Rare Top Decays at TLEP

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Introduction

- Top quark plays a key role in the quest for new physics which may manifest itself through direct signal and/or deviations from the SM predictions
- Study of top quark's flavor changing neutral current (FCNC) interactions is one of the important aspects for collider experiments in the later direction
- In the Standard Model FCNC intercactions are strongly suppressed: $Br(t \to u\gamma, uZ) \sim 10^{-16}$ and $Br(t \to c\gamma, cZ) \sim 10^{-14}$

[Acta Phys.Polon.B35(2004)2695]

New Physics Contributions

New physics contributions can significantly enhance top FCNC decay rates by several order of magnitude

BR	QS	$2HDM$	$MSSM$	$\not{R}SUSY$
$t \to u\gamma$	10^{-9}	–	10^{-6}	10^{-6}
$t \to uZ$	10^{-4}	–	10^{-6}	10^{-5}
$t \to c\gamma$	10^{-9}	10^{-6}	10^{-6}	10^{-6}
$t \to cZ$	10^{-4}	10^{-7}	10^{-6}	10^{-5}

[Acta Phys.Polon.B35(2004)2695]

Effective Lagrangian

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The most general effective Lagrangian to describe the top FCNC interactions can be modeled as (keeping up to dim 5 operators)

$$-\mathcal{L}^{\rm eff} = \frac{g}{2c_W}\mathcal{X}_{qt}\,\bar{q}\gamma_\mu(x^L_{qt}P_L + x^R_{qt}P_R)tZ^\mu + \frac{g}{2c_W}\kappa_{qt}\,\bar{q}(\kappa^v_{qt} + \kappa^a_{qt}\gamma_5)\frac{i\sigma_{\mu\nu}q^\nu}{m_t}tZ^\mu$$
$$+e\lambda_{qt}\,\bar{q}(\lambda^v_{qt} + \lambda^a_{qt}\gamma_5)\frac{i\sigma_{\mu\nu}q^\nu}{m_t}tA^\mu + g_s\zeta_{qt}\,\bar{q}(\zeta^v_{tq} + \zeta^a_{qt}\gamma_5)\frac{i\sigma_{\mu\nu}q^\nu}{m_t}T^a qG^{a\mu}$$
$$+\frac{g}{2\sqrt{2}}g_{qt}\,\bar{q}(g^v_{qt} + g^a_{qt}\gamma_5)tH + \mathrm{H.c.}$$

The corressponding branching ratios are related to the couplings as

$$\mathrm{Br}(t\to qZ)_\gamma = 0.472\ \mathcal{X}^2_{qt}$$
$$\mathrm{Br}(t\to qZ)_\sigma = 0.367\ \kappa^2_{qt}$$
$$\mathrm{Br}(t\to q\gamma) = 0.428\ \lambda^2_{qt}$$
$$\mathrm{Br}(t\to qg) = 7.93\ \zeta^2_{qt}$$
$$\mathrm{Br}(t\to qH) = 3.88\times 10^{-2}\ g^2_{qt}$$

(assuming $\Gamma^t_{tot} = \Gamma(t\to bW^+) = 1.61$ GeV)

Feynman diagram

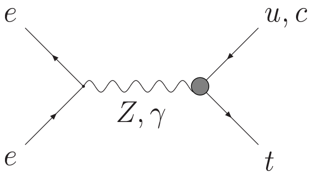


Figure: *Feynman diagram for single top production in e^+e^- collider*

The production cross-sections are

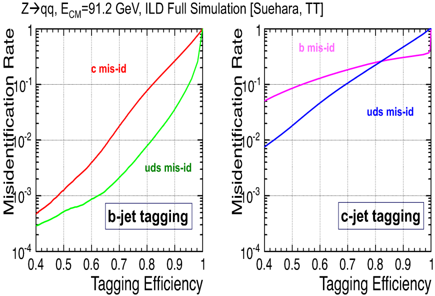
Z, γ_μ	2057.4	$\lvert X_{qt}\rvert^2$
$Z, \sigma_{\mu\nu}$	3218.0	$\lvert \kappa_{qt}\rvert^2$
γ	4811.7	$\lvert \lambda_{qt}\rvert^2$

Table: Cross sections (in fb) for single top (and anti-top) production at e^+e^- collider with $\sqrt{s} = 240$ GeV.

Simulations details

- The model file for FCNC interaction have been implemented using FEYNRULES and MADGRAPH interface.
- The event generated in MADGRAPH then interfaced with PYTHIA for showering and hadronisation.
- A jet has been formed using the iterative cone algorithm of PYTHIA with a cone size of $R = 0.4$
- The jet energy resulution is parametrised as $\frac{\sigma(E)}{E} = 30\%/\sqrt{E}$
- The following set of basic cuts have been applied on all the jets:
  $p_T^j > 20$ GeV, $|\eta^j < 2.5$, and $\Delta R(jj) > 0.4$

Higgs Hadronic Decays: Flavor Tagging



ILC detectors allow high performance b/c/g tagging
Precise measurement of BR(H→bb, cc, gg)

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We have worked with a true b-jet tagging efficiency of 80% and c (light)-jet rejection factor of 10 (100).

Signal $e^+e^- \to tj \to jjjj$.

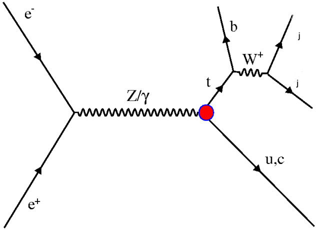

Figure: Feynman diagram for resonant slepton production leading to $eejj$ signal at the LHC.

Background $e^+e^- \to Wjj \to jjjj$ cross-section $= 686.77$ fb

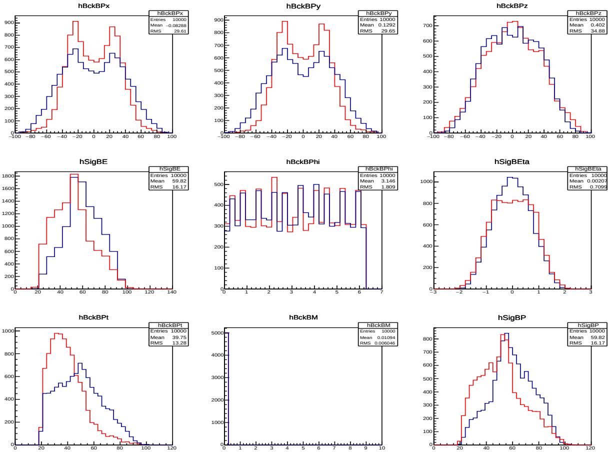

Fig. *b-jet kinematics: Signal (blue) and background (red) at* $\sqrt{s} = 240$ *GeV.*

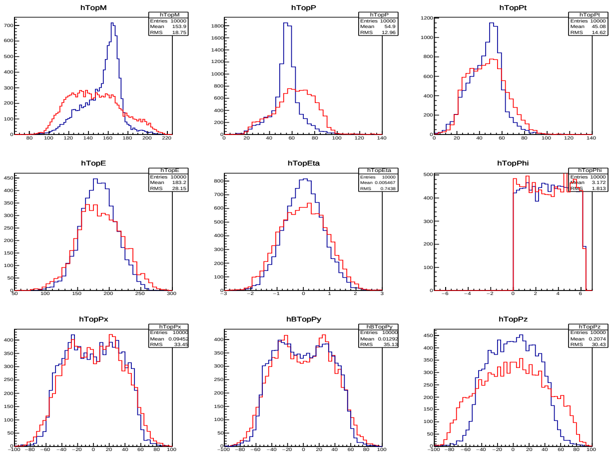

Fig. *top kinematics: Signal (blue) and background (red) at* $\sqrt{s} = 240$ *GeV.*

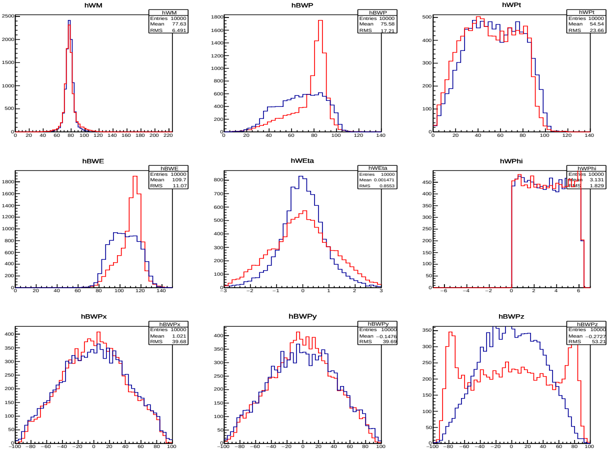

Fig. *W kinematics: Signal (blue) and background (red) at* $\sqrt{s} = 240$ *GeV.*

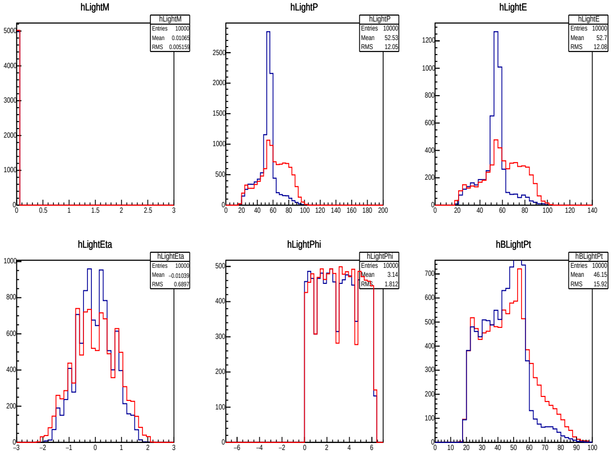

Fig. *Light(q)-jet kinematics: Signal (blue) and background (red) at* $\sqrt{s} = 240\ GeV.$

Conclusions

A full multivariate analysis in these kinematic variables can enhance the signal to background ratio to some extent.

"in progress...."