

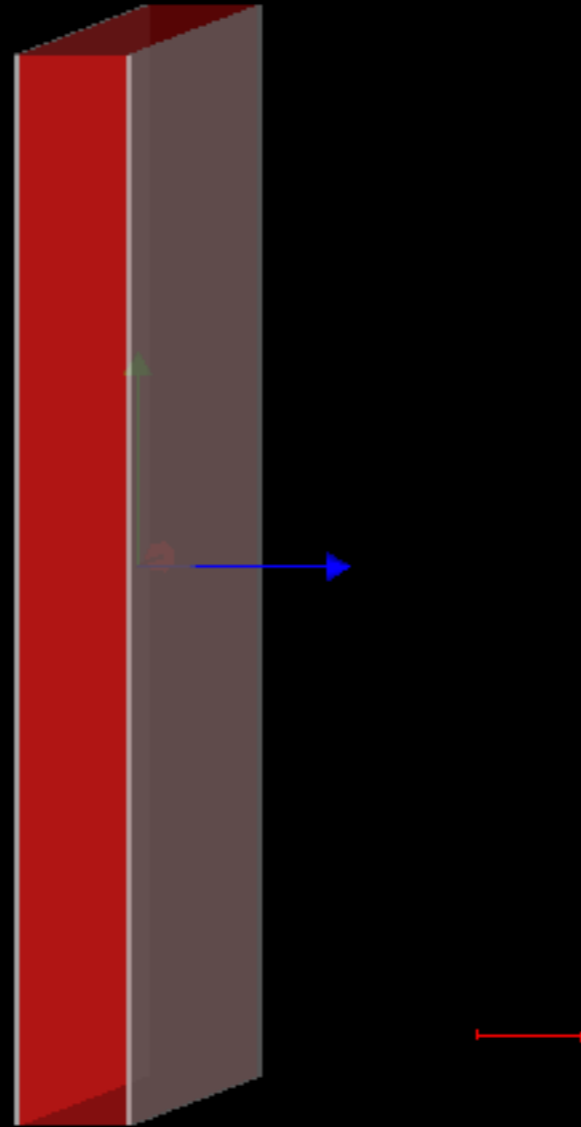
Conversione di fotoni di
511 KeV in FR4 di spessore
variabile

General Information

- GEANT version: geant4.10.03.p01
- G4MULTITHREADED (it usually works with 2 thread on my PC)
- G4VUserPhysicsList* physicsList = `new` FTFP_BERT_HP(); (from Alice)
- FR4 material definition (from Alice //Epoxy (for FR4))
- FR4 absorber thickness can be set run by run:
 - `void` FTMDetectorConstruction::SetFr4Thickness(G4double val)
 - `fr4ThicknessCmd = new` G4UICmdWithADoubleAndUnit("/FTM/detector/fr4Thickness",`this`);)
- "g4root.hh" namespace + G4AnalysisManager
 - `analysisManager->SetFileName("FTM_results");` The root file can be changed run by run

FR4 converter

Air (0.5 mm) + FR4 (fr4Thickness) + Air (0.5 mm)



FR4 material

Air (0.5 mm) + FR4 (fr4Thickness) + Air (0.5 mm)



```
//Epoxy (for FR4 )  
//from http://www.physi.uni-heidelberg.de/~adler/TRD/TRDunterlagen/RadiatonLength/tgc2.htm //???  
density = 1.2*g/cm3;  
G4Material* Epoxy = new G4Material("Epoxy" , density, numel=2);  
Epoxy->AddElement(elH, natoms=2);  
Epoxy->AddElement(elC, natoms=2);  
//SiO2 (Quarz)  
G4Material* SiO2 = new G4Material("SiO2",density= 2.200*g/cm3, numel=2);  
SiO2->AddElement(elSi, natoms=1);  
SiO2->AddElement(elO , natoms=2);  
//FR4 (Glass + Epoxy)  
density = 1.86*g/cm3;  
G4Material* FR4 = new G4Material("FR4" , density, numel=2);  
FR4->AddMaterial(Epoxy, fractionMass=0.472);  
FR4->AddMaterial(SiO2, fractionMass=0.528);  
fr4Material = FR4;
```

Gamma Gun

Air (0.5 mm) + FR4 (fr4Thickness) + Air (0.5 mm)



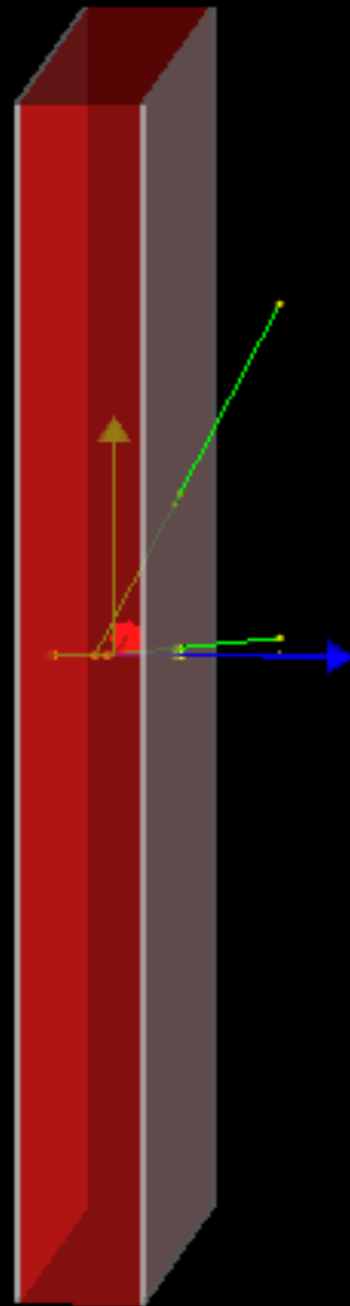
```
G4int n_particle = 1;
fParticleGun = new G4ParticleGun(n_particle);

// default particle kinematic
G4ParticleTable* particleTable = G4ParticleTable::GetParticleTable();
G4String particleName;
G4ParticleDefinition* particle
    = particleTable->FindParticle(particleName="gamma");
fParticleGun->SetParticleDefinition(particle);
fParticleGun->SetParticleMomentumDirection(G4ThreeVector(0.,0.,1.));
fParticleGun->SetParticleEnergy(20.*keV);
G4double detectorSizeZ = fDetector->GetDetectorSizeZ();
fParticleGun->SetParticlePosition(G4ThreeVector(0.*mm,0.*mm,-detectorSizeZ*0.5));
```



100 gamma in 10mm of FR4

Air (0.5 mm) + FR4 (fr4Thickness) + Air (0.5 mm)

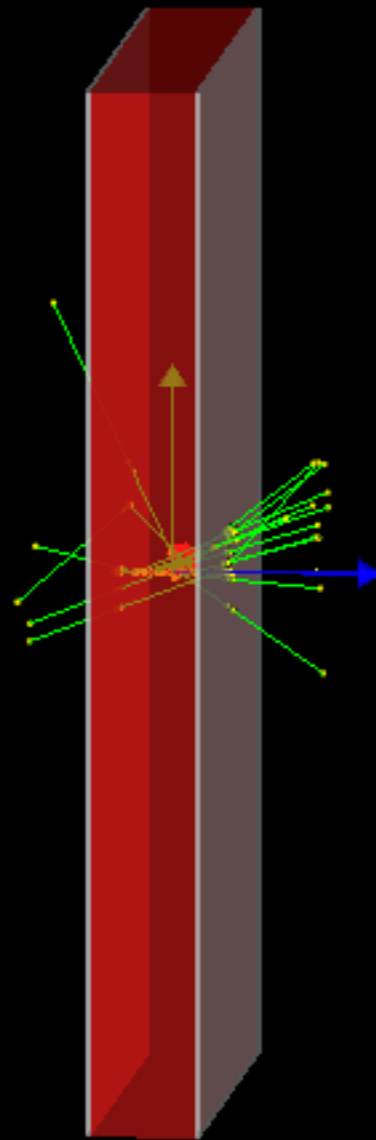


```
##### 10. mm FR4
/gun/particle gamma
/gun/energy 511 keV
/FTM/detector/fr4Thickness 10. mm
# (10. mm + 1mm)/2 = 5.5 mm (initial position of my gun)
/gun/position 0. 0. -5.5 mm
/analysis/setFileName FTM_511keV_fr4_10000um

/run/beamOn 100
```

1000 gamma in 10mm of FR4

Air (0.5 mm) + FR4 (fr4Thickness) + Air (0.5 mm)



```
##### 10. mm FR4
/gun/particle gamma
/gun/energy 511 keV
/FTM/detector/fr4Thickness 10. mm
# (10. mm + 1mm)/2 = 5.5 mm (initial position of my gun)
/gun/position 0. 0. -5.5 mm
/analysis/setFileName FTM_511keV_fr4_10000um

/run/beamOn 1000
```

Geant4

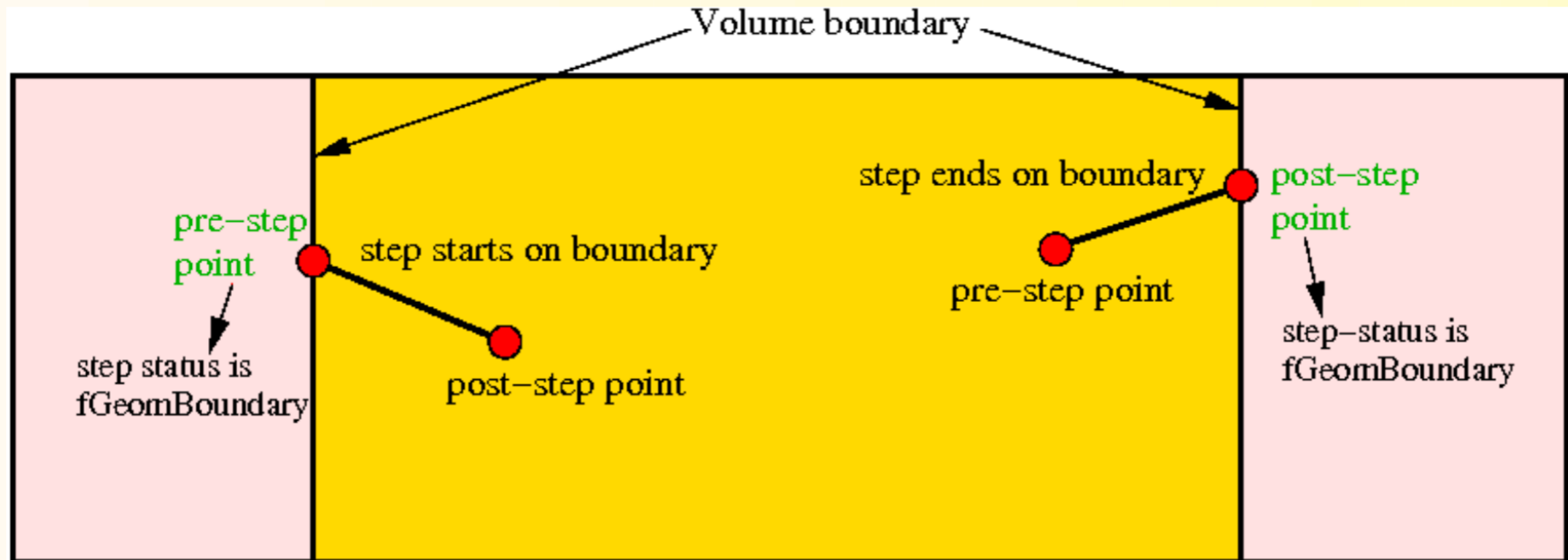
- Overview of important **terms and definitions**:

	Class	Description
Run	G4Run	Largest unit of simulation, that consist of a sequence of events: If a defined number of events was processed a run is finished.
Event	G4Event	Basic simulation unit in Geant4: If a defined number of primary tracks and all resulting secondary tracks were processed an event is over.
Track	G4Track	A track is NOT a collection of steps: It is a snapshot of the status of a particle after a step was completed (but it does NOT record previous steps). A track is deleted, if the particle leaves world, has zero kinetic energy (and no at-rest process occurs),
Step	G4Step	Represents a particle step in the simulation and includes two points (pre-step point and post-step point).
Step point	G4StepPoint	Represents an endpoint of a particle step

- Thanks to the multi-thread mode, several local runs are generated and merged at the end;
- Each run has a number of events
- For each event I follow each step in my detector

Strategy

- Step-points and geometrical boundaries (cont.):
 - Illustration of steps starting or ending on boundaries (steps are considered with respect to the yellow volume):



- I use boundary conditions to count the number of primary gamma and out coming electrons from FR4

Event example 1

```
G4WT0 > *****
G4WT0 > * G4Track Information: Particle = gamma, Track ID = 1, Parent ID = 0
G4WT0 > *****
G4WT0 >
G4WT0 > Step#    X      Y      Z      KineE  dEStep  StepLeng  TrakLeng  Volume  Process
G4WT0 >  0    0 fm   0 fm  -750 um  511 keV  0 eV    0 fm    0 fm    Top  initStep
G4WT0 >  1    0 fm   0 fm  -250 um  511 keV  0 eV    500 um  500 um  Top  Transportation
G4WT0 >  2    0 fm   0 fm   109 um  375 keV  0 eV    359 um  859 um  FR4  compt
G4WT0 >
:----- List of secondaries -----
G4WT0 >          e-: energy = 135.5 keV time = 2.864 ps
G4WT0 > :-----
```

G4WT0 > --- Step ID: 2 Secondary electron generated with Ek = 135.531 keV

```
G4WT0 >  3 -28.9 um  168 um  250 um  375 keV  0 eV    221 um  1.08 mm  FR4  Transportation
G4WT0 >  4 -131 um  761 um  750 um  375 keV  0 eV    782 um  1.86 mm  Bottom Transportation
G4WT0 >  5 -361 um  2.1 mm  1.88 mm  375 keV  0 eV    1.76 mm  3.62 mm  World OutOfWorld
G4WT0 >
G4WT0 > *****
G4WT0 > * G4Track Information: Particle = e-, Track ID = 2, Parent ID = 1
G4WT0 > *****
G4WT0 >
G4WT0 > Step#    X      Y      Z      KineE  dEStep  StepLeng  TrakLeng  Volume  Process
G4WT0 >  0    0 fm   0 fm  109 um  136 keV  0 eV    0 fm    0 fm    FR4  initStep
G4WT0 >  1 -28.7 um -29.4 um  166 um  79.8 keV 55.8 keV 84.1 um  84.1 um  FR4  msc
G4WT0 >  2 -32.1 um -24.4 um  193 um   0 eV  79.8 keV 57.9 um  142 um  FR4  eloni
```

Event example 2

G4WT0 > *****

G4WT0 > * G4Track Information: Particle = gamma, Track ID = 1, Parent ID = 0

G4WT0 > *****

G4WT0 >

Step#	X	Y	Z	KineE	dEStep	StepLeng	TrakLeng	Volume	Process
0	0 fm	0 fm	-750 um	511 keV	0 eV	0 fm	0 fm	Top	initStep
1	0 fm	0 fm	-250 um	511 keV	0 eV	500 um	500 um	Top	Transportation
2	0 fm	0 fm	186 um	200 keV	0 eV	436 um	936 um	FR4	compt

G4WT0 >

:----- List of secondaries -----

G4WT0 > e-: energy = 311.2 keV time = 3.123 ps

G4WT0 > :-----

G4WT0 > --- Step ID: 2 Secondary electron generated with Ek = 311.194 keV

3	-335 nm	-650 um	-250 um	200 keV	0 eV	783 um	1.72 mm	FR4	Transportation
4	-719 nm	-1.39 mm	-750 um	200 keV	0 eV	897 um	2.62 mm	Top	Transportation
5	-1.58 um	-3.07 mm	-1.88 mm	200 keV	0 eV	2.02 mm	4.63 mm	World	OutOfWorld

G4WT0 >

G4WT0 > *****

G4WT0 > * G4Track Information: Particle = e-, Track ID = 2, Parent ID = 1

G4WT0 > *****

G4WT0 >

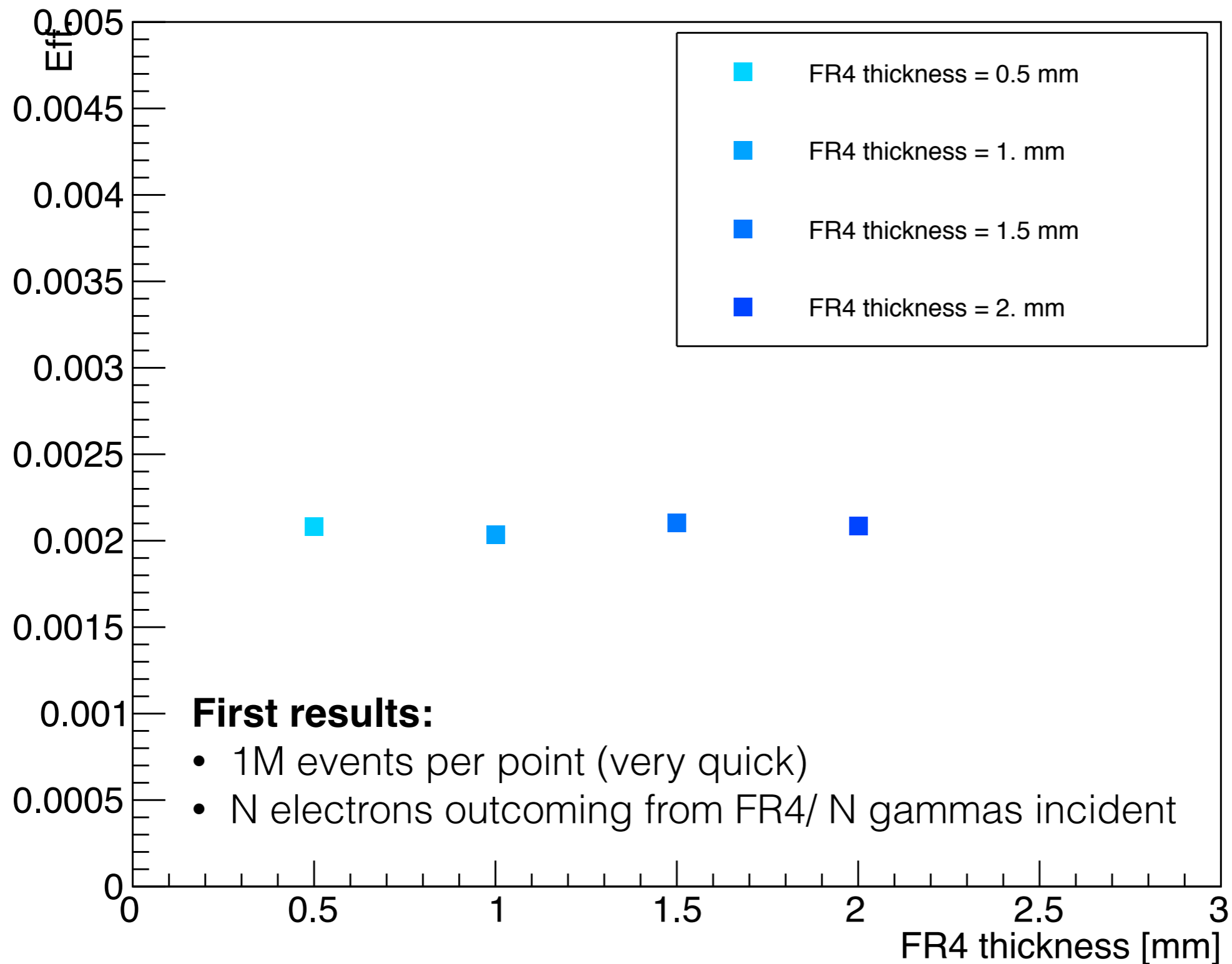
Step#	X	Y	Z	KineE	dEStep	StepLeng	TrakLeng	Volume	Process
0	0 fm	0 fm	186 um	311 keV	0 eV	0 fm	0 fm	FR4	initStep
1	-809 nm	4.86 um	219 um	303 keV	8.57 keV	33.6 um	33.6 um	FR4	msc
2	5.05 um	8.26 um	237 um	296 keV	6.47 keV	19.8 um	53.3 um	FR4	msc
3	9.56 um	7.78 um	250 um	293 keV	2.86 keV	14 um	67.3 um	FR4	Transportation

G4WT0 > --- Step ID: 3 Secondary electron of Ek 293.3 keV

4	252 um	4.08 um	750 um	293 keV	90.4 eV	556 um	623 um	Bottom	Transportation
5	806 um	12.6 um	1.88 mm	293 keV	4.6e-20 eV	1.25 mm	1.88 mm	World	OutOfWorld

Electron production probability

Electron production



Electron energy

