

CEPC Jet&Clusters

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- Jet Samples
- Jet Tasks

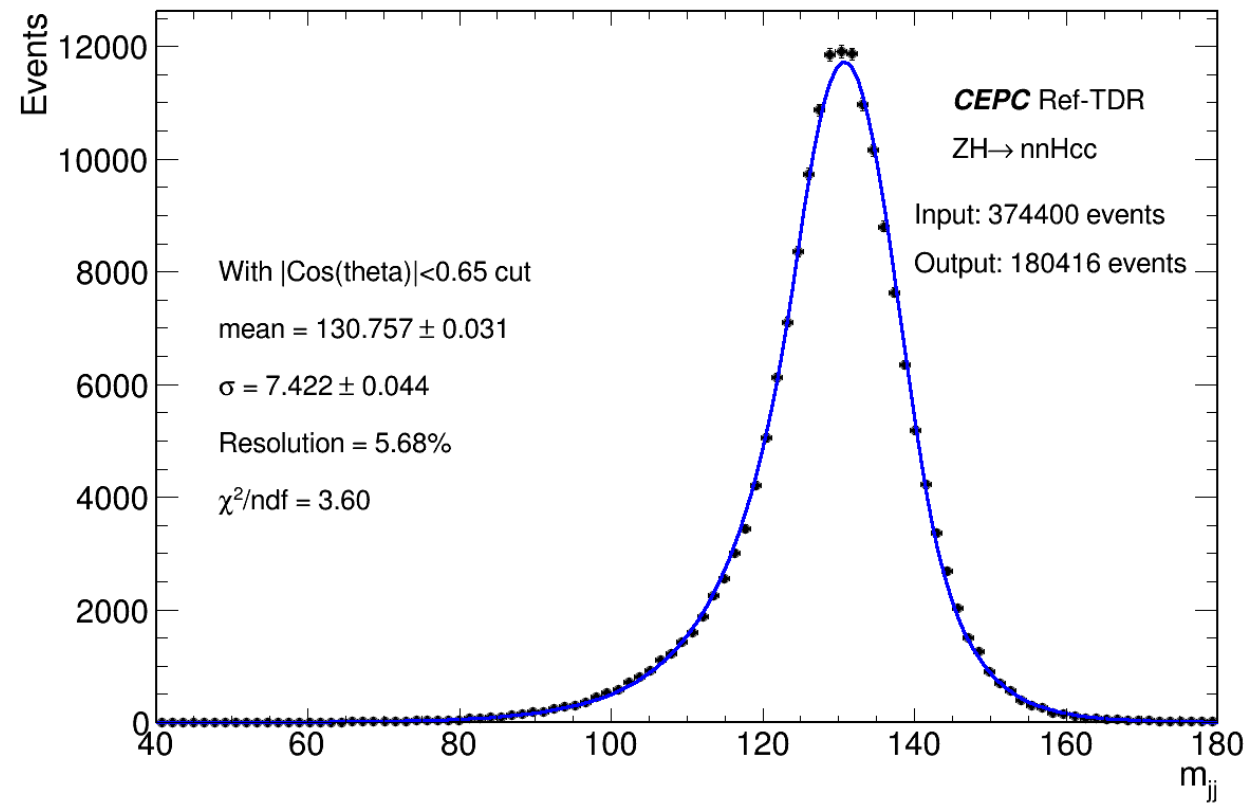
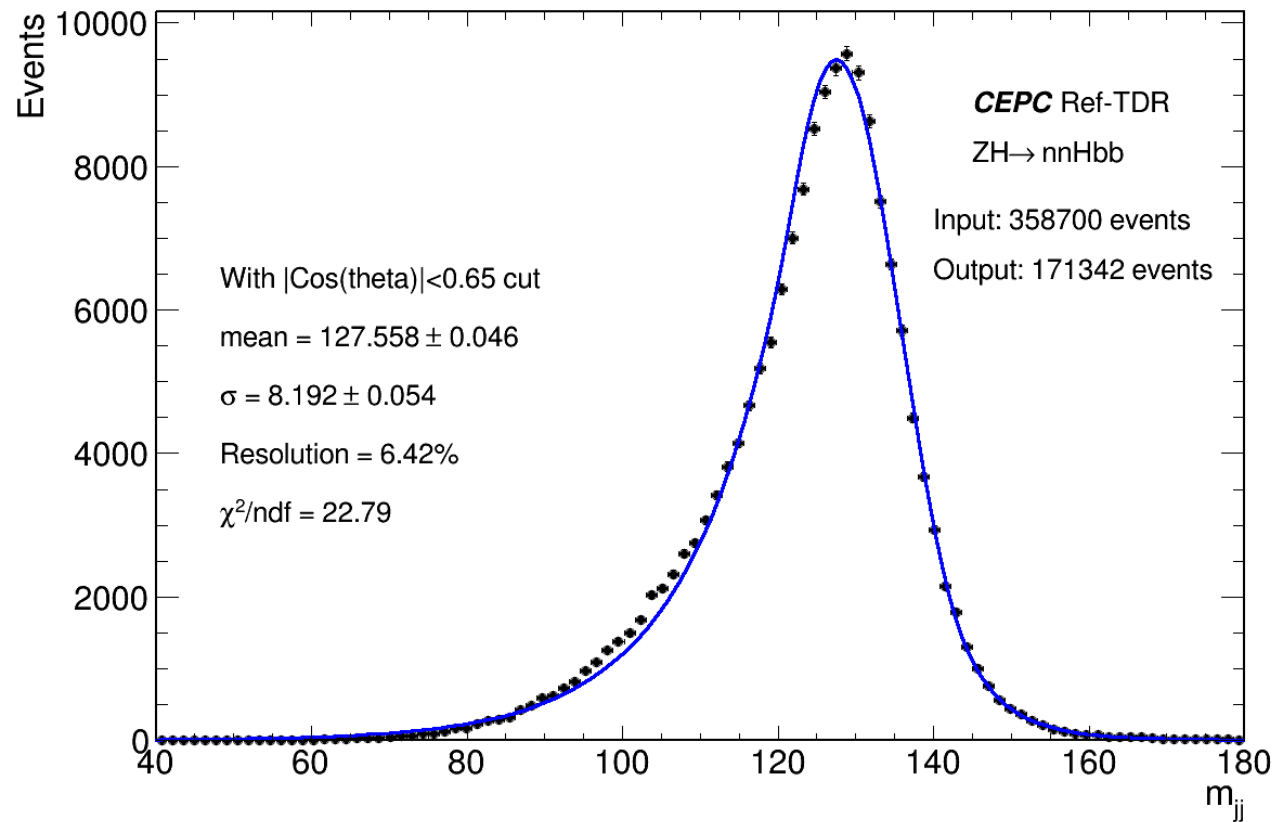
- /cefs/higgs/zhangkl/Production
 - 400k ZH->vvbb, cc, dd, ss, uu, gg samples ready.
- Tell me if you have sample requirement.

```
if (cc=="nnHbb") Flow->Add("/cefs/higgs/zhangkl/Production/E240_nnHbb/jet_total.root");  
if (cc=="nnHcc") Flow->Add("/cefs/higgs/zhangkl/Production/E240_nnHcc/jet_total.root");  
if (cc=="nnHdd") Flow->Add("/cefs/higgs/zhangkl/Production/E240_nnHdd/jet_total.root");  
if (cc=="nnHss") Flow->Add("/cefs/higgs/zhangkl/Production/E240_nnHss/jet_total.root");  
if (cc=="nnHuu") Flow->Add("/cefs/higgs/zhangkl/Production/E240_nnHuu/jet_total.root");  
if (cc=="nnHgg") Flow->Add("/cefs/higgs/zhangkl/Production/E240_nnHgg/jet_total.root");
```

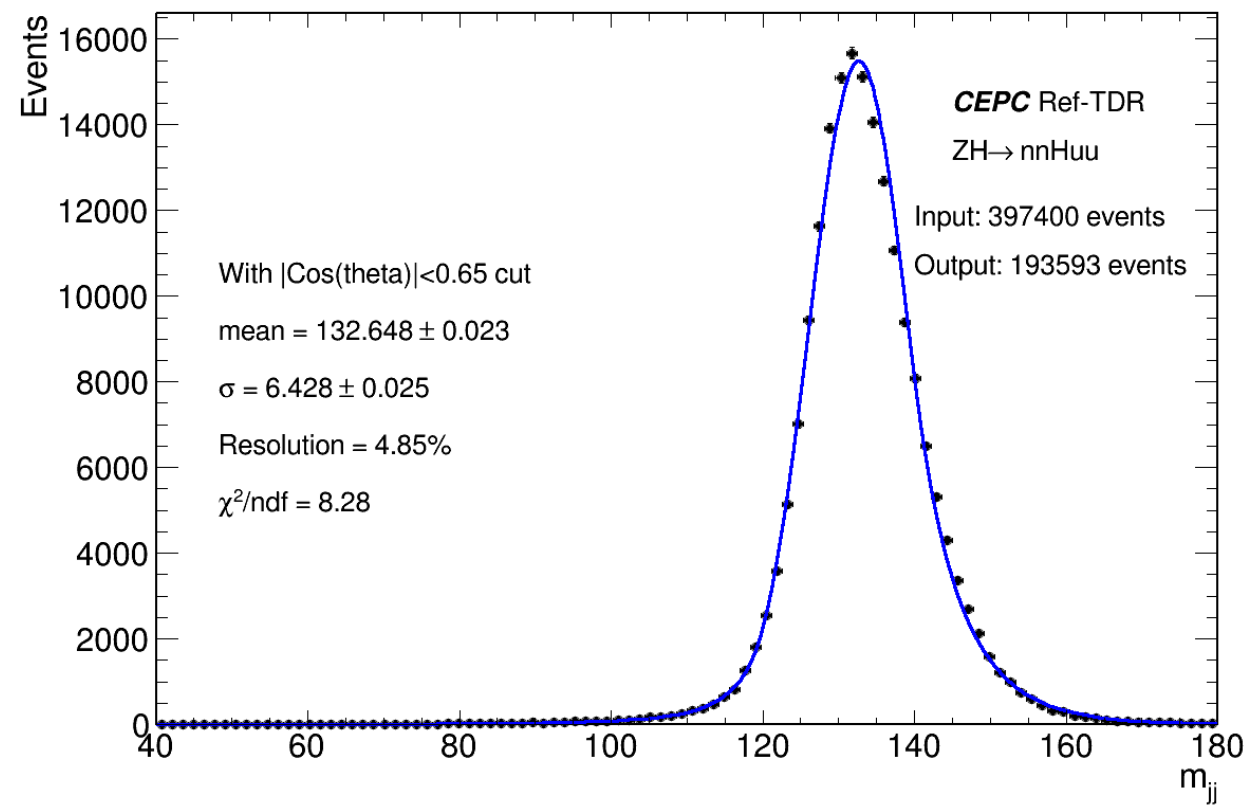
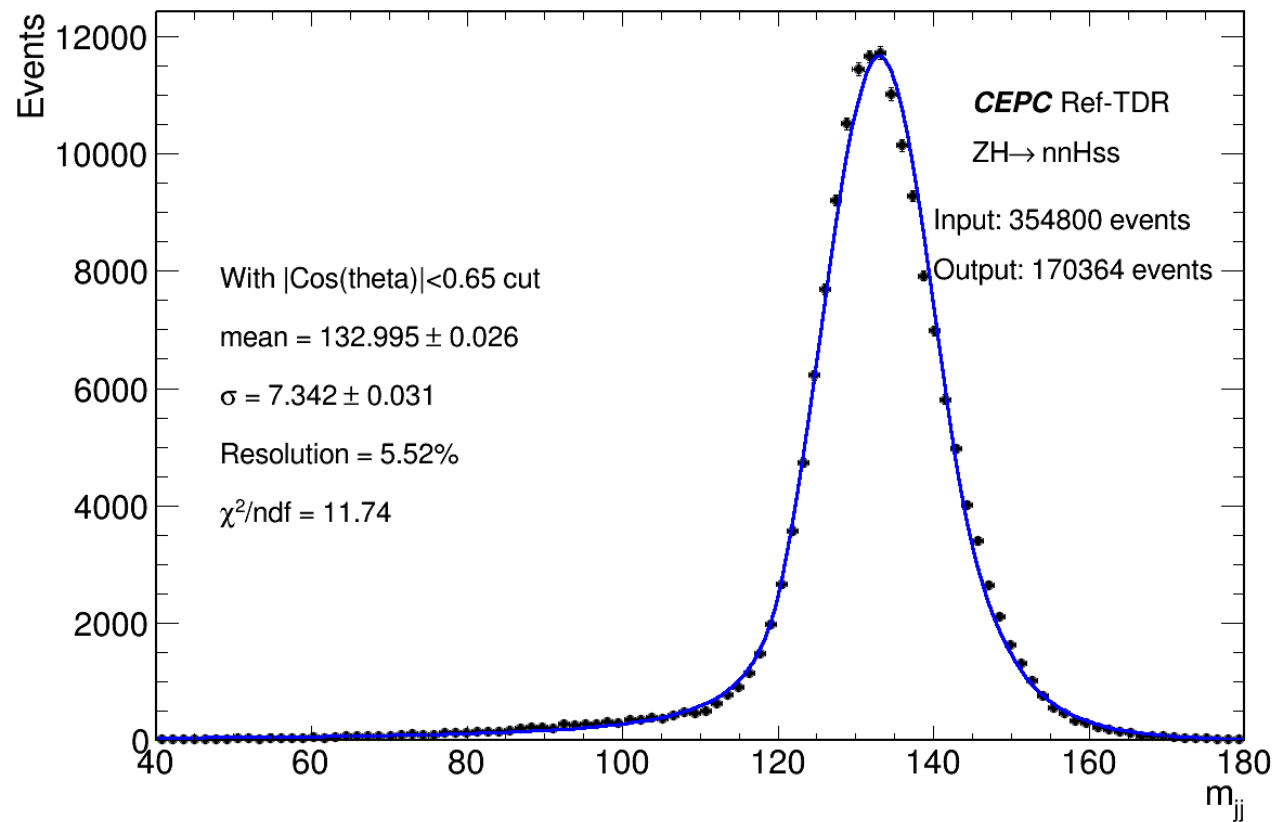
Jet with flavor



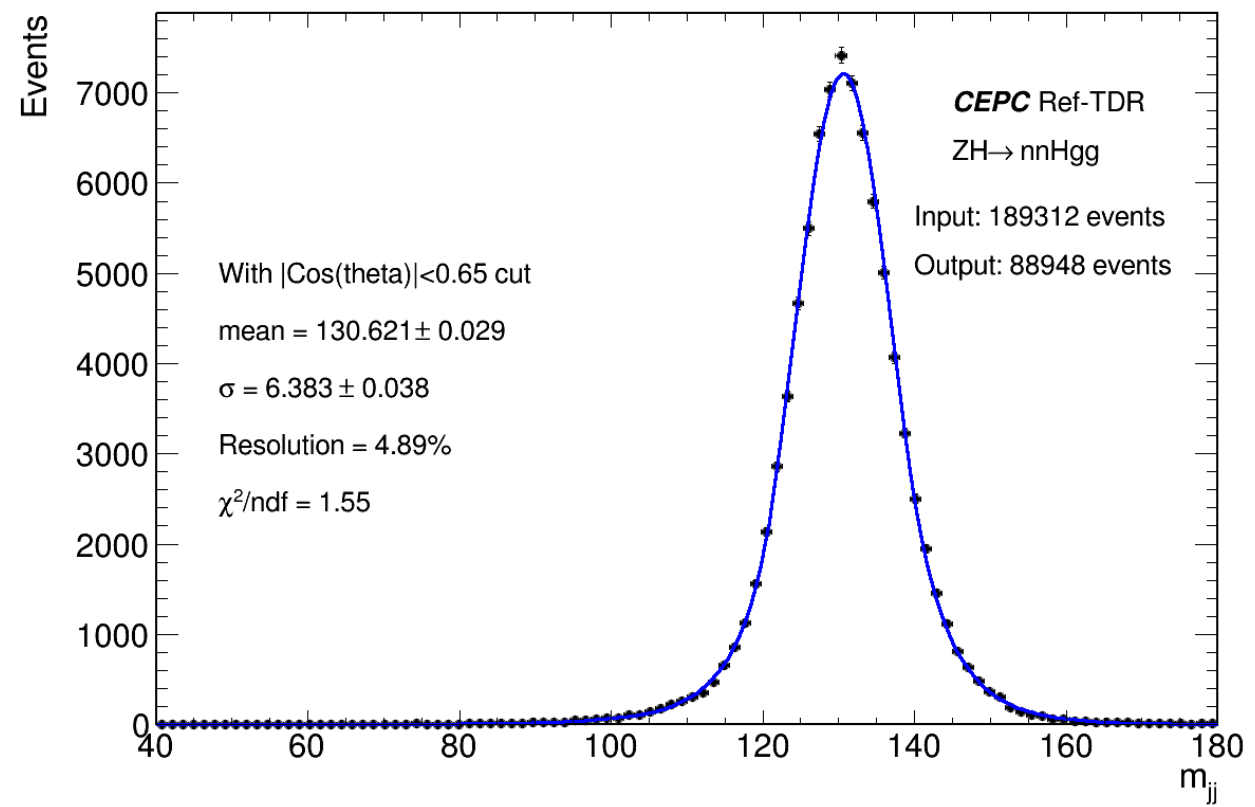
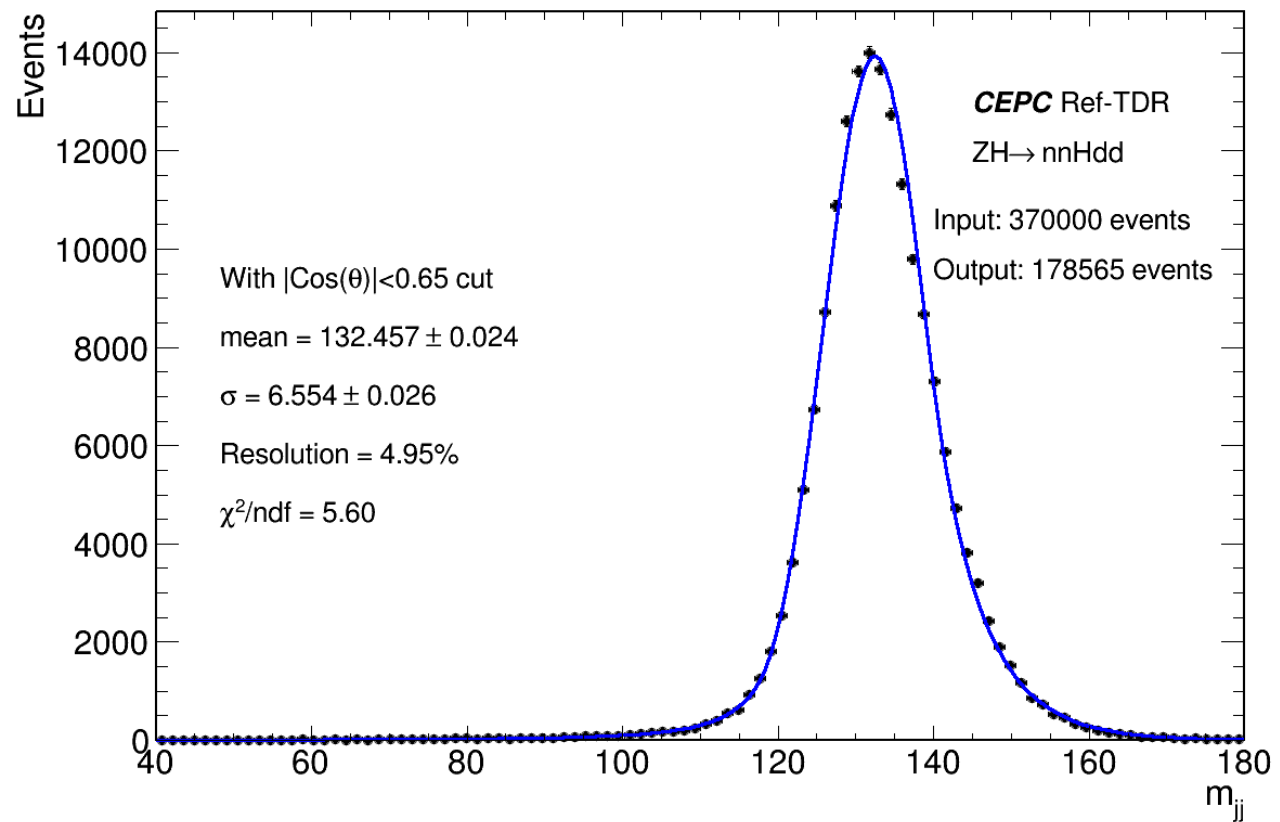
Behaviors need further study/check.
Mean Value;
Resolution...



Jet with flavor



Jet with flavor



Energy in Ecal and Hcal

Variables in jet.root:

Find definitions in GenMatch.cxx from Zebing

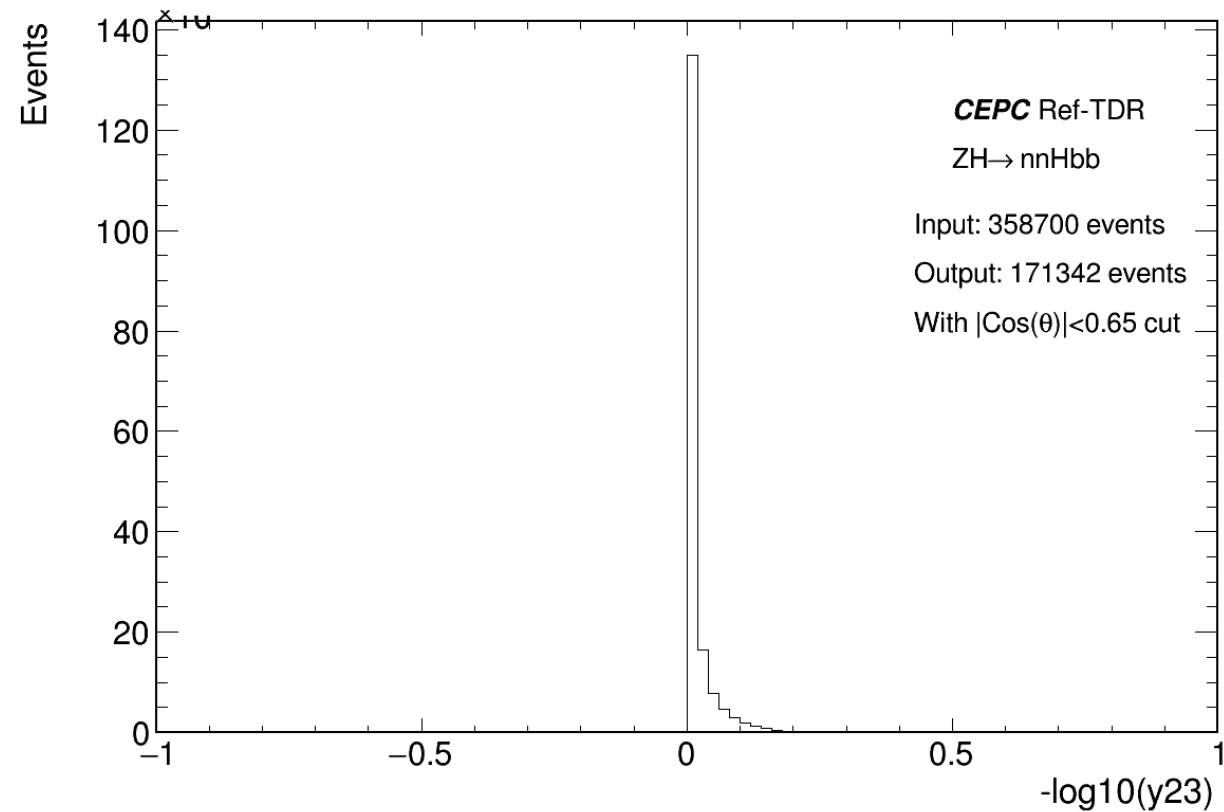
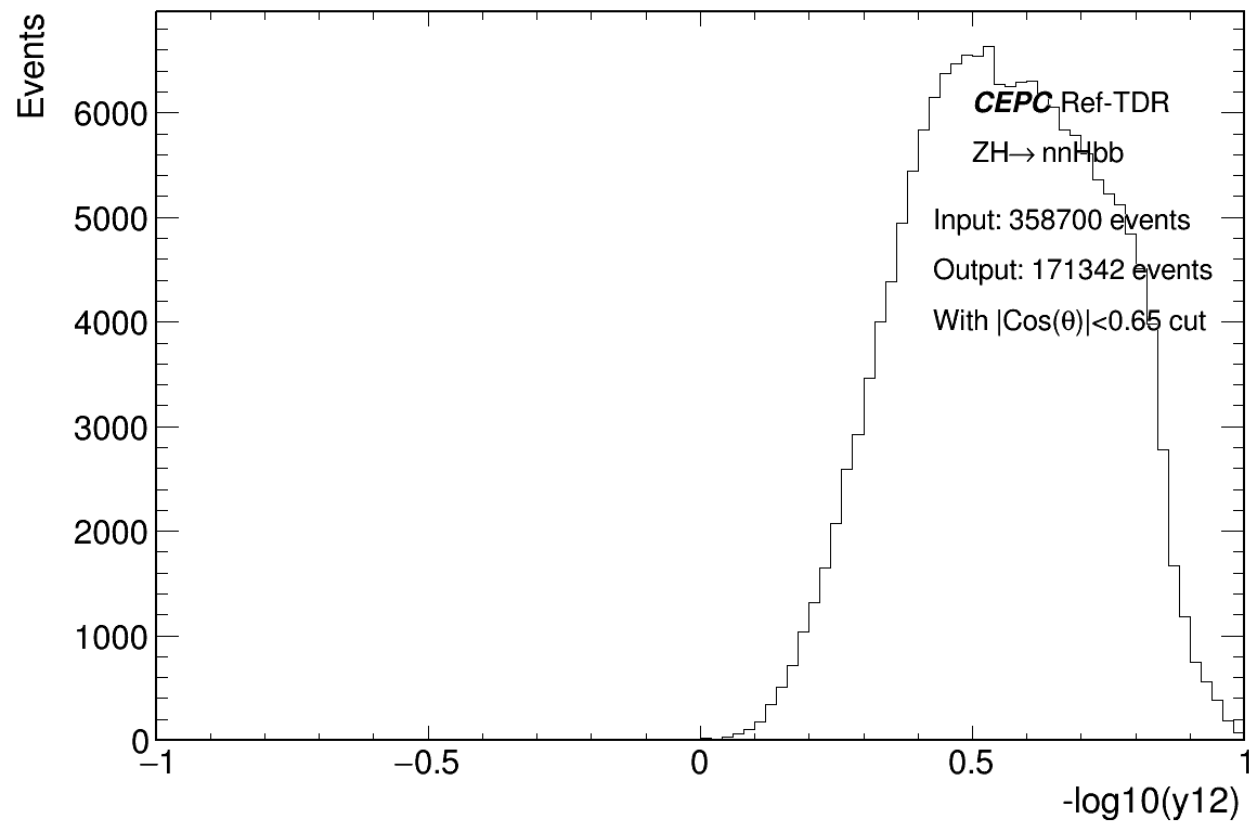
2130: E/Hcal boundary.

```
float PFO_Energy_Charge_Sector_Origin_E_temp = 0.0;
for (unsigned i = 0; i < pfo.clusters_size(); i++){
    if (TMath::Sqrt(pfo.getClusters(i).getPosition().x * pfo.getClusters(i).getPosition().x + pfo.getClusters(i).getPosition().y * pfo.getClusters(i).getPosition().y) < 2130){
        PFO_Energy_Charge_Ecal_temp += pfo.getClusters(i).getEnergy();
    }else{
        PFO_Energy_Charge_Hcal_temp += pfo.getClusters(i).getEnergy();
    }
}

PFO_Energy_Charge_Ecal.push_back(PFO_Energy_Charge_Ecal_temp);
PFO_Energy_Charge_Hcal.push_back(PFO_Energy_Charge_Hcal_temp);
```

Y12, y23...

ymerge variable. For original 2 jets events,
 Typically, its ymerge[0], or $-\log_{10}(y_{12})$ would be not zero,
 And all following y would be ~ 0 .
 A selection to distinguish n jets.



Jet tasks to do



Your contributions are welcome!

- Jet Gen Match
- JE, JA related plots
- BMR plots
- Neutral jet superclusters
- Particle gun one-type particle response
 - Photon: @Reda
- Remove isolated lepton/photon in PFO then jet clustering.
 - Need a quick PID

@Jiarong

@Yingqi

@Xiaotian

@Danning

Tasks sub priority



- Jet Event display
- Validation ee-kt algorithm with others.
- Validation generator Whizard with others.
- Flavors/JOI
- Endcap jet performance
- Repeat Ecal/Hcal performance

Isolated objects @Danning

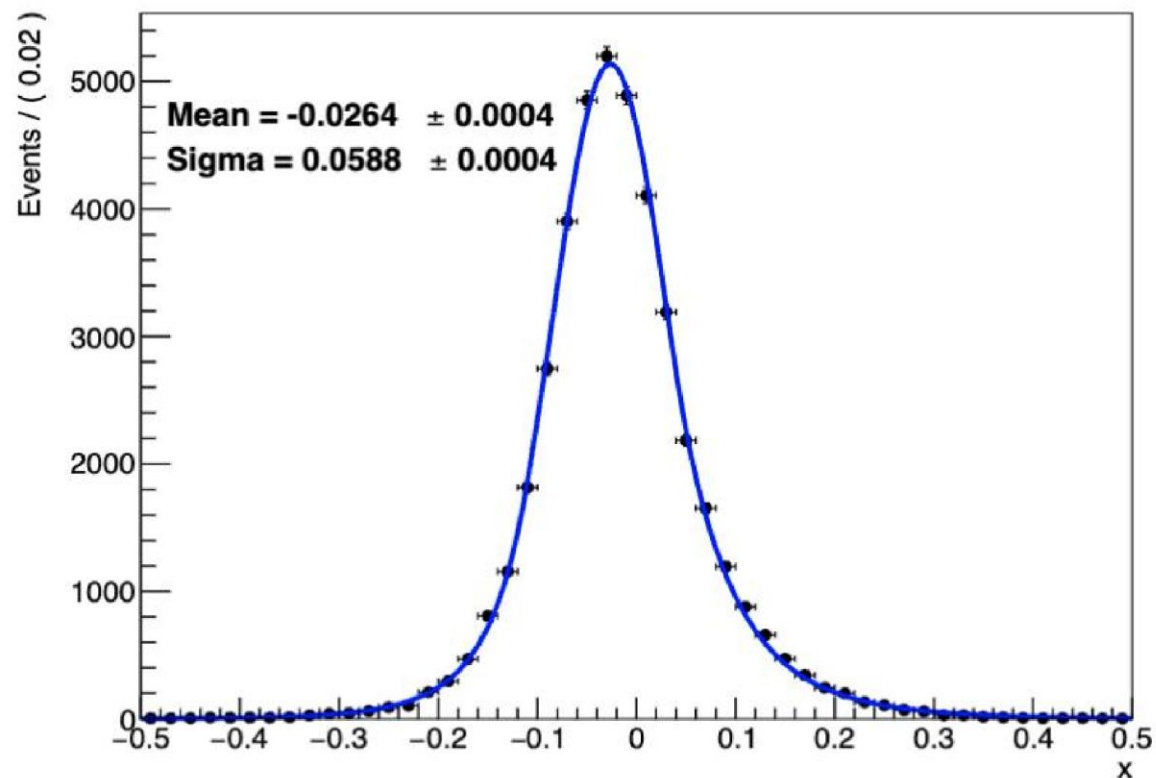


```
1 | Muon      Electron
2 | E_ecal / E_total    <0.5    >0.6
3 | E_total / P_track   <0.3    >0.9
4 |
5 | Muon, elctron: Charged+.
6 | Photon:          No track; No Charge; Only Ecal deposit.
7 |
8 | Energy threshold: ~10GeV.
9 |
10 | Overlap Removal. (Muon in Jet)
11 |
12 | - 实现简单的PID. e/mu /gamma separation.
13 | - isolated lepton/photon处理方式。参考ATLAS: dr0.4椎体内 其他objects 能量小于(0.1E+1) (0.022E+7) (yy->E, lepton->P) 数值待测试。
14 | - FixedCutLoose
15 |
16 | Sample like: Z->mm H->inclusive
17 |
```

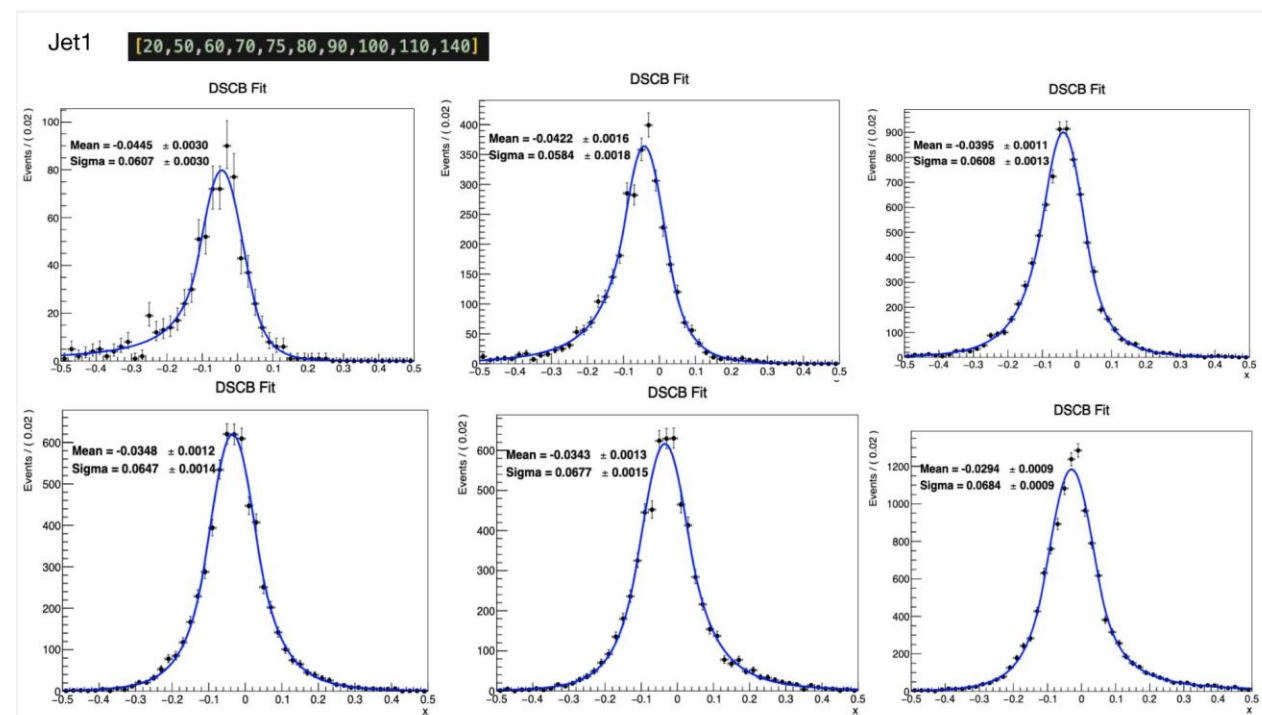
Backups

$\nu\nu\text{Hbb}$. With $|\cos\theta| < 0.85$

jet1 + jet2
DSCB Fit



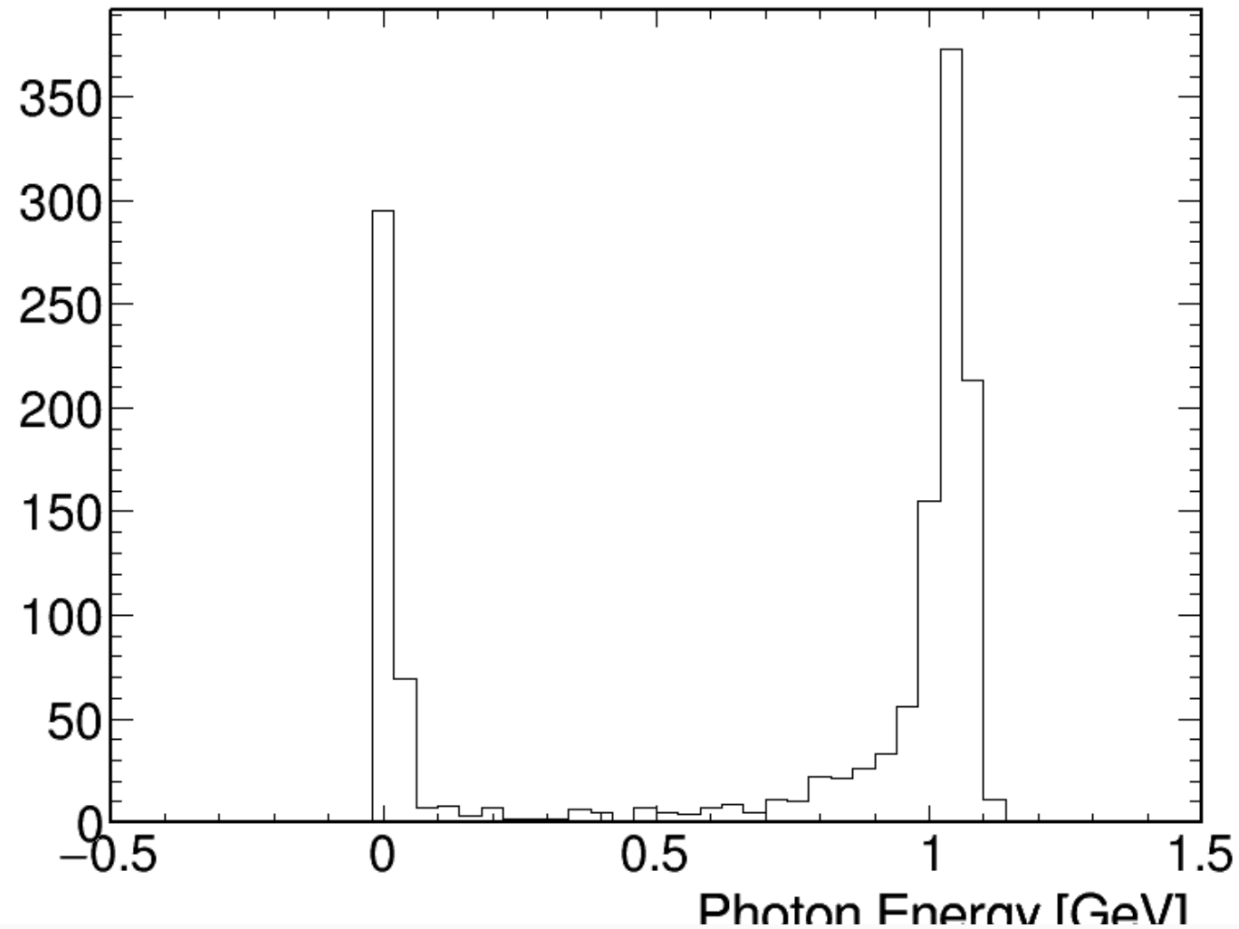
With different Energy bins.



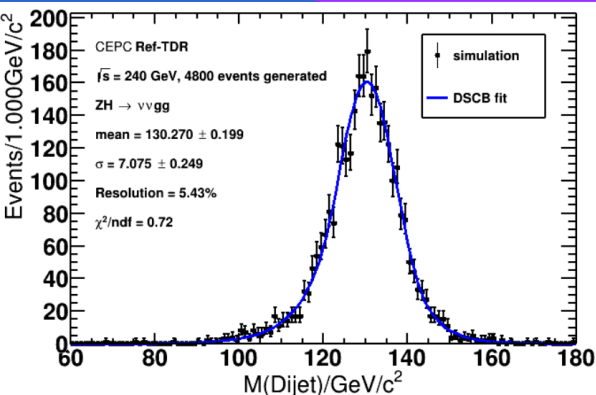
Single photon gun @ Reda

Start to look at the photon gun behavior.

For 1 GeV single photon events:



Performance study -- BMR



$ZH \rightarrow vvgg$
Release version:
CEPCSW_tdr24.9.1

$|\cos\theta_{jet}| < 0.85$:
 $m_H = 130.270 \pm 0.199$
Resolution 5.43%

Efficiency cutflow	
$ \cos\theta_{jet} < 0.85$	0.71
truthmatch	0.69
$\Delta R < 0.6$	0.65

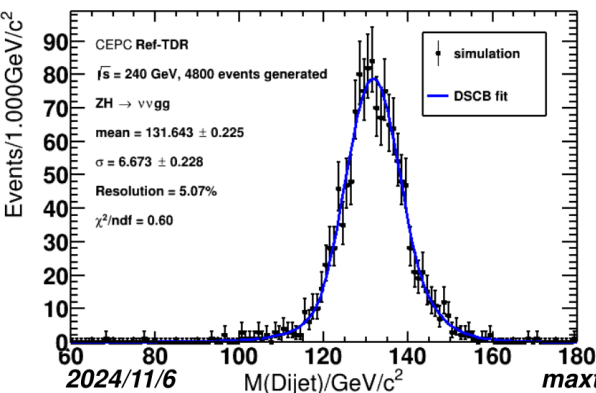
Efficiency cutflow	
$ \cos\theta_{jet} < 0.5$	0.32
truthmatch	0.31
$\Delta R < 0.6$	0.29

$|\cos\theta_{jet}| < 0.5$:
 $m_H = 131.643 \pm 0.225$
Resolution 5.07%

[reference](#)

Table 3. Higgs boson mass resolution (sigma/Mean) for different decay modes with jets as final state particles, after event cleaning.

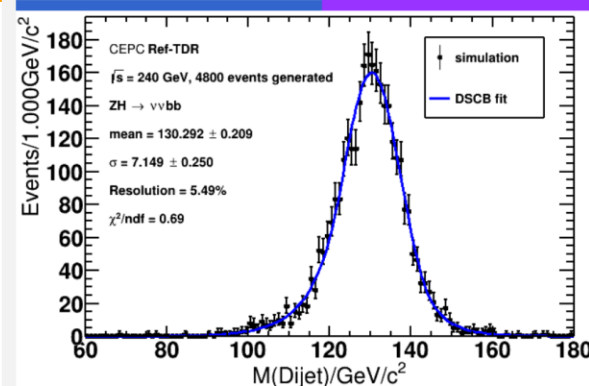
$H \rightarrow bb$	$H \rightarrow cc$	$H \rightarrow gg$	$H \rightarrow WW^*$	$H \rightarrow ZZ^*$
3.63%	3.82%	3.75%	3.81%	3.74%



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1

Performance study -- BMR



$ZH \rightarrow vvb$
CEPCSW_tdr24.9.1

$|\cos\theta_{jet}| < 0.85$:
 $m_H = 130.292 \pm 0.209$
Resolution 5.49%

Efficiency cutflow	
$ \cos\theta_{jet} < 0.85$	0.71
truthmatch	0.69
$\Delta R < 0.6$	0.65

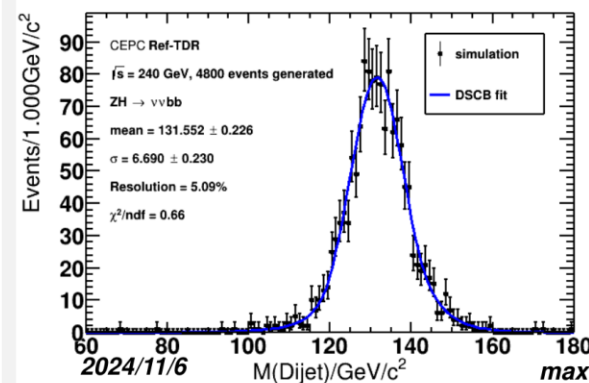
Efficiency cutflow	
$ \cos\theta_{jet} < 0.5$	0.32
truthmatch	0.31
$\Delta R < 0.6$	0.29

$|\cos\theta_{jet}| < 0.5$:
 $m_H = 131.552 \pm 0.226$
Resolution 5.09%

[reference](#)

Table 3. Higgs boson mass resolution (sigma/Mean) for different decay modes with jets as final state particles, after event cleaning.

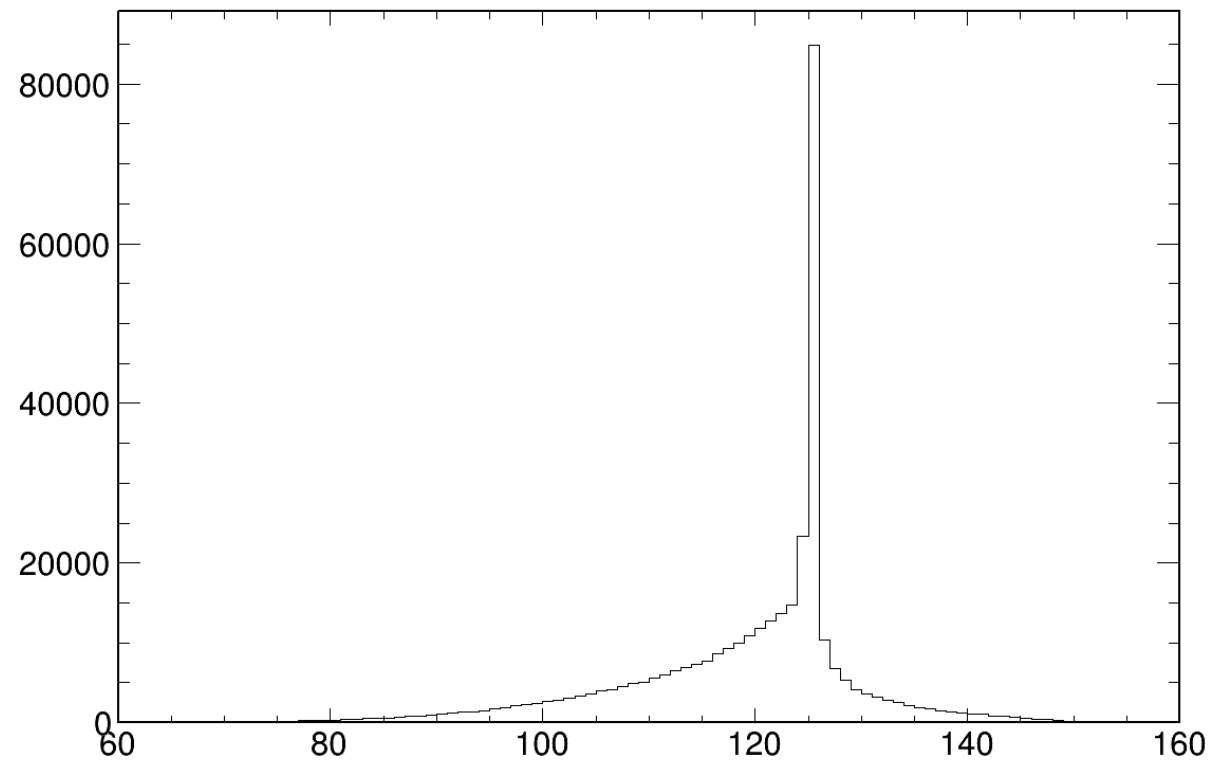
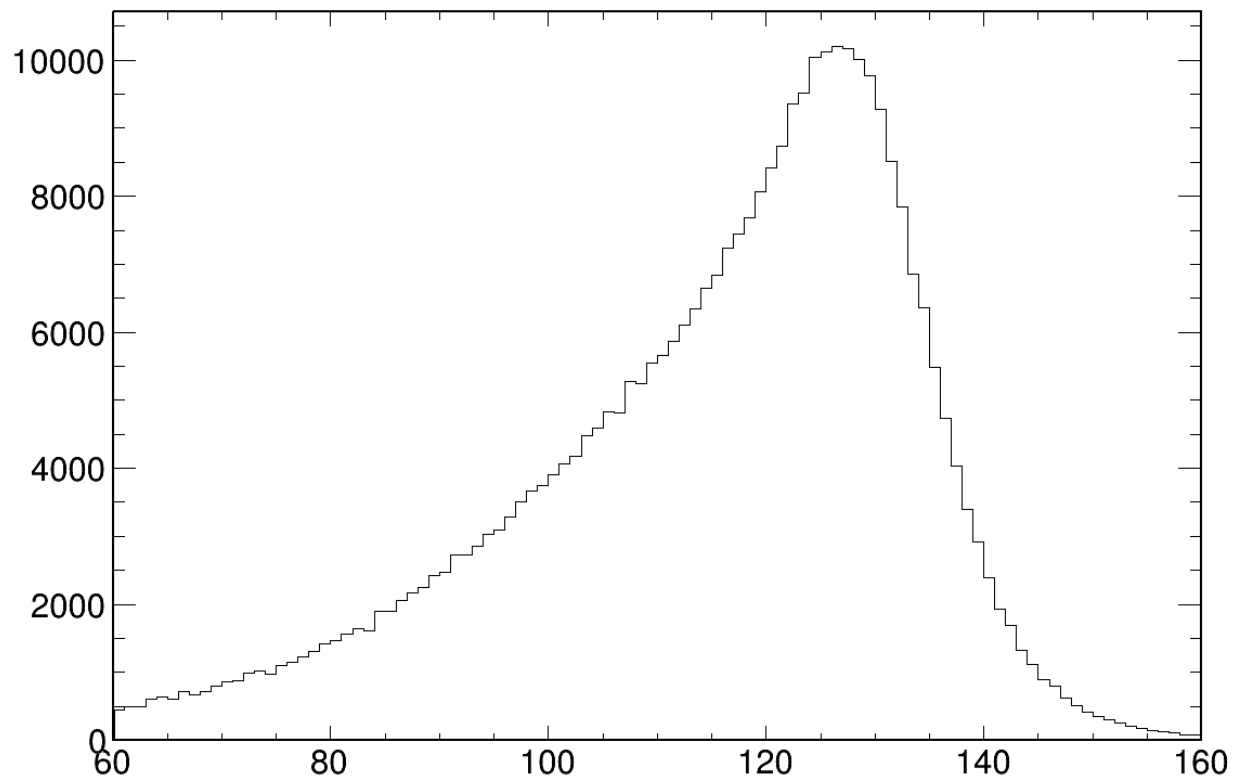
$H \rightarrow bb$	$H \rightarrow cc$	$H \rightarrow gg$	$H \rightarrow WW^*$	$H \rightarrow ZZ^*$
3.63%	3.82%	3.75%	3.81%	3.74%

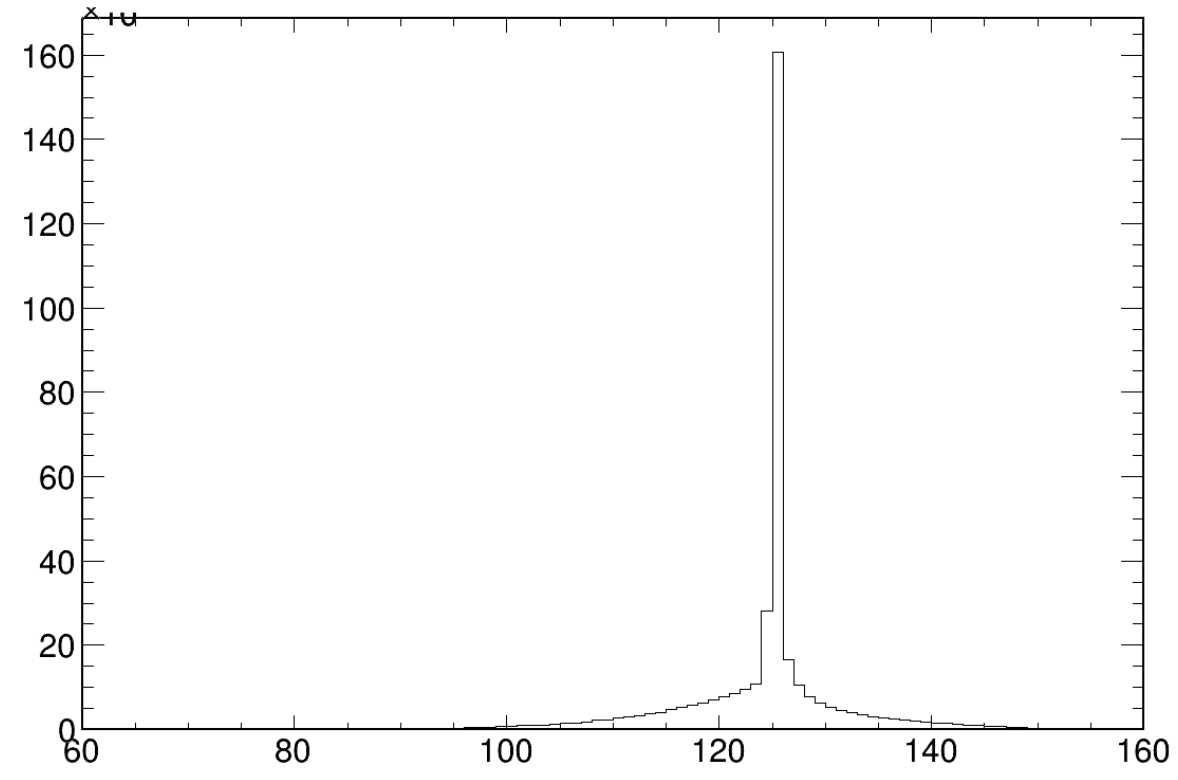
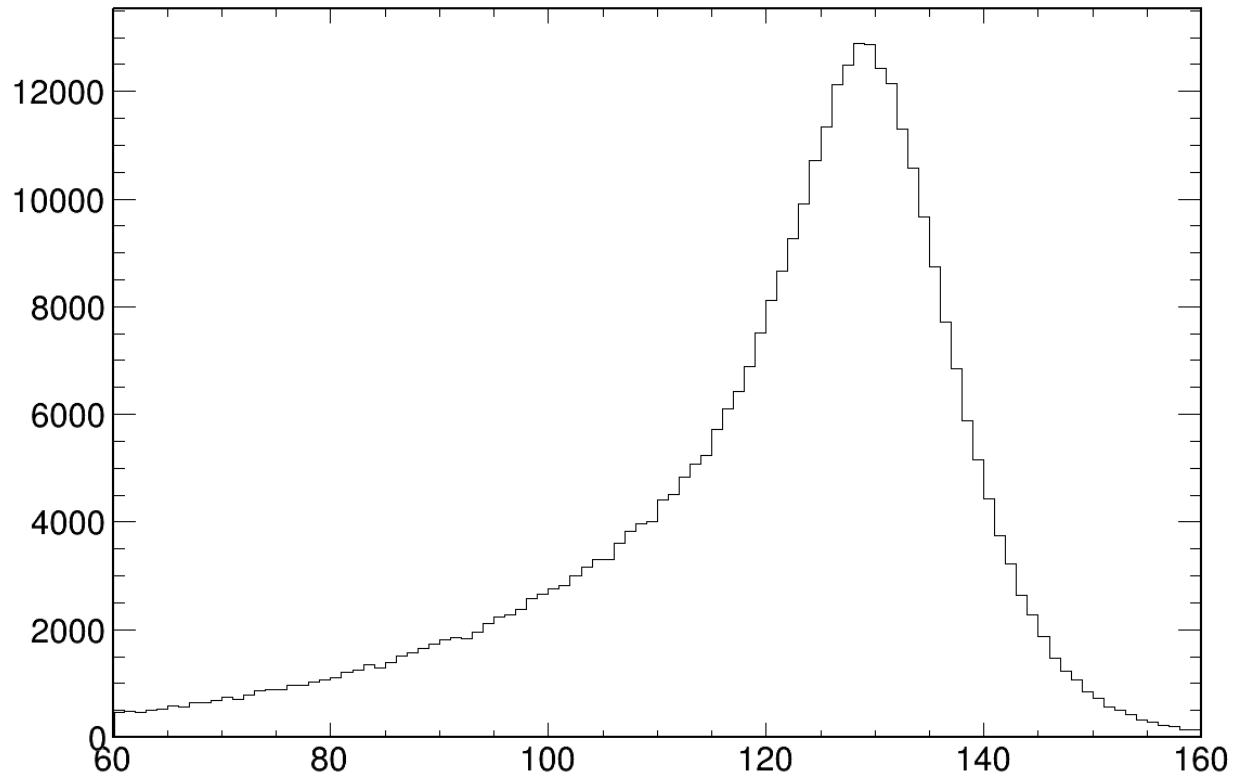


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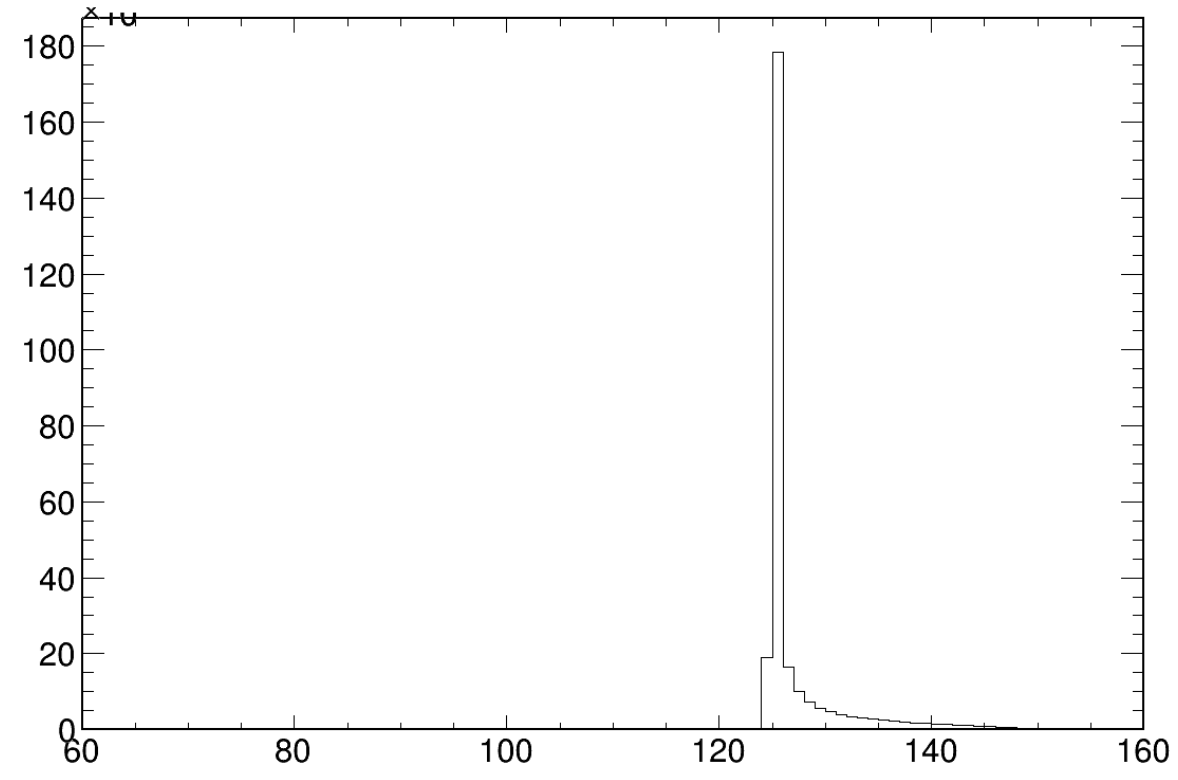
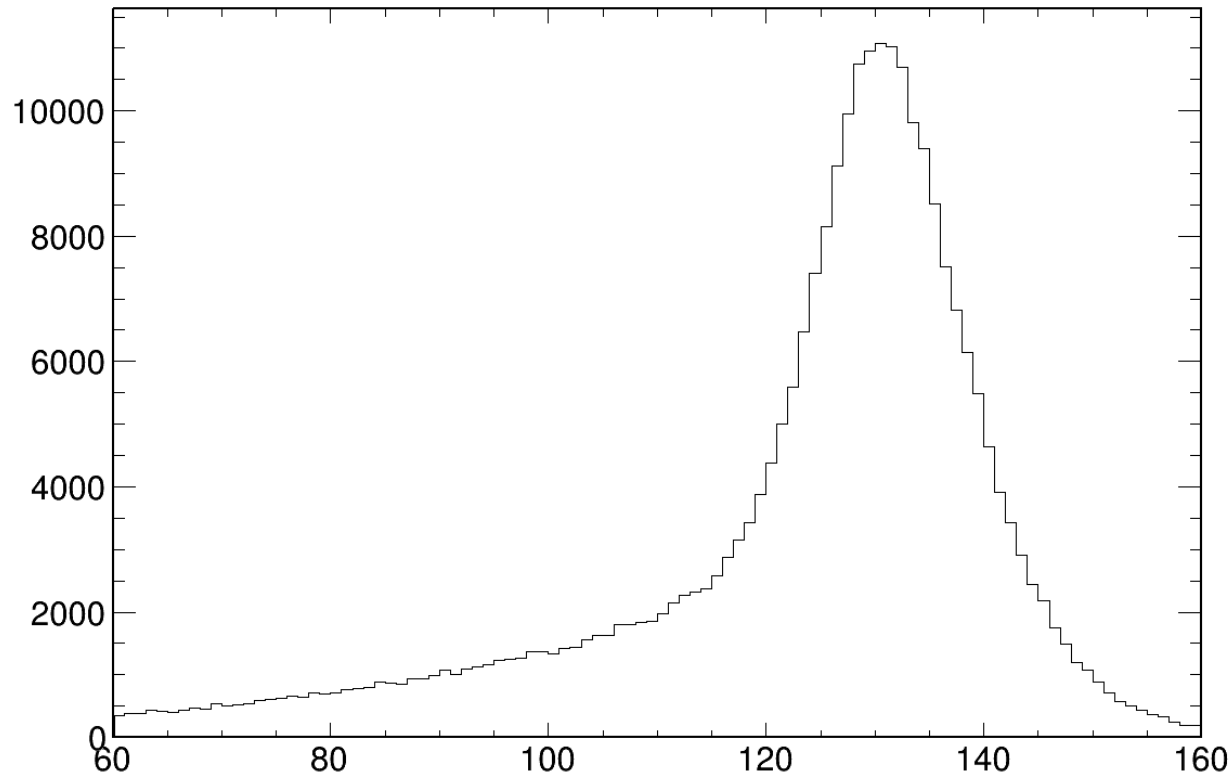
2

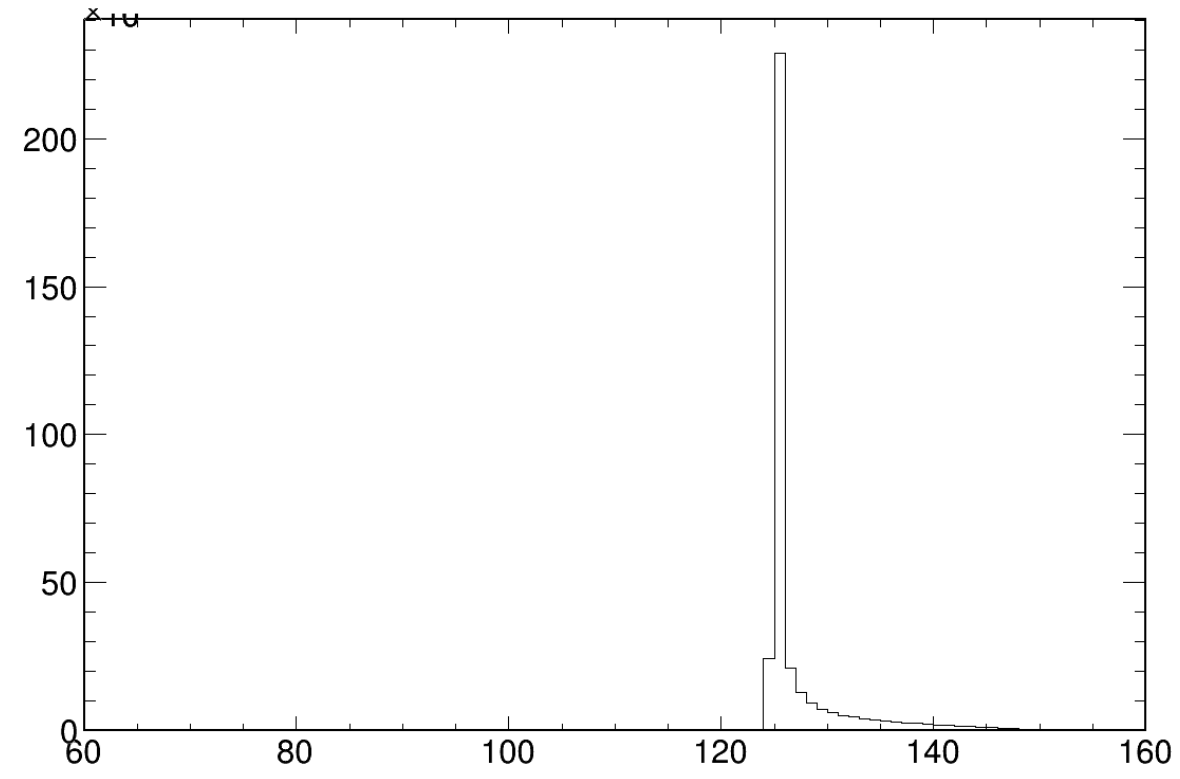
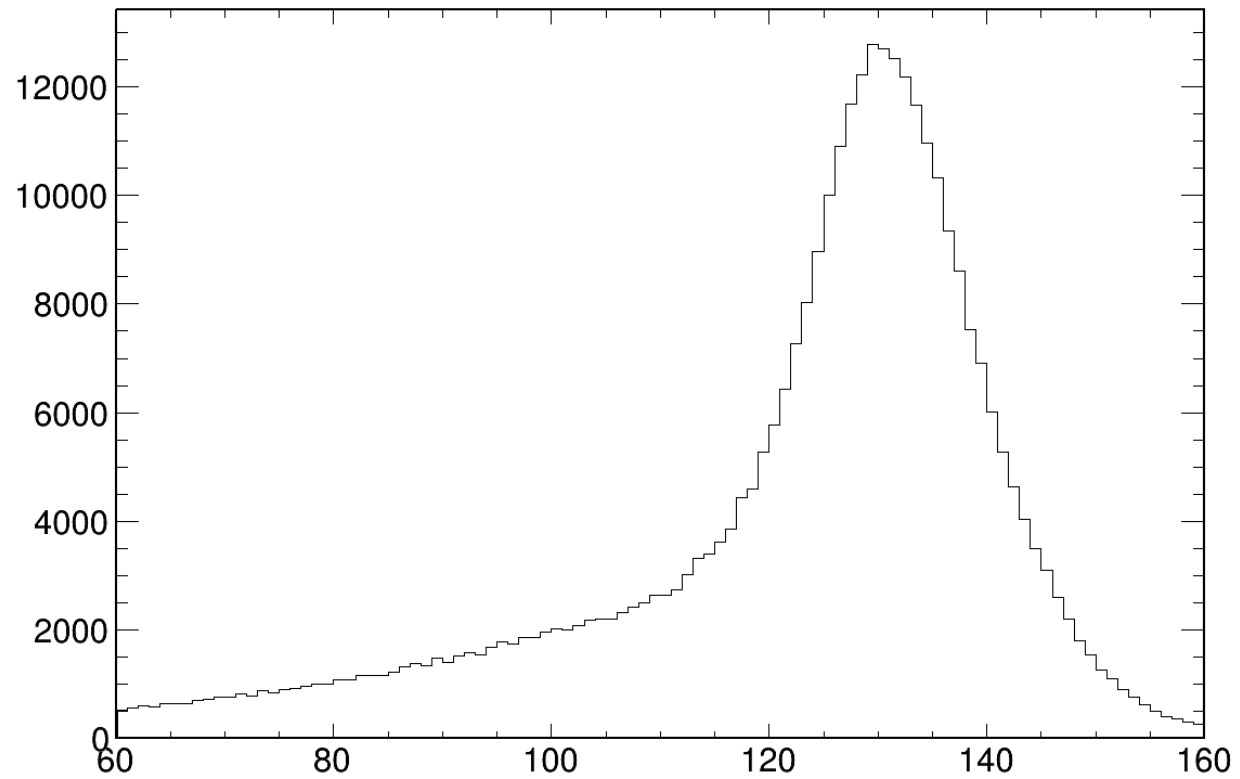
bb





dd





Machine Learnings on Jets



- P-CNN
 - <https://scipost.org/10.21468/SciPostPhys.7.1.014>
- Particle Flow Network
 - <https://arxiv.org/abs/1810.05165>
 - CEPC@Xiaotian : <https://arxiv.org/abs/2410.04465v2>
- LundNet
 - [https://doi.org/10.1007/jhep03\(2021\)052](https://doi.org/10.1007/jhep03(2021)052)
- ParticleNet
 - Arxiv:1902.08570
 - <https://github.com/hqucms/ParticleNet>

- <https://arxiv.org/abs/2202.03772>
- https://github.com/jet-universe/particle_transformer
- Platforms: <https://github.com/hqucms/weaver-core>
- Application on CEPC: [2309.13231](#), [PRL 132, 221802 \(2024\)](#)
- Tutorial on CEPC: <https://github.com/ZHUYFgit/CEPC-Jet-Origin-Identification>
- Inputs from CEPCsoft: `/cefs/higgs/zhangkl/AI/datasets`
- Inputs from LHC, [JetClass](#): `/cefs/higgs/zhangkl/AI/jetclass`
- Require higgsgpu group. Request on <https://ccsinfo.ihep.ac.cn/>
- Follow the tutorial, build the env if you are interested.

ParticleTransformer @ CEPC



- Variable list in M11origin.cc
 - Under development to CEPCSW
 - Unit as one jet: 4 momentum, M11 id information.....
- Train in Weaver: JetClass_full.yaml
- Submit jobs on IHEP: train_JetClass.sh
- Output: Pred.root: Label and score for each jets.
- Application: onnx format