Standalone Geant4 simulation for Compton polarimeter

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Motivation

- **We used EicRoot for our fast simulation of Compton polarimeter;**
- **For the IR study, EicRoot works fine but not flexible;**
- **The visualization on Rcf is quite slow if I work at home;**
- **People are discussing all the options for the future detector simulation;**
- **There is no harm for us to try a pure Geant4 simulation;**

Geant4 is the Object-Oriented toolkit which provides functionalities required for simulations in HEP and other fields.

Benefits of Object-Orientation help you to realize a detector simulator which is

- Easy to develop and maintain
- Well modularized
- Readable and Understandable to the collaborators

Installation of Geant4

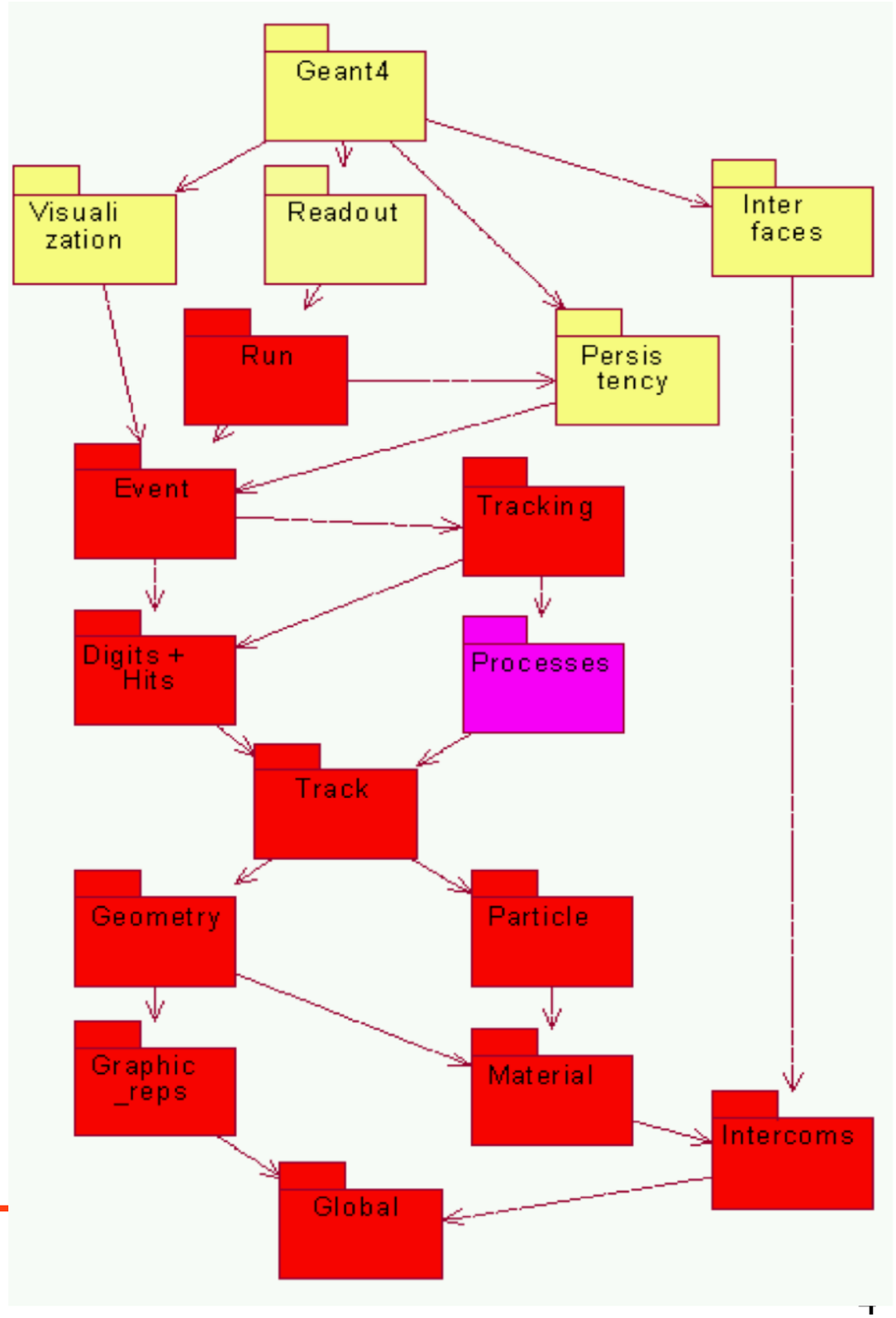
OS/Software Prerequisites:

Geant4 Toolkit Source Code;
macOS: Apple Clang (Xcode) 10 or higher;
CMake 3.8 or higher;
Qt User Interface and Visualization;

Building and Installing:

```
$ cd /path/to
$ mkdir geant4.10.06-build
$ ls
geant4.10.06  geant4.10.06-build


$ cd /path/to/geant4.10.06-build
$ cmake -DCMAKE_INSTALL_PREFIX=/path/to/geant4.10.06-install /path/to/geant4.10.06

$ cmake -DGEANT4_INSTALL_DATA=ON -DGEANT4_USE_OPENGL_X11=ON -DGEANT4_USE_XM=ON -DGEANT4_USE_QT=ON
-DGEANT4_USE_SYSTEM_CLHEP=ON  .

$ Make -j4
$ make install
$ . geant4.sh.  (source geant4.csh)
```

Geant4 work structure



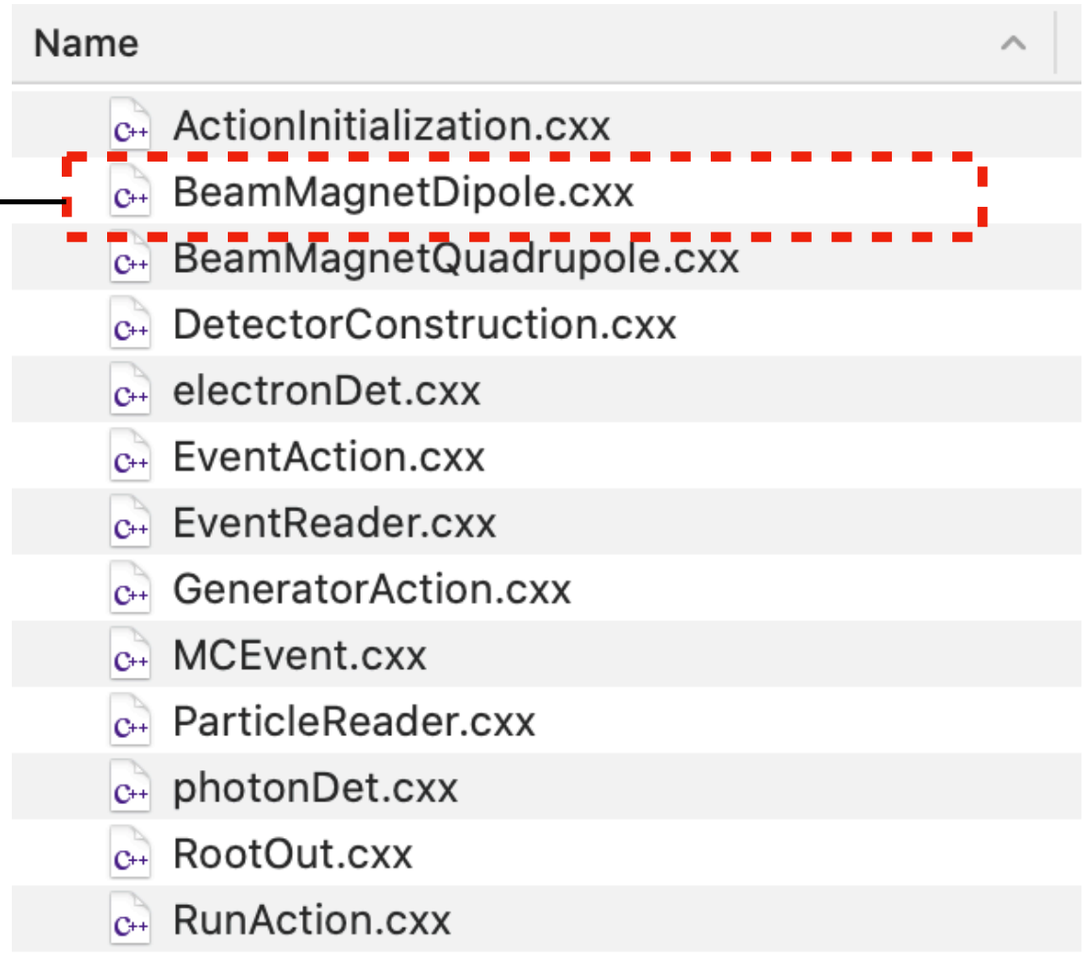

```
CMakeLists.txt
README.md
build
data
events.dat
gui.mac
include
init_vis.mac
input
macro
output
polarimeter_magnet.dat
run.cxx
run.mac
src
vis.mac
```

How to run:

cd build
cmake ../
make
./run

Magnet field setup

```
G4RotationMatrix* yRot = new G4RotationMatrix;
yRot->rotateY(angle*1e-3*rad);

G4String nam_inner = fNam+"_inner";
G4Cons *shape_inner = new G4Cons(nam_inner, 0, r2, 0, r1, length/2, 0, 360*deg);

G4Material *mat_inner = G4NistManager::Instance()->FindOrBuildMaterial("G4_Galactic");
G4LogicalVolume *vol_inner = new G4LogicalVolume(shape_inner, mat_inner, nam_inner);
vol_inner->SetVisAttributes( G4VisAttributes::GetInvisible() );

G4UniformMagField *field = new G4UniformMagField(G4ThreeVector(0, bfield, 0));
G4FieldManager *fman =  new G4FieldManager();

fman->SetDetectorField(field);
fman->CreateChordFinder(field);
//fman->SetChordFinder(fChordFinder);
//fman->GetChordFinder()->SetDeltaChord(1e-7*meter);

vol_inner->SetFieldManager(fman, true);

//put the inner core to the top volume
new G4PVPlacement(yRot, G4ThreeVector(xpos,ypos, zpos), vol_inner, nam_inner, top, false, 0);

//cylindrical outer shape
G4Tubs *shape_outer = new G4Tubs(fNam+"_outer", 0., dout, length/2-1e-4*meter, 0., 360.*deg);

//magnet vessel around the inner magnetic core
G4SubtractionSolid *shape_vessel = new G4SubtractionSolid(fNam, shape_outer, shape_inner);

G4Material *mat_outer = G4NistManager::Instance()->FindOrBuildMaterial("G4_Fe");
G4LogicalVolume *vol_vessel = new G4LogicalVolume(shape_vessel, mat_outer, fNam);

//vessel visibility
G4VisAttributes *vis_vessel = new G4VisAttributes();
vis_vessel->SetColor(0, 0, 1); // blue
vis_vessel->SetLineWidth(2);
vis_vessel->SetForceSolid(true);
//vis_vessel->SetForceAuxEdgeVisible(true);
vol_vessel->SetVisAttributes(vis_vessel);

//put the magnet vessel to the top volume
new G4PVPlacement(yRot, G4ThreeVector(xpos, ypos, zpos), vol_vessel, fNam, top, false, 0);
```

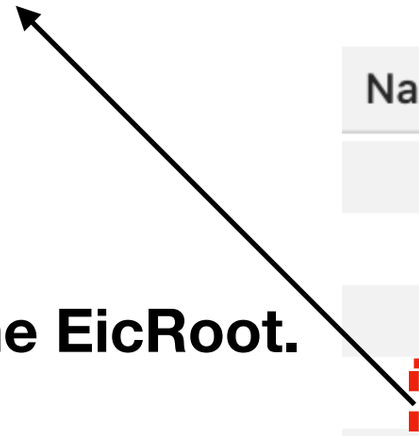


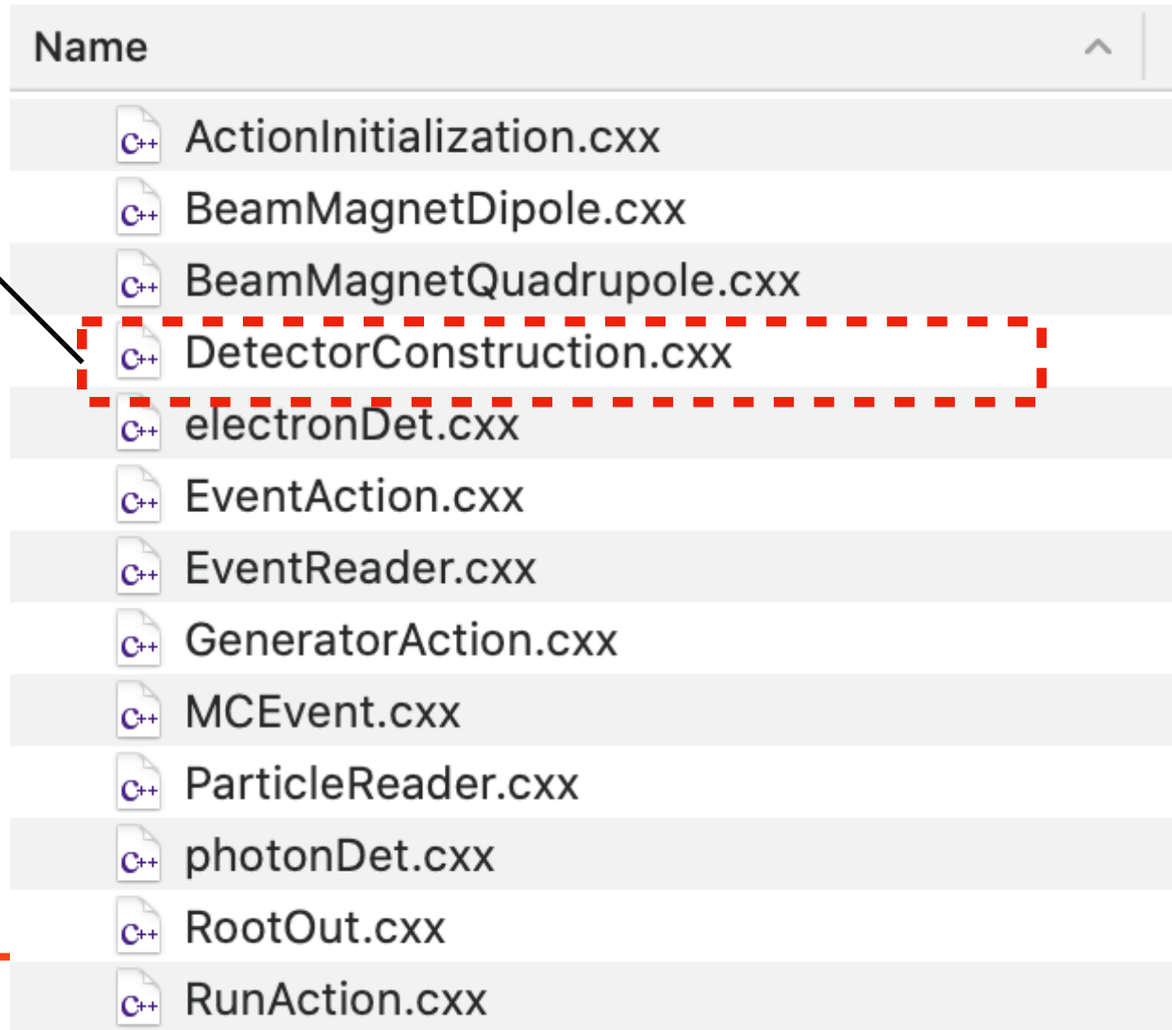
https://github.com/ZhengqiaoZhang/ComptonPolarimeter

Read the magnets parameters

```
name    center_x center_y center_z rin(z-in) rin(z-out)  dout   length   angle      B      gradient
##             [m]      [m]      [m]      [m]        [m]      [m]      [m]   [mrad]     [T]      [T/m]
DB DB23_1     0.352014     0         -0.7563  0.12  0.12    0.3     4.22367 -28.797750         -0.272916       0
QF QD12     0.285309     0         -3.7023  0.1   0.1     0.3     0.6     -19.198500         0                -12.8444
DB DB23      0.238873     0          -6.6488  0.07  0.07    0.3     4.22367  -9.5992496         -0.272916       0
QF QF11     0.228737     0         -9.5956  0.07  0.07    0.3     0.6      0           0                14.2077
QF QF10     0.228737     0         -20.319  0.085  0.085    0.25     0.6    -0.00           0                -6.87619
QF QF9     0.228737     0         -31.0425 0.1   0.1     0.25    0.6     -0.00           0                7.06014

~
```

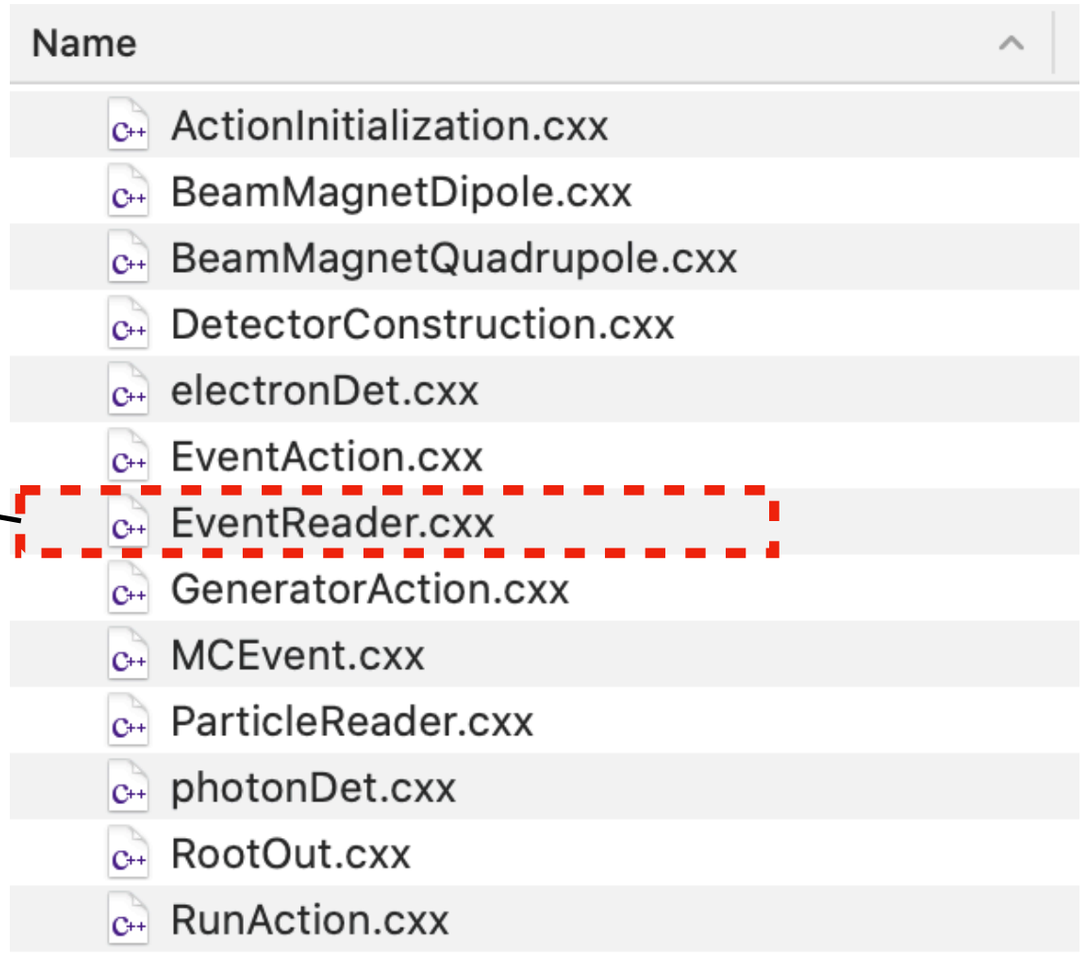
We can use the same madx file in the EicRoot.



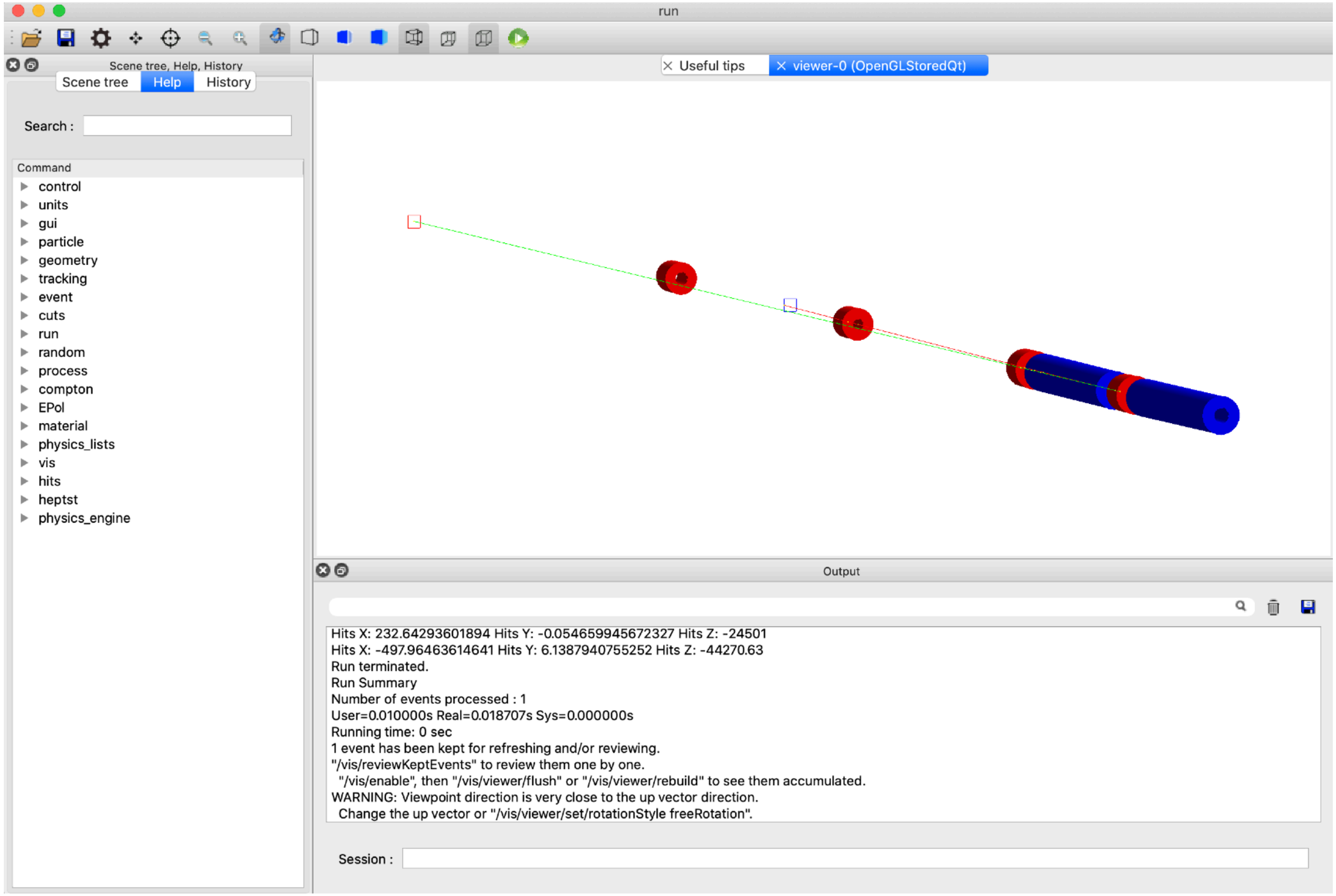


Read the events

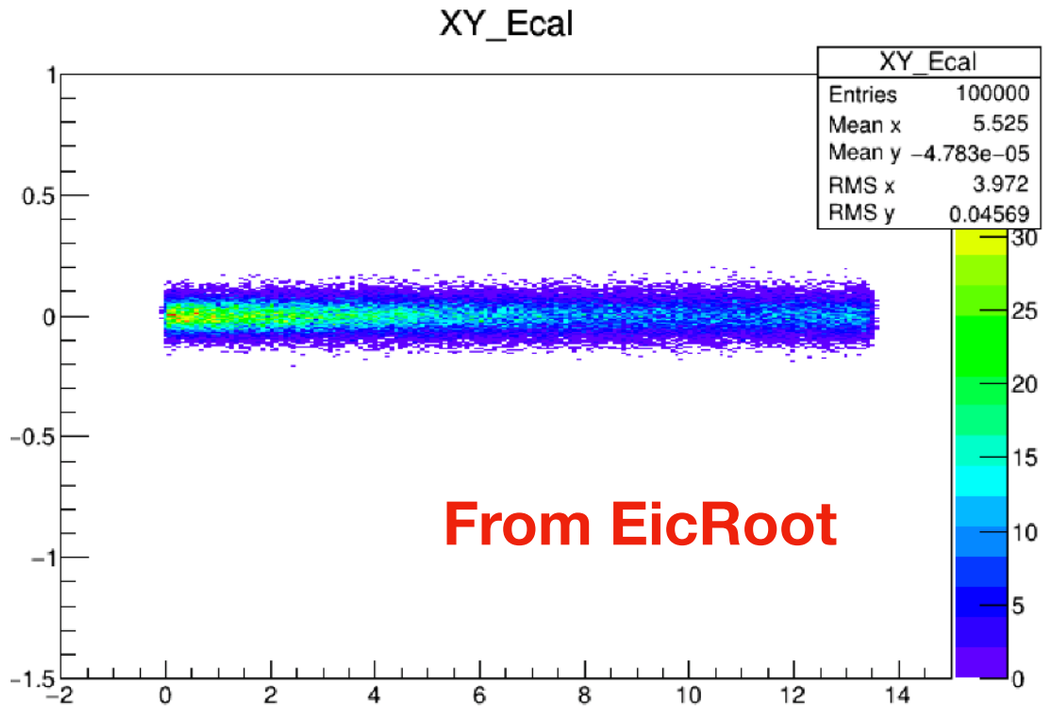
```
EVENT:   1 2 27.4464   0   -426.963
TRACK:   22 -0.125145 3.27271e-05 -6.52071
TRACK:   11 -0.220407 -3.27271e-05 -11.476

EVENT:   2 2 27.4464   0   -426.963
TRACK:   22 -0.00420616 3.88404e-05 -0.217943
TRACK:   11 -0.341346 -3.88404e-05 -17.7787

EVENT:   3 2 27.4464   0   -426.963
TRACK:   22 -0.0125582 -5.78333e-05 -0.656489
TRACK:   11 -0.332994 5.78333e-05 -17.3402

EVENT:   4 2 27.4464   0   -426.963
TRACK:   22 -0.050094 0.000117503 -2.61097
TRACK:   11 -0.295458 -0.000117503 -15.3857

EVENT:   5 2 27.4464   0   -426.963
TRACK:   22 -0.132789 2.85511e-05 -6.91671
TRACK:   11 -0.212763 -2.85511e-05 -11.08

EVENT:   6 2 27.4464   0   -426.963
TRACK:   22 -0.0684348 -4.32344e-05 -3.55787
TRACK:   11 -0.277117 4.32344e-05 -14.4388

EVENT:   7 2 27.4464   0   -426.963
TRACK:   22 -0.0532829 -0.000124104 -2.77589
TRACK:   11 -0.292269 0.000124104 -15.2208

EVENT:   8 2 27.4464   0   -426.963
TRACK:   22 -0.00312215 3.55004e-05 -0.161843
TRACK:   11 -0.34243 -3.55004e-05 -17.8348
```

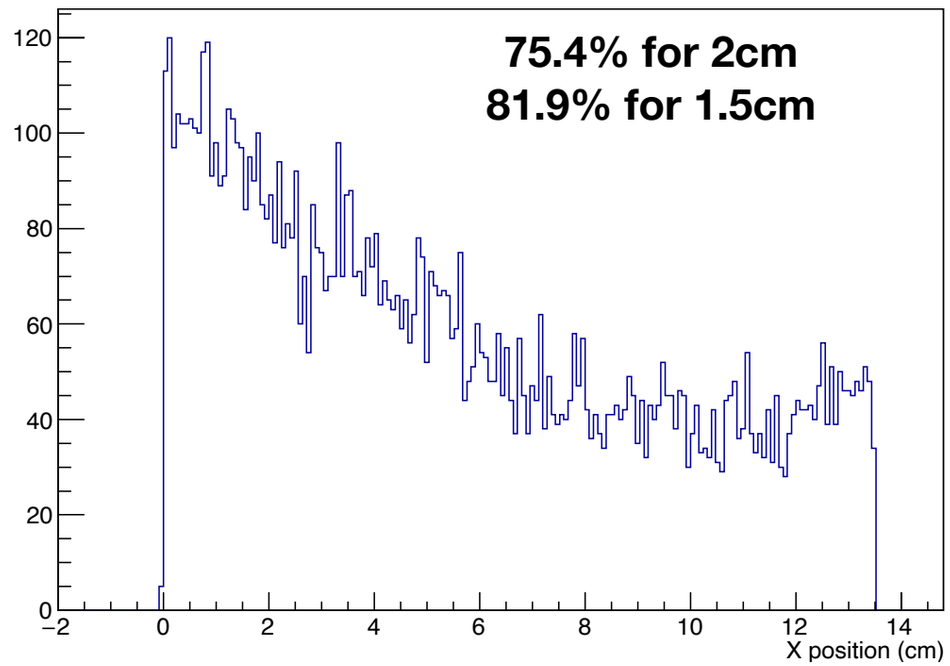


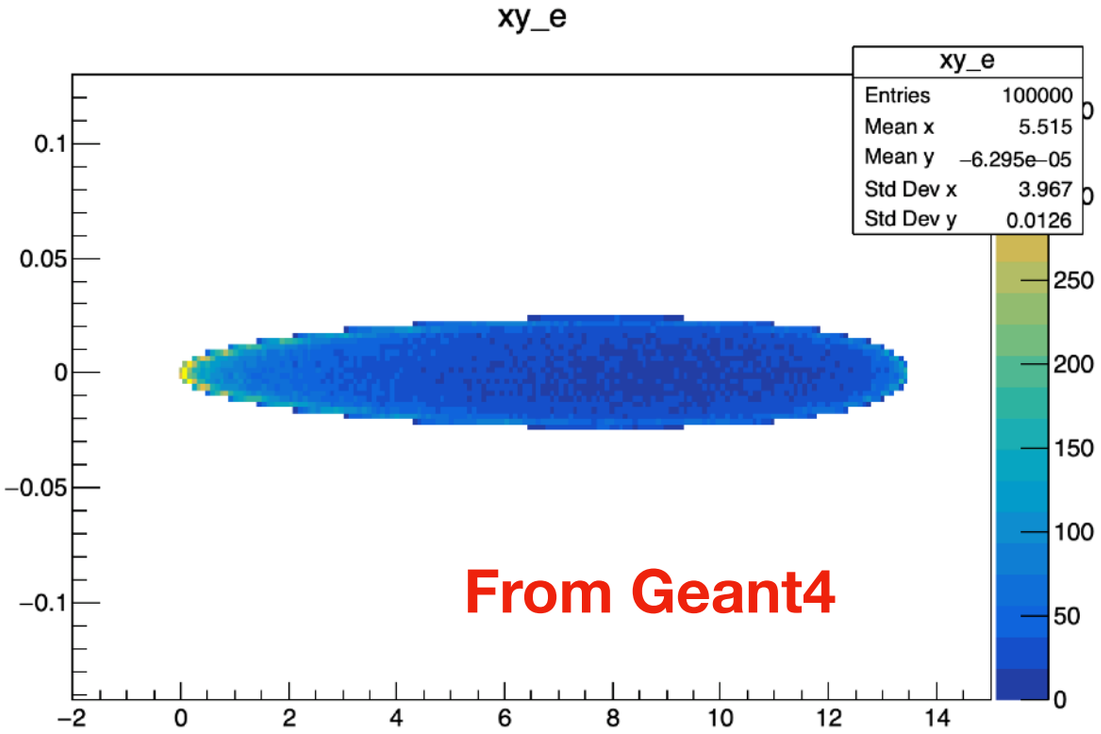
IR12 layout

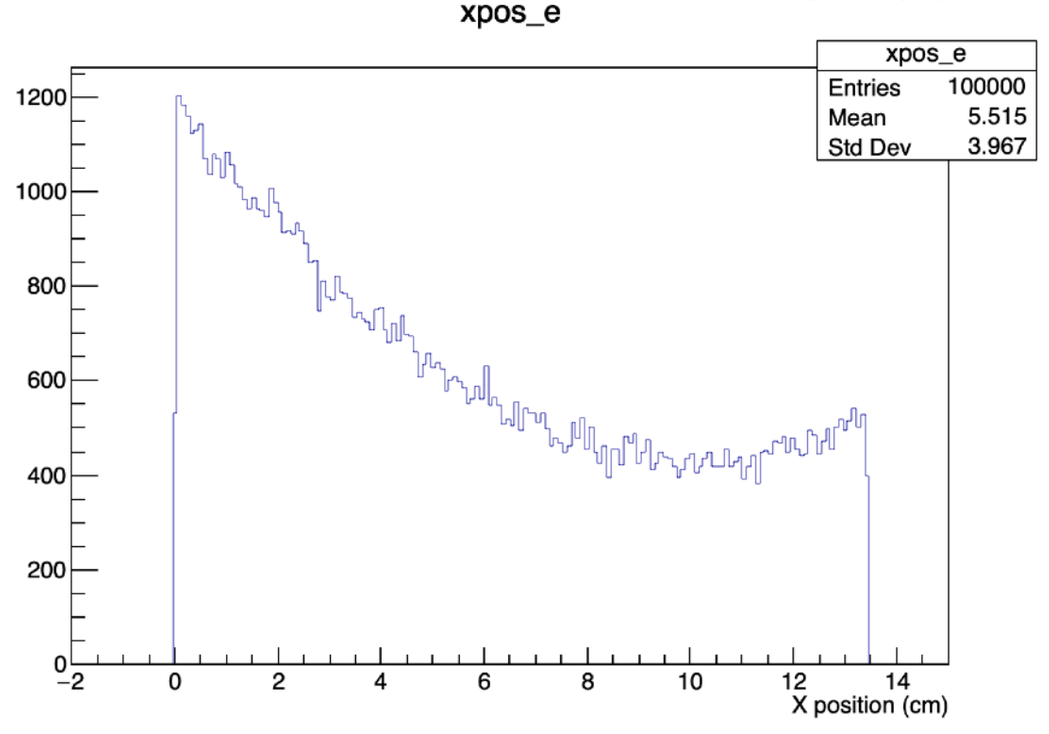

run
Scene tree, Help, History
Scene tree
Help
History
Search :
Command
control
units
gui
particle
geometry
tracking
event
cuts
run
random
process
compton
EPol
material
physics_lists
vis
hits
heptst
physics_engine
Useful tips
viewer-0 (OpenGLStoredQt)
Output
Hits X: 232.64293601894 Hits Y: -0.054659945672327 Hits Z: -24501
Hits X: -497.96463614641 Hits Y: 6.1387940755252 Hits Z: -44270.63
Run terminated.
Run Summary
Number of events processed : 1
User=0.010000s Real=0.018707s Sys=0.000000s
Running time: 0 sec
1 event has been kept for refreshing and/or reviewing.
"/vis/reviewKeptEvents" to review them one by one.
"/vis/enable", then "/vis/viewer/flush" or "/vis/viewer/rebuild" to see them accumulated.
WARNING: Viewpoint direction is very close to the up vector direction.
Change the up vector or "/vis/viewer/set/rotationStyle freeRotation".
Session :

Recoil electron positon









Thanks.