Studies of $e^+e^- \to b\bar{b}$ channel at the International Linear Collider

Final word on LEP A^b_{FB} anomaly

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Abstract

This poster presents studies for the International Linear Collider (ILC), a linear electron-positron collider with a nominal center-of-mass energy from 250 GeV to 500 GeV.

The results of the detector study allow for an estimation of the ILC precision on the b-quark electroweak couplings and form factors. The ILC will be able to resolve the LEP anomaly in the $b\bar{b}$ production process. The ILC precision on the right-handed $Z^0 b\bar{b}$ coupling, a prime candidate for effects of new physics, is calculated to be at least 5 times better than the LEP experiments.

Introduction

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Main Objectives

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Description of the heavy quark production

Electroweak production of the fermion pairs proceeds through the $f\bar{f}X$ vertex, where X represents neutral vector bosons, photon or Z^0 boson. The current at the $f\bar{f}X$ vertex can be expressed via form factors F as

$$\Gamma^{f\bar{f}X}_{\mu}(k^2, q, \bar{q}) = ie\{\gamma_\mu(F^X_{1V}(k^2) + \gamma^5 F^X_{1A}(k^2)) - \frac{\sigma_{\mu\nu}(q-\bar{q})^\nu}{2m_f}(iF^X_{2V}(k^2) + \gamma^5 F^X_{2A}(k^2))\}, \quad (1)$$

where $k^2 = (q+\bar{q})^2$ is the four momentum squared of the exchanged vector boson, q and $\bar{q}$ are the four vectors of the fermion f and antifermion $\bar{f}$ and m_f is the fermion mass. Further, γ_μ and γ_5 are the Dirac matrices, and $\sigma_{\mu\nu} = i/2(\gamma_\mu\gamma_\nu - \gamma_\nu\gamma_\mu)$.

The Standard Model values of the form factors are the following:

$$F^{f\gamma}_{1V} = Q^f,\ F^{f\gamma}_{1A} = 0,\ F^{fZ}_{1V} = \frac{I^f - 2Q^f \sin^2\theta_W}{2\cos\theta_W \sin\theta_W},\ F^{fZ}_{1A} = -\frac{I^f}{2\cos\theta_W \sin\theta_W}, \quad (2)$$

and all F_2 factor are zero. In the Eq. 2 I^f is the weak isospin number, $I^t = 1/2$ for top and $I^b = -1/2$ for bottom quark and Q^f is the electric charge, $Q^t = 2/3$ and $Q^b = -1/3$.

The following definition of the left-handed and right handed $Z^0 b\bar{b}$ couplings is used throughout the thesis:

$$g^Z_L = I^f - Q^f \sin^2\theta_W,\ g^Z_R = -Q^f \sin^2\theta_W, \quad (3)$$

In case of the polarized beams, the fermion form factors can be expressed in terms of the helicity of the initial electrons [**?**]:

$$\mathcal{F}^L_{ij} = -F^\gamma_{ij} + \frac{-1/2 + \sin^2\theta_W}{\cos\theta_W \sin\theta_W}\frac{s}{s - M^2_Z + i\Gamma_Z M_Z}F^Z_{ij}, \quad (4)$$

$$\mathcal{F}^R_{ij} = -F^\gamma_{ij} + \frac{\sin^2\theta_W}{\cos\theta_W \sin\theta_W}\frac{s}{s - M^2_Z + i\Gamma_Z M_Z}F^Z_{ij} \quad (5)$$

where $i = 1, 2$ and $j = V, A$, M_Z and Γ_Z are the Z^0 boson mass and width, respectively.

The key expression for the studies is the differential cross section of $f\bar{f}$ production for electron beam polarization $I = L, R$, expressed via the defined form factors:

$$\frac{d\sigma^I}{d\cos\theta} = \frac{3}{4}\mathcal{A}N_c\beta[(1+\cos^2\theta)[(\mathcal{F}^I_{1V} + \mathcal{F}^I_{2V})^2 + (\beta\mathcal{F}^I_{1A})^2] - 4\cos\theta(\mathcal{F}^I_{1V} + \mathcal{F}^I_{2V})\beta\mathcal{F}^I_{1A} + \sin^2\theta[\gamma^{-2}(\mathcal{F}^I_{1V} + \gamma^2\mathcal{F}^I_{2V})^2]] \quad (6)$$

where $\mathcal{A} = 4\pi\alpha^2/3s$ with α as the electromagnetic running coupling, N_c is the number of quark colors, β and γ are the velocity and the Lorentz factor of the produced fermion, respectively.

Results

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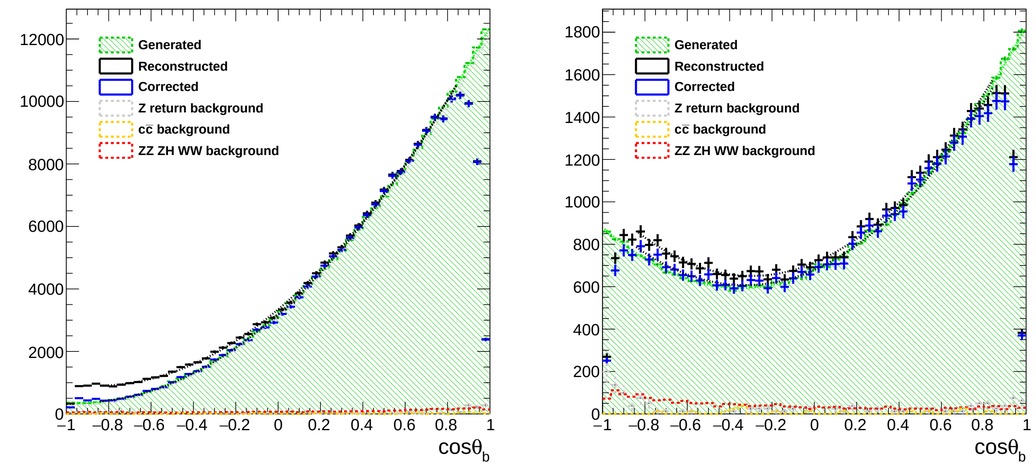

Figure 1: *Generated b-quark polar angle distribution compared to the final reconstructed b-quarks polar angle in left-handed case (a) and right-handed case (b) with overlaid background processes.*

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Treatments	Response 1	Response 2
Treatment 1	0.0003262	0.562
Treatment 2	0.0015681	0.910
Treatment 3	0.0009271	0.296

Table 1: Table caption

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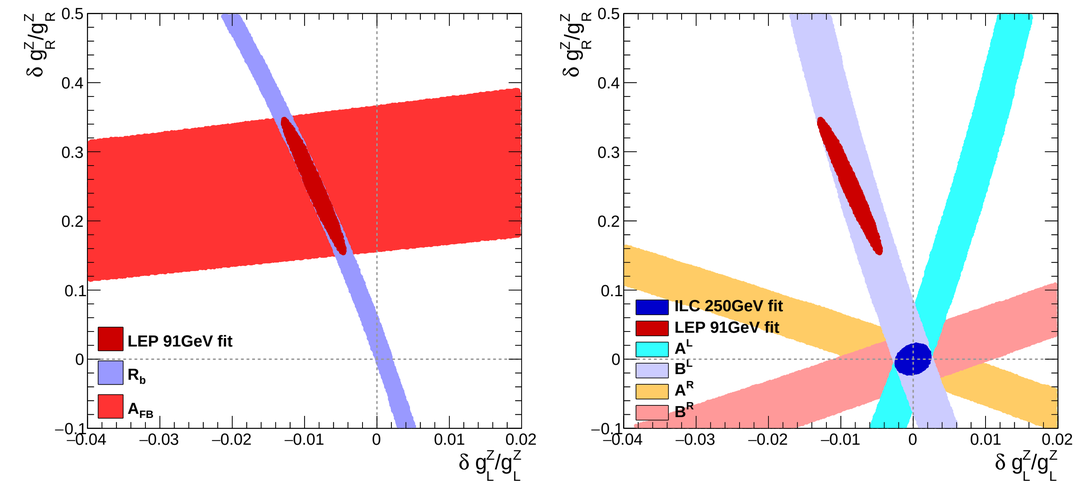

Figure 2: Tree level $\pm 1\,\sigma$ allowed regions defined by the forward-backward asymmetry and total cross section measurements at LEP (a) and ILC via the differential cross section fit (b). Dashed guidelines show the Standard Model value. The allowed region expected at the ILC is centered at Standard Model values of couplings.

Conclusions

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Forthcoming Research

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References

[1] A. B. Jones and J. M. Smith. Article Title. *Journal title*, 13(52):123–456, March 2013.

[2] J. M. Smith and A. B. Jones. *Book Title*. Publisher, 7th edition, 2012.

Acknowledgements

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