Garfield Simulation of CGEM

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Outline

- Introduction
- Method
- Lorentz Angle
- Primary ionization
- Electron shift
- Avalanche & Gain

Introduction

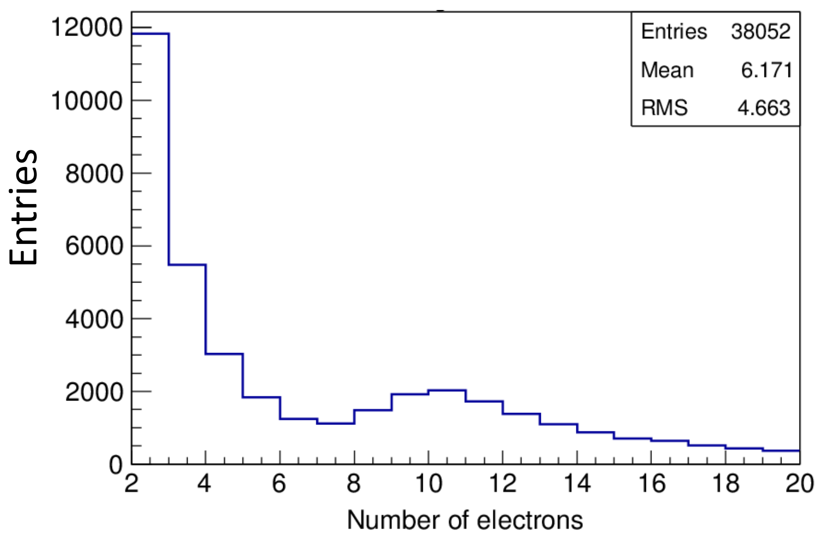
- Garfield is time consuming for the full triple-GEM simulation. So we will simulate the three GEMs separately.
- The incident particle interacts with gas and creates primary electrons.
- For “electron cluster”, it refers to the energy loss in a single ionizing collision of the primary charged particle and the secondary electrons produced in this process.

Method

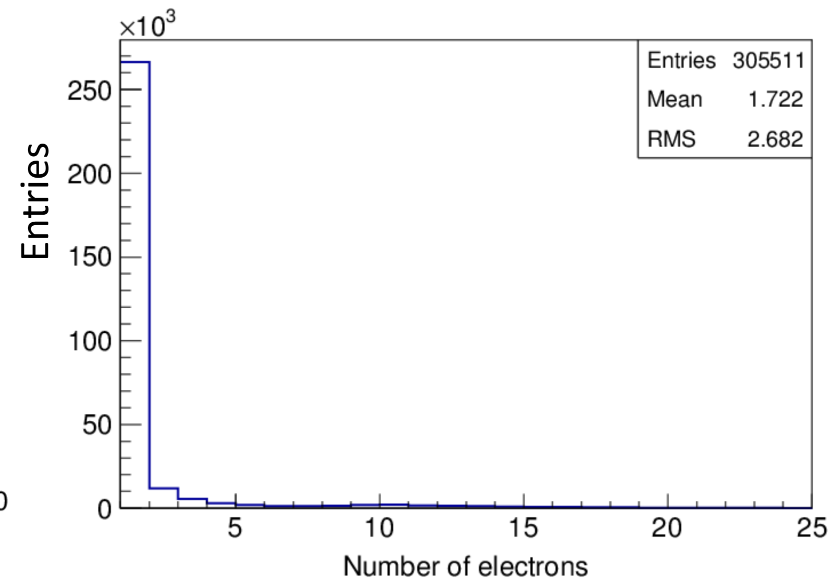
- Software
  - ANSYS: to model & mesh the GEM
  - Garfield++: to simulate electron avalanches
  - ROOT and C scripts: to analyse the data
- Garfield Simulation
  - Gas Mixture: Ar: iC4H10 (90: 10)
  - Avalanche Model: AvalancheMicroscopic
  - Particle: 20k orthogonal $\boldsymbol{\mu}$ tracks with momentum $1\mathrm{Gev/c}$ for primary electrons simulation. 20k electrons for electron avalanches simulation.
  - Magnetic Field: 1Tesla
  - High voltages on foils : 270V/GEM
  - Field: 1.5/3/3/5 kV/cm (Drift/Transfer1/Transfer2/Induction)

Primary ionization

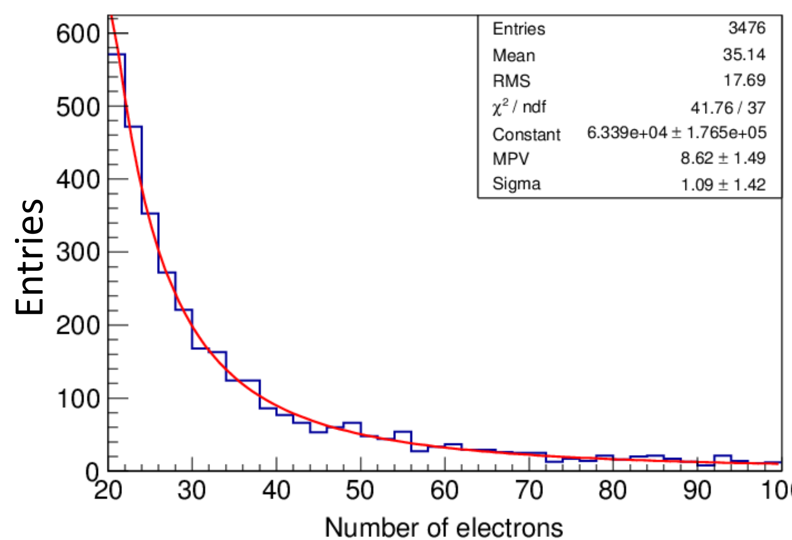
Range 2~20



Range 1~25



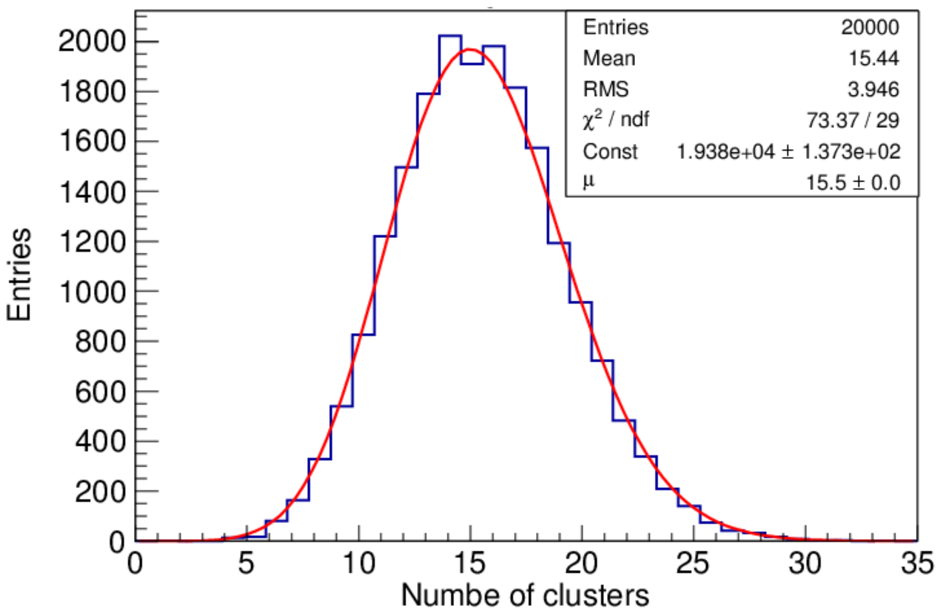
Range 20~100

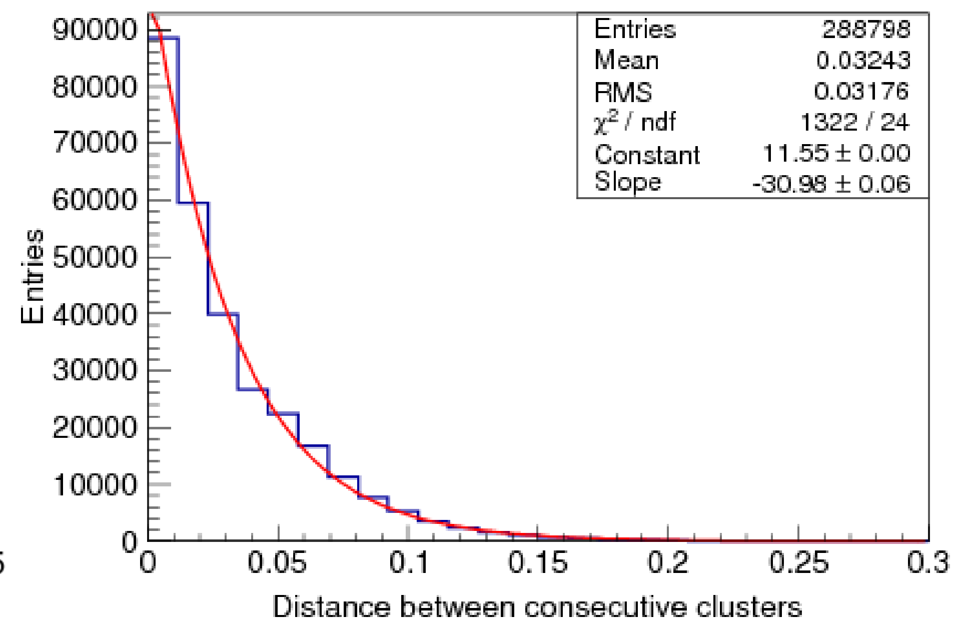


Number of Electrons in a Cluster in drift area (~5mm).

For range 20~100, the sampled value from the Landau fit.

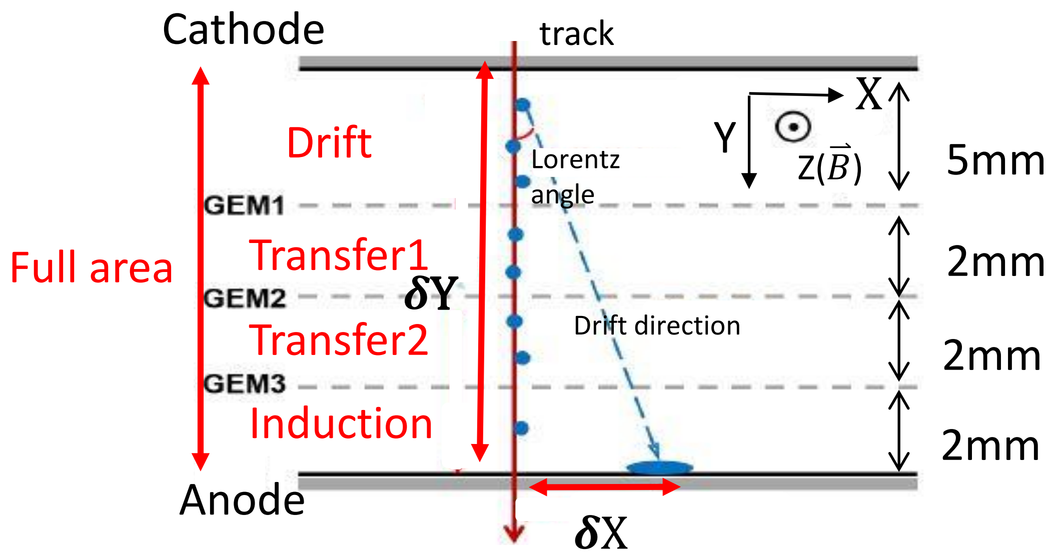
Primary ionization

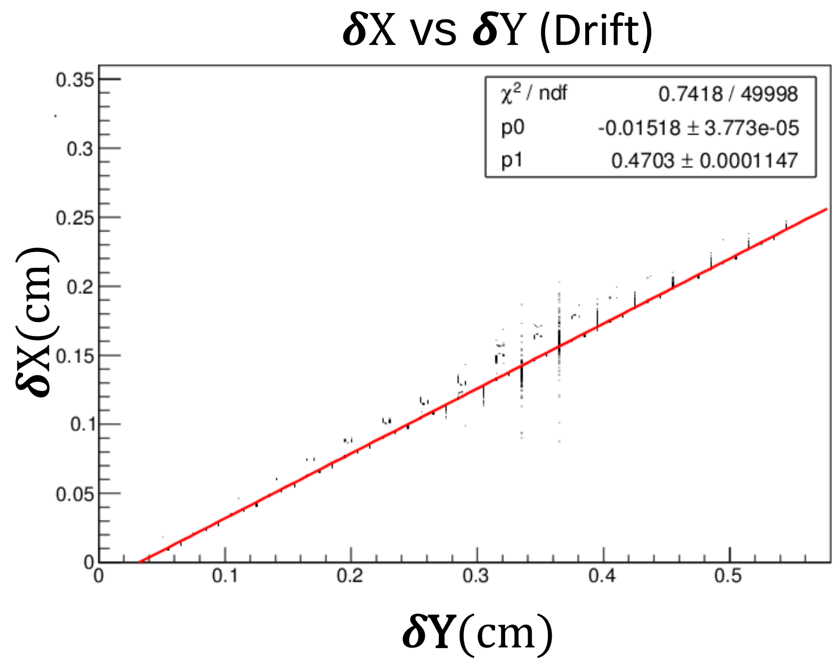




In drift area (~5mm) , the produced electron clusters is a Poisson distribution.
An Exponential probability gives the distance between two consecutive clusters.

Lorentz Angle



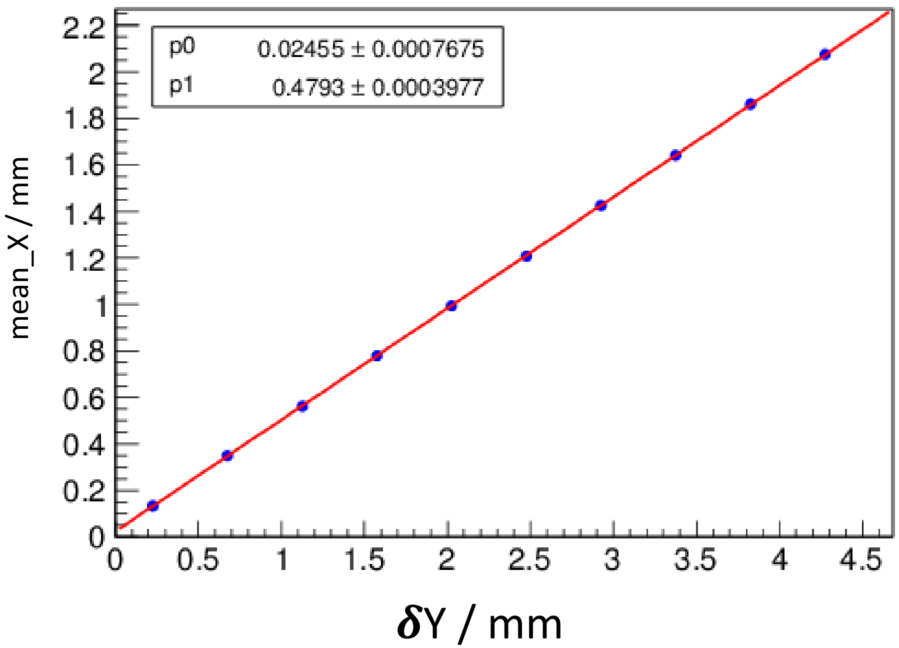


- In each area, simulate 1000 electrons separately in 50 equidistant bins.
- X is the direction which is perpendicular to E and B
- Y is the direction of electric field
- The Lorentz angle can be extracted from the plot

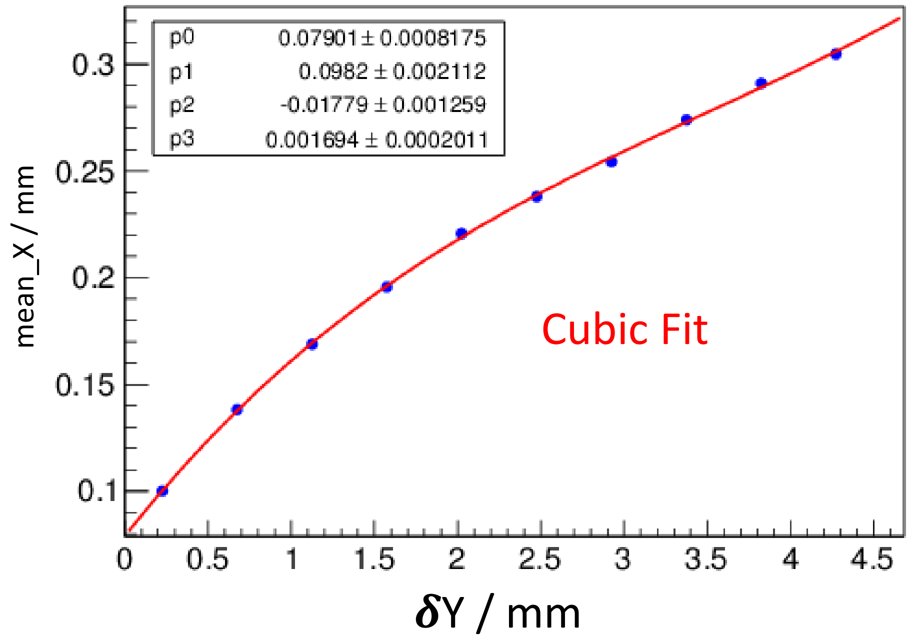
	Drift	Transfer1	Transfer2	Induction	Full area
Lorentz Angle	25.2	10.5	10.5	6.0	16.1
Electric Field (kV/cm)	1.5	3	3	5	

Electron shift(Gem1)

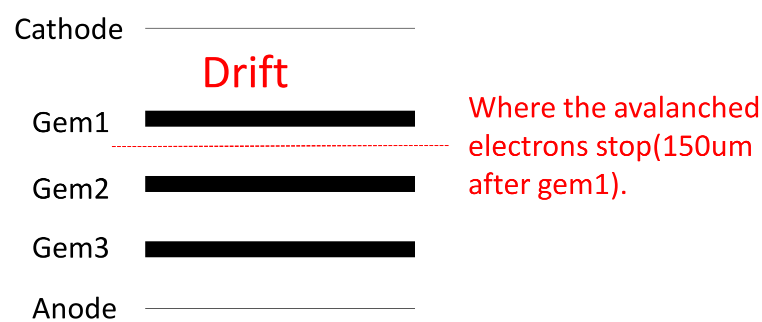
Mean_X vs $\boldsymbol{\delta}$Y



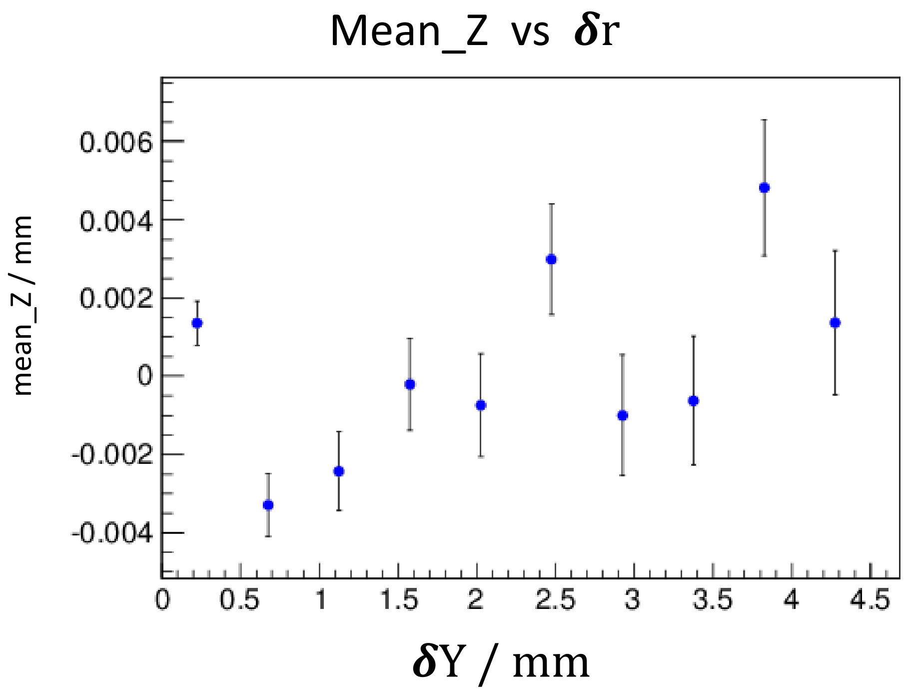
Sigma_X vs $\boldsymbol{\delta}$Y

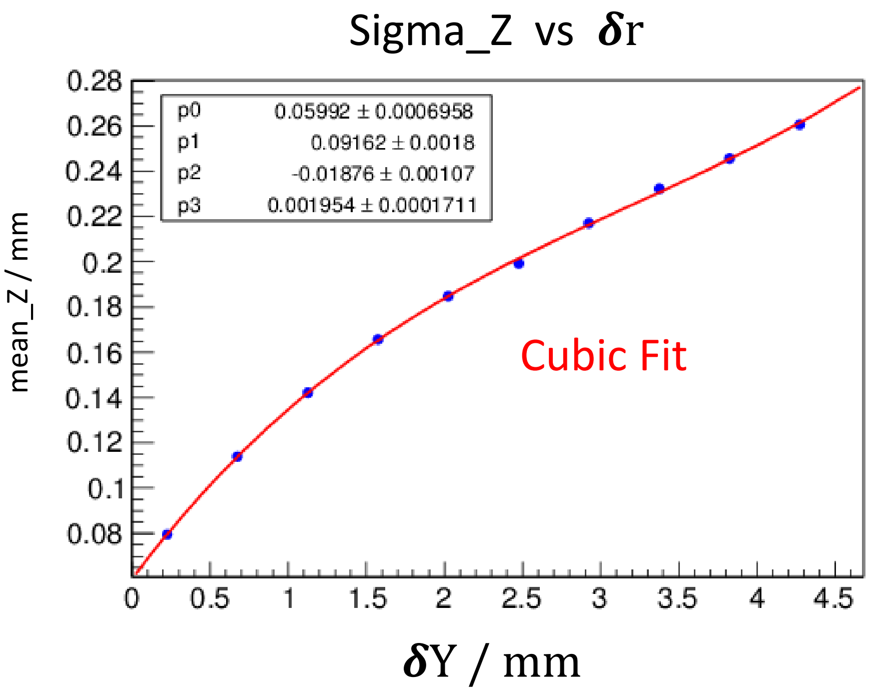


- In drift area, simulate 20k electrons separately in 10 equidistant bins.
- Generate a electron with uniform distribution in X&Z direction[-0.14, 0.14]mm, Y direction[bin width].
- Get the mean & sigma of avalanched electrons' shift in X direction vs $\boldsymbol{\delta}$r .



Electron shift(Gem1)

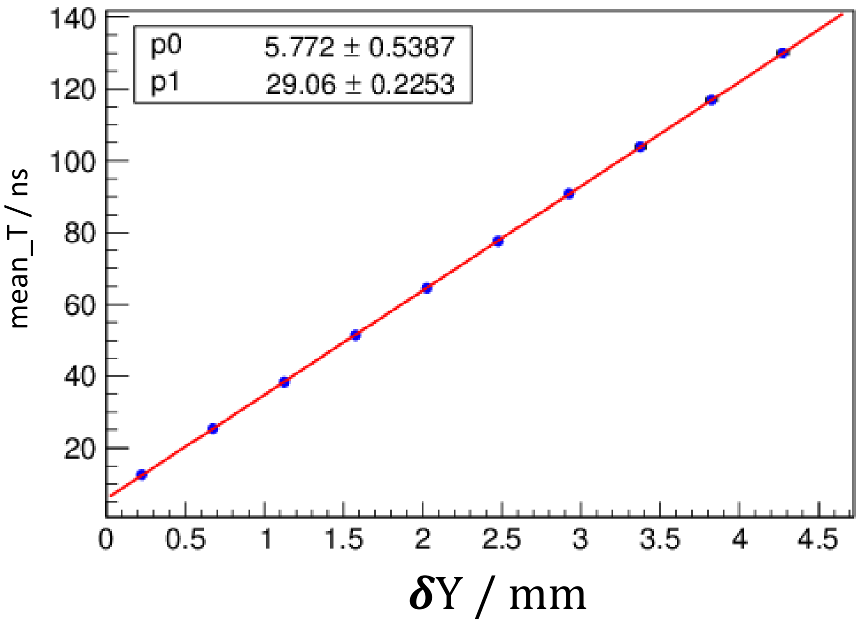




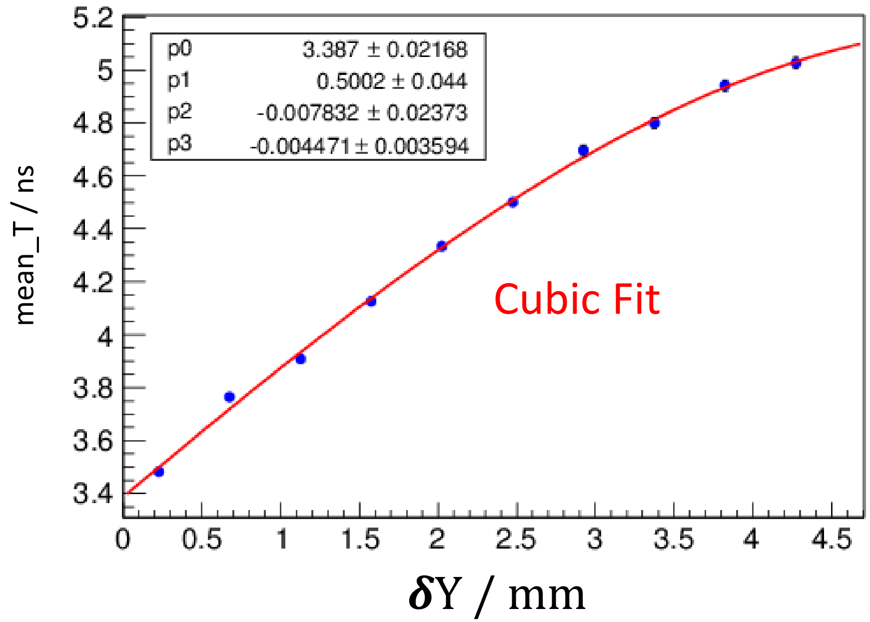
- In drift area, simulate 20k electrons separately in 10 equidistant bins.
- Generate a electron with uniform distribution in X&Z direction[-0.14, 0.14]mm, Y direction[bin width].
- Get the mean & sigma of avalanched electrons' shift in Z direction vs δr .

Electron shift(Gem1)

Mean_T vs δr



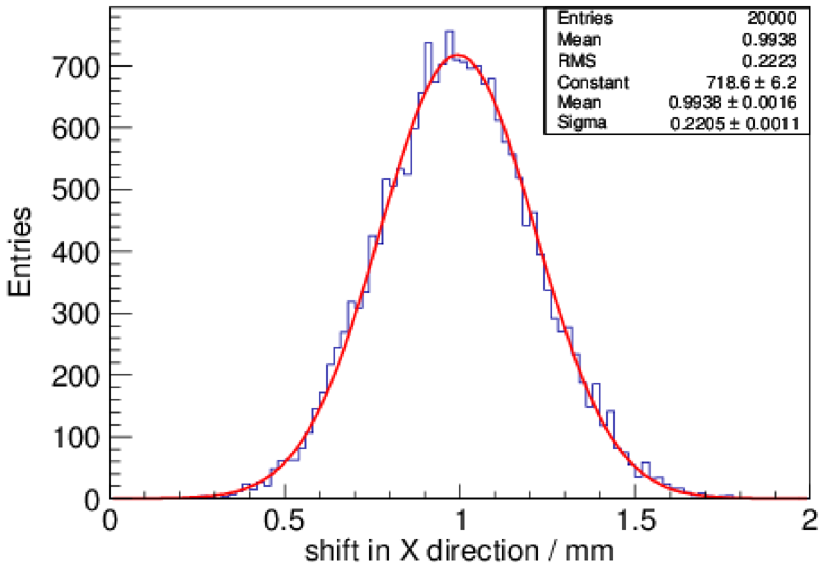
Sigma_T vs δr

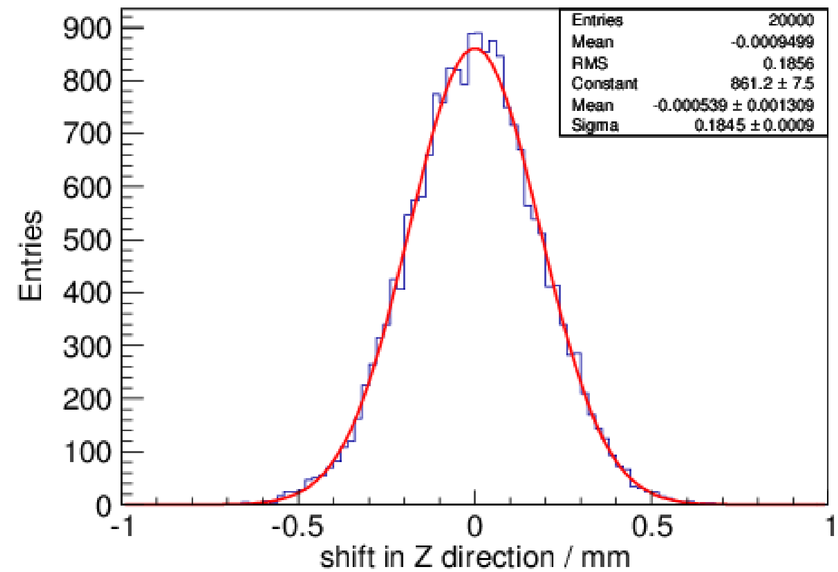


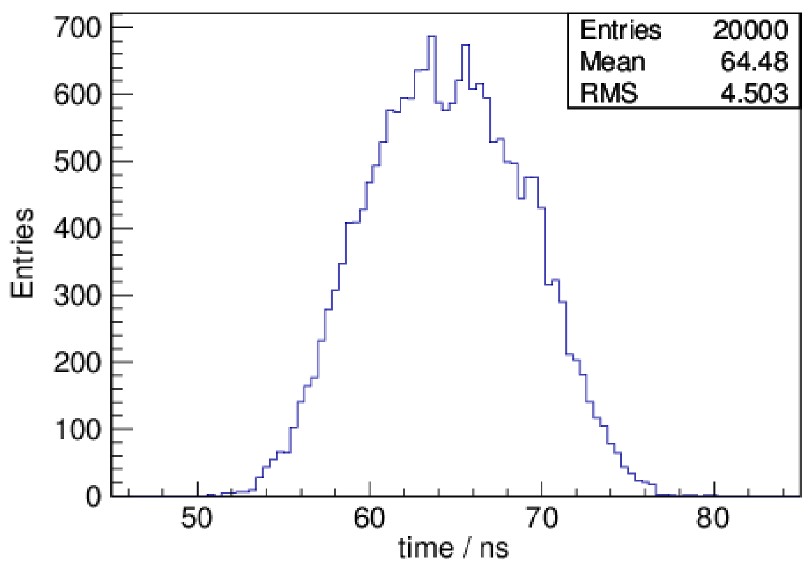
- In drift area, simulate 20k electrons separately in 10 equidistant bins.
- Generate a electron with uniform distribution in X&Z direction[-0.14, 0.14]mm, Y direction[bin width].
- Get the mean & sigma of avalanched electrons' drift time vs δr .

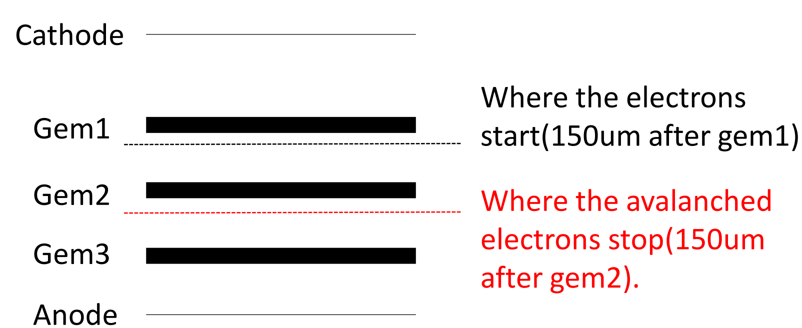
Electron shift(Gem1)

Simulate 20k electrons [2.75, 3.20]mm (uniform distribution) before gem1, then get the shift of avalanched electrons in X & Z direction 150um after gem1.



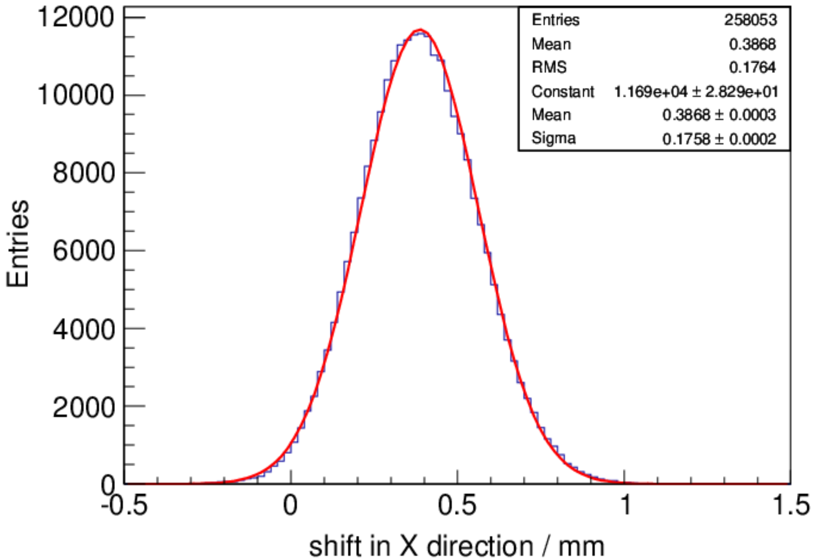


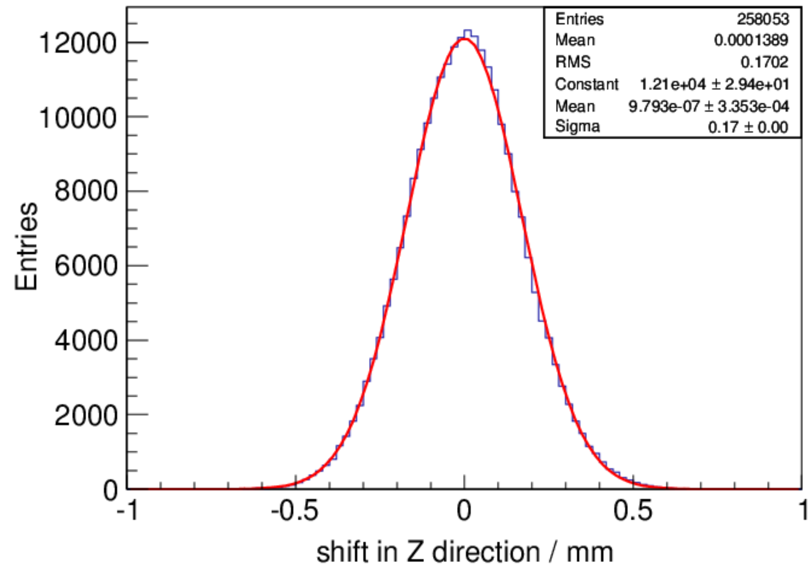


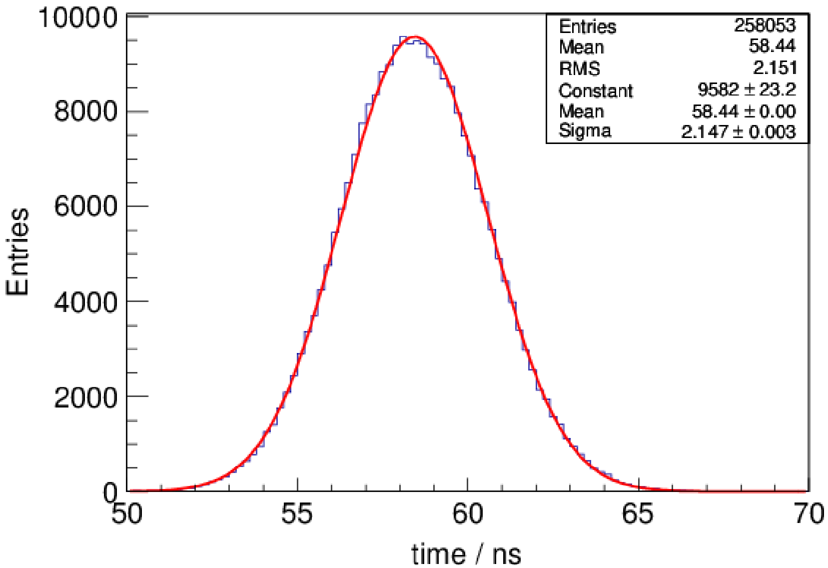


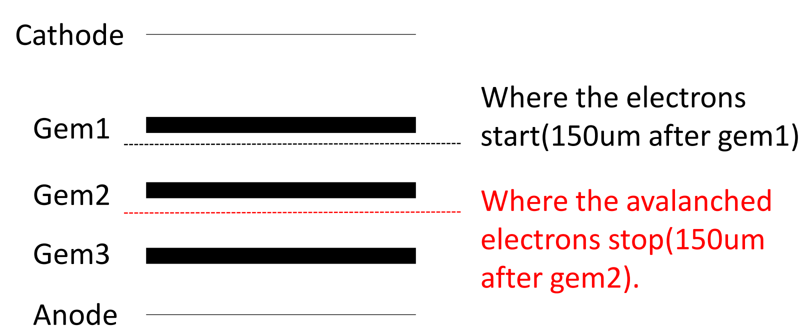
Electron shift(Gem2)

Simulate 20k electrons 150um after gem1, then get the shift of avalanched electrons in X & Z direction 150um after gem2.



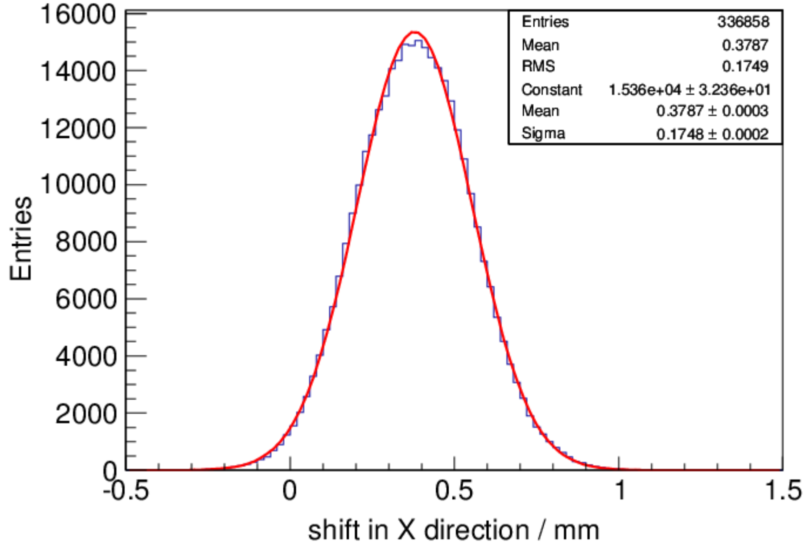


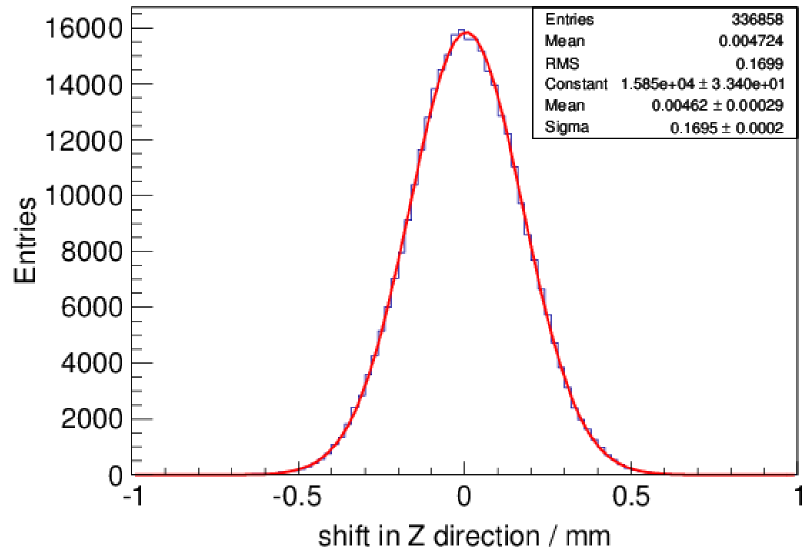


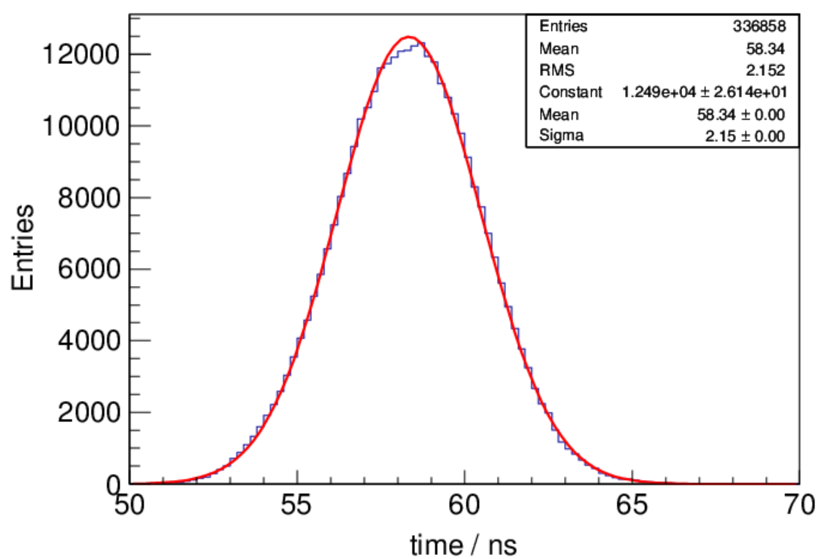


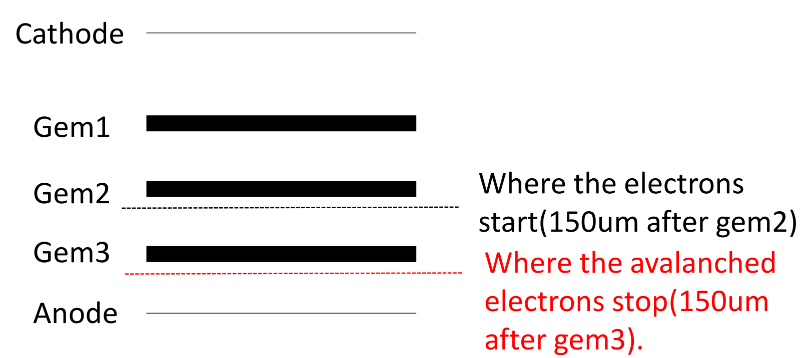
Electron shift(Gem3)

Simulate 20k electrons 150um after gem2, then get the shift of avalanched electrons in X & Z direction 150um after gem3.



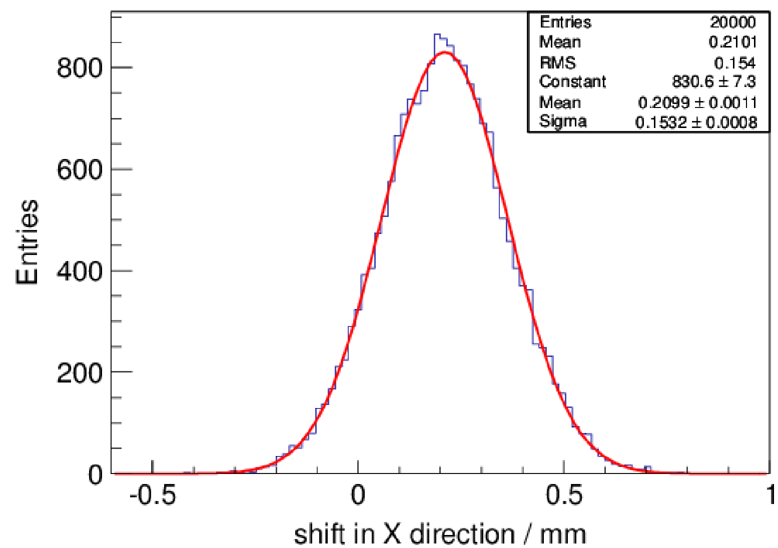


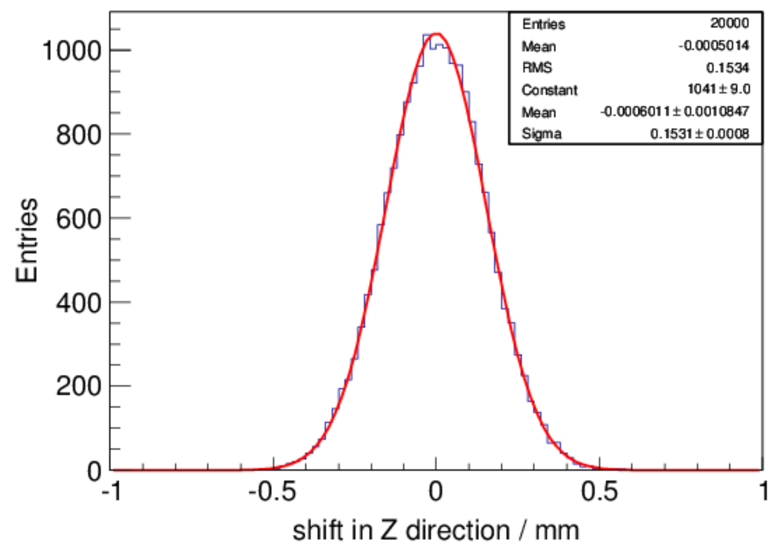


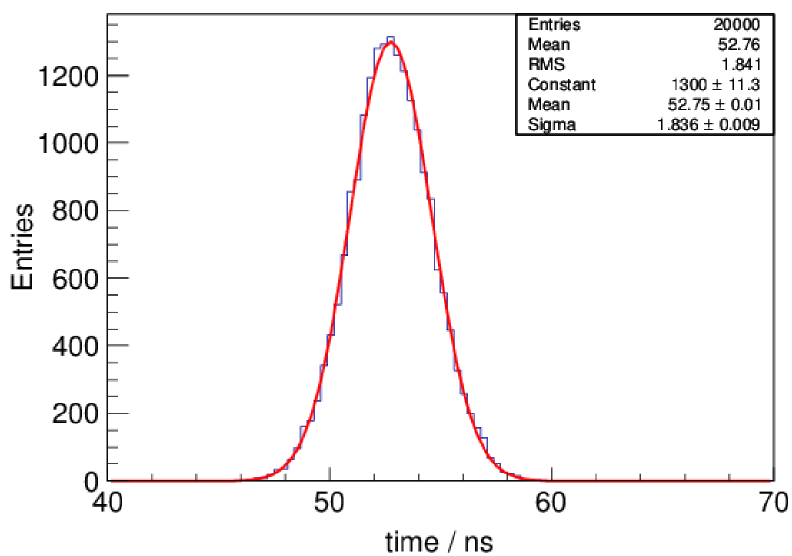


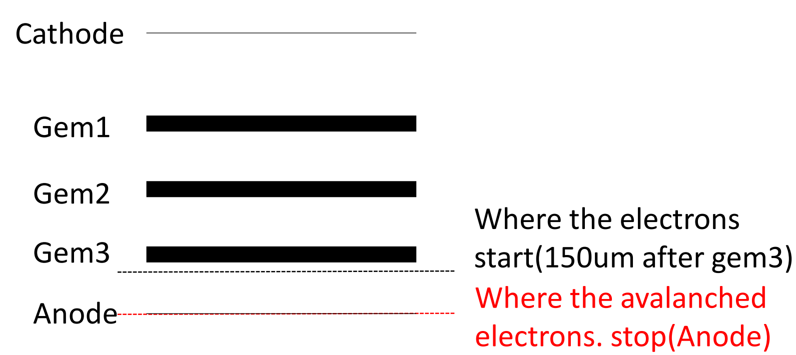
Electron shift(Induction)

Simulate 20k electrons 150um after gem3, then get the shift of avalanched electrons in X & Z direction in Anode.

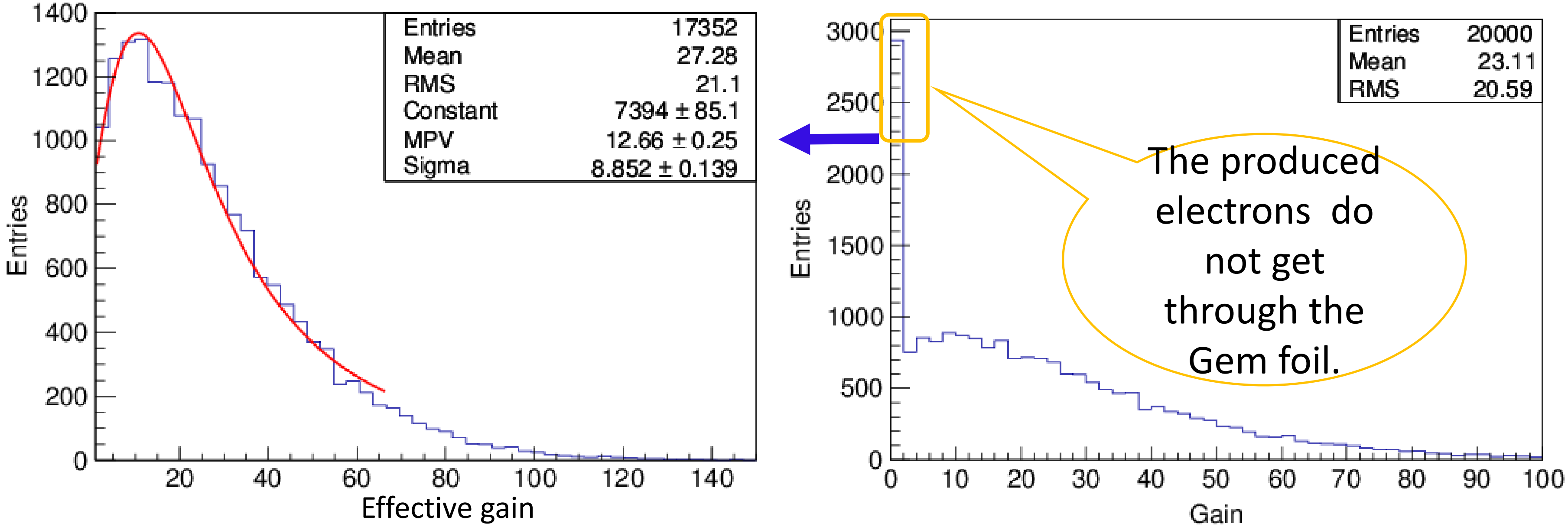






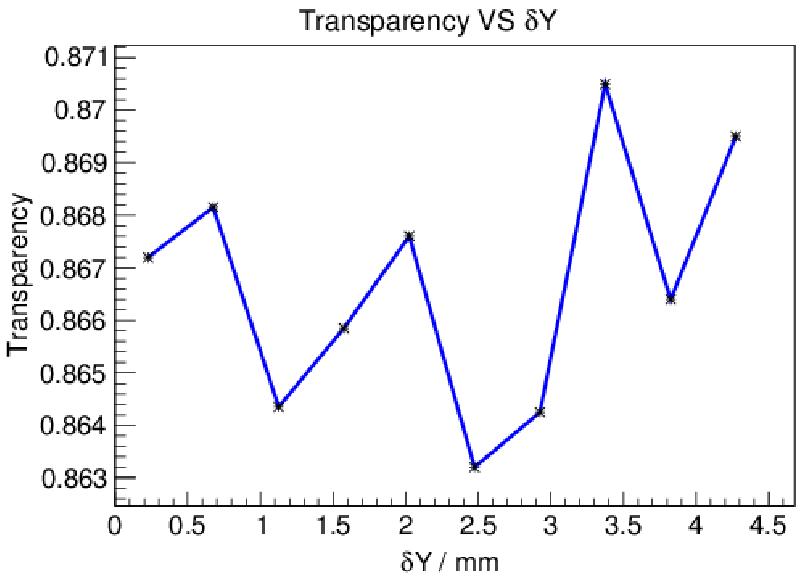


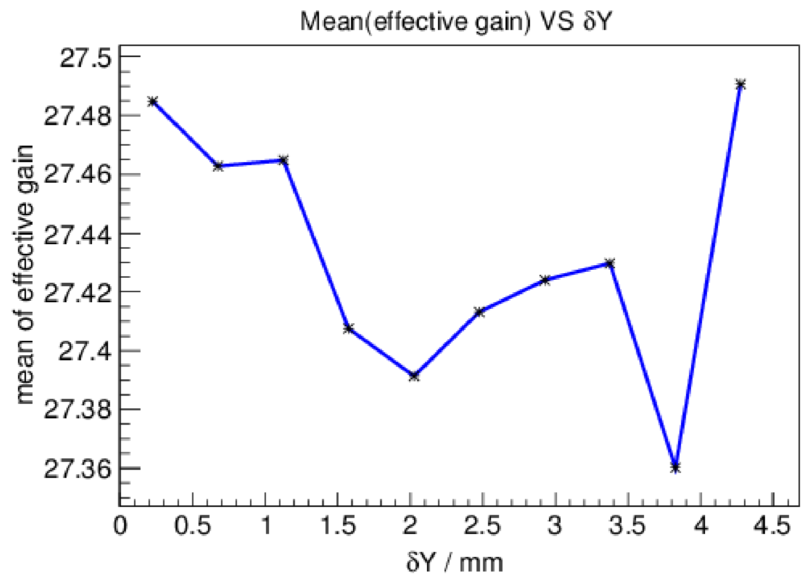
Avalanche & Gain ----Gem1



- Set an electron [2.75, 3.20]mm (uniform distribution) before the Gem1 foil and count multiplied electrons 150 µm after the Gem1 foil.
- Effective gain: Electrons get through the Gem1 foil, about 86.76%. It is sampled from a Landau.

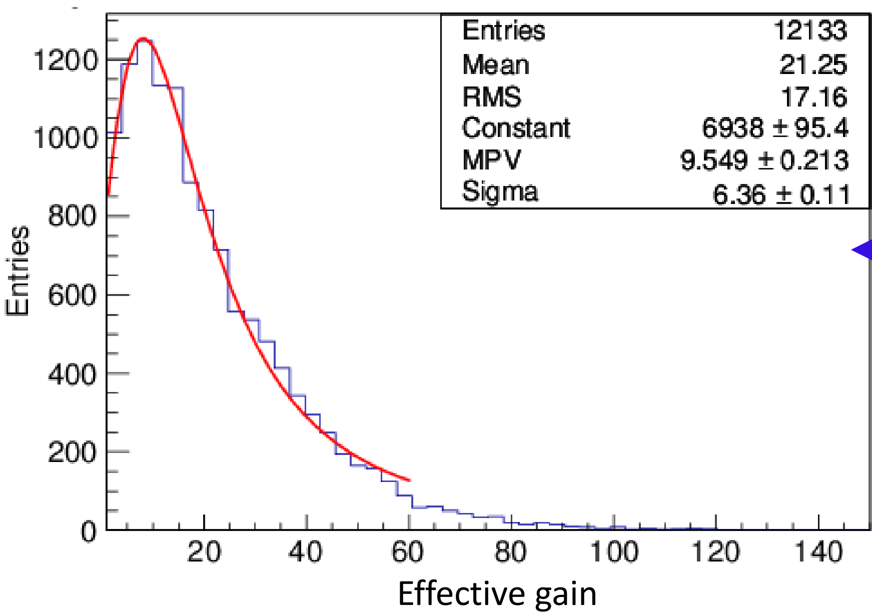
Avalanche & Gain ----Gem1

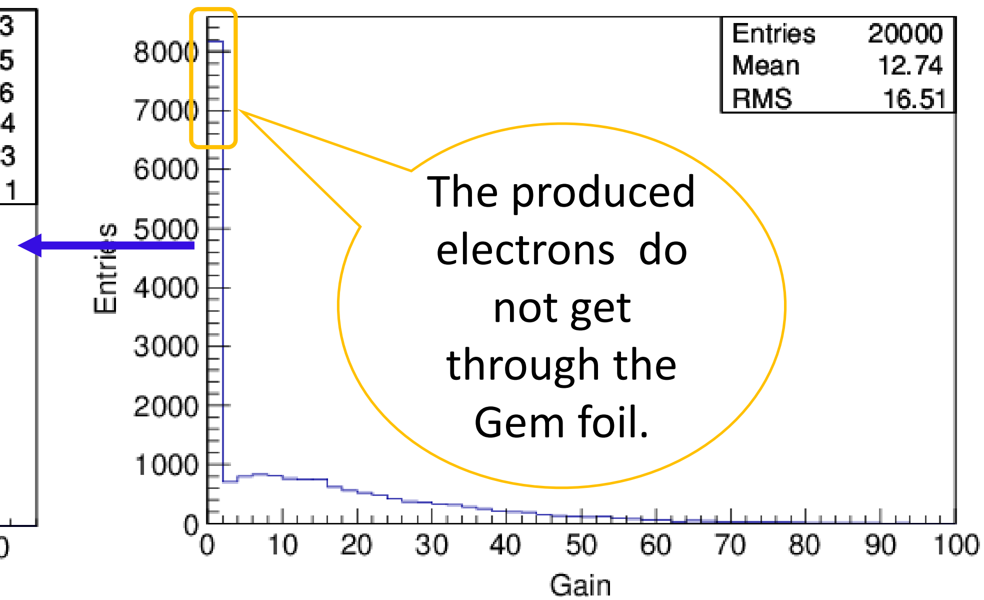




- In drift area, simulate **20**k electrons separately in **10** equidistant bins.
- Get the mean of effective gain and transparency vs ***δ***Y .

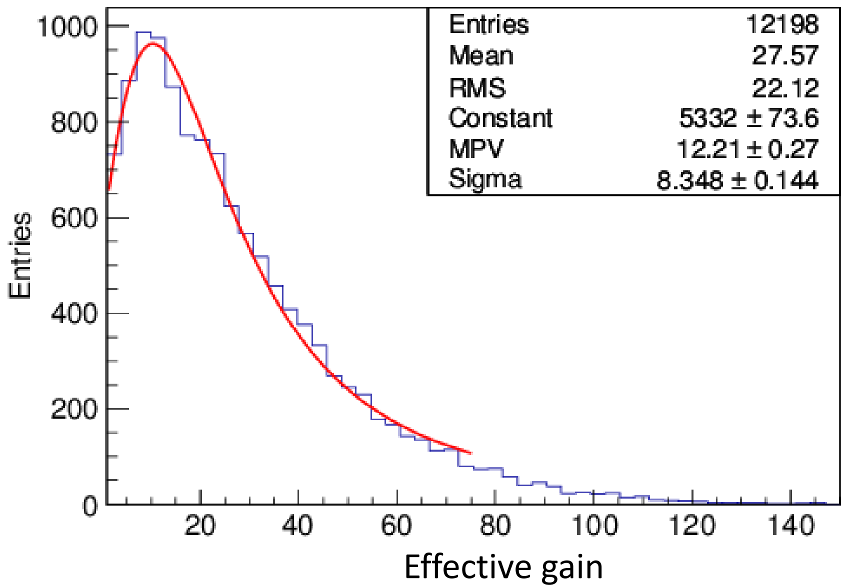
Avalanche & Gain ----Gem2

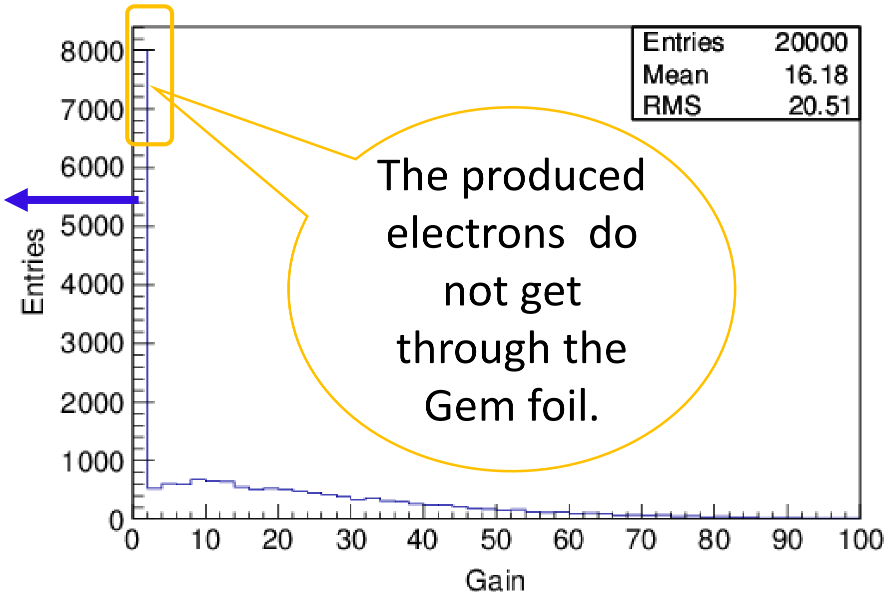




- Set an electron 150 μm after the Gem1 foil and count multiplied electrons 150 μm after the Gem2 foil.
- Effective gain: Electrons get through the Gem2 foil, about 60.67%. It is sampled from a Landau.

Avalanche & Gain ----Gem3





- Set an electron 150 μm after the Gem2 foil and count multiplied electrons 150 μm after the Gem3 foil.
- Effective gain: Electrons get through the Gem3 foil, about 60.99%. It is sampled from a Landau.