



# Geant4 Simulation Studies

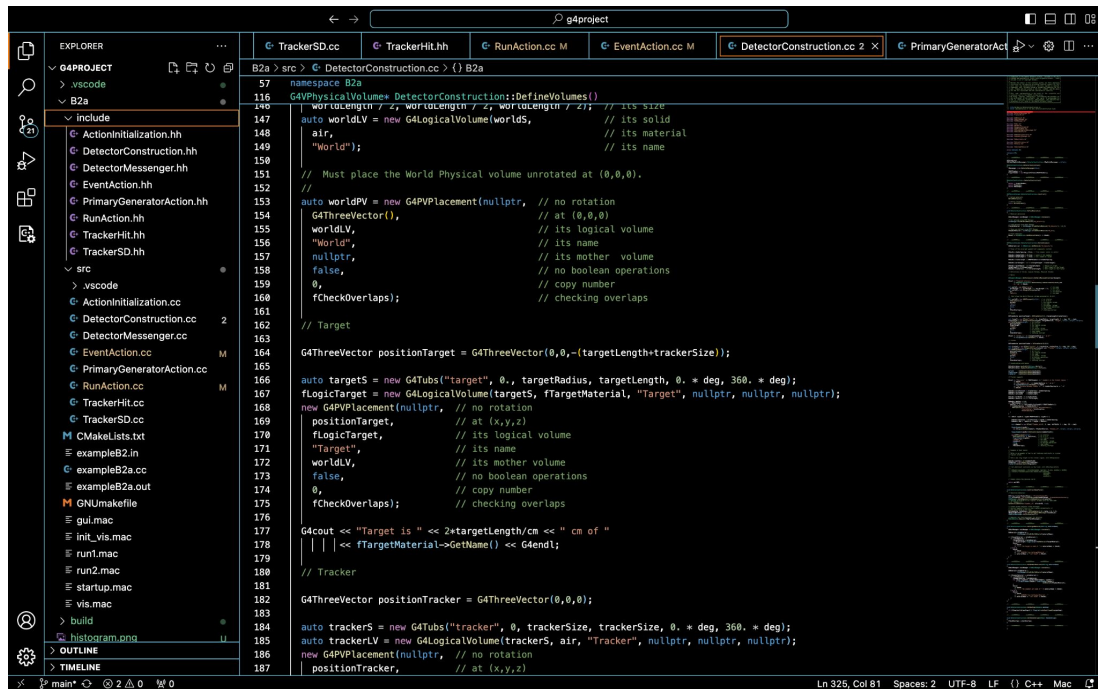
Claire Landgraf  
Jacob McMurtry  
Xiang Zhang

# 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):

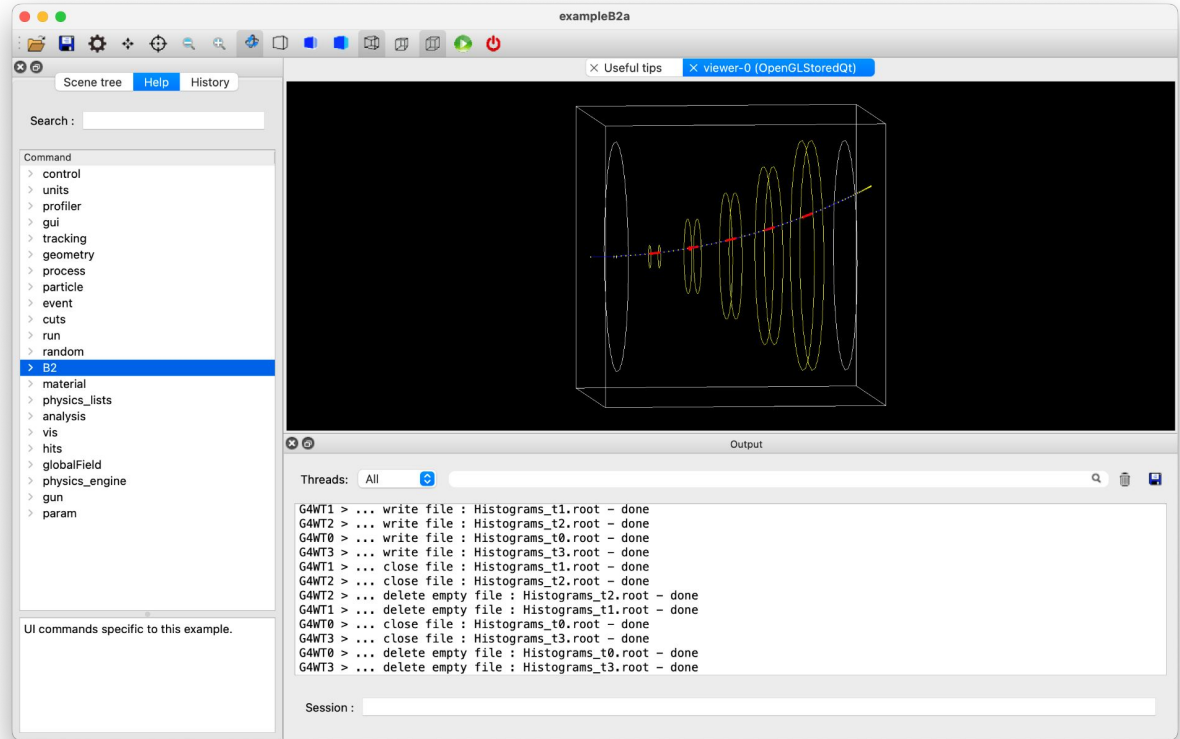
- Geant4 has a lot of moving parts
- Based our code on example B2a in the Geant4 library
  - Changes to detector operations occurred in TrackerSD and TrackerHit files
  - Changes to root file creation for data storage in RunAction and Event Action Files
  - Changes to physical geometries in DetectorConstruction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

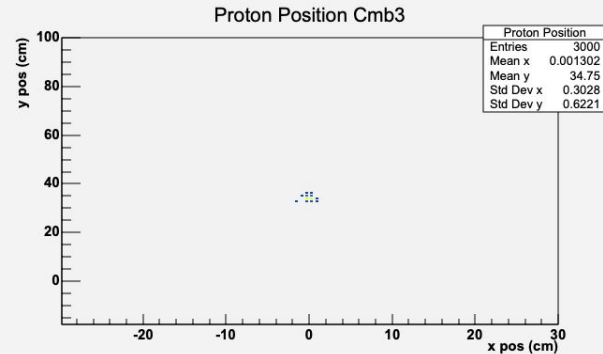
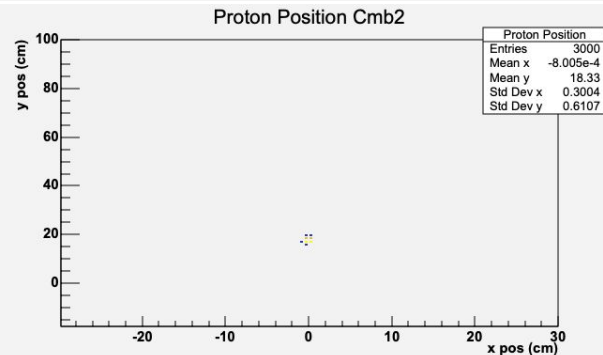
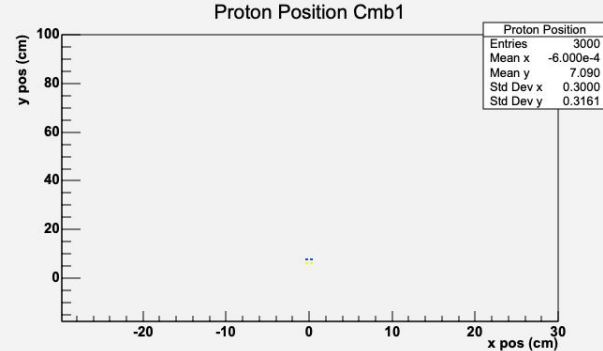


```
57 namespace B2a
116 G4PhysicalVolume* DetectorConstruction::DefineVolumes()
147 {
148     auto worldLV = new G4LogicalVolume(worldSD, // its size
149     air, // its solid
150     "World"); // its material
151     // Must place the World Physical volume unrotated at (0,0,0).
152     //
153     auto worldPV = new G4PVPlacement(nullptr, // no rotation
154     G4ThreeVector(), // at (0,0,0)
155     worldLV, // its logical volume
156     "World", // its name
157     nullptr, // its mother volume
158     false, // no boolean operations
159     0, // copy number
160     fCheckOverlaps); // checking overlaps
161     // Target
162     G4ThreeVector positionTarget = G4ThreeVector(0,0,-(targetLength+trackerSize));
163     auto targetS = new G4Tubs("target", 0, targetRadius, targetLength, 0, *deg, 360, *deg);
164     fLogicTarget = new G4LogicalVolume(targetS, fTargetMaterial, "Target", nullptr, nullptr, nullptr);
165     new G4PVPlacement(nullptr, // no rotation
166     positionTarget, // at (x,y,z)
167     fLogicTarget, // its logical volume
168     "Target", // its name
169     worldLV, // its mother volume
170     false, // no boolean operations
171     0, // copy number
172     fCheckOverlaps); // checking overlaps
173     G4cout << "Target is " << 2*targetLength/cm << " cm of "
174     | | << fTargetMaterial->GetName() << G4endl;
175     // Tracker
176     G4ThreeVector positionTracker = G4ThreeVector(0,0,0);
177     auto trackerS = new G4Tubs("tracker", 0, trackerSize, trackerSize, 0, *deg, 360, *deg);
178     auto trackerLV = new G4LogicalVolume(trackerS, air, "Tracker", nullptr, nullptr, nullptr);
179     new G4PVPlacement(nullptr, // no rotation
180     positionTracker, // at (x,y,z)
```

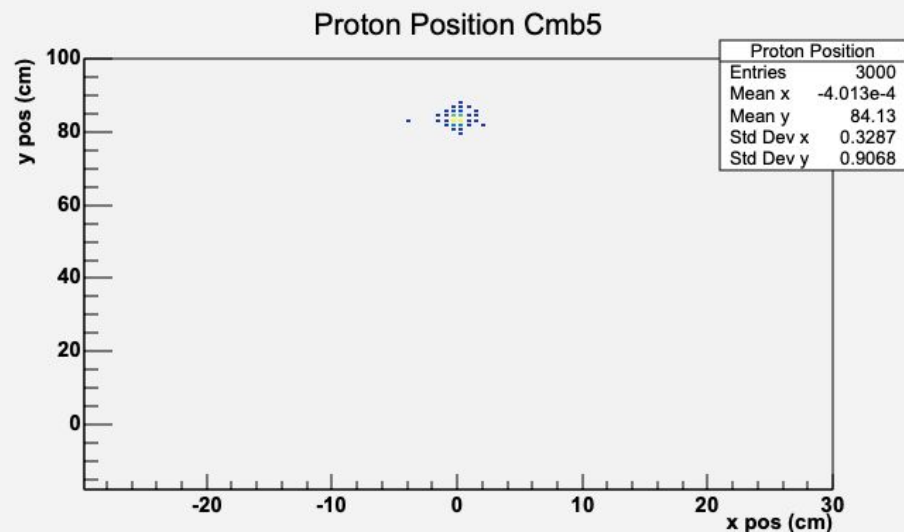
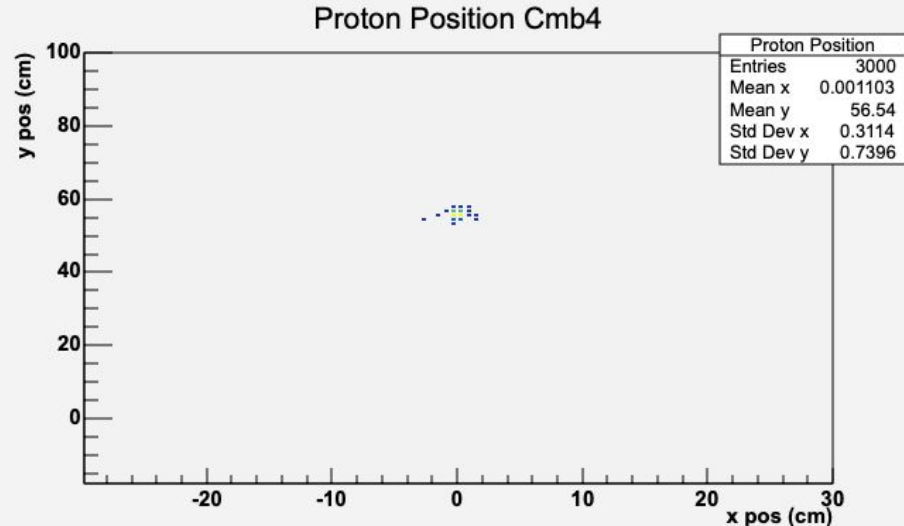
# Simulating a Tracking Detector:

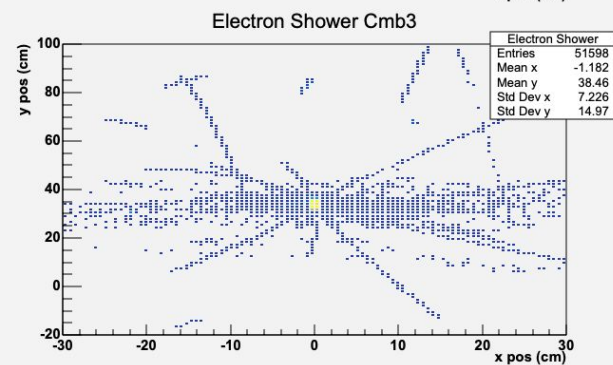
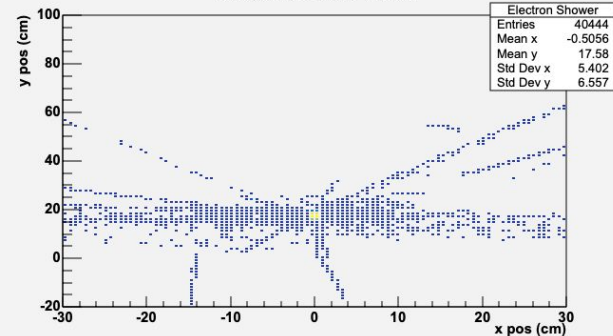
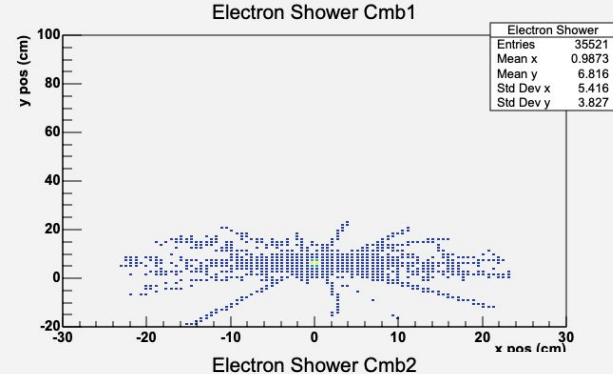
- Series of 5 “SensitiveDetectors”, regions filled with Xenon gas
- Spaced 80 cm apart (center to center)
- 20 cm thick
- Radius starts at 24 cm and increases by 54 cm each chamber



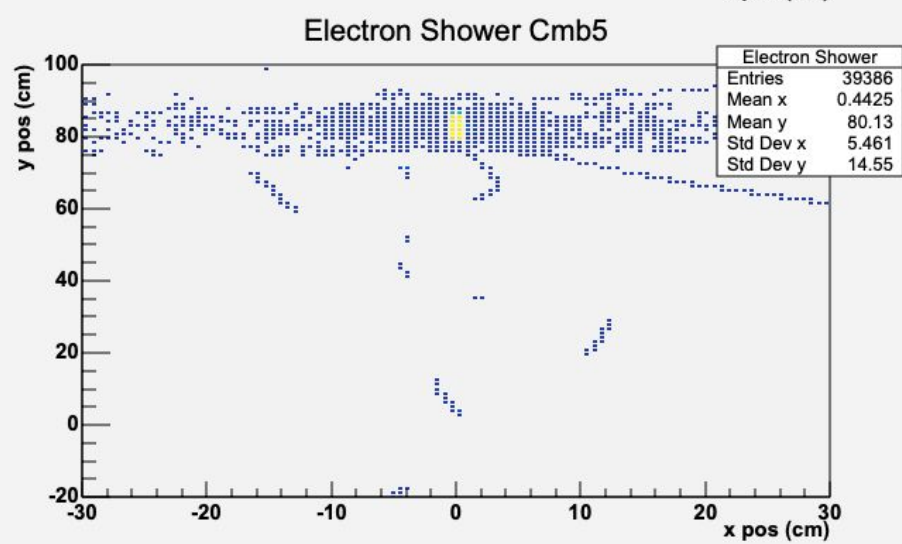
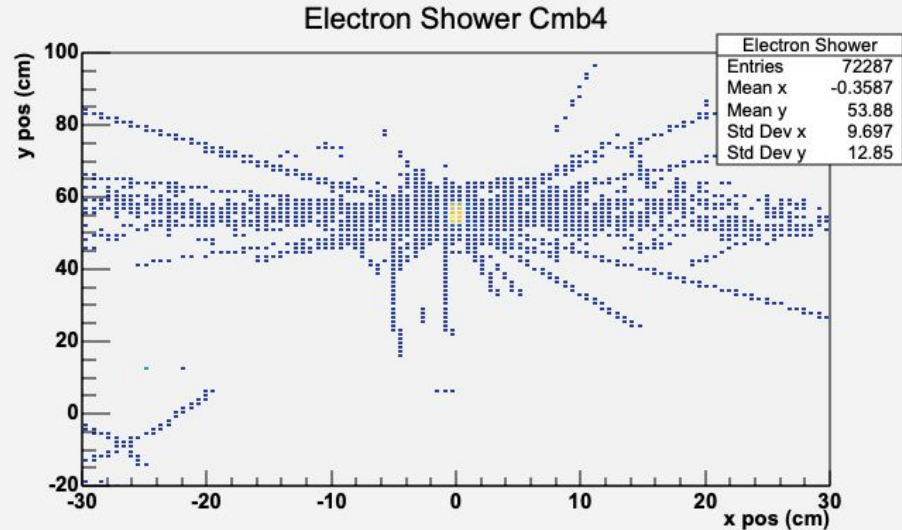


Using a 1 T magnetic field in the x direction (thus causing our protons to bend upwards), where does the initial proton hit?





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

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

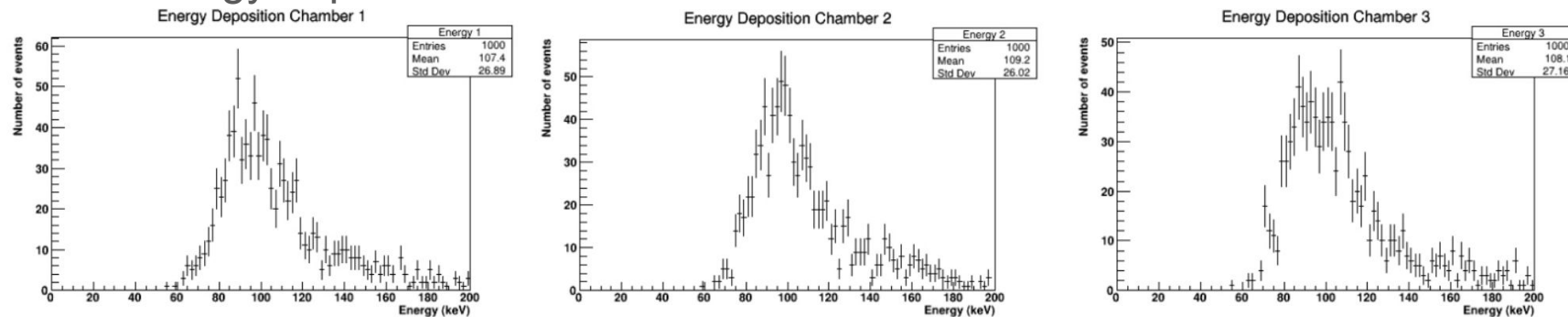
$$h = \frac{mv}{qB} - \sqrt{\left(\frac{mv}{qB}\right)^2 - x^2}$$

Magnetic field: 0

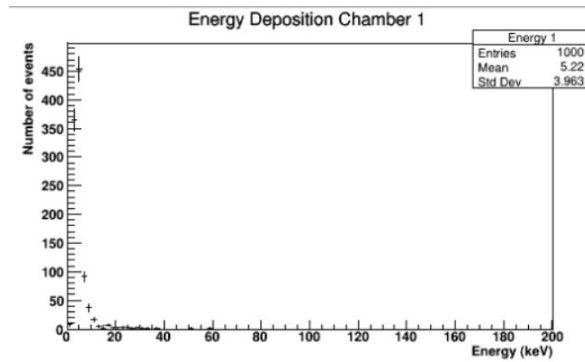
Energy of proton: 3GeV

# Varying materials within the chambers

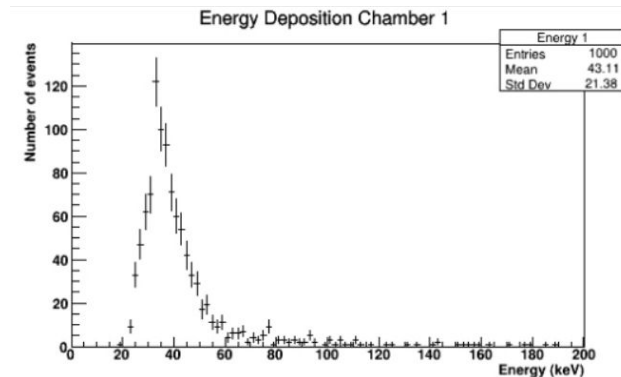
## Xenon energy deposition:



## Helium:

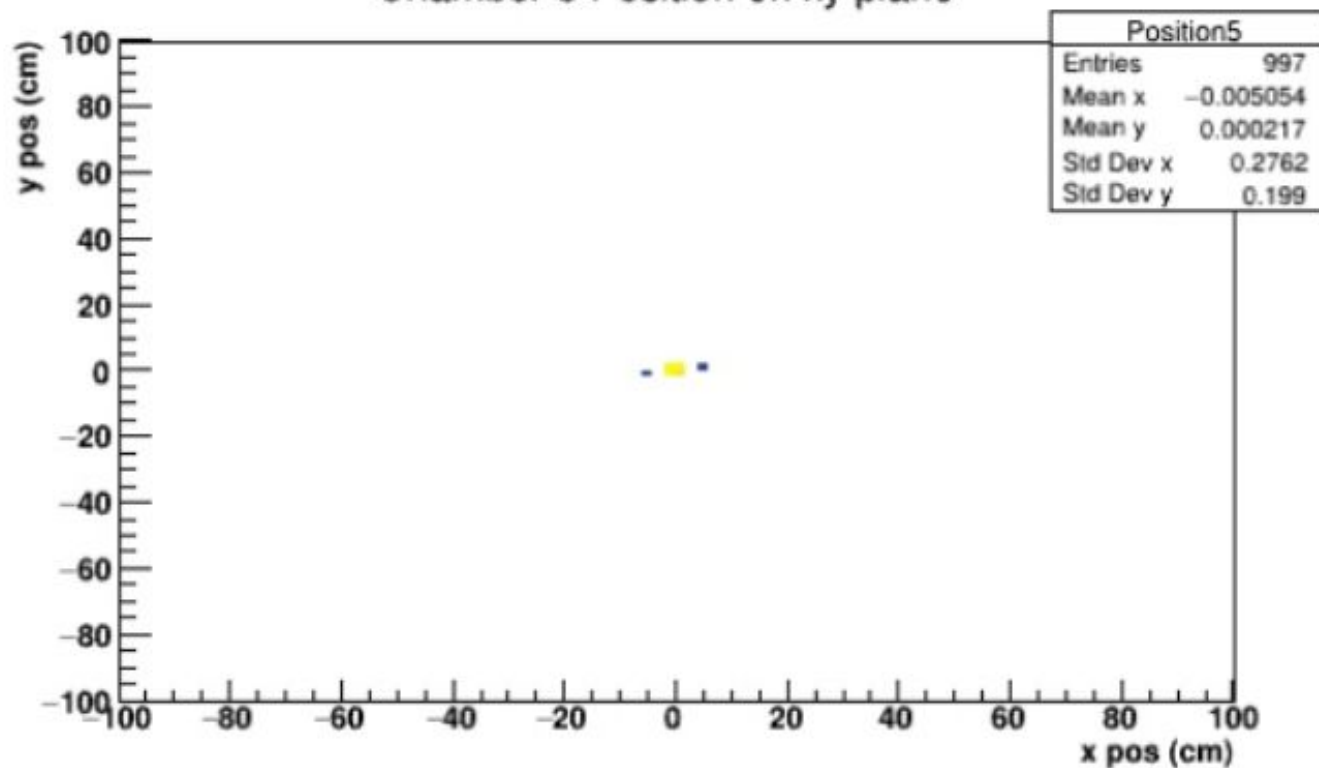


## Argon:



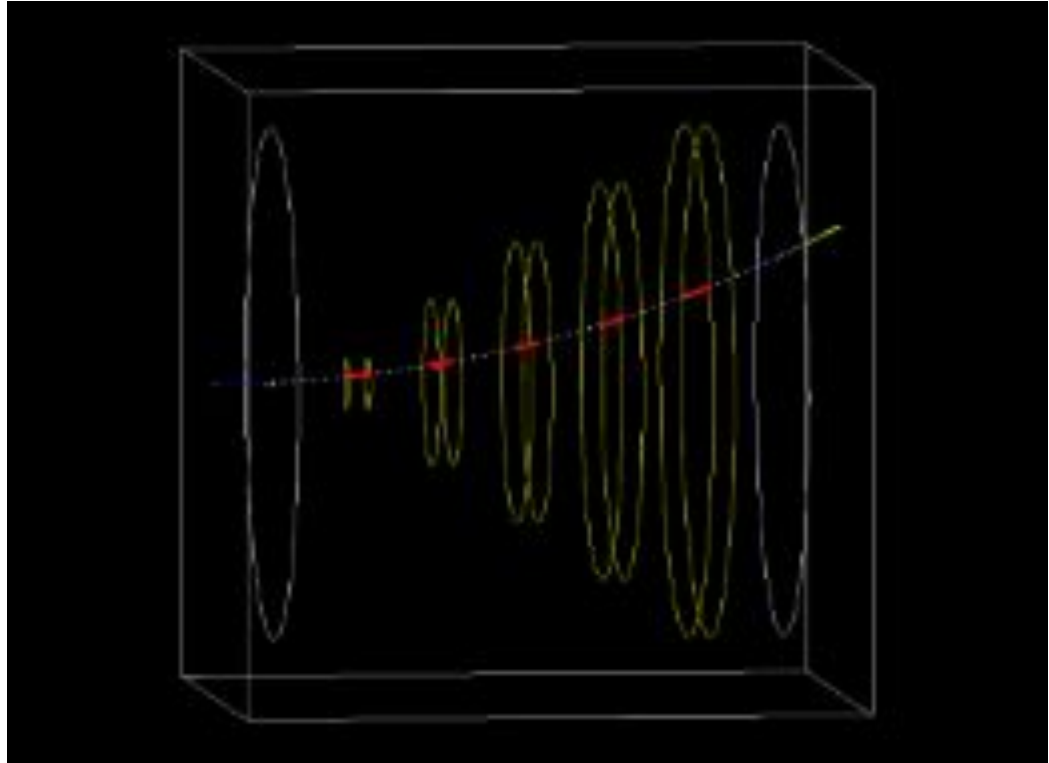


Chamber 5 Position on xy plane



# 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

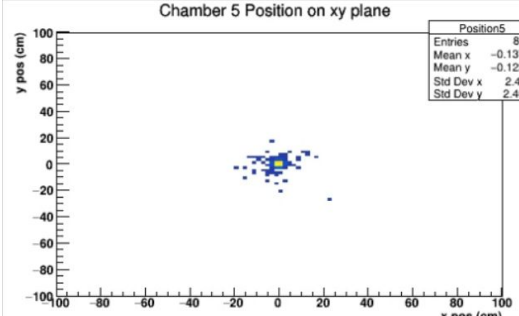
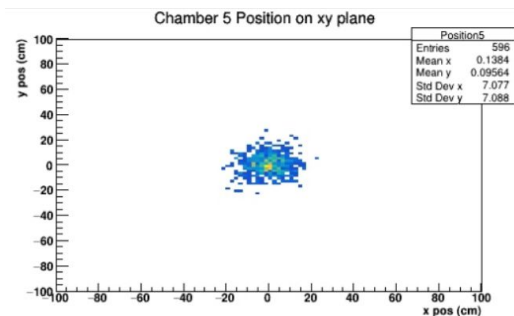
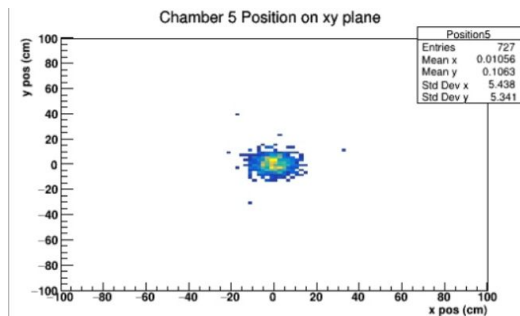
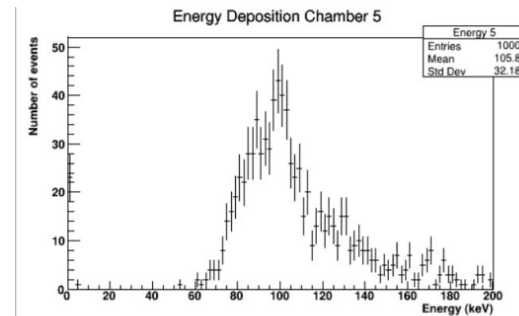
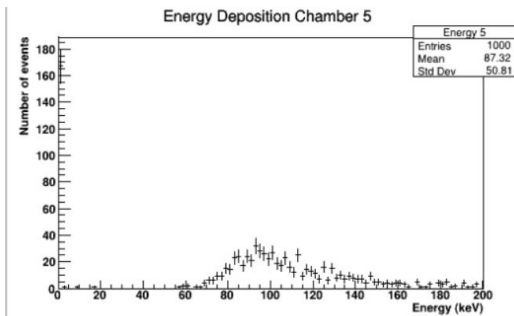
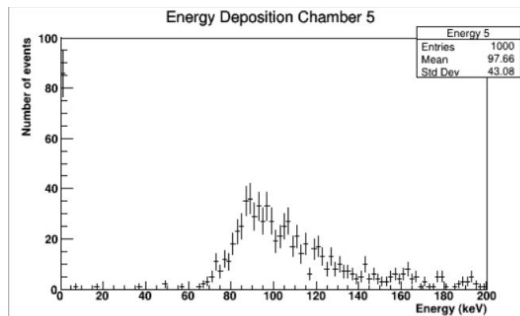
Energy of proton: 3GeV

Chamber: Xe

Pb target:

Au target:

Al target:



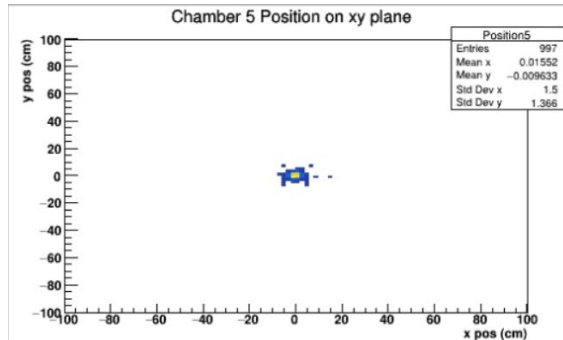
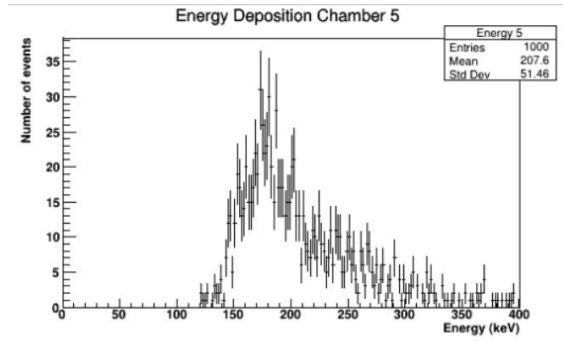
# Varying the energy of the proton beam

Magnetic field: 0

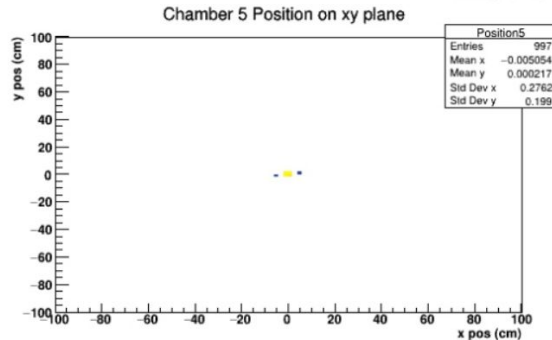
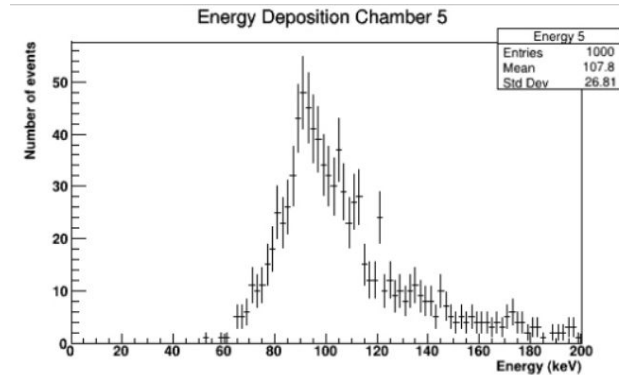
Energy of proton: 3GeV

Chamber: Xe

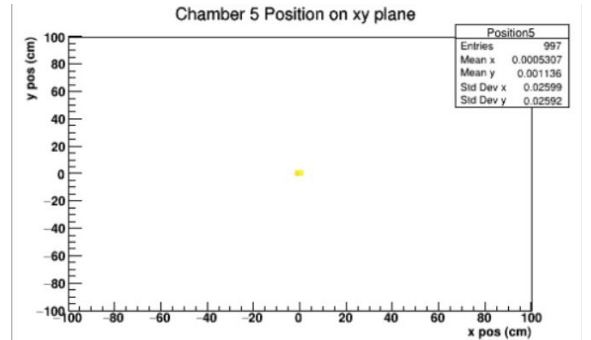
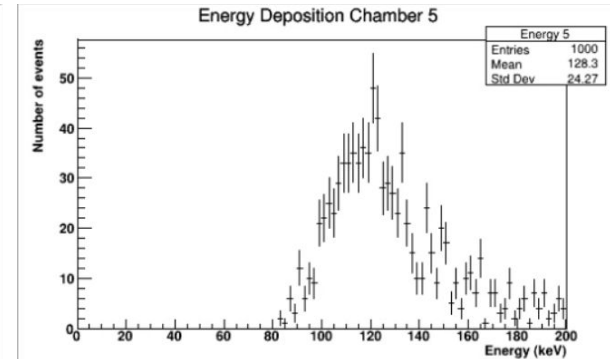
0.3GeV:



3GeV:

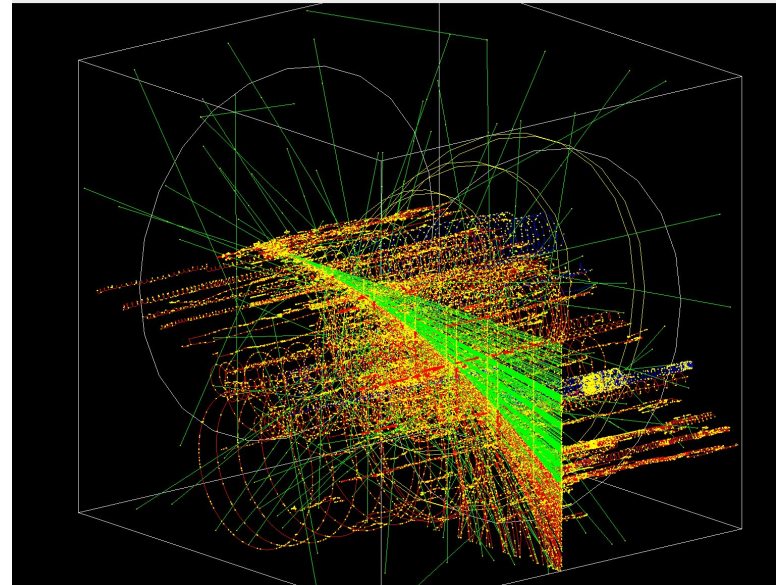
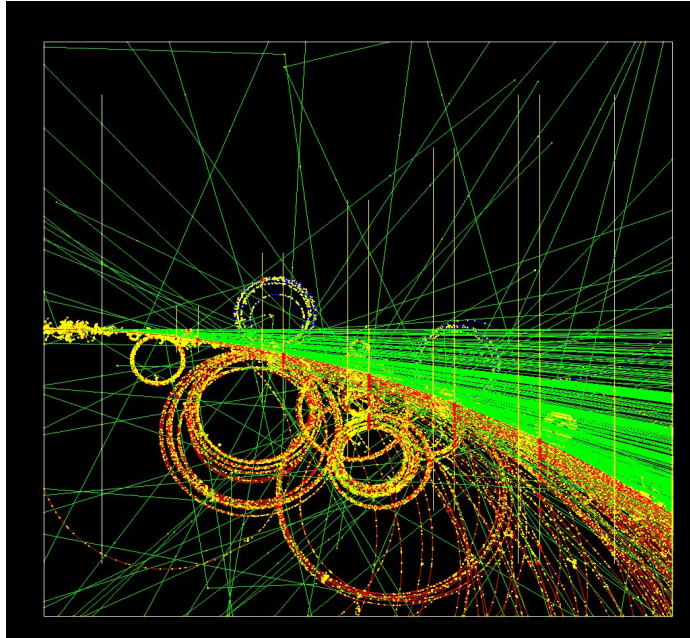


30GeV:

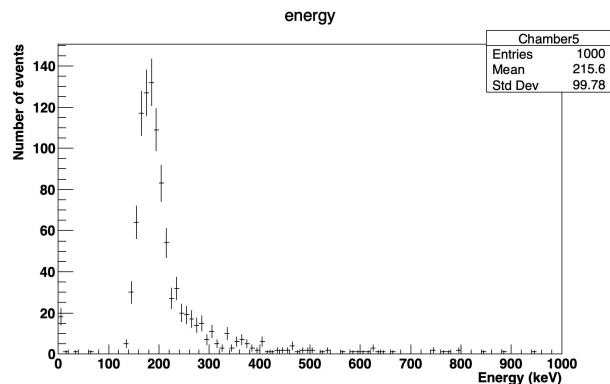
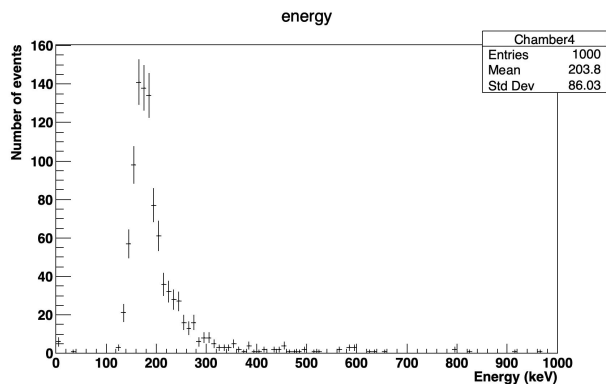
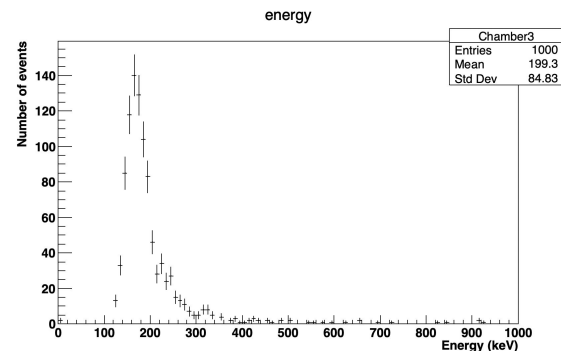
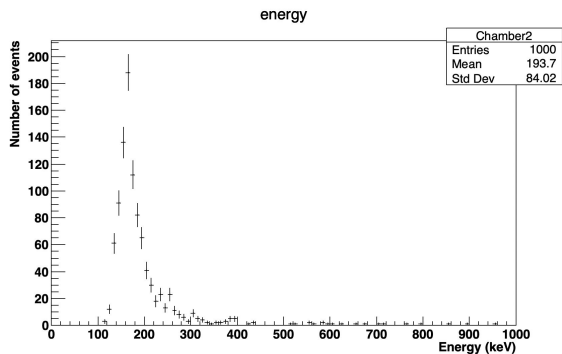
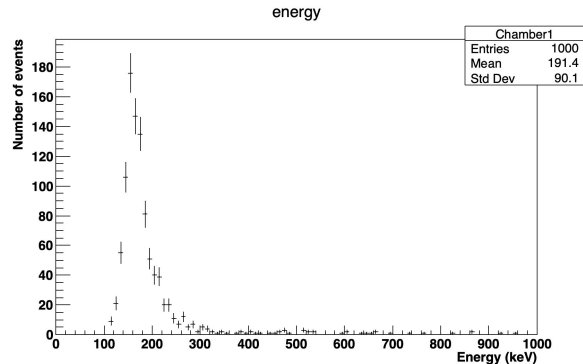


# Ep and Moller scattering simulation

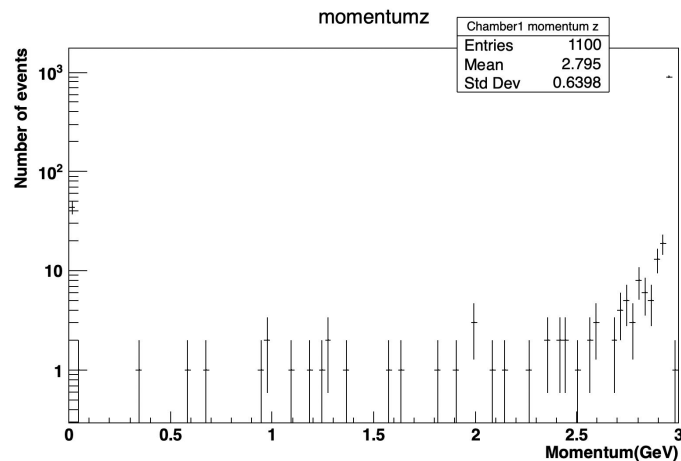
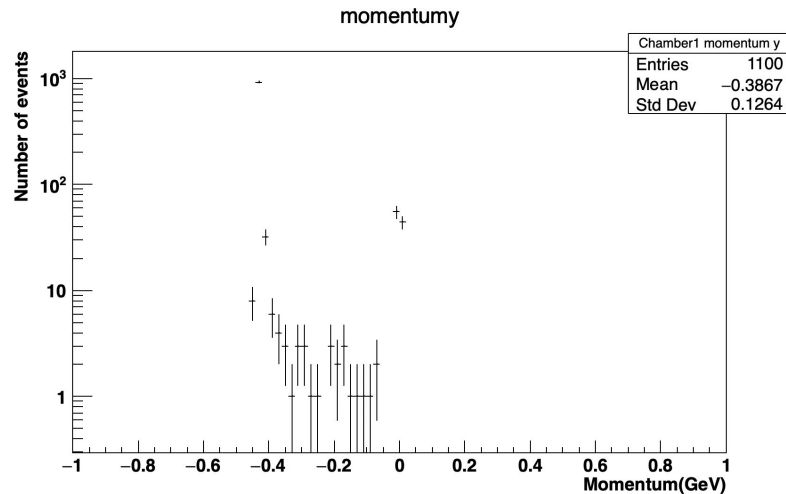
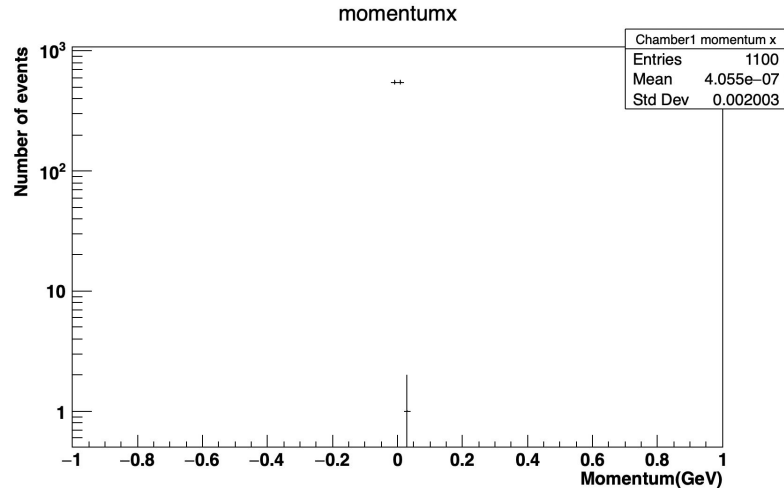
I use e- beam to hit fixed Hydrogen target. Here is the result for 1000 e- shooting to the target. The magnetic field is 1 tesla in positive x position.



# Results energy for electrons of my detectors



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



# Just for compare

