Study of Higgs to WW Coupling Measurement Performance through $e^+e^- \to \nu\bar{\nu}b\bar{b}$ at Future Circular Colider - Electron Positron

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This investigation seeks to evaluate the potential performance capabilities of the measurment of Higgs to WW coupling at the FCCee - a future e^+e^- collider. The signal process used in the investigation is $e^+e^- \to \nu\bar{\nu}b\bar{b}$ through WW Fusion, and considers various backgrounds. Unlike previous studies, this investigation closely evaluates the effect of detector performance on the coupling uncertainty. The model-independent uncertainty on Higgs to WW coupling is found to be !!! using an optimized detector.

Contents

I. INTRODUCTION

The requirement on the precision of knowledge of Higgs Boson properties necessary to find new physics scales as $1/\Lambda^2$ [?]. For new physics at 1 TeV, per-cent sensitivity in Higgs couplings is ncecessary, while a per-mil sensitivity is necessary for multi-TeV new physics discoveries.

An e^+e^- collider gives a clean and high-precision higgs factory useful for studying various higgs properties [?].

The total width of the Higgs, and thus different higgs couplings, can be determined model-independently by studing the processes $e^+e^- \to ZH$ and $e^+e^- \to \nu\bar{\nu}b\bar{b}$ through WW fusion.

Previous studies have been done investigating Higgs Decays at the ILC [?], at TLEP [?] and at LEP3 using the CMS detector [?].

This study concludes that by constructing a detector specifically for the FCCee to investigate Higgs couplings, the uncertainty on the coupling of Higgs to WW can be determined to !!! percent and the uncertainty on the total higgs width, can be model-independently found to be !!!.

II. OBJECTS

The signal process investigated is $e^+e^- \to \nu\bar{\nu}b\bar{b}$ through WW fusion

The visible decay products are two b-quarks, which hadronize into two jets which are the objects searched for by the detector. The mass of the b-quarks corresponds to the mass of the Higgs Boson

III. MC EVENT GENERATION AND DETECTOR SIMULATION

The generation of signal and background events was performed through Whizard [?] which is a next-to-leading order tool and includes initial state radiation. Parton showering and hadronization was done using Pythia 8 [3]. Detector simulation was done using Delphes [4]. A card was made to simulate an optimal detector for Higgs precision studies at the FCCee.

The signal event produced is $\nu\bar{\nu}b\bar{b}$ through WW Fusion. The background events considered are $\nu\bar{\nu}b\bar{b}$ through ZH, $\nu\bar{\nu}c\bar{c}$, $\nu\bar{\nu}q\bar{q}(q \neq b, c)$, $q\bar{q}l^+l^-$, $q\bar{q}l^-\nu$, $q\bar{q}q\bar{q}$, $q\bar{q}$, and $q\bar{q}\gamma$.

IV. CANDIDATE SELECTION

To select the WW Fusion $\nu\bar{nu}b\bar{b}$ signal, first a sample is created which looks for two jets reconstruccted using the anti-k_T algorithn wth a distance parameter of 1.5. The jets are b-tagged with an efficiency specified by !!!. Only events containing two jets which are both b-tagged are allowed. Events with isolated leptons are omitted.

Next, kinematic cuts are applied based on the distribution of various properties. The visible mass of the system is required to be between 110 and 140 GeV since the visible mass from the signal comes only from the Higgs. The visible PT of the system is required to be greater than 15 GeV. The visible PZ is required to be less than 90 GeV. The number of charged tracks in the two jets is required to be between 10 and 30. The acoplanarity angle greater than 0.1, lab angle between 1.5 and 3, and CosTheta of the leading jet less than 0.95 further eliminates backgrounds. The visible energy of the system and recoil mass of the di-jet system are not considered because the uncertainty in the cross section and branching ratio of the Higgs bb system is given by the shape fit of the recoil mass, since at 350 GeV the missing mass has a large separation between the ZH and WW Fusion processes.

V. STATISTICAL METHOD

The uncertainty in the quanitity of interest, $\sigma_{\nu\bar{\nu}H}$ x Br $(H \rightarrow b\bar{b})$ is found using a Maximum Likelihood tool from HiggsAnalysis/CombinedLimit [?]. This measurement is then combined with other measurements necessary to arrive at a total higgs width in a coupling tool [?].

The Maximum Likelihood tool allows the specification of systematic uncertainties. The unertainties used are a lognormal systematic uncertainty of 2.6% on luminosity and an individual lognormal uncertainty of 1% on each of the backgrounds and signal.

The analysis gives a total uncertainty of 2.29% in $\sigma_{\nu\bar{\nu}H} x Br(H \rightarrow b\bar{b})$. Compare this to an uncertainty of 10.5% at 240 GeV and 0.66% at 500 GeV given by the ILD paper [?].

The total higgs width was calculated to be !!! and the higgs WW coupling is calculated as !!!.

VI. RESULTS

The results found in this analysis suggests an improvement in the potential precision of Higgs to WW coupling measurements using an FCCee - specific detector, and improves the physics case for a circular electron positron precision higgs factory.

VII. CONCLUSION

This will be the conclusion.

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