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

Using the b-quark charge measurement

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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 $Z^0 bb$ 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

$$\Gamma_\mu^{f\bar{f}X}(k^2,q,\bar{q}) = ie\{\gamma_\mu(F_{1V}^X(k^2)+\gamma^5 F_{1A}^X(k^2)) - \frac{\sigma_{\mu\nu}(q-\bar{q})^\nu}{2m_f}(iF_{2V}^X(k^2)+\gamma^5 F_{2A}^X(k^2))\}, \tag{1}$$

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:

$$F_{1V}^{f\gamma}=Q^f,\ F_{1A}^{f\gamma}=0,\ F_{1V}^{fZ}=\frac{I^f-2Q^f\sin^2\theta_W}{2\cos\theta_W\sin\theta_W},\ F_{1A}^{fZ}=-\frac{I^f}{2\cos\theta_W\sin\theta_W}, \tag{2}$$

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:

$$g_L^Z = I^f - Q^f\sin^2\theta_W,\ g_R^Z=-Q^f\sin^2\theta_W, \tag{3}$$

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

$$\mathcal{F}_{ij}^L = -F_{ij}^\gamma + \frac{-1/2+\sin^2\theta_W}{\cos\theta_W\sin\theta_W}\frac{s}{s-M_Z^2+i\Gamma_Z M_Z}F_{ij}^Z, \tag{4}$$

$$\mathcal{F}_{ij}^R = -F_{ij}^\gamma + \frac{\sin^2\theta_W}{\cos\theta_W\sin\theta_W}\frac{s}{s-M_Z^2+i\Gamma_Z M_Z}F_{ij}^Z \tag{5}$$

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:

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

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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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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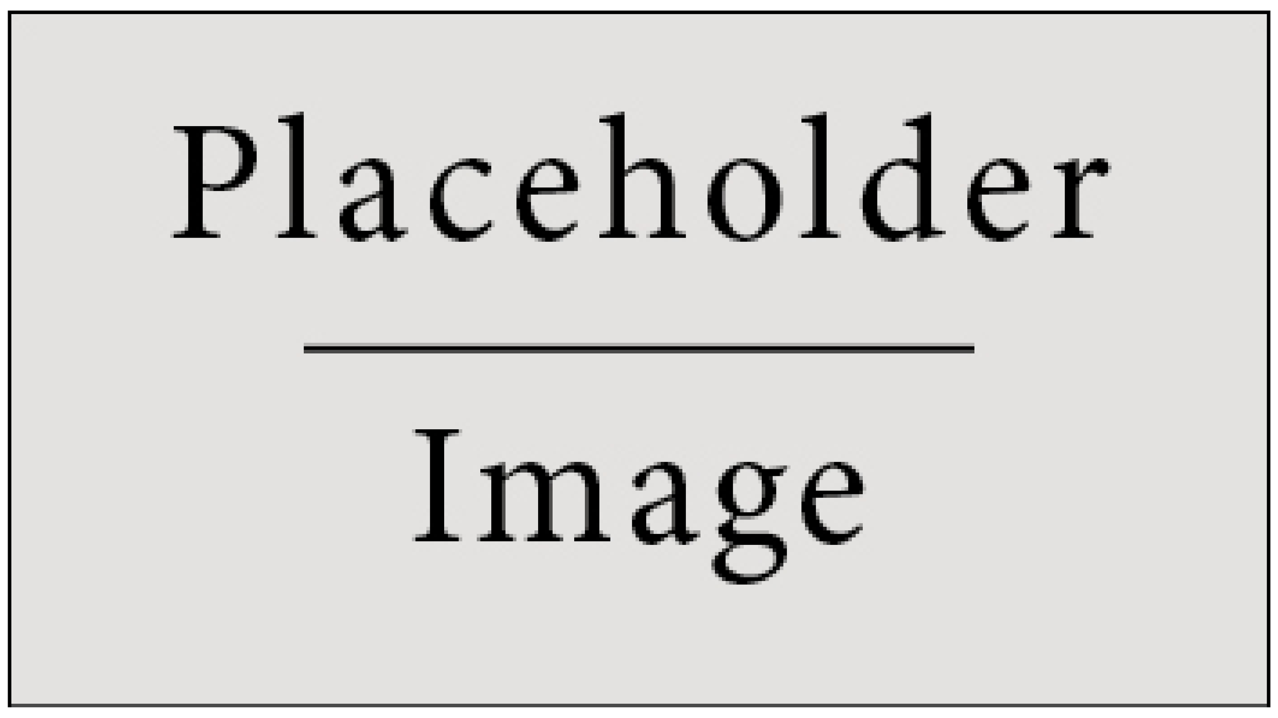

Figure 1: Figure caption

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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 2: Table caption

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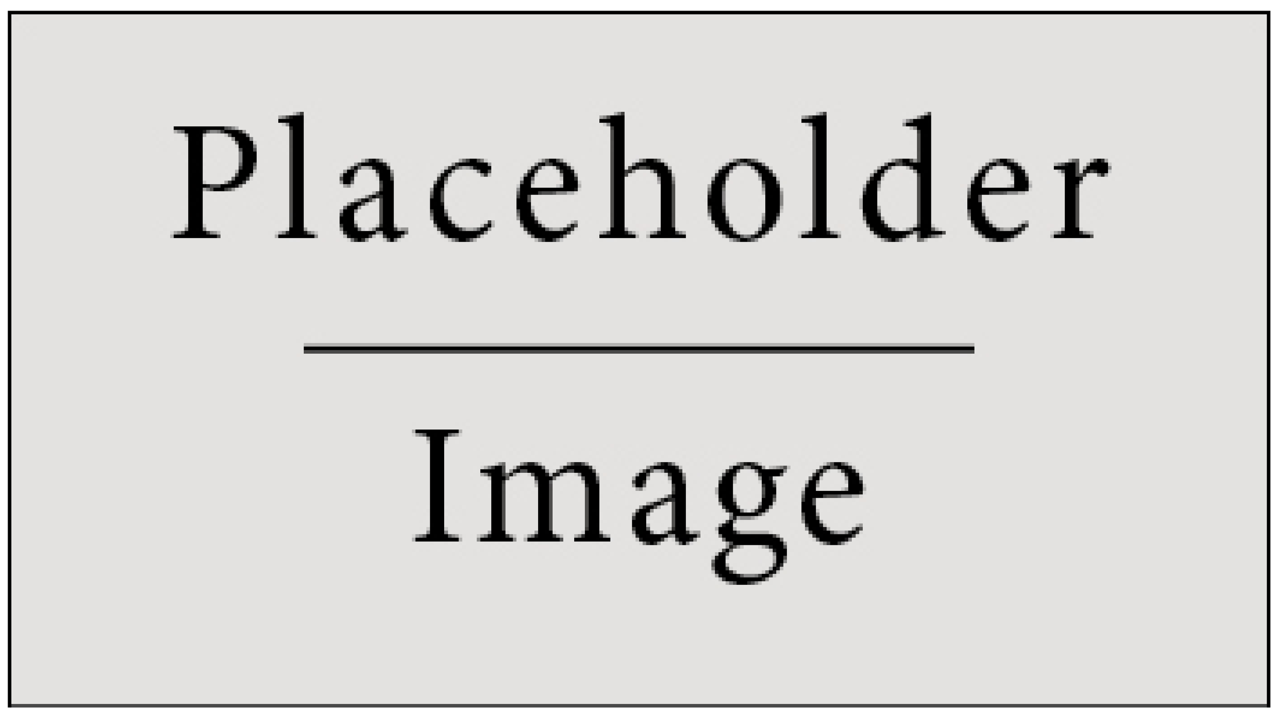

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Conclusions

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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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