

Size of absorber for MMC

- Thermodynamic energy fluctuation of sensor

: accounts for dominant part on energy resolution in ideal situation

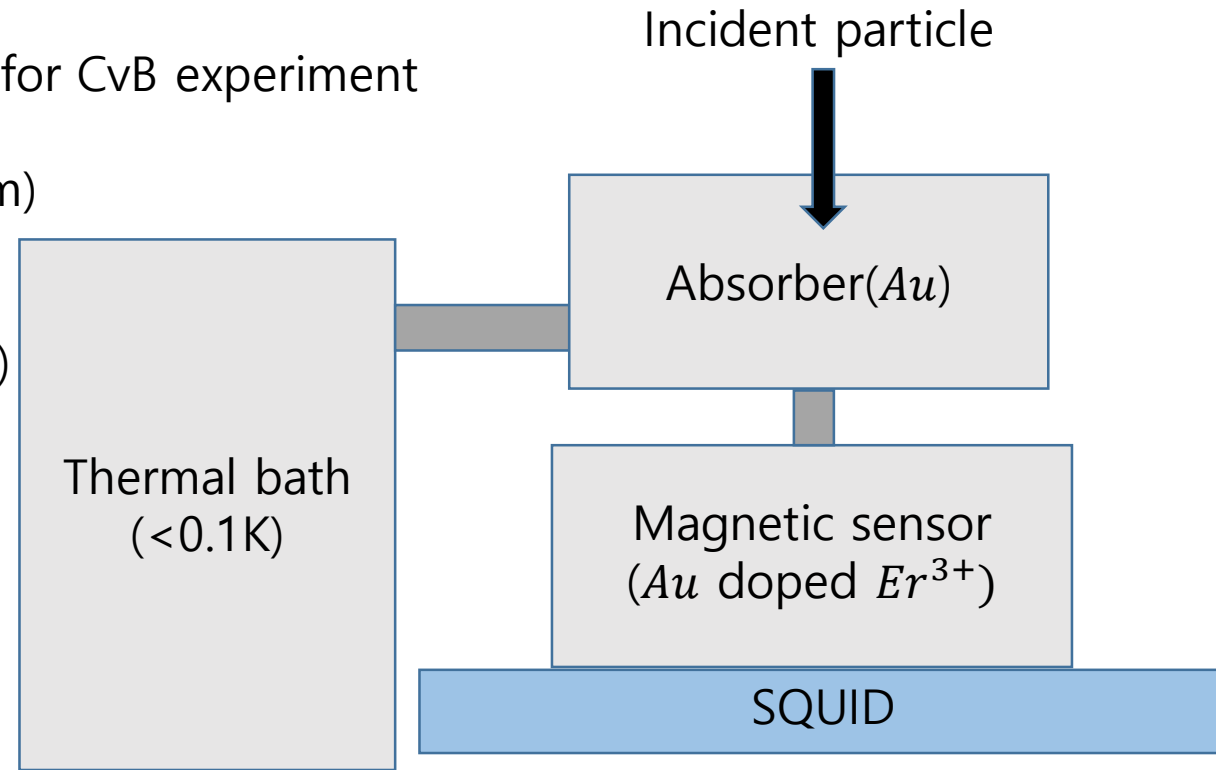
- $$\Delta E_{rms} = \sqrt{4k_B C_e T_0^2 \left[\frac{G_{eb}}{G_{Ze}} + \left(\frac{G_{eb}}{G_{Ze}} \right)^2 \right]^{1/4}}$$

- $\Delta E_{rms} \sim \text{volume of absorber}$, if neglect the volume dependence of $\frac{G_{eb}}{G_{Ze}}$ on absorber size ($G \sim \text{contact area}$)

- Absorber : Maybe, no need to be flat cylindrical shape for CvB experiment (x-ray exp. : external incident particle beam from source -> needs sufficient absorber area projected from the beam)

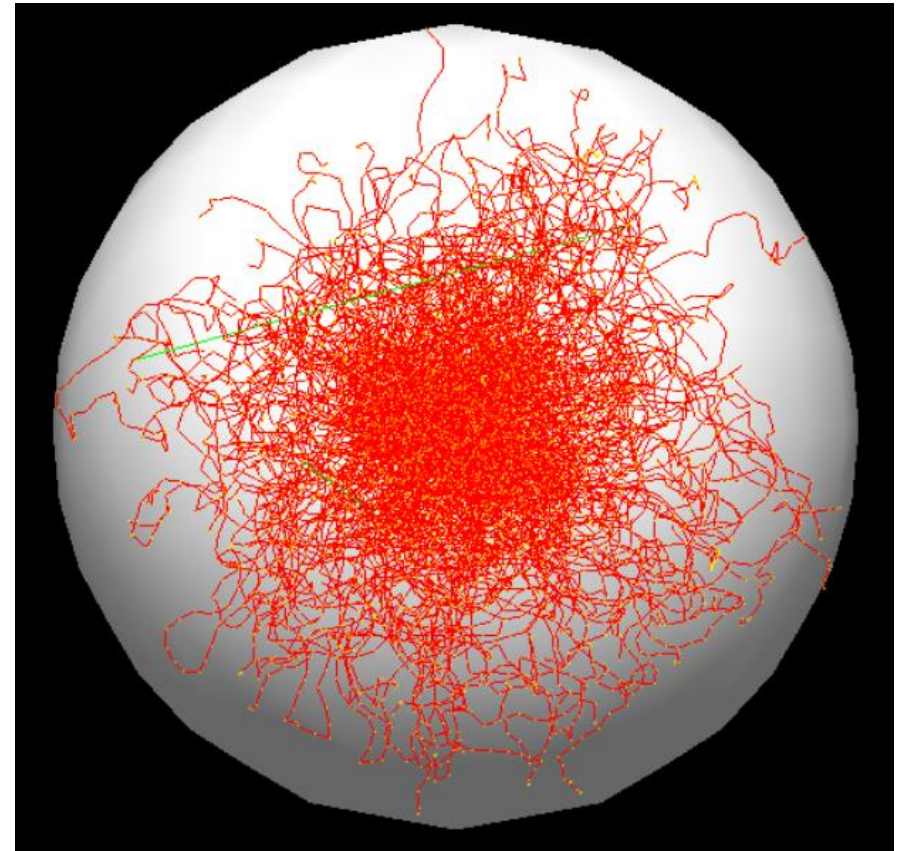
$240 \times 240 \times 5 \mu m^3 \rightarrow \Delta E_{rms} = 1.4 \text{ eV}$ in optimal case(50mK)

at low temperature. By the time the local electron temperature has reached about 1 K the absorbed energy is distributed within a volume of a few cubic micrometers. The further thermalization within the absorber can be described by thermal diffusion. The time scale for this process is mainly determined



Simulation with geant4 (need to be improved)

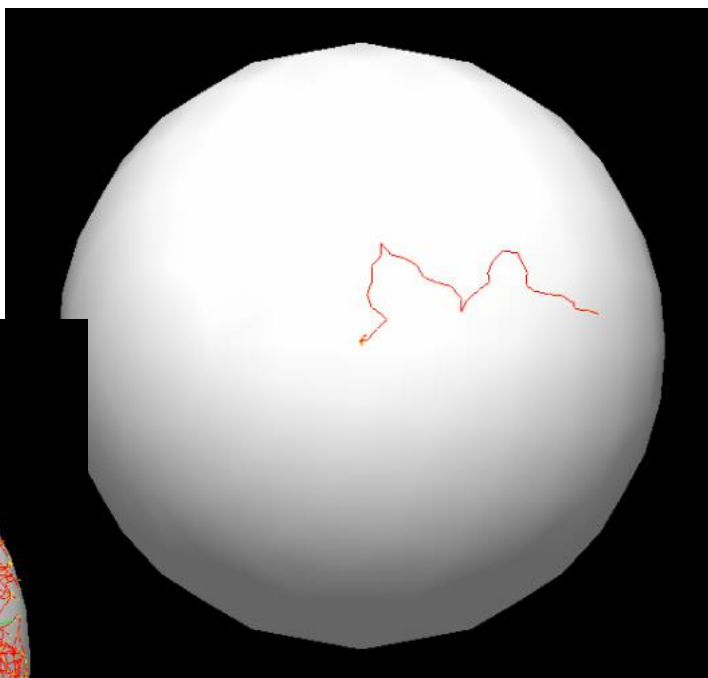
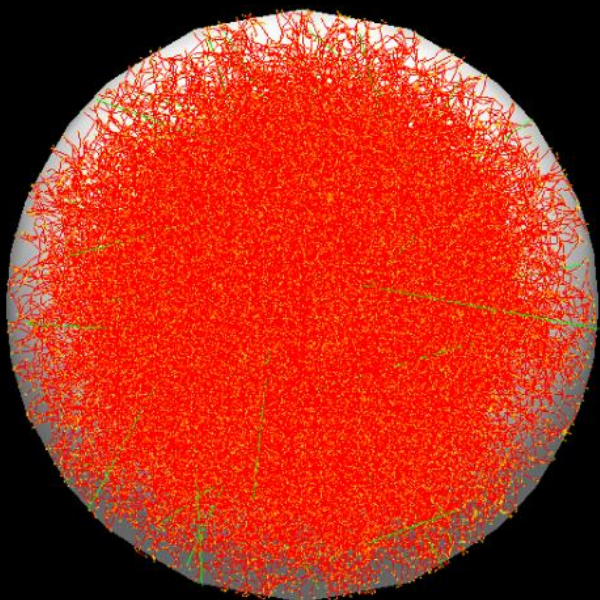
- A Electron from the beta decay of tritium source in gold absorber (18.6keV)
: loses its energy by interaction with the bound electron of gold (excitation or ionization)
- Find the maximally displaced step point from the center including secondary particles
- If possible, accurate simulation which could extract the electron temperature will give the more precise minimum absorber size
- At now, facing with incomprehensible results
: simulation step dependence on absorber size



results

1. Detector radius : $1 \mu m$

10000 source events

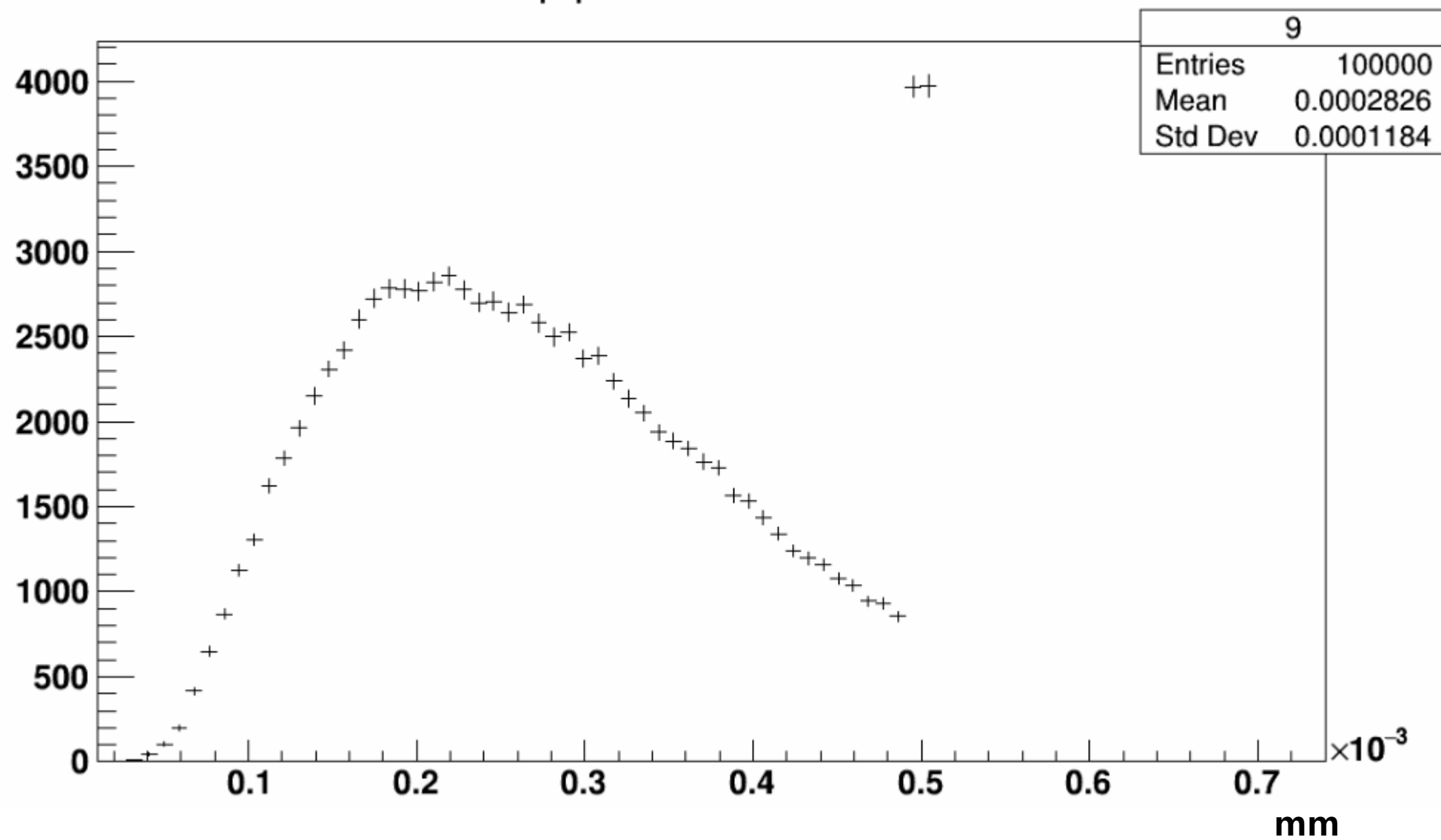


* G4Track Information: Particle = e-, Track ID = 1, Parent ID = 0									
Step#	X	Y	Z	KineE	dEStep	StepLeng	TrakLeng	Volume	Process
	0 fm	0 fm	0 fm	18.6 keV	0 eV	0 fm	0 fm	Detector	initStep
1	13.2 nm	14.8 nm	10 nm	18.6 keV	16.3 eV	24.1 nm	24.1 nm	Detector	MSC
2	36 nm	18.8 nm	23.5 nm	18.6 keV	28.8 eV	27.3 nm	51.4 nm	Detector	MSC
3	47.2 nm	13.5 nm	45.8 nm	18.6 keV	0 eV	26.3 nm	77.7 nm	Detector	MSC
4	62.1 nm	3.9 nm	63.7 nm	18.5 keV	68.8 eV	26.9 nm	105 nm	Detector	MSC
5	73 nm	4.15 nm	73 nm	17 keV	248 eV	14.7 nm	119 nm	Detector	eIoni
6	88.8 nm	9.11 nm	94.3 nm	16.9 keV	45.2 eV	28.9 nm	148 nm	Detector	MSC
7	110 nm	9.23 nm	97.1 nm	16.9 keV	15.4 eV	22.9 nm	171 nm	Detector	MSC
8	122 nm	27.8 nm	86.5 nm	16.8 keV	77.4 eV	24.8 nm	196 nm	Detector	MSC
9	127 nm	42.4 nm	68.2 nm	15.8 keV	1.07 keV	25 nm	221 nm	Detector	MSC
10	105 nm	56.3 nm	67.2 nm	15.7 keV	95 eV	26.4 nm	247 nm	Detector	MSC
11	85.5 nm	63.6 nm	61.9 nm	15.5 keV	196 eV	25.9 nm	273 nm	Detector	MSC
12	72.6 nm	84.7 nm	59.2 nm	15.3 keV	168 eV	29.7 nm	303 nm	Detector	MSC
13	75.8 nm	109 nm	49.8 nm	15.2 keV	131 eV	27.4 nm	330 nm	Detector	MSC
14	68.9 nm	131 nm	45.5 nm	15.2 keV	16.3 eV	24.3 nm	355 nm	Detector	MSC
15	71.5 nm	148 nm	26.9 nm	15 keV	129 eV	26.3 nm	381 nm	Detector	MSC
16	59.6 nm	169 nm	13.2 nm	14.6 keV	414 eV	29.3 nm	410 nm	Detector	MSC
17	70.7 nm	151 nm	2.9 nm	14.6 keV	16.5 eV	25.1 nm	435 nm	Detector	MSC
18	86.8 nm	144 nm	-12.9 nm	14.5 keV	69.3 eV	24.6 nm	460 nm	Detector	MSC
19	109 nm	133 nm	-19.1 nm	14.5 keV	22 eV	27 nm	487 nm	Detector	MSC
20	116 nm	113 nm	-29.1 nm	14.4 keV	69.1 eV	24.3 nm	511 nm	Detector	MSC
21	127 nm	105 nm	-47.7 nm	14.4 keV	0 eV	24.6 nm	536 nm	Detector	MSC
22	145 nm	97.9 nm	-63 nm	14.4 keV	20.4 eV	25.8 nm	562 nm	Detector	MSC
23	157 nm	77.6 nm	-76.4 nm	13.4 keV	1.02 keV	29.5 nm	591 nm	Detector	MSC
24	163 nm	57.2 nm	-69.5 nm	13.4 keV	0 eV	23.7 nm	615 nm	Detector	MSC
25	179 nm	75.4 nm	-67.3 nm	13.2 keV	187 eV	25.5 nm	640 nm	Detector	MSC
26	188 nm	91.3 nm	-83.4 nm	12.9 keV	274 eV	25.6 nm	666 nm	Detector	MSC
27	206 nm	106 nm	-92 nm	12.2 keV	738 eV	27 nm	693 nm	Detector	MSC
28	215 nm	120 nm	-78.7 nm	11.9 keV	268 eV	22.4 nm	715 nm	Detector	MSC
29	228 nm	139 nm	-77.3 nm	11.9 keV	0 eV	27.2 nm	743 nm	Detector	MSC
30	240 nm	156 nm	-88.9 nm	11.9 keV	50.5 eV	25.2 nm	768 nm	Detector	MSC
31	259 nm	153 nm	-105 nm	11.8 keV	88.3 eV	25.9 nm	794 nm	Detector	MSC
32	269 nm	132 nm	-109 nm	11.7 keV	131 eV	25 nm	819 nm	Detector	MSC
33	258 nm	120 nm	-127 nm	11.6 keV	34.5 eV	24.2 nm	843 nm	Detector	MSC
34	250 nm	101 nm	-132 nm	10.7 keV	886 eV	23.1 nm	866 nm	Detector	MSC
35	249 nm	90.8 nm	-151 nm	10.6 keV	96.3 eV	26.4 nm	892 nm	Detector	MSC
36	266 nm	85.2 nm	-169 nm	10.6 keV	54.3 eV	27.1 nm	919 nm	Detector	MSC
37	274 nm	82.9 nm	-192 nm	10.3 keV	292 eV	28.1 nm	947 nm	Detector	MSC
38	296 nm	70 nm	-199 nm	8.75 keV	1.54 keV	28.2 nm	976 nm	Detector	MSC
39	311 nm	61.5 nm	-185 nm	7.59 keV	1.16 keV	28.6 nm	1 um	Detector	MSC
40	333 nm	57.7 nm	-188 nm	7.51 keV	75.2 eV	26.5 nm	1.03 um	Detector	MSC
41	337 nm	57.9 nm	-191 nm	6.01 keV	97.4 eV	5.48 nm	1.04 um	Detector	eIoni
42	346 nm	52.9 nm	-206 nm	0 eV	6.01 keV	185 nm	1.22 um	Detector	eIoni

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* G4Track Information: Particle = e-, Track ID = 3, Parent ID = 1
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Step#      X          Y          Z      KineE      dEStep      StepLeng  TrakLeng      Volume      Process
0         337 nm      57.9 nm      -191 nm      1.4 keV      0 eV         0 fm        0 fm      Detector  initStep
1         339 nm      60.5 nm      -191 nm      0 eV         1.4 keV      22.5 nm     22.5 nm     Detector  eIoni
```

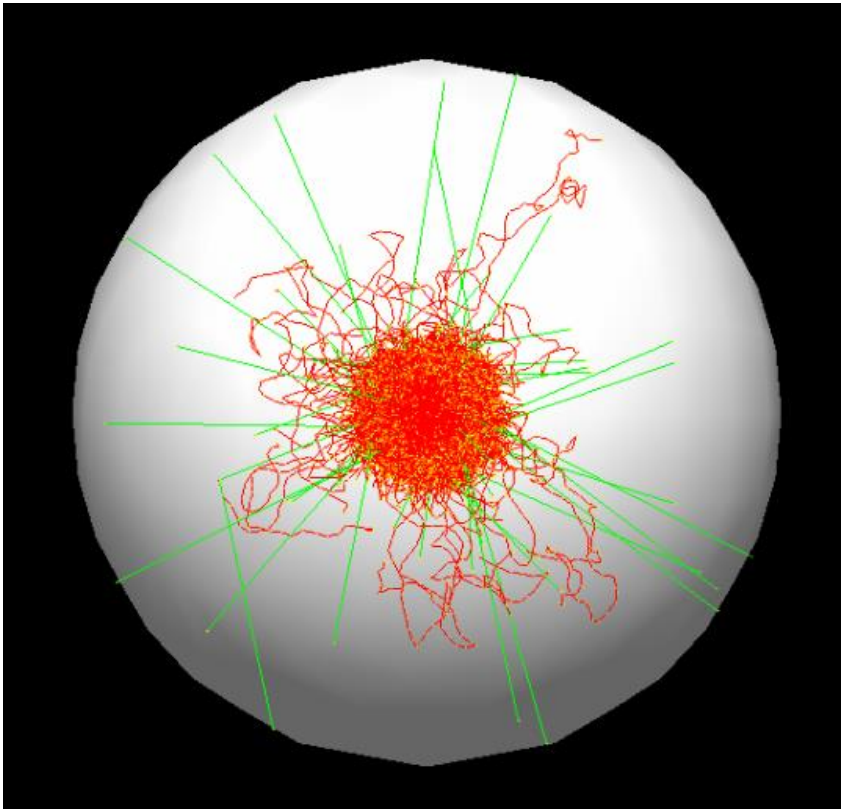
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* G4Track Information: Particle = e-, Track ID = 2, Parent ID = 1
*****
Step#      X          Y          Z      KineE      dEStep      StepLeng  TrakLeng      Volume      Process
   0      73 nm      4.15 nm      73 nm      1.27 keV      0 eV        0 fm        0 fm      Detector  initStep
   1     71.2 nm      6.19 nm     73.6 nm        0 eV      1.27 keV     20 nm       20 nm      Detector  eIoni
Run terminated.
```

maximum step point distance from the center



2. Detector radius : 1.3 μm

10000 source events



```
*****
* G4Track Information:  Particle = e-,   Track ID = 1,   Parent ID = 0
*****
```

Step#	X	Y	Z	KineE	dEStep	StepLeng	TrakLeng	Volume	Process
0	0 fm	0 fm	0 fm	18.6 keV	0 eV	0 fm	0 fm	Detector	initStep
1	46.7 nm	46.8 nm	12.5 nm	16.9 keV	339 eV	119 nm	119 nm	Detector	eIoni
2	62.6 nm	42 nm	-63.9 nm	10.2 keV	5.08 keV	467 nm	586 nm	Detector	eIoni
3	76 nm	8.25 nm	-59.7 nm	0 eV	10.2 keV	454 nm	1.04 um	Detector	eIoni

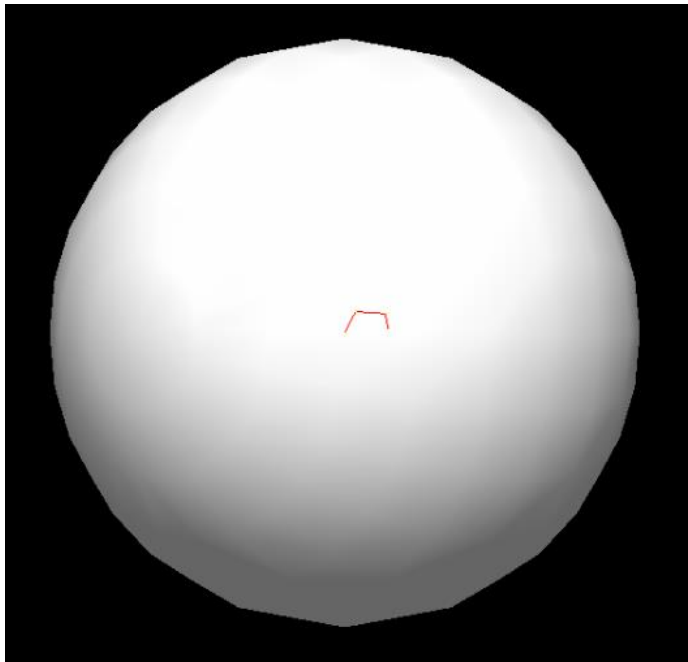
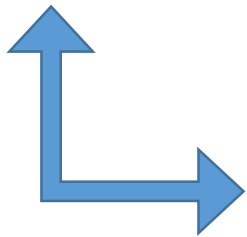
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*****
* G4Track Information:  Particle = e-,   Track ID = 3,   Parent ID = 1
*****
```

Step#	X	Y	Z	KineE	dEStep	StepLeng	TrakLeng	Volume	Process
0	62.6 nm	42 nm	-63.9 nm	1.63 keV	0 eV	0 fm	0 fm	Detector	initStep
1	65.7 nm	43.2 nm	-65.3 nm	0 eV	1.63 keV	27.2 nm	27.2 nm	Detector	eIoni

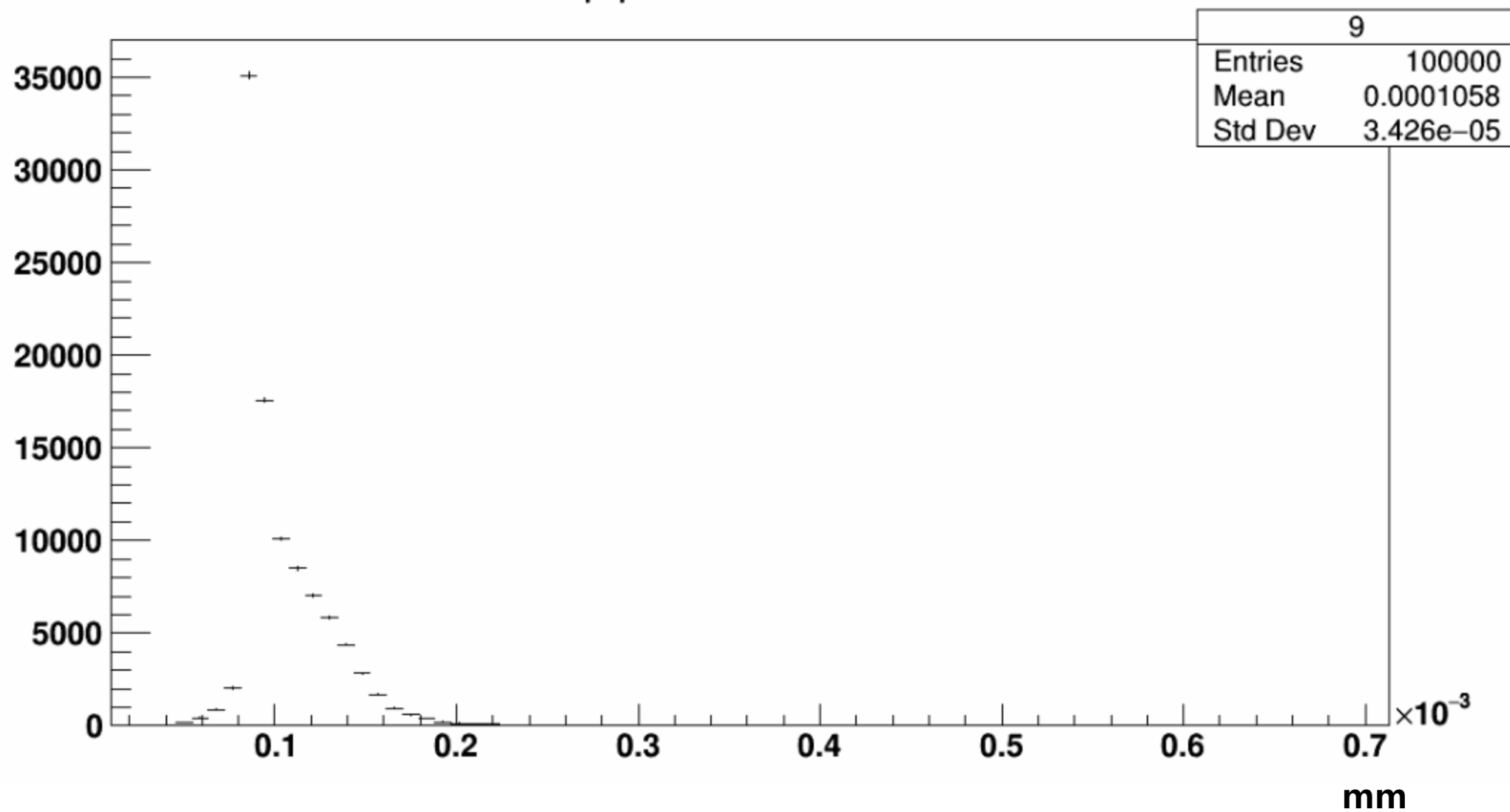
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*****
* G4Track Information:  Particle = e-,   Track ID = 2,   Parent ID = 1
*****
```

Step#	X	Y	Z	KineE	dEStep	StepLeng	TrakLeng	Volume	Process
0	46.7 nm	46.8 nm	12.5 nm	1.35 keV	0 eV	0 fm	0 fm	Detector	initStep
1	46.7 nm	49.7 nm	12.4 nm	0 eV	1.35 keV	21.4 nm	21.4 nm	Detector	eIoni

Run terminated.



maximum step point distance from the center



- 검출기 size(직경)가 1300nm를 넘어가면 multiple scattering(elastic coulomb)이 일어나지 않았음
- > multiple scattering model : G4UrbanMscModel (default for em particles including low E physics)

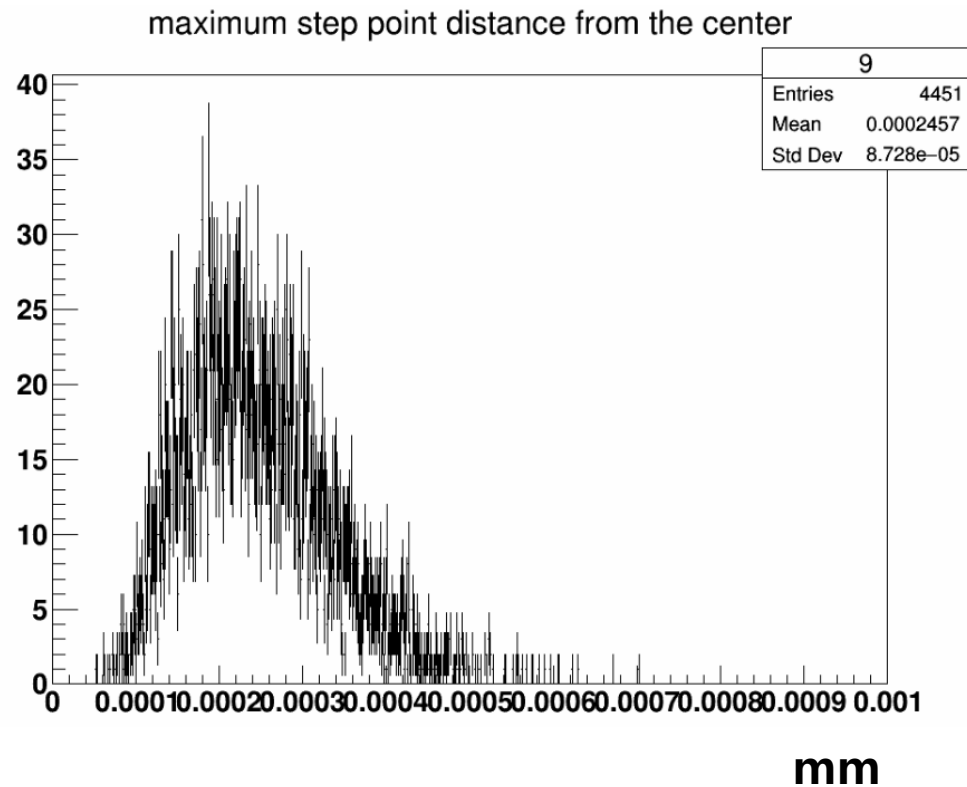
In G4UrbanMscModel.cc

- * distance : upper limit for maximum distance electron propagate as straight line
= (stopping length)*(1.20-Z*(1.62e-2-9.22e-5*Z)) ~ 0.5*(stopping length)
 - * safety : distance to nearest detector boundary
- distance > safety인 경우에만 multiple scattering이 일어나도록 짜여져 있다. -> 수정

distance at 18.6keV ~ 660 nm

- Ionization process에서는 step의 length를 가져올 때, model이 제공하는 cross-section per atom 을 바탕으로 한 mean free path 를 이용하지 않음. 이것을 수정.
- $10 \cdot l_{msc}$, l_{ioni} 중 짧은 길이가 step의 length를 결정 (2 ~ 30 nm)

R = 500nm



R = 650nm

