BESIII实验中CGEM探测器的Garfield模拟及数字化模型研究

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第七届全国先进气体探测器研讨会，广西大学，2017.11.11-12

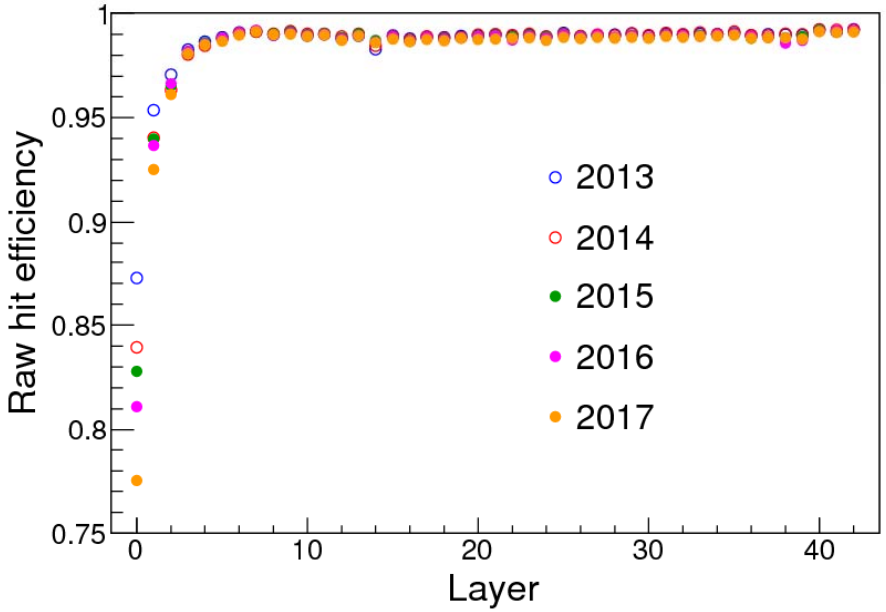
Outline

- Introduction
- Garfield simulation
- Digitization model and software

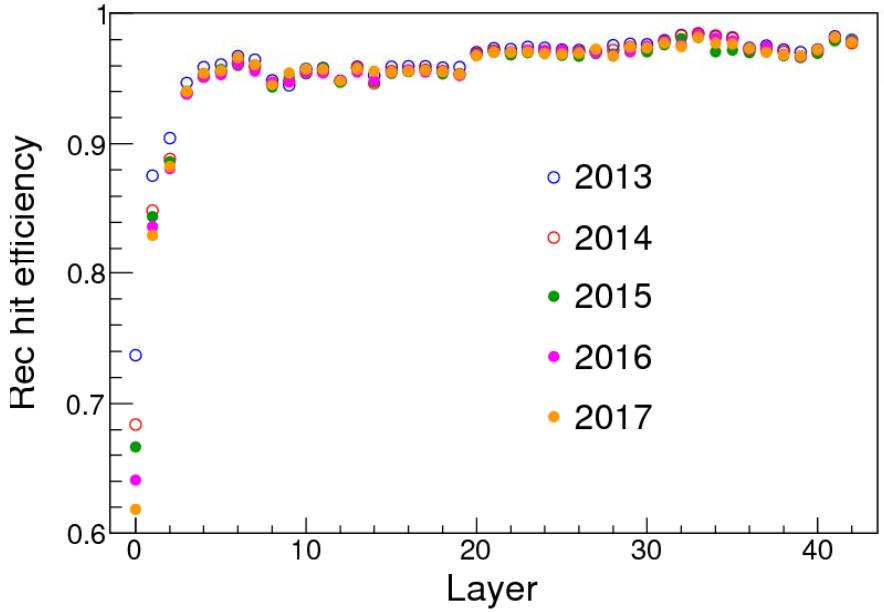
Aging of MDC inner chamber

- Hit efficiency of the BESIII MDC inner layers drops year by year due to aging
- Cylindrical GEM inner tracker (CGEM-IT) is a candidate for upgrade of MDC inner chamber

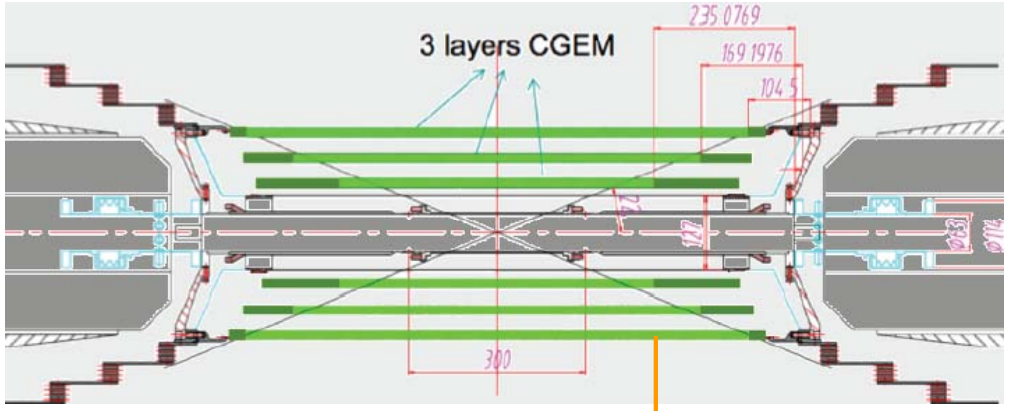
Raw hit efficiency vs layer



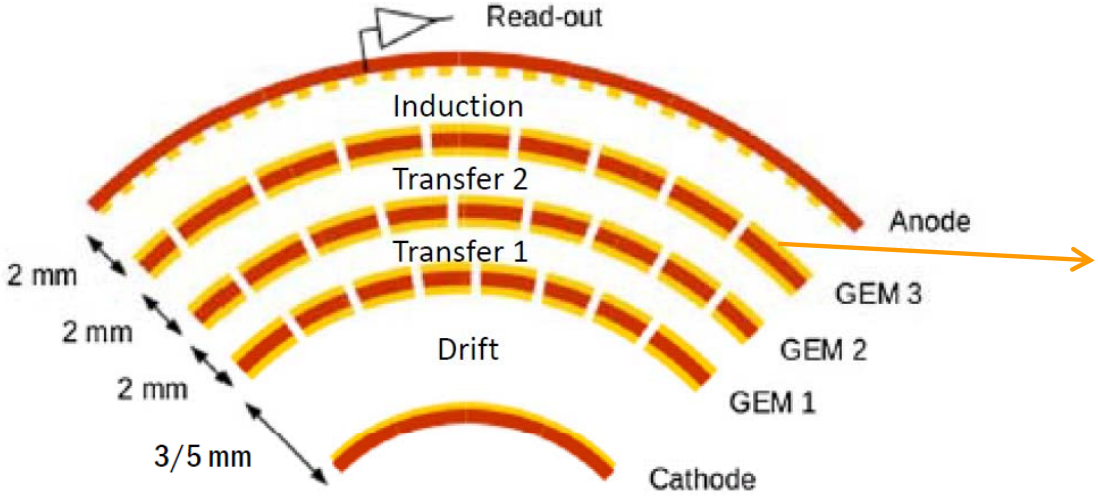
Rec hit efficiency vs layer

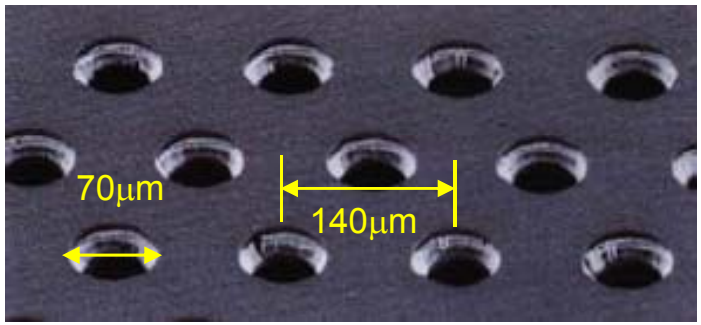


CGEM inner tracker



- 3 layer Cylindrical GEM
- Each layer composed by 3 gem foils
- Spatial resolution
  - $\sigma_{r\phi}$ ~ 130μm
  - σ_z < 1mm
- Coverage: 93%

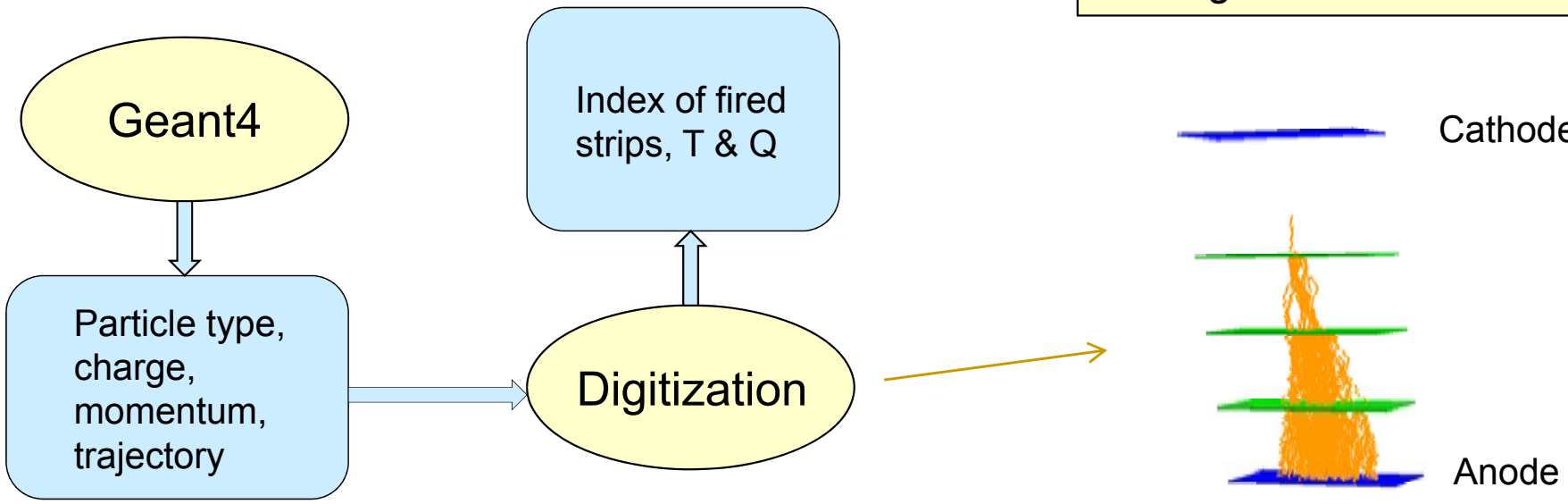




CGEM full simulation and digitization

- Geant4 gives particle information
- Digitization -- simulation of the detector response
- Modeling CGEM digitization:
  - Preliminary parameters from Garfield simulation
  - Coding in BESIII software framework
  - Tuning with experiment data

How to digitize the Lorentz angle, avalanche, diffusion and signal induction?



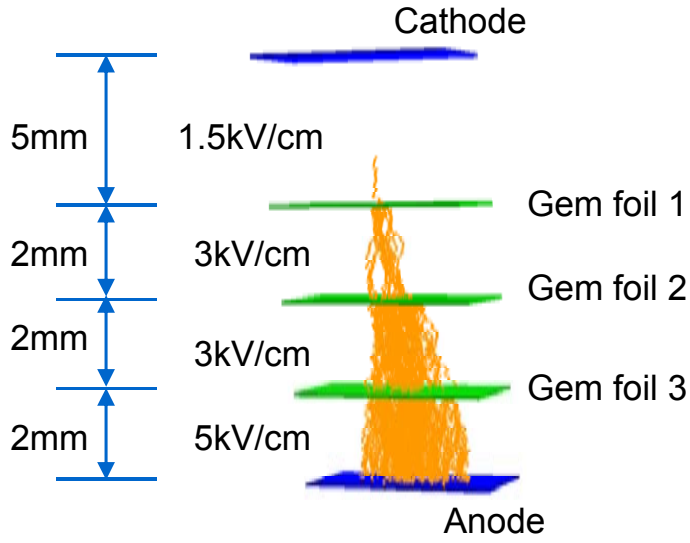
GARFIELD SIMULATION

Method

- Planar approximation to simplify the geometry
- Use Ansys to implement:
  - Construction of the material and geometry
  - Calculation of electric field
- Simulate ionization, drift and avalanche with Garfield++
  - Ignore the contribution of ionized electrons outside the drift region

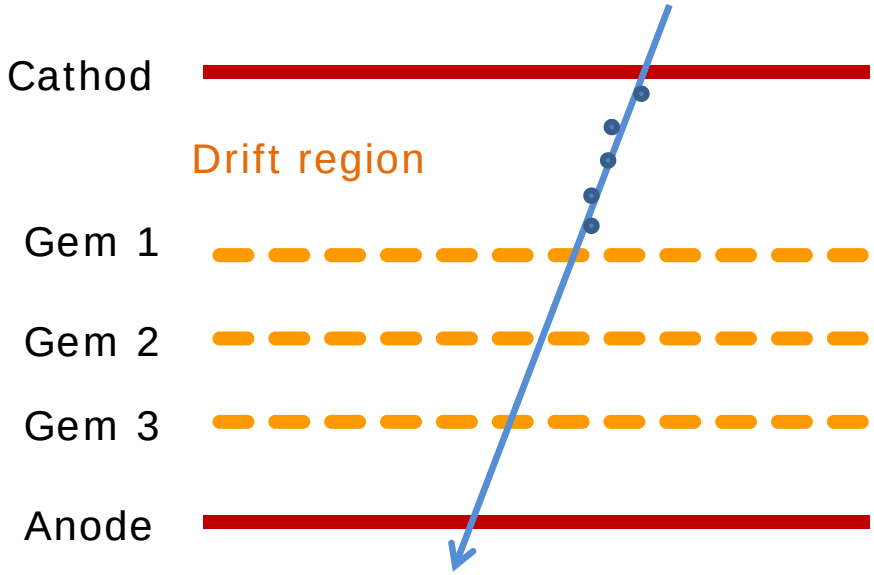
Configuration

- Gas Mixture: Ar:iC_4H_{10} (90:10)
- Avalanche Model: AvalancheMicroscopic
- Magnetic Field: 1Tesla
- High voltages on foils: 270V
- Electric field: 1.5 / 3 / 3 / 5 kV/cm
  (Drift/Transfer1/Transfer2/Induction)

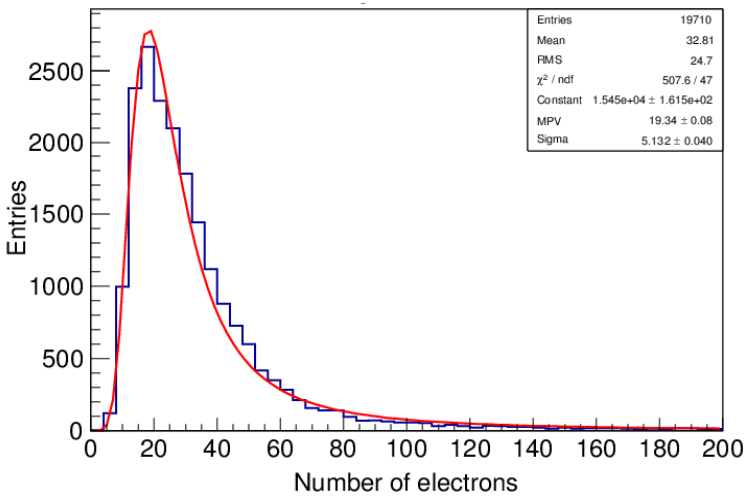


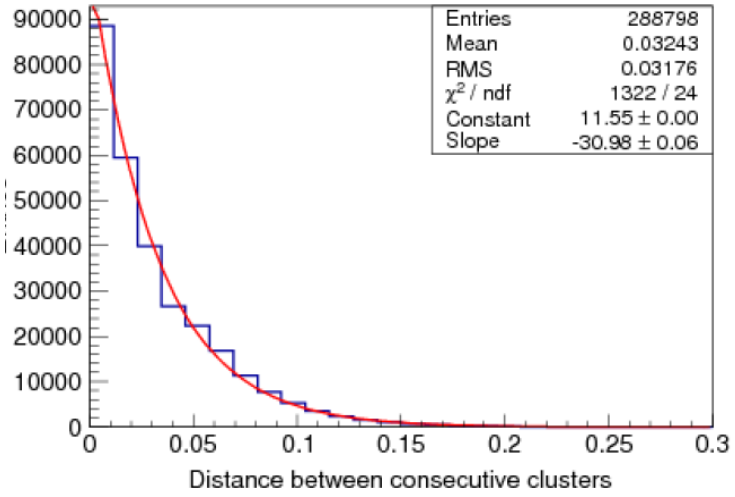
Ionization

- Geant4 gives the track information
- Garfield provides number and position of ionized electrons
- Consider the ionization only in drift region



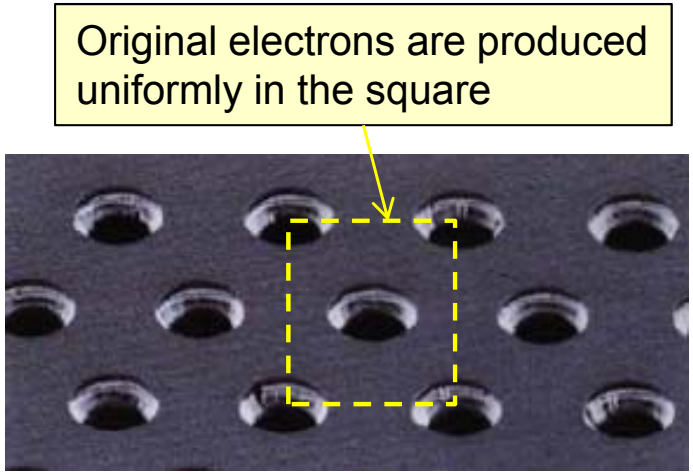
Results of 1GeV/c muon

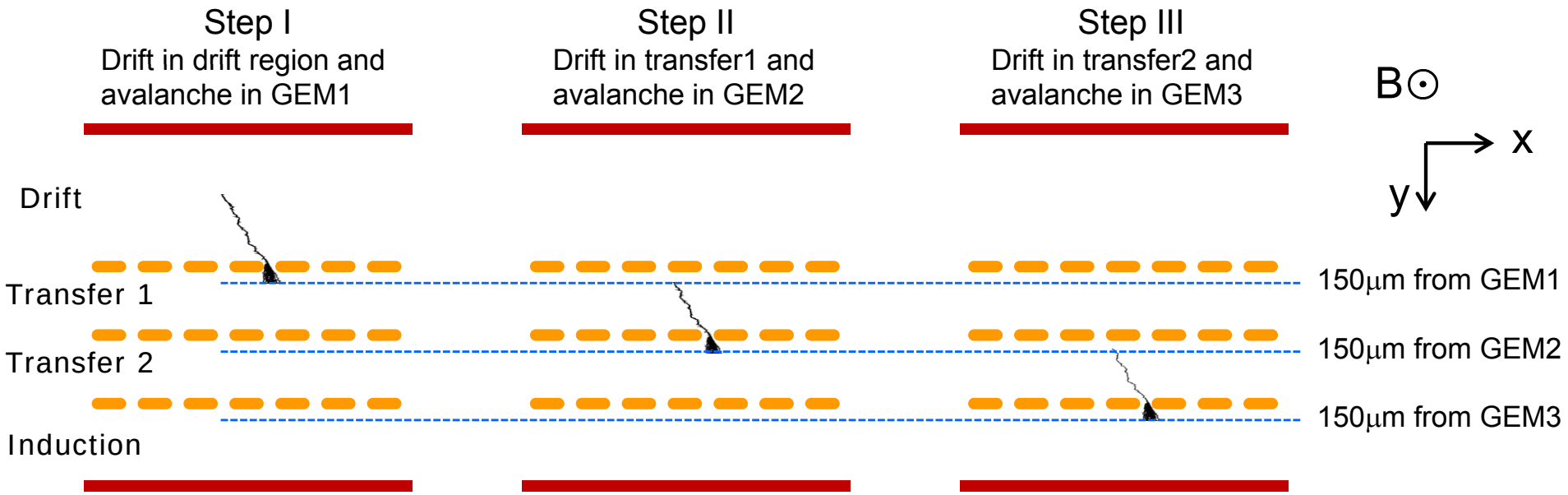




Drift and avalanche

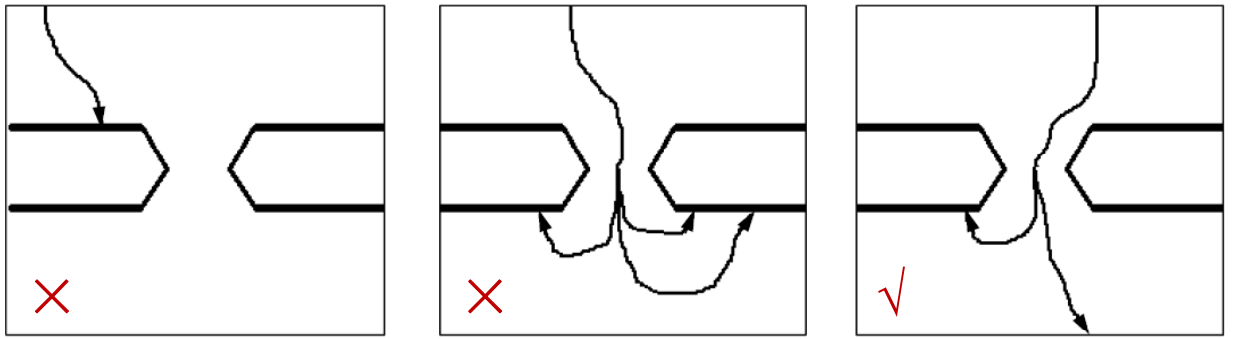
- Simulating the electron from ionization to induction is time consuming
- Solution is to divide the simulation into 3 steps



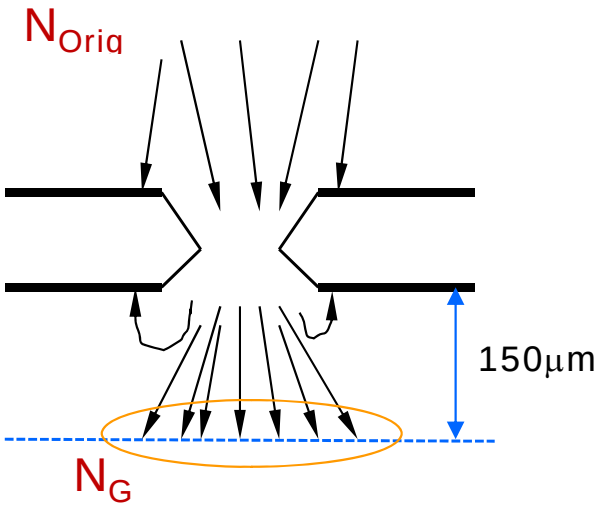


Transparency (τ) and Effective Gain (G_{eff})

$$\tau = N_T / N_{Orig}$$



$$N_G = N_{Orig} \cdot \tau \cdot G_{Eff}$$

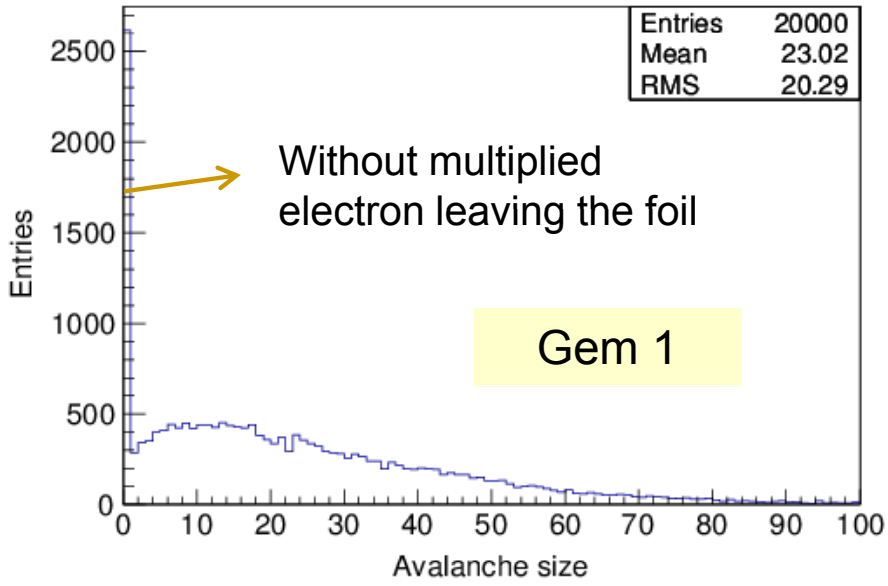


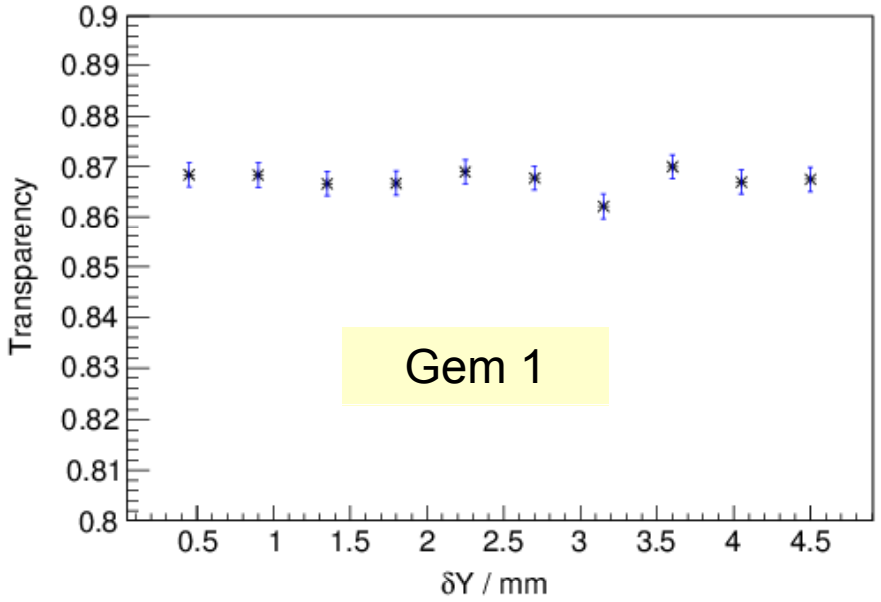
N_{Orig} : number of original electrons

N_T : number of original electrons with multiplied electron leaving the gem foil

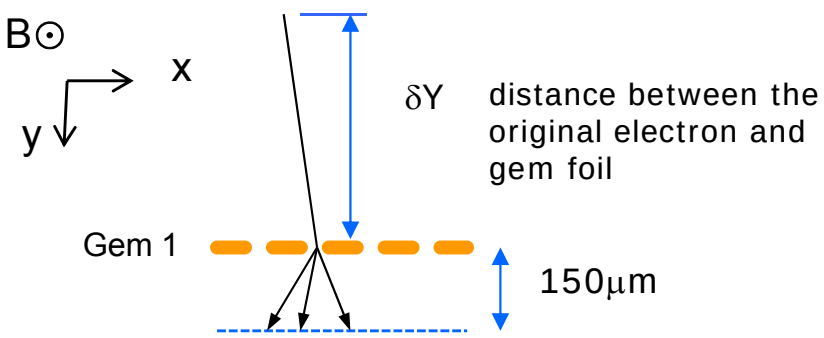
N_G : number of multiplied electrons which can leave the gem foil

Transparency (τ)

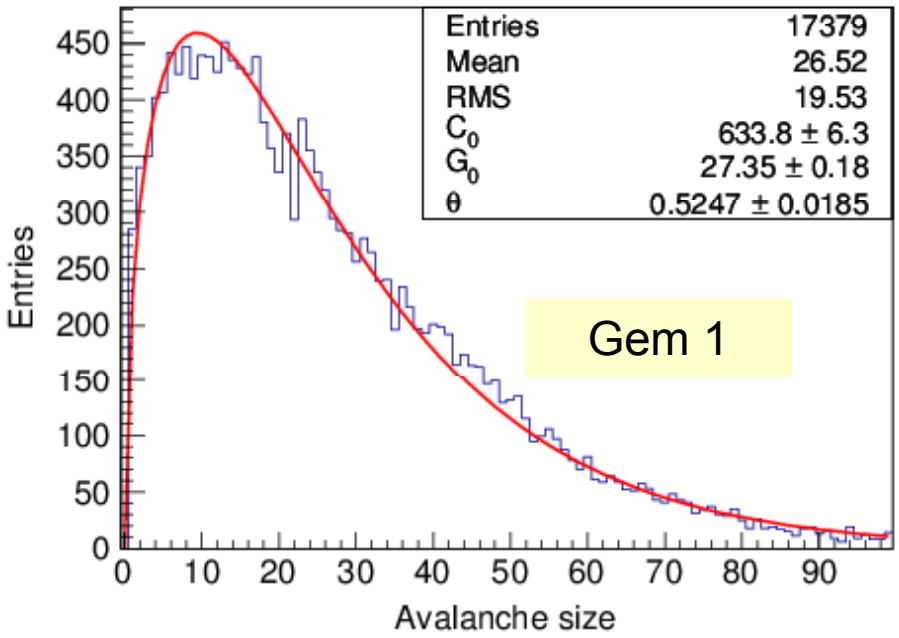


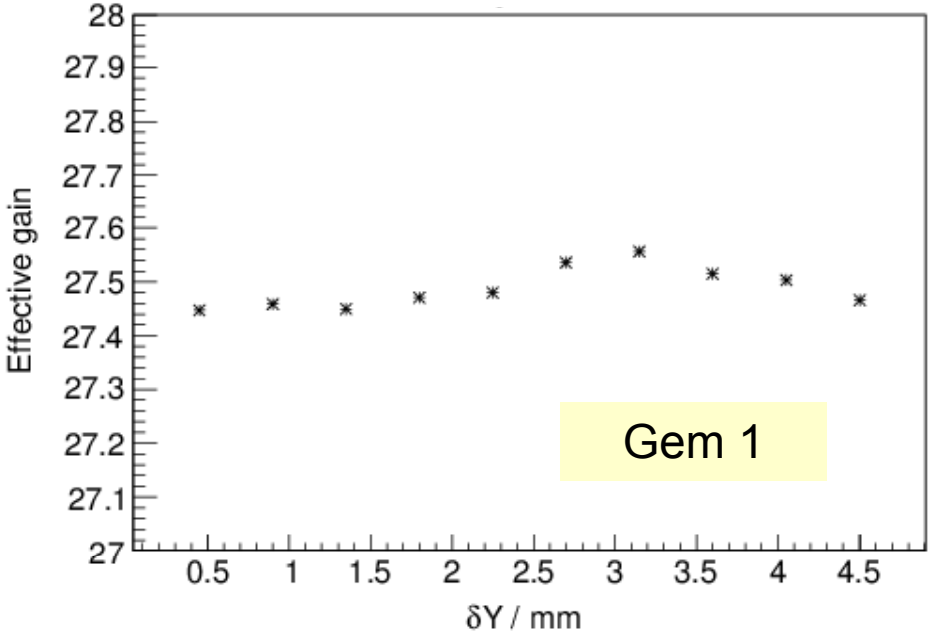


Gem	τ (%)
1	86.7
2	61.0
3	61.3



Effective gain (G_{Eff})



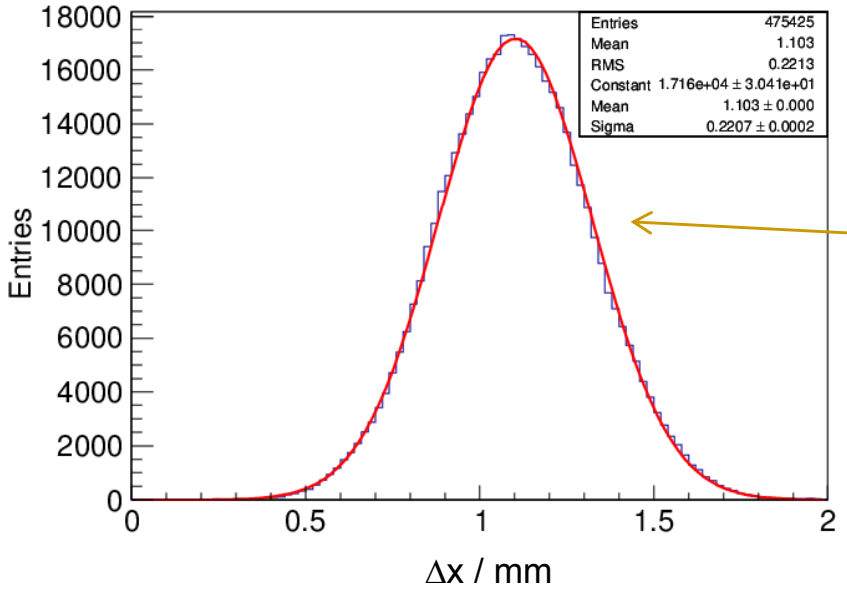


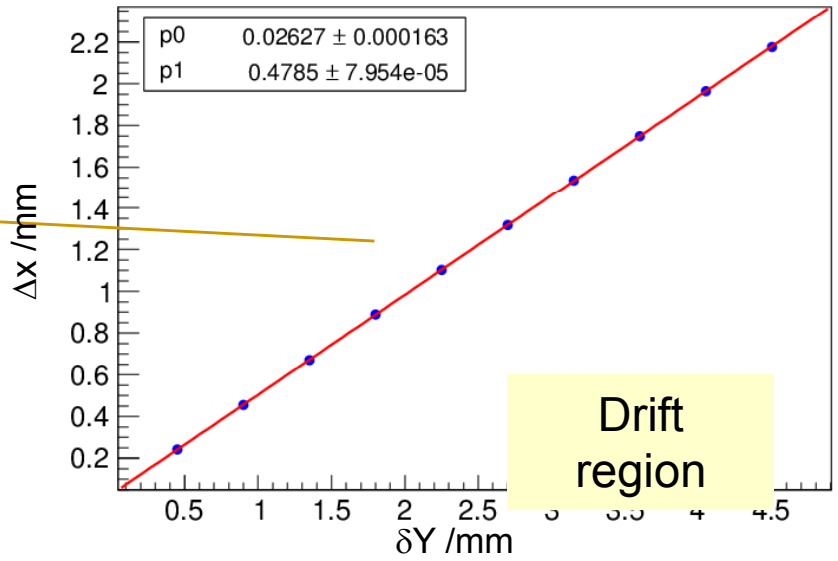
Polya Distribution

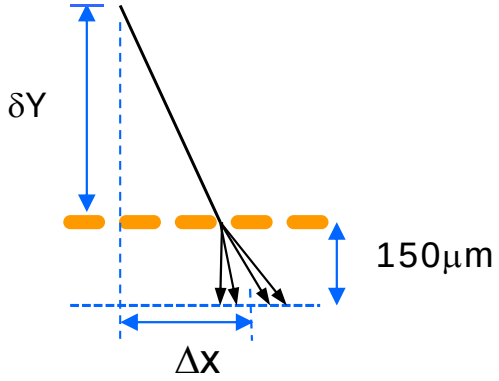
$$P(G) = C_0 \frac{(1+\theta)^{1+\theta}}{\Gamma(1+\theta)} \left(\frac{G}{G_0}\right)^{\theta} exp\left[-(1+\theta)\frac{G}{G_0}\right]$$

Gem	1	2	3
G_{Eff}	27.5	21.0	27.5

Lorentz angle (α)

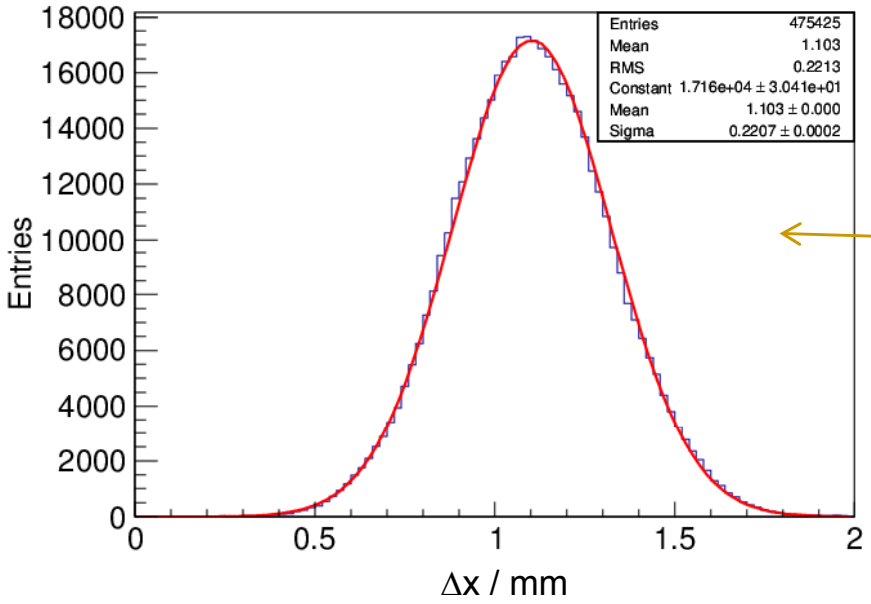


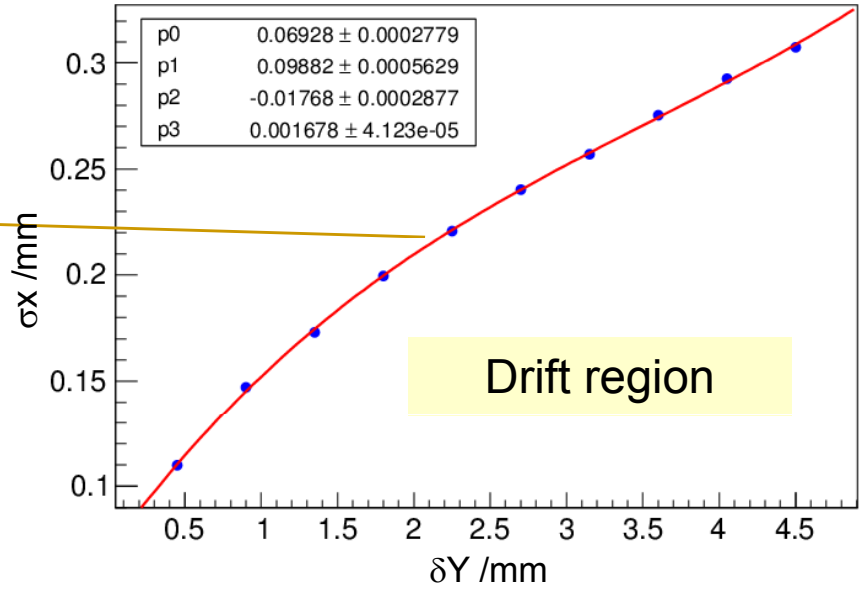


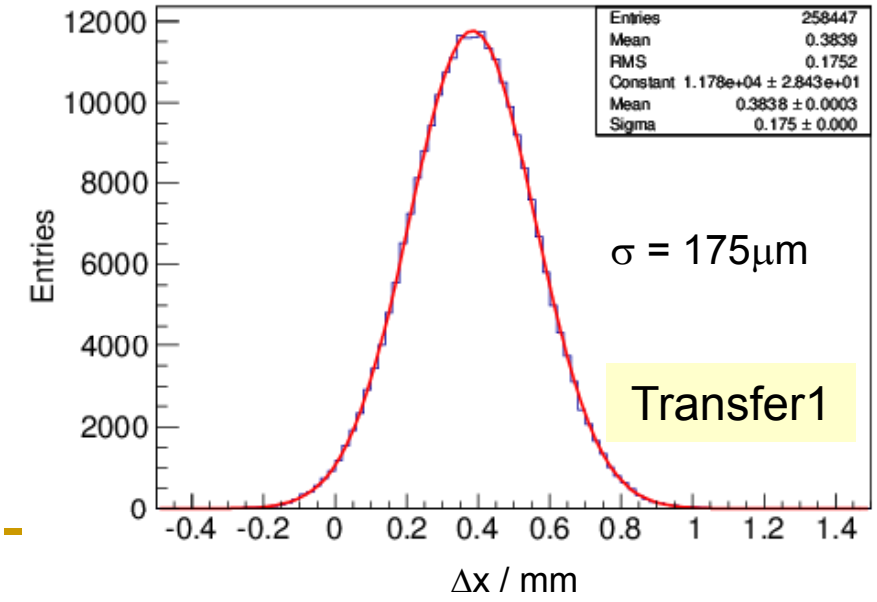


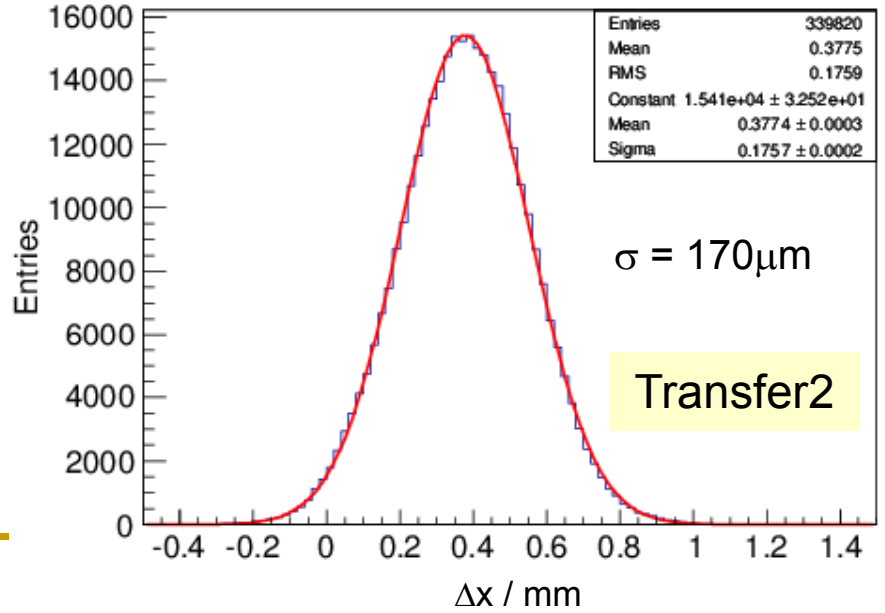
Region	α
Drift	25.2
Transfer1	10.5
Transfer2	10.5

Diffusion in x (perpendicular to B)

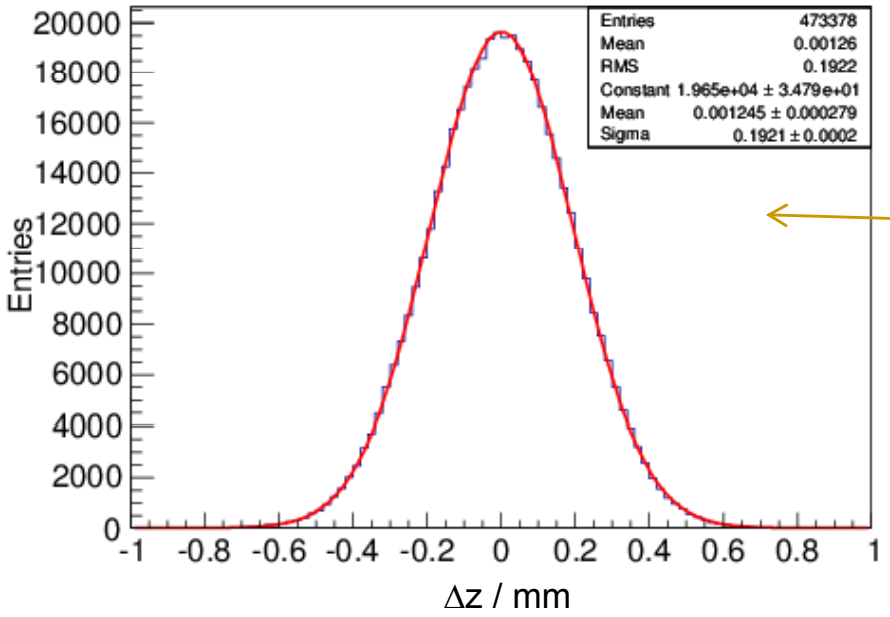


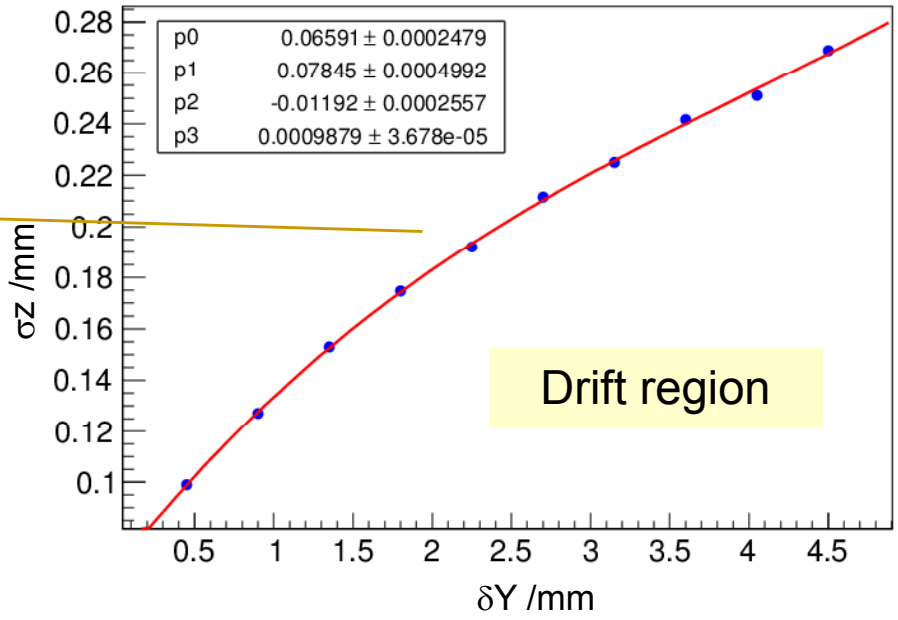


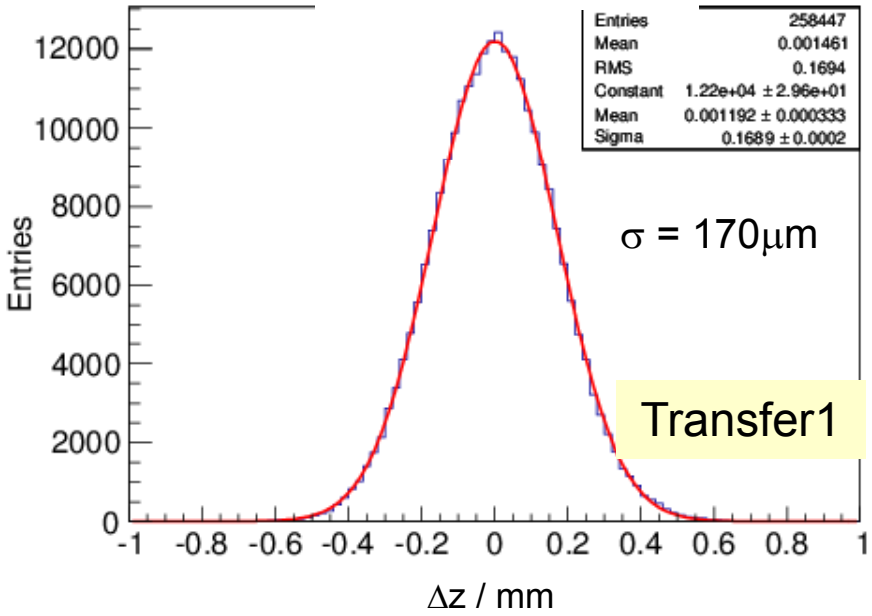


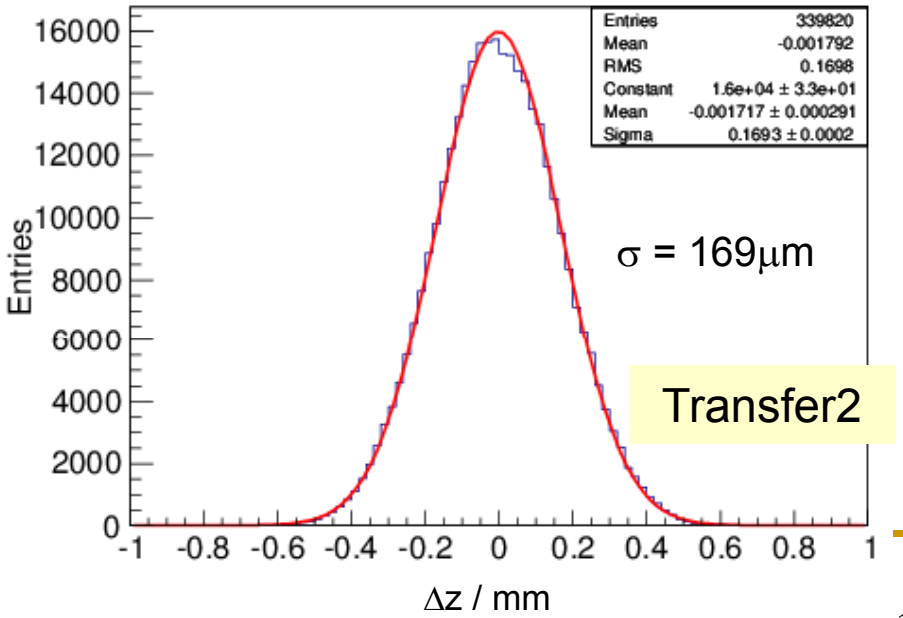


Diffusion in z (parallel to B)

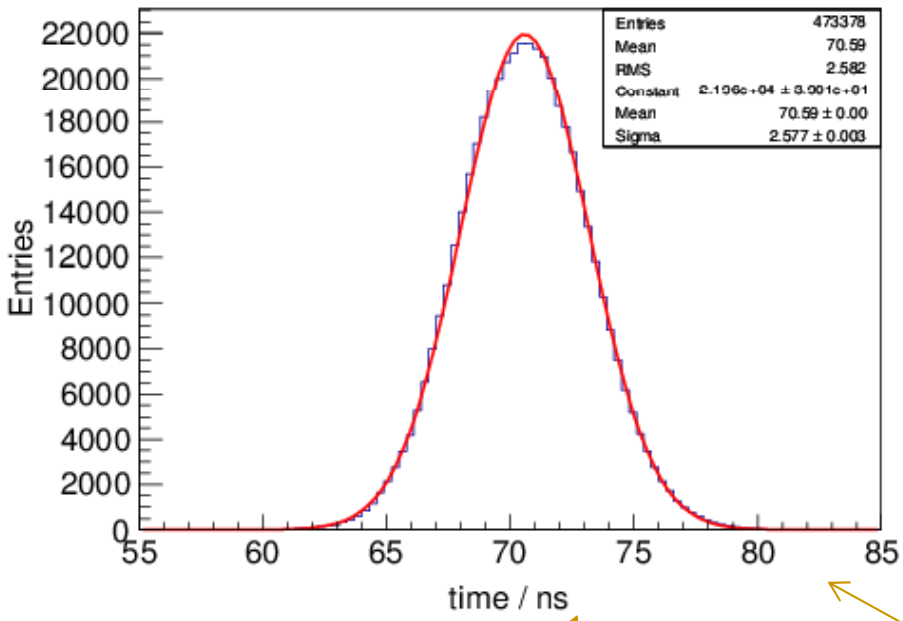


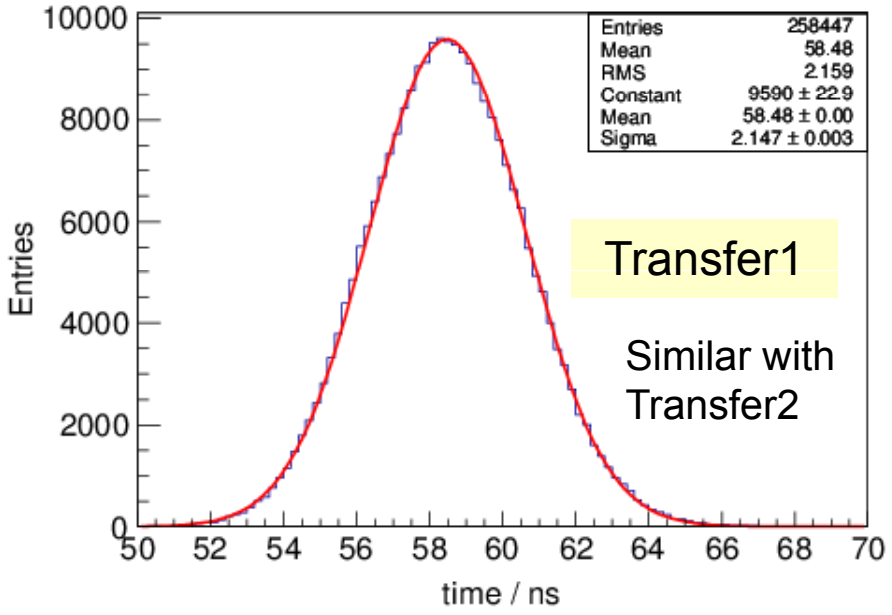






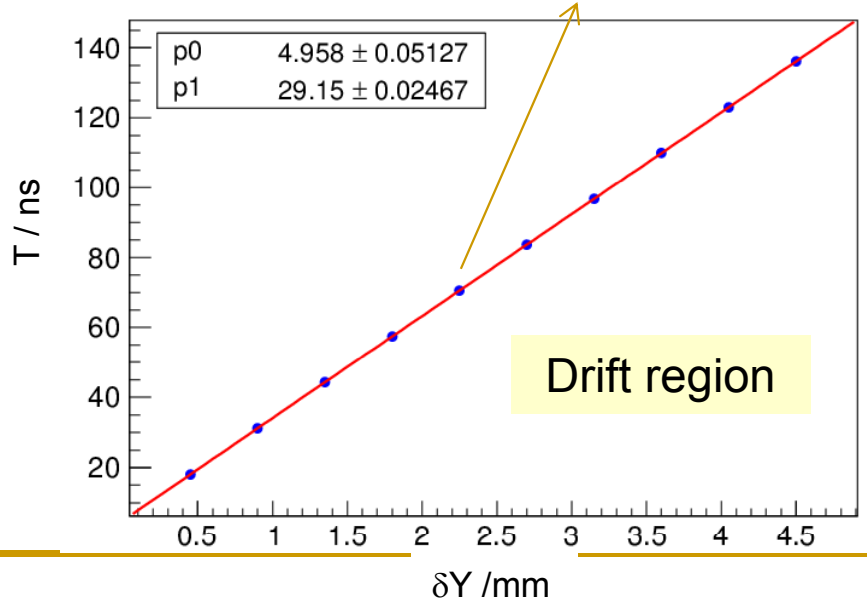
Drift time distribution



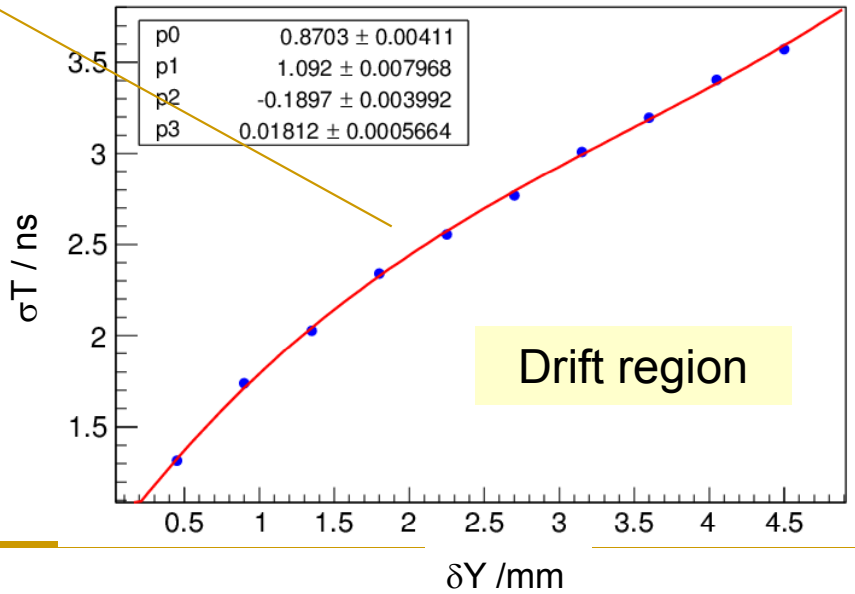


Transfer1

Similar with Transfer2



Drift region

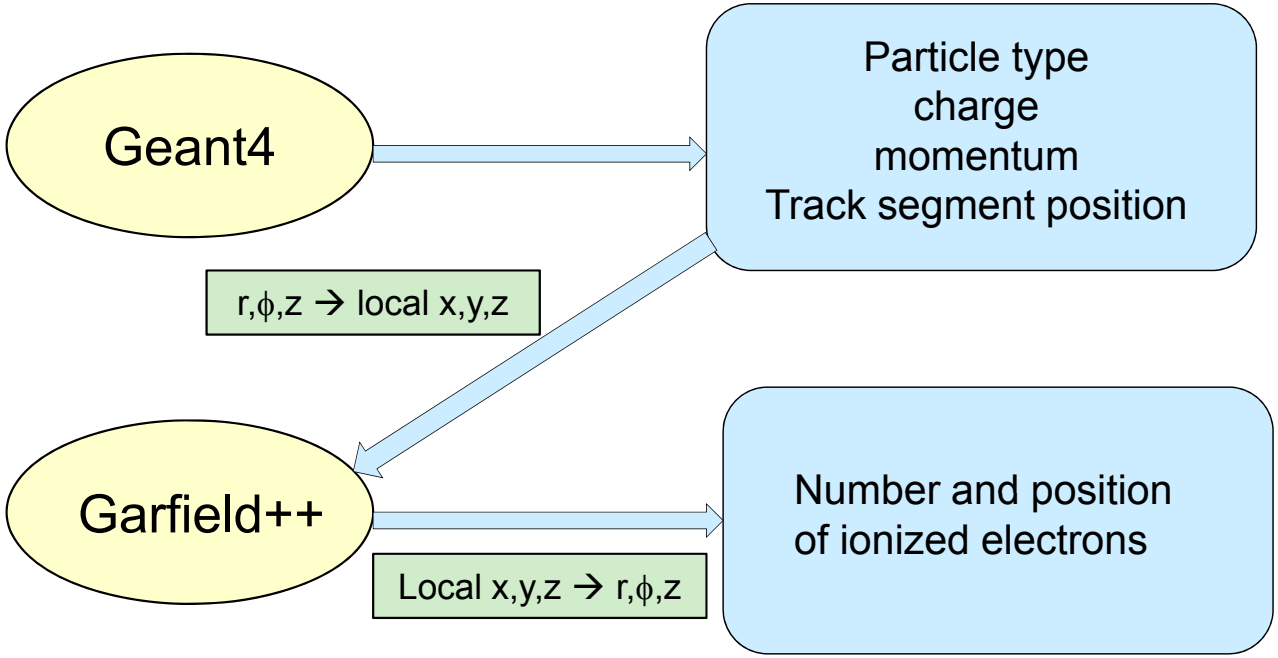


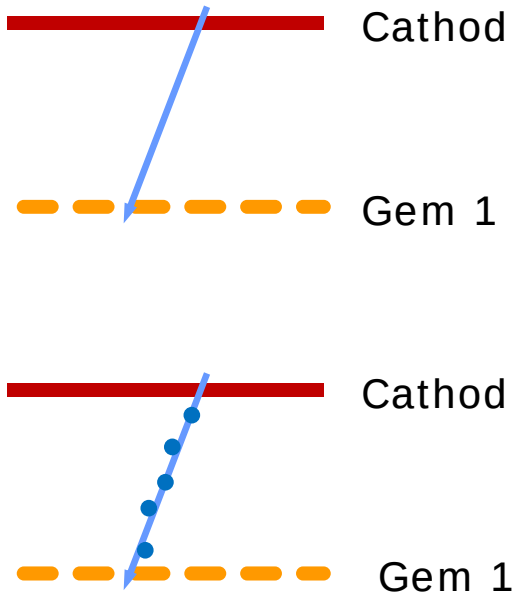
Drift region

DIGITIZATION MODEL AND SOFTWARE

Ionization

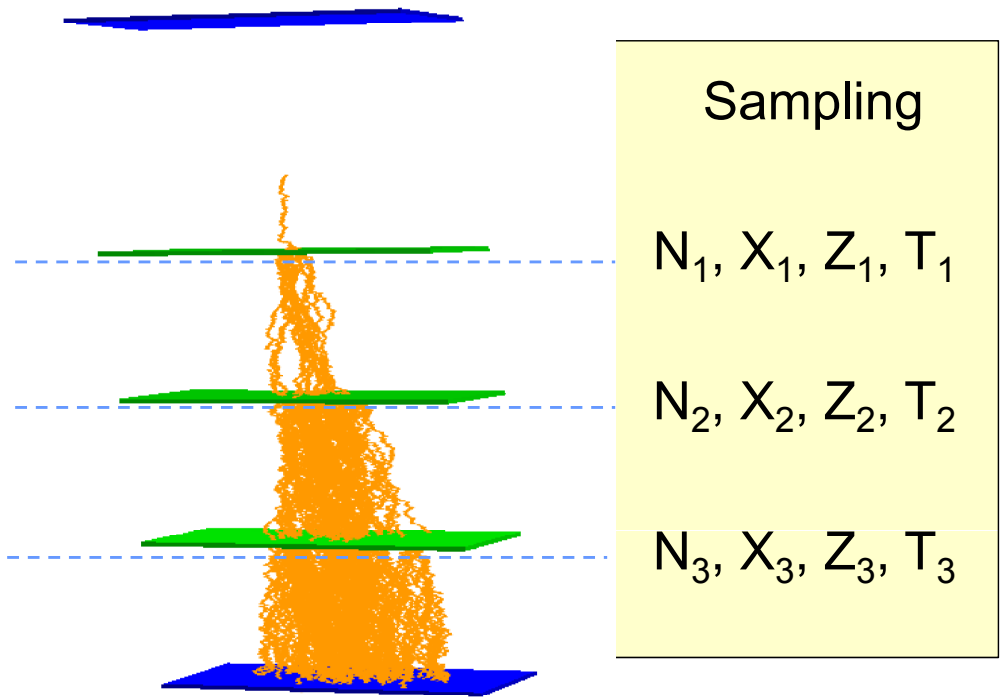
- Garfield++ has been integrated into BESIII software system as an external package to simulate ionization
- Conversion of global and local coordinate is used to simplify the geometry construction in Garfield
- Ignore the energy loss from Geant4





Drift and avalanche

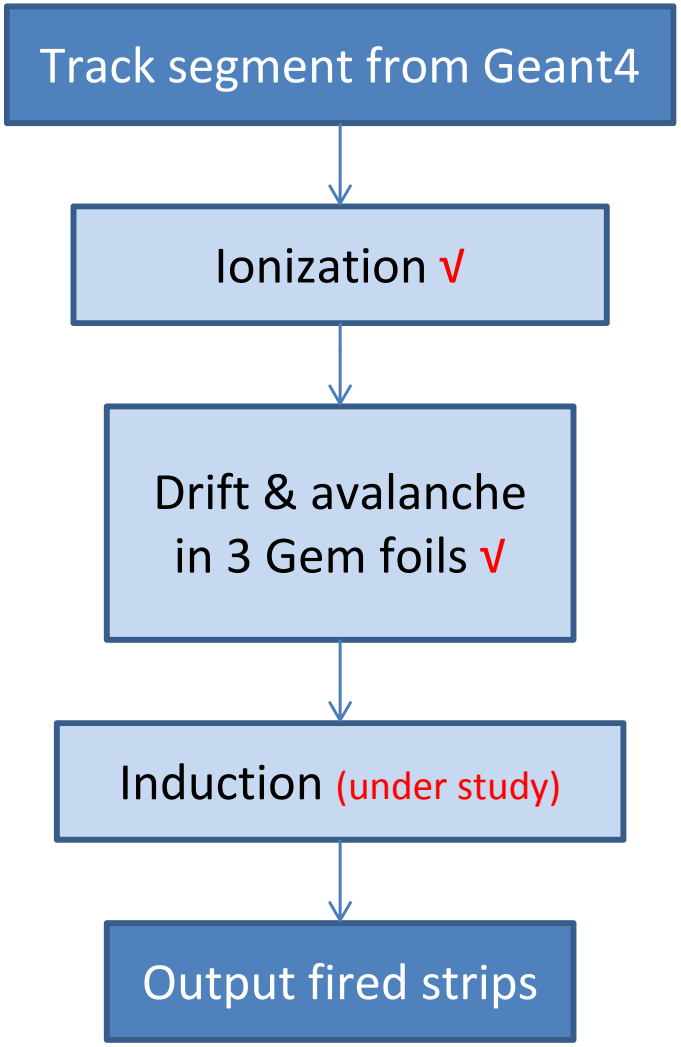
- Sample the parameters of multiplied electrons in 3 steps
  - Number of multiplied electrons (N)
  - Position (X, Z)
  - Drift time (T)



Induction

- Meet difficulties in the preliminary study with Garfield
- Described by drift in the first version
- Suggestions are welcome

Flow chart


Track segment from Geant4
Ionization √
Drift & avalanche in 3 Gem foils √
Induction (under study)
Output fired strips

Next to do

- Study of signal induction
- Simplify the sampling of drift and avalanche
- Tuning with experimental data

Status of event processing software

- Simulation
  - Construction of geometry and material √
  - Digitization: 1st version will be released
- Reconstruction
  - Cluster reconstruction √
  - Track segment finding √
  - Tracking combing MDC outer chamber: under study
  - Kalmam filter √
- Calibration and alignment
  - Is about to start

Summary

- Study the behavior of ionized electron in CGEM detector using Garfield++
- Modeling the CGEM digitization in BESIII software system
- Optimize the digitization model with experimental data in the next step

Thanks!