Top electroweak couplings study using di-muonic state at $\sqrt{s} = 500$ GeV, ILC

Physics Meeting 0113

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Current status

Started analysis using DBD samples which include all effects.

- Kinematical reconstruction considering ISR/BS photons.

Method of considering ISR/BS photons

Collinear approximation :

Photons are emitted on the beam directions

4-momenta of electron/positron

$$\vec{e}^{\,-} = \hat{\eta}_{e^-} E_{e^-}$$
$$\vec{e}^{\,+} = \hat{\eta}_{e^+} E_{e^+}$$

Before ISR/BS

$$\vec{\gamma}_{e^-} = \hat{\eta}_{e^-} E_{\gamma_{e^-}} = k_{e^-} \vec{e}^{\,-} \quad \text{with} \quad k_{e^-} = \frac{E_{\gamma_{e^-}}}{E}$$
$$\vec{\gamma}_{e^+} = \hat{\eta}_{e^+} E_{\gamma_{e^+}} = k_{e^+} \vec{e}^{\,+} \quad \text{with} \quad k_{e^+} = \frac{E_{\gamma_{e^+}}}{E}$$

$$(\vec{e}^{\,-})^* = \vec{e}^{\,-} - \vec{\gamma}_{e^-} = \hat{\eta}_{e^-} E(1 - k_{e^-})$$
$$(\vec{e}^{\,+})^* = \vec{e}^{\,+} - \vec{\gamma}_{e^+} = \hat{\eta}_{e^+} E(1 - k_{e^+})$$

After ISR/BS

→ Add k_{e^-}, k_{e^+} into minimization parameters

Method of considering ISR/BS photons

Thrust axis method

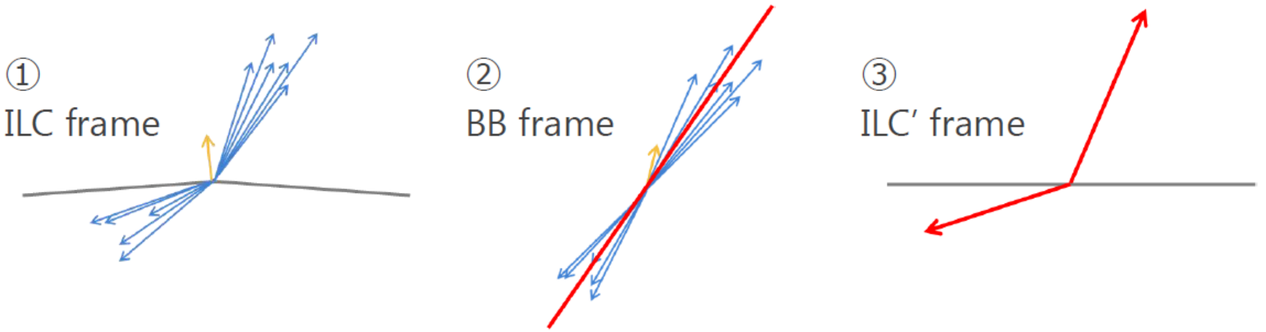
① Collect all hadronized particles from b and $\bar{b}$ quark and photons from isolated leptons in the ILC frame

② Boost them to their rest frame and calculate thrust axis in this frame (defined as the BB frame in this slide)

③ Boost the vectors along the thrust axis to the ILC′ frame

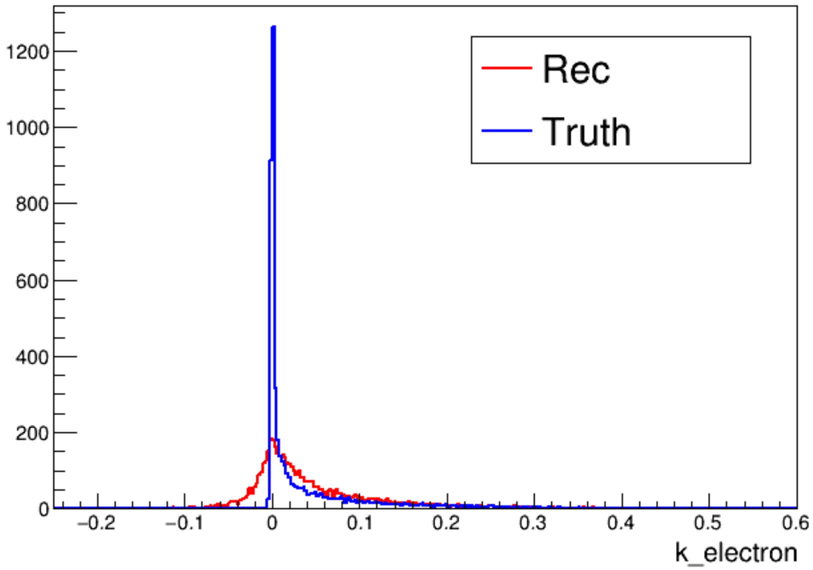
(ILC′ frame : the frame in which head-on-collision occurs)

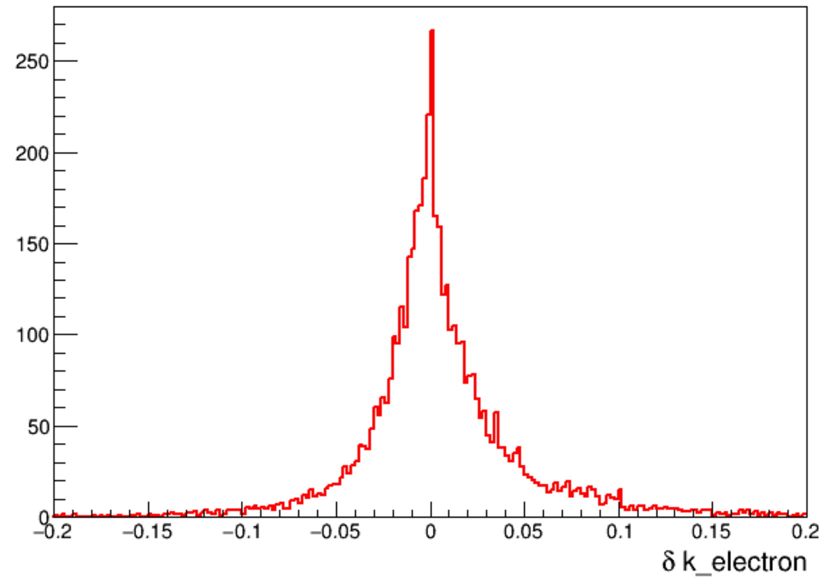
Boost the vectors to the e+e- rest frame with $\boldsymbol{k}_{e^-}, \boldsymbol{k}_{e^+}$



Preliminary results

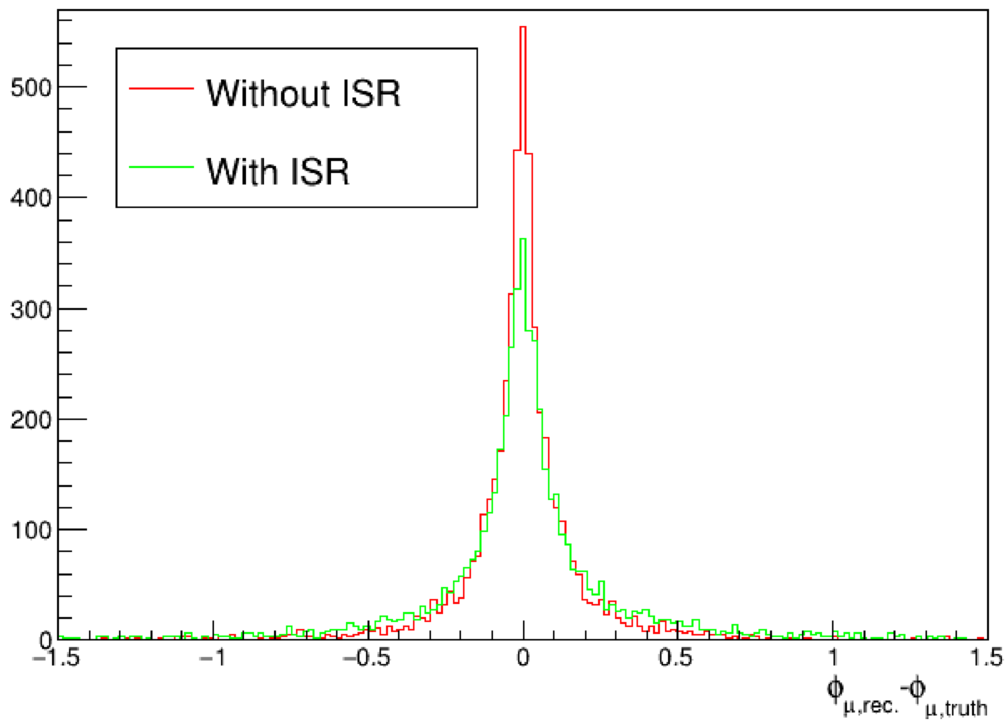
k_{e^-} distribution and deviation distribution





Preliminary results

Deviation distribution of ϕ_{μ^+}



Summary and Plan

- Started analysis using the DBD samples.
- Get preliminary results of the kinematical reconstruction considering ISR/BS photons

→ Apply the Matrix element method to the DBD samples

- Study about background events.

Backup

χ^2 algorithm : General

1. Define the χ^2_μ ;

$$\chi^2_\mu = \chi^2_{\mu^+} + \chi^2_{\mu^-},\quad \chi^2_{\mu^\pm} = \left(\frac{E^{**}_{\mu^\pm}(\theta_t,\phi_t,m_t,m_{\bar{t}},m_{W^+},m_{W^-}) - m_{W^\pm}/2}{\sigma\left[E^{**}_{\mu^\pm}\right]}\right)^2$$

The energy of $\mu^\pm$ in the $W^\pm$ rest frame, $E^{**}_{\mu^\pm}$, must be equal to $m_{W^\pm}/2$.

2. Define the δ^2_b ;

$$\delta^2_b = -2\log L_b - 2\log L_{\bar{b}},\quad L_b = \mathrm{CB}\left(E^{\mathrm{meas.}}_b - E^{\mathrm{rec.}}_b(\theta_t,\phi_t,m_t,m_{\bar{t}},m_{W^+},m_{W^-})\right)$$

The likelihood function is obtained from the assessment of b-jets energy.

3. Compound $\chi^2_{\mathrm{tot.}}$; $\chi^2_{\mathrm{tot.}} = \chi^2_\mu + \delta^2_b$

One minimizes the $\chi^2_{\mathrm{tot.}}$ to obtain the optimal solution; $(\theta_t,\phi_t,m_t,m_{\bar{t}},m_{W^+},m_{W^-})$.

χ^2 algorithm : Optional

The direction of b-jets is obtained by thrust axis method.

→ Add 4 angles $(\theta_b, \phi_b, \theta_{\bar{b}}, \phi_{\bar{b}})$ to the minimization parameters

→ Add constraints of 4 angles $(\theta_b, \phi_b, \theta_{\bar{b}}, \phi_{\bar{b}})$ to $\chi^2_{\mathrm{tot.}}$ as follows;

$$\chi^2_{\mathrm{direction}} = \chi^2_{\theta_b} + \chi^2_{\phi_b} + \chi^2_{\theta_{\bar{b}}} + \chi^2_{\phi_{\bar{b}}}, \qquad \chi^2_{\theta_b} = \left(\frac{\theta_b^{\mathrm{meas.}} - \theta_b}{\sigma[\theta_b^{\mathrm{meas.}}]} \right)^2$$

$(\chi^2_{\phi_b}, \chi^2_{\theta_{\bar{b}}}, \chi^2_{\phi_{\bar{b}}}$ are same as $\chi^2_{\theta_b})$

$$(\chi^2_{\mathrm{tot.}})' = \chi^2_{\mathrm{tot.}} + \chi^2_{\mathrm{direction}}$$

We can use $(\chi^2_{\mathrm{tot.}})'$ instead of $\chi^2_{\mathrm{tot.}}$ to get the optimal solution,

which is written in $(\theta_t, \phi_t, m_t, m_{\bar{t}}, m_{W^+}, m_{W^-}, \theta_b, \phi_b, \theta_{\bar{b}}, \phi_{\bar{b}})$