Istituto Nazionale di Fisica Nucleare
Sezione di Pavia

Muon system's studies

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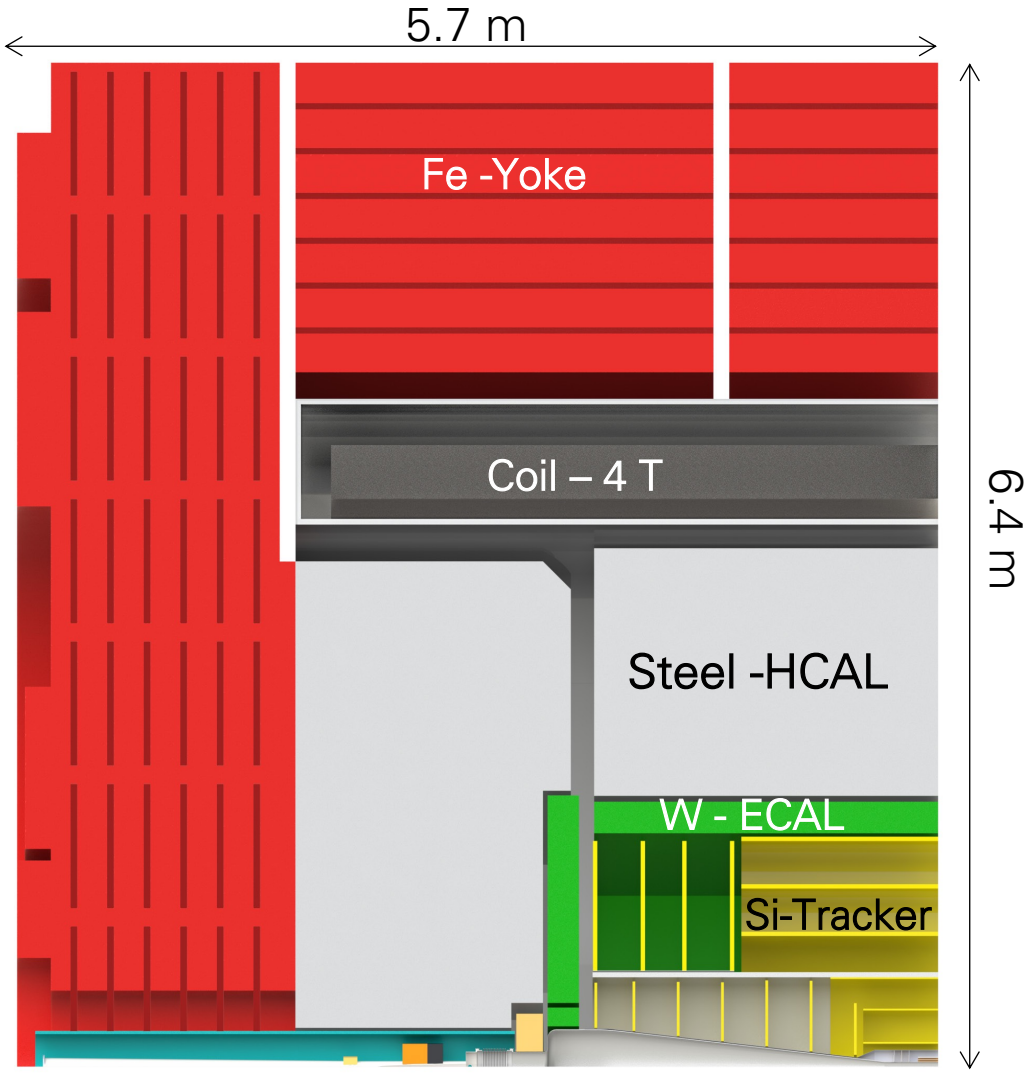
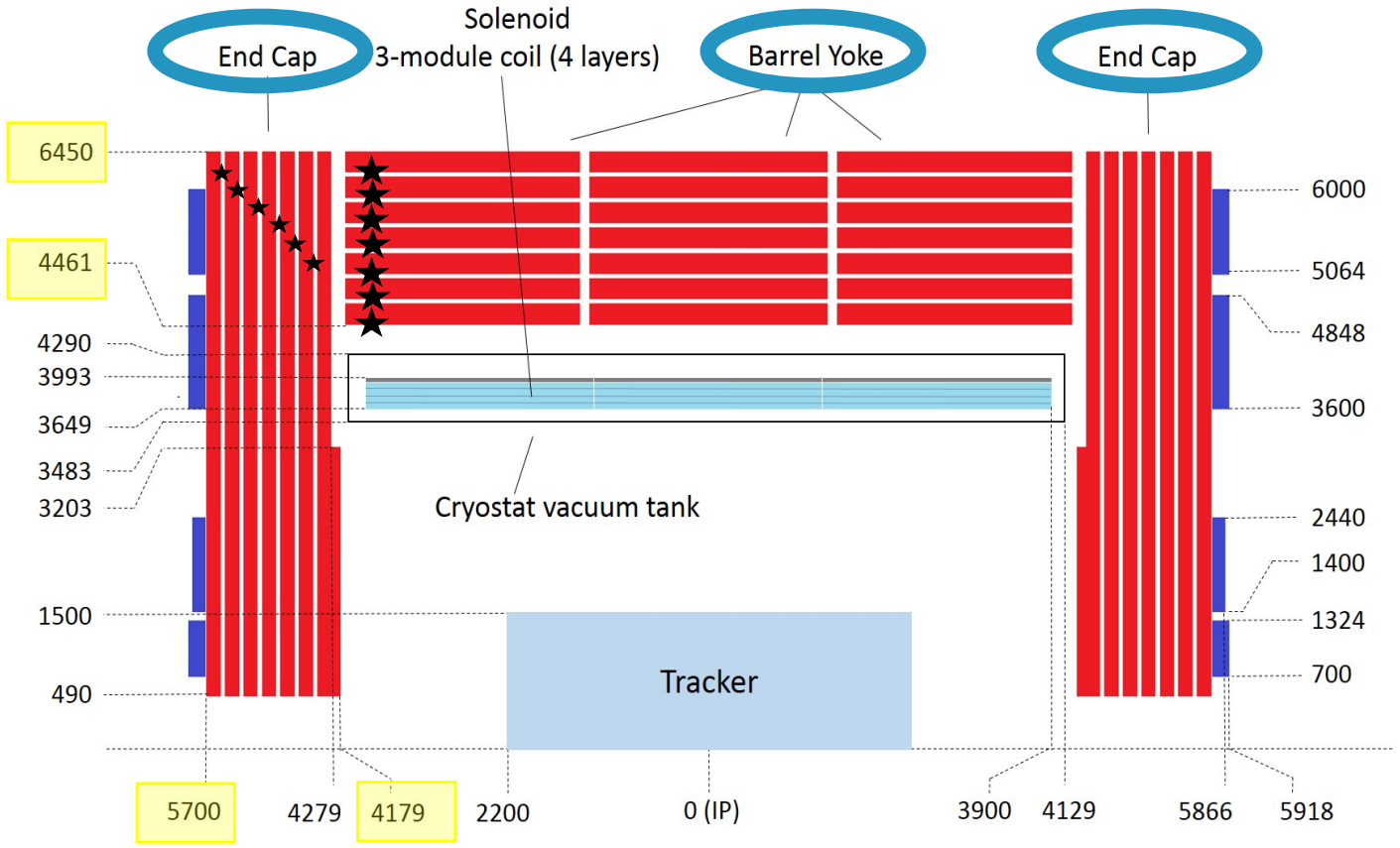
CLIC detector – Muon system



- 6/7 layers of detectors interleaved with the yoke steel plates
- layers : RPCs with cells of 30x30 mm^2



CLIC_o4_v14

CLIC_o3_v14_mod1/CLIC_o3_v14.xml

```
<constant name="YokeBarrel_inner_radius"     value="4461*mm"/>
<constant name="YokeBarrel_outer_radius"     value="6450*mm"/>
<constant name="YokeBarrel_half_length"      value="4179*mm"/>
<constant name="YokeBarrel_symmetry"         value="12"/>

<constant name="YokeEndcap_inner_radius"     value="446*mm"/>
<constant name="YokeEndcap_inner_radius2"    value="575*mm"/>
<constant name="YokeEndcap_outer_radius"     value="6450*mm"/>
<constant name="YokeEndcap_min_z"            value="4179*mm"/>
<constant name="YokeEndcap_max_z"            value="5638*mm"/>
```

```
<constant name="DetID_Yoke_Barrel"       value="13"/>
<constant name="DetID_Yoke_Endcap"       value="14"/>
```

7 layers
6 layers

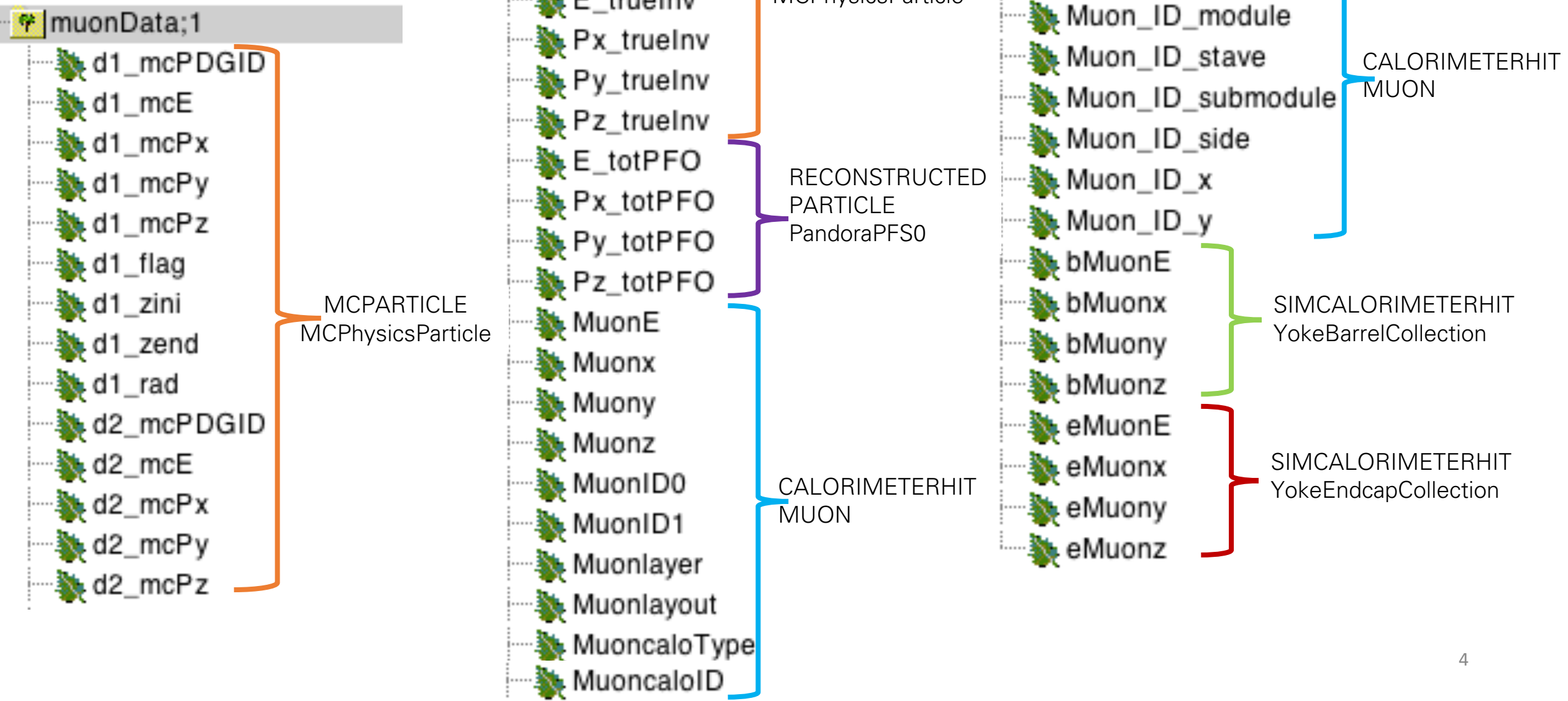
New processor - MuAnalyzer

Similar to JetAnalizer used for the calorimeter

5 input collection

```
MuonAnalyzer::MuonAnalyzer() : Processor("MuonAnalyzer") {

  // modify processor description
  _description = "MuonAnalyzer calculates properties of muons" ;


  registerInputCollection( LCIO::MCPARTICLE,
                "MCParticleCollectionName",
                "Name of the MCParticle input collection",
                m_inputMCParticleCollection,
                std::string("MCPhysicsParticles"));

  registerInputCollection( LCIO::RECONSTRUCTEDPARTICLE,
                "RECOParticleCollectionName",
                "Name of the RECOParticle input collection",
                m_inputRECOParticleCollection,
                std::string("PandoraPFOs"));

  registerInputCollection( LCIO::CALORIMETERHIT,
                 "MUON" ,
                 "Name of the MUON Digi collection",
                 m_muonColName,
                 std::string("MUON"));

  registerInputCollection( LCIO::SIMCALORIMETERHIT,
                 "YokeBarrelCollection" ,
                 "Name of the Yoke Barrel Muon collection",
                 m_bmuonColName,
                 std::string("YokeBarrelCollection"));

  registerInputCollection( LCIO::SIMCALORIMETERHIT,
                 "YokeEndcapCollection" ,
                 "Name of the Yoke Endcap Muon collection",
                 m_emuonColName,
                 std::string("YokeEndcapCollection"));

}
```

TTree


muonData;1
d1_mcPDGID
d1_mcE
d1_mcPx
d1_mcPy
d1_mcPz
d1_flag
d1_zini
d1_zend
d1_rad
d2_mcPDGID
d2_mcE
d2_mcPx
d2_mcPy
d2_mcPz
MCPARTICLE
MCPhysicsParticle
E_trueVis
Px_trueVis
Py_trueVis
Pz_trueVis
E_trueInv
Px_trueInv
Py_trueInv
Pz_trueInv
MCPARTICLE
MCPhysicsParticle
E_totPFO
Px_totPFO
Py_totPFO
Pz_totPFO
RECONSTRUCTED
PARTICLE
PandoraPFS0
MuonE
Muonx
Muony
Muonz
MuonID0
MuonID1
Muonlayer
Muonlayout
MuoncaloType
MuoncaloID
CALORIMETERHIT
MUON
Muon_ID_layer
Muon_ID_system
Muon_ID_module
Muon_ID_stave
Muon_ID_submodule
Muon_ID_side
Muon_ID_x
Muon_ID_y
CALORIMETERHIT
MUON
bMuonE
bMuonx
bMuony
bMuonz
SIMCALORIMETERHIT
YokeBarrelCollection
eMuonE
eMuonx
eMuony
eMuonz
SIMCALORIMETERHIT
YokeEndcapCollection

MUON collection

- MUON collection used in analysis
- MUON is the output collection of the DDSimpleMuonDigi

MUON = CalibrMUON * (YokeBarrelCollection + YokeEndcapCollection)

From DDSimpleMuonDigi.cc

```
registerProcessorParameter("CalibrMUON" ,
                           "Calibration coefficients for MUON" ,
                           _calibrCoeffMuon,
                           (float)120000.);
```

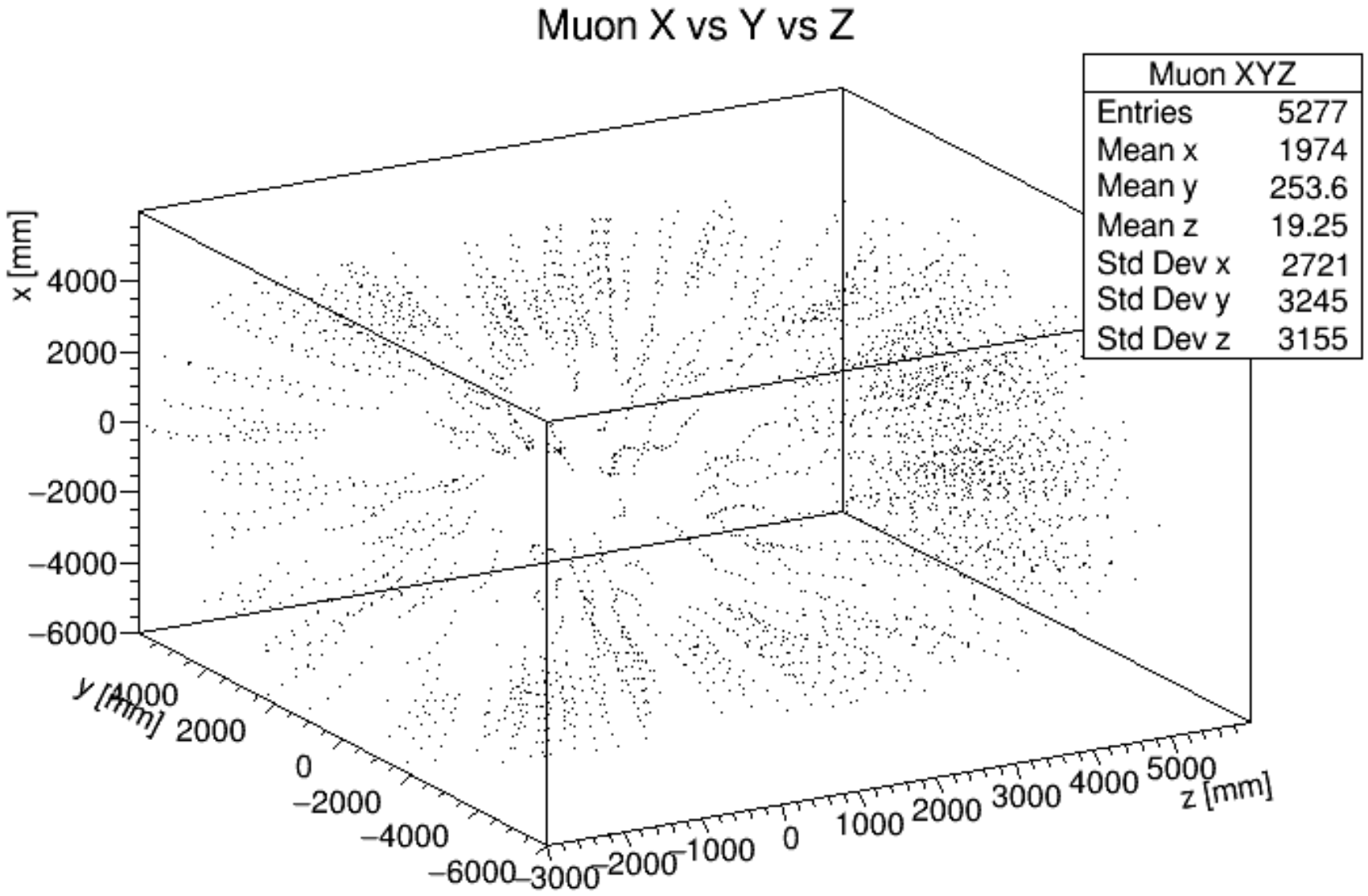
CalibrMUON set to **70.1**

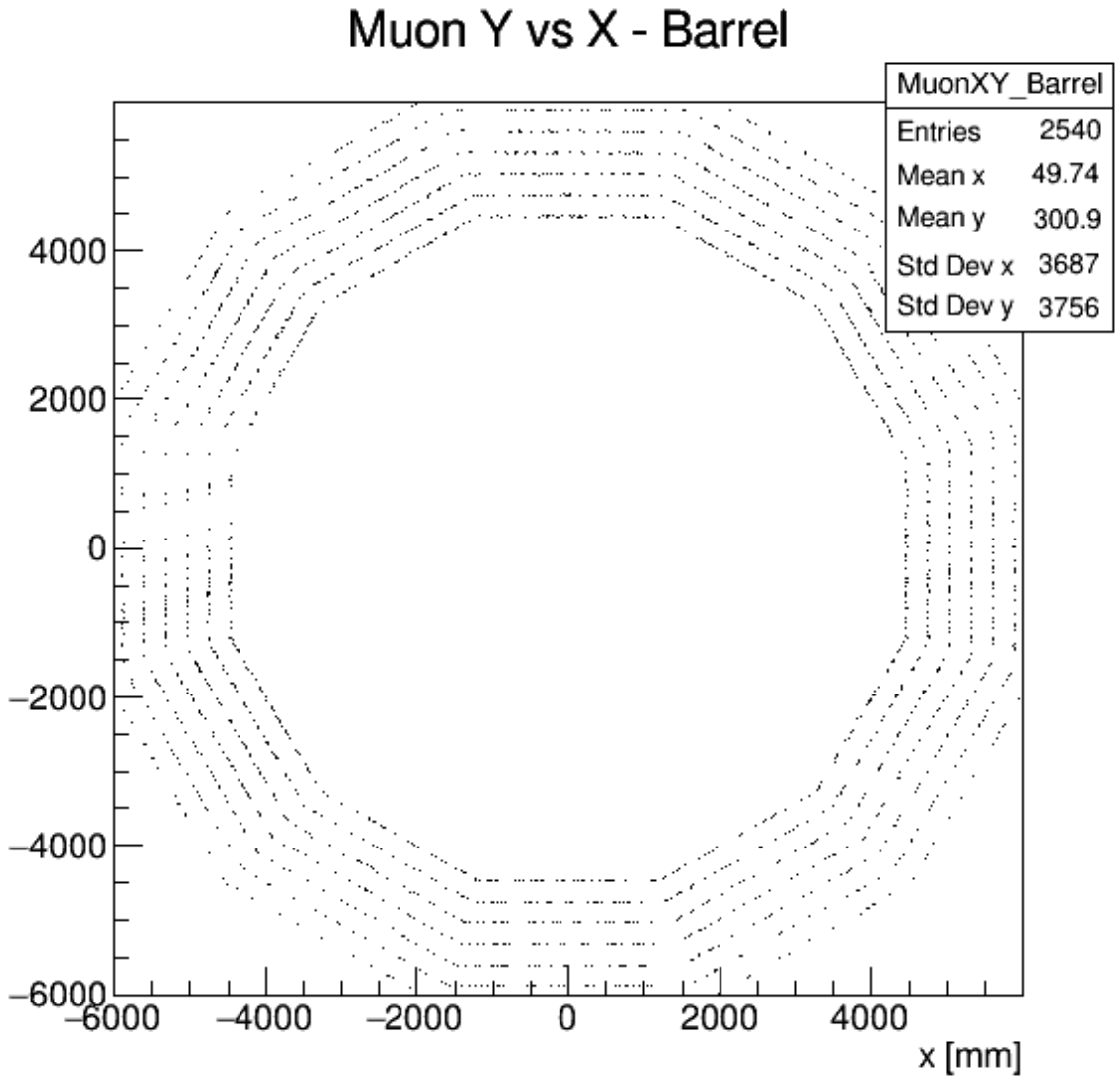
Simulation for test

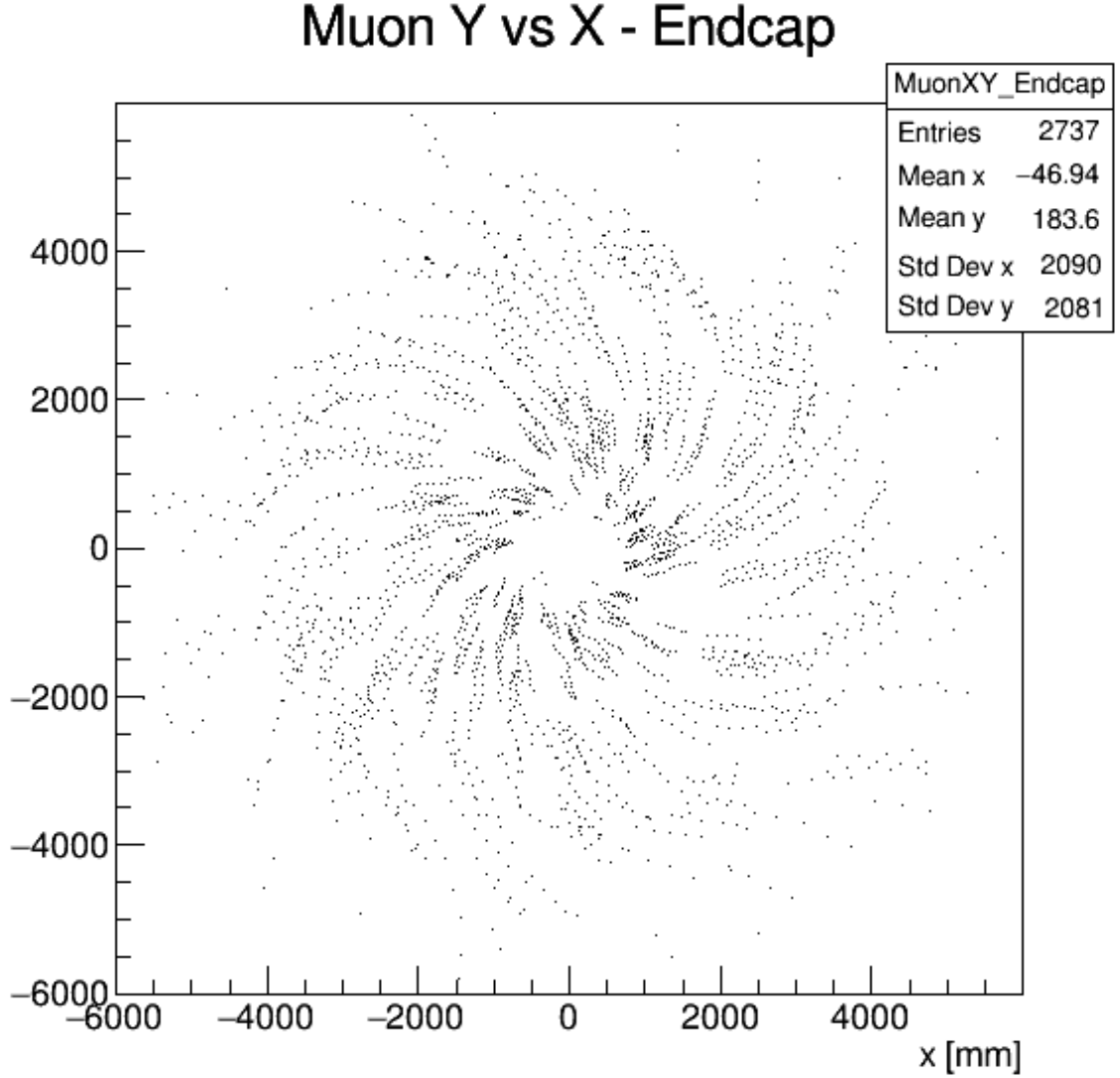
1000 muons

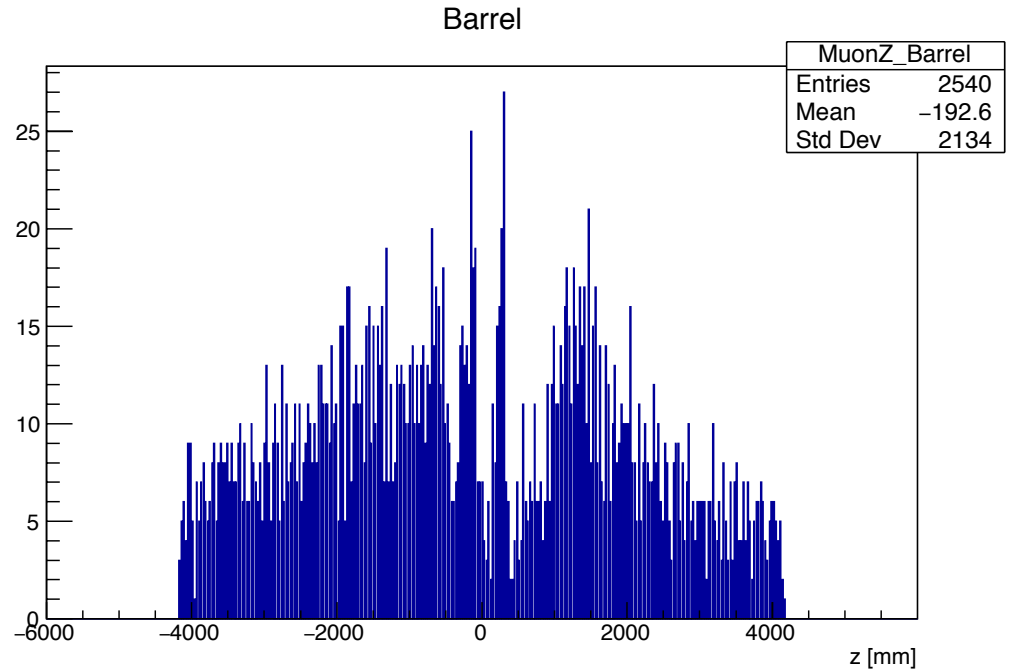
- momentum = 5 GeV
- charge: -1

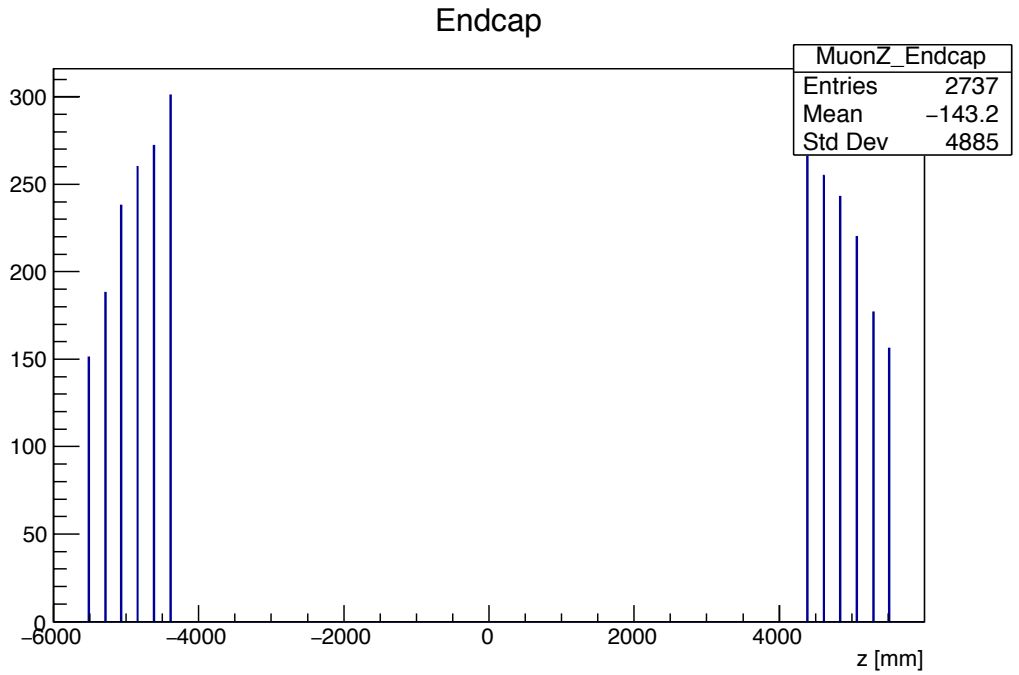
Uniformly spherically distributed around (0,0,0)

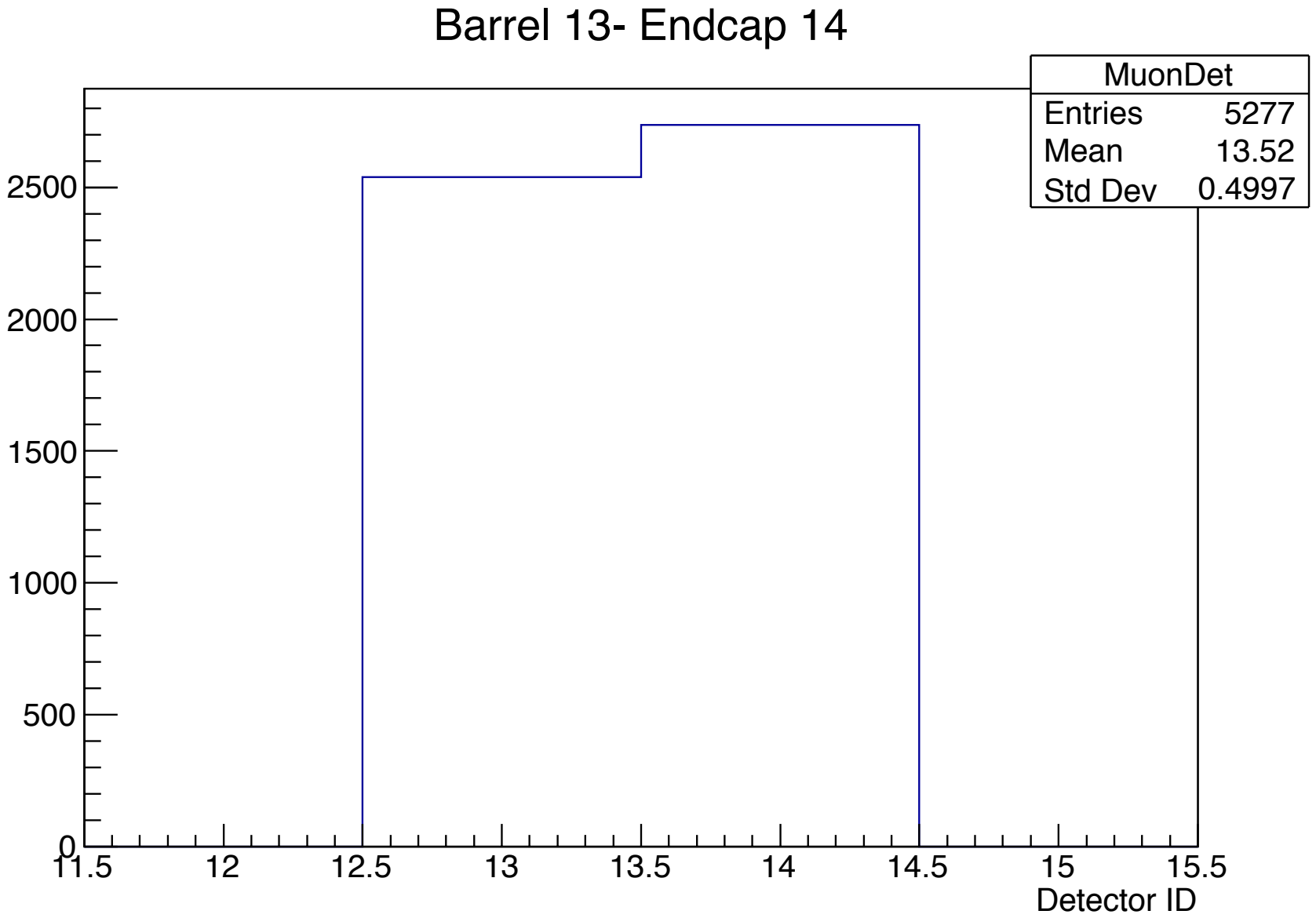



Muon Y vs X - Barrel
MuonXY_Barrel
Entries 2540
Mean x 49.74
Mean y 300.9
Std Dev x 3687
Std Dev y 3756
4000
2000
0
−2000
−4000
−6000
−6000
−4000
−2000
0
2000
4000
x [mm]

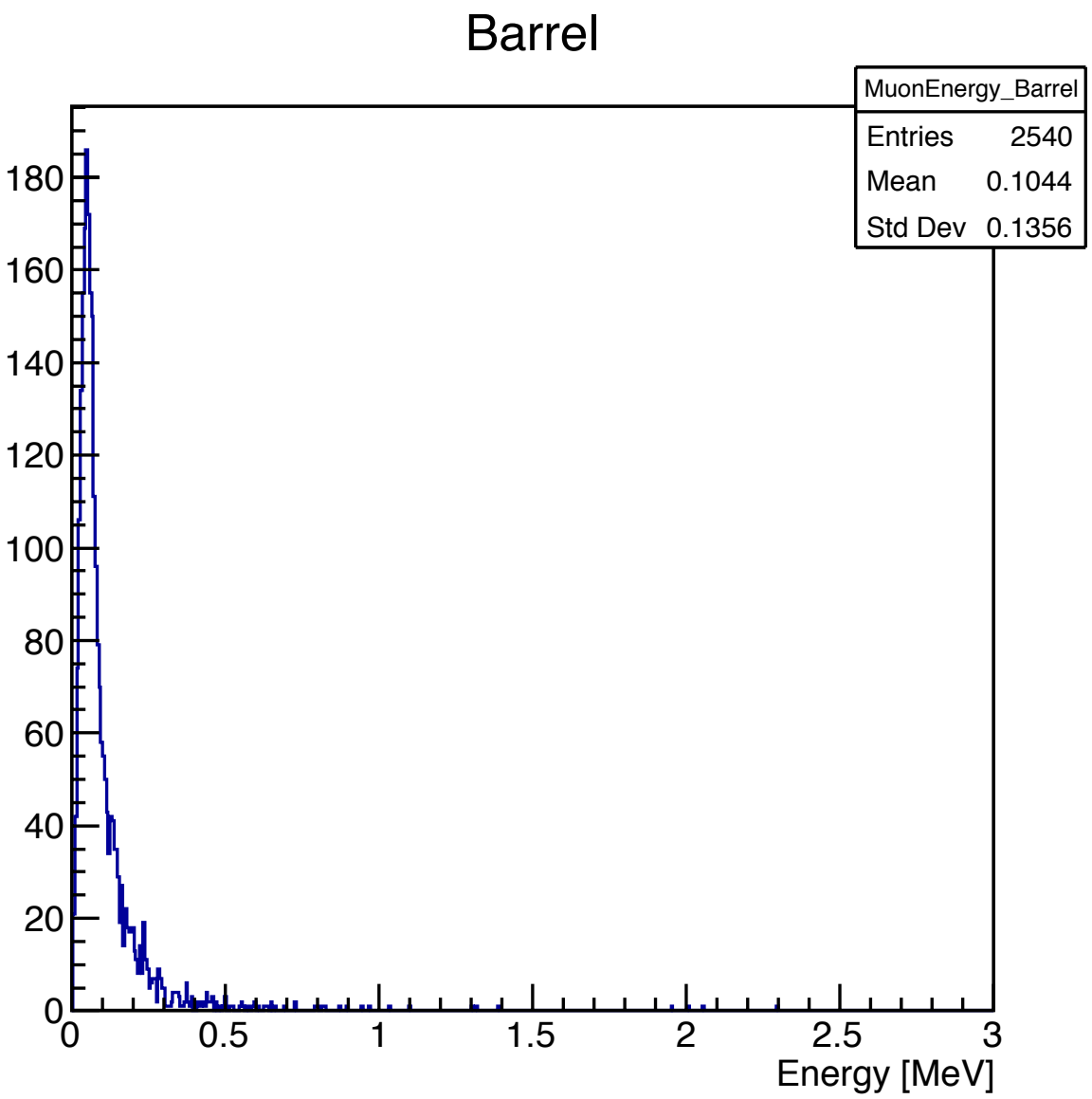

Muon Y vs X - Endcap
MuonXY_Endcap
Entries 2737
Mean x −46.94
Mean y 183.6
Std Dev x 2090
Std Dev y 2081
4000
2000
0
−2000
−4000
−6000
−6000
−4000
−2000
0
2000
4000
x [mm]

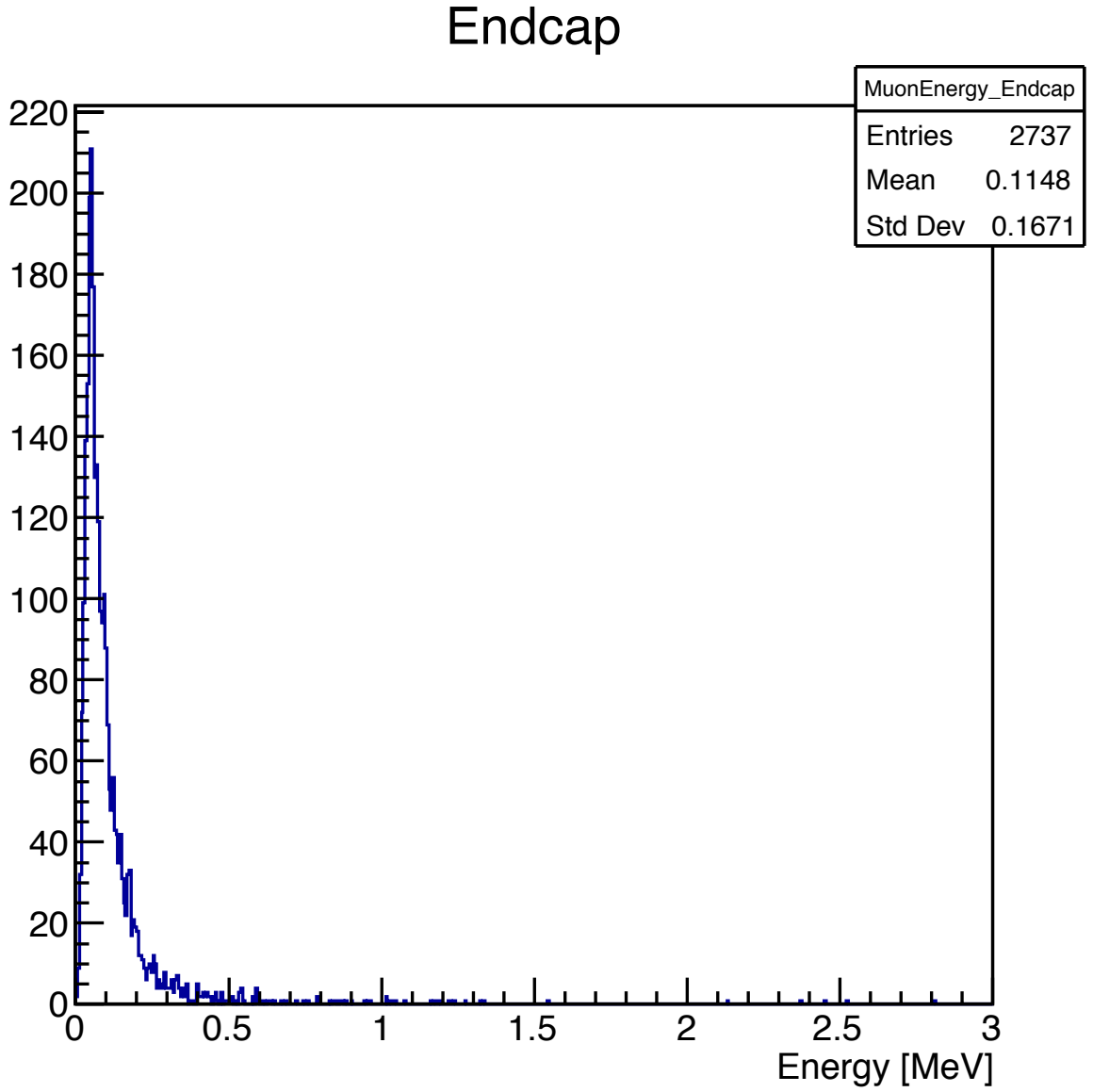

Barrel
MuonZ_Barrel
Entries 2540
Mean −192.6
Std Dev 2134
25
20
15
10
5
0
−6000
−4000
−2000
0
2000
4000
z [mm]

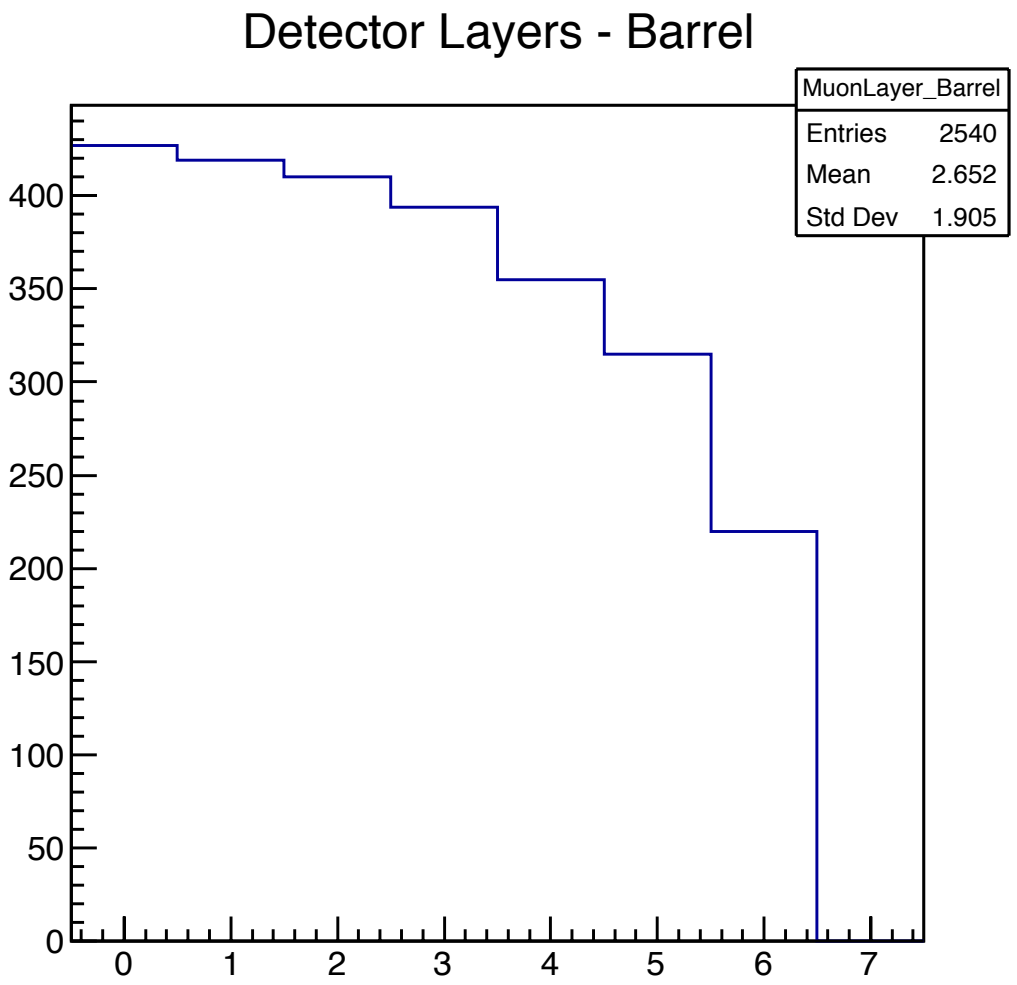

Endcap
MuonZ_Endcap
Entries 2737
Mean −143.2
Std Dev 4885
300
250
200
150
100
50
0
−6000
−4000
−2000
0
2000
4000
z [mm]

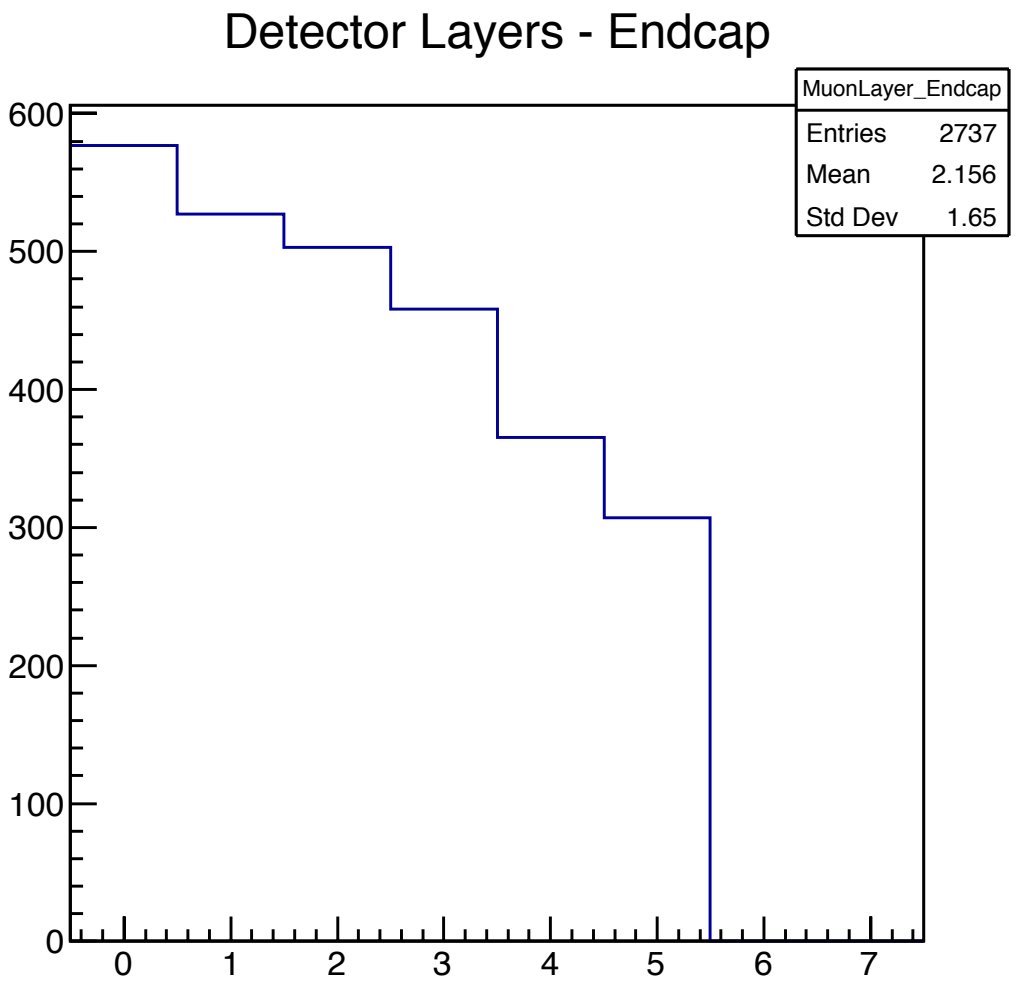

Barrel 13- Endcap 14
MuonDet
Entries 5277
Mean 13.52
Std Dev 0.4997
2500
2000
1500
1000
500
0
11.5
12
12.5
13
13.5
14
14.5
15
15.5
Detector ID

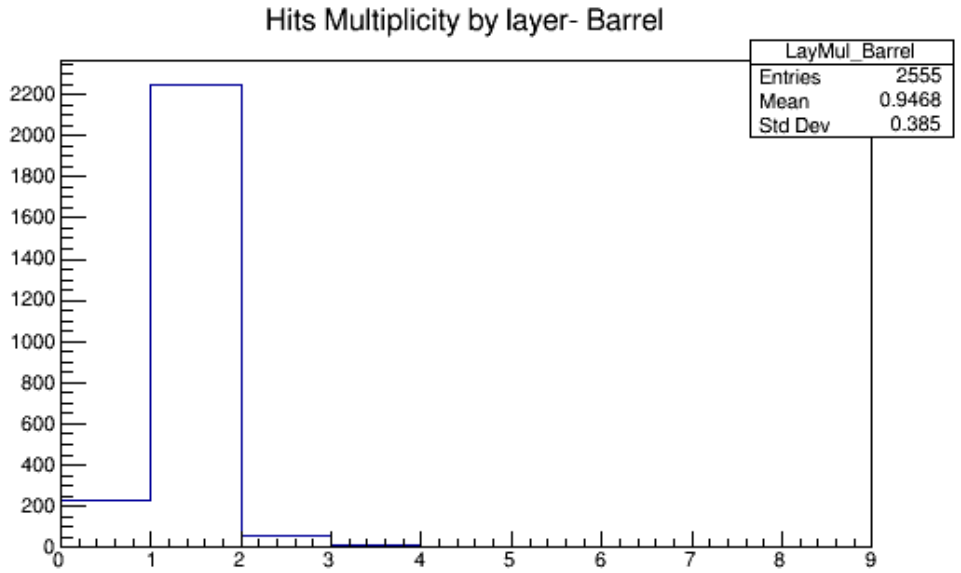
Energy

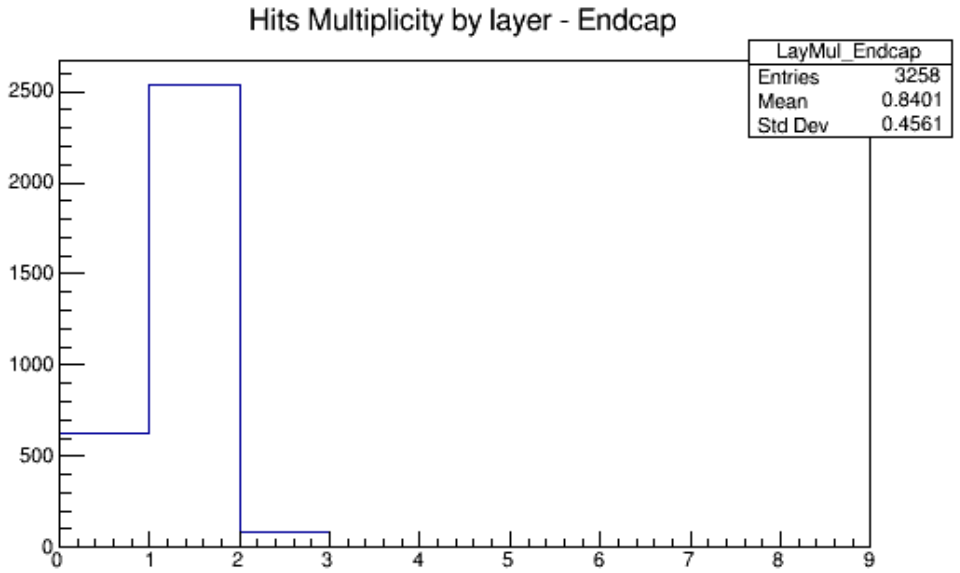

Barrel
MuonEnergy_Barrel
Entries 2540
Mean 0.1044
Std Dev 0.1356
0
20
40
60
80
100
120
140
160
180
0
0.5
1
1.5
2
2.5
3
Energy [MeV]

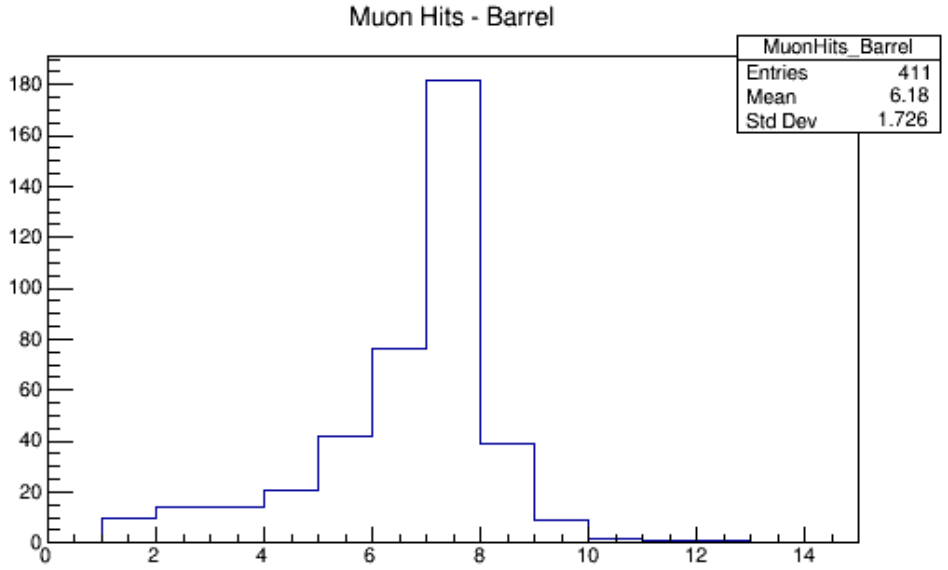

Endcap
MuonEnergy_Endcap
Entries 2737
Mean 0.1148
Std Dev 0.1671
0
20
40
60
80
100
120
140
160
180
200
220
0
0.5
1
1.5
2
2.5
3
Energy [MeV]

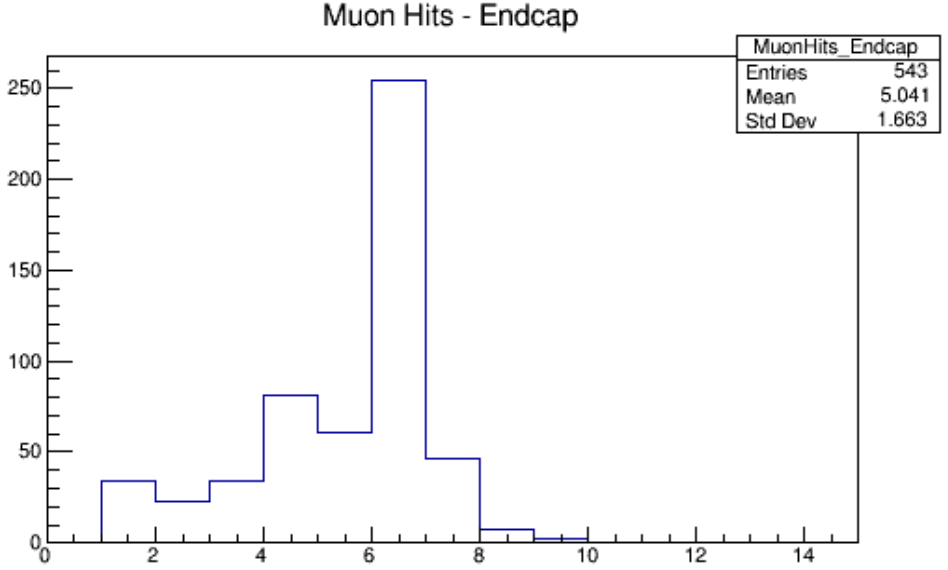

Detector Layers - Barrel
MuonLayer_Barrel
Entries 2540
Mean 2.652
Std Dev 1.905
0
50
100
150
200
250
300
350
400
0 1 2 3 4 5 6 7


Detector Layers - Endcap
MuonLayer_Endcap
Entries 2737
Mean 2.156
Std Dev 1.65
0
100
200
300
400
500
600
0 1 2 3 4 5 6 7

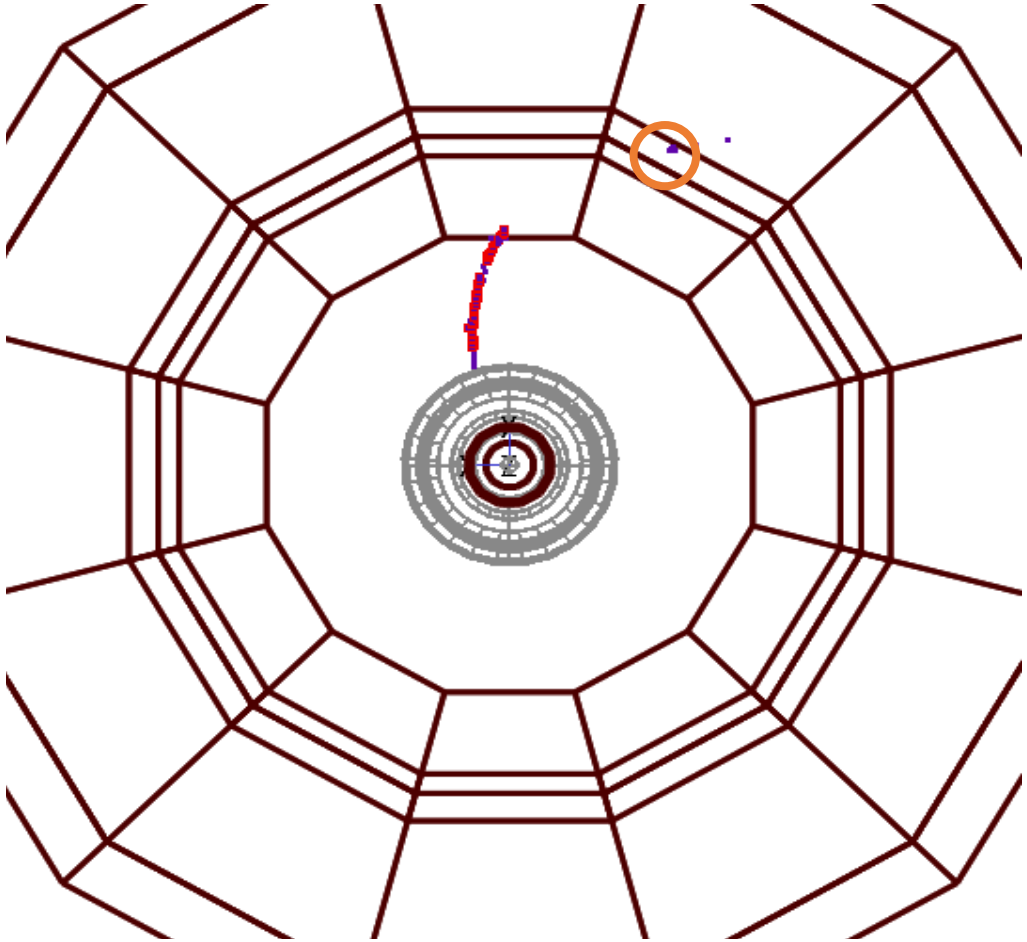


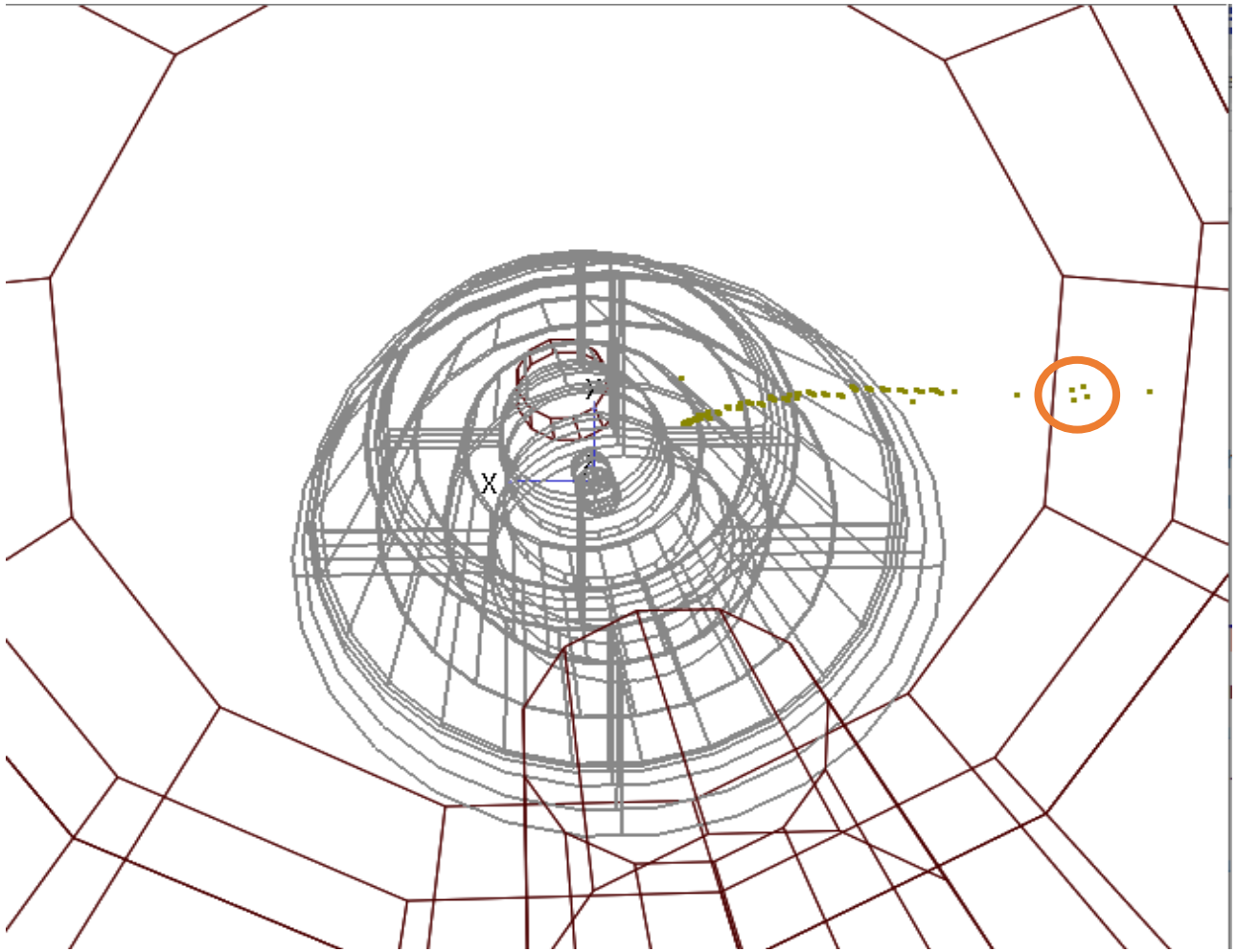






Some events with hits multiplicity > 1





Explanation: multiple hits in the same layer are due to electrons
Ionization electrons are stored, energy threshold set to 0.0 MeV

From clic_steer.py

```
## MinimalKineticEnergy to store particles created in the tracking region
#SIM.part.minimalKineticEnergy = 1.0*MeV
SIM.part.minimalKineticEnergy = 0.0*MeV
```