Top electroweak couplings at 500 GeV ILC

ILD Analysis/Software Meeting

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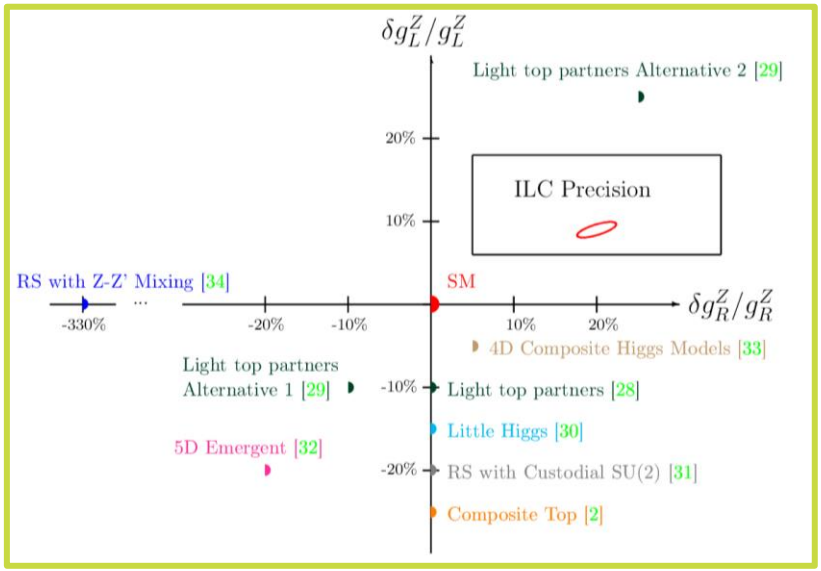
Motivation

The top quark mass is comparable with the electroweak symmetry breaking scale.

Top quark may be related to new physics behind EWSB, such as composite models,

so top quark electroweak coupling is a good probe of new physics.



Plot showing the predicted deviations of Z^0 couplings to t_L and t_R in composite models

arXiv:1403.2893 [hep-ph]

Precision expected at the ILC will allow to distinguish between models.

Topic

1. Semi-leptonic analysis : Reason of the migration effect
2. Fully-leptonic analysis : Cut study as first trial of this analysis

Top quark reconstruction for Semi-leptonic analysis

- Isolated lepton finding : #iso_lep =1
- Suppressing the overlay background using k_T algorithm
- Jet clustering using Durham algorithm (LCFIPlus package)
- 2 b-likeness jets were found (LCFIPlus package)
- Reconstruction of top quark decaying hadronic
- Minimizing the χ^2 to select the better combination of b and W;

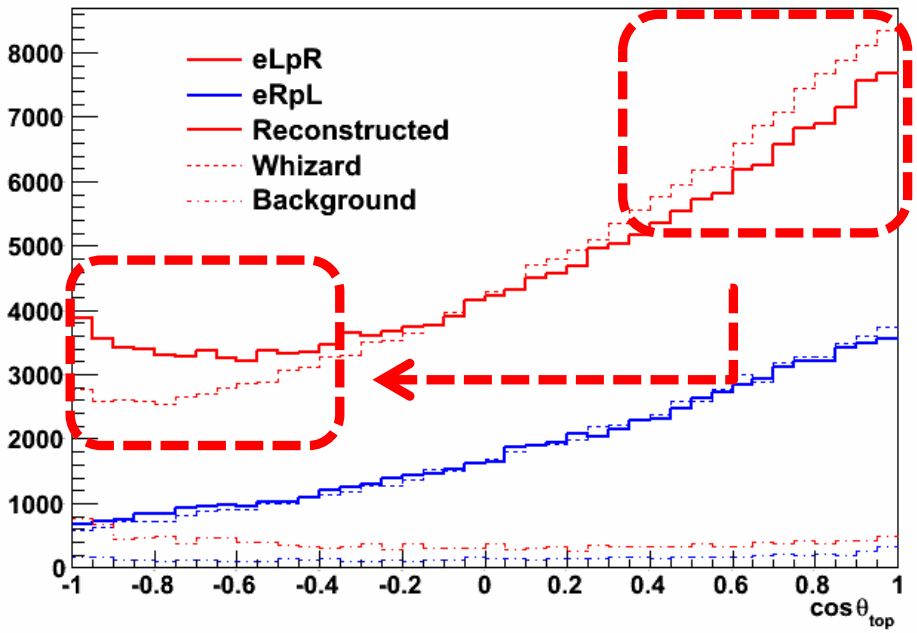
$$\chi^2 = \left(\frac{\gamma_t - 1.403}{\sigma_{\gamma_t}}\right)^2 + \left(\frac{p_b^* - 67.4}{\sigma_{p_{b^*}}}\right)^2 + \left(\frac{\cos\theta_{bW} - 0.23}{\sigma_{\cos\theta_{bW}}}\right)^2$$

γ_t : the Lorentz factor of top quark ($\gamma_t = E_t/m_t$)

p_b^* : the momentum of b quark in the rest frame of top quark

θ_{bW}: the angle between the b quark and the W boson in the ILC frame

Angular distribution of top decaying hadronic



Right-handed electron case (eRpL), Blue line

Precise reconstruction of θ_{top}

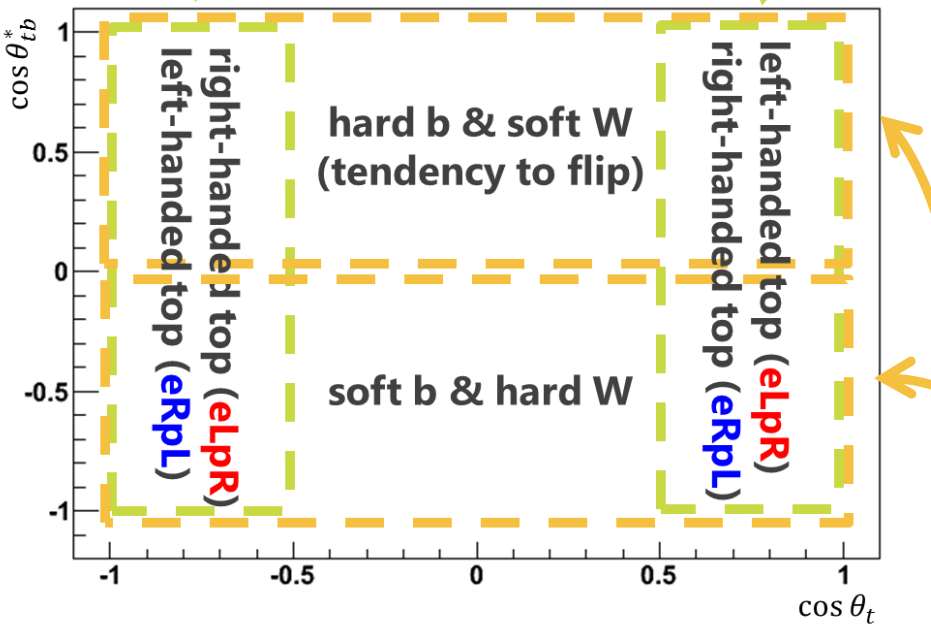
Left-handed electron case (eLpR), Red line

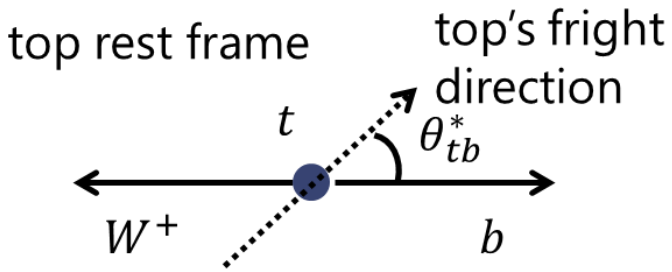
Considerable migrations of events passing from the forward hemisphere to the backward one.

→ It's called **the migration effect**.

In this analysis, the control of the migration effect is main problem

Correlation between $\cos\theta_t$ and $\cos\theta^*_{tb}$





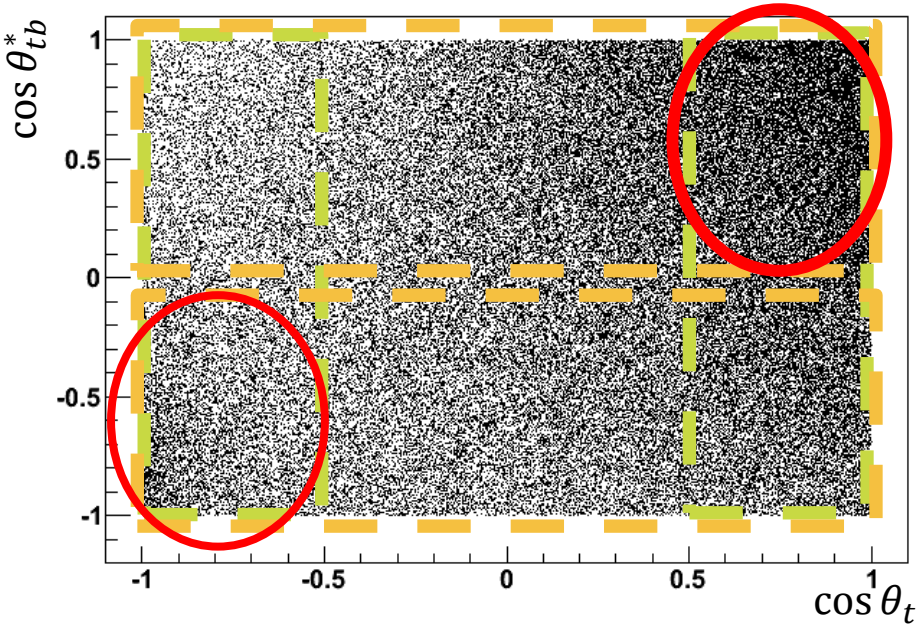
- The angular distribution for each combination of the initial and the top's polarization stems is determined by angular momentum conservation.

  (e.g.) $|M(e_L\bar{e}_R \to t_L\bar{t}_R)^{\gamma,Z}|^2 \propto (1+\cos\theta_t)^2$

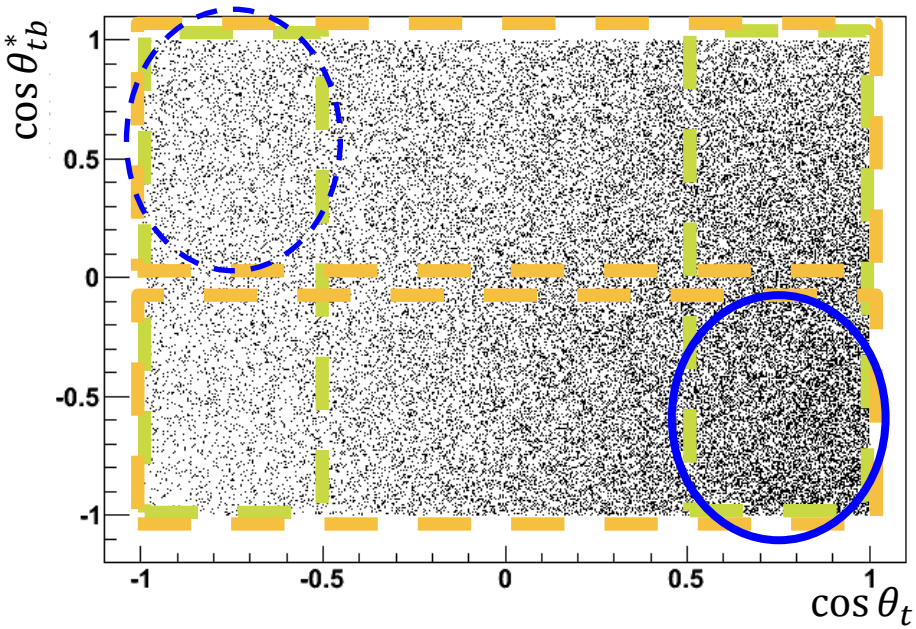
- When b quark is emitted to top's fright direction (opposite direction), b becomes hard (soft) and W becomes soft (hard).
- In the case of hard b and soft W, wrong association of b and W can flip the polar angle by π giving rise to migrations.

Correlation between $\cos\theta_t$ and $\cos\theta^*_{tb}$

eLpR



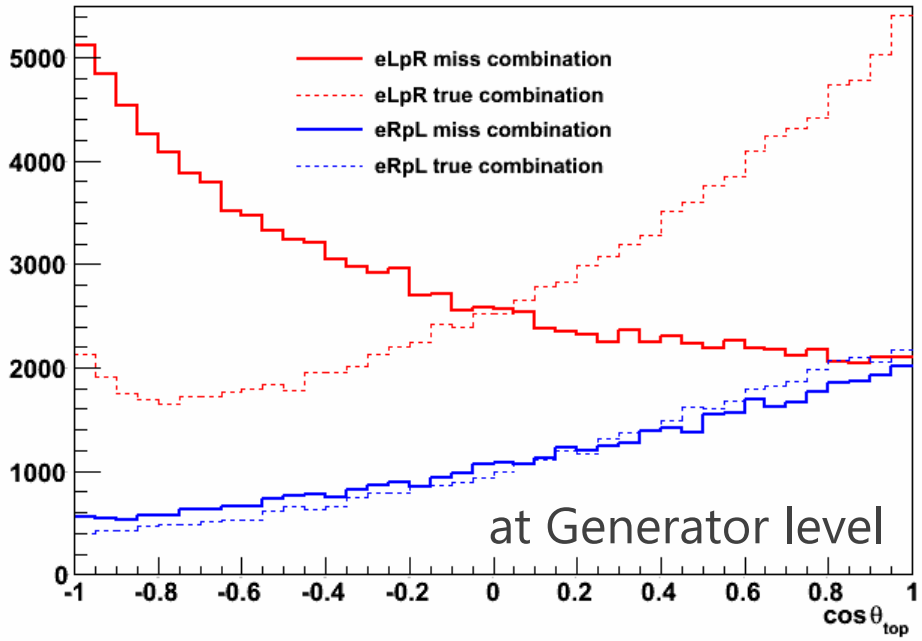
eRpL



at Generator level

- For left(right)-handed top case, b tends to be emitted to top's fright direction (opposite direction) because of the V-A structure.
- Distribution of events tending to flip ($\cos\theta^*_{tb}>0$) is **asymmetry** for eLpR case, on the other hand, it is almost symmetry for eRpL case.

The angular distribution of true and wrong association



Right-handed electron case (eRpL), Blue line

Little difference between true and wrong associated distributions

Left-handed electron case (eLpR), Red line

Almost opposite between true and wrong

The wrong has the opposite distribution to the true in the case of eLpR

→**The migrations happen in only the case of eLpR**

Current process for Fully-leptonic analysis

- Isolated lepton finding : #iso_lep =2
- Suppressing the overlay background using k_T algorithm
- Jet clustering using Durham algorithm (LCFIPlus package)
- 2 b-likeness jets were found (LCFIPlus package)

(Reconstruction events from their kinematics. → Not yet)

→My first trial of fully-leptonic analysis is cut study

Selection for fully-leptonic channel

Setting

Signal,Background : DBD samples, 500 GeV, 500 fb^{-1}, $P(e^-, e^+) = (-0.8, +0.3)$

I analyzed all considerable backgrounds referring the semi-leptonic analysis.

500 fb^{-1} (-0.8,+0.3)	ttbar Fully-leptonic (Signal)	ttbar Semi-leptonic	ttbar Fully-hadronic	llWW	uu,dd,ss, cc,bb
Generated	53289 (100%)	208505 (100%)	197432 (100%)	20502 (100%)	9497621 (100%)
# of lepton = 2	25482 (47.8%)	2716 (1.30%)	43 (0.022%)	7598 (37.1%)	6959 (0.0733%)
b-tag1 > 0.8 or b-tag2 > 0.8	22278 (41.8%)	2029 (0.973%)	28 (0.014%)	132 (0.644%)	1267 (0.0133%)
Thrust < 0.9	**21612 (40.6%)**	**2022 (0.970%)**	28 (0.014%)	114 (0.556%)	77 (0.00081%)

Selection for fully-leptonic channel

500 fb^{-1} (-0.8,+0.3)	xxWW	ZZ semi-leptonic	WW semi-leptonic	Single W semi-leptonic	Single Z ee
Generated	11405 (100%)	183053 (100%)	2785822 (100%)	2426503 (100%)	941270 (100%)
# of lepton = 2	793 (6.95%)	28343 (15.5%)	14528 (0.522%)	18143 (0.748%)	97536 (10.362%)
b-tag1 > 0.8 or b-tag2 > 0.8	13 (0.11%)	5110 (2.79%)	139 (0.0050%)	244 (0.010%)	13942 (1.48%)
Thrust < 0.9	11 (0.093%)	**1524 (0.833%)**	38 (0.0014%)	65 (0.003%)	**5727 (0.608%)**

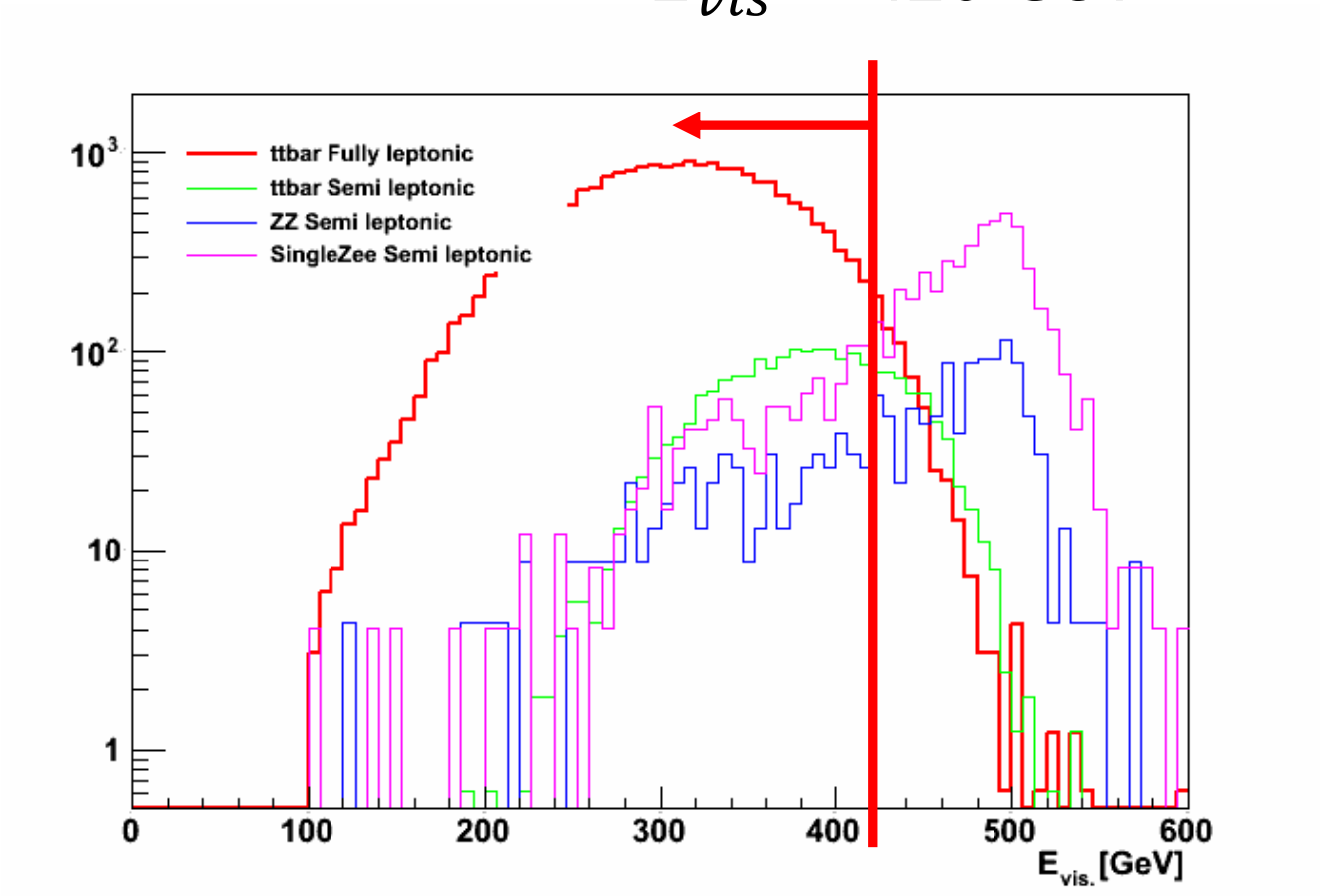
Main background：ttbar semi-leptonic, ZZ semi-leptonic and Single Z ee

→ I tried another criteria for cutting these backgrounds

Cut on the visible energy

The missing energy of the signal is smaller because of two missing neutrinos

E_{vis} < 420 GeV



Current results of cut study of fully-leptonic analysis

500 fb^{-1} (-0.8,+0.3)	ttbar Fully-leptonic (Signal)	ttbar Semi-leptonic	ZZ semi-leptonic	Single Z ee
Generated	53289 (100%)	208505 (100%)	183053 (100%)	941270 (100%)
# of lepton = 2	25482 (47.8%)	2716 (1.30%)	28343 (15.5%)	97536 (10.362%)
b-tag1 > 0.8 or b-tag2 > 0.8	22278 (41.8%)	2029 (0.973%)	5110 (2.79%)	13942 (1.48%)
Thrust < 0.9	21612 (40.6%)	2022 (0.970%)	1524 (0.833%)	5727 (0.608%)
evis< 420	20958 (39.3%)	1252 (0.600%)	502 (0.274)	1114 (0.118%)

Efficiency = 39.3%, Significance ($N_{sig.}/\sqrt{N_{sig.}+N_{bkg.}}$) = 135.8

(My signal samples include taus. Efficiency may improve from the application of a tau finder.)

Summary and plan

- Migration study (Semi-leptonic analysis)
  - The reason of migration effect is that distribution of events tending to flip is asymmetry for the eLpR case and it can be explained by the relation of polarization.
- Cut study (Fully-leptonic analysis)
  - I tried cut study as my first trial of fully-leptonic analysis.

- Stay in France in August and September to study the matrix element method (← fully-leptonic analysis)


Buckup

The ratio of true to wrong combination

This is the ratio of true to wrong combination on the reconstructed evens in the case of eLpR or eRpL.

(250fb-1)	True	Wrong
eLpR	75586 (84.3%)	14109 (15.7%)
eRpL	30286 (84.1%)	5712 (15.9%)

The ratio is same in both cases!

→ * The wrong combination distribution is different?

* When is the χ^2 of wrong smaller than it of true? (Now I'm studying)

Cut on the visible energy

I calculate the efficiency and significance($N_{sig.}/\sqrt{N_{sig.}+N_{bkg.}}$) changing the cut region on the visible energy

	2j	4j	4f_ZZ	singleZee		efficiency	significance
init	53263	208505	183053	941270		100.0%	45.2
#lep=2	25473	2716	28325	97545		47.8%	64.9
btag	22270	2029	5060	13948		41.8%	107.0
thrust	21605	2022	1503	5728		40.6%	123.0
evis< 425	21106	1300	559	1212		39.6%	135.7
evis< 420	20958	1252	502	1114		39.3%	135.8
evis< 415	20795	1198	488	1013		39.0%	135.7
evis< 410	20592	1144	468	941		38.7%	135.4

When Evis < 420, the significance is the maximum

→ I select this value.