Tracker Layout with LDT

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Jan 25, 2020

Starting point

According to the discussion of last meeting, we focus on barrel first, and start from a common geometry

Sub-detector	layer	+/-z(mm)	R(mm)	sigma_xy(mm)	sigma_z(mm)	X/X0(%)
BeamPipe	0	4225	14.5	---	---	0.15
vertex	1	62.5	16	0.0028	0.0028	0.15
vertex	2	62.5	18	0.006	0.006	0.15
vertex	3	125.	37	0.004	0.004	0.15
vertex	4	125.	39	0.004	0.004	0.15
vertex	5	125.	58	0.004	0.004	0.15
vertex	6	125.	60	0.004	0.004	0.15
VXTShell	7	145.	65	---	---	0.15
Si_pixel	8	371.	78	0.0072	0.0866	0.65
Si_pixel	9	665.	189	0.0072	0.0866	0.65
Si_pixel	10	2350	298	0.0072	0.0866	0.65
DC	11-160	2350	300-1800	0.1000	2/9999	1.20
Si_pixel	161	2350	1811	0.0072	0.0866	0.65

Sum: 5.0%

Typo fixing

using theta = pi/ firstly, and total matertials at theta=pi/2 is 5%

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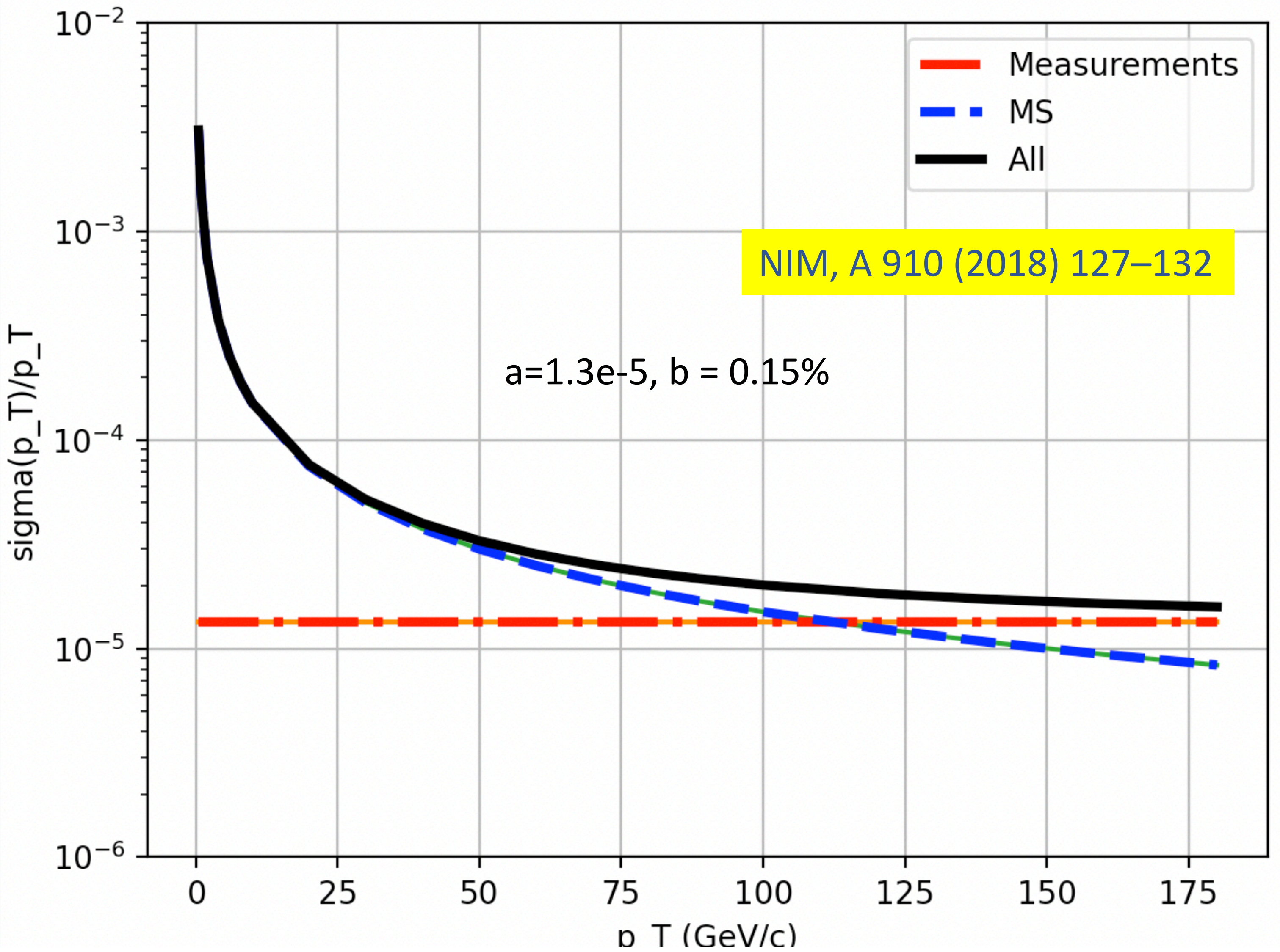
Analytical calculation

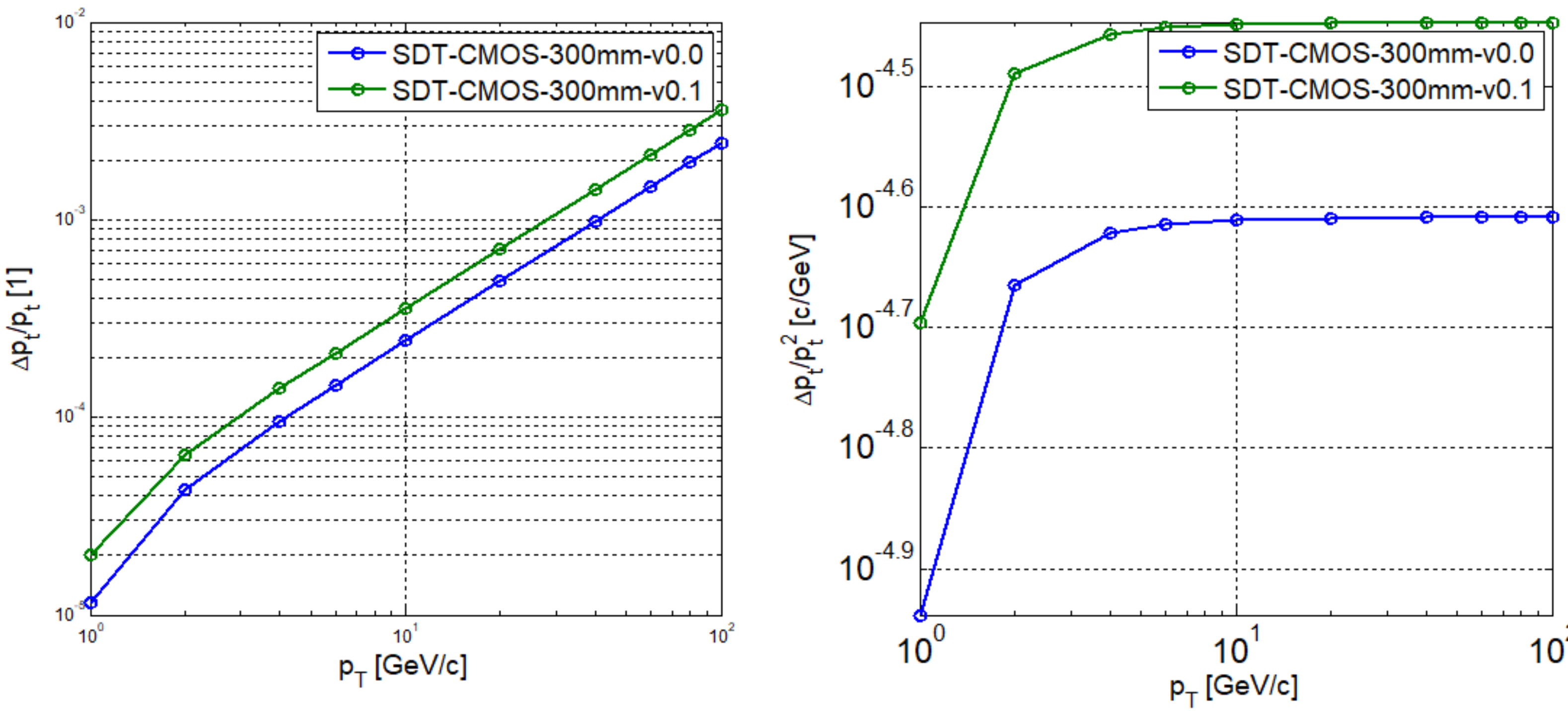


Assuming: equally spacing, same resolution

Numerical results

```
  0.5  dp/p =  (0.007e-3  1.533e-3), (a,b) = (    1.3e-5  153.3e-5)
  1.0  dp/p =  (0.013e-3  1.508e-3), (a,b) = (    1.3e-5  150.8e-5)
  2.0  dp/p =  (0.027e-3  1.502e-3), (a,b) = (    1.3e-5  150.2e-5)
  4.0  dp/p =  (0.054e-3  1.500e-3), (a,b) = (    1.3e-5  150.0e-5)
  6.0  dp/p =  (0.081e-3  1.500e-3), (a,b) = (    1.3e-5  150.0e-5)
  8.0  dp/p =  (0.108e-3  1.500e-3), (a,b) = (    1.3e-5  150.0e-5)
 10.0  dp/p =  (0.135e-3  1.500e-3), (a,b) = (    1.3e-5  150.0e-5)
 20.0  dp/p =  (0.270e-3  1.500e-3), (a,b) = (    1.3e-5  150.0e-5)
 30.0  dp/p =  (0.405e-3  1.500e-3), (a,b) = (    1.3e-5  150.0e-5)
 40.0  dp/p =  (0.539e-3  1.500e-3), (a,b) = (    1.3e-5  150.0e-5)
 50.0  dp/p =  (0.674e-3  1.500e-3), (a,b) = (    1.3e-5  150.0e-5)
 60.0  dp/p =  (0.809e-3  1.500e-3), (a,b) = (    1.3e-5  150.0e-5)
 70.0  dp/p =  (0.944e-3  1.500e-3), (a,b) = (    1.3e-5  150.0e-5)
 80.0  dp/p =  (1.079e-3  1.500e-3), (a,b) = (    1.3e-5  150.0e-5)
 90.0  dp/p =  (1.214e-3  1.500e-3), (a,b) = (    1.3e-5  150.0e-5)
100.0  dp/p =  (1.349e-3  1.500e-3), (a,b) = (    1.3e-5  150.0e-5)
120.0  dp/p =  (1.618e-3  1.500e-3), (a,b) = (    1.3e-5  150.0e-5)
140.0  dp/p =  (1.888e-3  1.500e-3), (a,b) = (    1.3e-5  150.0e-5)
160.0  dp/p =  (2.158e-3  1.500e-3), (a,b) = (    1.3e-5  150.0e-5)
180.0  dp/p =  (2.428e-3  1.500e-3), (a,b) = (    1.3e-5  150.0e-5)
```

No multiple scattering from LDT

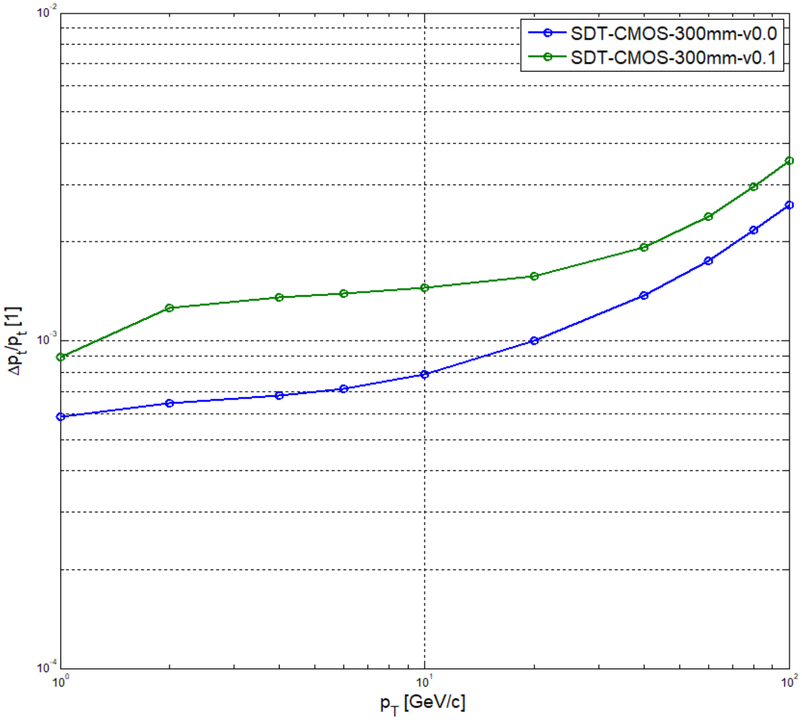


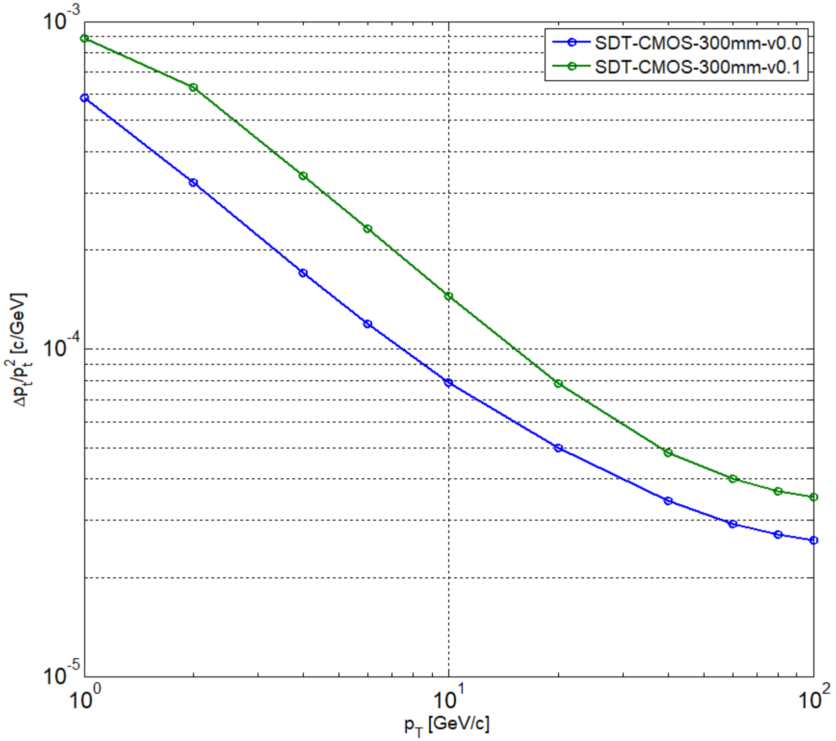
a = 2.5e-5, 3.6e-5 @ 10+ GeV

Numerical results

p_T (GeV)	w/i DC		w/o DC		notes
	dp_T/p_T	d(1/p_T)	dp_T/p_T	d(1/p_T)	
1	0.00001153	0.00001153	0.00002011	0.00002011	
2	0.00004325	0.00002162	0.00006472	0.00003236	
4	0.00009550	0.00002388	0.00013960	0.00003490	
6	0.00014571	0.00002428	0.00021213	0.00003536	
10	0.00024493	0.00002449	0.00035587	0.00003559	
20	0.00049161	0.00002458	0.00071369	0.00003568	
40	0.00098409	0.00002460	0.00142835	0.00003571	
60	0.00147638	0.00002461	0.00214279	0.00003571	
80	0.00196862	0.00002461	0.00285718	0.00003571	
100	0.00246084	0.00002461	0.00357155	0.00003572	

With multiple scattering from LDT





Numerical results

p_T (GeV)	w/I DC		w/o DC		notes
	dp_T/p_T	d(1/p_T)	dp_T/p_T	d(1/p_T)	
1	0.00058513	0.00058513	0.00089116	0.00089116	
2	0.00064628	0.00032314	0.00125535	0.00062767	
4	0.00068243	0.00017061	0.00135243	0.00033811	
6	0.00071450	0.00011908	0.00139421	0.00023237	
10	0.00079016	0.00007902	0.00144881	0.00014488	
20	0.00099687	0.00004984	0.00156863	0.00007843	
40	0.00137359	0.00003434	0.00192143	0.00004804	
60	0.00175756	0.00002929	0.00240012	0.00004000	
80	0.00216951	0.00002712	0.00294743	0.00003684	
100	0.00260253	0.00002603	0.00353197	0.00003532	

Comments on simulation of multiple scattering

$$\theta_0 = \frac{13.6 \text{ MeV}}{\beta c p} z \sqrt{\frac{x}{X_0}} \Big[1 + 0.088 \log_{10}(\frac{x\, z^2}{X_0 \beta^2})\Big]$$
$$= \frac{13.6 \text{ MeV}}{\beta c p} z \sqrt{\frac{x}{X_0}} \Big[1 + 0.038 \ln(\frac{x\, z^2}{X_0 \beta^2})\Big]$$

It describes scattering from a single material, while the usual problem involves the multiple scattering of a particle traversing many different layers and mixtures. Since it is from a fit to a Molière distribution, it is incorrect to add the individual θ_0 contributions in quadrature; the result is systematically too small.

It is much more accurate to apply it once, after finding x and X_0 for the combined scatterer. Please check it in your code

Summary

- Some differences below 10 GeV among different approaches might cause by different fit method
- I prefer LDT result, since the geometry details are somewhat moderate and fit with Kalman filter is validated.
- Next
  - # of SIT
  - R of each layer of VXD and SIT with constraints from DC(s)
  - Radius of beam pipe, thicker beam piple
  - Materials of all components, ranges, …
  - … …
  - Forward region