## **CEPC** Tracking System Optimization

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## Introduction

- Generally, with the increase of detector layers in TPC, the momentum resolution becomes better, but there is a jump point in some layers and an abnormal phenomenon when the momentum value is 1Gev.
- The effect of detector layers on the momentum resolution under different momentum values is studied.
- It mainly includes two aspects, the first is to keep the material budget of each layer in TPC unchanged, the second is to keep the total material budget in TPC unchanged. Details are as follows.

### • Parameter setting (details see backup)

	N layers	Res	oluton(µm)		
sub detector		r-Ф	$z_0$	Material budget (% $X_0$ )	
VXD	6	2.8/6/4/4/4/4	2.8/6/4/4/4/4	0.15per layer	
SIT	4	7.2	86.6	0.65	
TPC	10/20/30/140 /150/160	100	2000	1.2	
SET	1	7.2	86.6	0.65	

	N=10	N=20	 N=100	N=110	 N=160
single	0.00003356	0.00003356	 0.00003356	0.00003356	 0.00003356
total	0.0003356	0.0001678	 0.00003356	0.00003051	 0.00002097 5

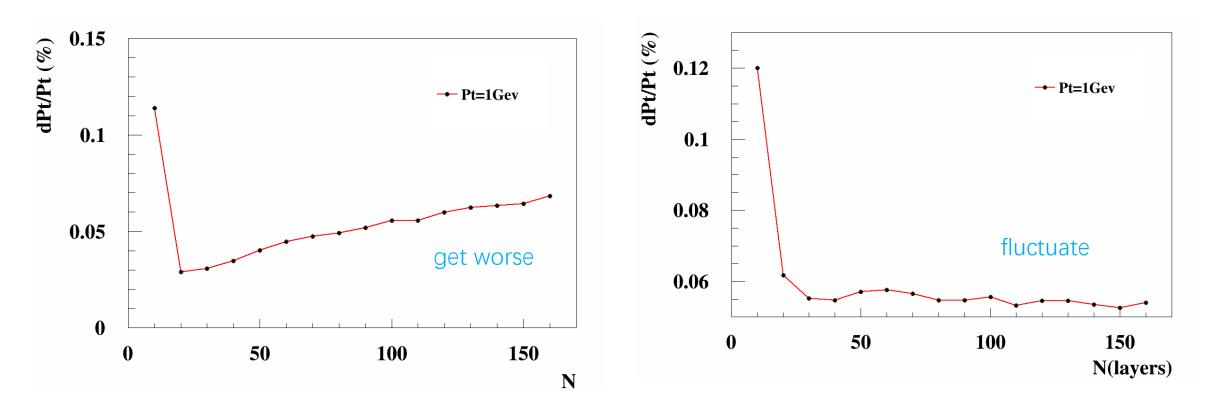
• single

The material budget of each layer in TPC is 0.00003356.

• total

material budget =  $\frac{0.00003356 \times 100}{N}$ 

- N represents the number of detector layers in TPC.
- The graph on the left represents the identical material budget for each single layer and the right keeps the total material budget constant.





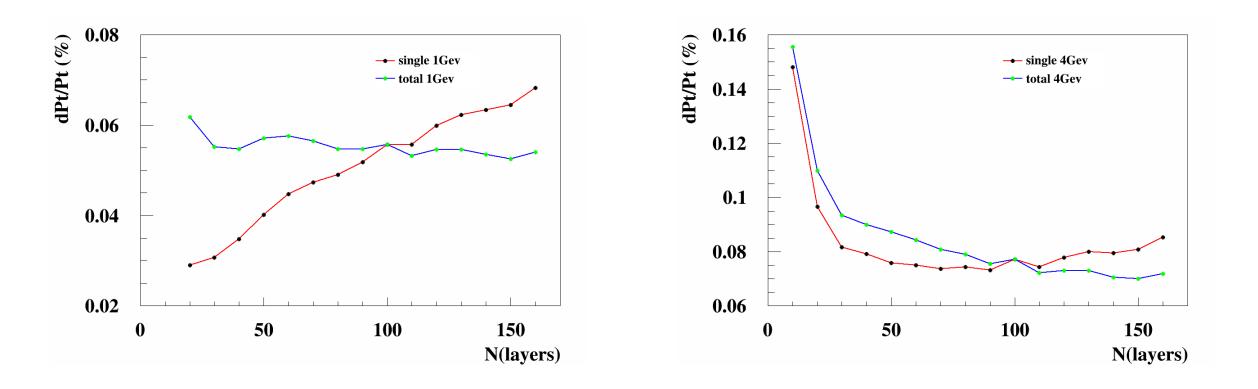
• Why have such a big jump between 10 layers and 20 layers?

Maybe it's related to the number of detector layers. The detector layers is neither the more the better nor the less the better and 10 layers may be a critical value.

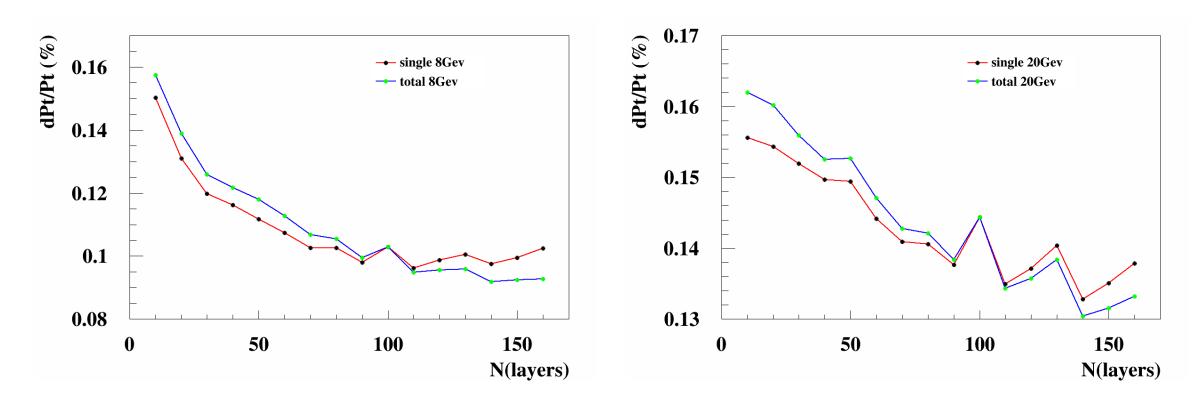
• Why does the momentum resolution of the left side of the image get worse with the increases of detector layers?

It is caused by low momentum value and low total material budget.

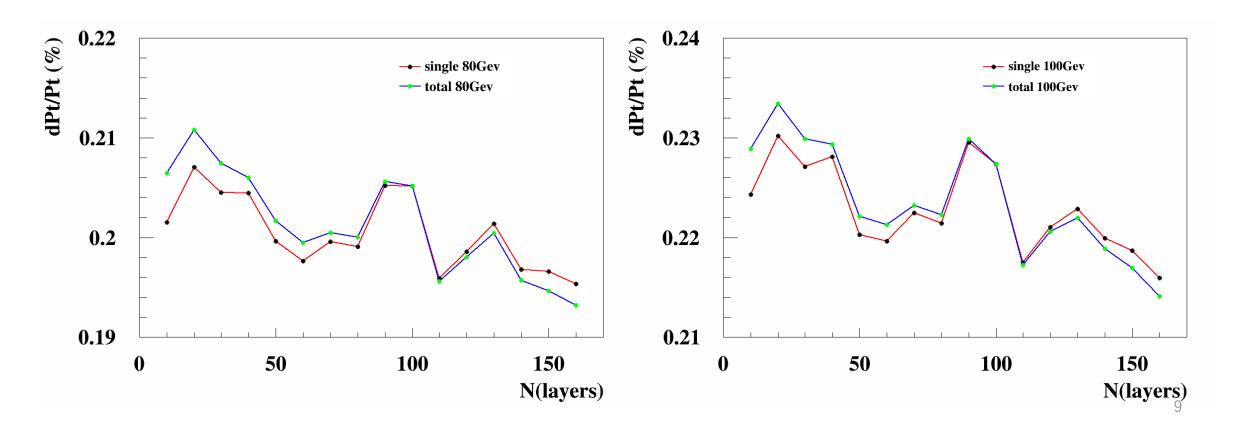
• A jump point is a maximum or minimum point that appears in a certain area.



- The momentum resolution is better when the number of detector layers is 110.
- The momentum resolution fluctuates up and down with the change of detector layers.



- A detector with 110 layers might be a good choice.
- The relationship between the momentum resolution and the number of layers may be up and down.



#### • Summary and plan

- If two different detectors have the same total material budget at a certain layers, the momentum resolution of the larger total material budget is better than the less one when the number of layers is lower than the certain layers.
- When it is greater than the number of layers, the result is just the opposite.
- The exact mathematical expression needs to be studied further.

# backup

1	01 LiC Detector-Toy (barrel)									
2	02 SDT-CEPC									
3	03 Version:	20	0201012							
4	04 Vertex Detector (VXD)									
5	05									
6	06 Number of layers	:	8							
7	07 Description (optional)	:	-Beamt					Vertex dete	ector	
8	08 Names of the layers (opt.)	:	XBT,	VTX1,	VTX2,	VTX3,	VTX4,	VTX5,	VTX6,	XVTXSHELL
9	09 Radii [mm]	:	14.5,	16.0,	18.0,	37.0,	39. 0,	58.0,	60.0,	65.0
10	10 Upper limit in z [mm]	:	4225,	62.5,	62.5,	125,	125,	125,	125,	145
11	11 Lower limit in z [mm]	:	-4225,	-62.5,	-62.5,	-125,	-125,	-125,	-125,	-145
12	12 Efficiency RPhi	:	0,	1.0,	1.0,	1.0,	1. 0,	1.0,	1.0,	0.0
13	13 Efficiency 2nd coord. (eg. z	):	-1							
14	14 Stereo angle alpha [Rad]	:	pi/2							
15	15 Thickness [rad. lengths]	:	0. 0015,	0.0015,	0.0015,	0.0015,	0.0015,	0. 0015,	0.0015,	0.0015
16	16 error distribution	:	0							
17	17 0 normal-sigma(RPhi) [le-6m]	:	2.8, 6,	4.0, 4.0,	4.0, 4.0					
18	18 sigma(z) [1e-6m]	:	2.8, 6,	4.0, 4.0,	4.0, 4.0					
19	19 1 uniform-d(RPhi) [1e-6m]	:	4.0							
20	20 d(z) [1e-6m]	:	4.0							
21	21									
22	22 Silicon Inner Tracker (SIT)									
23	23									
24	24 Number of layers	:	5							
25	25 Description (optional)	:		Si1	icon Inner	r tracker		TPC Inne	er Wall	
26	26 Names of the layers (opt.)	:	SIT1,	SI	т2,	SIT3,	SIT4,	XTPCW1		
27	27 Radii [mm]	:	78.0,	31	8,	558. <b>0</b> ,	798.0 ,	799.0		
28	28 Upper limit in z [mm]	:	150.0,	750	. 0,	1300. 0,	2900. 0,	2900.0		

28 29 30 31	28 Upper limit in z [mm]  :  150    29 Lower limit in z [mm]  :  -150    30 Efficiency RPhi  :  1.    31 Efficiency 2nd coord. (eg. z):  :  1.	. 0, -	750.0, 750.0, 1.00,	1300.0, -1300.0, 1.00,	2900.0, -2900.0, 1.0,	2900. 0 -2900. 0 0. 0	
32 33 34 35 36 37 38 39	32  Stereo angle alpha [Rad]  :  pi    33  Thickness [rad. lengths]  :  0.00    34  error distribution  :  .    35  0 normal-sigma(RPhi) [le-6m]  :  .    36  sigma(z)  [le-6m]  :  .    37  1 uniform-d(RPhi) [le-6m]  :  .  .    38  d(z)  [le-6m]  :  .    39  .  .  .  .	65, 0. 0 . 2 . 6 . 2	0065,	0. 0065,	0. 0065,	0. 002	
40 41 42 43 44 45 46 47 48 49 50 51 52	40 Time Projection Chamber (TPC)    41 sigma^2=sigma0^2+sigma1^2*sin (Weta)^2    42 Number of layers  10    43 Radii [mm]  800    44 Upper limit in z [mm]  290    45 Lower limit in z [mm]  -290    46 Efficiency RPhi  1    47 Efficiency z  1	, 1800 0 00003356	nm/h*sin(th	eta)*Ldrif	t[m]		
56	56 Silicon Tracker (SET)						
57	57						
58	58 Number of layers	: 2					
59	59 Description (optional)	: TPC out	ter wall		Ext	ernal Tracker-	
60	60 Names of the layers (opt.)	: XTP	CW2, SET	1			
61	61 Radii [mm]	: 1801.	0, 181	1			
62	62 Upper limit in z [mm]	: 290	0, 290	0			
63	63 Lower limit in z [mm]	: -290	0, -290	0			
64	64 Efficiency RPhi	: 0.0	0, 1.0				
65	65 Efficiency 2nd coord. (eg. z)	:	-	1			
66	66 Stereo angle alpha [Rad]	:	pi/	2			
67	67 Thickness [rad. lengths]	: 0.0	10, 0.006	5			
68	68 error distribution	:	0				
69	69 0 normal-sigma(RPhi) [le-6m]	: 7.	2				
70	70 sigma(z) [1e-6m]	: 86.	. 6				
71	71 1 uniform-d(RPhi) [1e-6m]	: 7.	. 2				
72	72 d(z) [1e-6m]	: 86.	6				
73	73						
74	74 Magnetic field and beam spot						
75	75						
76	76 Solenoid magnetic field [T]	: 3.0					
77	77 Range in x [mm]	: -0.0	0.0				
78	78 Range in y [mm]	: -0.0	0.0				
79	79 Range in z [mm]	: -0.0	0.0				
80							
							11

1    0	1 01 LiC Detector-Toy (barrel)	2	29 29 Lower limit in z [mm] : -150.0, -750.0, -1300.0, -2900.0, -2900.0
2  Structure  200002  1  10		3	30 30 Efficiency RPhi : 1.00, 1.00, 1.00, 1.0, 0.0
1  2			
$\begin{bmatrix} 2 & 3 \\ 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 \\ 0 & 0 &$			
i & Maner d Jurga  :			
1  0.300000000000000000000000000000000000			
$ \begin{bmatrix} 5 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 &$		Vonton datacton	
9    9    9    0		VTY4 VTY5 VTY6 VVTYSHFLL	
$ \begin{array}{ c c c c c c c c c c c c c c c c c c c$		3	36 36 sigma(z) [1e-6m]: 86.6
11  1100000000000000000000000000000000000			37 37 1 uniform-d(RPhi) [le-6m] : 7.2
10  10  10  1.0<			38 38 d(z) [1e-6m] : 86.6
10  10 <td< td=""><td></td><td></td><td>39 39</td></td<>			39 39
iii threes much ship land:  i: p1/2    iii threes much ship land:  i: p1/2 <td< td=""><td></td><td></td><td>40 40 Time Projection Chamber (TPC)</td></td<>			40 40 Time Projection Chamber (TPC)
b)  b)  b)  c)  c) <td< td=""><td></td><td></td><td></td></td<>			
10  10 <td< td=""><td>15 15 Thickness [rad. lengths] : 0.0015, 0.0015, 0.0015, 0.0015,</td><td>0.0015 0.0015 0.0015 0.0015</td><td></td></td<>	15 15 Thickness [rad. lengths] : 0.0015, 0.0015, 0.0015, 0.0015,	0.0015 0.0015 0.0015 0.0015	
10  10 <td< td=""><td>16 16 error distribution : 0</td><td></td><td></td></td<>	16 16 error distribution : 0		
0  0	17 17 0 normal-sigma(RPhi) [le-6m] : 2.8, 6, 4.0, 4.0, 4.0, 4.0		
0  0	18 18 sigma(z) [1e-6m] : 2.8, 6, 4.0, 4.0, 4.0, 4.0		
11  1  0.0  1  0    11  1  0.0  1  0  0    12  23  100  0  0  0  0  0    12  23  100  1  0	19 19 1 uniform-d(RPhi) [1e-6m] : 4.0	4	
12  22  23  24 <td< td=""><td>20 20 d(z) [1e-6m] : 4.0</td><td>4</td><td>46 Efficiency RPhi : 1</td></td<>	20 20 d(z) [1e-6m] : 4.0	4	46 Efficiency RPhi : 1
20  23  40  40  40  40  60  10  10    24  24  34  Mather of layers  i  5  10  25  100  10<	21 21	4	47 Efficiency z : 1
14  24  24  24  24  25 <td< td=""><td></td><td>4</td><td>48 Thickness [rad. lengths] 🔪 0.0003356 /</td></td<>		4	48 Thickness [rad. lengths] 🔪 0.0003356 /
bit  25 <t< td=""><td>23 23</td><td>4</td><td>49 sigma0(RPhi) [le-6m] : 100</td></t<>	23 23	4	49 sigma0(RPhi) [le-6m] : 100
B  20 Bases of the layers (opt.) : stri, stri, stri, stri, strin, str			50 50 sigmal(RPhi) [le-6m] :
[0] 0 20 80 Manes of the layers (sct.) : \$111, \$112, \$114, \$1041  514, \$174, \$114, \$174, \$114, \$174, \$114, \$174, \$114, \$174		5	51 51 Cdiff(RPhi) [le-6m/sqrt(m)] : 0
[1] 2] 2 Wadti Amil  : 74.0.  318.  536.0.  796.0.  797.0.    [2] 2 Woper Hist In 2 [m]  : 150.0.  750.0.  1300.0.  2500.0.  2500.0.    [3] 4 2 Woper Hist In 2 [m]  : 150.0.  750.0.  1300.0.  2500.0.  2500.0.    [4] 5 4 Cdiff(2)  [1e-6m]  : 0		5	
100 uper intrinitiant  1 dot 0		98.0, 799.0	
rs  rs    56  56    57  57    58  58    59  Description (optional) : TPC outer wall	28 28 Upper limit in z [mm] : 150.0, 750.0, 1300.0, 2	900.0, 2900.0	
56  51 Stilloon Tracker (SET)  7    57  57    58  58 Number of layers  :  2    59  59 Description (optional)  :  TFC outer wall  External  Tracker    60  60 Names of the layers (opt.)  :  XTCW2, SET1  Tracker    61  61 Radii [am]  :  2900, 2900  2900    63  100 relinit in z [ma]  :  -2900, -2900    64  64 Efficiency RPhi  :  0.0, 1.0    65  65 Efficiency 2nd coord. (eg. z):  -1    66  65 Efficiency 2nd coord. (eg. z):  -1    67  67 Thickness [rad lengths]  :  0.10, 0.065    68  error distribution  :  0.0  .0065    69  69 O normal-sigman(RPhi) [le-6m]  :  7.2    70  o sigma (c) [le-6m]  :  8.6    71  11 uniform-d(RPhi) [le-6m]  :  8.6    73  73  74  74 Magnetic field mobeam spot  7    74  74 Magnetic field mobeam spot  7  7  7.0  0.0			
$ \begin{array}{cccccccccccccccccccccccccccccccccccc$			
58  58  Number of layers  :  2    59  59  Description (optional)  :  TPC outer wall  TrackerExternal    60  00  Names of the layers (opt.)  :  NTPCW2, SET1  TrackerExternal    61  61  Radii [mm]  :  1801.0,  1811    62  20 upper limit in z [mm]  :  0.00,  1.00    63  63  Lower limit in z [mm]  :  0.0,  1.0    64  64  Efficiency RPhi  :  0.0,  1.0    65  65  Efficiency RPhi  :  0.0,  1.00    66  65  Strone angle alpha [Rad]  :  pi/2    67  67  77  Thickness Irad lengths]  :  0.00,    69  0 onmal-sigma (RPhi) [le-6m]  :  7.2  -    71  71  uniform-d(RPhi) [le-6m]  :  7.2  -    72  d(z)  (le-6m]  :  7.2  -    73  73  73  -  -  -    74			
59  59  Description (optional)  :  TPC outer wall External  Tracker    60  Names of the layers (opt.)  :  XIPOW2, SETI  IBI1    61  61  Radii [mm]  :  2900, 2900  1Bi1    62  Upper limit in z [mm]  :  2900, -2900  -2900    64  64  Efficiency RPhi  :  0.0  1.0    65  65  Efficiency 2nd coord. (eg. z):  -1  -1    66  66  Stereo angle alpha [Rad]  :  p1/2    67  71 thickness [rad. lengths]  :  0.010, 0.0065    68  68  error distribution  :  0    69  90  normal-sigma(RPhi) [le-6m]  :  7.2    70  sigma(z)  [le-6m]  :  86.6    71  71  1uniform=d(RPhi) [le-6m]  :  7.2    72  72  d(z)  [le-6m]  :  8.6    73  73  .  .  .  .  .    74  Magnetic field and beam spot  .			
60  60  Names of the layers (opt.)  :  XTPCW2, SET1    61  61  Radii [mm]  :  1801.0,  1811    62  62  Upper limit in z [mm]  :  2900,  2900    63  63  Lower limit in z [mm]  :  -2900,  -2900    64  64  Efficiency RPhi  :  0.0,  1.0    65  65  Forlicency 2nd coord. (eg.):  -1    66  66  Stereo angle alpha [Rad]  :  pi/2    67  67  Thickness [rad. lengths]  :  0.00, 0.0065    68  68  error distribution  :  0    69  69  0 normal-sigma(RPhi) [le-6m]  :  7.2    70  70  sigma(z)  [le-6m]  :  86.6    73  73  73  73  73    74  Magnetic field and beam spot  75  75  76  76 Solenoid magnetic field [T]  :  3.0    74  74  Magnetic field ingle  :  -0.0  0.0  0  1			
66  66  Stereo angle alpha [Rad]  :  p1/2    67  67  Thickness [rad. lengths]  :  0.010, 0.0065    68  68  error distribution  :  0    69  69  0 normal-sigma(RPhi) [le-6m] :  7.2    70  70  70  [le-6m] :  86.6    71  1 uniform-d(RPhi) [le-6m] :  7.2    72  72  d(z)  [le-6m] :  86.6    73  73			
67  67  Thickness [rad. lengths]  :  0.010, 0.0065    68  68  error distribution  :  0    69  69  0 normal-sigma (RPhi) [le-6m]  :  7.2    70  rsigma(z)  [le-6m]  :  86.6    71  1 uniform-d(RPhi) [le-6m]  :  7.2    72  72  d(z)  [le-6m]  :  86.6    73  73  .  .  .  .    74  74  Magnetic field and beam spot  .  .  .    75  75  .  .  .  .  .  .    76  Solenoid magnetic field [T]  :  3.0  . </td <td></td> <td></td> <td></td>			
70  70  sigma(z)  [le-6m] :  86.6    71  71  1 uniform-d(RPhi)  [le-6m] :  7.2    72  72  d(z)  [le-6m] :  86.6    73  73			
71  71  1 uniform-d(RPhi)  [1e-6m]  :  7.2    72  72  d(z)  [1e-6m]  :  86.6    73  73  .  .  .    74  74  Magnetic field and beam spot  .  .    75  .  .  .  .  .    76  Solenoid magnetic field [T]  :  3.0  .    77  77 Range in x [mm]  :  -0.0  0.0  .    78  78 Range in y [mm]  :  -0.0  0.0  .  1			
72  72  d(z) [le-6m] : 86.6    73  73    74  74 Magnetic field and beam spot    75  75    76  76 Solenoid magnetic field [T] : 3.0    77  77 Range in x [mm] : -0.0 0.0    78  78 Range in y [mm] : -0.0 0.0			
73  73    74  74 Magnetic field and beam spot    75  75    76  76 Solenoid magnetic field [T] : 3.0    77  77 Range in x [mm] : -0.0 0.0    78  78 Range in y [mm] : -0.0 0.0			
74  74 Magnetic field and beam spot    75  75    76  76 Solenoid magnetic field [T] : 3.0    77  77 Range in x [mm] : -0.0 0.0    78  78 Range in y [mm] : -0.0 0.0			
75  75    76  76 Solenoid magnetic field [T] : 3.0    77  77 Range in x [mm] : -0.0 0.0    78  78 Range in y [mm] : -0.0 0.0			
76  76 Solenoid magnetic field [T] : 3.0    77  77 Range in x [mm] : -0.0 0.0    78  78 Range in y [mm] : -0.0 0.0			
77  77 Range in x [mm]  : -0.0  0.0    78  78 Range in y [mm]  : -0.0  0.0			
78 78 Range in y [mm] : -0.0 0.0 1			
79 79 Range in z [mm] : -0.0 0.0			
		1	79 79 Range in z [mm] : -0.0 0.0

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