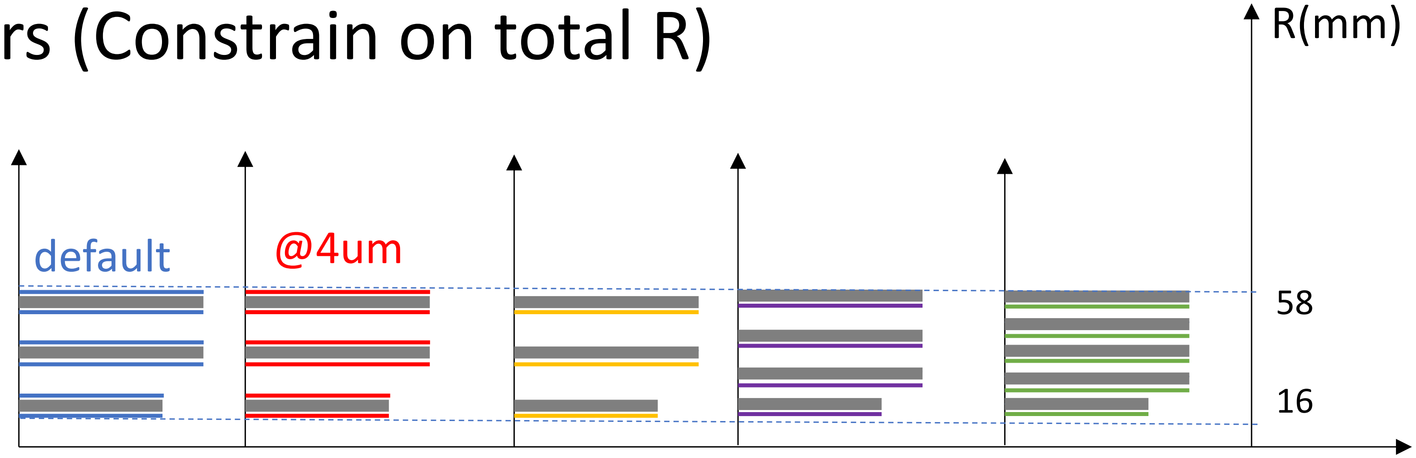
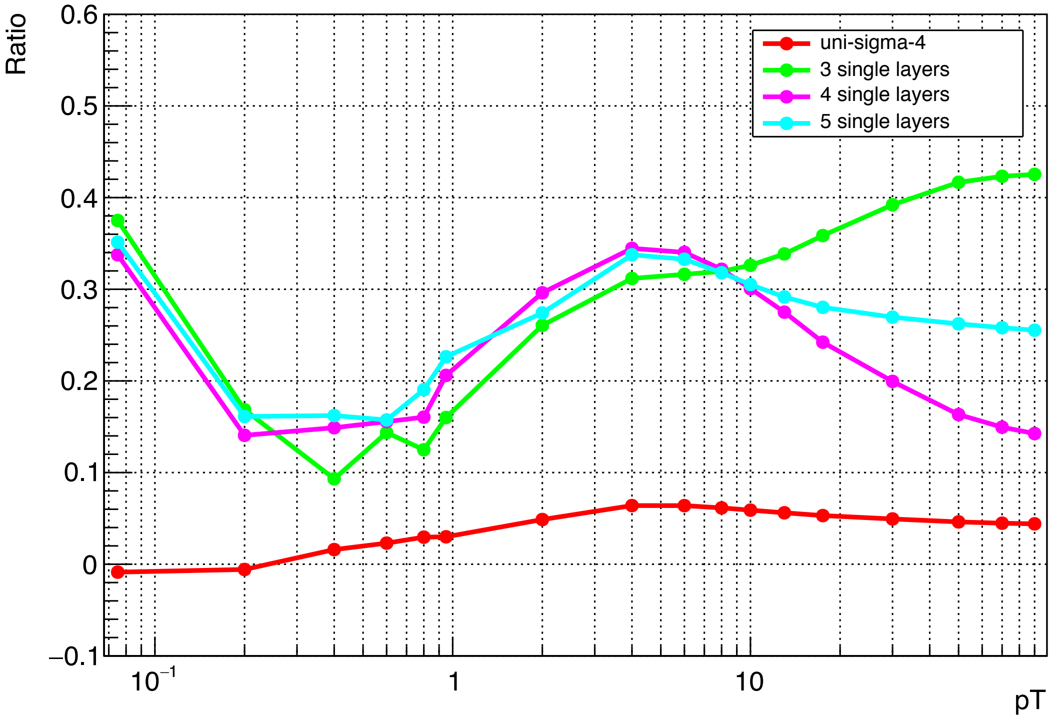
# Number of layers (Constrain on total R)

The statistic of each point is 5000




| | 3 single layers | 4 single layers | 5 single layers |
|---|---|---|---|
| R1 | 16 | 16 | 16 |
| R2 | 37 | 30 | 27 |
| R3 | 58 | 44 | 38 |
| R4 | | 58 | 49 |
| R5 | | | 58 |

$$\text{Ratio} = \frac{\sigma_{ip}}{\sigma_{ip\_default}} - 1$$

pT>10 GeV: 4 layers is the best

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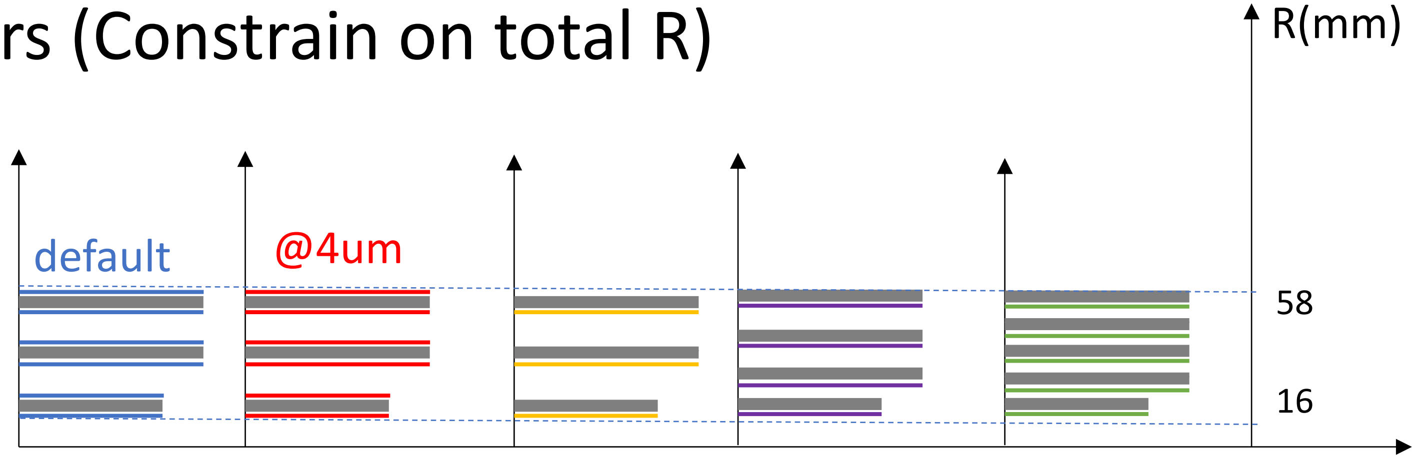


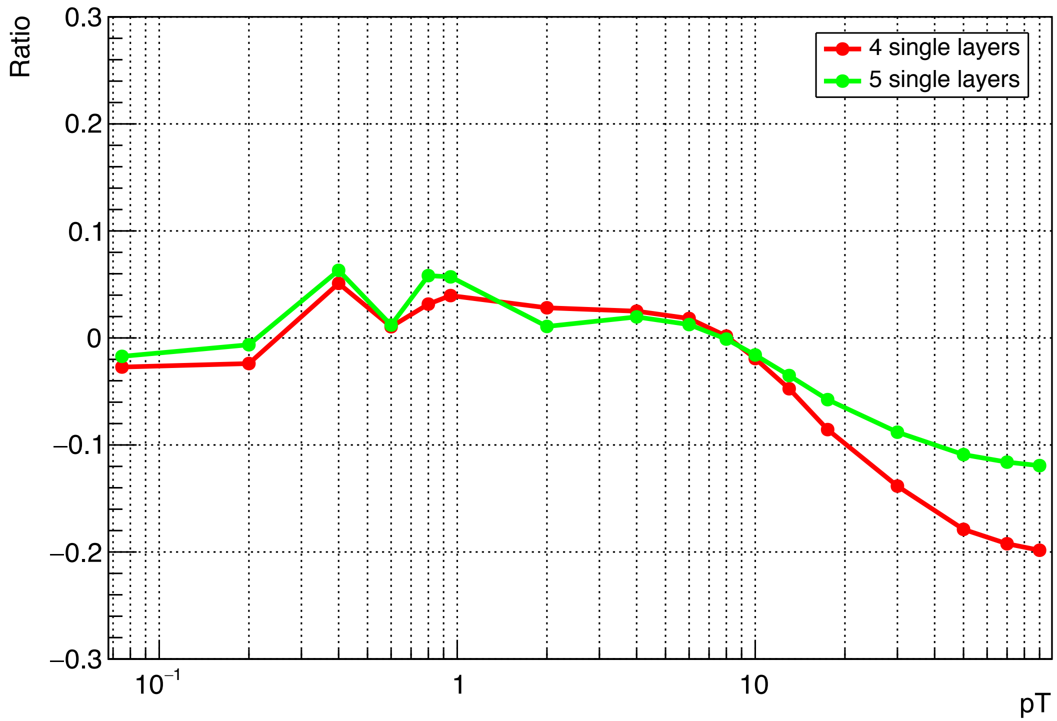


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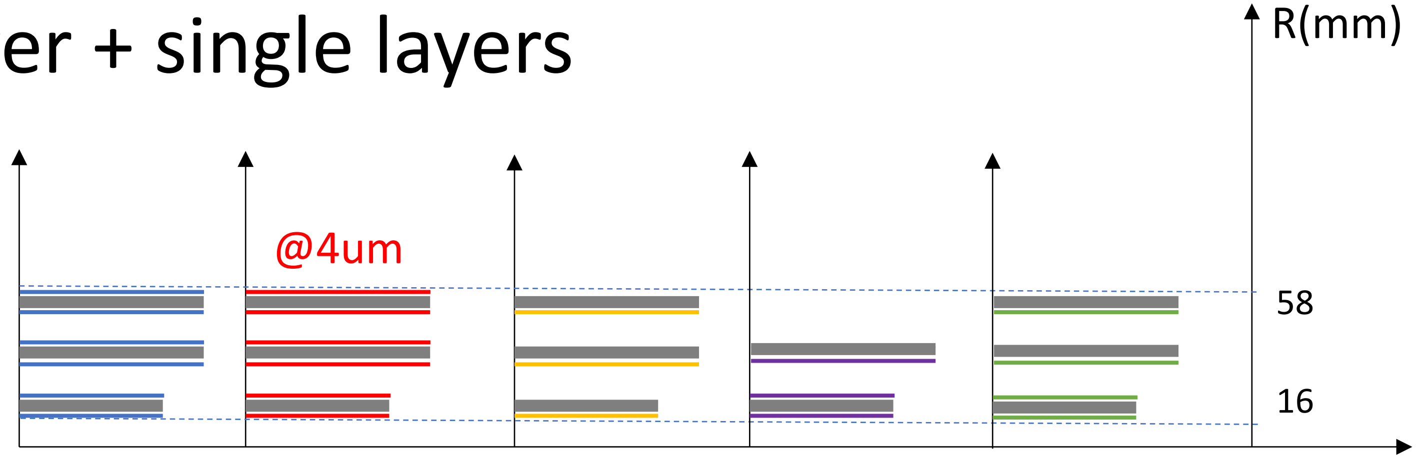
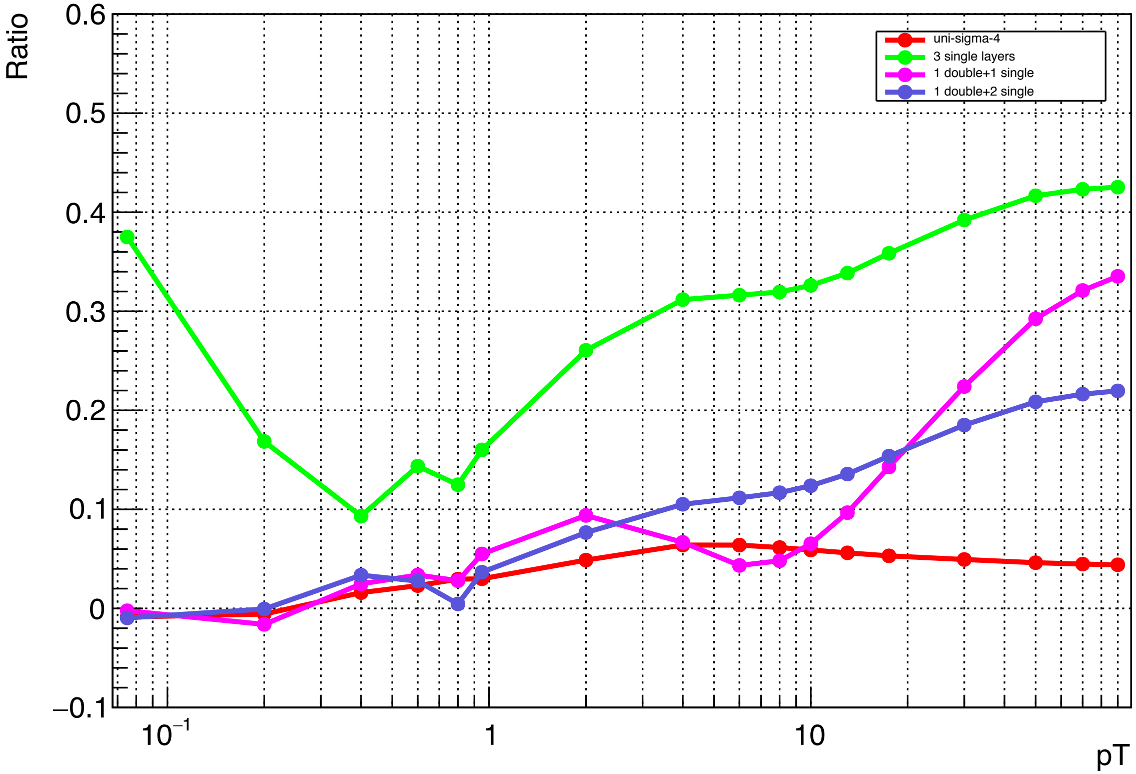
$$\text{Ratio} = \frac{\sigma_{ip}}{\sigma_{ip\_3layers}} - 1$$

0.2 GeV< pT<8 TeV: more layers worse
pT>8TeV: more layers better
pT>10 GeV: 4 layers is the best --> Strange??

# 1 double layer + single layers

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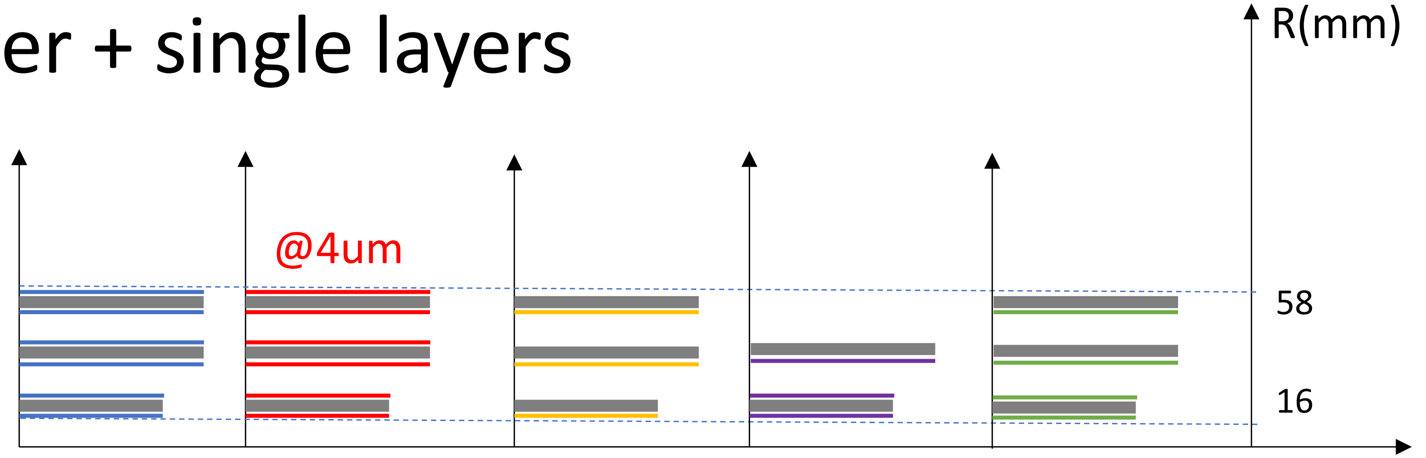
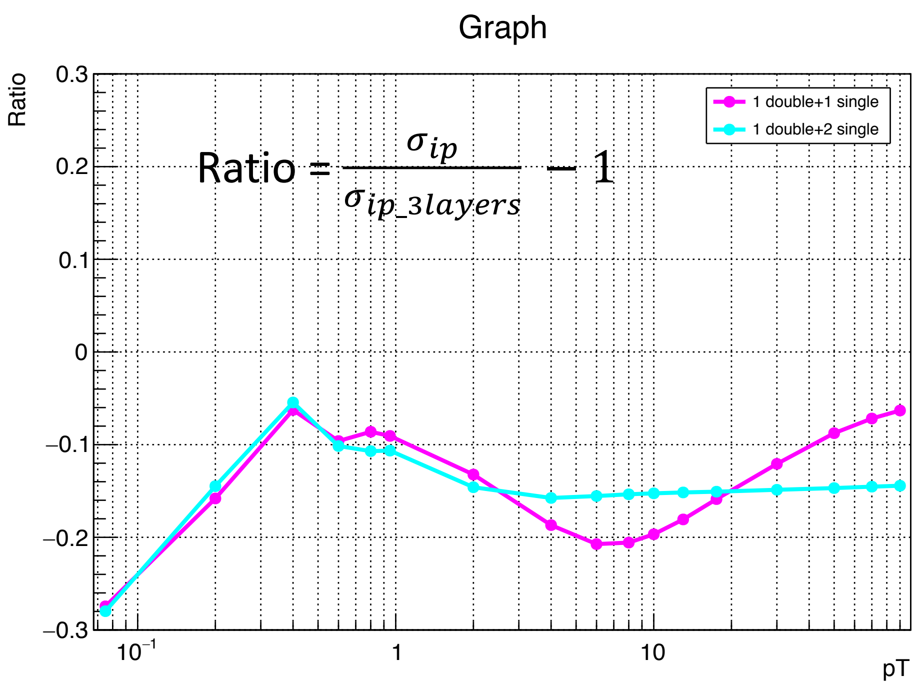
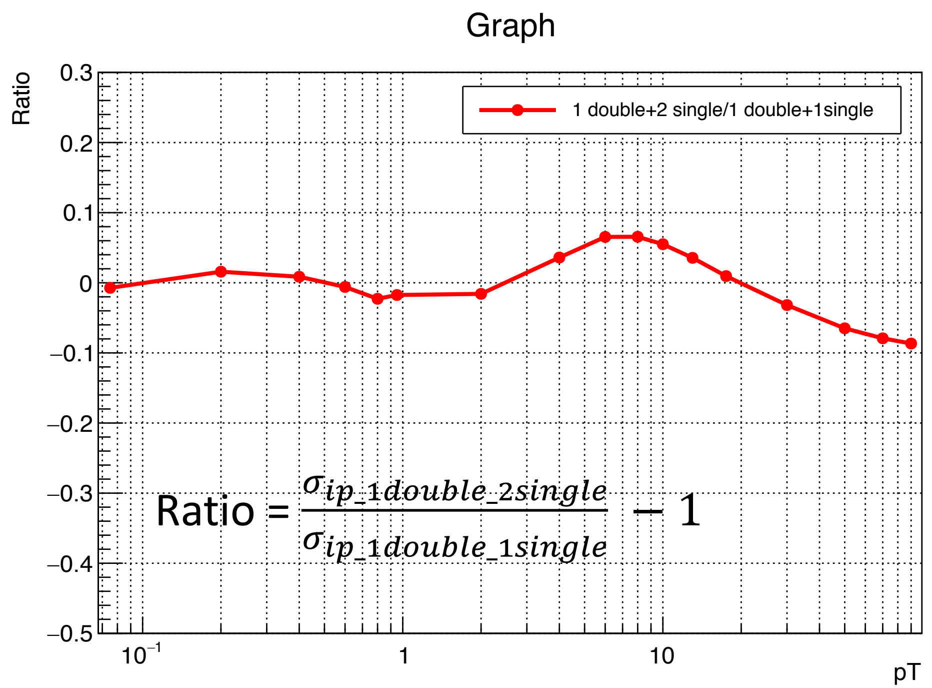


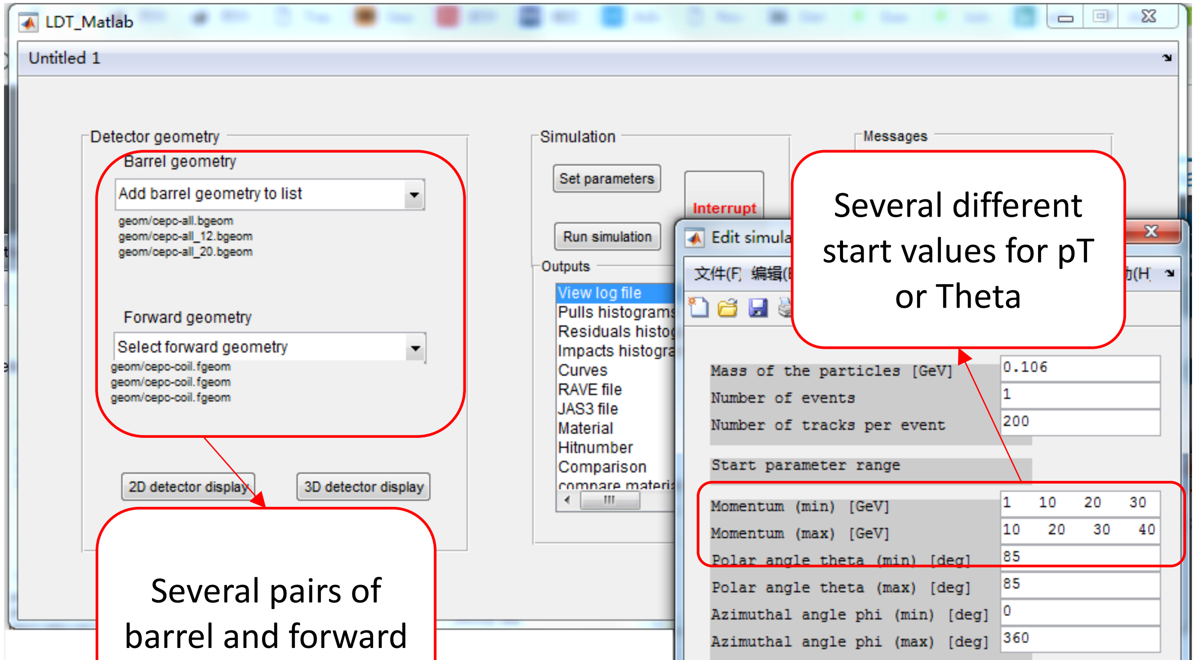
# Backup

# 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

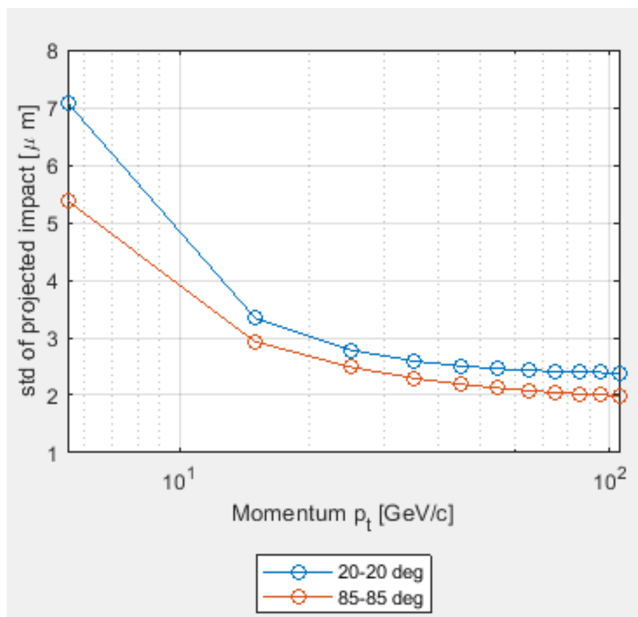
```
01 LiC Detector-Toy (barrel)
02 LDC-basic-Japan
03 Version:                   120208
04 Vertex Detector (VTX)
05
06 Number of layers           :   14
07 Description (optional)     : |-Beamt.-|-----------------------------------Vertex detector---------------------------------------------------------------------|
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]  :
21
```

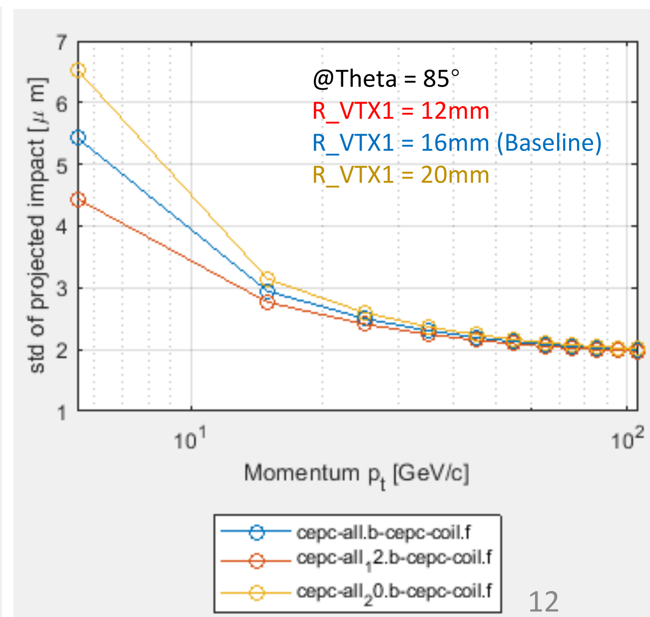
Compare detector setups as function of – momentum – polar angle




Several pairs of barrel and forward detector setups

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

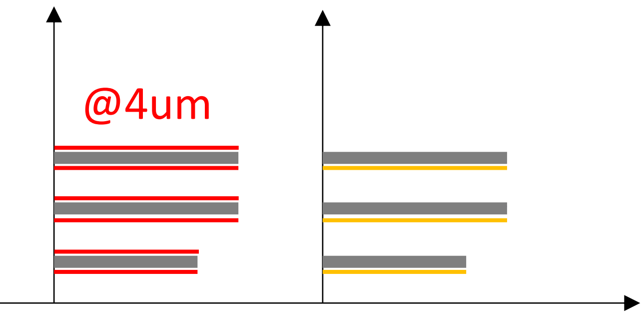


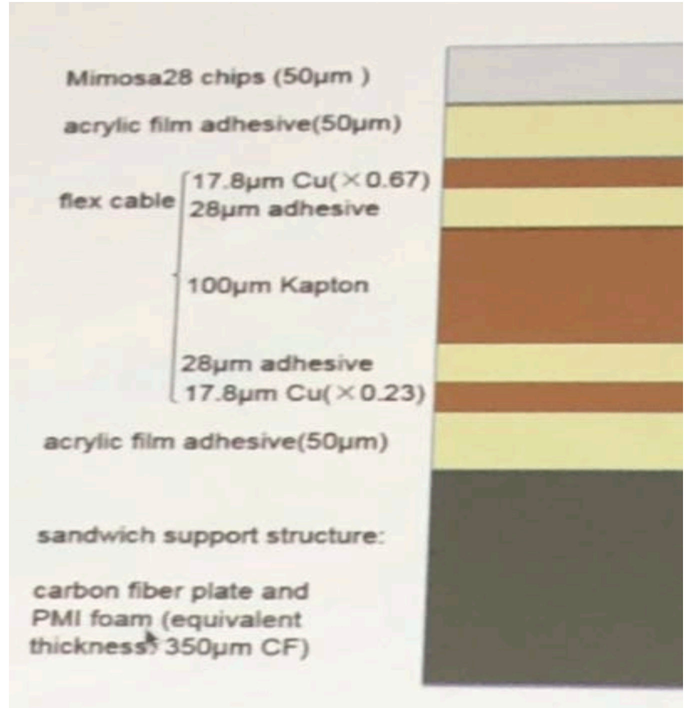
# omparison

um

ers + sigma 4um per layer +
material 0.267% X/X0




| (mm) | $\lvert z \rvert$ (mm) | $\lvert \cos\theta \rvert$ | $\sigma(\mu m)$ |
|---|---|---|---|
| 16 | 62.5 | 0.97 | 2.8 |
| 18 | 62.5 | 0.96 | 6 |
| 37 | 125.0 | 0.96 | 4 |
| 39 | 125.0 | 0.95 | 4 |
| 58 | 125.0 | 0.91 | 4 |
| 60 | 125.0 | 0.90 | 4 |



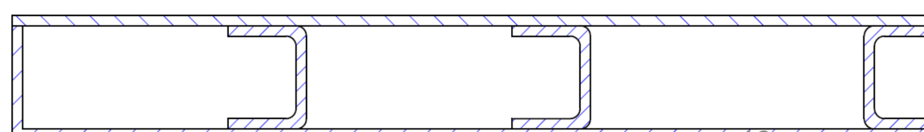

More details in Mingyi and J

Si: 50 um/9.37cm = 0.053%
Al: 21 um/8.897 cm = 0.021%
Kapton: 100 um/57.6 cm = 0.017%
Adhesive: 156 um/33.5 cm = 0.0466%
Carbon fiber: 350 um/29 cm = 0.121%

0.205% → Overlap of ladd structure *1.3

Not consider:

1. Carbon fiber C structure, which should increase the material budget
2. Structure to be optimized



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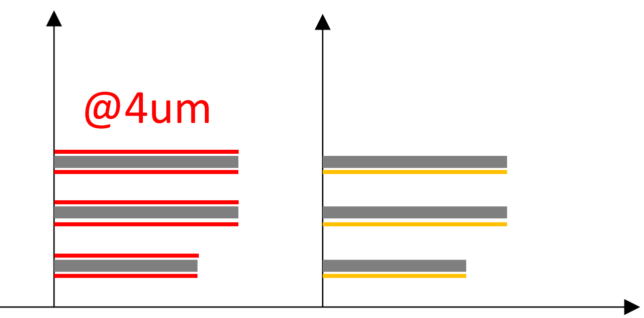


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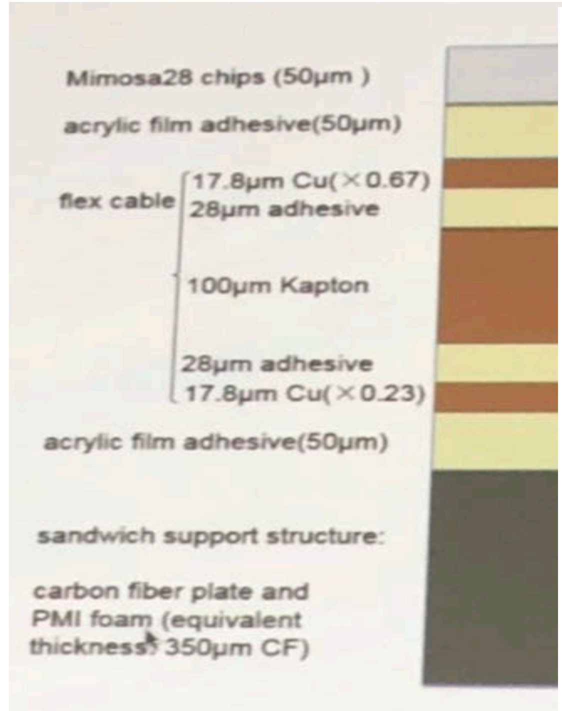


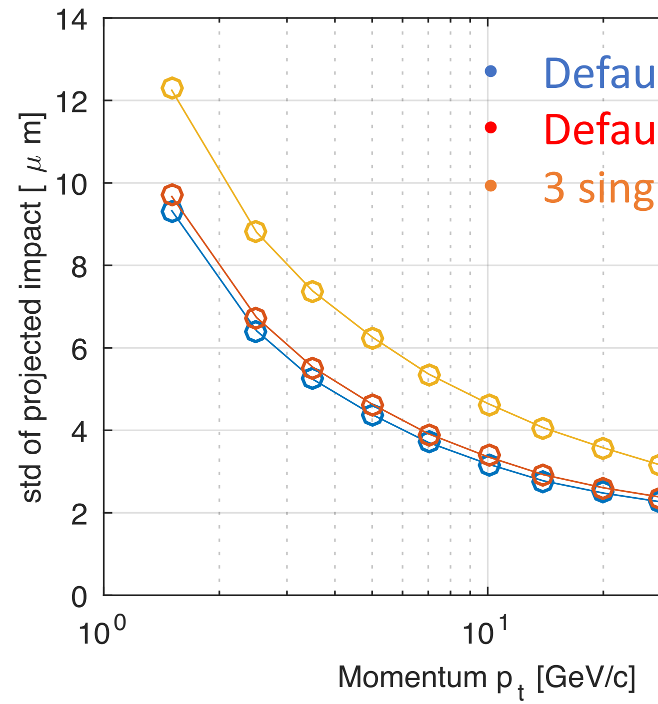


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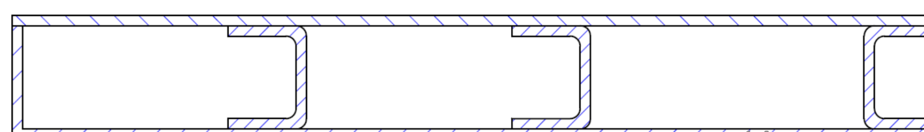

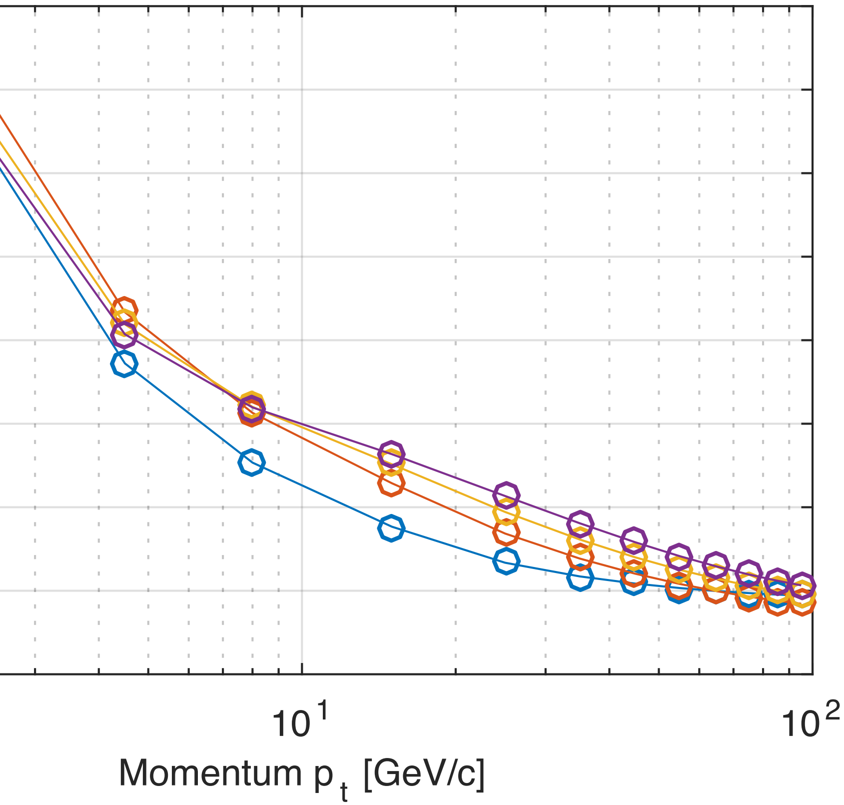


Distance between two layers

Default:

3 single layers + sigma 3um per layer + supportin
material 0.161%X0 + distance between two layer

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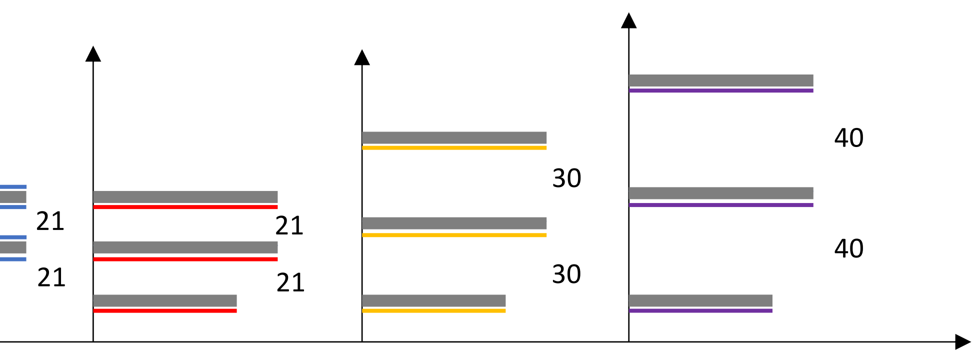
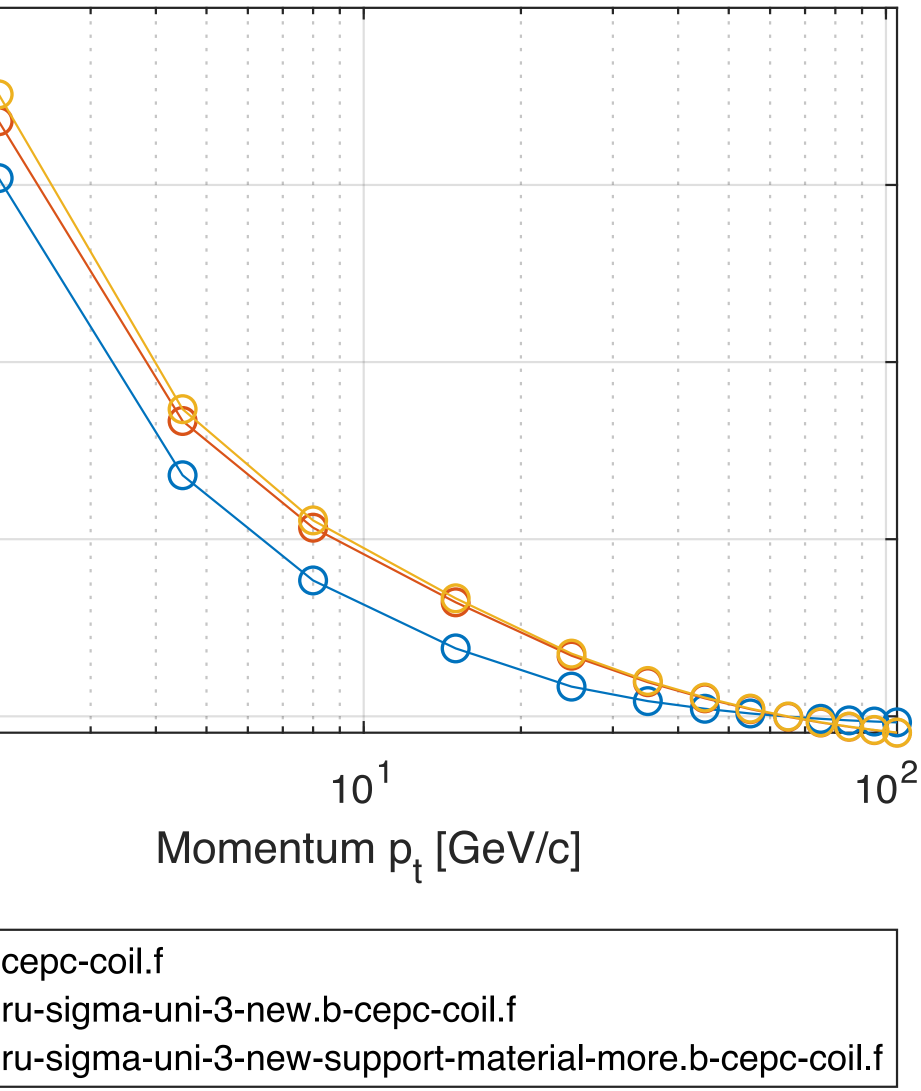


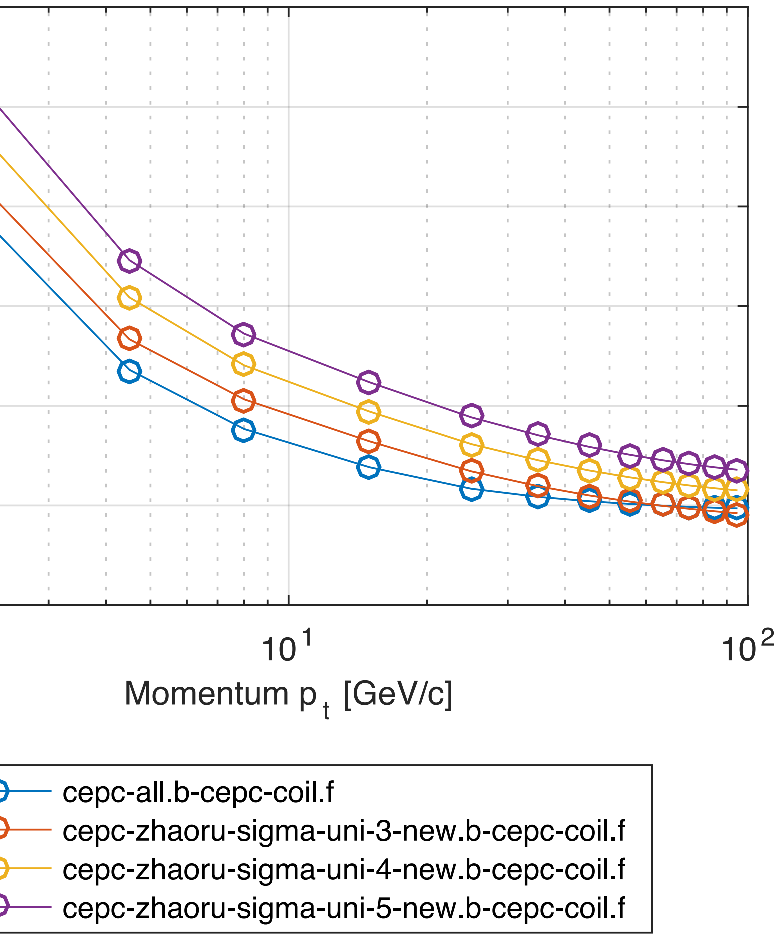



Supporting material budget

Default:

3 single layers + sigma 3um per layer + supportin
material 0.161%X0

3 single layers + sigma 3um per layer + supportin
material 0.0191%X0



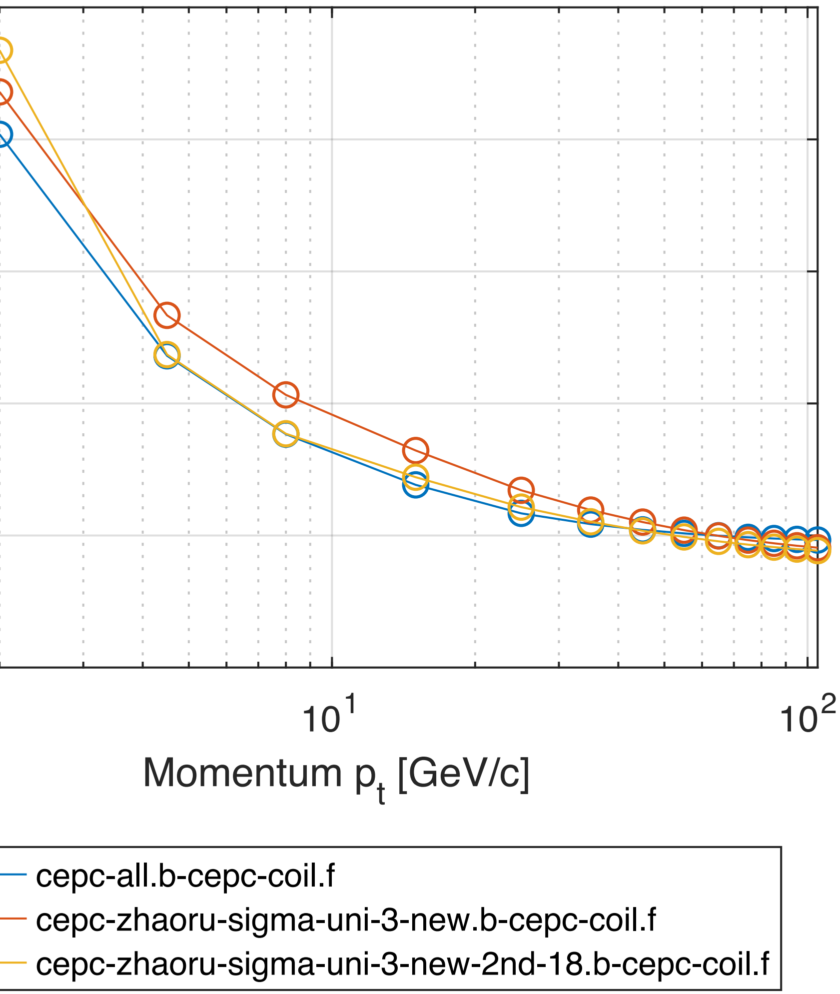

sigma

Default: 3 double layers

3 single layers + sigma 3um per layer + supportin material 0.161%X0

3 single layers + sigma 4um per layer + supportin material 0.161%X0

3 single layers + sigma 5um per layer + supportin material 0.161%X0




Relative radius of 2nd layer

Default: 3 double layers

3 single layers + sigma 3um per layer + supportin
material 0.161%X0

3 single layers + sigma 3um per layer + supportin
material 0.161%X0 + radius of 2nd layer 18mm