top final states at the LHC

LHC Physics Day

"LHC implications of CDF's AFB(tt) and Wjj bump"

CERN, May 6 2011

A partial and incomplete overview of the recent literature,

complementing what presented in other talks

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Direct detection of A_{FB}

A_{tFB} Meets LHC, J.Hewett et al, arXiv:1103.4618v2

$$\mathcal{A}_F(y_0) = \frac{N_t(y_0 < |y| < 2.5) - N_{\bar{t}}(y_0 < |y| < 2.5)}{N_t(y_0 < |y| < 2.5) + N_{\bar{t}}(y_0 < |y| < 2.5)},$$

signal optimized for $y_0 \sim 1.5$

If A_{FB} = SM

5σ measurement of A_{FB} with 60 fb^{-1} at 14 TeV 2-3σ measurement of A_{FB} with 10 fb^{-1} at 7 TeV

If A_{FB} = CDF (and using the Z' model of S. Jung et al, arXiv:0907.4112 , mZ'=160 GeV)

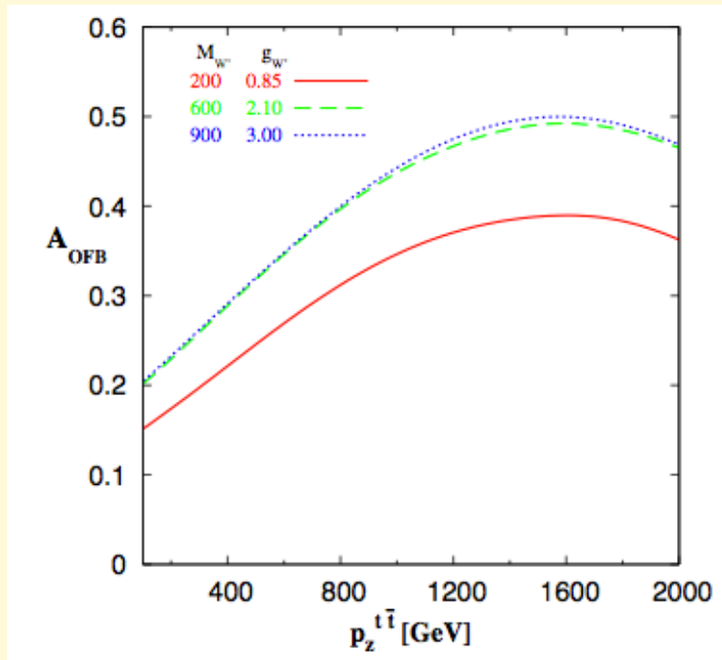
5σ measurement of A_{FB} with 2 fb^{-1} at 14 TeV 2σ measurement of A_{FB} with ~5 fb^{-1} at 7 TeV

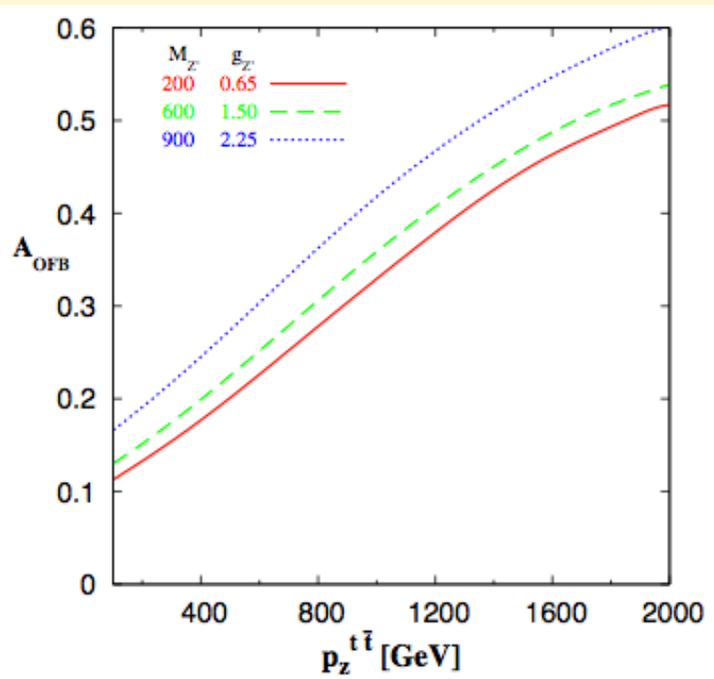
One-side Forward-backward Asymmetry, Y. Wang et al, arXiv:1008.2685

$$A_{\rm OFB} = \frac{\sigma(\Delta Y>0)-\sigma(\Delta Y<0)}{\sigma(\Delta Y>0)+\sigma(\Delta Y<0)}\Big|_{P^z_{t\bar{t}}>P^z_{\rm cut}, M_{t\bar{t}}>M_{\rm cut}}$$

$$= \frac{\sigma(\Delta Y<0)-\sigma(\Delta Y>0)}{\sigma(\Delta Y<0)+\sigma(\Delta Y>0)}\Big|_{P^z_{t\bar{t}}<-P^z_{\rm cut}, M_{t\bar{t}}>M_{\rm cut}}$$

Study of A_{OFB} for W'/Z' models consistent with CDF A_{FB}: B.Bhattacherjee et al, arXiv: 1102.0545





Color-octet s-channel resonances

A_{tFB} Meets LHC, J.Hewett et al, arXiv:1103.4618v2

J. Shu et al, arXiv:0911.3237
Y. Bai et al, arXiv:1101.5203
P. Ferrario et al, arXiv:0912.0687

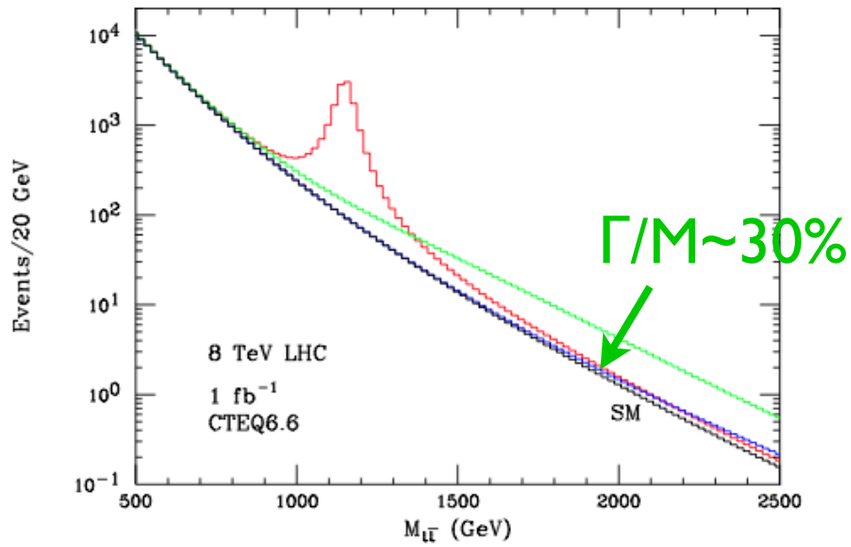


Figure 9: The $M_{t\bar{t}}$ distribution from the axigluon contribution plus the SM background at leading order. The red line is for the model with one axigluon and one vectorlike fermion described above with $M_{G'} = 1100$ GeV and $\theta = 30^\circ$. The green(blue) line is for the phenomenological axigluon model with $M_{G'} = 1(2)$ TeV, $g_A^u = 1.5$, $g_A^t = -2$ and $g_V = 0$. The black line represents the SM.

These models can be typically ruled out or detected with less lum using dijet final states

Discovery reach

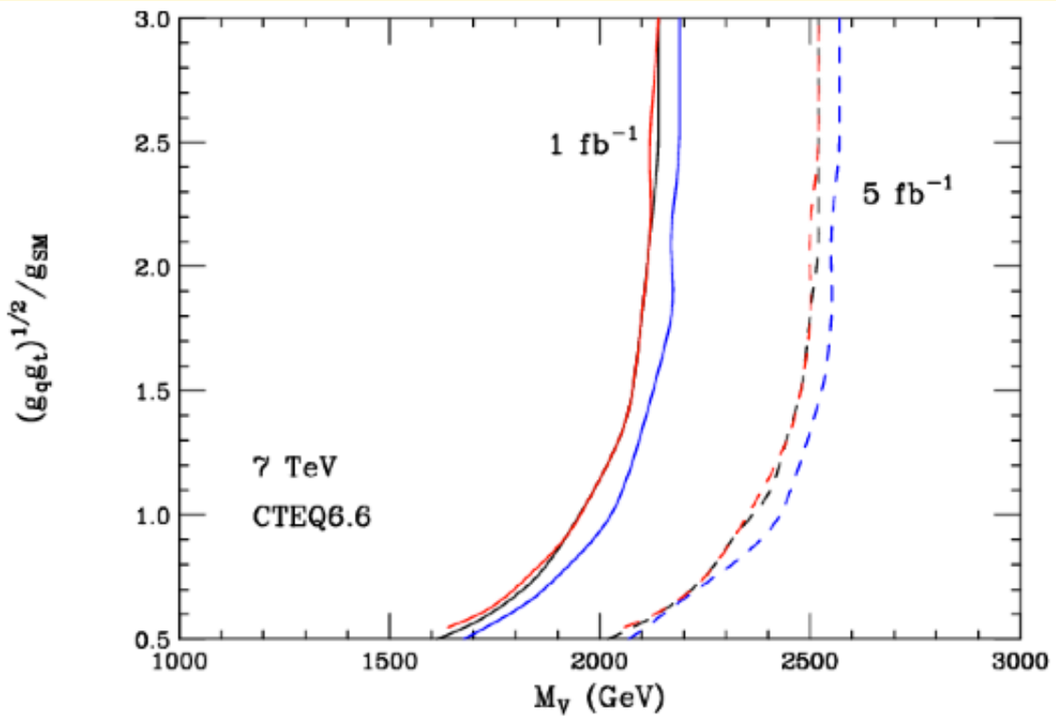


FIG. 3: Discovery reach in the coupling strength-mass plane for purely vector (axial) coupled color-octet vector resonances corresponding to the black (red) curves for the integrated luminosities as indicated for the semi-leptonic channel. The blue curves show the increase in discovery reach when the hadronic channel is also included.

4-fermion contact operators

J. A. Aguilar-Saavedra et al, arXiv:1008.3562
C. Zhang et al, arXiv:1008.3869
C. Degrande et al, arXiv:1010.6304

A_{tFB} Meets LHC, J.Hewett et al, arXiv:1103.4618v2

$$\mathcal{O}_{(L/R)(L/R)} = \frac{g_{eff}^2 \eta}{2\Lambda^2} \left(\bar{q}^a \gamma^\mu q^b\right)_{L/R} \left(\bar{t}^b \gamma_\mu t^a\right)_{L/R}$$

Study angular distributions:

$$\frac{d\sigma}{d\cos\theta} = \frac{\alpha_s \beta}{9s} \frac{\pi\eta}{2\Lambda^2} \left(\frac{4m^2}{s} + 1 + \beta\cos\theta + \beta^2\cos^2\theta\right)$$

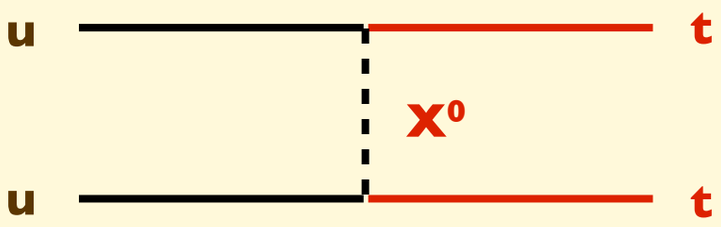
η	1 fb^{-1}	5 fb^{-1}
+1	3.2 (3.78)	4.8 (7.2)
−1	3.2 (3.6)	4.7 (6.0)

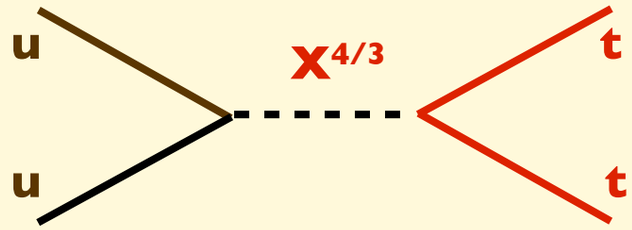
TABLE IV: 95% C.L. search reach in TeV for the contact interaction scale Λ with $\eta = \pm 1$ and 1 or 5 fb^{-1} of integrated luminosity at the 7 TeV LHC. The numbers outside (within) the parenthesis correspond to the semi-leptonic (semi-leptonic and hadronic) event sample.

tt final states

S. Jung et al, 0907.4112
J. Cao et al, 0912.1447
D. Choudhury et al, 1012.4750
J. Cao et al, 1101.4456
E.Berger et al, 1101.5625
B. Bhattacherjee et al,1102.0545

uu → tt via s- or t-channel exchange of resonance





S. Jung et al, 1103.4835

If vector:

- a neutral colour-singlet Z' ($SU(2)_L$ singlet or triplet)
- a neutral colour-octet g' ($SU(2)_L$ singlet or triplet)
- the charge 4/3 component of a colour-triplet $SU(2)_L$ doublet;
- the charge 4/3 component of a colour-sextet $SU(2)_L$ doublet.

If scalar:

- a neutral colour-singlet ($SU(2)_L$ doublet)
- a neutral colour-octet ($SU(2)_L$ doublet)
- the charge 4/3 component of a colour-sextet ($SU(2)_L$ triplet)

Extracting the same-sign tt production signal

Single-lepton charge asymmetry

Asymmetric Leptons for Asymmetric Tops: Rajaraman et al, arXiv:1104.0947

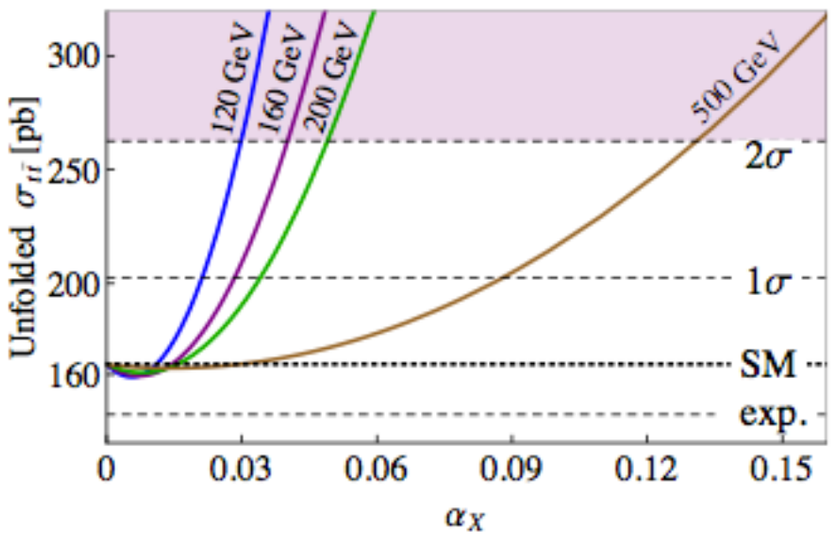
$$\mathcal{A}_{1\ell} \equiv \frac{N(\text{top pair} \to 1\ell^+) - N(\text{top pair} \to 1\ell^-)}{N(\text{top pair} \to 1\ell^+) + N(\text{top pair} \to 1\ell^-)} \,.$$

μ+≥4jets (1 b-tagged)
$p_{T\mu}$>20, $|\eta_\mu|$<2.5
$E_{T,j}$>25 GeV, $|\eta_j|$<2.5 MET>20

Example, in the context of the model of S. Jung, H. Murayama, A. Pierce and J. D. Wells, arXiv:0907.4112 [hep-ph].

$$\delta\mathcal{L} = Z'_\mu \bar{u}_R \gamma^\mu \left(g_X t_R + g'_X u_R\right) + \text{c.c.}.$$

$M_{Z'} = 160$ GeV, $\alpha_X = 0.024$,



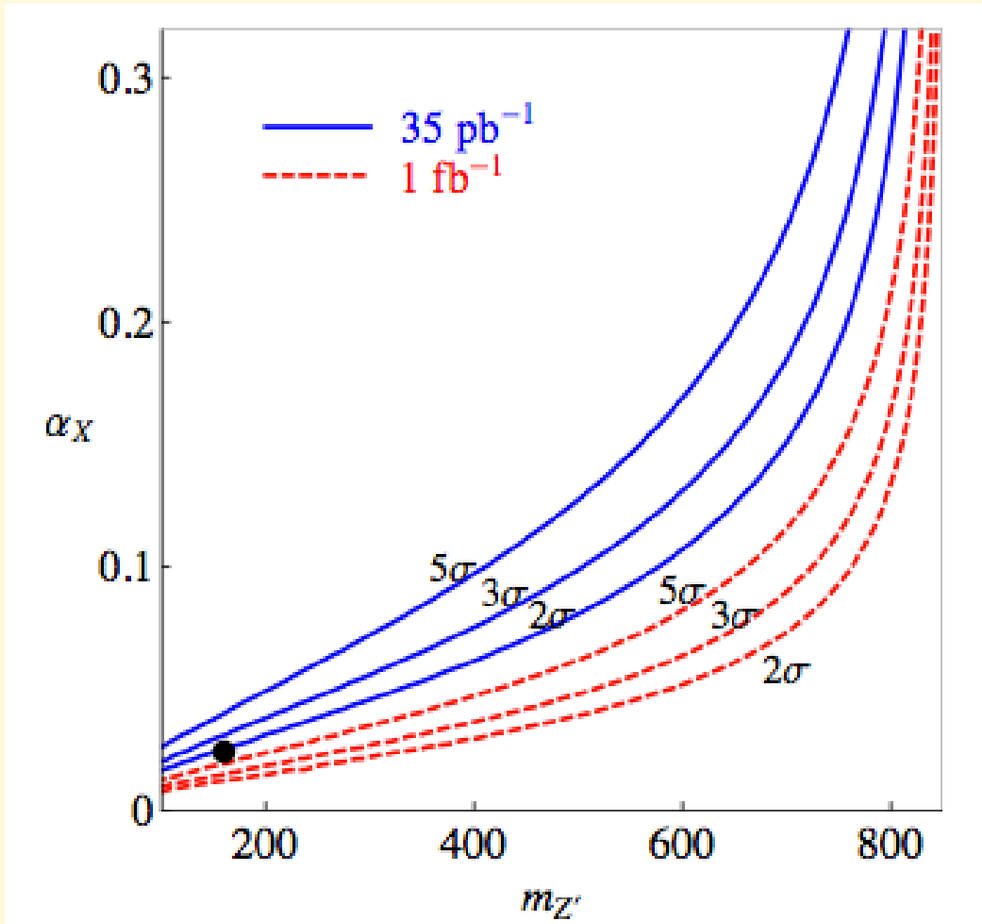
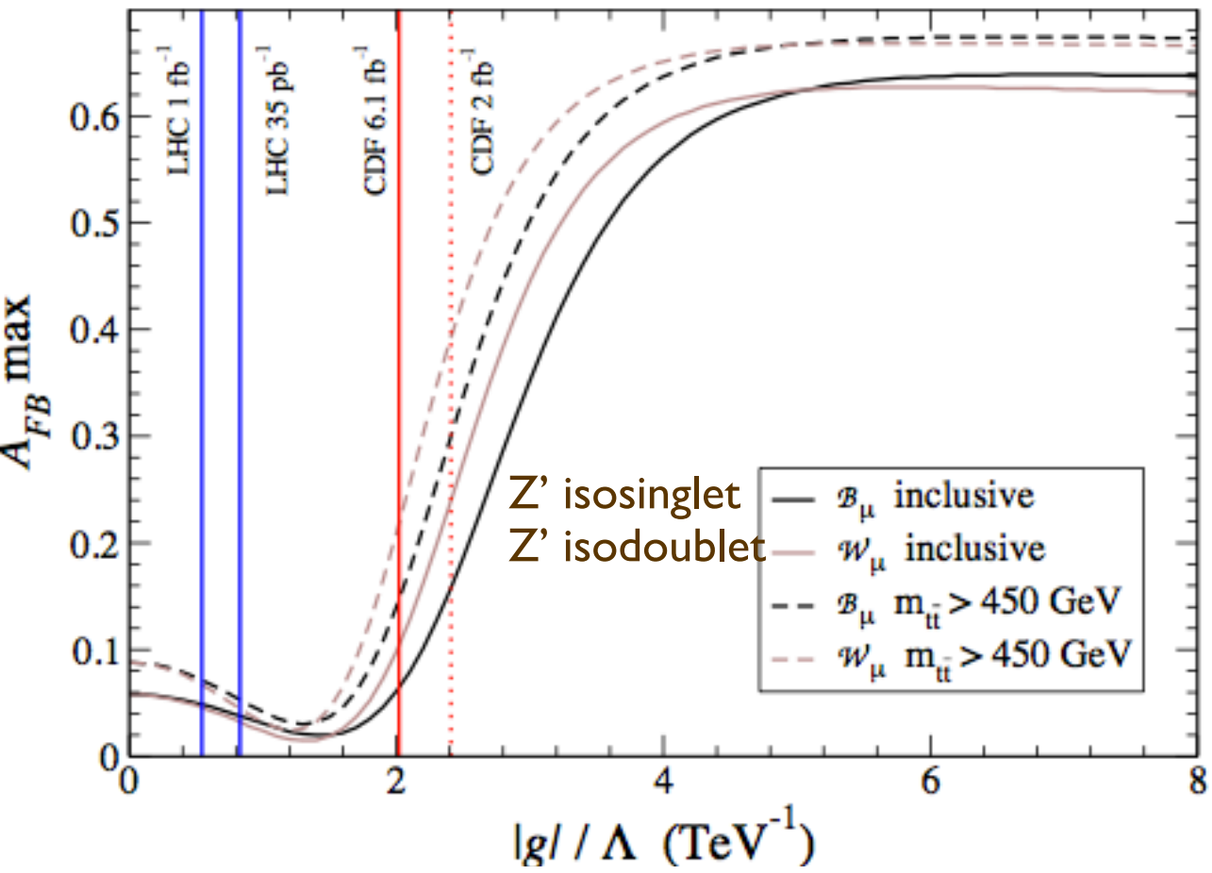


FIG. 2. Significance levels (2σ, 3σ, 5σ) for $L = 35$ pb^{-1} and $L = 1$ fb^{-1} in the $(m_{Z'}, \alpha_X)$ plane, from measurement of the single-lepton charge asymmetry, using the $1\mu + \not{E}_T + \geq 4j$ (b-tagged) channel at 7 TeV. The black dot represents the point ($m_{Z'} = 160$ GeV, $\alpha_X = 0.024$) discussed in the text.

tt final states

Constraints and implications studied in J. A. Aguilar-Saavedra et al, arXiv:1104.1385

Recent CDF limit (6.1 fb^{-1}) $\sigma(tt + \overline{tt}) \times \mathrm{Br}(W \to \ell\nu)^2 < 54$ fb



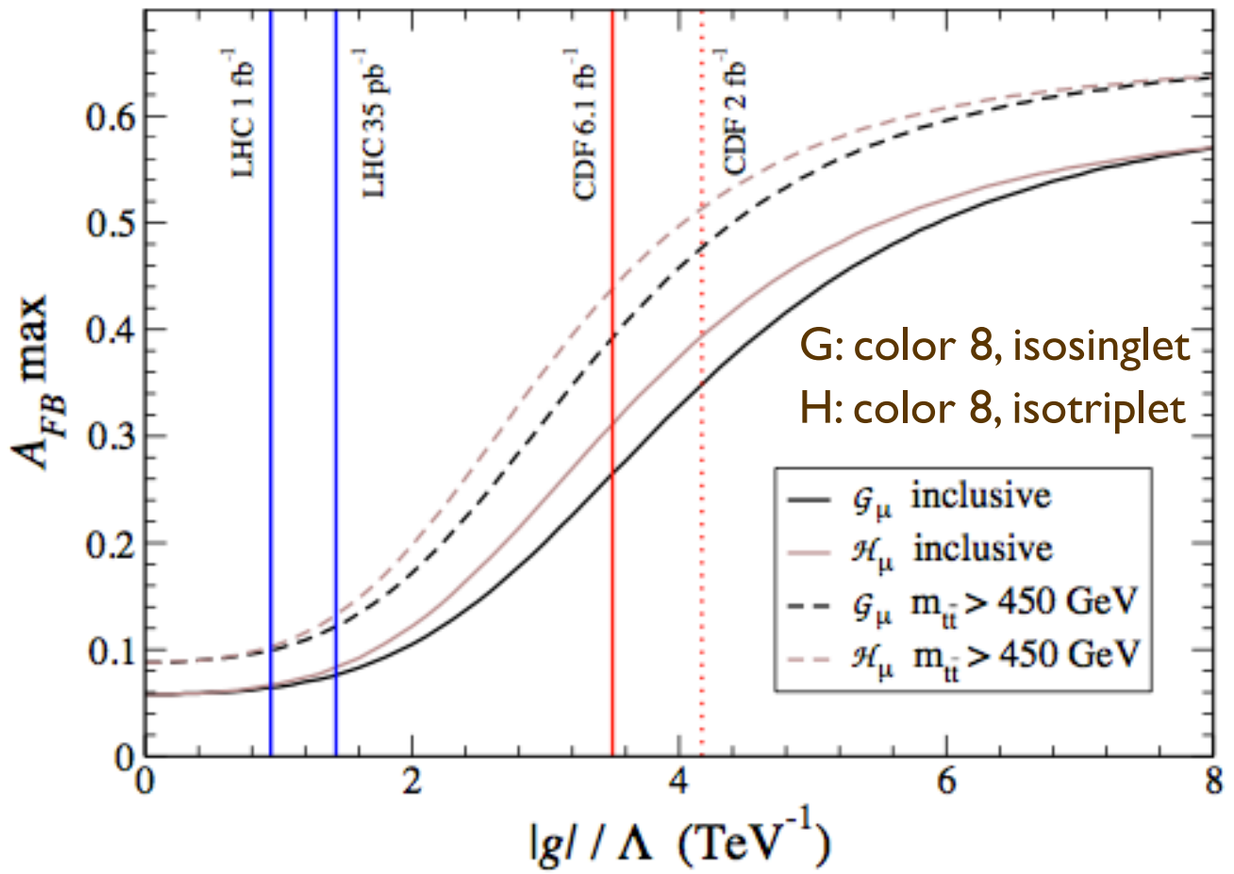


Figure 2: Maximum FB asymmetry from t-channel vector boson exchange as a function of the limit on $|g|/\Lambda$. The vertical red line corresponds to the present upper limit from CDF, and the blue line to the expected LHC limit with 35 pb^{-1}.

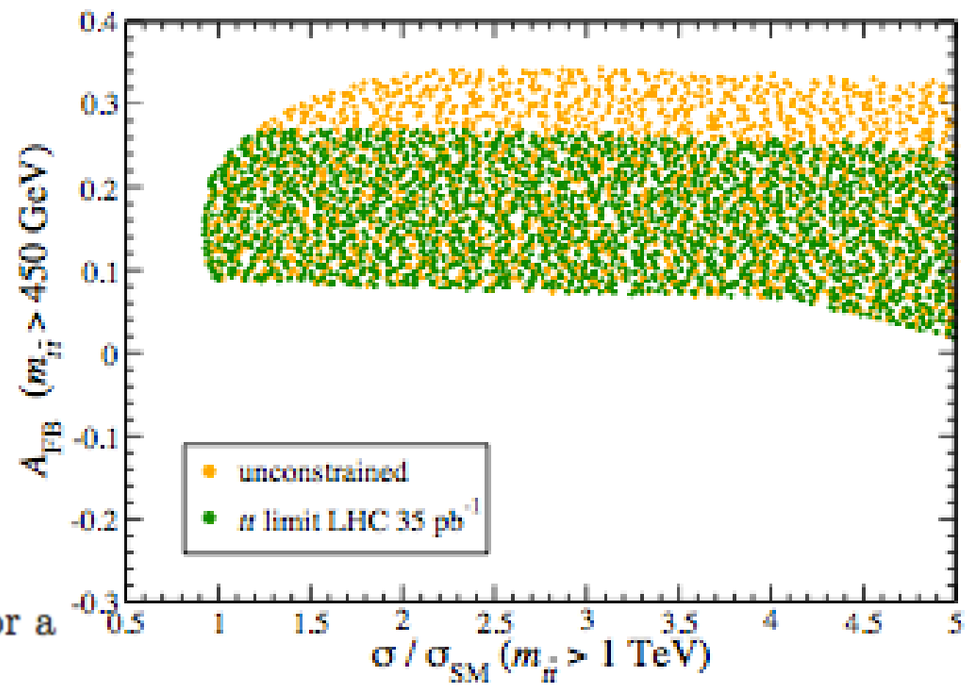


Figure 3: Allowed regions for the Tevatron $t\bar{t}$ asymmetry and the $t\bar{t}$ tail at LHC for a colour-singlet scalar ϕ.

Direct measurement of parity violation in ttbar production

New physics effects on top quark spin correlation and polarization at the LHC: a comparative study in different models, J.Cao et al. arXiv:1011.5564

$P_t = [\sigma(t_L) - \sigma(t_R)] / [\sigma(t_L) + \sigma(t_R)]$

$A_{LR} = [\sigma(t_L\ \mathrm{tbar}_R) - \sigma(t_R\ \mathrm{tbar}_L)] / [\sigma(t_L\ \mathrm{tbar}_R) + \sigma(t_R\ \mathrm{tbar}_L)]$

TABLE II: The maximal statistical significance N_S (defined in [11]) for P_t and A_{LR} at the LHC with an integrated luminosity of 1 fb^{-1}.

	RPV-MSSM (λ')		RPV-MSSM (λ'')		LR Model (Z')		Axigluon Model (g')	
	P_t	A_{LR}	P_t	A_{LR}	P_t	A_{LR}	P_t	A_{LR}
7 TeV	1.7 σ	1.9 σ	29.1 σ	36.5 σ	8.8 σ	9.9 σ	1.71 σ	1.95 σ
14 TeV	3.1 σ	3.5 σ	59.2 σ	68.3 σ	18.4 σ	20.6 σ	26.5 σ	32.8 σ

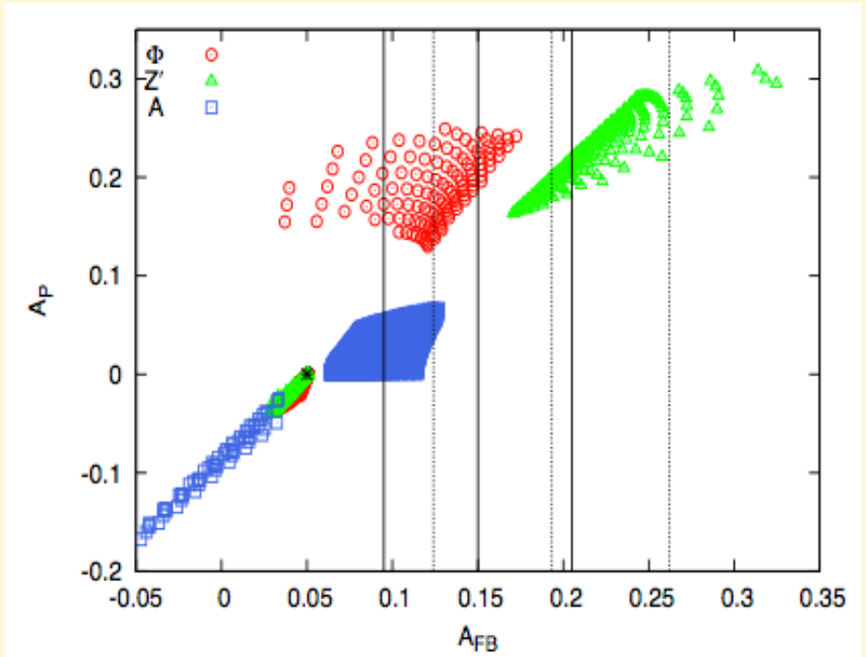
Does not include a realistic study of how the measurement would dilute the significance of P_t and A_{LR}

Top polarization, forward-backward asymmetry and new physics. D.Choudhury et al arXiv:1012.4750 (See also R. Godbole et al, arXiv:1010.1458)

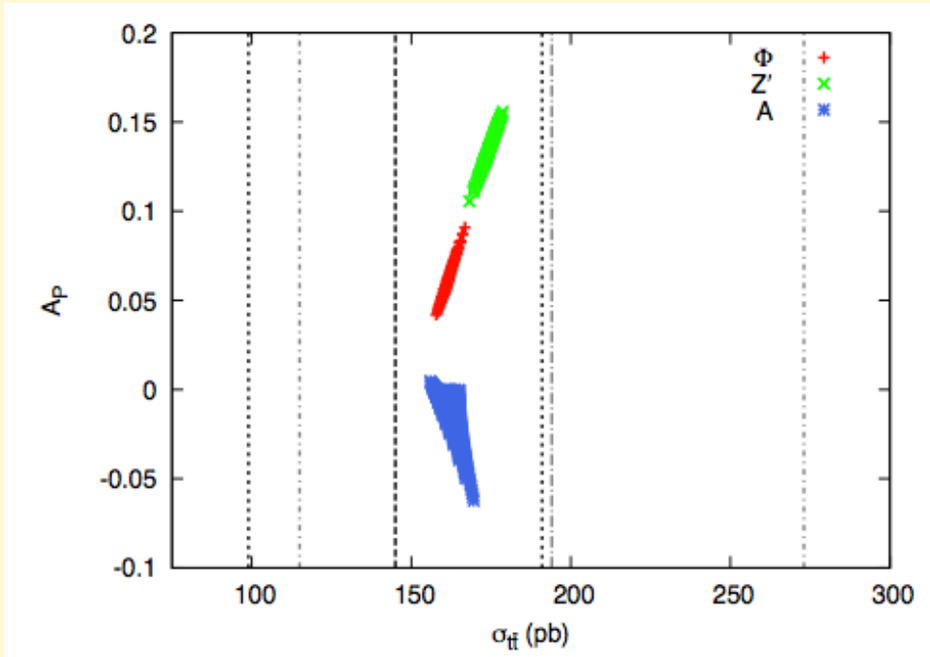
($A_P = P_t$ as defined above)

Φ: diquark, arXiv:0911.3237
Z' u t
A: axigluon, Frampton et al, arXiv:0911.2955 (see however Chivukula et al, 1007.0260)

Consider only model param's consistent with Tevatron σ_{tt} and M_{tt} spectrum



A_{FB} vs A_P correlation at the Tevatron



σ_{tt} vs A_P correlation at the Tevatron