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Analysis of $e^+e^- \to W^+W^- \to \bar{\nu}_e\nu_e H, H \to \bar{b}b$ Process at Future Circular Collider (FCC-ee) examined at a $\sqrt{s}$ = 365 GeV with a Luminosity of 3 ab^{-1}

Content

- Simulation of signal (\(e^+e^-\to\bar\nu_e\nu_eH,\,H\to b\bar b\)) and dominant backgrounds (ZH, ZZ, WW, \(t\bar t\)) at \(\sqrt{s}=365\) GeV, 3 ab\(^{-1}\), using \textsc{Whizard}, \textsc{Pythia} and \textsc{Delphes}.\\
- Preselection requiring = 2 jets and \(\cos\theta_{\rm miss}<0.98\).\\
- Reconstruction of key observables: dijet invariant mass (\(M_{bb}\)), missing transverse energy (MET), recoil mass, \(b\)-tagged jet kinematics and \(\cos\theta_{\rm miss}\).\\
- Multivariate analysis: training and hyperparameter tuning of a MVA BDT and XGBoost classifier via cross-validation.\\
- Performance comparison through ROC curves, Importance and BDT_Score, demonstrating the XGBoost model's superior separation and % improvement over cut-based selection.\\
- Implications for precise measurement of the \(H\to b\bar{b}\) coupling in the FCC-ee VBF channel.

Summary

We present a comprehensive analysis of the process (VBF)\[e^+e^-\ \to\ \bar{\nu}e\,\nu_e\,H,\quad H\to b\bar{b} \] at a centre-of-mass energy of \(\sqrt{s}=365\),GeV with an integrated luminosity of \(3\)\,ab\(^{-1}\). Signal and background samples were generated using \textsc{Whizard}, \textsc{Pythia} and \textsc{Delphes}, and processed with the \texttt{FCCAnalyses Framework}. After applying preselection cuts ((\texttt{event_njet\(\ge2\)}) and the missing–angle requirement \[\cos!\bigl(\theta{\rm miss}\bigr)\;<\;0.98, \]), we extracted key kinematic observables as invariant mass of dijets, missing transverse energy (\(\mathrm{MET}\)),recobuilder mass and momentum, recoil_mass, costheta_miss,MVA_Score ,and employed them to train multivariate classifiers. We compared a Boosted Decision Tree (BDT) implementation against an XGBoost model, optimizing hyperparameters via cross validation. The XGBoost classifier achieves superior separation power, yielding a signal significance enhancement of \(\mathrm{XX}\%\) over traditional cut-based methods. Our results demonstrate the effectiveness of advanced MVA techniques in isolating the (VBF)\[e^+e^-\ \to\ \bar{\nu}_e\,\nu_e\,H,\quad H\to b\bar{b} \] signature from dominant backgrounds (ZH, ZZ, WW, tt).

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