



Geant4 Simulation Studies

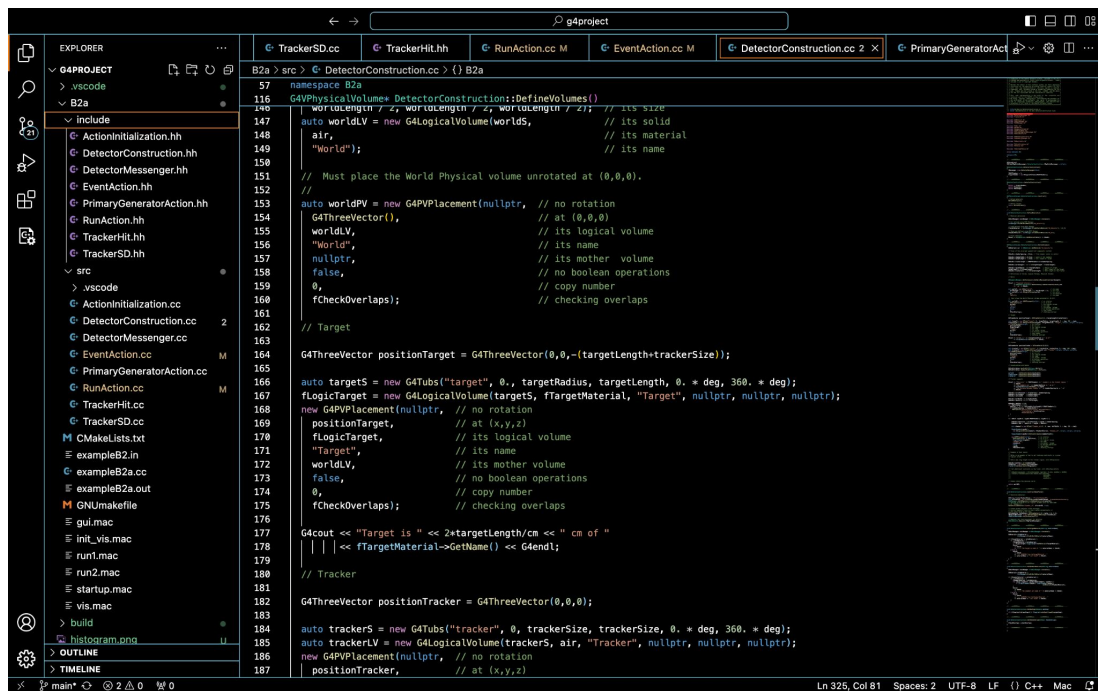
Claire Landgraf
Jacob McMurtry
Xiang Zhang

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):

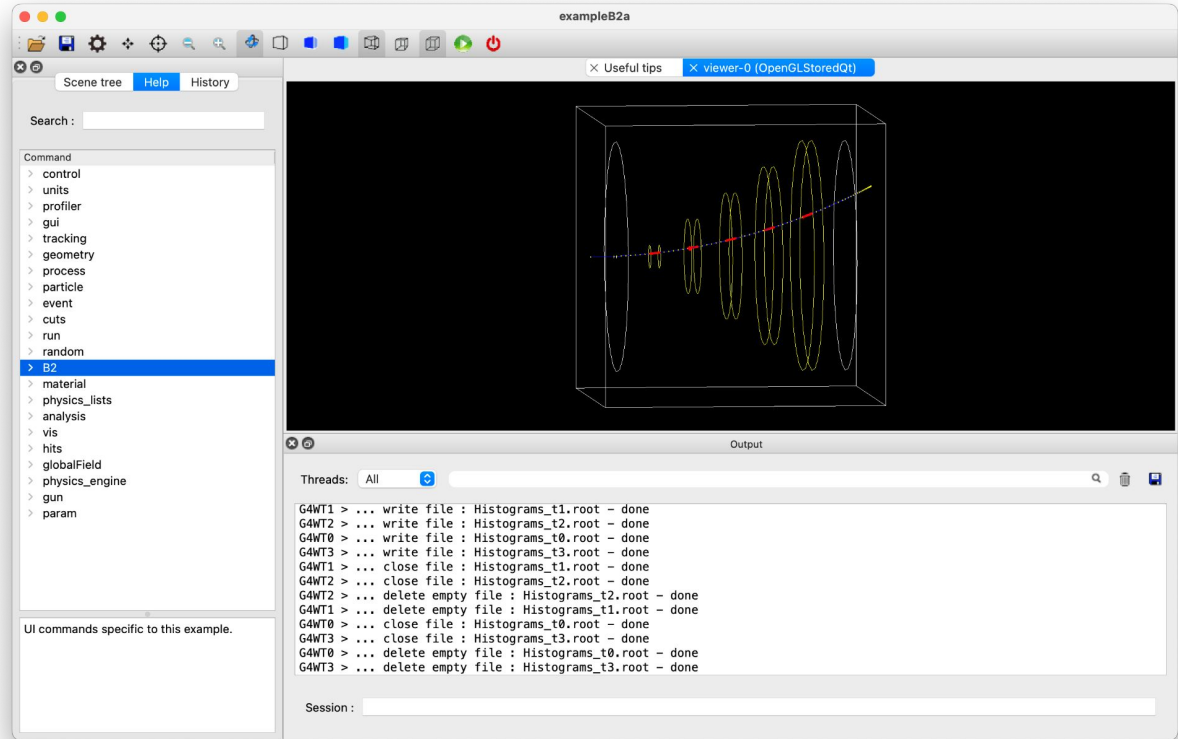
- Geant4 has a lot of moving parts
- Based our code on example B2a in the Geant4 library
 - Changes to detector operations occurred in TrackerSD and TrackerHit files
 - Changes to root file creation for data storage in RunAction and Event Action Files
 - Changes to physical geometries in DetectorConstruction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

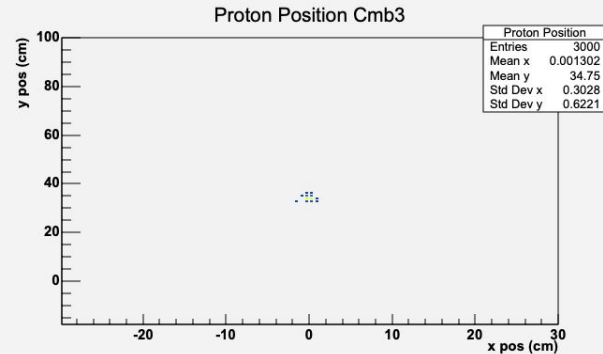
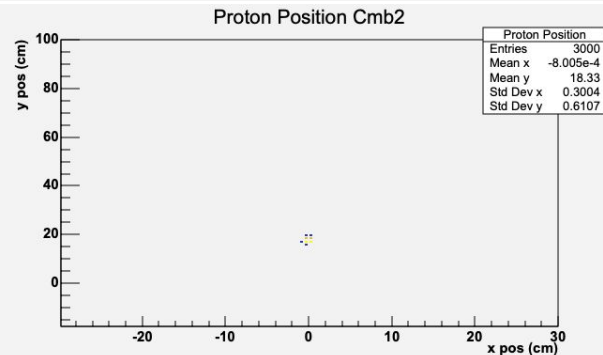
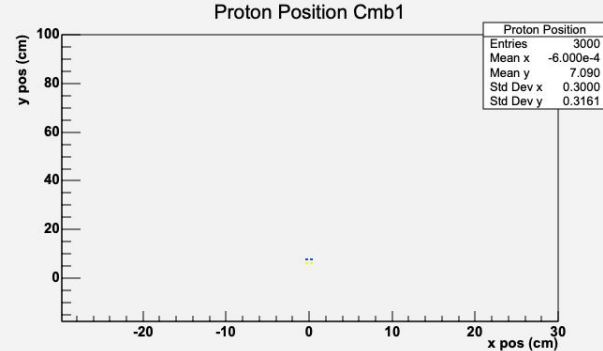


```
57 namespace B2a
58 {
59     G4PhysicalVolume* DetectorConstruction::DefineVolumes()
60     {
61         auto worldLV = new G4LogicalVolume(worldSD, // its size
62         // its solid
63         "World"); // its material
64         // its name
65         // Must place the World Physical volume unrotated at (0,0,0).
66         //
67         auto worldPV = new G4PVPlacement(nullptr, // no rotation
68         G4ThreeVector(), // at (0,0,0)
69         worldLV, // its logical volume
70         "World", // its name
71         nullptr, // its mother volume
72         false, // no boolean operations
73         0, // copy number
74         fCheckOverlaps); // checking overlaps
75         // Target
76         G4ThreeVector positionTarget = G4ThreeVector(0,0,-(targetLength+trackerSize));
77         auto targetS = new G4Tubs("target", 0., targetRadius, targetLength, 0. * deg, 360. * deg);
78         fLogicTarget = new G4LogicalVolume(targetS, fTargetMaterial, "Target", nullptr, nullptr, nullptr);
79         new G4PVPlacement(nullptr, // no rotation
80         positionTarget, // at (x,y,z)
81         fLogicTarget, // its logical volume
82         "Target", // its name
83         worldLV, // its mother volume
84         false, // no boolean operations
85         0, // copy number
86         fCheckOverlaps); // checking overlaps
87         G4cout << "Target is " << 2*targetLength/cm << " cm of "
88         | | << fTargetMaterial->GetName() << G4endl;
89         // Tracker
90         G4ThreeVector positionTracker = G4ThreeVector(0,0,0);
91         auto trackerS = new G4Tubs("tracker", 0, trackerSize, trackerSize, 0. * deg, 360. * deg);
92         auto trackerLV = new G4LogicalVolume(trackerS, air, "Tracker", nullptr, nullptr, nullptr);
93         new G4PVPlacement(nullptr, // no rotation
94         positionTracker, // at (x,y,z)
```

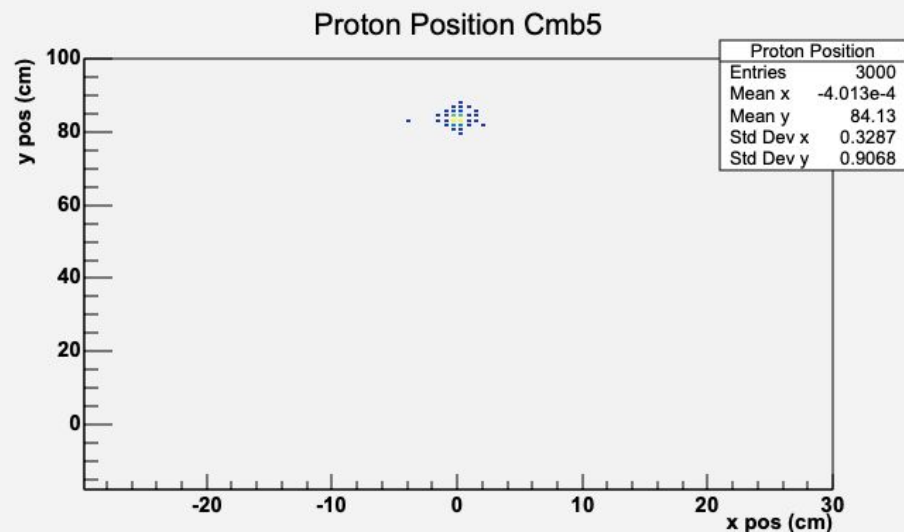
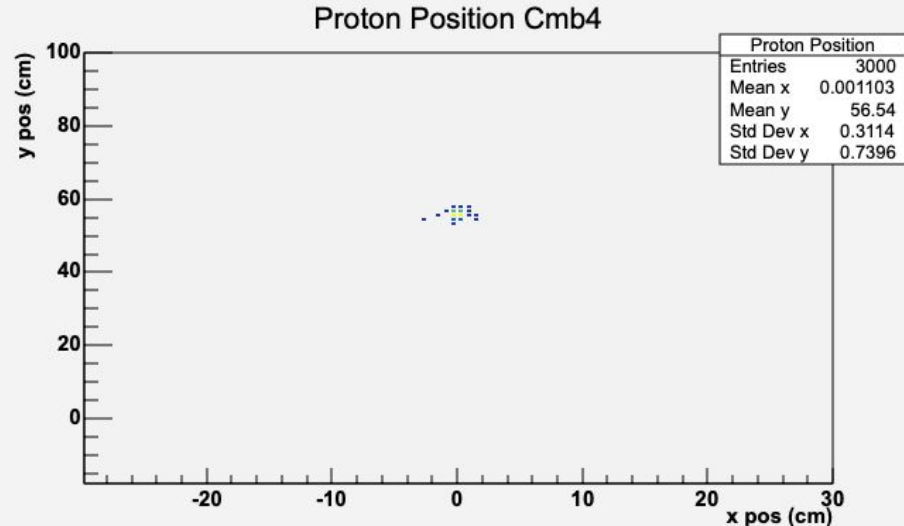
Simulating a Tracking Detector:

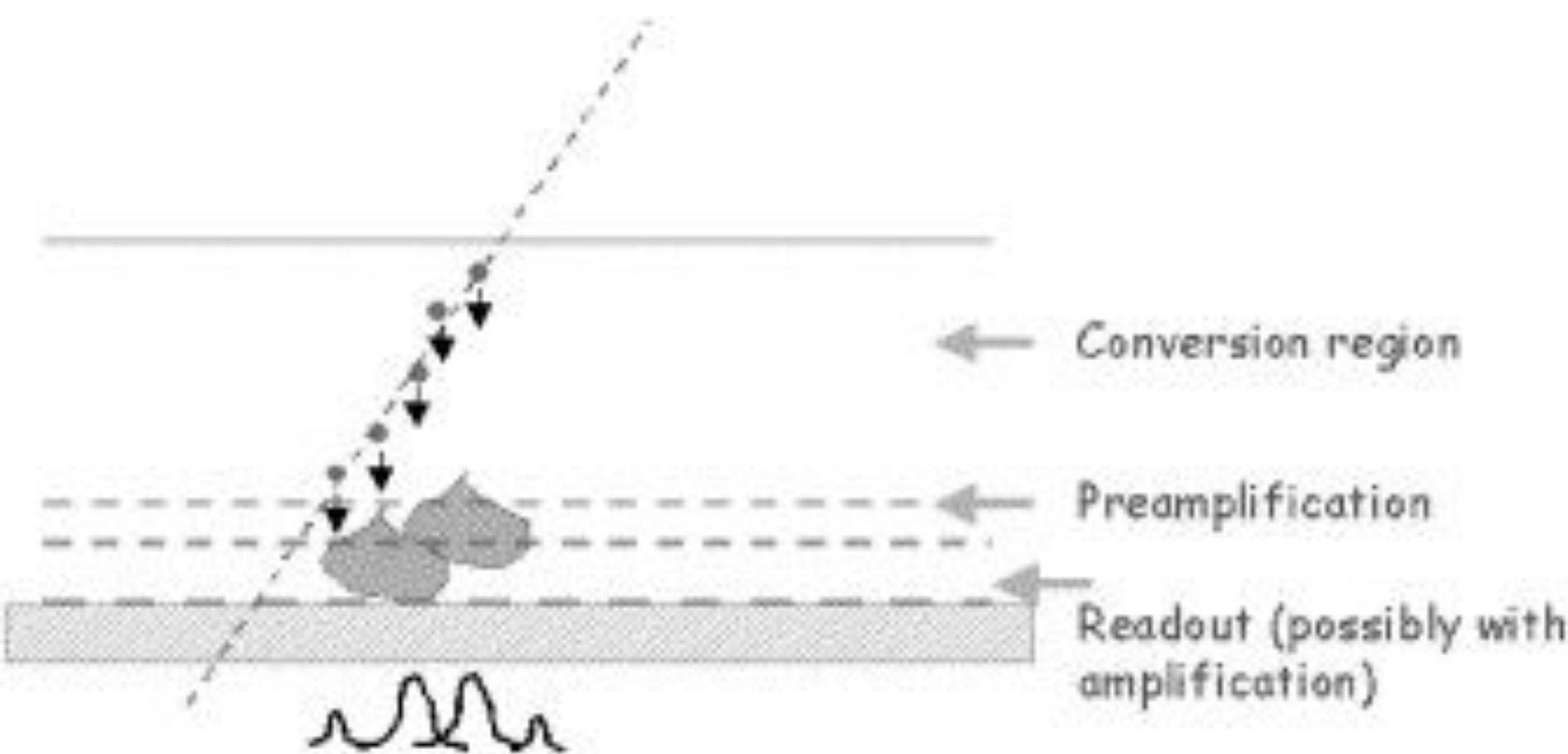
- Series of 5 “SensitiveDetectors”, regions filled with Xenon gas
- Spaced 80 cm apart (center to center)
- 20 cm thick
- Radius starts at 24 cm and increases by 54 cm each chamber

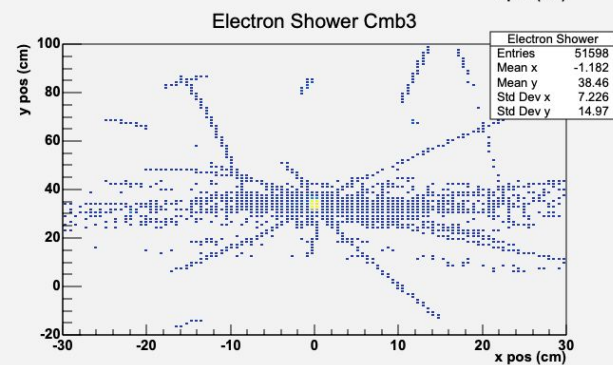
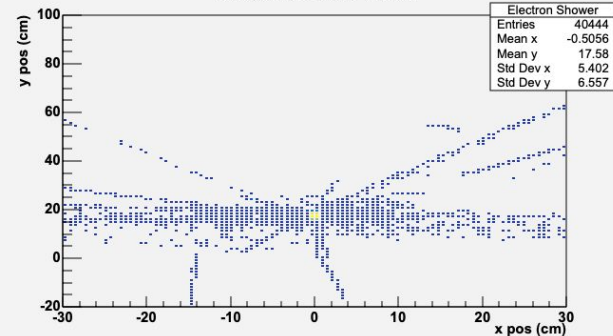
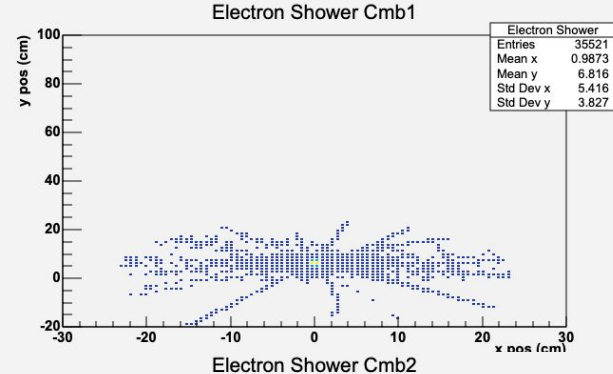




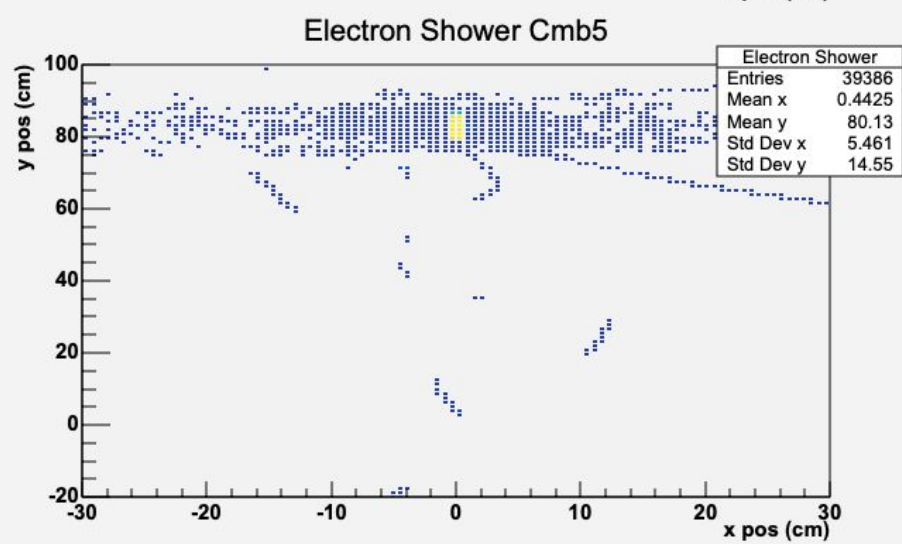
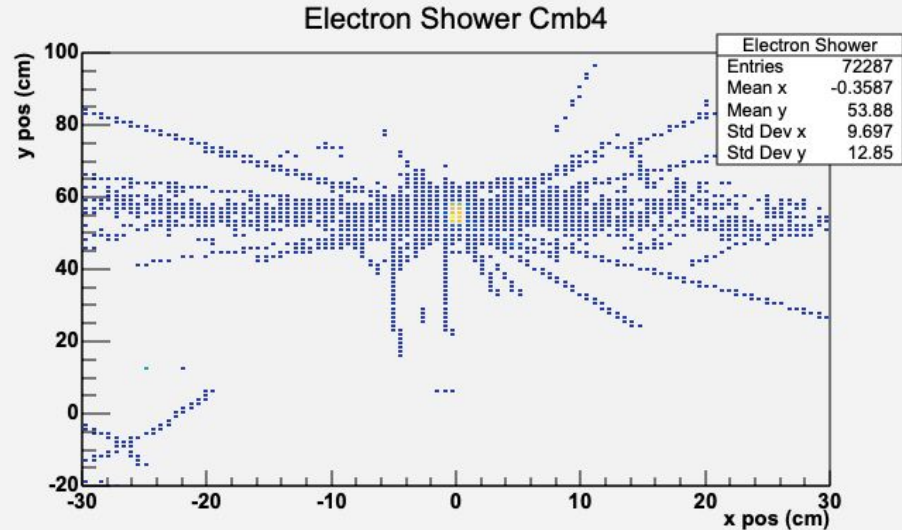
Using a 1 T magnetic field in the x direction (thus causing our protons to bend upwards), where does the initial proton hit?







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

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

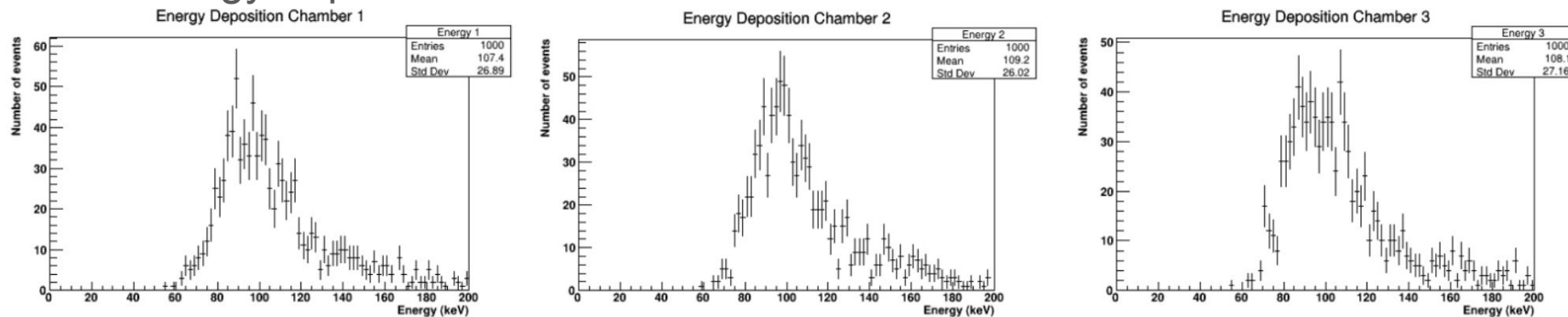
$$h = \frac{mv}{qB} - \sqrt{\left(\frac{mv}{qB}\right)^2 - x^2}$$

Magnetic field: 0

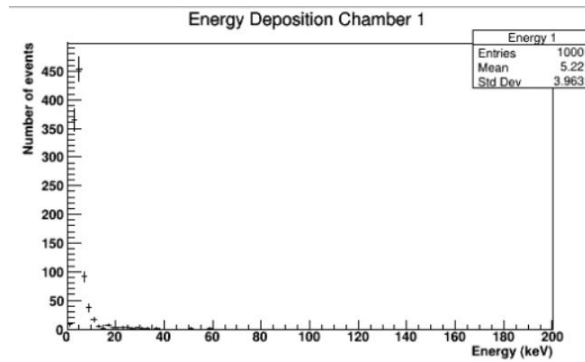
Energy of proton: 3GeV

Varying materials within the chambers

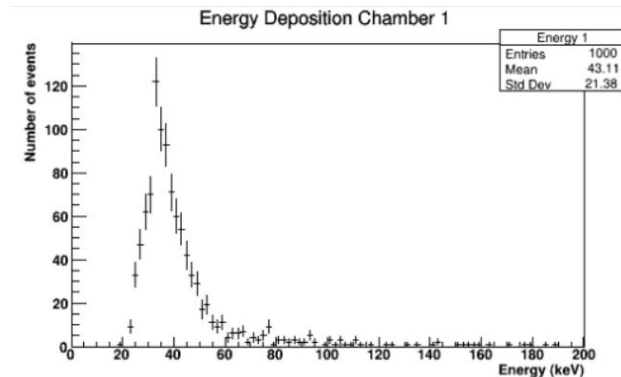
Xenon energy deposition:



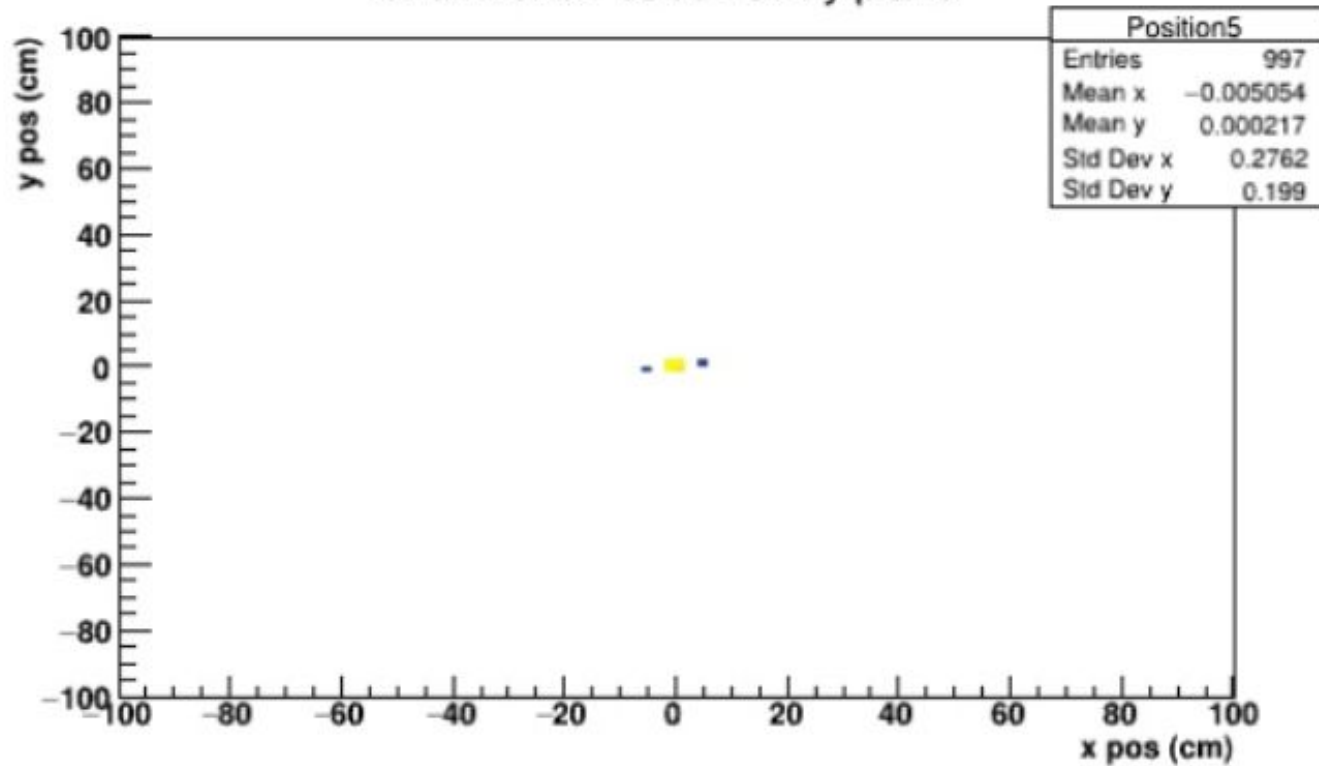
Helium:



Argon:

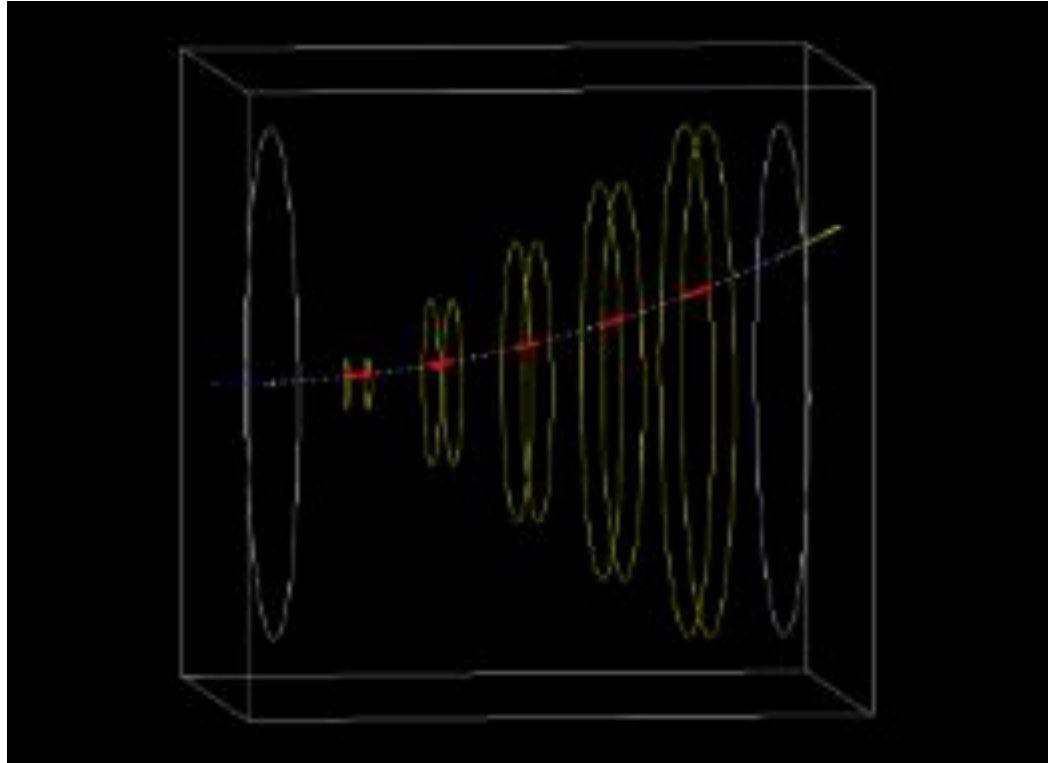


Chamber 5 Position on xy plane



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

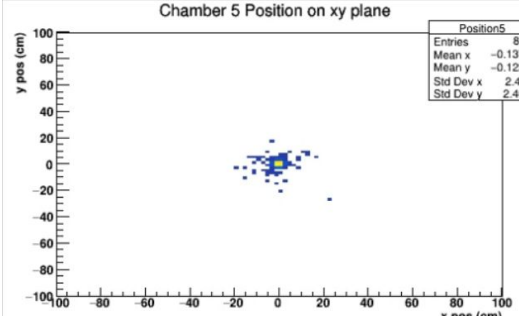
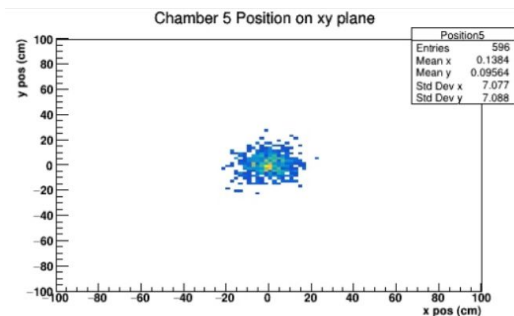
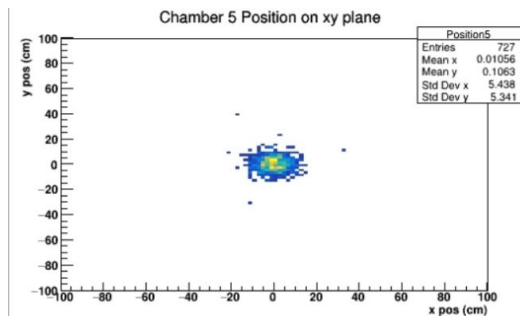
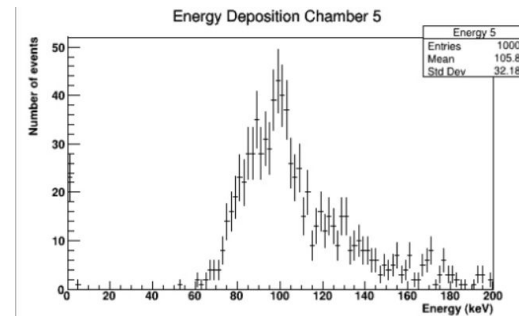
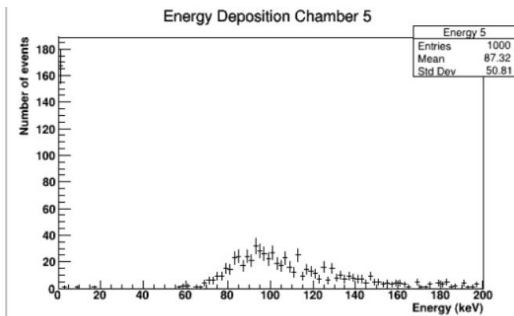
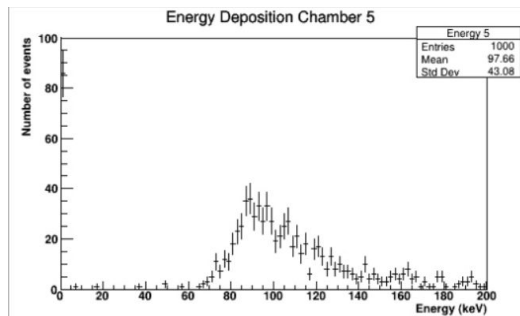
Energy of proton: 3GeV

Chamber: Xe

Pb target:

Au target:

Al target:



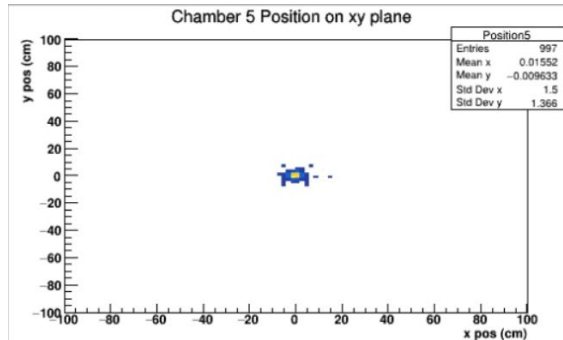
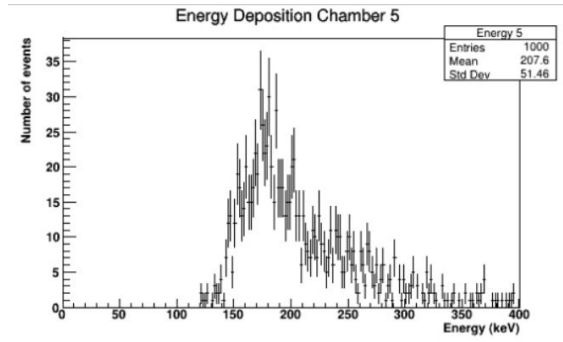
Varying the energy of the proton beam

Magnetic field: 0

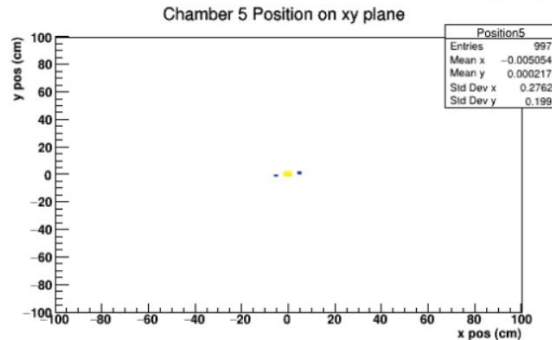
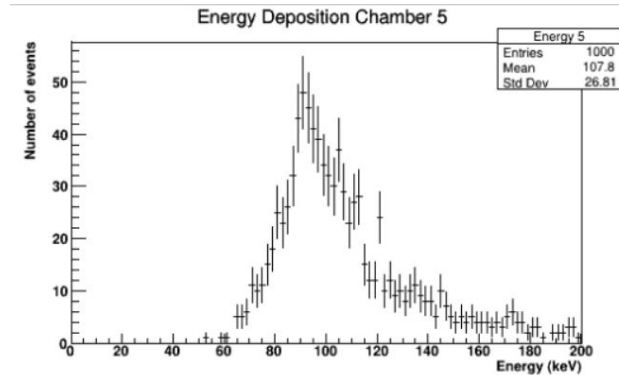
Energy of proton: 3GeV

Chamber: Xe

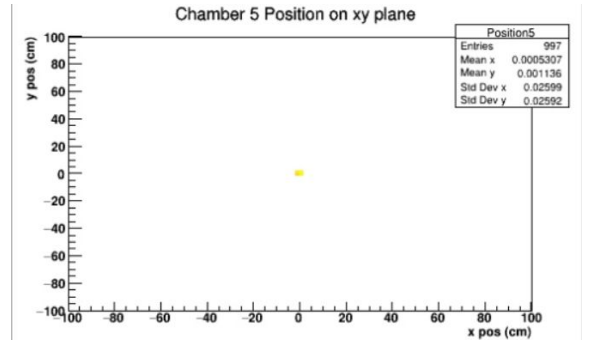
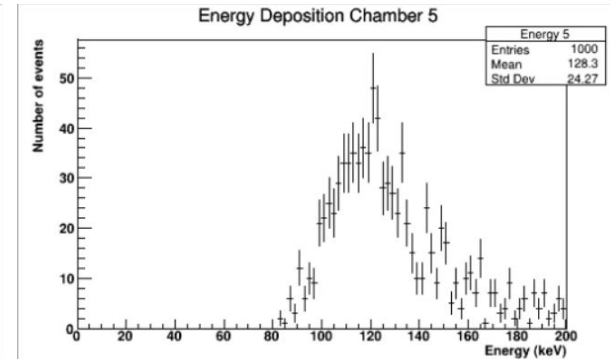
0.3GeV:



3GeV:

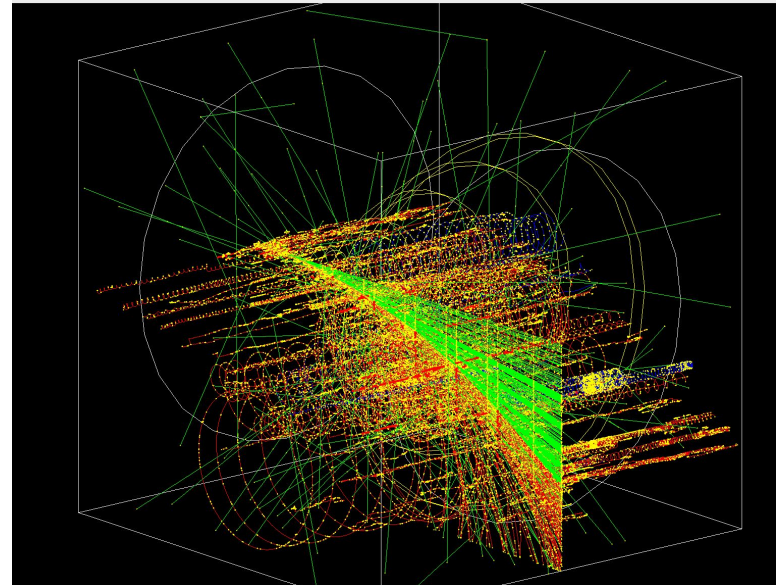
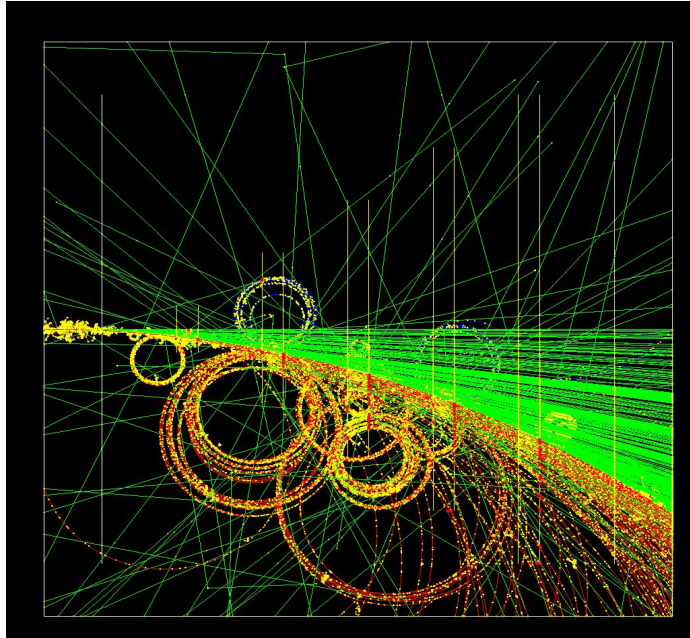


30GeV:

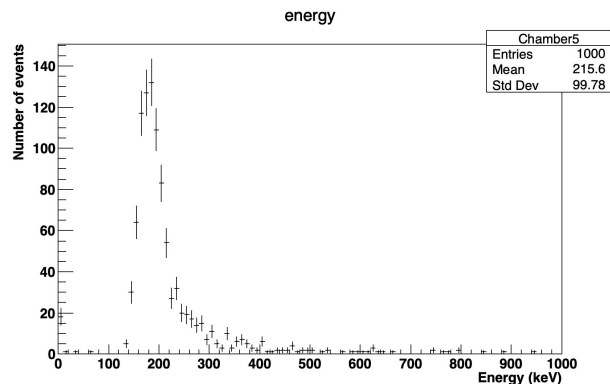
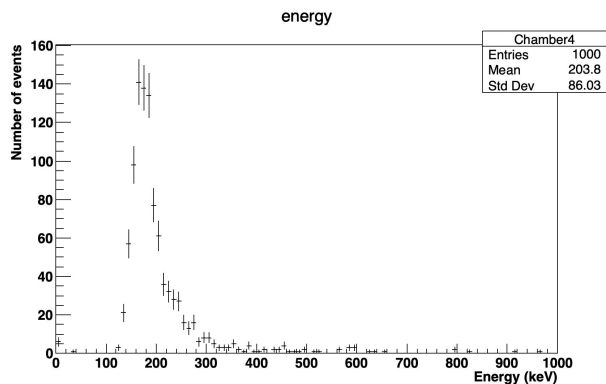
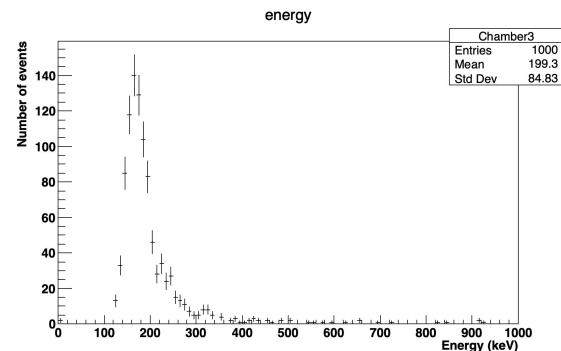
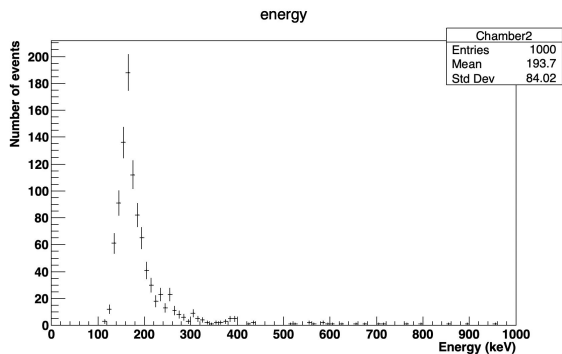
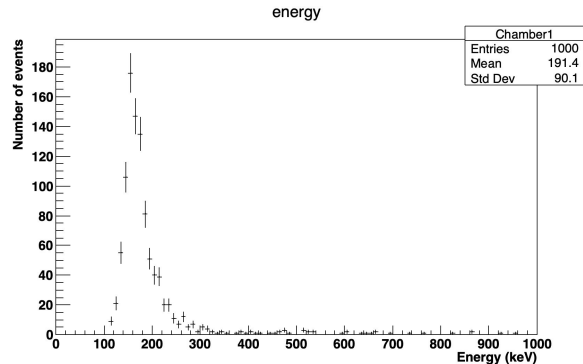


Ep and Moller scattering simulation

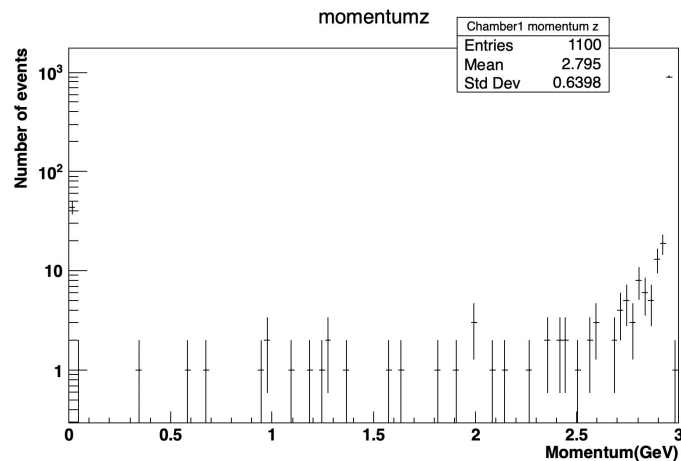
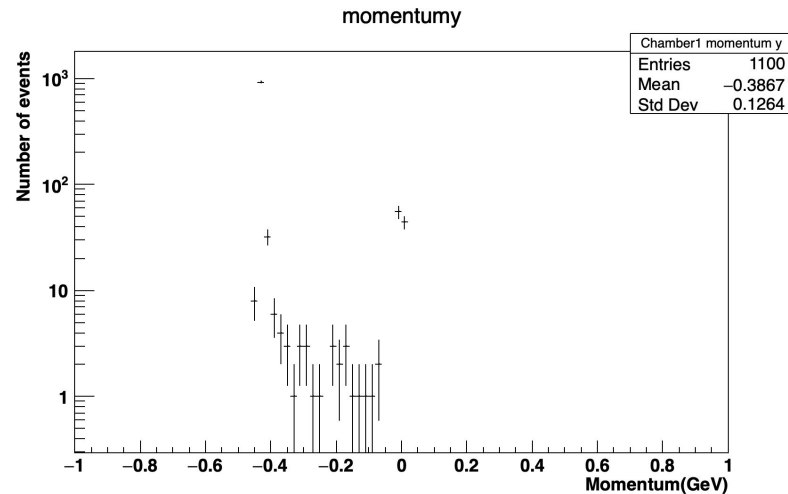
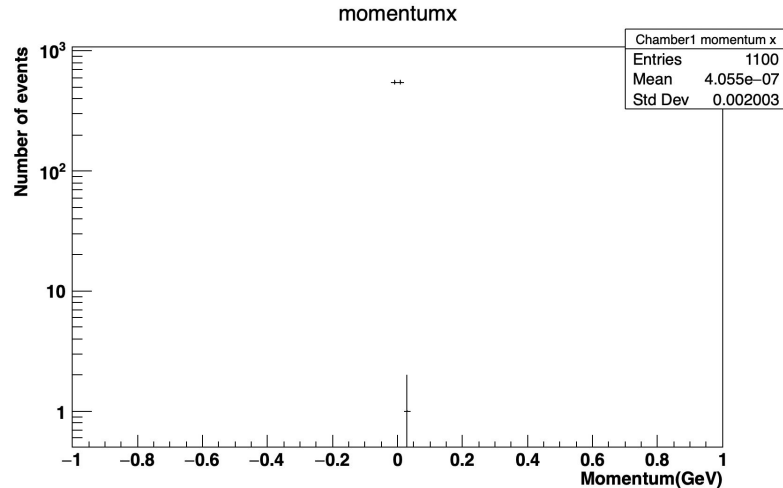
I use e- beam to hit fixed Hydrogen target. Here is the result for 1000 e- shooting to the target. The magnetic field is 1 tesla in positive x position.



Results energy for electrons of my detectors



Momentum distribution for electrons on the back edges in Chamber 1



Just for compare

