DETECTOR ACCEPTANCE AND CALORIMETER RESOLUTION REQUIREMENTS FOR HZ/WW FUSION CROSS-SECTION MEASUREMENT

Koji ISHII [a]

CERN CH-1211, Geneva 23 Switzerland

1 Introduction

Measurements of Higgs boson properties are important tasks at the future e^+e^- linear collider. Missing channel($\nu\nu$bb) is one of the good candidate to study the such properties because all the observable particles are the decay products of the one Higgs boson. Also both the HZ and the WW fusion process contribute to this final state with the interference term. We performed here a simulation study devoted to the measurement of the Higgs boson production cross-section in the missing channel. Since this channel is only available to observe the WW fusion process, it is interested to extract the contribution. We demonstrated an analysis of the enhanced WW fusion process using the recoil mass constraint. This channel is concerned with the detector performance and is a subject to study the requirements. The missing particles in the far forward region are directly affected the resolution of the reconstructed kinematics such as the Higgs(jet-jet) mass, the Z(recoil) mass and the Higgs production angle. The effects of the detector acceptance and resolution for this channel are presented.

2 Cross-section measurement

For the calculation of the cross-section and the event generate we use the standard PYTHIA/JETSET. The center of mass energy and Higgs mass are set to $\sqrt{s} = 300$ GeV and $M_h = 120$ GeV. The generated products are fed into the fast smearing detector simulation based on the JLC [1] parameters. The integrated luminosity is assumed to be 100 pb^{-1}, corresponding to the one year JLC operation.

The selection is classified to the kinematics and the b-tagging. The cuts of the kinematics are the followings:

- Multiplicities(tracks+clusters) > 20
- Acoplanarity angle $\theta_{acop} > 10°$
- Thrust value $|$ thrust $| < 0.95$
- Higgs production angle $| \cos\theta_{jj} | < 0.95$
- Visible energy $E_{vis} < 160$ GeV
- Higgs mass $100 < M_{jj} < 130$ GeV

[a] Postdoctoral fellow for research abroad, Japan Society for the Promotion of Science

In order to select both Higgs boson signal of HZ and WW fusion we use a loose cut of $\mid \cos\theta_{\mathrm{jj}} \mid < 0.95$ and not use a cut of recoil mass. After these cuts the selection efficiencies are found to be ~ 60 % for signal, ~ 1.2 % for WW, ~ 0.015 % for QQ and ~ 1.1 % for ZZ backgrounds. The b-tagging used here is a standard technique

Table 1: The expected number of signal and background events at the center of mass energy of 300 GeV, Higgs mass of 120 GeV and an integrated luminosity of 100 pb^{-1}.

Process	Selected Number of Events
HZ($\nu\nu$bb)	1403
WW fusion($\nu\nu$bb)	716
Other Higgs signal	46.3
QQ background	69.7
WW background	998
ZZ background	244
Weν background	49.0
Zee background	30.1

based on the normalised impact parameter of tracks [2]. The tagging efficiencies for the signal of $\nu\nu$bb and $\nu\nu$cc are estimated to be ~ 82 % and ~ 12 %, while for the background of WW, QQ and ZZ they are ~ 5.3 %, ~ 14.5 % and 19.4 %, respectively. The expected number of signal and background events are summarised in the table 1. A total selection efficiency is estimated to be ~ 49 %. An error of the measurement of the Higgs production cross-section including HZ and WW fusion process is found $\delta\sigma/\sigma = 2.7$ % at an integrated luminosity of 100 pb^{-1}.

To enhance the WW fusion process we can use a cut of the recoil mass. The $\mathrm{M}_{\mathrm{recoil}} > 140$ GeV reduced not only the HZ process but also the WW $\rightarrow$ lνqq background which is the dominant one. The 496 events of WW fusion process are expected to survive this cut, while the other Higgs process events and the total backgrounds are suppressed to be 206 and 498, respectively. An error of the measurement of the Higgs production cross-section for WW fusion process is obtained to be about 7 %. In actual we should take care the interference term between HZ and WW fusion process. For a realisation of including such the effect we can utilise a distribution of the Higgs production angle. A likelihood fitting may help to extract a contribution of the WW fusion process for the Higgs production cross-section.

3 Detector requirements study

3.1 Acceptance

The current JLC detector parameters are described in detail elsewhere [3]. The calorimeter covers the polar angle range $\mid \cos\theta \mid < 0.99$. The active mask is introduced in the range $0.98 < \cos\theta < 0.99$ in order to shield against a large number of secondary photons [4]. The missing particles in the far forward region is undesirable for the study of the missing channel. Furthermore the kinematic value of the Higgs production angle $\mid \cos\theta_{\mathrm{jj}} \mid$ tend to be in the forward region for the WW fusion

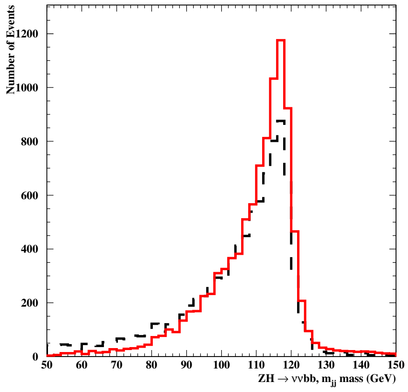

Figure 1: Higgs mass distribution for the acceptance of 0.98(lined) and 0.90(dotted).

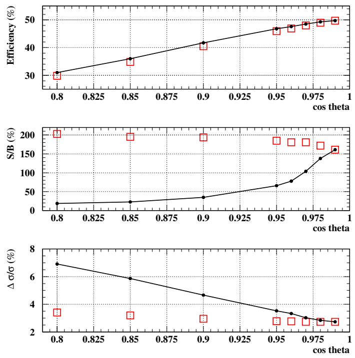

Figure 2: Acceptance dependences.

signal and main background processes. A beam-beam interaction is also a serious problem [5], which might be impossible to use the forward region detector.

Figure 1 is the Higgs mass distribution of the HZ($\nu\nu$bb) process. The lined histogram shows the acceptance of the range $|\cos\theta| < 0.98$, while the dotted histogram is the 0.90. The lower tail below the 100 GeV is occurred in result the loss of the signal events. The small coverage of the detector acceptance also causes a increase of the background events. In the range $0.97 < \cos\theta < 0.99$ WW(qqlν) background processes is increasing, while in the range $0.90 < \cos\theta < 0.97$ WW(qqqq) and QQ backgrounds are increasing. The results of the acceptance dependences are shown in the figure 2 with the circle. The signal efficiency(upper), the ratio of the Signal/Background(middle) and $\delta\sigma/\sigma$(lower) are figured. The $\delta\sigma/\sigma$(lower) becomes worse 4.7 % at the acceptance range $|\cos\theta| < 0.90$.

One of the solution to recover it is a tag of the particle which is in the forward region with having more than 10 GeV. The events having this tagged particle is regarded as the WW(qqlν) background process. The squared points shown in the figure 2 are the results of utilising this method. The efficiency is not changed, however, the S/B improved, so that the $\delta\sigma/\sigma$(lower) is recovered to be around 3.0 It suggests us that a calorimeter type of the active mask may be a powerful instrument.

3.2 Resolution

The lined histogram shown in the figure 3 is the Higgs mass distribution of the HZ($\nu\nu$bb) process in a case of the standard JLC detector resolution, $\sigma_{\mathrm{P_t}}/\mathrm{P_t} = 1.1 \times 10^{-4}\mathrm{P_t}, \sigma_{\mathrm{E}}/\sqrt{\mathrm{E}} = 15\%/\sqrt{\mathrm{E}}$ for e and $\gamma, \sigma_{\mathrm{E}}/\sqrt{\mathrm{E}} = 40\%/\sqrt{\mathrm{E}}$ for hadrons. The dashed one is two times better resolution case and the dotted one is two times worse case to the default values. Comparing to the acceptance no tail can be found. Figure 4 is the same but the each detector resolution was changed by two times worse(dotted). It is clear that the electromagnetic and hadronic calorimeter

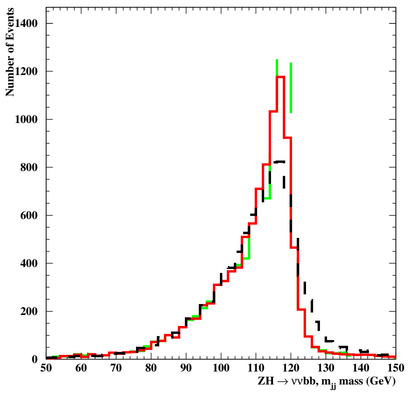

Figure 3: Higgs mass distribution for the resolution of the default JLC detector parameters(lined, see text), default $\times$ 0.5(dashed), default $\times$ 2.0(dotted).

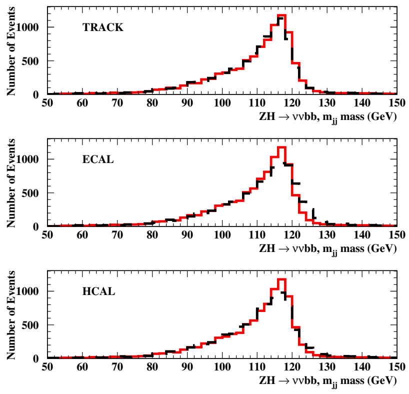

Figure 4: Higgs mass distribution for the various detector resolution. The track momentum(up), electromagnetic calorimeter energy(middle) and hadronic calorimeter energy(low).

resolution defined the mass resolution. However there is a small effect for the cross-section measurement because of the mass window of $100 < \mathrm{M_{jj}} < 130$ GeV in our case. Our results suggest that the electromagnetic calorimeter is most effective to the mass resolution. But for the detail of the detector requirements we should study the Higgs mass measurement and have to improve the current analysis of mass resolution such as the matching method of the tracks and the clusters.

4 Summary

At an accumulated luminosity of 100 pb^{-1}, we presented that the Higgs production cross-section for the HZ and WW fusion process is measured with the precision of the ~ 2.7 %. The WW fusion process can be estimated at the ~ 7 % level in which the interference term is ignored. For the acceptance study a good coverage is essential. The active mask and calorimeter are important role. The tag of more than 10 GeV particle at the forward region is one of the effective method to recover the acceptance loss. For the cross-section measurement the detector resolution is not severe requirements. The standard JLC detector parameters show a good performance.

References

1. JLC Group, JLC-I, KEK Report 92-16, December 1992.
2. I. Nakamura, "Cross-section/branching ratio measurement for Higgs M<160 GeV", in these proceedings.
3. T. Matsui, "Overview of the JLC detector model", in these proceedings.
4. T. Tauchi, "JLC IP Layout/Issues", in these proceedings.
5. S. Yamashita, "Effects of beam beam interaction and event overlap in Higgs study", in these proceedings.