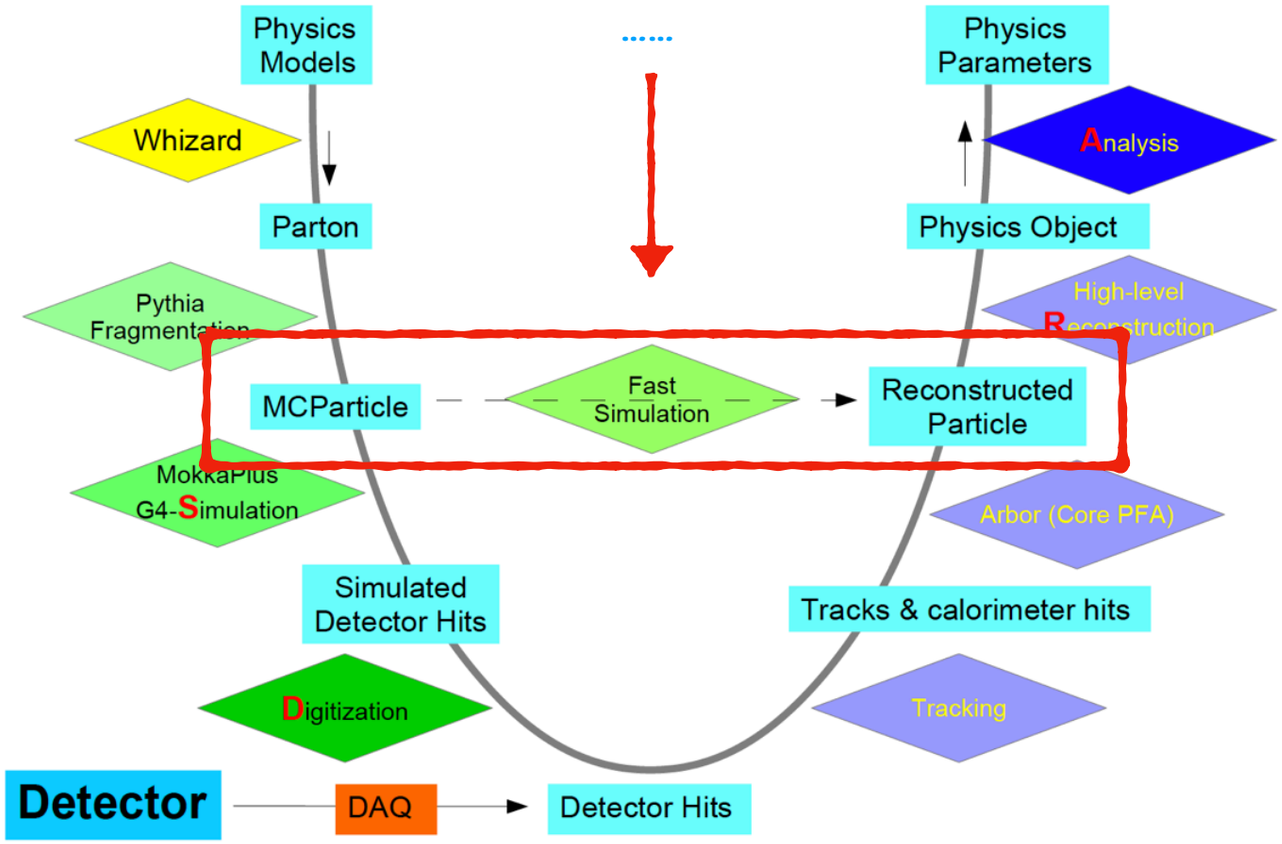
A PFA Fast Simulation Tool

Why need a Fast Simulation?

Fast Simulation

Smear according to
- Detection resolution
- Detection efficiency
- .....

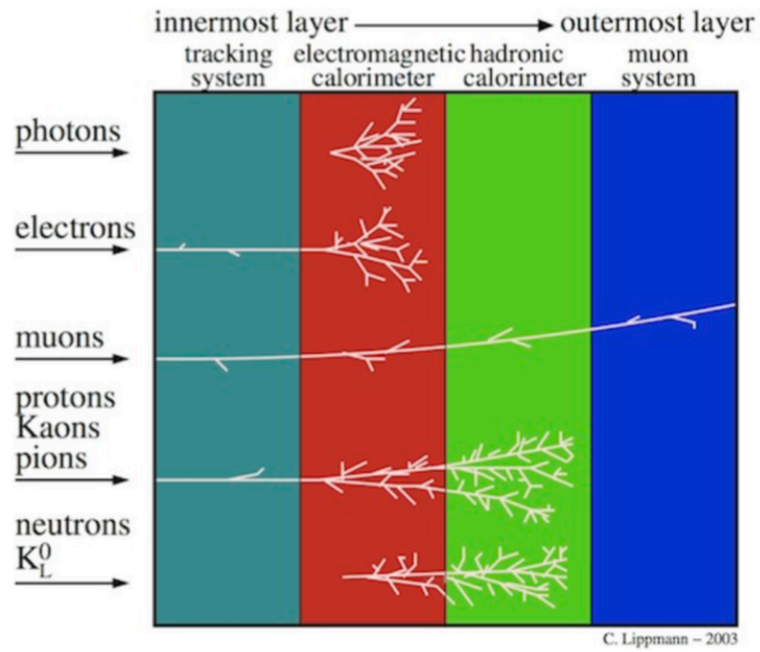


Particle Flow Algorithm (PFA)

Measure different particles in optimal sub-detector!

$$E_{jet} = E_{charged} + E_{\gamma} + E_{h^0}$$

65% 25% 10%



Charged particles - Tracker ~ 0.1%

Photons - ECAL ~ 15%

Neutral hadrons - HCAL ~ 50%

Validation with full simulation

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https://iopscience.iop.org/article/10.1088/1674-1137/43/2/023001/pdf

The Higgs signatures at the CEPC CDR baseline*

Hang Zhao(赵航)[1,2,3] Yong-Feng Zhu(朱永峰)[1,4] Cheng-Dong Fu(傅成栋)[1]
Dan Yu(于丹)[1] Man-Qi Ruan(阮曼奇)[1,2;1)]

[1]Institute of High Energy Physics, Chinese Academy of Sciences, Beijing 100049, China
[2]CAS Center for Excellence in Particle Physics, Beijing 100049, China
[3]Collaborative Innovation Center for Particles and Interactions, Hefei 230026, China
[4]University of Chinese Academy of Sciences, Beijing 100049, China

Sample

vvH, H→gg with event cleaning

Table 1. Event cumulative efficiency for Higgs boson exclusive decay at the CEPC with $\sqrt{s} = 240$ GeV.

	gg(%)	*bb*(%)	*cc*(%)	*WW**(%)	*ZZ** (%)
Pt_ISR < 1 GeV	95.15	95.37	95.30	95.16	95.24
Pt_neutrino < 1 GeV	89.33	39.04	66.36	37.46	41.39
|Cos(Theta_Jet)| < 0.85	67.30	28.65	49.31	–	–

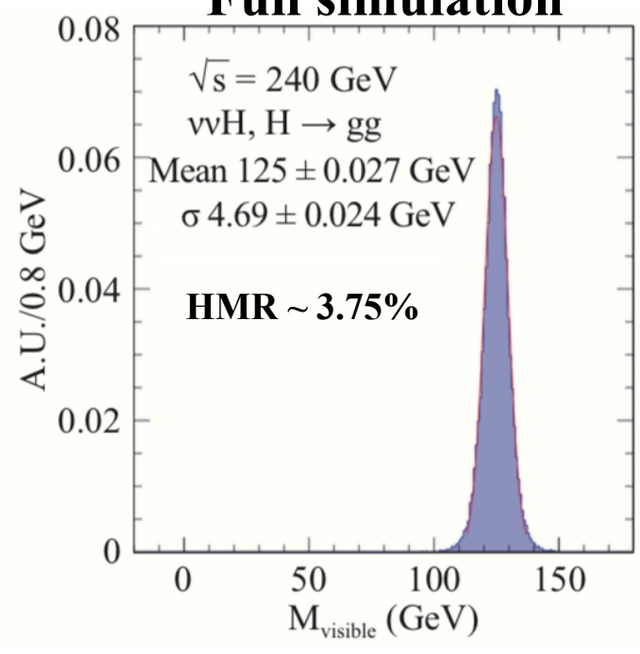
Quantification of Higgs Mass Resolution (HMR)

RMS/Mean instead of fitting

HMR is composed of

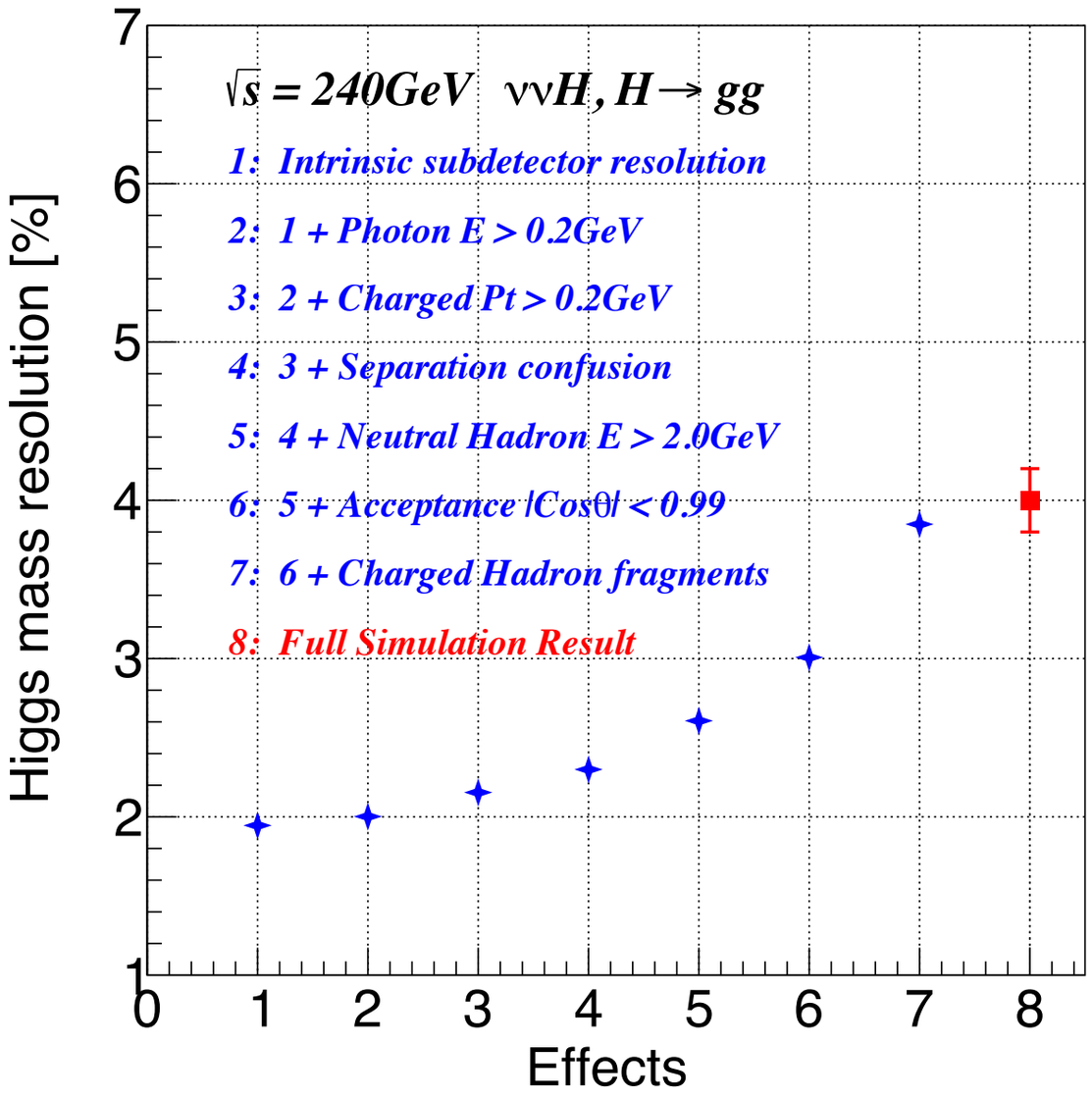
Sub-detector resolution
Reconstruction efficiency, threshold of E (P_t)
Acceptance
Fragmentation of charged hadron, HMR ~ 3.75%
Separation confusion, HMR ~ 3.83%

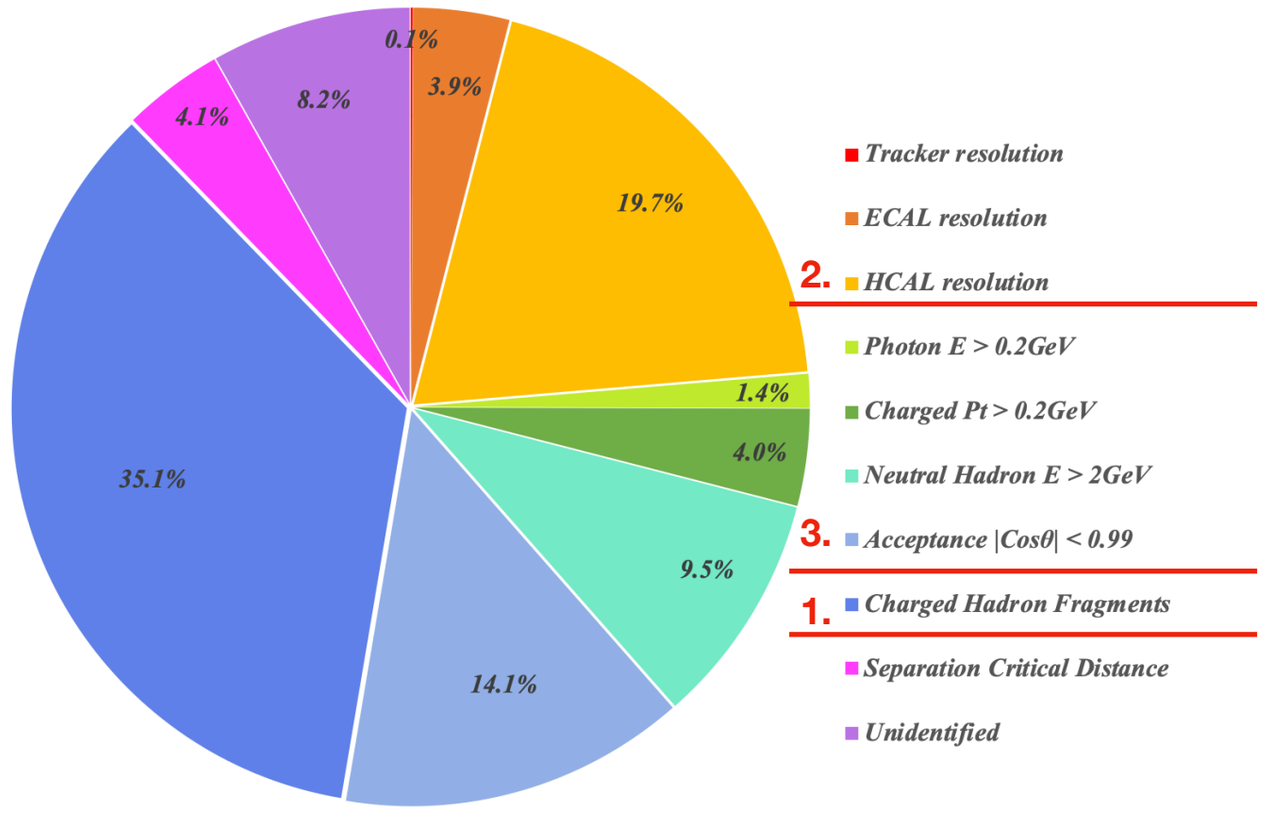
Full simulation



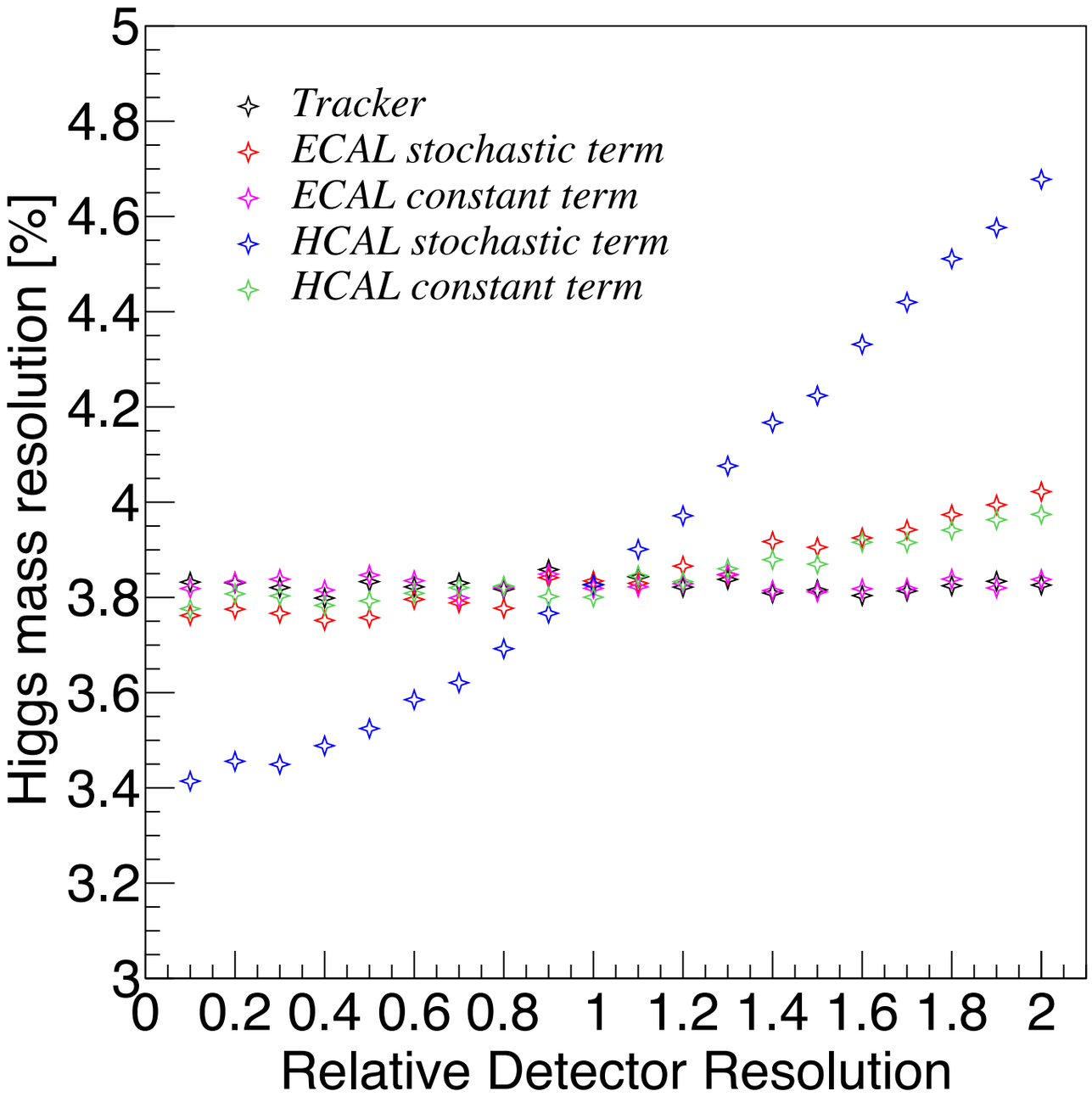
RMS = 5.283GeV
Mean = 125GeV
RMS/Mean ~ 4.23%

Contribution of each effect to HMR



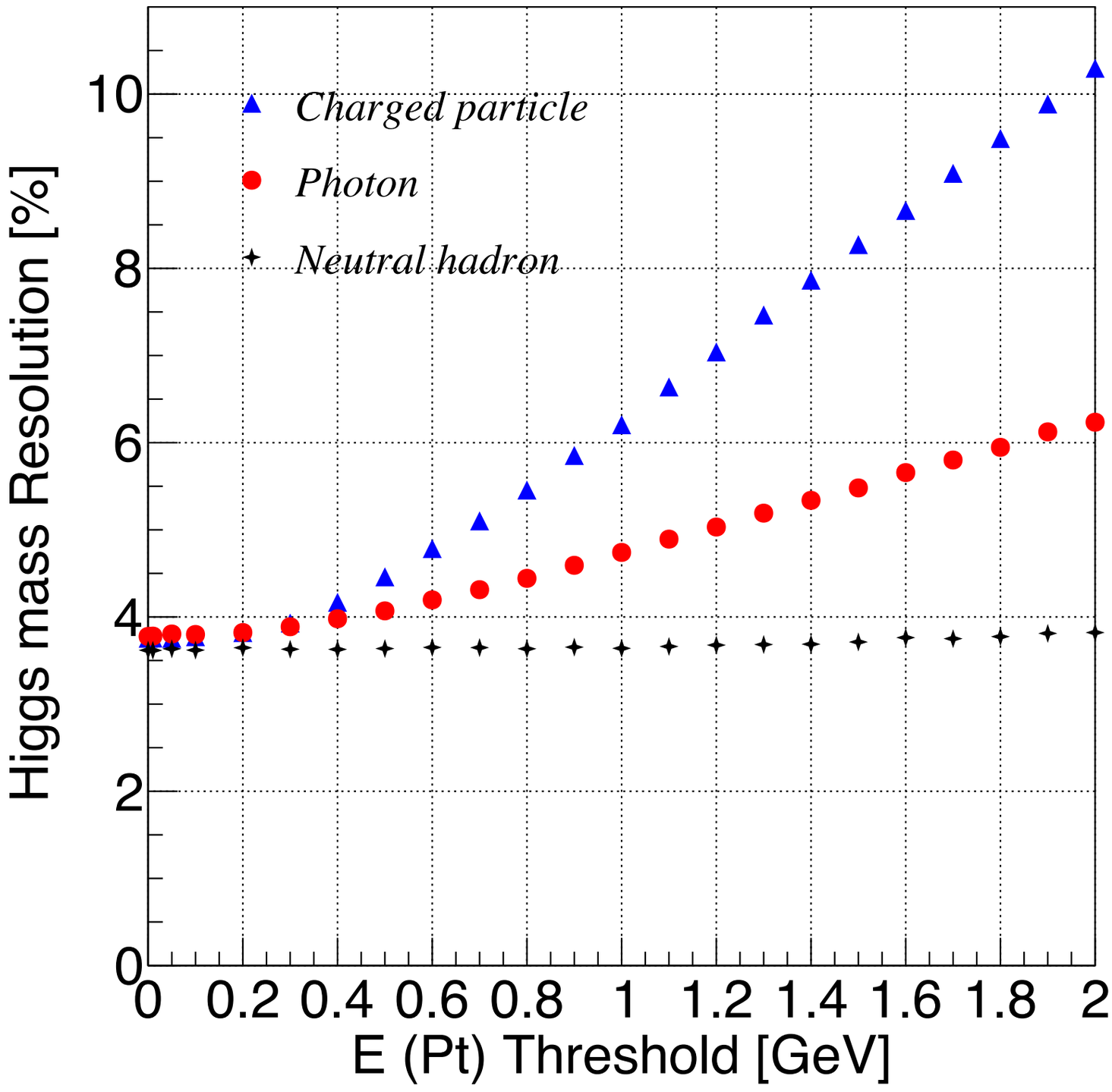


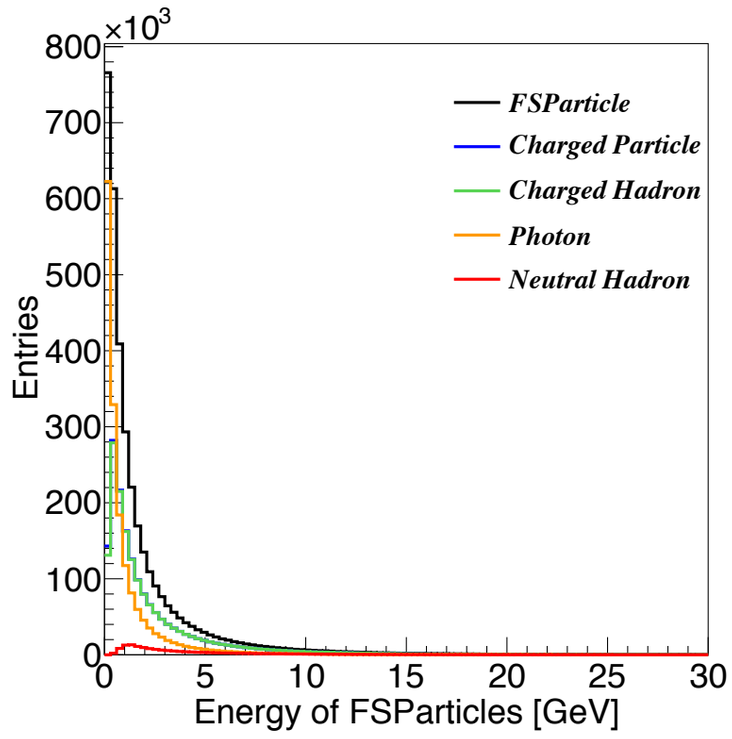
Sub-detector Resolution

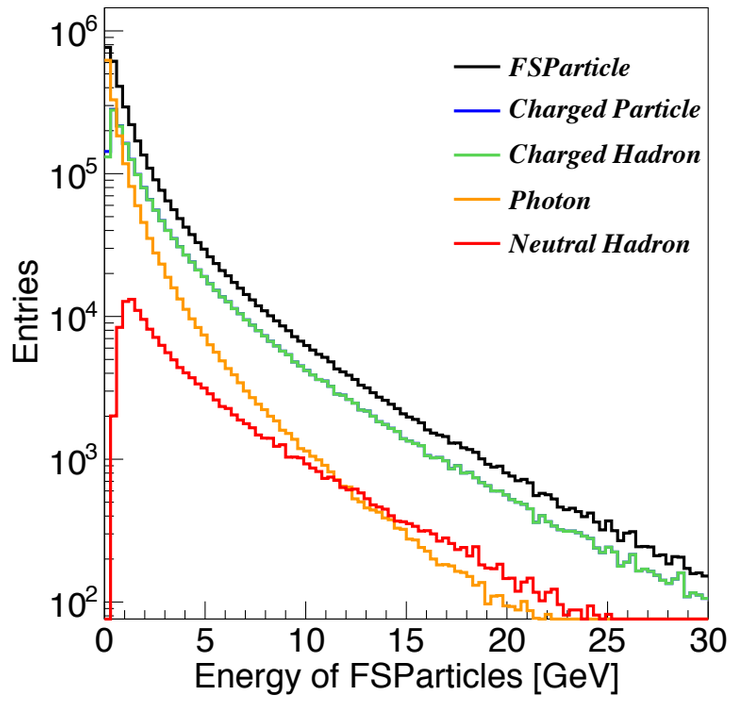


HCAL stochastic term > ECAL stochastic term > HCAL constant term > ECAL constant term ~ Tracker resolution

Threshold

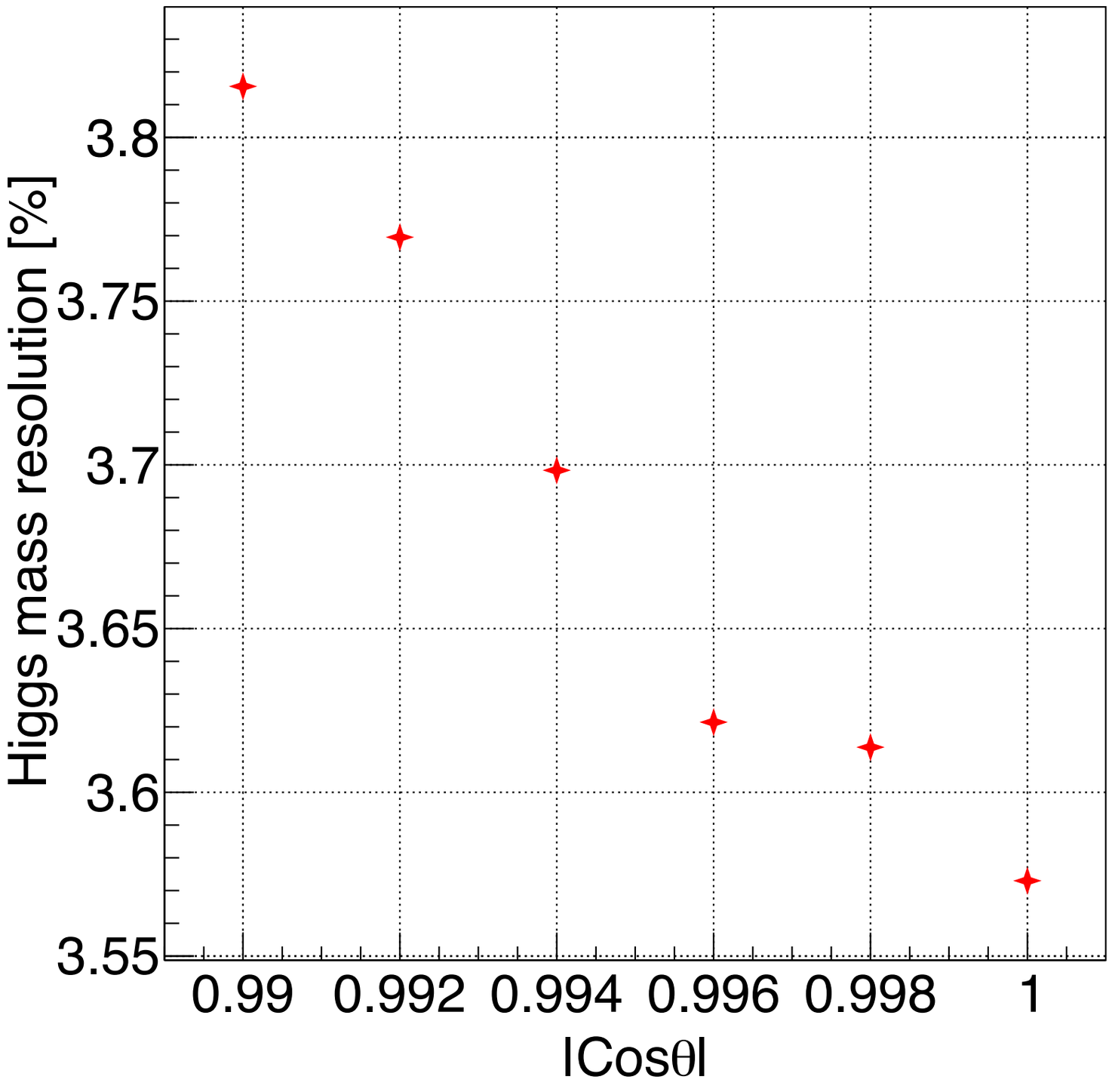

Higgs mass Resolution [%]
E (Pt) Threshold [GeV]
Charged particle
Photon
Neutral hadron
0
2
4
6
8
10
0 0.2 0.4 0.6 0.8 1 1.2 1.4 1.6 1.8 2

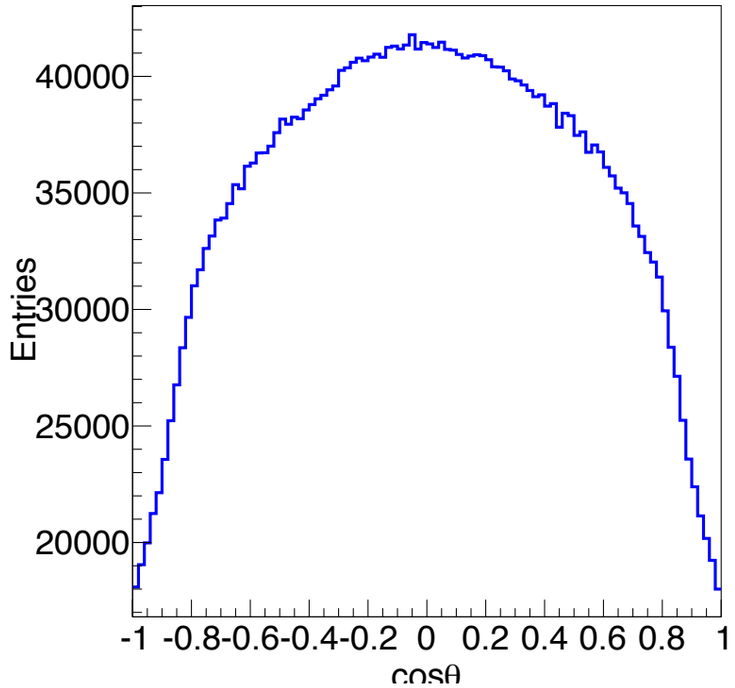

×10^3
Entries
Energy of FSParticles [GeV]
FSParticle
Charged Particle
Charged Hadron
Photon
Neutral Hadron
0
100
200
300
400
500
600
700
800
0 5 10 15 20 25 30

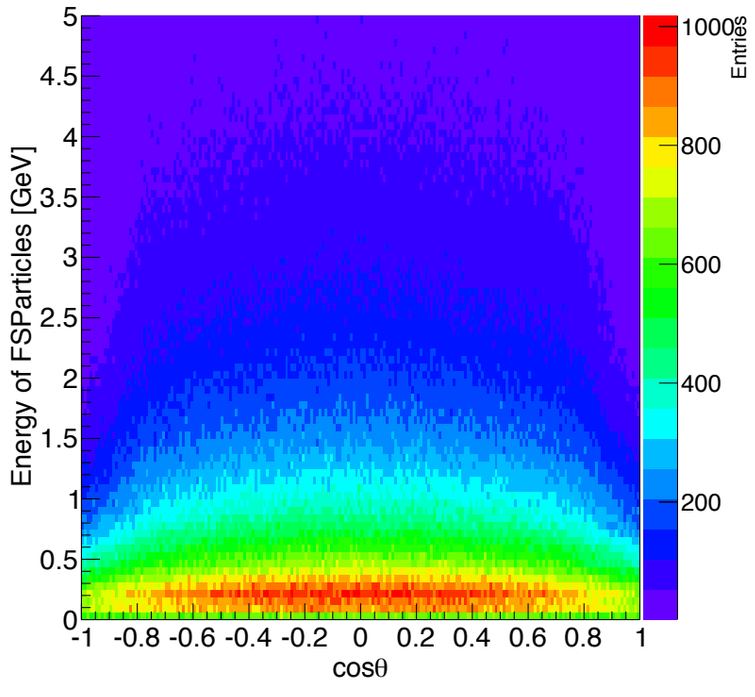

Entries
Energy of FSParticles [GeV]
FSParticle
Charged Particle
Charged Hadron
Photon
Neutral Hadron
10^2
10^3
10^4
10^5
10^6
0 5 10 15 20 25 30

Acceptance

~ 14%

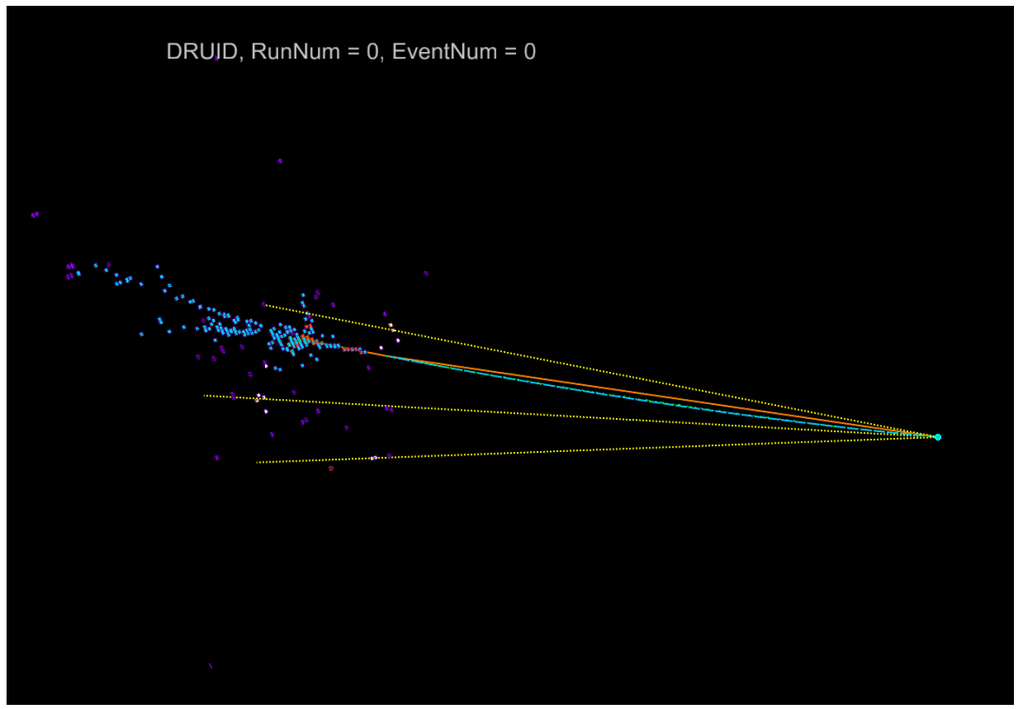


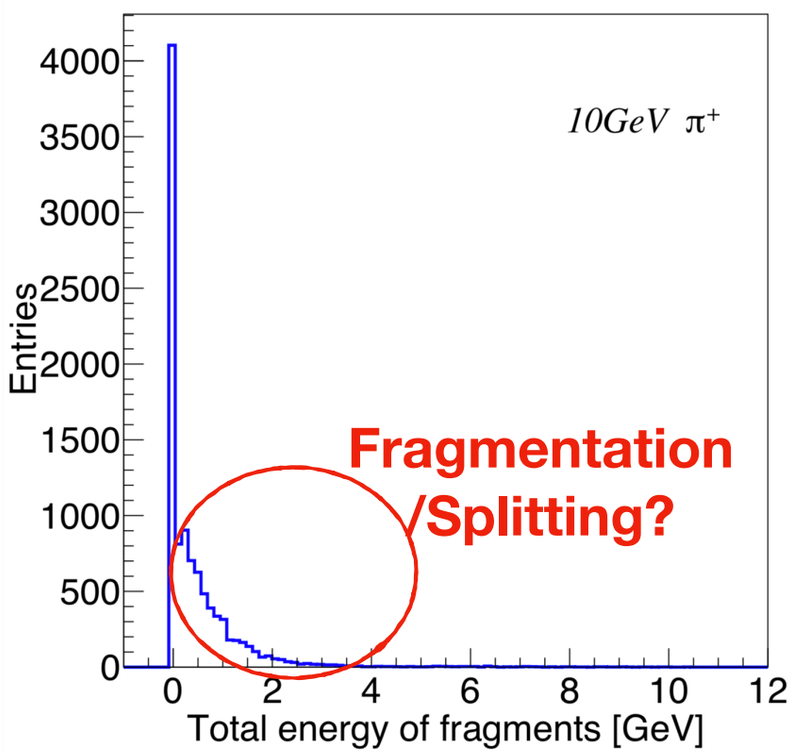


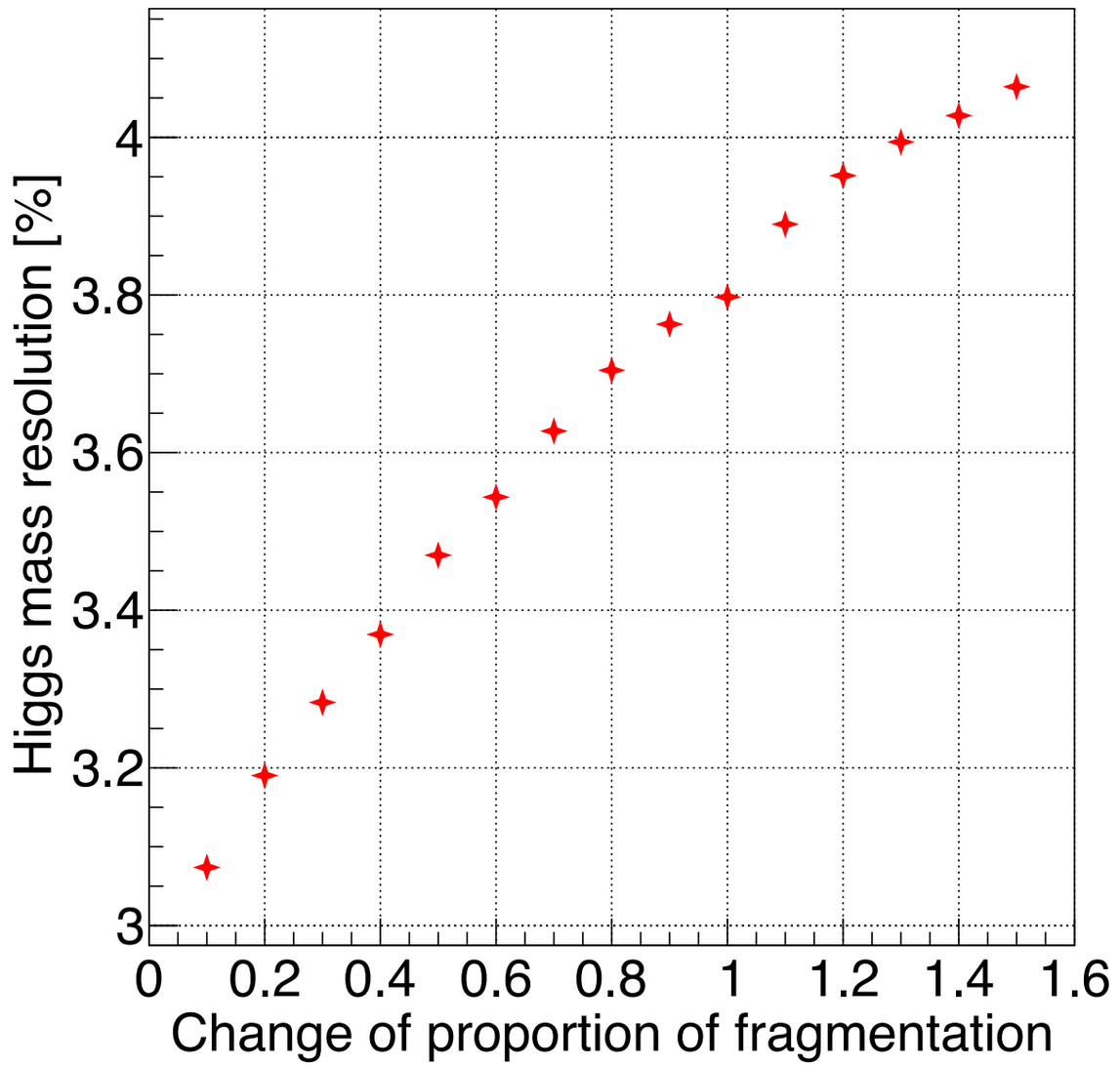


Fragmentation of Charged Hadron

The most severe effect! ~ 35%

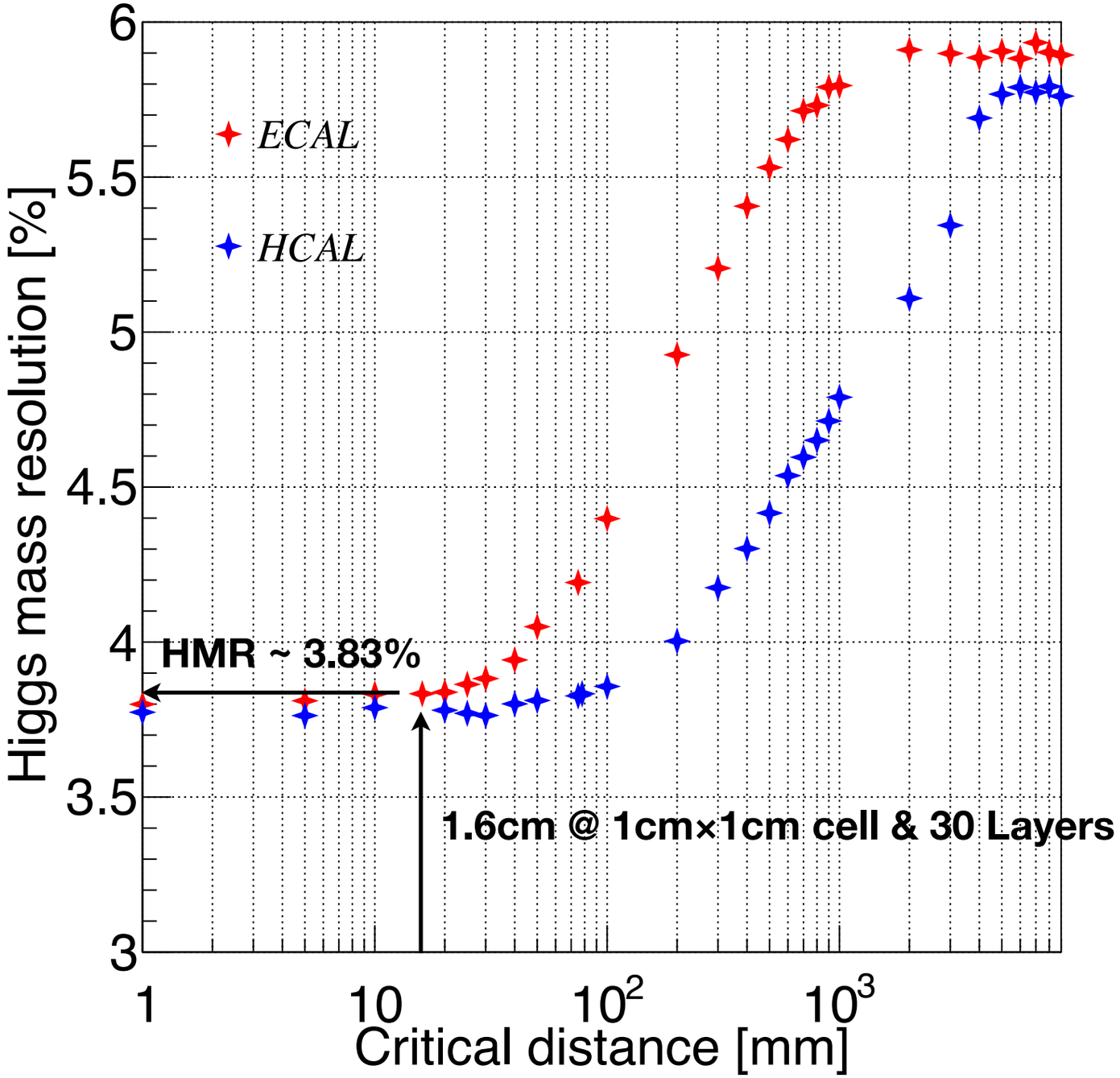






Confusion between nearby clusters

Baseline parameters: ECAL resolution = 17.1%/√E ⊕ 1% & Photon energy threshold = 200MeV



Conclusion

Effects already considered

Sub-detector resolution

Reconstruction efficiency, threshold of E (P_t)

Acceptance

Fragmentation of charged hadron

Overlapping between nearby clusters

Other effects will be considered next (HMR~3.83%->4.2%)

Tracker material, interaction inside tracker

……

Fragmentation of charged hadron **The most severe effect! ~ 35%**

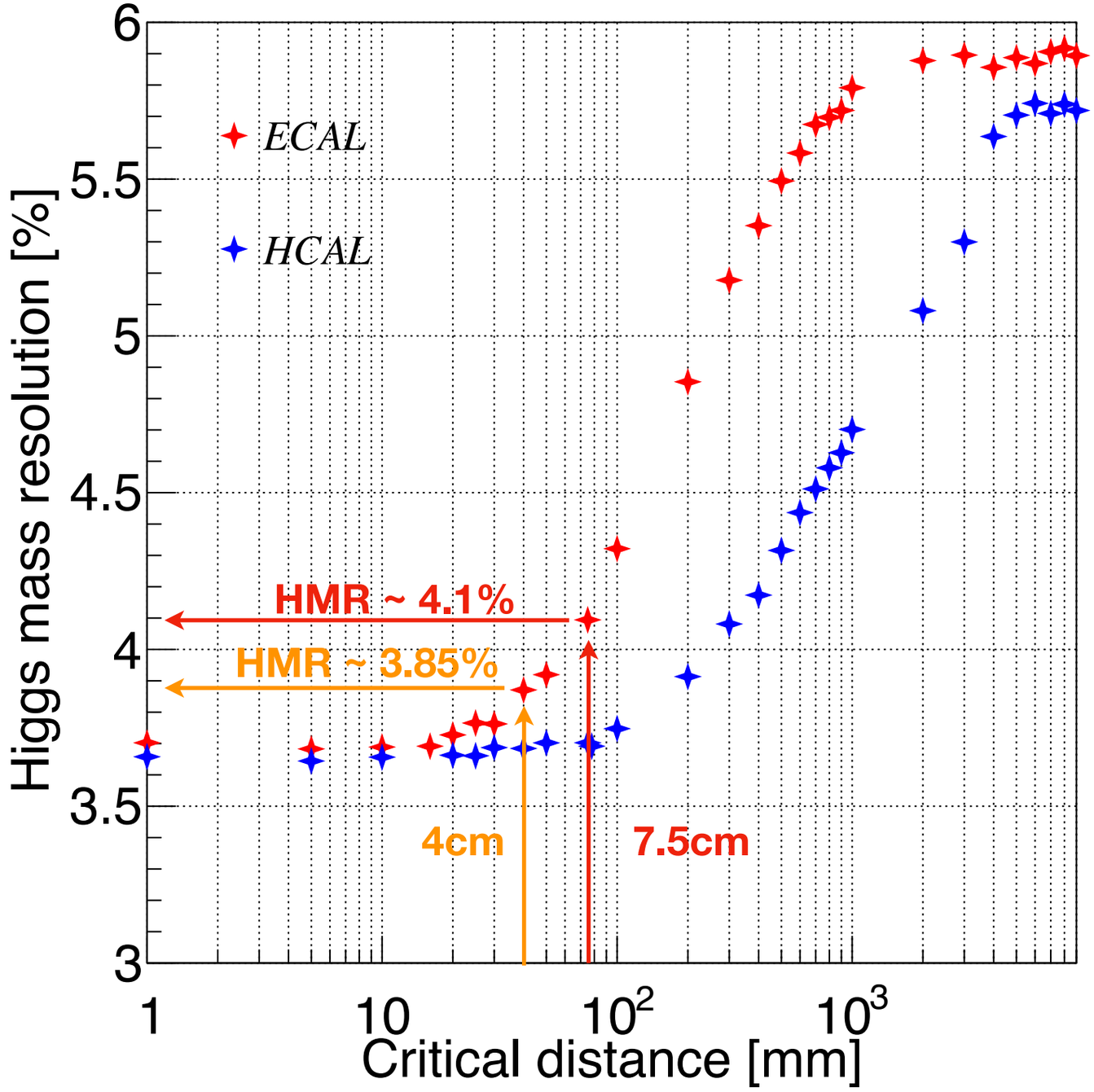
Pattern of fragments from full simulation

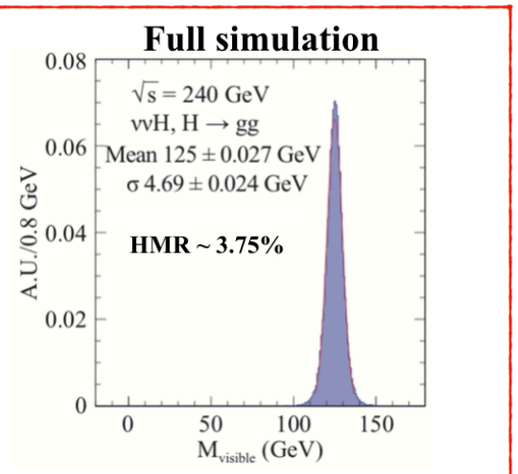
Potential of using time information to deal with slower fragments

Backup

Confusion between nearby clusters

ECAL resolution = 2%/√E ⊕ 1% & Photon energy threshold = 50MeV

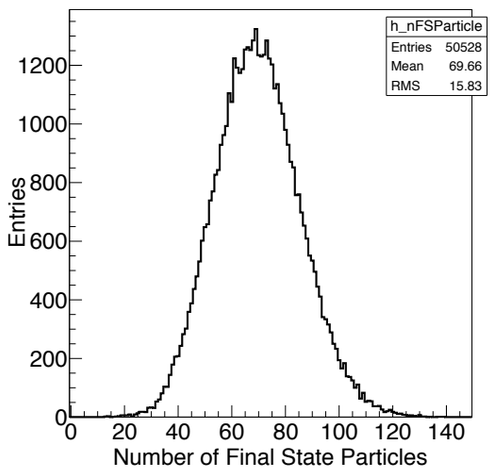


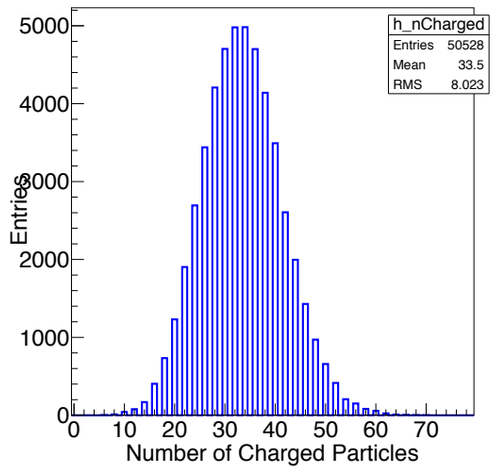


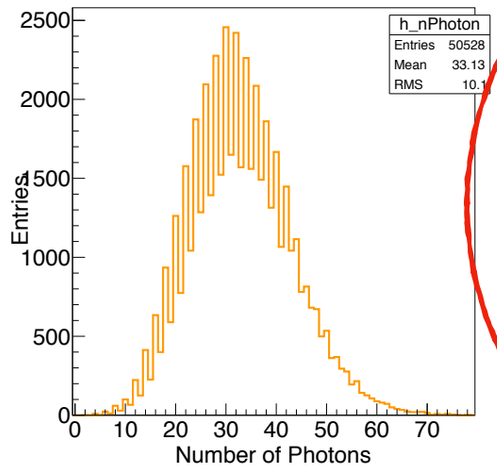
RMS = 5.283GeV
Mean = 125GeV
RMS/Mean ~ 4.23%

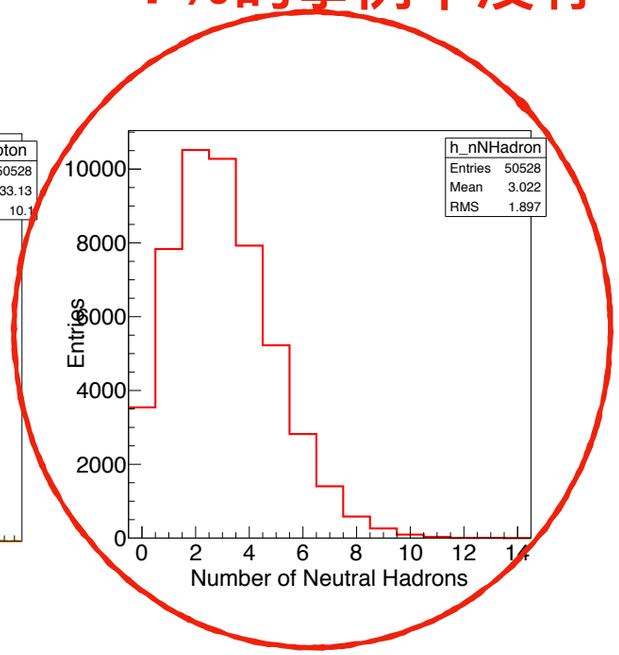
vvH->gg

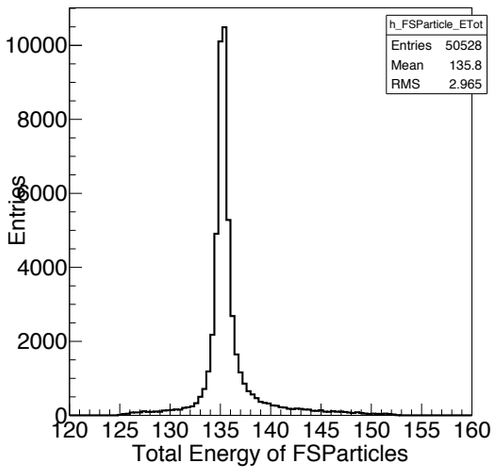
~ 7%的事例中没有中性强子

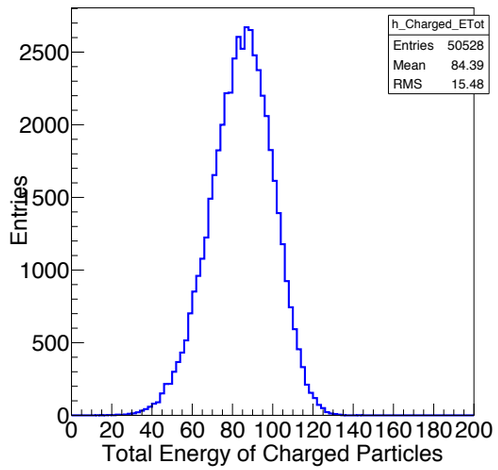


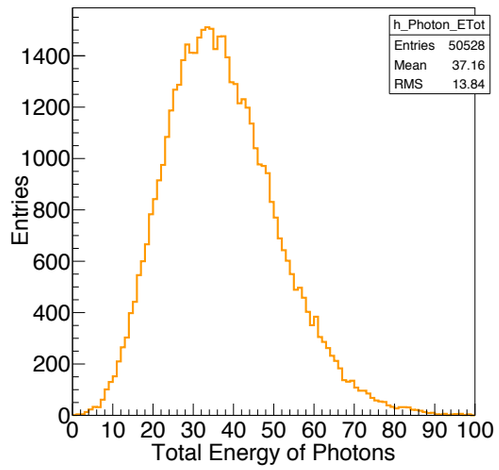


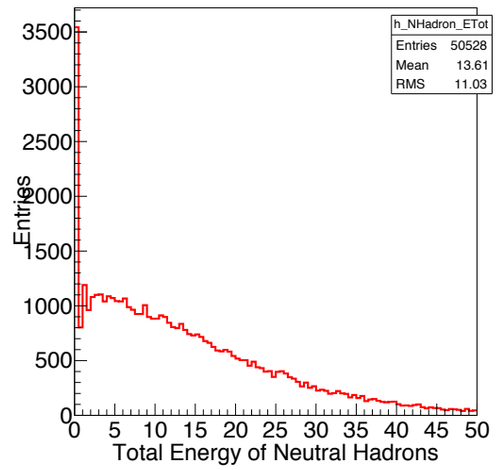


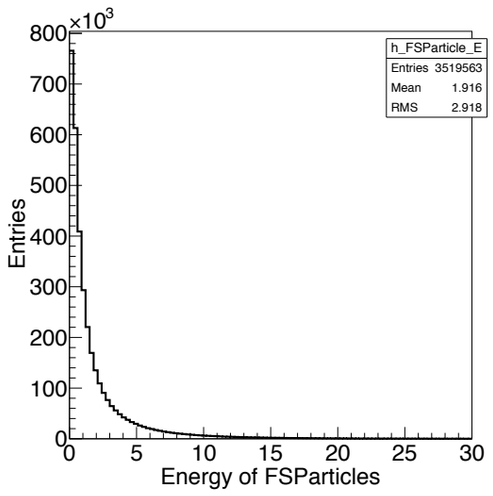


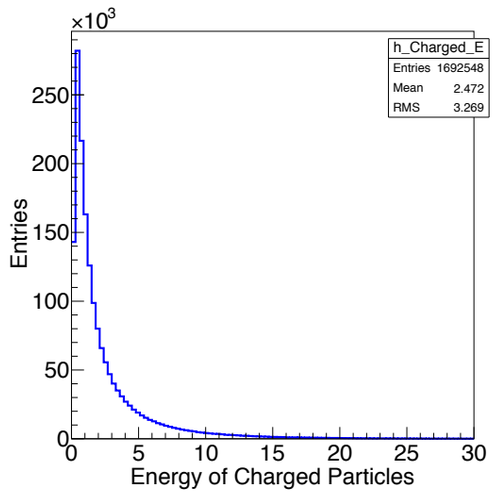


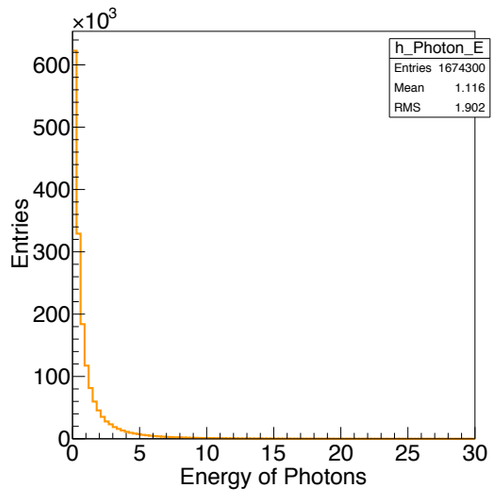


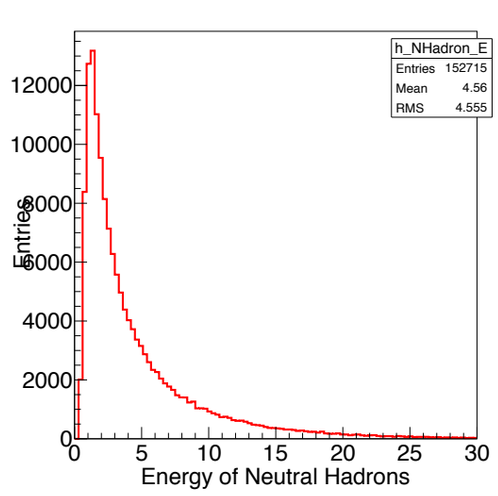


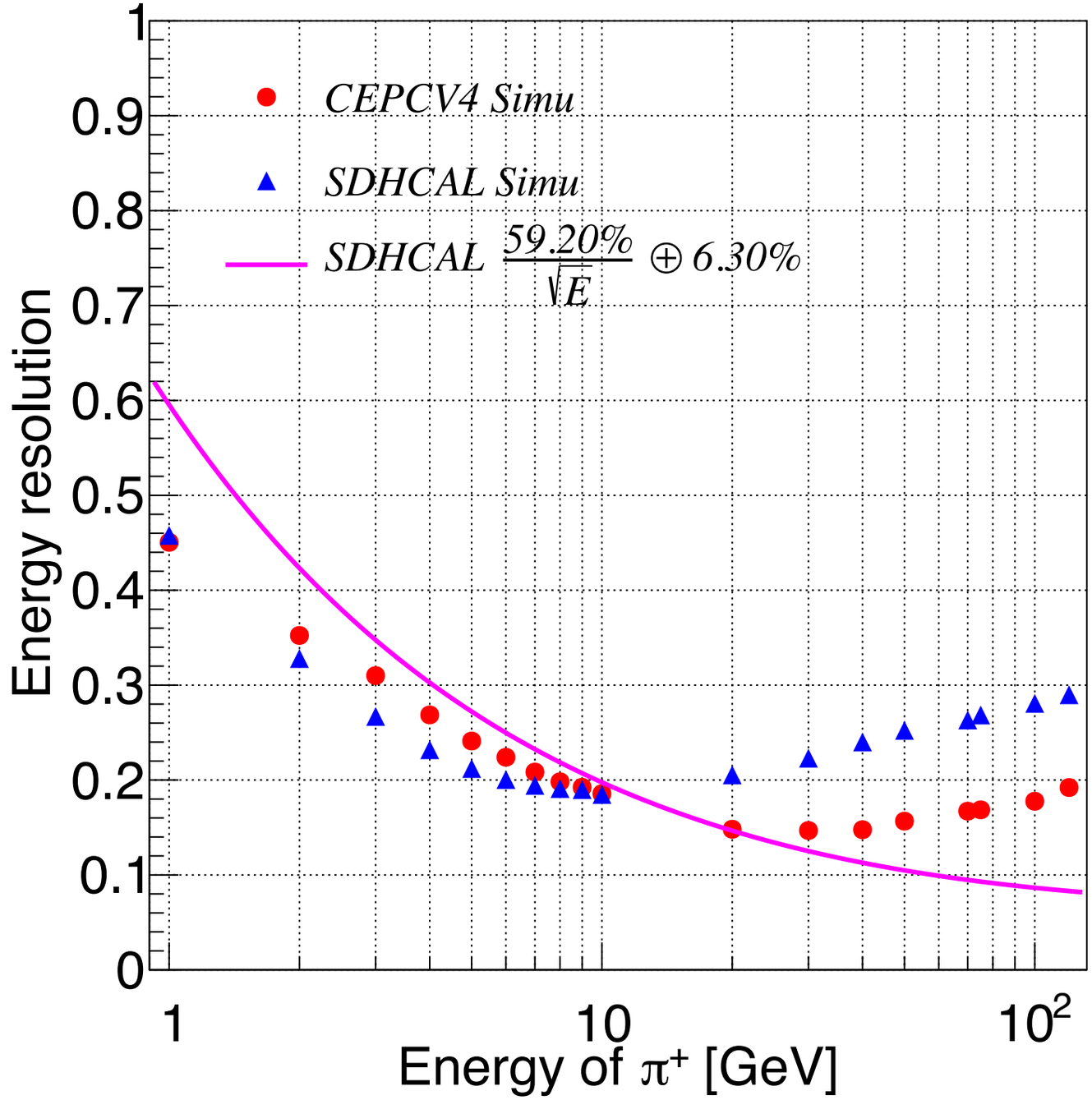











CEPCV4 Simu
SDHCAL Simu
SDHCAL $\frac{59.20\%}{\sqrt{E}} \oplus 6.30\%$
Energy resolution
Energy of π^+ [GeV]
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
1
10
10^2