# Geant4 Simulation Studies

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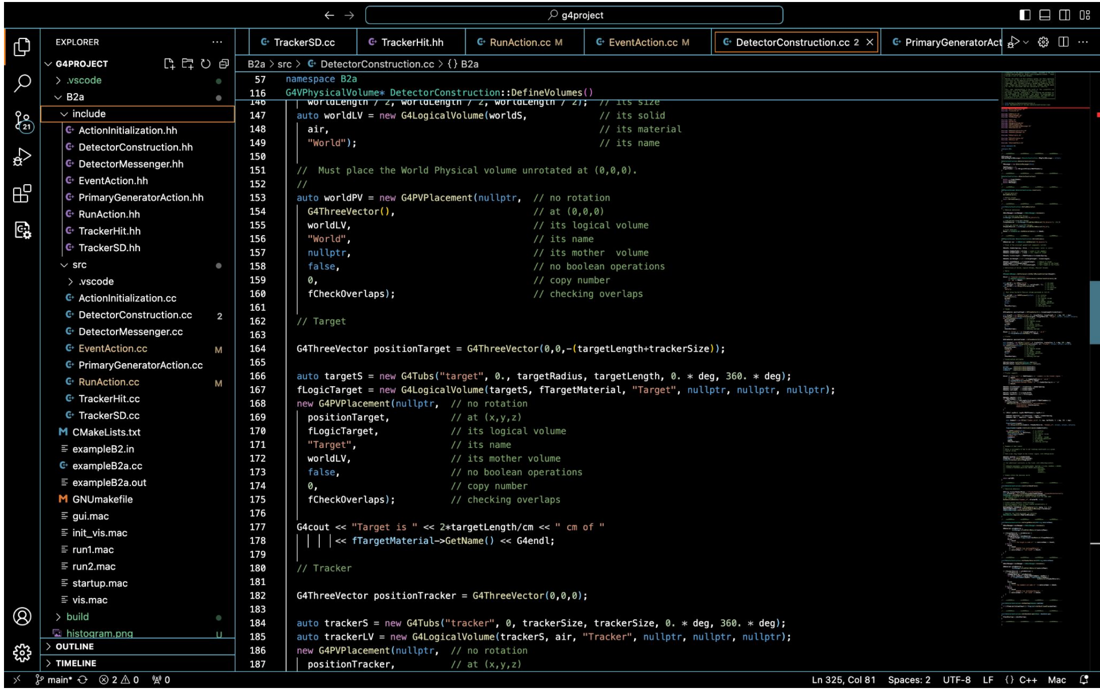
# Overview

- Intro to our Code
    - How it works
    - What’s the geometry
- Applications
    - Simulating a tracking detector (Jacob)
    - Energy deposition by varying different materials and particle energies (Claire)
    - Track Momentum analysis? (Xiang)

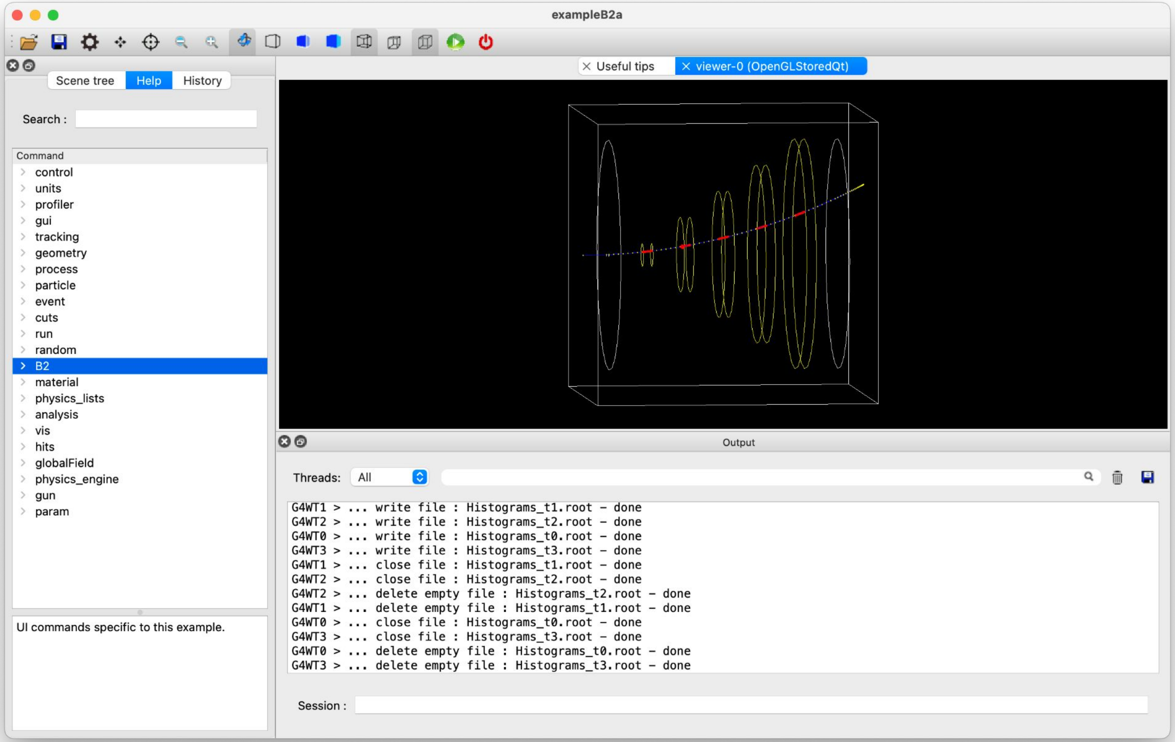
# Intro (Setting up our simulations):

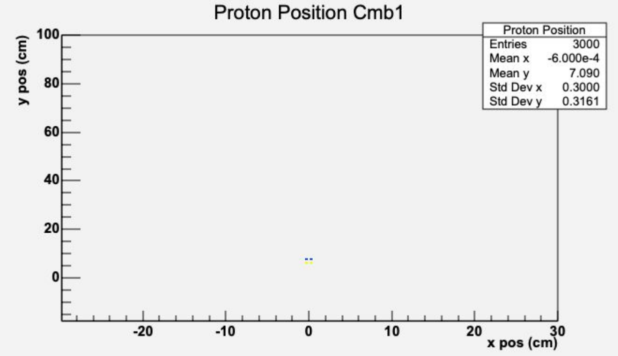
- Geant4 has a lot of moving parts
- Based our code on example B2a in the Geant4 library
  - Changes to detector operations occurred in TrackerSD and TrackerHit files
  - Changes to root file creation for data storage in RunAction and Event Action Files
  - Changes to physical geometries in DetectorConstruction file
  - Changes to incident beam in PrimaryActionGenerator File

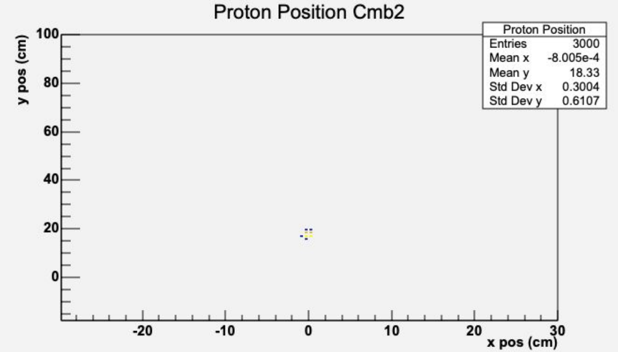


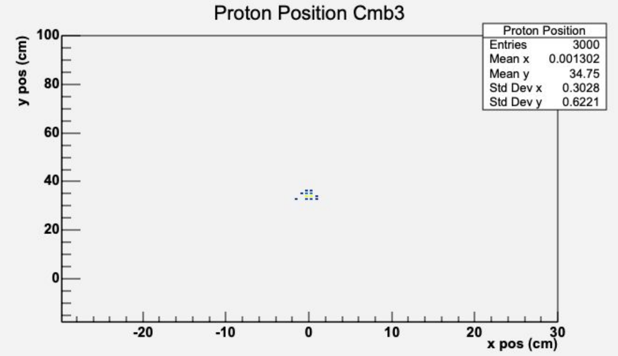
# Simulating a Tracking Detector:

- Series of 5 “SensitiveDetectors”, regions filled with Xenon gas
- Spaced 80 cm apart (center to center)
- 20 cm thick
- Radius starts at 24 cm and increases by 54 cm each chamber

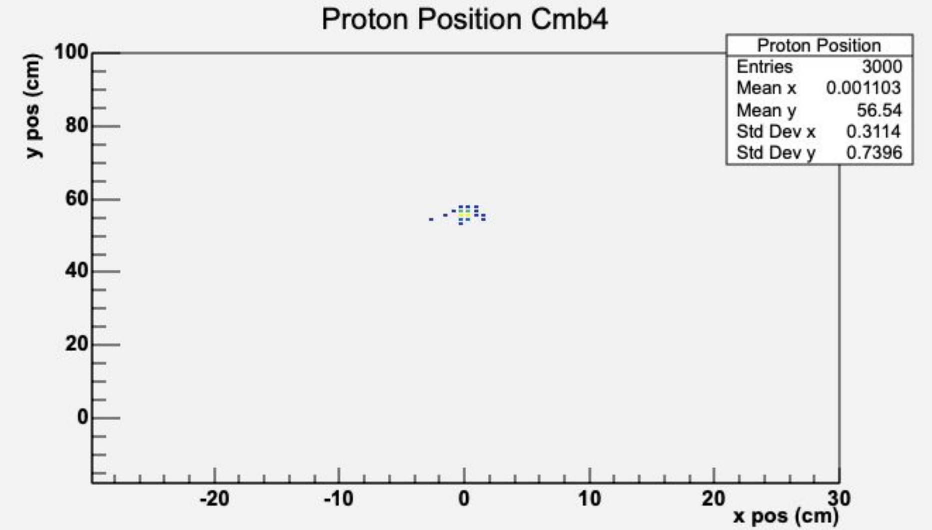


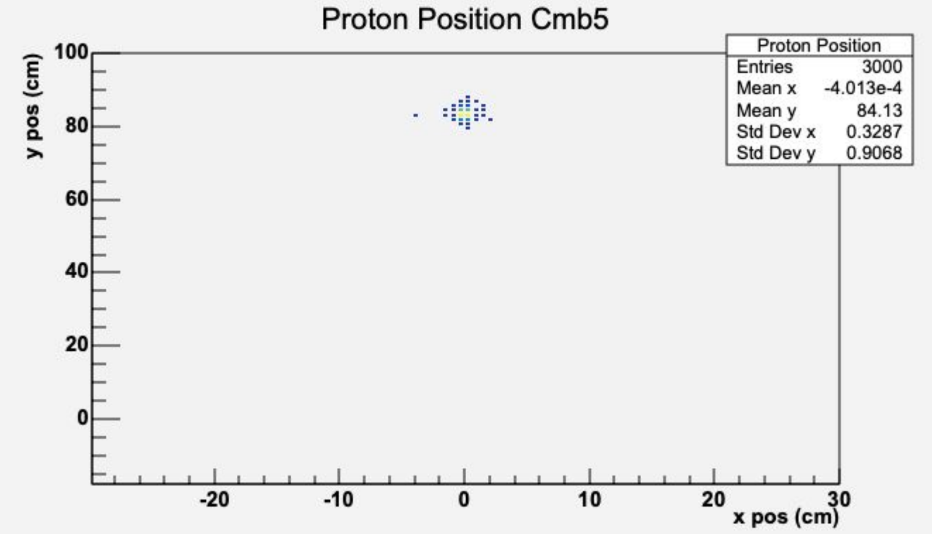


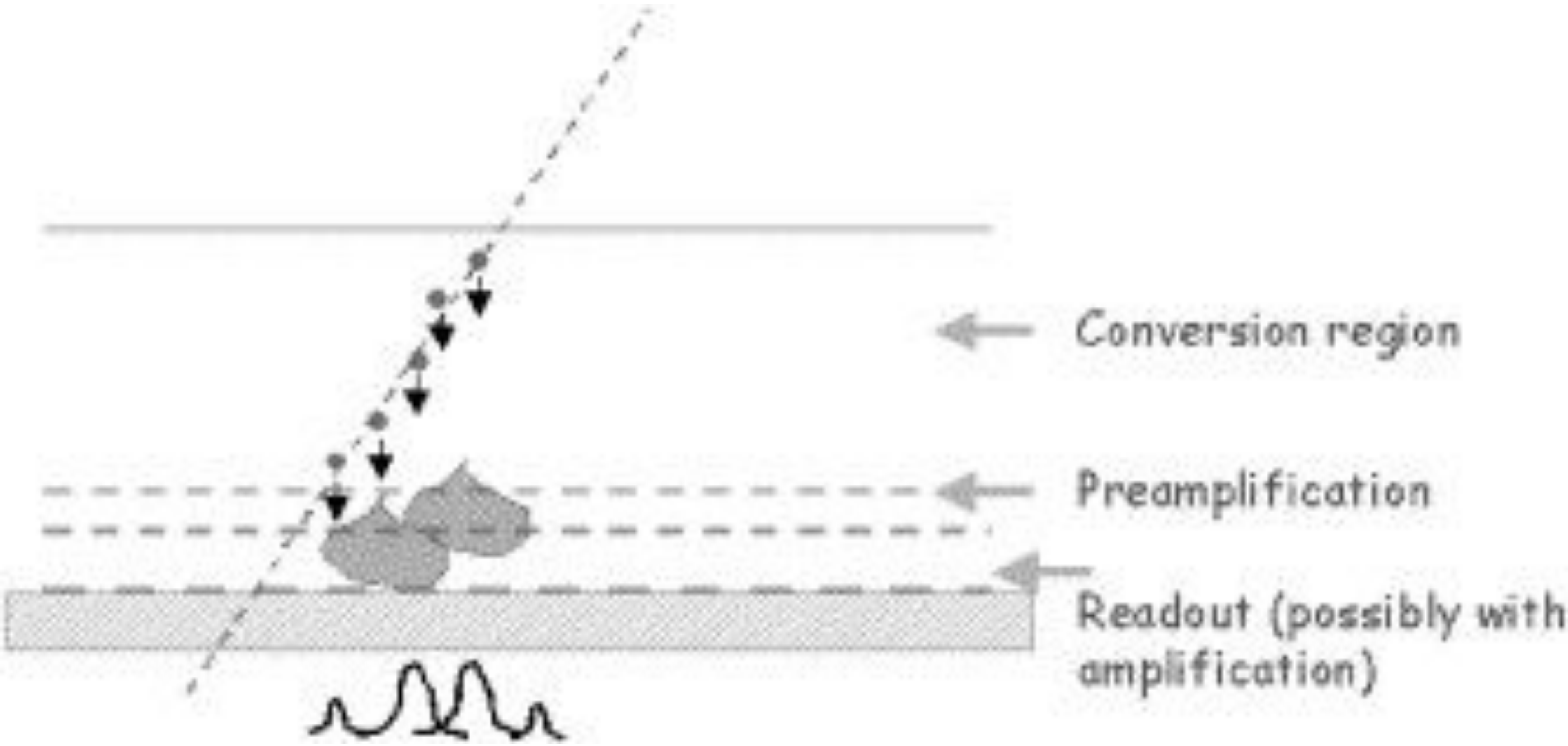



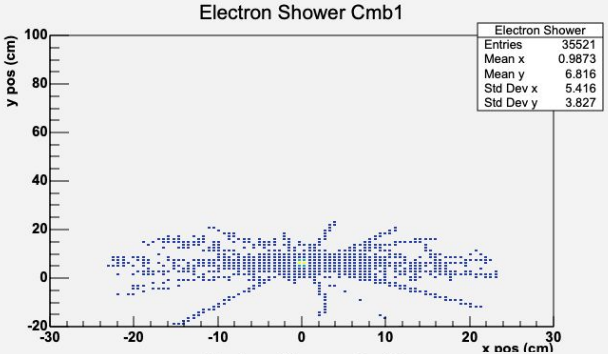



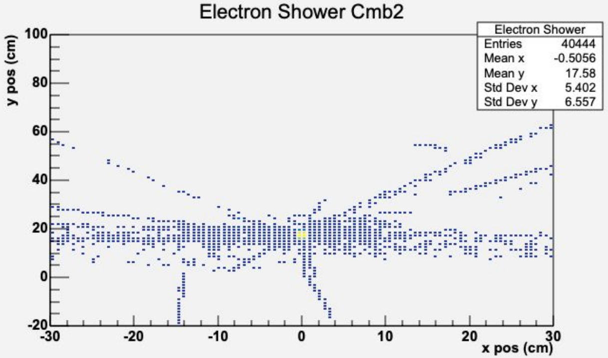

Using a 1 T magnetic field in the x direction (thus causing our protons to bend upwards), where does the initial proton hit?

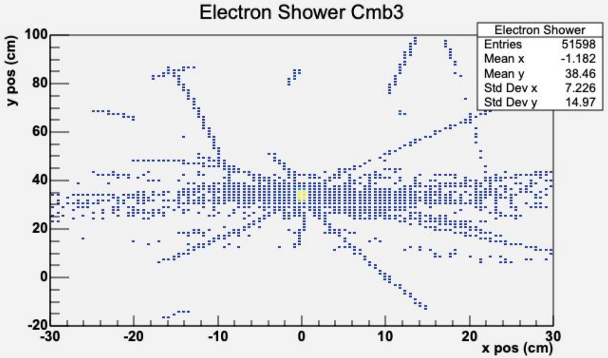


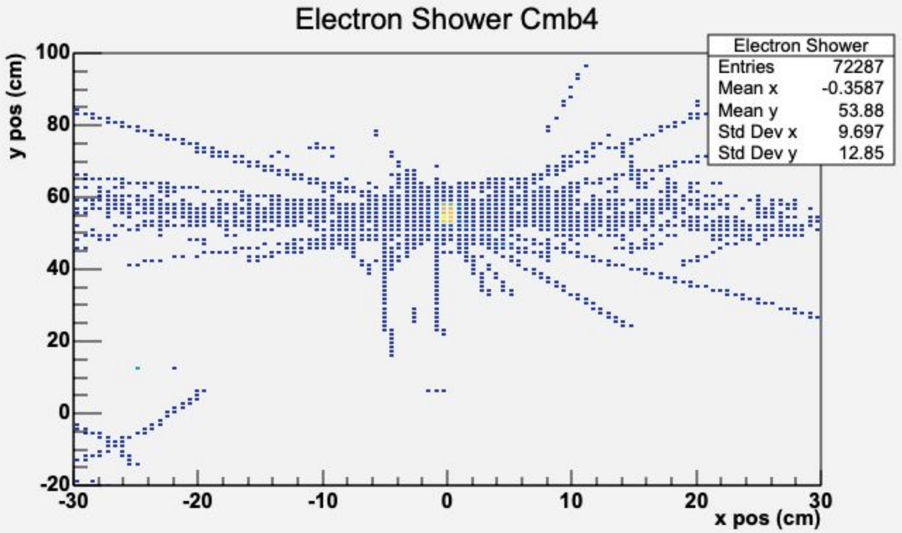

Conversion region
Preamplification
Readout (possibly with
amplification)

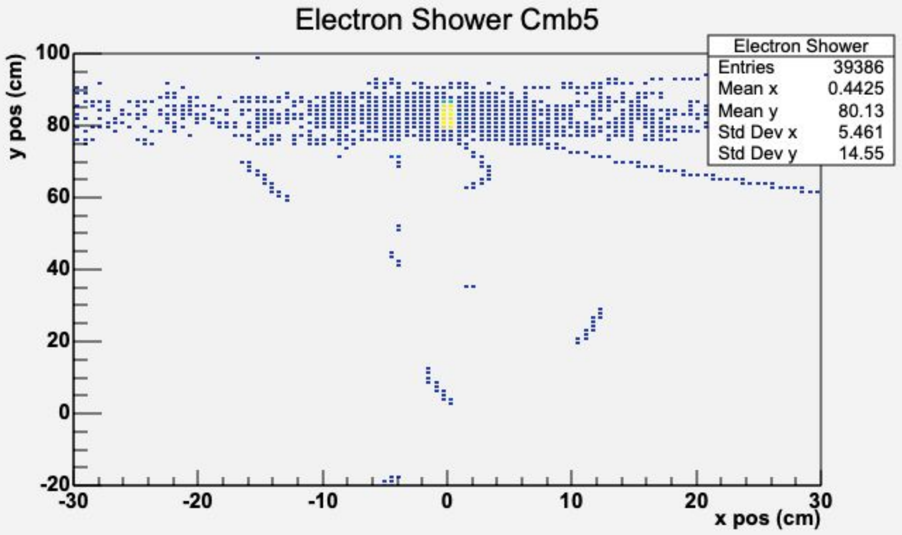



Compare this to the electron shower caused by the proton ionizing gas in our detector.



# Actual Tracks vs. Electron showers

| Chamber | Proton Track (cm) | Electron Shower (cm) | Predicted (cm) |
| --- | --- | --- | --- |
| 1 | 7.09 | 6.823 | ~5.38 |
| 2 | 18.33 | 17.57 | ~17.5 |
| 3 | 34.75 | 38.47 | ~37 |
| 4 | 56.54 | 53.88 | ~72.3 |
| 5 | 84.13 | 80.38 | ~100 |

Why the discrepancy?

- Rounding errors
- Electrons bending in the opposite direction
- Energy loss on each detector

$$\frac{mv^2}{r} = q\vec{v} \times \vec{B}$$

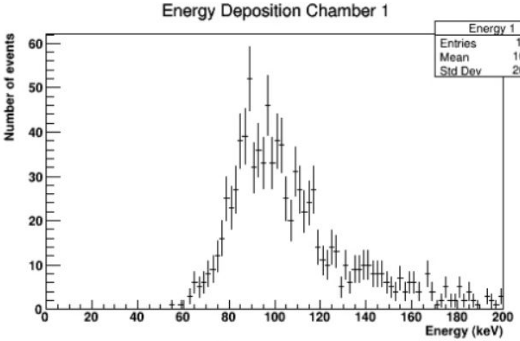
$$h = \frac{mv}{qB} - \sqrt{(\frac{mv}{qB})^2 - x^2}$$

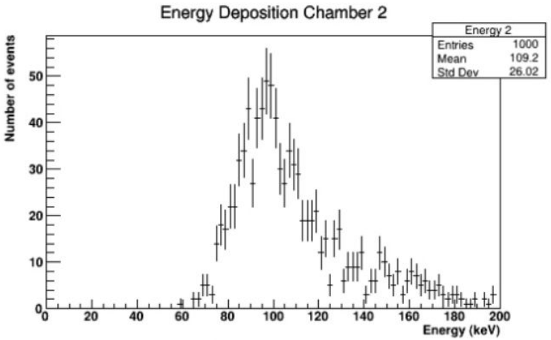
# Varying materials within the chambers

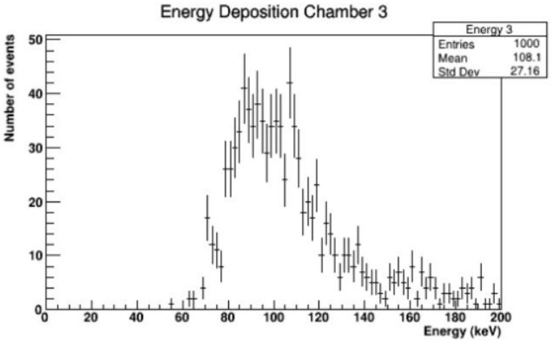
Magnetic field: 0

Energy of proton: 3GeV

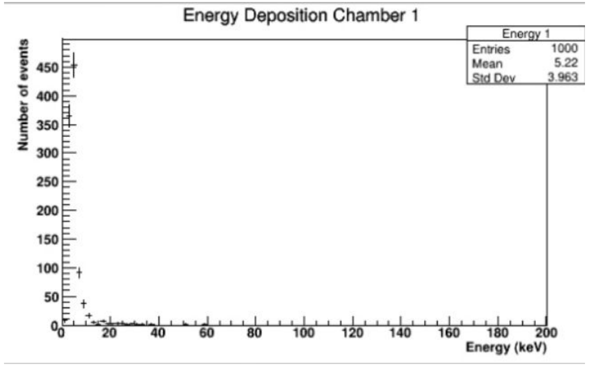
Xenon energy deposition:



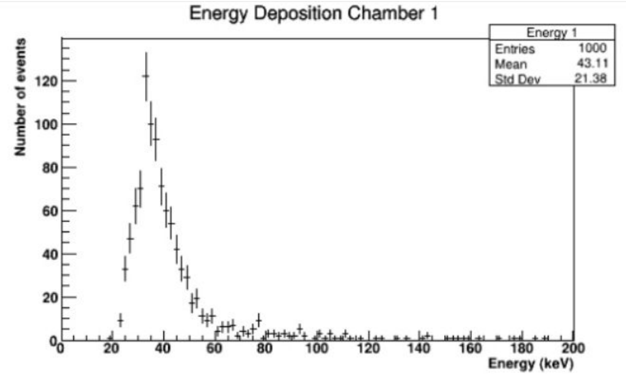



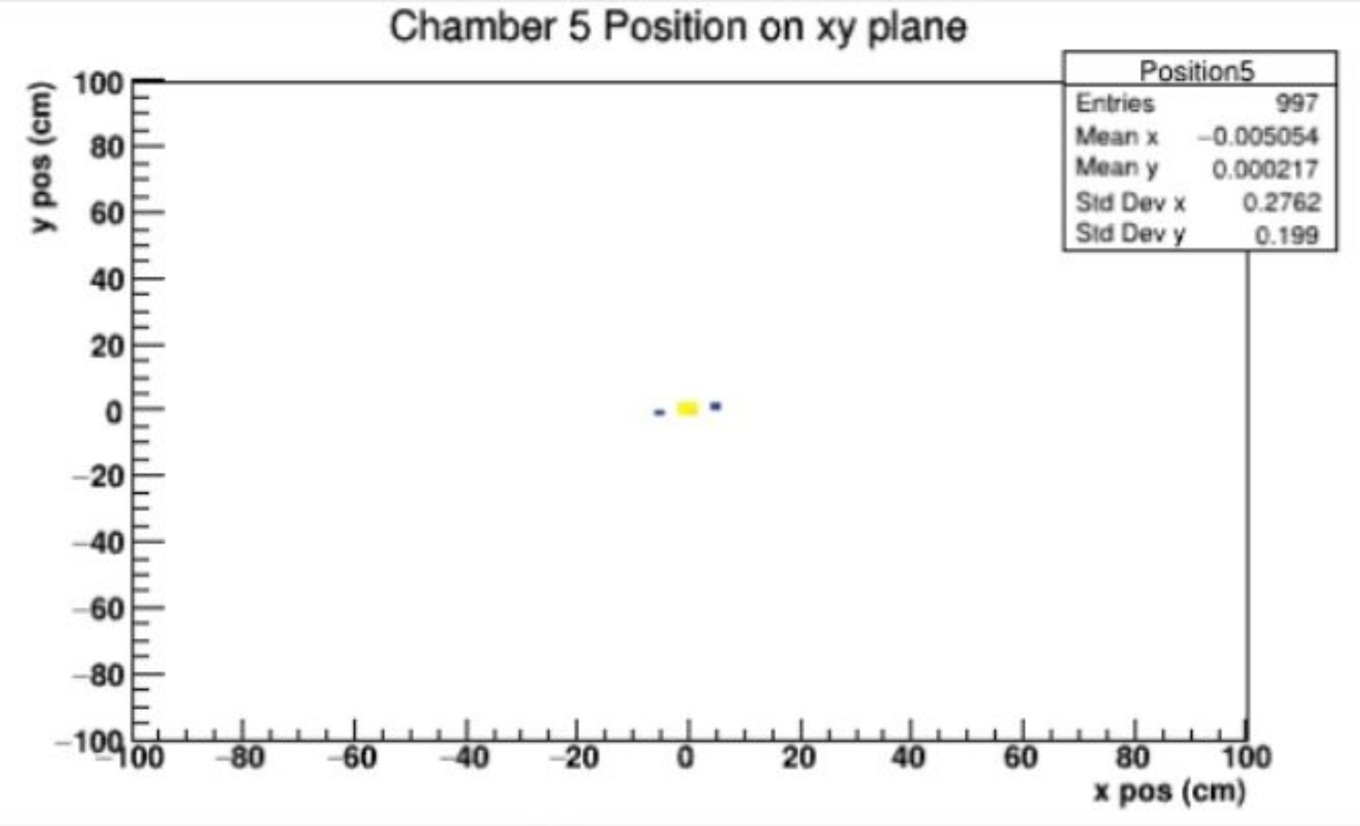




Helium:



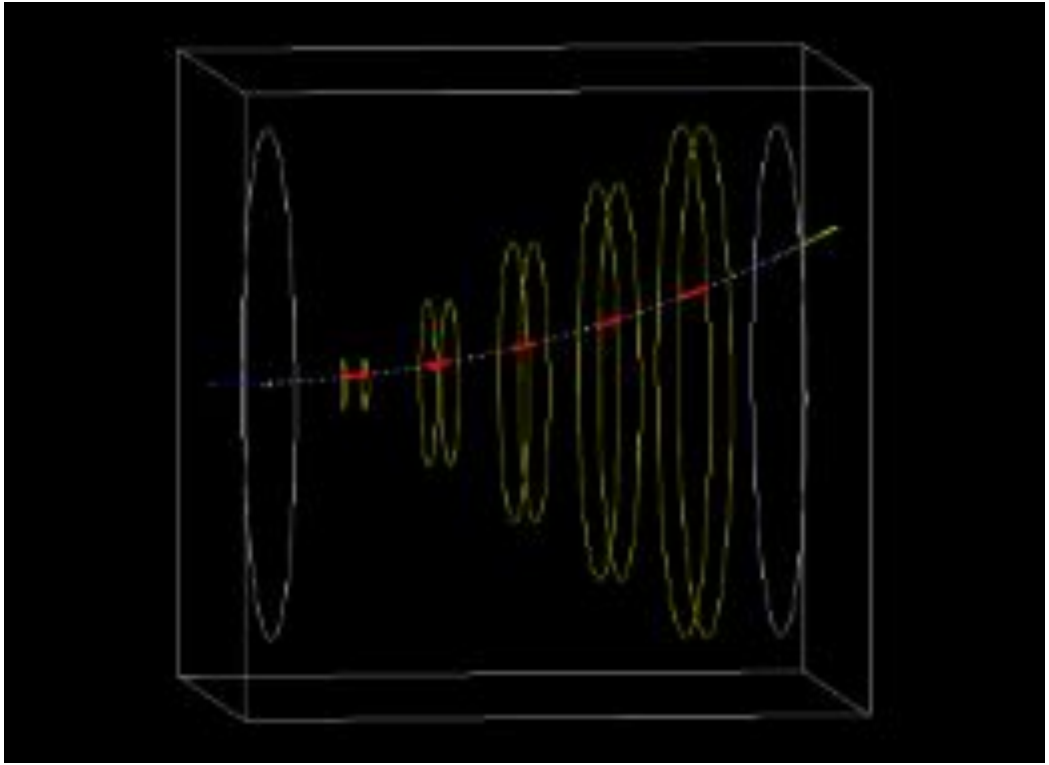

Argon:




Chamber 5 Position on xy plane
Position5
Entries 997
Mean x −0.005054
Mean y 0.000217
Std Dev x 0.2762
Std Dev y 0.199
y pos (cm)
100
80
60
40
20
0
−20
−40
−60
−80
−100
−100
−80
−60
−40
−20
0
20
40
60
80
100
x pos (cm)

# Adding a target

- Target radius of 2.5 cm
- Depth of 5cm
- 85 cm between target and first chamber
- Placed right in front of particle gun



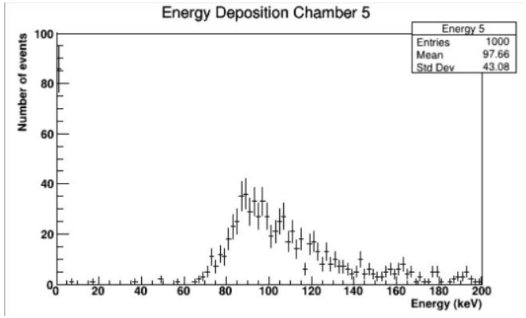
# Adding a target and varying the target material

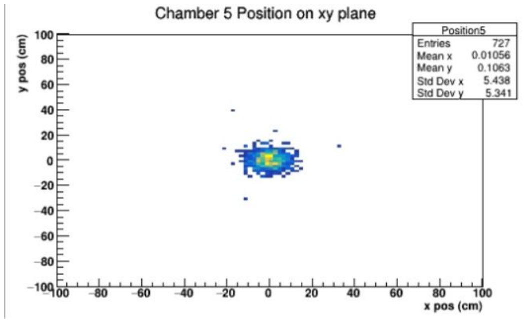
Magnetic field: 0

Energy of proton: 3GeV

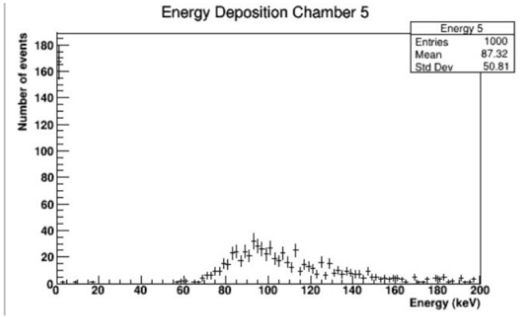
Chamber: Xe

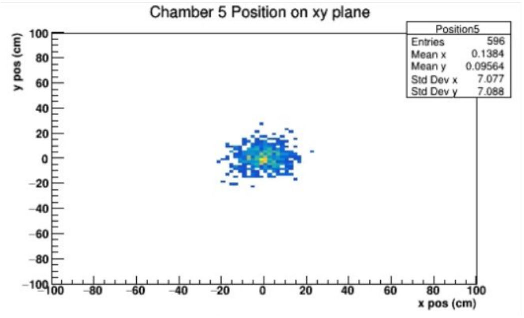
## Pb target:



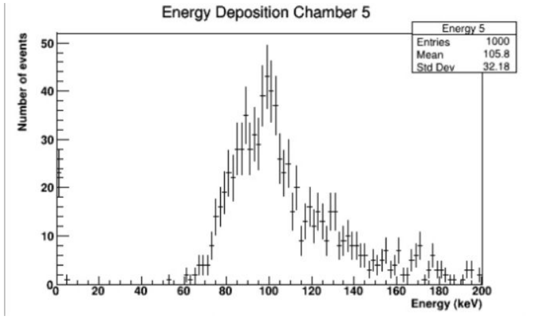



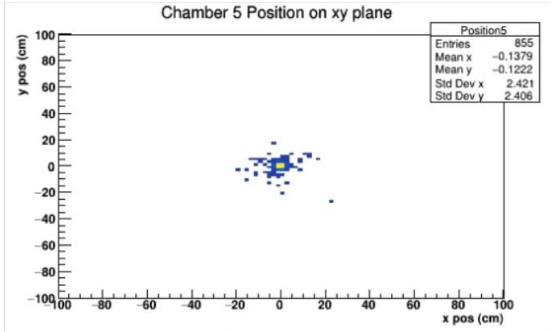

## Au target:




## Al target:



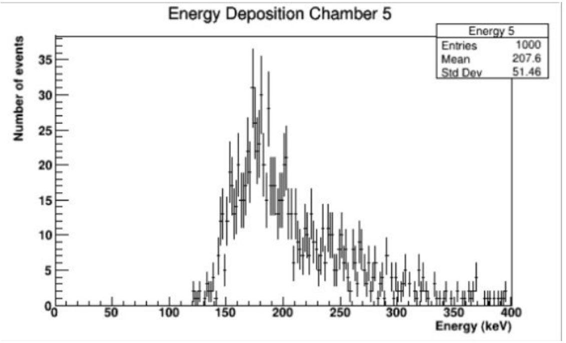
Magnetic field: 0

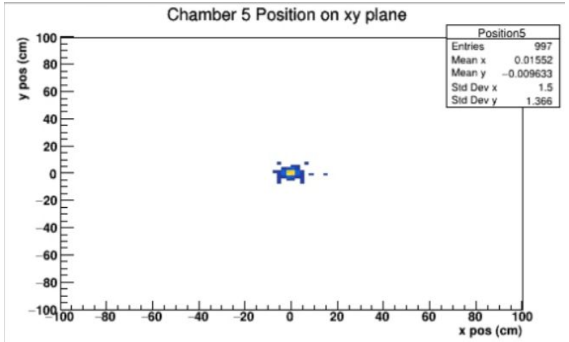
Energy of proton: 3GeV

Chamber: Xe

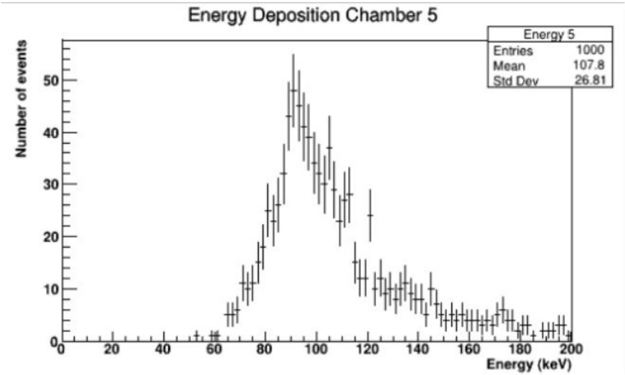
# Varying the energy of the proton beam

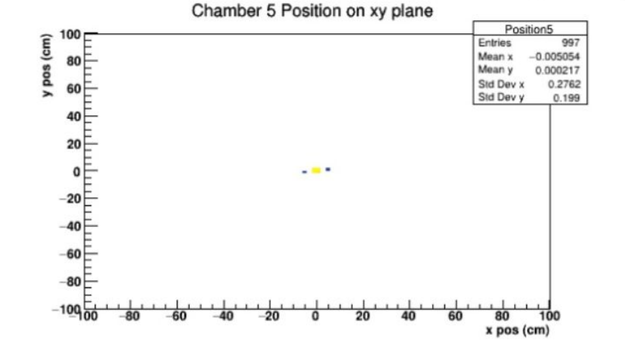
## 0.3GeV:



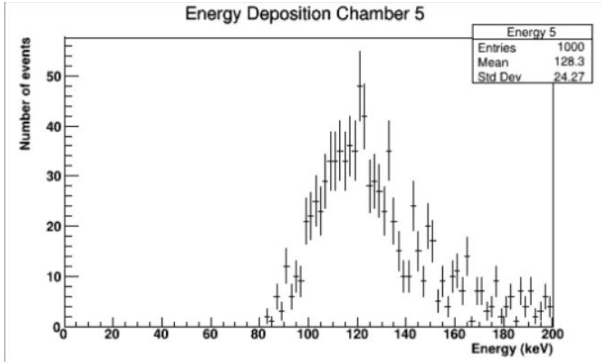



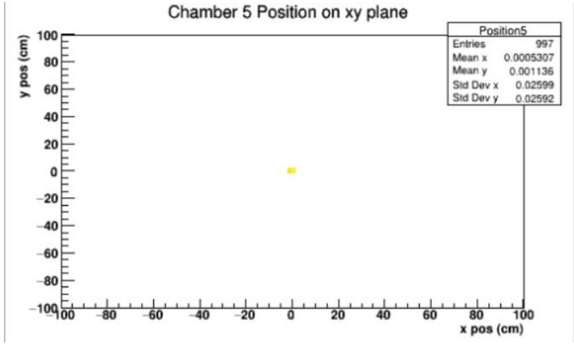

## 3GeV:



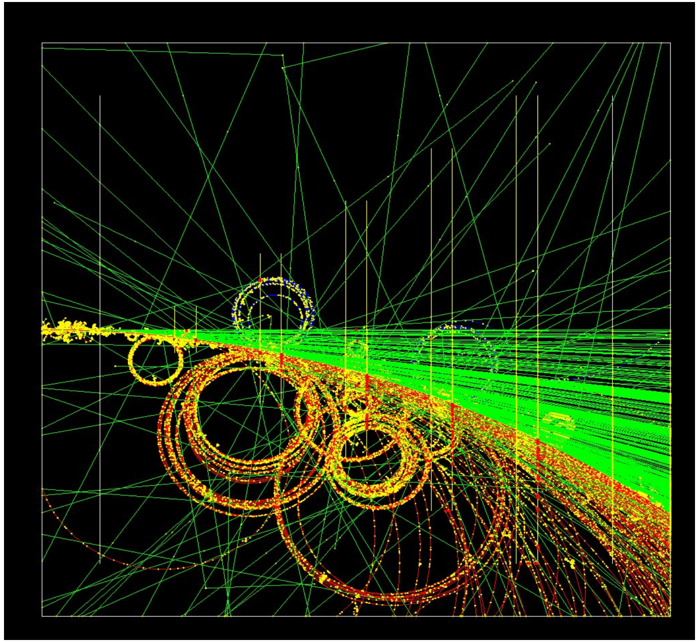

## 30GeV:

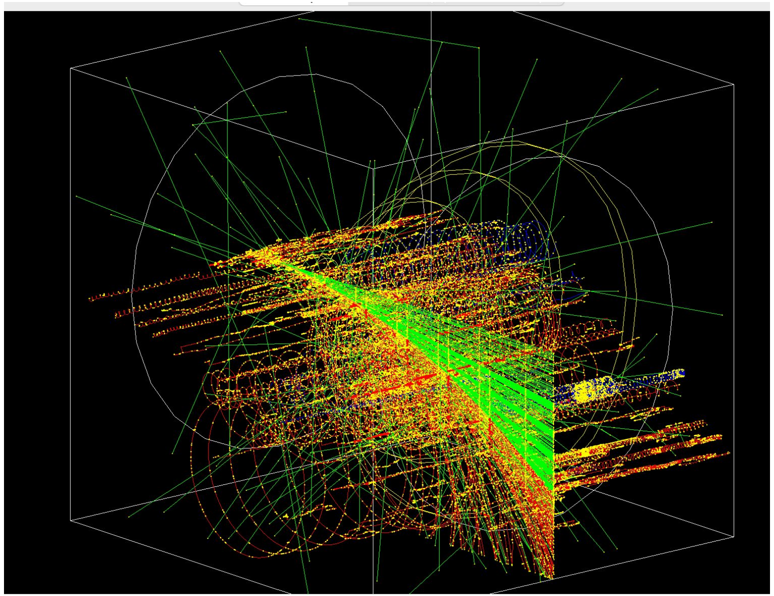


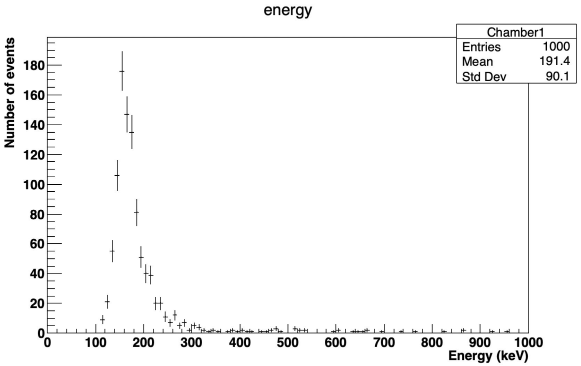
# Ep and Moller scattering simulation

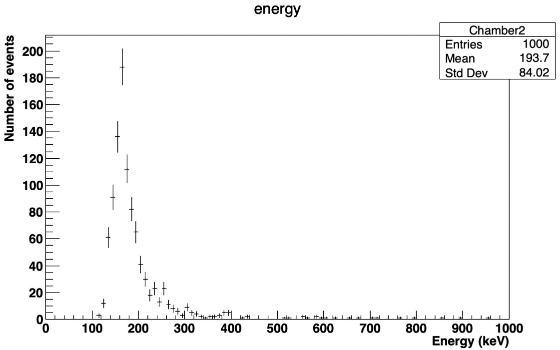
I use e- beam to hit fixed Hydrogen target. Here is the result for 1000 e- shooting to the target. The magnetic field is 1 tesla in positive x position.

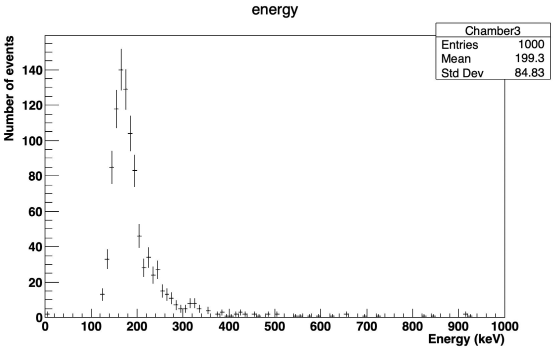


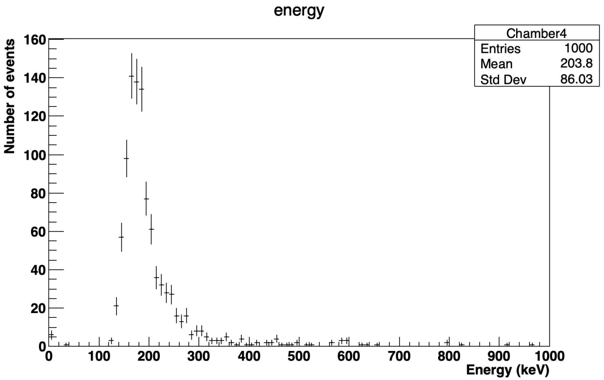


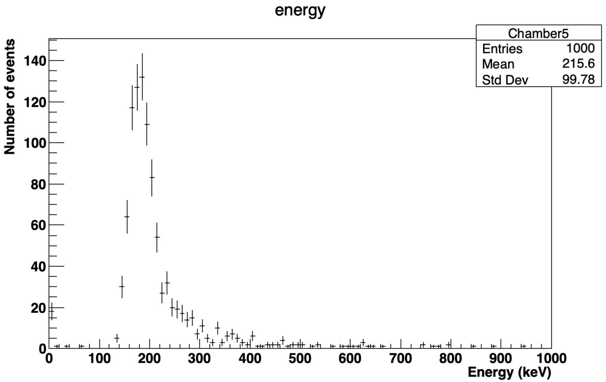
# Results energy for electrons of my detectors



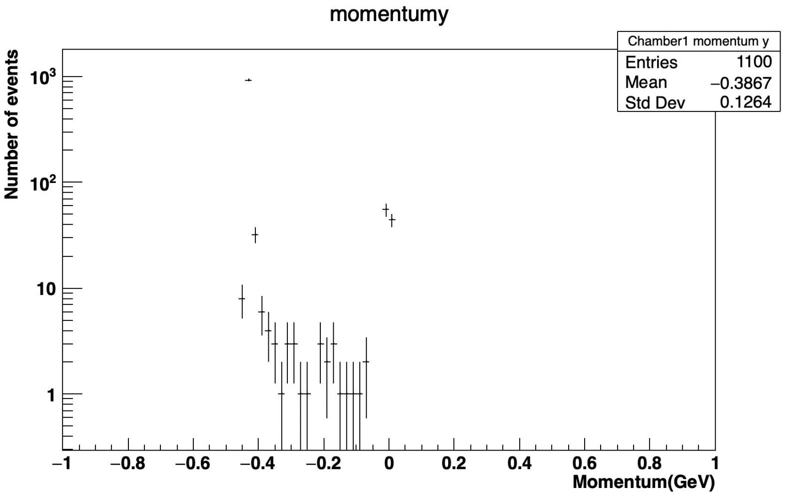



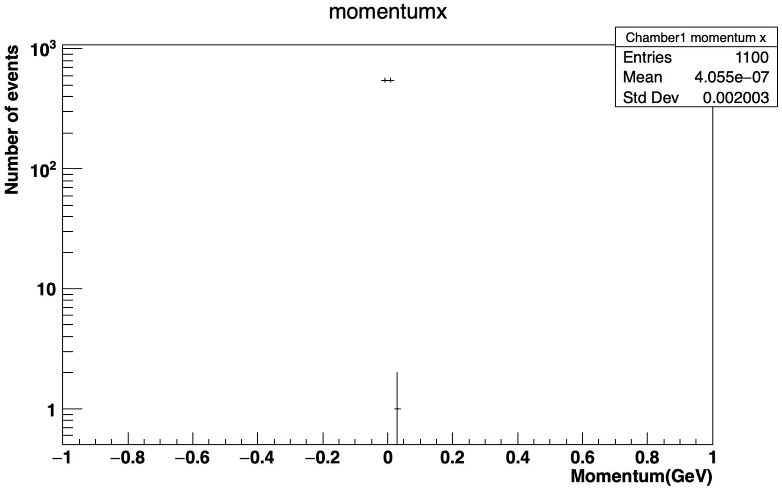



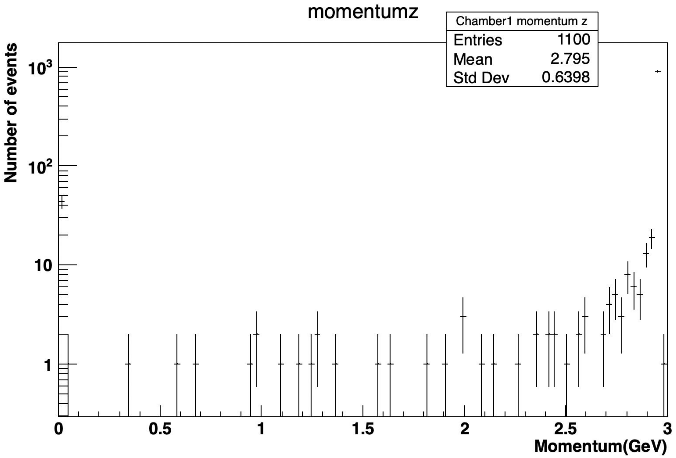



# Momentum distribution for electrons on the back edges in Chamber 1



# Just for compare