Reports for SDHCAL

The 3rd CEPC Physics-Software Workshop

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Outline

- Motivation and Simply introduction to SDHCAL
- Data samples and selections
- Analysis of 2015 data
- Summary and Next plan

Motivation

- As we know , The success of future high-energy experiments intended to investigate physics phenomena in the TeV range will be determined by their ability to precisely measure the energy of jets associated with the production of bosons such as $W^{\pm}, Z^{0}, H^{0}$.

- One of the most attractive techniques is based on the Particle Flow Algorithm (PFA) approach. A high-granularity hadronic calorimeter plays an essential role in PFA-based experiments including SDHCAL.

- The probability for more than one charged particle hitting the same readout pad increases for higher energy, especially in the central region of a shower. A calorimeter with multi-threshold readout(SDHCAL) is therefore considered . the SDHCAL records more detailed hit information for hadronic showers and has better energy resolution for jet energies above 40 GeV

SDHCAL(Semi-digital Hadron Calorimeter) Prototype

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

Total Layers: 48

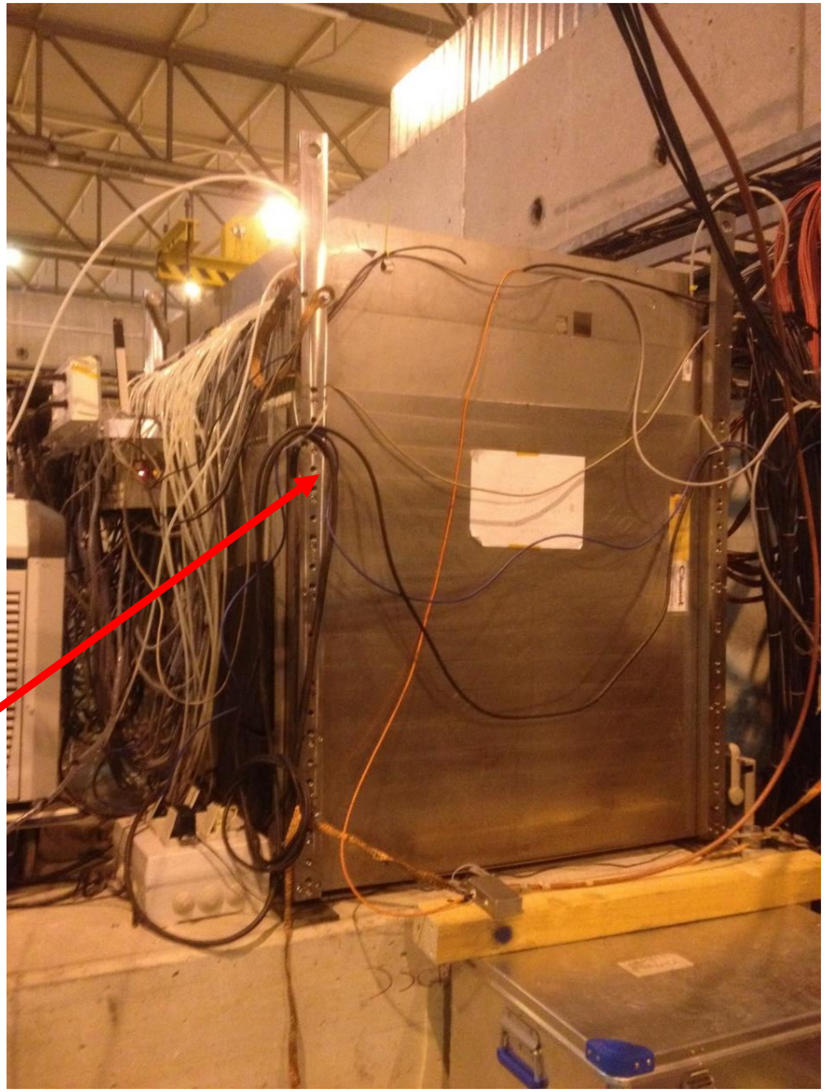
Total Channel(pads):3X48X64X48≈440000

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

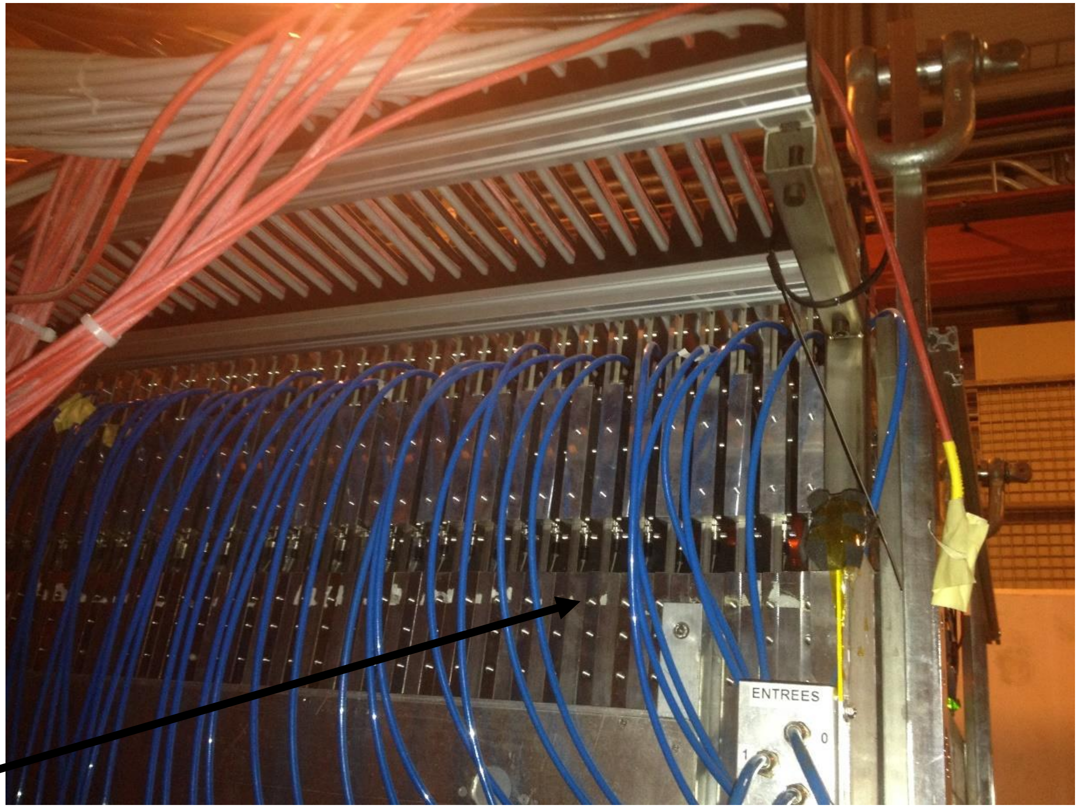
Including absorber and one cassettes

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

Stainless steel wall(2.5mm)

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

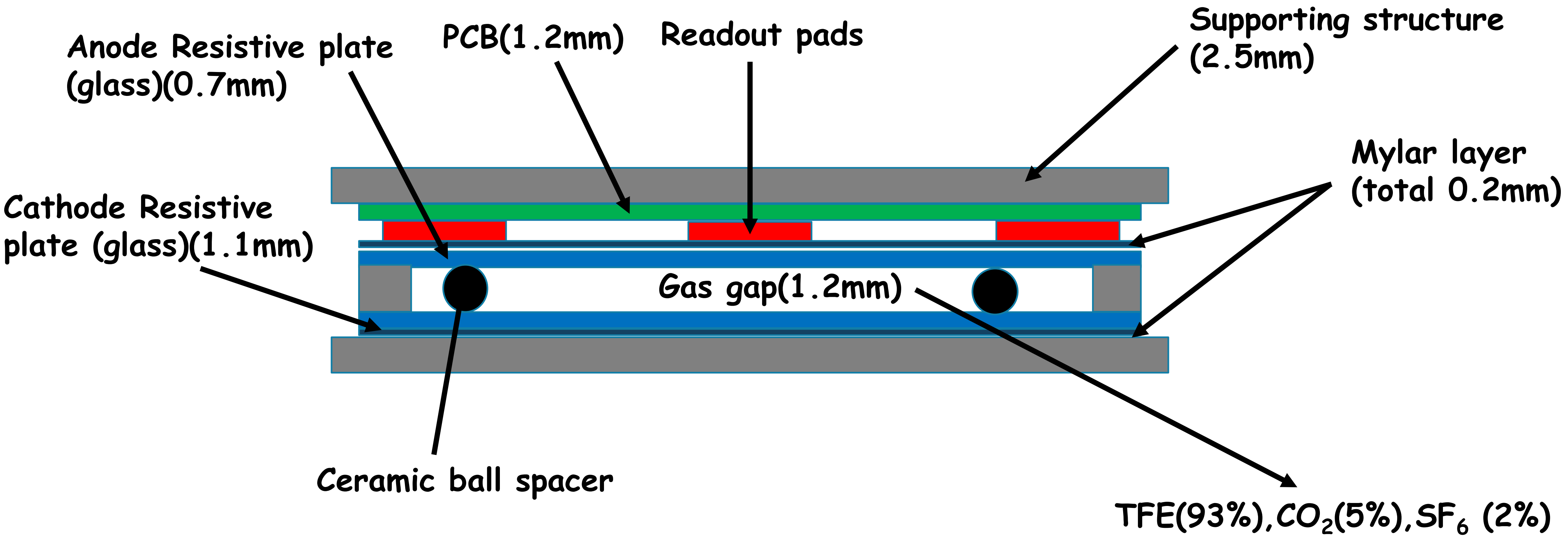
Stainless steel wall(2.5mm)



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

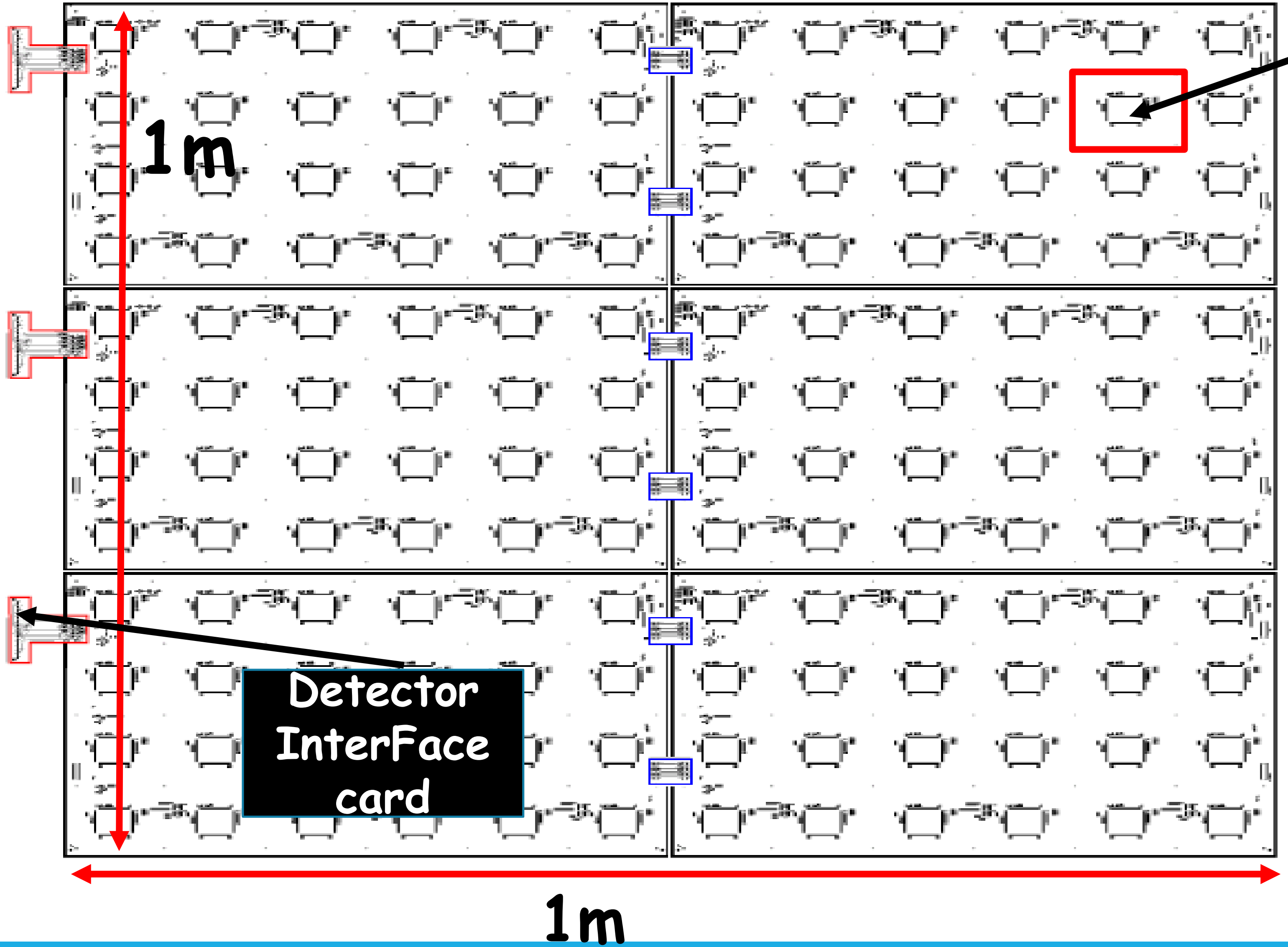
Sensitive layer(Total 6mm)

GRPC(3mm)+electronics(3mm)



A schematic of GRPC (not to scale)

Electronics readout



ASIC HARDROC(64 channel)
three-threshold (Semi-digital)
110fC,5pC,15pC

The average MIP-induced charge being around 1.2pC.

Aim to distinguish between pads crossed by few, many or very many charged particles using the threshold information

Per layer is made up of 3(DIF)X48(ASIC)

DIF: connect DAQ and ASIC, monitor power consumption and temperature

Data sample and selections

Data sample:SPS_Oco_2015

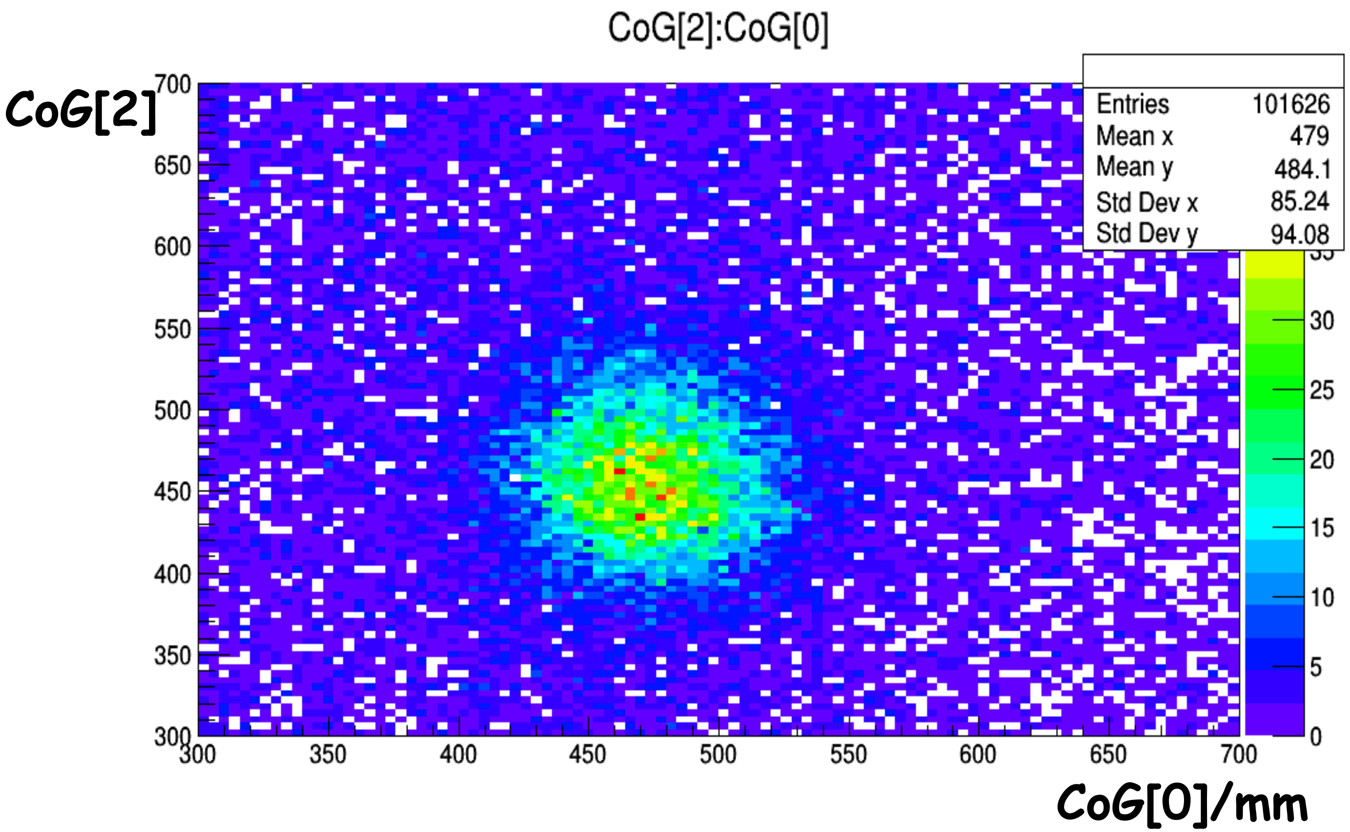
Particle: Pi+

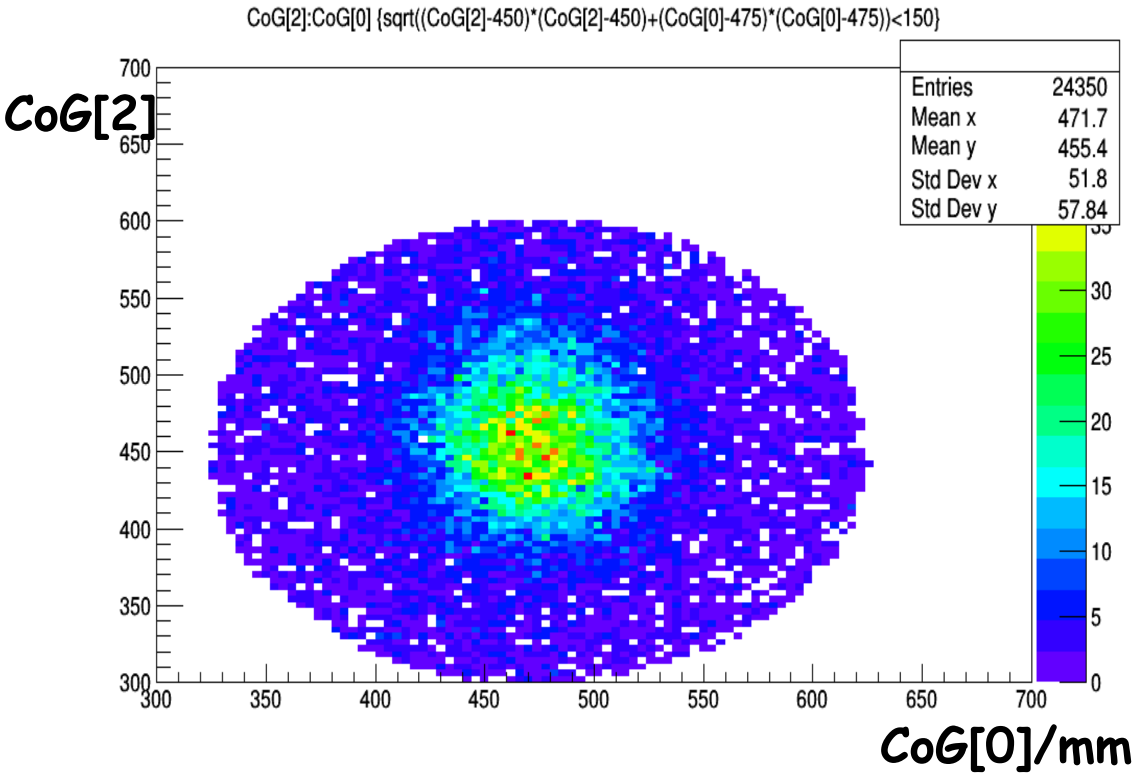
Energy:10-80GeV with uniform

10 GeV energy gap

selections

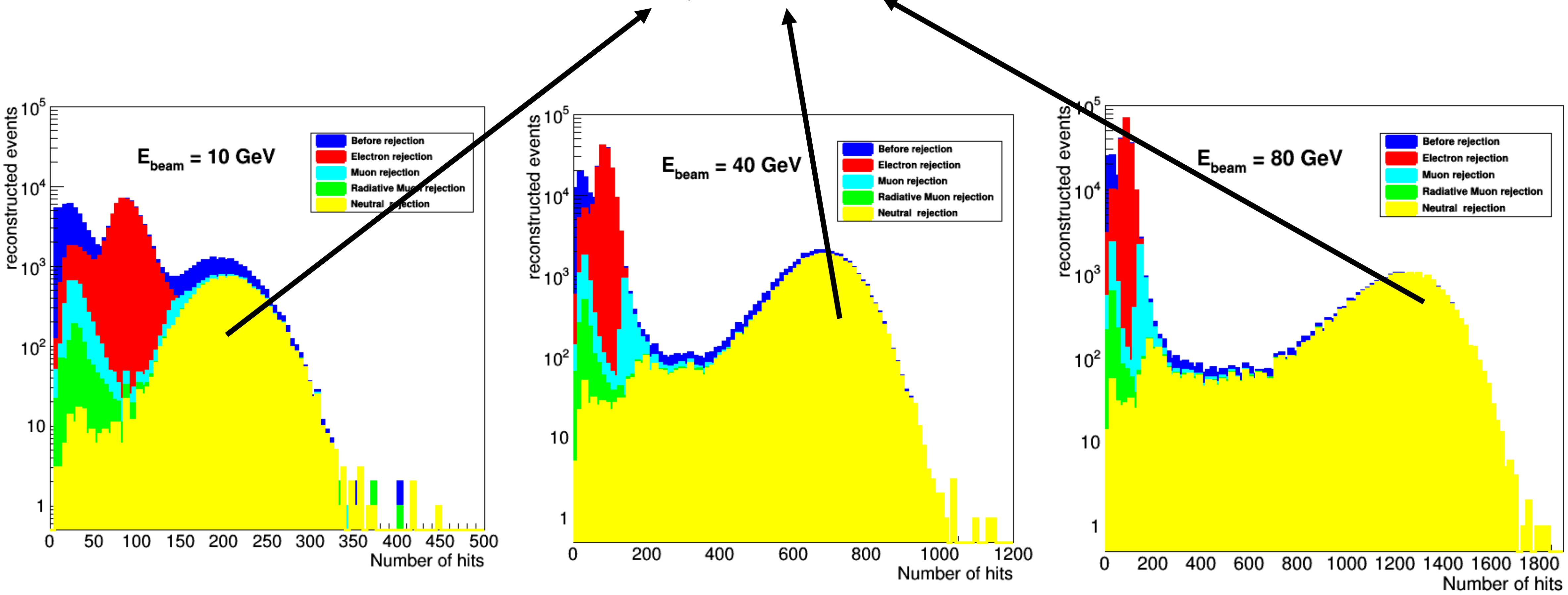
Type	Selections	Detail
Physical cut	Electron rejection	Shower start >=5 or Nlayer > 30
	Muon rejection	Nhit/Nlayer > 3.2(previous is 2.2)
	Radiative muon rejection	Nlayer(RMS > 5cm)/Nlayer>20%
	Neutral rejection	Nhit(belong to first 5 layers)> =4
Artificial cut	Beam position cut	r<r(given)





CoG[0],CoG[2] are the x and y position of hits in the first layer

Contributed by hadron showers

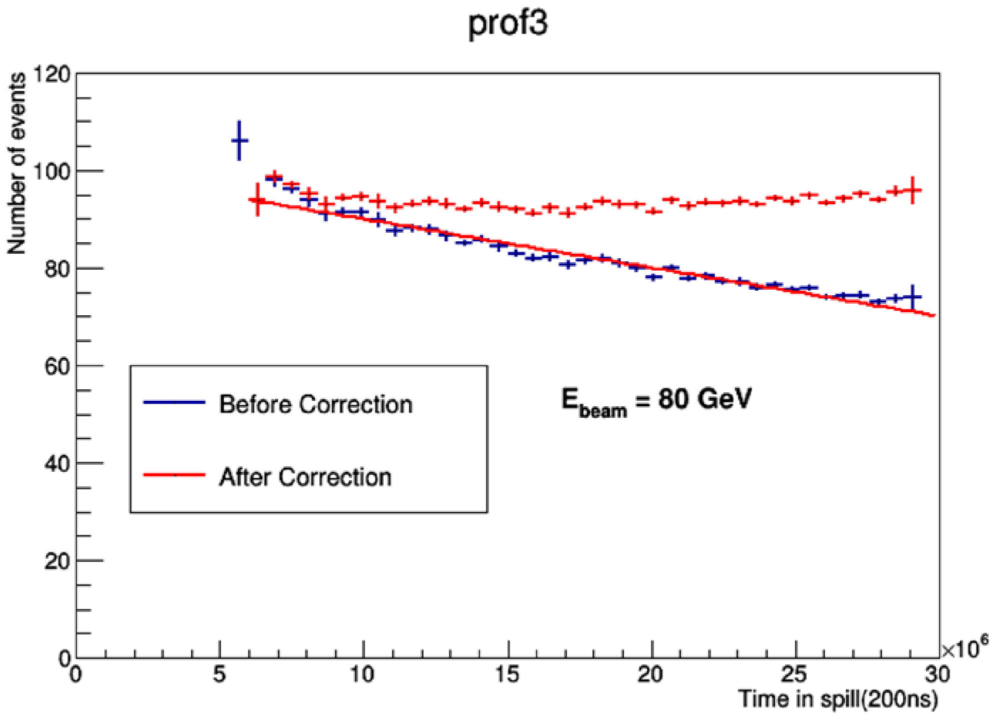


Applying 4 rejections step by step

Beam intensity correction

Correction formula:

$$N_{corr_j} = N_j - \lambda_j * T$$

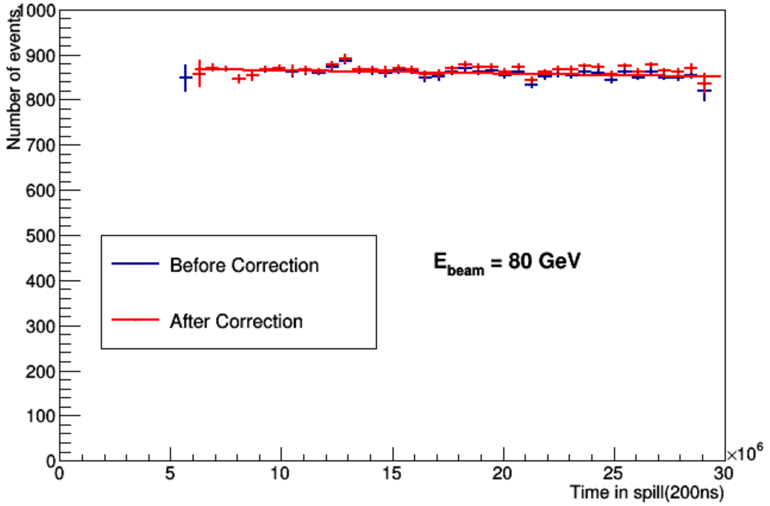


Where N_j is the number of hit of threshold j(=1,2,3)

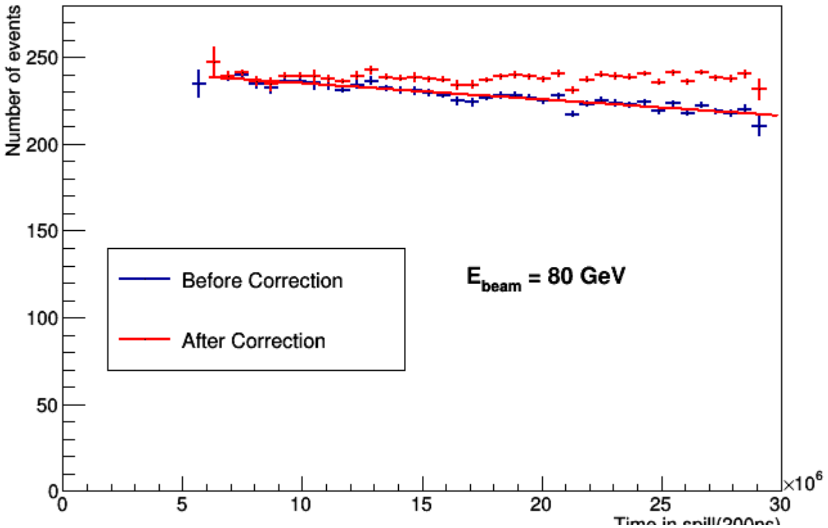
λ_j is the correction slope for threshold j

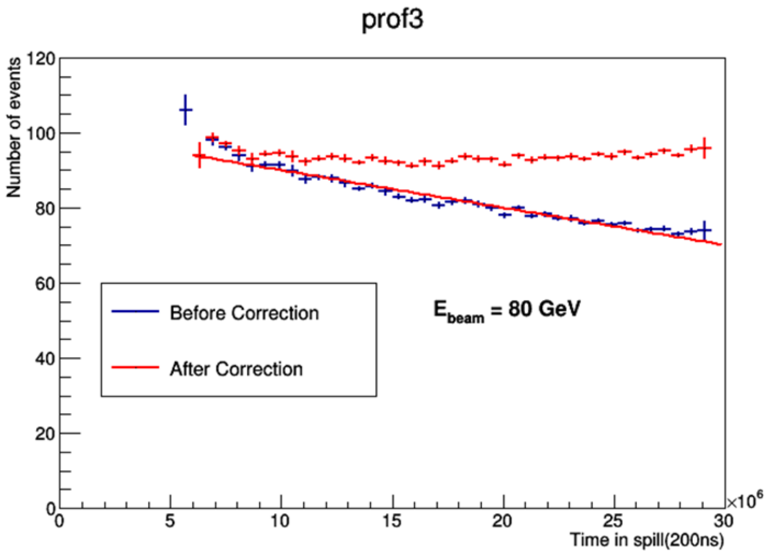
T is the time since start of the spill

Hits of Threshold 1

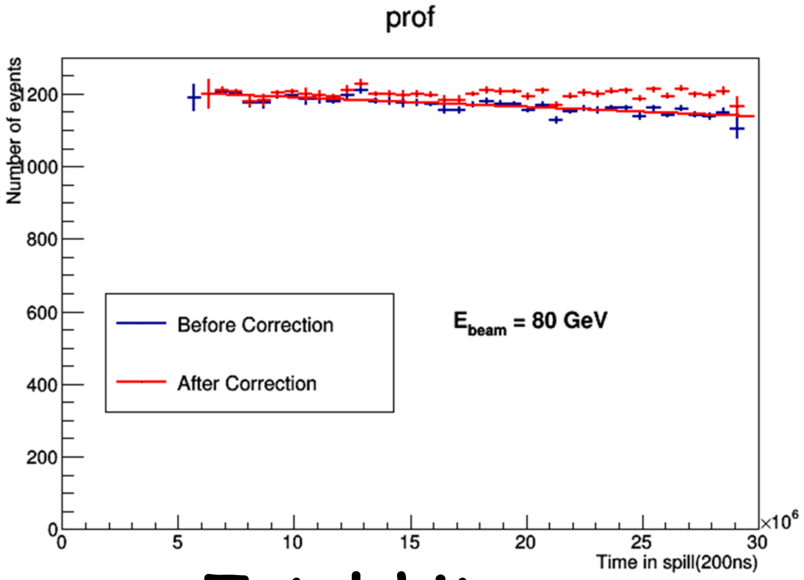


Hits of Threshold 2

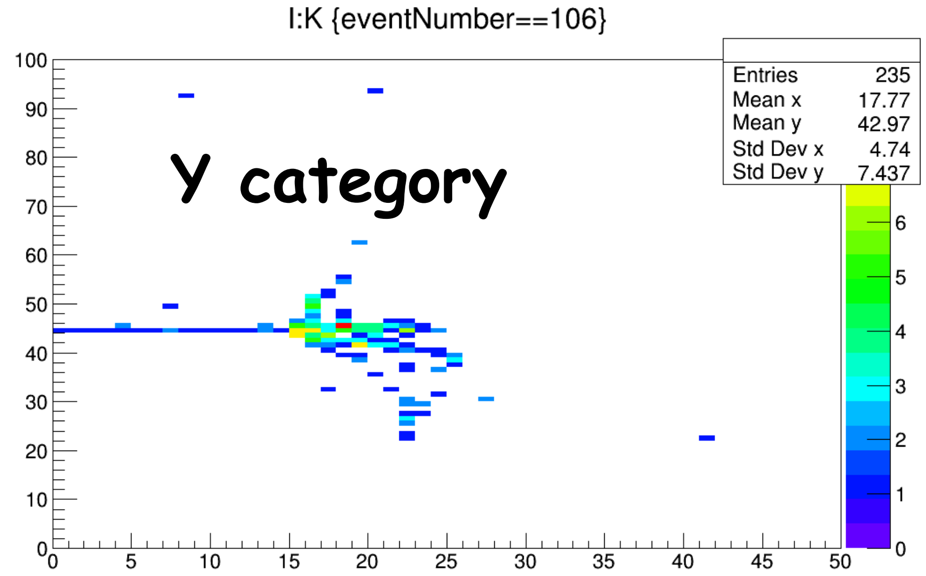


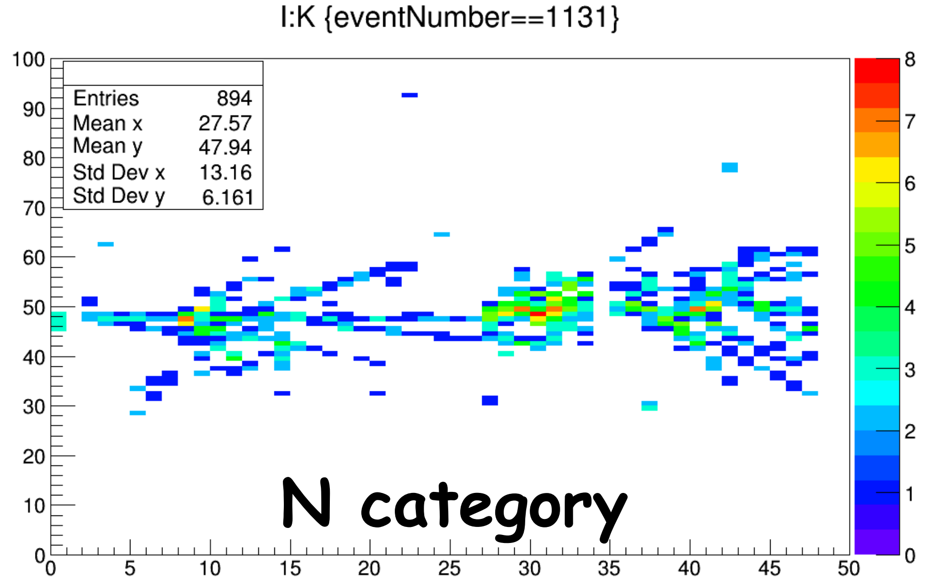


Hits of Threshold 3



Total hits





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

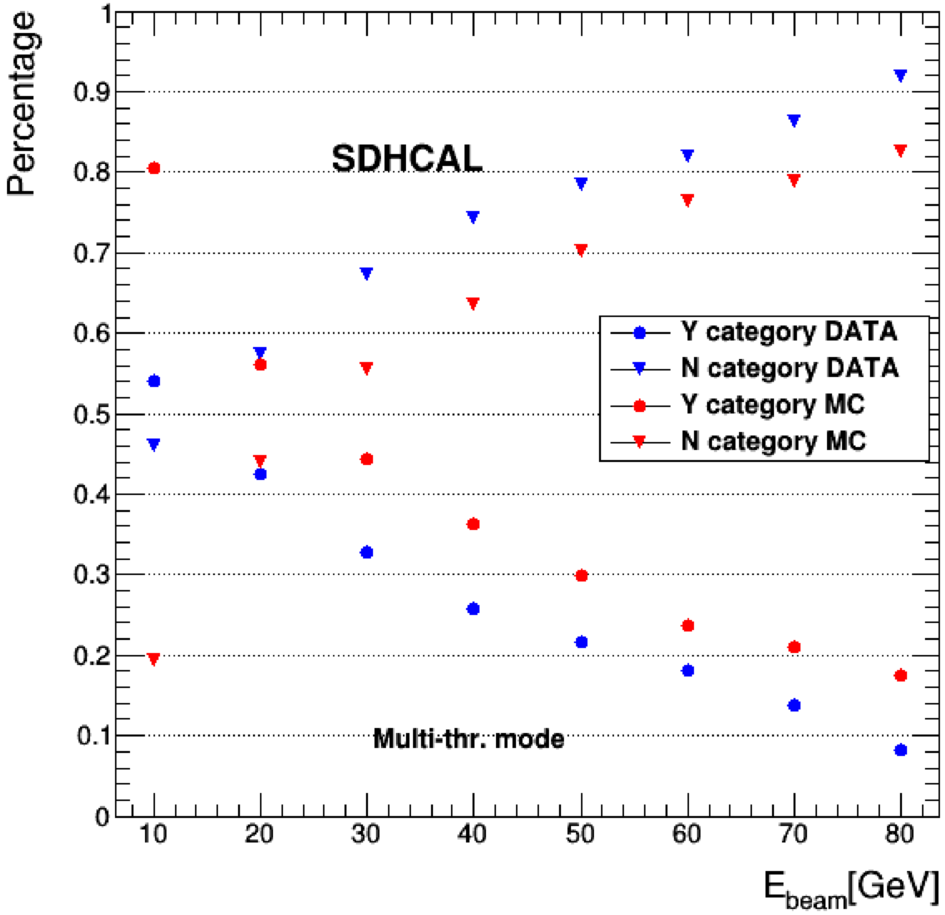
If no this means that the shower is fully contained in the prototype and tag the event Y

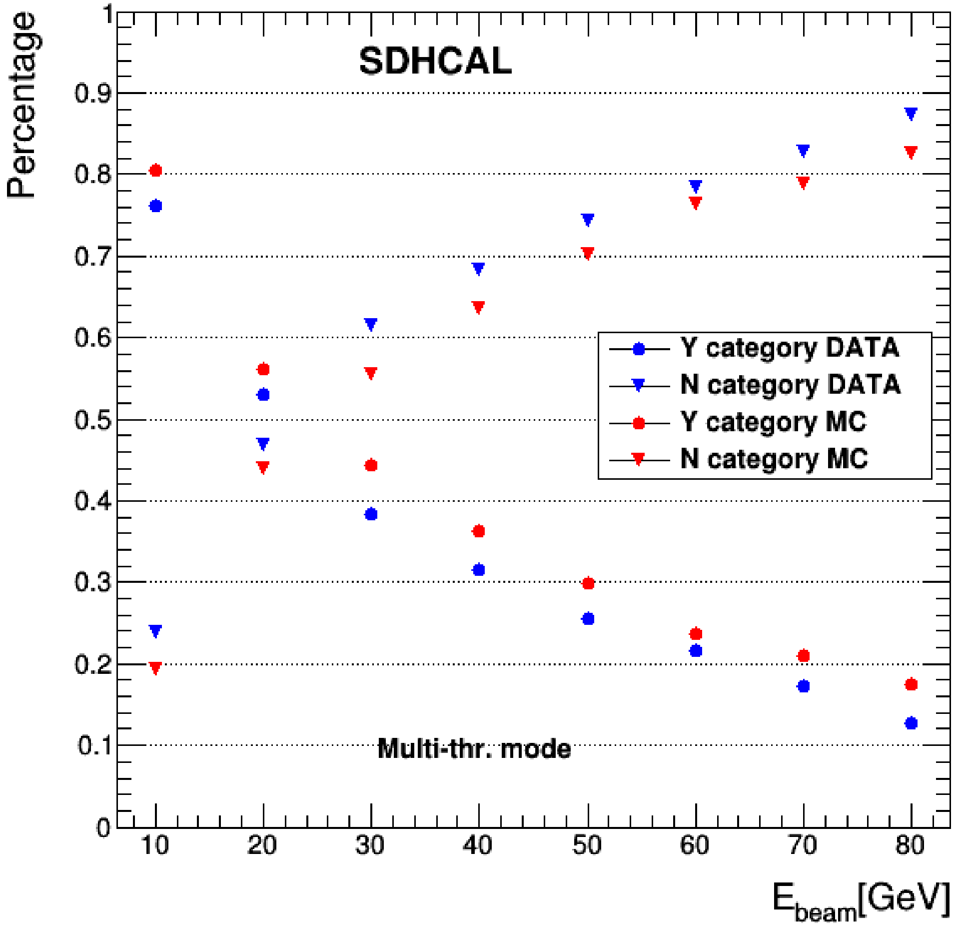
If yes that means that the shower is not fully contained and you can tag this kind of events as N

Update

Nhits/Nlayer > 2.2

Nhits/Nlayer > 3.2





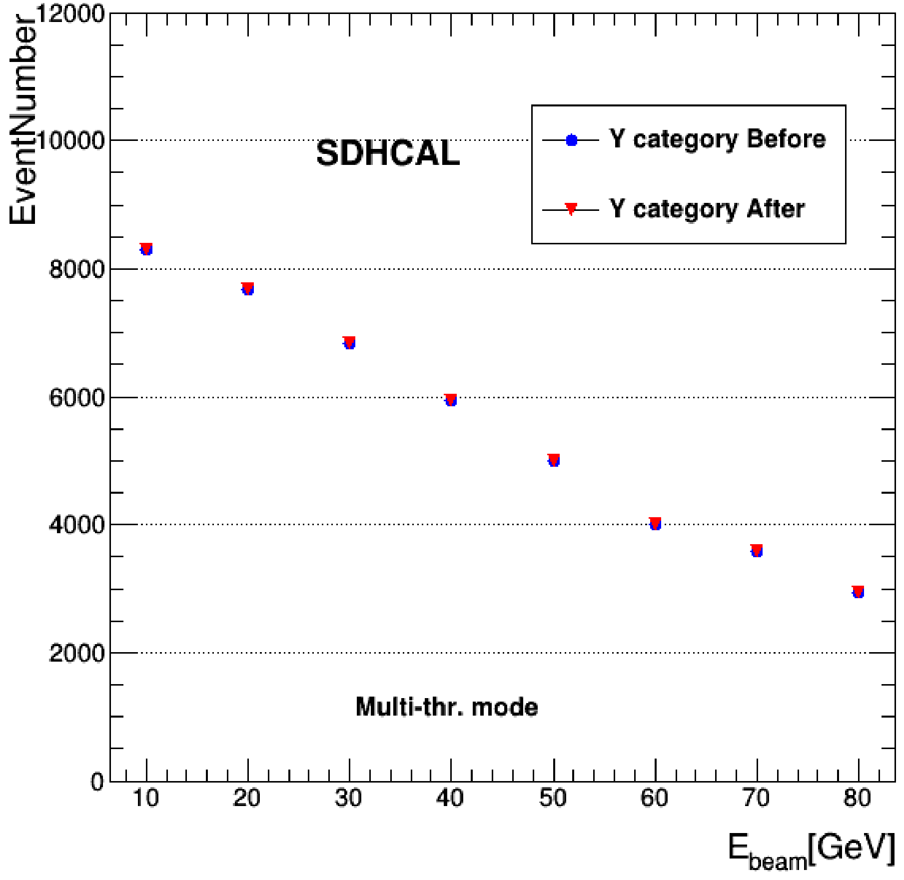
There is a large difference between MC and data

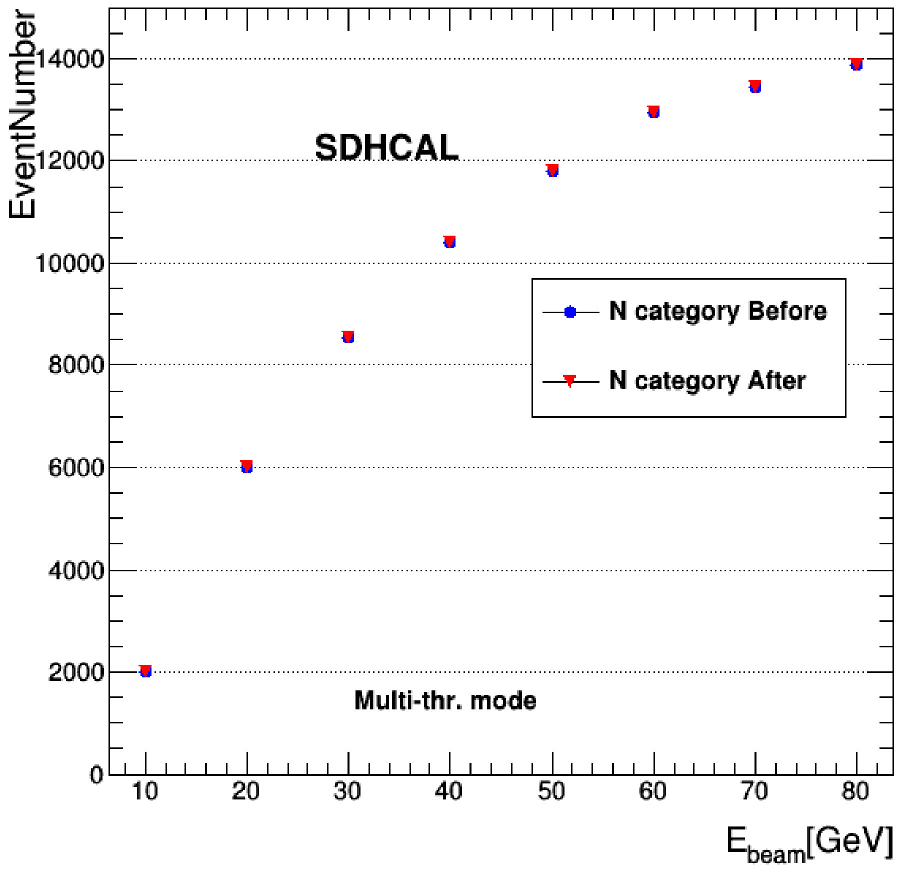
After updating , the difference between MC and data is very little

MC

Before:Nhits/Nlayer > 2.2

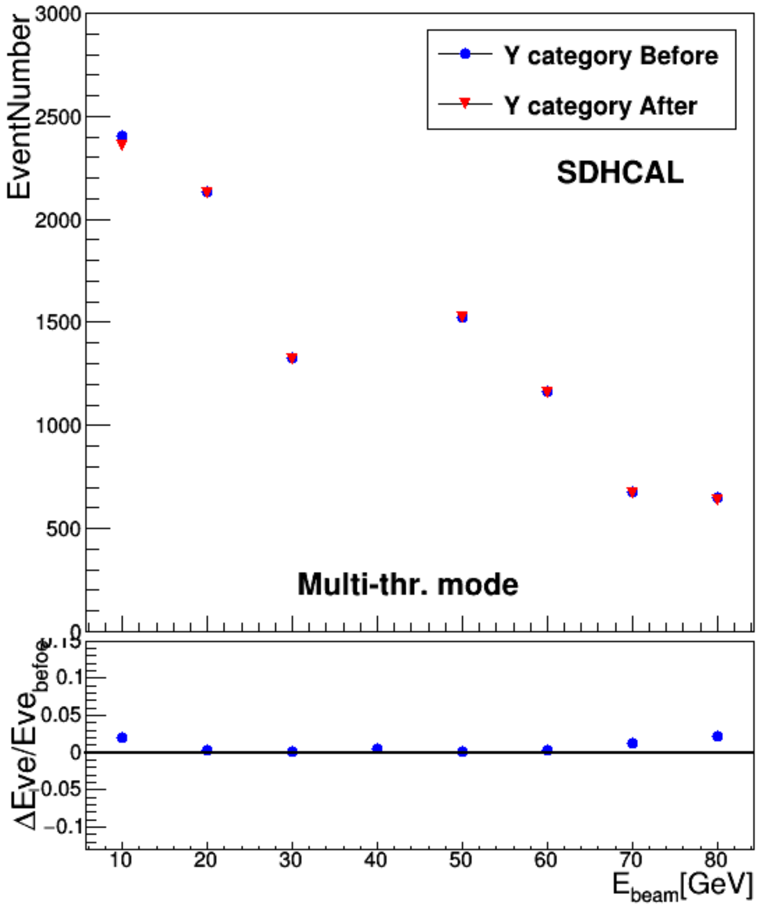
After:Nhits/Nlayer > 3.2

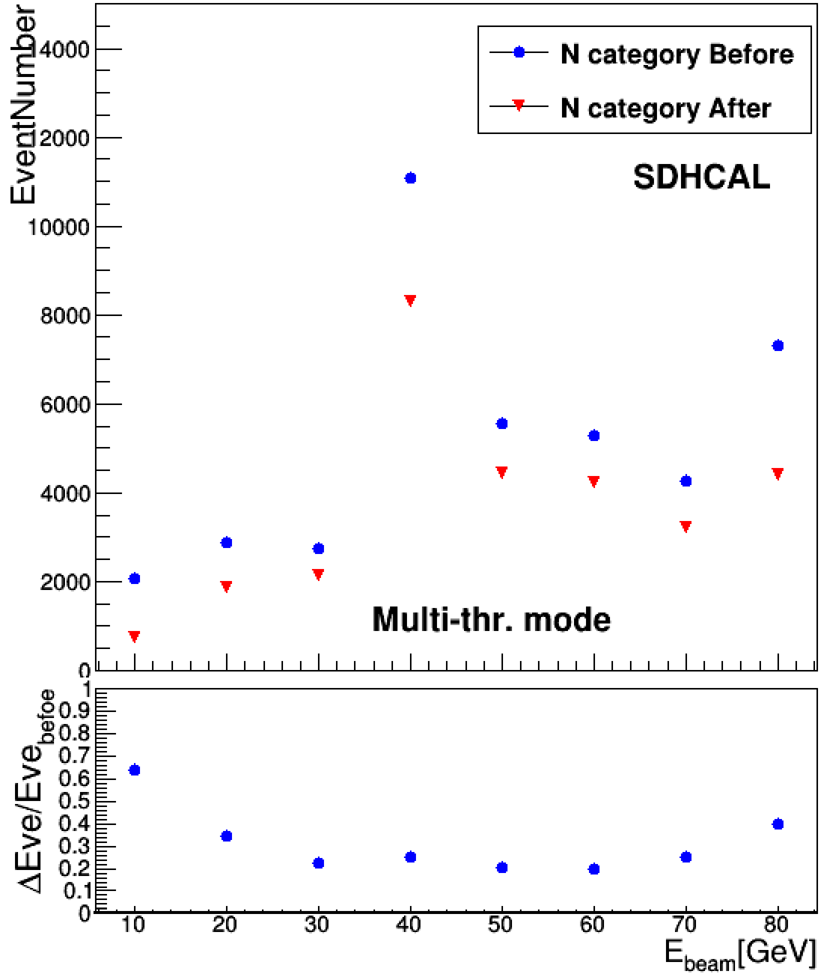




The two plots show the change of event number of MC after changing muon cut

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

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)

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

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

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

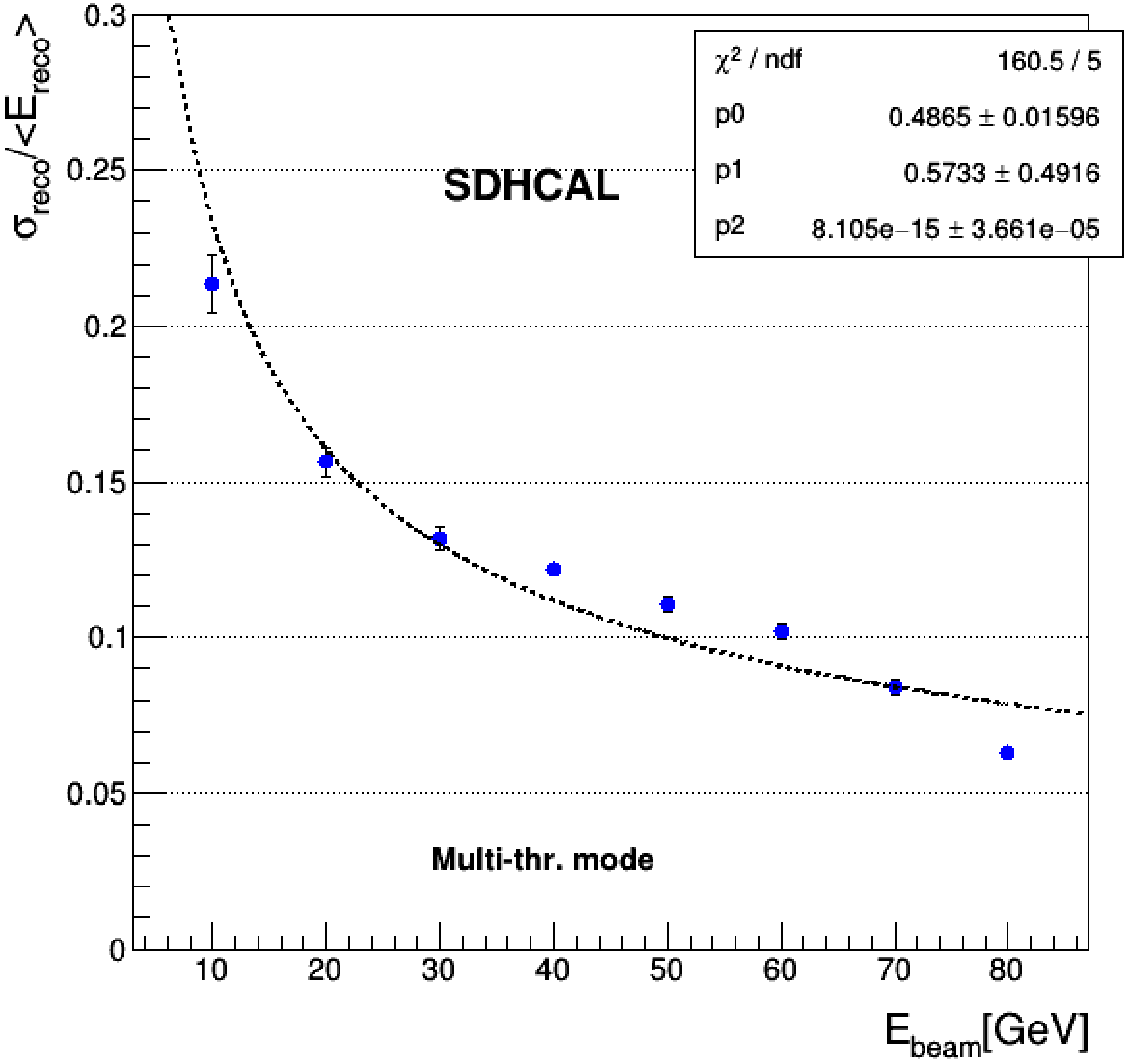
$$\chi^2 = \sum_{i=1}^{N} \frac{(E_{beam}^i - E_{reco}^i)^2}{\sigma_i^2}$$

N is the number of total events.

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

After the first step:

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

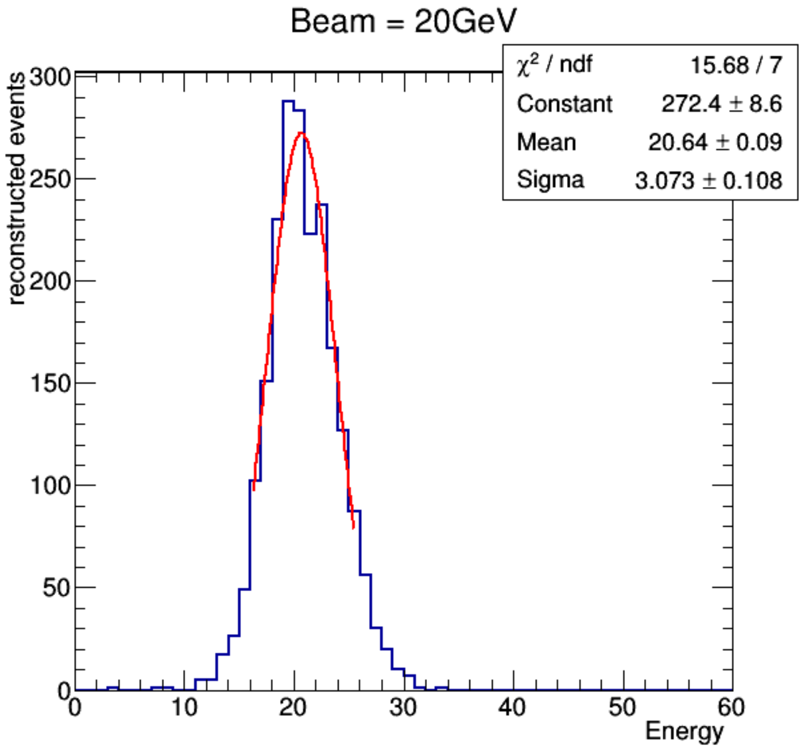


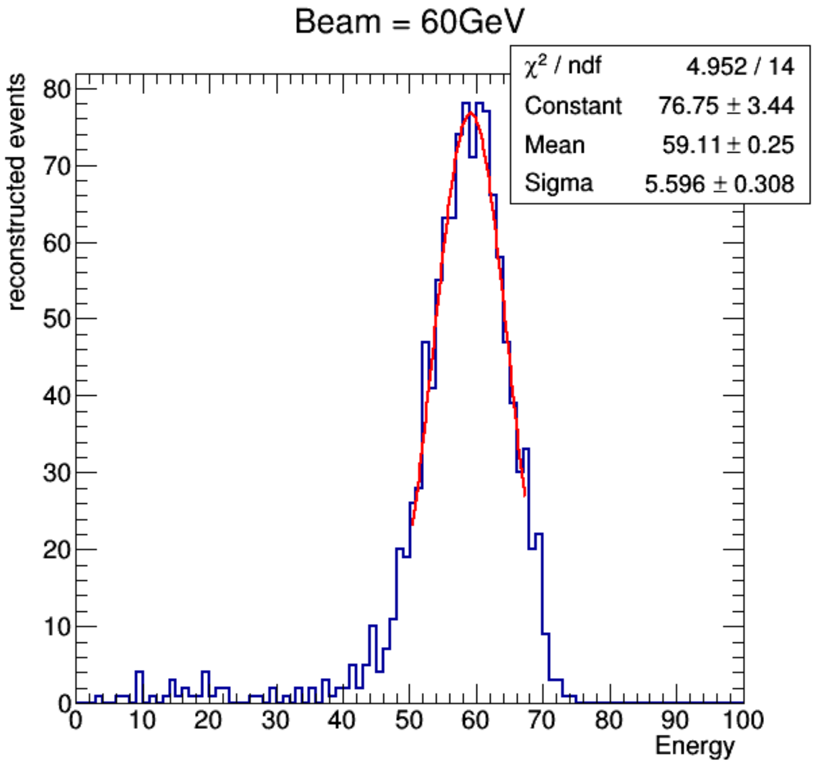
Fit function

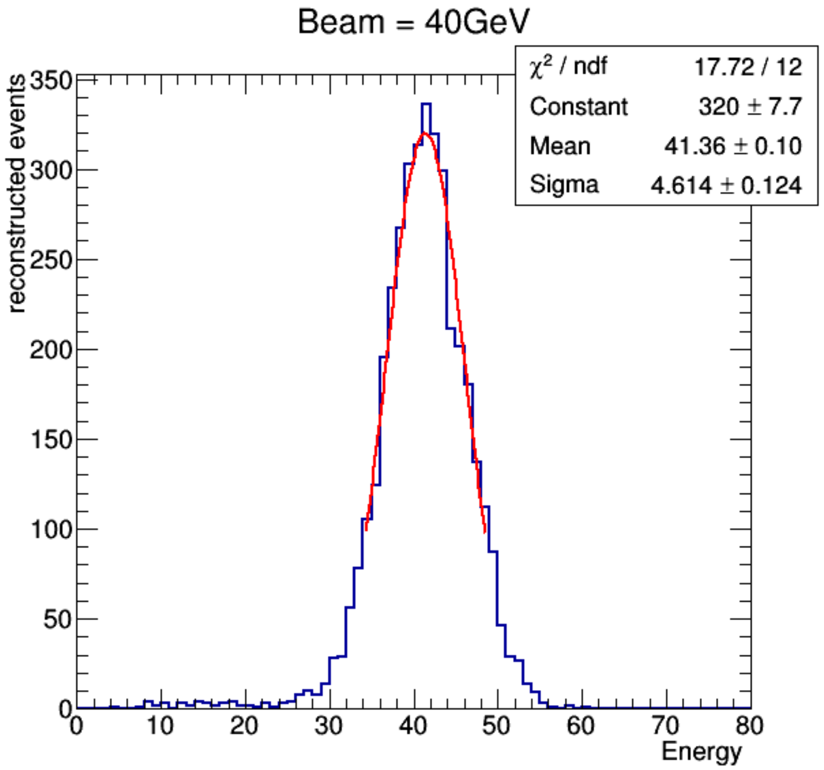
$$\left(\frac{\sigma}{E}\right)^2 = \frac{p0}{E} + \frac{p1}{E^2} + p2$$

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

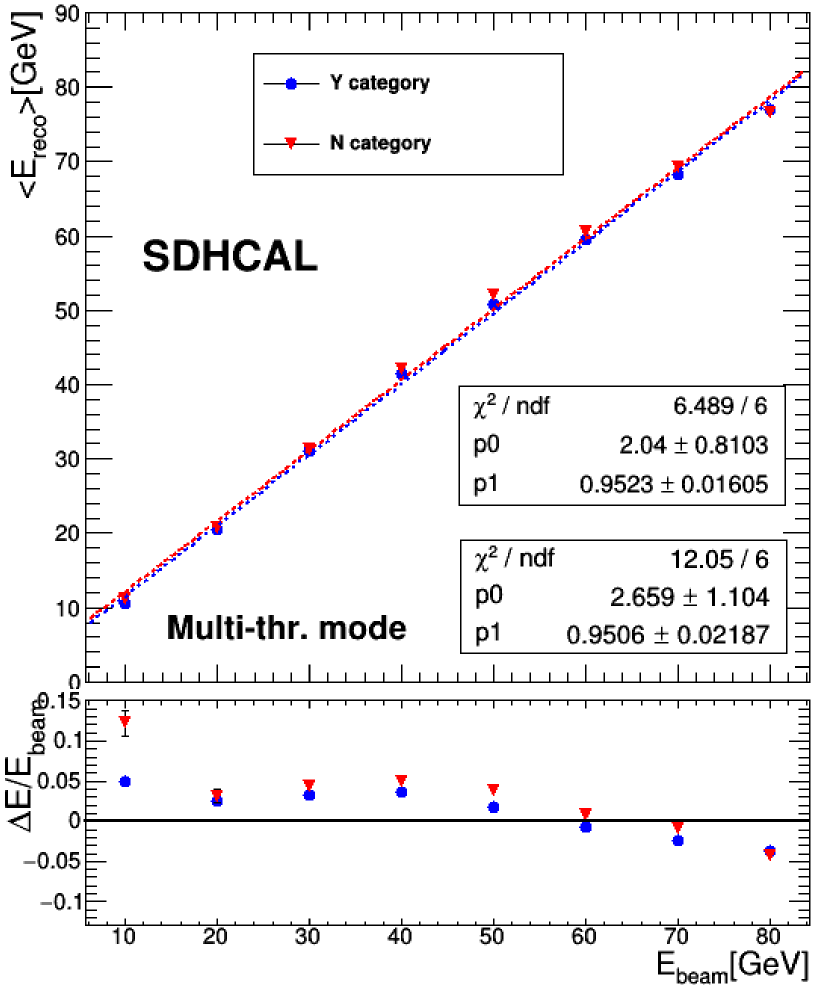
48Layers(Y category)

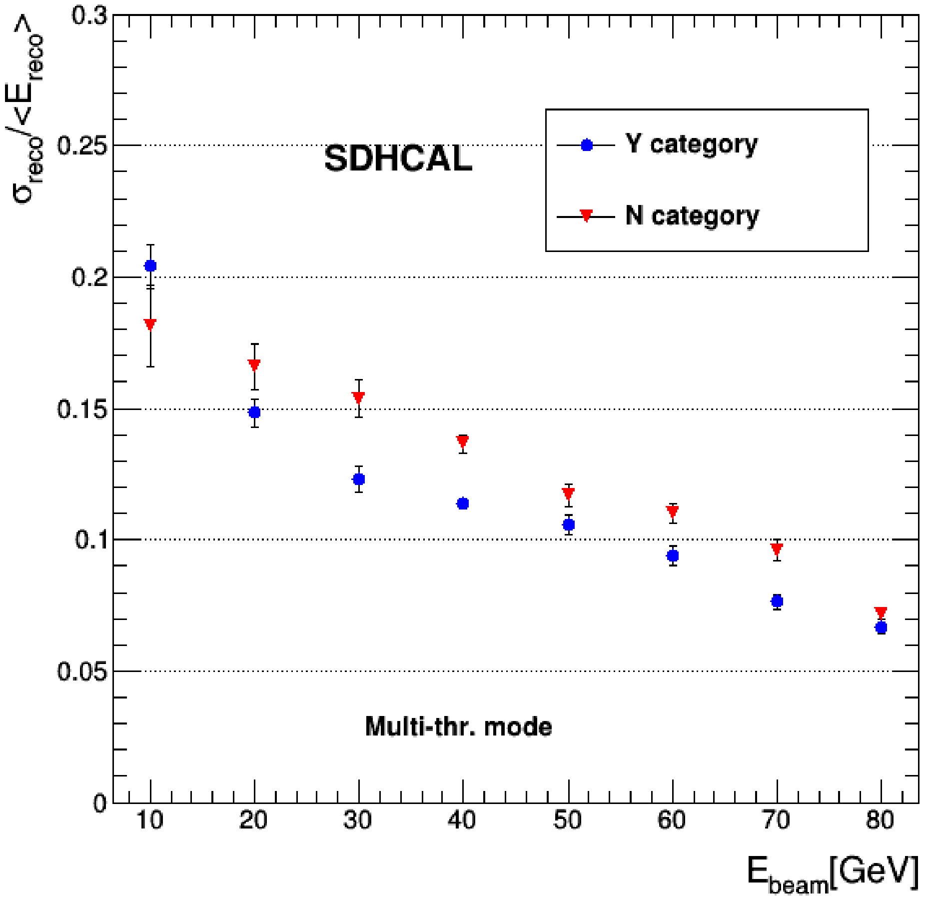






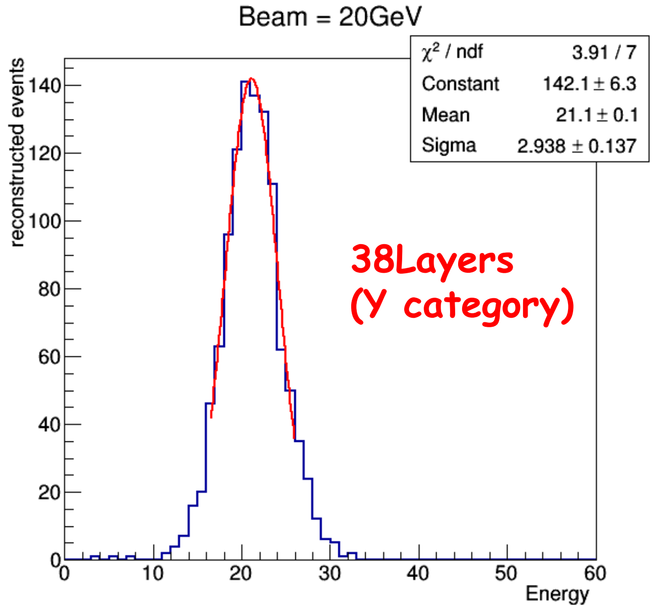
The distributions are fitted with a Gaussian Function in a 1.5σ range around the mean

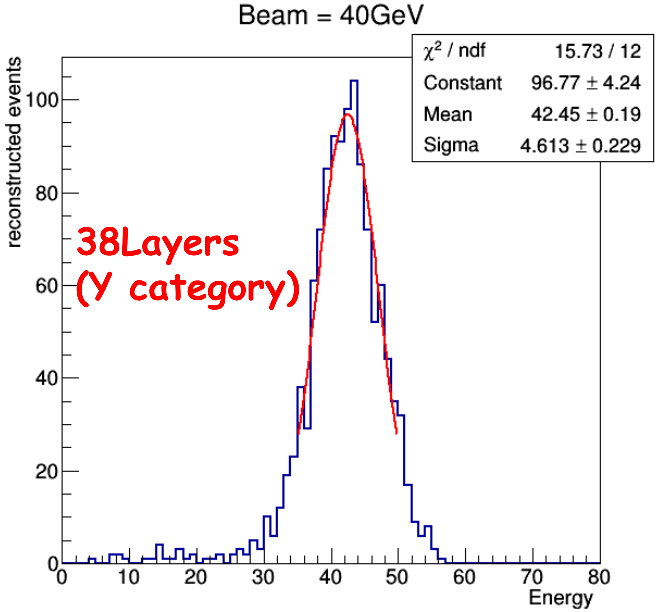


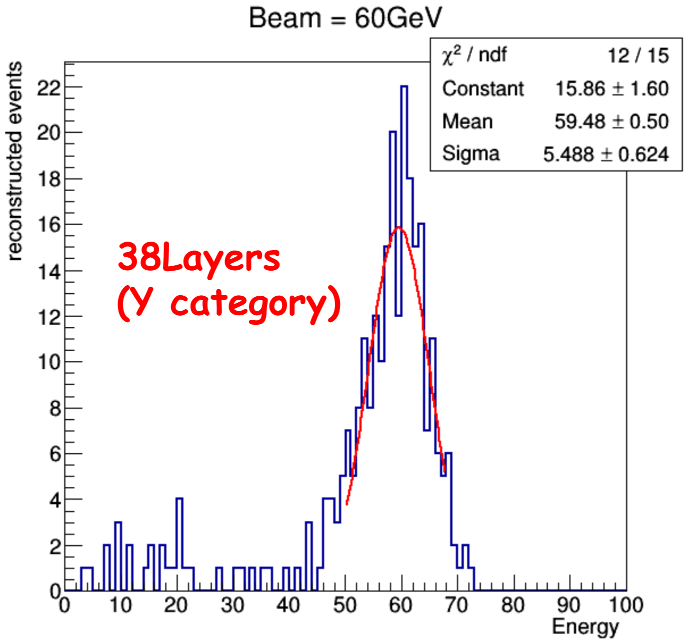


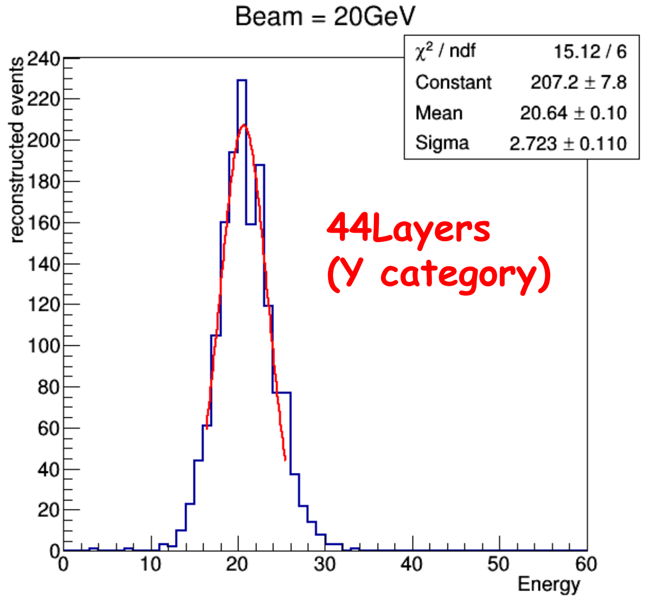
The results of Y are better than N including linearity and resolution

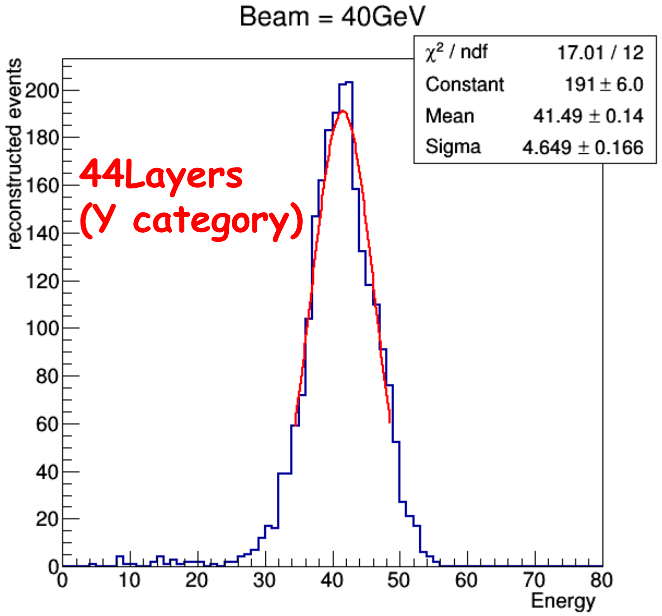
Analysis of 38,44,48 layers

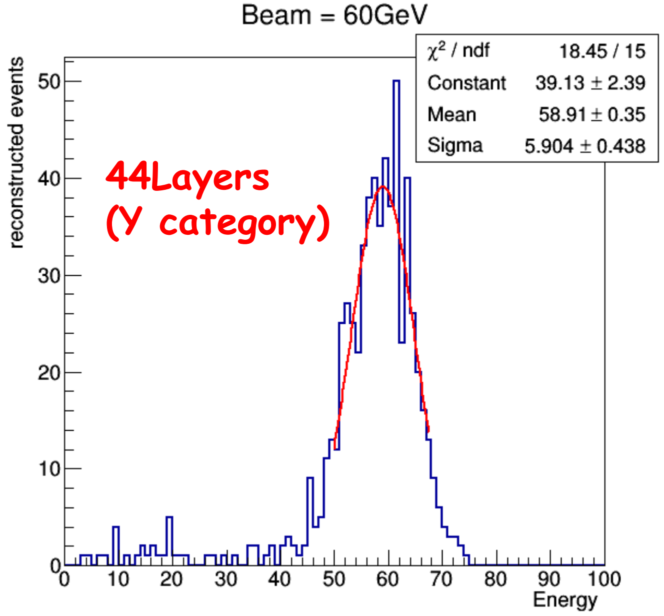

Beam = 20GeV
χ2 / ndf 3.91 / 7
Constant 142.1 ± 6.3
Mean 21.1 ± 0.1
Sigma 2.938 ± 0.137
38Layers
(Y category)
reconstructed events
Energy


Beam = 40GeV
χ2 / ndf 15.73 / 12
Constant 96.77 ± 4.24
Mean 42.45 ± 0.19
Sigma 4.613 ± 0.229
38Layers
(Y category)
reconstructed events
Energy

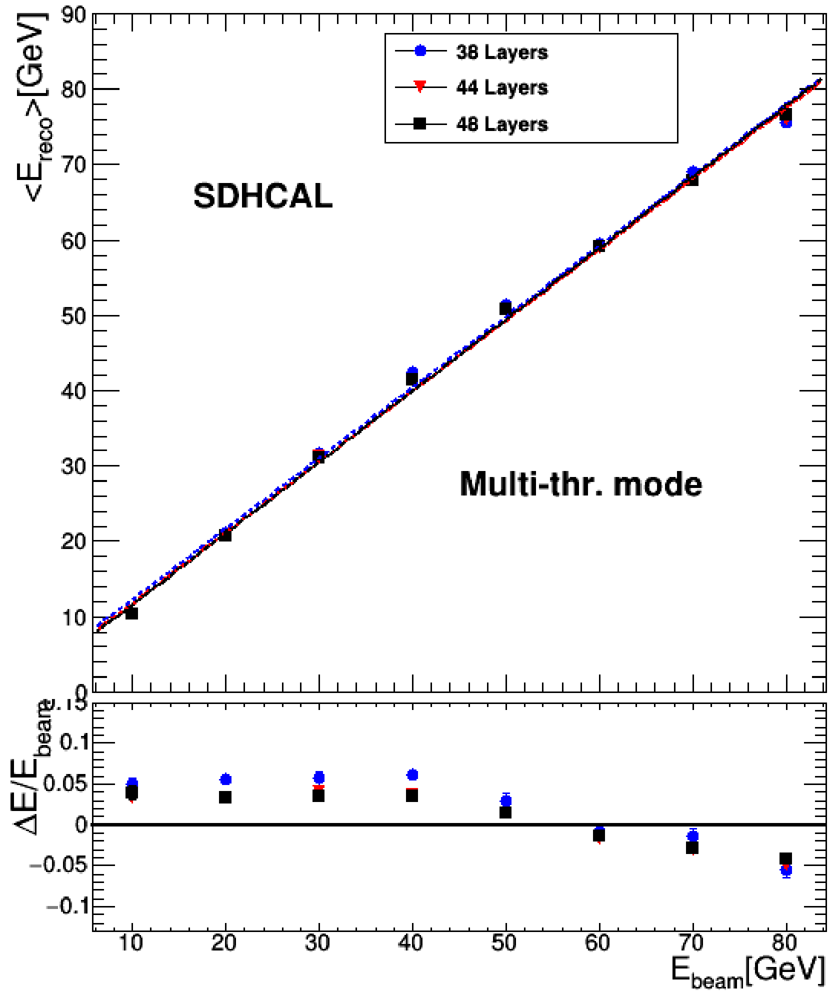

Beam = 60GeV
χ2 / ndf 12 / 15
Constant 15.86 ± 1.60
Mean 59.48 ± 0.50
Sigma 5.488 ± 0.624
38Layers
(Y category)
reconstructed events
Energy

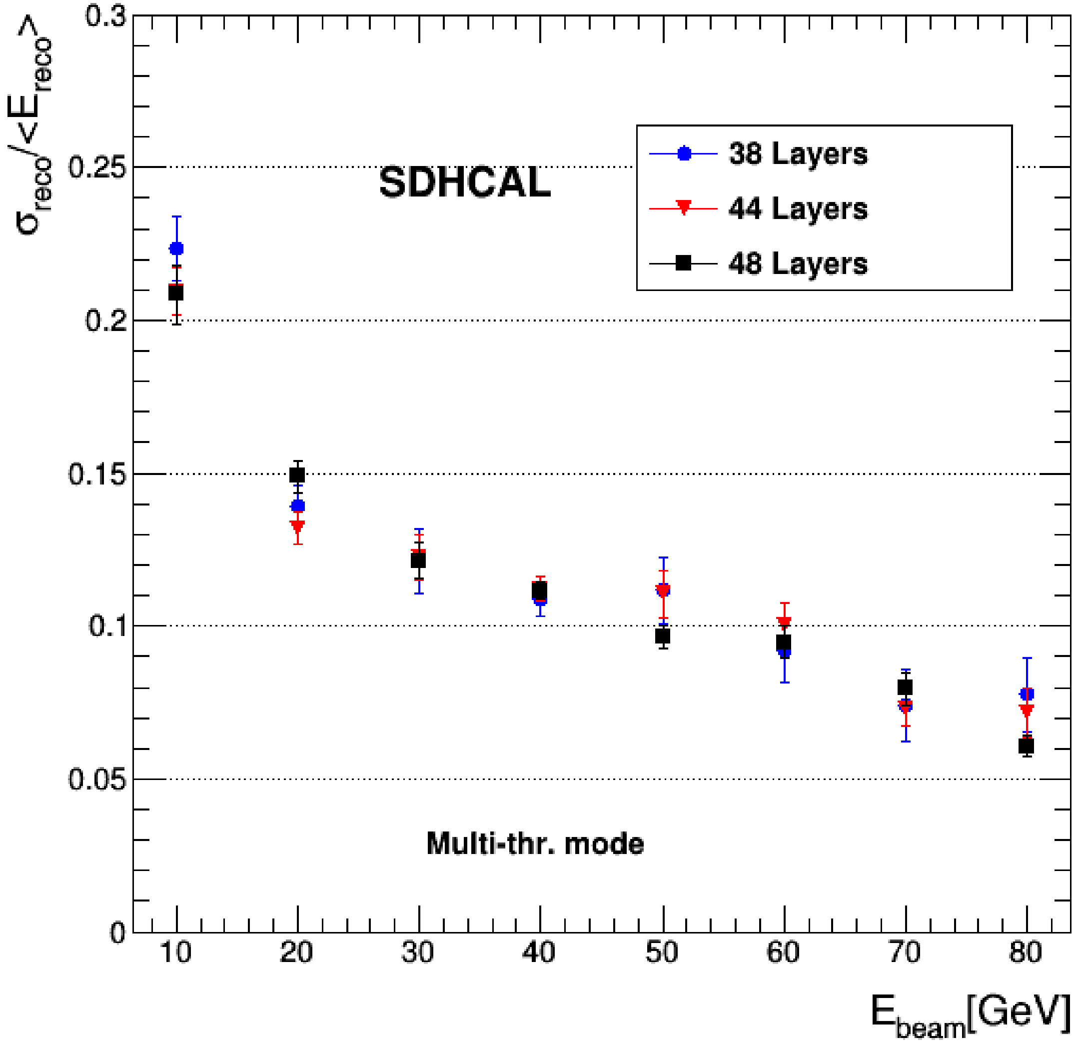

Beam = 20GeV
χ2 / ndf 15.12 / 6
Constant 207.2 ± 7.8
Mean 20.64 ± 0.10
Sigma 2.723 ± 0.110
44Layers
(Y category)
reconstructed events
Energy


Beam = 40GeV
χ2 / ndf 17.01 / 12
Constant 191 ± 6.0
Mean 41.49 ± 0.14
Sigma 4.649 ± 0.166
44Layers
(Y category)
reconstructed events
Energy

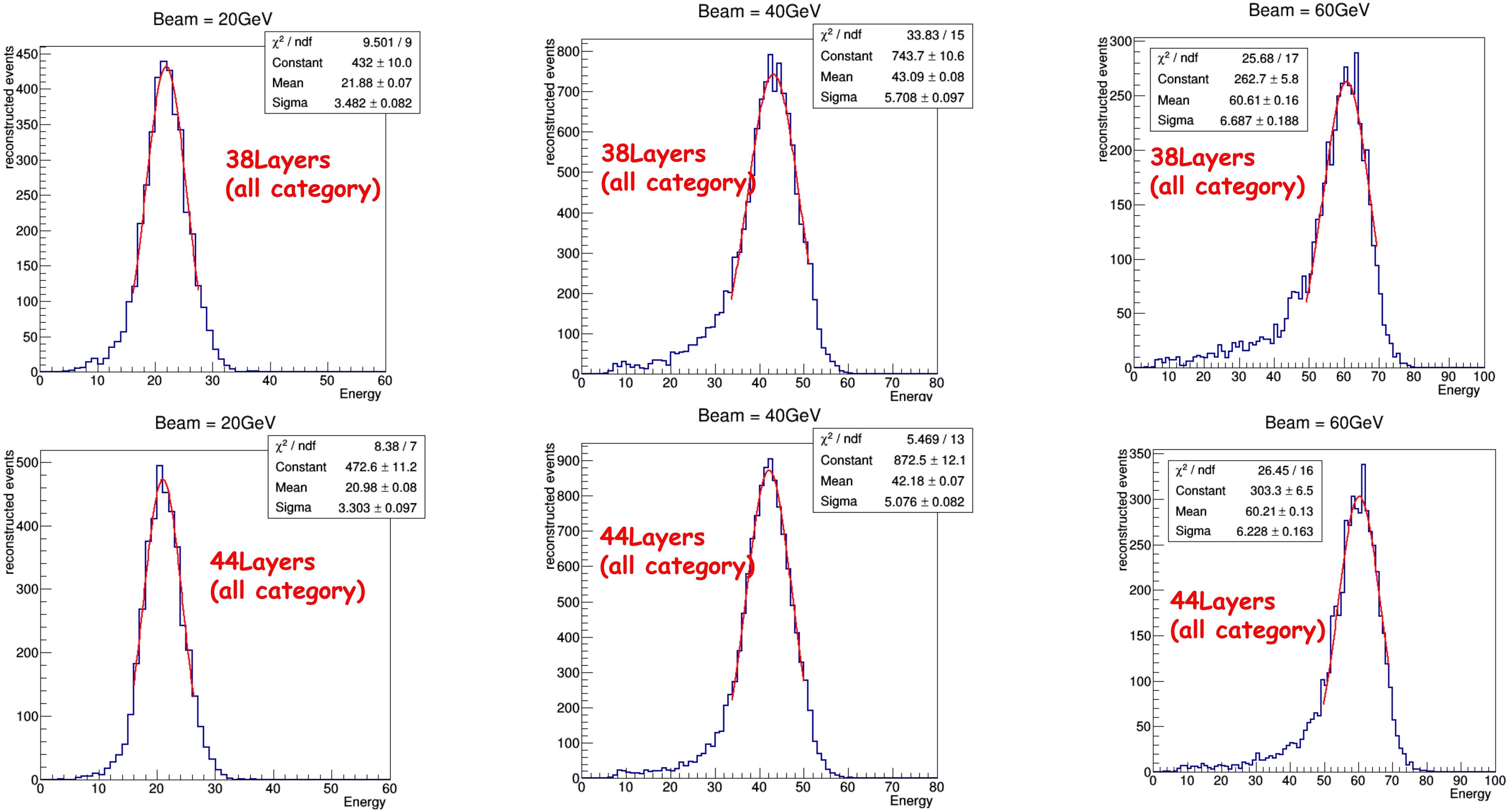

Beam = 60GeV
χ2 / ndf 18.45 / 15
Constant 39.13 ± 2.39
Mean 58.91 ± 0.35
Sigma 5.904 ± 0.438
44Layers
(Y category)
reconstructed events
Energy

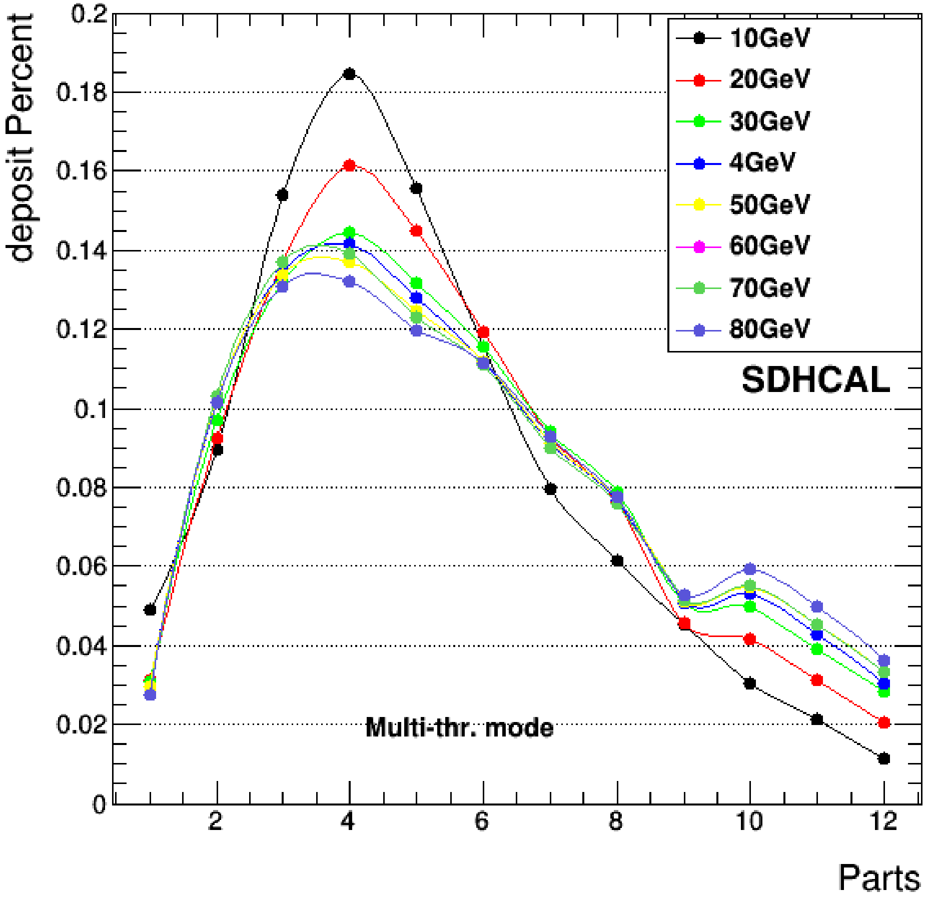
Results(Y category)



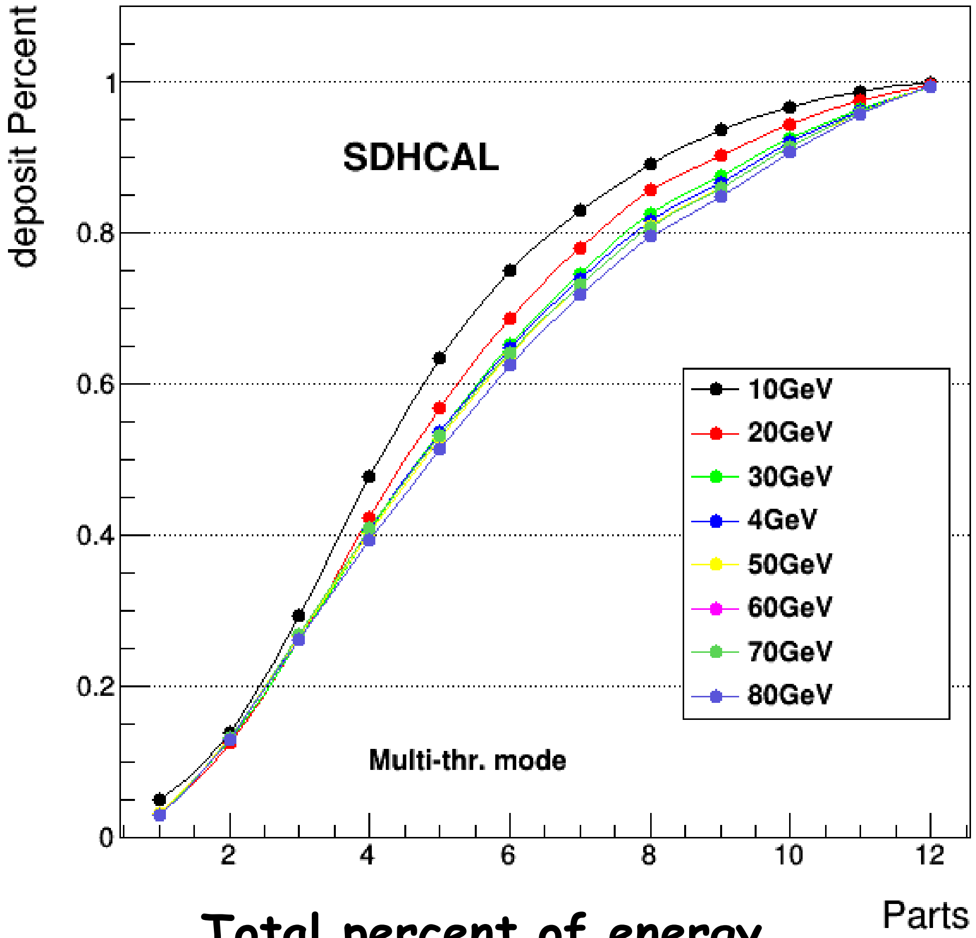


The fluctuation of Y category is large, So I have to use all category to see the results


Beam = 20GeV
χ2 / ndf 9.501 / 9
Constant 432 ± 10.0
Mean 21.88 ± 0.07
Sigma 3.482 ± 0.082
38Layers
(all category)
reconstructed events
Energy
Beam = 40GeV
χ2 / ndf 33.83 / 15
Constant 743.7 ± 10.6
Mean 43.09 ± 0.08
Sigma 5.708 ± 0.097
38Layers
(all category)
reconstructed events
Energy
Beam = 60GeV
χ2 / ndf 25.68 / 17
Constant 262.7 ± 5.8
Mean 60.61 ± 0.16
Sigma 6.687 ± 0.188
38Layers
(all category)
reconstructed events
Energy
Beam = 20GeV
χ2 / ndf 8.38 / 7
Constant 472.6 ± 11.2
Mean 20.98 ± 0.08
Sigma 3.303 ± 0.097
44Layers
(all category)
reconstructed events
Energy
Beam = 40GeV
χ2 / ndf 5.469 / 13
Constant 872.5 ± 12.1
Mean 42.18 ± 0.07
Sigma 5.076 ± 0.082
44Layers
(all category)
reconstructed events
Energy
Beam = 60GeV
χ2 / ndf 26.45 / 16
Constant 303.3 ± 6.5
Mean 60.21 ± 0.13
Sigma 6.228 ± 0.163
44Layers
(all category)
reconstructed events
Energy

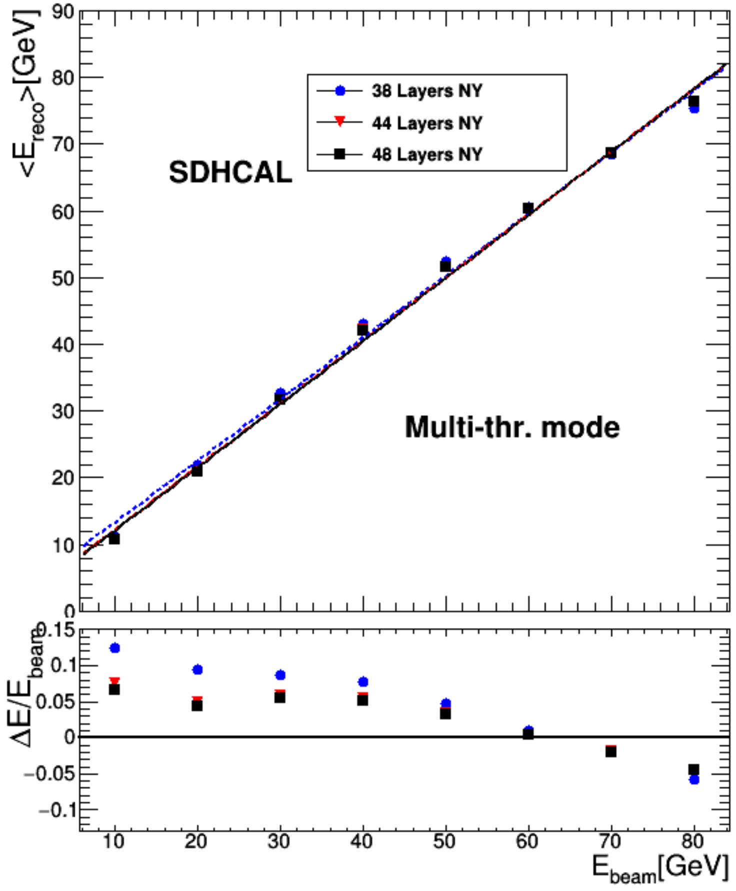


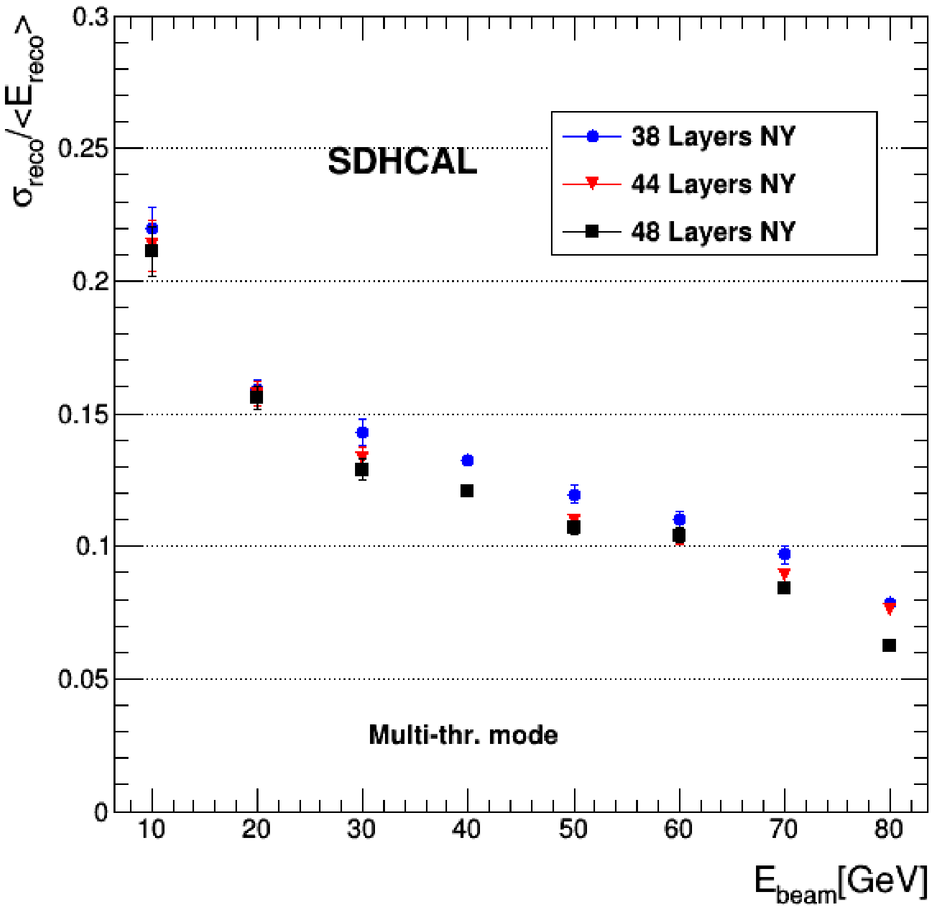
Percent of energy deposit in per parts



Total percent of energy deposit before a part you choose;

Results(all category)





These results are at the our expectation region.

Summary and Next plan

1、 a simple introduction about SDHCAL are given.
2、the comparison between 38,44 and 48 are given
3、The results show SDHCAL having good performance especially in high energy.

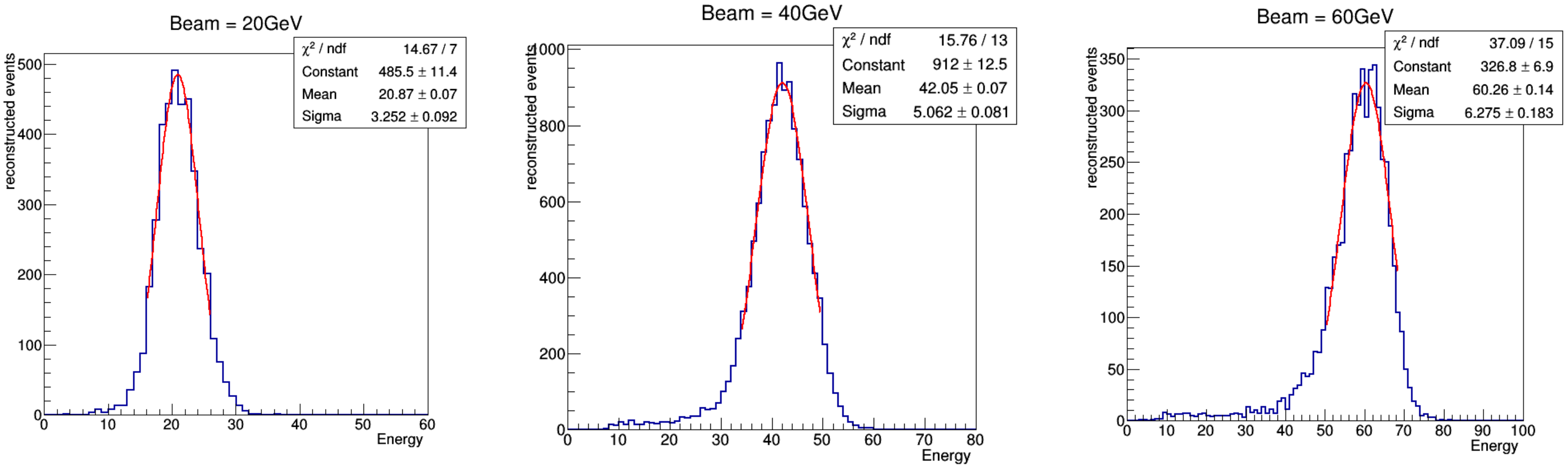
Next plan

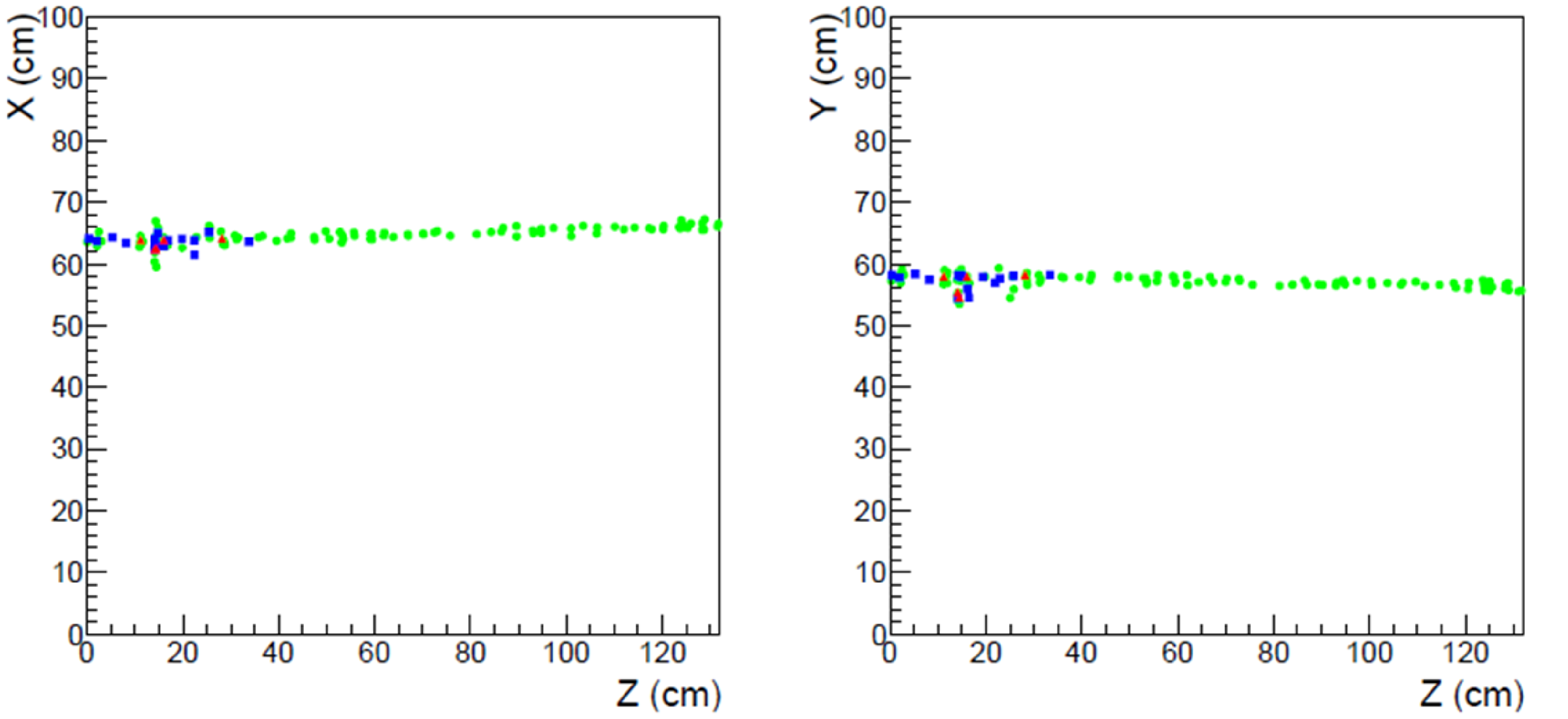
1、To Try to use the MVA method to improve(ANN,BDT…)

Thanks for your attention

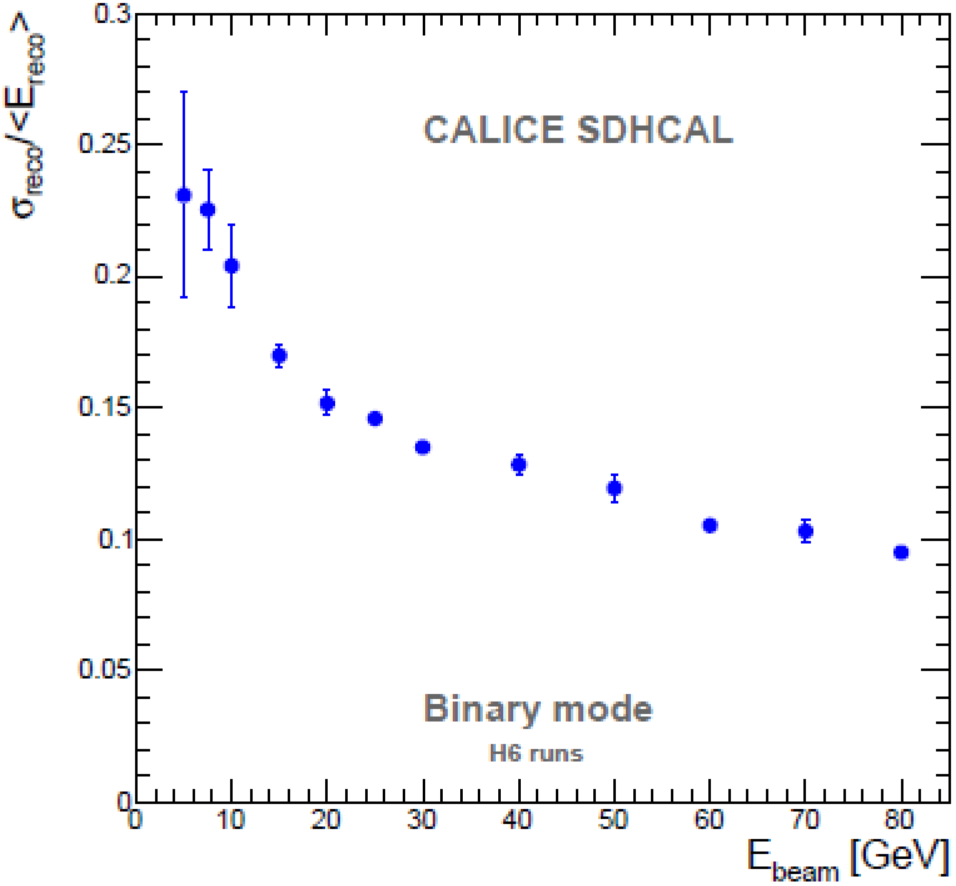
Backup

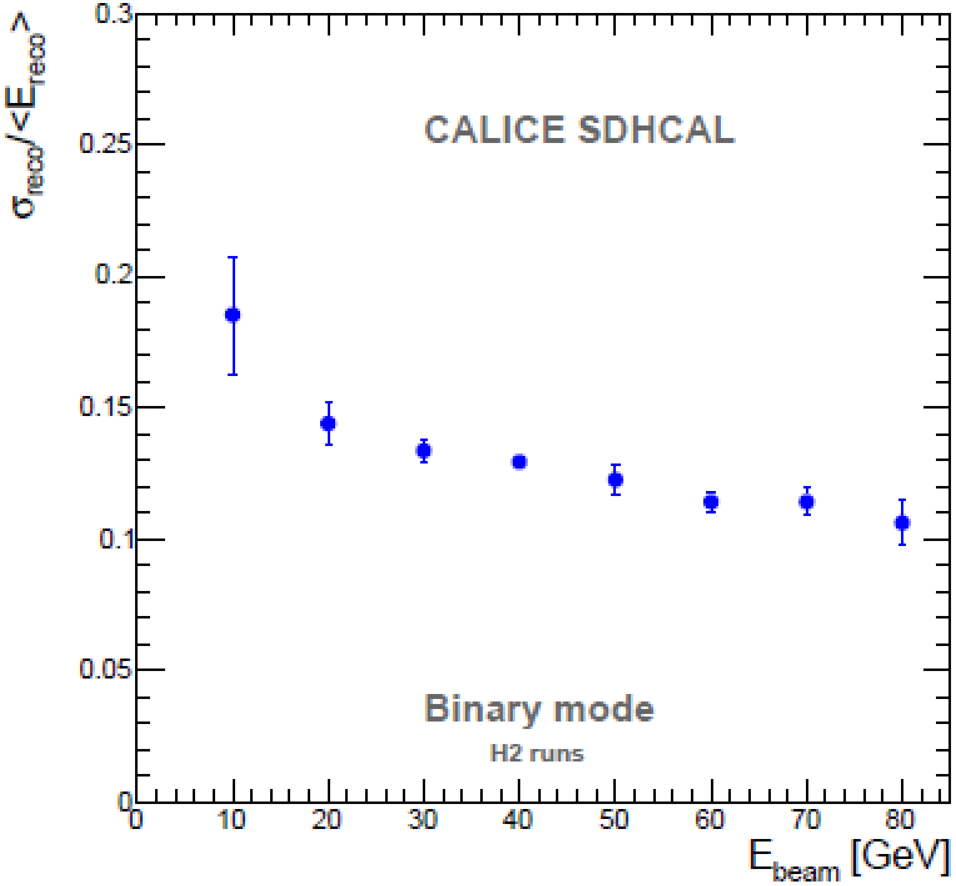
48Layers(all category)



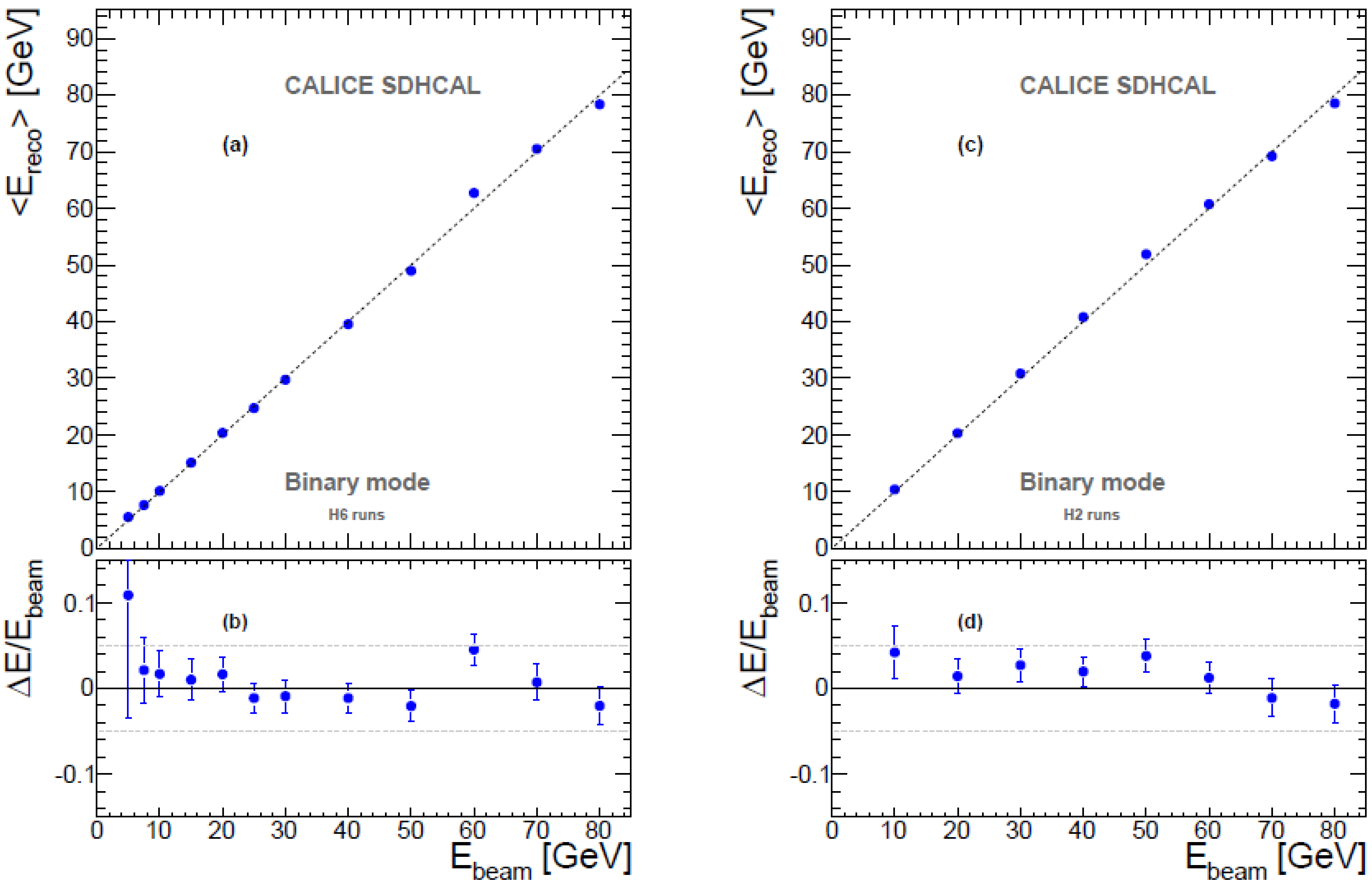


Radiative muon events display at 50 GeV





Binary Mode performance



Binary Mode performance