Two new physics paths to charm CP asymmetry

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[hep-ph/soon.!?!?][2] *with*
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Introduction

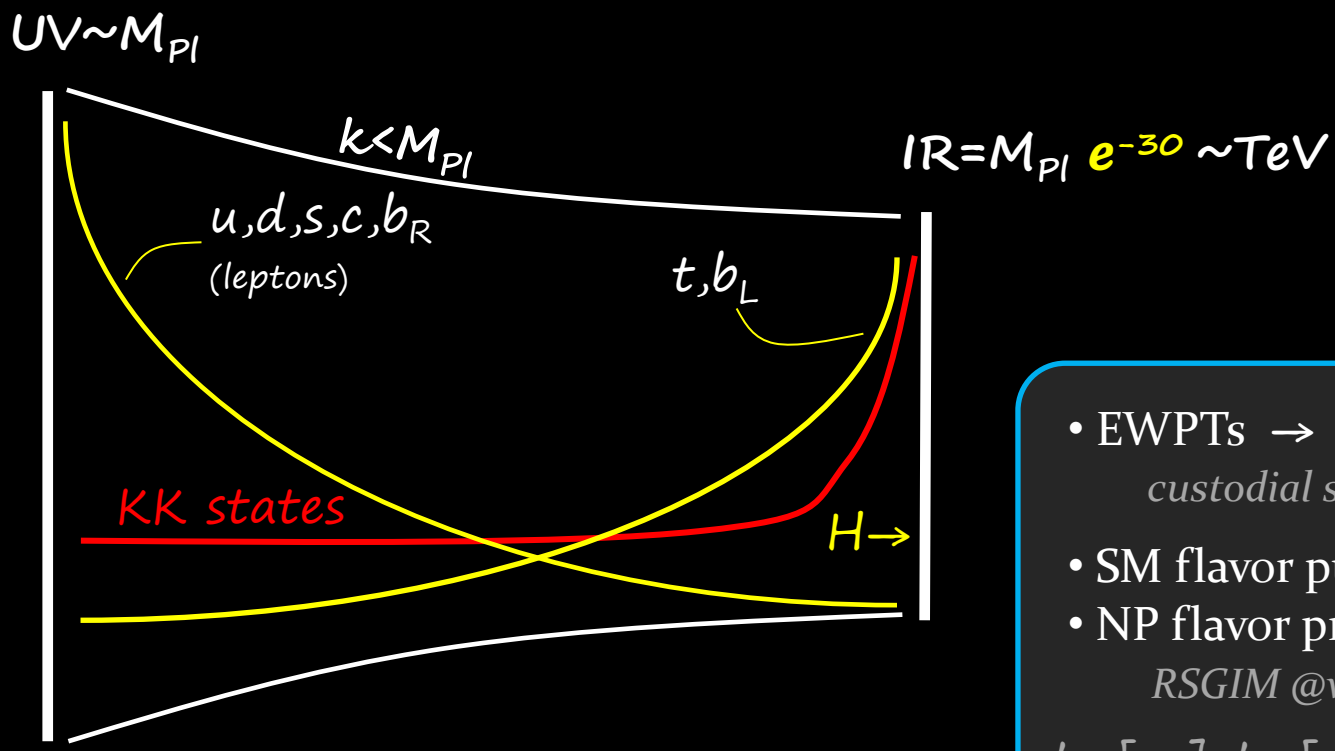
- LHCb+CDF: $\Delta a_{CP} = (-0.67 \pm 0.16)\% = 0 - 4.2\sigma$ = SM??
- if charm CPV is not SM-like, then 2 NP routes:
  - → $(uc)_{V+A}(qq)_{V+A}$ with $\Lambda_{4f} \approx 1.5\,\text{TeV}$ | *model dependent DDbar issue*
    Isidori et al '11
  - → $g_s m_c u_L \sigma_{\mu\nu} G^{\mu\nu} c_R$ with $\Lambda_8 \approx 20\,\text{TeV}$ | *no DDbar thanks to chirality flip*
    Grossman, Kagan, Nir '06
- NP must solve the hierarchy problem
  - $N_{susy}>0$: see Giudice, Isidori & Paradisi '12 & Hiller, Hochberg & Nir '12
  - $N_{susy}=0$: warped extra dimension (or 4D composite models) **this talk**
- $\Lambda_8 \sim 20\,\text{TeV}$ arises in flavor anarchic strong TeV dynamics
  → *implications ?*
- $\Lambda_{4f} \sim 1.5\,\text{TeV}$ possible if light RH-quarks are composite
  → *does it pass present dijet constraints ?*

The dipole way to charm CPV

RS + flavor anarchy

Warped essentials

RS'99: « Hierarchy problem is solved in AdS$_5$ bckg: $ds^2 = e^{-2ky} dx^2 - dy^2$ »



- EWPTs → m_{KK}>3-4TeV
  custodial symmetry @work
- SM flavor puzzle addressed
- NP flavor problem almost solved
  RSGIM @work, yet:

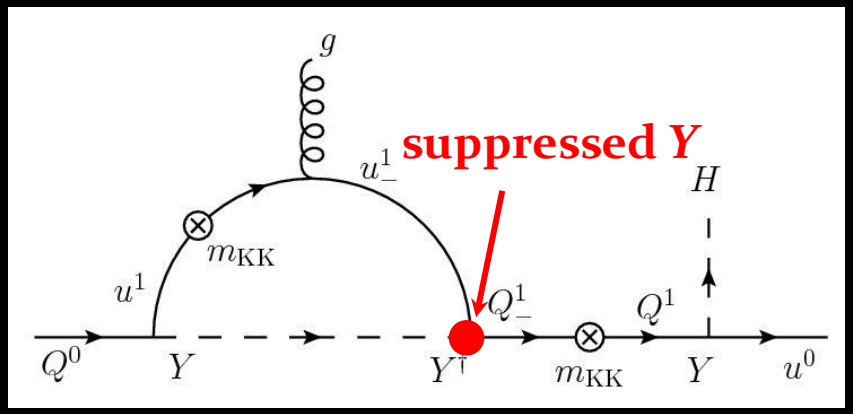
$Im[\epsilon_K]+Im[\epsilon'/\epsilon]$ → m_{KK}>5TeV

- a way out *(supported by Daya bay)*:
  down alignment, but up anarchy

Charm CPV from a chromo-dipole operator

CD, Kamenik, Perez & Randall '12

- Flavor changing dipole induced at 1-loop by Yukawa int.
- Bulk Higgs: «wrong» chirality KK fermions dominate



$$C_8 = \frac{\lambda_c Y_5^2}{16\pi^2 m_{KK}^2} O_\beta$$

H overlap corr. ≈0.1 for β=0

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

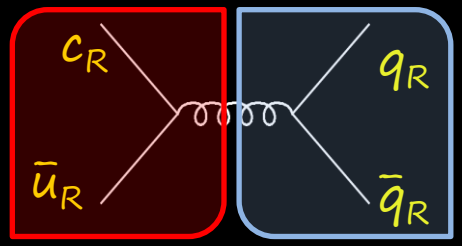
- First implications:
  - overlap suppression requires a larger *Y* than in generic 4D duals
    → DDbar mixing in 5D is typically more suppressed
  - gluon coupling is flavor blind → $a_{CP}(KK) = a_{CP}(\pi\pi)$

The 4-fermion way to charm CPV

RH quarks compositeness

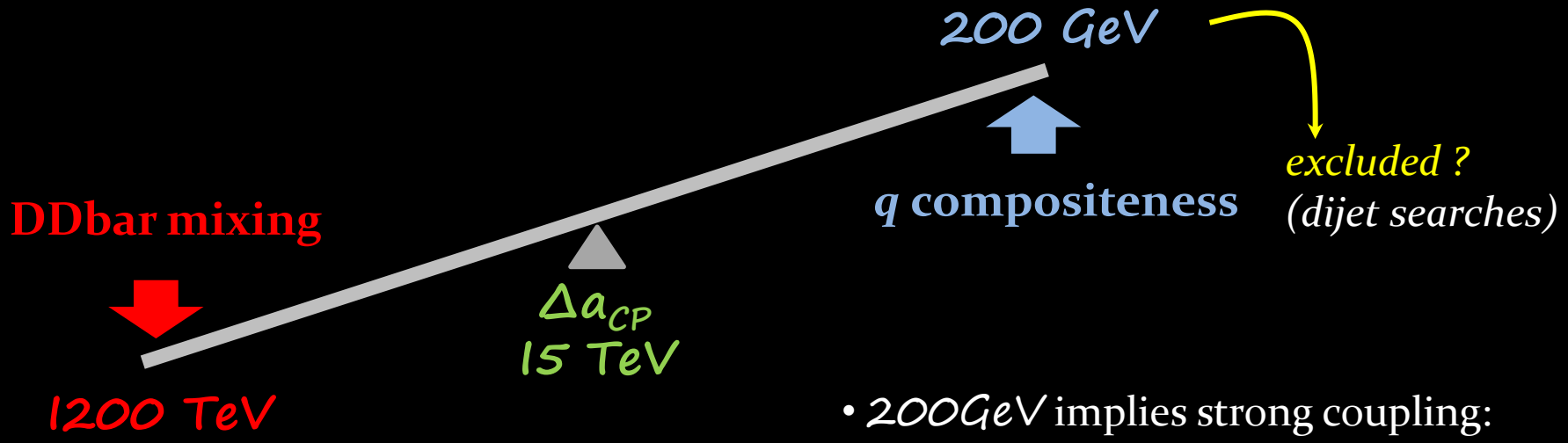
Charm CPV from composite RH light quarks

- for *S*-channel mediated *ubar c* → *qbar q* transitions:



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

- The D meson see-saw: $\Lambda_{\Delta c=2} \approx 1200\text{TeV} \gg \Lambda_{\Delta c=1} \approx 15\text{TeV}$

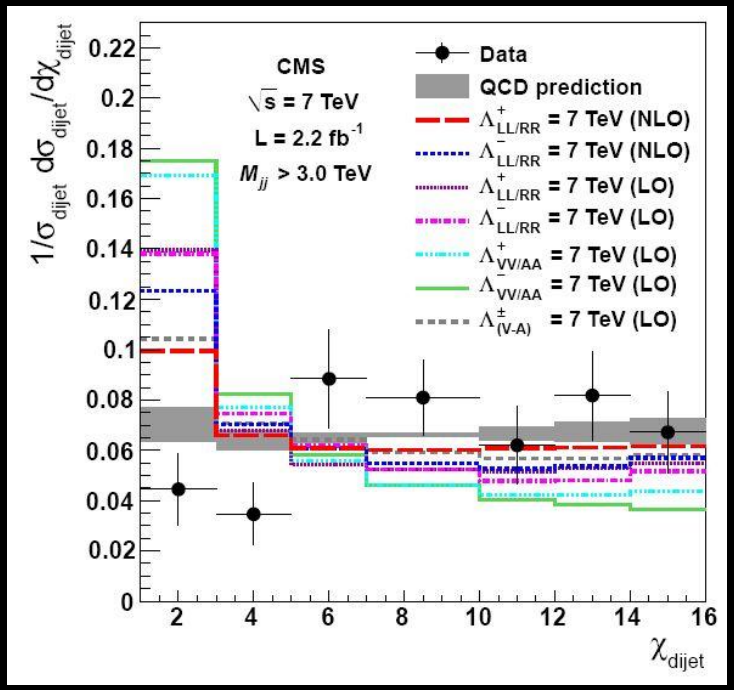


- 200GeV implies strong coupling:
  $\Lambda_{NDA} \sim 200\text{GeV} \times 4\pi \approx 2.5\text{TeV}$
- $q=u,d$ excluded $\Lambda_{uu} \geq 3\text{TeV}$
  → what if $q=s$?

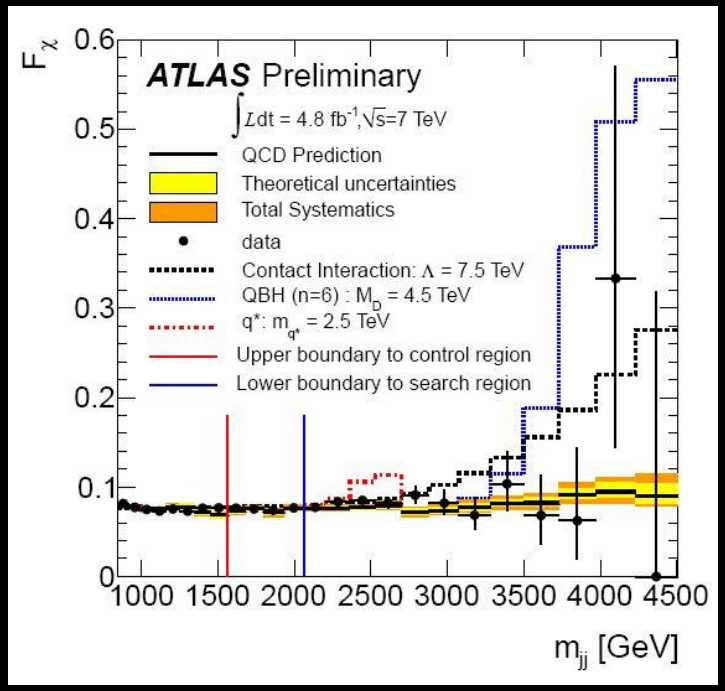
Dijet searches & compositeness scale

- Dijet searches sensitive to 4F operators involving light quarks
- strategy:
  - **QCD** mostly produces forward jets through the exchange of massless particles in t-channel
  - Contact interactions produce more isotropic jets → dominates @low y
  - construct angular variable $\chi = exp(2y)$ to exploit the different kin.

$\sigma^{-1} d\sigma/d\chi$ from CMS



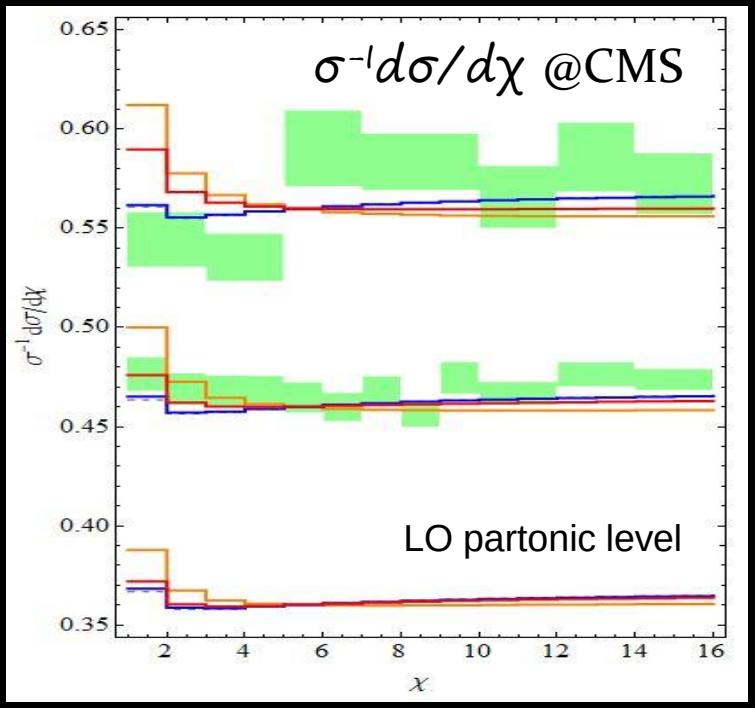
$F_\chi = \sigma(y<0.6)/\sigma(y<1.7)$ from ATLAS

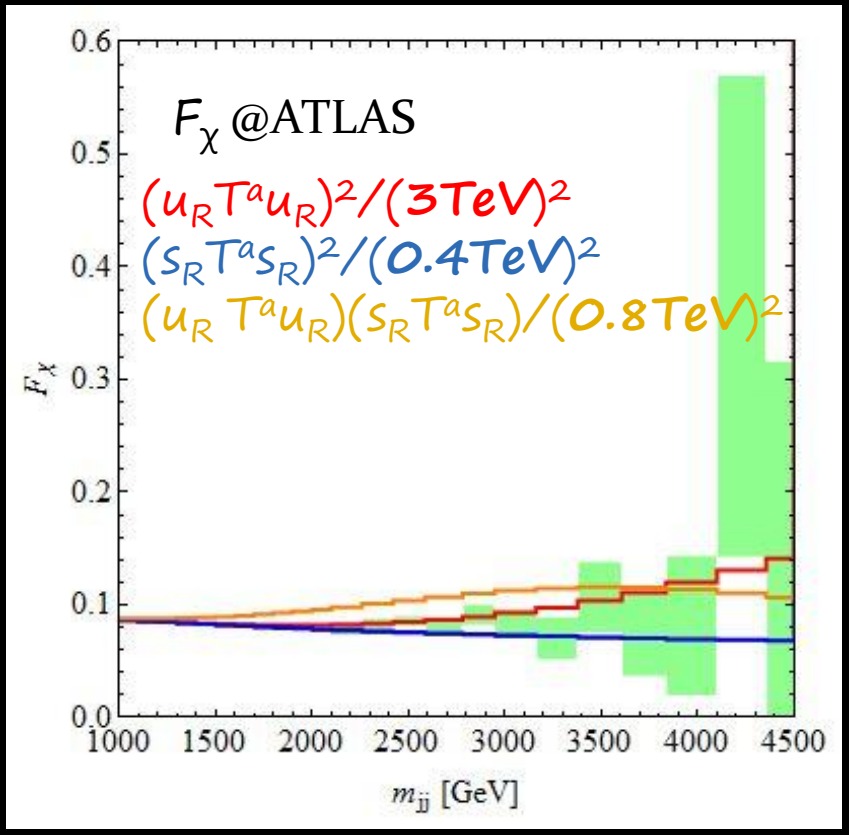


Light quark compositeness vs. dijet searches

see also Domenech, Pomarol & Sera '12

Δa_{CP} from s-channel FCNC → $(\bar{s}_R s_R)^2/(200\text{GeV})^2$





- color octet favored bounds for singlet is √3 stronger
- negative Wilson coefficient induced

mild tension but:

- NP matrix elem. for charm direct CPV are unknown
- NLO QCD corr. applied to NP weakens bounds by $o(20\%)$
- mostly strange jets are produced

Conclusions/Outlook

- warped Xdim + up-type flavor anarchy induces Q_8 with the right size to explain charm CPV with $a_{CP}(KK)=a_{CP}(\pi\pi)$

- composite s_R opens a 4F possibility for Δa_{CP}
  OK with dijets @LHC and predicts $a_{CP}(KK)\gg a_{CP}(\pi\pi)$

- other ways to distinguish between the 2 NP routes:
  - CPV in radiative D decays from Q_8 induced Q_7 (see Gino's talk)
  - strange dijets @LHC should pop up from a 4F operator

- naturalness + Δa_{CP} + top A_{FB} hints for an intriguing paradigm: partial compositeness + RH composite quarks