WORKS DONE IN THE PAST YEAR

- **Dark matter: the leptonic connection**

  with Ernest Ma and Gabe Shaughnessy,

  Phys. Lett. B673: 152(2009), arXiv:0901.1334 [hep-ph].

- **Model independent constraints among the Wtb, Zbb and Ztt couplings**

  with Edmond L. Berger and Ian Low, arXiv:0907.2191 [hep-ph].

- **Improved Predictions for Higgs Q_T at the Tevatron and the LHC**

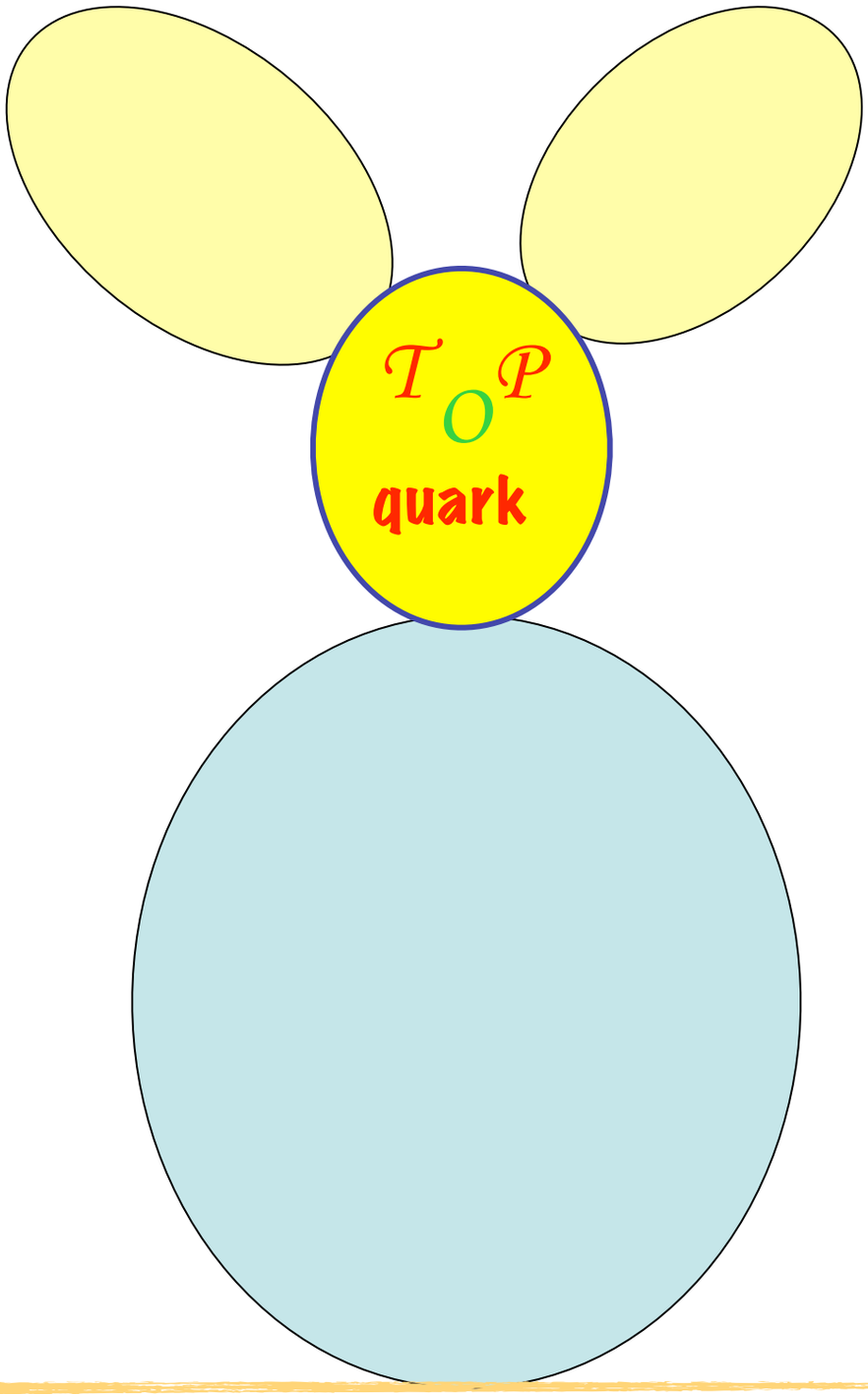
  with Chuan-Ren Chen, Carl Schmidt and C.-P. Yuan, arXiv:0909.2305 [hep-ph].

- **Next-to-Leading order cross sections for new heavy fermion production at hadron colliders**

  with Edmond L. Berger, arXiv:0909.3555 [hep-ph].

Pathways to new physics

- Top and Electroweak Symmetry Breaking



Pathways to New Physics

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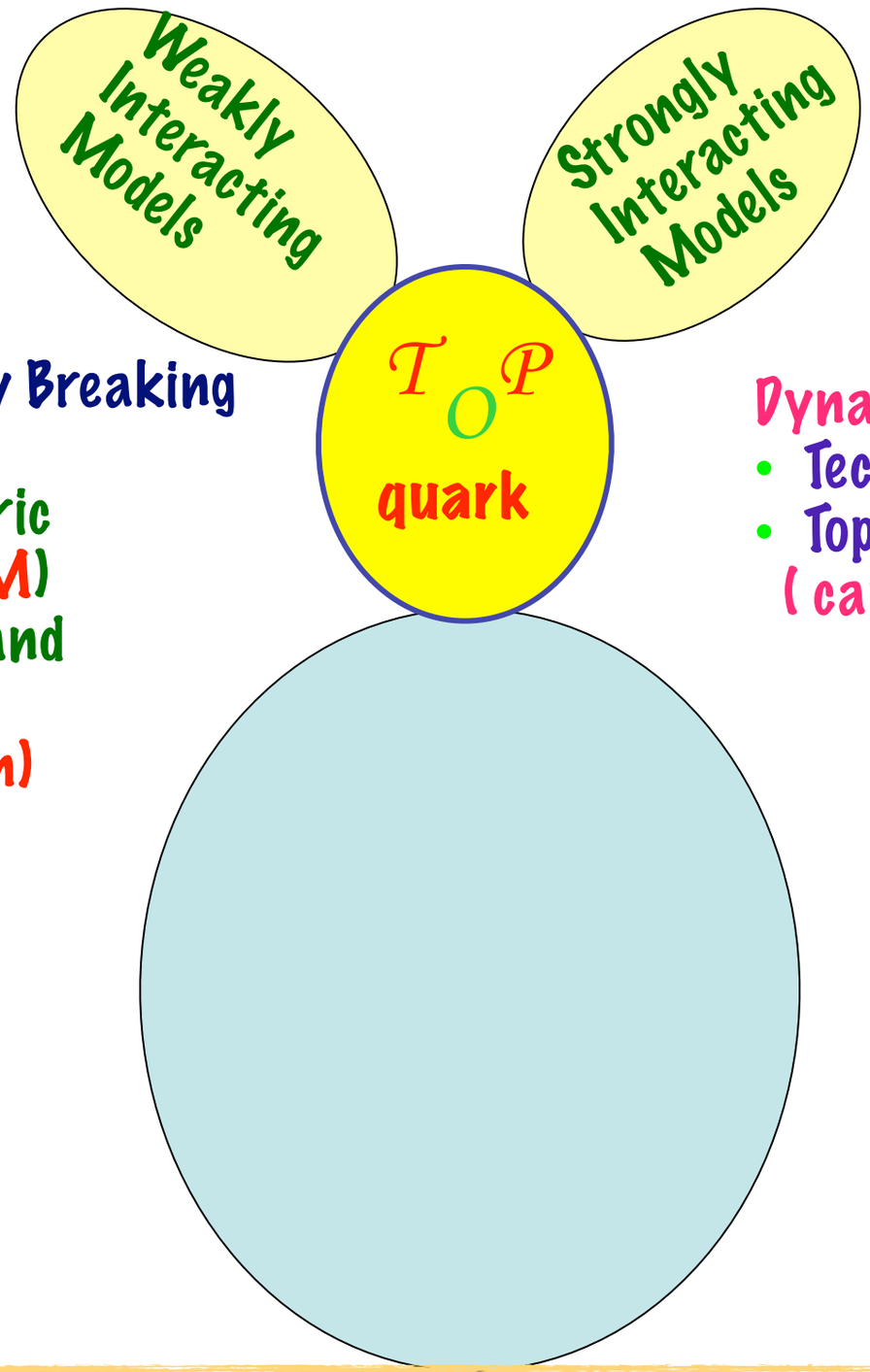
Top Down



Spontaneously Symmetry Breaking

- Minimal Supersymmetric Standard Model (MSSM) with Radiative EWSB and soft SUSY-breaking (elementary Higgs boson)

Dynamical Symmetry Breaking

- Technicolor
- TopColor / Condensate / Seesaw Models (can have composite Higgs bosons)

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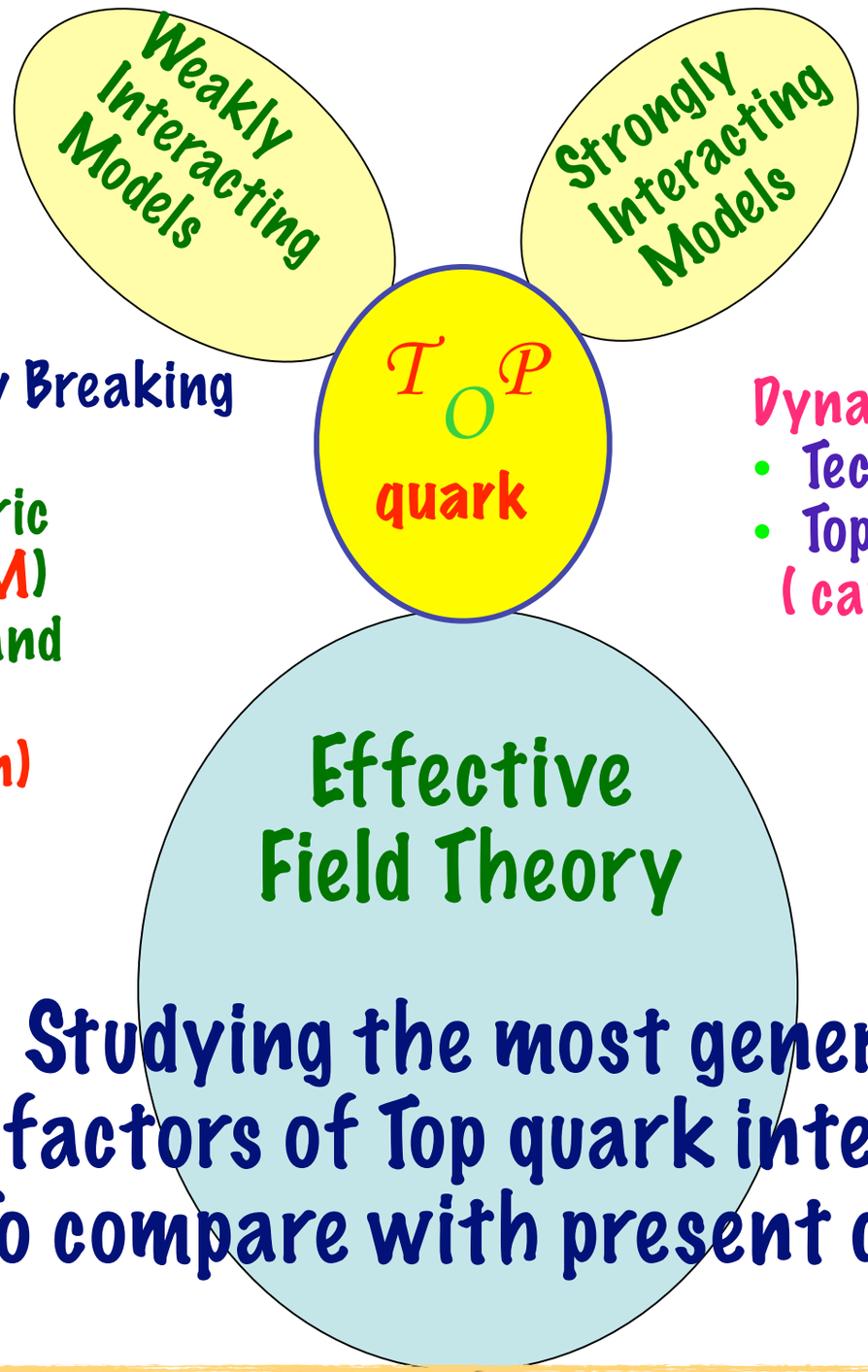

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Studying the most general
Form factors of Top quark interactions
To compare with present data

Bottom Up

Tree-level induced dim-6 operators

$$\mathcal{O}_{\phi q}^{(3)} = i\left(\phi^\dagger \tau^I D_\mu \phi\right)\left(\bar{q}\gamma^\mu \tau^I q\right),$$

$$\mathcal{O}_{\phi q}^{(1)} = i\left(\phi^\dagger D_\mu \phi\right)\left(\bar{q}\gamma^\mu q\right),$$

$$\mathcal{O}_{\phi t} = i\left(\phi^\dagger D_\mu \phi\right)\left(\bar{t}_R\gamma^\mu t_R\right),$$

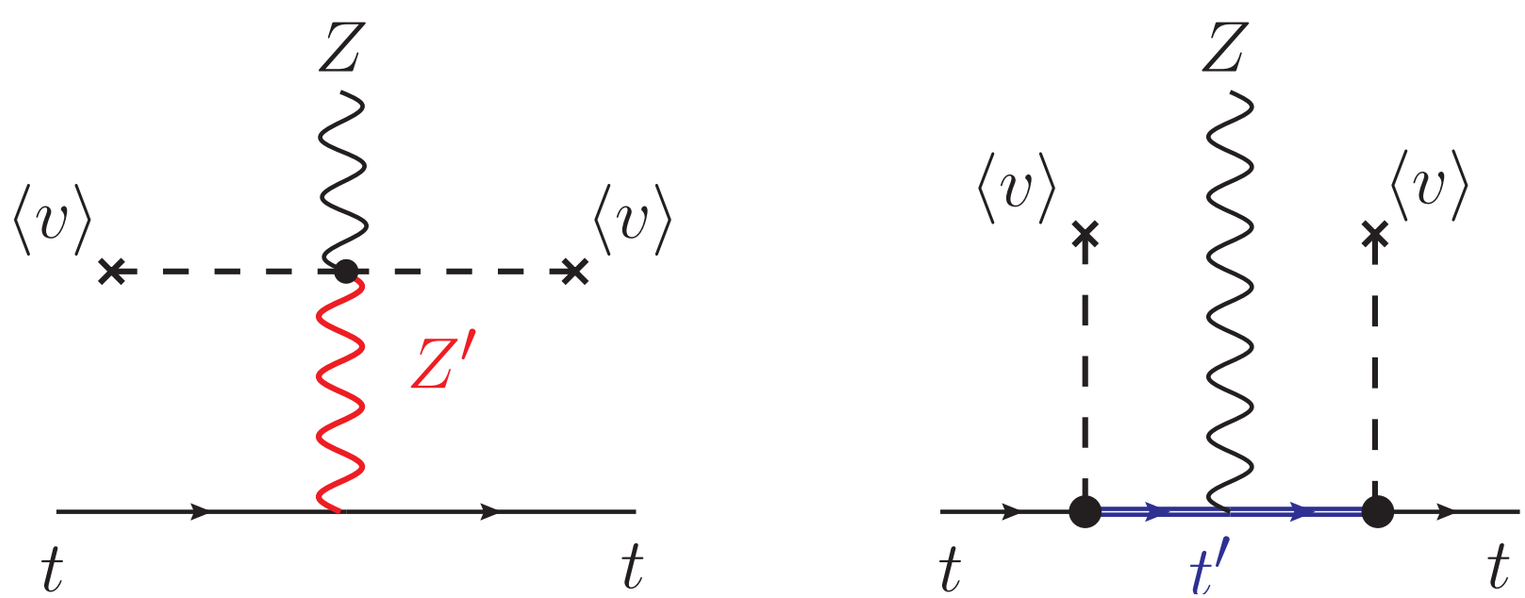
$$\mathcal{O}_{\phi b} = i\left(\phi^\dagger D_\mu \phi\right)\left(\bar{b}_R\gamma^\mu b_R\right),$$

$$\mathcal{O}_{\phi\phi} = \left(\phi^\dagger \epsilon D_\mu \phi\right)\left(\bar{t}_R\gamma^\mu b_R\right),$$

$$q = \begin{pmatrix} t \\ b \end{pmatrix}_L$$

$t_R \quad b_R$

ϕ : SM Higgs doublet



Effective Wtb, Ztt and Zbb couplings

$b \to s\gamma$

$-0.0007 < \frac{c_{\phi\phi} v^2}{2\Lambda^2} < 0.0025$

$$\mathcal{O}_{Wtb} = \frac{c_{\phi q}^{(3)} v^2}{\Lambda^2} \frac{g_2}{\sqrt{2}} W_\mu^+ \bar{t}_L \gamma^\mu b_L - \frac{c_{\phi\phi} v^2}{2\Lambda^2} \frac{g_2}{\sqrt{2}} W_\mu^+ \bar{t}_R \gamma^\mu b_R + h.c.$$

$$\mathcal{O}_{Zt\bar{t}} = \frac{\left(c_{\phi q}^{(3)} - c_{\phi q}^{(1)}\right) v^2}{\Lambda^2} \frac{\sqrt{g_1^2 + g_2^2}}{2} Z_\mu \bar{t}_L \gamma^\mu t_L - \frac{c_{\phi t} v^2}{\Lambda^2} \frac{\sqrt{g_1^2 + g_2^2}}{2} Z_\mu \bar{t}_R \gamma^\mu t_R$$

$$\mathcal{O}_{Zb\bar{b}} = -\frac{\left(c_{\phi q}^{(1)} + c_{\phi q}^{(3)}\right) v^2}{\Lambda^2} \frac{\sqrt{g_1^2 + g_2^2}}{2} Z_\mu \bar{b}_L \gamma^\mu b_L - \frac{c_{\phi b} v^2}{\Lambda^2} \frac{\sqrt{g_1^2 + g_2^2}}{2} Z_\mu \bar{b}_R \gamma^\mu b_R$$

R_b and $A_{FB}^{(b)}$

$\frac{\delta g_{Zb_L b_L}}{g_{Zb_L b_L}^{\rm SM}} \leq 0.25\%$

$\Rightarrow$ $c_{\phi q}^{(3)} + c_{\phi q}^{(1)} \simeq 0$

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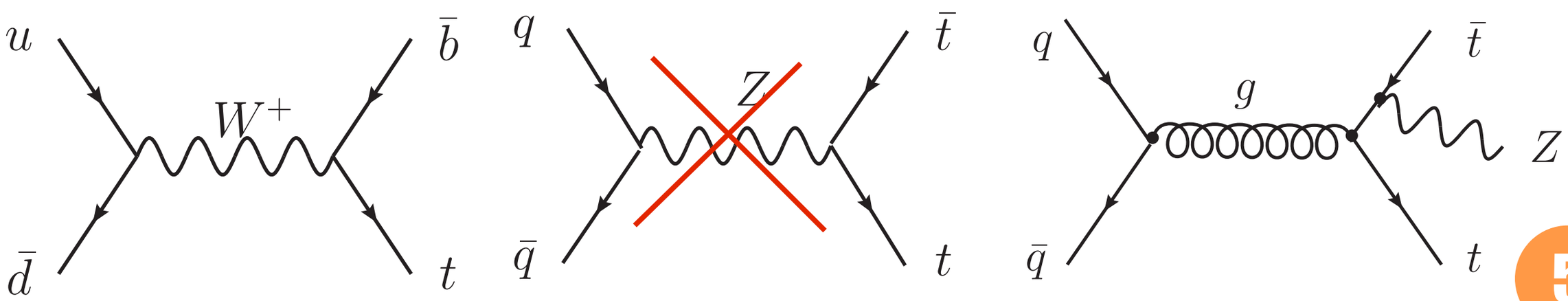
How to probe such an correlation?

$$\mathcal{O}_{Wtb} = \frac{g}{\sqrt{2}} \mathcal{F}_L W_\mu^+ \bar{t}_L \gamma^\mu b_L + h.c. \ ,$$

$$\mathcal{O}_{Zt\bar{t}} = \frac{g}{2c_w} Z_\mu \left(2\mathcal{F}_L \bar{t}_L \gamma^\mu t_L + \mathcal{F}_R \bar{t}_R \gamma^\mu t_R\right)$$

- At the Large Hadron Collider,



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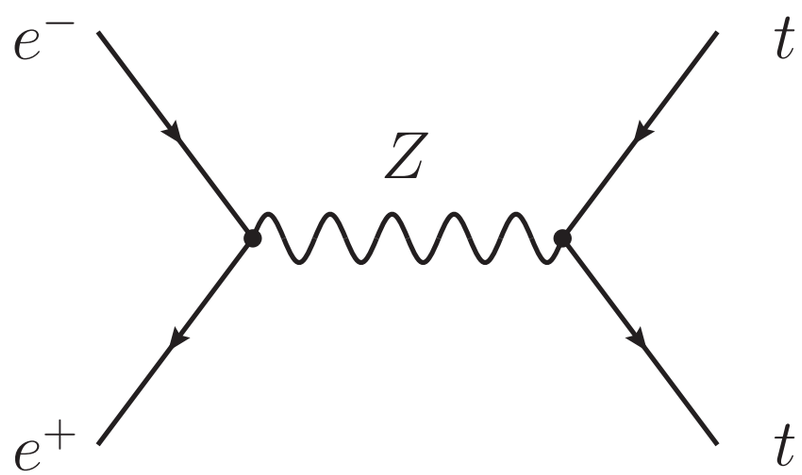
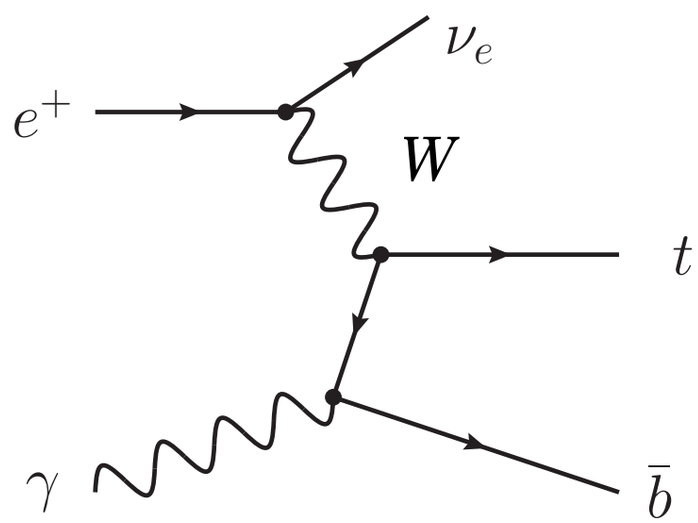
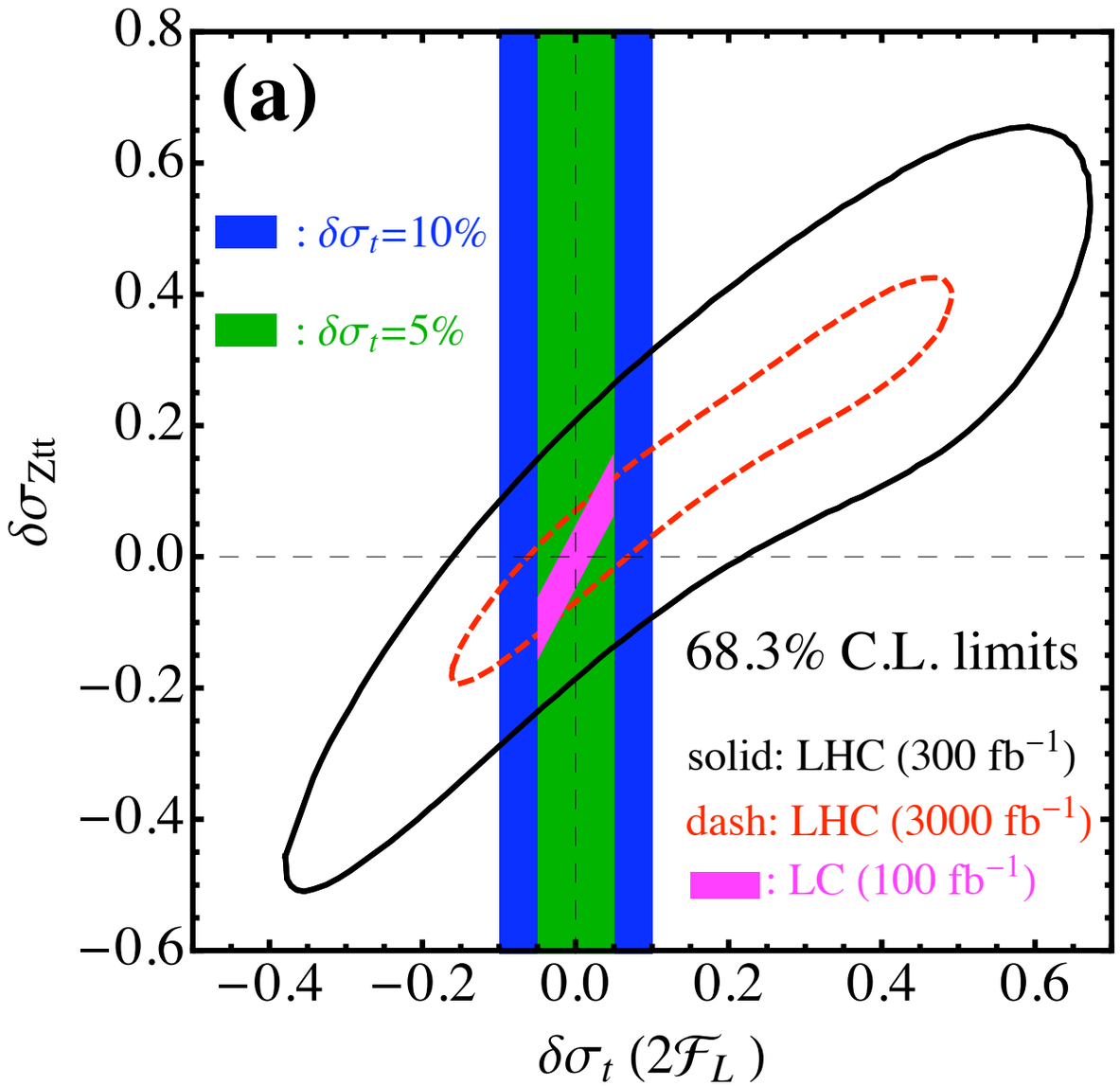
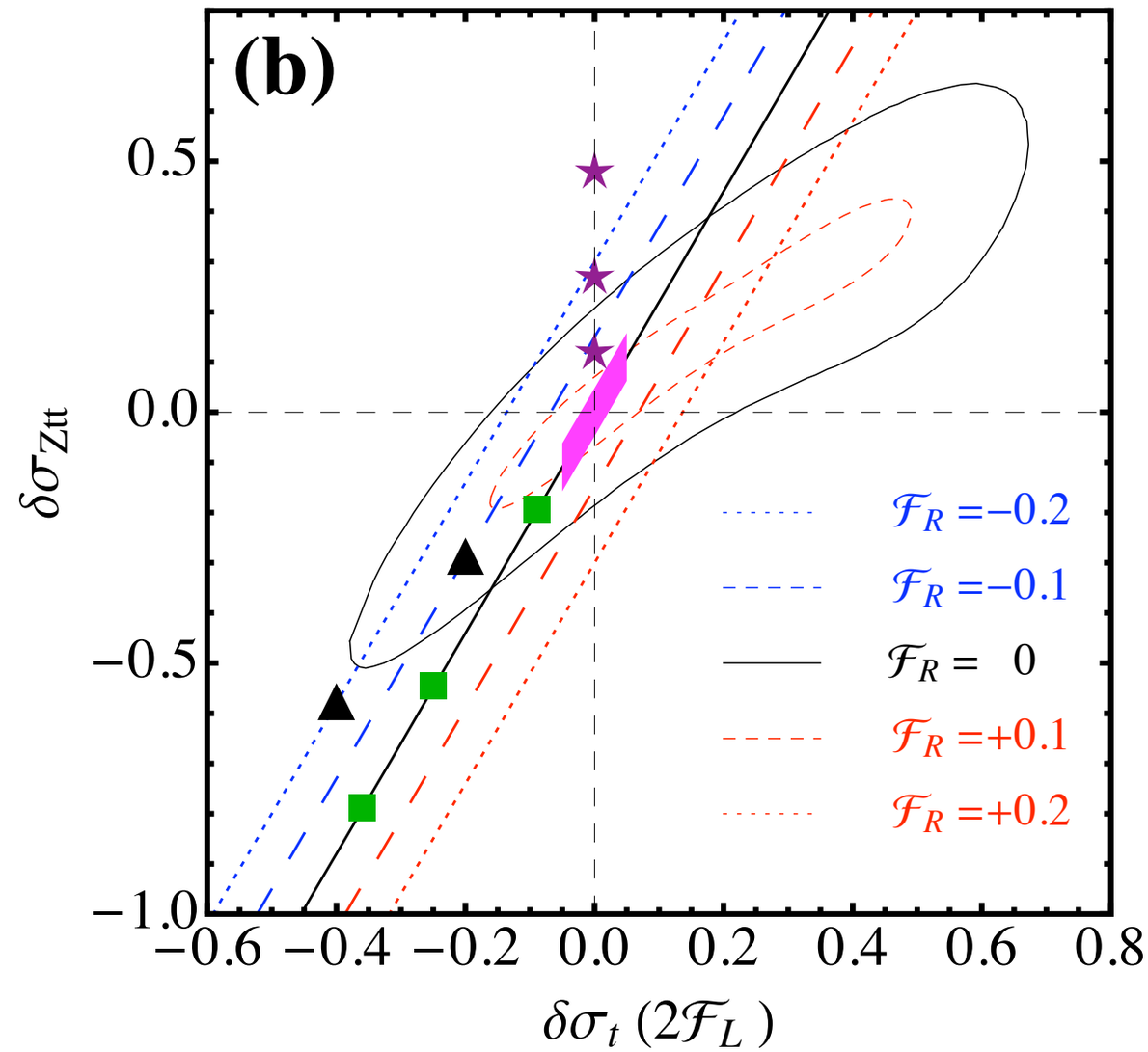
- At the Linear Collider





Measuring anomalous couplings at LHC





■ : left-handed t-prime

★: right-handed t-prime

▲: chiral 4th generation

Works to be posted soon

- **A dark matter model with non-Abelian gauge symmetry**
  with Hao Zhang, Chong Sheng Li and Zhao Li, arXiv:0910.xxxx [hep-ph] .

- **Next-to-leading order QCD corrections to single top production and decay at the LHC: 1. s-channel process**
  with Sarah Heim, Reinhard Schwienhorst and C.-P. Yuan, arXiv:0910.xxxx [hep-ph]..

- **Forward-Backward asymmetry of top quark pair production**
  with David McKeen, Jonathan L. Rosner, Gabe Shaughnessy and Carlos E.M. Wagner, arXiv: 0910.xxxx [hep-ph].

- **Associated LHC signatures of leptonic-favored dark matter models**
  with Gabe Shaughnessy, arXiv:0910(11).xxxx [hep-ph].

- **Dark matter study in effective field theory approach: connecting LHC and Cosmology**
  with Chuan-Ren Chen and Hao Zhang, arXiv: 0910(11).xxxx [hep-ph].

- **New physics and loop-induced decay of a scalar into two Z bosons**
  with Chris Jackson, Wai-Yee Keung, Ian Low and Jing Shu, arXiv: 0910.xxxx [hep-ph].

Works in progress

- **LHC coordinate analysis: searching for the SM Higgs boson**

  with Edmond L. Berger, Chris Jackson, Tao Liu and Gabe Shaughnessy

- **QCD resummation effects on Doubly charged scalar production at hadron colliders**

  with Edmond L. Berger and Zong-Guo Si

- **Search for new physics in Z boson pair at the LHC**

  with Edmond L. Berger, Jun Cao, Chong Sheng Li

- **and others ....**