BMR -- Status

- BMR performance in $ZH \rightarrow \nu\nu + gg/bb/cc$ with $\sqrt{s} = 240\mathrm{GeV}/c^2$
- Understanding of long tail in truth Higgs mass
- BMR detector performance with event cleaning
- Distributions and cuts
- Samples generated under CEPCSW_tdr24.12.0 -- master
  - /cefs/higgs/maxiaotian/CEPCSW/sample/nogenmatch/24.12.0/
  - /cefs/higgs/zhangkl/Production/2412/

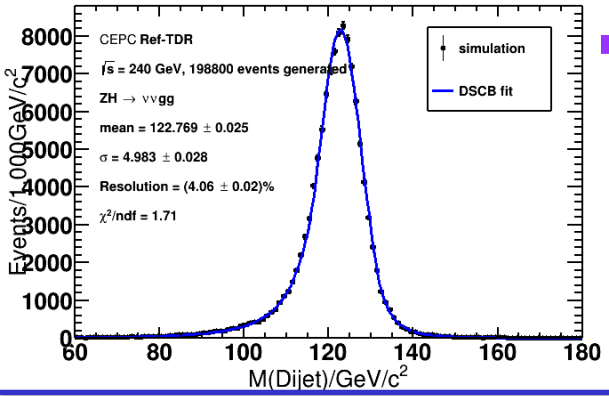
BMR -- performance

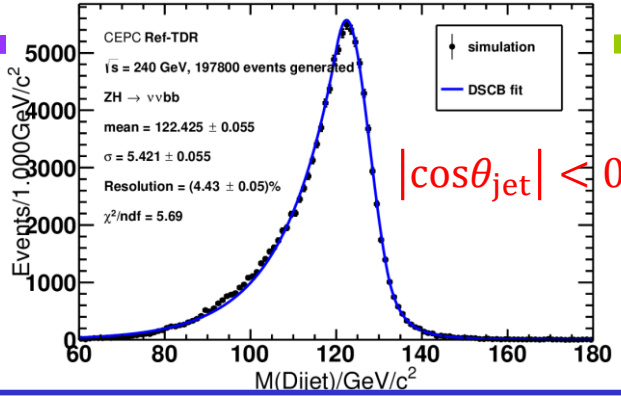
- BMR using different selections in $ZH \to \nu\nu + gg/bb/cc$ with $\sqrt{s} = 240\mathrm{GeV}/c^2$

Selection	process	$ZH \to \nu\nu gg$	$ZH \to \nu\nu bb$	$ZH \to \nu\nu cc$
$\lvert\cos\theta_{\mathrm{jet}}\rvert < 0.7$	BMR/%	4.06 ± 0.02	4.43 ± 0.05	4.21 ± 0.04
	Efficiency/%	59.3	58.0	57.9
$\lvert\cos\theta_{\mathrm{jet}}^{\mathrm{truth}}\rvert < 0.7$	BMR/%	4.03 ± 0.02	4.41 ± 0.05	4.18 ± 0.04
	Efficiency/%	54.1	54.6	54.7
$\mathrm{barrelratio} > 0.95$	BMR/%	3.81 ± 0.02	4.09 ± 0.06	4.00 ± 0.04
	Efficiency/%	26.5	38.8	37.4

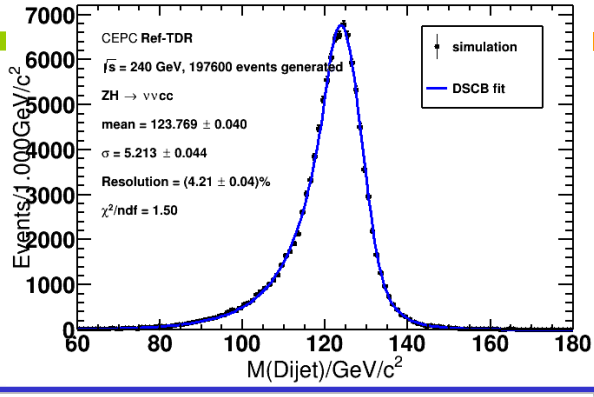
  - $\lvert\cos\theta_{\mathrm{jet}}\rvert < 0.7$: both jets $\cos\theta$ < 0.7
  - $\mathrm{Barrelratio} > 0.95$: ratio of mcparticle hitting barrel > 0.95
- Truth and reco level $\cos\theta_{\mathrm{jet}}$ cut's BMRs almost the same
- Barrelratio cut's BMRs improve a lot with lower efficiencies
  - BMR ranges from 3.81% to 4.09%

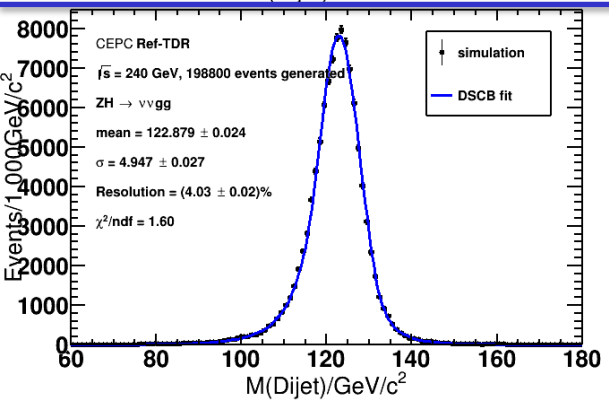
BMR -- fit

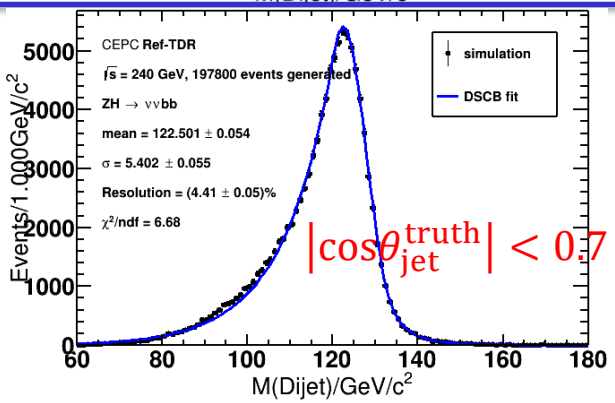




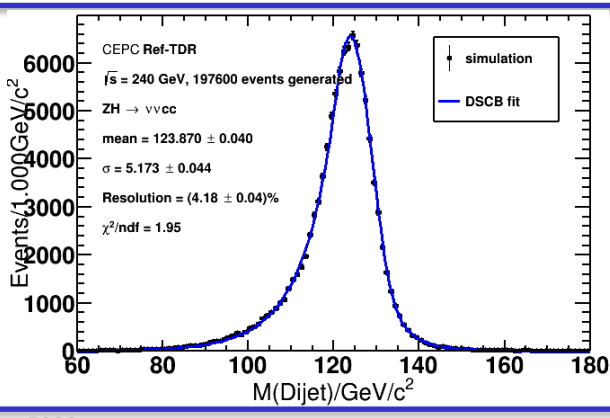
$|\cos\theta_{\text{jet}}| < 0.7$

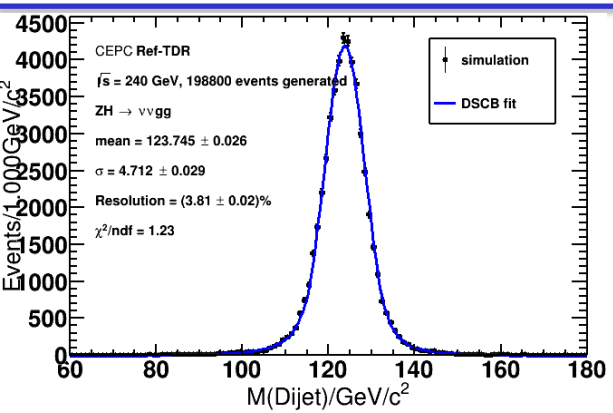




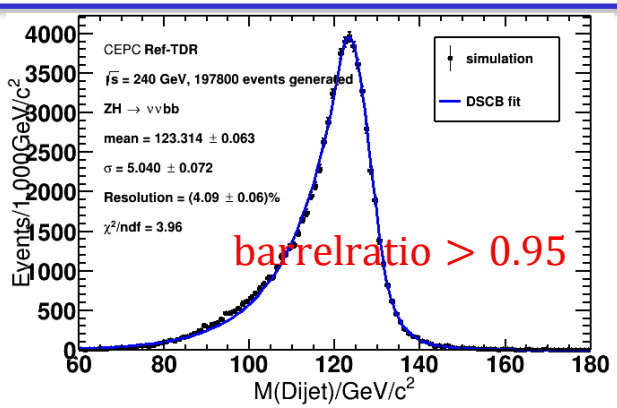


$|\cos\theta_{\text{jet}}^{\text{truth}}| < 0.7$



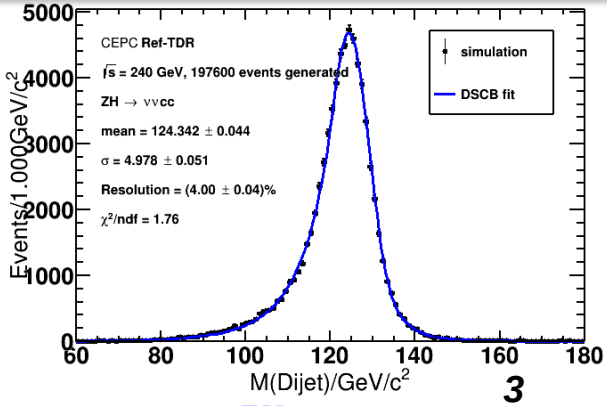


$ZH \to \nu\nu gg$



$\text{barrelratio} > 0.95$

$ZH \to \nu\nu bb$

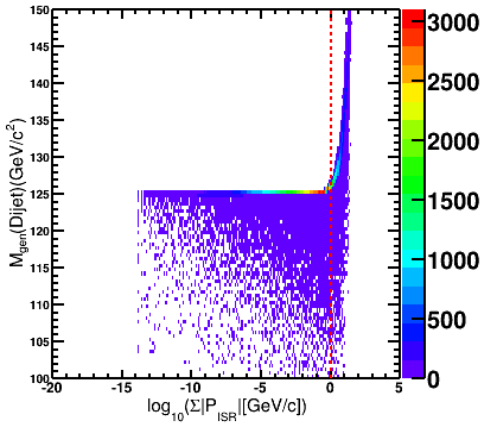


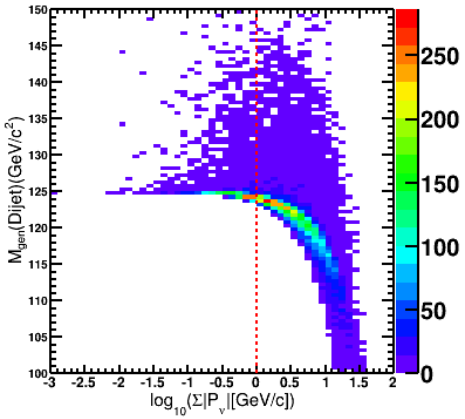
$ZH \to \nu\nu cc$

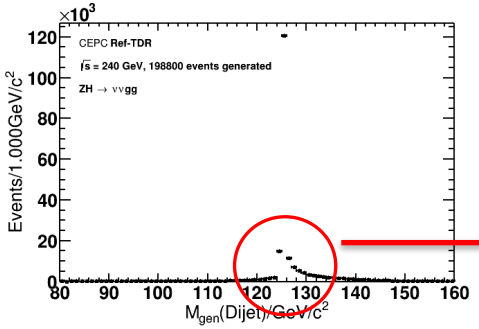
BMR -- tail in truth Higgs mass

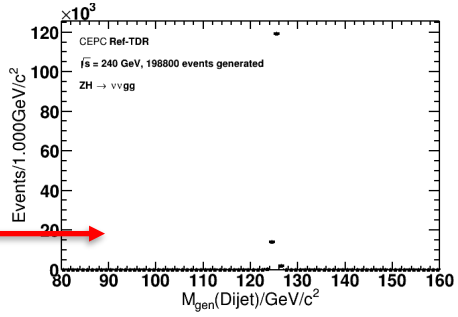
- Long tail of truth mass of Higgs in $ZH \rightarrow \nu\nu gg$
  - Strong correlations with $\Sigma P_{\mathrm{ISR}}/\Sigma P_{\nu}$ -> cut to remove tails

$\Sigma|P_{\mathrm{ISR}}| < 1\mathrm{GeV}/c$
$\&\Sigma|P_{\nu}| < 1\mathrm{GeV}/c$
Efficiency=0.725*0.938=68.0%

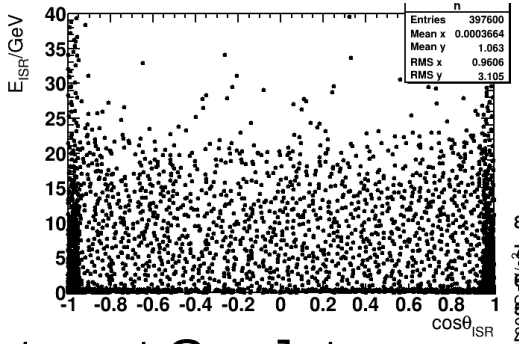


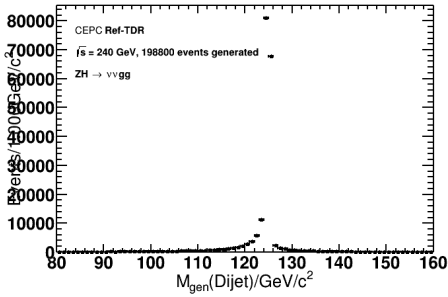






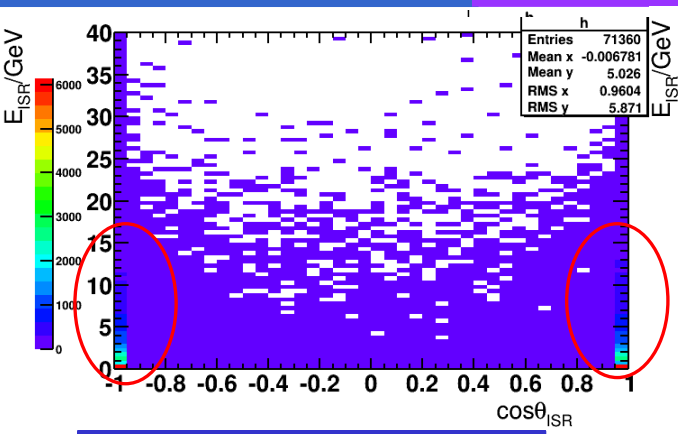
- ISR distribution
  - Ratio of ISR with energy > 1MeV: 42.85%
  - Ratio of ISR with energy > 1GeV: 14.47%
  - Ratio of ISR with cosθ > 0.99: 69.50%



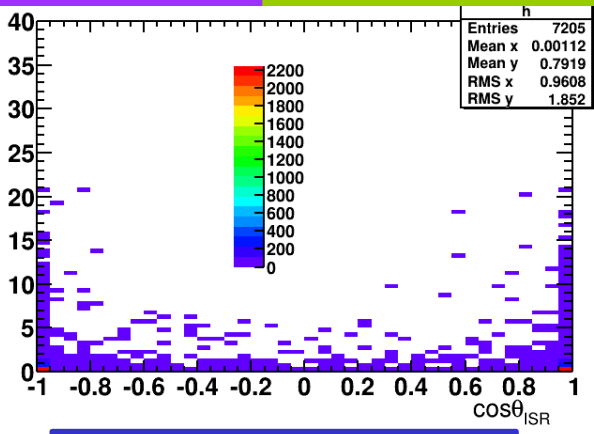


- Veto truth particle whose $\cos\theta > 0.99$ to get GenJet
  - High mass tail better but low mass tail worse

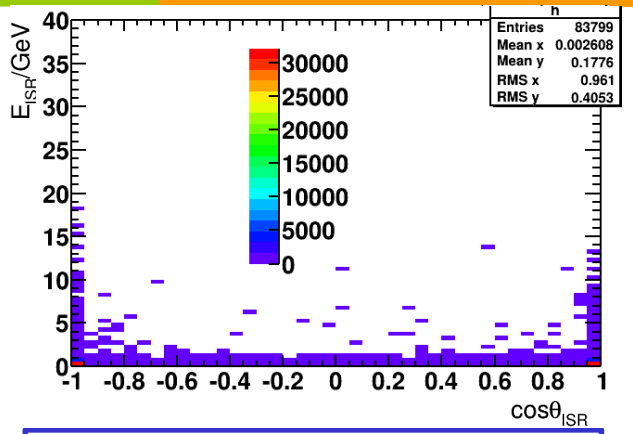
E_{ISR} VS $\cos\theta_{\mathrm{ISR}}$ VS $M^{\mathrm{gen}}_{\mathrm{Dijet}}$



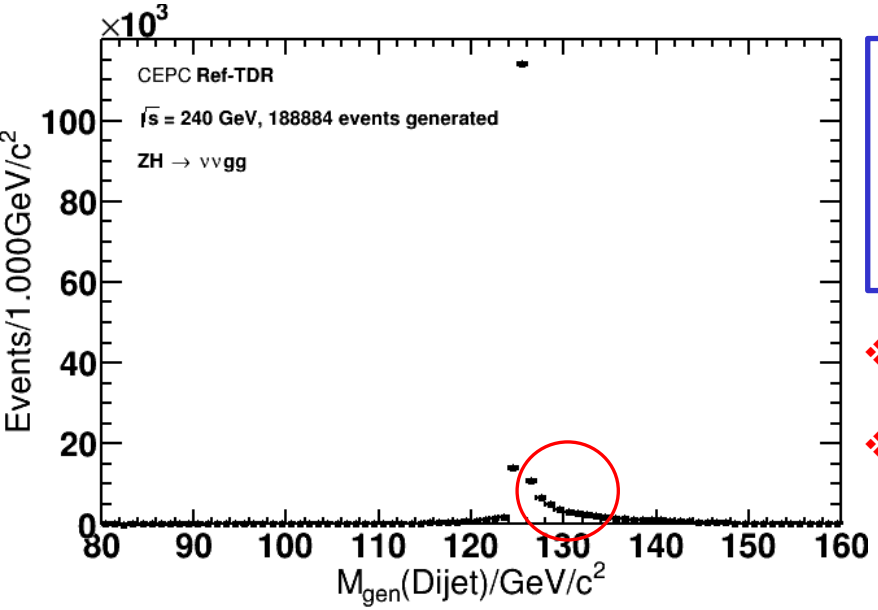
$M_{\mathrm{gen}}(\mathrm{Dijet}) > 126\mathrm{GeV}/c^2$



$M_{\mathrm{gen}}(\mathrm{Dijet}) < 124\mathrm{GeV}/c^2$



$124 < M_{\mathrm{gen}}(\mathrm{Dijet}) < 126\mathrm{GeV}/c^2$



$ZH \rightarrow \nu\bar{\nu}gg$

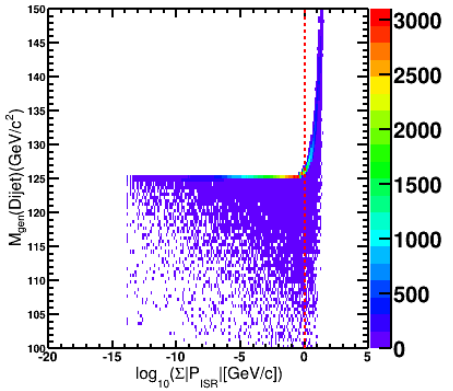
GenJet:

generatorStatus==1 and veto neutrinos

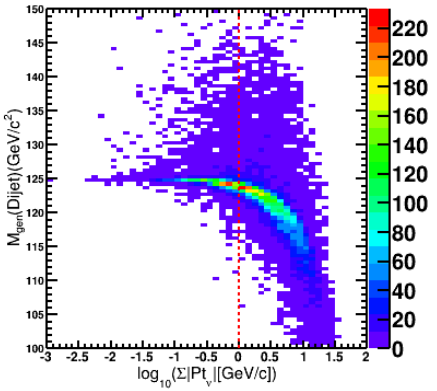
MCParticle pass ee_kt_algorithm

- Most ISR photons are along the beam
- Long tail in the right side could be explained by the high energy ISR photons which are included in the ee_kt_algorithm

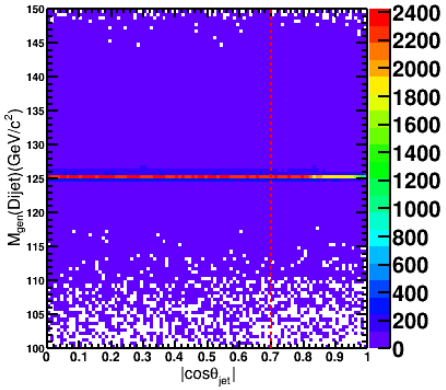
$M^{\mathrm{gen}}_{\mathrm{Dijet}}$ VS $\Sigma P(t)_{\mathrm{ISR}}/\Sigma P(t)_{\nu}$



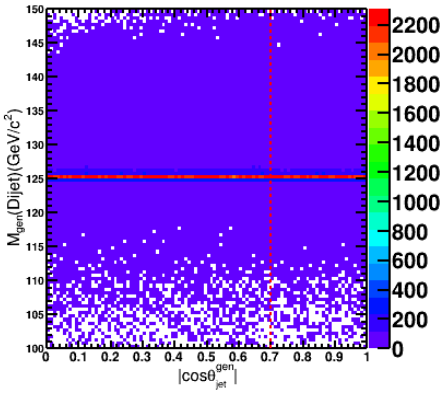
$\lg|\Sigma P_{\mathrm{ISR}}|$



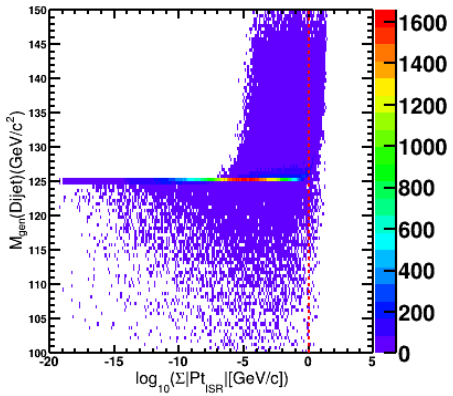
$\lg\Sigma|Pt_{\nu}|$



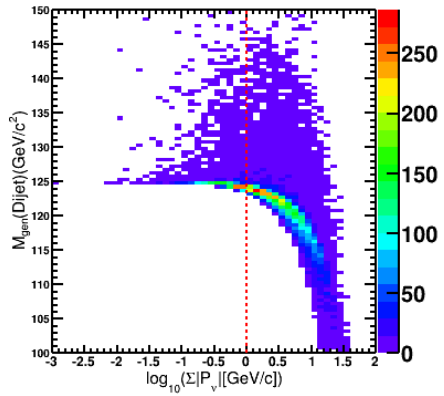
$|\cos\theta_{\mathrm{jet}}|$



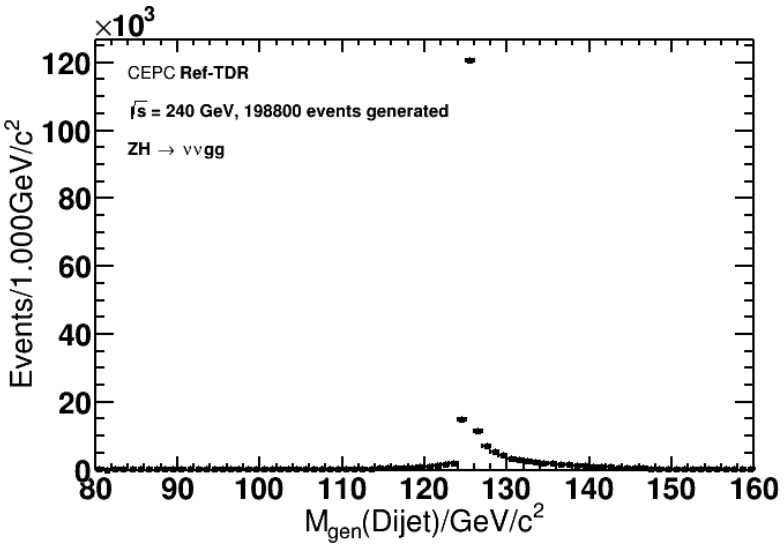
$|\cos\theta^{\mathrm{gen}}_{\mathrm{jet}}|$



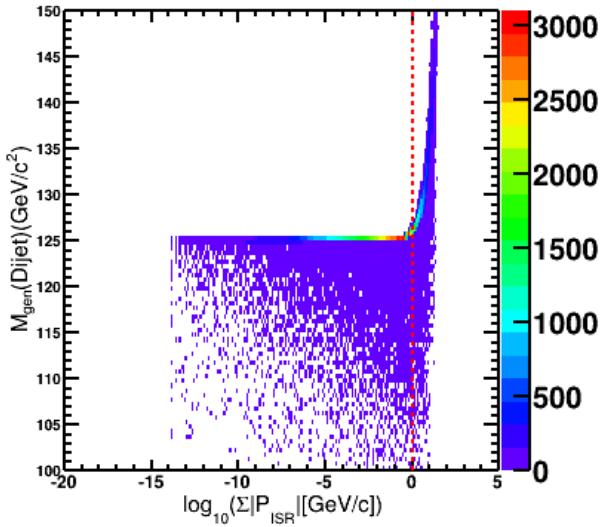
$\lg|\Sigma Pt_{\mathrm{ISR}}|$

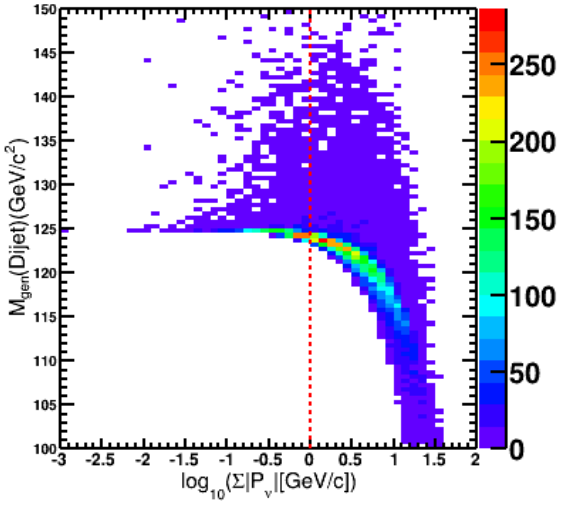


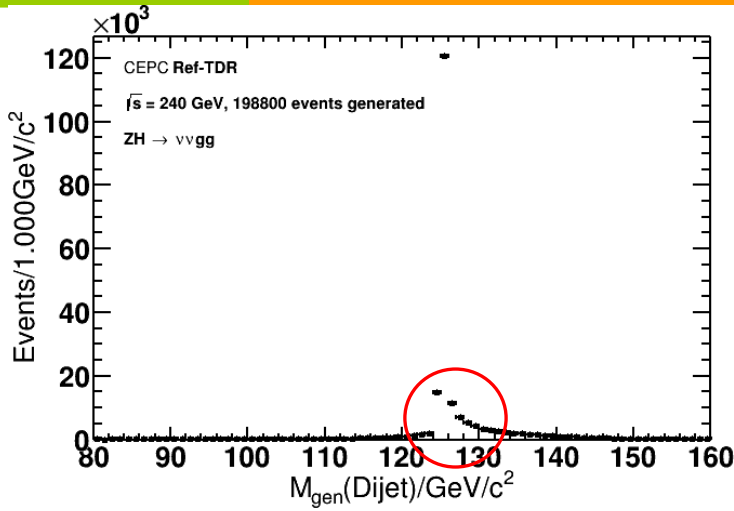
$\lg\Sigma|P_{\nu}|$

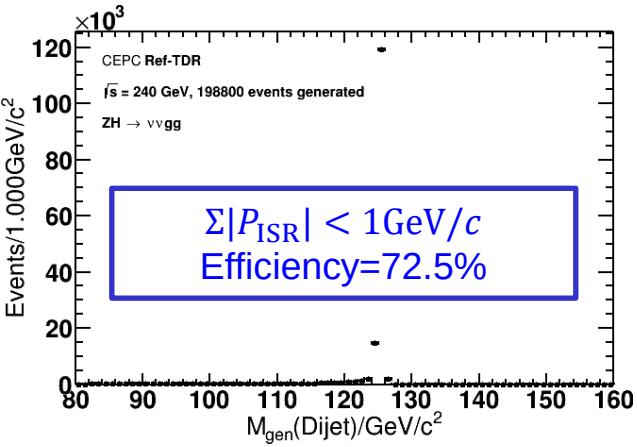


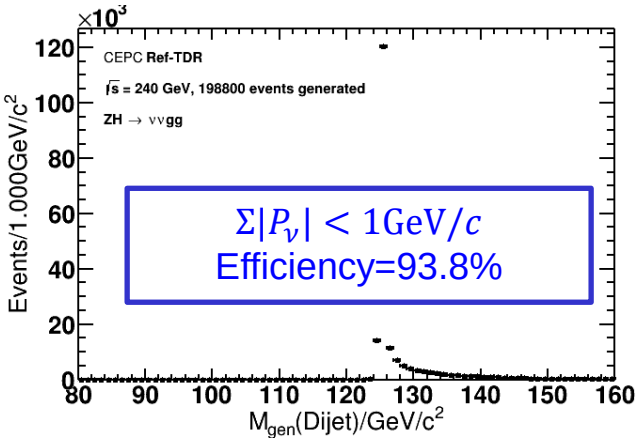
$M^{\mathrm{gen}}_{\mathrm{Dijet}}$ VS P_{ISR}/P_{ν}

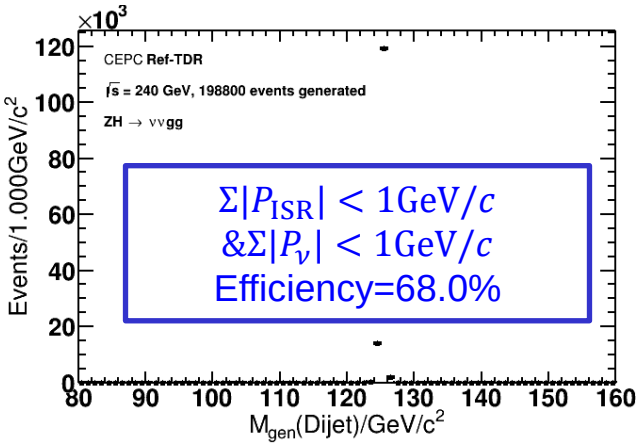




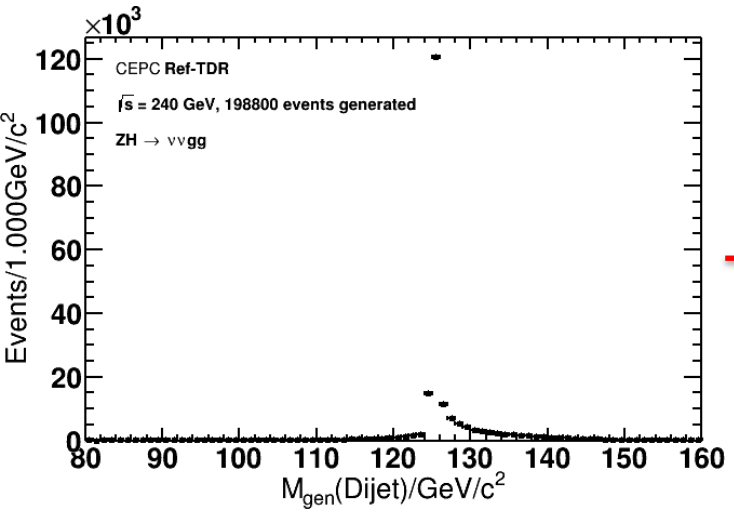


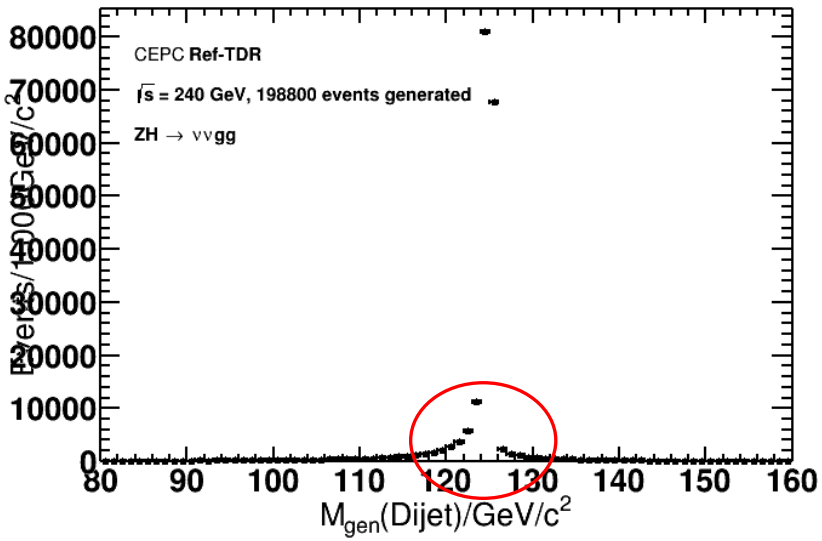






Veto truth particle whose $\cos\theta > 0.99$





BMR -- detector performance

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	–	–

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

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

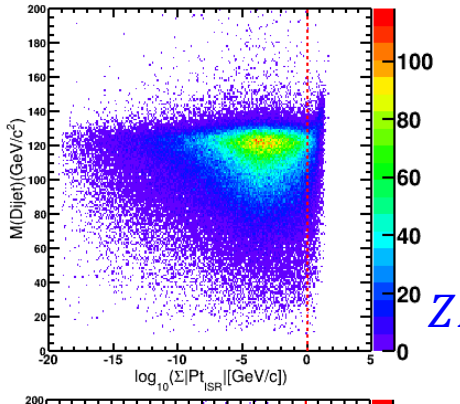
CDR reference

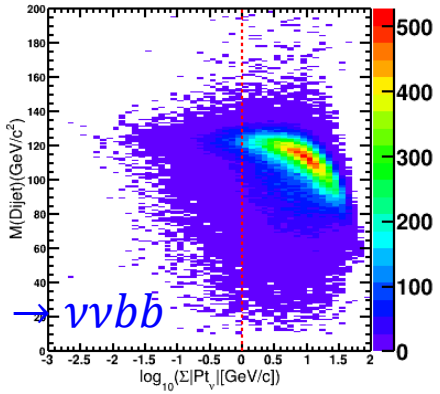
Efficiency cutflow/%	$ZH \to \nu\nu gg$	$ZH \to \nu\nu bb$	$ZH \to \nu\nu cc$
$\Sigma\|Pt_{\mathrm{ISR}}\| < 1\mathrm{GeV}/c$	95.3	95.4	95.4
$\Sigma\|Pt_{\nu}\| < 1\mathrm{GeV}/c$	89.8	39.3	66.6
$\|\cos\theta_{\mathrm{jet}}\| < 0.7$	53.1	22.0	38.0
BMR/%	3.99 ± 0.02	3.81 ± 0.03	4.10 ± 0.02
$\|\cos\theta_{\mathrm{jet}}^{\mathrm{truth}}\| < 0.7$	48.5	20.8	35.9
BMR/%	3.97 ± 0.02	3.76 ± 0.03	4.07 ± 0.02
barrelratio > 0.95	23.9	15.0	24.4
BMR/%	3.76 ± 0.02	3.62 ± 0.03	3.94 ± 0.03

Efficiency cutflow/%	$ZH \to \nu\nu gg$	$ZH \to \nu\nu bb$	$ZH \to \nu\nu cc$
$\Sigma\|P_{\mathrm{ISR}}\| < 1\mathrm{GeV}/c$	72.5	72.5	72.7
$\Sigma\|P_{\nu}\| < 1\mathrm{GeV}/c$	68.0	28.1	49.6
$\|\cos\theta_{\mathrm{jet}}\| < 0.7$	40.0	16.2	28.5
BMR/%	3.99 ± 0.03	3.82 ± 0.03	4.11 ± 0.03
$\|\cos\theta_{\mathrm{jet}}^{\mathrm{truth}}\| < 0.7$	37.2	15.5	27.4
BMR/%	3.97 ± 0.02	3.77 ± 0.03	4.09 ± 0.03
barrelratio > 0.95	18.1	11.1	18.4
BMR/%	3.77 ± 0.03	3.63 ± 0.04	3.96 ± 0.03

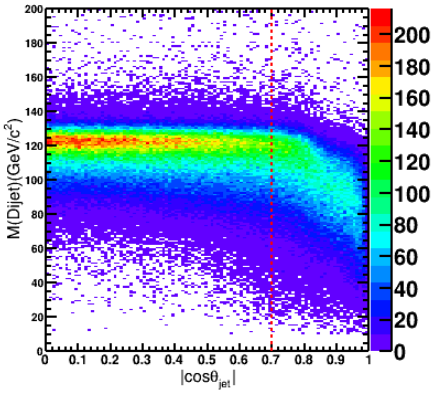
- Little difference with p and pt using different selections

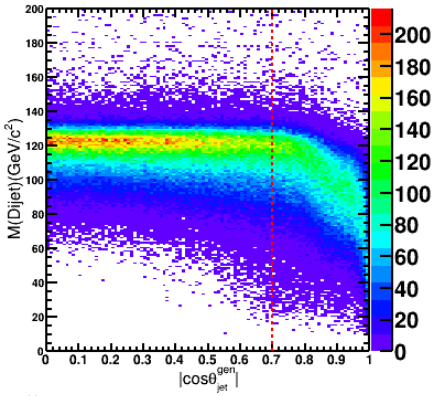
Distributions against M(Dijet) and cuts

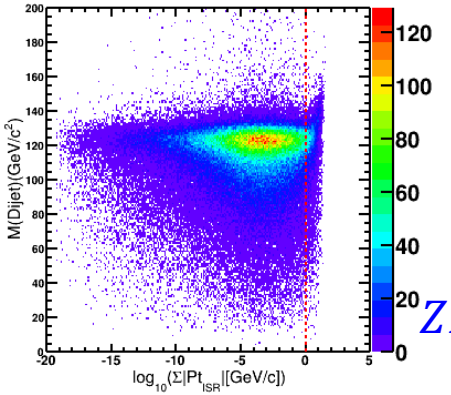


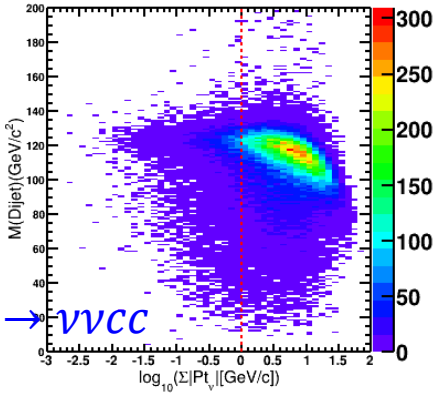


$ZH \rightarrow \nu\nu b\bar{b}$

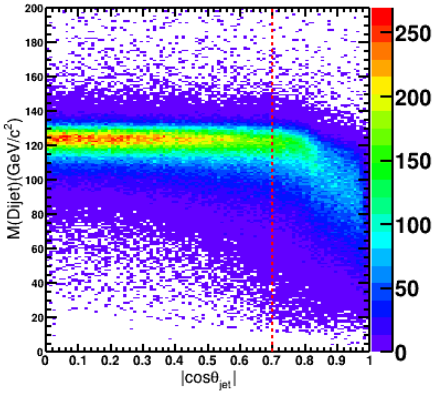


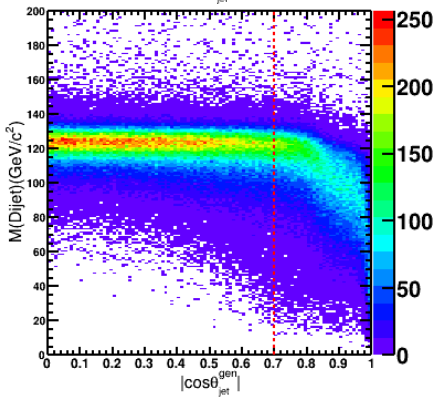


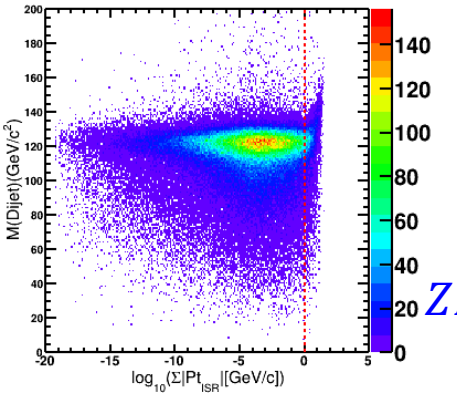


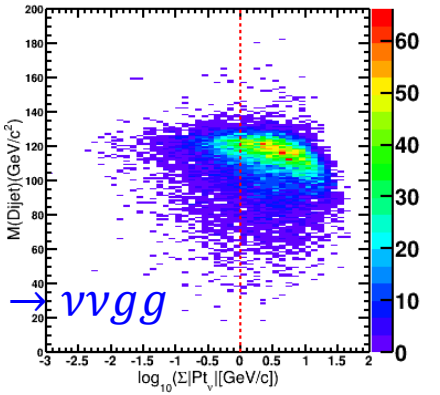


$ZH \rightarrow \nu\nu c\bar{c}$

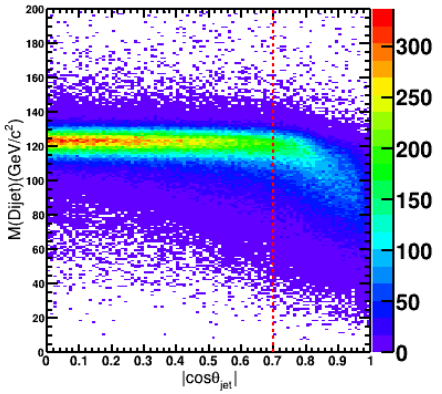


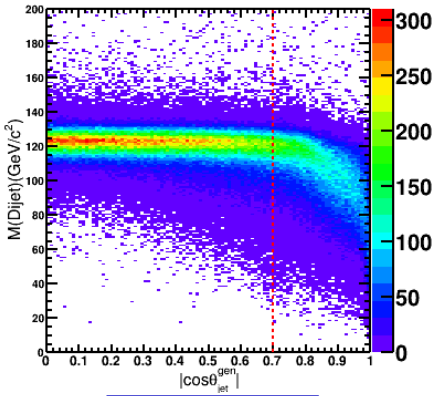






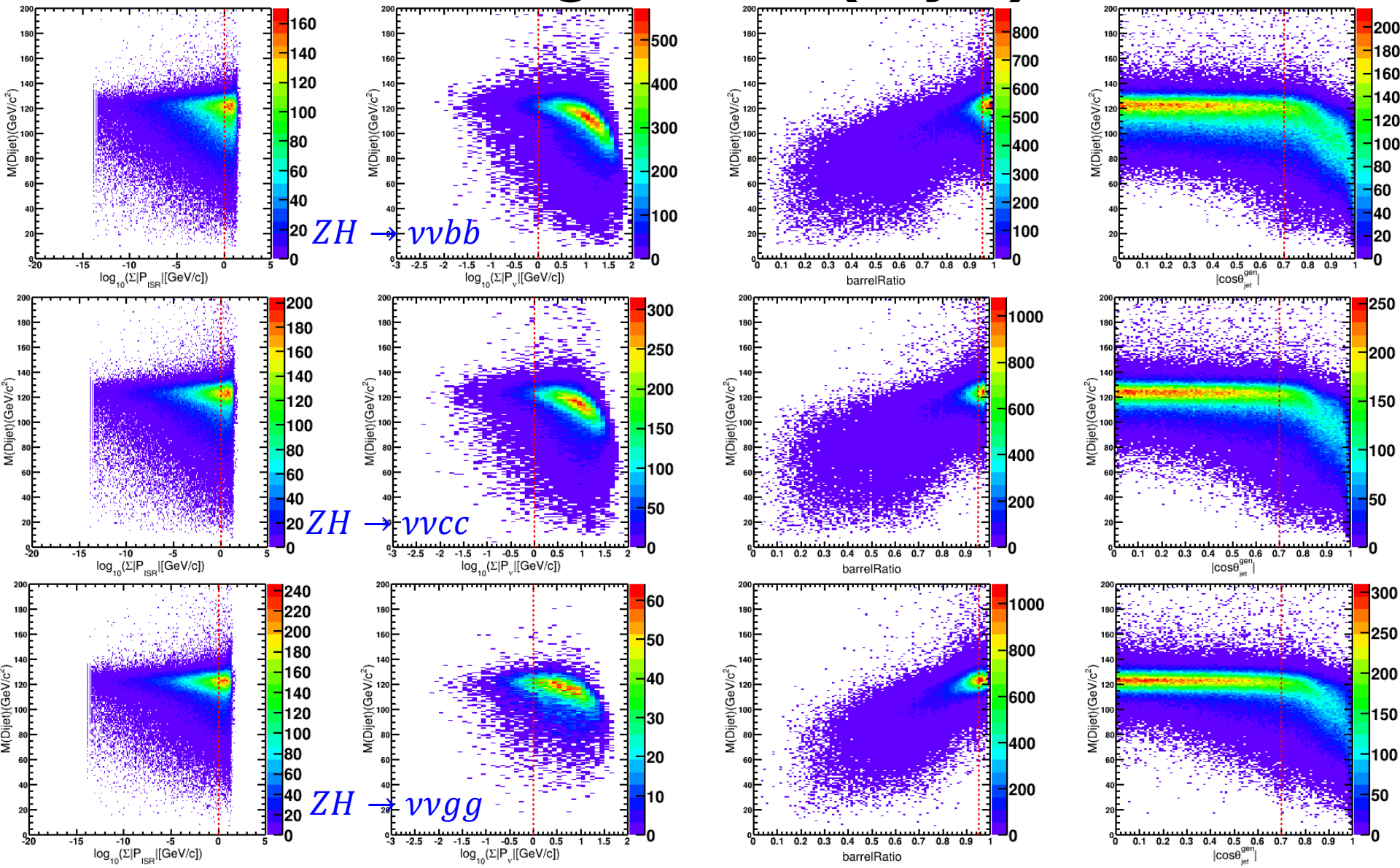
$ZH \rightarrow \nu\nu gg$





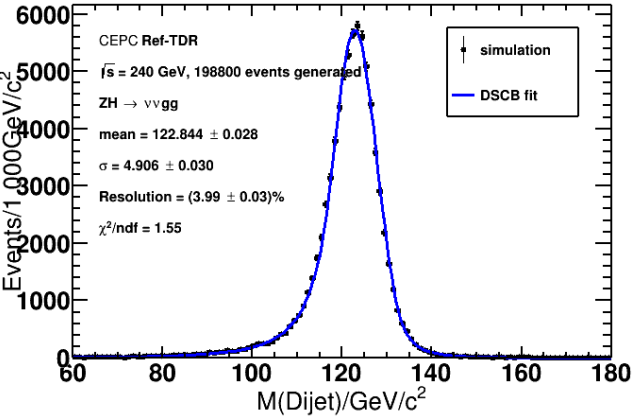
$\lg|\Sigma Pt_{\mathrm{ISR}}|$ $\lg\Sigma|Pt_{\nu}|$ $|\cos\theta_{\mathrm{jet}}|$ $\left|\cos\theta_{\mathrm{jet}}^{\mathrm{gen}}\right|$

Distributions against M(Dijet) and cuts

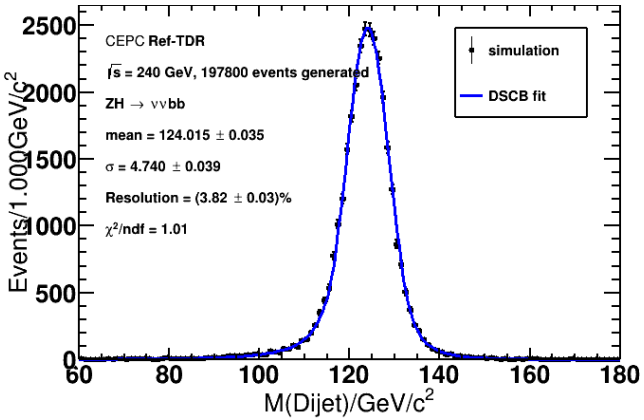


$\lg|\Sigma P_{\mathrm{ISR}}|$ | $\lg\Sigma|P_{\nu}|$ | barrelRatio | $\left|\cos\theta_{\mathrm{jet}}^{\mathrm{gen}}\right|$

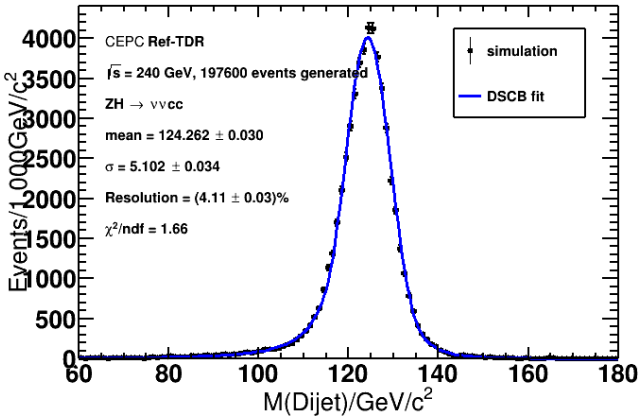
BMR -- fit with p/pt event cleaning



$ZH \to \nu\nu gg$

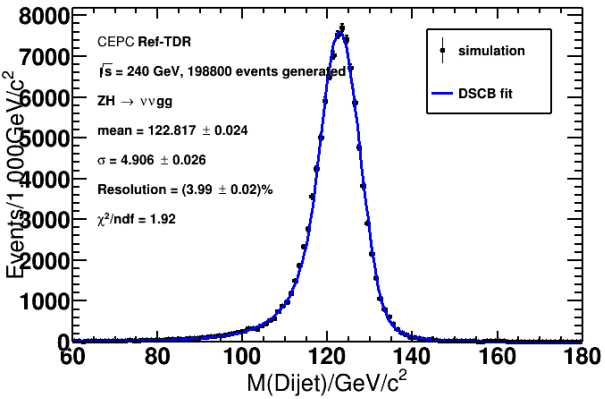


$ZH \to \nu\nu bb$

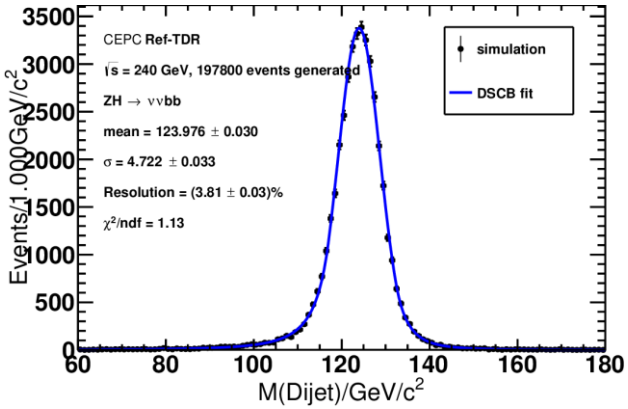


$ZH \to \nu\nu cc$

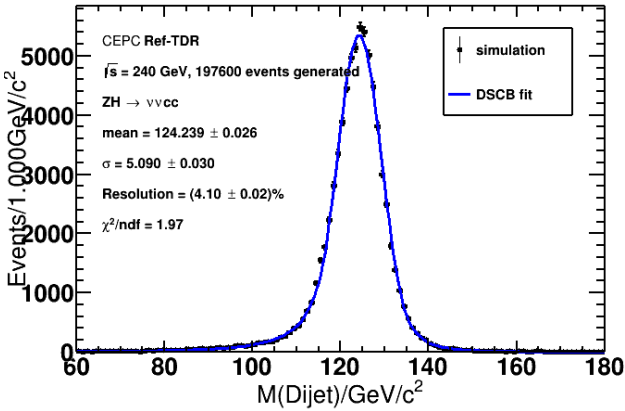
$|\cos\theta_{\text{jet}}| < 0.7$ With p event cleaning



$ZH \to \nu\nu gg$



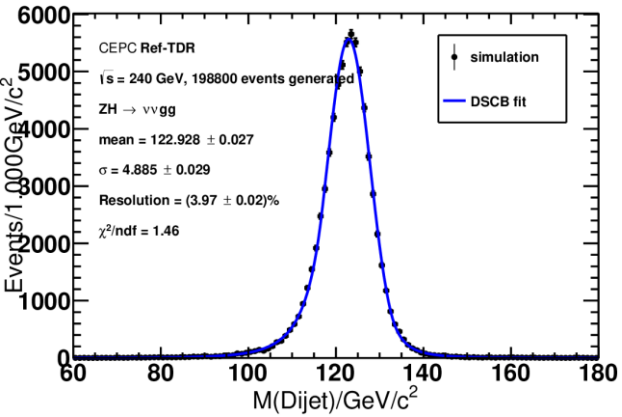
$ZH \to \nu\nu bb$



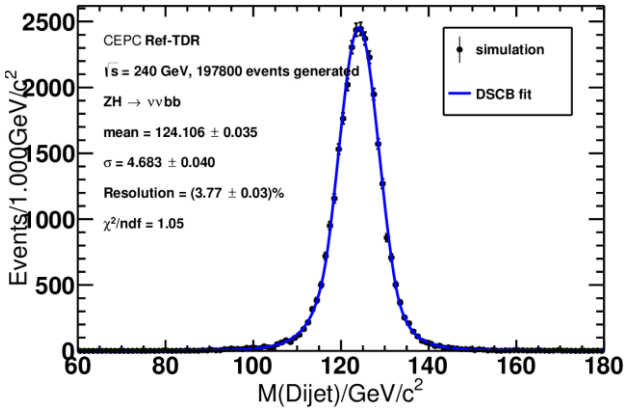
$ZH \to \nu\nu cc$

$|\cos\theta_{\text{jet}}| < 0.7$ With pt event cleaning

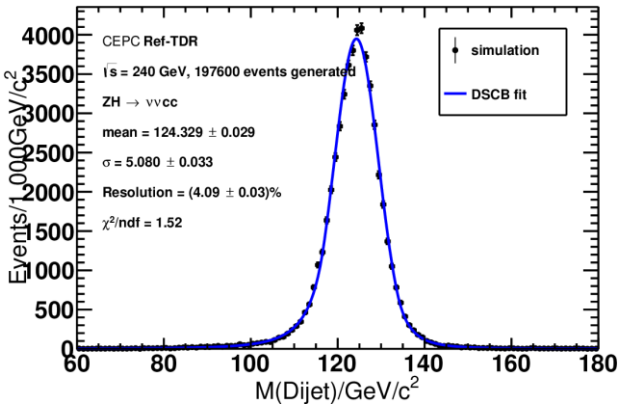
BMR -- fit with p/pt event cleaning



$ZH \to \nu\nu gg$

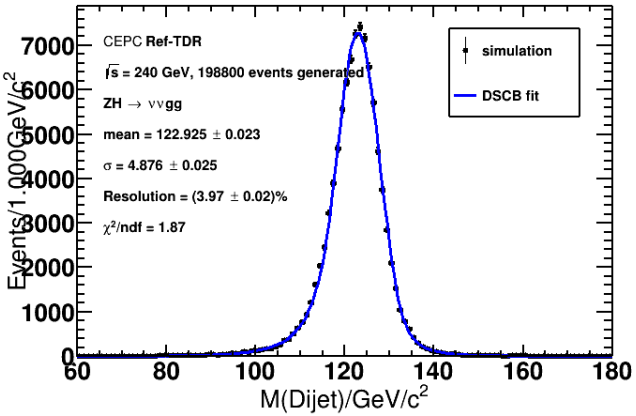


$ZH \to \nu\nu b\bar{b}$

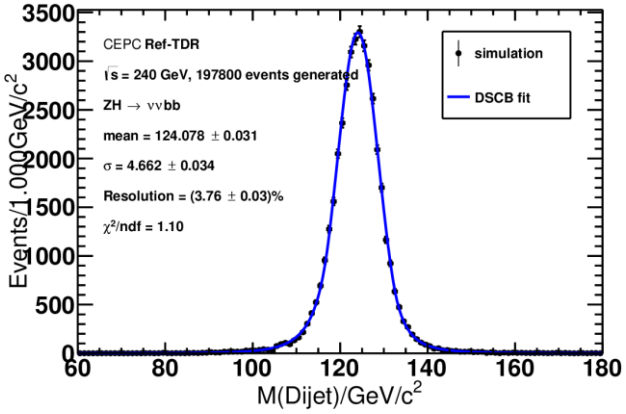


$ZH \to \nu\nu c\bar{c}$

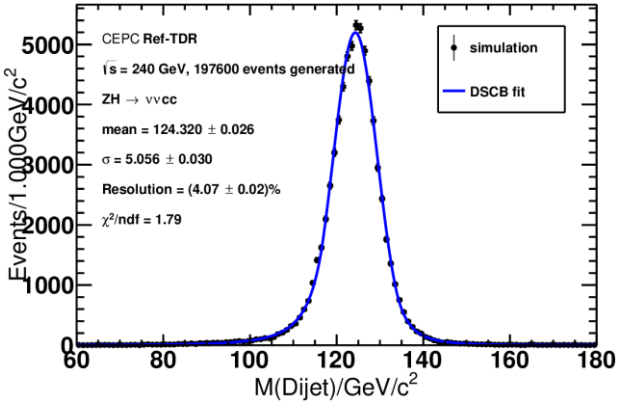
$|\cos\theta_{\text{jet}}^{\text{truth}}| < 0.7$ With p event cleaning



$ZH \to \nu\nu gg$



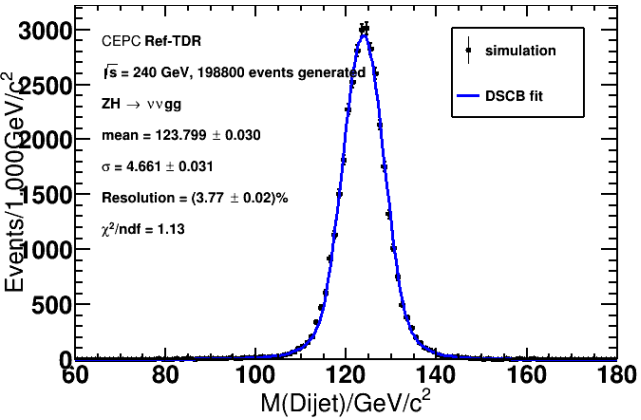
$ZH \to \nu\nu b\bar{b}$



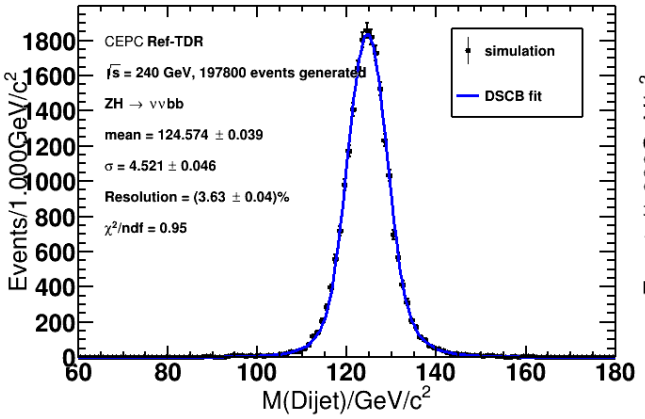
$ZH \to \nu\nu c\bar{c}$

$|\cos\theta_{\text{jet}}^{\text{truth}}| < 0.7$ With pt event cleaning

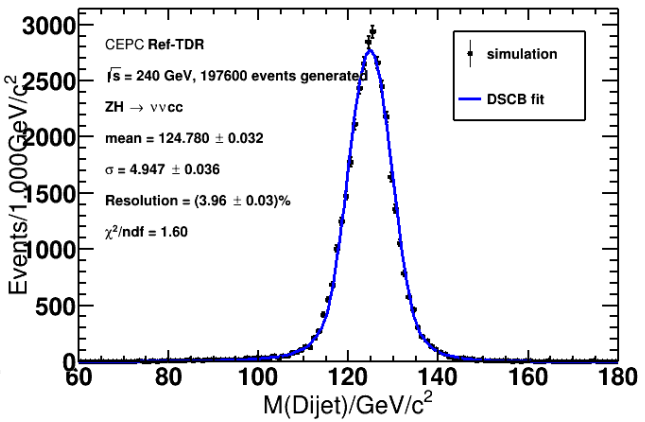
BMR -- fit with p/pt event cleaning



$ZH \to \nu\nu gg$

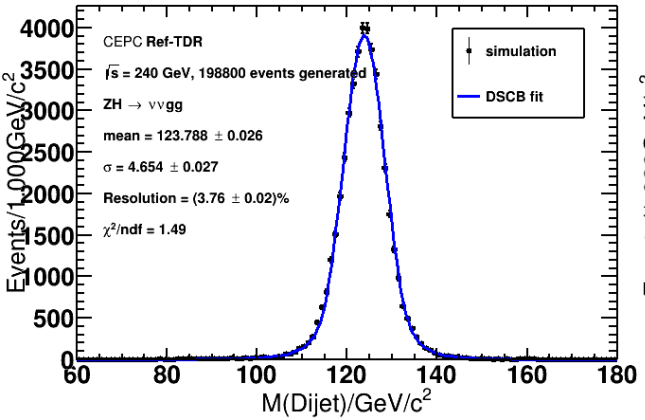


$ZH \to \nu\nu bb$

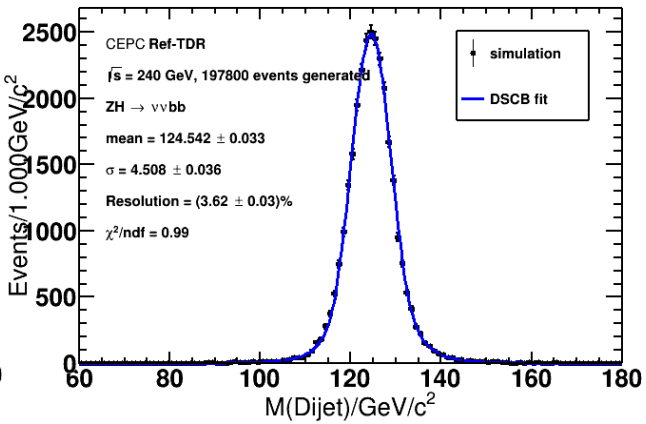


$ZH \to \nu\nu cc$

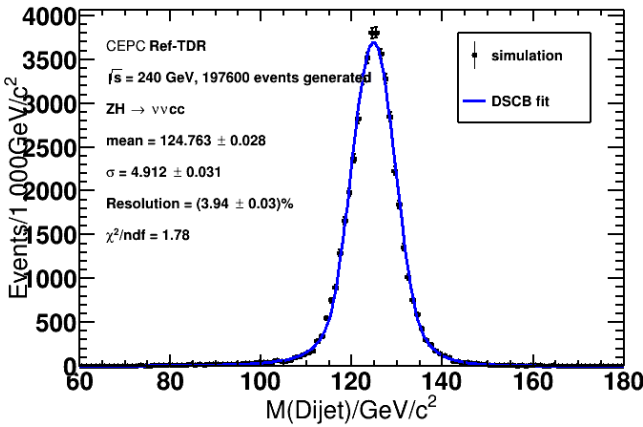
barrelratio > 0.95 With p event cleaning



$ZH \to \nu\nu gg$



$ZH \to \nu\nu bb$



$ZH \to \nu\nu cc$

barrelratio > 0.95 With pt event cleaning

BarrelRatio's code from genmatch

```
int Nmc = 0;
int Nmc_barrel = 0;
int n_status1 = 0;
for(const auto& Gen : *MCParticlesGen){
  if (Gen.getGeneratorStatus() != 1) continue;
  n_status1++;

  TVector3 part(Gen.getMomentum().x, Gen.getMomentum().y, Gen.getMomentum().z);

  if(n_status1<=4)
  {
    // ISR photon should not hit ECAL barrel
    if(Gen.getPDG()==22 && Gen.getEnergy()>0 && fabs(part.CosTheta())<0.85) Nmc_barrel = 0;
    continue;
  }
  Nmc++;
  if(fabs(part.CosTheta())<0.85) Nmc_barrel++;
}

barrelRatio = (double)Nmc_barrel/(double)Nmc;
```

barrelRatio from Fangyi: ratio of mcparticle hitting barrel