Top electroweak couplings study using di-leptonic state at $\sqrt{s}$ = 500 GeV, ILC with the Matrix Element Method

0119

Yo Sato[A]

Akimasa Ishikawa[A], Emi Kou[B], Francois Le Diberder[B], Hitoshi Yamamoto[A], Junping Tian[C], Keisuke Fujii[D], Ryo Yonamine[A]

Tohoku University[A], LAL[B], University of Tokyo[C], KEK[D]

Update from last meeting

At last meeting, we tried to loosen a cut criteria to recover the sensitivity.

Update

- Optimization the criteria
- Consider the irreducible background (single top production, WWZ)

Optimization for the binned analysis

χ^2 for the binned likelihood is defined as

$$\chi^2(\delta F) = \sum_{i=1}^{N_{\mathrm{bin}}} \frac{n_i^{\mathrm{data}} - n_i^{\mathrm{Sim.}}(\delta F)}{\sqrt{n_i^{\mathrm{data}}}}$$

n_i^{Sim} can be computed as

$$\begin{aligned}
n_i^{\mathrm{Sim.}}(\delta F) &= n_i^{\mathrm{Sim.\ sig}}(\delta F) + n_i^{\mathrm{Sim.\ bkg}} \\
&= \frac{L^{\mathrm{data}}}{L^{\mathrm{Sim.}}} \sum_{\omega_e \in bin_i} \left(1 + \omega(\Phi_e)\delta F + \tilde{\omega}(\Phi_e)\delta F^2\right) + n_i^{\mathrm{Sim.\ bkg}} \\
&= n_i^{\mathrm{Sim.\ sig}}(0)\left(1 + \langle\omega\rangle_i \delta F + \langle\tilde{\omega}\rangle_i \delta F^2\right) + n_i^{\mathrm{Sim.\ bkg}}
\end{aligned}$$

Optimization for the binned analysis

The precision can be obtained from the inverse of the second derivative of $\frac{1}{2}\chi^2$.

$$\begin{aligned}\frac{\partial^2}{\partial(\delta F)^2}\frac{1}{2}\chi^2(\delta F) &= \sum_{i=1}^{N_{\mathrm{bin}}}\frac{1}{n_i^{\mathrm{data}}}\left(\frac{\partial n_i^{\mathrm{Sim.\ sig}}(\delta F)}{\partial(\delta F)}\right) \\ &= \sum_{i=1}^{N_{\mathrm{bin}}}\frac{(n_i^{\mathrm{Sim.\ sig}}(0))^2}{n_i^{\mathrm{data}}}\langle\omega\rangle_i^2\end{aligned}$$

$n_i^{\mathrm{Sim.sig}}(0)$ is approximately same as $n_i^{\mathrm{data\ sig}}$

$$\frac{\partial^2}{\partial(\delta F)^2}\frac{1}{2}\chi^2(\delta F) \simeq \sum_{i=1}^{N_{\mathrm{bin}}}\left(\frac{n_i^{\mathrm{data\ sig}}}{\sqrt{n_i^{\mathrm{data\ sig}}+n_i^{\mathrm{data\ bkg}}}}\right)^2\langle\omega\rangle_i^2$$

Optimization for the binned analysis

That's why we use the significance, S, to optimize the criteria.

$$S = \frac{N^{sig}}{\sqrt{N^{sig} + N^{bkg}}}$$

The effect of the miss combination of μ and b-jet maybe affect on $< \omega >$ and we should care of it. But in my thesis, we only consider S.

Irreducible backgrounds

We have used $\boldsymbol{bb\mu\mu\nu\nu}$ as signal events.

However, these events are produced by several processes, such as **the single top production** and **WWZ** which don't depend on the form factor.

We should separate them from the top pair production and consider them as background.

(If we apply *the template method,* we don't need to care of it.)

We use following criteria to select the top pair production.

$$\left|M_{b\mu^+\nu} - 174\right| < 15 \ \& \ \left|M_{\bar{b}\mu^-\bar{\nu}} - 174\right| < 15 \text{ (at truth level)}$$

referring to arXiv:1411.2355 [hep-ex].

Cut table

選別項目	Signal	$t\bar{t}$	$t\bar{t}$ 以外	Background	qqll	bbll$\nu\nu$
No Cut	2837			8410633	91478	8491
μ selection	2618			327488	13827	381
b-tag$_{\mathrm{max}} > 0.5$ or b-tag$_{\mathrm{2nd}} > 0.3$	2489	2215	273	4143	2943	358
Quality cut ($q_{\mathrm{min}} < 11.5$)	2396	2103	195	624	258	312

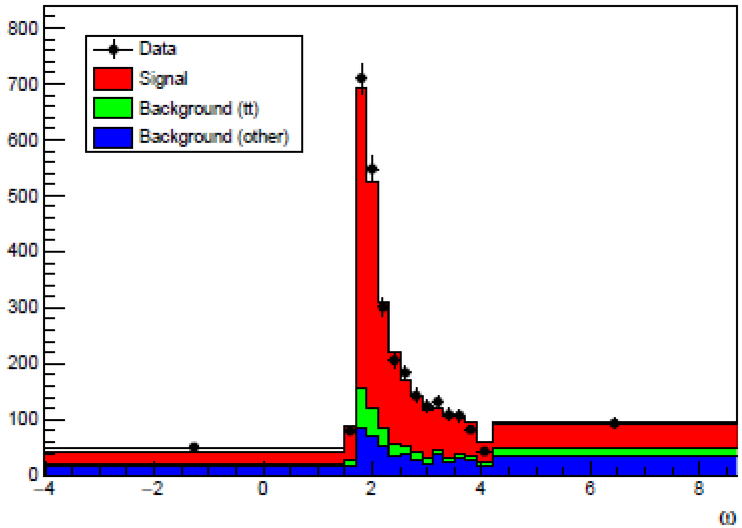
Left polarization

選別項目	Signal	$t\bar{t}$	$t\bar{t}$ 以外	Background	qqll	bbll$\nu\nu$
No Cut	1261			3751175	46344	3758
μ selection	1170			230260	6987	186
b-tag$_{\mathrm{max}} > 0.5$ or b-tag$_{\mathrm{2nd}} > 0.3$	1097	1046	79	2118	1468	179
Quality cut ($q_{\mathrm{min}} < 12.5$)	1046	976	70	297	132	149

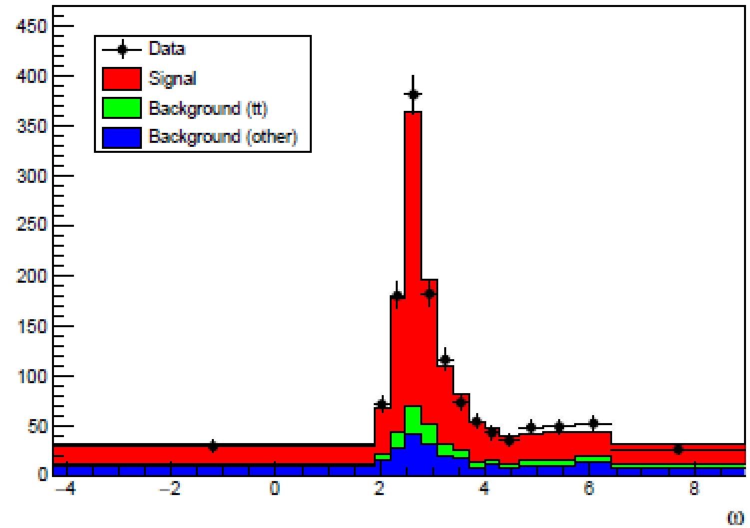
Right polarization

Results : $\widetilde{F}_{1V}^{\gamma}$

Results of 1 parameter fit. $\widetilde{F}_{1V}^{\gamma}$



(a)left



(b)right

$$\delta \widetilde{F}_{1V,\mathrm{fit}}^{\gamma} = -0.0038 \pm 0.0071, (\mathrm{C.L.} = 55.2\%)$$

Comparison with semi-leptonic analysis

Quantity	Standard model tree-level	ILC[40] L = 500 fb^{-1} semi-leptonic	ILC L = 500 fb^{-1} 本研究
F_{1V}^{γ}	2/3	± 0.002	± 0.0071
F_{1V}^{Z}	0.230	± 0.003	± 0.0128
F_{1A}^{γ}	0	-	± 0.0162
F_{1A}^{Z}	-0.595	± 0.007	± 0.0262
F_{2V}^{γ}	0	± 0.001	± 0.0058
F_{2V}^{Z}	0	± 0.002	± 0.0102

Quantity	Standard model tree-level	ILC[41] L = 500 fb^{-1} semi-leptonic	ILC L = 500 fb^{-1} 本研究
$\mathcal{R}eF_{2A}^{\gamma}$	0	± 0.005	± 0.0238
$\mathcal{R}eF_{2A}^{Z}$	0	± 0.007	± 0.0351
$\mathcal{I}mF_{2A}^{\gamma}$	0	± 0.006	± 0.0223
$\mathcal{I}mF_{2A}^{Z}$	0	± 0.010	± 0.0394

Deference of N_{signal} :

$$\frac{N_{\mathrm{semi-leptonic}}}{N_{bb\mu\mu\nu\nu}} \simeq \frac{\frac{6}{9} \times \frac{2}{9} \times 2}{\frac{1}{9} \times \frac{1}{9}} = 24$$

→ a factor of 5 can be expected.

Almost consistent with semi-leptonic analysis and our results are slightly better for some quantities intrinsically.