# Software Update
# GEM Digitization

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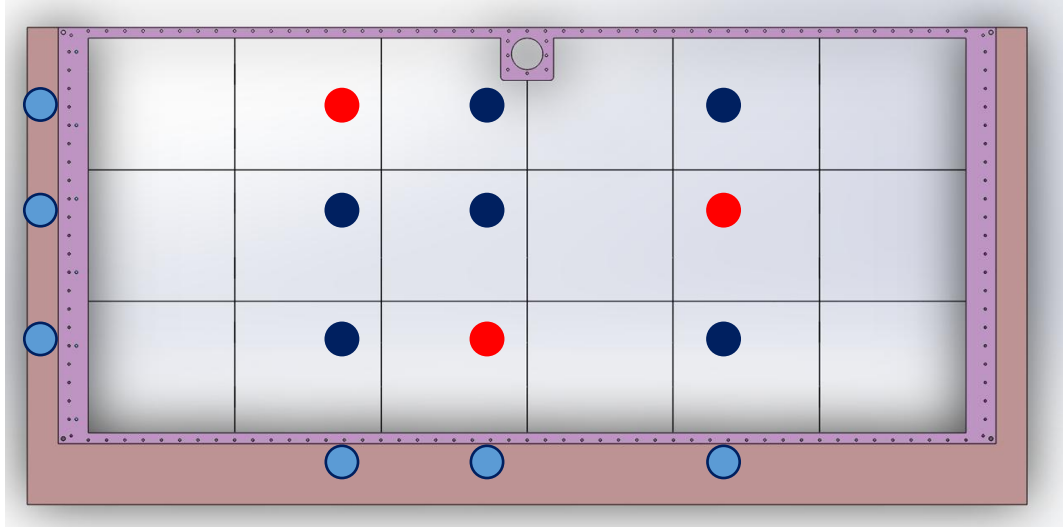
PRad-II / X17 Collaboration Meeting

2025/Sep/12

# Introduction

**Pure Geant4 simulation:**

- Hits on the detector sensitive volume
- Particle's "accurate" vertex information(vector, energy, time, deposition)
- But not include effects of detector and electronics



**Red:** 3 real hits
**Blue:** clusters on 2 layers of strips
**Black:** false hits

**Geant4 + GEM digitization, we could know:**

- The signal pulse we will get from APV25
- Signal pile up effect, cluster size on GEM
- How many hits would be reconstructed in an event

# Digitization Basic Structure

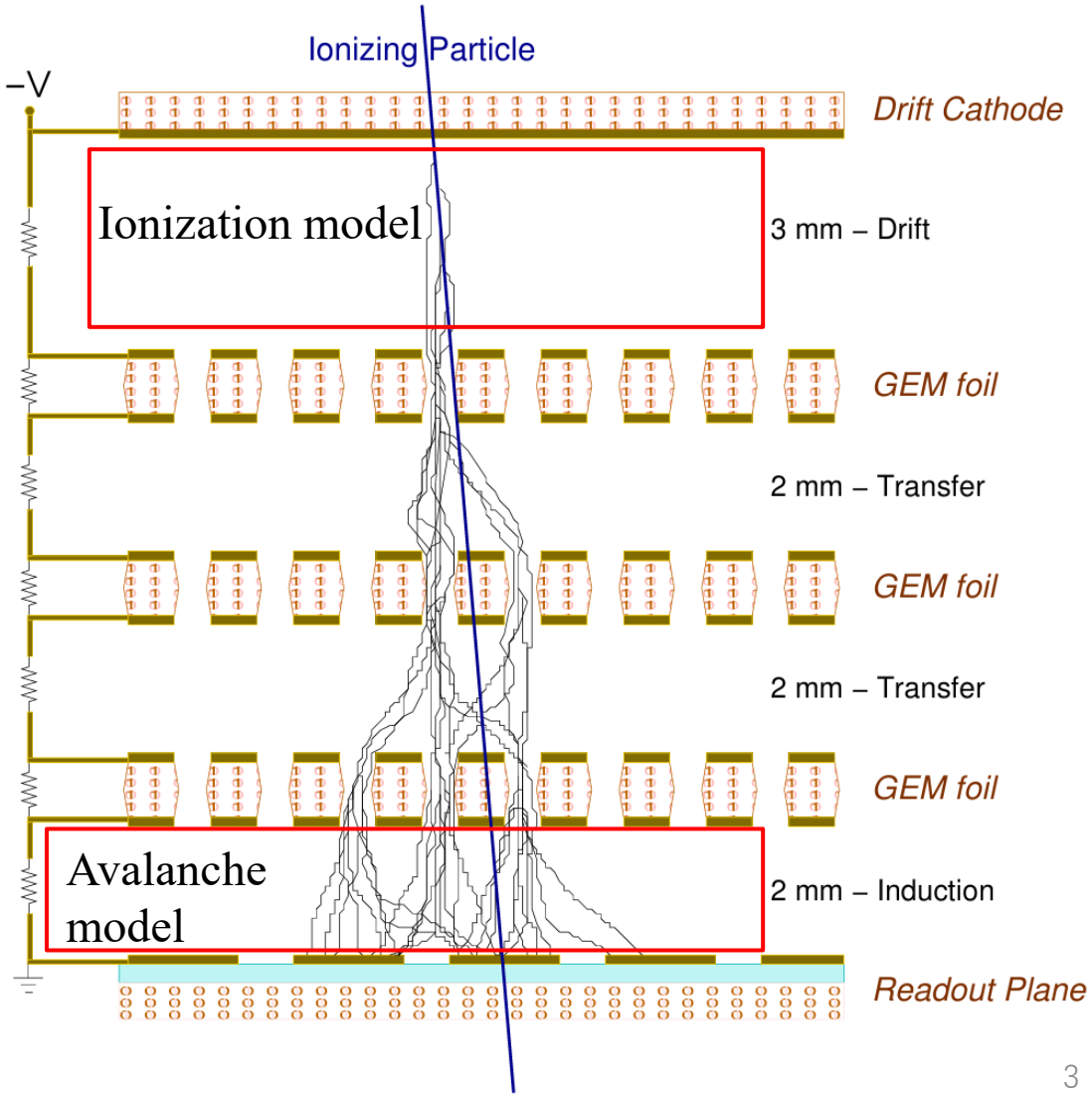
Basically 2 main processes, ionization and avalanche

**Ionization model:**

1. Number of ion pairs = Edep / 26eV (Poisson dist.)
2. Randomly put these ion electrons along the track
3. Traveling time to readout plane ($Drift\ v = 55\ mm/\mu s$)

**Avalanche model (for each ion electron):**

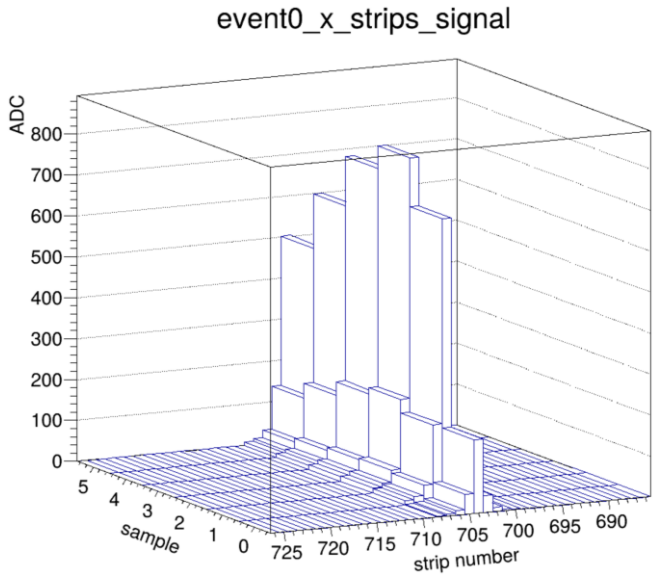
1. Charge number of multiplication (Gaussian, $\sigma = gain/\sqrt{20}$)
2. Spatial distribution described by Cauchy-Lorenz , ($diffusion = 0.1\ mm^2/\mu s$)
3. Numerical integration for charge on each strip
4. Generate pulse from charge for each strip ($decay\ time = 56\ ns$)



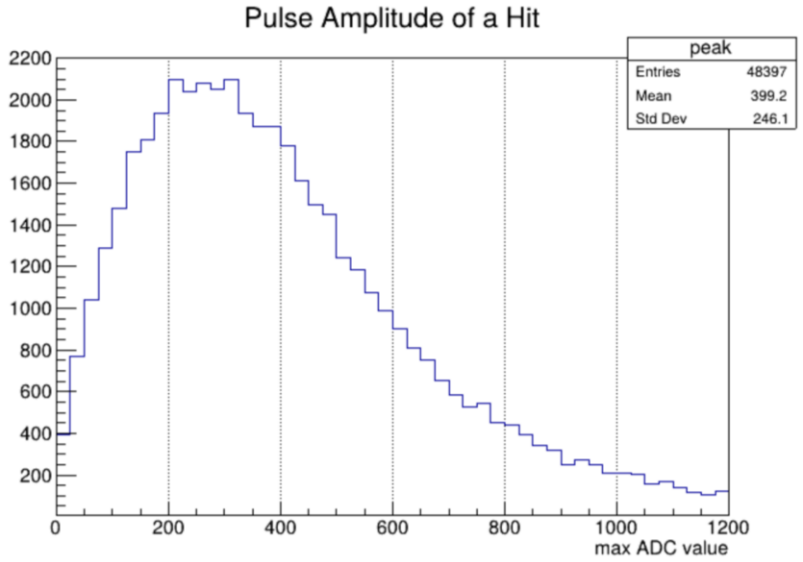
# Digitization Output of Signal Hit

- Digitization output pulse of a signal hit
- 25ns / sampling, total of 6 samples
- Assuming a trigger latency to let the pulse's peak occurs at 3rd sample (index 2)

- **Single hit events** for the gain measurement
- Adjust the mean gain coefficient of multiplication
- Calibrated with the GEM cosmic test data




Simulated APV25 pulse of single hit on GEM




Max ADC value in single hit events

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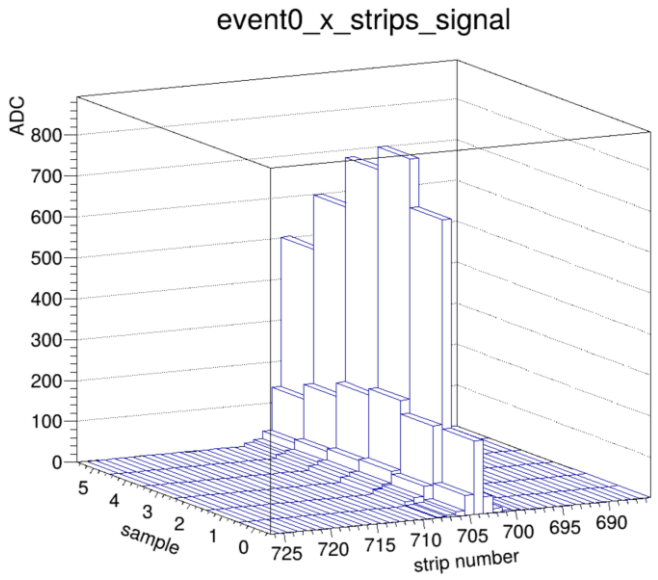
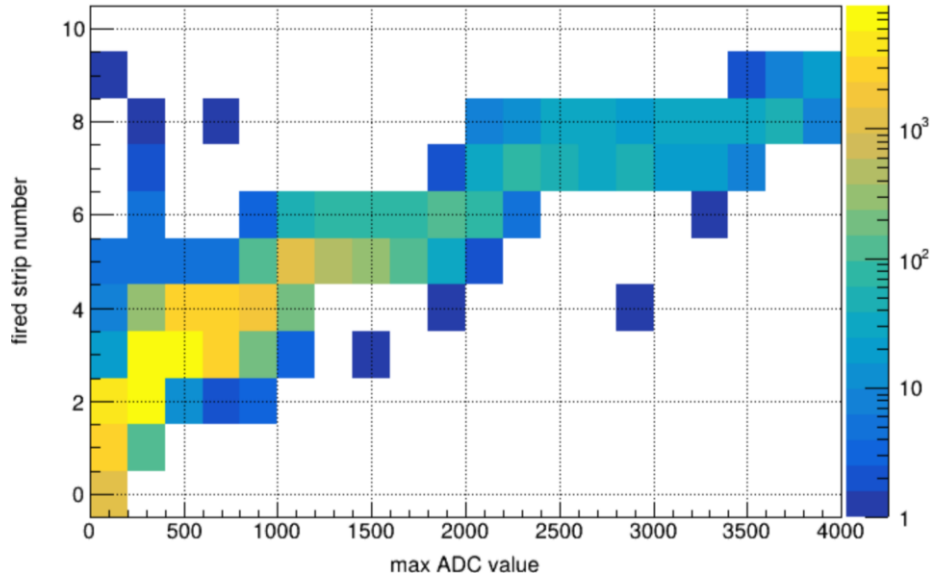



Simulated APV25 pulse of single hit on GEM

- **Single hit events** for the gain measurement
- Adjust the mean gain coefficient of multiplication
- Calibrated with the GEM cosmic test data
- Number of fired strips VS max ADC value




Number of fired strips in single hit events

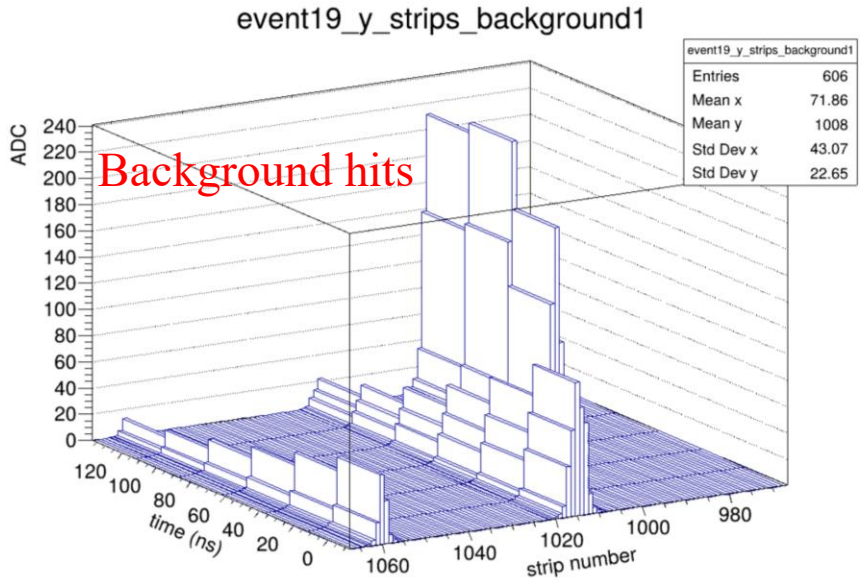
# **Add the Background** (X17,1um target, 50nA, He bag)

**Input simulation files**

- Signal file: energy of 30%-70% 2.2GeV e- in Geant4, single track
- Background file: 2.2GeV beam-on-target G4 simulation

**Process**

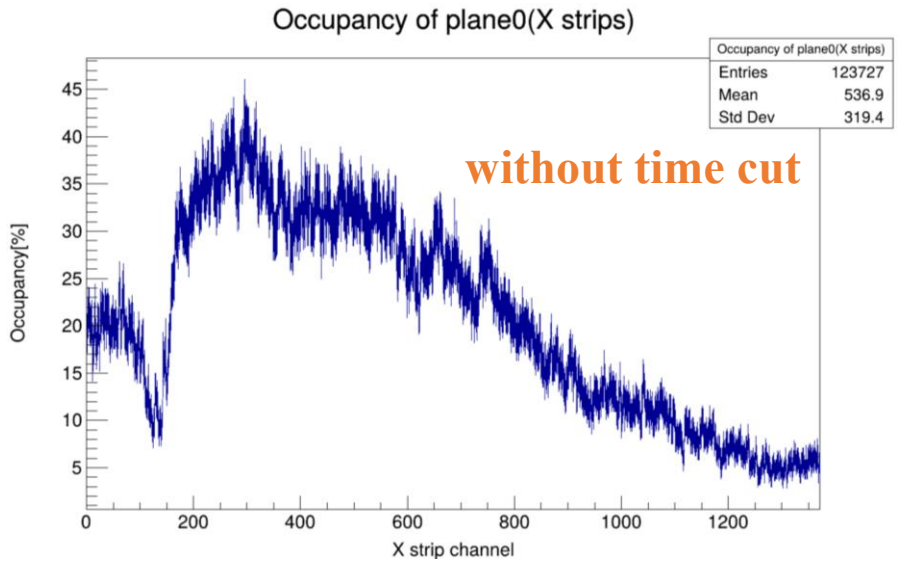
- Put one signal hit in each event, occurring at t = 0
- Open a time window(-200ns, 150ns) to put the entries from background root file(related to beam current)
- Each background entry has a random shift time(-200ns, 150ns)
- Average of 80 background hits on one chamber in this time window

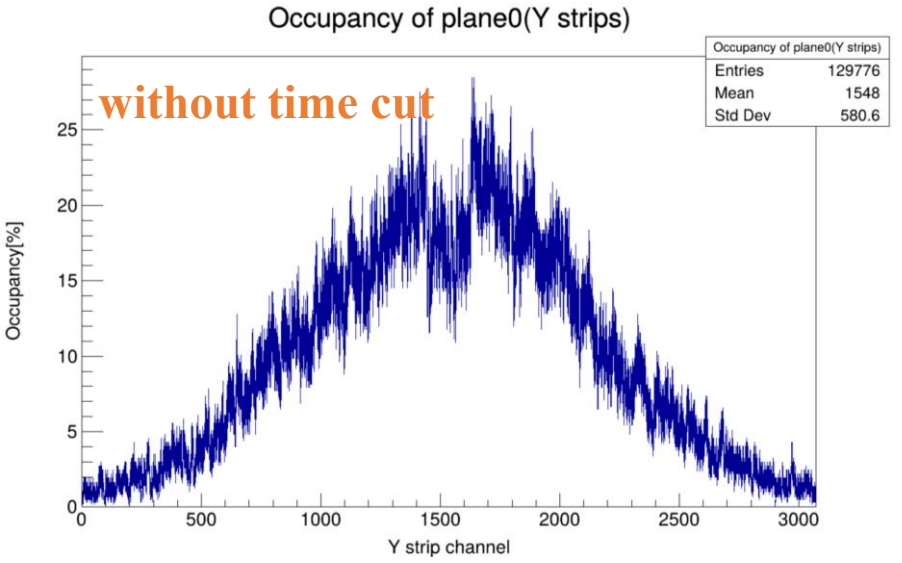



The digitized strip signals in output event

# **Occupancy of Strips** (X17,1um target, 50nA, He bag)

- Occupancy: the probability of a strip to be fired in an event
- Fired: mean ADC value of 6 samples is above threshold
- **80 average hits** and max **40%** occupancy is too high (no time cut)



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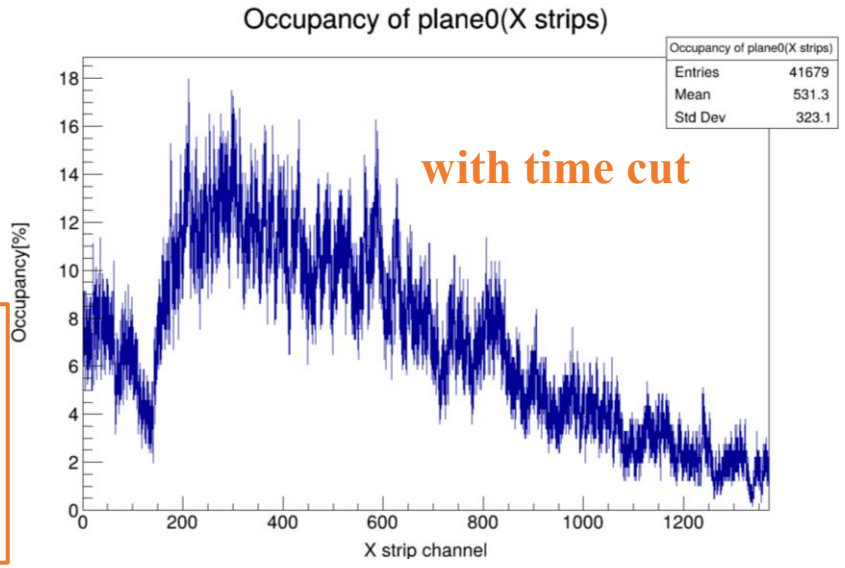
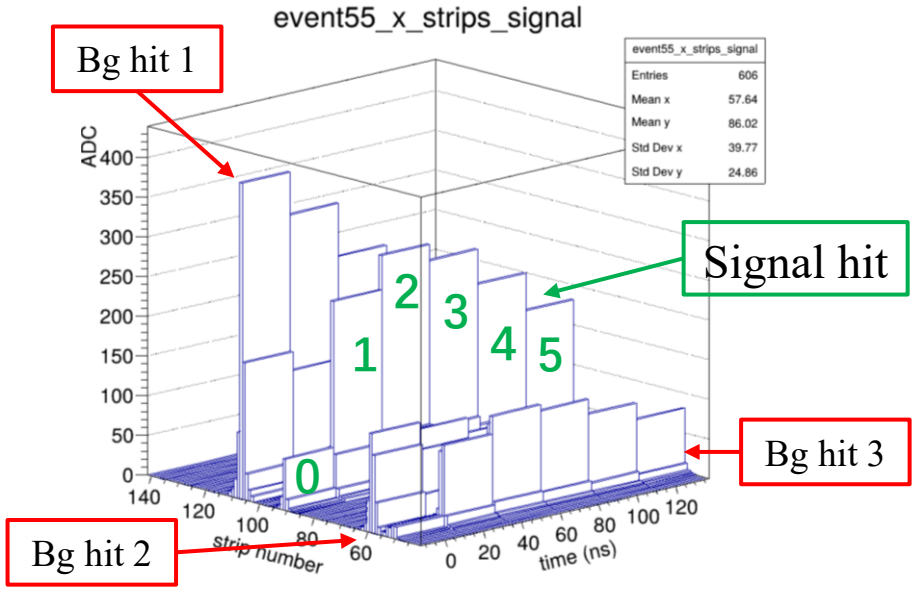
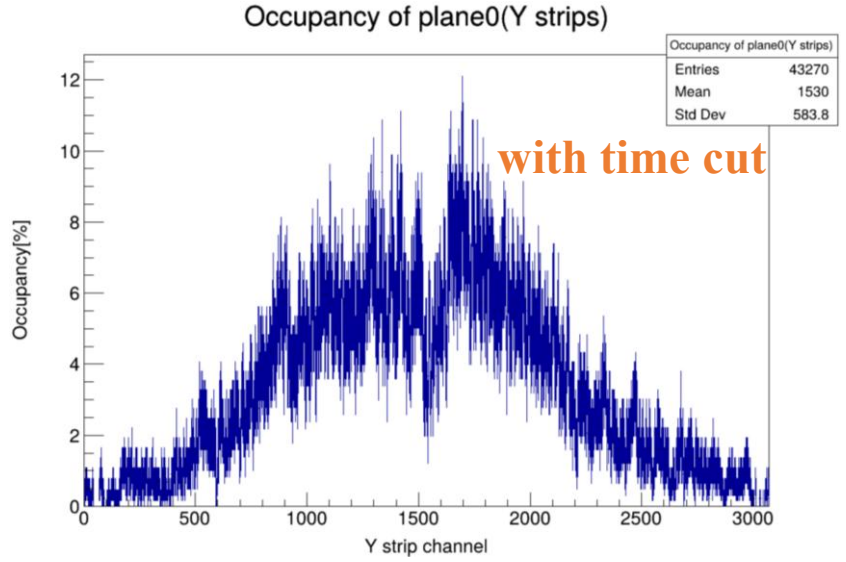
- Occupancy: the probability of a strip to be fired in an event
- Fired: mean ADC value of 6 samples is above threshold
- **80 average hits** and **max 40%** occupancy is too high (no time cut)
- Implement time cut to reject:
  - ➢ Remove strips that index of max sample is 0, 4, 5
- **~35 average hits, max 15%** occupancy are still not good (with time cut)



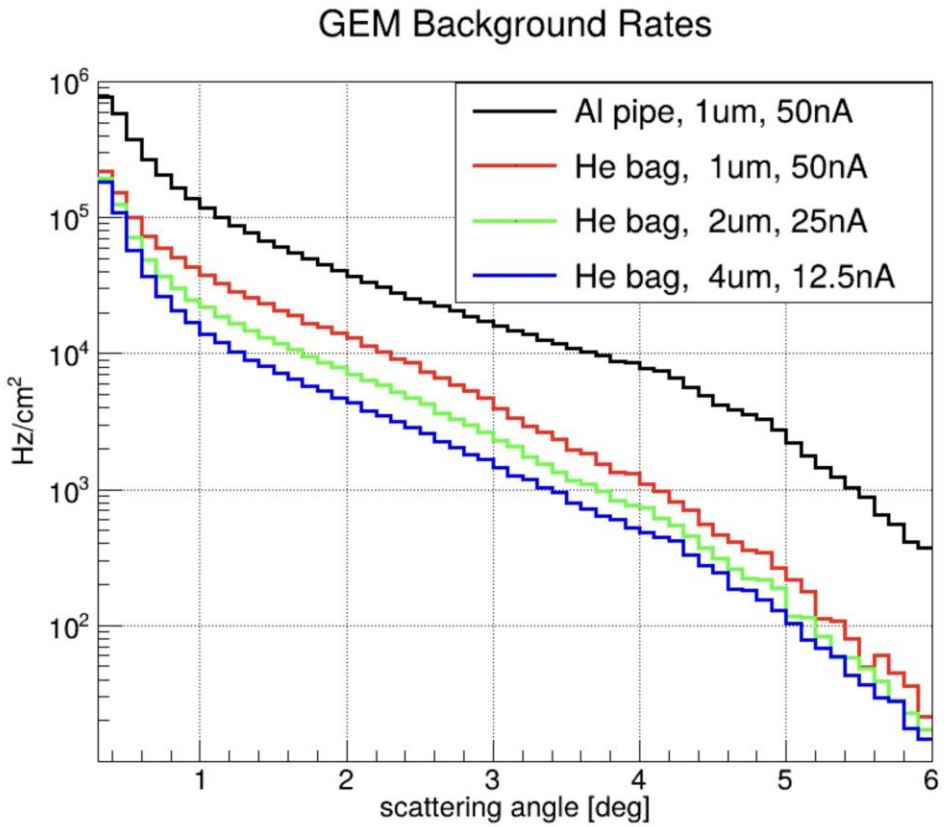



# Reduce Background Rates on GEM

**GEM background rates of different X17 configurations:**

- Helium bag instead of Aluminum vacuum pipe, will have significant lower rates
- 2um, 4um instead of 1um, will give another ~2, ~4 times lower rates



# Reduce Background Rates on GEM

Two main background source(He bag config.):

1. 30um Aluminum beam window
2. Helium gas in the bag

- Same luminosity with 1um, 50nA configuration
- Thicker target, lower beam current
- Background rate is expected to lower down

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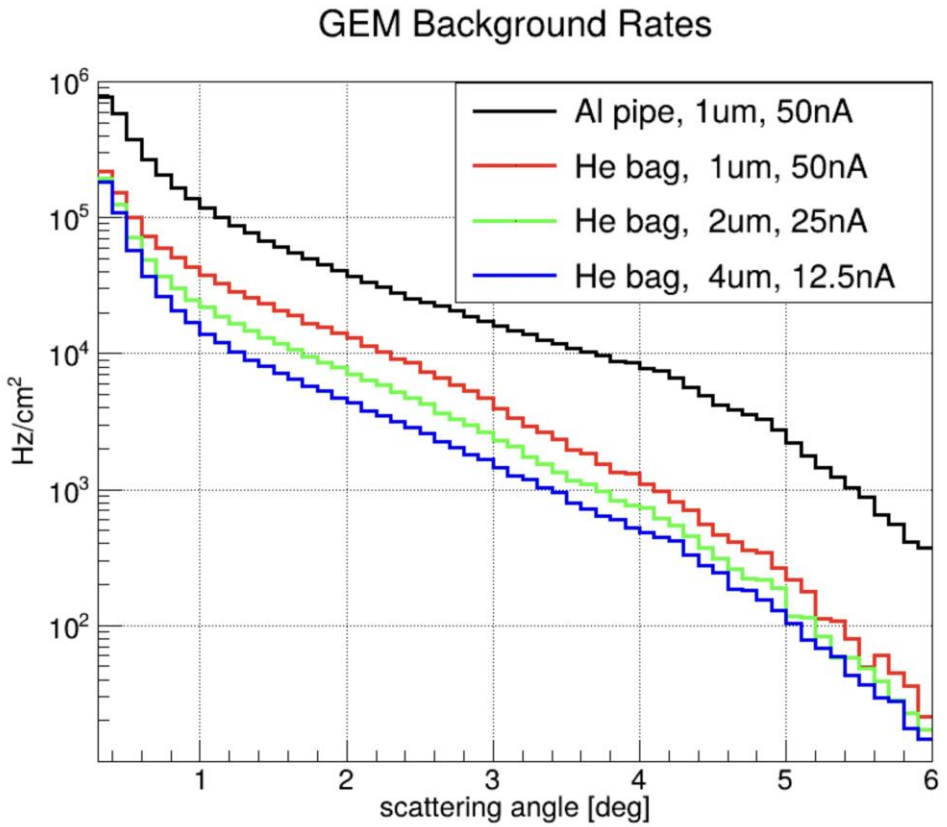

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- Same luminosity with 1um, 50nA configuration
- Thicker target, lower beam current
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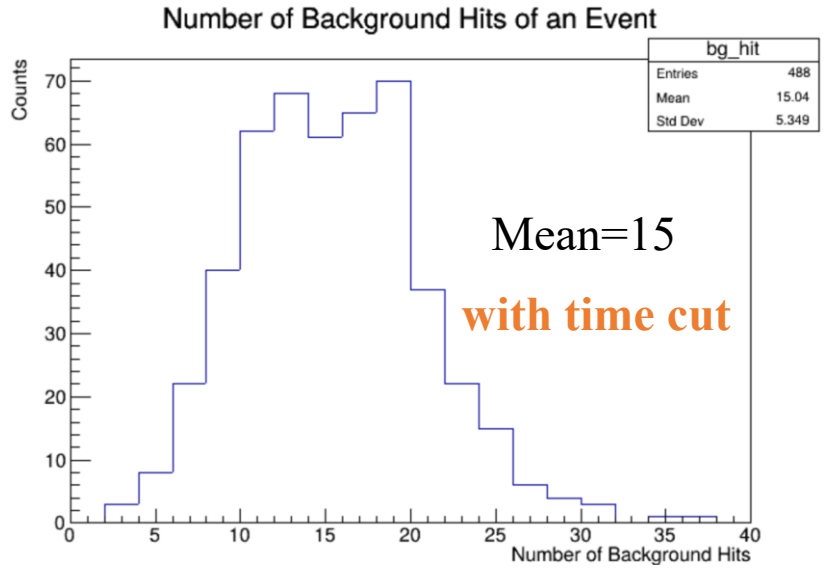
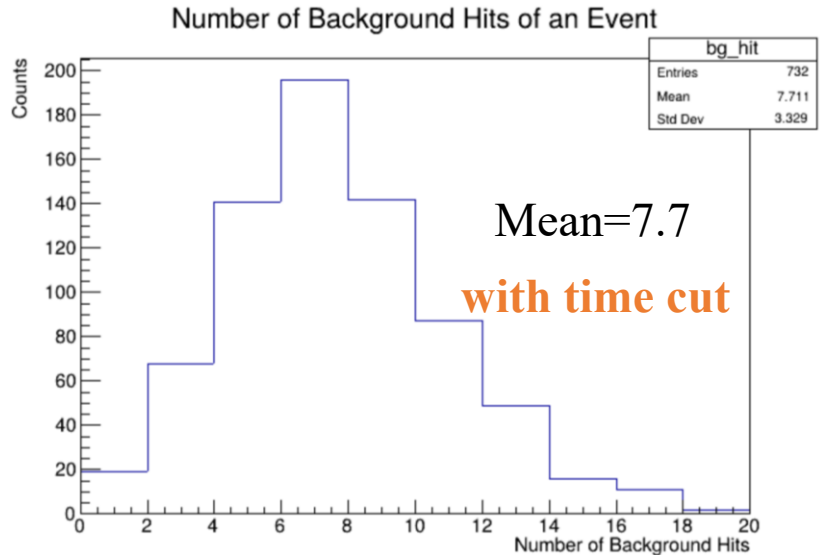
- 2 um target, 25 nA, He bag
- Background rejection time cut:
  - Max ADC appears at 2nd, 3rd, 4th sample

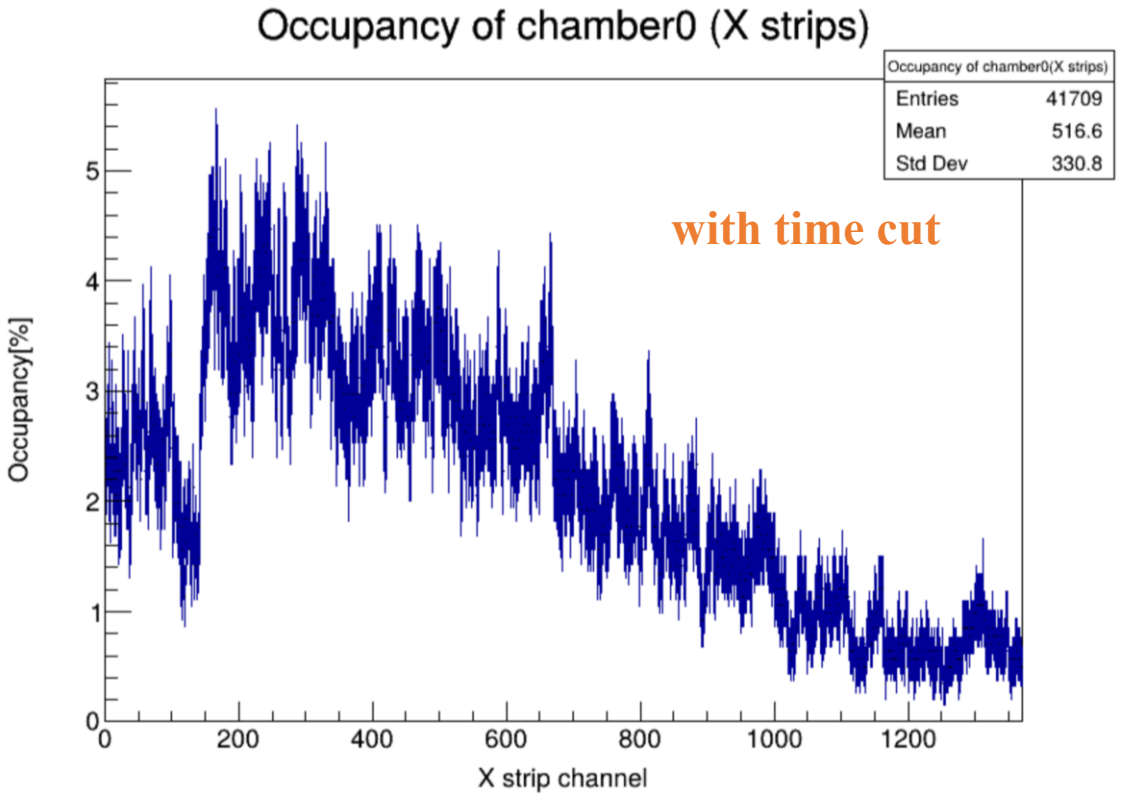


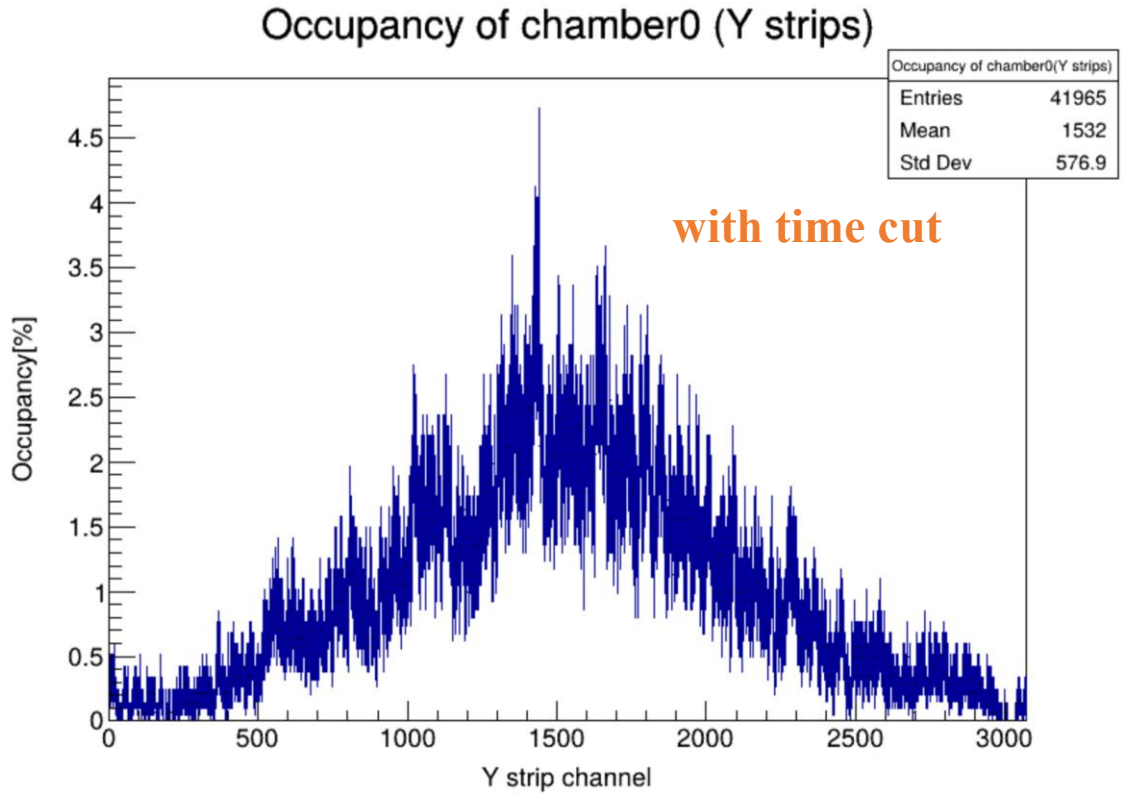

- 4 um target, 12.5 nA, He bag
- Background rejection time cut:
  - Max ADC appeares at 2nd, 3rd, 4th sample



# Thicker Target Is More Ideal for GEM

- **4um target, 12.5nA beam**
- Same luminosity with 1um target, 50nA beam
- Average of **7.7 hits** one chamber, **max of 4%** occupancy still acceptable



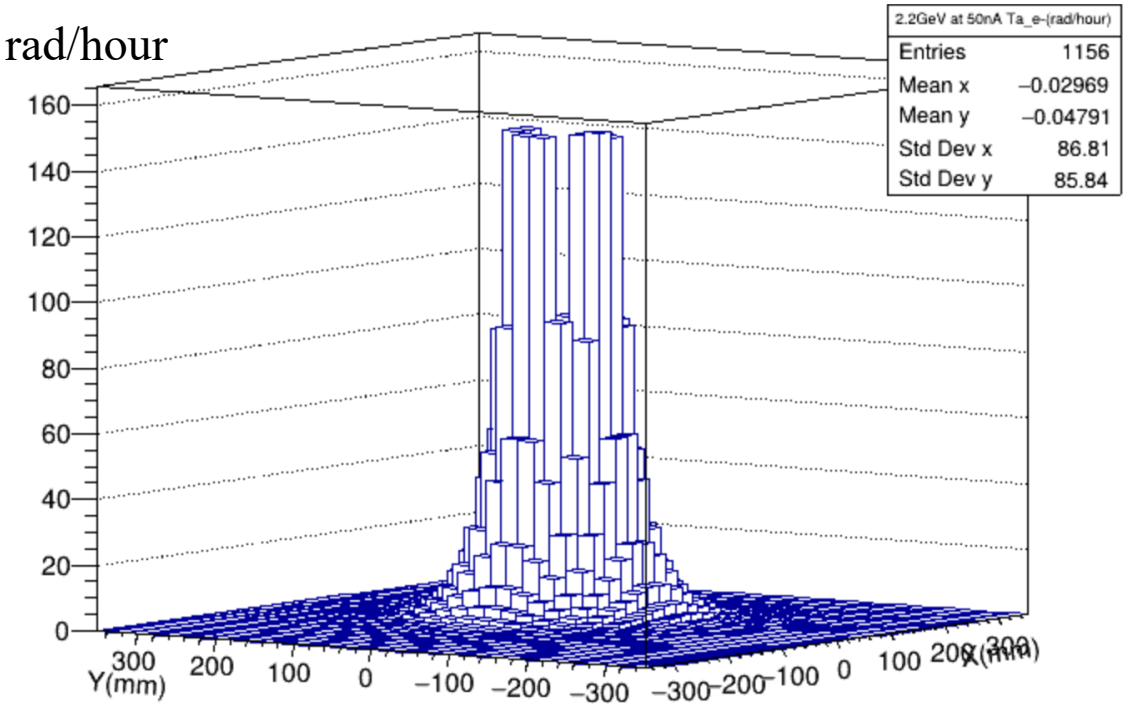



# Summary

- Have completed the development of GEM digitization
- Some effects are waiting to be added, such as cross talk
- The strips occupancy and background rates are too high on X17
- 4um, 12.5nA (instead of 1um, 50nA) could significantly reduce rate to 7.7 hits on one chamber per event
- Next step: try to reconstruct hits from digitization output

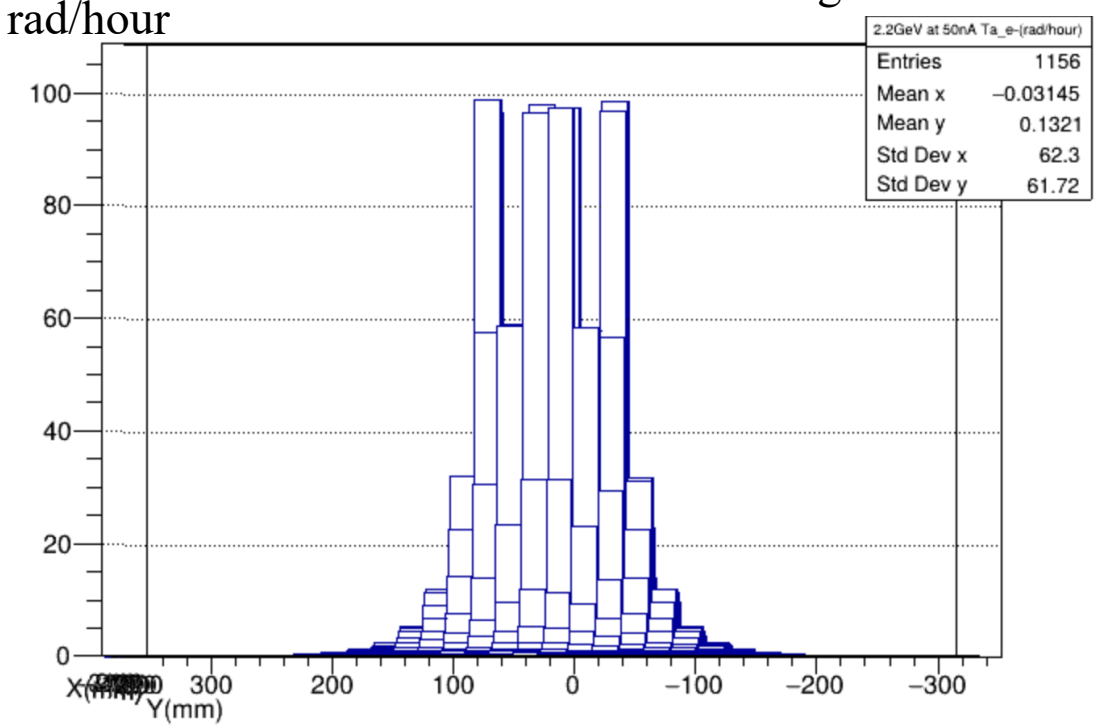
# HyCal Radiation Dose (rad/hour) – 1um Ta, 2.2GeV, 50nA

Small Absorber – Aluminum Pipe




1st open layer max dose: 150 rad/h
2nd open layer max dose: 50 rad/h

Small Absorber – Helium Bag




1st open layer max dose: 100 rad/h
2nd open layer max dose: 30 rad/h