Background Simulations and the Impact of thresholds

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https://indico.bnl.gov/event/20218/contributions/79344/attachments/49019/83526/EPIC_Background_Meeting_Shyam8August23.pdf

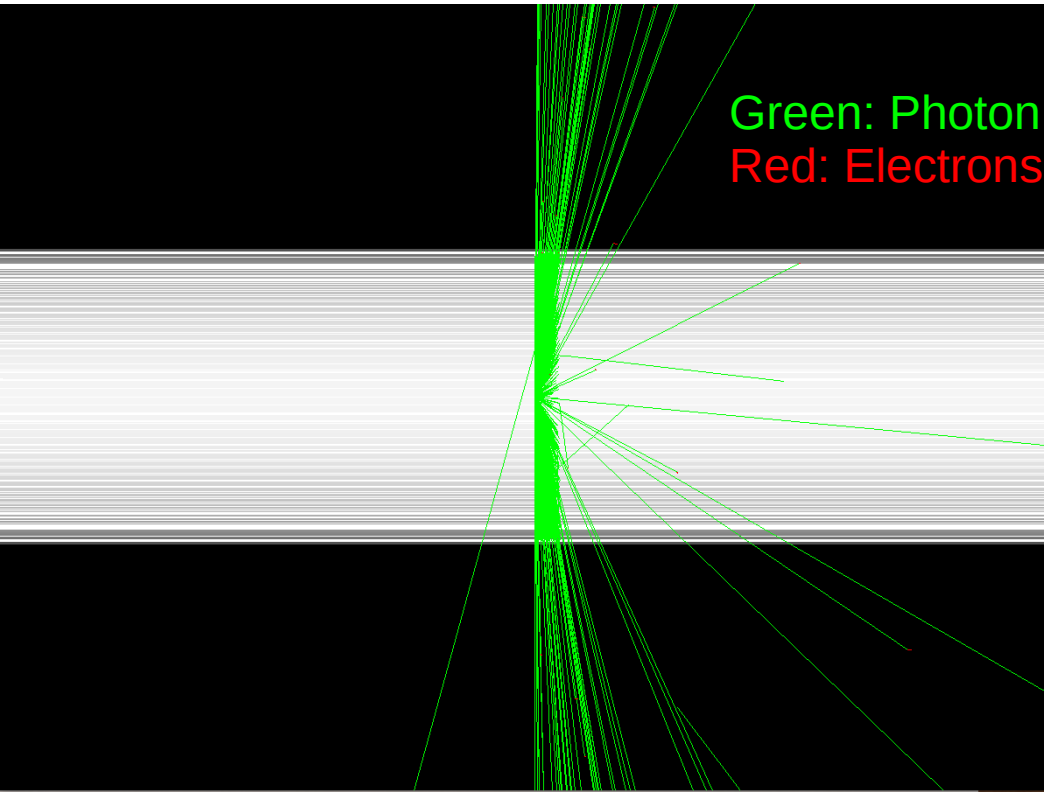
Simulation of Photons

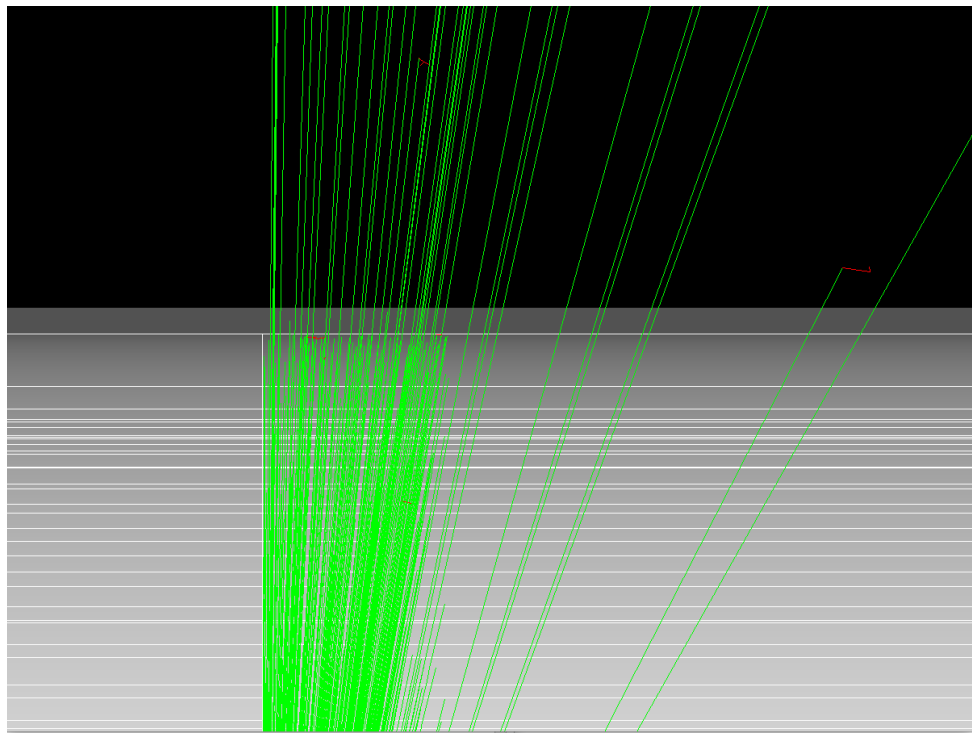
- 100 photons with energy 5-10 KeV and Theta: 80-90 deg with epic_craterlake_tracking_only.xml (epic: 23.08.0)
- npsim steering file setting:

```
## Enable lots of printout on simulated hits and MC-truth information
SIM.part.enableDetailedHitsAndParticleInfo = True

##  Keep all created particles
SIM.part.keepAllParticles = True

## Minimal distance between particle vertex and endpoint of parent after
##     which the vertexIsNotEndpointOfParent flag is set
##
SIM.part.minDistToParentVertex = 2.2e-14

## MinimalKineticEnergy to store particles created in the tracking region
SIM.part.minimalKineticEnergy = 0.5e-6*GeV

##  Printout at End of Tracking
SIM.part.printEndTracking = True

##  Printout at Start of Tracking
SIM.part.printStartTracking = True

## The name of the Geant4 Physics list.
SIM.physics.list = "FTFP_BERT"
```

Do we see electrons? As seen in FLUKA

Event display





Simulation Output

```
Geant4Output2EDM4hep INFO  Opened sim.edm4hep.root for output
GenerationInit   INFO  +++ Initializing event 1. Within run:0 event 1.
Gun              INFO  Shoot [0] [0.000 , 0.000] GeV gamma pos:(0.000 0.000 0.000)[mm] dir:( 0.000  0.000  1.000)
Gun              INFO  Particle [0] gamma       Mom:0.000 GeV vertex:( 0.000  0.000  0.000)[mm] direction:(-0.356 -0.929  0.099)
Gun              INFO  +-> Interaction [0] [0.000 , 0.000] GeV gamma pos:(0.000 0.000 0.000)[mm]
Gun              INFO  +++   +-> ID:  0 gamma       status:00000002 PDG:    22 Vtx:(+0.00e+00,+0.00e+00,+0.00e+00)[mm] time: +0.00e+00 [ns] #Dau:  0 #Par:0
PrimaryHandler   INFO  +++++ G4PrimaryVertex at (+0.00e+00,+0.00e+00,+0.00e+00) [mm] +0.00e+00 [ns]
ParticleHandler  INFO  +++ Event 0 Begin event action. Access event related information.
Geant4Output2EDM4hep INFO  +++ Saving EDM4hep event 0 run 0.
ParticleDump         +++ Geant4 Particle map              ---------- Track KEEP reasoning ----------
ParticleDump         +++ # of Tracks:    3          PDG Parent Primary Secondary Energy in [MeV] Calo Tracker Process/Par
ParticleDump           +++ TrackID:      0 [key:0]    22    -1 YES    YES     1    YES  0.00922 NO   NO      NO
ParticleDump           +++ TrackID:      1 [key:1]    11     0 NO     YES     1    YES   0.517 NO   NO      NO
ParticleDump           +++ TrackID:      2 [key:2]    11     1 NO     NO      0    YES   0.514 NO   NO      NO

GenerationInit   INFO  +++ Initializing event 2. Within run:0 event 2.
Gun              INFO  Shoot [1] [0.000 , 0.000] GeV gamma pos:(0.000 0.000 0.000)[mm] dir:( 0.000  0.000  1.000)
Gun              INFO  Particle [0] gamma       Mom:0.000 GeV vertex:( 0.000  0.000  0.000)[mm] direction:( 0.755 -0.656  0.017)
Gun              INFO  +-> Interaction [0] [0.000 , 0.000] GeV gamma pos:(0.000 0.000 0.000)[mm]
Gun              INFO  +++   +-> ID:  0 gamma       status:00000002 PDG:    22 Vtx:(+0.00e+00,+0.00e+00,+0.00e+00)[mm] t
ime: +0.00e+00 [ns] #Dau:  0 #Par:0
PrimaryHandler   INFO  +++++ G4PrimaryVertex at (+0.00e+00,+0.00e+00,+0.00e+00) [mm] +0.00e+00 [ns]
ParticleHandler  INFO  +++ Event 1 Begin event action. Access event related information.
Geant4Output2EDM4hep INFO  +++ Saving EDM4hep event 1 run 0.
ParticleDump         +++ Geant4 Particle map              ---------- Track KEEP reasoning ----------
ParticleDump         +++ # of Tracks:    2          PDG Parent Primary Secondary Energy in [MeV] Calo Tracker Process/Par
ParticleDump           +++ TrackID:      0 [key:0]    22    -1 YES    YES     1    YES   0.0087 NO   NO      NO
ParticleDump           +++ TrackID:      1 [key:1]    11     0 NO     NO      0    YES   0.517 NO   NO      NO
```

Output root file

```
*************************************************
*
*  Event   * TrackId * PDG * Mom (MeV)
*
*************************************************
*
*      0 *       0 *      22 * 0.0092239 *
*      0 *       1 *      11 * 0.0816107 *
*      0 *       2 *      11 * 0.0524541 *
*      1 *       0 *      22 * 0.0086952 *
*      1 *       1 *      11 * 0.0754647 *
*      2 *       0 *      22 * 0.0088865 *
*      2 *       1 *      11 * 0.0748755 *
*      2 *       2 *      11 * 0.0367856 *
*      3 *       0 *      22 * 0.0088142 *
*      3 *       1 *      11 * 0.0863847 *
*      4 *       0 *      22 * 0.0060503 *
*      4 *       1 *      11 * 0.0751911 *
*      5 *       0 *      22 * 0.0056097 *
*      5 *       1 *      11 * 0.0541562 *
*      6 *       0 *      22 * 0.0053079 *
*      6 *       1 *      11 * 0.0691902 *
*      7 *       0 *      22 * 0.0071301 *
*      7 *       1 *      11 * 0.0710815 *
*      8 *       0 *      22 * 0.0079055 *
*      8 *       1 *      11 * 0.0864462 *
*      8 *       2 *      11 * 0.0534816 *
*      8 *       3 *      11 * 0.0345899 *
*      9 *       0 *      22 * 0.0074156 *
*      9 *       1 *      11 * 0.0692253 *
*      9 *       2 *      11 * 0.0403311 *
```

```
root [2] events->Scan("MCParticles.PDG:sqrt(MCParticles.momentum.x*MCParticles.momentum.x+
MCParticles.momentum.y*MCParticles.momentum.y+MCParticles.momentum.z*MCParticles.momentum.z)")
```

Event No 0: From root file and prints

$m_e = 0.511$ MeV/c²

$$E_e = \sqrt{p^2 + m_e^2}$$

$$E_e = \sqrt{(0.0816107)^2 + (0.511)^2} = 0.5174759$$

$$E_e = \sqrt{(0.0524541)^2 + (0.511)^2} = 0.51368515$$

Simulation Output

```
Geant4Output2EDM4hep INFO  +++ Saving EDM4hep event 31 run 0.
ParticleDump           +++ Geant4 Particle map                    -------------- Track KEEP reasoning --------------
ParticleDump           +++ # of Tracks:     4          PDG Parent Primary Secondary Energy in [MeV] Calo Tracker Process/Par
ParticleDump              +++ TrackID:      0 [key:0]          22     -1 YES     YES     1    YES  0.00917 NO   NO      NO
ParticleDump              +++ TrackID:      1 [key:1]          11      0 NO      YES     2    YES     0.52 NO   NO      NO
ParticleDump              +++ TrackID:      2 [key:2]          11      1 NO      NO      0    YES    0.512 NO   NO      NO
ParticleDump              +++ TrackID:      3 [key:3]          11      1 NO      NO      0    YES    0.513 NO   NO      NO
```

Two consecutive flag 1

root [4] events->Scan("MCParticles.PDG:sqrt(MCParticles.momentum.x*MCParticles.momentum.x+MCParticles.momentum.y*MCParticles.momentum.y+MCParticles.momentum.z*MCParticles.momentum.z)*1000:sqrt(MCParticles.vertex.x*MCParticles.vertex.x*0.01+MCParticles.vertex.y*MCParticles.vertex.y*0.01)")

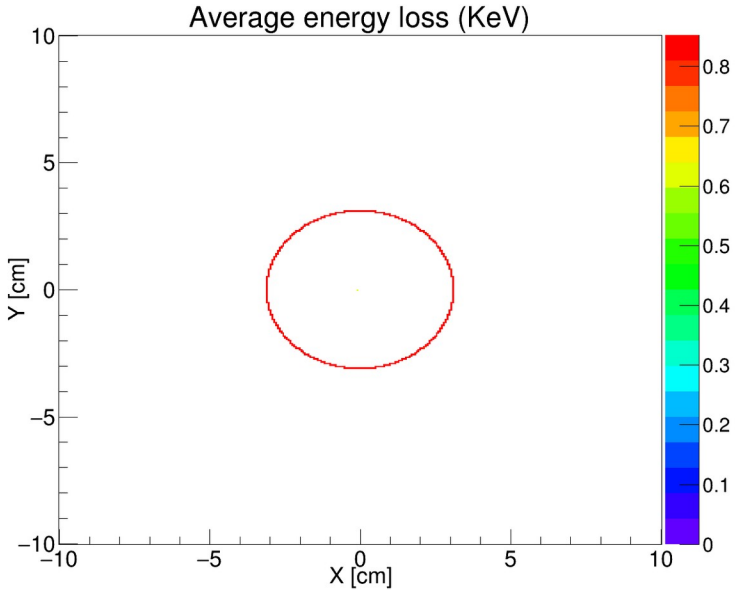
Event	TrackId	PDG	Mom (MeV)	Radius (cm)
0	0	22	0.0092239	0
0	1	11	0.0816107	3.1000776
0	2	11	0.0524541	3.1000796
1	0	22	0.0086952	0
1	1	11	0.0754647	3.1002421
2	0	22	0.0088865	0
2	1	11	0.0748755	3.1002652
2	2	11	0.0367856	3.1002651
3	0	22	0.0088142	0
3	1	11	0.0863847	27.067755
4	0	22	0.0060503	0
4	1	11	0.0751911	3.1003313
5	0	22	0.0056097	0
5	1	11	0.0541562	3.1002043
6	0	22	0.0053079	0
6	1	11	0.0691902	3.1000880
7	0	22	0.0071301	0
7	1	11	0.0710815	3.1002051
8	0	22	0.0079055	0
8	1	11	0.0864462	3.1003305
8	2	11	0.0534816	3.1003312
8	3	11	0.0345899	3.1003312
23	1	11	0.0786208	3.1001052
23	2	11	0.0324303	3.1001065
24	0	22	0.0097495	0
24	1	11	0.0974632	9.3557177
25	0	22	0.0081428	0
25	1	11	0.0744486	3.1001973
26	0	22	0.0056599	0
26	1	11	0.0506787	3.1002248
27	0	22	0.0083233	0
27	1	11	0.0903176	12.896380
28	0	22	0.0067580	0
28	1	11	0.0811346	3.1000820
28	2	11	0.0398697	3.1000836
29	0	22	0.0099243	0
29	1	11	0.0912327	4.8018585
29	2	11	0.0522171	4.8018610
30	0	22	0.0097000	0
30	1	11	0.0959815	3.1001857
30	2	11	0.0508479	3.1001866
31	**0**	**22**	**0.0091677**	**0**
31	**1**	**11**	**0.0937169**	**3.1000803**
31	**2**	**11**	**0.0344327**	**3.1000803**
31	**3**	**11**	**0.0435102**	**3.1000833**
32	0	22	0.0088231	0
32	1	11	0.0819413	3.1003001
33	0	22	0.0051211	0
33	1	11	0.0546229	3.1001244

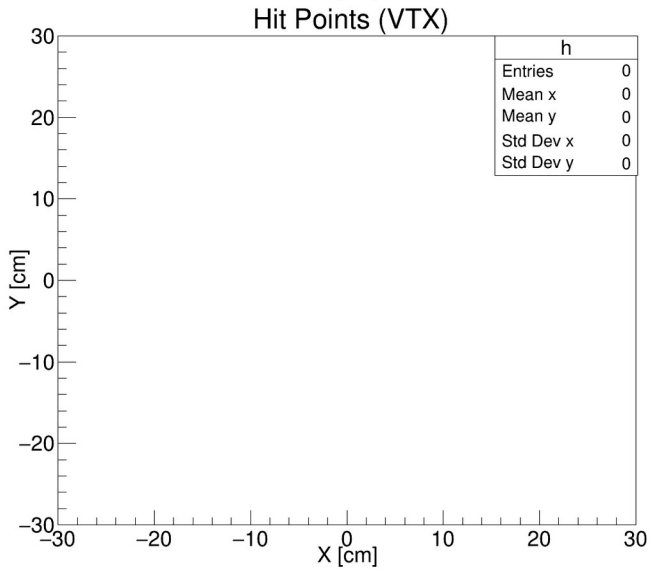
p_T (GeV/c) = 0.3 B[T] R[m]

$$R = \frac{0.0816107 * 1.0\,x\,10^{-3}}{0.3 * 1.7}$$

$$R = 0.000160\,m = 160\,\mu m$$

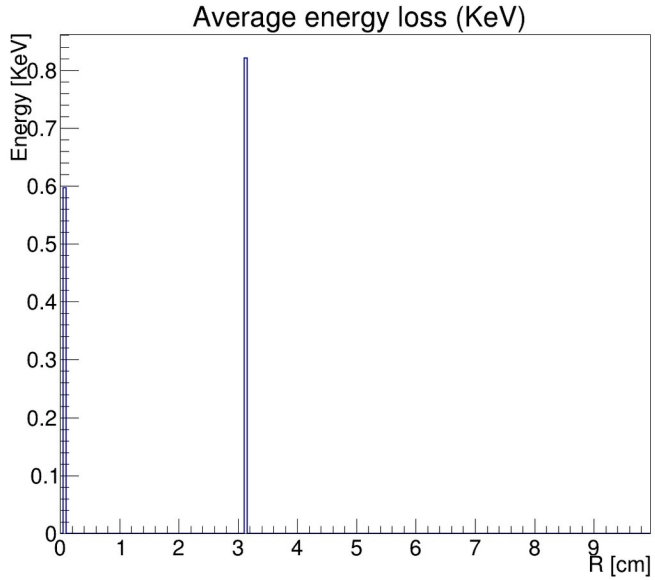
Photon of Energy 1 KeV





$$E_e = \sqrt{p^2 + m_e^2}$$

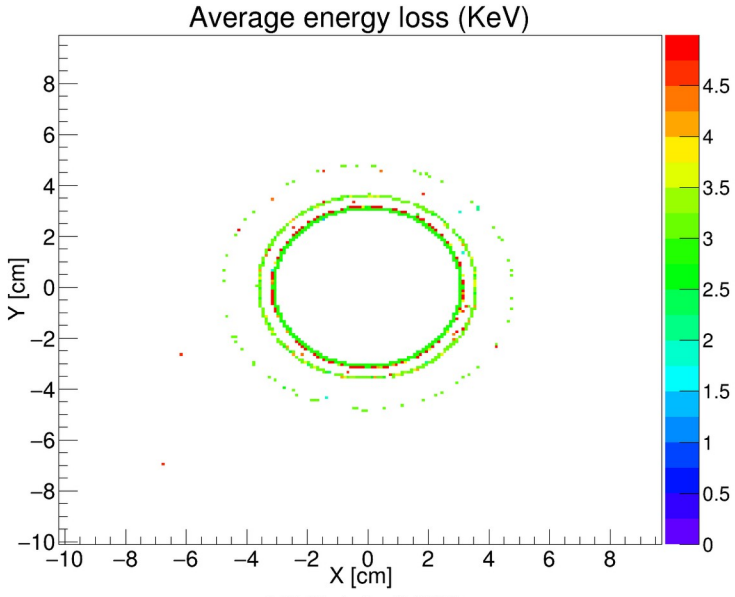
$$E_{Kin} = E_e - m_e$$



- 1 M Photons of energy 1 KeV
- Average kinetic energy of electron (KeV) only MC Particles with generated status !=1

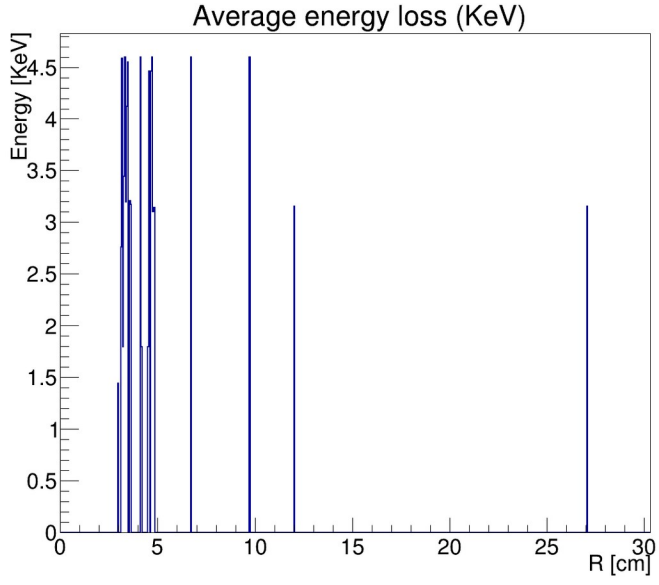
https://journals.aps.org/prl/abstract/10.1103/PhysRevLett.35.1522

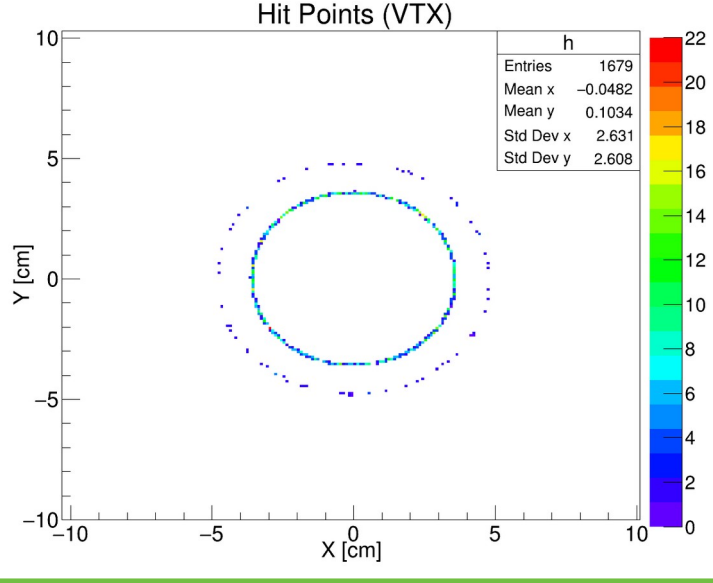
Photon of Energy 5 KeV

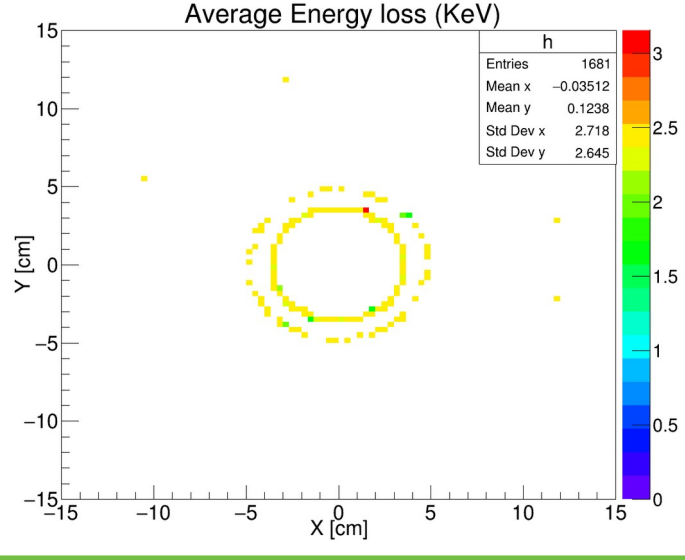


$$E_e = \sqrt{p^2 + m_e^2}$$

$$E_{Kin} = E_e - m_e$$



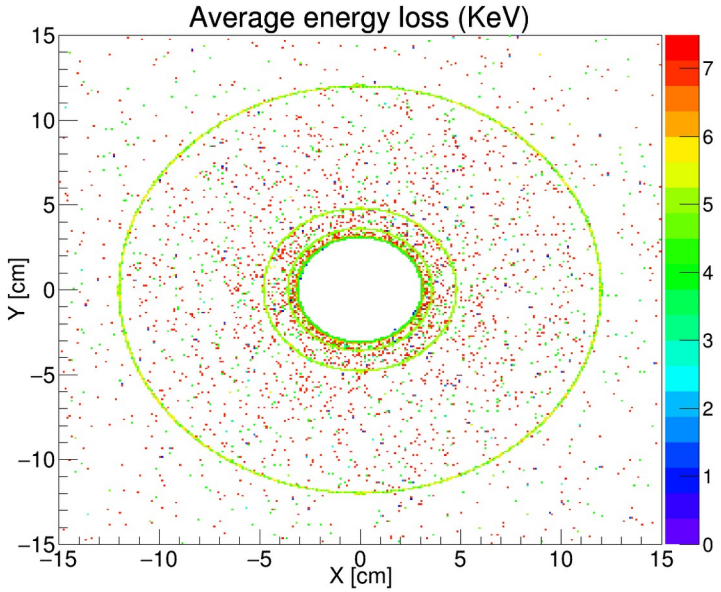




1 M Photons of energy 5.0 KeV
Average kinetic energy of electron (KeV) only MC Particles with generated status !=1

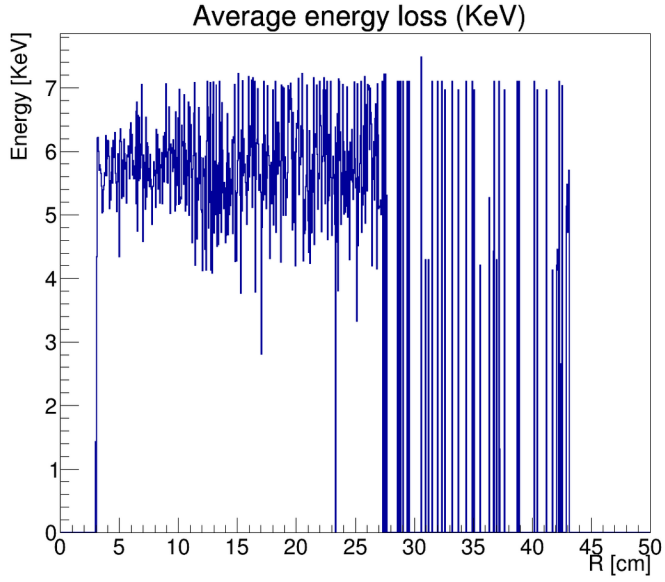
Note: Hit Points (VTX) show small entries
h1->Add(hist) method is correct instead of Draw("same") which is used in this case

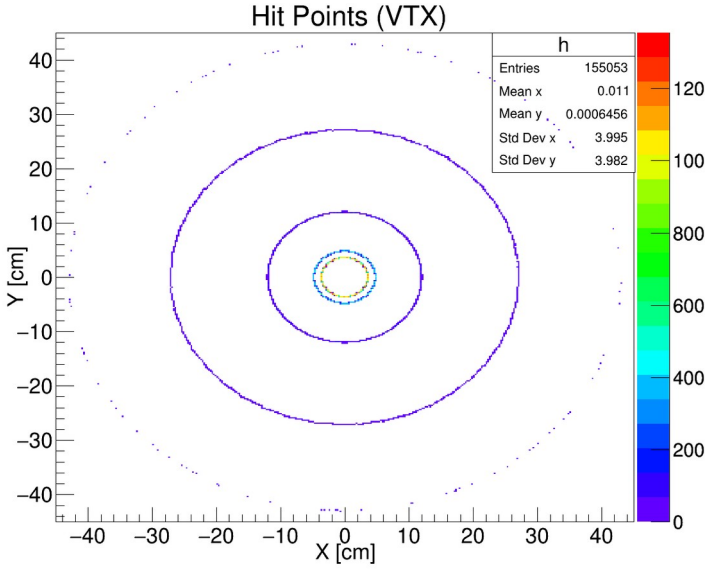
Photon of Energy 7.5 KeV

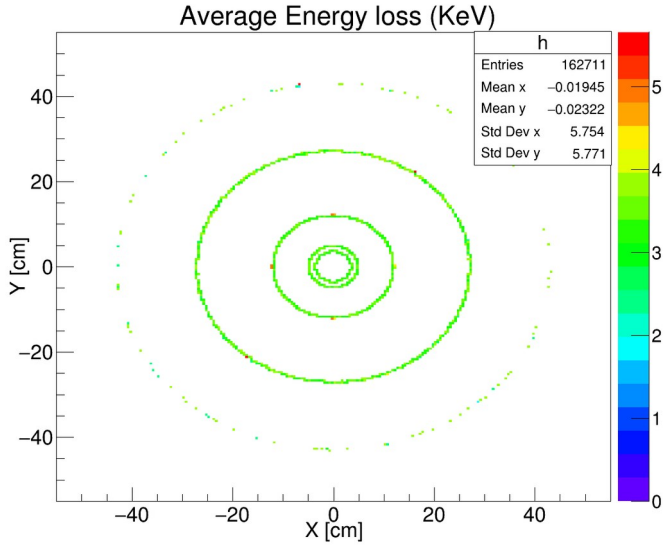


$$E_e = \sqrt{p^2 + m_e^2}$$

$$E_{Kin} = E_e - m_e$$



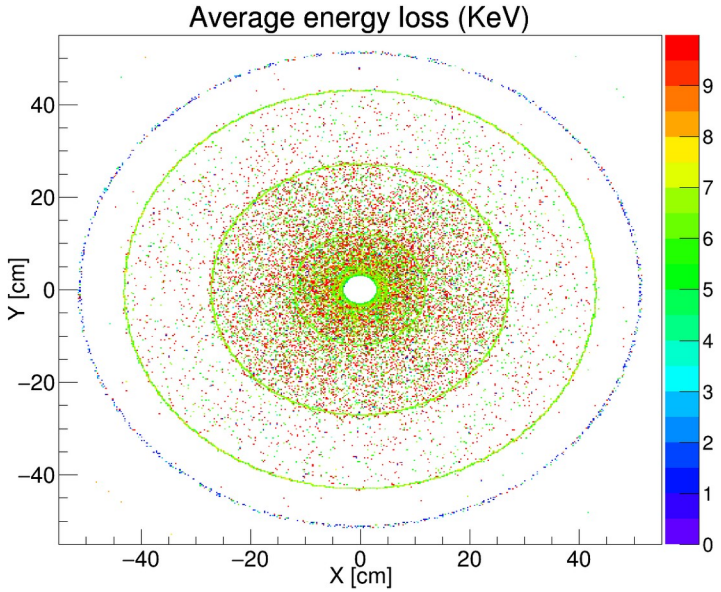




1 M Photons of energy 7.5 KeV
Average kinetic energy of electron (KeV) only MC Particles with generated status !=1

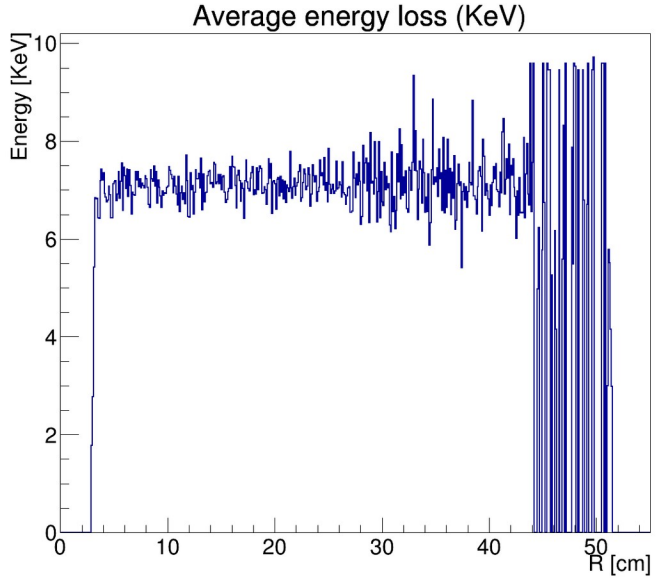
Note: Hit Points (VTX) show small entries
h1->Add(hist) method is correct instead of Draw("same") which is used in this case

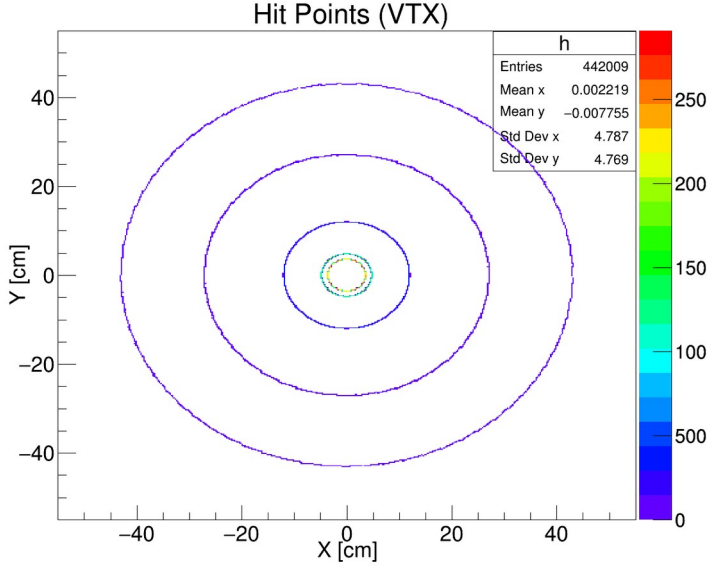
Photon of Energy 10.0 KeV

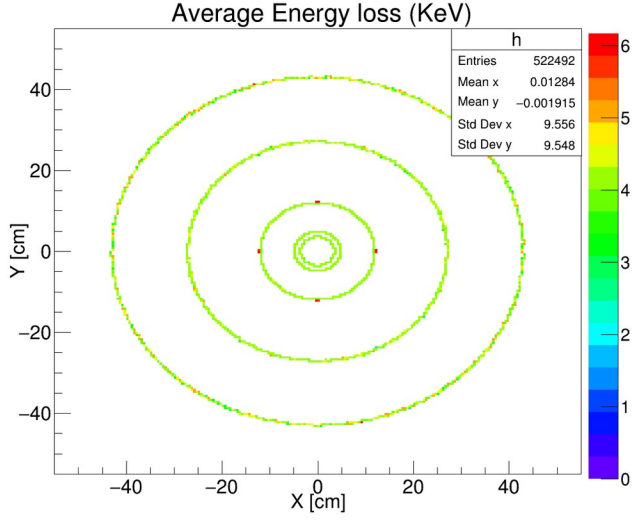


$$E_e = \sqrt{p^2 + m_e^2}$$

$$E_{Kin} = E_e - m_e$$



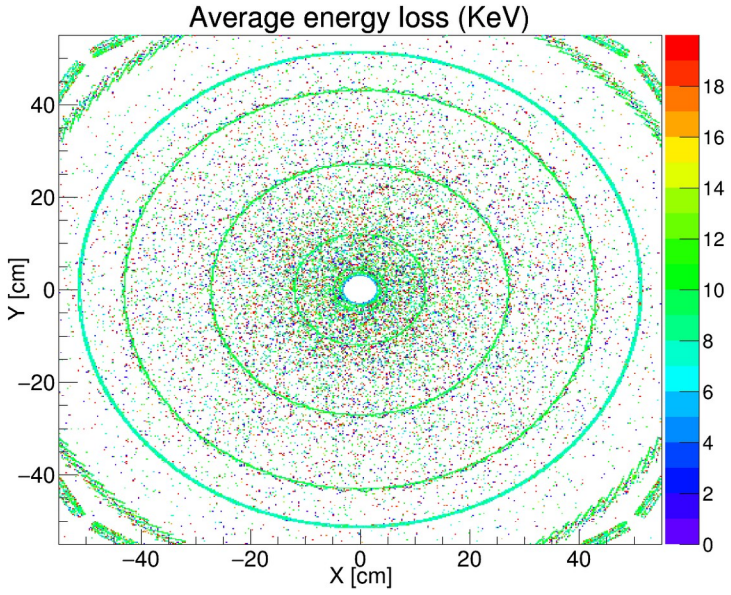




1 M Photons of energy 10.0 KeV
Average kinetic energy of electron (KeV) only MC Particles with generated status !=1

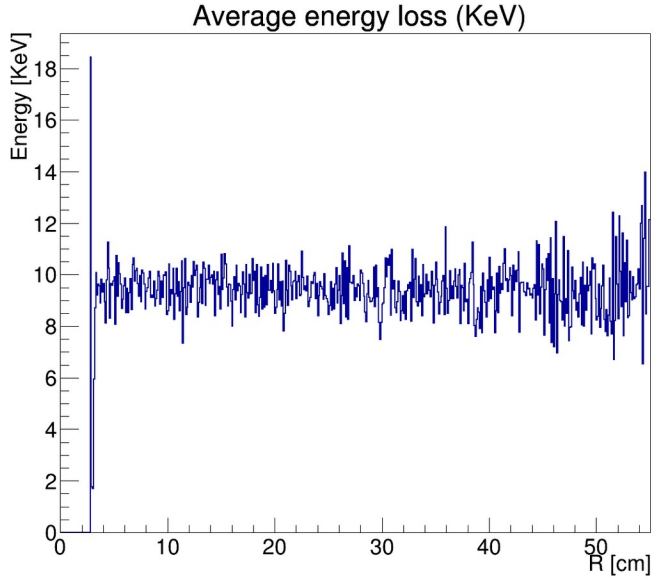
Note: Hit Points (VTX) show small entries
h1->Add(hist) method is correct instead of Draw("same") which is used in this case

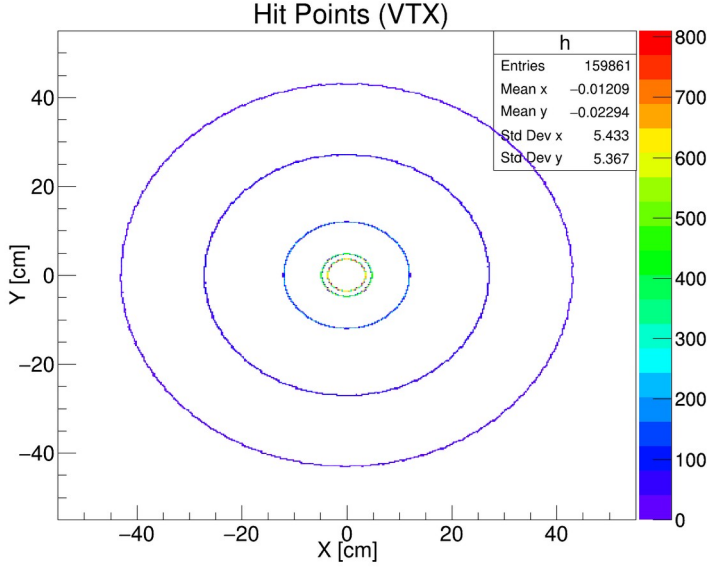
Photon of Energy 20.0 KeV

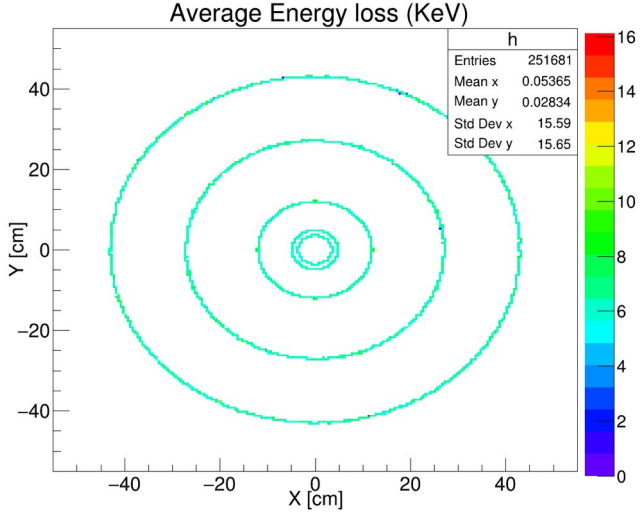


$$E_e = \sqrt{p^2 + m_e^2}$$

$$E_{Kin} = E_e - m_e$$



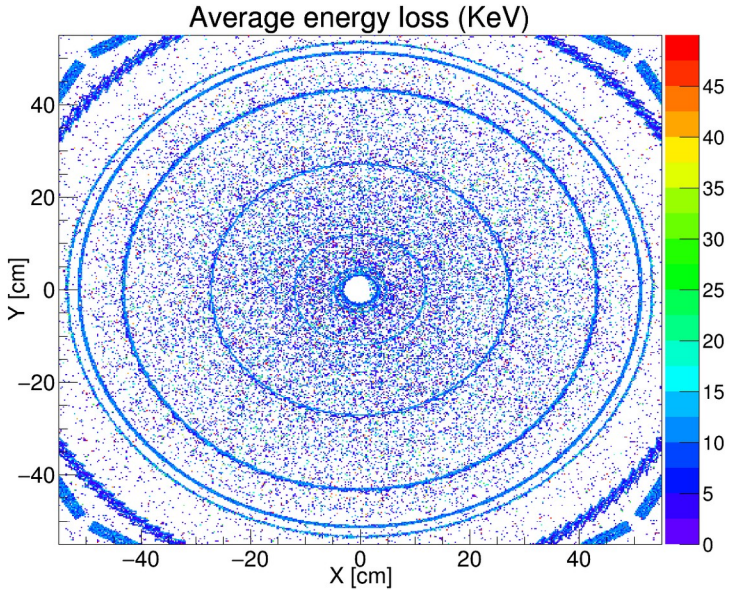




1 M Photons of energy 20.0 KeV
Average kinetic energy of electron (KeV) only MC Particles with generated status !=1

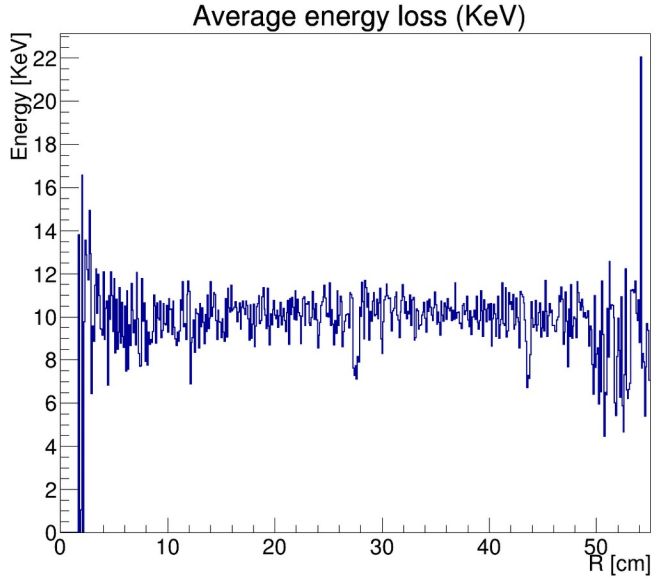
Note: Hit Points (VTX) show small entries
h1->Add(hist) method is correct instead of Draw("same") which is used in this case

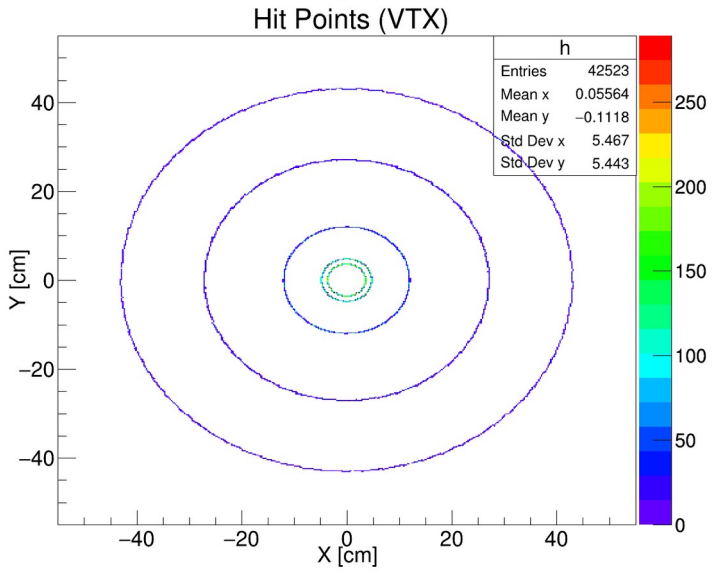
Photon of Energy 50.0 KeV

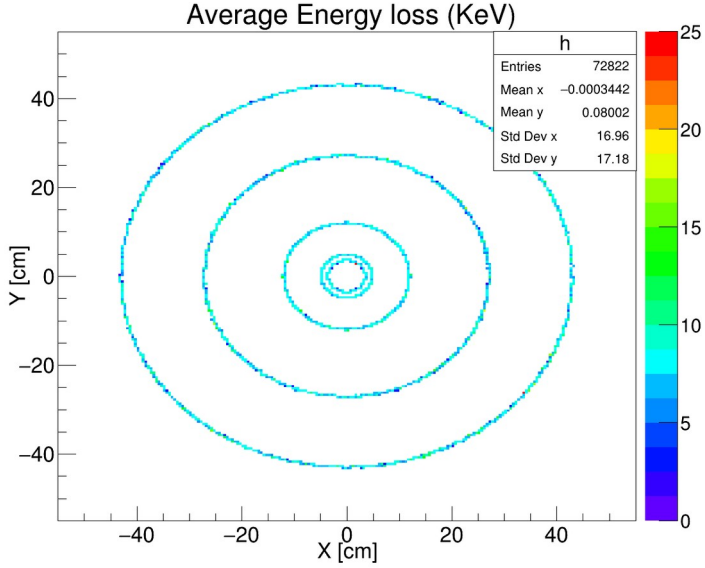


$$E_e = \sqrt{p^2 + m_e^2}$$

$$E_{Kin} = E_e - m_e$$



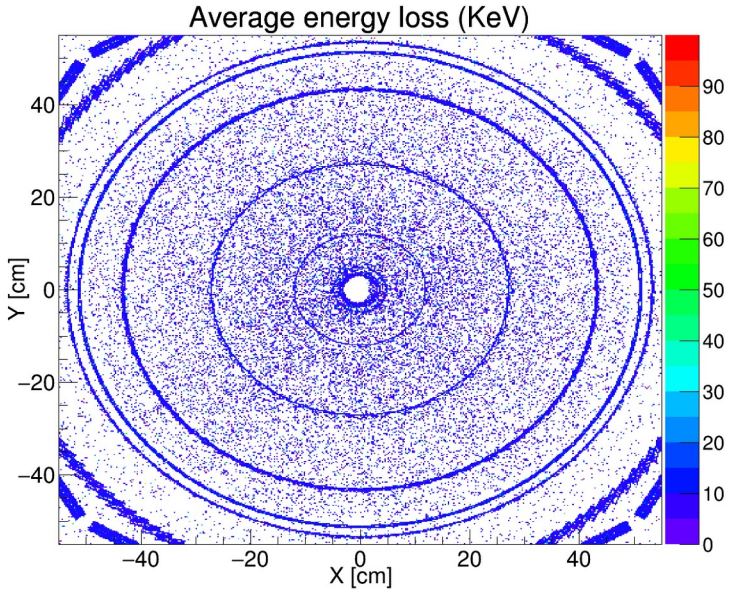




1 M Photons of energy 50.0 KeV
Average kinetic energy of electron (KeV) only MC Particles with generated status !=1

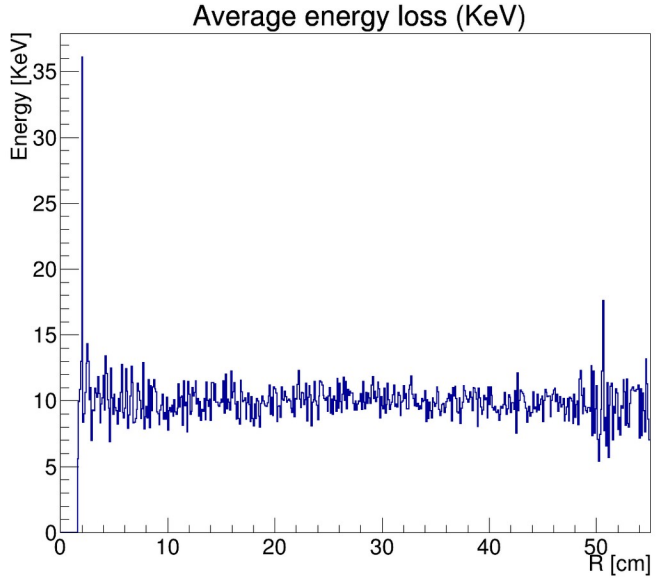
Note: Hit Points (VTX) show small entries
h1->Add(hist) method is correct instead of Draw("same") which is used in this case

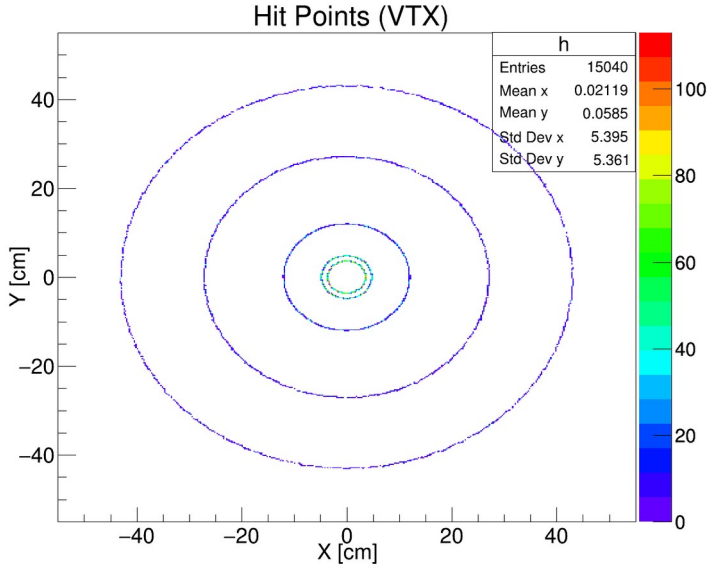
Photon of Energy 100.0 KeV

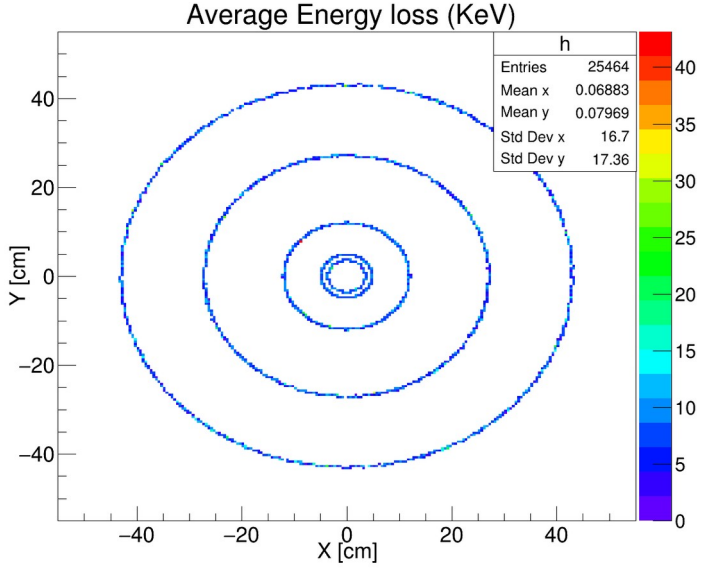


$$E_e = \sqrt{p^2 + m_e^2}$$

$$E_{Kin} = E_e - m_e$$



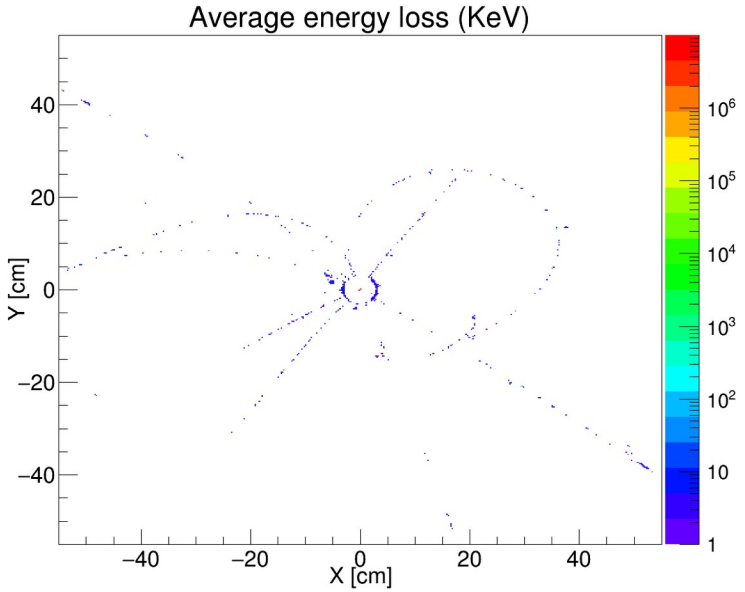




1 M Photons of energy 100.0 KeV
Average kinetic energy of electron (KeV) only MC Particles with generated status !=1

Note: Hit Points (VTX) show small entries
h1->Add(hist) method is correct instead of Draw("same") which is used in this case

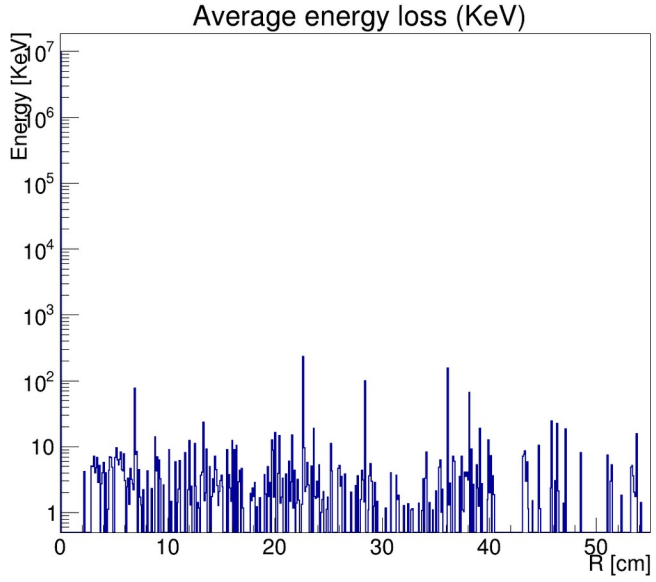
PYTHIA DIS File [1 Event] with full geometry

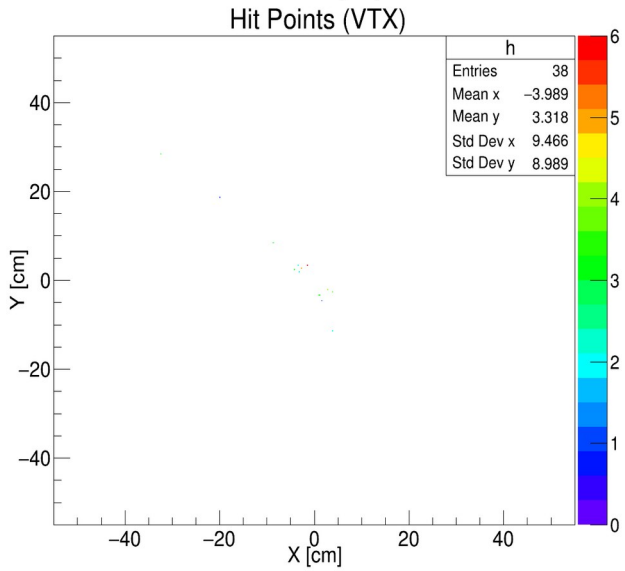


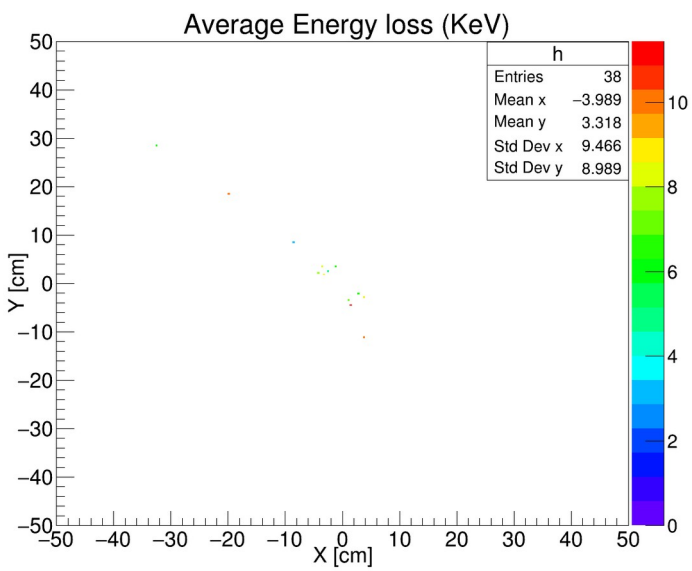
Selected secondary electrons only with generated status

$$E_e = \sqrt{p^2 + m_e^2}$$

$$E_{Kin} = E_e - m_e$$



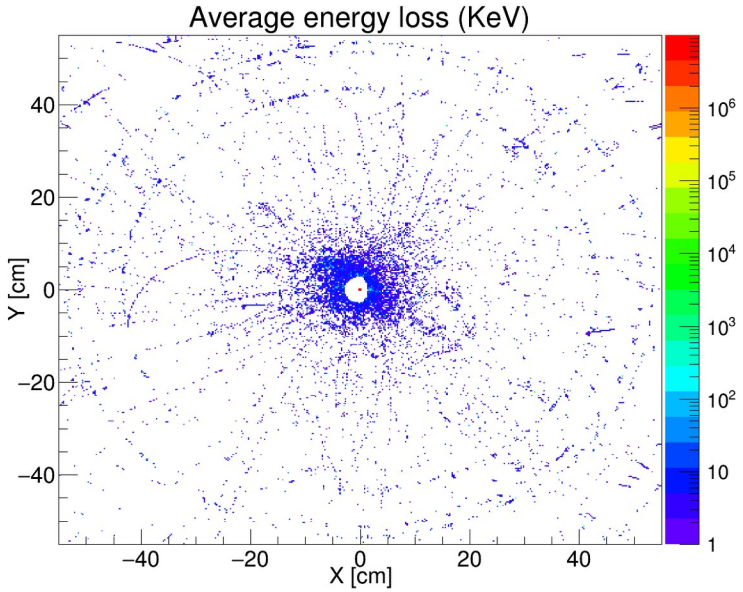




DIS File

The hepmc file is here:S3/eictest/EPIC/EVGEN/BACKGROUNDS/bgmerged_ep_noradcor.10x100_q2_10_100_run001_n_10000.hepmc

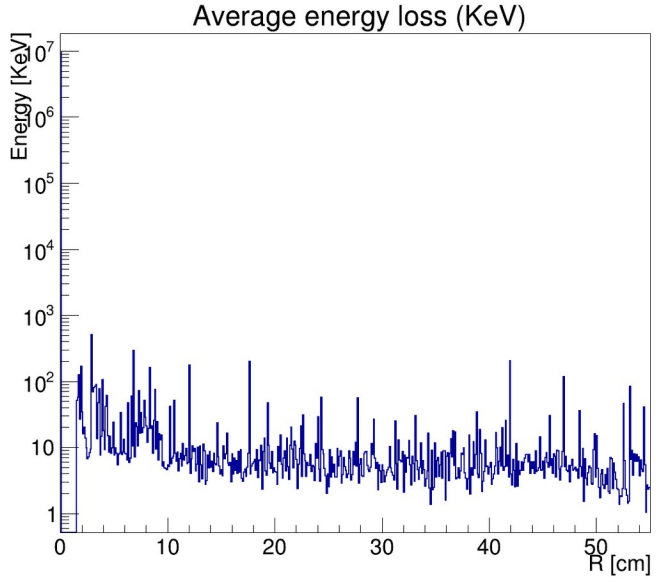
PYTHIA DIS File [10 Events] with full geometry

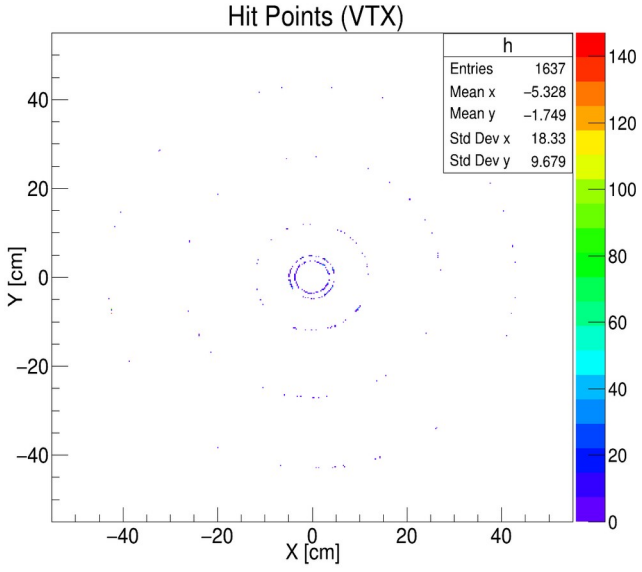


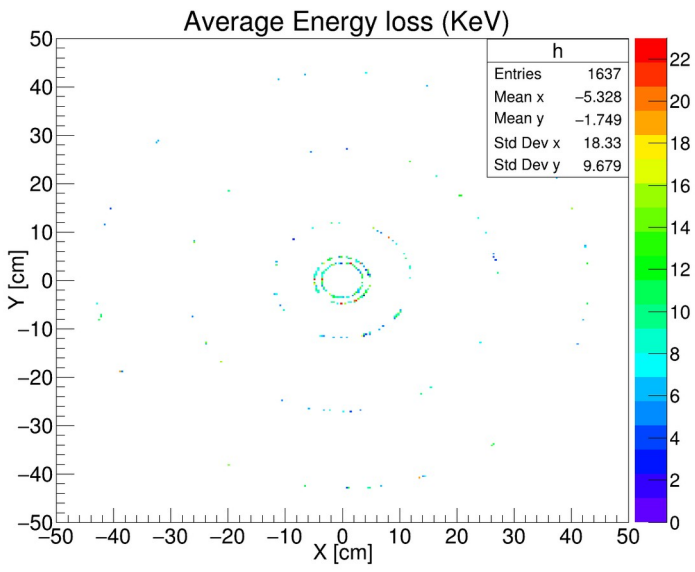
Selected secondary electrons only with generated status

$$E_e = \sqrt{p^2 + m_e^2}$$

$$E_{Kin} = E_e - m_e$$







DIS File

The hepmc file is here:S3/eictest/EPIC/EVGEN/BACKGROUNDS/bgmerged_ep_noradcor.10x100_q2_10_100_run001_n_10000.hepmc

FLUKA Simulation

Hx: 0.0 Hy: 0.0 Hz: 10.
R: 5.

RPP	BeamPipe	Xmin: -0.5	Xmax: 0.5	
		Ymin: -0.5	Ymax: 0.5	
		Zmin: 3.18	Zmax: 3.2557	
RPP	Au	Xmin: -0.5	Xmax: 0.5	
		Ymin: -0.5	Ymax: 0.5	
		Zmin: 3.2557	Zmax: 3.2562	
RPP	VTX0	Xmin: -0.5	Xmax: 0.5	
		Ymin: -0.5	Ymax: 0.5	
		Zmin: 3.6	Zmax: 3.604685	
RPP	VTX1	Xmin: -0.5	Xmax: 0.5	
		Ymin: -0.5	Ymax: 0.5	
		Zmin: 4.8	Zmax: 4.804685	
RPP	VTX2	Xmin: -0.5	Xmax: 0.5	
		Ymin: -0.5	Ymax: 0.5	
		Zmin: 12.0	Zmax: 12.004685	
RPP	BARR1	Xmin: -0.5	Xmax: 0.5	
		Ymin: -0.5	Ymax: 0.5	
		Zmin: 27.0	Zmax: 27.023425	
RPP	BARR2	Xmin: -0.5	Xmax: 0.5	
		Ymin: -0.5	Ymax: 0.5	
		Zmin: 42.0	Zmax: 42.051535	

Beam-pipe

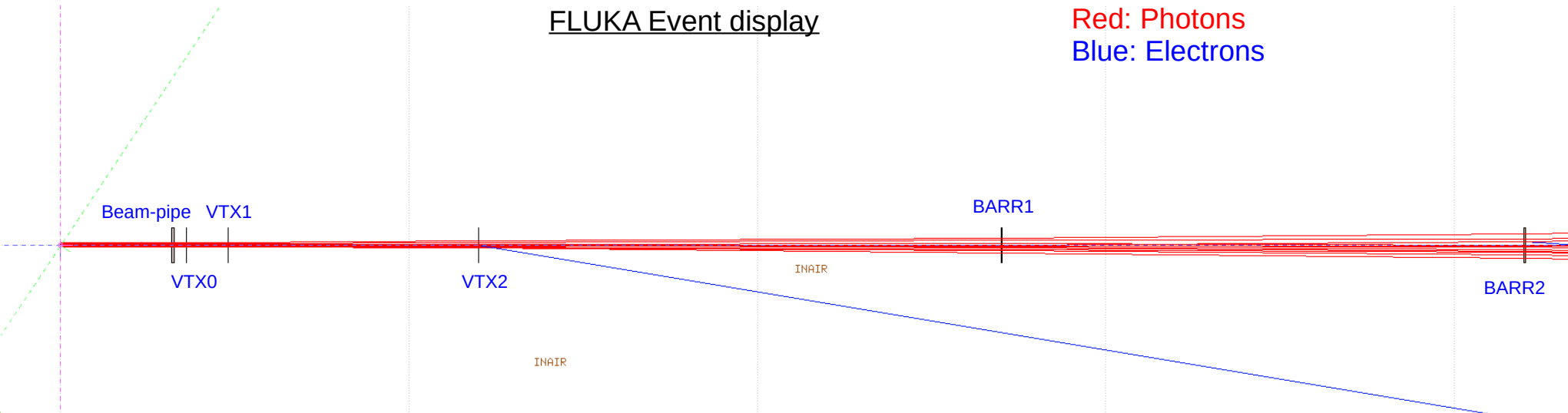
https://github.com/eic/epic/blob/77684d5f28f292b2e9b2a564eaf8155425e249b8/compact/central_beampipe.xml#L20

```
<beampipe/>
<IP_pipe
  OD="BeampipeOD"
  wall_thickness="0.757*mm"
  gold_thickness="5*um"
  crossing_angle="CrossingAngle"
```

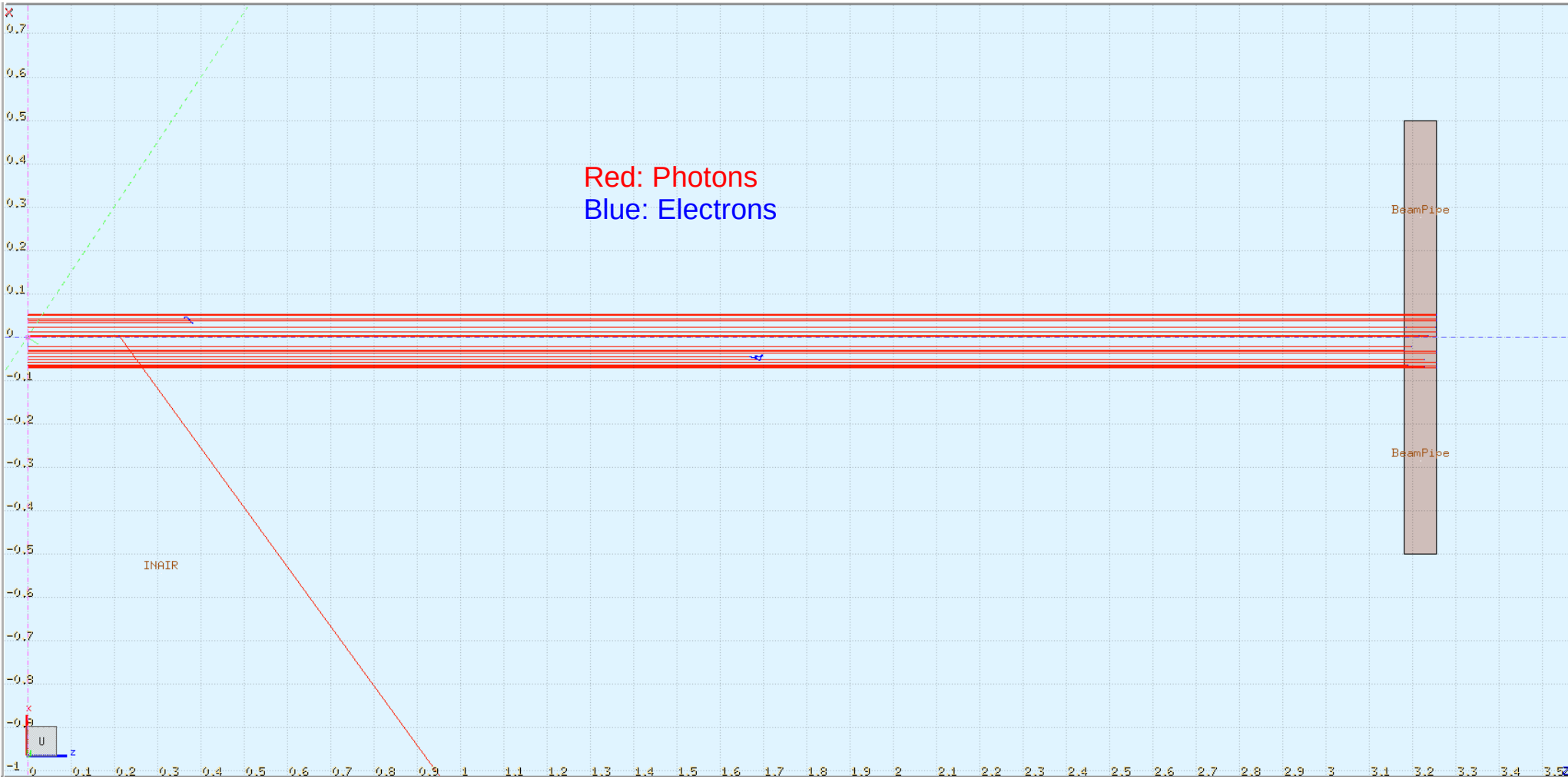
All unit are in cms

FLUKA Event display

Red: Photons
Blue: Electrons

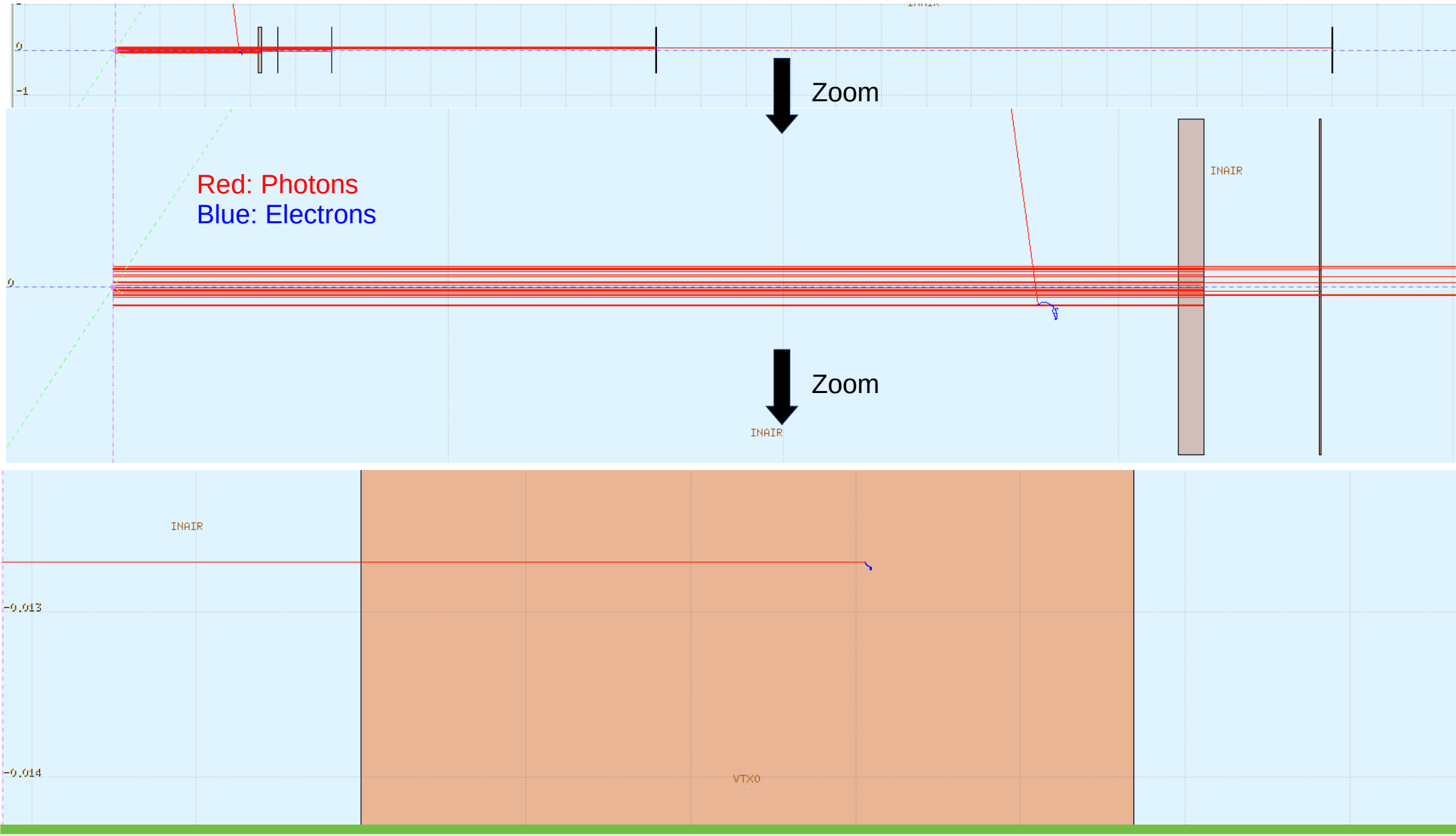


FLUKA Event display (5 KeV Photon)

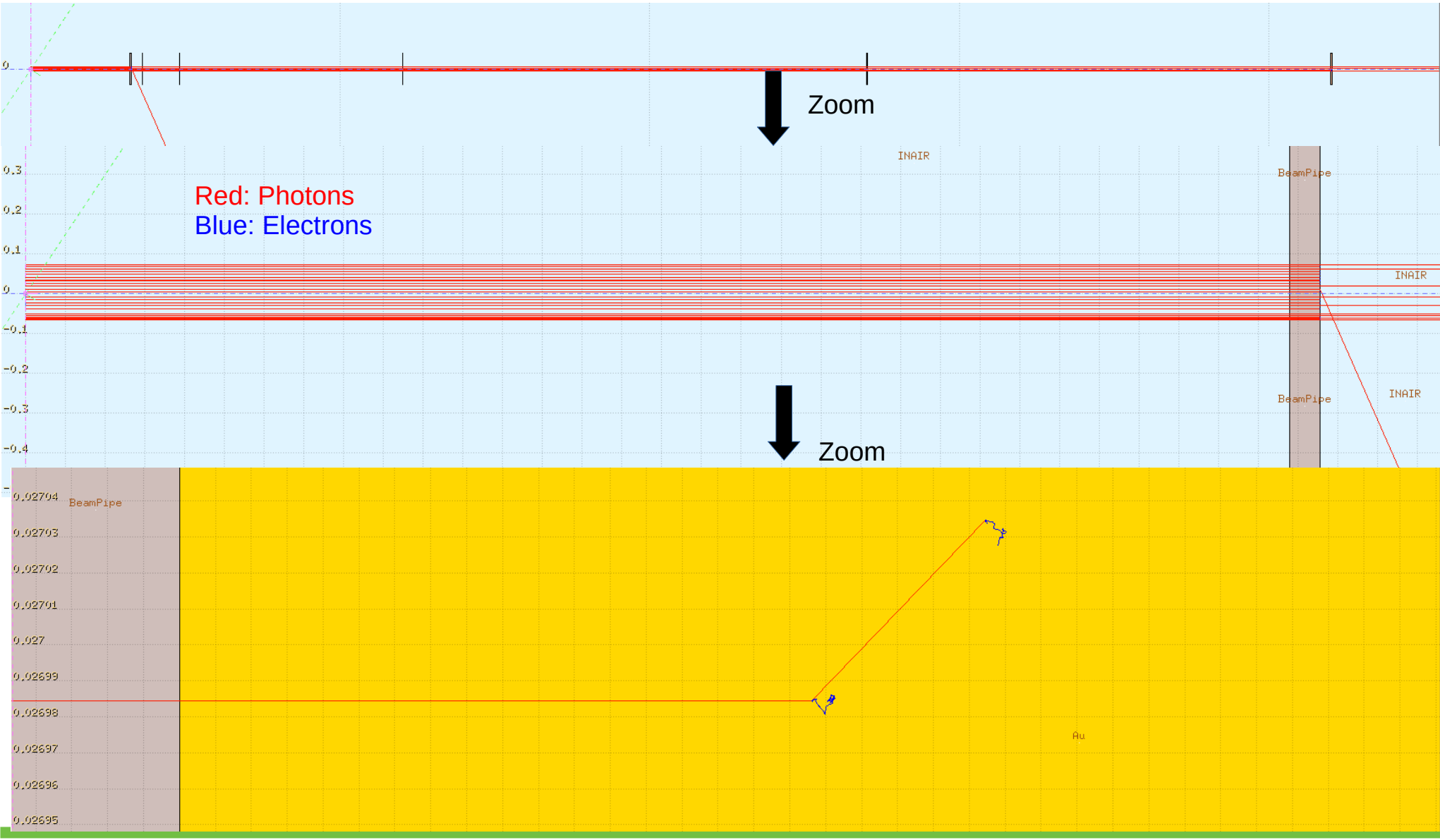


FLUKA Event display (5 KeV Photon)

FLUKA Event display (10 KeV Photon)

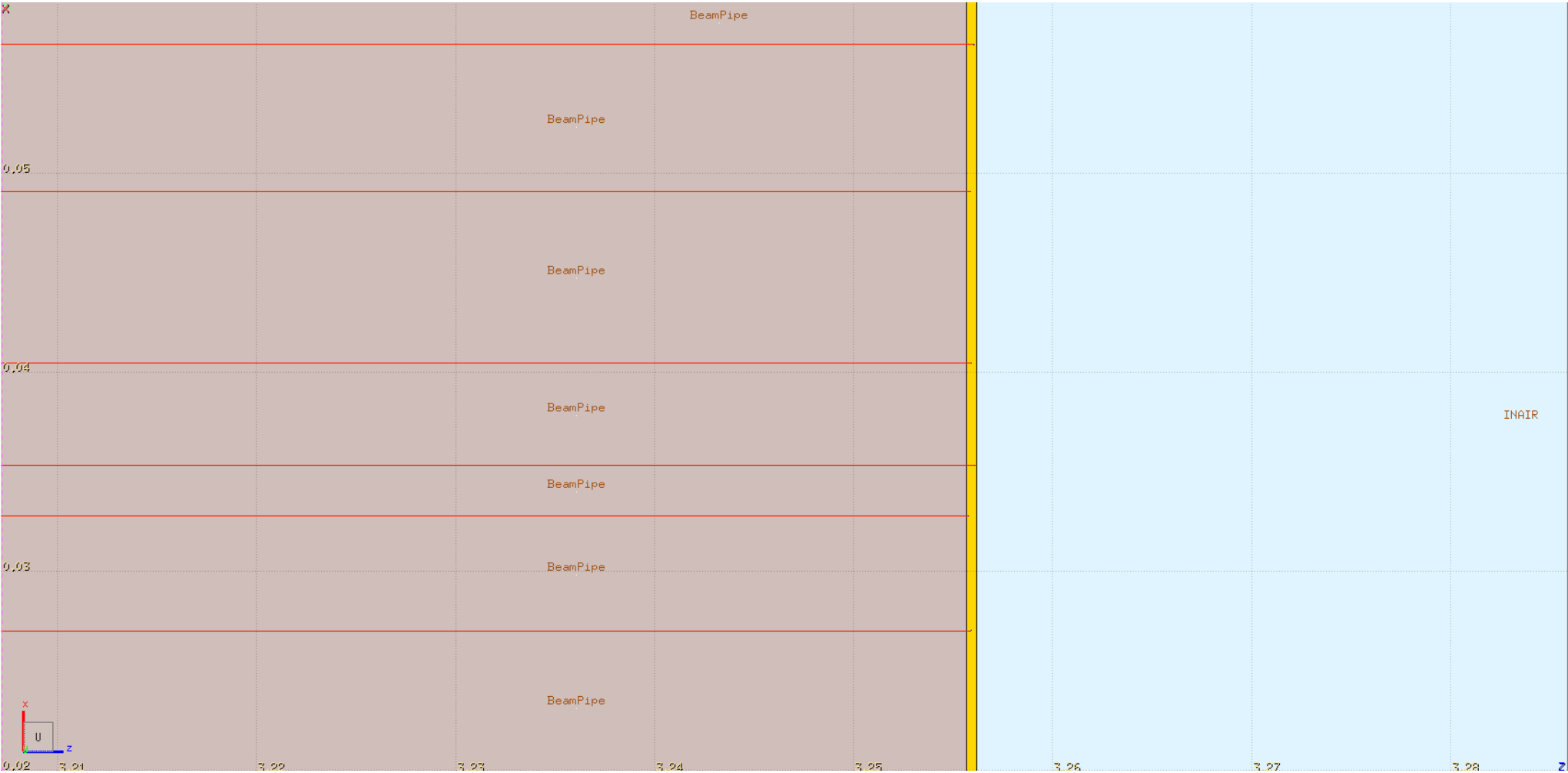


FLUKA Event display (20 KeV Photon)



FLUKA Event display (20 KeV Photon)

Gold layer playing an important role

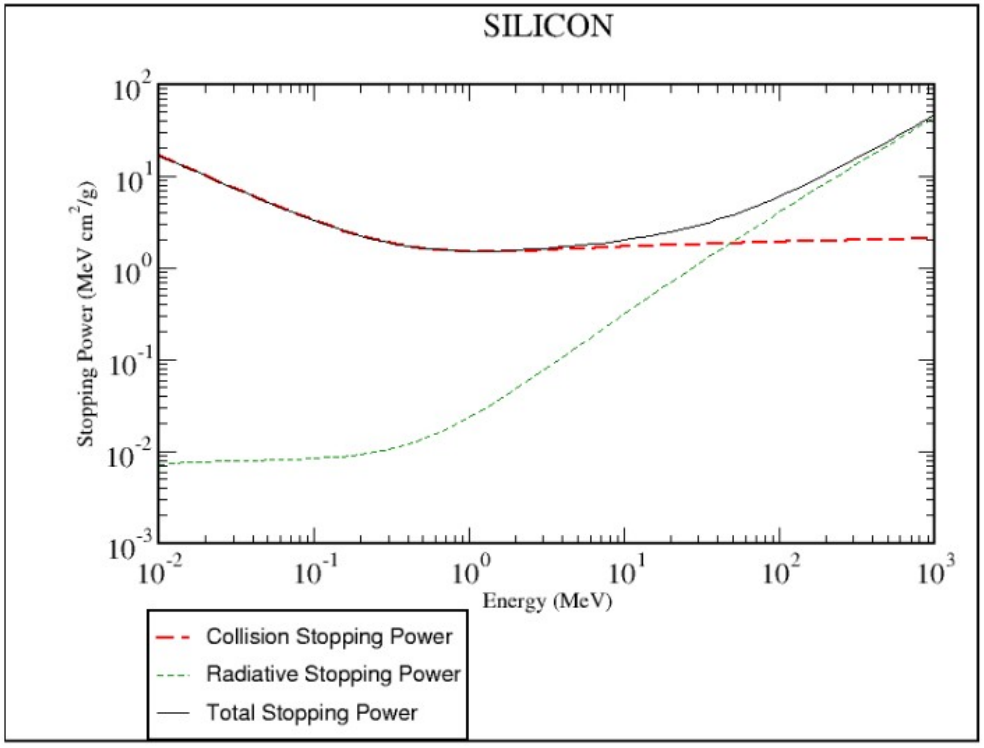


Summary

- Now we can see the photon is terminated by electron using photo-electric/compton effect.
- First look at the DIS events with background.
- Also created a similar model in FLUKA for understanding similar quantities.

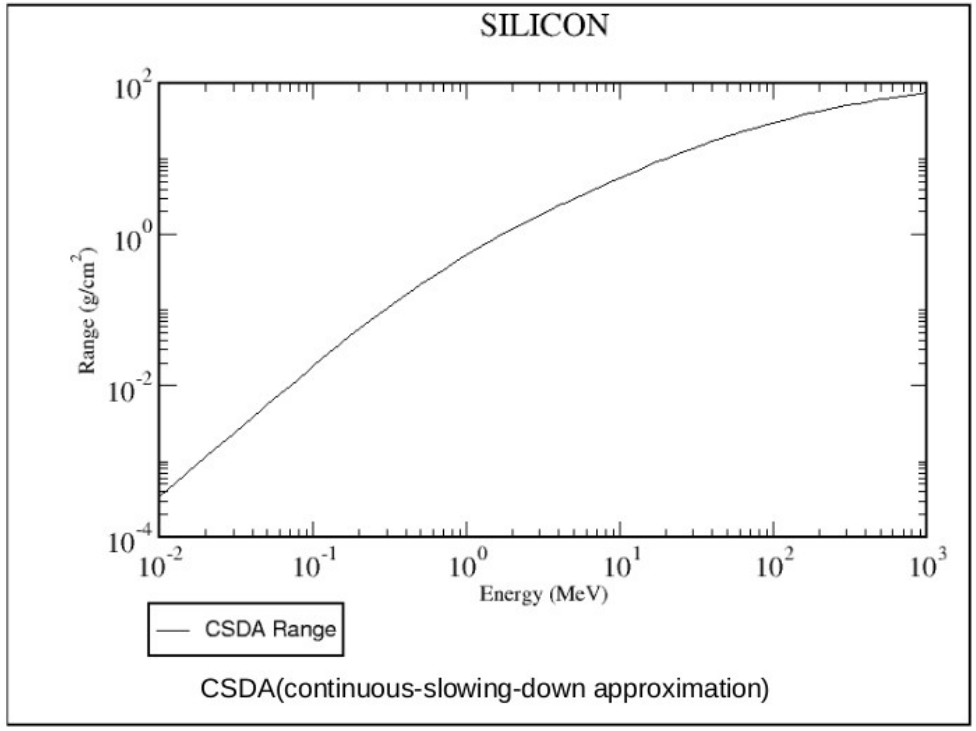
Thank You !!

ESTAR : Stopping Power and Range Tables for Electrons



Show compositional data for SILICON

ESTAR : Stopping Power and Range Tables for Electrons



Show compositional data for SILICON

Simulated using NIST database

10 KeV electron range = 1.485 μm

100 KeV electron range = 78 μm

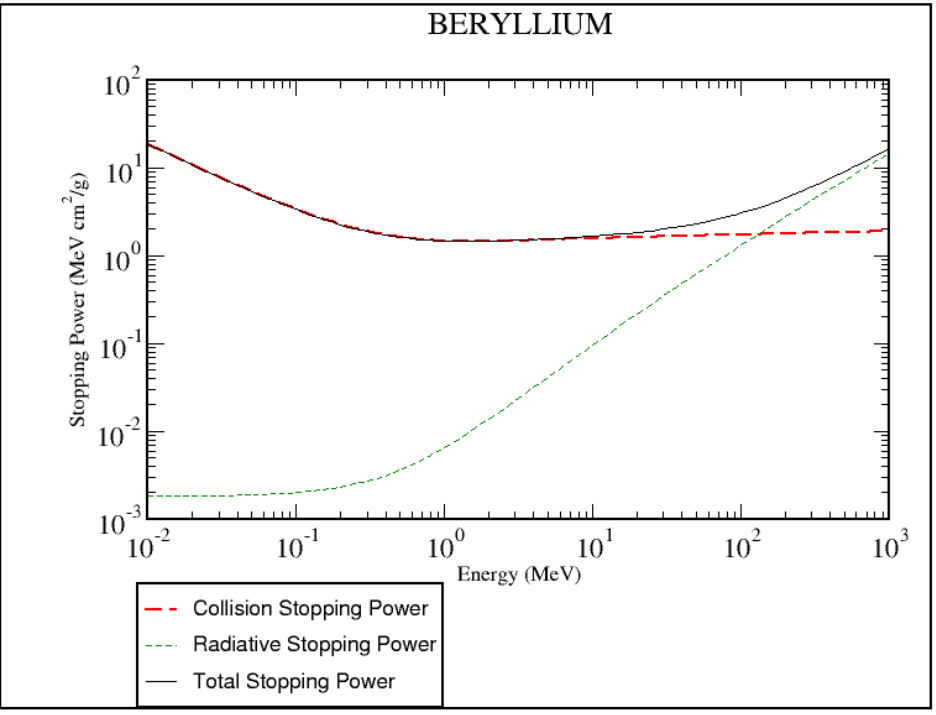
Composition of SILICON:

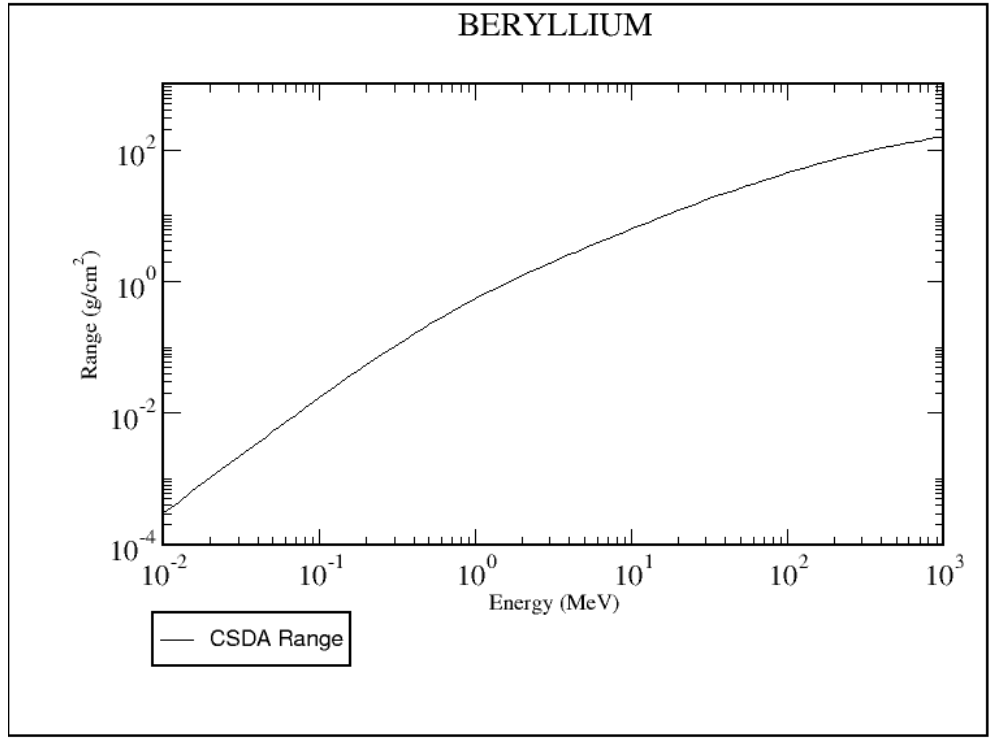
Density (g/cm³) = 2.33000E+00

Mean Excitation Energy (eV) = 173.000000

COMPOSITION:	
Atomic number	**Fraction by weight**
14	1.000000

Electron Stopping in Be





Simulated using NIST database

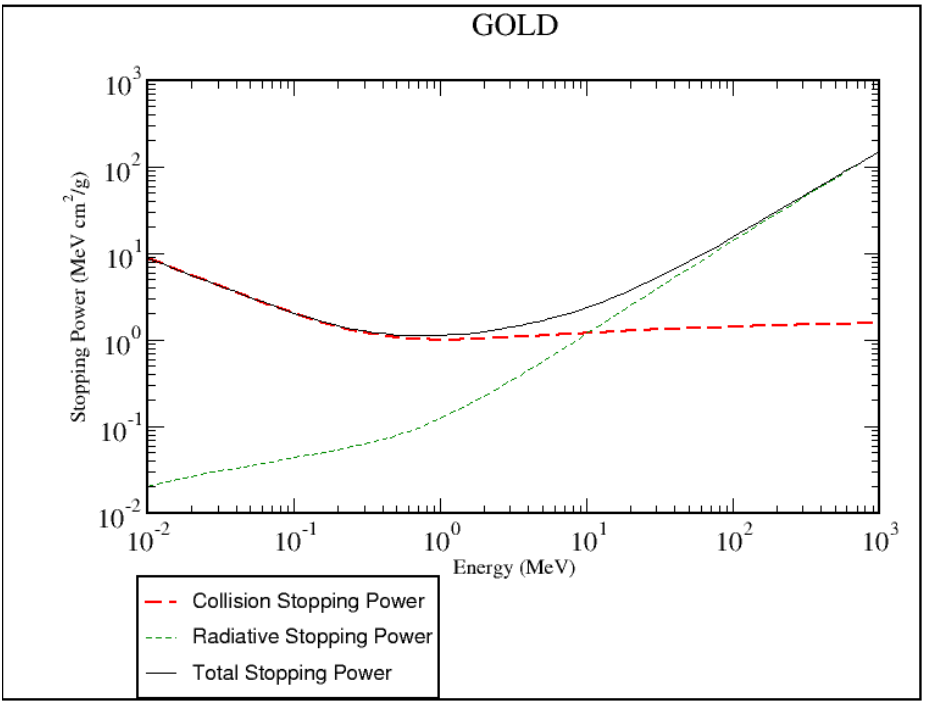
Composition of BERYLLIUM:

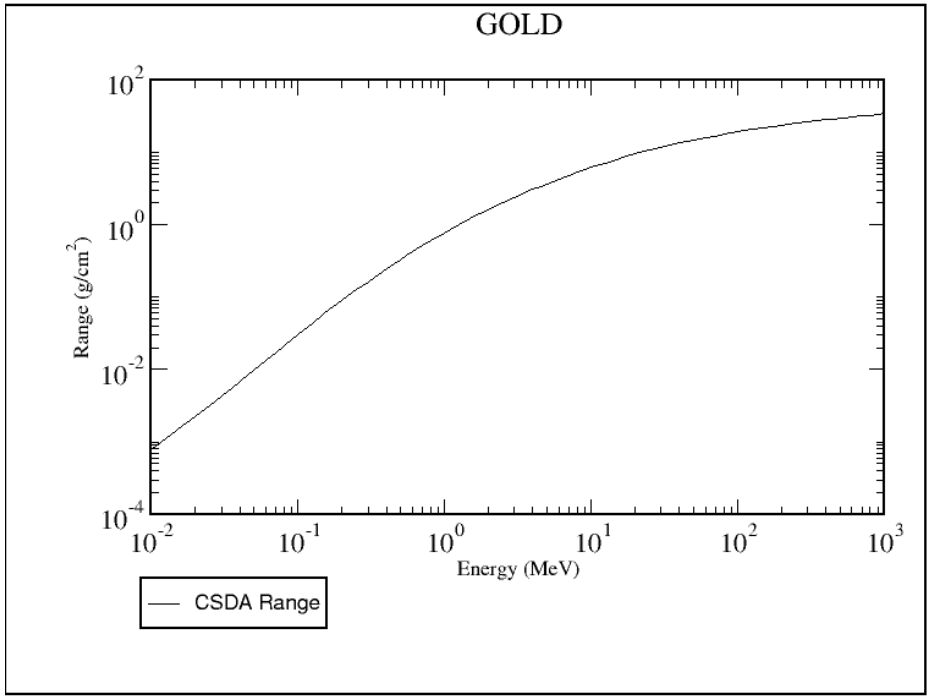
Density (g/cm^3) = 1.84800E+00

Mean Excitation Energy (eV) = 63.700000

COMPOSITION:	
Atomic number	**Fraction by weight**
4	1.000000

Electron Stopping in Au





Simulated using NIST database

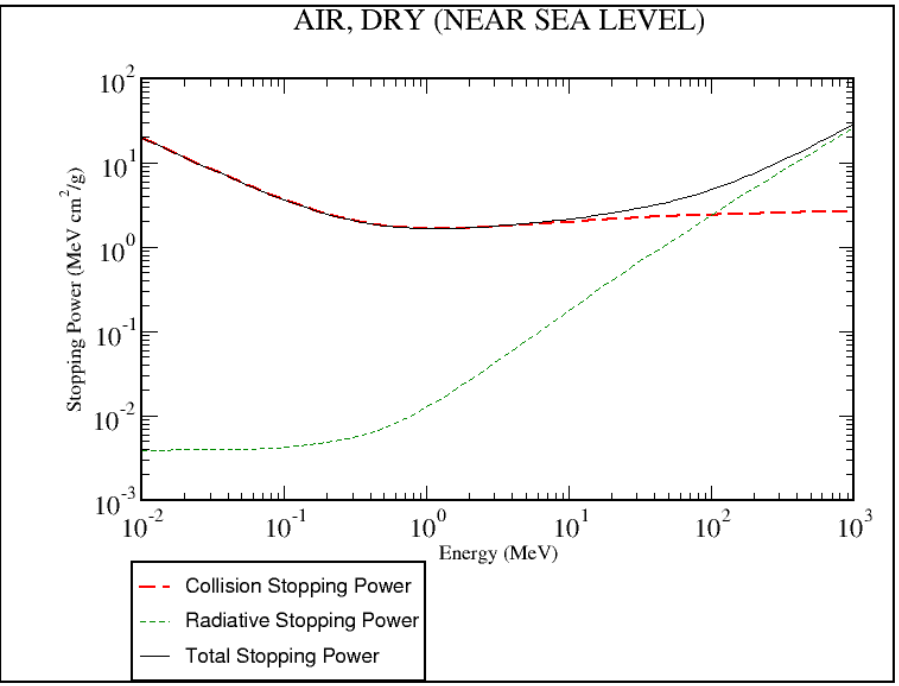
Composition of GOLD:

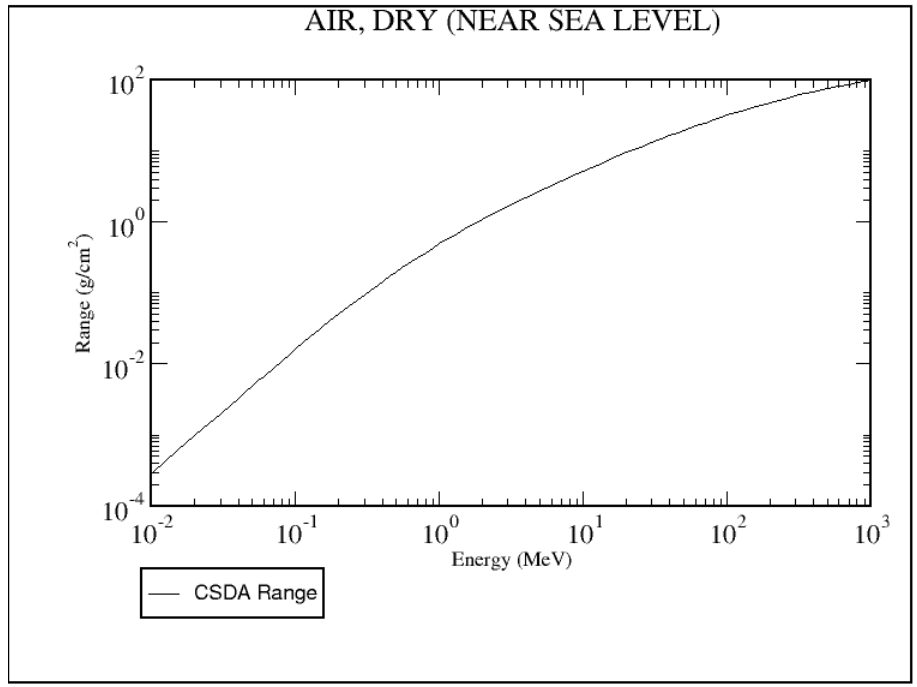
Density (g/cm^3) = 1.93200E+01

Mean Excitation Energy (eV) = 790.000000

COMPOSITION:	
Atomic number	**Fraction by weight**
79	1.000000

Electron Stopping in AIR





Composition of AIR, DRY (NEAR SEA LEVEL):

Density (g/cm^3) = 1.20479E-03

Mean Excitation Energy (eV) = 85.700000

COMPOSITION:	
Atomic number	**Fraction by weight**
6	0.000124
7	0.755267
8	0.231781
18	0.012827

Simulated using NIST database