

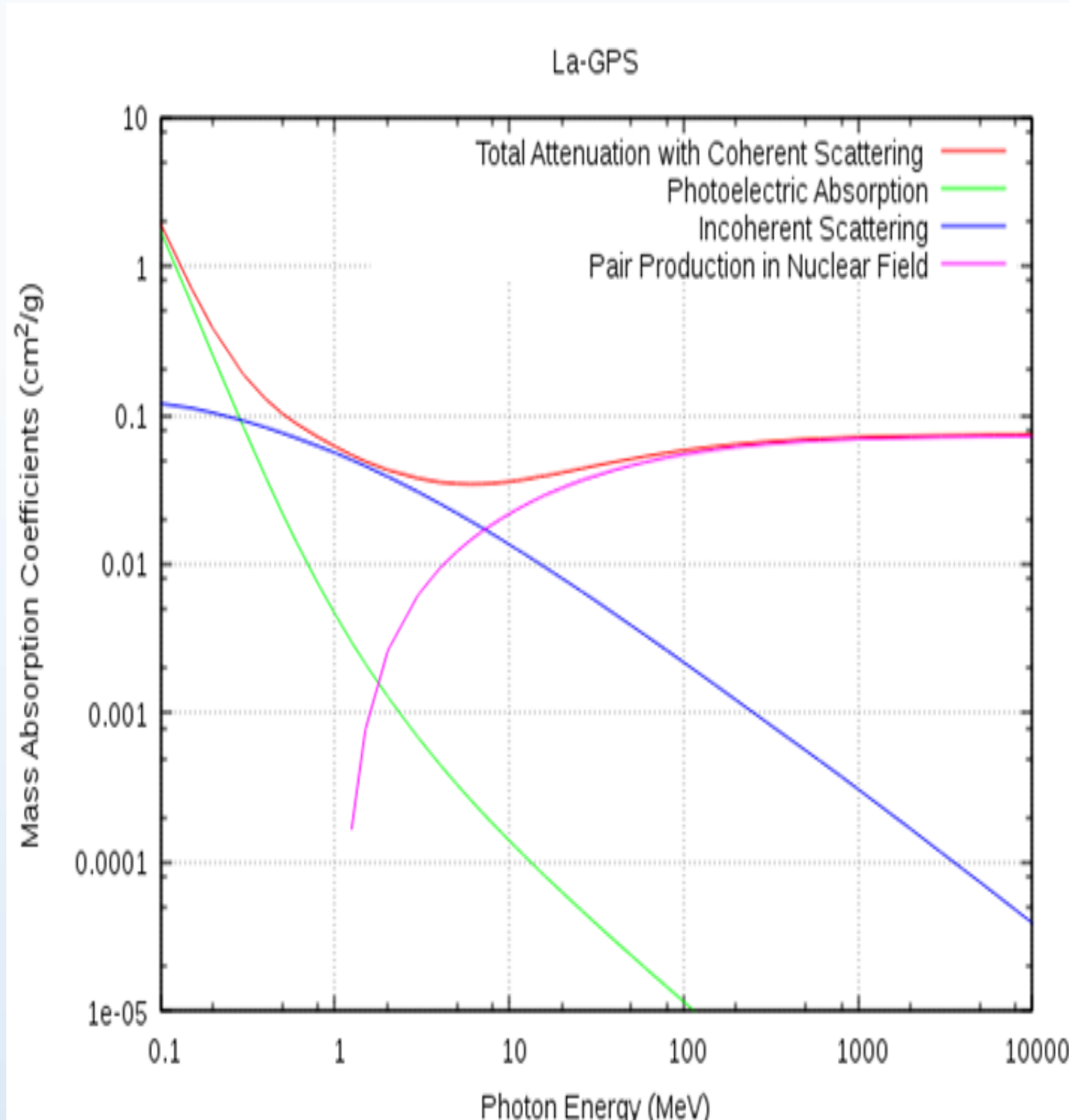


Proposal of Gamma Rays Detector with Position Resolution of 0.1 mm

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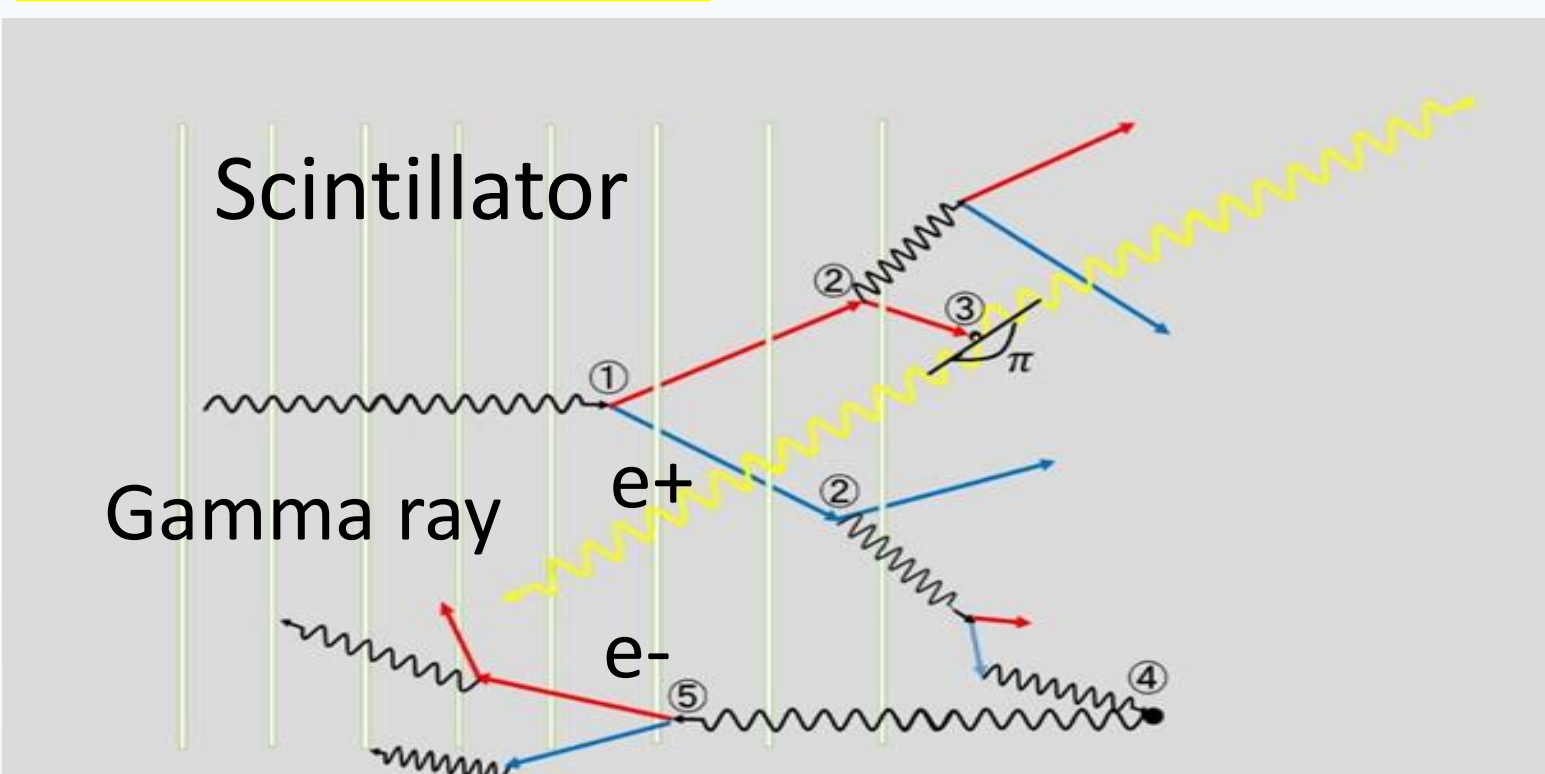
Abstract - In particle physics experiment, position resolution of typical detectors for gamma rays is approximately 10 mm at most. Our detectors have high position resolution because wave-length shifting fibers (WLSF) with a diameter of 0.2 mm are spread over the upstream face and the downstream face of the scintillator plate without a gap in the scintillator part.

Introduction



- The interaction of high energy gamma rays are mainly electron positron pair creation and electromagnetic shower spreads.
- Traditional method of gamma ray detector uses center of gravity calculation for all gamma ray's branches.
- Our detector uses La-GPS scintillators, because of high chemical stability, energy resolution as high as 4.4% and emission level as high as 40000ph/MeV.

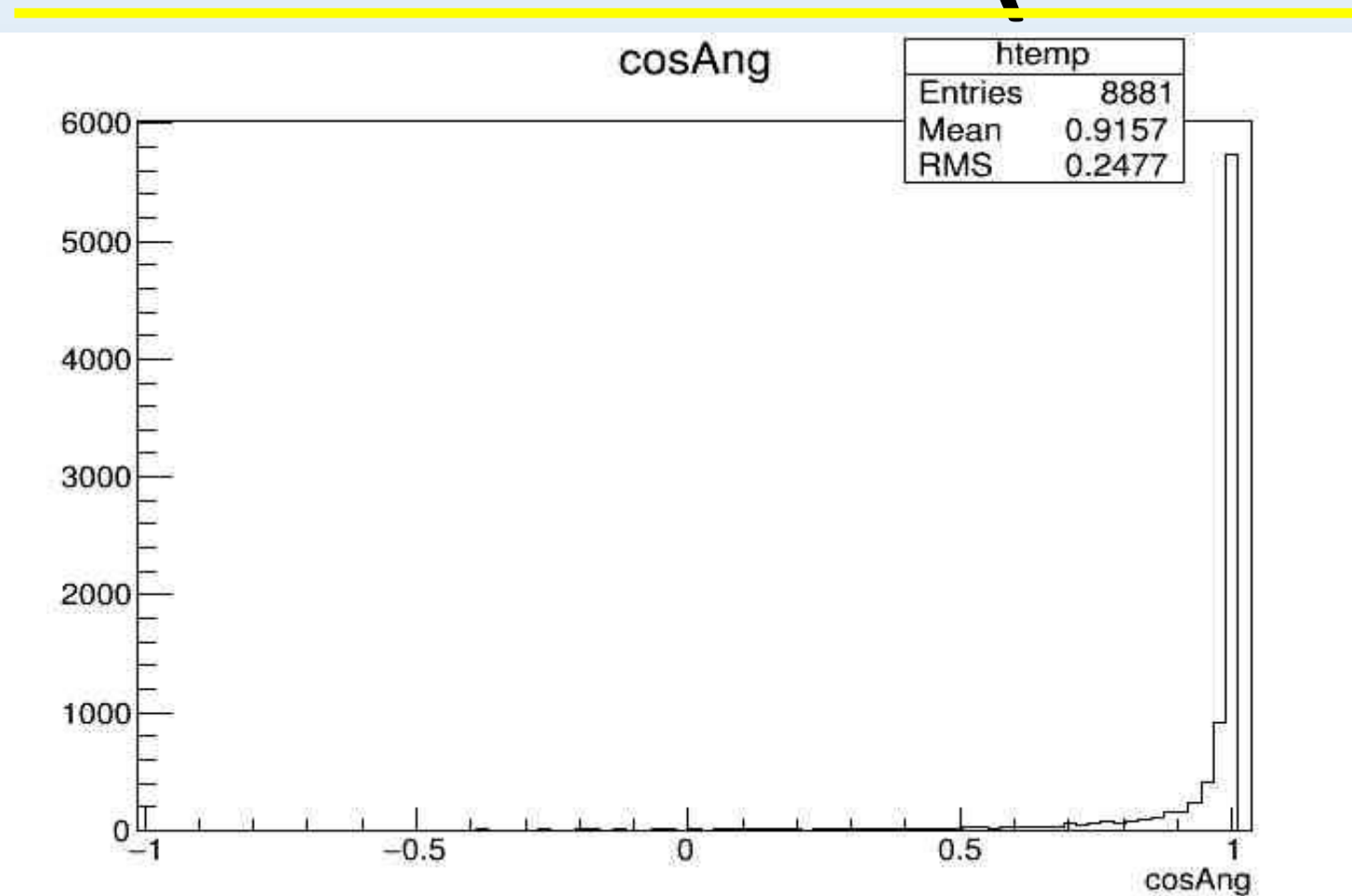
Method



- ① Electron-positron pair creation
- ② Bremsstrahlung radiation
- ③ Electron-positron pair annihilation
- ④ Large-angle Compton scattering
- ⑤ Electromagnetic shower in the reverse direction

We detect the positions of electrons and positrons in the next layer where first pair creation occurred.

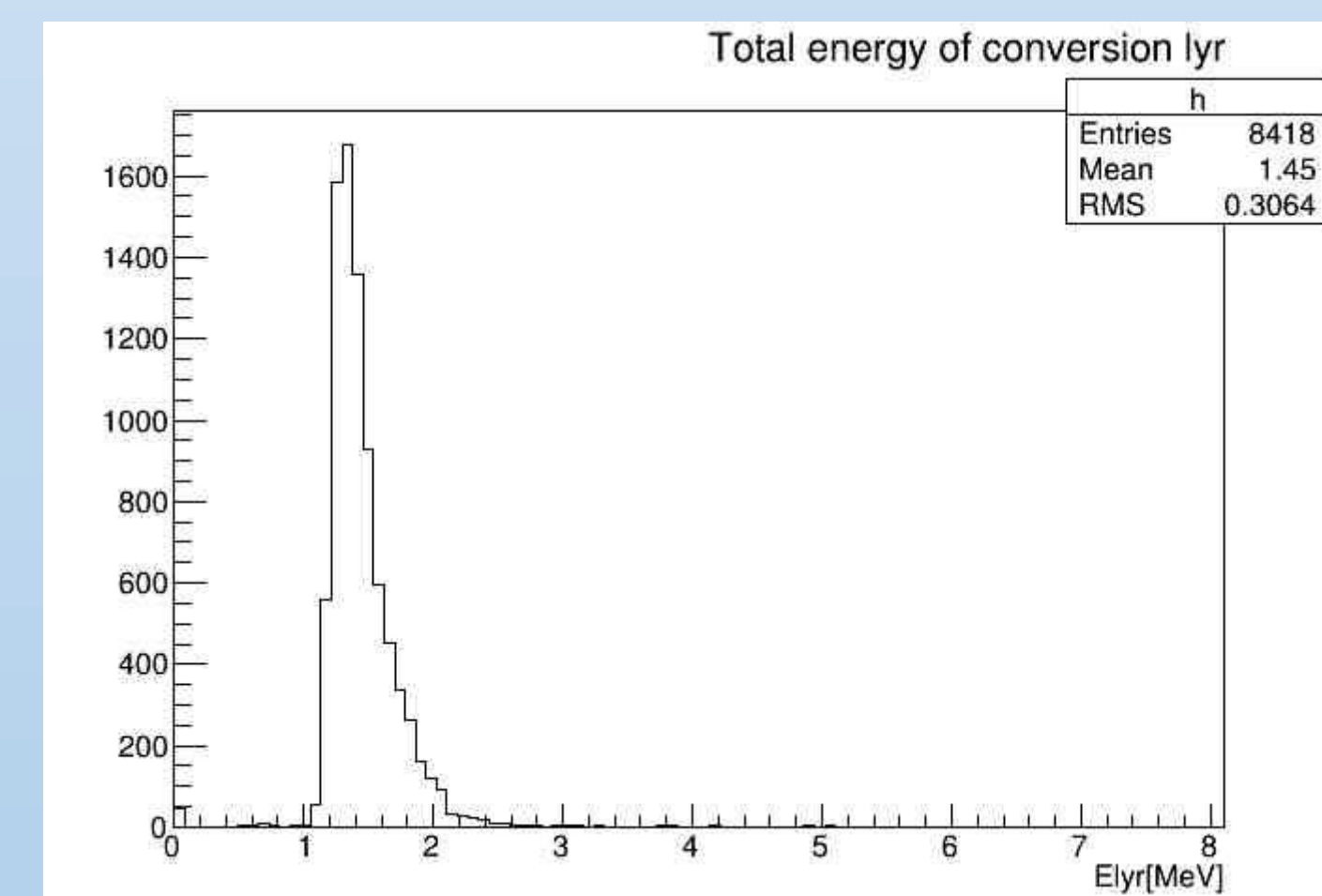
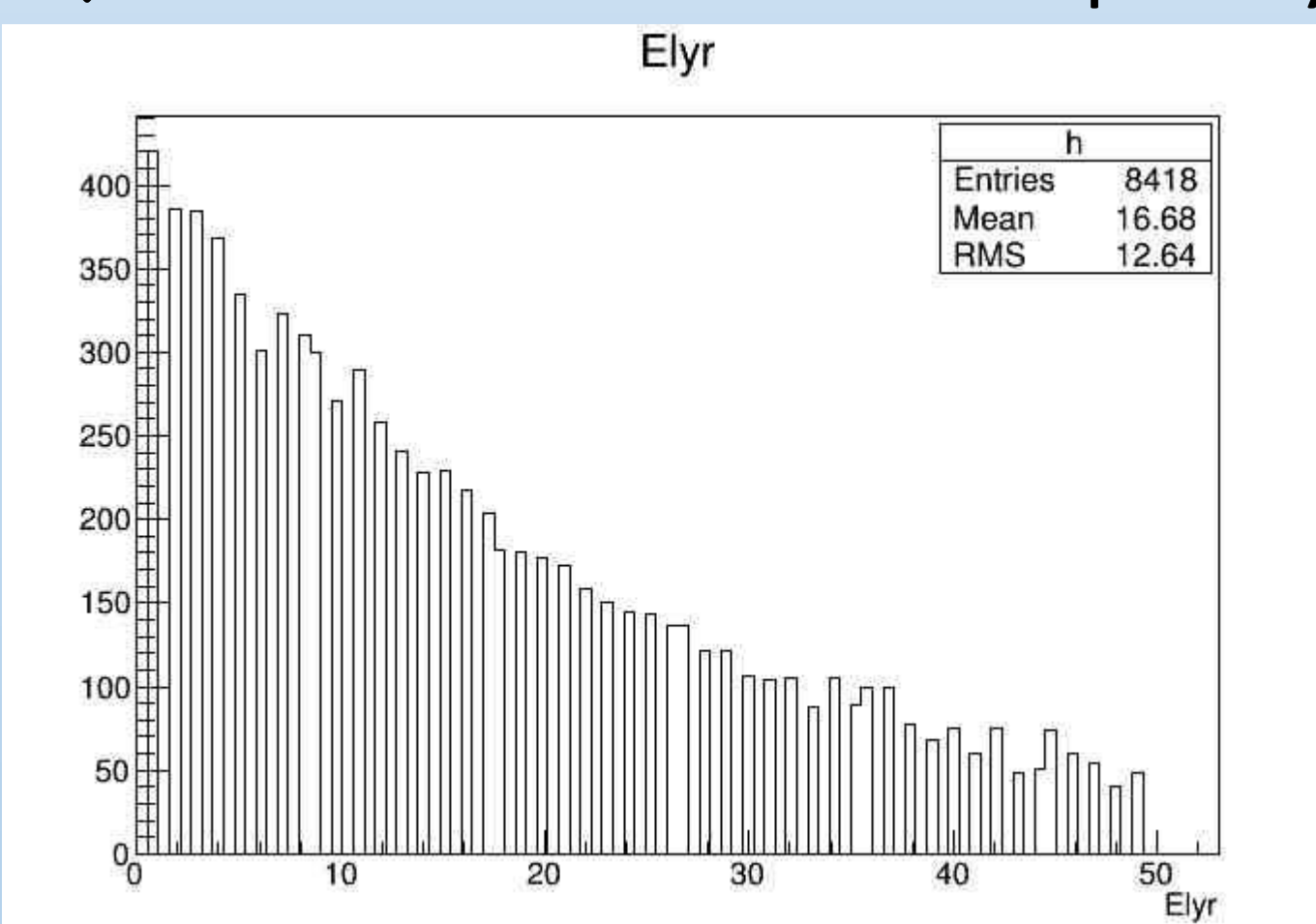
Simulation1(Geant4)



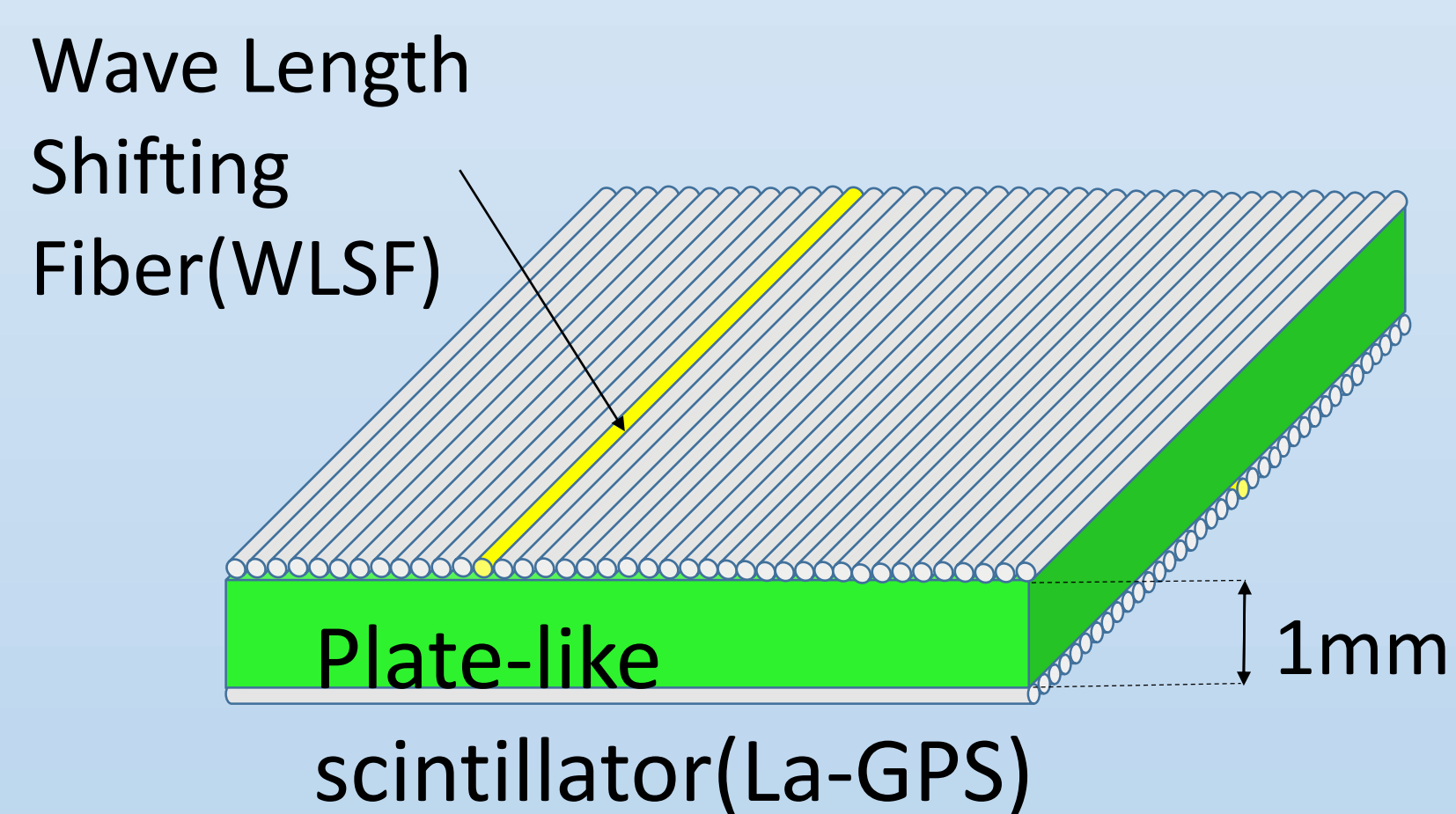
- 1 GeV gamma ray enter.
- ← The angle of pair creation is almost 0[rad].

The energy distribution in the next layer where first pair creation occurred. ↓

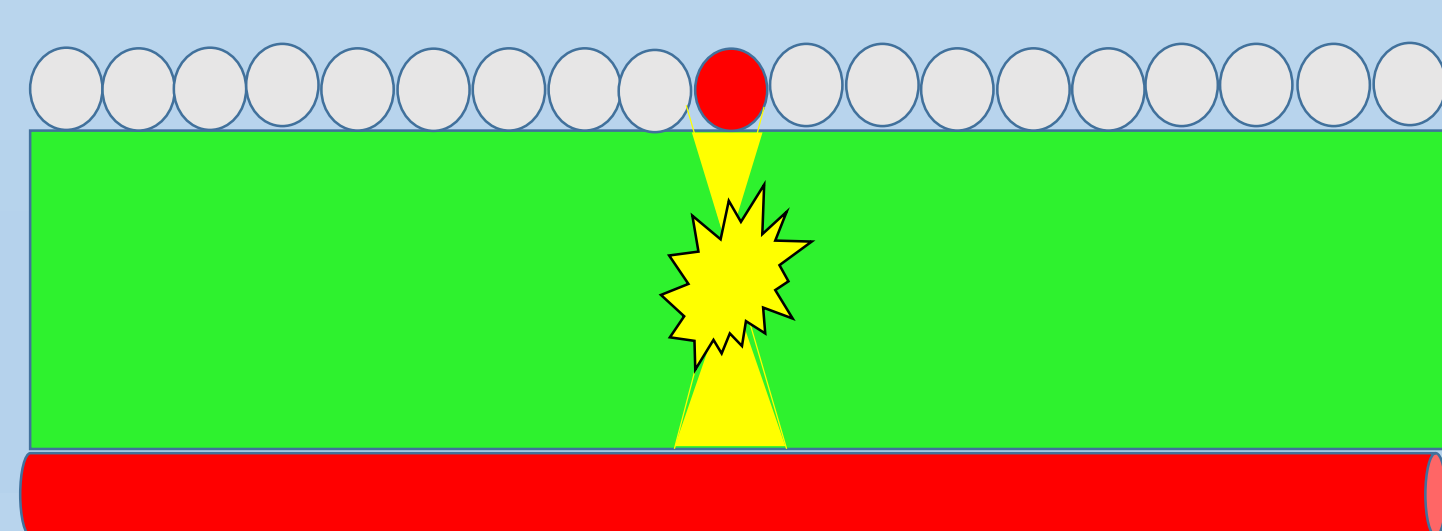
↓ Pair creation distribution per layer



Details of detection part



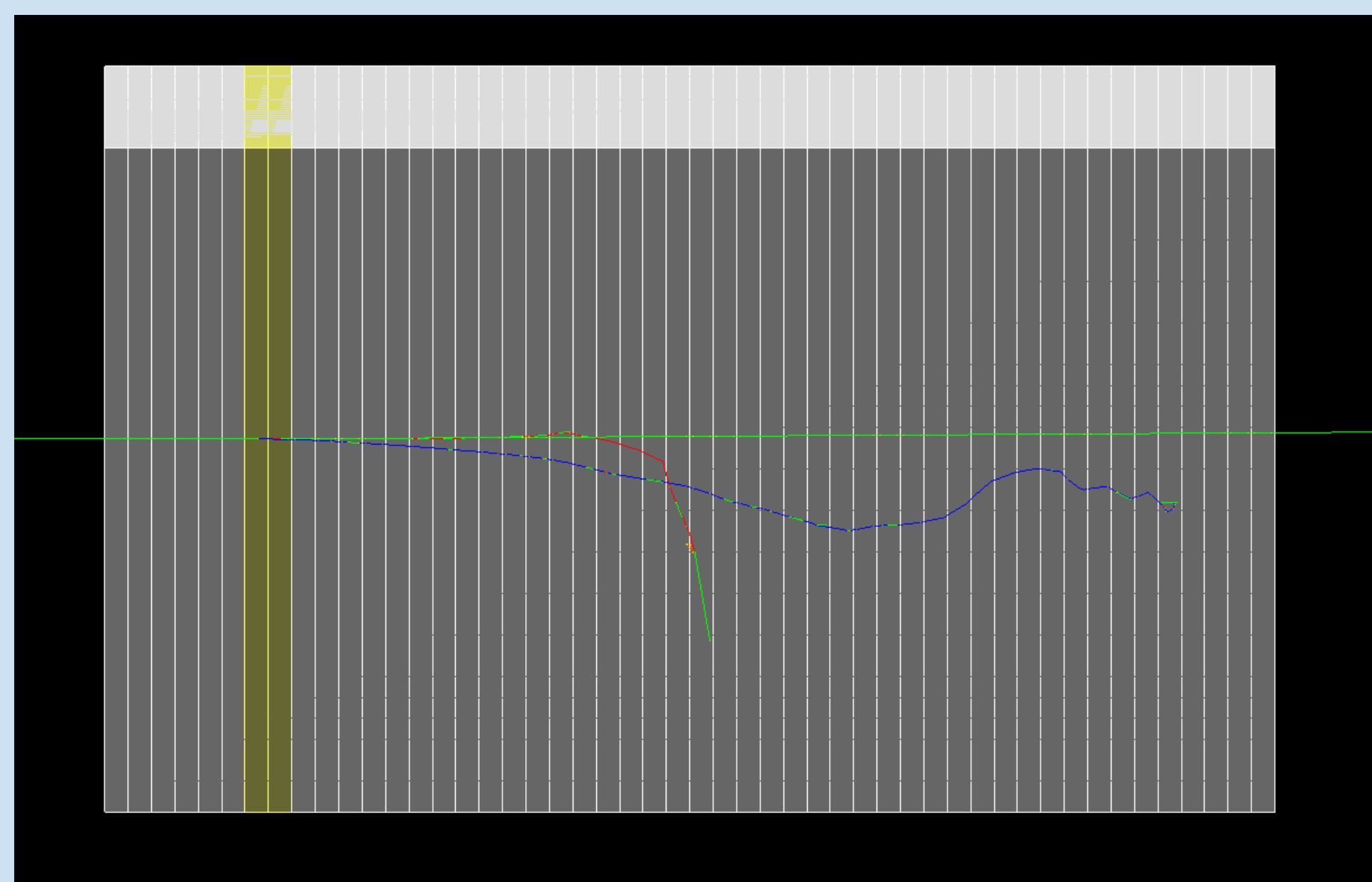
- WLSF is a kind of optical fiber.
- WLSF are spread vertical direction and the horizontal direction.
- WLSF's diameter is 0.2mm.
- Using ADC's center gravity calculation, the position resolution can be expected to be 0.1 mm.



- ① Scintillators emit by radiation.
- ② WLSF absorbed this light.
- ③ WLSF re-emits.

Currently, for 2.28 MeV beta ray, as a result of 6 times measurements, the position is 0.403 ± 0.082 mm in sigma.[1]

System Overview



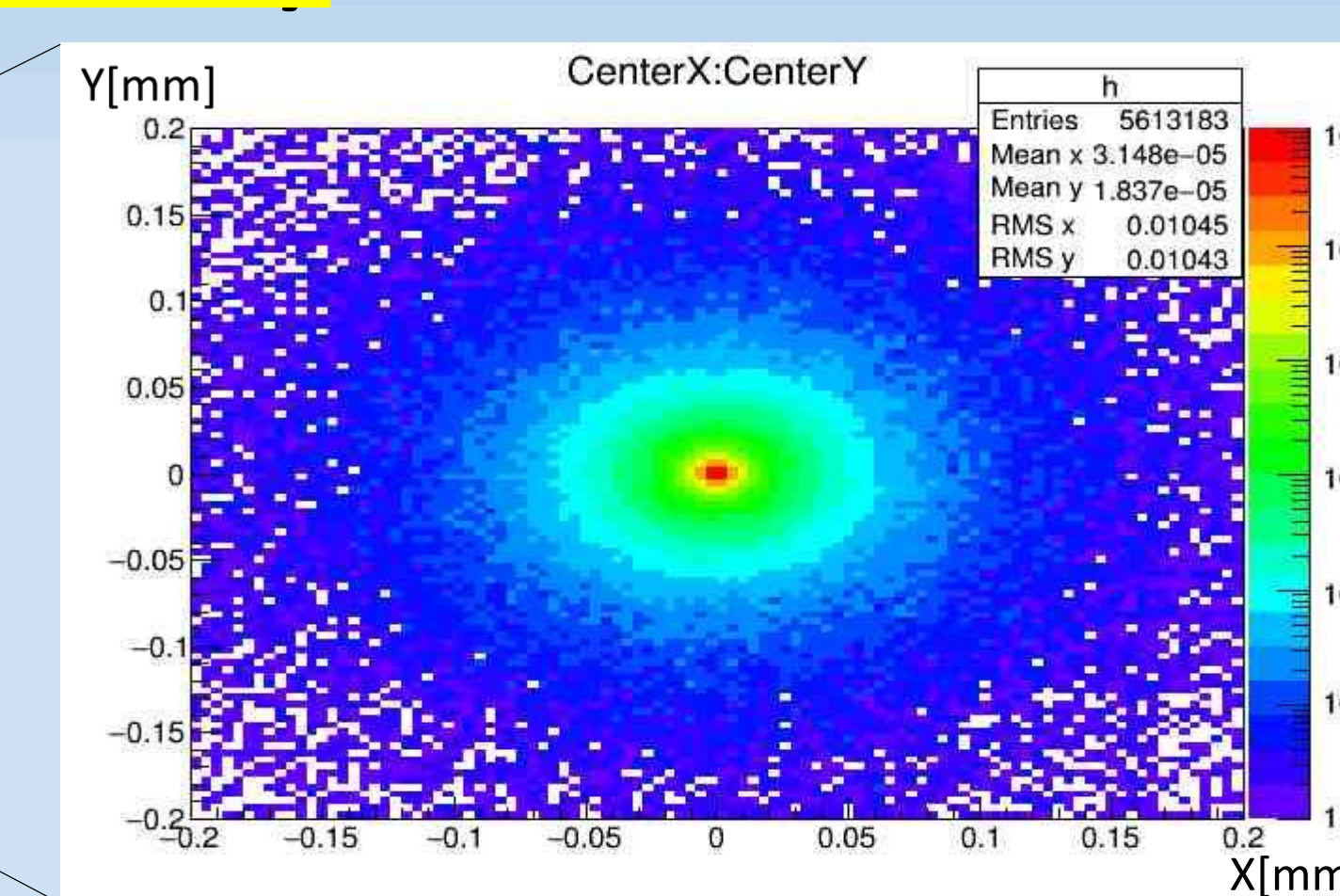
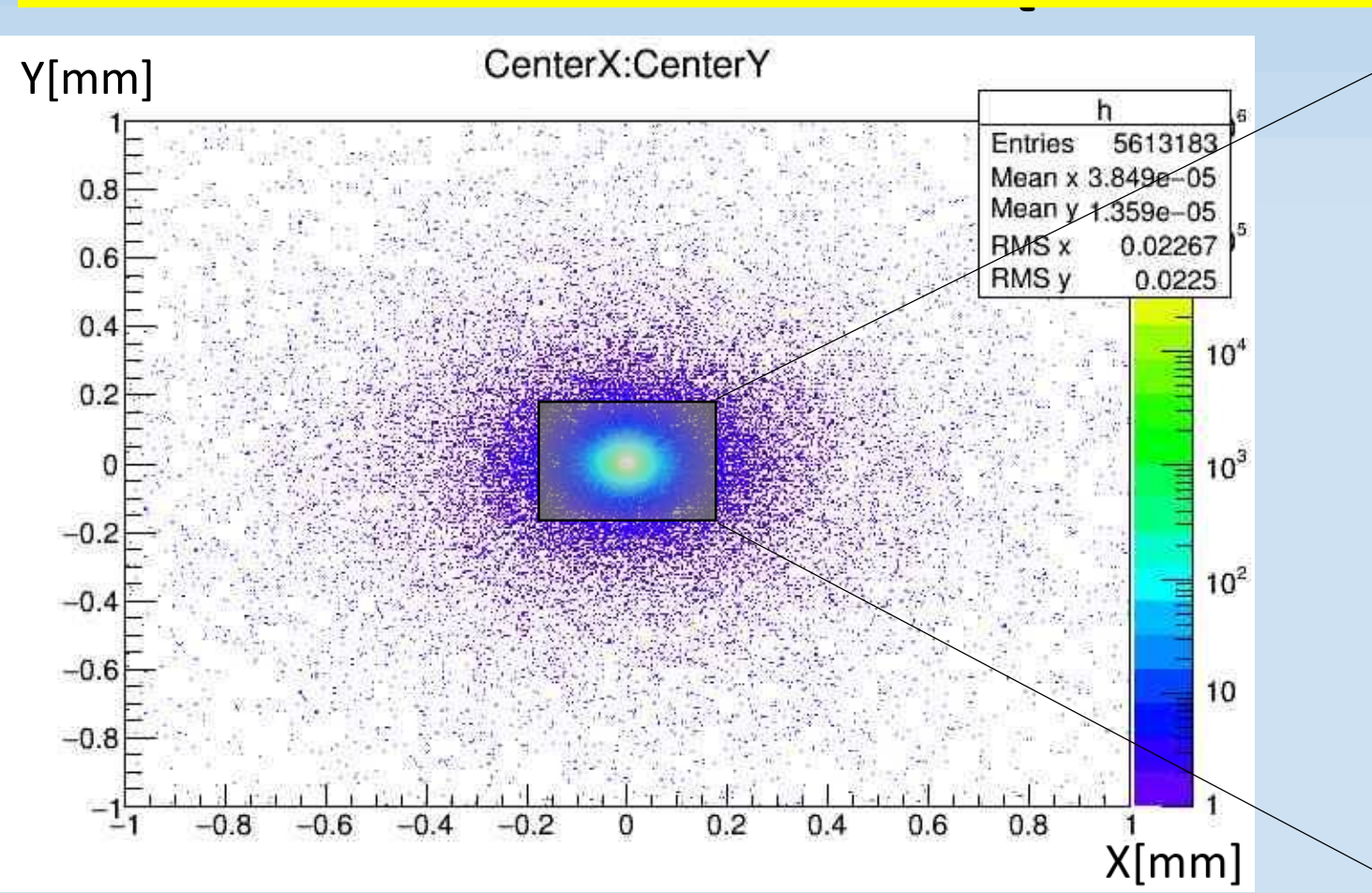
← The view of electromagnetic shower in our system.(GEANT4)
The effective area is yellow area.

- Density of La-GPS is 5.3[g/cm³].[2]
- Radiation length of La-GPS is approximately 8.31 [g/cm²]. [3]
- At about 5 cm, the intensity of gamma rays will be less than 99.5%.
- The number of layers is enough 50.

Acknowledgment

We would like to thank "KAKENHI" for providing research funding.

Simulation2(Geant4)



Conclusion

According to result of simulation1, the energy as high as approximately 1.45 [MeV] is deposited in the next layer where first pair creation occurred. Therefore, 58000ph can be anticipated in PMT. This can be said to be a sufficient amount of photon to analyze. According to result of simulation2, the percentage of number of event that electron and positron travel without interaction in the next layer where first pair creation is approximately 56.13%. The position resolution can be expected to be 0.1 mm or less.

Reference

- [1]T. Mizuno etal. "Development of Large-Area Charged Particle Detector with Inorganic Scintillator Plates and wavelength Shifting Fiber." in ANIMMA , 2017
- [2]C&A corporation , Product, Scintillator products, "La-GPS" <http://www.c-and-a.jp/GPS.html>
- [3]Particle Data Group, "Ba"(whose atomic number is nearly equal to effective atomic number of La-GPS) <http://pdg.lbl.gov/2016/AtomicNuclearProperties/index.html>