Reports for SDHCAL

Bing Liu[1], Haijun Yang[1], Imad Laktineh[2] ,Guillaume Garillot[2]

[1]SJTU,[2]IPNL

Outline

- Simple introduction to SDHCAL prototype
- Data samples and selections
- Analysis of 2015 data
- BDT progress
- Summary and Next plan

Simple introduction to SDHCAL

SDHCAL(Semi-digital Hadron Calorimeter) Prototype

Total Size:1.0x1.0x1.4m^3

Total Layers: 48

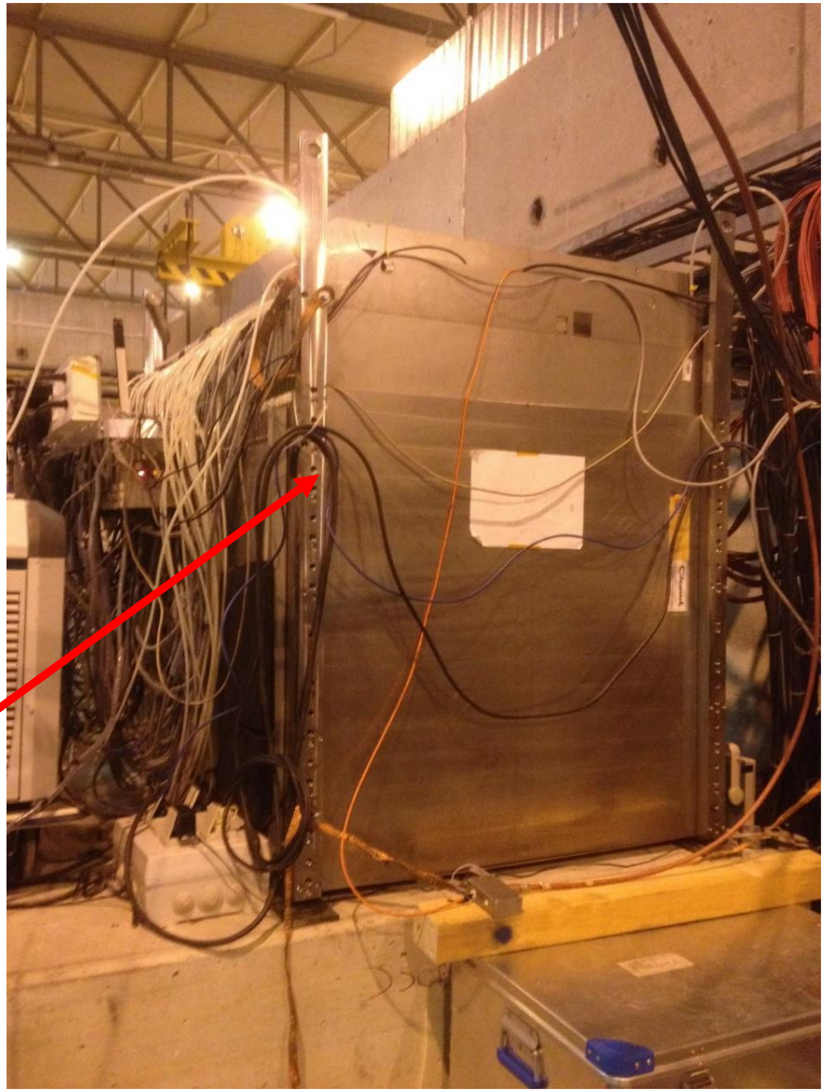
Total Channel(pads):3X48X64X48≈440000

Power consumption:$10\mu W/channel$

Per layer(≈28mm) including absorber and sensitive medium

Per layer Area:1.0x1.0m^2

SDHCAL



Structure of per layer

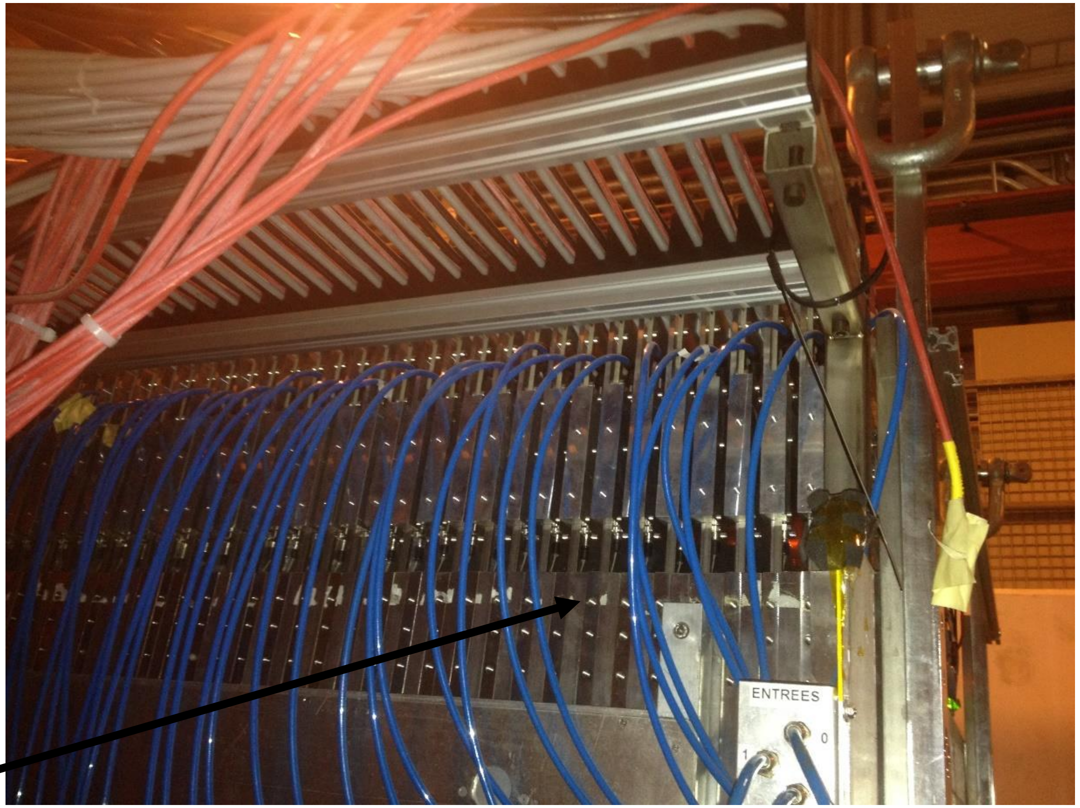
Including absorber and one cassettes

Stainless steel Absorber(15mm, $0.12\lambda_I, 1.14X_0$)

Stainless steel wall(2.5mm)

GRPC(6mm$\approx 0\ \lambda_I, X_0$)

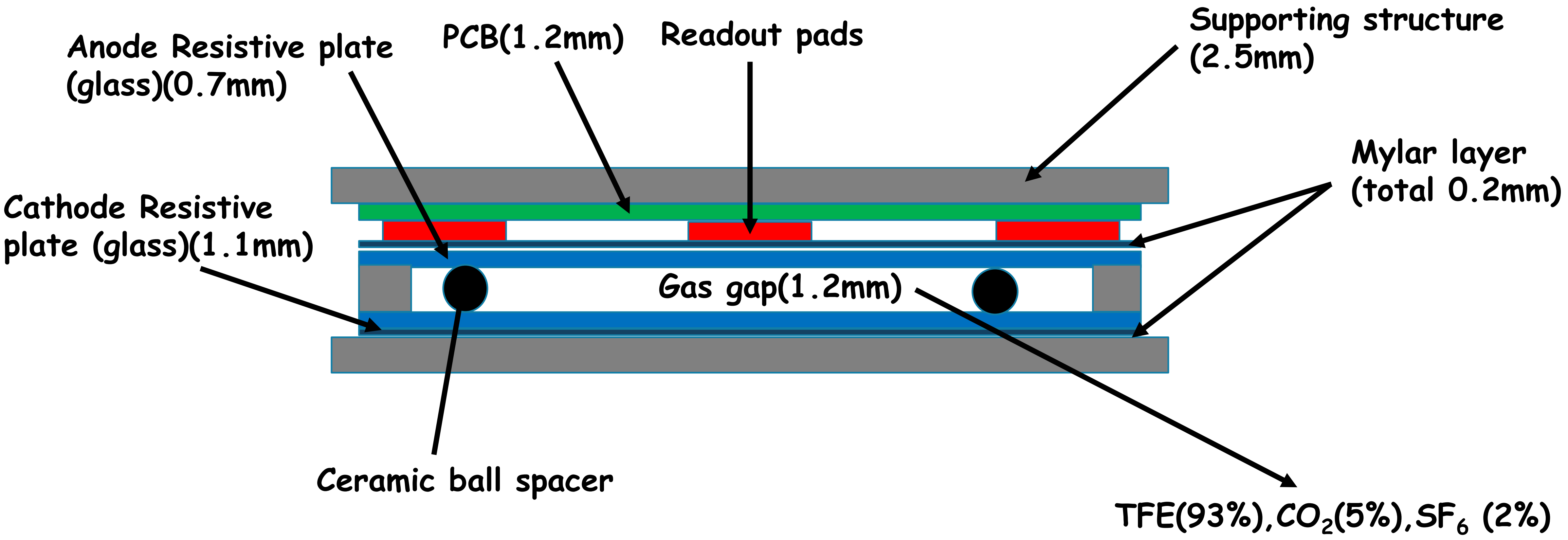
Stainless steel wall(2.5mm)



One cassettes($0.04\lambda_I, 0.38X_0$)

Sensitive layer(Total 6mm)

GRPC(3mm)+electronics(3mm)



A schematic of GRPC (not to scale)

Data simples and selections

Data sample and selections

Data sample:SPS_Oco_2015

Particle: Pi+

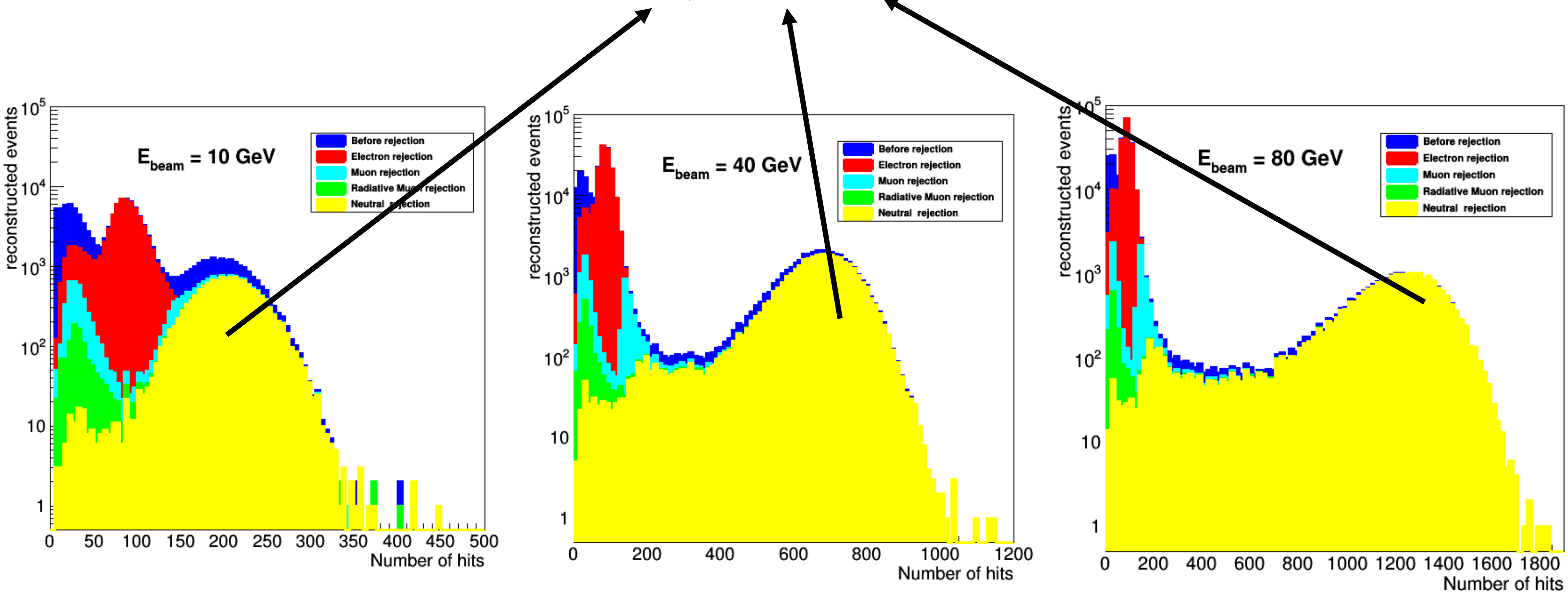
Energy:10-80GeV with uniform

10 GeV energy gap

selections

Type	Selections	Detail
Physical cut	Electron rejection	Shower start >=5 or Nlayer > 30
	Muon rejection	Nhit/Nlayer > 3.2(previous is 2.2)
	Radiative muon rejection	Nlayer(RMS > 5cm)/Nlayer>20%
	Neutral rejection	Nhit(belong to first 5 layers)> =4
Artificial cut	Beam position cut	r<r(given)

Contributed by hadron showers

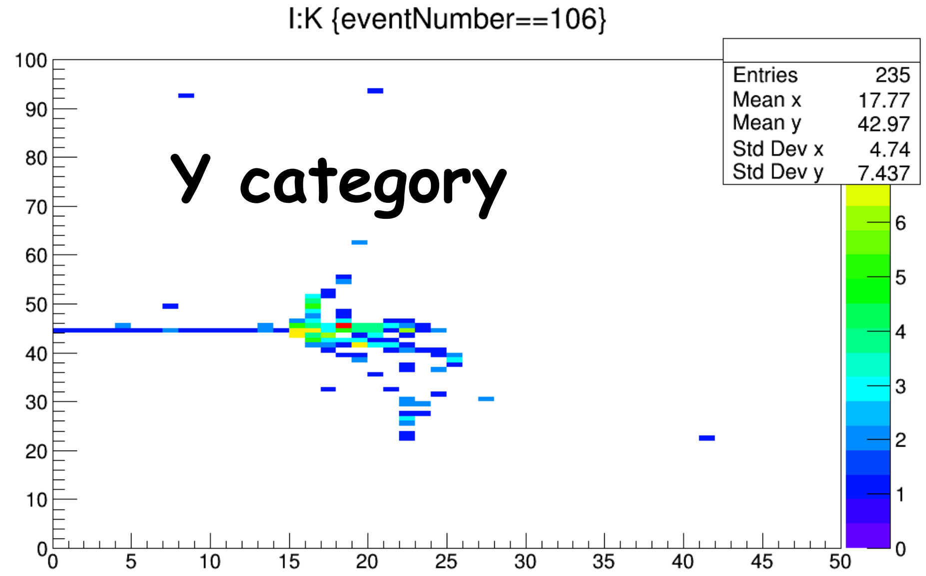


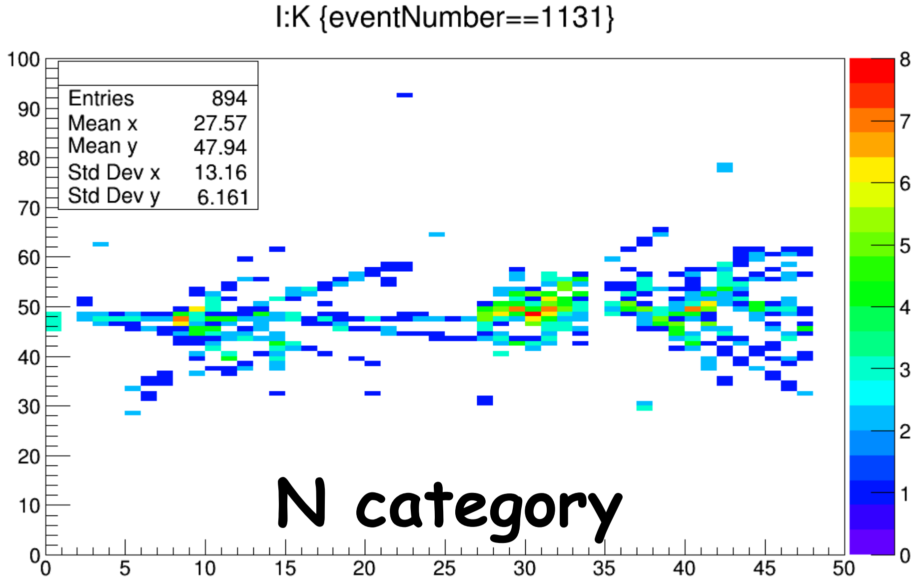
Applying 4 rejections step by step

Cut flow

Energy(GeV)	Total Events	After Electron rejection	After Muon rejection	After Radiative muon rejection	After Neutral rejection
10	123974	82223	10810	9685	9675
20	92053	68981	10250	9710	9701
30	49299	38134	7715	7319	7313
40	247428	190603	31329	29582	29544
50	97496	74933	14556	13644	13627
60	97988	76819	13629	12642	12625
70	101626	78547	10914	9865	9852
80	249478	196340	18884	15577	15541

Analysis of 2015 data





When looking at each event you can see if in this event at last 4 layers are fired (number44,45,46 and 47)

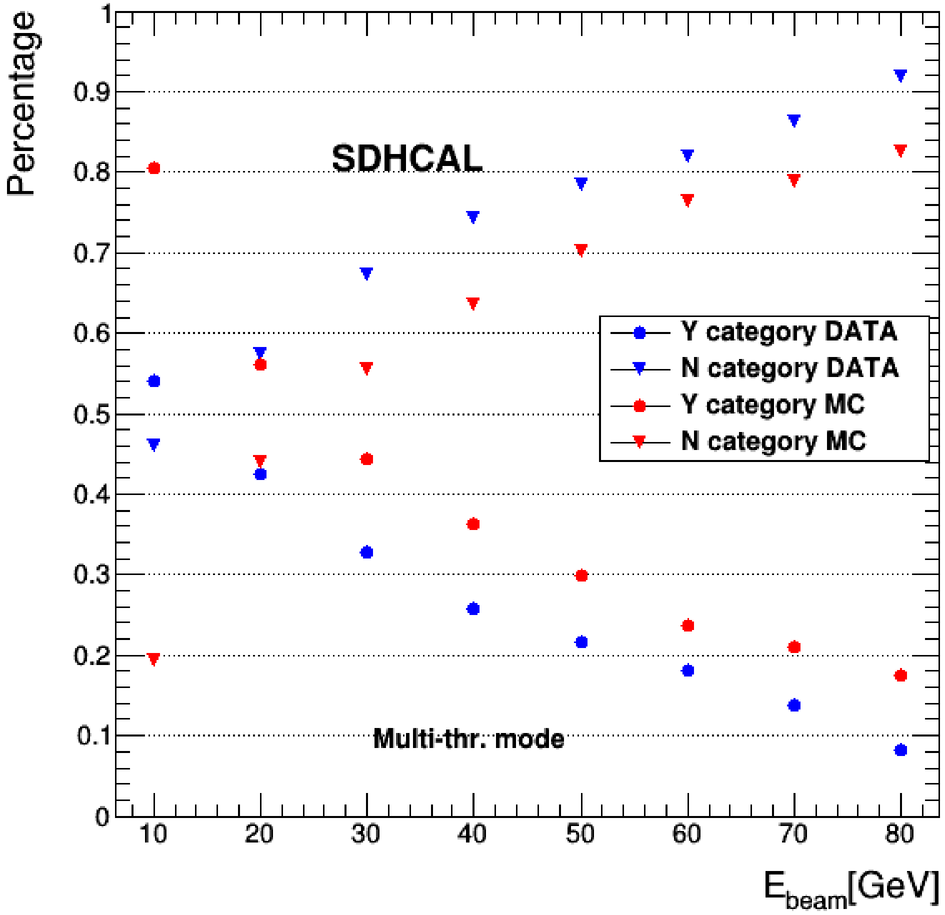
If no this means that the shower is fully contained in the prototype and tag the event Y

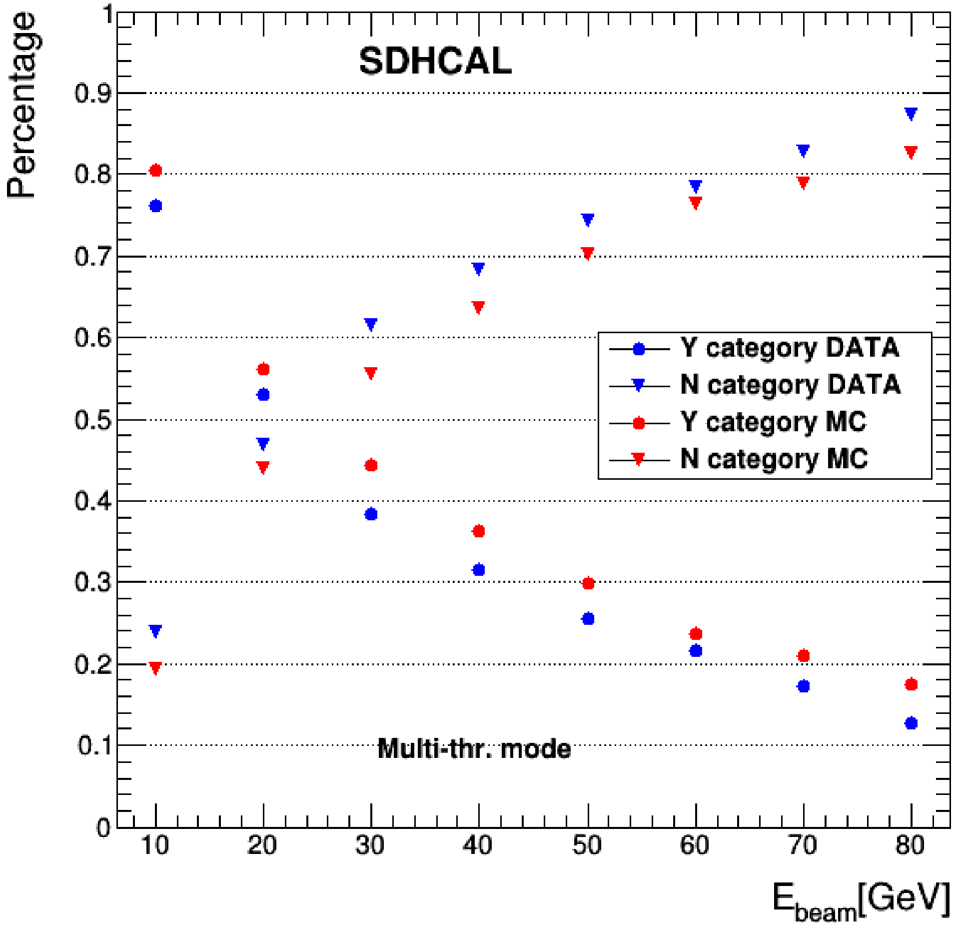
If yes that means that the shower is not fully contained and you can tag this kind of events as N

Nhits/Nlayer > 2.2

Update

Nhits/Nlayer > 3.2





There is a large difference between MC and data

After updating , the difference between MC and data is very little

Energy reconstruction

Energy reconstruction formula:

$$E_{reco} = \alpha N_1 + \beta N_2 + \gamma N_3$$

α, β, γ are parameterized as functions of total number of hits(N1+N2+N3)

$$\alpha = \alpha_1 + \alpha_2 N_{total} + \alpha_3 N_{total}^2$$

$$\beta = \beta_1 + \beta_2 N_{total} + \beta_3 N_{total}^2$$

$$\gamma = \gamma_1 + \gamma_2 N_{total} + \gamma_3 N_{total}^2$$

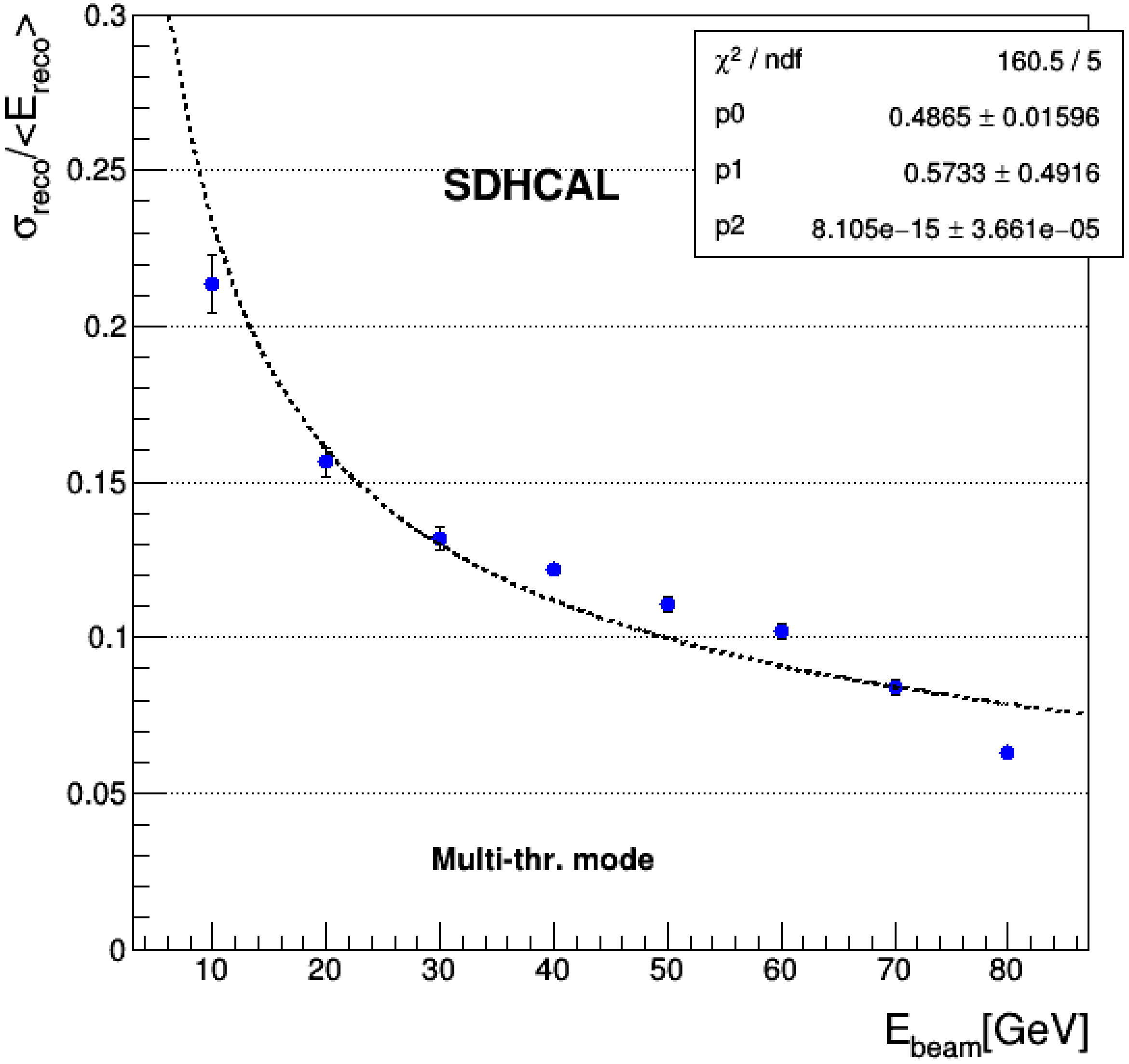
$$\chi^2 = \sum_{i=1}^{N} \frac{(E_{beam}^i - E_{reco}^i)^2}{\sigma_i^2}$$

N is the number of total events.

and $\sigma_i = \sqrt{E_{beam}^i}$. ← First step

After the first step:

$$\sigma_i = \sqrt{p0 * E_{beam}^i + p1 + p2 * E_{beam}^i * E_{beam}^i}$$

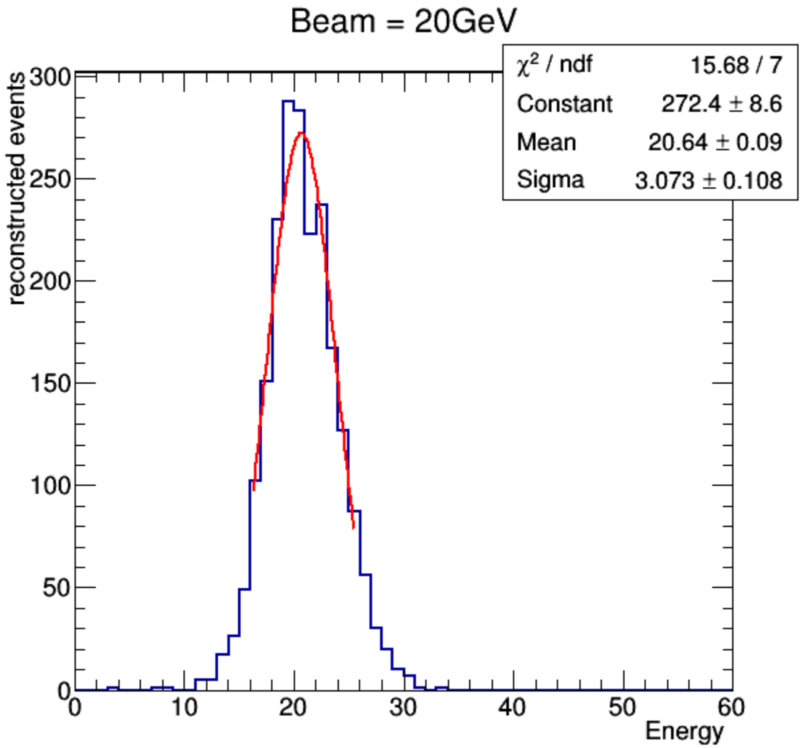


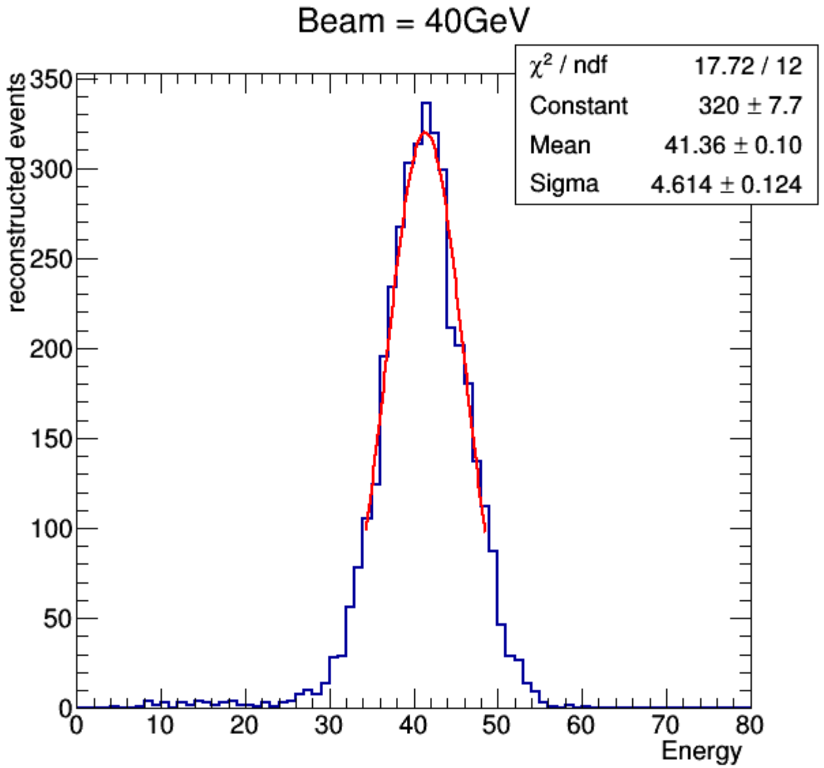
Fit function

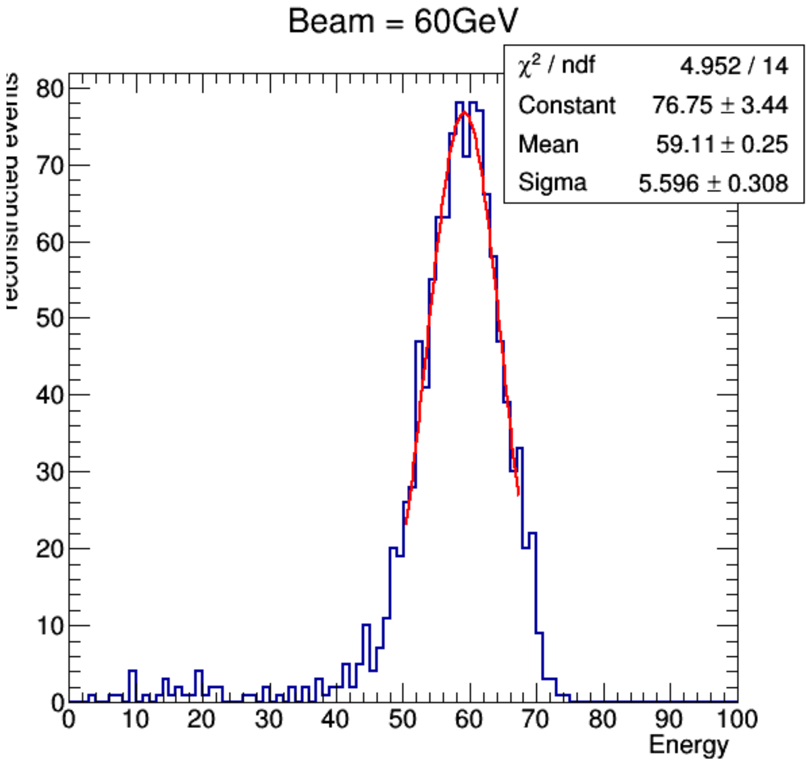
$$\left(\frac{\sigma}{E}\right)^2 = \frac{p0}{E} + \frac{p1}{E^2} + p2$$

When you get these three parameters then applying these into optimizer. After many loops , you get the final results.

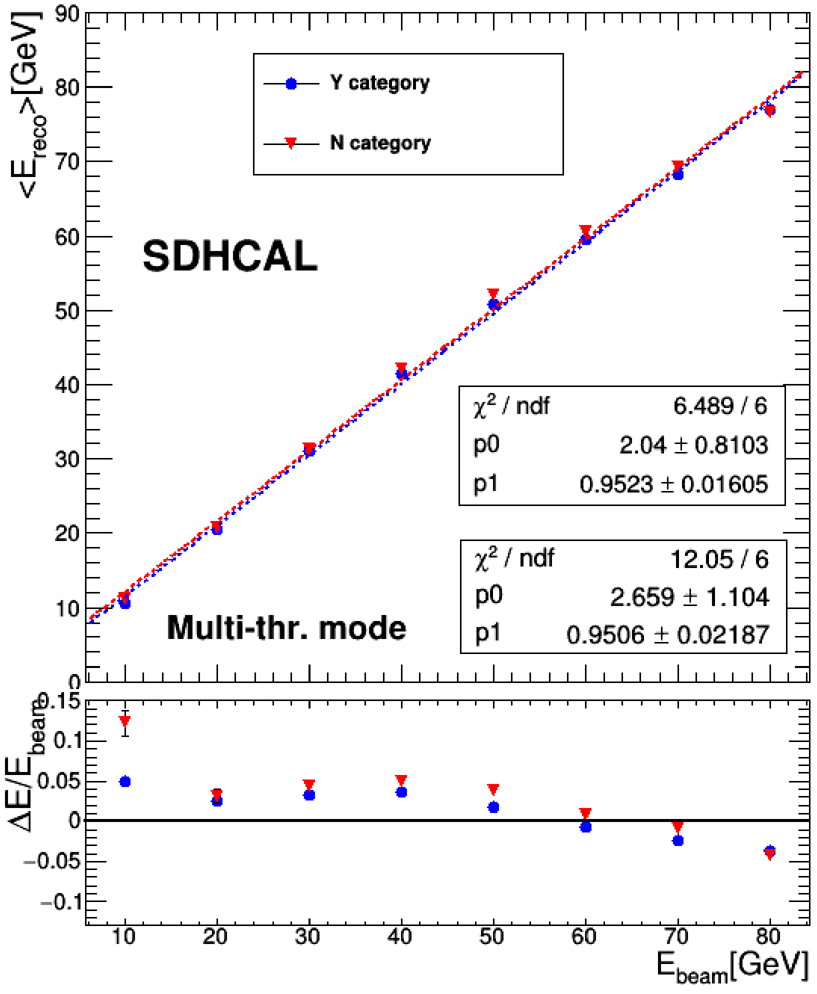
48Layers(Y category)

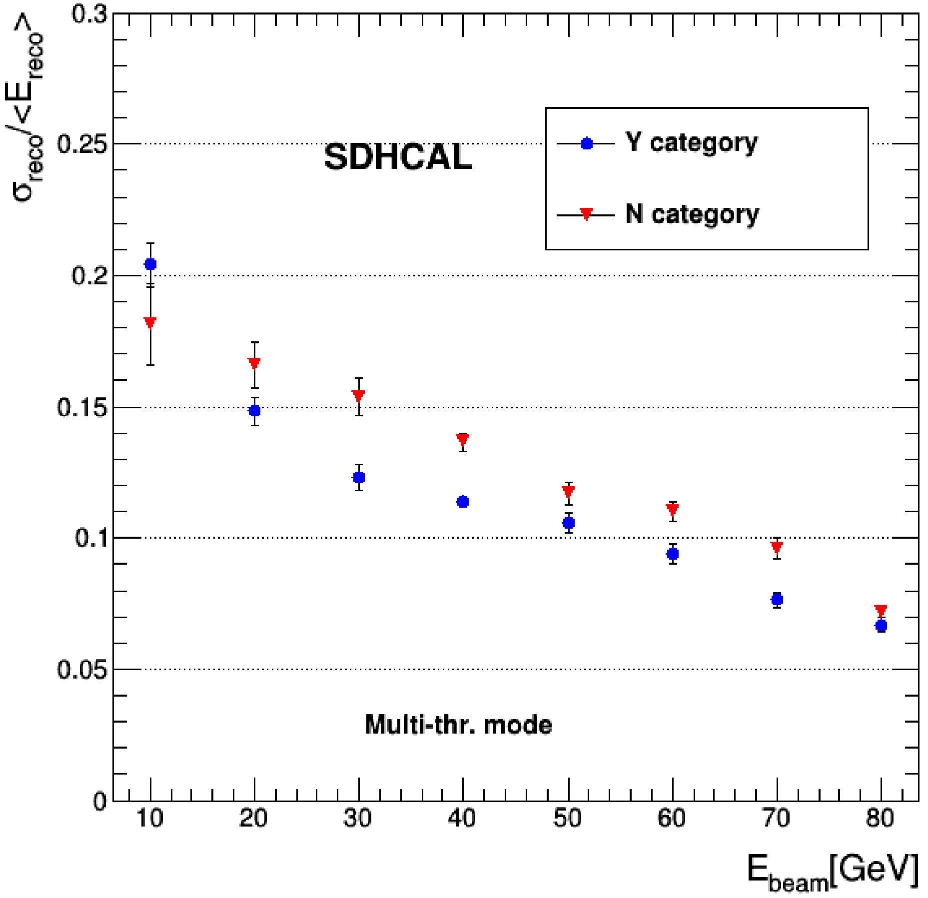




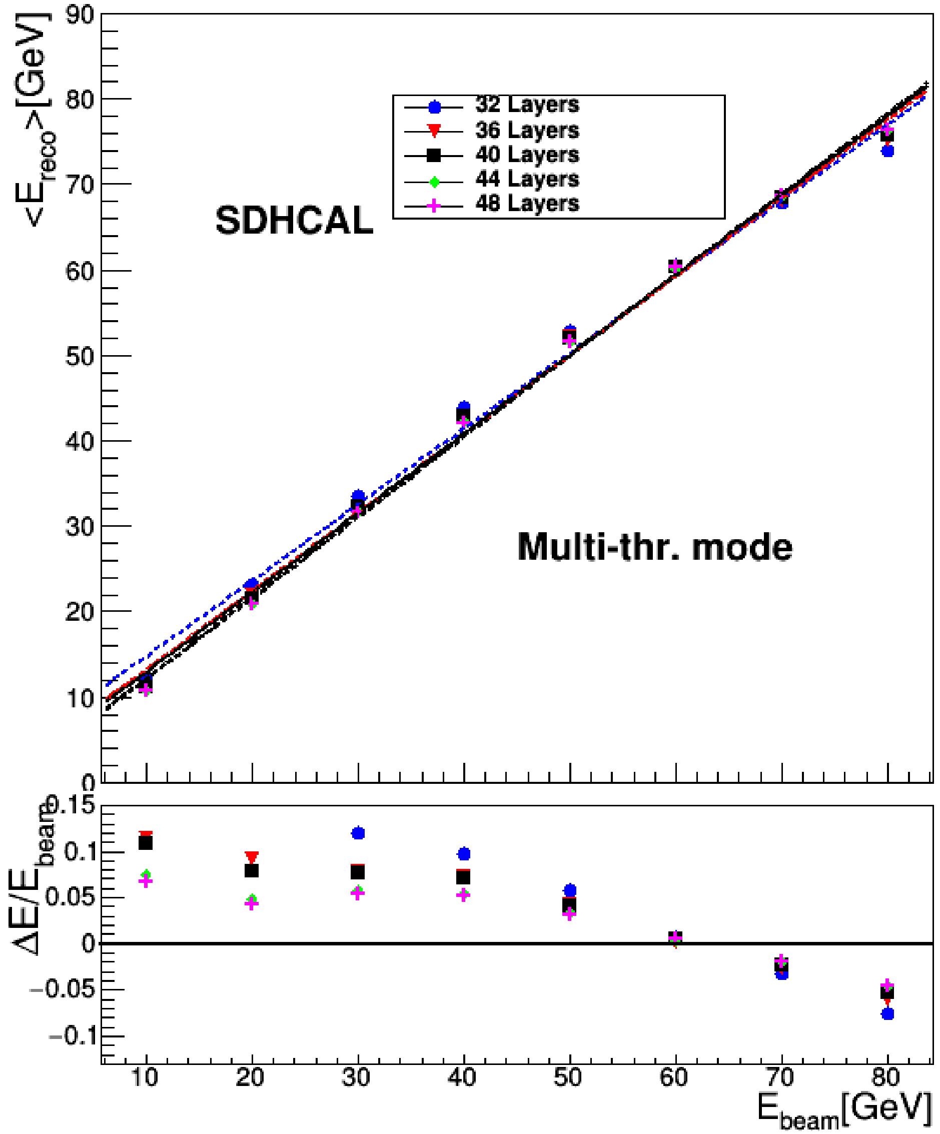


The distributions are fitted with a Gaussian Function in a 1.5σ range around the mean

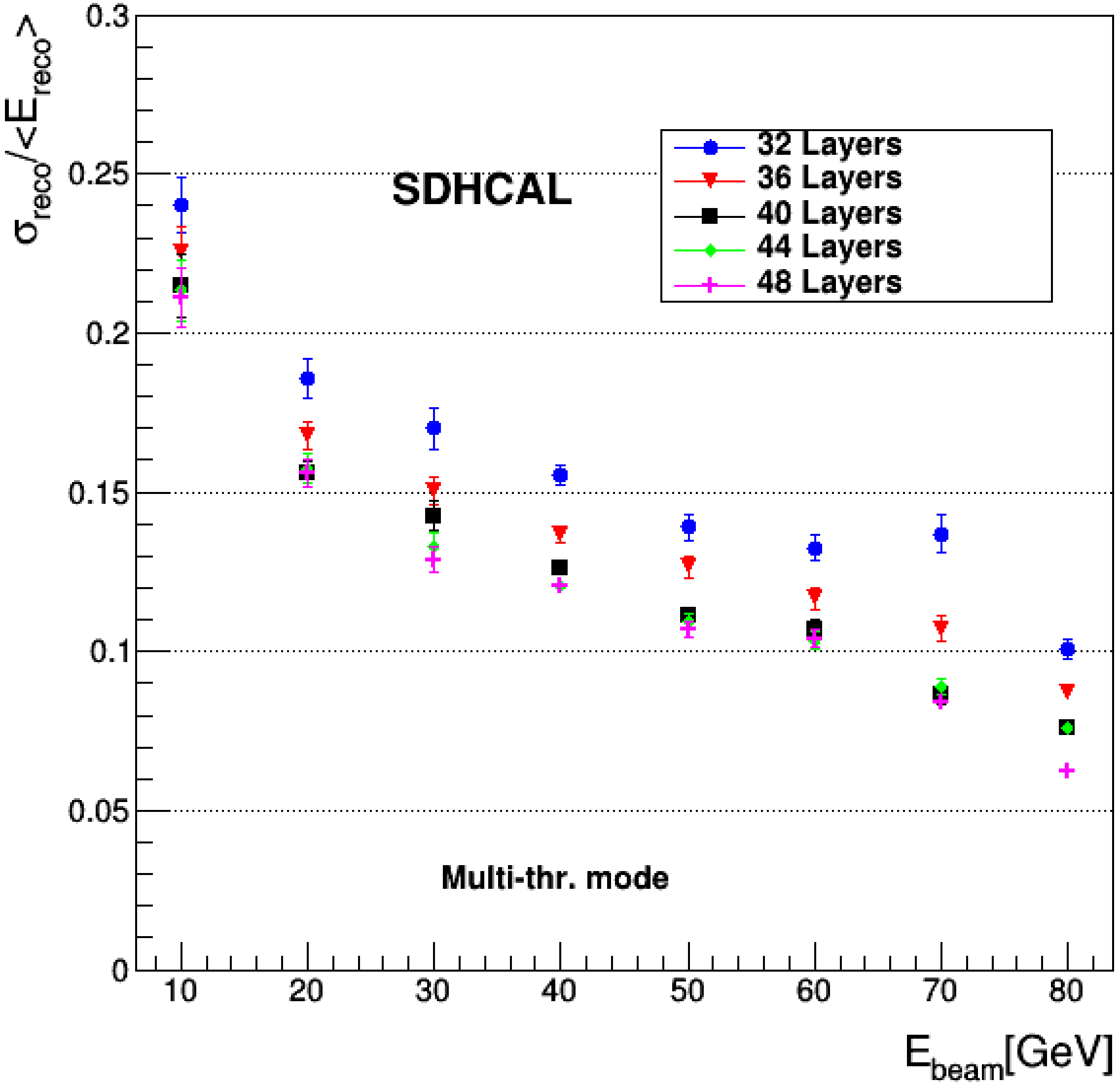




The results of Y are better than N including linearity and resolution

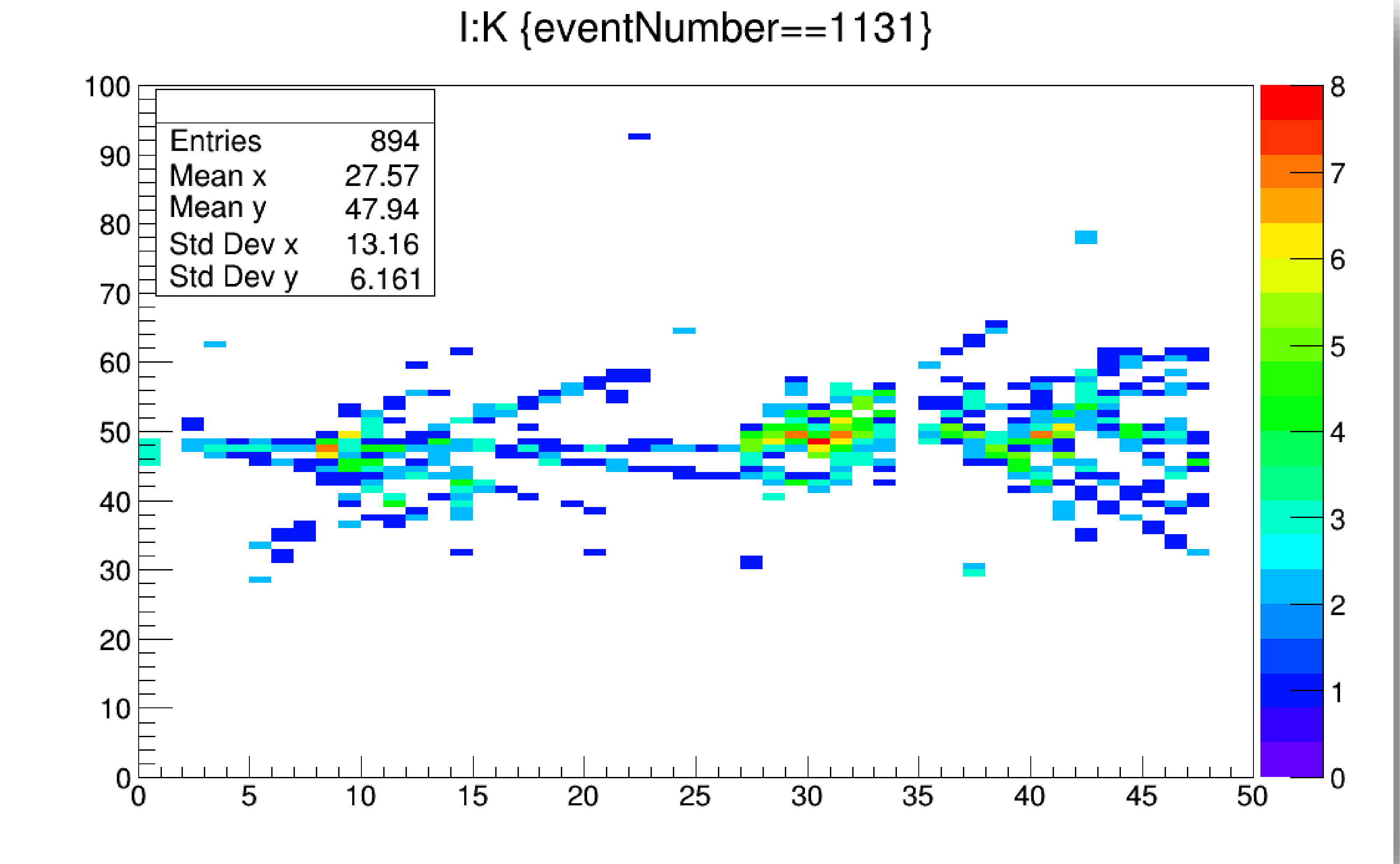


SDHCAL
32 Layers
36 Layers
40 Layers
44 Layers
48 Layers
Multi-thr. mode
<E_reco>[GeV]
ΔE/E_beam
E_beam[GeV]



SDHCAL
32 Layers
36 Layers
40 Layers
44 Layers
48 Layers
Multi-thr. mode
σ_reco/<E_reco>
E_beam[GeV]

BDT Progress



Energy reconstruction formula:

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$$\alpha = \alpha_1 + \alpha_2 N_{total} + \alpha_3 N_{total}^2$$

$$\beta = \beta_1 + \beta_2 N_{total} + \beta_3 N_{total}^2$$

$$\gamma = \gamma_1 + \gamma_2 N_{total} + \gamma_3 N_{total}^2$$

For the shower of Pion, it is made up of two components EM and hadronic .

We want to separate all events to two category , one is EM-like and other is non EM-like .

Then apply different nine parameter to these two category

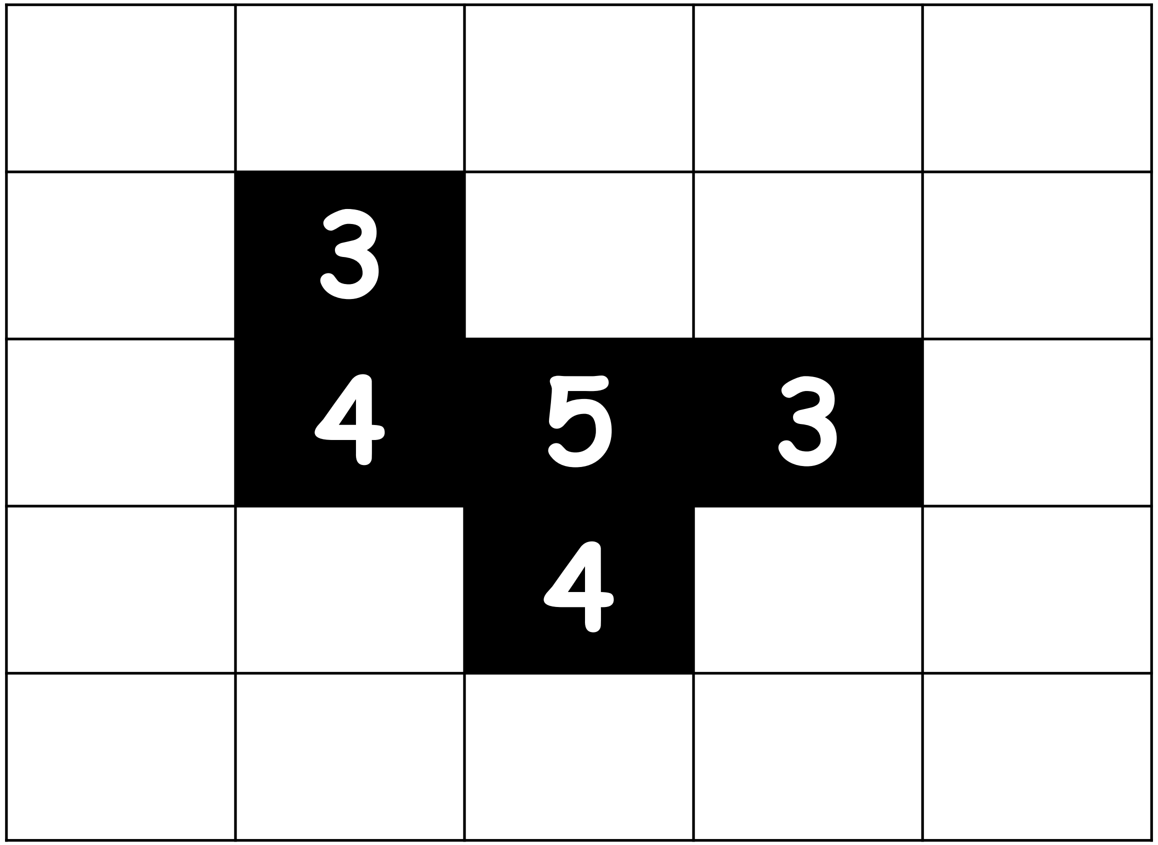
Density

As we known, EM components are more dense than hadronic parts, So we hope to help separate two category using density information

For every hit, you count the number neighbored itself(including itself) and then you add all number togother.

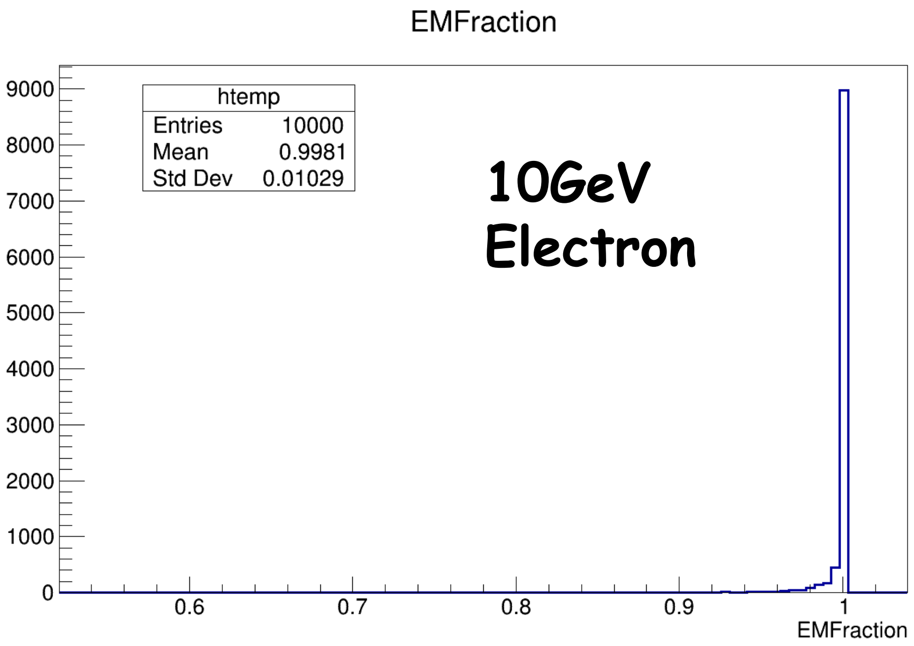
Finally the density equal to total number over total hits

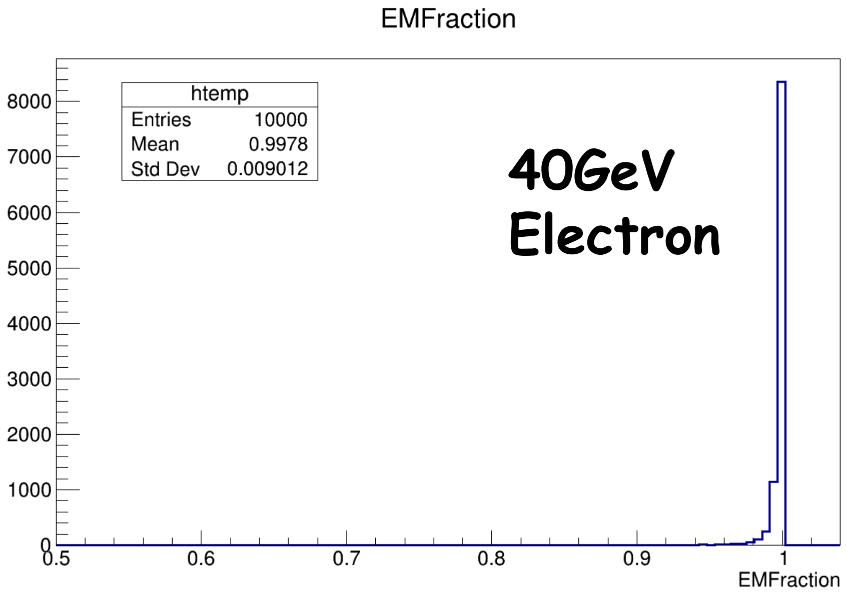
Density=(3+4+5+4+3)/5=3.8

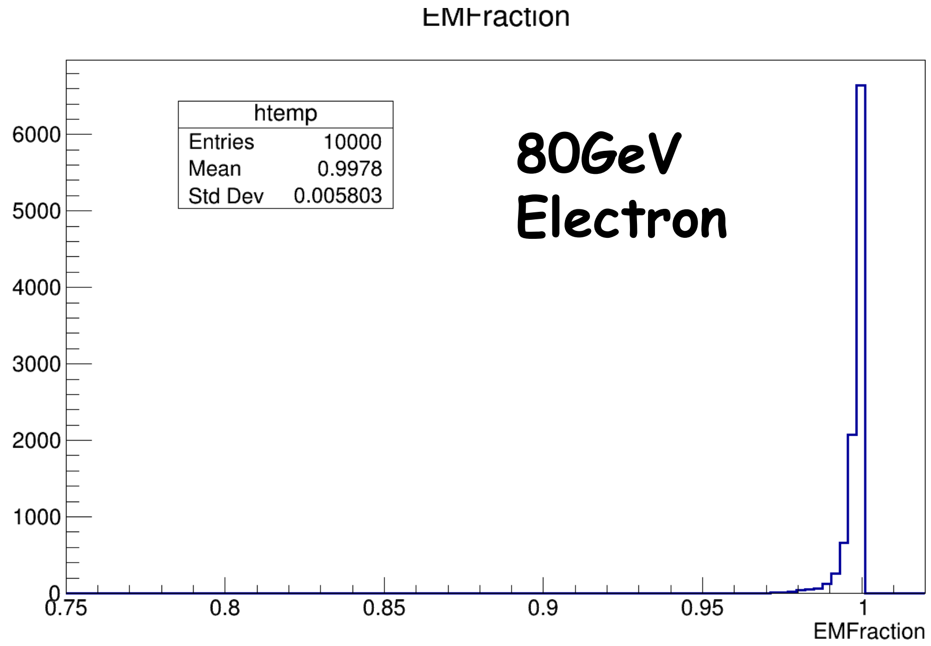


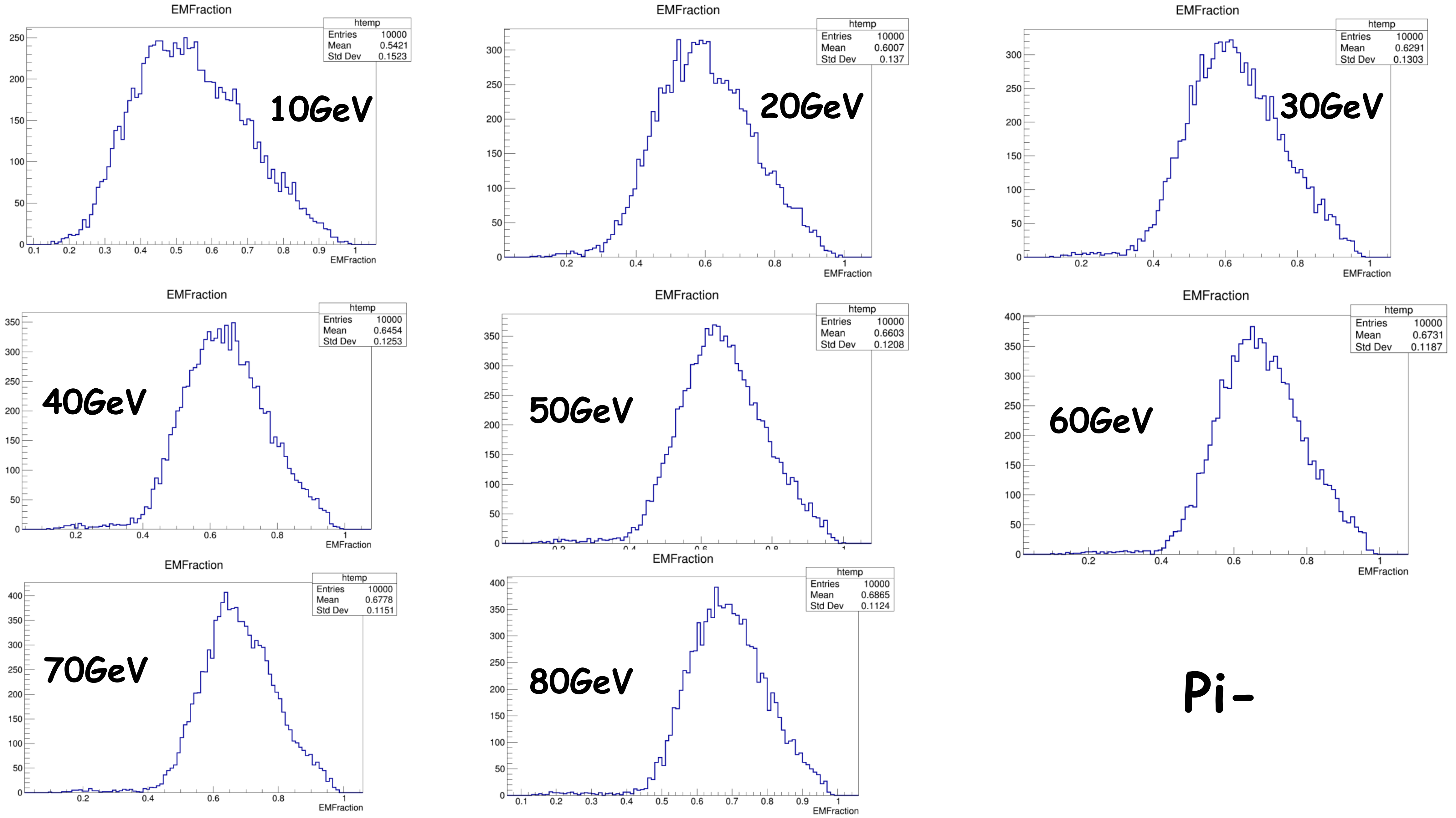
Fraction of EM energy over total energy

Checking the EMFraction is valid or not

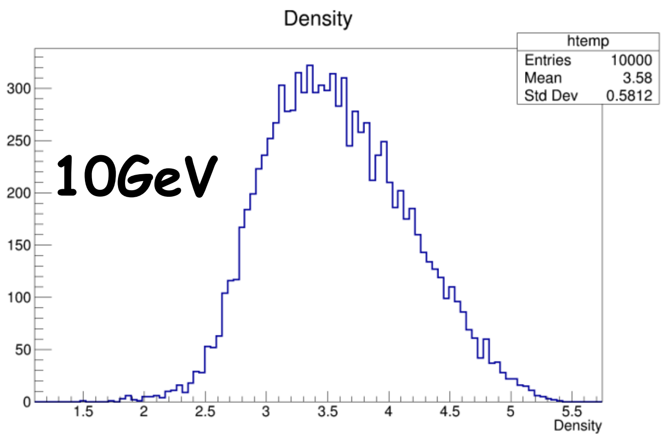


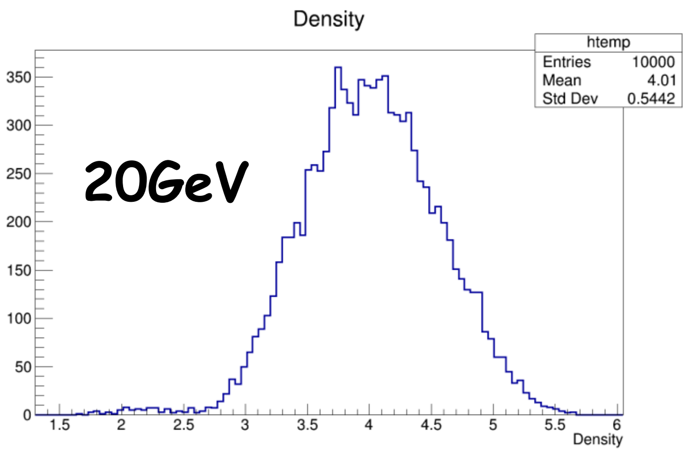


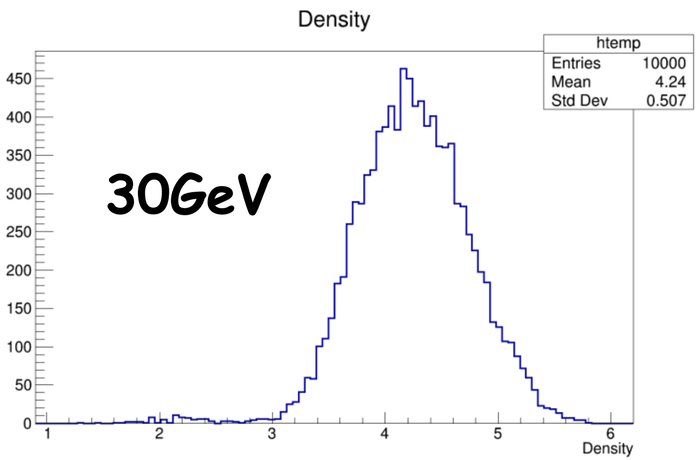


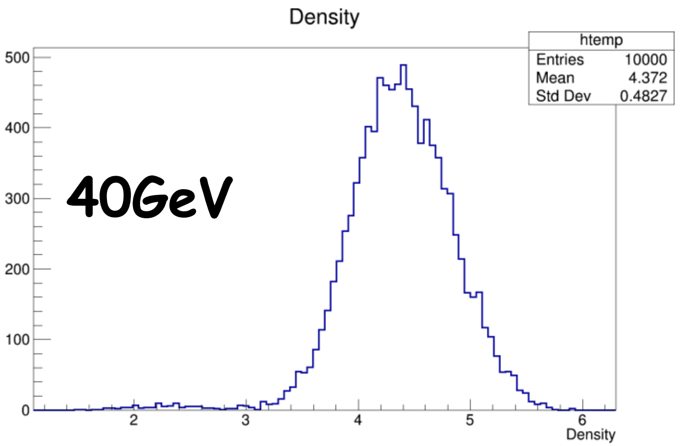

EMFraction
htemp
Entries 10000
Mean 0.5421
Std Dev 0.1523
10GeV
EMFraction
htemp
Entries 10000
Mean 0.6007
Std Dev 0.137
20GeV
EMFraction
htemp
Entries 10000
Mean 0.6291
Std Dev 0.1303
30GeV
EMFraction
htemp
Entries 10000
Mean 0.6454
Std Dev 0.1253
40GeV
EMFraction
htemp
Entries 10000
Mean 0.6603
Std Dev 0.1208
50GeV
EMFraction
htemp
Entries 10000
Mean 0.6731
Std Dev 0.1187
60GeV
EMFraction
htemp
Entries 10000
Mean 0.6778
Std Dev 0.1151
70GeV
EMFraction
htemp
Entries 10000
Mean 0.6865
Std Dev 0.1124
80GeV

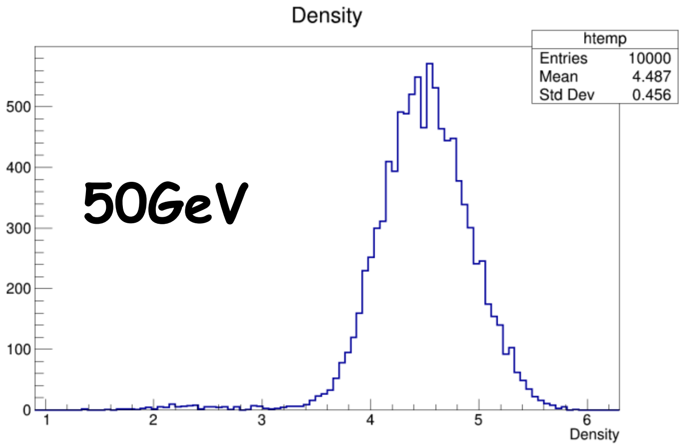
Pi-

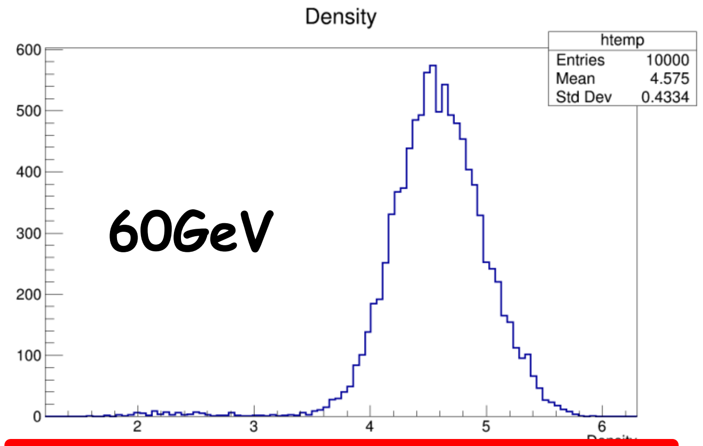

Density
htemp
Entries 10000
Mean 3.58
Std Dev 0.5812
10GeV
Density

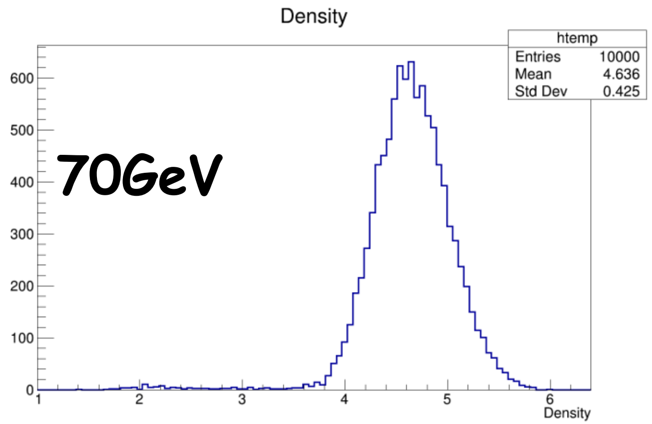

Density
htemp
Entries 10000
Mean 4.01
Std Dev 0.5442
20GeV
Density

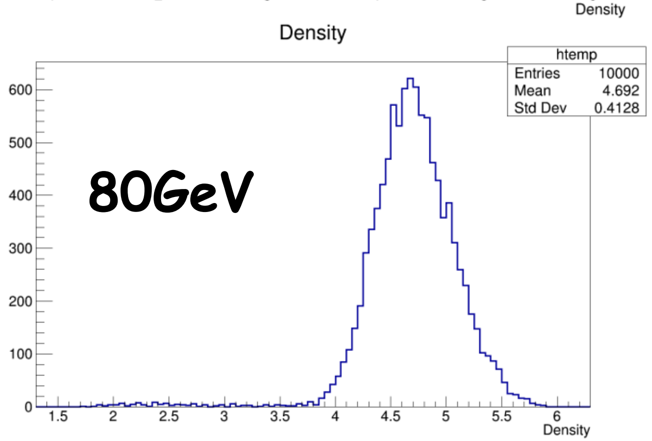

Density
htemp
Entries 10000
Mean 4.24
Std Dev 0.507
30GeV
Density

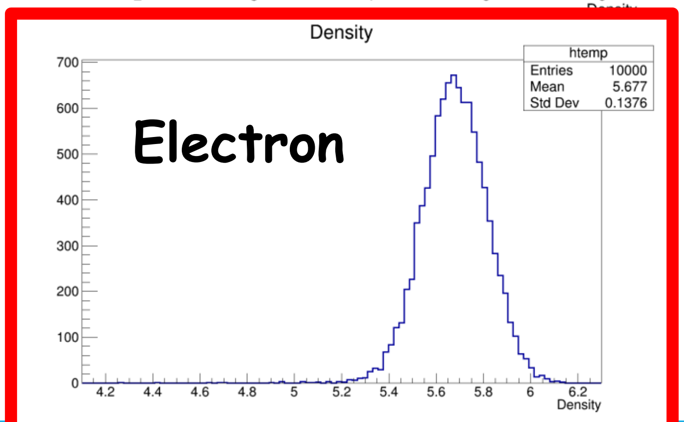

Density
htemp
Entries 10000
Mean 4.372
Std Dev 0.4827
40GeV
Density

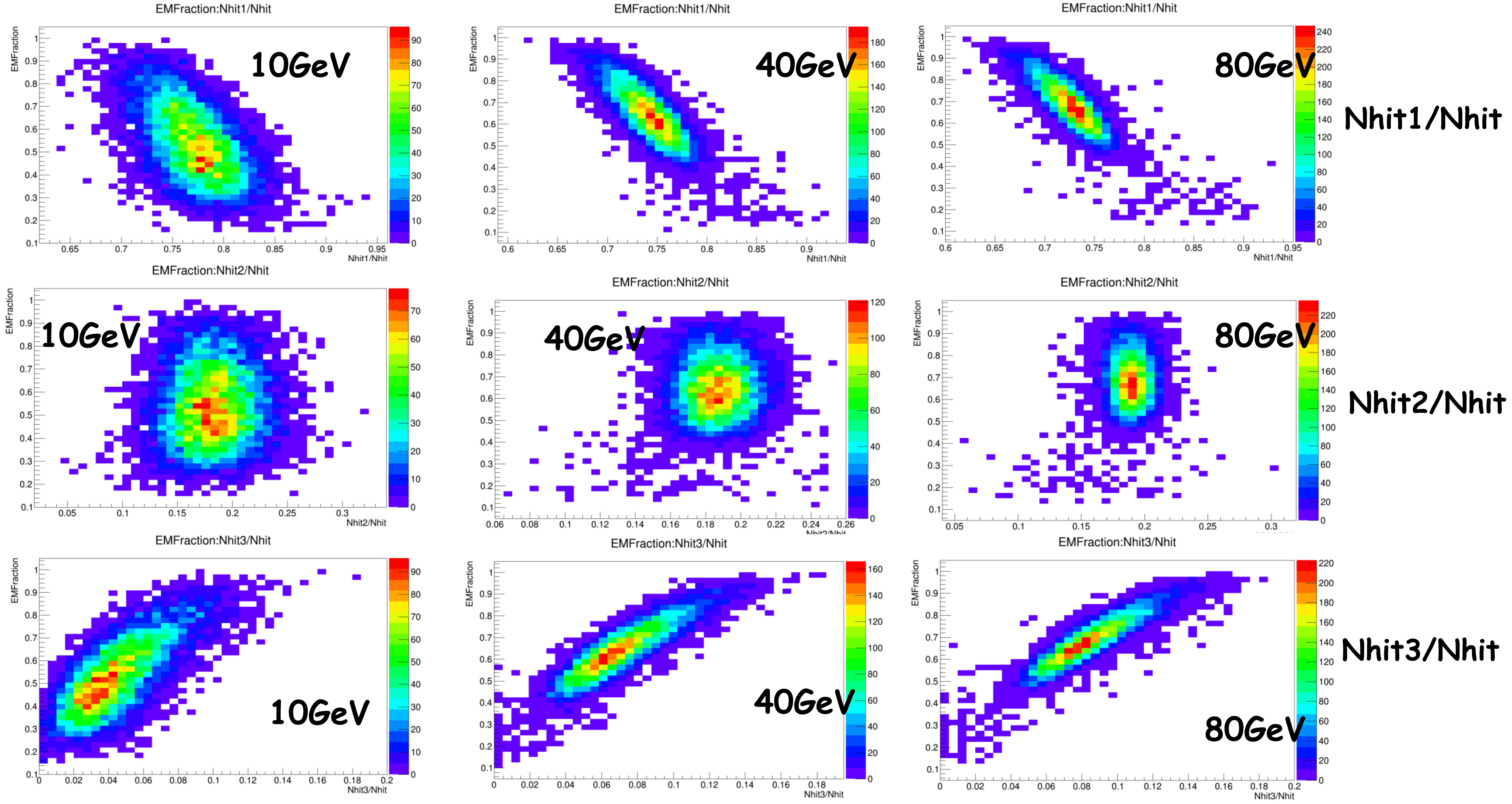

Density
htemp
Entries 10000
Mean 4.487
Std Dev 0.456
50GeV
Density

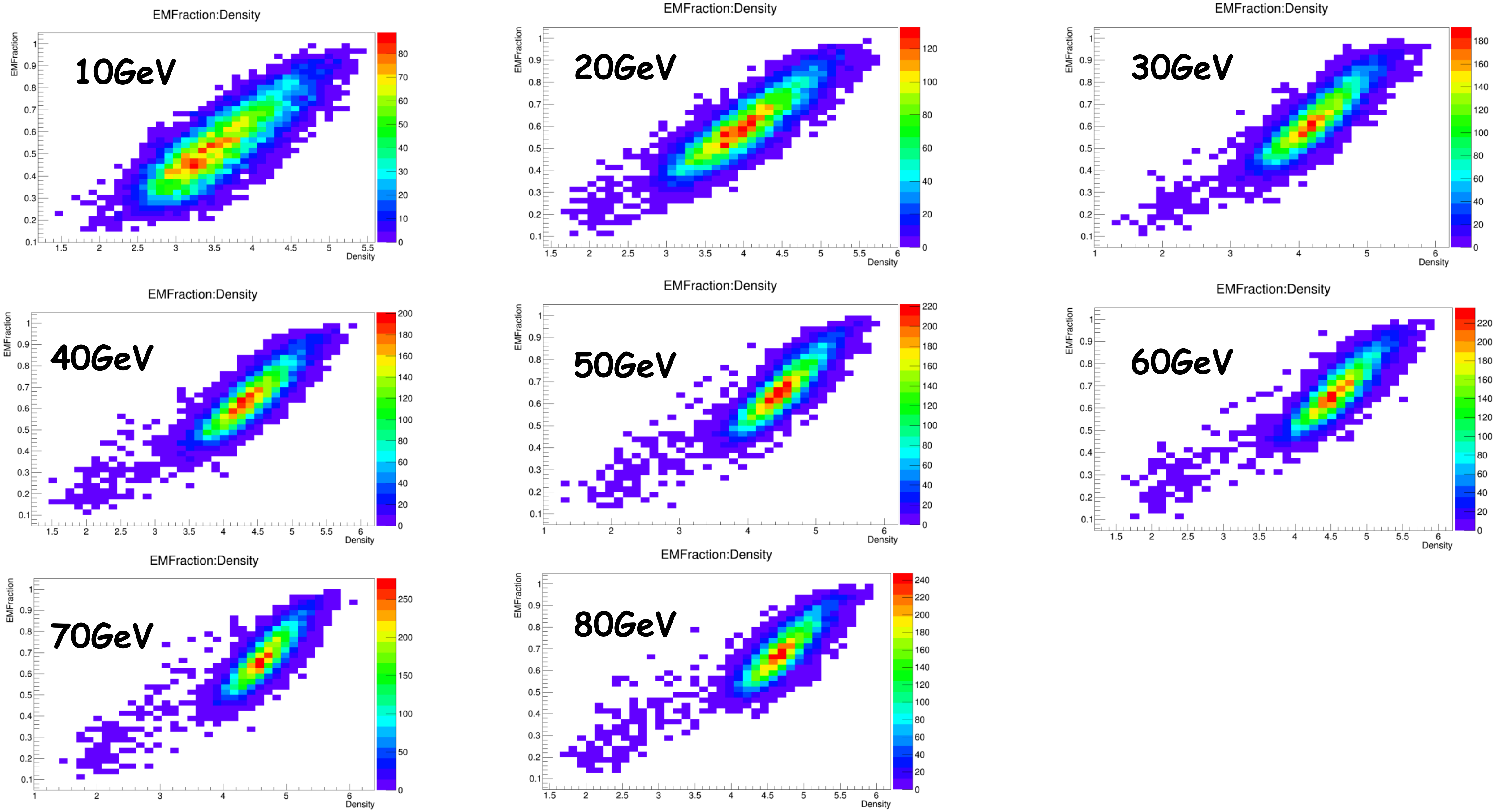

Density
htemp
Entries 10000
Mean 4.575
Std Dev 0.4334
60GeV

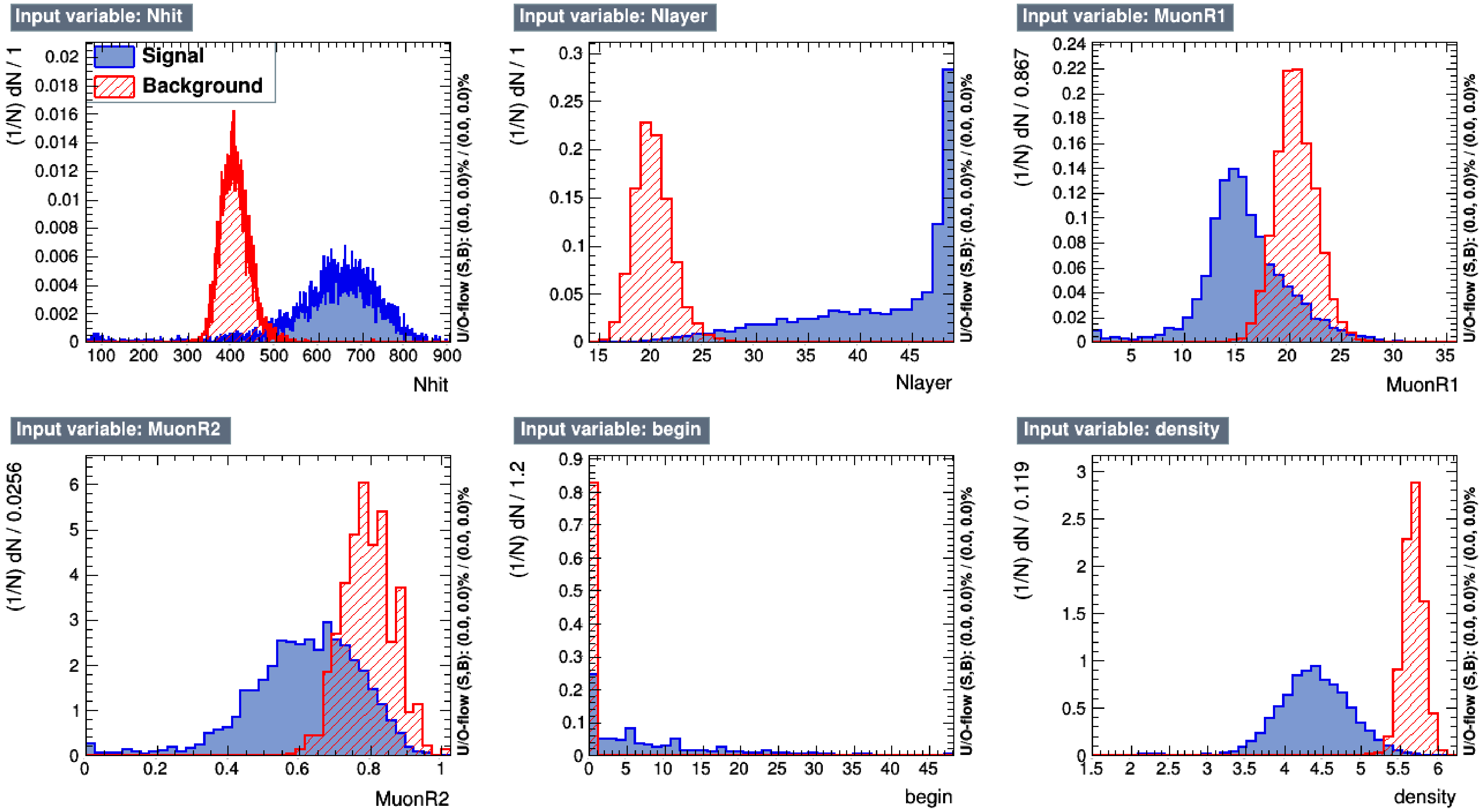

Density
htemp
Entries 10000
Mean 4.636
Std Dev 0.425
70GeV
Density


Density
htemp
Entries 10000
Mean 4.692
Std Dev 0.4128
80GeV
Density

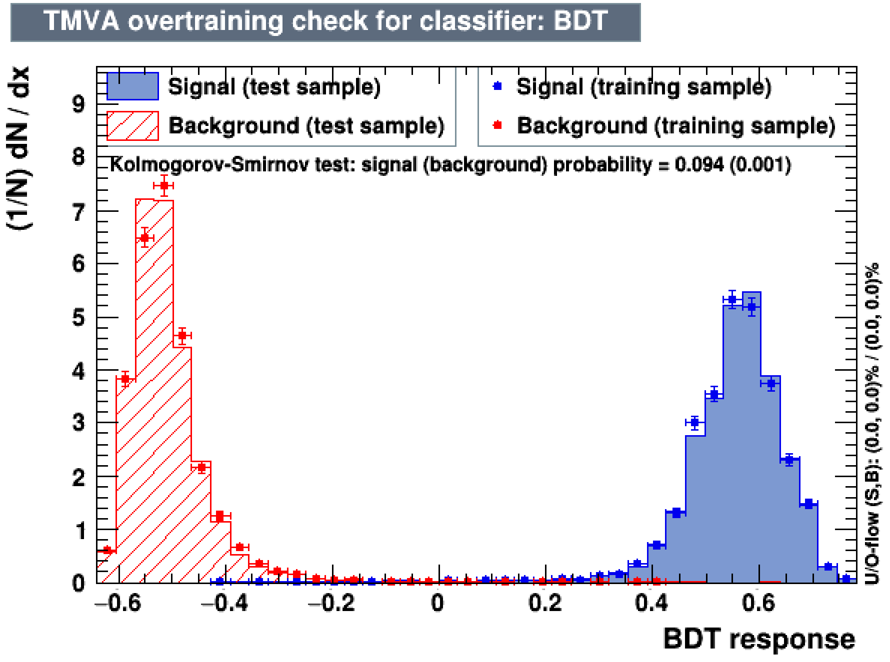

Density
htemp
Entries 10000
Mean 5.677
Std Dev 0.1376
Electron
Density

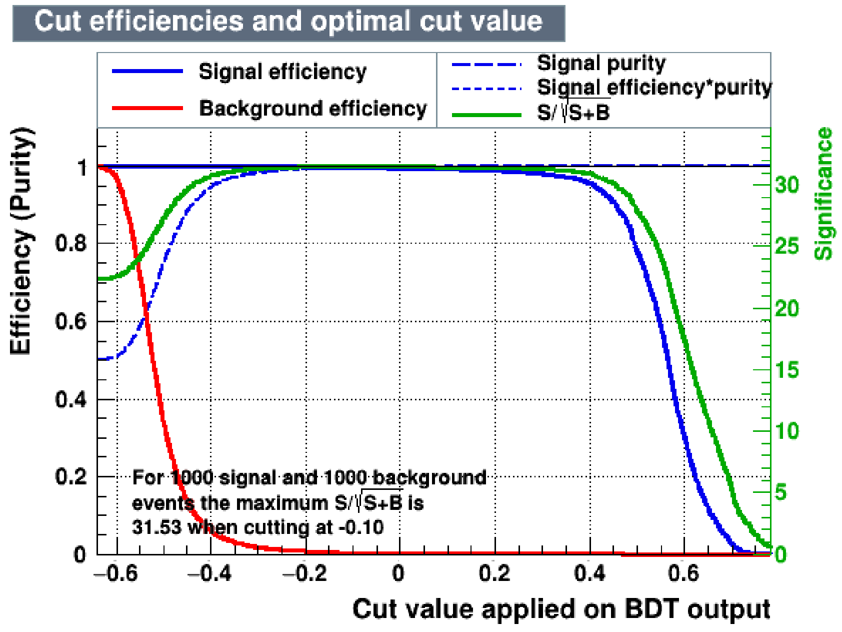

EMFraction:Nhit1/Nhit
10GeV
40GeV
80GeV
Nhit1/Nhit
EMFraction:Nhit2/Nhit
10GeV
40GeV
80GeV
Nhit2/Nhit
EMFraction:Nhit3/Nhit
10GeV
40GeV
80GeV
Nhit3/Nhit
EMFraction
Nhit1/Nhit
Nhit2/Nhit
Nhit3/Nhit

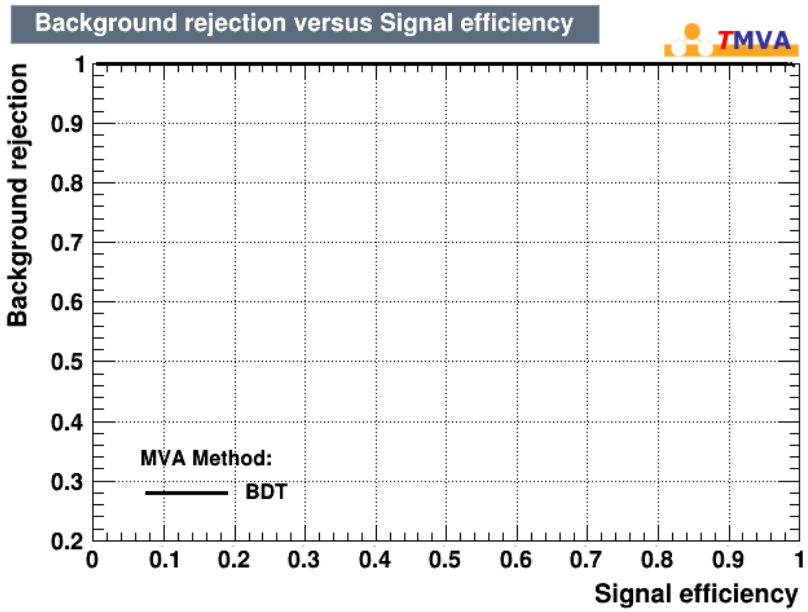

EMFraction:Density
10GeV
20GeV
30GeV
40GeV
50GeV
60GeV
70GeV
80GeV
EMFraction
Density



Signal:40GeV pi- ,Background:40GeV e-







The result after training and test

Using 5000 events for training,5000 events for test

Summary and Next plan

1、a simple introduction about SDHCAL are given.
2、the analysis results of 2015 data are given
3、The results show SDHCAL having good performance especially in high energy.
4、BDT progress in distinguishing different particle events (Only considering electron background now)

Next plan

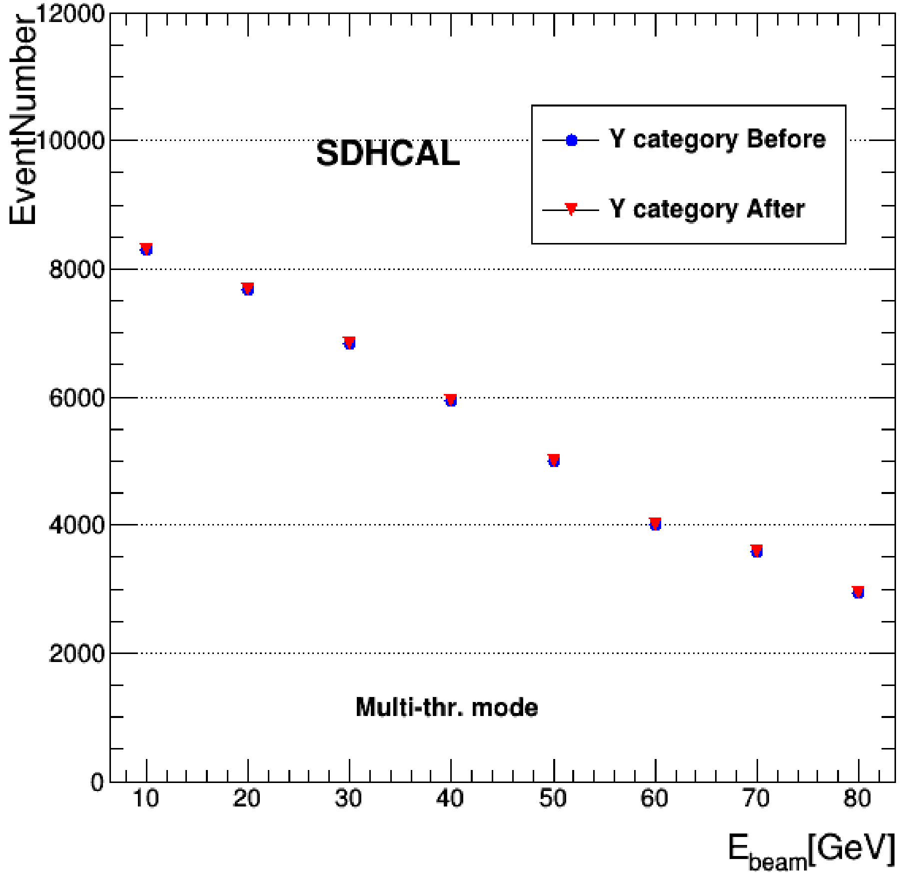
1、Considering the muon background and continue to use BDT to improve the results

Thanks for your attention

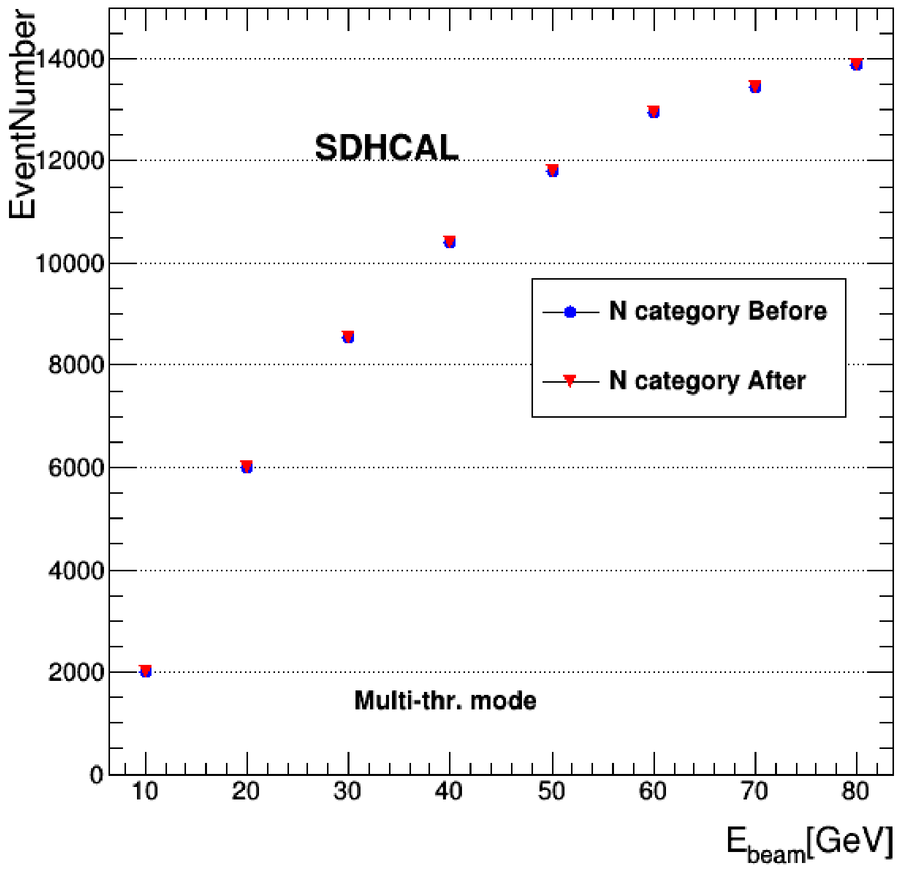
Backup

MC

Before:Nhits/Nlayer > 2.2



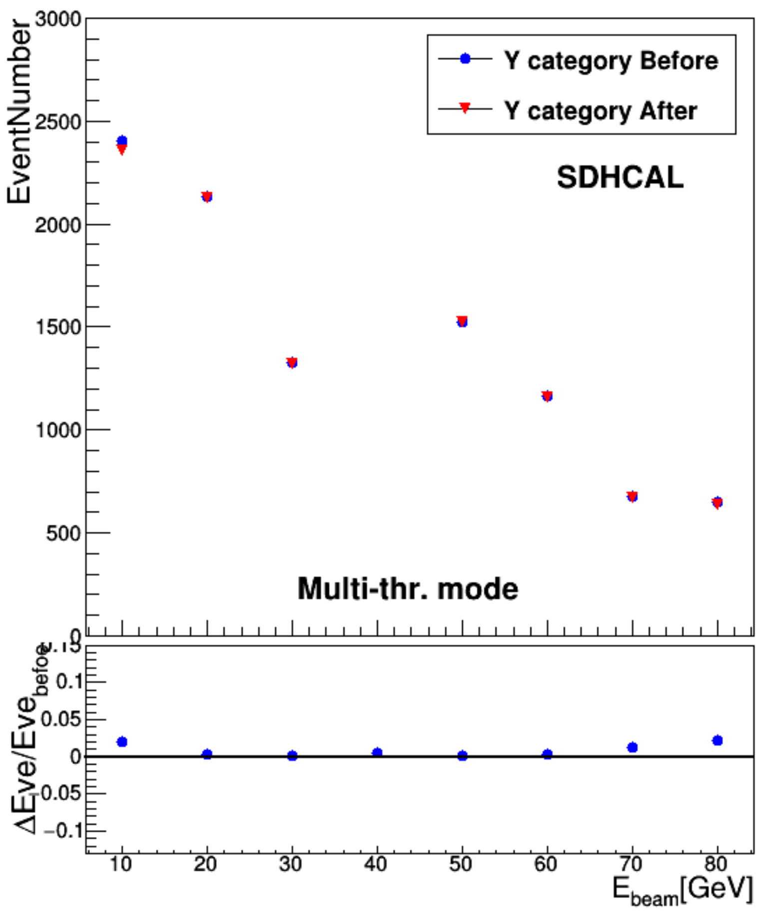
After:Nhits/Nlayer > 3.2



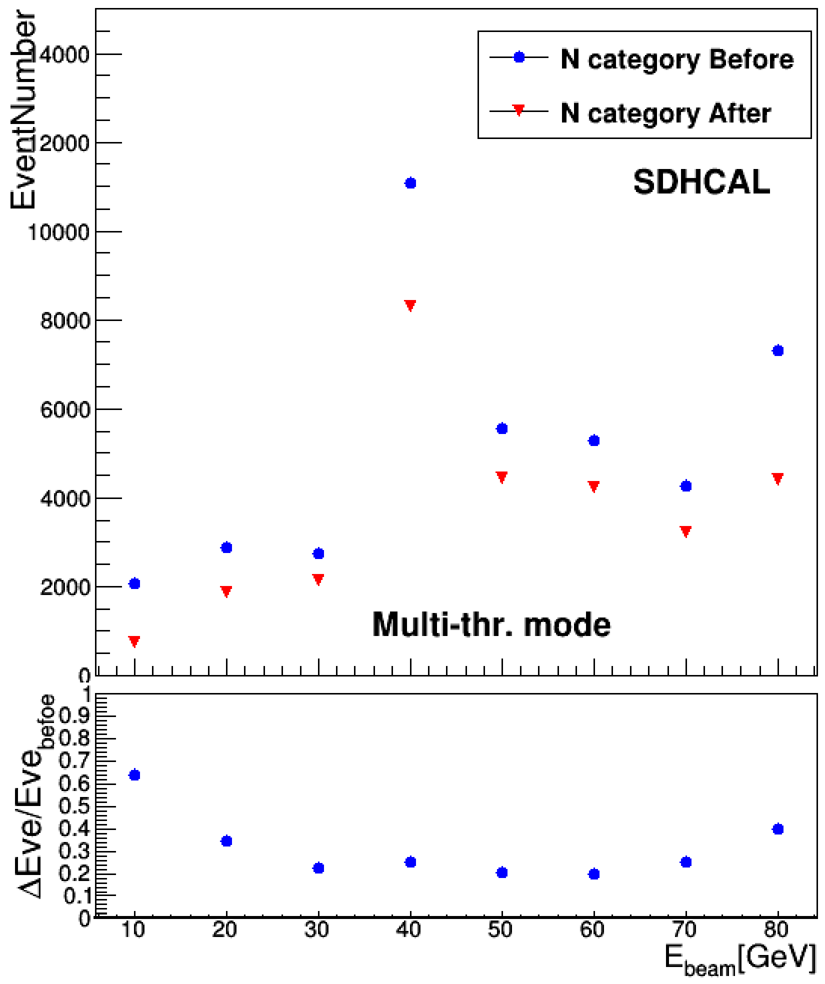
The two plots show the change of event number of MC after changing muon cut

DATA

Before:Nhits/Nlayer > 2.2

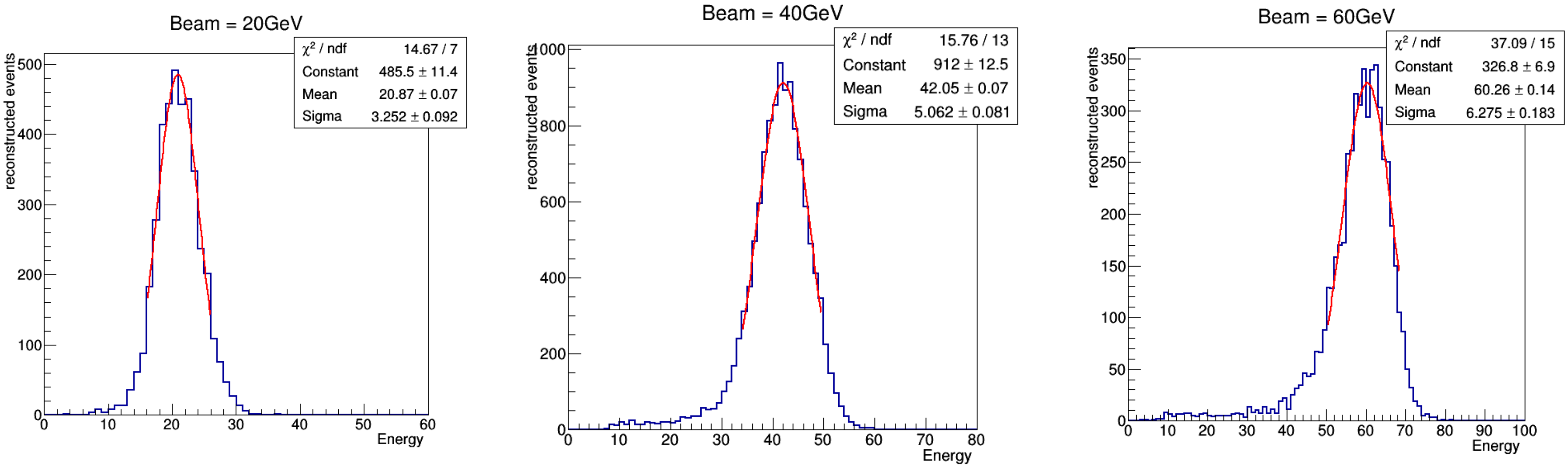


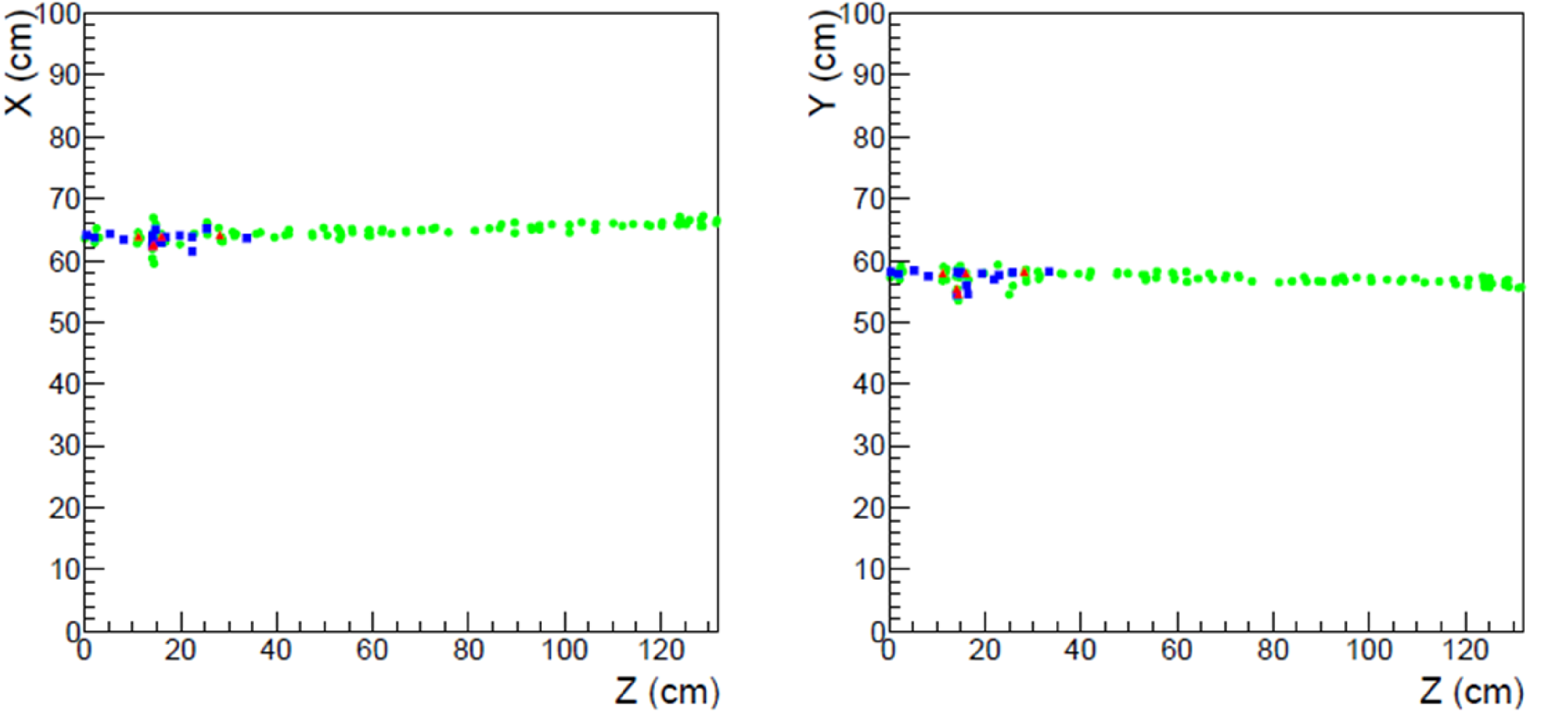
After:Nhits/Nlayer > 3.2



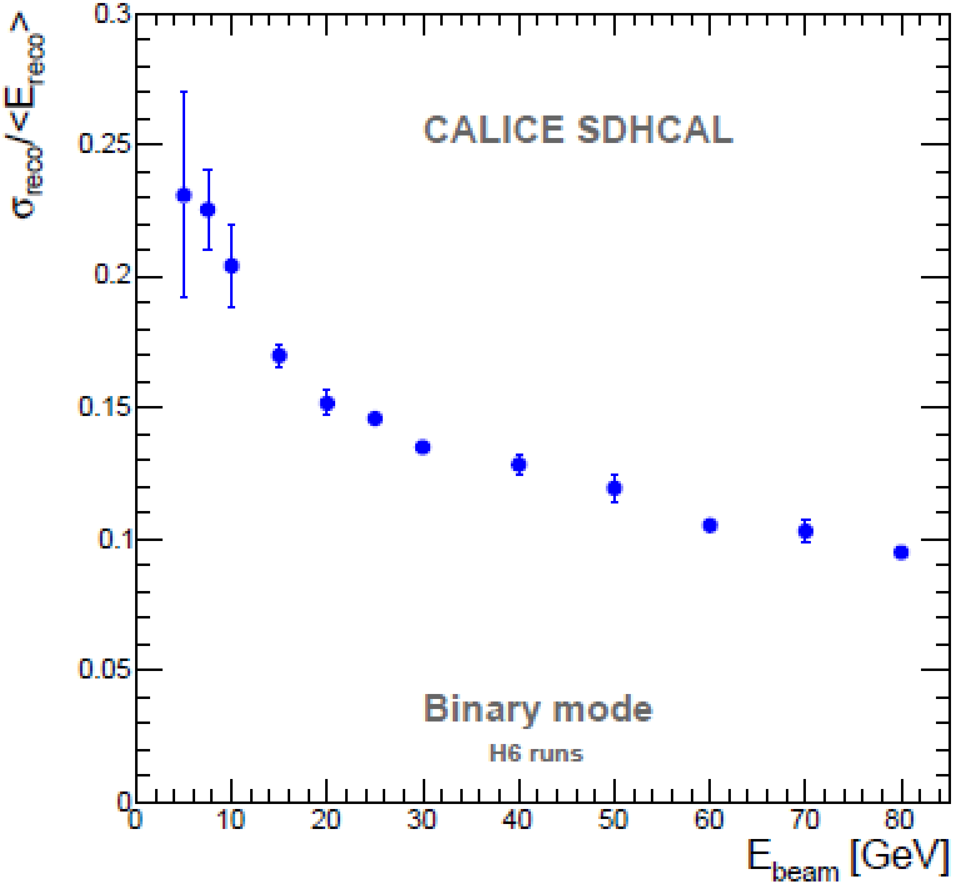
The two plots show the change of event number of data after changing muon cut

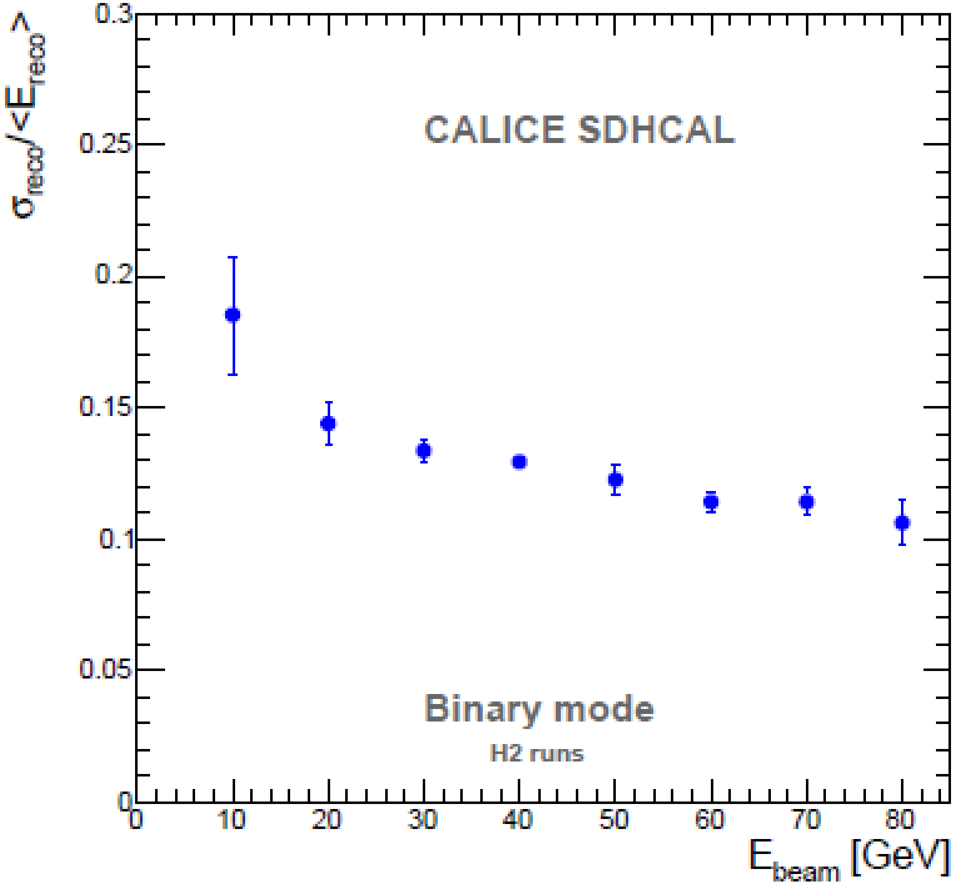
48Layers(all category)



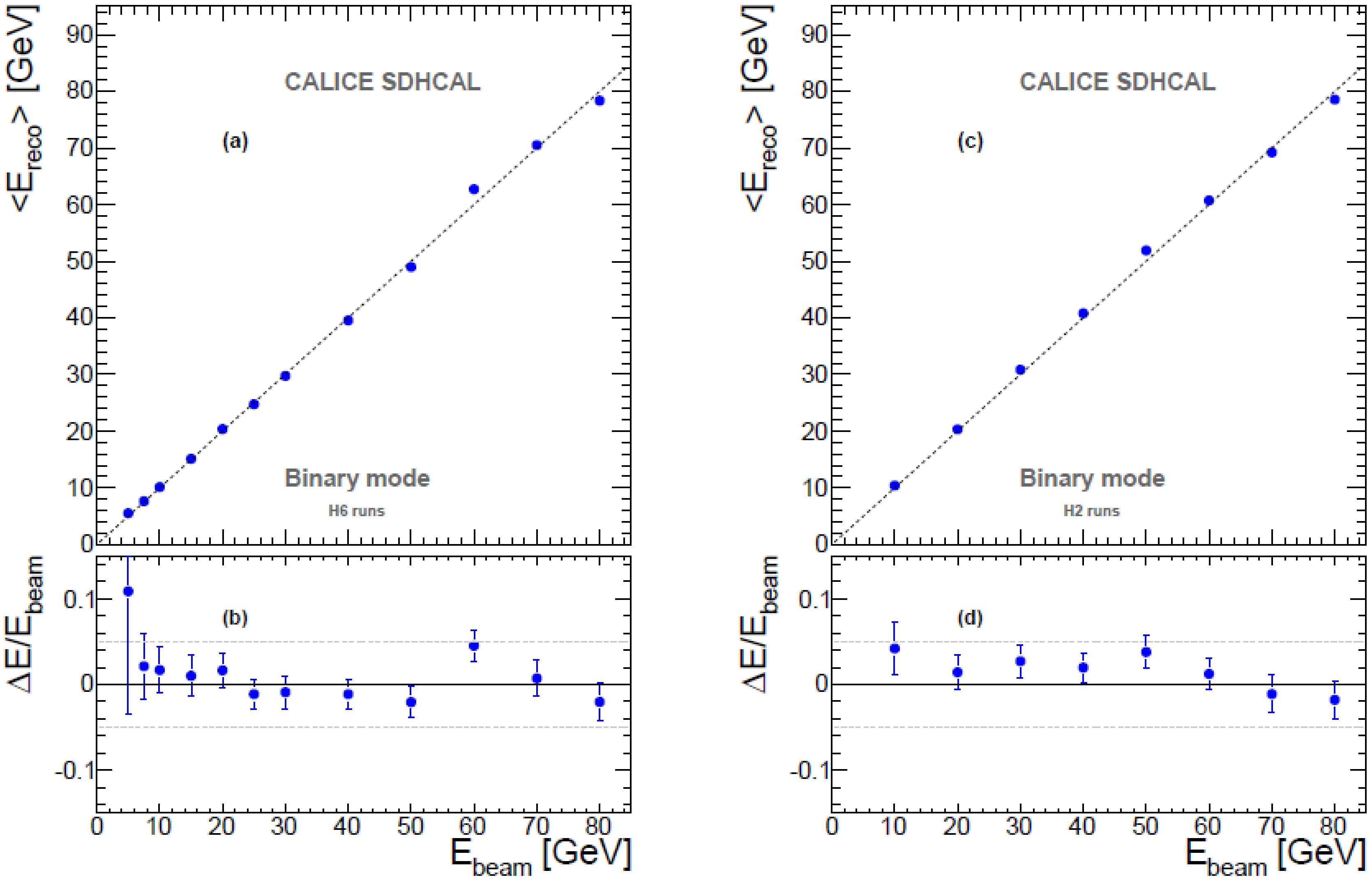


Radiative muon events display at 50 GeV





Binary Mode performance



Binary Mode performance