Chiral U(1) flavor models and flavored Higgs doublets for the top A_{FB} and the Wjj

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The 1st KIAS Phenomenology workshop,
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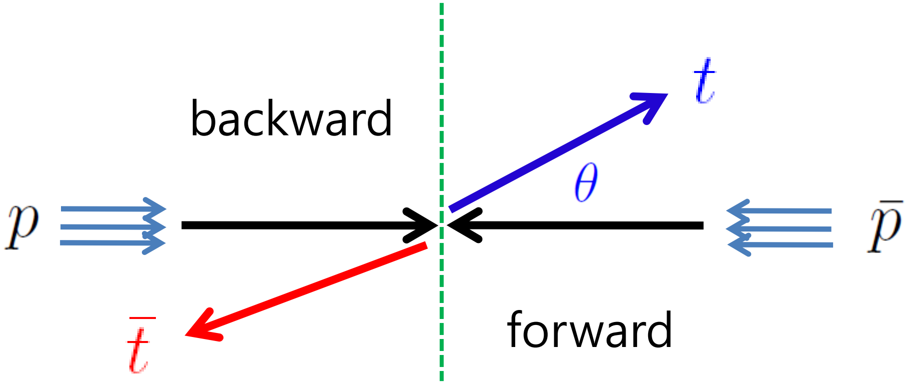
Top A_{FB} at Tevatron

- A_{FB} in top pair production : one of the most interesting quantities.
  - charge asymmetry when CP conservation is assumed.



$$A_{FB} = \frac{N(t; \cos\theta > 0) - N(t; \cos\theta < 0)}{N(t; \cos\theta > 0) + N(t; \cos\theta < 0)}$$

- Symmetric under charge conjugation at LO in the SM.
- At NLO, the interference of processes that differ under charge conjugation leads a small forward-backward asymmetry.

$$A^{t\bar{t}}_{\text{SM}} = 0.058 \pm 0.009 \quad \text{(MCFM)}$$

Top A_{FB} at CDF

CDF, 1101.0034

- CDF(2011) : lepton+jets channel (5.3 fb^{-1})

$$A^{p\bar{p}} = 0.150 \pm 0.055 \ \text{(stat+sys)} \qquad \sim 2\sigma$$

$$A^{t\bar{t}} = 0.158 \pm 0.075 \ \text{(stat+sys)} \qquad \sim 1.32\sigma$$

- $\Delta y = y_t - y_{\bar{t}}$

	CDF	SM	
$A^{t\bar{t}}(\lvert\Delta y\rvert < 1.0) =$	0.026 ± 0.118	0.039 ± 0.006	
$A^{t\bar{t}}(\lvert\Delta y\rvert > 1.0) =$	0.611 ± 0.256	0.123 ± 0.008	$\sim 2\sigma$

- $m_{t\bar{t}}$

	CDF	SM	
$A^{t\bar{t}}(m_{t\bar{t}} < 450\text{GeV}) =$	-0.116 ± 0.153	0.040 ± 0.006	
$A^{t\bar{t}}(m_{t\bar{t}} > 450\text{GeV}) =$	0.475 ± 0.114	0.088 ± 0.013	$\sim 3.4\sigma$

(See the talk by H.Kim and S.Choi.)

Top A_{FB} at CDF

- CDF (2011) : dilepton channel

From Hyunsoo Kim's talk,Tev2011

✔ Observed (including background)

$$A_{FB}^{obs} = 0.138 \pm 0.054\,(stat.)$$

✔ Observed (background subtracted)

$$A_{FB}^{sub} = 0.205 \pm 0.073\,(stat.) \pm 0.021\,(bkg\ shape)$$

✔ Detector effect corrected (true)

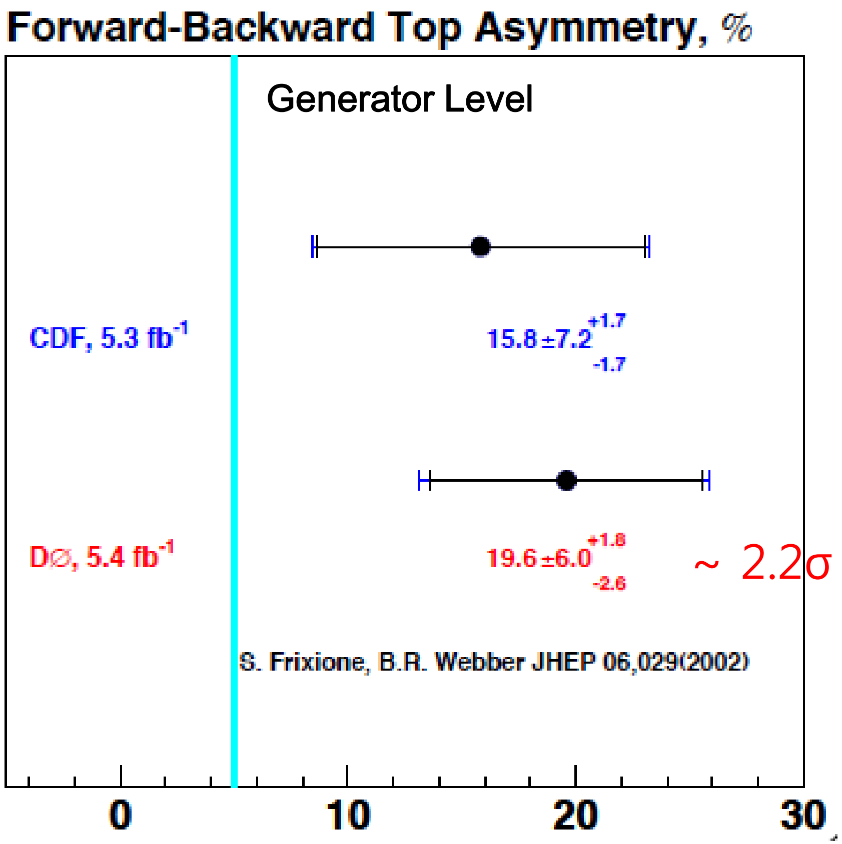
$$A_{FB}^{true} = 0.417 \pm 0.148\,(stat.) \pm 0.053\,(syst.)$$

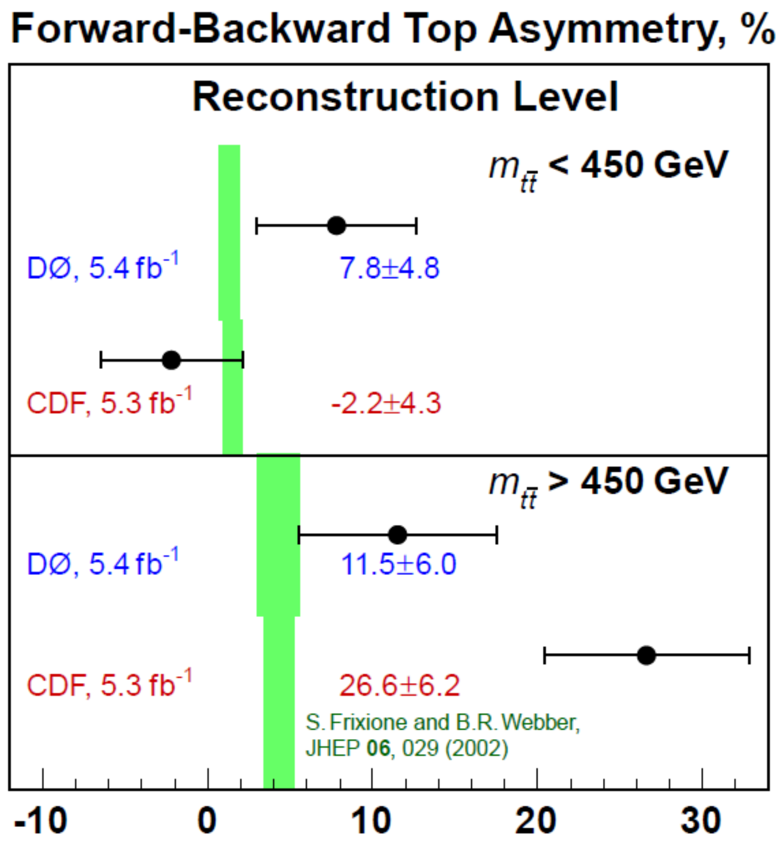
2.7σ from SM prediction 0.05 ± 0.01

Top A_{FB} at D0

From Regina Demina's talk,EPS-HEP 2011

- Using 5.4 fb^{-1} of data in the lepton+jets channel

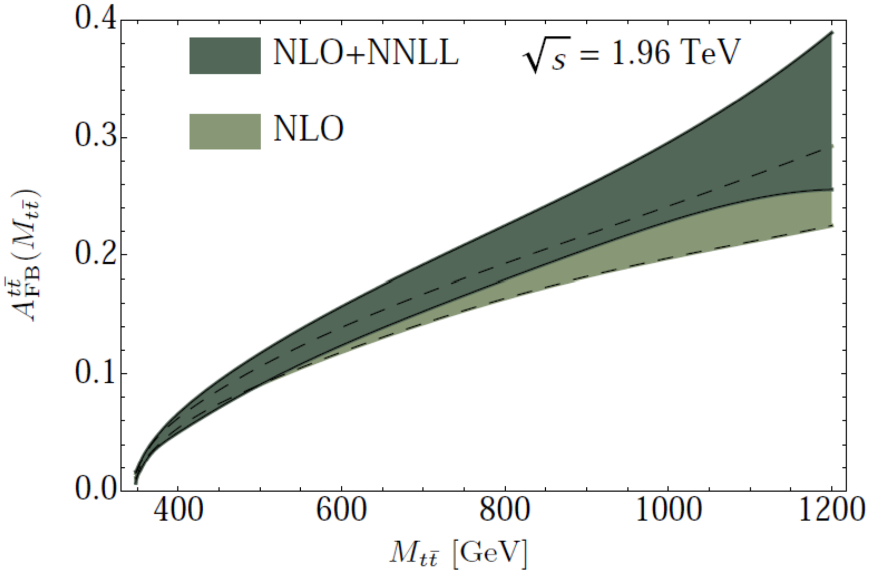


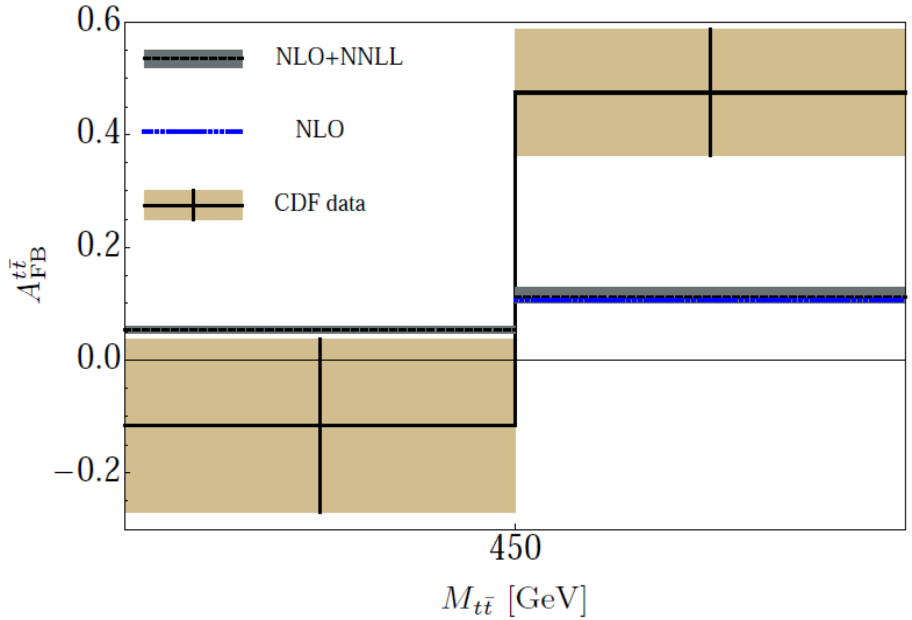


- consistent with CDF in the generator level.
- no convincing evidence for the dependence on $m_{t\bar{t}}$.

SM prediction at NLO+NNLL

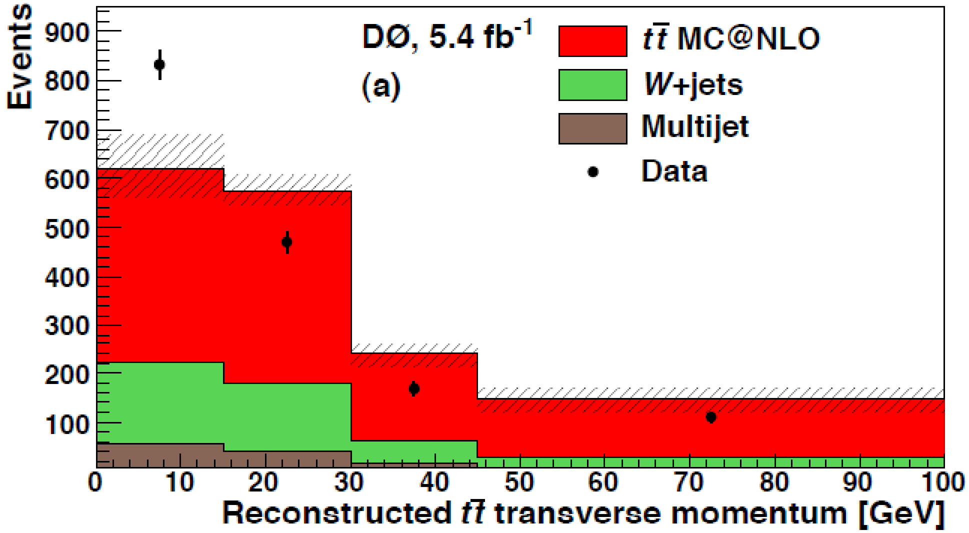
Ahrens,Ferroglia,Neubert,Pecjak,Yang,PRD84

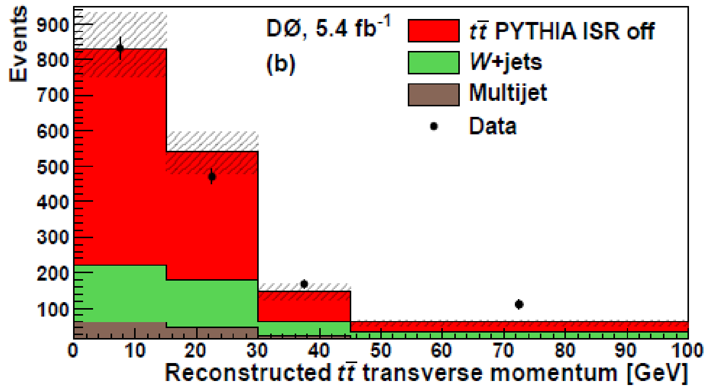


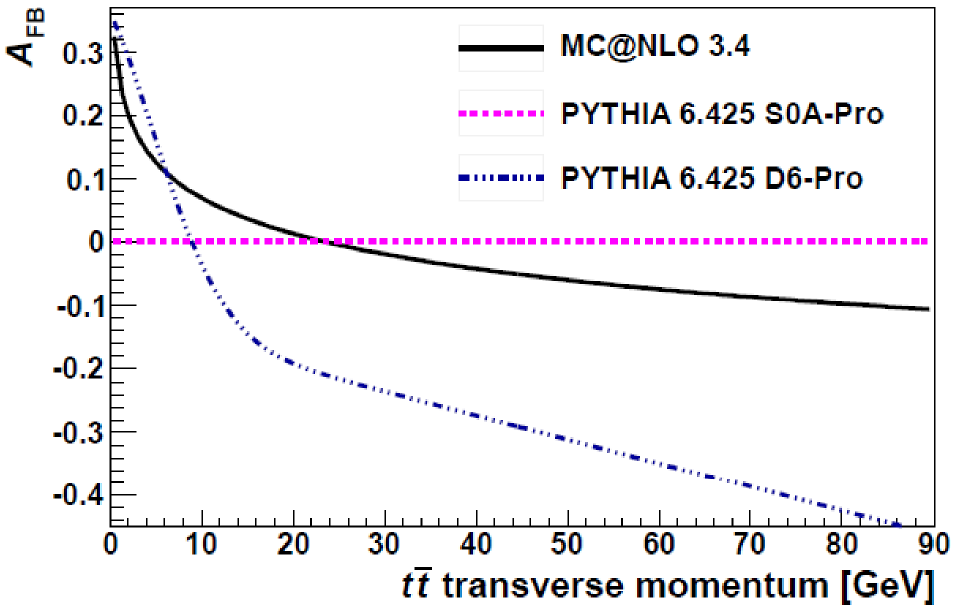


(In units of %)	$A_{FB}^{t\bar{t}}$	$A_{FB}^{t\bar{t}}(M_{t\bar{t}} < 450\ \text{GeV})$	$A_{FB}^{t\bar{t}}(M_{t\bar{t}} > 450\ \text{GeV})$
NLO	$7.14^{+0.67}_{-0.54}$	$5.3^{+0.4}_{-0.4}$	$10.4^{+1.0}_{-0.6}$
NLO+NNLL	$7.16^{+1.05}_{-0.68}$	$5.2^{+0.8}_{-0.6}$	$10.8^{+1.7}_{-0.9}$
CDF	15.8 ± 7.5	-11.6 ± 15.3	47.5 ± 11.2

$P_T^{t\bar{t}}$ dependence



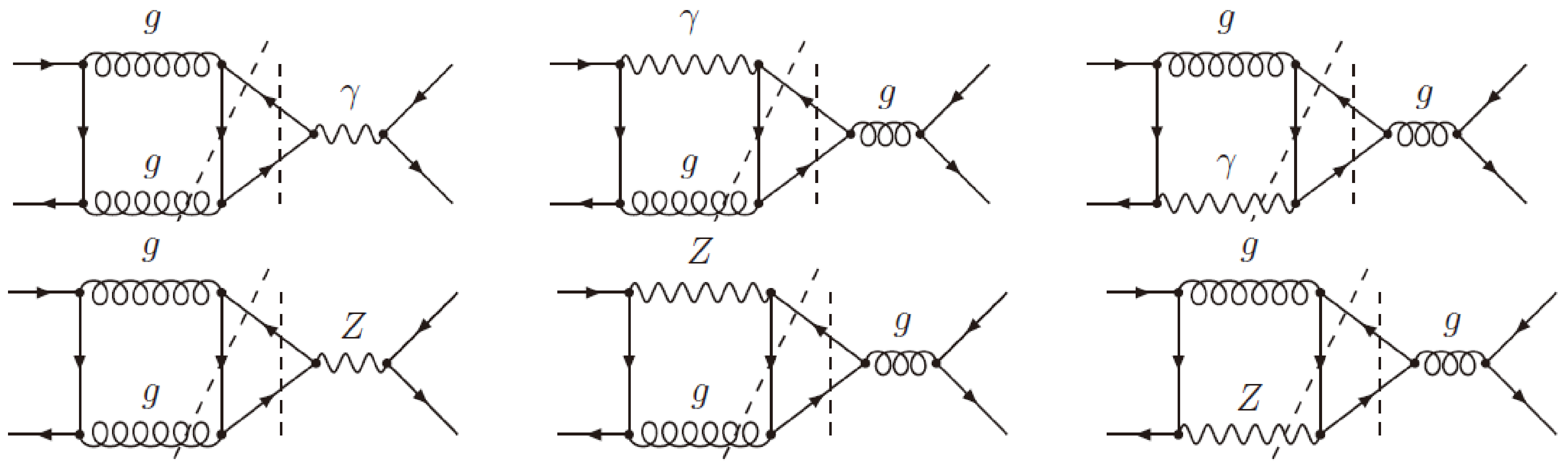




- D0 disagrees with MC@NLO.
- changes sign at ~ 20 GeV.
- the asymmetry would be enhanced if the data are lost at high pT.
- disagreement between MC generators.

EW contributions

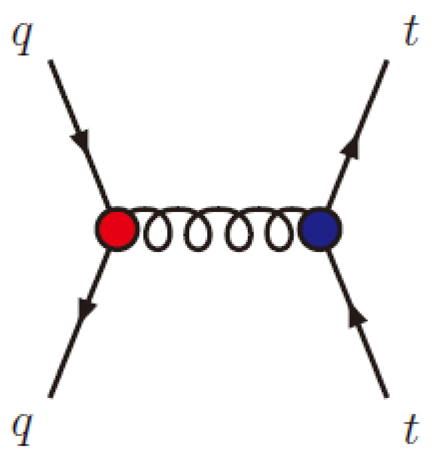
Kühn, Rodrigo, 1109.6830



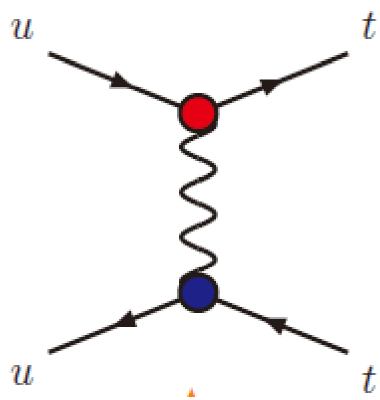
- reanalyze electromagnetic as well as weak corrections.
  - enhancement of A_{FB} by about a factor 1.1.
- restrict the $t\bar{t}$ system to a transverse momentum < 20 GeV.
  - enhancement of A_{FB} by factors between 1.3 and 1.5.

(In units of %)	$A_{FB}^{t\bar{t}}$	$A_{FB}^{t\bar{t}}(M_{t\bar{t}} < 450 \text{ GeV})$	$A_{FB}^{t\bar{t}}(M_{t\bar{t}} > 450 \text{ GeV})$
SM	8.7 ± 1.0	6.2 ± 0.4	12.8 ± 1.1
MCFM	5.8 ± 0.9	4.0 ± 0.6	8.8 ± 1.3
CDF	15.8 ± 7.5	-11.6 ± 15.3	47.5 ± 11.2

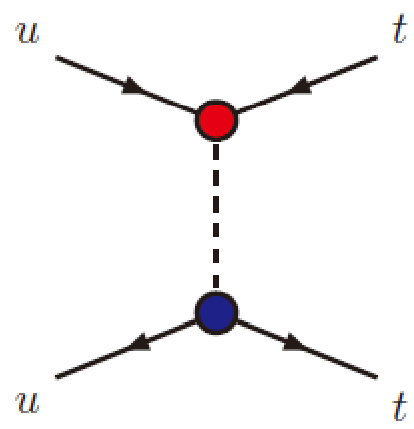
New models



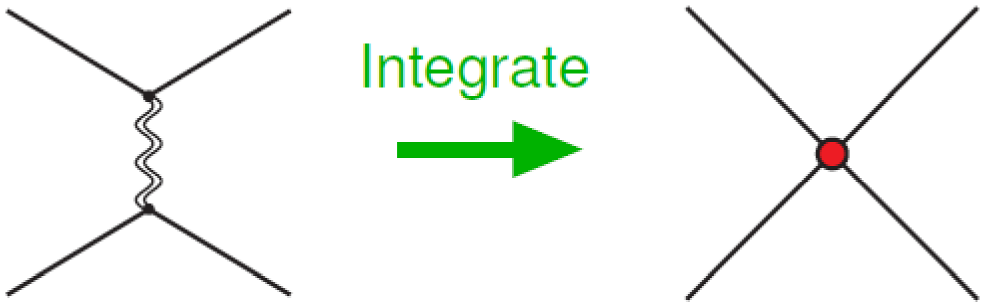
s-channel: coloured resonance $\mathcal{G}_\mu$



t-channel: Z', W', ϕ



u-channel: exotic scalars



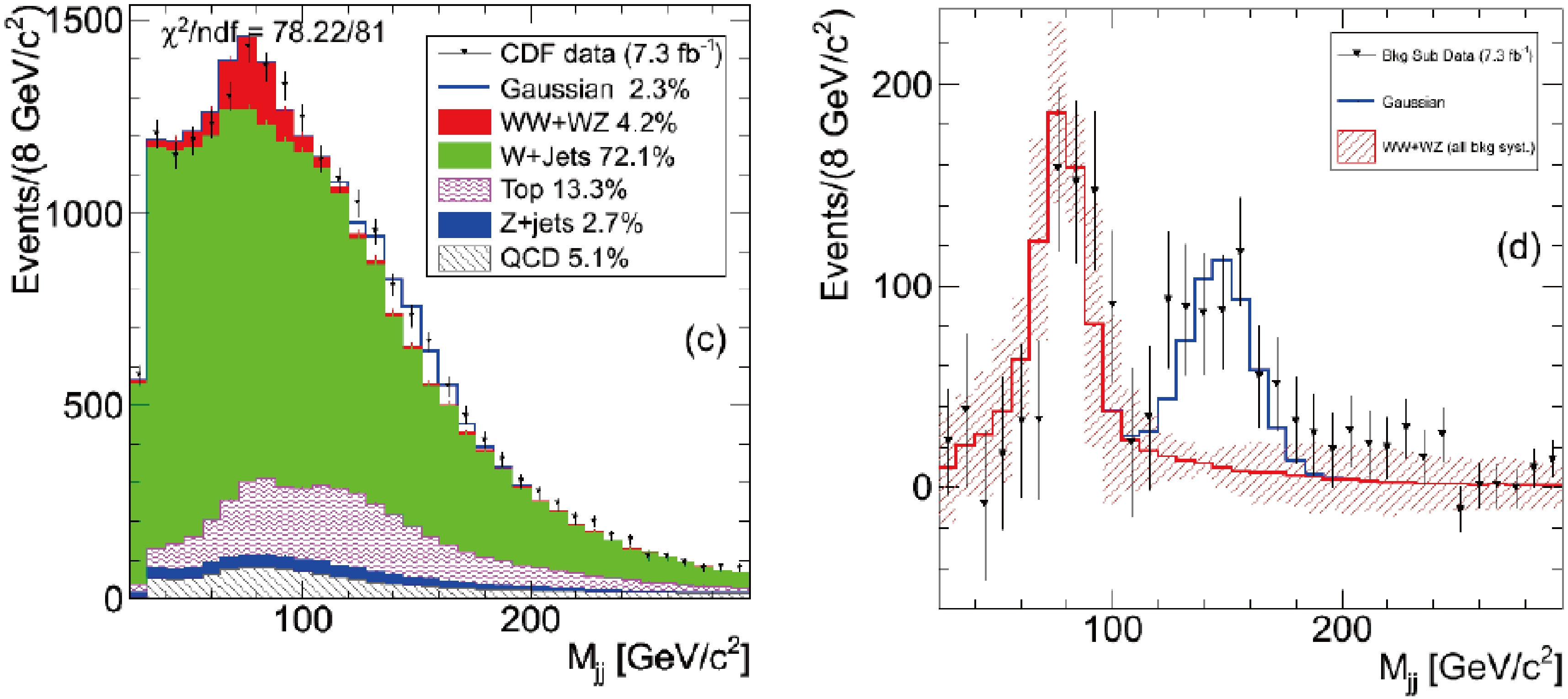
(new) heavy VB

4-fermion interaction

- flavor dependent.
- challenging to construct a realistic model.
  - anomaly free, renormalizable, realistic Yukawa couplings.

Wjj excess at CDF

From Punzi's talk, Blois 2011

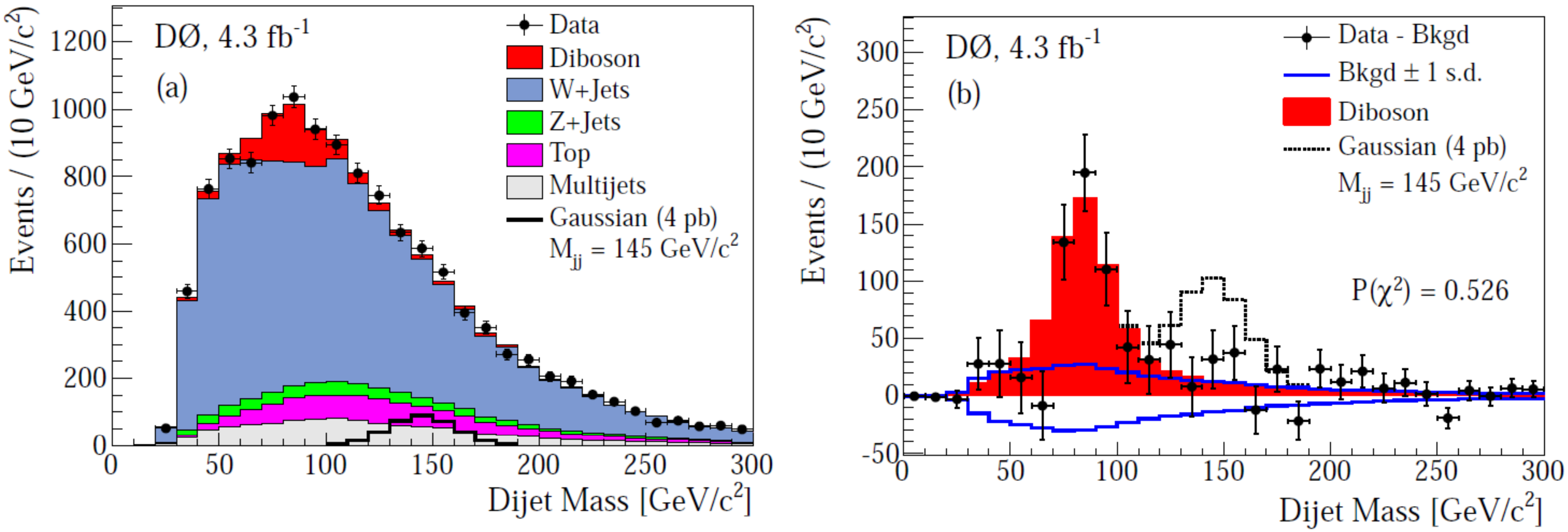


- 4.1 sigma deviation with 7.3 fb^{-1}.
- assume an additional Gaussian peak.
- $\sigma(p\bar{p} \to WX) \times Br(X \to jj)$ ~4 pb with $m_X \approx 145$ GeV.

(See the talks by Eichten, Song, H.Kim.)

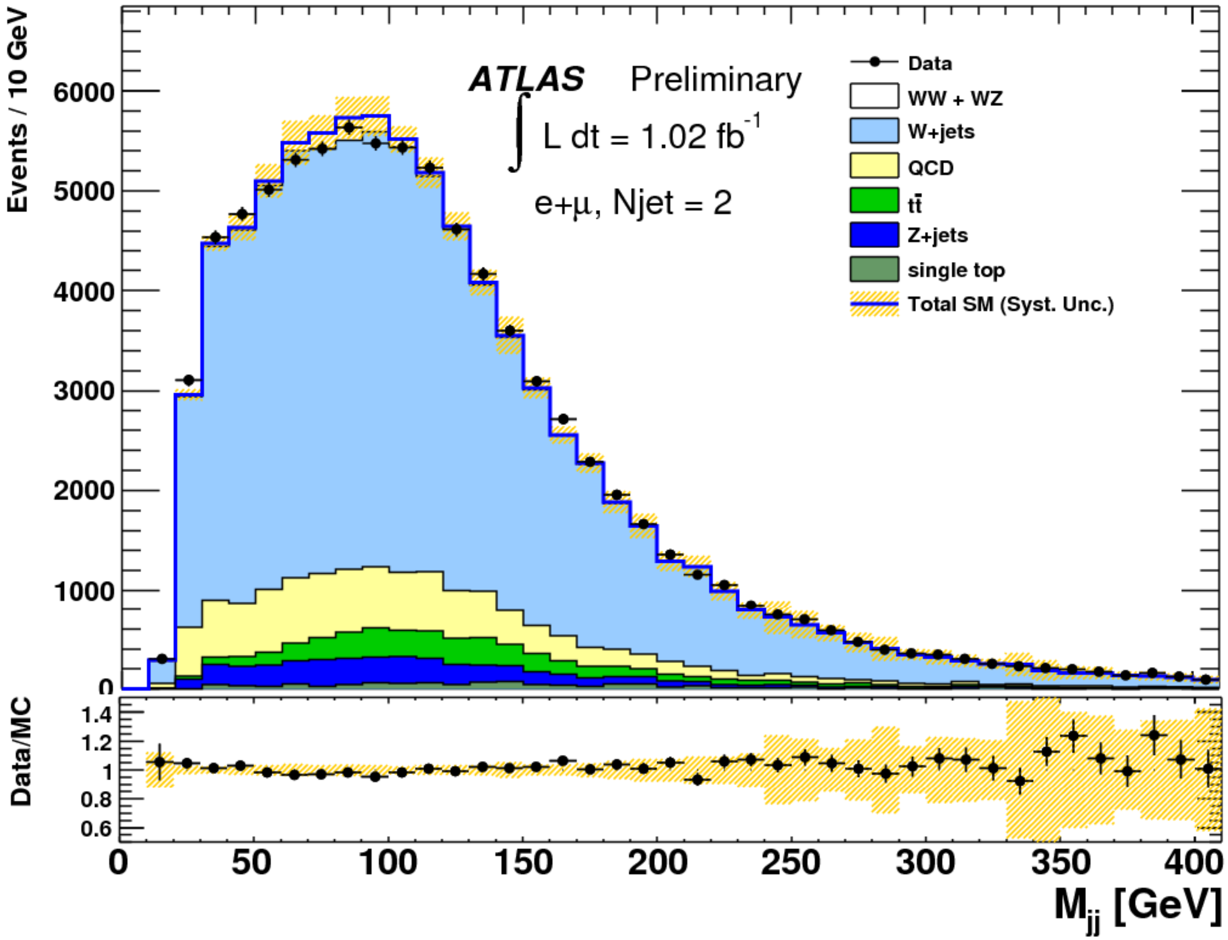
Wjj at D0

D0, 1106.1921



- no evidence for anomalous, resonant production of dijets.
- upper limits for the dijet production : 1.9 pb for m_{jj} = 145 GeV (95% C.L.).
- reject the hypothesis of a cross section of 4 pb at the level of 4.3 s.d.

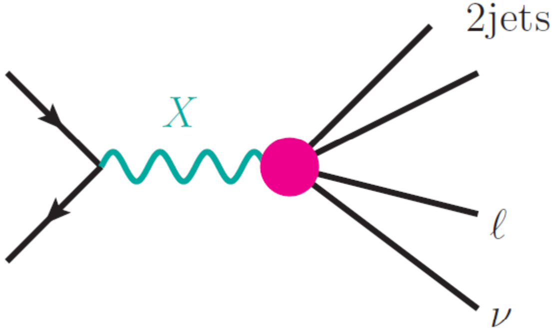
Wjj at ATLAS

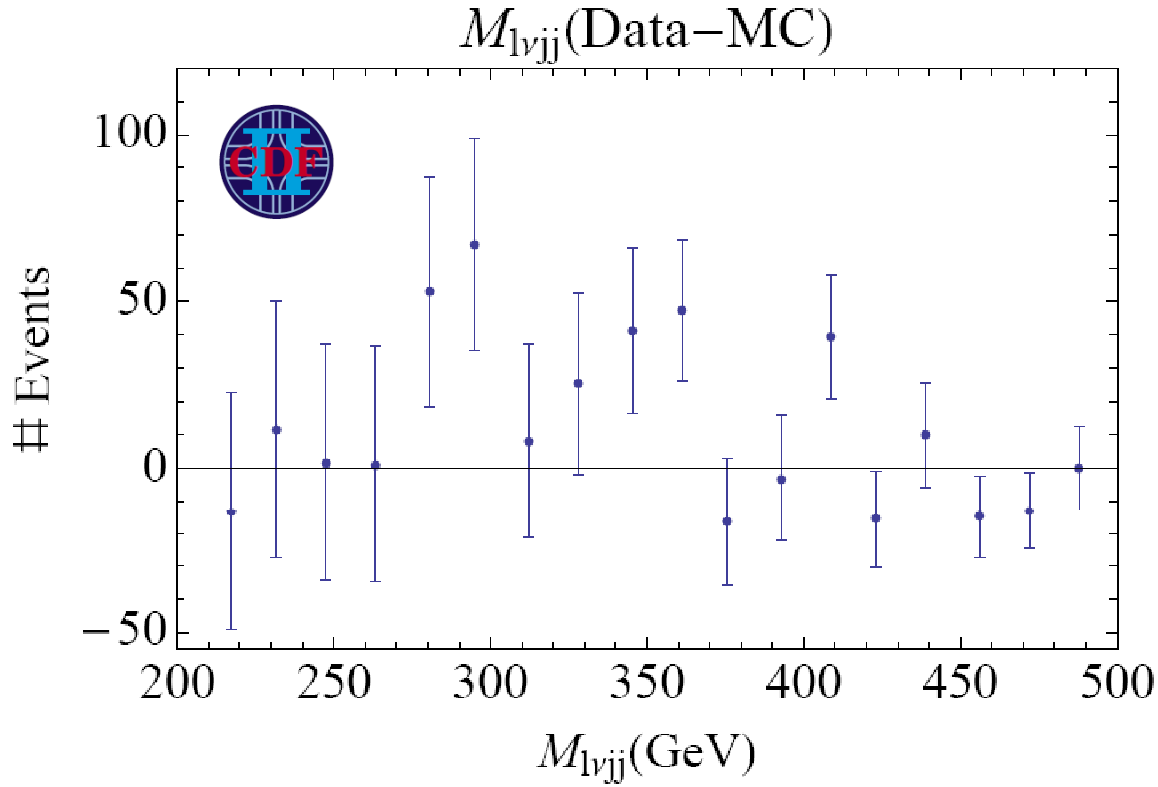


ATLAS Preliminary
∫ L dt = 1.02 fb-1
e+μ, Njet = 2
Data
WW + WZ
W+jets
QCD
tt̄
Z+jets
single top
Total SM (Syst. Unc.)
Events / 10 GeV
Data/MC
Mjj [GeV]

s-channel resonance?

Fan, Krohn ,Langacker, Yavin, 1106.1682





- difficult to derive any conclusion on an s-channel resonance.
- a broad excess in the region around $M_{l\nu jj}$ ~ 270 GeV?

Flavor dependent U(1)′ Model

• many studies for a relatively light Z′ gauge boson with mass ~ 150 GeV.

• the Z′ is associated with some U(1)′ gauge symmetry.

• better be leptophobic to avoid the LEP II and Drell-Yan bounds.

• approximately lighter than 200 GeV from the dijet production in the UA2 experiments.

• difficult to assign flavor-dependent charges to down-type quarks due to the strong constraints from FCNC experiments. (See the talk by Ligeti.)

• Yukawa interactions : additional Higgs fields.

• a flavor-dependent leptophobic U(1)′ : anomalous.
  - introduce additional fermions to cancel the gauge anomalies.

• Both Z′ and Higgs fields affect the top A_{FB} and Wjj production.

Flavor dependent U(1)′ Model

- Charge assignment : SM fermions

	$SU(3)$	$SU(2)$	$U(1)_Y$	$U(1)'$
Q_1	3	2	1/6	q_L
Q_2	3	2	1/6	q_L
Q_3	3	2	1/6	q_L
$\overline{D_1}$	$\overline{3}$	1	1/3	$-q_L$
$\overline{D_2}$	$\overline{3}$	1	1/3	$-q_L$
$\overline{D_3}$	$\overline{3}$	1	1/3	$-q_L$
$\overline{U_1}$	$\overline{3}$	1	−2/3	u_1
$\overline{U_2}$	$\overline{3}$	1	−2/3	u_2
$\overline{U_3}$	$\overline{3}$	1	−2/3	u_3
H	1	2	1/2	0

Left-handed quarks and right-handed down-type quarks have universal couplings.

Flavor-dependent

Higgs

Flavor dependent U(1)′ Model

- Charge assignment : Higgs fields

	$SU(3)_c$	$SU(2)_L$	$U(1)_Y$	$U(1)'$
H_1	1	2	1/2	$-q_L - u_1$
H_2	1	2	1/2	$-q_L - u_2$
H_3	1	2	1/2	$-q_L - u_3$
Φ	1	1	1	$-q_\Phi$

- introduce three Higgs doublets charged under U(1)′ in addition to H uncharged under U(1)′.

$$\begin{aligned} V_y &= y^u_{i1} H_1 \overline{U_1} Q_i + y^u_{i2} H_2 \overline{U_2} Q_i + y^u_{i3} H_3 \overline{U_3} Q_i \\ &+ y^d_{ij} \overline{D_j} Q_i i\tau_2 H^\dagger \\ &+ y^e_{ij} \overline{E_j} L_i i\tau_2 H^\dagger + y^n_{ij} H \overline{N_j} L_i . \end{aligned}$$

- The U(1)′ is spontaneously broken by U(1)′ charged complex scalar Φ.

Flavor dependent U(1)′ Model

- Anomaly cancelation requires extra fermions I: SU(2) doublets

	$SU(3)_c$	$SU(2)_L$	$U(1)_Y$	$U(1)'$
Q'	3	2	1/6	$-(q_1+q_2+q_3)$
D'_R	3	1	−1/3	$-(d_1+d_2+d_3)$
U'_R	3	1	2/3	$-(u_1+u_2+u_3)$
L'	1	2	−1/2	0
E'	1	1	−1	0
l_{L1}	1	2	−1/2	Q_L
l_{R1}	1	2	−1/2	Q_R
l_{L2}	1	2	−1/2	$-Q_L$
l_{R2}	1	2	−1/2	$-Q_R$

one extra generation

$SU(2)_L{}^2 \cdot U(1)'$

vector-like pairs

$U(1)'^2 \cdot U(1)$

a candidate for CDM

(See the talk by Omura.)

Flavor dependent U(1)′ Model

- 2 Higgs doublet model : $(u_1, u_2, u_3) = (0, 0, 1)$

	$SU(3)_c$	$SU(2)_L$	$U(1)_Y$	$U(1)'$
H	1	2	1/2	0
H_3	1	2	1/2	1
Φ	1	1	1	q_Φ

$$\begin{aligned} V_y &= y^u_{i1}\overline{Q_i}\widetilde{H}U_{R1} + y^u_{i2}\overline{Q_i}\widetilde{H}U_{Rj} + y^u_{i3}\overline{Q_i}\widetilde{H_3}U_{Rj} \\ &\quad + y^d_{ij}\overline{Q_i}HD_{Rj} + y^e_{ij}\overline{L_i}H\overline{E_j} + y^n_{ij}\overline{L_i}\widetilde{H}N_j. \end{aligned}$$

$$V_h = Y^u_{ij}\overline{\hat{U}_{Li}}\hat{U}_{Rj}\hat{h}_0 + Y^d_{ij}\overline{\hat{D}_{Li}}\hat{D}_{Rj}\hat{h}_0,$$

$$\begin{aligned} Y^u_{ij} &= \frac{m^u_i \cos\alpha}{v\cos\beta}\delta_{ij} + \frac{2m^u_i}{v\sin 2\beta}(g^u_R)_{ij}\sin(\alpha-\beta), \\ Y^d_{ij} &= \frac{m^d_i \cos\alpha}{v\cos\beta}\delta_{ij}, \end{aligned}$$

$\propto$ the fermion mass

Flavor dependent U(1)′ Model

- 3 Higgs doublet model: $(u_1, u_2, u_3) = (-q, 0, q)$

	$SU(3)$	$SU(2)$	$U(1)_Y$	$U(1)'$
H_1	1	2	1/2	q
H_2	1	2	1/2	0
H_3	1	2	1/2	$-q$
Φ	1	1	0	-1

$$\begin{aligned}\mathcal{L}_{\rm Y} &= y^u_{i1} H_1 \overline{U_1} Q_i + y^u_{i2} H_2 \overline{U_2} Q_i + y^u_{i3} H_3 \overline{U_3} Q_i \\ &+ y^d_{ij} H_2^\dagger \overline{D_j} Q_i + y^e_{ij} H_2^\dagger \overline{E_j} L_i + y^n_{ij} H_2 \overline{N_j} L_i .\end{aligned}$$

Flavor dependent U(1)′ Model

- Gauge coupling in the mass base

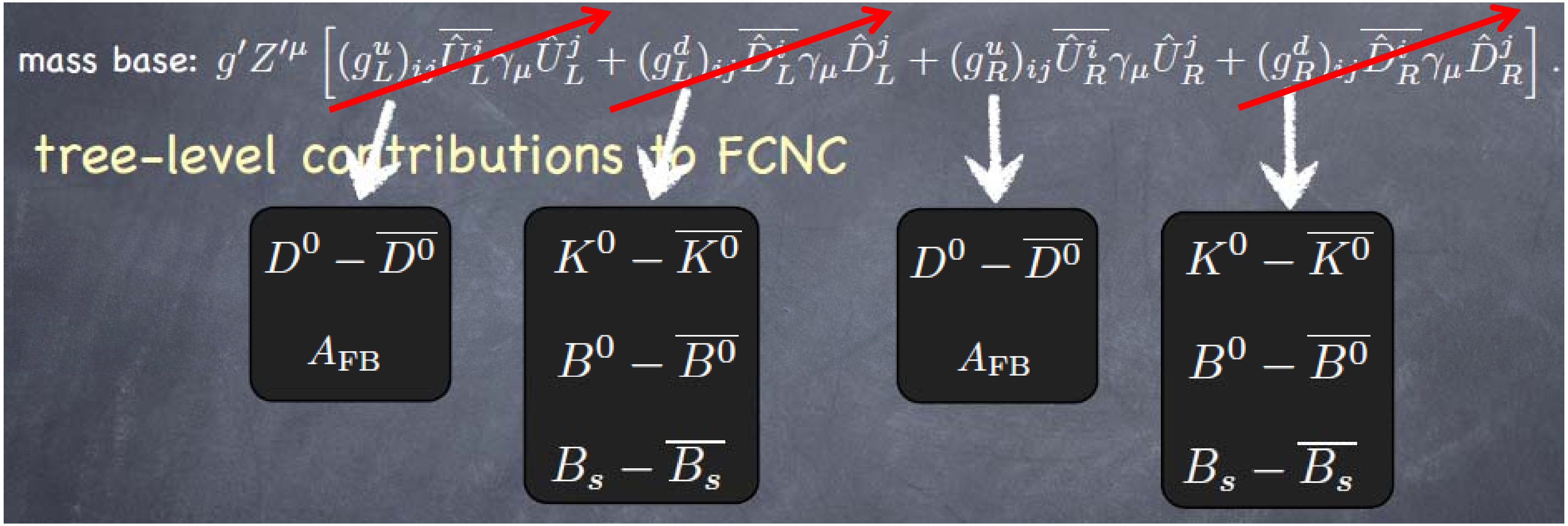
- Z′ interacts only with the right-handed up-type quarks

$$g' Z'^{\mu} \sum_{i,j=1,2,3} (g^u_R)_{ij} \overline{U_R}^i \gamma_\mu U^j_R$$

- The 3 X 3 coupling matrix g^u_R is defined by

$$(g^u_R)_{ij} = (U^u_R)_{ik} u_k (U^u_R)^\dagger_{kj}$$

biunitary matrix diagonalizing
the up-type quark mass matrix



Flavor dependent U(1)′ Model

- Yukawa coupling in the mass base (2HDM)

- lightest Higgs h: $V_h = Y^u_{ij}\overline{\hat{U}_{Li}}\hat{U}_{Rj}h + Y^d_{ij}\overline{\hat{D}_{Li}}\hat{D}_{Rj}h + Y^e_{ij}\overline{\hat{E}_{Li}}\hat{E}_{Rj}h + h.c.,$

$$Y^u_{ij} = \frac{m^u_i \cos\alpha}{v\cos\beta}\cos\alpha_\Phi \delta_{ij} + \frac{2m^u_i}{v\sin 2\beta}(g^u_R)_{ij}\sin(\alpha-\beta)\cos\alpha_\Phi,$$

$$Y^d_{ij} = \frac{m^d_i \cos\alpha}{v\cos\beta}\cos\alpha_\Phi \delta_{ij},$$

$$Y^e_{ij} = \frac{m^l_i \cos\alpha}{v\cos\beta}\cos\alpha_\Phi \delta_{ij},$$

- lightest charged Higgs h+: $V_{h^\pm} = -Y^{u-}_{ij}\overline{\hat{D}_{Li}}\hat{U}_{Rj}h^- + Y^{d+}_{ij}\overline{\hat{U}_{Li}}\hat{D}_{Rj}h^+ + h.c.,$

$$Y^{u-}_{ij} = \sum_l (V_{\rm CKM})^*_{li}\left\{\frac{\sqrt{2}m^u_l \tan\beta}{v}\delta_{lj} - \frac{2\sqrt{2}m^u_l}{v\sin 2\beta}(g^u_R)_{lj}\right\},$$

$$Y^{d+}_{ij} = (V_{\rm CKM})_{ij}\frac{\sqrt{2}m^d_j \tan\beta}{v},$$

- lightest pseudoscalar Higgs a: $V_a = -iY^{au}_{ij}\overline{\hat{U}_{Li}}\hat{U}_{Rj}a + iY^{ad}_{ij}\overline{\hat{D}_{Li}}\hat{D}_{Rj}a + iY^{ae}_{ij}\overline{\hat{E}_{Li}}\hat{E}_{Rj}a + h.c.,$

$$Y^{au}_{ij} = \frac{m^u_i \tan\beta}{v}\delta_{ij} - \frac{2m^u_i}{v\sin 2\beta}(g^u_R)_{ij},$$

$$Y^{ad}_{ij} = \frac{m^d_i \tan\beta}{v}\delta_{ij},$$

$$Y^{ae}_{ij} = \frac{m^l_i \tan\beta}{v}\delta_{ij}.$$

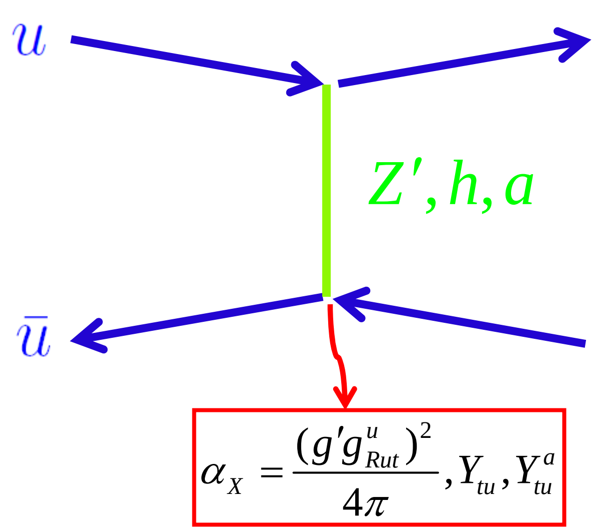
Top-antitop-quark pair production at Tevatron

1. Z′ dominant scenario

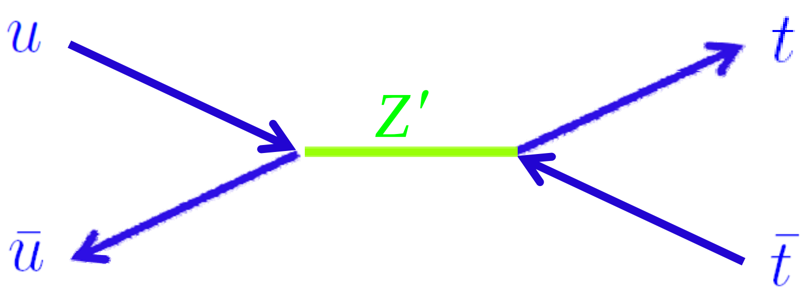
cf. Jung, Murayama, Pierce, Wells, PRD81(2010)

2. Higgs dominant scenario

cf. Babu, Frank, Rai, 1104.4782

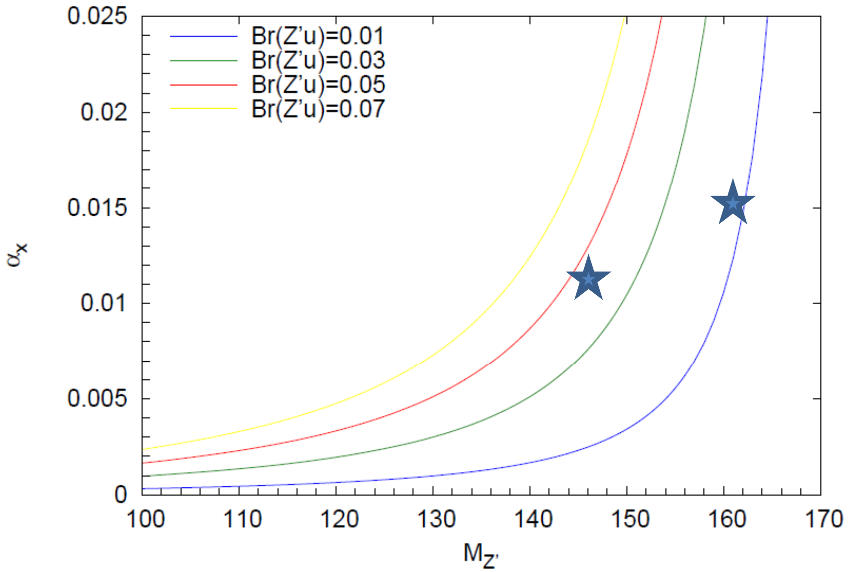


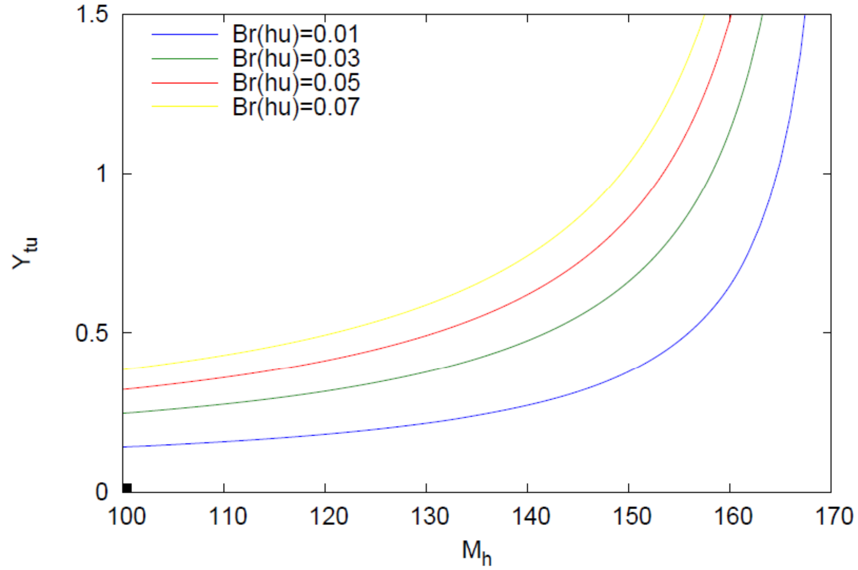
3. Mixed scenario



Top quark decay

- decay into W+b in SM : Br(t→Wb)~100%.
- If the top quark decays to $Z'+u$ or $h+u$, Br(t→Wb) might significantly be changed.



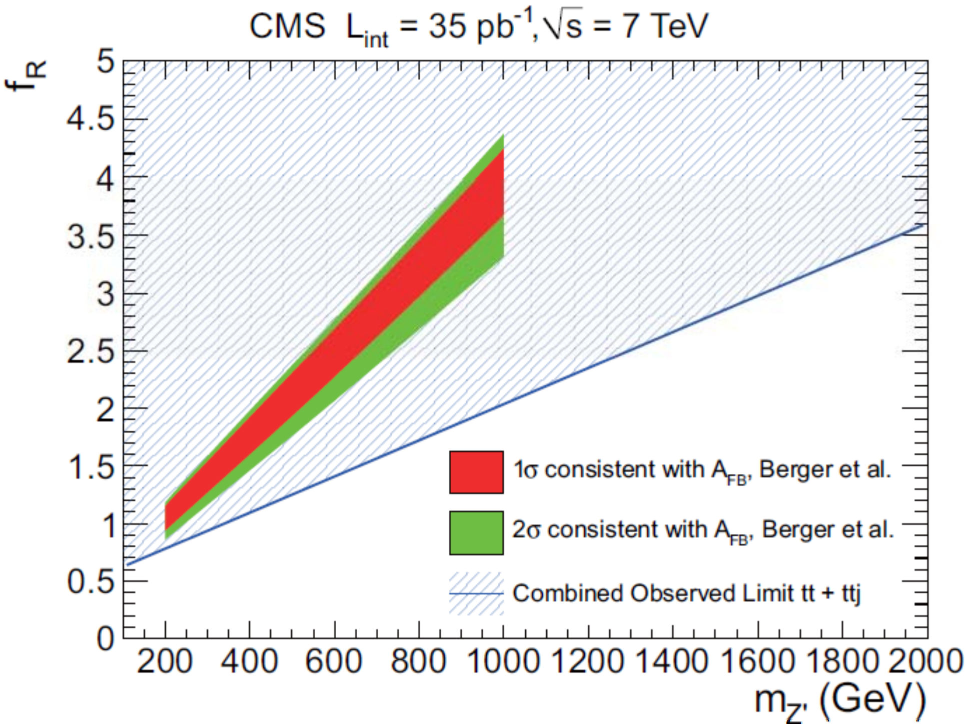


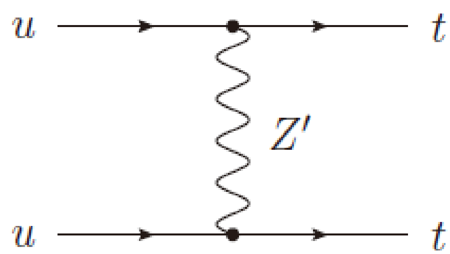
- assume Br(t →Z′u)<5% and $m_h > m_t$.
- $m_{Z'}$ = 145 or 160 GeV and m_h =180 GeV.

Same sign top quark pair production at LHC

CMS, 1106.2142

$$\mathcal{L} = g_W \bar{u} \gamma^\mu (f_L P_L + f_R P_R) t Z'_\mu + \text{h.c.},$$





Top FCNC

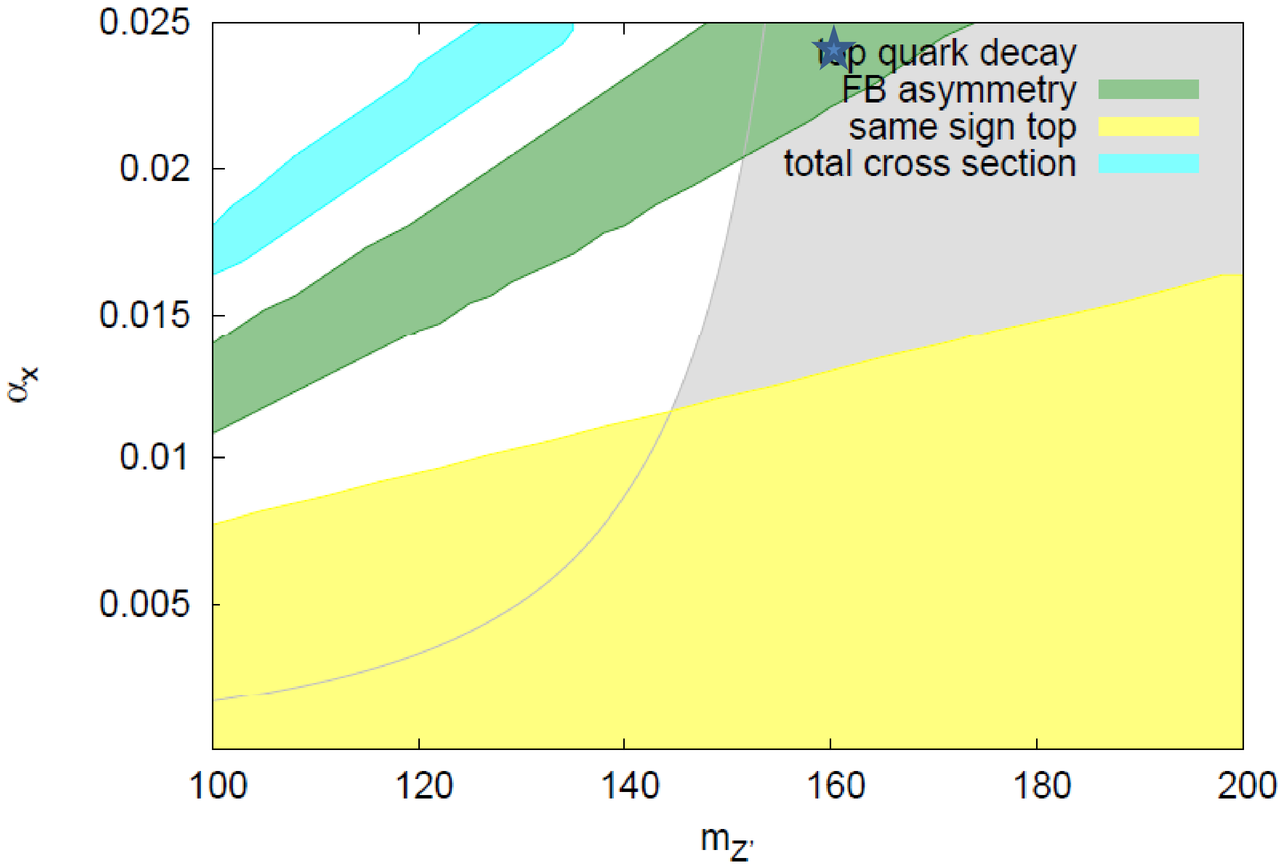
$$pp \to tt(j) < 17 \text{ pb at 95 CL.}$$

Can avoid this constraint?

- Interference between Z′ and scalar and pseudoscalar Higgs bosons.

Favored region

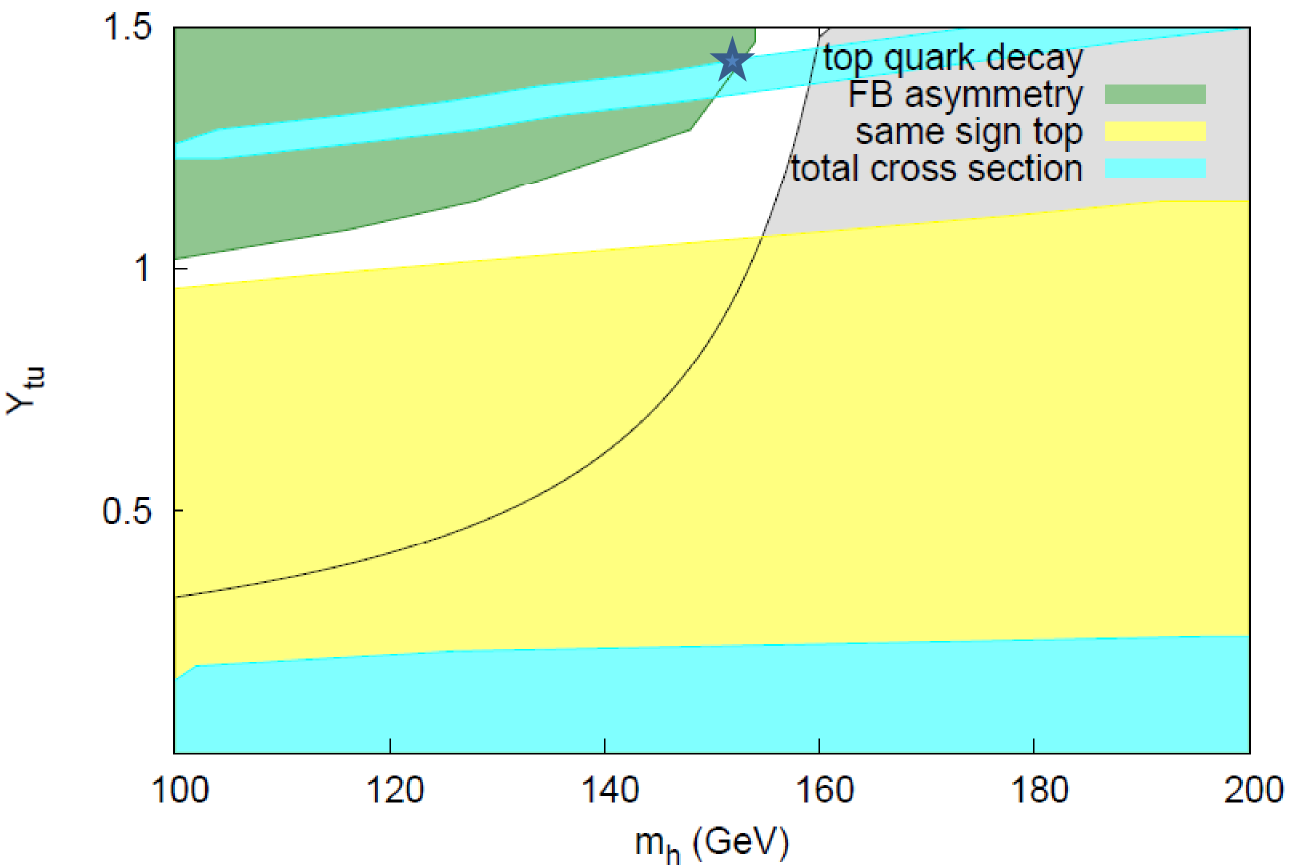
Z' dominant case



★ = Jung, Murayama, Pierce, Wells' model PRD81,015004 (2010)

Favored region

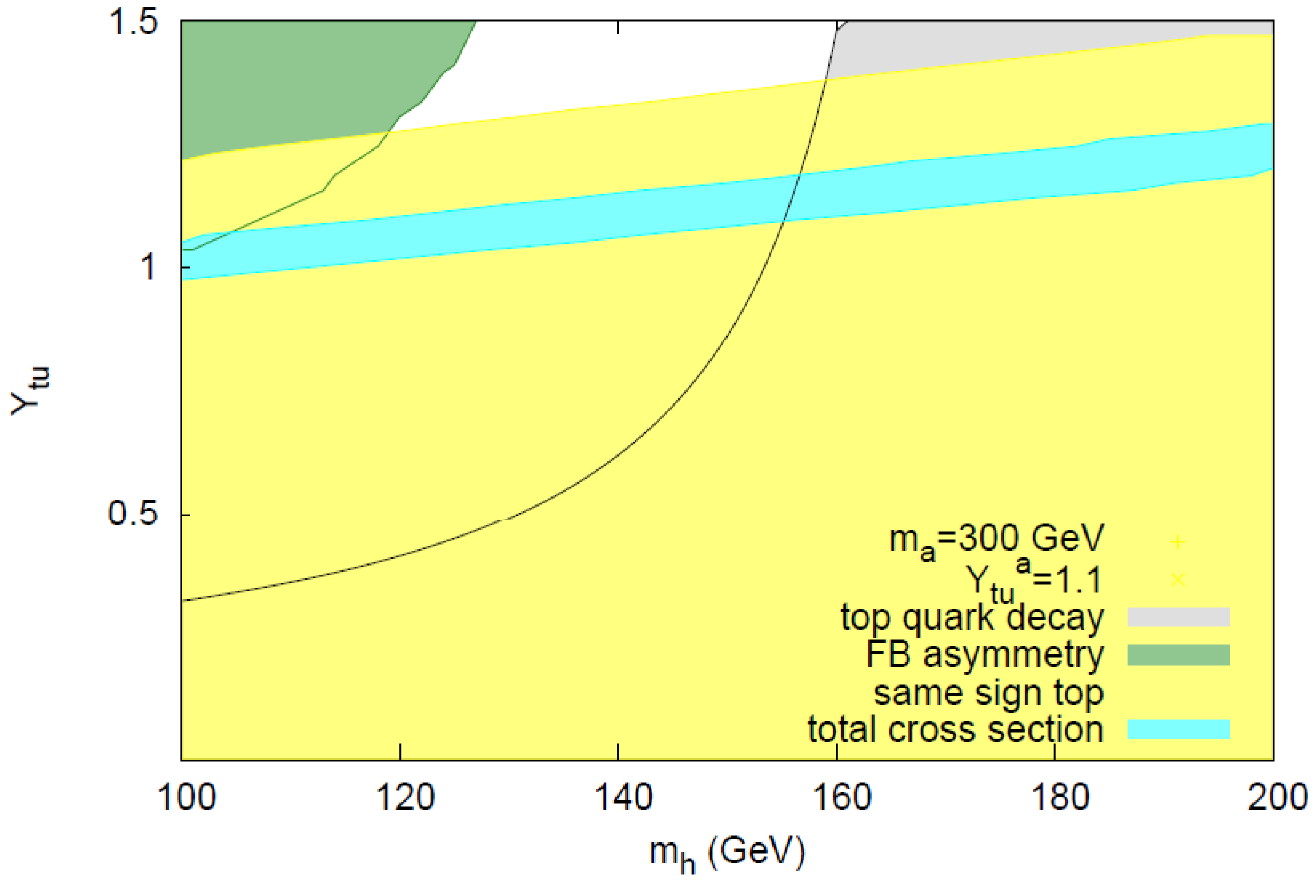
Scalar Higgs (h) dominant case



★ = Babu, Frank, Rai's model 1104.4782

Favored region

scalar (h) + pseudoscalar (a) Higgs case

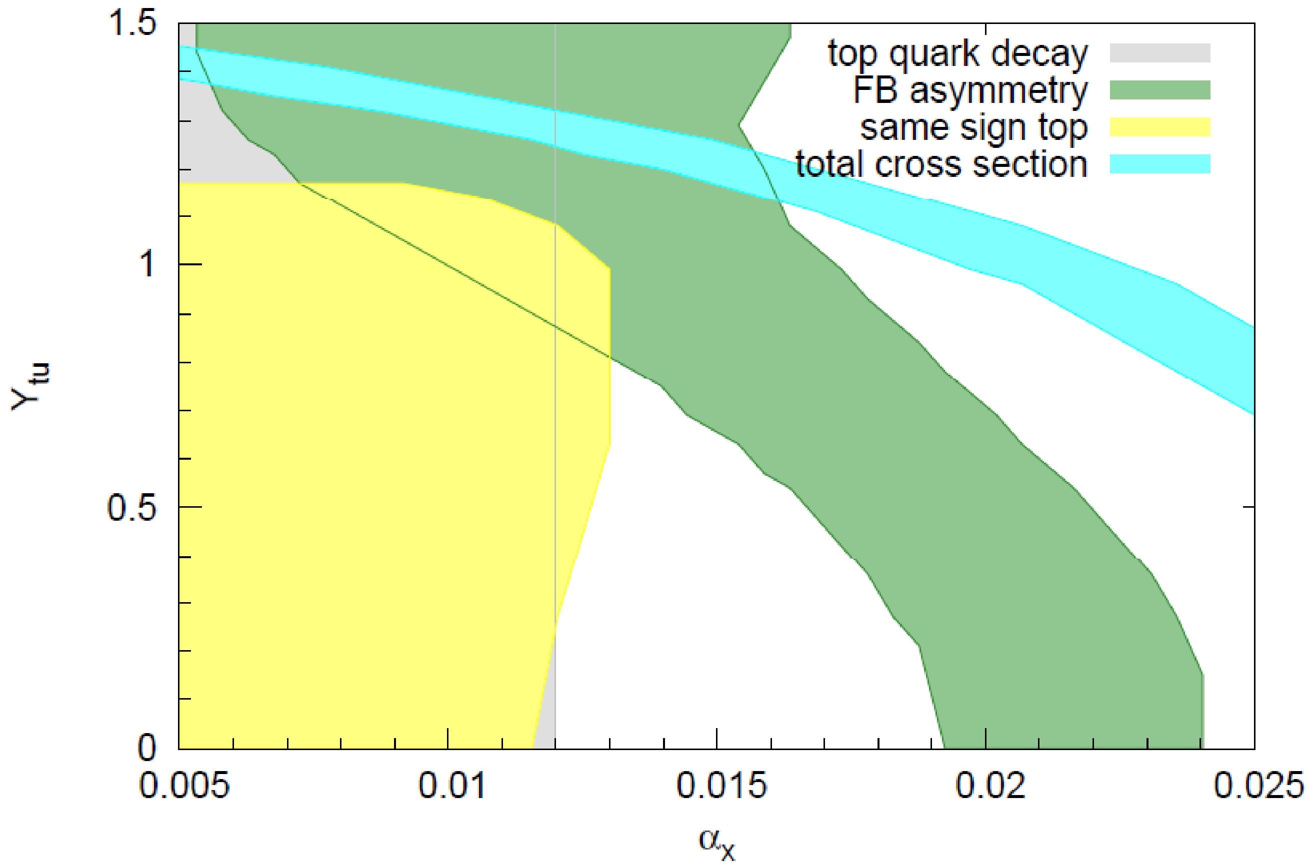


$m_a = 300$ GeV

$Y_{tu}^a = 1.1$

Favored region

Z′+h case



$m_{Z'} = 145$ GeV

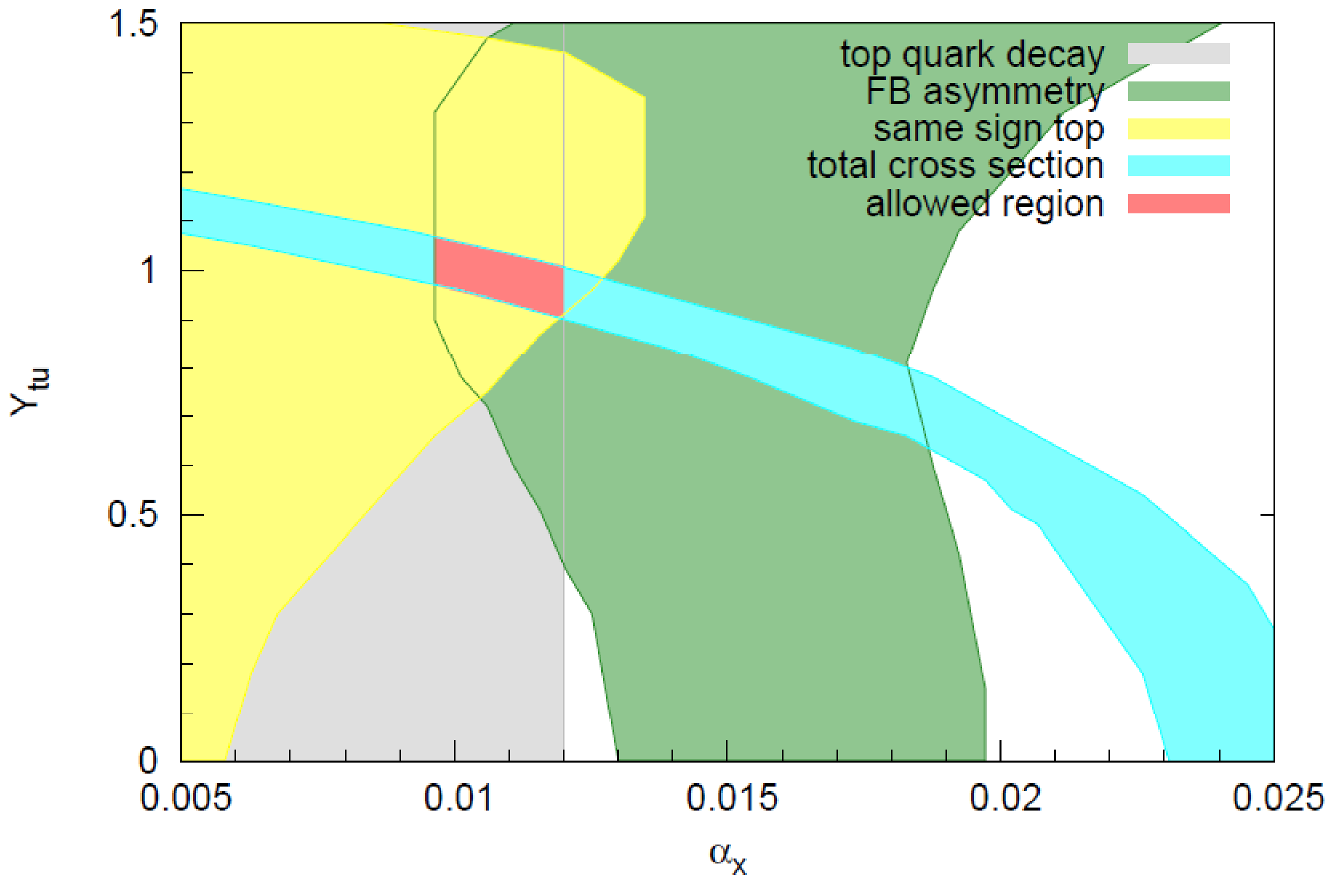
$m_h = 180$ GeV

$m_a = 300$ GeV

$Y^a_{tu} = 1.1$

Favored region

Z′+h+a case



$m_{Z'} = 145$ GeV

$m_h = 180$ GeV

$m_a = 300$ GeV

$Y_{tu}^a = 1.1$

$A_{FB} = 0.084 \sim 0.12$

A_{FB} versus σ_{tt}

$m_{Z'} = 145$ GeV

$180\text{ GeV} < m_h < 1\text{ TeV}$

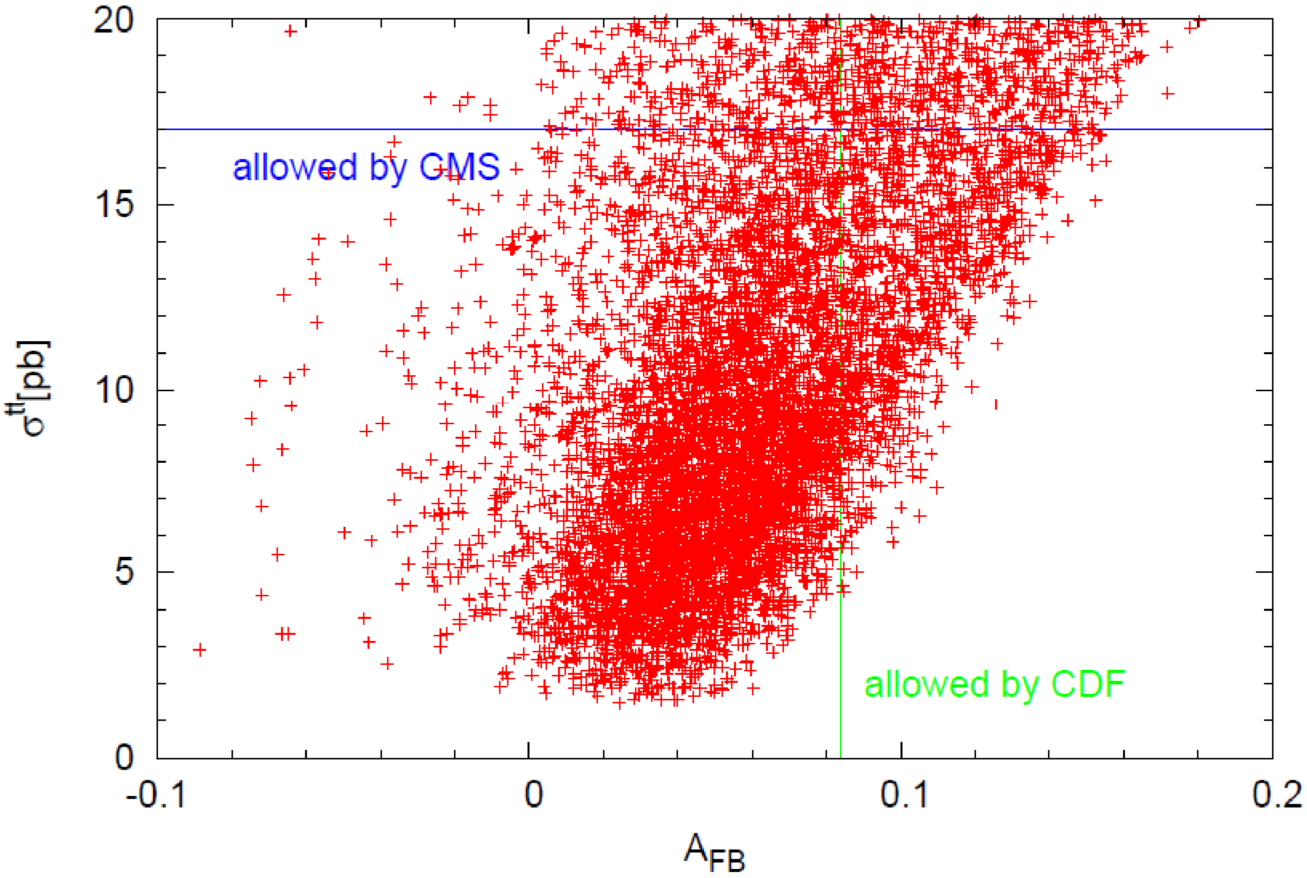
$180\text{ GeV} < m_a < 1\text{ TeV}$

$0.005 < \alpha_X < 0.025$

$0.5 < Y_{tu} < 1.5$

$0.5 < Y_{tu}{}^{a} < 1.5$

A_{FB} versus σ_{tt}



$m_{Z'} = 145$ GeV

180 GeV$< m_h < 1$ TeV

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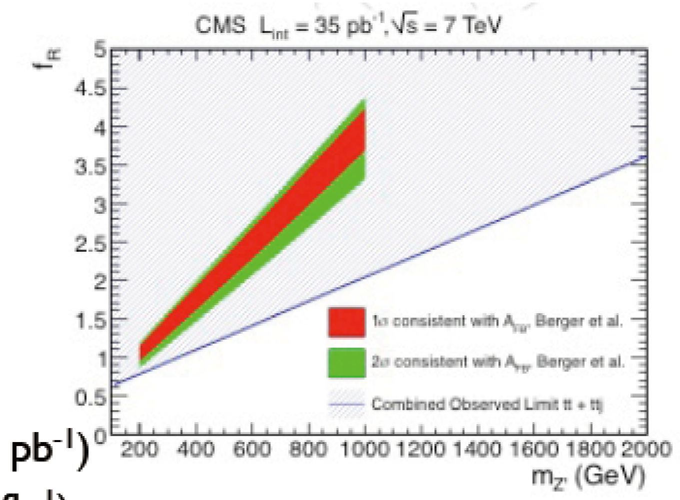
$0.005 < \alpha_X < 0.025$

$0.5 < Y_{tu} < 1.5$

$0.5 < Y_{tu}^{a} < 1.5$

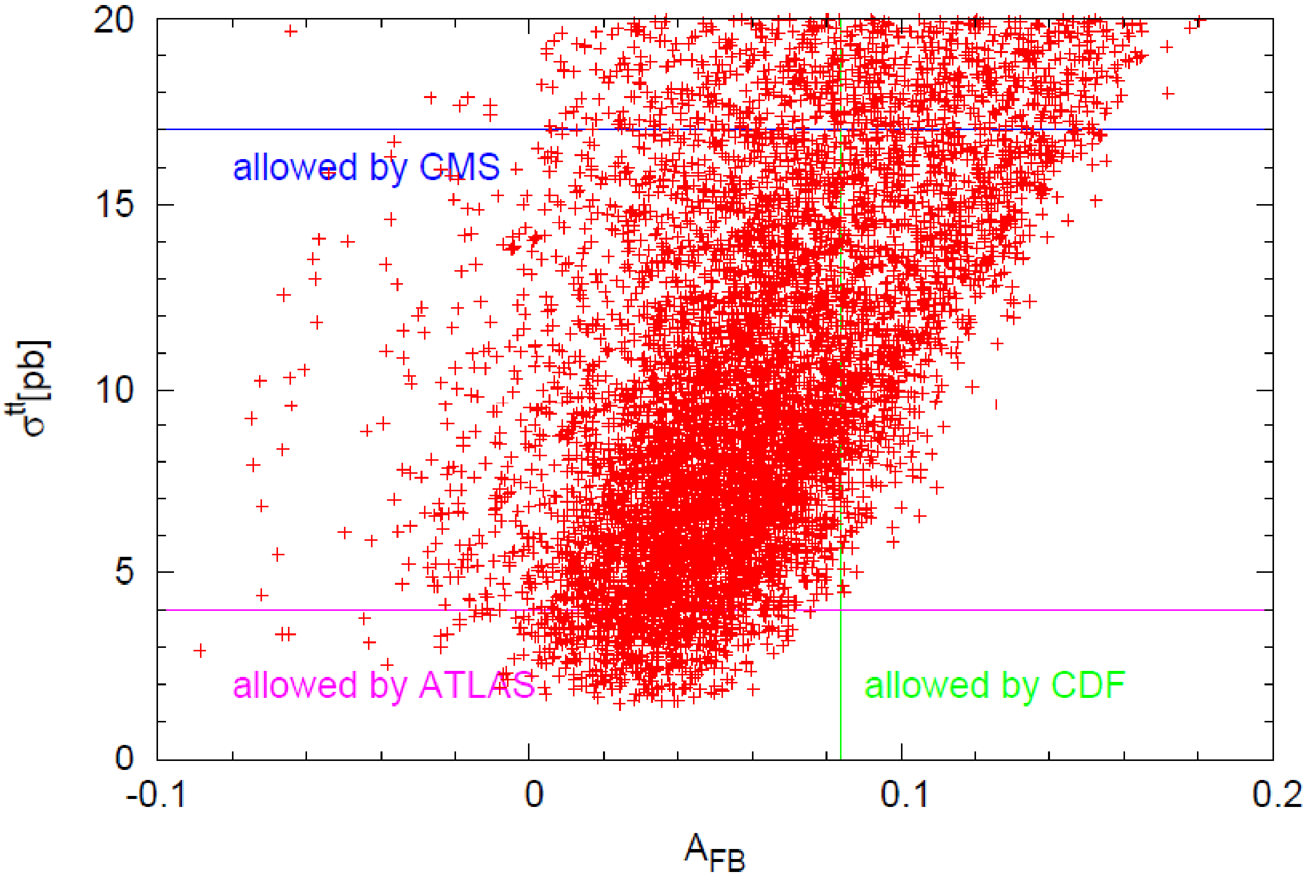
Same sign top pair production at ATLAS

- ATLAS and CMS have searched for flavor-changing neutral currents in the top sector
  - CMS EXO-11-065, JHEP 1108 (2011) 005
  - ATLAS CONF-2011-169
- Limits are set on cross section of m positive-sign top pairs
  - CMS, ee,mumu, emu: σ(Z'→ ttX)<17.0 pb (35 pb^{-1})
  - ATLAS, mumu: σ(Z'→ ttX)< 2.9 – 4.0 pb (1.6 fb^{-1})



From Blekman's talk, TOP2011

A_{FB} versus σ_{tt}



A_{FB} with SM NLO contribution

- In the SM,

$$A_{\rm FB}^{\rm SM} = \frac{\sigma_{\rm LO,F} + \sigma_{\rm NLO,F} - \sigma_{\rm LO,B} - \sigma_{\rm NLO,B}}{\sigma_{\rm LO} + \sigma_{\rm NLO}} = \frac{\Delta\sigma_{\rm LO} + \Delta\sigma_{\rm NLO}}{\sigma_{\rm LO} + \sigma_{\rm NLO}} \sim 8.7\%.$$

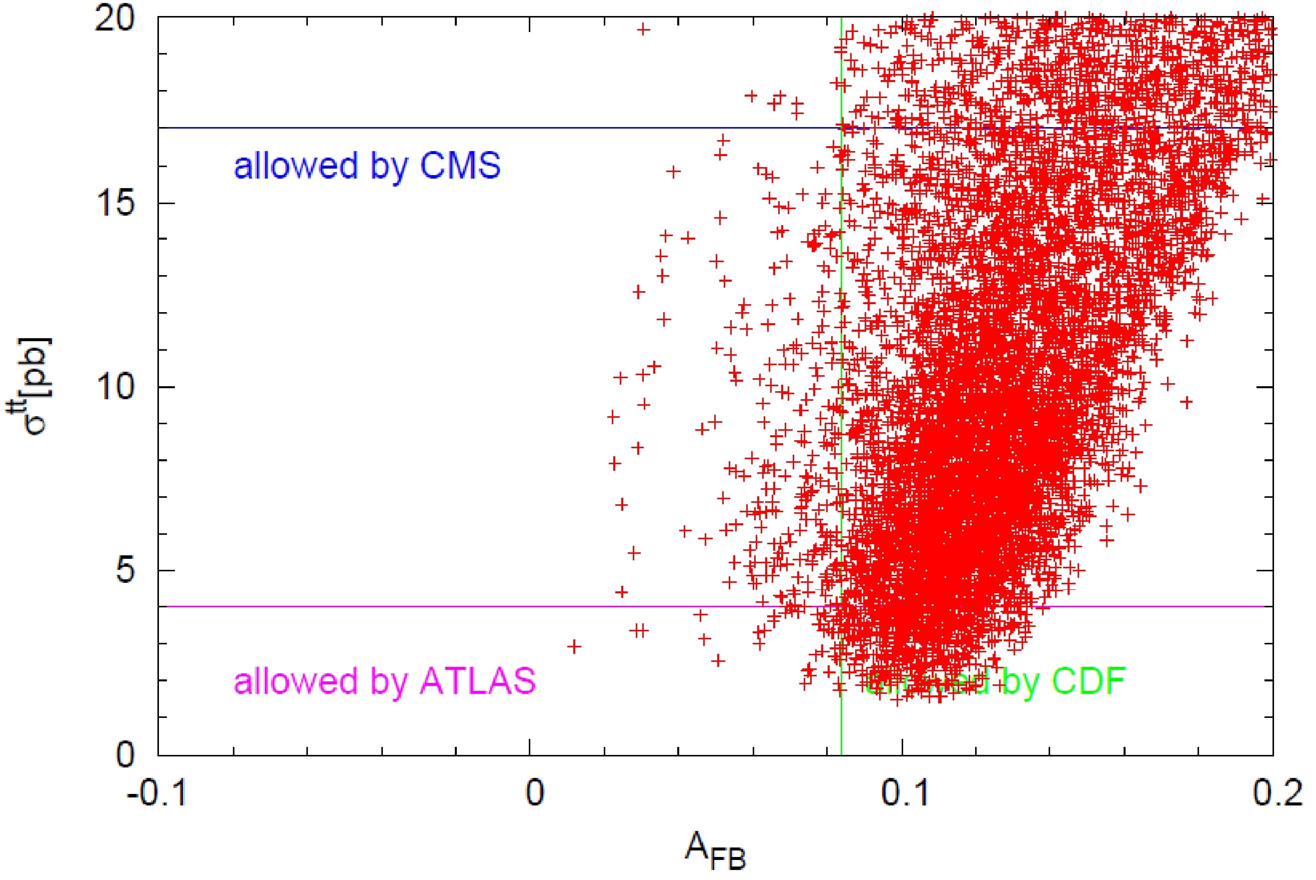
- In our calculation,

$$A_{\rm FB}^{\rm New} = \frac{K(\Delta\sigma_{\rm LO} + \Delta\sigma_{\rm NEW})}{K(\sigma_{\rm LO} + \sigma_{\rm NEW})} = \frac{\Delta\sigma_{\rm LO} + \Delta\sigma_{\rm NEW}}{\sigma_{\rm LO} + \sigma_{\rm NEW}} \sim 12\%.$$

- Consider both contributions of NLO and New physics,

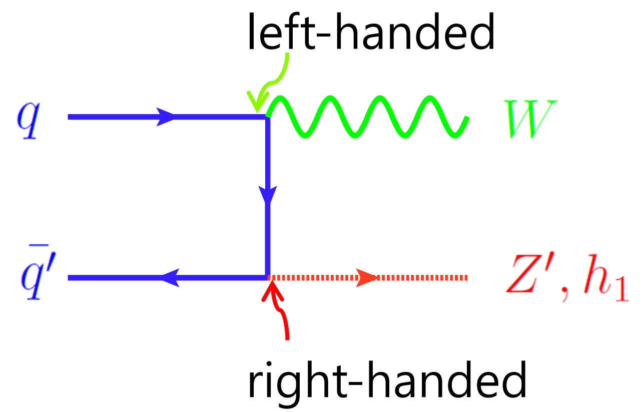
$$A_{\rm FB} = A_{\rm FB}^{\rm SM} + A_{\rm FB}^{\rm New} / K \sim 18\%.$$

A_{FB} versus σ_{tt}



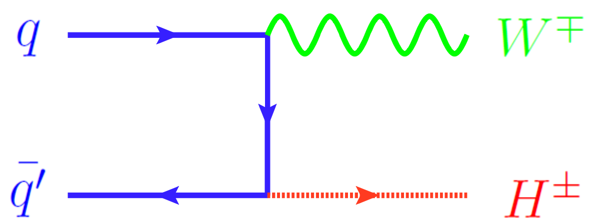
W+jj anomaly and flavor dependent U(1)′ model

• Since the Z′ boson and Higgs boson dominantly couples to the right-handed top quark, their contributions to the W+jj production are small.



~small

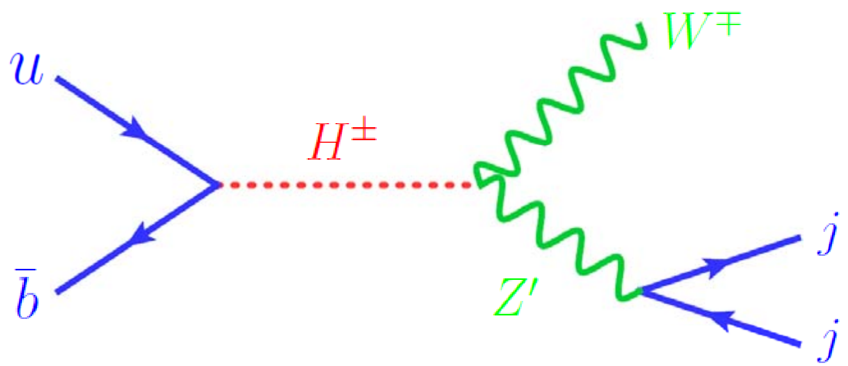
• Charged Higgs boson may contribute to the W+jj anomaly?



< 0.15 pb

W+jj anomaly and flavor dependent U(1)′ model

$$\mathcal{L} = -g' m_W \sin 2\beta H^+ W^{-\mu} Z'_\mu + h.c..$$



$m_{Z'} = 145$ GeV

$m_{h^+} = 270$ GeV

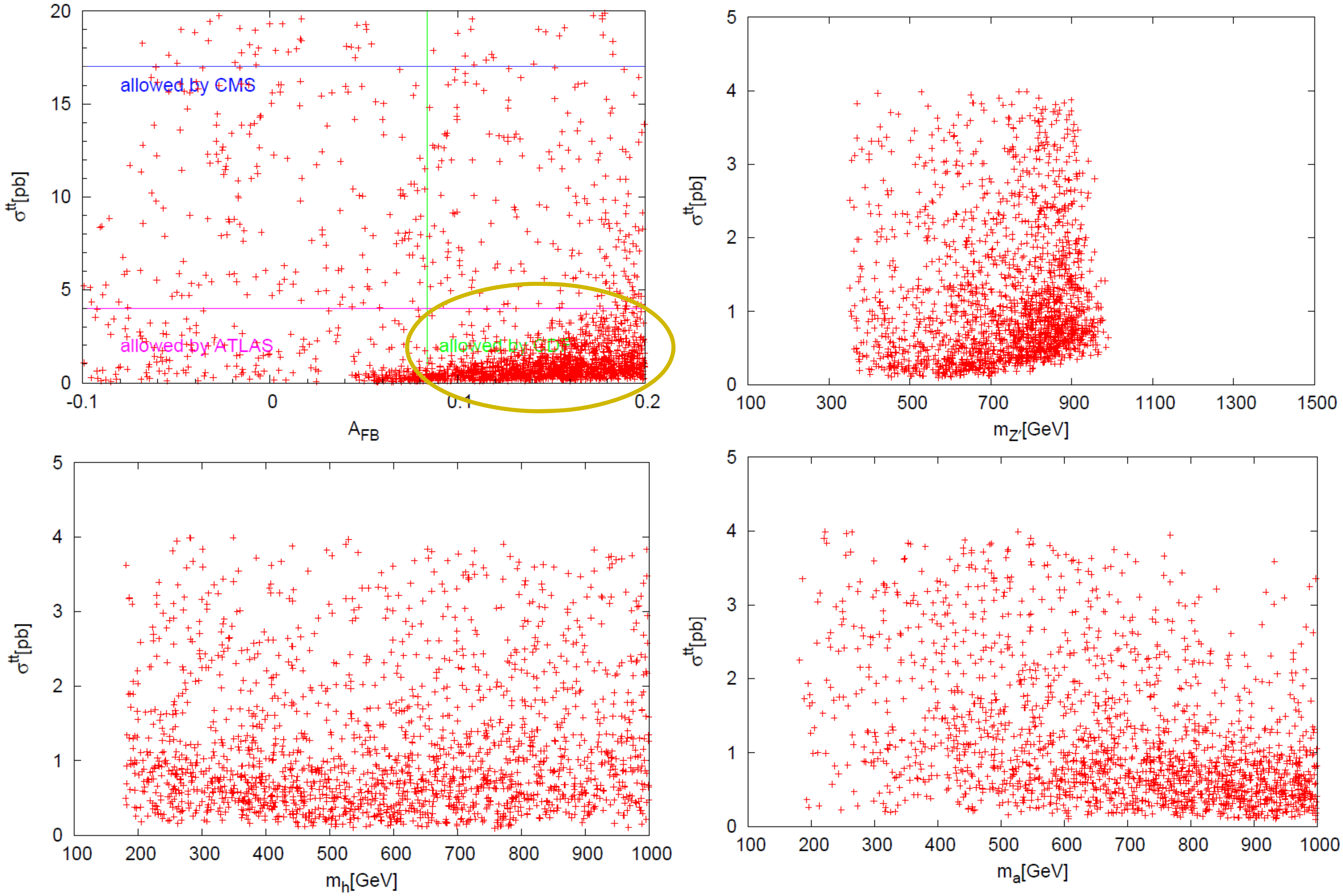
$$\sigma(Wjj) \lesssim O(10) \text{ pb} \times \sin^2 2\beta$$

More general case

$140\ \text{GeV} < m_{Z'} < 1.5\ \text{TeV}$

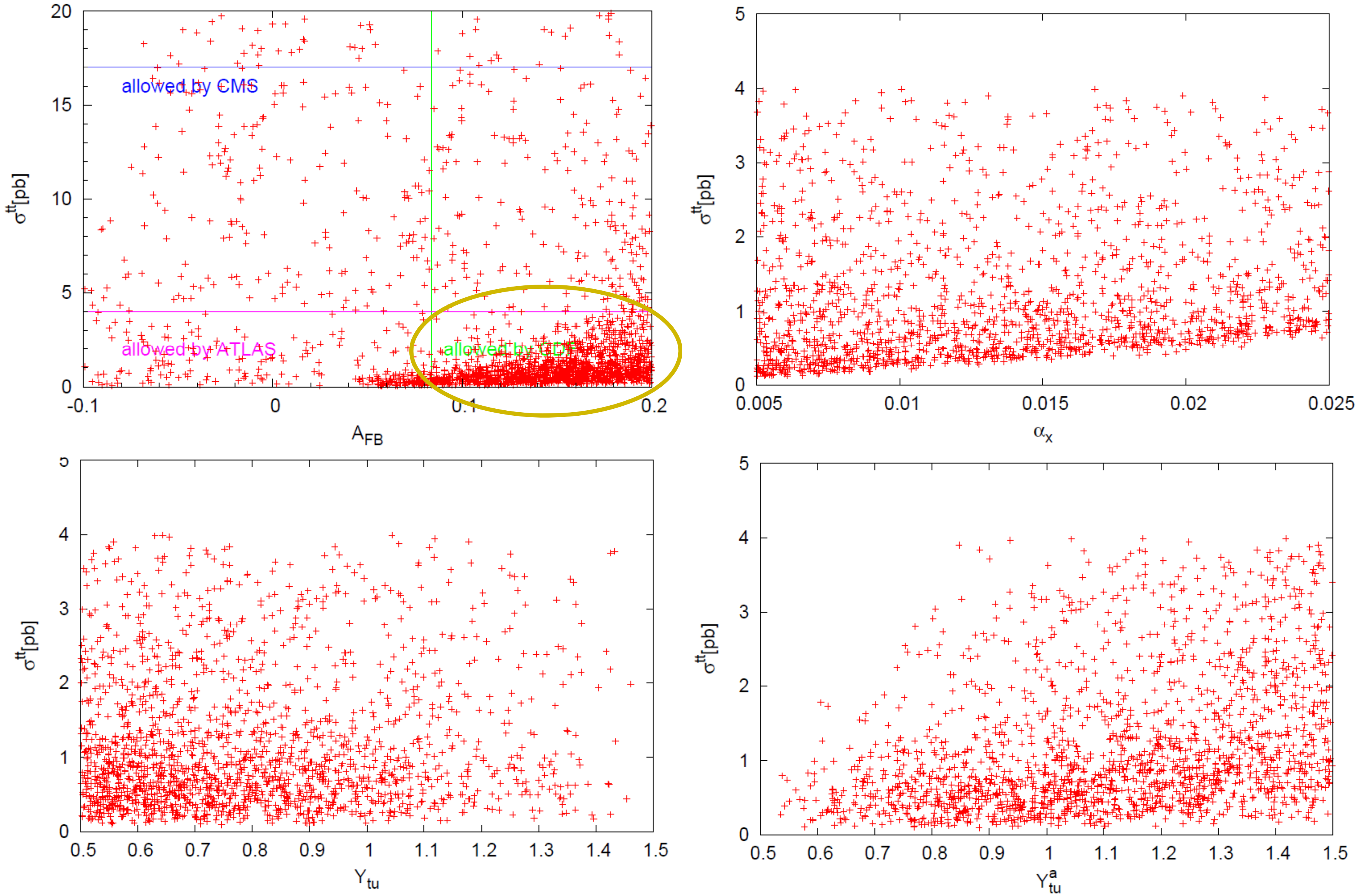
More general case

$140 \text{ GeV} < m_{Z'} < 1.5 \text{ TeV}$



More general case

140 GeV < $m_{Z'}$ < 1.5 TeV



Conclusions

• construct a compete U(1)′ model where the right-handed up-type quarks in the standard model are charged.

• require extra Higgs charged under U(1)′ for a realistic model.

• requires extra chiral fermions for anomaly cancellation → CDM.

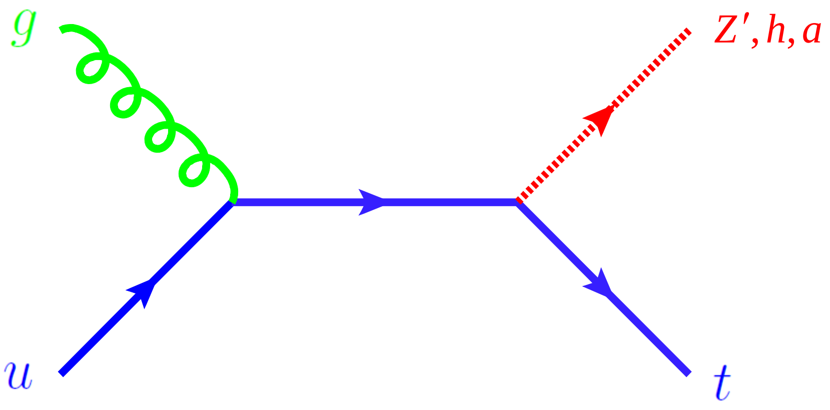
• Interferences between Z′, h, and a reduce the rate for the same sign top pair production.

• The CDF W+jj excess may be resolved by the WZ′ production through a charged Higgs mediation.

Thank you.

Backup slides

Single top quark production



- D0   D0, 1105.2788

$$\sigma(p\bar{p} \to tbq) = 2.90 \pm 0.59 \text{ pb}$$

- CMS   CMS, 1106.3052

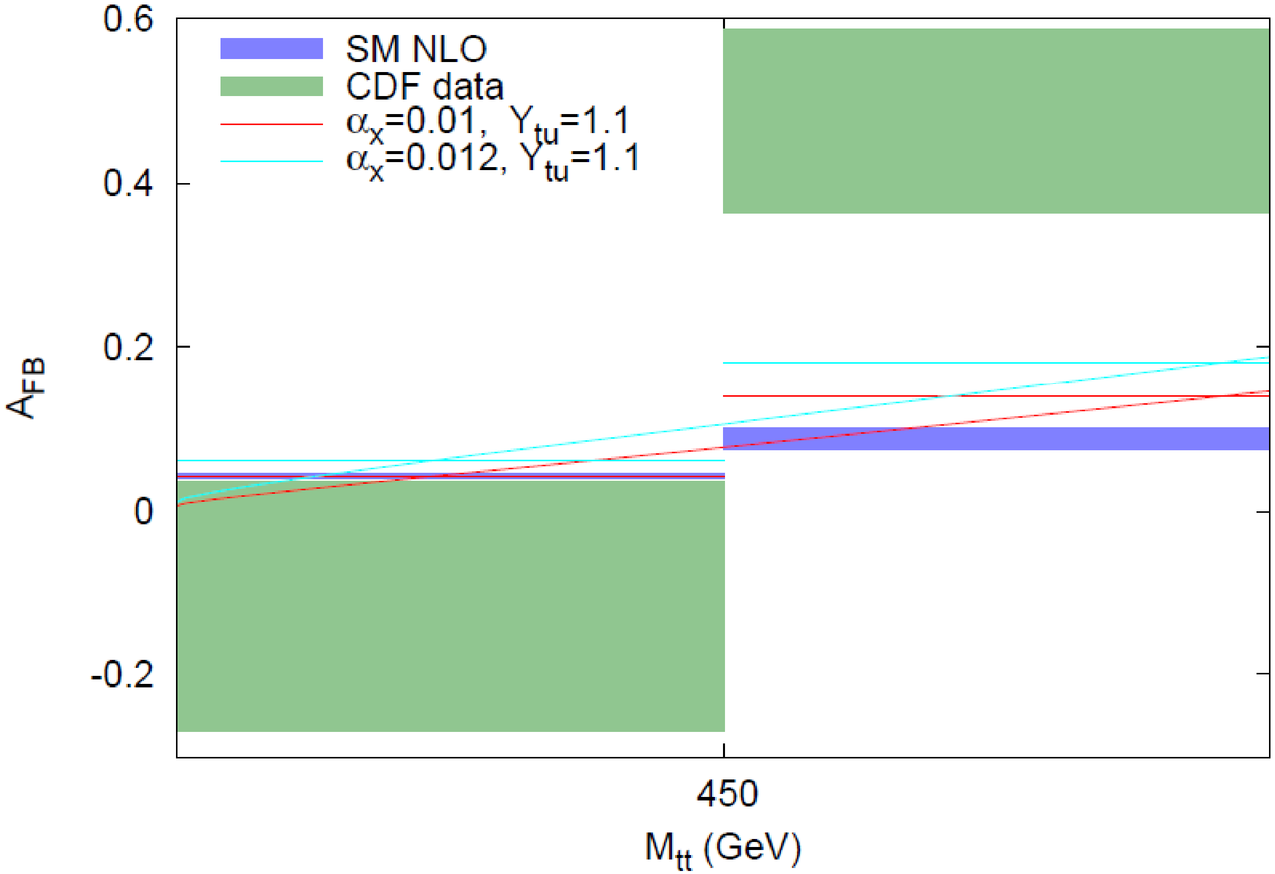
$$\sigma(pp \to tbq) = 83.6 \pm 29.8 \pm 3.3 \text{ pb}$$

In the SM,

$$\sigma(p\bar{p} \to tbq) = 2.26 \pm 0.12 \text{ pb}$$

$$\sigma(pp \to tbq) = 64.3^{+2.1+1.5}_{-0.7-1.7} \text{ pb}$$

Forward-backward asymmetry



Flavor dependent U(1)′ Model

• Anomaly cancelation requires extra fermions II: $SU(3)_c$ triplets

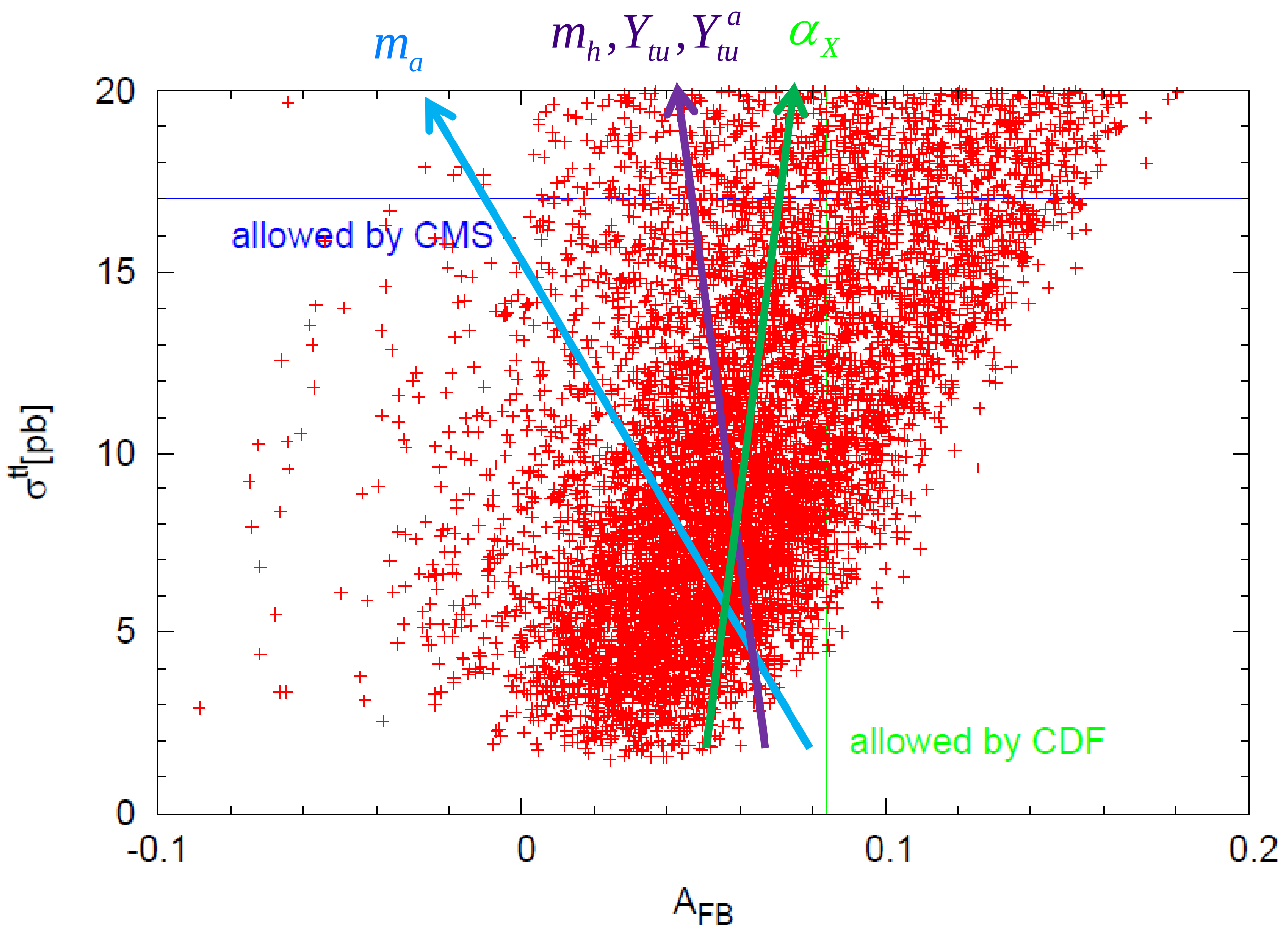
	$SU(3)_c$	$SU(2)_L$	$U(1)_Y$	$U(1)'$
q_{L1}	3	1	$-1/3$	Q_L
q_{R1}	3	1	$-1/3$	Q_R
q_{L2}	3	1	$-1/3$	$-Q_L$
q_{R2}	3	1	$-1/3$	$-Q_R$

• introduce the singlet scalar X to the SM in order to allow the decay of the extra colored particles.

$$V_m = \lambda_i X^\dagger \overline{D_{Ri}} q_{L1} + \lambda_i X \overline{D_{Ri}} q_{L2}$$

a candidate for CDM

A_{FB} versus σ_{tt}



$m_{Z'} = 145$ GeV

180 GeV $< m_h < 1$ TeV

180 GeV $< m_a < 1$ TeV

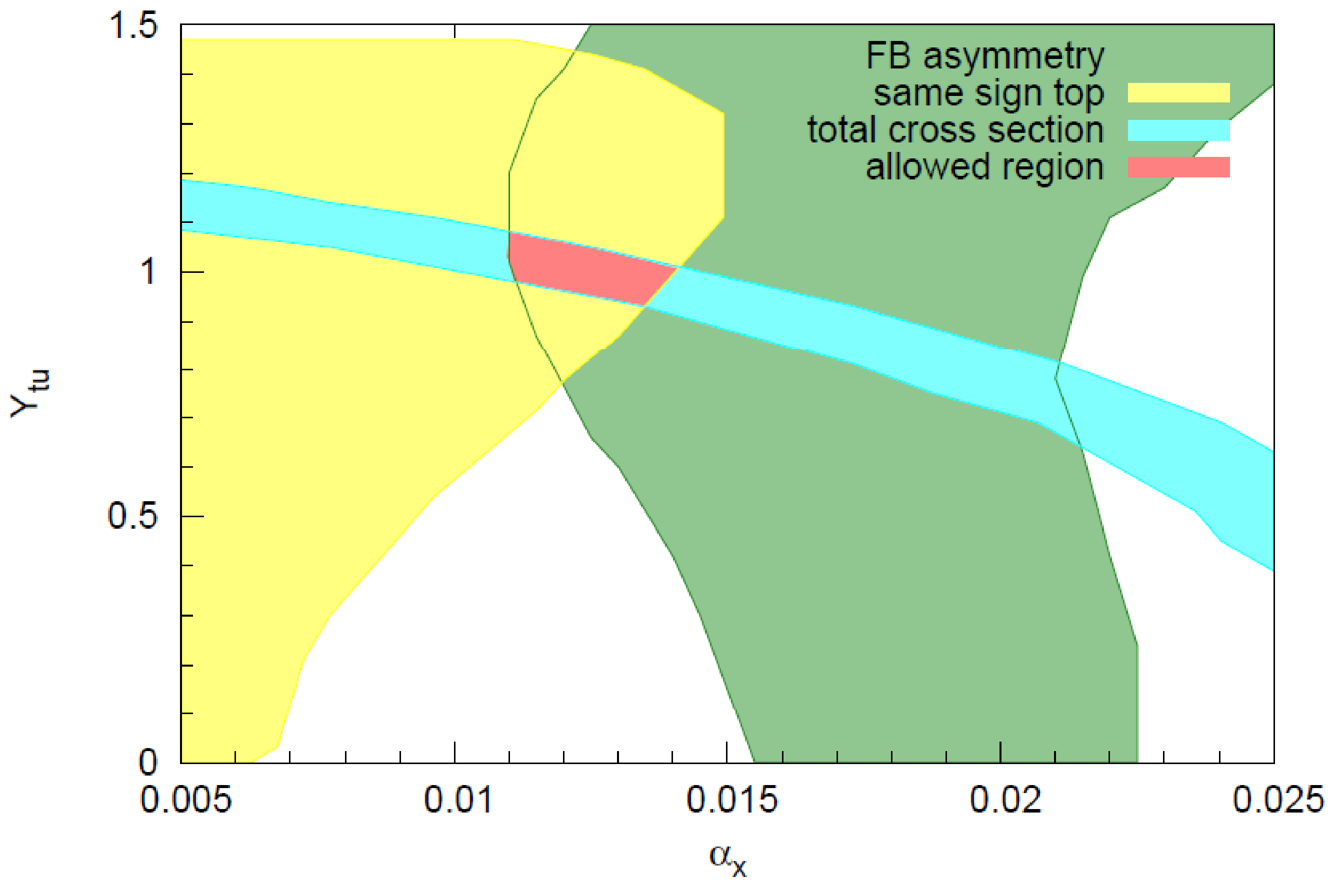
$0.005 < \alpha_X < 0.025$

$0.5 < Y_{tu} < 1.5$

$0.5 < Y_{tu}^a < 1.5$

Favored region

Z′+h+a case



$m_{Z'} = 160$ GeV

$m_h = 180$ GeV

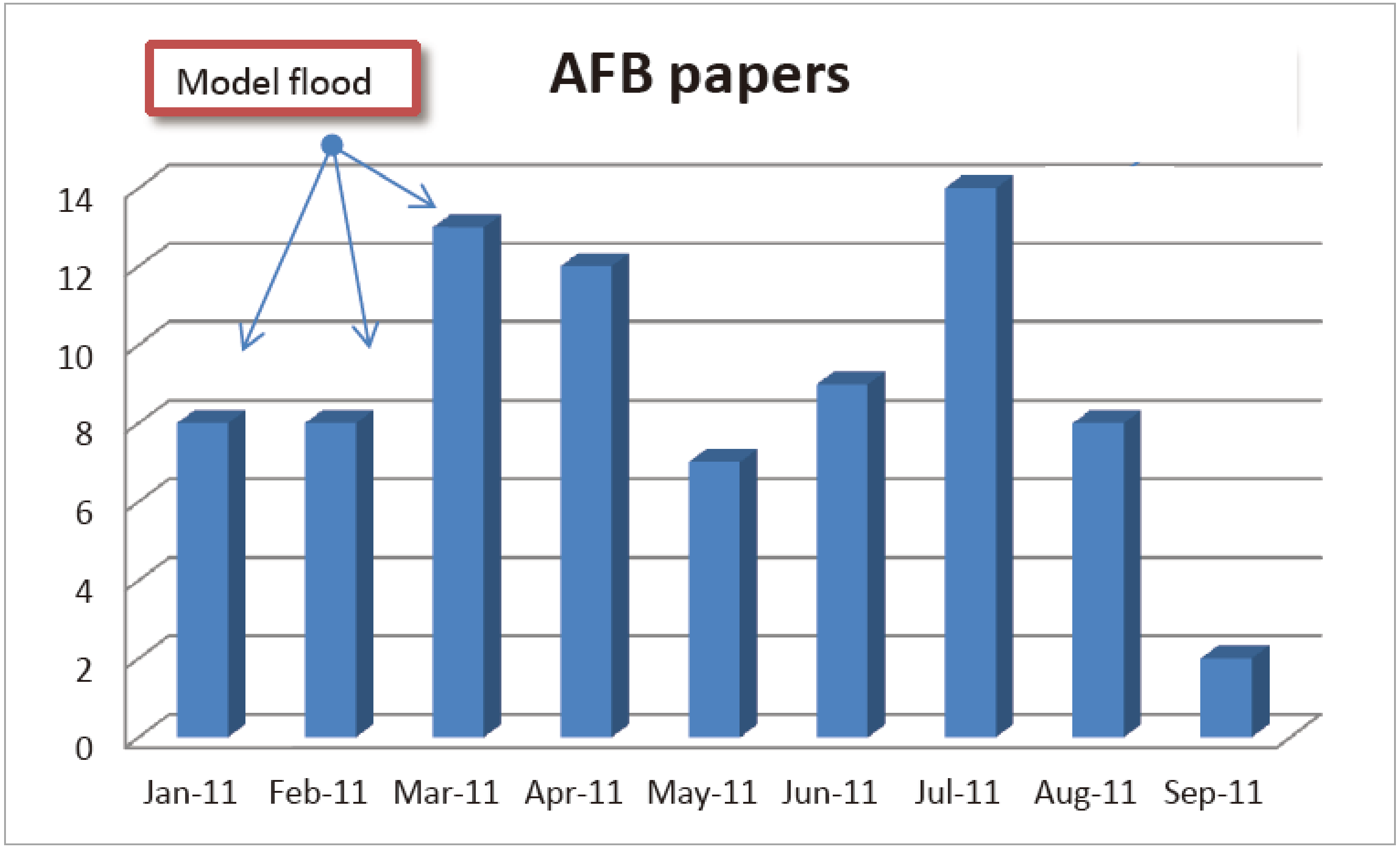
$m_a = 300$ GeV

$Y_{tu}^a = 1.1$

$A_{FB} = 0.084 \sim 0.12$

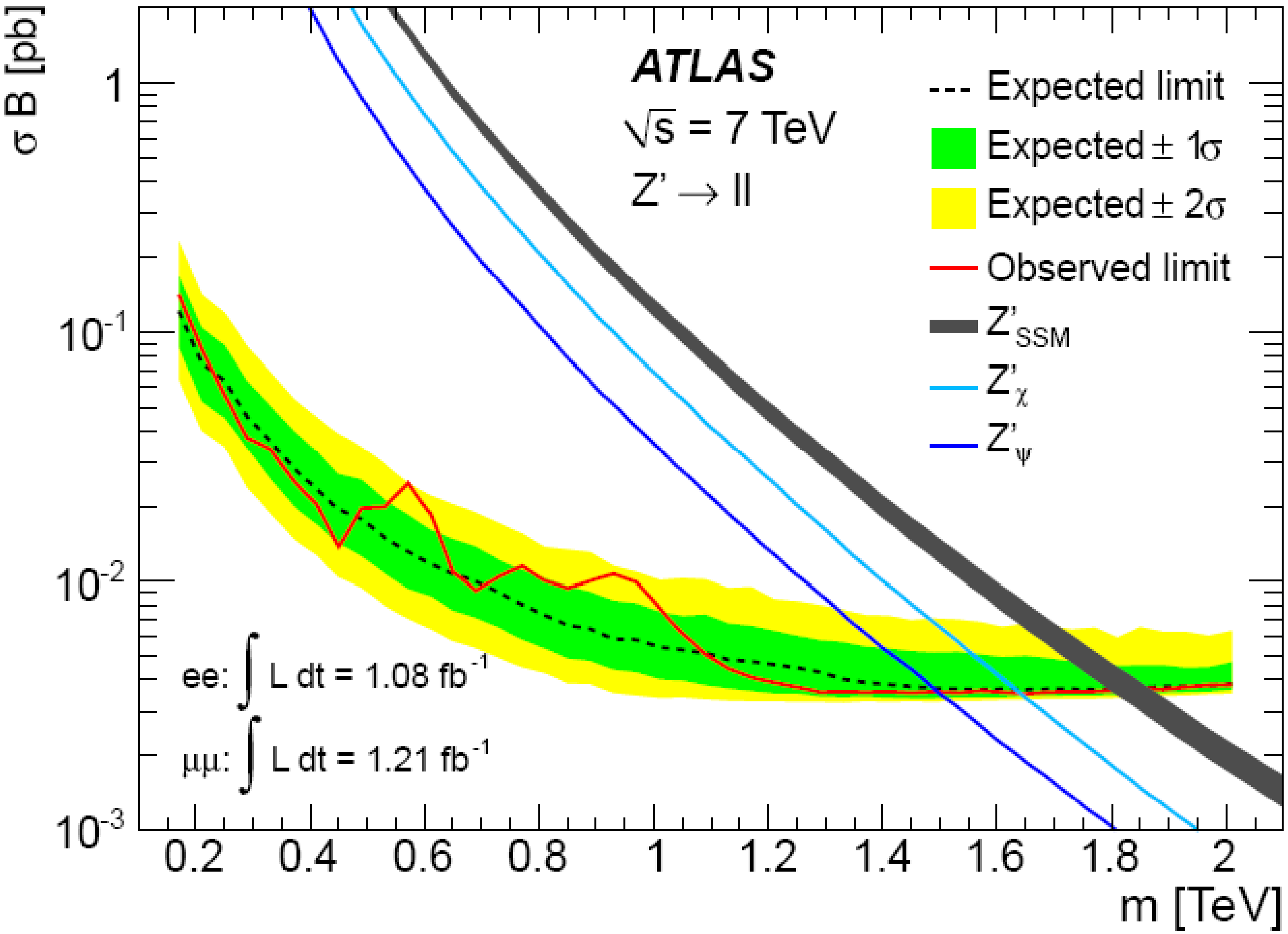
New models

From Saavedra's talk, TOP2011



Dilepton production at ATLAS

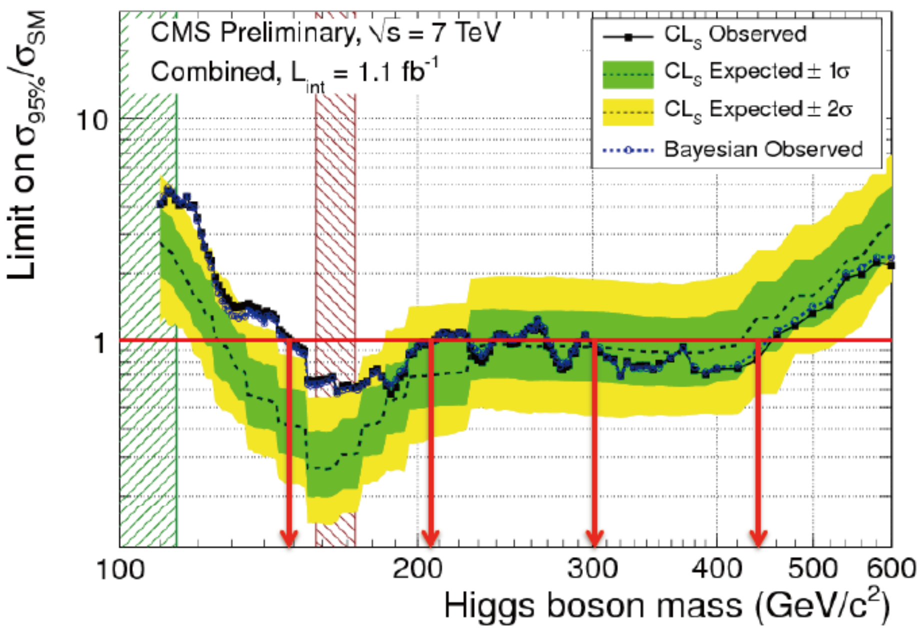
ATLAS, 1108.1582

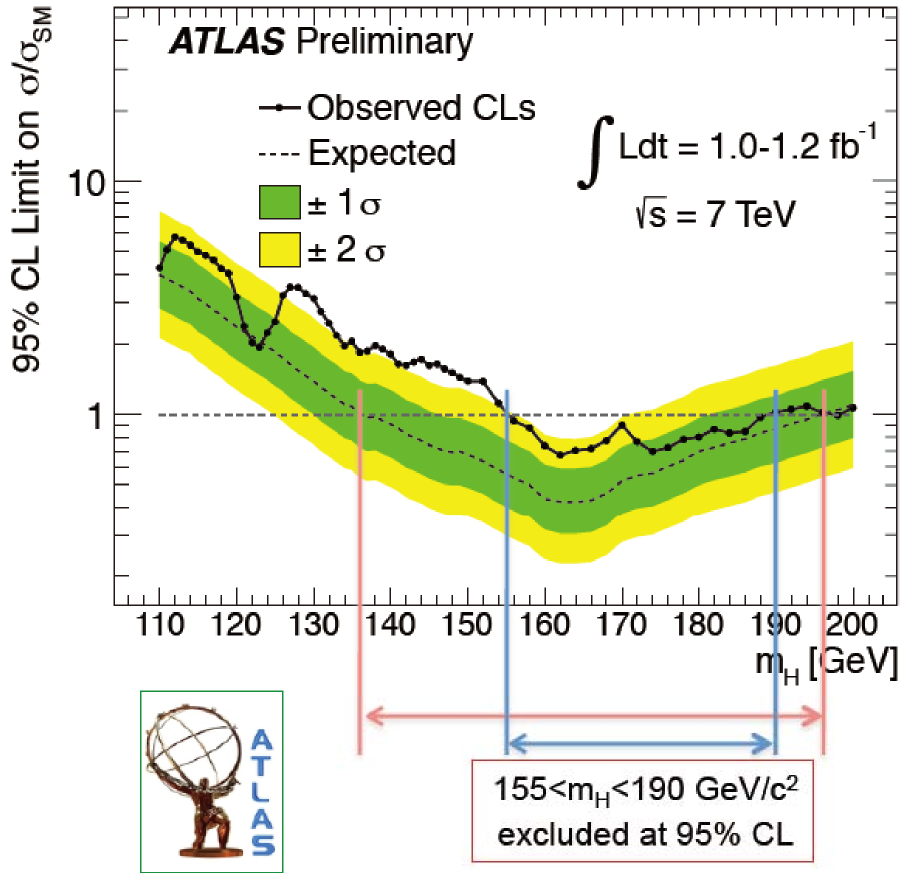


- excludes the Sequential SM Z' lighter than 1.83 TeV.

Higgs search at LHC

From Korytov and Cranmer's talks, EPS-HEP 2011





Excluded (GeV)

[149-206] … [300-440]

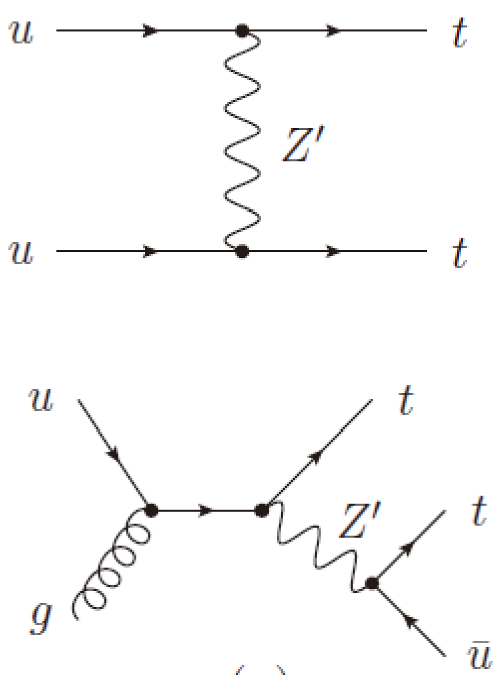
- m_h=180 GeV : conflict with Higgs mass bounds at CMS and ATLAS?
- The bounds are weaker because new decay channels are open.

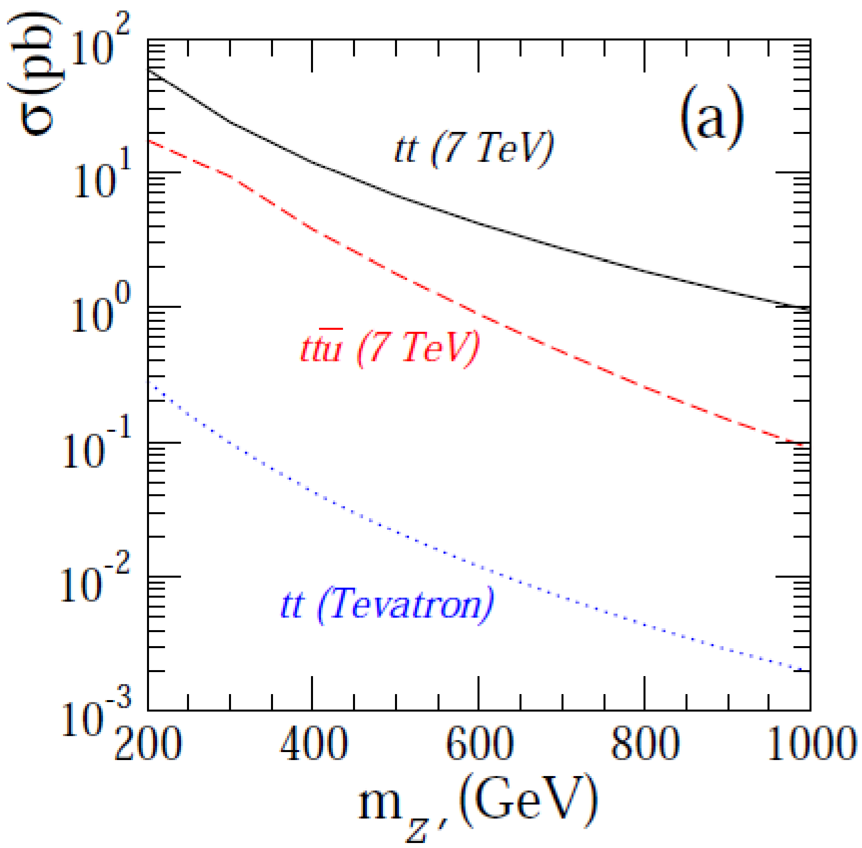
$$h \to t\bar{u}, h \to \Phi + \text{anything}$$

Same sign top quark pair production at LHC

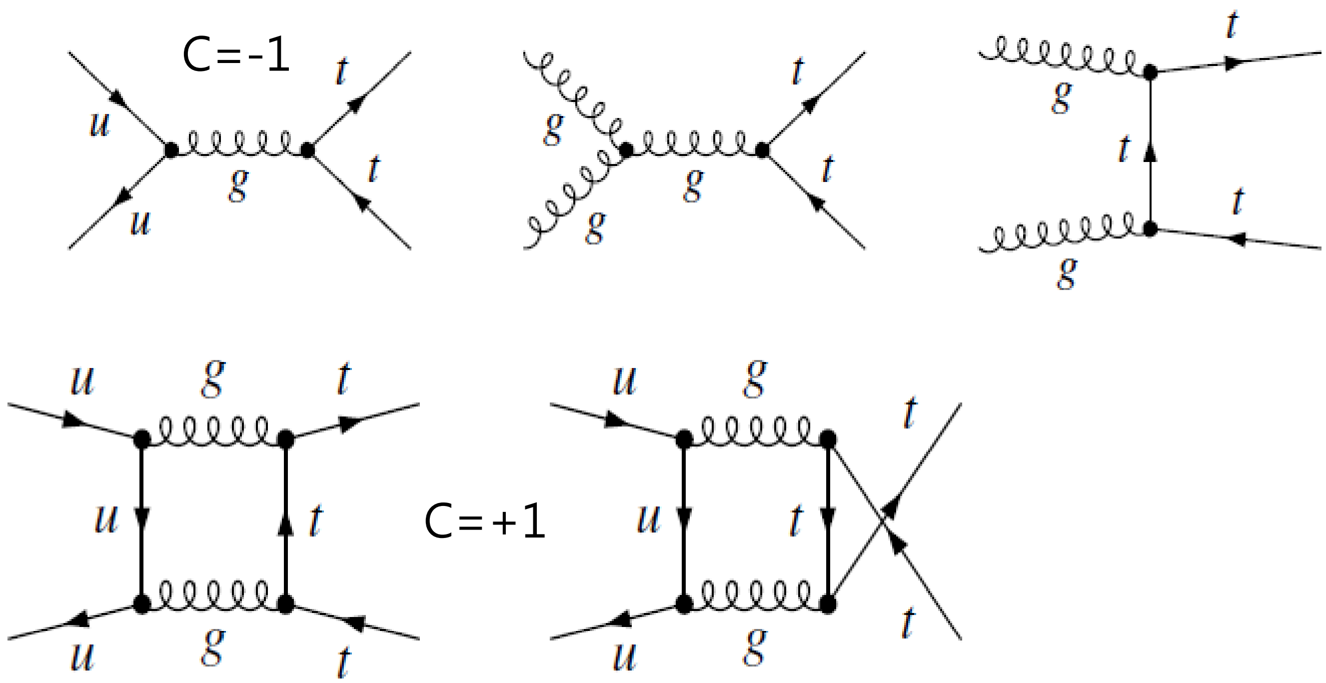
$$\mathcal{L} = g_W \bar{u} \gamma^\mu (f_L P_L + f_R P_R) t Z'_\mu + \text{h.c.},$$

Berger et al, 1101.5626

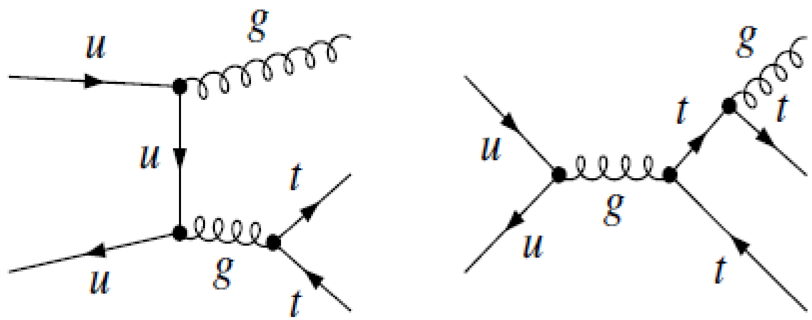




Top A_{FB} at Tevatron



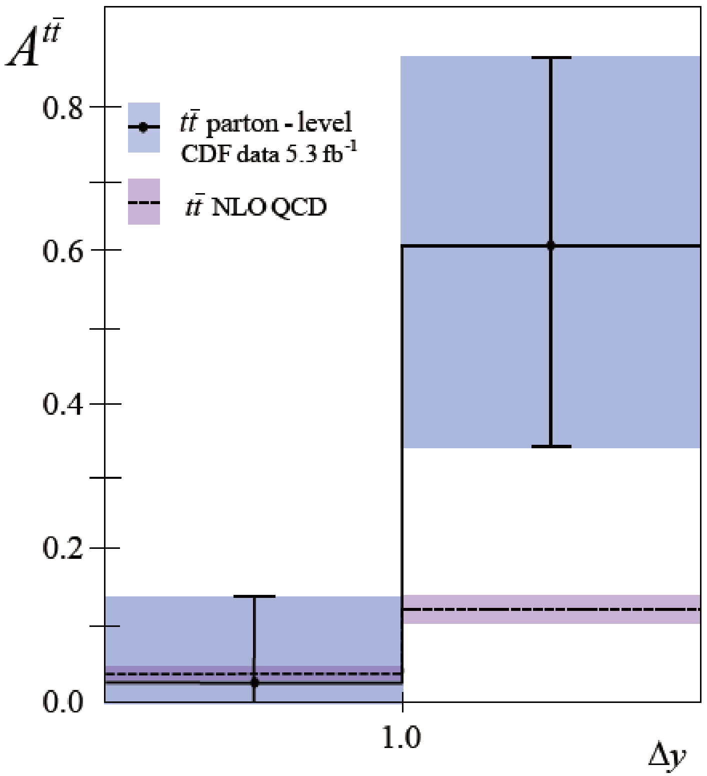
interference

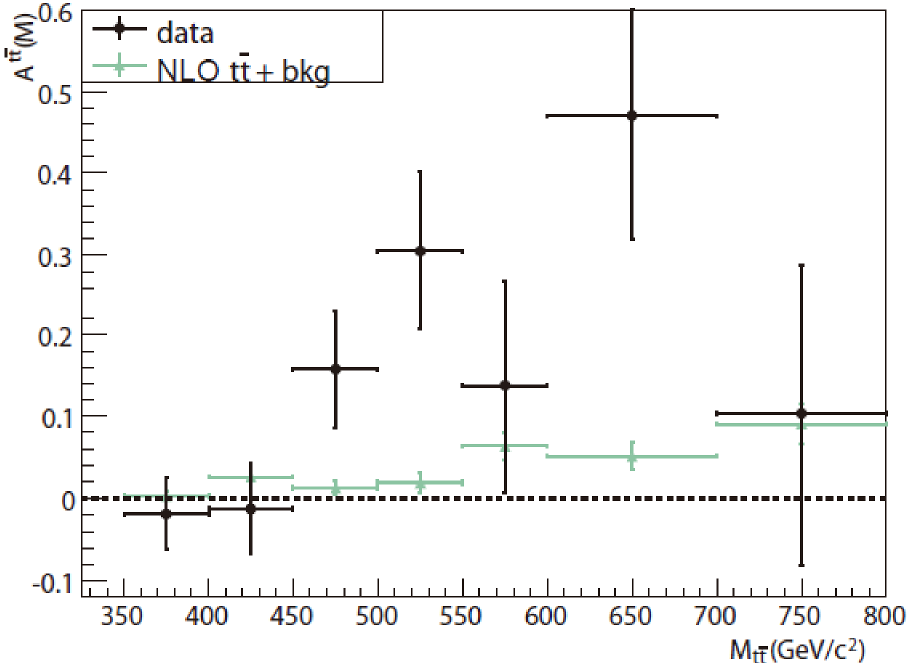


interference

Top A_{FB} at Tevatron

CDF, 1101.0034



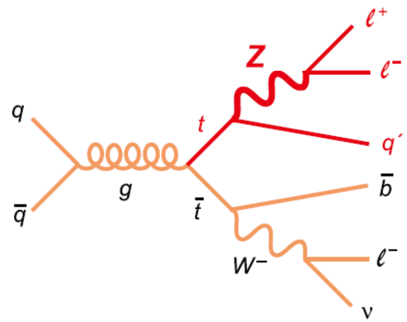


Flavor-changing neutral currents

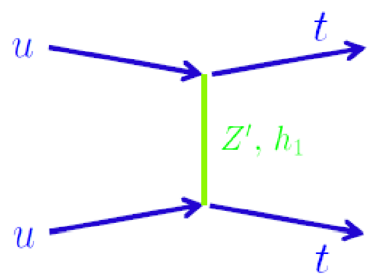
- FCNCs are suppressed in the SM (GIM mechanism).
- probe of new physics.
- FCNCs between down-type quarks and up-charm quarks.

$$K^0 - \bar{K}^0, B^0 - \bar{B}^0, B_s - \bar{B}_s, D^0 - \bar{D}^0 \text{ mixing.}$$

- top quark : no bound state.
- Which processes are proper for the test of the top FCNC?



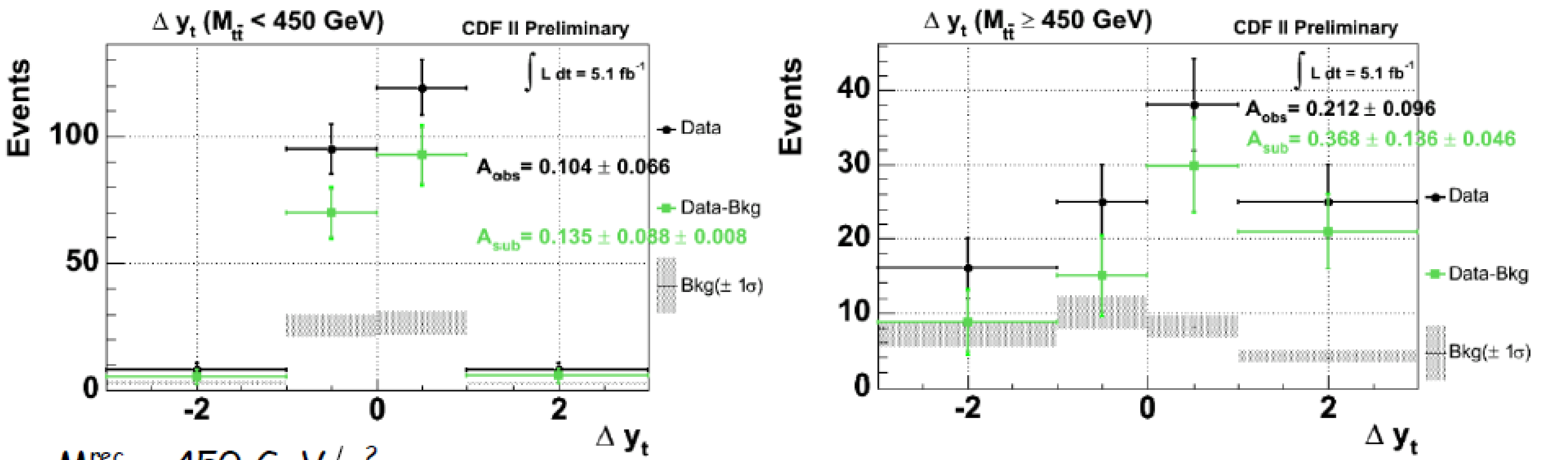
top decay



same sign top pair production

Top A_{FB} at CDF

From Hyunsoo Kim's talk,Tev2011



$M_{t\bar{t}}^{rec} < 450\ GeV/c^2$

$A_{FB}^{sub} = 0.135 \pm 0.088\,(stat.) \pm 0.008\,(bkg\ shape)$

$A_{FB}^{true} = 0.417 \pm 0.253\,(stat.) \pm 0.023\,(bkg\ shape) \pm 0.017\,(MC\,stat.) \pm ???$

$M_{t\bar{t}}^{rec} > 450\ GeV/c^2$

$A_{FB}^{sub} = 0.368 \pm 0.136\,(stat.) \pm 0.046\,(bkg\ shape)$

$A_{FB}^{true} = 0.411 \pm 0.162\,(stat.) \pm 0.055\,(bkg\ shape) \pm 0.010\,(MC\,stat.) \pm ???$

Wjj excess at CDF

CDF, PRL104, 101801 (2011)

- $p\bar{p} \to W(\to \ell\nu) + jj$ with data of 4.3 fb^{-1}.

- diboson channel.

- background of the Higgs boson search.

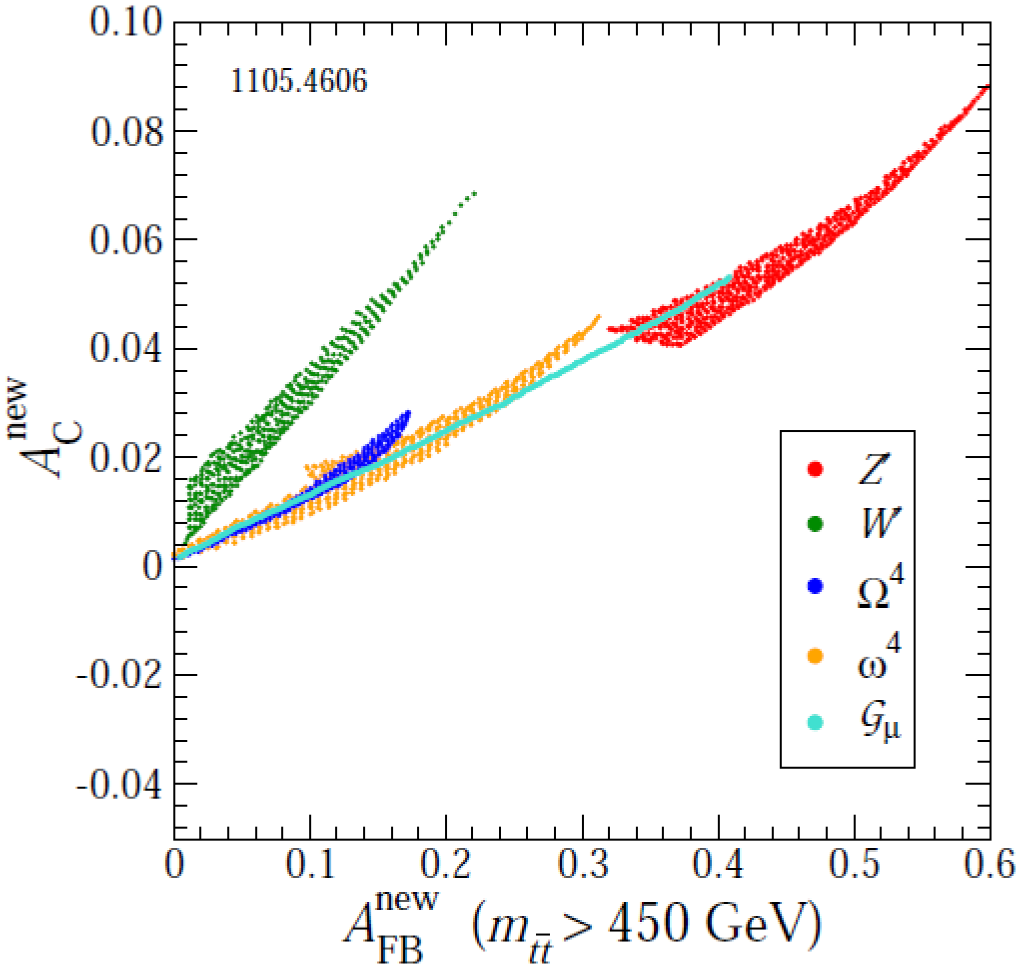
- no significant excess for WW or WZ.

  - confirmed by D0.

- increase the jet E_T threshold from 20 GeV to 30 GeV.

  - interest in a higher mass range.

Prediction for LHC charge asymmetry

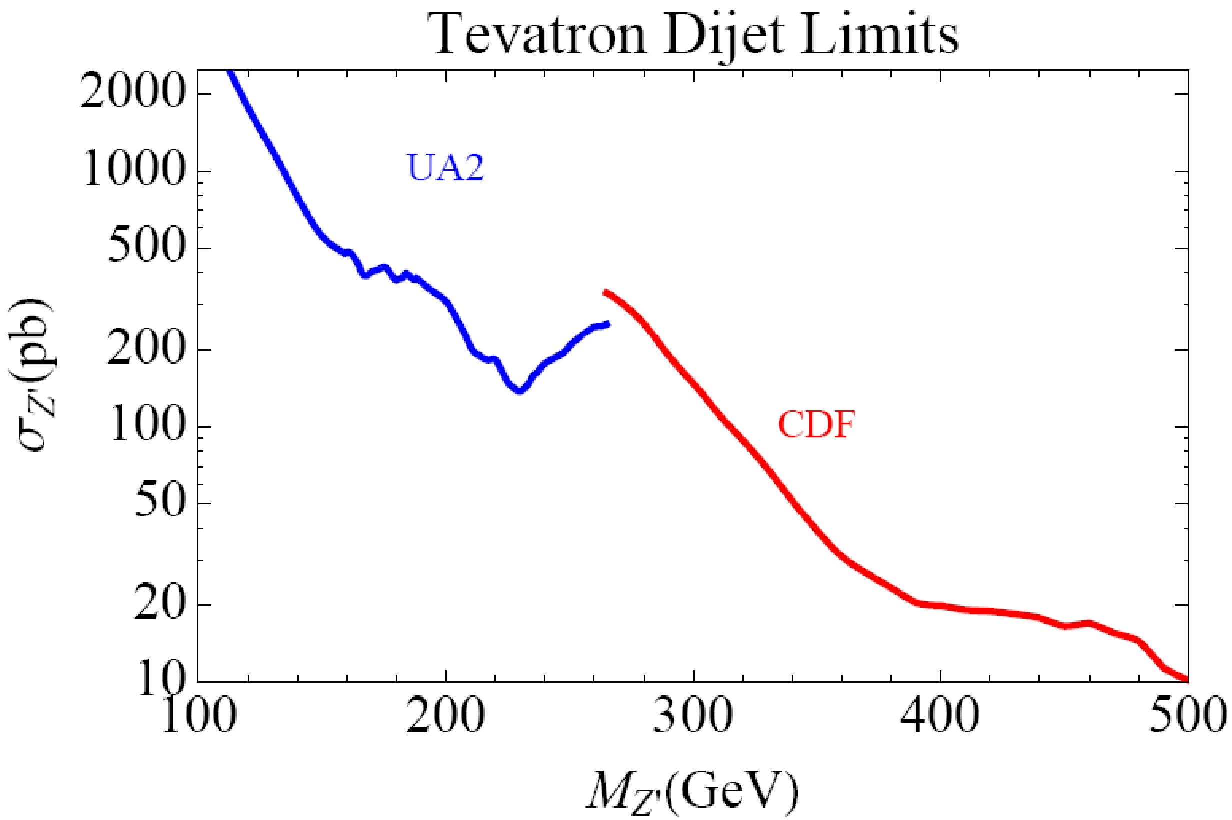


From Saavedra's talk, TOP2011

Dijet production

Fan, Krohn ,Langacker, Yavin, 1106.1682

- an extra resonance couples to the quarks : bound from $p\bar{p} \to jj$.



- assume $m_{Z'} < 200$ GeV and $m_{H^+} = 270$ GeV.