H→WW* analysis with semi-leptonic final states

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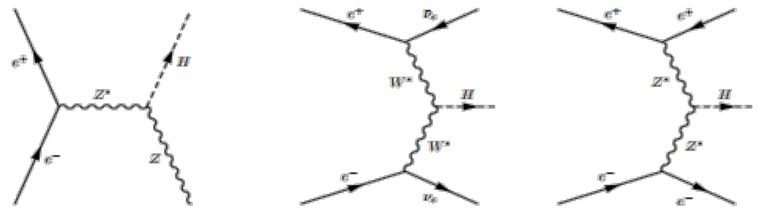
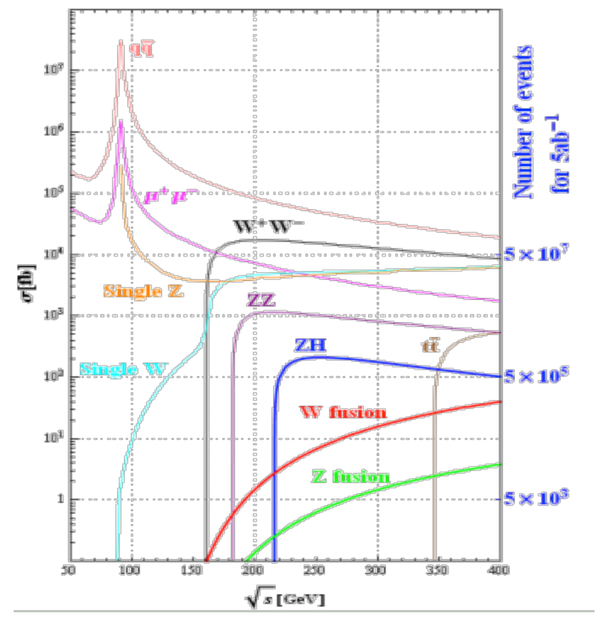
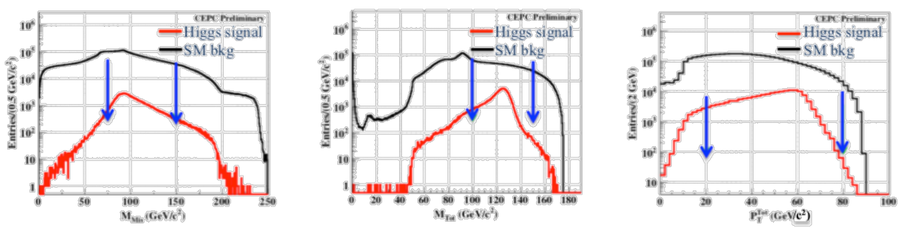
Introduction



- ZH process is the most dominant Higgs production at the CEPC. As is predicted in the Standard Model theory, the Br (H→WW*) is around 22%.
- H→WW* analysis is important to study Higgs couplings with vector bosons. Measurement of Br (H→WW*) is crucial for the determination of Higgs width.
- Various final states of W boson decay (leptons, MET, jets etc.) can provide a great benchmark to evaluate detector performance for CEPC.



Z→νν, H→WW*→qqqq

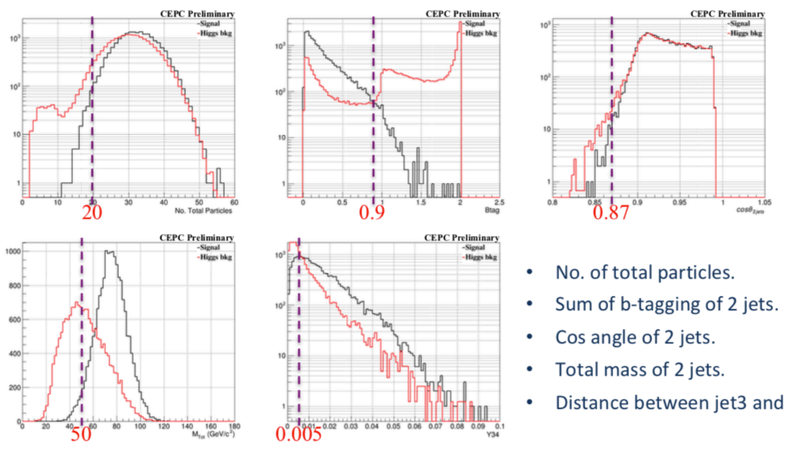


$75\ \mathrm{GeV}/c^2 < M_{Mis} < 150\ \mathrm{GeV}/c^2$
$100\ \mathrm{GeV}/c^2 < M_{Tot} < 150\ \mathrm{GeV}/c^2$
$20\ \mathrm{GeV}/c < p_T < 80\ \mathrm{GeV}/c$

Validation of pre-selection
$N^{Tot}_{Particle} > 20$
$Btag < 0.9$
$Cos\theta_{2jets} > 0.87$
$\Sigma|M^{2jet}_{Inv}| > 50\ \mathrm{GeV}$
$Y_{34} > 0.005$
Combined Variable

- $65\ \mathrm{GeV}/c^2 < M^{Real4jet}_{Inv} < 85\ \mathrm{GeV}/c^2$,
- $15\ \mathrm{GeV}/c^2 < M^{Virt4jet}_{Inv} < 50\ \mathrm{GeV}/c^2$,
- $M^{Virt4jet}_{Inv} > -7/3M^{Real4jet}_{Inv} + \frac{605}{3}\ \mathrm{GeV}/c^2$,

Event selections.



- No. of total particles.
- Sum of b-tagging of 2 jets.
- Cos angle of 2 jets.
- Total mass of 2 jets.
- Distance between jet3 and jet4.

Distributions of discriminant variables.

To select jet by two steps:

1. Assuming that only two jets in each event, all final particles are forced into two jets.
2. Four jets hypothesis are made to form all possible jet-pairs. The jet-pair with invariant mass closest to W mass is taken as the on-shell W decay and the remaining two jets are assigned to the off-shell W decay.

Br (H→WW*) measurement:

$$Br(H \to WW^*) = \frac{N_{sig}}{N_{total} \cdot \varepsilon \cdot Br_{rel.}}$$

$Br_{rel.}$ was given by the PDG:

	Total events N	$Br(W \to \ell\nu)$	$Br(W \to qq)$	$Br(Z \to \ell^+\ell^-)$	$Br(Z \to qq)$
Mean value	1060000	10.86%	67.41%	3.3658%	69.91%
Uncertainty	±4000	±0.09%	±0.27%	±0.0023%	±0.06%

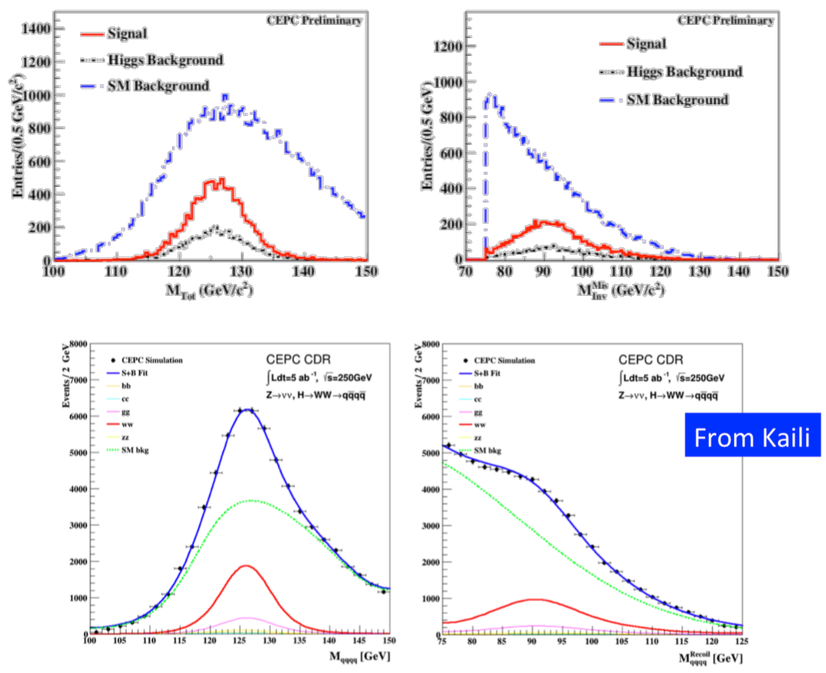
The result of Br (H→WW*) is 21.6%.
The precision is obtained by:

$$\Delta Br(H \to WW^*)/Br(H \to WW^*) = \sqrt{(\frac{\Delta N_{obs.}}{N_{obs.}})^2 + (\frac{\Delta N_{total}}{N_{total}})^2 + (\frac{\Delta Br_{rel.}}{Br_{rel.}})^2}$$

To combine precisions of each sub-channels:

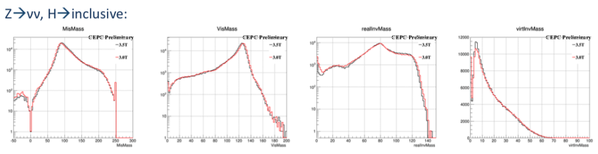
$$\Gamma^2_{ij} = \frac{\Gamma^2_i \Gamma^2_j}{\Gamma^2_i + \Gamma^2_j}$$

The total statistical uncertainty is 1.29%.

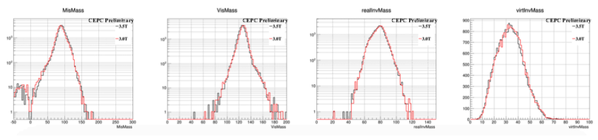


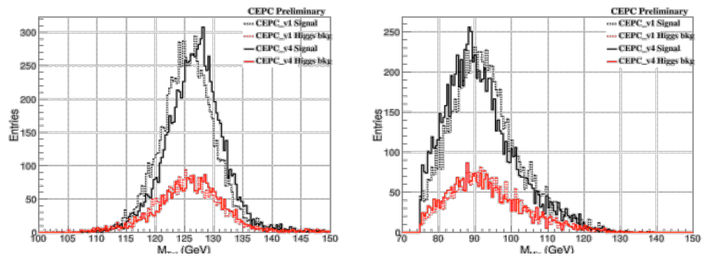
Total mass and missing mass after selections.
The post fit accuracy is 2.0% (from Kaili).

Z→νν, H→inclusive:



Z→νν, selected by H→WW→qqqq:

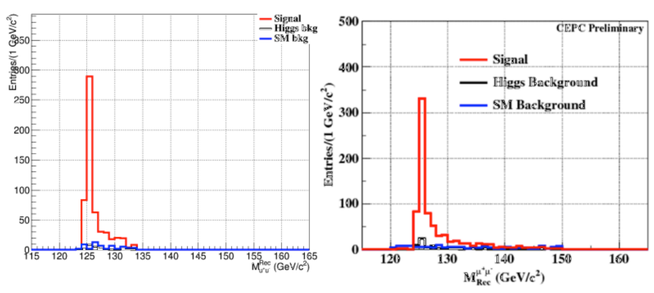




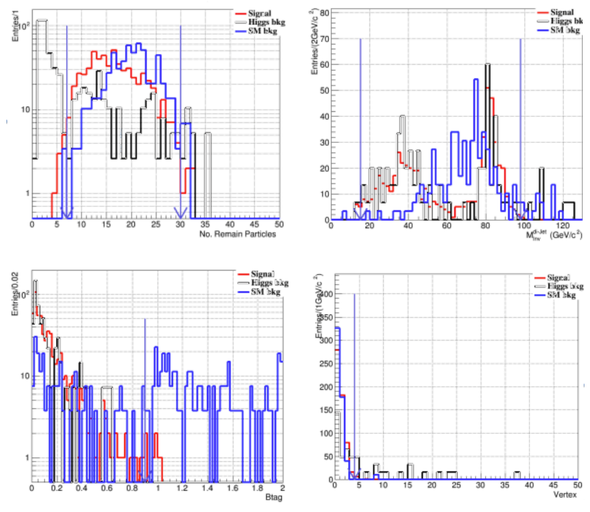
Comparisons between CEPC_v1 and v4.

Z→μμ, H→WW*→μνqq

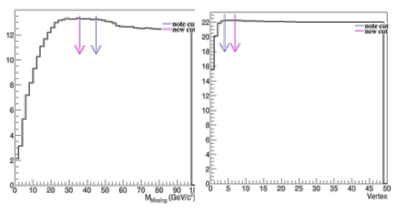
Total
$N_{ZPole} = 2; N_{Isolep} = 1; N_{Jets} = 2; l = \mu$
Validation of Pre-selection
$7 < N_{Remain} < 30$
$10\ \mathrm{GeV}/c^2 < M^{di-Jet}_{Inv} < 95\ \mathrm{GeV}/c^2$
$Btag < 0.9$
$M_{Missing} < 45\ \mathrm{GeV}/c^2$
$\sqrt{(\frac{D0}{sigD0})^2 + (\frac{Z0}{sigZ0})^2} < 4$
$p_T > 4\ \mathrm{GeV}/c$



Selections and recoil mass after selections.



- No. of remain particles
- Di-jet invariant mass
- Btag
- Vertex



Optimization of selections.

Expected accuracy

- CEPC_v1:

$$Accu. = \frac{\sqrt{S+B}}{S} = \frac{\sqrt{772+32+184}}{772} = 4.1\%$$

- CEPC_v4 with default selections:

$$Accu. = \frac{\sqrt{S+B}}{S} = \frac{\sqrt{627+24+203}}{627} = 4.7\%$$

- CEPC_v4 after optimization:

$$Accu. = \frac{\sqrt{S+B}}{S} = \frac{\sqrt{563+23+55}}{563} = 4.50\%$$

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