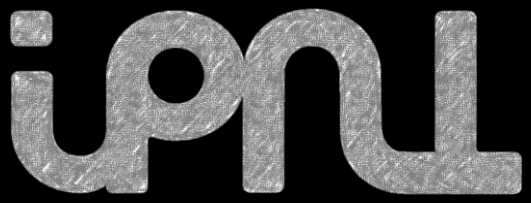
Status of Low Energy Data and Homogeneity Study for SDHCAL

Bing Liu, Garillot Guillaume, Imad Laktineh, Haijun Yang



12th workshop of FCPPL
Shanghai Jiao Tong University, April 24-27, 2019

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- PFA oriented calorimeter
- Technological prototype (SDHCAL)
- Semi-digital mode
- Energy reconstruction

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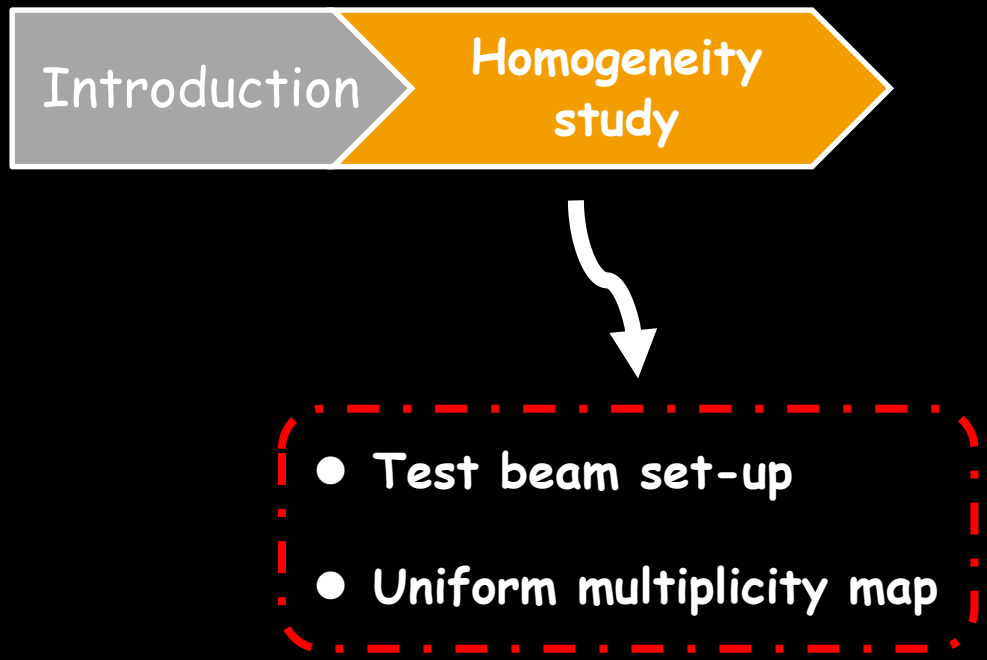
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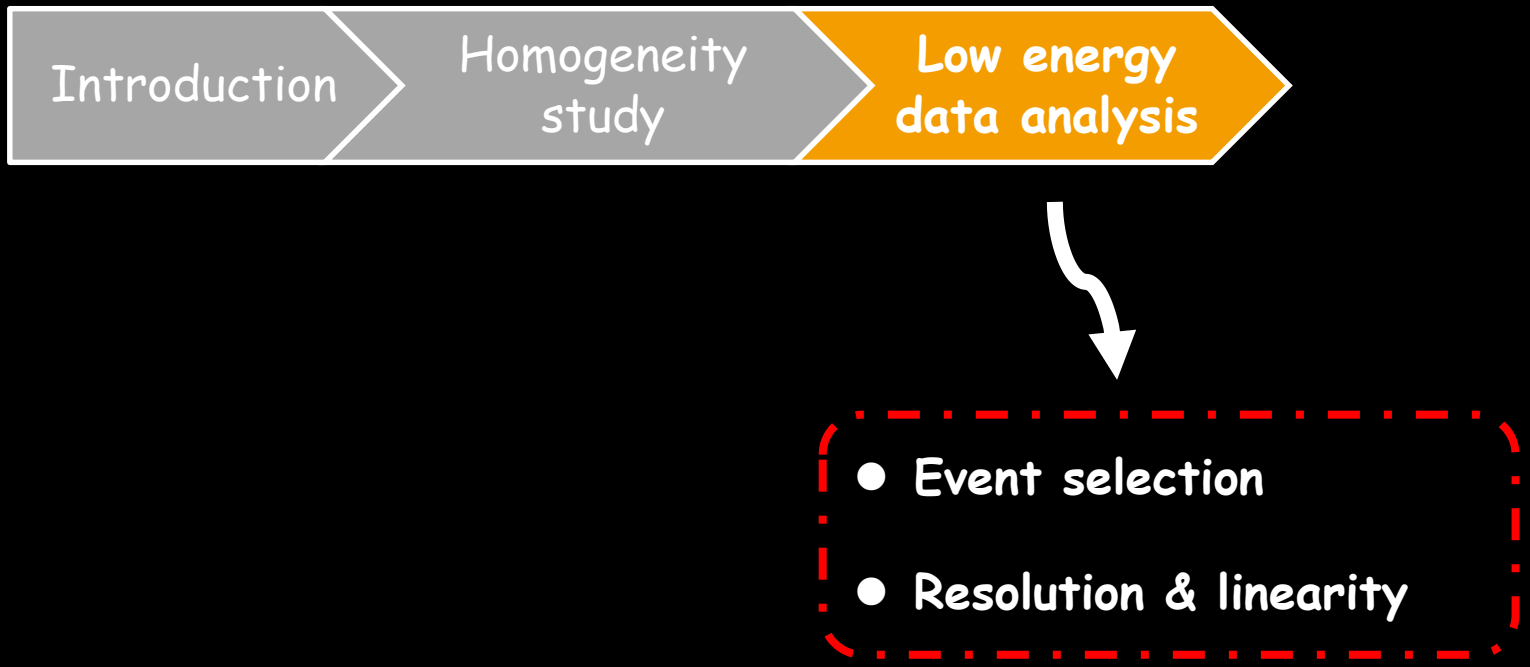
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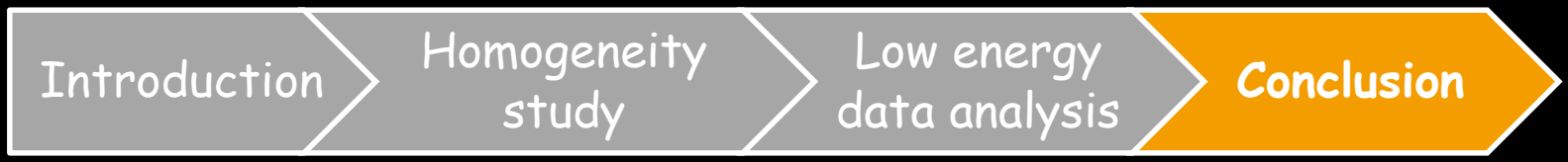
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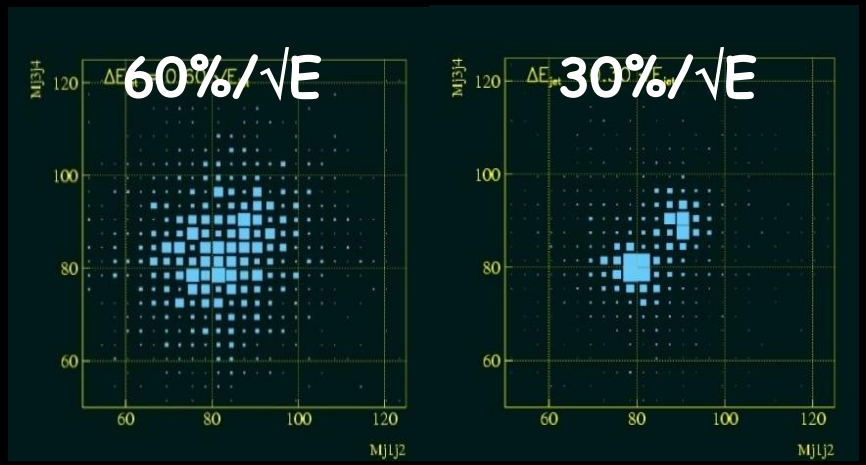
PFA oriented Calorimeter

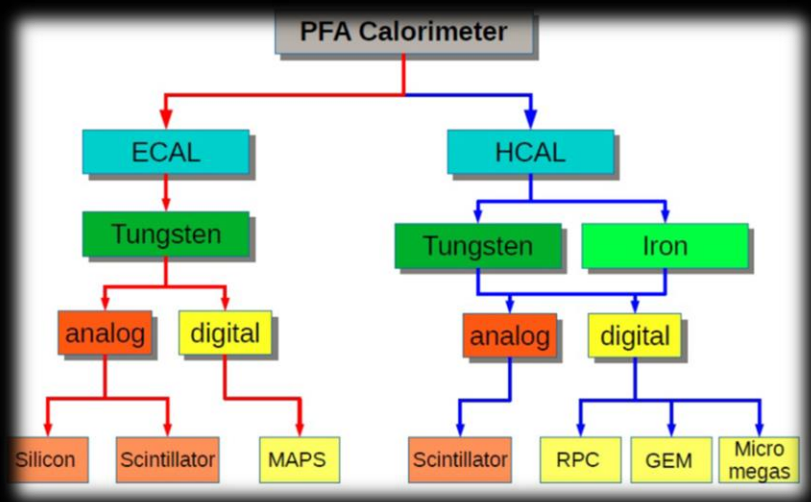
For future colliders, jet energy resolution will be a determinant factor of understanding high energy physics.



Simulation of W, Z reconstructed masses in hadronic mode.

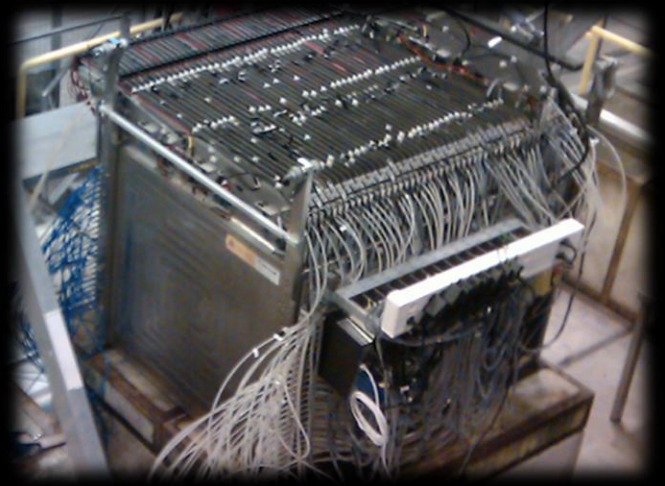
$$\sigma_{jet}^2 = \sigma_{charged}^2 + \sigma_{EM}^2 + \sigma_{hadronic}^2 + \sigma_{confusion}^2$$

high granularity Calorimeters



SDHCAL technological prototype(2011->)

48 layers of 2 cm stainless steel interleaved with planes made of Glass RPC and their embedded readout 2-bit electronics allowing a lateral segmentation of 1 cm^2



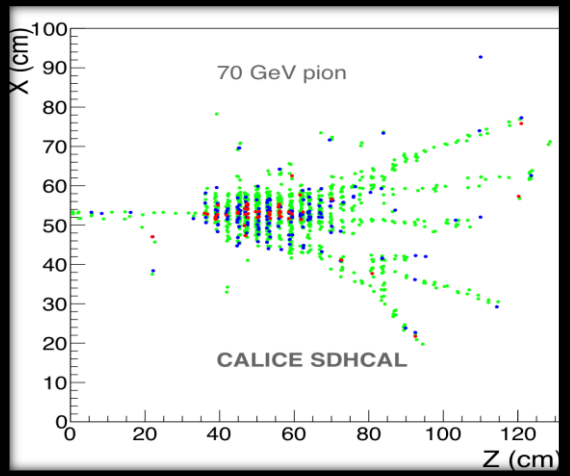
- Total Size:1.0x1.0x1.4m^3
- Pad size: 1cm X 1cm
- Total Channel(pads): ~440000

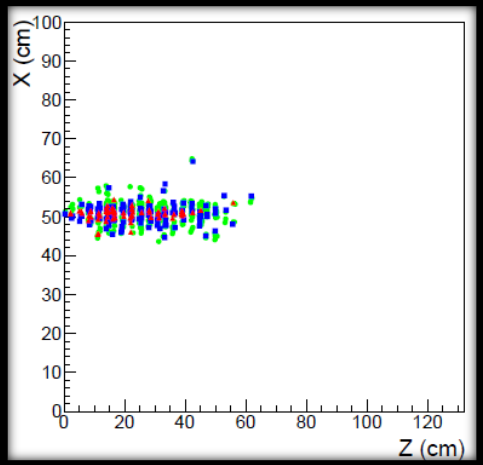
Semi-digital Mode

A simple binary readout leads to a very good energy resolution

High energy the shower core is very dense and saturation shows up

→ Multi-thresholds readout(Semi-digital) improves on energy resolution at energies> 30 GeV





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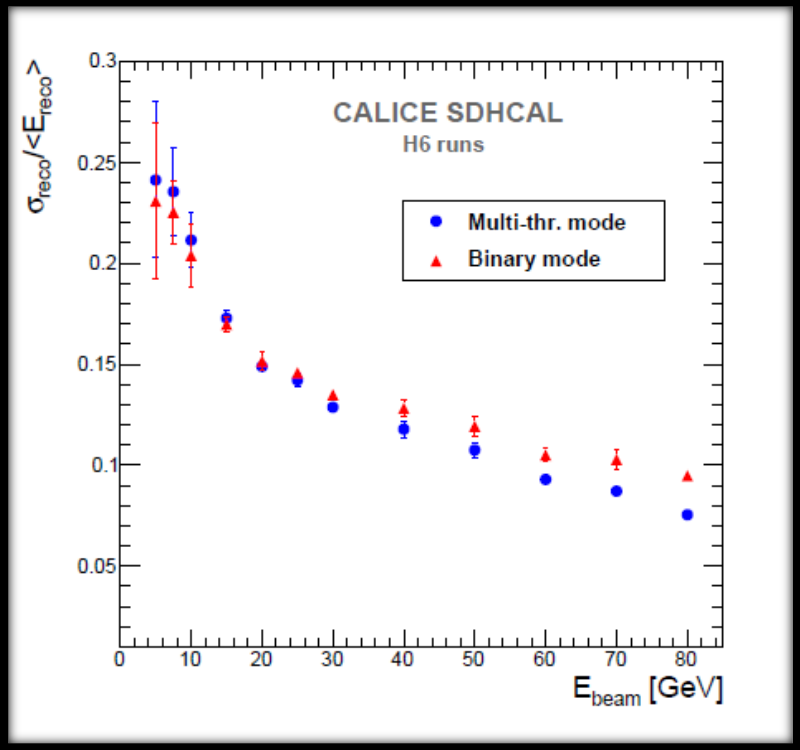

Semi-digital Mode

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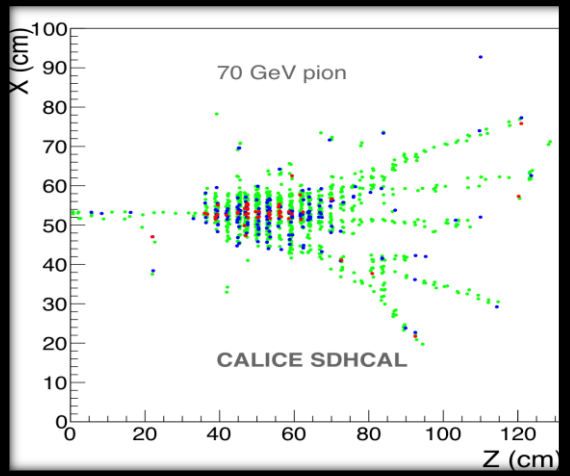
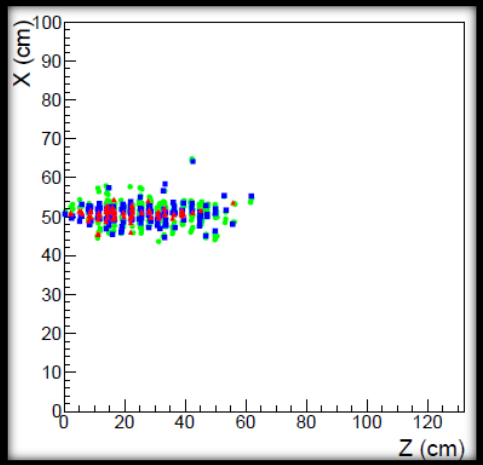




Energy reconstruction

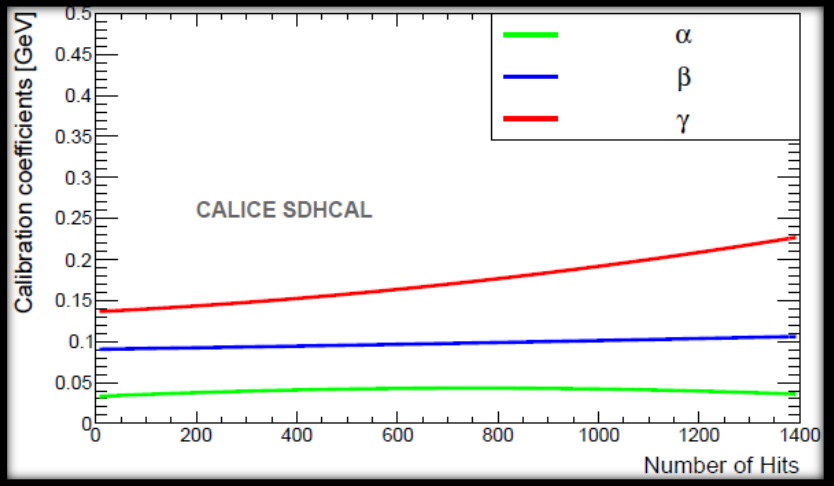
$$E_{reco} = \alpha N_1 + \beta N_2 + \gamma N_3$$

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

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

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

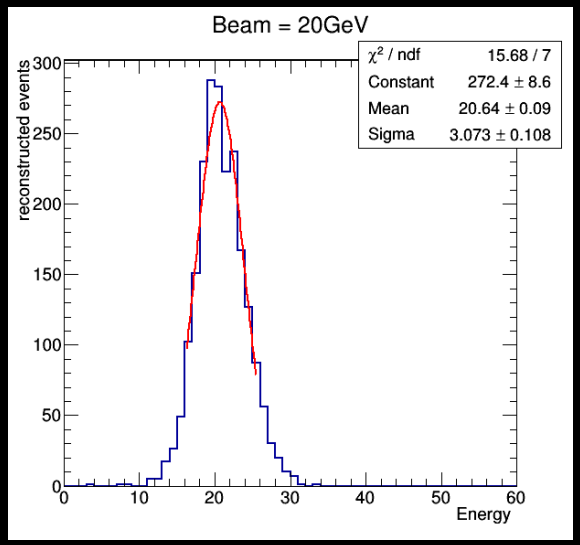
$$\gamma = \gamma_1 + \gamma_2 N_{total} + \gamma_3 N_{total}^2$$

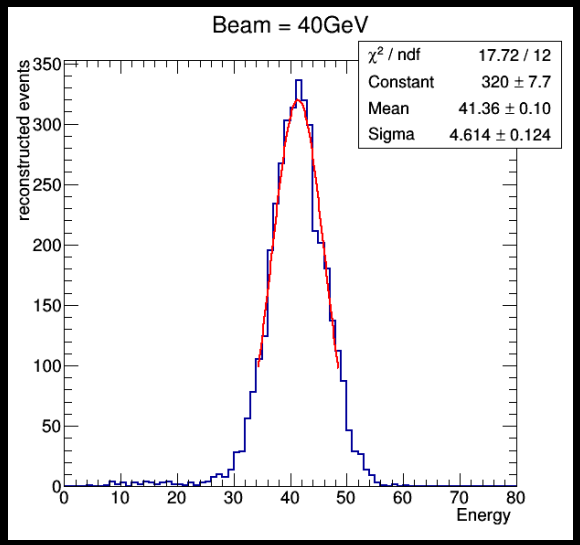


optimizer

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

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





Test beam setup: Standard & Uniform

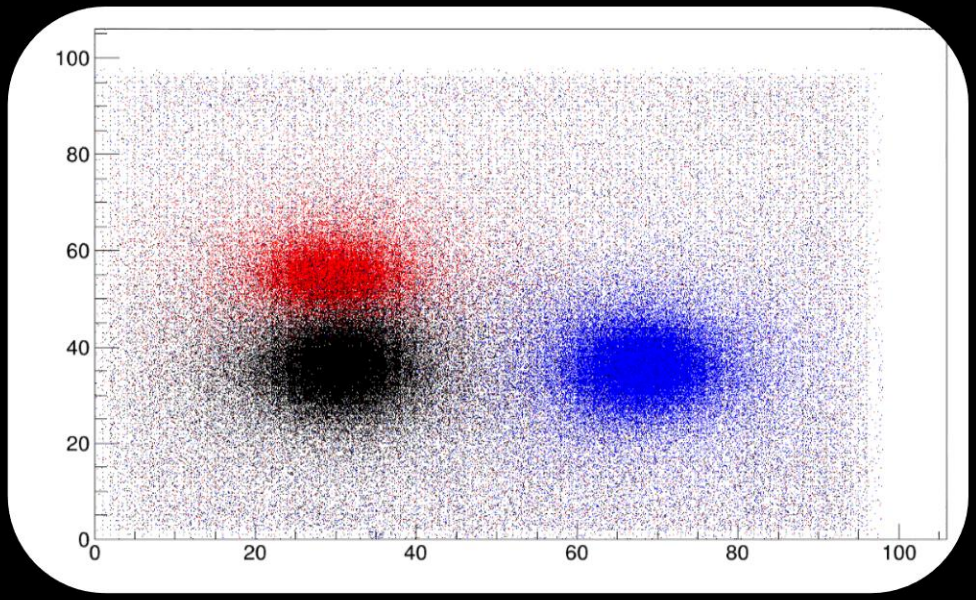
2017: 48 layers prototype

2018: 37 layers prototype plus SiW-Ecal

Standard: The all chips use the **same** three threshold

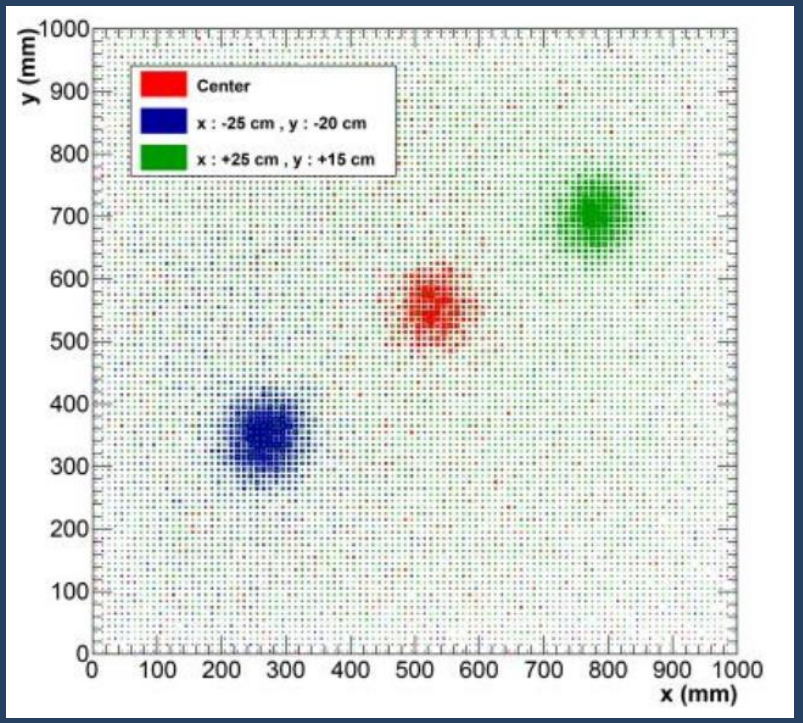
Uniform: In order to obtain more uniform performance of our prototype, use **different** threshold for each chips

Beam position



2018:

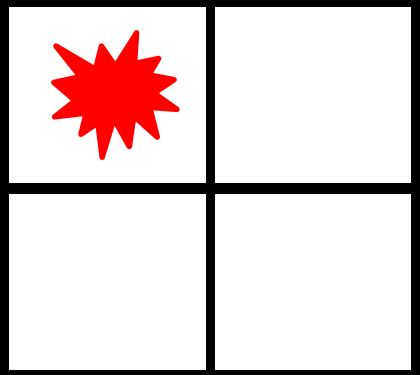
50GeV, two position
70GeV, three position



2017:

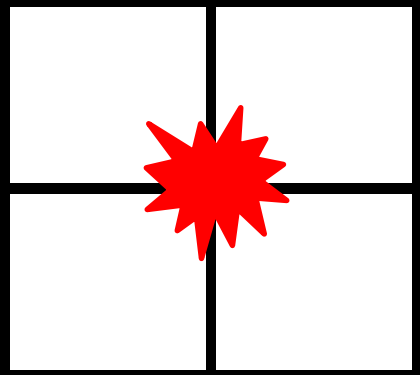
40GeV, two position
80GeV, three position

What is multiplicity



A

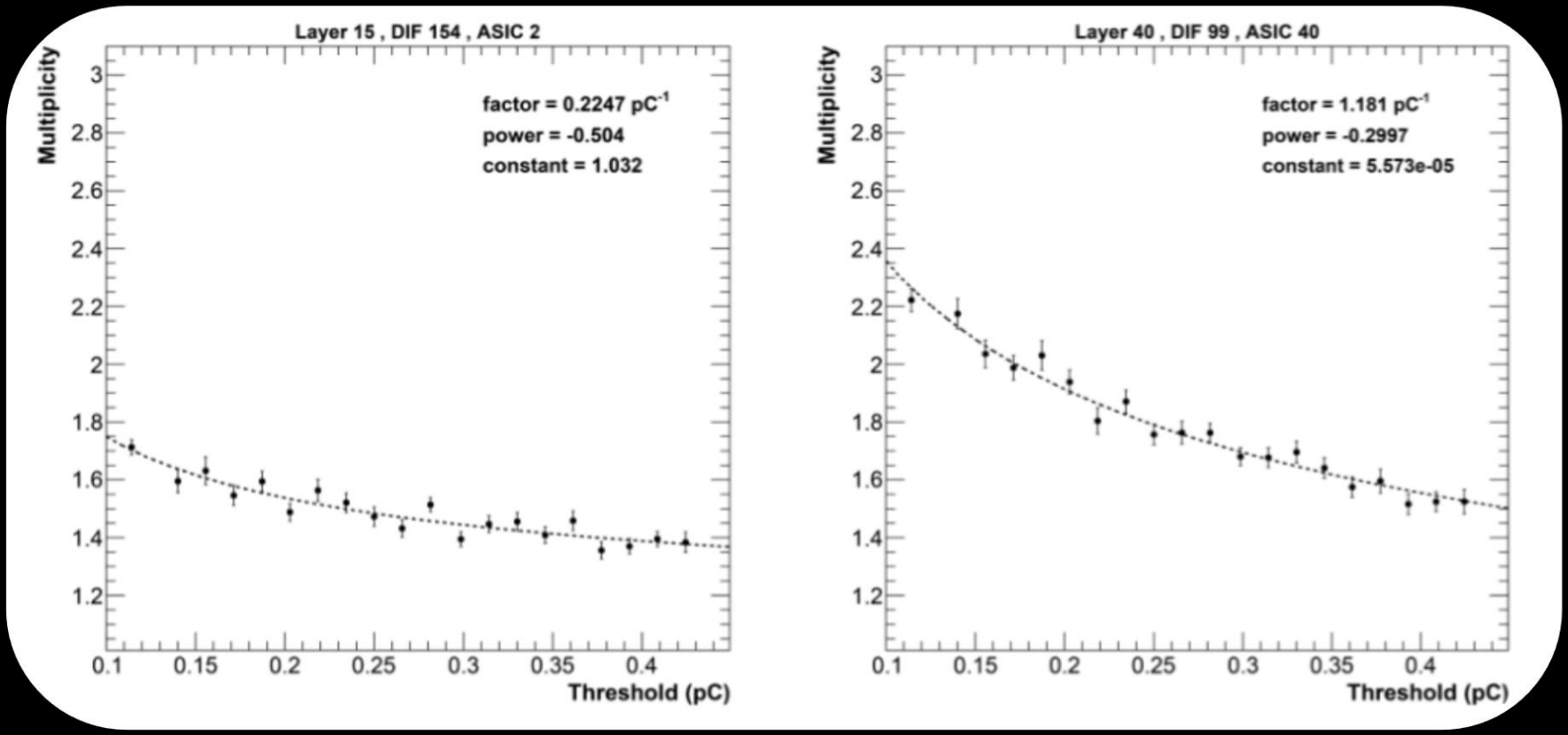
Multiplicity = 1



B

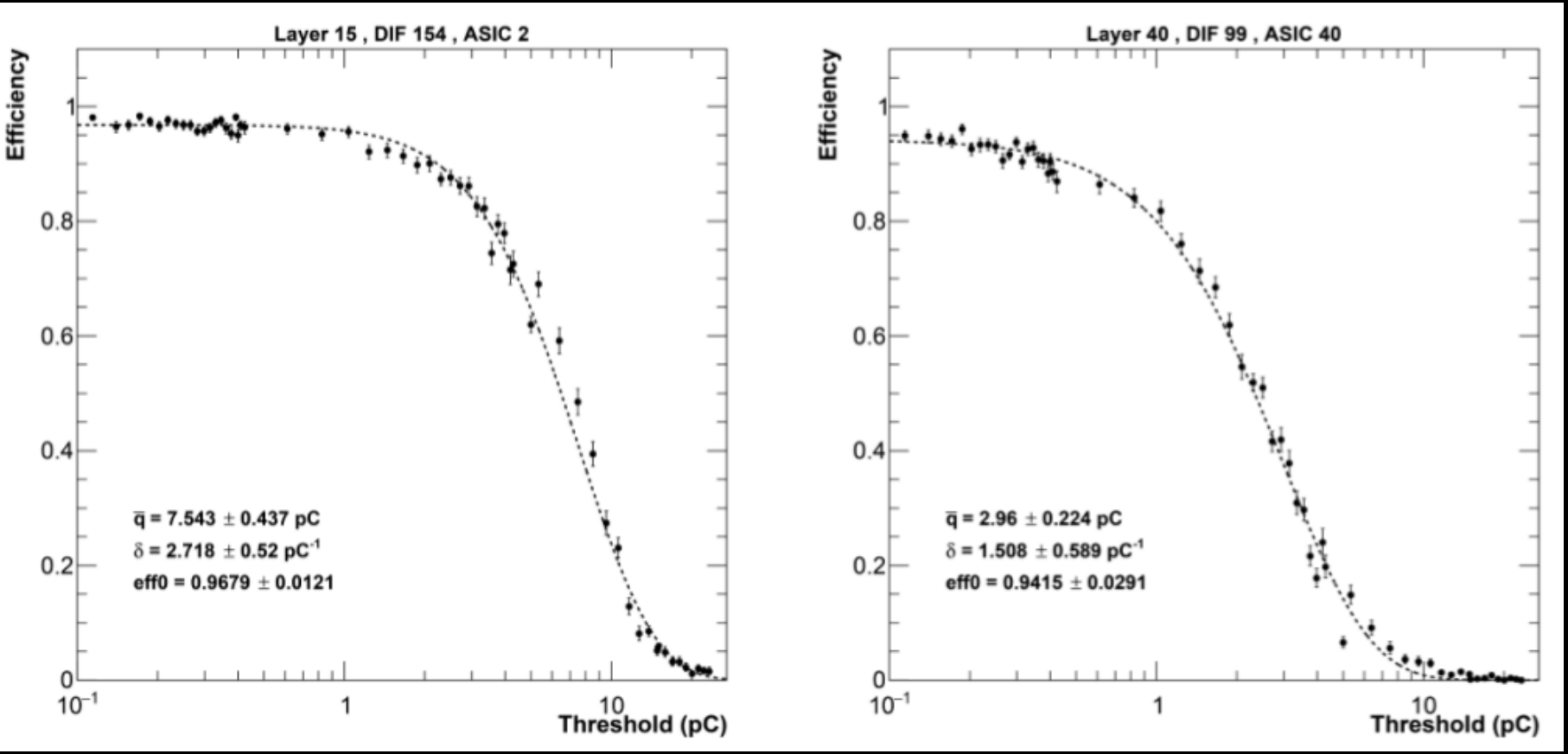
Multiplicity = 4

Multiplicity: How to play……



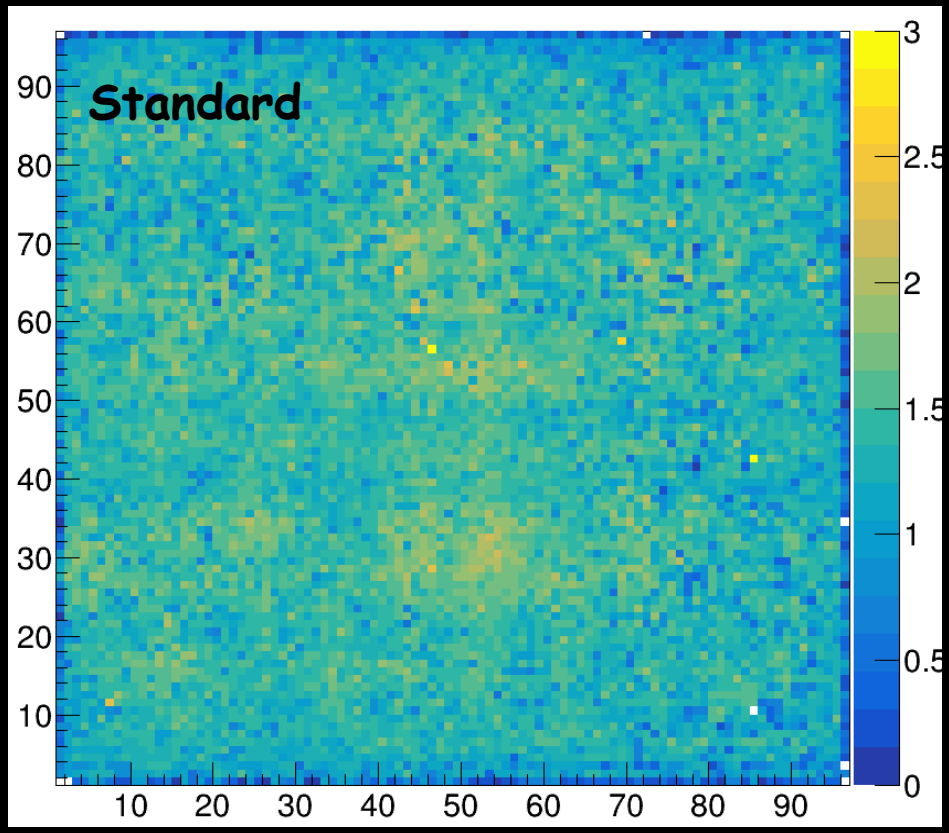
Basically, exposing the SDHCAL to the enough muon beams, get this curve by changing threshold step by step

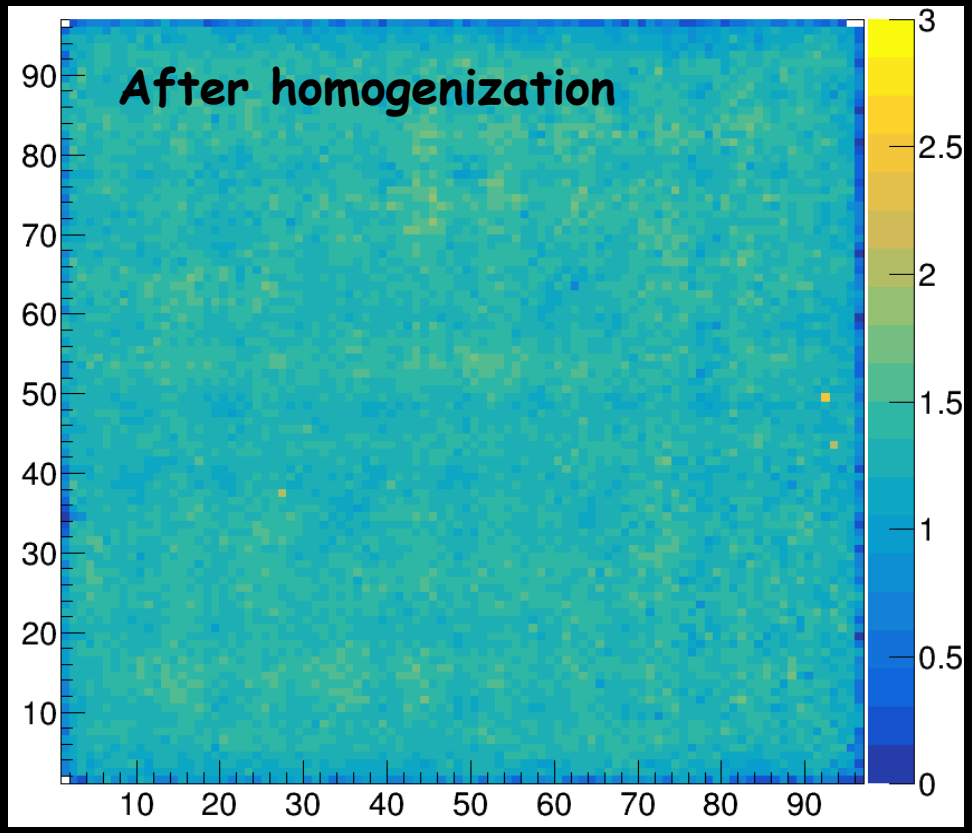
Efficiency: How to play……



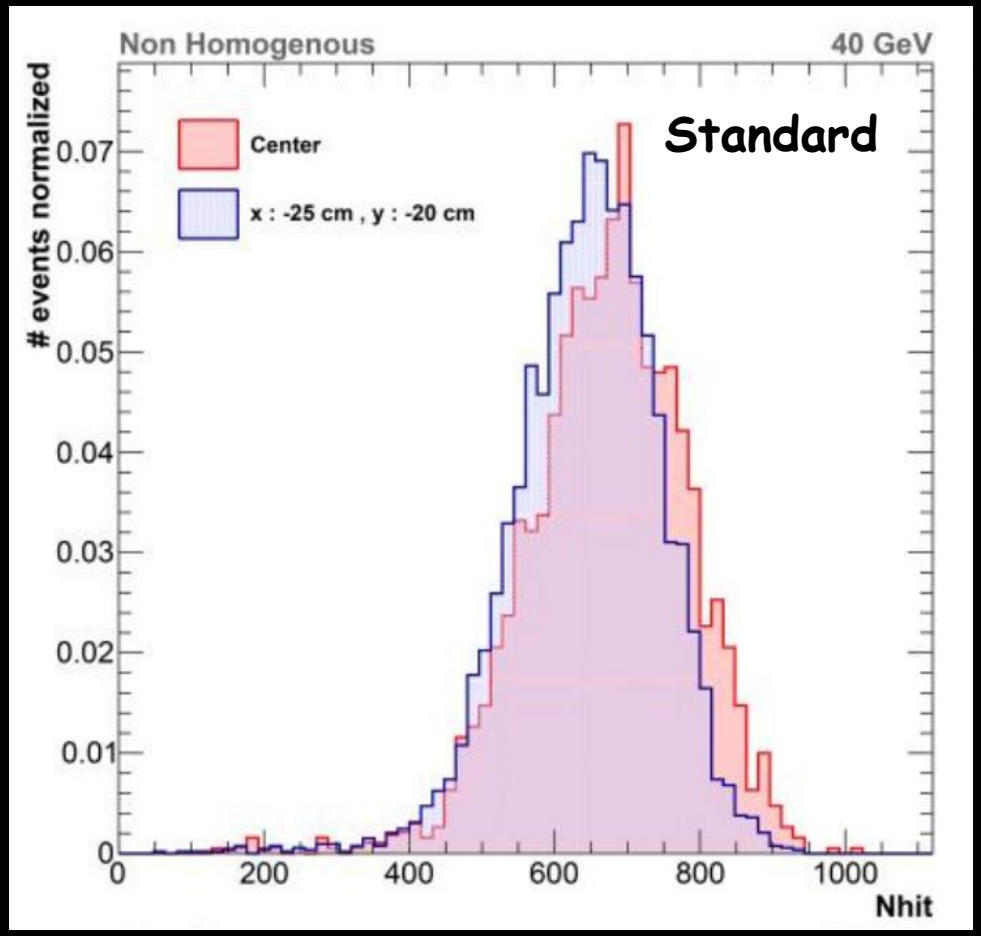
Efficiency is not sensitive to certain area of threshold

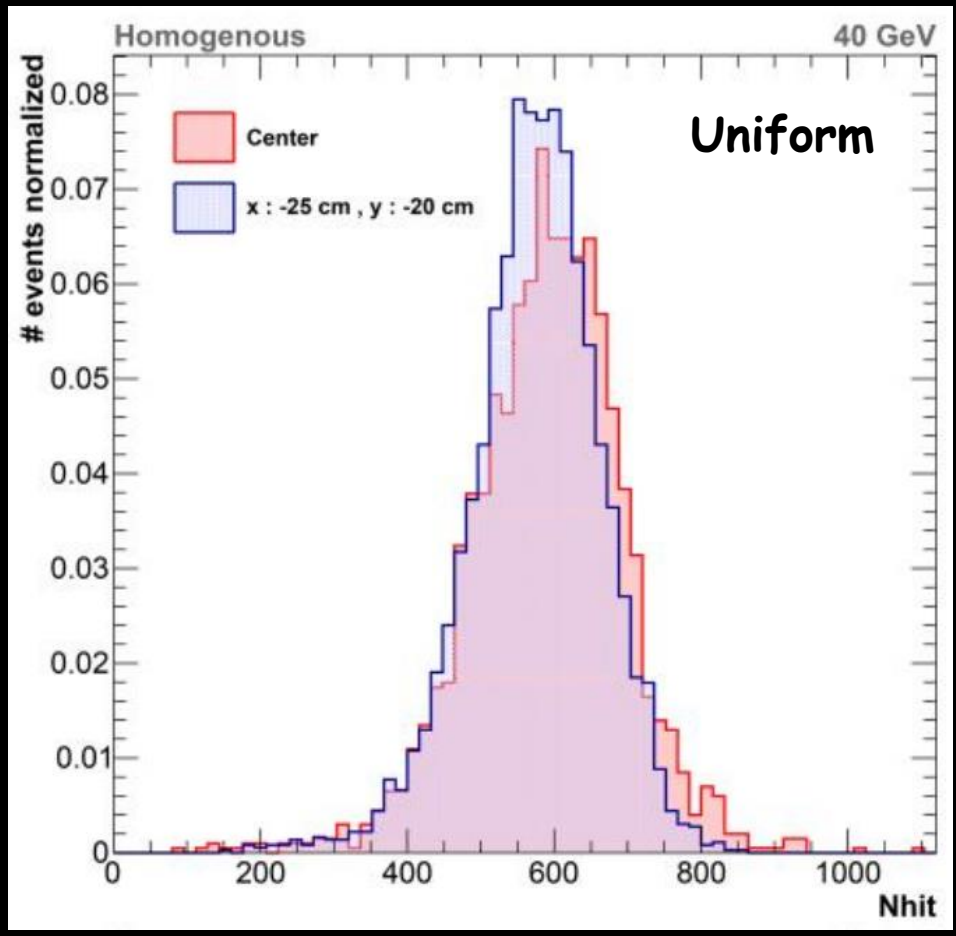
Multiplicity : Standard & After homogenization



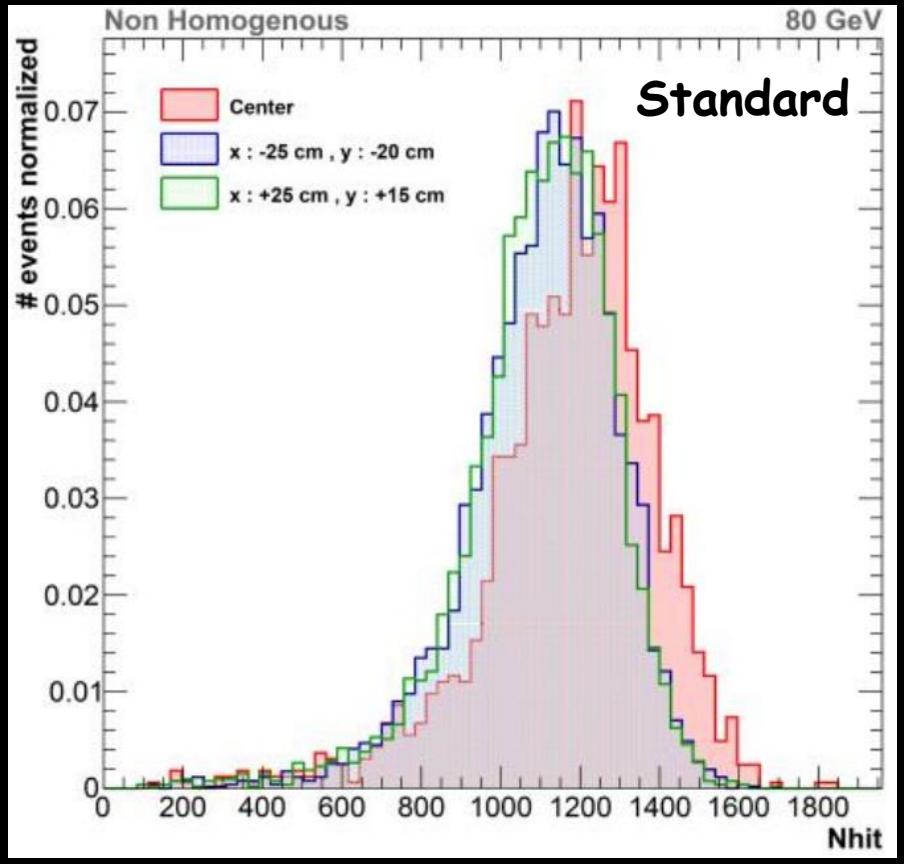


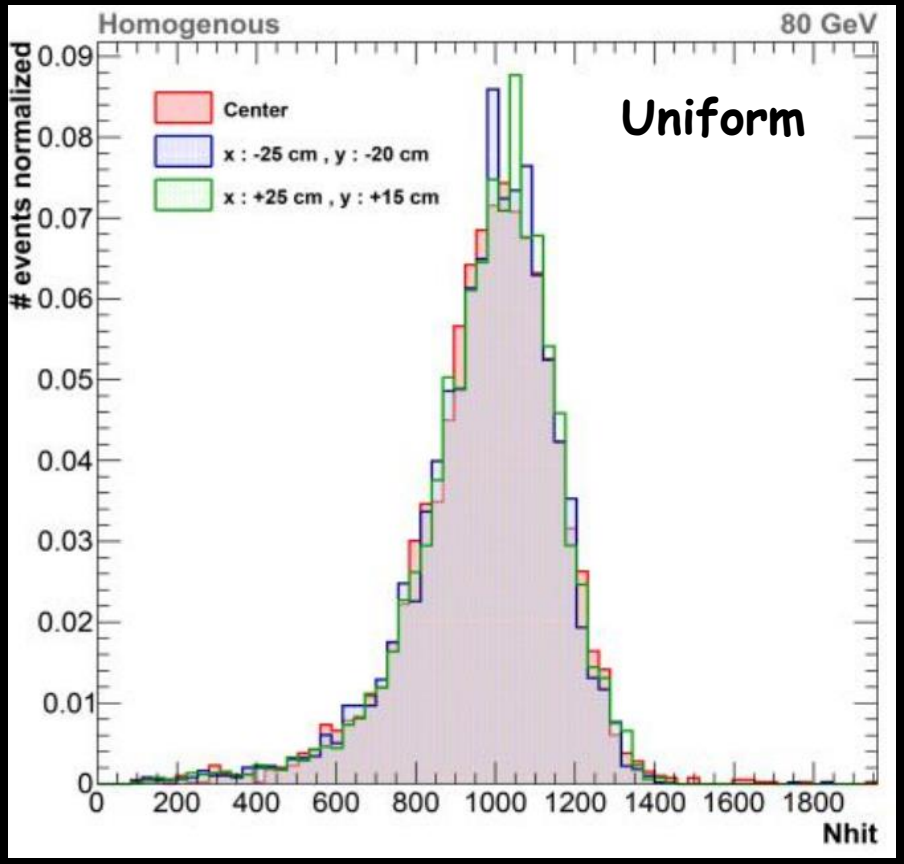
2017 results: 40GeV



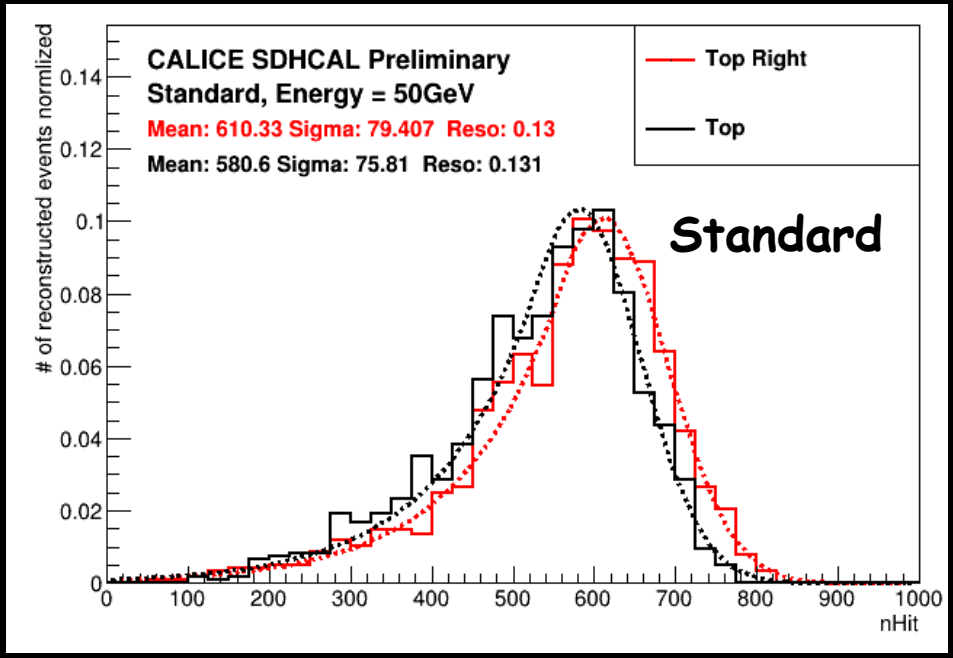


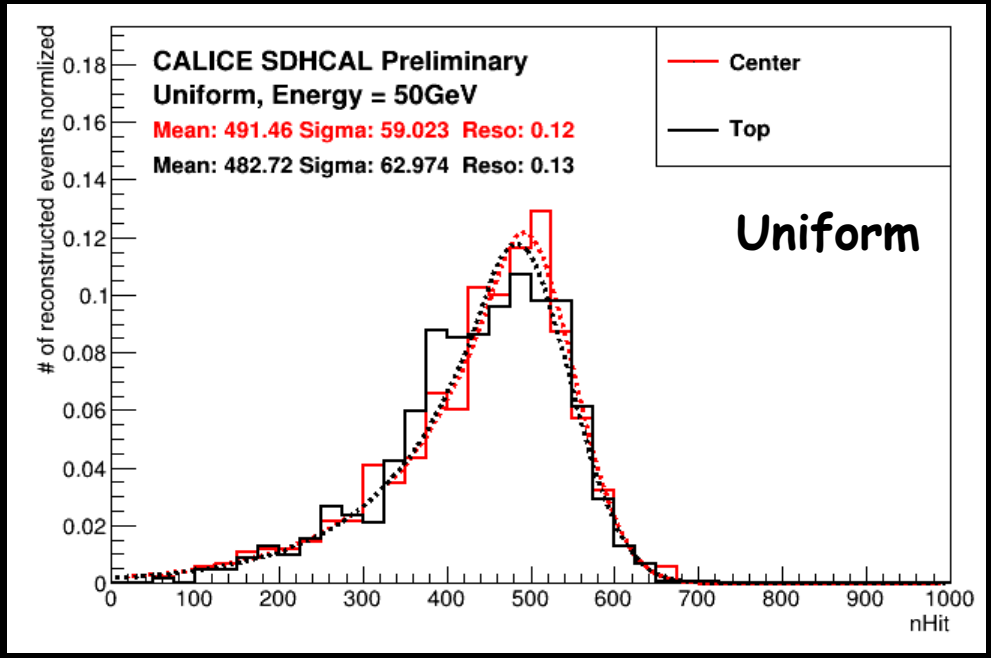
2017 results: 80GeV



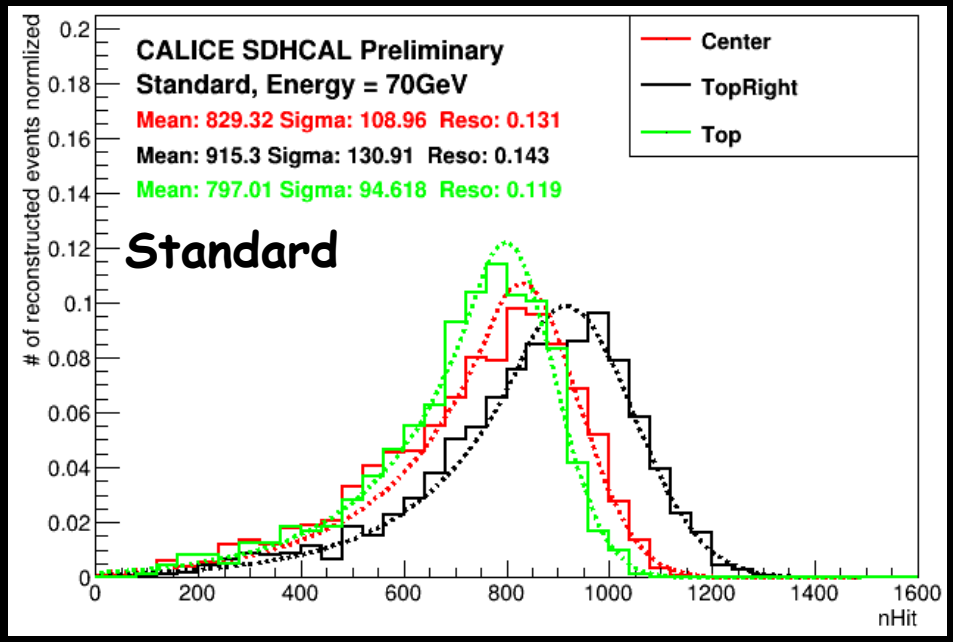


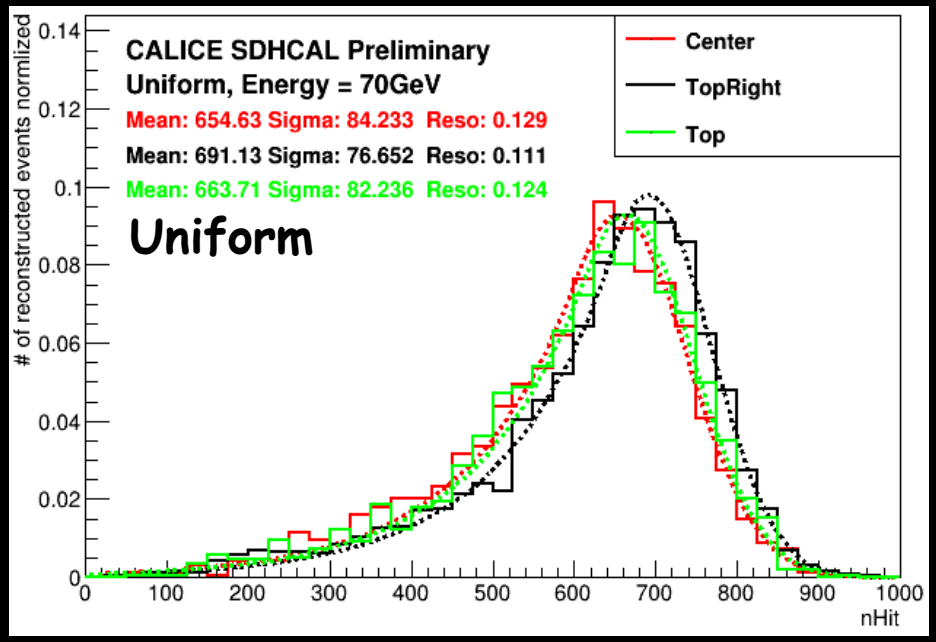
2018 results: 50GeV





2018 results: 70GeV





Relative Deviation to center position

Relative deviation = ΔNhit / Nhit

Nhit: the number of hits for beam position located in center

Δnhit: the difference between other position and centered position

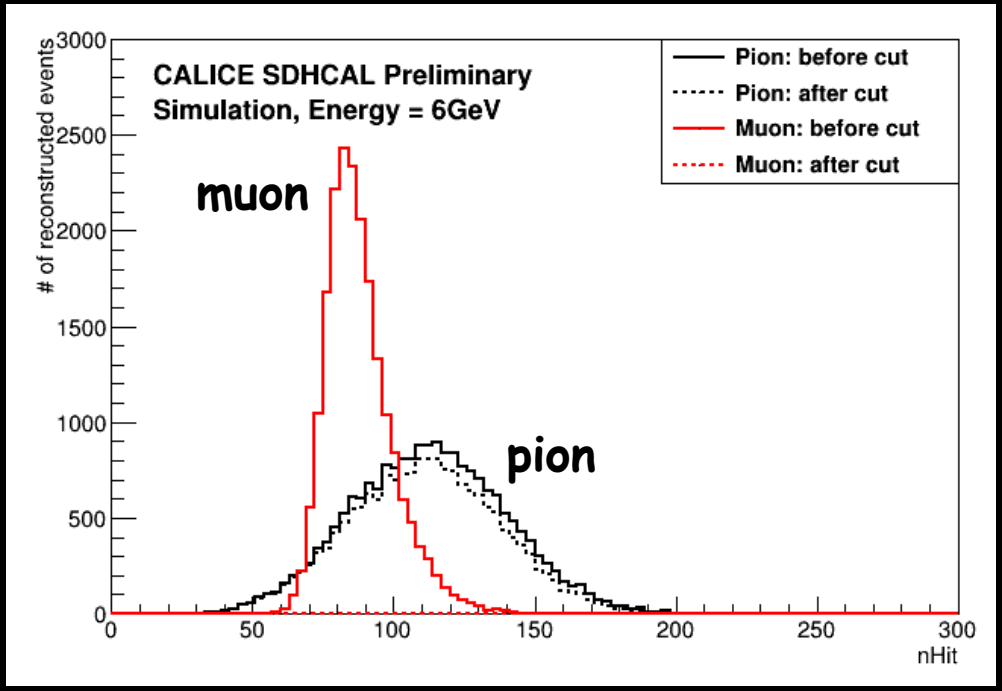
Year	Energy (GeV)	Standard		Uniform	
		Pos 1	Pos 2	Pos 1	Pos 2
2017	40	-4.2%		-2.8%	
	80	-6.0%	-6.6%	-0.5%	-0.1%
2018	50	5.2%		1.9%	
	70	10.0%	-3.9%	5.6%	1.4%

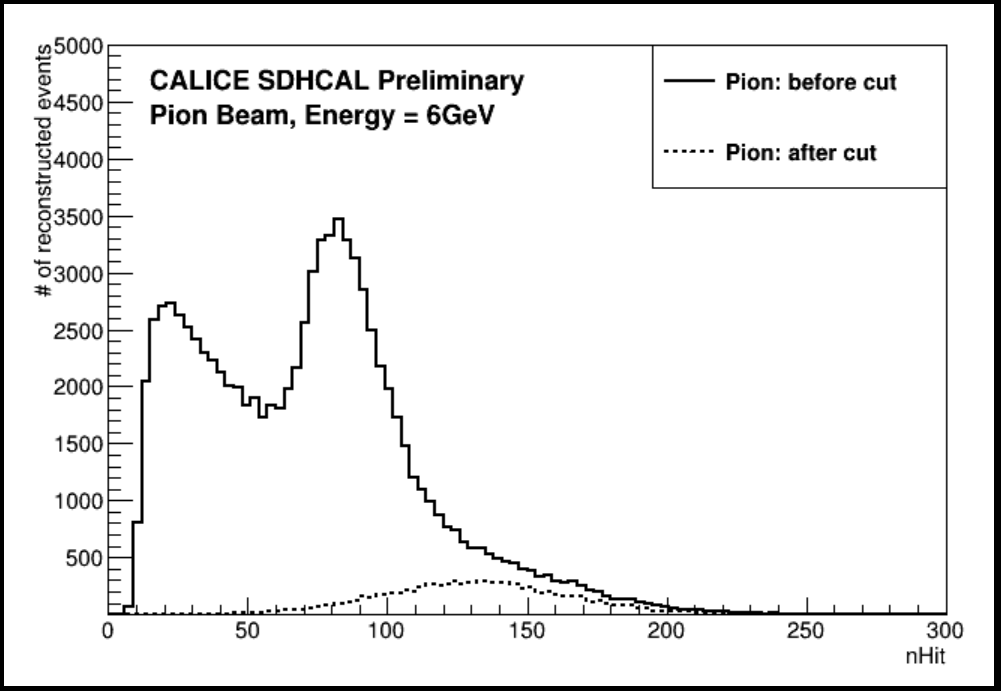
Beam status

Data samples were taken at PS, May 2015

- Energy(GeV) : 3, 4, 5, 6, 7, 8, 9, 10, 11
- Contamination : muons , (since using electron eliminator in test beam period(above 6GeV), the electron contamination is negligible. For energy lower than 6GeV, the electron contamination is also negligible by using BDT to check.)
- Simulation: FTF_BIC , geant4.9.6

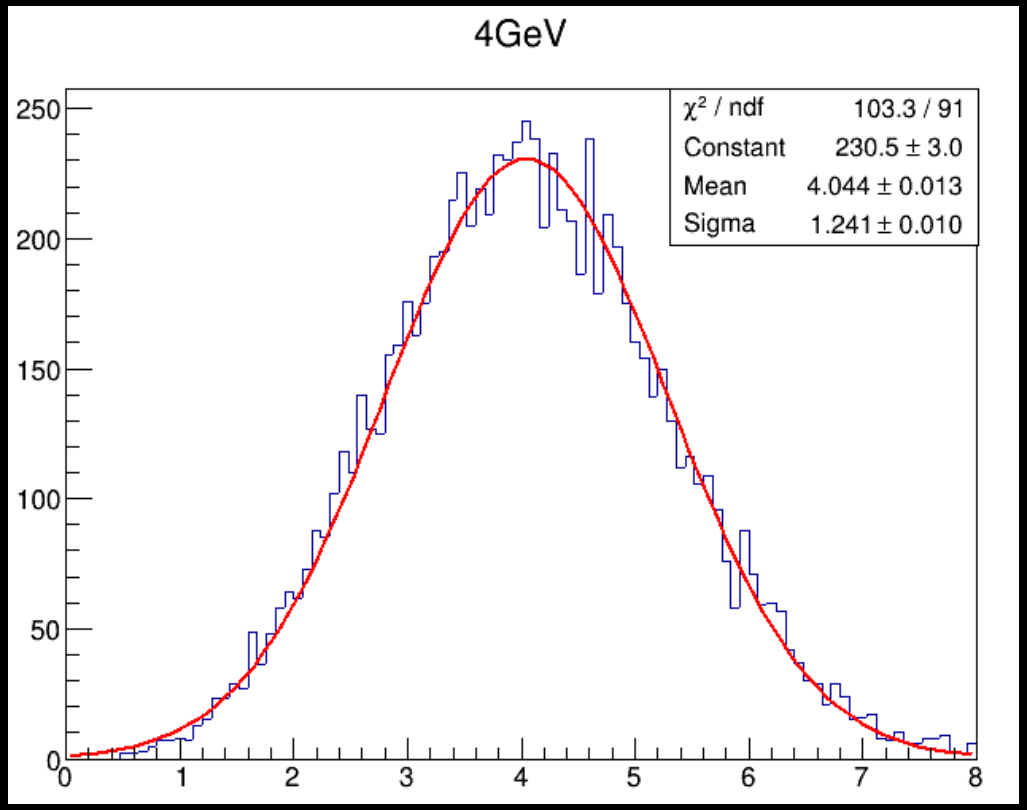
Event selection

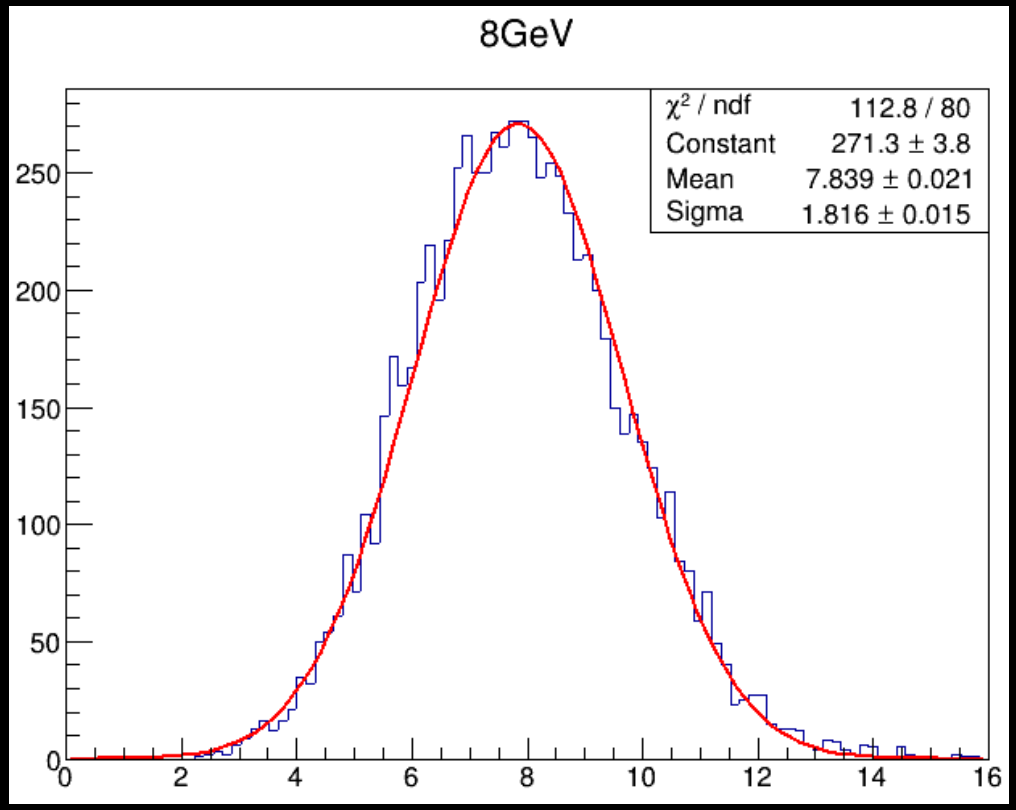




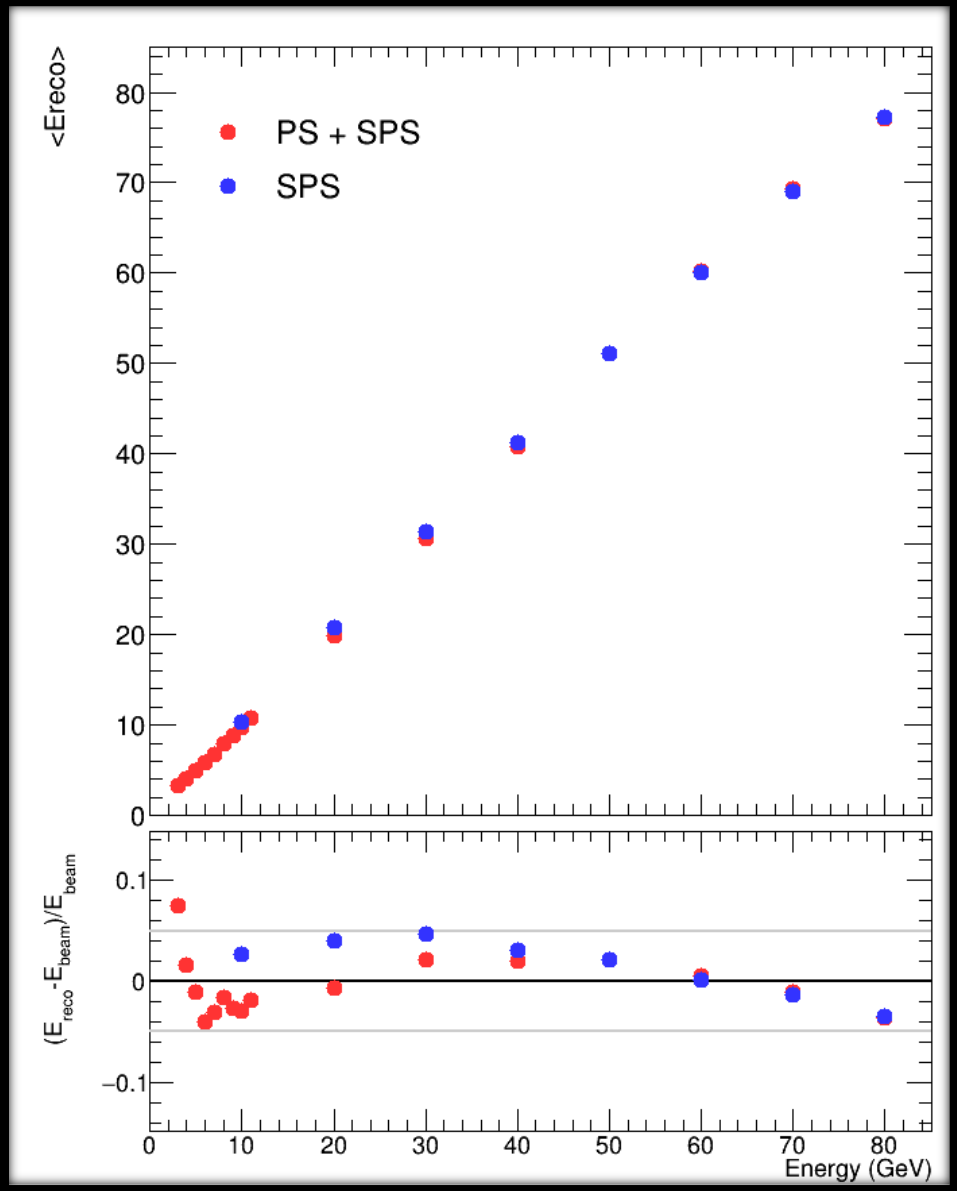
Energy reconstruction

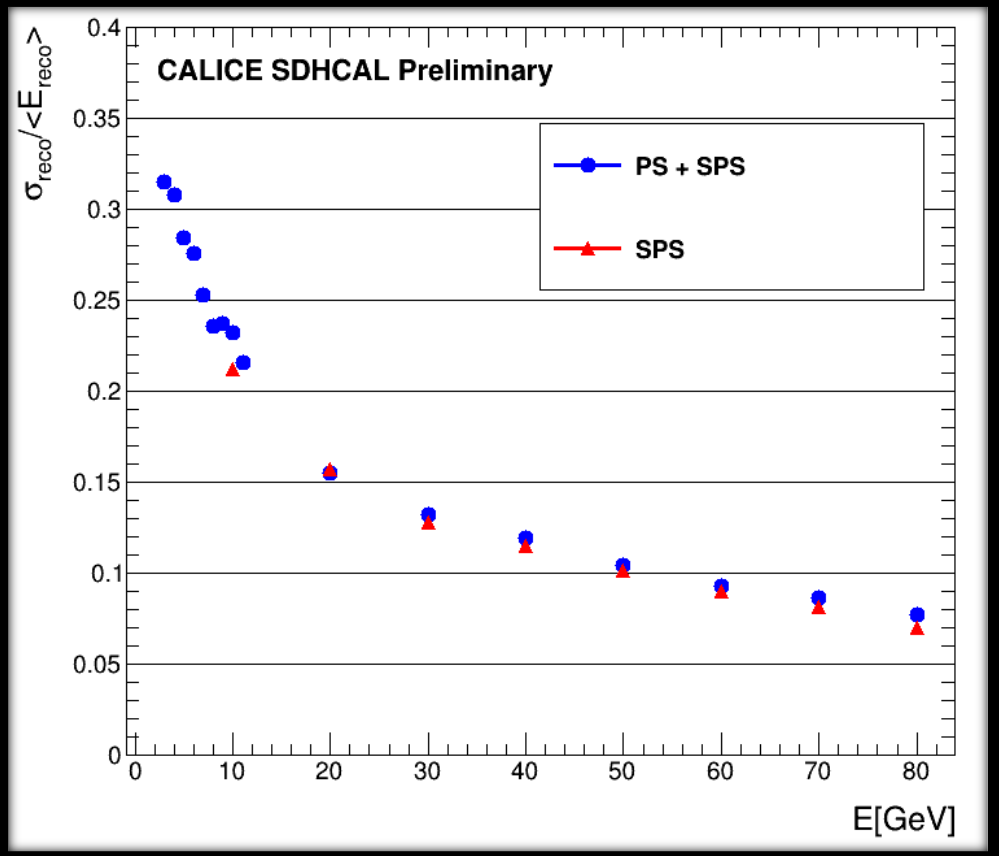
$$E_{reco} = \alpha N_1 + \beta N_2 + \gamma N_3$$





Energy resolution & linearity





SJTU-IPNL collaboration

Collaboration between the two groups have started in 2015.

I spent 3 months working on SDHCAL data analyse at IPNL in 2016. Then, I obtained a PhD grant of Chinese Scholarship Council(CSC) and started my joint PhD studies in September 2017 at IPNL.

A graduated PhD from the IPNL group obtained postdoc in SJTU.

Activities

RPC fabrication and test started at 2017

A work on the hadronic calorimeters section of the CEPC CDR by the two groups was finalized in 2018.

A work for the CEPC active-cooling system started at begin of 2019.

A work for the energy reconstruction & Particle identification using machine learning was finalized at start of 2019.

Conclusions

- After apply homogenization process, the perfomance of SDHCAL is improved
- The results of low energy beam data keep agreement with 20-80GeV SPS data.
- Excellent collaboration between the SJTU and IPNL teams.

Thanks for your attention !