ZH study with full simulation

TILC08 Sim/Rec section

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Hiroaki Ono

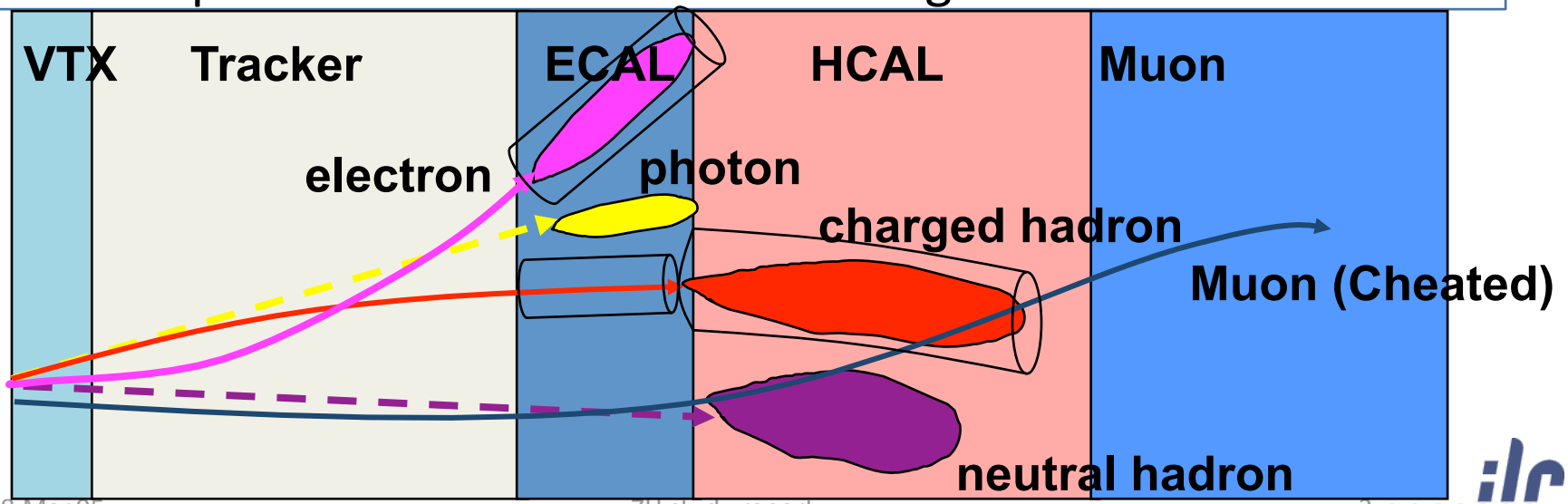
Nippon Dental University

Introduction

- We study the Higgs mass reconstruction at ZH mode with the full detector simulation based on the GLD simulation packages
  Jupiter(Detector simulation)→Satellites(PFA, analysis)
- GLD-PFA has achieved around 30%/sqrt(E) jet energy resolution for Z-pole event, so we try to study the physics process using this PFA.
- Compare the performance of GLD-PFA with the cheated (perfect clustering) PFA.
- ZH process at M_h=120GeV with
  - $ZH \rightarrow \nu\nu H$(2-jet), qqH(4-jet) at the E_{cm}=350GeV.
- M_h>120GeV case is also studied.

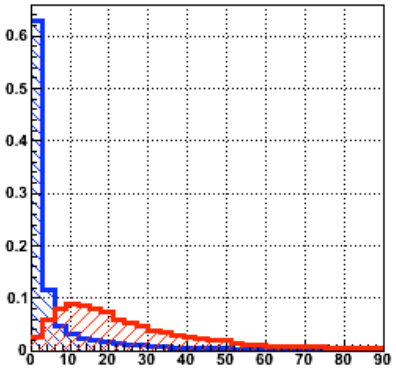
Realistic GLD-PFA scheme

1. Small clustering (Nearest neighboring method)
2. Photon finding (likelihood method)
   - Separate photon and charged clusters
3. Charged hadron finding
   - Tube based track cluster matching
4. Neutral hadron finding (Calculate likelihood)
   - Separate neutral hadron and charge scattered events

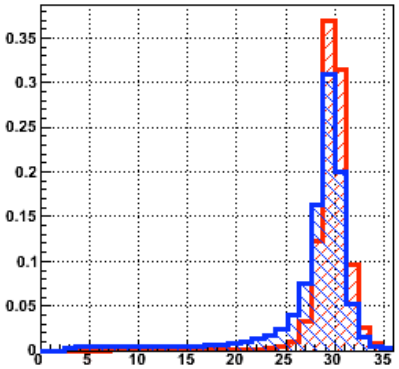


Detail of GLD-PFA (photon likelihood)

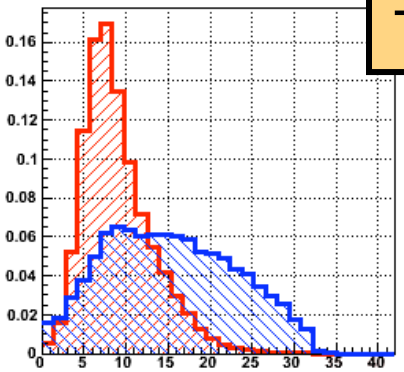
Track distance



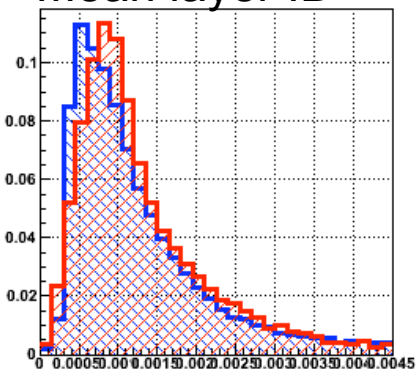
velocity



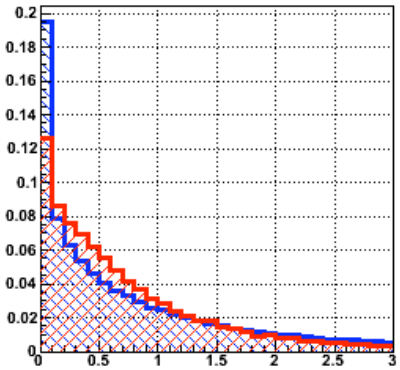
Edep/nhits



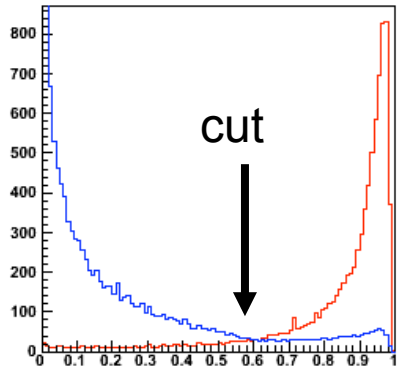
Mean layer ID



Shower fitting χ^2



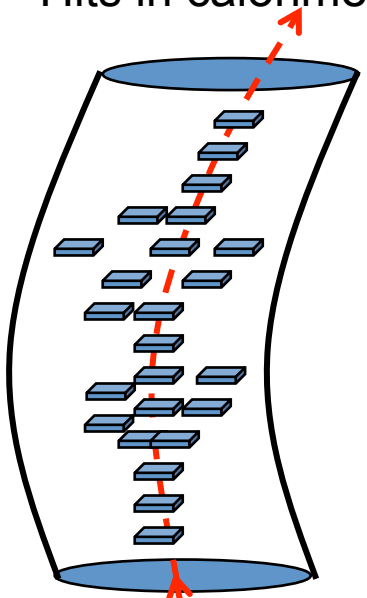
Photon likelihood



charged photon

Track-Cluster matching

Hits in calorimeter



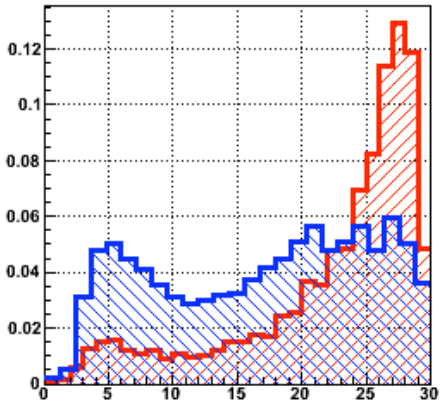
Charged track

Clustering in tube

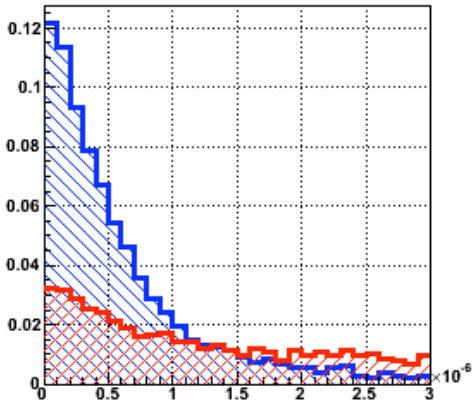
Photon and charge hadron are separated by the cut of photon likelihood output

GLD-PFA (Neutral hadron likelihood)

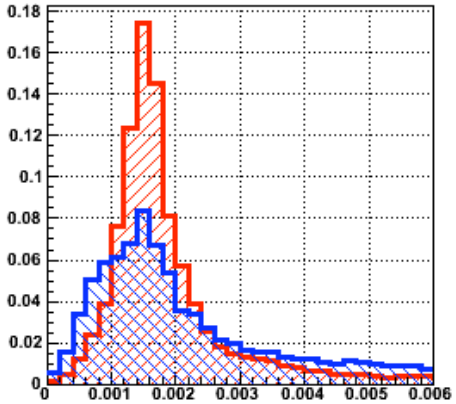
velocity



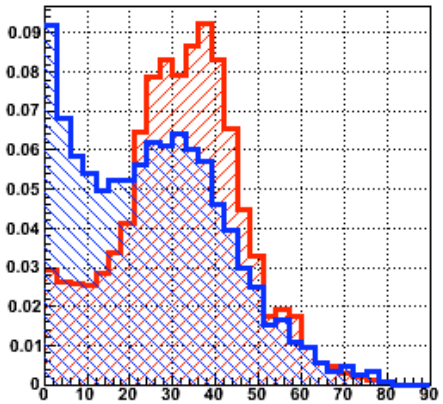
Energy density



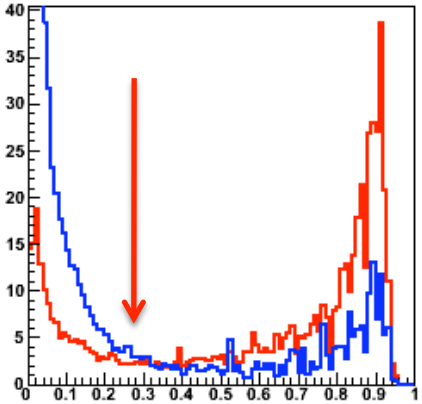
Edep/nhits



Mean layerID



Likelihood output



After passing through the GLD-PFA scheme

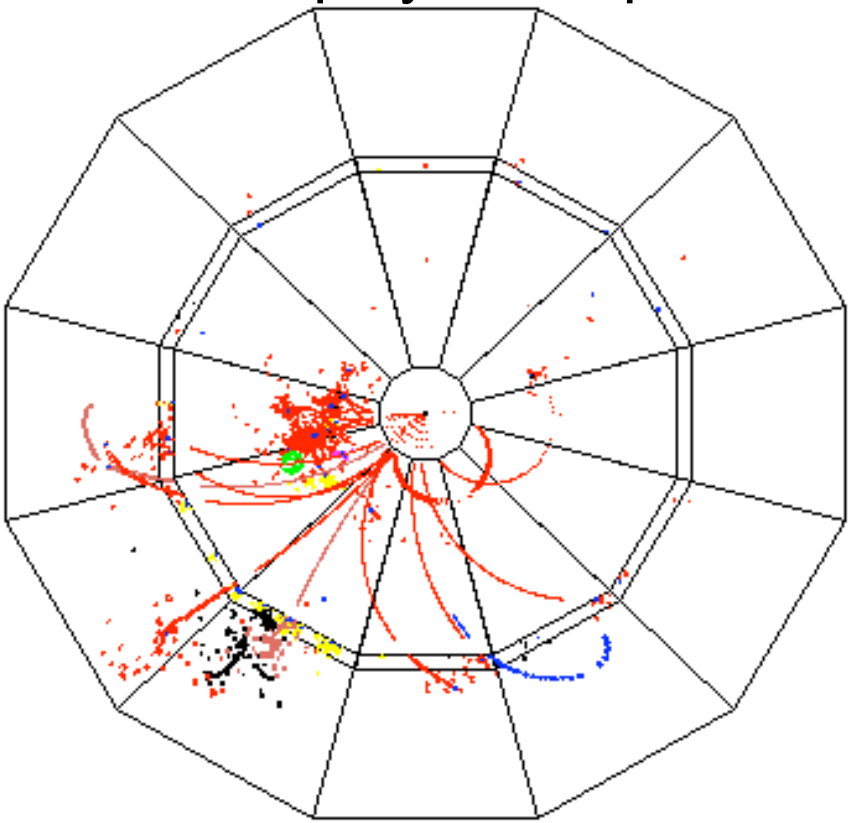
Apply the jet reconstruction

Satellite hits Neutral hadron

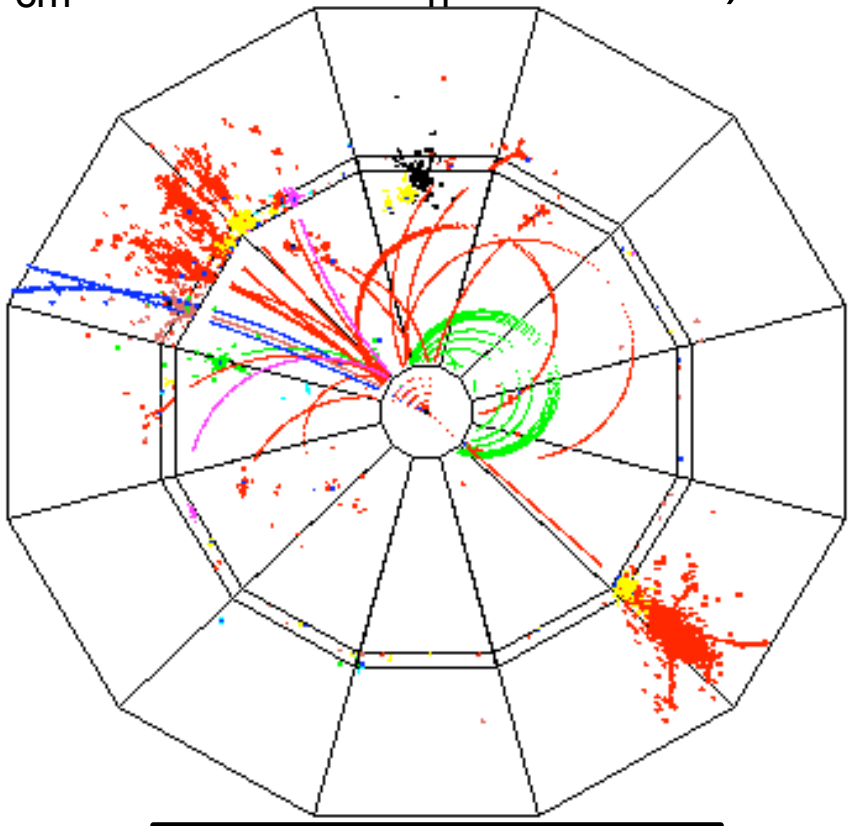
ZH study in GLD full simulation

Calorimeter cell size : 1cmx1cm, GLD geometry with GLD-PFA

Event display of ZH process (E_{cm}=350GeV, M_h=120GeV)



ZH→νν̄H (2-jet mode)



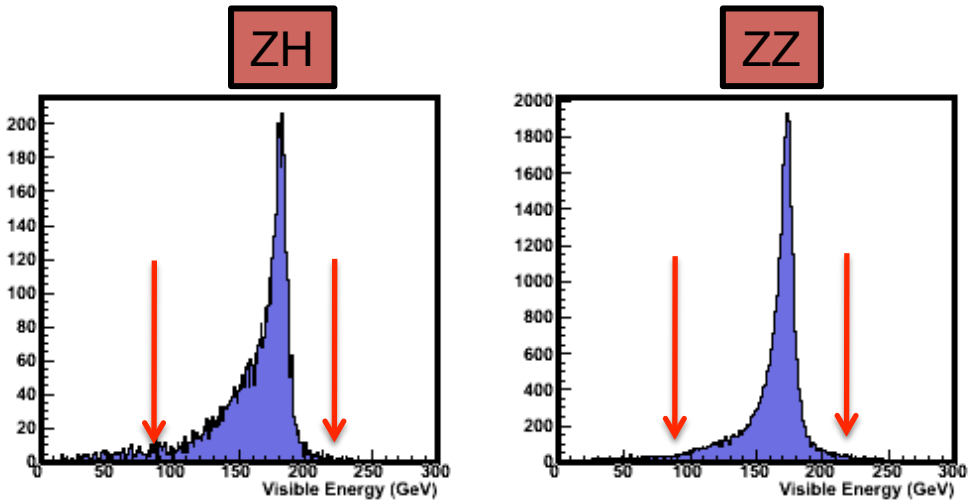
ZH→qq̄H (4-jet mode)

Selection criteria (ZH→ννH 2-jets)

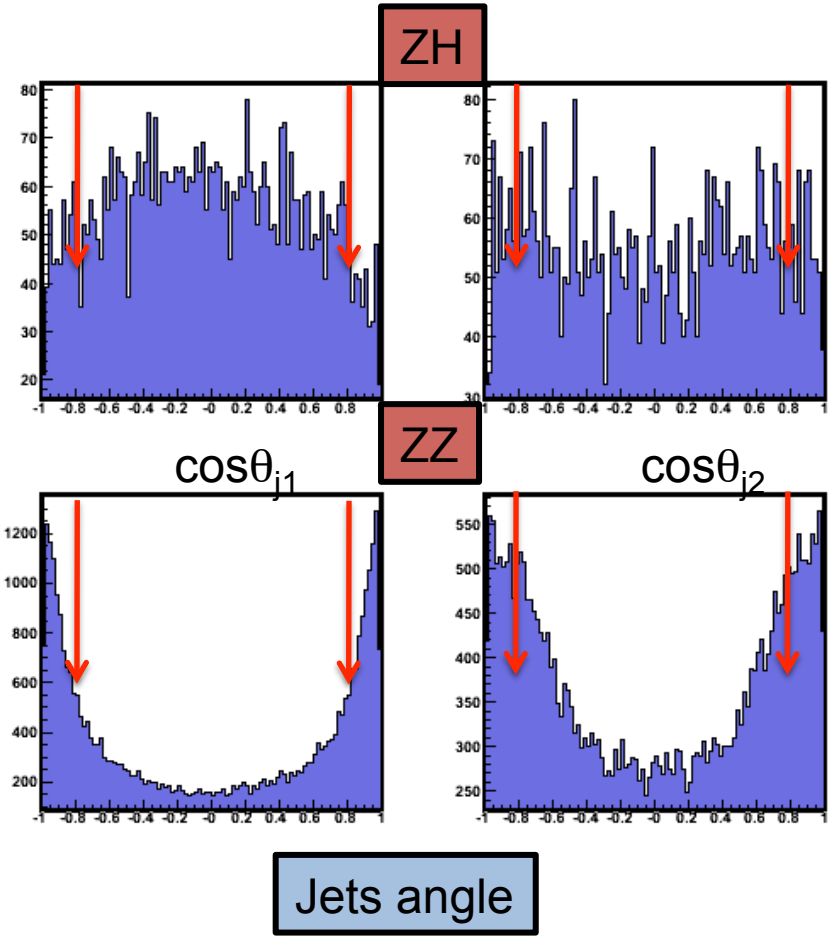
Selection criteria for 2 jets mode

- MissingP_t > 20 GeV (missing P_t)
- 90 < Evis < 220 GeV (Visible energy)
- |cosθ| < 0.8 (jet angle)
- NoffVtx > 6 (b-tagging)

E_{cm}=350GeV, M_h=120GeV



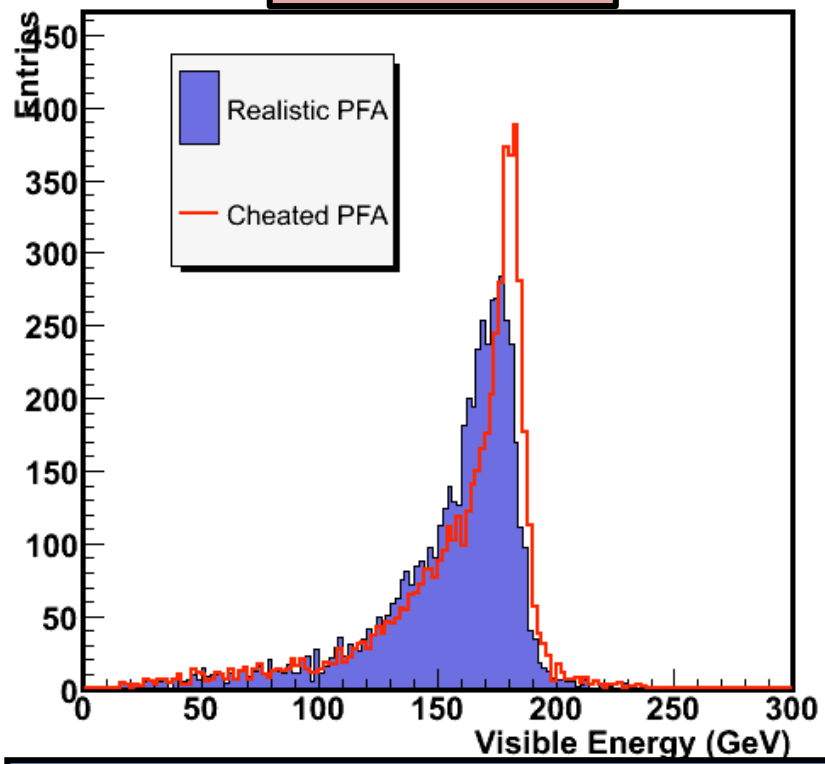
Visible energy



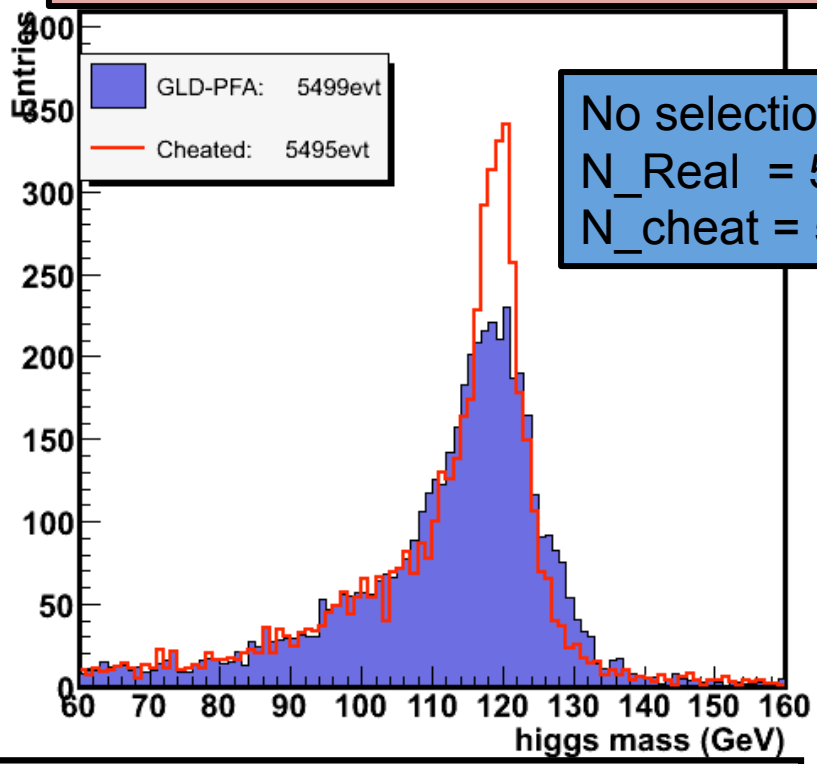
Jets angle

PFA performance comparison (2-jets)

Visible energy



Reconstructed Higgs mass (signal)



No selection
N_Real = 5499
N_cheat = 5495

Comparison between the jet reconstruction performance of cheated PFA and GLD-PFA. Higgs mass is reconstructed at 120GeV, but the width is wider than the GLD-PFA case.
Need to be improved the performance of GLD-PFA

Event selection for 2-jets mode

BG is only ZZ for now

ZH→ννH (2jet) 200 fb^{-1}	Cheated PFA (sig)	GLD-PFA (sig)	Cheaged PFA (bg)	GLD-PFA (bg)
# of signal	5495	5499	41998	41997
90<Evis<220 GeV	5152	5155	39873	39833
$\|\cos\theta_j\|$<0.8	3378	3420	14480	14516
Pt > 20 GeV	3357	3359	14325	14359
NoffVtx>6 (b-tag)	1057	1068	1574	1572
Efficiency	19.2%	19.4%	3.8%	3.7%

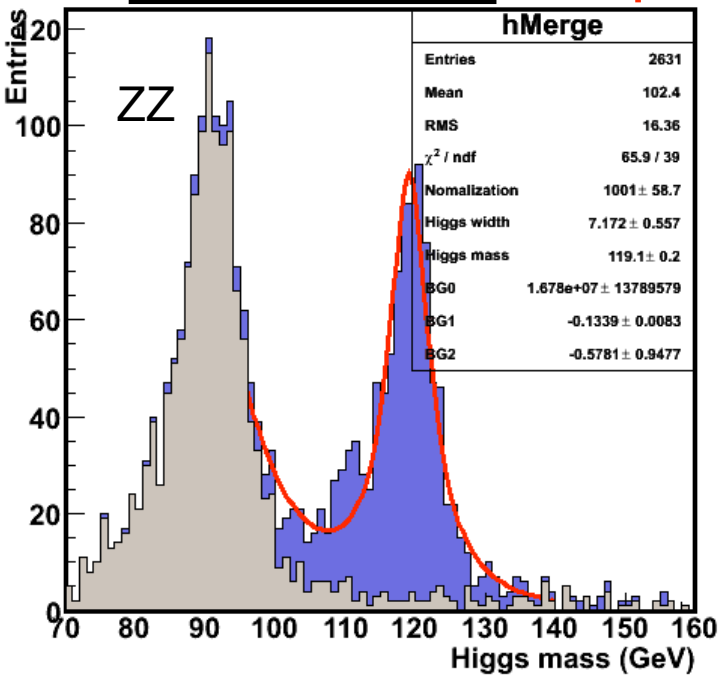
Almost same efficiency could be achieved by cheated and GLD PFA.

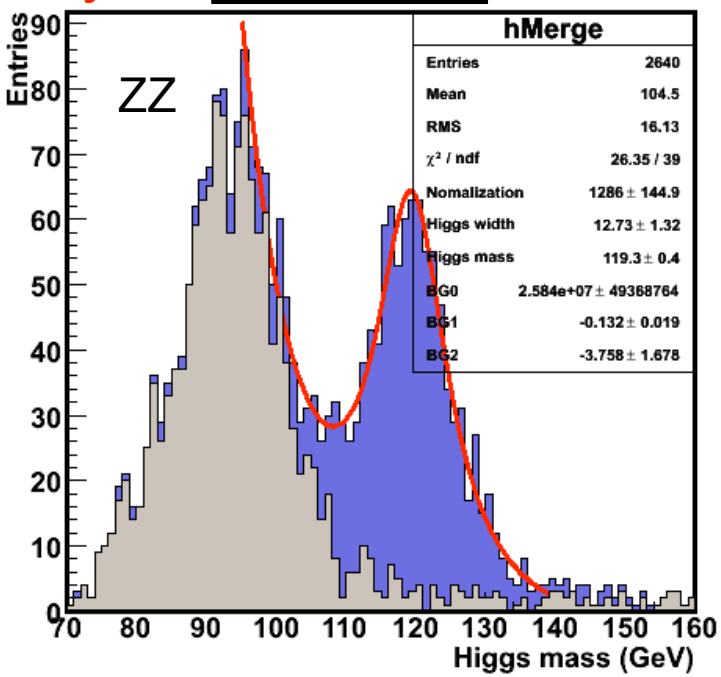
ZH→νν̄h (2-jets) E_{cm}=350GeV

Cheated PFA

preliminary

GLD-PFA





- Luminosity : $\mathcal{L}$=200 fb^{-1}
- Higgs mass is calculated as reconstruct invariant mass of 2-jets
- Background events are only ZZ mode

δMh=180MeV (Cheated)
δMh=380GeV (GLD-PFA)

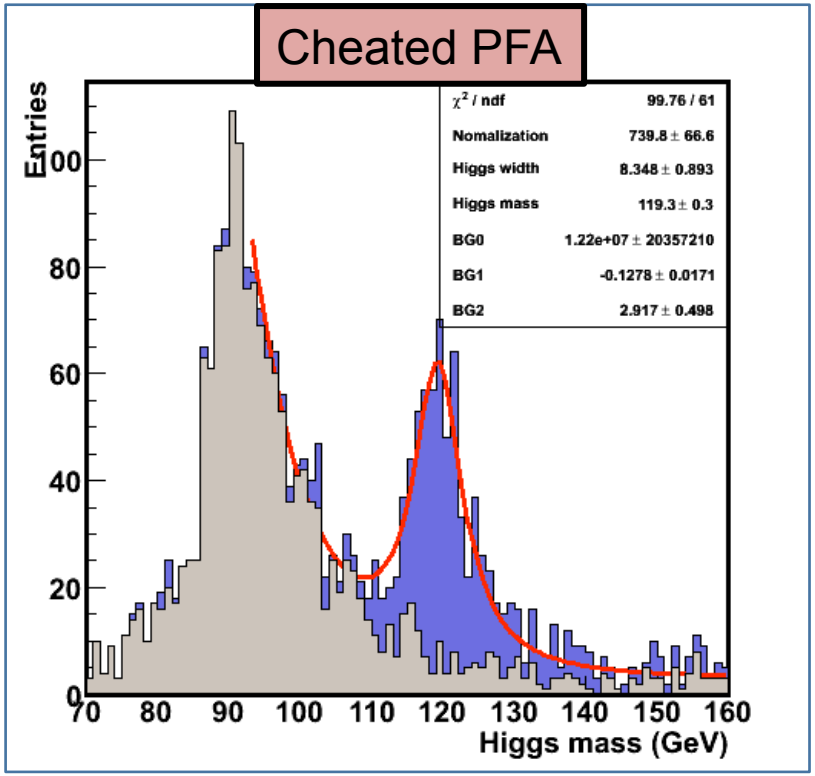
Higgs mass can be reconstructed for both PFA
but the width is still wider than cheated in GLD-PFA

Event selection for ZH→qqH (4-jet) E_{cm}=350GeV

Best jets combination is selected from the chi square of
$\chi^2=((M_{jj}-M_z)/\sigma_z)^2+((\text{Missing}M_h-M_z)/\sigma_z)^2$

$\mathcal{L}=50fb^{-1}$

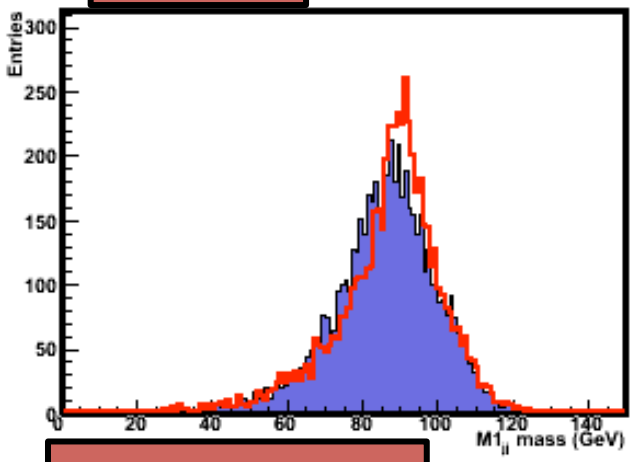
ZH→qqH (4jet)	Cheated PFA (sig)	GLD-PFA (sig)
# of signal	5750	5750
Evis>240 GeV	5552	5499
Chi2<20	2394	1303
$\|M_{jj}-91.2\|<20$ && $\|H_{mm}-91.2\|<40$ GeV	2124	1059
NoffVtx>6	1269	640



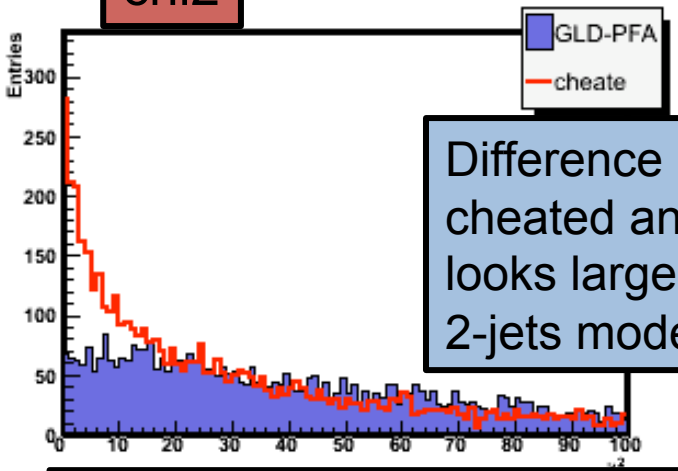
Chi2 cut efficiency looks low for GLD-PFA. That is caused by the difference of reconstructed energy between two PFAs.

PFA performance comparison (4-jets)

Z mass

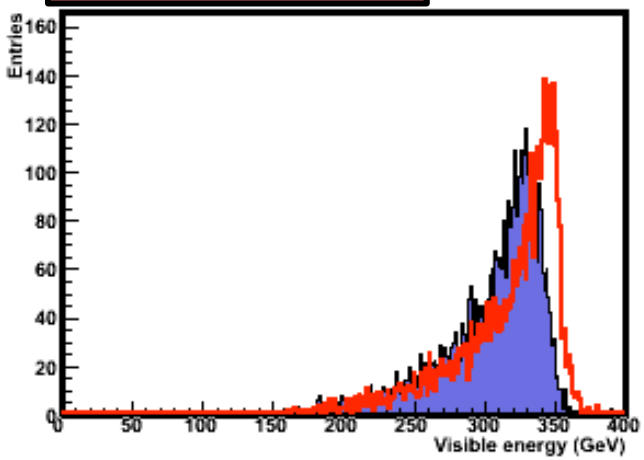


chi2

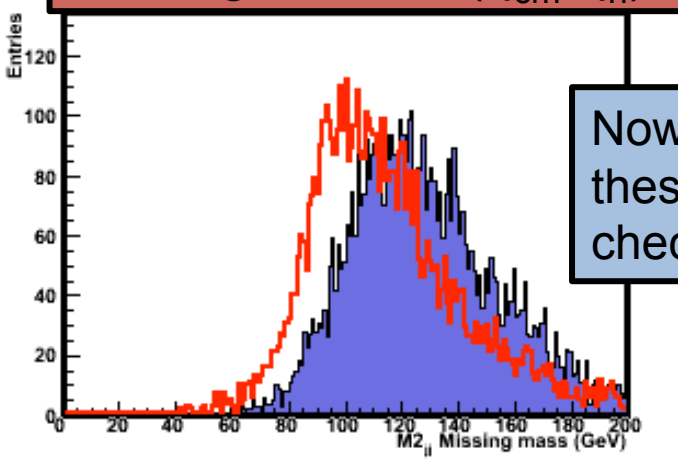


Difference between cheated and GLD PFA looks large compare to the 2-jets mode

Visible energy



Missing mass $M(q_{cm}-q_h)\sim Mz$



Now investigating these reason by checking jet by jet

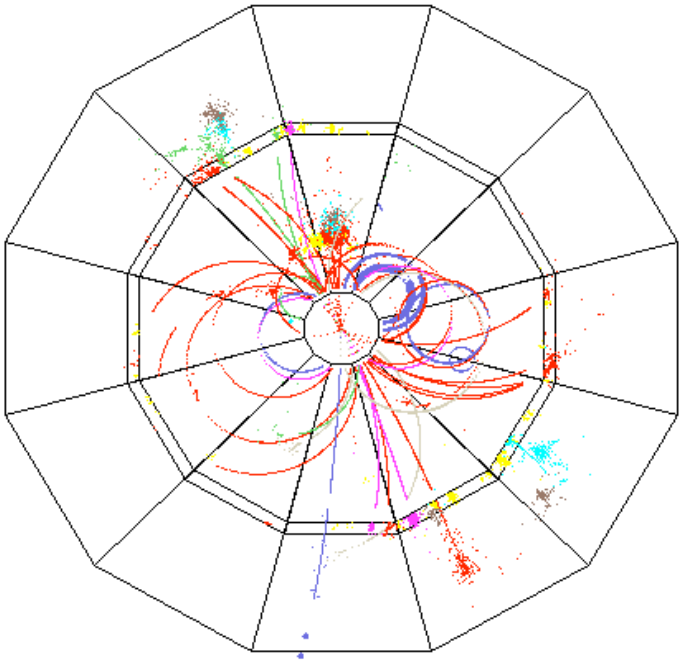
ZH study with Mh>120GeV

- Mh=160GeV case, decay branch to WW from Higgs increase (91%).
- Try to analyze multi-jets environment in full simulator, ZH→qqWW, W→qq'(6-jets) at E_{cm}=350GeV
- Cheated PFA is used for physics analysis first, then try to shift realistic PFA.
- Current study is signal only. Add background
  - tt→ qWqW (6-jets) at E_{cm}=350GeV
  - E_{cm}=250GeV case, tt background can be suppressed and better for the Higgs mass precise measurement.

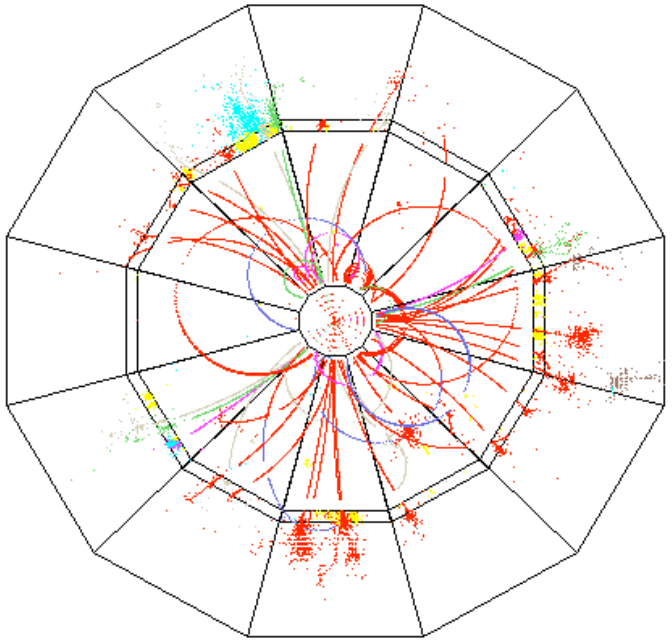
Event display of M_h=160GeV

ZH→qqH at M_h=160GeV (E_{cm}=350GeV) H→WW. W→lν, qq'

Z→qq, WW→νlqq (4-jet + l)



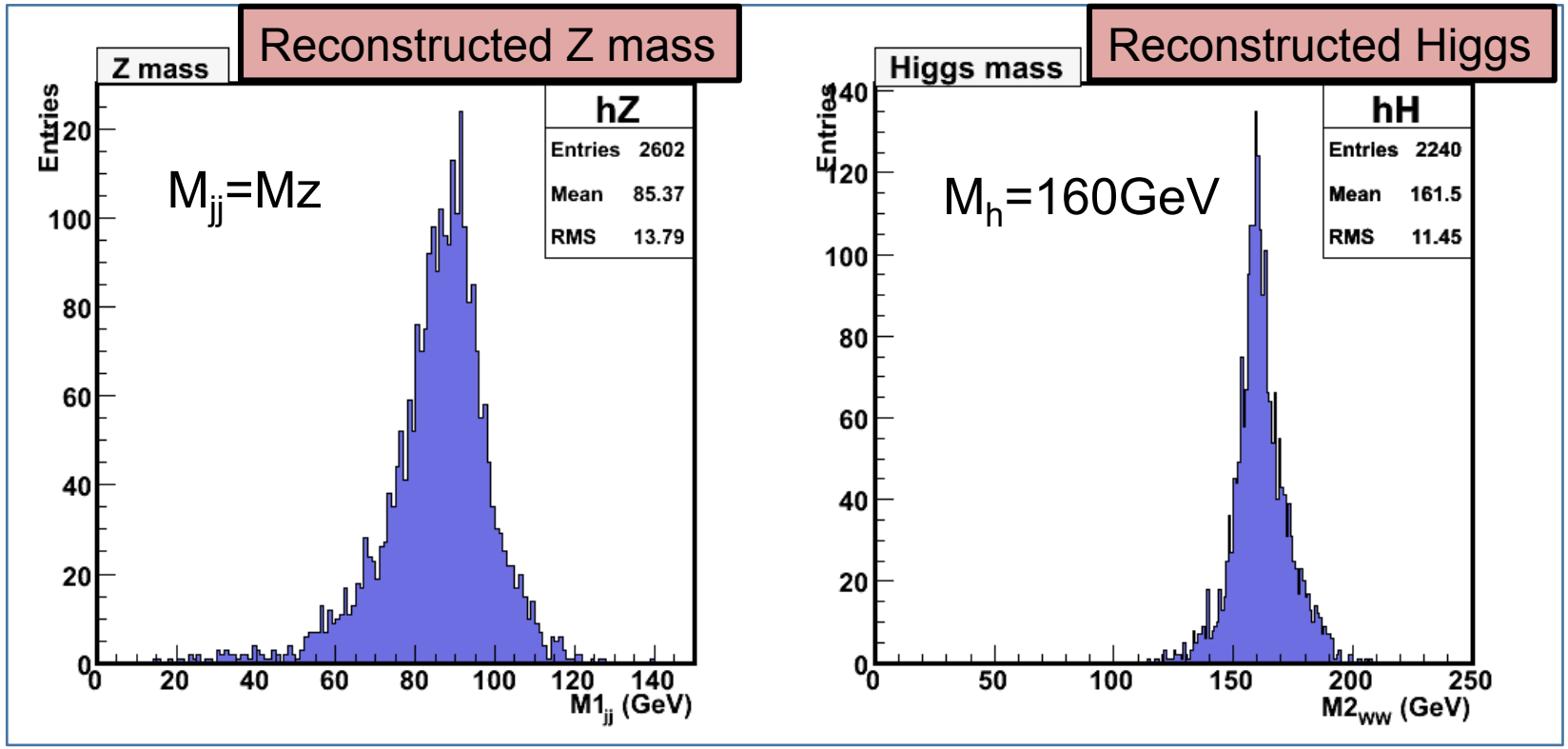
Z→qq, WW→qqqq (6-jets)



High momentum lepton can be tagged as leptonic decay mode

ZH→qqWW signal (M_h=160GeV)

ZH→qqWW, W→qq' (6jet) multi-jets event using cheated PFA for now



To select best jets combination, calculate the chi squire of

$\chi^2=((M_{jj}-M_z)/\sigma_z)^2+((M_{w1}-M_w)/\sigma_w)^2+((M_{w2}-M_w)/\sigma_w)^2$

Next step is realistic PFA reconstruction and background study

Summary and Next steps

- ZH event is studied with perfect and GLD PFA.
  - 2-jets mode, both PFA can reconstruct mass peak even though GLD-PFA is wider than perfect clustering.
  - 4-jets (multi-jets) event case, the difference of PFAs are much larger, now investigating this reason.
  - Need to be checked the difference with jet by jet.
- Need to be improve GLD-PFA performance
  - Re-clustering for better energy matching between calorimeter cluster energy and charged track.
  - Iteration of Z→qq(2-jet) event analysis
- Include other SM backgrounds for ZH study.

Backup

Decay branch of Higgs

M_h=120GeV

Br(h→bb) = 68% (2 jets)

M_h=140GeV

Br(h→WW) = 48%

Br(h→bb) = 34% (2 jets)

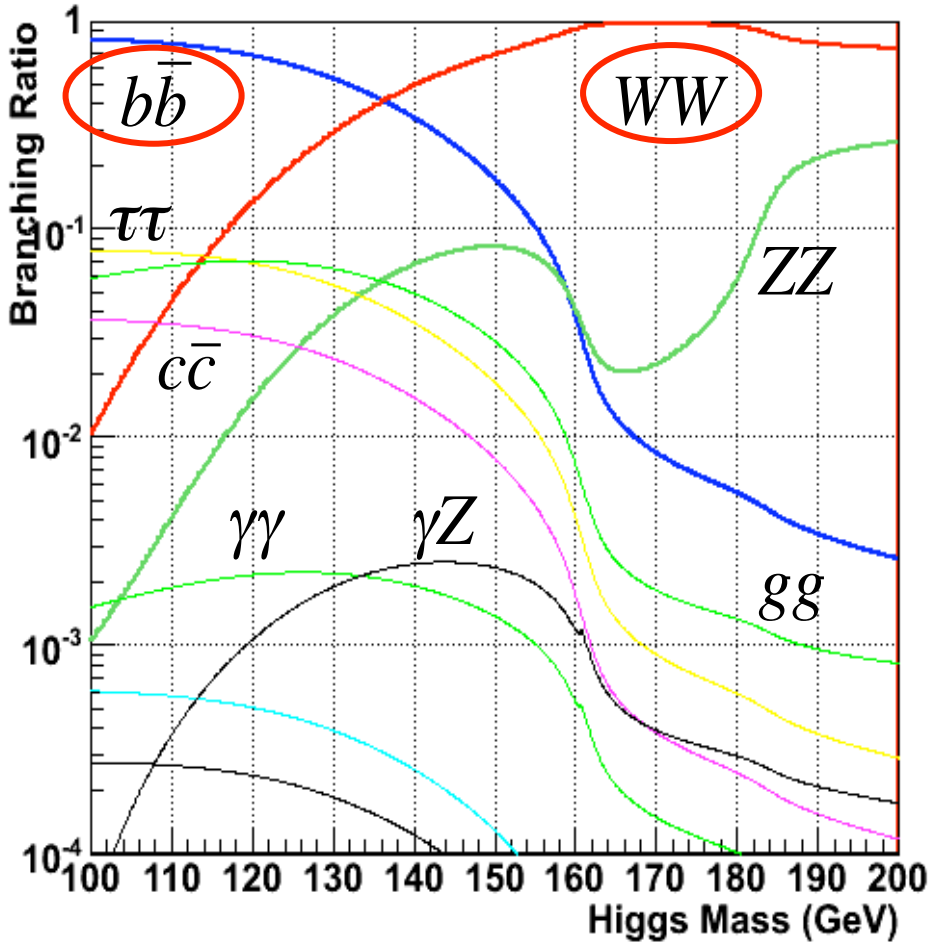
M_h=160GeV

Br(h→WW) = 91%

WW→qq'qq' (4 jets)

WW→lνqq' (lepton+2 jets)

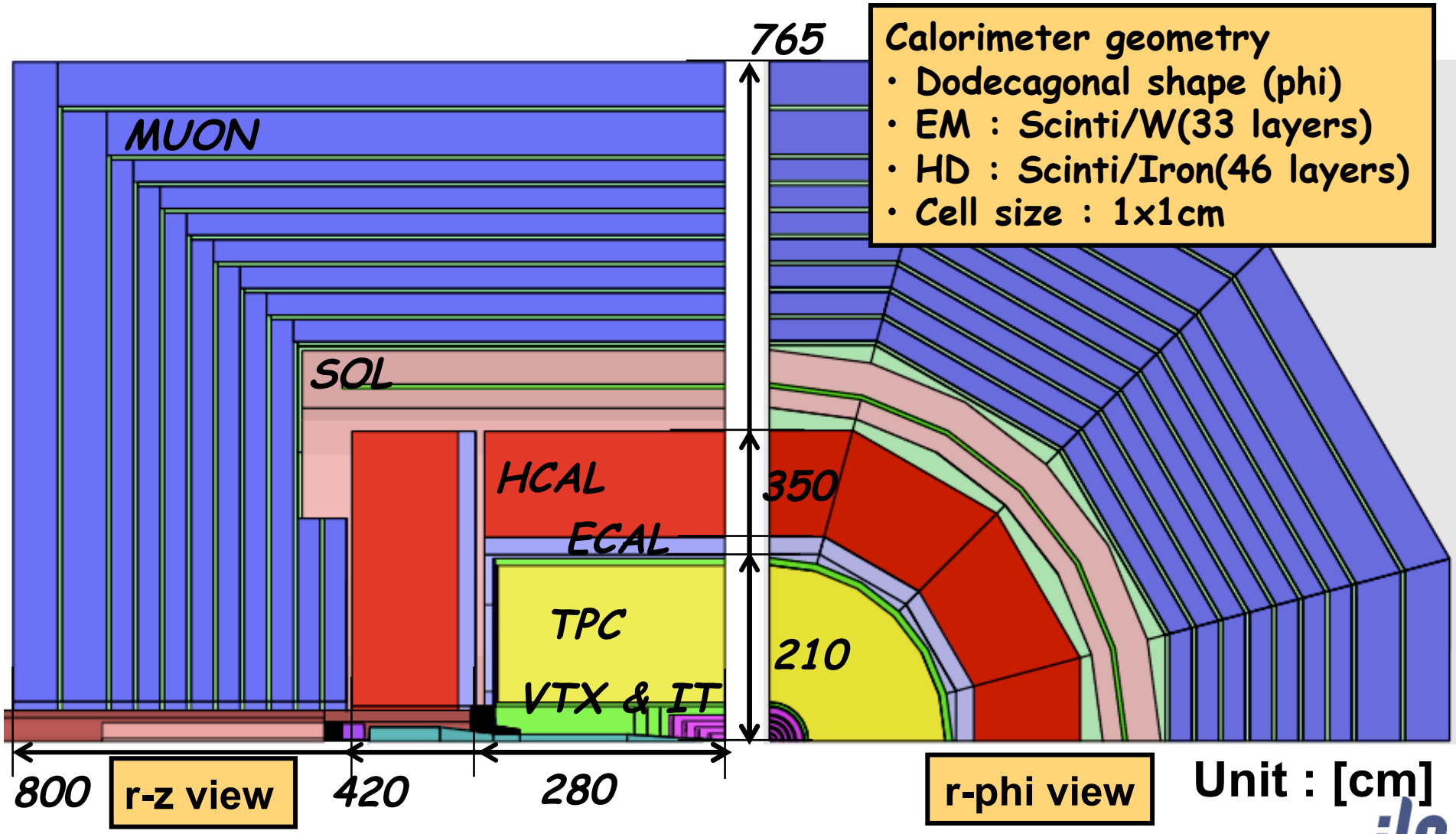
WW→lνlν (2 leptons)



Main decay mode

- M_h=120GeV : ***h→bb***
- M_h=140GeV : ***h→WW, h→bb***
- M_h=160GeV : ***h→WW***

Geometry in GLD Full Simulator (Jupiter)



Calorimeter geometry
- Dodecagonal shape (phi)
- EM : Scinti/W(33 layers)
- HD : Scinti/Iron(46 layers)
- Cell size : 1x1cm