- FCNC effective Lagrangian

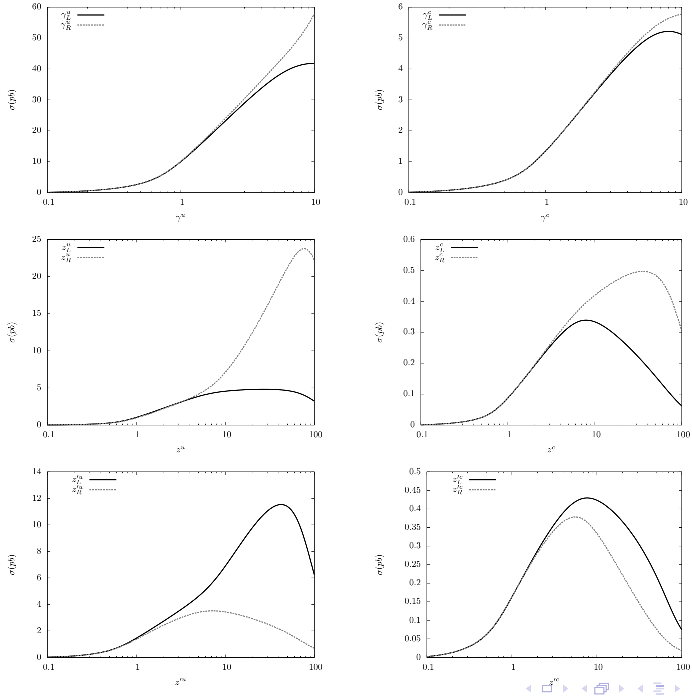
$$\mathcal{L}_{eff} = \sum_{U=u,c} \Big[i g_s \frac{\kappa_{gU}}{\Lambda} \bar{t} \sigma^{\mu\nu} \left[g_L P_L + g_R P_R\right] T^a U G^a_{\mu\nu} + ie \frac{\kappa_{\gamma U}}{\Lambda} \bar{t} \sigma^{\mu\nu} q_\nu \left[\gamma_L P_L + \gamma_R P_R\right] U A_\mu$$
$$+ i \frac{g_W}{2\, c_W} \frac{\kappa_{zU}}{\Lambda} \bar{t} \sigma^{\mu\nu} q_\nu \left[z_L P_L + z_R P_R\right] U Z_\mu + i \frac{g_W}{2\, c_W} \kappa'_{zU} \bar{t} \gamma^\mu \left[z'_L P_L + z'_R P_R\right] U Z_\mu \Big] + h.c.$$

- The FCNC vertex can be realized through following process at $e^- p$ collider:
  - At production and/or decay vertex through neutral current: $e^- p \to e^- \bar{t}$ (Only $tq\gamma$ and tqZ contribute at production vertex and g include at decay vertex)
  - At decay vertex through charged-current: $e^- p \to \nu_e \bar{t}, \bar{t} \to Vj$

- Dominant background processes are as follows:
  - $\sigma(e^- b \to \nu_e \bar{t}, \bar{t} \to \bar{b} W^-, W^- \to \ell^- \nu_\ell) = 0.39$ pb;
  - $\sigma(e^- b \to \nu_e \bar{t}, \bar{t} \to \bar{b} W^-, W^- \to jj) = 1.17$ pb.

- We take the signal cross section within 1σ of the dominant background cross sections above, i.e.,
  - $0.12 \text{ pb} < \sigma(e^- p \to e^- \bar{b} \ell^- \bar{\nu}_\ell + e^- b \ell^+ \nu_\ell) < 0.66$ pb;
  - $0.37 \text{ pb} < \sigma(e^- p \to e^- \bar{b} jj + e^- b jj) < 1.96$ pb.

Coup	Cross Section (pb) $\sigma(e^- p \to e^- \bar{b}\ell^- \bar{\nu}_\ell + e^- b\ell^+ \nu_\ell)$
$\gamma_L^u = 10^{-1}$	4.495×10^{-02}
$\gamma_R^u = 10^{-1}$	6.079×10^{-02}
$\gamma_L^c = 10^{-1}$	8.035×10^{-03}
$\gamma_R^c = 10^{-1}$	9.177×10^{-03}
$z_L^u = 10^{-1}$	6.032×10^{-03}
$z_R^u = 10^{-1}$	6.362×10^{-03}
$z_L^c = 10^{-1}$	6.772×10^{-04}
$z_R^c = 10^{-1}$	7.109×10^{-04}
$z_L'^u = 10^{-1}$	1.442×10^{-02}
$z_R'^u = 10^{-1}$	1.036×10^{-02}
$z_L'^c = 10^{-1}$	1.982×10^{-03}
$z_R'^c = 10^{-1}$	1.777×10^{-03}



γ_L^u
γ_R^u
$\sigma(pb)$
γ^u
γ_L^c
γ_R^c
$\sigma(pb)$
γ^c
z_L^u
z_R^u
$\sigma(pb)$
z^u
z_L^c
z_R^c
$\sigma(pb)$
z^c
$z_L'^u$
$z_R'^u$
$\sigma(pb)$
z'^u
$z_L'^c$
$z_R'^c$
$\sigma(pb)$
z'^c

- Diagram contributing to the process

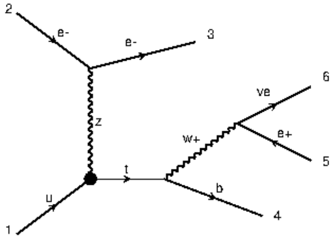


diagram 1 NP=1, QCD=0, QED=4

- Cross section shows steady increase with the coupling value for the process $e^- p \to \nu_e \bar{t}$. It shows the stange behaviour only when the decay of the top quark is introduced in the process.
- Hence we would like to investigate the reason analytically using the narrow width approximation.

- Partonic result for top decay width

$$\hat{\sigma} = \frac{4}{3} \frac{\Gamma_W^{u\bar{d}} \Gamma_W^{\ell\bar{\nu}_\ell}}{(\hat{s} - m_W^2)^2 + m_W^2 \Gamma_W^2}$$

- Under narrow width approximation

$$\frac{d\hat{s}}{(\hat{s} - m_W^2)^2 + m_W^2 \Gamma_W^2} \to \frac{\pi}{m_W \Gamma_W} \delta(\hat{s} - m_W^2)$$

- Hence the partonic top decay width becomes

$$\hat{\sigma} = \frac{4}{3} \pi \frac{\Gamma_W^{u\bar{d}} \Gamma_W^{\ell\bar{\nu}_\ell}}{m_W \Gamma_W} \delta(\hat{s} - m_W^2)$$