The 3rd generation quarks in warped models :
LHC predictions from LEP/Tevatron anomalies

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with

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Outline

I) Introduction: a warped model

II) A^t_{FB} and $t\bar{t}$ cross section @ Tevatron

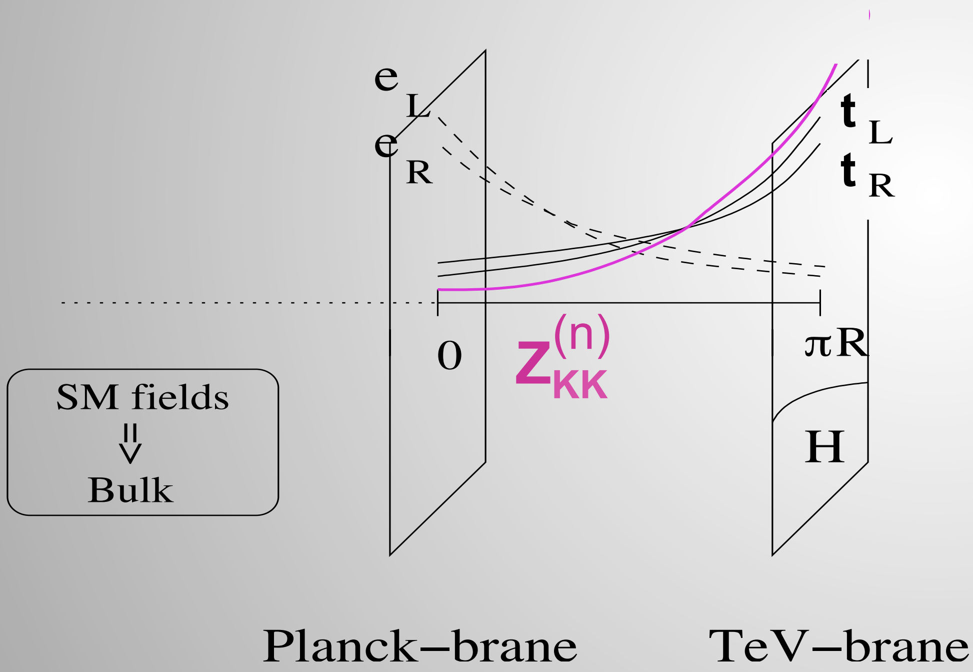
III) A^b_{FB} and EW precision tests @ LEP

IV) Constraints and predictions @ LHC

V) Conclusions

I) Introduction: a warped model

The Randall-Sundrum (RS) scenario with bulk fields:



- **RS addresses the gauge** ***hierarchy*** **:**

$$M_{grav} \approx TeV \approx Q_{EW}$$

Randall, Sundrum (1999)

- **RS generates the mass** ***hierarchies*** **:**

$$m_e << m_t$$

Gherghetta, Pomarol (2000)

…

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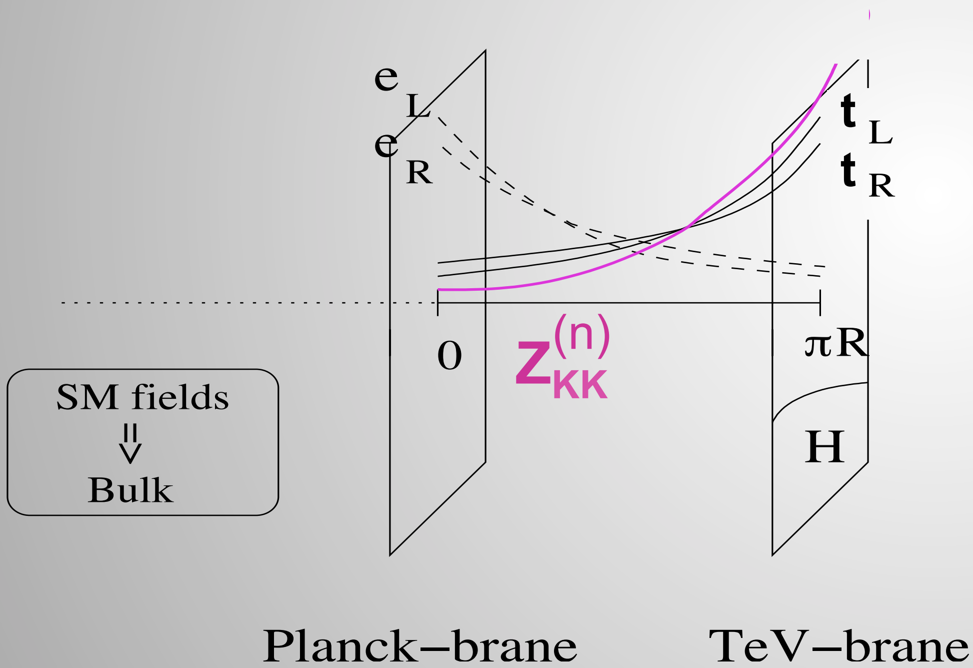

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➡ **New Physics effects in the heavy fermion sector !**

+ *attractive features of the RS scenario with bulk fields (= dual via AdS/CFT to composite Higgs & top models) :*

– WIMP candidates for the dark matter of universe:
  a LKP stable due to a possible KK-parity *(like in UED)*

– Unification of gauge couplings *(as in ADD)* at high-energies

– Fermion mixing angles and flavor structure *(as in ADD)* $\neq$ ***in SUSY***

– *Extra-Dimensions* =
  necessary ingredients for higher-energy string theories

The EW precision constraints in warped models :

Bulk gauge bosons/fermions mix with their KK excitations

=> tree-level contributions to EW observables

Ways out to respect the constraints from EW precision data for M_{KK}~TeV :

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Ways out to respect the constraints from EW precision data for M_{KK}~TeV :

~> Gauge custodial symmetry in the bulk

Agashe, Delgado, May, Sundrum (2003)

$$\begin{array}{ccc} O(4) & & SU(2)_L \times SU(2)_R \\ \Downarrow & \approx & \Downarrow \\ O(3) & & SU(2)_V \times P_{LR} \end{array}$$

~> Brane-localized kinetic terms for fermions/gauge fields

Carena et al. (2002) *Aguila et al. (2003)*

~> Modification of the AdS metric in the vicinity of the IR brane

Cabrer, Gersdorff, Quiros (2010)

« *Minimal* » representations under $SU(2)_L \times SU(2)_R \times U(1)_X$: $H=(2,2)_0$

$$\begin{pmatrix} t_{1L} & b'_L & q'_{-4/3L} \\ b_{1L} & q''_{-4/3L} & q'_{-7/3L} \end{pmatrix}_{-5/6} \quad (b_R \; q'_{-4/3R})_{-5/6} \quad \begin{pmatrix} q'_{5/3L} & t_{2L} \\ t'_L & b_{2L} \end{pmatrix}_{2/3} \quad (t_R)_{2/3}$$

"custodians"

$SU(2)_R \rightarrow U(1)_R$

$U(1)_R \times U(1)_X \rightarrow U(1)_Y$

$W_R^3 \quad B_X \rightarrow B_Y \quad (+ Z'^{KK})$

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Z' charges (I_{3R} isospin) and coupling ($g_{Z'} \sim 2$) **=>** Zbb couplings addressing A^b_{FB}

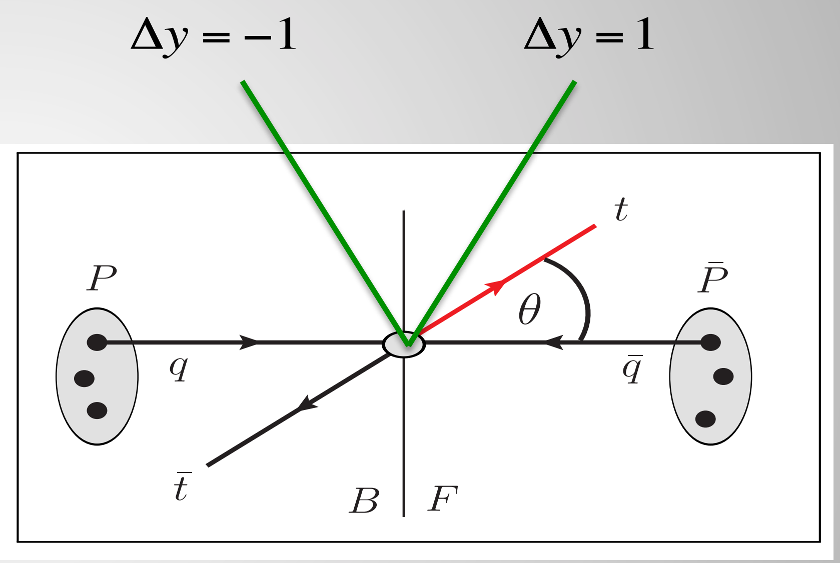
t_R singlet: no custodian top partners **=>** possible large $g^{KK} t\bar{t}$ couplings favor A^t_{FB}

II) A^t_{FB} and $t\bar{t}$ cross section @ Tevatron

A^t_{FB} at Tevatron

« What is the Forward-Backward asymmetry for the top quark ? »

≠ 0 with Parity-violating couplings



$$A^t_{\rm FB} = \frac{\sigma^F - \sigma^B}{\sigma^F + \sigma^B} = \frac{\sigma[\cos\theta^*_t : 0 \to 1] - \sigma[\cos\theta^*_t : -1 \to 0]}{\sigma[\cos\theta^*_t : 0 \to 1] + \sigma[\cos\theta^*_t : -1 \to 0]} = \frac{\sigma[y_t > 0] - \sigma[y_t < 0]}{\sigma[y_t > 0] + \sigma[y_t < 0]}$$

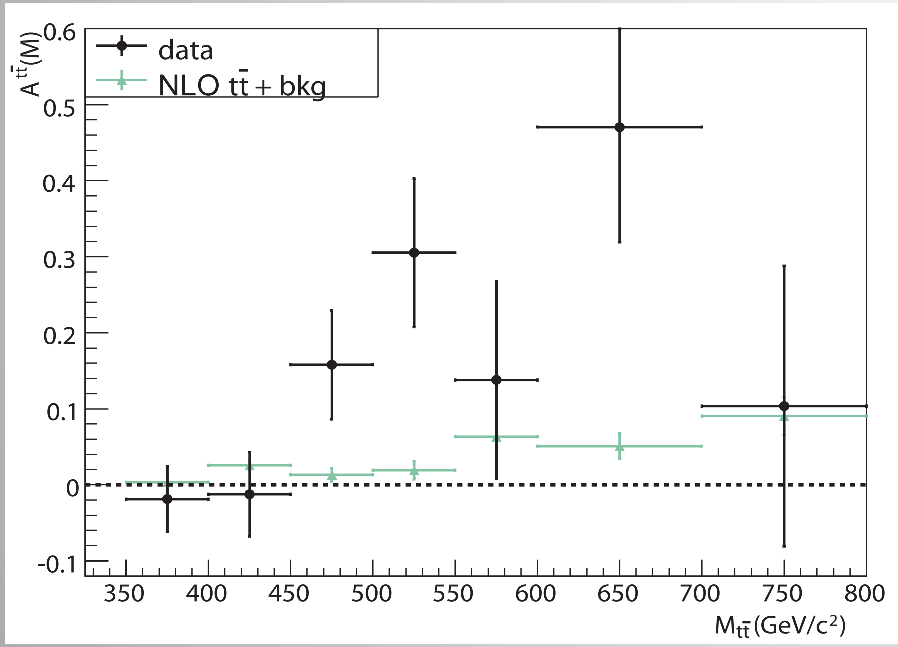
($t\bar{t}$ rest frame)

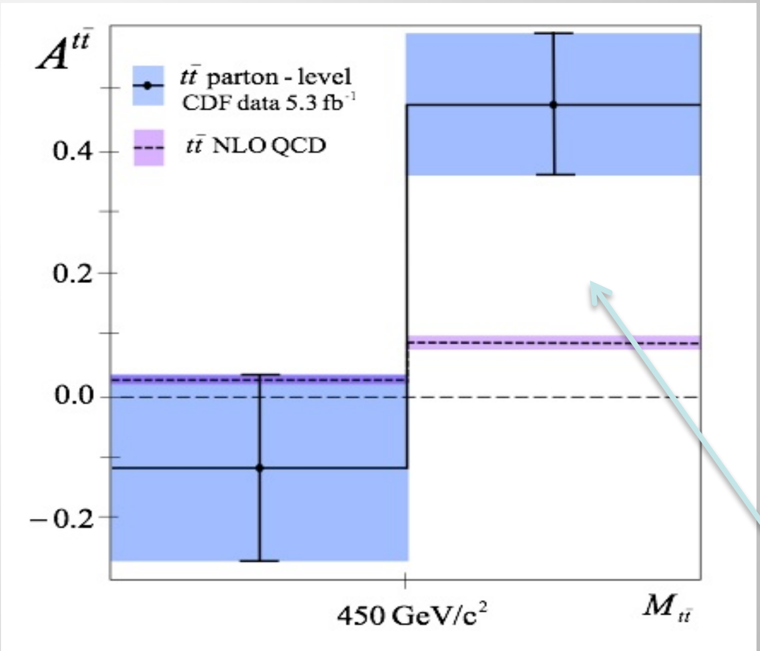
Rapidity : $y_t = \frac{1}{2}\ln[(E+p_z)/(E-p_z)] = \Delta y/2$

the data we use cause: most recent, unfolded and the only ones on rapidity dependence

01-2011 CDF in the lepton+jets channel with **5.3fb^{-1}** :

A^t_{FB} = 0.158 +/- 0.075 (**+1.3 sigma** from SM prediction)

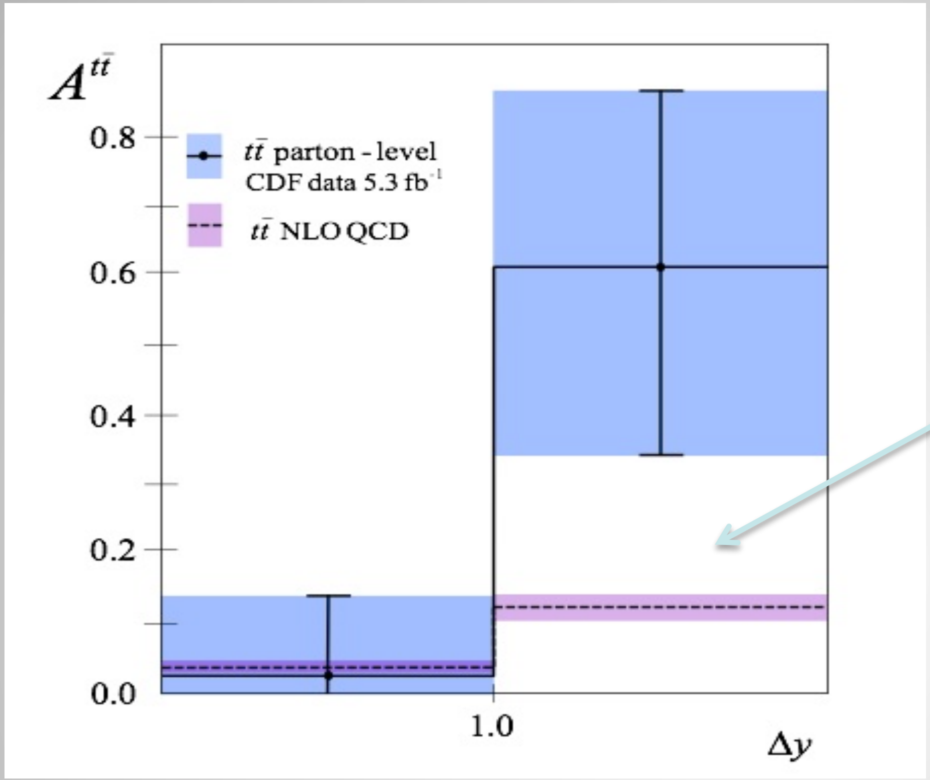




($t\bar{t}$ rest frame)

unfolding

+3.4 standard deviations from SM



+1.9 standard deviation from SM

($t\bar{t}$ rest frame, unfolded)

$$A_{\mathrm{FB}}^{|\Delta y|<1} = \frac{N(1 > \Delta y > 0) - N(-1 < \Delta y < 0)}{N(1 > \Delta y > 0) + N(-1 < \Delta y < 0)}, \quad A_{\mathrm{FB}}^{|\Delta y|>1} = \frac{N(\Delta y > 1) - N(\Delta y < -1)}{N(\Delta y > 1) + N(\Delta y < -1)}$$

$$|\Delta y| < 3$$

A^t_{FB} in the considered warped model

+ interferences with SM

(negligible EW gauge contrib.)

A^t_{FB} non-vanishing (Parity violation)

- $g_s\, Q(c\_t_L) \neq g_s\, Q(c\_t_R)$
- $g_s\, Q(c\_q_L) \neq g_s\, Q(c\_q_R)$

5D mass : c k

→ *slightly closer to TeV-brane :* $c\_u_L , c\_d_L \lesssim 0.5$

A^t_{FB} significant → $M_{KK} \sim 1.5 - 2$ TeV

EW tests not so far treated in this setup

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We will show that EW fits are OK for :

$c\_u/d_L \sim 0.44$, $c\_u/d_R \sim 0.8$, $c\_c/s_L \sim 0.6$, $c\_c_R \sim 0.6$, $c\_s_R \sim 0.49$, $c\_t/b_L \sim 0.51$, $c\_b_R \sim 0.53$, $c\_t_R \sim -1.3$

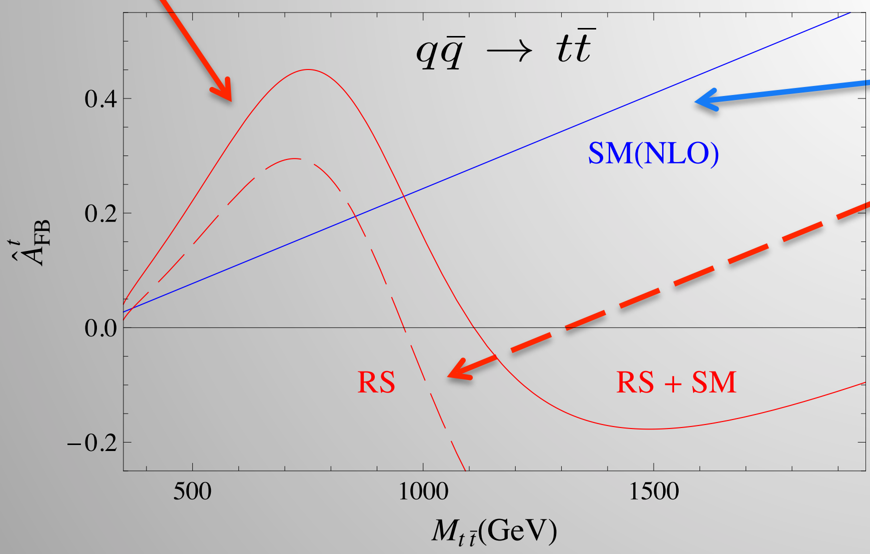
Asymmetry at parton level (neglecting 2nd/3rd generation + gluon initial state)…

$$\hat{A}^{LO}_{\rm FB}(\hat{s}) = a_q a_t \; \frac{4\pi\alpha_s^2(\mu_r)}{9} \frac{\beta_t^2 \; |\mathcal{D}|^2 \left[(\hat{s} - M_{KK}^2) + 2 v_q v_t \; \hat{s} \right]}{\hat{\sigma}^{\rm total}_{SM-LO}(\hat{s}) + \hat{\sigma}^{\rm total}_{RS+inter.-LO}(\hat{s})}$$

$$\left[\begin{array}{l} a_q = (Q(c_{q_R}) - Q(c_{q_L}))/2, \\ a_t = (Q(c_{t_R}) - Q(c_{t_L}))/2, \\ v_q = (Q(c_{q_R}) + Q(c_{q_L}))/2, \\ v_t = (Q(c_{t_R}) + Q(c_{t_L}))/2, \end{array} \right.$$

$$\hat{A}^{NLO}_{\rm FB}(\hat{s}) = \frac{(\hat{\sigma}^F_{SM-NLO}(\hat{s}) + \hat{\sigma}^F_{RS+inter.-LO}(\hat{s})) - (\hat{\sigma}^B_{SM-NLO}(\hat{s}) + \hat{\sigma}^B_{RS+inter.-LO}(\hat{s}))}{\hat{\sigma}^{\rm total}_{SM-NLO}(\hat{s}) + \hat{\sigma}^{\rm total}_{RS+inter.-LO}(\hat{s})}$$

$$\simeq \hat{A}^{LO}_{\rm FB}(\hat{s}) + \hat{A}^{SM-NLO}_{\rm FB}(\hat{s})$$



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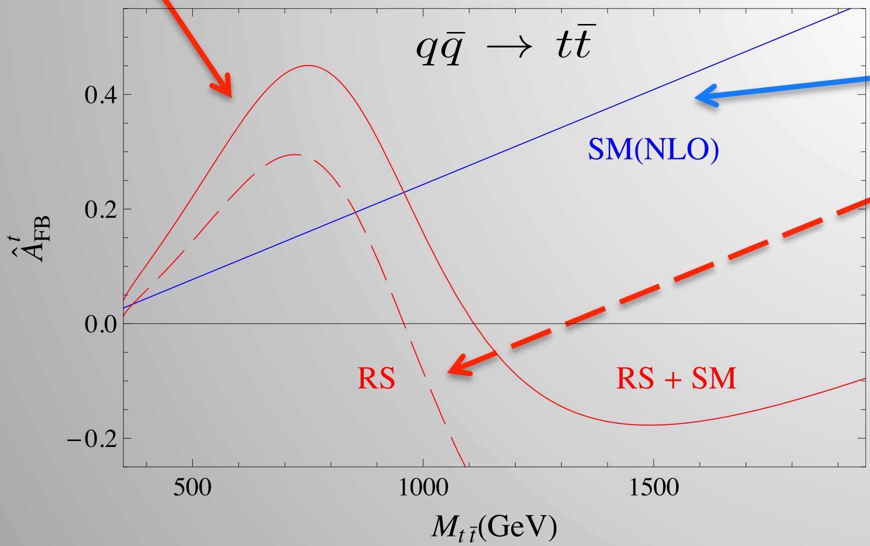
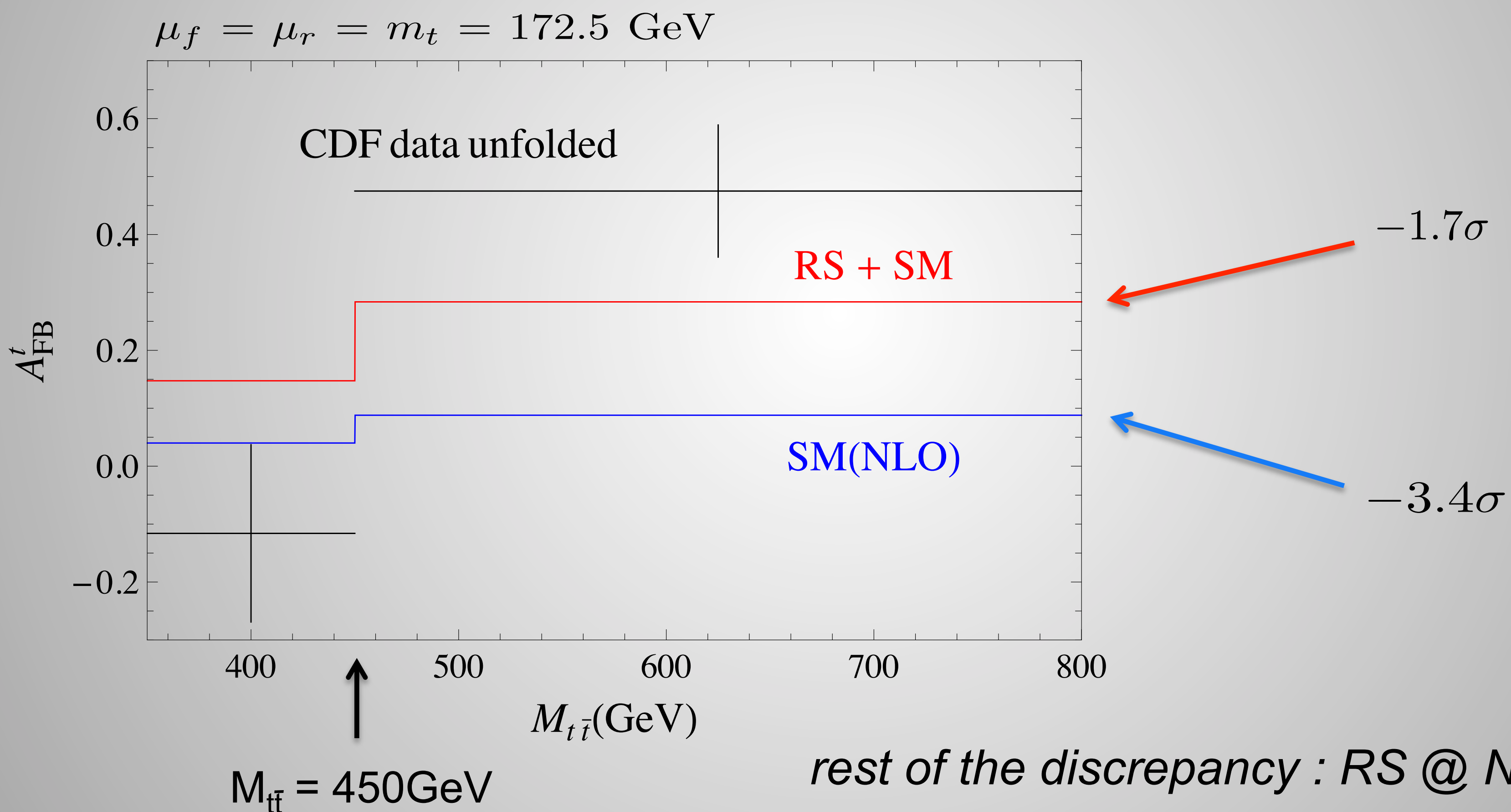


For our parameters such that:
$a_q a_t$ = -1.4 $v_q v_t$ = 0.7

⇒ Positive A^{LO}_{FB} in RS at low M_{tt} as wanted !

Full asymmetry after convolution with MSTW-2008…

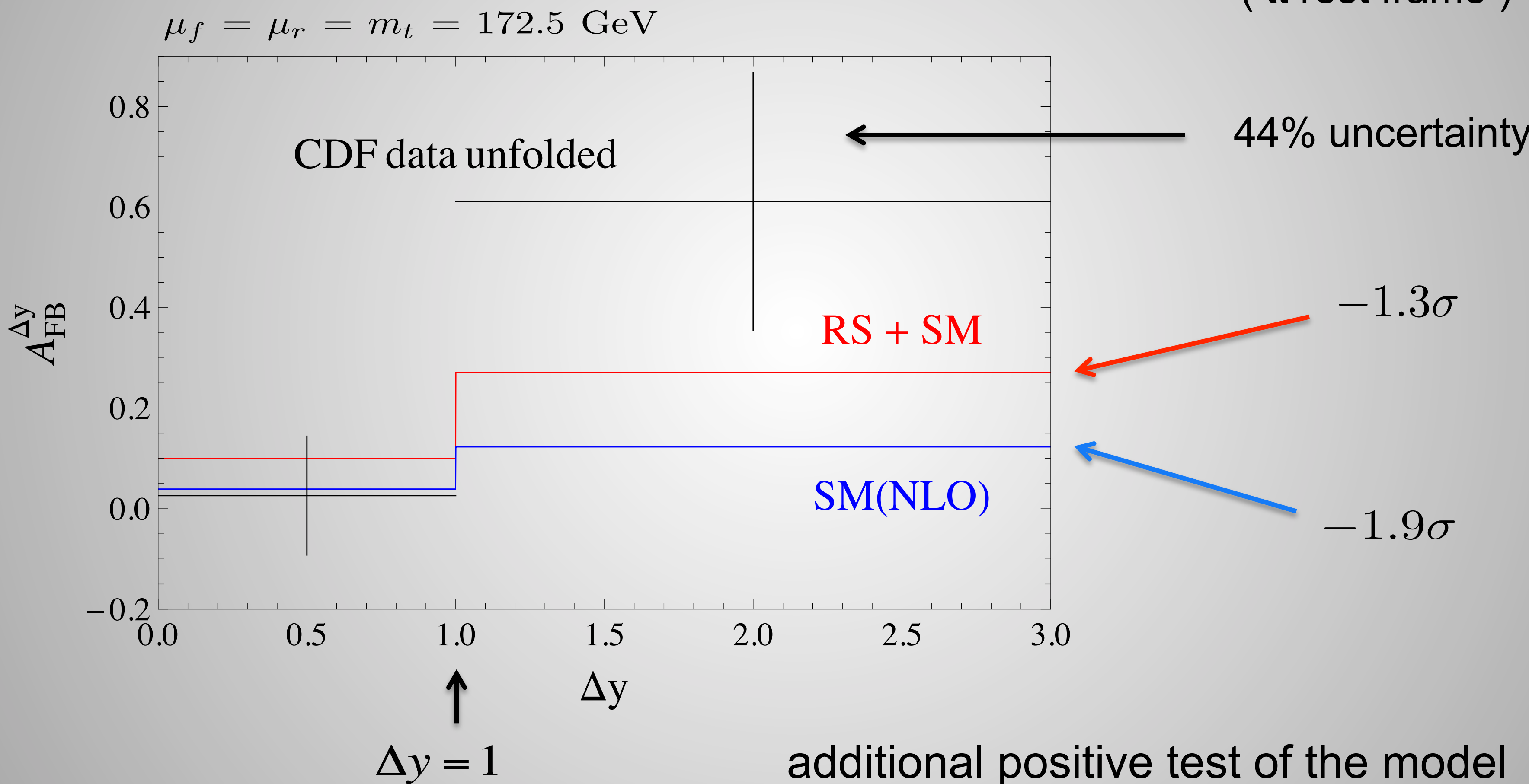
($t\bar{t}$ rest frame)



rest of the discrepancy : RS @ NLO ?

Full asymmetry as a function of rapidity…

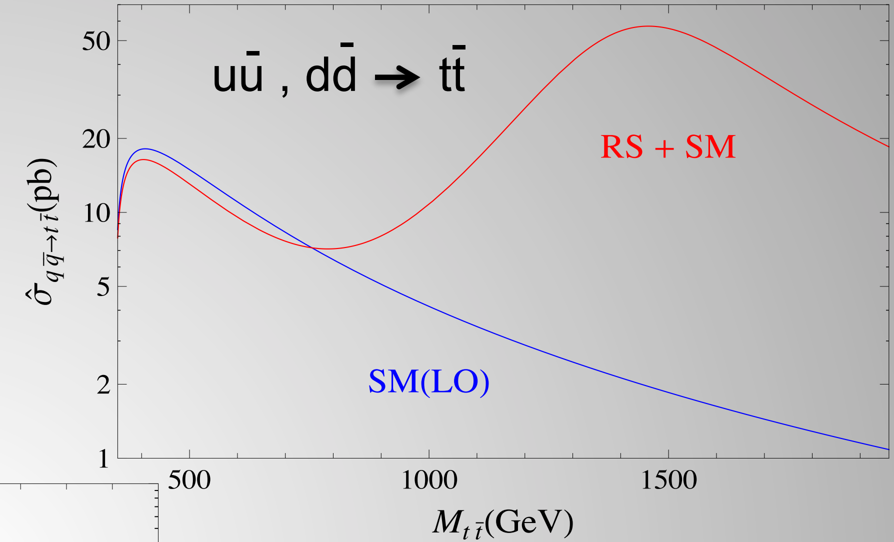
($t\bar{t}$ rest frame)

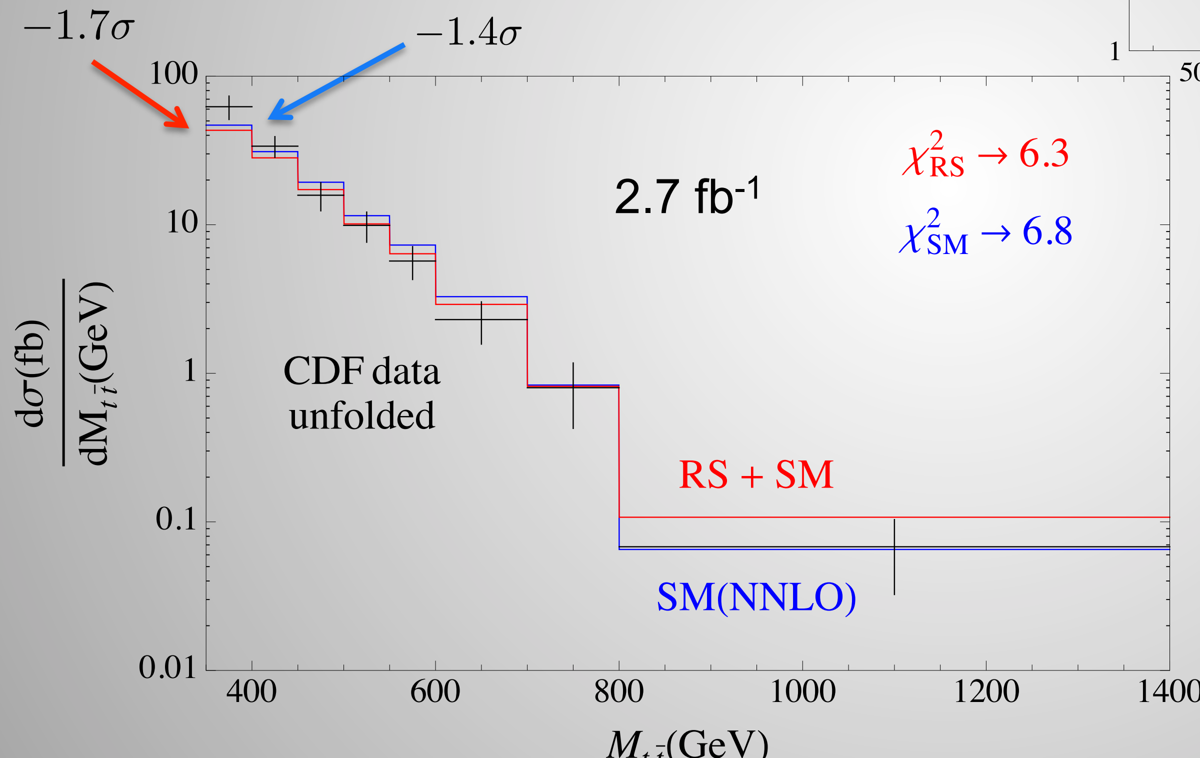


additional positive test of the model

One must take care of the differential $t\bar{t}$ production cross section in good agreement with the SM…

$$\frac{\mathrm{d}\sigma_{SM-NNLO}}{\mathrm{d}M_{t\bar{t}}}\left(1+\frac{\mathrm{d}\sigma_{RS+inter.-LO}}{\mathrm{d}M_{t\bar{t}}}\Big/\frac{\mathrm{d}\sigma_{SM.-LO}}{\mathrm{d}M_{t\bar{t}}}\right)$$





In SM :

$$\chi^2_{\rm SM}/d.o.f. = 6.8/8$$

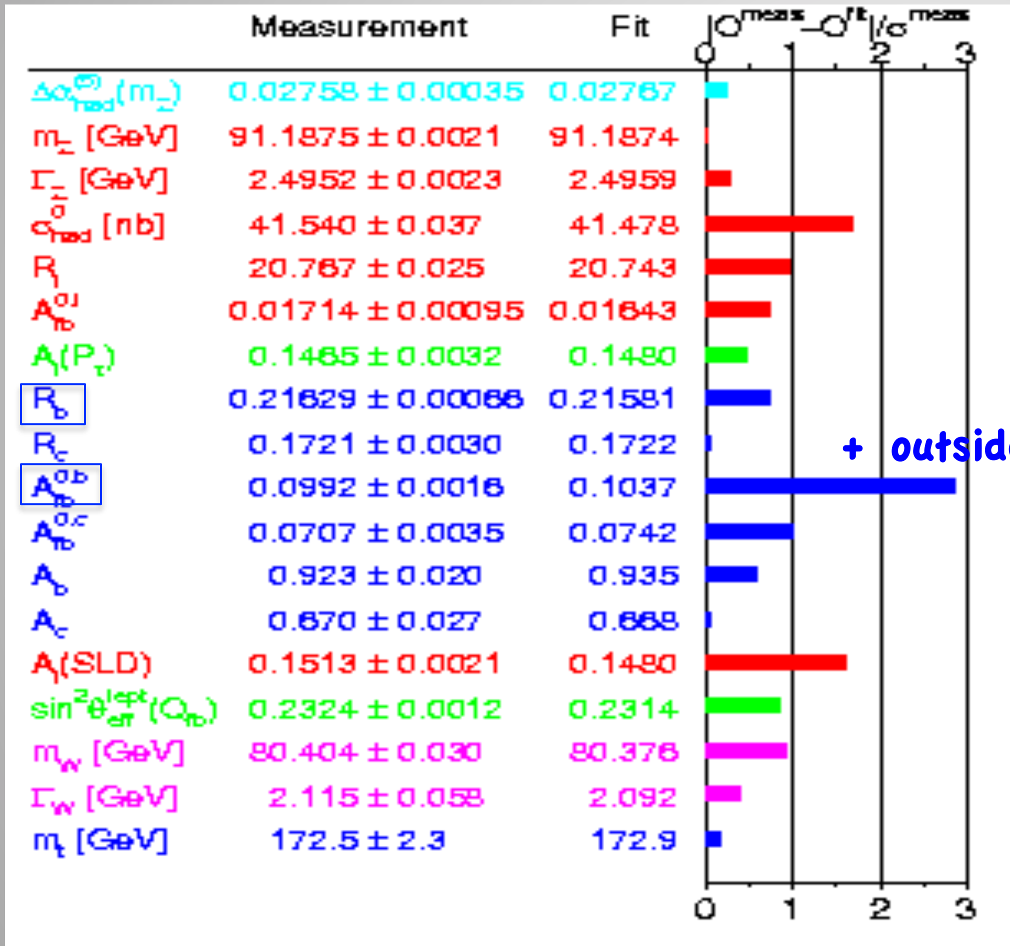
In RS :

$$\chi^2_{\rm RS}/d.o.f. = 6.3/8$$

$$m_t = 175\ \mathrm{GeV}$$

$$\mu_f = \mu_r = m_t$$

III) A^b_{FB} and EW precision tests @ LEP



+ outside Z pôle !

A^b_{FB} : a NP effect in the b sector ?

$$A^b_{FB}(p\hat{o}le) \equiv \frac{\int_0^{+1} \sigma_\theta d\cos\theta - \int_{-1}^{0} \sigma_\theta d\cos\theta}{\sigma_0(e^+e^- \to \gamma/Z \to b\bar{b})}$$

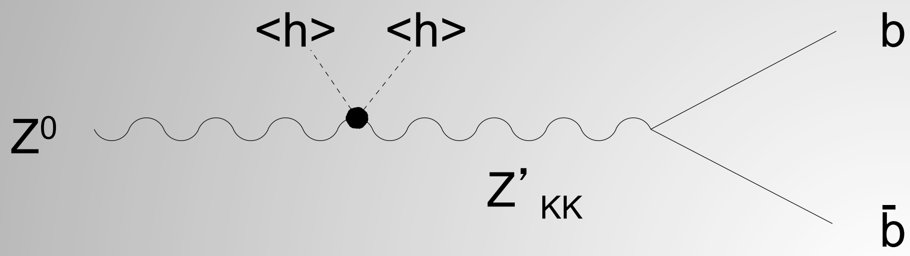
$$= \frac{3}{4} \frac{(Q_Z^{e_L})^2 - (Q_Z^{e_R})^2}{(Q_Z^{e_L})^2 + (Q_Z^{e_R})^2} \frac{(Q_Z^{b_L})^2 - (Q_Z^{b_R})^2}{(Q_Z^{b_L})^2 + (Q_Z^{b_R})^2}$$

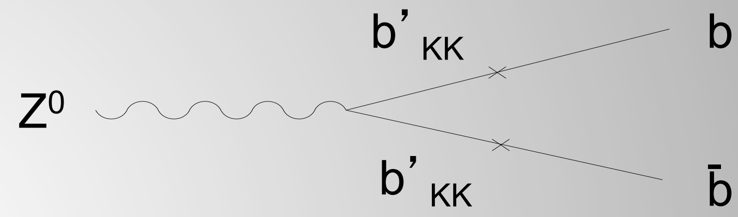
$$R_b \equiv \frac{\Gamma(Z \to b\bar{b})}{\Gamma(Z \to hadrons)}$$

$$= \frac{(Q_Z^{b_L})^2 + (Q_Z^{b_R})^2}{\sum_{q \neq t} [(Q_Z^{q_L})^2 + (Q_Z^{q_R})^2]}$$

Interpretation in a generic extra-dimensional model…

(difficult in SUSY)





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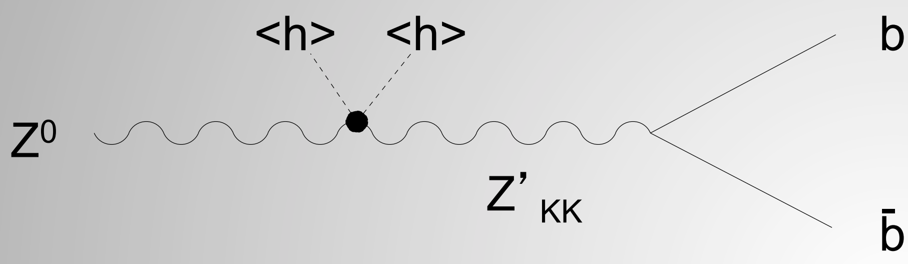
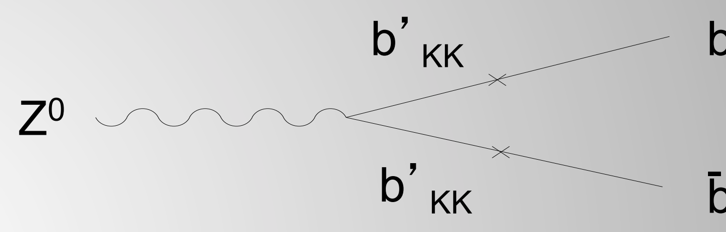




$$\left|\delta Q_Z^{f_l}\right| \approx 1 ‰ \quad << \quad \left|\delta Q_Z^{b_{L/R}}\right| \approx \left|-1.5/30\%\right|$$

$$\text{Coupling } Z_{KK} f_l \overline{f_l} \quad << \quad \text{Coupling } Z_{KK} b\bar{b}$$

$$\Downarrow$$

$$m_{b'}(c_{t_R}) \quad << \quad m_{f'}(c_{\text{light}})$$

$$m_t(c_{t_R}) \uparrow \quad \Rightarrow \quad m_{b'}(c_{t_R}) \downarrow$$

$$\Downarrow$$

'natural' conditions within the RS model

Summary of the EW observables…

Observable	**SM**	**RS**
$A^b_{FB}(m_Z)$	2.7σ	1.2σ
R_b	0.8σ	1.2σ
$A^c_{FB}(m_Z)$	0.9σ	0.9σ
R_c	0.0σ	0.5σ
$A^s_{FB}(m_Z)$	0.6σ	0.2σ
$\Gamma_{\rm had}(Z)$	1.3σ	1.0σ
$\Gamma_{\rm tot}(W)$	0.2σ	0.2σ
$\langle Q_{FB}\rangle$	1.1σ	0.1σ
$C_{1u}+C_{1d}$	0.2σ	0.8σ
$C_{1u}-C_{1d}$	1.1σ	0.1σ
$\chi^2/d.o.f.$	$25.3/17$	$19.8/17$

no more A^b_{FB} anomaly at the Z^0 pole

still fits well

+ Zuu/Zdd OK from Tevatron Run I & II & HERA (H1,ZEUS)

whole fit improved

IV) Constraints and predictions @ LHC

Comparison of the tt̄ cross section $\sigma_{t\bar{t}}$

in RS+SM NNLO (HATHOR) $\mu_{\rm F} = \mu_{\rm R} = m_t = 173$ GeV $\sqrt{s} = 7$ TeV

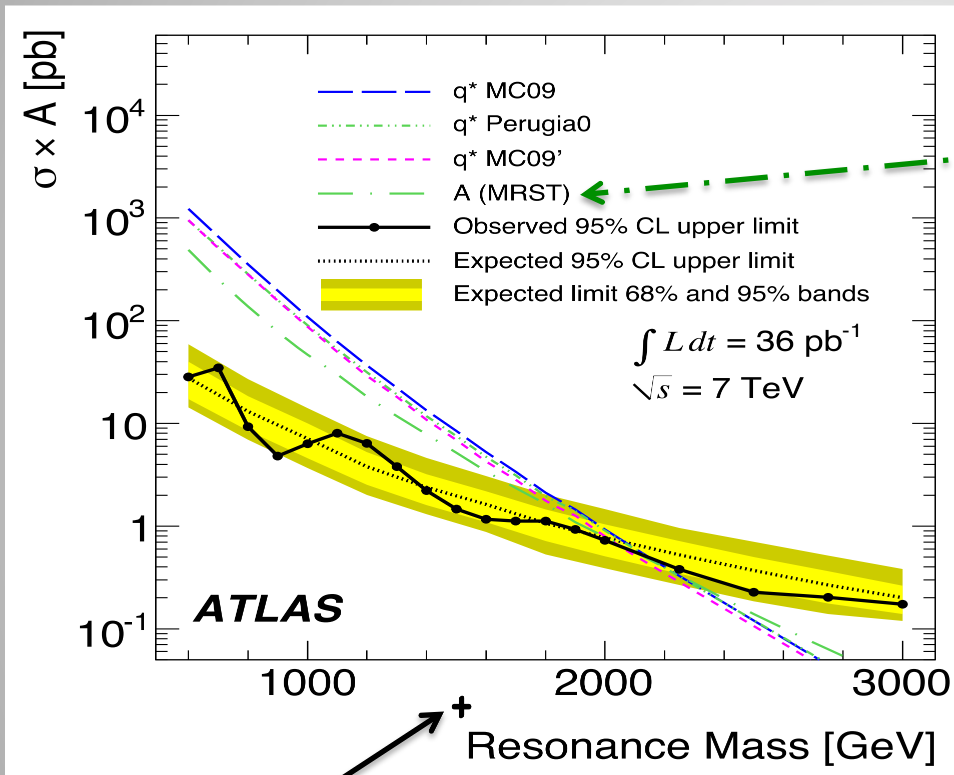
$\mathcal{L} = 35\ \mathrm{pb}^{-1}$

$\sigma(pp \to t\bar{t})$ at -0.86σ
SM at -0.81σ
from the ATLAS measurement, 180 ± 18.5 pb

$\sigma(pp \to t\bar{t})$ at $+0.36\sigma$
SM at $+0.31\sigma$
from the CMS measurement, 158 ± 19 pb

→ OK as major contribution from the gg initial state

Constraints from dijets



Axigluon - $SU(3)_L x SU(3)_R$

Frampton et al. (1987)
Bagger et al. (1987)

- ★ now including the width effect between 0.7 M_{KK} and 1.3 M_{KK}
- ★ we have also checked the angular distribution constraints

we've computed the ratio RS/Axigluon
=> KK gluon exchange @ 0.023 pb

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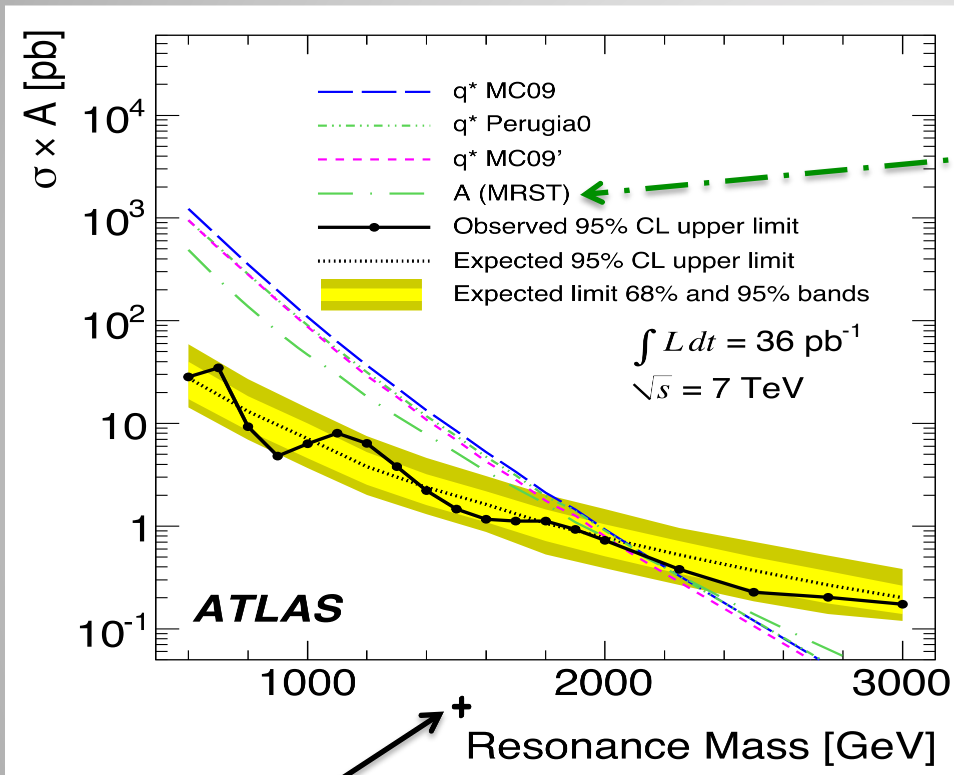

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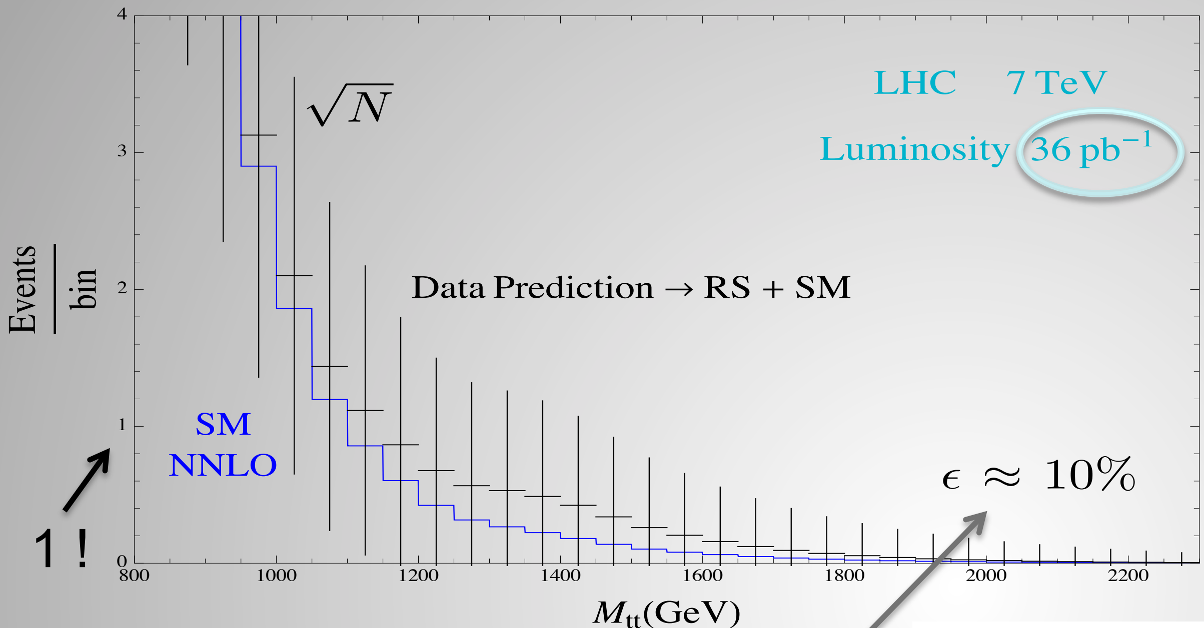
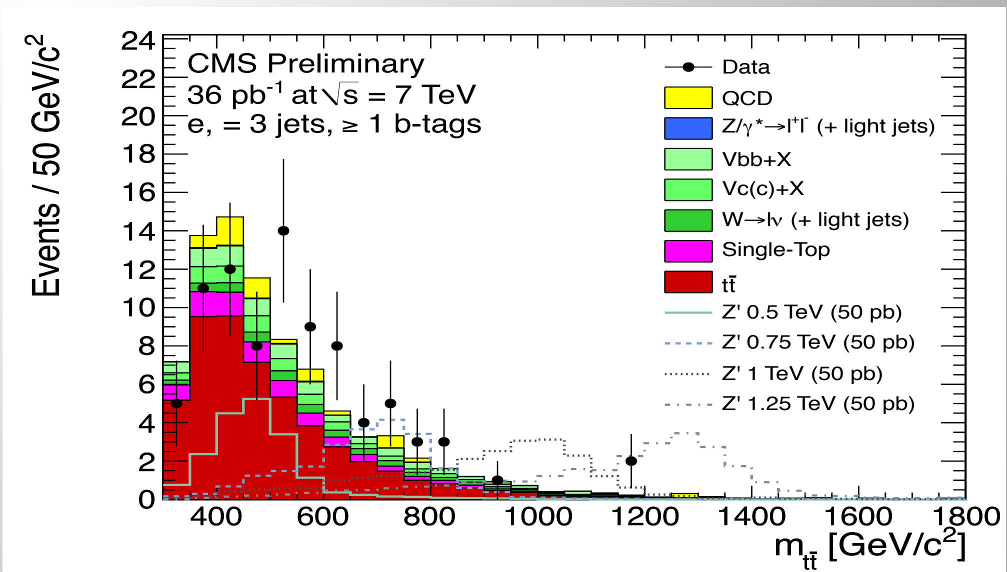
Coupling $g^{(1)}tt > g^{(1)}qq$

RS addresses A^t_{FB}
+ passes dijet bounds



Predictions on the M_{tt} distribution at LHC

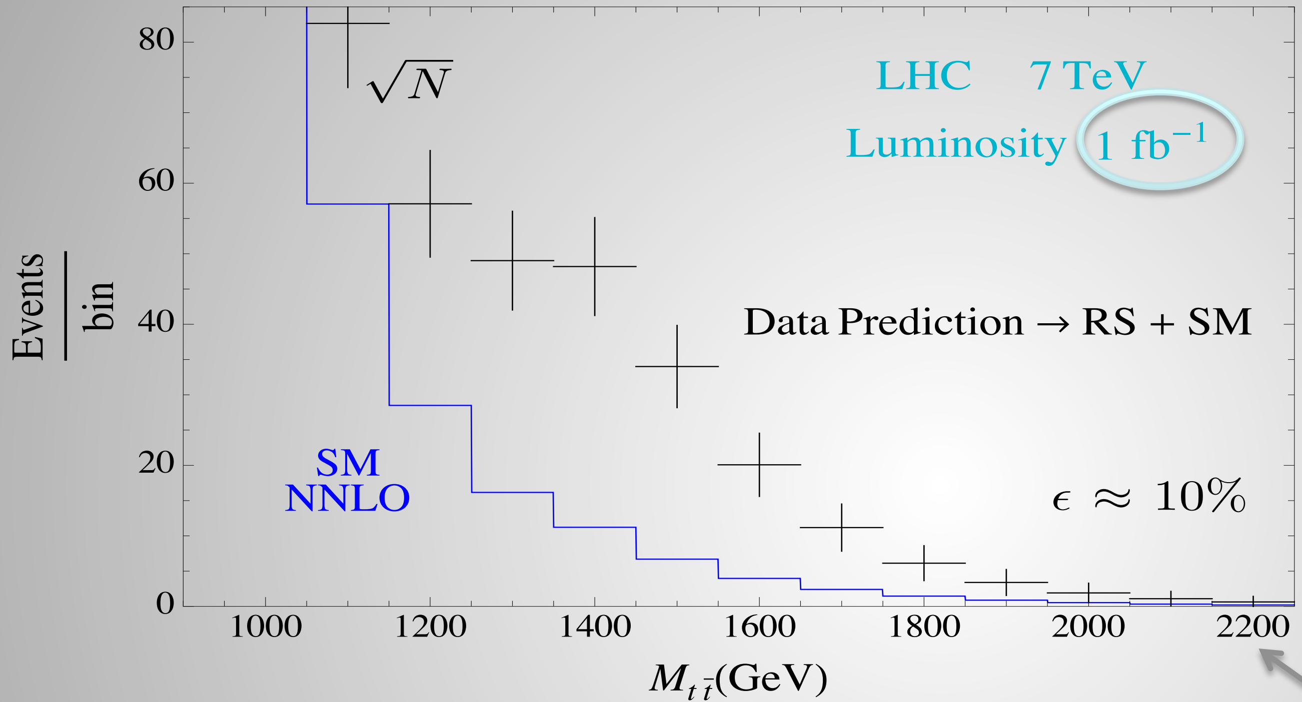
compatible



$t\bar{t}$ reconstruction efficiency taken

$$\mu_f = \mu_r = m_t = 173 \text{ GeV}$$

What does the RS model predicts at the expected luminosity of 1 fb^{-1} ?



..a KK gluon resonance

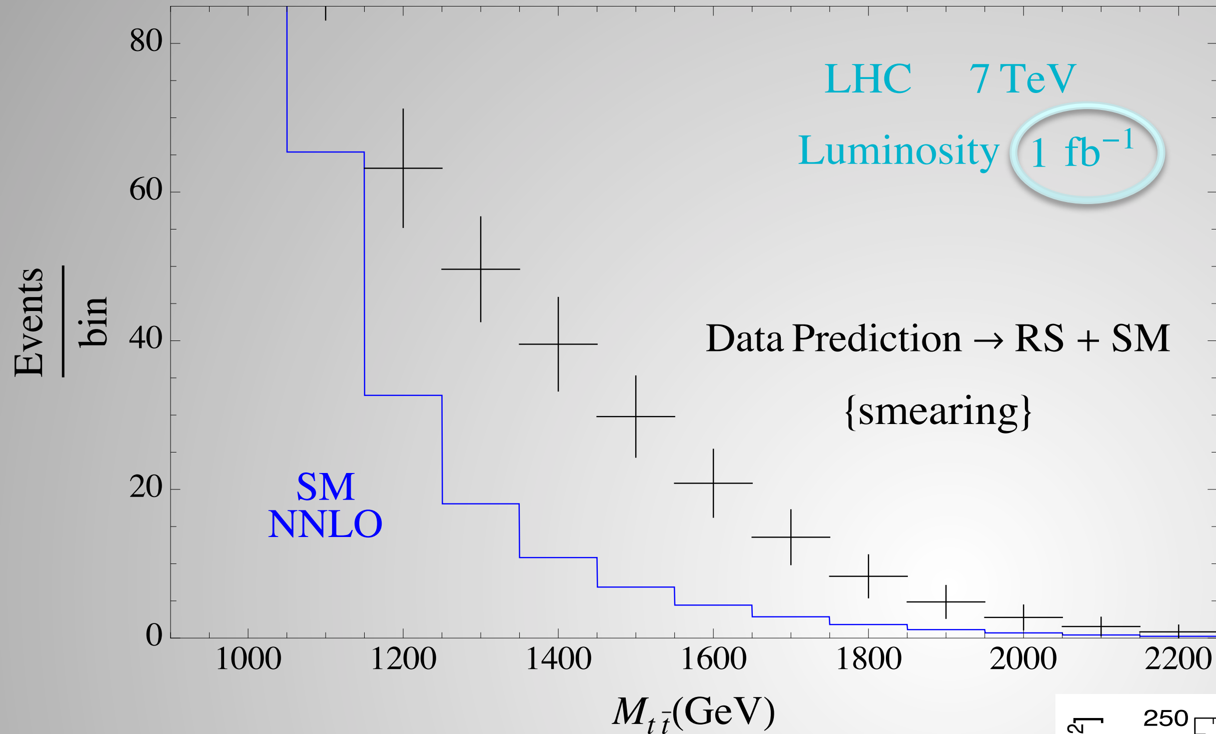
$$\Gamma_{g^{(1)}} \simeq 40\% M_{KK}$$

assuming 100 GeV bin resolutions

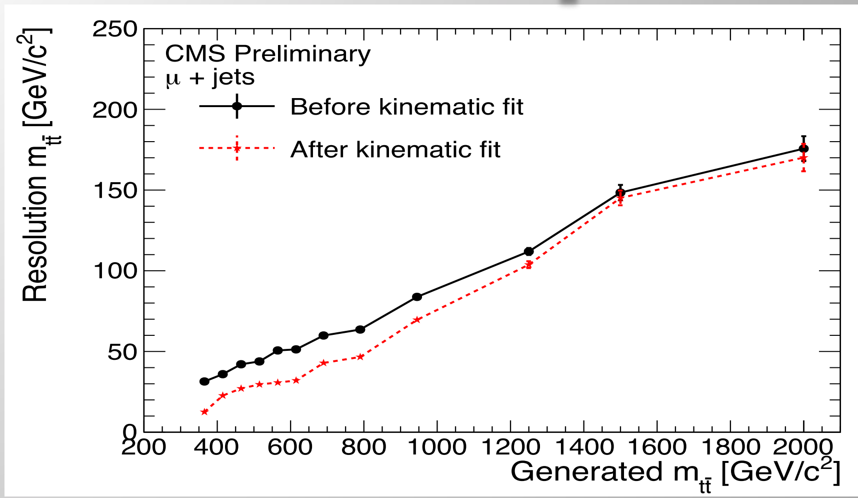
integration of the cross section e.g. over $[1050, 1750]$ GeV

↳ $Signal / \sqrt{Background} \cong$ 13.9

An excess should be clearly visible.



Smearing effect



$$Signal / \sqrt{Background} \cong 12.7$$

A great excess even simulating the $M_{t\bar{t}}$ experimental resolution:

V) Conclusions

- The 'warped paradigm', with theoretical motivations, predicts deviations from SM in the 3rd generation sector => *A^b_{FB} , A^t_{FB} = early indications ?*
- We suggest a geometrical RS realization addressing both A^b_{FB} and A^t_{FB}.
- The several constraints on the parameter space render this RS scenario quite predictive on the effects in the $t\bar{t}$ invariant mass ditribution @ LHC.
- One must wait for more data (Tevatron,LHC) in order to discriminate between the main A^t_{FB} interpretations: Z/W ', KK gluon, Axigluon, stop…
- This RS model addressing A^b_{FB}, A^t_{FB} predicts a **KK gluon resonance**

$\neq$

Other RS models usually with light **custodians copiously producable**

('**no-lose** signal' theorem in warped pheno. @ LHC)

Back up

Some useful formula's…

$$\cos\theta_t^* = \sqrt{1 + \frac{4m_t^2}{\hat{s} - 4m_t^2}}\ \tanh y_t$$

$$\frac{1}{\mathcal{D}} = \hat{s} - M_{KK}^2 + i\frac{\hat{s}}{M_{KK}^2}\sum_q\ \Gamma_{KK}^{g^{(1)}\to q\bar{q}} M_{KK}\frac{\beta_q[v_q^2(3-\beta_q^2)]/2 + a_q^2\beta_q^2}{v_q^2 + a_q^2}$$

$$\beta_t = \sqrt{1 - 4m_t^2/\hat{s}}$$

$$\sqrt{\hat{s}_0} \simeq \frac{M_{KK}}{(1 + \Gamma_{KK}^2/M_{KK}^2)^{1/4}}$$

$$\frac{\mathrm{d}\hat{\sigma}_{RS-LO}}{\mathrm{d}\cos\theta_t^*}(\hat{s}) = \frac{\pi\alpha_s^2(\mu_r)\beta_t}{9\hat{s}} \times$$

$$\hat{s}^2|\mathcal{D}|^2\Big[8v_q v_t a_q a_t \beta_t \cos\theta^* + (a_q^2 + v_q^2)\left(v_t^2(2 - \beta_t^2\sin^2\theta^*) + a_t^2\beta_t^2(1 + \cos^2\theta^*)\right)\Big]$$

$$\frac{\mathrm{d}\hat{\sigma}_{inter.-LO}}{\mathrm{d}\cos\theta_t^*}(\hat{s}) = \frac{\pi\alpha_s^2(\mu_r)\beta_t}{9\hat{s}} 4\hat{s}\mathrm{Re}(\mathcal{D})\left[v_q v_t\left(1 - \frac{1}{2}\beta_t^2\sin^2\theta^*\right) + a_q a_t \beta_t \cos\theta^*\right]$$

$$\left(\quad \left.\frac{\mathrm{d}\hat{\sigma}_{SM-LO}}{\mathrm{d}\cos\theta_t^*}(\hat{s})\right|_{q\bar{q}} = \frac{\pi\alpha_s^2(\mu_r)\beta_t}{9\hat{s}}\left\{2 - \beta_t^2\sin^2\theta^*\right\} \quad\right)$$

« How is A^t_{FB} measured at Tevatron in lepton+jet channels ? »

$$\Delta y = y_t - y_{\bar{t}} \qquad y_t = (y_t - y_{\bar{t}})/2$$

$$\Delta y = q(y_l - y_h) = q\Delta y_{lh}$$

↙ in the laboratory frame

$t \rightarrow W^+ b$, $W^+ \rightarrow l^+ \nu$

$t \rightarrow W^+ b$, $W^+ \rightarrow j\,j$

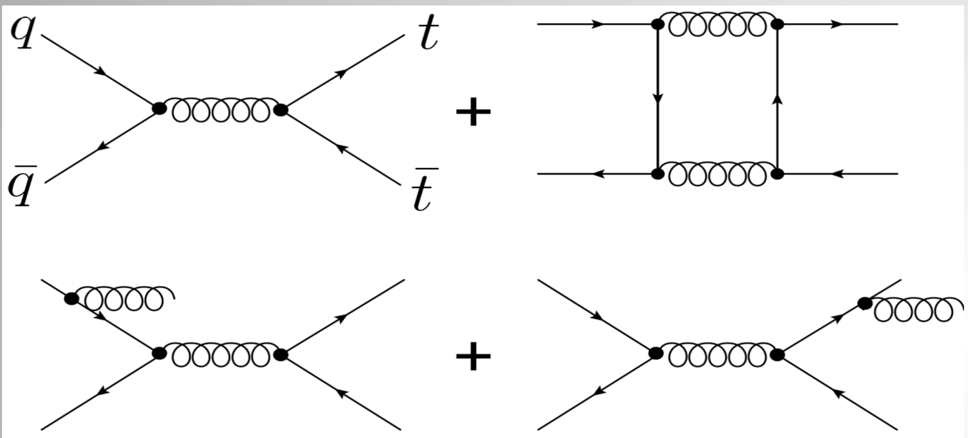
$$\boxed{A^t_{\mathrm{FB}} = \frac{N(\Delta y > 0) - N(\Delta y < 0)}{N(\Delta y > 0) + N(\Delta y < 0)} = \frac{N(q\Delta y_{lh} > 0) - N(q\Delta y_{lh} < 0)}{N(q\Delta y_{lh} > 0) + N(q\Delta y_{lh} < 0)}}$$

Other asymmetries…

$$A^{p\bar{p}}_{\mathrm{FB}} = \frac{\sigma[y^{p\bar{p}}_t > 0] - \sigma[y^{p\bar{p}}_t < 0]}{\sigma[y^{p\bar{p}}_t > 0] + \sigma[y^{p\bar{p}}_t < 0]} \qquad A^t_{\mathrm{C}} = \frac{\sigma_t[y_t > 0] - \sigma_{\bar{t}}[y_t > 0]}{\sigma_t[y_t > 0] + \sigma_{\bar{t}}[y_t > 0]} \qquad A^t_{\mathrm{C}} = A^t_{\mathrm{FB}} => CP$$

Standard Model (QCD) contribution to A^t_{FB}

C=-1 C=+1



C=-1 C=+1

$$A_{\rm FB}^{SM} = \frac{\sigma^F_{SM-NLO} - \sigma^B_{SM-NLO}}{\sigma^F_{SM-NLO} + \sigma^B_{SM-NLO}}$$

(vanishing at LO)

MCFM for SM *(m_t=172.5GeV, PDF=CTEQ)* @ NLO : **A^t_{FB} = 0.058** +/- 0.009

Ahrens et al. (2010) obtain *(m_t=173.1GeV, PDF=MSTW)* :

@ NLO : **A^t_{FB} = 0.067 $^{+0.006}_{-0.004}$** @ NNLO-approx : **A^t_{FB} = 0.064 $^{+0.009}_{-0.007}$** ($0.2 < \mu_f / TeV < 0.8$)

=> A^t_{FB} [M_{tt}>450GeV] anomaly probably not fully explained by QCD errors ~0.01

Measurements of A^t_{FB} at Tevatron

now 5.1fb^{-1}: see F.Badaud's talk

07-2010 D0 in the lepton+jets channel with **(0.9fb^{-1} then) 4.3fb^{-1}**
(ttbar frame, not unfolded = no subtracting bckgrd & effic. + no ttbar level) :
A^t_{FB} = 0.08 +/- 0.04 +/- 0.01 (**+1.7 sigma** from SM prediction)

03-2009 CDF in the lepton+jets channel with **(1.9fb^{-1} then) 3.1fb^{-1}**
(lab frame, unfolded) :
A^t_{FB} = 0.193 +/- 0.065 +/- 0.024 (**+2.1 sigma** from SM prediction)

01-2011 CDF in the dilepton channel with **5.1fb^{-1}**
(lab frame, unfolded) :
A^t_{FB} = 0.42 +/- 0.15 +/- 0.05 (+2.3 sigma from SM prediction)
(large error => +1.7 sigma from lept.+jets channel)
(lab frame, not unfolded) :
A^t_{FB} (M_{tt}<450GeV)= 0.104 +/- 0.066 (+1.6 sigma from SM prediction)
A^t_{FB} (M_{tt}>450GeV)= 0.212 +/- 0.096 (**+2.6 sigma** from SM prediction)

The way to compute it…

$$A_{\rm FB}^t = \frac{(\sigma_{SM}^F + \sigma_{RS}^F + \sigma_{inter.}^F) - (\sigma_{SM}^B + \sigma_{RS}^B + \sigma_{inter.}^B)}{(\sigma_{SM}^F + \sigma_{RS}^F + \sigma_{inter.}^F) + (\sigma_{SM}^B + \sigma_{RS}^B + \sigma_{inter.}^B)}$$

$$\Leftrightarrow \quad A_{\rm FB}^t = A_{\rm FB}^{RS} \times R + A_{\rm FB}^{SM} \times (1 - R)$$

Cao et al. (2010)

with

$$\begin{cases} A_{\rm FB}^{RS} = \dfrac{(\sigma_{RS-LO}^F + \sigma_{inter.-LO}^F) - (\sigma_{RS-LO}^B + \sigma_{inter.-LO}^B)}{(\sigma_{RS-LO}^F + \sigma_{inter.-LO}^F) + (\sigma_{RS-LO}^B + \sigma_{inter.-LO}^B)} \\ R = \dfrac{\sigma_{RS-LO}^{\rm total} + \sigma_{inter.-LO}^{\rm total}}{\sigma_{SM-LO}^{\rm total} + \sigma_{RS-LO}^{\rm total} + \sigma_{inter.-LO}^{\rm total}} \end{cases}$$

ex:

$$\sigma_{RS-LO}^F = \sigma_{RS-LO}[\cos\theta_t^* : 0 \to 1] =$$

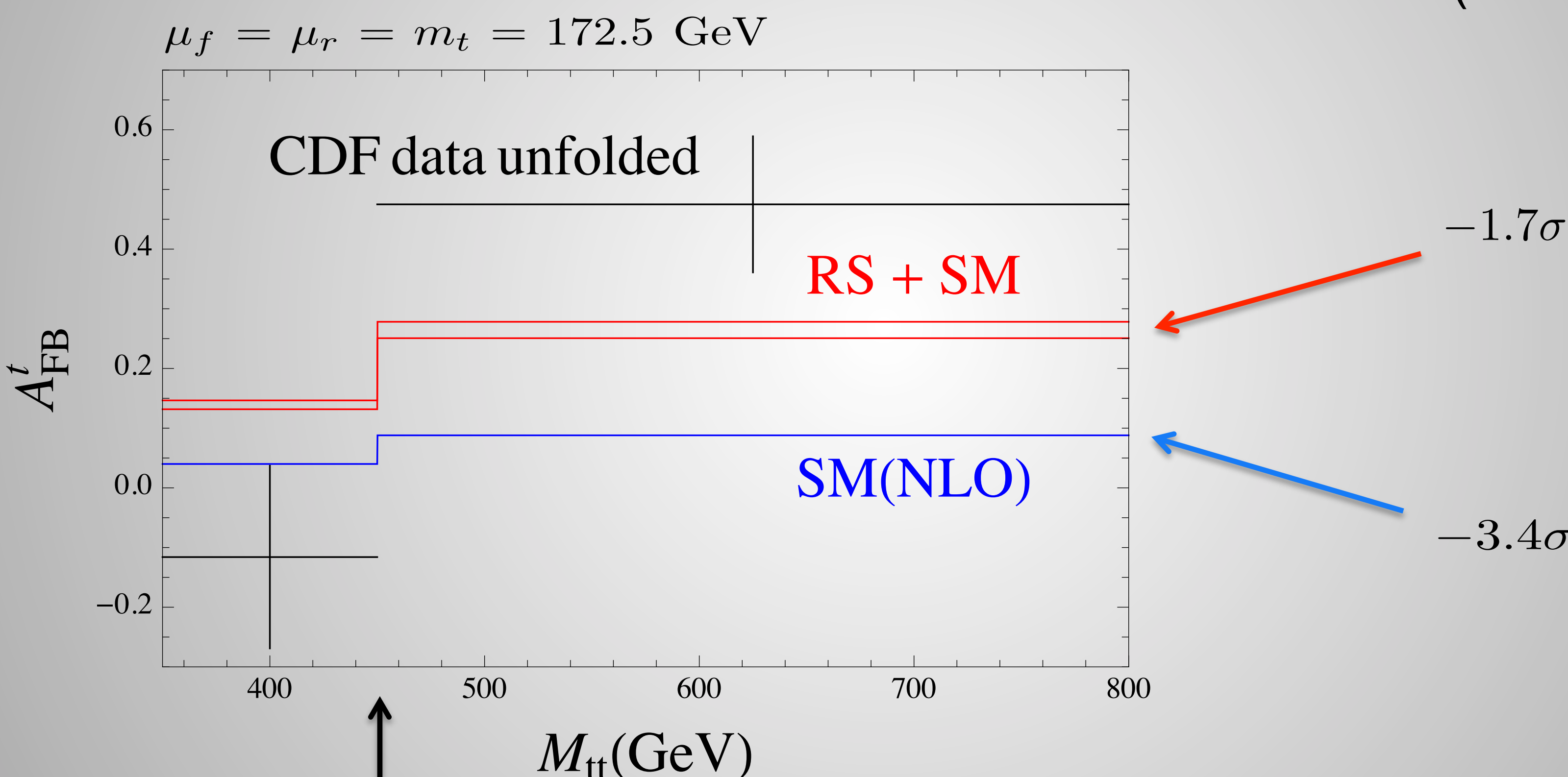
$$\sum_{ij} \int_{\tau_{min}}^{\tau_{max}} d\tau \Big[\int_0^1 d\cos\theta_t^* \Big(\frac{{\rm d}\hat{\sigma}_{RS-LO}}{{\rm d}\cos\theta_t^*}(\tau s) \Big)_{ij} \Big] \Big\{ \int_\tau^1 \frac{dx}{x} f_i(x, \mu_f) f_j(\frac{\tau}{x}, \mu_f) \Big\}$$

$$\tau_{min/max} = \hat{s}_{min/max}/s$$

MSTW-2008-NLO

Looking at the effect of MSTW *uncertainties [@ 90%C.L.]…*

(ttbar frame)



M_{tt} = 450GeV

no significant dependence as well on μ_f, μ_r and m_t

$1/(t - M_{KK}^2)$ $\quad -t \leq M_{KK}^2$ $\quad t = -M_{jj}^2/2$ $\quad M_{jj} = \sqrt{2} M_{KK} \sim 2$ TeV

$\cos\theta^\star = 0$

KK gluon produces less than 10% deviation

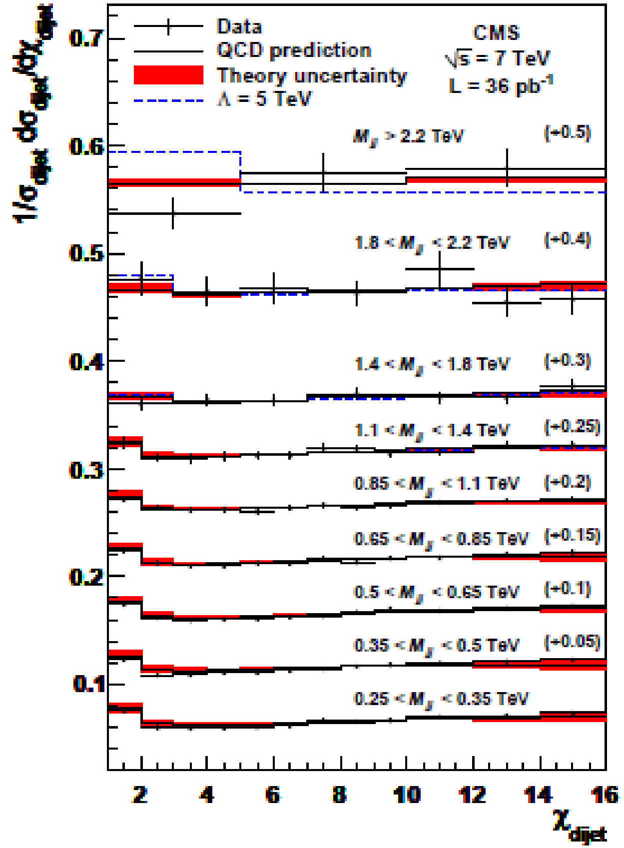
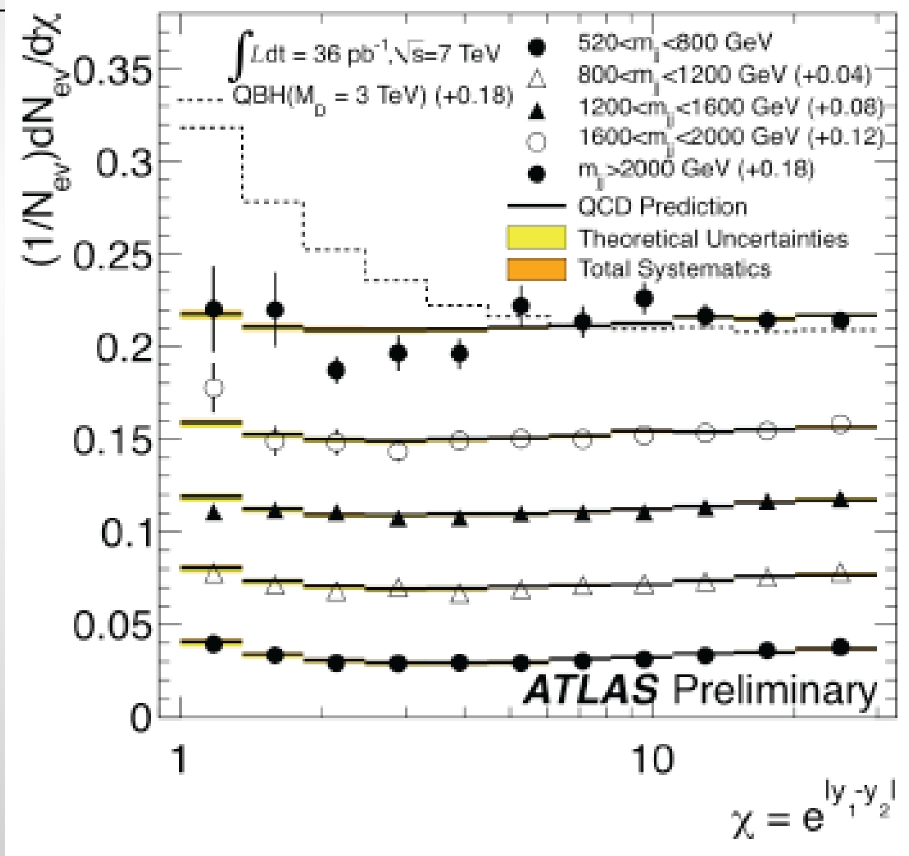
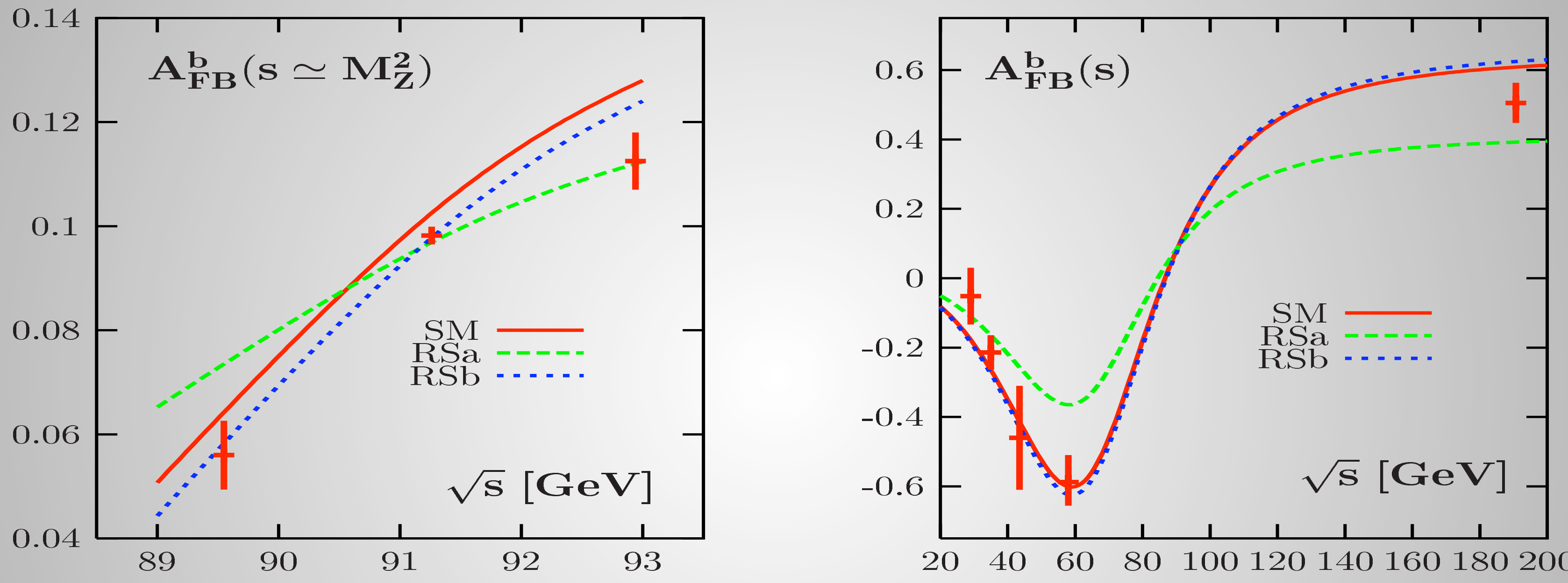


Figure 1: Normalized dijet angular distributions in several M_{jj} ranges, shifted vertically by the additive amounts given in parentheses in the figure for clarity. The data points include statistical and systematic uncertainties. The results are compared with the predictions of pQCD at NLO (solid histogram) and with the predictions including a contact interaction term of compositeness scale $\Lambda = 5$ TeV (dashed histogram). The shaded band shows the effect on the NLO pQCD predictions due to μ_r and μ_f scale variations and PDF uncertainties, as well as the uncertainties from the non-perturbative corrections added in quadrature.



Global A^b_{FB} fit @ and off the Z pôle :



SM : $\chi^2 = 24$ RSa : $\chi^2 = 20$ RSb : $\chi^2 = 14$

$$b_R \text{ under } SU(2)_L \times SU(2)_R \times U(1)_X : \begin{cases} Q_X = (B-L)/2 \Rightarrow I_R^3 = -1/2 & \text{RSa} \\ Q_X = -5/6 \Rightarrow I_R^3 = +1/2 & \text{RSb} \end{cases}$$

*What about the **whole** integrated top quark **asymmetry** and **cross section** ?*

Tevatron data [5] : 0.158 ± 0.075

SM [NLO] [5] : 0.058 ± 0.009 (-1.33σ)

RS+SM : 0.189 ± 0.010 $(+0.42\sigma)$ ← improves

[5] CDF Collaboration arXiv:1101.0034

Theoretical (HATHOR): $\sigma(p\bar{p} \to t\bar{t}) = 6.62 \pm 1$ pb

$\mu_R = \mu_F = m_t = 172.5$ GeV

MSTW PDF NNLO

Experimental (Tevatron): 7.50 ± 0.48 pb

CDF Collaboration, Note 9913, Run II, October 2009.

→ OK as heavy KK gluon with broad resonance