Flavour-changing physics beyond the Standard Model

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- Introduction: the SM as an effective theory
- What we learned so far about flavour physics BSM
- What we could still hope to learn
  - LFV in charged leptons
  - Very rare K decays
  - Helicity-suppressed B (and K) decays
- Q&A for 2014
- Conclusions
- Extra slides
  - Flavour constraints in the "constrained" MSSM
  - Large non-standard effetcs in B_s mixing

Introduction: the SM as an effective theory

Particle physics is described with good accuracy by a simple and *economical* theory:

$$\mathscr{L}_{\rm SM} = \mathscr{L}_{\rm gauge}(A_a, \psi_i) + \mathscr{L}_{\rm Higgs}(\phi, A_a, \psi_i)$$

- *Natural*
- Experimentally tested with high accuracy
- Stable with respect to quantum corrections
- Higly symmetric (*gauge & flavour symmetries*)

- *Ad hoc*
- Necessary to describe data (*clear indication of a non-symmetric vacuum*) but not tested in its dynamical form
- Not stable with respect to quantum corrections

Introduction: the SM as an effective theory

Particle physics is described with good accuracy by a simple and *economical* theory. However, this is likely to be only the low-energy limit of a more fundamentaly theory:

$$\mathcal{L}_{\rm eff} = \mathcal{L}_{\rm gauge}(A_a, \psi_i) + \mathcal{L}_{\rm Higgs}(\phi, A_a, \psi_i) + \sum_{d\geq 5} \frac{c_n}{\Lambda^{d-4}} O_n^{(d)}(\phi, A_a, \psi_i)$$

$\mathcal{L}_{\rm SM}$ = renormalizable part of $\mathcal{L}_{\rm eff}$
= all possible operators with $d \leq 4$
compatible with the gauge symmetry

most general parameterization of the new (heavy) degrees of freedom, as long as we perform low-energy experiments

Introduction: the SM as an effective theory

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new sources of flavour-symmtry breaking that we can explore only with low-energy exps.

Two key questions of particle physics today:

- Which is the energy scale of New Physics (Λ around TeV ?) → High-energy experiments (LHC) [*the high-energy frontier*]
- Which is the symmetry structure of the new degrees of freedom → High-precision low-energy exp. [*the high-intensity frontier*]

$$\mathscr{L}_{\text{eff}} = \mathscr{L}_{\text{gauge}}(A_a, \psi_i) + \mathscr{L}_{\text{Higgs}}(\phi, A_a, \psi_i) + \sum_{d\geq 5} \frac{c_n}{\Lambda^{d-4}} O_n^{(d)}(\phi, A_a, \psi_i)$$

3 identical replica of the basic fermion family

$[\ \psi_i = Q_L, u_R, d_R, L_L, e_R\ ]$ $\Rightarrow$ huge flavour-degeneracy [$U(3)^5$ group]

$$U(1)_L \times U(2)_B \times SU(3)_Q \times SU(3)_U \times SU(3)_D \times \ldots$$

Lepton number | Barion number | *Flavour mixing*

$$\mathcal{L}_{eff} = \mathcal{L}_{gauge}(A_a, \psi_i) + \mathcal{L}_{Higgs}(\phi, A_a, \psi_i) + \sum_{d\geq 5} \frac{c_n}{\Lambda^{d-4}} O_n^{(d)}(\phi, A_a, \psi_i)$$

3 identical replica of the basic fermion family
[$\psi_i = Q_L, u_R, d_R, L_L, e_R$] $\Rightarrow$ huge flavour-degeneracy [$U(3)^5$ group]

Within the SM the flavour-degeneracy is broken only by the Yukawa interaction:

in the quark sector:

$$\bar{Q}_L^i Y_D^{ik} d_R^k \phi \rightarrow \bar{Q}_L^i M_D^{ik} d_R^k$$

$$\bar{Q}_L^i Y_U^{ik} u_R^k \phi_c \rightarrow \bar{Q}_L^i M_U^{ik} u_R^k$$

Nowadays we have an *excellent knowledge* of all the physical couplings appearing in the quark- Yukawa sector...

$$M_D = \text{diag}(m_d, m_s, m_b)$$

$$M_U = V \times \text{diag}(m_u, m_c, m_t)$$

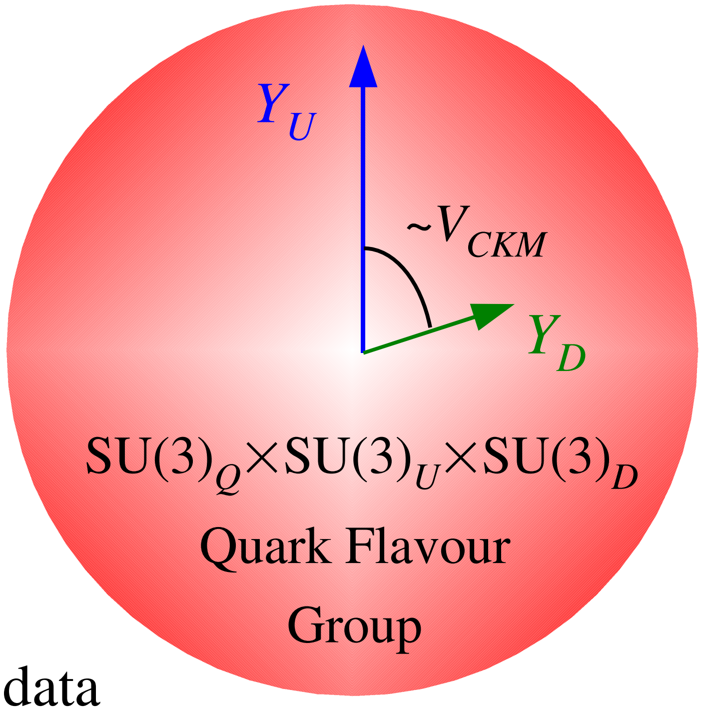
V → The CKM matrix

$$\mathscr{L}_{\rm eff} = \mathscr{L}_{\rm gauge}(A_a, \psi_i) + \mathscr{L}_{\rm Higgs}(\phi, A_a, \psi_i) + \sum_{d\geq 5} \frac{c_n}{\Lambda^{d-4}} O_n^{(d)}(\phi, A_a, \psi_i)$$

... while we still have a rather limited knowledge of the flavour structure of the new degrees of freedom (which hopefully will show up around the TeV scale)

We have some favourite scenarios, such as

MFV = *assumption that the SM Yukawa couplings are the only non-trivial flavour-breaking terms also beyond the SM*



However, at this stage these are still theoretical speculations, far from being clearly established from data

The main goal of future experiments in flavour physics is trying to understand if there are additional non-trivial flavour breaking terms beside the SM Yukawas

$$\mathcal{L}_{eff} = \mathcal{L}_{gauge}(A_a, \psi_i) + \mathcal{L}_{Higgs}(\phi, A_a, \psi_i) + \sum_{d\geq 5} \frac{c_n}{\Lambda^{d-4}} O_n^{(d)}(\phi, A_a, \psi_i)$$

... while we still have a rather limited knowledge of the flavour structure of the new degrees of freedom (which hopefully will show up around the TeV scale)

Rare flavour-changing transitions, particularly FCNCs [$q_i \to q_j + \gamma,\ l^+l^-, \nu\nu$], and loop-induced CP-violating observables, are the observables more sensitive to these new flavour-breaking couplings:

E.g.: $$A(s \to d)_{FCNC} \sim \frac{y_t^2 V_{ts}^* V_{td}}{16\,\pi^2 M_W^2} + \frac{\Delta_{sd}}{\Lambda^2}$$

- No SM tree-level contributions
- Strong SM suppression due to CKM hierarchy
- Predicted with high precision when dominated by short-distance (e.w.) dynamics

$$\mathscr{L}_{\rm eff} = \mathscr{L}_{\rm gauge}(A_a, \psi_i) + \mathscr{L}_{\rm Higgs}(\phi, A_a, \psi_i) + \sum_{d\geq 5} \frac{c_n}{\Lambda^{d-4}} O_n^{(d)}(\phi, A_a, \psi_i)$$

N.B.: General decomposition of flavour-violating observables:

$$A = A_0 \left[c_{SM} \frac{1}{M_W^2} + c_{NP} \frac{1}{\Lambda^2} \right]$$

(adimensional) effective couplings

trivial kinematical factors

This decomposition is very general. It holds also for forbidden processes ($\mu \rightarrow e\gamma$), charged currents ($B \rightarrow l\nu$), or CP-violating observables ($A_{CP}(B_d \rightarrow \psi K)$).

It is based only on the assumption that the new degrees of freedom respect the $SU(2)_L \times U(1)$ gauge symmetry

$$\mathcal{L}_{\rm eff} = \mathcal{L}_{\rm gauge}(A_a, \psi_i) + \mathcal{L}_{\rm Higgs}(\phi, A_a, \psi_i) + \sum_{d\geq 5} \frac{c_n}{\Lambda^{d-4}} O_n^{(d)}(\phi, A_a, \psi_i)$$

N.B.: General decomposition of flavour-violating observables:

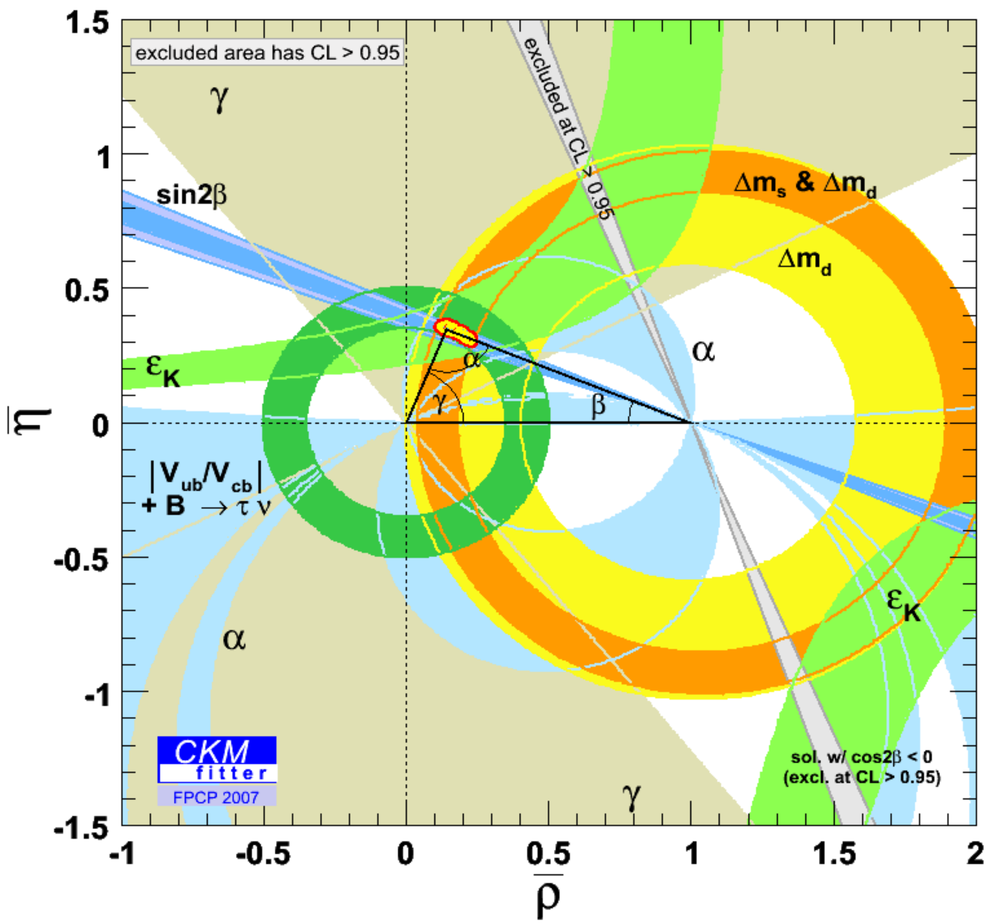
$$\Gamma \propto \left| c_{SM} \frac{1}{M_W^2} + c_{NP} \frac{1}{\Lambda^2} \right|^2$$

↓

- The sensitivity to the energy scale grows slowly with the statistics or the luminosity of the experiment ($\sigma \sim 1/N^{1/4}$) ⇒ new exps. should be ambitious...
- The interest of a given flavour obs. depends on the magnitude of c_{SM} vs. c_{NP} and on the theoretical error of c_{SM} ⇒ ...concentrate on clean & rare processes...
- No way to disentangle Λ & c_{NP}, but the combined information which can be extracted is fully complementary to direct searches at high-p_T: flavour symmetry structure of NP ⇒ ...and should not worry too much about the LHC

What we learned so far about flavour physics BSM

The SM is very successful in describing quark-flavour mixing: this is quite clear by looking at the consistency of the exp. constraints appearing in the so called CKM fits, and is confirmed by the absence of significant deviations from the SM in clean rare decays such as $B \to X_s \gamma$



↓

New physics effects in quark-flavour mixing can only appear as small corrections to the leading CKM mechanism

What we learned so far

FLAVOUR COUPLING: [$\lambda = \sin\theta_c \approx 0.22$]

ELECTROWEAK STRUCTURE

	$b \to s$ $(\sim\lambda^2)$	$b \to d$ $(\sim\lambda^3)$	$s \to d$ $(\sim\lambda^5)$
ΔF=2 box	$(b_L \Gamma s_L)^2$	$(b_L \Gamma d_L)^2$	$(s_L \Gamma d_L)^2$
ΔF=1 4-quark box	⋮		
gluon penguin			
γ penguin			
Z^0 penguin			
H^0 penguin			

The FCNC matrix:

each box correspond to an independent combination of dim.-6 gauge-invariant operators

What we learned so far

FLAVOUR COUPLING:

ELECTROWEAK STRUCTURE

	$b \to s$ $(\sim\lambda^2)$	$b \to d$ $(\sim\lambda^3)$	$s \to d$ $(\sim\lambda^5)$
$\Delta F=2$ box	$\Lambda > 100$ TeV from Δm_{Bs}	$\Lambda > 2\times10^3$ TeV from $A_{CP}(B_d \to \psi K)$	$\Lambda > 2\times10^4$ TeV from ε_K
$\Delta F=1$ 4-quark box			
gluon penguin	$\Lambda > 80$ TeV from $B(B \to X_s \gamma)$		$\Lambda > 10^3$ TeV from $\varepsilon'/\varepsilon_K$
γ penguin	$\Lambda > 150$ TeV from $B(B \to X_s \gamma)$		
Z^0 penguin	$\Lambda > 20$ TeV from $B(B \to X_s l^+ l^-)$		
H^0 penguin			

Bounds on Λ assuming O(1) flavour-changing couplings

What we learned so far

FLAVOUR COUPLING:

ELECTROWEAK STRUCTURE	$b \to s$ $(\sim\lambda^2)$	$b \to d$ $(\sim\lambda^3)$	$s \to d$ $(\sim\lambda^5)$
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ΔF=1 4-quark box			
gluon penguin			
γ penguin			
Z^0 penguin			
H^0 penguin			

If we want to keep Λ ~ TeV
(some) of the new eff. couplings
must be quite small

↓

we need some alignment between SM and BSM flavour-violating couplings

Scenarios such as MFV (=perfect alignment)
are favourite,
but they could also be only an
approxmate solution...

What we learned so far

FLAVOUR COUPLING:

ELECTROWEAK STRUCTURE

	$b \to s$ $(\sim\lambda^2)$	$b \to d$ $(\sim\lambda^3)$	$s \to d$ $(\sim\lambda^5)$
$\Delta F=2$ box	$A_{CP}(B_s \to \psi\phi)$	$\Lambda > 2\times10^3$ TeV from $A_{CP}(B_d \to \psi K)$	$\Lambda > 2\times10^4$ TeV from ε_K
$\Delta F=1$ 4-quark box			
gluon penguin	$\Lambda > 80$ TeV from $B(B \to X_s\gamma)$		
γ penguin	$\Lambda > 150$ TeV from $B(B \to X_s\gamma)$		
Z^0 penguin	$\Lambda > 20$ TeV from $B(B \to X_s l^+l^-)$		$K \to \pi\nu\nu$ $K_L \to \pi^0 l^+l^-$
H^0 penguin	$B_s \to \mu\mu$	$B_d \to \mu\mu$	

...there are still interesting corners which could hide sizable non-standard effects

What we could still hope to learn

General arguments:

- New exps. should be ambitious...
- ...concentrate on clean & rare processes...
- ...and should not worry too much about what will happen at the LHC

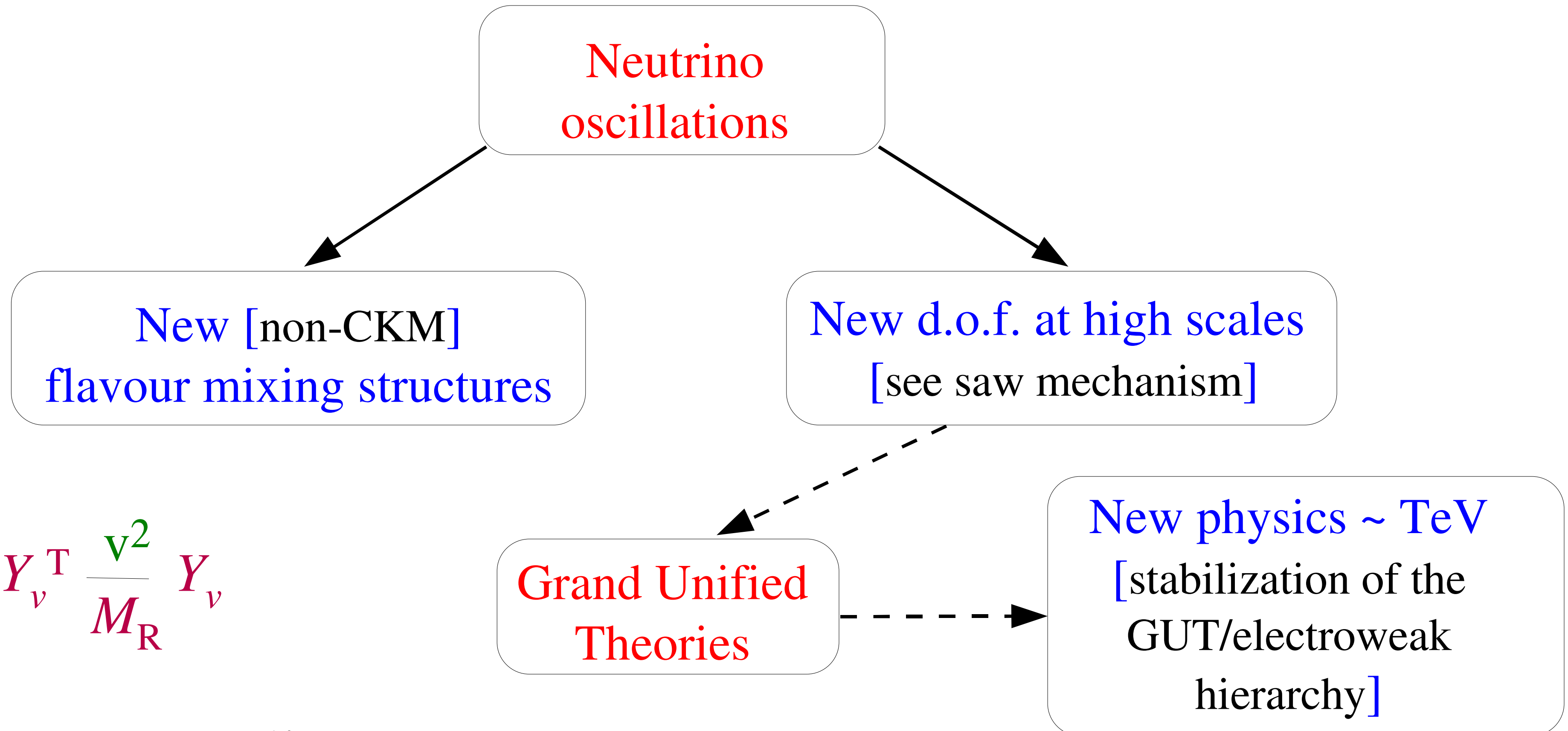
A closer look to three particulary relevant sectors:

LFV in charged leptons	Very rare K decays	Helicity- suppressed B (and K) decays

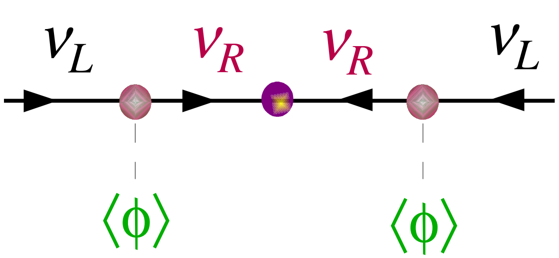
N.B.: This choice reflects some theoretical prejudicies...

I. Lepton Flavour Violation in charged leptons

After what we learned from neutrino physics, LFV in charged leptons is probably the most interesting search in the flavour sector:



$$m_\nu \sim Y_\nu^{T} \frac{v^2}{M_R} Y_\nu$$



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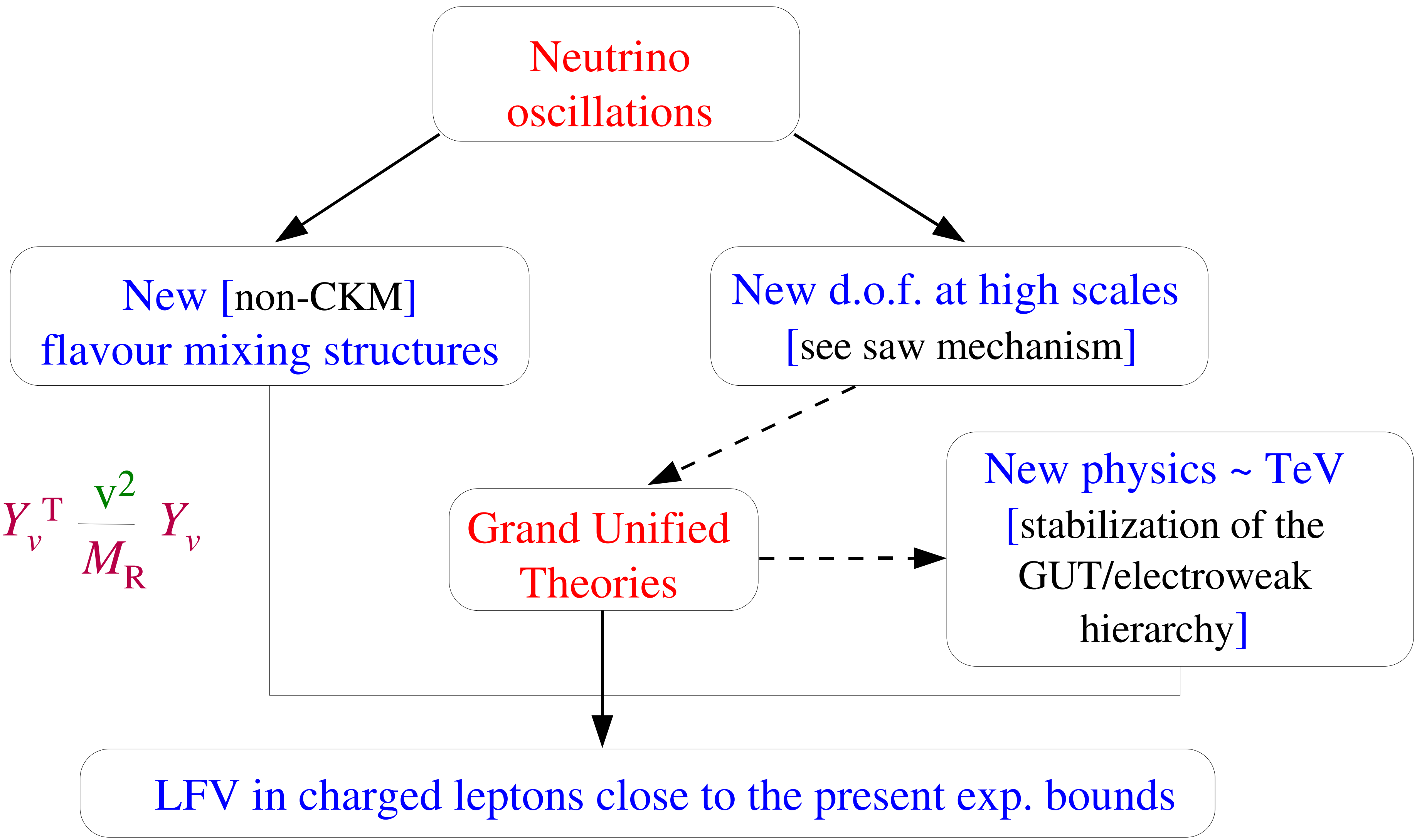
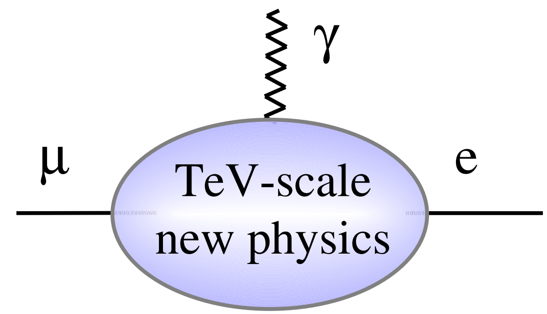


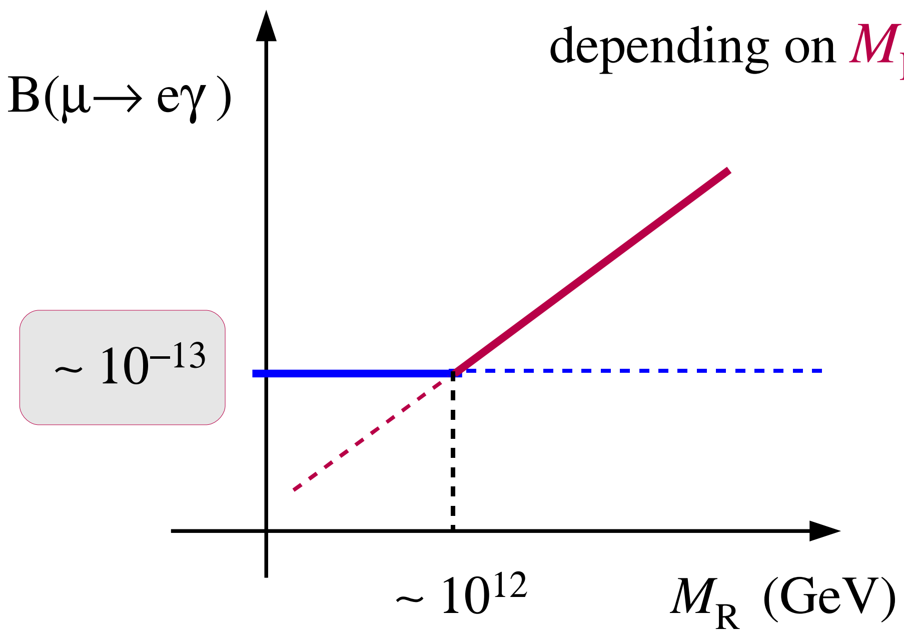
In non-GUT theories we can arbitrarily suppress LFV rates by lowering M_R (or the normalization of Y_ν). This is not possible in GUT frameworks ⇒ contribution from quark Yukawas which are M_R-independent

$$A(l_i \to l_j \gamma) = a\,[Y_e Y_\nu^+ Y_\nu]_{ij} + b\,[Y_U^+ Y_U Y_D]_{ij}$$



Normalization depending on M_R

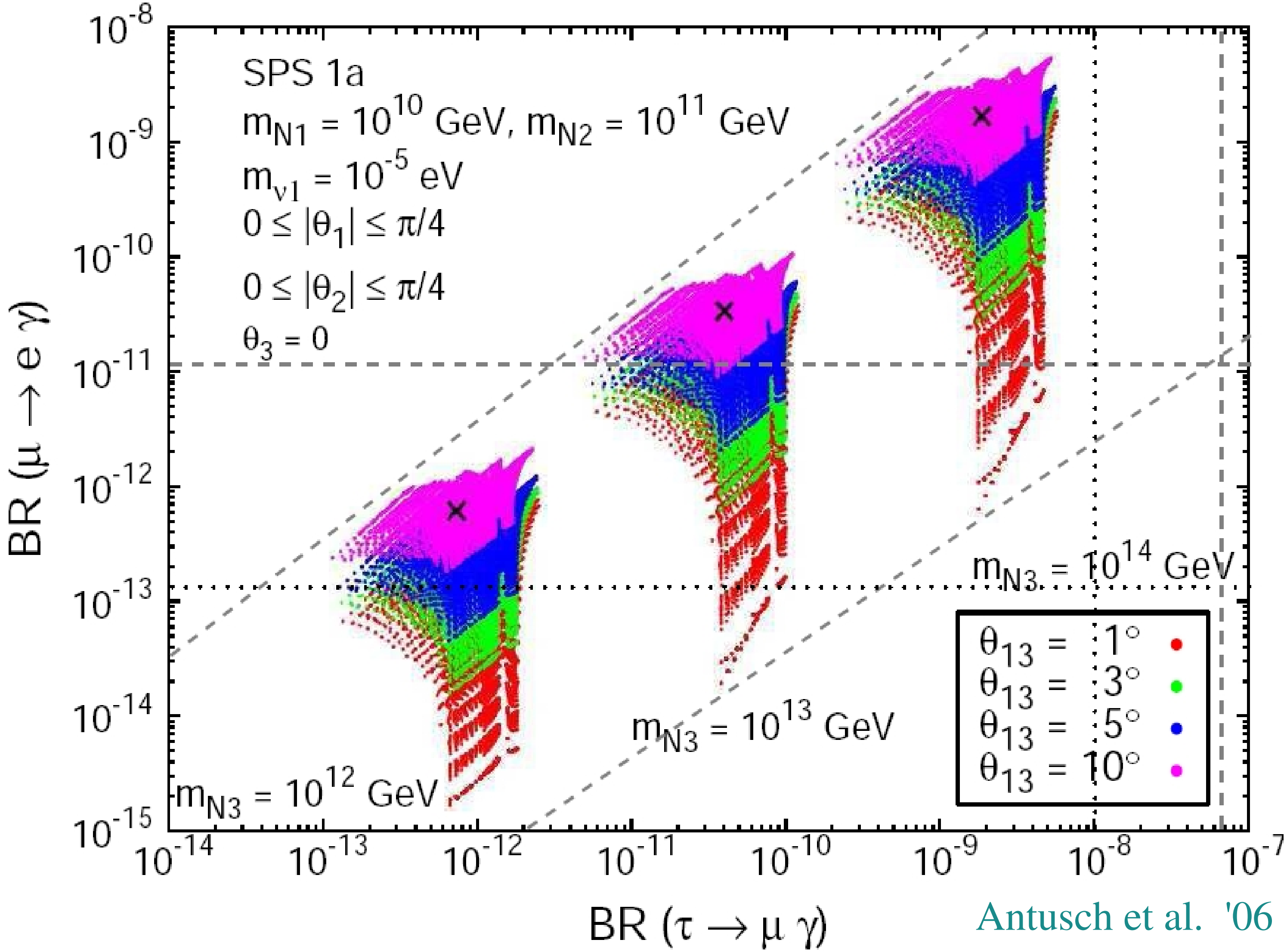
M_R independent



In GUT theories with new particles carrying lepton-flavor at the TeV scale (*e.g. the sleptons in the MSSM*)
MEG has high chances to see $\mu \to e\gamma$
(*but remember that* $\Gamma \sim \Lambda^{-4}$)

Ratios of different LFV rates are potentially a useful ingredient to distinguish different underlying mechanisms of flavour symmetry breaking

E.g. : $\tau \to \mu\gamma$ vs. $\mu \to e\gamma$ in MSSM + heavy N_R [no GUT constraints]



Antusch et al. '06

Note that $B(\tau)/B(\mu) > 1$ but it cannot be arbitrarily large

↓

if $B(\mu \to e\gamma) < 10^{-13}$ (not seen at MEG) very little hopes to see $\tau \to \mu\gamma$ at SuperB

II. *Very rare K decays*

The MFV hypothesis is unlikely to be exact:

- not compatible (in its more constrained form) with GUTs ⇒ at some level we should expect some *contamination from the lepton Yukawa couplings* in the quark sector
- it could well be only an approximate infrared property of the underlying theory ⇒ some *deviations* could appear *in the most suppressed processes*

⬇

Potentially large non-SM effects in $K \to \pi\nu\nu$ decays which receive the strongest CKM suppression within the SM ($V_{ts}^* V_{td} \sim \lambda^5$)

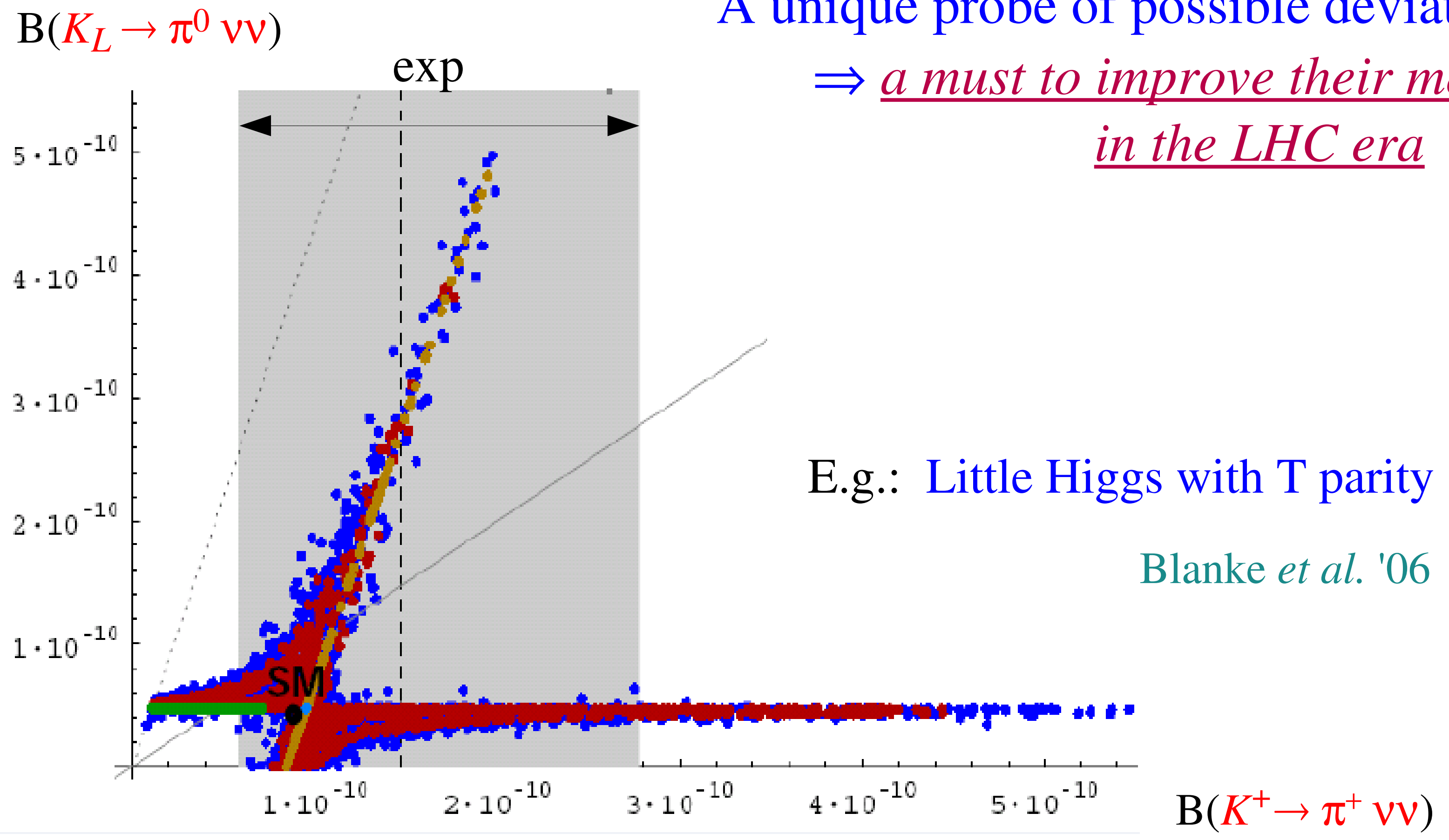
II. *Very rare K decays*

The unique features of $K \to \pi \nu\nu$

- Smallness of the CKM suppression factor ($V_{ts}{}^{*}V_{td} \sim \lambda^5$)
- High th. cleanness (unique for loop-induced meson decays):
  ~2% for BR(K_L) & ~ 5% for BR(K^+)

A unique probe of possible deviations from MFV

⇒ *a must to improve their measurements in the LHC era*



E.g.: Little Higgs with T parity

Blanke *et al.* '06

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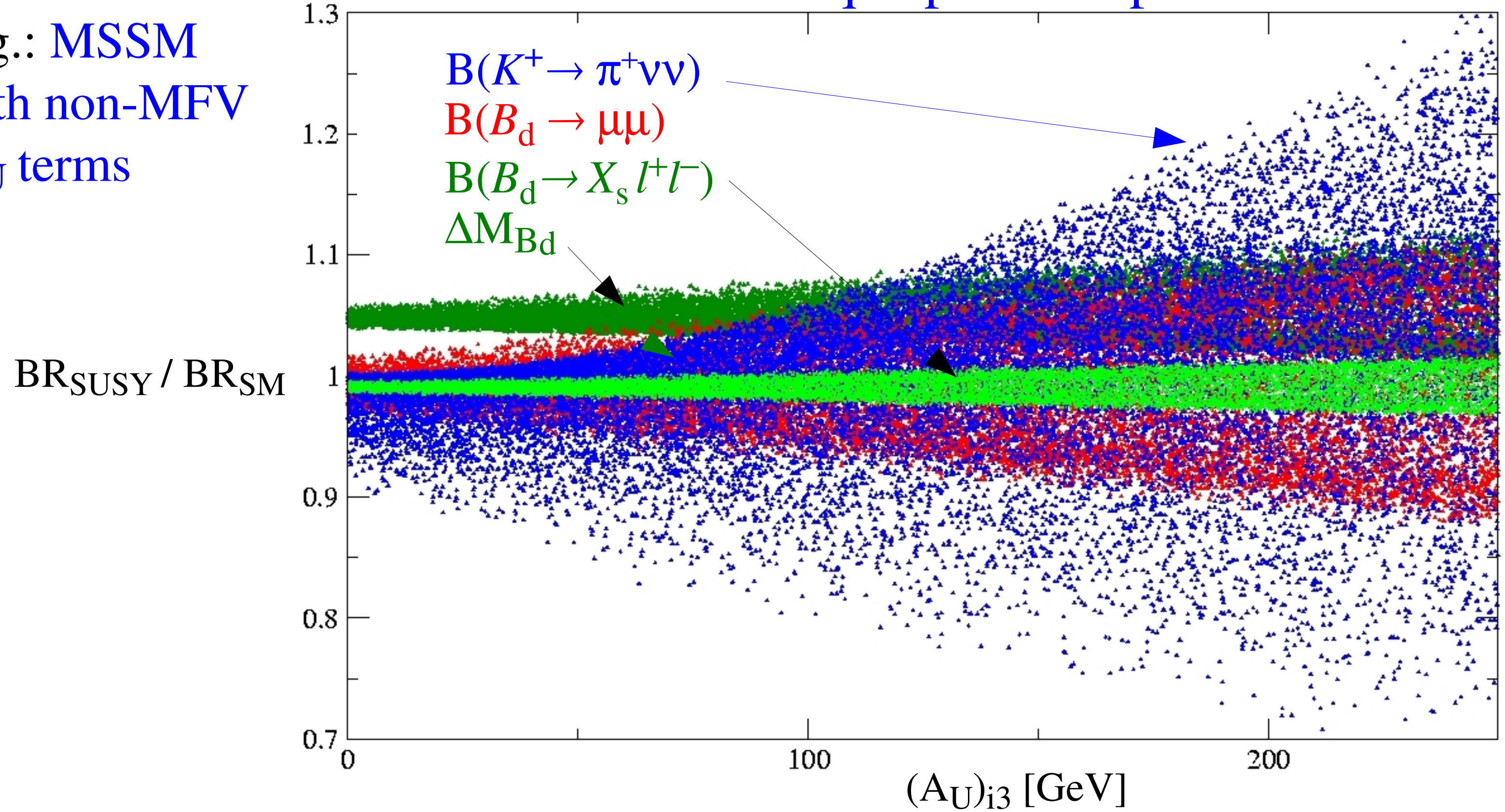
A unique probe of possible deviations from MFV

E.g.: MSSM with non-MFV A_U terms



G.I., Mescia, Paradisi, Smith, S.Trine, '06

III. Helicity-suppressed B (and K) decays

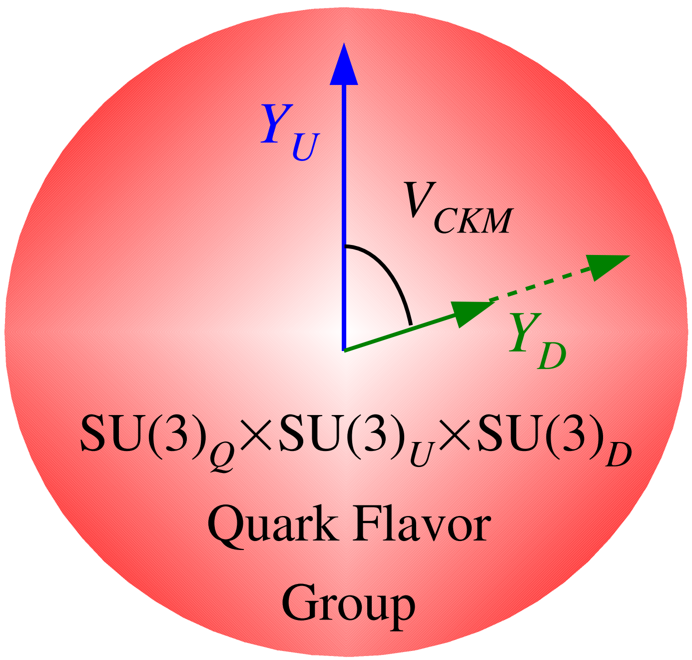
The MFV hypothesis is unlikely to be exact:

- not compatible (in its more constrained form) with GUTs ⇒ at some level we should expect some *contamination from the lepton Yukawa couplings* in the quark sector
- it could well be only an approximate infrared property of the underlying theory ⇒ some *deviations* could appear *in the most suppressed processes*
- In the wide class of models with more Higgs doublets, we are free to change Yukawas normalization

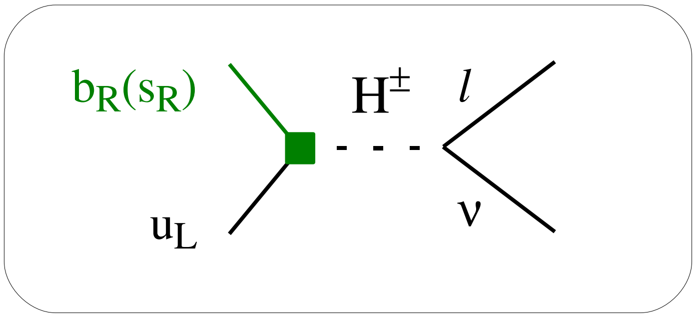
$$\mathrm{diag}(Y_U) = \mathrm{diag}(m_u) / \langle H_U \rangle$$

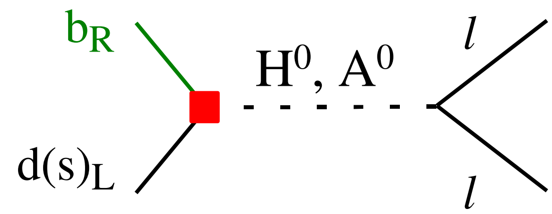
$$\mathrm{diag}(Y_D) = \mathrm{diag}(m_d) / \langle H_D \rangle = \tan\beta \, m_d / \langle H_U \rangle$$

⇒ some deviations could appear in helicity-suppressed B (and K) decays



III. *Helicity-suppressed B (and K) decays*





In models with 2 Higgs doublets (such as the MSSM) the $H^\pm$ exchange appears at the tree-level in charged-current amplitudes.
The effect is usually negligible (suppression of Yukawa couplings), except for helicity suppressed observables ($B,K \to l\nu$) or τ final states ($B \to D\tau\nu$)

Simple M_H & $\tan\beta$ dependence
[mild dependence on other parameters]:

$$B(B\to l\nu) = B_{SM} \left(1 - \frac{m_B^2 \tan\beta^2}{M_H^2 (1+\epsilon_0 \tan\beta)} \right)^2$$

- O[(10-30)%] effect in $B \to l\nu$
- O[(3-10)%] " " " $B \to D\tau\nu$
- O[(0.1-0.3)%] " " " $K \to l\nu$

III. Helicity-suppressed B (and K) decays

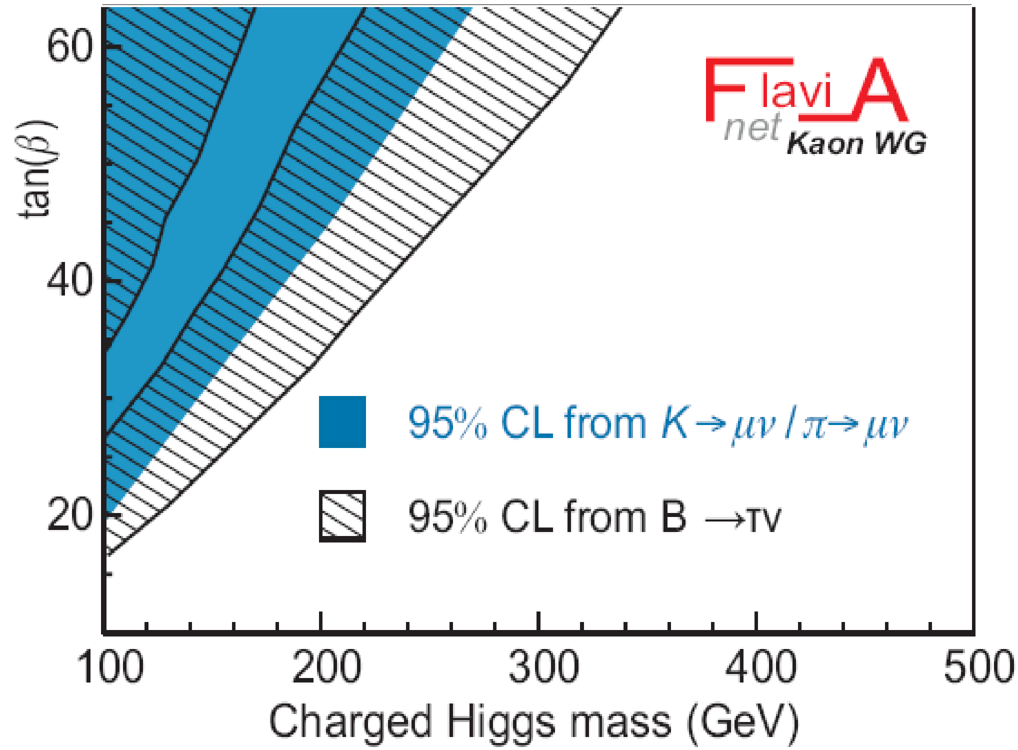
Present status:

$B(B \to \tau\nu) = (1.51 \pm 0.33)\times 10^{-4}$

Babar+Belle '09

$B(B \to \tau\nu)_{SM} = B_0\, F_B^{\,2}\, V_{ub}^{\,2} \approx 1.2\times 10^{-4}$

sizable theoretical (parametric) error



$B(K \to \mu\nu) = (63.66 \pm 0.17)\%$ KLOE '06

+ f_K/f_π @ 0.7% MILC, HPQCD '07-'08

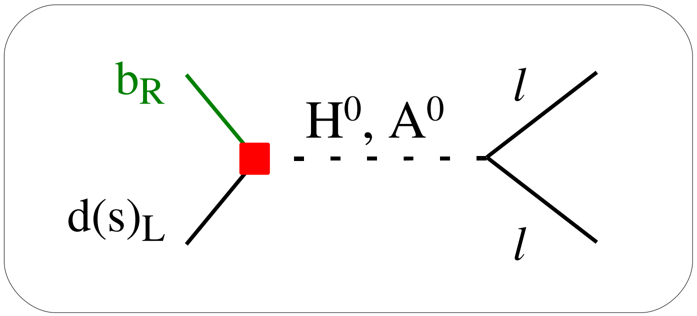
+ V_{us} @ 0.5% KLOE, NA48, KTeV '06-'08

RBC '08

Improving th. and exps. on these channels can lead to very valuable infos on M_H & tanβ !

N.B.: key role played by lattice QCD

III. *Helicity-suppressed B (and K) decays*



$B(B_s \to \mu\mu)_{SM} = 3.2(2) \times 10^{-9}$

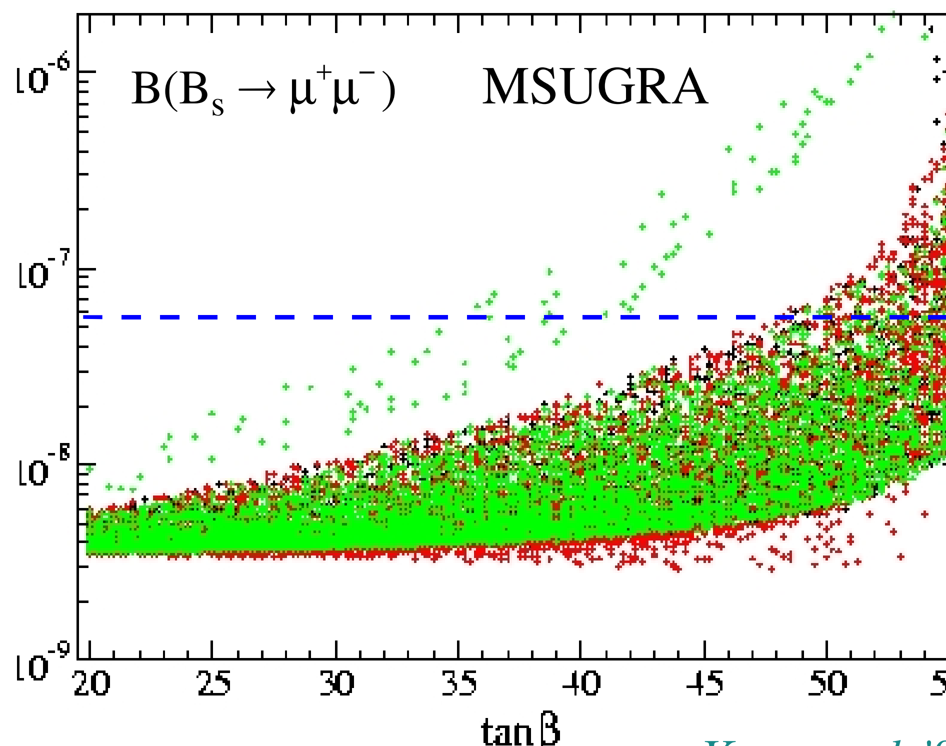
HPQCD '09

$B(B_s \to \mu\mu) < 5.8 \times 10^{-8}$ (95%CL)

[CDF '07]

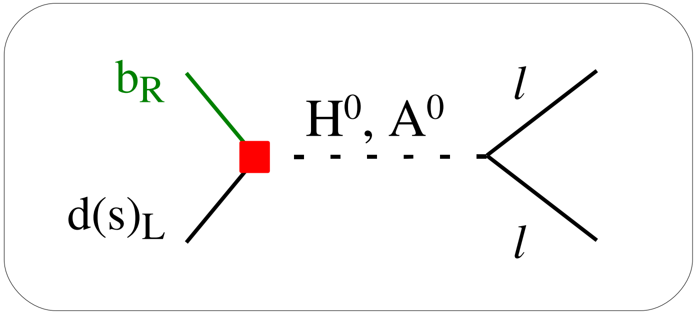
No Higgs-mediated tree-level FCNCs in MFV models. However, effective couplings generated at the one loop level ⇒ <u>deviations from SM potentially very large but more model dependent</u>

$$A(B \to l^+ l^-)_{SUSY} \sim \frac{m_b\, m_l}{M_A^2} \frac{\mu\, A_U}{\tilde{M}_q^2} \tan^3\beta$$



Kane *et al.* '03

III. Helicity-suppressed B (and K) decays



$B(B_s \to \mu\mu)_{SM} = 3.2(2) \times 10^{-9}$

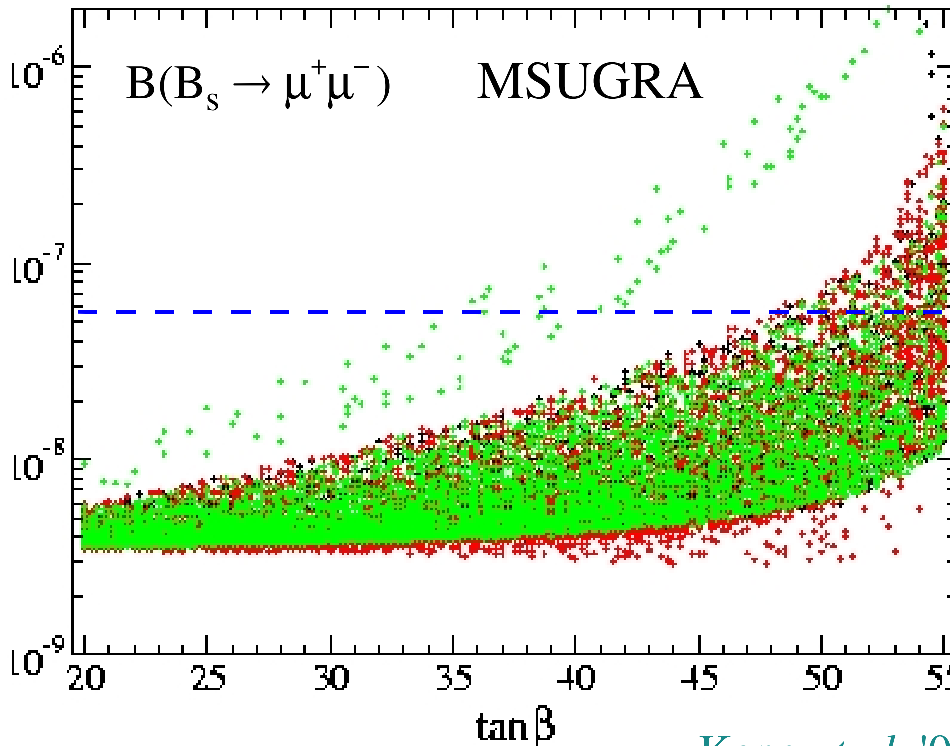
$B(B_d \to \mu\mu)_{SM} \approx 1.0 \times 10^{-10}$

e channels suppressed by $(m_e/m_\mu)^2$

τ channles enhanced by $(m_\tau/m_\mu)^2$

N.B.:

- Th. error controlled by F_B (⇒lattice). Not a big issue if deviations from SM are large, but important to improve in view of future precise measurements
- The $B(B_d \to \mu\mu)/B(B_s \to \mu\mu)$ ratio is a key observable to proof or falsify MFV



Kane *et al.* '03

Q&A for 2014

1) Suppose experiments find that all (or some) flavour signatures appear to be consistent with SM range & ATLAS/CMS find direct New Physics objects. What will be in this situation the next goals of Flavour physics after ~ 2014?

If LHC finds new physics we know that $\Lambda \lesssim 1$ TeV

$$A = A_0 \left[c_{SM} \frac{1}{M_W^2} + c_{NP} \frac{1}{\Lambda^2} \right]$$

↓

Some effect should show up in clean & short-distance dominated flavour-changing quark decay at the few % level

↓

Worth to improve the precision on the theoretically clean channels [$K\to\pi\nu\nu$, $B\to l\nu$, $B\to\mu\mu$,...] whose error is likely to be $\gtrsim$ 10% in 2014

Q&A for 2014

2) Suppose ATLAS/CMS find either only the SM Higgs or absolutely nothing. Is it still worth studying flavour physics in this scenario?

Yes !

We can probe scenarios with $\Lambda \gg$ 1 TeV and $c_{NP} = O(1)$

$$A = A_0 \left[c_{SM} \frac{1}{M_W^2} + c_{NP} \frac{1}{\Lambda^2} \right]$$

⇓

The only important point to check is the th. error on the SM contribution

LFV processes are free of this problem ($c_{SM} = 0$) ⇒ best candidates

Q&A for 2014

3) Are there any flavour observables that were not stressed by theory because there are beyond the experimental scope of next ~ 5 years?

Some interesting "forgotten" (but not totally impossible) candidates are

$K_L \to \pi^0 l^+ l^-$ [*The only hope to get a precise short-distance info on* $s \to d\gamma$]

$B \to e\nu$ [*The most suppressed among the helicity-suppressed modes:* $BR \sim 10^{-11}$]

Q&A for 2014

4) Which observables will not be theoretically limited by ~2014?

- LFV decays of charged leptons [$\mu \to e\gamma$, $\tau \to \mu\gamma$, $\mu N \to eN$,...]: virtually no limits
- LFU ratios [$K \to e\nu / K \to \mu\nu$, $B \to \mu\nu / B \to \tau\nu$, $B \to K\mu\mu / B \to Kee$,...]:
  th. errors of O(0.1%–1%), well below exp. accuracy in 2014
- Clean FCNCs [$K^+ \to \pi^+ \nu\nu$, $K_L \to \pi^0 \nu\nu$, $\Delta\Gamma_{CP}(B \to X_s\gamma)$, $A_{FB}(B \to X_s l^+ l^-)$]:
  th. errors of O(1%-5%), well below exp. accuracy in 2014
- Pure leptonic B decays [$B \to \mu\nu$, $B \to \mu\mu$]:
  th. errors of O(10%), could easily go to few % [Lattice QCD: f_B]

- Exclusive semileptonic B decays [$B \to \pi l\nu$, $B \to K\mu\mu$, ...]:
  th. errors of O(10%-30%), could go down? [Lattice QCD: $F_{B \to H}$]
- CPV in "golden" hadronic B decays [$A_{CP}(B_d \to \psi K)$, $A_{CP}(B_s \to \psi\phi)$]:
  th. errors ~ 2%, difficult to improve
- CPV in "peguin" hadronic B decays [$A_{CP}(B_d \to \phi\psi)$, $A_{CP}(B_s \to \psi\phi)$]:
  th. errors ~ 10%, difficult to improve

Q&A for 2014

5) Which are the key flavour observables to constrain the new physics parameter space? How do these observables relate to each other and help to distinguish new physics models?

Hope I help you to clarify this point during my talk...

but if I failed I have some additional material in the "extra slides"...

Conclusions

We learned a lot about flavour physics in the recent past...
..but what is still to be discovered is more !

TeV-scale NP models must have a rather sophisticated flavour structure (not to be excluded by present data) but we have not clearly identified this structure yet

⬇

Very important to continue high-precision flavour physics in the LHC era

- There is not a unique (or a unique class) of outstanding observable(s), we need to improve in several directions: B, τ, K, μ decays, concentrating on the theoretically-clean observables [*leptonic/semileptonic final states*]

- Full complementarity both between low-energy and high-Pt physics, and also between different low-energy facilities

Extra slides

Flavour constraints in the "constrained MSSM" (CMSSM)

The Minimal Supersymmetirc extension of the SM (MSSM) has more than 100 free parameters, most of them related to flavour-violating observables. Given the lack of high-pt data, at present it is very difficult to show the correlations of these observables, unless we employ simplifying assumptions.

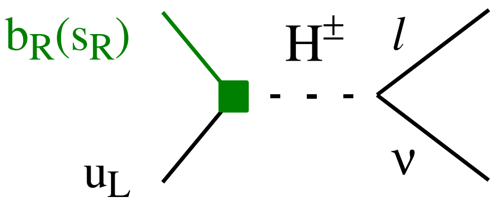
Most simple framework: CMSSM (also known as mSUGRA)

Scenario characterized by 4 free parameter [after imposing e.w. symmetry breaking]:

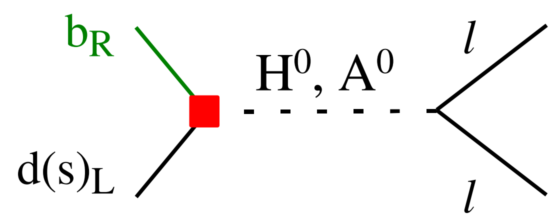
GUT param.

- M_0 = univ. soft scalar mass
- $M_{1/2}$ = univ. soft gaugino mass
- A_0 = univ. soft trilinear term
- μ, B ⟷ $\tan\beta$ + sgn(μ)

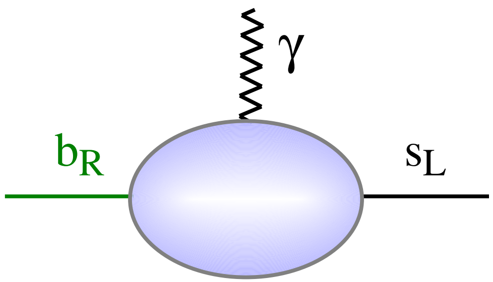
Flavour constraints in the "constrained MSSM" (CMSSM)



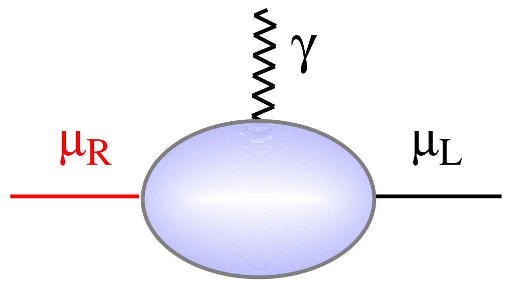
$B^{\pm} \to l^{\pm}\nu$
$(K^{\pm} \to l^{\pm}\nu)$



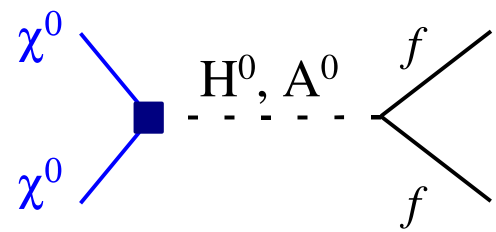
$B_{s,d} \to l^+ l^-$



$B \to X_s \gamma$



$(g\text{-}2)_\mu$



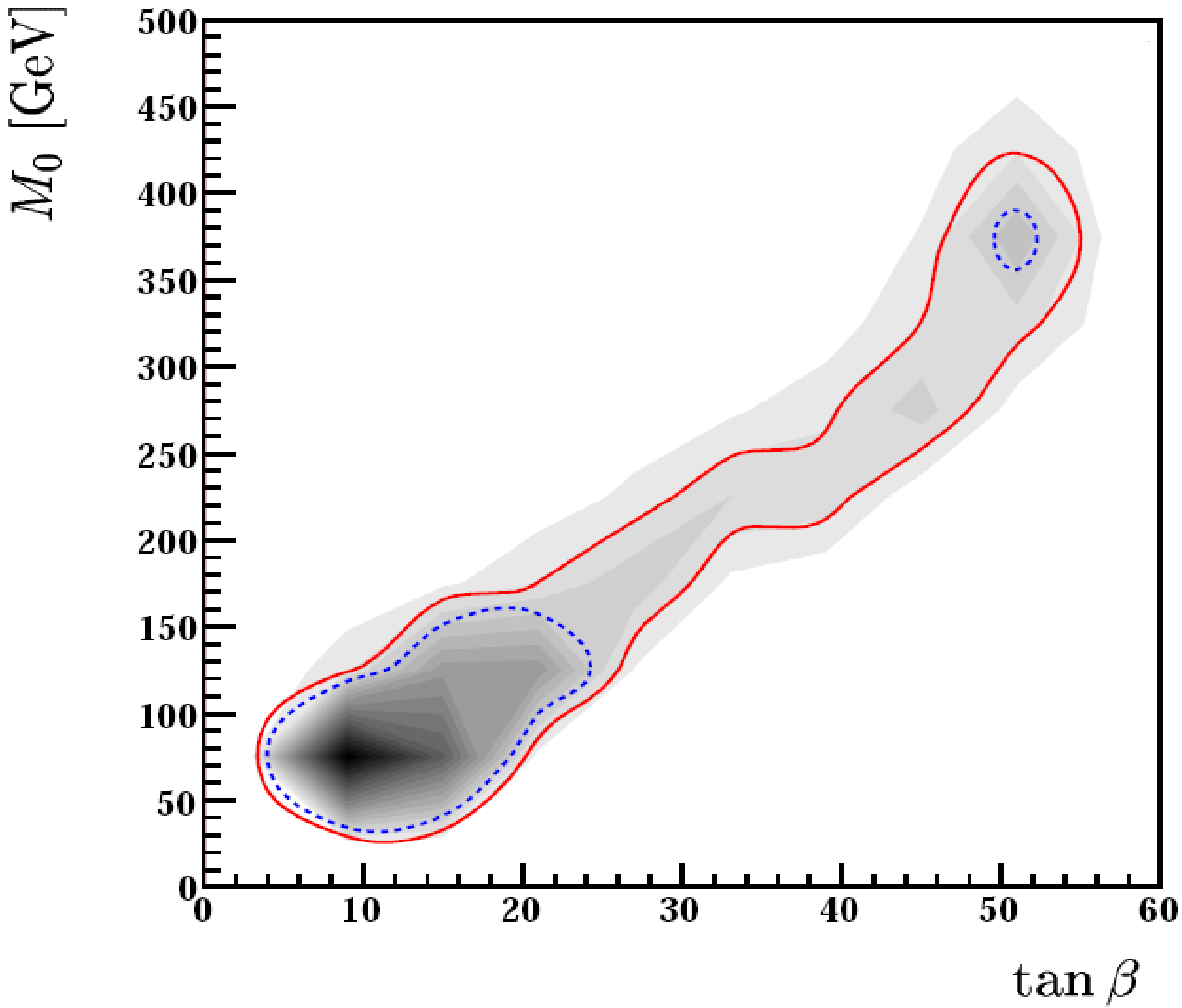
$\chi^0\chi^0 \to f f$

Even within this simplified framework, flavour constraints are key ingredients to reconstruct the theory from data

[interesting correlations of flavour physics, $(g\text{-}2)_\mu$ and dark matter annihilation amplitudes]

Flavour constraints in the "constrained MSSM" (CMSSM)

- Multi-parameter χ^2 fit
- fitting for all CMSSM parameters: M_0, $M_{1/2}$, A_0, $\tan\beta$;
- including relevant SM uncertainties (*e.g.* $m_{\rm top}$);

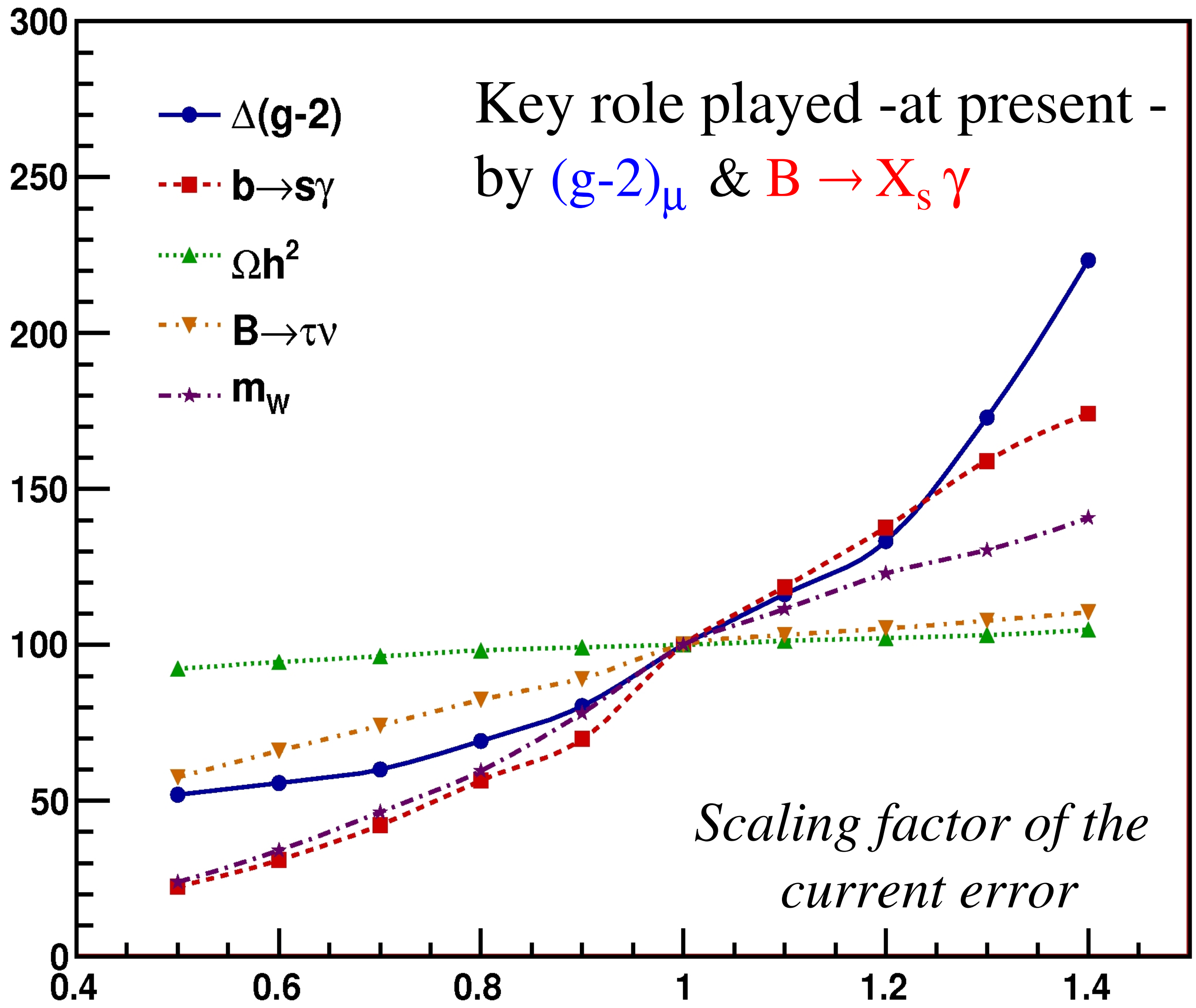


- overall preferred minimum at low $\tan\beta$, low squark mass;
- less preferred region at high $\tan\beta$, higher squark mass;
- consistent with previous studies.

Buchmuller et al.
arXiv: 0707.3447 [hep-ph]

Flavour constraints in the "constrained MSSM" (CMSSM)

Relative reduction of the preferred area in the $M_0 - \tan\beta$ plane



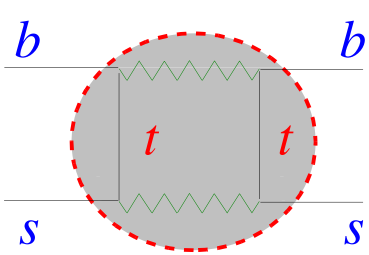
Buchmuller et al.
arXiv: 0808.4128 [hep-ph]

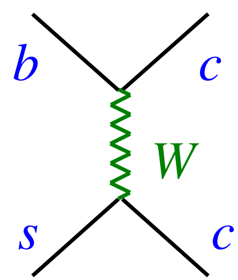
Reduced errors on flavour-violating observables would substantially constrain the model

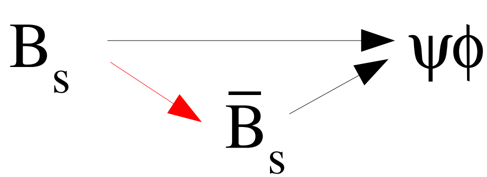
Large non-standard effetcs in B_s mixing

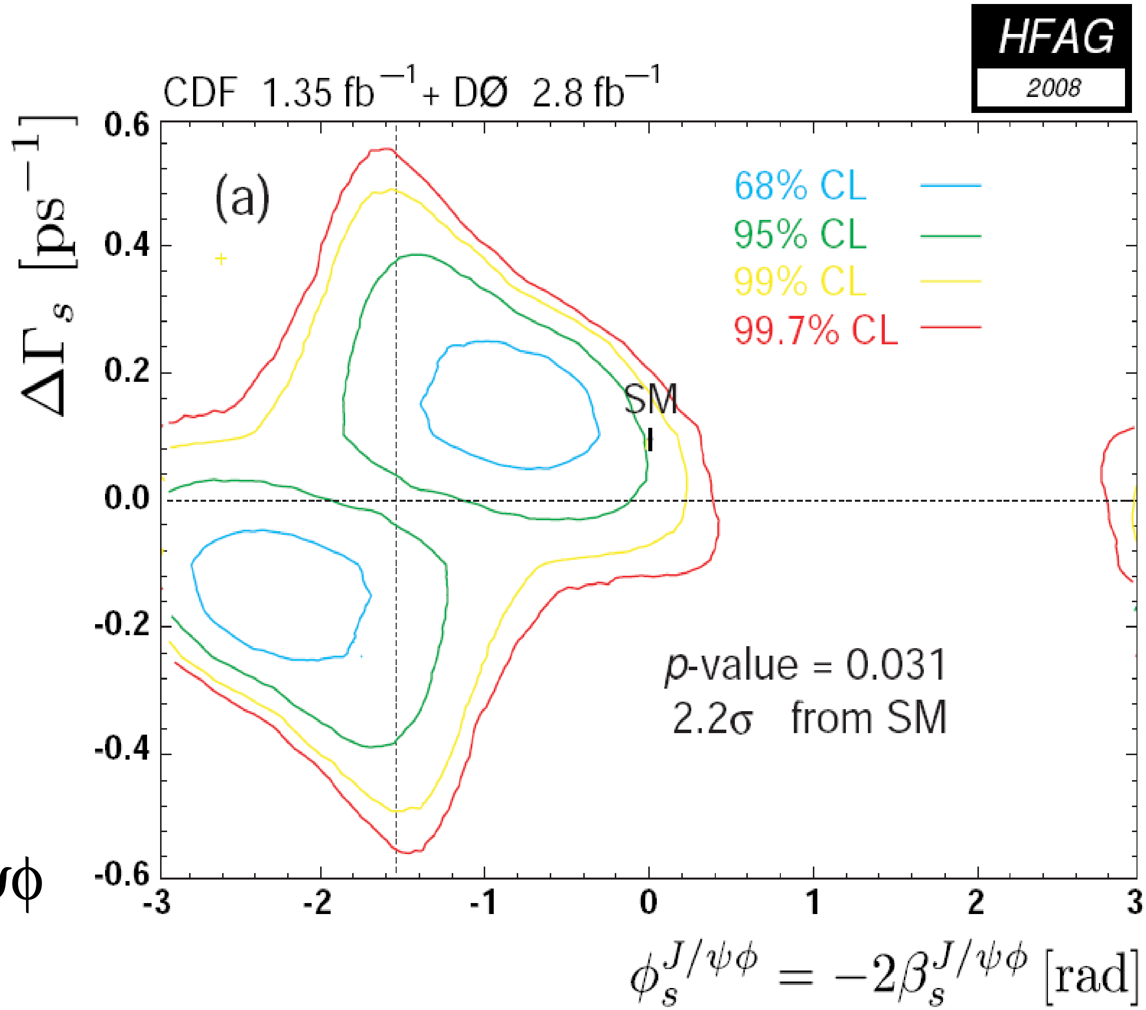
According to recent CDF & D0 results on $B_s \to \psi\phi$, there is a ~2σ deviation from the SM (and MFV) in the CPV phase of B_s mixing. *If confirmed*, this would rule out both SM and MFV hypothesis.

$$C\, e^{2i\phi} = \frac{\langle M \,|\, H^{SM+NP} \,|\, \bar{M} \rangle}{\langle M \,|\, H^{SM} \,|\, \bar{M} \rangle}$$









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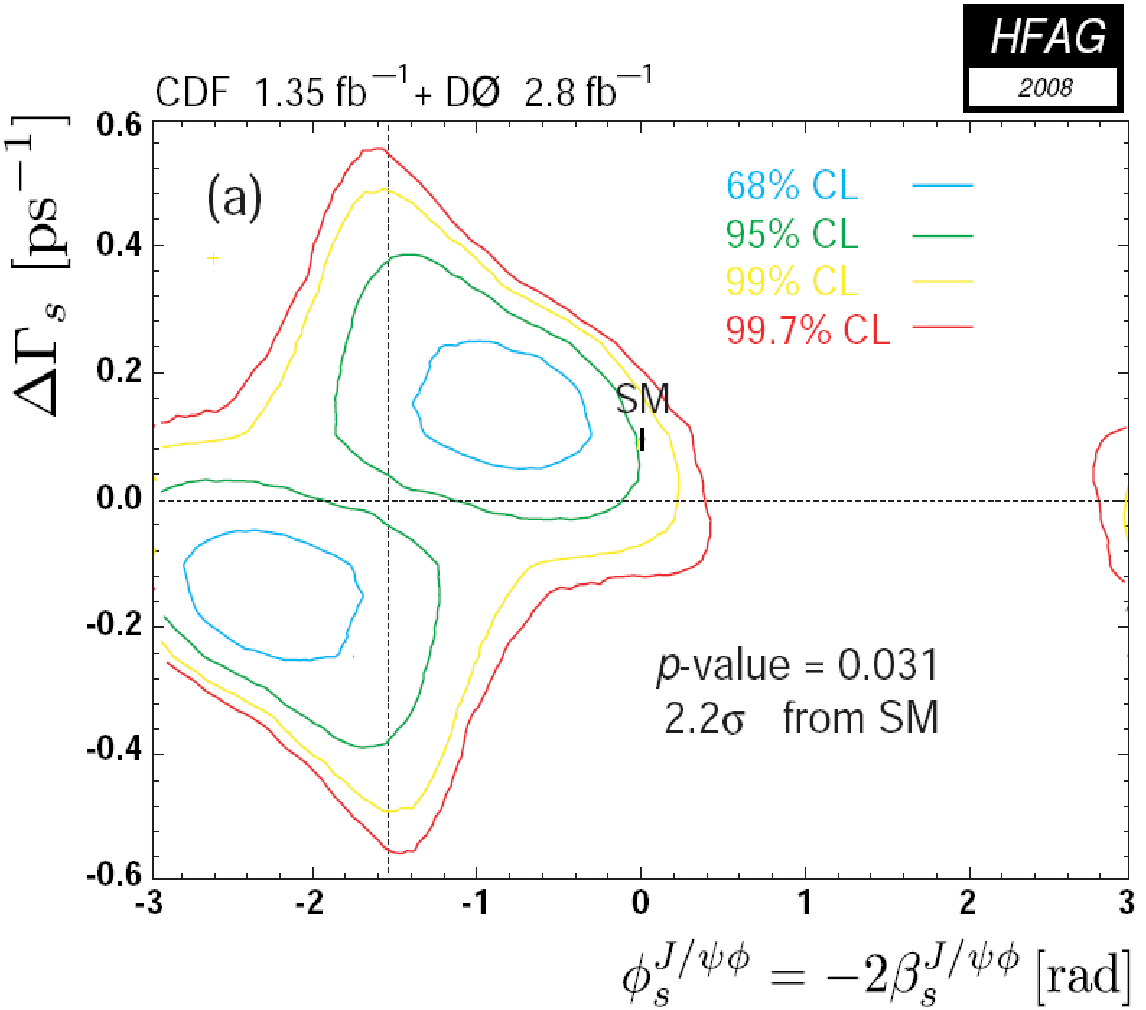
Caution needed given non-Gaussian errors (remember lesson from $B_d \to \phi K$)

On general grounds, such effect is also not very natural on the theory side, given the absence of deviations from SM in $\Delta M B_s$ & $B_d \to X_s \gamma$ ($b \to s$ transions)



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However, this effect could be accommodated in specific BSM frameworks

↓

If confirmed, we should expect non-standard effects "around the corner" in several other b→s observables, and possibly also in ε_K