charm CP & top FB asymmetries in warped extra-dimensions

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[hep-ph/1204.soon]^2 with

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&
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ILHCRTeVSP workshop
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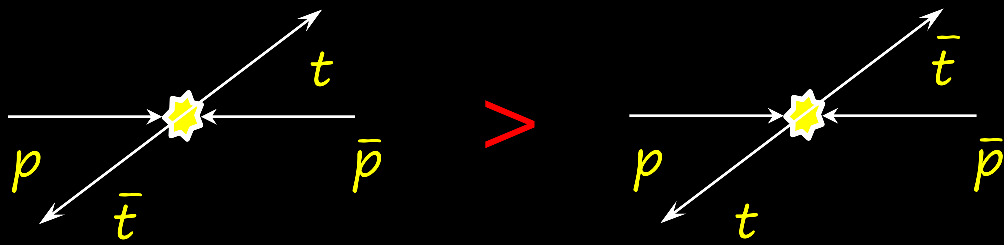
there are other interesting data! → is it new physics?

top A_{FB} @Tevatron



(unofficially) combining CDF+DO:

inclusive = (18±4)% = SM + 2.7σ
>450GeV= (28±6)% = SM + 3σ

still ok with currrent
A_C @LHC

$$\frac{\Gamma(D^0 \to K^+K^-) - CP}{+} - \frac{\Gamma(D^0 \to \pi^+\pi^-) - CP}{+} \neq 0$$

world average after CDF :
Δa_{CP} = (-0.67 ±0.16)% = 0 - 4.2σ = SM??

charm Δa_{CP} @LHCb+CDF

Intro/motivations

- Naturalness → new physics interacts « strongly » to tops
  → anomalies in top observables expected @round TeV scale

- Hadron colliders → top anomalies observable if NP also interacts sizably with light quarks (...or gluons)

- top AFB + naturalness → NP knows of t+u quarks

Damocles' sword = di-jets

- adding charm aCP a grand picture seems to emerge:
  « NP states couple sizably to the (mostly RH) up-sector »

EWPTs

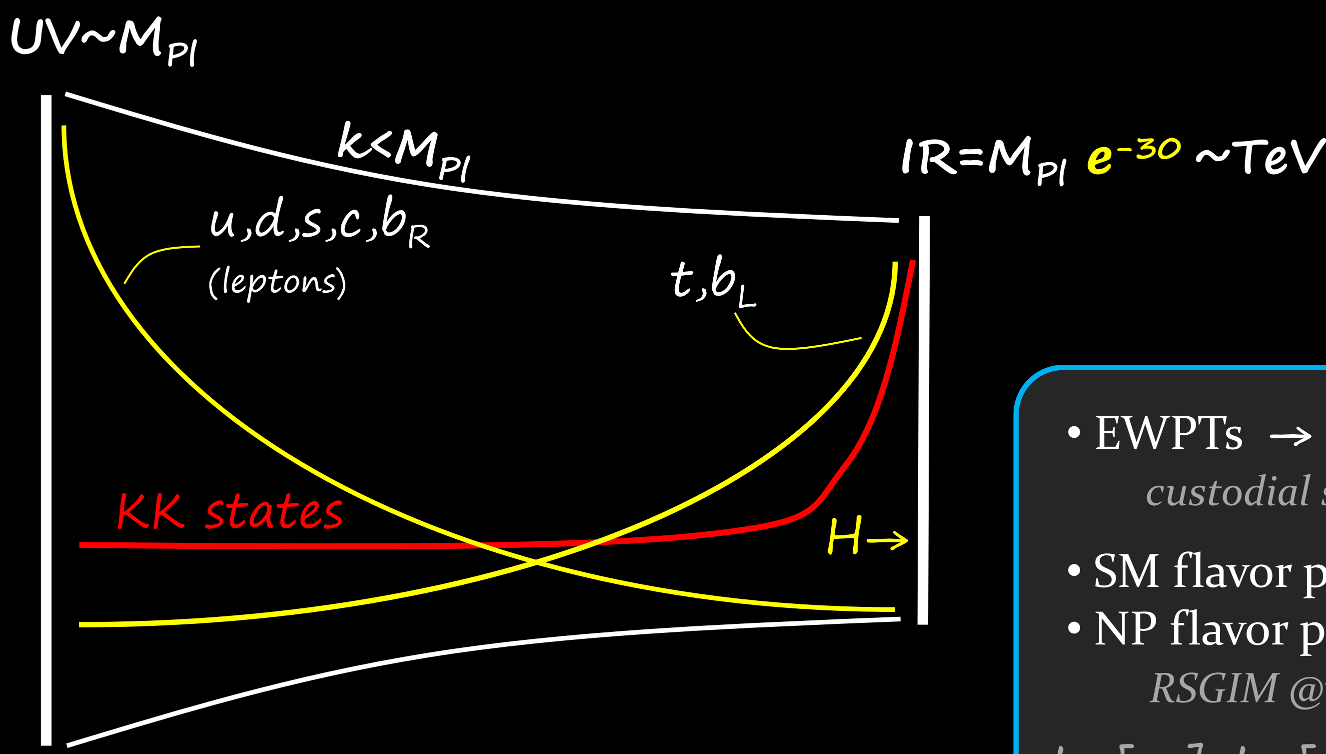
- is there a natural setup realizing this picture? (with Nsusy=0)
  → a dedicated framework is warped Xdim (or 4D composite duals)

Scenario 1

RS with Flavor Anarchy

Warped essentials

RS'99: « Hierarchy problem is solved in AdS5 bckg: $ds^2 = e^{-2ky} dx^2 - dy^2$ »



KK-gluon is the main player
@ hadron collider

- EWPTs → m_{KK}>3-4TeV

  custodial symmetry @work

- SM flavor puzzle addressed
- NP flavor problem almost solved

  RSGIM @work, yet:

  $Im[\epsilon_K]+Im[\epsilon'/\epsilon] \to m_{KK}>5TeV$

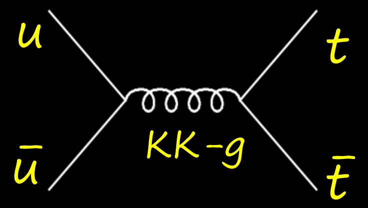
- a way out:

  down alignment, but up anarchy

Prediction of RS with flavor anarchy

anarchy: $Y_{u,d}$ & $C_{Q,u,d}$ = structureless flavor matrices

✓ top AFB? we need $(uu)_A(tt)_A$ with $\Lambda \approx TeV$ *e.g.* Weizmann group '11



elementary up has suppressed vector-like coupling to KK-g → no AFB!

✓ charm CPV? two possible NP routes:

→ $(\bar{u}c)_{V+A}(\bar{q}q)_{V+A}$ with $\Lambda_{4f} \approx 13TeV$ *(potential DDbar issue* Isidori et al '11*)*

elementary light quarks → Λ_{4f} >> 13TeV *...hopeless*

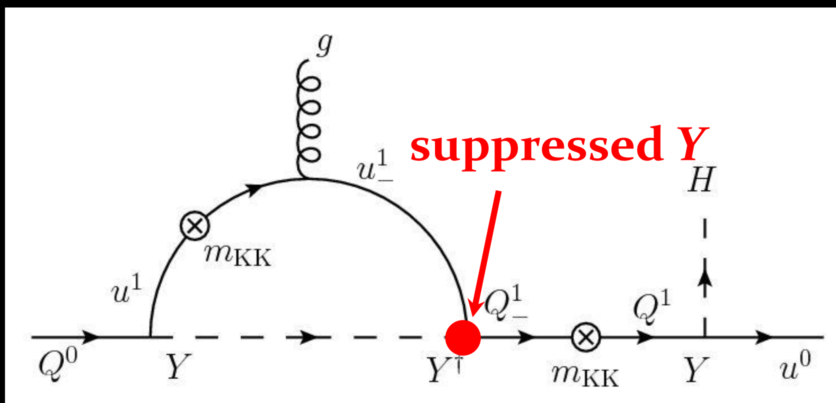
→ $g_s m_c \bar{u}_L \sigma_{\mu\nu} G^{\mu\nu} c_R$ with $\Lambda_8 \approx 20TeV$ *(no DDbar tension thanks to χ−flip* Grossman, Kagan, Nir '06*)*

light quark compositeness is swallowed in m_c → *hope!*

Charm CPV from a chromo-dipole operator

CD, Kamenik, Perez & Randall '12

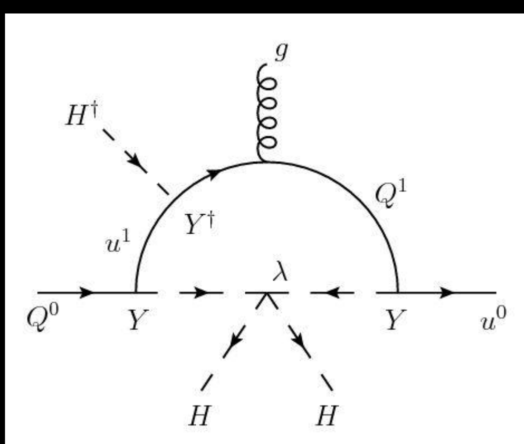
- flavor changing dipole induced at 1-loop by Yukawa int.
- «wrong» chirality KK fermions dominate for bulk Higgs



$$= \frac{g_s m_c \lambda_c Y_5^2}{16\pi^2 m_{KK}^2} \boxed{O_\beta}$$ H overlap corr. ≈ 0.1 for $\beta=0$

$\to \Delta a_{CP} = 0.6\%$ for $m_{KK}=3\,\mathrm{TeV}$, $Y_5=6$

- «same» chirality KK only induces $HH^\dagger Q H \sigma_{\mu\nu} G^{\mu\nu} u$



thanks to PQ-like symmetry of the Yukawa int.
same chirality Kks couple only to H, not $H^\dagger$

$\to$ IR higgs dipoles are one-loop finite !

$\to$ same chirality contrib. is $(v/m_{KK})^2$ suppressed

Suppressing dipoles in 4D duals

CD, Kamenik, Perez & Randall '12

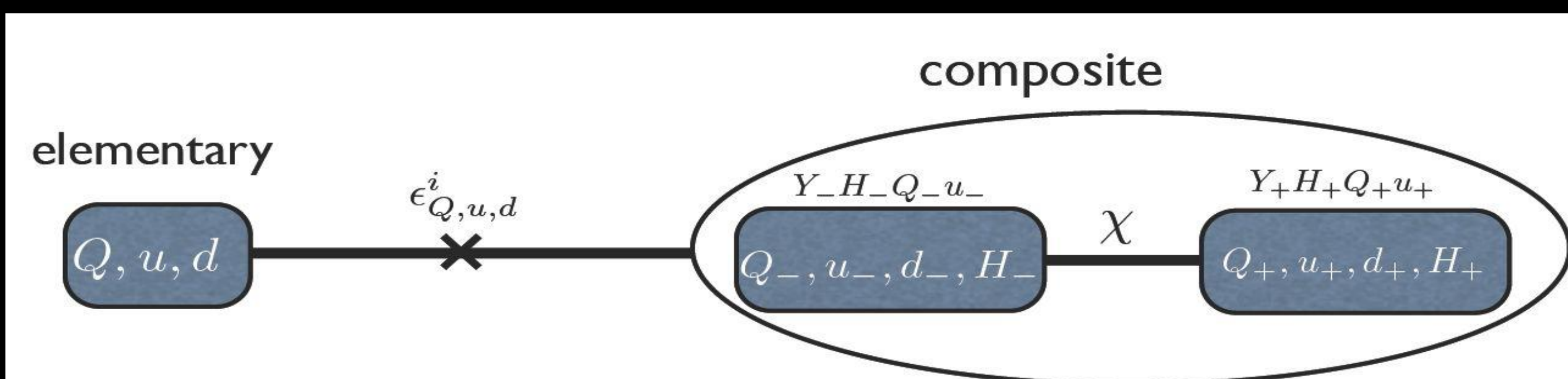
elementary
q, u, d

linear mixing

composite
$Q^{\pm}, U^{\pm}, D^{\pm}$ H
$L \supset Y\, Q^{+} H U^{+} + Y_{-}\, Q^{-} H U^{-}$

- generically: $Y \approx Y_{-}$ hence 2-site dipoles are unsuppressed
  → for m_{ρ}=3TeV, Y smaller than in 5d → DDbar mixing less suppressed

- but RS suppression is better capture by a 3-site model:



Scenario 2

RS with RH compositeness

see *e.g.* CD, Gedalia, Lee, Perez, Ponton '10
& Redi, Weiler '11

Moving away from anarchy in RH up-sector

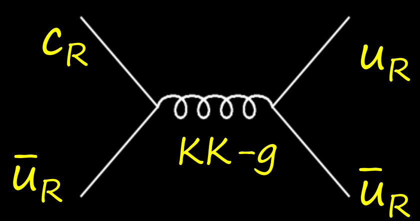
- composite u_R leads to larger A_{FB}, but from a «chiral» KK-g…

$(uu)_{V+A}(tt)_{V-A}$ → @interference level: $\delta A_{FB}^{>450} \approx -0.2 \times \delta\sigma_{700-800} < 10\%$

could be good enough but recall Damocles' sword!

CMS: «u_R composite scale > 3TeV» → max $\delta A_{FB}^{>450} \approx 6\%$ $(m_{KK}=3\text{TeV} \mid g_5=7)$

- composite u_R+c_R could lead to charm CPV via a 4F operator



$$\rightarrow \frac{1}{\Lambda_{uc}} \cdot \frac{1}{\Lambda_{uu}} \approx \frac{1}{(15\ \text{TeV})^2}$$

$\Lambda_{uc} > 1200\text{TeV}$
DDbar mixing

$\Lambda_{uu} > 200\text{GeV}$ excluded by dijets again..

… but what if $u_R u_R \rightarrow s_R s_R$?

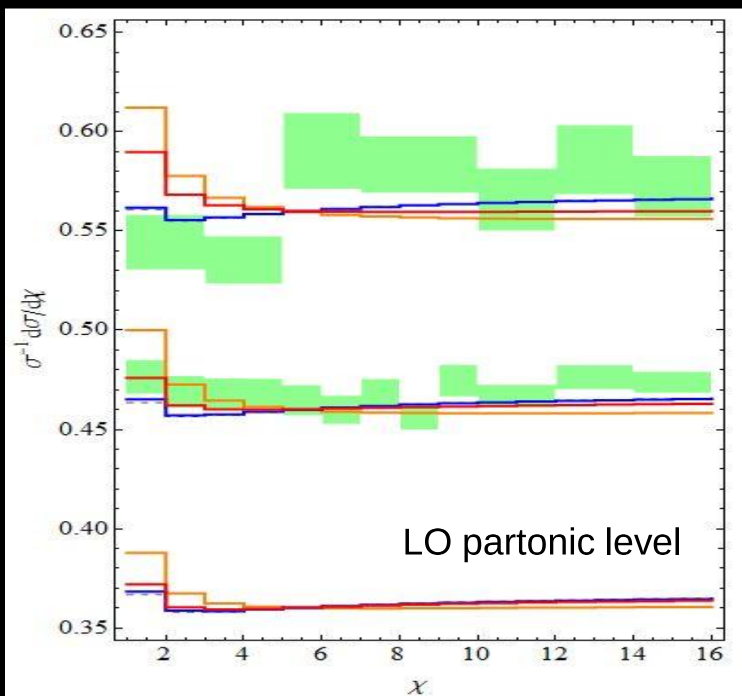
(strange is ~sea/valence suppressed inside p)

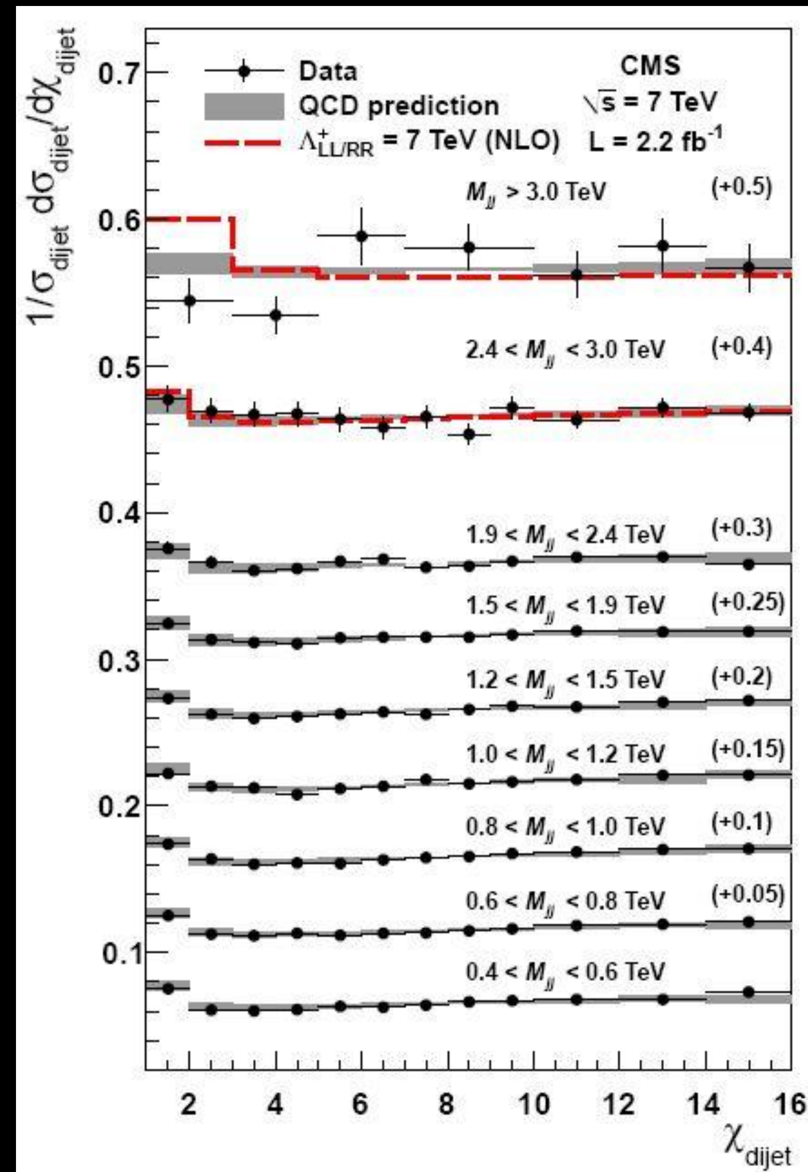
RH compositeness vs. dijet searches @CMS

$\chi = \exp(2 \times [\text{c.m.f rapidity}])$

QCD produces forward jets (~Rutherford-like scat.)

NP produces central jets → peaks at low χ





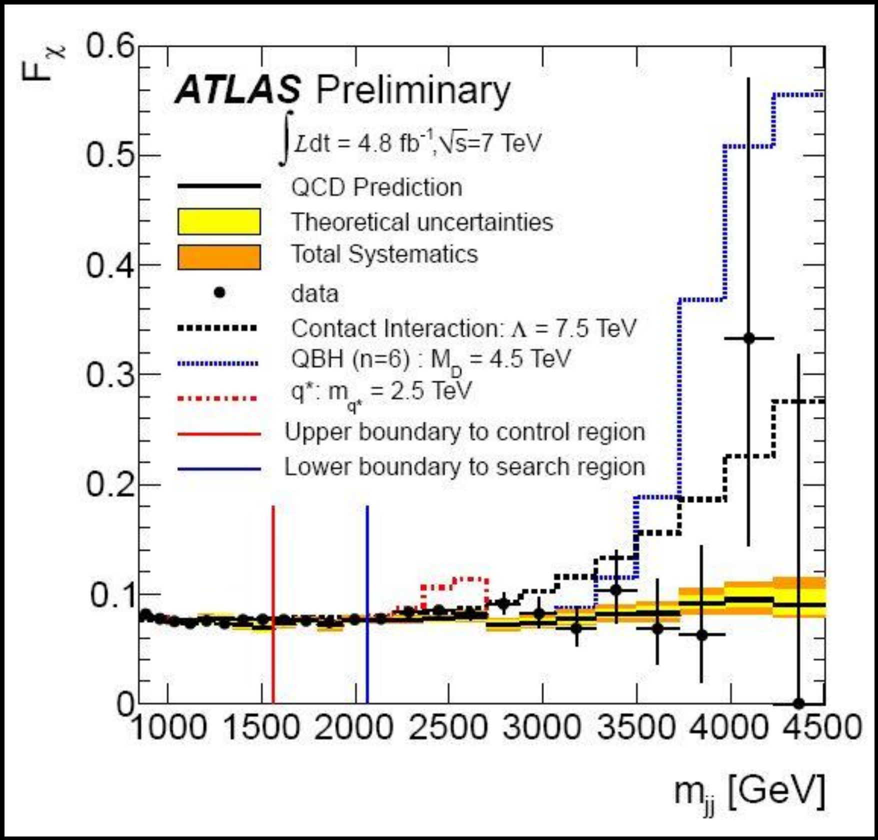
more or less allowed:

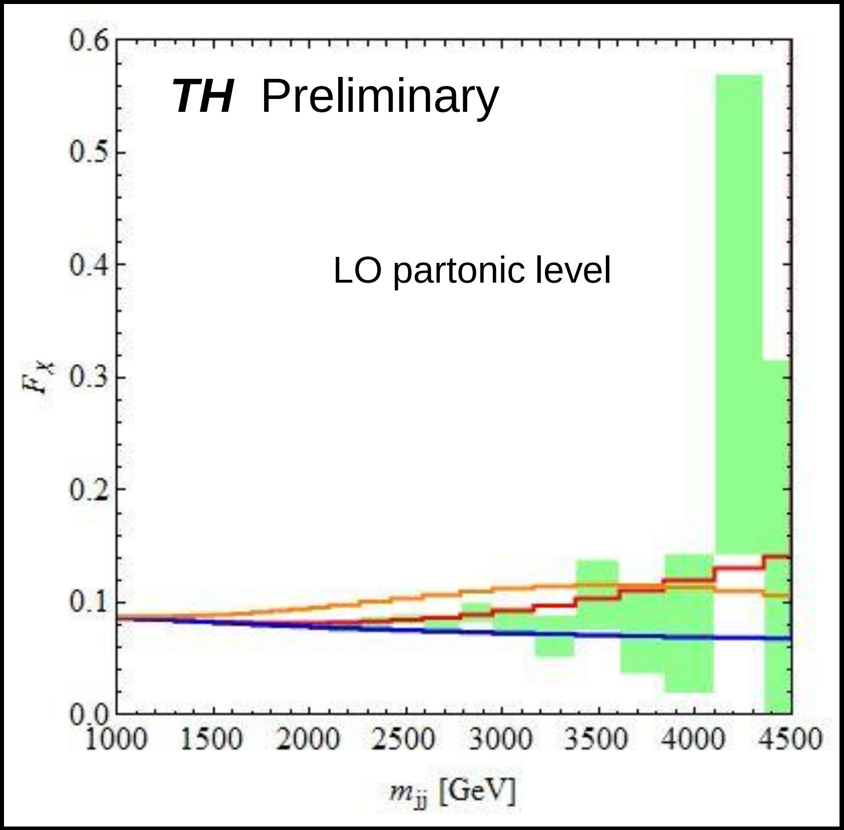
$(\bar{u}_R \gamma^\mu T^a u_R)^2/(3\,\text{TeV})^2$

$(\bar{s}_R \gamma^\mu T^a s_R)^2/(0.4\,\text{TeV})^2$

$(\bar{u}_R \gamma^\mu T^a u_R)(\bar{s}_R \gamma^\mu T^a s_R)/(0.8\,\text{TeV})^2$

RH compositeness vs. dijet searches @ATLAS





mild tension but:

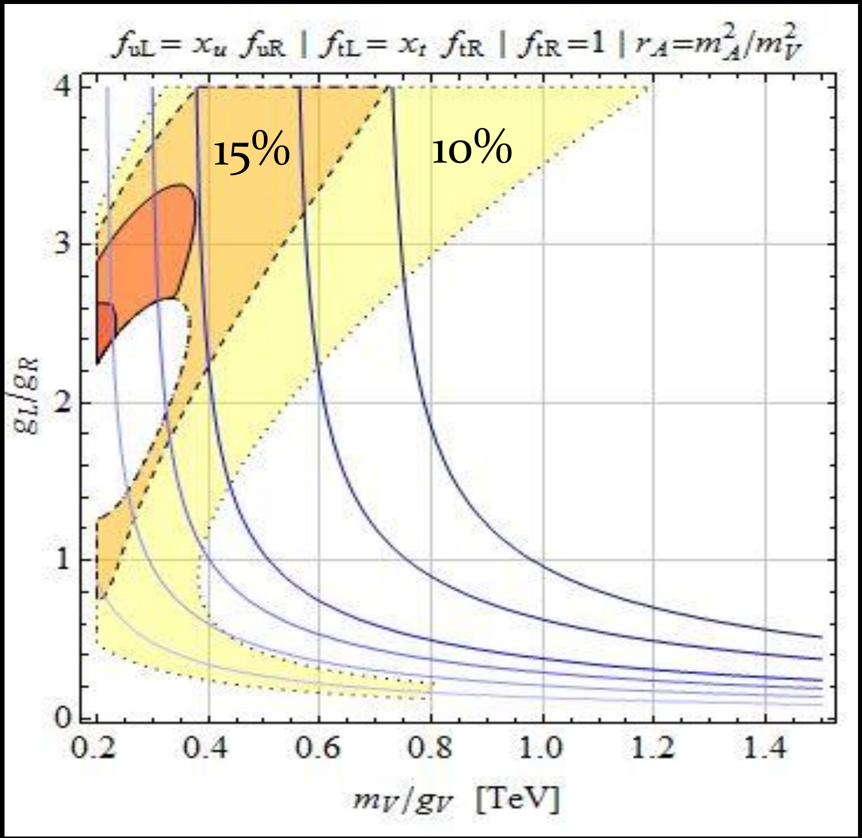
- we do not know the NP matrix el. for charm direct CPV
- NLO corr. applied to NP tend to weaken bounds by *O(20%)*
- mostly strange dijets are produced (is the analysis the same?)

Scenario 3
RS with RH compositeness
+ custodial SU(3)

Da Rold, CD, Grojean, Perez '12

RS + color SU3xSU3

- color SU3 extended to $SU3_L xSU3_R$ in the bulk
- $SU3^2$ needs to be broken to get quark masses → $\langle\phi\rangle=(3,3^*)$
- 1st put forward for solving ε_K Bauer et al. '11
- however this is still useful for A_{FB}



+ charm CPV? same story,
also achievable via 4F op.

→ this setup can accomodate
large NP A_{FB} + a_{CP} …
… and it's technically natural

outro/outlook

- if top+charm asym. are due to some NP, this hints for a natural paradigm where the RH-up sector is composite.
- charm CPV is «post-predicted» by flavor anarchy in the up-sector, and it predicts $a_{CP}(KK)=a_{CP}(\pi\pi)$, but no AFB…
- composite RH quarks allows for o(5%) AFB, opens the door of charm CPV via sR, compatible with present dijet searches and $a_{CP}(KK)>>a_{CP}(\pi\pi)$
- If larger AFB is needed, more drastic changes are required, eg. extend the color sym. to SU3xSU3, this can lead to o(15%) AFB + again direct charm CPV.
- looks contrived but still an interesting paradigm to keep an eye on:

  naturalness+A_{FB}(+a_{CP}) → composite up sector (+s_R)

  → dijet signal soon