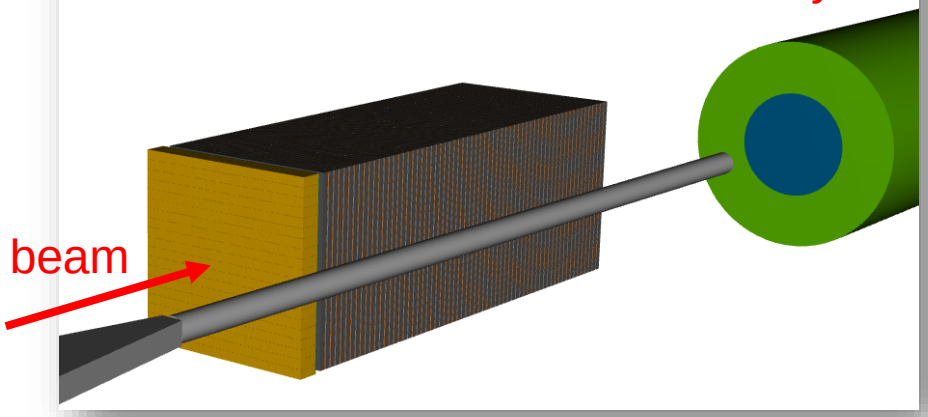
ZDC MC Simulation for ML project Status Update

Reminder : ZDC MC Setting

Beam shoot to ZDC center directly.



LYSO Crysal
60cm*60cm
3cm*3cm*7cm / cell
20*20 cells
7cm ~ 6X0 in Z

```
energyMin = "1*GeV"
energyMax = "20*GeV"
particle = "gamma"

ionCrossingAngle = -0.025 * radian
ZDC_r_pos = 3550 * cm
ZDC_x_pos = ZDC_r_pos * math.sin(-0.025)
ZDC_y_pos = 0 * cm
ZDC_z_pos = ZDC_r_pos * math.cos(-0.025)

SIM.numberOfEvents = 1000

SIM.enableGun = True
SIM.gun.position = (ZDC_x_pos, ZDC_y_pos, ZDC_z_pos)
SIM.gun.particle = particle
SIM.gun.momentumMin = eval(energyMin)
SIM.gun.momentumMax = eval(energyMax)
#SIM.gun.direction = (math.sin(-0.025), 0, math.cos(-0.025))
SIM.gun.thetaMin = ionCrossingAngle
SIM.gun.thetaMax = ionCrossingAngle
SIM.gun.phiMin = 0*degree
SIM.gun.phiMax = 0*degree
SIM.gun.distribution = "uniform"
SIM.gun.multiplicity = 1
```

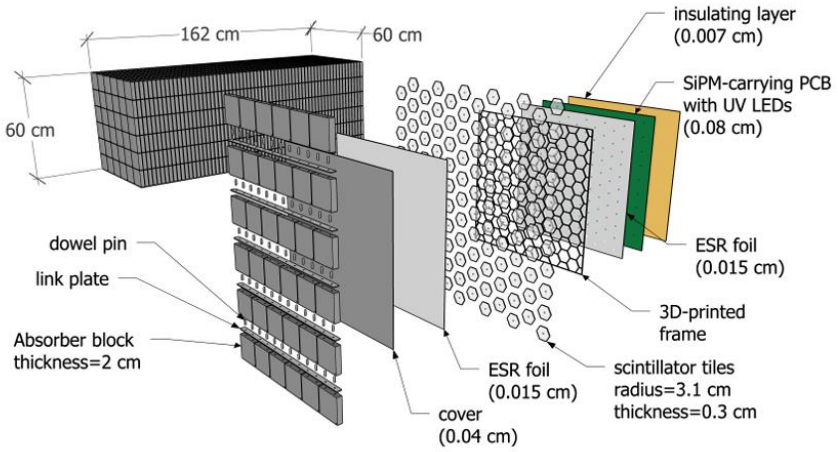
beam type and energy

beam position (starting point)

beam angle (spread)

Steering.py

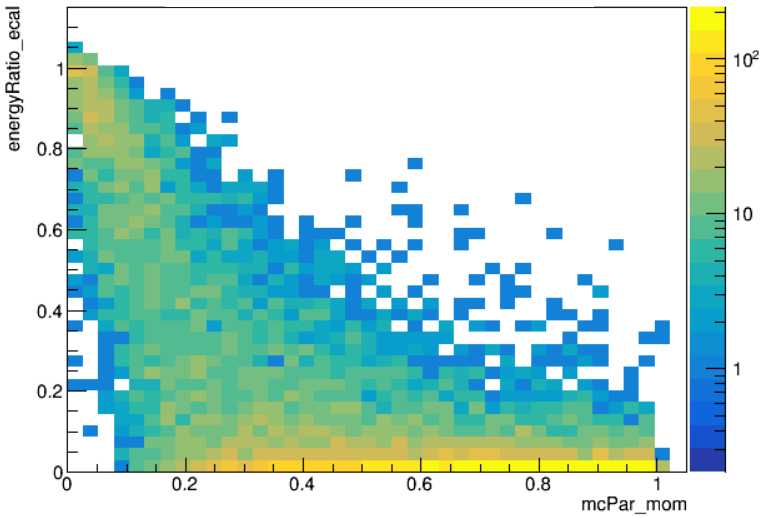
HCal



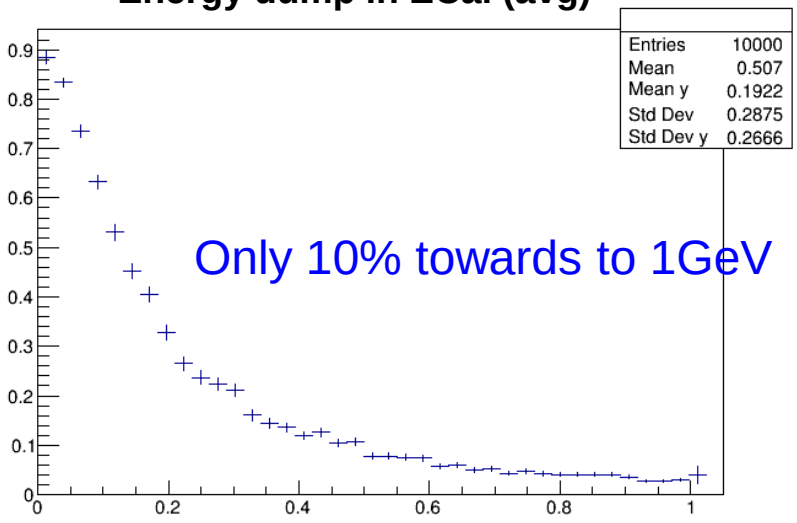
65cm in X, 60cm in Y, 163cm in Z
64 layers, 8 slice/layer
1 layer = steel + scintillator tile + SiPM

Reminder : Positron (0.01GeV ~ 1GeV)

Energy dump in ECal

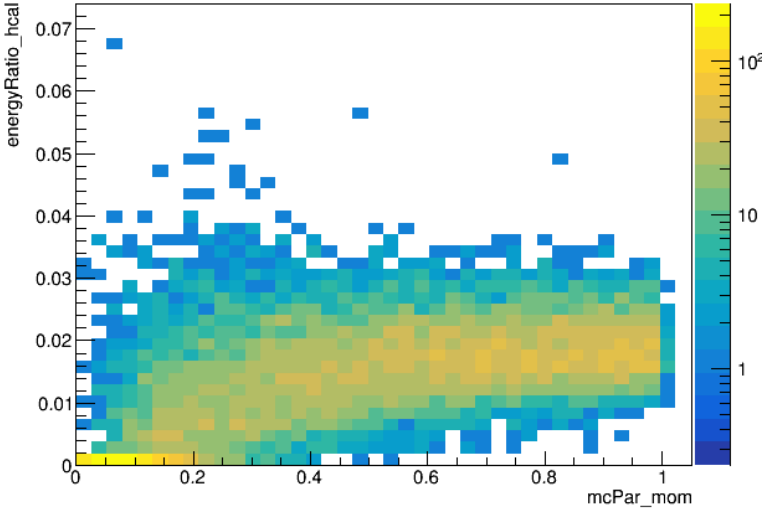


Energy dump in ECal (avg)

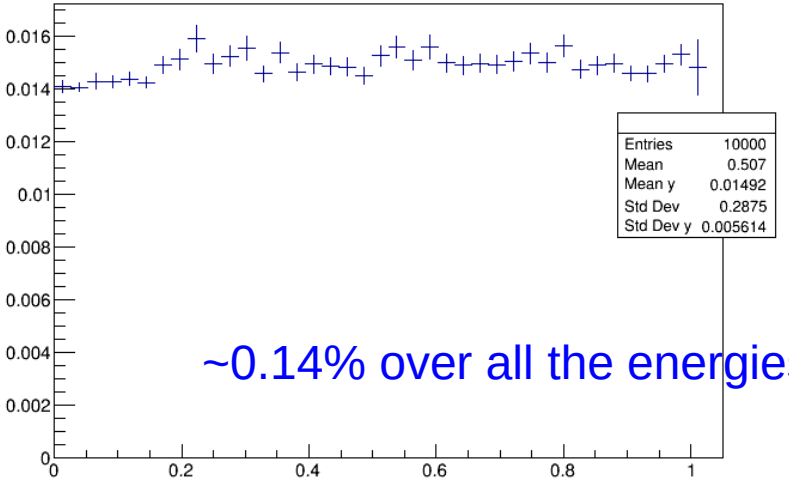


Only 10% towards to 1GeV

Energy dump in HCal

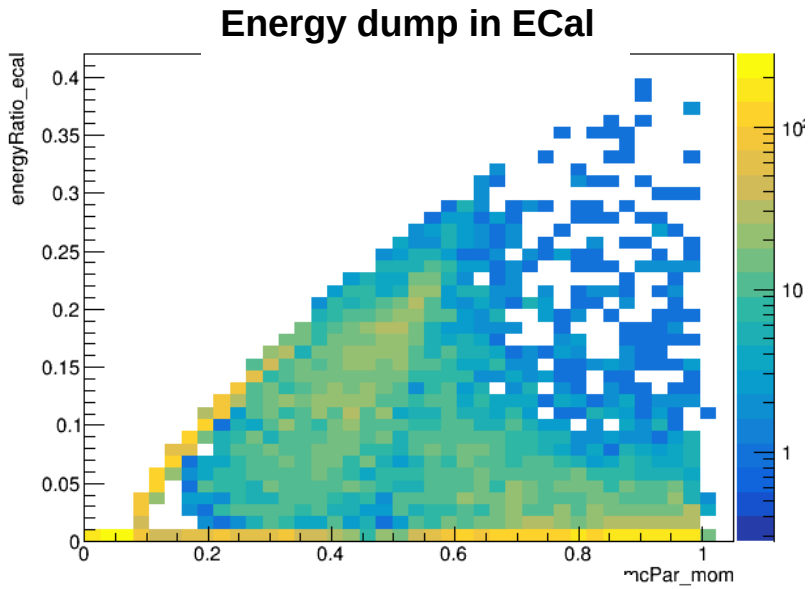


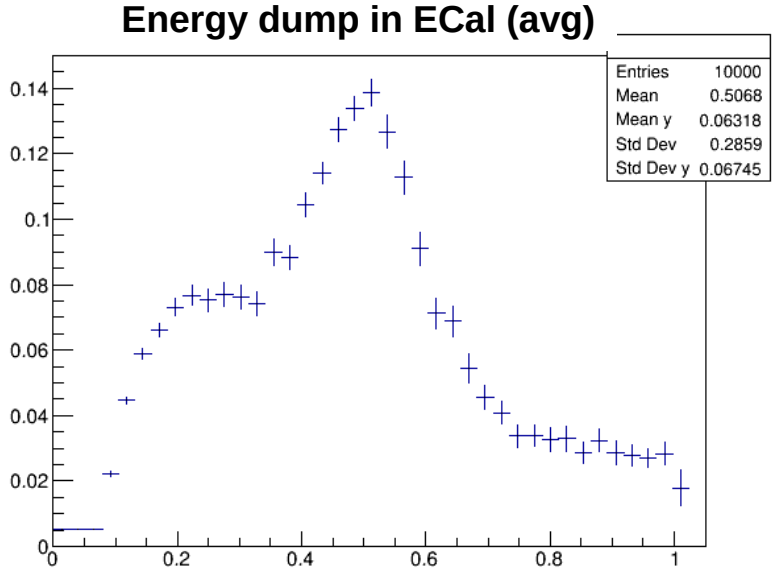
Energy dump in Hcal (avg)

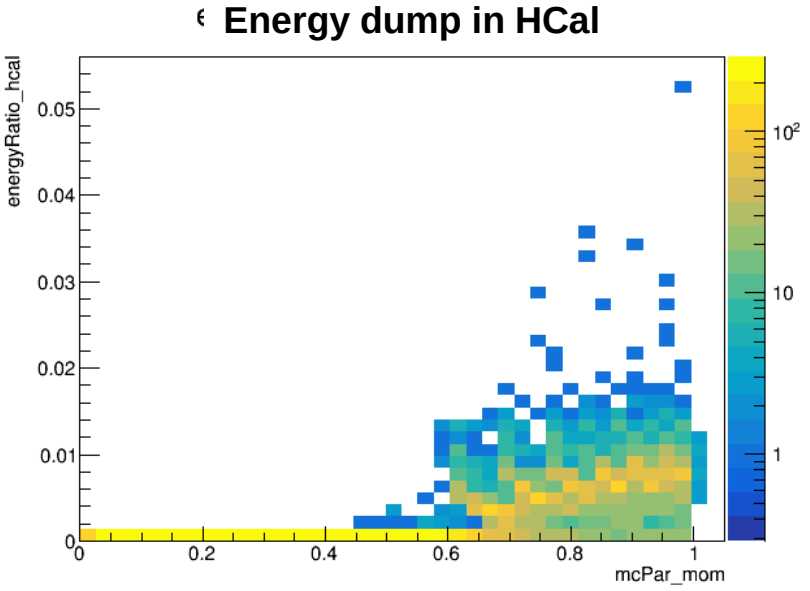


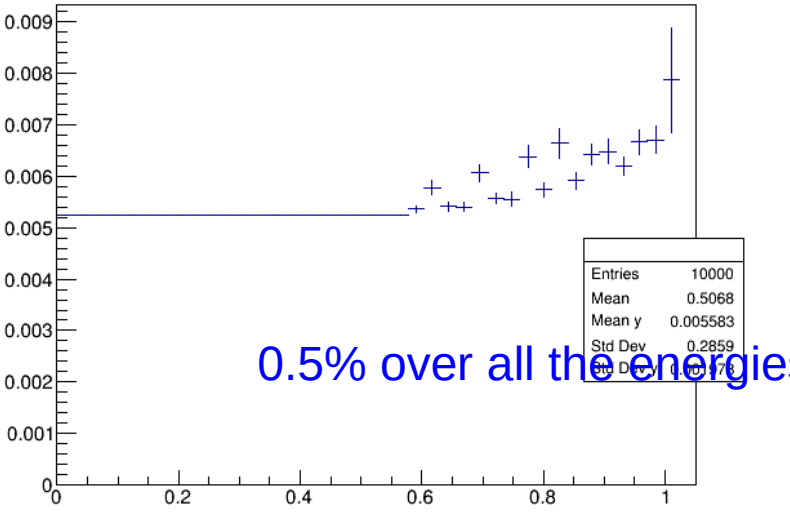
~0.14% over all the energies

Reminder : Proton (0.01GeV ~ 1GeV)







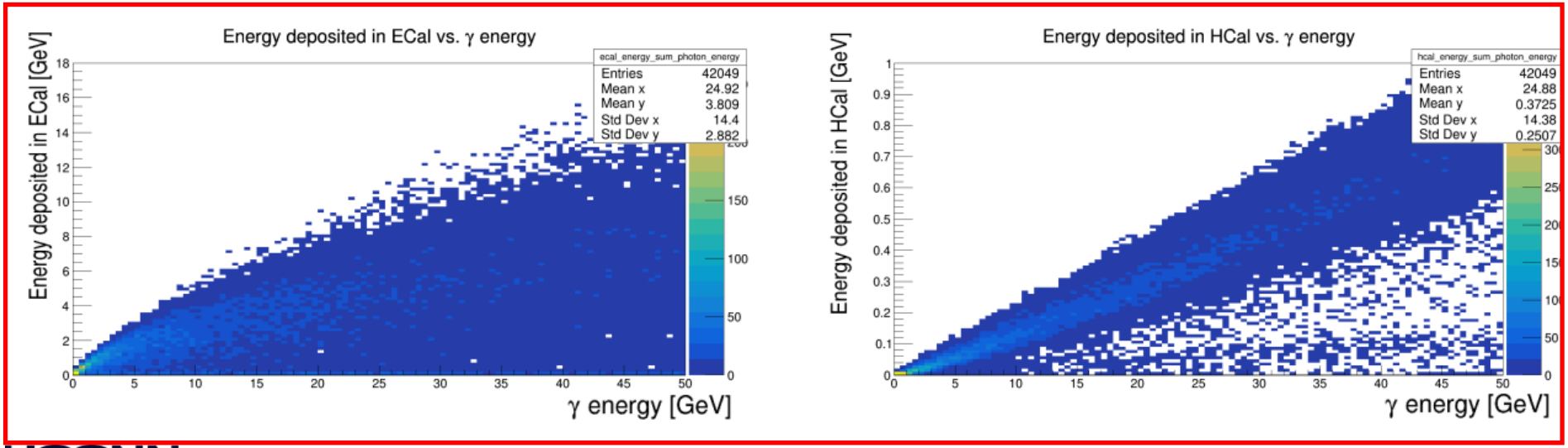


0.5% over all the energies

Latest Update form ZDC Meeting (Alessio I. University of Connecticut October 10, 2024)

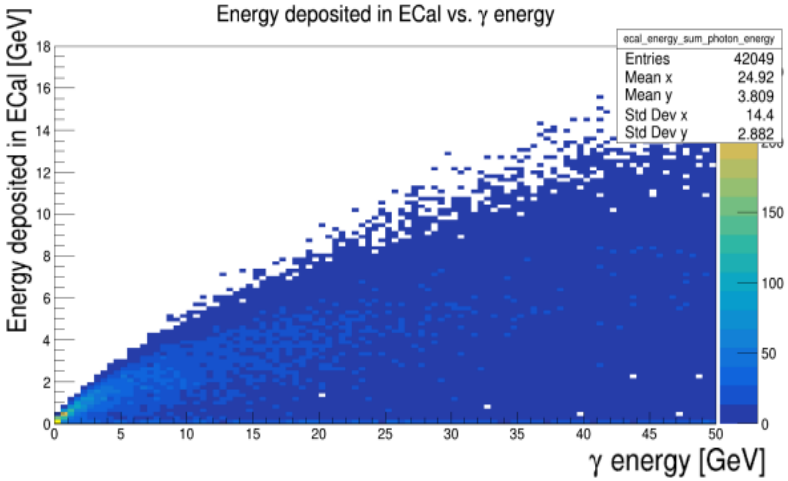
Single Photon ECal and HCal energy ratio

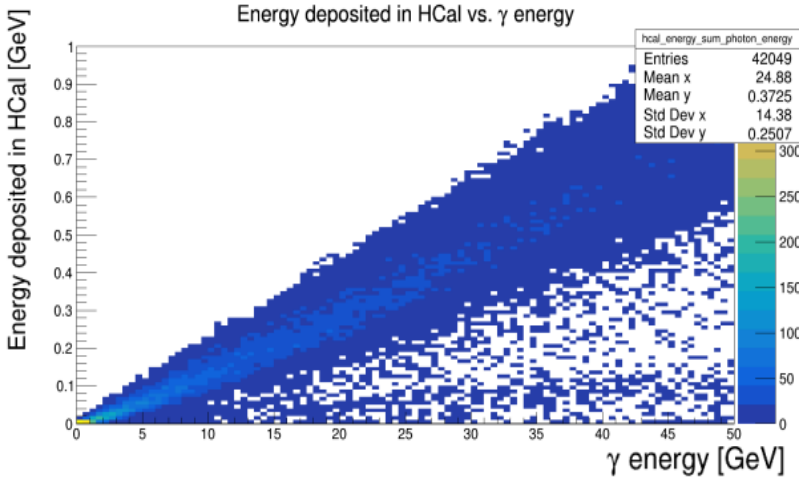
- ECal tiles are short, designed for low energy photons from nuclear breakup
- Most of the photon energy is deposited in ECal, but higher energy showers continue to propagate into the HCal
- Necessary to understand energy resolution for single photon for both calorimeters



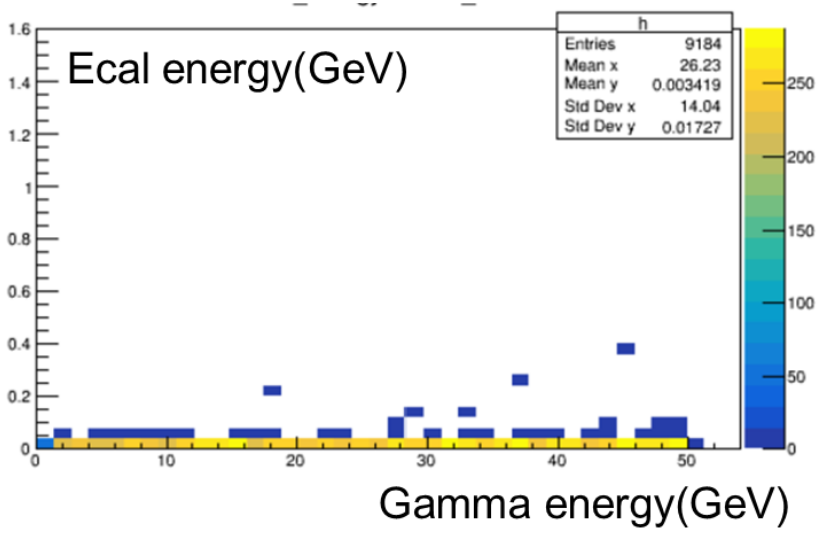
Communication w/ Alessio I. (1)

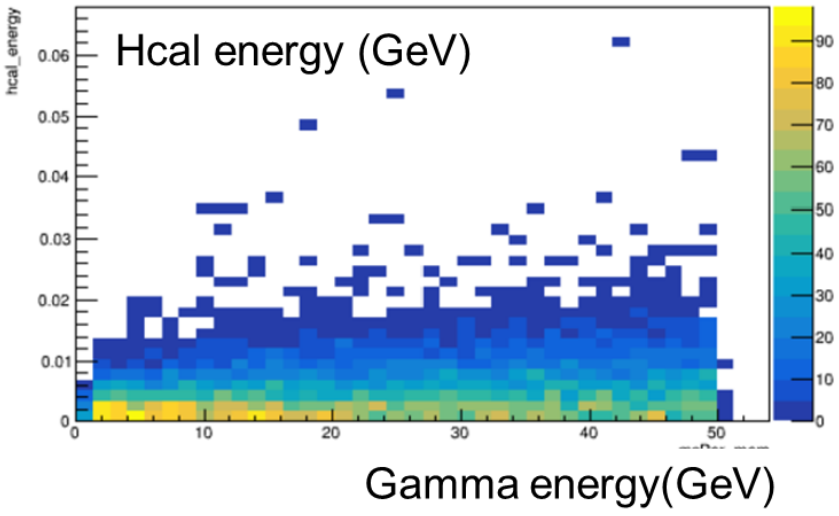
- Alessio I. : photon particle gun, full face coverage for the ZDC





- Chia-Yu : photon particle gun, shoot center of ZDC (my own steering file)



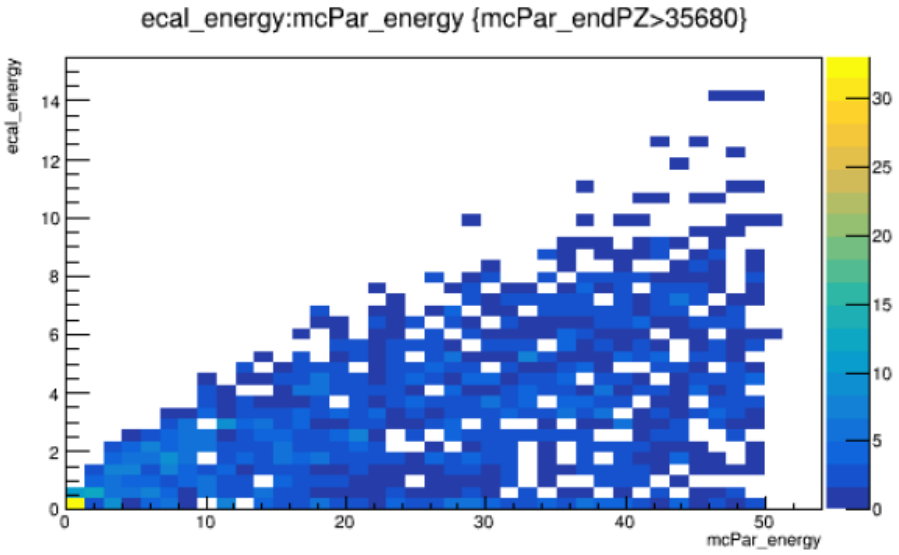


Communication w/ Alessio I. (2)

Thank you for reaching out. I want to clarify what my plots here are showing. The y-axis in these plots is the summed energy of all hits in the ECal and HCal, respectively, for all event in which the photon reaches the ZDC. The data being used is 100k events with single photon particle gun with full face coverage for the ZDC (I have attached my steering file as a .txt to this email). I think it's important to distinguish the results that come from directly shooting along the 25mrad line versus full face coverage as I noticed something anomalous with the ECal hit energies when shooting directly at the ZDC. When shooting photons directly at the ZDC along the (-sin(.025),0,cos(.025)) line, there is an abnormally small amount of energy deposited in the ECal for most events, much lower than events with full face coverage. I do not understand why this is occurring, but I avoid using that data for analysis as it does not seem correct.

Reproduce Alessio's results

- Using Alessio's steering file Results looks normal finally.
- The key point is not to shoot center of ZDC directly?

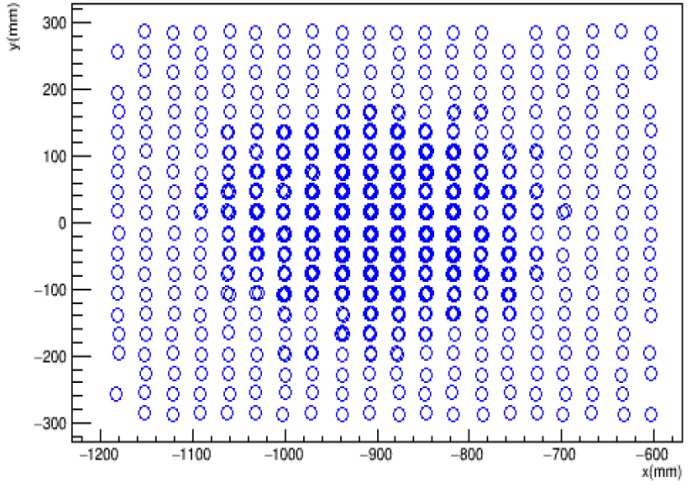


Shift Beam Position

- **Shoot at the center of ZDC**
  - SIM.gun.position = (ZDC_x_pos, ZDC_y_pos, ZDC_z_pos)

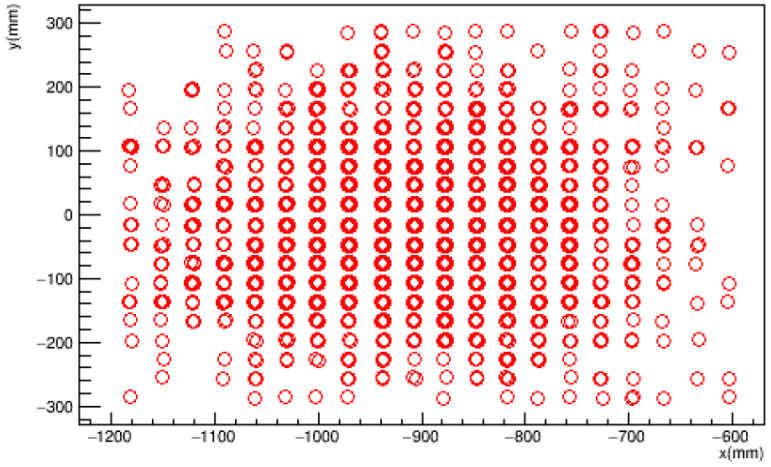
- **Shoot at the center of "crystal"**
  - SIM.gun.position = (ZDC_x_pos-15, ZDC_y_pos-15, ZDC_z_pos)
  - 15mm = half size of crystal width/length (crystal = 3cm*3cm*7cm)

10MeV-1GeV positron beam



shower profile of "shoot center of ZDC"

10MeV-1GeV positron beam



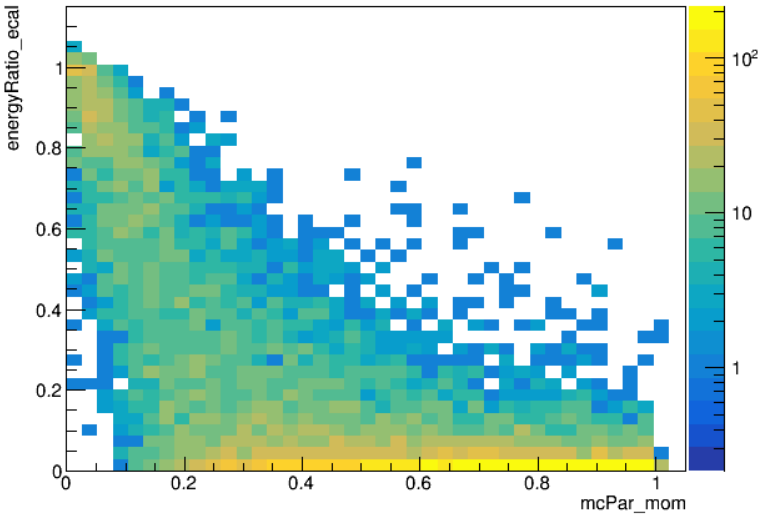
shower profile of "shoot center of crystal"

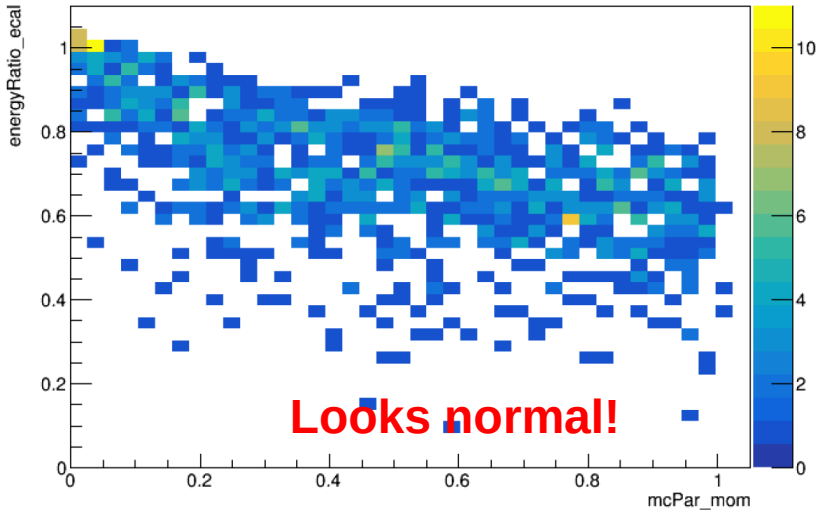
10MeV – 1GeV Positron Beam
Xaxis : BeamE(GeV), Yaxis : EnergyDump/BeamE

Shoot at the center of ZDC

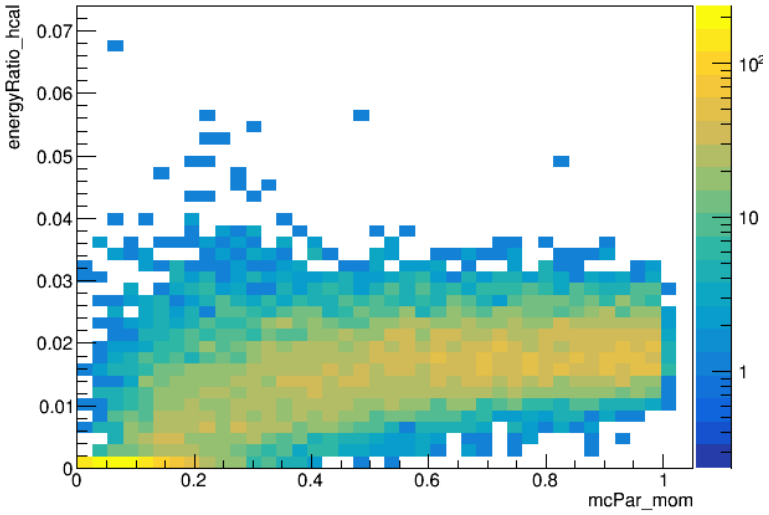
Shoot at the center of "crystal"

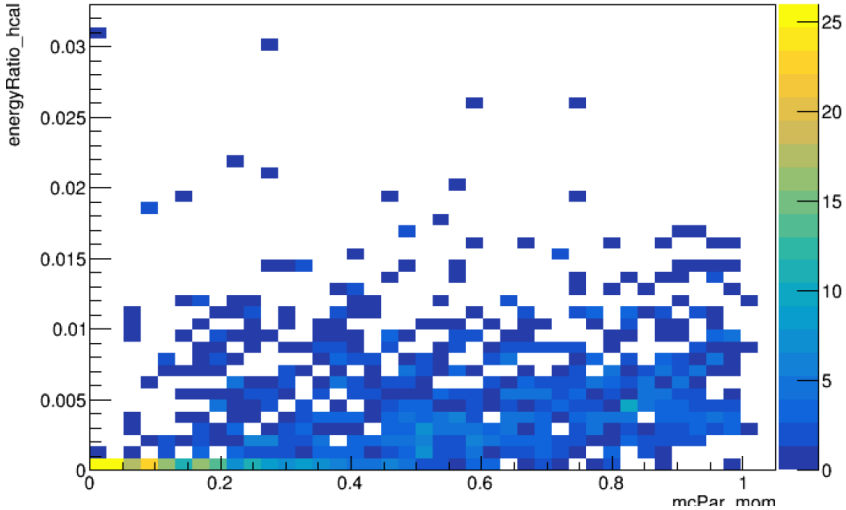
ECal





HCal





Shoot Wider Coverage

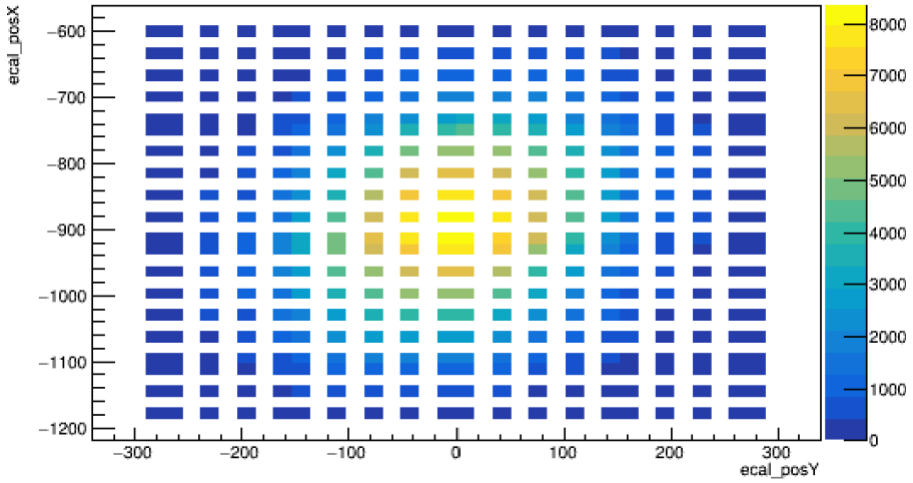
```
#energyMin = "1*GeV"
#energyMax = "20*GeV"
#particle = "gamma"
energyMin = "10*MeV"
energyMax = "20*GeV"
particle = "proton" #e+, don't use positron

ionCrossingAngle = -0.025 * radian
ZDC_r_pos = 35500
ZDC_x_pos = ZDC_r_pos * math.sin(-0.025)
ZDC_y_pos = 0
ZDC_z_pos = ZDC_r_pos * math.cos(-0.025)
shift = 0

SIM.numberOfEvents = 50000
SIM.enableGun = True
SIM.gun.particle = particle
SIM.gun.momentumMin = eval(energyMin)
SIM.gun.momentumMax = eval(energyMax)
SIM.gun.distribution = "uniform"
SIM.gun.multiplicity = 1

SIM.gun.position = (ZDC_x_pos-shift, ZDC_y_pos-shift, ZDC_z_pos)
SIM.gun.thetaMin = ionCrossingAngle - 23* degree
SIM.gun.thetaMax = ionCrossingAngle + 23* degree
SIM.gun.phiMin =   0* degree
SIM.gun.phiMax =  45* degree
```

No shift anymore

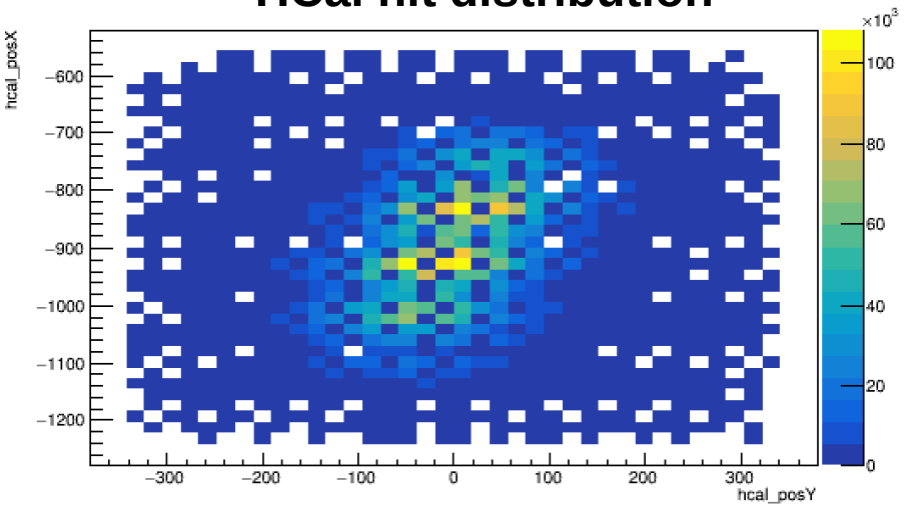
Add angle coverage
Theta = [- 23, 23] degree
Phi = [0, 45] degree
(cross check required)

Positron beam (50k evts, 10MeV-20GeV)

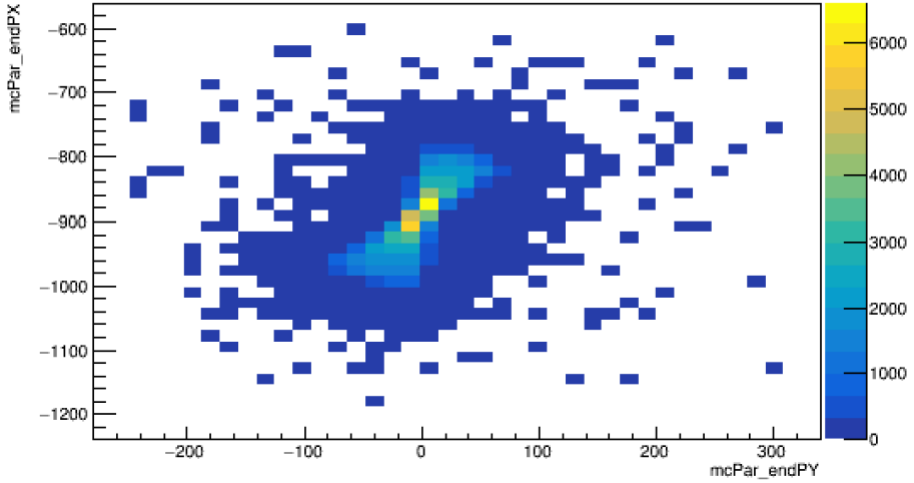
ECal hit distribution



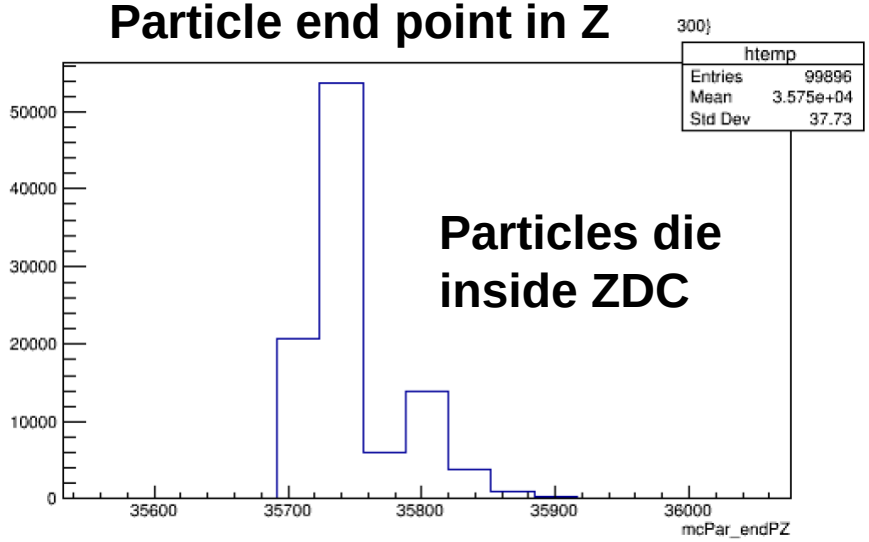
HCal hit distribution



Particle end point in XY

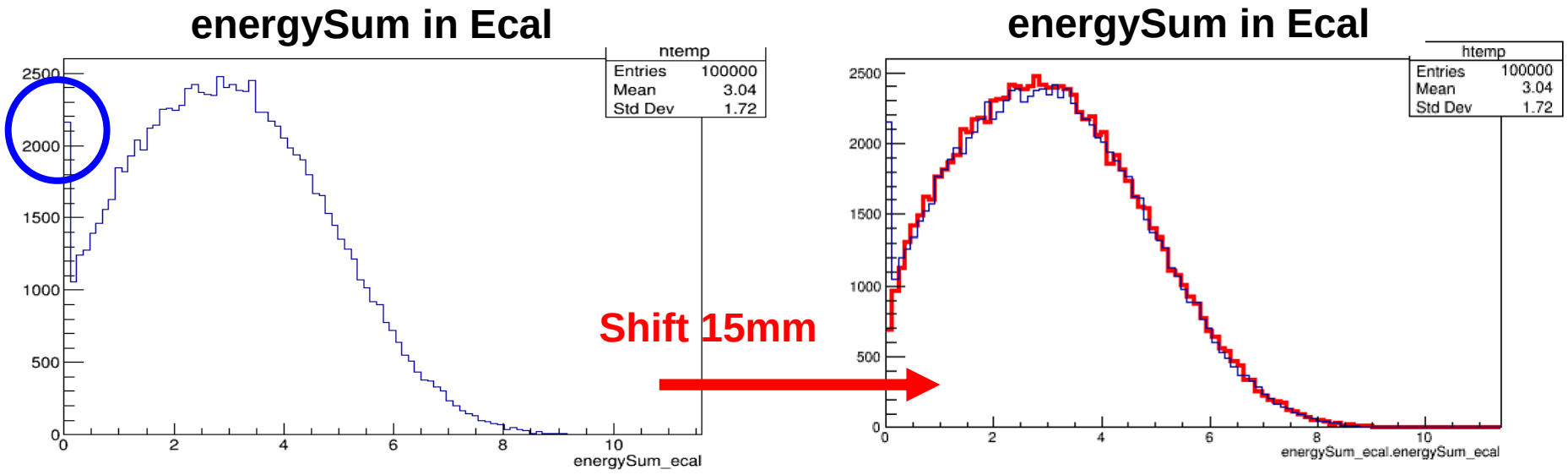


Particle end point in Z



Beam shoots into ZDC with specific angle, but not full coverage of ZDC though.

Positron beam (50k evts, 10MeV-20GeV)



- **If the starting point of beam is in the center of ZDC, there are still some events with almost zero energy dump in Ecal. No kinematic or geometry dependence observed.**
- **However, if we shift the beam 15mm in x and y. The problem is gone.**

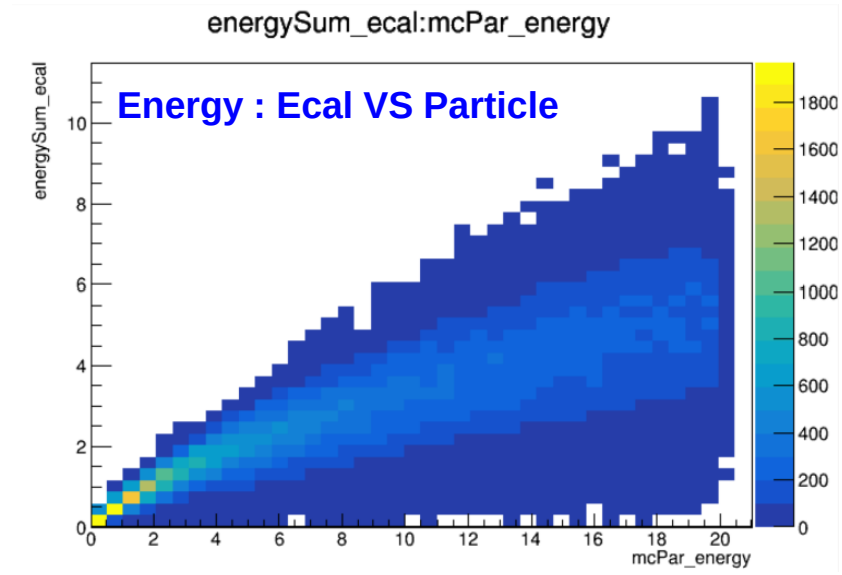
Shoot Wider Coverage + Shift 15mm

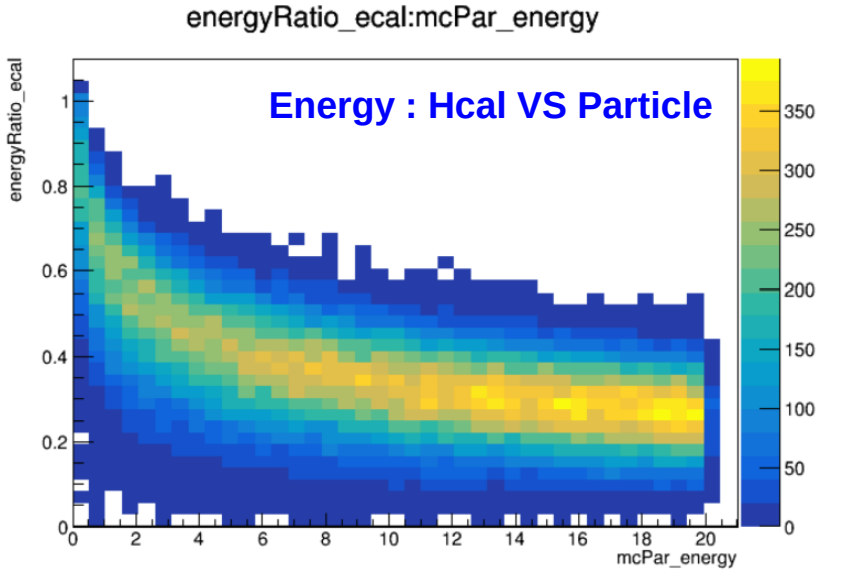
```
from g4units import cm, mm, GeV, MeV, degree, radian
SIM = DD4hepSimulation()

#energyMin = "1*GeV"
#energyMax = "20*GeV"
#particle = "gamma"
energyMin = "10*MeV"
energyMax = "20*GeV"
particle = "e+" #e+, don't use positron

ionCrossingAngle = -0.025 * radian
ZDC_r_pos = 35500
ZDC_x_pos = ZDC_r_pos * math.sin(-0.025)
ZDC_y_pos = 0
ZDC_z_pos = ZDC_r_pos * math.cos(-0.025)
shift = 15

SIM.numberOfEvents = 100000
SIM.enableGun = True
SIM.gun.particle = particle
SIM.gun.momentumMin = eval(energyMin)
SIM.gun.momentumMax = eval(energyMax)
SIM.gun.distribution = "uniform"
SIM.gun.multiplicity = 1

SIM.gun.position = (ZDC_x_pos-shift, ZDC_y_pos-shift, ZDC_z_pos)
SIM.gun.thetaMin = ionCrossingAngle - 23* degree
SIM.gun.thetaMax = ionCrossingAngle + 23* degree
SIM.gun.phiMin =    0* degree
SIM.gun.phiMax =   45* degree
```

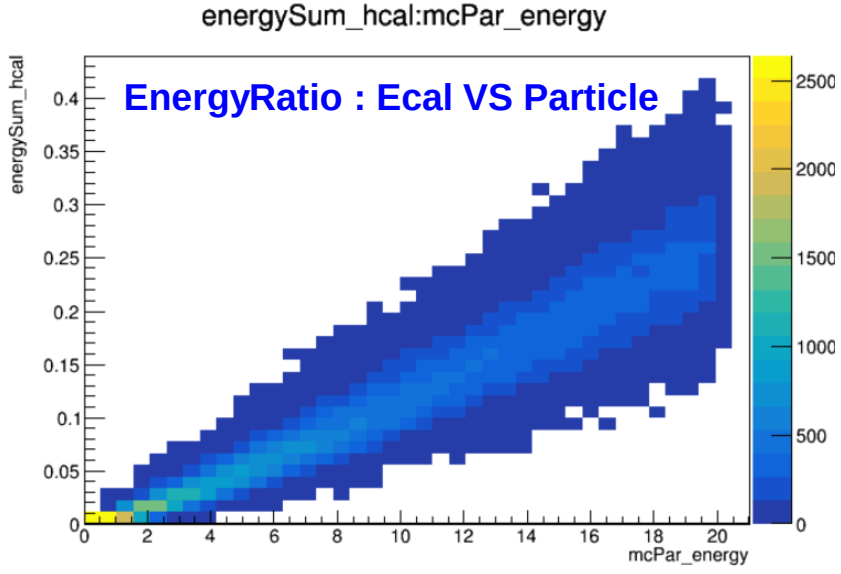
Beam starting point
shift 15mm

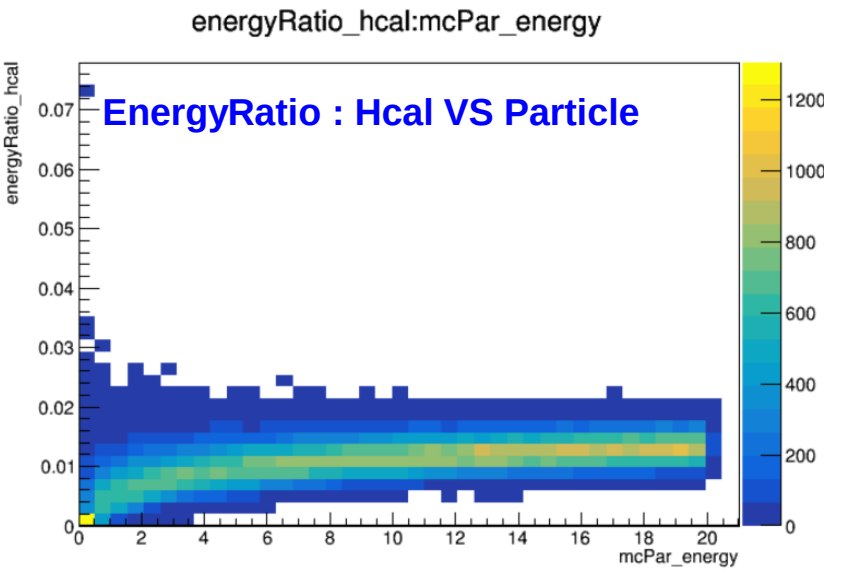
Beam angle
Theta = [- 23, 23] degree
Phi = [0, 45] degree
(cross check required)

Positron (50k evts, 10MeV-20GeV)

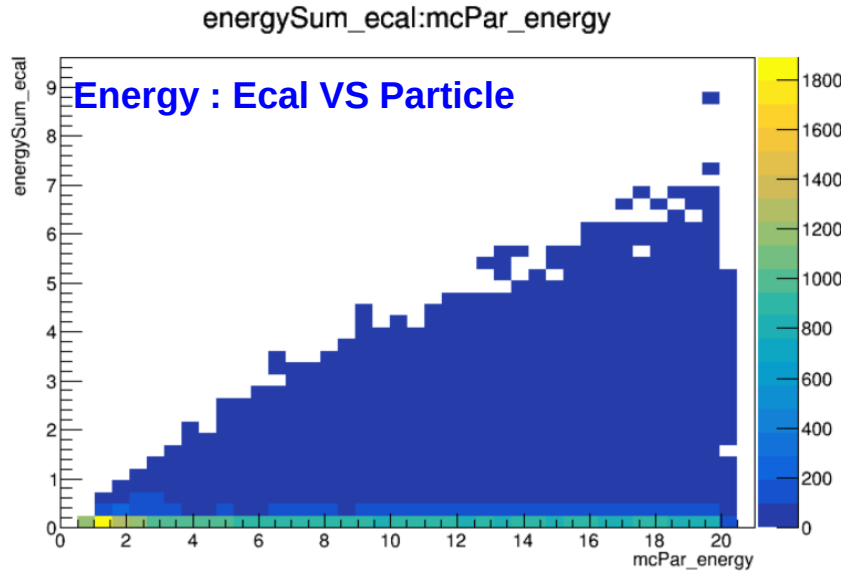


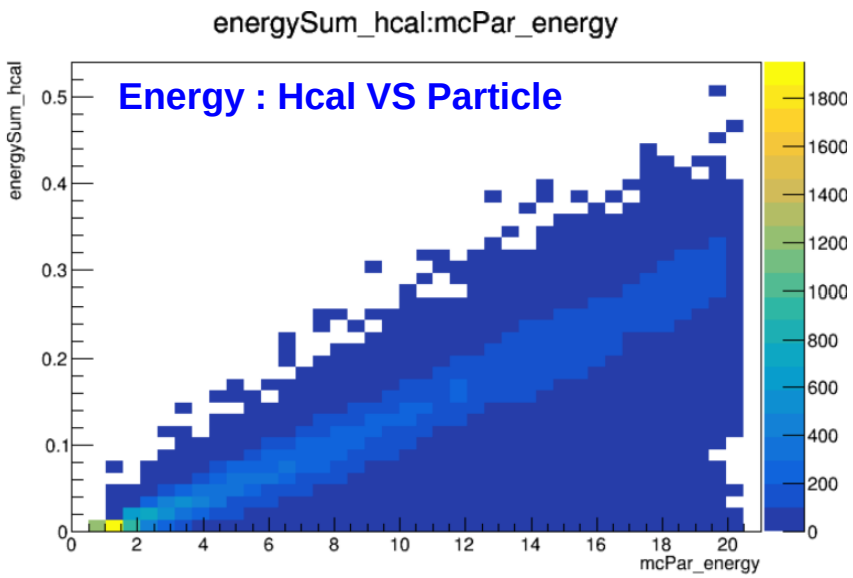


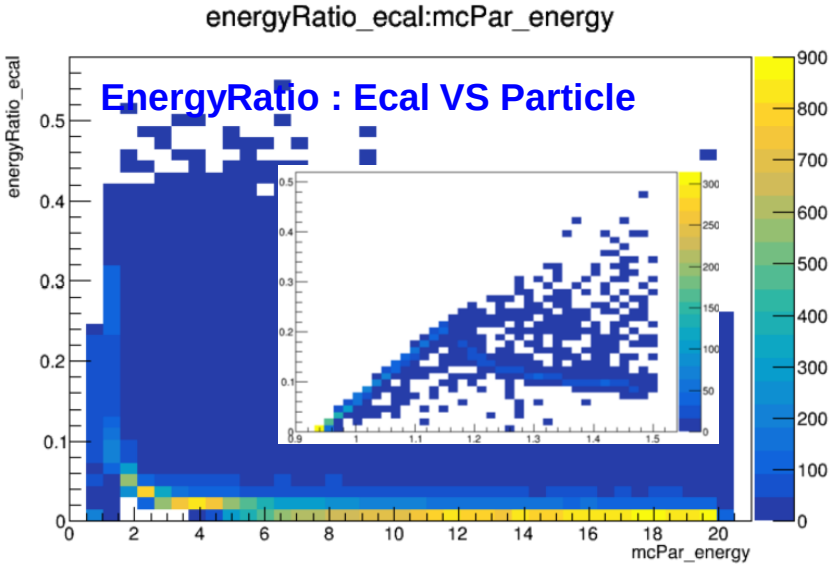


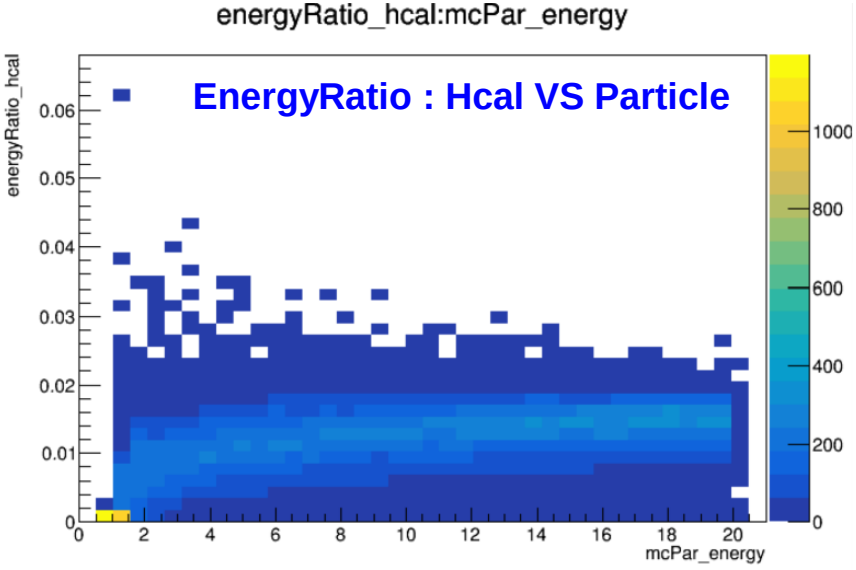


Proton (50k evts, 10MeV-20GeV)









Summary

- We could still test the angle setting, but the beam setting of MC sample should be ready.
- Do we generate MC sample under Grid? Need help to install eic-shell.