Performance study -- BMR

- Perform BMR study in $ZH \to \nu\nu + gg/bb/cc/uu/dd/ss$ with $\sqrt{s} = 240\mathrm{GeV}/c^2$
- Comparisons without/with event cleaning under $|\cos\theta_{\mathrm{jet}}| < 0.7$

Case	process	$ZH \to \nu\nu gg$	$ZH \to \nu\nu bb$	$ZH \to \nu\nu cc$	$ZH \to \nu\nu uu$	$ZH \to \nu\nu dd$	$ZH \to \nu\nu ss$
Physical level	BMR/%	4.06 ± 0.02	4.43 ± 0.05	4.20 ± 0.05	3.90 ± 0.02	4.08 ± 0.02	4.56 ± 0.02
	Efficiency/%	59.3	58.0	58.2	58.2	58.3	58.2
Detector level	BMR/%	3.99 ± 0.02	3.81 ± 0.03	4.04 ± 0.03	3.90 ± 0.02	4.06 ± 0.02	4.53 ± 0.02
	Efficiency/%	53.1	22.0	38.0	55.1	55.2	55.1

  - Event cleaning: $\Sigma|Pt_{\mathrm{ISR}}| < 1\mathrm{GeV}/c \& \Sigma|Pt_{\nu}| < 1\mathrm{GeV}/c$
  - Before event cleaning, BMR ranges from 3.90% to 4.56%
  - After event cleaning, BMR ranges from 3.81% to 4.53%
- Samples generated under CEPCSW_tdr24.12.0 -- master
  - /cefs/higgs/maxiaotian/CEPCSW/sample/nogenmatch/24.12.0/
  - /cefs/higgs/zhangkl/Production/job/

Performance study -- BMR

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%

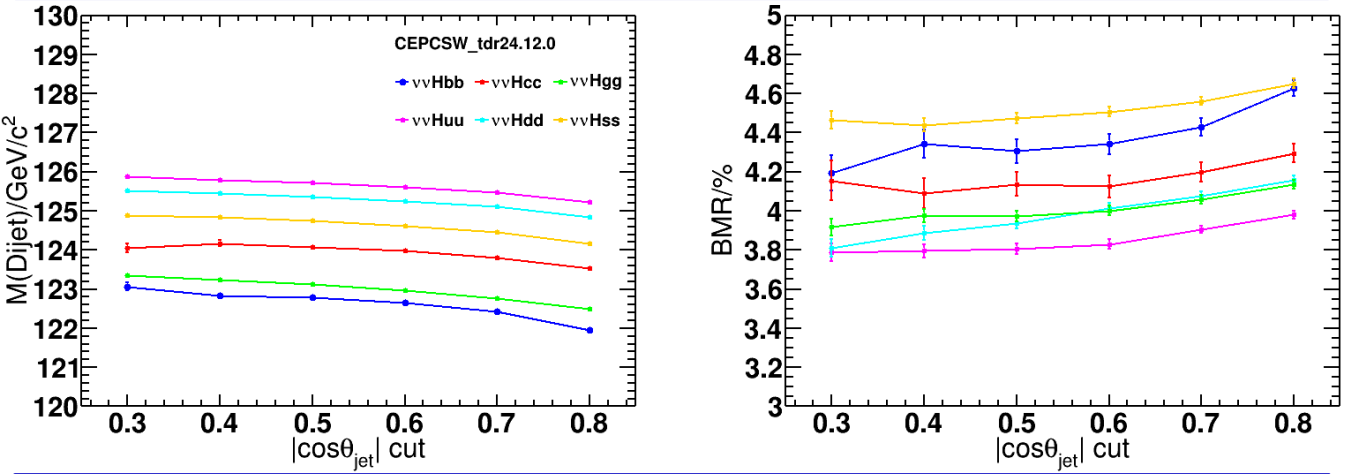
CDR reference

Process		$ZH \to \nu\nu gg$	$ZH \to \nu\nu bb$	$ZH \to \nu\nu cc$	$ZH \to \nu\nu uu$	$ZH \to \nu\nu dd$	$ZH \to \nu\nu ss$
Cumulative efficiency /%	$\Sigma\|Pt_{\mathrm{ISR}}\| < 1\mathrm{GeV}/c$	95.3	95.4	95.4	95.4	95.4	95.3
	$\Sigma\|Pt_{\nu}\| < 1\mathrm{GeV}/c$	89.8	39.3	66.5	94.9	94.9	94.8
	$\|\cos\theta_{\mathrm{jet}}\| < 0.7$	53.1	22.0	38.0	55.1	55.2	55.1
DSCB BMR/%		3.99 ± 0.02	3.81 ± 0.03	4.04 ± 0.03	3.90 ± 0.02	4.06 ± 0.02	4.53 ± 0.02

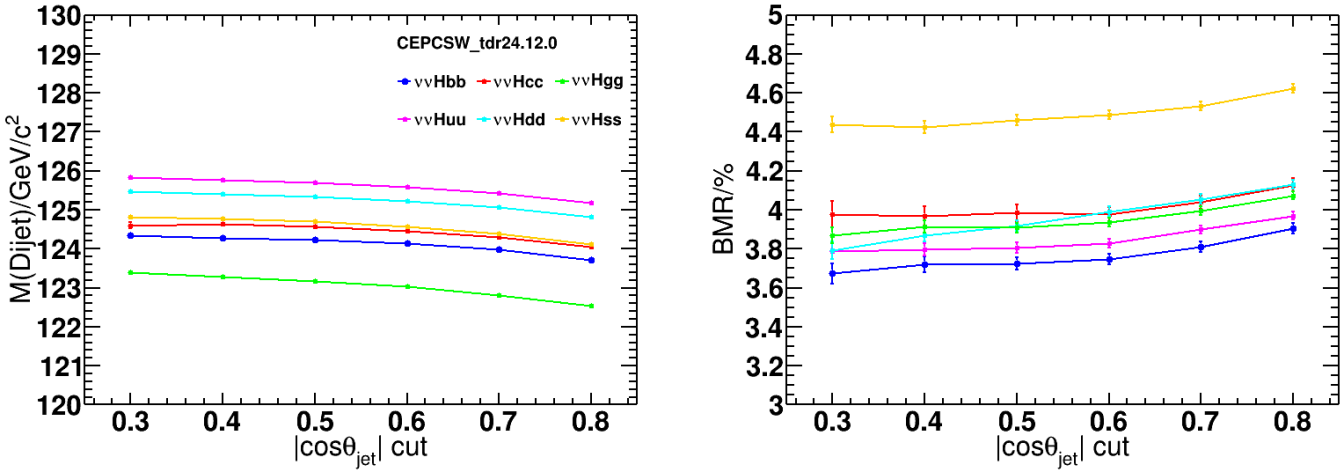
- Comparison between CDR reference and current results
  - Efficiencies of event cleaning match for $ZH \to \nu\nu gg/\nu\nu bb/\nu\nu cc$
  - BMR for $ZH \to \nu\nu gg/\nu\nu bb/\nu\nu cc$ is worse by 0.24%/0.21%/0.22%

Performance study -- BMR

Higgs mass and BMR distributions according to $|\cos\theta_{\mathrm{jet}}|$ cut -- no cleaning

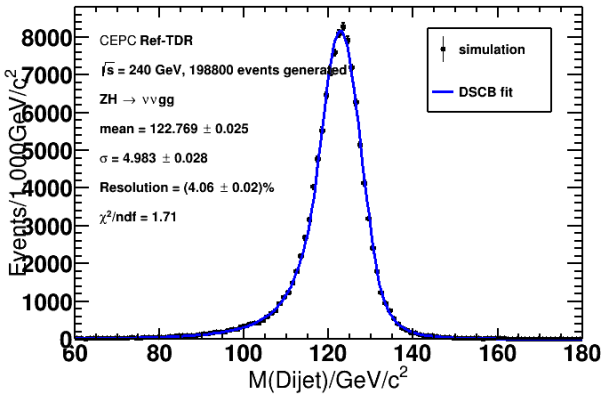


Higgs mass and BMR distributions according to $|\cos\theta_{\mathrm{jet}}|$ cut -- event cleaning

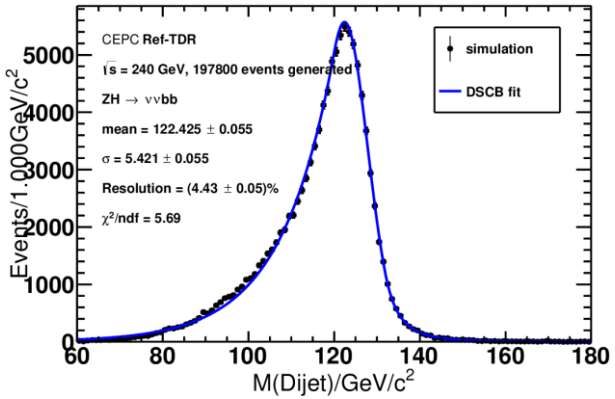


- Higgs mass around 125GeV/c^2
- ss BMR larger than else

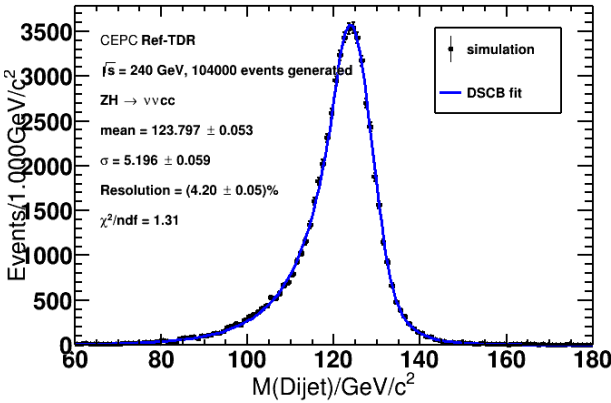
Performance study -- BMR



$ZH \to \nu\nu gg$

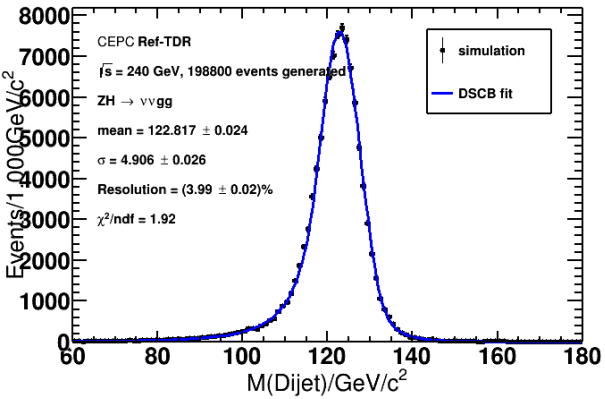


$ZH \to \nu\nu bb$

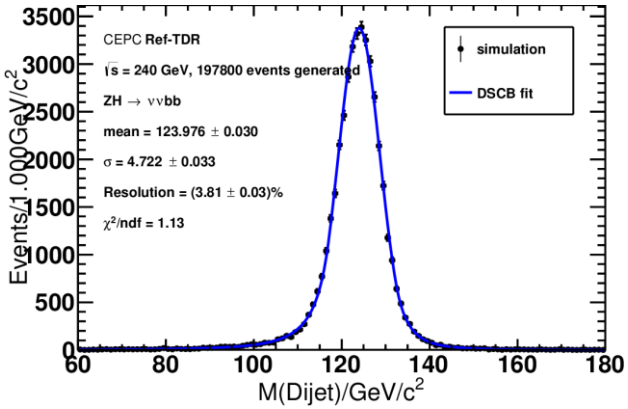


$ZH \to \nu\nu cc$

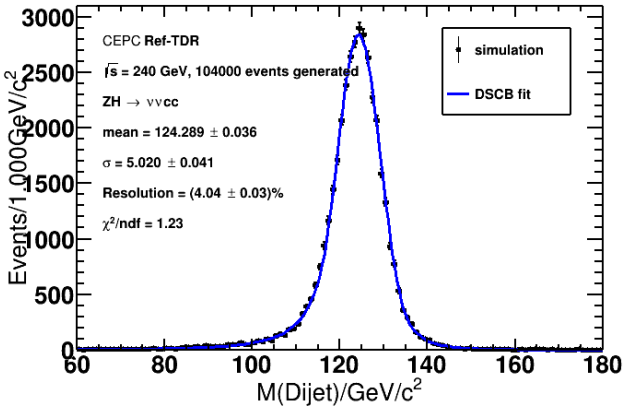
$|\cos\theta_{\text{jet}}| < 0.7$ Without event cleaning



$ZH \to \nu\nu gg$



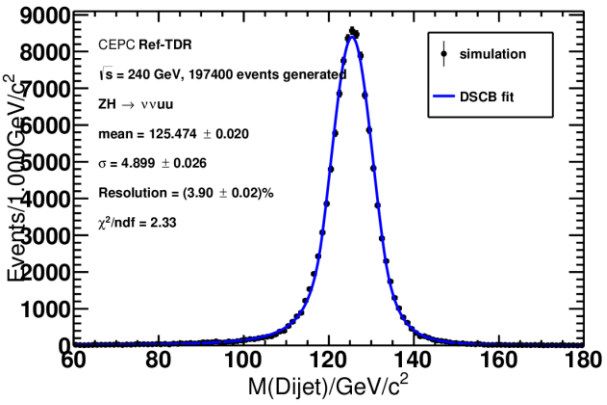
$ZH \to \nu\nu bb$



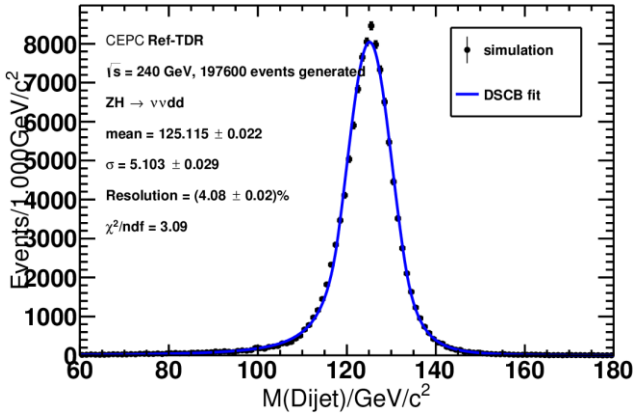
$ZH \to \nu\nu cc$

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

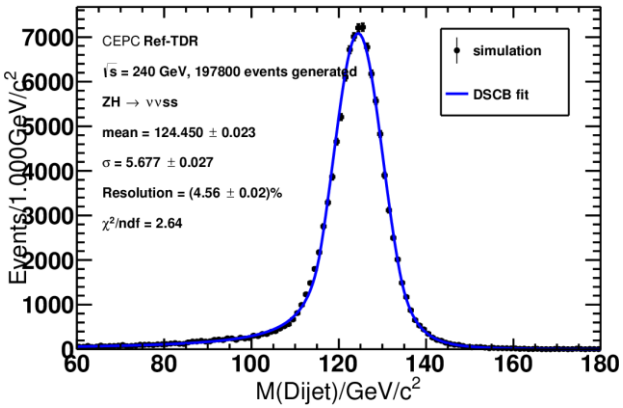
Performance study -- BMR



$ZH \to \nu\nu uu$

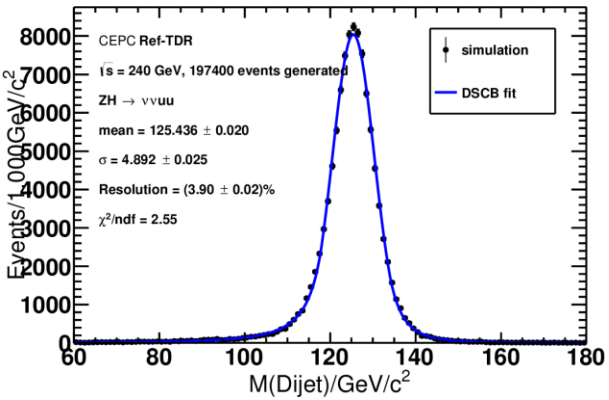


$ZH \to \nu\nu dd$

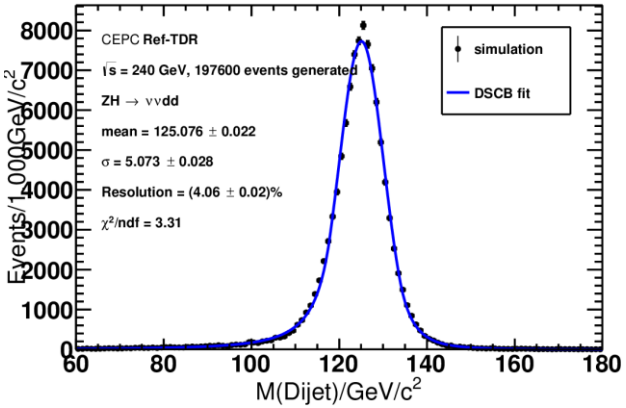


$ZH \to \nu\nu ss$

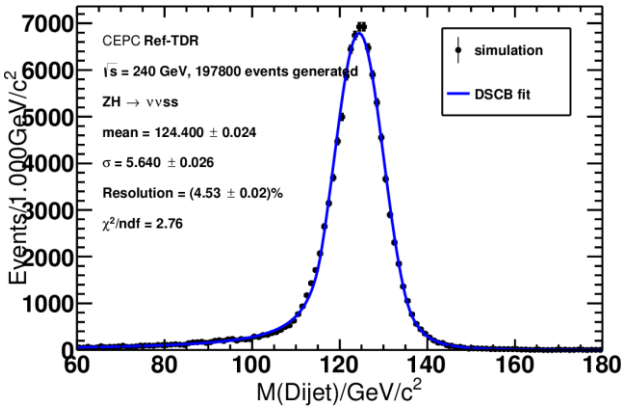
$|\cos\theta_{\text{jet}}| < 0.7$ Without event cleaning



$ZH \to \nu\nu uu$



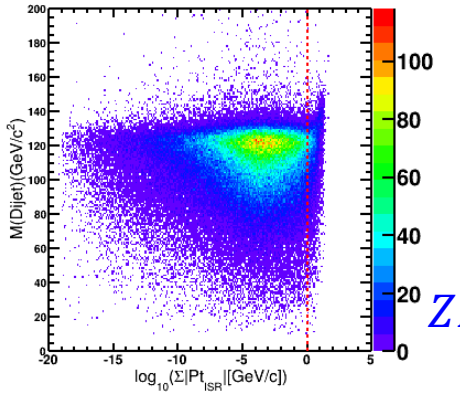
$ZH \to \nu\nu dd$



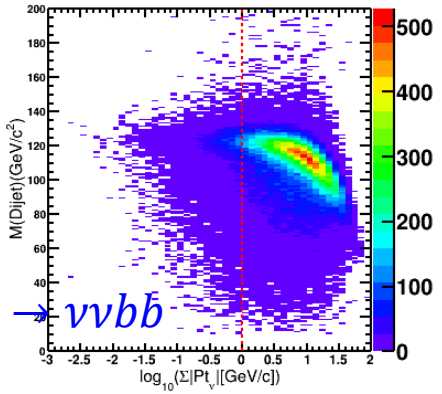
$ZH \to \nu\nu ss$

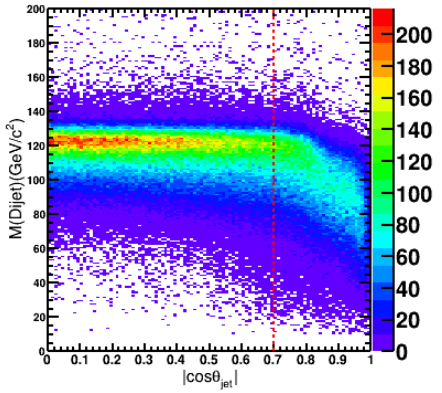
$|\cos\theta_{\text{jet}}| < 0.7$ With event cleaning

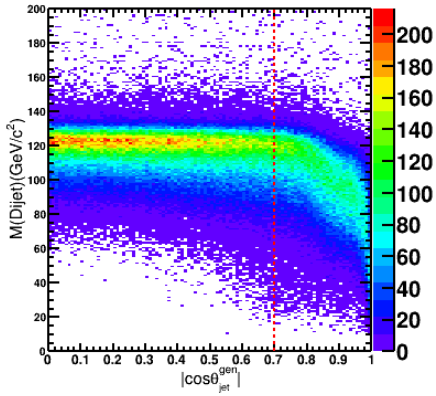
Distributions against M(Dijet) and cuts

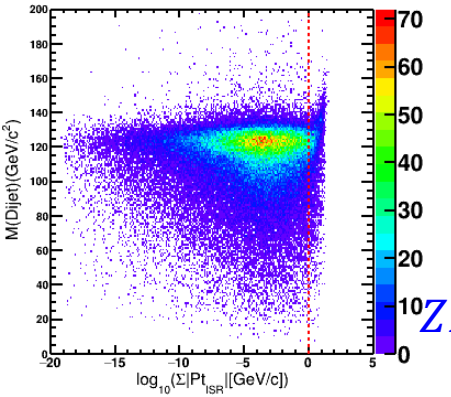


$ZH \rightarrow \nu\nu b\bar{b}$

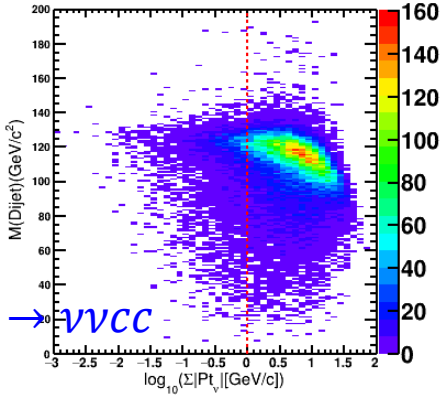


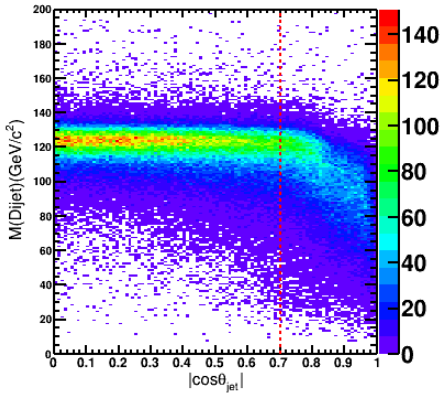


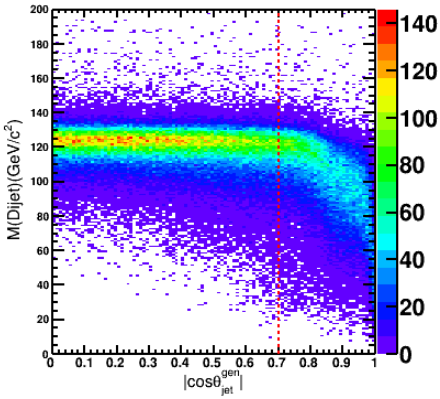


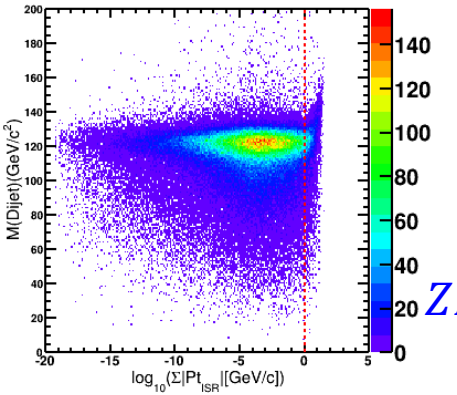


$ZH \rightarrow \nu\nu c\bar{c}$

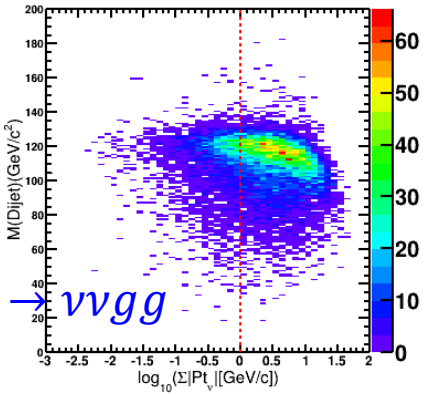


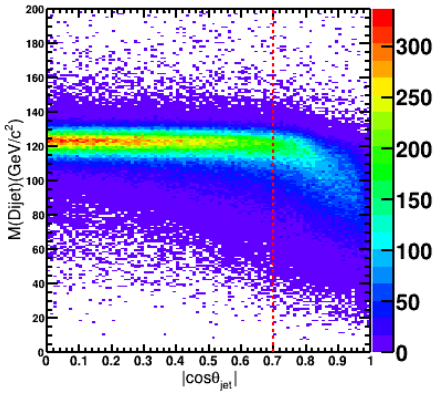


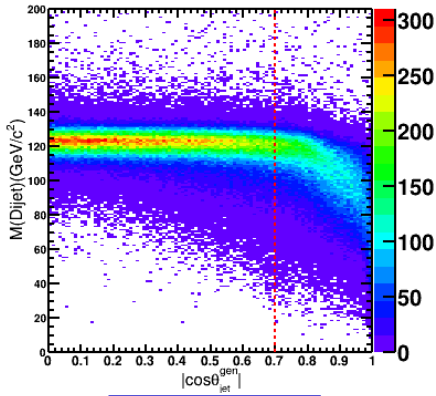




$ZH \rightarrow \nu\nu gg$

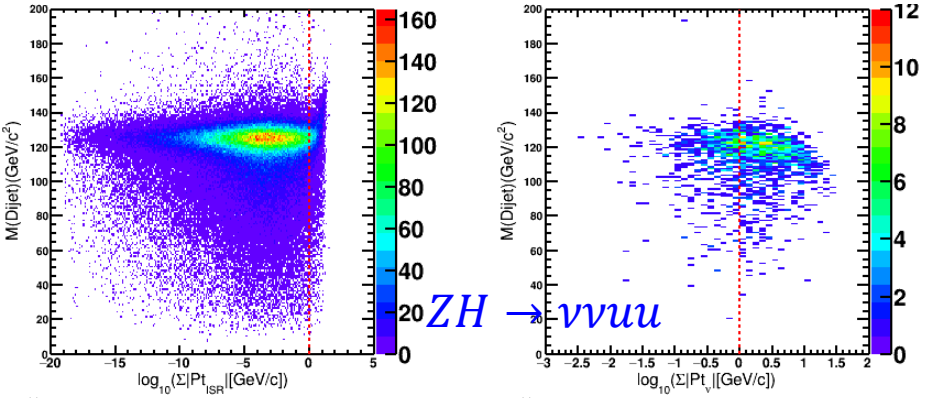




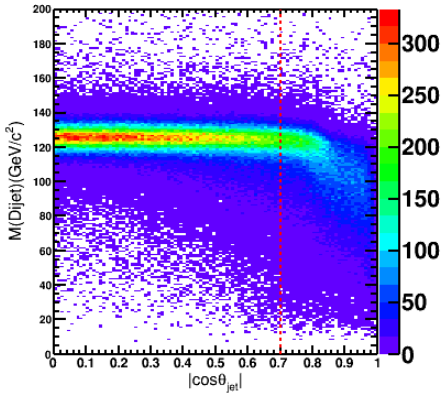


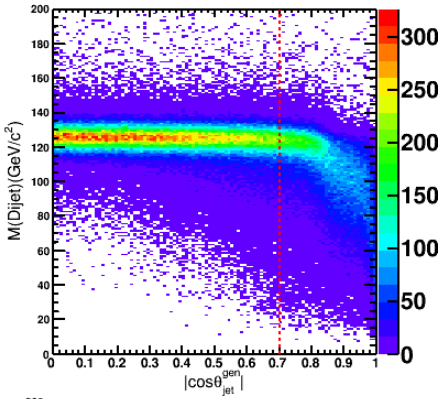
$\lg|\Sigma Pt_{\mathrm{ISR}}|$ $\lg\Sigma|Pt_{\nu}|$ $|\cos\theta_{\mathrm{jet}}|$ $\left|\cos\theta_{\mathrm{jet}}^{\mathrm{gen}}\right|$

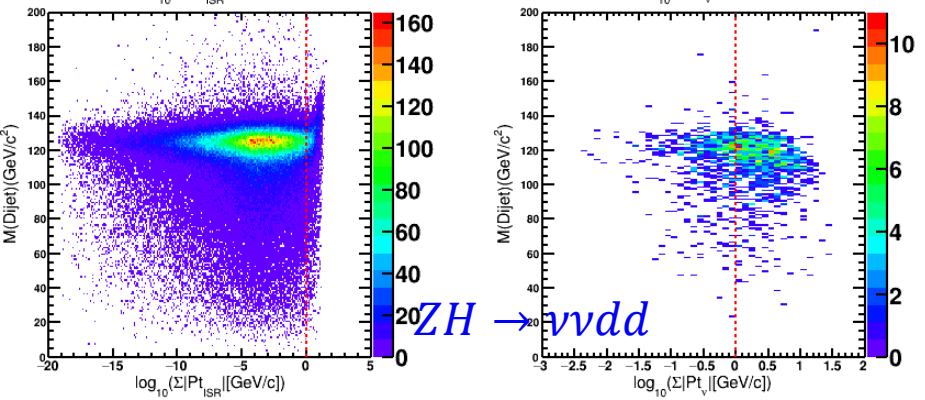
Distributions against M(Dijet) and cuts



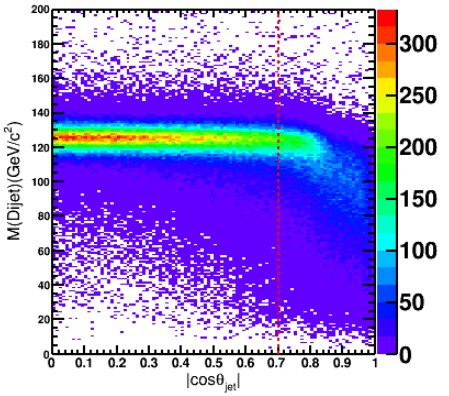
$ZH \rightarrow \nu\nu uu$

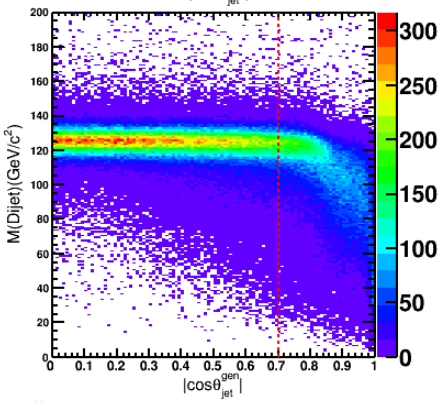


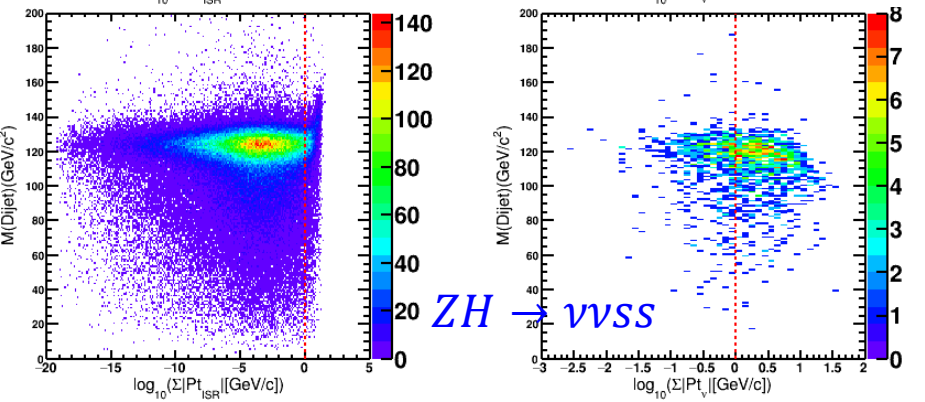




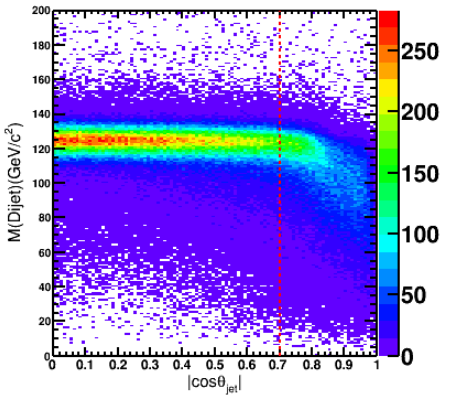
$ZH \rightarrow \nu\nu dd$

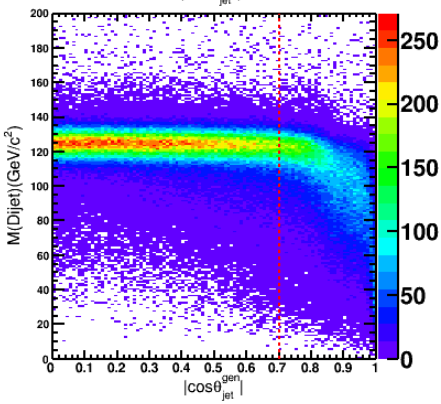






$ZH \rightarrow \nu\nu ss$





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

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

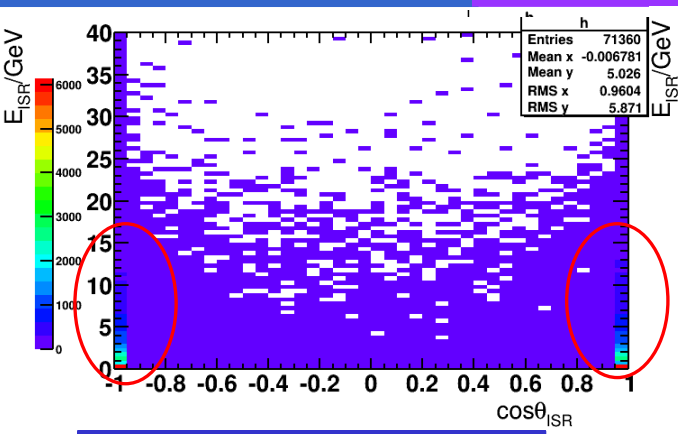
$|\cos\theta_{\mathrm{jet}}|$

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

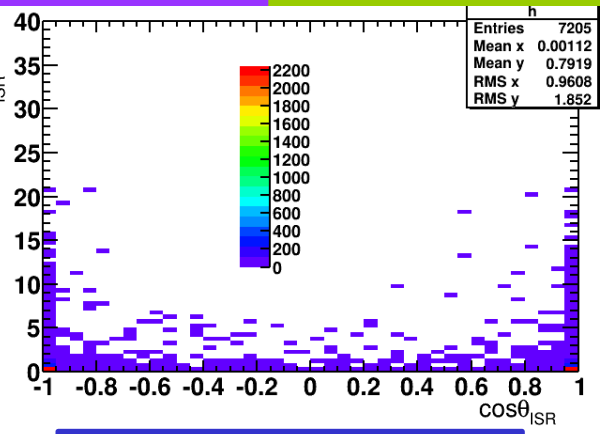
BarrelRatio's code from genmatch

```
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;
```

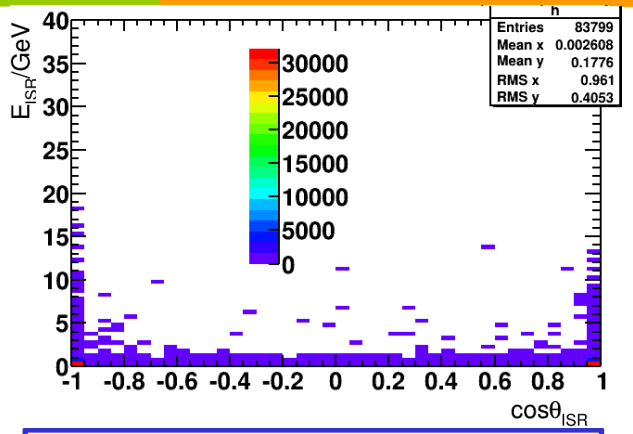
E_{ISR} VS $\cos\theta_{\mathrm{ISR}}$ VS $M^{\mathrm{gen}}_{\mathrm{Dijet}}$



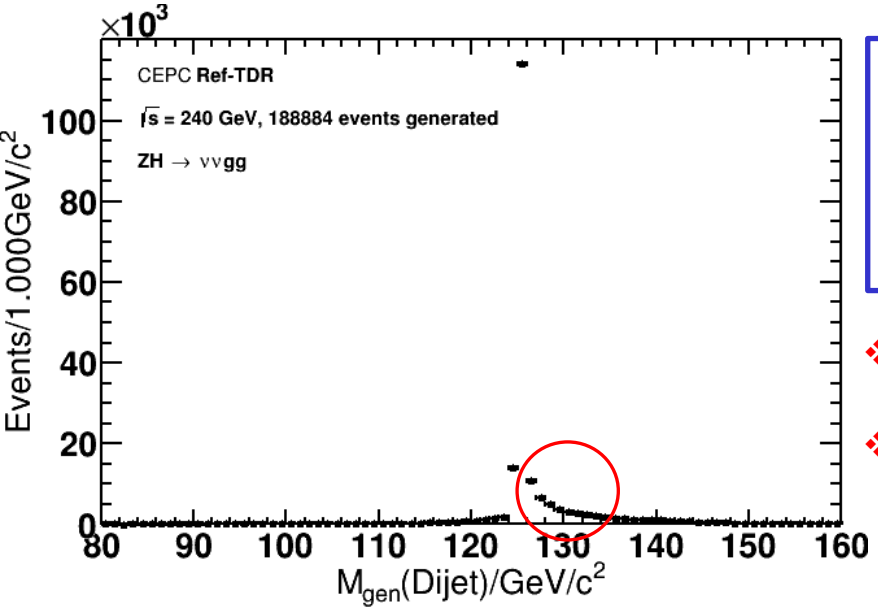
$M_{\mathrm{gen}}(\mathrm{Dijet}) > 126\mathrm{GeV}/c^2$



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



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



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

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 ISR photons in the round circle which are included in the ee_kt_algorithm