A simulation study on measurement of the polarization asymmetry A_{LR} using the initial state radiation at the ILC with center-of-mass energy of 250 GeV Department of Physics, Tohoku University

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1 Introduction

The future e^+e^- linear collider ILC is expected to be the key of model-independent determination of the couplings of the Higgs boson. In order to achieve this goal, the Higgs Effective Field Theory indicates that the left-right asymmetry A_{LR} needs to be measured more precisely. This study reports the result of a simulation study on measurement of the A_{LR} using the initial state radiation at the ILC with center-of-mass energy of 250 GeV. It is based on a fast SiD simulation in expected ILC condition. The SiD is one of the proposed detectors for the ILC and it is assumed to share the same interaction point with the International Large Detector (ILD) by push-pull configuration. Currently, A_{LR} has the relative error of approximately 1.5 %, which comes from the data of SLD detector at SLAC National Accelerator Laboratory.

2 Method

The signal process is defined by $e^+e^- \to q\bar{q}$ via Z boson production. In order to reconstruct the effective COM energy $\sqrt{s'}$, we follow the method used in the ALEPH at LEP to measure the beam energy with high precision. The x is a parameter regarding the effective COM energy and defined as the ratio of the ISR photon energy to the beam energy. Figure 1 and 2 show the x distribution before/after the selection cut.

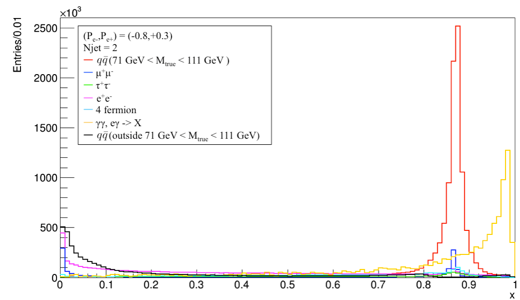

Figure 1: The x distribution before the selection cut with $(P_{e^-}, P_{e^+}) = (-0.8, +0.3)$

3 Result

Reconstruct the x value for only the events satisfying $0.75 < x < 0.95$. Assume the MC data for background is generated correctly. The number of signal can be obtained by subtracting the number of background events based on the MC data from the measured number of all events The number of events is summarized in Table 1. Then, the number of signal events is derived as:

	N_L (250 fb^{-1})	N_R (250 fb^{-1})
All Events (measure)	10434326	6794226
All Background Events (MC)	1051278	469413

Table 1: Number of all events and background events

$$N_L^{signal} = N_L^{total}(meas) - N_L^{bkg}(MC) = 9383048$$
$$N_R^{signal} = N_R^{total}(meas) - N_R^{bkg}(MC) = 6324813 \quad (1)$$

Using these numbers, A_{LR} can be calculated as:

$$A_{LR} = 0.21947 \pm 0.00038 \ (500 fb^{-1}) \qquad (2)$$

The sample is generated with $\sin^2\theta_{\mathrm{W}}$ of 0.22225 corresponding to the A_{LR} of 0.21930. With the full-data of 250 GeV operation at the ILC, the statistical error of the A_{LR} can be reduced to be half furthermore and it corresponds to the relative statistical error of about 0.1 %.

In order to remove MC modeling uncertainties for background events, the number of events is extracted from the integration of a fitting function. The x distribution for only signal events is fitted with three Gaussian functions. Then, the total x distribution is fitted with the signal function, another Gaussian function and a third-order function (see Figure 3 and 4). The latter two are introduced for fitting background events. Here, the shape of the signal function are fixed, while all parameters for the background function is floated. The result is summarized in Table 2.

	N_L (250 fb^{-1})	N_R (250 fb^{-1})	$\frac{N_L-N_R}{N_L+N_R}$	A_{LR}
All Events	10216660	6655036	0.21110	0.23797
Signal Events	9314017	6277252	0.19477	0.21956
Background Events	902643	377784	0.40991	0.46208

Table 2: The result of integration for each fitting function in the range of $0.75 < x < 0.95$

The statistical error is obtained by

$$A_{LR} = 0.21956 \pm 0.00040 \ (500 fb^{-1}) \qquad (3)$$

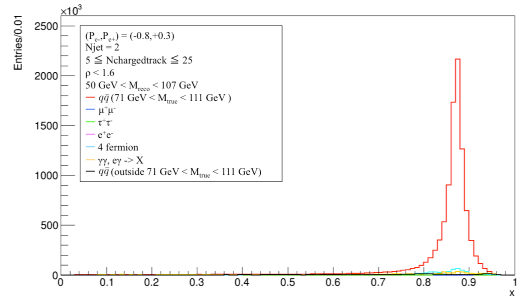

Figure 2: The x distribution after the selection cut with $(P_{e^-}, P_{e^+}) = (-0.8, +0.3)$

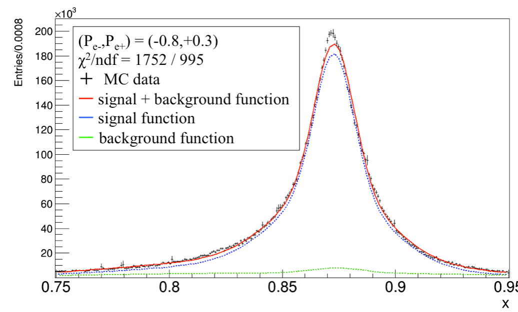

Figure 3: Fitting result for the x distribution with $(P_{e^-}, P_{e^+}) = (-0.8, +0.3)$

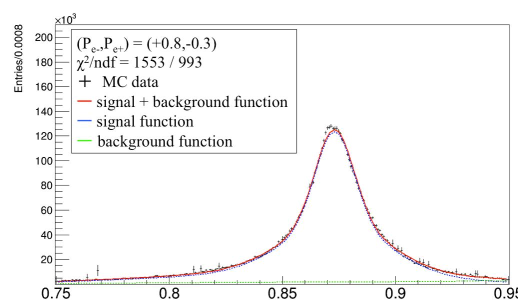

Figure 4: Fitting result for the x distribution with $(P_{e^-}, P_{e^+}) = (-0.8, +0.3)$