LumiCal Performance with a Tracking Detector

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Outline

- Introduction and motivation for the study
- Simulation with LuCaS
- Reconstruction with LumiCal clustering software
- LumiCal with and without tracking detector
- Summary and plans

Tracking Detector

- Improve polar angle measurement accuracy;
- LumiCal alignment;
- Provide more information to enable e/γ identification, important for various physics study.

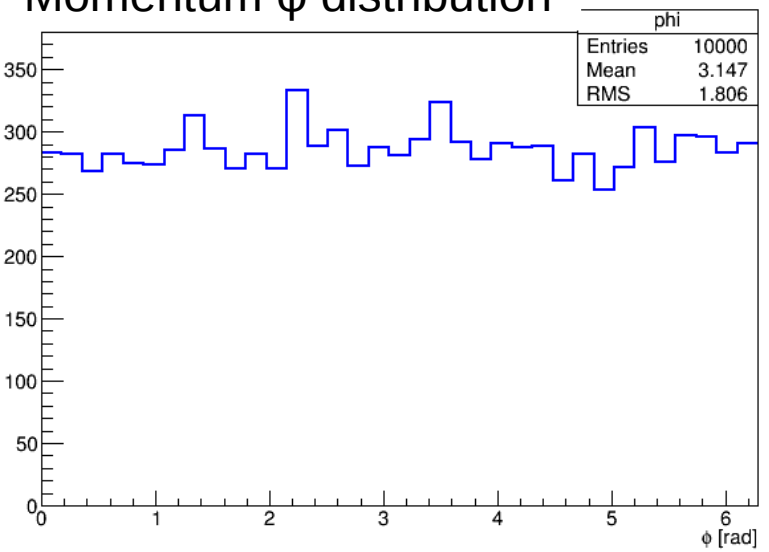
As a possible candidate could be Mimosa sensor

- Mimosa – MOS Active Pixel, developed in Strasbourg.
- Mimosa-28 is used in STAR inner tracker at RHIC, possibly will be approved for ALICE ITS upgrade;
- We are developing the facilities for Mimosa test at TAU;
- Important to evaluate the radiation dose and radiation hardness of the Mimosa sensor.

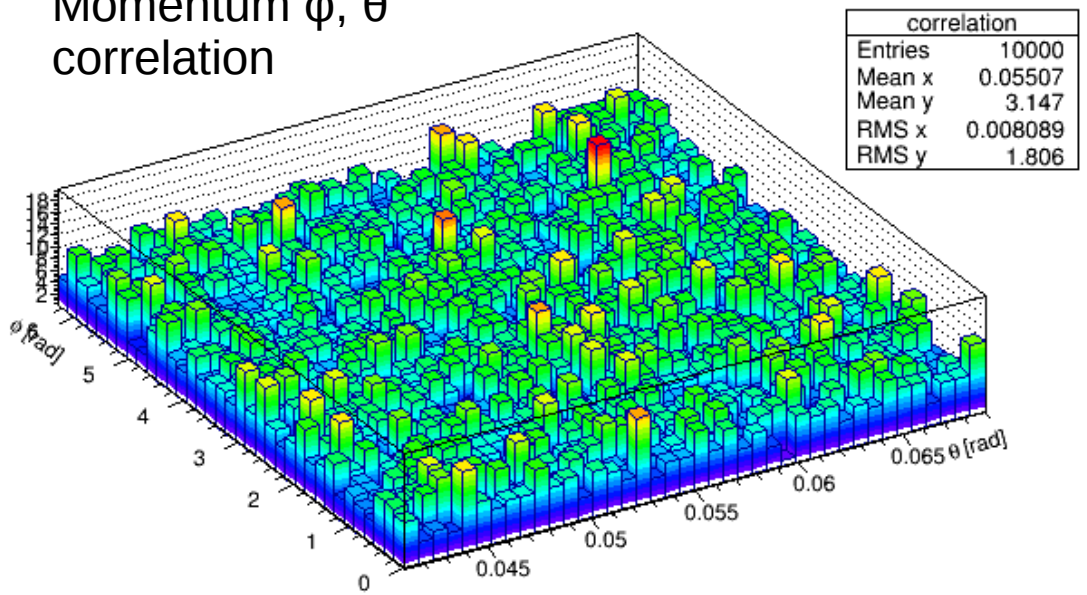
Generated Events

- Subset of 2000-5000 events out of 10000 were used for simulation
- Each event contains one e^-, 250 GeV;
- Uniformly distributed on momentum φ (0, 2π), θ (41, 69 mrad).

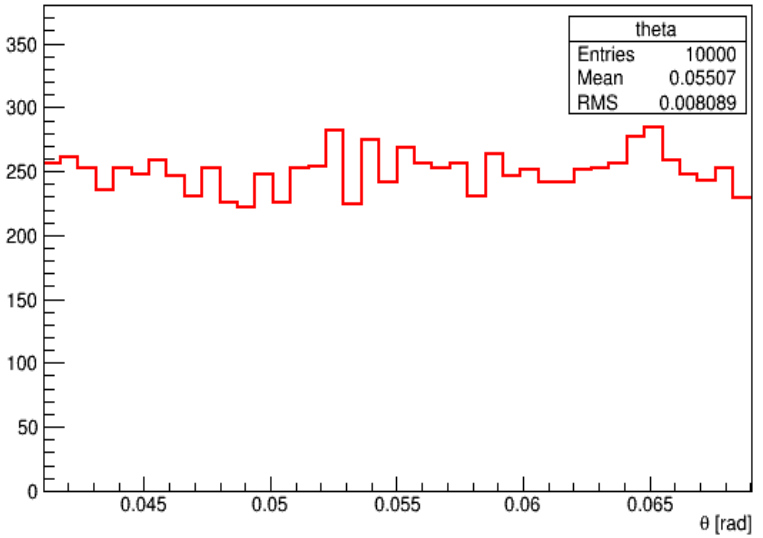
Momentum φ distribution



Momentum φ, θ correlation

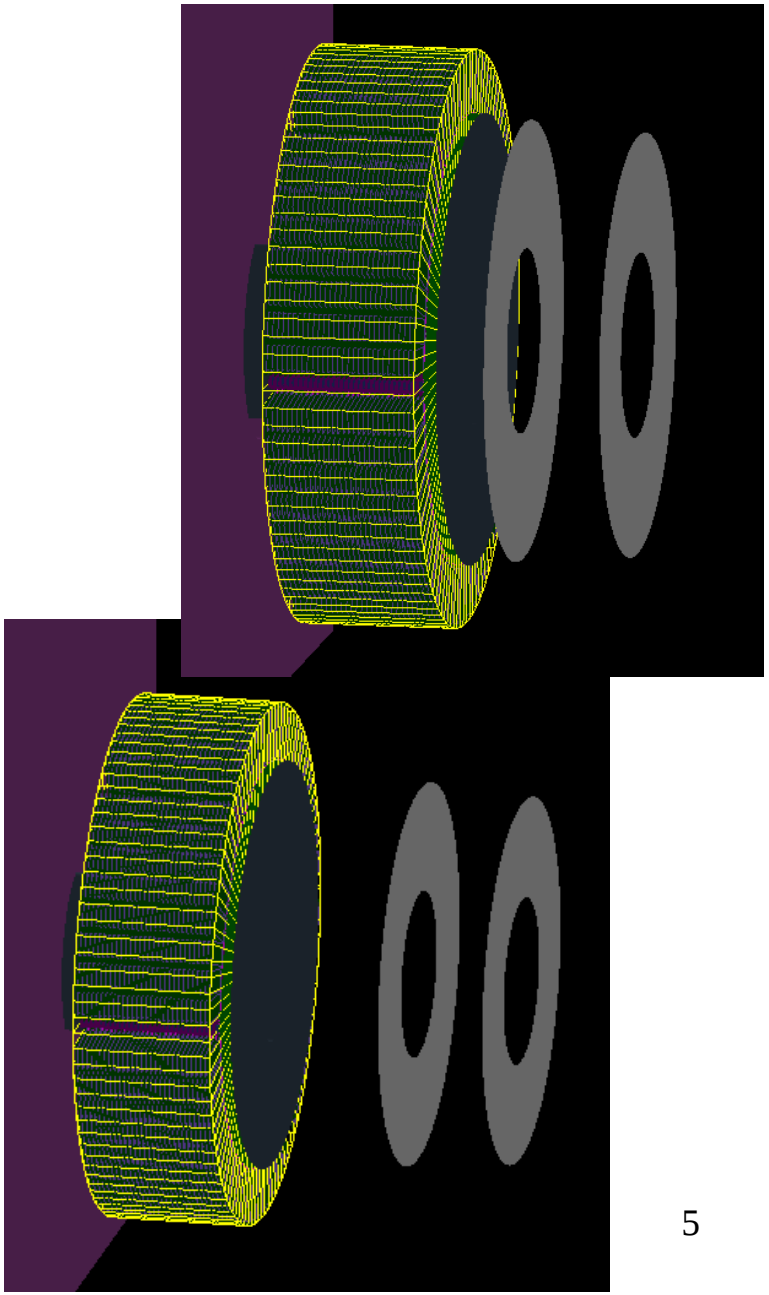


Momentum θ distribution



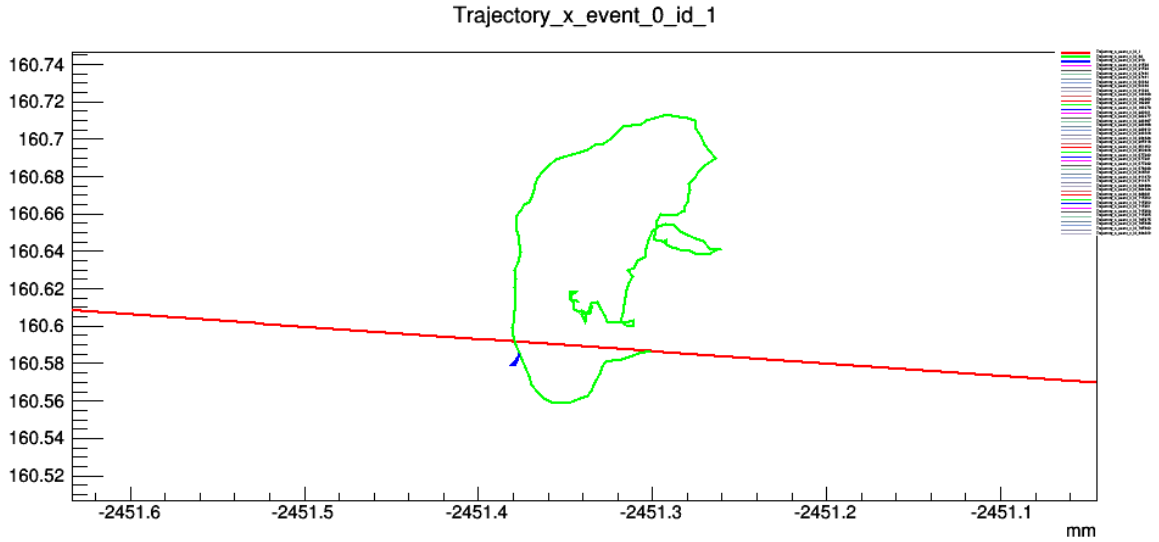
Simulation

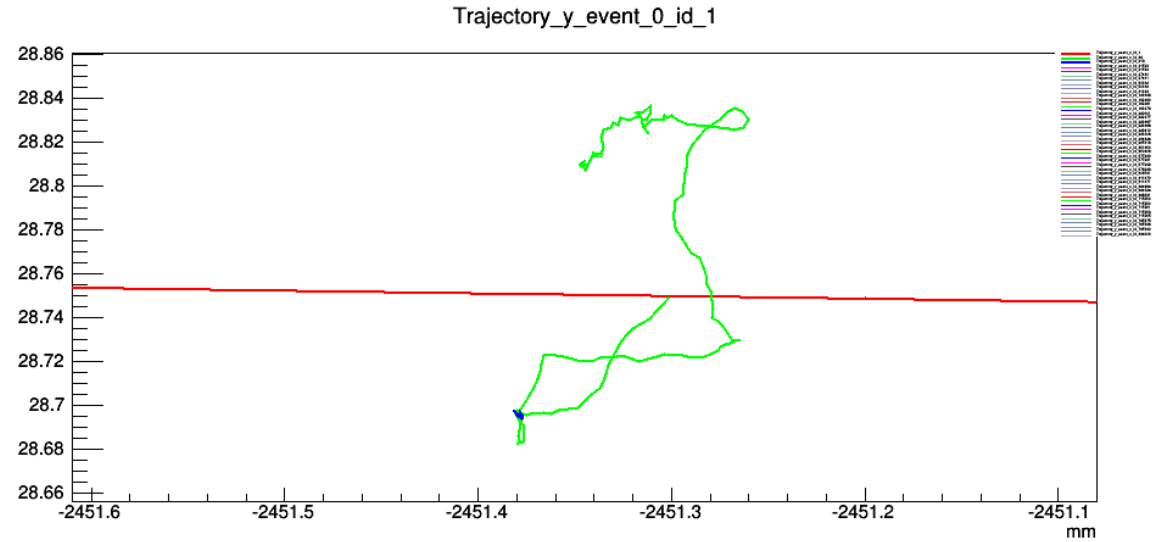
- Modified versions of LuCaS (Geant4 application) was used;
- Range cut: 20 μm (5 μm also was tested);
- Minimum step: 5 μm;
- Physics list: QGSP_BERT;
- Two layers of Si 100 μm thick;
- Different distance to LumiCal;



Comparison of Geant4 visualization and reconstruction from the hits

Tungsten was considered to have more secondary particles





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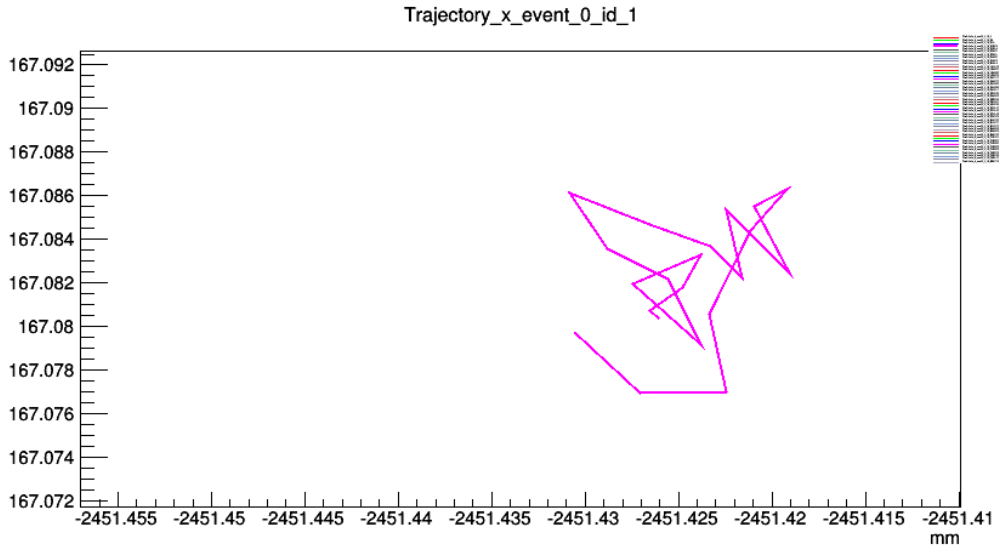
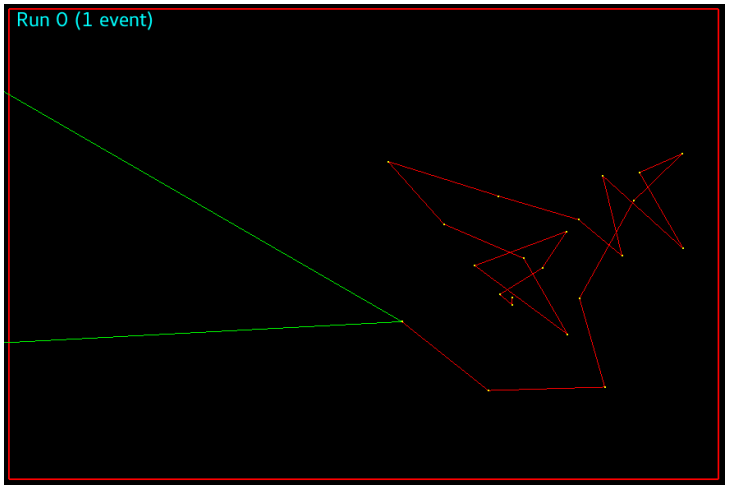
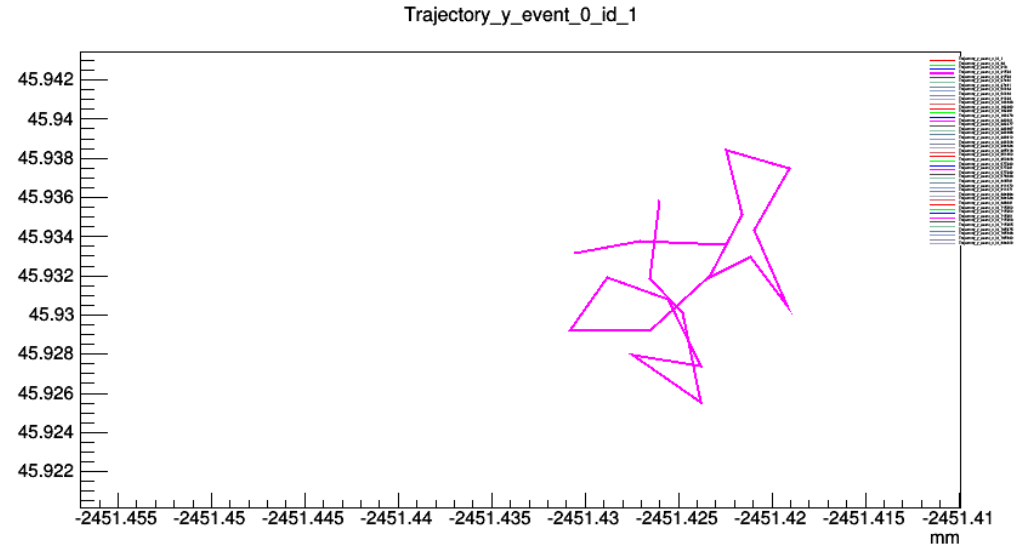
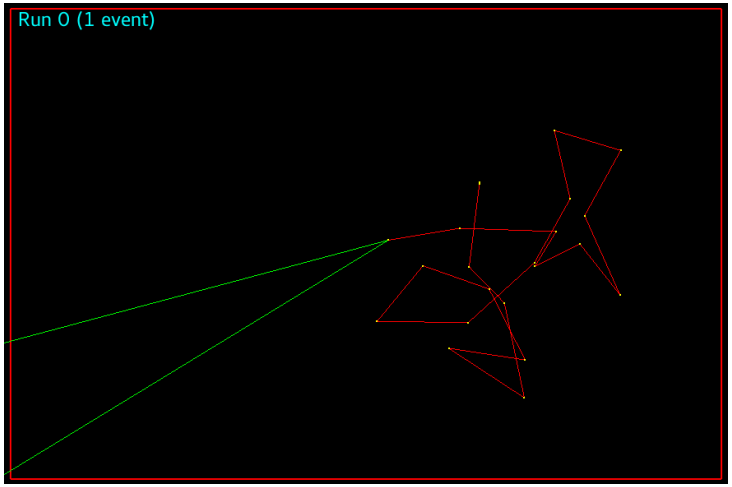
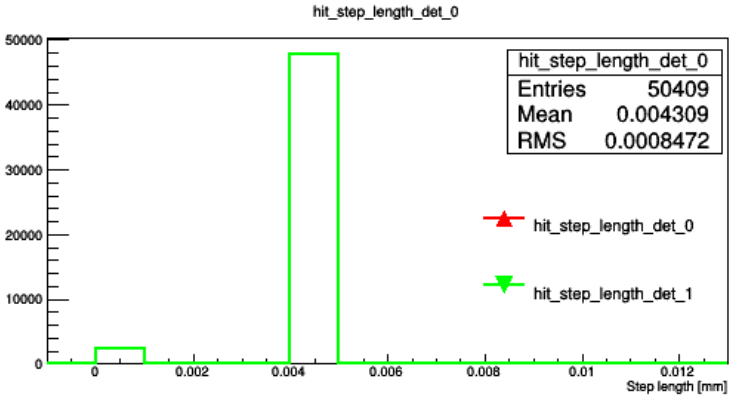


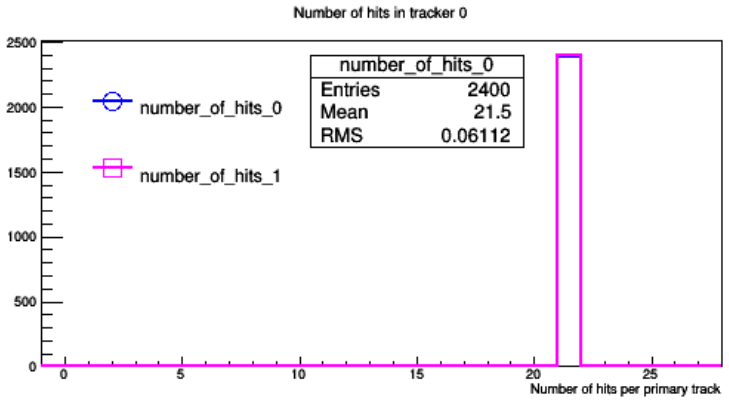


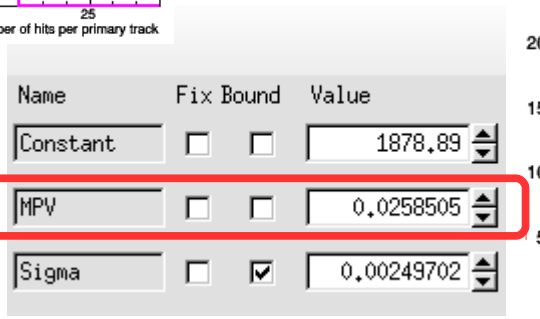


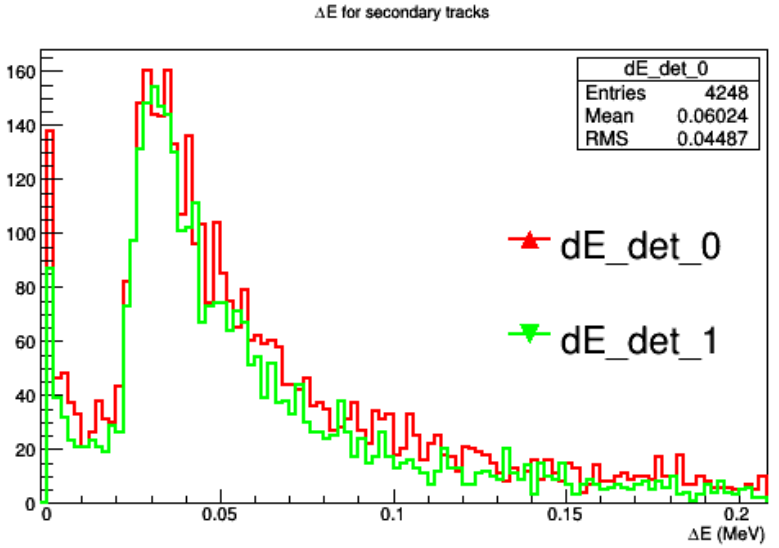


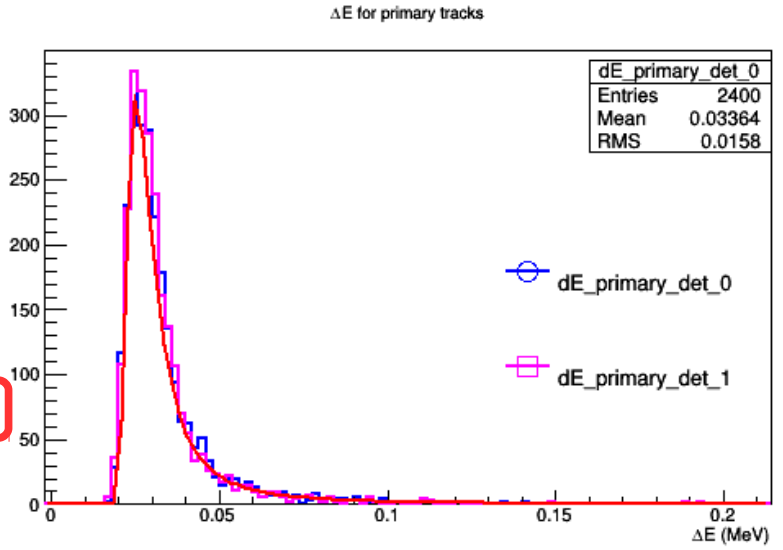
Energy Deposition and Step











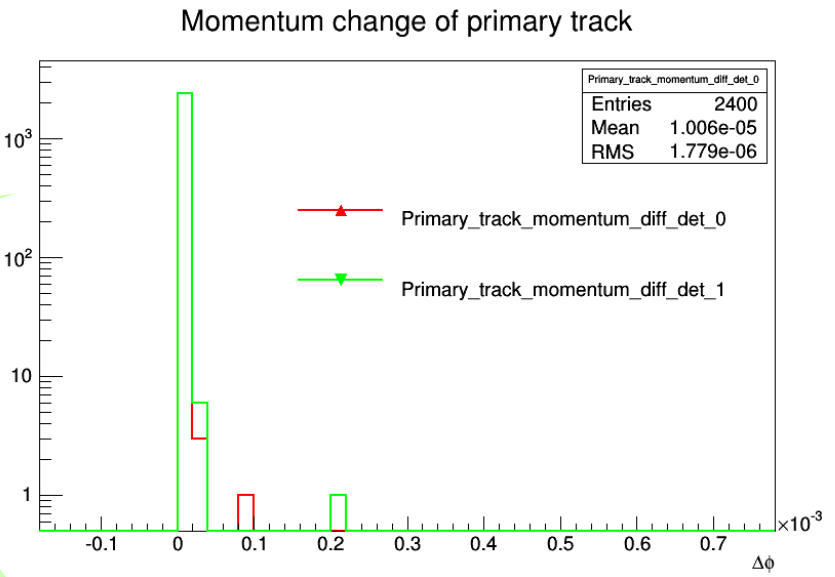
Primary Momentum Direction Change

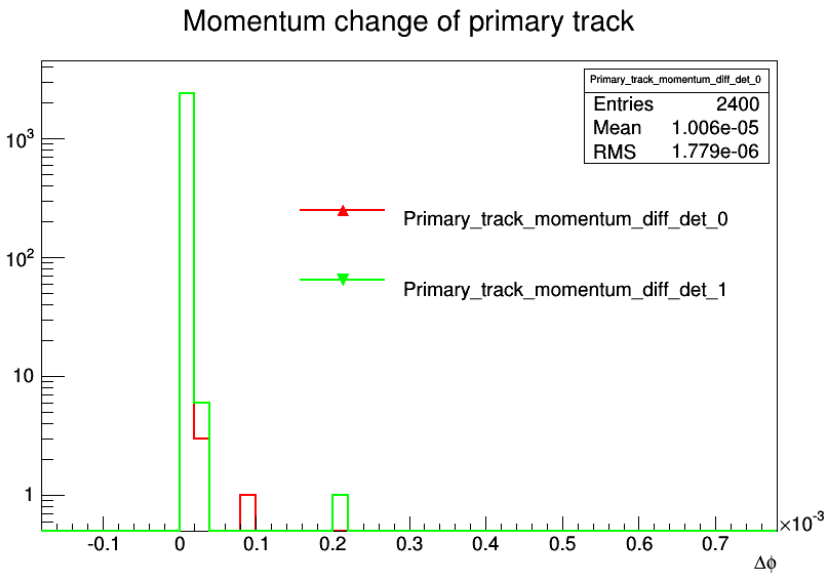
Distance from tracking sensors to LumiCal

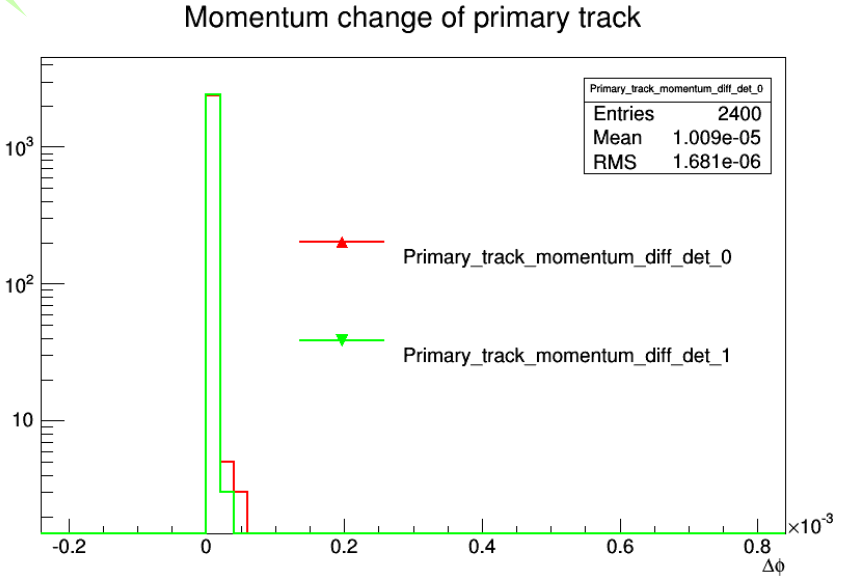
5 cm + 5 cm;

15 cm + 5 cm;

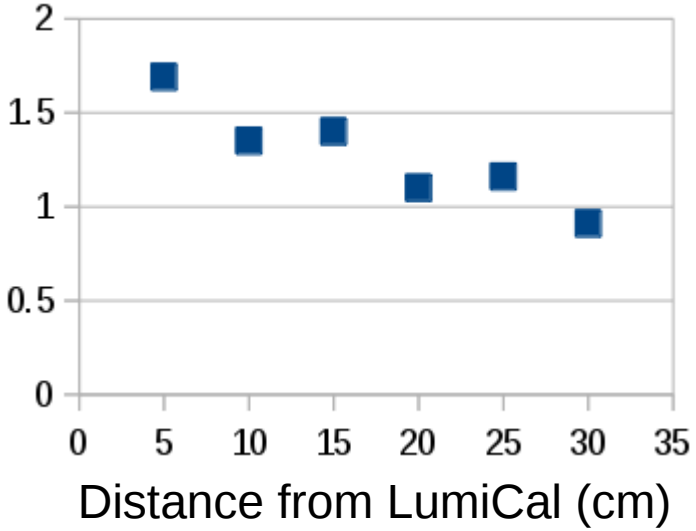
25 cm + 5 cm;

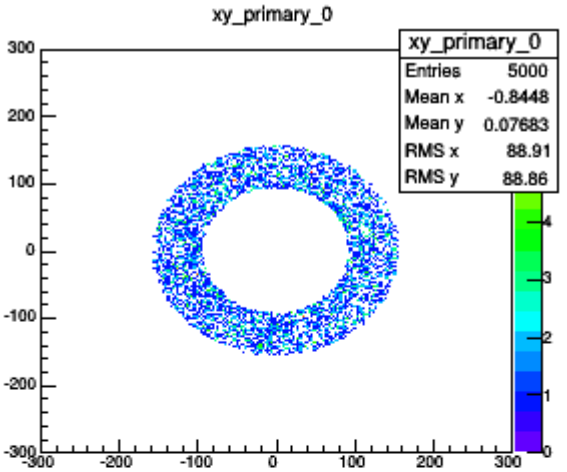


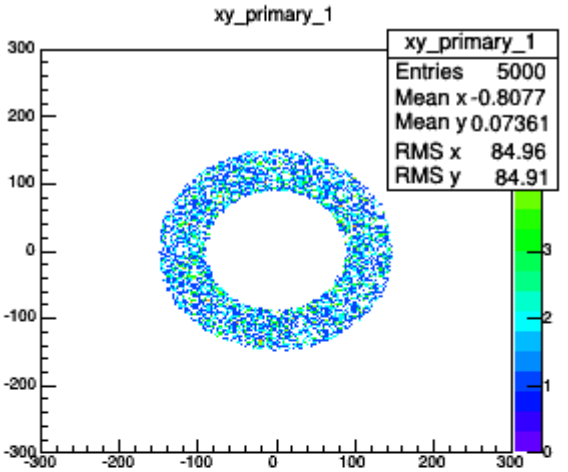


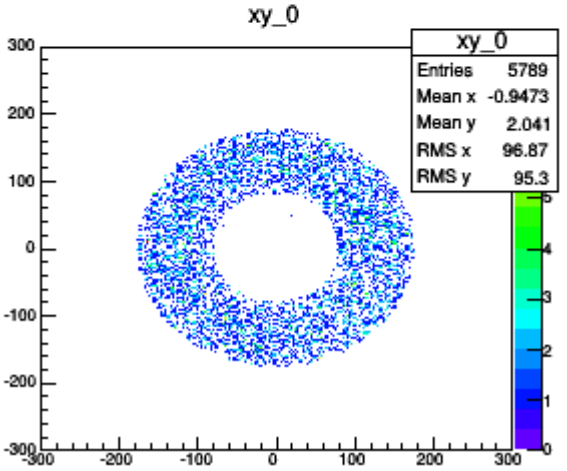


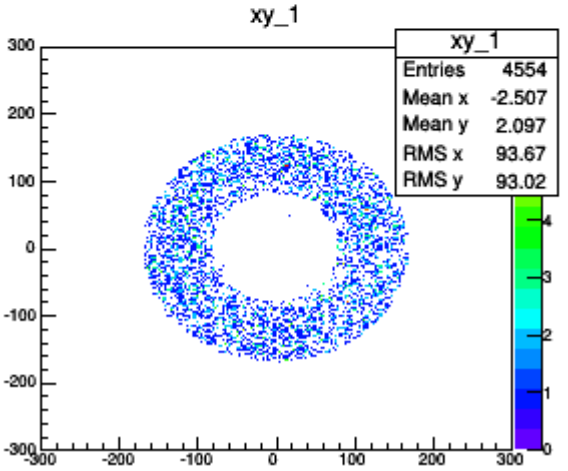
Secondary Rec. Points





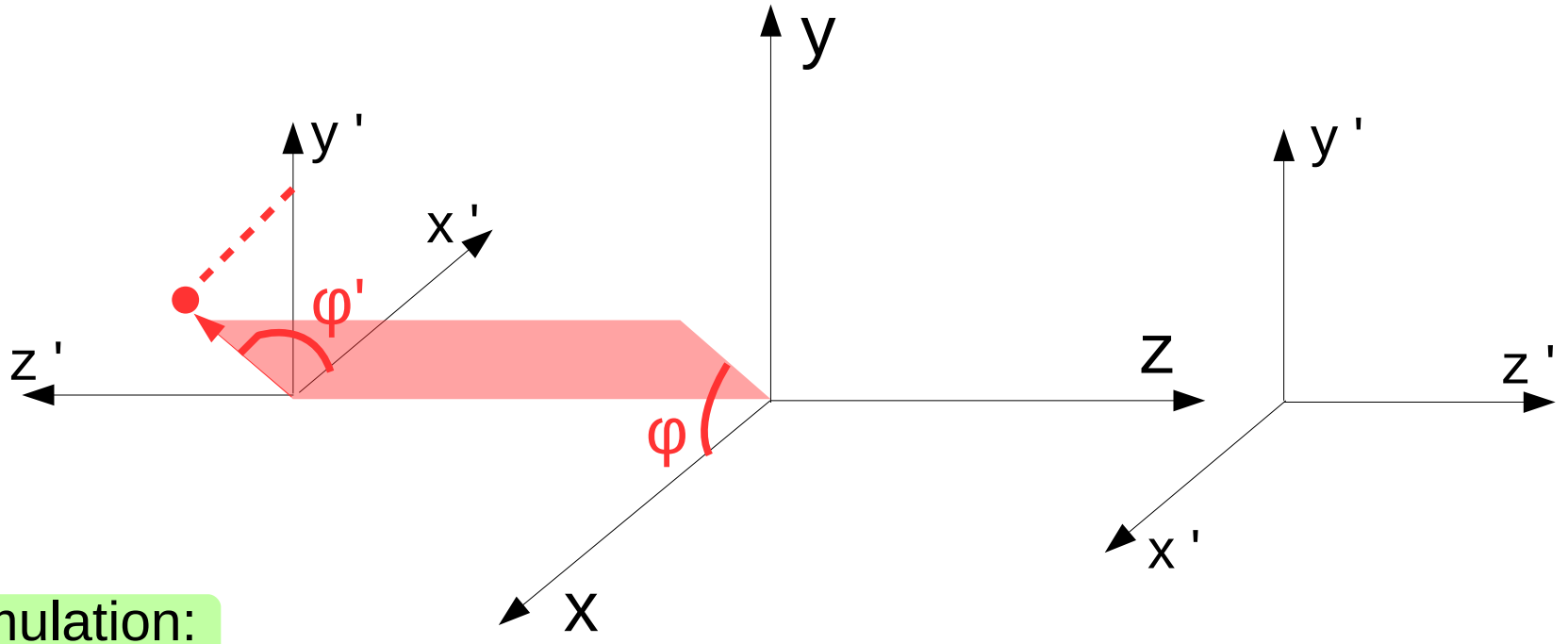






Dist. (cm)	5	10	15	20	25	30
Prim ev.	2400	2400	2400	2400	5000	5000
Second trck	4053	3235	3355	2649	5789	4554
sec/prim	1.69	1.35	1.4	1.1	1.16	0.91

LuCaS – Reconstruction Coordinates Mismatch



Simulation:

Global hit coordinate → local coordinate in LumiCal arm → R', φ' → Cell radial ID, Cell azimuthal ID

Reconstruction

Global hit coordinate ← R, φ ← Cell radial ID, Cell azimuthal ID

Cause the problem for Z<0

Reconstruction in LumiCal

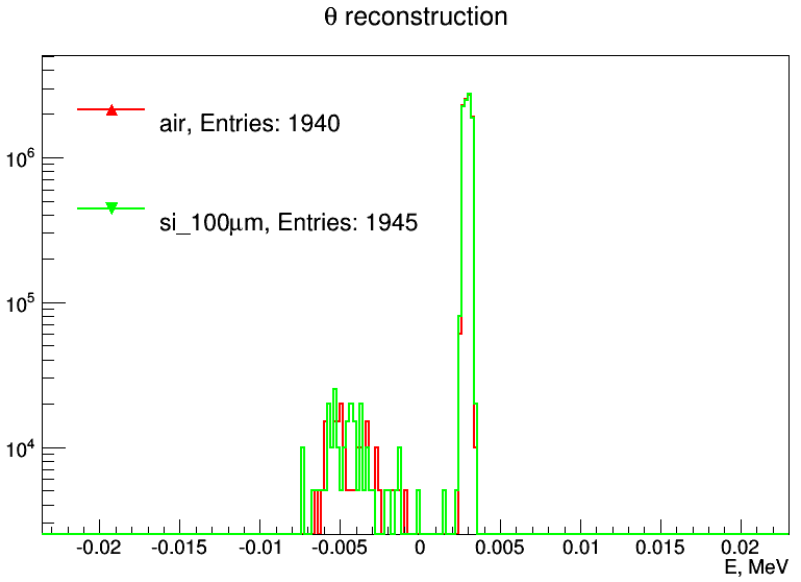
2 cases:

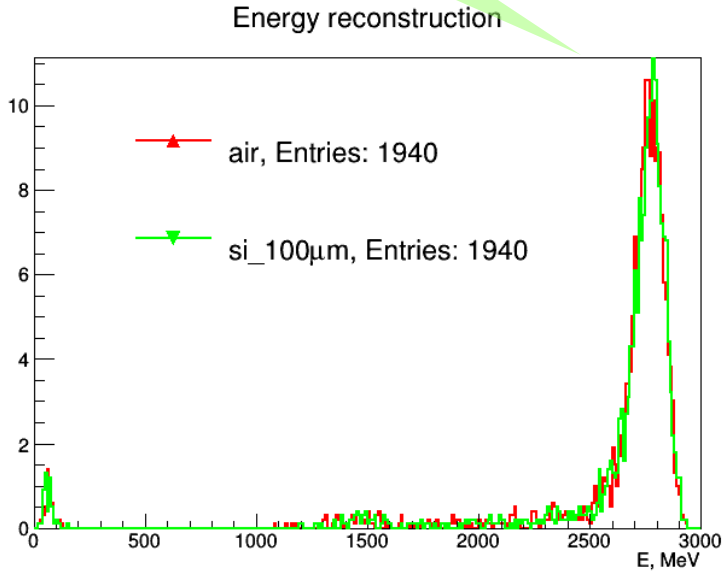
- without tracking detector (air);
- with 2 layer of 100 μm thick Si.

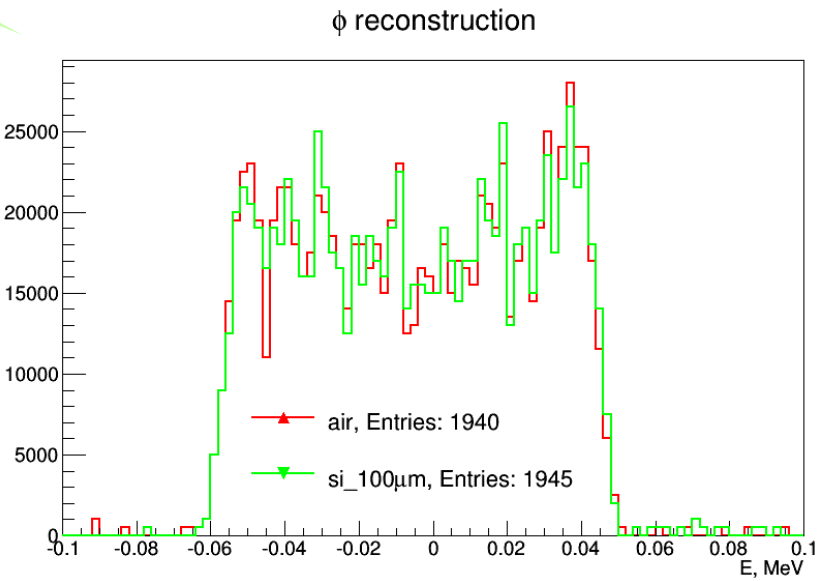
θ_gen – θ_reco;

φ_gen – φ_reco;

E_reco;





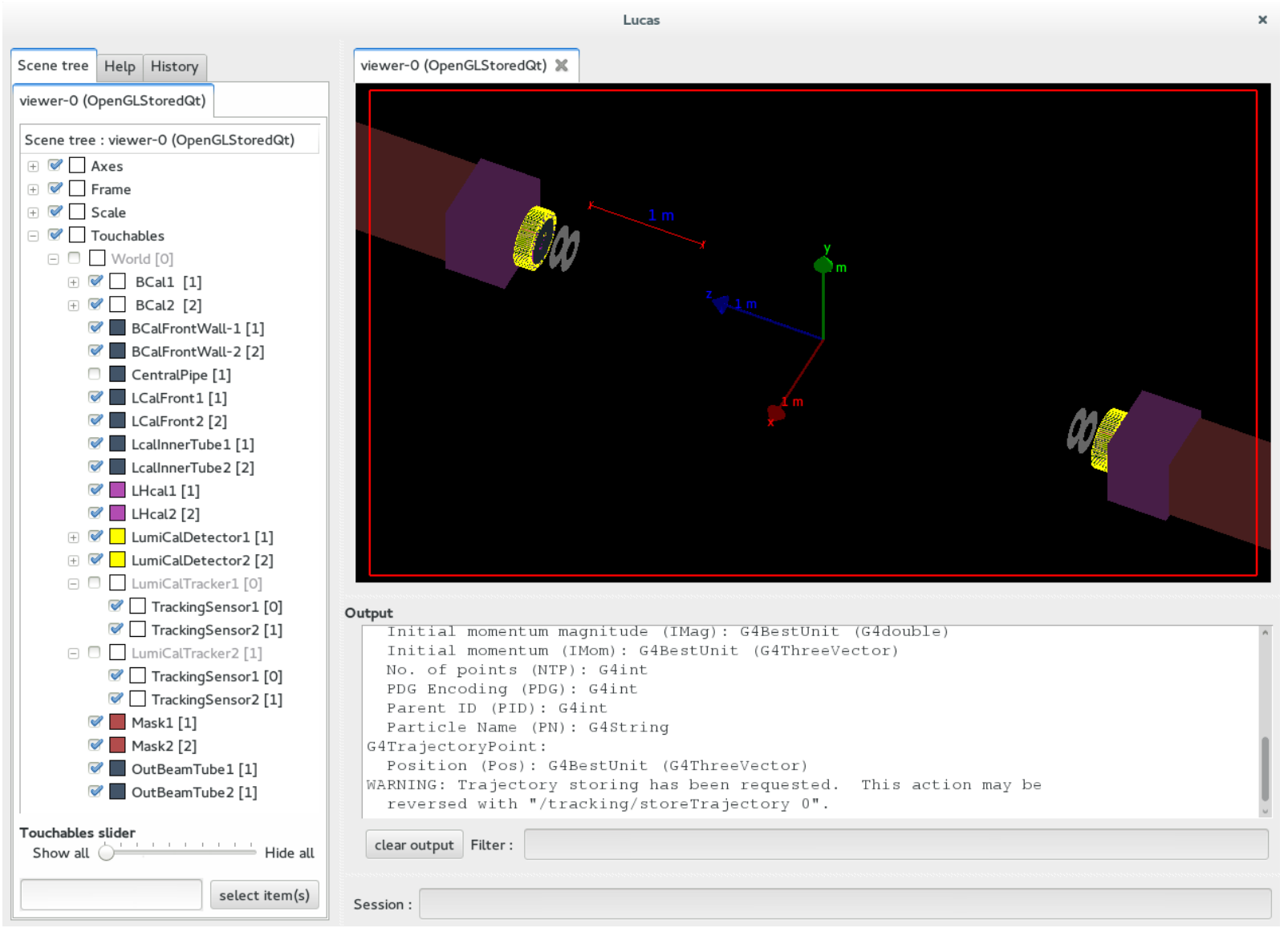


Summary and Plans

- There is significant occupancy of tracking detector caused by the scattered particles from LumiCal. It decreases as we move further from LumiCal.
- There is no visible influence of tracking detector on LumiCal performance, though more tests should be made with higher statistics and numerical evaluation.
- Include tracking detector in φ, θ reconstruction.
- Study different configurations of tracking detector.

Backup

LuCaS with qt UI

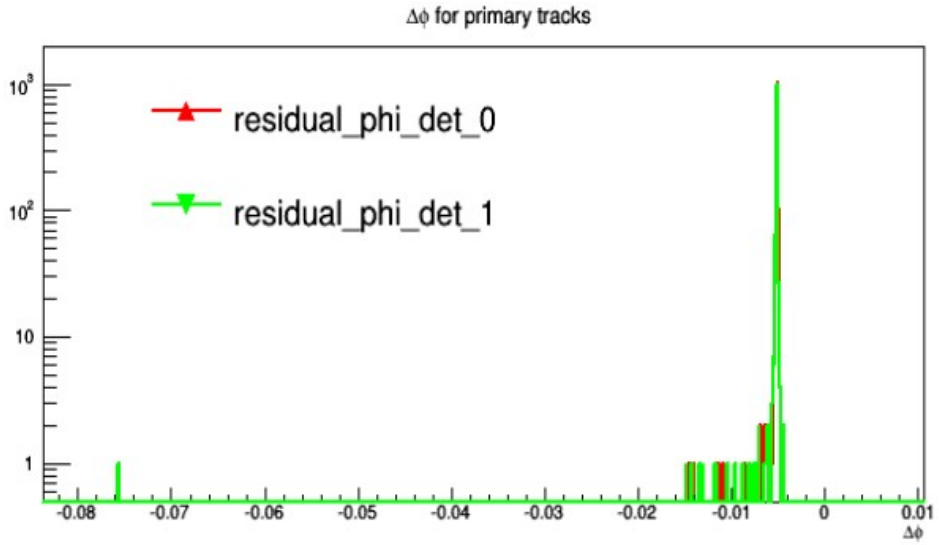


Geometry and Hits Implementation in LuCaS

```
  rotAng      = Setup::Beam_Crossing_Angle / 2.;
  rotAng1     = 180.*deg - rotAng;
  rotAng2     = rotAng;
..........
G4Transform3D trans1( G4RotationMatrix().rotateY(rotAng1),
                      G4ThreeVector( 0., 0., zpos).rotateY(rotAng1));
    G4Transform3D trans2( G4RotationMatrix().rotateY(rotAng2),
                      G4ThreeVector( 0., 0., zpos).rotateY(rotAng2));

                new G4PVPlacement( trans1 ,
                                   logicWholeLC,
                                   "LumiCalDetector1",
                                   logicWorld,
                                   false,
                                   1);
                new G4PVPlacement( trans2,
                                   logicWholeLC,
                                   "LumiCalDetector2",
                                   logicWorld,
                                   false,
                                   2);
...........
    G4ThreeVector LocalHitPos = theTouchable->GetHistory()-
GetTopTransform().TransformPoint(GlobalHitPos) ;
          G4double rho = LocalHitPos.getRho();
          G4double phi = LocalHitPos.getPhi();
```

Δφ


Δϕ for primary tracks
residual_phi_det_0
residual_phi_det_1
10³
10²
10
1
-0.08
-0.07
-0.06
-0.05
-0.04
-0.03
-0.02
-0.01
0
0.01
Δϕ