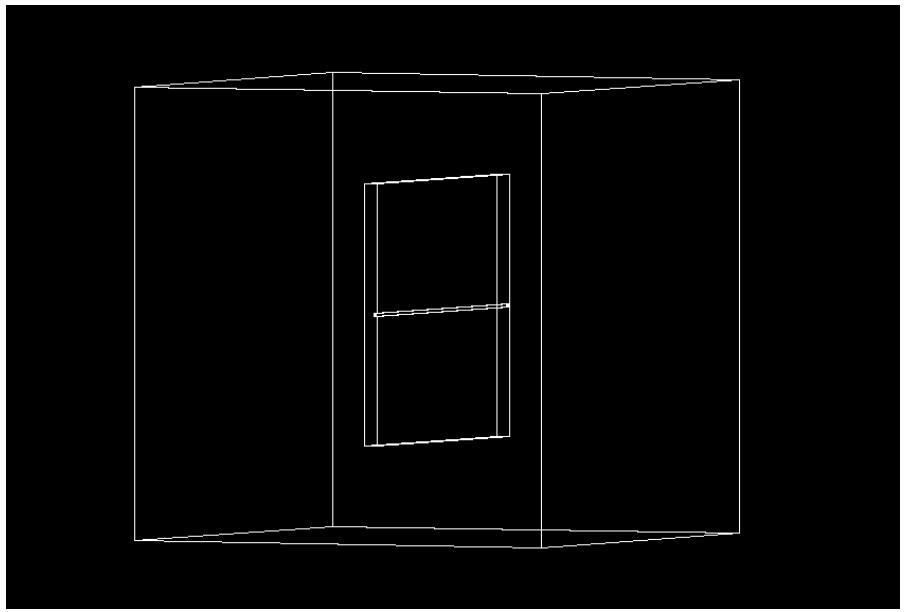
DCV Simulation

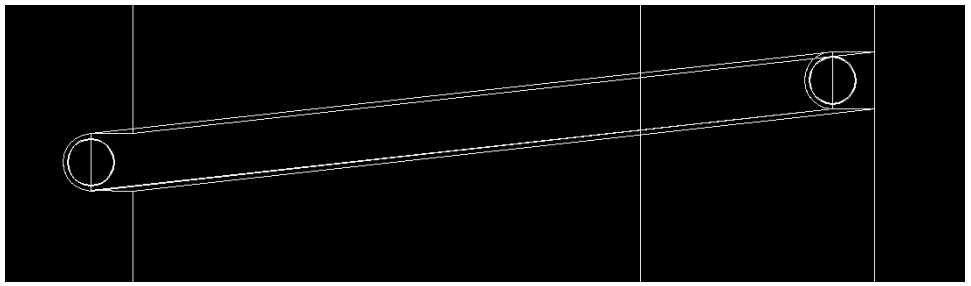
최재민

Geant4 동작방식

- Geant4는 beam이 지나가면서 Scintillator에 에너지를 남기는 것으로 시작한다.
- 그 후, Scintillator에 남겨진 에너지와 기입된 Scintillation proces를 바탕으로 photon을 발생시키고, photon 하나 하나를 따라가며 simulation을 하고 이를 저장(Analysismanager)하게 된다.

DetectorConstruction - geometry





- Plastic Scintillation에 G4SubtractionSolid를 이용해 Groove를 만들었다.
- 그 후, Groove의 반지름과 동심원을 그리도록 WLS-Fiber의 core와 cladding을 놓고, groove의 나머지 부분을 Optical Cement로 채웠다.

Scintillator EJ-200

PROPERTIES	EJ-200	EJ-204	EJ-208	EJ-212
Light Output (% Anthracene)	64	68	60	65
Scintillation Efficiency (photons/1 MeV e^-)	10,000	10,400	9,200	10,000
Wavelength of Maximum Emission (nm)	425	408	435	423
Light Attenuation Length (cm)	380	160	400	250
Rise Time (ns)	0.9	0.7	1.0	0.9
Decay Time (ns)	2.1	1.8	3.3	2.4
Pulse Width, FWHM (ns)	2.5	2.2	4.2	2.7
No. of H Atoms per cm^3 ($x10^{22}$)	5.17	5.15	5.17	5.17
No. of C Atoms per cm^3 ($x10^{22}$)	4.69	4.68	4.69	4.69
No. of Electrons per cm^3 ($x10^{23}$)	3.33	3.33	3.33	3.33
Density (g/cm^3)	1.023	1.023	1.023	1.023
Polymer Base	Polyvinyltoluene			
Refractive Index	1.58			
Softening Point	75°C			
Vapor Pressure	Vacuum-compatible			
Coefficient of Linear Expansion	7.8 x 10^{-5} below 67°C			
Light Output vs. Temperature	At 60°C, L.O. = 95% of that at 20°C No change from 20°C to -60°			
Temperature Range	-20°C to 60°C			

- 사용된 Scintillator EJ-200의 spec은 왼쪽의 표와 같다.

- 사용된 특성

- Material

Composition, Density(1.023g/cm3)

- Scintillation Process

Scintillation efficiency(10,000/1MeV), Decay time(2.1ns)

- Cerenkov Process

Refractive index(1.58)

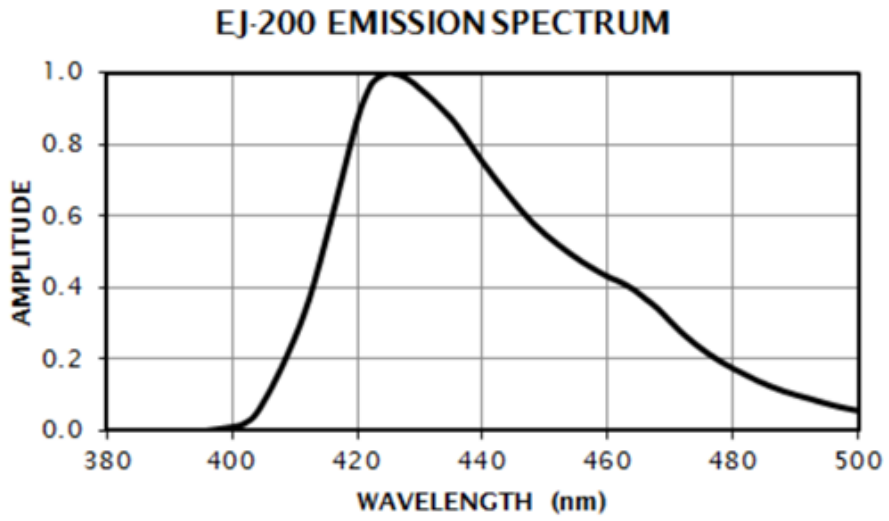
- Absorption Process

Light attenuation length(380cm, 2*20*200cm3의 scintillator 기준 – need to be optimized)

사용하지 못한 특성

Rise time(0.9ns) in Scintillation

EJ-200 Emission spectrum

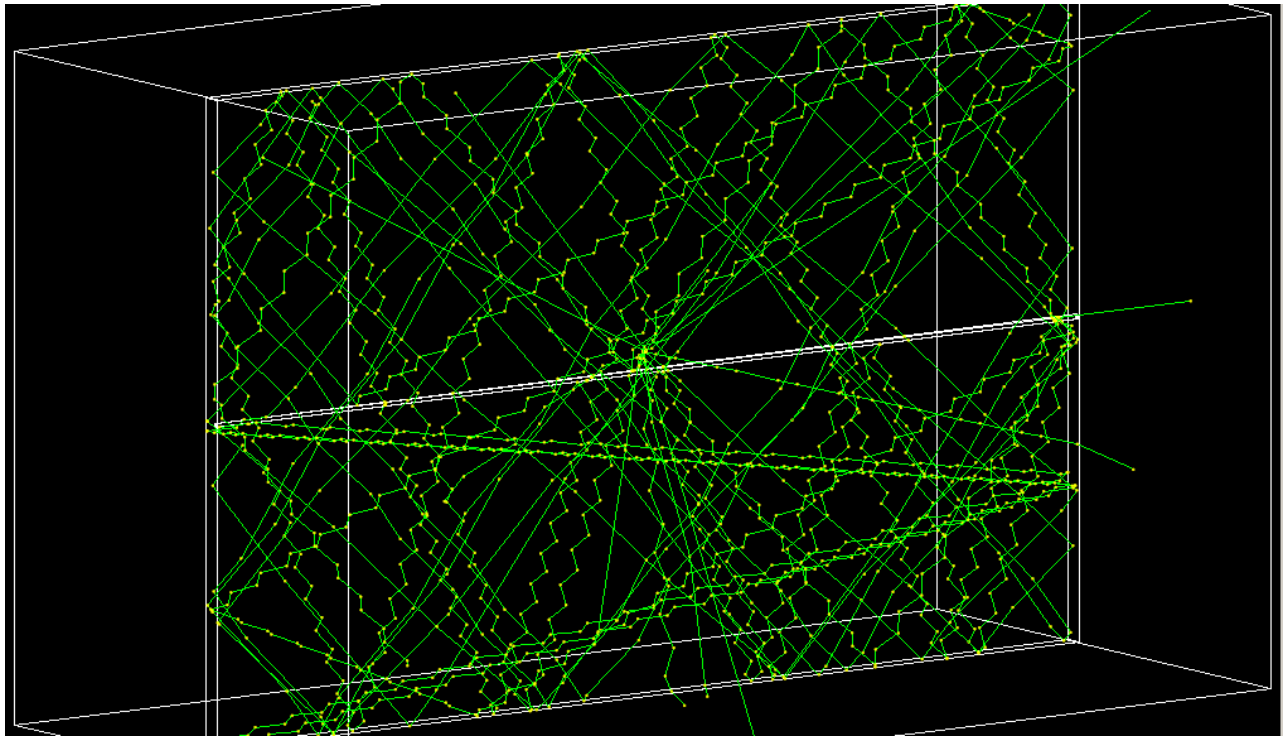


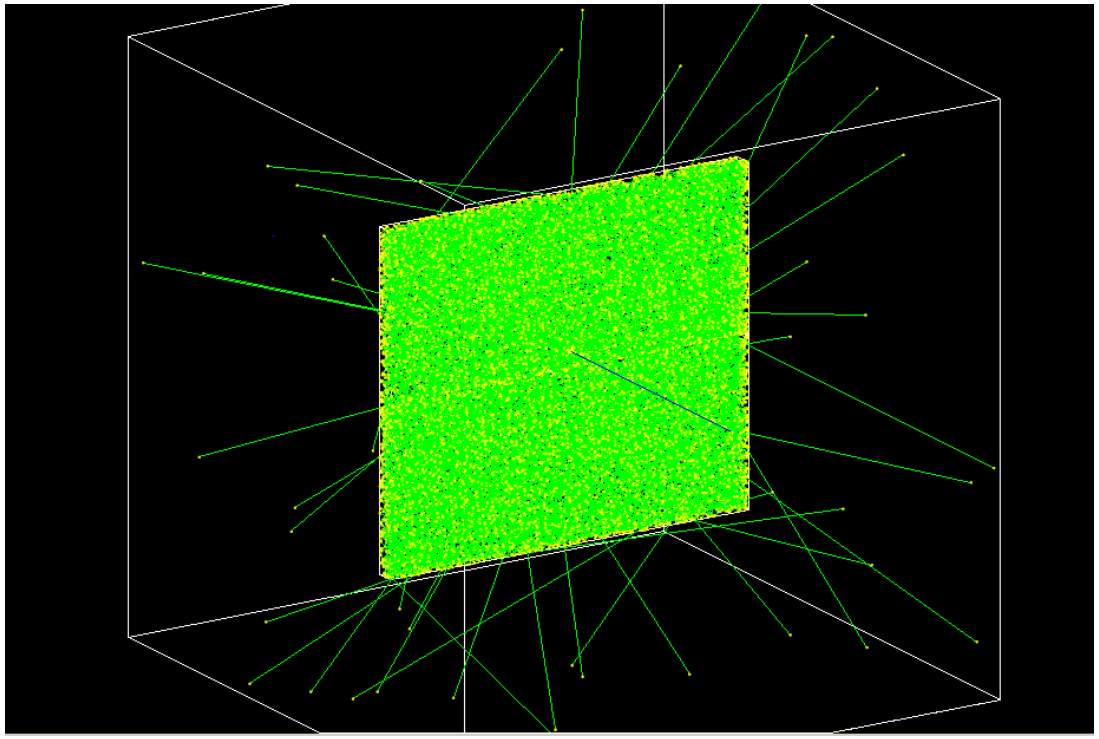

```
G4double PhotonEnergy[] =
  {
    3.100*eV, 3.061*eV, 3.024*eV, 2.988*eV,
    2.952*eV, 2.917*eV, 2.883*eV, 2.850*eV,
    2.818*eV, 2.786*eV, 2.755*eV, 2.725*eV,
    2.695*eV, 2.666*eV, 2.638*eV, 2.610*eV,
    2.583*eV, 2.556*eV, 2.530*eV, 2.505*eV,
    2.480*eV
  };
G4double Scintillation_EJ200[] =
      {
              0, 0.17, 0.21, 0.5,
              0.88, 1.0, 0.91, 0.83,
              0.77, 0.62, 0.5, 0.47,
              0.42, 0.37, 0.31, 0.21,
              0.18, 0.14, 0.1, 0.09,
              0.08

      };
```

- 이번 Scintillation process 에서 신경 썼던 부분은 발생되는 photon의 파장과 에너지를 어떻게 결정하느냐였다.
- Emission sepctrum에서 Amplitude는 광자의 에너지 비를 뜻한다.
- Scintillation process로 발생되는 총 에너지가 100이라고 생각한다면, 총 에너지 중 Amplitude의 분율(이 경우 총 합이 8.76이므로 약 11)에 해당하는 만큼 에너지가 420nm의 광자가 발생한다.

Scintillator Simulation





- Scintillation yield 100/MeV (실제론 10000/MeV이지만 위의 Simulation에서는 Detector의 부재 등으로 인해 사라지는 photo의 수가 적어 계산이 오래 걸리기 때문에 이를 간략히 하기 위해 100/MeV로 설정)

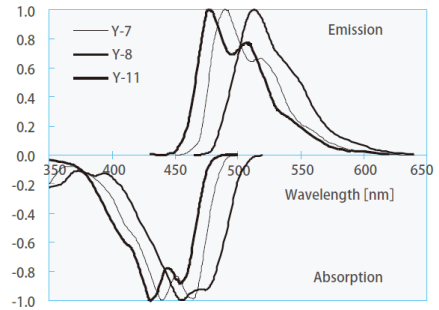
WLS-Fiber Y-11

Formulations [1]

Description	Emission			Absorption Peak[nm]	Att.Leng.[2] [m]	Characteristics
	Color	Spectra	Peak[nm]			
Y-7(100)	green	See the following figure	490	439	>2.8	Blue to Green Shifter
Y-8(100)	green		511	455	>3.0	Blue to Green Shifter
Y-11(200)	green		476	430	>3.5	Blue to Green Shifter (K-27 formulation) Long Attenuation Length and High Light Yield
B-2(200)	blue		437	375	>3.5	UV to Blue shifter
B-3(200)	blue		450	351	>4.0	UV to Blue shifter
O-2(100)	orange		550	535	>1.5	Green to orange shifter
R-3(100)	red		610	577	>2.0	Green to red shifter

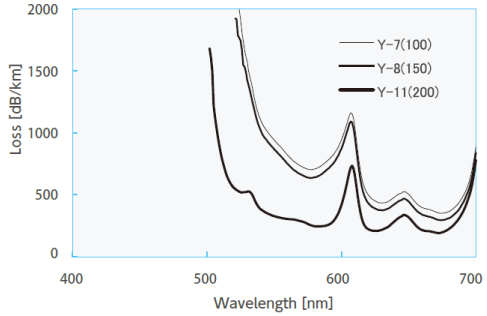
Absorption and Emission Spectra

Y-7, Y-8, Y-11



Transmission Loss

Y-7, Y-8, Y-11



- 사용된 WLS-Fiber Y-11의 spec은 왼쪽의 표와 같다.

- 사용된 특성

- Core

Composition, Density, Absorption spectra, Emission spectra, Refractive index

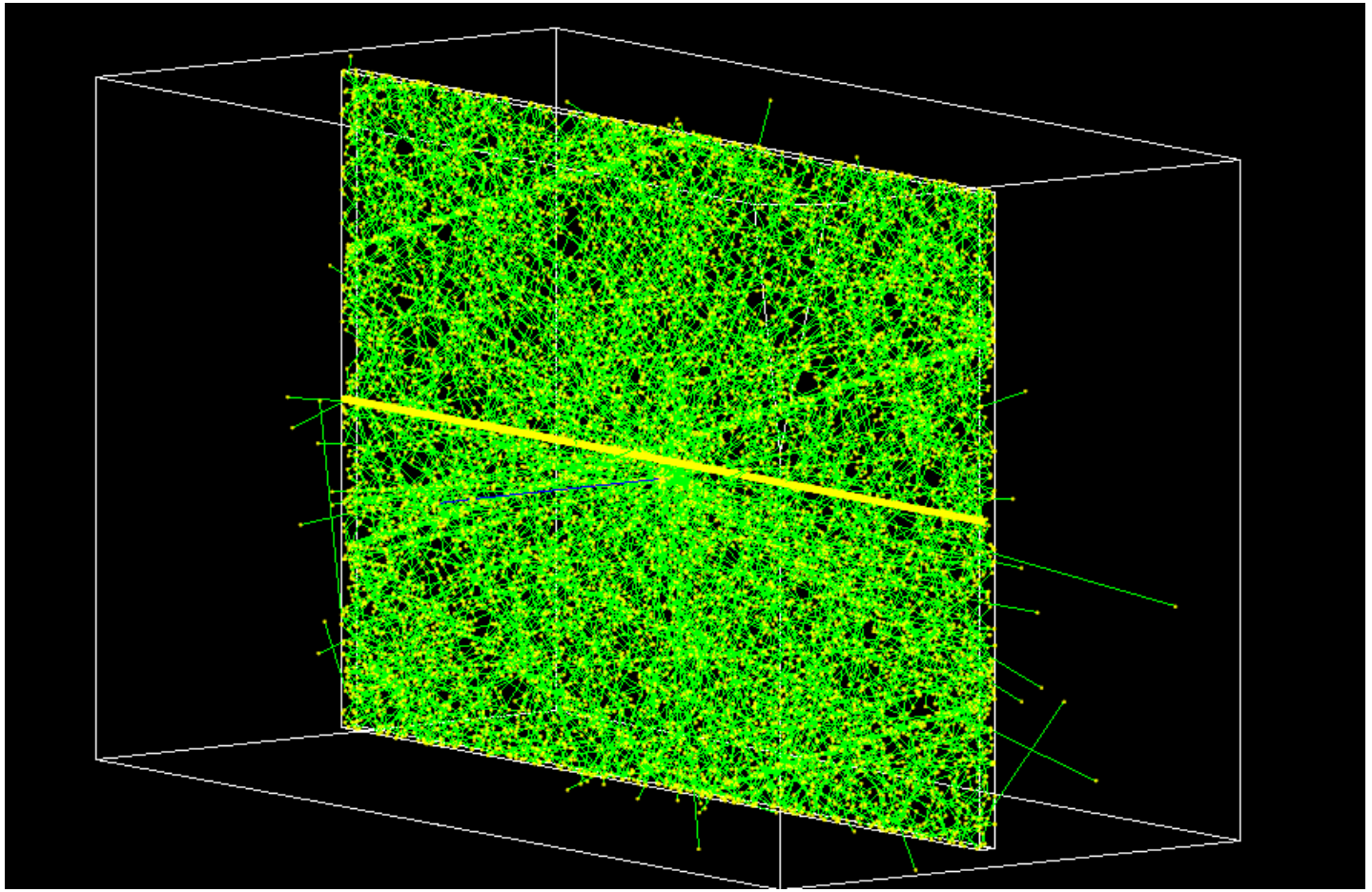
- Cladding

Refractive index

Simulation을 통해서 확인해야 하는 특성

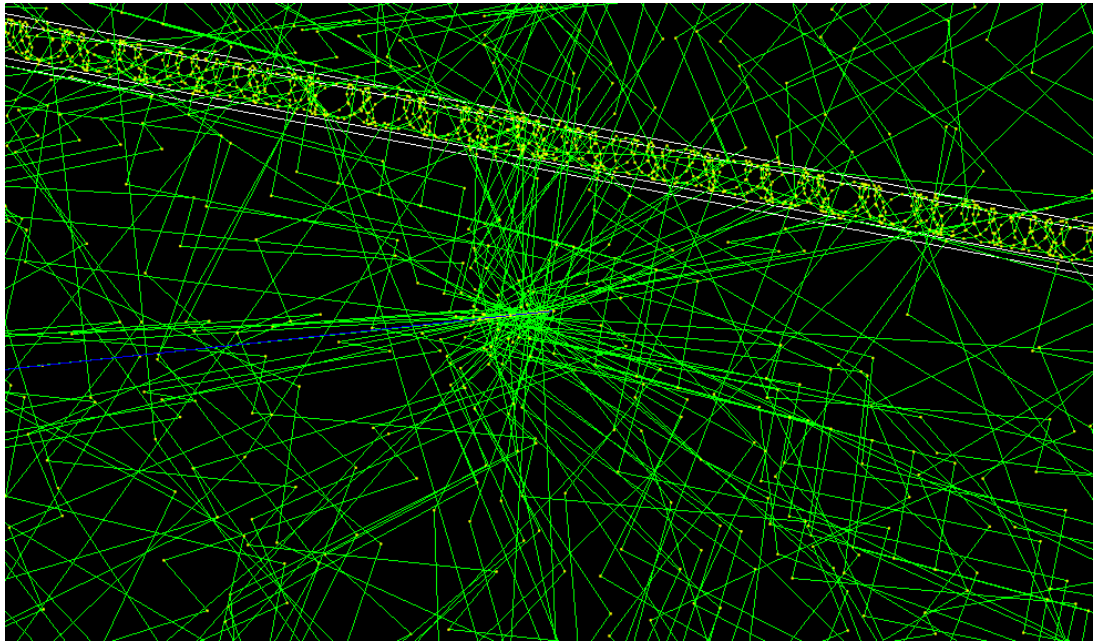
- Transmission Loss

Put the WLS-fiber



- Scintillation yield 100/MeV 으로 했을 때의 Simulation 결과

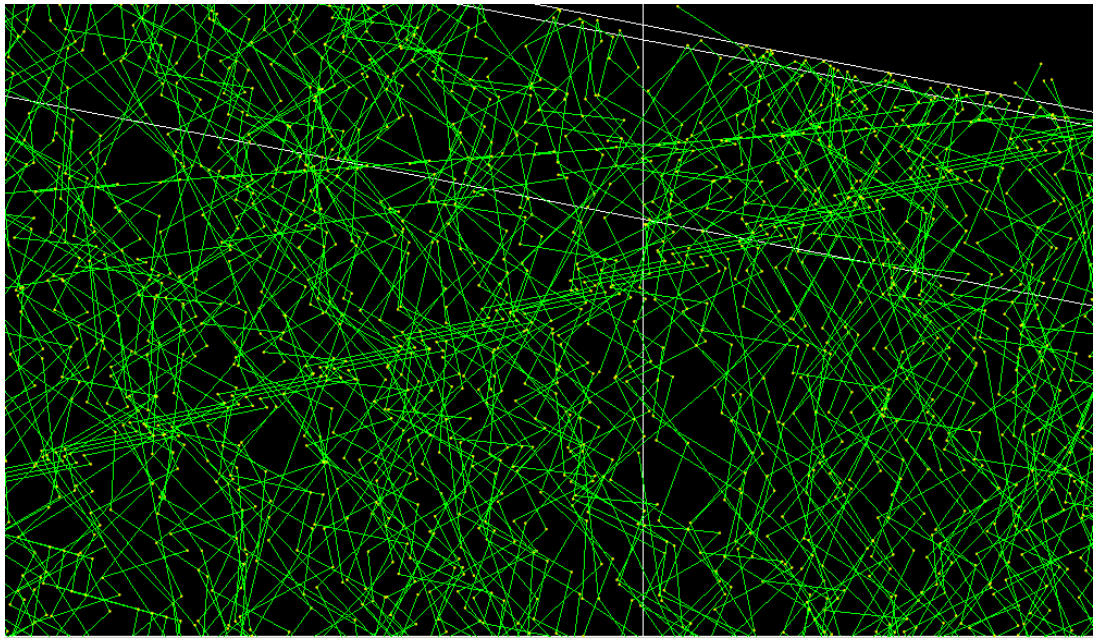
Simulation for Scintillation process



- Scintillation yield 100/MeV
- Shooted particle : mu+
- Energy of particle : 100GeV

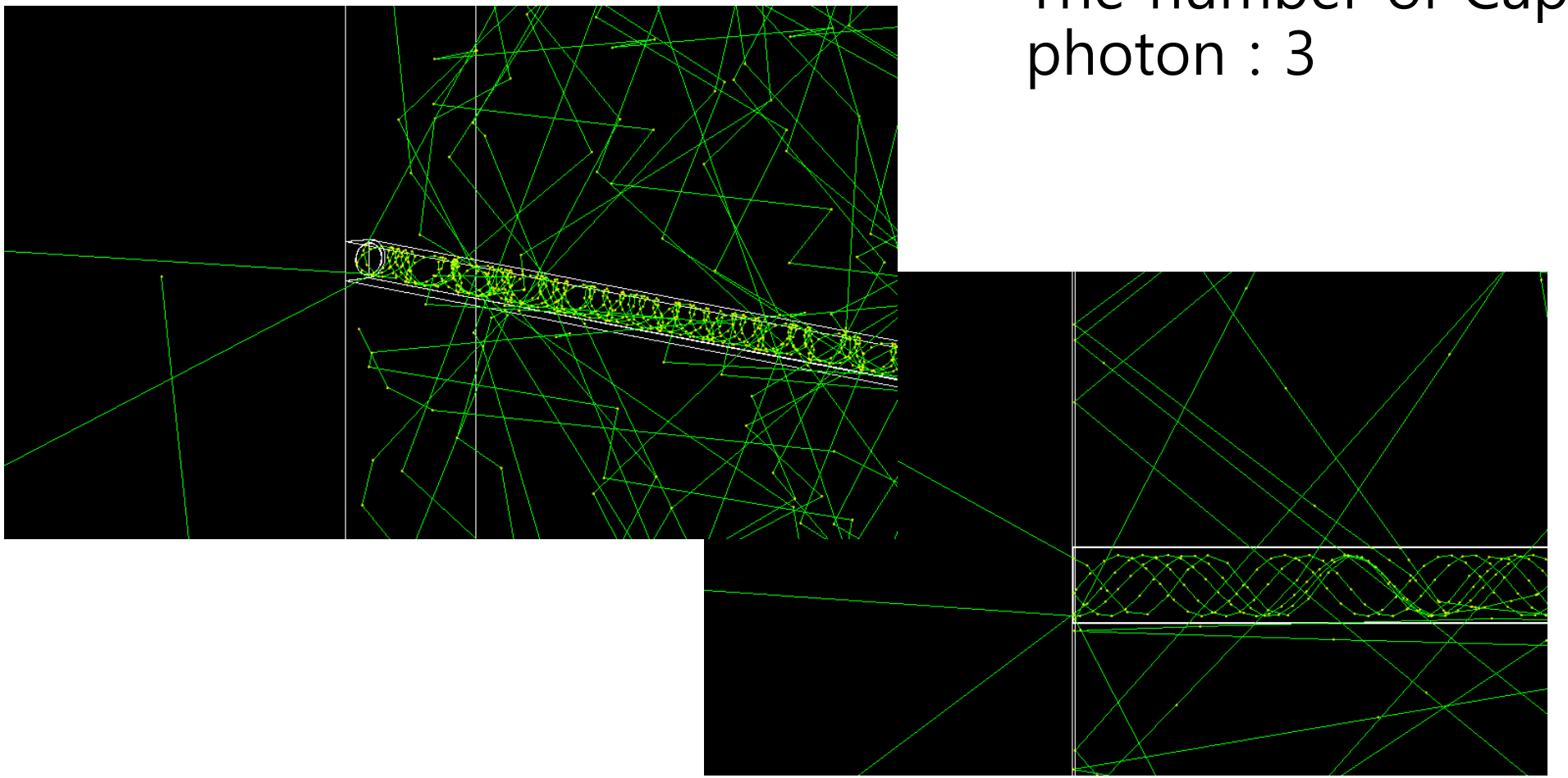
- Scintillation process : 65
- Cerenkov process : 30

Total Reflection



- Considering of refractive index of Plastic Scintillator 1.58, incident angle should be larger than 39.27.
- The probability of total reflection is 0.766

Simulation



- The number of Captured photon : 3

Capture in WLS-fiber