A new method to measure the Higgs mass at the ILC

Junping Tian[1,*]

[1] *International Center for Elementary Particle Physics,*
The University of Tokyo, Tokyo 113-0033, Japan

(Dated: October 19, 2018)

Abstract

* tian@icepp.s.u-tokyo.ac.jp

I. INTRODUCTION

A. Physics Motivation

Higgs mass precision is important for predicting partial widths of $H \to ZZ^*$ and $H \to WW^*$, henceforth for precisions of HZZ and HWW couplings measured at the ILC. Quantitatively,

$$\delta_Z = 7.7\delta m_H, \quad \delta_W = 6.9\delta m_H. \tag{1}$$

B. Detector Benchmark

Large or Small? Let physics speak.

C. Methodology

In process $e^+e^- \to ZH,\ Z \to f\bar{f},\ H \to b\bar{b}/c\bar{c}/gg$, using conservation of $\sum_i (p_x, p_y)_i = 0$

$$p_1 \sin\theta_1 \cos\phi_1 + p_2 \sin\theta_2 \cos\phi_2 = p_x \tag{2}$$

$$p_1 \sin\theta_1 \sin\phi_1 + p_2 \sin\theta_2 \sin\phi_2 = p_y \tag{3}$$

where index 1 and 2 are for two jets from H decay, p_x and p_y are transverse recoil vector against $Z \to f\bar{f}$. Values obtained from direct measurement are used for all variables except p_1 and p_2 which can be obtained by solving the two equations as

$$\begin{pmatrix} p_1 \\ p_2 \end{pmatrix} = \frac{p_t}{\sin\phi_{12}} \begin{pmatrix} \frac{\sin(\phi-\phi_2)}{\sin\theta_1} \\ \frac{\sin(\phi_1-\phi)}{\sin\theta_2} \end{pmatrix}, \tag{4}$$

where $\phi_{12} = \phi_1 - \phi_2$ and $p_t = \sqrt{p_x^2 + p_y^2}$.

D. Advantages

Comparing to the traditional method using recoil mass, the new method is not sensitive to various effects, such as beamsstrahlung, ISR and beam energy uncertainty, which are too significant at high $\sqrt{s}$ to use recoil method for precision Higgs mass measurement.

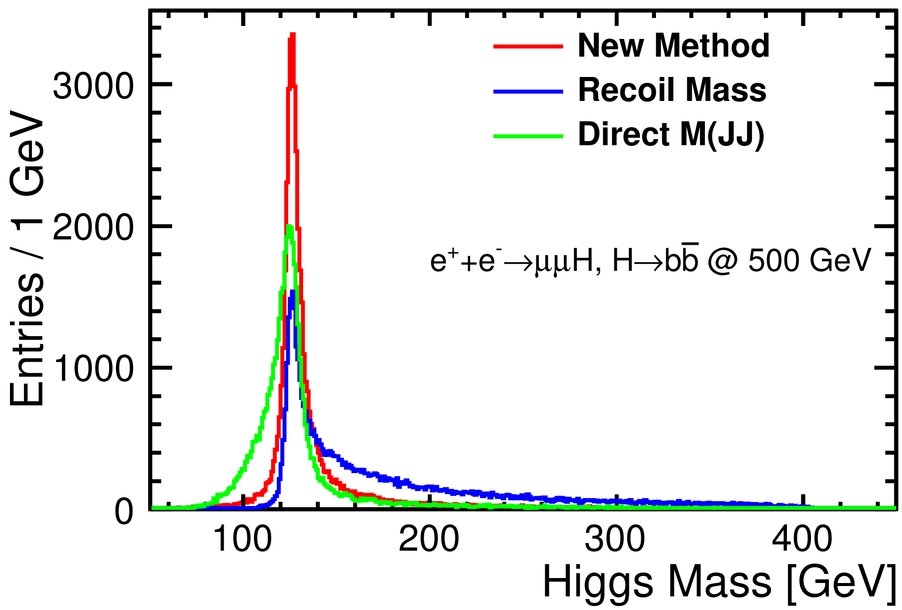

FIG. 1. Reconstructed Higgs Mass for 3 methods.

Comparing to another method which directly uses measured jet 4-momentum to reconstruct the di-jet invariant mass as Higgs mass, the new method doesn't need measured jet energy and only makes use of measured jet directions.

The advantage of the new method becomes manifest in Figure 1 where the Higgs mass from 3 methods are plotted based on full detector simulations (DBD samples).

Another good point is that the new method doesn't depend on the type of underlying boson which decayed into those two jets, namely it not only improves Higgs mass resolution for signal but also improves Z boson mass resolution for background such as ZZ. Therefore we have a powerful mean to control the systematic errors by looking at the reconstructed Z mass.

II. DETECTOR SIMULATION

A. Generator

B. Simulation and Reconstruction Tools

C. Detector Models

DBD, Large, Small...

III. DETECTOR PERFORMANCE

The aspects of detector performance which are important for benchmark analysis by the new method: In channel $Z \to \mu^+\mu^-$ or $Z \to e^+e^-$, momentum resolution for isolated leptons, and angular resolution for jet directions, shown in Figure 2

IV. RESULTS

[Full analysis Including background, cuts, normalization, etc.] Final distributions are shown in Figure 3. The expected Higgs mass precisions are 66MeV for Large, 81MeV for Small, which differ by around 22%.

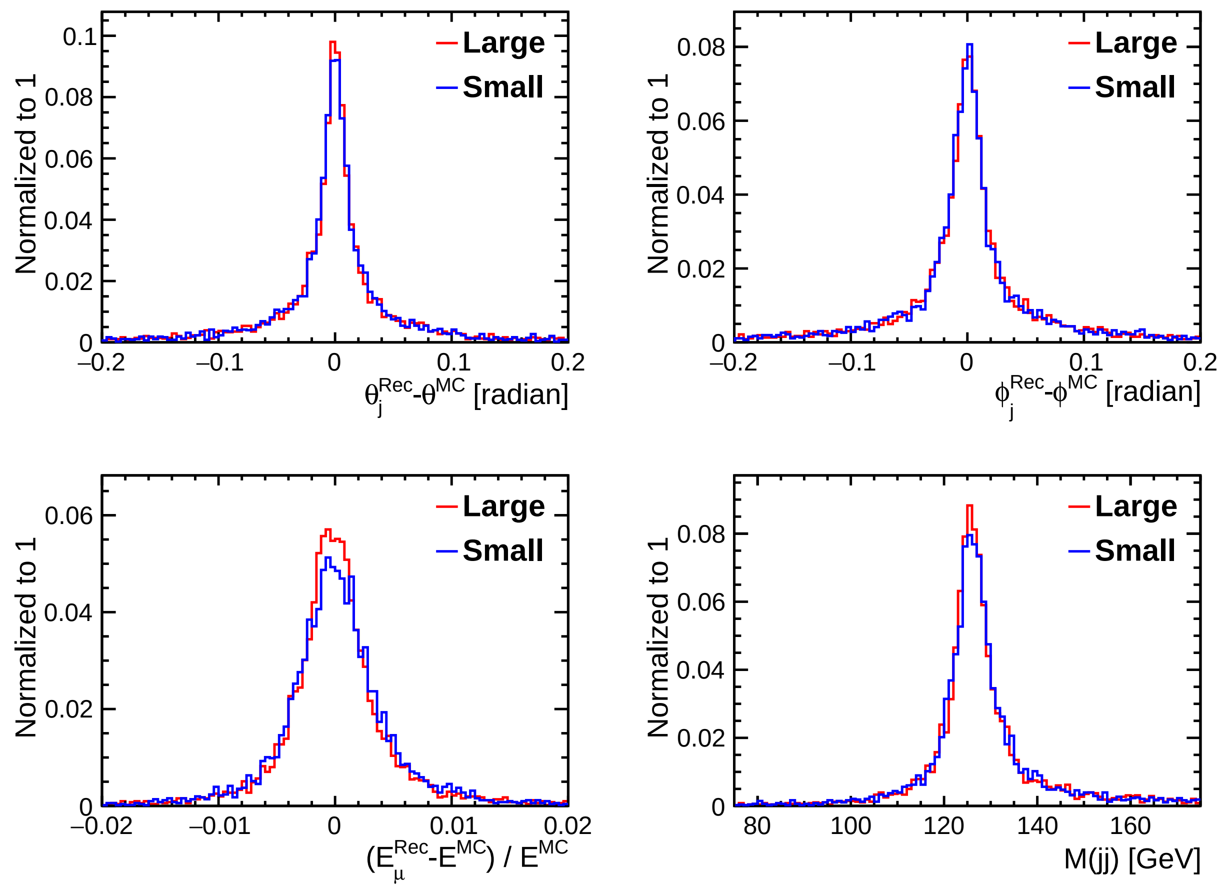

FIG. 2. Detector resolutions for: Jet Polar Angle, Jet Azimuthal Angle, Lepton Momentum, Higgs Mass.

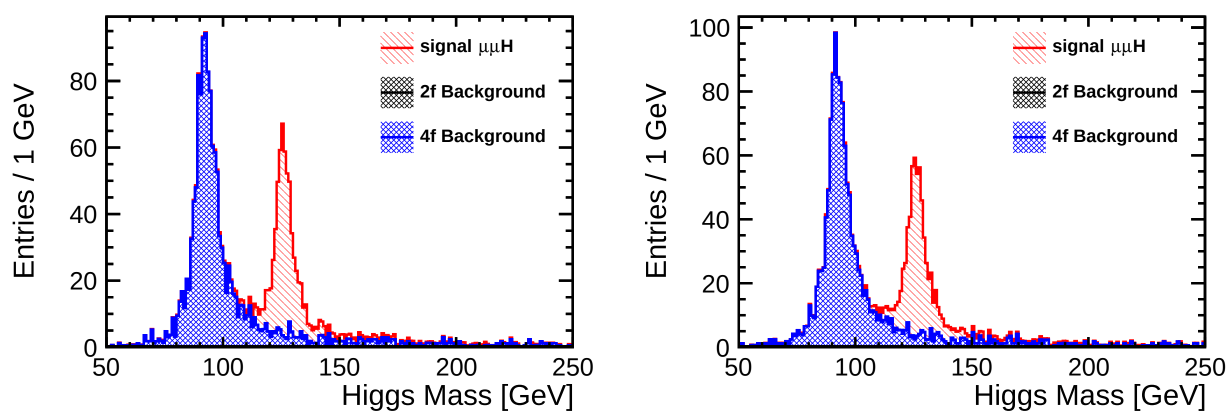

FIG. 3. Higgs mass distributions for signal and background for Large (left) and Small (right).